MPA MONITORING PLAN

OCTOBER 2014

About this Document

This document was developed to guide monitoring inside and outside of marine protected areas (MPAs) in California's Central Coast region. The Central Coast region, which stretches from Pigeon Point in San Mateo County southward to Point Conception in Santa Barbara County, contains 28 MPAs and one State Marine Recreational Management Area that were established in September 2007.

The monitoring plan has been designed to meet the requirements of the Marine Life Protection Act (MLPA) – to provide timely and useful monitoring results that inform adaptive management of the regional MPA network. It is not a monitoring workplan that specifies locations and methods for monitoring. Rather, it includes guidance on how to set those priorities and design data collection, analysis, and reporting of monitoring projects accordingly.

Monitoring plans are living documents; this plan will be refined and updated over time to reflect advances in scientific understanding and shifts in management priorities through transparent, participatory processes. This updated plan builds upon and updates a Central Coast MPA Monitoring Plan developed by the California Department of Fish and Wildlife (previously named the California Department of Fish and Game), and adopted by the California Fish and Game Commission in 2008. It incorporates results and new knowledge from the first five years of monitoring in this region as well as management priorities articulated during the first five-year management review of the regional MPA network in 2013. This updated plan also applies the MPA monitoring framework, which was adopted by the state in 2010, and it aligns monitoring with approaches in the other MLPA coastal regions.

This plan has been prepared by the California Ocean Science Trust in partnership with the California Department of Fish and Wildlife and with input from many in the Central Coast ocean community. It has been reviewed by the Department of Fish and Wildlife to ensure that it meets management needs, and was adopted by the Fish and Game Commission on October 8, 2014.

Citation: *Central Coast MPA Monitoring Plan*. MPA Monitoring Enterprise, California Ocean Science Trust, Oakland, California, USA. October 2014.

Central Coast

MPA Monitoring Plan

Developed to meet the requirements of California's Marine Life Protection Act

About the MPA Monitoring Enterprise (a program of California Ocean Science Trust)

The Ocean Science Trust is a non-profit organization based in Oakland, California. We believe that science is an important foundation for ocean resource management decisions. We work with scientists, citizens, managers, and policy-makers to build shared understanding and trust in science for healthy, resilient and productive coasts and oceans. The Monitoring Enterprise program leads the design and implementation of scientifically rigorous, cost-effective, and sustainable monitoring of the network of marine protected areas established in California under the Marine Life Protection Act. We engage a broad range of partners to ensure monitoring is based on rigorous science, reflects community interests and priorities, and meets management needs. More information can be found at http://www.oceansciencetrust.org.

About the California Department of Fish and Wildlife

The California Department of Fish and Wildlife is a lead trustee state agency responsible for managing California's diverse fish, wildlife, and plant resources and the habitats upon which they depend for their ecological values and for their use and enjoyment by the public. The MLPA mandates the Department of Fish and Wildlife as the lead agency responsible for the managing California's MPA network. The Department of Fish and Wildlife partnered with the California Ocean Science Trust to develop this Central Coast MPA Monitoring Plan, both in the extensive outreach conducted to inform its development, and in multiple review cycles to ensure that it reflects the best-available science and meets their management needs. More information can be found at http://www.dfg.ca.gov/marine/mpa/.

About the Fish and Game Commission

The California Fish and Game Commission is a state wildlife conservation agency consisting of five Commissioners, each appointed by the Governor and subject to confirmation by the Senate. The Fish and Game Commission is responsible for establishing and setting regulations for protected lands and waters (including MPAs). The California Department of Fish and Wildlife is charged with providing biological data and expertise to inform the Commission's decision making process. The Fish and Game Commission received this monitoring plan from the California Ocean Science Trust and the Department of Fish and Wildlife and adopted it in October 2014 for inclusion in the MLPA Master Plan for MPAs, thus formally establishing it as part of the policy guiding MLPA implementation. More information can be found online at http://www.fgc.ca.gov/.

Acknowledgements

This updated Central Coast MPA Monitoring Plan was prepared by the California Ocean Science Trust and the California Department of Fish and Wildlife with valuable assistance and input from many others. Scientists from throughout California and beyond, resource managers, tribal communities, and members of the Central Coast ocean community contributed significant and valuable time, knowledge, and experience. We are particularly grateful for the time and dedication of the more than 200 Central Coast community members who contributed their knowledge and insight at community gatherings and smaller informal discussions about priorities and interests related to Central Coast MPA monitoring. We are also grateful to those community members who provided input on an earlier draft version of this updated plan. Exceptional facilitation and communications support were provided by Eric Poncelet and Kelsey Rugani of Kearns & West and Kelly Sayce and Rachelle Fisher of Strategic Earth Consulting.

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EXECUTIVE SUMMARY

ROLE OF THIS PLAN

As a result of the Marine Life Protection Act (MLPA), passed by the California Legislature in 1999,[1] California is now home to the largest scientifically based network of marine protected areas (MPAs) in the nation. The Central Coast region is one of four MLPA coastal regions, and it stretches from Pigeon Point in San Mateo County, southward to Point Conception in Santa Barbara County. It contains 28 MPAs and one State Marine Recreational Management Area that were established in September 2007 (Figure 1-1). Baseline monitoring conducted from 2007-2012 established a benchmark of ecological and socioeconomic conditions in the region and provides a foundation for rigorous science-informed decisions moving forward. This Central Coast MPA Monitoring Plan will guide long-term monitoring inside and outside of MPAs in the region.

The MLPA requires monitoring to facilitate adaptive management, and the initial concepts and approaches for planning MPA monitoring were described in the 2008 MLPA Master Plan for MPAs. This Central Coast MPA Monitoring Plan is designed to meet the requirements of the MLPA. It provides guidance to the state, and to all monitoring partners, on a scientifically rigorous, cost-effective, and sustainable approach to MPA monitoring in the Central Coast. The plan is not a monitoring workplan that specifies locations and methods for monitoring. Rather, it includes guidance on how to set priorities and design data collection, analysis, and reporting of monitoring projects accordingly.

This plan is an update to the existing Central Coast MPA Monitoring Plan, which was released in 2008 by the California Department of Fish and Wildlife as part of the MLPA Master Plan for MPAs. It builds on the results of baseline MPA monitoring in the Central and North Central Coast, reflects management priorities articulated during the first five-year management review of the Central Coast MPA network in 2013, and aligns monitoring with approaches in the other MLPA coastal regions. It also applies the statewide MPA monitoring framework, which guides implementation of monitoring in tandem with adaptive management cycles in each MLPA region. Partnerships are core to the approach described within this plan. Efficient monitoring should work with other monitoring programs and build on existing data and knowledge, including that gathered during baseline monitoring. It was adopted by the California Fish and Game Commission on October 8, 2014 for inclusion in the MLPA Master Plan for MPAs, thus formally establishing it as part of the policy guiding MLPA implementation.

This plan was updated by the California Ocean Science Trust in partnership with the California Department of Fish and Wildlife through a transparent, participatory process that included broad input from stakeholders, scientists, tribal governments, fishermen, and other members of the Central Coast ocean community, and review by technical experts and managers. It is a living document, and it will be refined and updated over time to reflect advances in scientific understanding and shifts in management priorities.

SETTING THE SCOPE OF MPA MONITORING

MPA monitoring in California is guided by the MPA monitoring framework, which was adopted by the California Fish and Game Commission to be included as part of the MLPA Master Plan for MPAs. The monitoring framework is applied to the MPA network at a regional scale and used as the foundation for MPA monitoring in all four of California's coastal MPA regions. This provides consistency across the state, while also allowing flexibility for each regional MPA monitoring program to reflect unique physical and biological characteristics, priorities, and institutional capacity.

Two questions lie at the core of the statewide MPA monitoring framework:

1. Assessing ecosystem conditions and trends: How is the system doing?
2. Evaluating MPA design and management decisions: How are MPAs affecting the system?

This plan has been designed to result in clear and understandable reports that inform, in a timely manner, the wide range of decisions about MPA management that are made as part of the adaptive management cycle. As such, MPA monitoring itself is designed as a cyclic activity that is tied to the adaptive management process. It is implemented via a portfolio of partnerships that foster opportunities to advance monitoring to meet MLPA requirements, as well as other state mandates such as the Marine Life Management Act.

ADOPTING AN ECOSYSTEMS APPROACH

This plan adopts an ecosystems approach, in which monitoring goes beyond understanding the effects of MPAs on single species, to more broadly understanding the effects of multiple MPAs on ecosystem structure, function, and integrity. This helps to ensure that monitoring can assess the performance of MPAs relative to the six broad policy goals of the MLPA.

The monitoring framework specifies a set of ten Ecosystem Features that collectively represent and encompass California's marine ecosystems and human uses for the purposes of MPA monitoring. Consistent application of these Ecosystem Features in each regional monitoring plan allows for cross-regional comparisons and helps to ensure that monitoring is consistent with MLPA policy guidance, reflects public priorities, and explicitly incorporates humans within an ecosystems approach. The ten Ecosystem Features are:

- Rocky Intertidal Ecosystems
- Kelp & Shallow Rock Ecosystems (0-30m)
- Mid-depth Rocky Ecosystems (30-100m)
- Estuarine & Wetland Ecosystems
- Soft-bottom Intertidal & Beach Ecosystems
- Soft-bottom Subtidal Ecosystems (0-100m)
- Deep Ecosystems & Canyons (>100m)
- Nearshore Pelagic Ecosystems (i.e., the water column habitat within state waters, in depths >30m)
- Consumptive Uses
- Non-consumptive Uses

The ecosystems-based approach can also provide useful information for other marine resource management issues, such as fisheries management. For example, MPA monitoring of ecosystem components that focus on individual indicator species will generate new detailed data on the life history characteristics of fished species, which may be useful as inputs in population modeling studies by fishery scientists.

Beyond fisheries management, ecosystems-based MPA monitoring data can be used to increase the ability to address other relevant coastal/marine issues along the Central Coast, such as climate change, ocean acidification, and water quality.

ASSESSING ECOSYSTEM CONDITION & TRENDS

The MPA monitoring framework provides the basis for assessing ecosystem condition and trends, both inside and outside of MPAs, by monitoring key metrics for each of the ten Ecosystem Features. Under the monitoring framework, there are two options for monitoring ecosystem condition and trends: Ecosystem Feature Checkups and Ecosystem Feature Assessments.

Ecosystem Feature Checkups are designed to provide a coarse-grained evaluation of ecosystem conditions and trends using a set of "vital signs." Collectively, these vital signs can be used to evaluate Ecosystem Feature condition inside and outside of select MPAs and across the region as a whole. While the primary consideration for selecting vital signs is whether a particular metric provides key information about ecosystem condition, emphasis has also been placed on selecting vital signs that are cost-effective and that do not require technically demanding sampling protocols or equipment-intensive methods.

Ecosystem Feature Assessments are more detailed and technically demanding than Ecosystem Feature Checkups. These scalable assessments build upon and adapt well-tested monitoring methods, and they are designed to be practical to implement and interpret. In an Ecosystem Feature Assessment, condition is assessed by examining a limited set of key attributes, each comprised of a small number of strategically selected focal species or indicators.

The process of selecting monitoring metrics centers on identifying the most important aspects of the structure and function of each Ecosystem Feature, and requires balancing a range of priorities, interests, and perspectives. The metrics identified in this plan were developed from existing monitoring metrics identified in the original Central and North Central Coast MPA Monitoring Plans, which were developed through a robust, inclusive, and scientifically-sound process and stakeholder input. The monitoring metrics also build on the foundation of knowledge generated through the Central Coast MPA Baseline Program, which extended from 2007-2012. They were updated through a public process, during which input was collected from stakeholders and scientists throughout the Central Coast region. The resulting metrics were vetted by managers to ensure that they are feasible to implement, provide valuable insight into ecosystem condition and trends, and can be used to answer priority management questions.

Beyond the ecological monitoring metrics specified in this plan, consideration of contextual information is key to ensuring that analyses and interpretations of ecological MPA monitoring results are robust and scientifically sound. These natural and anthropogenic influences can act at a range of geographic and temporal scales, and they fall under three broad categories:

- Physical and Environmental Influences – including large-scale oceanographic and climate patterns, local and large-scale atmospheric and oceanic conditions, water quality, and soil chemistry.
- Socioeconomic and Human Influences – including economic conditions, fuel costs, historical and current land-use patterns, and compliance with MPA and other regulations.
- Contextual Ecological Information – including primary productivity, zooplankton and/or bacteria abundance, and invertebrate and/or fish recruitment.

Parallel sampling of contextual information and the monitoring metrics identified in this plan can be extremely valuable. Given the wide range of programs that already collect this type of information, partnership agreements with the agencies, groups, and organizations that collect this data will be the primary mechanism by which contextual data are brought to bear on MPA monitoring.

EVALUATING MPA DESIGN & MANAGEMENT DECISIONS

Establishing and managing a regional network of MPAs involves a wide range of decisions, from design decisions such as MPA size and spacing, to day-to-day governance decisions such as those related to managing visitors to MPAs and maintenance of existing infrastructure within MPAs. Thus, developing cost-effective monitoring approaches to evaluate key MPA design and management decisions in the Central Coast region is key to informing adaptive management of the regional MPA network.

Evaluations of management effectiveness are designed to provide insight about how well management actions are contributing towards achieving the MPA network goals. As guided by the monitoring framework, there are two categories of management effectiveness evaluation: short- and long-term. Short-term evaluations are those that are expected to be completed in one turn of the adaptive management cycle, which is currently identified as five years in the MLPA Master Plan for MPAs. Long-term evaluations are expected to take more than one turn of the adaptive management cycle because they are more difficult to address.

This plan includes an initial inventory of short- and long-term management evaluation questions to guide monitoring efforts of MPAs in the Central Coast. The questions reflect the priorities of managers, as well as input from stakeholders shared throughout the development of the monitoring plan. Choosing among candidate questions is a matter of balancing multiple priorities and needs, including management urgency and applicability, technical feasibility, time required, and cost and value of the information produced.

REPORTING MONITORING RESULTS

Sharing the results of monitoring is an important consideration in the design and implementation of all aspects of Central Coast MPA monitoring, and a critical component of adaptive management. Making monitoring results widely accessible and useful helps to build a foundation for science-informed decision making for California's oceans. As such, the process of sharing monitoring results will be a core component of the Central Coast MPA Monitoring Program, and it is informed by a set of guiding principles.

Approaches for sharing monitoring methods should build off of those that were developed as part of the Central Coast MPA Baseline Program, including written reports, events, and online platforms such as OceanSpaces.org. Ocean Science Trust and its partners at the Department of Fish and Wildlife and the Ocean Protection Council are working towards a reporting tool, or report card, that will present credible and useful results that are highly synthesized and clearly linked to monitoring results. Such products must consider issues such as transparency, timing, uncertainty in monitoring results, and framing. Implementing such a tool may require a robust expert judgment process that can be implemented consistently and efficiently across regions, and over multiple cycles of adaptive management.

DEVELOPING MONITORING PARTNERSHIPS

Partnerships are key to developing and implementing a cost-effective, sustainable MPA monitoring program. The Central Coast region is home to an extensive array of ocean and coastal expertise and scientific activity that provides a broad base of potential MPA monitoring partners and collaborators. Partnerships will allow the Central Coast MPA Monitoring Program to leverage resources, avoid duplication of effort, expand the community of people and organizations involved in monitoring, and multiply opportunities for monitoring results to inform processes beyond MPA management. Partnerships may involve work on data collection, data sharing, interpretation or dissemination of results, or integration of monitoring with decision making.

MPA monitoring in the Central Coast and in other regions has included a wide variety of partners in the past, such as universities, citizen science groups, non-governmental organizations, fishermen, tribal governments and communities, and federal and state agencies. Partnerships are an important means of expanding the value of MPA monitoring to a variety of additional management issues such as fisheries management, water quality, or climate change.

BUILDING AN EFFECTIVE MPA MONITORING PROGRAM

This plan is designed to be comprehensive and flexible. It can be implemented in a variety of configurations and still provide useful information to meet the requirements of the MLPA and the needs of MPA managers and decision makers. Building an effective monitoring program will always involve tradeoffs and choices that depend on the resources available, timing constraints, and other factors. Considerations of the intensity of monitoring, temporal flexibility, and geographic flexibility will guide strategic decision-making about monitoring. The monitoring program will also have flexibility in implementation options, including requests for proposals (RFPs), requests for qualifications (RFQs), and partnership agreements.

To ensure that it is as effective as possible, the MPA monitoring program needs to support adaptive management, which means carefully designing a program around the adaptive management cycle. A five-year monitoring cycle (to match the five-year cycle of MPA review recommended in the MLPA Master Plan for MPAs) would allow monitoring data collection and initial analyses to be staged over four years, with a fifth year dedicated to synthesis and sharing of findings.

California has already demonstrated significant support for MPA monitoring through investments in baseline monitoring in all four MLPA regions, starting with the Central Coast in 2007. In these programs, state funds were only part of the much broader investments made by partners and participants in each region. State investments should continue to be treated as an opportunity to seed monitoring activities that build upon and leverage ongoing activities.

At the June 10, 2014 Ocean Protection Council meeting, up to $3 million was authorized to support and seed the next five years of Central Coast MPA monitoring. Disbursement of funding is contingent upon Fish and Game Commission adoption of this plan, together with Ocean Protection Council approval of a workplan that will be developed by Ocean Science Trust, the Department of Fish and Wildlife, and the Ocean Protection Council.

A key step in building the monitoring program is to develop a picture of existing monitoring in the region. The Central Coast Monitoring Survey (open to participation from July 7 – September 26, 2014) examines the geographic and temporal coverage of monitoring activities, along with their compatibility with the indicators and metrics listed in Chapter 4. The survey results will help to identify gaps, overlaps, potential partnerships, and key assets, all of which can inform the workplan for investing potential state funds and leveraging other sources to support Central Coast MPA monitoring.

The results of the Central Coast Monitoring Survey and the guidelines described in this plan will be used to implement the next phase of Central Coast MPA monitoring. The workplan will lay out a funding schedule and structure of funding mechanisms, and it will include plans for reporting the results of monitoring. It will be an important step towards implementing monitoring, collecting data, and building a knowledge base that can serve the state as crucial input for the adaptive management of MPAs and other natural resource management issues. The workplan will lay the groundwork for strategic, thoughtful, and transparent decisions about cost-effective investments that help to meet the goals of the MLPA and facilitate adaptive MPA management.

MONITORING PLAN COLOR GUIDE

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1. Introduction

- Role of this plan
- Scope of this plan
- How this plan was updated

As a result of the Marine Life Protection Act (MLPA), passed by the California legislature in 1999, California is now home to the largest scientifically based network of marine protected areas (MPAs) in the nation.[1] This statewide network of MPAs, which stretches the entire length of the California coast, is implemented and managed in four coastal regions. The Central Coast region, which stretches from Pigeon Point in San Mateo County southward to Point Conception in Santa Barbara County, contains 28 MPAs and one State Marine Recreational Management Area that were established in September 2007 (Figure 1-1). Scientific monitoring is an essential and mandated component of fully implementing the MLPA. This Central Coast MPA Monitoring Plan will guide long-term monitoring, inside and outside of MPAs in the region.

ROLE OF THIS PLAN

This plan has been prepared by the California Ocean Science Trust in partnership with the California Department of Fish and Wildlife and with input from many in the Central Coast ocean community. It provides guidance to the state, and to all future monitoring partners, on a scientifically rigorous, cost-effective, and sustainable approach to MPA monitoring in the Central Coast.

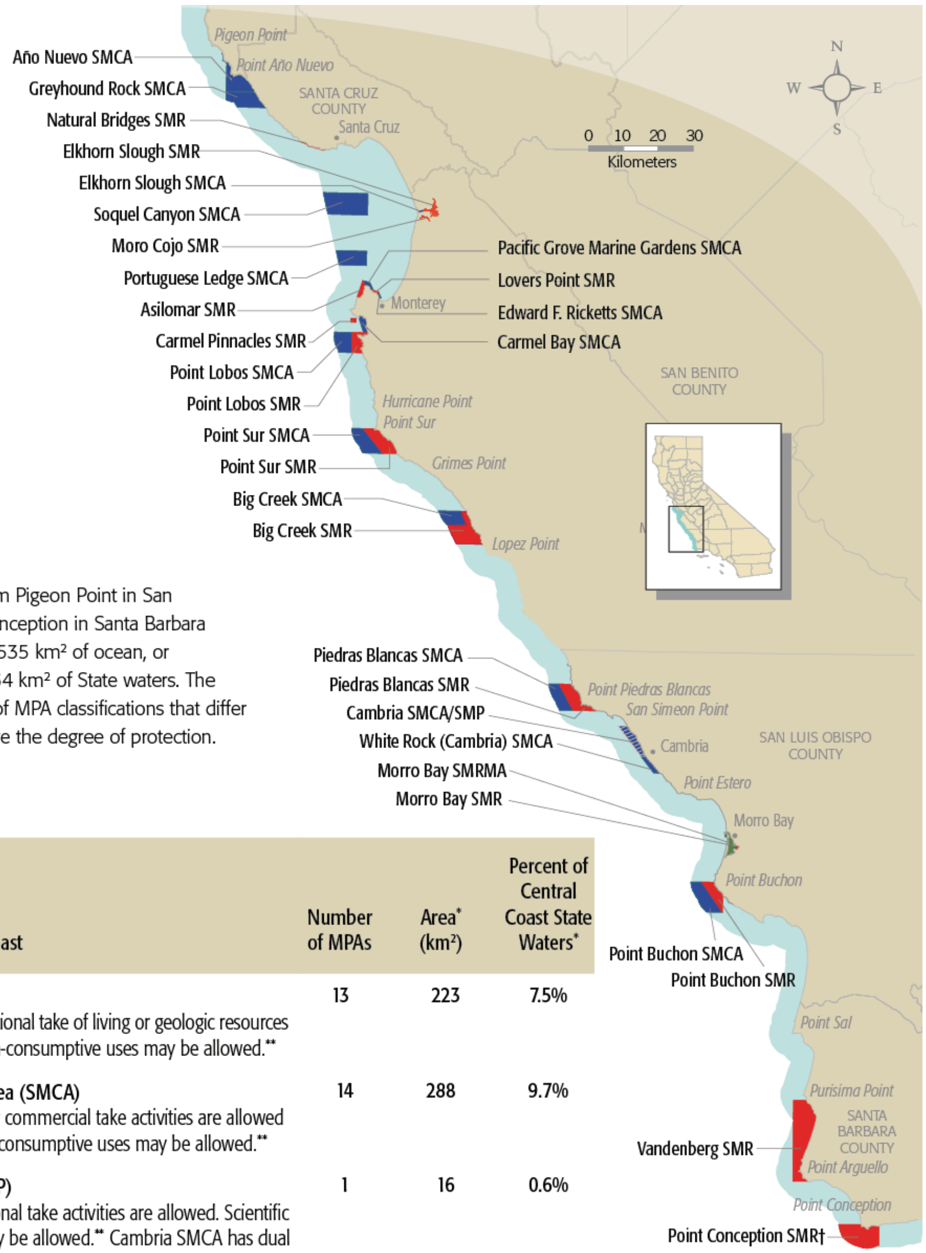
The monitoring plan has been designed to meet the requirements of the MLPA – to provide timely and useful monitoring results that inform adaptive management of the regional MPA network. It builds upon and updates a Central Coast MPA Monitoring Plan developed in 2007 by the Department of Fish and Wildlife and adopted by the California Fish and Game Commission in 2008 for inclusion in the MLPA Master Plan for MPAs. The plan also incorporates results and new knowledge from the first five years of baseline monitoring in this region, as well as management priorities articulated during the first five-year management review of the regional MPA network in 2013.

The plan will be implemented in late 2014 to launch a long-term MPA monitoring program in the region. It contains technical guidance and management priorities that will be considered alongside available resources to build an effective monitoring program. It is not a monitoring workplan that specifies locations and methods for monitoring. Rather, it includes guidance on how to set those priorities and design data collection, analysis, and reporting of monitoring projects accordingly.

Partnerships are key to building an efficient and cost-effective MPA monitoring program, and a partnerships-based approach is core to the approach described within this plan. Efficient monitoring should work with other monitoring programs and build on existing data and knowledge, including that gathered during baseline monitoring.

Through MPA monitoring, California is building a unique body of knowledge that can form the foundation for research and assessment of the state’s coastal and marine ecosystems. While the long-term Central Coast MPA Monitoring Program described in this plan must meet the mandated requirements of the MLPA, it has also been developed to provide useful information for other aspects of California’s ocean resource management. The partnerships and scientific knowledge gained from this program can be of considerable value across many different issues (e.g. climate change, fisheries management), and across many different government (e.g. local, state, and federal agencies) and non-government institutions. Through partnerships and collaborations across mandates and jurisdictions, more comprehensive monitoring can provide a greater return on investments in the statewide MPA network.

[1] For more information about California’s Marine Protected Areas, see also http://www.dfg.ca.gov/marine/mpa/.



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 km² of ocean, or approximately 18 percent of the 2,964 km² 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* (km²)	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.

Figure 1-1. *Map of MPAs within the Central Coast regional MPA network, with red, blue, and green indicating the different MPA classifications within the region. More information about Central Coast MPAs is available at: http://www.dfg.ca.gov/marine/mpa/ccmpas_list.asp.*

Monitoring plans are living documents; this plan is an update to the existing Central Coast monitoring plan,[2] and it may be refined and updated over time to reflect advances in scientific understanding and shifts in management priorities through transparent, participatory processes. This updated plan also applies the MPA monitoring framework, which was adopted by the state, and it aligns monitoring with approaches in the other MLPA coastal regions.

SCOPE OF THIS PLAN

MPA monitoring as defined in this plan is not limited to traditional research and data collection. It also includes evaluation and reporting of monitoring results, analysis of potential changes to monitoring, and implementation of any changes deemed to be necessary. This more inclusive and adaptive approach to monitoring ensures that the most current and relevant metrics are evaluated, and that the results of this monitoring are used to inform both future monitoring projects and management decisions. Synthesizing monitoring results and communicating about them with the public and with managers are also crucial components of MPA monitoring.

APPLYING THE MPA MONITORING FRAMEWORK

The MPA monitoring framework (Figure 2-2) guides implementation of monitoring in tandem with adaptive management cycles (Figure 2-1).[3] Implementing monitoring within the framework ensures that the results are relevant to scientists and managers, and that we maintain a balance among the wide array of activities included in monitoring. It also ensures statewide consistency of approach in the face of varying ecology, local priorities, and capacity and resources across MLPA regions. Each element of the framework is described and applied to the Central Coast region in Chapters 2-5 of this plan.

GUIDING THE CENTRAL COAST MPA MONITORING PROGRAM

We will use this plan to guide implementation of Central Coast MPA monitoring. While the plan does not specify particular activities, or an exact formula for monitoring at any given time, it does put forward a framework, guiding principles, and mechanisms for implementing monitoring. The Central Coast MPA Monitoring Program will be designed to assess the condition of, and trends in, regional MPAs by monitoring a selection of the metrics identified in Chapter 4. It will also be designed to evaluate a selection of the short- and long-term management evaluation questions identified in Chapter 5. The Program will make use of partnerships in accordance with guidelines in Chapter 7, and allocate funds based on considerations discussed in Chapter 8. And, as outlined in Chapter 6, the results of the Program will be shared widely and transparently, in ways that provide useful and timely information to decision makers and other stakeholders.

BUILDING ON THE BASELINE PROGRAM

The Central Coast MPA Baseline Program was launched in 2007, the same year that the regional MPA network took effect. Baseline monitoring under the MLPA 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

[2] California Marine Life Protection Act Master Plan for Marine Protected Areas, Jan. 2008, Appendix O, p. 51 – 85. http://www.dfg.ca.gov/marine/mpa/masterplan.asp. See also Fish and Game Code section 2853(c)(3).

[3] According to Fish & Game Code section 2852, “Adaptive Management, with regards to MPAs, means a management policy that seeks to improve management of biological resources, particularly in areas of scientific uncertainty, by viewing program actions as tools for learning. Actions shall be designed so that, even if they fail, they will provide useful information for future actions, and monitoring and evaluation shall be emphasized so that the interaction of different elements within marine systems may be better understood.” Additional discussion of how this plan supports adaptive management can be found in Chapter 2.

data to rigorously document and understand ocean ecosystem conditions in the initial years following MPA implementation.

In the Central Coast, researchers from academic institutions and government agencies, and fishermen involved in collaborative fisheries projects, collected data about kelp forests, nearshore fish populations, rocky intertidal habitats, deep-water habitats, and human uses. Collectively, these data provide a benchmark of ecological and socioeconomic conditions from 2007-2008, and examination of initial changes occurring from 2007-2012.

Results from these initial steps of monitoring in the Central Coast were analyzed and incorporated into the summary report '*State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012*,' which was publicly released in February 2013.[4] The Department of Fish and Wildlife used these results to inform the five-year management review of the Central Coast regional MPA network, and developed adaptive management recommendations that were presented to the Fish and Game Commission in November 2013.[5] Data, results, and reports from the Central Coast MPA Baseline Program are available online at OceanSpaces.org.

As part of the adaptive monitoring process, results from the Central Coast MPA Baseline Program were then used to assist in the selection of monitoring metrics presented in Chapter 4 of this plan. These metrics will guide the development of the next phase of MPA monitoring, timed to be in sync with the adaptive management cycle (see Chapter 2).

HOW THIS PLAN WAS UPDATED

The Central Coast MPA Monitoring Plan, which was first incorporated as an appendix to the MLPA Master Plan for MPAs in 2008, was an important foundation for this updated plan. In updating the Central Coast MPA Monitoring Plan, we had three important goals:

1. Apply the monitoring framework to the specific ecology and geography of the Central Coast.
2. Hear from Central Coast community members about opportunities for partnerships, and the local and regional priorities that define this part of California.
3. Update the scientific basis for Central Coast monitoring by incorporating new knowledge of the region from the Baseline Program and other sources.

In close collaboration with the Department of Fish and Wildlife, we have addressed these goals through a process that included broad input from stakeholders, scientists, tribal governments, fishermen, and other members of the Central Coast ocean community, and review by technical experts and managers (Table 1-1). We drew on existing knowledge from Central Coast baseline monitoring, the Central Coast MPA designation process, experience in developing monitoring plans and baseline monitoring in other MPA regions, and experience that the state has in implementing MPAs since 2007.

To account for advances in scientific understanding and shifts in management priorities since the original Central Coast MPA Monitoring Plan was released in 2008, the first step in updating this plan was to incorporate recently-available resources into a set of draft updated monitoring metrics for the region. These draft metrics incorporated the results from the Central Coast MPA Baseline Program and metrics identified in the original Central Coast MPA Monitoring Plan. Metrics identified in the more recently developed North Central Coast MPA Monitoring Plan were also included in the draft metrics for the Central Coast because of similarities in the geology, oceanographic forcing, and ecology between the two regions.

[4] The Central Coast MPA Baseline Program summary report, *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012*, is available at: http://oceanspaces.org/sites/default/files/regions/files/cc_results_report_0.pdf.
[5] The adaptive management recommendations from the Department of Fish and Wildlife are detailed in their memo to the Fish and Game Commission, available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=80499&inline=1.

Table 1-1. *Major steps in the development of the updated Central Coast MPA Monitoring Plan.*

Timing	Monitoring Plan Development Step
August – October 2013	Initial process design and collection of background materials
November – December 2013	Planning process for small and large group meetings with regional stakeholders, tribal governments and scientists
December 2013	Develop draft metrics that incorporate results from the Central Coast MPA Baseline Program, the existing Central Coast MPA Monitoring Plan (released in 2008), and the North Central Coast MPA Monitoring Plan
January 2014	Small group meetings and community gatherings with regional community members to identify stakeholder priorities; meetings with tribal government representatives to share monitoring priorities; consultations with scientists to identify key monitoring metrics
January – March 2014	Refinement of proposed monitoring metrics and management priorities to reflect stakeholder, tribal government and scientist input
February – March 2014	Development of draft updated monitoring plan in partnership with the Department of Fish and Wildlife, to align with management and policy priorities
March – April 2014	Vetting of technical components of draft monitoring plan by scientists, including some members of the Ocean Protection Council Science Advisory Team (OPC SAT)
May 14 – June 4, 2014	Public input period for draft updated monitoring plan
June – July 2014	Revision of monitoring plan in consideration of input received
October 8, 2014	Revised monitoring plan adopted by California Fish and Game Commission as an appendix to the MLPA Master Plan for MPAs

As a first step in understanding community perspectives on and priorities for MPA monitoring in the Central Coast, in January 2014, the Ocean Science Trust and the Department of Fish and Wildlife convened a series of community gatherings and small group meetings with Central Coast community members. This included meeting with Central Coast tribes to learn how local tribes would like to be informed by and involved in monitoring, and to explore how monitoring can consider a breadth of knowledge to better inform management decisions. These conversations with tribal governments, fishermen, citizen science groups, and academic research scientists led to specific recommendations for monitoring metrics and management evaluation questions, general concerns and suggestions about MPA monitoring, and suggestions of potential partners and sources of MPA monitoring data.[6] The three community gatherings, which were open to the public and followed the same agenda and format, were held in Morro Bay, Pacific Grove, and Santa Cruz, CA, attracting a combined attendance of more than 200 community members. The input shared by members of the Central Coast ocean community, including tribes, was used to update the draft monitoring metrics and draft management evaluation questions, and helped to shape guidance and recommendations throughout the plan.

In February and March 2014, a first draft of the Central Coast MPA Monitoring Plan was reviewed for technical merit and alignment with management needs and mandates by the California Department of Fish and Wildlife. To ensure that the final set of monitoring metrics appropriately reflect the best available science, we consulted with leading scientists on each of the Ecosystem Features to evaluate and refine draft monitoring metrics, including some members of the Ocean

[6] A summary of key themes expressed during the community gatherings and small group meetings is available at: http://oceanspaces.org/sites/default/files/regions/files/cc_communitygatherings_keythemes_final.pdf.

Protection Council's Science Advisory Team. The Ocean Science Trust carefully considered all comments received in revising this draft updated plan.

Ocean Science Trust, in partnership with the Department of Fish and Wildlife, released the draft Central Coast MPA Monitoring Plan for public input from May 14, 2014 through June 4, 2014. During the public input period, electronic copies of the draft monitoring plan were distributed via a wide array of Central Coast channels, including email announcements to a broad list of over 600 Central Coast and other community members, postings on OceanSpaces.org, listings on online community calendars, e-newsletter postings facilitated by organizations and groups throughout the region, and messages to all regional libraries. Hard copies of the draft monitoring plan were made available at a number of regional locations, including local harbor offices and Department of Fish and Wildlife field offices in Monterey, San Luis Obispo, and Santa Barbara. Researchers, fishermen, citizen scientists, non-governmental organizations, native communities, and staff from federal and state agencies submitted input, which ranged from specific suggestions for monitoring metrics and focal species, to more general comments and questions regarding planning and implementation of MPA monitoring.[7] In June and July 2014, the draft plan was revised in consideration of this wide range of insightful and constructive input.

It was adopted by the California Fish and Game Commission on October 8, 2014 for inclusion in the MLPA Master Plan for MPAs, thus formally establishing it as part of the policy guiding MLPA implementation.

[7] A summary of key themes expressed by those who provided input on the draft Central Coast MPA Monitoring Plan is available at: http://oceanspaces.org/sites/default/files/regions/files/cc-publicinput-keythemes-final.pdf.

2. Setting the Scope of MPA Monitoring

- MPA monitoring in an adaptive management context
- Reflecting policy guidance in the monitoring framework
- Introduction to the monitoring framework

The MPA monitoring framework, which was adopted by the California Fish and Game Commission to be included as part of the MLPA Master Plan for MPAs, guides monitoring and informs MPA management in each MLPA region. Consistent application of the framework to each MLPA region enables consistency in monitoring across the state while also allowing flexibility for each regional MPA monitoring program to reflect unique physical and biological characteristics, priorities, and institutional capacity. In this chapter, we describe the key elements of the monitoring framework, demonstrating how these collectively ensure that monitoring provides the information needed to inform management decisions and meets MLPA requirements.

MPA MONITORING IN AN ADAPTIVE MANAGEMENT CONTEXT

The monitoring framework is explicitly designed to guide monitoring in an adaptive management context – that is, the framework provides a structured mechanism to ensure that monitoring results are useful for making adaptive management decisions, and available at the right time to inform such decisions.

This is achieved partly by re-framing monitoring as a cyclical activity that is tied to the adaptive management of the MPAs themselves (Figure 2-1). As management actions are taken, so too should monitoring decisions be revisited and the monitoring plan updated to reflect changing management needs and make best use of available resources. Thus, while

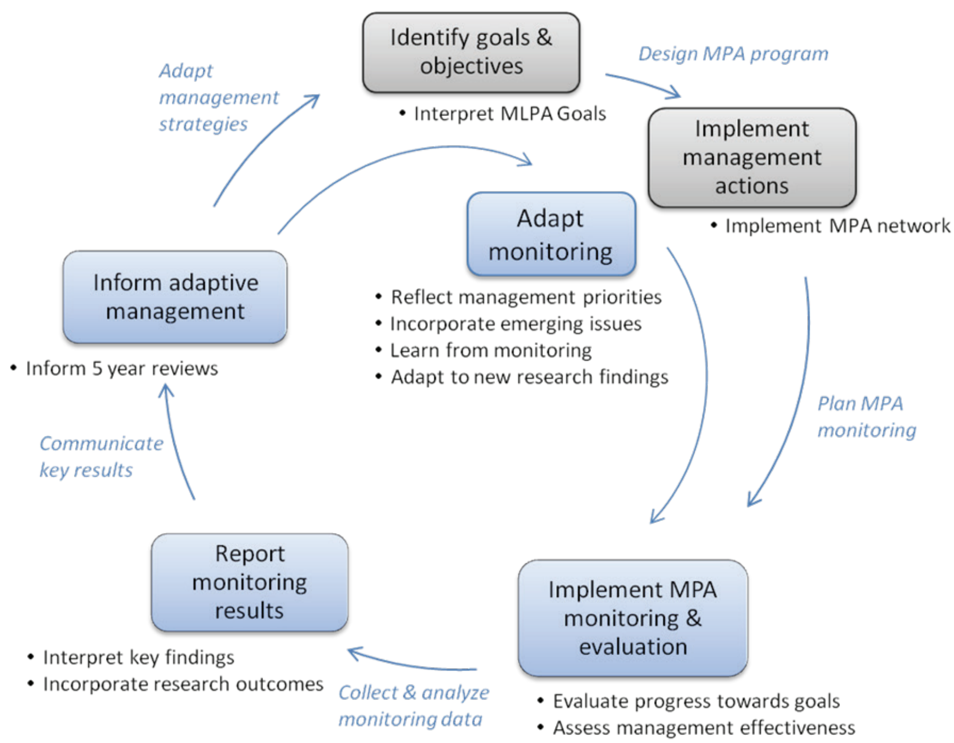


Figure 2-1. *An illustration of the adaptive management process, annotated to show application to the MLPA context. Monitoring must be designed to evaluate management actions in order to inform management review and adaptation. In addition, monitoring itself must be adapted periodically to remain relevant and useful.*

some monitoring data should be collected consistently over many years to build a robust time series, other monitoring questions may be quickly answered and should be updated to ensure continued management relevance. Monitoring should also evolve over time to take advantage of scientific advances, new or improved monitoring methods and approaches, and other opportunities to increase monitoring accuracy and effectiveness to inform the functionality of the regional network.

Components of the monitoring framework have been designed to guide the updating of regional monitoring programs. In addition, this monitoring plan is a living document, subject to periodic revision so that monitoring itself can be managed adaptively. The cyclic management reviews of Central Coast MPAs, as recommended in the MLPA Master Plan for MPAs, provide excellent opportunities to evaluate and refine monitoring, and to update this plan as needed.

Adaptive management and adaptive monitoring are both reflected in this updated Central Coast MPA Monitoring Plan. We have taken into account the advances in understanding gained through the Central Coast MPA Baseline Program, the North Central Coast MPA Baseline Program, and the first 5-year review of the Central Coast MPAs to refine the application of the monitoring framework to reflect shifts in management priority, increased scientific knowledge, and key and unique aspects of the Central Coast region.

REFLECTING POLICY GUIDANCE IN THE MONITORING FRAMEWORK

The MLPA requires "… monitoring, research, and evaluation at selected sites to facilitate adaptive management of MPAs and ensure that the [MPA] system meets the goals stated in this chapter."[8] Thus, the monitoring framework adopts an ecosystems approach to ensure that monitoring can assess performance of the MPAs towards these goals.

In addition, monitoring is guided by the MLPA Master Plan, which states that MPA monitoring and evaluation should be:

- Useful to managers and stakeholders for improving MPA management
- Practical in use and cost
- Balanced to seek and include scientific input and public participation
- Flexible for use at different sites and in varying conditions
- Holistic through a focus on both natural and human perspectives

This guidance is reflected in the scope of monitoring - including both ecological and socioeconomic metrics and questions – but also in the flexibility of the framework. The framework consists of multiple components, or modules, each of which can be tailored to make best use of available resources and capacity while reflecting both management and community priorities for monitoring. The framework also includes implementation options, presenting

GOALS OF THE MARINE LIFE PROTECTION ACT

1. Protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.
2. Help sustain, conserve and protect marine life populations, including those of economic value, and rebuild those that are depleted.
3. 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. Protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic values.
5. Ensure California's MPAs have clearly defined objectives, effective management measures and adequate enforcement and are based on sound scientific guidelines.
6. Ensure the State's MPAs are designed and managed, to the extent possible, as a network.

[8] California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3).

approaches by which local, traditional, citizen and academic expertise and capacity can be effectively included within regional monitoring programs.

The MLPA Master Plan also states, “To achieve the purpose of informing adaptive management, the results of monitoring and evaluation must be communicated to decision makers and the public in terms that they can understand and act upon,” and that “a comprehensive analysis of monitoring results should be conducted approximately every five years.” As detailed in Chapter 6, this monitoring plan has been designed to result in clear and understandable reports that inform management reviews as part of each turn of the adaptive management cycle.

The framework was designed not only to enable monitoring to meet the requirements and guidance of the MLPA, but also to provide useful information for other aspects of ocean resource management in California. It has been designed to be implemented via a portfolio of partnerships (see Chapter 7), that will foster opportunities to advance monitoring under several state mandates. For example, the State Water Resources Control Board has the authority to designate water quality protection areas that overlap with MPAs in the Central Coast, in both geography and intent. Thus, the monitoring framework has been designed with components that can be jointly implemented with information exchange and resource sharing between programs.

Similarly, particular consideration has been given to the relationship between the MLPA and the Marine Life Management Act (MLMA).[9] The MLMA mandated several significant changes in the way that California’s marine fisheries are managed and regulated. MPAs are recognized as playing an important role in contributing to achieving the goals of the MLMA.

INTRODUCTION TO THE MONITORING FRAMEWORK

CORE ELEMENTS OF THE FRAMEWORK

ECOSYSTEM FEATURES

Reflecting the policy guidance above while allowing for regional flexibility in monitoring programs, the top level of the monitoring framework consists of ten Ecosystem Features. These features collectively represent and encompass California’s marine ecosystems and human uses for the purposes of monitoring. Described in detail in Chapter 3, these Ecosystem Features were developed through extensive discussions within the science advisory teams and regional stakeholder groups in the South Coast, the North Central Coast, and the Central Coast MPA regions. The list of Ecosystem Features is the same in all four MPA regions, except when an Ecosystem Feature is not present within an MPA region.[10] Although we recognize the many connections between Ecosystem Features, separately identifying them builds flexibility into the monitoring framework. Ecosystem Features can be selected for inclusion in a regional monitoring program based on management needs, community priorities and capacity, and available resources.

Two questions lie at the core of MPA monitoring and can be applied to each of the ten Ecosystem Features:

1. What is the condition of the Ecosystem Feature, and how is it changing through time?
2. How are the MPAs affecting the condition of the Ecosystem Feature?

[9] California Fish and Game Code, Section 7050.

[10] While there is not yet a monitoring plan in place for the North Coast, an initial draft list of monitoring metrics within each of the ten Ecosystem Features was developed as part of the extensive planning process leading up to implementation of the North Coast MPA Baseline Program. See Appendix 1 of the North Coast MPA Baseline Monitoring Request for Proposals: http://www-csgc.ucsd.edu/FUNDING/PROP_PDFs/NCMPA/NorthCoastBaselineProgramRFP-Appendix1.pdf.

Figure 2-2 provides a conceptual overview of the monitoring framework anchored by these two questions and demonstrates the close link between monitoring and adaptive management of MPAs.

ASSESSING ECOSYSTEM CONDITION & TRENDS: HOW IS THE SYSTEM DOING?

To address the first question at the core of MPA monitoring, as in the North Central Coast and South Coast MPA Monitoring Plans, this plan recommends a set of monitoring metrics for each of the ten Ecosystem Features (Chapter 4). These metrics were developed through extensive consultation with leading scientists, input from stakeholders, results from Central Coast and North Central Coast baseline monitoring, and the metrics identified in the North Central Coast MPA Monitoring Plan and in the 2008 Central Coast MPA monitoring plan. The metrics are designed to allow the assessment of ecosystem condition and trends by two implementation options:

ECOSYSTEM FEATURE CHECKUP

Ecosystem Feature Checkups are designed to provide a coarse-grained evaluation of ecosystem condition and trends, using monitoring methods that require less technical expertise than the metrics identified in Ecosystem Feature Assessments. Checkups are conducted by monitoring "Vital Signs" within an Ecosystem Feature. For example, in Estuarine and Wetland Ecosystem Features, eelgrass areal extent—a relatively straightforward, low-cost, and standardized measure—is listed as a Vital Sign for conducting an Ecosystem Feature Checkup (see Chapter 4).

ECOSYSTEM FEATURE ASSESSMENT

Ecosystem Feature Assessments are more detailed and technically demanding than Checkups. They build upon and adapt well-tested monitoring methods and are designed for implementation by traditional research scientists from government agencies and research institutions. Condition and trends of each Ecosystem Feature are assessed by identifying a limited set of *key attributes* of the feature and evaluating the condition of these key attributes using a set of 3-5 strategically selected *focal species or indicators*. Collectively monitoring multiple key attributes gives a detailed assessment of how an ecosystem is doing. Assessments may, in some cases, provide a foundation for Checkups at later stages. For example, in Estuarine and Wetland Ecosystem Features, conducting an Ecosystem Feature Assessment (see Chapter 4) involves measuring both eelgrass areal extent *and* density.

EVALUATING MPA DESIGN AND MANAGEMENT DECISIONS: HOW ARE MPAS AFFECTING THE SYSTEM?

To address the second question at the core of MPA monitoring, this plan recommends monitoring that can be used to evaluate MPA design and management decisions, and thus assess the impacts that MPA implementation has on the system at a range of timescales. Answers to these questions may help managers to make adjustments to MPA management, or to MPAs themselves. We must therefore design evaluations to support adaptive management with timely and useful results. More information about the development of questions to evaluate MPA design and management decisions, and candidate short and long-term evaluation questions for the Central Coast region, are provided in Chapter 5.

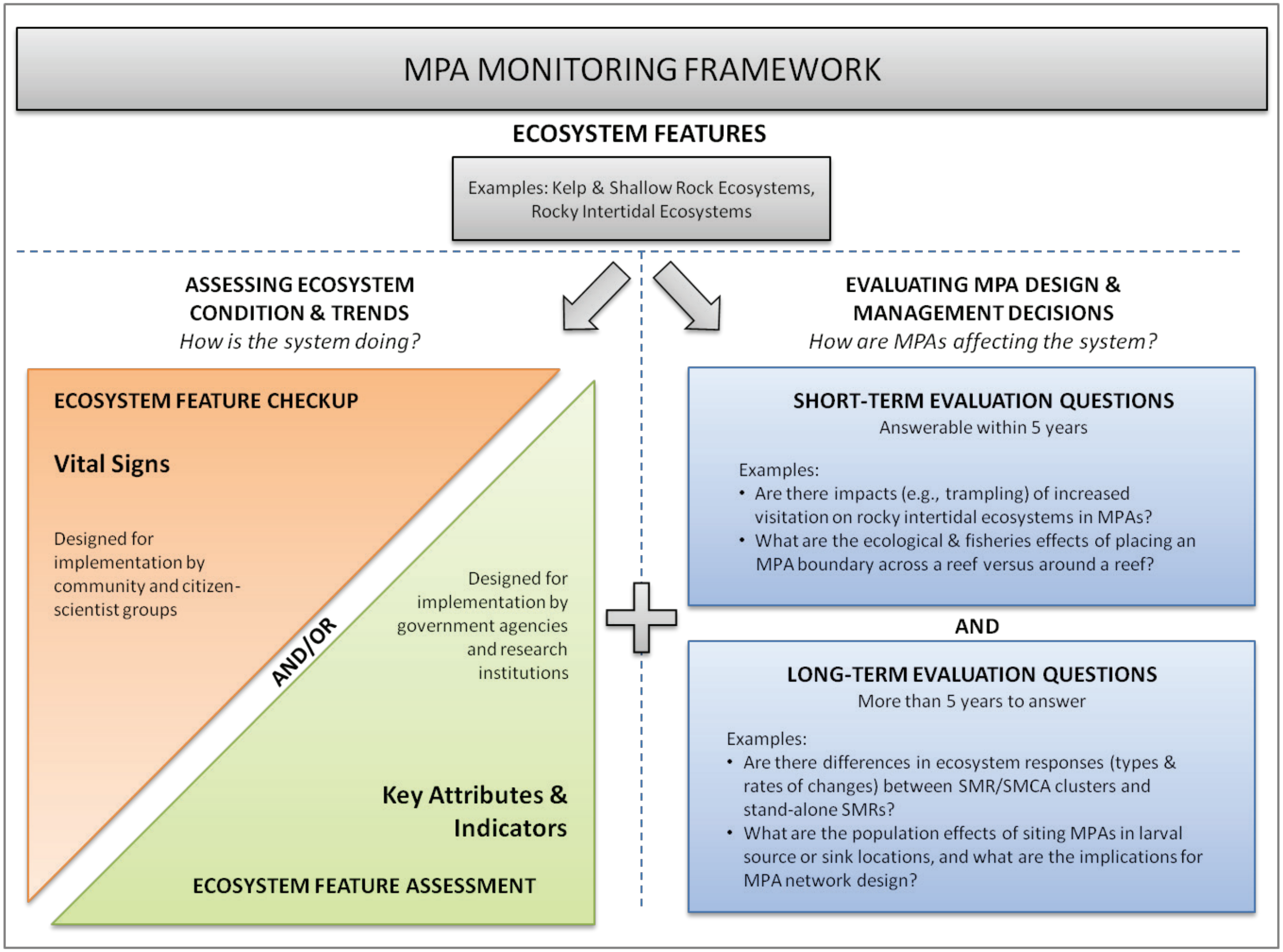


Figure 2-2. *Schematic diagram of the MPA Monitoring Framework showing the two principal monitoring elements: 1) Assessing Ecosystem Condition & Trends; and 2) Evaluating MPA Design and Management Decisions. Ecosystem condition and trends may be monitored using Ecosystem Feature Checkups, which employ monitoring metrics called vital signs, or through Ecosystem Feature Assessments, which employ key attributes and indicators or focal species as monitoring metrics. MPA design and management decisions are evaluated through answering targeted questions, including both short-term questions, expected to be answered within four years (one monitoring and reporting cycle), and long-term questions, expected to take longer than four years to answer. Monitoring is focused using ten Ecosystem Features, which collectively represent and encompass the Central Coast region's ecosystems, including humans, and is designed to deliver useful results in advance of the five-year MPA reviews recommended by the MLPA Master Plan for MPAs.*

SHORT-TERM EVALUATION QUESTIONS

Short-term management evaluation questions can be answered within one MPA monitoring and adaptive management cycle (currently every five years). These management evaluations may vary from region-to-region, but all are intended to provide information about shorter-term impacts of MPA implementation on an Ecosystem Feature. For example, one short-term management evaluation question included in this plan is: Do focal and/or protected species inside of MPAs stay the same or increase in size, numbers, and biomass relative to areas of similar habitat adjacent to and distant from MPAs? Do species richness and/or diversity stay the same or increase in MPAs relative to areas of similar habitat adjacent to and distant from MPAs?

LONG-TERM EVALUATION QUESTIONS

Long-term management evaluation questions can require multiple MPA monitoring and adaptive management cycles to answer. These questions provide insight about longer-term impacts of MPA implementation on an Ecosystem Feature. For example, one long-term management evaluation question included in this plan is: Are there different ecosystem responses (e.g., types and rates of changes) between MPAs that are and are not co-located with Areas of Special Biological Significance (ASBSs)? What, specifically, is the role of water quality protections offered by the ASBSs in the protections offered by MPAs?

APPLYING THE FRAMEWORK TO THE CENTRAL COAST

The MPA monitoring framework is applied to the MPA network at a regional scale. It is important to note that not every MPA within a regional network is comprehensively monitored every year. This reflects both the reality of funding availability and the range of monitoring activities needed to assess ecosystem condition and trends, and to evaluate MPA design and management decisions. Using the framework as the foundation for MPA monitoring ensures that, even though the intensity, timescale and geographic coverage of monitoring can vary, there is a balanced and consistent vision for developing MPA monitoring programs across California.

At its essence, the MPA monitoring framework provides guidelines and principles for developing a scalable monitoring program that can be responsive to capacity and funding. Selection of the ecosystem features, vital signs, and key attributes that are being monitored depends on the monitoring priorities and management evaluation questions that are being assessed. In all cases, MPA monitoring is linked to the MLPA adaptive management cycle to ensure that monitoring results can be summarized, communicated with managers and the general public, and used to inform MPA management reviews.

Changes in management and community priorities can be used to update the management and design evaluation questions identified for a region through the MPA monitoring framework. As mentioned above, monitoring itself is also adaptively managed through application of the monitoring framework. Monitoring protocols can be adjusted to reflect advances in scientific understanding and data collection techniques. The results of monitoring can also be used to refine the vital signs, key attributes, indicators, and focal species for ecosystem checkups and ecosystem feature assessments. Any changes must be made with the understanding that long-term data collection is also vital to understanding changes in Central Coast MPAs and to putting changes in context of both natural and anthropogenic drivers over time.

Application of the MPA monitoring framework provides an opportunity to strengthen existing partnerships, develop new partnerships, and consider multiple forms of science and knowledge, including citizen science, traditional ecological knowledge, and local knowledge. Partnerships aimed at drawing on these diverse activities are explored in more detail in Chapter 7 of this plan.

In the Central Coast, application of the MPA monitoring framework in developing key metrics for each Ecosystem Feature benefitted from the presence of over 40 regional institutions and universities with marine research or educational objectives. A number of ocean and coastal research scientists are based at these centers of learning, forming a robust source of expertise about the Ecosystem Features in Central Coast MPAs. Many of these scientists provided their input about monitoring metrics that best form vital signs, key attributes, indicators, and focal species for each Ecosystem Feature in this plan.

Application of the monitoring framework in developing key short- and long-term management questions is also unique in the Central Coast because the Monterey Bay National Marine Sanctuary encompasses a large portion of the region's ocean waters. This points to broader potential management applications of monitoring and potential partnerships in MPA monitoring and management. Federal protections of waters in the Monterey Bay National Marine Sanctuary must also be considered in selection of key management questions for Central Coast MPAs.

3. Adopting an Ecosystems Approach

- Focusing monitoring using Ecosystem Features
- Value of an ecosystem-based approach
- Ecosystem Features in the Central Coast

California has adopted an ecosystems approach to MPA monitoring. Ecosystems form the top level of the monitoring framework (see Chapter 2 and Figure 2-2) – providing an umbrella that encompasses species, populations, habitats, and human uses and interactions with the ocean. In this chapter, we describe this ecosystems approach, discuss the value of an ecosystems approach, and describe the ten Ecosystem Features as they are applied to the Central Coast region.

FOCUSING MONITORING USING ECOSYSTEM FEATURES

A key purpose of monitoring is to assess performance of the MPA network against the MLPA goals (see Chapter 2). These six goals are broad and there are many different components of California's marine ecosystems that could be monitored. The monitoring framework provides an approach to focus monitoring efforts and ensure that monitoring can assess performance relative to these broad policy goals.

The top level of the monitoring framework – the first step in focusing monitoring – is Ecosystem Features. Ecosystem Features are a limited set of targets for monitoring that collectively represent and encompass a geographic region.[11] In this case, the geographic region should be thought of as California's state waters.[12] Ten Ecosystem Features have been identified and adopted for MPA monitoring in California; consistent application of these Ecosystem Features in each regional monitoring plan ensures that the monitoring will meet the requirements of the MLPA, and allows for cross-regional comparisons. These Ecosystem Features were developed through a consultative process in the North Central and South Coast regions.[13] Drawing on key habitats defined during the MPA planning process and refined through scientific and community input during monitoring planning, these Ecosystem Features also ensure that monitoring is consistent with MLPA policy guidance, reflect public priorities, and explicitly incorporate humans within an ecosystems approach.

The ten Ecosystem Features are:

- Rocky Intertidal Ecosystems
- Kelp & Shallow Rock Ecosystems (0-30m)
- Mid-depth Rocky Ecosystems (30-100m)
- Estuarine & Wetland Ecosystems
- Soft-bottom Intertidal & Beach Ecosystems
- Soft-bottom Subtidal Ecosystems (0-100m)
- Deep Ecosystems & Canyons (>100m)
- Nearshore Pelagic Ecosystems (i.e., the water column habitat within state waters, in depths >30m)
- Consumptive Uses
- Non-consumptive Uses

[11] This approach is adapted from a monitoring and evaluation methodology developed by Foundations of Success (FOS), a non-profit organization with experience supporting planning, monitoring, and adaptive management of conservation and resource management projects in California and worldwide. Ecosystem Features are modeled on the FOS 'Conservation Targets,' but extended to explicitly include human interaction with ocean ecosystems. For more information on FOS, see www.fosonline.org.

[12] The boundary of California state waters is generally from mean high tide out to three nautical miles offshore, however there are several locations in the state where the state boundary is further offshore than three nautical miles but are still considered to be contiguous with the continental coastline (e.g., Monterey Bay).

[13] The South Coast MPA Monitoring Plan is available at http://oceanspaces.org/monitoring/regions/south-coast/planning, and the North Central Coast MPA Monitoring Plan is available at http://oceanspaces.org/monitoring/regions/north-central-coast/planning.

VALUE OF AN ECOSYSTEM-BASED APPROACH

MPA EFFECTS ON ECOSYSTEMS

The ecosystems approach to MPA monitoring fundamentally recognizes that complex interactions are taking place within, around, and across MPAs. We may observe specific changes within an MPA, but cannot know the cause or significance of an observed change without also understanding other components of the ecosystem. For example, certain species may be of particular interest due to their economic importance, cultural significance, or for another reason. However, a narrow focus on those species would be inadequate because observations of those species cannot on their own give us an adequate picture of the health of the entire system. Rather, we need to understand how those species fit into the community in order to make sense of changes that we might observe. An ecosystems approach allows us to simultaneously work toward the important MLPA goal of understanding ecosystem structure, function, and integrity,[14] and the performance of the MPA network towards the full set of six MLPA goals.

An ecosystems approach also provides structure to monitoring inside and outside of MPA boundaries. The goals of the MLPA are goals for all of California's ocean waters, not just the waters inside of MPA boundaries. Recognizing this, the MLPA Master Plan for MPAs calls for monitoring at select sites both inside and outside of individual MPAs.[15]

MPAs implemented under the MLPA limit or prohibit take of living marine resources. By reducing take,[16] MPAs may lead to increases in the abundance and size of some fish and invertebrate species within their boundaries. This initial effect of MPA implementation is one of the most widely demonstrated worldwide. Increases in the density and size of organisms inside of MPAs are generally predicted to be observable first in species with a lower age of maturation or those that grow faster, and with species or populations that previously were heavily fished. Slower-growing species such as rockfish may take a decade or even longer to respond. The rates and magnitudes of population changes are also likely to be influenced by the density of predators, which may itself increase in response to reduced take and cause reduced populations of prey, historical levels of fishing in areas subsequently designated as MPAs, and ongoing fishing activities inside MPAs that allow fishing and outside MPA boundaries. Monitoring of local species densities can be used to evaluate changes in predicted fast- and slow-responding species in addition to species that play key ecological roles within particular ecosystems.

Beyond effects on single species, MPAs may also result in indirect effects on communities and ecosystems. If abundances of functionally important fish and invertebrate herbivores and predators increase, cascading changes throughout the ecosystem may be expected, as ecological processes and interactions shift. Additionally, MPAs may increase ecosystem resilience, which is defined as the capacity of ecosystems to resist, or recover from, changes due to other types of influences (e.g., climate change impacts). Monitoring important aspects of ecosystems that contribute to ecosystem structure and function facilitates detection and interpretation of such community- and ecosystem-level effects of MPAs.

Ultimately, MPAs may also lead to fishery benefits through adult and larval spillover. Adult spillover occurs when increased fish production within MPA boundaries causes individuals to move outside of the MPA, where they influence the structure and function of broader ecosystems and support associated fisheries. Detection of these effects is challenging given that many species range over large geographic areas. However, analytical models that incorporate spatially explicit fishing data

[14] Goal 1 of the MLPA is to "Protect the natural diversity and abundance of marine life, and the structure, function and integrity of marine ecosystems." California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3). See also sections 2852(a), and 2856(a)(2)(H).

[15] California Marine Life Protection Act Master Plan for Marine Protected Areas, Revised Draft, Jan. 2008, p. 74. http://www.dfg.ca.gov/marine/mpa/masterplan.asp. See also Fish and Game Code section 2853(c)(3).

[16] Take is defined as to "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." California Fish and Game Code section 86.

and population dynamics information including effort and catch, combined with ecological data illustrating species densities and movement patterns, can reveal the contributions of MPAs to ecosystems and fisheries outside of their boundaries. Similarly, MPAs may affect larval transport patterns and impact adult production inside and outside MPAs, which may require the ability to track larval source and sink populations through new genetic, chemical, and other larval markers as well as additional oceanographic information. These latter effects of MPA implementation, however, may take many years to realize and detect.

INTERPRETING CHANGE USING CONTEXTUAL INFORMATION

The Ecosystem Features focus on ecological and socioeconomic aspects of California's ecosystems within the scope of the MLPA. However, these ecosystems are shaped by a range of natural and anthropogenic influences that act at a variety of temporal and spatial scales, including such large-scale physical oceanographic influences as the larger California Current Ecosystem, the El Niño Southern Oscillation, and the Pacific Decadal Oscillation.

In order to understand the effects of MPAs on these ecosystems, it is vital that the analysis and interpretation of monitoring results consider additional information about these natural and anthropogenic influences, often collected by other monitoring programs and data sources. This information, referred to as contextual information in this plan, includes information about the natural influences of the physical environment (such as atmospheric and oceanographic conditions, water quality, or geology) and human influences (such as economic conditions, regulatory changes, fuel costs, or land-use patterns). It may also include ecological information that provides context for interpreting results of the monitoring metrics described in Chapter 4, such as recruitment and primary productivity. Analysis and interpretation of MPA monitoring results will also consider MPA regulations and available information on MPA compliance. Because illegal take of marine organisms can influence the rates and magnitudes of population increases, information about types and levels of non-compliance will be incorporated into the interpretation of documented trends.

A more detailed discussion of contextual information is available in Chapter 4, and a discussion of the important role of partnerships in collecting and incorporating contextual data into the analysis and reporting of MPA monitoring results is available in Chapter 7 of this plan.

BENEFITS BEYOND THE MLPA

The Ecosystem Features in the MPA monitoring framework have been designed to meet the requirements of the MLPA. This ecosystem-based approach can also provide useful information for other marine resource management issues. For example, the MLPA envisions MPAs as a complementary tool for fisheries management,[17] and MPA monitoring will generate new, detailed, and fisheries-independent data on the abundance and biology of many species that are targeted by fisheries. Information about relative abundances and size distributions of fishery species generated through MPA monitoring may be useful as inputs for population modeling by fishery scientists. Also, in recognition of the establishment of California's MPA network, fishery scientists have begun to explore new ways to inform fishery managers about the status of fished populations based on, for example, expression of life history traits inside and outside of MPAs. Many nearshore species are targeted by fisheries and are also unassessed due to a lack of data. Management of these species in particular may benefit from the information generated through MPA monitoring, as the relevant new data streams become available to fishery managers. See Appendix A for a detailed discussion of potential options for integrating fisheries monitoring and the MPA monitoring described in this plan.

[17] Goal 2 of the MLPA is to "help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted." California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3).

Beyond fisheries management, ecosystems-based MPA monitoring data can potentially help scientists and managers to detect catastrophic ecological events (e.g., harmful algal blooms or sea star wasting disease), and to better understand the ecological impacts of changes in water quality, ocean acidification, and climate change in the Central Coast. California is now investing in research and monitoring that leverages the investment in the MPA network and develops new knowledge and new tools to advance our ability to holistically monitor and manage ocean resources.

ECOSYSTEM FEATURES IN THE CENTRAL COAST

Following are brief summaries of the Ecosystem Features as they are applied to the Central Coast region. Each summary provides a brief description and definition of the Ecosystem Feature together with considerations for MPA monitoring. Baseline monitoring in the region provided a snapshot assessment of many of these Ecosystem Features, a benchmark against which we can now evaluate changes inside and outside MPA boundaries.

ROCKY INTERTIDAL ECOSYSTEMS

The geographic extent of rocky intertidal ecosystems are defined, for the purposes of MPA monitoring, as areas of rock substrate occurring within the zone between mean high water and mean lower low water. This delimitation at the mean high water reflects the jurisdictional limit of the Marine Life Protection Act. This habitat is particularly common in the Central Coast region; it occurs along 48.9% of the coastline and includes exposed rocky cliffs, boulder rubble, exposed wave-cut platforms and sheltered rocky shores.

Rocky shores are typically characterized by multiple zones that are defined by tidal height and habitat-forming organisms (i.e., biogenic habitat). At the upper (landward) end of the intertidal zone, physical processes are the dominant regulators of community composition, and communities are typically dominated by encrusting species that can tolerate these harsh conditions. At the middle and lower end of the intertidal zone, species are subject to longer submersion, and ecological processes such as competition and predation play an important role in community structure. In the mid-intertidal zone, mussels and red, green, and brown algae provide structure and habitat. Kelps, other fleshy seaweeds, and seagrasses make up much of the habitat in the low intertidal zone, and at some sites purple urchins are important as bioeroders and habitat. Predatory birds like black oystercatchers feed on the wide variety of omnivorous and predatory invertebrates in rocky intertidal ecosystems, including giant owl limpets and whelks.

The underlying geology of rocky intertidal ecosystems plays an important role in determining community structure. Sandstone and shale beds are easily eroded by waves, which dislodge those organisms attached to the substrate but have little to no effect on burrowing organisms. Harder rocks such as granite are less likely to erode, providing a more permanent habitat for long-lived intertidal organisms that anchor to the substrate. Along the Central Coast, rocky intertidal ecosystems from Pigeon Point to Pacific Grove are dominated by sandstone and shale beds, while granite dominates the rocky substrate between Pacific Grove and Point Sur. South of Point Sur, rocky intertidal substrate is dominated by sandstones and a variety of other rock types.

This Ecosystem Feature is expected to be among the more challenging within which to detect and interpret changes that may occur within MPAs. Reduced take of marine organisms such as seaweeds can lead to increases in habitat availability and ultimately this habitat may provide important food and shelter for other fish and invertebrates. However, physical disturbance is a natural process in rocky intertidal systems that results in complex and patchy species distributions, complicating detection of MPA-related effects. The effects of natural physical disturbance may make it more difficult to detect MPA effects via inside-outside MPA comparisons. As a result, monitoring of rocky intertidal ecosystems should emphasize establishing robust temporal trends through an appropriate spatial sampling design.

As with estuaries and wetlands, and beach ecosystems, rocky intertidal ecosystems span the boundary between marine and non-marine habitats, and they are more frequently visited by people than other marine ecosystems. Distinguishing between the effects of MPAs, natural disturbances, and human uses can be difficult, due to the complex interactions of these factors. As a result, MPA monitoring has been structured to facilitate interpretation of ecological-human linkages across multiple Ecosystem Features. For example monitoring of human uses can be designed to occur in the same years and at the same sites as ecological monitoring of rocky shores.

KELP & SHALLOW ROCK ECOSYSTEMS (0-30M)

Kelp forests and shallow reefs in the Central Coast region are diverse, hosting a wide variety of marine plants, fish (e.g., nearshore rockfishes, cabezon, greenlings, lingcod), mobile invertebrates (e.g., red abalone, sea stars, and purple and red sea urchins) as well as many marine mammals (e.g., sea otters). As its name suggests, this Ecosystem Feature encompasses the full water column above rocky substrates at depths from 0-30 meters both with and without overlying kelp forests. Kelp forests consist of surface kelp canopies that extend to the water's surface and sub-canopy kelp that provides biogenic habitat vital to fishes, invertebrates, and other species. Kelp forests in the Central Coast are typically dominated by giant, bull, stalked, and Setchell's kelp. Rocky substrate below the kelp forest provides additional habitat for a diverse assemblage of species, and the settlement and growth of kelp and other algae. It is a relatively stable substrate, with kelp forests typically persisting from year-to-year.

Baseline MPA monitoring in the Central Coast region has increased our understanding of the structure and function of kelp and shallow rock communities. The density, abundance, and structure of kelp, fish, and invertebrate species vary geographically from north to south along the Central Coast region. In general, the density of giant kelp is highest in the northern portions of the Central Coast region, while stalked kelp and Setchell's kelp dominate in the central and southern portions of the Central Coast region. Fishes such as rockfish, perch, and seaperch are abundant throughout Central Coast kelp and shallow rock habitats.

Many nearshore rockfish inhabiting these habitats are long-lived – some species live more than 70 years – and individuals often do not reach maturity until six to eight years of age. These life history characteristics increase the predicted time to observe increases in population sizes that may follow MPA implementation. Implementation of monitoring therefore focuses initially on detection of local density differences inside and outside of MPAs. Gradual accumulation of data will help reveal the broader ecological role of these species as well as the broader population and ecosystem consequences of local protection.

Many of the possible effects of MPA implementation on this Ecosystem Feature are likely to be complicated by other ecosystem drivers and processes, often acting at large geographic and long temporal scales. Storms and waves can cause rapid changes in kelp forests by removing large numbers of kelp plants. In addition, across seasons and years, differences in the amount of cold, nutrient-rich upwelled water cause natural increases or declines in kelp, affecting the fish and invertebrates that rely on kelp for food and shelter. Decadal-scale shifts in the California Current can result in warm and cool regimes that impact species abundances. Anthropogenic influences on climate may contribute to changes in the frequency and intensity of storms, El Niño and La Niña events, and upwelling events. Changes in water quality due to human activities can also have large effects in these ecosystems and are thus important considerations. These physical ecosystem drivers can have important impacts on recruitment, which can in turn affect the time needed to detect changes in population densities of fishes and invertebrates. Consumptive human uses, such as kelp harvesting, can also impact kelp forest ecosystems. These natural and anthropogenic drivers will be considered in analysis of monitoring data from this Ecosystem Feature.

MID-DEPTH ROCK ECOSYSTEMS (30-100M)

In the Central Coast, the Mid-Depth Rock Ecosystem Feature consists of rocky outcrops and pinnacles inhabited by hundreds of fish and invertebrate species. These habitats support important fisheries in the Central Coast, including shelf rockfishes and lingcod. Reduced light levels mean that large kelps and photosynthetic algae are not often found in mid-depth waters. Consequently, much of the habitat is made up of structure-forming invertebrates such as sponges and hydrocorals. In mid-depth rock ecosystems, these animals serve as the structuring habitat for other, more mobile species like rock crabs. Piscivorous fishes like yelloweye rockfish and lingcod are key predators in Mid-Depth Rock Ecosystems.

As on shallower reefs, many of the ecologically and economically important species in mid-depth ecosystems are rockfishes and other predatory fishes that are long-lived and take a long time to reach sexual maturity. Potential population recoveries for these species are unlikely to occur rapidly following MPA implementation. Some habitat-forming sessile invertebrates like hydrocorals are very slow-growing, fragile, and susceptible to physical damage. Reduced use of fishing gear on the seafloor in MPAs is expected to contribute to increases in these species and the biogenic habitat that they create inside of MPAs. This potential effect can be assessed through analysis of trend data collected over long time periods for key habitat-forming species.

Mid-depth rock ecosystems can be influenced by a range of oceanographic drivers, including hypoxia, decadal-scale shifts in the California Current, and shifts in the timing and magnitude of upwelling. Consideration of physical oceanographic conditions through partnerships with other monitoring programs will be critical for accurately evaluating and interpreting ecological monitoring results in this ecosystem.

ESTUARINE & WETLAND ECOSYSTEMS

The Estuarine and Wetland Ecosystem Feature within the Central Coast region encompasses soft-sediment habitats, including tidal mudflats, eelgrass beds and areas of open water. For the purposes of MPA monitoring, these systems have a shoreward boundary at the extent of tidal reach and salt-water-associated vegetation. This boundary reflects the limit of the MLPA. The number of estuaries in the Central Coast is relatively limited compared to other MPA regions. There are two larger Central Coast estuaries: Morro Bay (a National Estuary Program) and Elkhorn Slough (a National Estuarine Research Reserve).

Eelgrass beds and marshes are found in Morro Bay and Elkhorn Slough, and they play an important functional role as foraging and nursery habitats for a diverse range of fish and invertebrate species including Pacific gaper clam, littleneck clam, mud shrimp, ghost shrimp, shiner surfperch, and other surfperches. Many fish species inhabit estuaries as juveniles before moving to kelp forests and other offshore habitats as adults. In addition, estuaries are important for anadromous species, which travel through this habitat on their way to spawning grounds in rivers. They are also important foraging, haul-out, and pupping habitat for marine mammals.

Shorebirds, waterfowl, and piscivorous birds are key components of estuarine and wetland habitats. The estuaries, coastal bays, and beaches of the Central Coast region are part of the Pacific Flyway and host thousands of migrating shorebirds and waterfowl. They are also important foraging and nesting areas for resident bird populations, such as great blue herons and egrets.

Estuaries and wetlands provide important habitat linkages among marine, aquatic and terrestrial ecosystems. As a result, their condition is closely tied to that of the surrounding watershed. For example, water quality characteristics of these ecosystems are strongly impacted by runoff and other changes to water in creeks and tributaries. In addition, invasive species in estuaries in the Central Coast region have the potential to dramatically alter species compositions and ecosystem functioning. As with beaches and rocky shores, estuaries and wetlands are among the most frequently-visited marine ecosystems in the Central Coast region. Consumptive and non-consumptive human uses, including fishing, waterfowl hunting, clam digging, bird watching, boating, and kayaking, can confound interpretation of ecological monitoring results. Distinguishing between MPA effects, natural disturbance effects, and human use effects can be difficult and monitoring will be structured to align human use and ecological data collection, and draw on other monitoring programs collecting contextual data on the physical environment and water quality.

SOFT-BOTTOM INTERTIDAL & BEACH ECOSYSTEMS

The Soft-Bottom Intertidal and Beach Ecosystem Feature is legally defined, for the purposes of MPA monitoring, as wave-dominated areas of sand and gravel substrate occurring below mean high water and above mean lower low water. There are two main types of beach in the Central Coast: long beaches and pocket beaches. Long beaches consist of at least 1km of contiguous sandy shoreline, while pocket beaches consist of less than 1km of sandy shoreline bounded by rocky shoreline. Similar to rocky intertidal systems, soft bottom intertidal and beach systems are especially dynamic, with high spatial and temporal variability within and between beaches. For example, within a single sandy beach, the upper intertidal zone experiences desiccation and warming during low tide, and inundation and cooling during low tide, while temperatures in the lower intertidal zone vary much less dramatically. In addition, waves and currents shift sand and sediment across large areas, causing dramatic changes within these systems.

Species assemblages inhabiting sandy beach habitats are often almost entirely supported by external nutrient input. Beach wrack is an especially important source of food and nutrients in these habitats. Beaches in the Central Coast have been little studied. However, results from the North Central Coast MPA Baseline Program show that pocket beaches are typically characterized by more abundant kelp wrack, wrack-associated invertebrates such as beach hoppers (talitrid amphipods), and terrestrial birds. Long beaches have more abundant sand crabs and shorebirds such as western snowy plover. Natural increases or decreases in the extent of wrack are partly driven by the changes occurring offshore in kelp-dominated habitats. As a result, while interactions between all ten Ecosystem Features are important, connectivity between beach and kelp forest ecosystems is especially important for invertebrates and birds in beach habitats.

Similar to rocky shores, estuaries and wetlands, beaches can be especially influenced by a range of different human factors that include indirect influences (e.g., coastal development and freshwater or polluted run-off) and direct influences of human visitation (e.g., disturbance or extraction of organisms). Combining ecological monitoring data with information on human uses allows accurate interpretation of observed trends in this ecosystem.

SOFT-BOTTOM SUBTIDAL ECOSYSTEMS (0-100M)

The Soft-Bottom Subtidal Ecosystem Feature encompasses benthic waters in the areas of sediment substrate occurring at depths between mean lower low water and 100m. Soft-bottom subtidal habitats are much more common than rocky subtidal habitats at all depth zones throughout the Central Coast region. Although these habitats appear simple and unstructured, they are actually dynamic, and associated species must contend with changes as waves and currents shift sand and sediment across large areas. Adding to the complexity are ripple scour depressions (RSDs) – deposits of coarse-grained sediments that are depressed below the surrounding sediment by 30-50cm, with areal extents ranging from hundreds to thousands of square meters. RSDs can be found in the Central Coast at depths below 30m, and they form important habitat for fishes and invertebrates. Brittle stars are common in soft-bottom subtidal habitats, and commercially important species, including Dungeness crab, sanddabs, and starry flounder, are often found in these habitats.

Many of the fish and invertebrate species in soft-bottom subtidal habitats are wide-ranging, and individuals are likely to move inside and outside of MPAs. Detecting the effects of MPA designation on these species is challenging, but insights can be garnered by combining ecological data with information about the spatial patterns of fishing occurring outside of MPAs.

Decadal-scale shifts in the California Current result in warm and cool regimes that affect the sediment-inhabiting communities in this ecosystem both directly and indirectly. Warm regimes can cause declines in plankton production, resulting in declines in benthic food availability and thus reduced population sizes and community shifts. On shorter timescales, El Niño events, which increase wave activity and storms (leading to sedimentation), can cause major short-term disturbances to these communities. Integrated analyses of trend data may facilitate the separation of MPA effects from other anthropogenic and natural system drivers.

DEEP ECOSYSTEMS & CANYONS (>100M)

Deep Ecosystems and Canyons include benthic habitats with both rocky and soft-bottom substrates in waters below 100m. There is an unusual abundance of large submarine canyons with heads that reach in the Central Coast region near Monterey Bay, Carmel Bay, and Big Sur. The largest canyon in the Central Coast region is the Monterey Submarine Canyon, which extends to a maximum depth of 1,475m. Canyons are areas of high structural complexity, and they provide important habitat for many fish and invertebrate species. In addition, canyons can affect ocean circulation patterns and are thus often important foraging areas for marine birds and mammals. Because photosynthetically active radiation (PAR) rarely penetrates to these depths, food webs are primarily supported by inputs of nutrients from sources external to the system. Many ecologically and economically important species are found in deep ecosystems, including flatfishes, bocaccio, and spot prawns.

Many fishes found in this ecosystem are long-lived and slow to reach sexual maturity, so significant changes in density or size-structure require long-term monitoring to identify. In addition, individuals of many of these species have broad home ranges and are thus likely to move between protected and unprotected areas, which may limit MPA effects. Combining ecological data with information about the spatial patterns of fishing, and integrating physical oceanographic data may help with the challenge of separating MPA effects from non-MPA effects on species in these habitats.

NEARSHORE PELAGIC ECOSYSTEMS

The Nearshore Pelagic Ecosystem Feature is defined as the water column overlaying the continental shelf in state waters at depths greater than 30m. Upwelling zones and retention areas are key oceanographic features, and the cool California Current plays an especially large role in shaping this habitat in the Central Coast. The increase in nutrients associated with upwelling supports a pelagic food web that includes phytoplankton, zooplankton, fishes such as widow rockfish and shortbelly rockfish, seabirds such as Brandt's cormorant, and marine mammals.

Many of the fish, seabird, and marine mammal species that are characteristic of this ecosystem are transient and have a large range. In addition, rockfishes are slow growing and take a long time to reach sexual maturity. Potential MPA-related population changes in these species are likely to take many years to detect. Focusing monitoring in part on pelagic fish species that have smaller home range sizes and were previously fished may allow detection of trends in local abundances and size structures of those species. Ultimately, these effects may be scaled up to detect network-level MPA effects on species with larger ranges.

The processes structuring Nearshore Pelagic Ecosystems frequently occur on spatial scales much larger than the adopted MPAs, and indeed much larger than the region as a whole. This Ecosystem Feature also occurs within the broader California Current ecosystem: a coastal upwelling biome extending from Alaska to Baja and structured by large-scale climate and oceanographic regimes including the Pacific Decadal Oscillation (PDO) and El Niño Southern Oscillation (ENSO, which includes El Niño and La Niña). Disentangling the effects of MPAs from these large-scale system drivers may be achieved by collecting ecological monitoring data over long time scales in protected and unprotected habitats, and carefully analyzing and interpreting the resulting time series in the context of physical oceanographic drivers.

CONSUMPTIVE USES

This Ecosystem Feature encompasses human use activities that involve the extraction of living marine resources. In the Central Coast region, this includes hand-collecting species on shore, by snorkeling, or by SCUBA diving and commercial and recreational fishing on shore or by boat. MPA monitoring has been designed to assess both the effects of consumptive uses on MPAs and ecosystems, and the effects of MPAs on consumptive uses. The socioeconomic effects of MPAs may be seen in the quality or economic value of a particular consumptive activity. The "use impacts" of MPAs are often reflected in the spatial patterns of human use, either through active shifts in resource use or through displacement effects, though such changes may also reflect processes and socioeconomic changes unrelated to MPAs.

Many of these activities, including the collection of organisms for scientific research, require licenses and permits. Illegal take of marine resources is a challenge for marine resource management worldwide, and it can greatly undermine MPA effectiveness. To be most effective, monitoring needs to be designed to facilitate detection of the effects of human uses while also considering available information on types and levels of compliance with MPA regulations.

Although defined as a separate Ecosystem Feature, trends in many consumptive uses are related to, and in some cases dependent upon, trends in key aspects of the ecological Ecosystem Features and broader oceanographic and climatic system drivers. It is important to forge appropriate links between the ecological and human use Ecosystem Features during the selection of monitoring metrics, data collection, and analyses. Perhaps most importantly, broad economic drivers strongly influence commercial and recreational fishing activities. This is evidenced in the recent declines in coastal economies and increases in fuel prices that have directly influenced commercial and recreational fishing ventures. In addition, MPA regulations are part of a broader suite of fisheries management regulations and tools that control fishing activity inside and outside of MPA boundaries. This suite of information should be incorporated into integrated analyses to examine trends in consumptive uses with respect to individual MPAs, key ports and access locations, and across the region as a whole.

NON-CONSUMPTIVE USES

In the Central Coast region, large numbers of residents and visitors enjoy shore-based and/or on-water non-consumptive recreational activities that include beach-going, diving, kayaking, board sports, and wildlife viewing. One goal of MPAs implemented under the MLPA is to increase recreational, study, and educational opportunities in ways that are consistent with the protection of biodiversity.[18]

MPA monitoring has been designed to assess both the effects of non-consumptive uses on MPAs and ecosystems, and the effects of MPAs on non-consumptive uses. Like consumptive uses, many of the non-consumptive uses in the region are closely tied to trends in marine ecosystems. Monitoring will establish links between these Ecosystem Features.

The specific effects of MPA implementation are likely to differ among specific non-consumptive uses and may include a complex suite of changes in patterns of recreational activity that differ among locations within the MPA network. Patterns

[18] Goal 3 of the MLPA is to "Improve recreational, educational, and study opportunities provided by marine ecosystems…" California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3).

of non-consumptive uses in the region are also the result of numerous other drivers that include economic circumstances, natural environmental conditions (such as weather), and illegal non-consumptive activities. Illegal activities can be a particular challenge in coastal MPAs that feature accessible populations of charismatic wildlife. MPA monitoring should take into account information about compliance with MPA regulations, and may also facilitate detection of the effects of illegal activities. Integrated analyses are needed to examine the effects of multiple system drivers and influences in order to reveal MPA-related changes in patterns of non-consumptive uses. These analyses may reveal patterns occurring on local scales (e.g., access points or ports), within individual MPAs, and across the region.

4. Assessing Ecosystem Condition & Trends

- How do we assess ecosystem condition and trends?
- Selecting metrics for Ecosystem Feature Checkups and Assessments
- Contextual information for Ecosystem Features
- Metrics for Ecosystem Feature Checkups and Assessments
- Advancing ecosystem monitoring through research & development

Adopted by the California Fish and Game Commission in 2010 to be included in the MLPA Master Plan for MPAs, the MPA monitoring framework provides the basis for building assessments of ecosystem condition and trends (see Chapter 2 and Figure 2-2), inside and outside of MPAs. The top level of the monitoring framework consists of ten Ecosystem Features that represent and encompass the key ecosystems and human uses in California's state waters, including the Central Coast (see Chapter 3). This chapter provides an overview of the different ways that ecosystem condition can be assessed, and describes the recommended monitoring metrics for assessing each Ecosystem Feature in the Central Coast.

HOW DO WE ASSESS ECOSYSTEM CONDITION AND TRENDS?

Regular assessment and long-term tracking of ecosystem condition – often referred to in other monitoring programs as 'status and trends monitoring' – is accomplished through monitoring of key metrics identified for each of the ten Ecosystem Features. The metrics recommended in this plan have been selected to provide insights into important components and functions of each Ecosystem Feature. Monitoring of these metrics includes repeated assessments of key ecological and human aspects of ecosystems that collectively describe the condition of the ecosystems, how they vary inside and outside of MPAs, and how they change over time.

In addition to providing structure and focus to the monitoring program, the Ecosystem Features allow for flexibility in implementing ecosystem condition assessments. Although we recognize the inter-relatedness of Ecosystem Features, separately identifying metrics for each allows a subset of features to be prioritized for monitoring, reflecting management priorities and available resources.

The MPA monitoring metrics may also benefit other management priorities and mandates, such as fisheries management, characterization of resources within federal management areas or other MPAs (e.g., Monterey Bay National Marine Sanctuary and Rockfish Conservation Areas), and assessments of the impacts of ocean acidification on California's coast (see Chapter 3). To the extent possible, monitoring metrics have been chosen that will benefit other programs without compromising the ability to assess the condition and trends of Central Coast ecosystems to meet the requirements of the MLPA.

BEGINNING WITH BASELINE MONITORING

In each MLPA region, the first step in monitoring is to establish a benchmark of ocean conditions and human activities against which future changes can be measured. The monitoring data and analyses that resulted from Central Coast baseline monitoring create a detailed picture of ocean conditions in the region, providing a benchmark of ecological and socioeconomic conditions and initial changes in the one to two years following Central Coast MPA implementation in 2007. Beyond the initial baseline research, state funding seeded additional analysis and monitoring in the Central Coast, including an examination of early changes that occurred from 2007-2012. As a result, baseline monitoring provides a foundation for managers, scientists, and citizens to track the pulse of marine ecosystems and make rigorous, science-informed decisions for Central Coast MPAs.

TRACKING CONDITION THROUGH CHECKUPS AND ASSESSMENTS

The MPA monitoring framework identifies two approaches by which the condition of each Ecosystem Feature may be monitored:

1. Ecosystem Feature Checkup, and
2. Ecosystem Feature Assessment.

Ecosystem Feature Checkups are designed to provide a coarse-grained evaluation of ecosystem condition and trends. This option was designed as an explicit component of monitoring with citizen science groups in mind. Resource monitoring programs often struggle to identify mechanisms by which citizen science groups can contribute rigorous scientific information to a broader program that includes academic and agency scientists. By creating this checkup option, the goal is to foster dialogue about the appropriate methods and approaches for citizen science participation in MPA monitoring. Citizen science groups are not intended to be confined to this checkup option, as many groups in the Central Coast region already employ methods and protocols to conduct Ecosystem Feature Assessments.

The core of these checkups is a set of "vital signs" for each Ecosystem Feature. Collectively, these vital signs evaluate Ecosystem Feature condition inside and outside of select MPAs and across the region as a whole. While the primary consideration for selecting vital signs is whether a particular metric provides key information about ecosystem condition, emphasis has also been placed on selecting vital signs that are cost-effective, reflect community priorities, and do not require technically demanding sampling protocols or equipment intensive methods. Details about the process of developing vital signs for Ecosystem Feature Checkups are provided in the section below. The vital signs are designed to function as a set – the minimum set of information that is needed to provide a coarse-grained evaluation of ecosystem condition. Thus, all the vital signs for an Ecosystem Feature should be monitored to enable that evaluation.

Ecosystem Feature Assessments provide a scalable method for monitoring ecosystem condition that is more detailed and technically demanding than Ecosystem Feature Checkups. These assessments build upon and adapt well-tested monitoring methods, and they are designed to be practical to implement and interpret.

In an Ecosystem Feature Assessment, condition is assessed by examining a limited set of key attributes, each comprised of a small number of strategically selected focal species or indicators (Figure 4-1). Details about the process of developing key attributes, focal species, and indicators for Ecosystem Feature Assessments are provided in the section below.

The vital signs and key attributes (and associated focal species or indicators) are presented for each Ecosystem Feature in the tables below. When a particular Ecosystem Feature is being monitored using the Ecosystem Feature Assessment approach, the full set of key attributes and associated focal species/indicators of that Feature should be monitored to allow assessment of ecosystem condition. Optional add-on key attributes and associated focal species/indicators are also included for each Ecosystem Feature. These provide additional insights about a particular feature but are more difficult or expensive to implement, and can be more challenging to interpret. These metrics may be selected as desired, but they should only be added to supplement the assessment metrics as resources permit.

To develop trends in ecosystem condition, vital signs, focal species and indicators are designed to be periodically collected inside and outside of select MPAs. This information will be synthesized to produce trajectories of change. Frequency and timing of data collection will depend on a range of factors including available resources, survey methods, and existing programs. In addition, given different rates of change and system drivers, the temporal and spatial design of this monitoring will likely vary among Ecosystem Features. These decisions are a core component of a thoughtful process to build, launch, and administer a monitoring program (see Chapter 8).

Research programs aimed at improving understanding of marine ecosystems and approaches to MPA monitoring may make metrics currently included in the optional add-ons more useful or feasible to implement in the future, or metrics currently listed in the Assessment approach more feasible for inclusion in the Checkups approach. The metrics recommended in this updated plan reflect such advances in monitoring, and future versions of this plan should reflect further advances in monitoring approaches. See Chapter 7 for a discussion of priority research needs to advance ecosystem monitoring and guide the development of research partnerships.

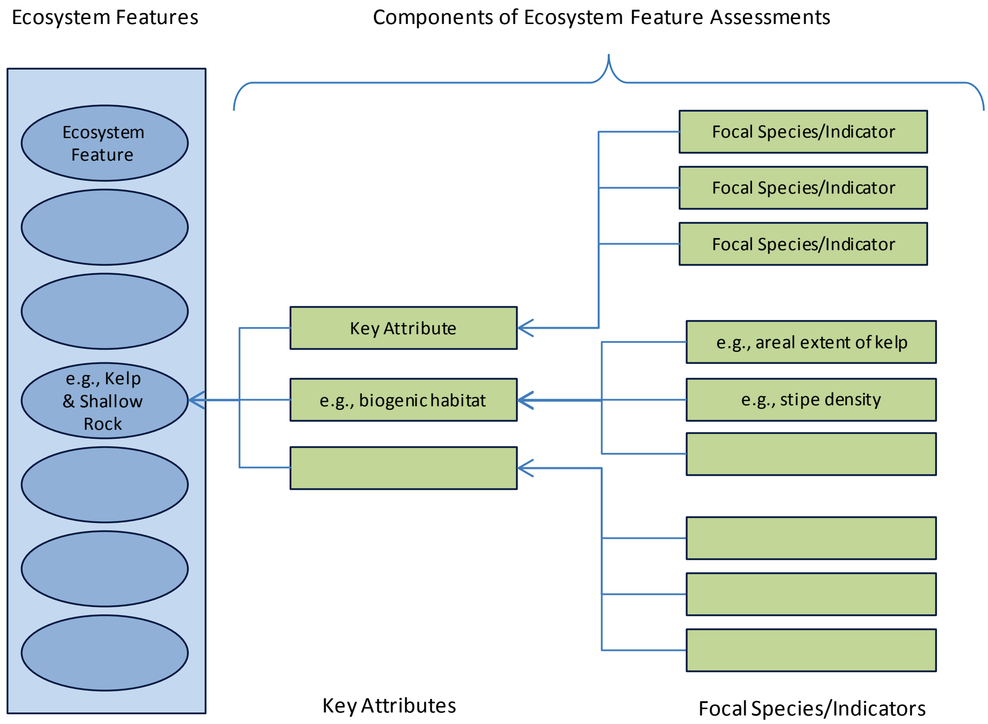


Figure 4-1. *Conceptual diagram of the structure of the Ecosystem Feature Assessment option for tracking the condition of Ecosystem Features. A limited set of focal species/indicators is selected to collectively assess the status of a key attribute. Collectively, the status of key attributes is used to assess the condition of the Ecosystem Feature. An illustrative example is provided here for the Kelp & Shallow Rock Ecosystem Feature.*

SELECTING METRICS FOR ECOSYSTEM FEATURE CHECKUPS AND ASSESSMENTS

SELECTION CRITERIA

There are many different components of each Ecosystem Feature that could be included in feature check-ups or assessments. Indeed monitoring programs often include long lists of candidate species for monitoring. A more efficient and cost-effective approach is to strategically identify the 'most important' aspects of the structure and function of each Ecosystem Feature. Collectively, this small set of strategically selected monitoring metrics, or 'pulse points', can provide a window into the condition of the whole Ecosystem Feature. Selecting this limited set of metrics requires balancing a range of priorities, interests, and perspectives. Both Ecosystem Feature Checkups and Ecosystem Feature Assessments retain an ecosystem-level focus and have been designed to efficiently leverage different types of existing or potential capacity to contribute to MPA monitoring in the Central Coast. For each Ecosystem Feature, one or both monitoring approaches may be used, in the same or different MPAs; the two options have been designed to provide compatible information, although at different levels of resolution.

ECOSYSTEM FEATURE CHECKUPS – VITAL SIGNS

The vital signs recommended in this chapter were chosen to reflect commonly observed changes in marine and coastal ecosystems, emphasizing those that may be sensitive to MPA effects. These changes include the availability of habitat (especially biogenic habitat), the size of fish species, the abundance of top-level predators, and specific human uses such as numbers of dive trips or visitors to tidepools. Emphasis was also placed on selecting vital signs that may be assessed with minimal technological and other resource requirements in order to best tap into potential community-based or citizen-science MPA monitoring programs. Currently, many of the vital signs indirectly link to overarching trends in marine ecosystems and human uses. This is in part due to limited scientific knowledge of the critical elements and processes maintaining marine ecosystems in the region. As scientific understanding of these ecosystems increases, the vital signs will be refined and adapted accordingly.

For the Consumptive Uses Ecosystem Feature, we prioritized vital signs that can be monitored using existing datasets and monitoring programs, primarily those collected by the Department of Fish and Wildlife as a regular component of fisheries management. Given the broad spatial scale and lower resolution in these data sets, interpretation will be most useful and robust at the Central Coast regional scale.

ECOSYSTEM FEATURE ASSESSMENTS – KEY ATTRIBUTES, FOCAL SPECIES, AND INDICATORS

As described above and illustrated in Figure 4-1, Ecosystem Feature Assessments are conducted by monitoring and evaluating focal species and indicators for a limited set of key attributes identified for each Ecosystem Feature.

Key attributes are designed to address at least one of the following criteria:

- Capture fundamental aspects of structure and functioning critical to maintaining the condition of an Ecosystem Feature through time
- Give an indication of the general condition and trends of the Ecosystem Feature
- Focus on system properties, processes, and functions (i.e., resilience, trophic structure, or nutrient cycling)

Ecosystems (and Ecosystem Features) are complex systems comprised of many different components held together by an intricate set of ecological and physical processes. Ideally, key attributes for assessing ecosystem condition would focus on system properties, processes and functions such as resilience, trophic structure or nutrient cycling. However, the science guiding the measurement and interpretation of such metrics is in its infancy and they are expensive to implement using current methods. Thus the key attributes in this plan include aspects of biogenic habitat together with functional species groups (e.g., omnivorous invertebrates or predatory fishes) within each Ecosystem Feature. As scientific understanding of ecosystem structure and function increases, monitoring approaches, including selected key attributes will be appropriately refined and adapted.

Each key attribute is assessed using focal species or indicators. Focal species and indicators provide information about the condition of a particular key attribute and how it changes over time. Indicators are monitoring metrics that are known to relate to the broader condition of an Ecosystem Feature. By contrast, focal species are intended to collectively provide insight into a particular aspect of a community or trophic structure.

In this plan, indicators were selected to capture aspects of spatial distribution and the size or extent of each key attribute, and focal species were selected to provide insight into components of the key attribute. More specifically, the focal species identified in this plan were selected to address at least one of the following criteria:

- Species that play a known and important ecological role
- Species that are likely fast and slow MPA responders
- Species with different life history characteristics
- Fished species which may be likely to show an MPA response, and unfished species for comparison
- To the extent possible, and without compromising the ability to track trends in key attributes, species identified as fishery management priorities in the Nearshore Fishery Management Plan, especially those managed under the MLMA[19]

The Ecosystem Feature Assessment monitoring metrics for the two human uses Ecosystem Features (Consumptive Uses and Non-Consumptive Uses) are structured differently than those for the ecological Ecosystem Features. The selected structure reflects well-established monitoring methods for these subject areas and will facilitate making analytical and interpretive links between the ecological and human uses Ecosystem Features. Analogous to the key attributes described above, key consumptive and non-consumptive uses have been identified for monitoring. A recommended minimum set of key human uses for focusing monitoring activities is described, as well as additional human uses that can be included where resources and methods permit.

For both the Consumptive Use and Non-Consumptive Use Ecosystem Features, an overarching set of indicators has been developed to assess these human uses and track changes over time. These indicators are tailored for each Ecosystem Feature to identify the most useful monitoring metrics, taking into account the standard methods employed to monitor patterns of human uses and socioeconomic trends. These indicators can be applied to each consumptive or non-consumptive use identified for monitoring. As with the ecological elements, the recommended monitoring metrics are not meant to provide an exhaustive characterization of the Ecosystem Feature, but to give an indication of the general status of the feature and trends over time.

SELECTION PROCESS

In updating the Central Coast vital signs, key attributes, indicators, and focal species, we benefited from the solid foundation formed by the 2008 Central Coast MPA Monitoring Plan[20] (including the MLPA Species Likely to Benefit List for the Central Coast),[21] the North Central Coast MPA Monitoring Plan, extensive knowledge of the Central Coast developed through baseline monitoring, and experience and insight from selection processes in other regions.

The metrics identified in this plan were developed from candidate monitoring metrics compiled from those identified in the original Central and North Central Coast MPA Monitoring Plans. This is a reflection of the overlap in the ecology and physical ocean drivers between the Central and North Central Coast regions. The initial metrics in the original Central and North Central Coast MPA Monitoring Plans were developed through robust, inclusive, and scientifically-sound processes with the Central Coast Regional Stakeholder Group (RSG), the Central Coast Science Advisory Team (SAT), former members of the North Central Coast RSG and SAT, and stakeholder input during the Central Coast and North Central Coast MPA implementation processes.

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[19] The Department of Fish And Wildlife Nearshore Fishery Management Plan (2002) is available at: http://www.dfg.ca.gov/marine/nfmp/.
[20] California Marine Life Protection Act Master Plan for Marine Protected Areas, Jan. 2008, p. 51 – 85. http://www.dfg.ca.gov/marine/mpa/masterplan.asp. See also Fish and Game Code section 2853(c)(3).
[21] California Marine Life Protection Act Master Plan for Marine Protected Areas, Jan. 2008, Appendix G, p. G-18 – G-29. http://www.dfg.ca.gov/marine/mpa/masterplan.asp.

To ensure that the list of candidate metrics best reflected the current priorities of Central Coast community members, we added metrics that were suggested at a series of three community gatherings that were held in the region in January 2014. These open community gatherings were convened by the Ocean Science Trust and the California Department of Fish and Wildlife with regional community members including tribal governments, fishermen, citizen science groups, and academic research scientists (see Chapter 1).[22]

The candidate metrics were further refined to reflect the results of Central Coast baseline monitoring. Metrics identified in baseline monitoring as being key in the region were added to the list of candidate metrics for the appropriate Ecosystem Features. Similarly, metrics identified as playing a less prominent role in an Ecosystem Feature than previously thought were removed from the list of candidate metrics for that Feature.

We gathered additional input about the updated Central Coast MPA monitoring metrics from regional research scientists with expertise in monitoring the Ecosystem Features. The scientists provided feedback about the candidate metrics, suggested additional metrics, and shared details about why each metric that they recommended should be a priority for monitoring in the region.

The draft Central Coast MPA Monitoring Plan was released for public input from May 14, 2014 through June 4, 2014 (see Chapter 1). Input included specific suggestions for monitoring metrics, and the metrics included in the draft monitoring plan were revised in consideration of this input.

The updated Central Coast MPA monitoring metrics were finalized for this plan after additional discussions with managers to ensure that they are feasible to implement, that they provide valuable insight into ecosystem condition and trends, and that they can be used to answer priority management questions.

CONTEXTUAL INFORMATION FOR ECOSYSTEM FEATURES

As discussed in Chapter 3, consideration of contextual information is needed for analysis and interpretation of MPA monitoring results. These natural and anthropogenic influences can act at a range of geographic and temporal scales, and they fall under three broad categories:

- Physical and Environmental Influences: A wide range of physical and environmental factors can influence Central Coast ecosystems, including large-scale oceanographic and climate patterns (i.e., the California Current, the El Niño Southern Oscillation, and the Pacific Decadal Oscillation), local and large-scale atmospheric and oceanic conditions (i.e., air and water temperature, salinity, pH), water quality (i.e., dissolved oxygen, nitrate levels), runoff, and soil chemistry.
- Socioeconomic and Human Influences: Central Coast ecosystems may be impacted by a range of non-MPA socioeconomic and human factors, such as economic conditions, fuel costs, historical and current land-use patterns, and compliance with MPA and other regulations.
- Contextual Ecological Information: Some ecological data provide important information for interpreting the monitoring metrics described for each Ecosystem Feature below. These contextual ecological factors include primary productivity (e.g., phytoplankton and chlorophyll measurements), zooplankton and/or bacteria abundance, and invertebrate and/or fish recruitment patterns.

Integrating contextual information with data on the monitoring metrics identified in the tables below can be extremely valuable. Given the wide range of programs that already collect this type of information (e.g., the Central and Northern

[22] A summary of key themes expressed during the community gatherings and small group meetings is available at: http://oceanspaces.org/sites/default/files/regions/files/cc_communitygatherings_keythemes_final.pdf.

California Ocean Observing System (CeNCOOS), water quality monitoring programs), partnership agreements will be the primary mechanism by which contextual data are brought to bear MPA monitoring. See Chapter 7 for a discussion of the important role that these partnerships will play in MPA monitoring.

METRICS FOR ECOSYSTEM FEATURE CHECKUPS AND ASSESSMENTS

The following sections of this chapter contain tables that describe the selected metrics (in alphabetical order) for long-term tracking of condition and trends of the ten Ecosystem Features, specifically identified for the Central Coast region. Figure 4-2 provides a guide to interpreting these tables. For each Ecosystem Feature, a summary list of the monitoring metrics is provided, including the metrics for the Ecosystem Feature Checkup (orange) and Assessment (green) options.

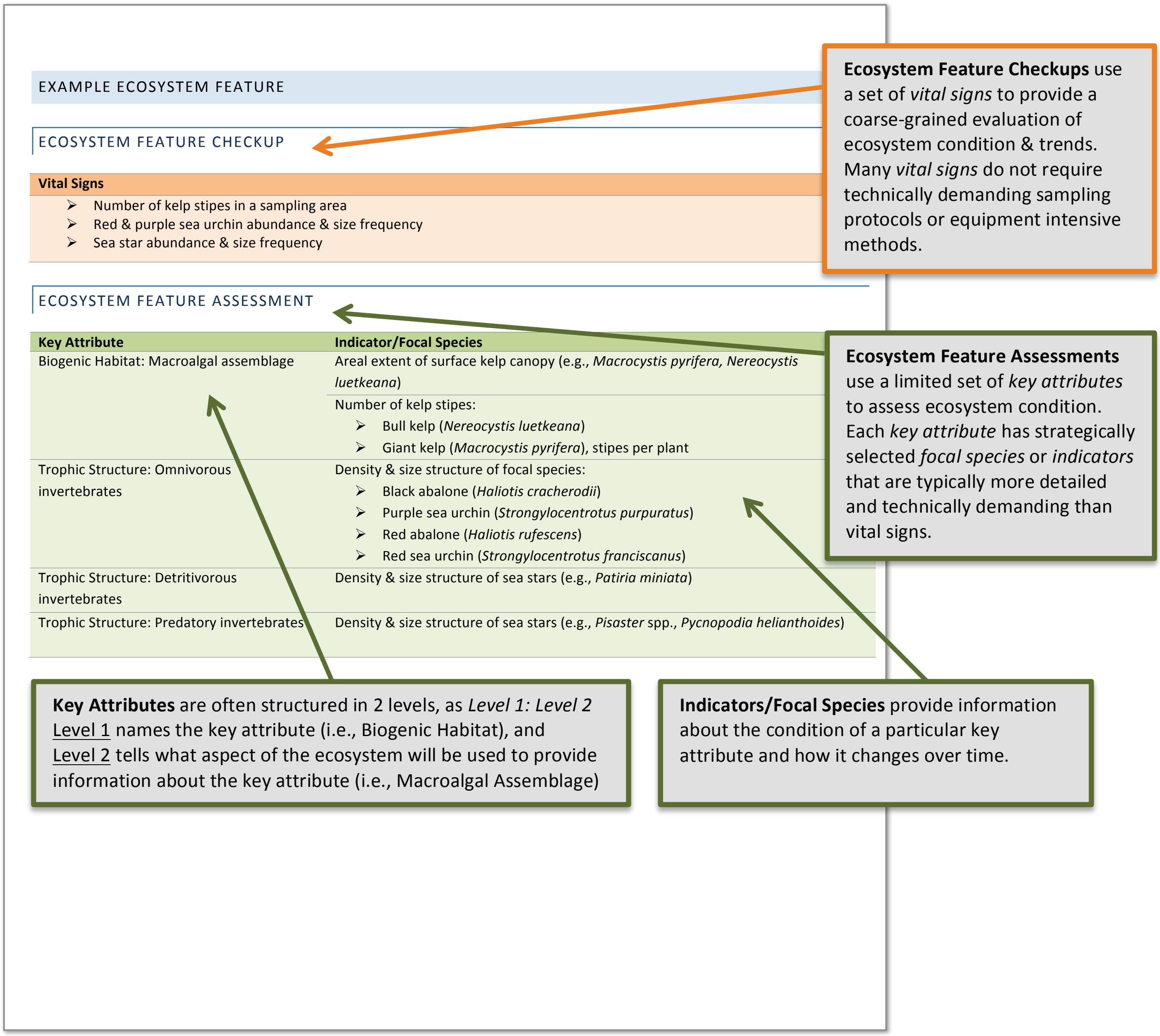


Figure 4-2. *A guide to interpreting the tables of long-term monitoring metrics selected for Ecosystem Feature Checkups and Ecosystem Feature Assessments of Central Coast MPAs.*

In the metrics that follow:

- “Abundance” refers to the number of individuals. Abundance measures collected via, for example, timed surveys and repeated through time can give a broad estimate of local population changes through time.
- “Density” refers to the number of individuals per defined unit area, typically measured using a quadrat or transect method and used to represent average density over a broader study site.
- “Recruitment rate” refers to the rate at which new individuals are added to a species’ population. Rather than measuring this directly, monitoring programs often use the proxy of settlement rate to estimate recruitment.
- “Total cover” refers to the total coverage of a species in a study area, such as the total extent of a kelp bed or mussel bed.
- “Percent cover” refers to the percent cover of a species in fixed plots within a study area, and is used primarily in comparisons of relative species prevalence within and among locations.
- “Size frequency” refers to the number of individuals in predetermined broad size categories.
- “Size structure” also refers to the number of individuals of defined size classes but is distinguished from size frequency by the higher resolution of size classes that are recorded in data collection.

ROCKY INTERTIDAL ECOSYSTEMS

ECOSYSTEM FEATURE CHECKUP

Vital Signs

- Black & red abalone abundance & size frequency
- Black oystercatcher abundance
- Coralline algae & rockweed percent cover
- Giant owl limpet abundance & size frequency
- Mussel bed total cover
- Ochre sea star abundance & size frequency
- Purple sea urchin abundance & size frequency

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat	Percent cover of focal species: ➢ Algae: ○ Brown algae (e.g., *Fucus* spp., *Postelsia palmaeformis, Silvetia compressa*) ○ Green algae (e.g., *Ulva* spp.) ○ Red algae (e.g., *Mastocarpus* spp., *Porphyra* spp.) ○ Turf algae (e.g., *Endocladia* spp.) ➢ Mussels (e.g., *Mytilus* spp.) ➢ Surfgrass (*Phyllospadix* spp.)
Trophic Structure: Omnivorous invertebrates	Density & size structure of focal species/species groups ➢ Black abalone (*Haliotis cracherodii*) ➢ Giant owl limpet (*Lottia gigantea*) ➢ Purple sea urchin (*Strongylocentrotus purpuratus*) ➢ Red abalone (*Haliotis rufescens*) ➢ Turban snails (e.g., *Chlorostoma funebralis*)
Trophic Structure: Predatory invertebrates	Density & size structure of focal species/species groups ➢ Predatory whelks (e.g., *Nucella emarginata*) ➢ Sea stars (e.g., *Pisaster ochraceus, Pycnopodia helianthoides*)
Trophic Structure: Predatory birds	Density of black oystercatchers (*Haematopus bachmani*)

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This set of information includes supplemental metrics that can be added as methods & resources permit.

Key Attribute	**Indicator/Focal Species**
Biogenic Habitat: Invertebrate assemblage	Recruitment rates of focal species/species groups: ➢ Barnacles (e.g., *Balanus glandula, Chthamalus dalli/fissus, Pollicipes polymerus, Semibalanus cariosus*, & *Tetraclita rubescens*) ➢ Mussels (e.g., *Mytilus* spp.)
Habitat provisioning: Juvenile fishes	Total abundance of YOY (young-of-the-year) rockfish
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Monkeyface prickleback (*Cebidichthys violaceus*) ➢ Sculpin (Cottidae)
Trophic Structure: Predatory birds	Diversity of shorebirds that concentrate on rocky habitats (e.g., black turnstones (*Arenaria melanocephala*), surfbirds (*Calidris virgata*))
	Diversity of piscivorous birds & shorebirds
	Total abundance of piscivorous birds & shorebirds
Diversity	Species diversity (functional groups of algae, fishes & invertebrates)
	Species richness (algae, fishes & invertebrates)

KELP & SHALLOW ROCK ECOSYSTEMS (0-30M)

ECOSYSTEM FEATURE CHECKUP

Vital Signs

- Foraging seabird abundance
- Lingcod abundance & size frequency
- Number of kelp stipes in a sampling area
- Painted greenling abundance & size frequency
- Red & purple sea urchin abundance & size frequency
- Rockfish abundance & size frequency
- Sea otter abundance
- Sea star abundance & size frequency

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat: Macroalgal assemblage	Areal extent of surface kelp canopy (e.g., *Macrocystis pyrifera, Nereocystis luetkeana*)
	Number of kelp stipes: ➢ Bull kelp (*Nereocystis luetkeana*) ➢ Giant kelp (*Macrocystis pyrifera*), stipes per plant
Trophic Structure: Omnivorous Invertebrates	Density & size structure of focal species: ➢ Black abalone (*Haliotis cracherodii*) ➢ Purple sea urchin (*Strongylocentrotus purpuratus*) ➢ Red abalone (*Haliotis rufescens*) ➢ Red sea urchin (*Strongylocentrotus franciscanus*)
Trophic Structure: Detritivorous Invertebrates	Density & size structure of sea stars (e.g., *Patiria miniata*)
Trophic Structure: Predatory Invertebrates	Density & size structure of sea stars (e.g., *Pisaster* spp., *Pycnopodia helianthoides*)
Trophic Structure: Planktivorous fishes	Density & size structure[1] of blue rockfish (*Sebastes mystinus*)
Trophic Structure: Omnivorous fishes	Density & size structure[1] of focal species: ➢ Black & yellow rockfish (*Sebastes chrysomelas*) ➢ Cabezon (*Scorpaenichthys marmoratus*) ➢ Gopher rockfish (*Sebastes carnatus*) ➢ Kelp rockfish (*Sebastes atrovirens*) ➢ Painted greenling (*Oxylebius pictus*) ➢ Striped seaperch (e.g., *Embiotica lateralis*) ➢ Black perch (e.g., *Embiotica jacksoni*)
Trophic Structure: Piscivorous fishes	Density & size structure[1] of focal species: ➢ Black rockfish (*Sebastes melanops*)

	➢ Copper rockfish (*Sebastes caurinus*) ➢ Lingcod (*Ophiodon elongatus*)
Trophic Structure: Predatory marine mammals	Foraging rates & diet of sea otters (*Enhydra lutris*)

[1] Size structure includes young-of-the-year where feasible.

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSEMENT

This set of information includes supplemental metrics that can be added as methods & resources permit.

Key Attribute	Indicator/Focal Species
Biogenic Habitat	Density of mid-canopy kelp (e.g., *Eisenia arborea*, *Laminaria setchellii, Pleurophycus gardneri,* & *Pterygophora californica*)
	Percent cover of sessile invertebrates
	Percent cover of turf algae (e.g., brown algae, fleshy red algae)
Trophic Structure: Omnivorous invertebrates	Density & size structure of California cucumber (*Parastichopus californicus*)
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Kelp greenling (*Hexagrammos decagrammus*) ➢ Señorita (*Oxyjulis californica*) ➢ Tubesnout (*Aulorhynchus flavidus*)
Habitat provisioning: Juvenile fishes	Total abundance of YOY (young-of-the-year) rockfish
Trophic Structure: Predatory seabirds	Foraging rate, breeding population size, & fledging rate of focal species: ➢ Brandt's cormorant (*Phalacrocorax penicillatus*) ➢ Pelagic cormorant (*Phalacrocorax pelagicus*) ➢ Pigeon guillemot (*Cepphus columba*) (not fledging rate)
	Diet of focal species: ➢ Brandt's cormorant (*Phalacrocorax penicillatus*) ➢ Pigeon guillemot (*Cepphus columba*)
Diversity	Species diversity (functional groups of algae, fishes & invertebrates)
	Species richness (algae, fishes & invertebrates)

[1] Size structure includes young-of-the-year where feasible.

MID-DEPTH ROCK ECOSYSTEMS (30-100M)

ECOSYSTEM FEATURE CHECKUP

Vital Signs

- Cabezon abundance & size frequency
- Dwarf rockfish abundance & size frequency
- Lingcod abundance & size frequency
- Rock crab abundance & size frequency
- Rockfish average & maximum size, by species or functional group

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat: Sessile invertebrates	Total cover & density of structure forming invertebrates
Trophic Structure: Omnivorous invertebrates	Density & size structure of rock crabs (e.g., *Cancer* spp., *Metacarcinus* spp.)
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Canary rockfish (*Sebastes pinniger*) [1] ➢ Pile surfperch (*Rhacochilus vacca*)
Trophic Structure: Planktivorous fishes	Density & size structure[1] of blue rockfish (*Sebastes mystinus*)
Trophic Structure: Piscivorous fishes	Density & size structure[1] of focal species: ➢ Blackeye goby (*Rhinogobiops nicholsii*) ➢ Bocaccio (*Sebastes paucispinis*) ➢ Copper rockfish (*Sebastes caurinus*) ➢ Lingcod (*Ophiodon elongatus*) ➢ Rosy rockfish (*Sebastes rosaceus*) ➢ Vermilion rockfish (*Sebastes miniatus*) ➢ Yelloweye rockfish (*Sebastes ruberrimus*)
Habitat Provisioning: Dwarf rockfishes	Dwarf rockfish density (multiple species)

[1] Size structure includes young-of-the-year where feasible.

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This set of information includes supplemental metrics that can be added as methods & resources permit.

Key Attribute	Indicator/Focal Species
Biogenic Habitat: Sessile invertebrates	Percent cover & density of focal species: ➢ Black corals (e.g., *Antipathes* spp.) ➢ Hydrocorals (e.g., Stylasterina) ➢ Plumose anemones (*Metridium* spp.) ➢ Soft corals (e.g., Octocorallia) ➢ Structure-forming sponges (Porifera)

Trophic Structure: Omnivorous invertebrates	Density of focal species: ➢ Sea stars (e.g., *Ceramaster* spp., *Mediaster aequilis, Pteraster* spp.) ➢ Sheep (spider) crabs (e.g., *Loxorhynchus grandis*)
Trophic Structure: Suspension-feeding invertebrates	Density of focal species: ➢ Basket stars (e.g., *Gorgonocephalis eucemis*) ➢ Crinoids
Trophic Structure: Omnivorous fishes	Density & size structure[1] of focal species: ➢ China rockfish (*Sebastes nebulosus*) ➢ Gopher rockfish (*Sebastes carnatus*)
Diversity	Species diversity (functional groups of fishes & invertebrates)
	Species richness (fishes & invertebrates)

[1] Size structure includes young-of-the-year where feasible.

ESTUARINE & WETLAND ECOSYSTEMS

ECOSYSTEM FEATURE CHECKUP

Vital Signs

- Clam abundance & size frequency (gaper, geoduck, & littleneck clams)
- Eelgrass areal extent
- Ghost & mud shrimp abundance
- Marine bird, shorebird, & duck diversity & abundance
- Marine mammal abundance (colony size)
- Surfperch abundance & size frequency

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat	Areal extent of eelgrass (e.g., *Zostera marina*)
	Density & percent cover of eelgrass (e.g., *Zostera marina*)
Habitat Provisioning: Infaunal assemblage	Density of focal species: ➢ Fat innkeeper worm (*Urechis caupo*) ➢ Ghost shrimp (*Neotrypaea californiensis*) ➢ Littleneck clam (*Protothaca staminea*) ➢ Mud shrimp (*Upogebia pugettensis*) ➢ Pacific gaper clam (*Tresus nuttallii*)
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Black seaperch (*Embiotoca jacksoni*) ➢ Diamond turbot (*Hypsopsetta guttulata*) ➢ Pile surfperch (*Rhacochilus vacca*) ➢ Shiner surfperch (*Cymatogaster aggregata*) ➢ Striped seaperch (*Embiotoca lateralis*) ➢ Topsmelt (*Atherinops affinis*)
Trophic Structure: Predatory waterbirds	Total abundance & diversity of piscivorous birds, shorebirds, & waterfowl (dabbling & diving ducks)
Habitat Provisioning: Marine mammals	Density of marine mammals

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This set of information includes additional metrics that can be added as methods & resources permit.

Key Attribute	Indicator/Focal Species
Biogenic Habitat	Areal extent of native oyster beds (*Ostrea lurida*)
	Areal extent of sea lettuce (*Ulva* spp.)

Habitat Provisioning: Epifaunal invertebrates	Density of focal species: ➢ Eelgrass isopod (*Idotea resecata*) ➢ Gammarid amphipod (Gammaridae)
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Gobies (Gobiidae)
Trophic Structure: Predatory fishes	Abundance of focal species: ➢ Bat ray (*Myliobatis californica*) ➢ California halibut (*Paralichthys californicus*) ➢ Leopard shark (*Triakis semifasciata*) ➢ Starry flounder (*Platichthys stellatus*)
Trophic Structure: Predatory marine birds	Abundance & foraging rates of focal species/groups: ➢ Piscivorous birds ➢ Shorebirds
Trophic Structure: Predatory marine mammals	Abundance & foraging rates of sea otters (*Enhydra lutris*)
Diversity	Species diversity (functional groups of fishes & invertebrates)
	Species richness (fishes & invertebrates)

SOFT-BOTTOM INTERTIDAL & BEACH ECOSYSTEMS

ECOSYSTEM FEATURE CHECKUP

Vital Signs

- California grunion abundance
- Fresh kelp abundance on shore
- Marine bird & shorebird diversity & abundance
- Sand crab abundance
- Surfperch abundance & size frequency

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat	Density & composition of macrophyte wrack
Trophic Structure: Suspension feeders	Density & size structure of sand crabs (*Emerita analoga*)
Trophic Structure: Detritivorous invertebrates	Density & composition of wrack-associated invertebrates
Trophic Structure: Omnivorous fishes	Density & size structure of surfperch (Embiotocidae)
Trophic Structure: Predatory marine birds	Species diversity of shorebirds
	Total abundance of shorebirds

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This set of information includes additional metrics that can be added as methods & resources permit.

Key Attribute	Indicator/Focal Species
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Night smelt (*Spirinchus starksi)* ➢ Surf smelt (*Hypomesus pretiosus*)
Trophic Structure: Predatory marine birds	Breeding population size & fledging rate of western snowy plover (*Charadrius nivosus nivosus*)
	Foraging rate of shorebirds
Diversity	Species diversity (functional groups of fishes & invertebrates)
	Species richness (fishes & invertebrates)

SOFT-BOTTOM SUBTIDAL ECOSYSTEMS (0-100M)

ECOSYSTEM FEATURE CHECKUP

Vital Signs

- Dungeness crab abundance & size frequency
- Flatfish total abundance & size frequency
- Halibut abundance & size frequency
- Rock crab abundance (*Cancer* spp., *Metacarcinus* spp.)

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat	Total cover of biogenic habitat (e.g., sea whips & sea pens (Octocorallia))
Habitat Provisioning: Infaunal assemblage	Abundance & size structure of sand dollars (*Dendraster excentricus*)
	Functional diversity of benthic infauna (feeding guilds)
Trophic Structure: Omnivorous invertebrates	Density & size structure of focal species/species groups: ➢ Dungeness crabs (*Metacarcinus magister*) ➢ Rock crabs (*Cancer* spp., *Metacarcinus* spp.) ➢ Sea Cucumbers (e.g., *Parastichopus californicus*)
Trophic Structure: Suspension-feeding invertebrates	Density & size structure of brittle sea stars (e.g., *Amphiodia urtica*)
Trophic Structure: Predatory fishes	Density & size structure of focal species/species groups: ➢ Halibut (*Paralichthys* spp.) ➢ Sanddabs (*Citharichthys* spp.) ➢ Starry flounder (*Platichthys stellatus*)

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This set of information includes supplemental metrics that can be added as methods & resources permit.

Key Attribute	Indicator/Focal Species
Trophic Structure: Predatory seabirds	Fledging rate of Brandt's cormorant (*Phalacrocorax penicillatus*)
	Foraging rates, breeding population size, & diet of focal species: ➢ Brandt's cormorant (*Phalacrocorax penicillatus*) ➢ Pigeon guillemot (*Cepphus columba*)
Diversity	Species diversity (functional groups of fishes & invertebrates)
	Species richness (fishes & invertebrates)

DEEP ECOSYSTEMS & CANYONS (>100M)

ECOSYSTEM FEATURE CHECKUP

Deep ecosystems pose unique challenges for data collection and sampling at these depths typically requires the use of methods such as ROVs and submersibles. At this time, methods that would be amenable for use by citizen-scientist or community groups have yet to be developed. Should this change, appropriate vital signs will be developed.

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	Indicator/Focal Species
Biogenic Habitat: Sessile invertebrates	Density of focal species/groups: ➢ Anemones (e.g., *Metridium* spp. & *Urticina piscivora*) ➢ Black corals (*Antipathes* spp.) ➢ Sea pens (*Anthoptilum* spp., *Ptilosarcus* spp., *Stylatula* spp.) ➢ Sponges (Porifera)
Trophic Structure: Omnivorous invertebrates	Density & size structure of focal species/groups: ➢ Box crabs (e.g., *Lopholithodes foraminatusi*) ➢ Fragile red sea urchin (*Strongylocentrotus fragilis*) ➢ Galatheid crabs (Galatheidae) ➢ Sea stars (e.g., *Ceramaster* spp., *Luidia foliolata, Mediaster aequilis, Pteraster* spp., *Pycnopodia helianthoides*, *Thrissacanthias penicillatus*) ➢ Spot prawn (*Pandalus platyceros*)
Trophic Structure: Suspension-feeding invertebrates	Density & size structure of focal species/groups: ➢ Basket stars (e.g., *Gorgonocephalis eucemis*) ➢ Crinoids
Trophic Structure: Predatory fishes	Density & size structure[1] of focal species/group: ➢ California (*Raja inornata*) & longnose (*Raja rhina*) skates ➢ Flatfishes (e.g., Dover (*Microstomus pacificus*), English (*Parophrys vetulus*) & Petrale (*Eopsetta jordani*) sole, Pacific sandab (*Citharichthys sordidus*)) ➢ Rockfishes (e.g., bank rockfish (*Sebastes rufus*), bocaccio (*Sebastes paucispinis*), canary rockfish (*Sebastes pinniger*), cowcod (*Sebastes levis*), sablefish (*Anoplopoma fimbria*), & yelloweye rockfish (*Sebastes ruberrimus*)) ➢ Spotted ratfish (*Hydrolagus colliei*) ➢ Thornyheads (*Sebastolobus* spp.)

[1] Size structure includes young-of-the-year where feasible.

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This set of information includes additional metrics that can be added as methods & resources permit.

Key Attribute	Indicator/Focal Species
Trophic Structure: Detritivorous fishes	Total abundance of hagfish (*Eptatretus stoudii*)
Habitat Provisioning: Dwarf rockfishes	Total abundance of dwarf rockfishes (multiple species)
Diversity	Species diversity (functional groups of fishes & invertebrates)
	Species richness (fishes & invertebrates)

NEARSHORE PELAGIC ECOSYSTEMS

ECOSYSTEM FEATURE CHECKUP

Vital Signs
➢ Brandt's cormorant abundance ➢ Semi-pelagic/pelagic rockfish average & maximum size

ECOSYSTEM FEATURE ASSESSMENT

Key Attribute	**Indicator/Focal Species**
Trophic Structure: Planktivorous fishes	Density & size structure of focal species: ➢ Blue rockfish (*Sebastes mystinus*) ➢ Shortbelly rockfish (*Sebastes jordani*)
Trophic Structure: Omnivorous fishes	Density & size structure of focal species: ➢ Widow rockfish (*Sebastes entomelas*) ➢ Yellowtail rockfish (*Sebastes flavidus*)
Trophic Structure: Predatory seabirds	Abundance of foraging Brandt's cormorant (*Phalacrocorax penicillatus*)
Trophic Structure: Predatory marine mammals	Abundance of marine mammals

OPTIONAL ADD-ONS FOR ECOSYSTEM ASSESSMENT

This information includes supplemental metrics that can be added as methods & resources permit.

Key Attribute	**Indicator/Focal Species**
Trophic Structure: Ichthyoplankton	Ratio of fished species to unfished species
	Total abundance of indicators/focal species: ➢ Ichthyoplankton ➢ Rockfish larvae
Trophic Structure: Predatory seabirds	Diet of Brandt's cormorant (*Phalacrocorax penicillatus*)

CONSUMPTIVE USES

ECOSYSTEM FEATURE CHECKUP

Vital signs identified for Consumptive Uses are designed to be derived from existing Department of Fish & Wildlife datasets and monitoring programs.

Vital Signs
➢ Spatially-referenced landings (weight & value) of key species (nearshore rockfish, Dungeness crab, red urchin, California halibut, & market squid) for the commercial fishery ➢ Spatially-referenced landings (number & weight) of key species (rockfish, lingcod & California halibut) by commercial passenger fishing vessels (CPFVs) ➢ Spatially-referenced CPUE of key species (as above) per fishing block & port by CPFVs

ECOSYSTEM FEATURE ASSESSMENT

CONSUMPTIVE USES TO BE MONITORED

For each consumptive use or activity, key fishery species for monitoring include economically and ecologically important species.

Consumptive Uses to be Monitored
Commercial Fishing ➢ California halibut (*Paralichthys californicus*) ➢ Dungeness crab (*Metacarcinus magister*) ➢ Market squid (*Loligo opalescens*) ➢ Nearshore finfish (e.g., cabezon (*Scorpaenichthys marmoratus*), kelp greenling (*Hexagrammos decagrammus*), monkeyface prickleback (*Cebidichthys violaceus*), rockfish (*Sebastes* spp.))[23] ➢ Pacific sardines (*Sardinops sagax caerulea*) & northern anchovies (*Engraulis mordax*) ➢ Red sea urchin (*Strongylocentrotus franciscanus*) ➢ Spot prawn (*Pandalus platyceros*)
Recreational Fishing – Commercial passenger fishing vessels (CPFVs) ➢ Cabezon (*Scorpaenichthys marmoratus*) ➢ California halibut (*Paralichthys californicus*) ➢ Dungeness crab (*Metacarcinus magister*) ➢ Lingcod (*Ophiodon elongatus*) ➢ Rockfish (*Sebastes* spp.) ➢ Salmon (*Oncorhynchus* spp.)

[23] A set of 19 species of nearshore finfish were selected for management by the Department of Fish and Wildlife as part of the Nearshore Fisheries Management Plan. For the full list of nearshore finfish, see: https://www.dfg.ca.gov/marine/nfmp/

INDICATORS

Each consumptive use is monitored using the same indicators. Note, however, that given different expected rates of change over time, not all indicators need to be implemented at the same time, or at the same frequency. Indicators for Consumptive Use are:

Indicators for Consumptive Uses (for each Consumptive Use, above)

1. Number of people or vessels engaged in the activity
2. Spatially-referenced level of activity
    a. Number of fishing trips per fishing location, vessel, port & region
    b. Landings (pound & revenue) of key species per trip, fishing location, vessel, port & region
    c. Catch per unit effort (CPUE) of key species per trip, fishing location, vessel, port & region
    d. Location & intensity of fishing before & after implementation of MPAs
    e. Number of fishermen/anglers
3. Economic value or quality of activity
    a. Landings value of key species per trip, fishing location, vessel, port & region
    b. Net revenue or expenditures (commercial and/or recreational fisheries)
4. Knowledge, attitudes and perceptions of participants
    a. Motivation
    b. Satisfaction
    c. Quality of life
    d. Attitudes & perception of MPAs over time

OPTIONAL CONSUMPTIVE USES TO BE MONITORED

This information includes supplemental Consumptive Use metrics, some or all of which can be monitored using the same indicators above, as methods & resources permit.

Optional Consumptive Uses to be Monitored
Recreational Fishing – Boat-based ➢ California halibut (*Paralichthys californicus*) ➢ Dungeness crab (*Metacarcinus magister*) ➢ Lingcod (*Ophiodon elongatus*) ➢ Nearshore rockfish (*Sebastes* spp.)
Recreational Fishing – Shore-based ➢ California halibut (*Paralichthys californicus*) ➢ Lingcod (*Ophiodon elongatus*) ➢ Nearshore rockfish (*Sebastes* spp.)
Recreational Fishing – Clamming ➢ Littleneck clams (*Protothaca staminea*) ➢ Pacific gaper clams (*Tresus nuttallii*)
Scientific collecting ➢ Total number of active scientific collecting permits, by site

NON-CONSUMPTIVE USES

ECOSYSTEM FEATURE CHECKUP

Vital Signs
➢ Number of boat-based wildlife viewing trips, vessels & visitors per port & viewing locations ➢ Number of diving trips, vessels & divers per access point & dive site ➢ Number of shoreline wildlife viewers to estuarine, wetland & beach ecosystems ➢ Number of visitors to rocky intertidal ecosystems for tidepooling

ECOSYSTEM FEATURE ASSESSMENT

NON-CONSUMPTIVE USES TO BE MONITORED

Non-Consumptive Uses to be Monitored
Boating
Educational use (i.e., formal curriculum)
Kayaking
SCUBA diving
Shore-based wildlife viewing
Tidepooling

INDICATORS

Each non-consumptive use is monitored by applying the same indicators listed below. Note, however, that not all indicators need to be implemented at the same time, or at the same frequency. Indicators for Non-consumptive uses are:

Indicators for Non-Consumptive Uses (for each Non-Consumptive Use, above)
1. Level of activity a. Number & location of trips (spatial use & intensity) 2. Level of expenditure 3. Knowledge, attitudes & perceptions of participants a. Motivation – including MPAs b. Satisfaction – e.g., likelihood of return

OPTIONAL CONSUMPTIVE USES TO BE MONITORED

This information includes supplemental Non-Consumptive Use metrics, some or all of which can be monitored using the same indicators above, as methods & resources permit.

Optional Non-Consumptive Uses to be Monitored
Recreational beach use

ADVANCING ECOSYSTEM MONITORING THROUGH RESEARCH & DEVELOPMENT

RESEARCH PRIORITIES

As discussed in Chapter 2, MPA monitoring must adapt based on lessons learned from previous monitoring efforts and a changing context. The constantly evolving scientific understanding of ecosystem structure, function, and integrity is an important aspect of that process. Scientific and technological progress changes what is possible in MPA monitoring. Capitalizing on this scientific and technological progress requires an awareness of the broader scientific context of MPA monitoring. Following are discussions of particularly promising areas of research that have the potential to advance ecosystem monitoring and guide the development of research partnerships (further considerations for establishing partnerships are included in Chapter 7).

Despite a long history of research, our understanding of marine ecosystem structure and function remains incomplete. Anthropogenic changes in marine ecosystems, such as loss of habitat and decreased abundances of many top-level predators, have been well-documented globally. However, much research remains to be done to increase our understanding of the mechanisms of ecosystem recovery and the ecosystem components and processes that confer resiliency. Research increasingly targets these questions, but further support is necessary to adapt and understand the results of these efforts in the context of ongoing and increasing changes in climate, oceanographic conditions, and marine ecosystems. This increased knowledge of ecosystems should be coupled with an investigation of the mechanisms, methods, and technologies that can be applied to efficiently and cost-effectively collect ecosystem-level monitoring data that is relevant and applicable to management decisions.

Three priority research goals have been identified to guide research that supports MPA monitoring and evaluation, and that informs MPA management:

1. Advanced monitoring methods, including developed and tested new approaches, tools and technologies for efficient monitoring data collection, analysis and interpretation
2. Advanced understanding of the interactions between socioeconomic and ecological ecosystem elements
3. Advanced understanding of marine ecosystem structure and function

Potential focuses for research within these core topics are identified and briefly listed below. These priorities represent initial candidates for research topics based on lessons learned from the Central Coast MPA Baseline Program and MPA monitoring in other regions, as well as input received during the development of this plan. These research topics will be updated in future versions of the Central Coast MPA monitoring plan to reflect advances in understanding and changes in management priorities.

ADVANCING MONITORING METHODS & TECHNOLOGIES

- Application of existing and new modeling frameworks to:
    - Analyze monitoring data and increase our understanding of the drivers and mechanisms of ecosystem condition and trends.
    - Evaluate the performance and relationships among selected indicators to inform management about predicted magnitude and timing of responses, effects of co-variables and potential alternative indicator choices.
    - Assess the role of MPAs in ecosystem conservation given different scenarios of climate change and recommend improved monitoring approaches.

  - Estimate pre-MPA fishing levels by combining monitoring data with modeling studies.
  - Predict the effectiveness of MPAs in ecosystem conservation inside MPA boundaries and beyond given different model scenarios of future fishing distribution and intensity.
  - Model connectivity and effects of MPA sizes to inform future adaptive management decisions.
  - Work with oceanographic data at a scale appropriate to MPA management decisions.
- Development and testing of novel statistical frameworks, including Bayesian approaches, for analysis of ecosystem trends, including trends in ecosystem characteristics such as resilience and stability
- Investigation into, and testing of, new technologies (or technology not commonly applied to MPA monitoring) to increase the efficiency and effectiveness of MPA monitoring. Potential examples include:
  - Baited Remote Underwater Video (BRUVs) and other remotely operated platforms and/or video technologies.
  - Remote sensing including acoustics
  - Stable isotopes
  - Genetics and genomics applications (e.g. rapid assessment technologies such as environmental DNA)

UNDERSTANDING SOCIOECONOMIC & ECOLOGICAL INTERACTIONS

- Develop methods for measuring and tracking rates of human activity in coastal areas.
- Linking socioeconomic data gathered through MPA monitoring with broader socioeconomic analyses occurring through other programs.
  - Changes in market and non-market values associated with natural resource conditions.
  - Spatial information about broad patterns of coastal human use of natural resources.
- Development of frameworks, methods, and processes to explicitly link ecological and socioeconomic data.

UNDERSTANDING MARINE ECOSYSTEM STRUCTURE & FUNCTION

- Increase understanding of ecosystem resilience and application for MPA monitoring including:
  - Ecological mechanisms conferring increased resilience, including the roles of robustness, resistance to change, recovery rates and reversibility of change, and methods to monitor these ecological processes
  - Role of non-linear dynamics, synergies or thresholds in ecosystem resilience and approaches to monitor these dynamics
  - Links between resilience and diversity or productivity measures and applications for MPA monitoring
- Development of indicators of ecosystem condition including:
  - Indicators of trophic structure
  - Indicators of ecological functioning including 'strong interactors' and key processes
  - Indicators that capture organismal or population condition, such as measures of genetic changes in fish populations, physiological and biochemical condition (e.g., energy stores, lipid content, RNA:DNA ratios), and fecundity and size at maturity.
  - Improved understanding of the links between oceanographic parameters, zooplankton and phytoplankton, and ecosystem condition.
  - Indicators associated with larval connectivity, including settlement/recruitment and fecundity of populations.

DEVELOPING RESEARCH PARTNERSHIPS

The research goals and associated focal topic areas listed above are complex and span a range of scientific disciplines. Successfully conducting research in support of these overarching goals will require multi-disciplinary research collaborations and partnerships to share and use existing information, and to leverage existing or planned research programs. While research and development is fundamental to an adaptive monitoring program, it is likely to take many years to fully implement this component and generate results that can inform the monitoring program.

5. Evaluating MPA Design & Management Decisions

- Evaluating management effectiveness
- MPA design and management decisions in the Central Coast
- Short- and long-term evaluation questions

Establishing and managing a regional network of MPAs involves a wide range of decisions, from design decisions (e.g., MPA size and spacing) to day-to-day management decisions (e.g., managing visitors to MPAs). This chapter describes the approach for structuring and implementing monitoring that evaluates key MPA design and management decisions in the Central Coast region. The results of these evaluations will be used to inform adaptive management of the regional MPA network.

EVALUATING MANAGEMENT EFFECTIVENESS

HOW DOES MONITORING EVALUATE MANAGEMENT EFFECTIVENESS?

Classic implementation of resource monitoring programs typically has two components: 'status and trends' monitoring - as described in Chapter 4 - and 'management effectiveness' monitoring. Together, these two components of monitoring can assess the state of an ecosystem or resource and the role that management actions are playing in protecting or sustaining that resource. In this chapter, we describe how management effectiveness monitoring is applied to the specific case of California's Central Coast MPAs. As its name implies, this type of monitoring investigates the effectiveness of management actions in moving towards management goals.

Management effectiveness evaluations are a critical component of monitoring but are often misunderstood because they do not resemble the most familiar form of monitoring – that of repeated collection of data over time to build a time series. Rather, evaluations of MPA design and management decisions are designed to answer priority questions. These evaluations are akin to research experiments, often requiring hypothesis formulation, methods development, and data collection, analysis, and reporting. In some cases, these evaluations may require new data collection, while in others, they may be best addressed through analyses of existing data and/or application of models that can generate projections of the effects of particular decisions. As with the ecological monitoring described in Chapter 4, management effectiveness evaluations should also include consideration of non-MPA factors, such as other state and federal regulations and/or socioeconomic conditions, on MPA design and management.

IMPLEMENTATION OPTIONS: SHORT- AND LONG-TERM EVALUATIONS

In the context of the MPA planning process, many design and management decisions have already been made. Continued adaptive management of the regional MPA network may include many additional decisions, such as revisions to existing management or policy guidance, or new decisions to address an emerging issue. One current challenge is to understand how to best prioritize potential evaluations in a way that most efficiently applies available resources to inform adaptive management.

As a first step, the monitoring framework identifies two separate categories of management effectiveness evaluations: short- and long-term evaluations (see also Chapter 2). The decision of how a potential evaluation is categorized is based upon the estimated time needed to generate robust scientific information that can confidently be used to inform management decisions. Short-term evaluations are those expected to be completed in one turn of the adaptive management cycle – currently 5 years as recommended by the MLPA Master Plan for MPAs. Long-term evaluations are those expected to take more than one turn of the adaptive management cycle to address. Distinguishing between short and long-term evaluations helps to ensure that some of the long-term questions, which are often more difficult to address, are not omitted from a monitoring program. Allocating some resources to these questions in the near-term ensures that we begin to build a body of knowledge to inform long-term management decisions.

PRIORITIZING EVALUATION QUESTIONS

There are many possible short- and long-term management evaluation questions. When identifying candidate questions, both the decision to be evaluated and the expected response or impact on the marine environment should be carefully and specifically articulated. Once multiple candidate questions are formulated, choosing among them is a matter of balancing multiple priorities and needs. Following are descriptions of five important considerations that can guide prioritization of candidate evaluation questions: management urgency, management applicability, technical feasibility, time required, and cost and value of the information produced (Figure 5-1).

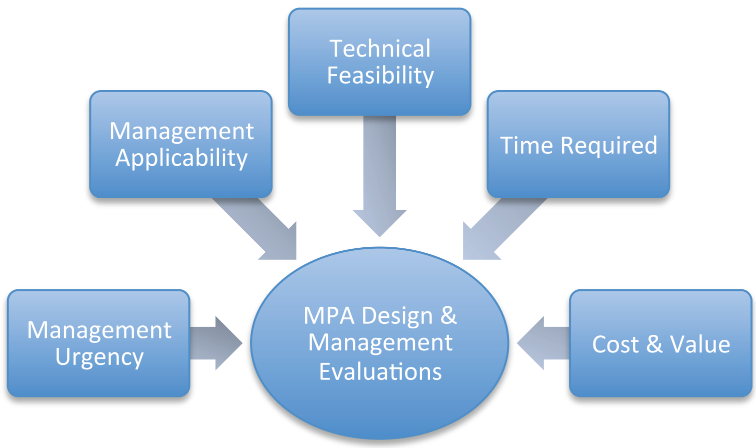


Figure 5-1. *Schematic illustrating the considerations that guide prioritization of candidate questions for MPA design and management evaluations.*

MANAGEMENT URGENCY

Some decisions, or potential decisions, can be informed if scientific evaluation results are available quickly. This is often the case when a resource is at risk or when user conflicts are occurring. Management effectiveness evaluations can help to decide between courses of action currently under debate and evaluate any that are implemented. While this may take several rounds of evaluation, assessments aiding current decisions can help to establish the practice of adaptive management and tailor ongoing MPA implementation to current conditions. For example, increased visitor use of an area may disturb breeding birds, prompting consideration of rules maintaining a certain distance between visitors and birds. Evaluation could test a set buffer between birds and visitors to see if bird disturbance decreases. If disturbances do not decrease, evaluations could test either an increased buffer or a different strategy, such as visitor education.

MANAGEMENT APPLICABILITY

Evaluations of design or management decisions should produce results that are directly applicable to the decision or decisions being evaluated. This means that evaluation questions need to be addressed in a way that is useful to managers, which requires considering the types of findings that will be produced and the timing of those findings. The most applicable questions are framed in consideration of local needs and context. For example, an evaluation of the effects of MPA size could simply characterize MPAs of different sizes in terms of fish populations or active nursery grounds. However, the results of this evaluation could be even more applicable to managers if it provides information on the relationship of MPA size to key elements of the ecology or socioeconomics of the Central Coast region, and if it generates predictions of the effects of different MPA sizes or size ranges. Applicability could also be increased by addressing network or habitat-wide concerns that may inform management in multiple MPAs, rather than decisions related only to a single MPA.

TECHNICAL FEASIBILITY

We must also consider the technical difficulty or feasibility of answering evaluation questions. There may be some questions that are of direct interest to managers, but for which there is simply not adequate capacity or understanding to address in a useful way. For example, our ability to understand larval connectivity to address large scale network questions in often limited by technology and cost. Management evaluation efforts that are considered likely to generate information robust enough to inform management should be prioritized.

TIME REQUIRED FOR ROBUST EVALUATION

Questions requiring more than one turn of the adaptive management cycle to evaluate (currently 5 years as recommended by the MLPA Master Plan for MPAs) should be considered early in order to generate information as soon as possible. For example, MPA design decisions relating to larval connectivity among individual MPAs are likely to take many years to evaluate, reflecting the influence of oceanographic cycles and naturally high variability in larval production and recruitment. These types of questions are sometimes discounted due to the uncertainty associated with working on such a long time scale, but they are extremely important in overall evaluations of MPA network effectiveness. Therefore, all time scales will be considered in planning evaluations of management effectiveness. Both short- and long-term evaluations will be prioritized according to the time required for each stage of the work and how that timeline intersects with management decisions.

COST AND VALUE OF THE INFORMATION PRODUCED

While most evaluations are likely to occupy some middle ground of cost and value, priority should be given to low-cost, high-value projects. Budget justifications and assessments of available resources will be important in evaluating costs, along with information about opportunities to leverage existing resources or data and cost-sharing options (more detail on cost-effectiveness is provided in Chapter 8). Value can be demonstrated or assessed against the criteria described above. For example, documented connections to a pressing management need or concern from the public may be considered in judging the potential value of a proposed management effectiveness evaluation.

MPA DESIGN AND MANAGEMENT DECISIONS IN THE CENTRAL COAST

The implementation of the regional MPA network included many different design and management decisions. Subsequently, significant experience has been gained in monitoring and management during the first 5-year baseline monitoring and adaptive management cycle. New management issues have also surfaced, such as determining how to best consider existing infrastructure within MPAs.

To guide long-term MPA monitoring efforts in the Central Coast, an initial inventory of potential short- and long-term management evaluation questions is included below. Because this monitoring plan is a living document, the inventory should be reviewed and updated together with the monitoring metrics detailed in Chapter 4 as part of the adaptive management cycle. As part of this inventory, a small number of short-term evaluation questions are identified as high-priority for the next phase of MPA monitoring in the region. The inventory and prioritized evaluations were compiled from the following sources:

- During the MPA planning process, science and design guidelines were developed for the Central Coast regional MPA network (e.g., MPA size and spacing, representation and replication of habitat types).[24] In preparing their alternative MPA proposals, members of the Regional Stakeholder Group used these guidelines to make many decisions about other MPA design and planning considerations (e.g., siting and boundary placement of individual MPAs, allowed human uses in each MPA, developing goals and objectives).
- The Central Coast region was the first regional MPA network to be implemented under the MLPA and further experience was gained in subsequent regional MPA planning processes in the adjoining North Central and South Coast regions.[25] Some design and management decisions in these regions, reflected in the monitoring plans for each region,[26] are also relevant to the Central Coast.
- Findings from Central Coast baseline monitoring were synthesized and shared. Baseline monitoring addressed some early management questions and others were raised through analyses of monitoring results,[27] and in discussions at the Central Coast five-year symposium.[28] These findings informed the first five-year management review, prepared by the Department of Fish and Wildlife and presented to the Fish and Game Commission in November 2013, including guidance for management effectiveness evaluations looking forward.[29]
- During January 2014, community gatherings were held through the Central Coast region to learn about local interests and priorities for MPA monitoring. Members of the Central Coast ocean community gathered to share ideas, questions and concerns for potential inclusion in the next steps of MPA (see Chapter 1).
- The draft Central Coast MPA Monitoring Plan was released for public input from May 14, 2014 through June 4, 2014 (see Chapter 1). Input included specific suggestions for management evaluation questions, and the evaluation questions included in the draft monitoring plan were revised in consideration of this input.

SHORT- AND LONG-TERM EVALUATION QUESTIONS

SHORT-TERM EVALUATION QUESTIONS

Short-term questions are those that can be assessed within one turn of the adaptive management cycle. Here, a list of short-term evaluation questions is presented, with prioritization given to the first three questions (denoted by *):

- ***How has compliance changed since the MPAs were first implemented?**
  All partners in MPA implementation recognize that compliance is a key component of management. To increase compliance, MPA managers can engage in education and outreach activities such as placing signs at public access sites to MPAs that describe the boundaries and the restrictions within the MPA, and posting MPA

[24] MLPA Master Plan for MPAs, Chapter 3, California Department of Fish and Wildlife, January 2008: http://www.dfg.ca.gov/marine/mpa/masterplan.asp.
[25] For historical information about the MPA planning processes for each region along the California coast, see: http://www.dfg.ca.gov/marine/mpa/planningprocess.asp.
[26] The South Coast MPA Monitoring Plan is available at http://oceanspaces.org/monitoring/regions/south-coast/planning, and the North Central Coast MPA Monitoring Plan is available at http://oceanspaces.org/monitoring/regions/north-central-coast/planning.
[27] The Central Coast MPA Baseline Program summary report, *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012*, is available at: http://oceanspaces.org/sites/default/files/regions/files/cc_results_report_0.pdf.
[28] Proceedings and videos of presentations from the State of the California Central Coast Symposium are available at: http://oceanspaces.org/monitoring/regions/central-coast/sharing-results.
[29] The adaptive management recommendations from the Department of Fish and Wildlife are detailed in their memo to the Fish and Game Commission, available at: https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=80499&inline=1.

information at kiosks located at public marinas. The role of monitoring is to assess resulting changes in compliance levels and, where possible, to deepen understanding of the relationship between compliance with MPA regulations and enforcement presence, education, or outreach activities. Answers to this short-term evaluation question can provide guidance to MPA managers on increasing MPA compliance.

- ***What is the relationship between MPAs and the displacement, compaction, and concentration of nearshore fishing efforts?**
  Commercial and recreational fishers experience the most immediate and direct impacts of MPA implementation. Understanding the nature and extent of those affects, as well as steps that could ameliorate negative changes would help to ensure that MPAs remain a valued community resource.

- ***What are the ecosystem effects of scientific collecting inside MPAs?**
  Provisions of the MLPA require monitoring and research. Monitoring and scientific activities within MPAs are necessary to understand potential MPA effects, inform management at state and federal agencies, and contribute to an improved understanding of ocean health and dynamics. The Central Coast has a high concentration of marine laboratories and research institutions, many of which conduct monitoring inside of MPAs. At the state level, in order to approve or deny a scientific collecting permit (SCP), the Department of Fish and Wildlife evaluates a proposed project against the goals, objectives, and classification type of an MPA, and ultimately considers whether it is appropriate within an MPA. Determining the scope of cumulative impacts from the effects of multiple SCPs within any one MPA and ensuring that the goals and objectives of the MPA are being met is a management challenge. Currently, Department staff and members of the Ocean Protection Council's Science Advisory Team are developing a risk assessment tool to identify potential cumulative impacts prior to issuing a SCP.

- **Do focal and/or protected species inside of MPAs stay the same or increase in size, numbers and biomass relative to areas of similar habitat adjacent to and distant from MPAs? Do species richness and/or diversity stay the same or increase in MPAs relative to areas of similar habitat adjacent to and distant from MPAs?**
  The first two goals of the MLPA (see Chapter 2 for more details) are to protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems; and to help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted. Evaluating the impacts of MPAs on focal species, and on species richness and/or diversity provides important information to managers (see Appendix A for a discussion of potential connections with fisheries managers). To be answerable as a short-term evaluation question, data collection and analysis should focus on fast-growing and early-maturing species, as these are most likely to respond first to MPA implementation. If focal species are not increasing in size, numbers, and/or biomass relative to similar habitat, or if species richness and/or diversity do not increase in MPAs relative to similar habitat, then an evaluation of the size, location, and regulations within a particular MPA may be warranted. Any potential evaluation should take into account other processes that may impact these metrics, such as physical oceanographic drivers.

- **What changes, if any, can we expect in focal and/or protected species in response to MPA protections?**
  While the previous short-term evaluation question focuses on *observed* changes in focal and/or protected species, this question on *expected* changes. Consideration of expected changes in focal and/or protected species in response to MPA protections has been core to MPA monitoring in the Central Coast. For example, the monitoring metrics in the original Central Coast MPA Monitoring Plan, released by the Department of Fish and Wildlife in 2008, were identified as the species most likely to benefit from MPA implementation in the region. Continued evaluation of expected changes in the vital signs, focal species, and indicators identified in Chapter 4 of this plan

will be valuable in the adaptive management of Central Coast MPAs. Such evaluations will likely rely on modeling studies.

- **Is there a relationship between MPA implementation and the safety of recreational and commercial fishing operations?**
  Implementation of MPAs may result in a shift of fishing from sites that are nearshore to those that are further offshore, with fishermen needing to travel a greater distance from port. At the community gatherings and small group meetings that informed this plan (see Chapter 1), community members expressed concern that changes in fishing sites may result in the exposure of commercial/recreational fishing operations to increased risk. Evaluation of whether potential shifts in fishing sites have changed the safety of commercial/recreational fishing operations is an important management consideration.

LONG-TERM EVALUATION QUESTIONS

Long-term questions need more than one adaptive management cycle to address, largely due to the complexity and dynamism of the marine environment. These questions may require considerable cost-sharing to be feasibly addressed, and are well suited to long-term partnerships between the state, the academic community, and other partners.

Long-term evaluations encompass many different aspects of MPA network design and function. Consistent with the application of the monitoring framework in the North Central and South Coast regions, potential evaluations have been grouped together into categories that represent the major areas of science guidance during the MPA planning process. Each category can include both socioeconomic and ecological evaluations. It is also worth noting that long-term evaluations are not intended to question the accuracy of the original science guidance but rather to ensure continued relevance to current conditions and refinement based on experience following MPA implementation. In addition, the questions listed in each category should be considered as starting points for discussion only, as considerable focusing and refinement would be required to design effectiveness studies to answer them.

SIZE AND SHAPE

Based on scientific information about the movement patterns of multiple species, the MLPA Master Plan for MPAs recommends that MPAs extend a minimum of 3–6 miles along the coastline, and that "larger MPAs, spanning 6–12.5 miles of coastline, are probably a better choice given current data on adult fish movement patterns". The MLPA Master Plan for MPAs also gives guidance on shape, noting that MPAs should extend from the intertidal to deeper offshore to accommodate the movement of species between shallow nursery or spawning grounds and deeper adult habitats, and to protect the diversity of species that live at different depths. Taken together, these MPA size guidelines were developed to provide for the persistence of bottom-dwelling fish and invertebrates within MPAs.[30] Since the Central Coast is composed of a patchwork of habitats, size and shape recommendations should be locally tailored for priority concerns within the geographic and oceanographic context.

Evaluations of the size and shape guidelines, as implemented, will be particularly useful if they reveal thresholds or discontinuities in the responses of Ecosystem Features, or feature components. Evaluations of the effects of size are likely to rely on a combination of modeling and empirical assessment, and may be facilitated by including MPAs from several MLPA regions.

[30] MLPA Master Plan for MPAs, Chapter 3, California Department of Fish and Wildlife, January 2008: http://www.dfg.ca.gov/marine/mpa/masterplan.asp.

- What is the relationship between the alongshore span of an MPA and the protection afforded to organisms with different home range sizes, movement patterns, and pelagic larval durations?
- Is "spillover" of fishery species related to MPA size? If so, what are the implications for designing MPAs to achieve ecosystem protection and potential benefits to fisheries?
- If fishing occurs along the boundaries of MPAs, what are the effects on species and communities inside MPAs of different sizes and how does this relate to MPA size?
- Are there differences in ecosystem responses (e.g., types and rates of changes observed) among MPAs of different sizes? Are there thresholds or discontinuities in the ways in which ecosystems respond that are a function of MPA size, and what are the implications for network design? In particular, are there differences between ecosystem responses in MPAs that do and do not meet the minimum size recommended in the science guidelines?
- Does the shape of an MPA allow for protection of both shallow nursery or spawning grounds and deeper adult habitats? Does the diversity of species present within an MPA vary between those that encompass both intertidal and deep habitats and those that do not?

SPACING

The science guidance on MPA spacing,[31] meaning the recommended distance between adjacent MPAs, is based on analysis of scientific information about the larval dispersal distances of various marine organisms. The MLPA Science Advisory Team recommended spacing MPAs approximately 31-62 miles apart to be within the larval dispersal ranges of important bottom-dwelling fish and invertebrate groups. As with the questions above, evaluations of the effects of MPA spacing are likely to rely on a combination of modeling and empirical assessment, and may be facilitated by including MPAs from several MLPA regions.

- What are the effects of different inter-MPA distances on connectivity between MPAs, either through larval exchange or movement of adults?
- Is there a relationship between the distance between replicate habitat types and recruitment? Does the relationship differ for species with dissimilar pelagic larval durations (PLDs)?
- How does the distance between an MPA and an external 'source' of, for example, juveniles or larvae, influence ecosystem responses (e.g. types and rates of changes observed) inside an MPA?

HABITAT PROTECTION

The MLPA Master Plan for MPAs suggests that all key habitat types should be protected in MPAs with three to five replicates of each habitat type per biogeographic region. The Central Coast also has a number of unique features that motivated implementation of MPAs that should continue to be covered by MPA designations. These features include large submarine canyons, rare estuaries, renowned diving and whale-watching locations, giant kelp forests, and research areas associated with marine science and education institutions.

Habitat representation is widely used in MPA planning as a proxy for different biological communities, based on the knowledge that different species and biological communities are associated with different habitats and that many species are dependent on different habitat types at different stages of their life cycles. Evaluations of design decisions relating to habitat representation can thus range from assessment of the extent to which MPAs do include the identified habitat types (e.g., through detailed mapping) to evaluation of species-habitat relationships to assess the extent to which the identified habitat types are associated with different species, life stages, or biological communities.

[31] MLPA Master Plan for MPAs, Chapter 3, California Department of Fish and Wildlife, January 2008: http://www.dfg.ca.gov/marine/mpa/masterplan.asp.

- How are the MPAs used by species that inhabit shallow nearshore habitats when young and move to deeper habitats as adults, and what are the implications for the offshore extent of MPAs?
    - What role do deep water habitats play in larval transport?
- Are there differences in ecosystem responses (e.g., types and rates of changes observed) between MPAs in which habitats are contiguous and those with similar but patchily distributed habitats?
- Is 'spillover' of fishery species affected by habitat continuity across MPA boundaries, and what are the implications for designing MPAs to achieve ecosystem protection and potential benefits to fisheries?
- In MPAs that meet the minimum size guidelines, do species and communities associated with specific habitat types exhibit different responses (e.g., types and rates of changes) based on how much of their preferred habitat is represented in the MPAs?
- Are there unique habitats that contribute significantly to the biodiversity of the region that are not represented in the MPAs or identified key habitats?
- Do recruitment rates of selected species change over time inside versus outside MPAs in different habitats? Does this recruitment affect adult abundance? Do reserves retain large, mature, fecund adults?

PLACEMENT AND SITING

In designing proposed MPA networks for the Central Coast region, stakeholders considered where MPAs were located relative to unique habitat features and important human activity locations. Stakeholders considered the potential effects of MPA siting on, for example, types and levels of human activity inside MPAs, and enforcement of and compliance with MPA regulations. Stakeholders also considered how siting MPAs could enhance or reduce MPA network connectivity.

- What are the population effects of siting MPAs in larval source or sink locations, and what are the implications for MPA network design?
- Are there different ecosystem responses (e.g., types and rates of changes) between MPAs that are and are not co-located with Areas of Special Biological Significance (ASBSs)? What, specifically, is the role of water quality protections offered by the ASBSs in the protections offered by MPAs?
- Are there different ecosystem responses in populations of commercially and recreationally regulated fish species between MPAs that are and are not co-located with other protected areas (e.g., rockfish within and outside of the Rockfish Conservation Areas; other state and federally-regulated areas)?
- What are the effects on visitation and associated recreational opportunities of siting MPAs adjacent to public versus private land, or adjacent to recreational access points including ports and harbors?
- How has non-consumptive use and enjoyment of MPAs changed since implementation? Has the public's perceived value or desire to visit MPAs changed?

MARINE PROTECTED AREA DESIGNATIONS

The Central Coast includes a mosaic of different kinds protected waters in the MPA network, where activities are restricted according to the level of protection deemed necessary to protect the resources in a particular location. These include State Marine Reserves (SMR) which prohibit all take and consumptive uses except for research activities, State Marine Conservation Areas (SMCA), which allow select recreational and commercial take, State Marine Parks (SMP), which allow select recreational take, and State Marine Recreational Management Areas (SMRMA), which allow subtidal protection equivalent to an MPA while allowing legal waterfowl hunting. These designations in many cases overlap federal designations of NOAA Marine Sanctuaries (Monterey Bay), NOAA Fisheries Rockfish Conservation Areas, NOAA Essential Fish Habitat, National Estuarine Research Reserves (Elkhorn Slough), National Estuary Programs (Morro Bay), and local or state parks.

- Are there differences in ecosystem responses (e.g., types and rates of changes) between MPAs with different levels of protection?
- Are there differences in ecosystem responses (e.g., types and rates of changes) between MPAs that do and do not allow fishing?
- Do SMR/SMCA clusters provide greater protection than stand-alone SMRs, for example through a "buffer" effect?
- Does the level of compliance differ between SMRs and SMCAs?
- What is the relative effectiveness for the designated levels of protection?
- In regions where MPA designations have resulted in changes in consumptive and non-consumptive human uses, have there been a related changes in wildlife behavior?

6. Reporting Monitoring Results

- Sharing monitoring results: a core responsibility
- Guiding principles
- Lessons from baseline monitoring
- Looking forward

The technical aspects of designing and implementing MPA monitoring are only valuable if the results of monitoring are shared in useful ways. Thus, the process of sharing monitoring results will be a core part of the Central Coast MPA Monitoring Program. Sharing monitoring results includes making raw data accessible, synthesizing results through analysis and expert judgment, and communicating in a variety of forms to a wide range of audiences. It also includes the development of processes, capacity, and technological infrastructure to support those activities. Sharing results is an important first-order consideration in the design and implementation of all aspects of Central Coast MPA monitoring. This chapter discusses the principles that will guide us in sharing monitoring results, and the key resources and tools that we can bring to bear on this activity.

SHARING MONITORING RESULTS: A CORE RESPONSIBILITY

The MLPA Master Plan for MPAs recognizes that sharing monitoring results is a critical component of adaptive management. It calls for communication of results "to decision-makers and the public in terms that they can understand and act upon." In other words, it is not enough to simply pass data along to MPA managers. The process of sharing monitoring results should include consideration of the broad array of partners, decision makers, and other communities that have a stake in monitoring results and MPA management. This is also reflected in The California Collaborative Approach: Marine Protected Area Partnership Plan (MPA Partnership Plan),[32] which calls for broad participation in MPA implementation across communities. By making monitoring results widely accessible and useful, we are not just delivering on a mandate; we are building a foundation for participatory, broadly inclusive assessment and evaluation of MPAs, and for science-informed decision making for California's oceans.

Like other aspects of MPA monitoring and management, the approach to sharing the results of Central Coast monitoring will continue to evolve over time. It must be tailored to the needs of managers and other audiences, appropriately use evolving technology and media, build on lessons learned across the MLPA regions, and rely on partnerships.

GUIDING PRINCIPLES

Although the sharing of monitoring results will evolve over time, a set of durable principles guides this activity. As described below, these principles are rooted in best practices for effective communication and the mandate to promote broad accessibility and usability of monitoring data and results.

TRANSPARENCY OF ANALYSIS AND REPORTING

The Central Coast MPA Monitoring Program should provide a transparent account of how monitoring results are generated, the information and data used to arrive at those results, and associated measures of error or uncertainty. This includes the monitoring methods themselves, as well as the steps followed to generate information products based on monitoring data.

[32] The California Ocean Protection Council is leading the development of *The California Collaborative Approach: Marine Protected Area Partnership Plan* (MPA Partnership Plan). The Partnership Plan is planned to be incorporated into the MLPA Master Plan for MPAs. More information is available at the Ocean Protection Council website: http://www.opc.ca.gov/.

For example, in the State of the Central Coast report of results from the Central Coast MPA Baseline Program,[33] a reader can follow links from individual figures and charts back to the data that informed them, which are freely available on OceanSpaces.org. Online data include descriptions of methods and protocols and important metadata to facilitate independent analyses by anyone with an interest.

In addition to data, transparency should apply to the process of developing and sharing the results of MPA monitoring. From technical review to expert judgment and public input processes, there are many mechanisms that can be brought to bear on information products as they are developed. It is not always possible to share everything about these processes. For example, in some cases, the names of participants must be withheld as part of anonymous scientific peer review. However, in all cases we strive to communicate clearly and openly about the process of sharing monitoring results.

AVAILABILITY AND ACCESSIBILITY OF DATA

Ensuring that the results of monitoring are available and accessible is important, both for meeting state requirements, and for realizing the broadest possible value of MPA monitoring activities. The primary venue for posting Central Coast monitoring data will continue to be OceanSpaces.org, where data from the Central Coast MPA Baseline Program are already available.[34]

While data availability is an important goal, in specific cases we must make provisions for sensitive and confidential information such as fishing locations, endangered species locations, or personal identity of participants in surveys and interviews. Access to these types of data can be addressed through non-disclosure agreements administered by agencies and institutions such as the Department of Fish and Wildlife and universities, data aggregation, or anonymization of observations. In such cases, we will communicate about those limitations openly.

INTUITIVE AND USEFUL REPORTING

Reporting tools and summaries should be tailored to specific audiences in terms of timing, framing of the information, and the intended use of the data. It is not enough to make raw data available, or to provide simple lists of analytical results. Considerable time and effort must be devoted to presenting monitoring findings in useful ways. Later in this chapter, we describe the range of approaches that have been taken in the Central Coast and elsewhere, which includes reports, events, and platforms to support dialog within and across communities.

In addition to developing a range of tools, we must also carefully consider the timing and focus of manager needs. Sustained engagement of agency staff (e.g., the Fish and Game Commission and Department of Fish and Wildlife) helps to shape effective delivery of monitoring results and set reasonable expectations within the management community that will use those results in implementing the MLPA.

USE OF EXPERT JUDGMENT

Evaluation of the performance of individual MPAs and the MPA network means assessing the condition or health of the Ecosystem Features (described in Chapters 3 and 4) inside and outside of MPA boundaries. Such assessments require expert judgment.

[33] The Central Coast MPA Baseline Program summary report, *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012*, is available at: http://oceanspaces.org/sites/default/files/regions/files/cc_results_report_0.pdf.
[34] Data collected as part of the Central Coast MPA Baseline Program are available at: http://oceanspaces.org/data.

Expert judgment, also referred to as 'best professional judgment', is used in a variety of fields, including risk assessment, decision sciences, resource management and regulatory decision-making. The term refers to a process leading to assertions based on specialized knowledge or experience. In the case of MPA monitoring, expert judgment is an essential tool; what indicators to select, what monitoring projects to implement and how to interpret data are all decisions requiring expert judgment.

There are many ways to structure an expert judgment process and represent its results. Natural resource managers have tried a wide variety of approaches, guided by factors such as management need, governance issues, available resources, or complexity of the scientific problem. Through background research, a series of interviews with practitioners, and workshops, the Ocean Science Trust has compiled a variety of lessons learned and other guidance on conducting expert judgment processes. This guidance is organized into a framework that includes recommendations for good-practice in planning and executing an expert judgment process. [35] This framework will be applied in the Central Coast MPA Monitoring Program, including the processes to develop and share monitoring results. The expert judgment framework provides helpful guidance based on lessons learned, but it does not prescribe a specific process. Further planning and pilot projects will be necessary as we work toward a system that can be used consistently for MPA monitoring across regions over the long-term.

ADAPTING AND PLANNING OVER THE LONG-TERM

Although any particular event, information product, or technology for sharing monitoring results is a reflection of its current context, we must also consider the goal of sustaining a monitoring program and sharing results over the long-term. This means developing reporting tools that can not only meet current needs, but also evolve over time as needs change. For example, a graphical report card system reporting on the health of particular Ecosystem Features may be instructive and useful the first time it is used. But if that system is used over years or decades, gaining credibility among scientists and managers, and serving a growing audience that has come to intuitively understand, respect, and trust the data that it represents, the potential success is far greater. This kind of sustainability requires flexibility and long-term thinking and acceptance.

LESSONS FROM BASELINE MONITORING

Approaches to sharing monitoring results will evolve over time and can build from what we learn in the Central Coast and in other regions. Included below are brief descriptions of approaches taken to sharing monitoring results as part of the Central Coast MPA Baseline Program.

STATE OF THE CENTRAL COAST REPORT

Sometimes referred to as the "e-book," or "the glossy," this report presents key findings and high-level summaries from the Central Coast MPA Baseline Program. It was produced in both hard copy and electronic forms and aimed at a general audience. The electronic version includes dynamic data visualizations, figures with links to access underpinning data, and the ability to track user interest through page-view data. A document like the State of the Central Coast report serves as a useful record or time-stamp of key milestones, in this case the culmination of the Central Coast MPA Baseline Program. As is evident in this updated plan, the report serves as a useful reference as monitoring in the region evolves over time.

[35] For more on lessons learned, and best practices for using expert judgment to inform natural resource management, see the Ocean Science Trust's handbook on expert judgment, *Putting the Pieces Together*, at: http://calost.org/science-advising/?page=expert-judgment.

THE CENTRAL COAST SYMPOSIUM

At the end of the baseline monitoring period, researchers, managers, and a wide range of other stakeholders came together to share, discuss, and build upon the results of the Central Coast MPA Baseline Program at the three-day State of the California Central Coast Symposium. Baseline researchers shared key findings alongside a variety of other scientists, resource managers and engaged community members, reflecting not only the foundation that the baseline program has built, but also the great potential for the next phase of monitoring in this region. An event like this provides a valuable opportunity to organize a community around a shared understanding of monitoring results, and to understand different perspectives on policy and other issues.[36]

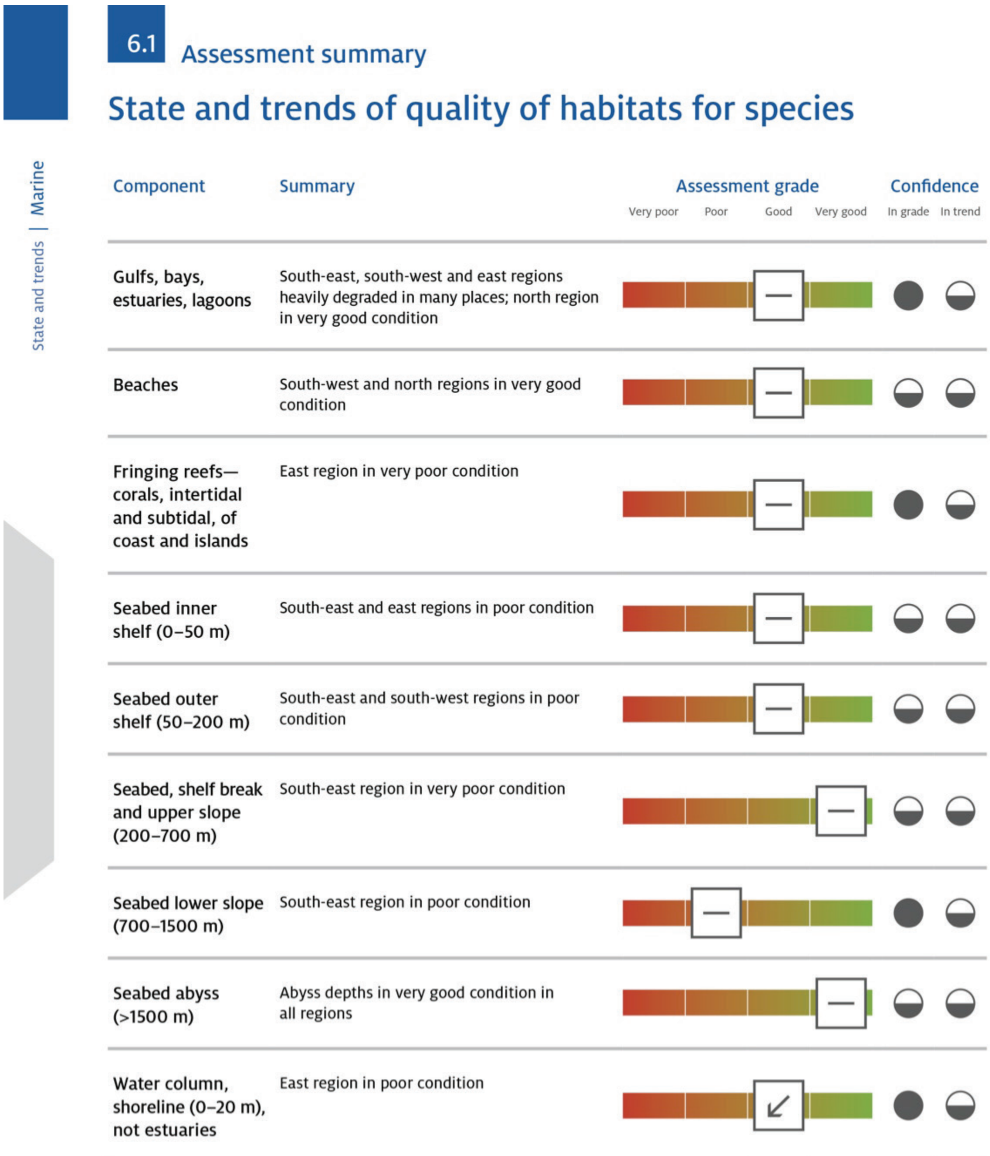
OCEANSPACES.ORG

OceanSpaces.org, an online community that fosters new knowledge of ocean health, will continue to serve as an important venue for sharing MPA monitoring results and processes in a variety of forms. While important documents and raw data can be accessed on OceanSpaces.org, this is only part of the role that the site plays in sharing monitoring results. Any individual or organization can also communicate, create, and share information with a broader community of people with a stake in the health of California's oceans on OceanSpaces.org. An online community is potentially more dynamic than a report, with far greater capacity for sustained interaction than an event such as the Central Coast symposium. However, ongoing effort and investment are needed to grow and foster a community of engaged users.

LOOKING FORWARD

Drawing on the principles described above and from lessons learned during the baseline period, the Ocean Science Trust is working toward a reporting tool that can serve decision makers' needs for robust, highly synthesized MPA monitoring results. Figure 6-1 shows an example of a reporting tool, which uses a grading system represented through a color bar to depict habitat or ecosystem condition, and other symbols to represent uncertainty and confidence in the assessment. There is also flexibility for providing narrative context and an account of underlying data and analyses. As outlined above, developing a reporting tool such as this requires careful consideration of issues such as transparency, timing, and framing. It also requires a robust expert judgment process that can be implemented consistently and efficiently across regions, and over multiple cycles of adaptive management. Ocean Science Trust will work closely with its state partners at the Ocean Protection Council and the Department of Fish and Wildlife, and with a wide range of other experts to explore approaches for developing a report card system that applies the principles outlined above.

[36] Proceedings and videos of presentations from the State of the California Central Coast Symposium are available at: http://oceanspaces.org/monitoring/regions/central-coast/sharing-results.



6.1 Assessment summary

State and trends | Marine

State and trends of quality of habitats for species

Component	Summary
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

Figure 6-1. *One example of the style of report card that may be useful for reporting MPA monitoring results in California. This example comes from the 2011 Australia State of the Environment report, available at: http://www.environment.gov.au/science/soe/2011. For an additional discussion of expert judgment and reporting tools, see the Ocean Science Trust's handbook on expert judgment, available at: http://calost.org/science-advising/?page=expert-judgment.*

7. Developing Monitoring Partnerships

- Building a partnerships approach
- Potential MPA monitoring partners and collaborators
- Opportunities beyond MPA monitoring

Cost-effective, sustainable monitoring is not possible without partnerships. Building a monitoring program in isolation would be prohibitively expensive and, given the extensive monitoring activity that is already occurring throughout the Central Coast, it would involve considerable duplication of effort. This chapter describes our philosophy, intent, and general principles for MPA monitoring partnerships. The information outlined in this chapter is a cornerstone for building a monitoring program in the region (see Chapter 8 for a description of the process underway to build a partnerships-based monitoring portfolio in the Central Coast).

BUILDING A PARTNERSHIPS APPROACH

As was demonstrated in the State of the Central Coast Symposium in February 2013, and further supported during a series of community gatherings held throughout the Central Coast in January 2014, this region is home to an extensive array of ocean and coastal expertise and scientific activity.[37,38] Through partnerships, we leverage resources, avoid duplication of effort, expand the community of people and organizations involved in monitoring, and multiply opportunities for monitoring results to inform processes beyond MPA management. We explicitly acknowledge that partnerships built by a community of people and institutions that are committed to actively stewarding and participating in the MPA network, and/or who have a stake in the MPA network, are crucial to establishing and maintaining a monitoring program over time.

Our approach to partnerships is aligned with the MPA Partnerships Plan for statewide implementation of the MLPA.[39] The Partnership Plan is an overarching guidance document, developed under the leadership of Ocean Protection Council, which advances a shared vision of linking agencies and organizations across geographic and jurisdictional scales. An important component of this approach is a network of statewide County Collaboratives, which are rapidly becoming an important cross-cutting institutional resource for tapping into existing energy, expertise, and resources at the local scale.

Partnerships may focus on, but are not limited to, data collection, data sharing, interpretation of results, dissemination of results, or integration of monitoring with decision making. As we pursue a partnerships approach, it is important to acknowledge the presence of and need to respect the differing priorities and mandates that each program in a partnership may have. Each partnership takes shape with different levels of formality, resource- and knowledge-sharing, duration, and scope, depending on opportunities and mutual interest. As a result, while partnerships have great potential to increase efficiency and cost-effectiveness, each one requires both a carefully tailored approach that considers mutually beneficial outcomes, and establishment of trust and shared understanding.

[37] Proceedings and videos of presentations from the State of the California Central Coast Symposium are available at: http://oceanspaces.org/monitoring/regions/central-coast/sharing-results.
[38] For a summary of key themes shared during these community gatherings, visit http://oceanspaces.org/sites/default/files/regions/files/cc_communitygatherings_keythemes_final.pdf.
[39] The California Ocean Protection Council is leading the development of *The California Collaborative Approach: Marine Protected Area Partnership Plan* (MPA Partnership Plan). The Partnership Plan is planned to be incorporated into the MLPA Master Plan for MPAs. More information is available at the Ocean Protection Council website: http://www.opc.ca.gov/.

POTENTIAL MPA MONITORING PARTNERS AND COLLABORATORS

MPA monitoring in the Central Coast and in other regions has included a wide variety of partners in the past, such as universities, citizen science groups, non-governmental organizations, fishermen, tribal governments and communities, and federal and state agencies. Now that the Central Coast MPA Baseline Program is complete, the range of collaborators is only expected to grow in the future as we pursue both a wider variety of monitoring questions (such as those associated with management effectiveness), and opportunities to inform additional management dialogues (such as fisheries and climate change). As mentioned above, partnerships are not just focused on the technical work of gathering data; they can also focus on, for example, sharing of data and results, and development and dissemination of products.

Based on experiences in the Central Coast MPA Baseline Program and recent engagement with organizations and communities throughout the region, we have begun to develop guidelines for working in productive partnerships with a variety of groups. These guidelines are beneficial to both MPA monitoring and the groups' priorities. We will abide by these guidelines in building and launching the next phase of monitoring in the region (see Chapter 8) to maintain these partner relationships.

COMMERCIAL AND RECREATIONAL FISHERMEN

The potential for valuable scientific contributions from fishermen is widely recognized in marine science and management. Partnerships with commercial and recreational fishing groups can tap a rich source of contemporary and historical knowledge about ocean ecosystems. At the same time, fishermen can gain from increased involvement in, and access to, ecological, social, and economic data collection. With extensive—and most often daily—time spent on the water, fishermen tend to speak from a livelihood perspective that can align well with stewardship goals. Fishermen also have a considerable stake in MLPA implementation and in understanding MPA effects on marine fisheries and ecosystems.

In baseline monitoring in the Central Coast and in other regions, recreational and commercial fishermen have actively shared their knowledge and collaborated with scientists in a variety of ways. Fishermen have collected data, informed experimental design, aided data analysis and interpretation, and responded to surveys aimed at understanding consumptive use patterns. This is a strong foundation on which to build, and we are interested in exploring how to strengthen these activities and seek out additional roles that fishermen want to play in MPA monitoring. At community gatherings and other meetings that informed this plan, commercial and recreational fishermen stressed their historical perspective as a potential means both to address concerns about shifting baselines, and to build long-term data sets around species of interest.

There are a number of principles that should guide partnerships that involve fishermen in MPA monitoring:

- Dedicate time to understand fishermen's needs and interests related to monitoring and information gathering, and commit to working with established leadership in fishing communities.
- Develop shared expectations based on trust, respect, and mutual understanding and interests.
- Respect privacy and the opportunity costs of participating in monitoring projects.
- Design collaborations that work toward the mutual benefit of all parties involved.
- Consider and articulate approaches for exchanging information, particularly sensitive and protected data.

There is still a need to distill lessons from experiences in California and elsewhere about the best approaches to establishing meaningful and productive monitoring partnerships with commercial and recreational fishermen. In the Central Coast, as in other regions, we will maintain open lines of communication and continue to work with fishermen to help determine the best way forward.

TRIBAL GOVERNMENTS AND COMMUNITIES

Central Coast tribes have a long history of stewarding natural resources in support of tribal coastal communities. Local tribes hold in-depth knowledge about the region and its natural environment that is both unique and worthwhile. Partnering with tribes that express a desire to collaborate in monitoring can help to acknowledge, represent, and value traditional ecological knowledge (TEK) in monitoring and management activities, which in turn can strengthen our mutual understanding of the local ecology. Effective partnerships with tribal governments can ensure that MPA monitoring informs both tribal governance and the management needs of California. This adds efficiency and cooperation to the region's decision-making. Fundamentally, partnerships with tribes will help to ensure that MPA monitoring respects and values tribal rights and traditions, which is in line with the tribes' role as stewards of land and ocean resources.

There are a number of tribal governments and communities throughout the Central Coast, each with a different capacity and desire to engage with MPA monitoring and other marine resource issues, as well as differences in governance structures and traditions. As requested by those tribes we have met with, the first step to effective tribal partnerships is learning more about each Central Coast tribe while creating the space for tribal leaders to decide how they wish to engage in the MPA monitoring process.

The Ocean Science Trust continues to actively building partnerships with tribal governments and we respect the potential range of desires and capacities to engage with MPA monitoring. Our initial discussions have illuminated multiple types of potential partnerships. For example, there is an opportunity for broader dissemination of monitoring results to inform ocean stewardship decisions by tribal governments. The foundation for this kind of partnership was laid during the community meetings that informed the development of this plan. Tribal leaders will continue to be invited to share input about Central Coast MPA monitoring, and should be involved in communicating key results.

We welcome continued dialogue to understand and incorporate tribal monitoring priorities, indicators, and approaches. It is our intention to make the resulting monitoring data as helpful as possible for tribal research and management activities. We will continue to reach out to tribal partners to ensure that other approaches are valued appropriately and that, to the extent possible, research methods incorporate and are compatible with tribal practices (i.e. employing a no-waste approach to lethal fish sampling, establishing pathways for non-sampled fish parts to be used).

There is also potential for partnerships that are centered on management effectiveness evaluations (see Chapter 5). These evaluations should also include tribal concerns, as determined through regular communication with tribal leaders. This is already underway, as input from the community gatherings and conversations with local tribal governments informed the development of short- and long-term evaluation questions (see Chapter 5).

We respect and acknowledge the importance of both developing the most appropriate forums for establishing relationships with Central Coast tribes, and exploring appropriate ways to share mutually beneficial information, as appropriate. We will continue to reach out to Central Coast tribes and together develop approaches and guidelines for information exchange, delivery, and publication.

As we continue to build relationships with tribal governments, we will seek to uphold the following principles for partnership and collaboration on monitoring:

- Dedicate time to understand the needs and interests of Central Coast tribes related to monitoring, information sharing, and ocean conditions and health.
- Develop shared expectations based on trust, respect, and mutual understanding.
- Design partnerships that work toward the mutual benefit of all parties involved.

- Consider and articulate approaches for partnership, including those focused on the sharing of information, particularly sensitive and protected data.
- Respect and, as possible, incorporate multiple environmental worldviews and approaches to knowledge gathering.
- Conduct integration of any traditional knowledge into monitoring in partnership with Central Coast tribes.

CITIZEN SCIENCE

The term "citizen science" describes a wide array of activities that partner community members and professional scientists in scientific inquiry. Though the concept of citizen science is not new, it has recently grown in popularity, visibility, and diversity. This trend is linked to new technologies, efforts to increase science literacy, and increasing recognition of the useful and rigorous data that citizens can generate. Citizen science programs are valuable beyond data collection because they provide educational and study opportunities for the public to participate in MPA monitoring, helping to meet a core goal of the MLPA (see Chapter 2).[40]

Citizen science offers a spectrum of options for non-professional scientists to get involved in MPA monitoring. We can already point to baseline monitoring projects across MPA regions that have involved citizen scientists. From volunteer divers collecting data on rocky reefs to high school students investigating sandy beach and rocky intertidal systems, the programs range widely in their scientific approach, the volunteer communities who participate, and their overall structure and mission.

Going forward, there may be more opportunities to involve citizen science programs in MPA monitoring. The Ocean Science Trust's California Citizen Science Initiative (CCSI) has identified more than 30 individual citizen science projects or programs focused on coastal and ocean issues in the Central Coast. Not all of these programs will be a good fit for MPA monitoring partnerships. For example, some may not focus on issues of direct relevance to the monitoring framework, and some may not see a benefit in working directly on MPAs. Others may simply be unable to operate at the scale or level of technical detail needed for the Central Coast MPA Monitoring Program. However, there may be untapped potential for cost-effective and mutually beneficial collaboration beyond the groups that have already played a role in MPA monitoring.

The CCSI is exploring the challenges and opportunities for engaging Central Coast citizen science groups. The final results of this initiative will include a guidance document, developed collaboratively with citizen science practitioners, that details best practices for establishing partnerships. The guidance document is currently under development and will be completed alongside the initial steps to build a monitoring program in the Central Coast.[41] Three preliminary guidelines for partnering with citizen science in the Central Coast include:

- Assess resource needs carefully. There is strong potential for cost-effective monitoring through citizen science, including cost-savings over other approaches. However, we must avoid the common misconception that citizen science is free. Even volunteer-based programs require extensive support. Volunteer coordination is a time-intensive activity, and independent citizen science groups often lack the infrastructure and technical capacity that might be taken for granted in larger professional research organizations (e.g. data management, analytical capacity, and computing facilities).
- Support innovative ways to ensure scientific credibility and rigor. There are many examples of citizen scientists producing highly rigorous, credible data and research. However, assessing the credibility of citizen science—from experimental design and implementation to analysis and reporting—can be a challenge. There are many different

[40] Goal 3 of the MLPA is to "Improve recreational, educational, and study opportunities provided by marine ecosystems…" California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3).
[41] The guidance document will be available in late summer 2014. Visit http://oceanspaces.org/project/california-citizen-science-initiative to access the guidance document and for information about the Citizen Science Initiative.

ways to deal with this challenge, but working with citizen science programs may in some cases involve a preliminary step of establishing measures for ensuring adequate scientific standards.

- Build partnerships around the needs of the citizen scientists, and the citizen science program. Each citizen science program involves a particular recipe for success: what brings in new volunteers, and what keeps existing volunteers engaged? What is the balance of goals such as education, stewardship, and scientific progress? Partnerships should be sensitive to these considerations, while also focusing on the priorities for Central Coast MPA monitoring.

STATE AND FEDERAL AGENCIES

A variety of state and federal agencies already conduct research and monitoring that overlaps with the goals and framework of MPA monitoring. In the Central Coast region, the Monterey Bay National Marine Sanctuary has a long-standing protected area monitoring program and deep expertise in monitoring, data management, and information sharing. Other areas of potential partnerships include fisheries monitoring by federal, state, and private organizations, water quality monitoring by the State Water Resources Control Board (focused on Areas of Special Biological Significance), and federal monitoring conducted by Morro Bay National Estuary Program and Elkhorn Slough National Estuarine Research Reserve. We will work to build mutually beneficial partnerships with government entities, which can involve collaborations ranging from the alignment of indicator selection processes to the analysis and sharing of monitoring results. Federal, state, and local agencies and commissions also make decisions based on their staff's research and scientific results from partners. Research and monitoring and informing decision-making constitute two types of partnerships with governmental organizations.

ACADEMIC INSTITUTIONS AND OTHER RESEARCH ORGANIZATIONS

As a driving force in our evolving understanding of ocean condition and health, academic researchers (including those from universities, government laboratories, non-governmental organizations, and private industry) have played, and will continue to play, a crucial role in MPA monitoring. In addition to considerable capacity to conduct monitoring and work with monitoring data, this community brings cutting-edge ecological thinking (see Chapter 4), and novel institutional arrangements that can improve the way in which monitoring is conducted. In some cases, multi-institution consortia and other networks throughout the state (and throughout the West Coast) can be of particular value by facilitating a unified approach to issues such as experimental design, analysis, and data management.

While baseline MPA monitoring has already benefitted immensely from productive partnerships with academic researchers, there are opportunities to build on that success. University students -- particularly at the Masters and Ph. D. level -- represent a potentially immense and largely underutilized resource for MPA monitoring throughout the state. Academic researchers also have the potential to tap large financial resources such as federal funders. Substantively linking proposed research directly to a state priority such as MPA monitoring can be mutually advantageous by improving chances of a successful proposal and increasing the resource pool contributing to the implementation of this plan. In our evolving partnerships with academic researchers we will work to realize more of these opportunities.

OPPORTUNITIES BEYOND MPA MONITORING

We must also consider partnerships that extend beyond the scope of the MPA monitoring described in this plan, but that may inform or be informed by MPA monitoring. Some such partnerships may include water quality, climate change, or fisheries management, each of which is described below. While these issues and the many kinds of science and monitoring associated with them are not addressed explicitly in the MLPA, they are important considerations for MPA monitoring for three reasons: First, research and monitoring associated with issues outside the scope of the MLPA may help in the interpretation of MPA monitoring data and results. Second, there may be significant overlap in the kinds of information needed to satisfy monitoring requirements across issues such as water quality and fisheries management, and we must work to avoid duplication of effort. Third, MPAs and MPA monitoring have an important role to play in advancing California's work on issues such as fisheries management and climate change. MPA monitoring should be designed with these opportunities in mind.

OCEANOGRAPHY, WATER QUALITY, AND OTHER CONTEXTUAL DATA

Contextual data, which include data from physical oceanographic (i.e., temperature and currents), water quality, and atmospheric monitoring, are very important in analyzing and interpreting the results of MPA monitoring. Contextual data provides information about physical drivers that may affect ecosystem health, such as El Niño and La Niña, climate change, upwelling, and large oceanic currents. This data is key to putting observed trends in perspective and considering non-MPA drivers of change in analysis of MPA monitoring data. Contextual data may also help to connect relatively local MPAs or regional MPA networks to global-scale effects and processes. The Central and Northern California Ocean Observing System (CeNCOOS) played a key role in Central Coast baseline monitoring and the reporting of monitoring results by providing a description of physical oceanographic dynamics during the baseline period.

In addition to physical oceanographic data (i.e. temperature and currents), data on water quality, weather, and climate may be helpful in understanding the condition of ocean ecosystems, and the role that MPAs play in a complex system. Some individual MPAs in the Central Coast are co-located with Areas of Special Biological Significance – protected areas monitored and maintained for water quality by the State Water Resources Control Board.[42] This co-location of MPAs and Areas of Special Biological Significance provides an important opportunity for coordinating data collection, analysis, and interpretation.

FISHERIES MANAGEMENT

MPA management and fisheries management have many points of overlap, as exemplified in the Marine Protected Areas and Fisheries Integration Workshop, which was convened by the Department of Fish and Wildlife in 2011.[43] However, there are important differences between the scope of monitoring and the ultimate information needs of their associated monitoring programs. The MPA monitoring framework focuses on ecosystem-based monitoring inside and outside of individual MPAs, the regional MPA network, and the region itself. In contrast, fisheries monitoring has traditionally focused on individual stocks of fished species and their status, or the status of fisheries targeting them. Thus, while MPA monitoring often takes a multi-species, place-based approach, focusing on individual MPAs and then scaling up to regional network effects, fisheries monitoring generally focuses on one of a few local target species populations and then scales up to broad regional populations or stocks. Both MPA monitoring and fisheries monitoring may include information on species life history characteristics and changes in fishing locations and impacts to fishermen. Despite differences in framing, scale, and purpose of the two monitoring types, there are important opportunities for coordination and collaboration between MPA monitoring and fisheries management.

Among the many possible intersections between MPA monitoring and fisheries management, there are two main themes: ecology and socioeconomics. In both cases, there is potential for data sharing and there may even be opportunities for

[42] More information about the Areas of Special Biological Significance (ASBS) program, including ASBS locations, is available at: http://www.waterboards.ca.gov/water_issues/programs/ocean/asbs_areas.shtml.
[43] A proceedings report from the Marine Protected Areas and Fisheries Integration Workshop is available at: http://www.dfg.ca.gov/marine/mpa/mfig.asp.

collaboration on specific studies or projects that satisfy multiple objectives. For example, MPA monitoring data may provide information on species life history characteristics for fished species and the role of MPAs in observed trends of those species. They may also aid in implementing ecosystem-based fisheries management. At the same time, fisheries management data may help to put the results of MPA monitoring in a broader context.

Both fisheries monitoring and MPA monitoring focus on consumptive use by humans, and enforcement of regulations that limit consumptive use. Socioeconomic data from commercial passenger fishing vessel (CPFV) and commercial fisheries logbooks have already played a role in analysis and reporting of MPA monitoring results, and there is potential to expand this work.[44] In the future, some studies to address management effectiveness may provide useful context to both fisheries managers and MPA managers. For example, a study of how fishing communities have been impacted by MPA implementation (see Chapter 5) could provide helpful background for observed patterns of fishing activity and broader changes in the fishing industry. While the central focus of MPA monitoring is to meet the goals of the MLPA, MPAs have been envisioned as an important tool for fisheries management in California since 2002 as described in the Department of Fish and Wildlife's Nearshore Fishery Management Plan.[45] The potential synergies discussed above may provide opportunities to leverage existing state funds, and strengthen multiple state programs simultaneously. Moreover, these opportunities also exist beyond state agencies as tribal governments and federal government agencies engage in fishery management activities. As is further described in Appendix A, we will actively work with the Department of Fish and Wildlife, tribal governments, federal agencies and other partners to foster these opportunities.

[44] See page 31 of the Central Coast MPA Baseline Program summary report, *State of the California Central Coast: Results from Baseline Monitoring of Marine Protected Areas 2007-2012*, which presents data on enforcement of MPAs and data from the California Recreational Fishing Survey (CRFS) (http://oceanspaces.org/sites/default/files/regions/files/cc_results_report_0.pdf). The baseline projects focused on consumptive uses also made use of fishing logbook data from the Department of Fish And Wildlife.

[45] The Department of Fish And Wildlife Nearshore Fishery Management Plan (2002) is available at: http://www.dfg.ca.gov/marine/nfmp/.

8. Building an Effective MPA Monitoring Program

- Using this plan to build a monitoring program
- Implementing a monitoring program

Strategic implementation of this plan will organize a wide range of resources—communities of engaged and motivated partners, funding streams, data, and knowledge—around the issues that matter most to the future of California's coastal and ocean ecosystems. MPA monitoring is both a crucial element of the MLPA and an important opportunity for California. The previous chapters have described the building blocks of a framework for MPA monitoring in the Central Coast. In this chapter we focus on the practical challenge of implementing a program based on those building blocks. The next phase of Central Coast MPA monitoring is intended to be thoughtful and strategic in order to support adaptive management of California's MPAs and ultimately realize broader opportunities. The sections below present the key considerations that will guide strategic decision-making about monitoring and a practical approach to guiding investments based on those considerations.

USING THIS PLAN TO BUILD A MONITORING PROGRAM

This monitoring plan is designed to be comprehensive. It provides full coverage of Central Coast Ecosystem Features, an extensive account of management effectiveness questions, and broad consideration of potential synergies between the monitoring activities mandated under the MLPA and other management needs (e.g. fisheries management, water quality). The plan is also designed to be flexible. It can be implemented in a variety of configurations and still provide useful information to meet the requirements of the MLPA and the needs of MPA managers and decision makers. Flexibility is particularly important because the level of state investment in MPA monitoring can be unpredictable, and the nature of that investment is likely to change over time.

Whether it is next year, in five years, or in 50 years, building an effective monitoring program will always involve tradeoffs and choices that depend on the resources available, timing constraints, and other factors. This section discusses the various considerations that will inform the development of Central Coast MPA monitoring—how we will take the framework, guidelines, and goals described in this document and build an ongoing program.

SETTING PRIORITIES WITHIN THE MONITORING FRAMEWORK

MPA monitoring in the Central Coast must balance the two core elements of the monitoring framework (see Figure 2-2 in Chapter 2): Assessing Ecosystem Condition and Trends (Chapter 4) and Evaluating MPA Design and Management Decisions (Chapter 5). Both elements are necessary to best inform adaptive management. Assessments of ecosystem condition provide the most basic evaluation of MPA performance, with a focus on aspects of the Central Coast that are of great public interest, such as the status of kelp forests or particular invertebrate and fish species, or trends in consumptive and non-consumptive human uses. Evaluations of MPA design and management decisions provide targeted information that directly addresses issues of most pressing concern to MPA managers.

We must also set priorities within the two core monitoring framework elements. For example, Chapter 5 provides an extensive list of potential evaluations of MPA design and management that could be useful to managers and other stakeholders. These can be prioritized based on available resources, partnership opportunities, capacity constraints, and current and future management needs.

Priority-setting within ecosystem assessments will also be necessary, as it is unlikely that available resources will enable a full assessment of ecosystem condition for each of the ten Ecosystem Features in any given year. There are three types of flexibility within the ecosystem condition assessment side of the monitoring framework: intensity of monitoring, temporal flexibility, and geographic flexibility.

INTENSITY OF MONITORING

A key source of flexibility in this monitoring plan is the ability to prioritize across Ecosystem Features and implement monitoring at different levels of investment (e.g. Ecosystem Feature Assessment versus Ecosystem Feature Check-up) within Ecosystem Features. Decisions about a given Ecosystem Feature may be based on available resources, data needs, and partnership opportunities, as well as a feature's priority relative to other features. If budgets are extremely tight during a given adaptive management cycle, some features can be prioritized over others based on an understanding of core management needs.

TEMPORAL FLEXIBILITY

While continuous long-term datasets are desirable, it is not necessary or practical to monitor each of the ten Ecosystem Features every year, and periodic gaps in monitoring can be managed. Indeed, funding resources may be most efficiently used by staggering data collection among selected Ecosystem Features. Metrics or Ecosystem Features that are strongly related to one another may be efficiently monitored together, and this monitoring may occur in the same year. For example, an efficient monitoring program may monitor Soft-Bottom Intertidal and Beach Ecosystem Features in the same year as recreational Non-Consumptive Uses to enable identification of relationships among these features.

GEOGRAPHIC FLEXIBILITY

It is also not necessary or practical to monitor every single Central Coast MPA in any given year. There are 29 Central Coast MPAs with varying classifications that often encompass different sets of habitats, depths, and features. The MLPA Master Plan for MPAs identifies the potential for State Marine Reserves (SMRs) to take first priority as the backbone to a monitoring program.[46] We can also use results from the baseline monitoring period to understand how particular sites may serve as proxies for similar sites in other MPAs. This provides an opportunity to streamline our approach to understanding both the progress of the MPA network throughout the region, and the broader picture of ecosystem condition and trends.

THE MONITORING AND REPORTING CYCLE

MPA monitoring needs to support adaptive management decision making, which means carefully designing a program around that timeframe. A five-year monitoring cycle (to match the five-year cycle of MPA review recommended in the MLPA Master Plan for MPAs) would allow monitoring data collection and initial analyses to be staged over four years, with a fifth year dedicated to synthesis and sharing of findings.

Given the mandate that MPA monitoring results be shared in accessible and useful forms (see Chapter 7), this element of the plan is a crucial part of MPA monitoring implementation. The Ocean Science Trust will work closely with the Department of Fish and Wildlife, the Fish and Game Commission, the Ocean Protection Council, funders, and monitoring partners to develop shared expectations around the timeline for adaptive management and the goals that must be met in order to effectively support that process through the next phase of Central Coast MPA monitoring.

[46] California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3).

The monitoring framework has been designed so that monitoring can extend across multiple turns of the adaptive management cycle, if necessary. For example, some of the evaluation questions outlined in Chapter 5 would take more than a decade to answer with any certainty. Investments in these types of activities should come with the shared expectation that results will be inconclusive in the near term, but highly valuable in the long-term if monitoring is sustained effectively.

COST-EFFECTIVENESS

A cost-effective monitoring program will be achieved through several different strategies, detailed below.

USING THE BASELINE

The Central Coast MPA Baseline Program was valuable not only because the monitoring data have provided a new understanding of Central Coast ecosystems, but also because it provides a foundation for building a cost-effective long-term monitoring program in the region. Characterizations of Ecosystem Features that resulted from baseline monitoring data have helped to hone lists of indicators (see Chapter 4) that are both efficient and effective. Furthermore, the operational experience gained from the Central Coast MPA Baseline Program provides lessons for future monitoring efforts.

LEVERAGING ONGOING EFFORTS

Given the broad and deep community of ocean and coastal researchers in the Central Coast, there are many activities and resources that can be brought to bear on MPA monitoring with minimal direct investment from the MPA monitoring program. For example, a university scientist with federal funding could potentially align her data collection efforts with the priorities outlined in this plan. This would allow her to contribute valuable data to the adaptive management cycle while increasing her program's relevance in the eyes of federal funders. Our efforts to identify such opportunities through an online survey are described further below.

PARTNERING AROUND SHARED PRIORITIES

In planning and implementing MPA monitoring, there may be opportunities to satisfy the objectives of multiple programs or agencies, and perhaps obtain matching funds. For example, there may be increasing opportunities for MPA monitoring to inform data-poor fisheries and other fisheries management processes, which can help to meet a core goal of the MLPA and MLMA (see Chapter 2, and Appendix A).[47,48] Similarly, mandated water quality monitoring often overlaps with MPA monitoring – geographically and in the methods employed and data collected. We will pursue these partnership opportunities whenever possible.

EFFICIENT MONITORING

Beyond the strategies listed above, we must also work to improve the efficiency of monitoring activities themselves. Over time, we will learn about potential improvements in technology, sampling structures, and programmatic approaches. These lessons will be incorporated into the monitoring program on an ongoing basis, whether we are looking at the potential for scalable citizen science approaches to rocky intertidal monitoring, or for lower-cost remotely operated vehicle (ROV)

[47] Goal 2 of the MLPA is to "help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted." California Marine Life Protection Act, Statutes 1999, Chapter 1015, Fish and Game Code section 2853(c)(3).
[48] California Fish and Game Code, Section 7050.

platforms. One strength of a monitoring program that is tied to the adaptive management cycle itself is the built-in opportunity to innovate and reduce costs as we learn and adjust over time.

SUSTAINABILITY AND CONTINUITY OVER TIME

MPA monitoring is a long-term endeavor, and planning for program sustainability is important. As mentioned above, long-term datasets are critical to answering some of the key questions about MPA management effectiveness and ecosystem conditions and health. Some studies will need to extend for at least a decade before they can detect changes, thus their value should only increase with time. In some cases, this priority must be balanced with other considerations discussed above. For example, if more cost-effective monitoring options become available for a particular Ecosystem Feature in 10 years, we must carefully consider the analytical implications of any potential departure from past data collection practices.

IMPLEMENTING A MONITORING PROGRAM

INVESTMENTS IN MPA MONITORING

At the June 10, 2014 Ocean Protection Council meeting, up to $3 million was authorized to support and seed the next five years of Central Coast MPA monitoring. Disbursement of funding is contingent upon Fish and Game Commission adoption of this plan, together with Ocean Protection Council approval of a workplan that will be developed by Ocean Science Trust, the Department of Fish and Wildlife, and the Ocean Protection Council (see below).

As mentioned above, the Central Coast MPA Monitoring Plan must be flexible in order to accommodate different levels of investment in monitoring programs by the state and a shifting landscape for additional resources and partnership opportunities. While direct investments are important to the success of MPA monitoring, these will never constitute the entire resource base that supports the program. As we have emphasized throughout this plan, a partnerships approach is crucial for the sustainability and broad success of MPA monitoring. We should measure the total investment in MPA monitoring based on the many ways in which participants contribute their time, expertise, and other resources to this large-scale undertaking. Accounting for volunteer hours contributed by citizen scientists, tracking matching funds by university researchers, and counting the number of community members who attend public meetings about monitoring priorities are all important forms of investment that are crucial to the broader success of Central Coast MPA monitoring.

California has already demonstrated significant support for MPA monitoring through investments in baseline monitoring in all four MLPA regions, starting with the Central Coast in 2007. Even in these programs, state funds were only part of the much broader investments made by partners and participants in each region. Any state investment should be treated as an opportunity to seed monitoring activities that build upon and leverage ongoing activities.

SURVEY OF CENTRAL COAST MPA MONITORING CAPACITY

The Central Coast community includes world-class ocean researchers engaged in a wide array of monitoring activities, but it is not always easy to see an accurate picture of what this community is doing at a given time, let alone how that activity relates to the priorities and needs outlined in this plan. A key step in building the monitoring program is to develop this picture through an online survey that assesses current monitoring activities and capacity throughout the Central Coast. The survey (open to participation from July 7 – September 26, 2014) examines the geographic and temporal coverage of monitoring activities, along with their compatibility with the indicators and metrics listed in Chapter 4. We anticipate that the results will show gaps, overlaps, potential synergies, and key assets, all of which can form the basis of a workplan for investing potential state funds and leveraging other sources to support Central Coast MPA monitoring.

The survey results will reflect the Central Coast monitoring community, and they may be of interest to the members of that community. In light of this, and in keeping with our commitments to transparency and participatory processes as we design and implement monitoring, much of the survey data will be available to the public through OceanSpaces.org. This will allow visualization of, and engagement with, various measures of the Central Coast monitoring community.

IMPLEMENTATION OPTIONS

In addition to the temporal and geographic flexibility of monitoring activities described earlier in this chapter, there is flexibility in implementation options for monitoring. We can choose among different mechanisms to efficiently and cost effectively support monitoring activities. The three main approaches to investing in MPA monitoring will be requests for proposals (RFPs), requests for qualifications (RFQs), and partnership agreements.

REQUESTS FOR PROPOSALS (RFPS)

A RFP solicits ideas for monitoring projects that address an area of need where the operational requirements are loosely defined, at best. Submitted proposals outline the specifics of project implementation, such as experimental design, technical requirements, and deliverables. Because of this, individual proposals may vary widely within the bounds set by the RFP. RFPs represent an opportunity to access the best and most creative thinking of potential knowledge producers.

RFPs are most appropriate in cases where the optimal approach to monitoring is not yet known and innovation is a program priority. With this option, funders can consider a wide range of proposed activities, each of which may have strengths and weaknesses in addressing monitoring program priorities.

REQUESTS FOR QUALIFICATIONS (RFQS)

A RFQ lays out a very specific project plan and solicits competitive bids for completion of the work by various contractors. Compared with a RFP, this mechanism is typically much more specific about project design and the deliverables that will be required, and bids vary only in terms of the projected costs and the specifics of how particular requirements will be met. RFQs represent an opportunity to efficiently invest in very particular activities, specified by the funder.

RFQs are most appropriate in cases where the goal is to continue monitoring activities that have been successful in the past. The goal of RFQs is to consider various approaches—especially cost-structure—to a very specific activity, as defined by the funder.

PARTNERSHIP AGREEMENTS

Partnership agreements—generally realized through a memorandum of understanding (MOU)—leverage ongoing activities that are supported through other sources (e.g. philanthropic, federal, or private funding). Unlike RFPs and RFQs, partnership agreements do not directly fund on-the-ground monitoring activities. However, partners may expand or adjust monitoring activities to better align with Central Coast MPA monitoring as part of the agreement, and some investment may be needed to support the relationship. For example, program funds might support an analyst who can integrate a partner's existing data with results from other areas of MPA monitoring. Analysis, tool development, and data management are particularly important aspects of implementing MPA monitoring for which partnership agreements can offer a useful mechanism.

A WORKPLAN FOR CENTRAL COAST MPA MONITORING

When the results of the Central Coast Survey have been analyzed, we can use those findings, and the funding mechanisms described above to implement a program that represents the next phase of Central Coast MPA monitoring. As specified in the June 10, 2014 Ocean Protection Council resolution, we will collaborate with Ocean Protection Council and the Department of Fish and Wildlife to develop a workplan covering the period of the next adaptive management cycle, laying out a funding schedule and a structure of RFPs, RFQs and/or partnership agreements. The document will also include plans for sharing the results of MPA monitoring, following the guidelines presented in Chapter 6. This approach means that, regardless of the level of investment, we are not simply dividing available funds evenly over the period of the adaptive management cycles, or across the various elements of the monitoring framework. We will make strategic, thoughtful, and transparent decisions about cost-effective investments that enable us to meet the goals of the MLPA and uphold the guidelines described in the first section of this chapter. The workplan is a crucial step toward getting our partners into the field, collecting data and building a knowledge base that can serve the state as crucial input to MPA adaptive management and natural resource management more broadly.

APPENDIX A. INTEGRATING FISHERIES MONITORING AND MPA MONITORING

Through MPA monitoring, California is building a unique body of knowledge that can form the foundation for research and assessment of the state's coastal and marine ecosystems. While the long-term Central Coast MPA Monitoring Program described in this plan must meet the mandated requirements of the MLPA, it has also been developed to provide useful information for other aspects of California's ocean resource management. The partnerships and scientific knowledge gained from this program can be of considerable value across many different issues (e.g. climate change, ocean acidification, water quality, and fisheries management), and across many different government (e.g. local, state, and federal agencies) and non-government institutions. As we describe further in Chapter 7 of this plan, partnerships and collaborations across mandates and jurisdictions, can provide a greater return on investments in the statewide MPA network.

At the same time, MPA monitoring can benefit considerably from partnerships with monitoring programs focused on other issues. In this appendix we focus in on the relationship between fisheries monitoring and MPA monitoring in California. The needs and priorities of fisheries managers, as well as the considerable knowledge held by fishery scientists, have been informing MPA planning, implementation, and monitoring from the beginning of the MLPA process. But there is more we can do to integrate these two domains, to the benefit of both.

This appendix has been updated and adapted based on: 1) text included in the South Coast and North Central Coast MPA Monitoring Plans, 2) public input on a draft Central Coast MPA Monitoring Plan released in May, 2014, and 3) close consultation with Department of Fish and Wildlife partners involved in both MPA and fisheries management. As discussed in the following sections, inclusion of this appendix directly reflects the current priorities of Department of Fish and Wildlife managers and fishery scientists working to leverage resources and cost-effective approaches to fisheries monitoring and emerging scientific approaches, including those associated with the state's network of MPAs.

FISHERIES AND MPA MONITORING: DIFFERENCES AND KEY POINTS OF OVERLAP

Although MPA monitoring and fisheries monitoring clearly overlap, there are fundamental differences in the scope of monitoring and the ultimate information needs of the respective programs. As described above and elsewhere, the MPA monitoring framework focuses on ecosystem-based monitoring of individual MPAs, the regional MPA network, and the region itself. MPA monitoring seeks to determine the condition of, and trends in, overall ecosystem components as part of evaluating MPA effectiveness towards achieving MLPA goals.

In contrast, fisheries monitoring has traditionally focused on individual stocks of fished species and their status, or the status of fisheries targeting them. Thus, while MPA monitoring often takes a multi-species, place-based approach, focusing on individual MPAs and then scaling up to regional network effects, fisheries monitoring generally focuses on one or a few local target species populations and then scales up to broad regional populations or stocks. Both MPA monitoring and fisheries monitoring may include information on species life history characteristics, changes in fishing locations and impacts to fishermen, although differences of scale between the two monitoring types typically remain.

Even so, the two types of monitoring are not mutually exclusive and should be designed to be mutually reinforcing. From the perspective of ecosystem-based MPA monitoring, fisheries data are critical for interpreting changes within MPAs over time as well as for allowing comparisons between MPAs and areas that continue to be fished. Similarly, MPA monitoring will generate new, detailed data on the abundance and biology of many species targeted by fisheries. Information on relative abundances and size distributions of fishery species generated through MPA monitoring may be useful as input for population modeling by fishery scientists, as long as the scale is broad enough to make meaningful model assumptions or be sufficiently representative of a stock. Also, fisheries managers are now examining how population status of species within MPAs can be used to help estimate unfished abundance, recruitment rates, and other key fisheries information. For example, fishery scientists have begun exploring new ways to inform fishery managers of the status of fished populations, based upon differences in species density inside and outside multiple MPAs within a population's range. Further, MPAs (particularly no-take MPAs) provide a unique reference point for how ecosystems function in the absence of fishing as well as how recovery occurs within previously fished areas.

Many fisheries policies reference ecosystem-based fishery management. Some of the underlying data needed to support ecosystem-based fishery management may also be obtained through MPA monitoring, such as assessments of ecosystem condition. For example, the Marine Life Management Act (MLMA) broadened the focus of fisheries management to include consideration of the ecosystem, including the entire community of organisms (both fished and unfished) and the environment and habitats those species depend on.[49]

When considered together, MPA and fisheries monitoring programs can be developed to maximize the utility of data collected, particularly when the monitoring includes fished species sampled at a geographic scale that is useful on a population or stock basis, and occurs with adequate replication over a sufficient time scale to detect real change. Activities described below represent an approach to developing and implementing additional fisheries monitoring that builds on, and takes maximum advantage of, the MPAs for informing fisheries management.

CONSIDERING FISHERIES MANAGEMENT WITHIN MPA MONITORING IMPLEMENTATION

Three different options for integrating fisheries management considerations into MPA monitoring are described below. While neither mutually exclusive nor exhaustive, these three options illustrate the kinds of activities that could be undertaken, depending on available resources and capacity. They range from basic implementation that is most closely aligned with proposed MPA monitoring, to new partnerships and programs designed around priority management questions:

- Option 1. Existing fisheries indicators within the MPA monitoring framework
- Option 2. Candidate fisheries indicators to add to the MPA monitoring plan
- Option 3. Collaboratively developed research and monitoring questions

Most existing fisheries information comes from fishing records provided by commercial fishermen and Commercial Passenger Fishing Vessels (CPFV) operators, and from direct monitoring of commercial and recreational fisheries by the Department of Fish and Wildlife and the National Marine Fisheries Service or via research surveys. Existing data can provide broad geographic information on stock biology, fisheries catch, profitability, general locations, numbers of fishermen, and other details. Basic integration of fisheries monitoring may be best achieved through leveraging cost-effective approaches and emerging scientific approaches for MPA monitoring. Additional data collection may also be feasible through collaborations and partnerships with other groups and individuals, particularly fisheries participants. For example, programs may be developed that increase the resolution of spatial data recording fishing locations. As further discussed in Chapter 7, fishermen can also provide detailed ecological information on catch, bycatch, and other indicators in coordination with Department of Fish and Wildlife and National Marine Fisheries Service. In the case of recreational fisheries, fishing groups or individuals may provide location-specific fishing information, or become active participants in scientific monitoring. The most intensive option presented below will require partnerships and collaborations with additional agencies and research institutions to implement new monitoring programs and/or new research projects, and it may also require use of emerging scientific approaches or technologies.

[49] California Marine Life Management Act, 1998, Fish & Game Code sections 90-99.5, 105, 7050-7090, 8585-8589.7, 8842, and 9001.7.

OPTIONS FOR INTEGRATING FISHERIES AND MPA MONITORING

The following fisheries monitoring recommendations describe activities that, if implemented, could answer priority fisheries management questions, focusing on relationships with MPAs and MPA monitoring. The information developed will also be useful for other fisheries management processes and will be available for analysis in a variety of contexts. The intent here is to describe the application of the approach and facilitate further development of this activity based on mutual interest of potential partners.

As with an ecosystem-based approach to MPA monitoring, understanding of ecosystem structure and function to support implementation of ecosystem-based fishery management is incomplete. The three options below also focus on monitoring metrics and questions for which data can be feasibly collected and interpreted. However, it is also possible to identify information needs that may warrant further research and development to support ecosystem-based fishery management. Research in support of supplemental fisheries monitoring could be designed to increase our understanding of concepts such as maximum food chain length, connectance, species richness and redundancy, and how these metrics may be applied to inform ecosystem-based fishery management. Increased understanding of these concepts, combined with lessons learned from implementing MPA monitoring, will help to refine and improve our approach to these issues with each turn of the adaptive management cycle.

OPTION 1: EXISTING FISHERIES INDICATORS WITHIN THE MPA MONITORING FRAMEWORK

Although the MPA monitoring framework adopts an ecosystems approach and includes indicators that contribute to assessment of ecosystem condition, species and indicators are included that may also be informative for fisheries management. Indeed, monitoring metrics have been chosen that will benefit fisheries management as much as possible without compromising the ability to meet MLPA monitoring requirements. These include species or fisheries that are either high volume or high value in the Central Coast region; that are recreationally or culturally important to the region; species that are of a key management focus; or those that are representative of the region’s ecosystems. Such fisheries-informative elements of the existing monitoring plan occur within these monitoring plan components:

- Ecological indicators of ecosystem condition and trends - Many of the recommended ecological indicators (listed in Chapter 4) are species and species groups that are targeted by commercial and recreational fisheries. Examples include cabezon, blue rockfish, vermilion rockfish, lingcod, spot prawn, and Dungeness crab, among many others. Data collected on these species typically includes densities or abundances and size structure, inside and outside MPAs.
- Socioeconomic indicators of trends in consumptive use - In terms of fisheries activities, many of the metrics for assessing the Consumptive Uses Ecosystem Feature are directly tied to fisheries information provided by fishermen or to monitoring conducted by Department of Fish And Wildlife and National Marine Fisheries Service. For CPFVs and for select commercial fisheries with logbooks, these metrics include the spatial distribution of catch, effort (including the type of gear and level of effort), and catch-per-unit-effort (CPUE).
- MPA design and management questions – Several of the questions related to evaluation of MPA design and management decisions will be directly applicable to fisheries management decisions as well, if implemented. For instance, a potential short-term MPA management question includes examining the relationship between MPA locations, density of fished species inside and outside MPAs (as available through current monitoring efforts), and the distribution and intensity of nearshore fishing for those fisheries where spatial catch and effort information is available.

OPTION 2: CANDIDATE FISHERIES INDICATORS TO ADD TO THE MPA MONITORING PLAN

Option 2 involves identification and prioritization of fisheries indicators to supplement, but fit within, the existing MPA monitoring framework. These could be either additional metrics for the current indicator species listed in Chapter 4, additional species to add for monitoring listed in Chapter 4, or increased sampling efforts for some metrics.

Additional metrics that may warrant an initial examination for key species include:

- Local density,
- Age and growth differences,
- Sex ratios and fecundity, and
- Larval and juvenile recruitment rates inside and outside MPAs.

Key species that currently are not included in the MPA monitoring plan listed in Chapter 4, but could be added for monitoring due to their management and policy relevance, may include those listed within the Nearshore Fishery Management Plan[50] or other key fisheries in the region. Candidate species for inclusion based on these criteria include:

- Brown rockfish – *Sebastes auriculatus*
- Grass rockfish – *Sebastes rastrelliger*
- Olive rockfish – *Sebastes serranoides*

OPTION 3: COLLABORATIVELY-DEVELOPED RESEARCH AND MONITORING QUESTIONS

The most intensive approach to integrating MPA and fisheries monitoring focuses on additional questions that may require new research or development of new methods. The following areas have been identified in consideration of management/policy priorities, MPA-relevance, feasibility, scientific merit, and gaps in current knowledge regarding the interaction between MPAs and other fishery management tools. For each element, brief information is provided on what might be required to implement new supplemental monitoring. Again, the intent here is to illustrate application of the approach.

These and other potential focus areas may be further evaluated and explored, depending on resources available, and the interest of key partners. Each focus area and potential questions may be further specified by considering particular species of management interest. For example, development of data-poor methodologies using certain MPAs as reference reserves is a current management priority for nearshore species including those covered in the Nearshore Fishery Management Plan. Implementation of these activities, if desired, should align with such efforts.

FOCUS AREA 1 –MPA EFFECTS ON LOCAL FISHERIES

Information Need: Spatial patterns of fishing, including catch location and effort (this information is currently only available for CPFVs, private recreational boats, and the few commercial fisheries with logbooks).

- **Question 1. Do MPAs concentrate fishery effort in particular areas and what effect does that have on the fish populations? Are there "edge effects" (concentrated fishery activities along MPA boundaries)?**

  Potential approach: Spatially explicit monitoring of fisheries activities, including catch location and CPUE, through logbooks, observers, vessel monitoring systems, aerial monitoring programs, or other fishery observation programs, in relation to ecological data collected under the MPA monitoring framework.

[50] The Department of Fish And Wildlife Nearshore Fishery Management Plan (2002) is available at: http://www.dfg.ca.gov/marine/nfmp/.

- **Question 2. Do MPAs contribute to serial depletion of species or geographic zones?**

  Potential approach: Long-term monitoring of species abundances for individual fished species within specified zones, in relation to spatial fishing patterns.

- **Question 3. Does the absence of fishing pressure affect prey diversity (or is prey diversity higher in unfished areas) for key fished species (increasing resilience)?**

  Potential approach: Evaluate diets of key fished species inside and outside multiple MPAs.

FOCUS AREA 2 – STOCK CONSEQUENCES OF PROTECTED SUB-POPULATION

Information Need: Evaluating the quality of habitat as it relates to key fisheries or key fished species.

- **Question 1. For critical habitat of key fished species, what are the differences in habitat quality between study areas inside and outside MPAs?**

  Potential approach: Evaluate habitat used by young-of-year (YOY), juveniles, sub-adults, and adults. In order to evaluate habitat, improve the resolution of habitat mapping to identify habitat complexity; and conduct diver and remotely operated vehicle (ROV) surveys to provide supplemental information on the distribution of and use of microhabitats by different life stages of key fished species.

Information Need: Juvenile, sub-adult and adult production within MPAs, and contribution to the local fishery through movement of these life stages from MPAs to fished areas outside MPAs.

- **Question 1. Does spillover occur?**

  Potential approach: Mark/recapture and sonic tagging of juvenile, sub-adult, and adults combined with model approach/empirical data to identify movement patterns of key fished species inside and outside of MPAs (particularly identifying net movement across the MPA boundaries).

- **Question 2. Does spillover contribute to local fisheries?**

  Potential approach: Mark/recapture and sonic tagging combined with model approach/empirical data to estimate mortality rates of key fished species from MPAs and contribution to total catch.

Information Need: Contribution of nursery habitat protection within MPAs with estuarine, rocky intertidal, and shallow nearshore habitat for key fished species.

- **Question 1. Do shallow nearshore, rocky intertidal, and estuarine areas within MPAs produce greater numbers of YOY for key fished species?**

  Potential approach: Measure abundance of fished species in shallow nearshore, rocky intertidal, and estuarine habitats inside and outside MPAs, and assess habitats of similar quality.

Information Need: Contribution of protected adult population to stocks through increased production of young.

- **Question 1. Are life-history traits (age structure, size at maturity, sex ratio, overall fecundity) different within MPAs? If so, does this result in differences in total spawning biomass available inside and outside?**

  Potential approach: Long-term tracking of changes in life history traits over time inside and outside MPAs.

- **Question 2. For which species and which MPAs are larval stages of key fished species transported out of MPAs, and if so, where do they go?**

  Potential approach: Track larval source and sink populations and identify the source of larvae found inside and outside MPAs. New genetic, chemical, and other larval markers as well as oceanographic information would be needed.

- **Question 3. What is the contribution of key fished species within MPAs to the larval and YOY abundance inside and outside MPAs?**

  Potential approach: Build upon the answers derived from Questions 1 and 2, examining YOY abundance inside and outside MPAs, and using genetic marker information to determine the origin of YOY fish.

FOCUS AREA 3 –NEW TOOLS TO ASSESS POPULATIONS AND INFORM FISHERY MANAGEMENT

Information Need: New or modified tools to assess populations (including data-poor species) and establish allowable catches and other fishery regulations.

- **Question 1. How can protected sub-populations be incorporated into traditional or refined stock assessment models and into fishery regulations?**

  Potential approach: This will need to be addressed through a multi-pronged approach that includes: evaluation of MPA monitoring data to develop or refine parameter estimates in traditional stock assessment models; expansion of models to incorporate new parameters or simulation scenarios that partition populations according to protection status; focused sampling inside and outside MPAs to collect additional information required for refining or developing new parameter estimates; and incorporation of results into the state and federal management process. This is an adaptive process, with additional data providing the means to refine parameters and models, review outcomes, and ultimately evaluate and revise management regulations.

- **Question 2. Which alternative assessment tools currently being developed (e.g., length-based stock assessment, density ratio models) best align with MPA monitoring data collection and also usefully inform fisheries management? What are the limitations of existing monitoring data for this purpose?**

  Potential approach: Comparative testing, using existing data, of the results from selected assessment approaches applied to priority fishery species and assessment of the utility of model outcomes as a basis for fishery regulations. For example, comparative testing of data-limited models (that use data collected from a collaborative fisheries Central Coast MPA study) is currently being conducted using management strategy evaluation.

FOCUS AREA 4 – EMERGING CONCEPTS TO SUPPORT ECOSYSTEM-BASED FISHERIES MANAGEMENT

Information Need: Research into ecosystem structure and function and the interaction with fisheries management measures to support application and use of ecosystem-based fisheries metrics.

- **Question 1. What metrics can be used to characterize food webs and ecosystem structure, and how can these metrics be applied to support ecosystem-based fisheries management?**

  Potential approach: Investigation of concepts including maximum food chain length, connectance, species richness, prey diversity, and species redundancy.

- **Question 2. What metrics can be used to characterize ecosystem functioning, including species interactions, and how can these metrics be applied to support ecosystem-based fisheries management?**

  Potential approach: Investigation of inter- and intra-specific interactions, diet, and nutrient cycling using stable isotopes to develop management-applicable metrics informative of ecological processes.

- **Question 3. What are the ecosystem-level impacts of more and larger individuals in MPAs, and how might this inform ecosystem-based fisheries management measures?**

  Potential approach: Kelp-sea otter-urchin dynamics are well-documented and could provide a starting point for examining the effects of more, larger predators (e.g., sea otters and cabezon) on kelp forest ecosystems. An understanding of the effects of differentially targeting larger individuals could inform fisheries management.