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Pacific Rocky Intertidal Monitoring: Trends and Synthesis

pacificrockyintertidal.org

Final Report (Public Version)

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FINAL TECHNICAL SUMMARY

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BACKGROUND

Oil and gas activities, especially the tankering of oil along the California coast and the extraction of oil from OCS activities, raise the possibility of an oil spill or other impact to coastal resources. Population monitoring of coastal biota in central and southern California provides baseline information in case an event such as a spill damaged these resources. In 1997, the Bureau of Ocean Energy Management (BOEM) initiated the formation of a long-term monitoring program, the Multi-Agency Rocky Intertidal

Network (MARINe), which currently includes over 30 partners consisting of federal, state and local government agencies, universities, tribes and private organizations. The MARINe consortium monitors over 140 rocky shore sites and is the largest and longest-running program of its kind; sites in some regions have been sampled for 30 years. Through this study, BOEM funds biannual monitoring at 24 established rocky intertidal sites along the California mainland adjacent to OCS operations. The study also funds operation and maintenance of the shared MARINe database, and coordination of MARINe committees.

OBJECTIVES

A primary objective for this research is to continue the ongoing monitoring program that provides a basis for determining if change in rocky shoreline communities adjacent to producing OCS facilities can be attributed to operations or accidents from OCS facilities. The 24 BOEM-funded sites are on the shorelines adjacent to existing oil and gas OCS facilities. Resource data from the MARINe database also support information needs for BOEM's renewable energy program along the Pacific coast. Another important objective is to provide an ecological context for the 24 BOEM-funded sites, by comparing trends and patterns in community dynamics to other sites stretching from southern Alaska to San Diego, California, monitored using identical MARINe methods. The long-term nature of this monitoring project, coupled with its large spatial scale, allows for a better understanding of changes to rocky intertidal communities in the Southern California Bight that have occurred since the OCS program was initiated. A monitoring program of this temporal and spatial magnitude provides insight into whether changes might be attributed to natural (e.g. El Niño events, disease) or human induced (e.g. trampling, climate change) factors. This large-scale monitoring effort is a collaboration between MARINe and many other groups. Two major MARINe partners that support monitoring efforts at numerous sites are the National Park Service (NPS), and the Partnership for Interdisciplinary Study of Coastal Oceans (PISCO). A complimentary biodiversity monitoring effort was developed by Dr. Pete Raimondi and the MARINe Science Panel, funded initially by BOEM and PISCO. These Biodiversity surveys were continuously funded by PISCO over a period of 10 years, and over 140 sites have been established and sampled using this protocol. Additional objectives include oversight of a centralized database, and publication of metadata for the BOEM-funded long-term data set.

A final goal for this study is to initiate the production of a comprehensive web-based data report for all rocky intertidal monitoring sites within the MARINe network (including sites in CA, OR, WA, and AK), beginning with the BOEM-funded sites in central and southern California. This web-based product includes detailed information about the MARINe project including methods, descriptive information about regions, sites, and species targeted, as well as extensive summaries of trends and patterns observed within sites and among regional groupings of sites. Trend data can be viewed either in static summary graph form or by using an interactive graphing tool, which displays user-defined site and species summary data. This website will allow evaluation of Long-Term and Biodiversity survey data and comparison to similar historic data. This synthesis of long-term, rocky intertidal monitoring data in a centralized, easily accessible location is unprecedented in scope, and it is our hope that this information will be of great value to resource managers, researchers, and the general public.

DESCRIPTION:

Long-term monitoring sites are sampled using fixed plots in target community assemblages; this approach is similar to that developed by the Channel Islands National Park in the 1980's and intertidal studies funded in the 1970's by the Minerals Management Service (now BOEM) (Littler 1979). Fixed plots provide a cost effective approach to sampling for assessment of change—a critical feature for sustaining a long-term program. Targeting key species or assemblages allows the sampling effort to focus on ecologically important components of the assemblage, and provides greater statistical power to detect changes over time and space. Methods are outlined in more detail in our web report (www.pacificrockyintertidal.org), and detailed descriptions can be found in Engle, 2005.

Permanent plots for long-term monitoring are monitored at twenty-four sites in the central/southern California region, stretching from Point Sierra Nevada in the north to Dana Point in the south. Sites are located approximately 10-30 kilometers apart and span nearly 600 kilometers of California coastline.

Monitoring surveys target thirteen key species or species groups: rockweeds (*Silvetia compressa* and *Hesperophycus harveyanus*), turfweed (*Endocladia muricata*), red algae *Mastocarpus* and *Mazzaella* spp., anemones (*Anthopleura elegantissima/sola*), barnacles (*Chthamalus* spp. and *Balanus glandula*), goose barnacles (*Pollicipes polymerus*), mussels (*Mytilus californianus*), surfgrass (*Phyllospadix scouleri/torreyi*), seastars (*Pisaster ochraceus*), owl limpets (*Lottia gigantea*), and black abalone (*Haliotis cracherodii*). Not all target species are sampled at each site. Additional species are targeted at other sites in the MARINe network (www.pacificrockyintertidal.org). Some species are sampled in the field by counts or point-contact procedures, but most sampling is accomplished by photographing quadrats. The resulting digital images are scored in the lab for percent cover of both the target species and other general taxa included in the plots using a point contact method.

Dr. Pete Raimondi, the Project Manager, coordinates the study, and specifically oversees monitoring in San Luis Obispo and northern Santa Barbara County sites. Dr. Rich Ambrose at UCLA does companion monitoring for southern Santa Barbara and Los Angeles Counties. Dr. Steve Murray and Dr. Jennifer Burnaford at CSUF and Dr. Jayson Smith at CSUP monitor sites in Orange County. Dr. Jack Engle at UCSB coordinates MARINe efforts, particularly with regard to protocol standardization and documentation. In addition, the BOEM Pacific Regional Intertidal Survey and Monitoring (PRISM) Team participates in the sampling, and other program functions to assure continued coordination with BOEM is maintained.

STUDY RESULTS:

The analysis highlighted by this report includes long-term monitoring trends for the 24 BOEM-funded sites, as well as regional trends for the study region encompassing these sites. Additional coast-wide trends and site-specific results (including Biodiversity Survey Findings) can be viewed at: www.pacificrockyintertidal.org.

During the 2007-2010 period, semi-annual sampling of sessile and motile species was done within permanent plots at 23 of the 24 sites. One site, Government Point, has not been sampled since 2006 due to a change in access restrictions. No additional sites were set up using direct BOEM funding, but from 2007-2010, nearly 40 additional sites were established within the MARINe network using co-funding from the State of California (Marine Protected Area (MPA) and Areas of Special Biological Significance (ASBS) funding) and the U.S. Fish and Wildlife Service. Another significant event that occurred was the acceptance of MARINe protocols by the U.S. National Park Service monitoring program (for Redwood National Park and Olympic National Park). These protocols are also now being used as the basis of monitoring programs in Park Service areas on the east coast of the United States.

The following is a brief summary of individual species trends for the central/southern California region specified for this report. Trends are generally summarized for the entire period over which a site has been monitored, up to spring, 2010.

Silvetia (golden rockweed) declined in cover at all sites north of Point Conception, except Boathouse, which lies just to the north of this important biogeographic barrier (approx. 25 km north). Slight declines were also evident at most sites south of Point Conception, with the exception of Dana Point, where cover was quite stable over the 15 year time period that this site has been monitored. *Silvetia* cover tended to fluctuate seasonally, with slightly higher cover in fall than in spring at all sites. At both sites where *Hesperophycus* (olive rockweed) was sampled, cover decreased substantially in the first few years of monitoring, and then leveled off. Cover of *Endocladia* (turfweed) declined at all sites where it was sampled, although the degree of decline ranged from slight (5 sites) to moderate (4 sites). As with *Silvetia*, cover of *Endocladia* fluctuated seasonally at most sites, but in the opposite direction, with higher cover in spring than in fall.

Mastocarpus (Turkish washcloth) experienced a general decline while *Mazzaella* (iridescent weed) cover remained relatively stable over time at both sites where these algae were sampled. *Anthopleura* (anemone) cover was relatively stable over time at three sites where this species was sampled, and declined slightly at three other sites. Extreme fluctuations in sand cover occurred at five sites in the low-lying fixed plots used for monitoring *Anthopleura* abundance. *Chthamalus/Balanus* (acorn barnacle) cover varied over time and among sites, which was not surprising for these relatively short-lived species. Overall, barnacle cover was relatively stable over time at nine sites, declined slightly at four sites, moderately at five sites, and substantially at two sites. *Pollicipes* (goose barnacle) cover was constant over time at two sites, but showed both a decreasing over-time trend and a seasonal trend (with higher cover in fall) at Carpinteria. Mussel cover was relatively stable over time at ten of the twenty-one sites where it is sampled and at one site cover increased slightly. Four sites showed a slight decreasing trend in mussel cover over time and at six sites decline was substantial. The 1997/98 El Niño event was associated with a decline in mussel cover at seven sites. Five sites recovered from this impact, but two did not. Recovery plots were largely dominated by bare rock and non-coralline crusts, but *Silvetia* cover has gradually been increasing over time in these plots.

Phyllospadix (surfgrass) cover was highly seasonal, with higher cover in fall than in spring at all sites except Cayucos, where transects are located in pools, and Hazards, where transects are located in the extreme low zone. Sand cover in surfgrass plots was an important factor at several sites, particularly at Coal Oil Pt., where plants were frequently partially covered and, on one occasion, completely buried by sand. Surfgrass cover along transects declined slightly over time at three sites, and moderately at three others. A particularly impressive recovery was documented at Stairs, where surfgrass, and even some of the substrate upon which the surfgrass grows, was removed by large surf associated with the 1997/98 El Niño event. As of 2010, cover had nearly recovered to original levels. A similar recovery from impacts of the El Niño event was observed at Paradise Cove.

Pisaster (seastar) counts were variable from sample to sample at nearly all sites for this highly mobile species. Ten sites appeared to show a general increase in number over time, six sites generally declined in number, and four sites were relatively stable. *Lottia* (owl limpet) abundance was quite variable over time at many sites. The mean number of owl limpets per plot declined over time at eight sites, remained about the same at five sites, and increased slightly at three sites.

Arguably the most important result of this long-term monitoring project is the continued decline of black abalone at all sites within the regions funded by BOEM. The black abalone has been placed on the Endangered Species List as a result, in part, of trends documented by this study. The decline during this period was more muted than in the past, but still present. These declines were coupled with a near-absence of abalone recruitment, indicating that recovery, if it occurs, will be slow.

In an effort to better characterize the communities targeted by photoplots, motile invertebrates have been counted in select plot types for the past several years. Limpets and littorines were the most abundant (and most variable) motile invertebrates, present mostly in barnacle and *Endocladia* plots. The turban snail, *Tegula funebralis,* was common in *Silvetia*, *Endocladia*, and mussel plots. Mussel plots also contained the whelk, *Nucella* spp. and the chiton *Nuttallina* spp. *Lepidochitona hartwegii* was found nearly exclusively in *Silvetia* plots.

SIGNIFICANT CONCLUSIONS:

The MARINe monitoring program is the largest and longest-running project of its kind; some BOEM-funded sites have been sampled for 20 years. Long-term data from within the BOEM-funded region have been invaluable for rocky intertidal community damage assessment and resource management decisions. After the 1997 Torch Oil spill, broad-scale, long-term data at BOEM-funded sites allowed us to separate impacts due to hydrocarbon exposure from concomitant impacts of the 1997/98 El Niño event. During the 2007-2010 period, MARINe data were used for the Natural Resource Damage Assessment (NRDA) process for two oil spills. In each of these cases, damage assessment would not have been possible without a measure of natural long-term variation both within and outside of the area impacted by the oil spill. The results of these analyses indicate that our sampling is robust for detecting anthropogenic effects due to oil spills and our protocols are now accepted for the assessment of impact determination. This accomplishment led to a contract to modify our protocol to use in the NRDA process for hard surface (rocky) areas affected by the Deep Water Horizon, which elevates the acceptance of the MARINe Long-Term Monitoring methods to a national scale.

MARINe surveys have also been instrumental in documenting the ongoing, massive declines of black abalone due to withering syndrome. Declines were first detected on the mainland at BOEM-funded sites in Santa Barbara County. Long-term monitoring has allowed us to document patterns in decline related to water temperature, and map the northward progression of the disease. Additional studies coupled to the MARINe monitoring were carried out to determine the extent of the critical habitat for the species. These two data sets were combined to estimate the population size of black abalone and results were critical to the listing of the species as endangered. MARINe monitoring data were also used by the State of California to aid in the design of the MPA network for southern California mandated by the Marine Life Protection Act. These intertidal datasets were used to delineate biogeographic regions and calculate optimal sizes for intertidal MPA's. Additionally, MARINe datasets were the foundation of the assessment of potential impacts to the State designated Areas of Special Biological Significance.

STUDY PRODUCT(S):
In partnership with PISCO, we have produced a comprehensive, web-based data report (www.pacificrockyintertidal.org) that can be updated on a regular basis. Static summary graphs of long-term data can be revised as new data become available, and information relevant to the project, including methods and products resulting from the work, will be current. The report also provides user-generated mapping and graphing features, allowing users to create customized graphs to display specific data of interest. The temporal and spatial coverage of this web-based presentation of the MARINe long-term monitoring approach and resulting data is unprecedented, and it is our hope that it becomes a useful tool for researchers and resources managers, as well as a go-to source of information for the general public about the coastal environment.

Additional products include annual updates of the MARINe database, collection and archival of photos and specimens, conference presentations, peer reviewed papers, posters, and reports. For a full listing see www.marine.gov/Findings/Publications.html.

STUDY REPORT

PART I: INTRODUCTION, OBJECTIVES, AND APPROACH

1.1 Introduction

Rocky intertidal shores occur at the interface between the terrestrial and marine environments. This unique location results in a physical complexity that leads to high biological diversity, including many species that are found only in this narrow band of coastal habitat. Rocky shores are also the most accessible marine habitat, which fosters a strong public appreciation of these communities, but also makes them vulnerable to degradation resulting from human activities. Natural temporal variation in rocky intertidal systems can be quite high, and can occur on the scale of months (seasonal), years, and even decades, so long-term monitoring is essential for separating natural change from human-induced.

Because rocky intertidal communities are highly diverse and subject to constant change, monitoring of these areas must be done in a well-designed, systematic manner, over long periods of time. Our monitoring program began with the goal of developing an approach that would enable researchers to collect statistically sound data using methods that were simple enough to maintain over the long-term, using minimal resources. This program has grown into a consortium of groups that now monitor sites along the entire Pacific Coast of North America (from southern Alaska to San Diego, California), as well as several East Coast sites in Maine and New Hampshire.

Federal, state and local agencies have recognized the importance of baseline information on coastal ecological resources by funding the establishment of a network of monitoring stations. Of the more than 140 established MARINe sites, over half are funded by Federal agencies, (e.g., Bureau of Ocean Energy Management (BOEM), The National Park Service), and the balance are funded by private, State, and non-governmental entities. The biological information acquired during these surveys is incorporated into resource databases hosted by MARINe and Partnership for Interdisciplinary Study of Coastal Oceans (PISCO). This innovative monitoring approach was initiated by the Channel Islands National Park in the early 1980’s (Davis 1985; Richards and Davis 1988). In 1990, the Cabrillo National Monument in San Diego County began long-term rocky intertidal monitoring (Davis and Engle 1991). Monitoring in Santa Barbara County began in 1992 with a project funded jointly by BOEM, formerly the Minerals Management Service (MMS), which funded monitoring of intertidal and subtidal resources (Ambrose et al. 1992a, b), and the County of Santa Barbara, which funded monitoring of wetland resources (Ambrose et al. 1993). In 1994, it was expanded by the California Coastal Commission (CCC) to include the northern Channel Islands (particularly Santa Cruz Island) and Ventura and Los Angeles Counties (Engle et al. 1994). The CCC projects include monitoring of subtidal, rocky and sandy intertidal and, for Los Angeles/Ventura Counties, wetland resources. Although the monitoring network is principally motivated by oil and gas activities, the information it generates provides valuable information about the status and trends of the biological resources of the region, similar to the Environmental Protection Agency (EPA)'s Environmental Monitoring & Assessment Program (EMAP) but on a finer spatial scale. The National Research Council (NRC) has also emphasized the value of coordinated regional monitoring efforts (NRC 1990a, b).

Central California Rocky Intertidal Habitats

Rocky intertidal communities in Central California (Pigeon Point to Point Conception) are known for their diverse and relatively pristine biota. Much of the coast is remote and undeveloped but the natural beauty and coastal resources of this region, (which includes Monterey Bay, the Big Sur Coastline, and San Luis Obispo), make it a popular tourist destination. The Central California region is dominated by the cold-temperate Oregonian biogeographic province, but warmer-water species more characteristic of the southern (Californian) biogeographic province begin to show up in the southern portion of the region, and can move far to the north during El Niño events.

The rocky shore communities of Central California are vulnerable to oil spills, primarily from major coastal tanker traffic, but also from terminal operations and onshore pipeline breaks. Natural oil seeps also exist, resulting in the presence of tar on many rocky shores, particularly in the southern portion of the region. In recent years there have been spills affecting marine resources from onshore operations at Avila (1992), Guadalupe (1994), and Vandenberg Air Force Base (1997).

A portion of the Central California region is included in the Monterey Bay National Marine Sanctuary (Pigeon Pt. to Cambria). The region includes thirteen State Marine Reserves, in which all fishing is prohibited, and fifteen State Marine Conservation Areas, in which limited commercial or recreational take is allowed (California Department of Fish and Game, 2007).

Extensive historical information about marine communities in this region is available, particularly for the Monterey Bay area, where several university marine labs (Long, Moss Landing, Hopkins) and research facilities (MBARI, NOAA, Elkhorn Slough NERR) are located. Farther south, long-term surveys were done to assess the impact of the Diablo Canyon Nuclear Power Plant on intertidal and near shore communities (North et al. 1989, Tenera Environmental 1988a, b, 1994). Research on seasonal and successional variation in intertidal community structure was done at three sites within the region (Kinnetics Laboratories, Inc. 1992a, b), and MARINe Long-Term monitoring has been done in the Central California region since 1992. Baseline monitoring for newly established Marine Protected Areas began in 2007. Within this region, 40 Long-Term sites have been established, 10 of which are BOEM-funded.

Southern California Rocky Intertidal Habitats

The Southern California region begins at Point Conception (Government Point), an important biogeographical transition area for rocky intertidal organisms, and extends to the Mexican border. Much of the region occurs within the Southern California Bight, where the coast turns sharply inward to the east and receives protection from prevailing northwesterly winds and swells by the Channel Islands offshore. This results in relatively benign oceanographic conditions most of the time, though periodic southern storms can have a devastating impact on south facing stretches of the coast. A large gyre that exists within the bight creates sea surface temperatures that are warmer, on average, than coastal sections to the north and (to a certain extent) to the south.

Sandy habitats comprise a much greater proportion (approximately 75%) of the shoreline in southern California than they do in central and northern California (Littler and Littler, 1979). Many of the monitoring sites are located on isolated rocky habitats that are flanked by wide stretches of beach, and experience frequent periods of burial and scour. This, along with abundant sunshine and the predominance of warmer coastal air temperatures, creates harsh conditions for species that are intolerant to desiccation. Thus, rocky intertidal communities are largely devoid of larger foliose algae such as the fleshy reds that are so common to the north. These are replaced by abundant turf forming species such as corallines and filamentous red algae, and sun-tolerant rockweeds.

Much of the Southern California coastline is heavily urbanized and subject to multiple anthropogenic influences, including storm water run-off, harvesting, and trampling. At monitoring sites that are closer to urban centers, the direct influence of people on the rocky intertidal community is substantial (Thompson et al. 1993). The mainland region includes eight State Marine Reserves, in which all fishing is prohibited, eighteen State Marine Conservation Areas (SMCAs), in which limited commercial or recreational take is allowed, and eleven no-take SMCAs (California Department of Fish and Game, 2012).

The threat of an oil spill from offshore tanker ships and onshore pipelines, production platforms, and terminal operations is high, though no major spills have occurred within the region for many years. Natural oil seeps are prominent features, especially at Point Conception (Government Point), Coal Oil Point, and Carpinteria.

The southern California coast has been well-studied, with numerous universities supporting marine-focused programs located within the region. Previous monitoring studies include surveys at 7 mainland locations done in the 1970's by the U.S. Bureau of Land Management (now BOEM) for the Southern California Bight Baseline Study (Littler 1979), and long-term surveys (since 1975) at 4 sites along the Palos Verdes Peninsula. Mussel bed communities were characterized at several sites within the region in the 1970's (Straughan and Kanter, 1977). Seaweed abundances and diversity were examined at numerous sites in the 1950's and 1960's (Dawson, 1965), with some locations resampled in the 1970's (Thom and Widdowson, 1978). MARINe Long-Term Monitoring Surveys have been done in this region since 1990. Baseline monitoring for newly established Marine Protected Areas began in 2012. Within this region, 27 Long-Term sites have been established, 14 of which are BOEM-funded sites.

Central and Southern California Rocky Shoreline

The extent of rocky shoreline varies substantially in central and southern California (Ambrose et al. 1989). The northern section of the region is predominantly rocky (Table 1). San Luis Obispo County has the most extensive stretch of rocky shores (54 mi, or 58% of its coastline) in the region, (except for the Channel Islands). Ventura and Orange Counties have the least rocky shoreline, each with 3 miles or 7% of the coastline.

Location	Coastline Length (mi)	Miles Rocky	Miles Sandy	% Rocky	% Sandy
San Luis Obispo Co.	93	54	39	58	42
Santa Barbara Co.*	110	26	84	24	76
Ventura Co.*	41	3	38	7	93
Los Angeles Co.*^	77	26	51	34	66
Orange Co.	41	3	38	7	93
San Diego Co.	76	11	65	14	86
Channel Islands	273	211	62	77	23

* excludes Channel Islands ^ includes harbor breakwaters

Table 1: Extent of rocky and sandy shores for central/southern California. (Mainland data from Littler and Littler, 1979. Island data from Littler and Littler 1980)

The biological communities of the mainland from San Luis Obispo County in the north to Orange County in the south are distinctly different north and south of Point Conception (Murray and Littler 1981, Ambrose et al., 1992a, b).

1.2 Objectives

A primary objective for this research was to continue the ongoing monitoring program that provides a basis for determining if change in rocky shoreline communities adjacent to producing OCS facilities can be attributed to operations or accidents from OCS facilities. The 24 BOEM-funded sites are on the shorelines adjacent to existing oil and gas OCS facilities. Resource data from the MARINe database also support information needs for BOEM’s renewable energy program along the Pacific coast. Another important objective was to provide an ecological context for the 24 BOEM-funded sites, by comparing trends and patterns in community dynamics to other sites monitored using identical MARINe methods, ranging from southern Alaska to San Diego, California. The long-term nature of this monitoring project, coupled with its’ large spatial scale, allows for a better understanding of changes to rocky intertidal communities in the Southern California Bight that have occurred since the OCS program was initiated. A monitoring program of this temporal and spatial magnitude provides insight into whether changes might be attributed to natural (e.g. El Niño events, disease) or human induced (e.g.

trampling, climate change) factors. This large-scale monitoring effort is a collaboration between MARINe and many other groups. Two major MARINe partners that support monitoring efforts at numerous sites are the National Park Service (NPS), and the Partnership for Interdisciplinary Study of Coastal Oceans (PISCO). A complimentary biodiversity monitoring effort was developed by Dr. Pete Raimondi and the MARINe Science Panel, funded initially by BOEM and PISCO. These Biodiversity surveys were continuously funded by PISCO over a period of 10 years, and over 140 sites have been established and sampled using this protocol. Additional objectives include oversight of a centralized database, and publication of metadata for the BOEM-funded long-term data set.

A final goal for this study was to initiate the production of a comprehensive web-based data report for all rocky intertidal monitoring sites within the MARINe network (including sites in CA, OR, WA, and AK), beginning with the BOEM-funded sites in central and southern California. This web-based product includes detailed information about the MARINe project including methods, descriptive information about regions, sites, and species targeted, as well as extensive summaries of trends and patterns observed within sites and among regional groupings of sites. Trend data can be viewed either in static summary graph form or by using an interactive graphing tool, which displays user-defined site and species summary data. This website enables users to view important trends and patterns in the Long-Term and Biodiversity survey data from the central and southern California regions and to make comparisons to similar historic data from other regions. This synthesis of long-term, rocky intertidal monitoring data in a centralized, easily accessible location is unprecedented in scope, and it is our hope that this information will be of great value to resource managers, researchers, and the general public.

1.3 Approach

Rocky intertidal areas tend to be dominated by several “key” species, which often form distinct vertical bands/zones along the shoreline. These species shape the community by creating habitat for other species, or through activities such as grazing or predation. The Long-Term Monitoring approach developed by MARINe focuses on these key species, with the idea that changes in these species will impact other species in the community. This targeted approach allows us to detect relatively small changes in the abundance of species, at effort levels that can be sustained for the long-term. Targeted species are monitored within fixed plots annually or semi-annually. Layered upon this “core” approach are the additional goals of documenting species richness and changes in the distribution of species within and among sites over time. Biodiversity Surveys, designed to capture information about the rocky intertidal community as a whole (rather than targeted species) are used to address these goals. These surveys are much more intensive and require a high-level of expertise and consistency in the identification of marine organisms, and are thus done by a single group at UC Santa Cruz (cbsurveys.ucsc.edu) and on a less frequent schedule, typically every 3-5 years.

In combination, the long-term, targeted species approach and the biodiversity surveys provide a wealth of information about the structure and dynamics of rocky intertidal communities along the Pacific Coast of North America. Our monitoring program is the largest, and longest-running of its kind; sites in some regions have been sampled for 20-30 years. The long-term information about the dynamics and diversity of rocky intertidal habitats enables us to: 1) Assess impacts due to natural and human induced disturbance events (e.g. El Niño events, oil spills), 2) Detect shifts in community make-up due to factors such as disease, species introductions, and climate change, and 3) Provide context for more focused experimental work.

Survey Methods

Long-Term Monitoring Surveys use fixed plots to document changes in percent cover, or abundance of targeted species or species assemblages. This fixed-plot approach allows the dynamics of rocky intertidal species to be monitored with reasonable sampling effort and provides sufficient statistical power to detect changes over time and space. The MARINe survey methods can be divided into two tiers: "core" procedures that are done by all groups at all sites, and "optional" procedures that are done by groups with funding and staffing to support additional work. Long-Term Monitoring Surveys currently target 25 key species or species assemblages. Not all target species are sampled at each site. For more information regarding the sampling methods, please consult the Long-Term Monitoring Protocol (available at www.pacificrockyintertidal.org).

The Biodiversity Surveys provide detailed information about biodiversity and community structure. These surveys were designed to measure diversity and abundance of algae and invertebrates found within rocky intertidal communities on the western coast of temperate North America. Biodiversity Surveys are comprised of four components, all sampled along the same transects: 1) point contact estimates of intertidal cover and substrate characteristics; 2) quadrat sampling to estimate the density of mobile invertebrates; 3) swath transects to estimate the density of seastars, abalone, and other large mobile invertebrates; and 4) topography (elevation relative to mean low low water). Although Biodiversity Surveys have been done at all BOEM-funded sites, the findings are not included in this report. This report summarizes findings from Long-Term monitoring surveys at the 24 BOEM-funded sites. To view Biodiversity Survey findings, and for more information regarding the sampling methods, please consult the Biodiversity Survey Protocol (available at www.pacificrockyintertidal.org).

Target Species Monitoring

To accomplish the first objective, target species at 24 established rocky intertidal sites along the mainland coast of Southern and Central California adjacent to producing platforms are monitored (Table 2, Figure 1).

Site Name	SiteID	North/ South Order	Group	Principal Investigator	Year Established	Last Sampled
Point Sierra Nevada	PSN	1	UCSC	Pete Raimondi	1995	2011 Fall
Piedras Blancas	PBL	2	UCSC	Pete Raimondi	1997	2011 Fall
Cambria/Rancho Marino	RMR	3	UCSC	Pete Raimondi	2001	2011 Fall
Cayucos	CAY	4	UCSC	Pete Raimondi	1995	2011 Fall
Hazards	HAZ	5	UCSC	Pete Raimondi	1995	2011 Fall
Shell Beach	SHB	6	UCSC	Pete Raimondi	1995	2011 Fall
Occulto	OCC	7	UCSC	Pete Raimondi	1992	2011 Fall
Purisima	PUR	8	UCSC	Pete Raimondi	1993	2011 Fall
Stairs	STA	9	UCSC	Pete Raimondi	1992	2011 Fall
Boathouse	BOA	10	UCSC	Pete Raimondi	1992	2011 Fall
Government Point	GPT	11	UCSC	Pete Raimondi	1992	2006 Fall
Alegria	ALEG	12	UCLA	Rich Ambrose	1992	2011 Fall
Arroyo Hondo	ARHO	13	UCLA	Rich Ambrose	1992	2011 Fall
Coal Oil Point	COPT	14	UCLA	Rich Ambrose	1992	2011 Fall
Carpinteria	CARP	15	UCLA	Rich Ambrose	1992	2011 Fall
Mussel Shoals	MUSH	16	UCLA	Rich Ambrose	1994	2011 Fall
Old Stairs	OLDS	17	UCLA	Rich Ambrose	1994	2011 Fall
Paradise Cove	PCOV	18	UCLA	Rich Ambrose	1994	2011 Fall
White Point	WHPT	19	UCLA	Rich Ambrose	1994	2011 Fall
Point Fermin	PTFM	20	UCLA	Rich Ambrose	1999	2011 Fall
Crystal Cove	CRCO	21	CSUF	Jayson Smith/Jennifer Burnaford	1996	2011 Fall
Shaws Cove	SHCO	22	CSUF	Jayson Smith/Jennifer Burnaford	1996	2011 Fall
Treasure Island	TRIS	23	CSUF	Jayson Smith/Jennifer Burnaford	1996	2011 Fall
Dana Point	DAPT	24	CSUF	Jayson Smith/Jennifer Burnaford	1996	2011 Fall

Table 2: Sites sampled from north to south, group and Principle Investigator (PI) responsible for sampling.

Location of sampling sites

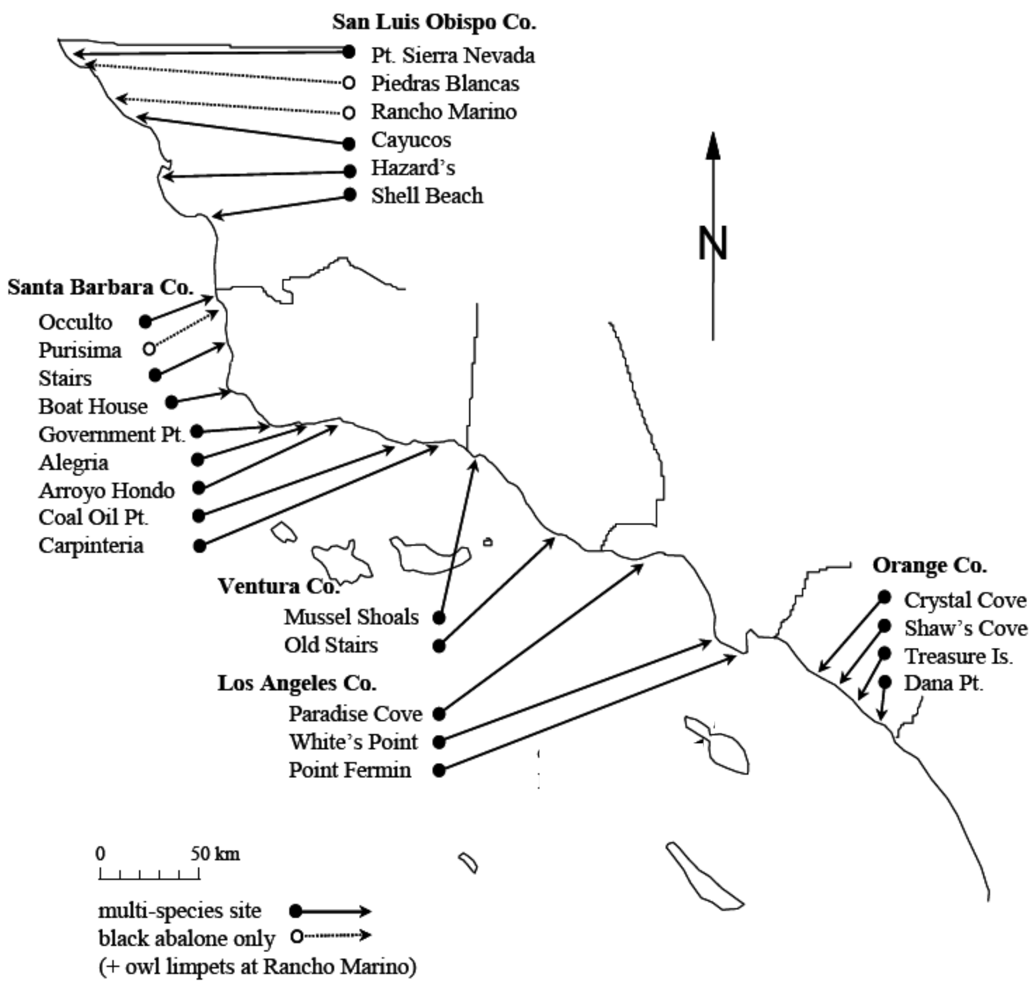

Figure 1: Location of Sampling Sites

Target species include: rockweeds (*Silvetia compressa* and *Hesperophycus harveyanus*), turfweed (*Endocladia muricata*), red algae *Mastocarpus* and *Mazzaella* spp., anemones (*Anthopleura elegantissima/sola*), barnacles (*Chthamalus* spp. and *Balanus glandula*), goose barnacles (*Pollicipes polymerus*), mussels (*Mytilus californianus*), surfgrass (*Phyllospadix scouleri/torreyi*), seastars (*Pisaster ochraceus*), owl limpets (*Lottia gigantea*), and black abalone (*Haliotis cracherodii*). Not all target species are sampled at each site, and additional species are targeted at other sites in the MARINe network. Table 3 shows the target species at each of the sites sampled. Detailed descriptions for all species targeted by MARINe surveys, (including habitat, geographic range, and natural history) are available in Appendix 1 and at www.pacificrockyintertidal.org.

	Target Species													
Site Name	anthopleura	chthamalus/balanus	endocladia	haliotis	hespero-phycus	lottia	masto-carpus	mazzaella	mytilus	pisaster	pollicipes	postelsia	recovery	silvetia
Point Sierra Nevada		x		x	x		x	x	x	x		x		x
Piedras Blancas Lighthouse		x		x			x		x	x		x		x
Rancho Marino Reserve				x		x								
Cayucos		x	x	x	x	x			x	x				x
Hazards		x	x			x		x	x	x				x
Shell Beach		x	x				x		x	x				x
Occulto		x	x						x	x				
Purisima				x										
Stairs		x	x	x		x			x	x			x	x
Boathouse	x	x	x	x		x			x	x				x
Government Point		x	x	x		x			x	x	x			x
Alegria	x	x				x			x	x	x			
Arroyo Hondo		x							x	x				
Coal Oil Point	x								x					
Carpinteria	x	x				x			x	x	x			
Mussel Shoals	x	x				x			x	x				
Old Stairs	x	x	x			x			x	x				
Paradise Cove		x	x			x			x	x				
Whites Point		x	x			x			x	x				
Point Fermin		x				x			x	x				x
Crystal Cove		x				x			x	x				x
Shaws Cove		x	x			x			x	x				x
Treasure Island		x							x	x				x
Dana Point		x				x			x	x				x

Table 3: Target species sampled (X) at the 24 sample sites.

Mussels, barnacles, anemones and algal species are photographed in fixed rectangular plots and scored in the lab or field (barnacles at some sites) by scoring species occurring under 100 points overlaid onto each image. Five replicate plots per target species are photographed each time a site is surveyed. Surfgrass cover is estimated using a point contact method along 10-meter long transects. Owl limpets are measured and counted in five replicate, 1-meter circular plots. Abalone are counted and measured in three replicate irregular plots. Sea stars are counted, measured and classed by color in either 2-meter wide, 10-meter long band transects or irregular plots, depending on the habitat. In many of the target species plots, we also sample the associated motile species (Table 4). To optimize future environmental impact assessments, sites have been established systematically over a broad geographic range and each species is monitored at several sites within that range.

Monitoring of long-term sites is typically done in fall and spring each year, although the motile species are sometimes sampled only once per year (see Table 4). There can be considerable seasonal changes in the rocky intertidal community, especially after stormy winters and hot summers. October or November is usually the first period after summer with low tides during the daytime (daylight is required for photographing plots), and is appropriate for determining the post-summer community. March or April is an appropriate time to determine the post-winter community, and there are once again low tides during the daytime.

	Target Species								
Site Name	chthamalus / balanus	endocladia	hespero-phycus	mastocarpus	mytilus	pollicipes	recovery	silvetia	Motile Sampling Notes
Crystal Cove	X				X			X	
Dana Point	X				X			X	
Shaws Cove	X	X			X			X	
Treasure Island	X				X			X	
Piedras Blancas Lighthouse	X			X	X			X	Spring sampling only
Alegria	X				X	X			Spring sampling only
Arroyo Hondo	X				X				Spring sampling only
Carpinteria	X				X	X			Spring sampling only
Coal Oil Point					X				Spring sampling only
Mussel Shoals	X				X				Spring sampling only
Old Stairs	X	X			X				Spring sampling only
Paradise Cove	X	X			X				Spring sampling only
Point Fermin	X				X			X	Spring sampling only
Whites Point	X	X			X				Spring sampling only
Boathouse	X	X			X			X	
Cayucos	X	X	X		X			X	
Government Point	X	X			X			X	
Hazards	X	X			X			X	
Occulto	X	X			X				No Fall 2007 sampling
Point Sierra Nevada	X		X		X			X	
Shell Beach	X	X		X	X			X	
Stairs	X	X			X		X	X	No Fall 2007 sampling

Table 4: Target species plots in which motile organisms are sampled

Depending on the size of the site and the number of target species being monitored, 2-5 samplers (minimum of 2 trained biologists) are typically needed to complete the collection of field data on a given tide. Pacific Region Intertidal Survey and Monitoring (PRISM) Team, formerly MMS Intertidal Team (MINT) biologists assist in the collection of the field data at as many as 20 of the sites depending on tidal cycles. Travel to and from sites benefited from cost sharing since several sites can be surveyed during one tide cycle.

Protocols used to collect the data are standardized, coordinated with other members of MARINe, and are not altered without prior approval of BOEM. A base protocol was standardized across the Bight among MARINe members and was maintained at each site; additional protocols needed to address site specific problems or answer species-specific questions are sometimes added with BOEM approval. Additional protocols which do not add to field costs overall are accommodated in order to address important research questions, so long as they are disseminated to and agreed upon (where appropriate) by all MARINe members.

Collection of field data is carried out by the University of California, Santa Cruz (UCSC), University of California, Los Angeles (UCLA), and California State University, Fullerton (CSUF) (Table 2).

Coordination—Internal and with MARINe

Since several teams of biologists are needed to collect data at over 140 established sites (including the 24 BOEM-funded sites), coordination among field teams is essential to ensuring that the data collected are of the highest quality and are comparable across sites. Therefore, strong coordination is needed between the Principal Investigators (PI)'s to ensure continuity since the tasks are inherently integrated between Universities. This coordination includes regular meetings, email, phone calls and joint participation in the field to ensure that individual PIs are not inadvertently making changes in protocols or data processing which affect other teams.

Strong coordination is also needed between BOEM and MARINe to ensure that MARINe is providing data in a timely fashion to BOEM and that MARINe products directly meet the needs of the scientists, including the BOEM PIs. BOEM agreed to provide a MARINe coordinator to that end. The duties of the coordinator include:

1. Facilitating the development of the database by:
    a. Acting as a liaison between the database consultant and MARINE researchers in developing timely responses to database questions.
    b. Coordinating with the BOEM researchers in particular and MARINE researchers in general to ensure their data and metadata inputs are complete and timely.
    c. Providing a broad range of knowledge regarding the MARINE sites and technical issues to the database consultant to ensure that the database will be useful to researchers when it is completed.
2. Organizing and moderating biannual Steering Committee, Science Panel and Database Panel meetings for MARINe.
3. Providing ongoing coordination with the MARINe committee representatives and organizations outside MARINe to facilitate continued long-term funding of MARINe sites.
4. Working with MARINe to develop automated standardized field datasheets.
5. Working with MARINe to reach agreement and develop procedures which promote timely release of data to the public.

These tasks are done at all campuses but the responsibility for coordination was centered at the University of California, Santa Barbara (UCSB).

Data management

Data management is centralized at UCSC. Duties include administering data in the MARINe (access) database and excel spreadsheets. All campuses are responsible for uploading data using data forms, but no alterations to the database are made without approval from the data administrator. Data are accessible via the Microsoft Access relational database management system interface, and revisions are made approximately twice per year. Data are available to all agencies and interested parties that make specific requests.

Project management

The UCSC portion of the program (monitoring in San Luis Obispo and northern Santa Barbara County) is managed by the Principal Investigator, Dr. Pete Raimondi. Dr. Raimondi has been a Principal Investigator of the BOEM-funded rocky intertidal inventory project since its inception and has been responsible for data analysis of the project for over ten years. Dr. Raimondi is responsible for overseeing financial aspects of the project, and in particular, is responsible for ensuring completion of project objectives and deliverables. This is done, in part, through coordination meetings and conference calls. However, the main means of ensuring performance is through the yearly workshops where all PIs get together along with staff to review the status of the project.

Dr. Rich Ambrose at UCLA does companion monitoring for southern Santa Barbara and Los Angeles Counties. Dr. Steve Murray and Dr. Jennifer Burnaford at CSUF, and Dr. Jayson Smith at CSUP monitor sites in Orange County. Dr. Jack Engle at UCSB coordinates MARINe efforts, particularly with regard to protocol standardization and documentation. In addition, the BOEM Pacific Regional Intertidal Survey and Monitoring (PRISM) Team participates in the sampling, and other program functions to assure continued coordination with BOEM is maintained.

PART II: ROCKY INTERTIDAL MONITORING STUDY

2.1 Long-Term Monitoring

Description of sites

Long-Term Monitoring sites are typically established in areas where the coastline consists of contiguous rocky reef. These rocky reefs are usually quite broad (typical width between 30-50 m) and long (typical length between 50-500 m). Contiguous rocky reefs are the most stable of rocky intertidal habitats, and targeting a specific habitat type results in higher consistency among sites, which allows for better comparisons among sites and regions. This basic level of consistency in site selection is important, because targeted reefs vary immensely by rock type, shape, rugosity, exposure, surrounding habitat, human visitation levels and other factors, which all contribute to explaining patterns in long-term community dynamics.

For each of the 24 BOEM-funded sites, detailed information is now available through the www.pacificrockyintertidal.org website. The information on each site page includes (where applicable): regional location, access restrictions, visitation, physical and geological characteristics, and coastal orientation. Long-Term Monitoring Survey information such as year established, research (monitoring) group, and species targeted is also included on each site page. To view site pages for the 24 BOEM-funded sites, see Appendix 2.

Study Results: Summary of Trends

For each Long-Term Monitoring site, a detailed description of the trends and patterns in species' abundances, along with trend graphs for each plot type is available at www.pacificrockyintertidal.org.

Long-Term percent cover trend graphs for photo plots and transect data show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. For motile invertebrate species counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. A mean count across all plots is also displayed for *Lottia*. For *Pisaster*, *Haliotis*, and *Postelsia* counts, the sum of all individuals across all plots is displayed.

The report summarizes Long-Term Monitoring trends for the 24 BOEM-funded sites, as well as regional trends for the study region encompassing these sites. Additional coast-wide trends and site-specific results (including Biodiversity Survey findings) can be viewed at: www.pacificrockyintertidal.org. Trends are generally summarized for the entire period over which a site has been monitored, up to spring, 2010.

To view site specific graphs and trend descriptions for the 24 BOEM-funded sites, see Appendix 3. For site specific graphs and trend descriptions for species of concern (*Haliotis*, *Lottia*, and *Postelsia*), see Appendix 4 (available in CONFIDENTIAL report only).

Discussion

The following is a brief summary of individual species trends for the central/southern California region specified for this report. Additional, coast-wide trends and site-specific results can be viewed at: www.pacificrockyintertidal.org. Trends are generally summarized for the entire period over which a site has been monitored

Silvetia (golden rockweed) declined in cover at all sites north of Point Conception, except Boathouse, which lies just to the north of this important biogeographic barrier (approx. 25 km north). Slight declines were also evident at most sites south of Point Conception, with the exception of Dana Point, where cover was quite stable over the 15 year time period that this site has been monitored. *Silvetia* cover tended to fluctuate seasonally, with slightly higher cover in fall than in spring at all sites. At both sites where *Hesperophycus* (olive rockweed) was sampled, cover decreased substantially in the first few years of monitoring, and then leveled off. Cover of *Endocladia* (turfweed) declined at all sites where it was sampled, although the degree of decline ranged from slight (5 sites) to moderate (4 sites). As with *Silvetia*, cover of *Endocladia* fluctuated seasonally at most sites, but in the opposite direction, with higher cover in spring than in fall.

Mastocarpus (Turkish washcloth) experienced a general decline while *Mazzaella* (iridescent weed) cover remained relatively stable over time at both sites where these algae were sampled. *Anthopleura* (anemone) cover was relatively stable over time at three sites where this species was sampled, and declined slightly at three other sites. Extreme fluctuations in sand cover occurred at five sites in the low-lying fixed plots used for monitoring *Anthopleura* abundance. *Chthamalus/Balanus* (acorn barnacle) cover varied over time and among sites, which was not surprising for these relatively short-lived species. Overall, barnacle cover was relatively stable over time at nine sites, declined slightly at four sites, moderately at five sites, and substantially at two sites. *Pollicipes* (goose barnacle) cover was constant over time at two sites, but showed both a decreasing over-time trend and a seasonal trend (with higher cover in fall) at Carpinteria. Mussel cover was relatively stable over time at ten of the twenty-one sites where it is sampled and at one site cover increased slightly. Four sites showed a slight decreasing trend in mussel cover over time and at six sites decline was substantial. The 1997/98 El Niño event was associated with a decline in mussel cover at seven sites. Five sites recovered from this impact, but two did not. Recovery plots were largely dominated by bare rock and non-coralline crusts, but *Silvetia* cover has gradually been increasing over time in these plots.

Phyllospadix (surfgrass) cover was highly seasonal, with higher cover in fall than in spring at all sites except Cayucos, where transects are located in pools, and Hazards, where transects are located in the extreme low zone. Sand cover in surfgrass plots was an important factor at several sites, particularly at Coal Oil Pt., where plants were frequently partially covered and, on one occasion, completely buried by sand. Surfgrass cover along transects declined slightly over time at three sites, and moderately at three others. Surfgrass at many sites was hit hard by the 1997/98 El Niño, with plants and in some cases, portions of the reef itself, getting ripped out or removed by powerful storm waves. This was especially true at Stairs, where surfgrass declined by nearly 80%. El Niño associated decline was also seen at Arroyo Hondo, Carpinteria, and Paradise Cove. Cover was relatively stable at four sites in the north (Point Sierra Nevada, Cayucos, Hazards and Shell Beach), and Alegria, and actually increased at Government Point (although sampling was last done here in 2006).

Pisaster (seastar) counts were variable from sample to sample at nearly all sites for this highly mobile species. Ten sites appeared to show a general increase in number over time, six sites generally declined in number, and four sites were relatively stable. *Lottia* (owl limpet) abundance was quite variable over time at many sites. The mean number of owl limpets per plot declined over time at eight sites, remained about the same at five sites, and increased slightly at three sites.

Arguably the most important result of this long-term monitoring project is the continued decline of black abalone at all sites within the regions funded by BOEM. The black abalone has been placed on the Endangered Species List as a result, in part, of trends documented by this study. The decline during this period was more muted than in the past, but still present. These declines were coupled with a near-absence of abalone recruitment, indicating that recovery, if it occurs, will be slow.

In an effort to better characterize the communities targeted by photoplots, motile invertebrates have been counted in select plot types for the past several years. Limpets and littorines were the most abundant (and most variable) motile invertebrates, present mostly in barnacle and *Endocladia* plots. The turban snail, *Tegula funebralis*, was common in *Silvetia*, *Endocladia*, and mussel plots. Mussel plots also contained the whelk, *Nucella* spp. and the chiton *Nuttallina* spp. *Lepidochitona hartwegii* was found nearly exclusively in *Silvetia* plots.

2.2 Comparison with other MARINe sites

Broad Scale Pattern Graphs

Mosaic plots show broad patterns of abundance over space and time for the most commonly occurring target species (see Appendix 5). Abundance is depicted as a function of color (darker=more abundant). Five broadly distributed (within the entire range of MARINe sites) taxa are sampled at BOEM-funded sites: Surfgrass (*Phyllospadix* spp.), Barnacles (*Balanus glandula/Chthamalus dalli/fissus*), Mussels (*Mytilus californianus),* Rockweed (*Silvetia compressa*), and Turfweed (*Endocladia muricata*).

Phyllospadix cover at many of these central and southern California sites was much lower than at sites both to the north and south. Surfgrass beds at several BOEM-funded sites (Coal Oil Point, Carpinteria, and Paradise Cove) are inundated with sand on a seasonal basis, and low cover was often a result of sand burial. Surfgrass at many sites was hit hard by the 1997/98 El Niño, including those to the south of the BOEM-funded sites. Sampling at sites to the north of the BOEM-funded region did not begin until 1999, thus the impact of this powerful El Niño event on northern surfgrass beds is unknown.

Cover of the relatively short-lived acorn barnacles (*Balanus/Chthamalus*) fluctuated at most sites throughout the entire range of MARINe sites. Cover was consistently highest at the northernmost sites in Oregon, where recruitment is higher and generally more consistent than at sites to the south. 13 of the 24 BOEM sites experienced a decline in barnacle cover associated with the 1997/98 El Niño.

Mussel cover was generally much lower in mussel plots at southern sites (including BOEM-funded), as compared to those in the north. Mussel beds at southern and some central California sites tend to be smaller and sparser than those at more northern sites, and beds are often only a single layer of mussels thick, in contrast to multi-layer beds further north (Melissa Miner, personal observation). As with other taxa, there is a strong 1997/98 El Niño signal in the cover data, with declines occurring at 12 BOEM sites.

Cover of *Silvetia* at the BOEM-funded sites in Orange County was consistently among the highest overall, when compared across the entire range of MARINe sites. Cover was also high at Pt. Fermin, just to the north, and Boathouse, north of Pt. Conception. A general pattern of decline was apparent across MARINe sites overall, with very few exceptions. This pattern appeared to be most severe in the north, including several BOEM sites in Santa Barbara and San Luis Obispo Counties.

Endocladia cover was quite sparse at most BOEM-funded sites, and appeared to be declining overall in many areas. By comparison, cover was generally higher at most northern California sites. This pattern did not hold at the two northernmost Oregon sites, where *Endocladia* occurs much lower in the intertidal than it does in California, and is typically not very abundant.

To view Mosaic Plots for all mainland sites surveyed by MARINe, see Appendix 5 and www.pacificrockyintertidal.org.

2.3 Significant Results

The MARINe monitoring program is the largest and longest-running project of its kind; some BOEM-funded sites have been sampled for 20 years. A significant result of the BOEM-MARINe study is the fact that these data have been instrumental in assisting in several California State analyses, including Marine Protected Areas (MPAs), Areas of Special Biological Significance (ASBS) and Natural Resource Damage Assessment (NRDA). This program has specifically been recognized by the California Water Quality Monitoring Council for allowing "state agencies and other users to obtain an increasingly detailed understanding of the extent and condition of rocky intertidal habitats, and the impacts of both natural and anthropogenic stressors on those habitats" (Jonathan Bishop and Dale Hoffman-Floerke, personal communication, February 29, 2012).

With the launch of the new web-based, report at www.pacificrockyintertidal.org, graphical displays depicting trends and patterns in the abundance of targeted species for all MARINe sites over time are easily accessible, and can be regularly updated. In addition, the website's Interactive Map and Graphing Tool allows users to select specific regions or sites to view, and design summary graphs to include specific species and/or years of interest. Long-term data from within the BOEM-funded region have been invaluable for rocky intertidal community damage assessment and resource management (see examples below) and it is our hope that this new web-based interactive tool will increase the accessibility and usability of MARINe data.

Black abalone status

One of the most important results of the MARINe long-term monitoring program is the ongoing documentation of massive declines in black abalone populations due to withering syndrome, and the nearly complete lack of recruitment to areas where populations have been decimated (Miner et al. 2006). Declines were first detected on the mainland at BOEM-funded sites in Santa Barbara County (Altstatt et al. 1996). Long-term monitoring has allowed us to document patterns in decline related to water temperature, and map the northward progression of the disease (Raimondi et al. 2002). Additional studies coupled to the MARINe monitoring surveys were carried out to determine the extent of the critical habitat for the species. These two data sets were combined to estimate the population size of black abalone and results were used to argue for the listing of the species as endangered.

Marine Protected Areas (MPAs)

MARINe long-term monitoring data were used by the State of California to aid in the design of the Marine Protected Area (MPA) network mandated by the Marine Life Protection Act. Long-Term and Biodiversity intertidal datasets were used to delineate biogeographic regions and calculate optimal sizes for intertidal MPAs. MARINe long-term data will also be used to assess the effectiveness of these newly established MPAs (California Department of Fish and Game, 2008).

Areas of Special Biological Significance (ASBS)

Data from MARINe surveys have been used to compare areas within and outside of Areas of Biological Significance (ASBS), and have been the foundation for studies that have ranged from simple assessment of potential impact to baseline characterization of whole regions (Raimondi, et al. 2011b). Study areas range from a single ASBS (e.g. Mugu Lagoon to Latigo Point ASBS) to locations on a regional scales, (e.g. Los Angeles Regional Board, etc.).

Oil Spills and Natural Resource Damage Assessment (NRDA)

A primary objective for our research is to continue the ongoing monitoring program that provides a basis for determining if change in rocky shoreline communities adjacent to producing OCS facilities can be attributed to operations or accidents from these facilities. Our goal was to develop methods that would detect effects of oiling (~20% change) on intertidal communities.

In 1997, analysis following the Torch/Platform Irene Oil Spill showed that it was possible to detect change in percent cover of barnacles and mussels as small as 8-15% using our fixed plot sampling protocol. Importantly, it was also possible to differentiate between natural changes such as the El Niño storms and the effects of the oil spill (Raimondi et. al, 1999).

During the 2007-2010 funding cycle, we had the opportunity to test our methodology in the Natural Resource Damage Assessment (NRDA) process for two oil spills: Cosco Busan and Dubai Star/San Francisco Bay. Although oiling from both of these spills was patchy in coverage (heavy in some places but moderate to light in most), we were able to use Long-Term Monitoring data to detect the effects of the oil spill and provide a basis for the determination of NRDA impact as well as calculation of the size of the impact (Raimondi et. al, 2009, 2011a).

In each of these cases, damage assessment would not have been possible without a measure of natural long-term variation both within and outside of the area impacted by the oil spill. The results of these analyses indicate that our sampling does pick up anthropogenic effects due to oil spills. Previously, our protocols had not been tested in this manner, but they are now an accepted approach for the assessment of impacts to intertidal hard surfaces (natural and man-made). This accomplishment led to a contract to modify our protocol to use in the NRDA assessment for hard surface areas affected by the Deep Water Horizon oil spill that occurred in the Gulf of Mexico in 2010. This elevates the acceptance of the MARINe Long-Term Monitoring methods to a national scale.

PART III: STUDY PRODUCTS

3.1 Website and Interactive Map

Pacific Rocky Intertidal Monitoring: Trends and Synthesis

The www.pacificrockyintertidal.org website was launched in 2011, and is a comprehensive assessment of the entire MARINe region that covers species dynamics at spatial scales from tens to thousands of kilometers and temporal scales from seasons to decades. This is the most comprehensive assessment of a marine ecosystem ever done, and will include data from nearly 200 sites ranging from Southeast Alaska to Mexico. In addition to data summary features, the website includes details about MARINe monitoring methods, site information, data interpretation, and products resulting from the research. Importantly, all information, including changes in methods and data updates, can be incorporated rapidly to ensure that all information is accurate and current. It is our hope that this web-based product becomes a useful tool for researchers and resources managers, as well as a go-to source of information for the general public about the coastal environment.

Interactive Map and Graphing Tool

The Interactive Map and Graphing Tool were designed to allow a customized display of the specific sites of interest on a map. In addition, customized plots can be created for specific site/species combinations.

When a specific site is selected, summary information is displayed underneath the map, with a link to the specific site page on www.pacificrockyintertidal.org. In addition, visitors can use the "polygon" feature to select a region of interest and then display the sites located within that region. Additional filter tools are also available on the Interactive Map to view the sites of specific interest to each user.

The Graphing Tool allows users to display graphs by survey type (Long-Term or Biodiversity), and by method (Percent Cover vs. Species Counts vs. Species Size for Long-Term; Point Contact vs. Quadrat vs. Swath data for Biodiversity). These dynamic graphs are a powerful way to view data for the specific site, survey and species of interest.

3.2 Presentations, Publications, Reports, and Sample Data Requests

Products include the following: continual enhancements to the MARINe Database; updates to the public MARINe website, (which includes current news and research); restructuring of the private website; online availability of all MARINe data on www.piscoweb.org, (including data not included in the Access Database); the update of the MARINe Handbook, including updated tables and protocol enhancements; archival of photos and specimens; conference presentations, peer reviewed papers and posters, and reports; and organization and recording of data and info requests.

Listed below are products of MARINe (including those produced using BOEM funding, using data collected at BOEM-funded sites, or presented at a BOEM-funded workshop) for the beginning of the current funding cycle. For a full listing see http://www.marine.gov/Findings/Publications.html.

Presentations (2011-2012)

Altstatt, J. 2012. Updating BOEM intertidal site maps. MARINe Annual Workshop, Santa Cruz, CA.

Ambrose, R. and T. Yap. 2012. Panorama photo evaluation. MARINe Annual Workshop, Santa Cruz, CA.

Ammann, K. and D. Lohse. 2011. Monitoring species range shifts: potential implications of global climate change. MARINe Annual Workshop, Santa Barbara, CA.

Ammann. K and L. Gilbane. 2012. Monitoring intertidal temperature. MARINe Annual Workshop, Santa Cruz, CA.

Ammann. K. 2012. Range shifts species identification. MARINe Annual Workshop, Santa Cruz, CA.

Anderson, M. 2011. Dubai Star oil spill & the mobilization of MARINe. MARINe Annual Workshop, Santa Barbara, CA.

Bell, C., K. Ammann, M. George and P. Raimondi. 2011. Assessing suitable habitat and the population size of black abalone (*Haliotis cracherodii*) for critical habitat designation. Beyond the Golden Gate Research Symposium, San Francisco, CA.

Bell, C., K. Ammann, N. Fletcher, M. George, D. Lohse, M. Miner, D. Orr, P. Raimondi and M. Redfield. 2012. Black abalone habitat surveys and the restoration of intertidal recruitment habitat on San Clemente Island – A pilot study to aid in the species recovery. The Western Section of the Wildlife Society 2012 Annual Conference. Sacramento, CA.

Blanchette, C. 2011. Drafting a Climate Change protocol. MARINe Annual Workshop, Santa Barbara, CA.

Blanchette, C. 2011. Southern California low intertidal invertebrates. MARINe Annual Workshop, Santa Barbara, CA.

Carr, M. 2012. Applications of monitoring kelp forest ecosystems. MARINe Annual Workshop, Santa Cruz, CA.

Degrassi, A. And J. Smith. 2011. Potential drivers of macroalgal preferences in southern California marine consumers. Southern California Academy of Sciences Annual Meeting, Pomona, CA.

deNesnera, K., L. Anderson, and P. Raimondi. 2012. Exploring mussel bed restoration strategies on Vandenberg Air Force Base. The Western Section of the Wildlife Society 2012 Annual Conference. Sacramento, CA.

deNesnera, K., L. Anderson, and P. Raimondi. 2012. Mussel restoration strategies. MARINe Annual Workshop, Santa Cruz, CA.

deNesnera, K.L.. and Anderson, L.M. 2011. Mussel transplantation as a strategy for restoration of injured mussel beds. Western Society of Naturalists Meeting. Vancouver, WA.

Denny, M. 2011. Worst-case scenarios: predicting extreme ecological events. MARINe Annual Workshop, Santa Barbara, CA.

Engle, J. 2011. Multi-Agency Rocky Intertidal Network status. MARINe Annual Workshop, Santa Barbara, CA.

Engle, J. 2012. Intertidal species master spreadsheet. MARINe Annual Workshop, Santa Cruz, CA.

Engle, J. 2012. Multi-Agency Rocky Intertidal Network status. MARINe Annual Workshop, Santa Cruz, CA.

Engle, J. and C. Bell. 2012. Mussel measurement protocol. MARINe Annual Workshop, Santa Cruz, CA.

Fletcher, N., M. Redfield, D. Orr, and P. Raimondi. 2011. Long-term rocky intertidal monitoring informs design of Marine Protected Areas for the North Central Coast study region. Beyond the Golden Gate Research Symposium, San Francisco, CA.

Fong, D., M. Anderson & I. Oshima. 2012. San Francisco Bay intertidal monitoring. MARINe Annual Workshop, Santa Cruz, CA.

Gaddam, R. and M. Miner. 2012. MARINe web report and data trends. MARINe Annual Workshop, Santa Cruz, CA.

Gilbane, L. 2011. Drafting a protocol for data archival. MARINe Annual Workshop, Santa Barbara, CA.

Gilbane, L. 2012. Synopsis of Workshop Science Meeting. MARINe Annual Workshop, Santa Cruz, CA.

Graham, S. 2012. San Clemente Island intertidal monitoring. MARINe Annual Workshop, Santa Cruz, CA.

Helix, M.E. 2011. Drafting Outreach articles for magazines. MARINe Annual Workshop, Santa Barbara, CA.

Helix, M.E. 2011. Overview of Multi-Agency Rocky Intertidal Network. MARINe Annual Workshop, Santa Barbara, CA.

Helix, M.E. 2012. Overview of Multi-Agency Rocky Intertidal Network. MARINe Annual Workshop, Santa Cruz, CA.

Johnston, K. 2012. Santa Monica Bay Monitoring. MARINe Annual Workshop, Santa Cruz, CA.

Kenner, M. 2012. San Nicolas Island intertidal monitoring program. MARINe Annual Workshop, Santa Cruz, CA.

Kusic-Heady, K. 2012. Patterns from biodiversity data. MARINe Annual Workshop, Santa Cruz, CA.

Lee, S. 2011. Sampling surfgrass (*Phyllospadix* spp.) transects. MARINe Annual Workshop, Santa Barbara, CA.

Lohse, D. 2012. Monitoring intertidal species vertical distributions. MARINe Annual Workshop, Santa Cruz, CA.

Lohse, D. 2012. Surveys for climate change and invasive species. MARINe Annual Workshop, Santa Cruz, CA.

Lohse, D. and C. Bell. 2012. Barnacle plot close-up photographs. MARINe Annual Workshop, Santa Cruz, CA.

Lohse, D. and K. Ammann. 2012. Monitoring intertidal species range shifts. MARINe Annual Workshop, Santa Cruz, CA.

Mazzone, S. 2012. Quinault Nation intertidal monitoring in Washington. MARINe Annual Workshop, Santa Cruz, CA.

Miller. K.A. 2012. Intertidal seaweed voucher protocol. MARINe Annual Workshop, Santa Cruz, CA.

Miner, M. 2012. Intertidal species reconnaissance protocol. MARINe Annual Workshop, Santa Cruz, CA.

Miner, M. and R. Gaddam. 2012. MARINe web report trend graphs. MARINe Annual Workshop, Santa Cruz, CA.

Murray, S., R.F. Ambrose, J. Engle, P. Raimondi and S. Weisberg. 2011. Developing indicators for monitoring the status of rocky shores. MARINe Annual Workshop, Santa Barbara, CA.

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Orr, D., C. Bell. D. Lohse, and P. Raimondi. 2011. Why long-term rocky intertidal monitoring matters? Beyond the Golden Gate Research Symposium, San Francisco, CA.

Orr, D., M. Redfield, C. Bell N. Fletcher and P. Raimondi. 2011. How rocky intertidal monitoring in the Monterey Bay National Marine Sanctuary informs Natural Resource Damage Assessments: A case study of the Cosco Busan oil spill. Monterey Bay National Marine Sanctuary Currents Symposium, Monterey, CA.

Pister, B. and T. Philippi. 2011. 20 Years of rocky intertidal monitoring at Cabrillo National Monument: analysis of long-term trends. MARINe Annual Workshop, Santa Barbara, CA.

Raimondi, P. 2011. How MARINe and Go-Kit data informed assessment of the Cosco Busan spill. MARINe Annual Workshop, Santa Barbara, CA.

Raimondi, P. 2012. Black abalone and sea otters. MARINe Annual Workshop, Santa Cruz, CA.

Raimondi, P. and C. Bell. 2012. MARINe black abalone data trends. MARINe Annual Workshop, Santa Cruz, CA.

Redfield, M. 2011. Marine Protected Areas Monitoring. MARINe Annual Workshop, Santa Barbara, CA.

Smith, J. 2012. Updating Orange County intertidal site maps. MARINe Annual Workshop, Santa Cruz, CA.

Smith, J. 2012. Water Quality Monitoring Council intertidal web portal. MARINe Annual Workshop, Santa Cruz, CA.

Smith, J., S. Vogt, K.A. Miller, S. Lee and J. Engle. 2011. Conspicuous low intertidal macrophytes. MARINe Annual Workshop, Santa Barbara, CA.

Smith, J.R., S.N. Murray, S.C. Vogt, F.N. Creedon, D.J. Eernisse and C.N. Navarro. 2011. Introduced seaweeds on urban southern California shores: effects on native community structure and trophic dynamics. Western Society of Naturalists Meeting. Vancouver, WA.

Valentich-Scott, P. 2011. Common rocky intertidal bivalves of the West Coast. MARINe Annual Workshop, Santa Barbara, CA.

VanBlaricom, G. and M. Neuman. 2012. Black abalone recovery projects. MARINe Annual Workshop, Santa Cruz, CA.

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Vogt, S. 2011. Does the introduced red alga Caulacanthus ustulatus (Gigartinales, Rhodophyta) affect upper rocky intertidal communities in southern California waters? Southern California Academy of Sciences Annual Meeting, Pomona, CA.

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Whitaker, S. and D. Richards. 2012. Intertidal visual trend graphics. MARINe Annual Workshop, Santa Cruz, CA.

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Huff, T.M. 2011. Effects of human trampling on macro- and meiofauna communities associated with intertidal algal turfs and implications for management of protected areas on rocky shores (Southern California). *Marine Ecology* 32:335-345.

Mislan, K., C. Blanchette, B. Broitman and L. Washburn. 2011. Spatial variability of emergence, splash, surge and submergence in wave-exposed rocky-shore ecosystems. *Limnology and Oceanography* 56:857-866.

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Smith, J.R., S.C. Vogt, and F.N. Creedon. 2011. Biological assessment of three rocky intertidal sites in San Diego. Report prepared for Weston Solutions, Inc. 56p.

Tierra Data, Inc. 2011. San Clemente Island rocky intertidal monitoring surveys. Naval Facilities Engineering Command Southwest, Coastal IPT (contract N68711-05-D-8004/Task Order 0058).

Westin Solutions Inc. 2011. La Jolla Shores Areas of Special Biological Significance regional compliance monitoring 2010-2011. Final Report prepared for City of San Diego. 62p.

Sample Data Requests (2011-2012)

Ocean Imaging

Project: Aerial Imagery classification and accuracy assessments
Data Request: Site coordinates and data to compare with Aerial Imagery to determine accuracy of general species classifications

**Virginia Tech Department of Geosciences*

Project: Examination of gastropod community composition related to predatory crab density (in and out of MPAs)
Data Request: Gastropod abundance and species richness data

**Yale School of Forestry & Environmental Studies – Aaron Reuben*

Project: Artificial reef creation/potential marine contamination
Data Request: Dana Point datasets

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APPENDIX

The Appendices for this report consists of pages extracted from the web report in March, 2012 (www.pacificrockyintertidal.org). For the most up to date versions of the following pages, please visit the website.

Appendix 1: Target Species

Anthopleura (Anemones)

Chthamalus/Balanus (Acorn Barnacles)

Semibalanus (Thatched Barnacle)

Tetraclita (Pink Barnacle)

Pollicipes (Goose Barnacle)

Mytilus (California Mussel)

Fucus (Northern Rockweed)

Hesperophycus (Olive Rockweed)

Pelvetiopsis (Dwarf Rockweed)

Silvetia (Golden Rockweed)

Endocladia (Turfweed)

Mastocarpus (Turkish Washcloth)

Mazzaella (Iridescent Weed)

Neorhodomela (Black Pine)

Red Algal Turf - Photo Plots

Tar

Recovery

Rock (Above Barnacles)

Egregia (Feather-Boa Kelp)

Saccharina (Sea Cabbage)

Red Algal Turf - Transects

Phyllospadix (Surfgrass)

Pisaster (Ochre Star)

Haliotis (Abalone)

Lottia gigantea (Owl Limpet)

Postelsia (Sea Palm)

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Long-Term Monitoring Target Species

CLICK HERE FOR A TARGET SPECIES REFERENCE POP-UP

Target species (also called key or indicator species) are species or species groups specifically chosen for Long-Term Monitoring Surveys. They dominate particular zones or biotic assemblages in rocky intertidal habitats. The criteria for selecting target species include the following:

- Species ecologically important in structuring intertidal communities.
- Species that are competitive dominants or major predators.
- Species that are abundant, conspicuous or large.
- Species whose presence provides numerous microhabitats for other organisms.
- Species that are slow growing and long-lived.
- Species that have interesting distributions along California coasts.
- Species found throughout California shores.
- Species characteristic of discrete intertidal heights.
- Species that are rare, unique, or found only in a particular intertidal habitat.
- Species approaching their biogeographic limits in California.
- Species that have been well studied, with extensive literature available.
- Species of special human interest.
- Species vulnerable and/or sensitive to human impacts, especially from oil spills.
- Species with special legal status.
- Introduced or invasive species.
- Species harvested by sport or commercial activities.
- Practical species for long-term monitoring.
- Readily identifiable species.
- Sessile or sedentary species of reasonable size.
- Non-cryptic species.
- Species located high enough in the intertidal to permit sufficient time to sample.

Below is a list of the species (and or areas) currently targeted by Long-Term Monitoring Surveys

Photo Plots - Biological

Anthopleura (Anemones)

Chthamalus/Balanus (Acorn Barnacles)

Semibalanus (Thatched Barnacle)

Tetraclita (Pink Barnacle)

Pollicipes (Goose Barnacle)

Mytilus (California Mussel)

Fucus (Northern Rockweed)

Hesperophycus (Olive Rockweed)

Pelvetiopsis (Dwarf Rockweed)

Silvetia (Golden Rockweed)

Endocladia (Turfweed)

Mastocarpus (Turkish Washcloth)

Mazzaella (Iridescent Weed)

Neorhodomela (Black Pine)

Red Algal Turf - Photo Plots

Photo Plots– Non-biological

Tar

Recovery

Rock (Above Barnacles)

Transects

Egregia (Feather-Boa Kelp)

Saccharina (Sea Cabbage)

Red Algal Turf - Transects

Phyllospadix (Surfgrass)

Species Counts and Sizes

Pisaster ochraceus (Ochre Star)

Species of Concern

The following species are monitored at MARINe sites, where appropriate, but access to data is restricted to help minimize collecting pressure on these vulnerable species. To login and view trend graphs for sensitive species, click here.

Haliotis (Abalone)

Lottia gigantea (Owl Limpet)

Postelsia

pacificrockyintertidal.org home

pacificrockyintertidal.org home

Anthopleura (Anemones)

Anthopleura elegantissima (Brandt 1835), *Anthopleura sola* (Pearse & Francis 2000)

Phylum Cnidaria, class Anthozoa, order Actiniaria, family Actiniidae

PREVIOUS SPECIES | GOOGLE IMAGE RESULTS | NEXT SPECIES
CLICK HERE FOR A TARGET SPECIES REFERENCE POP-UP.

Description

A. elegantissima: clonal anemone with radiating lines on oral disk, up to 8 cm across tentacular crown (generally smaller than *A. sola*). Column is greenish to white in color, often covered with shell debris. Tentacles are greenish to pinkish in color (Morris et al. 1980).

A. sola: solitary anemone with radiating lines on oral disk, up to 25 cm across tentacular crown (generally larger than *A. elegantissima*). Previously thought to be the same species as *A. elegantissima*, but now recognized as a sibling species (Pearse and Francis 2000). Small individuals located relatively close together can be confused with *A. elegantissima* and the two species have been grouped together for Long-Term Monitoring.

Habitat and Geographic Range

Anemones are abundant on rocks, in tidepools or crevices, and on pier pilings; they are characteristic of the middle intertidal zones of semi-protected rocky shores of both bays and outer coasts. *A. elegantissima* ranges from Alaska to Baja California (Morris et al. 1980) and *A. sola* from central California to Baja California.

Synonyms

Cribina xanthogrammica, C. elegantissima

Similar species

Anthopleura xanthogrammica has a solid green oral disk and a firmer column when withdrawn. It also has small, closely arranged, irregularly shaped tubercles on the column (in contrast to *A. sola,* which has prominent rounded bumps arranged in rows). *A. xanthogrammica* has a tighter oral sphincter muscle than *A. sola.*

Natural History

Previously thought to be a single species, *Anthopleura elegantissima* and *Anthopleura sola* were described as genetically, ecologically, and developmentally distinct by Pearse and Francis (2000). While the two species are similar in appearance, *A. sola* grows larger (to 25 cm) and is solitary compared to the smaller (to 8 cm) *A. elegantissima*, whose clones are typically aggregated. *Anthopleura elegantissima* is able to persist practically indefinitely and in great abundance under normal conditions because genetically-identical individuals are periodically produced by longitudinal fission (Sebens 1982). Non-clonemates are spatially separated after aggressive stinging battles. *Anthopleura sola* does not divide and can be confused with *A. xanthogrammica*, which occurs south of Point

Conception only in areas up upwelling. The three species of *Anthopleura* typically host symbiotic unicellular algae (zooxanthellae and/or zoochorellae) that can contribute to their overall energy budget (Muller-Parker and Davy 2001). The symbiotic algal type present within a given anemone depends on a number of factors, including light condition, tidal height, and temperature (Verde and McCloskey 2007). At latitudes south of 38˚N, zooxanthellae are the exclusive symbionts in *Anthopleura* species and the green color of most individuals is due to pigments produced by the animal itself, not the alga (which is golden-brown in color) (Secord and Augustine 2000). Above 38˚N, symbiotic zoochorellae increase in abundance northward, and are responsible for the “grass green” anemones found in low light conditions, such as dimly lit caves (Secord and Augustine 2000, Pearse 2007).

Both *A. sola* and *A. elegantissima* are abundant on semi-protected rocky shores. *A. sola* is common in tidepools and subtidally, and *A. elegantissima* often occurs as small densely aggregated clones in middle intertidal zones, especially sand-influenced habitats (Morris et al. 1980). Extensive carpets of these clones may occur, but often go unrecognized under low tide conditions because the anemones contract to small blobs covered with sand and shell fragments that provide protection from desiccation. Anemone mats create a moist microenvironment that allows the development of some other species, such as coralline algae and sand tube worms (*Phragmatopoma californica*) at higher intertidal levels than they would normally occur (Taylor and Littler 1982).

Anthopleura species are quite resistant to disturbances from shifting sands (Raimondi et al. 1999). They not only withstand moderate sand abrasion, but also resist shallow sand burial by extending their columns to re-expose the tentacles and oral disk. If buried deeper, they can survive for at least 3 months by metabolizing body tissue (Sebens 1980). *Anthopleura* spp. are not known to be unusually sensitive to oiling. Recovery from major disturbances may take 1-2 years or more (see Vesco & Gillard 1980).

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Chthamalus/Balanus (Acorn Barnacles)

Chthamalus fissus (Darwin 1854), Chthamalus dalli (Pilsbry 1916), *Balanus glandula* (Darwin 1854)

Phylum Arthropoda, class Maxillopoda, order Sessilia

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Description

C. fissus/dalli: small barnacle, up to 8 mm in diameter. Shell is brown-grey in color and smooth. Operculum is oval. These species are virtually indistinguishable in the field.

B. glandula: bigger barnacle than *C. fissus/dalli*, up to 22 mm in diameter. Shell is white to gray in color. Operculum is white and diamond-shaped. Plates are deeply ridged (Morris et al. 1980).

Habitat and Geographic Range

C. fissus/dalli: common on rocks, pier pilings, and hard-shelled organisms, high and upper middle intertidal zones. *C. fissus* extends from San Francisco, CA to Baja California; *C. dalli* is found from Alaska to San Diego California (Morris et al. 1980).

B. glandula: abundant on rocks, pier pilings, and hard-shelled animals within the high and middle intertidal zones of bays and the outer coast from the Aleutian Islands (Alaska) to Bahía de San Quintín (Baja California) (Morris et al. 1980).

Synonyms

Chthamalus microtretus

Similar species

Balanus crenatus typically occurs subtidally, but is occasionally present in the very low intertidal and can be distinguished from *B. glandula* by the shape and margins of the opercular plates. The exoskeleton plates are generally more smooth and fragile.

Juvenile *Semibalanus cariosus* can be distinguished by the margins of the opercular plates.

Natural History

Acorn barnacles, *Chthamalus fissus/dalli* and *Balanus glandula*, typically dominate the high intertidal zone along the western coast of North America. Acorn barnacle species can be difficult to identify in photographic monitoring, but *Balanus glandula* can be distinguished from *Chthamalus fissus/dalli* by its larger size (to 22 mm), whiter color, and diamond-shaped operculum. The configurations of their exoskeletal plates also differ. To distinguish *C. fissus* from *C. dalli* requires dissection and microscopic examination of the opercular plates. A bent morph of *Chthamalus fissus*, similar to that seen in the Gulf of California species *Chthamalus anisopoma*, has been documented at several Long-Term Monitoring sites (Miner et al. 2005).

Acorn barnacles are hermaphroditic as adults and spawn often, at variable times throughout the year (Hines 1978). The planktonic larvae can settle in incredible densities (to 70,000/m^2), forming a distinct band along the upper intertidal that contain few other invertebrates except littorines and the heartiest limpets. *Balanus* can out-compete *Chthamalus* by crowding or smothering, but *Chthamalus* can occupy higher tide levels than Balanus because it is more resistant to desiccation. Lower on the shore, acorn barnacles mix in with the *Endocladia* (Turfweed) assemblage, and are also common on mussel shells. *Chthamalus* grows rapidly, but only survives a few months to a few years. *Balanus* can live longer (to 10 years), but its larger size and lower tidal position subject it to higher levels of mortality from predatory gastropods and ochre sea stars. Acorn barnacles (particularly *Balanus glandula*) facilitate the recruitment of *Endocladia* and fucoid algae by reducing the grazing pressure of limpets (Farrell 1991). Long-Term Monitoring data have shown this facilitation at several sites, where barnacle plots have become slowly inundated by *Endocladia, Pelvetiopsis*, and *Silvetia* (Miner et al. 2005).

Acorn barnacles are highly vulnerable to smothering from oil spills because floating oil often sticks along the uppermost tidal levels. Significant, widespread barnacle impacts were reported after the 1969 Santa Barbara oil platform blow-out (Foster et al.1971) and the 1971 collision of two tankers off San Francisco (Chan 1973). However, high recruitment rates may promote relatively rapid recovery of acorn barnacles; disturbance recovery times ranging from several months to several years have been reported (see Vesco & Gillard 1980).

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Semibalanus (Thatched Barnacle)

Semibalanus cariosus (Pallas 1788)

Phylum Arthropoda, class Maxillopoda, order Sessilia, family Archaeobalanidae

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Description

Sessile barnacle with a diameter up to 60 mm comprised of 6 white wall plates that may be brownish, gray, or greenish. The wall plates are composed of vertical tube-like ribs, which, especially in the lower half, become downward-pointing fingerlike or "thatchlike" projections.

Habitat and Geographic Range

Attached to rocks, floats, or pilings along exposed shores, mid intertidal to shallow subtidal. Common in the low intertidal zone, below the densest band of *Balanus glandula* and near *Mytilus californianus*; Bering Sea to Morro Bay, Central California; Japan (Morris et al. 1980).

Synonyms

Balanus cariosus

Similar species

Tetraclita rubescens has a similar thatched appearance but it is a pinkish red color and has only 4 plates.

Natural History

Eggs of *Semibalanus cariosus* are brooded in the winter and the planktonic cyprid larvae settle in the spring (fall and winter on the open Washington coast). The larvae preferentially settle near adult barnacle shells. Lifespan is up to 15 years (Morris et al. 1980). Within the Salish Sea, *S. cariosus* prefers steep shores with strong currents and waves but on the open coast it is found in deep cracks, overhanging ledges and protected locations (Ricketts et al. 1985). In central California this species grows individually, but in the Pacific Northwest colonies can sometimes be so dense that the thatched appearance is not immediately evident. These barnacles grow very tall and narrow when densely aggregated. These dense patches of *Semibalanus* can significantly reduce survivorship and recruitment of conspecific as well as other barnacle species through direct predation of cyprids (Navarrete and Wieters 2000). When *Semibalanus* are small they may be bulldozed off the rocks by grazing limpets such as *Lottia digitalis*. The large size of adults likely protects them from major predators such as *Nucella* (whelks) and the ochre seastar, *Pisaster ochraceus*.

A disturbance study in Kachemak Bay AK, done as part of the Exxon Valdez oil spill assessment, concluded that *S. cariosus* requires more than 2.5 years to fully recover from scraping disturbance. *Semibalanus* had not recovered to control levels in cleared plots after the three year study was completed (Highsmith et al. 2001).

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Tetraclita (Pink Barnacle)

Tetraclita rubescens (Darwin 1854)

Phylum Arthropoda, class Maxillopoda, order Sessilia, family Tetraclitidae

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Description

Sessile barnacle with a diameter usually to 30 mm, rarely to 50 mm. Exoskeletal wall consists of four plates with no basal plate (all other local acorn barnacles have 6 plates). The shells of adults are pink to reddish and appear thatched, while the shells of (uneroded) juveniles are white (Morris et al. 1980).

Habitat and Geographic Range

Common in middle to low intertidal zones on rocks exposed to strong surf from Cape Mendocino, Northern Califonia to Baja California (Carlton 2007).

Synonyms

Tetraclita squamosa rubescens

Similar species

Megabalanus californicus, which is pink and has a smoother operculum and smooth area between plates. Also, the shell of young *T. rubescens* can resemble *Semibalanus cariousus,* but it has four wall plates instead of six.

Natural History

Thatched barnacles are usually found growing as solitary individuals rather than in aggregations, like acorn barnacles (Engle and Davis 1996). Thatched barnacles are brooders, and do not become reproductive until they are about 2 years old (18mm in diameter). In California, as many as 3 broods of 1,000–50,000 nauplius larvae (depending on parent size) can be released by an individual in one summer (Morris et al. 1980). *Tetraclita rubescens* may live as long as 15 years (Hines 1978). These barnacles are effective competitors for space, and may influence the distribution of mussels and other species (Foster et al. 1988). In the lower intertidal zone, individuals may grow large enough to avoid predation by sea stars and gastropods (Morris et al. 1980). Up until the 1990s the northern range limit was thought to be San Francisco; however; more recent studies have placed the northern limit several hundred kilometers farther north into Northern California (Connolly and Roughgarden 1998), possibly in response to global climate change (Dawson et al. 2010). Barnacles might be sensitive to sewage pollution (Littler and Murray 1975) and recovery from disturbance may take more than 2 years.

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Pollicipes (Goose Barnacle)

Pollicipes polymerus (Sowerby 1833)

Phylum Arthropoda, class Maxillopoda, order Pedunculata, family Pollicipedidae

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Description

A stalked barnacle that grows to 8 cm tall with more than 5 white shell plates surrounded by scales and a black, tough, fleshy peduncle roughened by inconspicuous calcareous spicules (Morris et al. 1980). The mantle (upper portion of body under plates) is typically black, but can be a brilliant red in low-light areas, such as in caves or on the undersides of rocks (J. Pearse, pers. com.).

Habitat and Geographic Range

Common species that usually grows in clusters but is also found mixed with the California Mussel, *Mytilus californianus*, *P. polymerus* inhabits the middle intertidal zone on wave-exposed, rocky shores (Morris et al. 1980) from Sitka, Alaska south to at least Punta Abreojos (Baja California) (Ricketts 1985).

Synonyms

Mitella polymerus

Similar species

Other goose barnacles such as *Lepas* are oceanic and attach to floating logs, net floats and other objects that sometimes wash ashore.

Natural History

Pollicipes polymerus feed on particles of detritus in the backwash of waves (Morris et al. 1980) and, for this reason, are found in crevices or areas that channel water back to the ocean (Kozloff 1983). *Pollicipes* are brooders, and swimming nauplii larvae are released about 30 days after fertilization (Morris et al. 1980). Young goose barnacles settle preferentially among other *Pollicipes*, forming tight clusters on exposed outcrops, ridges and walls, just above or intermixed with mussel beds. Goose barnacles are slow-growing, reaching sexual maturity at around 5 years and living up to 20 years (Morris et al. 1980). The body temperature of *P. polymerus* can be colder than expected from corresponding ambient temperatures due to evaporation from the peduncle (Morris et al. 1980). They are resistant to desiccation and can withstand all but the highest wave exposures. *Pollicipes* have been shown to be susceptible to oiling (Foster et al. 1971, Chan 1973) and recovery from disturbance may be slow. Another *Pollicipes* species (*Pollicipes pollicipes*) is collected for human consumption in European countries. Since *P. pollicipes* has been in short supply, *Pollicipes polymerus* has been exported from British Columbia to these countries (Morris et al. 1980). Populations have been reduced in accessible areas where goose barnacles are collected for food.

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Mytilus (California mussel)

Mytilus californianus (Conrad 1837)

Phylum Mollusca, class Bivalvia, order Mytiloida, family Mytilidae

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Description

Mussel shell to about 130 mm long. Shell is a bluish-black color, often with eroded white valves and darker at margins. Anterior end of shell is sharply pointed. Prominent radial ribbing but also concentric growth lines present (Morris 1980).

Habitat and Geographic Range

Abundant, often on surf-exposed rocks and pier pilings. Found mainly in upper-middle intertidal zone on outer coast and can be found subtidal and offshore to 24 m (depth). Aleutian Islands, Alaska to southern Baja, California (Morris 1980).

Synonyms

None

Similar species

Bay mussels, *Mytilus galloprovincialis and Mytilus trossulus*, can co-occur with *M. californianus* but are most common in sheltered habitats because of their weaker byssal threads (Morris et al. 1980). They have smooth valves, lacking radiating ridges, with strong, elbow-curve at umbo and are less eroded than *M. californianus*.

Natural History

The California mussel forms extensive beds, which may be multi-layered (usually in the northern part of its range). Mussels attach to hard substrate by secreting byssal threads at the base of the foot (Morris et al. 1980). Byssal thread production appears to be possible only when water flow is < 50 cm/s. Although wave action in the intertidal results in flow rates much higher than this, mussel aggregations greatly reduce water flow within the beds and make possible the production of byssal threads (Carrington et al. 2008). Thick (^{3} 20 cm) beds of California mussels trap water, sediment, and detritus that provide food and shelter for an incredible diversity of plants and animals, including cryptic forms inhabiting spaces between mussels as well as biota attached to mussel shells (Paine 1966; MacGinitie & MacGinitie 1968; Suchanek 1979; Kanter 1980, Lohse 1993). For example, MacGinitie & MacGinitie (1968) counted 625 mussels and 4,096 other invertebrates in a single 25 cm^2 clump, and Kanter (1980) identified 610 species of animals and 141 species of algae from mussel beds at the Channel Islands. Kinnetics (1992) documented locational differences in the composition and abundance of mussel bed species. Northern sites had densely packed, multi-layered beds, but the more open southern sites had higher species diversity.

The California mussel spawns all year but spawning peaks in July and December in CA. Young mussels settle preferentially into existing beds at irregular intervals, grow at variable rates depending on environmental conditions and eventually reach ages of 8 years or more (see Morris et al. 1980, Ricketts et al. 1985). *M. californianus* is a filter feeder, and is quarantined from collection/consumption from late spring to early autumn because the toxin from a dinoflagellate accumulates in the tissue (Kozloff 1983). This toxin can cause paralysis and death.

While mussels can tolerate typical rigors of intertidal life quite successfully, desiccation likely limits the upper extent of mussel beds, storms tear out various-sized mussel patches and sea stars prey especially on lower zone mussels. Beds that are already patchy or thinned by human disturbance (e.g. via trampling or collection for bait) have increased susceptibility to wave damage. Mussels have also been found to be adversely affected by oil spills (Chan 1973; Foster et al. 1971). Recovery from disturbance varies from fairly rapid (if clearings are small and surrounded by mussels that can move in) to periods greater than 10 years (if clearings are large and recruitment is necessary for recolonization) (Vesco & Gillard 1980, Kinnetics 1992).

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Fucus (Northern Rockweed)

Fucus distichus (Linnaeus)

Kingdom Chromista, phylum Ochrophyta, class Phaeophyceae, order Fucales, family Fucaceae

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Description

This olive-brown thallus can reach up to 50 cm tall and 15-25 mm wide. Individuals in protected sites are often larger than those at exposed ones. Branches are flattened and dichotomously branched with a distinct midrib. Reproductive conceptacles are concentrated at branch tips (swollen when mature).

Habitat and Geographic Range

Fucus is common in the upper mid-intertidal zone, in exposed to protected outer and inner coast locals, from Alaska to Southern California (Lamb and Hanby 2005). In the Pacific Northwest and Alaska (particularly on sheltered shorelines), *Fucus* is often the dominant species of algae, forming a broad, distinctive band in the mid-intertidal.

Synonyms

Fucus gardneri

Similar species

Can be confused with the other common rockweeds: *Hesperophycus californicus, Pelvetiopsis limitata,* and *Silvetia compressa*. In California, *Fucus* has broader fronds and larger receptacles than the other species and, unlike *H. californicus*, can have irregularly spaced white hairs along the midrib rather than paired hairs and has less ruffled fronds. Fronds of *Silvetia* and *Pelvetiopsis* lack a midrib.

Natural History

Fucus forms broad, dense canopies in the mid intertidal zone and can extend well into the high zone, with plants becoming smaller and less dense at the upper edge of its tidal range. This fucoid is tolerant of a wide range of salinities, and occurs on the outer coast, on protected inland shores, and even in areas inundated by freshwater (O'Clair and Lindstrom 2000). *Fucus* canopies are important for providing protection from desiccation to a suite of other algae and invertebrates. Some grazers inhabiting the *Fucus* understory have been shown to facilitate the persistence of the rockweed by selectively grazing other algae that compete with Fucus for space. For example, the littorine, *Littorina sitkana* aids in the succession of *Fucus* by preferentially consuming more ephemeral algae like *Ulva lactuca* and *Enteromorpha* (Lubchenco 1983).

The life history of this algal species is diplontic, with a diploid thallus and gamete formation via meiosis (Searles 1980). When mature, receptacles (swollen, yellowish bumps) on the blade tips release gametes at low tide. Eggs are fertilized with the incoming tide, and the resulting zygotes secrete adhesive and attach to the substratum (O'Clair and Lindstrom 2000). Individuals are thought to live approximately 2-3 years at exposed sites, and approximately 4-5 years in protected areas (O'Clair and Lindstrom 2000).

It has been shown that desiccation, which affects this upper-intertidal species, can weaken *Fucus* thalli and thereby increase mortality from water motion via stipe breakage (Haring et al. 2002). However, *Fucus* is able to recover rapidly from desiccation when submerged; the same study showed that it is capable of recouping enough water within in 30 seconds to be able to withstand a dynamic load which broke experimentally desiccated stipes. In addition to desiccation, this alga is highly sensitive to oil contamination as shown by the documented dramatic population collapse following the *Cosco Busan* oil spill in 2007 (Cosco Busan Oil Spill Trustees 2012). However, it appears to be even more sensitive to heat, as was demonstrated by the increased *Fucus* mortality in hot water cleaned areas versus un-treated rocks following the Exxon Valdez oil spill in 1989 (De Vogelaere and Foster 1994). Despite high initial mortality rates following the Exxon Valdez spill, *Fucus* cover increased to match levels in reference areas by 1992; however, the uniform age structure of the cohort that recruited post-spill created an unstable population that precluded full recovery for more than seven years after the spill (Driskell et al. 2001).

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Hesperophycus (Olive Rockweed)

Hesperophycus californicus (Decaisne 1864)

Kingdom Chromista, phylum Ochrophyta, class Phaeophyceae, order Fucales, family Fucaceae

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Description

This perennial thallus ranges from olive green to brown in color and 10-50 cm in height. *H. californicus* is dichotomously branched although it often appears irregularly branched due to axis breakage. Midribs are flattened in terminal thallus portions and paired white hairs along the mid-rib are present. Tips of branches swell up when reproductive, resulting in gas-filled, oval receptacles (Abbott and Hollenberg 1976).

Habitat and Geographic Range

Locally abundant to infrequent in upper intertidal, usually at higher tidal levels but sometimes mixed with *Fucus* on rocks in central California. In southern California, *Hesperophycus* characteristically occurs at tidal elevations immediately above *Silvetia,* replacing *Fucus* south of Pt. Conception. The range of this species reaches from Santa Cruz, California to Islas San Benito, Baja California (Abbott and Hollenberg 1976).

Synonyms

Previously known as *Hesperophycus harveyanus*

Similar species

Can be confused with the other common rockweeds: *Fucus gardneri, Pelvetiopsis limitata,* and *Silvetia compressa*. In California, *Fucus* has broader, less ruffled fronds and larger receptacles than the other species and, unlike *H. californicus*, can have unpaired white hairs along the midrib rather than paired. Fronds of *Silvetia* and *Pelvetiopsis* lack a midrib.

Natural History

Hesperophycus is a fairly common fucoid alga along the central coast of California, found in the upper-mid tidal regions sometimes mixed with *Silvetia* or *Fucus* (Raimondi et al. 1999). A study on Santa Cruz Island by Blanchette et al. (2000) found that *H. californicus* size is reduced by increased wave strength due to tattering; this reduction in thallus size may then increase survivorship by reducing drag without damaging the alga's staying power. *Hesperophycus* is particularly susceptible to oiling (Dawson and Foster 1982), and is believed to have declined in abundance along the southern California mainland.

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Pelvetiopsis (Dwarf Rockweed)

Pelvetiopsis limitata (Gardner 1910)

Kingdom Chromista, phylum Ochrophyta, class Phaeophyceae, order Fucales, family Fucaceae

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Description

This perennial brown alga stands between 4-8cm tall and is light tan to olive in color arising from a small discoid holdfast. The densely branched thallus is cylindrical at the base, becoming flattened to cylindrical in the upper fronds. The dichotomously divided branches tend to arch inward and lack midribs (Abbott and Hollenberg 1976).

Habitat and Geographic Range

Found on tops of rocks, rarely on sides, in the upper intertidal zone; frequents more wave-exposed sites. Range extends from Vancouver Island, British Columbia, to Cambria (San Luis Obispo County), CA (Abbott and Hollenberg 1976).

Synonyms

Pelvetia fastigiata limitata

Similar species

Can be confused with the other common rockweeds: *Fucus gardneri, Hesperophycus californicus,* and *Silvetia compressa*. *Fucus* and *Hesperophycus* generally have wider fronds with midribs, whereas *Silvetia* and *Pelvetiopsis* have narrower fronds that lack a midrib. *Silvetia* has a longer basal stipe and is typically found at lower tidal levels than *Pelvetiopsis* (Abbott and Hollenberg 1976).

Natural History

Pelvetiopsis limitata is considered a good indicator organism of exposed rocky coasts. It forms extensive zones in the high intertidal region and is fed on by limpets and other invertebrate grazers. *Pelvetiopsis* is most closely related to *Hesperophycus* (Serrão et al. 1999), with both genera producing one large egg per oogonium. Two species of *Pelvetiopsis* occur in California, *P. limitata* and *P. arborescens*. The former species more closely resembles a dwarf *Fucus*, whereas the latter is similar in appearance to a small *Silvetia* due to its more cylindrical branches (Abott and Hollenberg 1976). In central California, *Pelvetiopsis* can co-occur with *Silvetia compressa* although *Pelvetiopsis* is generally found at higher tidal elevations. When identification is in doubt, specimens can be examined microscopically to determine the number of eggs per oogonium. *Pelvetiopsis* has only one egg per oogonium while *Silvetia* has two and *Fucus* eight. Little scientific attention has been given to *Pelvetiopsis,* leaving much of its reproductive periodicity, longevity, and ecology unknown. *Pelvetiopsis* may be an indicator species of human traffic. A study on human trampling effects showed that *P. limitata* was markedly absent from the most heavily trampled sites and suggested that it may be highly susceptible to breakage especially when growing on the edges of rocks (Beauchamp and Gowing 1982). *Pelvetiopsis* also becomes detached from the substrate during winter storms which are predicted to increase in intensity and frequency due to climate change. Recruitment and survival of *Pelvetiopsis* embryos are higher under the canopy of adults especially in higher tidal elevations (Skene 2009). Predicted effects of climate change and the resulting sea level rises on this high zone species include increased rates of adult mortality and limited ability to shift its distribution to higher elevations (Skene 2009).

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Silvetia (Golden Rockweed)

Silvetia compressa (J.Agardh, E.Serrão, T.O.Cho, S.M.Boo & Brawley, 1999), *Silvetia compressa deliquescens* (P.C.Silva, 2004)

Kingdom Chromista, phylum Ochrophyta, class Phaeophyceae, order Fucales, family Fucaceae

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Description

Silvetia compressa: The typical mainland form is an olive green or yellowish brown plant about 30 cm long (up to 90 cm long), composed of thick, narrow, dichotomous fronds that often appear irregularly branched because of axis breakage. A finer-branched, lighter-colored form is more typical of the Channel Islands (Abbott and Hollenberg 1976; Silva et al. 2004).

Silvetia compressa deliquescens: Thalli slender relative to *S. compressa*, with more branches (Abbott and Hollenberg 1976).

Habitat and Geographic Range

Silvetia compressa: Locally abundant in the midtidal zone, forming beds on rocks somewhat protected from open surf. Ranges from Horswell Channel, British Columbia to Punta Baja, Baja California (Abbott and Hollenberg 1976).

Silvetia compressa deliquescens: Found in Pebble Beach (Monterey Co.) and Channel Islands, where it is abundant and replaces *S. compressa* (Abbott and Hollenberg 1976).

Synonyms

S. compressa previously known as *Pelvetia fastigiata* and *Pelvetia compressa*

Silvetia compressa deliquescens previously known as *Pelvetia fastigiata* f. *gracilis*

Similar species

Can be confused with the other common rockweeds: *Hesperophycus californicus, Pelvetiopsis limitata,* and *Fucus gardneri. Fucus* and *Hesperophycus* generally have wider fronds with midribs, whereas *Silvetia* and *Pelvetiopsis* have narrower fronds that lack a midrib. *Pelvetiopsis* develops tiny pits (cryptostomata) with white hairs but these are inconspicuous (Abbott and Hollenberg 1976). Silvetia generally occurs lower than *Pelvetiopsis.*

Natural History

Silvetia is a dominant perennial alga that allows algae and many animals to live higher up on the shore by creating a moist microhabitat (Hill 1980, Gunnill 1983, Sapper and Murray 2003). Like other rockweeds, reproductive structures are produced in swollen branch termini called receptacles. Unlike *Fucus* and *Hesperophycus*, these are rarely inflated with gases. Gametangia occur in pits (conceptacles) that dot the surface of fertile receptacles. Gametes are released during receding tides and dispersal is very limited (Johnson and Brawley 1998). In spite of being a tough and long-lived species, *Silvetia* is slow-growing, experiences irregular recruitment and has low survivorship (Gunnill 1980). *Silvetia* is susceptible to trampling (Denis and Murray 2001) and oiling because of its midtidal height and recovery from disturbance is believed to be long (Hill 1980, Vesco and Gillard 1980). A recent study has shown that *Silvetia* can be transplanted and reestablished for restorative purposes (Whitaker et al. 2010).

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Endocladia (Turfweed)

Endocladia muricata (J. Agardh 1841)

Kingdom Plantae, phylum Rhodophyta, class Florideophyceae, order Gigartinales

Description

Thalli are densely bushy, dark red to blackish brown tufts, 4-8 cm tall. Branches are cylindrical throughout, covered with small conical spines (Abbott and Hollenberg 1976)

Habitat and Geographic Range

Locally abundant on tops or vertical faces of rocks or epiphytic on other organisms (e.g. mussels and barnacles) in the high to mid-intertidal zones. Alaska to Punto Santo Tomas, Baja California, including Channel Islands (Abbott and Hollenberg 1976).

Synonyms

Previously known as *Gigartina muricata*

Similar species

Gelidium pusillum and *Caulacanthus ustulatus. G. pusillum* lacks spines on its branches and has more spatulate tips. *C. ustulatus* is redder, finer, and not as rough to the touch.

Natural History

Endocladia is common north of Point Conception and one of the most common algae in central California, forming distinctive dark bands along the upper shoreline. *Endocladia* abundance fades in warmer waters to the south, being largely replaced in lower portions of its zone by other small red algae (e.g. *Gelidium* spp.) *Endocladia* often grows with other small reds (e.g. *Mastocarpus papillatus*, *Gelidium* spp.) to form a low, tight turf that traps sediment and moisture, and provides a sheltered microhabitat for a host of small organisms. Glynn (1965) found over 90 species associated with *Endocladia* clumps in Monterey. *Endocladia* has been shown to facilitate recruitment of *Silvetia compressa*, possibly by providing propagules protection from dislodgement, grazing, and/or desiccation (Johnson and Brawley 1998). Turfweed also can provide habitat for attachment of young mussels. Expanding mussel patches may displace *Endocladia*, but it can then grow on the mussel shells, creating a layered assemblage. Some *Endocladia* clumps appear donut- or crescent-shaped; this condition may be caused by storms tearing out center areas possibly weakened by accumulated anoxic sediment.

Endocladia is hardy and quite resistant to desiccation, yet vulnerable to oiling from spills due to its location in the high intertidal. Recovery from natural or human disturbances may vary from 1 to more than 6 years (see Kinnetics 1992).

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Mastocarpus (Turkish Washcloth)

Mastocarpus complex (C.Agardh 1821)

Kingdom Plantae, phylum Rhodophyta, class Florideophyceae, order Gigartinales

Description

The *Mastocarpus* complex targeted by MARINe includes morphologies previously identified as *Mastocarpus papillatus* (Lindstrom et al 2011). Morphology within the complex can be highly variable. Each thallus stands less than15 cm tall, with flattened dark to brownish red blades that are thin yet tough. Blades vary in width, are covered thickly or sparsely with papillae of various sizes, are ribbed along the margin, and have tips which are usually divided dichotomously. Male plants lack papillae and are light rose to greenish or yellowish in color (Abbott and Hollenberg 1976, Kozloff 2000).

Habitat and Geographic Range

Common in the high to mid-intertidal zones, this alga complex often dominates these zones in central and northern California and but is less abundant south of Santa Barbara. Range extends from Alaska to Pta. Baja, Baja California (Abbott and Hollenberg 1976).

Synonyms

Gigartina papillata

Similar species

Members of another species complex, formerly identified as *Mastocarpus jardinii,* can be confused with members of the *M. papillatus* complex. *Mazzaella affinis* is similar in color and shape to male *M. papillatus*, but is usually shorter and grows in dense continuous mats rather than as discrete individuals. All *Mastocarpus* species and another red alga, *Pikea* have crustose phases in their life histories, making field-identification of the crusts to species level difficult. *Hildenbrandia* and *Ralfisa* are other dark crusts but these are thinner than “Petrocelis” (the crustose phase of the *M. papillatus* complex).

Natural History

There is great variability in the growth forms of the *Mastocarpus papillatus* complex. Individuals vary in the size and density of papillae present, amount of branching, and thallus thickness. Surprisingly, Carrington (1990) found that the amount of drag force that an individual was subjected to in high flow environments did not correlate strongly with morphology, including thallus diameter (the area where breakage most commonly occurs). However, Kitzes and Denny (2005) did find a positive relationship between both thallus cross-sectional area and material strength with increasing wave force, indicating a selective force or adaptive ability of individuals living in high wave energy environments.

Mastocarpus exhibits two distinct life cycles: a sexual alternation of generations involving three separate stages, and an asexual direct life cycle that produces only female fronds. The distribution of sexual and asexual populations varies both with latitude, and tidal height within a given site, a pattern of spatial separation called geographic parthenogenesis (Fierst et al.2010). In sexual populations, the upright thallus is the haploid, gametophytic stage, with separate male (typically greenish or yellowish) and female (typically dark red) blades. Males release spermatia, which fertilize ova retained by females. The fertilized diploid zygotes remain attached to the female blades, and are visible as bumps (carposporophytes), on the surface. Carposporophytes release diploid carpospores, which settle and grow into diploid tetrasporophytes, smooth, dark black-red to olive brown crusts typically 2-2.5 mm thick. These crusts were once thought to be a separate species, called “Petrocelis”. “Petrocelis” produces tetraspores via meiosis, which are released and settle to grow into the haploid male or female blades.

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Mazzaella (Iridescent Weed)

Mazzaella splendens, Mazzaella flaccida (Setchell & Gardner 1937)

Division Rhodophyta, class Rhodophyceae, order Gigartinales

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Description

Mazzaella flaccida has rubbery blades 20-30 (140) cm long, 8-20 cm wide that are elongate to heart-shaped and iridescent yellow-green with purple or brown near base of blade. Thallus has a short stipe (<2 cm long) and a perennial discoid holdfast (Abbott and Hollenberg 1976).

Mazzaella splendens blades range from 20-40 cm (2m) long and 12-24 (40) cm wide. Blades are typically heart-shaped, rubbery, and violet to blackish in color, with a blue, iridescent sheen when wet. This alga has a perennial, fleshy holdfast out of which a 3-6 cm stipe grows (Abbott and Hollenberg 1976).

Habitat and Geographic Range

Mazzaella flaccida is abundant in the mid to low intertidal zones. It also grows on mid-shore rocks (saxicolous) and the upper limit is close to mid-tide level (~+1 m). It is the most conspicuous blade-like alga in Central CA.

Mazzaella splendens is a common saxicolous alga found from the low intertidal to subtidal (7m) on exposed coasts. The two subspecies of *M. splendens* have a combined range that extends from southeast Alaska to Punta Baja, Baja California (Hughey and Hommersand 2010).

Synonyms

Mazzaella flaccida: Iridea flaccida

Mazzaella splendens: Iridea cordata var.cordata, Iridea cordata var. splendens

Similar species

M. flaccida and *M. splendens* are most similar to one another (see above descriptions) and can be virtually indistinguishable in the field. *M. splendens* has a slightly longer stipe and occurs lower on the shore. *M. flaccida* has a shorter stipe and is iridescent yellowish-green with purple or brown only on basal portion of blade (Abbott and Hollenberg 1976). For Long-Term Monitoring purposes *M. flaccida and M. splendens* are combined into the

Mazzaella category.

Natural History

The similarities in thalus shape and color of the many species of *Mazzaella* have resulted in numerous taxonomic reorganizations within the group with 24 currently recognized species.Within this complex group, the *splendens* clade currently includes four species (*Mazzaella flaccida, Mazzaella linearis, Mazzaella sanguinea* and *Mazzaella splendens*) with recent molecular and morphological work identifying six clades and two subspecies within this taxonomically challenged clade (Hughey and Hommersand 2010).

M. flaccida and *M. splendens* are red algae with separate male and female thalli and three different life history phases. Within each species, individuals of all phases are isomorphic (the same size and shape) despite differences in tissue ploidy (i.e. 1N gametophyte versus 2N tetrasporophyte). For both *M. flaccida* and *M. splendens*, individuals of different phases can be differentiated visually when reproductive—the male gametophyte thallus will be smooth, the 1N female gametophyte thallus will have large, rough bumps, and the tetrasporophyte thallus will have many, closely-packed small bumps (Thornber et al. 2006)—or via chemical analysis when non-reproductive by looking at the carrageenan content (McCandless et al. 1975). In a field study by Thornber et al. (2004) they found *M. flaccida* and *M. splendens* gametophytes to be more abundant in the field than the sporophytes, resulting in part from a more fecund sporophyte generation which creates the gametophytes. However, while *M. splendens* adhered closely to the predicted ratio of ~60% haploid: 40% diploid, *M. flaccida* exhibited a dramatically higher proportion of gametophytes. This is possibly due to the fact that per capita mortality rates for *M. flaccida* were 11% greater for haploids than diploids (Thornber 2004). Relative abundances of the different *M. flaccida* tissue ploidy's (1N gametophyte versus 2N tetrasporophyte) in the field have also been shown to be impacted by herbivory seeing as herbivores, e.g. the snail *Tegula funebralis*, have shown preferences for gametophyte over sporophyte, as well as reproductive over non-reproductive, tissue (Thornber 2006).

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Neorhodomela (Black Pine)

Neorhodomela larix (Turner 1819)

Kingdom Plantae, phylum Rhodophyta, class Florideophyceae, order Ceramiales

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Description

This red alga forms brownish-black turfs with thalli that fall mostly between 10-20 (maximum 30) cm. Thalli consist of several to many erect axes which whorl around a common base, like a bottle brush. The short, wiry branches and branchletts are blunt and mostly uniform in length (Abbott and Hollenberg 1976).

Habitat and Geographic Range

An abundant species in wave restricted areas on rocks, primarily on sand-swept reefs. *Neorhodomela larix* ranges from the North Alaska to Baja California, Mexico (Lamb and Hanby 2005). Rare south of Government Pt. (Santa Barbara Co.).

Synonyms

Rhodomela larix

Similar species

Odonthalia floccosa have loose bushy tufts of branches with sharp tips compared to the tighter tufts with blunt tips of *N. larix*. *O.washingotniensis* has branches distinctly and markedly flattened resembling a flattened "primitive" Christmas tree. *Neorhodomela oregona* is quite similar in appearance to *N. larix*, but it is not quite as coarse and stiff, it has more orders of branching, and its branchlets are not so obviously bunched (O'Clair and Lindstrom 2000).

Natural History

N. larix is a tough perennial alga with annual thalli that either get beaten back or torn loose by winter storms, leaving behind small tufts or encrusting holdfasts (Abbott and Hollenberg 1976, D'Antonio 1985). When a thallus is broken off, rather than pulled up from the base, the remaining attached portion may persist throughout the following spring and summer (D'Antonio 1982). It is thought that individual axes may live 1 to 3 years while the boundaries of *N. larix* clumps may be maintained for >25 years (D'Antonio 1985). A study of turf-forming algal communities in the low intertidal region of the Oregon coast described *Neorhodomela larix* as one of the most abundant, wave-sheltered red algal species (Menge et al. 1993). *Neorhodomela larix* has an isomorphic life cycle; gametophytes look identical to tetrasporophytes (O'Clair and Lindstrom 2000). Spore release can occur at all times during the year except during winter, but Menge et al. (1993) documented low recruitment, suggesting that the high abundance of this alga depends on vegetative growth and long persistence. *N. larix* is a host for at least 17 species of sessile plants and animals on the central coast in Oregon (D'Antonio 1985). D'Antonio (1985) suggests that epiphytes decrease the growth rate of *N. larix*, increase the probability of axis breakage, and decrease reproductive output while providing food for littorine snails and gammarid amphipods that live in the beds of this alga.

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Red Algal Turf - Photo Plots

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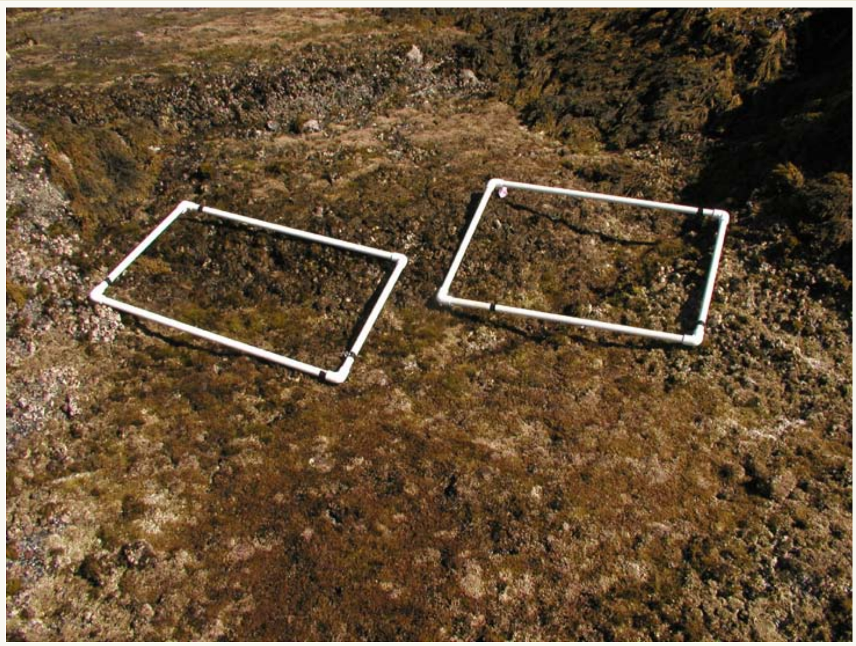

Some photoplots at Southern California monitoring locations target single or mixed species of turfy filamentous red algae (other than *Endocladia muricata*), primarily *Gelidium* spp and *Chondracanthus canaliculatus*. These species or species groups were chosen because they were especially prominent at certain sites, representing unique tidal zones. Such turfs can form low thickets that support communities of tiny invertebrates that are highly productive and important as food for larger organisms such as fishes and shore birds (see also Red Algal Turf - Transects).

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Tar - Photo Plots

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Petroleum tar is a non-biological feature targeted in some photoplots. For monitoring purposes, tar includes fresh or weathered oil or thicker tar coating the substrate. Both natural and anthropogenic in origin, floating oil and tar from seeps, leaks, and spills can wash ashore and stick to intertidal rocks. The Santa Barbara region in particular is rich with oil field deposits, with coastal tar seeps utilized historically by Native Americans to caulk their boats. Gas and oil/tar have been documented seeping from beneath shallow coastal waters such as off Coal Oil Point and from other deeper-water locations in the region. As a result, some shoreline areas along the islands and mainland can have locally dense tar cover in the upper intertidal, especially where wave action is slow to erode it. These areas may signify nearby seeps, or be a reflection of local conditions (e.g., currents, winds, swells and topography such as coves) that foster the accumulation of floating debris.

Tar was selected as a target feature to evaluate the longevity of tar patches, the frequency of fresh depositing, and its biological effects. Tar may smother barnacles, limpets, and other creatures; coat seaweeds (reducing their ability to utilize sunlight); and interfere with settlement and grazing by intertidal life. Seasonal and long-term interactions can be elucidated by monitoring both tar and marine species abundance trends.

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Recovery Plots

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At two MARINe sites, we have been provided with the opportunity to study the natural recovery of an intertidal community following extreme disturbance events. In 1997/98, powerful surf caused by a strong El Niño event removed huge sections of reef (up to 17m x 5m) at Stairs, a Central California region site. This massive disturbance event left several large, newly exposed areas of bare rock, within which we established “Recovery” plots to document community succession in the mid-intertidal region. Nearly all succession studies are done in artificially cleared patches which, because they are usually small relative to the size of the reef, often recover via encroachment by surrounding species. Because the newly exposed areas at Stairs were so large, they were likely to recover via colonization by propagules and thus had the potential to develop into communities quite different from surrounding, undisturbed areas. Eight recovery plots were originally set-up, but four have been lost over time due to additional large-wave events that have removed more sections of reef.

Two recovery plots were also established in 2003 at Sandhill Bluff, another Central California site, where an area of mussel bed (3m x 2m) was cleared when a section of rock exfoliated. Monitoring recovery from natural disturbance events helps us to better understand patterns of community change in the rocky intertidal.

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Rock Plots

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One of the most conspicuous patterns observed in this long term monitoring program is a trend toward zonal transitions among species assemblages. At sites distributed across the latitudinal breadth of the MARINe monitoring network, species assemblages have exhibited periodic, upward shifts in the intertidal. For example, *Silvetia* assemblages have encroached upon the *Endocladia* plots, and *Endocladia* has moved into barnacle plots. These upward shifts appear to be cyclic, with zonal transitions reversing after some time period and assemblages returning to their "original" state. However, with sea-level rise and other climate-change related factors, it is possible that these short-term cyclic zonal shifts could instead become long-term directional change. At most MARINe sites, the area above the barnacles consists primarily of bare rock, but we have not been specifically targeting the "extreme high" zone for change, and thus would be unable to document an upward shift of the barnacle zone.

To address this issue, "Rock Plots" have been recently added at a number of MARINe sites in the Southern California region and on the Channel Islands. These plots will aid in documenting any upward shifts of communities into the extreme high zone, and could potentially serve as an early warning sign of rising sea level or other effects of climate change.

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Egregia (Feather-Boa Kelp)

Egregia menziesii (Turner 1808)

Kingdom Chromista, Phylum Ochrophyta, Class Phaeophyceae, Order Laminariales

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Description

Thick, flattened, and strap-like axes (each referred to as a rachis), with numerous small, lateral blades (can be flat, broad, narrow, filiform to cylindrical) and floats along the margin. Thallus arises from a dense, hapterous holdfast which can become fleshy and cone-like in large plants (Abbott and Hollenberg 1976). Thallus morphology approximately correlated with geographic distribution: northern populations (Alaska to Cape Mendicino) have tuberculate rachi, smooth sporophylls, and narrow, thick spatulate laterals (Blanchette et al. 2002); populations from Los Angeles to Baja California have smooth rachi, wrinkled sporophylls, and both broad, spatulate and narrow, filiform laterals; populations located in between have mixed and variable morphologies; southern California thalli initially produce spatulate laterals but then begin producing filiform laterals as they grow (Henkel 2003).

Habitat and Geographic Range

Common on lower intertidal rocks, in protected to moderately wave-exposed areas from mid- to subtidal (20m), *E. menziesii* is often found mixed with *Macrocystis* at the inner edges of kelp beds as well as growing in mixed stands with *Phyllospadix* spp. This species inhabits a geographic range from Alaska to Punta Eugenia, Baja California (Abbott and Hollenberg 1976).

Synonyms

Includes entities previously assigned *Egregia laevigata*

Similar species

Juvenile *Eisenia arborea* is corrugated on the blade surface, whereas *Egregia* is smooth (southern) or uncorrugated and tuberculate (northern).

Natural History

Egregia is one of the most conspicuous algae in the intertidal zone. It provides shelter for many species of understory algae and invertebrates (Humphrey 1965). *Notoacmea insessa* is a limpet only found on *Egregia*, where it grazes on the rachis, producing oval scars or pits. This grazing activity can result in axis breakage and cause mortality in the kelp

(Black 1974). *Egregia* is sensitive to desiccation and heat stress on the lowest midday tides (Engle and Davis 1996). High mortality has been associated with warm water events, such as during the 1982/83 El Niño period (Gunhill 1985). Poor water quality might also affect *Egregia,* as it was noticeably absent near a sewage outfall (Littler and Murray 1975). If recruitment is successful, recovery of *Egregia* populations can occur in as little as five months to 2 years due to fast growth rates (Murray and Littler 1979, Vesco and Gillard 1980).

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Saccharina (Sea Cabbage)

Saccharina sessile (C. Agardh 1824)

Kingdom Chromista, phylum Ochrophyta, class Phaeophyceae, order Laminariales, Family Laminariaceae

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Description

This brown kelp has no stipe as an adult, with an often well-developed holdfast. The blades vary between bright and dark brown and can grow to 150 cm in length and 80 cm wide, more commonly 30-50 cm long. There is much variation in morphology among individuals from a broad, ruffled or bullate blade to a smooth and deeply divided blade (Abbott and Hollenberg 1976).

Habitat and Geographic Range

Saccharina sessile is dominant in the lower intertidal from AK to OR, especially areas of low to moderate wave exposure (Graham et al. 2000) Found on rocks in the mid to low-intertidal zones in sheltered bays to open coasts from Aleutian Islands, AK to Monterey, CA. Rare in California (Armstrong 1984, Abbott and Hollenberg 1976).

Synonyms

Hedophyllum sessile

Similar species

None

Natural History

Saccharina sessile blade morphology differs between exposed and sheltered areas. In protected locations the blades are broad, ruffled and generally longer (30-50 cm), which, according to Armstrong (1989), is an adaptation to life in low flow areas which increases water flow across the thallus for nutrient absorption and gas exchange. In exposed areas the blades are smooth and deeply divided, rarely more than 30 cm tall, allowing for a more compact shape at high current speeds (Armstrong 1989), although thallus size, not morphology appears to be the most important factor in reducing drag (Milligan & DeWreede 2004). Individuals at wave exposed sites have also been shown to have stiffer and stronger tissues and larger mean breaking strains than those found at more sheltered locations (Armstrong 1982).

Saccharina becomes fertile in the late fall and winter with maximum sporophyte growth during the summer (O'Clair and Lindstrom 2000). As with other kelps, *Saccharina* has a microscopic gametophyte stage that produces gametes that fuse and form microscopic sporophytes that eventually grow into the visible macrophytes. These microscopic stages are found primarily near adult macrophytes, and may be able to persist until environmental conditions are favorable for reproduction or growth (Fox and Swanson 2007). *Saccharina* is a poor competitor with other algae, and thrives in the presence of grazers, which generally prefer other algae, thus freeing up space for the kelp (O'Clair and Sandstrom 2000). *Saccharina* provides canopy cover for many low intertidal species, including the chiton *Katharina tunicata*. Unlike most other grazers, *Katharina* will eat *Saccharina*, and chews on and burrows into the holdfasts of young plants. This action degrades holdfast integrity and makes these smaller individuals susceptible to wave-induced mortality (Markel and DeWreede 1998).

Saccharina may be sensitive to warming oceanic water temperatures; Lüning and Neushul (1978) found that female gametophyte fertility peaked at 12˚ C and dropped to 0% at 17˚ C in samples from central CA and individuals of this species from Friday Harbor, WA and Vancouver Is, British Columbia demonstrated positive net photosynthesis only in the -1.5 ˚ C - 15 ˚ C water temperature range (Lüning and Freshwater 1988). Climate change coupled with anthropogenic eutrophication may also indirectly impact *Saccharina* productivity through increased phytoplankton blooms. A study by Kavanaough et al. (2010) showed that *S. sessile* is negatively affected by shading that mimics phytoplankton-induced light limitation. The results link light limitation with strongly decreased growth rates and abundances of *S. sessile* and conclude that in open coast systems, where perennial macrophytes such as kelp and surf grasses are important habitat modifiers, large-scale reduction of macrophytes via phytoplankton shading could lead to profound modifications of coastal ecosystem dynamics.

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Red Algal Turf - Transects

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Red algal turf is a mixed species assemblage of low-growing (<7 cm high) algae that carpets the middle intertidal zones of coastal reefs, particularly in southern California. Species composition within the turf community varies geographically. In San Diego County this turf can contain as many as 67 types of small red, brown, and green algae; however, red algae predominate - in particular calcium carbonate containing articulated coralline algae of the genus *Corallina*. (Stewart & Myers 1980; Stewart 1982; Stewart 1989a,b).

Red turf is best developed on relatively flat reefs where the algal mat forms a meshwork that traps sand and shell particles. By cementing firmly to the rock, the perennial calcareous algae form a low, but highly structured thicket that supports diverse epiphytic plants and infaunal animals. These smaller, inconspicuous organisms are of high ecological importance due to their abundance, high productivity, and importance as prey for larger organisms like shore birds (Brown and Taylor 1999). The sea anemone, *Anthopleura*, is the most conspicuous invertebrate within the turf assemblage. Turf may also enhance recruitment of mussels by providing attachment surfaces and a relatively sheltered micro-environment. Typically, the algal turf zone is located just above the surf grass zone, because turf is better able to withstand desiccation (Stewart 1989a). The *Corallina* species dominating the turf can bleach and die-back during daytime exposures to dry air, or filaments may be broken off by storm waves, but erect portions grow back from the crusts that persist after such disturbances (Stewart 1989b). They also are highly resistant to sand abrasion and burial which commonly occurs on low-sloping reefs. *Corallina* crusts can survive more than a year under sand; once re-exposed, they regain pink color and start growing erect portions within two weeks (Stewart 1989b).

Red algal turf was chosen for long-term monitoring at San Diego County sites because it is widespread in the middle intertidal zone; may bleach or die in response to oil, municipal wastes, or other pollutants (Foster et al. 1988); and typically occurs on flat reefs where most tidepool visitors walk during mid and low tide periods. Trampling can "wear down" the turf, break crusty *Corallina* filaments, and crush tiny invertebrate inhabitants. Huff (2011) conducted experimental trampling studies in San Diego, finding that bare space increased in trampled plots, and that trampled plots exhibited shifts in invertebrate species composition as well as significant declines in marine life richness and abundance.

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Phyllospadix (Surfgrass)

Phyllospadix scouleri, Phyllospadix torreyi (W.J. Hooker 1838)

Kingdom Plantae, phylum Tracheophyta, class Monocots, order Alismatales, family Cymodoceaceae

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Description

Surfgrass is an angiosperm with true leaves, stems, and rootstocks; not an alga.

P. scouleri leaf blades are characteristically flat and wide (2-4 mm) reaching no longer than 3 feet in length. Leaves arise from a congested rhizotomous base and flowers are found near the base on short stalks (1-6 cm).

P. torreyi leaves are characteristically less than 2 mm wide and are generally more firm, cylindrical, and wiry than *P. scouleri*. Leaf blades can reach up to 10ft long. The leaves arise from a congested rhizotomous base with flowers on elongate stalks (>10 cm long). (Adams 2006).

Habitat and Geographic Range

P. scouleri can be found at or below zero tide level or in mid-low tide pools from Sitka, Alaska, to Baja California (O'Clair and Lindstrom 2000). Mostly found on rocks without sand inundation. (Kozloff 1996).

P. torreyi can be found at or below zero tide level or in mid-low tide pools from Southern Vancouver Island California to Baja California (Wyllie- Echeverria and Ackerman 2003). *P. torreyi* is more likely to be found in sand-scoured areas than is *P. scouleri* (Kozloff 1996).

Synonyms

None

Similar species

Zostera marina has broader leaves and occurs in more wave-protected locations. *Phyllospadix serrulatus* has serrated margins that can be felt by stroking the leaf margin and occurs from Cape Arago, Oregon north to Alaska

Natural History

Surf grasses grow as perennials and adult plants are reproductively dioecious with male and female flowers on different adult plants. Surf grasses can pollinate both underwater and at the surface in sea water. Surfgrass ranks amongst the most productive of the marine primary producers (Duarte and Chiscano 1999), with these habitats providing shelter for many invertebrates and supporting many species of algae (Stewart and Myers 1980). The red algae *Smithora naiadum* and *Melobesia mediocris* are exclusively epiphytic on sea grasses (Abbott and Hollenberg 1976). Surfgrass also provides nursery habitat for fishes and invertebrates, some of which are commercially important, such as the California spiny lobster (Engle 1979).

Surfgrass beds increase water clarity by filtering water and trapping sediments and can stabilize the sediment, preventing erosion. Seagrass metabolism changes the concentration of carbon and oxygen in water by sequestering carbon dioxide and respiring oxygen. Surfgrass forests can modify the severity of water currents, making near shore habitats relatively protected from big surf. The structure of surfgrass canopies modifies water current velocity and waves, enhancing sedimentation of suspended particles and preventing sediment resuspension (Garcia and Duarte 2001).

Phyllospadix is susceptible to desiccation and heat stress during low midday tides (Raimondi et al. 1999). It is also sensitive to sewage (Littler and Murray 1975) and oiling (Foster et al. 1988). If the rhizome systems remain viable, recovery following disturbance can be fairly rapid; however, if the entire bed is lost recovery is slow because recruitment is sporadic and restoration projects have thus far been unsuccessful (Turner 1983, 1985). Other threats to surfgrasses include coastal development, thermal pollution (power plants), invasion of non-natives (e.g. *Caulerpa taxifolia*), and dislodgement caused by anchors. The sensitivity of seagrass habitats to declines in ecosystem health coupled with their fundamental role in sheltering countless other species (many of which have commercial value) has led to their protection at the United States federal level under Section 404 of the Clean Water Act as well as in Section 10 of the Rivers and Harbors Act. The Environmental Protection Agency holds the responsibility of enforcing these pieces of legislation which aim to protect these habitats from unpermitted dredging and filling activities (Green 2003).

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Pisaster (Ochre Star)

Pisaster ochraceus (Brandt 1835)

Phylum Echinodermata, class Asteroidea, order Forcipulatida

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Description

Highly variable in color; most commonly purple, but can also be orange, orange-ochre, yellow, reddish, or shades of brown. A "brilliant purple" morph is common in the inland waters of Washington and British Columbia. Average arm radius in CA/OR is around 9 cm (Harley et al. 2006, Raimondi et al. 2012) but can reach 3x this size. Individuals usually have 5 arms but this can vary from 4 to 7. Aboral surfaces have many small white spines arranged in detached groups or in a reticulate pattern, generally forming a star-shaped design on central part of disk (Morris et al. 1980). Tube feet on the undersides of arms have suckers that allow them to remain attached to rock in high wave energy shores.

Habitat and Geographic Range

Common in the middle to low intertidal zones on wave-swept rocky shores. Also found subtidally on rocks to 90 m. Juveniles are cryptic and are often found in crevices, under rocks and within mussel beds. Prince William Sound (Alaska) to Baja California, Mexico (Lamb & Hanby 2005)

Synonyms

None

Similar species

Pisaster giganteus has fewer, bigger, and longer aboral spines surrounded by blue rings than *P. ochraceus* and these spines are more uniformly spaced and never form a star-shaped pattern. *Pisaster brevispinus* is pink with small, white spines and is a low intertidal to subtidal species (Morris et al. 1980). *Evasterias troschelii* has longer, more slender arms than *P. ochraceus*, and spines on the central part of the disk do not form a star-shaped pattern.

Natural History

Pisaster ochraceus sea stars have long been referred to as keystone species in the rocky intertidal (Paine 1966, Menge 2004) and, while they are known to have a wide diet (including barnacles, snails, limpets, and chitons), mussels are their primary prey items on the open coast (Morris et al. 1980, Harley et al 2006). In the protected inland waters of Washington and British Columbia, mussels are often rare and *Pisaster* feeds primarily on barnacles and whelks (Harley et al. 2006). Using their tube feet to pull the valves apart, *Pisaster* are able to evert their stomachs and insert them between the valves of a mussel (Morris et al. 1980). Interactions between ochre stars and their prey have been well researched, especially the role of *P.ochraceus* in determining the lower limit of northern mussel beds (Paine 1966, 1974; Dayton 1971). Motile prey have been shown to exhibit escape responses to the chemical presence of *Pisaster* (Morris et al. 1980). A study examining the effect of low tide body temperature of *P. ochracheus* on feeding rates showed that aerial body temperatures experienced by *P. ochraceus* can have profound effects on predation rates (Pincebourde et al. 2008).

Ochre sea stars stand out in the intertidal due to their vibrantly contrasting color differences, ranging from bright orange to purple. Data from long term monitoring has shown a consistent color frequency of approximately 20% orange stars across a large geographic range of exposed coast (Raimondi et al. 2007). The underlying cause of color polymorphism in *P. ochraceus* is not fully understood, but it has been suggested that diet may play a key role (Harley et al. 2006).

Pisaster ochraceus is a broadcast spawner, with fertilization occurring in the water and development resulting in a free-swimming, feeding larva (Morris et al. 1980). These sea stars are able to regenerate arms that are lost and are thought to live up to 20 years (Morris et al. 1980). Ochre stars have few predators, but seagulls and sea otters occasionally eat them, and they are often collected by curious tidepool visitors due to their striking colors. Throughout southern California, severe declines of *P. ochraceus* (and other seastar) populations have been documented in association with warm-water periods since 1978, with greatest losses during El Niño events such as occurred in 1982-1984 and 1997-1998 (Eckert et al. 2000). The causative agent for this seastar "wasting disease" has not been confirmed, but may be a *Vibrio* bacterium (Eckert et al. 2000). Population recovery, apparently due to cooler-water conditions and large recruitment events, has been documented in many, but not all areas (Blanchette et al. 2006, Raimondi et al. 2012). *P. ochraceus* wasting disease has recently been recorded as far north as British Columbia, also associated with high water temperatures (Bates et al. 2009). Sensitivity to oil spills is not well known, but Chan (1973) saw no obvious effects from a San Francisco oil spill.

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Haliotis (Black Abalone)

Haliotis cracherodii (Leach 1814)

Phylum Mollusca, class Gastropoda, order Archaeogastropoda

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Description

Shell exterior is dark blue, dark green, or black, smooth and usually epiphyte-free; up to 20cm in length. There are usually five to nine open respiratory pores sitting flush with the shell's surface. Shell interior is pearly, with pink and green iridescence. The mantle and tentacles are black (Morris et al. 1980).

Habitat and Geographic Range

Black abalone inhabit suitable rocky substrate from the high intertidal zone to 6 m depth but are most abundant in the mid-low intertidal. Their current range is from about Point Arena in northern California to Southern Baja California (MARINe). Black abalone are rare north of San Francisco and south of Punta Eugenia, Baja with unconfirmed sightings reported as far north as Coos Bay, Oregon (Cox 1962, Morris et al 1980).

Synonyms

Similar species

A smooth dark shell and 5-9 round, flat shell holes distinguishes black from other abalone species. *H. rufescens*, which sometimes occurs intertidally, has a reddish to pink colored shell, commonly overgrown, and 3-4 open shell holes which are externally raised.

Natural History

Black abalone are typically found clustered in crevices, under boulders, or on the walls of surge channels along exposed shores. Little is known about the requirements of newly settled black abalone, but they are believed to inhabit cryptic locations such as narrow crevices, undersides of boulders, and the interstices of mussel beds (Tissot 1995, Dan Richards pers. com.). Juveniles appear to be fairly motile, and likely graze on crustose coralline algae and micro flora, such as diatom films (Garland et al. 1985, Shepherd and Turner 1985); adults tend to be more sessile, feeding primarily on drift algae, especially brown kelps (Bergen, 1971, Blecha et al.,1992, Leighton and Boolootian1963, Morris et al. 1980). Growth varies with size, location, and other environmental factors, but does appear to be slow—about 20mm in the first year, and 10-20mm per year over the next several years, then slowing at sizes of approximately 100mm (Leighton and Boolootian1963, Morris et al. 1980). Black abalone become reproductively mature at around 45mm (between 3-7 years old) (Ault 1985). Absolute longevity has not been determined, but ages greater than 30 years appear likely based on tagging and other population studies (e.g. VanBlaricom 1993). Before recent catastrophic declines (see below), black abalone were very abundant and could occasionally be seen stacked on top of each other, reaching densities of more than 100/m² (Douros 1987, Richards and Davis 1993).

Black abalone are broadcast spawners, and fecundity (number of gametes produced) is directly related to adult size, with older, larger individuals producing significantly higher numbers of gametes than newly mature, smaller animals. Because gametes are released into the turbulent intertidal environment, close proximity of male and female abalone is assumed to be necessary for successful fertilization to occur (Prince et al. 1987, Miller & Lawrenz-Miller 1993). The requirements of black abalone larvae are not well known, but based on studies of other abalone species, it is thought that they spend 3-10 days in the water column before settling (e.g. McShane 1992). Larvae are thought to be relatively passive, and recruitment is believed to be generally localized, particularly in areas with offshore features such as kelp beds, which have been shown to retain larvae of other abalone species (McShane et al. 1988, Prince et al. 1988, Hamm & Burton 2000, Chambers et al. 2006). Other abalone species require the presence of crustose coralline algae to induce settlement (Morse et al 1979), and it is assumed (although not verified) that black abalone share this requirement.

Although once an important human resource, the black abalone fishery was closed in 1993 due to massive population declines. Intense fishing may have been responsible for declines in southern California, but the primary cause of decline throughout much of the black abalone's range is a fatal disease called withering syndrome (WS). WS is caused by a gastrointestinal Rickettsiales-like prokaryote that interferes with digestion and results in the shrinking of an animal's foot and eventual weakening so it can no longer attach to the substratum (Friedman et al. 2000). Declines were first documented on the Channel Islands in 1985 and subsequently spread to the mainland in 1992 (Lafferty & Kuris 1993, Richards & Davis 1993, Altstatt et al. 1996, Raimondi et al. 2002). Now a federally listed endangered species, *H. cracherodii's* decline continues to spread north, with little to no signs of recovery at impacted sites. WS tends to move rapidly during El Niño events, when ocean temperatures are warm; hence cooler water sites to the north may only be temporarily protected (Raimondi et al. 2002). The general pattern of mortality once die-offs begin is that the population decreases by > 95%, leaving a few scattered individuals. This scarcity of survivors is a serious threat to black abalone recovery, because individuals are often too distant from one another for successful fertilization to occur (see reproduction above). We have seen virtually no recruitment of new individuals to mainland sites that have been impacted by WS, and, only recently, minimal recruitment to island sites. Ironically, successful recruitment into areas impacted by mass mortality events may be dependent on the presence of healthy, conspecific adults. These large, long-lived grazers may maintain suitable conditions for recruitment of conspecifics by preventing colonization of other organisms by pre-empting space on the substratum and dislodging newly settled larvae or algal spores through their movements and grazing (Cox 1962, Leighton & Boolootian 1963, Blecha et al. 1992, Richards & Davis 1993, Miner et al 2006). Our work suggests that following mass mortality events, communities that formerly supported large numbers of abalone change from open areas dominated by crustose coralline algae and bare rock to habitat encrusted with increased cover of sessile invertebrates and fleshy algae (Miner et al. 2006).

In addition to WS, other sources of mortality include: smothering by sand burial, dislodgment by storm waves, and predation by octopus, sea stars, fishes, and sea otters (Morris et al. 1980; VanBlaricom 1993). Oil impacts are not well known, but black abalone mortality was documented following an oil spill in Baja California (North et al. 1965). In response to the mass mortalities along the coast of California, black abalone are now protected under the USA Endangered Species Act. An Abalone Recovery Management Plan was adopted by the state of California in 2005. In October 2011, the National Marine Fisheries Service designated critical habitat for black abalone. Various projects are in place to monitor the species' status, better understand WS, increase knowledge about the requirements for successful reproduction and recruitment, protect and restore (where appropriate) black abalone habitat, and minimize illegal harvest.

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Lottia gigantea (Owl Limpet)

Lottia gigantea (Sowerby 1834)

Phylum Mollusca, class Gastropoda, order Patellogastropoda

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Description

Shell length can be 100mm (Lindberg 1981) or greater (Raimondi et al. 2012). Shell is oval with a low profile and anterior apex. Exterior surface is chocolate brown with white markings (can have checker board pattern) and often rough and eroded. The interior is dark with a brown margin and prominent owl-shaped markings within bluish muscle scar. Side of foot is gray and sole is orange or yellow (Morris et al. 1980). When on mussel beds apex is more centered and resembles *Lotia pelta* (i.e., smooth).

Habitat and Geographic Range

Common on cliff faces and rocks on wave-exposed shores in the high and middle intertidal zone. Washington to Baja California (Morris et al. 1980). Scarce north of San Francisco.

Synonyms

Similar species

Distinguished from other *Lottia* spp. by large size, low height and anterior apex.

Natural History

Lottia gigantea can either be territorial, maintaining and defending clearings of thick algal film, or non-territorial, intruding on other limpets' algal farms to graze (Stimson 1969. Shanks 2002). *L. gigantea* are protandrous hermaphrodites, with a transformation from male to female generally occurring in association with increased size, and the acquisition of a territory (Wright 1989). Thus non-territorial individuals tend to be the smaller males, while larger individuals are typically females with farms (Lindberg and Wright 1985). *L. gigantea* maintain territories on rocks by grazing or bulldozing other competitors for rock space (Stimpson 1970). This action creates space and promotes the algal growth upon which they graze (Stimson 1973). Territorial owl limpets, which can occupy the same farms for at least 4 years, have been shown to graze at much lower rates than non-territorial owl limpets, who must acquire food rapidly from another limpet's farm before they are bulldozed off (Shanks 2002). Algal farms vary in appearance with *L. gigantea* size and structural features of the substrate, creating a patchwork of differing microhabitats. Lindberg et al. (1998) have shown that if *L. gigantea* are removed from an area, cover of erect, fleshy algae increases, followed by increases in the number of small limpets, thus changes in *L. gigantea* populations may greatly affect abundances of other species (Kido and Murray 2003). *L. gigantea* tend to occupy one or more characteristic "home scars" within their territories. Here the shell margin conforms to the rock surface, making a tight seal to hold moisture during low tide. The owl limpet can be found at the edge of mussel beds or under rock faces to prevent desiccation or decrease wave exposure (Raimondi et al. 1999). The largest limpets are estimated at 10–15 years old and are believed to breed in the fall and early winter in California (Morris et al. 1980).

Although limpets and their feeding territories may be vulnerable to oiling, oil impacts are unclear. Owl limpets were not obviously affected by the 1971 San Francisco oil spill (Chan 1973), but recovery from any major disturbance likely would be lengthy (Raimondi et al. 1999). Commercial harvesting of *L. gigantea* is illegal throughout California, but recreational take of up to 35 individuals per day is allowed outside areas designated as marine reserves. Harvesters typically collect large, likely female individuals, which may skew the gender ratio of *L. gigantea* populations and decrease reproduction (Kido and Murray 2003). Illegal take is among the biggest threats to owl limpet populations, and assessment of long-term monitoring of *L. gigantea* shows that the amount of enforcement against poaching is a better predictor of size structure than proximity to population centers or visitation to intertidal sites (Engle et al. 2006).

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Postelsia (Sea palm)

Postelsia palmaeformis (Ruprecht 1852)

Kingdom Chromista, phylum Ochrophyta, class Phaeophyceae, order Laminariales, Family Laminariaceae

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Description

Resembles a small palm tree, up to 60 cm tall with a thick, flexible, cylindrical stipe and small hapterous holdfast. Plants can have as many as 100+ grooved blades that reach 25 cm long and hang down when plants are exposed at low tide. Mature plants turn from green to golden brown. Usually found growing in extensive stands (Abbott and Hollenberg 1976).

Habitat and Geographic Range

Found in mid-intertidal zone in areas of high wave exposure; distribution patchy, but typically abundant where present. Vancover I., Br. Columbia, to San Luis Obispo Co., Calif. (Abbott and Hollenberg 1976).

Synonyms

None

Similar species

None

Natural History

This annual brown alga exhibits heteromorphic alternation of generations, with two distinct phenotypic phases: the macroscopic diploid (2N) sporophyte and the microscopic haploid gametophyte (1N) (Blanchette 1996). *Postelsia* sporophytes generally first appear in winter, grow rapidly in spring, become reproductive in late spring/early summer and are typically ripped out by large winter storms (Blanchette 1996). Spores are released during low tide and remain in grooves of blades, dripping off the slender tips onto the surrounding substrate, which results in very limited dispersal (Abbott and Hollenberg 1976). These spores grow into haploid gametophytes, which release gametes that fuse and grow into the visible sporophytes.

Postelsia appears to have a complex relationship with the mussel, *Mytilus californianus*. The microscopic female and male gametophytes establish themselves within mussel beds, which may be ideal for germination and protection from wave exposure. When mussels are cleared from the rocks by harsh waves or predation, the diploid sporophytes resulting from gamete release can begin to grow (Blanchette 1996). Without a disturbance to open up space within the mussel beds, the juvenile *Postelsia* sporophytes would be excluded by the competitively dominant mussels (Paine 1988). *Postelsia* can recruit to areas other than gaps in mussel beds (e.g. on mussels, barnacled, turf algae), but populations are more stable and densities are highest within these bare patches (Paine 1988). Range of this alga is limited by physical (light/dessication) and biological (competition with mussels) factors (Nielsen et al. 2006).

Edible seaweed harvesting has been a cottage industry since the late 1970s, which has historically included the collection of *Postelsia*. However, the sea palm is now a protected species and illegal to harvest in British Columbia, Washington and Oregon. In California, recreational harvesting is illegal, but commercial harvesting remains legal. Between 2000 and 2001, it is estimated that between 2 and 3 tons of *Postelsia* were harvested in California. The blades are eaten raw or are dried, and dried blades sell for up to US$45 per pound. Commercial harvesters of *Postelsia* must purchase a US$100 license, pay a royalty to the State of California (US$24 per wet ton of algae harvested), and submit a monthly harvest log (Miller 2002). Common practice is to clip blades above the meristem which allows for regeneration of new blades. However, removing blades can limit a sporophyte's ability to produce spores and contribute to subsequent populations. Recovery from harvesting depends greatly on the season of collection, suggesting that additional regulation of the timing of harvest could help to protect *Postelsia* from overharvesting (Thompson et al. 2007).

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Appendix 2: Site Descriptions

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Point Sierra Nevada

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Point Sierra Nevada is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. When the site was established in 1995, it was accessible only by crossing private property (Hearst Corporation), and received very little visitation (occasional trespassers). Then in 2005 the land was transferred to CA State Parks (now part of Hearst San Simeon State Park) and human visitation, particularly by fishermen, increased substantially. The site is fairly remote, which affords it protection from large numbers of visitors, but fishermen are now seen nearly every time the site is sampled. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Sierra Nevada is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and pebble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Point Sierra Nevada were established in 1995, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Hesperophycus* (Olive Rockweed), *Silvetia* (Golden Rockweed), *Mastocarpus* (Turkish Washcloth), *Mazzaella* (Iridescent Weed), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001, 2003, and 2004. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 20 meters (seaward), and 15 meters (along shore) x 20 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Point Sierra Nevada, please contact Pete Raimondi.

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Piedras Blancas

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Piedras Blancas is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Piedras Blancas State Marine Reserve. The property adjacent to Piedras Blancas is an old lighthouse station and public access to the area is restricted. The land is managed by the Bureau of Land Management, and docent-led public tours are occasionally done, but access to the intertidal has been limited to researchers. The area to the south is an important elephant seal rookery, and an offshore island is heavily used by shorebirds and pinnepeds, so localized nutrient levels are likely quite high. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Piedras Blancas is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Piedras Blancas were established in 1997 (with expanded monitoring implemented in 2007 as part of the MLPA), and are done by University of California Santa Cruz. Surveys at this site are not done on a regular basis. Long-Term MARINe surveys target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Mastocarpus* (Turkish Washcloth), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2008. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Piedras Blancas, please contact Pete Raimondi.

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Cambria/Rancho Marino

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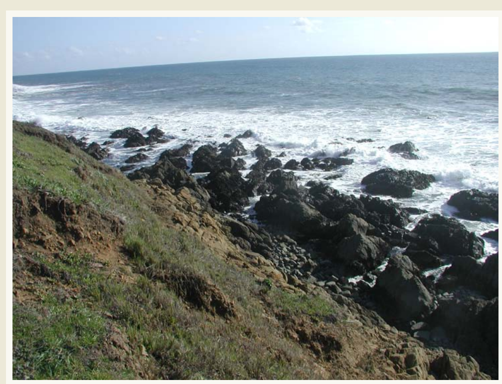
Cambria/Rancho Marino is located in the Central Coast region of California, in the Kenneth S. Norris Rancho Marino Reserve (part of the University of California Research Reserve Network). The site is located within the White Rock (Cambria) State Marine Conservation Area. Access to the site is restricted due to its location on the UC Reserve. This moderately sloping site consists of consolidated bedrock benches and large boulders separated by surge channels.

Cambria/Rancho Marino is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Cambria/Rancho Marino were established in 2001, and are done by University of California Santa Cruz. Water temperature is monitored at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2005. The Biodiversity Survey grid encompasses one section that is approximately 29.6 meters (along shore) x 33 meters (seaward). Click here to view Biodiversity Survey findings at this site.



For more information about Cambria/Rancho Marino, please contact Pete Raimondi.

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Cayucos

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Cayucos is located in the Central Coast region of California. Prior to 1998, the coastal land adjacent to the site was privately owned, although public use of the property was common. The property was then purchased by the state, and in 2002, the area was converted to CA State Park land (Estero Bluffs State Park), further opening up access to the general public. This site is near the Morro Bay/Virg's Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cayucos is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, and boulder fields. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Cayucos were established in 1995, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Hesperophycus* (Olive Rockweed), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2008. The Biodiversity Survey grid encompasses two sections that are approximately 9 meters (along shore) x 25 meters (seaward), and 18 meters (along shore) x 25 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Cayucos, please contact Pete Raimondi.

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Hazards

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Hazards is located in the Central Coast region of California, within Montaña de Oro State Park. This site is near the Morro Bay/Virg's Mussel Watch site. Visitation by tidepoolers and surfers at this park is fairly high. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Hazards is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is northwest.

Long-Term Monitoring Surveys at Hazards were established in 1995, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), *Mazzaella* (Iridescent Weed), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2005. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 50 meters (seaward), and 14.5 meters (along shore) x 50 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Hazards, please contact Pete Raimondi.

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Shell Beach

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Shell Beach is located in the Central Coast region of California. This site is near the San Luis Obispo Bay/Point San Luis Mussel Watch site. The site is located within a developed stretch of coastline, with stairs leading to the beach downcoast of the site, and human use is fairly high. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Shell Beach is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Shell Beach were established in 1995, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), *Mastocarpus* (Turkish Washcloth), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2006. The Biodiversity Survey grid encompasses two sections that are approximately 9 meters (along shore) x 33 meters (seaward), and 18 meters (along shore) x 33 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Shell Beach, please contact Pete Raimondi.

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Occulto

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Occulto is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). The site's location on VAFB largely restricts human use, although the reef is used by military personnel for fishing. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds, which are separated by large sandy surge channels.

Occulto is dominated by consolidated bedrock, which is bordered upcoast and downcoast by sandy beaches. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Occulto were established in 1992, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), Mytilus (California Mussel), *Endocladia* (Turfweed), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

For more information about Occulto, please contact Pete Raimondi.

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Purisima

Purisima is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). Purisima is accessed via a trail through sand dunes and along a beach and this remote location on VAFB severely limits human visitation. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Purisima is on a long, rocky point dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, cobble and sandy beach.

Long-Term Monitoring Surveys at Purisima were established in 1993, and are done by University of California Santa Cruz. Water temperature is monitored at this site.

For more information about Purisima, please contact Pete Raimondi.

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Stairs

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Stairs is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). This site is located within the Vandenberg State Marine Reserve. The site's location on VAFB largely restricts human use, although the reef is occasionally used by military personnel for fishing. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Stairs is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Stairs were established in 1992, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species and/or areas: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), Recovery, *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001, 2003, and 2004. The Biodiversity Survey grid encompasses two sections that are approximately 9 meters (along shore) x 50 meters (seaward), and 18 meters (along shore) x 50 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Stairs, please contact Pete Raimondi.

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Boathouse

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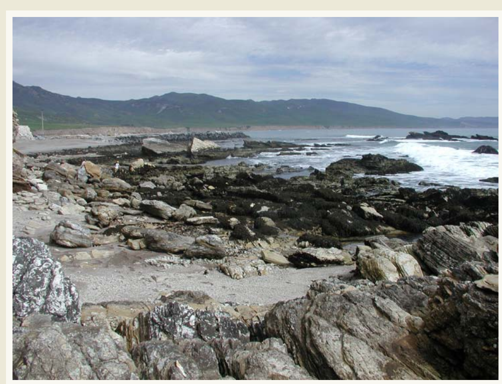
Boathouse is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). Boat House's location on VAFB limits human visitation, but it is a popular destination for military personnel, and the area is used by surfers, scuba divers and fishermen. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Boathouse is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Boathouse were established in 1992, and are done by University of California Santa Cruz. Long-Term MARINe surveys currently target the following species: *Anthopleura* (Anemones), *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2007. The Biodiversity Survey grid encompasses two sections that are approximately 21 meters (along shore) x 20 meters (seaward), and 6 meters (along shore) x 10 meters (seaward). Click here to view Biodiversity Survey findings at this site.



For more information about Boathouse, please contact Pete Raimondi.

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California South

CA South sites

The Southern California region begins at Point Conception (Government Point), an important biogeographical transition area for rocky intertidal organisms, and extends to the Mexican border. Much of the region occurs within the Southern California Bight, where the coast turns sharply inward to the east and receives protection from prevailing northwesterly winds and swells by the Channel Islands offshore. This results in relatively benign oceanographic conditions most of the time, though periodic southern storms can have a devastating impact on south facing stretches of the coast. A large gyre that exists within the bight creates sea surface temperatures that are warmer, on average, than coastal sections to the north and (to a certain extent) to the south.

Sandy habitats comprise a much greater proportion (approximately 75%) of the shoreline in southern California than they do in central and northern California. Many of the monitoring sites are located on isolated rocky habitats that are flanked by wide stretches of beach, and experience frequent periods of burial and scour. This, along with abundant sunshine and the predominance of warmer coastal air temperatures, creates harsh conditions for species that are intolerant to desiccation. Thus, rocky intertidal communities are largely devoid of larger foliose algae such as the fleshy reds that are so common to the north. These are replaced by abundant turf forming species such as corallines and filamentous red algae, and sun-tolerant rockweeds.

Much of the Southern California coastline is heavily urbanized and subject to multiple anthropogenic influences, including storm water run-off, harvesting, and trampling. At monitoring sites that are closer to urban centers, the direct influence of people on the rocky intertidal community is substantial. The region includes six State Marine Reserves, in which all fishing is prohibited, and eighteen State Marine Conservation Areas, in which limited commercial or recreational take is allowed (eight of these are no-take, except in special situations).

The threat of an oil spill from offshore tanker ships and onshore pipelines, production platforms, and terminal operations is high, though no major spills have occurred within the region for many years. Natural oil seeps are prominent features, especially at Point Conception (Government Point), Coal Oil Point, and Carpinteria.

The southern California coast has been well-studied, with numerous universities supporting marine-focused programs located within the region. Previous monitoring studies include surveys at 7 mainland locations done in the 1970’s by the U.S. Bureau of Land Management (now BOEM) for the Southern California Bight Baseline Study and long-term surveys (since 1975) at 4 sites along the Palos Verdes Peninsula. Kanter and Straughan characterized mussel bed communities at several sites within the region in the 1970’s. Dawson examined seaweed abundances and diversity at numerous sites in the 1950’s and 1960’s, with some locations resampled by Thom and Widdowson in the 1970’s. MARINe Long-Term Monitoring Surveys have been done in this region since 1990, and Biodiversity Surveys were first done in 2001, with precursor “1-time surveys” conducted at 9 sites in the 1990’s. Baseline monitoring for newly established Marine Protected Areas will begin in 2012.

The Pacific Rocky Intertidal Monitoring sites located within the Southern California region are listed below (arranged north to south):

Government Point

Alegria

Arroyo Hondo

Coal Oil Point

Carpinteria

Mussel Shoals

Old Stairs

Sequit Point

Lechuza Point

Paradise Cove

Abalone Cove

White Point

Point Fermin

Buck Gully South

Crystal Cove

Shaws Cove

Heisler Park

Treasure Island

Dana Point

Cardiff Reef

Scripps

La Jolla Caves

Navy North

Navy South

Cabrillo 1

Cabrillo 2

Cabrillo 3

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Government Point

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Government Point is located in the South Coast region of California, within the Point Conception State Marine Reserve. This site is approximately 1.5 km downcoast from Point Conception, an important biogeographical barrier, and is near the Point Conception Mussel Watch site.

Government Point is arguably one of the most important sites monitored by the MARINe group because it is located at the junction of two major biogeographic provinces (cold-temperate Oregonian and warm-temperate Californian), where the ranges of many marine species begin or end. Thus, it gives us the unique opportunity to study species that might be living at their maximum tolerance level to certain environmental stressors, such as temperature or wave exposure. Monitoring community change in the marine environment at this unique location provides important insight to understanding the impacts of global climate change.

Government Point is accessed via private property, and there is almost no human visitation. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Government Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. Some unique features of the site include deep water directly offshore and numerous natural hydrocarbon seeps in the surrounding offshore benthos. Naturally occuring tar is common at this site, particularly in the high zone. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Government Point were established in 1992, and are done by University of California Santa Cruz. Surveys have not been done since 2006, when ownership of the land adjacent to the site changed hands. Long-Term MARINe surveys target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Pollicipes* (Goose Barnacle), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2006. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 25 meters (seaward), and 15 meters (along shore) x 25 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Government Point, please contact Pete Raimondi.

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Alegria

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Alegria is located in the South Coast region of California. This site is located in Hollister Ranch, which requires special access approval to visit and sample. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Alegria is dominated by a mixture of consolidated sandstone and mudstone bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Alegria were established in 1992, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species and/or areas: *Anthopleura* (Anemones), *Chthamalus/Balanus* (Acorn Barnacles), *Pollicipes* (Goose Barnacle), *Mytilus* (California Mussel), Rock (Above Barnacles), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001, 2003, and 2004. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Alegria, please contact Rich Ambrose.

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Arroyo Hondo

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Arroyo Hondo is located in the South Coast region of California. This site is 0.2 miles west of the Arroyo Hondo Canyon Mouth Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Arroyo Hondo is dominated by a mixture of consolidated sandstone and mudstone bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Arroyo Hondo were established in 1992, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species and/or areas: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), Rock (Above Barnacles), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2005. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Arroyo Hondo, please contact Rich Ambrose.

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Coal Oil Point

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Coal Oil Point is located in the South Coast region of California, in the Coal Oil Point UC reserve. The site is located within the Campus Point State Marine Conservation Area, and is near the Santa Barbara Point Mussel Watch site. This gently sloping site consists of relatively flat terrain.

Coal Oil Point is dominated by a mixture of consolidated sandstone and mudstone bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. Sand innundation of the plots (sometimes 100% cover in the *Anthopleura* plots) is common at this site. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Coal Oil Point were established in 1992, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species: *Anthopleura* (Anemones), *Mytilus* (California Mussel), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2002 and 2006. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Coal Oil Point, please contact Rich Ambrose.

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Carpinteria

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Carpinteria is located in the South Coast region of California, on Carpinteria State Beach, and is near the Carpinteria State Beach Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Carpinteria is dominated by a mixture of consolidated sandstone and mudstone bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Carpinteria were established in 1992, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species and/or areas: *Anthopleura* (Anemones), *Chthamalus/Balanus* (Acorn Barnacles), *Pollicipes* (Goose Barnacle), *Mytilus* (California Mussel), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001. The Biodiversity Survey grid encompasses one section that is approximately 27 meters (along shore) x 50 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Carpinteria, please contact Rich Ambrose.

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Mussel Shoals

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Mussel Shoals is located in the South Coast region of California. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Mussel Shoals is dominated by a mixture of consolidated sandstone bedrock, riprap, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of boulder fields and sandy beach at this site. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Mussel Shoals were established in 1994, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species and/or areas: *Anthopleura* (Anemones), *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), Rock (Above Barnacles), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Mussel Shoals, please contact Rich Ambrose.

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Old Stairs

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Old Stairs is located in the South Coast region of California. This site is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS). This site is near the Point Mugu Old Stairs Mussel Watch site. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Old Stairs is dominated by a mixture of consolidated sandstone bedrock, riprap, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of boulder fields and sandy beach at this site. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Old Stairs were established in 1994, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species and/or areas: *Anthopleura* (Anemones), *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Endocladia* (Turfweed), Rock (Above Barnacles), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001. The Biodiversity Survey grid encompasses two sections that are approximately 6 meters (along shore) x 20 meters (seaward), and 21 meters (along shore) x 20 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Old Stairs, please contact Rich Ambrose.

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Paradise Cove

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Paradise Cove is located in the South Coast region of California. The site is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS), within the Point Dume State Marine Conservation Area. There is at least one storm water discharge in the vicinity of this site, and this site is 1.2 miles northeast of the Point Dume Mussel Watch site. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Paradise Cove is dominated by a mixture of consolidated sandstone bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southeast.

Long-Term Monitoring Surveys at Paradise Cove were established in 1994, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Endocladia* (Turfweed), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001, 2006, and 2010. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 10 meters (seaward), and 15 meters (along shore) x 10 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Paradise Cove, please contact Rich Ambrose.

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White Point

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White Point is located in the South Coast region of California, and is 0.2 miles southeast of the Palos Verdes Royal Palms Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

White Point is dominated by a mixture of consolidated basalt bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at White Point were established in 1994, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Endocladia* (Turfweed), and *Pisaster* (Ochre Star). In addition, motile invertebrates, barnacle recruitment, and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2008. The Biodiversity Survey grid encompasses two sections that are approximately 6 meters (along shore) x 25 meters (seaward), and 21 meters (along shore) x 25 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about White Point, please contact Rich Ambrose.

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Point Fermin

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Point Fermin is located in the South Coast region of California. This site is near the San Pedro Fishing Pier Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Fermin is dominated by a mixture of consolidated sandstone and basalt bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southeast.

Long-Term Monitoring Surveys at Point Fermin were established in 1999, and are done by University of California Los Angeles. Long-Term MARINe surveys currently target the following species and/or areas: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), Rock (Above Barnacle), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates and mussel size structure are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001. The Biodiversity Survey grid encompasses two sections that are approximately 18 meters (along shore) x 50 meters (seaward), and 9 meters (along shore) x 50 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Point Fermin, please contact Rich Ambrose.

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Crystal Cove

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Crystal Cove is located in the South Coast region of California, in Crystal Cove State Park. The site is located in an Area of Special Biological Significance (Irvine Coast Marine Life Refuge ASBS) within the Crystal Cove State Marine Conservation Area, and is near the Crystal Cove State Beach Mussel Watch site. This site is one of many rocky reefs located on the Crystal Cove State Park grounds, which receives a high number of visitors, including tidepoolers. Reef Point, where the site is located, has a flattened and angled bench separated by crevices resulting from uplifted bedding planes.

Crystal Cove is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. Sand levels in the splash and upper intertidal zone vary greatly within a year, sometimes covering the upper limits of barnacles. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Crystal Cove were established in 1996, and are conducted by California State University Fullerton. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Phyllospadix* (Surfgrass), and *Pisaster* (Ochre Star). In addition, motile invertebrates, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001, 2003, and 2004. The Biodiversity survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Crystal Cove, please contact Jayson Smith and Jennifer Burnaford.

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Shaws Cove

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Shaws Cove is located in the South Coast region of California, within the Laguna Beach State Marine Reserve. This site is popular for fishing, diving, recreational visitors, and educational field trips resulting in multiple anthropogenic disturbances. Docent educators are frequently on site. The site is characterized by flattened and gently sloping bedrock benches separated by crevices and channels.

Shaws Cove is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Shaws Cove were established in 1996, and are conducted by California State University Fullerton. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), *Endocladia* (Turfweed), *and* Pisaster (Ochre Star). In addition, motile invertebrates, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

Biodiversity Surveys were done by University of California Santa Cruz in 2001 and 2005. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Shaws Cove, please contact Jayson Smith and Jennifer Burnaford.

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Treasure Island

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Treasure Island is located in the South Coast region of California, within the Laguna Beach State Marine Conservation Area. This site is located just below a luxury resort and is heavily impacted by high levels of human visitors. Docent educators are frequently on site. The site is a gently sloping bedrock bench separated by large pools and channels.

Treasure Island is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. Sand levels in the splash and upper intertidal zones vary greatly throughout the year. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Treasure Island were established in 1996, and are conducted by California State University Fullerton. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), and *Pisaster* (Ochre Star). In addition, motile invertebrates, mussel size structure, and water temperature are monitored at this site. Click here to view Long-Term trends at this site.

For more information about Treasure Island, please contact Jayson Smith and Jennifer Burnaford.

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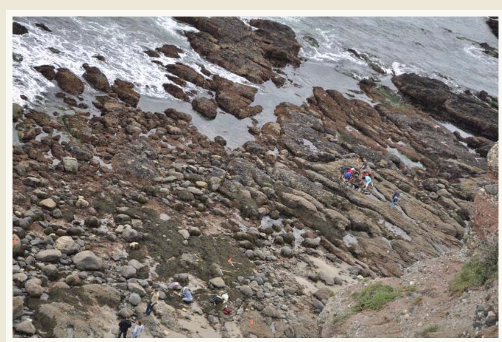
Dana Point

CLICK HERE FOR LONG-TERM TRENDS
CLICK HERE FOR BIODIVERSITY SURVEY FINDINGS

Dana Point is located in the South Coast region of California, within the Dana Point State Marine Conservation Area, and is near the Dana Point Mussel Watch site. The Ocean Institute is located at the entrance of the long reef and provides educational materials to the numerous schools that visit this site, some that make the hike to the monitoring location at the end of the reef. The site is located at the upcoast portion of this reef and is characterized by granitic boulders mixed with flattened benches.

Dana Point is dominated by a mixture of consolidated bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Dana Point were established in 1996, and are conducted by California State University Fullerton. Long-Term MARINe surveys currently target the following species: *Chthamalus/Balanus* (Acorn Barnacles), *Mytilus* (California Mussel), *Silvetia* (Golden Rockweed), and *Pisaster* (Ochre Star). In addition, motile invertebrates, mussel size structure, ans water temperature are monitored at this site. Click here to view Long-Term trends at this site.



Biodiversity Surveys were done by University of California Santa Cruz in 2001, 2006, and 2010. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 25 meters (seaward). Click here to view Biodiversity Survey findings at this site.

For more information about Dana Point, please contact Jayson Smith and Jennifer Burnaford.

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Appendix 3: Summary of Trends

Point Sierra Nevada

Piedras Blancas

Cayucos

Hazards

Shell Beach

Occulto

Stairs

Boathouse

Government Point

Alegria

Arroyo Hondo

Coal Oil Point

Carpinteria

Mussel Shoals

Old Stairs

Paradise Cove

White Point

Point Fermin

Crystal Cove

Shaws Cove

Treasure Island

Dana Point

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Point Sierra Nevada Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle plots at Point Sierra Nevada consist almost exclusively of *Chthamalus dalli/fissus*, although *Balanus glandula* are recorded on rare occasion (note that species were not distinguished until 2001). Cover of *Chthamalus* spp. varied inversely with rock cover nearly perfectly, with little else occurring in these plots. Littorines were consistently common in the barnacle plots and limpets were also present in moderate numbers.

Mytilus cover in mussel plots remained high and extremely stable at Point Sierra Nevada, hovering just above 80% for nearly the entire 15 year monitoring period. Rock and the goose neck barnacle, *Pollicipes* generally made up the remainder of cover within the plots. Limpets were the most common motile invertebrate within the mussel plots, and exhibited a seasonal fluctuation in abundance, with higher numbers in fall than in spring. Other motile inverts consistently found within the mussel plots included three types of snails (littorines, *Tegula*, and *Nucella*), a chiton (*Nuttallina*), and the lined shore crab (*Pachygrapsus*).

Hesperophycus cover within its target plots started out high (around 90%) and then declined precipitously to around 15%, where it hovered for several years before recovering slightly and stabilizing at around 30%. The loss of this rockweed corresponded with increases in cover of bare rock and *Endocladia*. Littorines were variable in abundance, but generally quite common in the *Hesperophycus* plots. Limpets were less abundant, but still common in these rockweed plots, and the black turban snail, *Tegula*, was consistently present in low numbers.

Another species of rockweed, *Silvetia*, has also declined over time in plots where it is targeted at Point Sierra Nevada. Initial mean cover was >90%, and has steadily declined to around 45%. In some plots, *Mytilus*, *Endocladia*, or *Mastocarpus* has moved in, but a fair amount of bare space (rock) remains. Littorines and limpets were generally common, but variable in abundance over time within *Silvetia* plots. The black turban snail, *Tegula*, was also consistently common.

In *Mastocarpus* plots, cover of the red alga is highly seasonal, with higher cover in fall than in spring, but the general trend overtime is one of decline. The seasonal pattern of *Mastocarpus* varies inversely with cover of the red turf alga, *Endocladia*, also present in the plots. The way in which hydrodynamic forces affect intertidal plants may help to explain seasonal variation in size of *Mastocarpus* populations. When water velocities are low, such as during the summer months in central California, hydrodynamic forces do not limit thallus size (Carrington 1990). However, as water velocity increases, larger plants are torn out. Small plants may be able to better withstand large hydrodynamic forces associated with winter swell. Indeed, our plots generally contain smaller plants (and hence lower cover) in the spring.

Mean cover of *Mazzaella* was relatively constant over time within plots where it is targeted, although some seasonal variation was apparent (commonly higher in fall than spring). Reductions in *Mazzaella* cover were often associated with increases in cover of articulated corallines, suggesting that coralline algae persisted as a stable understory below *Mazzaella*, and reduced canopy cover of *Mazzaella* simply exposed more corallines. Dominant species in the broad group “other red algae” included *Chondracanthus canaliculatus*, and *Gelidium* spp. As with *Mastocarpus*, larger blades of *Mazzaella* tend to be ripped out during winter storms, leaving a perennial basal crust behind. In early spring, our plots tended to have mostly small plants that had just begun to grow back.

Surfgrass (*Phyllospadix*) cover hovered at around 80% along the transects where this species is targeted. Mean cover exhibited slight seasonal variation, with lower cover in the spring following winter storms that ripped out plants and abraded leaves.

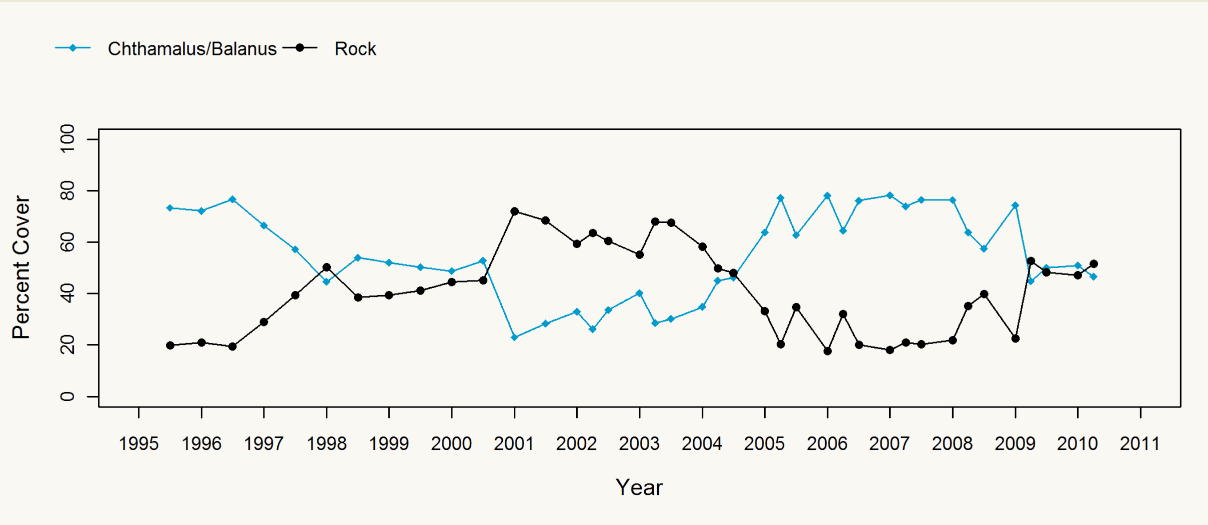
Counts for the ochre star, *Pisaster ochraceus*, in the seastar plots at Point Sierra Nevada varied substantially over time, and may show a slight decreasing trend over time. Individuals were generally large, with only a few samples where significant numbers of small individuals were recorded, suggesting that recruitment to this site tends to be patchy. The ochre star was the only species recorded in our plots at Point Sierra Nevada, but biodiversity surveys also documented the bat star, *Patiria*, the sunflower star, *Pycnopodia*, and the leather star, *Dermasterias*. No obvious patterns emerge from the *Pisaster* size data, other than juveniles (<20mm) were present in early samples, but haven’t been recorded since spring 2005.

Photo Plots

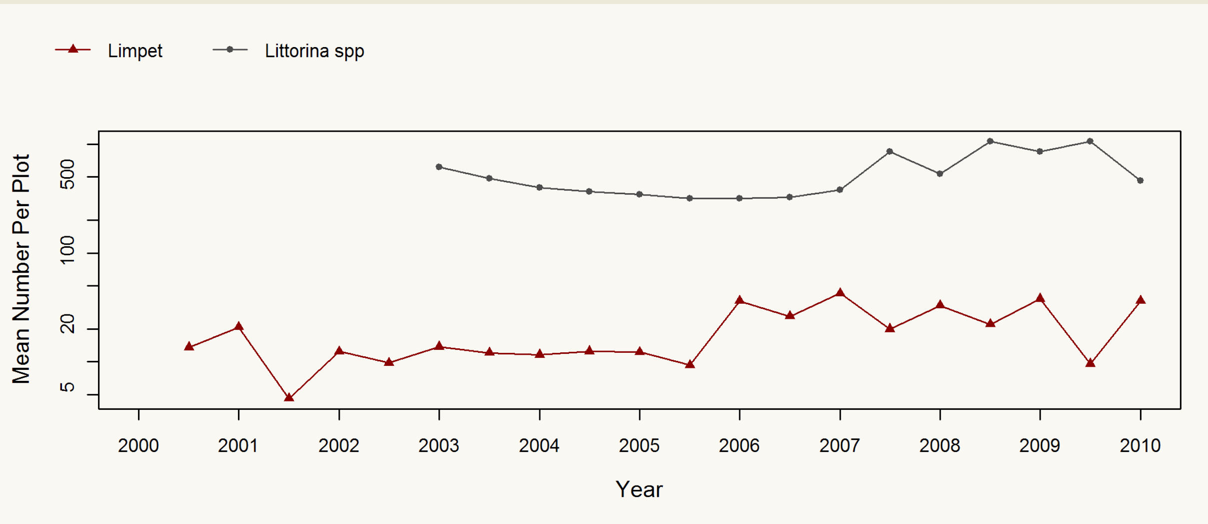
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

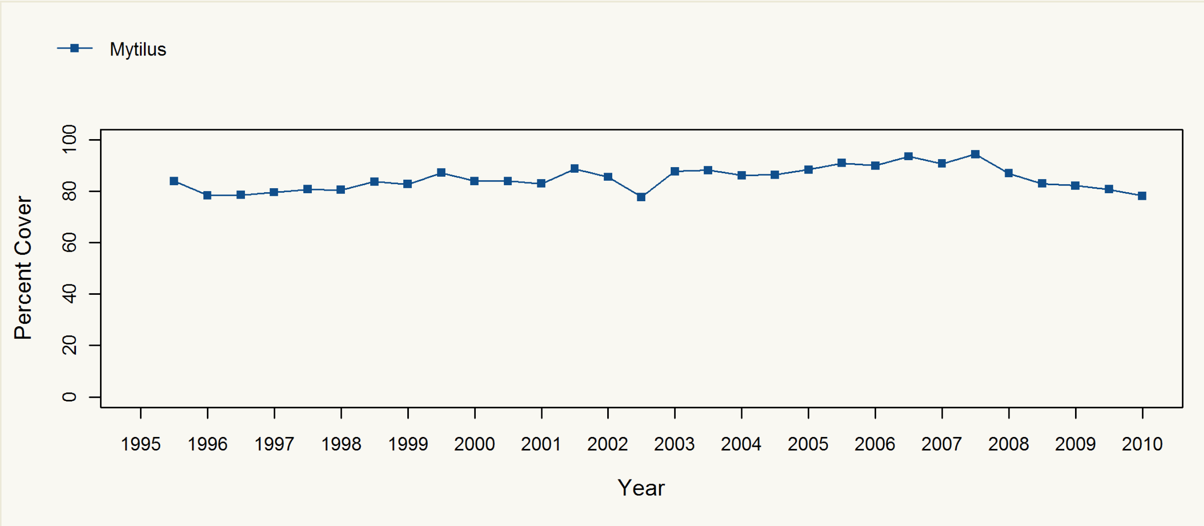
Chthamalus/Balanus (Acorn Barnacles) - percent cover



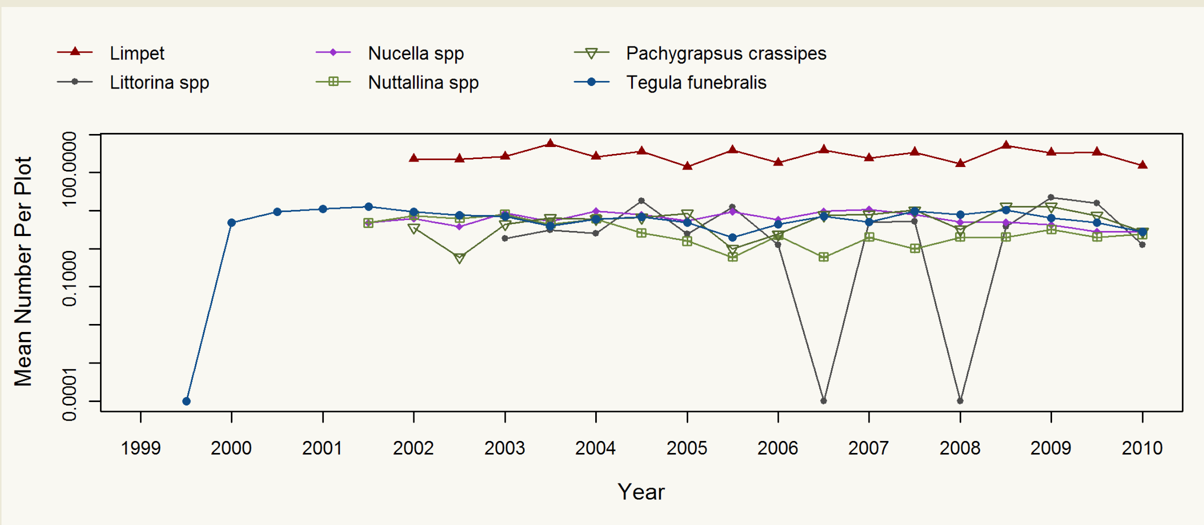
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



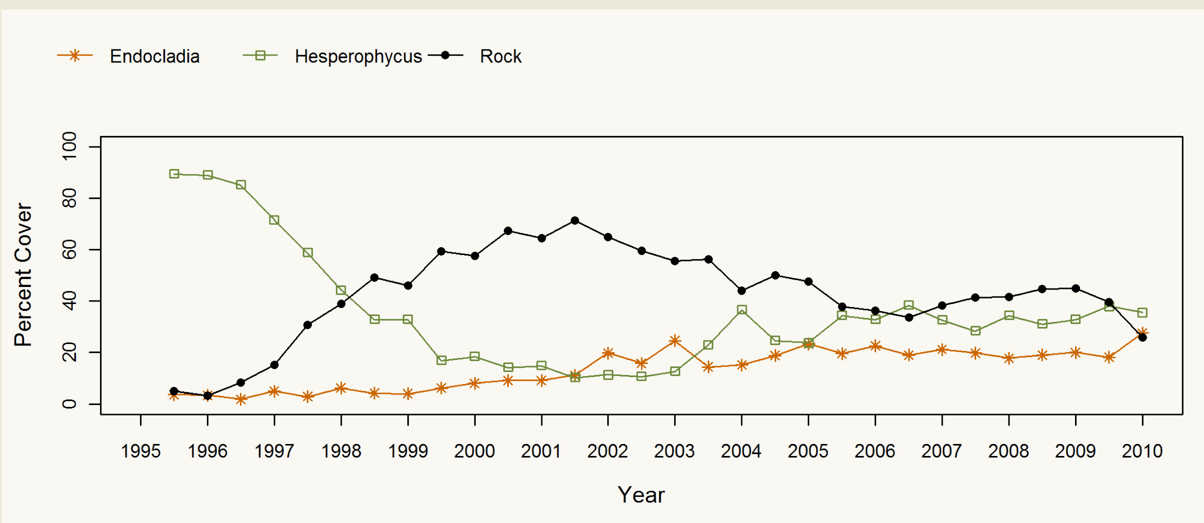
Mytilus (California Mussel) - percent cover



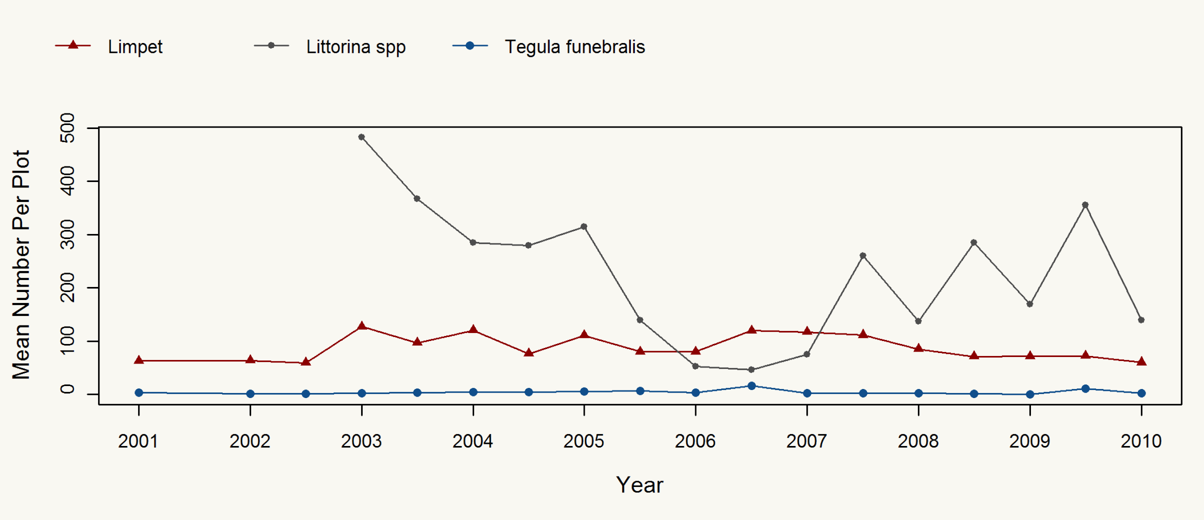
Mytilus (California Mussel) - motile invertebrate counts



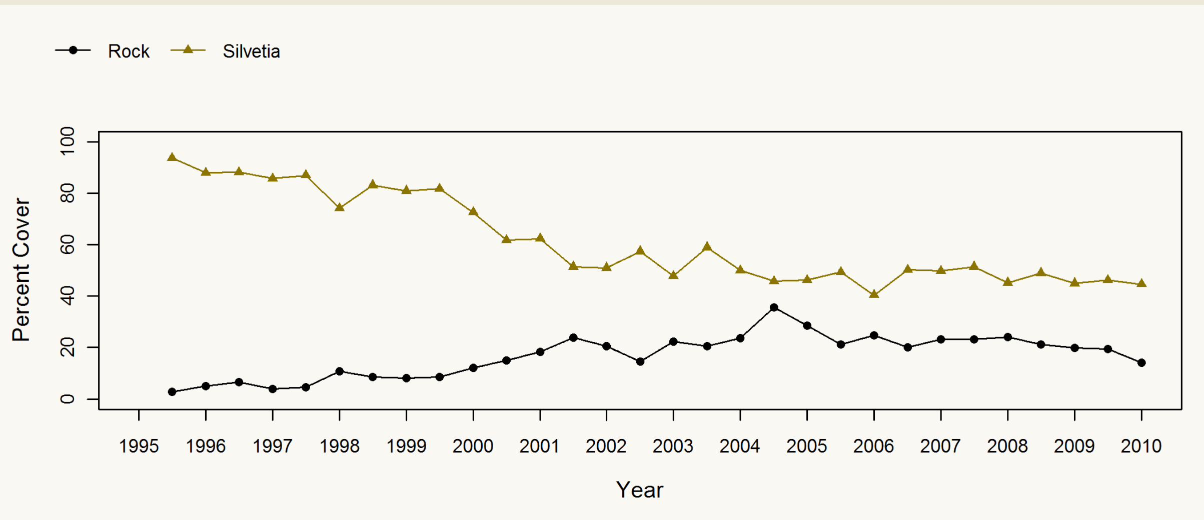
Hesperophycus (Olive Rockweed) - percent cover



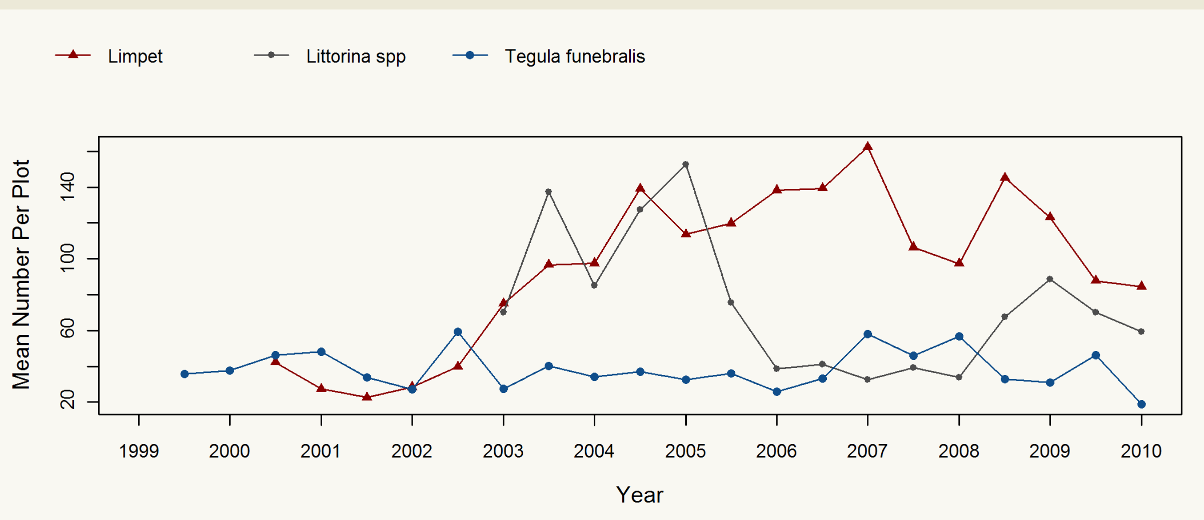
Hesperophycus (Olive Rockweed) - motile invertebrate counts



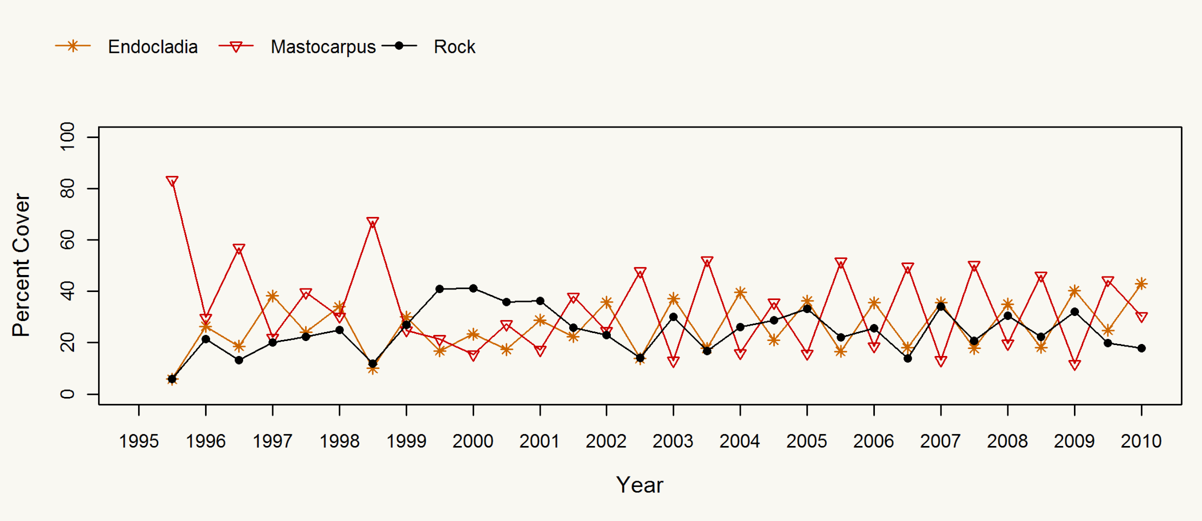
Silvetia (Golden Rockweed) – percent cover



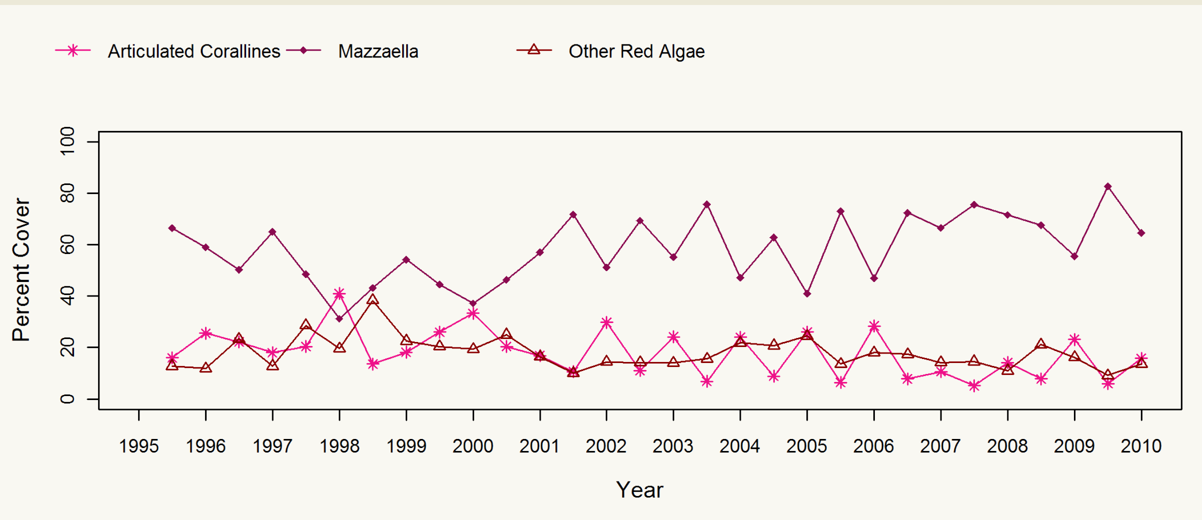
Silvetia (Golden Rockweed) – motile invertebrate counts



Mastocarpus (Turkish Washcloth) – percent cover



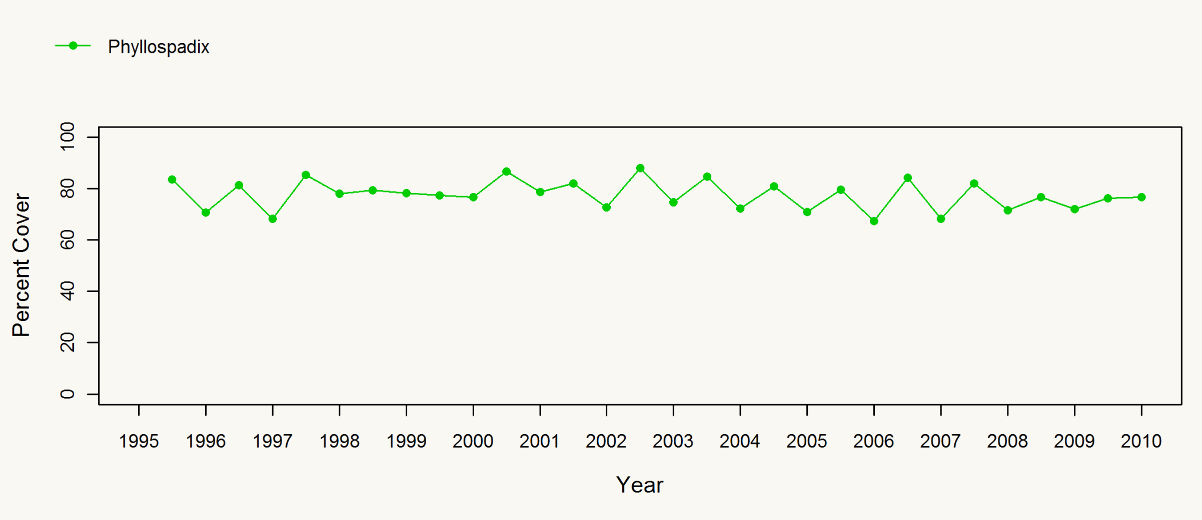
Mazzaella (Iridescent Weed)



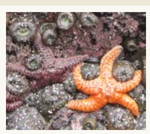
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

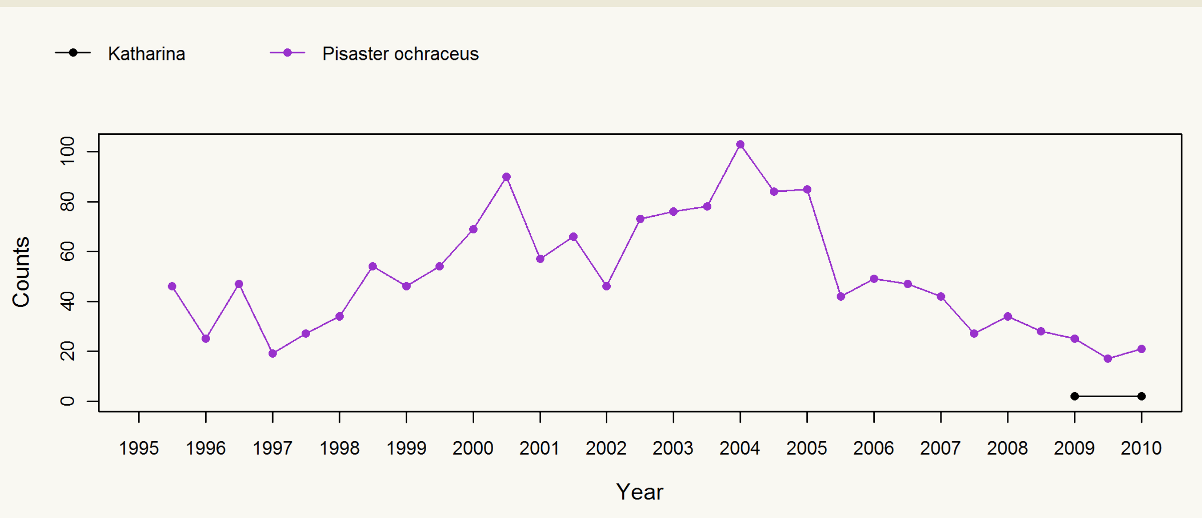


Species Counts and Sizes

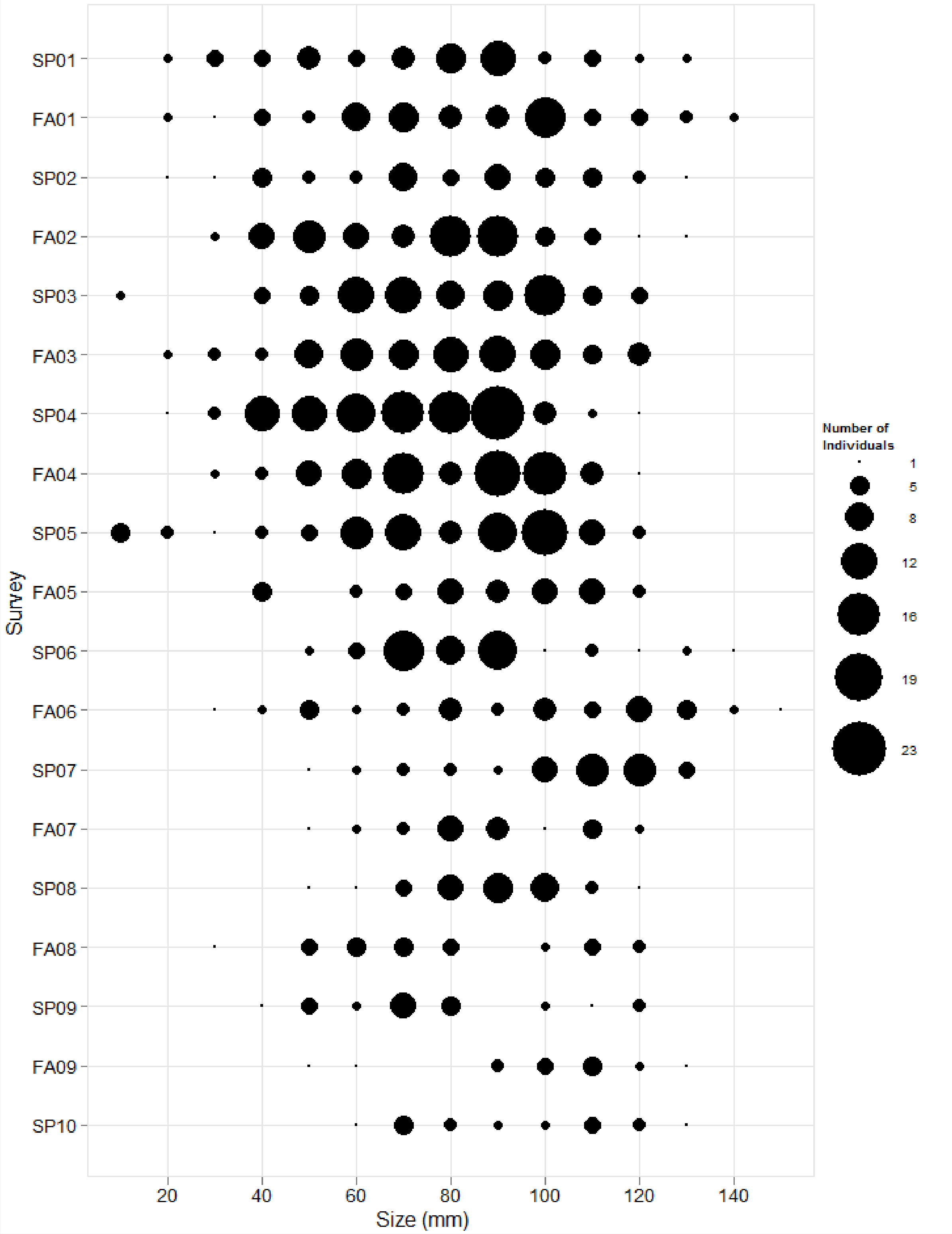


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Piedras Blancas Long-Term trends

SEE BELOW FOR TREND GRAPHS

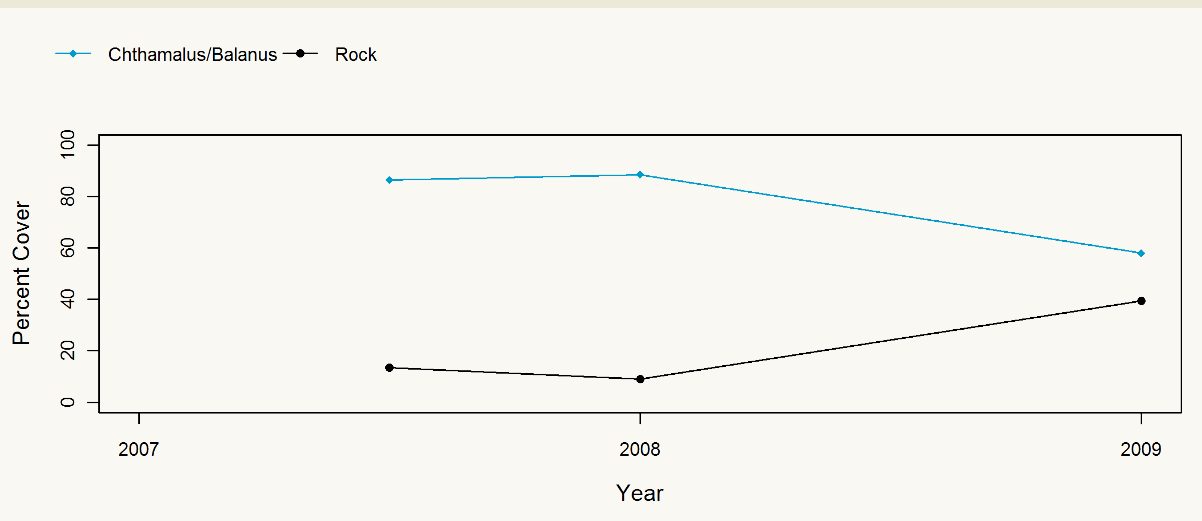
In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Photo Plots

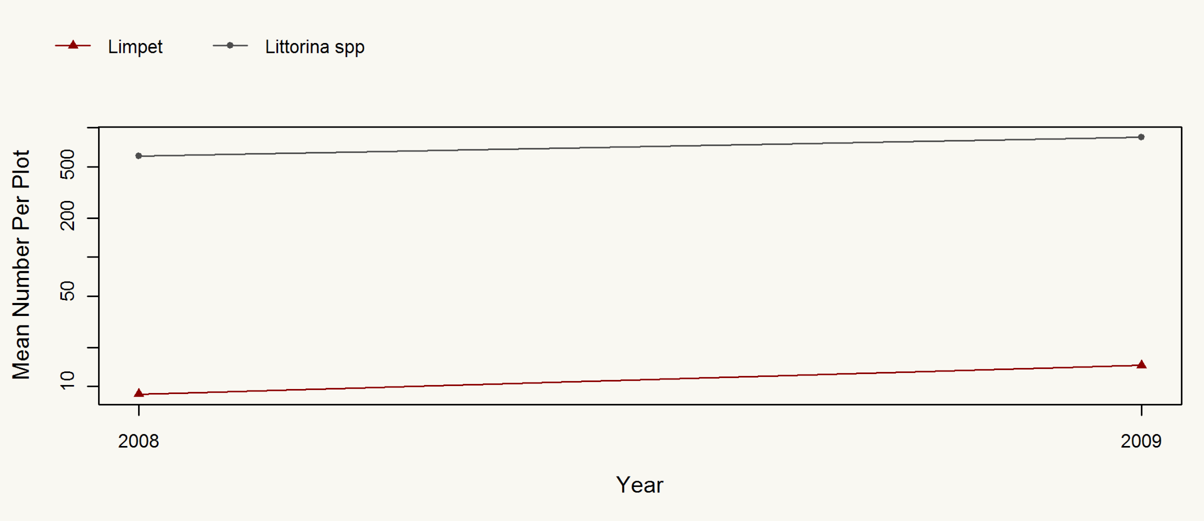
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

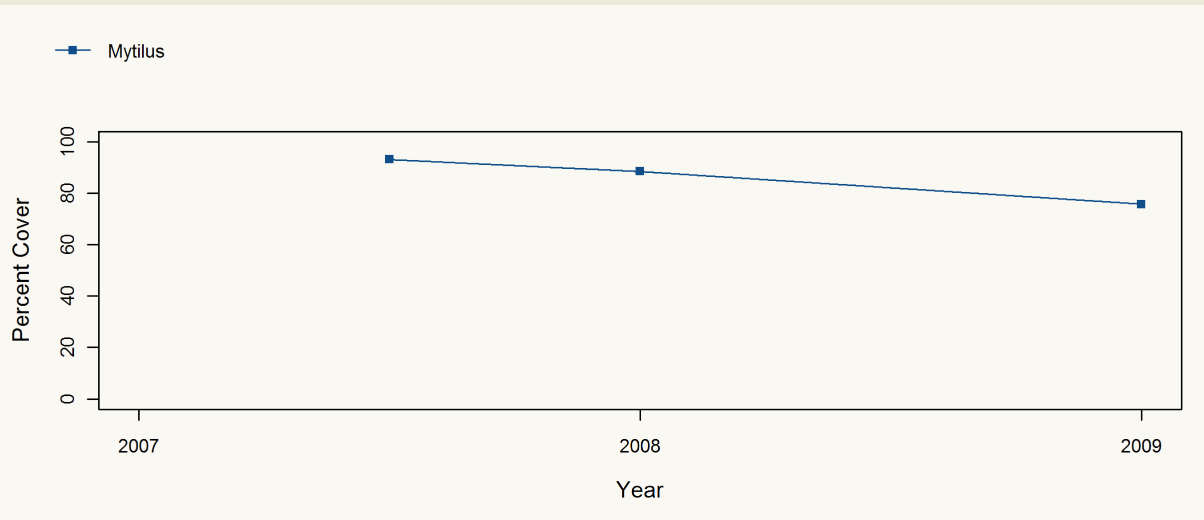
Chthamalus/Balanus (Acorn Barnacles) - percent cover



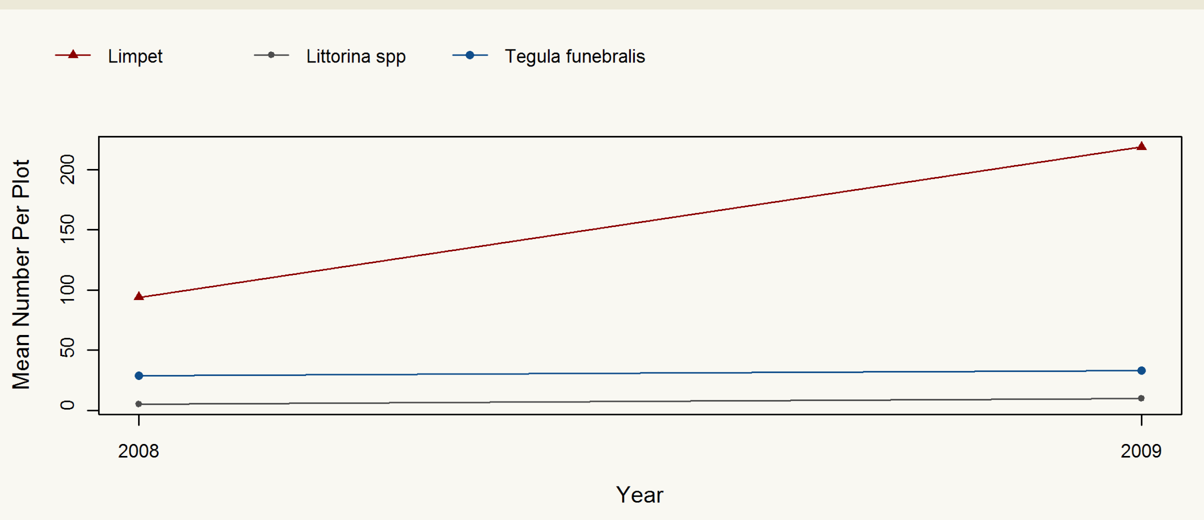
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



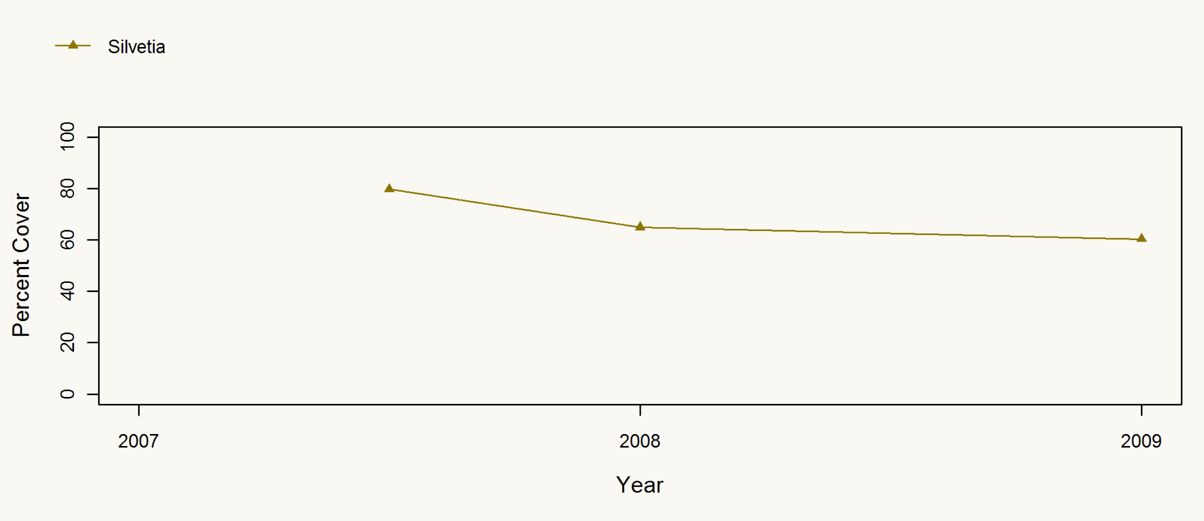
Mytilus (California Mussel) – percent cover



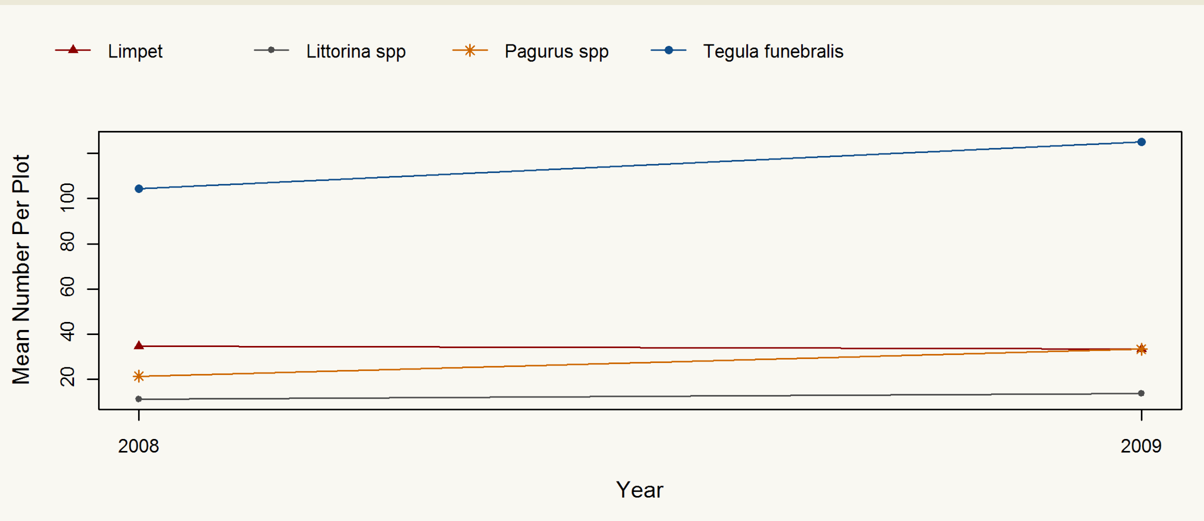
Mytilus (California Mussel) – motile invertebrate counts



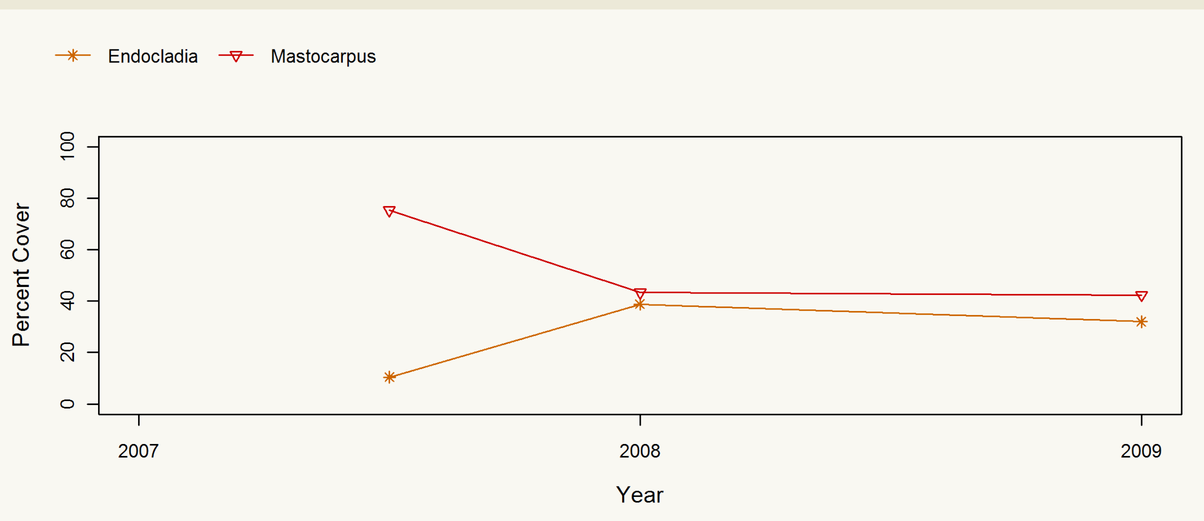
Silvetia (Golden Rockweed) – percent cover



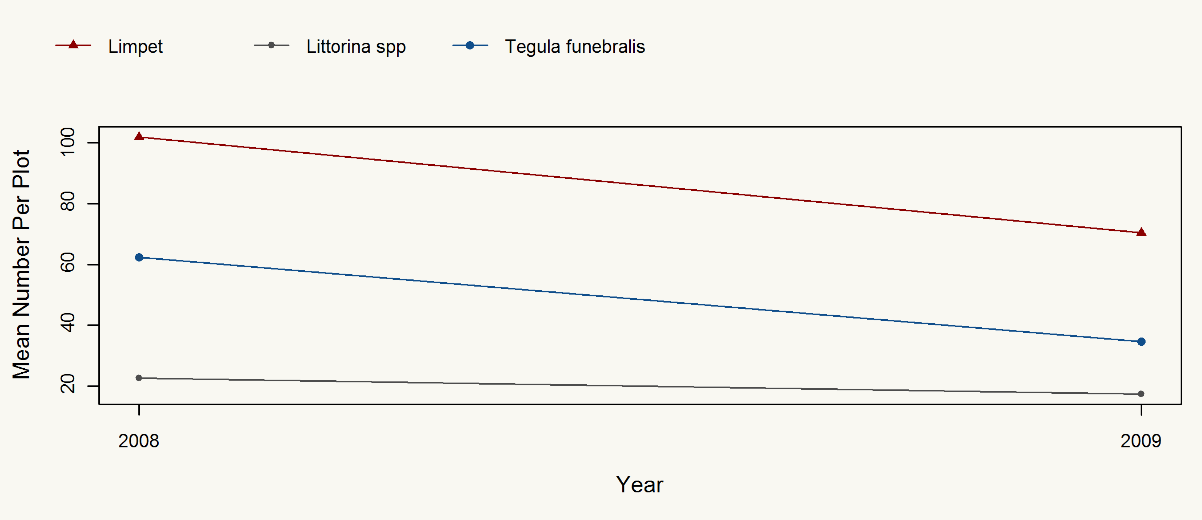
Silvetia (Golden Rockweed) – motile invertebrate counts



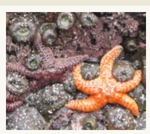
Mastocarpus (Turkish Washcloth) – percent cover



Mastocarpus (Turkish Washcloth) – motile invertebrate counts

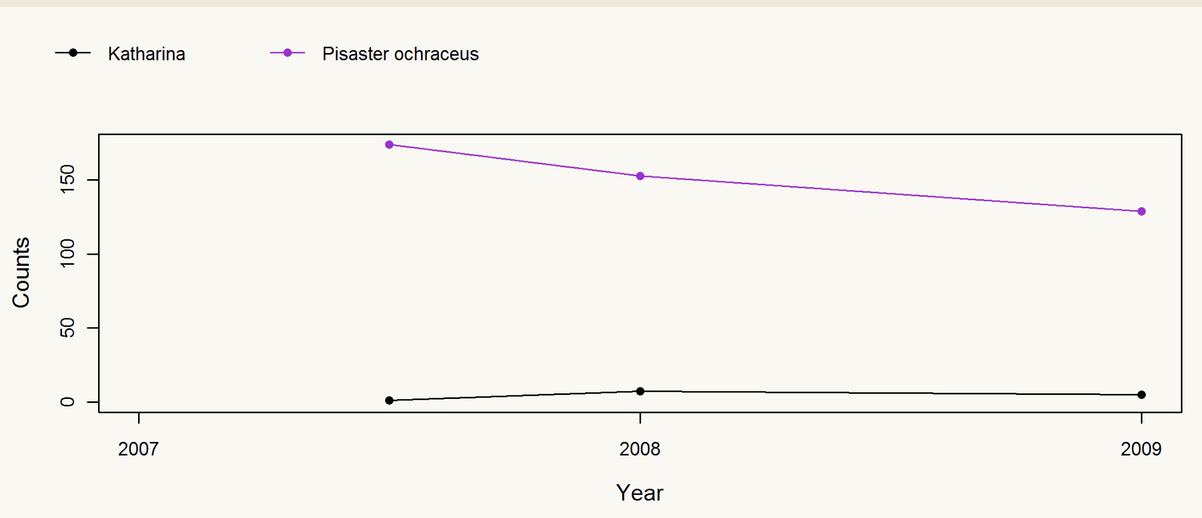


Species Counts and Sizes

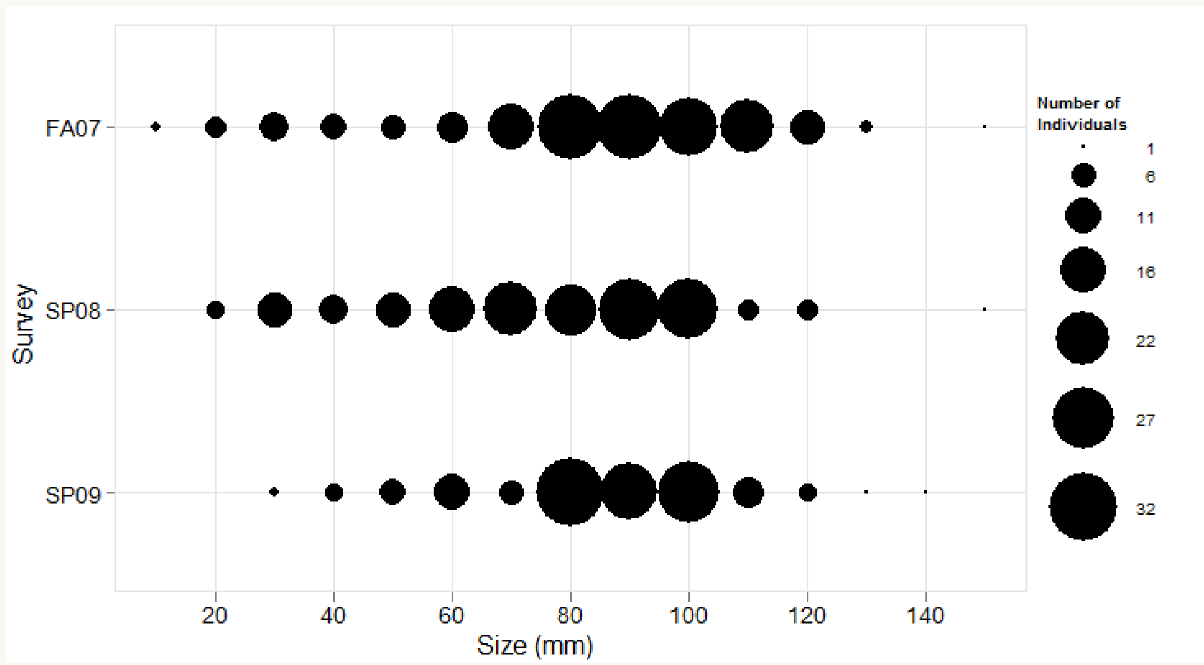


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Cayucos Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle plots at Cayucos contained nearly pure stands of *Chthamalus dalli/fissus*, with very few *Balanus glandula* recorded (note that species were not distinguished until 2001). Cover of *Chthamalus* varied inversely with rock cover, with little else occurring in these plots. Littorines were common in the barnacle plots and limpets were also present in moderate numbers. The turban snail, *Tegula funebralis*, occurred consistently in the plots in low numbers.

Mussel plots at Cayucos consisted mainly of their targeted species, *Mytilus californianus*. When cover of *Mytilus* declined, rock cover increased, indicating that bare space was generally not colonized by other species. Mussel cover declined somewhat between 1999-2001, and then increased to over 90% cover in 2005-2006, followed by a more recent decline to near-original levels. Limpets were abundant in the mussel plots and exhibited strong seasonal variation, with much higher numbers in fall than in spring.

Decline of the upper-shore rockweed, *Hesperophycus*, was striking at Cayucos during the first few years it was monitored, where cover dropped from over 90% to less than 20%. *Hesperophycus* cover then stabilized at around 20-30% for nearly 13 years, but has recently increased slightly. Although some reduction in *Hesperophycus* abundance occurred site-wide, declines were more severe within permanent plots. Thus the plots did not necessarily reflect site-wide coverage of this rockweed. Limpets, littorines, and the turban snail, *Tegula funebralis*, were all common within *Hesperophycus* plots.

Silvetia cover was quite high during the first 5 years at Cayucos, but experienced a substantial decline in 2001, followed by more gradual decline until 2006, when cover appeared to stabilize. *Endocladia* and *Hesperophycus* have increased in these plots over time, filling in some of the space vacated by *Silvetia*. *Silvetia* cover was highly seasonal, with lower values in spring vs. fall samples. This pattern is present at many sites, and may be due to a combination of factors including seasonal growth cycles, physical removal by winter storms and desiccation from extreme low tides that occurred in the middle of the day in the spring (timing of low tide is cyclical, so low tides are not always mid-day in spring in this region). *Tegula funebralis* and limpets were abundant in *Silvetia* plots, and the chiton, *Lepidochitona hartwegii*, was consistently present. This chiton is frequently associated with *Silvetia*, which it uses for protection from desiccation.

Endocladia cover was relatively stable over time. A significant drop in 1998 was followed by a recovery to near-original levels. Limpets and littorines were common in the *Endocladia* plots, which had a large amount of bare space, where diatoms typically grow and provide food for these grazers.

Surfgrass cover at Cayucos was consistently high over time, with only slight dips during the 1997/98 El Niño event, and again in 2001. The lack of a seasonal pattern in surfgrass cover at Cayucos is likely due to the unique location of the transects at this site. Unlike other sites, where surfgrass transects were established in areas that drain during low tide, transects at Cayucos are located in large pools, which reduces the amount of stress experienced by the plants due to air exposure, and perhaps also abrasion.

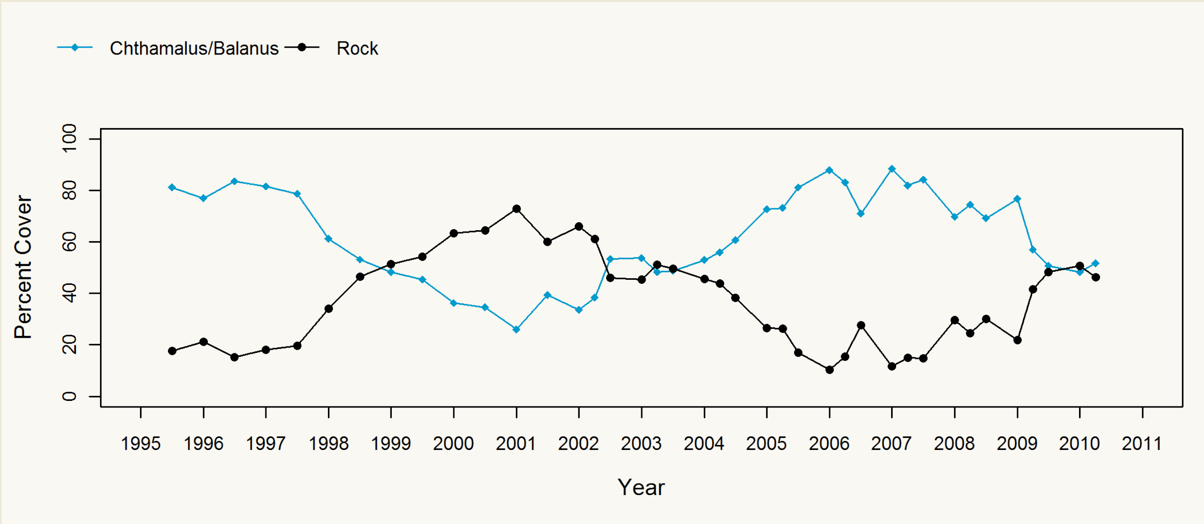
Pisaster numbers have been variable, but increasing overall at Cayucos. We have seen increases only in the larger size classes, indicating that individuals are moving into the plots from outside, rather than recruiting to the plots.

Photo Plots

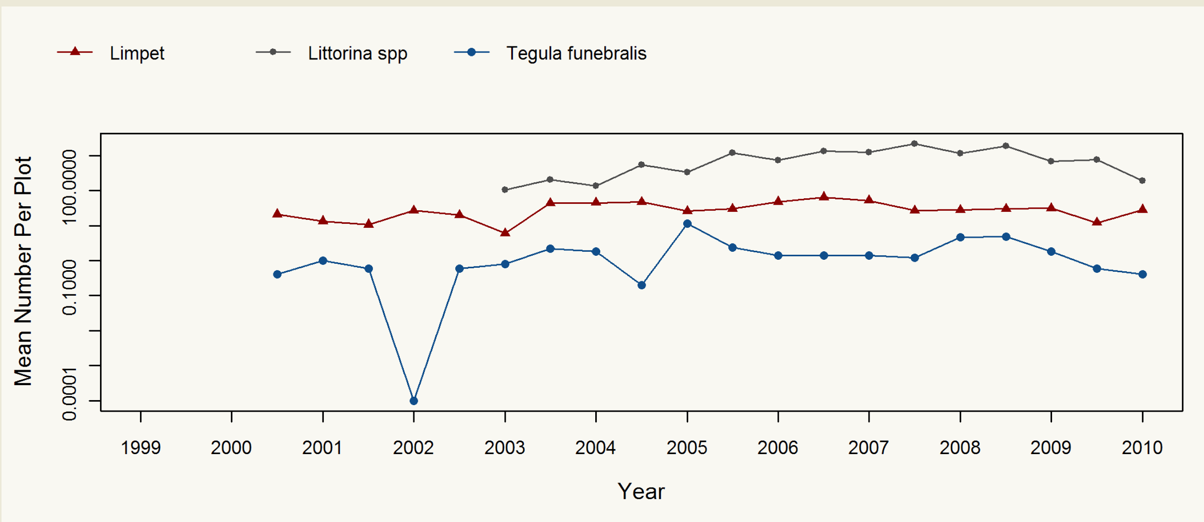
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

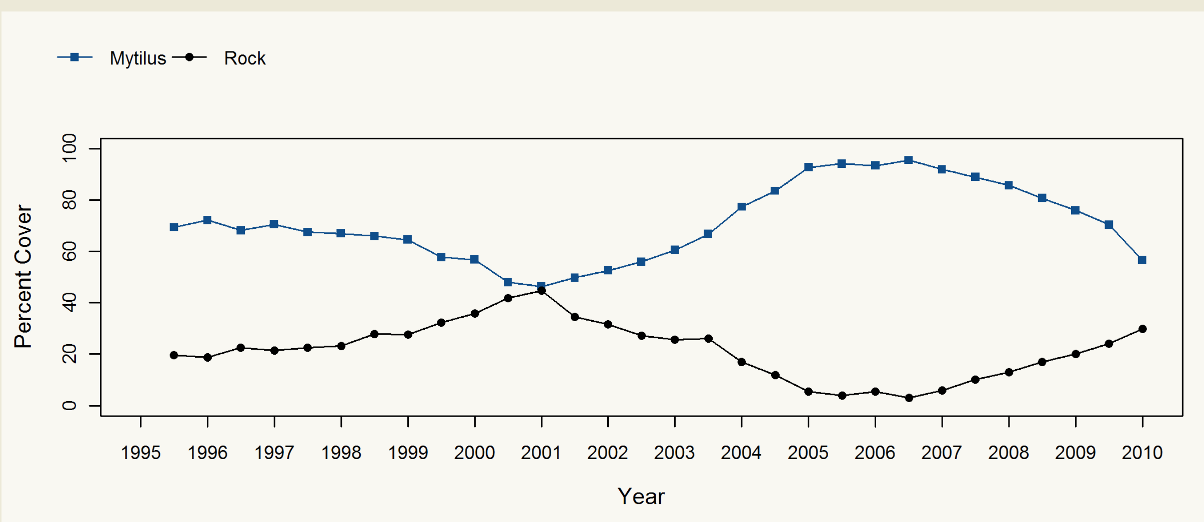
Chthamalus/Balanus (Acorn Barnacles) – percent cover



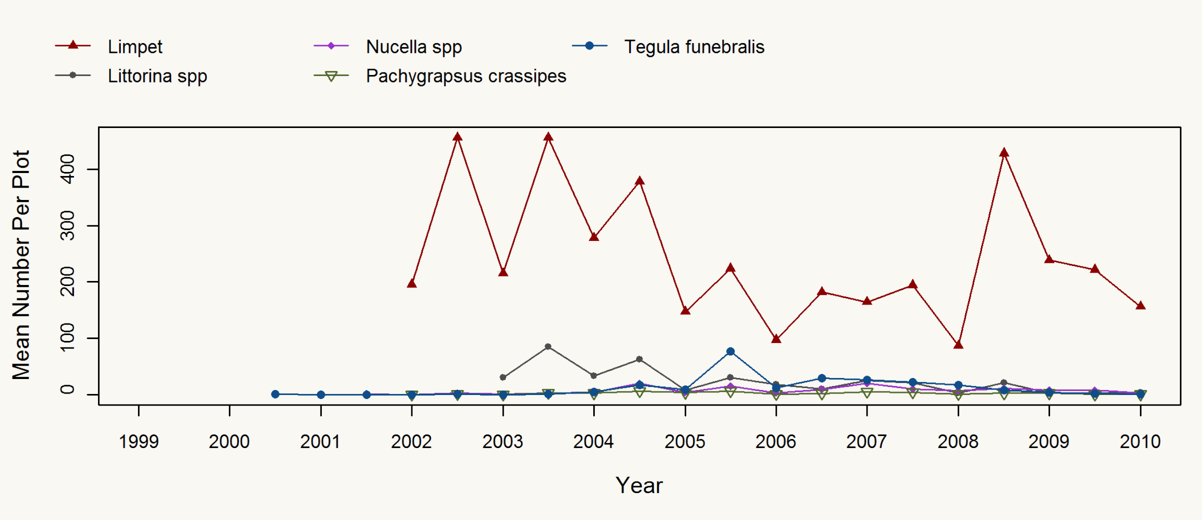
Chthamalus/Balanus (Acorn Barnacles) – motile invertebrate counts



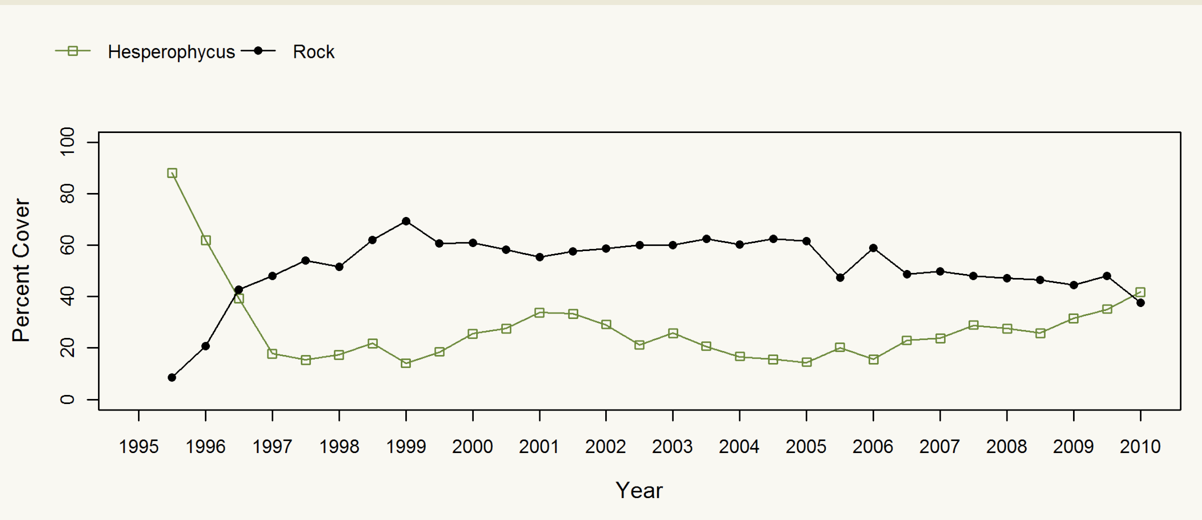
Mytilus (California Mussel) – percent cover



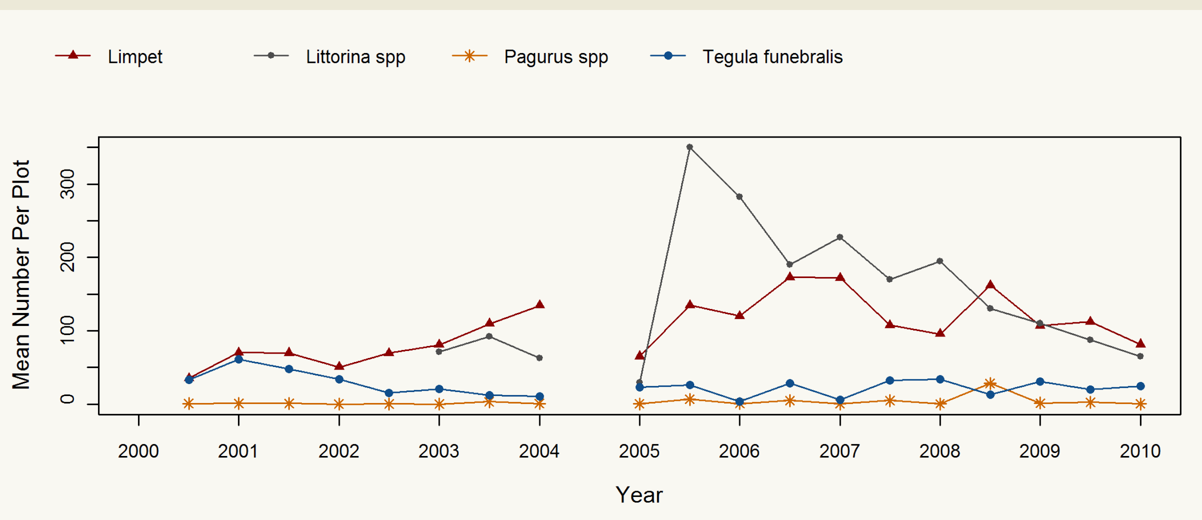
Mytilus (California Mussel) – motile invertebrate counts



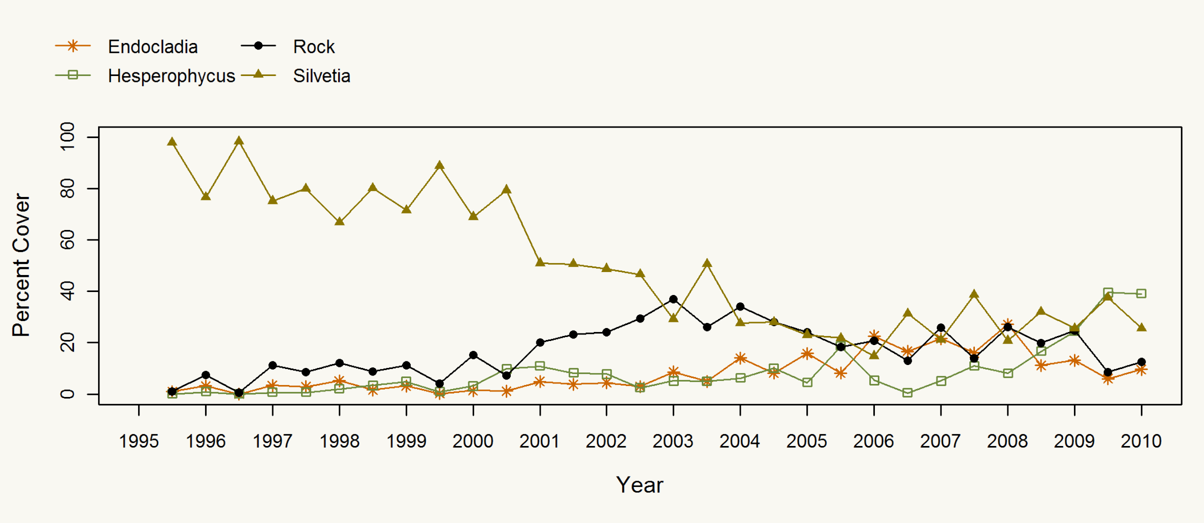
Hesperophycus (Olive Rockweed) - percent cover



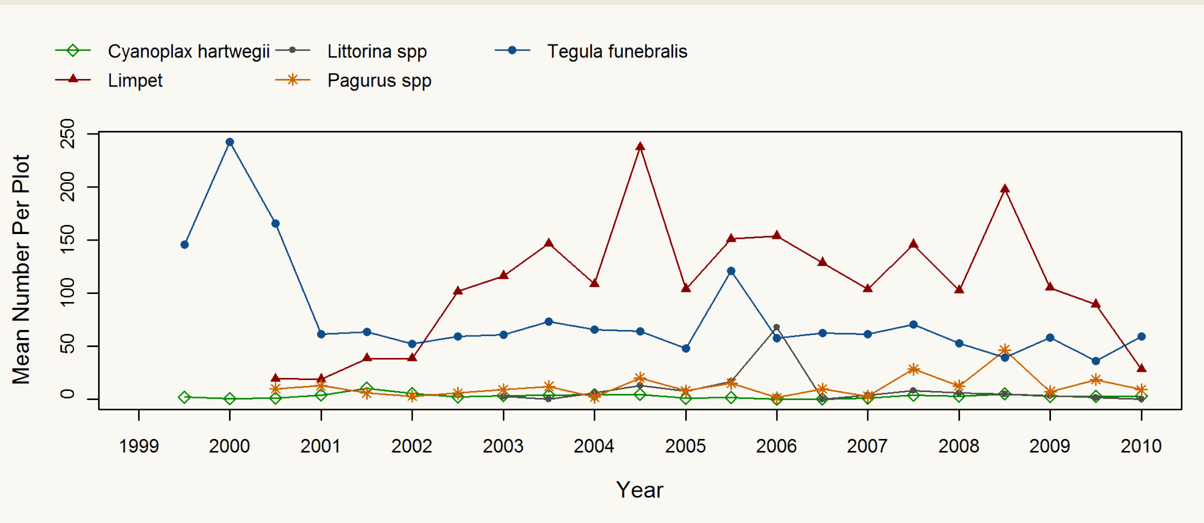
Hesperophycus (Olive Rockweed) - motile invertebrate counts



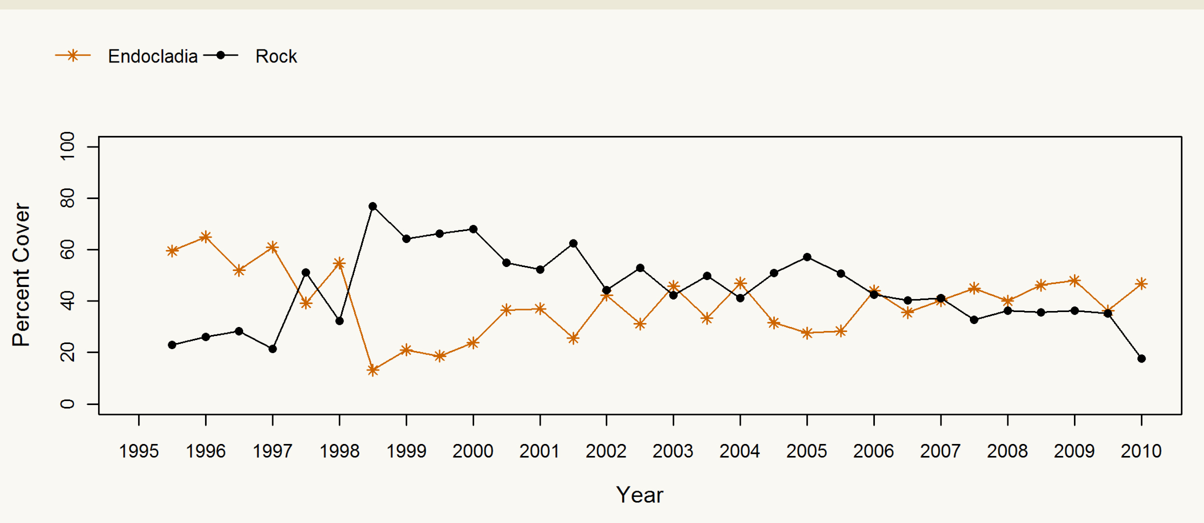
Silvetia (Golden Rockweed) - percent cover



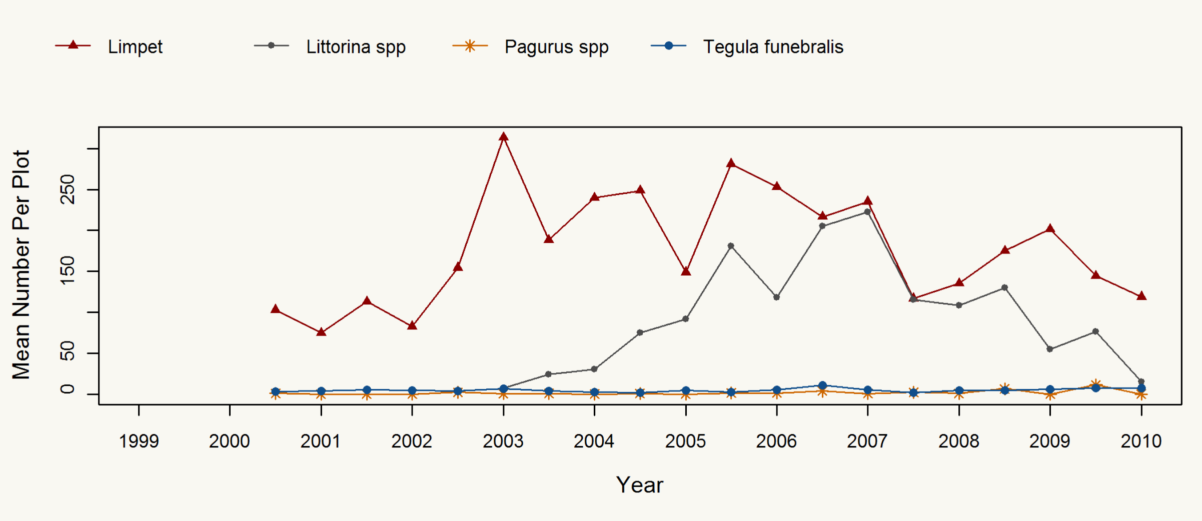
Silvetia (Golden Rockweed) – motile invertebrate counts



Endocladia (Turfweed) – percent cover



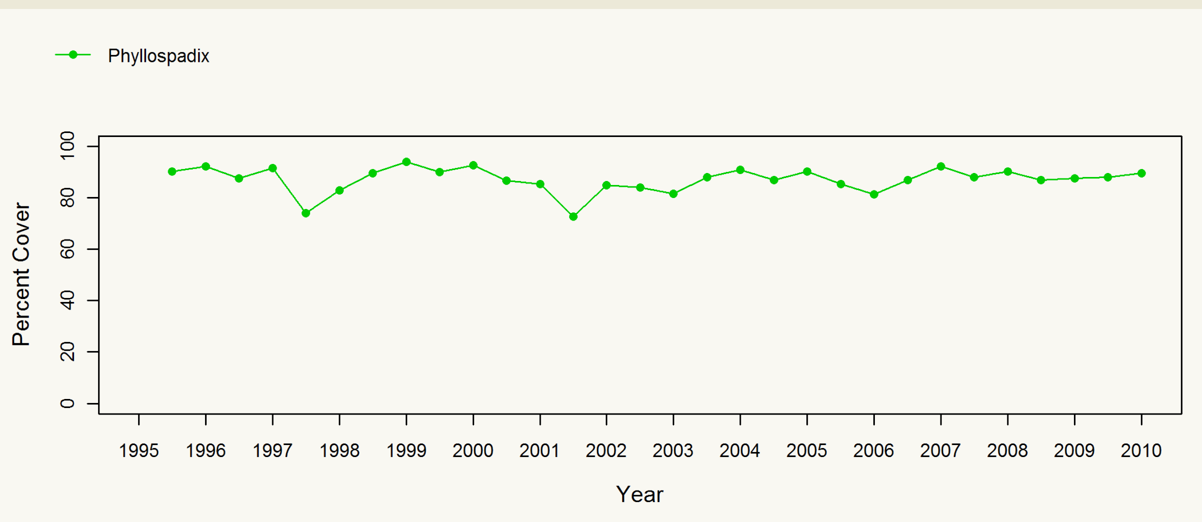
Endocladia (Turfweed) – motile invertebrate counts



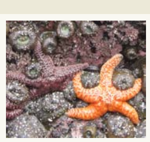
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

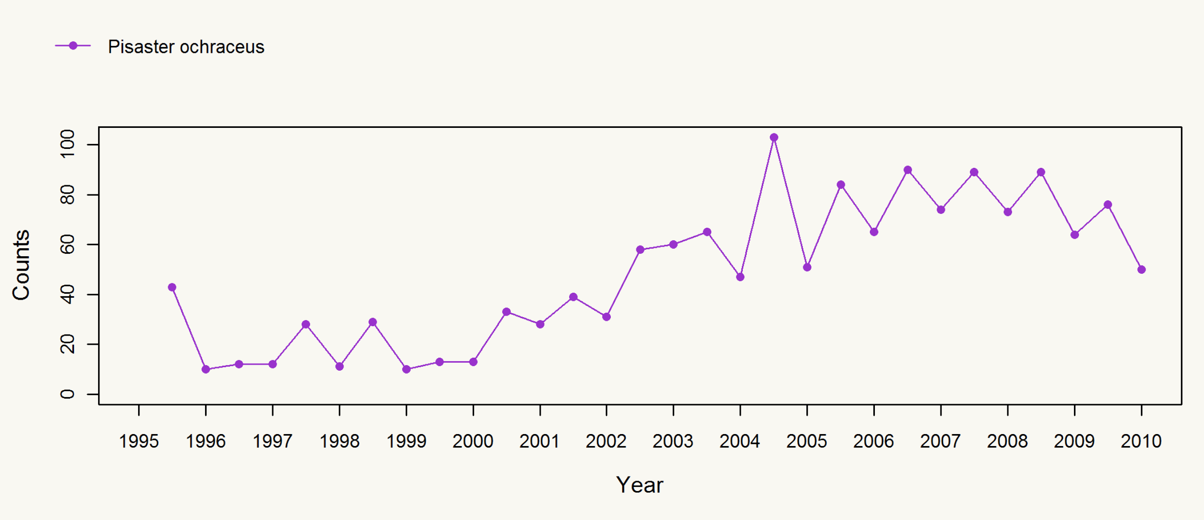


Species Counts and Sizes

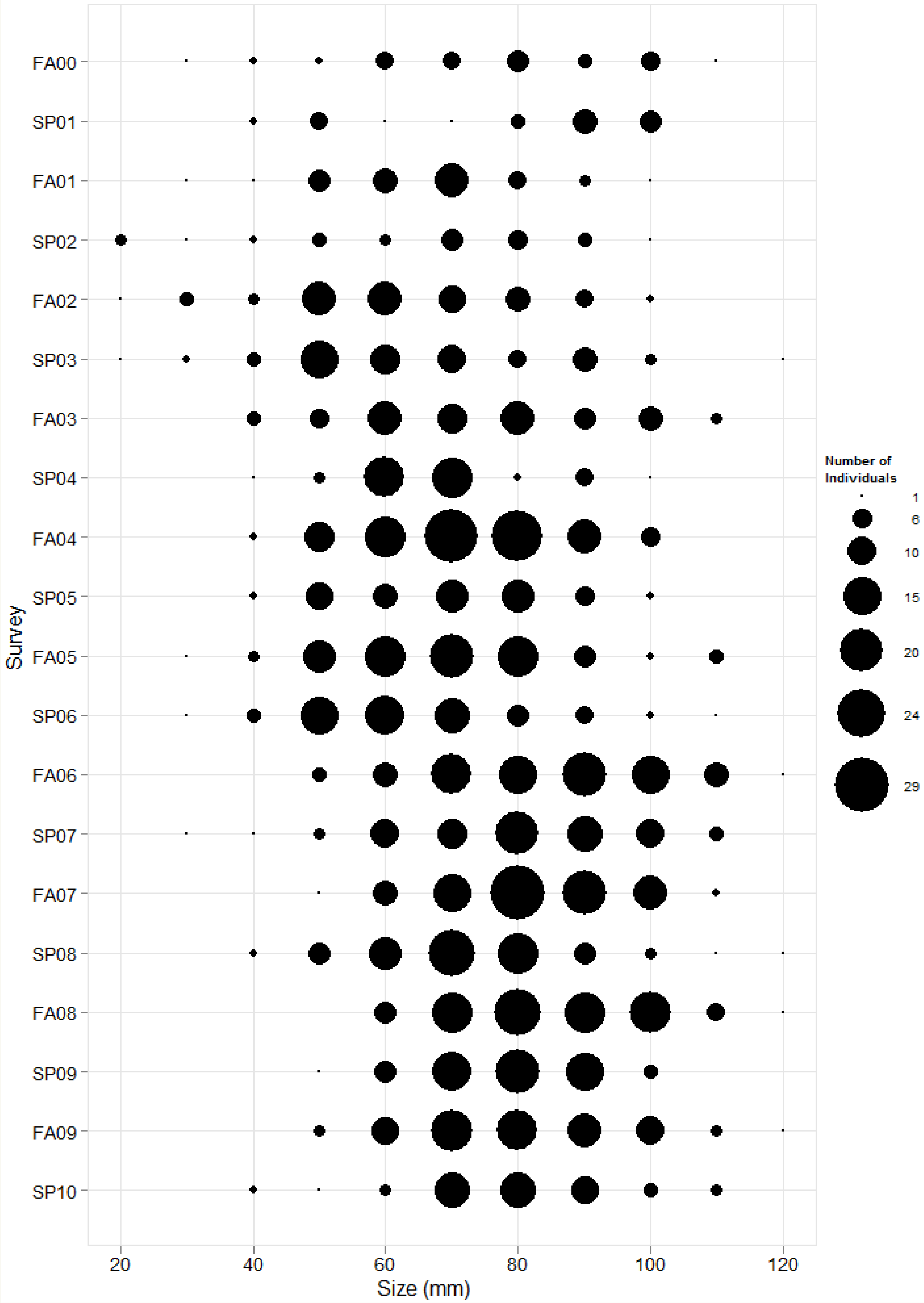


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Hazards Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The barnacle plots at Hazards are located in an area heavily influenced by sand, and declines were often associated with scouring events. This was particularly true in spring 2003, when the opportunistic red alga, *Porphyra*, colonized large patches of bare space recently cleared by sand scour. A mixture of *Chthamalus* and *Balanus* was present in these plots. Littorines were typically present in very high numbers, often upwards of 1000 individuals per plot, while limpets tended to be an order of magnitude less common.

Initial mussel cover was somewhat low at Hazards (approximately 45%) because plots were established fairly high in the mussel zone to make sampling easier when large swells were present at the site. Denser mussel beds were present at Hazards, but were located on exposed outer reefs. An added benefit to placing the mussel plots higher in the intertidal is that *Pollicipes* cover was fairly high in the plots (almost 20%), so goose barnacles could be monitored along with the mussels. Both *Mytilus* and *Pollicipes* cover have been relatively stable at Hazards. Limpets were the most abundant motile invertebrate in the mussel plots and varied seasonally, with higher counts in fall than in spring. *Tegula funebralis* and *Nucella* spp. (mostly *N. emarginata/ostrina*) were also common.

Silvetia has declined gradually, but substantially over time at Hazards. As *Silvetia* cover has decreased, limpet cover has increased, likely due to the additional "open" space (crustose algae covered rock) available for grazing. The turban snail, *Tegula funebralis* is also common in the *Silvetia* plots at Hazards.

Endocladia declined during the first few years that it was monitored at Hazards, but has hovered around 10-20% cover since this initial decline. As with many other sites, turfweed cover fluctuated seasonally, with higher cover in spring than in fall. The open space resulting from the reduced cover of *Endocladia* has been colonized by barnacles, which have gradually increased in cover over time. Littorines are the most abundant motile invertebrate present in the *Endocladia* plots. *Tegula funebralis* and limpets are also common.

Mean cover of *Mazzaella* remained relatively constant over time at Hazards. Unlike Pt. Sierra Nevada, the only other site where *Mazzaella* is targeted, there was no apparent seasonal variation in cover. "Other Red Algae" consisted mainly of *Chondracanthus canaliculatus*.

Phyllospadix cover at Hazards remained high over time, although it should be noted that averages are not always based on all three transects. Transects at this site were established in the very low intertidal, and thus cannot always be sampled. In SP02 and FA04 transects were not accessible for sampling. In FA02, SP03, SP09, and FA09 only the highest transect could be sampled. In FA05, SP06, FA07, FA08, and SP10 only two transects were accessible.

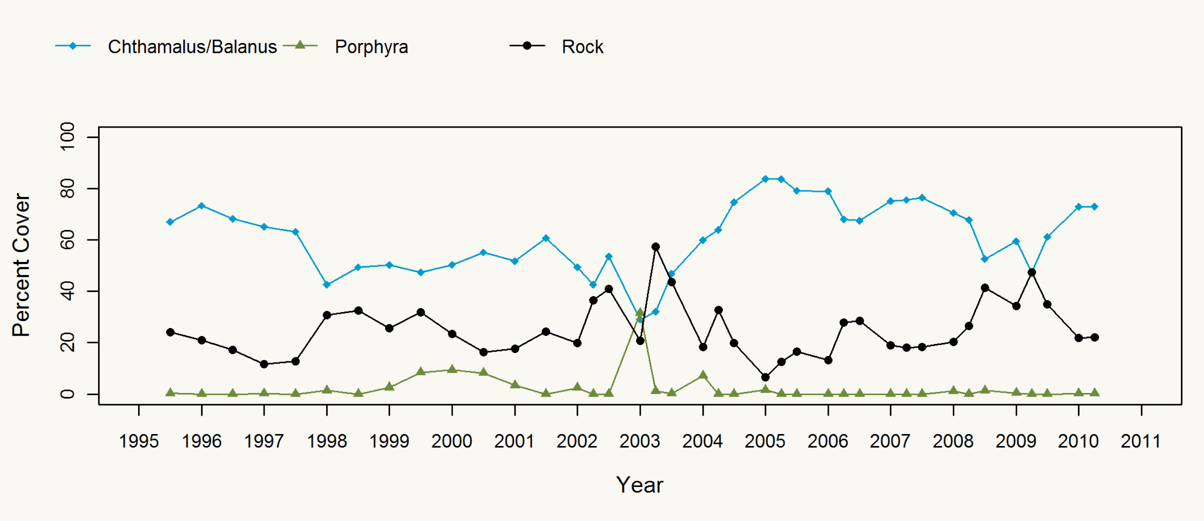
Pisaster ochraceus were abundant but variable in the plots where they are monitored at Hazards. Numbers increased substantially in 2006/2007, and size data suggest that this increase may have been due to a large recruitment event just before this period as large numbers of juveniles were recorded.

Photo Plots

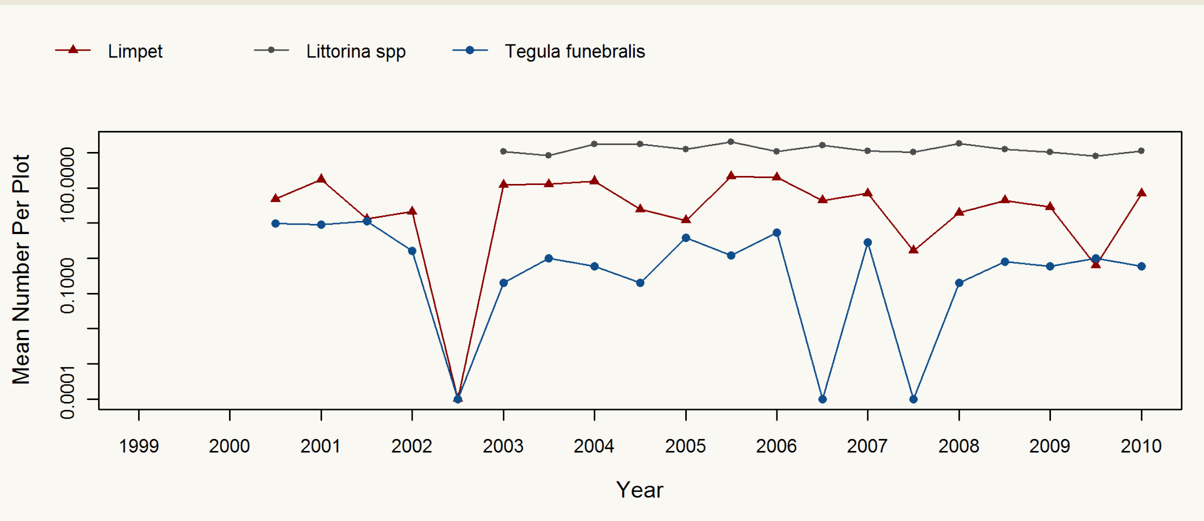
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

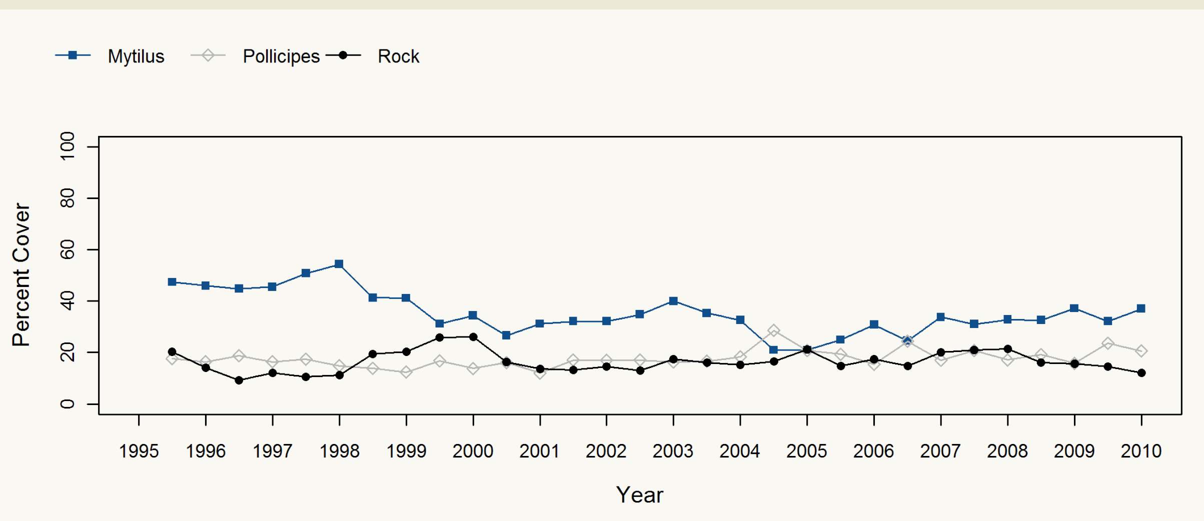
Chthamalus/Balanus (Acorn Barnacles) - percent cover



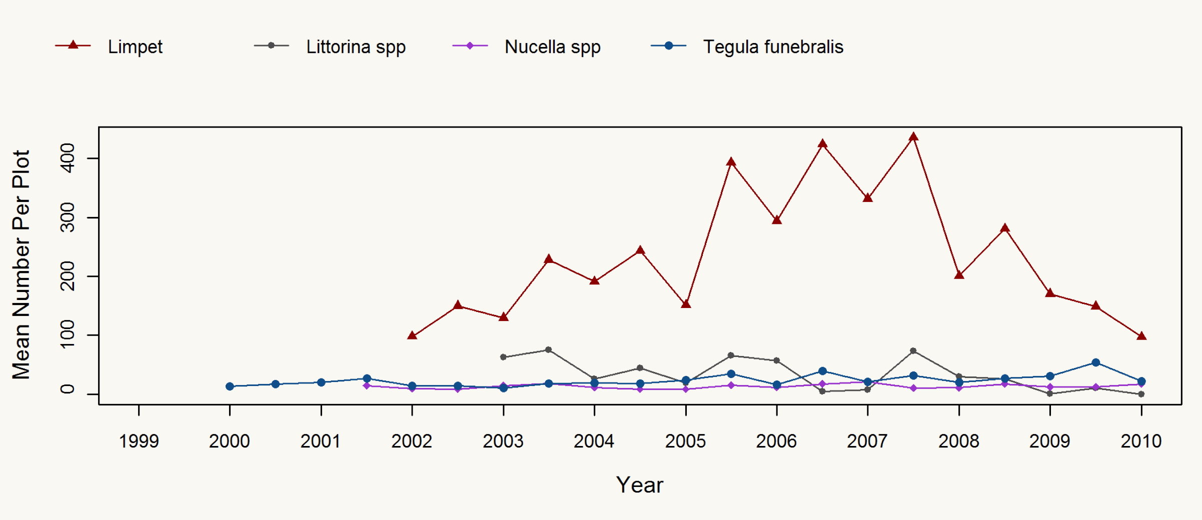
Chthamalus/Balanus (Acorn Barnacles) – motile invertebrate counts



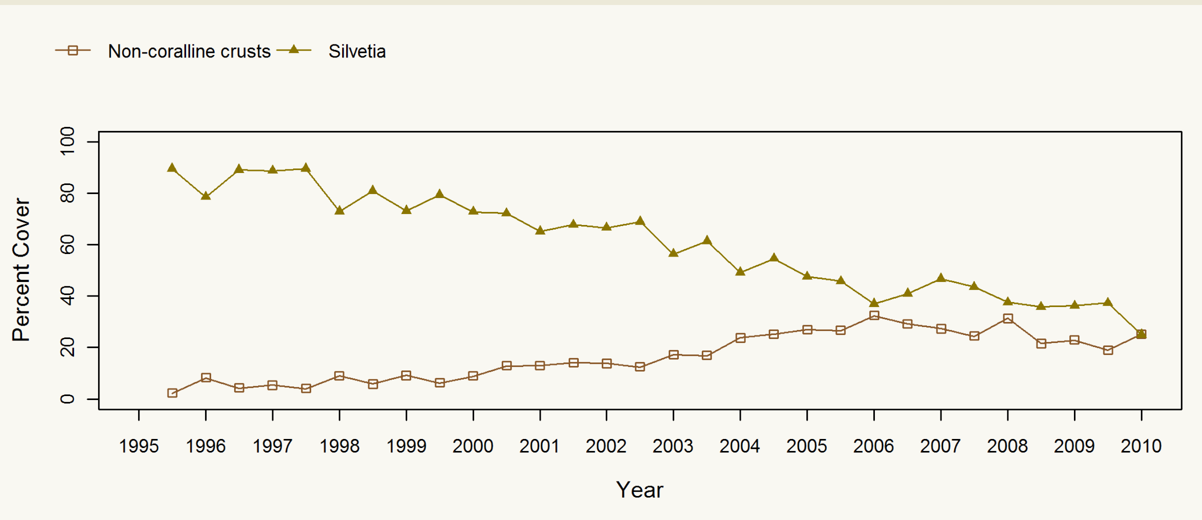
Mytilus (California Mussel) – percent cover



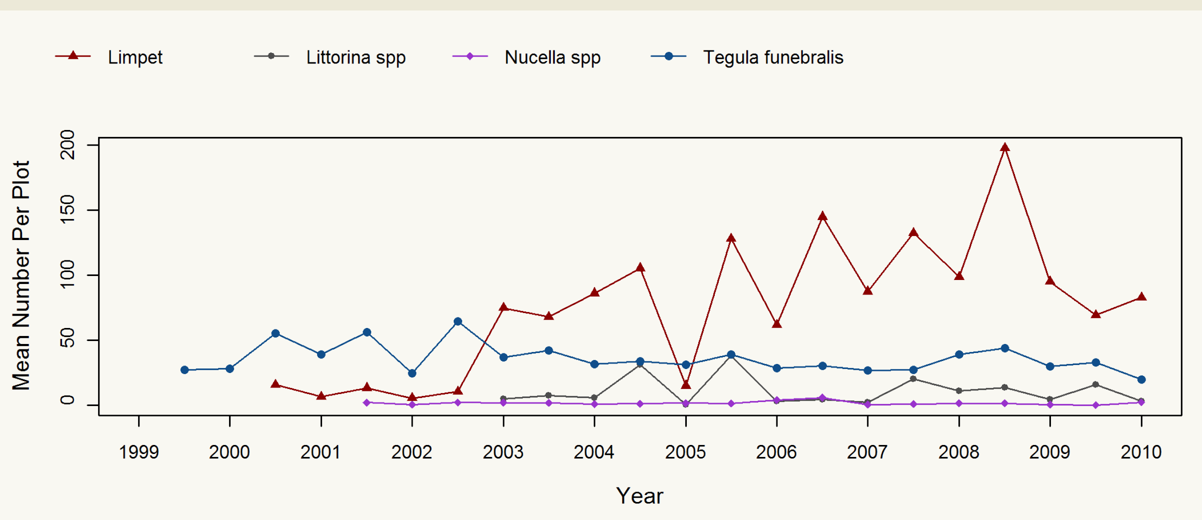
Mytilus (California Mussel) – motile invertebrate counts



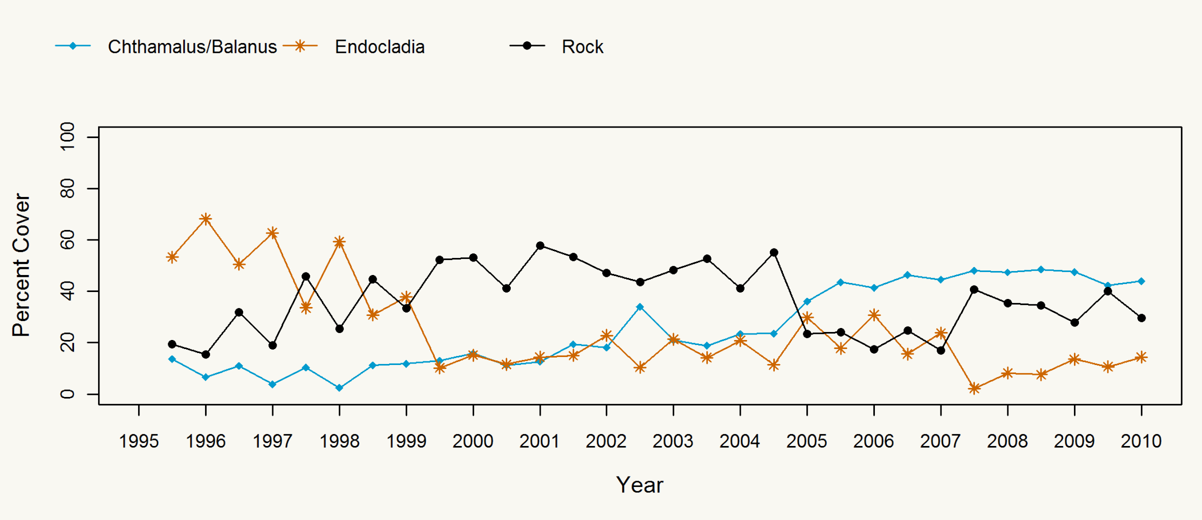
Silvetia (Golden Rockweed) – percent cover



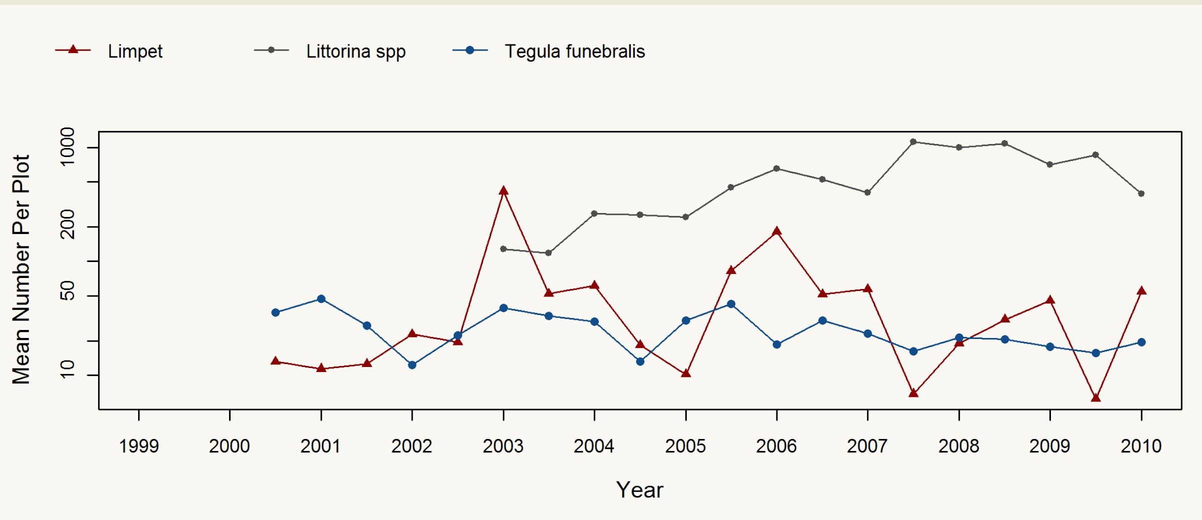
Silvetia (Golden Rockweed) – motile invertebrate counts



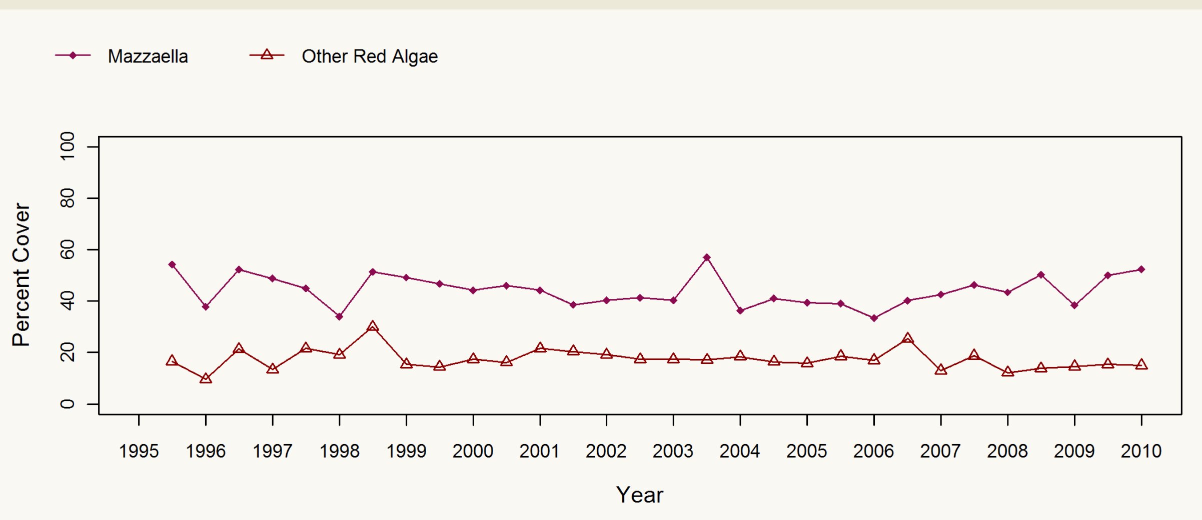
Endocladia (Turfweed) – percent cover



Endocladia (Turfweed) – motile invertebrate counts



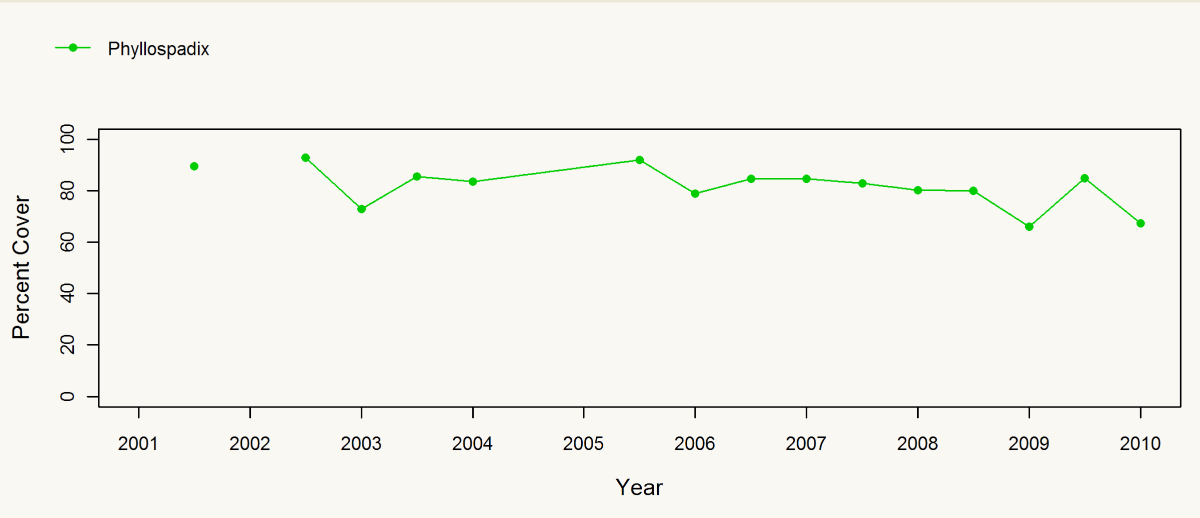
Mazzaella (Iridescent Weed)



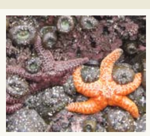
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

< (Surfgrass)

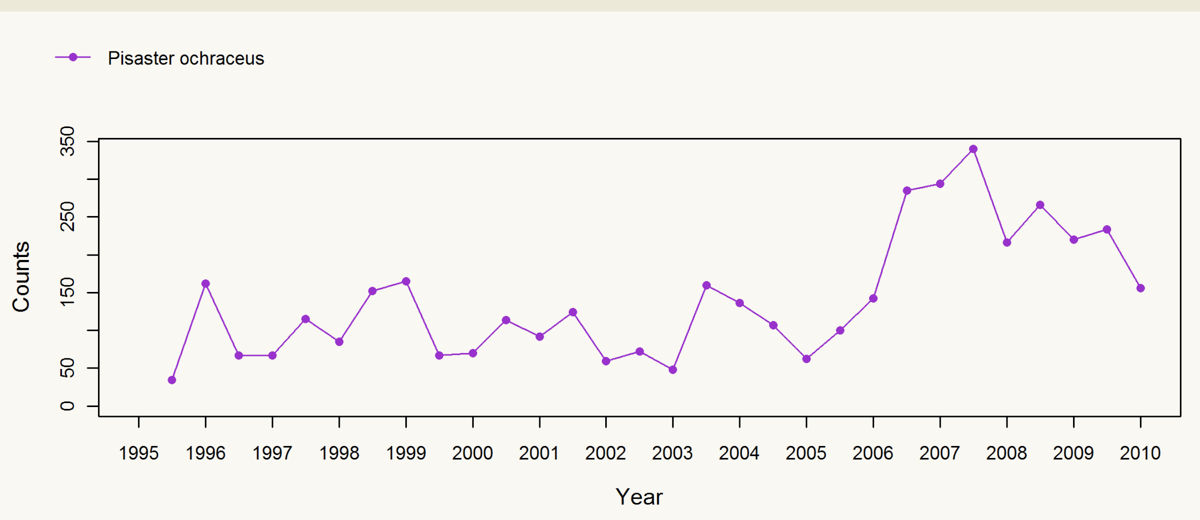


Species Counts and Sizes

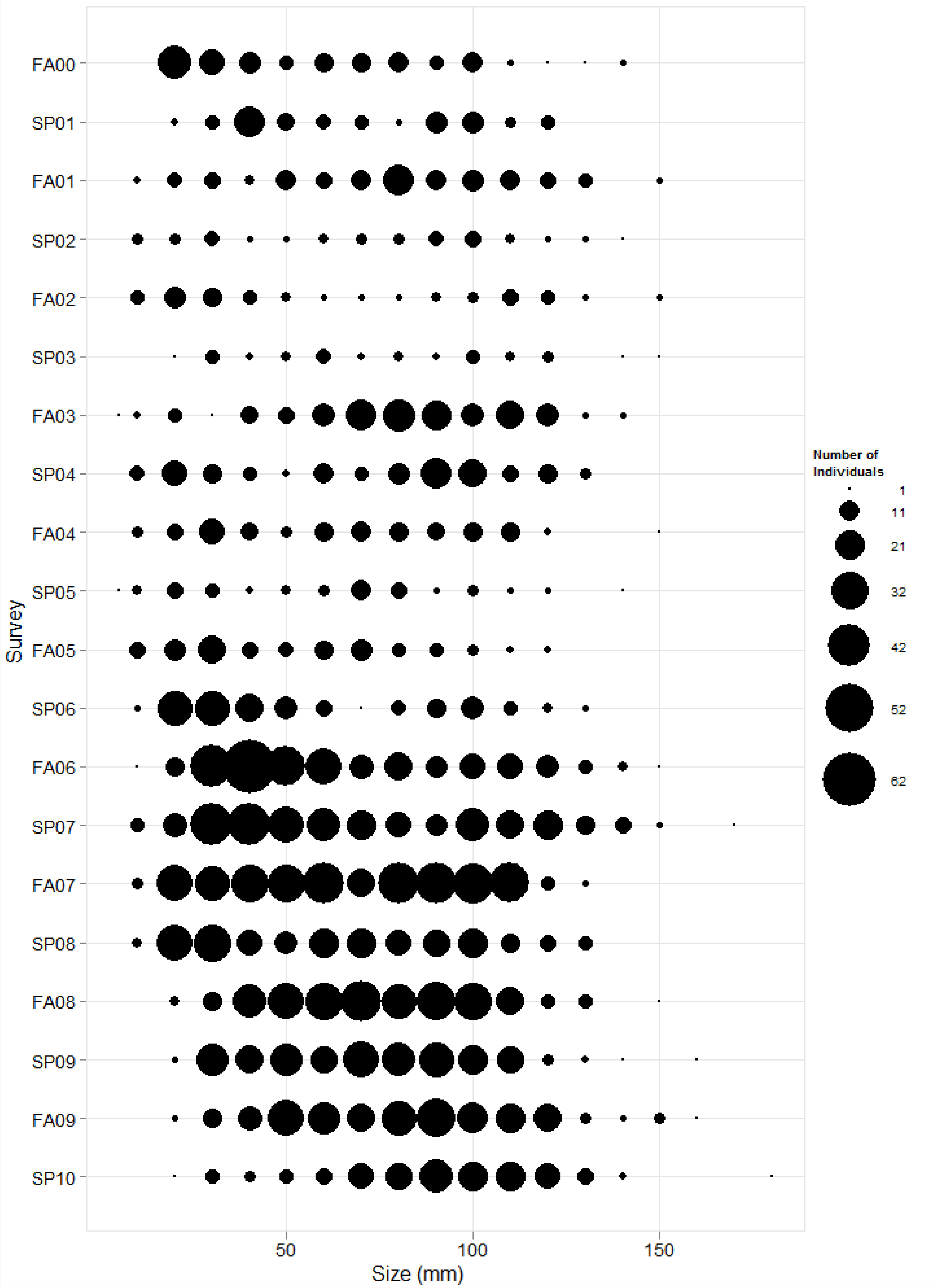


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Shell Beach Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle plots at Shell Beach consist almost exclusively of *Chthamalus dalli/fissus*, although *Balanus glandula* are recorded on rare occasion (note that species were not distinguished until 2001). Barnacle cover was consistently high at this site until 2008, when a sharp drop occurred. As of summer 2010, barnacles had not recovered to initial levels. Littorines were the most abundant motile invertebrate in these plots, followed by limpets. *Tegula funebralis* was commonly found in low numbers.

Mussel cover at Shell Beach was initially high, but then declined during the 1997/98 El Niño event. Mussels experienced a brief recovery in 2003/2004, but then rapidly declined to low levels in subsequent years. Shell Beach is a highly accessible site and thus decline may be due, in part, to trampling and collection for food or bait. The mussel bed at Shell Beach is extremely small, and would be highly impacted by even a small level of collecting. *Endocladia* has slowly colonized the open space within the mussel plots, which could potentially enhance any future settlement of mussels, as this turf alga can act as an ideal recruitment environment for mussels. Fluctuations in the broad group "other invertebrates" largely consisted of periodic mass settlement events of the tube worm *Phragmatopoma,* followed by gradual die-offs. Limpets, and the turban snail *Tegula funebralis*, were quite common in mussel plots at Shell Beach.

Endocladia dominates the mid-intertidal at Shell Beach. This is evident in the trend plots for *Silvetia*, where rockweed cover steadily declined over time, and was replaced largely by turf weed. *Endocladia* was also the most abundant species in *Mastocarpus* plots. Plots established to target *Endocladia* are located in the upper-mid intertidal zone, where the turf weed appeared to be near its upper limit, sharing dominance with barnacles. Littorines, limpets, and *Tegula funebralis* were variable but generally abundant in both *Silvetia* and *Endocladia* plots (motile invertebrates are not counted in *Mastocarpus* plots). *Cyanoplax hartwegii* was present in *Silvetia* plots initially when the shelter-providing rockweed was more common, but became much rarer after cover declined to near zero.

Phyllospadix cover remained relatively high over time at Shell Beach, and exhibited the strong seasonal variation seen at many other sites, with higher cover in fall than in spring. "Other Red Algae" consisted mainly of *Chondracanthus canaliculatus* and *Gastroclonium subarticulatum*.

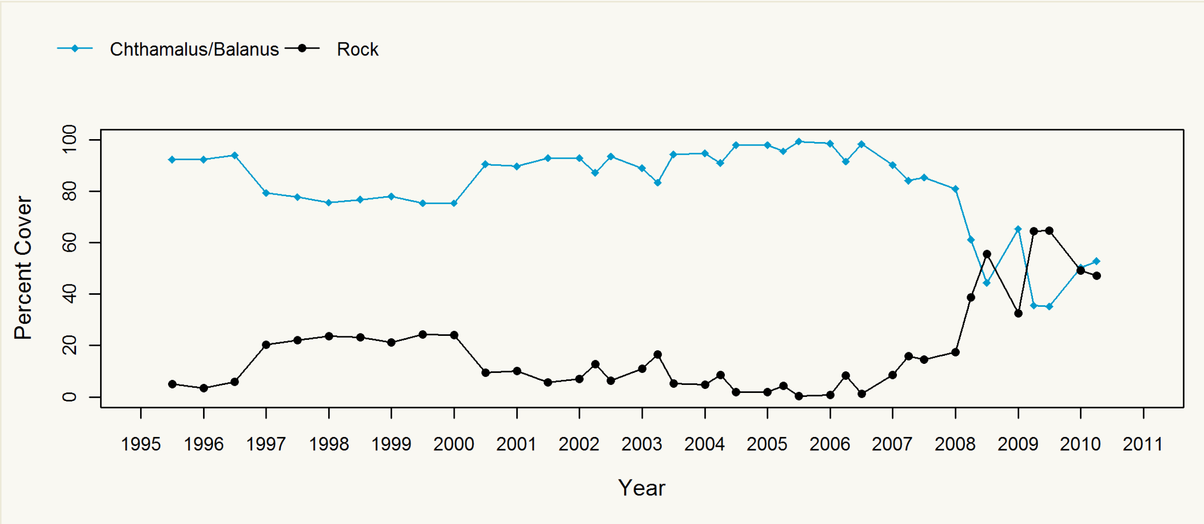
Counts of the seastar, *Pisaster ochraceus*, were variable over time, but in general not very high when compared to other sites. As discussed above, the mussel bed at Shell Beach is small and not very dense; thus the low number of seastars at this site is likely a result of low food availability. *Pisaster* size tended to be skewed toward the larger end of the scale, with juveniles rarely present.

Photo Plots

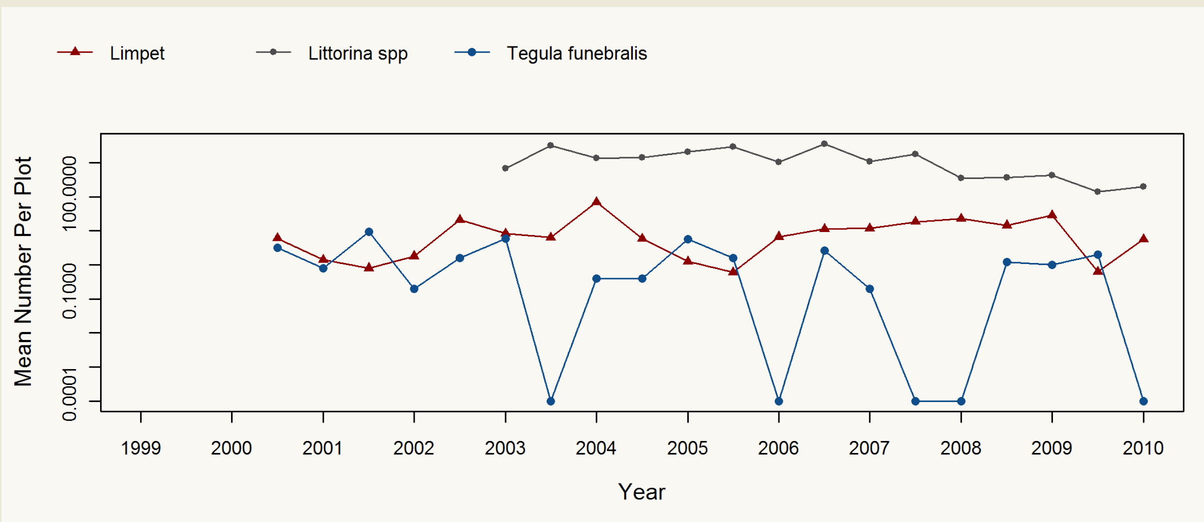
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

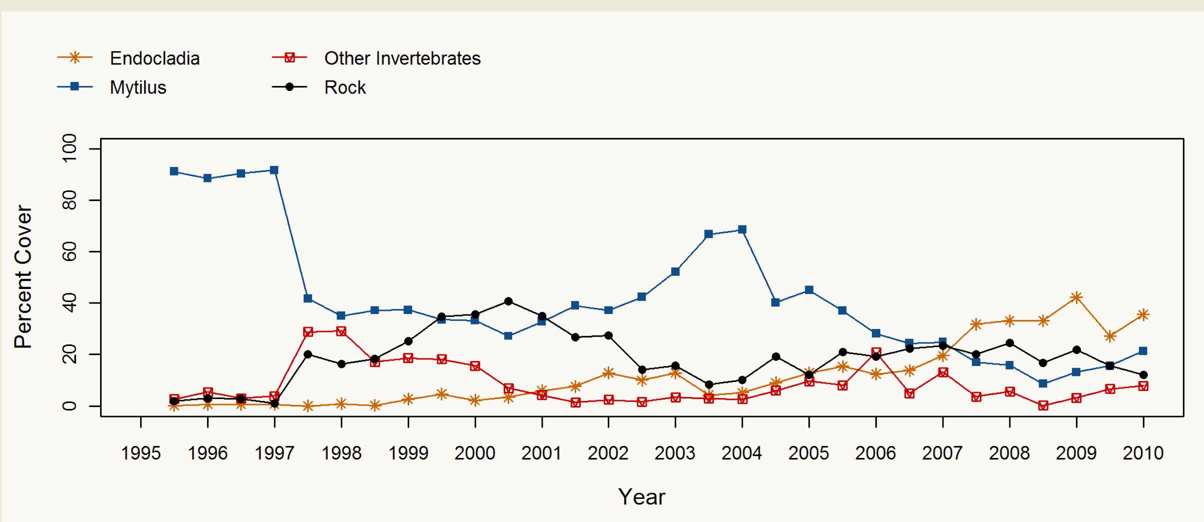
Chthamalus/Balanus (Acorn Barnacles) - percent cover



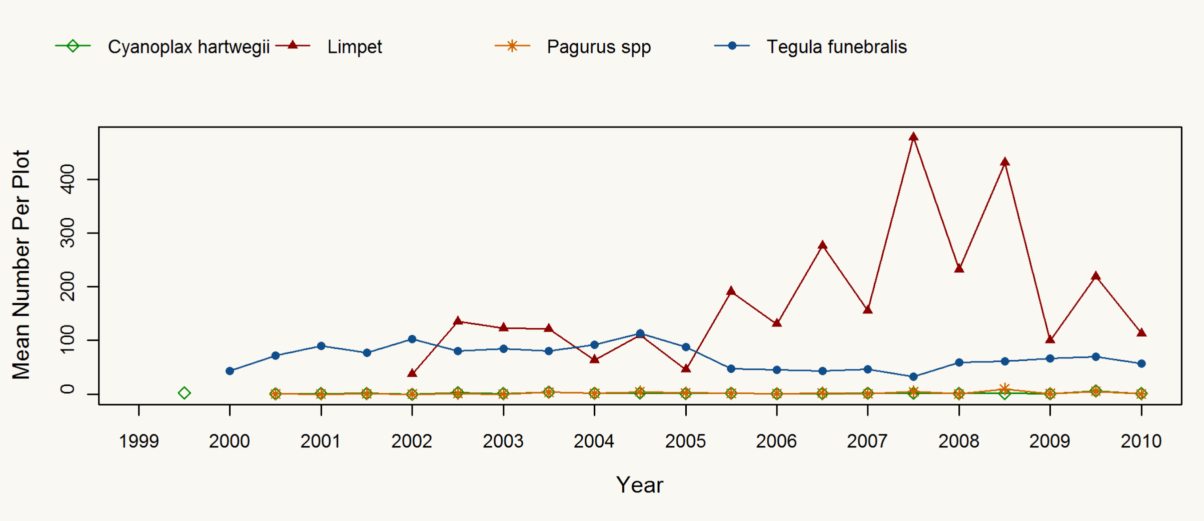
Chthamalus/Balanus (Acorn Barnacles) – motile invertebrate counts



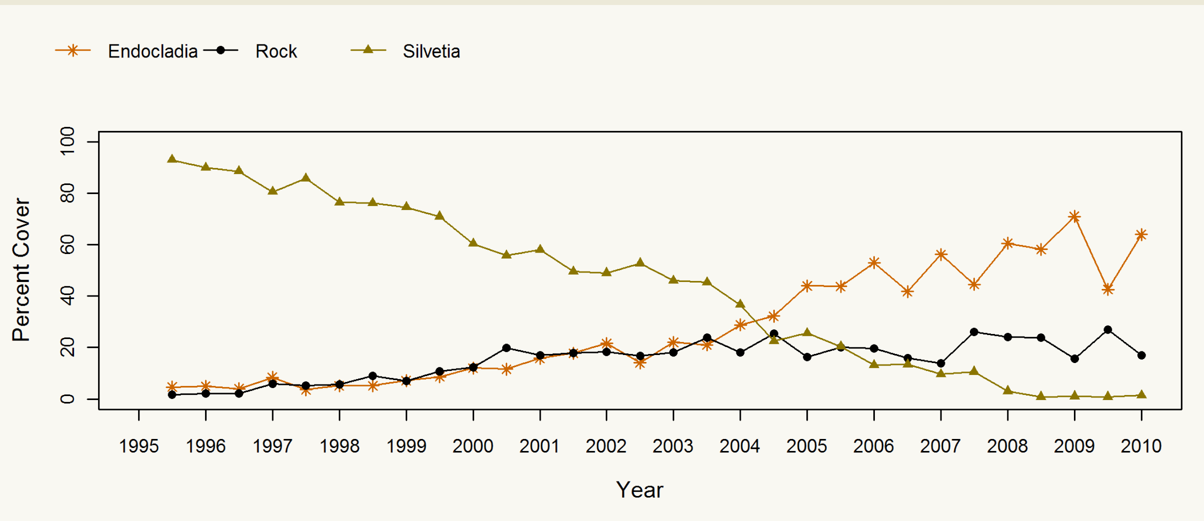
Mytilus (California Mussel) – percent cover



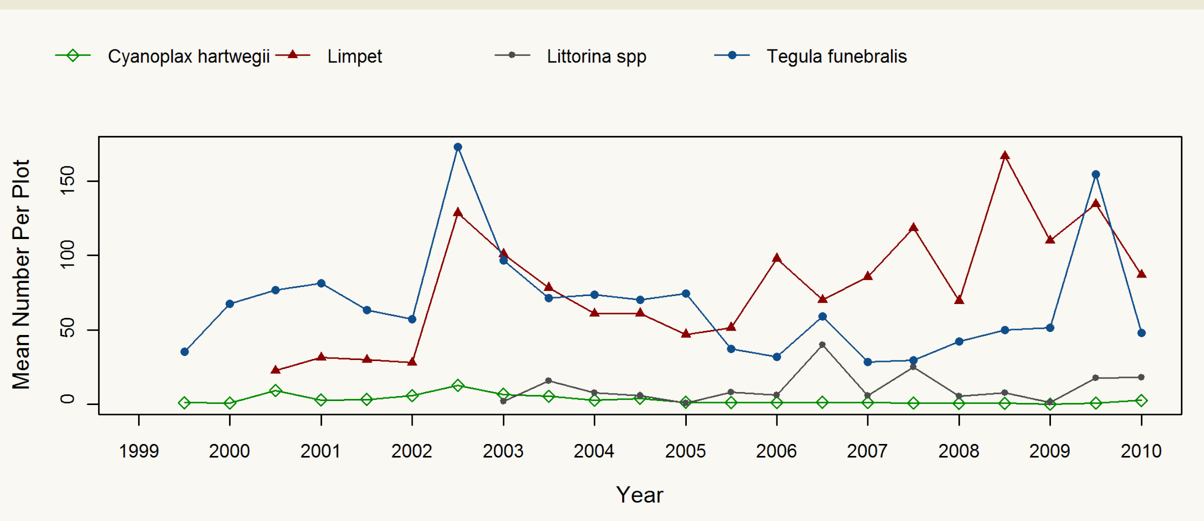
Mytilus (California Mussel) – motile invertebrate counts



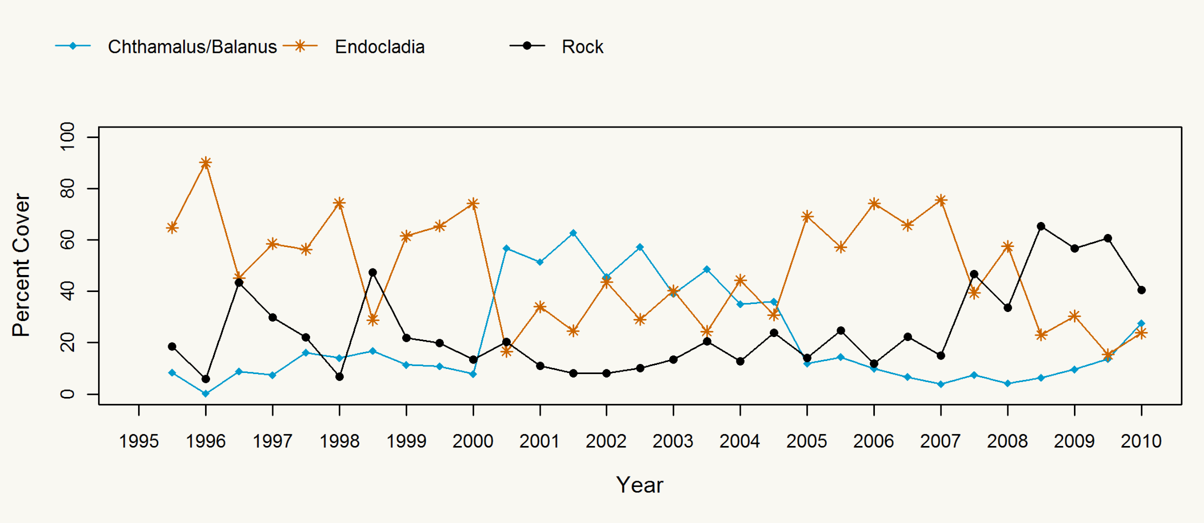
Silvetia (Golden Rockweed) – percent cover



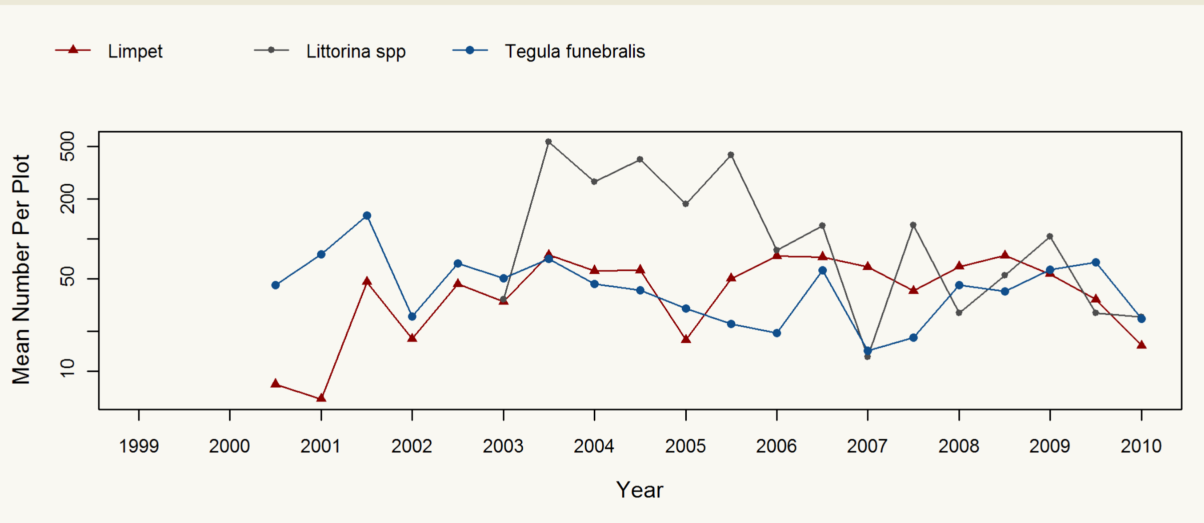
Silvetia (Golden Rockweed) – motile invertebrate counts



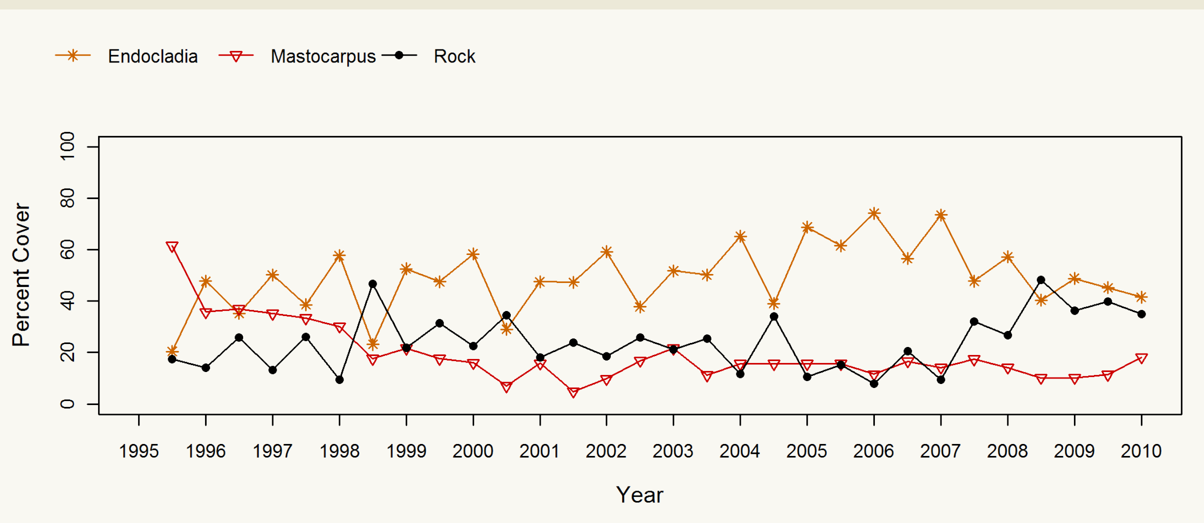
Endocladia (Turfweed) – percent cover



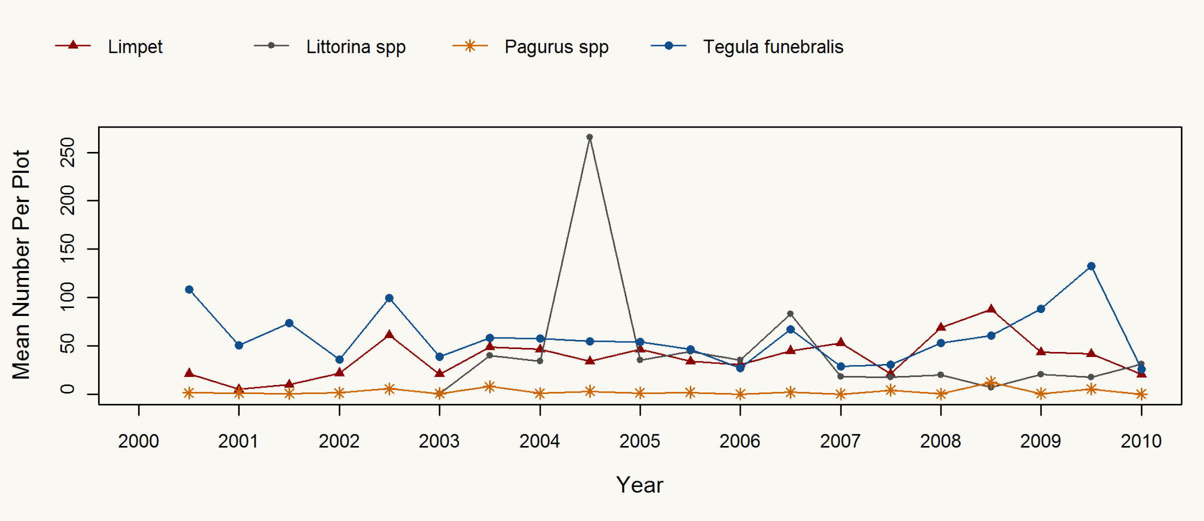
Endocladia (Turfweed) – motile invertebrate counts



Mastocarpus (Turkish Washcloth) – percent cover



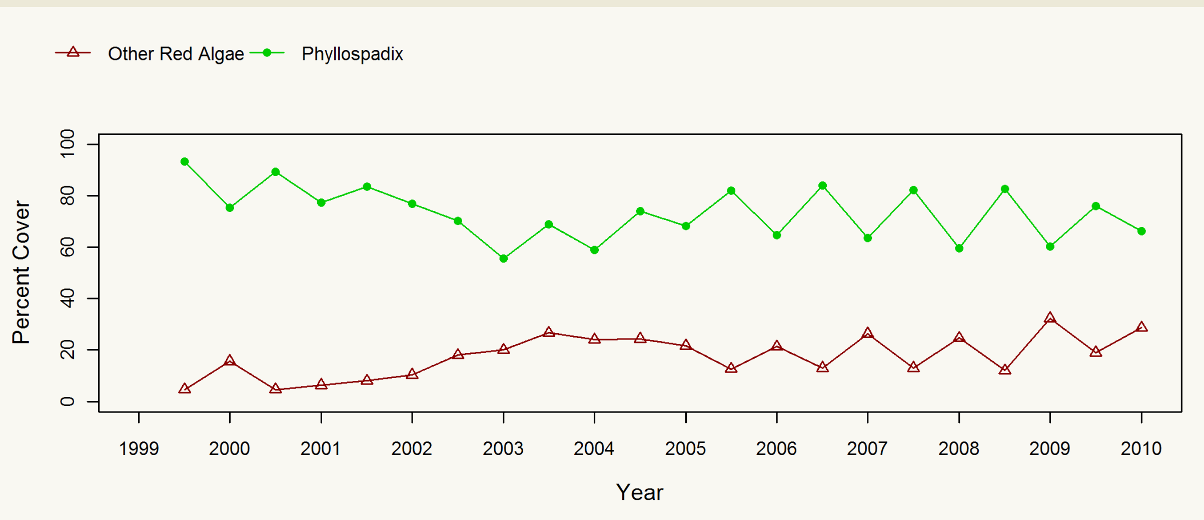
Mastocarpus (Turkish Washcloth) – motile invertebrate counts



Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

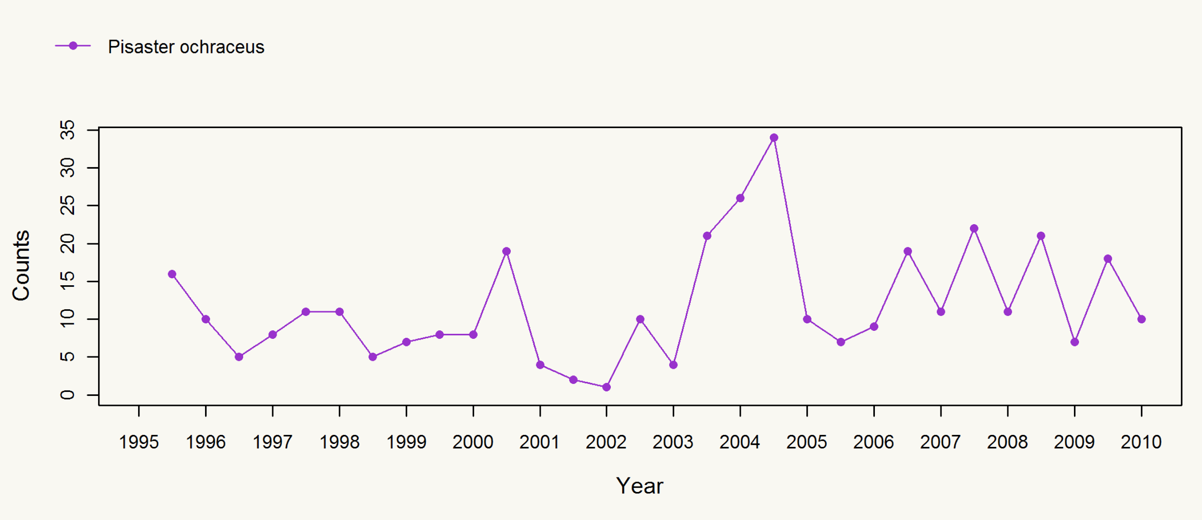
Phyllospadix (Surfgrass)



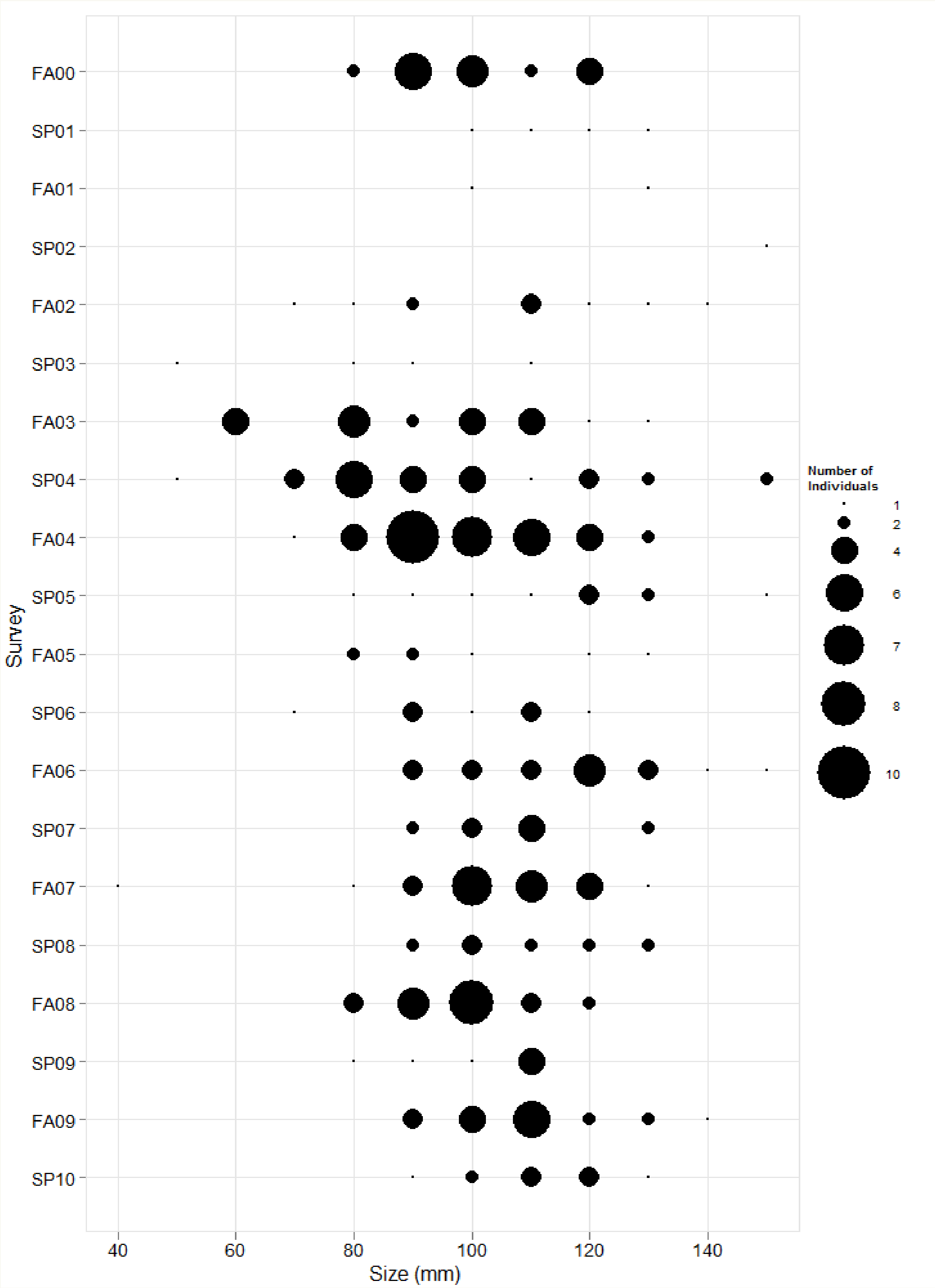
Species Counts and Sizes

Species Counts and Sizes (where recorded) for Pisaster are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Occulto Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacles (a mixture of *Chthamalus fissus/dalli* and *Balanus glandula*) within plots at Occulto declined substantially during the first few years of monitoring, but recovered somewhat in more recent years. While bare space was still present in the plots, much of it has become occupied by mussels and several algal species, including *Endocladia, Silvetia* and *Cladophora*. Barnacles recruiting into this site tended to settle above the barnacle plots, in an area that is at a higher tidal elevation than barnacles were commonly found when monitoring began at Occulto thirteen years ago. Thus, although barnacles in the plots have declined substantially, they are still common at the site overall. Limpets and littorines were common in these high intertidal plots, and a few *Nucella* spp. were found amongst the mussels.

Mytilus cover within the mussel plots at Occulto remained high over time in all but one plot, where mussels were partially removed in winter of 1995, followed by recovery, and then completely torn out in winter 2005. Mussel cover has been slowly recovering in this plot, but other species have colonized the available bare space, including *Mazzaella*, *Phragmatopoma*, and articulated corallines. Limpets are the most abundant motile invertebrate counted in the mussel plots, but other species such as the whelk, *Nucella* spp. (mostly *N. emarginata/ostrina*), and the chiton, *Nuttallina* spp., were also commonly found.

Mytilus has steadily recruited into the *Endocladia* plots and is now a dominant part of what used to be a turf weed dominated community at Occulto. Presence of *Mytilus* does not necessarily exclude *Endocladia*, as the alga can grow on top of mussels. Indeed, *Endocladia* abundance at the site overall is described as “common to abundant”. Limpets and littorines were the most common motile invertebrate found in the *Endocladia* plots, with a few *Nucella* present within mussel patches.

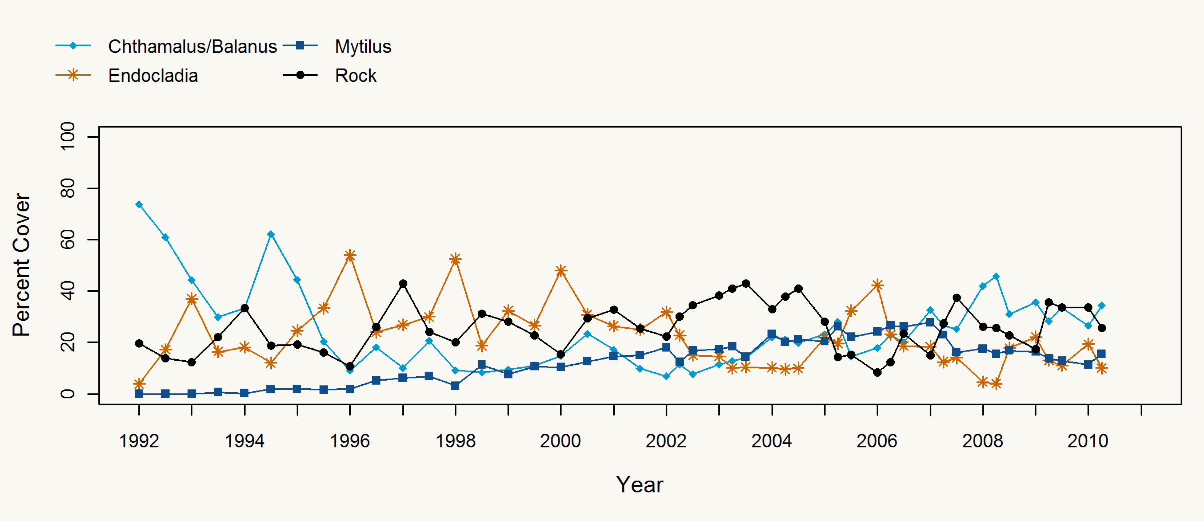
Pisaster counts at Occulto were highly variable, largely because they are influenced by sampling conditions, as much of the plot consists of steep reef edges that can be difficult to sample when the swell is large. Seastar size spanned the entire range with both juvenile and large individuals commonly found.

Photo Plots

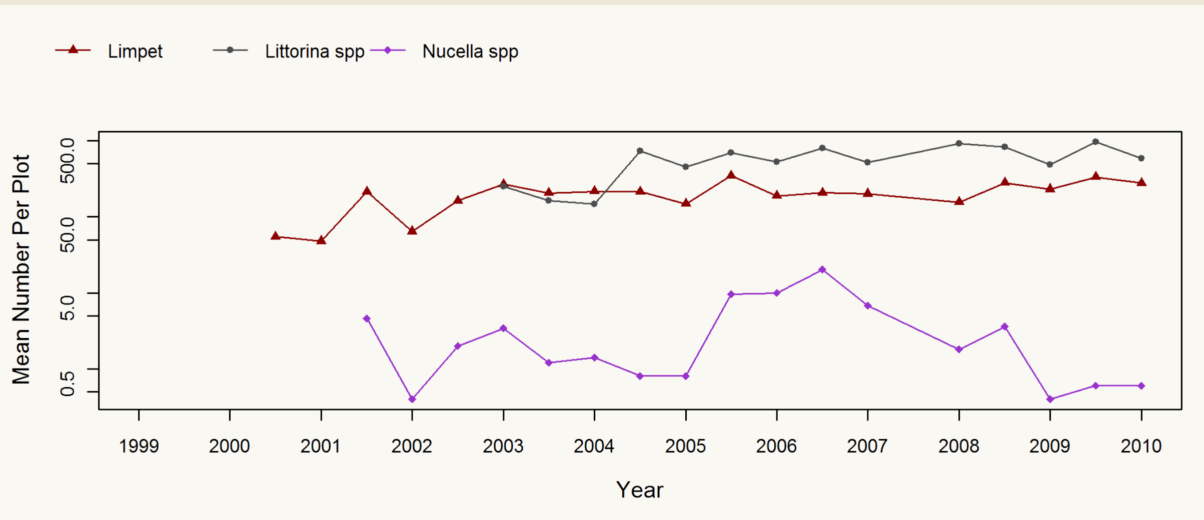
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

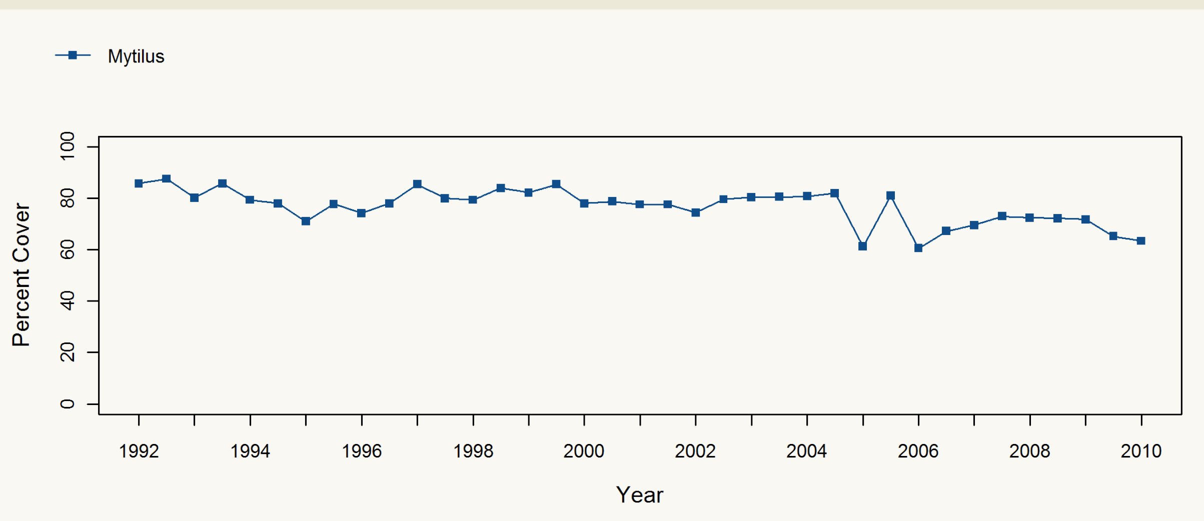
Chthamalus/Balanus (Acorn Barnacles) - percent cover



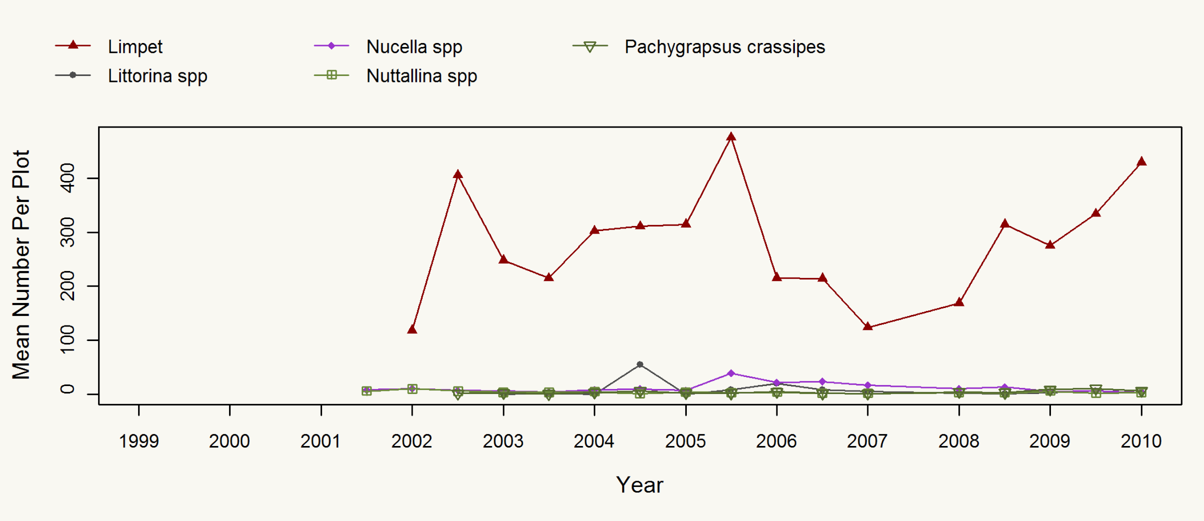
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



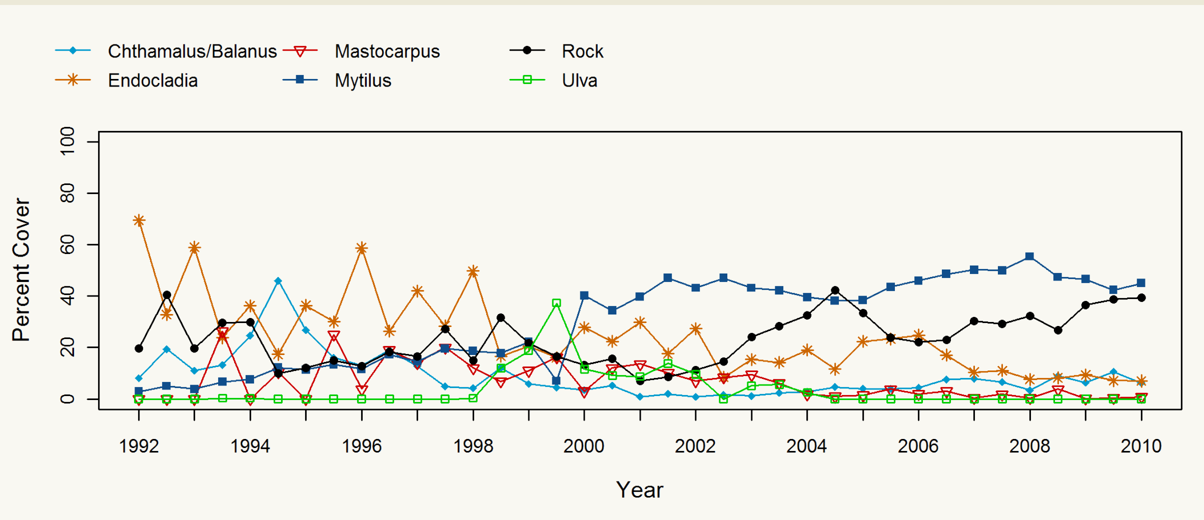
Mytilus (California Mussel) - percent cover



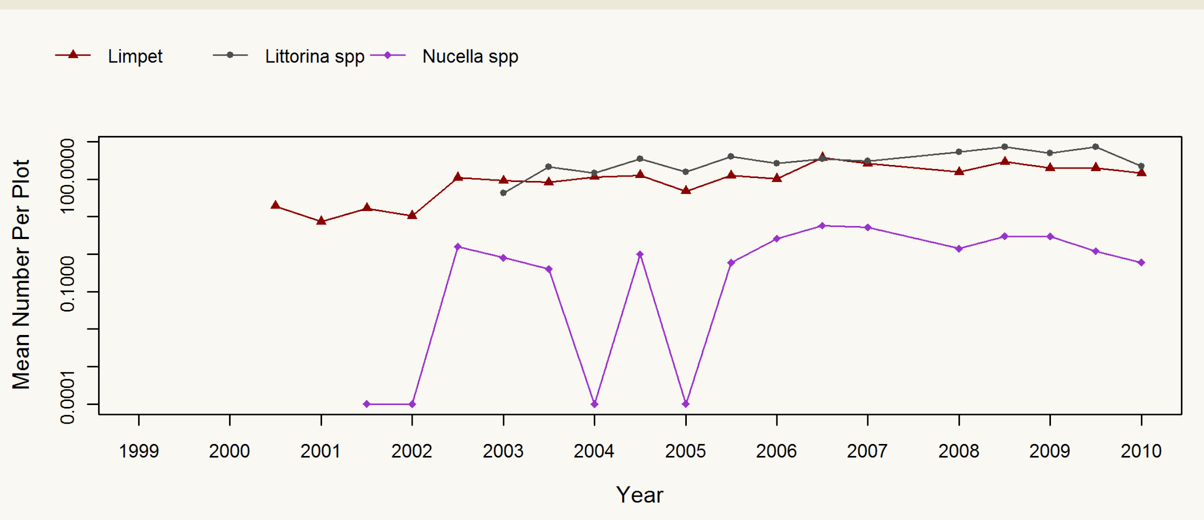
Mytilus (California Mussel) - motile invertebrate counts



Endocladia (Turfweed) – percent cover



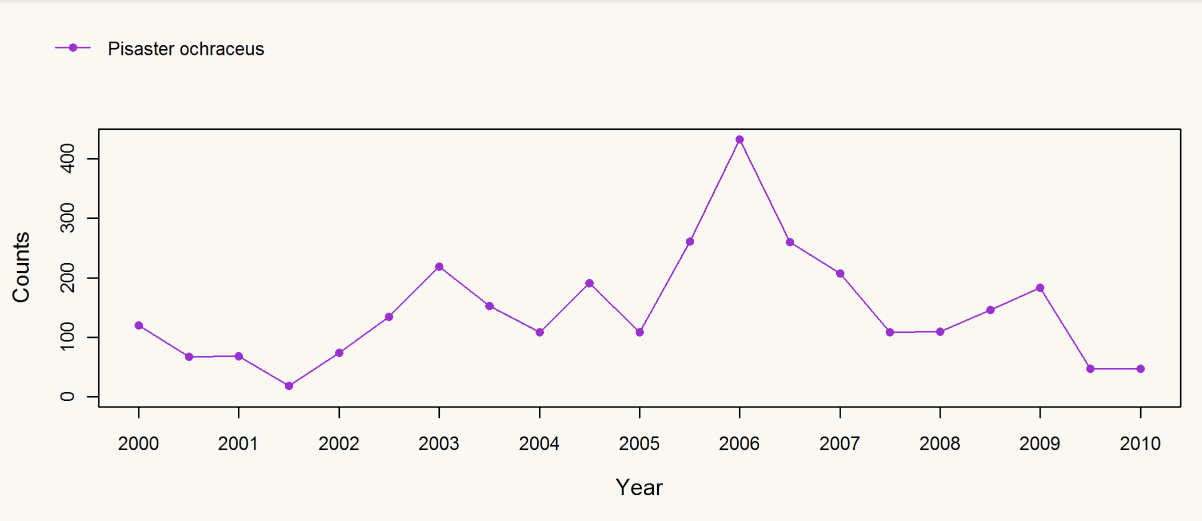
Endocladia (Turfweed) – motile invertebrate counts



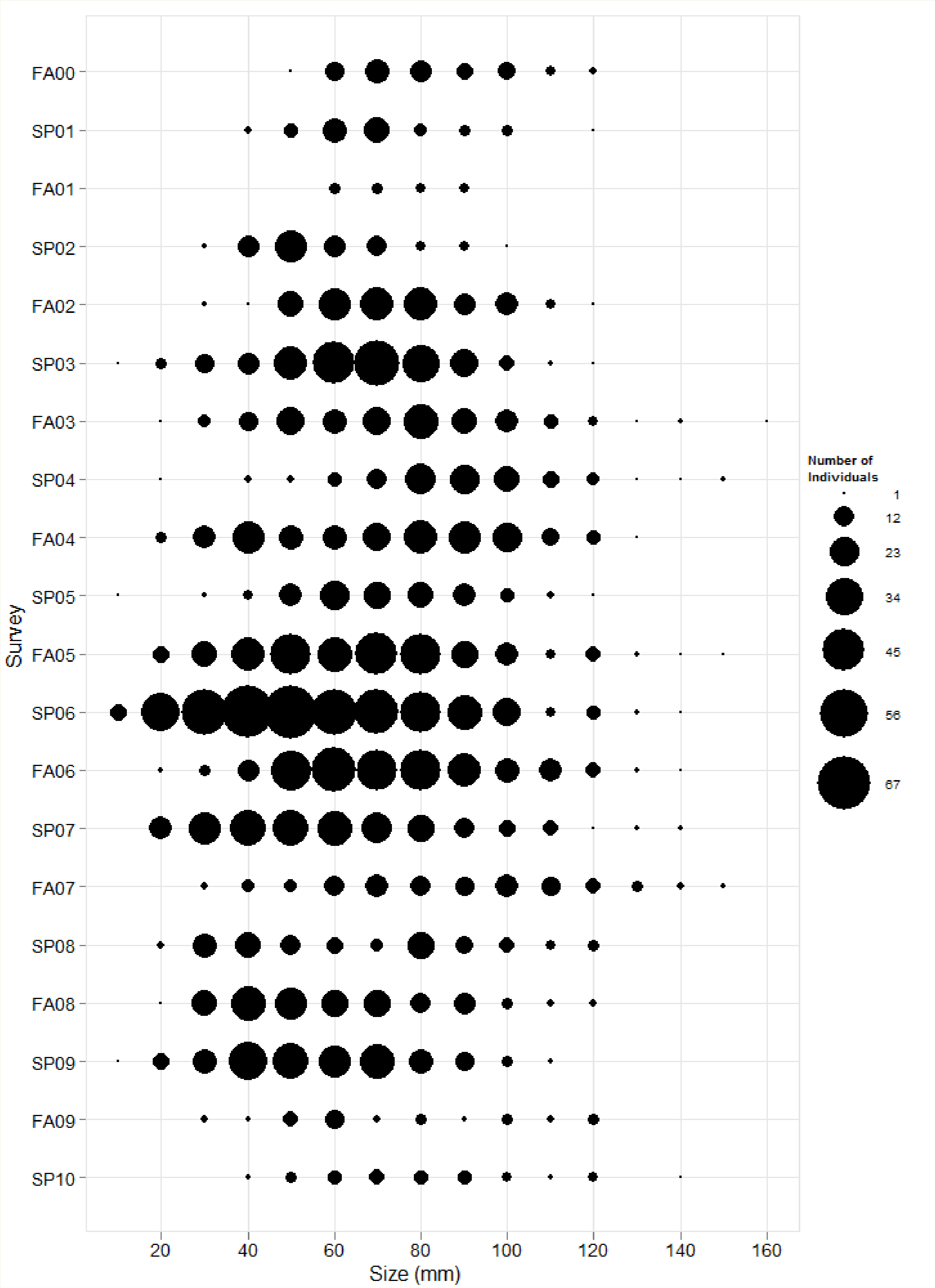
Species Counts and Sizes

Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Stairs Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle plots at Stairs consist solely of *Chthamalus fissus/dalli* (note that species were not distinguished until 2001). Barnacle cover remained fairly high until 1997/1998, when both a large El Niño event and an oil spill impacted the site, and may have affected barnacles (see discussion below and "Publications and Data Products" section). Barnacle cover continued to plummet until around 1999/2000, when levels in all plots were less than 10%. A slight recovery was seen in four plots beginning in 2004, but cover has remained low in the fifth plot. No other species was recorded at any significant level within these plots. Limpets and littorines were present in the barnacle plots at Stairs, but were not as abundant as at most other sites.

Mytilus californianus cover in mussel plots was quite high until 1997, when Stairs was hit hard by a series of large-wave events associated with the 1997/98 El Niño. Mussels were likely stressed by the warmer water, and were ripped out in two plots by large waves. Some recovery has occurred in these plots over time, but slow, steady decline in two other plots has resulted in a mean cover of around 40% since 1998. Species filling in the available space within mussel plots include: *Mazzaella* spp, articulated corallines, and non-coralline crusts (crustose forms of non-coralline red algae). Limpets were by far the most common motile invertebrate present in mussel plots at Stairs. Other species present included the snails, *Tegula funebralis* , *Nucella* spp. (mostly *N. emarginata/ostrina*) and littorines, and the chiton, *Nuttallina* spp.

Cover of the rockweed, *Silvetia*, within plots where it was targeted was initially high, and then declined somewhat in 1995. As with most other species at Stairs, *Silvetia* was severely impacted by the 1997/98 El Niño event, and cover declined and then stabilized (with seasonal variation) at around 25%. This decline was accompanied by a slight increase of *Endocladia*, but rock cover also increased, indicating that some open space was not colonized by other species. Non-coralline crusts increased in several plots, and another rockweed, *Fucus,* colonized one plot. Although *Silvetia* cover has declined in the plots, it is common at the site overall. In fact, Stairs is one of the only sites in the entire MARINe network where all four west-coast rockweed species are present (*Pelvetiopsis*, *Hesperophycus*, *Silvetia*, and *Fucus*). Limpets and the turban snail, *Tegula funebralis,* were the most common species found within *Silvetia* plots at Stairs. Littorines were also present.

Endocladia cover in the *Endocladia* plots remained relatively constant over time, with strong seasonal variation (higher in spring). This seasonal fluctuation is typical of *Endocladia* and was observed at other sites. Limpets and littorines were abundant in these high intertidal plots.

"Recovery" plots were established after the 1997/98 El Niño event, when huge sections of reef (up to 17m x 5m) were removed by extreme wave events, leaving several large, newly exposed areas of bare rock. These natural clearings provided us with a unique opportunity to document community succession in the mid-intertidal. Nearly all succession studies are done in artificially cleared patches, which are small relative to the reef size and often recover via encroachment by surrounding species. Because newly exposed sections of reef at Stairs were so large, they were likely to "recover" via colonization by propagules and thus had the potential to develop into communities quite different from surrounding, undisturbed areas. Eight recovery plots were originally set-up, but four have been lost over time due to subsequent large-wave events that have removed additional sections of reef. "Non-coralline crusts", the crustose forms of red and brown algae, were among the earliest colonizers of these completely bare plots. In these plots, non-coralline crusts consisted primarily of *Ralfsia* spp., *Petrospongium rugosum*, and the crustose form of *Mastocarpus* (formerly called "*Petrocelis*"). Unexpectedly, the green alga, *Cladophora*, also colonized a few plots early on and then disappeared. Non-coralline crusts have persisted in all remaining recovery plots, and the rockweed, *Silvetia* has also moved in. A large amount of bare rock is still present, so it is likely that it will be several more years before these plots reach a "stable state".

Surfgrass (*Phyllospadix*) was impacted more than any other species by the 1997/98 El Niño event, experiencing a nearly 80% loss between fall 1997 (pre-storm destruction) and spring 1998 (post-destruction). Surfgrass grows from rhizome-like holdfasts, and has difficultly re-establishing itself once these holdfasts have been removed. The large wave events associated with the El Niño storms ripped out nearly all rhizomes, and even removed large sections of rock within the transects where surfgrass is sampled. Thus, it is surprising and encouraging that surfgrass has been steadily recovering in the years following this destructive event. Only two transects were sampled in fall 1998.

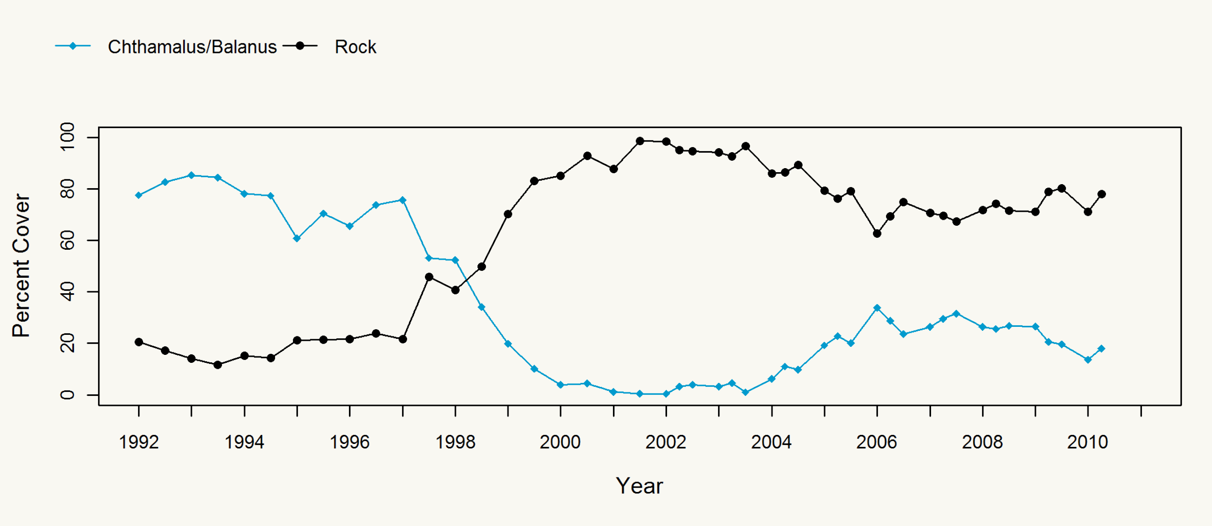
Pisaster (ochre seastar) numbers have fluctuated substantially at Stairs, but the long-term trend shows little change overall. *Pisaster* sizes are fairly evenly distributed for most samples, with radius measurements generally concentrated between 30mm-130mm, indicating good recruitment and retention of adults.

Photo Plots

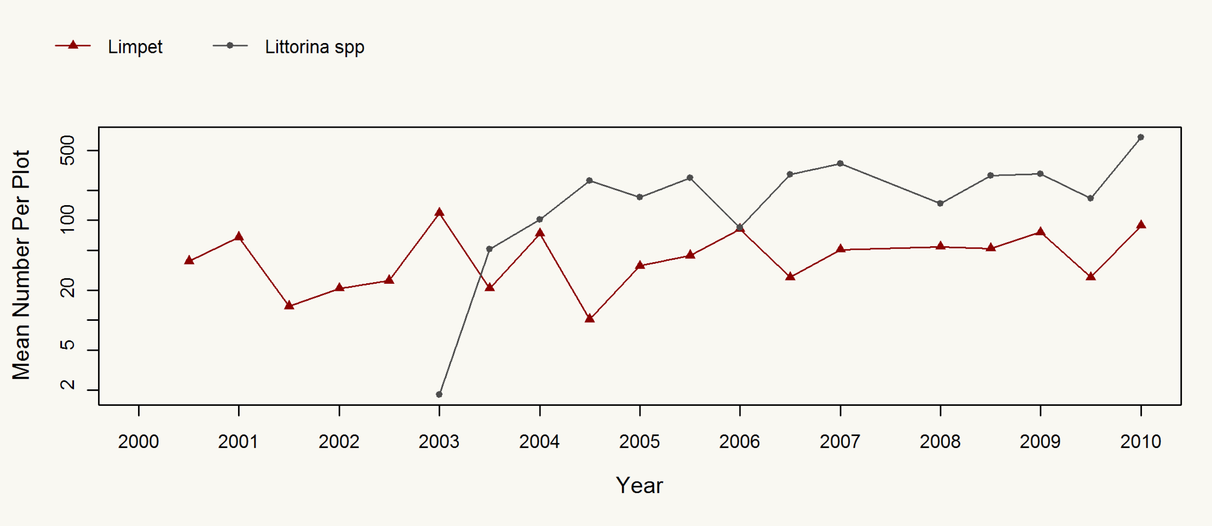
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

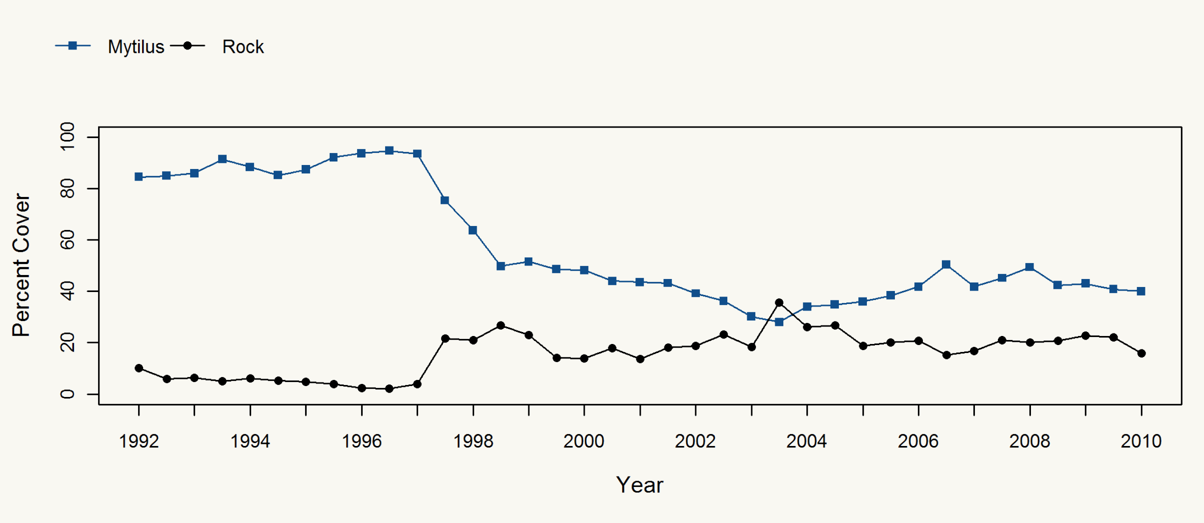
Chthamalus/Balanus (Acorn Barnacles) - percent cover



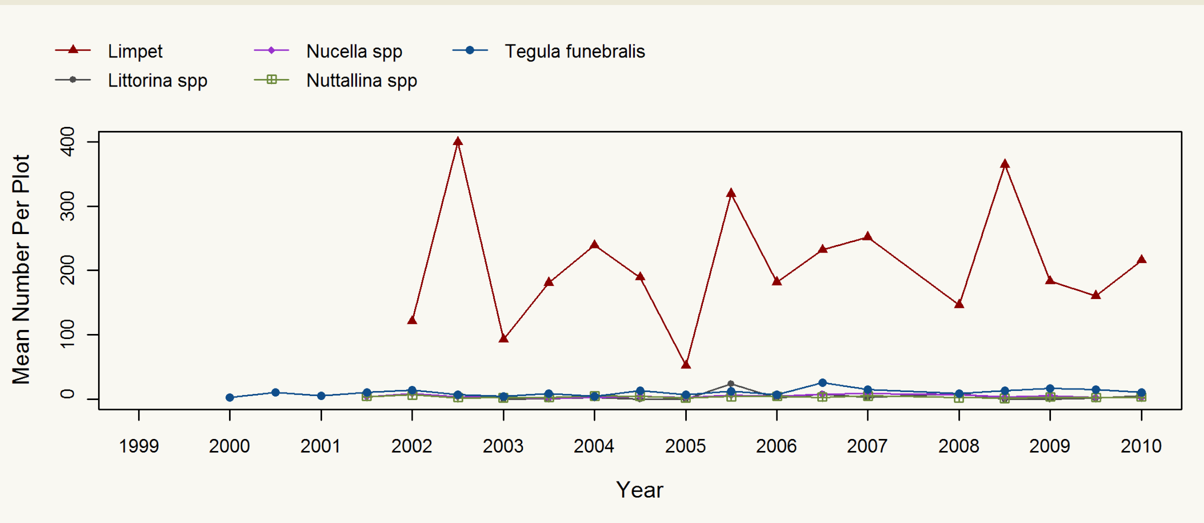
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



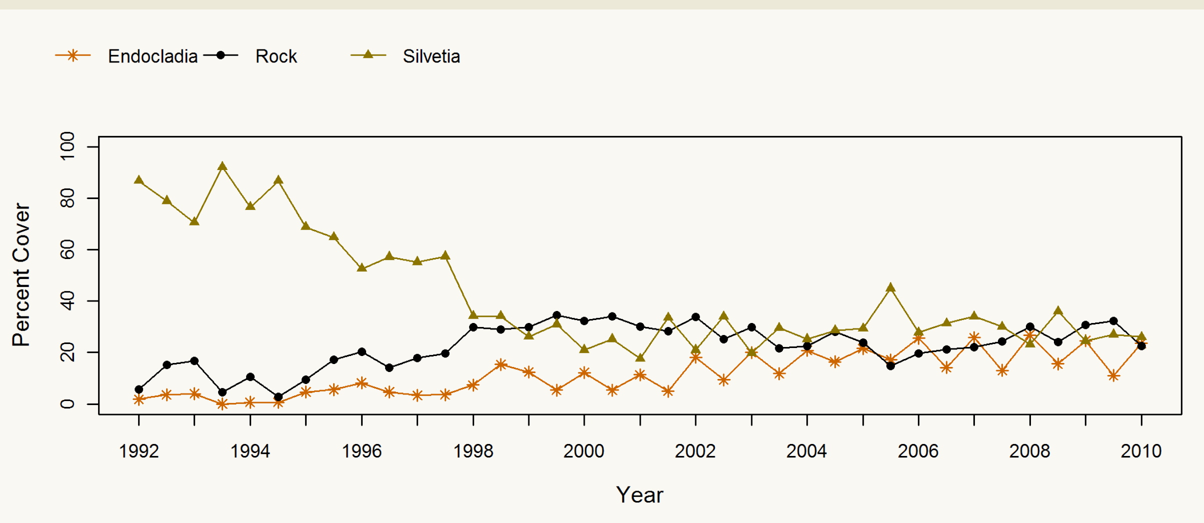
Mytilus (California Mussel) - percent cover



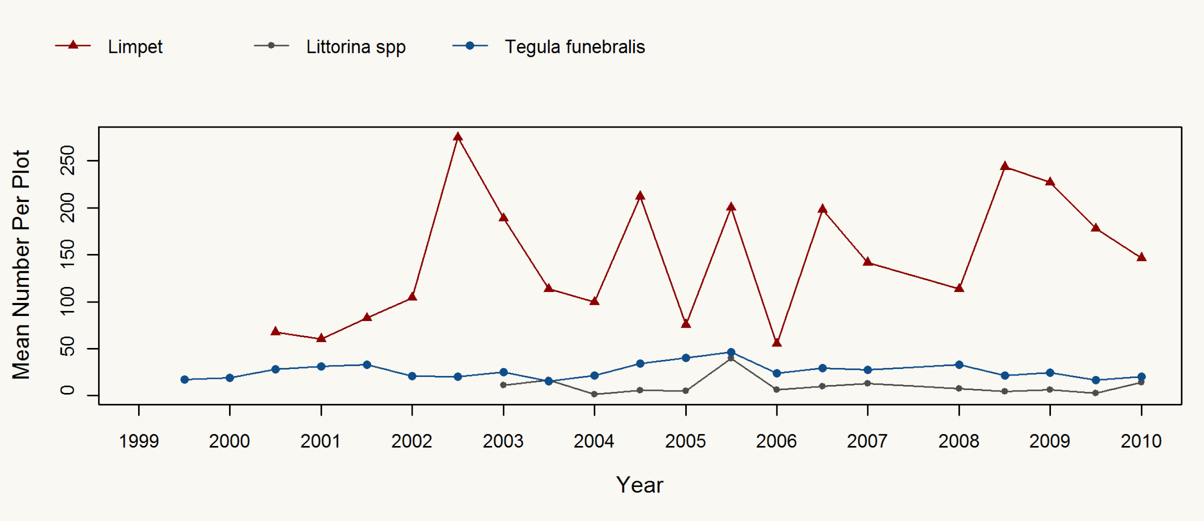
Mytilus (California Mussel) – motile invertebrate counts



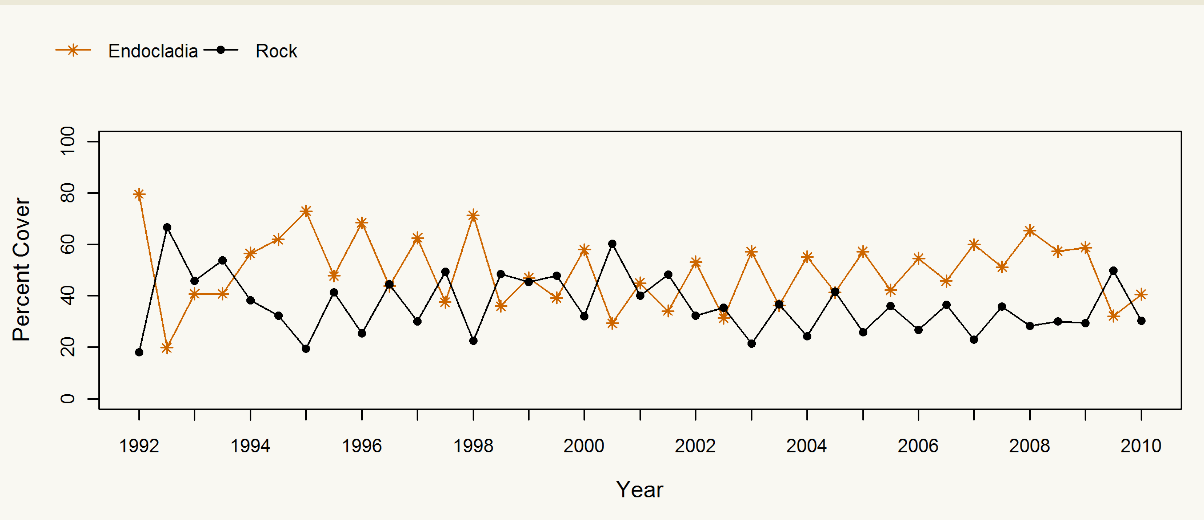
Silvetia (Golden Rockweed) – percent cover



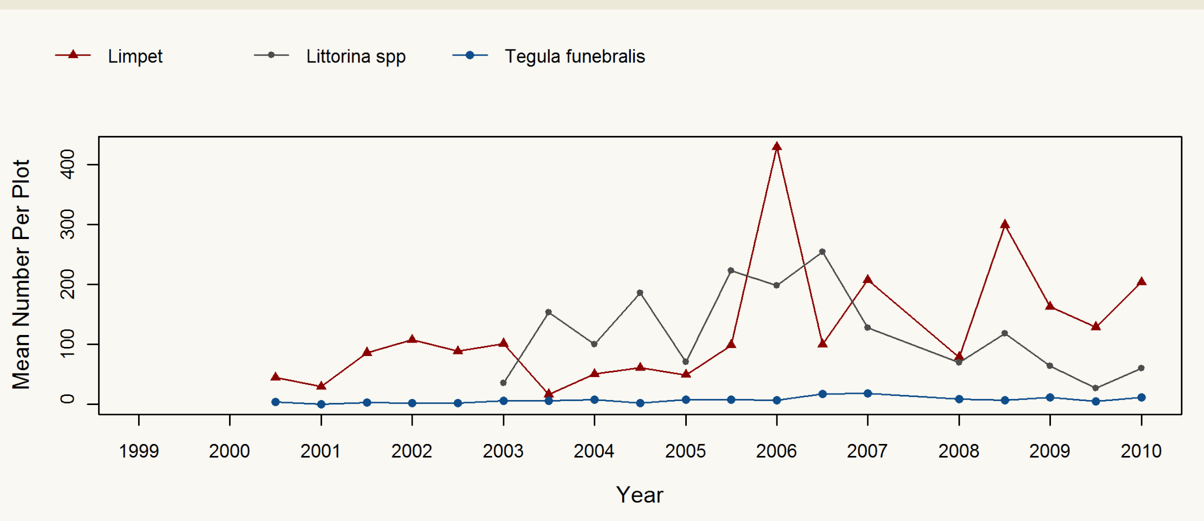
Silvetia (Golden Rockweed) – motile invertebrate counts



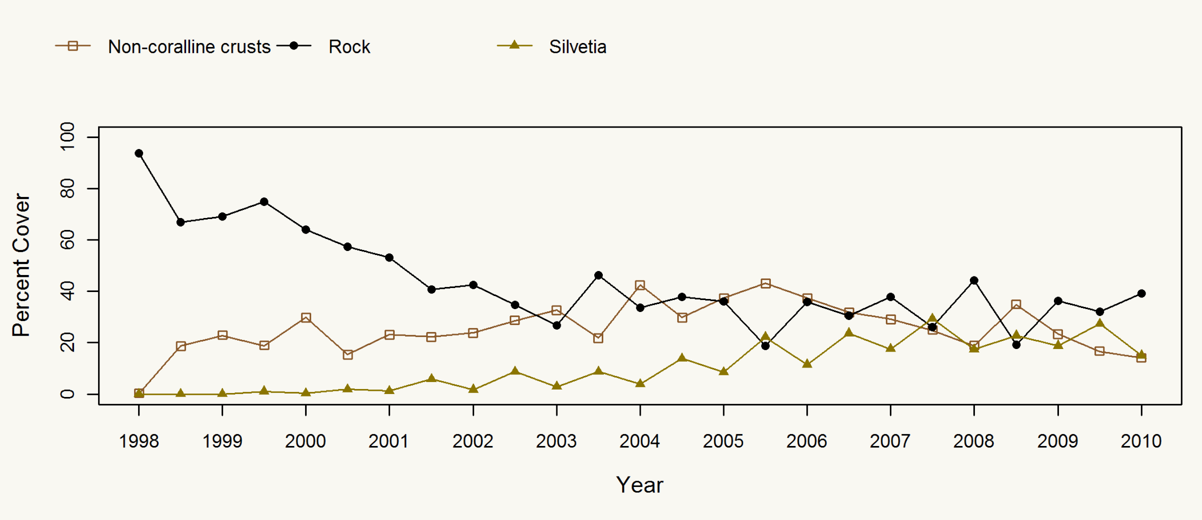
Endocladia (Turfweed) – percent cover



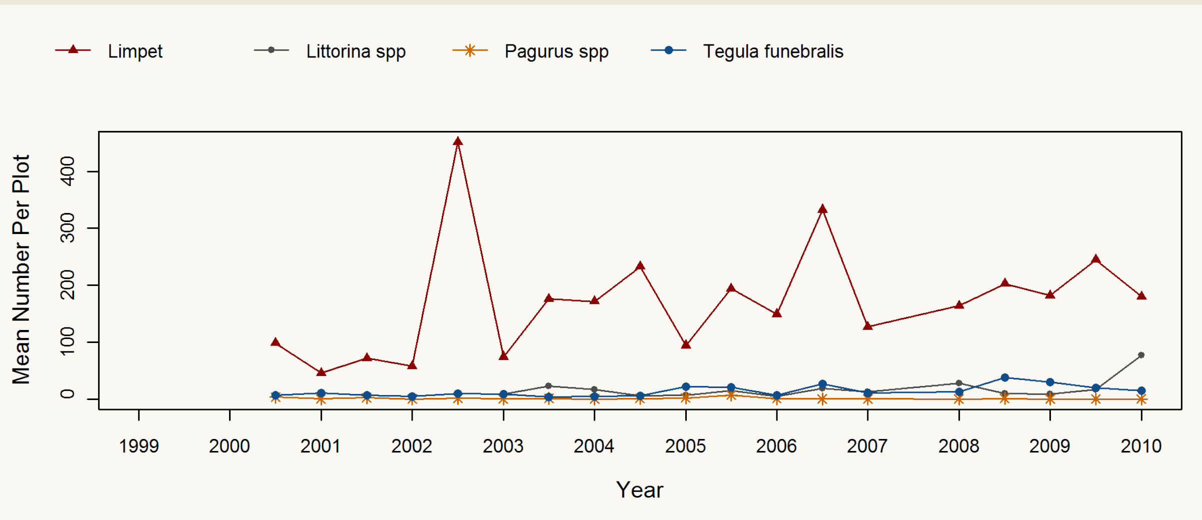
Endocladia (Turfweed) – motile invertebrate counts



Recovery – percent cover



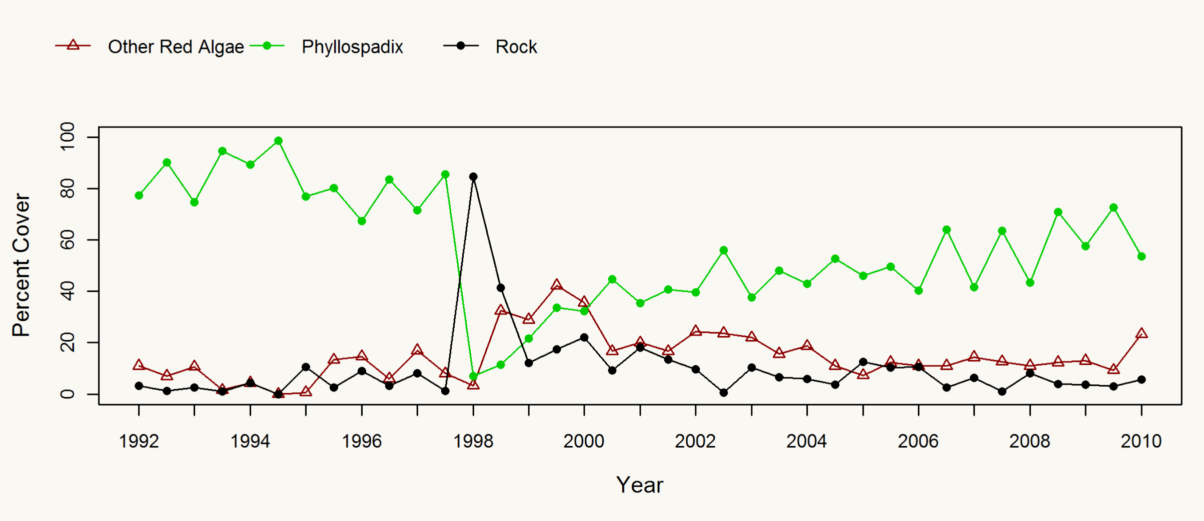
Recovery - motile invertebrate counts



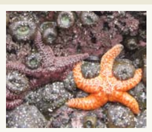
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

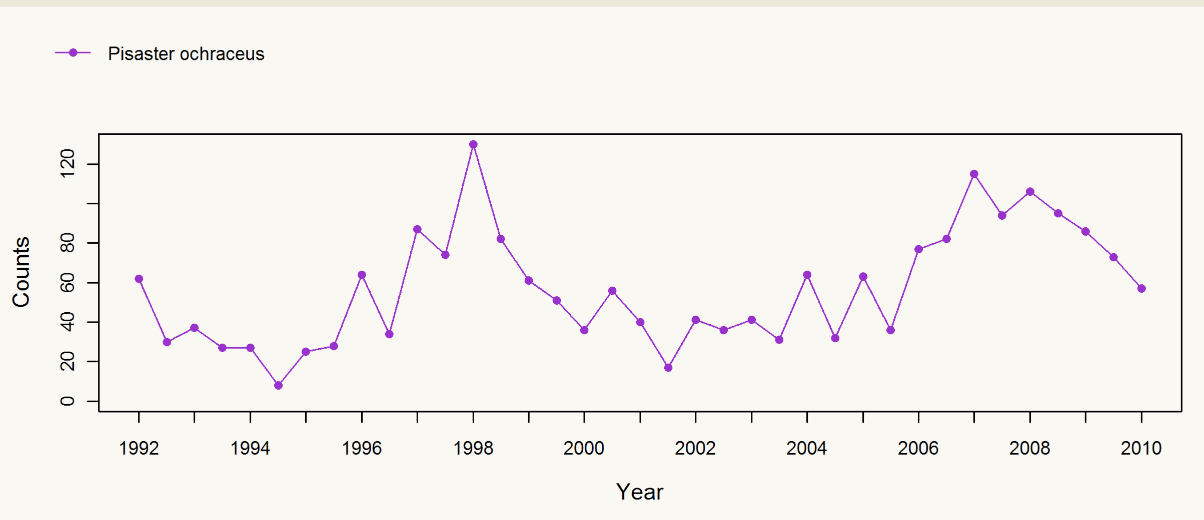


Species Counts and Sizes

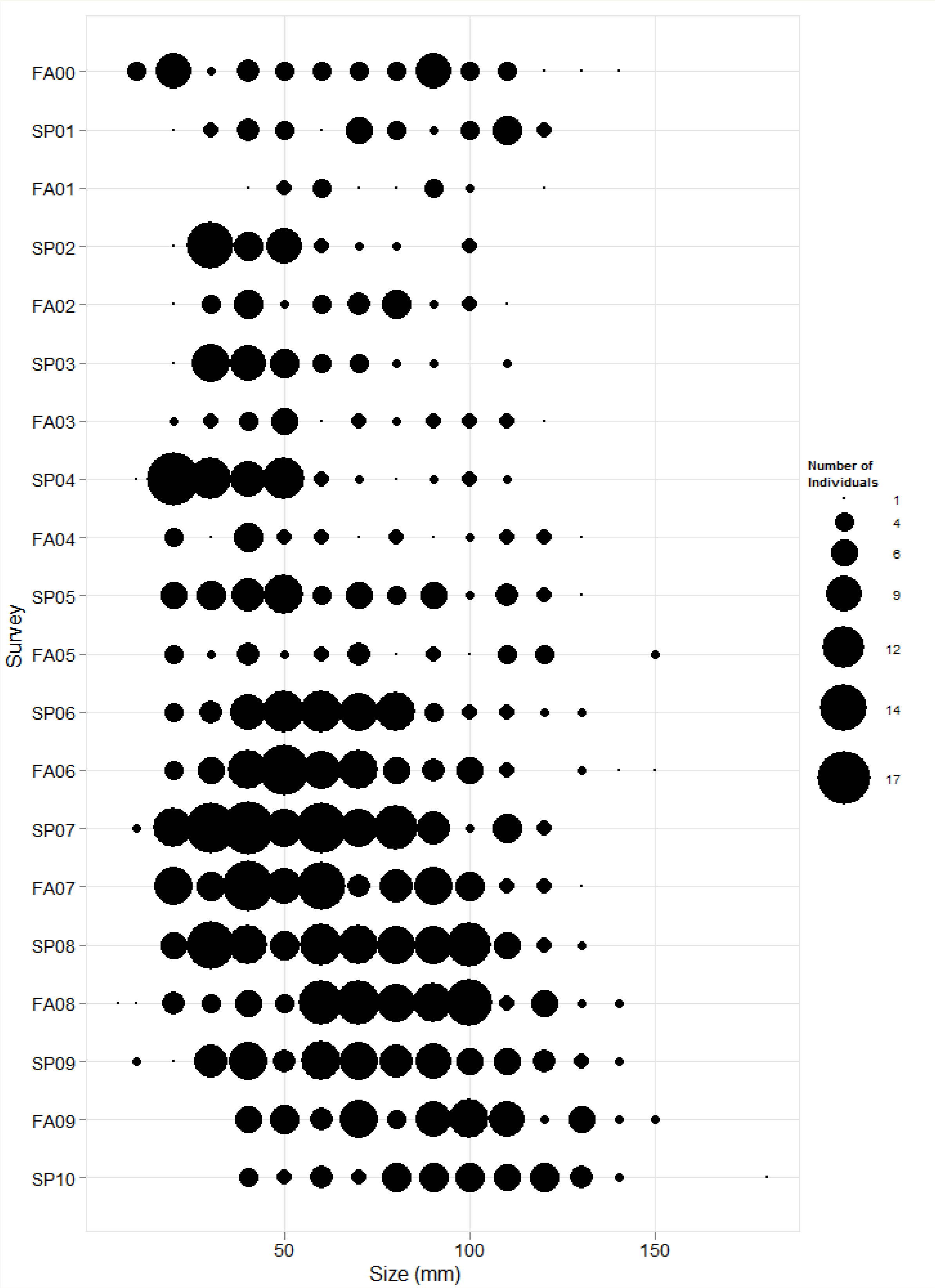


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Boathouse Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Anemone plots at Boathouse are mainly a mixture of medium-sized, solitary *Anthopleura sola*, and several small species of red algae (primarily *Chondracanthus canaliculatus*). *Chondracanthus canaliculatus* has been recorded as having high cover at this site overall by the biodiversity surveys. Anemone cover has been fairly low but constant over the nearly 20 year span that this long-lived species has been monitored.

Barnacle plots at Boathouse mainly consist of *Chthamalus dalli/fissus*, although *Balanus glandula* has occasionally reached cover levels as high as 15-20% in three of the five plots (note that species were not distinguished until 2001). Cover of *Chthamalus/Balanus* in the barnacle plots at Boathouse was initially high (approximately 80%) and then plummeted to around 20% for the next several years, replaced largely by the red turf alga, *Endocladia*. *Endocladia* cover remained fairly high in most plots until around 2001, when it experienced a sharp decline in all five photoplots. *Endocladia* cover remained low in all but one plot, which is somewhat lower in tidal elevation, and thus desiccation stress on the alga is likely lower. The decline in *Endocladia* cover was accompanied by an increase in *Chthamalus/Balanus* cover, which steadily rose until 2004, when it stabilized around 80%.

A similar swapping of species occurred in the *Endocladia* plots, where declines of the red turf alga in 1992 and 1998 were followed by steady increases in the rockweed, *Silvetia*. *Silvetia* cover experienced a sharp decline in 2008, and it appears that *Endocladia* is beginning to fill the available bare space.

Silvetia cover in *Silvetia* plots remained high over much of the nearly 20 year monitoring period, although cover declined somewhat around 2008/2009. In some plots this open space remains bare, whereas in others it has been filled in somewhat by *Endocladia* and the red blade alga *Mazzaella*. Silvetia plots were not sampled in fall 1995.

Further investigation into the dynamic interaction among barnacles, *Endocladia*, and *Silvetia* over space in the upper intertidal has revealed that the barnacle zone has experienced periods where it shifted upward, into areas that were previously bare rock. It had long been assumed that the upper limits of species' zones were set by physical factors such as temperature and emersion time, and were thus stable, while the lower limits were set by biological interactions (e.g. competition and predation). However, the upward shifts of species zones documented in this study suggest that facilitation, a biological factor, is important for establishing species' upper limits. In this case, barnacles are facilitating the upward movement of *Endocladia* by providing favorable settlement substrate and a refuge from grazers, and *Endocladia* is providing suitable habitat for *Silvetia*, above the zone where it previously occurred. The process is likely "reset" every so often by an extreme event (e.g. large storm waves or a period of above average warm weather), which removes *Endocladia* and *Silvetia* living above their "normal" tidal level, freeing up bare space for new settlement of barnacles.

Limpets and littorines were the dominant motile invertebrates in the barnacle and *Endocladia* plots. These species were also present in the *Silvetia* plots, but generally to a lesser degree. A third species, *Tegula funebralis* was common in all three plot types, increasing in abundance with decreasing tidal height, with counts generally highest in *Silvetia* plots and lowest in barnacle plots. A fourth species, *Pagurus* spp. was common only in *Silvetia* plots.

Mytilus cover remained relatively high throughout most of the nearly 20 year period that mussel plots have been monitored at Boathouse. One exception was plot 4, which was accidently cleared in winter 2005 by another researcher working at the site. Recovery of *Mytilus* has been slow in this plot, likely because a number of owl limpets (*Lottia gigantea*) moved into the open space. These large grazers maintain algal "farms", within which they remove most newly settled organisms in order to provide a large area for diatoms to grow. Limpets were by far the most common motile invertebrate counted in the mussel plots. These were largely small individuals that we do not identify to species, but as stated above, there has been an increase in *Lottia gigantea* numbers in these plots, particularly in plot 4.

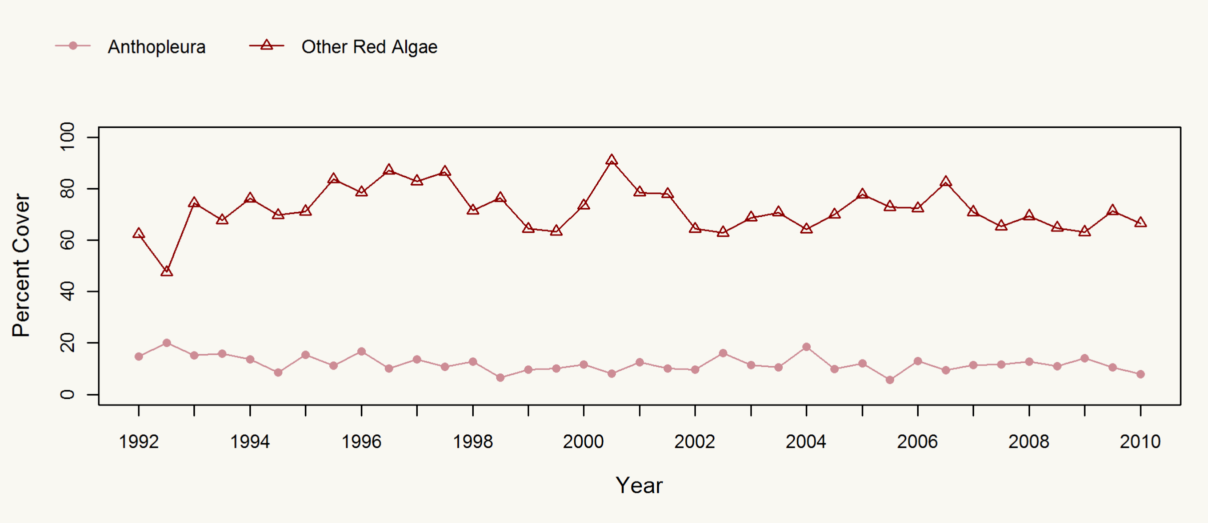
Seastars at Boathouse were variable in number over time, but have shown no long-term trend of decline or increase. High variation in abundance is expected among samples for highly mobile species such as seastars. Relatively small (<50mm) *Pisaster ochraceus* are common at this site, indicating that recruitment to the region must be fairly constant. Boathouse is one of the few sites monitored by MARINe where the bat star, *Patiria miniata*, is found consistently in seastar plots. This species typically occurs in the subtidal, or very low intertidal, below our monitoring plots.

Photo Plots

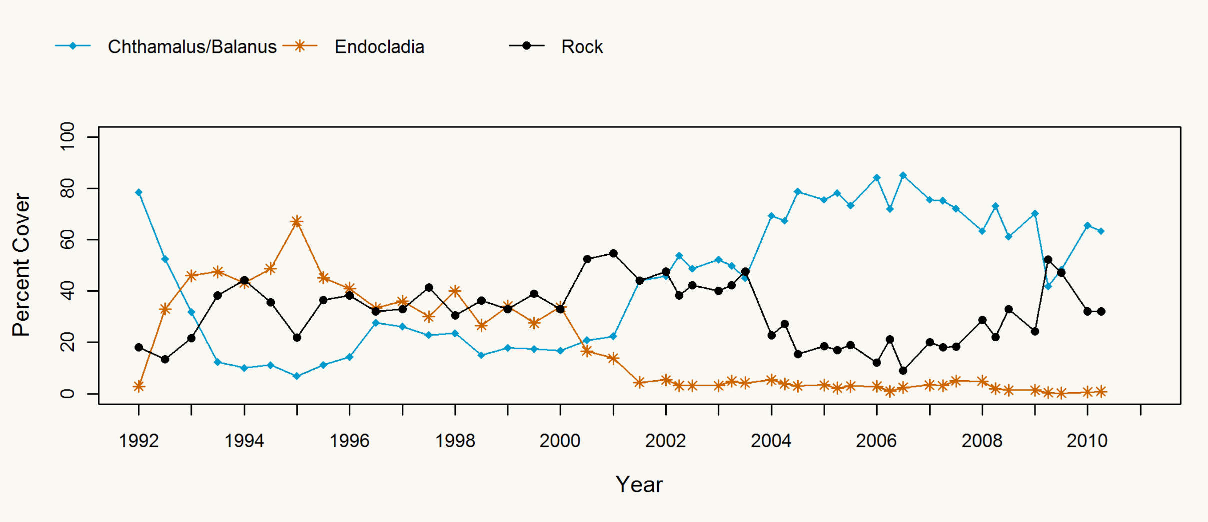
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

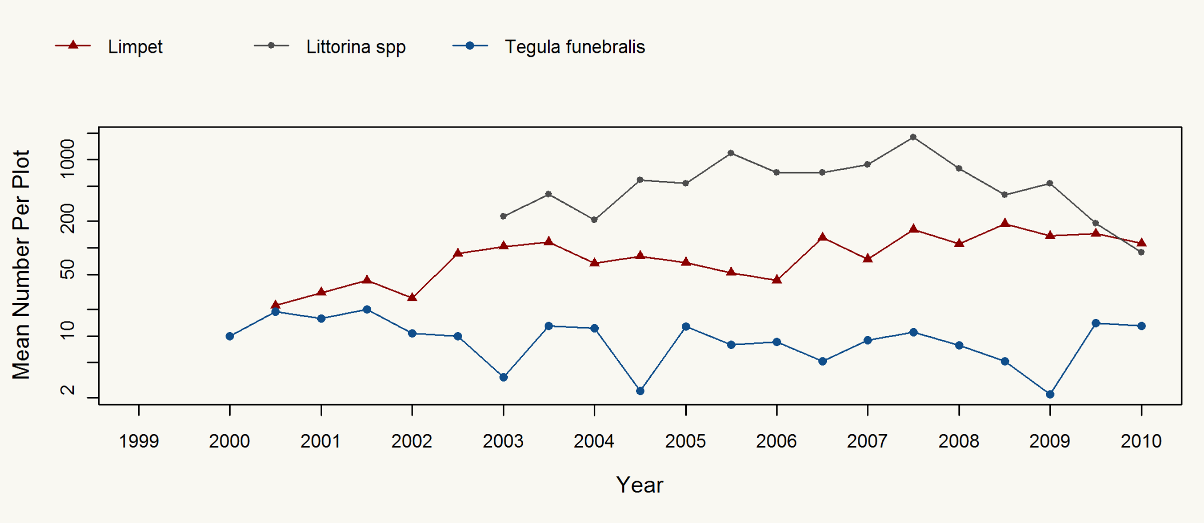
Anthopleura (Anemones)



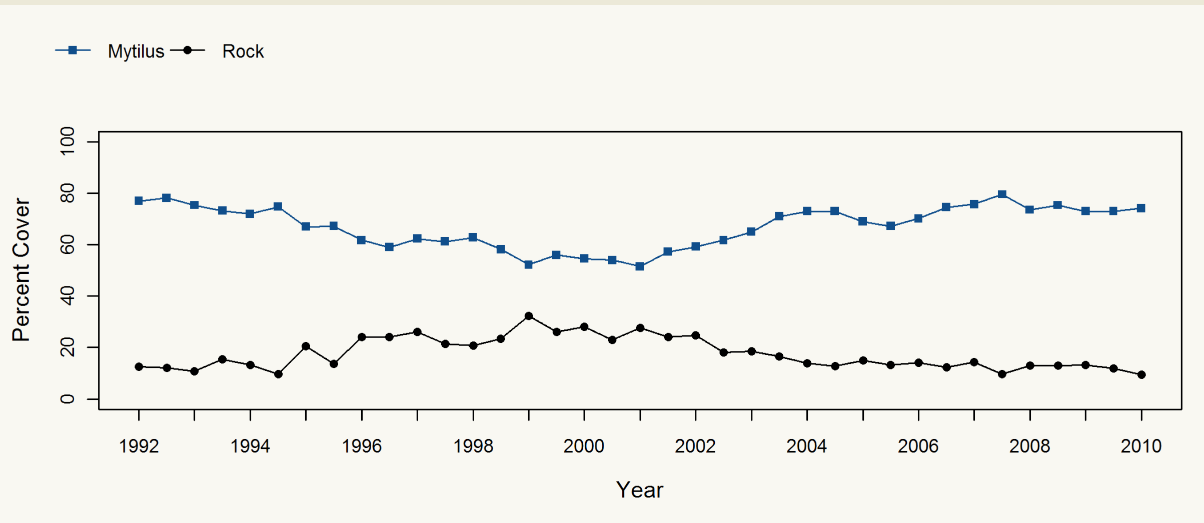
Chthamalus/Balanus (Acorn Barnacles) - percent cover



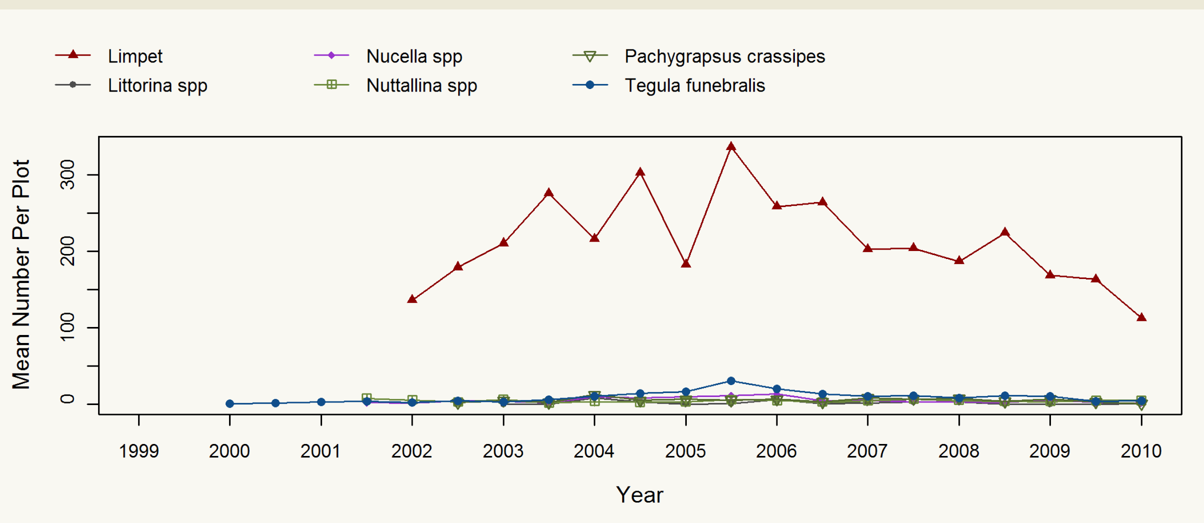
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



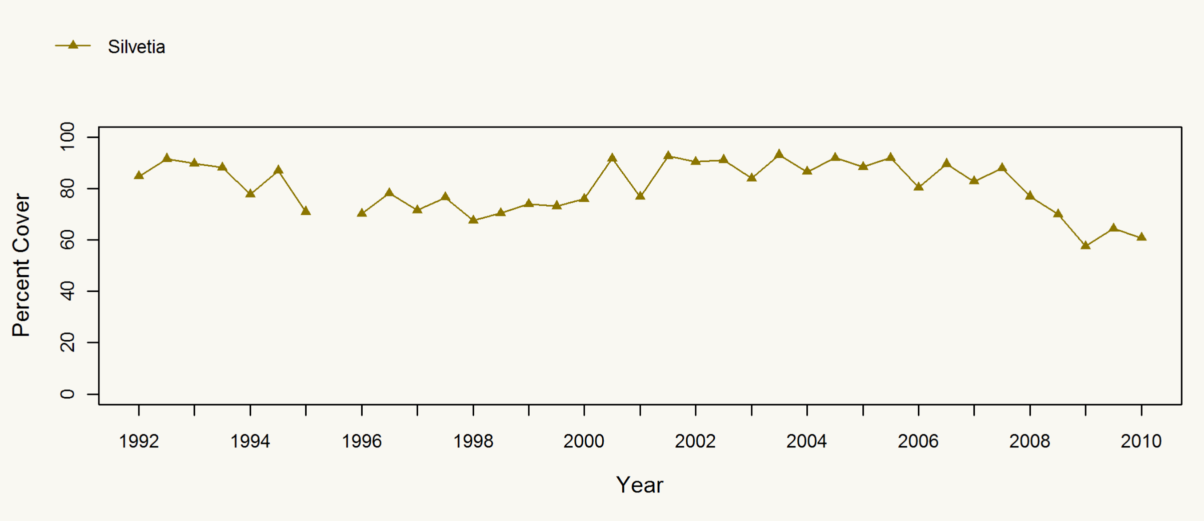
Mytilus (California Mussel) – percent cover



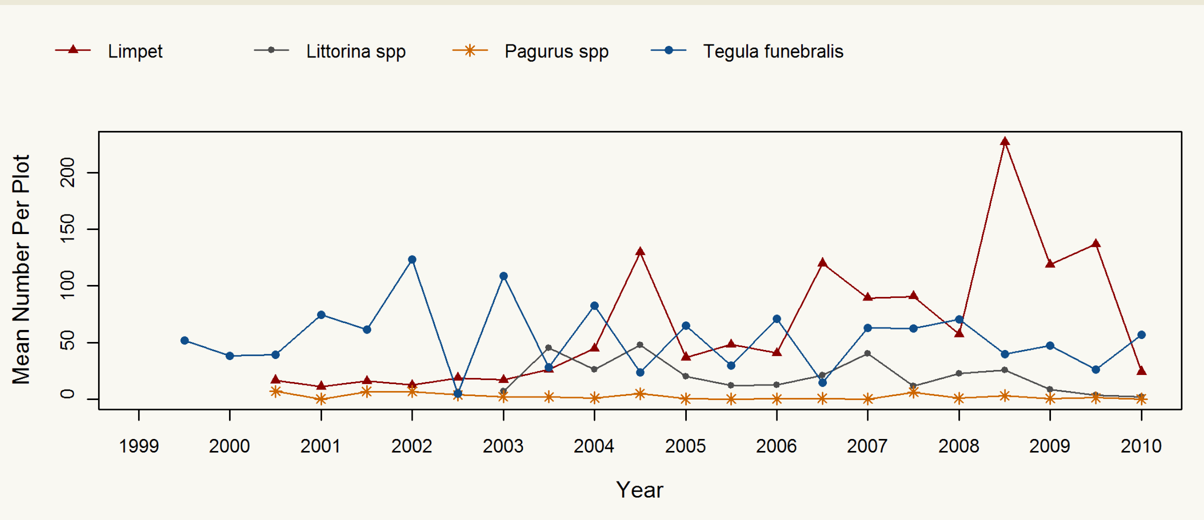
Mytilus (California Mussel) – motile invertebrate counts



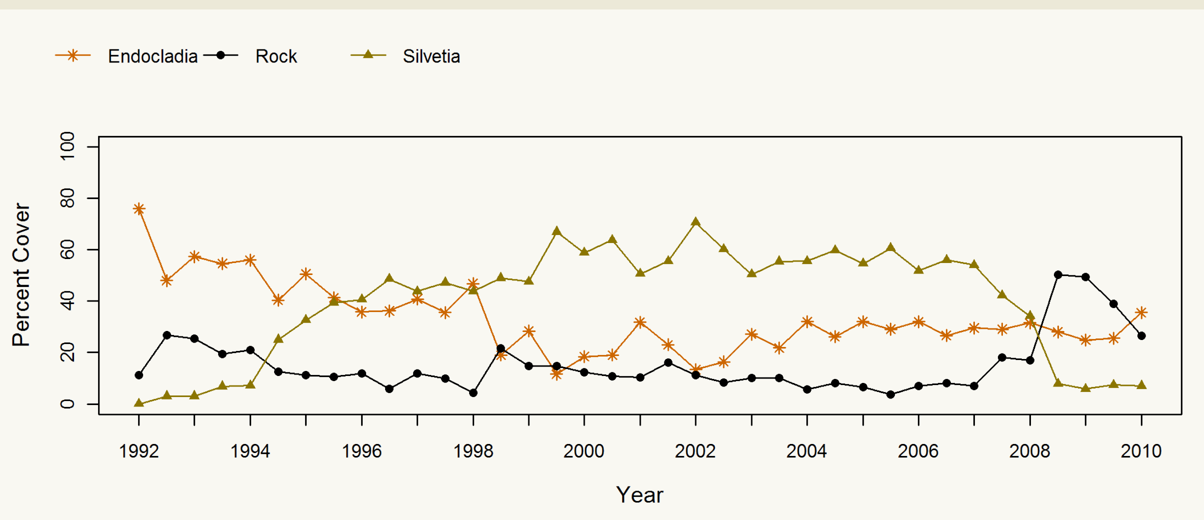
Silvetia (Golden Rockweed) – percent cover



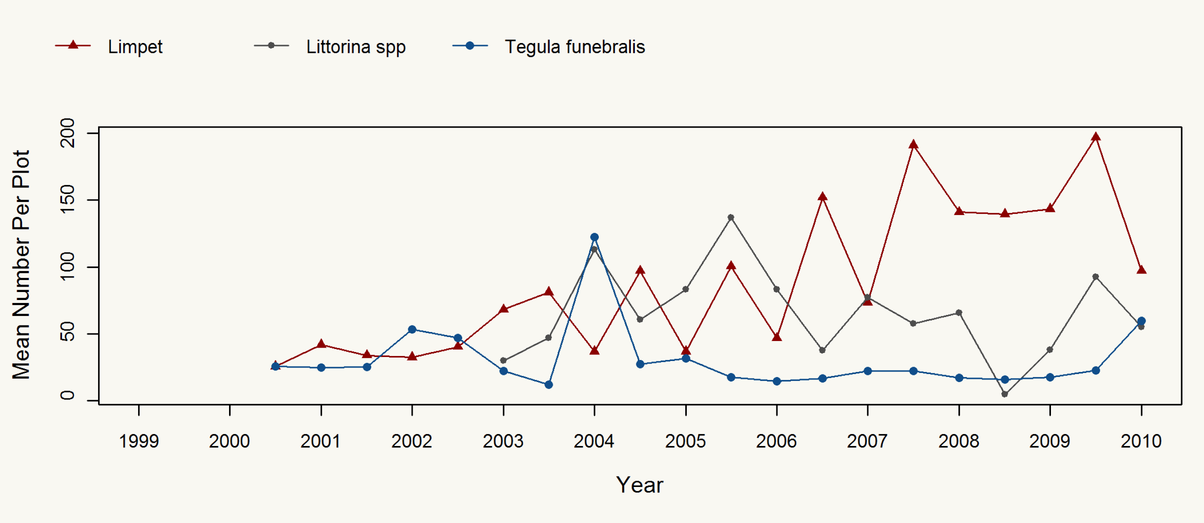
Silvetia (Golden Rockweed) – motile invertebrate counts



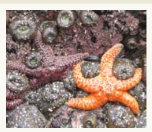
Endocladia (Turfweed) – percent cover



Endocladia (Turfweed) – motile invertebrate counts

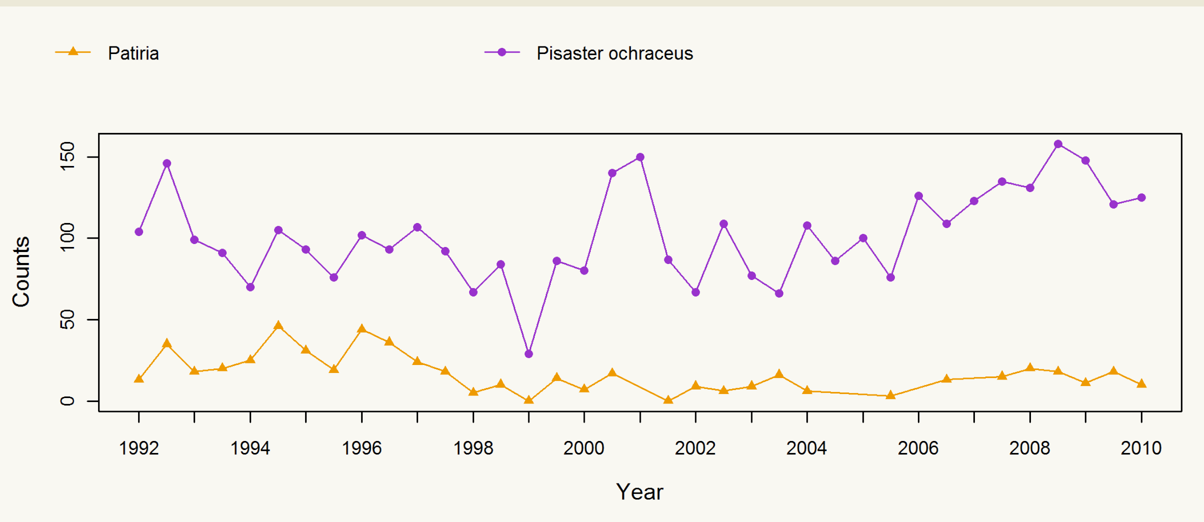


Species Counts and Sizes

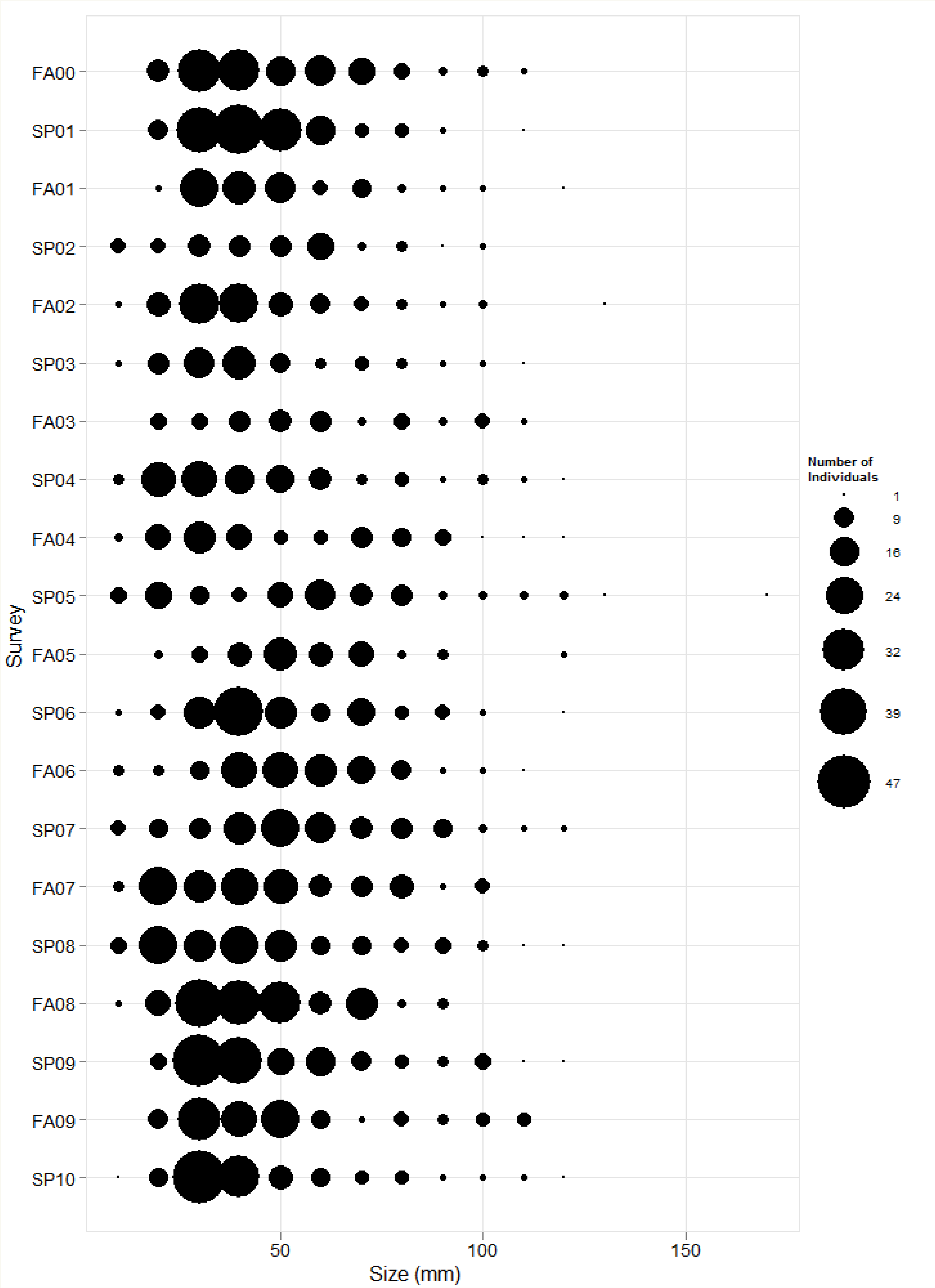


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Government Point Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Long-term monitoring at Government Pt. was not done in fall 1999, and then ended in 2006 due to site access restrictions. We hope to regain access in the near future, as the location of this site at the junction of two major biogeographic provinces ranks it among the most important in our program.

A mixture of *Chthamalus fissus/dalli and Balanus glandula* was present in the barnacle plots at Government Pt. These barnacles facilitate recruitment of the turfweed, *Endocladia muricata*, by reducing grazing pressure by limpets. We have observed this facilitation at Government Pt., where dips in barnacle cover are associated with increases in turfweed cover in the plots. Limpets and littorines were both abundant within these plots.

Cover of the gooseneck barnacle, *Pollicipes,* was quite constant over time at Government Pt. These long-lived barnacles are harvested for food in many areas accessible to the public, but are protected from collection pressure at Government Pt.

The California mussel (*Mytilus californianus*), forms a dense bed in the mid-low intertidal zones of Government Pt., which provides food and shelter for an incredible diversity of organisms. Large storm events can tear out patches of mussels, as is evidenced by the dip in mussel cover during the 1997/98 El Niño period. This storm-induced decline was followed by rapid recovery, and long-term cover of mussels at Government Pt. was quite stable through 2006. Limpets were the most common motile invertebrate found in the mussel plots, but a number of other species were also common, including the snails, *Tegula funebralis, Nucella* spp. and littorines, and the shore crab, *Pachygrapsus crassipes*.

A significant downward trend in the cover of *Silvetia compressa* at Government Pt. was evident through 2006, and it would be useful to know if this trend has continued in recent years. As with many other sites, *Silvetia* showed a seasonal pattern in cover, with lower values in spring vs. fall samples. *Silvetia* plots contained high numbers of *Tegula funebralis* and limpets. Littorines and *Nucella* spp. were also common.

Turfweed (*Endocladia muricata*) forms distinctive dark red bands in the high zone of rocky intertidal shores north of Pt. Conception/Government Pt. Turfweed abundance fades in warmer waters to the south, thus monitoring at Government Pt. is critical for detecting the potential effects of warming water trends that might be associated with climate change. Turfweed provides habitat for a host of tiny organisms, and facilitates the recruitment of rockweeds. Turfweed abundance at Government Pt. has been highly variable over time, with typically much higher cover in spring than in fall. Littorines and limpets were the most common motile invertebrates found in these high intertidal plots.

Surfgrass (*Phyllospadix* spp.) beds are highly productive ecosystems, providing structurally complex microhabitats for a rich variety of organisms. Surfgrass provides nursery habitat for various fishes and invertebrates, including the California spiny lobster. Surfgrass can be particularly sensitive to pollution and oil spills, and large patches can be removed by high wave energy events, such as those associated with El Niño periods. Indeed, the surfgrass cover at Government Pt. experienced substantial decline only once in the 15 years that we monitored it—during the 1997/98 El Niño event. As observed at most other sites, *Phyllospadix* cover fluctuated seasonally, with higher cover in fall than in spring.

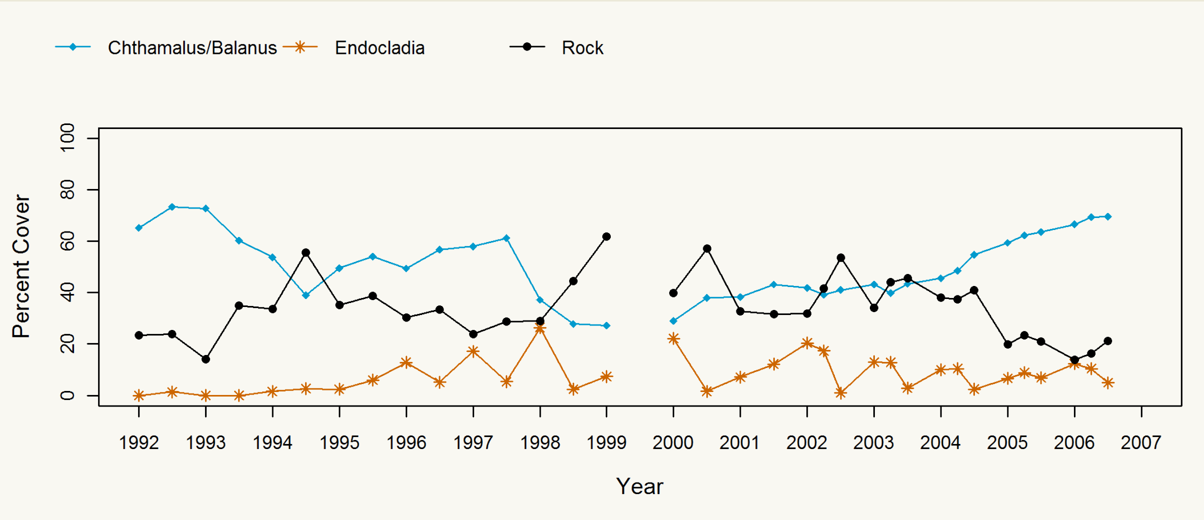
The ochre star (*Pisaster ochraceus*) is much more common north of Pt. Conception/Government Pt. than it is south of this biogeographic barrier, making Government Pt. an important site for detecting any impacts to this species that might spread northward up the coast, such as disease, or declines due to warming ocean temperatures. Seastar numbers were variable at Government Pt., but appeared to be increasing over the last few years that this site was sampled. Seastar sizes spanned the entire range, with abundant large individuals and juveniles commonly found, indicating a healthy population with ample recruitment. Plot 1 at Government Pt. is quite low in tidal height and cannot be sampled when waves are large, as was the case in spring 1992 and spring 2001. No seastar plots could be sampled in spring 1993.

Photo Plots

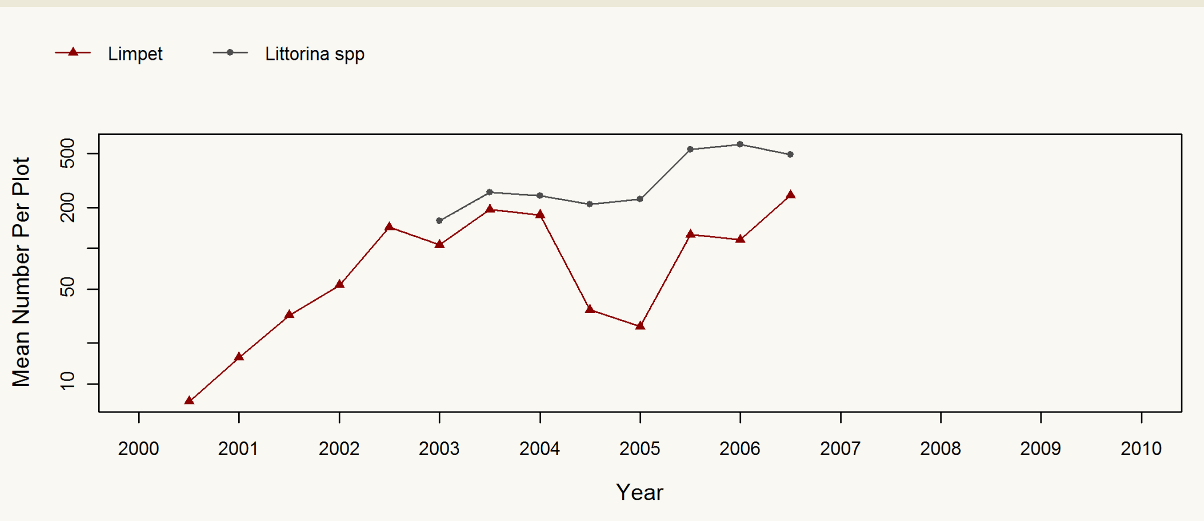
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

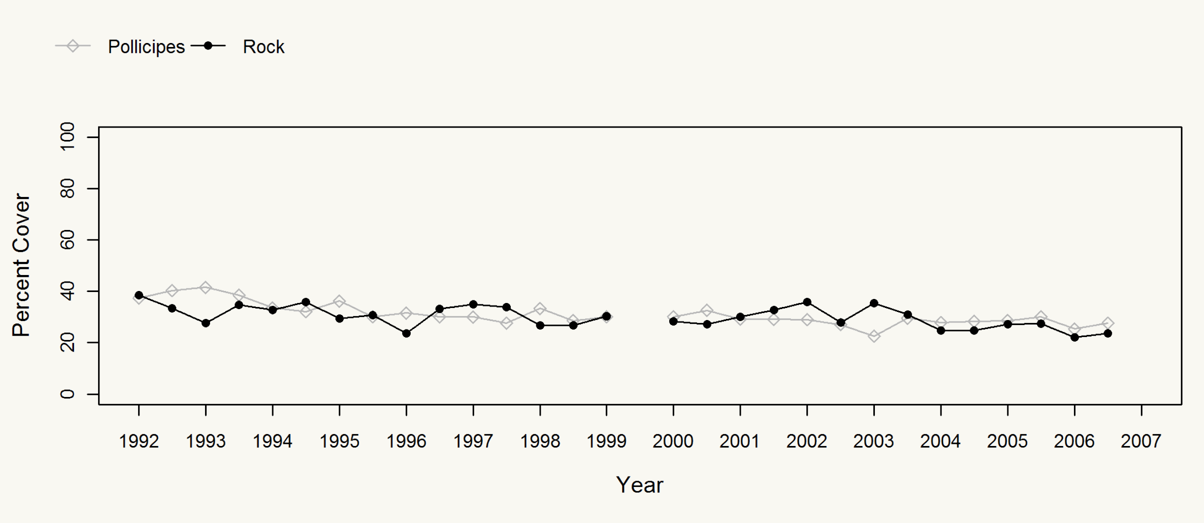
Chthamalus/Balanus (Acorn Barnacles) - percent cover



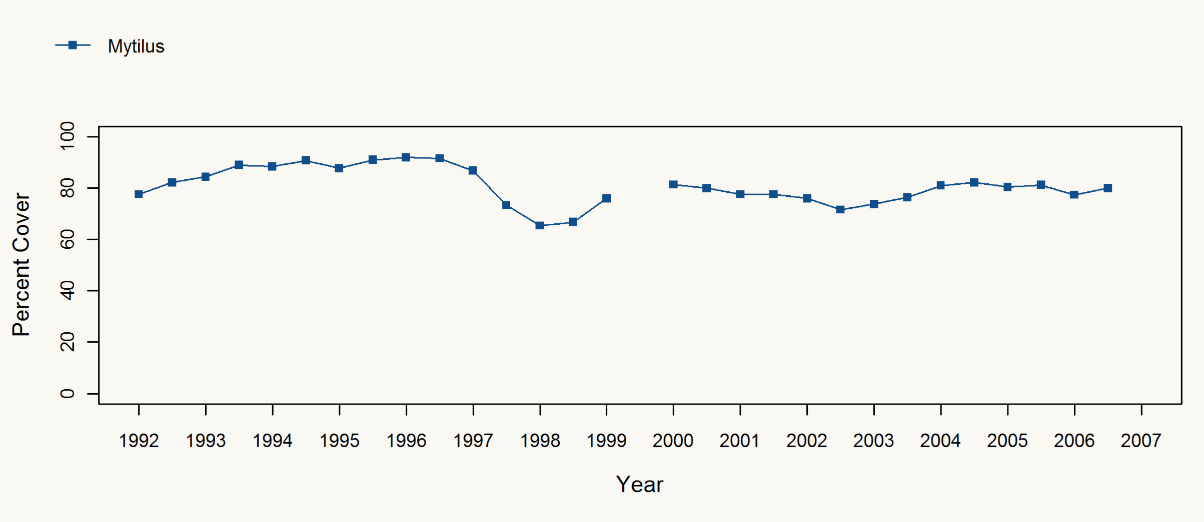
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



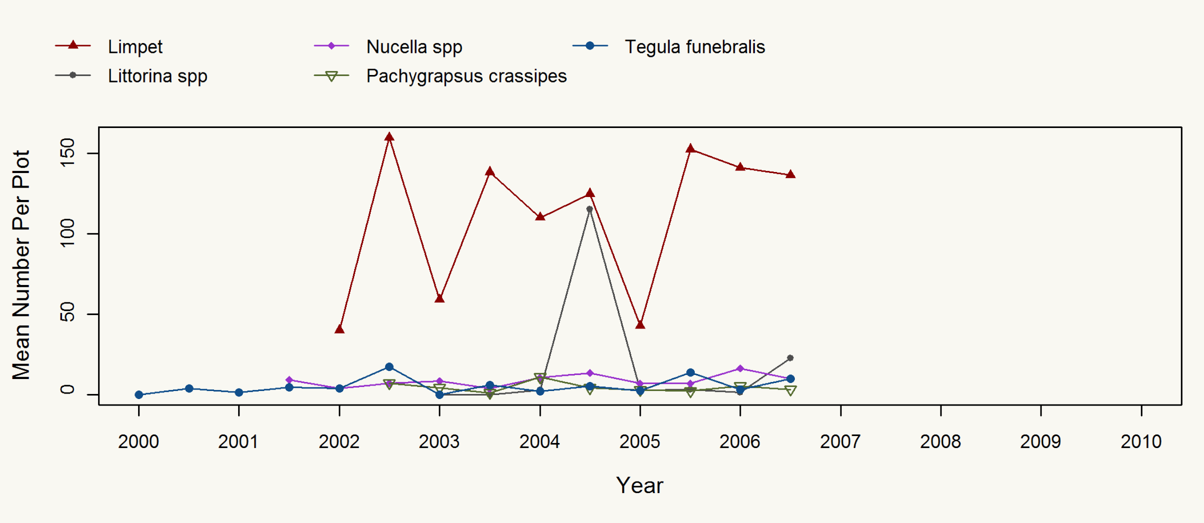
Pollicipes (Goose Barnacle)



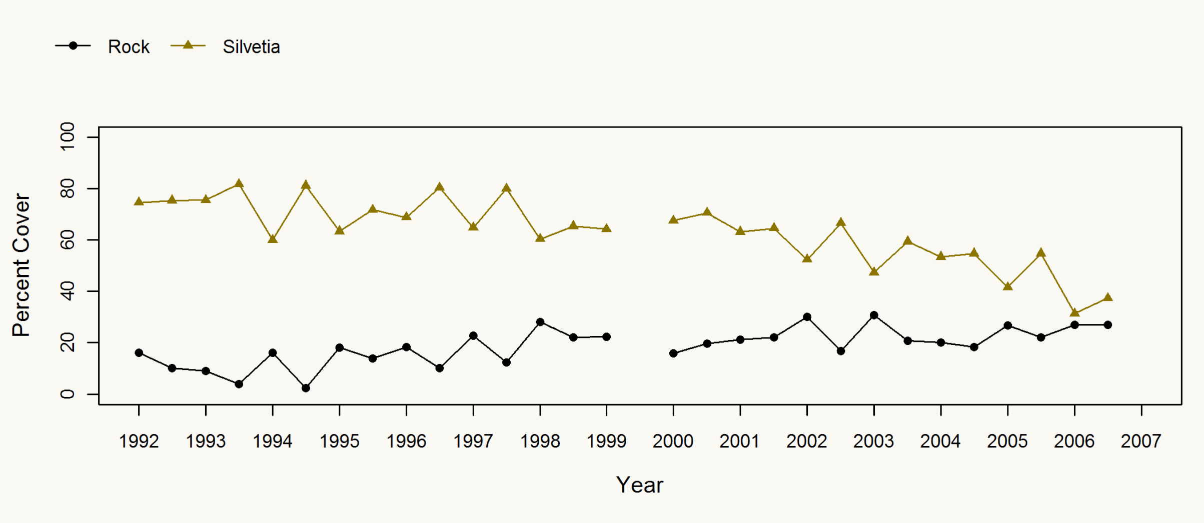
Mytilus (California Mussel) - percent cover



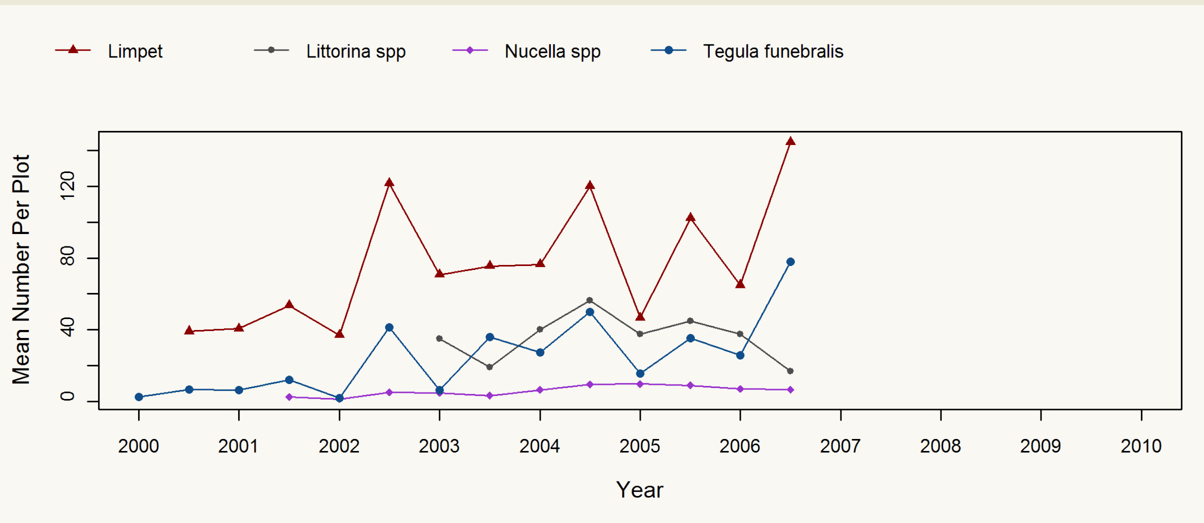
Mytilus (California Mussel - motile invertebrate counts)



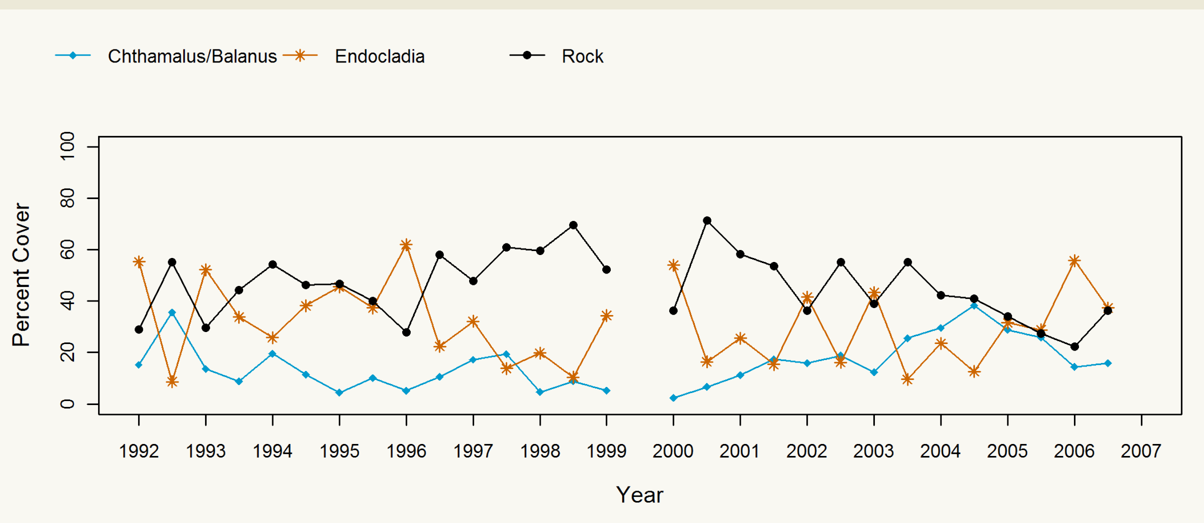
Silvetia (Golden Rockweed) - percent cover



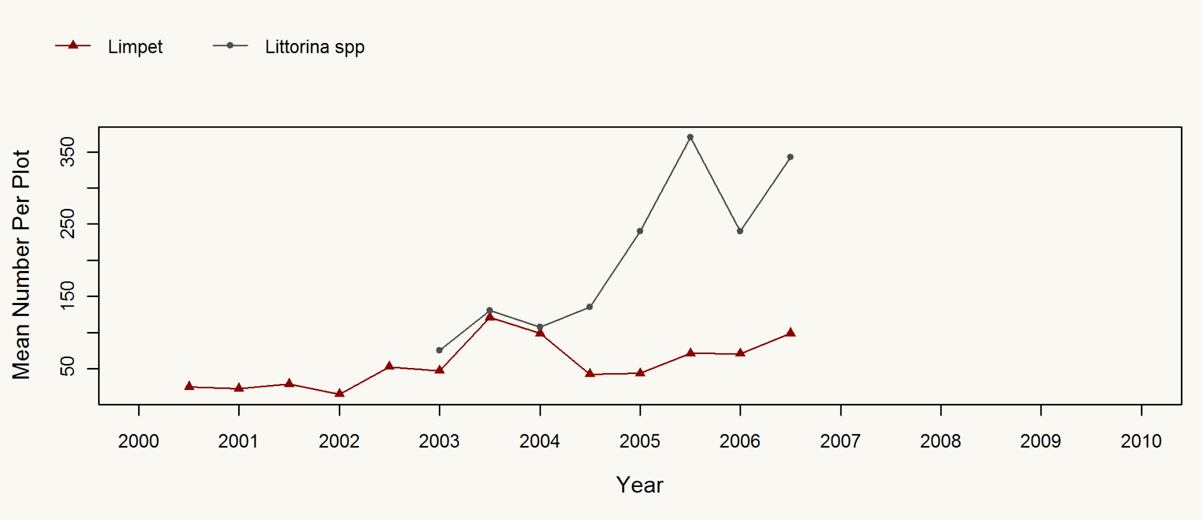
Silvetia (Golden Rockweed) – motile invertebrate counts



Endocladia (Turfweed) – percent cover



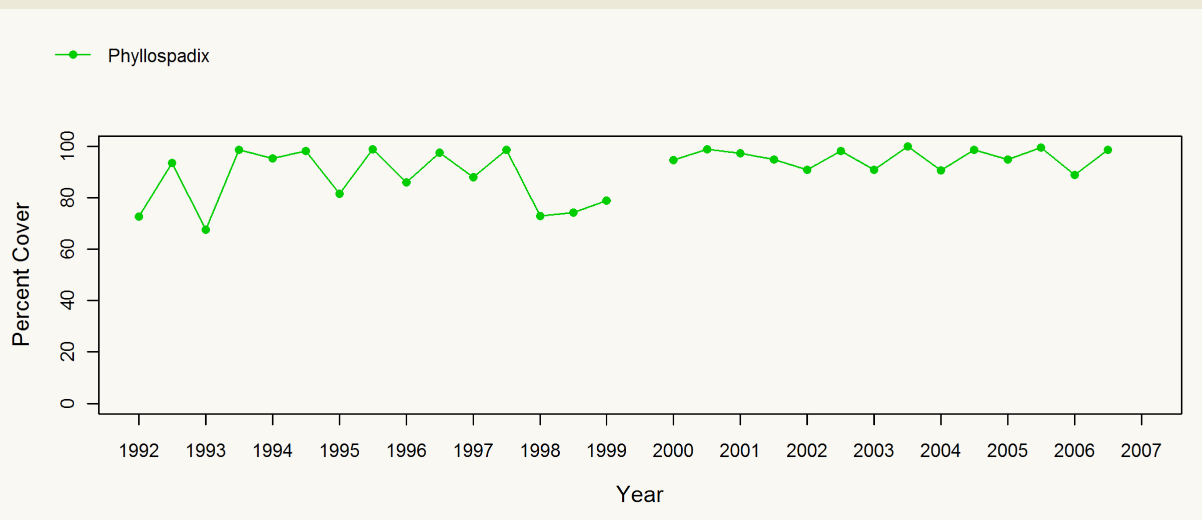
Endocladia (Turfweed) – motile invertebrate counts



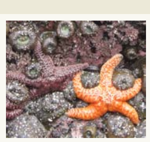
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

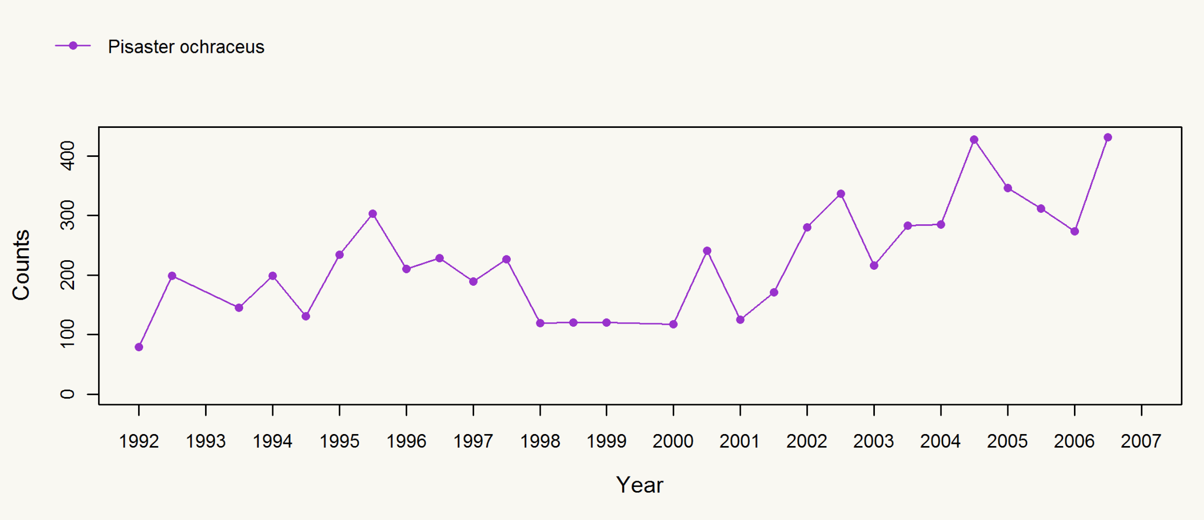


Species Counts and Sizes

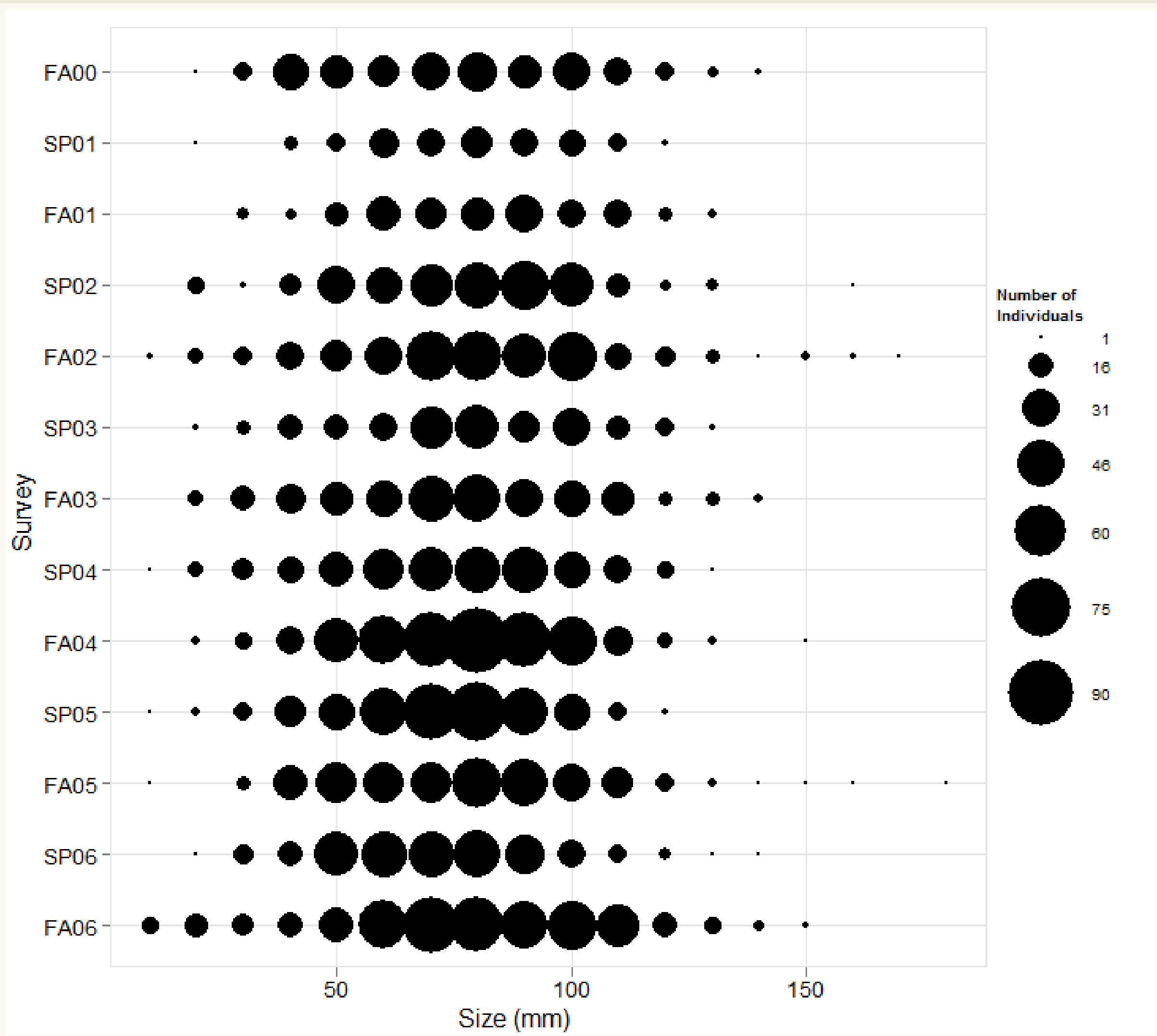


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Alegria Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The anemone plots at Alegria consist primarily of the colonial anemone, *Anthopleura elegantissima* rather than the solitary anemone *Anthopleura sola* (note that these were considered a single species prior to the past several years and they are not distinguished in our sampling methods). *Anthopleura* cover declined steadily from plot establishment in 1992 through 1999, after which there have been fluctuations between 40% and 80% cover. Cover of *Anthopleura* varied inversely with rock and/or sand with only low cover of other taxa (mostly barnacles and turf algae) within one or more plots.

The barnacle plots at Alegria consist of a mixture of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula* with the former dominating some plots and a more even mixture in others. One of the original plots at this site was lost completely due to a rock breakout while another became dominated by a persistent *Lottia gigantea* farm. Two plots were added in recent years (spring 2007 and spring 2008) as replacements. Barnacle cover varied inversely with rock as periodic scour episodes have occurred. In recent years, *Endocladia*, mussels and anemones have begun encroaching on three of the plots, but the average cover has yet to meet the threshold for inclusion in the graphs. Motile invertebrate counts at this site began seasonally in the Fall of 2000 (with littorines added the following fall of 2001) and were changed to annual sampling in 2004. Both littorines and limpets have been steadily abundant in the *Chthamalus* plots with the former ranging around 1000 individuals per plot and the latter ranging more variably between 10 and 100 individuals per plot. Whelks (*Nucella* sp.) have also been present in low numbers except in 2002 and 2006 when the numbers dropped to zero.

The *Pollicipes* plots at this site have remained stable throughout the years with around 20% cover *Pollicipes*, 40-50% cover mussels, and rock varying from about 20-40%. Motile invertebrate counts show that limpets have been common and highly variable within the *Pollicipes* plots with abundance as high as 80 individuals per plot on two occasions. Littorines have been less common in these plots at less than 40 individuals per plot. In addition, whelk snails (*Nucella* spp.) and shore crabs (*Pachygrapsus crassipes*) have been present in low numbers.

Mytilus cover in the mussel plots began around 80% on average in 1992, declined gradually to about half that in 1998, then gradually rebounded to over 60% by 2004. Then a reef-wide crash occurred in 2006 with cover dropping to zero in, and in the vicinity of, the photoplots. These plots are located on a wide, low-relief reef flat that was presumably scoured during a large winter storm. Mussels are still present in other, more high-relief areas within the site, such as the reef where the *Pollicipes* plots are located. The reef flat population has yet to recover. In the meantime, the plots have become dominated by a mixture of barnacles, colonial anemones, prostrate *Phragmatopoma*, articulated corallines and other turf algae, and patches of *Phyllospadix*. One small recruitment event offered some promise of recovery in the spring of 2011, but those mussels had disappeared by the following fall sampling. Motile invertebrate sampling show frequent but low numbers of whelks (*Nucella* spp), shore crabs (*Pachygrapsus crassipes*) and volcano limpets (*Fissurella volcano*). On the other hand, *Tegula funebralis* snails have been more common and increased to large numbers (over 120 individuals per plot) until 2006 when the mussel population, and the *Tegula* population with it, crashed. Following the mussel crash, limpet numbers began to increase as bare rock became more prevalent. The numbers of *Tegula* for the spring of 2004 were similar to the preceding and following sampling seasons.

Rock ("Above Barnacles") plots were added to this site in the fall of 2008 to document any upward spread of intertidal species as a result of global climate change or other factors. These plots are expected to remain dominated by bare substrates unless barnacles or other species begin to encroach upon them. Other than a few spots of tar, these plots have yet to see any barnacle recruitment.

Surfgrass (*Phyllospadix*) transects were added to Alegria in the fall of 2001. Since that time the mean cover of surfgrass has hovered in the 70-80% range with seasonal oscillation (lower cover in the spring following winter storms that ripped out plants and abraded leaves; recovery by fall). There have been no long-term trends in surfgrass cover. These transects were established at the inshore margin of an extensive, thick surfgrass bed which extends into the subtidal.

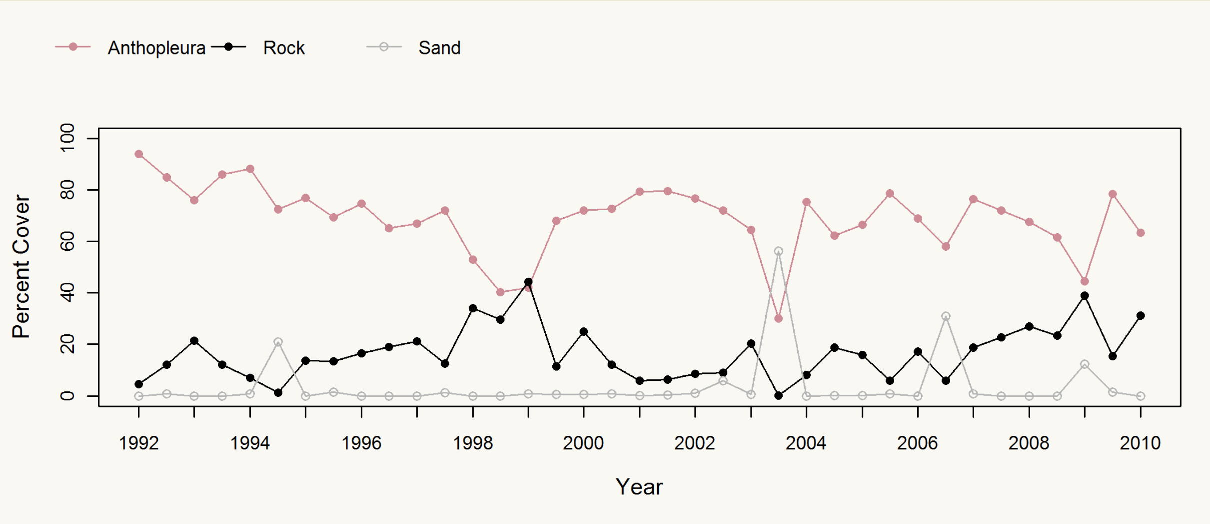
Seastar (*Pisaster ochraceus*) plots were added to this site in the spring of 2002 and consist of three large irregular plots surrounding an area of high relief rock pinnacles and deep tidepools. At the first sampling, the total number of seastars counted and measured was around 120. That number increased to over 200 by the following fall, but declined sharply thereafter and has been hovering around 40 seastars since 2006. While a few smaller (<50mm radius) stars have been found at this site throughout the years, those encountered tend to be larger (>60mm). General observations, along with the size distribution depicted in the trend graph, suggest that stars are moving in and out from the subtidal rather than recruiting to the monitoring site.

Photo Plots

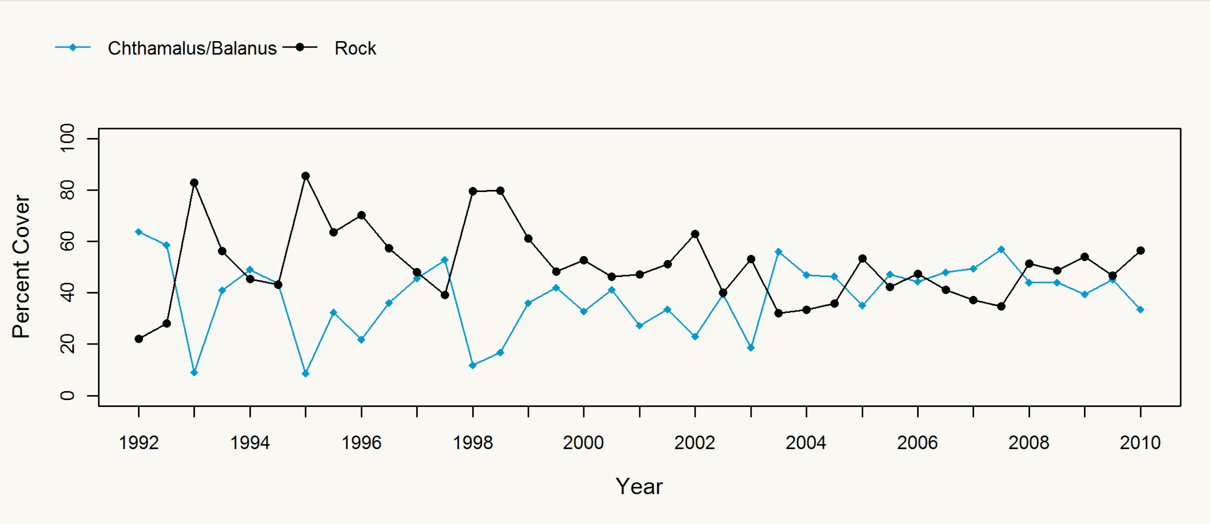
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

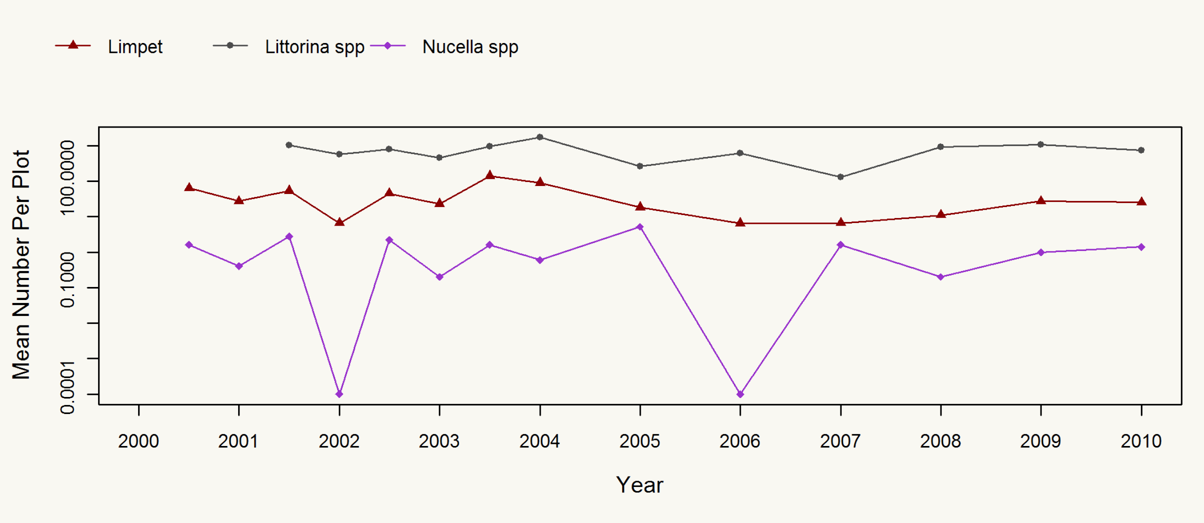
Anthopleura (Anemones)



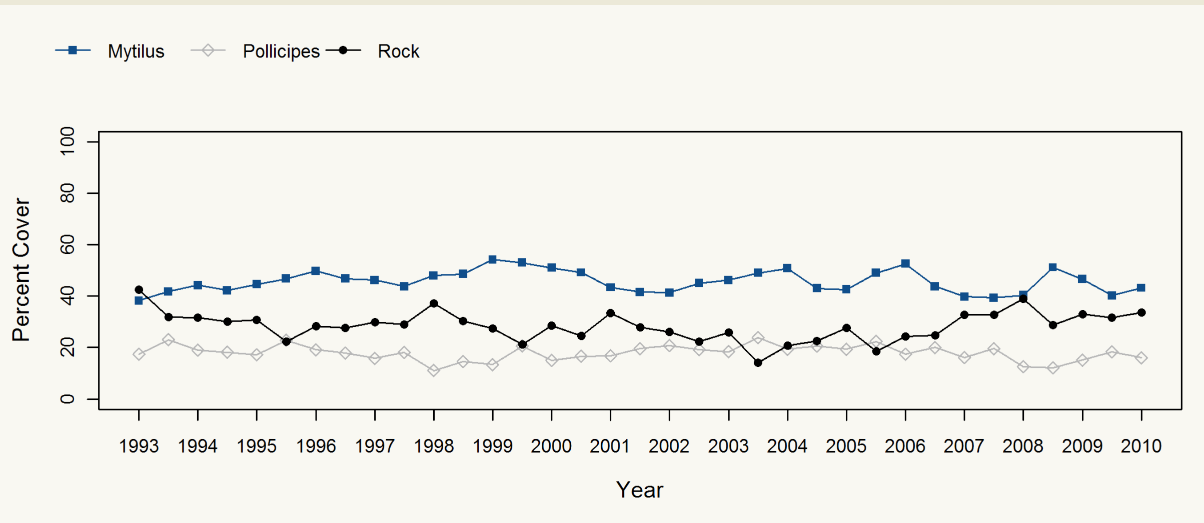
Chthamalus/Balanus (Acorn Barnacles) - percent cover



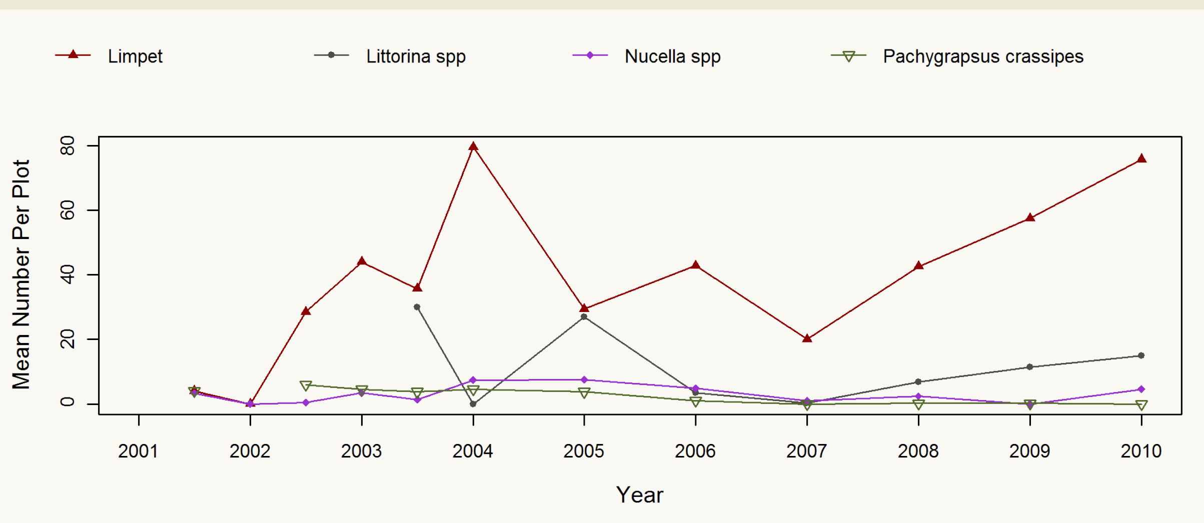
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



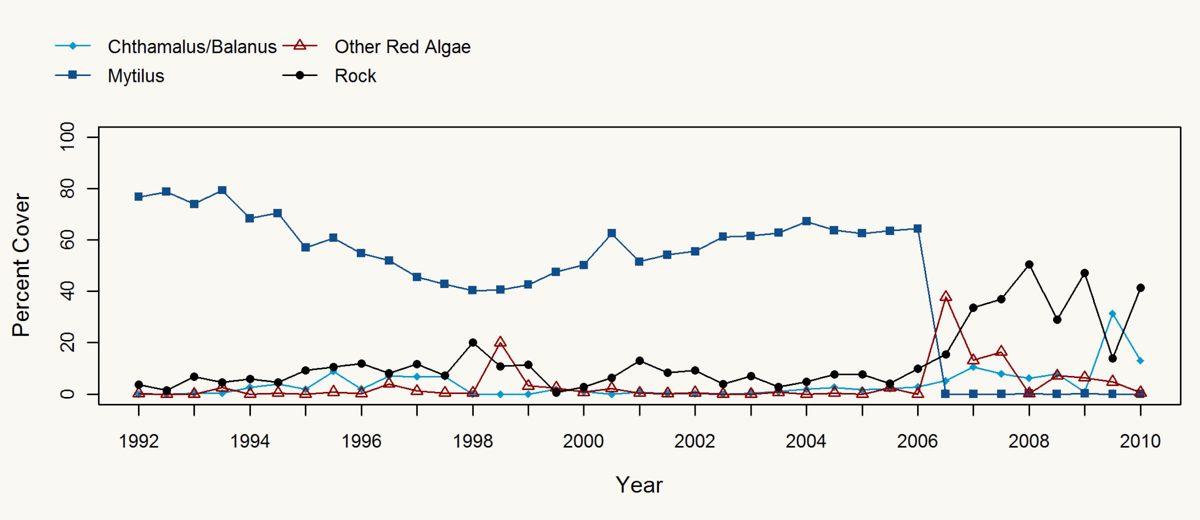
Pollicipes (Goose Barnacle) - percent cover



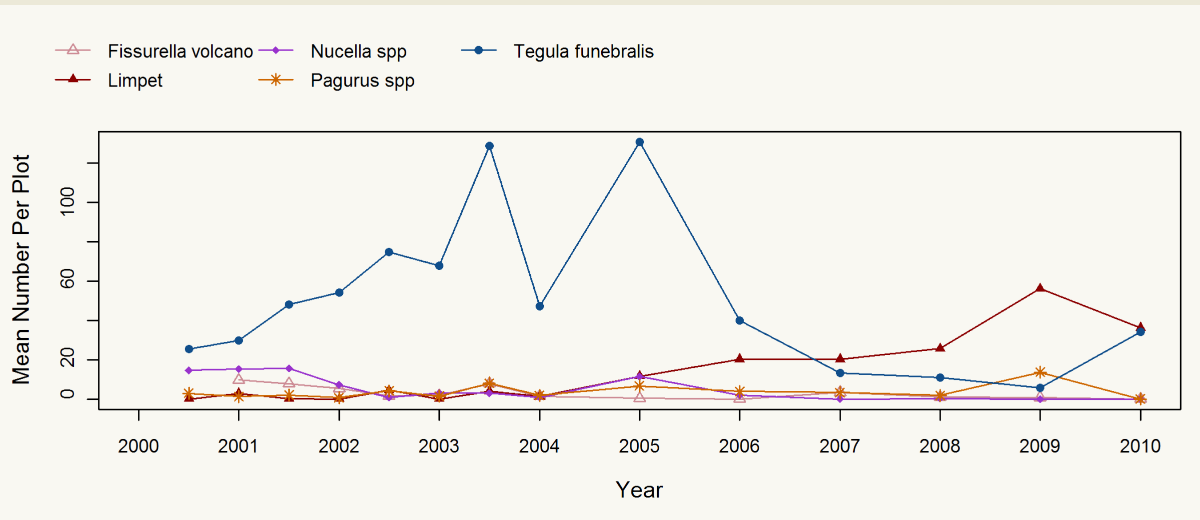
Pollicipes (Goose Barnacle) - motile invertebrate counts



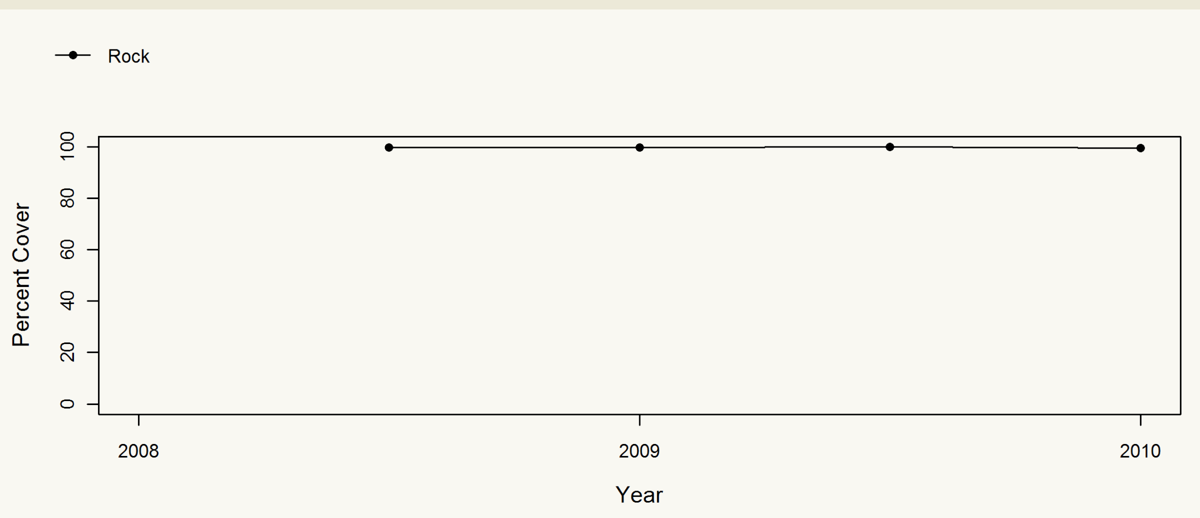
Mytilus (California Mussel) - percent cover



Mytilus (California Mussel) - motile invertebrate counts



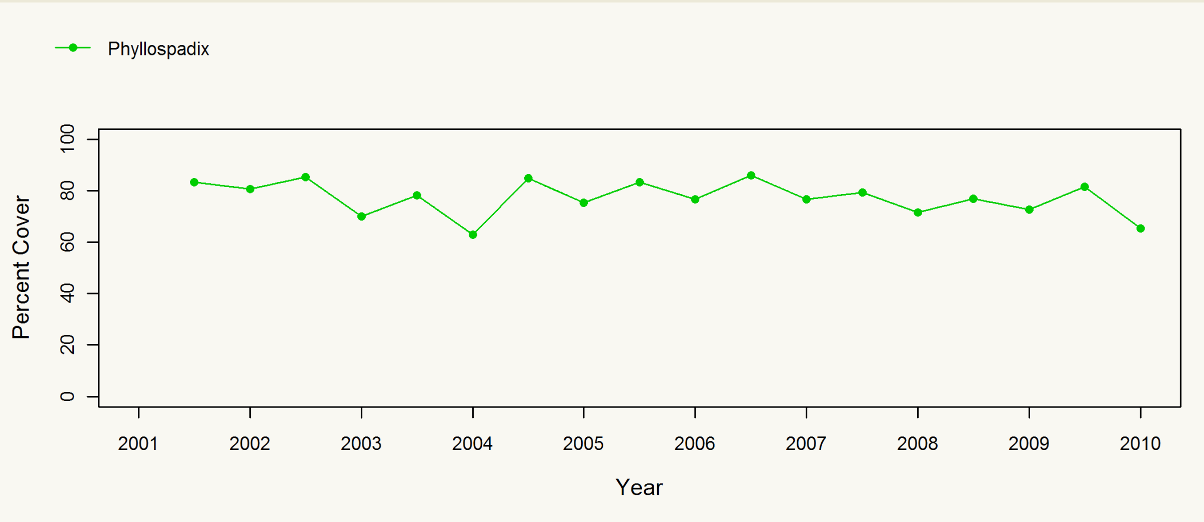
Rock (Above Barnacles)



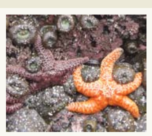
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

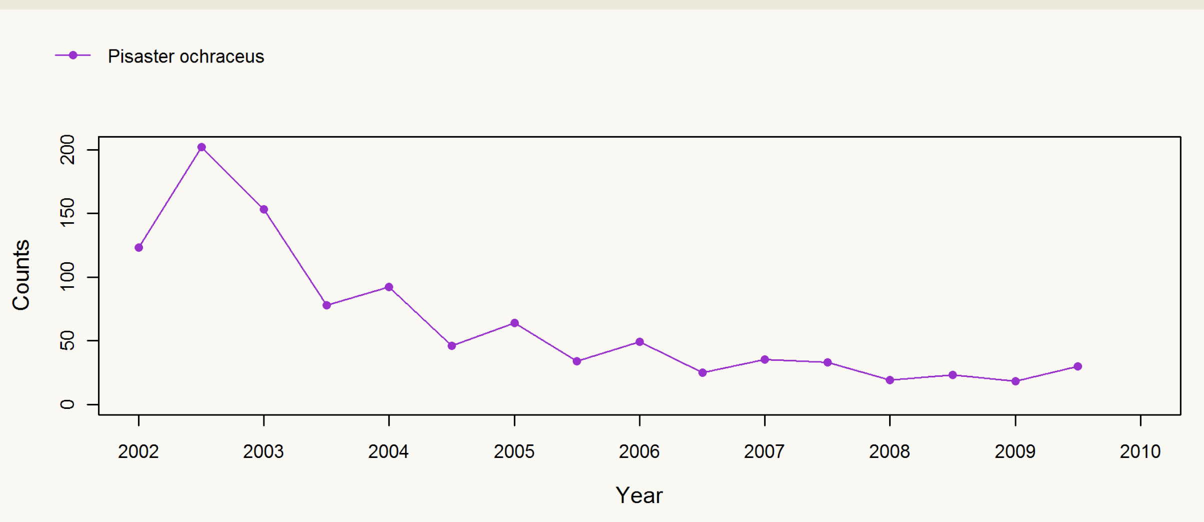


Species Counts and Sizes

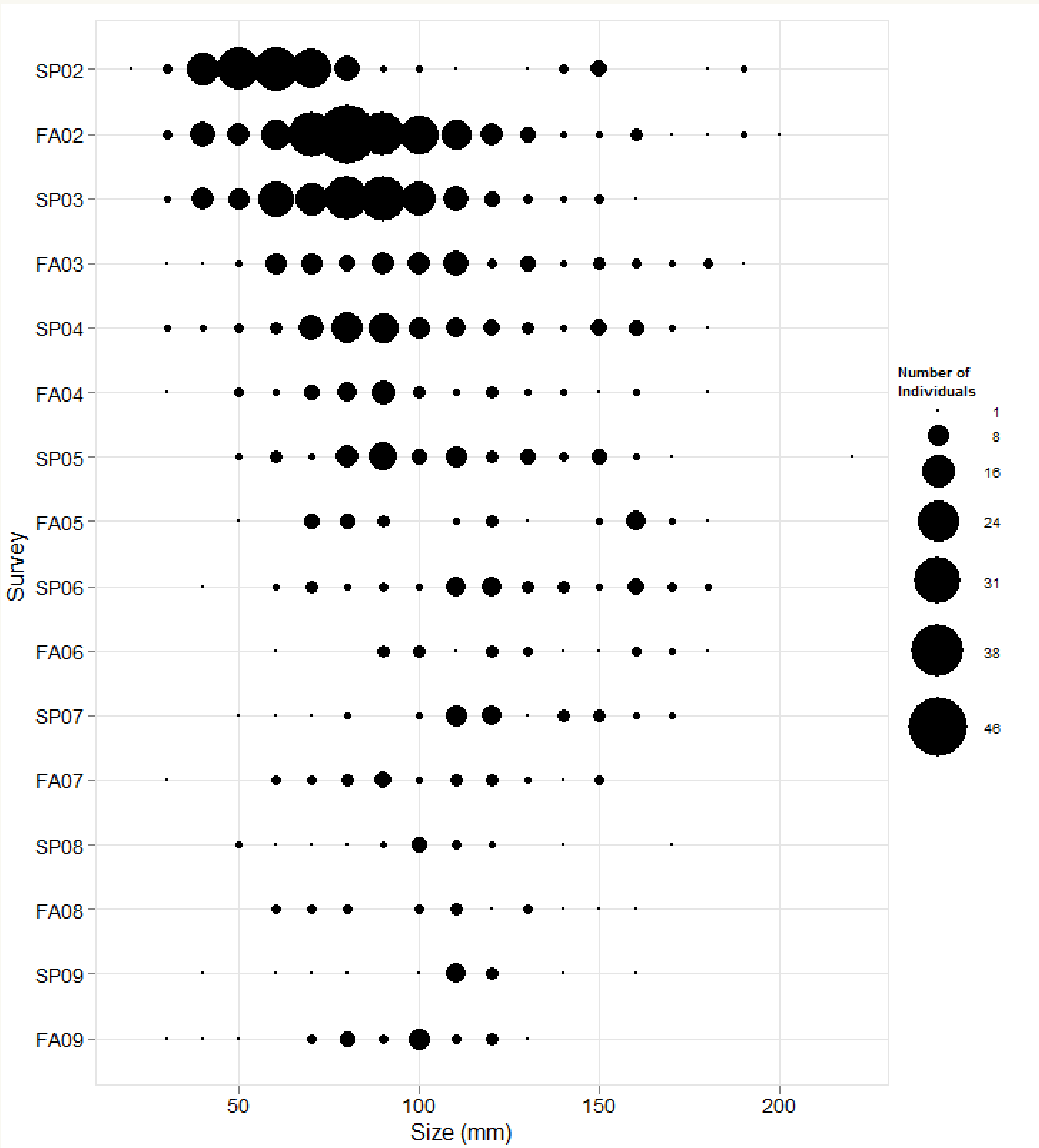


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Arroyo Hondo Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The barnacle plots at Arroyo Hondo consist of a mixture of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula*. Two plots are located on a smooth, nearly vertical sandstone reef outcrop and consist almost completely of *Chthamalus* spp. barnacles, while the other three plots are on rougher, lower sloped outcrops and have approximately 25% relative cover of *Balanus*. Barnacle cover varied inversely with rock as periodic scour episodes have occurred. This scour has been especially pronounced in the two plots on smooth sandstone where near 100% barnacle removal has occurred several times. The other three plots are more stable and have been encroached upon to varying degrees by a mixture of *Endocladia*, mussels and anemones. The average cover of these taxa has yet to meet the threshold for inclusion in the graphs. Motile invertebrate counts at this site began seasonally in the fall of 2000 and were changed to annual sampling in 2004. Within the barnacle plots, limpets and littorine numbers have remained high and reasonably steady throughout this time. Snails (*Nucella* spp. and *Tegula funebralis*) have been present in low numbers during most sampling events.

Mytilus cover in the mussel plots began around 80% on average in 1992, declined gradually to under 60% through 1997, then declined precipitously to about 10% by fall 1998. After that mussel cover rebounded to about 70% by 2002 where it remained for several sampling seasons, then declined to around 50% by 2005 where it has remained ever since. Both the decline of the late 1990s and the 2002 recovery were represented by all five mussel photoplots. The subsequent cover reduction since 2005 has primarily been the result of a single plot which has exhibited very low (near zero) mussel cover since that time, with clonal anemones becoming the primary space occupier of that plot outside of bare rock. Three other plots have remained high in mussel cover, save for the occasional small breakout, while the remaining plot has been mixture of bare rock with recurring mussel patches. As with the barnacle plots, motile invertebrate counts within the mussel plots began seasonally in fall 2000 and were changed to annual sampling in 2004. Within the mussel plots, limpets numbers have exhibited large fluctuations with mean numbers ranging from near zero to over 250 per plot. These fluctuations are the result of recruitment pulses of small (<5mm) limpets. The factors contributing to these pulses, and the fate of these individuals through time, is not clear. Aside from limpets, littorines and other snails (*Nucella* spp. and *Tegula funebralis*) are typically found in the plots in low numbers and chitons (*Nutallina* spp.) are found occasionally. Littorines have been encountered more frequently in recent seasons, though it should be pointed out that these were not consistently sampled in the mussel plots prior to 2006.

Rock ("Above Barnacles") plots were added to this site in the fall of 2008 to document any upward spread of intertidal species as a result of global climate change or other factors. These plots are expected to remain dominated by bare substrates unless barnacles or other species begin to encroach upon them. Other than bare rock and a few bits of tar, a few barnacles (up to 1-2% cover in some plots) were found in most plots by the fall of 2009. In the spring of 2010, the lower portions of most of the rock plots were covered by sand.

The mean cover of Surfgrass (*Phyllospadix* spp.) has fluctuated widely throughout the years at Arroyo Hondo. Throughout the 1990's and up to 2002, mean surfgrass cover varied from a high of around 90% to a low of around 30%, but with cover rebounding to the higher end every few seasons or so and the long-term mean remaining around 80%. Since 2002, *Phyllospadix* has undergone a decline with cover now fluctuating between 25 and 60% for the last several years. Declines in surfgrass have been met with increases in red algae (mostly *Chondracanthus* sp.) and articulated corallines. Initially, only two transects were installed at this site due to limited habitat on a single horizontal reef top. However, a third transect was added in the spring of 2001 to achieve consistency with other sites. The addition of this third transect coincides with the declines in surfgrass cover, but general observations are that the surfgrass declines (and increases in algae) have been consistent across all three transects.

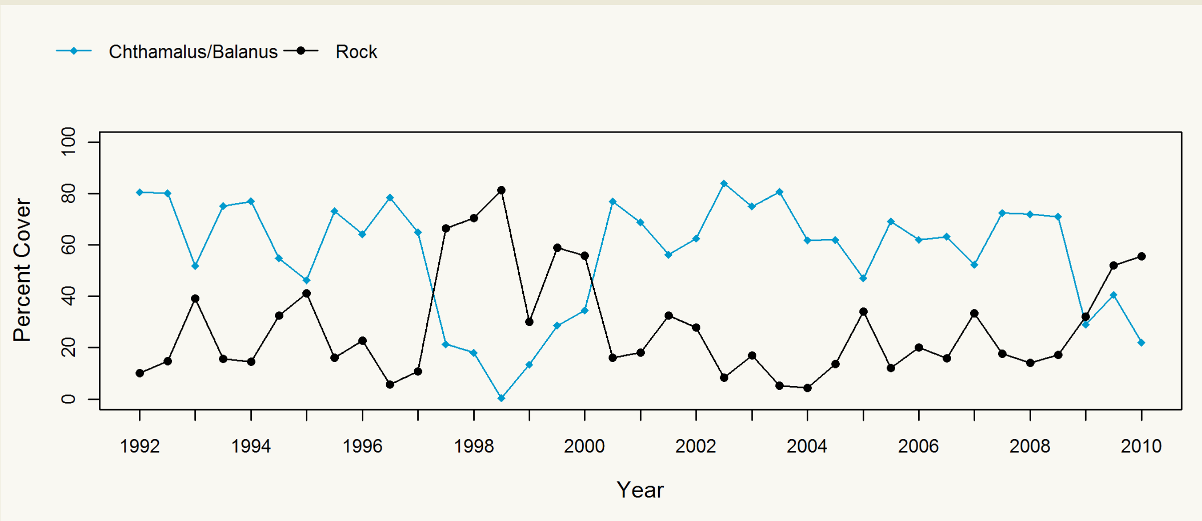
Seastar (*Pisaster ochraceus*) numbers have fluctuated widely at this site from over 60 stars counted and measured to just a few, with peaks in 1992, 1997 and 2002. Since 2002, there has been a general decline in seastar numbers to nearly zero in 2010. In some periods, seastar numbers show some suggestion of seasonal variation with higher numbers in the spring compared to the fall. These data have historically been collected within three short transect swaths. However, in the spring of 2004, the push for methodological consistency among sites prompted the addition of a series of three large irregular plots encompassing most of the monitoring site to be sampled alongside the transects. These plots contained a higher number of stars, compared to the transect data, during their first few seasons of sampling (expected given the greater amount of area sampled), but with declines converging toward the transect data numbers in more recent seasons and likewise approaching zero by 2010. Seastar sizes have been measured since the fall of 2000. A large recruitment pulse occurred in the fall of 2001 and the growth of these stars is evident in these trend graphs. No other significant recruitment events have observed. Despite the fact that our monitoring reef is separated from other reefs by expanses of sand, it seems from our size and abundance data that stars are able to migrate to and from the reef.

Photo Plots

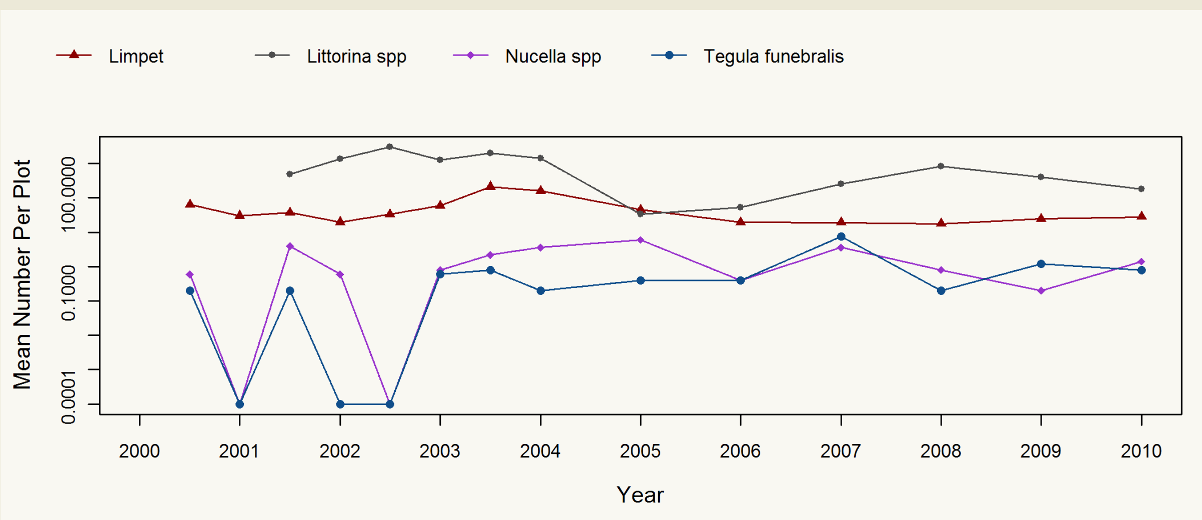
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

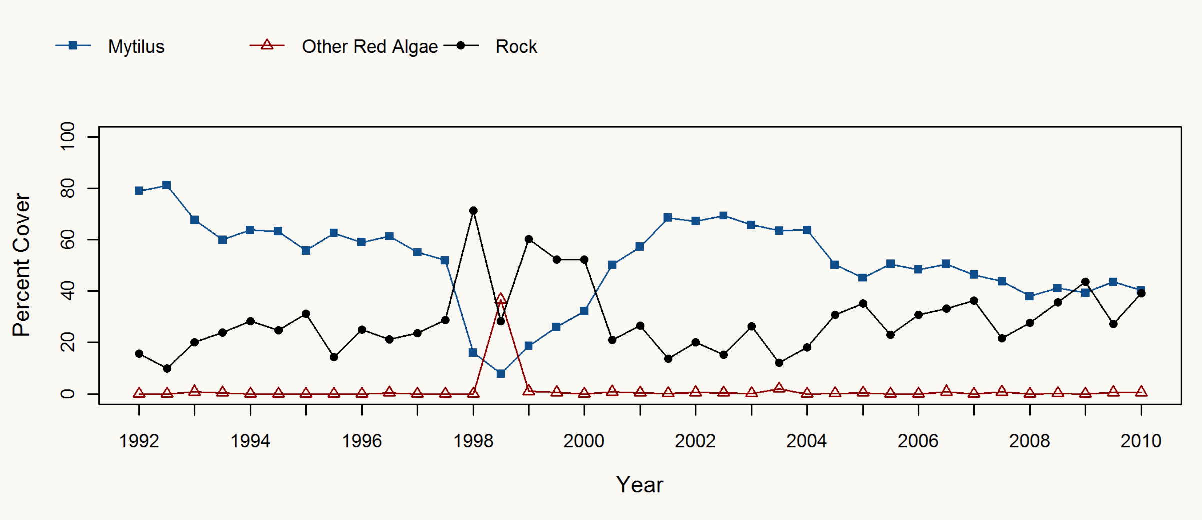
Chthamalus/Balanus (Acorn Barnacles) - percent cover



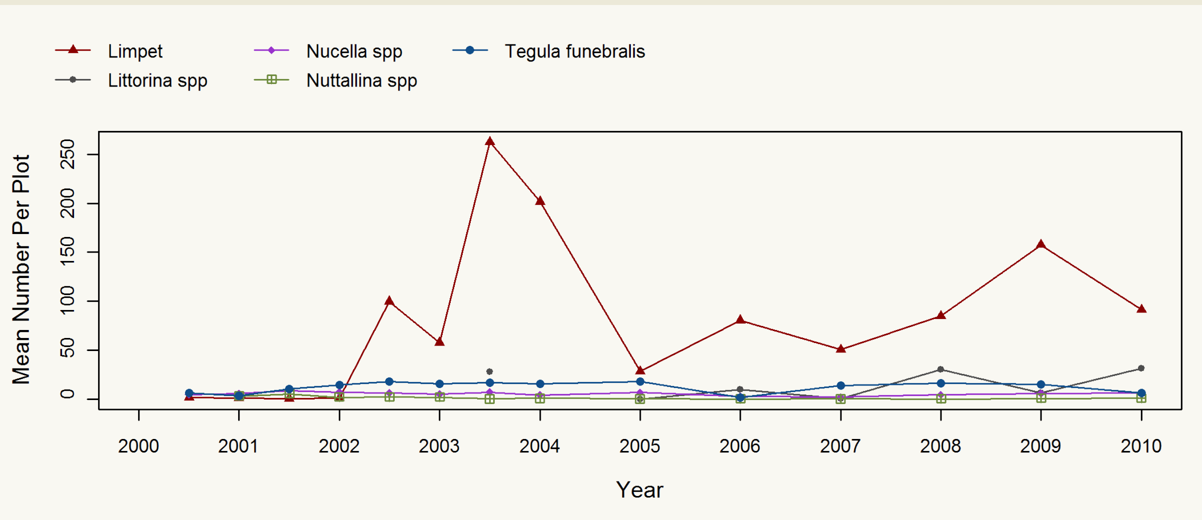
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



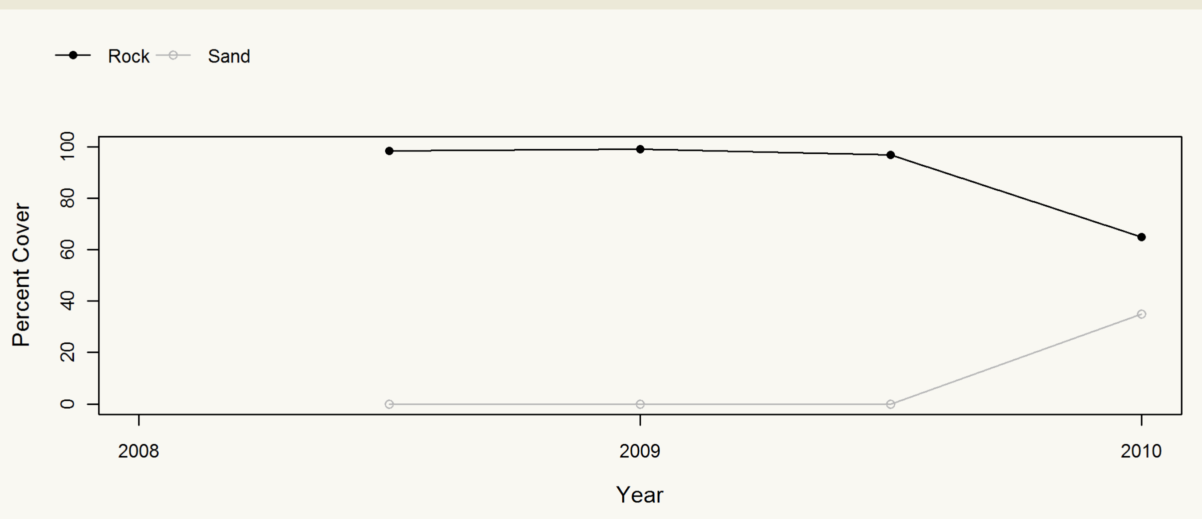
Mytilus (California Mussel) - percent cover



Mytilus (California Mussel) – motile invertebrate counts



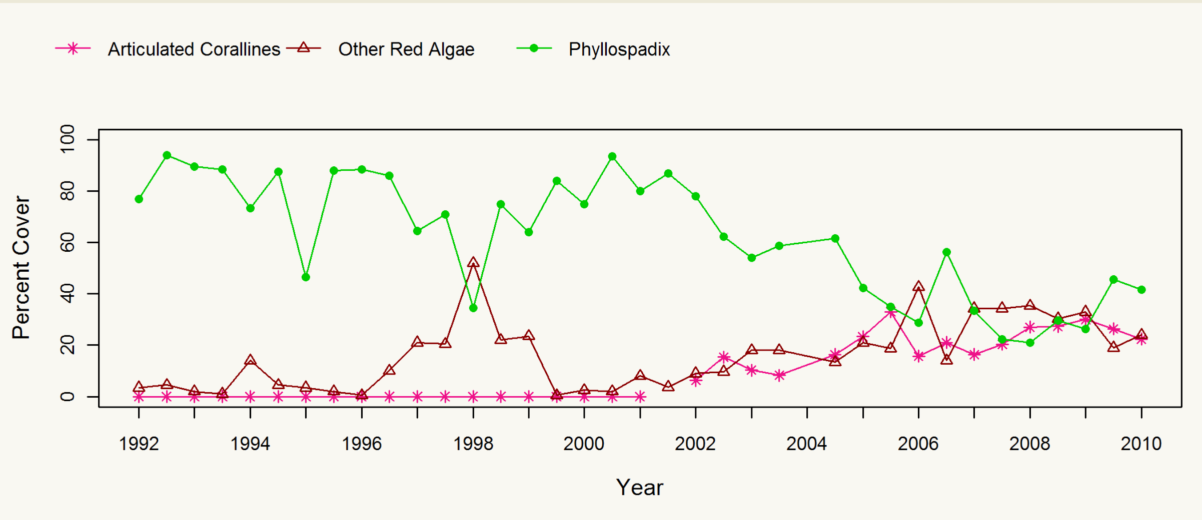
Rock (Above Barnacles)



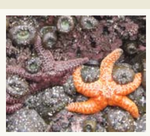
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

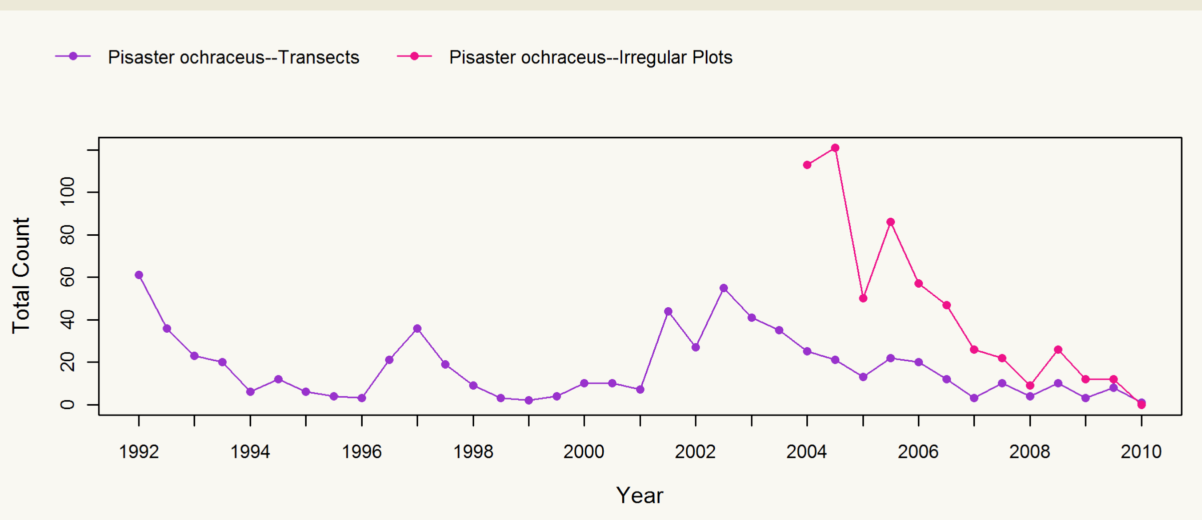


Species Counts and Sizes

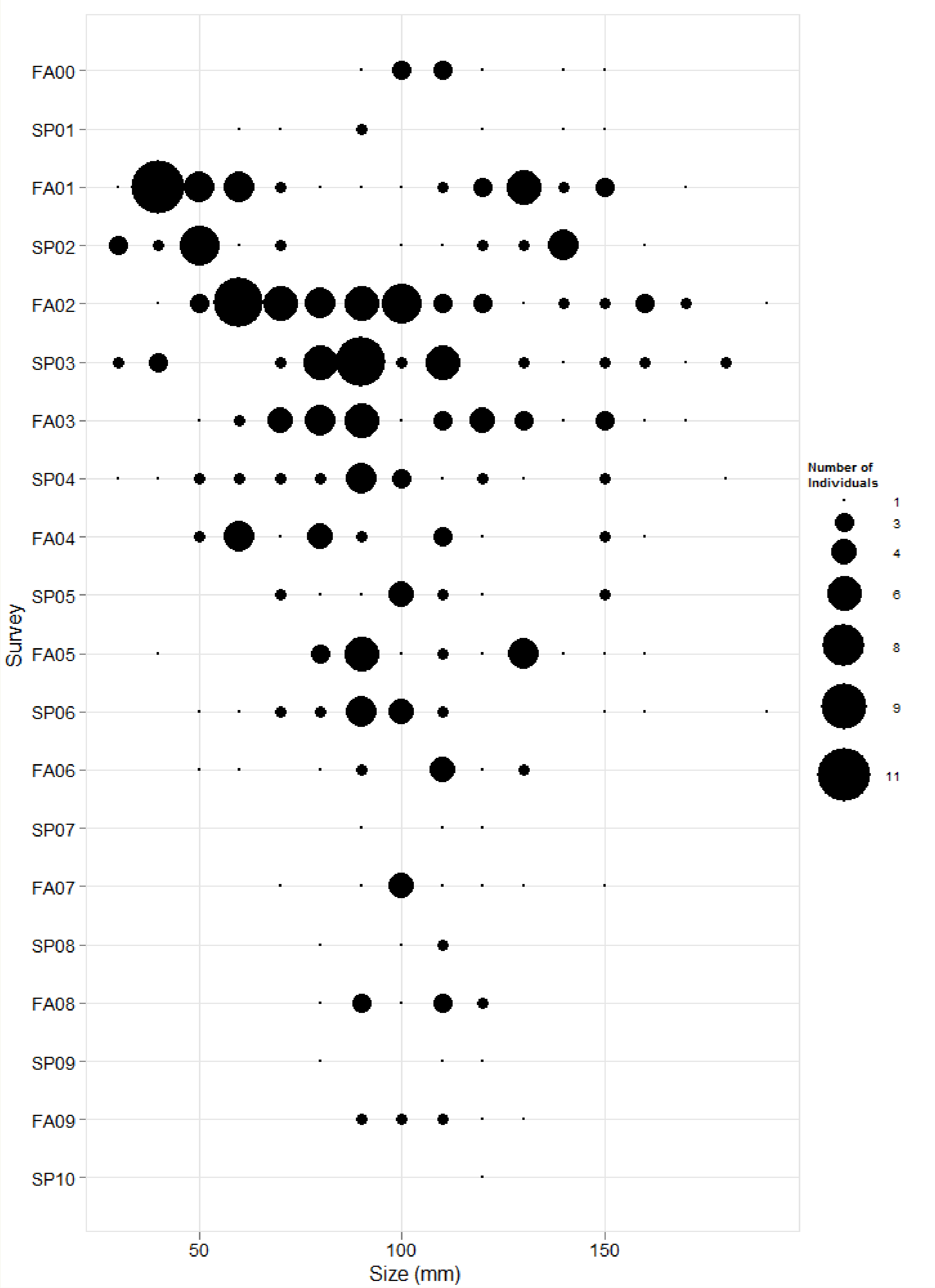


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes in Transects



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Coal Oil Point Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The anemone plots at Coal Oil Point consist primarily of the solitary anemone, *Anthopleura sola* rather than the colonial anemone *Anthopleura elegantissima* (note that these were considered a single species prior to the past several years and they are not distinguished in our sampling methods). Cover of *Anthopleura* has undergone a gradual decline from around 25% in 1992 to less than 10% in 2010 with cover estimates interrupted every few seasons by periods of near complete sand burial. Aside from sand, the dominant taxa occupying these plots are species of filamentous red algae which have been lumped with a few other seldom-encountered species into the "other red algae" category. These algae, though fluctuating wildly in relation to sand burial, are also showing signs of decline since about 2006. Alternatively, the ephemeral alga *Ulva* has been increasing over this period, along with bare rock.

Mussel plots were added to this site in the fall of 2003. Since that time, the mean cover of *Mytilus* declined initially from around 80% to around 60% by the fall of 2004, but has remained generally steady in the 60-70% range thereafter. Much of the decline is the result of a single plot in which a mussel breakout gave way to an open patch of rock and barnacles that has persisted since that time. Annual motile invertebrate sampling has occurred in these plots since their inception (always in the spring, though with an additional sampling in the fall of 2003). Limpets along with *Nucella* spp. and *Tegula funebralis* snails have undergone slight fluctuations during this time, until the dramatic increase in *Tegula* in 2010.

The mean cover of Surfgrass (*Phyllospadix*) has fluctuated widely throughout the years at Coal Oil Point with seasonal variation (lower in spring, higher in fall) along with intermittent periods of sand burial. Throughout the years, the cover of *Phyllospadix* hovered around the 60% to 80% range. Dips below that level were the result of sand burial, rather than plant and/or rhizome loss. Even where leaves were lost the plants would quickly regenerate from the rhizomes upon emergence from burial. Beginning in 2003 the seasonal pattern began to break down and surfgrass cover increased steadily until 2005. Seasonal variation returned in 2006, but then in 2007 the surfgrass population crashed in the absence of sand burial, and this time there was extensive rhizome loss as well. Mean surfgrass cover declined to almost zero by the spring of 2008 and has recovered only slightly since that time. Filamentous red algae and bare rock have increased in the wake of the surfgrass declines. As of 2010 *Phyllospadix* cover was close to 20% and in subsequent sampling events, some suggestion of rhizome recovery has been observed at this site.

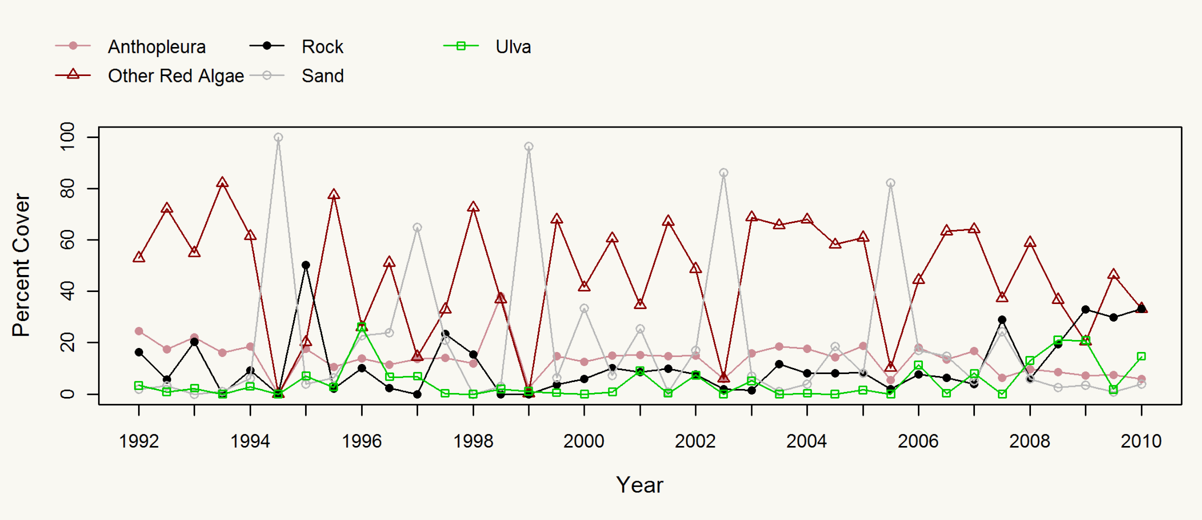
The numbers of seastars at Coal Oil Point have never been high enough to warrant plot establishment. However, in the spring of 2010, the decision was made to initiate 30 minute timed searches for seastars at this site. In that sampling season a total of 8 seastars were counted and measured.

Photo Plots

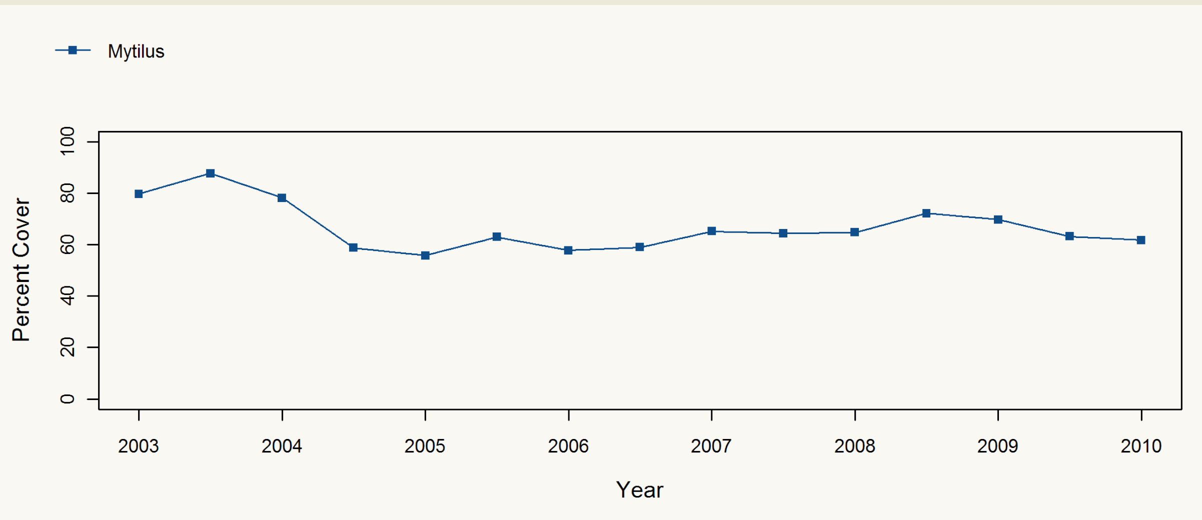
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

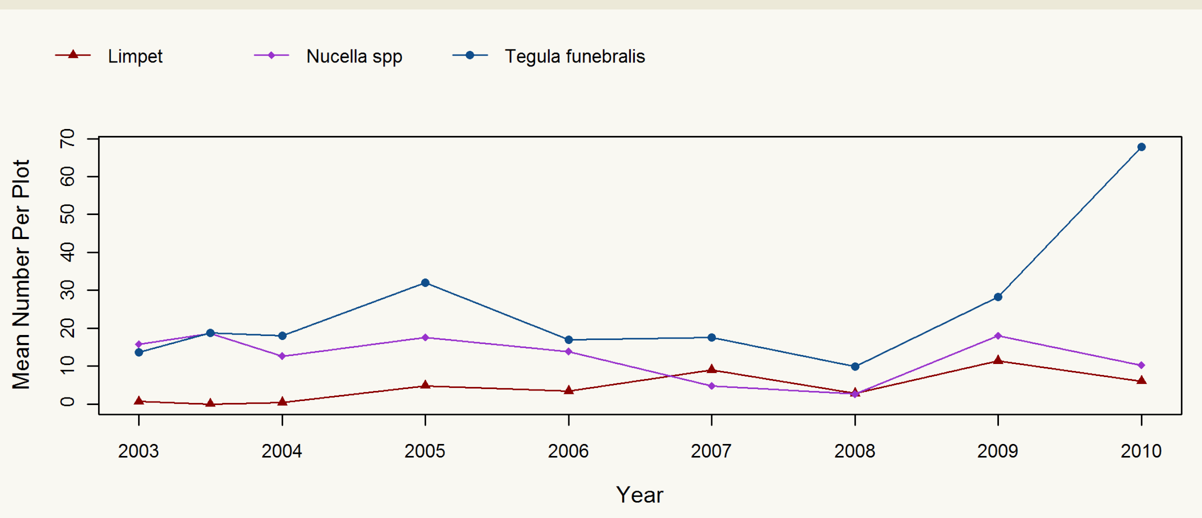
Anthopleura (Anemones)



Mytilus (California Mussel) - percent cover



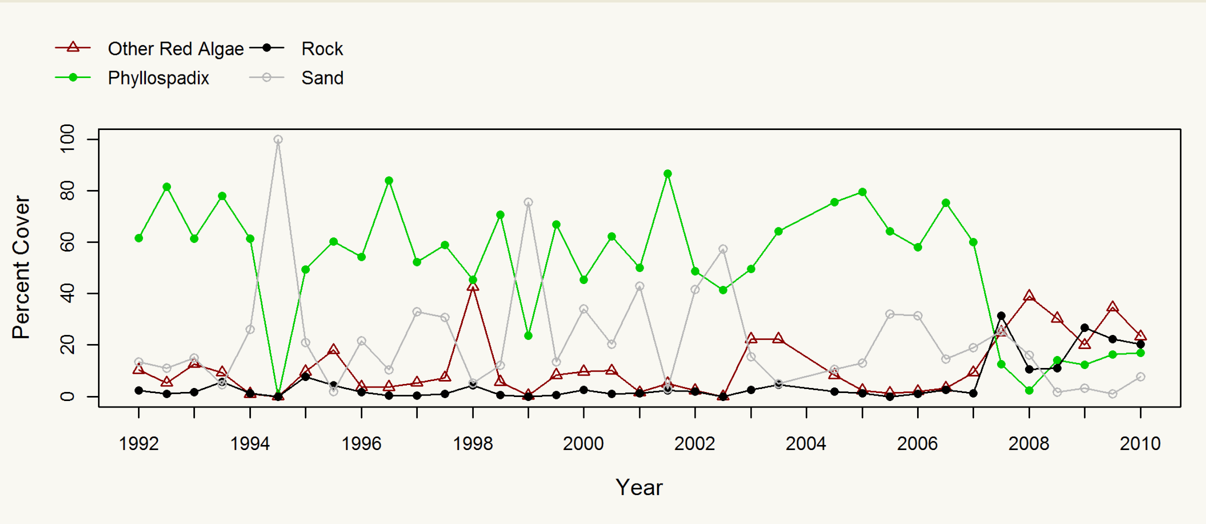
Mytilus (California Mussel) - motile invertebrate counts



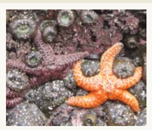
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

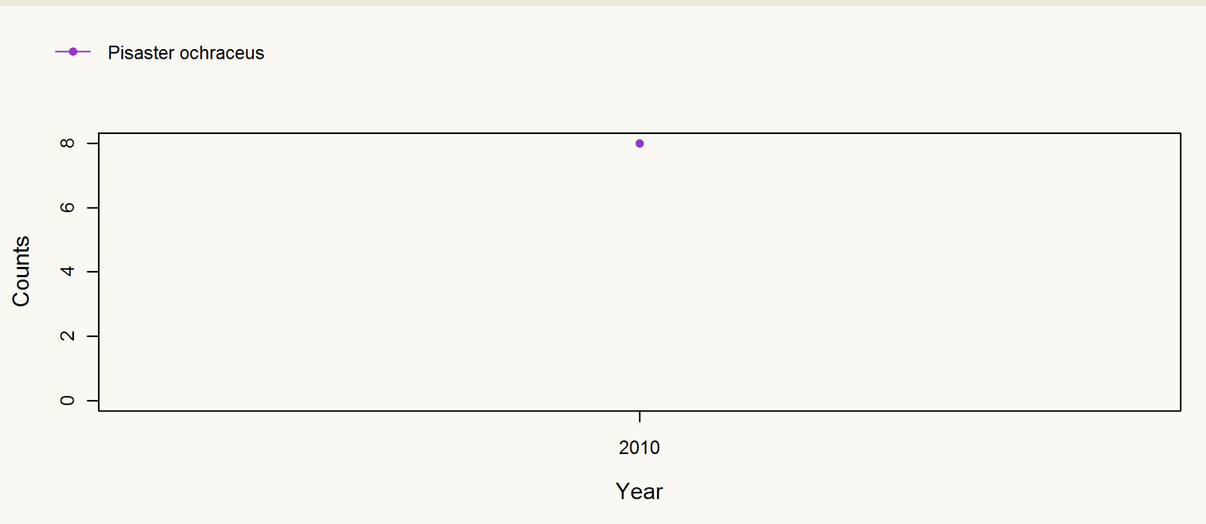


Species Counts and Sizes



Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



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Carpinteria Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The anemone plots at Carpinteria consist primarily of the solitary anemone, *Anthopleura sola* rather than the colonial anemone *Anthopleura elegantissima* (note that these were considered a single species prior to the past several years and they are not distinguished in our sampling methods). Cover of *Anthopleura* has hovered around 30% plus or minus 10% since plot inception in 1992. At the same time, other red algae (a lumped group with filamentous red algae as its primary component) have fluctuated wildly from 10 to nearly 80% cover, largely coincident with periods of sand inundation. In recent years, one species of red algae (*Gracilaria* spp.) along with patches of *Phyllospadix* sp. have been increasing within and around the anemone photoplots, though these trends are not apparent in the figure.

The barnacle plots at this site consist of a mixture of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula* with the former dominating some plots and a more even mixture in others. Unlike some other monitoring sites, most of these barnacle plots are located atop rock outcrops and, with one exception, are not subject to periodic sand scour and/or burial. Thus they have not experienced dramatic fluctuations in barnacle cover as a whole, though one plot is subjected to regular scour and is nearly always covered by ephemeral *Ulva* with little barnacle cover. The plots experienced a strong recruitment pulse in 1994 resulting in a mean barnacle cover around 90%. This was followed by a gradual decline to less than 40% cover through 1998, an increase to 60% by 2004, and a decline to 30% by 2008. Presently the mean cover is stable at around 40%. Motile invertebrate counts at this site began seasonally in the fall of 2000 and were changed to annual sampling in 2004. Within the barnacle plots, limpets are abundant and have fluctuated between 50 and 200 individuals per plot on average. Littorines are also abundant and have varied widely throughout the years from almost none in 2007 to an average of around 1000 individuals per plot in 2002. Presently the numbers of both limpets and littorines are approaching 200 individuals per plot.

The *Pollicipes* plots at this site started out in 1992 with abundant *Pollicipes* cover (~60%) compared to mussel cover (~10%). Throughout the years, there has been a gradual reversal in the relative cover of these two species with mussels presently around 50% and *Pollicipes* around 30%. *Pollicipes* has shown seasonal variation (lower in spring, higher in fall) with the inverse pattern reflected in bare rock. One significant *Pollicipes* population crash occurred in 2008, followed by strong recruitment and an equally abrupt rebound by the following spring. Motile invertebrate counts within the *Pollicipes* plots show the regular occurrence of whelk snails (*Nucella* spp.) and shore crabs (*Pachygrapsus crassipes*) in the range of 5-10 individuals per plot on average. Limpets are generally more abundant but have fluctuated wildly from just a few to nearly 100 individuals per plot on average.

The Mussel plots at Carpinteria have been highly variable throughout the years ranging from over 90% mean cover of *Mytlius* to nearly zero. Periods of mussel decline were caused by extensive mussel bed breakouts that are in turn the result of frequent episodes of pounding surf on the outer reef at this site. Pulses in cover of the ephemeral alga *Ulva* spp. have occurred in the wake of these mussel breakouts. Data gaps are caused by the presence of harbor seals on this portion of the site which, when present, prevent access to the plots. Motile invertebrate sampling shows that chitons (*Nuttalina* spp.) and snails (*Nucella* spp. and *Tegula funebralis*) are regular occupants of these mussel plots, along with littorines, which were more common in the fall of 2003, and limpets, which show two strong abundance peaks in fall of 2003 and fall of 2009.

The mean cover of Surfgrass (*Phyllospadix* spp.) at this site has fluctuated throughout the years from about 10 to 90%, with seasonal variation (lower in spring, higher in fall) and one period of particularly low cover from the fall of 1998 to the spring of 2000. During that latter period, the apparent decline in *Phyllospadix* was met by a corresponding increase in the kelp *Egregia menziesii*, while seasonal dips through the years resulted in increases of red algae (primarily filamentous red algae but also including *Gracilaria* sp. and a few other species). *Egregia* had another pulse of cover in the fall of 2008 but this did not coincide with an apparent *Phyllospadix* decline. The disparity between these two events is likely the result of changes in sampling methodology: in the early years, samplers would record the topmost species encountered at the sampling point, but after 2000, in situations where fronds of *Egregia* lay atop a *Phyllospadix* understory, both species would be recorded for that sampling point. Thus, some portion of the apparent *Phyllospadix* decline of the late 1990's may be misleading as the increasing *Egregia* may have been merely covering over a healthy *Phyllospadix* understory. Since 2001, *Phyllospadix* cover has hovering around 50% with some minor and/or seasonal variation.

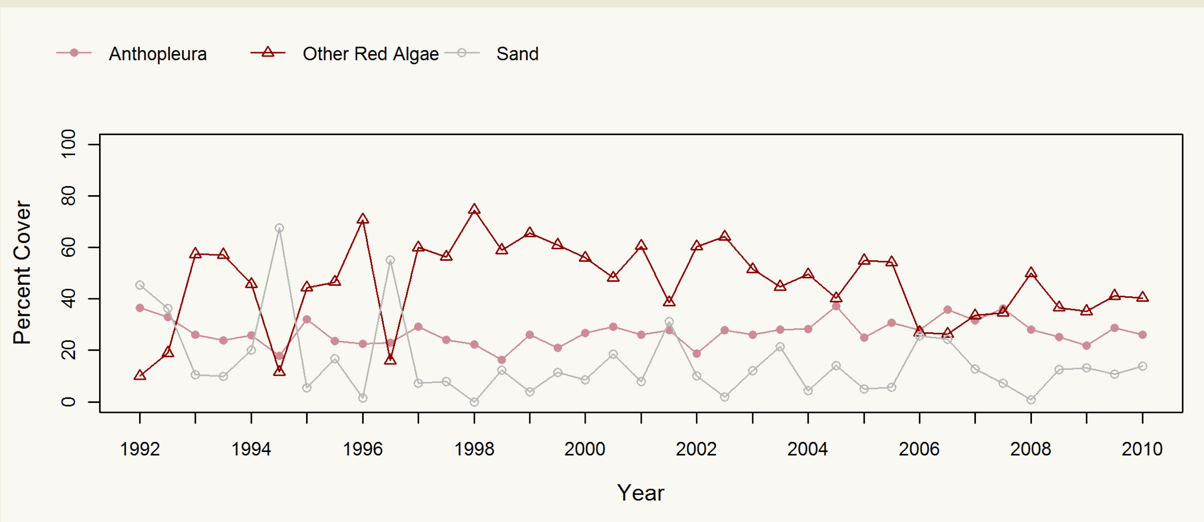
Seastar (*Pisaster ochraceus*) abundance within the original transect swaths has been variable at this site from over 70 stars counted and measured to just a few. Seastar numbers were particularly low from 1994 through 1999 followed by a period of higher numbers from 2002 to 2006. Seastar numbers show some seasonal variation with higher numbers in the spring compared to the fall. In the spring of 2004, the push for methodological consistency among sites prompted the addition of a series of three large irregular plots to be sampled alongside the transects. Compared to the transect data, these plots contained a higher number of stars during their first few seasons of sampling (expected given the greater amount of area sampled), but with declines converging toward the transect data numbers in more recent seasons. Seastar sizes have been measured since fall 2000. A large recruitment pulse was evident in the spring of 2002. The growth of these seastars through time is can be seen in these trend graphs through spring 2006, after which abundance drops off. No other significant recruitment events have observed. Given the pulse of larger stars appearing in spring 2010, along with general observations, it seems that stars are able to migrate to and from the reef from the contiguous subtidal. These data have historically been collected within three short transect swaths.

Photo Plots

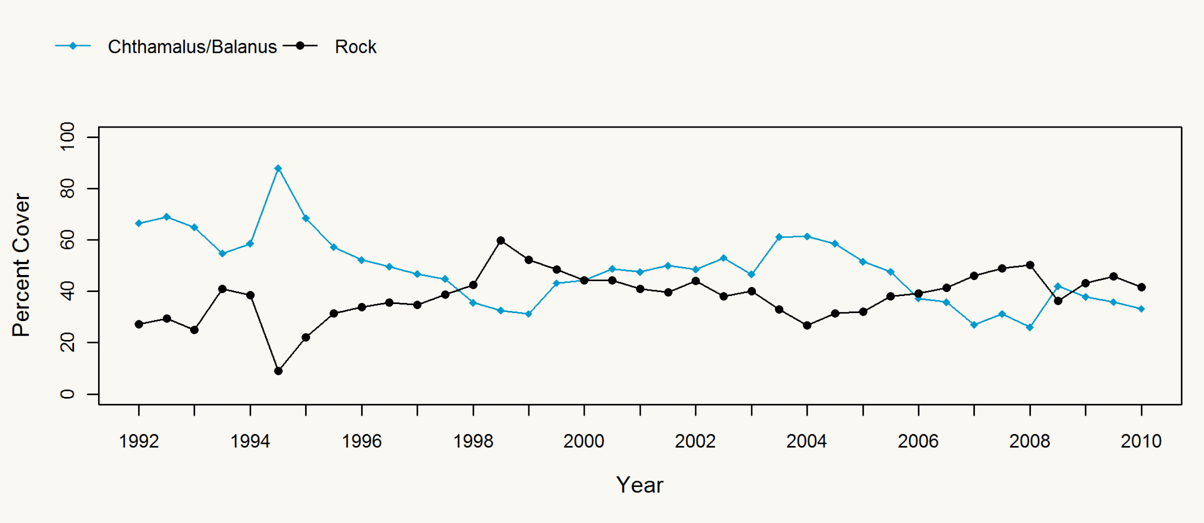
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

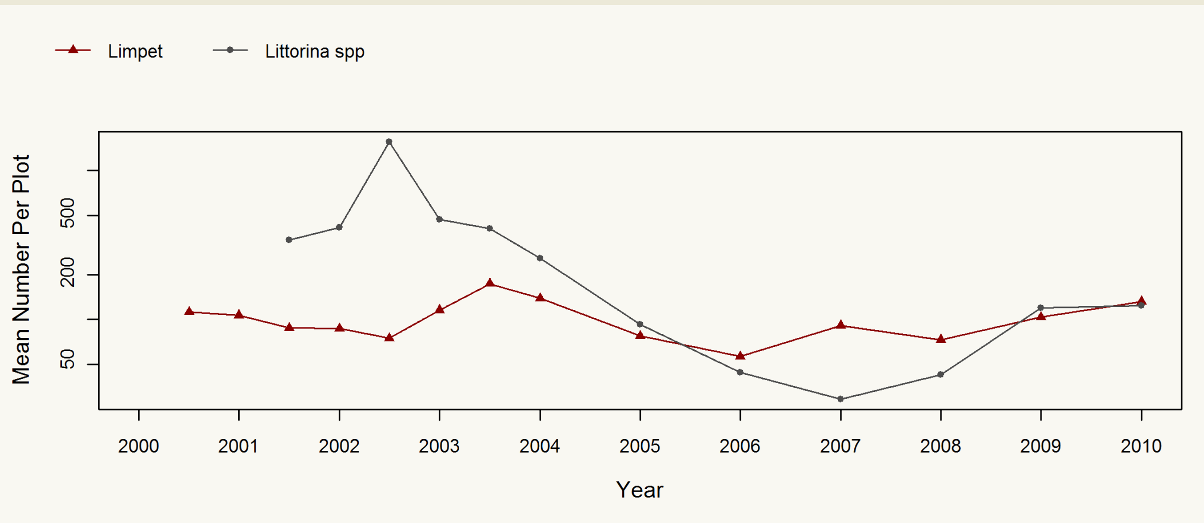
Anthopleura (Anemones)



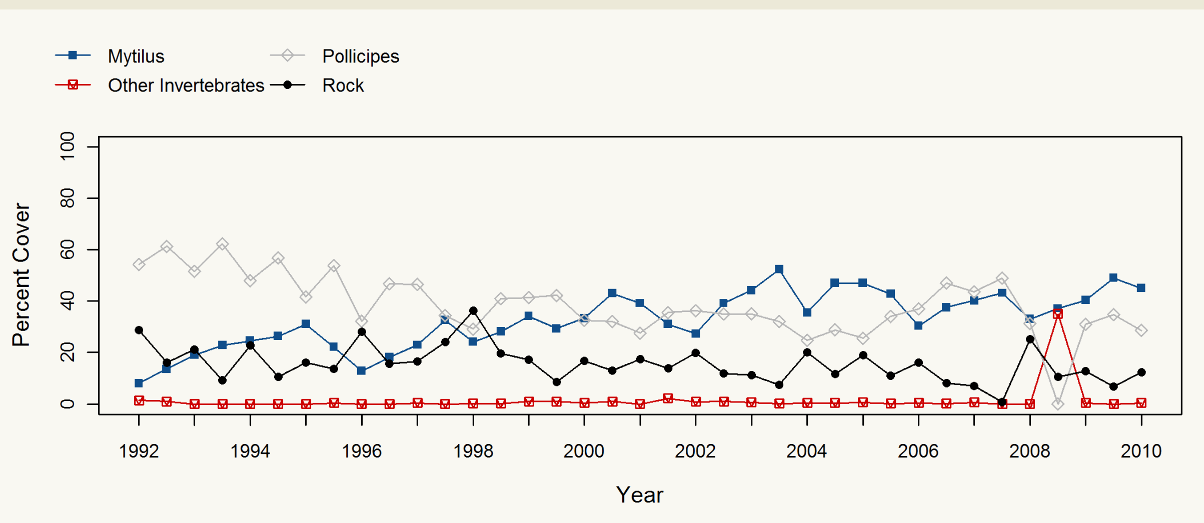
Chthamalus/Balanus (Acorn Barnacles) - percent cover



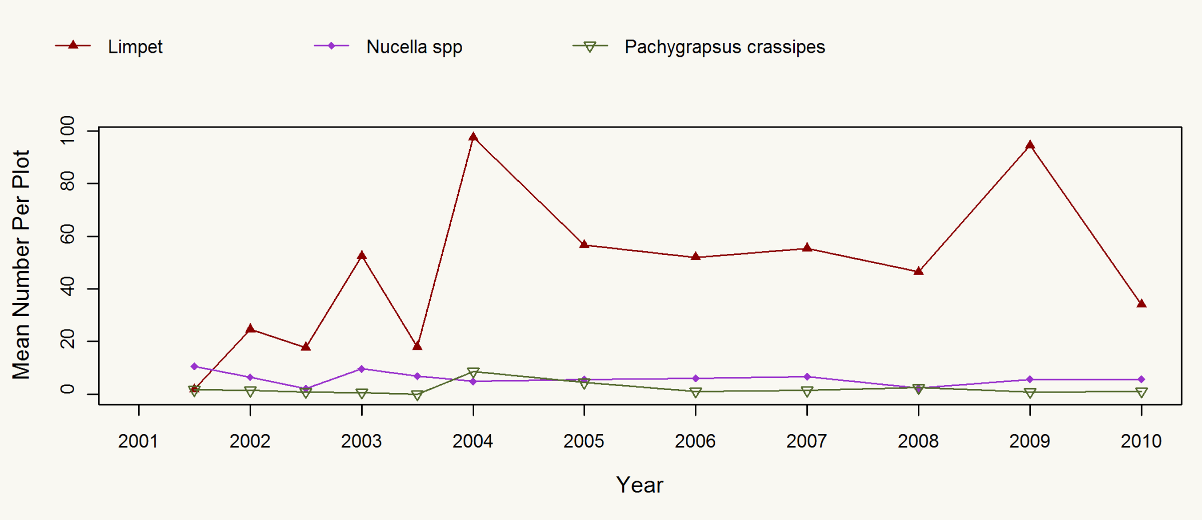
Chthamalus/Balanus (Acorn Barnacles) – motile invertebrate counts



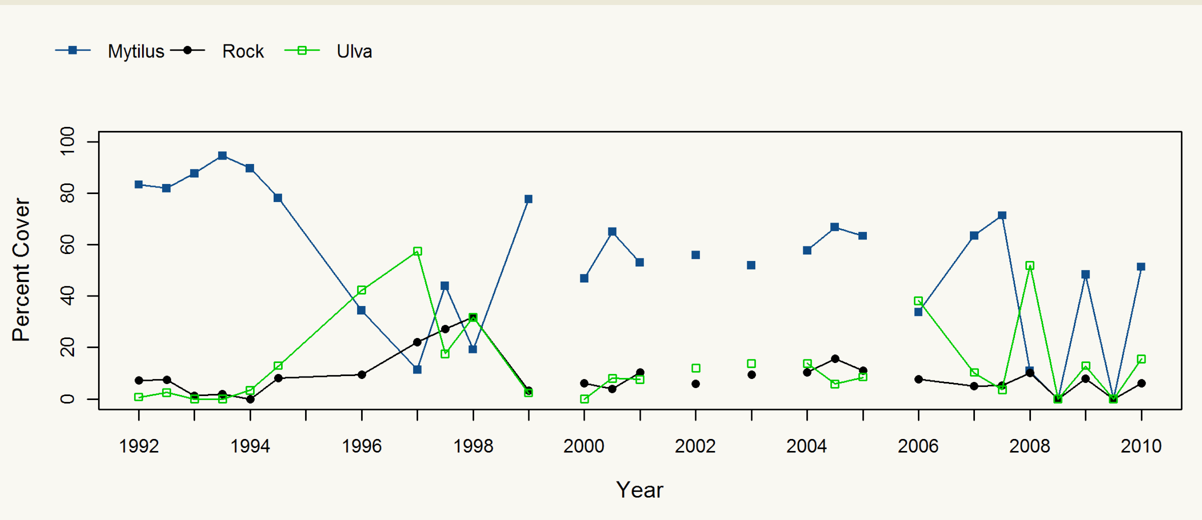
Pollicipes (Goose Barnacle) – percent cover



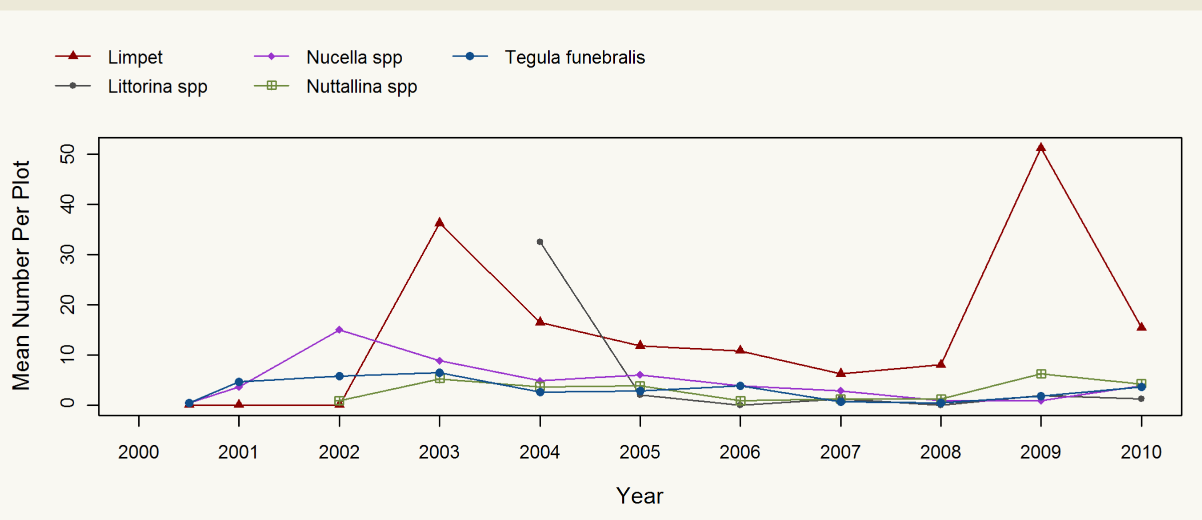
Pollicipes (Goose Barnacle) – motile invertebrate counts



Mytilus (California Mussel) – percent cover



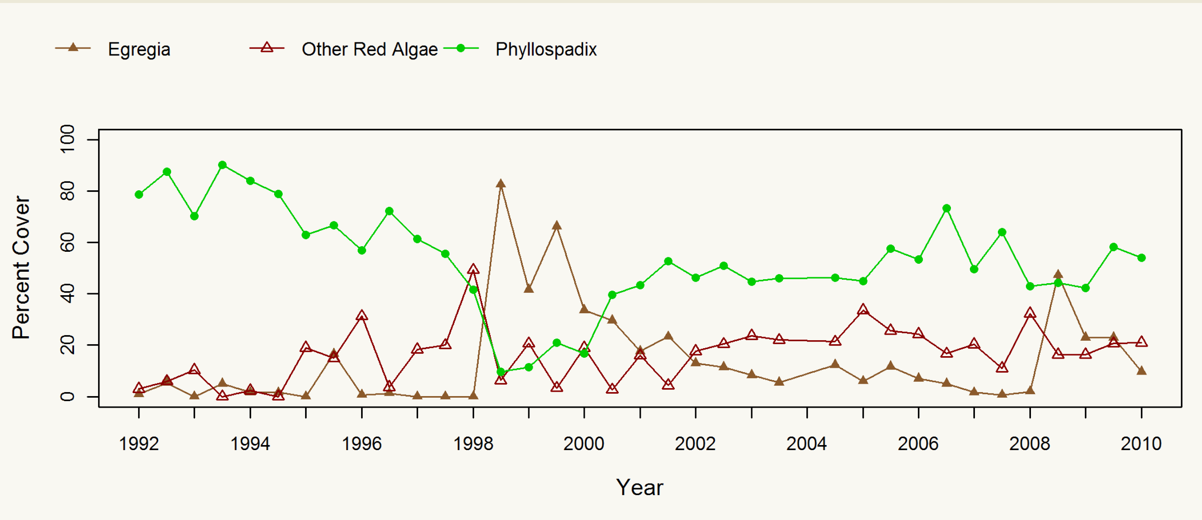
Mytilus (California Mussel) – motile invertebrate counts



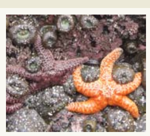
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

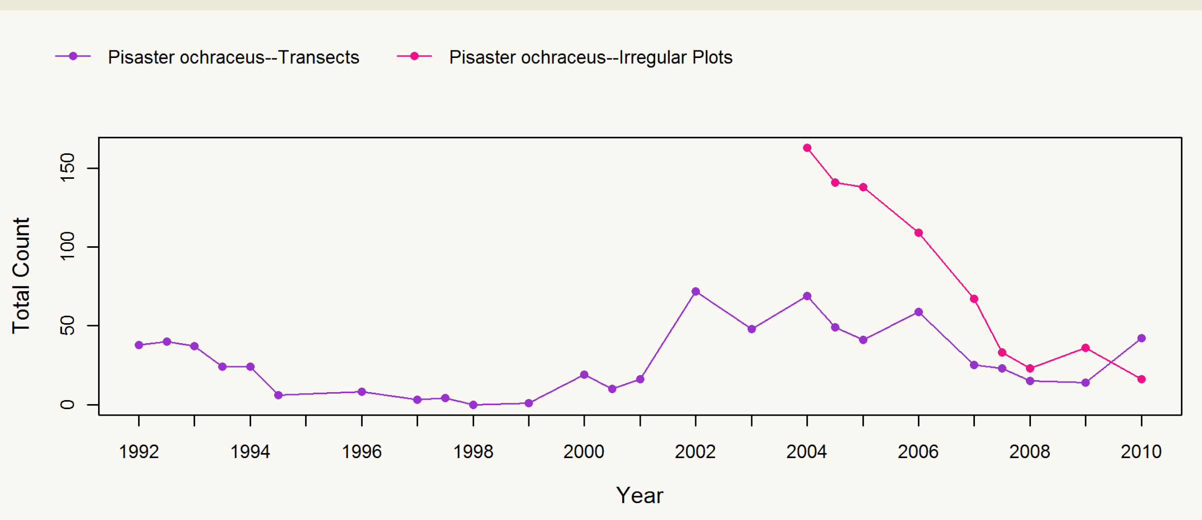


Species Counts and Sizes

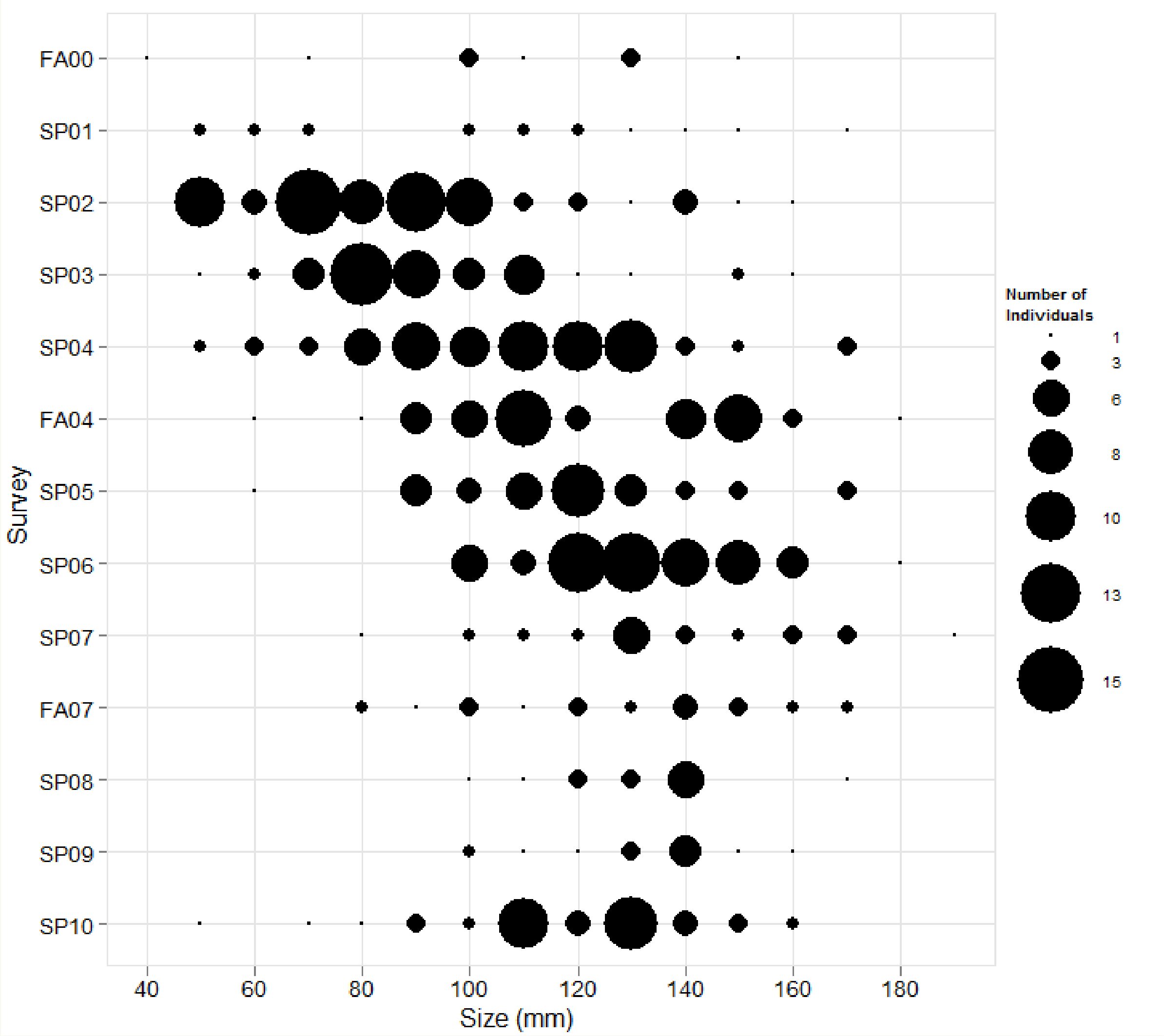


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes in Transects



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Mussel Shoals Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The anemone plots at Mussel Shoals consist primarily of the colonial anemone, *Anthopleura elegantissima* rather than the solitary anemone *Anthopleura sola* (note that these were considered a single species prior to the past several years and they are not distinguished in our sampling methods). Within the anemone plots, the mean cover of *Anthopleura* began close to 100% in 1994, declined gradually to under 60% by 1998, then hovered around 80% for several years through 2004. Since then, two additional cycles of lesser decline and recovery have occurred with the mean cover back in the 80% range presently. Much of the variability seen here is the result of a single plot which, since its inception, has alternated back and forth between anemone dominated and mussel dominated cover. Of the remaining four plots, two have exhibited less drastic variability, with periods of increased turf algae cover, while the other two plots have changed very little with *Anthopleura* clones covering nearly 100% of the plots. In fact, one of these plots has had a consistent anemone clone separation line in the same position for over ten years.

The barnacle plots at this site consist of a mixture of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula* with the former dominating some plots and a more even mixture in others. These plots are located on sloping riprap boulders in an area subjected to recurring scour by sand and cobble. This is reflected in the data which show barnacle cover (and, inversely, bare rock), fluctuating extensively and repeatedly throughout the years. Barnacle cover has been reduced to near zero twice during the monitoring period (spring of 1996 and spring of 2007) with less significant declines to around 40% occurring four other times. In each case, high recruitment has allowed these plots to rebound within a single sampling season with cover usually reaching levels of 80 to 90%. One plot disappeared completely in the late 1990's as the boulder it was housed on became dislodged and overturned. A replacement plot was installed, but shortly thereafter, a subsequent storm flipped the boulder over again allowing the sampling of that missing plot to resume. While the orientation of that plot has changed somewhat, making it more susceptible to encroachment by mussels, anemones and turf algae, it continues to be sampled along with its replacement plot. Motile invertebrate counts at this site began seasonally in the fall of 2000 and were changed to annual sampling in 2004. Within the barnacle plots, littorines and limpets are both highly abundant with the former varying in the neighborhood of 500 individuals per plot and the latter around 50 per plot. Like barnacles, limpets were scoured to nearly zero in the spring of 2006.

The mussel plots at have been fairly stable throughout the years with mussel cover in the 80 to 90% range most of that time. A single decline occurred in 2005 and 2006 reducing mussel cover to about 60%. Since then, mussel cover gradually increased to near 100% in 2009 and has been just a bit lower since then. These plots are mostly comprised of small and tightly packed mussels, and in addition are located on the shoreward side of a large rock ridge, presumably making them more resistant to scour or breakout. The data from the Motile invertebrate sampling show that snails (*Nucella* spp. and *Tegula funebralis*) were more common in the mussel plots in the first few years of sampling. Shore crabs (*Pachygrapsus crassipes*) were also a bit higher then as well. In recent years, the abundance of these motiles, along with littorines, has been low (less than ten individuals per plot). Limpets, on the other hand, started out low in the early years, but with increases to over 50 individuals per plot in the later years. This may be partly due to methodological changes: prior to 2006, only limpets on rock were included in the counts whereas limpets occurring on mussel shells were added after that.

Rock ("Above Barnacles") plots were added to this site in the fall of 2008 to document any upward spread of intertidal species as a result of global climate change or other factors. These plots are expected to remain dominated by bare substrates unless barnacles or other species begin to encroach upon them. As of the spring of 2010, no barnacles had been recorded, although a few small recruits had been observed within these plots.

The mean cover of Surfgrass (*Phyllospadix* spp.) at this site has declined from around 80% to near 40% since the inception of these transects in 1994. This decline occurred precipitously between 1995 and 1998 after which the cover remained near 40% for around seven years. Then an additional decline proceeded gradually with the mean cover hitting a low of around 20% in the spring of 2009. Since then, the cover has rebounded back to around 40%. The initial decline in the late 1990's was met with an increase in bare rock, and *Egregia* has had periods of higher cover, but species of red algae (primarily *Chondracanthus* sp., *Gastroclonium* sp. and filamentous species) have come to fill in most of the habitat that had previously been occupied by *Phyllospadix*.

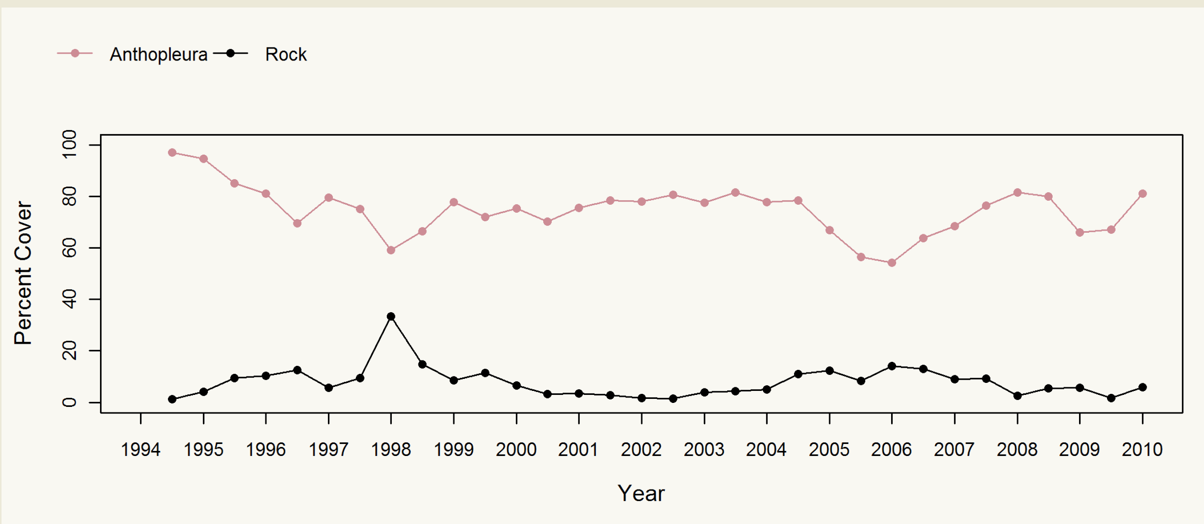
Seastar (*Pisaster ochraceus*) abundance has been variable at this site from over 90 stars counted and measured within the plots to around ten. Seastar numbers peaked in 1996, were particularly low from 1998 to 2001, and have shown seasonal fluctuations (lower in spring, higher in fall) since then with numbers on the lower end of the range as of spring 2010. Seastar sizes have been measured since the fall of 2000. Their sizes tend to be relatively large at this site compared to others with relatively low recruitment of small (<50mm) individuals in the earlier sampling seasons, and almost no individuals smaller than 90mm observed since the spring of 2004. This suggests that, despite extensive sand barriers offshore of the sites, the seastar population at the site is maintained through migration in and out of the site rather than through recruitment.

Photo Plots

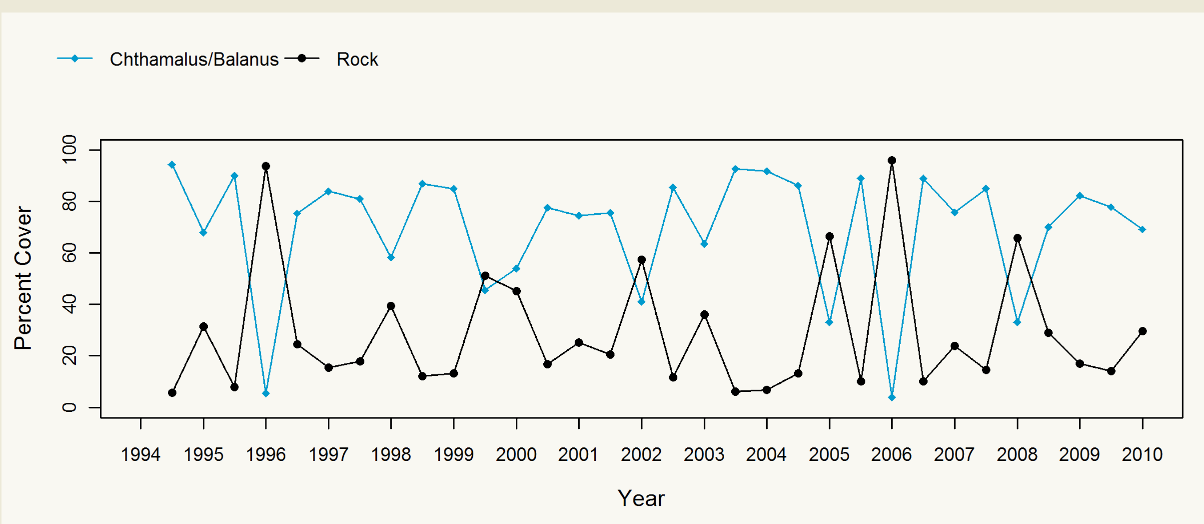
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

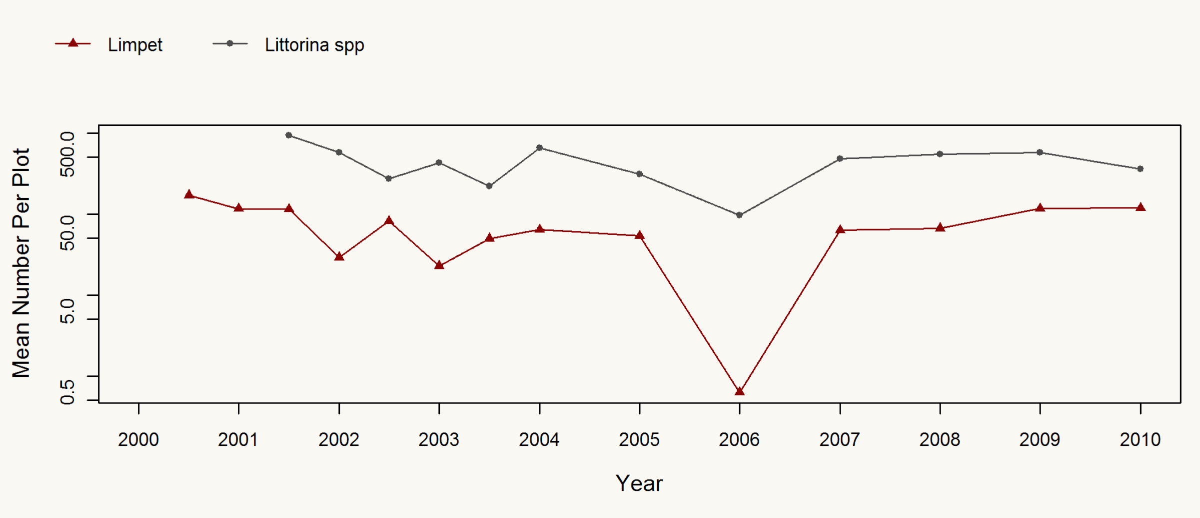
Anthopleura (Anemones)



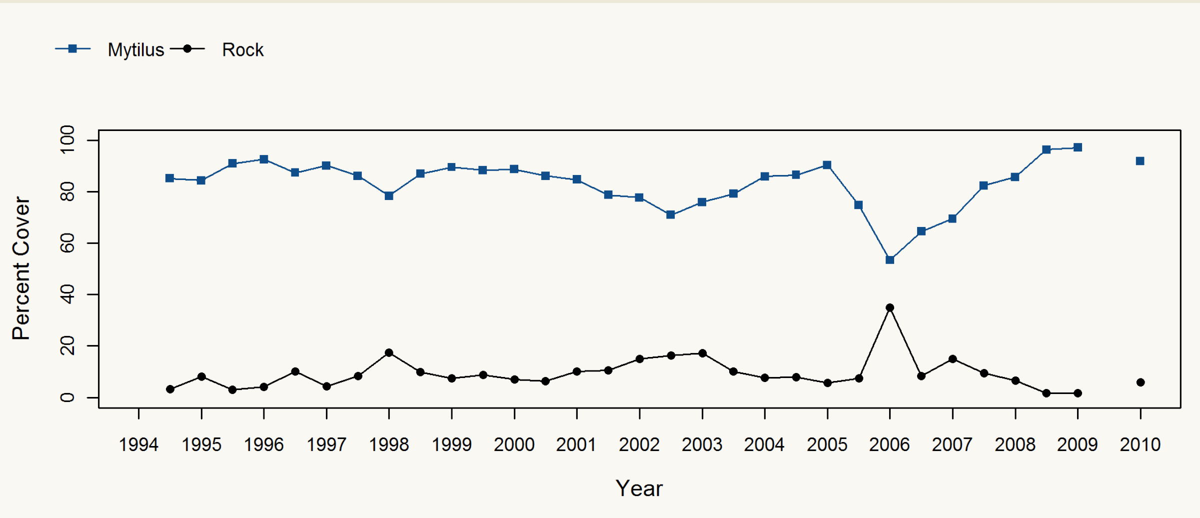
Chthamalus/Balanus (Acorn Barnacles) - percent cover



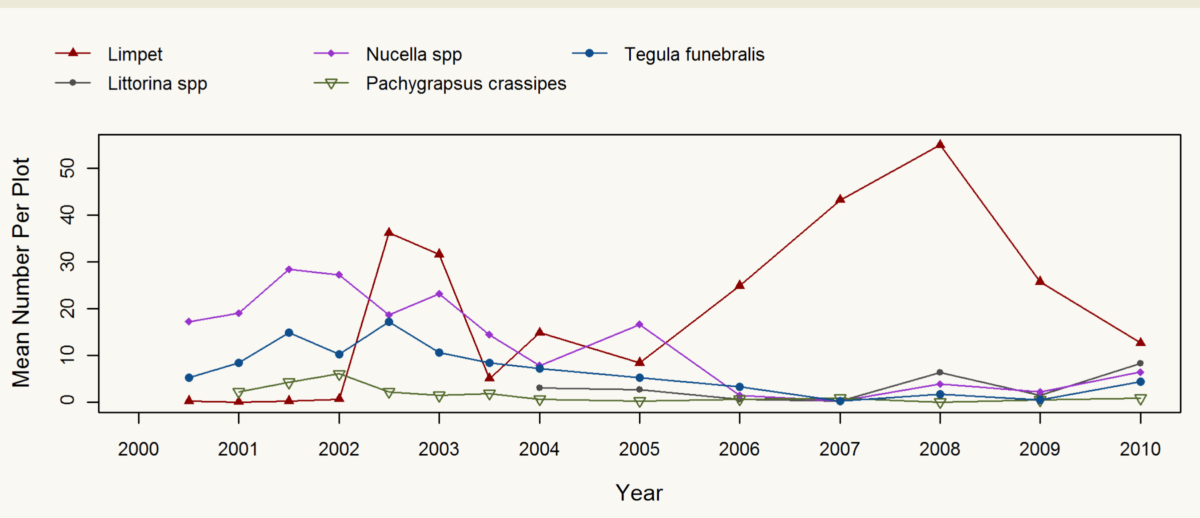
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



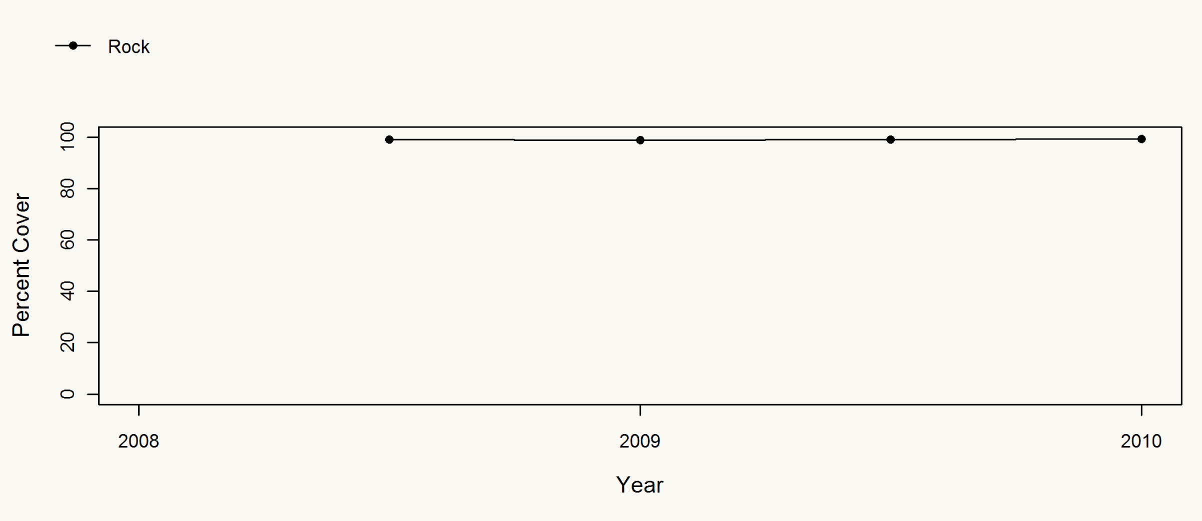
Mytilus (California Mussel) – percent cover



Mytilus (California Mussel) – motile invertebrate counts



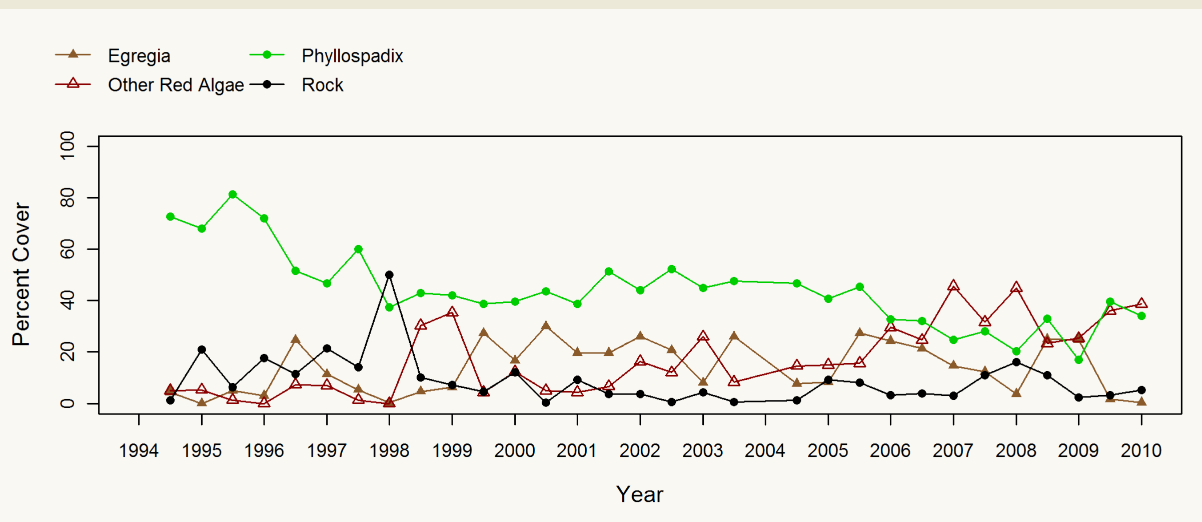
Rock (Above Barnacles)



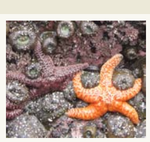
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

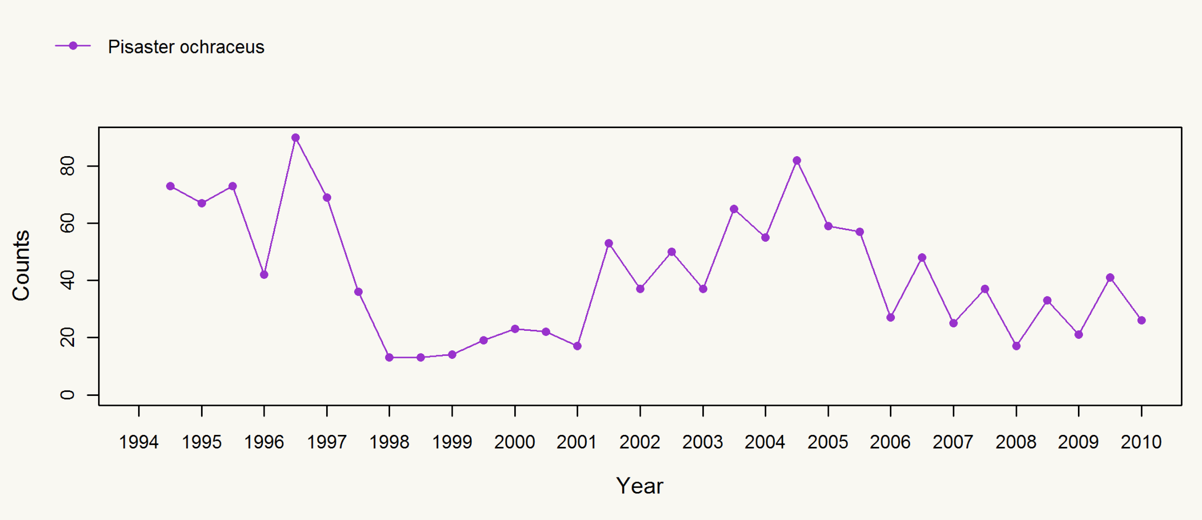


Species Counts and Sizes

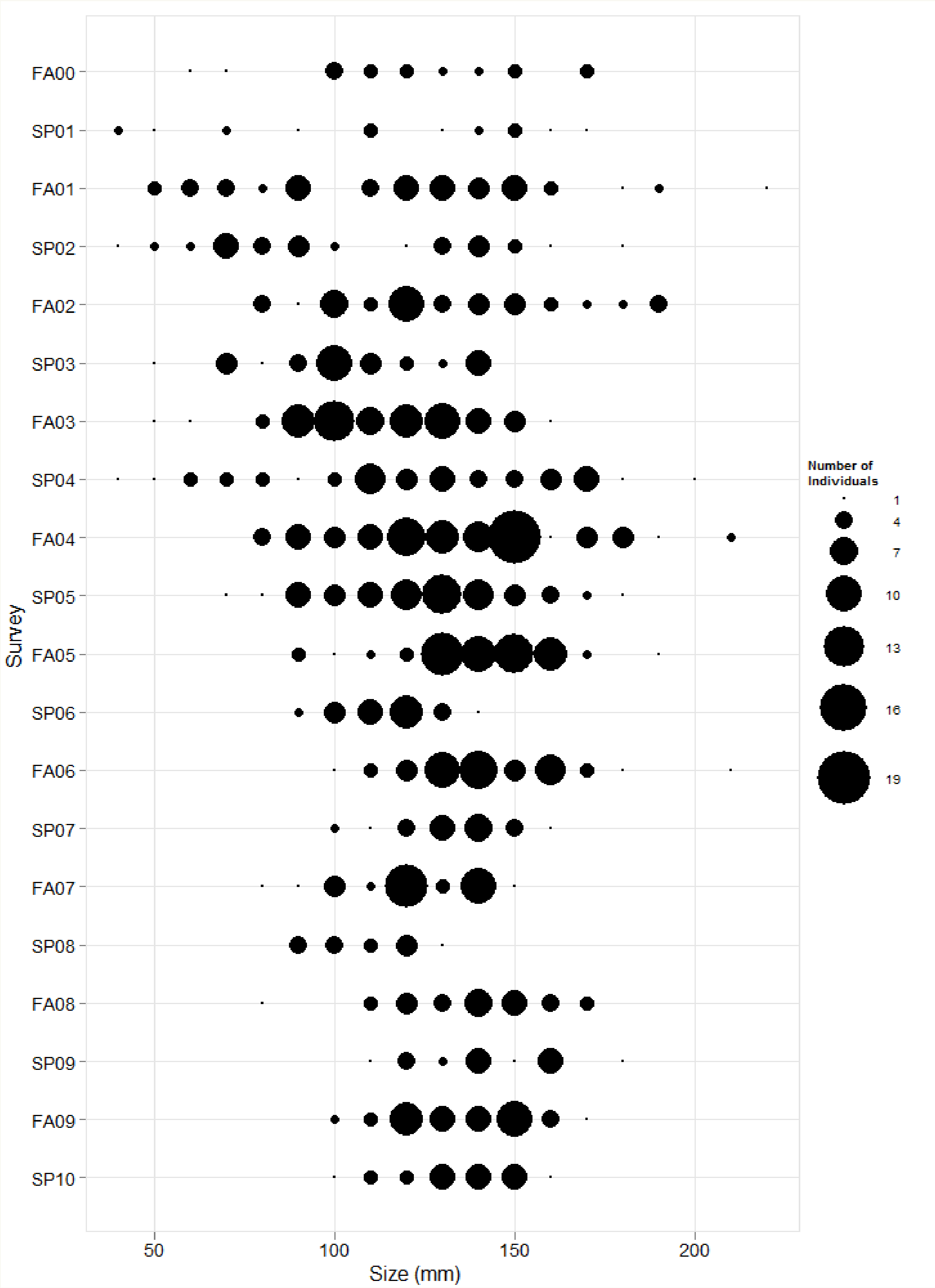


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Old Stairs Long-Term trends

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In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The anemone plots at Old Stairs consist primarily of the colonial anemone, *Anthopleura elegantissima* rather than the solitary anemone *Anthopleura sola* (note that these were considered a single species prior to the past several years and they are not distinguished in our sampling methods). These plots showed greater variability due to sand inundation from their inception in 1994 through 2002, and more gradual change thereafter with cover ultimately declining from 70% to around 40%. Sand burial has not been a significant factor since 2002 though scour could still be influencing the plots. As anemones have declined, invertebrate species (primarily *Phragmatopoma* and encrusting tunicates) and red algal species (namely *Chondracanthus* sp. and filamentous species) have taken their place, with each of these groups increasing to a mean cover of around 20%. Each of these plots has a unique ecological story to tell. One has a recurring colony of *Phragmatopoma* that grows for a period of time and then gets broken away, another has persistent colonies of both sponges and tunicates, along with recurring *Egregia* holdfasts which have periods of growth and senescence. Two others have persistent patches or red algae and mussels respectively, and the final plot has remained nearly covered by colonial *Anthopleura*.

The barnacle plots at this site consist of a mixture of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula* with the former being the dominant component of all plots. Since their inception, barnacle cover has declined from nearly 100% in 1994 to less than 20% in 2010. In fact, a single plot, which has remained at nearly 100% barnacle cover throughout the monitoring period, is responsible for most of that twenty percent. The other four plots have become dominated by *Endocladia*, *Mytilus*, or a mixture of these two species along with bare rock. In the past two seasons, small patches of *Endocladia* have been observed in that last barnacle dominated plot suggesting that it too may transition away from barnacle dominance. Motile invertebrate counts at this site began seasonally in the fall of 2000 and were changed to annual sampling in 2004. Littorines were added to the protocol in the fall of 2001. Within the barnacle plots, littorines and limpets are both highly abundant with the former varying in the neighborhood of 1000 individuals per plot and the latter steady at around 100 per plot. *Nucella* spp. snails are also common with around ten individuals per plot in most seasons, though these were absent during three sampling events.

Shortly after site establishment, the mussel plots exhibited a precipitous decline in mean *Mytilus* cover from around 80% in spring 1995 to near 30% the following fall. This decline was met by a corresponding increase in barnacle cover along with bare rock. After that, mussels began a gradual recovery interrupted by brief declines of varying degrees. One of these subsequent declines occurred in 2004-2005 the other in 2009, and both were the result of breakouts in the mussel beds, presumably due to heavy winter storms. Consistent recruitment of young mussels to this site has allowed these mussel beds to regenerate before other opportunistic species could become established in the plots. The data from the Motile invertebrate sampling show consistent low levels of chitons (*Nuttalina* spp.) and littorines in these mussel plots, along with higher and more variable numbers of whelks (*Nucella* spp.). In addition, limpets have been quite abundant and highly variable in these plots since the spring of 2002.

The *Endocladia* plots at this site are a mixture of turfweed, barnacles, mussels, and bare rock with no clear patterns developing throughout the monitoring period except that bare rock appears to be increasing of late. Mean *Endocladia* cover has varied between about 10 and 50%, barnacles have varied more dramatically between 20 and 60%, and mussels have remained steadier at around 10 to 30%. The data from the Motile invertebrate sampling show consistent low levels of chitons (*Nuttalina* spp.) and whelks (*Nucella* spp.) in the *Endocladia* plots, along with higher and more variable numbers of limpets and littorines.

Rock ("Above Barnacles") plots were added to this site in the fall of 2008 to document any upward spread of intertidal species as a result of global climate change or other factors. These plots are expected to remain dominated by bare substrates unless barnacles or other species begin to encroach upon them. As of the spring of 2010, no barnacles had been recorded in the photoplot sampling, although a few small recruits had been observed within these plots. (Note - the decline of rock to zero in spring 2010 depicted in this figure is an error). The annual motile invertebrate counts began in these new rock plots in 2009. So far, the only motile invertebrates present in these plots are littorines, whose numbers declined by about half between the first two sampling events.

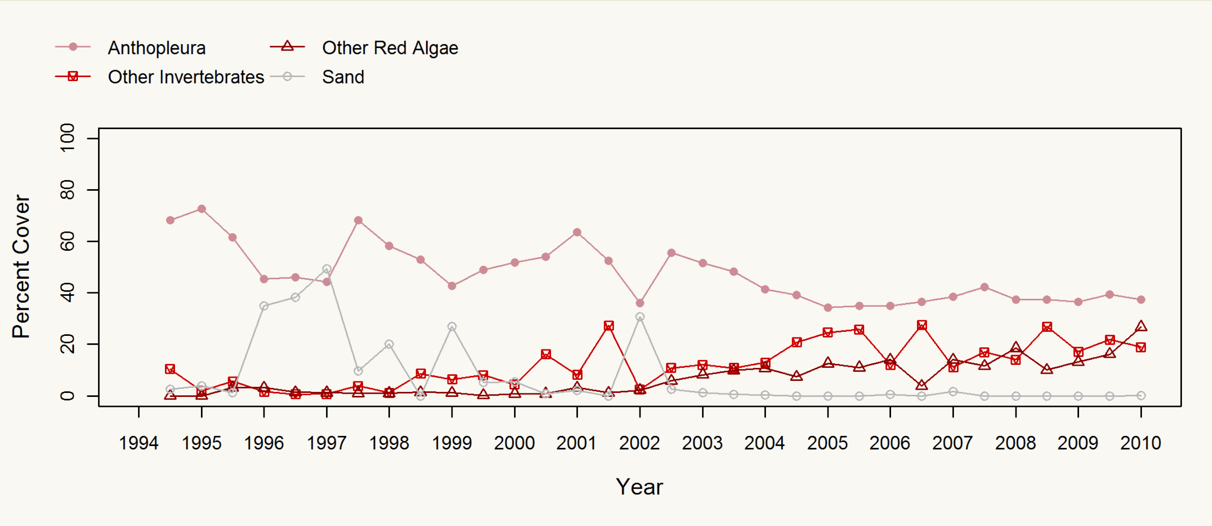
Seastar (*Pisaster ochraceus*) abundance within the original transect swaths began at around 30 total stars and remained below that level for the first 5 years of sampling. After 2000, the numbers of stars began to increase and become more variable, both through time, and seasonally (with higher numbers in the spring compared to fall). In the spring of 2004, the push for methodological consistency among sites prompted the addition of a series of three large irregular plots to be sampled alongside the transects. These data show a high number of stars during their first few seasons of sampling, and then declining numbers for the 1.5 years, followed by a gradual increase. The size distribution figure shows that the population of seastars at Old Stairs is comprised of mostly larger individuals but with a fair amount of consistent recruitment (presence of stars less than 50mm). There are no clear pulses of recruitment that have moved through the population. Seastars are often observed to be partially or completely buried in sand near the base of the reef structures at this site. The degree to which recruitment, or migration from the subtidal maintains the seastar population at this site is not clear. The increase in seastar abundance in 2007 is associated with generally larger stars, suggesting an influx of stars from the subtidal.

Photo Plots

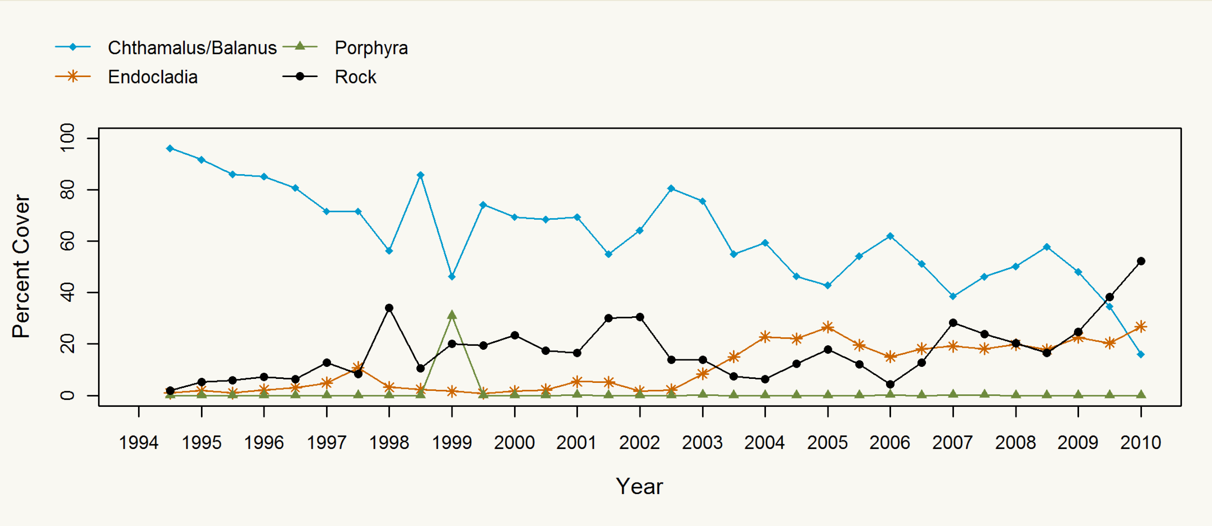
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

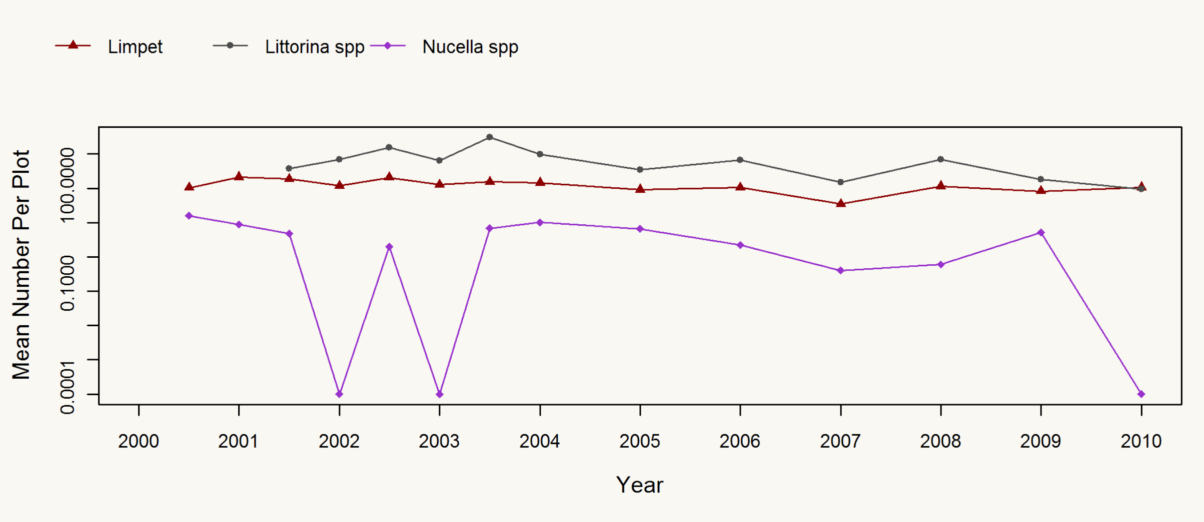
Anthopleura (Anemones)



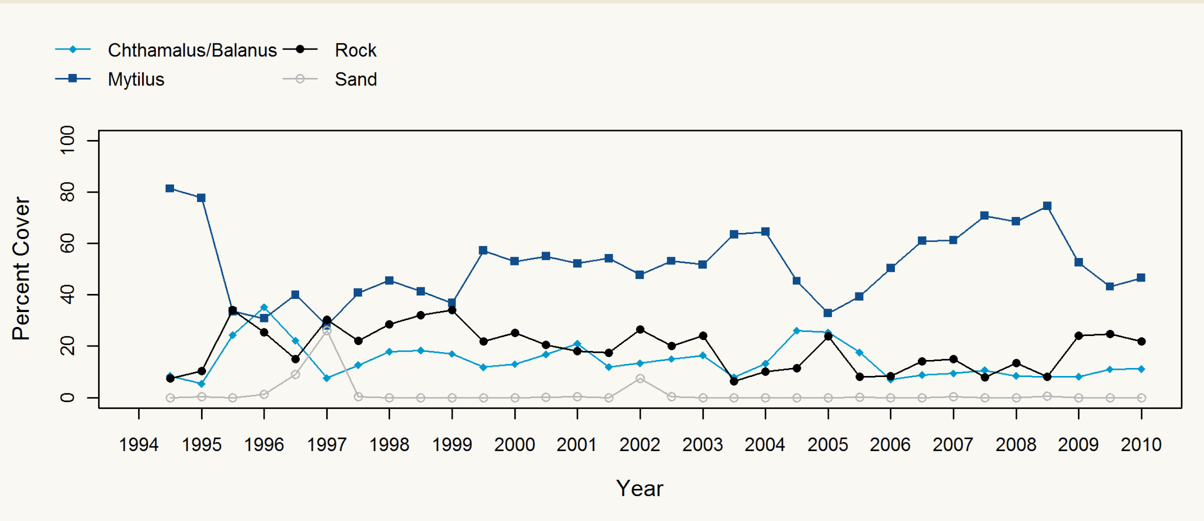
Chthamalus/Balanus (Acorn Barnacles) - percent cover



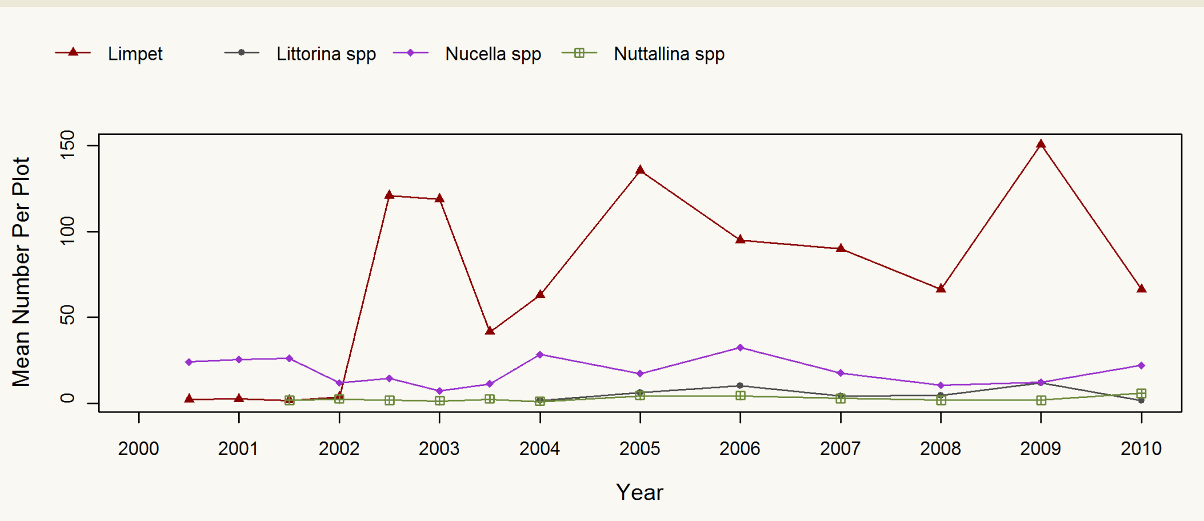
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



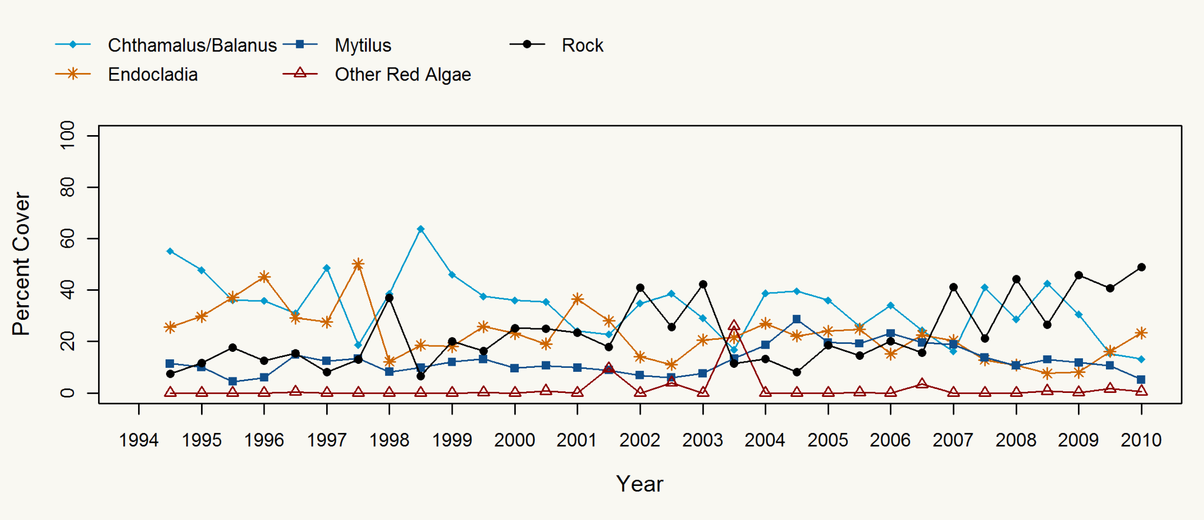
Mytilus (California Mussel) - percent cover



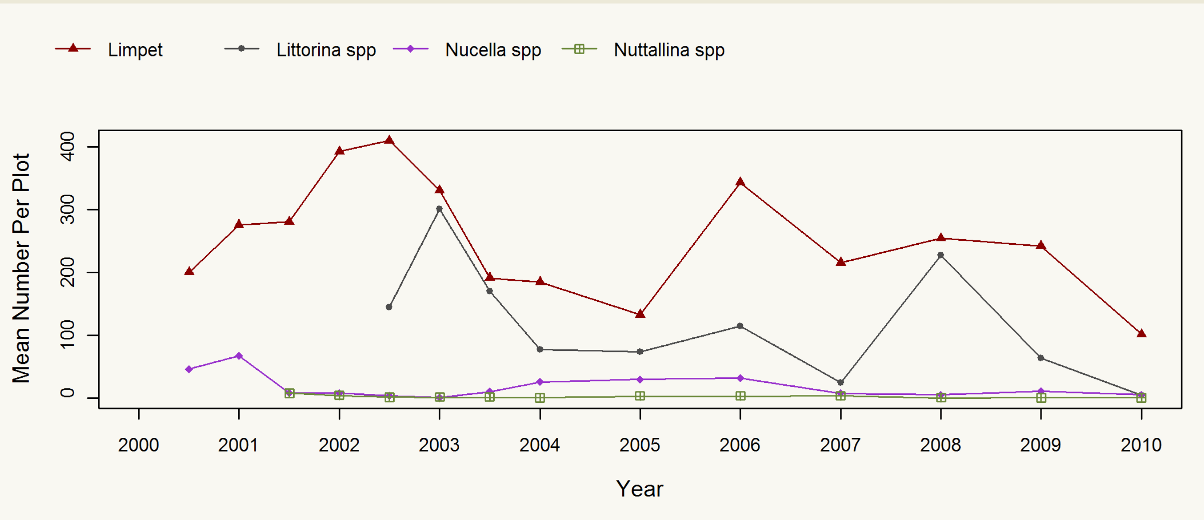
Mytilus (California Mussel) - motile invertebrate counts



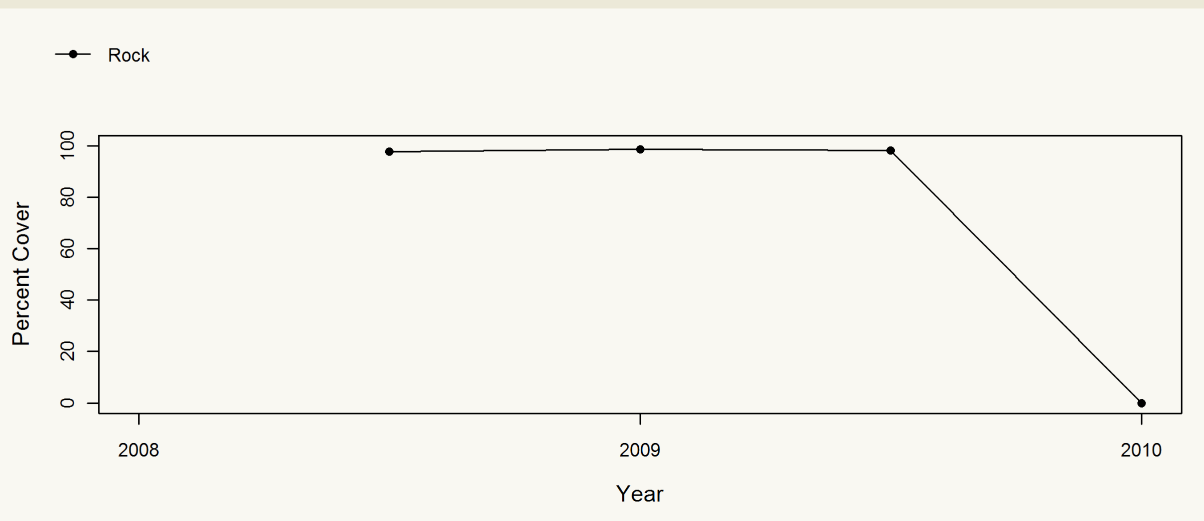
Endocladia (Turfweed) - percent cover



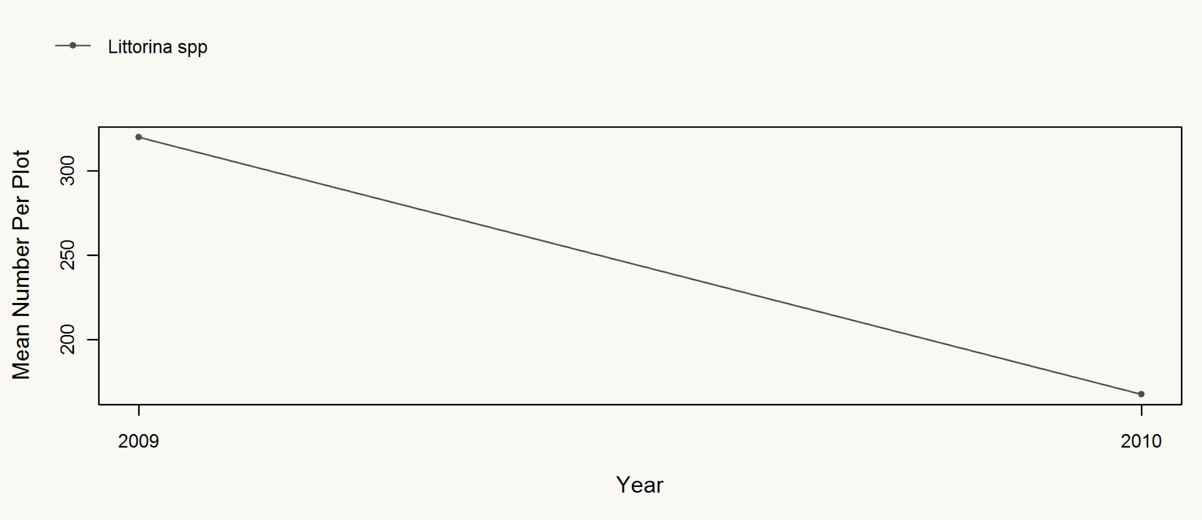
Endocladia (Turfweed) – motile invertebrate counts



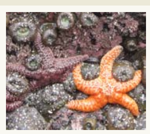
Rock (Above Barnacles) – percent cover



Rock (Above Barnacles) – motile invertebrate counts

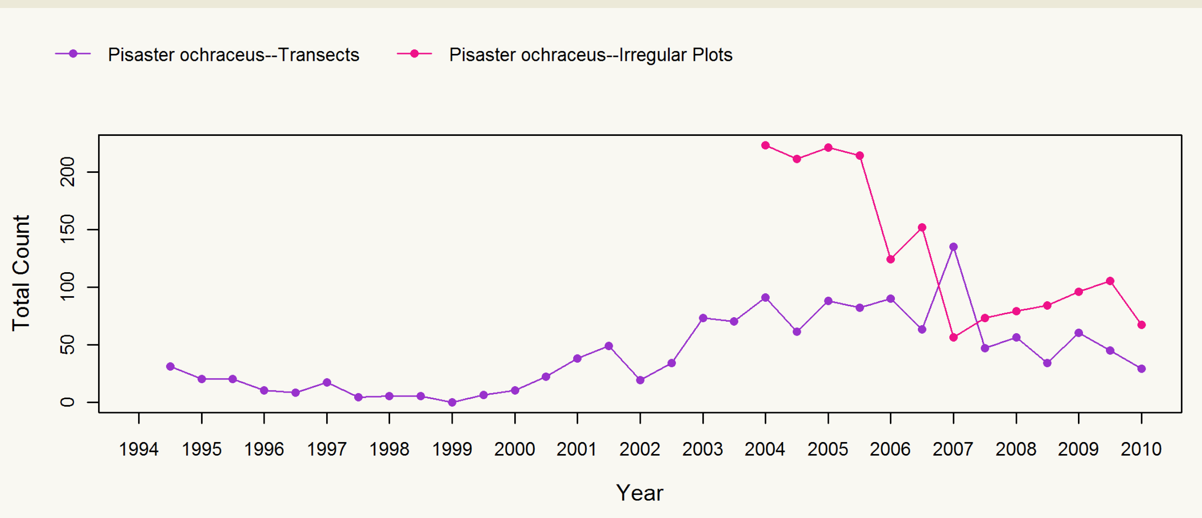


Species Counts and Sizes

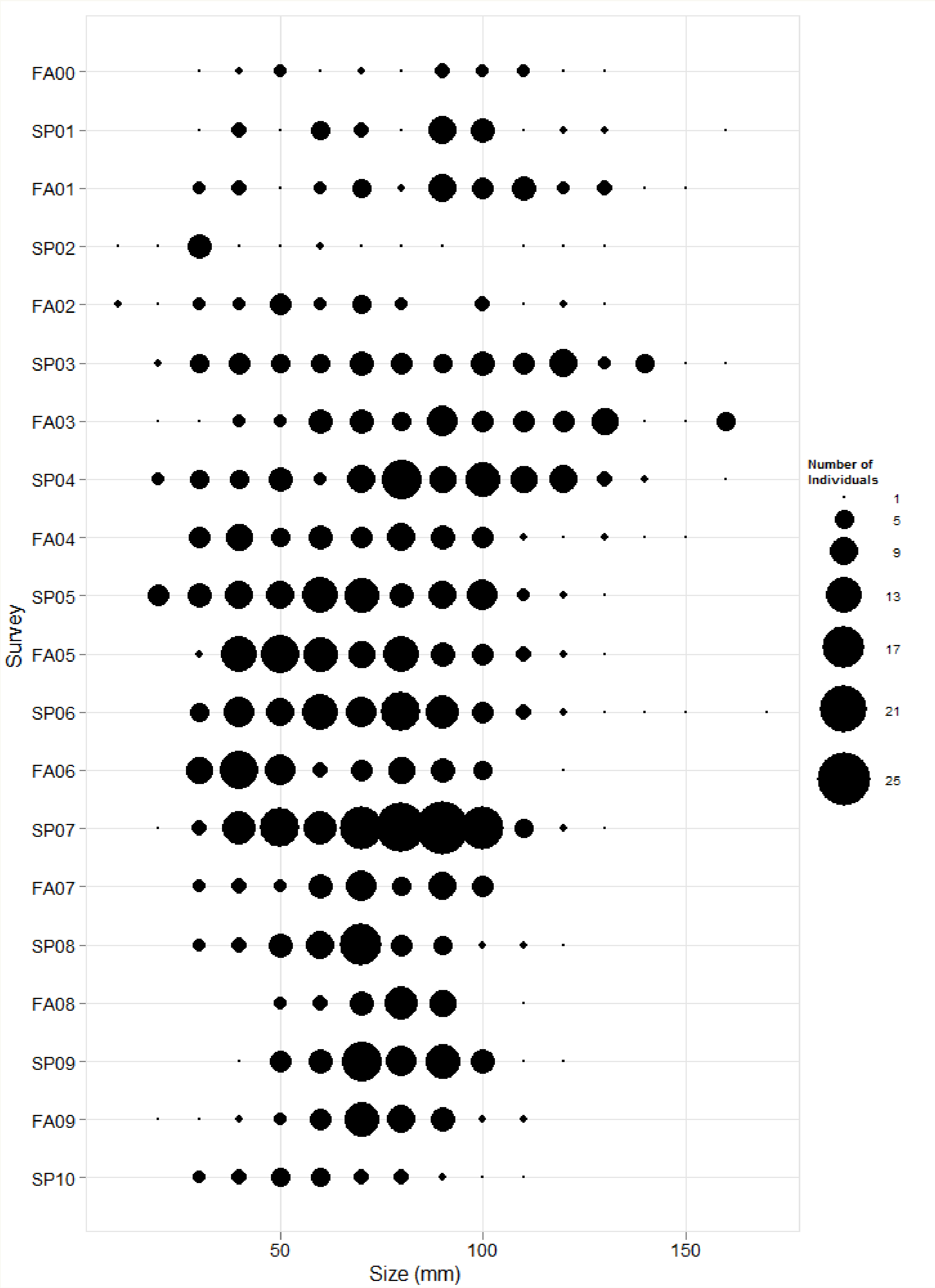


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes in Transects



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Paradise Cove Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The barnacle plots at Paradise Cove consist of a mixture of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula* with the former being the overwhelming dominant component of all plots. In general, barnacle cover has varied inversely with bare rock with a small net decline of around 10% since their inception in 1994. In recent years these plots were invaded from below by *Endocladia* (mostly as epiphytes on barnacles), and this was suggestive of a possible ecological transition, but this *Endocladia* has all but disappeared in the past few seasons. Motile invertebrate counts at this site began seasonally in the fall of 2000 and were changed to annual sampling in 2004. Littorines were added to the protocol in the fall of 2001. Within the barnacle plots, littorines were highly abundant and varied gradually in the neighborhood of 1000 to 2000 individuals per plot on average. Limpets were also common and varied gradually between 5 and 50 individuals per plot on average. Motile invertebrate data were not obtained for these plots in 2004.

The mussel plots at have been fairly stable throughout the years with mussel cover in the 80 to 90% range most of that time. A gradual decline in 1998 and a more precipitous decline in 2005 were each followed by gradual recoveries. Not evident in this trend graph are changes in bed depth that have occurred throughout the years. For example, in 2006 a line of advancing seastars just below these photoplots caused the mussels to pile up atop one another, changing what had been a tight monolayer to a loose multilayered bed. The data from the Motile invertebrate sampling show consistent low levels of snails (*Tegula funebralis*), along with higher and more variable numbers of limpets. Peaks in limpet abundance occurred in 2003 and 2008 with the latter far exceeding the former.

Patterns of cover in the *Endocladia* plots have been dynamic with *Endocladia*, barnacles, mussels and rock all becoming dominant at one time or another. *Endocladia* started out with a mean cover of around 20% in 1994 and it is close to that same level at the present; However, in the intervening years, turfweed rose to nearly 60% cover shortly after plot inception and remained there for 8 years before a precipitous crash in 2004. Barnacles had initially been at over 40% cover in 1994, but then declined to very low numbers by 1996 where they have largely remained ever since. On the other hand, mussel cover was negligible for the first nine years of sampling, but then began increasing in 2003 and reached 60% cover by 2006. Subsequently, the mean mussel cover dropped back to 30% in the fall of 2008 and has remained close to that point ever since. And as mussels have declined, recordings of bare rock have become more common and are currently near the 60% level. The data from the Motile invertebrate sampling show wide swings in both limpets and littorines in the Paradise Cove *Endocladia* plots. Limpets started out in the spring of 2000 with a mean abundance of 100 individuals per plot and dropped to half that amount on two different occasions, but were back around 140 per plot by 2010. On the other hand, littorines started out at 140 limpets per plot in 2003 and were almost completely gone by 2010.

The mean cover of Surfgrass (*Phyllospadix* spp.) has fluctuated widely throughout the years at this site with seasonal variation (lower in spring, higher in fall) along with intermittent periods of modest sand burial. Throughout the years, the cover of *Phyllospadix* hovered around 60% plus or minus 10 percent with one significant population decline in 1997 and 1998. This period was marked by an initial increase in sand through the first two seasons of the decline, and then a sharp increase in rock during the spring 1998 sampling. This is suggestive of *Phyllospadix* loss due to sand burial and/or scour followed by sand removal and subsequent *Phyllospadix* recovery. Red algae also showed seasonal increases that were the inverse of the seasonal *Phyllospadix* declines.

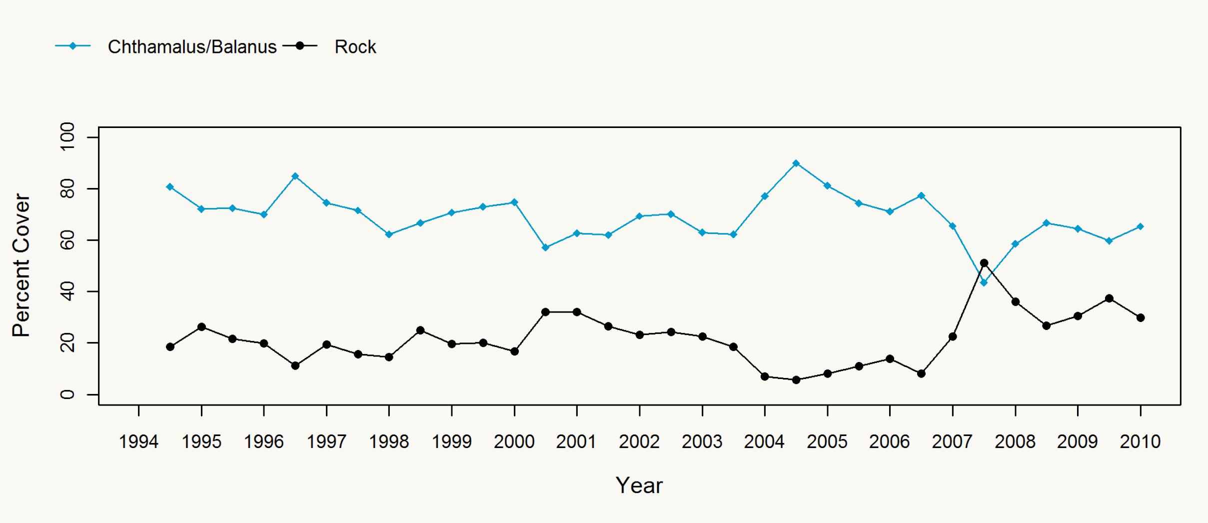
Seastar (*Pisaster ochraceus*) plots were added to this site in the spring of 2002 and consist of three large irregular plots surrounding an area of medium relief rock and shallow tidepools. At the first sampling, the total number of seastars counted and measured was around 180. That number increased to nearly 300 by the following fall, but began to decline thereafter and has been hovering around 100 seastars since 2005. While smaller (<50mm radius) stars have been common at this site throughout the years, those encountered tend to be larger (>70mm). General observations, along with the size distribution depicted in the trend graph, suggest that most seastars are moving in and out from the subtidal though some may be recruiting to the monitoring site as young stars.

Photo Plots

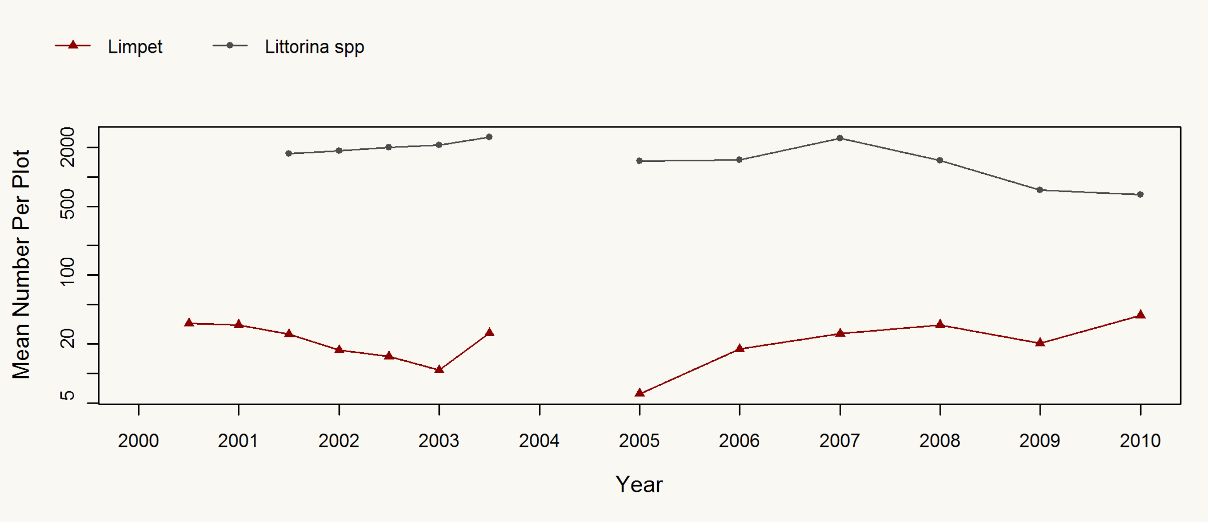
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

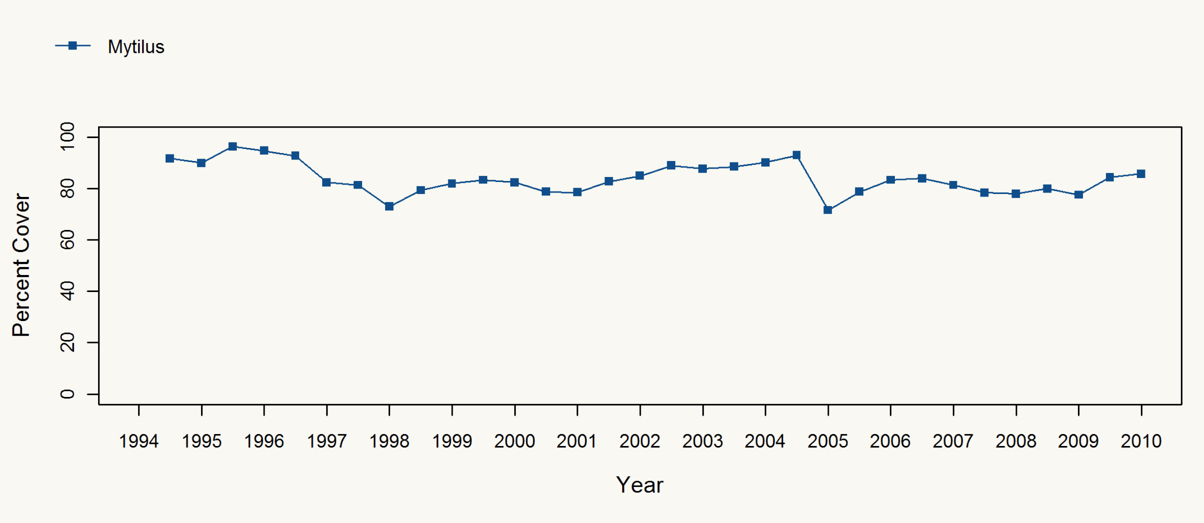
Chthamalus/Balanus (Acorn Barnacles) - percent cover



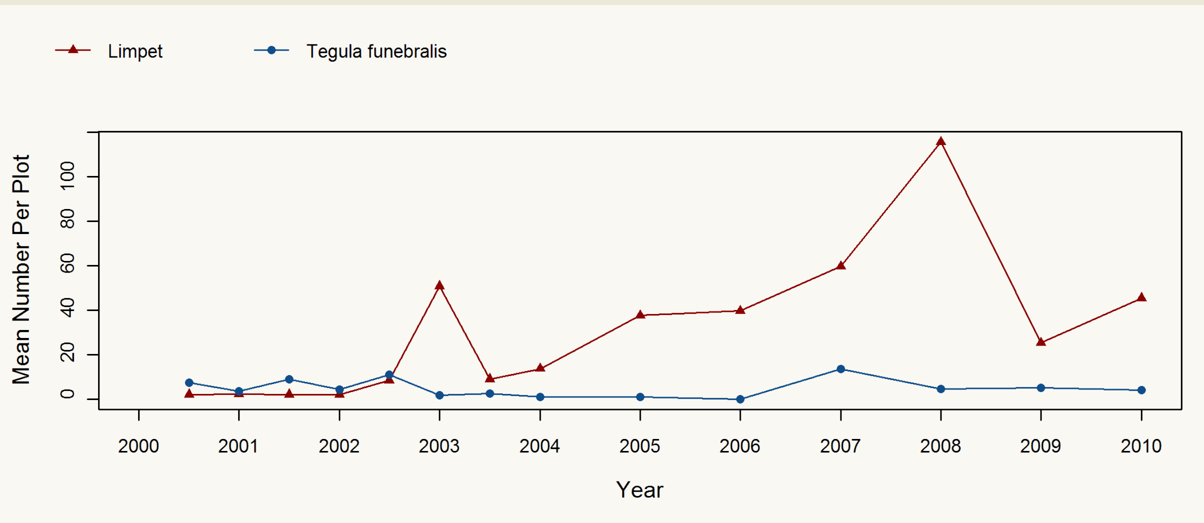
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



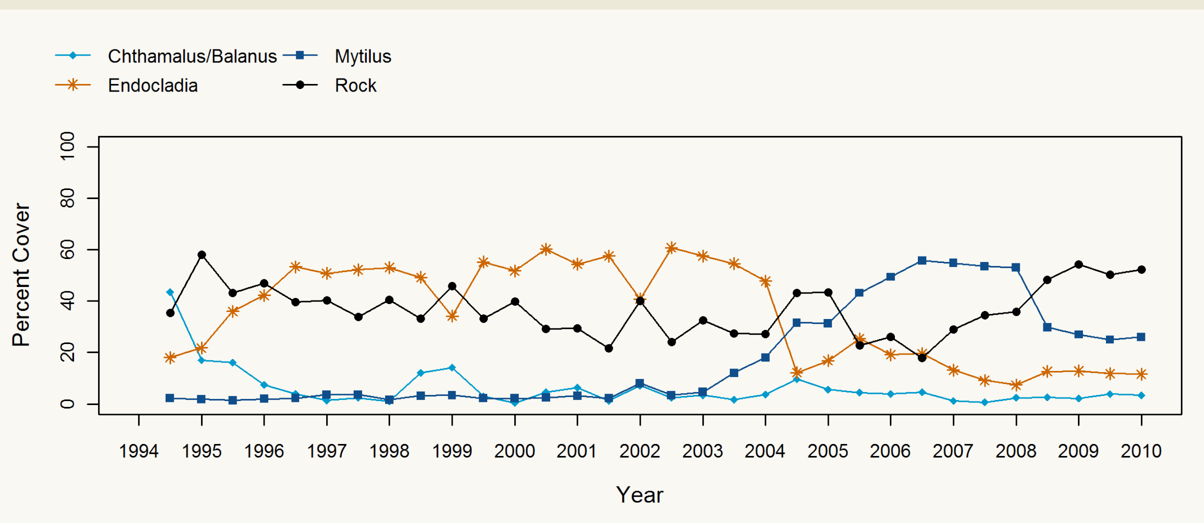
Mytilus (California Mussel) - percent cover



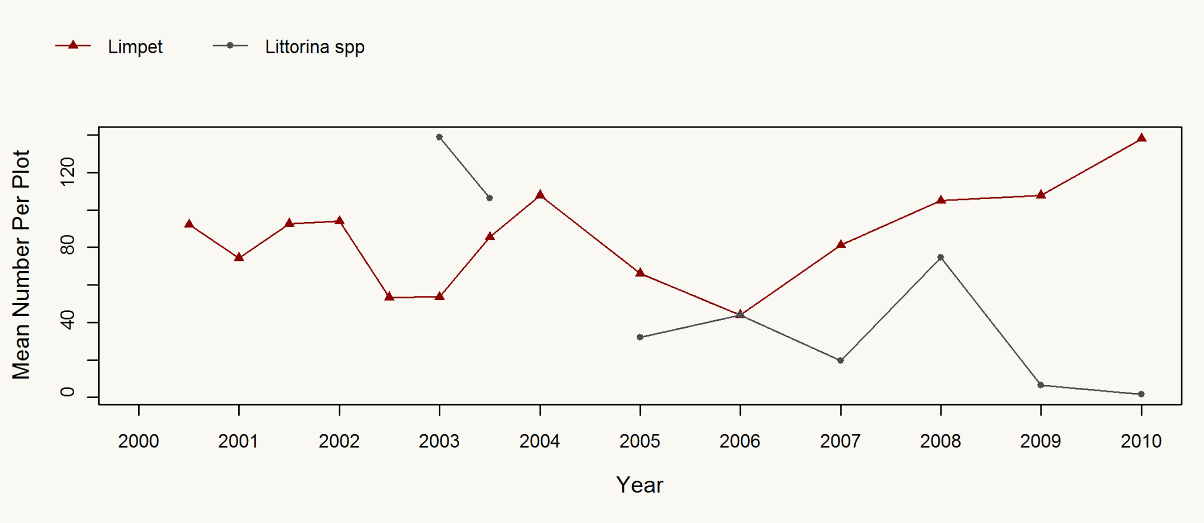
Mytilus (California Mussel) – motile invertebrate counts



Endocladia (Turfweed) – percent cover



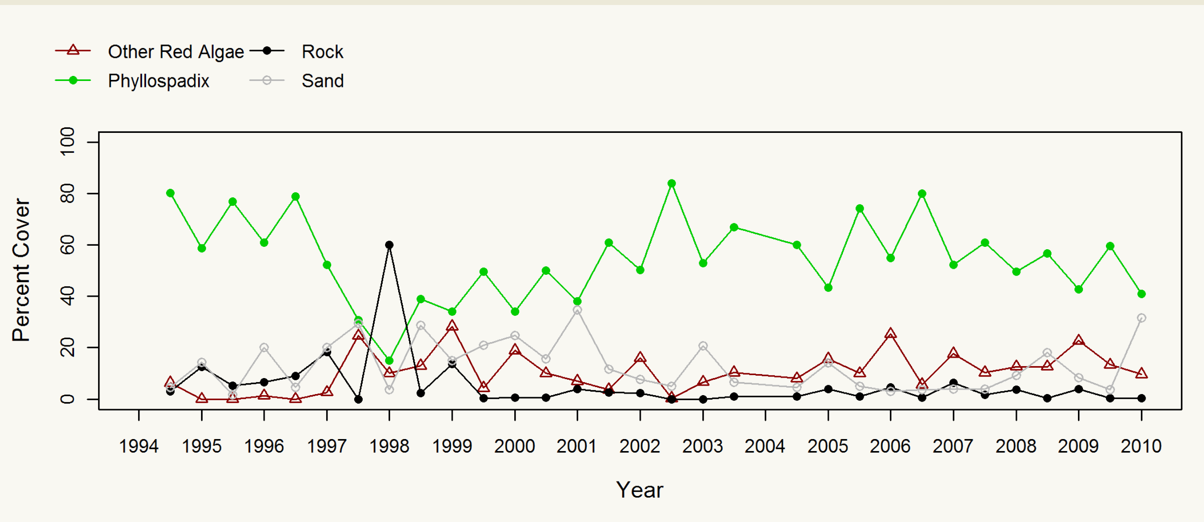
Endocladia (Turfweed) – motile invertebrate counts



Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

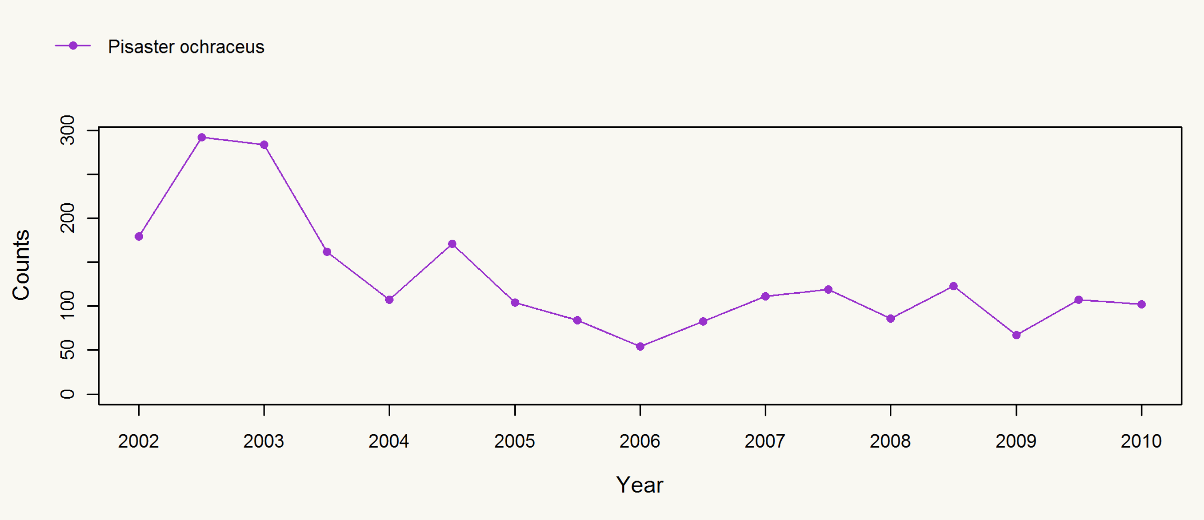
Phyllospadix (Surfgrass)



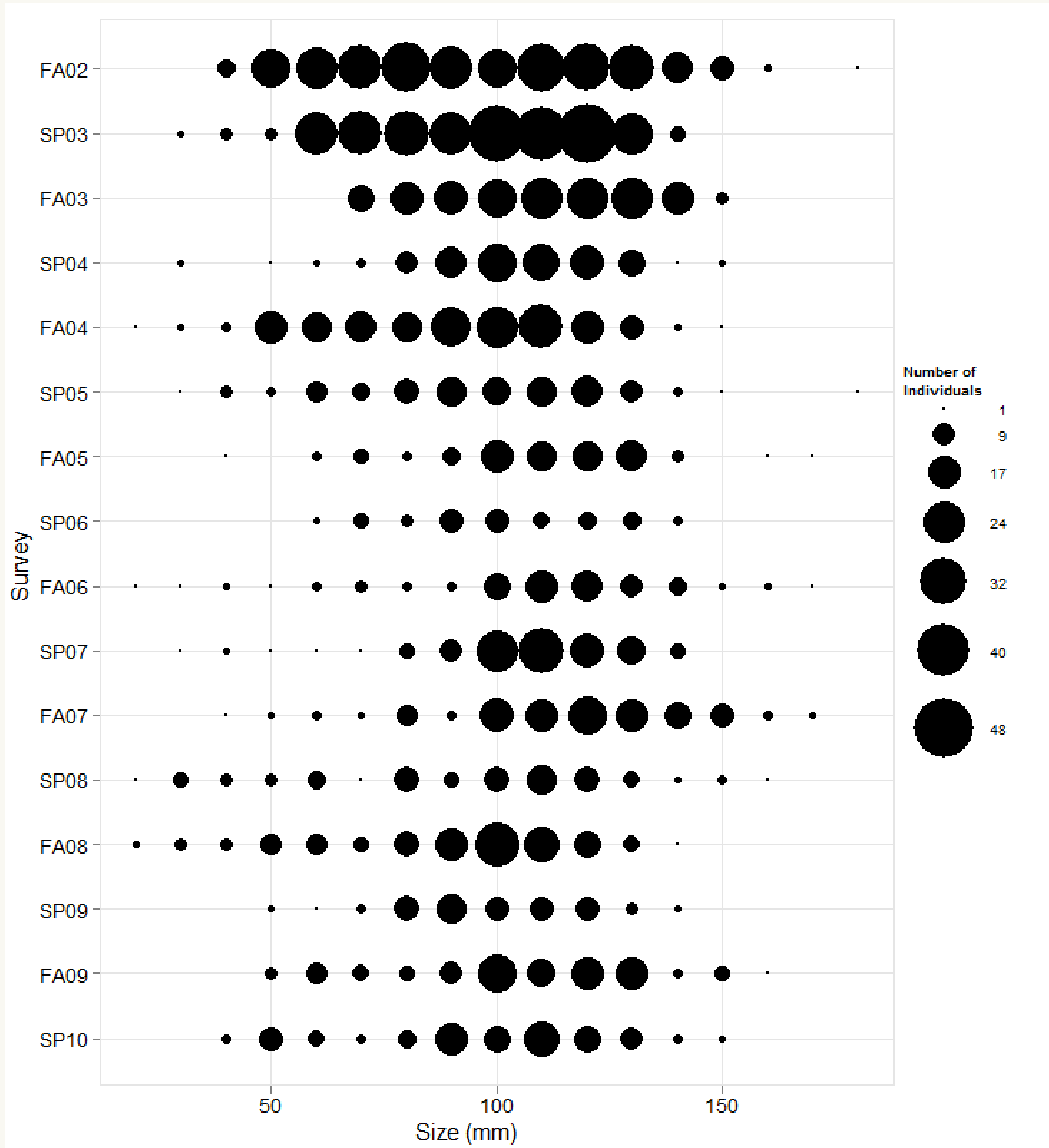
Species Counts and Sizes

Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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White Point Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The barnacle plots at White Point consist of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001) and *Balanus glandula* with separate plots (5 of each) designated at this site based on the each the early dominance of each genera. However, as at all the southern California MARINe sites, these genera are not distinguished in the sampling of either plot type and are at collectively reported as "barnacle" cover here. Within these ten barnacle plots, barnacle cover has declined gradually throughout the monitoring period with one episode of precipitous decline and recovery in the late 1990's. Recordings of bare rock shot up during that period and have remained high ever since. In addition, the cover of red algae have gradually increased throughout the years and have begun filling in the plots as barnacles declined. In the earlier years, a single red alga was responsible for this increase which has been loosely identified as a very low growing form of *Mazzaella affinis* characterized by very small bladelets thickly emerging from a crustose base. Initially, this *M. affinis* carpet spread into the a significant portion of a single plot with as second plot impacted to a lesser extent. But in recent years those patches have grown and all plots have been invaded to some extent. And in 2002, the newly introduced and invasive alga, *Caulacanthus*, began spreading into these plots, initially growing atop the *M. affinis* carpet and then spreading further into the plots. These plots seem to be experiencing a slow transition toward an algae dominated state. Motile invertebrate counts at this site began seasonally in the Spring of 2001 (with littorines added the following fall) and were changed to annual sampling in 2004. Both limpets and littorines have been abundant in the *Chthamalus* plots with up to 500 or more individuals per plot in some sampling events and high variation generally. Neither species has shown variability tied to species cover in the photoplot sampling.

Mussels cover in the mussel plots remained high and largely stable in most years until 2006 when it dropped steeply from the 80% or greater range down to around 50% in 2008. After that a moderate rebound occurred with mussel cover leveling out in the 60 to 70% range through 2010. Two plots were largely responsible for this decline having undergone partial to complete mussel breakouts, presumably as a result of strong winter storms. However, mussel bed contraction has also been a factor at this site, albeit less severe than at other sites in southern California. In general, the beds at this site are characterized by tightly packed monolayers of small to medium sized mussels commonly with interspersed bare patches. In some plots, and in portions of mussel beds across the site, mussels are covered by a layer of epiphytic *Caulacanthus* that is thick enough to obscure the mussels completely in places. Thus far, *Caulacanthus* has not been observed to cause mussel mortality, but the spread of this species could certainly be having an influence on mussel recruitment and bed replenishment locally within this site. The data from the Motile invertebrate sampling show that limpets are common in the mussel plots in the range of around 100 individuals per plot in most years. *Nuttalina* sp. chitons and littorines are also present in these plots in low numbers. The infrequency of snails in these plots is notable, though *Nucella* snails are occasionally found in low numbers.

Within the turfweed plots, *Endocladia* cover is seasonal (higher in spring, lower in fall) and has declined from the 70 to 80% range found in initial years of sampling to around 40 to 50% in most years since. Cover dropped to a particularly low level below 20% in the spring of 2007 but rebounded to near 60% by the last reported sampling in 2010. Barnacles and bare rock have generally, but imperfectly, trended inversely to *Endocladia* cover. And red algae cover, which in this case is almost entirely comprised of *Caulacanthus* cover, has been increasing in the turfweed plots since the early 2000's. This alga has invaded many of the available topographic lows within these plots while *Endocladia* has been more successful in retaining the higher ground. Motile intertebrate counts within the turfweed plots depict a high abundance and a high variability of both limpets and littorines. However, multiple data points for both taxa in 2006 indicate a data problem that requires resolution before these data can be reliably interpreted.

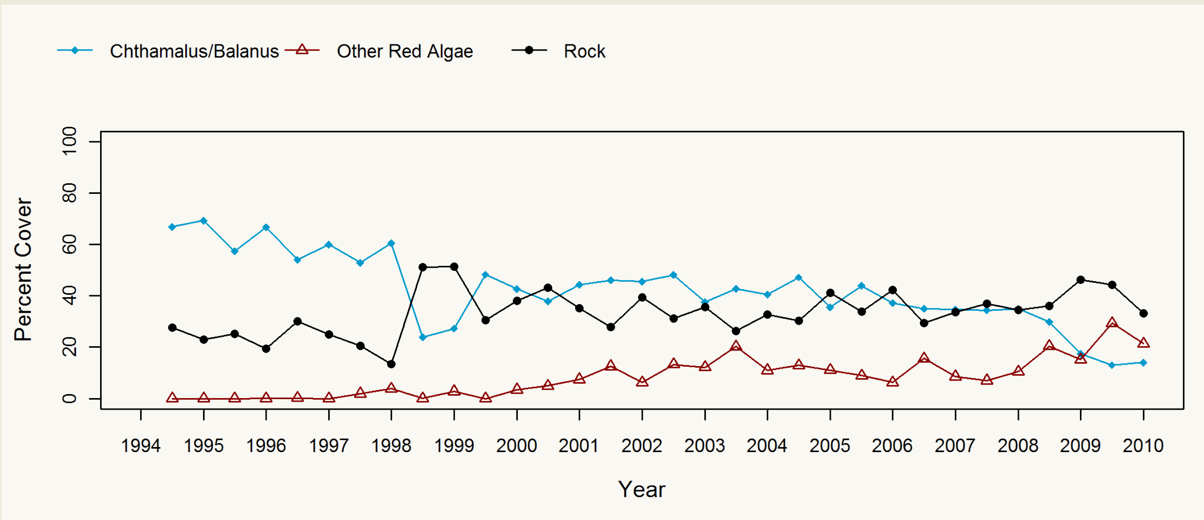
Seastar (*Pisaster ochraceus*) plots were added to this site in the fall of 2003 and consist of three large irregular plots surrounding an area of medium relief rock which includes several large cracks and ledges. The initial samples yielded just under 50 total individuals each. Then abundance increased considerably in 2006 and 2007 to a high of around 200 seastars followed by a drop to basal levels in 2009 and another increase to over 100 total stars thereafter. Recruitment is common at this site with seastars in the 50mm or less range found in most seasons. It appears that a large recruitment event was responsible for the 2006-2007 increase, and the size frequency distribution follows the growth of those seastars throughout subsequent seasons. However, stars in the larger size classes are generally rare at White Point which is likely the result of high, and largely unregulated, human visitation, species manipulation and harvesting at this site.

Photo Plots

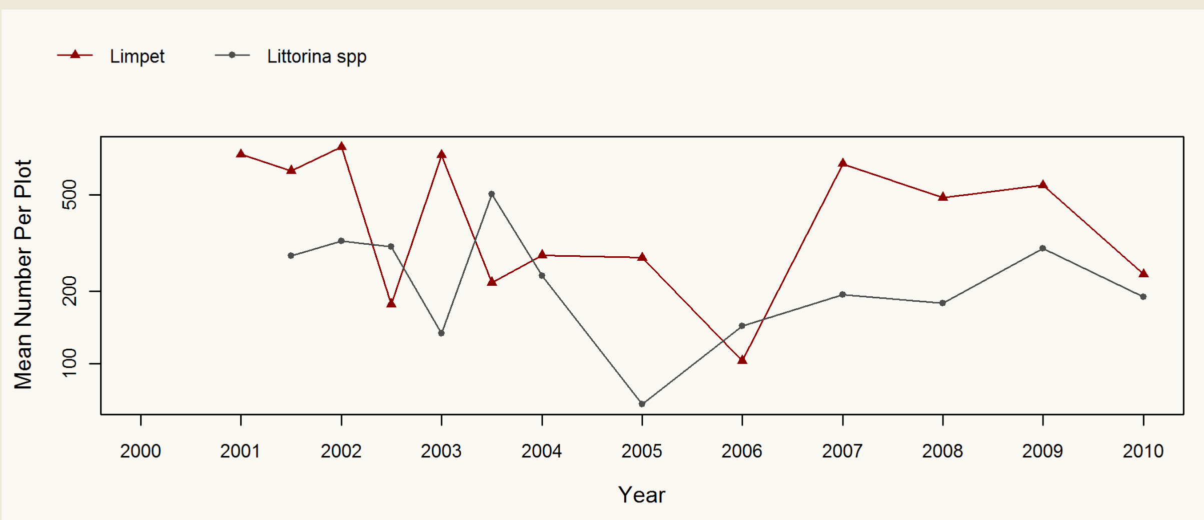
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

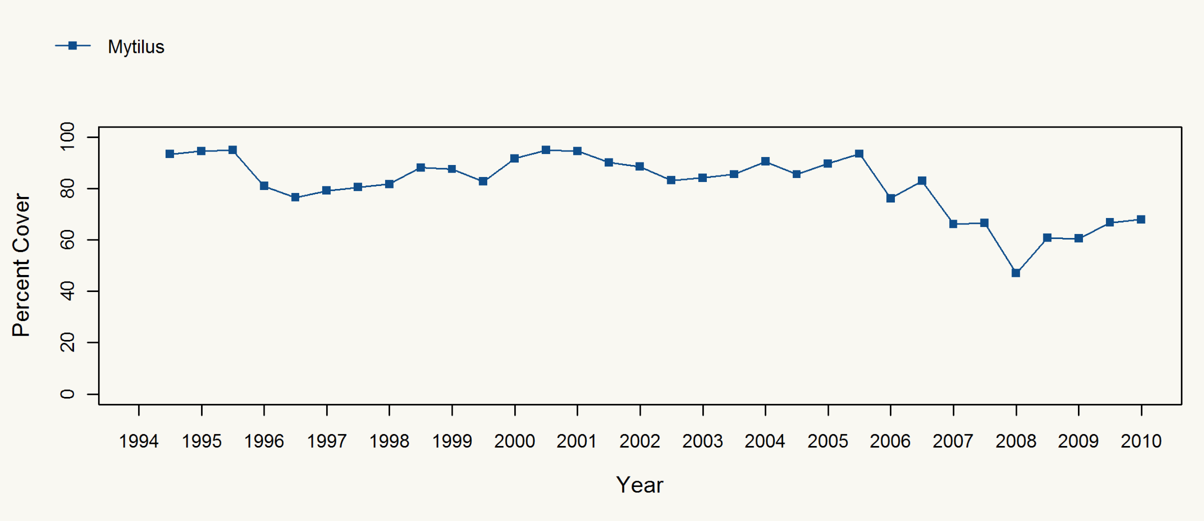
Chthamalus/Balanus (Acorn Barnacles) - percent cover



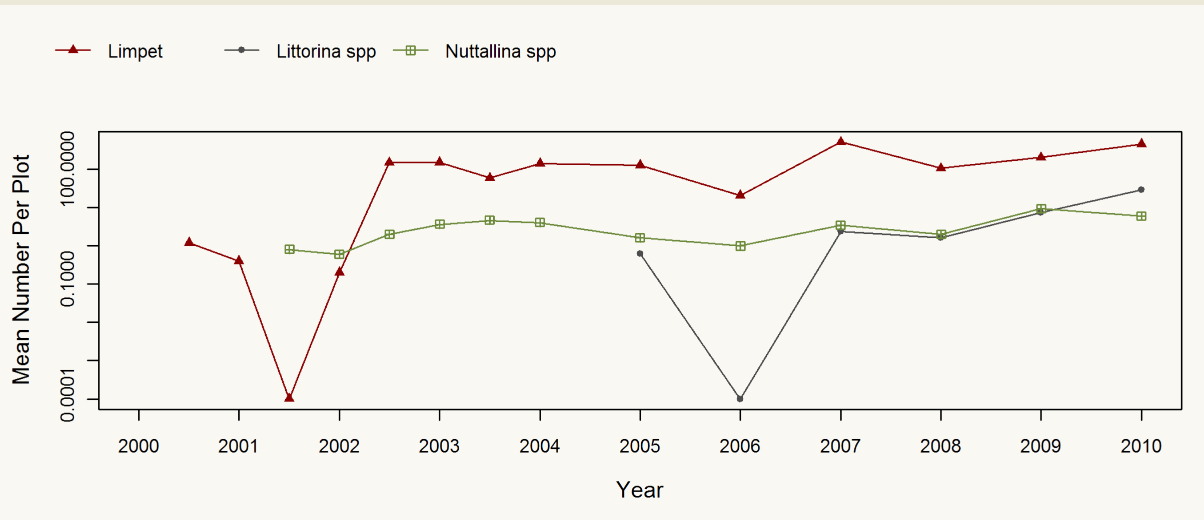
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



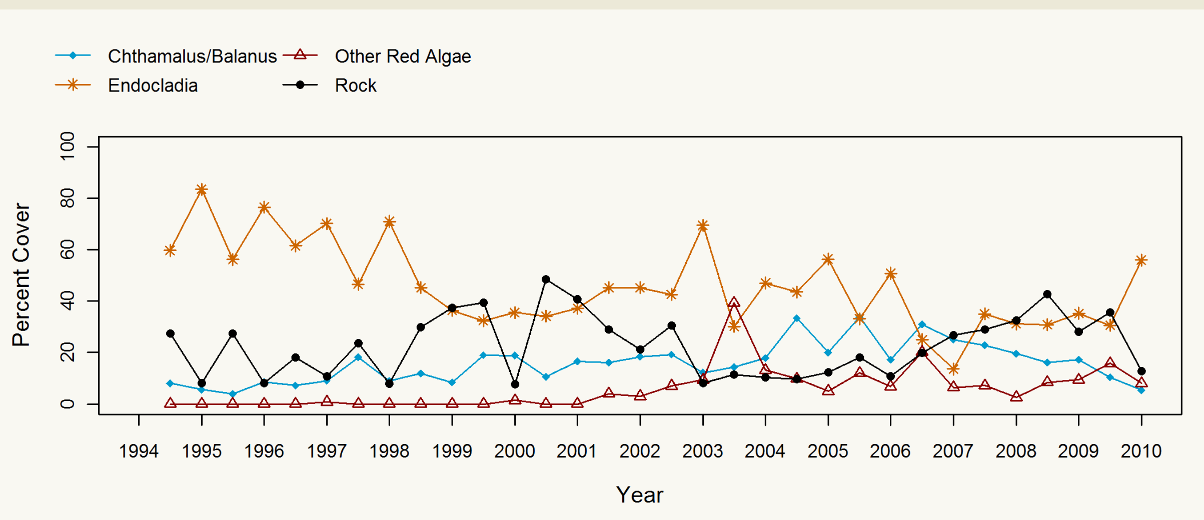
Mytilus (California Mussel) - percent cover



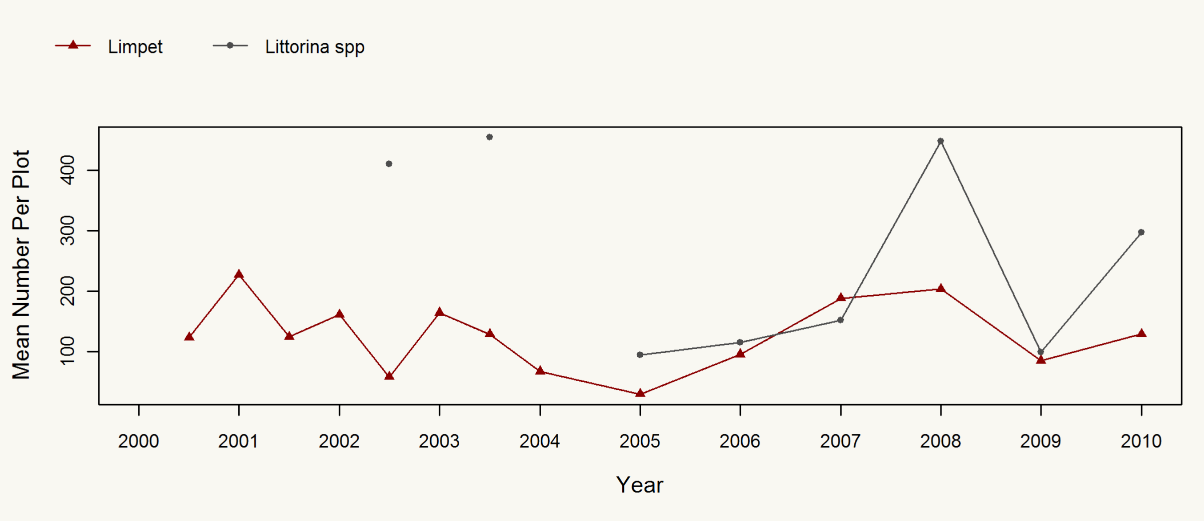
Mytilus (California Mussel) – motile invertebrate counts



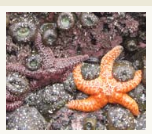
Endocladia (Turfweed) – percent cover



Endocladia (Turfweed) – motile invertebrate counts

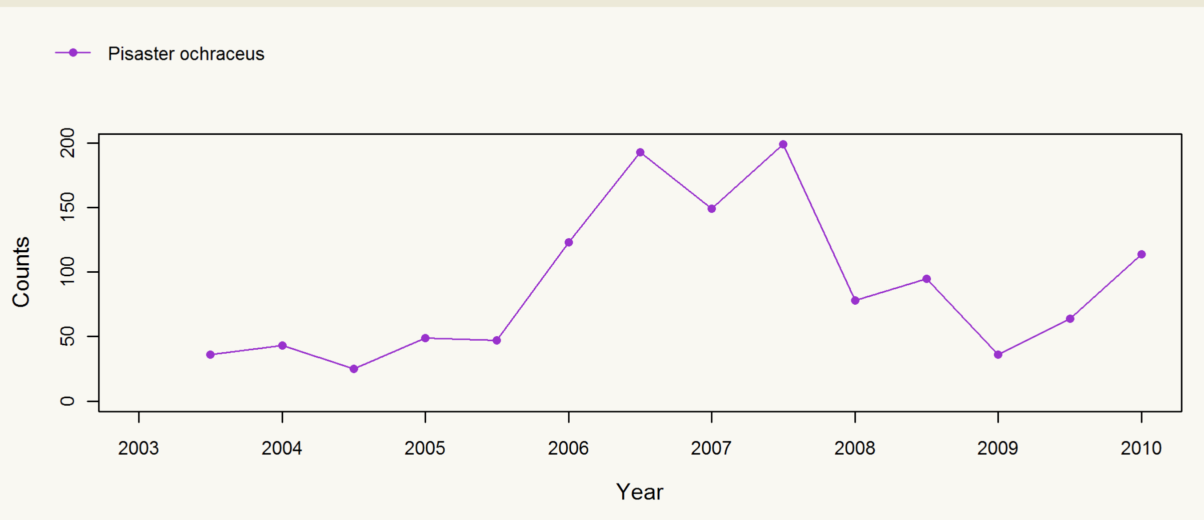


Species Counts and Sizes

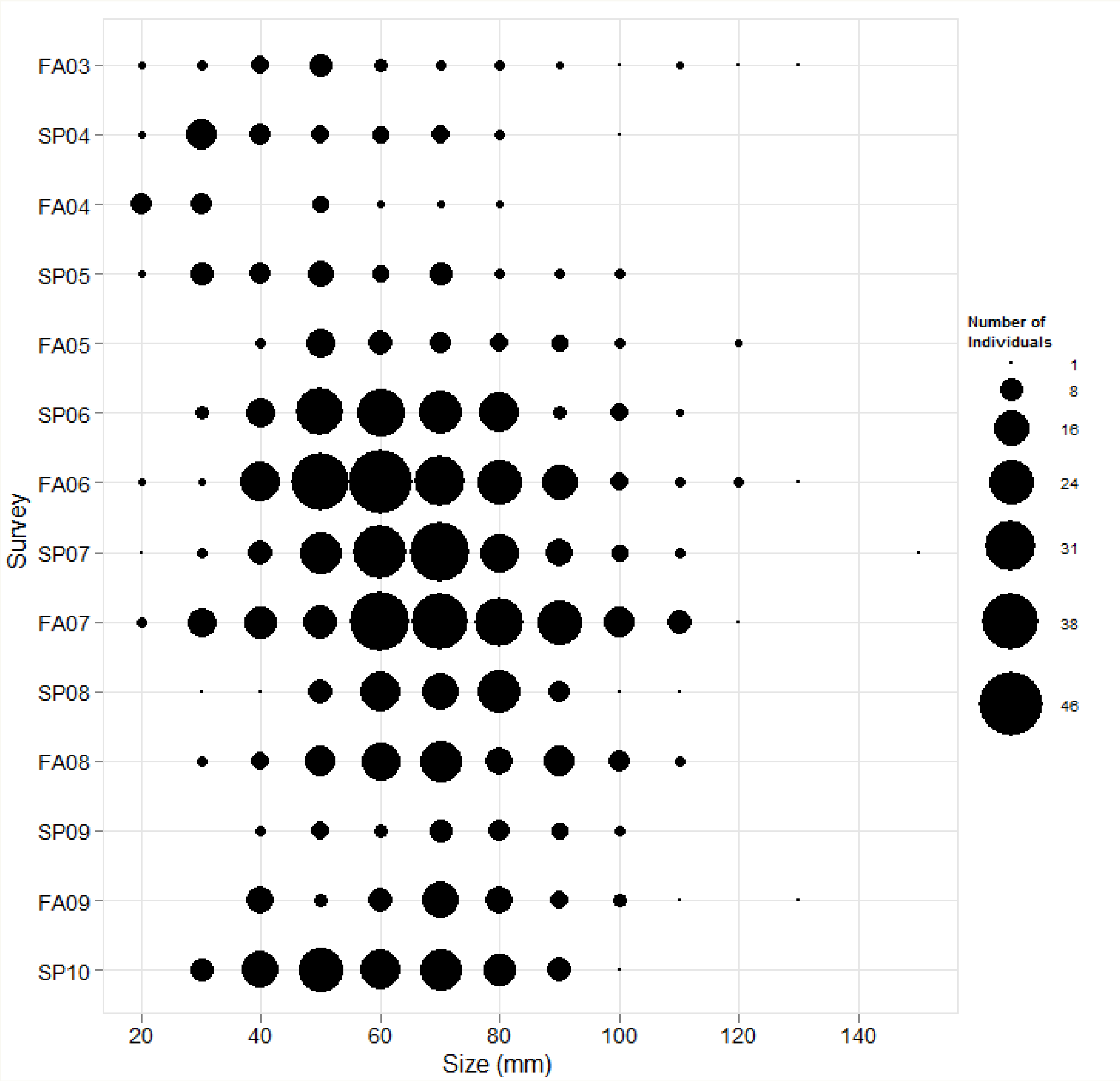


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Point Fermin Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

The barnacle plots at Point Fermin consist exclusively of *Chthamalus dalli/fissus* (note that species were not distinguished until 2001). Cover of *Chthamalus* typically varied inversely with rock cover, with relatively little else occurring in these plots. When this site was established in fall 2009, mean barnacle cover started out around 60%, declined to around 40% by 2003, when it rose to nearly 80% by 2004, and then declined after 2006 to around 25% where it remained through 2010. Inversely, rock began around 40% declined to around 20% by 2004, and then increased to 75% after 2006. Motile invertebrate counts at this site began seasonally in the fall of 2000 and were changed to annual sampling in 2004. Littorines were added to the protocol in the fall of 2001. Within the barnacle plots, littorines were highly abundant and were consistently in the neighborhood of 1000 individuals per plot. Limpets also started out common with around 50 individuals per plot on average, but then gradually declined and were very uncommon in the barnacle plots by 2010.

Mussels have declined substantially at the Point Fermin monitoring site. Mytilus cover in and around the mussel plots started close to 100% at site inception in 1999, but immediately began a steady decline leveling off at around 15% by 2003. The plots have remained largely unchanged since that time. Three plots became completely devoid of mussels (except for a few small isolated recruits), while one remained steady at around 70% cover and the last plot contains one small persistent patch of mussels. These plots are representative of the surrounding reefs as widespread mussel bed contractions have occurred at this site, as has been the case at many other sites in southern California. As the mussel bed contracted, bare rock and barnacles became more prevalent, as did the cover of species that do not appear in this graph (*Tetraclita*, *Lottia gigantea*, chitons (*Nuttalina* sp.), crustose algae, articulated coralline algae, and others). *Caulacanthus* also invaded the lower and wetter portions of these mussel plots as that introduced and invasive alga spread throughout this site several years ago. As indicated above, a small number of mussels have recruited into the plots since the decline, but these have never survived beyond a season or two. The data from the Motile invertebrate sampling show that limpets, chitons (*Nuttalina* sp.) and shore crabs (*Pachygrapsus crassipes*) were all common in the mussel plots prior to the decline, each with and abundance of around 10 individuals per plot. As mussels declined, limpet abundance increased dramatically to around 1000 individuals per plot and shore crabs began a slow, then more rapid decline to near zero in 2010, while chiton abundance held steady. The sampling of littorines began in 2006. Littorine abundance in these mussel plots has remained generally low with less than 10 individuals per plot on average.

Within the rockweed plots, *Silvetia* has been seasonally variable (lower in spring and higher in fall) with the mean cover remaining steady near 100% (fall highs) for the first 5 years of sampling. Starting in 2005, the cover started to decline gradually with fall highs dropping first to around 90% and then to 80% by 2009. Much of this decline is due to a single plot which had dropped to less than 50% cover by fall 2010 and has declined further to less than 20% in subsequent years. The other plots are still in the 70 to 90% cover range during their fall highs. As *Silvetia* has declined, bare rock has become more prevalent in these plots, as have crustose algae and the invasive species *Caulacanthus*, neither of which appear in this figure. Motile intertebrate counts within these plots show that *Cyanoplax* spp. chitons are common under the rockweed canopy. These chitons exhibit seasonal variation in synchrony with *Silvetia*, suggesting that these chitons move to other areas as the rockweed thins out in the plots. In recent years, these chitons showed a reduction in their seasonal increases, and later in their basal abundance to just a few chitons per plot. Hermit crabs (*Pagarus* spp.) exhibited a similar, but more dramatic, pattern with their numbers high and variable in the earlier years of sampling, but then dropping to zero by 2004. Meanwhile turban snails (*Tegula funebralis*) displayed an opposite trend with their numbers growing in recent years, and limpets have likewise become more abundant (and also more variable) in recent years.

Rock ("Above Barnacles") plots were added to this site in the fall of 2008 to document any upward spread of intertidal species as a result of global climate change or other factors. These plots are expected to remain dominated by bare substrates unless barnacles or other species begin to encroach upon them. As of the spring of 2010, no barnacles had been recorded, although a few small recruits had been observed in cracks and fissures within these plots.

The mean cover of Surfgrass (*Phyllospadix* spp.) at Point Fermin has shown seasonal variation (lower in spring, higher in fall) with moderate fluctuations and an overall increase in cover from around 60% in the initial sampling to around 80% in latter years (fall highs). Algal species have also shown seasonal variation with *Egregia* cover generally following *Phyllospadix* cover (though with lower seasonal swings), and red algae and articulated corallines displaying the inverse pattern (cover increasing when *Phyllospadix* is lower).

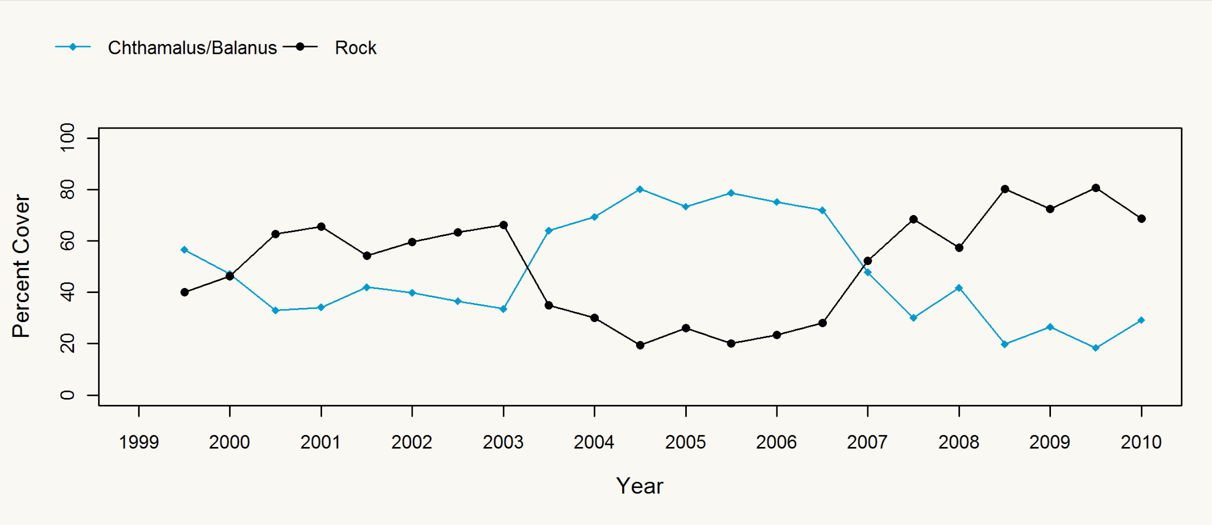
Seastar (*Pisaster ochraceus*) plots were added to this site in the spring of 2003 and consist of three large irregular plots surrounding an area of medium relief rock which includes several cracks and ledges. Seastars were common at this site when these plots were initiated, but declined steadily over the next two years such that just a few stars have been counted and measured each season since 2005. These plots are representative of the site as a whole. In recent seasons, timed searches of the entire site turned up just a few additional seastars. The size frequency figure indicates that the large number of seastars found during the first sampling seasons, in part, may have been the result of a large recruitment pulse occurring sometime in the preceding years. Recruitment has been low since that point but has, along with potential migration in and out from the adjacent subtidal, helped to keep the numbers of seastars above zero at this site.

Photo Plots

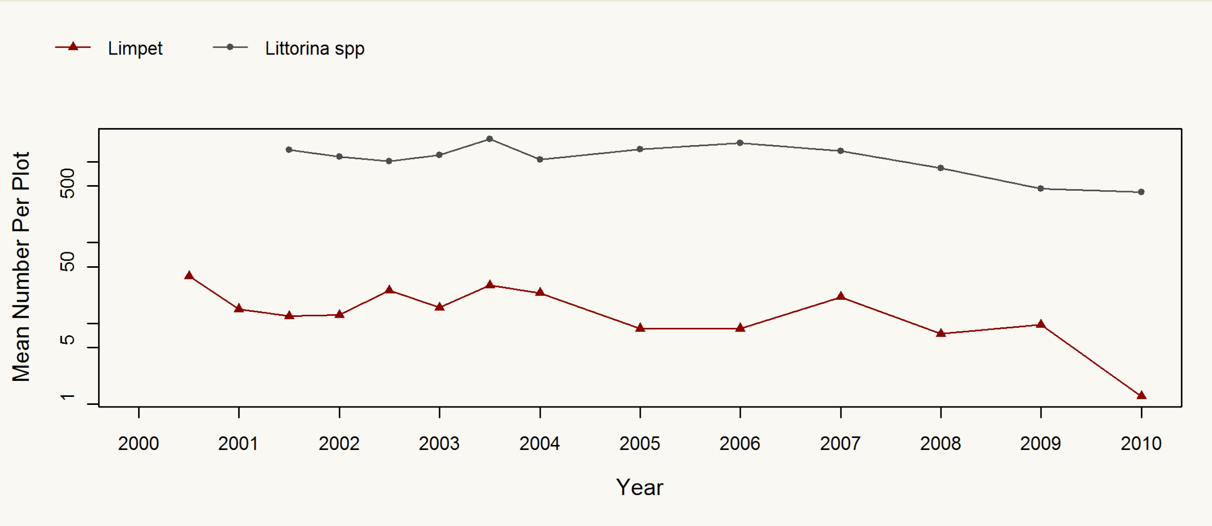
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

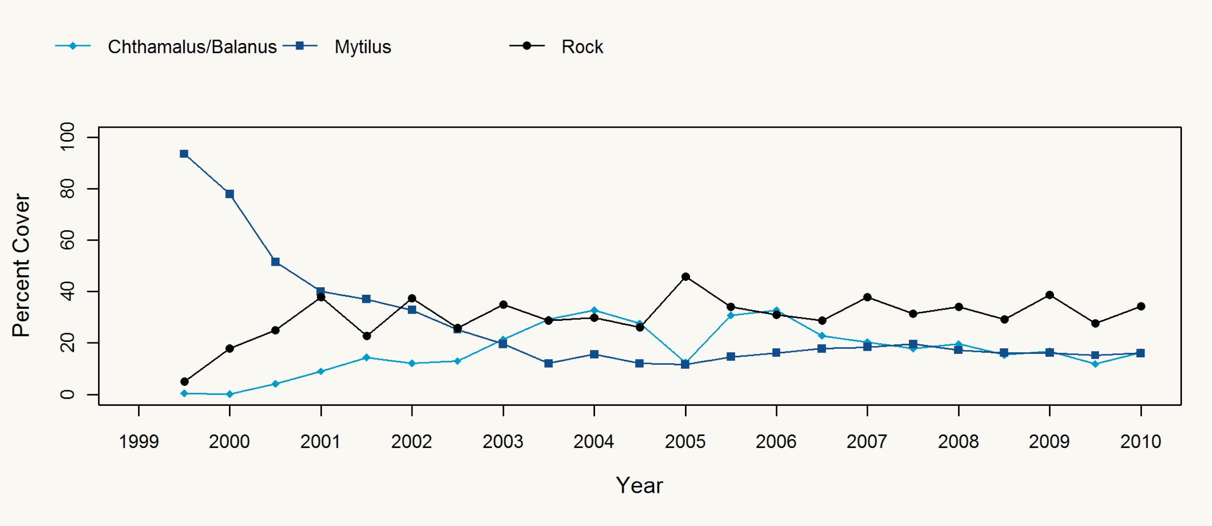
Chthamalus/Balanus (Acorn Barnacles) - percent cover



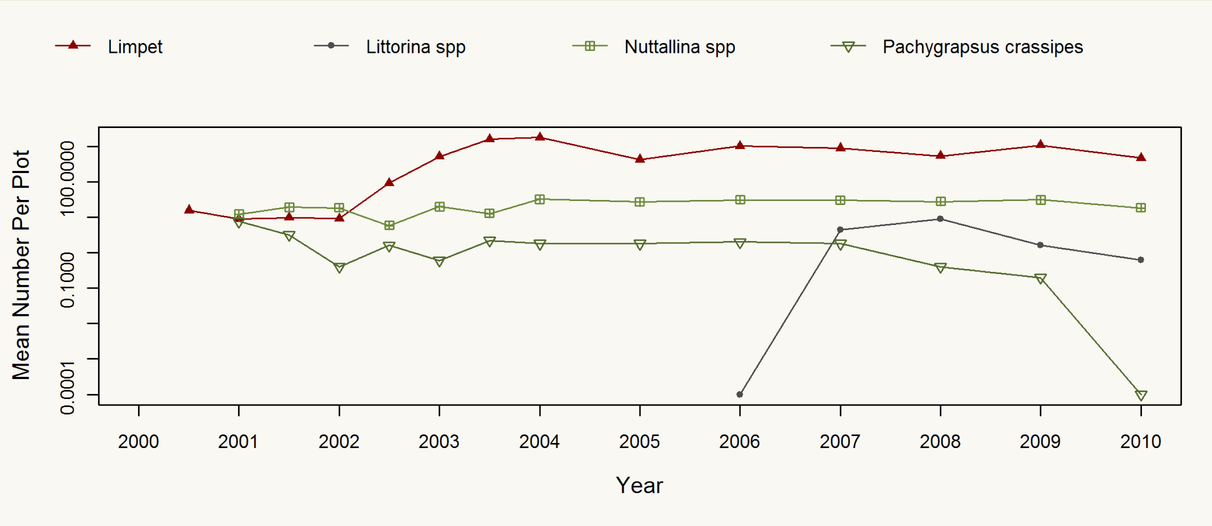
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



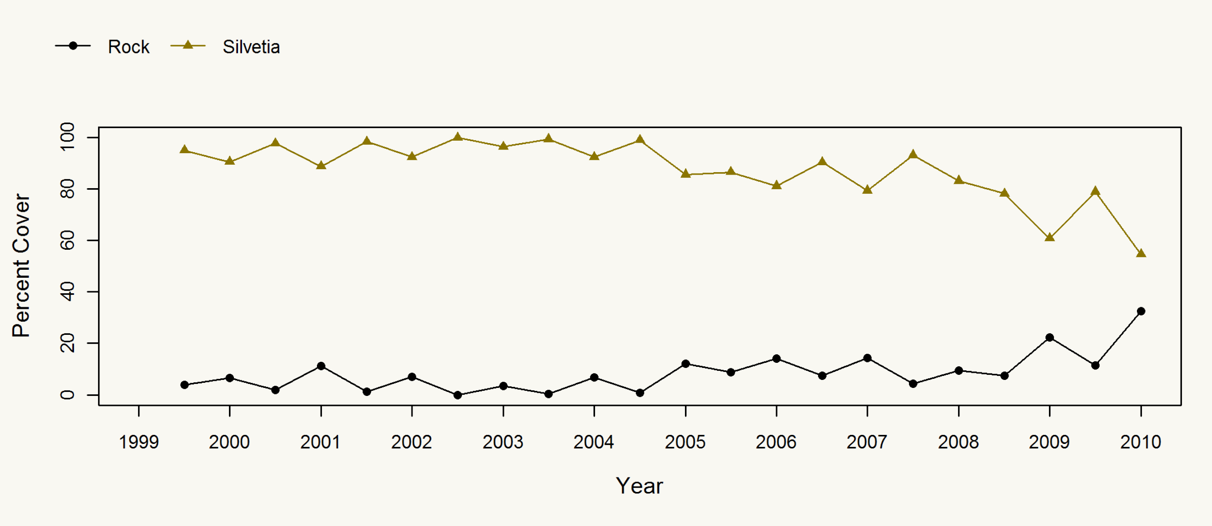
Mytilus (California Mussel) – percent cover



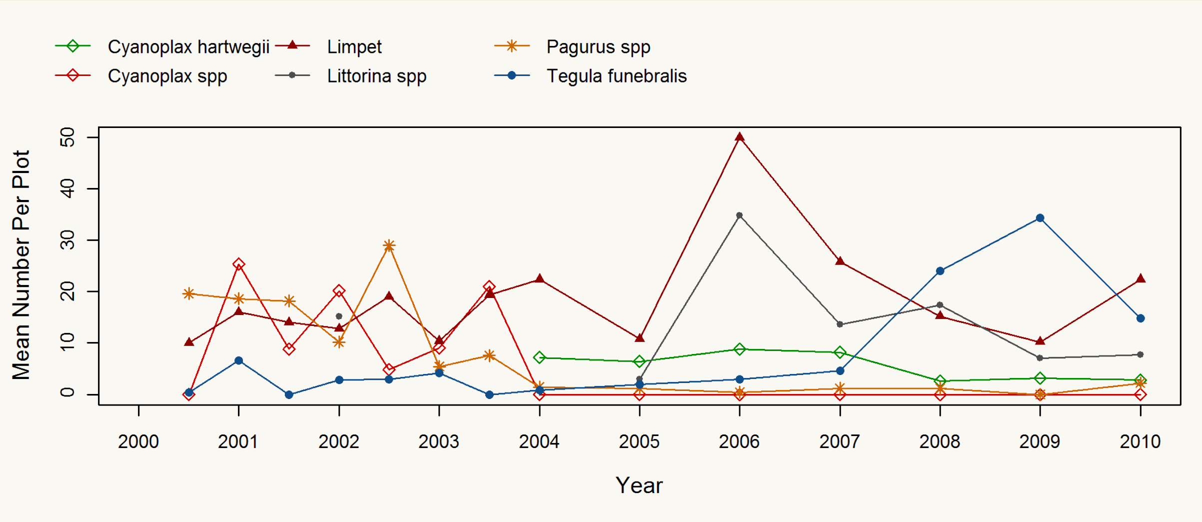
Mytilus (California Mussel) – motile invertebrate counts



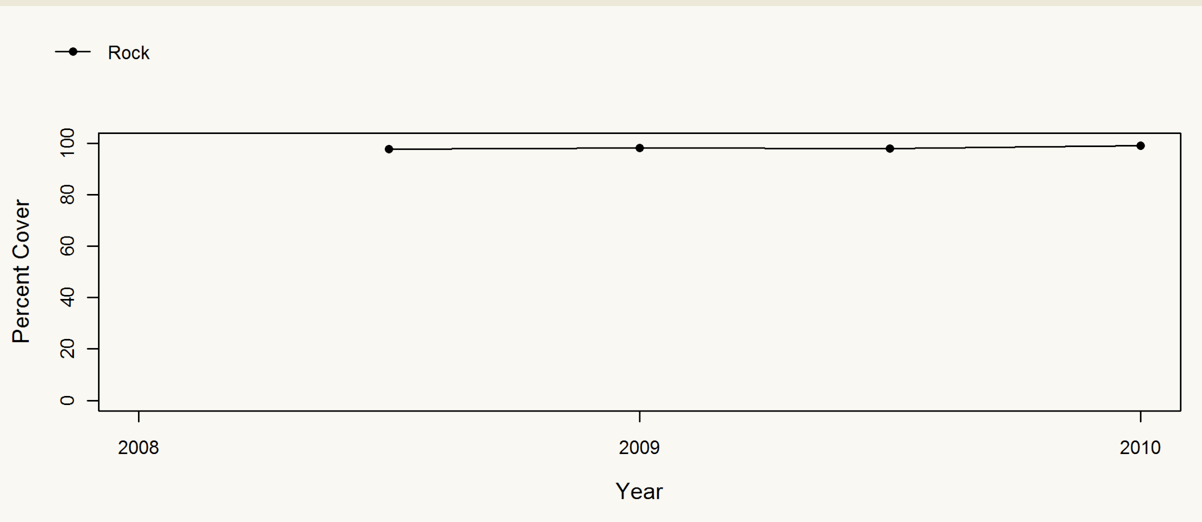
Silvetia (Golden Rockweed) – percent cover



Silvetia (Golden Rockweed) - motile invertebrate counts



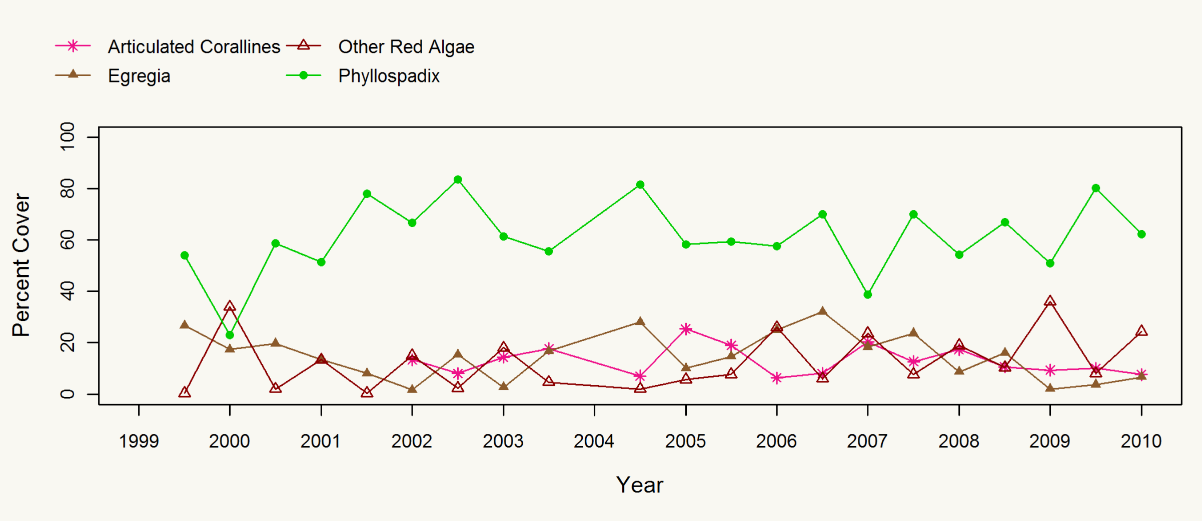
Rock (Above Barnacles)



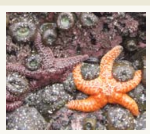
Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

Phyllospadix (Surfgrass)

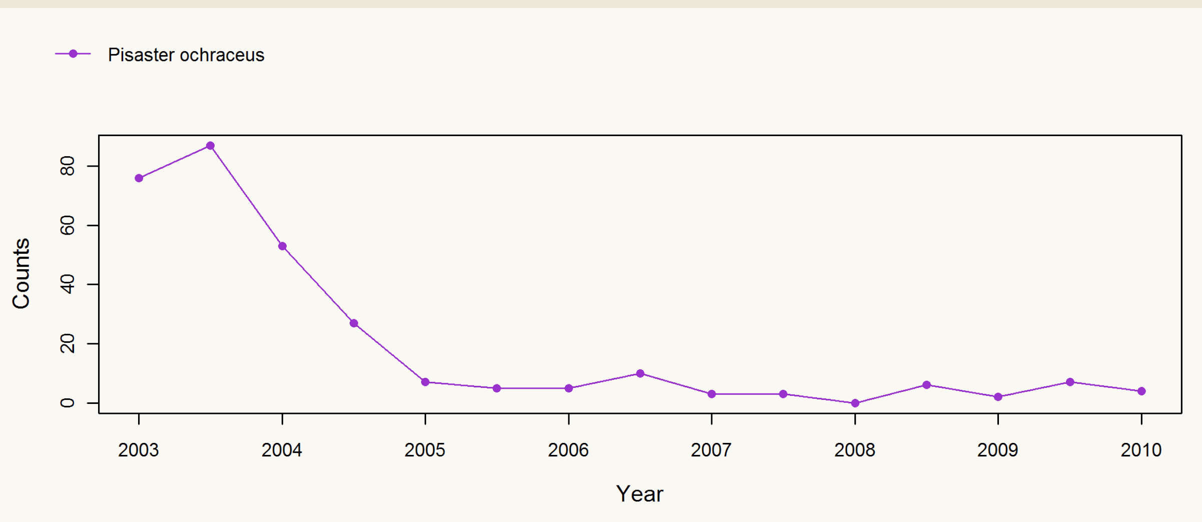


Species Counts and Sizes

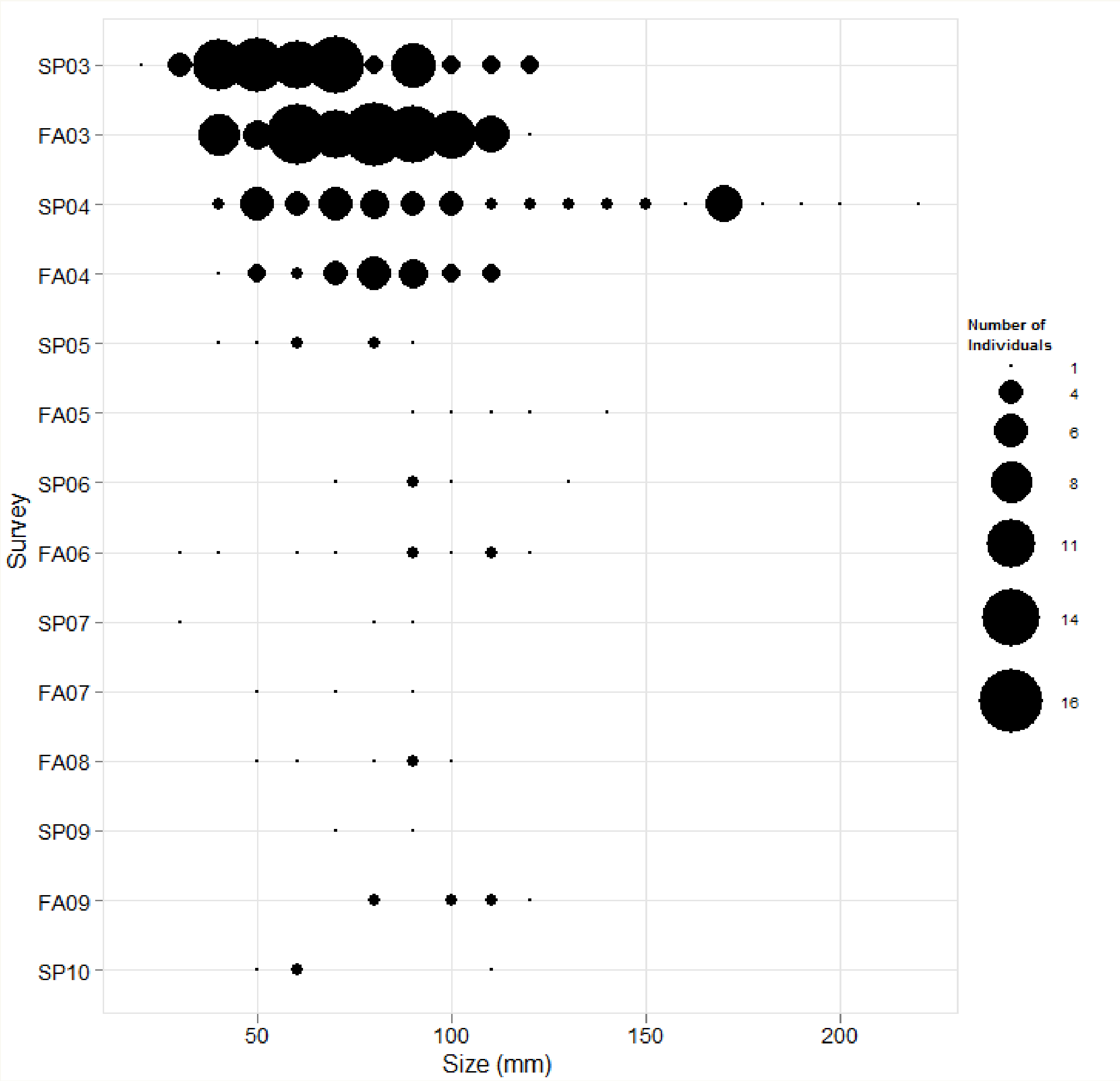


Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster (Ochre Star) - counts



Pisaster (Ochre Star) - sizes



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Crystal Cove Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

From 1996-2006, overall barnacle cover at Crystal Cove was generally high (50 to 80% cover) although abundance of barnacles fluctuated among sampling periods. For most plots, the majority of the area not covered by barnacles was simply bare (recorded as bare rock) aside from the occasional and short-lived appearance of small patches of algae such as the ephemeral sea lettuce *Ulva* and the red turf *Caulacanthus*. Mussels (*Mytilus* spp.) did recruit occasionally into barnacle plots, but their numbers were generally low with the exception of a single plot in which mussel cover began to increase steadily in 2001. Average cover of mussels reached a peak of 16% in spring 2007; this was driven mostly by high mussel abundance in a single plot. In 2006, barnacle cover dropped sharply across all plots, resulting in an increase in recorded coverage of bare rock. Since this drop, barnacle cover has begun to slowly increase again. Barnacle plots have consistently contained extremely high numbers of limpets and periwinkles (*Littorina* spp.). Genreally, higher numbers of *Littorina* are recorded in fall than in spring sampling periods.

From 1996 to 2006, mussel cover in Crystal Cove mussel plots remained relatively high (above 60%) with the notable exception of a large drop in cover associated with the 1997-1998 El Niño. Several different species moved in to fill the space opened up by this decline in mussel cover, including the annelid *Phragmatopoma*, the ephemeral alga *Ulva*, and articulated coralline algae; yet cover of these species declined over the next two years as mussels recovered to original cover levels. Following this recovery, mussel cover remained relatively high until 2007 when a moderate decline was observed following a storm with extraordinarily large waves. The effect of the storm was variable in space: some plots lost only a small amount of mussel cover but one plot was completely denuded of all mussels. Bare space created by the storm was filled quickly by a variety of algae including articulated corallines and non-calcified red algae. Since 2007 overall mussel cover has remained below 60% while cover in individual plots has been dynamic. In the plot most heavily affected by the storm, mussel cover has remained low in subsequent years of monitoring; and in other plots, minor disturbances have caused smaller occasional reductions in mussel cover. Mobile animals in mussel plots consisted primarily of limpets in the genus *Lottia*, whose numbers were highly variable over time.

Rockweeds show variation in cover within years with a pattern of higher cover in fall than in spring. Across years, there appeared to be a slight and slow decline in rockweed cover from 2004 - 2010. Space created by the reduction in *Silvetia* cover was filled by a variety of species including mussels and the red turf alga *Caulacanthus*, though in general these other species did not persist long in *Silvetia* plots. Several types of mobile invertebrates, including hermit crabs and turban snails, were regularly found in low abundance in the rockweed plots. Limpets (*Lottia* spp) were the most abundant group of mobile animals in these plots; although numbers varied greatly over time, limpet counts were typically at least five times higher than counts of any other taxon.

Surfgrass (*Phyllospadix*) cover varied within years (with higher cover in fall than in spring) and among years. Despite these temporal fluctuations, surfgrass cover remained generally high at this site (typically above 50% cover). While the feather boa kelp *Egregia* was the only other species with a notable contribution to cover in surfgrass habitat, several species of red algae (e.g. *Pterocladiella* and *Plocamium*) have been consistently present in this zone in low abundance. This habitat is also heavily influenced by sand movement: sand cover typically fluctuated between 3 and 22 %.

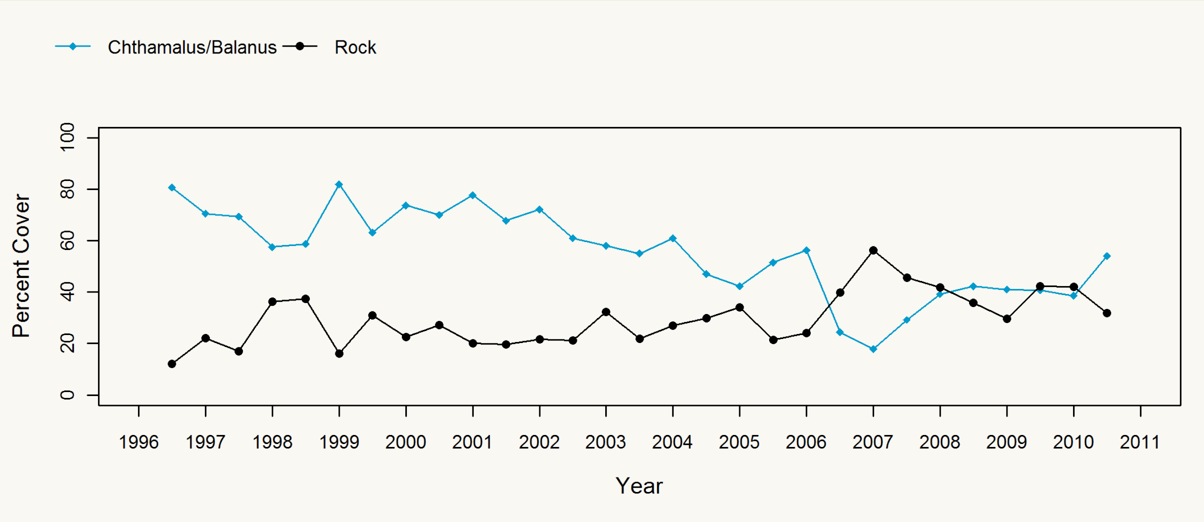
Sea star (*Pisaster*) counts at this site varied greatly over the sampling period, with peaks in numbers in 1999 and 2008.

Photo Plots

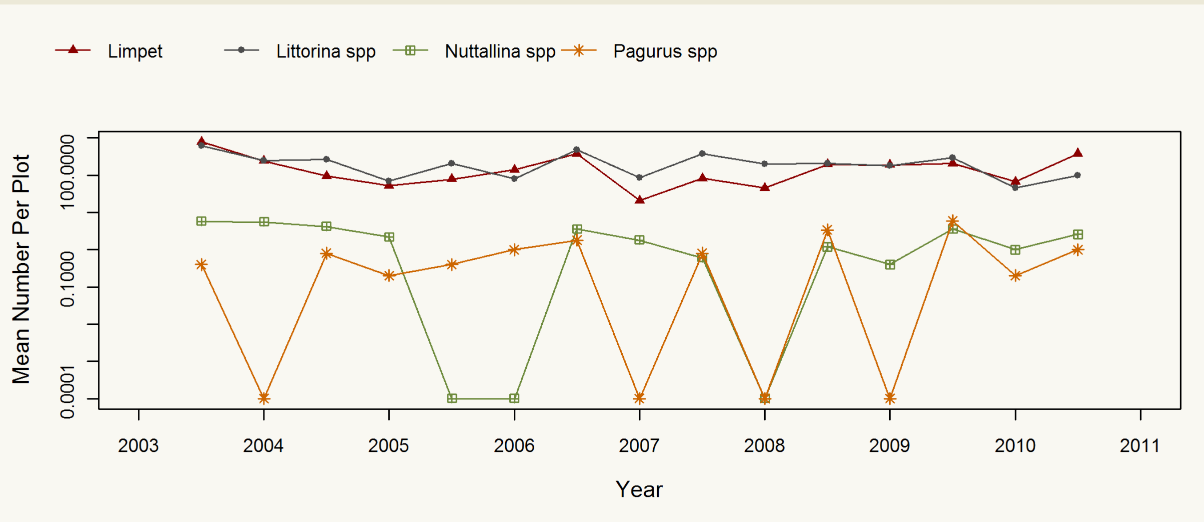
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

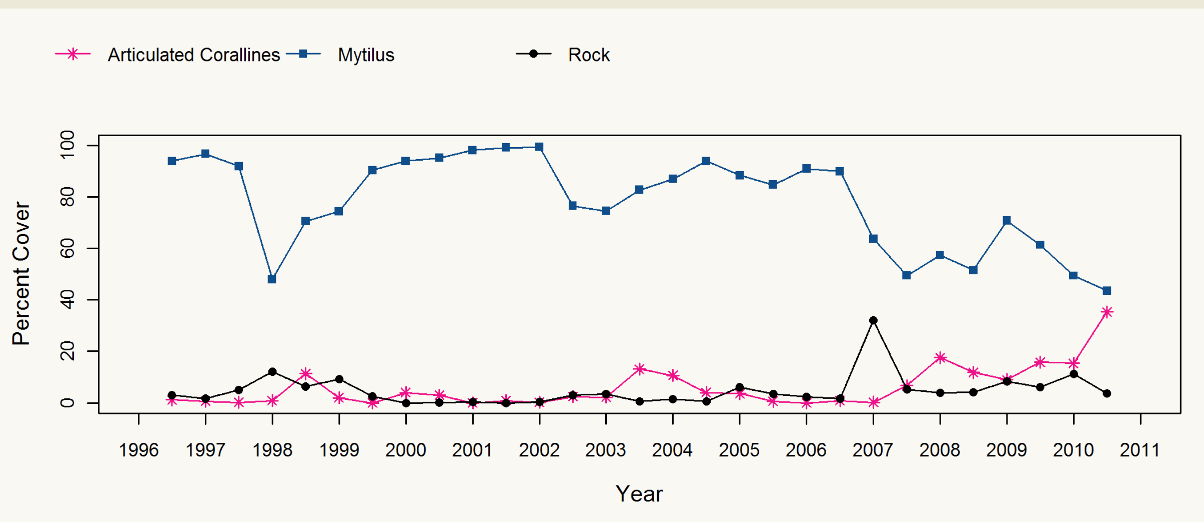
Chthamalus/Balanus (Acorn Barnacles) - percent cover



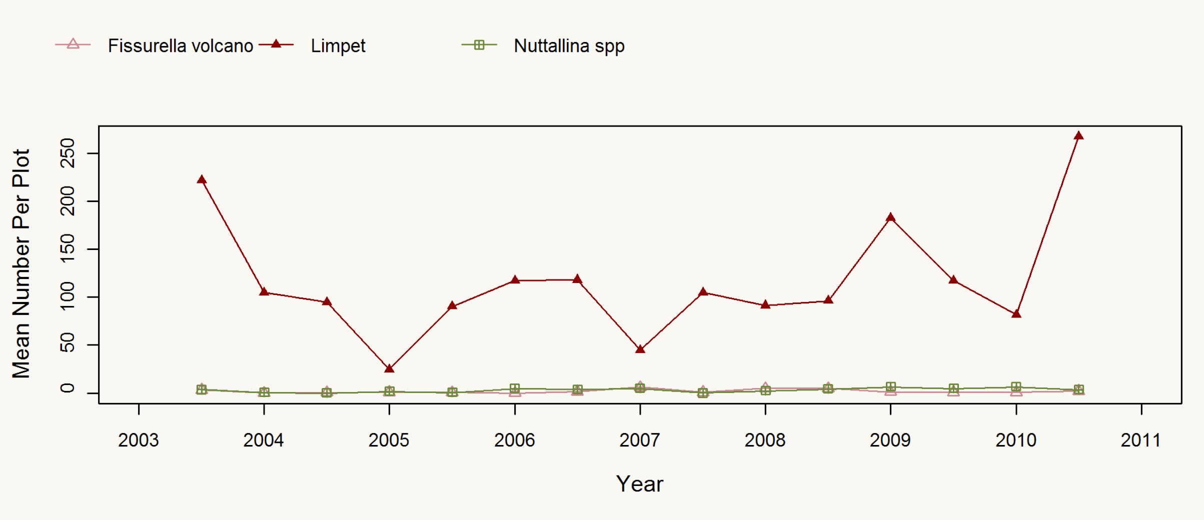
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



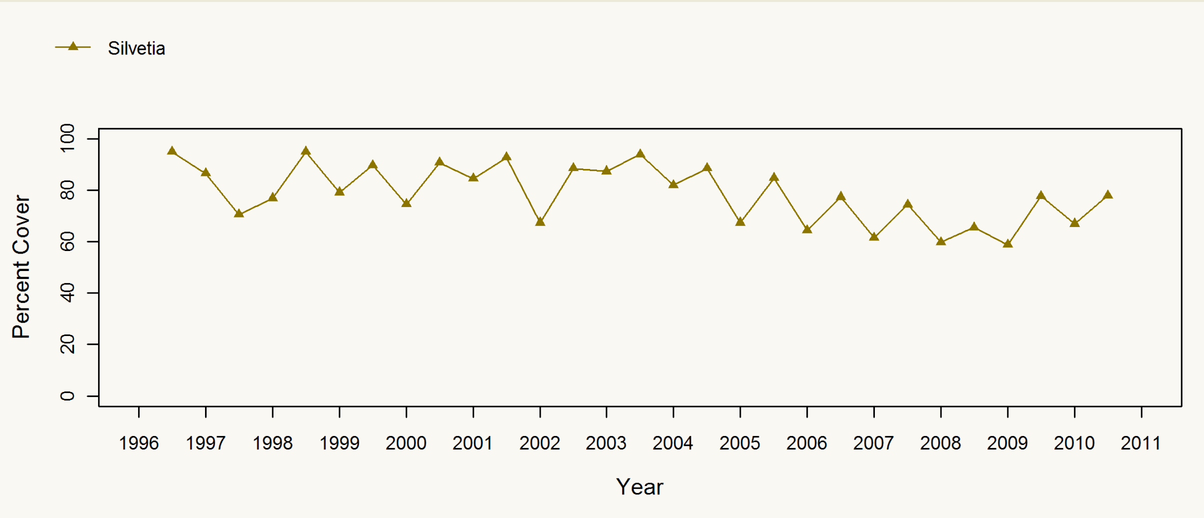
Mytilus (California Mussel) - percent cover



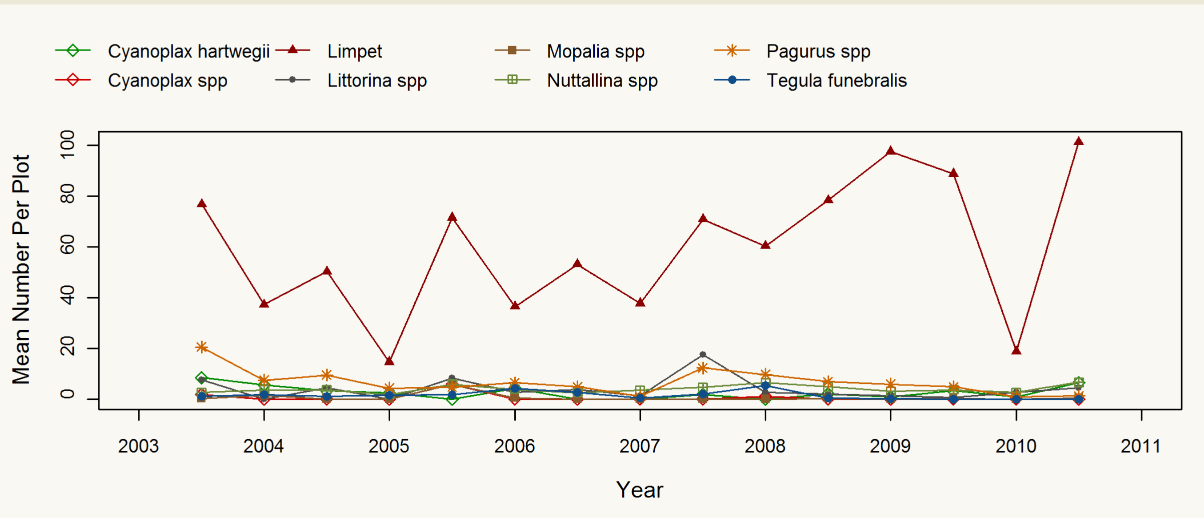
Mytilus (California Mussel) – motile invertebrate counts



Silvetia (Golden Rockweed) – percent cover



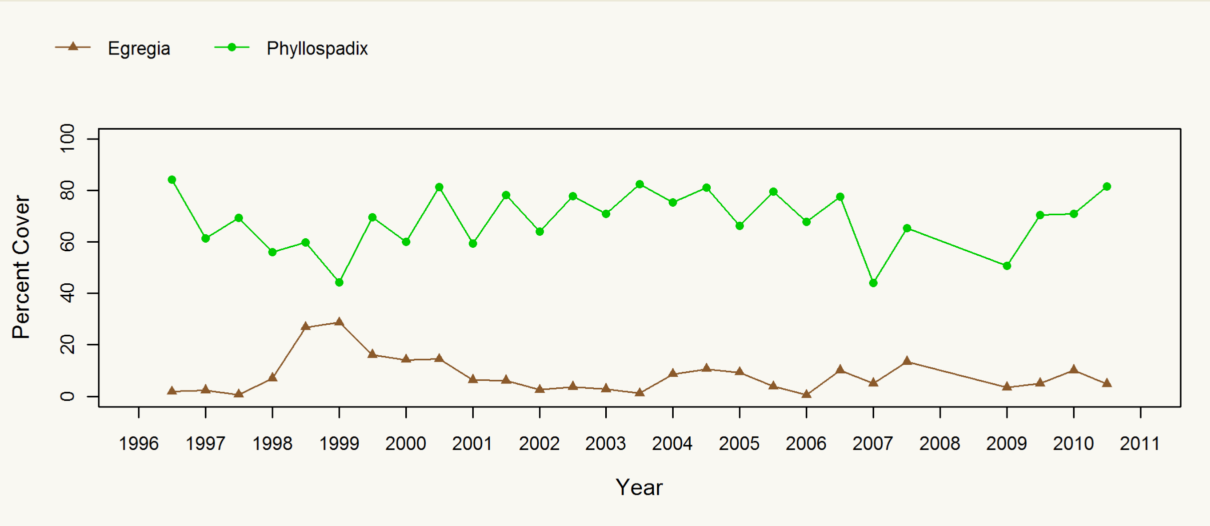
Silvetia (Golden Rockweed) – motile invertebrate counts



Transects

Below are the trends observed for each Transect target species at this site. Long-Term trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events.

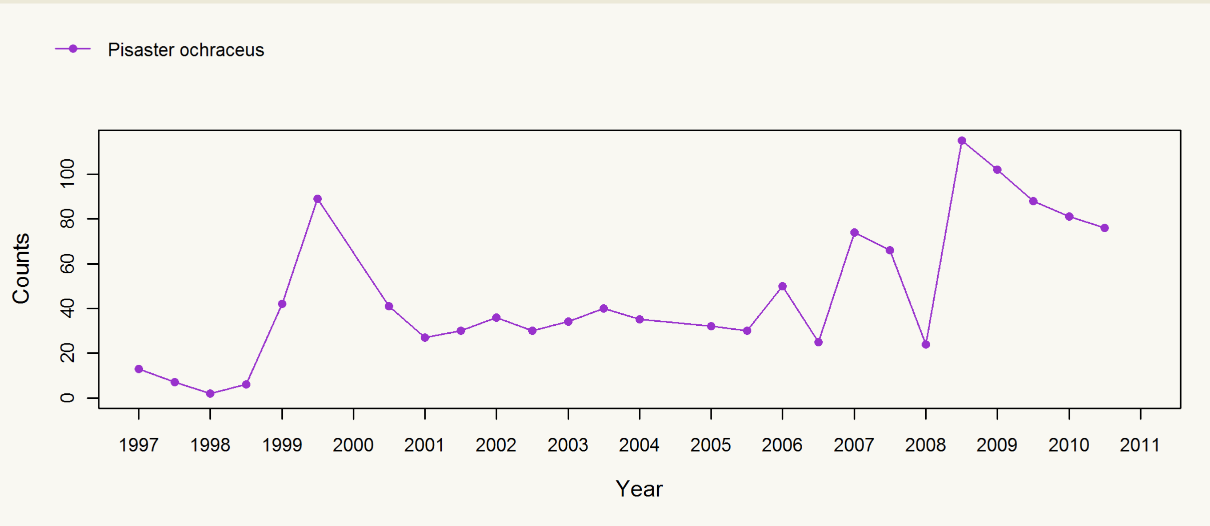
Phyllospadix (Surfgrass)



Species Counts and Sizes

Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster ochraceus (Ochre Star)



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Shaws Cove Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle cover at Shaws Cove remained high from initiation of the monitoring in 1996 through 1999. Subsequently there appears to have been a steady but minor decline in cover from 1999-2007 with concurrent increases in the cover of bare rock. From 2007-2010, cover consisted of approximately half bare rock and half barnacles. After barnacles, non-coralline crusts were the next most abundant spaceholders observed in this zone. However, the abundance of non-coralline crusts was low (less than 2% cover most years) with a maximum of close to 7% cover in fall 2009. In fall of 1998, the red alga *Endocladia* encroached into barnacle plots with an average cover of ~2.5%. After fall 1998, cover of *Endocladia* was highly variable but never exceeded 1% of the plot. On rare occasions, recruitment of *Hesperophycus* was observed but individuals typically died off before the next sampling period. Motile invertebrate surveys in barnacle plots recorded high numbers of *Littorina* spp. and variable numbers of small limpets. Both motile invertebrates exhibited minor seasonal patterns with higher counts typical in the fall sampling period.

As in other sites in this region, mussel cover at Shaws Cove remained relatively static from Fall 1996 through Fall 1997, but cover declined during the 1997-1998 El Niño. During this period of lowered mussel cover, a moderate amount of bare rock cover was recorded. Other spaceholders included barnacles, crustose corallines, articulated corallines, and non coralline crusts. Interestingly, crusts and articulated corallines alternated in terms of the group which was more abundant in mussel plots from spring 1998 to spring 2000. From 1998 to 2006, mussel cover steadily increased. The largest increase in cover was observed in fall 2003 (increase of 20% cover) as gaps within the mussel plots were filled with adult mussels (recruitment did not appear to play a role). In spring 2007, a storm accompanied by large waves resulted in a moderate decrease in overall mussel cover. This storm caused a ~35% loss in cover but the patchy nature of the disturbance resulted in 2 plots being almost completely denuded of mussels while two plots remained undisturbed. In disturbed plots, there was an increase in cover of the ephemeral alga *Ulva* in fall 2007 followed by a steady increase of barnacles which replaced *Ulva* in 2008 and 2009. Since the loss of mussels in 2007, mussel cover has changed little in subsequent years. Motile invertebrate counts were dominated by limpets, showing a seasonal pattern of higher counts in the fall sampling period.

Rockweeds at Shaws Cove exhibited typical variations in cover within a year and across years with a pattern of higher cover in the fall than in the spring sampling periods. From 2004 through Spring 2010, there was a minor but steady decline in rockweed cover. By fall 2008, rockweeds had disappeared entirely from one plot. During this decline, bare rock cover increased in the plots. Some space created by the reduction in *Silvetia* cover was occupied by barnacles; low cover of crustose algae, *Caulacanthus*, articulated corallines, and mussels was also observed. In Fall 2010, *Silvetia* abundance increased in plots, returning average rockweed abundance to 2006 levels. Motile invertebrate counts were dominated by *Littorina* spp. and limpets with *Littorina* spp. numbers increasing in fall of 2005.

Abundance of the red alga *Endocladia* (turfweed) has varied greatly (from 7 to 52% cover) at Shaws Cove since initiation of monitoring in 1996. The period with the highest cover occurred between spring 2001 and spring 2003 with cover values between 40 and 50%. Large losses (~20%) in cover occurred in fall 2000, fall 2003, and fall 2007. Bleaching seems to have caused the largest loss of cover in 2003 (~25%); in spring 2003 observers noted damaged thalli, and large portions of the turfweed were gone by the next sampling period. In fall 2007, cover reached a low of 7% and has only increased moderately since then. In addition to *Endocladia*, bare rock and barnacles contributed to overall cover in these plots. Like *Endocladia*, recorded cover of bare rock and barnacles was highly variable over the years. Barnacle cover, on average, hovered around 30% with peaks in fall 1997 and spring 2006 at ~60% cover. Rockweed cover in *Endocladia* plots was relatively low from 1996 to spring 2003 but increased from fall 2003 to fall 2006, reaching a peak of 20% in fall 2004. Most of this change was driven by a dramatic increase in cover in two plots (which were located adjacent to the rockweed bed). Motile invertebrate counts were dominated by *Littorina* spp. and limpets with numbers remaining static over the years.

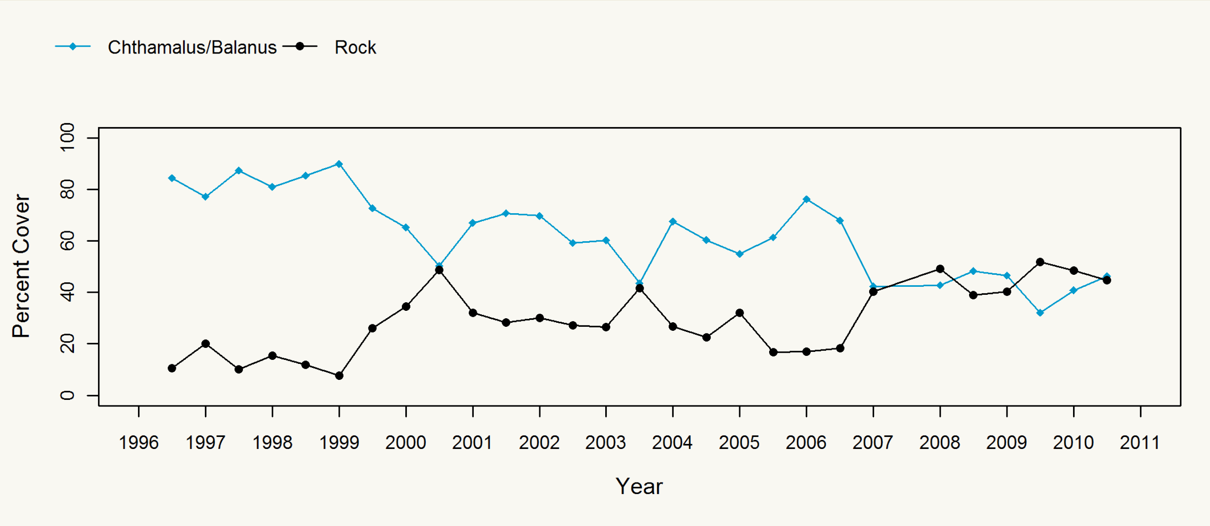
Sea Star (*Pisaster*) counts are taken over the entire site at Shaws Cove. Sea star numbers varied greatly over the sampling period with peaks in 2004, 2006, and 2009.

Photo Plots

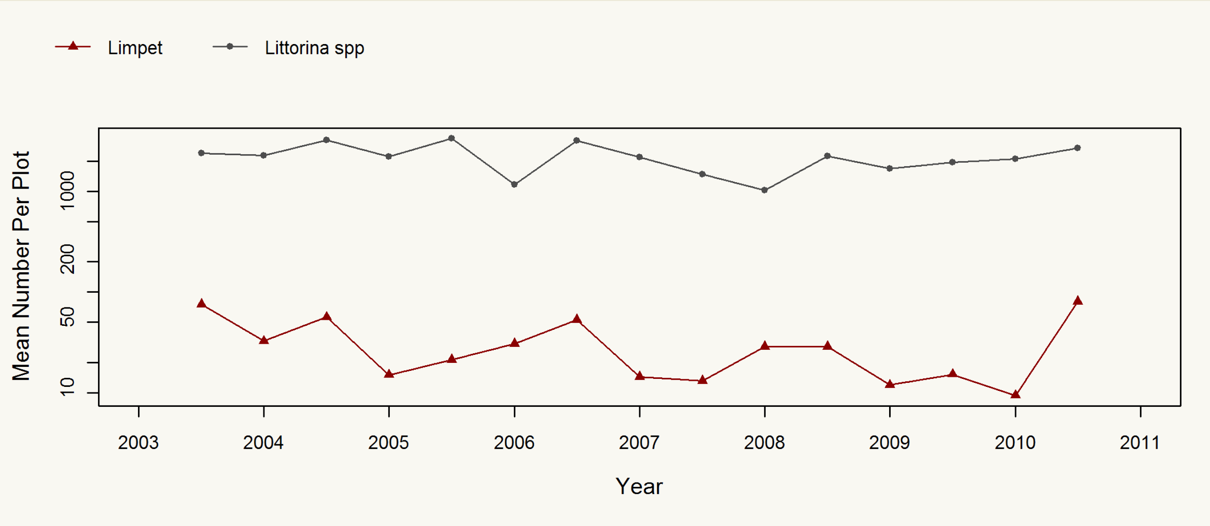
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

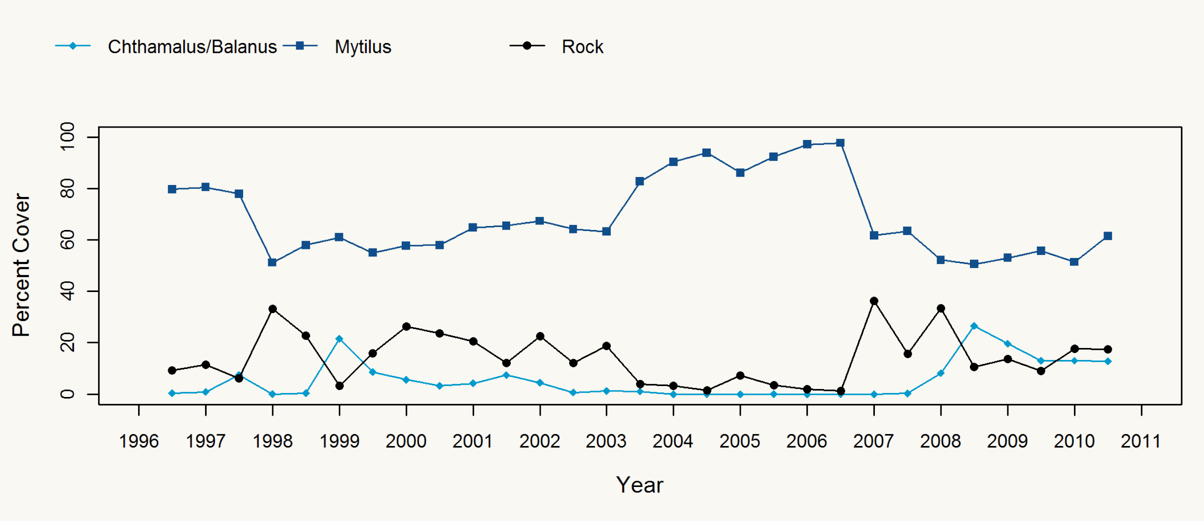
Chthamalus/Balanus (Acorn Barnacles) - percent cover



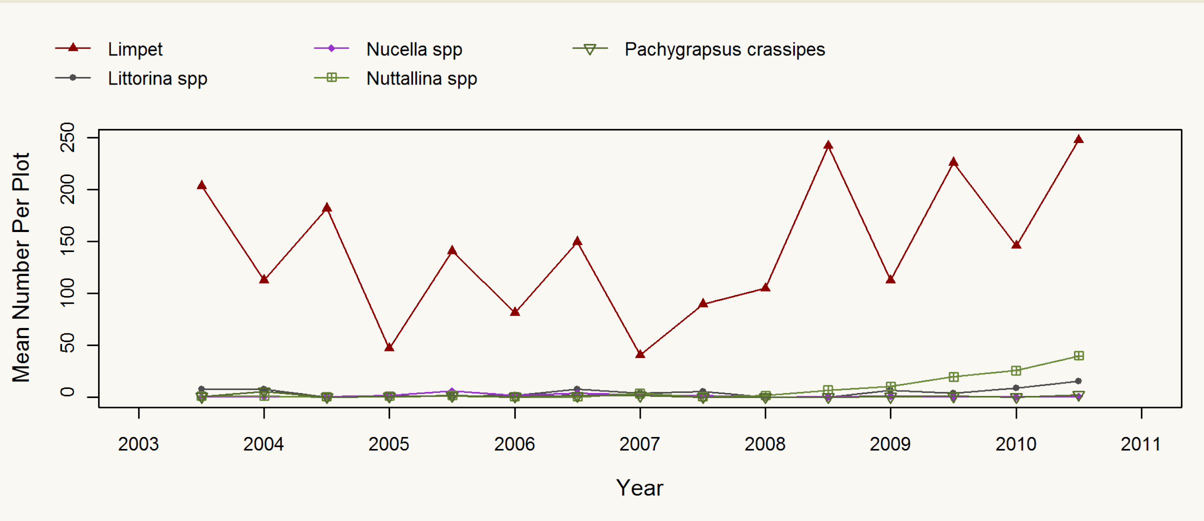
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



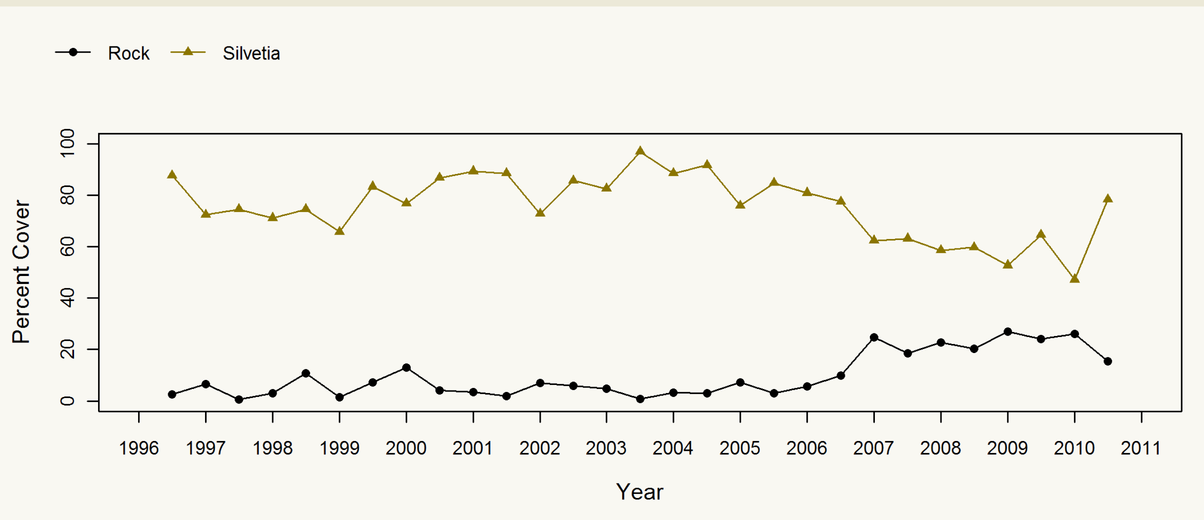
Mytilus (California Mussel) - percent cover



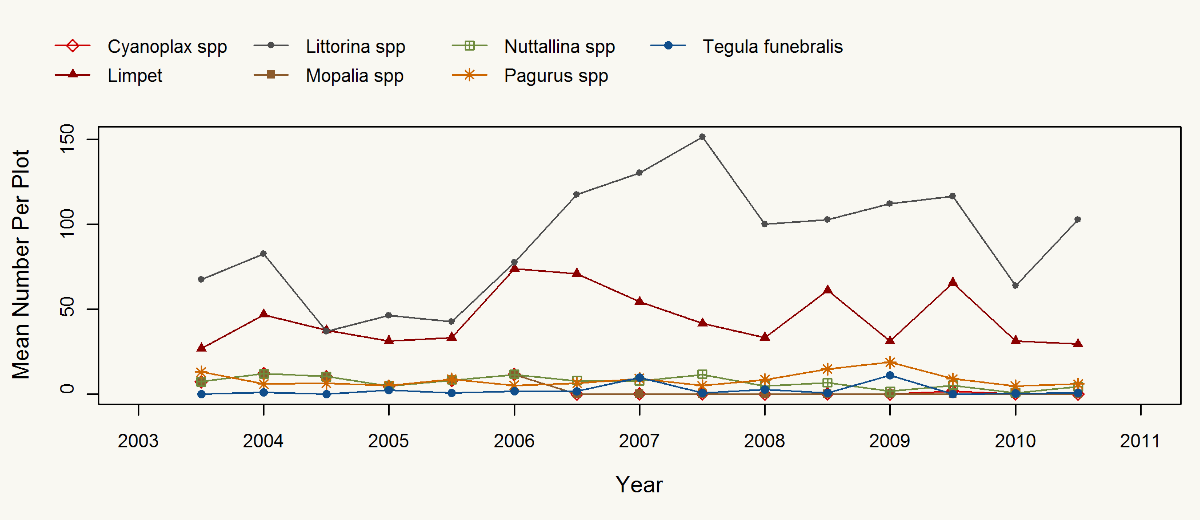
Mytilus (California Mussel) – motile invertebrate counts



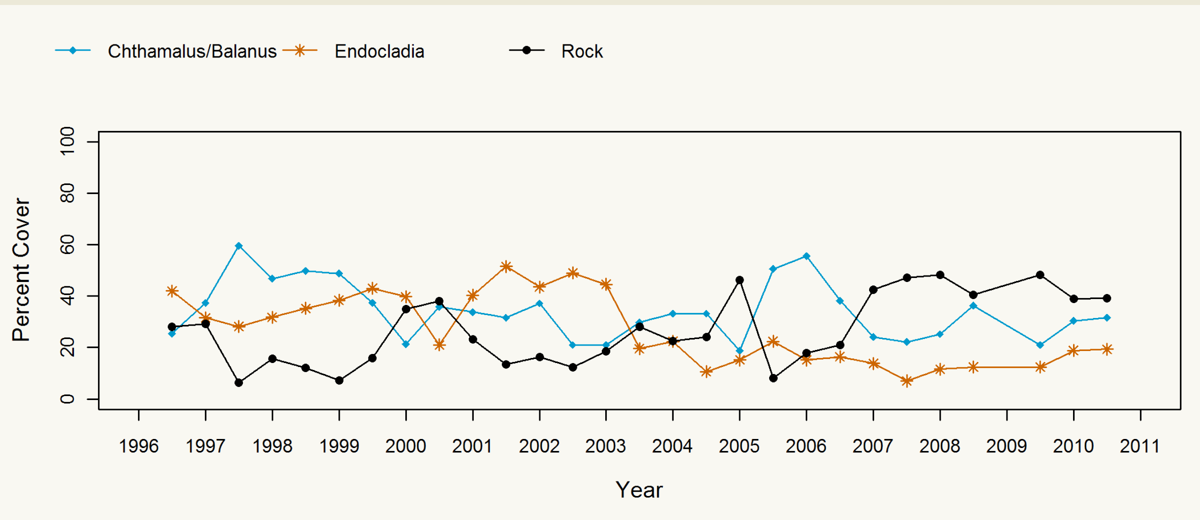
Silvetia (Golden Rockweed) – percent cover



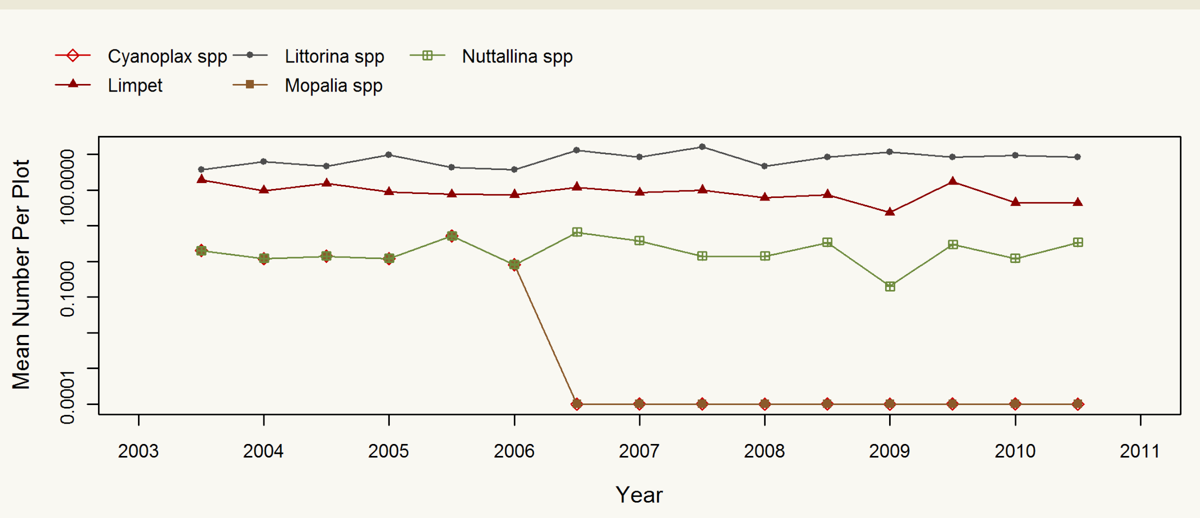
Silvetia (Golden Rockweed) – motile invertebrate counts



Endocladia (Turfweed) - percent cover



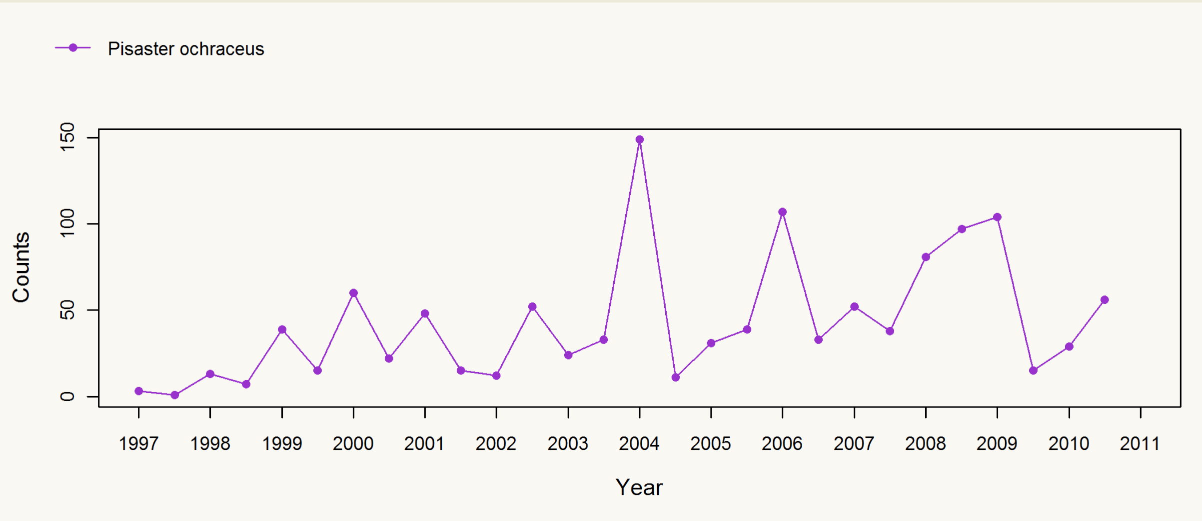
Endocladia (Turfweed) - motile invertebrate counts



Species Counts and Sizes

Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster ochraceus (Ochre Star) - counts



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Treasure Island Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle cover at Treasure Island exhibited a general decline over the course of the monitoring period, particularly between 1999 and 2003. Following low cover values of ~40% in 2003, there was a recovery period in which barnacles increased to ~80% cover, but subsequently abundance declined again to 40% by fall 2010. During periods of low barnacle cover, there were concurrent increases in the cover of bare rock. From 2009-2010, cover consisted of approximately half bare rock and half barnacles. Cover of the ephemeral alga *Ulva* cover was very low in all samples from 1996-2005. However, in two plots, there were large inundations of *Ulva* in fall 2005, spring 2006, and spring 2007 with additional increases in *Ulva* in one plot in spring 2008 and spring 2010. Non-coralline crusts exhibited two peaks in cover in spring 2003 (17%) and spring 2008 (9%), reducing bare rock cover during those periods. *Littorina* spp. counts in barnacle plots are extremely high with only occasional limpets found during certain sampling seasons.

Mussel cover at this site was relatively low at initiation of the monitoring and decreased during subsequent sampling into the 1997-1998 El Niño. Cover remained low through 2002 but recovered to moderate levels in 2003 - 2004 with an increase of 40% during that year. Since 2004, mussel abundance declined slightly. Unlike the other sites in the region, the severe 2007 storm only resulted in a 10% loss of mussel cover in monitored plots, although mussel loss did occur at this site in the lower intertidal zone (below the area of the fixed photoplots). Bare rock cover was often high during periods of low mussel cover, with exception of seasons when barnacle cover increased, such as in fall 1999 and spring 2002. Other taxa found in the mussel plots included crustose corallines, *Tetraclita*, and non-coralline crusts but cover of these groups was highly temporally variable. In spring 2002, the large increase in 'other brown algae' (15% cover) was driven mostly by an increase in *Petrospongium rugosum*. Limpet counts in mussel plots varied greatly over time with peaks in 2004, while other motile invertebrates were relatively low in numbers.

Rockweed cover showed seasonal fluctuations typical of this region with higher cover in the fall than in spring sampling periods. Rockweeds exhibited highly variable cover over time with a general pattern of decline since 2004. The lowest cover (~38%) occurred in spring 2006. At this time, barnacle cover reached its peak (~40%); aside from this high value, barnacles generally covered 5-10% of the surface in rockweed plots (on average). Cover of bare rock was highly variable, reaching peaks (20-25%) in 1999 and between 2007 and 2009. Mussel cover was very low in rockweed plots from 1996 to 2003 but increased to 4-9% cover after 2004. *Hesperophycus* was absent from 1996 to 2002, but abundance increased for a short period in 2003 with a peak of 8% cover in spring; this increase was short-lived, as it was followed by a die off in fall. *Hesperphycus* cover remained low until fall 2009 and the alga was not found in *Silvetia* plots at this site in 2010. Articulated corallines, crustose corallines, non-coralline crusts, other red algae, and *Ulva* were also common in *Silvetia* plots but highly variable in cover over time. Motile invertebrate counts were dominated by *Littorina* spp. and limpets.

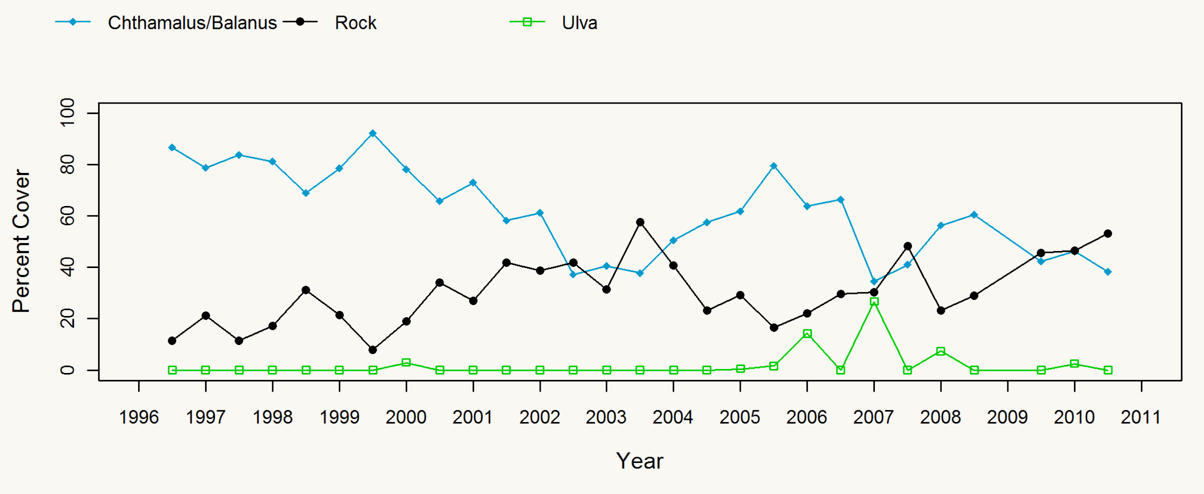
Sea star (*Pisaster*) counts, which were low from 1996 to 2004, increased dramatically in 2006. After this 2006 peak, sea star abundance varied greatly among sampling periods from 2006 - 2010.

Photo Plots

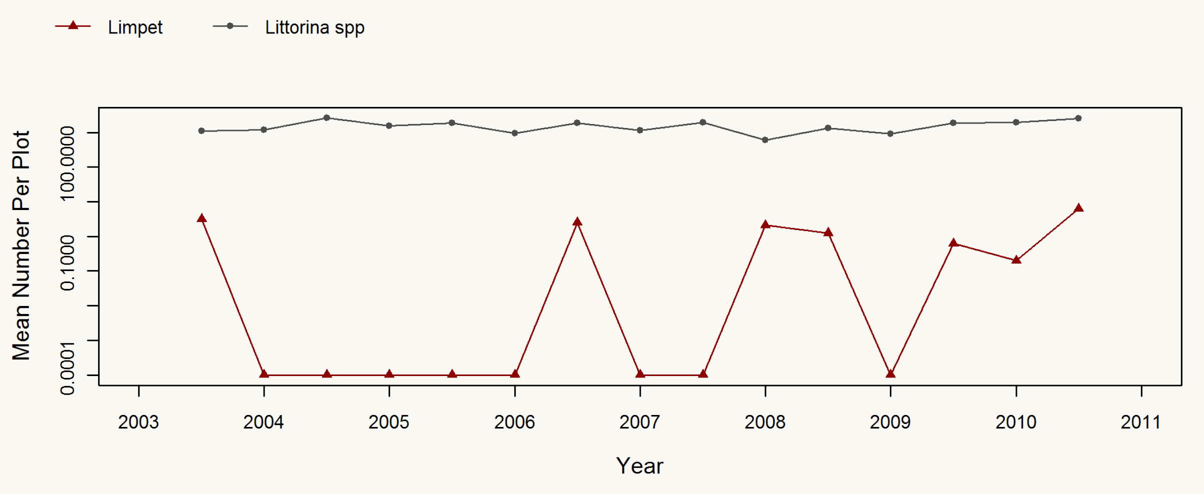
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

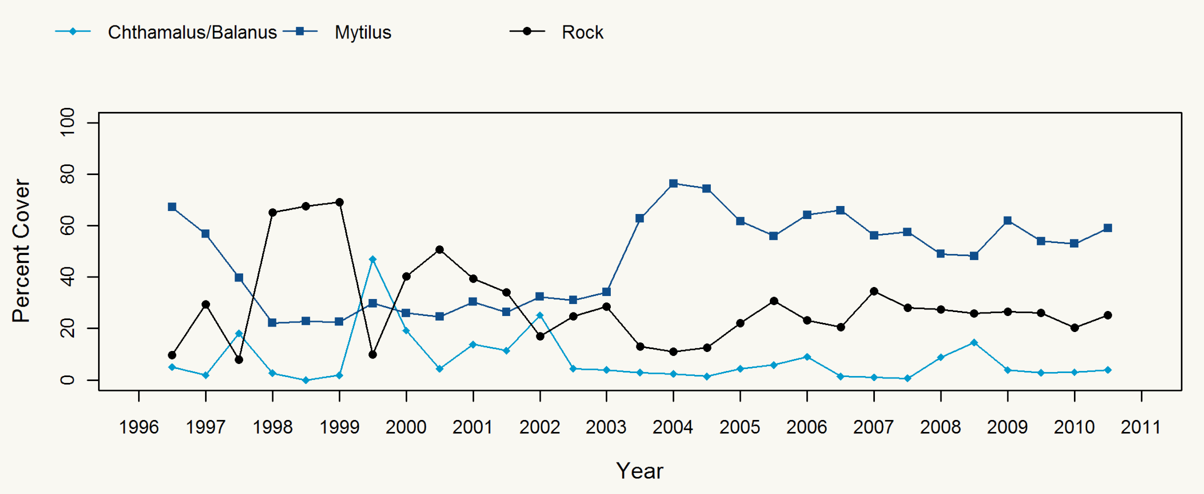
Chthamalus/Balanus (Acorn Barnacles) - percent cover



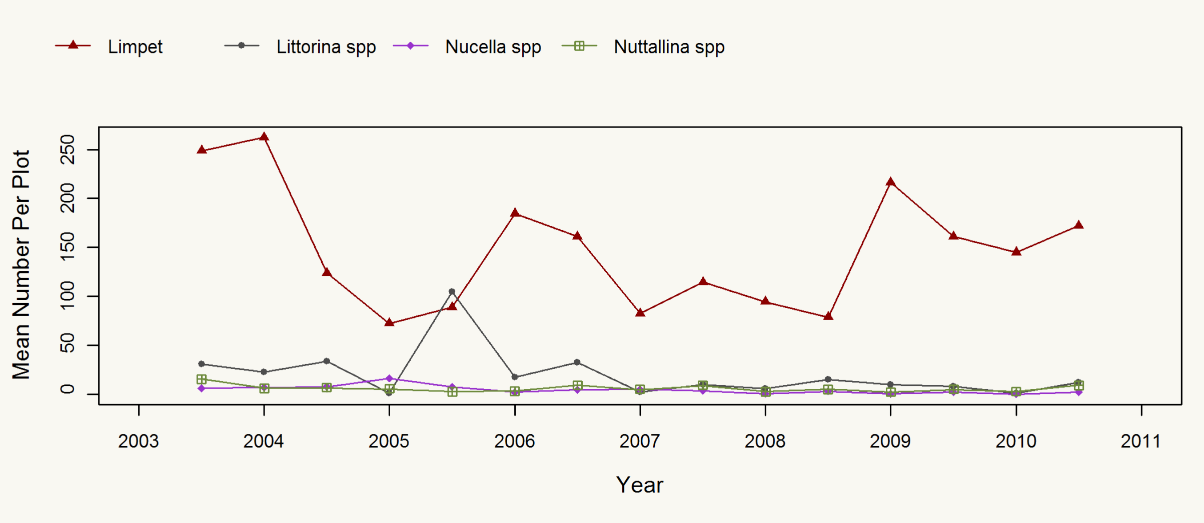
Chthamalus/Balanus (Acorn Barnacles) - motile invertebrate counts



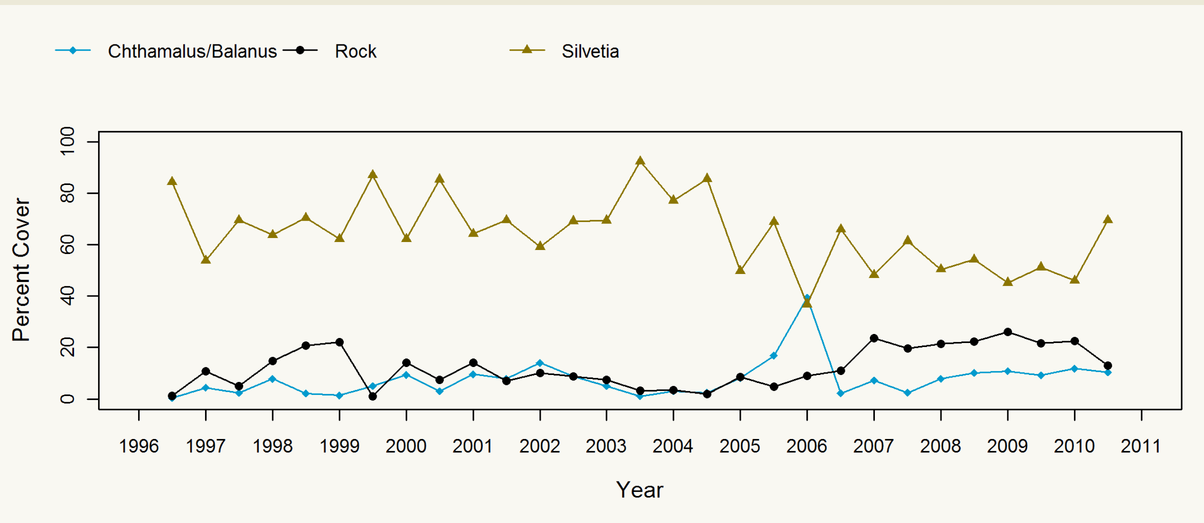
Mytilus (California Mussel) - percent cover



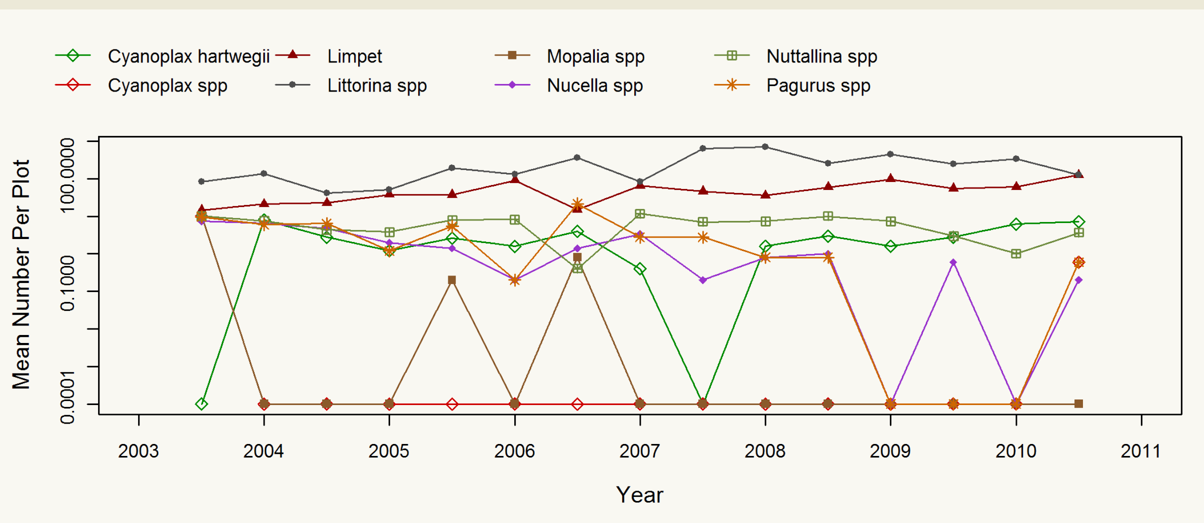
Mytilus (California Mussel) - motile invertebrate counts



Silvetia (Golden Rockweed) – percent cover



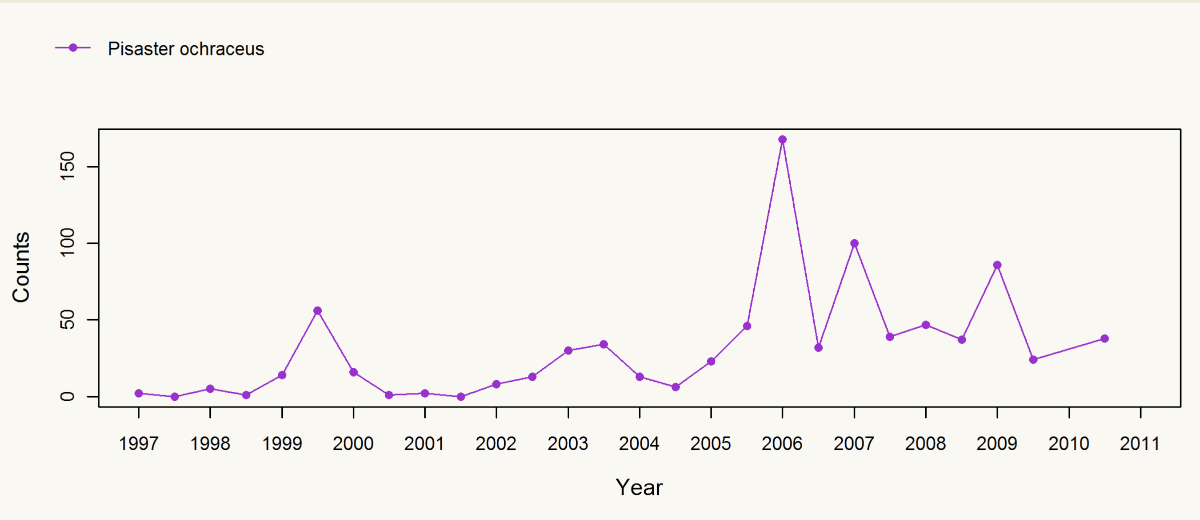
Silvetia (Golden Rockweed) – motile invertebrate counts



Species Counts and Sizes

Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster ochraceus (Ochre Star)



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Dana Point Long-Term trends

SEE BELOW FOR TREND GRAPHS

In order to standardize species resolution across all MARINe groups, and over time, some species (typically rare) were lumped for graphical presentation of Long-Term monitoring data. See lumped categories for definitions (some variation occurs between methods and over time).

Barnacle cover at Dana Point showed frequent small increases and decreases since initiation of sampling in 1996, with a trend of declining cover over time. On a few occasions, small amounts of algae (including the rockweed *Silvetia*, the ephemeral sea lettuce *Ulva*, the brown blade *Endarachne* and the red turf *Caulacanthus*) recruited into barnacle plots, but these algae did not persist. Instead, rock in barnacle plots that was not occupied by barnacles generally remained bare. Snails in the genus *Littorina* were consistently found in very high abundance in barnacle plots. Limpets (genus *Lottia*) were also consistently present but at much lower densities than *Littorina*.

Mussel cover at Dana Point showed fewer fluctuations than barnacle cover from 1996 to 2006, though mussel cover did decrease during the 1997-1998 El Niño. After recovering following the El Niño, mussel cover dropped again in spring 2007 following a storm with extraordinarily large waves. As at other sites in the region (e.g. Crystal Cove) the effects of the storm were variable in space, with some plots losing more of their mussel cover than other plots. In general, following a drop in mussel cover, space on the rock not covered by mussels remained bare with occasional recruitment of barnacles (acorn barnacles and *Tetraclita*). Low and fluctuating cover of the red turf alga *Caulacanthus* has been observed on top of mussels in several plots since the early 2000s. After the 2007 storm, plots that lost large numbers of mussels have been slow to recover, and mussel abundance has remained relatively low. Several groups of molluscs are consistently found in low abundance in mussel plots (e.g. the chiton *Nuttallina*, the turban snail *Tegula funebralis*, and the periwinkle genus *Littorina*) but only limpets (genus *Lottia*) were found in very high abundance.

Rockweed cover at this site fluctuated within years (often with higher cover during fall sampling periods than spring sampling periods). Small amounts of sand were occasionally observed in a few of the rockweed plots during fall sampling, but overall sand influence appeared to be low. Across years, rockweed cover remained relatively high (above 60% of plot area, on average) from 1996 to 2010. When the cover of *Silvetia* dipped, the cover of bare rock typically increased: aside from the red turf alga *Caulacanthus* (which appeared at low levels in a few plots) and crustose algae, few other space-holding species were observed in rockweed plots. Limpets (*Lottia* sp) were very abundant in *Silvetia* plots, although limpet abundances fluctuated greatly over time (from a high average of 100 individuals per plot to a low average of approximately 20 individuals per plot). The turban snail *Tegula funebralis* was also regularly found in rockweed plots, though numbers of the snail were typically lower than the number of limpets.

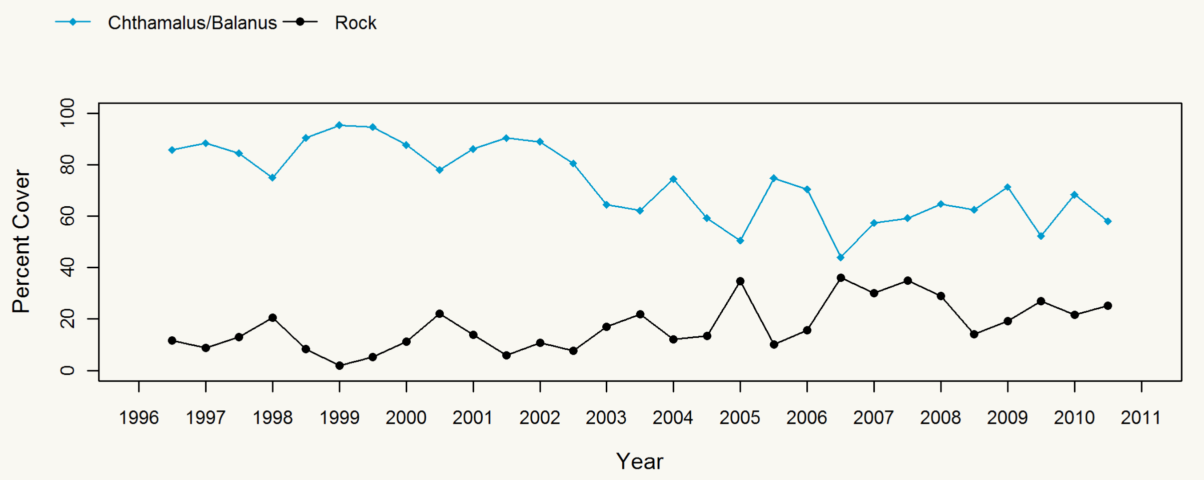
Sea star (*Pisaster*) counts showed peaks in abundance in 2003 and 2008, but compared to other sites in Orange County (Crystal Cove, Shaws Cove, and Treasure Island) sea star counts at Dana Point were low throughout the monitoring period.

Photo Plots

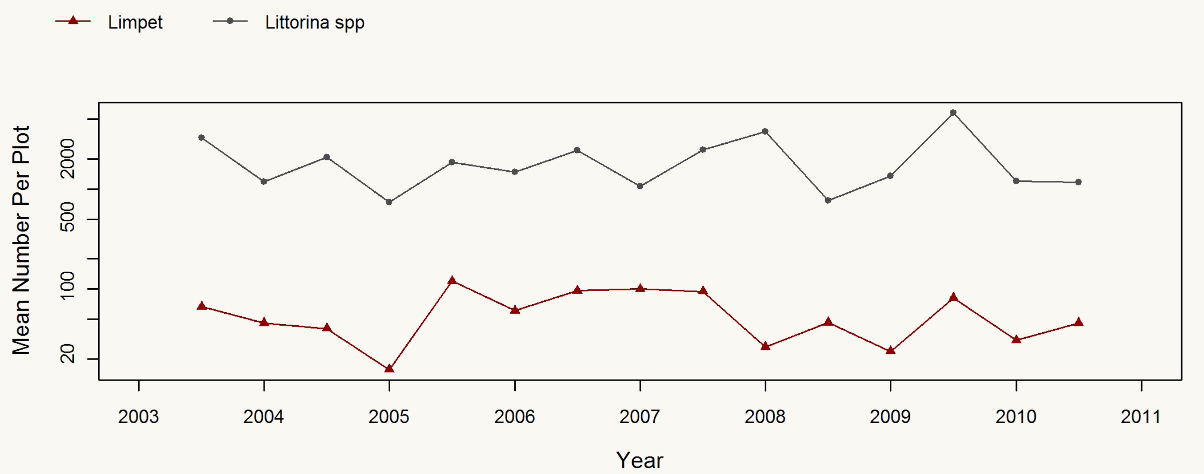
Below are the trends observed for each Photo Plot target species at this site. Long-Term percent cover trend graphs show all species that reached a minimum of 25% cover during any single point in time within a given target species assemblage. Breaks in trend lines represent missed sampling events. For additional species observed that did not meet this 25% threshold, please use the Interactive Map.

For motile invertebrate Species Counts, a mean across all plots was calculated, and only those species with a value of at least 5 individuals for at least one sample are shown. For motile invertebrate size trend graphs by site, please use the Interactive Map.

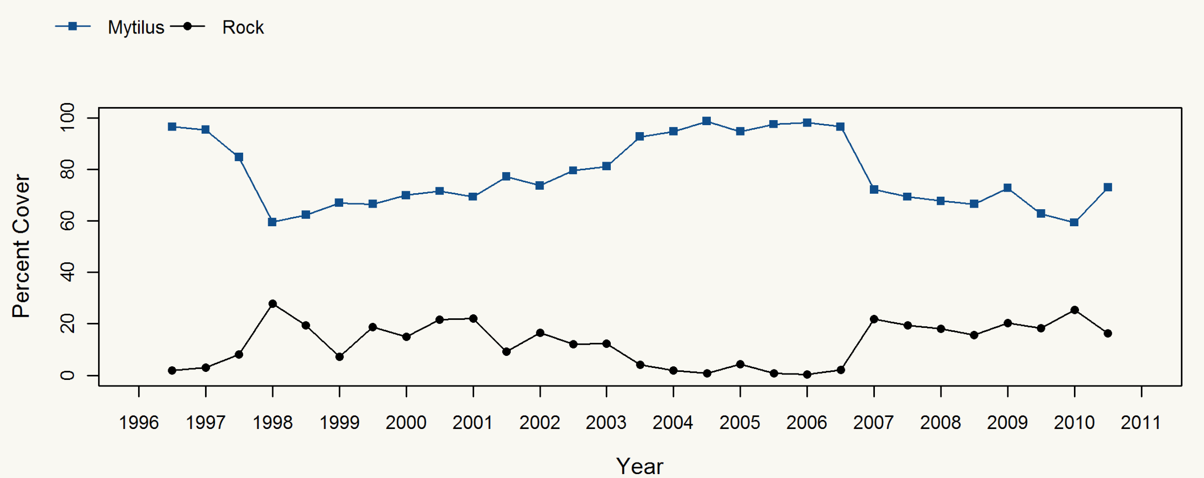
Chthamalus/Balanus (Acorn Barnacles) - percent cover



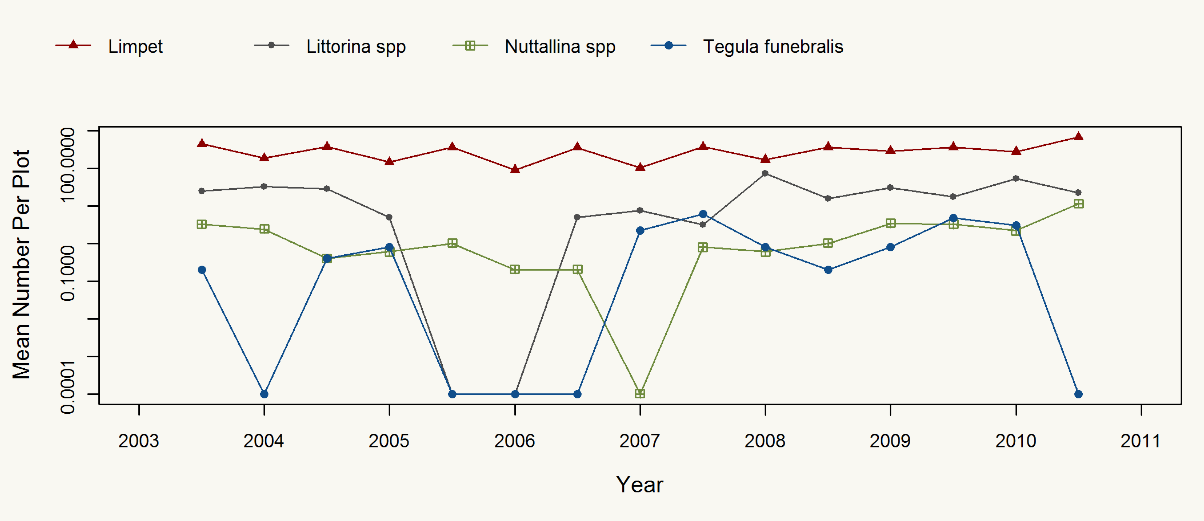
Chthamalus/Balanus (Acorn Barnacles) – motile invertebrate counts



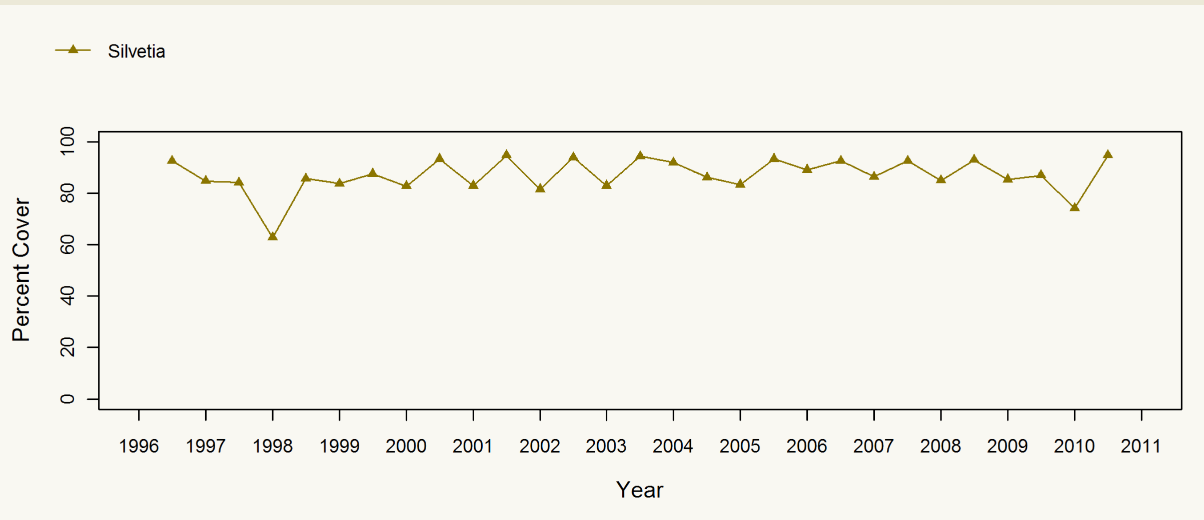
Mytilus (California Mussel) – percent cover



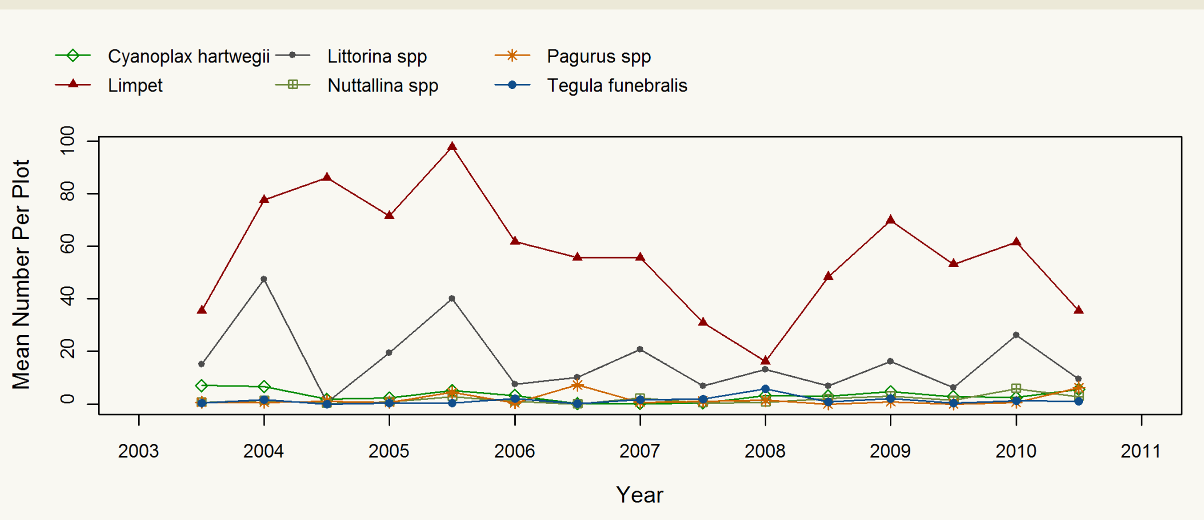
Mytilus (California Mussel) – motile invertebrate counts



Silvetia (Golden Rockweed) – percent cover



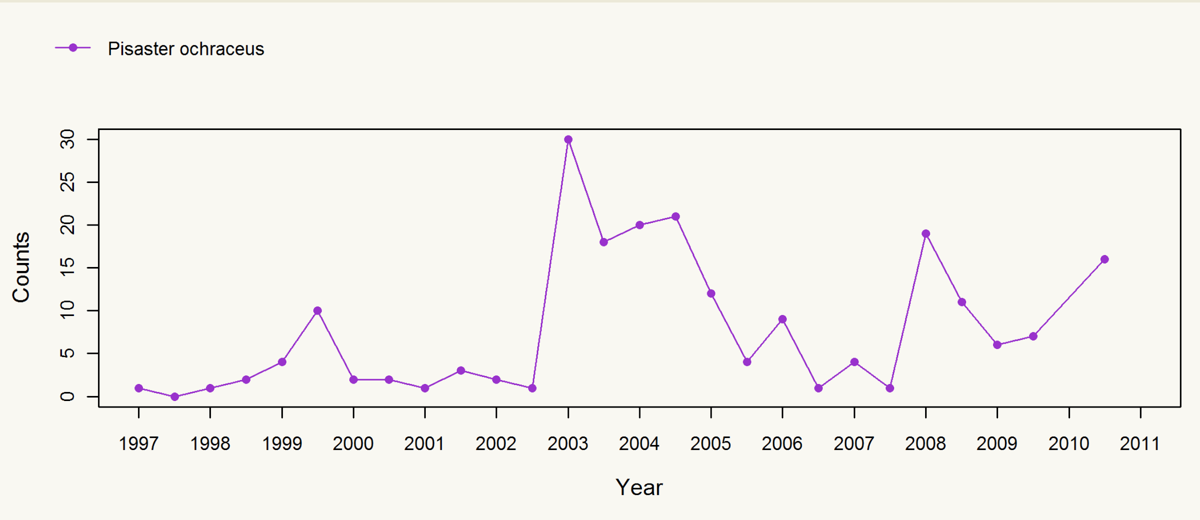
Silvetia (Golden Rockweed) – motile invertebrate counts



Species Counts and Sizes

Species Counts and Sizes (where recorded) for *Pisaster* are shown below for this site. The sum of all individuals across all plots is displayed.

Pisaster ochraceus (Ochre Star) - counts



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Interactive Map

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Appendix 5: Regional Mosaic Plots

Phyllospadix

Chthamalus/Balanus

Mytilus

Silvetia

Endocladia

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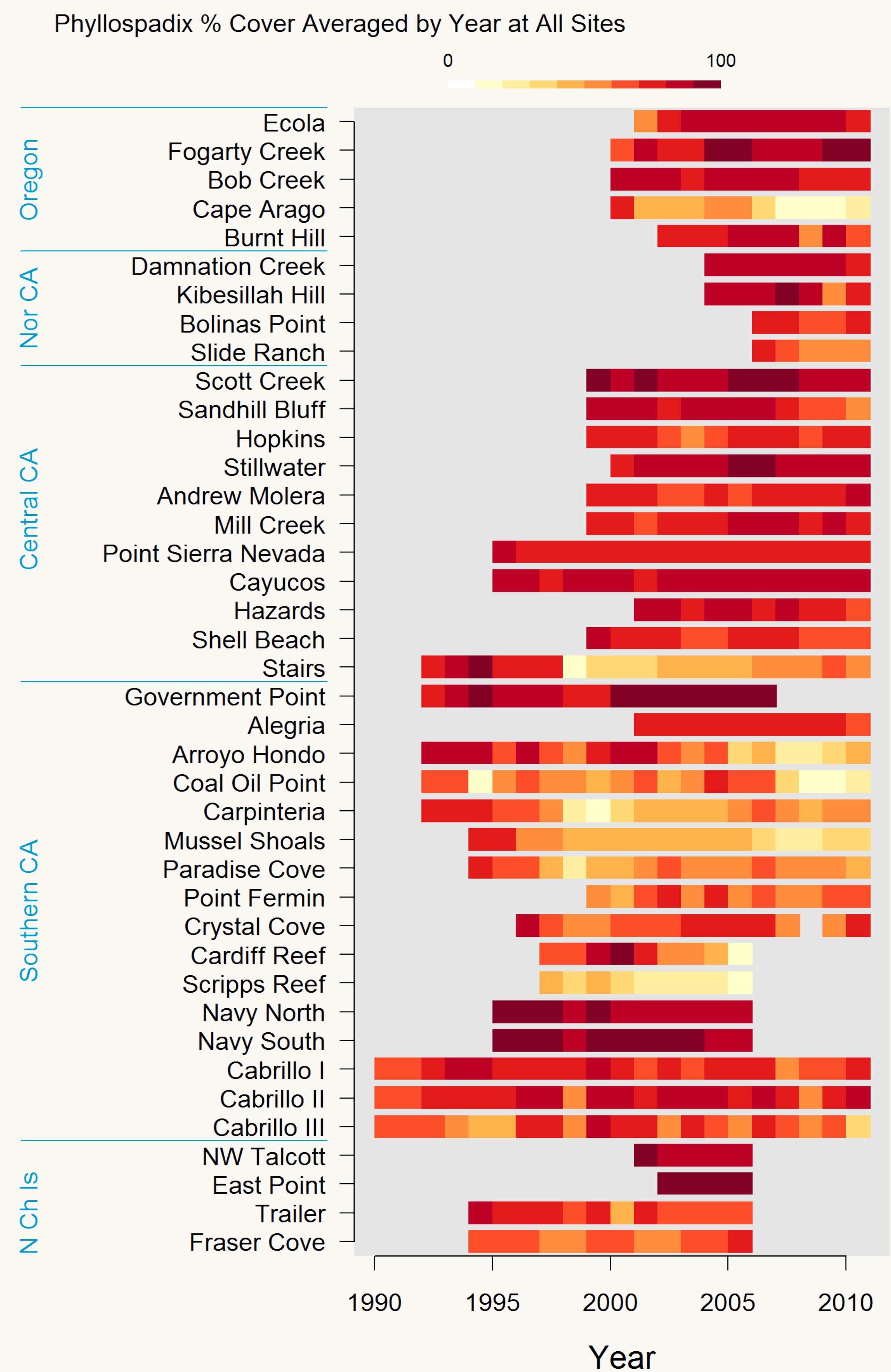
Mosaic Plot for All Sites

Phyllospadix (Surfgrass)



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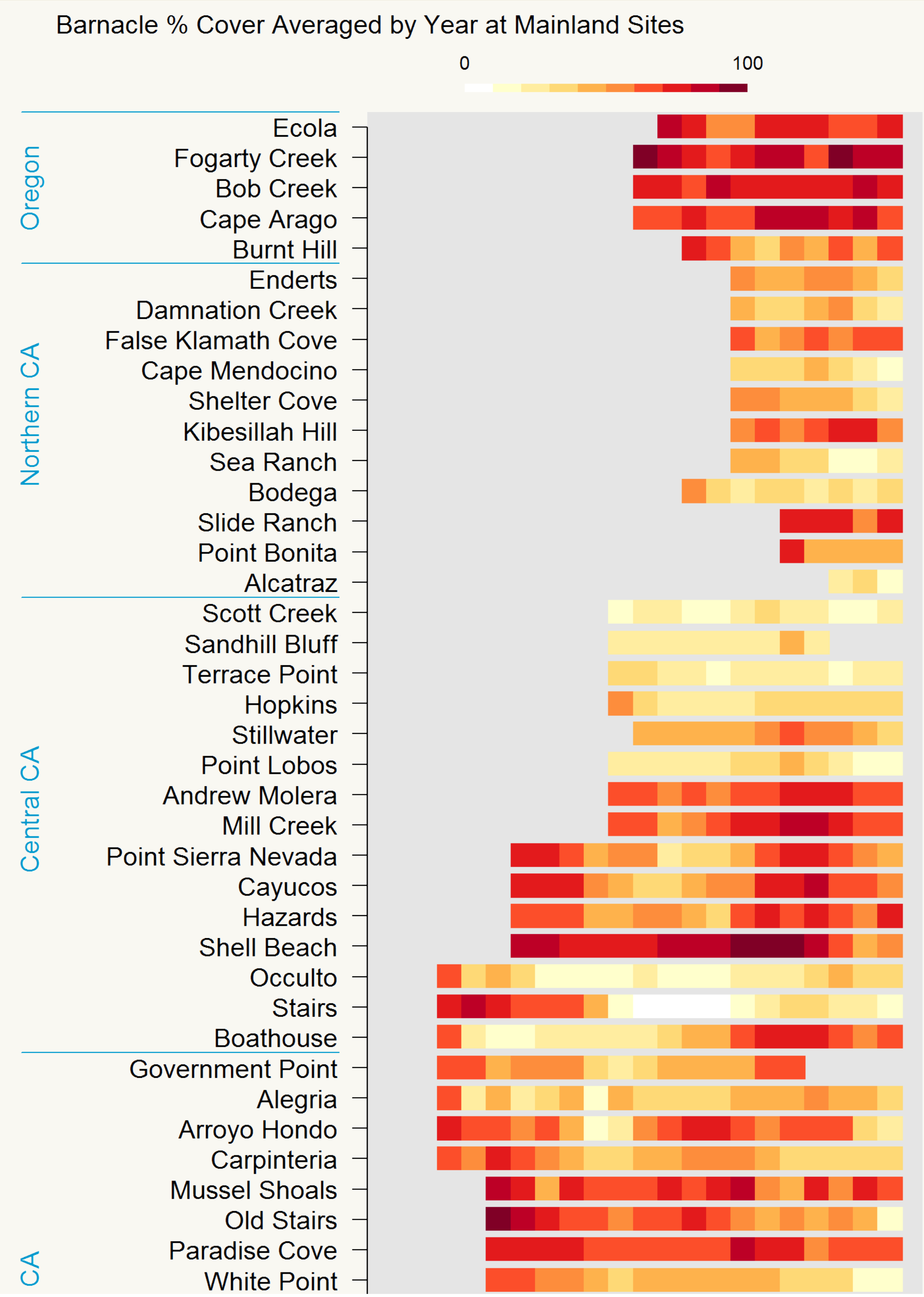
Mosaic Plot for Sites from Oregon to Southern California

Chthamalus/Balanus (Acorn Barnacles)



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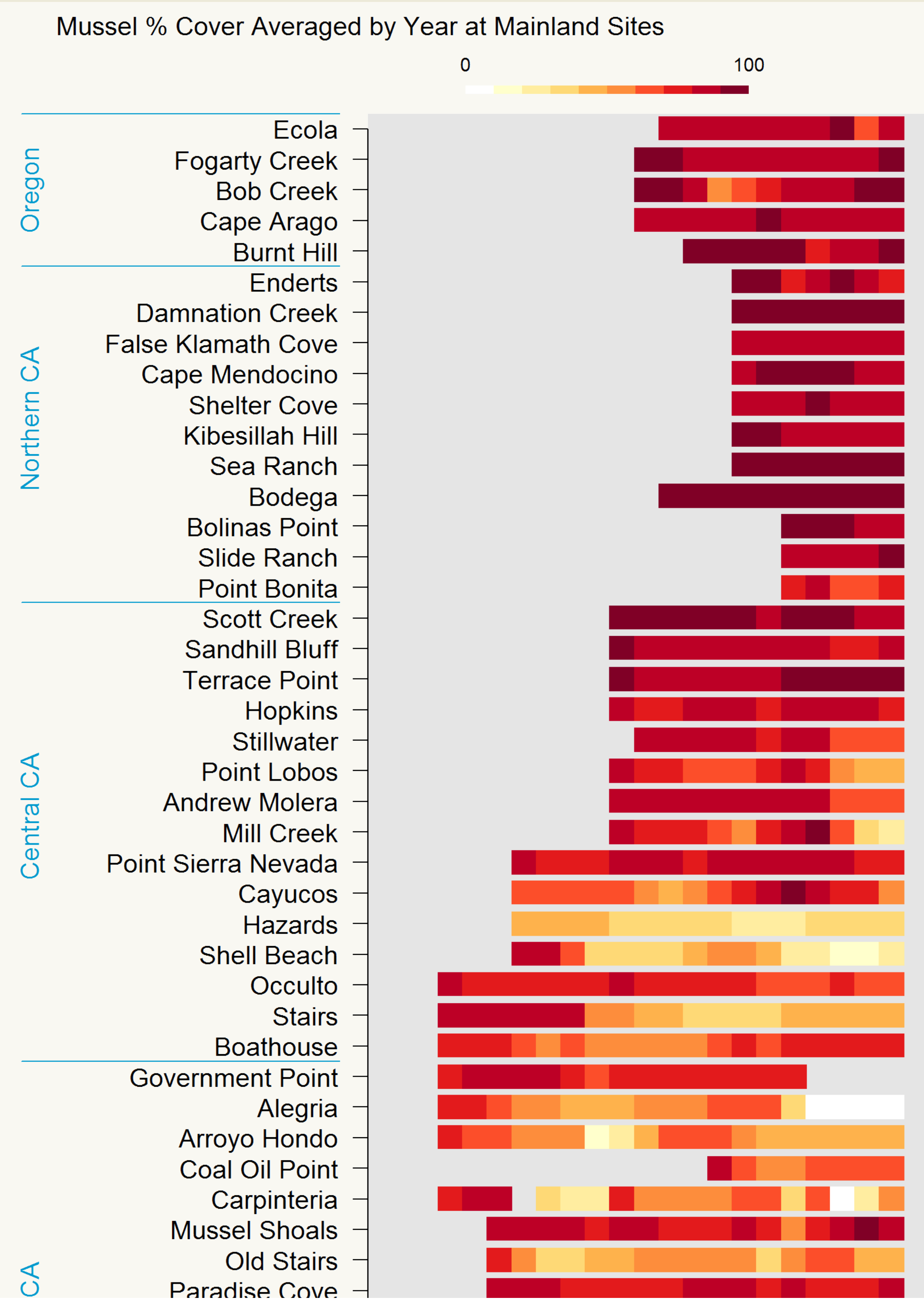
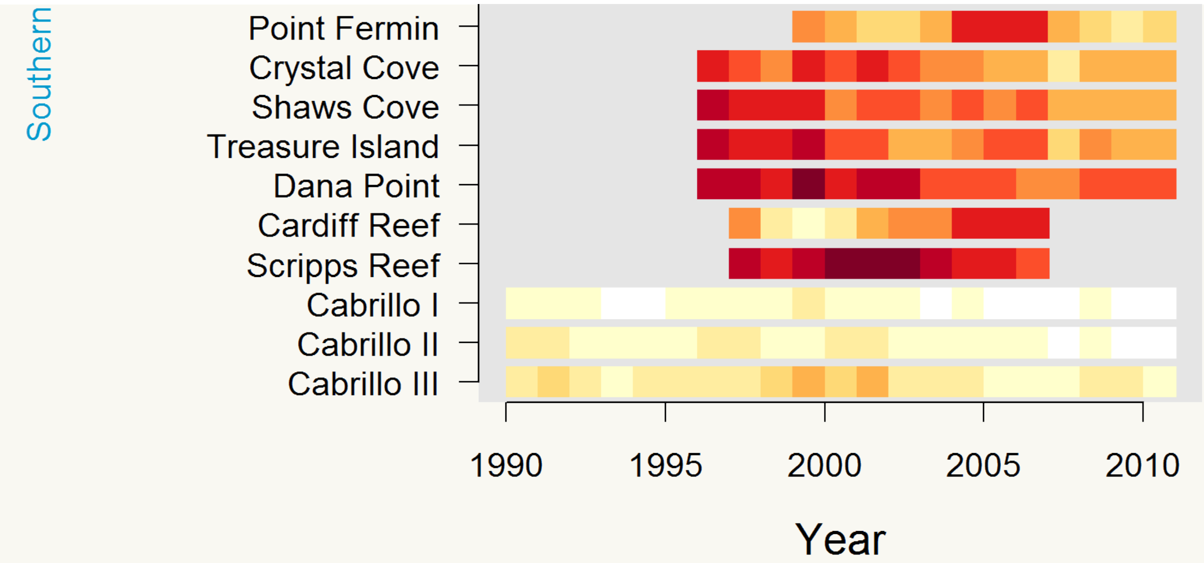
Mosaic Plot for Sites from Oregon to Southern California

Mytilus (California Mussel)





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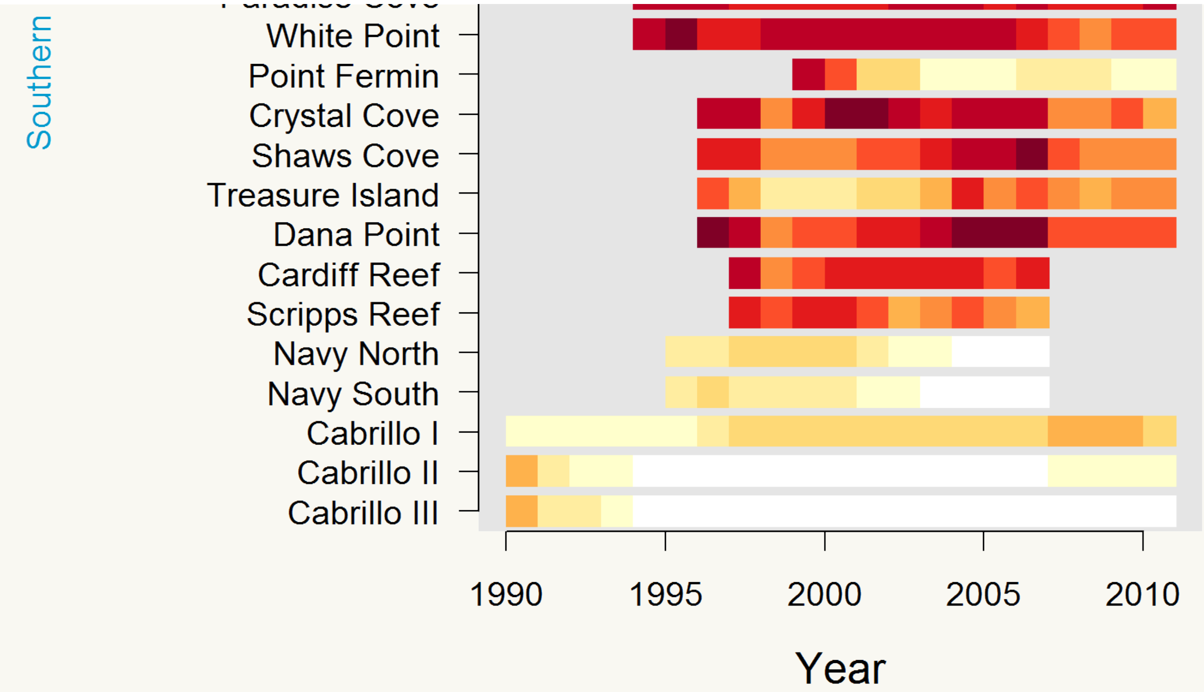

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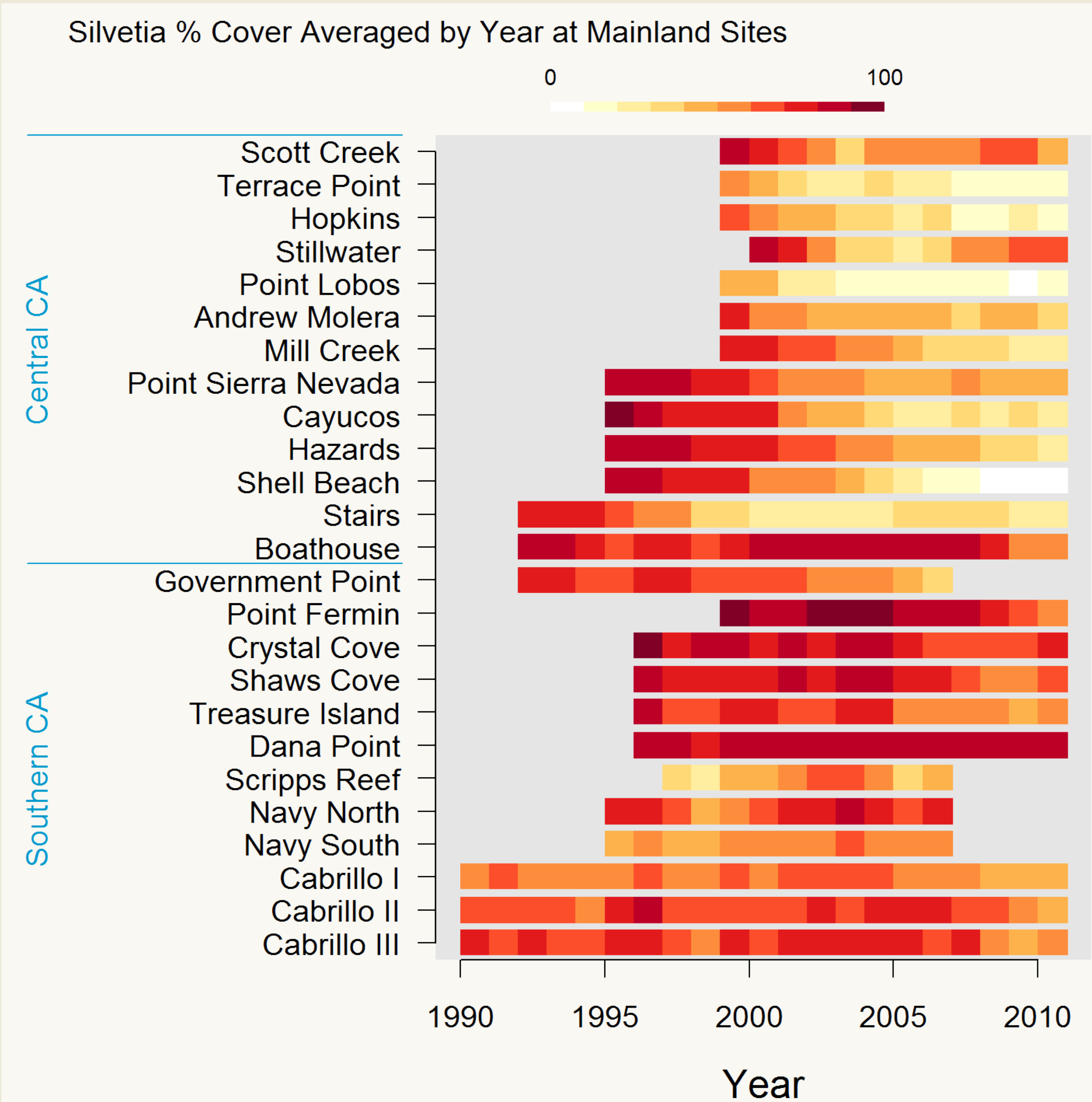
Mosaic Plot for Sites from Oregon to Southern California

Silvetia (Golden Rockweed)



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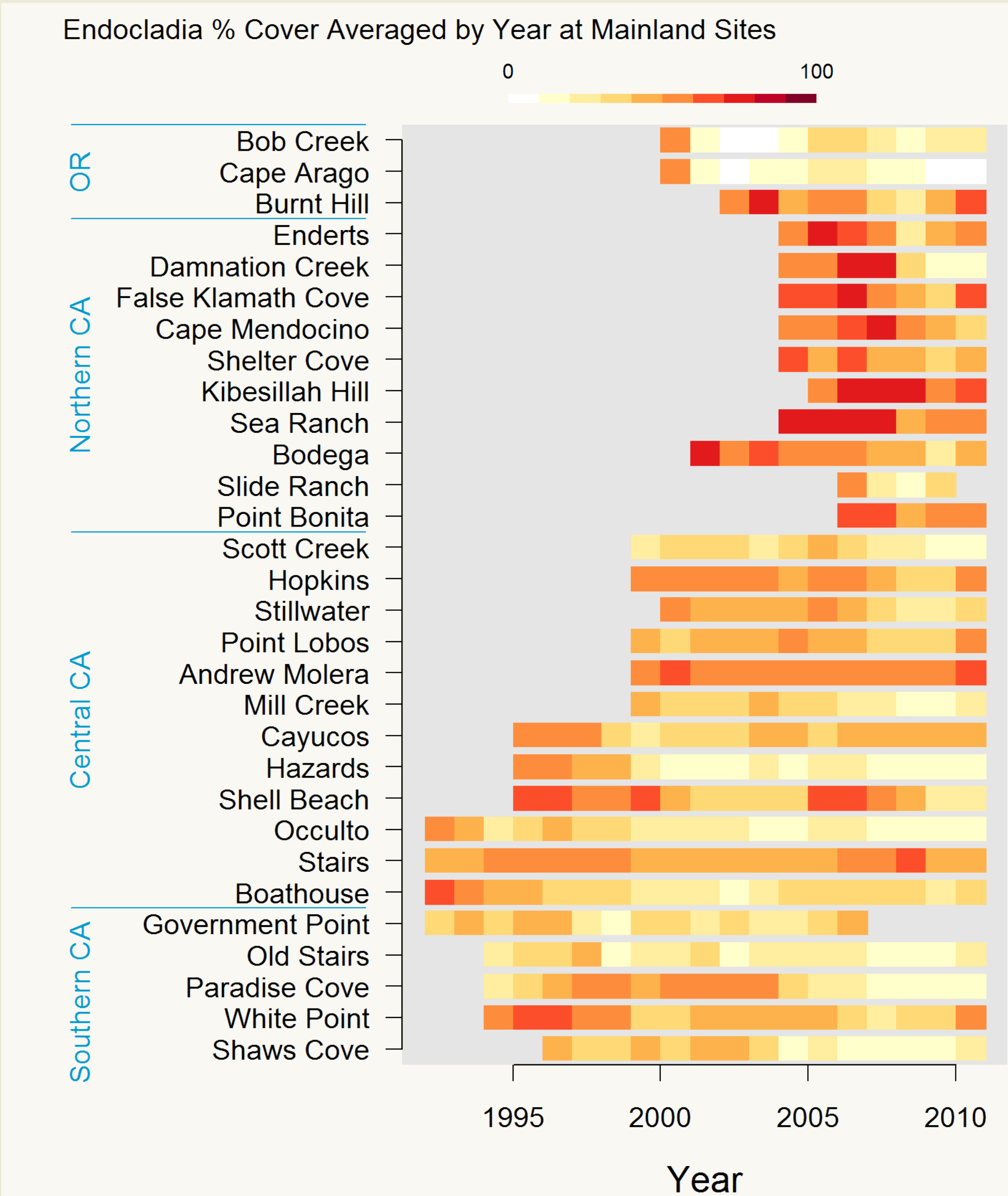
Mosaic Plot for Sites from Oregon to Southern California

Endocladia (Turfweed)



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