State of the California Central Coast

Results from Baseline Monitoring of Marine Protected Areas 2007–2012

This report was produced by the California Ocean Science Trust working in partnership with the California Department of Fish and Wildlife, and in collaboration with the Central Coast MPA Baseline Program Principal Investigators as well as many other partners and colleagues in the region. Over the past year, many scientists have conducted data analyses, provided results and reviewed sections of the report. We thank everyone for their expertise, dedication and generous time given to this project.

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About This Report

This report is intended to provide everyone with an interest in California's Central Coast with scientific information about the ecological and socioeconomic conditions in the two years following Marine Protected Area (MPA) implementation as well as initial changes that occurred from 2007 to 2012. This report will be provided to the California Department of Fish and Wildlife and the California Fish and Game Commission to inform the recommended five-year management review of the regional MPA network.

The report summarizes key findings from the 2007–08 Central Coast Marine Protected Areas Baseline Data Collection Projects, which were a collaborative effort among the California Coastal Conservancy, Ocean Protection Council, Department of Fish and Wildlife and California Sea Grant. It also includes ecological, biological, oceanographic and socioeconomic information and findings from key partners as well as background information from the Department of Fish and Wildlife.

Additional Resources

Summary reports of the baseline program, which were created by Sea Grant, are available at www.csgc.ucsd.edu/BOOKSTORE/comp_publications.html.

More information about the Central Coast MPAs, including boundaries, regulations, planning documents and management updates, is available at www.dfg.ca.gov/mlpa.

Additional baseline monitoring information, including existing reports, comprehensive results and raw data, is available on OceanSpaces at www.oceanspaces.org.

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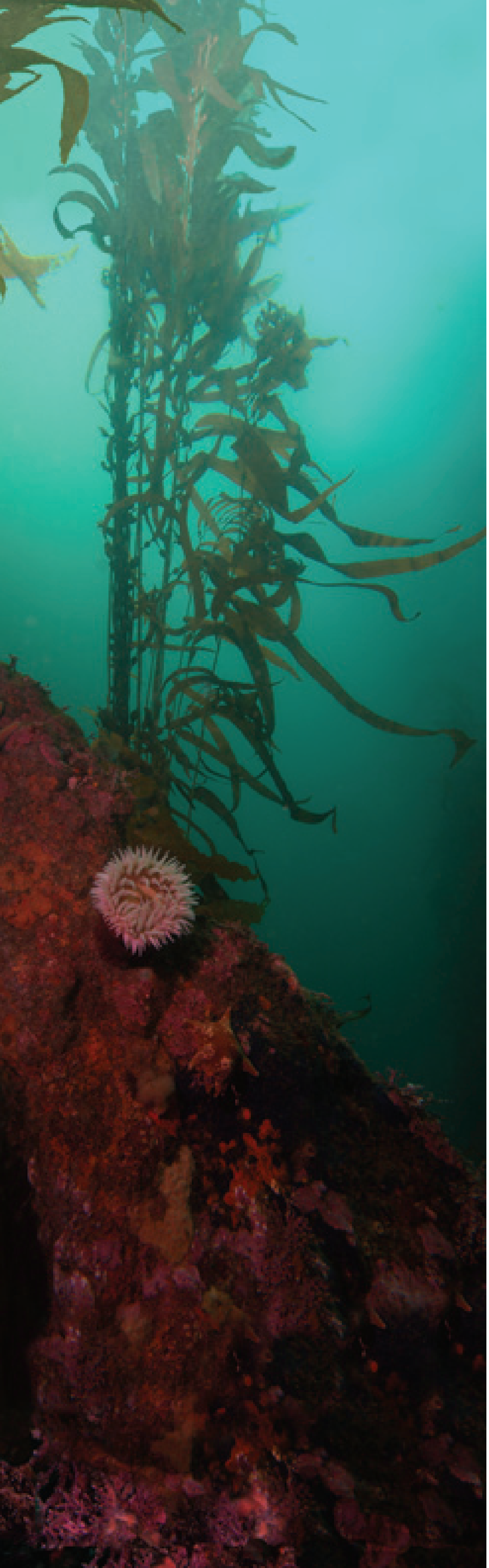

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Introduction

Summary & Key Findings

A New Science-based Network of MPAs

With the passage of the Marine Life Protection Act in 1999, California became the first in the nation to require a statewide network of marine protected areas (MPAs) to protect the integrity of marine ecosystems, rebuild depleted marine life populations, including those of economic value, and improve ocean health. In 2007, 29 MPAs were implemented in the Central Coast region—the first of four regional MPA networks that collectively form the statewide system.

Citizens, scientists, managers and policy experts participated in a unique, collaborative and science-based effort to design and implement these MPAs. The public process also set the stage for a community of participants to stay informed and engaged in the implementation, scientific monitoring and adaptive management of the region's MPAs.

A Benchmark of Ecological and Socioeconomic Conditions

Planning is just the first chapter; scientific monitoring is essential to evaluate the effects of MPAs and inform ocean management. California has embarked on a novel and cost-effective public-private partnership that has developed a framework for MPA monitoring designed to 'take the pulse' of ocean ecosystems and to evaluate the effectiveness of MPA management. Once the MPAs are in the water, the monitoring effort begins. The first step is to establish a benchmark of ocean conditions and human activities, against which future changes can be measured.

This report shares the results from these initial steps of monitoring in the Central Coast—providing a benchmark of ecological and socioeconomic conditions in the one to two years following MPA implementation and examining early changes that occurred from 2007 to 2012. Along with proceedings from the State of the California Central Coast Symposium, this information will be provided to the California Department of Fish and Wildlife and the California Fish and Game Commission to inform the recommended five-year management review of the Central Coast regional MPA network.

A Foundation for Science-Informed Decisions for Our Oceans

The scientific data gathered and analyses conducted add up to the most detailed picture created of current ocean conditions along California's Central Coast. This is an important time stamp that will inform our understanding of our changing world. From ongoing MPA monitoring to fisheries and water quality management and climate change adaptation, this scientific benchmark provides a foundation for citizens, scientists and managers to keep a finger on the pulse of marine systems and make rigorous science-informed decisions for our oceans.

Central Coast MPAs are on Track

Some species have demonstrated early changes

- In kelp forests, a range of economically important fishes, including cabezon, lingcod and black rockfish increased in abundance in MPAs compared to similar locations outside MPAs.
- On rocky shores, numbers and sizes of protected black abalone and harvested owl limpets have increased inside MPAs in this 5-year window.

Long-established MPA reveals the pace of change in marine life

- Monitoring results from one of the oldest MPAs in the region, Point Lobos, indicate that this MPA is home to higher numbers and larger individuals of economically important fishes than neighboring reefs, and reveal the pace of change in temperate marine ecosystems.

Fishing opportunities continue in a diversified local ocean economy

- Both recreational and commercial fishing continue to be an integral part of the Central Coast, and a shift in activities, such as whale watching tours offered by the CPFV fleet, demonstrate adaptation and resilience in the local ocean economy.

A benchmark established for evaluating future performance

- Kelp forests, rocky shores, mid-depth and deep ecosystems in the Central Coast region are characterized by distinct communities of marine plants, invertebrates and fishes. These communities are set amidst an intricate backdrop of variable geology, dynamic ocean conditions and complex human interactions.
- Commercial and recreational fishing industries are a reflection of a complex interplay among environmental and economic conditions, and the regulatory landscape. Monitoring results set the stage to evaluate long-term socioeconomic effects of the MPAs.

Looking Forward

Deeper understanding

- California's investment in seafloor mapping yielded the first comprehensive, high-resolution map of the state's sea floor. Valuable information detailing the full complexity and distribution of habitats, including key fish nursery habitats, adds to the body of science used to plan and cost-effectively manage the MPAs. This information will support future decisions on a range of ocean issues.
- The ecosystems-based approach to MPA monitoring sets the stage for an integrated approach to ocean science and management, incorporating threats such as impaired water quality from land-based sources.

Science-informed decisions

- Monitoring results can facilitate better decision-making on a variety of ocean issues, for example, informing adaptive management of the MPAs, informing fisheries management under the Marine Life Management Act (MLMA) and improving our understanding of how climate change affects marine systems.

Engaged communities

- Broad community involvement has laid the groundwork for increased stewardship and compliance in support of effective MPA management.

Durable partnerships

- Academic institutions, citizen scientists, fishing communities and state and federal agencies are poised to work together to conduct ongoing monitoring that is efficient and cost-effective.

Introduction to the Central Coast

The marine and coastal waters of California's Central Coast region are among the most biologically productive in the world. Giant kelp grow as tall as trees, forming underwater forests. Ocean waters range from shallow estuaries to depths of nearly a mile (1.6 km) in the Monterey Submarine Canyon. The seafloor, composed of many types of rock and sediment, creates a mosaic of habitats. Seagrass meadows and rocky reefs fringe the rugged coastline.

Collectively, these habitats are home to a tremendous diversity of species—26 marine mammals, 94 seabirds, 4 sea turtles, more than 340 fishes, thousands of invertebrates and more than 450 marine algae. Dynamic oceanographic conditions on Pacific-wide and regional scales drive seasonal, annual and decadal changes in ocean productivity and help to shape these nearshore habitats and marine life. The species assemblages found here are globally unique.

Coastal communities are closely linked to the region's productive waters and depend on healthy resources for fisheries and coastal tourism. Among others, the sardine and market squid fisheries provide fresh seafood regionally and throughout the world. The Central Coast and its iconic towns such as Monterey and Santa Cruz are popular destinations for diving, kayaking, recreational fishing, whale watching, marine research and educational activities.

Goals of the Marine Life Protection Act

(1999, Chapter 10.5 of the California Fish & Game Code, §2850–2863)

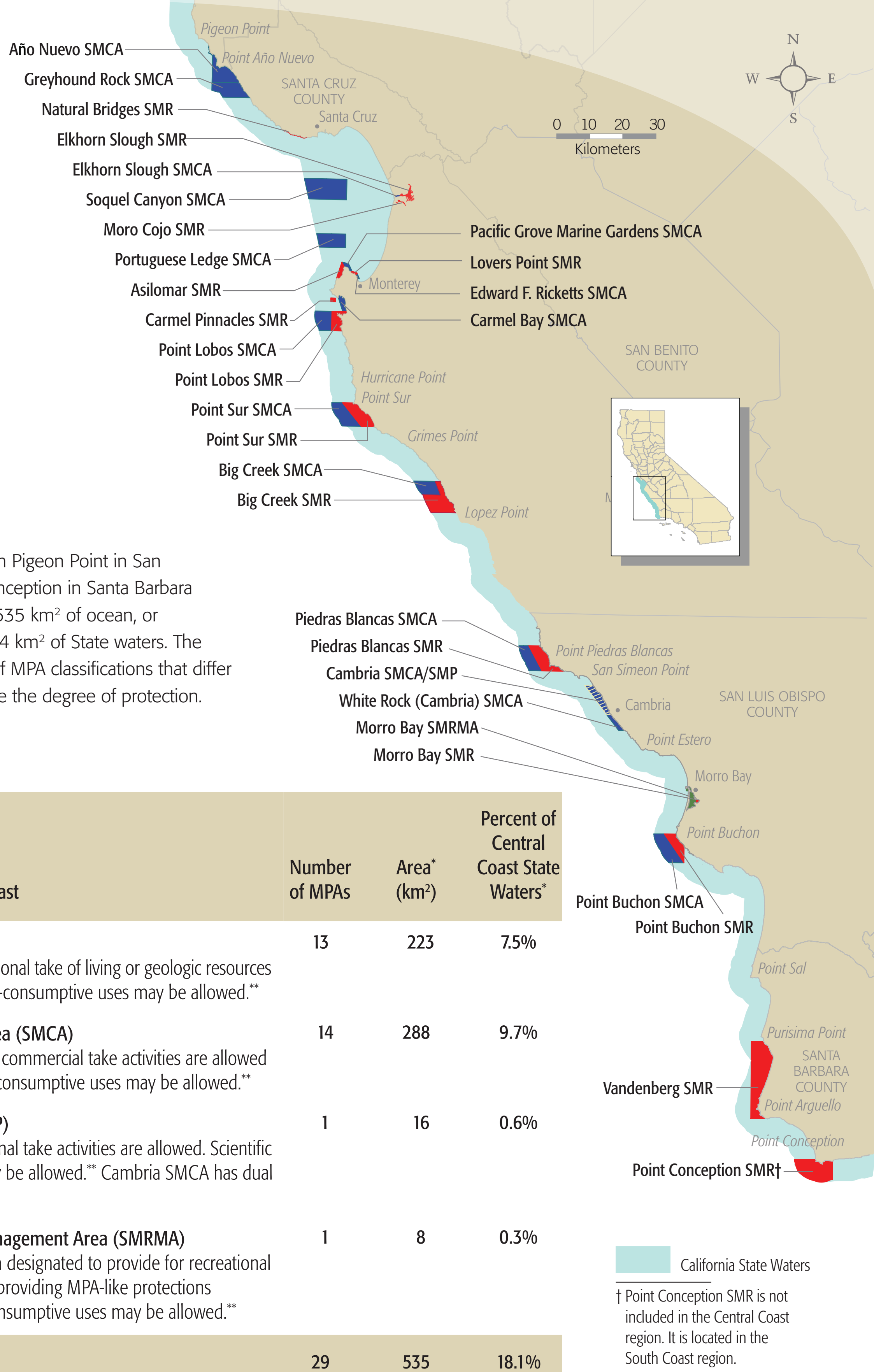
1. To protect the natural diversity and abundance of marine life, and the structure, function and integrity of marine ecosystems.
2. To help sustain, conserve and protect marine life populations, including those of economic value, and rebuild those that are depleted.
3. To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.
4. To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.
5. To ensure that California's MPAs have clearly defined objectives, effective management measures and adequate enforcement and are based on sound scientific guidelines.
6. To ensure that the state's MPAs are designed and managed, to the extent possible, as a network.

Central Coast MPAs

The creation of a statewide network of Marine Protected Areas (MPAs) is a relatively new approach to marine resource management. While an individual MPA functions to protect organisms and ecological linkages within a specific area, a network of MPAs is designed to sustain marine life at a regional scale by supporting important processes such as dispersal of larvae among sites and protecting ecosystems, such as kelp forests, at multiple locations. An MPA network includes individual MPAs of different sizes and degrees of protection and can complement single-species fisheries management to maintain and improve ocean health.

The California Marine Life Protection Act (MLPA, Chapter 10.5 of the California Fish & Game Code, §2850–2863) was passed by the California legislature in 1999 and directed the state to reevaluate and redesign California's system of marine protected areas (see box). Through the MLPA Initiative, California began a collaborative multi-year public process to plan the new network of MPAs*. To ensure that local needs were addressed in the planning process, California's coastline was divided into five regions, four coastal regions and San Francisco Bay. Citizens appointed to a regional stakeholder group designed the regional MPA network with evaluations by scientists and guidance from an expert policy panel. In 2007, the Central Coast became the first region in which a network of 29 MPAs (see map) was implemented.

*In California, state law defines a marine protected area as a named, discrete, marine or estuarine area seaward of the mean high tide line or the mouth of a coastal river that has been designated to protect or conserve marine life and habitat.



The Central Coast region extends from Pigeon Point in San Mateo County southward to Point Conception in Santa Barbara County. The region's 29 MPAs cover 535 km^2 of ocean, or approximately 18 percent of the 2,964 km^2 of State waters. The Central Coast MPA network consists of MPA classifications that differ in their allowed activities and therefore the degree of protection.

MPA Classifications in the Central Coast	Number of MPAs	Area* (km^2)	Percent of Central Coast State Waters*
State Marine Reserve (SMR) An area where all commercial and recreational take of living or geologic resources is prohibited. Scientific research and non-consumptive uses may be allowed.**	13	223	7.5%
State Marine Conservation Area (SMCA) An area where select recreational and/or commercial take activities are allowed to continue. Scientific research and non-consumptive uses may be allowed.**	14	288	9.7%
SMCA/State Marine Park (SMP) An SMP is an area where select recreational take activities are allowed. Scientific research and non-consumptive uses may be allowed.** Cambria SMCA has dual designation as an SMP.***	1	16	0.6%
State Marine Recreational Management Area (SMRMA) A non-terrestrial marine or estuarine area designated to provide for recreational hunting opportunities to continue while providing MPA-like protections subtidally. Scientific research and non-consumptive uses may be allowed.**	1	8	0.3%
Total for Central Coast Region*	29	535	18.1%

* Numbers for area and percent represent rounded values.

** Research within MPAs is allowed pursuant to obtaining a California Department of Fish and Wildlife issued Scientific Collecting Permit.

*** SMCA/SMP: The California Fish and Game Commission designated Cambria SMCA, which was subsequently also adopted as Cambria SMP by the State Park and Recreation Commission (August 2010) with the same boundaries and no change to regulations. Therefore, this marine protected area has dual designations, as reflected in the table.

Introduction to MPA Monitoring

Need for Monitoring: What Is Monitoring and Why Do We Do It?

The Marine Life Protection Act requires that the statewide network of MPAs be monitored to evaluate progress toward meeting the Act's goals and that the results of monitoring be disseminated to inform MPA management decisions. California has adopted a framework for MPA monitoring designed to "take the pulse" of ocean ecosystems and to evaluate the effectiveness of MPA management.

Taking the Pulse of California's Oceans

California's approach to monitoring takes an ecosystems-based approach that efficiently and cost-effectively assesses the health of California's oceans and tracks how it is changing through time. Key aspects or "pulse points" of an ecosystem are identified that, when measured together, give a complete picture of the health of an ecosystem. For example, by monitoring species at the top of the food web, such as seabirds, scientists can draw conclusions about the status of plants or forage fish they depend on, and thus of the ecosystem as a whole. Humans are indicators, too. For example, by surveying, where people are fishing, we can understand the influence and socioeconomic effects of MPAs on particular fisheries. Monitoring can be conducted by community and citizen-science groups, as well as by government agencies and research institutions.

Evaluating MPA Design and Management Decisions

Many decisions go into creating a network of MPAs: how big should they be? How far apart? What activities should be allowed within their boundaries? MPA monitoring in California explicitly considers how these decisions affect marine life and human activities. Learning how ecosystems respond to MPAs of different sizes, or the economic effects of MPA location, helps decision-makers understand how MPAs work and supports more effective ocean management.

MPA Monitoring Is Useful Beyond MPA Management

Information from MPA monitoring can facilitate better decision making on a variety of ocean issues, for example, informing fisheries management under the Marine Life Management Act and improving our understanding of how climate change affects marine systems.

California's Approach: A New Framework, Implemented in Two Phases

California has established a statewide network of MPAs to protect ocean ecosystems and is using scientific monitoring to evaluate their effects and inform ocean management. The state has adopted a two-phase approach to tracking the health of marine life and habitats in and around the MPAs: a baseline program and ongoing monitoring.

Phase 1: Baseline Program

The baseline program starts once MPAs take effect. It has two purposes: to establish an ecological and socioeconomic benchmark against which future MPA performance can be measured; and to assess whether there have been any initial changes resulting from MPA implementation. Baseline monitoring is a unique opportunity to collect a broad suite of ecological and socioeconomic data to rigorously document and understand ocean ecosystem conditions in the one to two years after the MPAs take effect. The findings presented in this report are an outcome of baseline monitoring.

Phase 2: Ongoing Monitoring

Ongoing MPA monitoring is designed to "take the pulse" of marine ecosystems and ocean-based human activities so we can learn how they are changing through time and how MPAs are affecting them. This involves looking at particular species, populations, habitats and human activities for instance, on beaches or within kelp forests. When considered together, the health of all of these ecosystems provides a snapshot of overall ocean conditions, both regionally and statewide, and a measure of how they are changing through time inside and outside MPAs. Ongoing monitoring also addresses key management questions to provide answers that can inform future adaptive management reviews of the regional and statewide MPA network.

Central Coast Baseline Monitoring

Central Coast Baseline Data Collection Projects

Baseline monitoring was launched in 2007 in the Central Coast region. With the support of the Ocean Protection Council (OPC), and through a request for proposals and competitive review process administered by California Sea Grant, five projects were selected to collect socioeconomic and ecological data. In addition, an ongoing citizen-science program—California Reef Check—and the Department of Fish and Wildlife's ROV program joined the baseline program collaboration. In 2011, with additional OPC support, up-to-date socioeconomic data were added to the baseline program. Together, these researchers from academic institutions and government agencies, as well as fishermen involved in collaborative fisheries projects, conducted surveys of kelp forests, nearshore fish populations, rocky intertidal habitats and deep-water habitats. Researchers also collected socioeconomic data. This suite of ecological and socioeconomic data allows us to paint a broad picture of the condition of Central Coast marine ecosystems.

Adding Data and Results to Understand the Central Coast Setting

Establishing a benchmark of baseline conditions requires not only information on the ecology and socioeconomics of the region, but also an understanding of the broader physical habitat, oceanographic and socioeconomic context in which the MPAs are placed. In the Central Coast region, projects led by Francisco Chavez and colleagues at the Monterey Bay Aquarium Research Institute (MBARI) and the Central and Northern California Ocean Observing System (CeNCOOS) analyzed data on oceanographic conditions, while Rikk Kvitek of California State University, Monterey Bay and colleagues mapped seafloor habitats as part of the California Seafloor Mapping Program (CSMP). Information on the level of compliance with MPA regulations from the Department of Fish and Wildlife also contributes to our understanding of baseline conditions. Together, this contextual information complements the data collected as part of baseline monitoring and contributes to the baseline assessments of the region.

Baseline Monitoring Studies

Socioeconomics of Fisheries

Social science researchers, led by Cheryl Chen and Charles Steinback of Ecotrust, conducted a socioeconomic survey and mapped the value of areas for commercial fisheries and the commercial passenger fishing vessel (CPFV or "party boat") fleet.

Kelp Forest Ecosystems

Mark Carr from the University of California Santa Cruz (UCSC) led a project that used SCUBA to quantify fish, invertebrates and algae on nearshore rocky reefs and in kelp forests both inside MPAs and at associated reference sites.

Rocky Intertidal Ecosystems

Pete Raimondi from UCSC led a team of marine ecologists who surveyed invertebrates and algae along the rocky shoreline in the MPAs and associated reference sites.

Remotely Operated Vehicle (ROV) Surveys

Using a ROV equipped with a video camera, scientists from the California Department of Fish and Wildlife documented fish abundance inside and outside of MPAs.

Submersible Surveys

Rick Starr, of California Sea Grant and Moss Landing Marine Laboratories, (MLML) and Mary Yoklavich, of NOAA, led scientists who used a submersible to count and measure fish and invertebrates in deep waters in eight MPAs and eight reference sites.

Data Collection by Volunteer Divers

A network of trained volunteer divers led by Reef Check California collected scientific data on fish, invertebrates and algae on rocky reefs in kelp forests.

Collaborative Fishing Surveys

Rick Starr of California Sea Grant and MLML and Dean Wendt of Cal Poly San Luis Obispo collected data on recreational and commercially important nearshore fish species in collaboration with commercial fishermen, charter boat captains and volunteer recreational anglers.

Socioeconomic Baselines

Social scientists and economists led by Edward Glazier and John Petterson compiled a socioeconomic baseline for evaluating the effects of the Central Coast MPAs on commercial and recreational fishing, as well as divers, kayakers, surfers and other non-consumptive users.

Setting the Scene

Introduction

The Central Coast MPA Baseline Program collected a broad array of data ranging from deep reefs, kelp forests and rocky shores to patterns of fishing and recreational use. These data are used to set the benchmark of starting conditions inside and outside MPAs and to measure progress toward the goals of the Marine Life Protection Act.

However, California's marine and coastal ecosystems are also shaped by many other natural and human influences. A dynamic ocean environment influenced by global processes, such as El Niño cycles, overlies diverse habitats shaped by geologic structures and water movements. Human interactions with the ocean also shape these dynamic ecosystems—changes in fishery regulations, economic conditions and MPA compliance drive trends in the size and distribution of marine species that are observed inside and outside MPAs.

Physical habitats, oceanography and the socioeconomic environment set the scene for California's Central Coast and the regional MPA network. An understanding of this context is important for interpreting MPA monitoring results.

Oceanographic Conditions

The Central Coast region is located within the California Current system, one of the most biologically productive ecosystems in the world. The California Current flows south from the Pacific Northwest to Baja California, far offshore along the edge of the continental shelf. Currents, winds, water temperature and other oceanographic conditions along the Central Coast are always changing (see next page). Those changes—which occur on time scales from milliseconds to decades—affect the fishes, invertebrates and other marine life inside and outside the region's MPAs. For example, seasonal changes in ocean conditions cause fluctuations in the biological productivity of coastal waters and multi-year trends in ocean conditions associated with the Pacific Decadal Oscillation (PDO) affect the entire ecosystem from phytoplankton to sardines and anchovy to salmon.

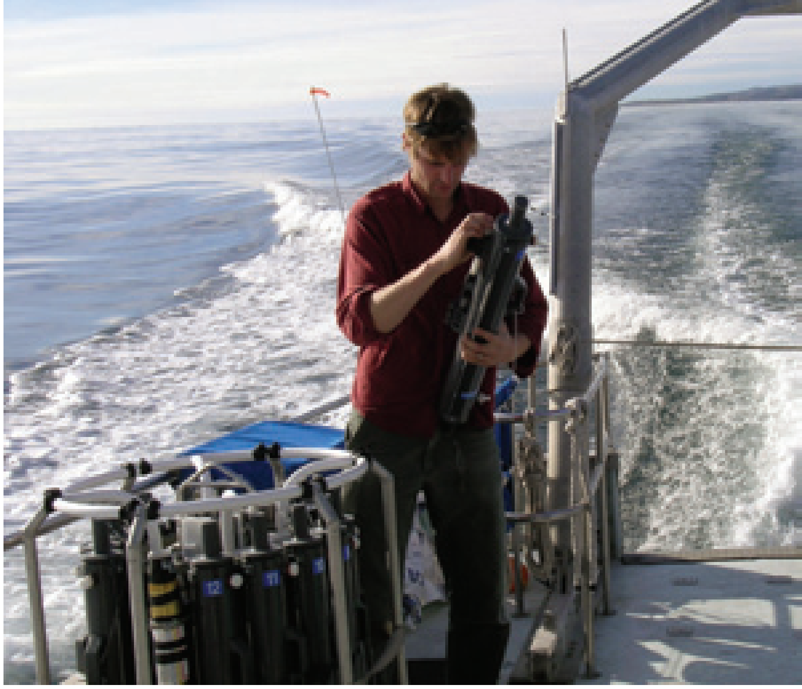
Dr. Francisco Chavez and colleagues at the Monterey Bay Aquarium Research Institute (MBARI) and the Central and Northern California Ocean Observing System (CeNCOOS) have collected oceanographic information for the Central Coast region. This information allows data collected by baseline monitoring studies to be placed in the context of long term environmental changes.

Detecting Local Patterns

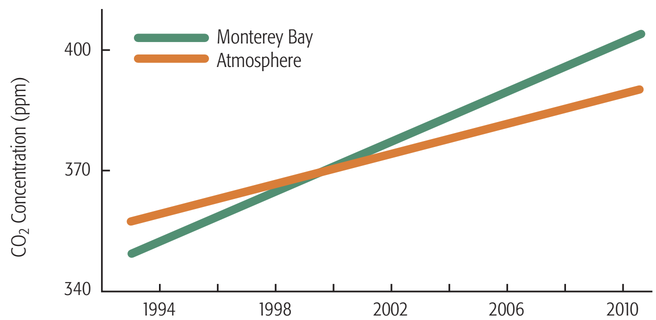
Despite the vast size of the Pacific Ocean, the coastline itself creates local differences in ocean conditions. Wind-exposed capes such as Año Nuevo and Point Conception are often characterized by strong winds and upwelling. In their lee, such as in Monterey Bay, winds, upwelling and offshore water movement tend to be weaker. Dense phytoplankton blooms often develop in these upwelling shadows. Strong fronts, which can form, for example, where slow and fast-moving currents collide, attract a diverse community of predators.

Paying Attention to Long-term Trends

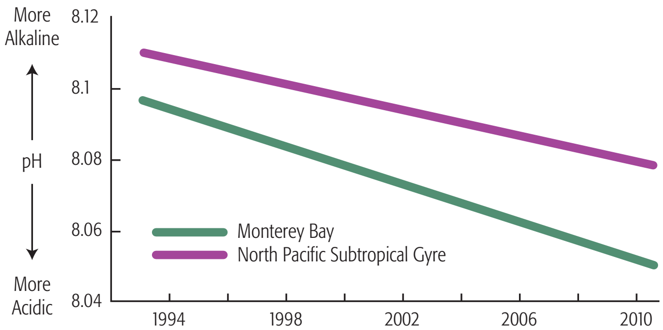
Since 1998, including during the baseline monitoring period, the California Current has been colder and more productive, it has had lower oxygen at depth and El Niño events have been weaker. El Niño events, which occur every five to seven years, cause reduced upwelling and increased sea surface temperatures off the California coast. For the past twenty years, dissolved carbon dioxide and ocean acidity have also been slowly increasing (see figures at right). These long-term, large-scale changes may affect the condition of marine life along the Central Coast now and in the future.



Rising Carbon Dioxide (CO_2) Levels



Declining pH

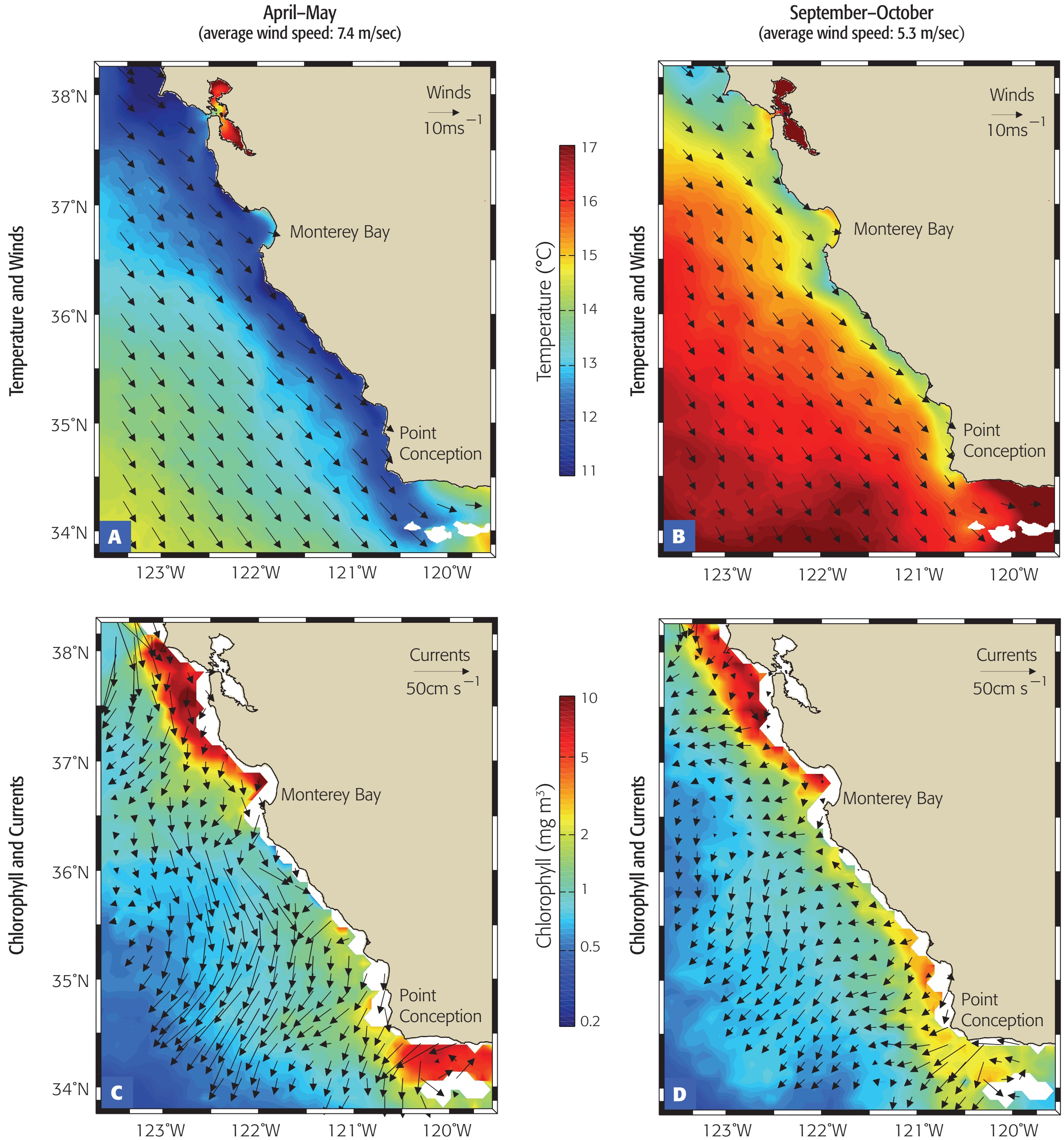


Upper figure: Since 1992, levels of dissolved carbon dioxide in Monterey Bay (dark green) have risen faster than atmospheric levels of carbon dioxide (orange) as a result of the cool condition after 1998. Lower figure: The pH of water in Monterey Bay (light green) has decreased at a rate similar to the pH in the North Pacific subtropical gyre (purple) but is lower because of upwelling. Source: MBARI

Large-Scale Climatic Phenomena Strongly Influence Fish Populations

Throughout the last century, sardine and anchovy populations of the Central Coast have correlated closely with trends in the Pacific Decadal Oscillation (PDO). During warm phases of the PDO, sardine populations tend to increase, while anchovy populations decrease. During cool phases of the PDO, the opposite occurs.

Tracking Seasonal Changes



Left column (panels A and C): In spring and early summer, strong winds blow southward along the Central Coast (arrows in panel A). These winds drive water away from the coastline, creating strong offshore currents (arrows in panel C). The offshore currents draw deeper, colder water to the surface along the coast (blue color in panel A), in a process called upwelling. Because upwelled water is rich in nutrients, it stimulates growth of phytoplankton (red, orange and yellow colors in panel C).

Right column (panels B and D): In the late summer and fall, winds diminish, leading to weaker offshore currents (arrows in panel D), and less upwelling of cold, nutrient-rich water (panel B). This results in warmer water temperatures and less abundant growth of phytoplankton (panels B and D). Source: MBARI, NASA, NOAA

Seafloor Habitats

The California seafloor is structurally complex and geographically variable. It can be divided into a variety of habitats, each with unique physical and biological characteristics. These seafloor habitats provide food and refuge to a great diversity of fishes, invertebrates and other marine life. Until recently, only large-scale, low-resolution seafloor habitat maps were available for the Central Coast, leaving a gap in our understanding of the fine-scale distribution of seafloor habitats and the species associated with them. Using the latest remote sensing, GIS and video technologies coupled with field sampling, the California Seafloor Mapping Program (CSMP) began generating data in 2007 to create the first comprehensive, high-resolution (1:24,000 scale) map of California's seafloor. Since then, CSMP has mapped nearly all 14,500 square kilometers of state waters along California's coast, including the entire Central Coast region, both inside and outside of MPAs. A report has recently been developed containing detailed seafloor maps of all 29 MPAs.

Unveiling Habitat Heterogeneity

The seafloor habitat maps produced by the CSMP illuminate the presence of substantial and variable structural complexity along the California coast, the extent of which was previously unknown. For example, the maps reveal a high concentration of depressed deposits of coarse-grained sediment, otherwise known as rippled scour depressions (RSDs) or sorted bedforms. RSDs were first described through side-scan sonar surveys conducted from Bodega Bay to Point Arena in 1984, but the CSMP provided higher resolution maps of RSD distribution along the entire coast of California. RSDs contribute to seafloor structural complexity, which drives the distribution of benthic marine life. Researchers are currently exploring whether RSDs provide important habitat for fishes, such as juvenile rockfishes and invertebrates (see box at right).

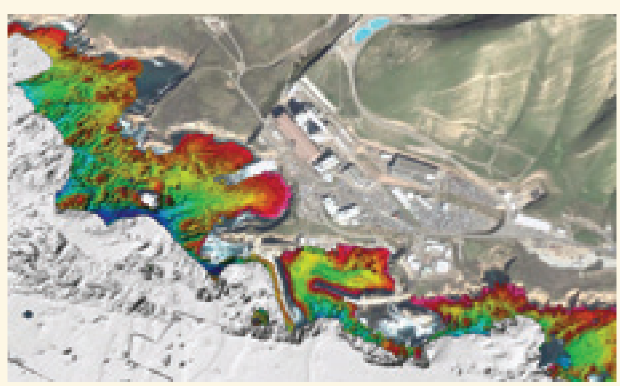
To support the MPA planning process in the Central Coast, scientific guidelines in the MLPA Master Plan were created to advise the design of regional MPA networks. These guidelines included information about how regional habitats should be represented in MPAs and how much of a particular habitat type should be included in an MPA in order to adequately protect its associated species. In the Central Coast, the best available scientific data were used to identify habitat, including proxy measures such as maximum kelp extent and areas targeted by fishing communities for rockfish. With the new seafloor habitat maps in hand, researchers conducted analyses to compare the results of habitat classifications using the new seafloor mapping data to the conclusions of analyses of habitat representation that were made during the MPA planning process using habitat proxies. The results confirm that the guidelines used were sufficient for estimating habitat representation inside MPAs and provided an accurate proxy for representing rocky reefs within MPAs.

Filling in the "White Zone"

Researchers use ships and planes equipped with specialized remote sensing technology to map the seafloor. However, obstacles such as fog, rocky shoals, cloudy water and floating kelp prevent these methods from being successful along the immediate coastline, which leaves a "white zone" where no mapping data has been collected. Using a unique mapping vessel called the *KelpFly*, researchers are now filling in the white zone, providing needed coverage to complete seafloor mapping of California's coast. *Source: CSUMB*

KelpFly

Mapping coverage with traditional mapping methods

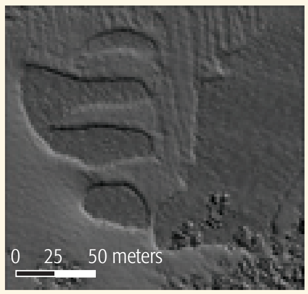


Mapping coverage in the "white zone" using the *KelpFly*

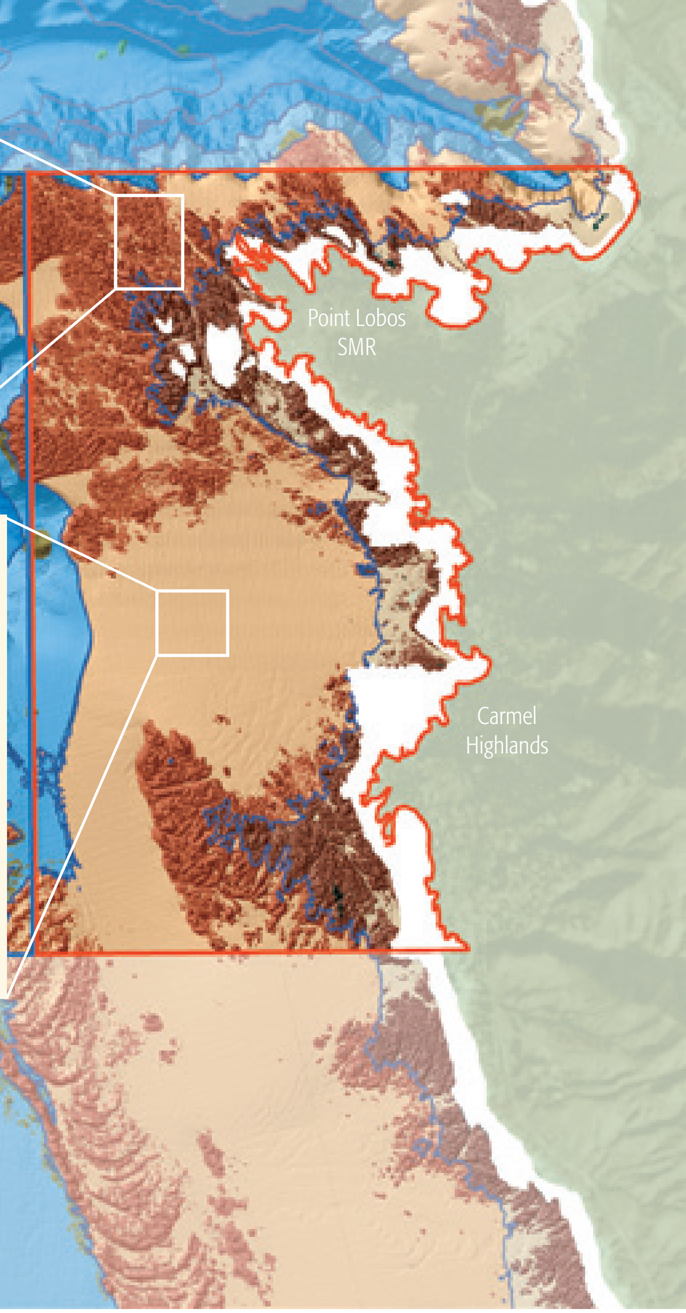
All Rock Is Not Equal

Predictive habitat models developed based on the CSMP data can be used to further our understanding of how variation in habitat affects species distribution. Recent studies have revealed unexpected patterns among fish species and specific rocky reef features. Results suggest that, in the eyes of a fish, all rock is not the same. *Source: CSUMB*

Rippled Scour Depressions



The CSMP has revealed rippled scour depressions (RSD) to be abundant and widespread along the inner continental shelf of California. Ranging from hundreds to thousands of square meters in areal extent, RSDs are 30- to 50-cm deep depressions that add complexity and patchiness to relatively homogeneous unconsolidated sedimentary substrates on the inner continental shelf. The CSMP initiated research to explore the ecological impact of these distinct features on species distribution and abundance. Preliminary ROV studies have found young-of-the-year rockfish, especially canary rockfish, to be strongly associated with RSDs. *Source: CSUMB*



Seafloor Habitats of Point Lobos MPAs

Linking Geology and Biology

The new seafloor maps provide the foundation for developing predictive habitat models for California coastal ecosystems. Made possible by the advent of advanced remote sensing and GIS technologies, these predictive habitat models have been used extensively only in terrestrial habitats until recently. By using features in the seafloor maps, the models can predict where, for example, particular fish or invertebrate species may be found. As a consequence, we have gained a greater understanding of species-habitat relationships and have been able to predict the distribution of important fisheries species such as rockfishes (see box above).

Strengthening MPA Monitoring

Comprehensive coverage of high-resolution seafloor habitat mapping is unique to California. The maps and other data products produced through the CSMP are important resources for resource managers, researchers and all groups involved in MPA monitoring. These data are contributing to a greater understanding of distribution patterns of, and micro-habitat use by, important species. Because of the development of predictive habitat models, monitoring sites can be chosen to encompass the widest variety of habitats and to target specific species of fish. The CSMP data will continue to inform MPA monitoring, enabling the development of more efficient and cost-effective MPA monitoring that will more precisely characterize ecological variability within California's highly diverse seafloor habitats.

Socioeconomics

Central Coast Communities

From the most populous county in the Central Coast, San Mateo, south to Santa Barbara, communities in the Central Coast are closely linked to the marine and coastal environment. Five commercial fishing ports—Santa Cruz, Moss Landing, Monterey, Morro Bay and Avila/Port San Luis—form an important part of the local economy. The recreational fishing business, together with recreational activities such as whale-watching and scuba diving, draw large numbers of visitors to the region each year. Indeed, the iconic Monterey Bay and Big Sur coastline are prime tourist destinations for international visitors.

Experiencing Change

The Central Coast region, like California more broadly, has a growing population. Census statistics reveal that individual counties experienced population increases of between 8 and 16% between 1990 and 2006. As populations increased, many other changes occurred in the region's ocean-related economy.

Commercial passenger fishing vessel (CPFV or "party boat") trips have decreased cross the region, and many operators are increasingly pursuing opportunities such as whale-watching and leisure cruises to diversify their customer base. In addition, the total number of commercial fishermen operating in the Central Coast decreased by almost 70% from 1992 to 2011 (see figure opposite). Over the same period, the average ex-vessel revenue per fisherman has increased steadily, although operating expenses have also risen.

These socioeconomic changes occur over both long and short time scales. Short-term fluctuations in fuel prices increase operating costs, and longer-term changes in the oceanic environment, such as temperature regime shifts, can affect the abundance of some fish species. These shifts are occurring with a backdrop of changing fishing regulations (see box), such as salmon fishery closures in 2008 and 2009. Thus, understanding the causes of changing employment patterns, industry contributions to local economies and fishery participation is a difficult task. Changing regulations, national and local economic conditions, and environmental dynamics each play a role.

Select Regulations Affecting Ocean Resources In the Central Coast

General Regulations & Recreational Fishing

- **1992**: Monterey Bay National Marine Sanctuary created
- **1997**: Magnuson–Stevens Sustainable Fisheries Act reauthorized and amended; Reauthorized again 2007
- **1998**:
  - Marine Life Management Act
  - Nearshore Fisheries Management Act
- **1999**: **Marine Life Protection Act**
- **2000**:
  - Rockfish bag limits reduced and number of hooks per line limited
  - Revisions to groundfish management
- **2001**: Seasonal closures for rockfish and lingcod established

Commercial Fishing

- **1994**: Groundfish restricted access program
- **1995**:
  - Dungeness crab limited entry program
  - Commercial trap permits for finfish
- **1997**: Market squid limited entry program
- **1998**: General commercial trap permits
- **2000**:
  - Coastal pelagic species finfish limited entry program
  - Emergency set gill and trammel net closures
- **2001**: New regulations for nearshore species

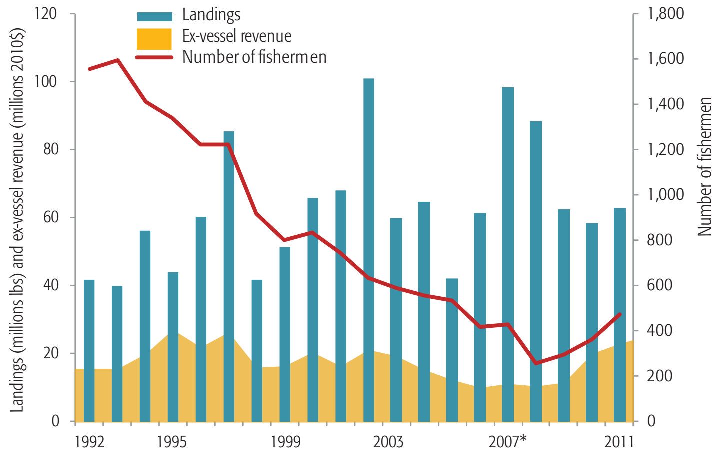
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001

Close Connections to Ocean Management

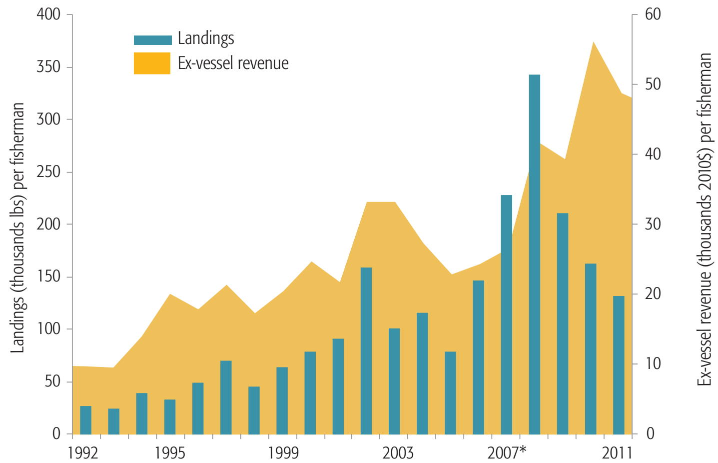
With a strong connection to the ocean, Central Coast communities are affected directly by state and federal management and policy decisions on marine resources. One such resource management decision was the establishment in 1992 of the Monterey Bay National Marine Sanctuary, which encompasses 13,784 square kilometers of ocean and 444 kilometers of coastline from Cambria to Marin and overlaps a significant portion of the Central Coast region. State and federal fishery management regulations together form a complex landscape that are part of the socioeconomic picture for Central Coast MPAs.

The last two decades have seen shifts in commercial fishing landings and revenues. Upper right: Total commercial landings, ex-vessel revenue and total number of commercial fishermen operating in the region. Lower right: Average ex-vessel revenue per commercial fisherman and average total landings per commercial fisherman. Source: Ecotrust, DFW

Total commercial landings and revenue



Average commercial landings and revenue per fisherman



* Central Coast MPAs implemented in 2007

2002
- Nearshore Fishery Management Plan adopted
- Set gill and trammel net closures
- Spot prawn restricted access program

2003
- Seasonal closures for nearshore rockfish
- Nearshore fishery restricted access program
- Federal groundfish permit/boat buyback program (NMFS)
- Spot prawn trawl gear prohibition
- Rockfish Conservation Areas established

2004
- CA Rockfish Conservation Areas established

2005
- Market Squid Fishery Management Plan

2006
- Pacific Coast Groundfish FMP & Essential Fisheries Habitat (EFH), Amendment 19
- California halibut bottom trawling prohibited in Monterey Bay

2007
- **Central Coast MPAs implemented**

2008
- Ocean salmon fishing closed all year for most of the state

2009
- Ocean salmon fishing closed all year from Horse Mt. to US/Mexico border

2010
- Limited ocean salmon fishing season

2011
- Number of days for ocean salmon fishing slightly lower than that allowed in early 2000s for most areas

MPA Enforcement and Compliance

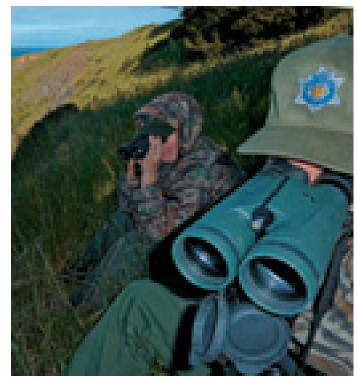
Contributing to MPA Effectiveness

Enforcement of, and compliance with, MPA regulations can directly affect the success of MPAs. In the Central Coast region, enforcement officers report a relatively high level of compliance, although violations may occur when the public is unaware of the MPA boundaries and regulations. While only a small number of people knowingly violate regulations, even a single poaching event can have a significant impact on determining the effectiveness of an MPA. In 2009, for example, California Department of Fish and Wildlife (DFW) wardens caught a poacher who had taken 60 black abalone from a Central Coast MPA.

The DFW is the primary agency responsible for enforcing MPA regulations. In the Central Coast region, DFW has large patrol vessels that can respond to violations in progress and conduct general patrols. Partner agencies including California State Parks, the U.S. Coast Guard and the National Oceanic and Atmospheric Agency (NOAA) also assist DFW in enforcing resource-related activities or provide an additional enforcement presence, but they do not always have the necessary authority or training to take independent action. In total, approximately 30 enforcement personnel are assigned to positions in the Central Coast region who may respond to MPA violations. A variety of watercraft are available to coastal wardens to assist in accessing the MPAs in their area.

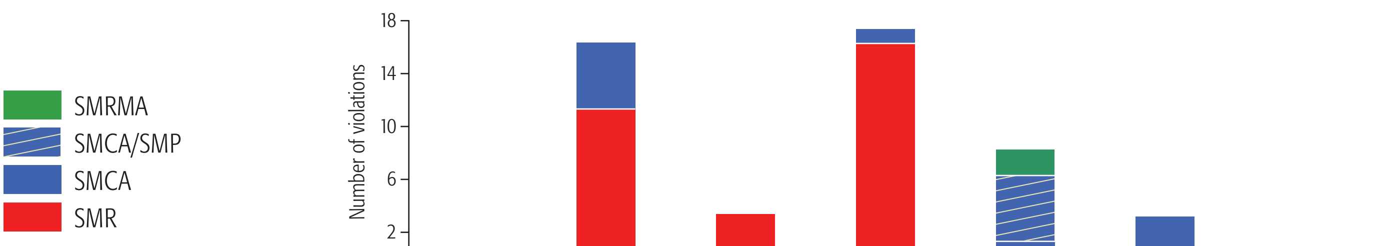
Violations in Central Coast MPAs 2007–2012

DFW-Law Enforcement Division (LED) collects data from the entire state concerning violations. While LED is working on finer-resolution analysis of the data to determine specific violation types, it does not currently differentiate MPA violations from the general category of marine-related violations.



Based on analysis of the data available, DFW concluded that in the Central Coast region from September 2007 to March 2012, 377 marine-related citations (tickets) were issued containing 495 individual violations. Approximately 47 (9.5%) of these violations can be

Number of Violations in Central Coast MPAs



MPAs with violations (from N to S)	2007 *	2008	2009	2010	2011	2012 **	Total
Lovers Point SMR	0	2	0	0	0	0	2
Asilomar SMR	0	0	0	1	0	0	1
Piedras Blancas SMR	0	7	3	13	0	0	23
Piedras Blancas SMCA	0	0	0	0	0	3	3
White Rock (Cambria) SMCA	0	0	0	1	1	0	2
Cambria SMCA/SMP	0	0	0	0	5	0	5
Morro Bay SMRMA	0	0	0	0	2	0	2
Point Buchon SMR	0	2	0	2	0	0	4
Point Buchon SMCA	0	5	0	0	0	0	5
Total	0	16	3	17	8	3	47

* MPAs were implemented in September 2007.

** For 2012, data were available for January through March only.

Source: DFW

associated with specific MPAs. These 47 MPA-related violations occurred in nine of the 29 MPAs along the Central Coast, with 30 violations occurring in State Marine Reserves (SMR), 10 in State Marine Conservation Areas (SMCA), five in the SMCA/State Marine Park, and two in State Marine Recreational Management Areas (SMRMA). Geographically, 94% of the MPA-related violations in the Central Coast occurred within 65 kilometers of Morro Bay, which is the base port for one of the large patrol vessels in the region. This proximity of violations to the location of a large patrol vessel indicates an increased rate of patrol and detection in the area.

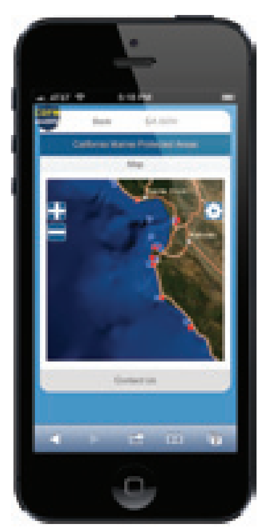
With enhanced technologies and community support, the effectiveness of compliance can increase through better surveillance, detection and interdiction; education and outreach about MPA boundaries and rules; and use of monitoring results to guide education and enforcement efforts. Future changes in the rate and spatial distribution of MPA-related violations will need to take into account changes and improvements in enforcement and compliance efforts.

MPA Education and Outreach

Education and outreach are important tools used to encourage compliance with MPA regulations, as well as foster an understanding of the statewide network. Initial outreach efforts for the Central Coast MPAs included posting frequently asked questions, change-of-regulation notices and maps at popular recreational sites and commercial processing locations. In addition, online resources were updated and efforts were made within existing DFW programs to increase informed discussions with user groups and individuals. DFW produced a summary brochure for the Central Coast MPAs that included MPA specific maps, boundaries, coordinates and regulations both in hard copy and on the web (www.dfg.ca.gov/mlpa/guidebooks.asp).

DFW also recognizes that building partnerships with local, state and federal agencies and regional non-profits will assist with long-term outreach efforts that will ultimately support the education and outreach efforts for the statewide MPA network. Specifically, DFW collaborated with California State Parks, Monterey Bay National Marine Sanctuary and the Monterey Bay Sanctuary Foundation to develop MPA-specific signage in the Monterey area and to craft language for individual MPA brochures and exhibits.

DFW maintains an MPA-specific website (www.dfg.ca.gov/mlpa) that has both statewide and regional components, and DFW responds to public inquiries about MPAs via telephone and two dedicated e-mail addresses (MLPAcomments@wildlife.ca.gov and AskMarine@wildlife.ca.gov). In addition, people can use a cell phone or other web-enabled device to access a mobile version of the web page (dfg.ca.gov/m/MPA/), where they can track their locations in real time relative to MPA boundaries and easily access MPA regulations.



Establishing a Benchmark

Introduction

Seafloor habitats, oceanography and the socioeconomics of the Central Coast set the scene for the regional MPA network, providing a complex and dynamic backdrop to the MPAs. Of course, ocean ecosystems and the marine life and communities that they harbor are also a part of the dynamic fabric of California's coastal waters.

Ocean ecosystems change over time, and these changes are driven by multiple factors. To assess the performance of MPAs as a resource management and conservation tool, MPA monitoring takes the pulse of ocean ecosystems by documenting changes in ecosystem condition inside and outside protected areas. Baseline monitoring in the first years after MPA implementation is a critical first step and provides an important time stamp of ecological and socioeconomic conditions in the region.

Beginning in 2007, academic, agency and citizen-scientists gathered baseline data in the region. By studying a range of ecosystems, from rocky shores and kelp forests to deep reefs, researchers documented patterns in marine life populations and communities through the Central Coast region. These ecological patterns, together with patterns of human use, including commercial and recreational fishing, create the first region-wide benchmark of ocean ecosystem conditions and the reference point for examining future changes.

Kelp and Shallow Rock Ecosystems

Key Findings

- Driven by differences in geology and oceanic environments, kelp forest ecosystems in the Central Coast cluster into six distinct community types based on fish, invertebrate and kelp abundances.
- Seven kelp species were recorded in scuba surveys, but from Sandhilll Bluff to just south of Point Buchon the kelp canopy is formed primarily by giant kelp.
- Diverse fish communities were dominated in numbers by blue rockfish and tubesnouts, followed closely by señoritas and striped seaperch.
- Results from separate sets of surveys conducted by academic and citizen scientists revealed similar patterns of fish and invertebrate densities, as well as community types. Together, these programs can complement one another and collect data from a broader geographic range than either could alone.
- Habitat differences underlie differences in fish assemblages; results from the Collaborative Fisheries Research Program showed similar composition at paired inside MPA and outside reference sites, providing a robust foundation for ongoing monitoring.

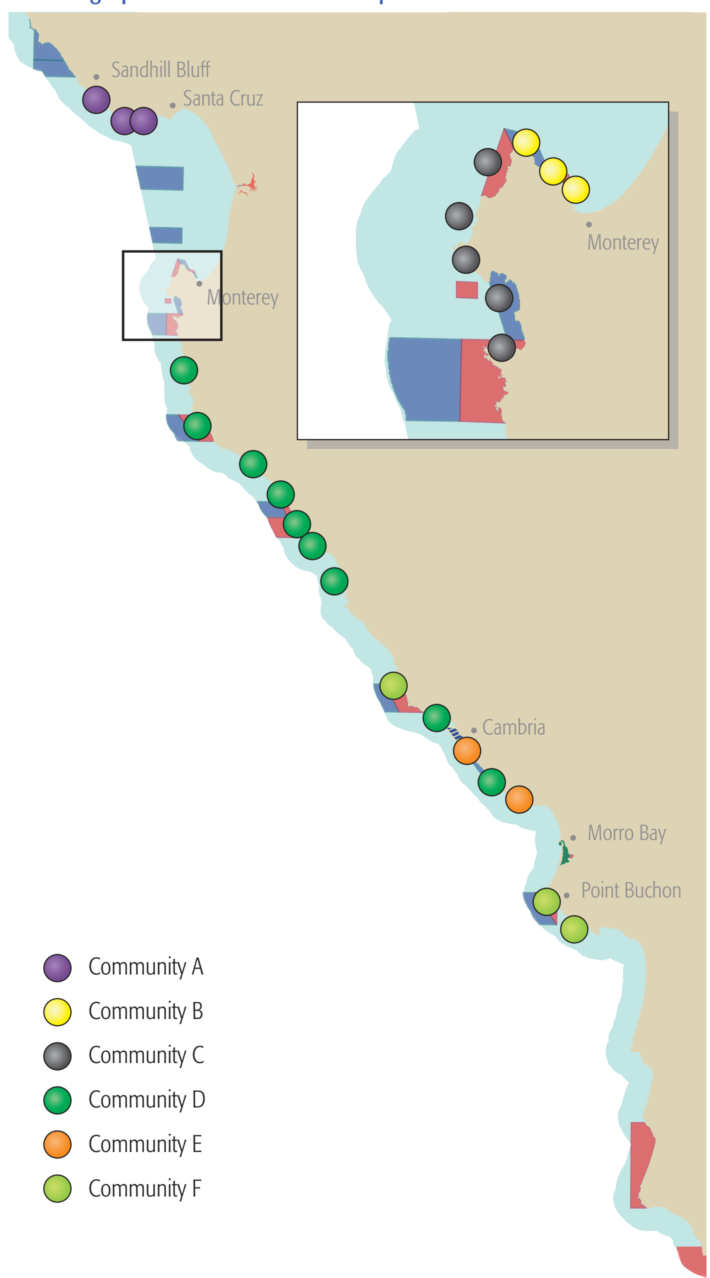
With canopies extending to the water's surface, kelp forests are home to a wide variety of marine plants and algae, fishes, invertebrates, marine birds and marine mammals. Light abounds in these shallow waters, and the presence of rock provides hard surfaces, allowing for the settlement and growth of kelp and other algae. Structural complexity provided by the rocky seafloor and multiple kelp species creates important refuge habitat and feeding grounds for many species of fish (e.g., rockfishes, bocaccio, cabezon, greenlings, lingcod), mobile invertebrates (e.g., abalones, rock crabs, sea stars, sea urchins) and sea otters. These highly productive and species-rich ecosystems support human activities such as commercial and recreational fishing, kayaking and scuba diving.

Geographic and Temporal Variation

While less common than soft-bottom habitats, the shallow rock habitats that support kelp forests are found throughout the Central Coast region. Shallow rock, which includes rocky habitats found at depths less than 30 m, exists within 19 of the 22 nearshore MPAs in the region and covers more than 40% of the seafloor habitat within most of these MPAs. Therefore, while they are less common in the region as a whole, rocky reefs are an important habitat in the MPAs themselves.

While the movement of sand and cobble caused by storm-generated waves and currents, as well as sediment runoff from nearby shorelines, can change the amount of rocky reef in the region from year-to-year, these habitats tend to remain relatively stable, and kelp beds persist from year to year. However, the extent of kelp beds does exhibit seasonal and annual variation, with the extent of giant kelp in the Central Coast region ranging from a low of 6.5 square kilometers to a high of 47 square kilometers. In some years, the Central Coast region contains nearly half (~45%) of the statewide extent of giant kelp (*Macrocystis pyrifera*).

Geographic Distribution of Six Kelp Forest Communities



Geographic and temporal variation in kelp abundance is tied to both the reproductive biology (i.e., annual vs. perennial) of the dominant canopy-forming kelp species and environmental conditions. Winter storm activity and changing oceanographic conditions affect the extent of the kelp beds along the California coast. Heavy wave action can scour benthic rocks, removing kelp and leaving bare rock for colonization by new kelp spores. In general, the effect of El Niño (see Oceanographic Conditions, p. 10) on upwelling regimes (and thus water temperature) increases from north to south, while wave intensity increases from south to north. These variable conditions contribute to the seasonal and interannual variation in kelp abundance by affecting kelp growth rates.

Academic and Volunteer Scuba Divers Jointly Monitor Kelp Forest Ecosystems

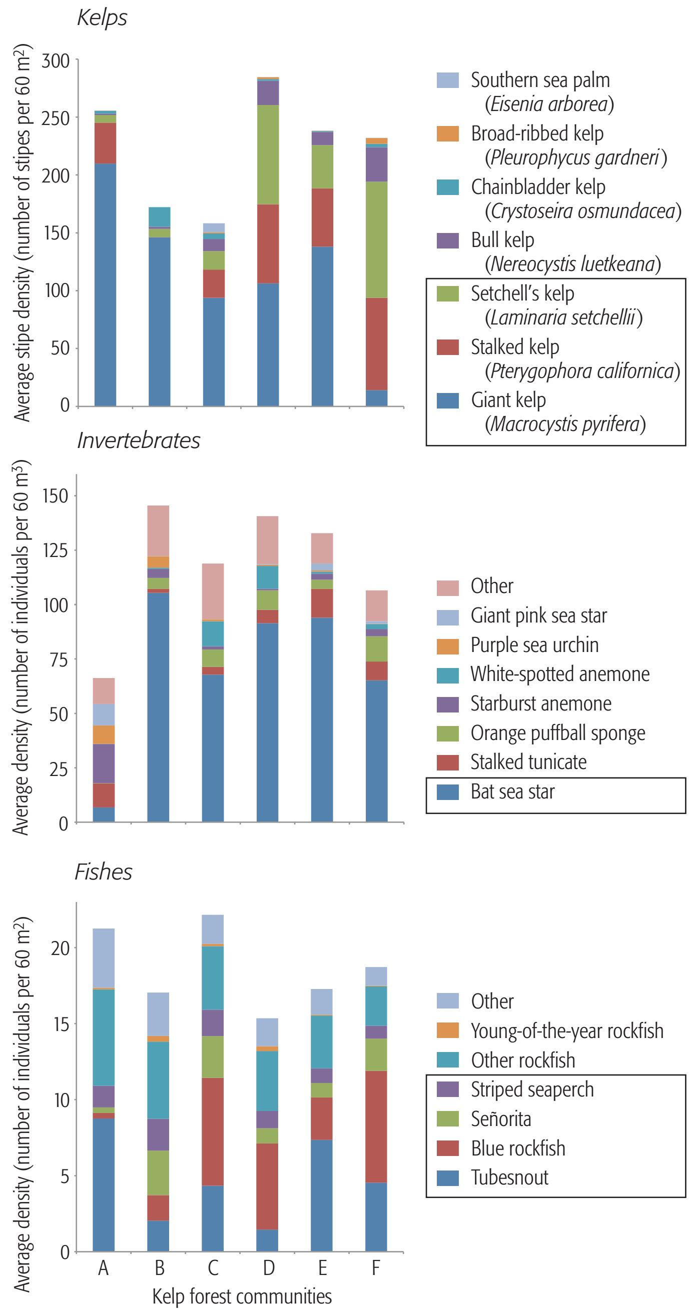
Ecological monitoring within kelp forest ecosystems was completed through SCUBA surveys conducted by both academic and citizen-scientists. The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) is a collaborative program that focuses on long-term ecosystem research and monitoring. In more than 1,200 survey hours covering approximately 7,500 acres of kelp forest habitat, PISCO divers recorded data on approximately 39,000 fish, 71,000 macroinvertebrates and 67,000 canopy-forming kelps, encompassing over 100 species. Reef Check California divers, including 150 local citizen-scientists who volunteered their time to contribute to marine monitoring, surveyed 18 additional sites across the region, completing a total of 139 surveys. Reef Check divers focused on monitoring 73 economically and ecologically important species of fishes, invertebrates and algae. Surveys for both programs were conducted at sites with kelp forests dominated by giant kelp (*M. pyrifera*) south of Sandhill Bluff, as the presence of sharks in the region limits safe diving locations.

Identifying and Characterizing Communities

Analysis of the data collected by scuba divers revealed the presence of six distinct types of kelp forest communities, referred to as Communities A–F for the remainder of this section. Survey sites were clustered based on species assemblages, including all kelps (7 taxa), fishes (30 taxa) and invertebrates (32 taxa) monitored. Community D includes the highest number of survey sites and is distributed from just south of the Point Lobos SMR south to the Cambria Air Force Station.

The physical environment can influence the biological community observed at a given location. Community A is found in unique habitats dominated by bedrock with flat relief (0–10 cm) and very little boulder and cobble substrate. All other communities are found in habitats that are dominated by bedrock with shallow relief (10 cm–1 m). In addition to the dominant substrate and relief types, Community C is found in habitats with more moderate (1–2 m) and high relief (> 2 m) than the others, and Community E is found in habitats with the most boulder and cobble substrates.

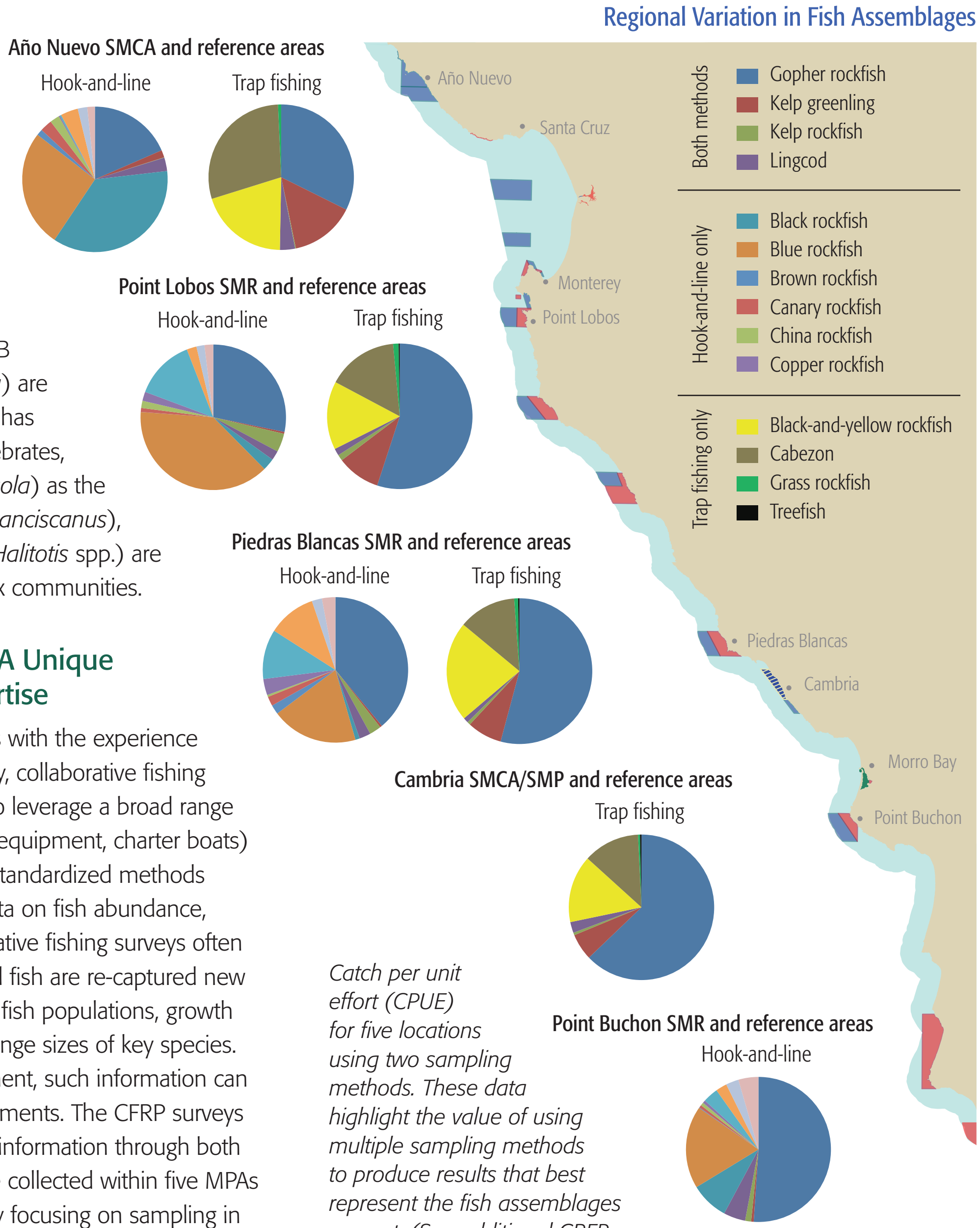
Benchmark conditions for six kelp forest communities



Average density of kelps, invertebrates, and fishes by kelp forest community. All species included in the graphs are those that characterize the communities. "Other" encompasses all species that account for less than 10% of the density within any of the communities. The black boxes surround the species that were identified through the clustering analyses to distinguish among the communities. Source: PISCO, UCSC

The density and abundance of kelp, fish and invertebrate species varied geographically among the six communities. In general, there was a transition from communities characterized by high density of giant kelp (Communities A, B, C) to communities characterized by a higher density of stalked kelp (*Pterygophora californica*) and Setchell's kelp (*Laminaria setchellii*) (communities D, E, F). Although bull kelp (*Nereocystis luetkeana*) generally has a more northern distribution, giant kelp (*M. pyrifera*) is more abundant within the PISCO and Reef Check sampling areas and increases in density from south to north. The southernmost community has a unique combination of kelp and fish densities that may be more akin to kelp forests found within the South Coast region, rather than those within the Central Coast.

Blue rockfish (*Sebastes mystinus*) and tubesnout (*Aulorhynchus flavidus*) are the dominant fish species throughout the region, other than within Community B where señoritas (*Oxyjulius californica*) are the most common. Tubesnouts are the most common species within communities A and E. In communities B through E, bat sea stars (*Patiria miniata*) are in relatively high density. Community A has the lowest overall abundance of invertebrates, with starburst anemone (*Anthopluera sola*) as the dominant species. Red sea urchin (*S. franciscanus*), rock crab (*Cancer* spp.) and abalone (*Halitotis* spp.) are in relatively low abundance within all six communities.



Catch per unit effort (CPUE) for five locations using two sampling methods. These data highlight the value of using multiple sampling methods to produce results that best represent the fish assemblages present. (See additional CRFP results on pp 27, 39–40.)

Source: MLML, Cal Poly

Collaborative Fishing Surveys: A Unique Opportunity to Combine Expertise

By combining the expertise of scientists with the experience and skills of the local fishing community, collaborative fishing surveys provide a unique opportunity to leverage a broad range of expertise and existing capacity (e.g., equipment, charter boats) to generate baseline monitoring data. Standardized methods were developed and used to collect data on fish abundance, size and species composition. Collaborative fishing surveys often include tagging fish; when these tagged fish are re-captured new information is documented about local fish populations, growth rates, movement patterns and home range sizes of key species. In addition to informing MPA management, such information can feed into federal and state stock assessments. The CFRP surveys of nearshore fish assemblages collects information through both hook-and-line and trap fishing. Data are collected within five MPAs and their associated reference areas. By focusing on sampling in fewer locations than other monitoring projects, this program was able to conduct multiple surveys per year at each location, thus providing the resolution needed to understand individual MPA effects.

The ten most frequently caught species were similar among MPAs, and the composition between paired MPAs and references is more similar than among MPAs, indicating that the reference sites are well-suited for comparisons with associated MPAs. Catch rates for most species were higher in MPAs than in reference sites indicating the difference existed prior to the establishment of MPAs.

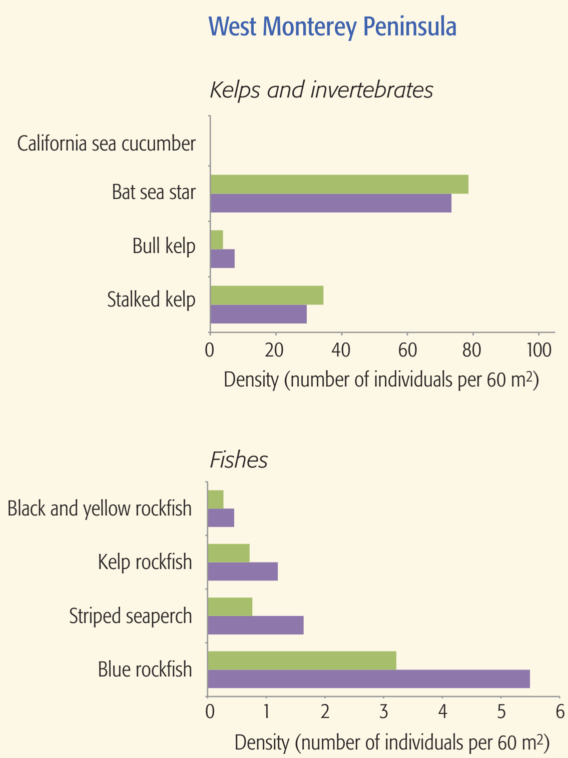
Led by Rick Starr (California Sea Grant and Moss Landing Marine Laboratories) and Dean Wendt (CalPoly San Luis Obispo), the California Collaborative Fisheries Research Program (CFRP) collects data on nearshore fish assemblages. From 2007–2012, scientists, charter boat captains, commercial fishermen, and more than 400 volunteer anglers spent a total of 5,286 hours fishing with commercial fish traps and hook-and-line gear in rocky habitats less than 40 m deep. Completing 308 surveys over the five-year period, data were collected on 44,877 fishes from 46 different species.

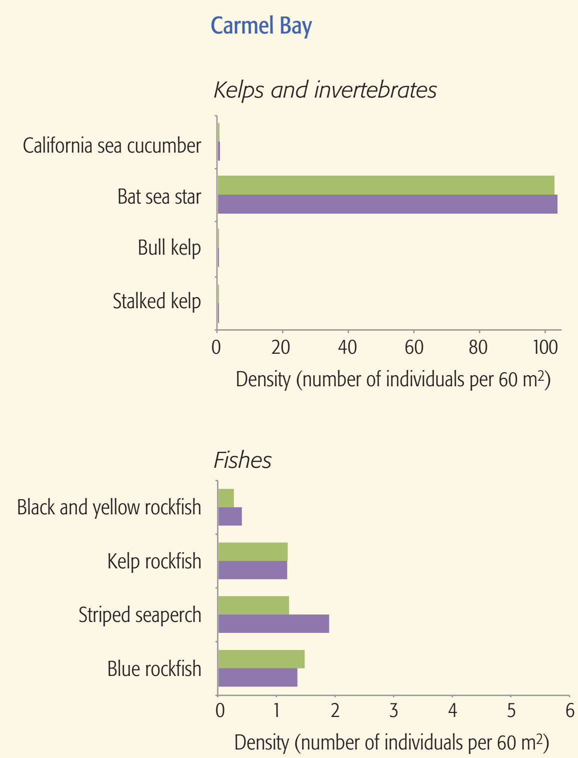
Reef Check and PISCO: Integrating Citizen-Science and Academic Monitoring Programs

Policy-makers, community members and researchers across a broad array of disciplines recognize the value of volunteer-based citizen-science in generating data, promoting education and stewardship, and solving complex problems. The utility of information collected by citizen-scientists for informing decision making depends on the quality and compatibility of observations as compared with academic monitoring efforts.

Here we compare the results of two years of surveys conducted at comparable sites by Reef Check California and PISCO within two areas along the Central Coast: West Monterey Peninsula and Carmel Bay. While PISCO counts fish throughout the water column and Reef Check only counts fish along the seafloor, the two programs detected similar relative densities of fish species. These two programs also identified similar community clusters (see map p. 20). Together, Reef Check and PISCO can generate more data spanning a broader geographic range than either could alone. *Source: PISCO, UCSC, Reef Check*

- Reef Check
- PISCO





Mid-Depth and Deep Ecosystems

Key Findings

- Fish communities varied throughout the region, with seven distinct communities identified across three depth-zones.
- At mid-depths (30–100 m), fish densities were more than 56% higher in the northern part of the Central Coast region. Big Creek SMR and SMCA harbored fish densities that were more than 40% higher than at all other sites 100–200 m deep.
- Soquel Canyon emerged as its own distinct community. It has a higher diversity of species, a higher density of five depleted rockfish species and deep-sea stony corals.
- Paired survey sites inside and outside of eight deep-water MPAs did not differ in their fish communities, providing a robust baseline for tracking potential MPA effects in the future.
- Previously economically important species including petrale sole, bocaccio, cowcod, canary, darkblotched, widow and yelloweye rockfishes are found at low densities throughout the region.

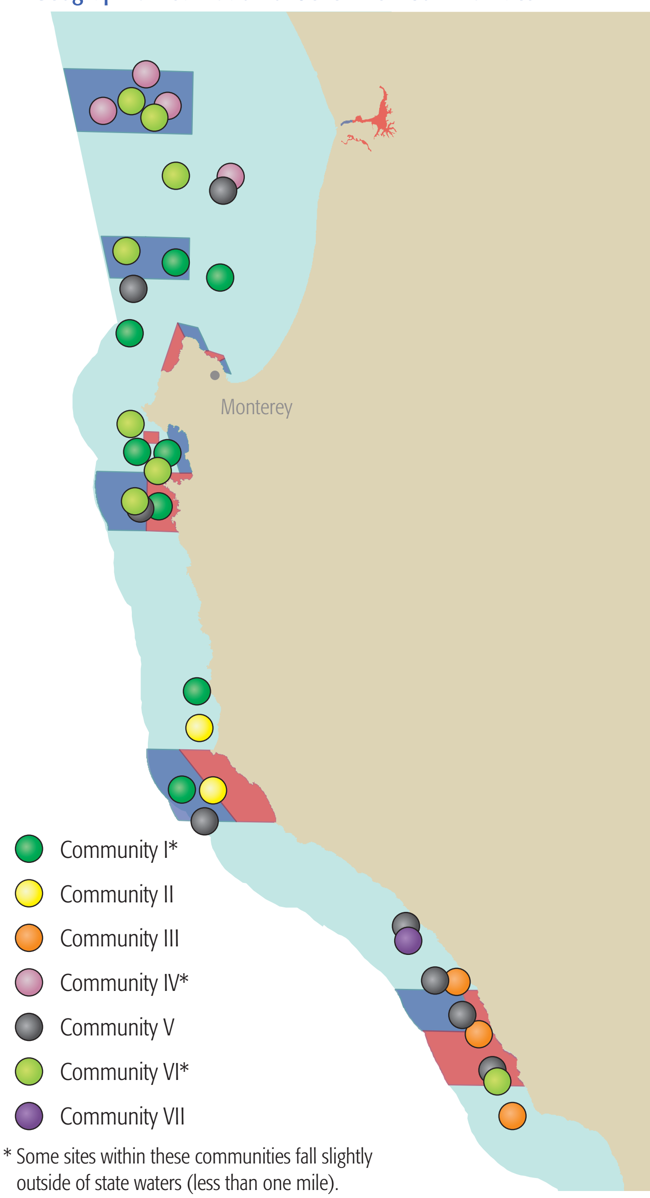
Mid-depth and deep habitats—those occurring at depths greater than 30 m—are home to hundreds of species of fishes and invertebrates. Ranging from deep rock outcrops and underwater pinnacles to expanses of soft sediments and submarine canyons more than 1,000 m deep, these habitats have supported important fisheries in the Central Coast for decades. Far less is known, however, about deep-water communities than those more easily seen and studied in shallow waters.

Deep habitats and the fish communities they support are an important component of the Central Coast marine ecosystems. Canyons, in particular, affect ocean circulation patterns and attract marine birds and mammals that feed on aggregated fish and plankton. Light is absent in the deepest waters, and these communities rely significantly on nutrient inputs from shallow marine life and nutrient-rich waters rising from deep waters off the continental shelf. Baseline MPA monitoring provides an opportunity to document in detail patterns of fish and invertebrate communities throughout the region, thereby deepening our understanding of these ecosystems and setting the benchmark for future monitoring.

Physical Factors Drive Community Patterns

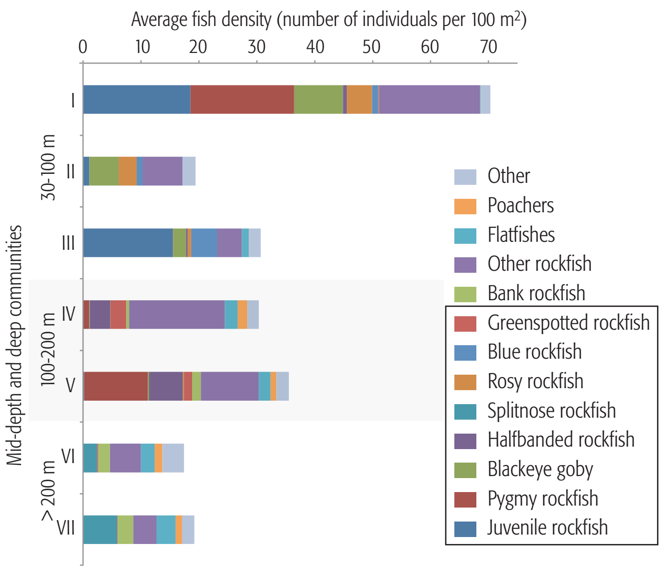
Mid-depth and deep habitats cover approximately 75% of the seafloor in state waters. Of the 29 MPAs designated in the Central Coast region, 21 contain mid-depth and deep soft-bottom habitat, while 18 contain mid-depth and deep hard-bottom habitat. Physical conditions change dramatically with depth; as water depth increases, light intensity and temperature decrease. This range in seafloor habitats and the changing environmental conditions affect community assemblages, including both predatory fishes and invertebrates, along with their food sources. Fish densities and the number of species tend to decrease from the productive, oxygen-rich shallow habitats to the light-limited offshore depths.

Geographic Distribution of Seven Fish Communities



* Some sites within these communities fall slightly outside of state waters (less than one mile).

Benchmark conditions for all seven mid-depth and deep ecosystems



Average density of fishes by mid-depth and deep community. The species included in the graph are those that characterize the communities. "Other" encompasses all species that account for less than 10% of the density within any of the communities. The black box surrounds the species that were identified through the clustering analyses to distinguish among the communities. Source: NOAA Southwest Fisheries Science Center

Identifying and Characterizing Communities

Descending from 30 m to more than 200 m, researchers observed changing species and habitats with water depth. Generally, diverse assemblages of rockfishes inhabited rock outcrops and pinnacles, while flatfishes were more abundant in the broad expanses of soft-sediment. Characteristic fishes such as blackeye goby *(Rhinogobiops nicholsii)*, rosy rockfish *(Sebastes rosaceus)*, blue rockfish *(S. mystinus)* and juvenile rockfishes dominated communities between 30 and 100 m. By comparison, splitnose and bank rockfishes, poachers and flatfishes defined fish communities in the deepest waters below 200 m. Some species were seen across a broad range of depths, while others were more restricted in their depth distribution; blackeye goby were rarely observed below 100 m, while poachers and eelpout were rarely seen above 100 m.

Researchers identified seven distinct fish communities (referred to as Communities I–VII) associated with different habitats and depths. Three communities were identified in mid-depth (30–100 m) habitats: Community I, which included parts of Monterey Bay and Point Sur SMCA, had the greatest abundance of fish assemblage, while Community II, which included Point Sur SMR, had the lowest fish abundance. At depths between 100 and 200 m, two different fish communities were identified: Community

Monitoring Deep Habitats in a Manned Submersible

Led by Rick Starr (California Sea Grant and Moss Landing Marine Labs) and Mary Yoklavich (NOAA, Southwest Fisheries Science Center), scientists deployed the manned submersible 'Delta' to collect baseline monitoring data from deep habitats in 2007 and 2008. In 2007, researchers surveyed 164,000 m^2 of seafloor habitats from 24 m–364 m deep, made direct observations from within the submersible, and videoed deep rocky banks and outcrops, canyons, cobble fields and mud flats inside eight Central Coast MPAs and outside these MPAs at comparable reference sites. From 337 transects, 66,000 fish were identified, counted and measured. Analysis of the video revealed 158,000 aggregating and 14,000 structure-forming invertebrates. Surveys at these sites were repeated in 2008, with a total of 376 transects conducted.

IV, which was mostly within Soquel Canyon, and Community V, which included sites at this depth from Monterey Bay south to Big Creek SMR. Community IV had higher densities of canary rockfish *(S. pinniger)*, widow rockfish *(S. entomelas)*, yellowtail rockfish *(S. flavidus)* and greenstriped rockfish *(S. elongatus)* than any other mid-depth or deep seafloor community. At depths below 200 m, two different fish communities were identified: Community VI, which included sites from Monterey Bay south to Point Lobos and sites within the Big Creek SMR, and Community VII, which included reference areas for the Big Creek MPAs. Community VI had the highest proportion of non-rockfish species (> 40%), such as poachers, flatfishes and hagfish (*Eptatretus* spp). Densities of poachers and flatfishes were similar between Communities VI and VII, but Community VII had higher density of rockfishes.

Researchers observed diverse invertebrate assemblages throughout the mid- and deep-water ecosystems. Feather stars, corals, sponges and anemones were primarily associated with rocky habitat, while seastars and brittlestars were observed in a variety of habitats. Fished invertebrates such as crabs, shrimp, urchins and mollusks occurred at low levels compared to non-fished invertebrates, but they also varied across the region.

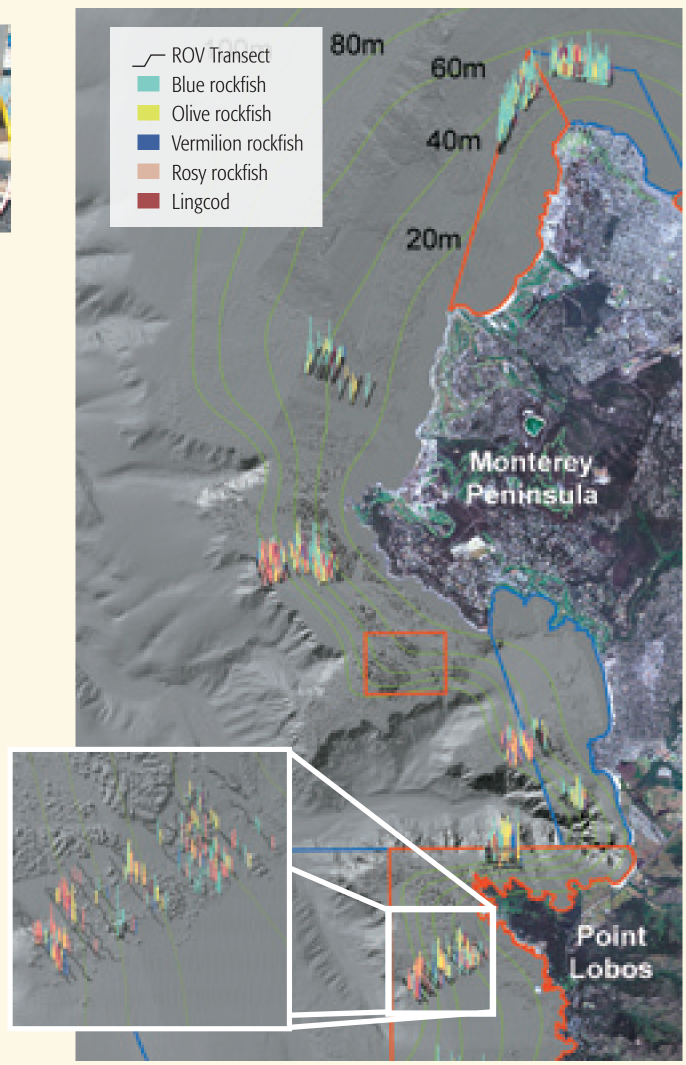
Habitat type, depth and oceanographic features, together with human influences including fishing, underlie the patterns in fish and invertebrate communities seen in offshore habitats of the Central Coast. Documenting these patterns provides an important starting point for long-term monitoring to detect potential changes in fish and invertebrate communities inside and outside of MPAs over time.

Remotely Operated Vehicle (ROV) Surveys Can Inform Fisheries and MPA Management

ROV surveys, led by the California Department of Fish and Wildlife, were conducted in rocky habitats at depths from 20 to 120 m in six MPAs and associated reference sites outside MPA boundaries. The ROV was "flown" approximately 0.5 m above the ocean bottom along 25 m^2 transects while a forward-facing video camera recorded fish on the reefs and schooling above in the water column. Video images enabled researchers to estimate the length of every fish recorded along the transects.

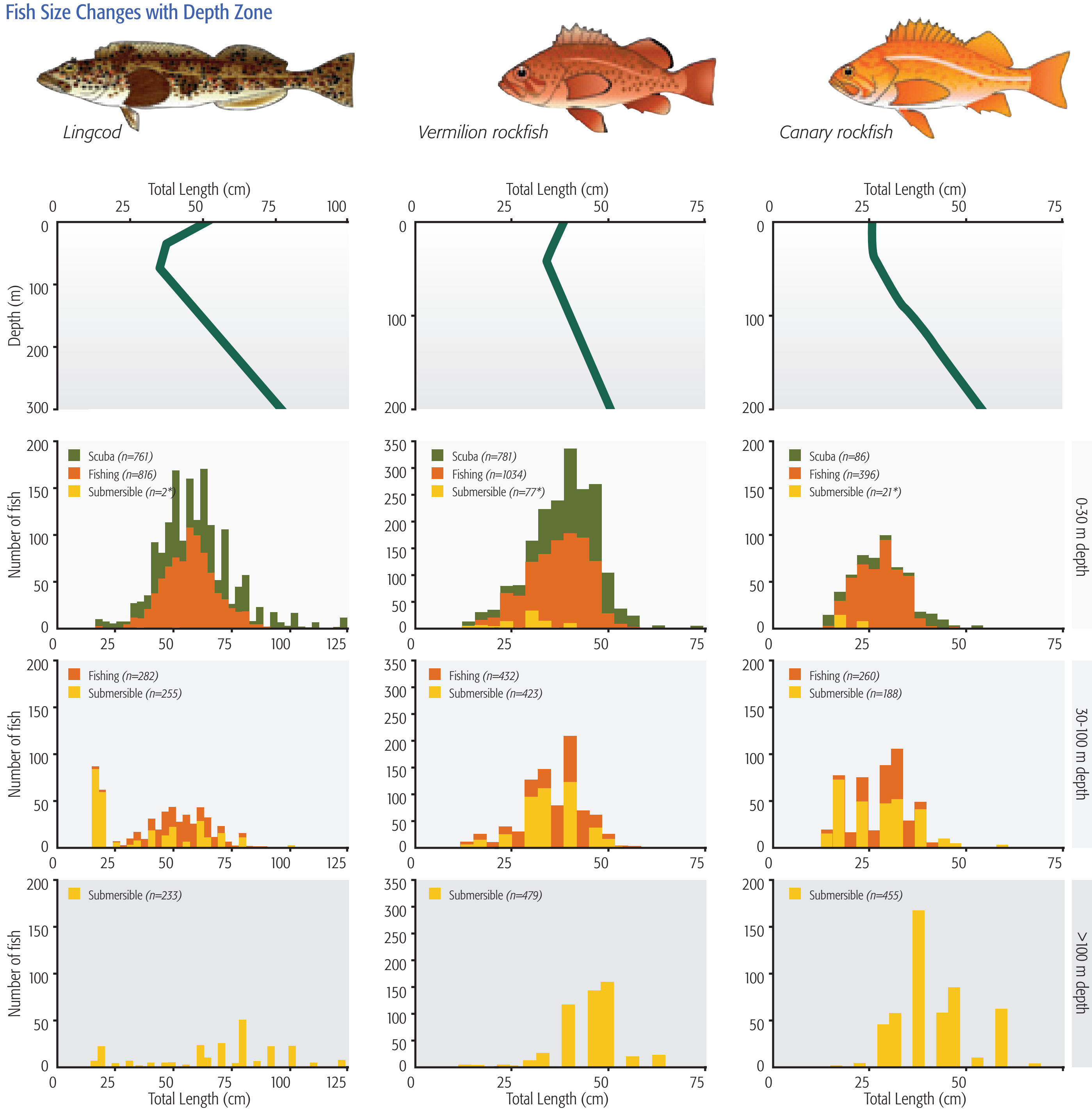
Analysis of this footage provided results that precisely depict the spatial location, depth and habitat associations of 36 species of fishes (8,133 individuals), including many of economic importance. By carefully designing the monitoring methods to focus on identifying and counting fish, these results are useful beyond MPA management.

In addition to the species highlighted here, collectively the distribution of the 36 observed species contributes to the mid-depth habitats benchmark against which future MPA performance can be measured. In addition, the data and results support stock assessments and fishery management, jointly serving management under the Marine Life Protection Act and Marine Life Management Act.



This figure shows how relative abundance of fish along ROV transect lines are distributed within Monterey peninsula and Point Lobos study sites. These select species are highly associated with rocky habitat. Note that blue rockfish and olive rockfish are common at all depths surveyed while rosy rockfish and lingcod become more common in deeper waters. Source: DFW

Fish Size Changes with Depth Zone



To establish a benchmark of fish size against which future changes can be measured, data on fish length were combined from the PISCO scuba surveys, the California Collaborative Fishing Research Program fishing surveys and the Delta submersible surveys. The broad scope of baseline monitoring provides an opportunity to look at a range of depths and habitat types. Several fish species show strong patterns of change in average length with depth, suggesting that juvenile and adult fish occupy different habitats. Smaller (younger) individuals tend to live in shallower waters, whereas larger (older) individuals tend to live in deeper waters. By combining data from several sampling methods, we gain a complete picture of the existing size structure of fish species at depths from shallow to deep waters in the Central Coast region. Source: PISCO, UCSC, MLML, Cal Poly, NOAA SW Fisheries Center

* Few submersible surveys were conducted from 0–30 m, which is reflected in the low fish counts at this depth.
Bar graphs are based on the same data as the line graphs. Fish less than 15 cm are not included in these figures.

Rocky Intertidal Ecosystems

Key Findings

- Along the coastline, rocky intertidal ecosystems are characterized by six distinct community types.
- Four of these communities have high abundance of marine plants (e.g., surfgrasses and algae) and relatively low cover of invertebrates (Communities 1–4).
- Two of these communities have nearly equal cover of both marine plants and invertebrates (Communities 5–6).
- Physical conditions—such as ocean swell, water temperature, and the slope and texture of the rocks—influence the abundance and distribution of organisms within this ecosystem and create a complex geographic pattern of community distribution.

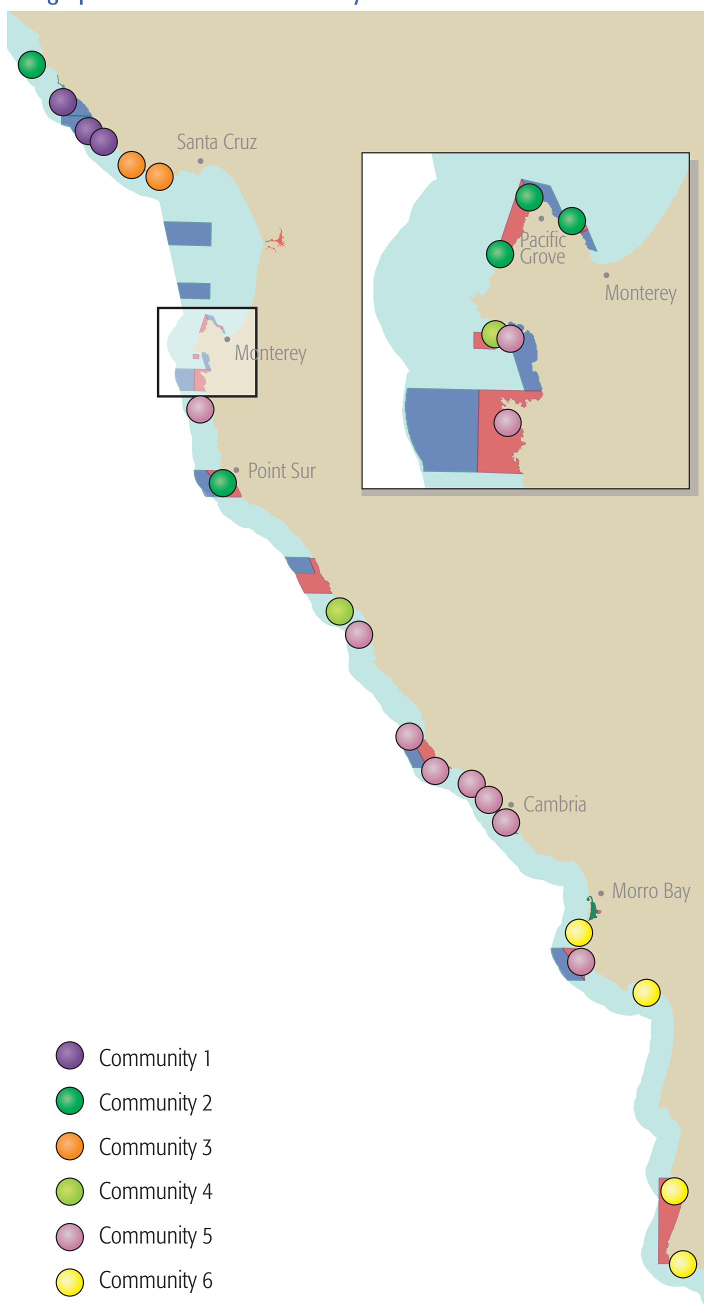
Rocky intertidal ecosystems are found along nearly half (48.9%, 336 kilometers) of the coastline within the Central Coast region and include exposed rocky cliffs, boulder rubble, exposed wave-cut platforms and sheltered rocky shores. These ecosystems are characterized by multiple zones that are defined by tidal height and the organisms that create habitat for other species. Areas that are high in the intertidal are often exposed to the air and sun, and are dominated by barnacles and other encrusting species that can tolerate these harsh conditions. By contrast, the mid and lower zones are subject to submersion, leading to an abundance of different species vying for open space and supporting a greater abundance of marine predators like seastars. Rocky intertidal ecosystems within the Central Coast are important centers of biodiversity, especially wave-cut rocky platforms, where a broad range of species are found at high, mid, and low tidal heights.

Underlying Geology and Physical Factors Affect Community Structure

While tidal height has a dramatic effect on the composition of plants and animals in the intertidal at all sites, the type of rock is often more important at the regional scale. Specifically, different types of rock vary in their suitability for different intertidal organisms. For example, sandstone and shale beds are frequently eroded by waves, which dislodge organisms attached to the rock surface. However, waves have little to no effect on the great abundance of burrowing organisms often associated with these substrates. In contrast, harder rocks such as granite are much more stable and provide more permanent places for long-lived intertidal organisms to anchor themselves. Different types of rock also vary in rugosity, or roughness, which can affect the ability of intertidal organisms to successfully attach to the bottom.

There are three unique geologic categories found within the region. Exposed rocky substrates from Pigeon Point south to the Pacific Grove Marine Gardens SMCA are composed mostly of sandstone and shale beds. Continuing south, from Pacific Grove to Point Sur, granite dominates the rocky substrate, a unique feature of the Central Coast region. South of Point Sur, the substrate is

Geographic Distribution of Six Rocky Intertidal Communities



composed of sandstones and a variety of other rock types (e.g., greenstone, serpentinite, argillite, greywacke).

In addition to differences in substrate, rocky intertidal sites also vary in their physical environment, including differences in their exposure to ocean waves, coastal fog, water temperature, scouring sand and gravel, and even trampling of organisms from visitors exploring tidepools. Each of these differences in physical environment can change the suitability of rocky substrate for different kinds of organisms. The net result is that one rocky intertidal site might look quite different from others because of its unique combination of substrate and physical environment. Understanding which organisms are found at each site when MPAs are implemented, establishes an important baseline, which will increase understanding of how these communities change over time.

UC Santa Cruz Leads Rocky Intertidal Monitoring

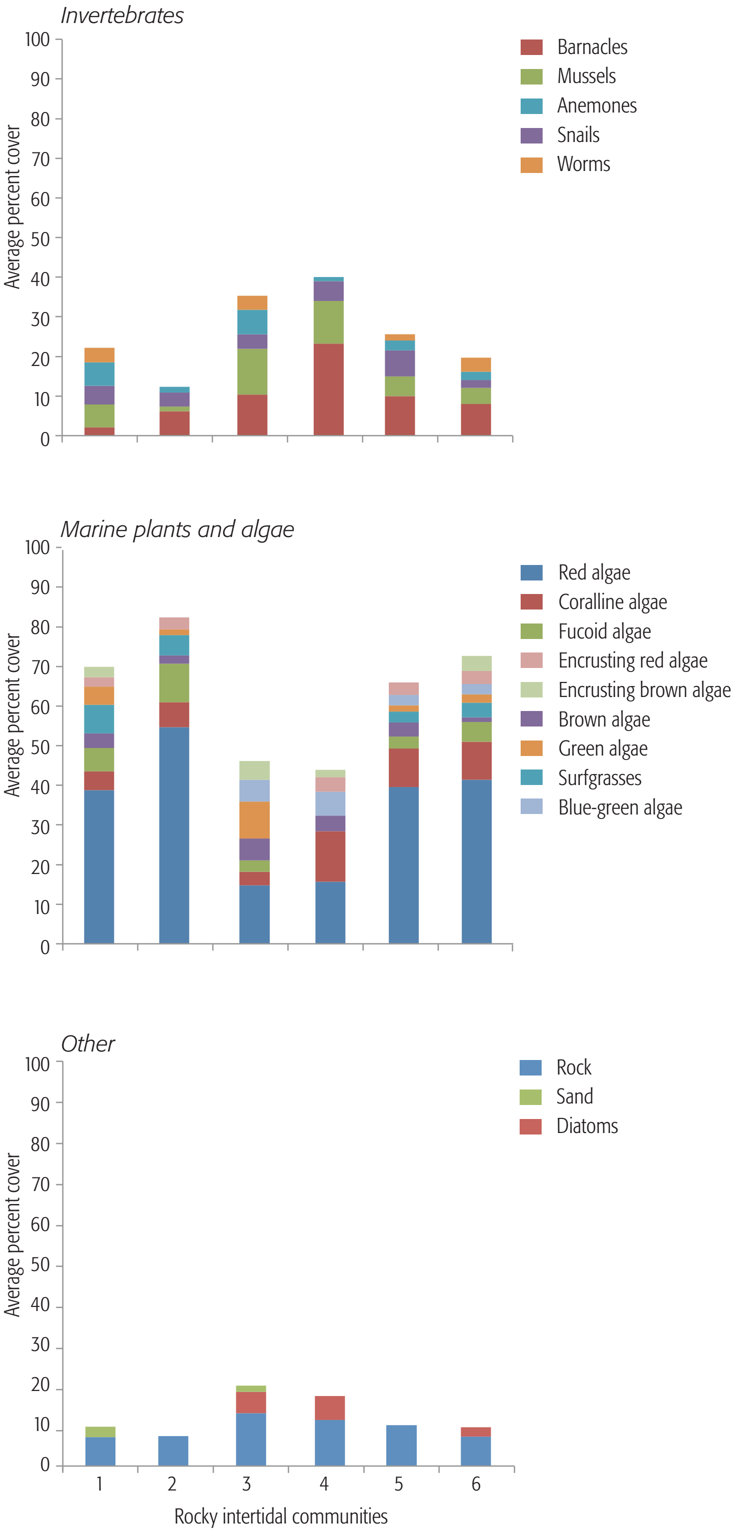
Ecological monitoring of rocky intertidal sites was led by Dr. Pete Raimondi, a PISCO scientist at University of California, Santa Cruz. Dr. Raimondi and his team surveyed 40 rocky intertidal sites; 18 of these are within MPAs with wave-cut rocky platforms and sheltered rocky shores, which describes 72% of the rocky intertidal shores within the Central Coast. Historical data are available for twenty-nine of these sites, many of which have been sampled since before 2000. Sites characterized by rocky cliffs were not monitored, due in part to difficulty in accessing such locations.

Identifying and Characterizing Communities

As expected based on local differences in substrate type and physical environment, rocky intertidal sites showed significant differences from one to another and could be grouped into six distinct community types. These communities were identified through an evaluation of the percent of the available space occupied by marine “plants” (e.g., algae and surfgrasses), invertebrates (e.g., barnacles, mussels, snails), and other intertidal space occupiers (e.g., rock, sand, diatoms) (see map). Communities 1, 2, 5, and 6 are characterized by relatively lower cover of invertebrates and higher cover of marine plants. In contrast, Communities 3 and 4 are characterized by relatively lower cover of marine plants and higher cover of invertebrates.

In addition to the biological characteristics of these communities, there are also distinct physical environments associated with them. Swell and wave exposure, rock rugosity (or roughness), substrate slope, and water temperature also influence the abundance and diversity of species in the rocky intertidal. Sites within Communities 1, 2, 5, and 6 experience much lower swell and wave exposure than sites within Communities 3 and 4. In addition to higher swell and wave exposure, Community 3, which is found near and within the Natural Bridges MPA, has relatively higher water temperature, and Community 4, which includes sites within Carmel Bay and near Lopez Point, has relatively steeper and more textured rock than other sites. Also, Communities 1 and 3 are the only communities where sand was observed.

Benchmark Conditions for Six Rocky Intertidal Communities



Average percent cover of space occupiers by rocky intertidal communities. Species included are those that characterize the community groups (i.e., highest density), rather than those that distinguish among the community groups. Source: PISCO, UCSC

In addition to these overall differences, communities also varied in their species composition of plants and animals. Red algae is the dominant marine plant within most communities, except for Community 4 where cover of red algae and coralline algae are nearly equal. Barnacles are the dominant invertebrate for all communities except for Communities 1 and 3. Mussels *(Mytilus californianus)* are the most abundant invertebrate for Community 1, and cover of mussels and barnacles is nearly equal for Community 3. Community 2, which extends from Carmel Bay south to Point Buchon, has the highest cover of marine plants (~80%) and the lowest cover of invertebrates (~12%), including the lowest percent cover of mussels.

Rocky intertidal habitats are affected by a variety of human and natural disturbances, whether trampling of organisms from visitors exploring tidepools, damage from wave action associated with winter storms or rising sea levels due to climate change. Documenting the patterns of community structure seen in these ecosystems provides an important starting point against which future changes can be compared. Having this benchmark will allow us to understand of how these systems are changing through time and what factors may be contributing to those changes.

Human Uses: Commercial and Recreational Fishing

Key Findings

- Over the last two decades, the contribution of individual fisheries to overall commercial fishing revenues has fluctuated due to market forces, environmental conditions and regulatory changes (e.g., the salmon closure in 2008 and 2009).
- Total revenues have also fluctuated over the last 20 years. Market squid has, on average, been the most significant contributor to total revenues across the region.
- Between 20 and 35 CPFV vessels have been operating in the region over the last decade. Numbers declined from 2000 to 2009 and then increased in 2010 and 2011. CPFV operators are increasingly pursuing opportunities such as whale-watching and leisure cruises to diversify their customer base.
- Estimated catch from private boat-based recreational anglers dropped from 2006 to 2008, but then landings rebounded between 2010 and 2011.

There are many different changes in human activity that we might expect to see as a result of MPAs being established. Patterns of human use, including commercial and recreational fishing, create a benchmark of socioeconomic conditions at the time of MPA implementation. Of course, assessments of the contributions of MPAs to regional socioeconomic activity need to bear in mind the economic, cultural, regulatory and demographic changes that are the backdrop for a regional network of MPAs.

Our understanding of the socioeconomics of fisheries in the Central Coast is informed by studies conducted by Impact Assessment in 2008 and Ecotrust in 2011, as well as data collected by DFW through the California Recreational Fisheries Survey (CRFS). Most recently, Ecotrust accessed a range of existing data on fishing activity and also interviewed individuals from both industries, to develop a broad understanding of socioeconomic change in the Central Coast, and the role that MPAs may play in those processes.

Commercial purse seine vessels like the one pictured above target coastal pelagic species such as market squid and Pacific sardine.

Measuring Socioeconomic Activities Inside & Outside MPAs

Spatial and Socioeconomic Change in Commercial and CPFV Fisheries

To survey the commercial fishing and commercial passenger fishing vessel (CPFV) fleet in the Central Coast region, Ecotrust developed a custom-built Geographic Information System (GIS) survey tool known as Open OceanMap. Semi-structured interviews were conducted in person and fishermen were asked various socioeconomic questions, information on operating costs, and information on the impacts of MPAs and other major drivers of change in their fisheries. Fishermen were also asked to map their fishing grounds for each key fishery they participate in. In the course of the study, Ecotrust interviewed 12 CPFV captains/owners (out of 28 estimated in operation at the time) and 29 fishermen working across 10 target fisheries, who averaged 51 years in age and 26 years of experience.

Central Coast MPA Socioeconomic Baseline Data Collection Project

To generate preliminary baseline information about the Central Coast region, Impact Assessment Inc. (IAI) conducted the Central Coast MPA Socioeconomic Baseline Data Collection Project. This involved extensive fieldwork and data aggregation focused on commercial and recreational fishing communities, and on recreational activities. These data played an important role in characterizing the region and informing the Ecotrust study, which built on IAI's work in examining initial changes due to MPA implementation.

California Recreational Fisheries Survey

The California Recreational Fisheries Survey (CRFS), conducted by DFW since 2004, estimates total marine recreational finfish catch and effort from four different modes of fishing in California—private and rental boats, beach and bank, man-made structures (such as piers and jetties), and commercial passenger fishing vessels (CPFVs). This coordinated sampling survey, which generates thousands of data points each year, provides accurate and timely estimates of marine recreational finfish catch and effort. For the private and rental boat mode (reported in 'Initial Changes' p. 43), fishing location data is collected on the scale of "microblocks"—each 1 square mile. Trends related to MPAs were examined by evaluating catch and effort in microblocks inside, outside, and along the boundaries of MPAs.

Commercial Fishing: Economic Fluctuations and Geographic Variation

Over the last two decades, the contribution of individual fisheries to overall commercial fishing revenues in the Central Coast varied greatly (see figures at right) due to a variety of factors including market forces, cycles of environmental conditions and fish abundance, and regulatory changes, such as the salmon closure in 2008–2009. The Dungeness crab-trap fishery, for example, has seen a relatively consistent increase in revenue over the last two decades, while purse seine fisheries for coastal pelagic finfish and market squid have fluctuated with environmental conditions, which strongly influence the presence of these species in the Central Coast waters.

Observed changes did not take place evenly across the region. For example, California halibut hook-and-line fishing revenues increased recently in all Central Coast ports except for Avila/Port San Luis, which has seen a greater increase in live near-shore finfish revenues than in other ports.

Total revenues have also fluctuated significantly over the last 20 years. Market squid has, on average, been the most significant contributor to total revenues across the region. Salmon also played a consistently important role in total revenues, attenuating somewhat just before salmon closures went into effect in 2008 and 2009. Revenues from coastal pelagic species increased dramatically in those two years, which also saw very low revenues from market squid.

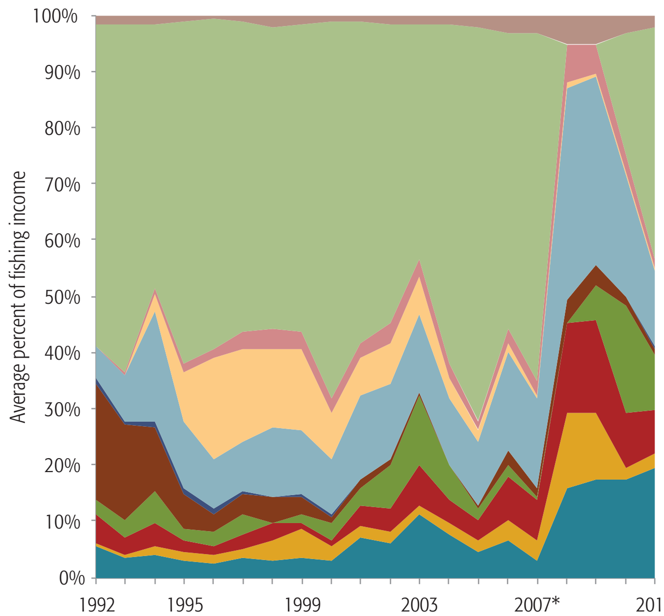
Changes in the CPFV fleet

Between 20 and 35 CPFVs have been operating along the Central Coast over the last ten years, more than half of which are based in Monterey and Santa Cruz. The total number of CPFVs operating in the Central Coast generally decreased from 2000–2009, and then increased in the subsequent two years. This roughly mirrors trends in the total number of trips taken by the CPFV fleet over that time period (see figure, next page), according to data kept by DFW.

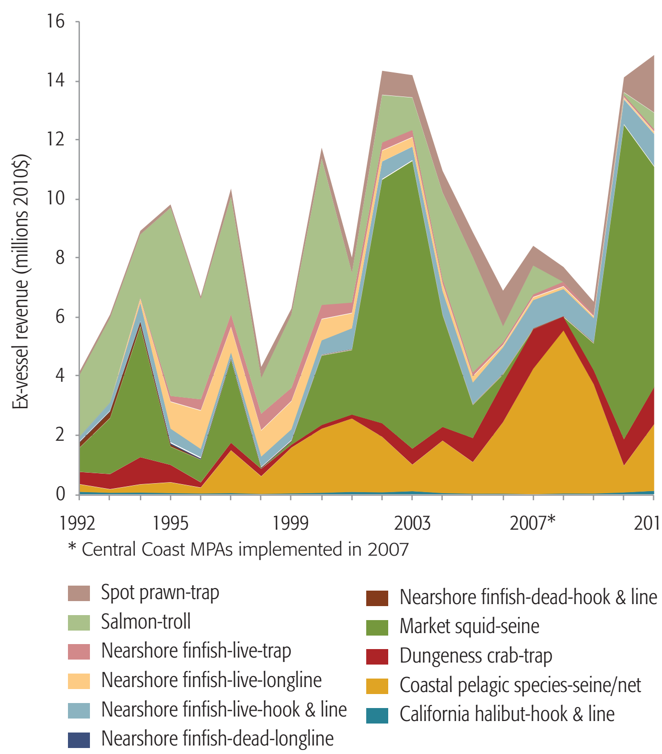
Notably, the northern and southern ports within the Central Coast are different. The total number of trips from Morro Bay increased over the last decade, while trips from northern ports have generally decreased. Rockfishes, lingcod and cabezon are important components of the catch in the Central Coast region.

The industry has also been changing in response to fluctuating environmental conditions, regulatory changes and other factors. Salmon, albacore tuna and flatfish were taken at the beginning of the study period (2000), but were replaced in later years by sanddabs, Pacific mackerel, Dungeness crab and Humboldt squid. New season and depth restrictions were placed on rockfishes during the early 2000s while salmon catches decreased during the mid-2000s, likely due to reduced availability of fish.

Contribution of Individual Fisheries to Commercial Income

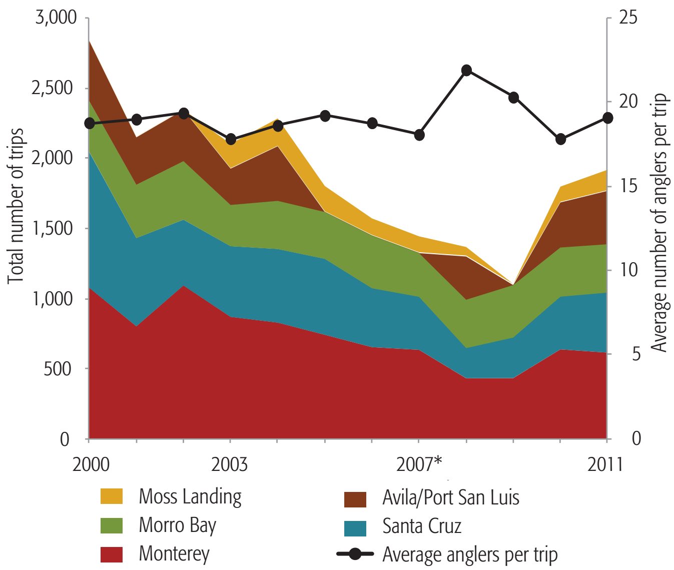


Commercial Fishing Revenues

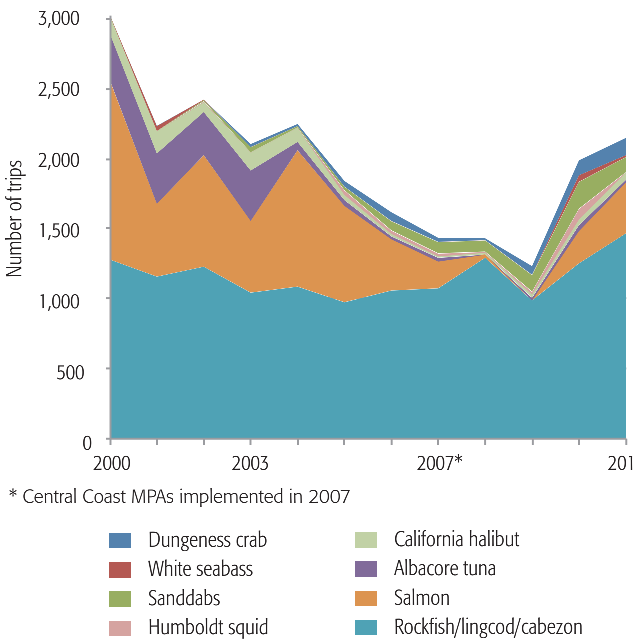


The relative role of each Central Coast commercial fishery fluctuates from one year to the next due to a wide range of factors. Data are averaged across all ports, individual ports may show different patterns. Upper: Relative contribution of individual fisheries to the average total income from eleven "fisheries of interest," selected based on their economic importance, occurrence in state waters and susceptibility to changes associated with MPA implementation. Lower: Total revenues from fisheries of interest also fluctuate from year to year. Source: Ecotrust, DFW

Commercial Passenger Fishing Vessel Activity: By Port



Commercial Passenger Fishing Vessel Activity: By Fishery



Different perspectives on how Commercial Passenger Fishing Vessel (CPFV) activity has changed in recent years. Upper: Total number of CPFV trips from 2000–2011 by Central Coast port and average number of anglers per trip. Lower: The prevalence of select fisheries in CPFV trips each year. Source: Ecotrust, DFW

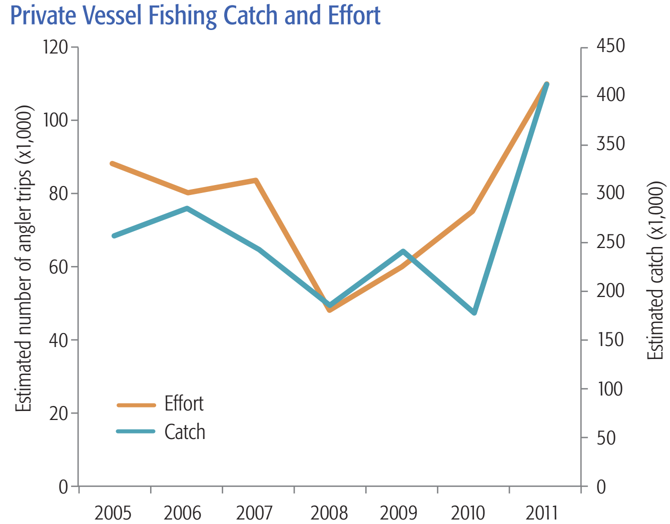
Recreational Fishing

Private and rental skiffs, with some exceptions, generally fish closer to port or launch ramp areas than CPFVs, although albacore anglers may travel considerable distances. In general, the most important areas for private recreational boat fishing are within 10 miles of the marinas and launch ramps of Santa Cruz, Moss Landing, Monterey, Cambria, Morro Bay and Port San Luis.

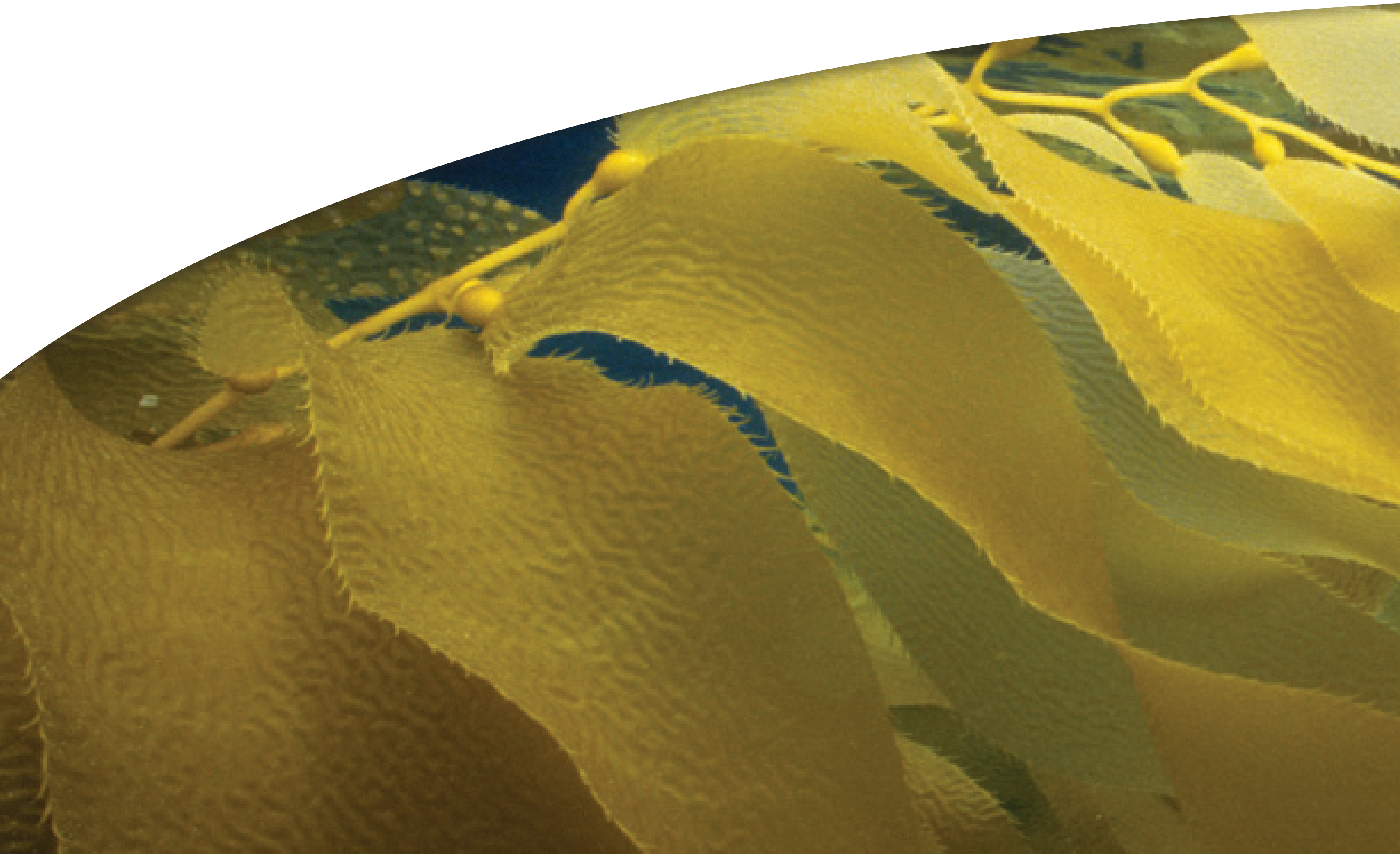
Between 2007 and 2008 the estimated number of anglers in the region fell, but then increased every year after (see figure below). Concordantly, estimated catch dropped between 2006 and 2008, with landings rebounding between 2010 and 2011. Boat-based anglers and divers generally have a target species or species group in mind when they head out to fish. In this region, this may include salmon, rockfish/lingcod/cabezon/kelp greenling, California halibut, sanddabs and albacore. Sampled anglers targeting salmon dropped to zero in all three counties during the salmon closures in 2008 and 2009 while those targeting rockfish remained relatively stable through this same period. In particular locations—Santa Cruz and San Luis Obispo counties—anglers targeting halibut increased during these years.

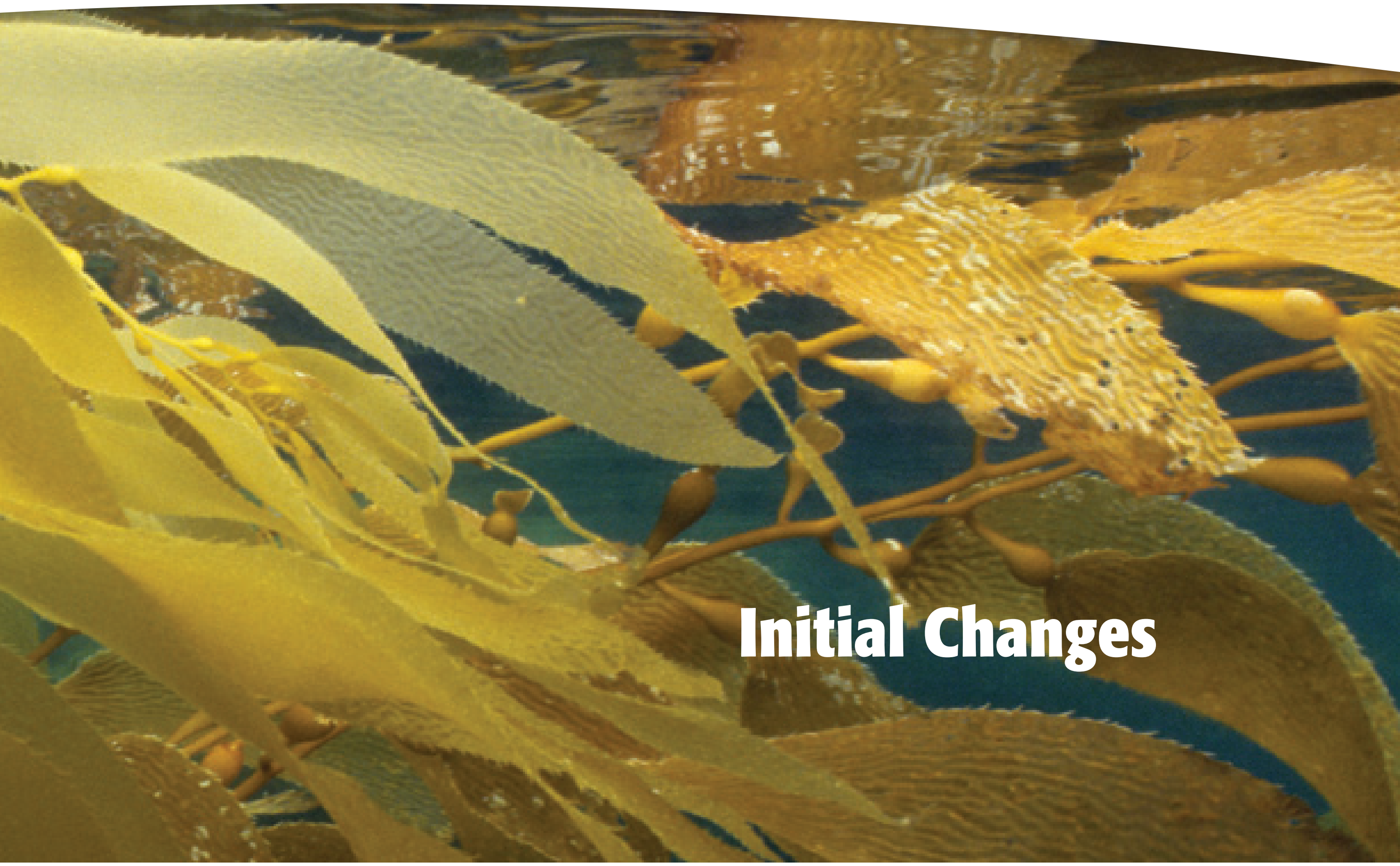
Looking forward to long-term monitoring, this complex picture of change and adaptation in both commercial and recreational fisheries is likely to continue in the region, driven by a multitude of interacting social and biological factors. The data collected and compiled establish a reference point in a time series that documents the changing socioeconomic health of fishing communities. In the future, this can be used to assess progress towards the goals of the Marine Life Protection Act as well as to inform other marine spatial planning measures.

Private Vessel Fishing Catch and Effort



Survey-based estimates of the total number of angler trips and total catch (number of kept and returned dead fish) from private vessels in the Central Coast from 2005–2011. Source: CRFS, DFW





Initial Changes

Introduction

The Central Coast regional MPA network is designed to achieve the goals of the Marine Life Protection Act—to protect marine life and habitats, restore depleted populations, and provide recreational opportunities, among others. However, change happens slowly in temperate ocean ecosystems. Deep and shallow reefs are inhabited by long-living and slow-maturing rockfish while algae and invertebrate populations on rocky shores fluctuate in response to wind and wave disturbance.

By comparison, change in human uses such as geographic patterns of commercial fishing or landings from commercial passenger fishing vessels (CPFVs or "party boats") may be more readily observable. Examining initial ecological and socioeconomic changes in the first five years following MPA implementation sets the stage to document trajectories of marine life, habitats and human uses over many years and begins to build the time series needed to evaluate MPA performance.

Initial Ecological Changes

Key Findings

- Black abalone increased in size inside MPAs, suggesting increased compliance within MPAs and/or effective MPA enforcement.
- Owl limpets increased in size between 2007 and 2011 with the greatest increases inside MPAs, suggesting protection from fishing pressure.
- In kelp forests and on nearshore reefs, some fish species (e.g., cabezon, lingcod, black rockfish) increased in relative abundance in MPAs compared to reference areas.
- Catch per unit effort (CPUE) data from the Collaborative Fisheries Research Program provides the resolution needed to detect individual MPA effects and responses of individual species to MPA implementation.

By reducing fishing, MPAs can lead to increases in the abundance and size of some fish and invertebrates. Not all species should be expected to respond equally, or at the same rates, to MPA implementation. Increases in size and abundance inside MPAs are generally predicted to be observable first in faster-growing and predatory species, and in species or populations that were previously fished inside the MPA boundaries. This initial effect of MPA implementation is one of the most widely demonstrated worldwide and was also seen in the initial monitoring results of the Channel Islands MPAs published in 2008.

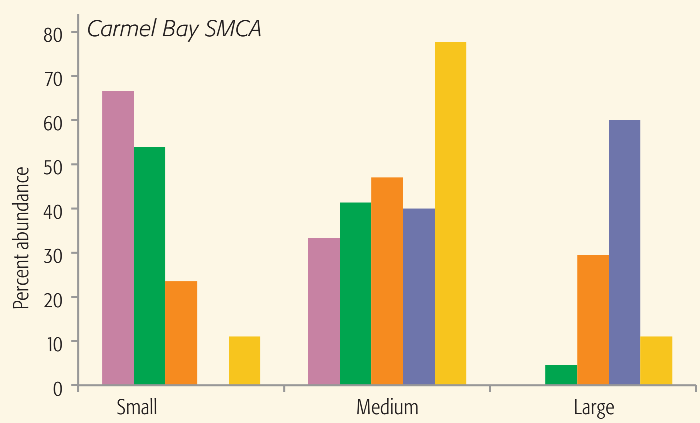
Central Coast marine ecosystems are home to many species that are long-lived and slow to reach reproductive age, such as many rockfishes. Detecting changes in abundance or size in these species in the first 5 years following MPA implementation is therefore not likely. However, some initial changes were observed. Moreover, baseline monitoring researchers have also put the first data points on time series that document long-term changes in ecosystem condition. Indeed, monitoring of the Pt. Lobos State Marine Reserve, which was originally established in 1973, demonstrates that while MPAs can have a positive effect on some species, it can take decades for changes to be observed.

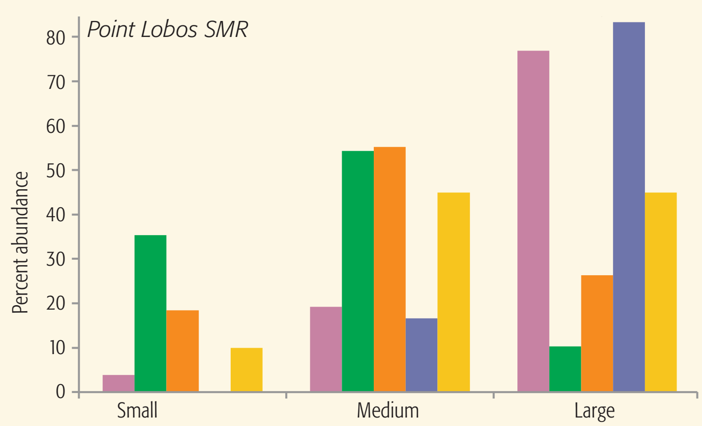
Old Versus New: the story of slow but lasting changes

Along with the new MPAs designated under MLPA, the Central Coast is home to some of the oldest MPAs in the state. Change in these MPAs has occurred slowly and is emblematic of the complex ways in which ecosystems respond to MPAs.

One of the oldest MPAs is the Point Lobos State Marine Reserve (SMR), which was established in 1973 and then enlarged as part of the redesign of the state's MPAs under the MLPA. Citizen-scientists with Reef Check collected data in this MPA and in nearby locations in Carmel Bay. By looking at the sizes of fishes observed in 2007 and 2008, researchers identified differences between the long-protected Point Lobos sites and newly protected kelp forests in Carmel Bay State Marine Conservation Area. The higher abundances of large fish seen inside the Point Lobos SMR are indicative of the changes expected inside an MPA that has been in place for nearly 40 years. *Source: Reef Check*

Vermilion/canary rockfish
Blue rockfish
Yellowtail/olive rockfish
Lingcod
Copper rockfish





Rockfishes: small (<15 cm), medium (15–30 cm), large (>30 cm)
Lingcod: small (<15 cm), medium (15–50 cm), large (>50 cm)

Initial Changes in Size & Abundance

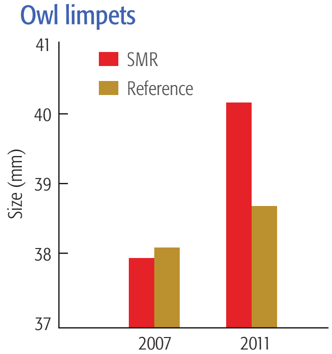
On rocky shores in the region, Baseline Program researchers surveyed many different invertebrates, algae and fishes (see p. 29 for more about this project). Among these species, owl limpets *(Lottia gigantea)* showed an overall increase in individual size between 2007 and 2011. This change in size was greater inside marine reserve (SMR) boundaries, suggesting that the MPAs played a role in protecting this species and allowing individuals to grow to a larger size.

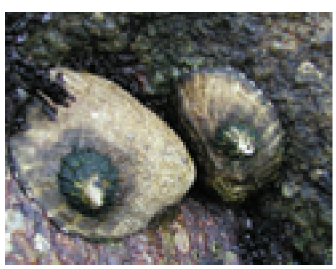
A slow-growing species that can live for up to 20 years and grow to 9 cm in diameter, owl limpets are not characteristic of "fast-responding" species. However, populations are fished and often the largest individuals are gathered first. Increases in size inside MPAs may thus be expected following a reduction in fishing pressure. Interestingly, owl limpets are protandric hermaphrodites; they grow from juveniles into males and turn into large females later in life. Future changes in size and abundance inside MPAs may also change the sex ratio—the number of females relative to males—and the reproductive potential of local populations.

Black abalone *(Haliotis cracherodii)* also increased in size within MPAs during this five-year period. However, a different explanation is needed for this change. Commercial and recreational black abalone fishing have been prohibited in California for many years, and since 2009 this species has been afforded additional protection under the Federal Endangered Species Act. Increases in size inside the newly created MPAs are therefore unlikely to be associated with a reduction in legal fishing pressure and may instead suggest a reduction in poaching activity inside MPA boundaries. It is interesting to note that in 2009 wardens from the Department of Fish and Wildlife caught a poacher with 60 black abalone from an MPA (see p. 16). As baseline monitoring transitions into ongoing monitoring, researchers can track patterns of change in size and abundance and overlay this with patterns of compliance with MPA regulations to understand differences in MPA performance.

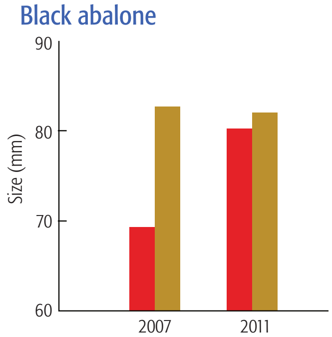
In addition to paying attention to focal species, such as black abalone and owl limpets, assessments of MPA effects can be approached by evaluating whether there is more evidence of change within MPAs than expected based on natural temporal variability. This approach was used to assess evidence of MPA effects in intertidal and kelp forest ecosystems. In rocky intertidal ecosystems, mobile species showed a significant relative increase in abun-

Owl limpets



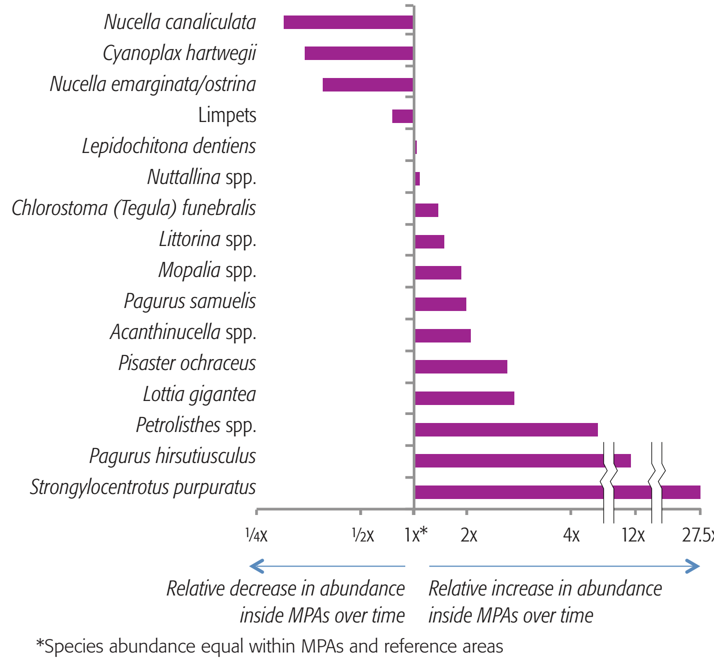


Black abalone



Average changes in the size of owl limpets (upper) and black abalone (lower) between 2007 and 2011 inside State Marine Reserves (SMR) and outside at comparable reference points. Source: PISCO, UCSC

Changes in abundance of mobile species



Change in the abundance of mobile rocky intertidal invertebrate species between 2007 and 2011 inside MPAs relative to comparable reference points outside MPAs. Bars extending to the right of the reference line indicate an increase in abundance inside MPAs relative to reference areas. Bars to the left indicate a relative decrease in abundance. The length of the bar indicates the magnitude of the change inside MPAs relative to reference areas. Source: PISCO, UCSC

dance inside MPAs compared to control sites (see figure above). In contrast, for sessile rocky intertidal species there was no difference inside versus outside MPAs. In kelp forest ecosystems, surveys of fishes revealed some changes in biomass inside relative to outside MPAs (see figure at right).

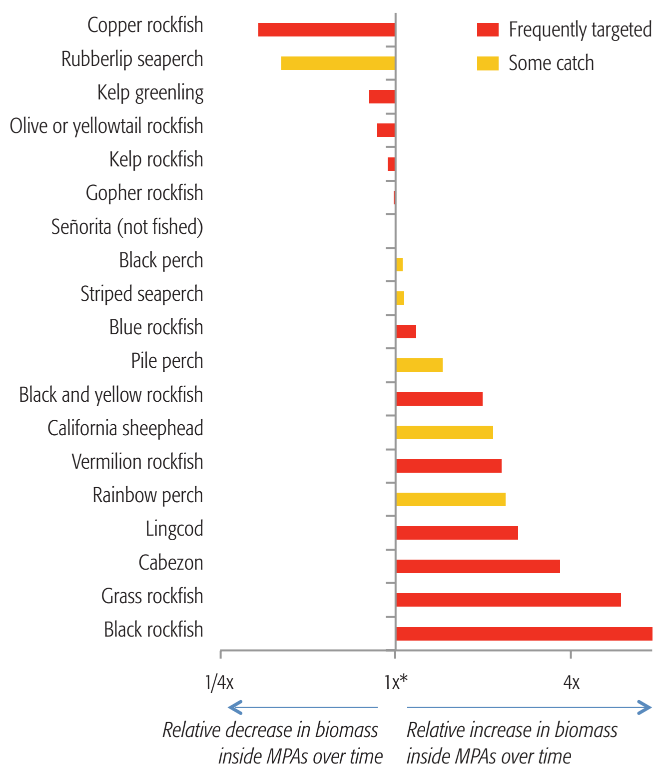
Initial changes in biomass

Surveys of kelp forest fish by PISCO (see p. 21 for a description of this project) documented some changes in the biomass of mature fish, even during the relatively brief five-year period. Black rockfish, grass rockfish, cabezon and lingcod showed the largest increases; all four of these species are fished in waters outside the MPAs. Collectively these findings suggest that fished species have responded most noticeably to establishment of the regional MPA network.

Patterns of change are, however, complex and regional-level summary results can sometimes mask differences between individual MPAs. As results from the Collaborative Fisheries Research Program on p.39 illustrate, fish population responses can differ from one MPA to the next. These graphs show that when combining data across the region (see overall graphs opposite), fish abundance within MPAs and reference areas both increased from 2007 to 2011. However, data for individual MPAs and reference areas show more complex patterns, with cases of increases and decreases both inside and outside MPAs.

Over time, researchers can examine habitat, oceanographic, ecological and other differences between MPAs to understand these differing patterns of change. These initial results begin to build our understanding of MPA performance and provide information that can be used in the future to adaptively manage the MPA network to rebuild populations and protect ecosystem structure and function, including in the face of new challenges, such as climate change.

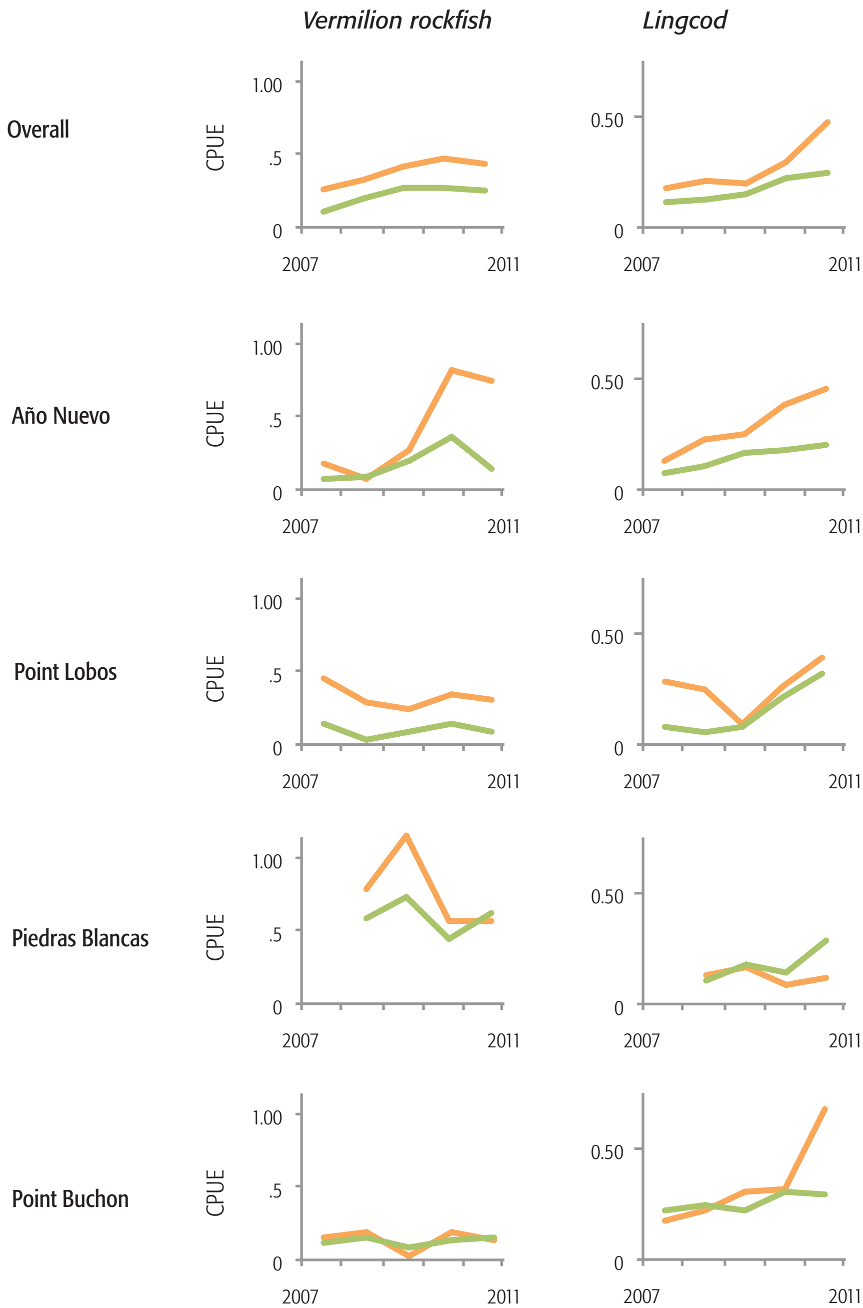
Changes in fish biomass

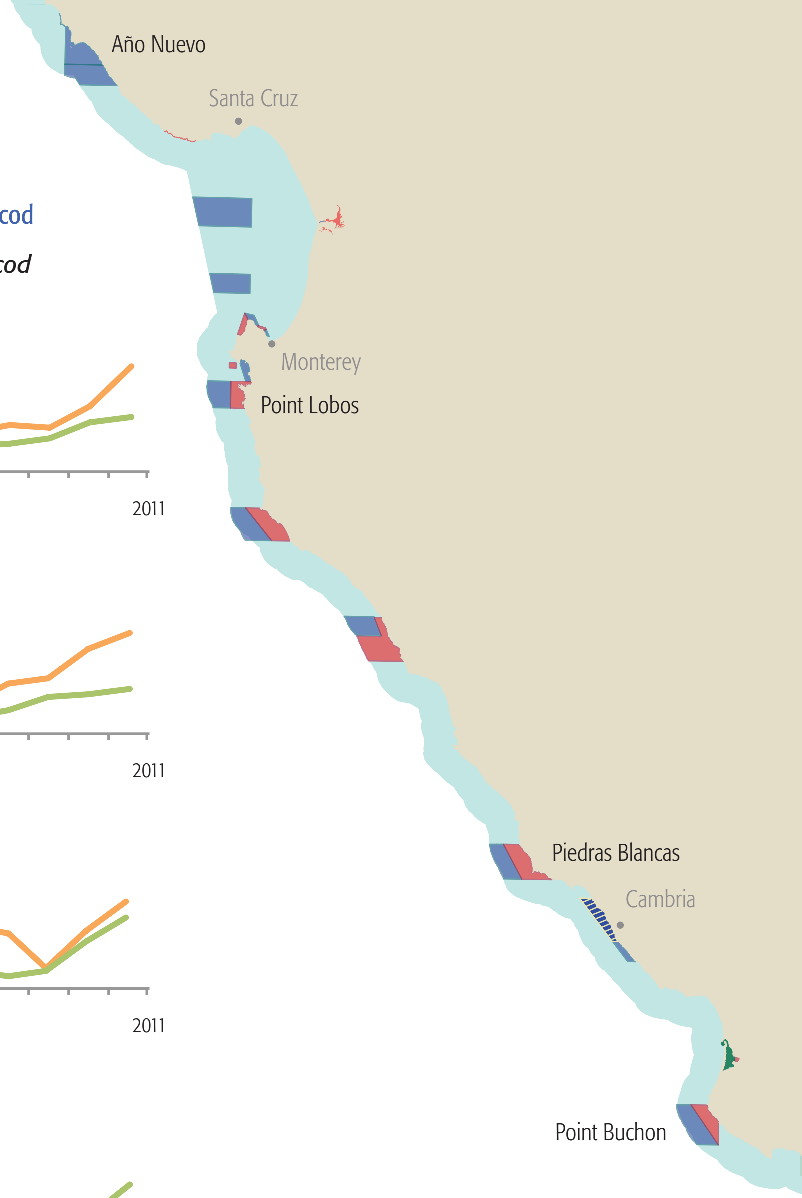


*Fish biomass equal within MPAs and reference areas.

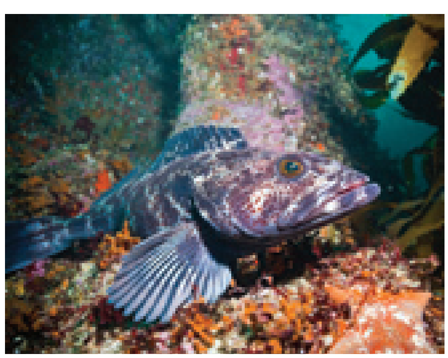
Change in the biomass of mature adult fish within kelp forests in the Central Coast between 2007 and 2011. Bars extending to the right indicate an increase in abundance or size inside MPAs relative to reference areas. Bars to the left indicate a relative decrease in abundance or size. The length of the bar indicates the magnitude of the change; red indicates fished species and yellow indicates species with some catch. Source: PISCO, UCSC

Changes in Catch per Unit Effort (CPUE) for vermilion rockfish and lingcod





MPA
Reference

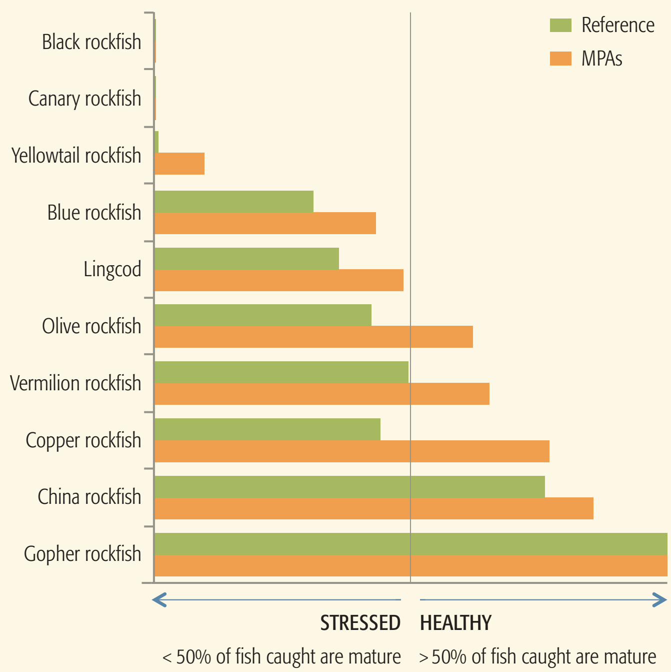


MPA-specific results from the Collaborative Fisheries Research Program show that the CPUE of vermilion rockfish and lingcod increased in some MPAs and declined in others. While not a statistically significant difference, the overall regional patterns vary between vermilion rockfish and lingcod. Overall, vermilion rockfish show little change from 2007 to 2011; whereas lingcod show a general increase both inside and outside MPAs from 2007 to 2011. Each graph shows the change over time inside the MPA (orange line) and at a comparable reference area outside the MPA (green line). The graphs include the average CPUE values for each of the four or five years included. Source: MLML, Cal Poly

MPAs protect mature fish

A commonly used measure to assess the "health" of a fish population is the proportion of mature fish in the population. In general, as fish grow older they also grow larger; thus for most fish species, fish length can be used to predict whether or not a fish is mature. Percent of mature fish was estimated from abundance and length data for each fish population. For example, if at least 50% of the individual lingcod are mature at 39 cm, then the percent of lingcod that are at least 39 cm in length is calculated. These data provide a proxy for the reproductive capacity of a population and thus insight into whether the population is "stressed" or "healthy". In this figure, bars that extend beyond the gray line (to the right) indicate fish populations that are "healthy", where greater than 50% of the fish caught were mature. Bars that do not extend to the gray line (to the left) indicate fish populations that are "stressed", where less than 50% of the fish caught were mature.

Focusing on Año Nuevo, Point Lobos, Piedras Blancas, and Point Buchon, reference areas have fewer mature fish than MPAs for nearly all species. For example, populations of copper rockfish, vermilion rockfish, and olive rockfish are healthy within MPAs but stressed within reference areas. However, populations of gopher rockfish are healthy both inside and outside MPAs. For these and other fish species, the nearshore waters provide habitat for mature fish and thus are vital for the future of these populations. On the other hand, mature fish of some species are not found in shallow waters, either because they are no longer present (i.e., black rockfish) or because mature individuals are more often found in deeper waters (i.e., canary rockfish). Thus, these data suggest that nearshore MPAs are valuable for protecting mature fish populations of many species, but offshore MPAs are also important because larger, mature individuals for some species are found in deeper water. *Source: MLML, Cal Poly*



Initial Socioeconomic Changes

Key Findings

- MPAs affected the activity of more than half of commercial fishermen, according to interviewed fishermen. The greatest impacts were reported by nearshore finfish and Dungeness crab fishermen.
- The number of CPFV trips in the region increased after the implementation of MPAs for all ports except Morro Bay.
- Rockfish, the largest CPFV fishery (in terms of total catch and number of trips taken), was the most heavily impacted fishery due to MPA implementation, according to interviews with boat captains.
- Almost half of the CPFV captains who conduct other activities–such as government charters, recreational diving trips and research diving trips–reported generally beneficial impacts of the MPAs due to increased interest.

Some immediate socioeconomic changes due to MPA implementation under the Marine Life Protection Act are expected. MPAs limit or prohibit the take of living marine resources from within MPA boundaries thereby changing patterns of fishing or harvesting. Such changes occur rapidly, and fishing communities must adapt and change as new MPA regulations take effect.

Understanding the longer, one- to five-year, socioeconomic impacts of MPAs is more challenging because socioeconomic change occurs amid a wide array of cultural, political, economic and environmental factors. One approach is to consider change over a longer time period and examine trends in fisheries before and after MPA implementation. Combined with surveys of commercial and CPFV operators, this approach can provide important context for understanding the initial socioeconomic effects of the regional MPA network. Data presented here and in 'Establishing a Benchmark' (see p. 31–33) begin to paint this picture, but more time is required to establish firm links between MPAs and broad-scale socioeconomic change.

Adaptation in Commercial Fleets

Planning of the Central Coast regional MPA network considered the potential socioeconomic impacts of MPA designation and policy guidance was developed to minimize, to the extent feasible, the socioeconomic effects of MPA implementation on commercial and recreational fisheries. A survey of Central Coast commercial fishermen conducted by Ecotrust (see p. 31 for a description of this project), sought to measure some of the socioeconomic effects that did occur.

In that survey, more than half of the commercial fishermen surveyed (82.8%) indicated that their fishing had been impacted in some way by MPAs. This response was most frequently heard from fishermen in the Dungeness crab trap (85.7%) and live nearshore finfish fisheries (81.3% of fishermen) and

Percent of Central Coast Commercial Fishermen Indicating Direct Impact (Positive or Negative) from MPAs for Each Fishery

Fisheries	Number of Fishermen Responding	Percent of Respondents Reporting Impacts
California halibut: hook-and-line	10	60%
Coastal pelagic species: seine/net	4	75%
Dungeness crab: trap	7	86%
Market squid: seine	4	75%
Nearshore finfish: live	16	81%
Salmon: troll	13	15%
Spot prawn: trap	3	67%

Source: Ecotrust

only infrequently heard from salmon troll fishermen (15.4% of fishermen). In part, this reflects the location of the MPAs themselves; all of the live nearshore finfish fishermen who indicated an impact also noted that they had lost traditional fishing areas to MPAs and almost half surveyed (43.8%) reported having to travel longer distances—often past MPAs—in order to fish. In addition approximately half of the State Marine Conservation Areas allow commercial salmon fishing. These impacts reported by fishermen varied both by fishery and also by MPA. Across the region, California halibut—hook-and-line and nearshore finfish—live fishermen reported being impacted by the largest number of MPAs (20 MPAs).

Decadal Changes in the CPFV Fleet

As with commercial fishing, we would expect to see some immediate changes in recreational fishing activity aboard CPFVs as a result of MPA implementation, but it is difficult to draw a link between those changes and broader outcomes. For example, at roughly the same time that the Central Coast MPAs were implemented, the economy went into recession and a two-year closure of the salmon fishery went into effect. Despite these various pressures, the number of CPFV trips occurring in the Central Coast increased from 2009–2011 (after the implementation of MPAs) for all ports except for Morro Bay, which remained much the same (see p. 33).

Central Coast CPFV Fishermen Indicating Direct Impact from MPAs for Each Fishery or Activity

Fisheries/Activities	Number of Fishermen Responding	Percent of Respondents Reporting Impacts
Albacore tuna	6	0%
California halibut	6	67%
Dungeness crab	2	50%
Humboldt squid	1	0%
Rockfish/lingcod	11	100%
Salmon	11	18%
Sanddab	5	40%
White sea bass	5	0%
Whale watching	6	17%
Other*	7	43

Source: Ecotrust

* Other includes: Funeral services, government charters, recreational diving, and research charters

While it is not possible to show how MPAs influenced or contributed to the recent increase in CPFV activity, the Ecotrust study did examine some of the more proximate impacts of MPAs on the industry through interviews with boat owners and captains. All CPFV captains interviewed indicated that particular CPFV activities had been affected by MPAs in some way, such as loss of traditional fishing areas or having to travel longer distances (see table p.42).

Similar to commercial fishing, impacts due to MPAs varied by fishery, and some MPAs impacted CPFV operations more than others. Interviewees reported no impacts at all for white seabass, Humboldt squid and albacore tuna fisheries (see table above). Other fisheries of interest had varying impacts from salmon (18.2% of 11 respondents) to rockfish/lingcod, where 100% of 11 respondents reported direct impacts to operations.

Positive changes due to MPAs were also documented. Of the CPFVs that conduct activities, such as government charters, research charters and recreational diving trips, almost half (42.9%) reported generally beneficial impacts due to increased interest.

The owners and captains interviewed by Ecotrust indicated that the rockfish/lingcod/cabezon fishery, the most prominent CPFV fishery by far (see p.33), was impacted by 20 MPAs, and the California halibut fishery was impacted by 12 MPAs. All other recreational fisheries of interest were impacted by three or fewer MPAs.

Recreational Fishing: Private Vessel Anglers

One of the potential initial changes to recreational fishing due to MPAs is a shift in fishing effort to areas outside MPAs. To detect whether this has occurred, DFW analyzed CRFS microblock (see p.31 for a description of CRFS) data to look for trends in fishing effort inside, outside, and along the boundaries of MPAs.

Private vessel anglers sampled from 2005–2011 primarily fished in CRFS microblocks located outside of MPAs (see table below) indicating a relatively high level of compliance post MPA implementation. The percentage of surveyed anglers in microblocks with an MPA boundary (referred to as "MPA Edge" in the table below) increased slightly in the two years following implementation (2008–2009), but then decreased in 2010–2011. Overall, fishing effort in areas that became MPAs decreased by 2.2% (from 4.7 to 2.5%). Effort outside MPAs increased by 1.2% (from 82.4 to 83.6%). These initial results indicate that large shifts in effort to areas outside and adjacent to MPAs have not occurred for this mode of recreational fishing.

Additionally, the CRFS data suggest that anglers are taking advantage of salmon fishing opportunities provided by some SMCAs. In 2010-2011, once the salmon closures ended, over half of the sampled anglers fishing inside of the MPAs targeted salmon, while outside of the MPAs, the rockfish-lingcod-cabezon group was targeted more than salmon.

Percent of Sampled Anglers Fishing from Private Vessels

Year Range (sample size)	Inside MPAs*	MPA Edge**	Outside MPAs***
2005–2007: Pre-MPA implementation (1,560)	4.7% (542)	12.9% (1,490)	82.4% (9,528)
2008–2009: Post-MPA implementation (4,922)	1.4% (69)	21.0% (1,035)	77.6% (3,818)
2010–2011: Post-MPA implementation with open salmon season (6,452)	2.5% (159)	14.0% (902)	83.6% (5,391)

Source: CRFS, DFW

* embedded entirely inside a Central Coast Region MPA;
** contains an MPA boundary somewhere within and sometimes portions of MPAs;
*** does not contain any part of an MPA.

Over One-Third of Central Coast MPAs Provide for Recreational Fishing Opportunities

Of the 15 SMCAs in the region, 13 provide some recreational fishing opportunities. For example, 12 SMCAs allow the recreational take of salmon, 4 allow the recreational take of finfish, and an additional 2 SMCAs provide shore fishing opportunities. Visit the Department of Fish and Wildlife website (www.wildlife.ca.gov) for additional information on fishing regulations and opportunities in Central Coast MPAs.

Conclusion and Next Steps

Informing MPA Management

Monitoring California's network of MPAs provides scientific information to inform management decisions. Baseline MPA monitoring results from the Central Coast are available to everyone to inform the first recommended 5-year management review of the regional MPA network in 2013. These results also provide the foundation for a partnerships-based ongoing MPA monitoring program in the Central Coast. The Central Coast MPA monitoring plan will be updated in 2013 and used to guide the next cycle of monitoring data collection. Ongoing MPA monitoring will take the pulse of ocean ecosystems and ocean-based human activities so we can continue to learn how they are changing through time, and how MPAs are affecting them.

oceanSPACES

A new online community and the hub of monitoring information, data and results from California's network of MPAs.

Visit OceanSpaces to view comprehensive results from baseline monitoring in the Central Coast, download data or find out more about the groups involved in monitoring in this region. This summary report is also available on OceanSpaces in an interactive format that includes additional figures, images and videos.

OceanSpaces is an online community that fosters new knowledge of ocean health. The platform brings everyone together with a stake in the health of California's ocean—scientists, fishermen, tribal members, resource managers, policymakers and citizens—offering new opportunities for individuals to communicate, create and share information. From sharing data and results from California's network of marine protected areas, to forming new collaborations, OceanSpaces is building community support around ocean science.

Individuals, groups and organizations can join OceanSpaces, create profile pages and post research updates, photos, newsfeeds and more. You can also create a new group around any topic of interest and invite other members to join. This is a great way to collaborate, post messages and share information. OceanSpaces helps you connect with a wider community.

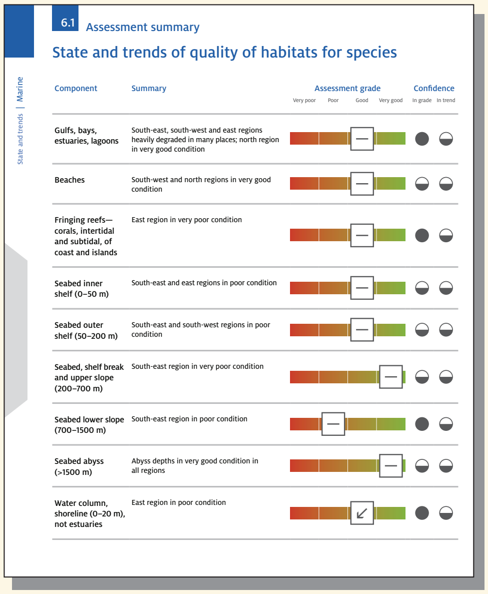
www.oceanspaces.org

A New Report Card for California's Oceans

Ocean resource management, as in terrestrial ecosystems, often means making hard decisions. Decision-makers are often asked to modify management measures based on the best-available science. In the case of monitoring MPAs there are many such decisions. What indicators to select, what monitoring projects to implement and how to interpret data are all decisions requiring scientific judgment. But how do we ensure that these judgments are credible and trustworthy, so that the information can be reliably used by managers and decision-makers?

Moreover, the questions themselves are seemingly getting harder. Within conservation and natural resource management a historical focus on single species is giving way to ecosystem-level protection goals. Globally MPAs are being established to protect ecosystems, protect biodiversity, or restore ocean health. Measuring progress towards these goals and providing managers and decision-makers with ecosystem condition or 'health' assessments is cutting-edge science.

To explore this dual challenge, California kelp forest ecologists are working alongside managers to pilot a new approach for sharing monitoring results. In a project led by the Ocean Science Trust, scientists are using baseline monitoring data together with expert judgment to assess the health of Central Coast kelp forests and to develop a new report card for sharing condition assessments. The 5-year management review of the Central Coast regional MPA network provides a first opportunity to test and refine this approach so that future report cards on California's oceans best support science-informed decision making.


State and trends | Marine

6.1 Assessment summary

State and trends of quality of habitats for species

Component	Summary	Assessment grade (Very poor, Poor, Good, Very good)	Confidence (In grade, In trend)
Gulfs, bays, estuaries, lagoons	South-east, south-west and east regions heavily degraded in many places; north region in very good condition		
Beaches	South-west and north regions in very good condition		
Fringing reefs—corals, intertidal and subtidal, of coast and islands	East region in very poor condition		
Seabed inner shelf (0–50 m)	South-east and east regions in poor condition		
Seabed outer shelf (50–200 m)	South-east and south-west regions in poor condition		
Seabed, shelf break and upper slope (200–700 m)	South-east region in very poor condition		
Seabed lower slope (700–1500 m)	South-east region in poor condition		
Seabed abyss (>1500 m)	Abyss depths in very good condition in all regions		
Water column, shoreline (0–20 m), not estuaries	East region in poor condition		

Representation of the report card style being piloted for California's kelp forests. This example is drawn from the 2011 Australia State of the Environment report (www.environment.gov.au/soe/2011/index.html)

Partners

Contributors