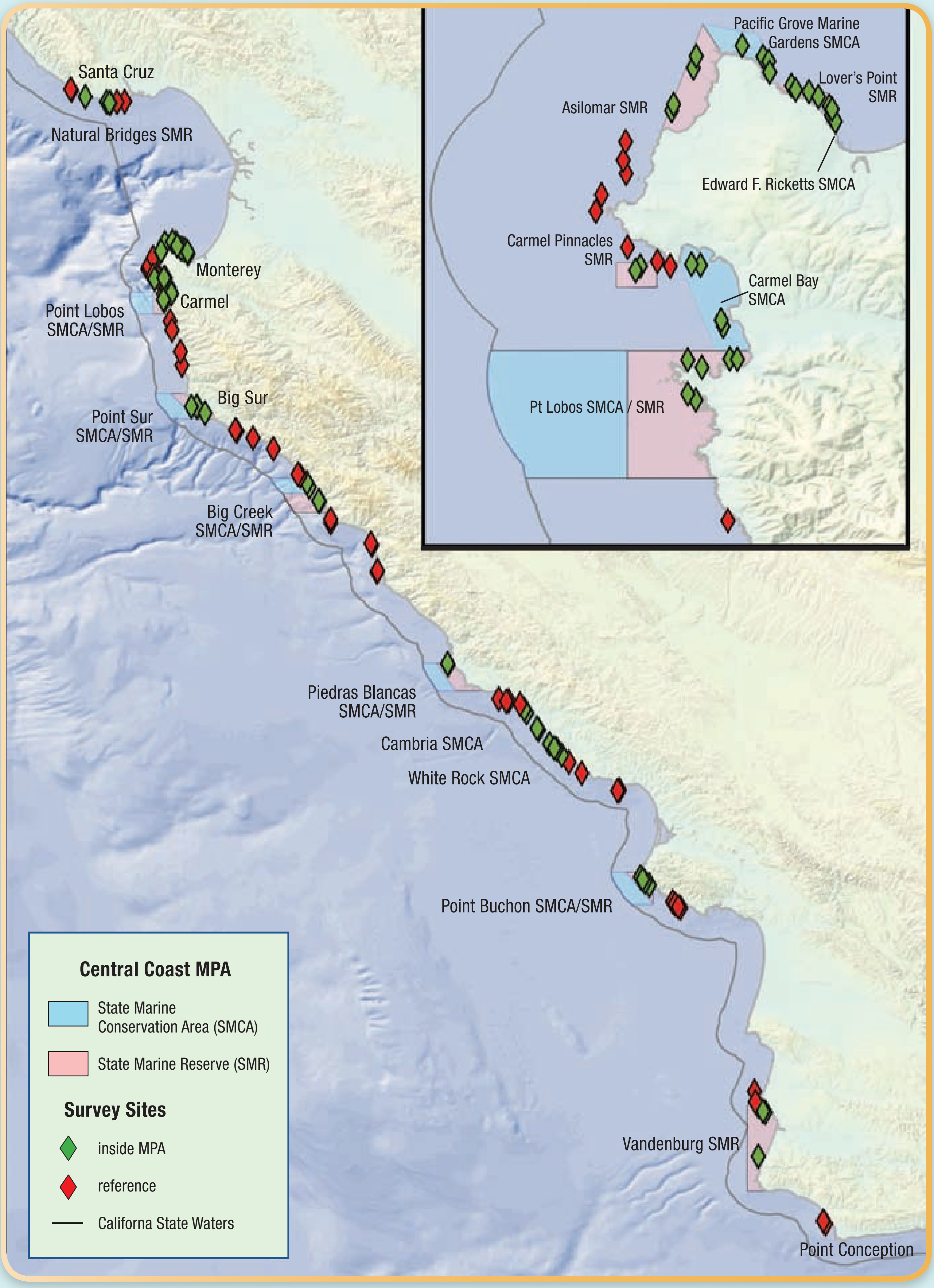
Monitoring MPAs by SCUBA in waters off Central California

2007/8 results of PISCO baseline monitoring surveys

PISCO Survey Sites for Central Coast MLPA Marine Protected Areas

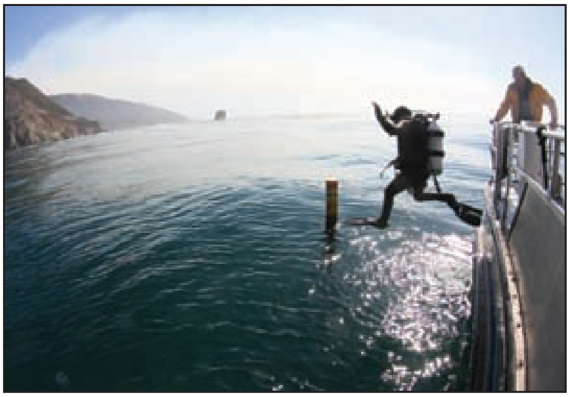


Introduction

California coastal oceans face many threats, including habitat loss, reduced water quality, invasive species, marine debris, overfishing, and the increasing threats posed by climate change and ocean acidification. These coastal threats reduce the health of marine ecosystems and the valuable services provided to coastal communities. To counteract these threats, marine resource managers are using multiple tools to manage marine ecosystems, including ecosystem-based fisheries management and networks of marine protected areas (MPAs). MPAs protect representative marine habitats by restricting some human activities to varying degrees, depending on the type of MPA. Rather than using a single species approach, MPAs function to protect all organisms and ecological linkages within an ecosystem.

In 1999 the California Legislature passed the Marine Life Protection Act (MLPA), which was established to "*redesign California's system of marine protected areas (MPAs) to function as a network in order to: increase coherence and effectiveness in protecting the state's marine life and habitats, marine ecosystems, and marine natural heritage, as well as to improve recreational, educational and study opportunities provided by marine ecosystems subject to minimal human disturbance.*"

In September 2007, upon implementation of the first MLPA MPA network on the central California coast (Pigeon Point to Point Conception), and with funding from the California Ocean Protection Council administered by California Sea Grant, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) initiated baseline surveys to monitor these MPAs. Of the 29 MPAs established in the Central Coast Study Region (CCSR), 17 MPAs contain kelp and 14 can be safely sampled using SCUBA. The baseline surveys focused on both subtidal and intertidal systems for the central coast, characterizing ecosystem attributes such as biodiversity, community structure, and population abundance and size structure. Baseline surveys were conducted in both 2007 and 2008. By monitoring these ecosystem attributes, scientists can make comparisons inside vs. outside MPAs, track changes in ecosystem attributes over time, and evaluate if MPAs are having the desired results.



SCUBA Survey in Big Sur Scott Gabara

This booklet describes patterns in MLPA state marine reserves (SMR) generated from the first 2 years of baseline data collected; SMRs are one type of MPA that provides protection from all forms of fishing and resource extraction. This project represents the most extensive ecological surveys to date of kelp forests along the central coast of California.

Tube-dwelling anemone Steve Lonhart

Table of Contents

Front cover photo: *Steve Lonhart*
Back cover photo: *Scott Gabara*
Algae and substrate drawings: *Claire Saarman*
MPAs and Dive Sites map: *Images provided by the California Department of Fish and Game*

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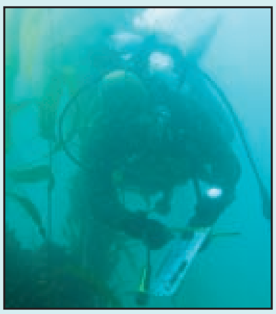
Methods

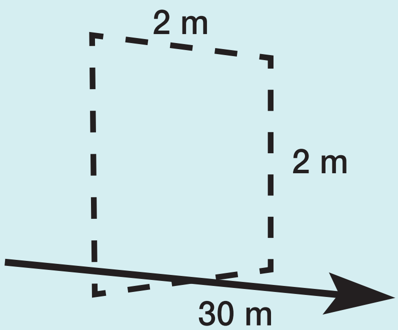
Scott Gabara

Fish Surveys

In each of the 14 coastal MPAs within the CCSR sampled using SCUBA, 4 sites inside and 4 sites outside of the MPA were selected using a random stratified approach. At each of these sites divers collected data on the size and abundance of all conspicuous fish species found at 4 depth zones (5, 10, 15, and 20 m deep). At each depth zone, pairs of divers surveyed 3 transects (30 m long by 2 m wide by 2 m tall) at three levels within the water column (benthic, mid-water and canopy), totaling 36 transects per site.

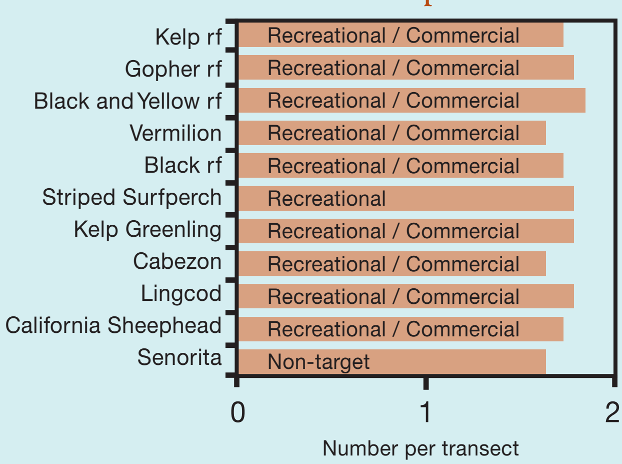


PISCO research diver conducts fish survey



Data from these fish surveys are summarized here to illustrate community patterns across the MPA network. Density estimates (number of individuals encountered on a standard transect) of 11 common fish species are graphed for each group of MPA and reference sites in the CCSR. These species are listed in the example graph below, along with their status as targets of commercial and recreational fishing, recreational fishing only, or non-targeted species.

Fishes–example

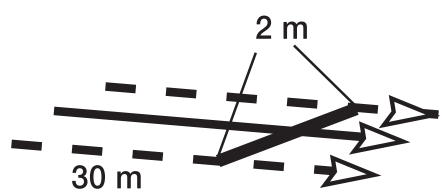


Benthic Surveys

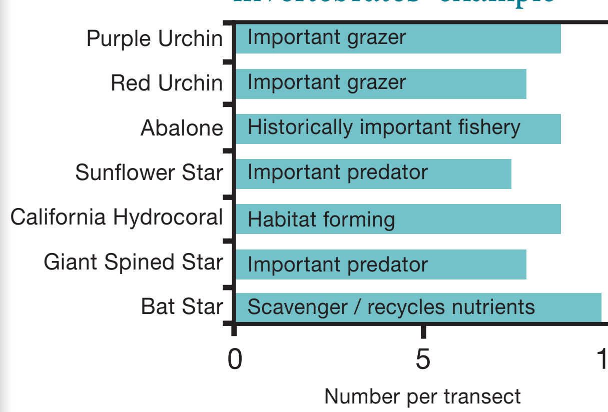
Divers collected data on the size and abundance of canopy forming kelp and the abundance of understory algae and invertebrates in separate surveys. Among the many invertebrate species encountered by divers, 7 key species were selected because of the important ecological roles they play in structuring kelp forest communities within the CCSR. Density estimates for these species are presented to portray similarities and differences among sites across the MPA network. These benthic community data were collected from 2 transects (30 m long by 2 m wide) at three depths (5, 12.5, and 20 m deep), totaling 6 transects per site.

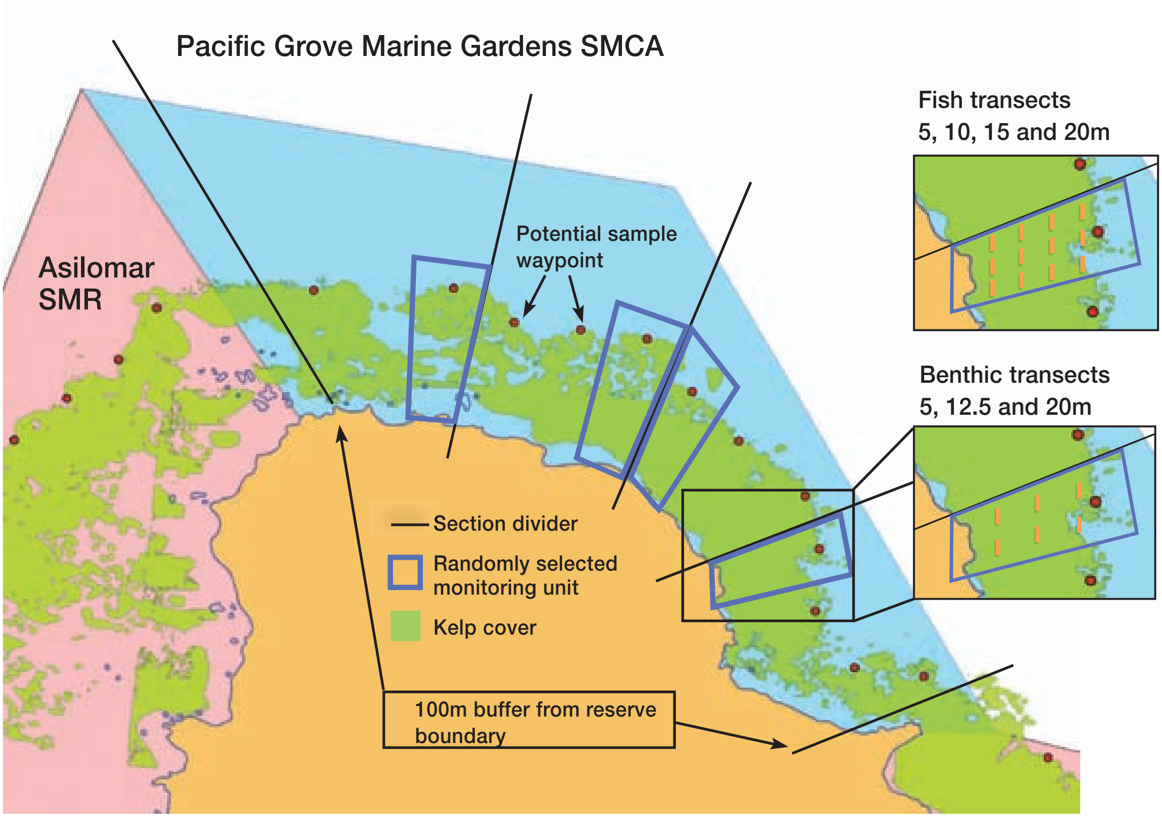
Detailed descriptions of sampling protocols are at: http://www.piscoweb.org/research/science-by-discipline/ecosystem-monitoring/kelp-forest-monitoring

PISCO benthic community transect



Invertebrates–example

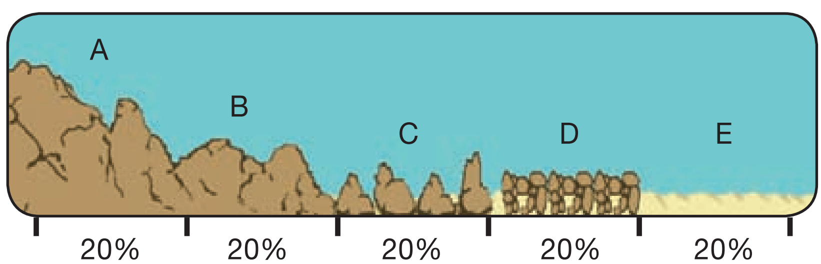




Schematic diagram of stratified random sampling design.

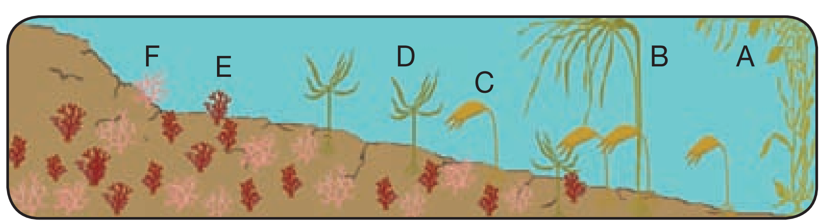
Substrate

Divers conducting benthic surveys record the substrate type and vertical relief of the rocky reef along each transect. We summarized the substrate characteristics of each MPA and reference site using a graphic representation. Substrate is classified as one of the following categories: (A) high-relief contiguous reef (>1 m vertical), (B) low-relief contiguous reef (<1 m vertical), (C) boulders (10 cm - 1 m diameter), (D) cobble (<10 cm diameter), or (E) sand. The width of the category indicates its relative percentage of cover in the survey area.

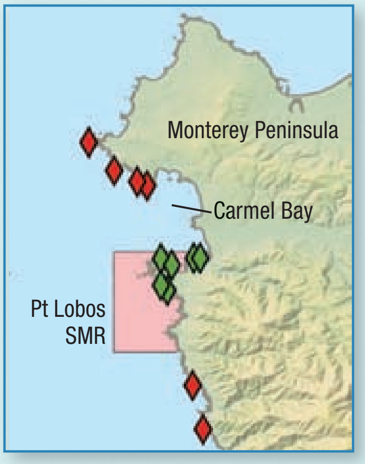


Algae

The algal assemblages at each MPA and reference site are also depicted in graphic form. The number of algae in these images represents the relative abundance of the canopy forming giant kelp species (A) *Macrocystis pyrifera* and (B) *Nereocystis luetkeana*, the sub-canopy kelps (C) *Laminaria setchellii* and (D) *Pterygophora californica*, as well as the percent cover of (E) fleshy red algae and (F) articulated coralline algae, which often dominate the algal understory.

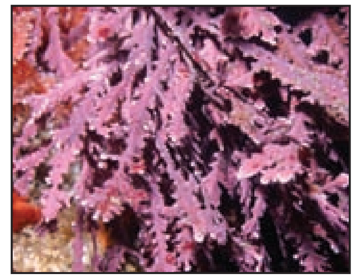


Point Lobos SMR



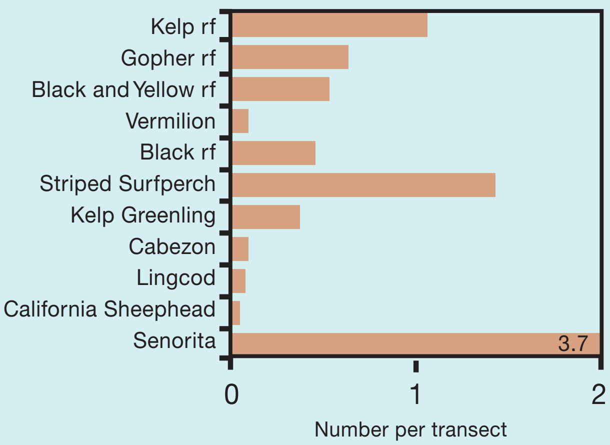
California hydrocoral and red urchin Steve Lonhart

On land, the Point Lobos State Park is characterized by dramatic geological formations. Underwater, the MPA is similarly made up of mostly high-relief contiguous bedrock. High densities of giant kelp (*Macrocystis*) dominate the forest canopy, and coralline red algae are present in higher densities here than any other sites in the CCSR. Large numbers of cabezon and senorita were observed. Among the invertebrate species counted, California hydrocorals and red urchins were particularly abundant.



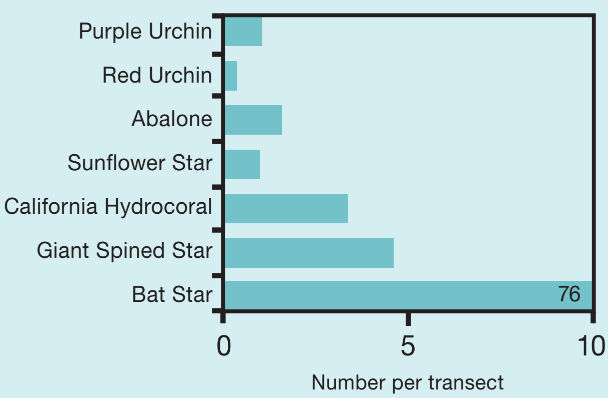
Articulated coralline alga Steve Lonhart

Fishes



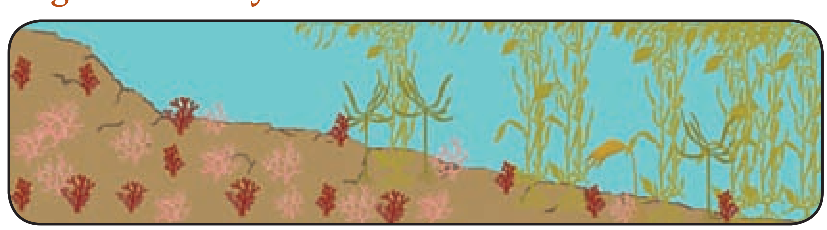
Cabezon Steve Lonhart

Invertebrates



Substrate

Algal Community



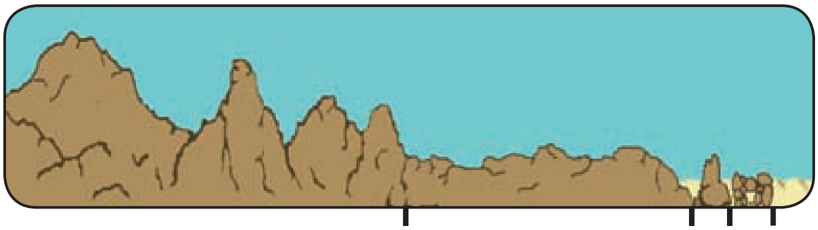
Point Lobos Reference

Pterygophora Steve Lonhart

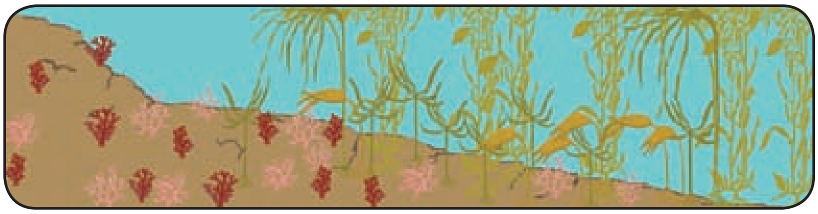
The reference sites for Point Lobos SMR have similar habitat characteristics: high-relief substrates comprised almost entirely of bedrock. Giant kelp densities were also similar to those seen within the MPA. The sub-canopy kelps *Laminaria* and *Pterygophora* were present in somewhat higher numbers. Urchin densities were high at both the MPA and reference sites, but purple urchin densities were higher here than at any of the other MPA or reference sites. Fish densities were generally extremely high at these reference sites. Kelp, black and yellow, and black rockfishes were recorded at the highest densities seen along the CCSR. Striped surfperch and lingcod also occurred in particularly high numbers.

Black rockfish Steve Lonhart

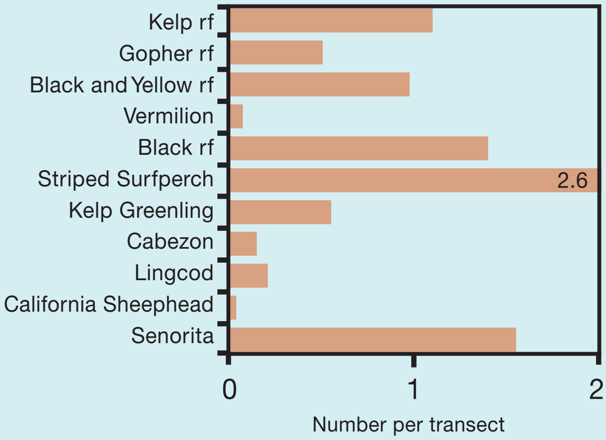
Substrate



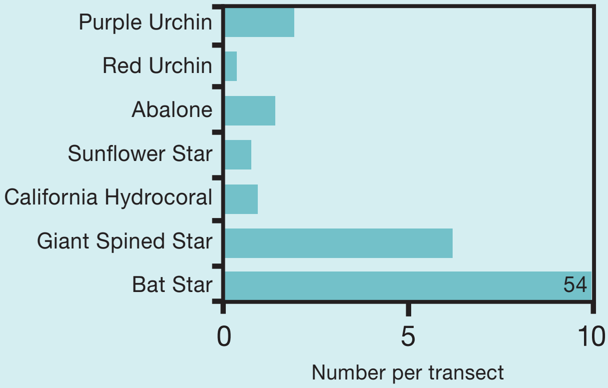
Algal Community

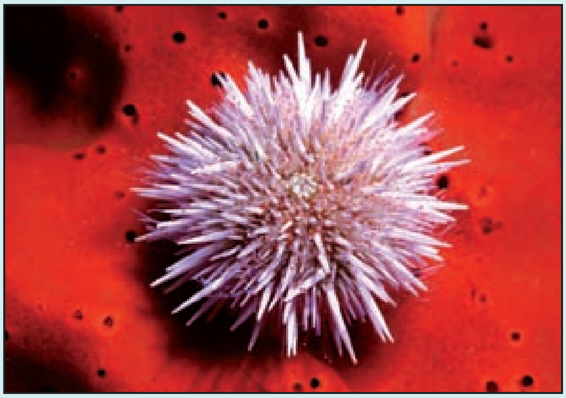


Fishes



Invertebrates



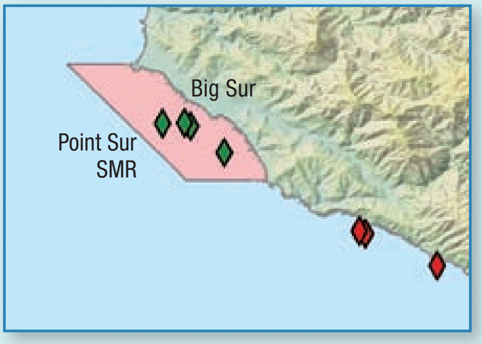


Purple sea urchin Steve Lonhart

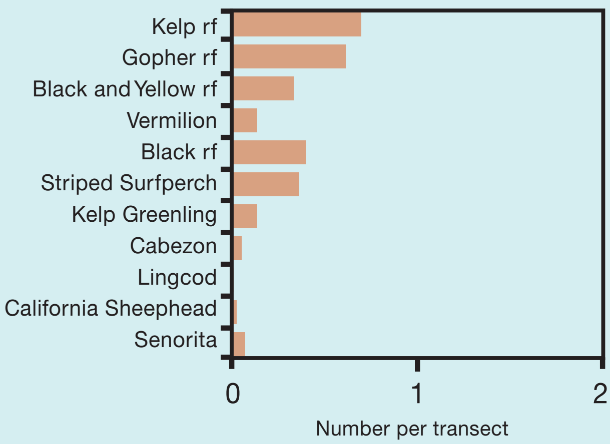
Point Sur SMR

Red alga

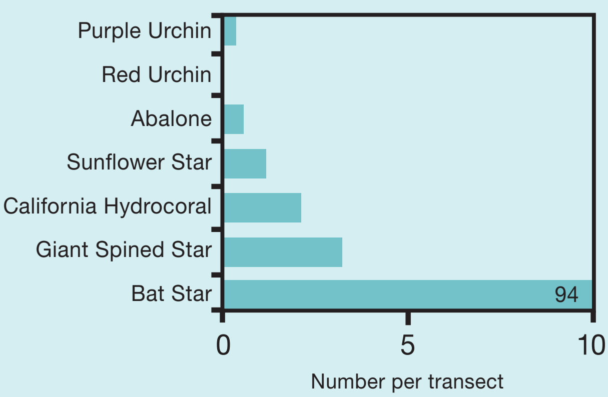
Steve Lonhart



Fishes



Invertebrates



Kelp rockfish

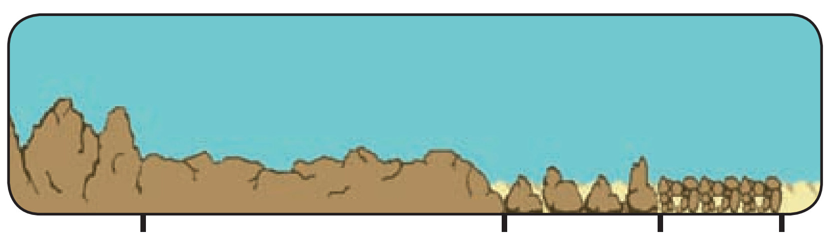
Scott Gabara

Substrate types in the Point Sur SMR are generally low-relief bedrock and large areas of boulders and cobble. The sub-canopy was dominated by dense stands of the stalked kelp *Pterygophora*, and the understory had the highest percent cover of fleshy red algae seen in any of the CCSR MPAs. Fish densities were generally low here, although kelp rockfish were seen in particularly high densities, and predatory sunflower stars were more abundant here than at other MPAs.

Sunflower star

Steve Lonhart

Substrate



Algal Community

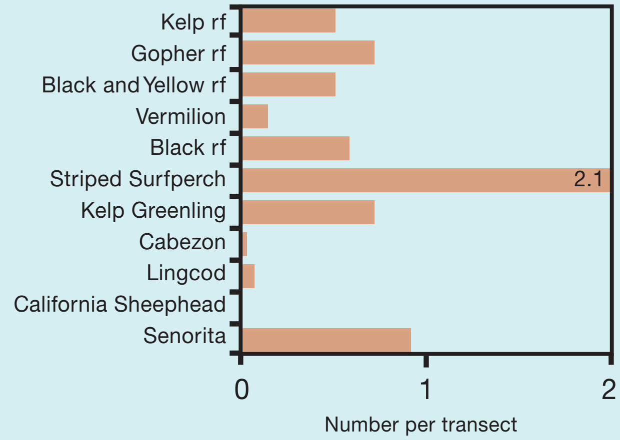
Female kelp greenling Steve Lonhart

Point Sur Reference

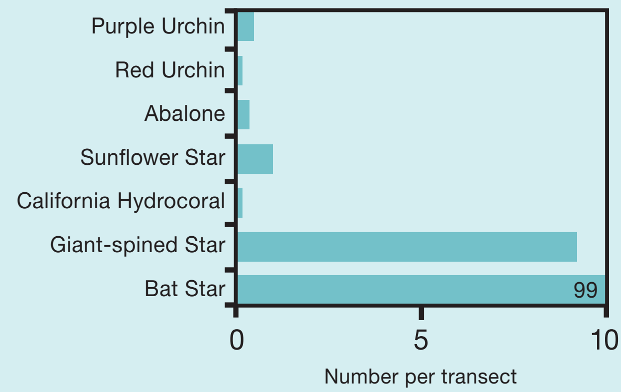
The reference sites at Point Sur were very similar to those within the MPA, but with more patchy areas of sand interspersed with areas of low-relief bedrock, boulder and cobble. Despite the high cover of sand and lower availability of hard substrate, density of the giant kelp (*Macrocystis*) at these sites was recorded at the highest level seen among sites in the CCSR. Kelp greenlings, a fish commonly seen in mixed sand and low-relief reef habitat, were particularly abundant here, as was the giant-spined star, an important predator in kelp forest communities.

Macrocystis Steve Lonhart

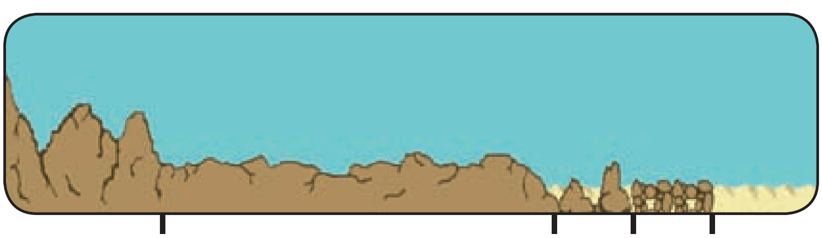
Fishes



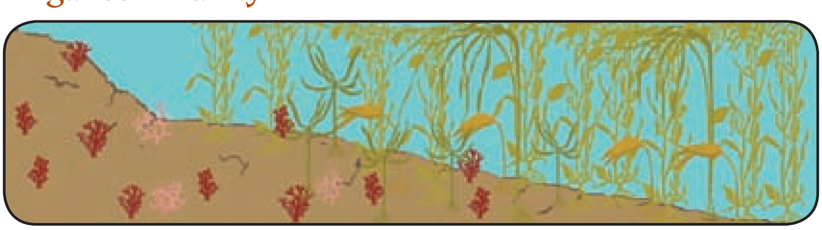
Invertebrates



Substrate

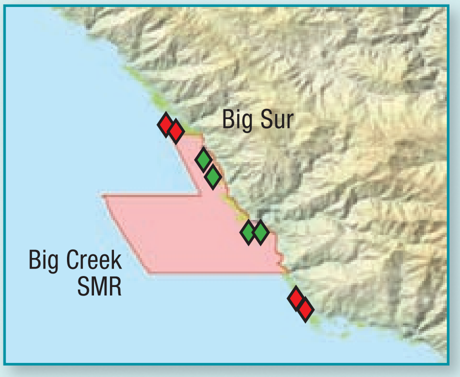


Algal Community



Giant-spined Star Steve Lonhart

Big Creek SMR



Red abalone

Steve Lonhart

Like the MPA and reference sites at Point Lobos, the habitat in Big Creek SMR is also characterized by high cover of giant kelp (*Macrocystis*) and moderately high-relief bedrock. Much of the current Big Creek SMR has been protected from fishing since 1993 (more than a decade before the central coast MPA network was established) as part of a previously existing MPA, and it is likely some differences between the MPA and reference sites have developed since then. Some of the highest densities of red abalone seen in the CCSR were recorded in Big Creek SMR. The California sheephead, a species more commonly found in southern California, was relatively abundant here, as were gopher rockfish.

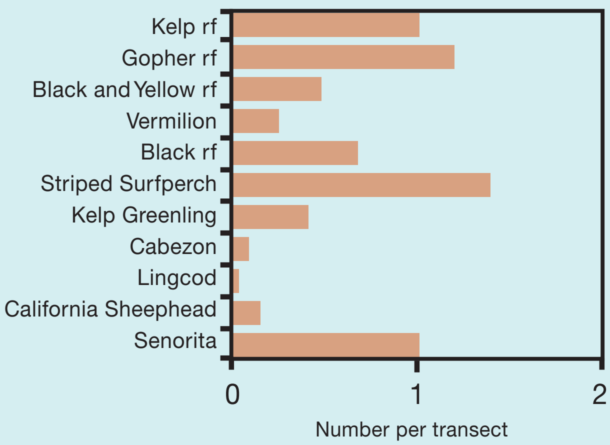
California sheephead

Steve Lonhart

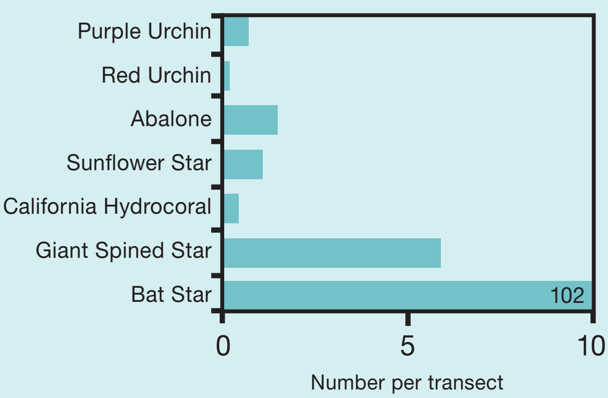
Gopher rockfish

Steve Lonhart

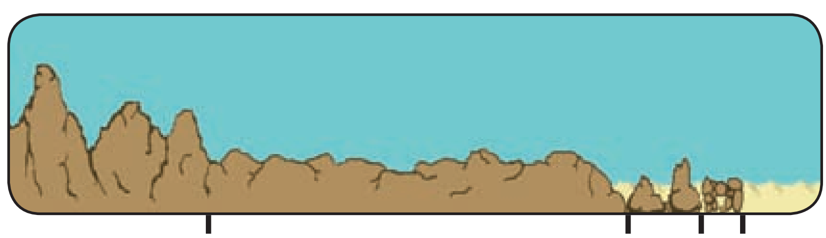
Fishes



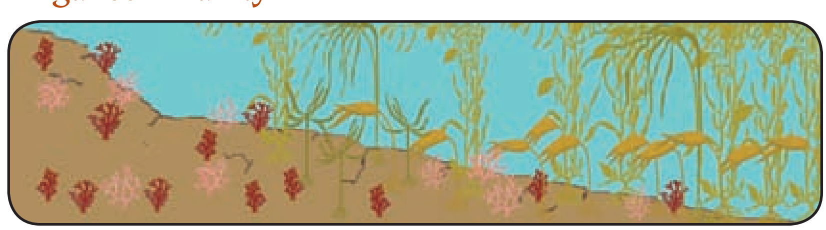
Invertebrates



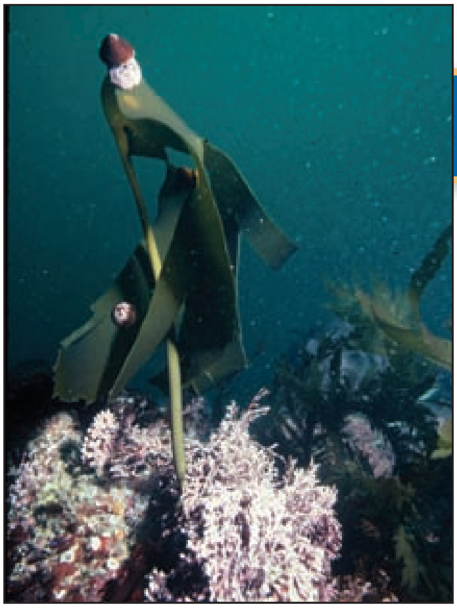
Substrate



Algal Community

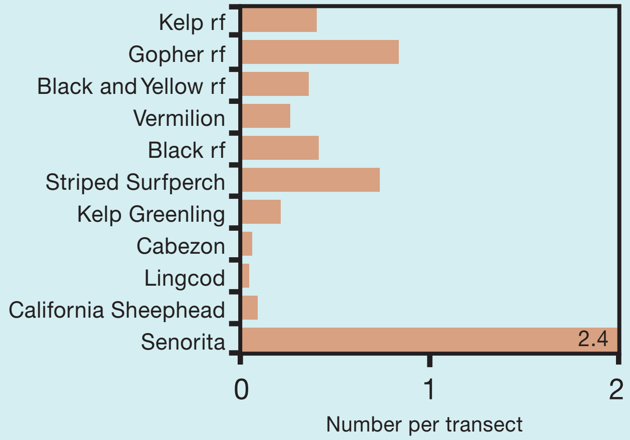


Big Creek Reference



Laminaria James Watanabe, Hopkins Marine Station

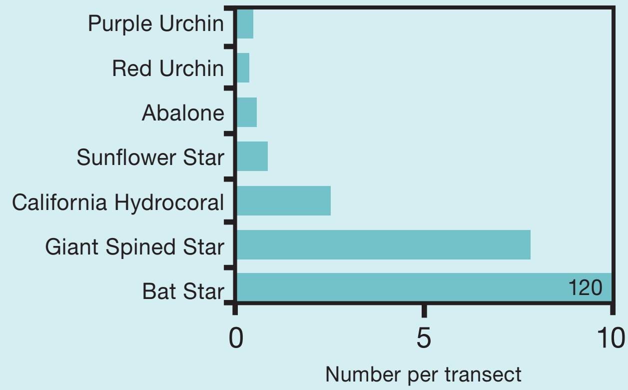
Fishes



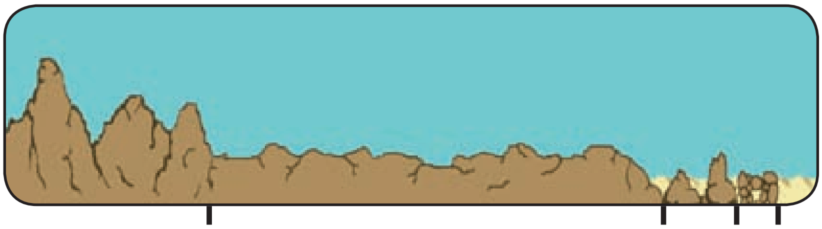
Reference sites for Big Creek SMR share the same general habitat characteristics seen in the MPA: cover of high giant kelp and extensive areas of contiguous bedrock. The rocky reef is covered with dense growths of foliose red algae and high densities of the sub-canopy kelp *Laminaria*. Rockfish species were seen in high densities here, particularly vermilion rockfish, which are relatively rare at other study sites in the CCSR. Bat stars, which are ubiquitous scavengers on kelp forest detritus, were at their highest densities at these sites.

Vermilion rockfish Chad King/SIMoN NOAA

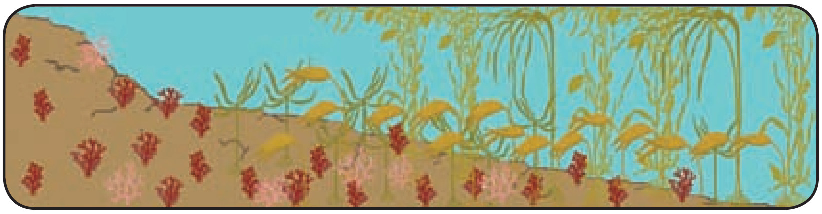
Invertebrates



Substrate

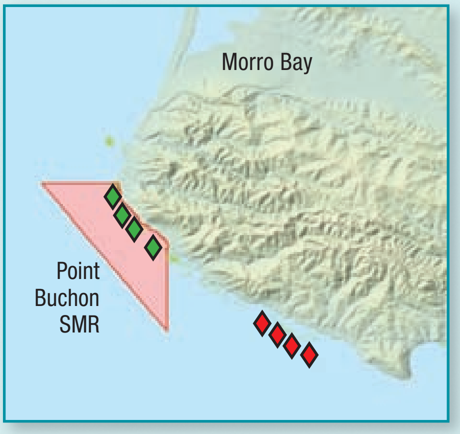


Algal Community

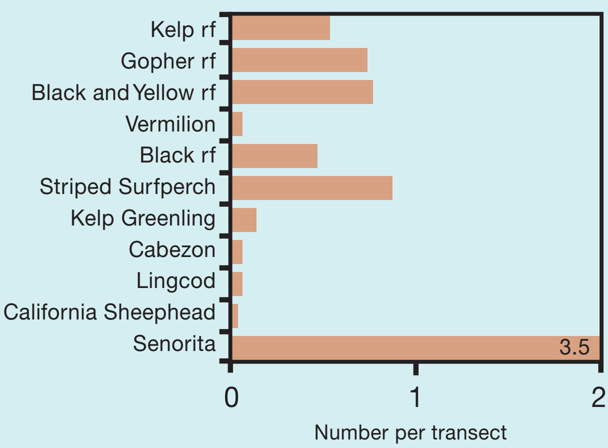


Bat star Steve Lonhart

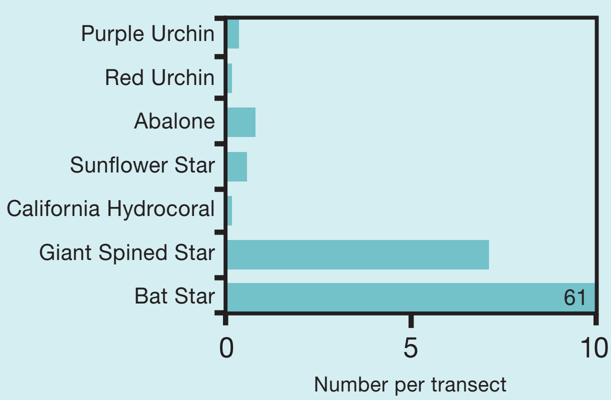
Point Buchon SMR

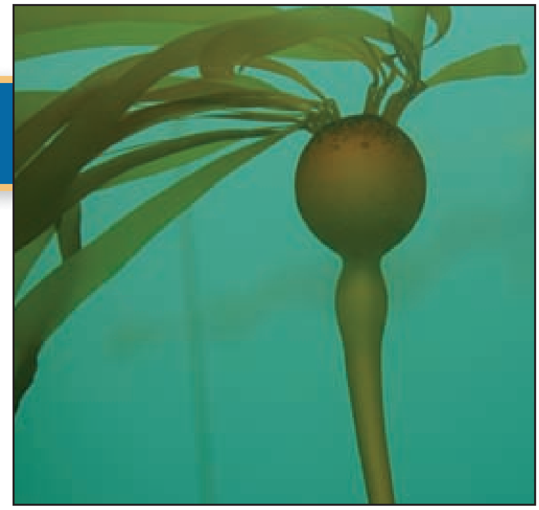


Fishes



Invertebrates



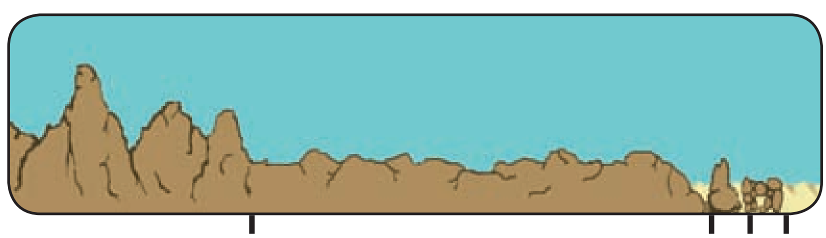


Nereocystis Steve Lonhart

Further south along the central coast, kelp forest communities gradually change as giant kelp becomes less dense and in some areas, particularly around Point Buchon, is replaced entirely by bull kelp (*Nereocystis*). Substrates within the MPA were generally low-relief and mostly bedrock. Gopher rockfish and senorita were seen at relatively high densities within this MPA.

Senorita fish http://pt-lobos.com

Substrate



Algal Community

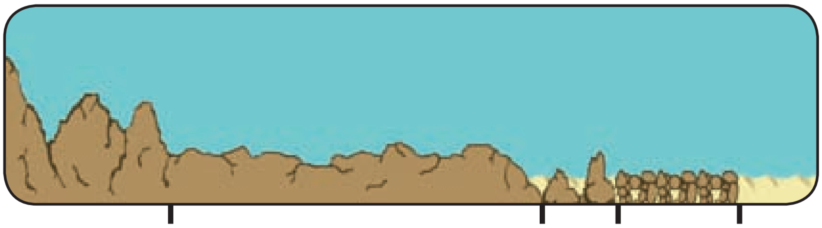
Lingcod Steve Lonhart

Point Buchon Reference

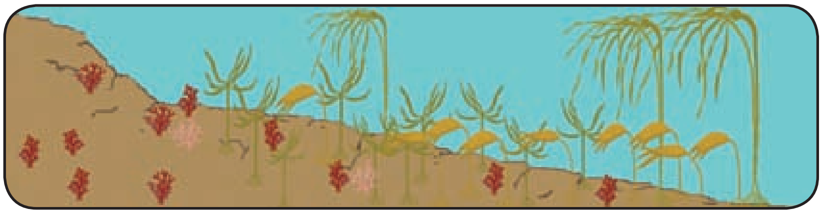
Reference sites for Point Buchon SMR were notable for an almost complete lack of giant kelp (*Macrocystis*) and the highest densities of bull kelp recorded on the central coast. Habitat was similar to sites within the MPA, but with higher coverage of boulder and cobble. The fish assemblage was also similar to that seen within the MPA with moderate densities for most species. Among invertebrate species, sunflower stars were notably abundant.

Nereocystis Steve Lonhart

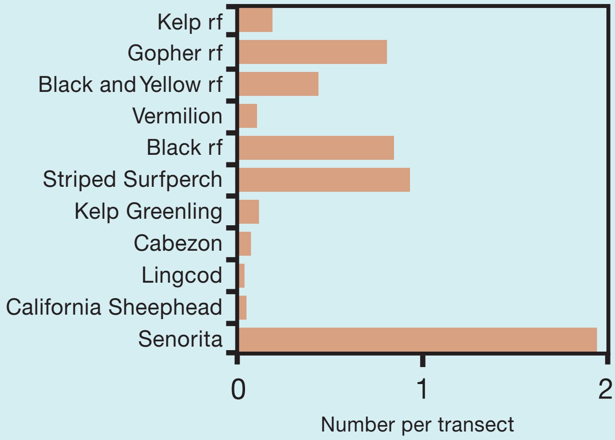
Substrate



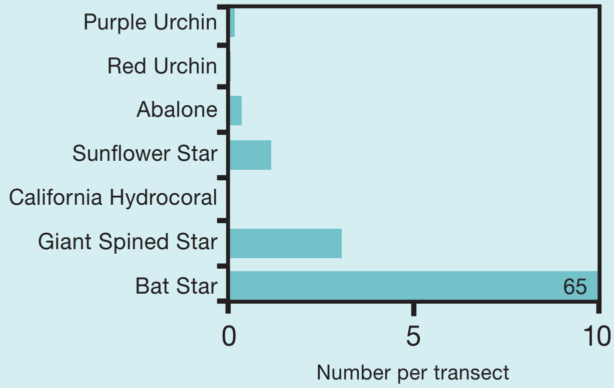
Algal Community

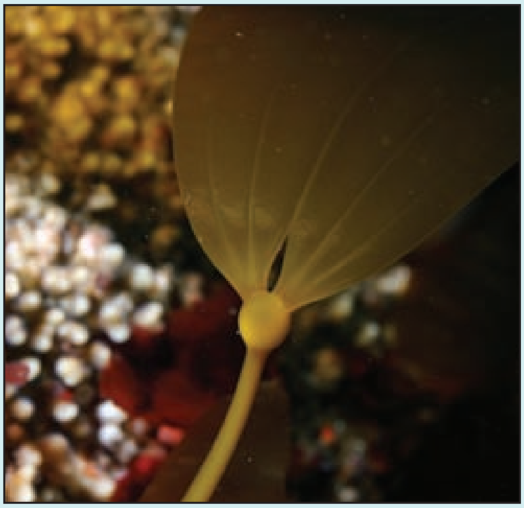


Fishes



Invertebrates





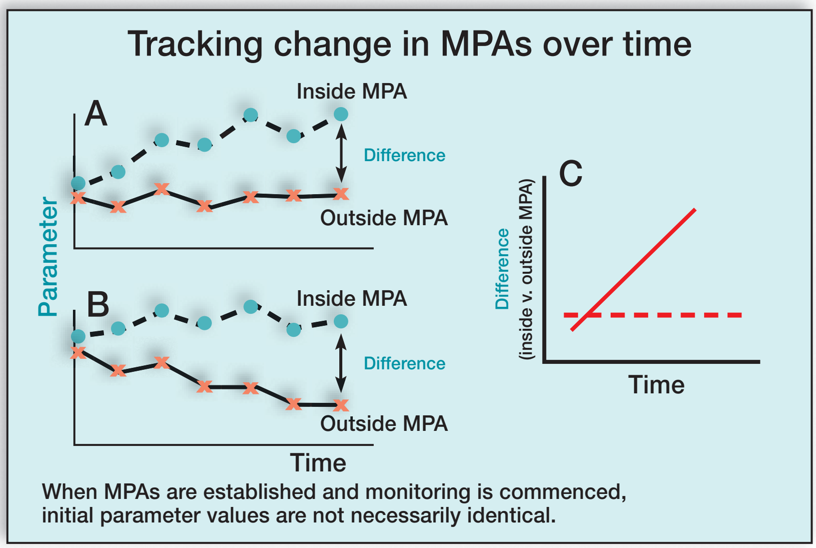
Young Nereocystis Steve Lonhart

Baseline Monitoring Summary

Monitoring to detect subtle changes in long-lived species is a long-term endeavor. This two-year baseline will provide the basis for long-term evaluations of MPA and reference sites. Baseline data will be useful for evaluation of MPAs that will occur 5-to 10 years after their establishment, and also for longer-term changes. Many ecological responses are likely to take much longer to detect, due to the slow rate of change that is typical of these ecosystems.

Throughout the CCSR there is great geographic variation in both physical and ecological structure of kelp forests. For example, the continuous expanse of high-relief bedrock at Point Lobos differs from the gently sloping, low-relief bedrock and sand found at Point Sur. Similarly, the abundance of algae, fishes and invertebrates displayed similar patterns of variation at this broad geographic scale. These patterns of ecological variability among kelp forests are related to physical conditions, such as reef structure, substrate type (e.g., granite versus sandstone), topography and slope, and oceanographic conditions (e.g., exposure to ocean swell and coastal upwelling).

Despite this geographic variation in kelp forest ecosystems, many of the MPAs surveyed were similar to their reference sites in both reef structure and the biological communities they support. At all sites, the patterns of abundance for the 7 species of invertebrates presented here are similar. Although reference sites are chosen to exhibit similar attributes to MPA sites, monitoring data can reveal subtle differences in communities and habitat characteristics. These differences in initial conditions do not prevent scientists from detecting diverging trends between MPA and reference sites which emerge over time, allowing evaluation of MPA networks.



(A) *By comparing trends such as species diversity, fish size and abundance between MPAs and reference sites, managers can detect reserve effects by tracking the increasing differences in these trends over time*

(B) *Even if there are no increases seen within MPAs, diverging trends can indicate that MPAs are having their intended effects*

(C) *The slope of the line (solid) indicates the rate at which trends are diverging between MPA and reference sites. If the line remains horizontal (dashed) then MPAs are not having a measurable influence on the surrounding ecosystem*

By monitoring MPA Networks over time we can:

- **Observe any emerging ecological effects of individual MPAs and the network as a whole**
  Even with the natural variability in communities and habitats, tracking the differences between MPAs and references sites over time allows scientists to detect emerging MPA effects.

- **Improve our understanding of how MPA networks function**
  Patterns identified from monitoring studies, such as the fluctuations in abundance of key species, can be combined with computer models that simulate both the function of kelp forest ecosystems and the dispersal of larvae by ocean currents. These models can tell us what the most important things are to measure to keep track of ecosystem health, and additionally, can tell us whether having MPAs linked in networks provides greater benefits than individual MPAs operating in isolation.

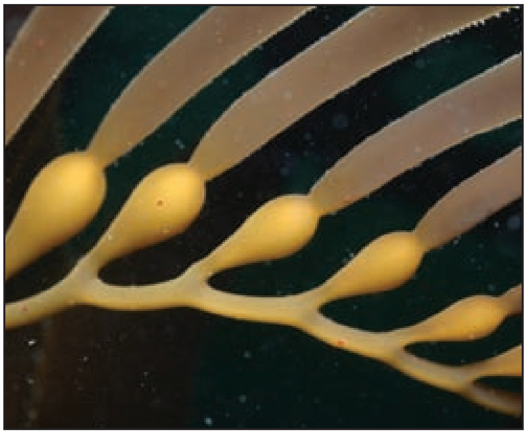
- **Detect broad patterns of ecological change across the entire MPA network**
  By observing trajectories of ecological change over time across the network, scientists can identify similar patterns of change occurring both inside and outside MPAs as being the result of large-scale ecological processes affecting the region as a whole. Distinguishing these changes from fishing effects allows us to inform evaluations of MPA performance, and to better understand responses of ecosystems to network-wide changes in ocean climate.

- **Help inform adaptive management of the MPA network**
  By distinguishing the relative responses of ecosystems in MPAs that differ in their design or regulations, MPA monitoring can help to determine how well MPAs with different designs (e.g., size, shape, spacing) and different allowed uses meet their conservation goals.

Scott Gabara

Future Steps

Baseline studies are only the initial step in evaluating the effectiveness of MPAs as conservation tools. Monitoring ecosystem attributes through time is critical to determining how individual MPAs and networks protect the integrity and resiliency of ecosystems. To fulfill the need for evaluation and adaptive management in the short term, the results of this baseline and subsequent monitoring are intended to be reviewed in detail approximately 5 years after implementation of the MPAs and every 5 years thereafter. Evaluations will provide managers with information such as relative success of these MPAs at meeting their conservation goals and providing insight into which design criteria (i.e., size, shape, allowed activities) are most useful to enhance their effectiveness, and if large-scale environmental processes affect the region as a whole. These evaluations will allow resource managers to adaptively manage MPA networks to ensure they are fulfilling the goals they were established to achieve.



Macrocystis Steve Lonhart

Monitoring studies are critical to the evaluation of MPAs as conservation tools. MPAs and monitoring programs also offer scientists and resource managers opportunities to learn about the influence of humans and changing natural phenomena on these ecosystems.

By using the MPA as an ecological baseline, we can compare how areas inside and outside the MPA change over time. This will allow us to:

- **Use observed differences in abundance and size structure of fished populations to assess the state of fished populations**
  To better assess the state of fished stocks, we can compare data from outside to inside the MPA or provide population data for stocks outside the MPAs that have not been formally assessed.

- **Determine potential ecosystem-wide effects of fishing in kelp forests**
  Observed local differences between ecosystems inside and outside of MPAs suggest ecosystem-wide effects of human uses such as fishing. Similarly, monitoring inside of MPAs allows scientists to separate ecosystem-wide effects of natural perturbations, such as climate change, from more localized and direct human-use impacts. Using this knowledge is critical to informing an ecosystem-based approach to management.

Conclusion

In conjunction with ocean observations, continued monitoring of ecosystems can reveal the drivers of ecosystem change, particularly as they influence ecosystem productivity, function, resiliency and services. When combined with socio-economic monitoring studies, ecological monitoring can identify how ecosystem effects from MPAs are both caused by and influence changes in human-use patterns. This knowledge will help managers consider and adjust how humans use and manage these ecosystems to protect them in the face of a changing climate.

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For more information on PISCO, visit http://www.piscoweb.org/

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