# California Marine Life Protection Act (MLPA) Initiative
# Central Coast Study Region
# Marine Protected Area Monitoring Plan

**FINAL**

***January 15, 2007***

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This document is designed as an adjunct to the Master Plan for Marine Protected Areas (CDFG 2006) to be included in Section 8.4.2 of the Central Coast Regional Management Plan. The monitoring plan was constructed using the framework described in Section 6 of the Master Plan and follows the approach described by Pomeroy et al. (2004). All background information, including the description of the region, goals and objectives, and descriptions of proposed MPAs, are included here by reference. Information is only repeated where necessary.

As stated in Section 6 of the Master Plan, the purpose of monitoring is to measure performance relative to stated goals and objectives and provide information for adaptive management. The Marine Life Protection Act (MLPA) calls for monitoring of selected areas to assist with adaptive management of the MPA network. Monitoring is also needed for evaluation of regional goals and objectives as well as MPA-specific objectives. Given the anticipated size of the statewide network as well as network components, monitoring all MPAs for all goals and objectives is not feasible. Rather, where MPAs share goals and/or objectives, a representative subset of MPAs will be monitored to determine performance. It is expected that most objectives for each MPA will be evaluated.

Performance indicators are needed for biophysical and socioeconomic systems as well as management and enforcement. The goals and objectives that are intended as guidelines for the design of the MPA network are considered separately.

To develop monitoring to determine if regional goals and MPA-specific objectives are being met, an overarching question and monitoring activities to answer the question were developed for each objective (Appendix 1). Similar objectives were then combined to show commonalities in questions and monitoring activities among MPAs. All MPA-specific objectives were linked to regional goals. In general, the objectives consolidated into primary objectives (e.g., protect species diversity) with more particular focus on an area or a species group for specific MPAs or groups of MPAs. The primary objectives are presented in the following text along with explanations of the relationship between the objectives, monitoring questions and activities. Because the objectives were developed by stakeholder groups, sometimes words in the objectives carry a different meaning than equivalent words used in the scientific literature. Where necessary, differences in terminology are explained.

Collaboration will be important in all aspects of monitoring. Collaboration can build financial, institutional and intellectual synergies, producing more with better results. Academic institutions and governmental agencies have ongoing monitoring programs that will provide valuable data. Volunteer programs are being developed and have the potential to greatly augment the scope of sampling. Commercial and recreational fishermen have in-depth, personal knowledge that can inform all aspects of monitoring. It will be desirable to work with commercial fishermen who have boats and fishing gear as well as specialized knowledge of fishing that will be needed to conduct some of the monitoring proposed in this plan. It is expected that fishermen will be used for trapping, hook-and-line fishing and other studies (e.g., poke-pole fishing) recommended in this plan. Cooperative sampling will be an integral part of this monitoring program and sampling will build upon existing programs as much as possible.

## I. BIOPHYSICAL MONITORING

### Goals and Objectives

Biophysical information is needed to evaluate the following regional goals: Goal 1) to protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems; Goal 2) to help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted; Goal 4) to protect marine natural heritage, including protection of representative and unique marine life habitats in central California waters, for their intrinsic value; and Goal 6) to ensure that the central coast's MPAs are designed and managed, to the extent possible, as a component of a statewide network (Section 8.4.1). Evaluation of management and design of the MPA network and network components is discussed in the respective sections on "Management and Enforcement Monitoring" and "Evaluation of Network Design" below.

### Monitoring Ecosystem Attributes

The primary objectives pertaining to ecosystems (Table 1) are to: 1) protect and maintain ecosystem structure and function, 2) protect and maintain particular areas with high species diversity and abundance, and 3) protect and maintain food webs (trophic structure), including a forage base.

Table 1. MPA-specific objectives for ecosystem protection.

| Primary Objective | Focal area or group | MPAs |
|---|---|---|
| Protect range of ecosystem functions | | |
| | Lee of headland | Ano Nuevo SMR, Point Sur SMR |
| | Between upwelling zones | Big Creek SMR, Point Buchon SMR |
| | Biogeographic transition zone | Vandenberg SMR |
| | Variety of habitats | Point Lobos SMR, Vandenberg SMR |
| Protect areas of high species diversity; maintain species diversity and abundance | | Ano Nuevo SMR, Piedras Blancas SMR, Cambria SMR, Point Buchon SMR, Vandenberg SMR |
| | Nearshore Fishery Management Plan species | Greyhound Rock SMCA |
| | Submarine canyon | Soquel Canyon SMCA, Portuguese Ledge SMCA, Big Creek SMCA, Big Creek SMR |

| **Primary Objective** | **Focal area or group** | **MPAs** |
|---|---|---|
| | Granitic shallow hard bottom | Hopkins SMR, Asilomar SMR, Point Lobos SMR |
| | Lee and north of headland | Point Sur SMR |
| | Estuarine Area | Elkhorn Slough SMR, Elkhorn Slough SMP, Morro Bay SMRMA, Morro Bay SMR |
| | Benthic species | Greyhound Rock SMCA, Piedras Blancas SMCA |
| Protect natural trophic structure, including forage base | | Elkhorn Slough SMR, Point Sur SMR, Point Sur SMCA, Piedras Blancas SMR, Cambria SMR, Point Buchon SMR, Point Buchon SMCA, Vandenberg SMR |
| | Seabirds | Ano Nuevo SMR, Greyhound Rock SMCA, Point Lobos SMR, Point Lobos SMCA, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA, Morro Bay SMRMA, Morro Bay SMR, Vandenberg SMR |
| | Marine mammals | Ano Nuevo SMR, Greyhound Rock SMCA, Point Lobos SMR, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA, Vandenberg SMR |
| | Higher trophic level fish | Ano Nuevo SMR, Point Lobos SMR, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR |

While the objectives are intended to provide protection to ecosystems, ecosystems are not bounded in small areas. An MPA provides protection by means of regulations to a specific area containing part of the ecosystem. The regulations primarily limit fishing, but may restrict other activities that have the potential to damage resources. It is assumed that human activities, particularly fishing, have reduced or eliminated populations of some species in some areas, changing feeding and other ecological relationships, resulting in alterations in ecosystem attributes. With the restriction of deleterious activities, ecosystem attributes should recover within the protected area.

The questions associated with the first objective, to protect and maintain ecosystem structure and function are: 1) are ecosystem attributes in the MPA affected by fishing? 2) if so, after it is protected, do they recover over time? and 3) if not, after it is protected, are they maintained over time? To answer these and the following questions, it will be necessary to compare ecosystem attributes within MPAs to reference areas outside MPAs to distinguish effects of fishing and other anthropogenic activities from other factors affecting the ecosystem (See “Measuring Performance” below).

Indicators for ecosystem structure and function include species composition, species diversity and number of species with increased recruitment. The expectation is that a full complement of species is present and that abundances are within the range of normal variability. If that is the case, then competition between species, predator/prey relationships and other functional attributes should be normal as well. If the MPA serves as a nursery, initial juvenile recruitment should be enhanced relative to reference areas outside MPAs. The number of species with enhanced recruitment measures the magnitude of the nursery function across species. Species composition and diversity can be calculated from measurements of the number of species and their relative abundances within a sample. Measuring recruitment is discussed in the section “Population Monitoring” below.

The questions associated with the second objective, to protect and maintain a natural trophic structure, are: 1) Is trophic structure in the MPA affected by fishing? 2) if so, does it recover over time? and 3) if not, is it maintained over time? Trophic structure can be calculated by estimating trophic level from diets and/or stable isotopes and organizing species into feeding guilds. Because diet can change with life stage, size information will also be needed. Describing trophic structure also includes estimating flow rates of biomass between trophic levels.

The third objective, to protect and maintain areas of high species diversity and abundance, assumes that the areas chosen for protection are special in that they support more species and/or higher abundances than the norm. The definition of “diversity” used here, following the Master Plan (CDFG 2006, Appendix J), includes only the number of species (species richness), not both species richness and equitability of relative abundances among species, as is often the case in the published literature. The questions associated with this objective are: 1) is population size of particular species and/or species richness high within the MPA? 2) if not, does population size and/or species richness increase over time? 3) if so, is population size and/or species richness maintained over time?

While an ecosystem includes all species and their physical environment, it will not be possible to sample all organisms from bacteria to marine mammals and the processes that affect and link species. In the best of circumstances, the choice of what to monitor would be based on conceptual or quantitative models of the system that draw on detailed scientific knowledge to predict outcomes of various scenarios (e.g., warm water from El Niños, protection afforded by MPAs). Because they articulate assumptions about underlying causal factors that drive the system, such models also facilitate interpretation of monitoring data. Since rocky intertidal and kelp bed systems are relatively well known, it may be possible to construct first-generation models for these systems. Research and development in this area could be used to inform the monitoring program in future years.

In the meantime, measuring ecosystems will involve using survey techniques that capture data for a broad array of species (algae, invertebrates and fish), selected to reflect a diversity of taxa and ecological roles and functions, including focal species. Focal species were chosen from a list developed by the Science Advisory Team of species likely to benefit from MPAs (CDFG 2006, Appendix G) and include keystone species, species that provide habitat structure (e.g., mussels and giant kelp), and species targeted by MPA-specific objectives (e.g., overfished rockfishes). Lists of focal species or, sometimes higher taxonomic, categories are shown below for each monitoring element.

## Population Monitoring

The primary objectives pertaining to populations (Table 2) are to: 1) protect natural size, age and genetic structure; 2) enhance reproductive capacity; 3) help protect larval sources; 4) protect particular species of interest; and 5) help restore overfished species.

Table 2. MPA-specific objectives for protection of populations of interest.

| **Primary Objective** | **Focal Area or Group** | **MPAs** |
|---|---|---|
| Protect natural size, age and genetic structure | | |
| | Invertebrates | Ano Nuevo SMR, Greyhound Rock SMCA, Elkhorn Slough SMR, Elkhorn Slough SMP, Point Lobos SMR, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA, Cambria SMR, Morro Bay SMRMA, Morro Bay SMR, Point Buchon SMR |
| | Rockfish | Ano Nuevo SMR, Greyhound Rock SMCA, Piedras Blancas SMR, Cambria SMR, Point Buchon SMR, Vandenberg SMR |

| **Primary Objective** | **Focal Area or Group** | **MPAs** |
|---|---|---|
| | Finfish | Elkhorn Slough SMR, Point Lobos SMR, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA, Cambria SMR, Morro Bay SMRMA, Morro Bay SMR, Point Buchon SMR, Vandenberg SMR |
| Enhance reproductive capacity | | |
| | Invertebrates | Ano Nuevo SMR, Greyhound Rock SMCA, Elkhorn Slough SMR, Point Lobos SMR, Piedras Blancas SMR, Cambria SMR, Morro Bay SMRMA, Morro Bay SMR, Point Buchon SMR, Point Buchon SMCA, Vandenberg SMR |
| | Finfish | Ano Nuevo SMR, Greyhound Rock SMCA, Elkhorn Slough SMR, Point Lobos SMR, Cambria SMR, Morro Bay SMRMA, Morro Bay SMR, Point Buchon SMR, Vandenberg SMR |
| | Deepwater finfish | Soquel Canyon SMCA, Portuguese Ledge SMCA, Point Lobos SMCA, Big Creek SMCA, Big Creek SMR |
| | Shelf finfish | Point Sur SMR, Point Sur SMCA, Piedras Blancas SMCA |
| | Rockfish | Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Vandenberg SMR |
| | Groundfish | Point Lobos SMCA, Point Buchon SMCA |
| Help protect larval sources | | Point Sur SMR, Point Sur SMCA, Piedras Blancas SMR |

| **Primary Objective** | **Focal Area or Group** | **MPAs** |
|---|---|---|
| | Invertebrates | Ano Nuevo SMR, Greyhound Rock SMCA, Point Lobos SMR, Piedras Blancas SMR, Cambria SMR, Point Buchon SMR, Point Buchon SMCA, Vandenberg SMR |
| | Finfish | Ano Nuevo SMR, Greyhound Rock SMCA, Point Lobos SMR, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Piedras Blancas SMR, Piedras Blancas SMCA, Cambria SMR, Point Buchon SMR, Point Buchon SMCA, Vandenberg SMR |
| Protect particular species | | |
| | Listed marine birds | Ano Nuevo SMR, Greyhound Rock SMCA, Elkhorn Slough SMR, Moro Cojo Estuary SMR, Hopkins SMR, Asilomar SMR. Point Lobos SMR, Morro Bay SMRMA, Morro Bay SMR, Vandenberg SMR |
| | Southern sea otter | Ano Nuevo SMR, Greyhound Rock SMCA, Elkhorn Slough SMR, Hopkins SMR, Asilomar SMR, Point Lobos SMR, Morro Bay SMRMA, Morro Bay SMR, Vandenberg SMR |
| | Rockfish | Soquel Canyon SMCA, Portuguese Ledge SMCA, Hopkins SMR, Asilomar SMR, Point Sur SMR, Point Sur SMCA, Cambria SMP, Cambria SMR, Point Buchon SMR, Point Buchon SMCA, Vandenberg SMR |

| **Primary Objective** | **Focal Area or Group** | **MPAs** |
|---|---|---|
| | Invertebrates | Ed Ricketts SMCA, Point Buchon SMCA, Vandenberg SMR |
| Help restore overfished species | | |
| | Groundfish | Soquel Canyon SMCA, Portuguese Ledge SMCA, Point Lobos SMCA, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA |

The amount of protection afforded a population by MPAs depends on the proportion of the population within MPAs and the residence time of that proportion. When most of the population lives within MPAs and the species is relatively sedentary, protection will be high. When the species is broadly distributed and/or mobile, protection will be lower. MPAs may provide protection for a critical life stage. In this case, protection may be high even when a majority of the population is not protected.

Protection of size, age and genetic structure as well as larval sources goes hand-in-hand with protection of the population. With reduced mortality, it is expected that the number and size of individuals within MPAs will increase, in time resulting in a natural size and age structure. However, the relatively higher abundance of larger fish within an MPA may increase predation on juveniles, resulting in a lower abundance of juveniles within than outside an MPA. With increasing numbers of large females, reproductive capacity should increase (be enhanced). If a MPA acts as a nursery site, there should be more juveniles inside the MPA than in outside reference areas. The increase in recruitment could result from self-recruitment (larvae settling back to the populations from which they were spawned) or from recruitment from outside areas. If a MPA acts as a spawning site, there should be increased reproductive output from that MPA.

The contribution of the MPAs to the restoration of overfished species can, in part, be measured by the increase in abundance within MPAs compared to areas outside of MPAs. Presumably, enhanced reproduction will also increase abundance of depleted species outside of MPAs. However, at present, it is difficult to follow the movement of larvae (or other propagules) produced in MPAs, although new genetic and other approaches can provide measures of larval dispersal, demographic connectivity between populations, and self-recruitment. It is also difficult to determine if settling larvae survive and grow to reproductive size. The potential contribution of MPAs to restoration of depleted populations can be calculated, but measuring the realized potential will require further research and development.

Indicators for population monitoring include: 1) population size, 2) proportion of the regional population within MPAs, 3) size and age distribution, 4) recruitment and mortality, 5) number of juveniles, 6) number of reproductive females, and 7) number of larvae or offspring per adult.

Population size can be calculated from measurements of density and the amount of available habitat. Estimating the proportion of the regional population within MPAs will require an estimate of the total abundance of the population within the region and residence time within MPAs. Tagging and/or acoustic sampling can be used to measure residence time. Size measurements will be needed for calculating size and age distributions, recruitment and mortality, number of juveniles and reproductive females, and number of larvae per adult. Age distributions will also require regressions of age at size. The number of juveniles, number of reproductive females and number of larvae per adult will require measurements of sex ratios, size at maturity and number of larvae produced within each size class.

For seabirds and mammals, the primary indicator is the number of offspring per adult, which can be measured by monitoring breeding activity.

## Habitat Monitoring

Objectives pertaining to protection of habitats (Table 3) include: 1) inclusion and replication of a diversity of habitats within the MPA network and network components, 2) inclusion of a diversity of habitats within individual MPAs, 3) protection of particular habitats, and 4) protection of habitats with a specified designation (e.g., as a State Marine Reserve).

Table 3. MPA-specific objectives for habitats.

| **Primary Objective** | **Focal Area or Group** | **MPAs** |
|---|---|---|
| Protect area with diversity of habitats | | |
| | Estuary | Elkhorn Slough SMR, Elkhorn Slough SMP, Morro Bay SMRMA, Morro Bay SMR |
| | Shallow hard and soft bottom, deep hard and soft bottom, submarine canyon | Soquel Canyon SMCA, Portuguese Ledge SMCA, Point Lobos SMR, Point Lobos SMCA, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA, Cambria SMR, Point Buchon SMR, Vandenberg SMR |
| | Intertidal, pinnacles, kelpbeds, submarine canyons, etc. | Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Cambria SMR, Point Buchon SMR, Vandenberg SMR |
| Protect area with an oceanographic feature | | |
| | Upwelling plume | Point Sur SMR, Point Sur SMCA, Piedras Blancas SMR |
| | Transition zone | Vandenberg SMR |
| Protect particular habitat | | |
| | Intertidal | Ano Nuevo SMR, Piedras Blancas SMR |
| | Estuary in SMR | Elkhorn Slough SMR, Moro Cojo Estuary SMR, Morro Bay SMR |
| | Pinnacle | Carmel Pinnacles SMR |
| | Submarine canyon head in SMR | Point Sur SMR, Point Lobos SMR |

Habitat objectives were used in designing network components and will be realized with implementation of the MPAs. Determining if the objectives are met will require measuring the amount of each habitat in the MPAs. Measurements are needed over time because anthropogenic activities can change habitats. The location of oceanographic features may also change over time.

The indicator for habitat monitoring is the amount of habitat in each habitat category. While this indicator only measures quantity, indicators of quality are not currently available. Research to develop indicators of quality would be very useful. Measuring habitat will require calculating habitat areas from existing fine-scale habitat maps, kelp bed aerial survey photos, and mapping previously unmapped hard and soft bottom substrates, eelgrass and surfgrass beds. It will also require using satellite imagery to map the location of upwelling plumes near Point Sur and the location of the transition zone near Point Conception.

## Network Monitoring

As discussed in Section 3, the MLPA Science Advisory Team (SAT) developed guidelines as a framework for the design process with the intention of producing a network of MPAs that met the goals and objectives of the MLPA. Monitoring to evaluate the execution of the guidelines is discussed in the section "Evaluation of Network Design" below. Monitoring to evaluate the management of the network is discussed in the section "Management and Enforcement Monitoring". Monitoring to evaluate biological properties of the network is discussed here.

Biological connectivity of the network and network components depends on the movement of adults and larvae or other propagules (e.g., spores) between individual MPAs. As discussed above, adults and juveniles gain protection by residence within an MPA. The residence may be within a single MPA or within multiple MPAs. With larvae, the expectation is that some larvae produced in an MPA will settle and grow within another MPA. Of course, larvae settling in any one area are likely to come from multiple sources. Larvae settling in an MPA may come from areas outside of MPAs and larvae produced in an MPA may settle in or outside MPAs. To measure connectivity, the source of the settling larvae must be known.

With the current state of knowledge, it is possible to measure adult and juvenile movement with acoustic tags and/or mark and recapture studies. Although measuring larval production and settlement in the field is possible, tracking larval dispersal and determining larval sources is difficult. However, new genetic and other approaches can provide measures of larval dispersal, demographic connectivity between populations, and self-recruitment (larvae settling back to the populations from which they were spawned). Larval dispersal can also be modeled. With additional research, it may be possible to improve methods for tracking larvae or develop other approaches for measuring network properties. The biophysical monitoring program will provide useful information on, among other things, adult movement and the change in the density, size structure and larval production of populations over time. Research is needed to provide guidance on how to use the data to measure connectivity.

## Measuring Performance

Performance will be measured for the network as a whole, for network components, and for groups of MPAs with common objectives. In some instances, performance will be measured for a single MPA.

Performance needs to be measured relative to a known or expected outcome or management goal. In some instances, the measure of performance is obvious and easily measured. For instance, Regional Goal 4, Objective 1, is to include estuaries, heads of submarine canyons and pinnacles within MPAs. The measure of performance in this case is simply the number of each habitat type in the MPAs and the measure of success is one in each habitat category. Most of the time, however, measuring performance is more complex.

Laboratory experiments are designed so all conditions are the same for treated groups (e.g., rats given a drug) and control groups (rats not given the drug). Given that the only factor that differs is the treatment, any difference between the groups can be attributed to the treatment. With studies conducted in nature, it is not possible to control most factors driving the system. It is possible to compare areas with and without an impact (e.g., establishing MPAs), but measuring the impact requires differentiating the response from the impact from responses caused by other factors, not a simple task.

One approach to this problem is Before-After-Control-Impact (BACI) monitoring (Green 1979, Stewart-Oaten 1986). In a BACI design, samples are taken in impacted and reference areas before and after the impact starts. The assumption is that while uncontrolled conditions are changing, they are equally affecting both sites. In the absence of the impact, the two sites may differ, but will track each other.

The BACI design is good in theory, but, in practice, it is difficult to find true control or reference sites. If an impact is localized and habitat is broadly distributed inside and outside the impact zone, it may be possible to find paired impact and reference sites. But in the central coast region, the MPAs are miles in length and similar habitat is not always present in close proximity. For instance, for Ed Ricketts SMCA, Lovers Point SMR, and Pacific Grove Marine Gardens SMCA on the Monterey Peninsula, the closest shallow hard bottom habitat that could be used for a reference is off Del Monte, in Monterey Bay. Not only is there a difference in wave exposure, a factor known to affect the distribution of intertidal and shallow subtidal marine organisms, between Del Monte and the Peninsula, there is a range in wave exposures along the Peninsula. There is also a difference in habitat. The substrate at Del Monte is generally low relief shale, whereas the substrate on the Monterey Peninsula is primarily medium to high relief granite.

Another problem is that the BACI design assumes that the impact operates independently inside and outside the impact zone; that is, when the impact starts, it will not change the level of impact outside the impact zone. In this case, the distribution and level of fishing effort outside MPAs is expected to change at the time of implementation and will continue to change over time, not remain constant as is expected with a BACI design.

A solution to these problems is to measure across the range of variability, making sure that there are data for the most important factors that drive the system, and to dissociate the response due to MPAs from the responses caused by other factors. The data can be analyzed using multivariate techniques such as ordination analysis or multivariate analysis of variance. As with the BACI design, the analysis will involve establishing a difference in a trend over time in MPAs as compared to outside areas, but comparisons are chosen by similarities in forcing factors, not geographical location. As with a BACI design, “before” data can be used to establish preexisting differences between sites as well as temporal variability; however, because the response manifests as a trend over time, “before” data are not required as long as there are sufficient data to establish the initial status and trend in the system. The number of samples that are needed to establish the initial status and trend as well as the number of MPAs and reference sites that should be sampled depends, in large part, the question, the variability of the system and the statistical test that will be used; however a minimum of three samples is needed to compute a variance, a measure of variability.

*Forcing Factors*

For this monitoring program, the most important forcing factor to measure is fishing effort before and after implementation of the MPAs. Populations in MPAs are expected to respond in relation to the prior level of fishing effort, with more response in heavily fished than in lightly fished MPAs. Fishing effort in areas outside MPAs will change not only in response to the MPAs, but also in response to changes in the regulatory, economic and social environment. Because fishing effort in outside areas is variable in time and space, all MPA/reference comparisons will need to consider fishing effort. The evaluation of MPAs will also need to consider if displaced fishing effort is affecting areas outside of MPAs.

For recreational fishing, the Department's California Recreational Fishing Survey (CRFS) collects data on catch and fishing effort for private and rental boats, commercial passenger fishing vessels (CPFVs), man-made structures such as piers and jetties, and beaches and banks. The data can be referenced to 1 minute of latitude by 1 of longitude (approximately 1 square nautical mile), a scale that will allow analysis at the level of an individual MPA.

Because the survey began in 2004 as a modification of a previous recreational fishing survey, and will continue through time, CRFS is a source of baseline and post-implementation data. Logbooks submitted to the Department from CPFV's will also provide valuable long-term data.

Collecting data for commercial fishing is more problematic. Data from logbooks submitted to the Department are available for spot prawn, and squid, although spot prawn data do not have fine spatial resolution. Data for other types of commercial fishing will need to be collected from a new program. Methods could include shipboard transponders and/or observers, remote sensing or aerial surveys, and/or incentive-based voluntary reporting. Information on preferred areas for fishing collected by Ecotrust can serve as a proxy for pre-implementation fishing effort.

As noted in the discussion of MPA design and definition of habitats (Section 3), the distribution of marine species is known to vary with latitude, depth, substrate, and oceanography. The latitude and longitude of sites and samples can be easily measured with Global Positioning Systems (GPS). From latitude and longitude, it will be possible to locate sites along a north/south gradient and measure proximity to such features as upwelling centers, canyons and river mouths and locate samples relative to the edge of the MPA. Water depth can be measured with depth gauges and/or fathometers.

Substrate characteristics affect burrowing and attachment behaviors, among other things. In hard bottom habitats, it is important to know the type (e.g., granite, sandstone) and texture (e.g., cobble, bedrock) of the substrate as well as relief (height above the bottom), aspect and rugosity. In soft bottom habitats, it is important to know the texture of the sediment (e.g., mud or sand). In mixed bottom habitats, it is important to measure the amount of mud, sand, cobble and boulders. Collection of data on substrate characteristics can be included in visual sampling protocols for both hard and soft bottom substrates.

The oceanographic environment changes both in space and time. Fortunately, good information is available to create a picture of the oceanographic environment. Satellites provide pictures of surface water temperature and color, showing upwelling zones and offshore jets, among other features. Meteorological data (air temperature, atmospheric pressure, wind speed and direction), and wave height, period and direction are measured with a series of offshore buoys maintained by The National Data Buoy Center, the National Ocean Service, the Monterey Bay Aquarium Research Institute and others (www.ndbc.noaa.gov). The Coastal Ocean Currents Monitoring Program (COCMP) provides real-time data on surface currents. Closer to shore, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) has buoys that measure subsurface temperature and currents. Buoys offshore of Monterey and Port San Luis, operated by the National Water Level Program, measure tides and sea level. All this information can be used to establish the large-scale oceanographic environment (e.g., El Niños) and well as more local phenomena (e.g., upwelling zones and jets).

Other anthropogenic (human-induced) impacts besides fishing must also be considered. Information is needed on the location, size and composition of discharges from municipal wastewater and power plants, rivers and storm drains. Municipal wastewater and power plants have individual monitoring programs that will provide long-term data on discharges and biological effects. In Monterey Bay, the Central Coast Long-Term Environmental Assessment Network (CCLEAN, www.cclean.org) monitors municipal discharges, five major rivers and 16 streams and storm drains. Soft bottom habitats are sampled for benthic species composition and sediment chemistry.

*Performance Measures*

If MPAs function as expected, in species which were previously fished, the total number of individuals and the number of large individuals should increase within MPAs relative to reference sites. Based on this expectation, a measure of performance is the prediction that analysis will show that previously fished species will increase over time in MPAs in: 1) total abundance, 2) number of large fish and invertebrates, 3) number of reproductive females; and 4) number of larvae/adult (i.e., fecundity). A target suite of fished species will be chosen for each habitat type. Not every species may respond as expected because changes in predator/prey and competitive interactions, among other things, can cascade through the ecosystem in unexpected ways. For instance, a predatory species may increase in abundance and eat more young-of-the year fish of a prey species. To measure the trend, given limited pre-implementation data, it will be important to take samples at the time of implementation and during the initial stages of the response.

As previously noted, changes in populations and ecosystems will occur over time. Some changes may occur rapidly. However, because many species in central California are slow growing and recruitment is often sporadic, it may take many years for changes to be fully realized. On the other hand, there is need for evaluation and adaptive management in the short term. It is, therefore, recommended that the results of the monitoring be reviewed in detail approximately 5 years after implementation of the MPAs and every 5 years thereafter.

## **Monitoring Activities**

Monitoring activities are presented by habitat type listed in order of priority. Recommendations of the Baseline Science-Management Panel (BSMP) were considered in setting priorities, but modified for the purpose of long-term monitoring. Deep water rocky habitat was ranked first because it supports many of the species mentioned in the objectives (e.g., rockfish and other groundfish species) and, based on the Ecotrust analysis, this habitat has had the most consumptive use. Shallow rocky habitat, including kelp beds, was ranked second because it supports many of the species mentioned in the objectives. Because habitat mapping is required for the evaluation of Goal 4 and many MPA-specific objectives (Table 3), it is considered high priority and ranked third. Within medium priority activities, deep water soft bottom and rocky intertidal were ranked one and two, respectively. Low priority activities are not included here. Measuring residence time of species is needed to evaluate the level of protection afforded by MPAs and is considered for each habitat type. Understanding biological networks will require research and is therefore not included here.

*Deep Water (> 30m) Hard Bottom Monitoring*

Eighteen MPAs have deep water (> 30 m) hard bottom habitat (Table 4) with seven having habitat in >100 m. Six MPAs have submarine canyon habitat (Table 5).

There is no ongoing monitoring of high and medium relief deep water hard bottom and canyon habitats in the central coast region. In 2003, the National Marine Fisheries Service (NMFS) extended the sampling area for their annual trawl surveys for groundfish to include all of Washington, Oregon and California from approximately 55 to 1280 m. To avoid losing the nets, higher relief areas are avoided, but the trawls do sample lower relief hard bottom habitat. In 1992-1993 Yoklavich, et al. (2000) surveyed benthic fish populations in Soquel Canyon. In 1997-1998 Yoklavich, et al. (2002) surveyed benthic fish populations inside and outside of the Big Creek Marine Ecological Reserve (now Big Creek State Marine Reserve). Both surveys were conducted with a submersible. Strip transects were videotaped to provide documentation of fish abundance and habitat type.

Table 4. MPAs with deep water (> 30 m) hard bottom habitat (area in $mi^2$).

| MPA Name | 30-100 m | 100-200 m | >200 m |
|---|---|---|---|
| Soquel Canyon SMCA | 2.38 | 2.05 | 0.87 |
| *Portuguese Ledge SMCA* | 0.38 | 1.62 | 1.51 |
| *Pacific Grove Marine Gardens SMCA* | 0.14 | 0 | 0 |
| *Asilomar SMR* | 0.08 | 0 | 0 |
| *Carmel Pinnacles SMR* | 0.37 | 0 | 0 |
| *Carmel Bay SMCA* | 0.04 | 0 | 0 |
| *Pt. Lobos SMR* | 1.13 | 0 | 0 |
| *Pt. Lobos SMCA* | 0.26 | 1.64 | 0.95 |
| *Point Sur SMR* | 1.8 | 0 | 0 |
| *Point Sur SMCA* | 1.84 | 0.01 | 0 |
| *Big Creek SMCA* | 0.06 | 0.05 | 0.02 |
| *Big Creek SMR* | 0.11 | 0.01 | 0.03 |
| *Piedras Blancas SMR* | 0.15 | 0 | 0 |
| *Piedras Blancas SMCA* | 0.56 | 0 | 0 |
| *Cambria SMR* | 0.02 | 0 | 0 |
| *Point Buchon SMR* | 0.75 | 0 | 0 |
| *Point Buchon SMCA* | 0.69 | 0.02 | 0 |
| *Vandenberg SMR* | 0.25 | 0 | 0 |

Table 5. MPAs with deep water (> 30m) canyon habitat (area in $mi^2$).

| MPA Name | 30-100 m | 100-200 m | >200 m |
|---|---|---|---|
| Soquel Canyon SMCA | 0.02 | 0.6 | 2.25 |
| *Portuguese Ledge SMCA* | 0 | 0 | 1.72 |
| *Carmel Bay SMCA* | 0.02 | 0 | 0 |
| *Pt. Lobos SMR* | 0.01 | 0 | 0 |
| *Pt. Lobos SMCA* | 0.02 | 0.15 | 0.15 |
| *Big Creek SMCA* | 0.12 | 0.1 | 2.29 |
| *Big Creek SMR* | 0.25 | 0.29 | 3.17 |

For the Channel Islands MPA monitoring program in southern California, a Remotely Operated Vehicle (ROV) is used to survey fish in hard bottom habitats beyond the reach of divers (20-80 m) (http://www.dfg.ca.gov/mrd/fir/dss.html). Survey techniques used in ROV and submersible surveys are similar, but not identical. To compare methods, Dr. Milton Love and Donna Schroeder surveyed two of the ROV survey sites with a submersible in 2005. Results of the comparison should be available soon. Nasby et al. (2002) integrated detailed seafloor mapping and submersible transects to estimate fish densities across broad areas of a deepwater bank off Oregon.

Existing survey techniques can be used to measure size and density of conspicuous benthic fish and invertebrates, including all focal fish species (Table 6), although some work will be needed to create detailed sampling protocols, including quality assurance/quality control (QA/QC). Survey methods need to be developed for invertebrates. Strip survey techniques should provide data for all focal invertebrates, except crabs and spot prawn, which will need to be sampled with traps. In areas with limited visibility, sampling with traps and/or fishing gear will be needed. Targeted research projects can provide data on residence times of selected focal species. Starr et al. (2000, 2002) have developed techniques for tagging and tracking deep water species such as bocaccio and greenspotted rockfishes.

Table 6. Focal fish and invertebrate species for deep water (> 30m) hard bottom habitats.

| Common Name | Scientific Name | Reason for Selection |
|---|---|---|
| bocaccio | *Sebastes paucispinis* | shift number, size |
| cowcod | *Sebastes levis* | shift number, size |
| lingcod | *Ophiodon elongates* | shift number |
| blue rockfish | *Sebastes mystinus* | shift number size |
| greenspotted rockfish | *Sebastes chlorosticus* | shift size |
| copper rockfish | *Sebastes caurinus* | shift size |
| olive rockfish | *Sebastes serranoides* | shift size |
| squarespot rockfish | *Sebastes hopkinsi* | fished |
| yelloweye rockfish | *Sebastes ruberrimus* | shift number |
| yellowtail rockfish | *Sebastes flavidus* | shift size |
| widow rockfish | *Sebastes entomelas* | shift number |
| vermilion rockfish | *Sebastes miniatus* | shift size |
| galatheid crabs | Galatheidae | incidental catch in spot prawn fishery |
| red rock crab | *Cancer productus* | fished, incidental catch in spot prawn fishery |
| crinoids | *Florometra serratissima* | habitat forming |
| sponges | Porifera | habitat forming |
| anemones | *Metridium spp., Urticina picivora* | habitat forming |
| black corals | *Antipathes spp.* | ecosystem component |
| basket stars | *Gorgonocephalis eucemis* | habitat forming |
| sea stars | *Ceramaster* spp*., Mediaster aequilis, Pteraster* spp. | predatory |
| spot prawn | *Pandalus platyceros* | fished |

*Shallow Water (< 30m) Hard Bottom Monitoring*

Eighteen MPAs have shallow water (< 30m) habitat (Table 7).

The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) has ongoing monitoring at 14 sites within the central coast region, with 10 inside MPAs (Table 7, Figure 2). Sites have been sampled annually, starting between 1999 and 2004, depending on the site. Divers conduct visual surveys of conspicuous fish species and count selected invertebrate and algal species along replicate 30 x 2 m transects. Uniform contact sampling is used to measure substrate type and relief as well as the percent cover of benthic organisms. The monitoring program for the Diablo Canyon Nuclear Power Plant has been sampling for fish and invertebrates since 1978 (Tenera 1998).

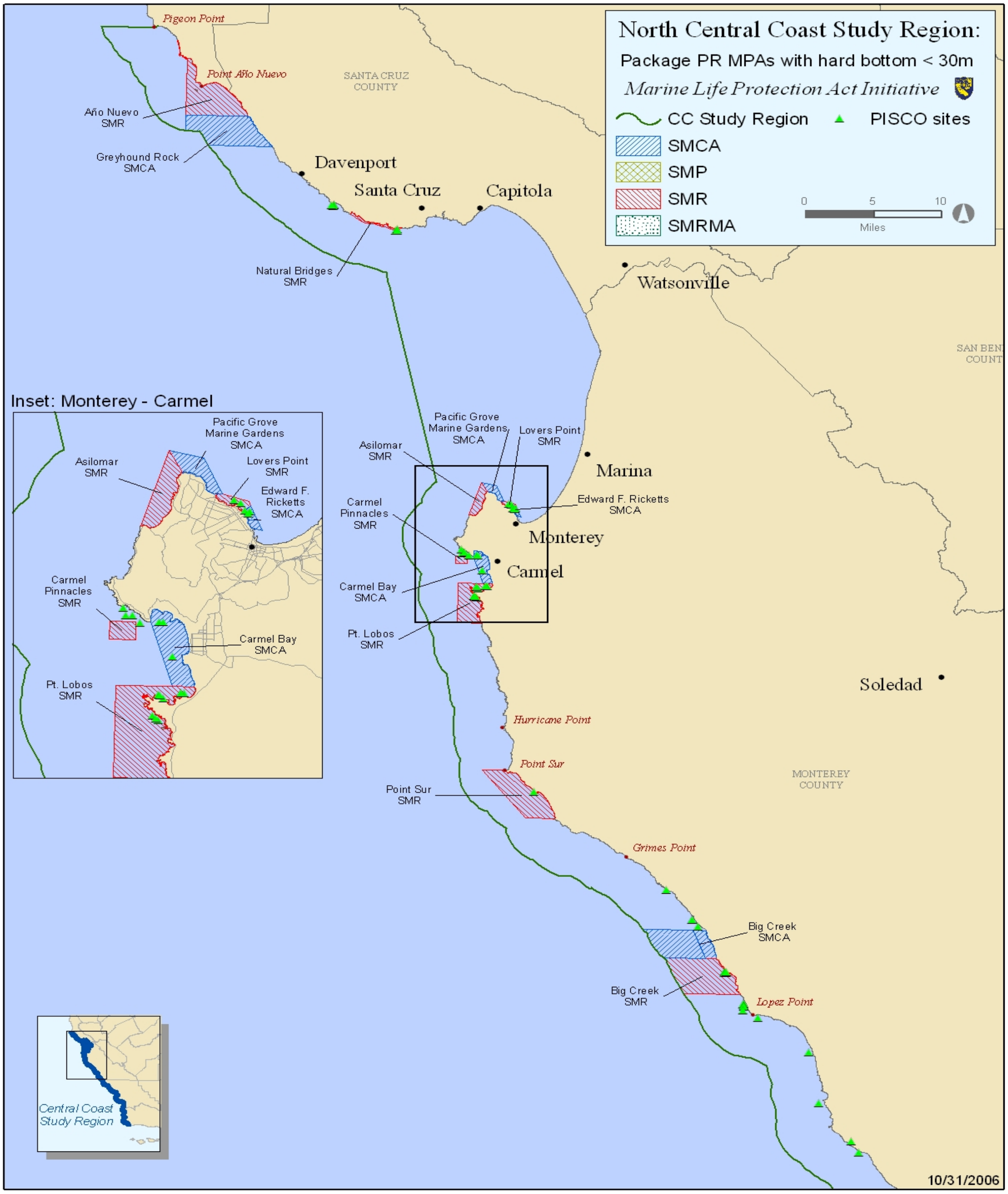
Table 7. MPAs with shallow water (< 30m) hard bottom habitat (area in $mi^2$).

| **MPA Name** | **Hard 0-30** | **Average Kelp** | **Pisco Sampling Site** |
|---|---|---|---|
| *Año Nuevo SMR* | 3.56 | 0.01 | X |
| *Greyhound Rock SMCA* | 1.96 | 0.01 | X |
| *Natural Bridges SMR* | 0.58 | 0.02 | X |
| *Edward F. Ricketts SMCA* | 0.06 | 0.05 | X |
| *Lovers Point SMR* | 0.09 | 0.08 | X |
| *Pacific Grove Marine Gardens SMCA* | 0.48 | 0.14 | |
| *Asilomar SMR* | 0.59 | 0.11 | |
| *Carmel Pinnacles SMR* | 0.07 | 0.01 | |
| *Carmel Bay SMCA* | 0.71 | 0.30 | X |
| *Pt. Lobos SMR* | 1.03 | 0.27 | X |
| *Point Sur SMR* | 3.41 | 0.84 | X |
| *Big Creek SMCA* | 0.40 | 0.17 | |
| *Big Creek SMR* | 0.57 | 0.21 | X |
| *Piedras Blancas SMR* | 1.60 | 0.50 | X |
| *Cambria SMP* | 1.34 | 0.57 | X |
| *Cambria SMR* | 1.02 | 0.38 | X |
| *Point Buchon SMR* | 0.60 | 0.21 | |
| *Vandenberg SMR* | 3.27 | 0.02 | X |

Reef Check, a volunteer organization, has 12 stations in the central coast region, 11 in MPAs. Additional sites inside and outside MPAs will be added as the program expands. Sampling began in the fall of 2006 and will continue twice a year in the spring and fall. Reef Check protocols are adapted from the PISCO/CRANE protocols and will provide density and size information for all the focal species. Surveys are limited to depths less than 18 m. REEF, another volunteer organization, uses timed searches and records the relative abundance of species. REEF data cannot be used to evaluate changes in density but may provide additional information on species diversity.

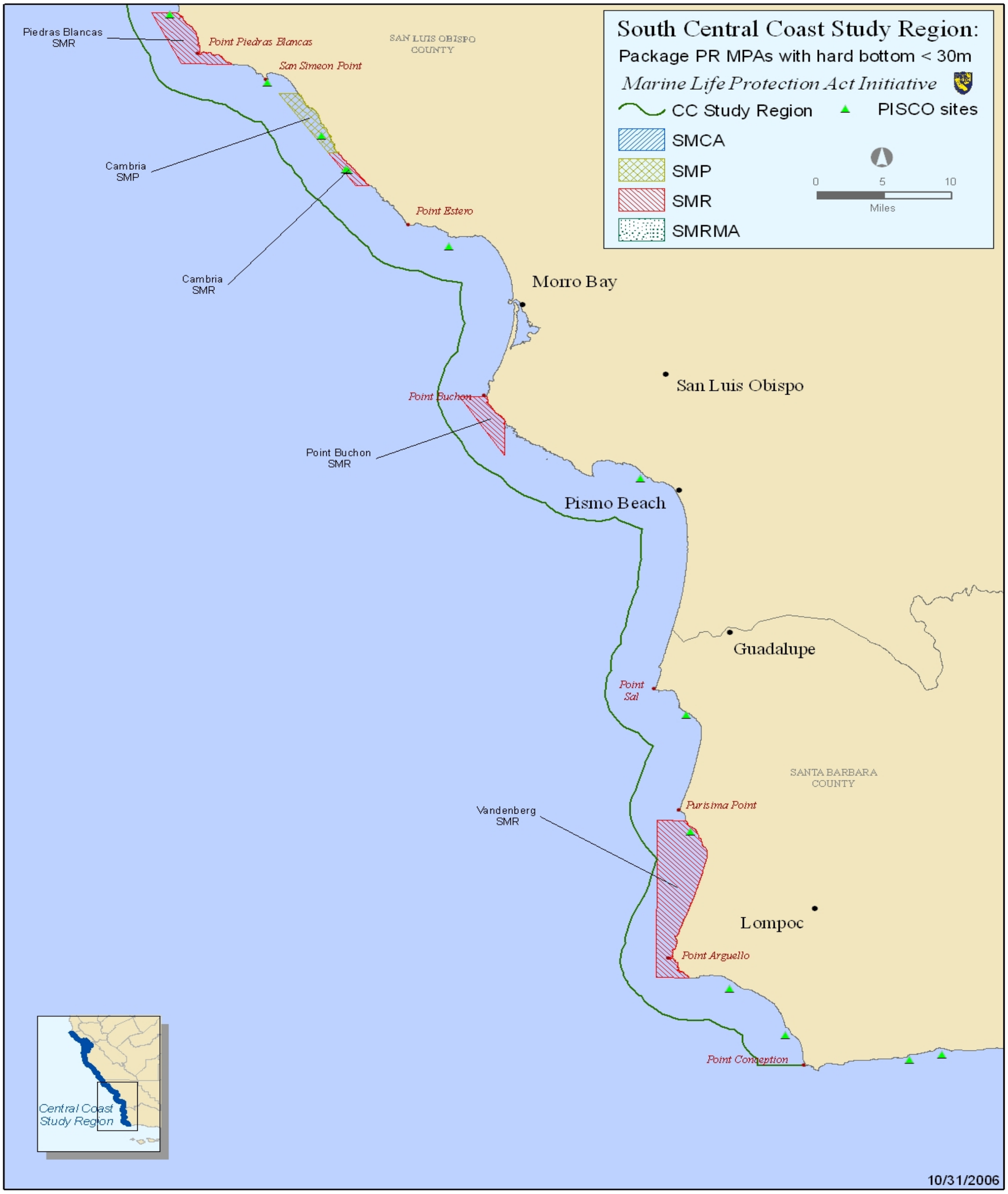
Diver surveys will be used to measure density and size of conspicuous benthic fish and invertebrate species at most sites. At some sites, particularly Año Nuevo SMR, and Greyhound Rock SMCA, where diver safety precludes scuba surveys, ROVs may be used. Survey techniques are expected to be similar to those used by PISCO and CRANE, but may be modified for the particular circumstance. Visual surveys will provide data for all focal species (Table 8), except grass rockfish, cabezon, and brown rock crab. Traps and/or hook and line fishing will be needed for these species and to sample areas with limited visibility.

Figure 1. Location of sites sampled by The Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) in the central coast region.




SMCA = state marine conservation area SMP = state marine park
SMR = state marine reserve SMRMA = state marine recreational management area

Figure 1. Continued.




SMCA = state marine conservation area SMP = state marine park
SMR = state marine reserve SMRMA = state marine recreational management area

Table 8. Focal fish and invertebrate species for shallow water (< 30m) hard bottom habitats.

| Common Name | Scientific name | Reason for selection |
|---|---|---|
| lingcod | *Ophiodon elongatus* | shift number |
| kelp greenling | *Hexagrammos decagrammus* | fished |
| grass rockfish | *Sebastes rastrelliger* | fished |
| brown rockfish | *Sebastes auriculatus* | fished |
| vermilion rockfish | *Sebastes miniatus* | shift size |
| copper rockfish | *Sebastes caurinus* | shift size |
| black rockfish | *Sebastes melanops* | shift number |
| blue rockfish | *Sebastes mystinus* | shift size |
| olive rockfish | *Sebastes serranoides* | shift size |
| gopher rockfish | *Sebastes carnatus* | fished |
| kelp rockfish | *Sebastes atrovirens* | fished |
| cabezon | *Scorpaenichthys marmoratus* | fished |
| black surfperch | *Embiotoca jacksoni* | major component of ecosystem |
| striped surfperch | *Embiotoca lateralis* | major component of ecosystem |
| abalones | *Haliotis* spp | shift number, size |
| red urchin | *Strongylocentrotus franciscanus* | fished, removal affects other species |
| purple urchin | *Strongylocentrotus purpuratus* | population level affects other species |
| sea stars | *Pisaster* spp. | keystone species |
| brown rock crab | *Cancer antennarius* | fished |
| bull kelp | *Nereocystis luetkeana* | habitat forming |
| giant kelp | *Macrocystis pyrifera* | habitat forming |

*Deep Water (> 30m) Soft Bottom Monitoring*

Twenty-one MPAs have mid and deep water (> 30m) soft bottom habitat (Table 9). All 21 have habitat between 30 and 100 m; 7 have habitat in deeper water.

Table 9. MPAs with mid and deep water (>30 m) soft bottom habitat (area in $mi^2$).

| MPA Name | Soft 30-100 m | Soft 100-200 m | Soft >200 m |
|---|---|---|---|
| *Año Nuevo SMR* | 2.70 | 0.00 | 0.00 |
| *Greyhound Rock SMCA* | 9.03 | 0.00 | 0.00 |
| Soquel Canyon SMCA | 13.20 | 1.77 | 3.14 |
| *Portuguese Ledge SMCA* | 1.46 | 4.45 | 1.48 |
| *Pacific Grove Marine Gardens SMCA* | 0.02 | 0.00 | 0.00 |
| *Asilomar SMR* | 0.01 | 0.00 | 0.00 |
| *Carmel Pinnacles SMR* | 0.07 | 0.00 | 0.00 |
| *Carmel Bay SMCA* | 0.05 | 0.00 | 0.00 |
| *Pt. Lobos SMR* | 2.32 | 0.06 | 0.00 |
| *Pt. Lobos SMCA* | 0.18 | 2.94 | 2.88 |
| *Point Sur SMR* | 2.34 | 0.00 | 0.00 |
| *Point Sur SMCA* | 8.10 | 0.00 | 0.00 |
| *Big Creek SMCA* | 2.19 | 0.36 | 6.12 |
| *Big Creek SMR* | 2.61 | 0.84 | 7.05 |
| *Piedras Blancas SMR* | 2.56 | 0.00 | 0.00 |
| *Piedras Blancas SMCA* | 8.20 | 0.00 | 0.00 |
| *Cambria SMP* | 0.44 | 0.00 | 0.00 |
| *Cambria SMR* | 0.33 | 0.00 | 0.00 |
| *Point Buchon SMR* | 4.66 | 0.00 | 0.00 |
| *Point Buchon SMCA* | 7.93 | 2.91 | 0.00 |
| *Vandenberg SMR* | 9.69 | 0.00 | 0.00 |

Besides the annual trawl survey by NMFS described in “Deep Water (>30m) Hard Bottom Monitoring”, there is no ongoing monitoring of mid and deep water soft bottom habitats . Submersible surveys by Yoklavich, et al. (2000) in Soquel Canyon, and Yoklavich, et al. (2002) in and adjacent to Big Creek Marine Ecological Reserve (now Big Creek SMR) included deep water soft bottom habitat. Hixon and Tissot (2007) ran submersible transects for fishes and invertebrates over deep mud seafloors off Oregon. Monitoring protocols used to survey hard bottom habitat can be adapted to monitor soft bottom habitats. Trawls can also be used. Visual survey techniques will capture all focal species except Dungeness crab, which can be sampled with traps. Trawls can capture all species, although sea pens may be under-represented because they anchor into the substrate.

Table 10. Focal fish and invertebrate species for mid and deep water (> 30 m) soft bottom habitats.

| Common Name | Scientific Name | Reason for Selection |
|---|---|---|
| petrale sole | *Eopsetta jordani* | shift number, size |
| Dover sole | *Microstomus pacificus* | fished |
| English sole | *Parophrys vetulus* | fished |
| slender sole | *Lyopsetta exilis* | fished |
| rex sole | *Glyptocephalus zachirus* | fished |
| Pacific sandab | *Citharichthys sordidus* | fished |
| sablefish | *Anoplopoma fimbria* | fished |
| splitnose rockfish | *Sebastes diploproa* | fished |
| chilipepper | *Sebastes goodei* | fished |
| spotted ratfish | *Hydrolagus colliei* | ecosystem component |
| shortspine thorneyhead | *Sebastolobus alascanus* | fished |
| longspine thorneyhead | *Sebastolobus altivelis* | fished |
| California skate | *Raja inornata* | fished |
| longnose skate | *Raja rhina* | fished |
| sea pens | *Stylatula spp, Ptilosarchus spp, Anthoptilum spp.* | habitat forming |
| flat mud star | *Luidia foliolata*. | predator |
| sunflower star | *Pycnopodia helianthoides* | predator |
| carpet star | *Thrissacanthias penicillatus* | predator |
| fragile red sea urchin | *Allocentrotus fragilis* | ecosystem component |
| Dungeness crab | *Cancer magister* | fished |

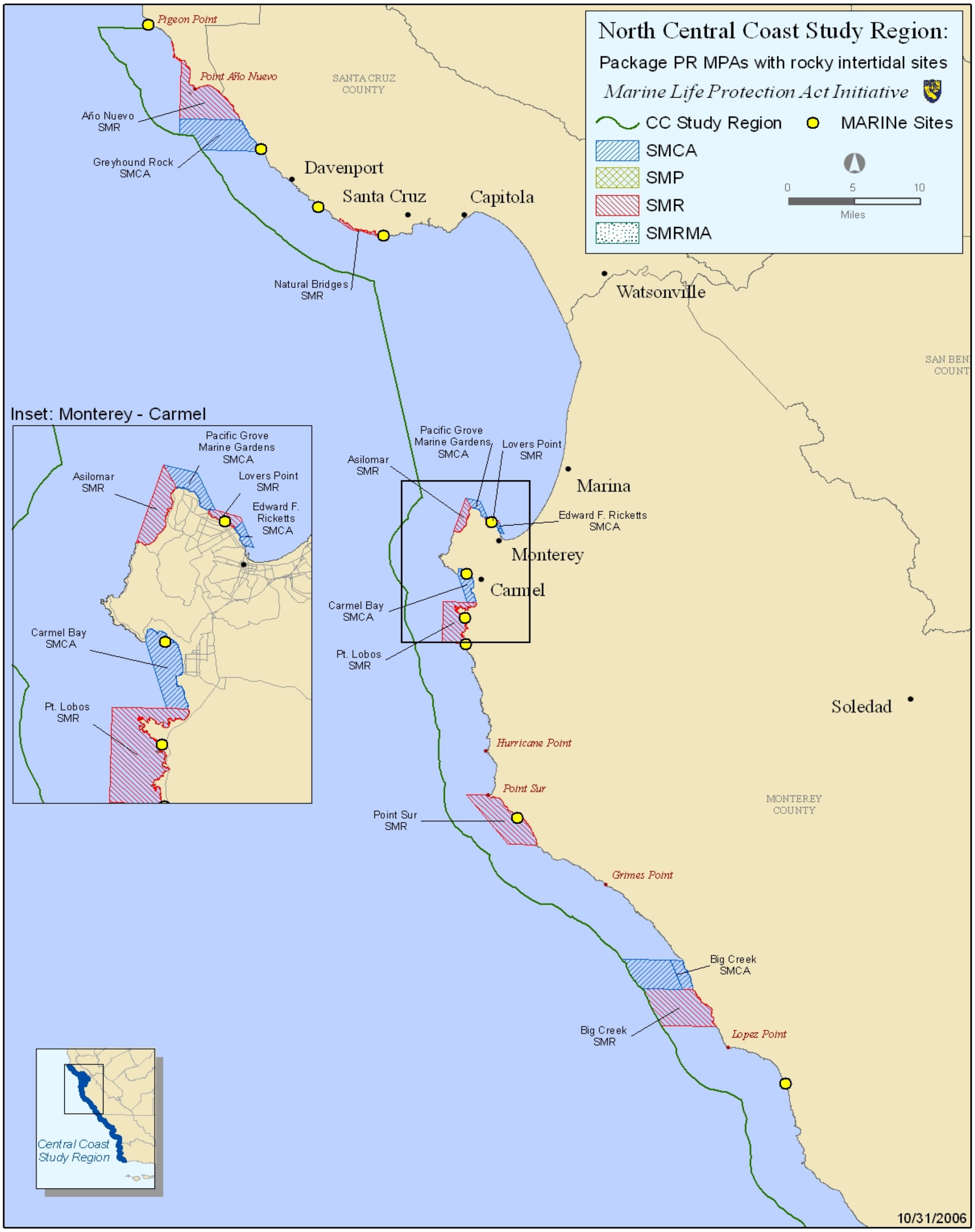
*Rocky Intertidal Monitoring*

Twelve MPAs have rocky intertidal habitat (Table 11). The Multi-Agency Rocky Intertidal Network (MARINe), a partnership of more than 40 federal, state, academic and other institutions, monitors 20 sites in the central coast region; five sites are inside MPAs (Table 11, Figure 3).

Table 11. MPAs with rocky intertidal habitat (area in $mi^2$).

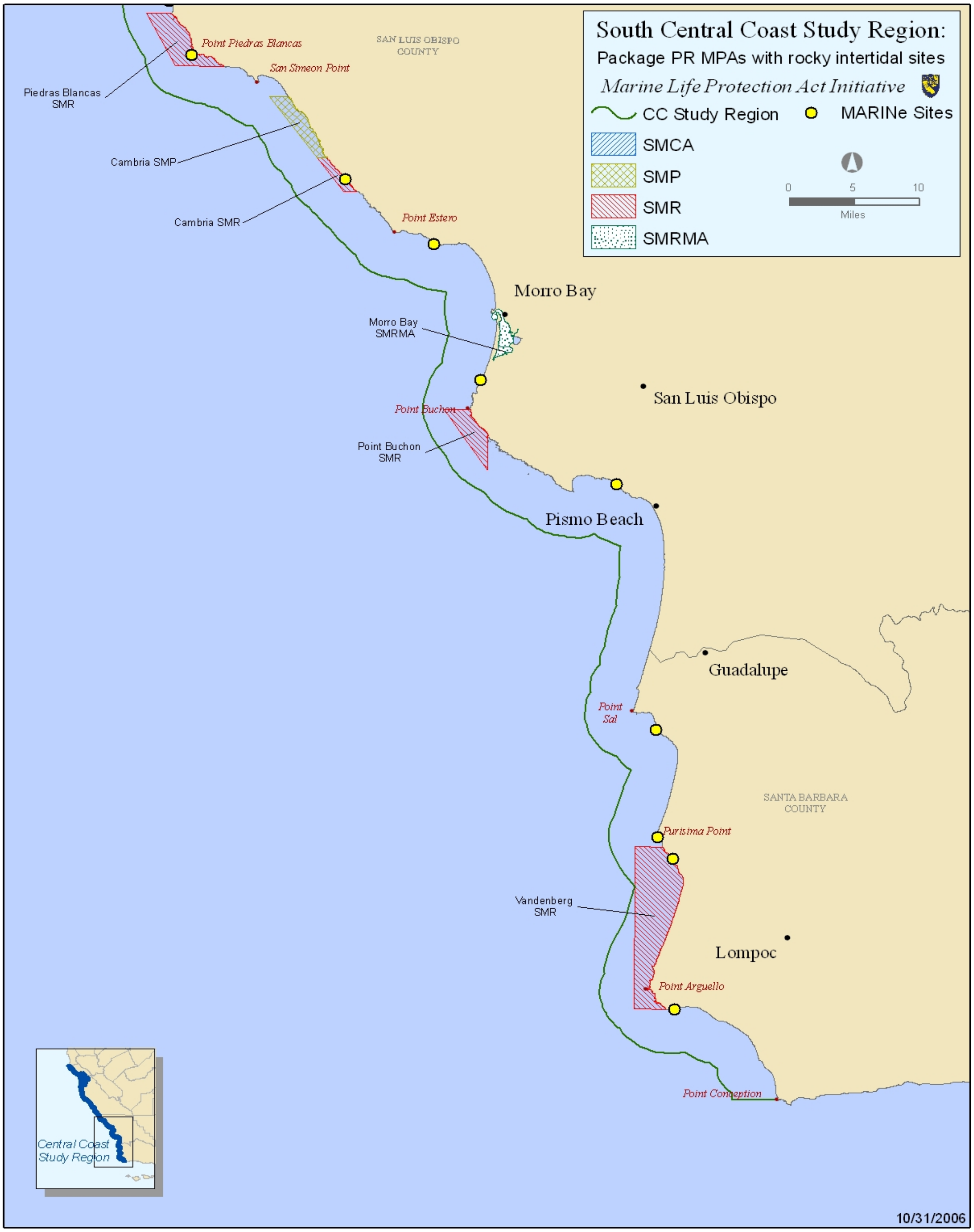
| **MPA Name** | **Rocky intertidal and cliff** | **MARINe monitoring site** |
|---|---|---|
| *Año Nuevo SMR* | 4.89 | |
| *Greyhound Rock SMCA* | 3.31 | X |
| *Natural Bridges SMR* | 3.58 | |
| *Edward F. Ricketts SMCA* | 0.8 | |
| *Lovers Point SMR* | 1.42 | X |
| *Pacific Grove Marine Gardens SMCA* | 1.92 | |
| *Asilomar SMR* | 2.85 | |
| *Carmel Bay SMCA* | 2.62 | X |
| *Pt. Lobos SMR* | 13.67 | X |
| *Point Sur SMR* | 3.71 | X |
| *Big Creek SMCA* | 1.77 | |
| *Big Creek SMR* | 2.95 | |
| *Piedras Blancas SMR* | 5.83 | X |
| *Cambria SMP* | 3.77 | |
| *Cambria SMR* | 4 | |
| *Morro Bay SMRMA* | 0.18 | |
| *Point Buchon SMR* | 2.74 | |
| *Vandenberg SMR* | 9.55 | X |

Figure 2. Location of MARINe intertidal hardbottom monitoring sites in the central coast region.




SMCA = state marine conservation area SMP = state marine park
SMR = state marine reserve SMRMA = state marine recreational management area

Figure 2. Continued.




SMCA = state marine conservation area          SMP = state marine park
SMR = state marine reserve          SMRMA = state marine recreational management area

MARINe uses two sampling protocols: a "core" protocol that measures the percent cover of 12 target species (Table 12), and a more intensive "biodiversity" protocol. Core sites are sampled twice a year in the fall and spring. Biodiversity sampling occurs irregularly.

The percent cover of target species as well as other associated species is measured by photographing approximately five permanent 50 X 75 cm plots established in areas of high target species density. The photographs are then scored in the laboratory using point-contact methods. In areas with sufficient populations, the number and size distribution of owl limpets (*Lottia giantea*) is measured in five permanent circular plots. Band transects or irregularly-shaped plots, depending on the site, are used to estimate the number and size of black abalone (*Haliotis cracherodii*) and seastars (primarily *Pisaster ochraceus*). Timed searches are used where densities are too low for band transects. The cover of surfgrass and associated species is measured on approximately three permanent transects, 10 m long, with point contact methods.

Table 12. Focal fish and invertebrate species for intertidal hard bottom habitats.

| Common Name | Scientific Name | Reason for Selection | MARINe Target Species |
|---|---|---|---|
| black abalone | *Haliotis cracherodii* | shift number, size | X |
| owl limpet | *Lottia gigantea* | shift size | X |
| California mussel | *Mytilus californianus* | habitat forming | X |
| ochre sea star | *Pisaster ochraceus* | keystone species | X |
| aggregating anemone | *Anthropleura elegantissima/sola* | ecosystem component | X |
| small acorn barnacle | *Chthamalus dalli/fissus/Balanus glandula* | ecosystem component | X |
| large acorn barnacle | *Tetraclita rubescens* | ecosystem component | X |
| gooseneck barnacle | *Pollicipes polymerus* | ecosystem component | X |
| turban snail | *Tegula funebralis* | harvested | |
| feather boa kelp | *Egregia menziesii* | habitat forming | X |
| rockweed | *Hesperophycus californicus* | habitat forming | X |
| rockweed | *Silvetia compressa* | habitat forming | X |
| turfweed | *Endocladia muricata* | habitat forming | X |
| surfgrass | *Phyllospadix scouleri/torreyi* | habitat forming | X |
| monkeyface prickleback | *Cebidicthys violaceus* | local depletion | |

The Long-term Monitoring Program and Experimental Training for Students (Limpets) program samples four rocky intertidal sites at Carmel Pt., San Simeon, Pigeon Pt., and Pt. Bonita. Limpets is a volunteer program, principally run by teachers. Sampling methods include total organism counts, single vertical transects, and random quadrats with estimates of the number and percent cover of selected species. The type of data and temporal coverage varies.

The list of focal species for intertidal hardbottom and MARINe target species (Table 12) are identical except for the inclusion of turban snails and monkeyface prickleback. These two species were included because they are harvested. While turban snails are not a MARINe target species, they are sampled annually. MARINe protocols will not provide data for fish such as the monkeyface prickleback. Special studies, including trapping and/or hook and line fishing using the traditional recreational gear known as a “poke pole”, will be needed for this species.

The spatial and temporal extent of the MARINe program will provide valuable long-term baseline information for the evaluation of MPAs. It is expected that additional monitoring will closely follow MARINe protocols. However, it may be necessary in some instances to augment the sampling with additional replication and/or random sampling.

*Marine Mammal and Seabird Monitoring*

If some fish and invertebrate species increase in size and number as expected, MPAs may affect seabirds and marine mammals by increasing or shifting their forage base.

Focal seabirds and marine mammals (Table 13) occur throughout the central coast region.

NMFS and the Monterey Bay National Marine Sanctuary (MBNMS) have a program called Collaborative Survey of Cetecean Abundance and the Pelagic Ecosystem (CSCAPE) which conducts annual surveys of marine mammals. Track lines are surveyed on a large scale grid (~ 160 km) from the US/Canadian border to the US/Mexico border and on a smaller grid (18.5 km) within the boundaries of the MBNMS. Although the survey targets marine mammals, seabirds are also recorded. The sampling provides good information on abundances, but the grid is too large for monitoring individual MPAs.

The United States Geological Service (USGS) conducts surveys of sea otters in the spring and fall in the area between Monterey Bay and Santa Barbara. Sightings are made from shore or with aerial surveys in inaccessible areas. Burney LeBoeuf, at U.C. Santa Cruz, has conducted annual surveys of elephant seals in the MBNMS since 1968.

Dr. Jim Harvey and students at the Moss Landing Marine Laboratory conduct biannual surveys of shorebirds and annual surveys of harbor seals and sea otters in Elkhorn Slough. Elkhorn Slough National Estuarine Research Reserve program volunteers have surveyed shorebirds at 24 sites bimonthly since 1998. Surveys are also conducted at rookeries to determine breeding success for herons, egrets, cormorants and Caspian terns.

Table 13. Focal marine birds and mammals.

| Common Name | Scientific Name | Reason for Selection |
|---|---|---|
| **Marine Birds** | | |
| Brandt's cormorant | *Phalacrocorax penicillatus* | disturbance, increase in forage base |
| brown pelican | *Pelecanus occidentalis* | disturbance, increase in forage base |
| common murre | *Uria aalge* | disturbance, increase in forage base |
| double-crested cormorant | *Phalacrocorax auritus* | disturbance, increase in forage base |
| pelagic cormorant | *Phalacrocorax pelagicus* | disturbance, increase in forage base |
| rhinocerous auklet | *Cerorhinca monocerata* | disturbance, increase in forage base |
| pigeon guillemot | *Cepphus columba* | disturbance, increase in forage base |
| grebes | *Podicipedidae* | increase in forage base |
| loons | Gaviidae | increase in forage base |
| marbled murrelet | *Brachramphus marmoratus* | disturbance, increase in forage base |
| sooty shearwater | *Puffinus griseus* | hot spots for prey, indicator of prey availability |
| Cassin's auklet | *Ptychoramphus aleuticus* | Indicator of krill and larval fish abundance |
| black oyster catcher | *Haematopus bachmani* | intertidal ecosystem component |
| ***Marine Mammals*** | | |
| sea otter | *Enhydra lutris* | keystone species |
| California sea lion | *Zalophus californianus* | predator |
| harbor seal | *Phoca vitulina* | predator |
| elephant seal | *Mirounga angustirostris* | predator |
| harbor porpoise | *Phocoena phocoena* | aggregate in specific areas |

Shorebird populations in Morro Bay have been monitored biannually by Morro Bay National Estuary Program volunteers in conjunction with the PRBO Conservation Science (PRBO). Since 1992, from April through August, PRBO has conducted weekly surveys of seabird abundance, breeding performance, and diet at Año Nuevo Island and monthly diet surveys since 2001.  At Vandenberg SMR, PRBO has conducted weekly surveys (April through August) of breeding seabird population size and performance since 1999 and seabird diets and seabird and marine mammal foraging distributions since 2000. Roosting seabird distributions have been surveyed biweekly from January through December since 2001.

Strip surveys can be used to measure the distribution and abundance and foraging patterns of focal species of seabirds and mammals. Surveys of breeding sites can measure breeding success (number of offspring per adult). Studies of diet can provide information for evaluation of foraging behavior and reproductive success, as well as information on the availability of prey species.

*Coastal Marsh and Estuary Monitoring*

Nine MPAs have coastal marsh and estuarine habitat (Table 14); most of the habitat is in Elkhorn Slough and Morro Bay.

Table 14. MPAs with coastal marsh and estuary habitat (area in $mi^2$).

| MPA Name | Coastal marsh | Tidal flats | Eelgrass | Estuary |
|---|---|---|---|---|
| *Natural Bridges SMR* | 0.68 | 0.00 | 0.00 | 0.00 |
| *Elkhorn Slough SMR* | 9.16 | 9.16 | 0.03 | 1.48 |
| *Elkhorn Slough SMP* | 0.95 | 0.99 | 0.01 | 0.09 |
| *Moro Cojo SMR* | 0.00 | 0.00 | 0.00 | 0.46 |
| *Piedras Blancas SMR* | 0.00 | 0.00 | 0.00 | 0.01 |
| *Cambria SMP* | 0.47 | 0.15 | 0.00 | 0.01 |
| *Morro Bay SMR* | 1.52 | 0.72 | 0.00 | 0.3 |
| *Morro Bay SMRMA* | 6.69 | 5.23 | 1.04 | 3.01 |
| *Vandenberg SMR* | 0.01 | 0.01 | 0.00 | 0.00 |

Both Elkhorn Slough and Morro Bay have ongoing monitoring. As part of the Elkhorn Slough National Estuarine Research Reserve program, volunteers have collected water quality samples monthly at 24 stations since 1998. Baited traps are used to capture crabs and visual surveys are done of surface burrow structures to measure populations of gaper clams, fat innkeeper worms, and ghost shrimp. Since 1994, Morro Bay National Estuary Program volunteers have conducted annual aerial and sonar surveys to map the distribution and abundance of eelgrass in the Bay.

Ongoing monitoring will provide sufficient information for some focal species (Table 15). Monitoring in Elkhorn Slough will provide information for ghost shrimp, innkeeper worms, and gaper clams. Surveys would need to be conducted in Morro Bay for these species. Eelgrass is mapped in Morro Bay, but not in Elkhorn Slough. Given the limited amount of habitat, mapping eelgrass in Elkhorn Slough may not be cost effective.

At present, there is no ongoing monitoring for focal fish species in Morro Bay or Elkhorn Slough. In Elkhorn Slough there is some historical data from Moss Landing Marine Lab research projects and class trawls, but nothing after 2003. Trawl, gill net, and/or trap sampling will be needed for the evaluation of focal fish species.

Table 15. Focal species for estuaries.

| **Common Name** | **Scientific Name** | **Reason for Selection** |
|---|---|---|
| topsmelt | *Atherinops affinis* | lay eggs on plants |
| leopard shark | *Triakis semifasciata* | use estuary as nursery, fished |
| black surfperch | *Embiotoca jacksoni* | fished |
| shiner surfperch | *Cymatogaster aggregata* | fished |
| ghost shrimp | *Calianassa* spp. | collected for bait |
| innkeeper worm | *Urechis caupo* | ecosystem component |
| gaper clams | *Tresus* spp. | ecosystem component |
| eelgrass | *Zostera* spp. | habitat forming |

## II. SOCIOECONOMIC MONITORING

### Goals and Objectives

Socioeconomic information is needed to evaluate regional Goal 3: to improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbances, and to manage these uses in a manner consistent with protecting biodiversity. Evaluating this goal will require monitoring human activities, the effect of the activities on the ecosystem, and the effectiveness of management. Monitoring human activities will be discussed in this section. Information on ecosystem effects will be provided by biophysical monitoring. Information on management will be provided by management monitoring.

Most MPA-specific objectives related to human use are discussed in Section IV because they are intended to guide network and network component design. Two objectives, to increase positive socioeconomic benefits and minimize negative socioeconomic impacts, are discussed here.

### Measuring Performance

To evaluate changes in opportunities for recreation, education and research (goal 3), it will be necessary to measure activities within and outside MPAs before and after implementation. In contrast to the biophysical system, impacts on activities will begin to occur simultaneously with implementation. In this case, a baseline can be established with existing data and/or user surveys. If the MPAs function as expected, the level of activity should increase inside MPAs.

The MPA-specific objective to increase positive socioeconomic benefits applies primarily to non-consumptive uses in Piedras Blancas SMR, recreational fishing in Cambria SMP, and non-consumptive diving in six MPAs (Table 16). Part of the data needed for the evaluation of non-consumptive uses will be provided by monitoring for the evaluation of Goal 3. In addition, surveys of will be needed for non-consumptive uses at Piedras Blancas SMR, recreational fishing at Cambria SMP, and diving at six sites.

The MPA-specific objective to minimize negative socioeconomic impacts was not intended to meet the technical definition of minimization, that is, to produce the lowest possible outcome, but rather as a direction to take an action that would ameliorate socioeconomic impacts. For instance, establishing a SMCA which encompasses part of the Rockfish Conservation area (Table 16) would have less impact than establishing a SMCA in an area without existing restrictions on some kinds of fishing. To evaluate the objective, it will be necessary to determine that the action was completed and then measure the socioeconomic impacts of the action.

While the monitoring is primarily designed to provide data needed to evaluate performance relative to the goals and objectives, there is also a desire to understand the overall socioeconomic impact of the MPA network and network components. This not only includes changes in non-consumptive recreational, educational and research activities, but also social and economic ramifications for users and associated communities. There is a particular need to measure changes in recreational and commercial fishing and non-consumptive uses, not only as part of the evaluation of social and economic impacts, but also to determine if displacement of fishing activity is increasing biological impacts outside of MPAs. Monitoring for the evaluation of Goal 3, for MPA-specific objectives, and for the overall socioeconomic evaluation is described below. Priorities for monitoring developed by the BSMP are provided in the following text; however, priorities for baseline and long-term monitoring will differ. As noted in the report of the MLPA Initiative Staff (2006), prioritization is primarily a policy decision, not a scientific judgment.

## Non-Consumptive Recreation, Education, and Research

Indicators for recreation include the number of recreational trips by activity (scuba diving, boating and kayaking, wildlife viewing, tidepooling), and recreational participant satisfaction. Indicators for education are the number of educational trips and the number of classroom study units related to central coast MPAs. Indicators for research are the number of research projects in the MPAs and the number of citations of publications resulting from projects in MPAs.

Establishing a baseline for the indicators will require surveys, literature reviews or other data collection, as there is little existing information. Most of the existing information on recreational activities is aggregated at the level of the county and state, a scale too large to be useful for evaluating the central coast network or individual MPAs. LaFranchi and Tamanaka (2005) conducted a preliminary survey of recreational use in Monterey and Santa Cruz Counties. These data are useful, but limited in scope.

Surveys of non-consumptive users as well as educational and research institutions can be done via mail or the internet or, in the case of present use, by intercepting people on site. Survey instruments can be designed to collect information about the time and location of use, attitudes, perceptions, and cost. The BSMP considered a survey of divers high priority because divers are most directly affected by MPA designation. The survey would include effort by location and time, travel cost and expenditures. Including other user groups (kayakers, wildlife viewing and unplanned activities) and information on knowledge, attitudes, and perceptions for all users was considered medium priority.

A literature search can be conducted to establish a baseline number of research publications as well as the number of post-implementation citations.

## Consumptive Uses

As noted above, determining the location and intensity of fishing before and after implementation of the MPAs is critical to the assessment of biophysical impacts (e.g. from displaced fishing effort) as well as socioeconomic impacts.

For recreational fishing, the Department's California Recreational Fishing Survey (CRFS) collects data on catch and fishing effort for private and rental boats, commercial passenger fishing vessels (CPFVs), man-made structures such as piers and jetties, and beaches and banks. The data can be referenced to 1 minute of latitude by 1 minute of longitude, a scale that will allow analysis at the level of an individual MPA.

Because the survey began in 2004 as a modification of a previous recreational fishing survey, and will continue through time, CRFS is a source of baseline and post-implementation data. Logbooks submitted to the Department from CPFV's will also provide valuable long-term data. Analyzing the existing data is high priority. Additional data may be needed to fill in gaps or refine the scale of the CRFS data.

For the economic and social dimension, the BSMP considered collecting data on costs and earnings from businesses depending on recreational consumptive use and measuring the knowledge, attitudes and perceptions of recreational users medium priority.

For commercial fishing, data from logbooks submitted to the Department will provide information on catch and fishing effort for spot prawn, and squid, although spot prawn data do not have fine spatial resolution. Data for other types of fishing will need to be collected from a new program (high priority). Methods could include remote sensing or aerial surveys, observers, and/or incentive-based voluntary reporting. As an alternative, interviews with commercial fishermen could be used to determine the stated importance of fishing locations. The BSMP ranked the alternative approach medium priority.

Data on costs and earnings, employment and other characteristics can be collected to ascertain economic and social effects of MPAs on fishery participants and fishing operations (medium priority). The BSMP determined that socioeconomic data on coastal communities should not be a priority; however, impacts can be measured by analyzing linkages between resource users and coastal communities.

## III. MANAGEMENT AND ENFORCEMENT MONITORING

### Goals and Objectives

Information related to management and enforcement is needed for the evaluation of regional Goal 5) to ensure that central California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines; and Goal 6) to ensure that the central coast's MPAs are designed and managed, to the extent possible, as a component of a statewide network. There are no MPA-specific objectives pertaining to management and enforcement.

Design elements, including clearly defined objectives, scientific guidelines and network and network component properties, are discussed in the next section. Biological properties of the network and network components are discussed in "Biophysical Monitoring".

### Measuring Performance

The framework for the evaluation of Management and Enforcement is provided by the Regional MPA Management Plan. The Plan is the guide for implementation and a measure of performance is implementation relative to the Plan.

The Management Plan includes the following elements:

1. Introduction ("*Why?*" and "*Where?*")
    a. Description of region
    b. Regional design and implementation considerations
    c. Regional goals, and objectives
    d. Description of individual MPA boundaries (including maps), regulations, and objectives
2. General Activities and Locations ("*What?*" and *"Where?"*)
    a. Scientific Monitoring and Research plan
    b. Outreach, Interpretation and Education plan
    c. Enforcement plan
    d. Contingencies and Emergency Planning
3. Operations ("*How?*")
    a. Equipment and Facilities
    b. Staffing
    c. Collaborations and Potential Partnerships
4. Costs and Funding ("*How Much?*")

   a. Estimated costs
   b. Potential funding sources
5. Timelines and Milestones ("*When?*")
   a. Timeline and Criteria for Implementation
   b. Timeline for Evaluation and Review of Effectiveness

Evaluation of management performance should consider the nature and extent of work performed to implement each program activity, specifically: 1) scientific monitoring; 2) outreach, interpretation and education; 3) enforcement; and 4) contingency and emergency planning. The descriptions of program elements should include information on equipment and facilities; staff and budget; collaborators, partners, and stakeholder involvement; as well as the timelines and milestones that have or have not been met.

The evaluation of program elements should consider implementation relative to regional goals and objectives, as well goals and objectives in individual activity plans (e.g., the scientific monitoring plan). The effect of staffing and budget on implementation should also be evaluated. To determine if central coast MPAs are operating as a network component, and if the regional network is operating as part of a statewide network, implementation should be evaluated for consistency within the regional and statewide system. Inconsistencies should be explained.

Although management and enforcement will begin with implementation, time is needed to create an operational history. To have sufficient information, management and enforcement should be evaluated 5 years after implementation.

Indicators for all program elements include extent of implementation and extent of stakeholder and public involvement. Indicators specific to program elements follow.

## **Program Indicators**

One indicator for the first program element "scientific monitoring" is the availability of information for adaptive management. The description of scientific monitoring should include program objectives, use of the data for evaluation of regional and MPA-specific goals and objectives, and use of the data for adaptive management. Data gaps should be identified, and availability and use of the data by stakeholders, researchers, and other outside entities described.

Indicators for the second program element "outreach, interpretation, and education" include distribution of materials explaining the regulations, understanding and acceptance of the regulations, distribution of educational materials, the presence of interpretive signs, and extent of stakeholder involvement. The description of outreach, interpretation, and education should include use of the materials by stakeholders and other groups, as well as a measure of stakeholder understanding of the materials.

Indicators for the third program element "enforcement" include clearly defined enforcement procedures, enforcement coverage, and information dissemination to encourage compliance.

The description of enforcement should include the number and extent of patrols, citations, and contacts with users.

Indicators for the fourth program element "contingency and emergency planning" include speed of response and presence of residual problems. The description of emergency responses should include an evaluation of the availability of resources and lessons learned

## IV. EVALUATION OF NETWORK DESIGN

Monitoring to evaluate the execution of the guidelines is discussed in this section. Monitoring to evaluate the management of the network or network component is discussed in the section "Management and Enforcement Monitoring" and monitoring to evaluate biological properties of the network or network component is discussed in "Biophysical Monitoring".

Regional goals providing guidance on network design are: Goal 5) to ensure that central California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines; and Goal 6) to ensure that the central coast's MPAs are designed and managed, to the extent possible, as a component of a statewide network.

MPA-specific objectives for network design (Table 16) provide directions for: 1) siting MPAs (e.g., site a MPA adjacent to a terrestrial park/reserve); 2) meeting network criteria for size, shoreline extent, etc.; 3) increasing socioeconomic benefits; 4) minimization of negative socioeconomic impacts; 5) provision for some types of fishing and/or harvest; and 6) provision for research and education.

Table 16. MPA-specific objectives for network design.

| Primary Objective | Focal Area or Group | MPAs |
|---|---|---|
| Site MPA in a particular area | | |
| | Adjacent to terrestrial state park | Ano Nuevo SMR, Point Sur SMR, Big Creek SMR, Big Creek SMCA, Piedras Blancas SMR |
| | Adjacent to Pacific Grove | Pacific Grove SMCA |
| | On Monterey Peninsula and accessible for recreation | Pacific Grove SMCA, Carmel Bay SMCA |
| Meet network criteria for size, shoreline extent, etc. | | |

| **Primary Objective** | **Focal Area or Group** | **MPAs** |
|---|---|---|
| | Size | Soquel Canyon SMCA, Portuguese Ledge SMCA, Point Sur SMR, Point Sur SMCA, Big Creek SMR, Piedras Blancas SMR, Piedras Blancas SMCA, Point Buchon SMR, Point Buchon SMCA, Vandenberg SMR |
| | Minimum shoreline and offshore extent | Point Lobos SMR, Point Lobos SMCA |
| Increase positive socioeconomic benefits | | |
| | Area with high natural heritage values | Piedras Blancas SMR |
| | State Marine Park in area of traditional recreational use | Cambria SMP |
| | Area with recreational non-consumptive diving | Hopkins SMR, Pacific Grove SMCA, Asilomar SMR, Carmel Pinnacles SMR, Point Lobos SMR |
| Minimize negative socioeconomic impacts | | |
| | SMCA in Rockfish Conservation Area | Soquel Canyon SMCA, Portuguese Ledge SMCA, Point Lobos SMCA, Point Sur SMR, Point Sur SMCA, Big Creek SMCA, Big Creek SMR, Point Buchon SMCA |
| | By limiting depth of SMR | Hopkins SMR, Asilomar SMR |
| | By expanding MPA instead of establishing a new one | Point Lobos SMR |
| | By establishing a SMRMA in area with little fishing | Morro Bay SMRMA |
| | By maintaining size and shape of SMCA | Carmel Bay SMCA |

| Primary Objective | Focal Area or Group | MPAs |
|---|---|---|
| | By allowing some types of fishing | Elkhorn Slough SMP, Soquel Canyon SMCA, Portuguese Ledge SMCA, Ed Ricketts SMCA, Pacific Grove SMCA, Carmel Bay SMCA, Point Lobos SMCA, Point Sur SMCA, Big Creek SMCA, Cambria SMP, Point Buchon SMCA |
| Provide for research and education | | |
| | Establish MPA near research and interpretive facilities and terrestrial reserves | Elkhorn Slough SMR, Soquel Canyon SMCA, Portuguese Ledge SMCA, Hopkins SMR, Point Lobos SMR, Asilomar SMR, Big Creek SMCA, Big Creek SMR, Piedras Blancas SMR, Morro Bay SMRMA |
| | Establish SMCA and SMRs allowing comparison of areas with and without harvest and/or fishing | Ed Ricketts SMCA, Pacific Grove SMCA, Carmel Bay SMCA, Point Lobos SMCA, Big Creek SMCA, Big Creek SMR |
| | Enhance monitoring by expanding MPA or including existing monitoring sites | Ed Ricketts SMCA, Hopkins SMR, Pacific Grove SMCA, Point Lobos SMR, Asilomar SMR, Carmel Bay SMCA, Point Sur SMR, Piedras Blancas SMR, Cambria SMP, Cambria SMR, Point Buchon SMR, Vandenberg SMR |

At the first level, evaluating goals and objectives related to network and network component design will be a matter of going through the directives one by one to determine if the directions have been followed. Some goals and objectives, however, need to be evaluated further to determine if the outcome is as expected. For instance, the goal requiring objectives for each MPA has been met in this document, but determining if they are "clearly defined" will take additional evaluation to determine areas of confusion. To assure that all the necessary information is available, when monitoring is needed for full evaluation, the objectives are also included in the appropriate monitoring section.

## V. DATA MANAGEMENT, ASSESSMENT AND COMMUNICATION

The Department will be the lead agency for data management, assessment and communication. Data will be collected from the monitoring programs and outside sources and integrated into a database. Data will be analyzed to evaluate performance of the network and network components relative to the goals and objectives, and provide the information needed for adaptive management. Results and conclusions will be communicated to resource managers and the public. Long-term storage and management of data will be provided by the Department's Biogeographic Data Branch.

To assure data quality and integrity, quality assurance/quality control (QA/QC) procedures will be needed from field sampling to data analysis. Where appropriate, sampling equipment needs to be calibrated and tested prior to use. When sampling at sea, limits need to be set on operating conditions (e.g., wave height, water clarity) to provide for safety of the crew and to assure data quality and consistency. Data entered into electronic format should be double checked. Data in electronic format should be verified with range checks and other tests of reasonableness. QA/QC procedures and operations should be documented.

QA/QC is also needed to assure data consistency, particularly when data are collected by separate programs. Sampling methods need to be standardized. Sampling protocols should be written in detail and distributed to all survey participants. Field notes, ship logs, and other records need to be kept to demonstrate that protocols were followed; deviations in protocols need to be documented. In some instances, it may be necessary to conduct inter-calibrations to measure data consistency among participants.

Scientific and public review will also be needed. It is expected that stakeholder and scientific advisory groups will be involved in monitoring, data analysis and evaluation.

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