State of the California North Central Coast

A Summary of the Marine Protected Area Monitoring Program 2010-2015

This document, the **State of the California North Central Coast: A Summary of the Marine Protected Area Monitoring Program 2010-2015** (State of the Region report), provides a summary of the results from the North Central Coast Marine Protected Area Baseline Program (Baseline Program) and other assessments from monitoring over the first five years of marine protected area (MPA) implementation in California's North Central Coast region. It is designed to share highlights and learning from the Baseline Program and to serve as a guide to the full portfolio of scientific reports that have been developed over the last five years. This summary State of the Region report is designed to inform potential management recommendations from the first five years of MPA implementation in the region, and will be provided to the California Fish and Game Commission in Spring 2016.

This report was produced by the California Ocean Science Trust in partnership with California Department of Fish and Wildlife and Ocean Protection Council. We acknowledge and are deeply appreciative of the work and input on the part of many partners and collaborators in the region, including the academic, agency, consulting and citizen scientists who conducted the work upon which this report is built. We have aimed to depict this collaborative effort throughout this document and on OceanSpaces.org.

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Everything in this summary report can be explored in more depth on **OceanSpaces.org**. Dive into the State of the North Central Coast page on OceanSpaces.org for the full portfolio of scientific reports and analyses from the first five years of MPA monitoring in this region.

OceanSpaces is California's digital home for MPA monitoring data and results. It houses hundreds of data packages, projects, and synthesis products—a collective body of scientific knowledge to make science-informed decisions for our coasts and oceans.

As you explore this document, use the interactive links and icons provided to delve deeper. Connect to a wealth of resources available on OceanSpaces using your phone or tablet, and join the online community to engage with the science and track the health of California's oceans.

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A network of marine protection

California is home to a statewide network of marine protected areas (MPAs) designed to meet the goals of the Marine Life Protection Act (MLPA), including protecting marine habitats and ecosystems, improving sustainable human use of our ocean, and protecting California's marine natural heritage. The MPAs are designed and managed, to the extent possible, as a network. Collectively, they can serve as a living laboratory for understanding and supporting ocean health, and exploring the effects of existing and emerging stressors.

Monitoring, research, and evaluation support adaptive management of MPAs. This report summarizes findings from the North Central Coast MPA Baseline Program (Baseline Program) and other monitoring activities in the region, and is a guide to the numerous resources that inform our understanding of the region, all available on OceanSpaces.org. Results of baseline monitoring provide a rigorous foundation for science-informed decision making by the California Fish and Game Commission and many other state and federal partners.

New partnerships working to achieve MPA network goals

In California, implementing the MPAs has motivated a coordinated approach to ocean resource management, stretching across jurisdictions, communities, academic disciplines, and institutions. Since 2010, university scientists, K-12 students, state and federal agencies, fishermen, volunteer divers, and non-profit organizations, among many others, have collaborated to deepen our knowledge of this region. The result is an unprecedented understanding of the state of the North Central Coast, and a set of relationships that will serve California for years to come.

A changing and dynamic ocean environment

Variability in the ocean environment impacts marine life and coastal communities. The region's ecosystems are particularly shaped by upwelling, freshwater runoff, and Pacific Ocean influences (like the El Niño Southern Oscillation and the Pacific Decadal Oscillation). At the same time, climate change and associated changes in ocean chemistry are impacting the ocean environment, including changes in temperature, sea level, and ocean acidificaton and hypoxia.

Long-term monitoring will be critical to help determine and mitigate the effects of climate change, which will affect the ability of the MPA network to meet the goals of the MLPA.

A comprehensive benchmark

Establishing a benchmark of ocean conditions and human activities against which future changes can be measured is an important time stamp, providing a starting point for a long-term monitoring program.

- Strong upwelling events in 2008 and 2010 led to increases in phytoplankton, a vital resource for marine food webs.
- Researchers documented over half-a-million seabirds; nearly 99% breed adjacent to MPAs, 83% of which breed on the Farallon Islands alone.
- Thousands of invertebrates and fish were observed in mid-depth and deep water ecosystems. Combining biological surveys and seafloor maps revealed important life history patterns and population distributions for many species, including commercially important rockfishes and lingcod.
- Patterns in commercial fisheries are driven by many factors including natural population cycles, policy change, management action, and economics. The Dungeness crab fishery has been particularly important to the North Central Coast in recent years.

Summary and Key Findings

- Recreational abalone harvesters contribute significantly to the coastal economy. The number of charter fishing trips decreased by more than half from 2000-2009, then began rebounding.
- Baseline monitoring demonstrated how academic, citizen, and agency scientists can collaborate to survey beaches and surf zones, rocky intertidal ecosystems, and kelp forests, to provide cost-effective, long-term monitoring of these ecosystems.

Connections enhance learning and new tools

A suite of projects through the Baseline Program brought together data and partnerships across multiple programs, generating new insights about ecological and human linkages across the region, and piloting new tools to support long-term monitoring.

Long-term monitoring hints at initial changes

It can take many years to see the impacts of MPAs and understand regional trends. However, data from long-term monitoring programs in the region provide us with a glimpse of recent changes.

- Long-term monitoring at Stornetta Ranch revealed that the establishment of the Sea Lion Cove MPA marked the beginning of a sharp increase of red abalone there, which has continued through 2015.
- Remotely operated vehicle (ROV) surveys inside and outside MPAs throughout the region in 2015 found increased abundances of some rockfishes and lingcod. Several hundred brown rockfish were observed in 2015, in contrast to only five individuals seen in 2009 and 2011.
- Surveys in 2014-2015 found shrunken kelp forests, followed by high sea urchin densities surpassing anything seen in the region in the past 10 years, leading researchers to examine the role of changing ocean conditions and the mass sea star die off.

MPA monitoring data inform a range of resource management decisions

MPAs are living laboratories, serving as tools for understanding ocean health in the face of sudden events, long-term trends, and climate change.

- In 2011 a severe invertebrate die-off occurred along the Sonoma Coast, resulting in thousands of dead abalone washing ashore. Rapid response by state agencies, researchers, and citizens, led to nimble management actions and thorough documentation of the event.
- In 2013 a mysterious wasting syndrome caused a mass die-off of sea stars across the west coast. Long-term monitoring programs, state resource managers, and baseline MPA monitoring gave California an early start on tracking the progression of the outbreak.
- MPA monitoring data provides knowledge of changing ecological conditions that is essential to track and respond to the effects of ocean acidification and hypoxia.

Strategic investments build long-term durability

Baseline monitoring generated novel scientific findings, strengthened partnerships, and developed new tools and approaches. Together, we are using this foundation to build scientifically rigorous, partnership-based long-term MPA monitoring in the North Central Coast and statewide.

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North Central Coast State of the Region: By the Numbers

Baseline MPA monitoring in the North Central Coast has shown what it means to take a partnerships approach to MPA monitoring. A vast array of partners have come together to produce the data and science that underpin the State of the Region report, and make these resources available to everyone:

$4+ million investment in this region by the State

$1+ million leveraged by monitoring partners

20+ government, academic, private, non-profit, fishing, and citizen science groups forming partnerships, and investing time and resources.

11 baseline monitoring projects and peer reviewed technical reports

800+ monitoring sites

85 data packages

25+ interactive web map layers on MarineBIOS using baseline data

8 reports on monitoring methods development and science integration

6 products describing management and environmental context

30 outreach and education documents

And 1 online platform that brings it all together.

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Setting the Scene

The North Central Coast Region

The North Central Coast Region covers 763 square miles of state waters and extends about 470 miles along the coastline, from Alder Creek just north of Point Arena, south to Pigeon Point, and includes the state waters around the Farallon Islands. The region hosts diverse ecosystems, from sandy beaches and rocky headlands, to kelp forests and rocky reefs. These ecosystems support thousands of species, including marine mammals, seabirds, sea turtles, fishes, invertebrates, and marine algae, and provides habitat for numerous threatened or endangered species, including black abalone, Chinook salmon, leatherback sea turtles, Steller sea lions, and Marbled Murrelets.

The region is among the most biologically productive marine areas in the world, due in part to its position within the California Current Large Marine Ecosystem (CCLME) with its persistent upwelling of cold, nutrient-rich water. Coastal communities depend on the region's waters for productive fisheries, recreational activities, and tourism. Major commercial fisheries in the region include squid, Dungeness crab, California halibut, salmon, nearshore finfish (rockfish), and sea urchins. Recreational opportunities abound, from fishing rockfish and salmon, to abalone diving, kayaking, wildlife watching, and beach walking.

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California's MPA Network

The MLPA, passed by the California legislature in 1999, directs the State to develop, evaluate, and adapt California's system of MPAs to meet six key goals.

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.

The North Central Coast regional MPA network, implemented in 2010 following a science-based and stakeholder driven planning process, covers about 20% of state waters in the region. Most of the network allows certain types of take, but 11% is designated as no-take reserves. By reducing other stressors, MPAs can help buffer these diverse ecosystems against long-term climate change impacts.

Introduction to MPA Monitoring

The goal of MPA monitoring is to evaluate progress toward MLPA goals and to provide data that can inform MPA management decisions. As outlined by the State's MPA Monitoring Framework, monitoring consists of assessing ecosystem conditions and trends, together with management effectiveness evaluations.

Establishing a benchmark through baseline monitoring

Establishing a benchmark of ecological and socioeconomic conditions in the region at the time of MPA implementation sets the stage for a comparison of these baseline results with future monitoring results. This allows us to track changes inside and outside of MPAs over time, providing the necessary information to evaluate the effects of MPA management and network design. Managers learn from these evaluations and improve management approaches over time through a process of adaptive management.

Baseline monitoring in the North Central Coast

Baseline monitoring began in this region in 2010 with the North Central Coast MPA Baseline Program an investment of $4 million by the State. This Baseline Program was implemented through a partnership among California Ocean Protection Council (OPC), California Ocean Science Trust, California Department of Fish and Wildlife (CDFW), and California Sea Grant.

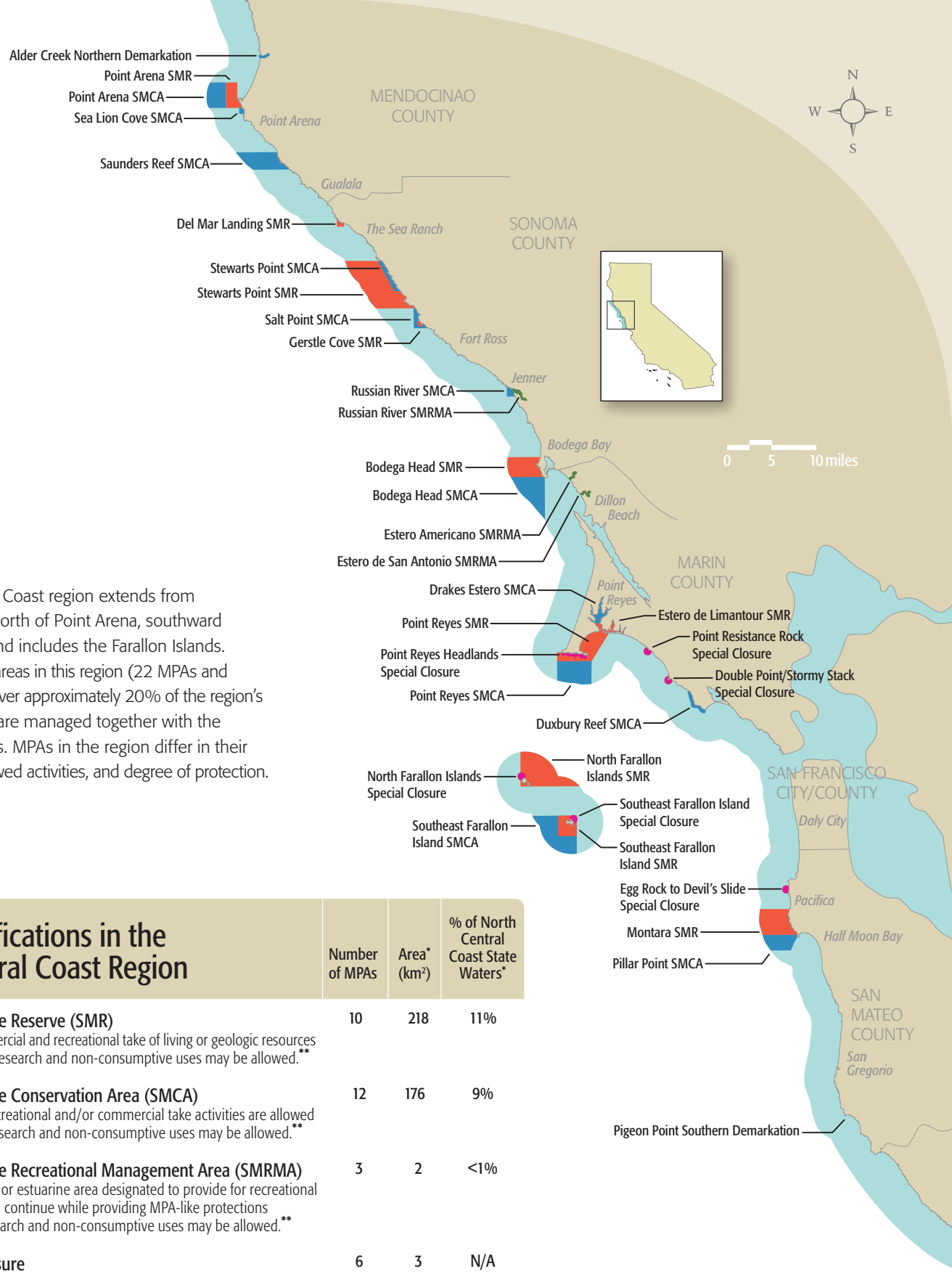
Eleven projects, selected through a competitive process that included peer review of all proposals, encompass a breadth of ecosystems and human uses in the region. These projects collected data from 2010-2012, providing a snapshot of the region. Additional state and private investments in 2013 and 2014 secured a deeper understanding of the region through new research that linked findings across projects.

Establishing a comprehensive benchmark of ecosystem conditions and human uses in the region also requires an understanding of the broader oceanographic, socioeconomic, and management context of the region, which has been contributed by a variety of monitoring partners.

The scientific learning from baseline monitoring in the North Central Coast is designed to inform potential management recommendations from the first five years of MPA implementation in the region. This State of the Region summary report is anticipated to be delivered to the California Fish and Game Commission in Spring 2016.

A partnership-based approach

The California Collaborative Approach: Marine Protected Areas Partnership Plan, adopted by the OPC in 2014, recognizes that implementing, monitoring, and managing California's network of MPAs requires many forms of collaboration. This is certainly the case for MPA monitoring in a region as large and diverse as the North Central Coast. The data and results that form our understanding of the state of the region come from partnerships among more than 20 academic institutions, state and federal partners, non-profit organizations, fishermen, and citizen groups. Through these collaborations, we have developed a better understanding of the region, while laying important groundwork for future monitoring. Working together across communities, organizations, and disciplines, helps us to expand the value, relevance, and efficiency of MPA monitoring.



The North Central Coast region extends from Alder Creek, just north of Point Arena, southward to Pigeon Point, and includes the Farallon Islands. The 25 protected areas in this region (22 MPAs and three SMRMAs) cover approximately 20% of the region's State waters, and are managed together with the six special closures. MPAs in the region differ in their classifications, allowed activities, and degree of protection.

MPA Classifications in the North Central Coast Region

	Number of MPAs	Area* (km²)	% of North 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.**	10	218	11%
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.**	12	176	9%
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.**	3	2	<1%
Special Closure An area adjacent to seabird rookeries or marine mammal haul-out sites, where access or boating activities are restricted.***	6	3	N/A
California State Waters			

* 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.

*** These small closures (300' and 1,000') often overlap with other MPA's and provide additional protection in sensitive areas.

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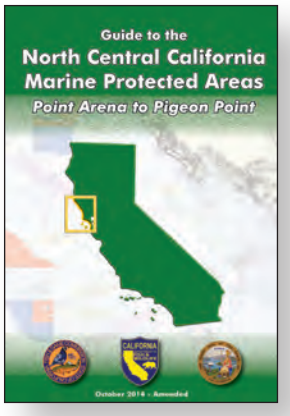
MPA Management in the North Central Coast

MPA monitoring is one of many aspects of natural resource management, which also includes outreach and education, enforcement and compliance, and policy and permitting. Understanding the broader history and current context of ocean resource management informs accurate interpretation of monitoring results, and highlights areas for continued improvement.

Outreach and education



Public outreach efforts in the region, led by CDFW, have focused on increasing public awareness and understanding of the region's MPA locations and regulations. Information has been made available through traditional CDFW venues (such as sport and commercial fishing regulatory publications, notice of regulatory changes, newsletter posts, and press releases), interpretive signs installed at key coastal access points, and via the web and blogs. The CDFW MPA website offers site-specific maps, boundaries, regulations, and MPA Overview Sheets for each MPA. The mobile version of the MPA page allows users to track their location and regulations in real time from their web-enabled devices. Partnerships are also a key component of the CDFW's outreach efforts in the region.

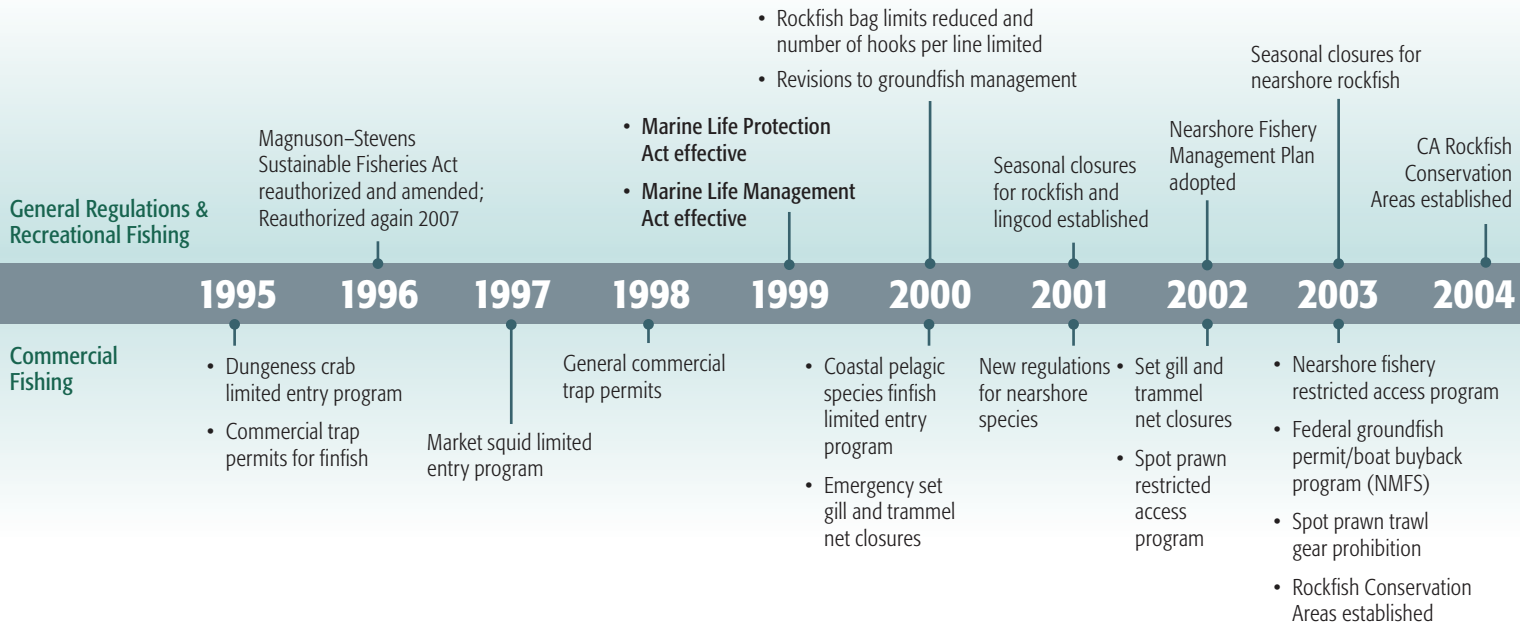
Enforcement and compliance

MPA effectiveness is influenced by enforcement of, and compliance with, MPA regulations. Understanding patterns of violations allows targeted approaches to educate a diverse constituency, enforce regulations, and interpret monitoring results. CDFW is the primary agency responsible for enforcing MPA regulations, with 14 enforcement officers in the North Central Coast, and occasional assistance from California State Parks, National Parks Service, the U.S. Coast Guard, and the National Oceanic and Atmospheric Administration.

Over time, an understanding of enforcement and compliance patterns will be important in interpreting the results of ecological monitoring, and in determining the overall effectiveness of MPAs in the region in meeting the goals of the MLPA. Records of CDFW citations from January 2010 to December 2014 in the North Central Coast show approximately 215 violations in the MPAs (6% of the total violations in the region), occurring within 14 of the 25 MPAs. Of these 215 violations, 47% occurred in Sonoma County, and 39% in Montara SMR. Some violations may be attributed to a lack of knowledge about MPA boundaries and regulations, further emphasizing the important links among outreach, education, and compliance.

Better technology and community support will increase compliance through improved surveillance systems, detection, and interdiction. The CDFW-Law Enforcement Division is advancing finer resolution analyses, to determine specific violation types and strategically plan continued enforcement efforts. Find out more at: http://wildlife.ca.gov/Conservation/Marine/MPAs.

Regulations Affecting Ocean Resources



THE MPA COLLABORATIVES NETWORK: A LOCAL VOICE IN MPA MANAGEMENT

Recognizing the opportunity to engage, support, and learn from local coastal communities, a network of MPA Collaborative groups along the California Coast was established. These Collaboratives provide a forum for diverse stakeholders to support stewardship of the region's MPAs at a county level. By bringing together representatives from governmental agencies (city, county, state, federal, and tribal), environmental organizations, fishing groups, academic institutions, and others, MPA Collaboratives are building partnerships in MPA enforcement, monitoring, education, and outreach at the local level.

There are four active MPA Collaboratives in the North Central Coast Region: San Mateo, Sonoma, Mendocino, and the Golden Gate (representing both Marin and San Francisco Counties). Each Collaborative works with state partners to advance local priorities, activities, and projects. Collaborative projects in this region have included:

- An offshore MPA ambassador and boat captain outreach program for the Greater Farallones;
- An MPA brochure designed with fishermen and docents, for Marin and San Francisco MPAs; and
- A Sonoma County MPA video focusing on K-12 MPA education, the science of marine protection, the history of fishing and tribal uses in Sonoma, and fun uses of MPAs

MPA COLLABORATIVE NETWORK

In the North Central Coast MPA Region

2005
Market Squid Fishery Mgmt. Plan Enacted

2006
Pacific Coast Groundfish FMP & Essential Fisheries Habitat, Amendment 19

2007

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

Ocean salmon fishing closed all year for most of the state

2010
North Central Coast MPAs established

Limited ocean salmon fishing season

2011
Temporary emergency closure of red abalone fishery along Sonoma County

Reduced fishing season in most areas north of Humboldt

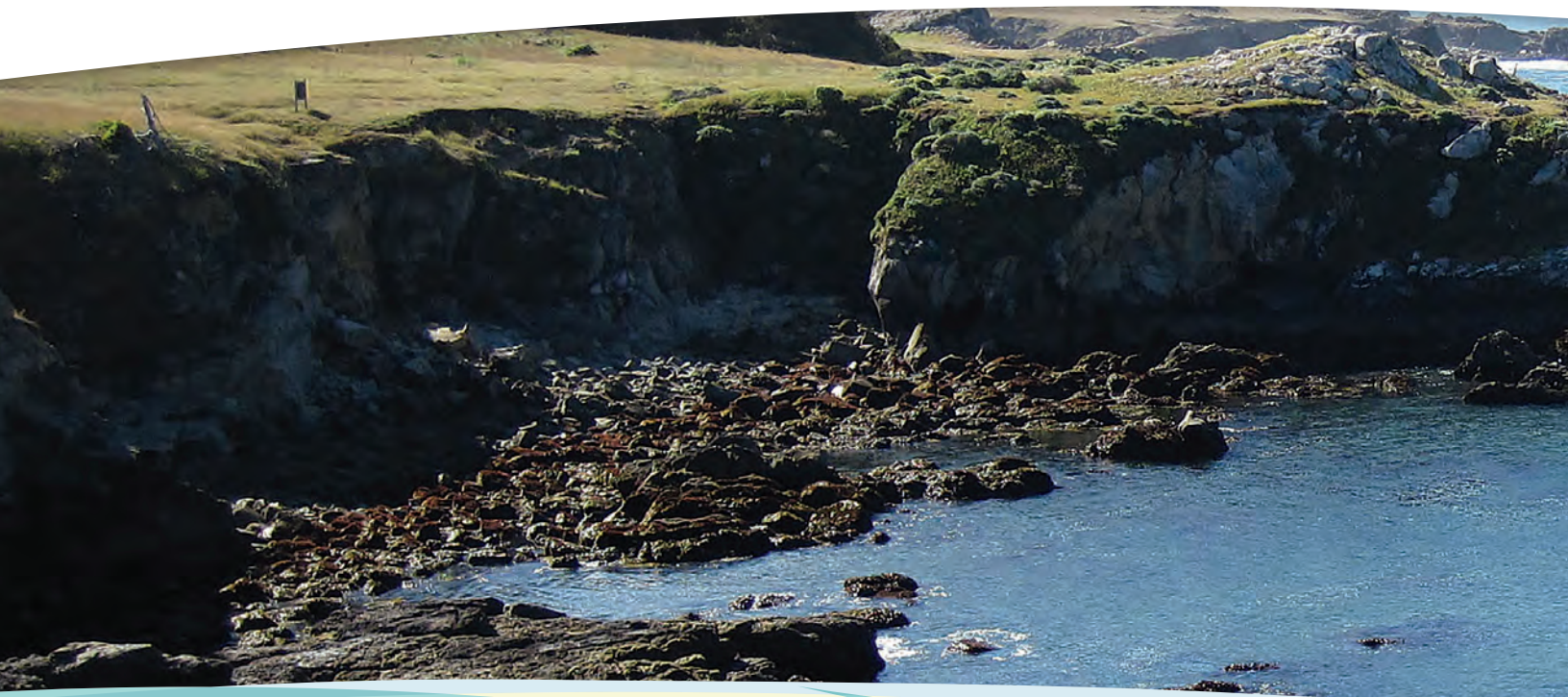
2012
Statewide MPA Network completed

Number of days for ocean salmon fishing slightly increased

2013
Small adjustments to salmon season

2014
Abalone fishery restrictions triggered by low densities in the Ft. Ross area

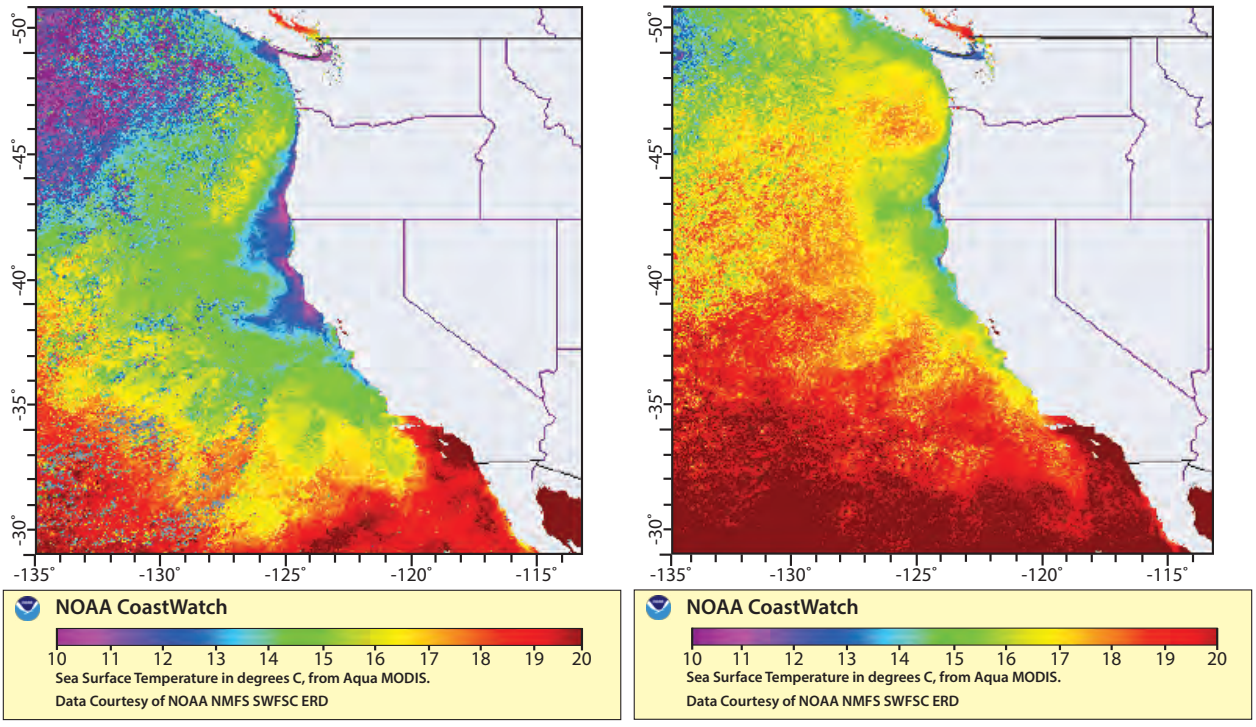
2015
Expansion of Greater Farallones National Marine Sanctuary



Environmental Context

Observed ecological and human use patterns are driven in part by environmental variability and a changing climate. An important goal of MPA monitoring is to understand changing oceanographic patterns and their implications for MPA effectiveness.

Environmental conditions in the North Central Coast vary in response to three primary drivers: upwelling, freshwater runoff, and Pacific Ocean influences. The wind-driven coastal upwelling of cold, nutrient-rich waters and the patterns of freshwater runoff from the land combine to create a clear seasonality in the region.



Monthly average sea surface temperature for July 2011 (left) and July 2015 (right). Figure from North Central California MPAs: CeNCOOS Report on Environmental Conditions 2010-2015 (Largier et al 2015).

Establishing a Benchmark

The large-scale conditions in the Northeast Pacific Ocean combine with these seasonal drivers to create large year-to-year differences in conditions.

The Central and Northern California Ocean Observing System (CeNCOOS) worked with regional partners to reveal important environmental fluctuations in the last five years, including:

- High freshwater runoff in early 2011, followed by low winter runoff persisting from 2012 to present, caused by the major, multi-year drought being experienced in California.
- Strong upwelling index in 2012, 2013 and 2014, with colder than usual water during upwelling season in 2012 and 2013.
- Anomalously warm surface waters in 2014 and 2015, and anomalously high sea levels in late 2014 and early 2015.
- A strong El Niño developing in 2015

The complex and dynamic oceanographic conditions highlight the importance of coupling environmental and ecological data collection and analyses. Efforts are underway to coordinate long-term ecological and oceanographic monitoring programs to understand the drivers and causes of observed changes.

Ecological Conditions and Human Uses

The North Central Coast MPA Baseline Program developed the first thorough characterization of the ecological and socioeconomic conditions of the region, creating a benchmark against which future MPA performance can be measured.

Linking to existing CDFW programs

CDFW operates long-standing monitoring programs that contribute important data and results for MPA monitoring. Kelp forest canopy coverage data have been collected using multispectral aerial imagery within variable time periods and regions from 1989 to present, and deepwater visual surveys of MPAs using a remotely operated vehicle (ROV) have been conducted since 2000. Each of these projects provides important historical context. The Baseline Program project that used aerial imagery to map habitats also used these kelp canopy data to develop maps of kelp persistence in the region, providing a deeper understanding of the patterns of variation over time. New ROV surveys are being conducted in the North Central Coast throughout 2015, as part of CDFW's statewide effort to continue monitoring existing sites and establish new monitoring sites.

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North Central Coast Benchmark — Hig

The results of 11 projects that comprise the Baseline Program are summarized in a Snapshot Report, released in 2013. Together, these projects blanketed the region, describing all Ecosystem Features present in the region, producing peer-reviewed technical reports, and delivering 85 publicly available data packages.

CONSUMPTIVE USES

NON-CONSUMPTIVE USES

MID–DEPTH ROCK

SOFT-BOTTOM INTERTIDAL & BEACH ECOSYSTEMS

- Kelp wrack, which supports a rich diversity of invertebrates and terrestrial birds, is four times greater on pocket beaches than long beaches.
- Due to geography and physical attributes, beach conditions varied widely throughout the year and across the region but were similar inside and outside MPAs.
- Academic and citizen scientists can collaboratively survey birds, sand crabs, surfperch, kelp wrack, and human uses to provide cost-effective, long-term monitoring of beaches.

ROCKY INTERTIDAL ECOSYSTEMS

- The region's rocky shores are teeming with life: researchers documented 256 rocky intertidal species across 19 monitoring sites.
- Most sites are dominated by attached red algae, mussels, and barnacles, with littorinid snails and limpets gliding over them.
- Select species of surfgrass, algae, mussels, and snails characterize the region's distinct rocky intertidal communities. These, together with other ecologically important species such as sea stars, could serve as indicators of change.

ESTUARINE & WETLAND ECOSYSTEMS

- Eelgrass bed coverage varies from 7% in Drakes Estero SMCA to 42% in Estero de San Antonio SMRMA. This habitat serves as vital nursery grounds and refuge for many species, including Dungeness crabs.
- Estuaries and wetlands contain a high diversity of habitats, from saltmarsh to mudflats, which in turn support a high biodiversity including shorebirds, fishes, and invertebrates.
- Ocean Imaging generated imagery at a resolution of 1-2 meters. High-resolution imagery like this can serve as an important tool for monitoring habitat shifts.

KELP & SHALLOW ROCK ECOSYSTEMS (0-30 M)

- Divers documented the cover or abundance of 129 species of fish, invertebrates, and algae.
- Kelp forests in the region support high abundance of blue rockfish and red sea urchins both inside and outside MPAs.
- Academic and citizen surveys produced similar results, and both are playing an important role in our understanding of ecosystem condition.

NON-CONSUMPTIVE USES

- People from North Central Coast counties make more than 22-million trips per year to their local coast, and coastal recreation contributes $1.2 billion annually to Bay Area economies.
- The most popular coastal activities were scenic enjoyment, going to the beach, photography, biking or hiking, and watching seabirds and other marine life from shore.

ghlights from Baseline Data Collection

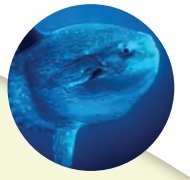
ROCKY INTERTIDAL

KELP & SHALLOW ROCK

ESTUARINE & WETLAND ECOSYSTEMS

SOFT BOTTOM INTERTIDAL & BEACH

SOFT BOTTOM SUBTIDAL


NEARSHORE PELAGIC

MID-DEPTH ROCK ECOSYSTEMS (> 30-100 M) & SOFT BOTTOM SUBTIDAL ECOSYSTEMS

- Thousands of invertebrates, over 8,400 fish, and a variety of substrates were observed in the mid-depth and deep water ecosystems. A third of these fish were observed near the South Farallon Islands.
- Researchers identified 13 species of fish and invertebrates as potential indicators for long-term monitoring using underwater cameras, including lingcod, rock crabs, and plumose anemones.
- Taken together, biological surveys and seafloor maps have revealed important life history information about several fished species, including rockfishes and lingcod.

NEARSHORE PELAGIC ECOSYSTEMS

- Researchers documented over half-a-million seabirds, nearly 99% of which breed adjacent to MPAs, and 83% of which breed on the Farallon Islands alone.
- Long-term data from the U.S. Fish and Wildlife Service show positive trends in some species, such as a 379% increase in Common Murres from 1989 to 2012.
- Two strong upwelling events in 2008 and 2010 led to increases in phytoplankton productivity.
- Monitoring seabirds, which forage offshore and breed on land, can provide important insights into pelagic ecosystems, potentially acting as an indicator for systems that are challenging and costly to monitor.

For a complete list of North Central Coast Baseline Program projects, go to page 26.

CONSUMPTIVE USES

- Annual commercial landings for fisheries of interest averaged 7.9 million pounds and $18 million in ex-vessel revenue from 1992-2013, with notable increases in the Dungeness crab fishery since 2009.
- Annual commercial revenue per Dungeness crab fisherman more than tripled, rising to $131,577 per fisherman after 2010. This is likely because of a peak in the natural cycle of Dungeness crabs, and increased fishing effort by both California and out-of-state fishermen.
- Charter fishing anglers dropped by more than half from 2000-2009, largely due to fishery restrictions (e.g., the 2008-2009 salmon closures) and the recent economic declines after the salmon fishery reopened in 2009. Charter fishing rebounded after the closure, but generally has not reached pre-closure levels.

- Recreational abalone harvesters contribute significantly to the coastal economy, spending an average of $1,000 per harvester on their sport in 2010, with Fort Ross and Timber Cove as the most popular sites.

Explore more of the baseline monitoring results in the Snapshot Report.

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Broadening Participation in MPA Monitoring

A partnerships approach to MPA monitoring means broadening participation beyond conventional academic science. The Baseline Program explored the potential role for local experts and citizen science, through collaboration with three different existing programs (LiMPETS, Beach Watch, and Reef Check California) and one novel project working with recreational anglers.

- The LiMPETS (Long-term Monitoring Program and Experiential Training for Students) program brought 3,300 North Central Coast K-12 students from 60 schools to the coast, where they surveyed sandy beach and rocky intertidal ecosystems. The collaboration provided useful data, and feedback that can help improve the role of student volunteers in long-term monitoring of coastal ecosystems.

- Since 1993, adult volunteers in the Beach Watch program have conducted more than 14,000 surveys on 39 beaches in the region, collecting data on birds, marine mammals, and human activities. The resulting long-term data set provides a foundational understanding of the dynamic context of bird and mammal populations over the past 20 years.

- Highly trained volunteer divers with Reef Check California conducted yearly surveys of kelp and shallow rock ecosystems in the North Central Coast starting in 2006. This program was developed with rigorous academic input, collaboration with CDFW, and training from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), and provides a publicly available data set for the region.

- Scientists at UC Davis, Sonoma State University, and UC Santa Barbara collaborated with CDFW and 49 recreational anglers to design and implement a novel protocol for surveying surf zone fishes. They developed a catch-and-release method that collects data compatible with CDFW ongoing monitoring, creating a cost-effective approach for expanding surf perch surveys.

Connecting the Dots

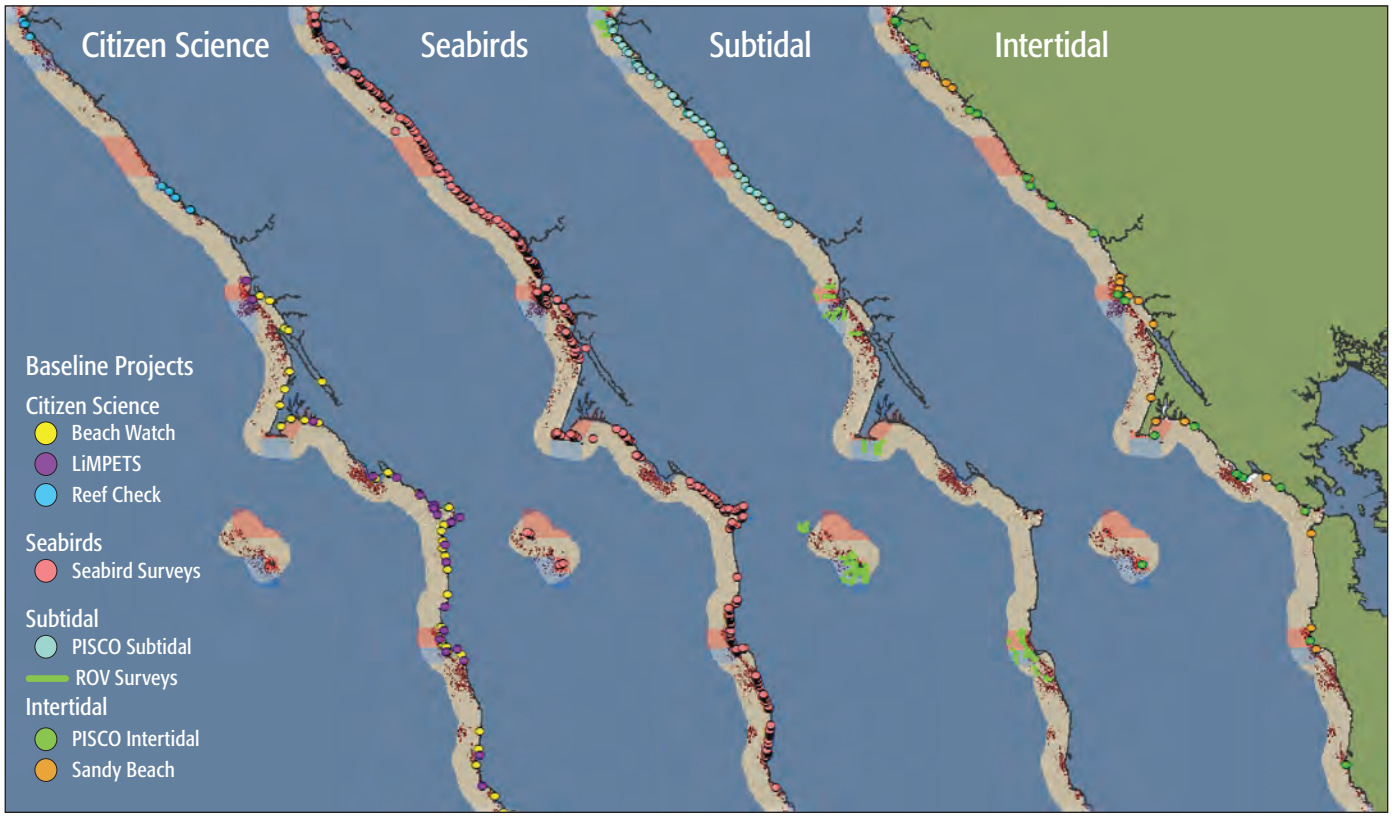
A particular challenge of MPA monitoring is bringing together data from a wide diversity of projects, to develop an integrated view of these complex, interconnected systems. Several such integrative projects have added depth to our understanding of the region in the initial five years since MPA implementation.

Connections among ecosystems: kelp forests, rocky intertidal zones, bays and sandy beaches

Sandy beach ecosystems rely on inputs of beach wrack — tangled piles of washed up seaweed and sea grasses — from kelp forests, rocky intertidal habitats, and estuaries and bays. New analyses revealed the particular importance of these local productive habitats for supplying the wrack, while wind, waves, and beach characteristics also play a role. These connections among habitats and ecosystems are an important consideration in effective management of the regional MPA network.

Layering patterns of biodiversity

Different Ecosystem Features are necessarily monitored in different ways, and linking the resulting data sets presents a technical challenge. Researchers explored ways to reveal meaningful patterns across baseline monitoring projects, and identified species richness (the total numbers of species found during surveys) as a common currency. They then tested approaches to mapping this metric across diverse projects and geographies to get a broad view of biological richness patterns across the region.



Distribution of Baseline Program biological sampling sites, aligned to visualize monitoring efforts and cross connections throughout the region. Map from Integrating Spatial Data into Marine Protected Area Monitoring and Management (Williams et al 2015), an integration project of Ocean Science Trust, CDFW, and CSUMB. See page nine for MPA designations.

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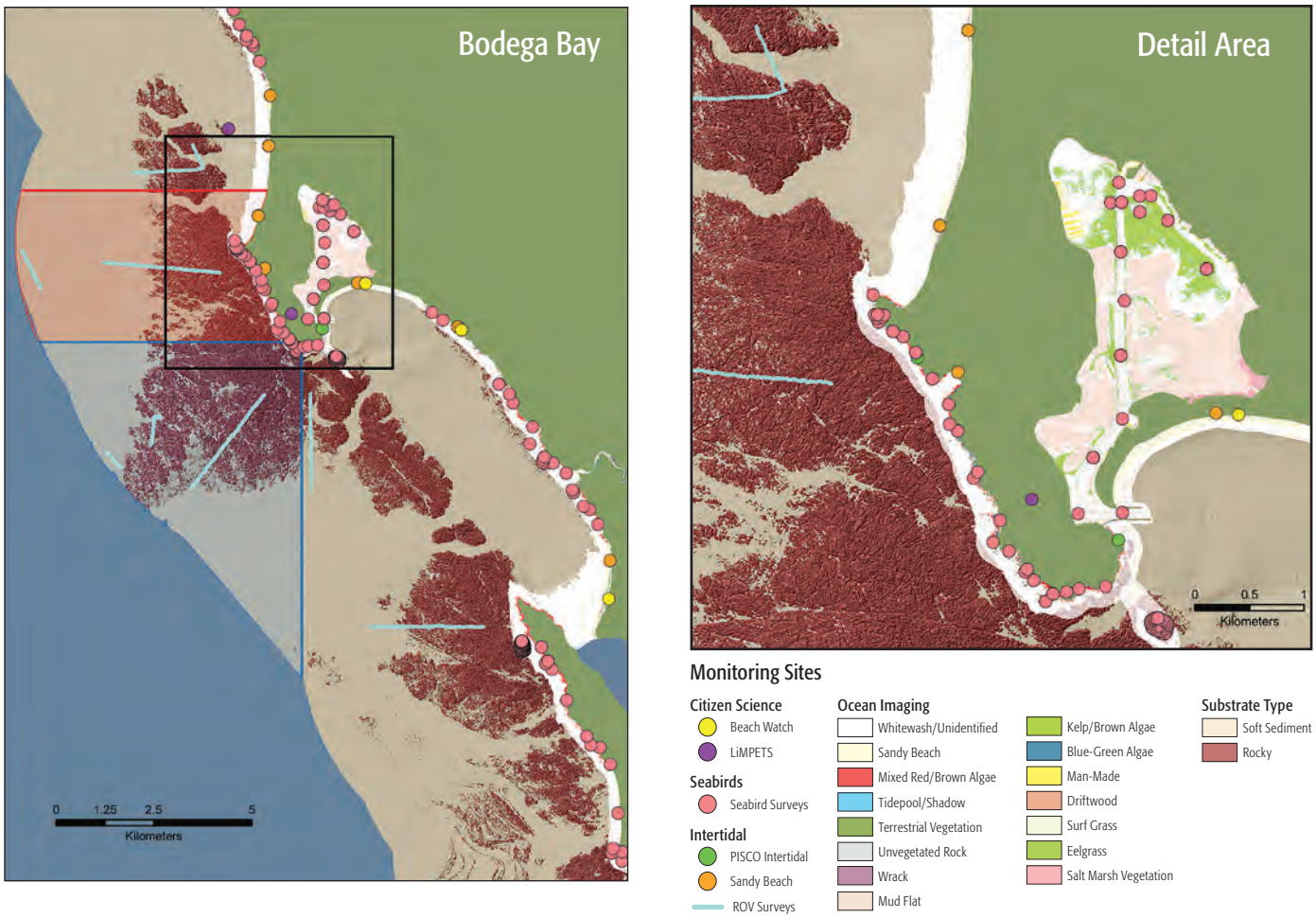

Example of the synthesis of CSCMP seafloor mapping, Baseline Program habitat mapping, and biological monitoring data in Bodega Bay, CA. Figure from Integrating Spatial Data into Marine Protected Area Monitoring and Management (Williams et al 2015).

Taking geographic patterns into account

The geology and structural complexity of the seafloor is an important factor in the distribution of habitats for marine plants, algae, and animals. A team of researchers and managers explored the complementary resources of the seafloor data from the California Seafloor and Coastal Mapping Program (CSCMP) and the biological data from the Baseline Program. They identified Point Arena, Bodega Bay, and Half Moon Bay as locations with strong potential for deepening our understanding of the region by linking these data sets. Linking seafloor habitats with overlying biological data in these locations sets the stage for coordinating future efforts.

Linking ecology and human use of fished populations

Connecting fisheries data (e.g., commercial logbook and landings information, rockfish catches by charter boat anglers) with ecological data about fish populations collected by MPA monitoring projects (e.g., fish abundance) can help us understand the utility of these data for informing fisheries and MPA management. Researchers identified ways that these data can be tied together, identified mismatches, and highlighted ways to align spatial, temporal, and species-level data collection to allow deeper analyses.

Exploring Initial Changes

Baseline monitoring focused on conditions in the North Central Coast at the time of MPA implementation. However, we can also gain valuable insights from programs that have collected data at specific locations for many years. Significant changes in marine life populations are not expected within five years, but some initial changes provide early hints of how ecosystems may change into the future.

Promising signs at Stornetta

Prior to MPA implementation, Stornetta Ranch was a *de facto* reserve until it was opened for coastal access and recreational fishing in 2004. Long-term monitoring data from CDFW and the Multi-Agency Rocky Intertidal Network (MARINe) show that both the total population, as well as the population of red abalone that were of legal size to collect for recreational fishing, declined. The establishment of the Sea Lion Cove SMCA added protection for the marine communities, and 2010 marks the beginning of a dramatic increase in both legal-sized and total number of red abalone, which has continued through 2015. This increase in legal-sized red abalone means there are more large, highly reproductive females, and could lead to documented "MPA spillover effects," in which high abalone populations in a reserve start to populate the areas outside of the reserve.

Rockfish on the rise?

Initial observations from the CDFW deep water ROV surveys in 2015 revealed some notable trends in several species of fish and invertebrates. Throughout both fished and non-fished sites in the region, researchers observed increased abundances of canary, china, and brown rockfishes, as well as lingcod, as compared to surveys in 2009 and 2011. The most striking of these changes was in the number of brown rockfish, increasing from five to several hundred throughout all sites in the region. The drivers of these trends are uncertain, and researchers are conducting further analyses to reveal any site or MPA specific changes.

Unexpected Kelp forest declines

Recent surveys from Reef Check California found surprisingly reduced kelp forests, followed by high sea urchin densities surpassing anything seen in the region over the past ten years of data collection. Researchers are examining the potential role of unusually warm waters in leading to decreased kelp (an important food supply), driving hiding urchins out into the open to search for food. The disappearance of urchin predators due to the sea star wasting syndrome may also play a role, and continued monitoring and assessments will help clarify the causes of these declines.

Fishing opportunities continue

Commercial and recreational fisheries can fluctuate in response to a multitude of factors. Aggregated CDFW commercial fishery data from 1992 through 2013 found that after a dip through the late 2000s, the total landings and ex-vessel revenue, as well as the number of fishermen and landings per fisherman, increased between 2010-2013. Landings and revenue reached levels comparable to those in the 1990s, largely due to increases in the Dungeness crab trap and market squid fisheries.

CDFW records for recreational fisheries (including fishing from private vessels, charter vessels, beaches, and piers) show that the number of fishing trips and fish caught decreased to a low in 2008, increased in 2009, and for charter and private vessels, continued to rebound through 2013.

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The wealth of knowledge about this region from MPA monitoring is useful for a wide range of ocean resource management decisions. From tracking the effects of a changing climate to managing fisheries, MPA monitoring results are being put to work to serve California broadly.

Tracking the Impacts of a Changing Climate

Climate change has profound implications for ocean health, fishing industries, recreation, and other human uses. The MPAs are living laboratories, an important resource for understanding ocean health in the face of a changing climate. What we learn about climate change from MPA monitoring can benefit ocean resource management in other arenas, such as fisheries. It is also important to incorporate an evolving understanding of climate change into MPA management, as we track progress toward MLPA goals. Many state, federal, academic, and other partners, such as the Greater Farallones National Marine Sanctuary (GFNMS), Ocean Science Trust, CDFW, and California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) are working together on this challenge.

Building Coupled Ocean Acidification and MPA Monitoring Programs

The West Coast Ocean Acidification and Hypoxia (OAH) Science Panel explicitly recognizes the region-wide value of the ecological data produced through MPA monitoring. These data create a crucial pathway to inform cross-jurisdictional adaptation and mitigation strategies to ameliorate impacts and enhance ecosystem resilience.

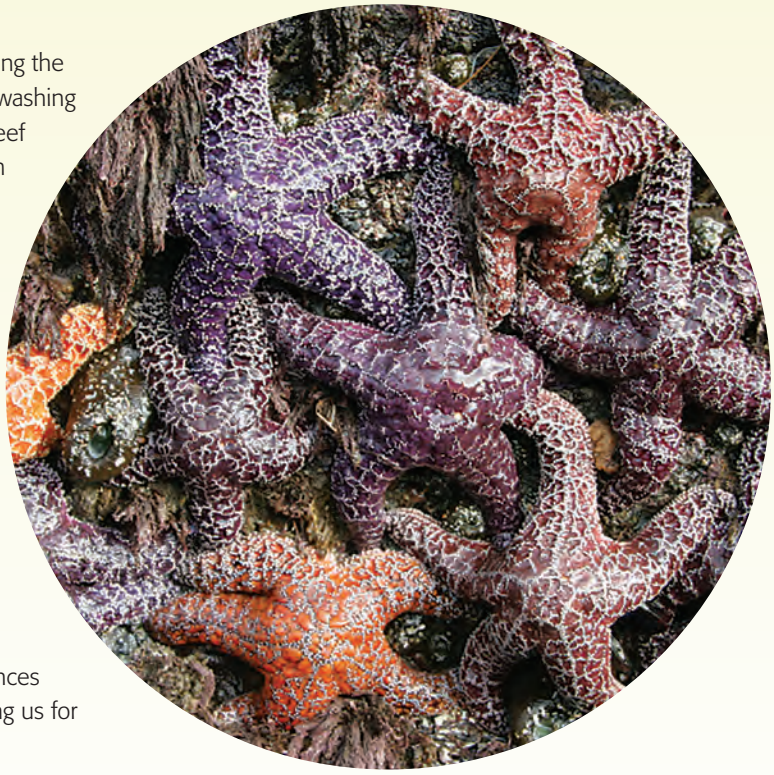
Linking Natural Resource and Water Quality Management

Water quality information provides important context for understanding the drivers of ecosystem condition and for interpreting trends. In the 1970s, the State Water Resources Control Board (SWRCB) established water quality protection areas, called Areas of Special Biological Significance (ASBS), throughout California. Nine of these ASBSs were established in the North Central Coast, and they are monitored and maintained for water quality by the SWRCB. Ocean Science Trust, SWRCB, and UCSC are exploring collaborations to coordinate data collection activities across programs. Leveraging resources, capacity, and expertise across water quality and MPA monitoring programs will increase our understanding of ecosystem condition and trends, and will result in more efficient and cost-effective monitoring programs.

Informing Ocean Management Decisions

Alerting Decision-makers to Unexpected Events

In 2011, a severe invertebrate die-off event occurred along the Sonoma Coast, resulting in thousands of dead abalone washing ashore. Monitoring projects led by CDFW, PISCO, and Reef Check led to nimble management responses by the Fish and Game Commission, and contributed to a thorough accounting of population changes before and after the die-off. The timely data collection, made possible by the already-existing network of collaborating government, academic and citizen science researchers, ensured that we have this event on record to understand the causes and examine future population dynamics.



Starting in 2013, a wasting syndrome caused a mass die-off of sea stars across the West Coast. Long-term monitoring programs, including CDFW, MARINe, PISCO and LiMPETS, gave California an early start on tracking progression of the outbreak. Today, the data allow us to explore the causes and assess the ecological consequences of this die-off on the marine community, better preparing us for capturing and learning from future events.

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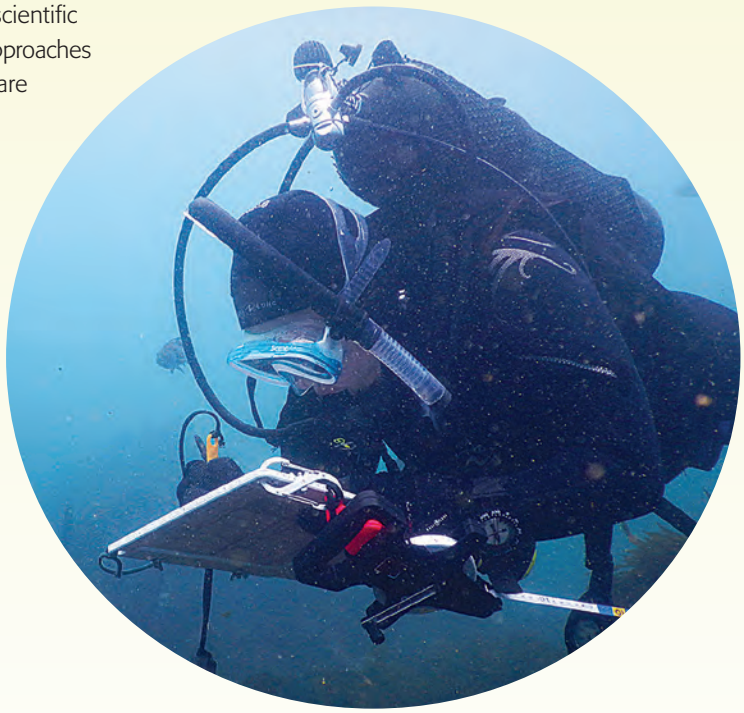
Learning from Baseline Monitoring

Baseline monitoring has provided California with novel scientific findings, strengthened partnerships, and new tools and approaches that have established a strong foundation. Together we are well positioned for the next phase of MPA monitoring in the North Central Coast and statewide.

In addition to what we have learned from the last five years, long-term MPA monitoring will take into account capacity in the region and the priorities of CDFW and other state partners. MPA monitoring results can be integrated across regions to inform statewide MPA network evaluation.

Baseline monitoring focused on indicators and focal species listed in the North Central Coast MPA Monitoring Plan. Scientific results and lessons learned from these projects will help us to hone our approach to the next phase, as we develop coordinated long-term monitoring in the region.



Looking Forward: Planning for Long-Term Monitoring

Testing New Methods and Tools

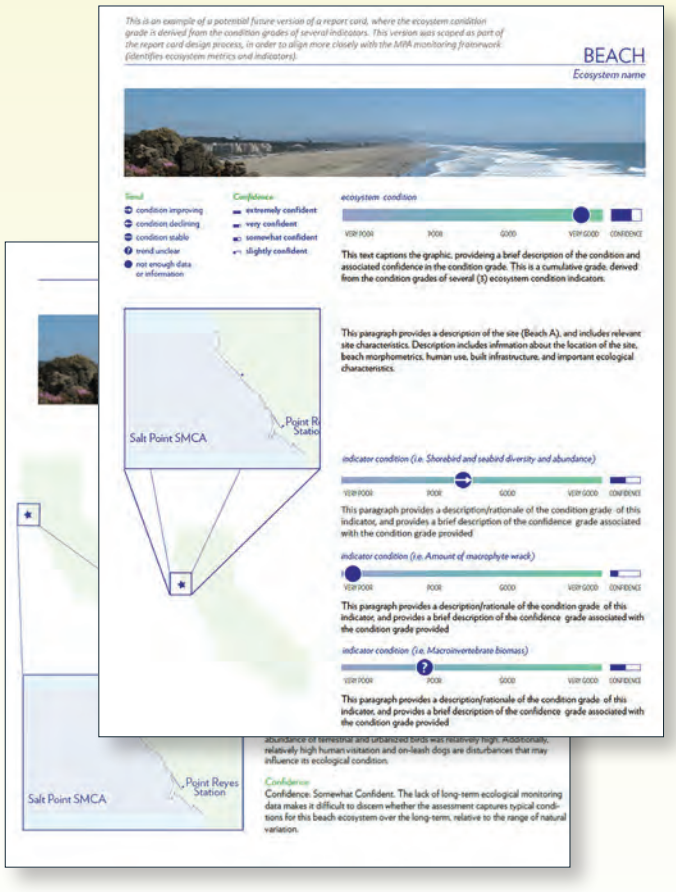
As management and policy needs change within the fluid landscape of technological advances, changing environmental drivers, and rapid ecological responses, new tools can help address future decision-making challenges.

Updating new indices of ocean condition

The Multivariate Ocean Climate Indicator (MOCI) is a climate index developed during the Baseline Program to assess the impacts of climatic variables on ecological changes. Researchers are building on this progress to streamline the metrics, create publicly available quarterly updates, and expand the methods along the California coast.

Piloting a report card for ecosystem health

Ecologists and managers collaborated to develop a process for assessing the condition, or health, of California's marine ecosystems using expert judgment. In a recent case study, experts used baseline monitoring data from the beach and surf zone project, together with data from local and federal agencies, to test the process and pilot a report card for communicating results. Through this work, we have developed an approach that concisely displays the results of monitoring and could be used to communicate results broadly. We will continue to refine this process and tool, together with state partners and experts.



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Filling in the nearshore "White Zone"

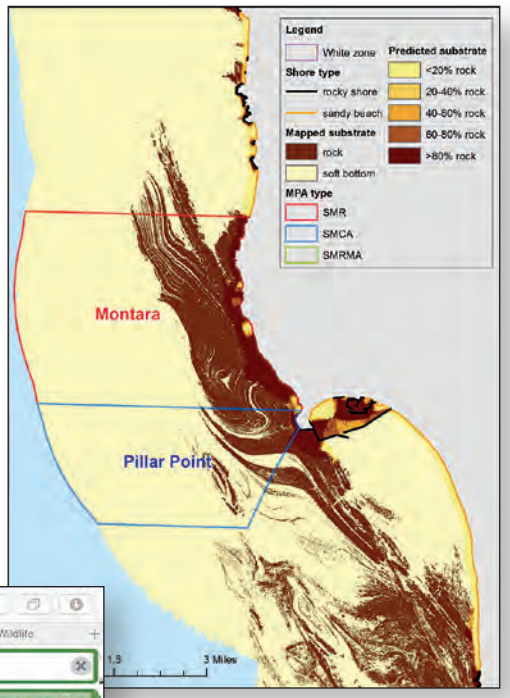
The State's investment in the California Seafloor and Coastal Mapping Program created a wealth of benthic habitat data, yet there remains a key data gap in shallow water (<10m) due to navigational hazards and the challenges of operating in dense kelp forests. This area has been called the "White Zone" due to its common representation on maps as a white space. Researchers and managers developed new methods to leverage the existing data to create predictive maps of seafloor characteristics in the white zone.

These predictive maps support a range of management efforts, such as population modeling, and setting expected rates of population change within MPAs to better evaluate MPA performance. The complete set of maps for the North Central Coast is publicly available through the CDFW web mapping and geographic information system (GIS) data distribution platform, MarineBIOS, and the newly developed methods are now being applied to the white zones across the whole state.

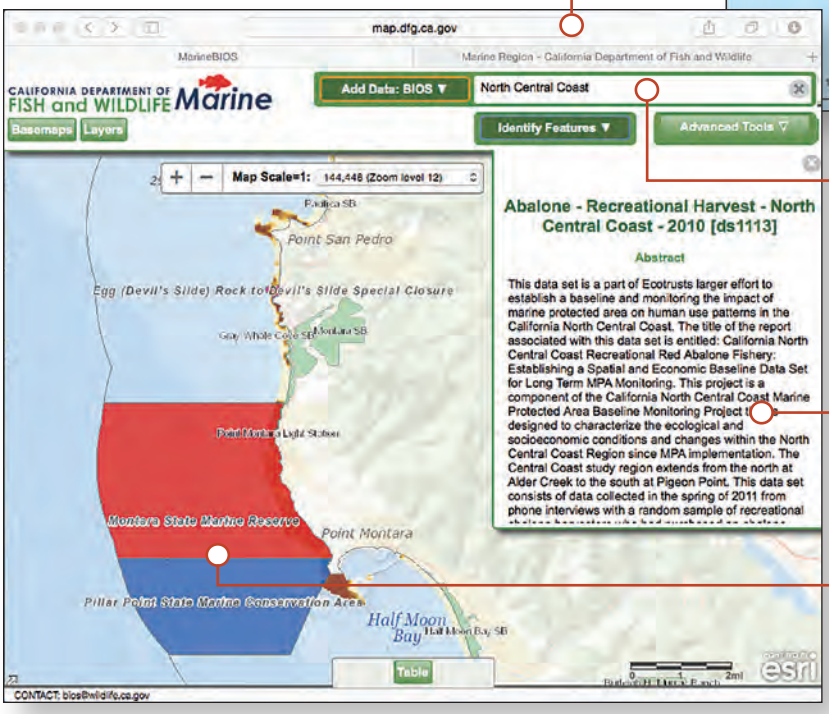
Figure shown at right is from the North Central Coast MPA Baseline Program Integration: Filling in the Nearshore "White Zone" (Saarman et al 2015).

Interactive Mapping

CDFW is working with Ocean Science Trust, PISCO, interns from California State University Monterey Bay (CSUMB), and many others to bring in new data sets as map layers on MarineBIOS. This site will continue to be updated with new layers as they become available, to provide publicly available data and searchable maps of monitoring results, regulatory boundaries, and relevant marine resource planning data. It's a great place for looking up the boundaries and regulations of marine protected areas or investigating the attributes of benthic and intertidal habitat information.



Visit the public, interactive map and data access service at: ***https://map.dfg.ca.gov/marine***



Search for North Central Coast Study Region (NCCSR) monitoring data in the BIOS data catalog, to add layers to your map or download source GIS data.

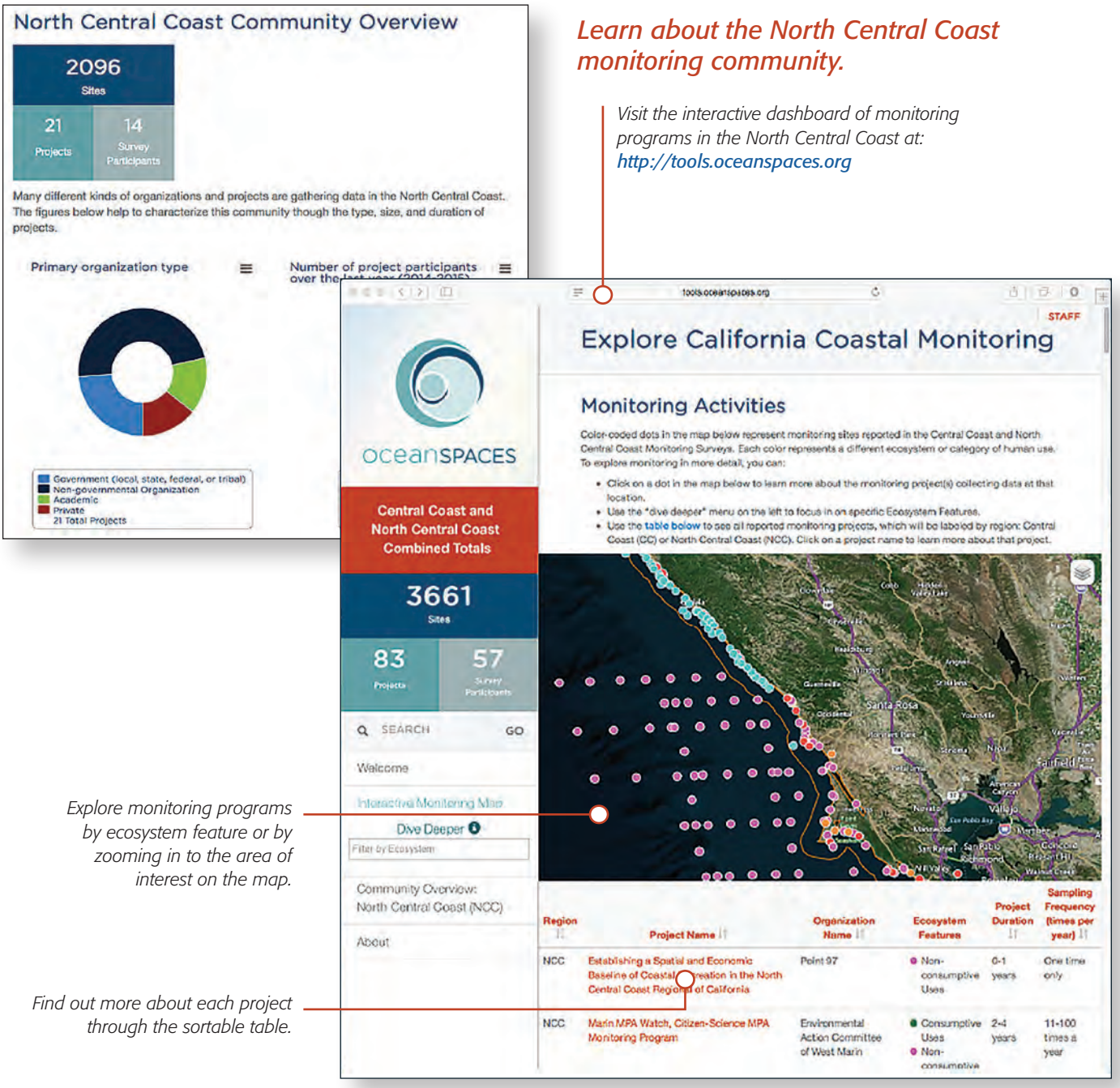
Access metadata (descriptions and attributes) of each data layer, and sources for more information

Use interactive map tools to explore overlaps of habitats, MPA boundaries, and resource management features by adding layers (MPAs and "white zone" layers shown here).

Building Partnerships and Leveraging Existing Capacity

The North Central Coast Monitoring Survey is providing a detailed picture of the current monitoring capacity in the region. The results help identify the geographic and temporal coverage of monitoring activities inside and outside of the region's MPAs, and the compatibility of those activities with the metrics and priorities outlined in the North Central Coast MPA Monitoring Plan. The survey results are publicly available through an interactive Dashboard, an online platform to learn about and connect with the monitoring community.

Results will help Ocean Science Trust, CDFW, OPC, and partners design and implement a partnership-based plan for cost-effective, long-term MPA monitoring.



Learn about the North Central Coast monitoring community.

Visit the interactive dashboard of monitoring programs in the North Central Coast at: ***http://tools.oceanspaces.org***

Explore monitoring programs by ecosystem feature or by zooming in to the area of interest on the map.

Find out more about each project through the sortable table.

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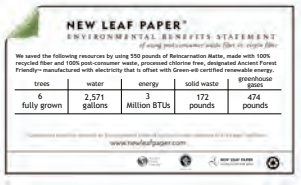
NORTH CENTRAL COAST MPA BASELINE PROGRAM PROJECTS

1. **Baseline Characterization of Sandy Beach and Surf Zone Ecosystems** (Sonoma State University, UCSB, UC Davis)
2. **Baseline Characterization of Birds, Mammals and Human Uses** (Beach Watch)
3. **Baseline Characterization of Rocky Intertidal Ecosystems** (PISCO, UCSC)
4. **Baseline Characterization of Rocky Intertidal and Sandy Beach Systems** (LiMPETS)
5. **Baseline Characterization of Kelp Forest Ecosystems** (PISCO, UCSC)
6. **Baseline Characterization of Kelp Forest Ecosystems** (Reef Check California)
7. **Baseline Characterization of Soft and Rocky Deep Water Ecosystems** (CSUMB, IfAME, MARE)
8. **Baseline Characterization of Nearshore-foraging Seabirds** (USFWS, Point Blue Conservation Science)
9. **Baseline Characterization of Human Uses** (EcoTrust)
10. **Nearshore Habitat Mapping Using Multispectral Aerial Imagery** (Ocean Imaging)
11. **Characterization and Indicators of Oceanographic Conditions** (Farallon Institute)

TABLE OF ACRONYMS

CDFW	California Department of Fish and Wildlife
CeNCOOS	Central and Northern California Ocean Observing System
CSCMP	California Seafloor and Coastal Mapping Program (CSCMP, also known as CSMP)
CSUMB	California State University, Monterey Bay
GFNMS	Greater Farallones National Marine Sanctuary
IfAME	Institute for Applied Marine Ecology
LiMPETS	Long-term Monitoring Program and Experiential Training for Students
MARE	Marine Applied Research and Exploration
MARINe	Multi-Agency Rocky Intertidal Network
MLPA	Marine Life Protection Act
MPA	marine protected area
OAH	ocean acidification and hypoxia
OEHHA	Office of Environmental Health Hazard Assessment
OPC	Ocean Protection Council
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
ROV	remotely operated vehicle
SMCA	State Marine Conservation Area
SMR	State Marine Reserve
SMRMA	State Marine Recreational Management Area
SWRCB	State Water Resources Control Board
UCSB	University of California Santa Barbara
UCSC	University of California, Santa Cruz
USFWS	United States Fish and Wildlife Service



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