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

DRAFT FINAL
December 6, 2006

Comments on this draft should be forwarded to MLPAComments@resources.ca.gov, by December 31, 2006. Comments should be as specific as possible, and please reference the page or section to which the comment applies.

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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 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 is expected that cooperative sampling will be an integral part of this monitoring program and that 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.

Ecosystem Monitoring

The primary objectives for 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
	Granitic shallow hard bottom	Hopkins SMR, Asilomar SMR, Point Lobos SMR
	Lee and north of headland	Point Sur SMR
	Esturarine 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

Primary Objective	Focal area or group	MPAs
	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

An MPA "protects" an ecosystem by curtailing fishing. The assumption is that fishing has reduced or eliminated populations of some species, changing feeding and other relationships, resulting in the loss of a normal ecosystem. With limited or no fishing, the ecosystem should recover.

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

Indicators for ecosystem structure and function include species abundance, 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, juvenile recruitment should be enhanced. Species abundance can be calculated from species density and the amount of available habitat or other metrics of abundance (e.g., percent cover). Species composition and diversity can be calculated from measurements of species density within a sample. Measuring enhanced 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.

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 questions associated with the objective are: 1) is species abundance and/or diversity higher within the MPA, 2) if not, do they increase over time, 3) if so, are they maintained over time.

While an ecosystem includes all species and their physical environment, it will not be possible to sample everything from bacteria to fish 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., El Niños, establishment of 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 (Appendix 2) and includes keystone species, species that provide habitat structure (e.g., mussels and giant kelp), and species targeted by MPA-specific objectives (e.g., overfished rockfish). Lists of focal species are shown below for each monitoring element.

Population Monitoring

The primary objectives for 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
	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

Primary Objective	Focal Area or Group	MPAs
	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 fish	Soquel Canyon SMCA, Portuguese Ledge SMCA, Point Lobos SMCA, Big Creek SMCA, Big Creek SMR
	Shelf fish	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
	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

Primary Objective	**Focal Area or Group**	**MPAs**
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
	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 residence time. 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 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 adult 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. With increasing numbers of large females, reproductive capacity should increase (be enhanced). If a MPA acts as a nursery, there should be more juveniles inside the MPA than in outside reference areas.

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 the MPAs. Presumably, enhanced reproduction will also increase abundance of depleted species outside of MPAs. However, at present, it is difficult, if not impossible, to follow the movement of larvae (or other propagules) produced in MPAs or determine if they 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 species 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 one-time studies to determine sex ratios, size at maturity and number of larvae produced at each size.

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

Habitat Monitoring

Objectives for 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, 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 come into force 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 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 to form a framework for the design process that would produce 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. Monitorng 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) among 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.

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. Larval dispersal can 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 goals and 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 is the number of each habitat type in the MPAs and the measure of success is one in each 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 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, called Before-After-Control-Impact (BACI) monitoring, was proposed by Stewart-Oaten (1996). In a BACI design, samples are taken in impacted and reference areas before and after the impact starts. The assumption is that while 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 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.

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 is data for the most important factors that drive the system, and 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 is not required as long as there is sufficient data to establish the initial status and trend in the system.

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 prior 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.

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 minute of longitude (approximately one 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). 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).

Anthropogenic (human-induced) impacts 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, the number of fish and the number of large fish should increase in fished species within MPAs. Based on this expectation, a measure of performance is the prediction that analysis will show an increase over time in MPAs in: 1) abundance, 2) number of large fish, 3) number of reproductive females; and 4) number of larvae/adult. 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 predator may increase in abundance and eat more young-of-the year fish. To measure the trend, 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 groundfish) and, based on the Ecotrust analysis, 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 canyon habitat (Table 5).

There is no ongoing monitoring of deep water hard bottom and canyon habitats in the central coast region. 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 (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 (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

MPA Name	30-100 m	100-200 m	>200 m
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.

Existing survey techniques can be used to measure size and density of conspicuous benthic fish, 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, which will need to be sampled with traps. 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 crabs	Cancer productus	Fished, incidental catch in spot prawn fishery
cup corals	Balanophyllia elegans	habitat forming
cridoids	Florometra serratissima	habitat forming
sponges	Porifera	habitat forming
anemones	Metridium spp., Urticina picivora	habitat forming

Common Name	Scientific Name	Reason for Selection
basket stars	Gorgonocephalis eucemis	habitat forming
sea stars	Ceramaster spp., Mediaster aequilis, Pteraster spp.	keystone species
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 (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 to sample 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 (Appendix 3), but may be modified for the particular circumstance. Visual surveys will provide data for all focal species (Table 8) except grass rockfish and brown rock crab. Traps and/or hook and line fishing will be needed for these two species.

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

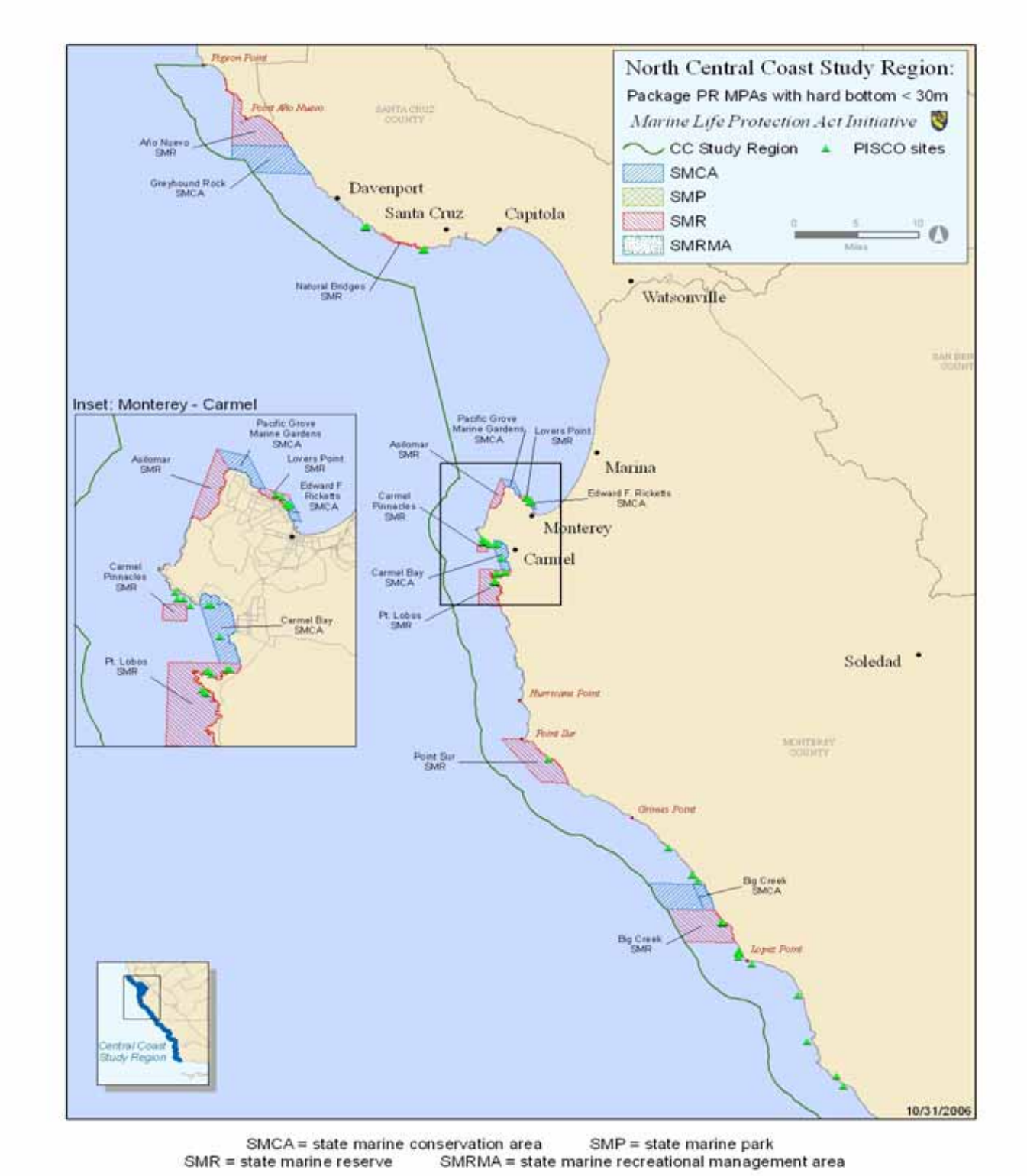
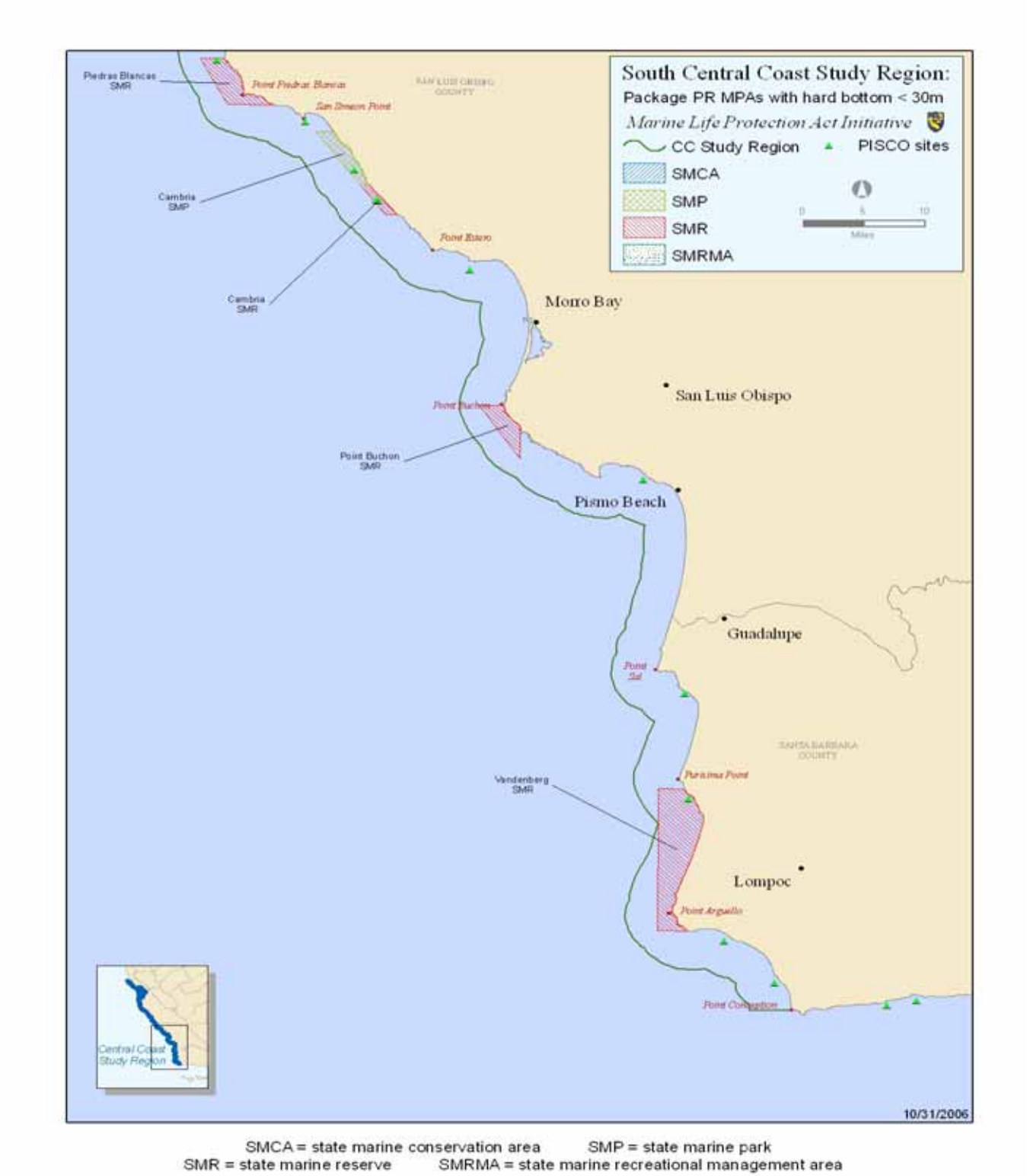


Figure 1. Continued.



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
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 effects other species
purple urchin	Strongylocentrotus purpuratus	population level effects 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.

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

MPA Name	Soft 30-100 m	Soft 100-200 m	Soft >200 m
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

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. Monitoring protocols used to survey hard bottom habitat can be adapted to monitor soft bottom habitats. These visual survey techniques will capture all focal species except Dungeness crab, which can be sampled with traps.

Table 10. Focal fish and invertebrate species for mid and deep water (> 30 m) hard 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
sea pens	Stylatula spp, Ptilosarchus spp	habitat forming
sea stars	Astropecten spp.	keystone species
Urchins	Allocentrotus fragilis	keystone species
Dungeness crab	Cancer magister	fished

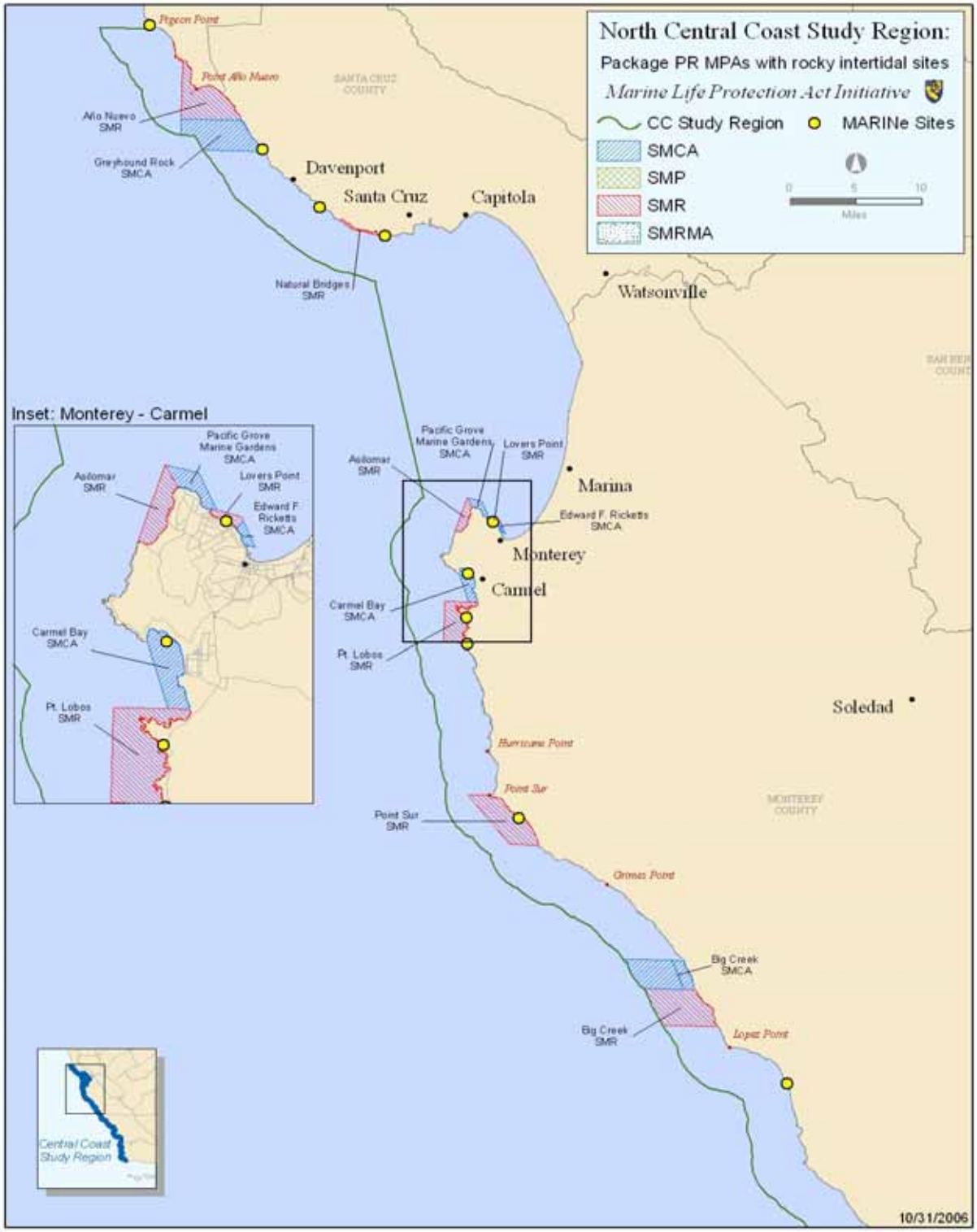
Rocky Intertidal Monitoring

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.

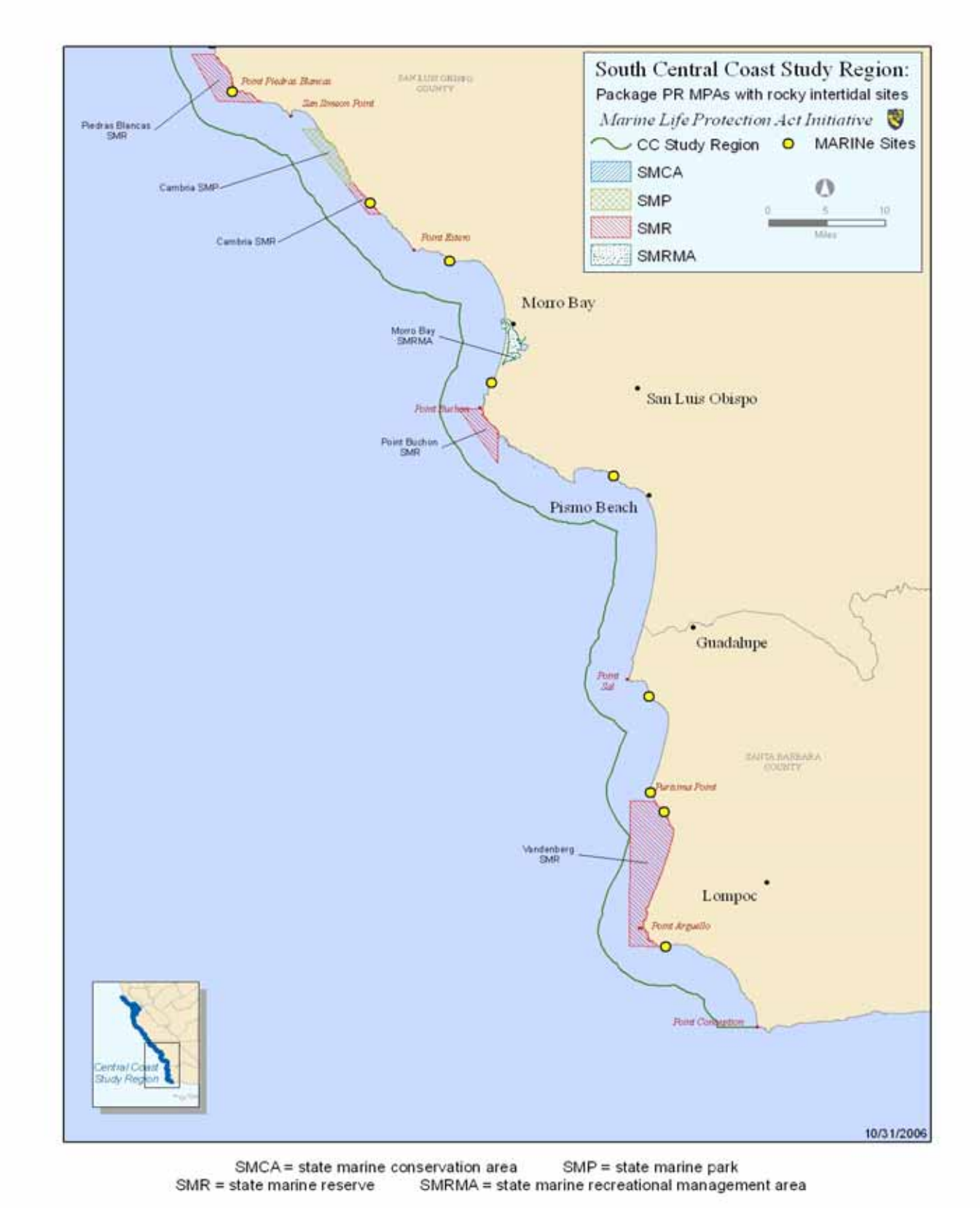
MPA Name	Rocky intertidal and cliff	MARINe monitoring site
Año Nuevo SMR	4.89	
Greyhound Rock SMCA	3.31	X
Natural Bridges SMR	3.58	
Edward F. Ricketts SMCA	0.8	
Lovers Point SMR	1.42	X
Pacific Grove Marine Gardens SMCA	1.92	
Asilomar SMR	2.85	
Carmel Bay SMCA	2.62	X
Pt. Lobos SMR	13.67	X
Point Sur SMR	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 limpets	Lottia gigantea	shift size	X
California mussels	Mytilus californianus	keystone species	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 snails	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, 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.

The National Marine Fisheries Service (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	keystone species
harbor seal	Phoca vitulina	keystone species
elephant seal	Mirounga angustirostris	keystone species
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 (sq. mi.).

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 and/or gill net 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 worms	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 the 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.

The MPA-specific objective to increase positive socioeconomic benefits applies to non-consumptive uses in Piedras Blancas SMR, recreational fishing in Cambria SMP, and non-consumptive diving in 6 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 6 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 in the Rockfish Conservation area (Table 16) would have less impact than establishing a SMCA in an area without restrictions. To evaluate the objective, it will be necessary to determine that the action was completed and then track the catch per unit effort over time in the fishery of concern to see if fishing effort is maintained.

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, 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 minute of longitude (approximately one 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. 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 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 is discussed in the section "Management and Enforcement Monitoring" and monitoring to evaluate biological properties of the network 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 alowing 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 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 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.

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