EVALUATION OF ANTHROPOGENIC IMPACTS ON THE SAN DIEGO COASTAL KELP FOREST ECOSYSTEM

Annual Project Report (2015 – 2016)

By

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Submitted to

City of San Diego Public Utilities Department

April 1, 2016

1 Introduction

The coastal shelf off San Diego is a premier recreational area with beaches that attract tourists from all over the world. The most charismatic of the marine communities that occur in the region are the highly productive giant kelp forests (*Macrocystis pyrifera*), especially the Point Loma and La Jolla Kelp Forests, which provide food and shelter for many species of marine fishes and invertebrates and attract thousands of recreational divers and fishermen each year. These kelp forests are the largest forests on the west coast of the United States and are the most important fishing grounds for the commercial red sea urchin (*Strongylocentrotus franciscanus*) and spiny lobster (*Panuliris interruptus*) fisheries in all of California. Consequently, it is critically important to identify and monitor the effects of human disturbance on these characteristic marine communities to support their management against a backdrop of continually varying environmental conditions.

Primary human impacts to San Diego's coastal waters and ecosystems include (1) treated wastewater discharge through two open ocean outfalls, (2) accidental discharges of untreated waters, (3) nonpoint discharges including sediments and associated contaminants via storm drains and surface runoff from local watersheds, and (4) the transport and disposal of contaminated sediments originating from other sources (e.g., dredging from San Diego Bay). All of these impacts have had deleterious effects on kelp forest communities throughout the world, especially near heavily urbanized areas. Off San Diego County, most of those impacts occurred prior to the adoption and implementation of strategies termed 'best practices' for wastewater and stormwater discharge management that began more than three decades ago. Prior to the 1960's, San Diego municipal wastewater entered San Diego Bay and the open ocean through a diffuse system of small outfalls. This practice ceased when the Point Loma Ocean Outfall (PLOO) was completed in 1963 and began to discharge treated wastewater through a modern diffuser system designed to achieve rapid dilution thus limiting the impacts of sewage discharge on coastal marine life and public health. Presently the PLOO outfall extends well past the giant kelp forest off Pt. Loma and discharges advanced primary treated wastewater ~7.3 km offshore in waters ~100 meters deep. The South Bay Ocean Outfall passes near the Imperial Beach kelp forest and discharges secondarily treated effluent ~5.6 km offshore of Imperial Beach at a depth of ~30 meters.

Surface runoff originates from several watersheds that are affected by human land use, including agriculture, heavy industry, and general urbanization. Outflows of contaminated waters from such sources as the Tijuana River, San Diego Bay, Mission Bay, the North County lagoons, and the northern transport of contaminants along the coast originating from south of the USA-Mexico border may also impact local water quality and kelp forest conditions. Human disturbances of our coastal environment also interact with a highly dynamic ocean climate that varies on time scales from seasons, to years to decades. Therefore, understanding natural climatic patterns and regime shifts is a critical component to consider when monitoring kelp forest stability and health.

The City of San Diego, as part of its enhanced ocean monitoring objectives for the San Diego coastal region, has contracted with the Scripps Institution of Oceanography to monitor the status and trends of kelp forests off San Diego from below the southern tip of Point Loma to North County (see Figure 1). This represents continuation of more than 35 years of research and monitoring of kelp forests off San Diego. This report is an annual update of the work accomplished and a summary of kelp forest status and trends off San Diego for the period spanning the winter of 2015 and the early winter of 2016.

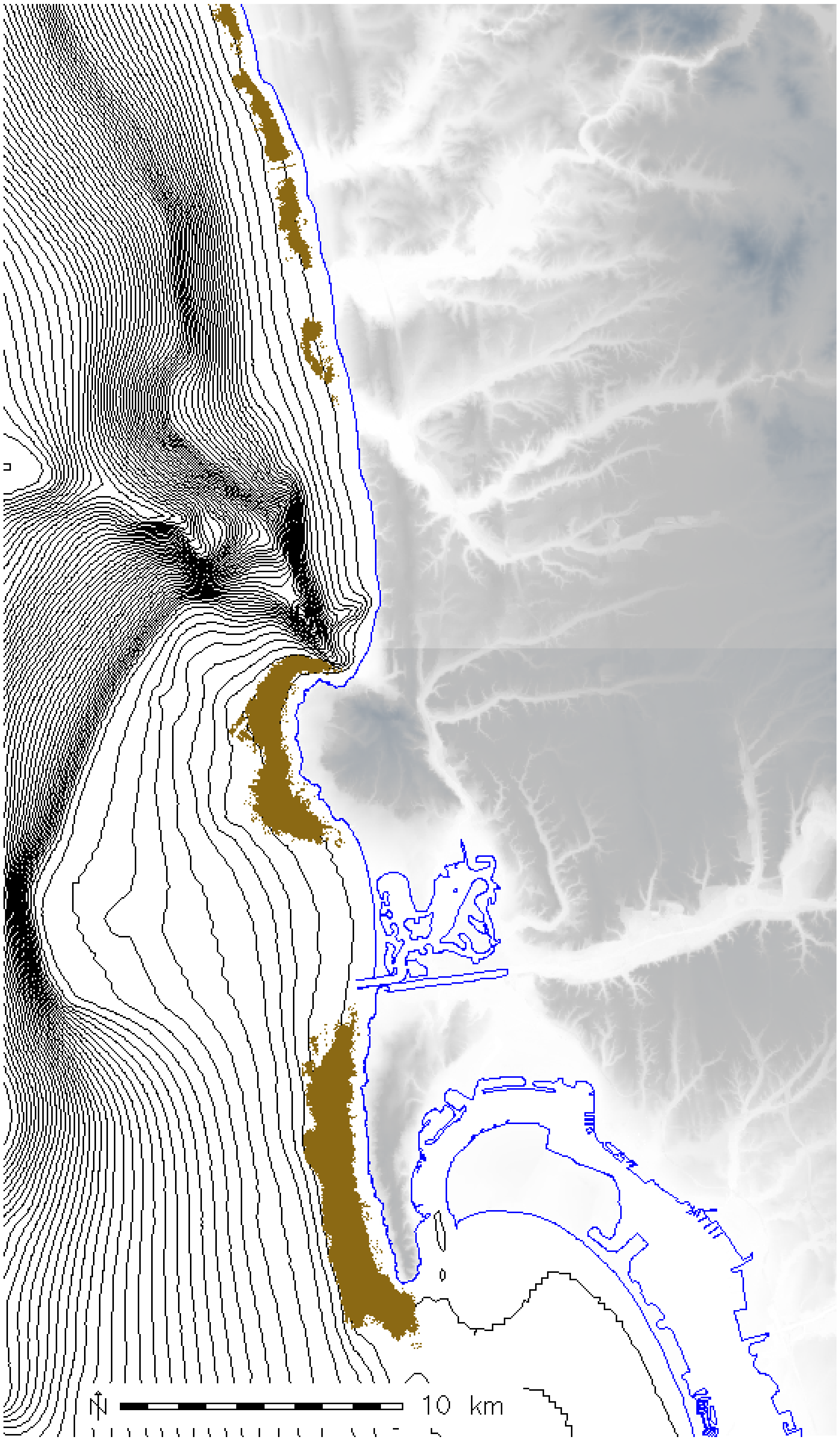

Figure 1. Map of the kelp forests of San Diego County from Cardiff to San Diego Bay. Kelp forest locations are indicated by golden areas and include the North County, La Jolla, and Pt. Loma kelp forests (from north to south). Depth contours are shown at 10m intervals beginning at 10m depth, and the coastline is indicated by blue.

The main components of the kelp forest ecosystem monitoring program include seasonal assessments of density, reproductive condition, recruitment and mortality of the three dominant kelp species. These species include the giant kelp *Macrocystis pyrifera,* which is the most important habitat-structuring species in the region, and the two most conspicuous understory kelps *Pterygophora californica* and *Laminaria farlowii*. Monitoring is conducted at 21 sites distributed at different depths off Point Loma, La Jolla, Del Mar, Solana Beach, and Cardiff (see Figures 2-4 for locations of study sites in Pt. Loma, La Jolla, and North County, respectively) and includes most of the macroalgal species that occur at these study sites. Several other species, most of which represent the algal turf community, are also monitored at the study sites. Baited camera sites have recently been added within the La Jolla and Pt. Loma kelp forests to follow trends in fish species and abundance over time (see Figure 5 for location of baited camera study sites).

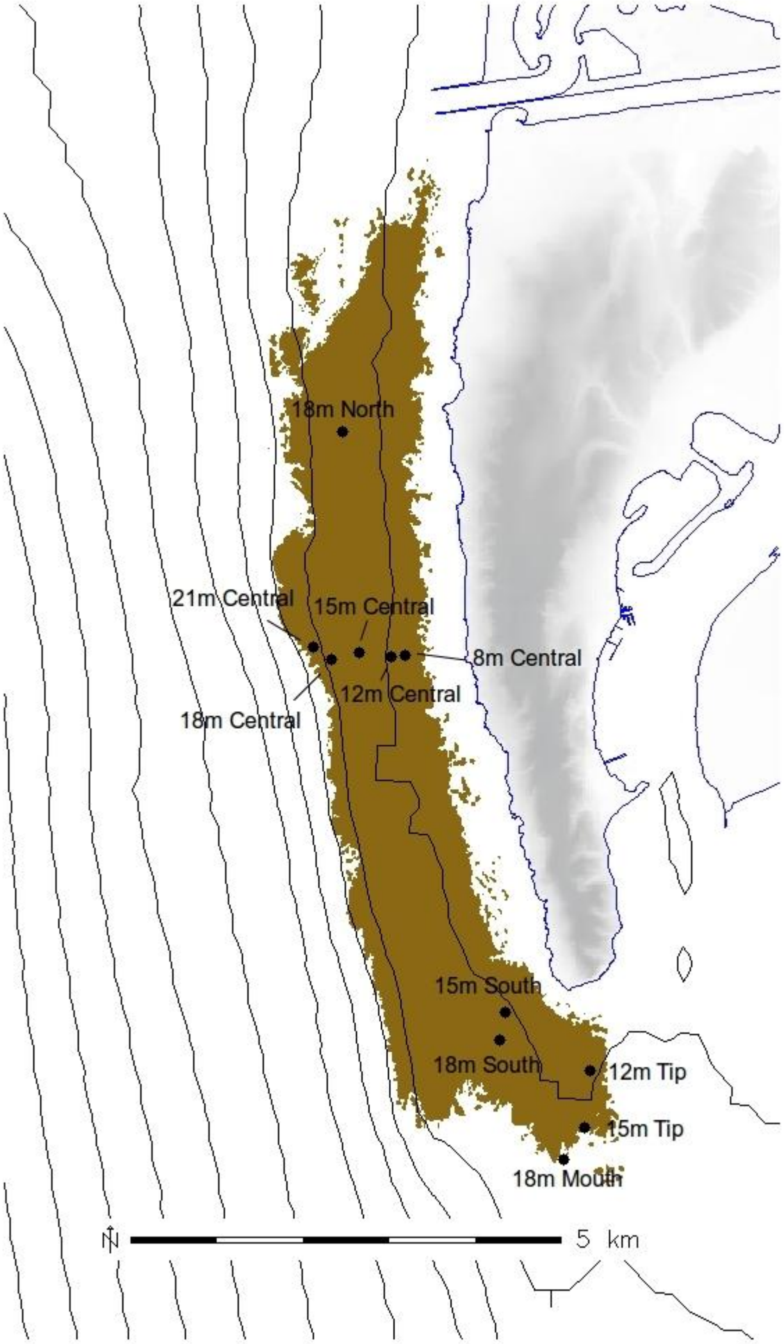

Figure 2. Map of the Pt. Loma kelp forest (golden area) and the locations of study sites (solid circles). Depth contours are indicated in 10m intervals beginning at a depth of 10m.

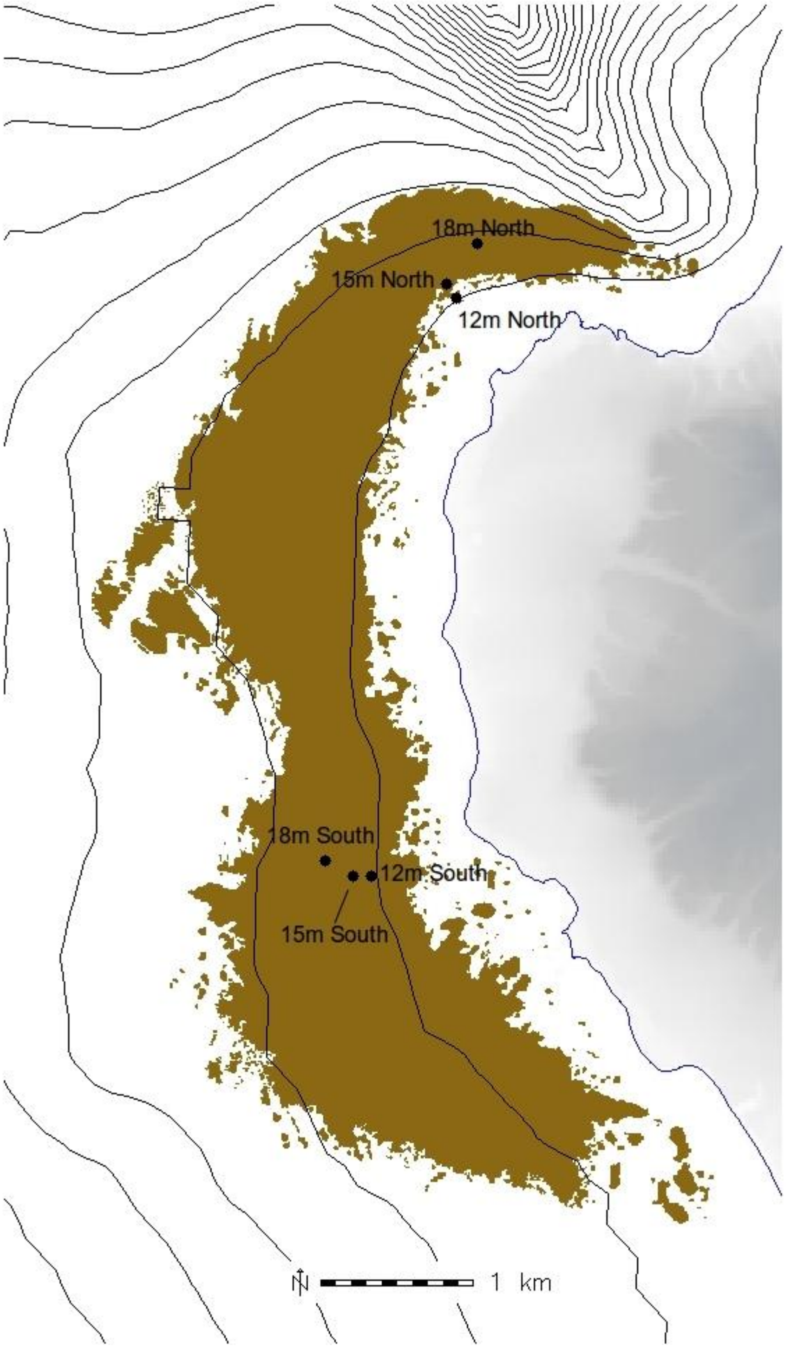

Figure 3. Map of the La Jolla kelp forest (golden area) showing the locations of study sites (solid circles). Depth contours are indicated in 10m intervals beginning at a depth of 10m.

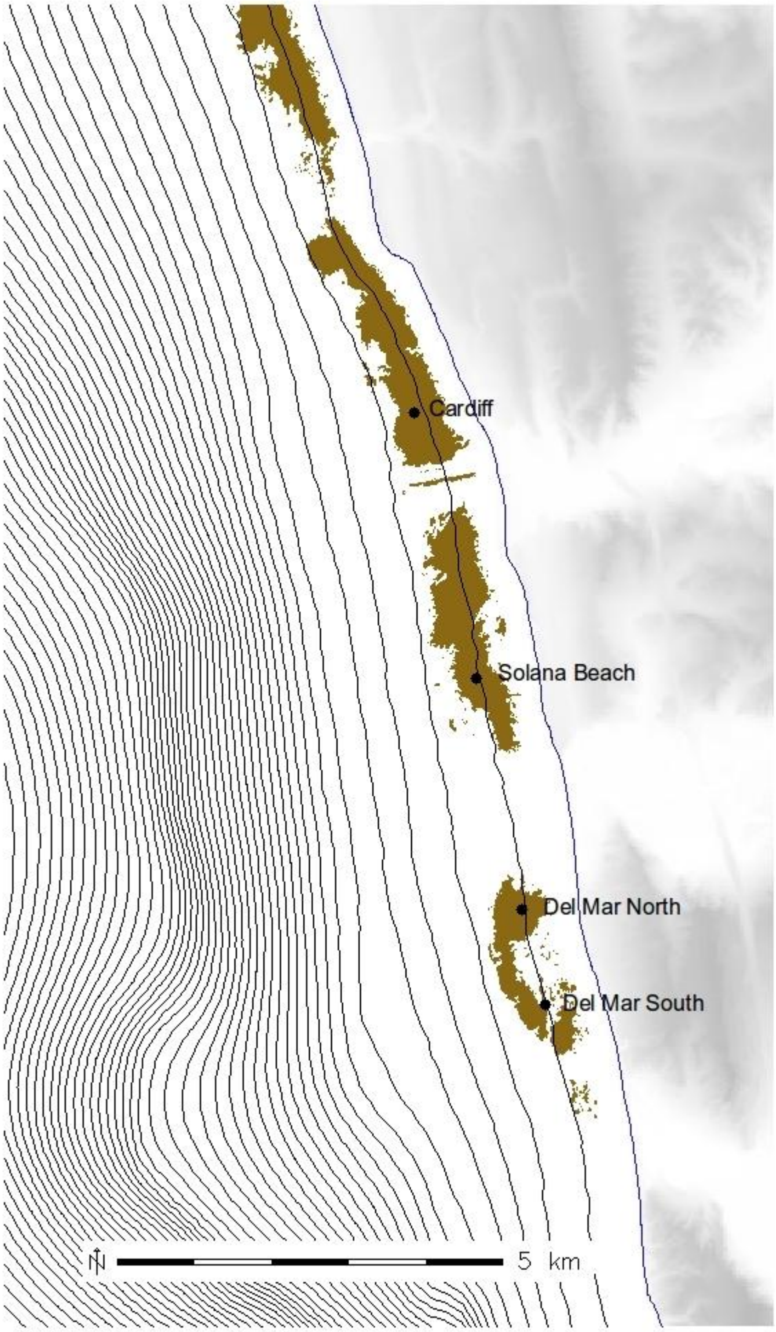

Figure 4. Map of the North County kelp forest (golden area) and locations of permanent study sites (solid circles) including from north to south Cardiff, Solana Beach, Del Mar North and Del Mar South. Depth contours are indicated in 10m intervals beginning at a depth of 10m.

Kelp forest monitoring also includes determining trends in the population sizes of the most important herbivores in the system. These include two species of sea urchins that compete with one another and with abalones for their preferred food, giant kelp (*M. pyrifera*). Red (*Strongylocentrotus franciscanus*) and purple sea urchins (*Strongylocentrotus purpuratus*) are the most important grazers on kelps based on both the frequency and magnitude of their impact. Consequently, these and other invertebrates are counted annually along permanently fixed transect lines (400m² per site). Additional surveys focus on the recruitment rates and activity levels of sea urchins. Sea urchins are collected in 1 m² haphazard quadrats placed in suitable habitat near all of the Point Loma and La Jolla study sites. These two different types of data, estimates of recruitment and local density, allow us to evaluate the relative impacts of sea urchin migration and recruitment of new individuals on kelp stands. We also monitor for evidence of sea urchin disease that can lead to mass mortality events. These events could release large areas of the kelp forest from grazing pressure, resulting in the redevelopment of *M. pyrifera* surface canopy.

Ocean climate is a critical factor affecting kelp forests because giant kelp is limited by the supply of dissolved nitrogen along the southern California coastline. Nitrogen availability is inversely related to ocean temperature. The concentration of bioavailable forms of nitrogen become severely limiting for giant kelp reproduction and growth at temperatures greater than ~15˚ to 16˚C. Therefore, the monitoring program also includes comprehensive measurements of bottom water temperatures at all kelp monitoring sites. Nitrate, the principal species of dissolved inorganic nitrogen that is utilized by kelps, is essentially absent in waters greater than 15˚C. Consequently, extended periods of elevated nearshore ocean temperatures result in severe kelp nutrient stress. The most recent data indicate that the trend in bottom temperatures across the central Pt. Loma shelf were at or near the greatest observed on record for the entire time series, which extends to 1984 (see Fig. 5), indicating that kelps, particularly *Macrocystis pyrifera* have been nutrient stressed since the fall of 2014. Interestingly, bottom temperatures at the two deeper central Pt. Loma stations (depths = 21 and 33 m) have cooled somewhat indicating that El Niño conditions off San Diego are beginning to dissipate as of winter 2016.

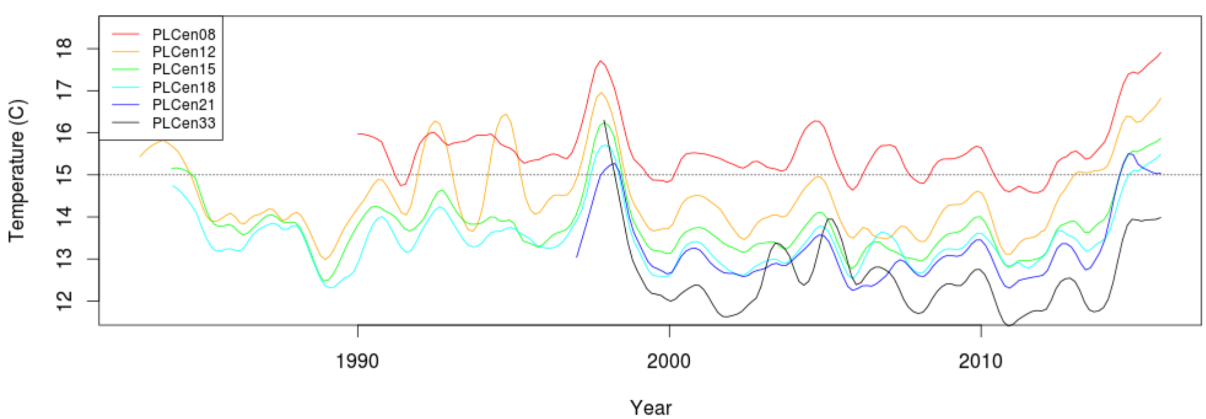

Figure 5. Time series of bottom temperature trend at five study sites off central Pt. Loma. The 15ºC nitrate threshold for giant kelp growth is indicated by the dotted horizontal line. The previous largest El Nino on record during this time series occurred in 1997 but the recent NE Pacific warming ("The Blob") coupled with the El Nino of 2015/16 has surpassed the 1997 event in both magnitude and duration.

Kelp loss can also occur due to mechanical distress from the movement of sand within low bottom-relief areas such as North County. In areas such as these, natural sand migration and artificial beach replenishment can lead to kelp losses as sand is naturally transported offshore towards the kelp forests. This can result in significant kelp mortality and prevent kelp regrowth for extended periods of time. Sediment levels near all North County study sites are monitored for this reason.

Winter storms represent another significant source of stress for giant kelp forests. Winter storm tracks in the NE Pacific typically shift southward during El Niño events, and this past winter has been no exception. Six storm events during the winter of 2015/2016 generated swell whose significant height (defined as the arithmetic averages of height and period of the highest 1/3rd of the observed waves) was greater than three meters. Waves greater than three meters cause significant giant kelp mortality by ripping up entire plants and stranding them on nearby beaches. The shallowest kelp forests off San Diego, such as those off of North County, are the most vulnerable. Two of the six storms during the winter of 2015/2016 exposed San Diego kelp forests to significant wave heights greater than 4 meters. Waves this large also damage understory kelps by exposing them to extreme wave surge and abrasion by unconsolidated sediments, cobbles, and rocks. Damage to understory kelps was observed at all of our study sites shallower than ~16 meters.

2 Work Accomplished

The following work was conducted during the present reporting period (winter of 2015 to the winter of 2016).

- The growth and reproduction of all macroalgae was monitored monthly at five core sites located along a cross-shore transect off central Pt. Loma (see Fig. 2). The growth rates of *Laminaria farlowii* and *Pterygophora californica* from 2010 to 2015 at the central Pt. Loma study sites are shown in Figures 6 and 7, respectively. The average number of stipes per plant for *Macrocystis pyrifera* (a proxy of growth and standing stock) is shown in Figure 8 for the same sites and period.

- Density, recruitment, and mortality of three of the most ecologically important macroalgae (*Macrocystis pyrifera*, *Pterygophora californica*, and *Laminaria farlowii*) were monitored at all permanent study sites on a quarterly basis (4 seasons - spring 2015, summer 2015, fall 2015, and winter 2016). Densities of adult and recruit (number of prebifurcates, the earliest observable life history stage) *Macrocystis pyrifera* observed at all of the study sites are shown in Figures 9 and 10, respectively. Percent cover of *Laminaria farlowii*, at the central Pt. Loma and all La Jolla sites is shown in Figure 11. Densities of *Pterygophora californica* at the Pt. Loma and La Jolla study sites are shown in Fig. 12. For purposes of comparisons among the La Jolla study sites, the densities of *Macrocystis pyrifera* and *Pterygophora californica* and percent cover of *Laminaria farlowii* are shown in Fig. 13.
- Megafaunal benthic invertebrates were surveyed along the permanent transect lines at all study sites during the spring of 2015. The densities of the purple sea urchin, *Strongylocentrotus purpuratus*, the most common sea urchin at our study sites, are shown from 2010-2015 in Figure 14.
- Sea urchin recruitment was assessed in the spring and fall of 2015 at 19 sites. There are too few sea urchins in the North County forests to conduct size frequency sampling. Recruitment rates of the purple and red sea urchins (*Strongylocentrotus purpuratus* and *Strongylocentrotus franciscanus*, respectively) at the central and southern Pt. Loma and La Jolla study sites for the period 2010 to 2014 are shown in Figures 15 and 16.

- Temperature sensors were deployed quarterly on the seafloor at every permanent study site and on moorings located at the 8, 15, 21, and 33 meter sites off Central Pt. Loma.
- Baited fish video cameras were deployed at two sites off La Jolla (one located near the south La Jolla 18 meter site and one near the North La Jollla 18 meter site) and one site off Pt. Loma (near the south Pt. Loma 18 meter site) to monitor trends in sizes and relative abundance of the most common kelp forest finfish species. Video analyses are in progress.
- Sediment levels were monitored at all North County sites during each season: spring 2014, summer 2014, fall 2014, and winter 2015. The time series of sediment levels at the North County study sites is shown in Figure 17 for the period 2010 to 2015.
- All study sites were regularly maintained to assess the locations and conditions of the permanent transect lines, markers and temperature moorings.

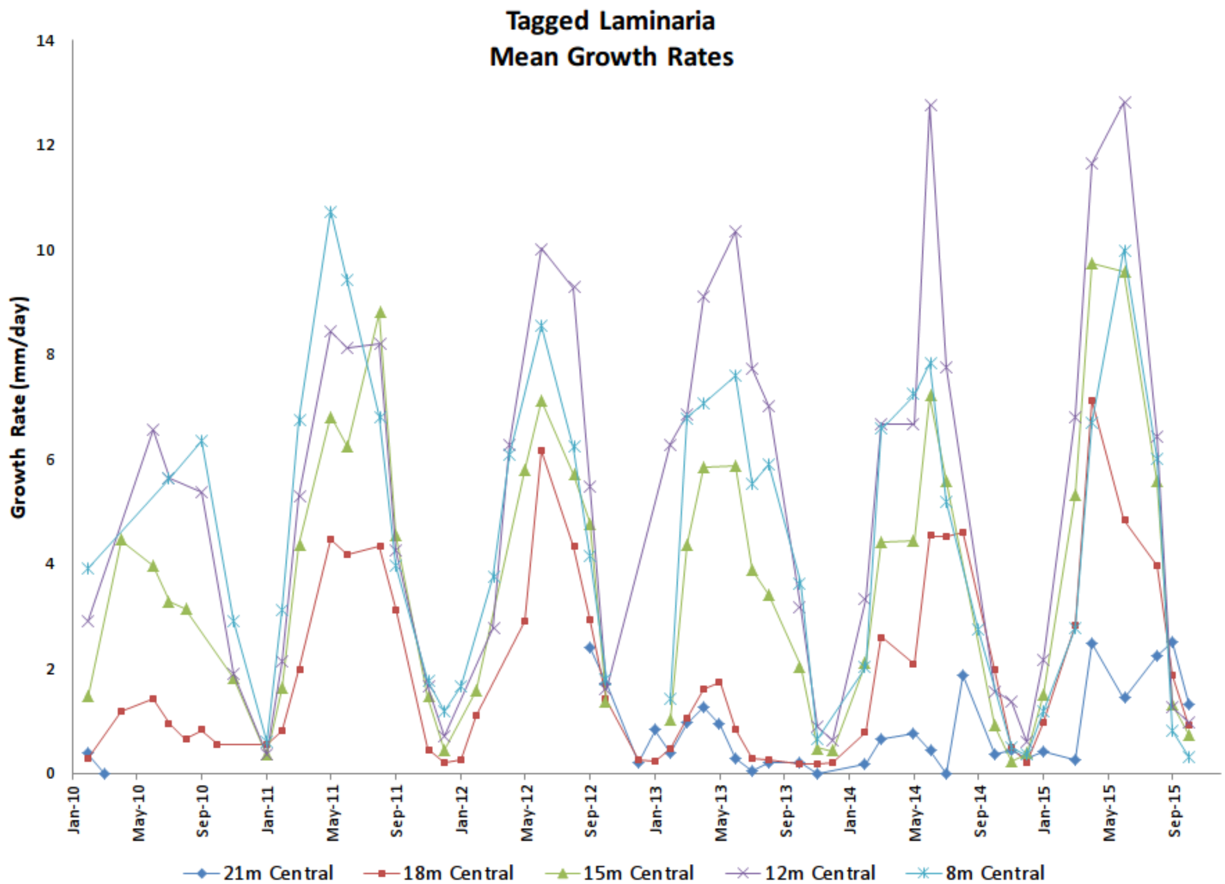

Figure 6. Growth rates of *Laminaria farlowii* at the central Point Loma sites.

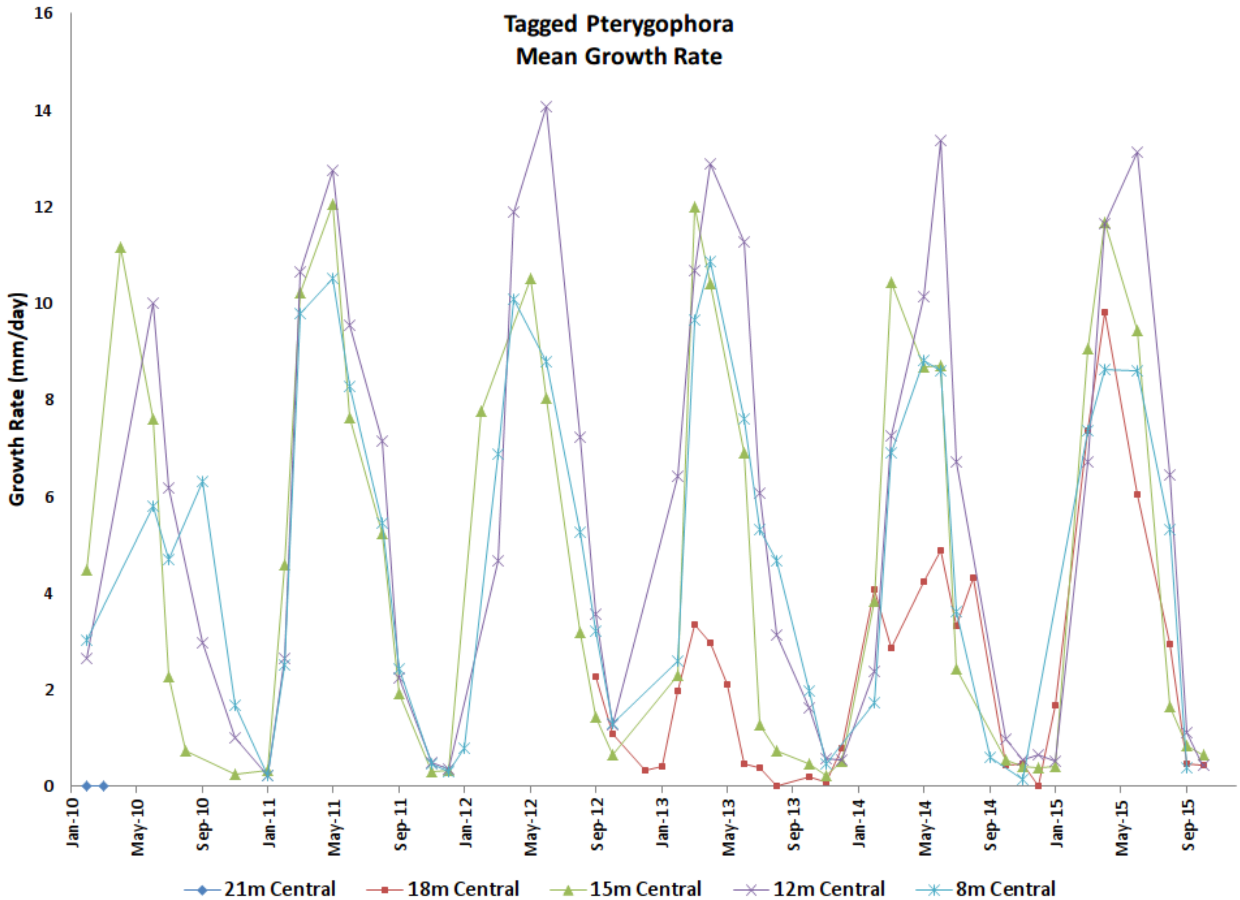

Figure 7. Growth rates of *Pterygophora californica* at the central Point Loma sites.

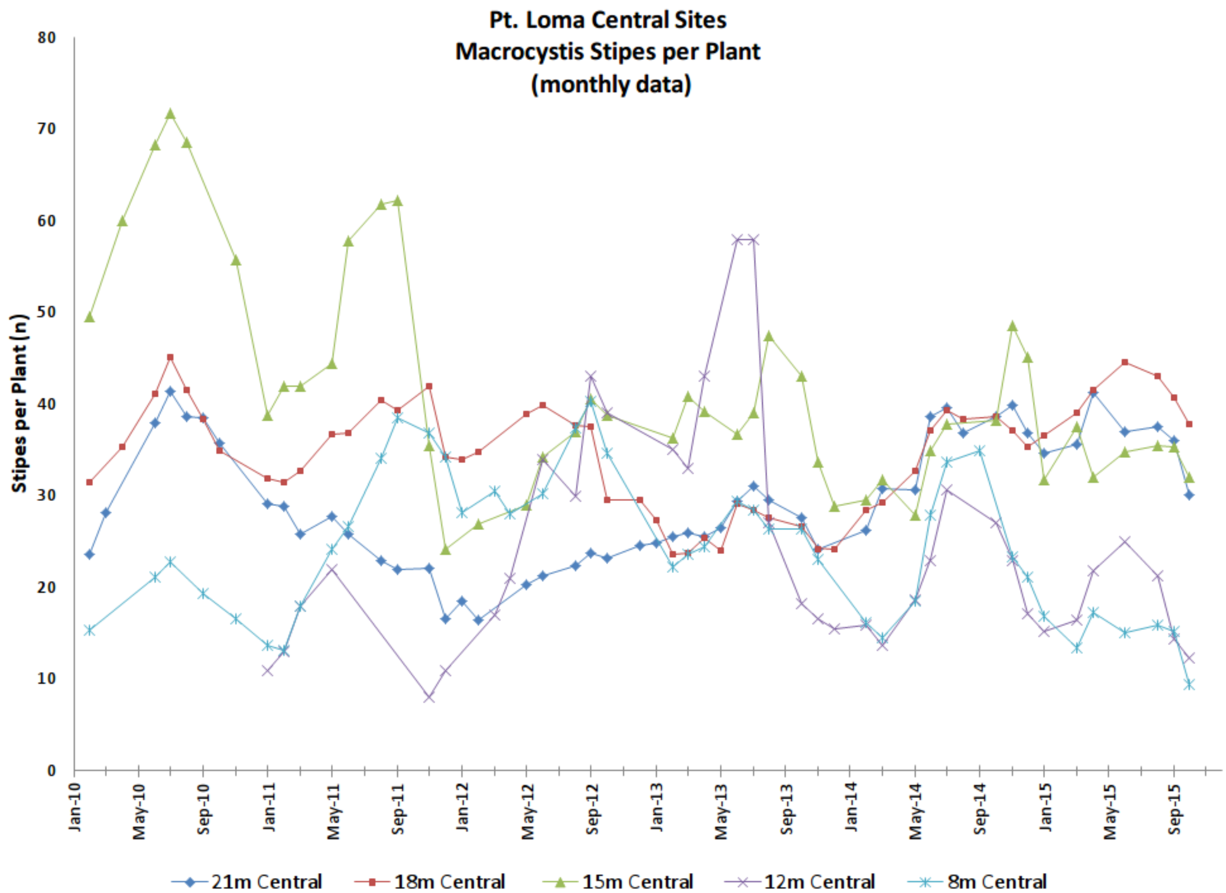

Figure 8. Mean number of stipes per giant kelp plant (*Macrocystis pyrifera*) at the Central Point Loma sites.

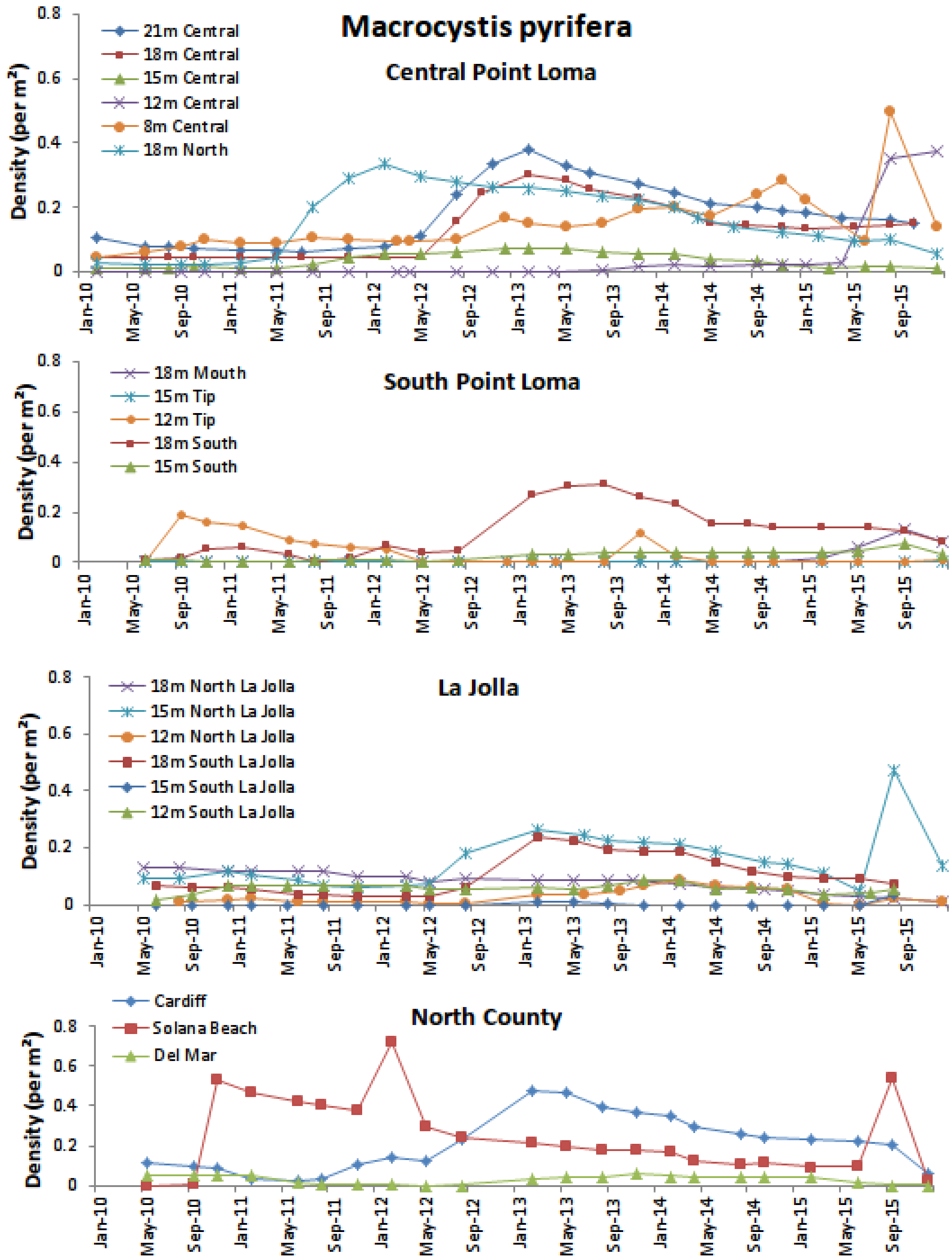
Macrocystis pyrifera
Central Point Loma
21m Central
18m Central
15m Central
12m Central
8m Central
18m North
South Point Loma
18m Mouth
15m Tip
12m Tip
18m South
15m South
La Jolla
18m North La Jolla
15m North La Jolla
12m North La Jolla
18m South La Jolla
15m South La Jolla
12m South La Jolla
North County
Cardiff
Solana Beach
Del Mar
Density (per m²)
0
0.2
0.4
0.6
0.8
Jan-10
May-10
Sep-10
Jan-11
May-11
Sep-11
Jan-12
May-12
Sep-12
Jan-13
May-13
Sep-13
Jan-14
May-14
Sep-14
Jan-15
May-15
Sep-15

Figure 9. Density of *Macrocystis pyrifera* at the central and southern Point Loma sites, and the La Jolla and North County study sites.

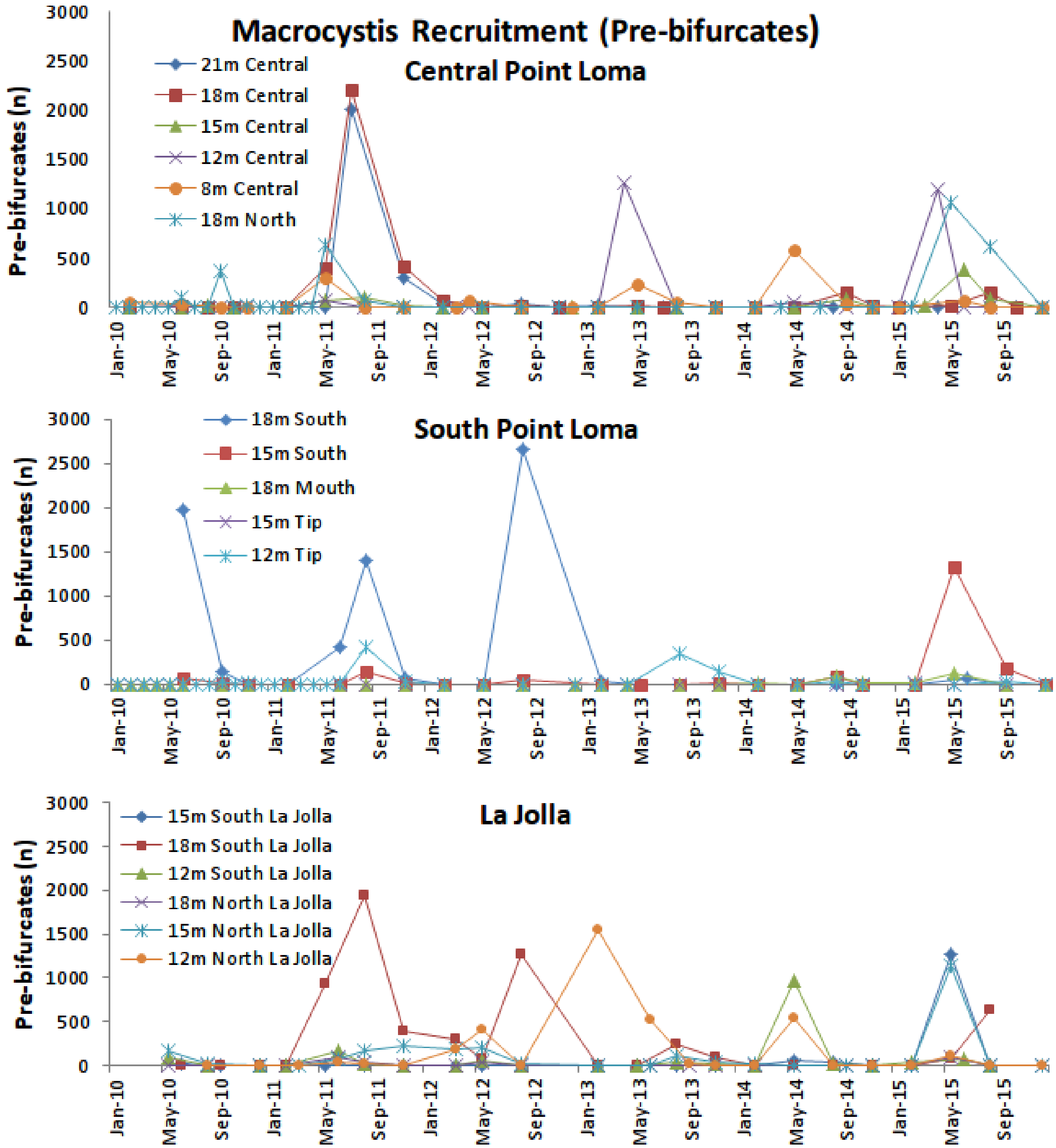

Figure 10. Recruitment of *Macrocystis pyrifera* at the central and southern Point Loma, La Jolla, and North County study sites.

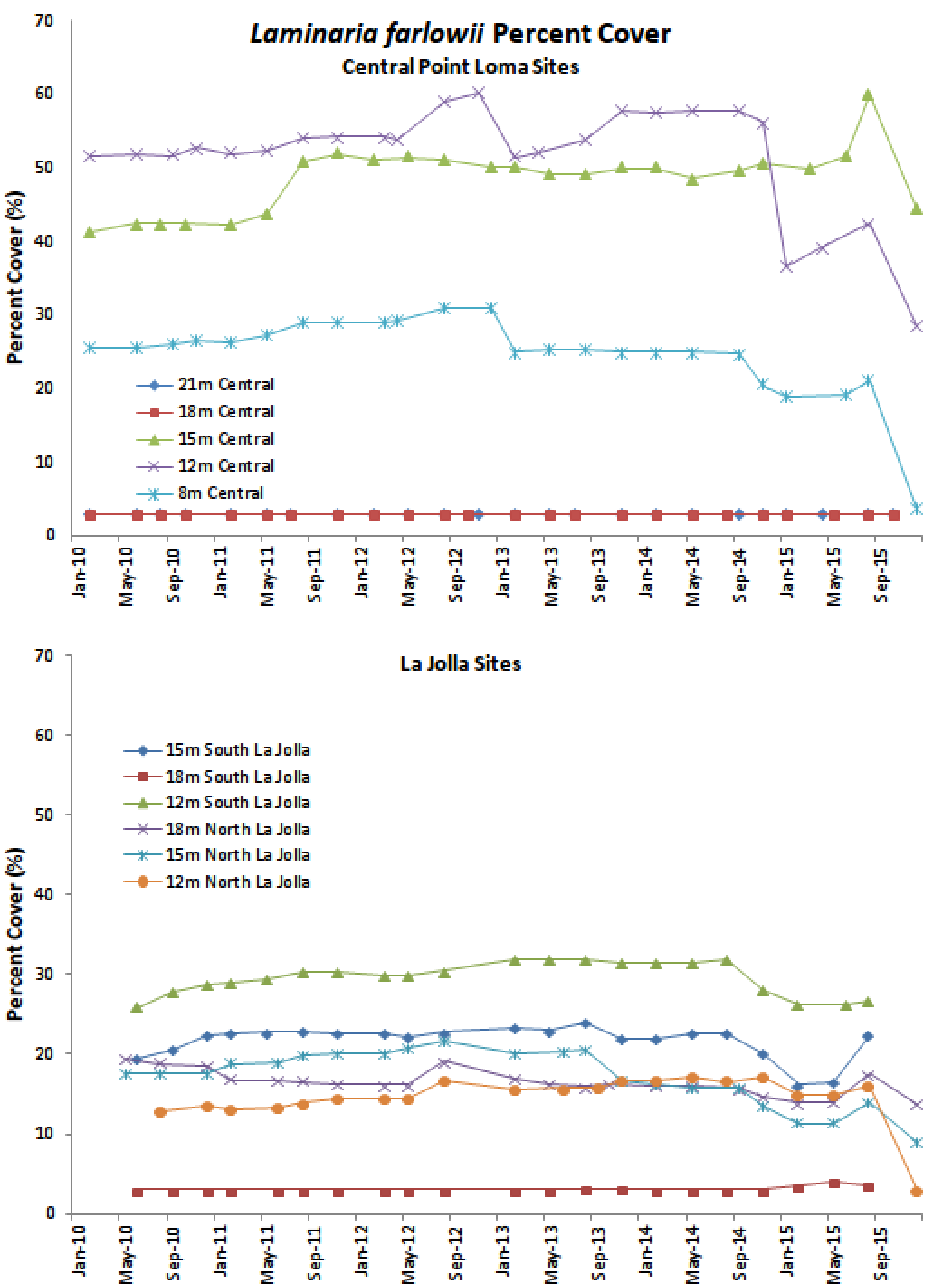

Figure 11. Percent cover of *Laminaria farlowii* at the central Point Loma and La Jolla study sites.

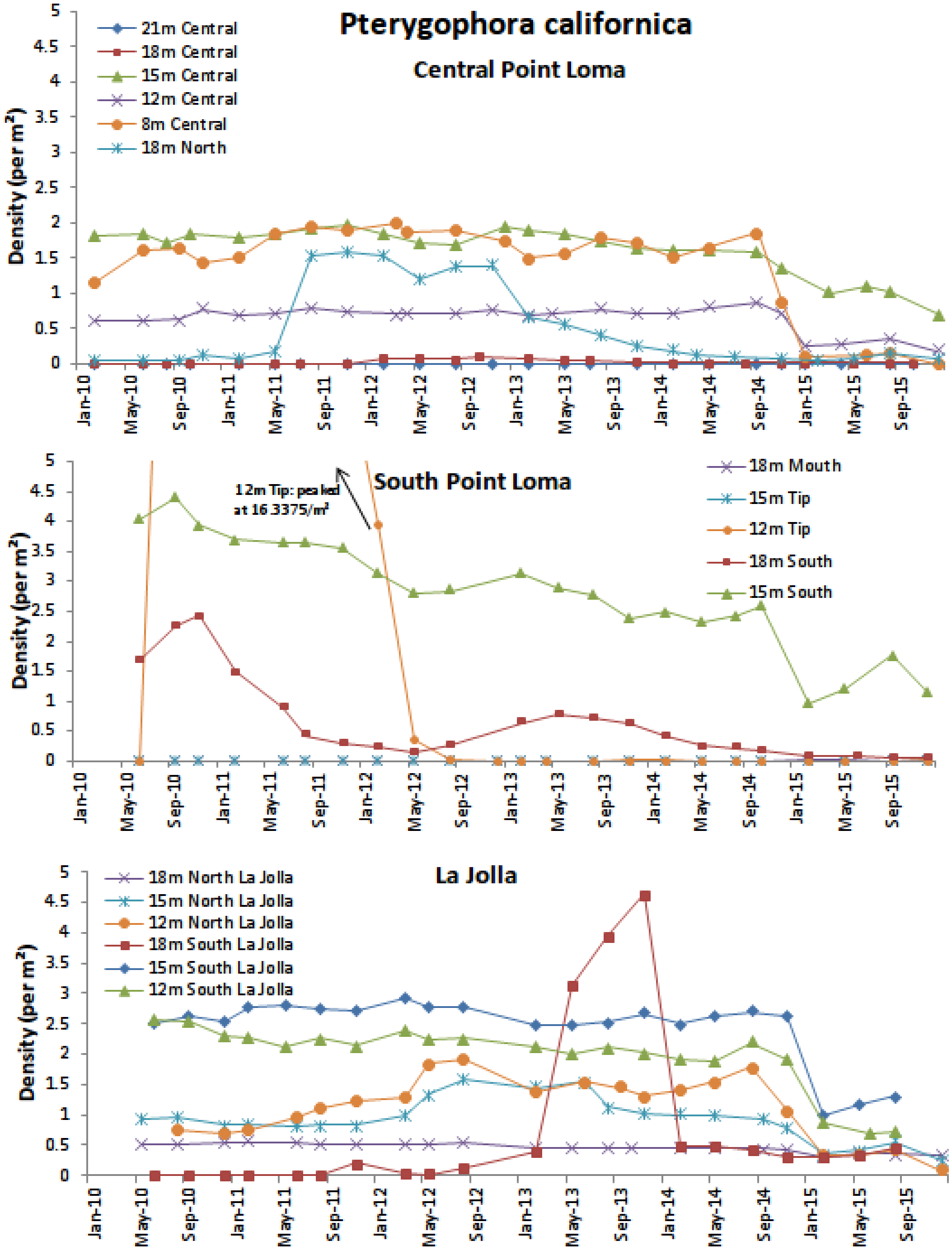

Figure 12. Density of *Pterygophora californica* at the central and southern Point Loma and La Jolla study sites.

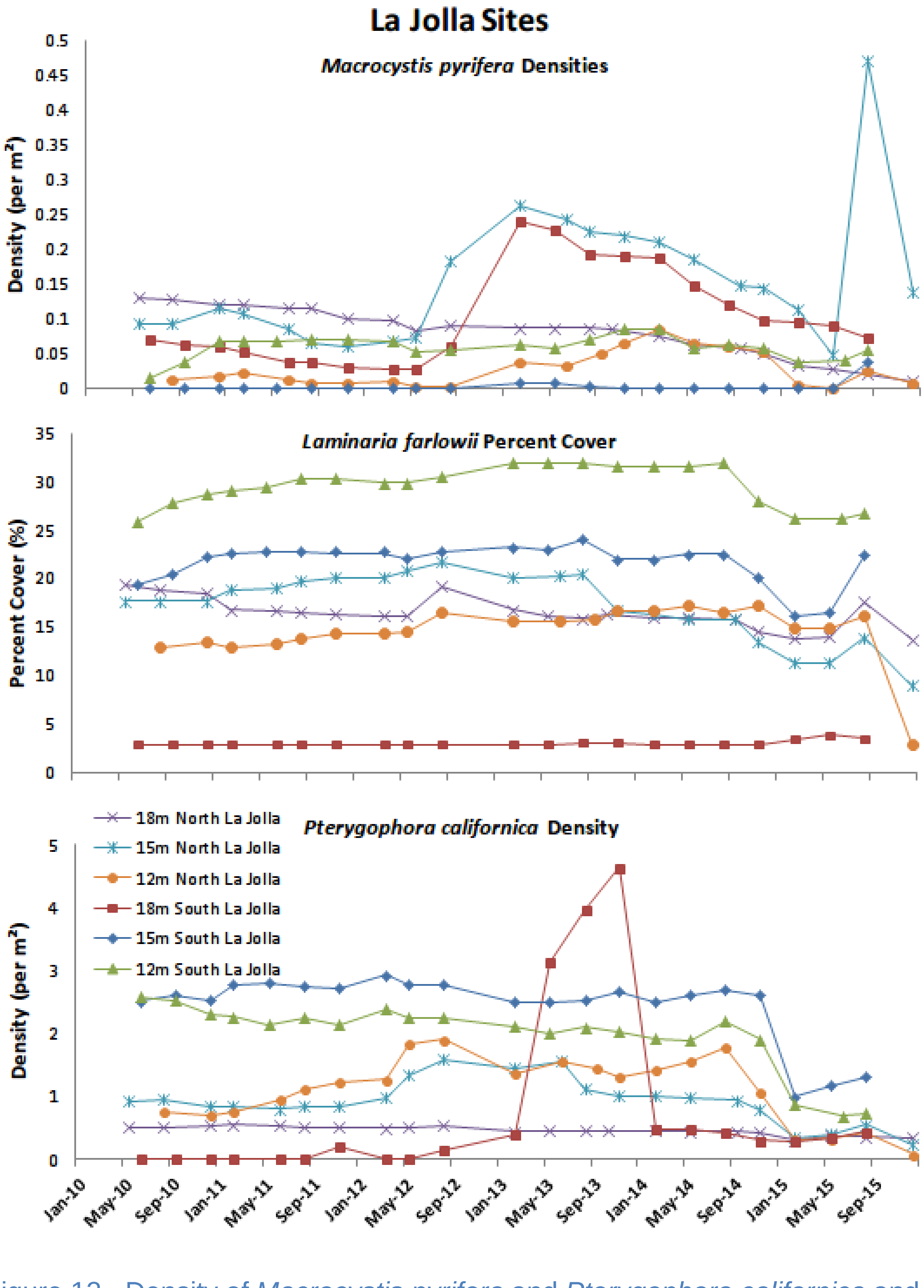

Figure 13. Density of *Macrocystis pyrifera* and *Pterygophora californica* and percent cover of *Laminaria farlowii* at the La Jolla kelp forest study sites.

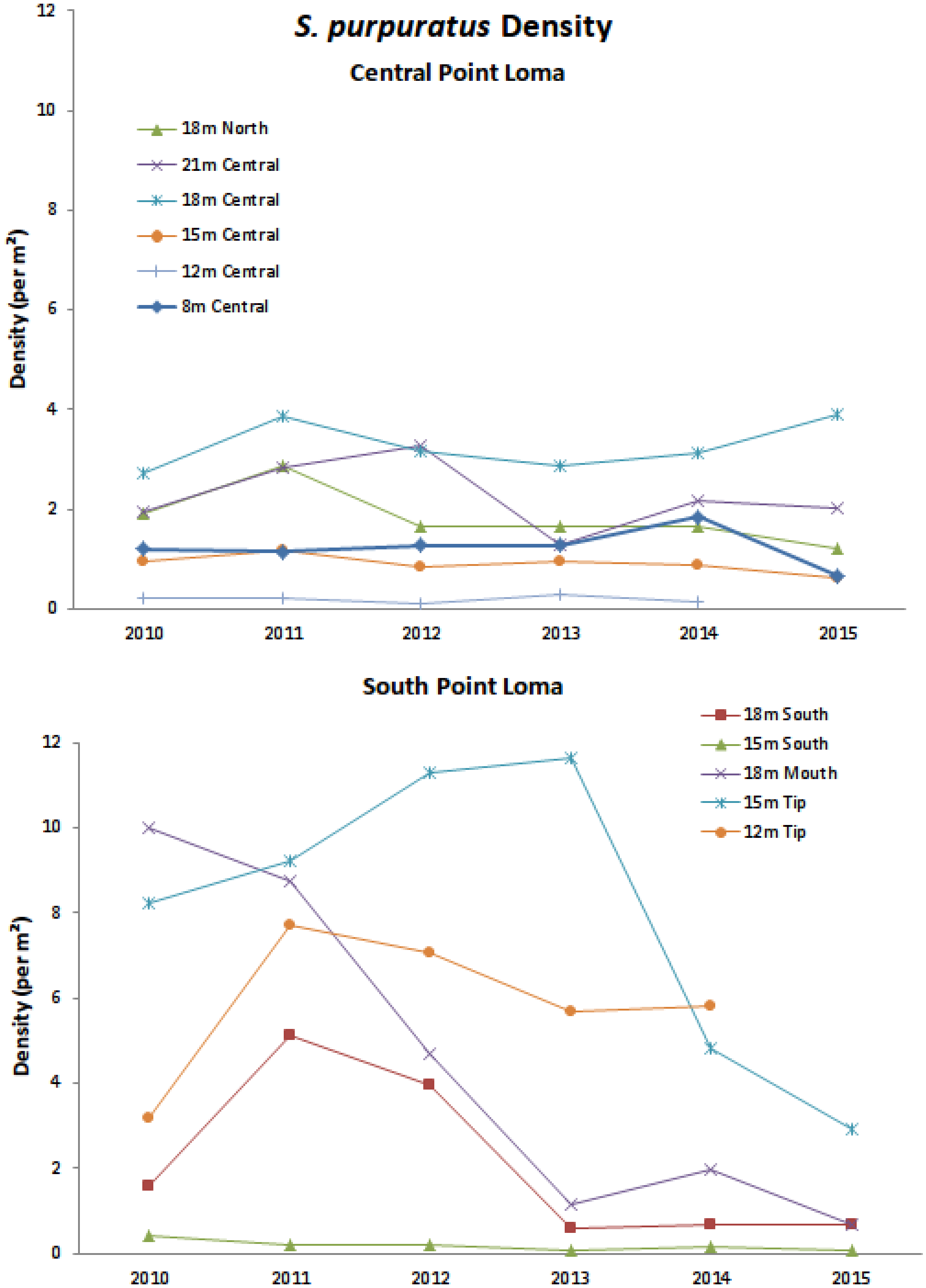

Figure 14. Densities of the purple sea urchin, *Strongylocentrotus purpuratus*, at the central and southern Point Loma study sites. Data for 2015 is presently being collected this spring.

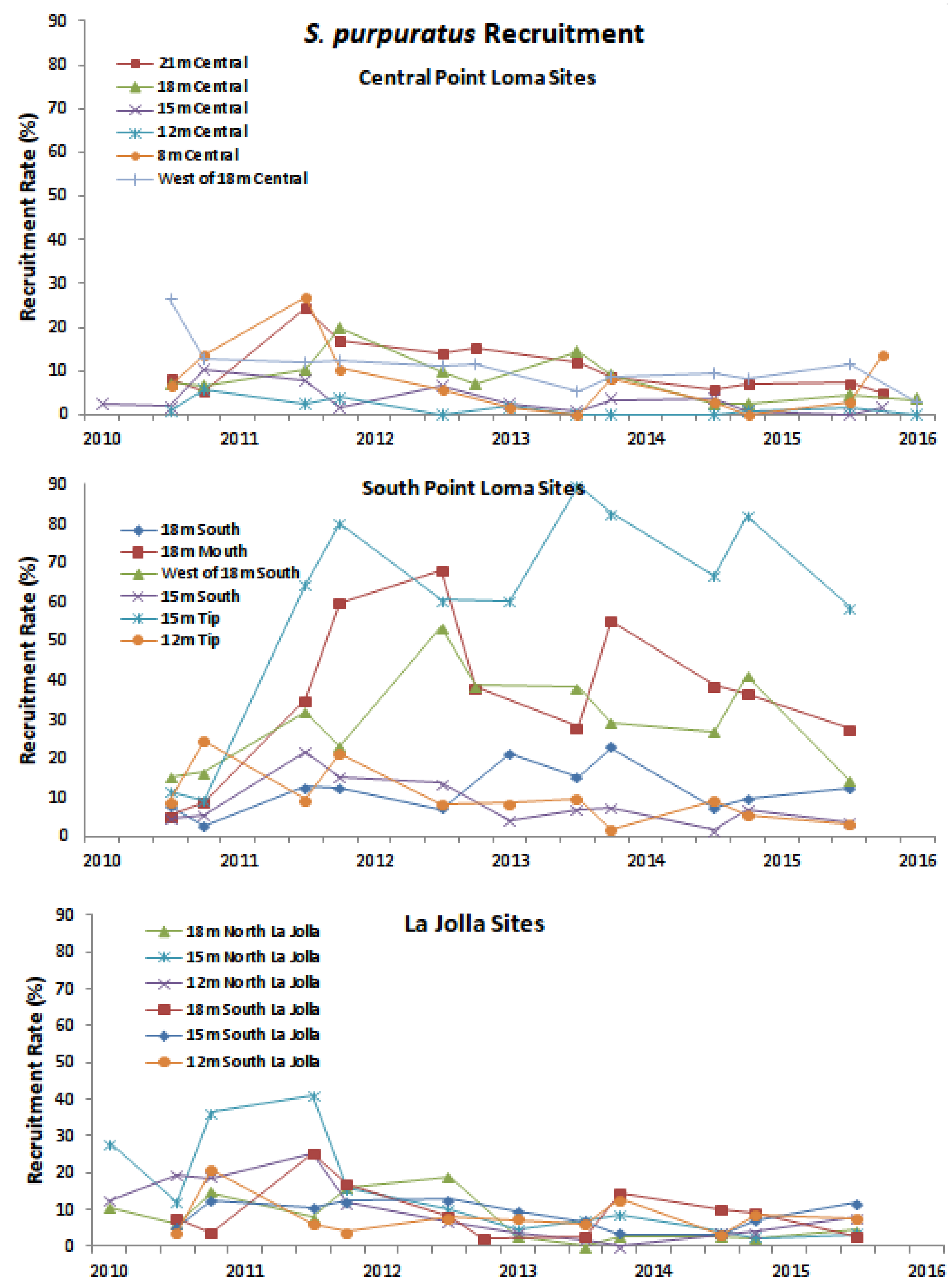

Figure 15. Recruitment rates of the purple sea urchin, *Strongylocentrotus purpuratus*, at the central and southern Point Loma and La Jolla study sites.

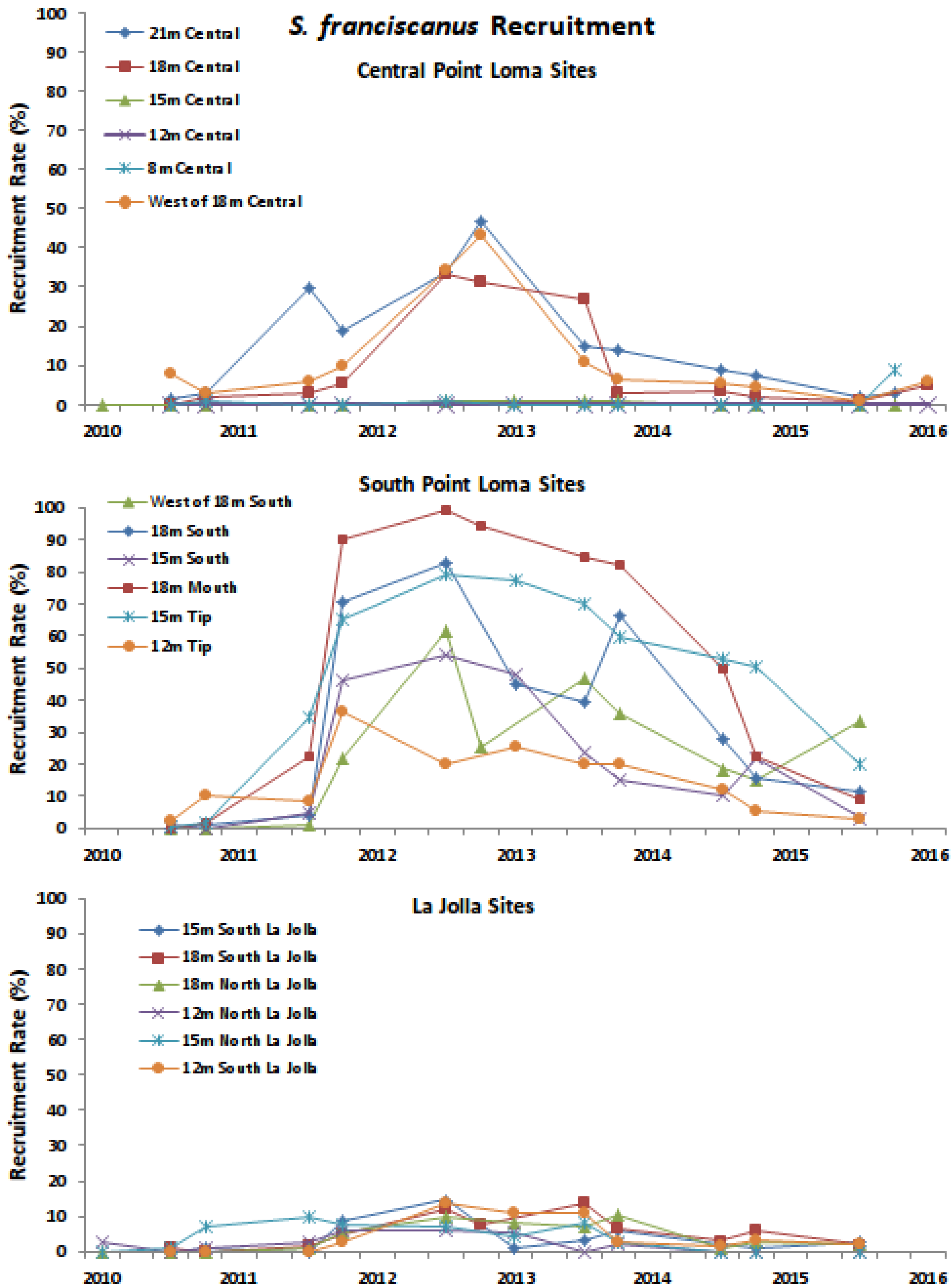

Figure 16. Recruitment rates of the red sea urchin, *Strongylocentrotus franciscanus*, at the central and southern Point Loma and La Jolla study sites.

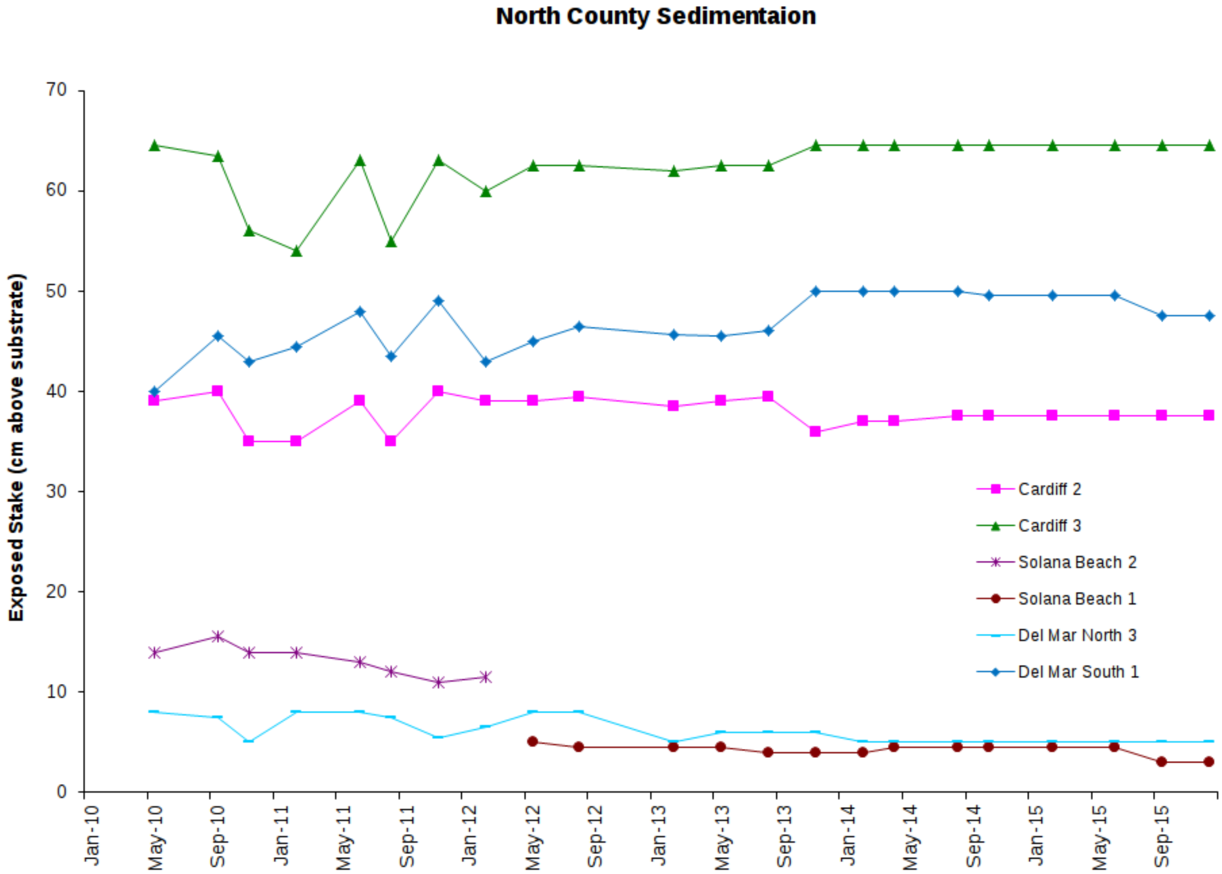

Figure 17. Time series of relative sediment heights for the North County study sites (2010-2015). Decreases in exposed stake height (ordinate axis) indicate increased sediment levels.

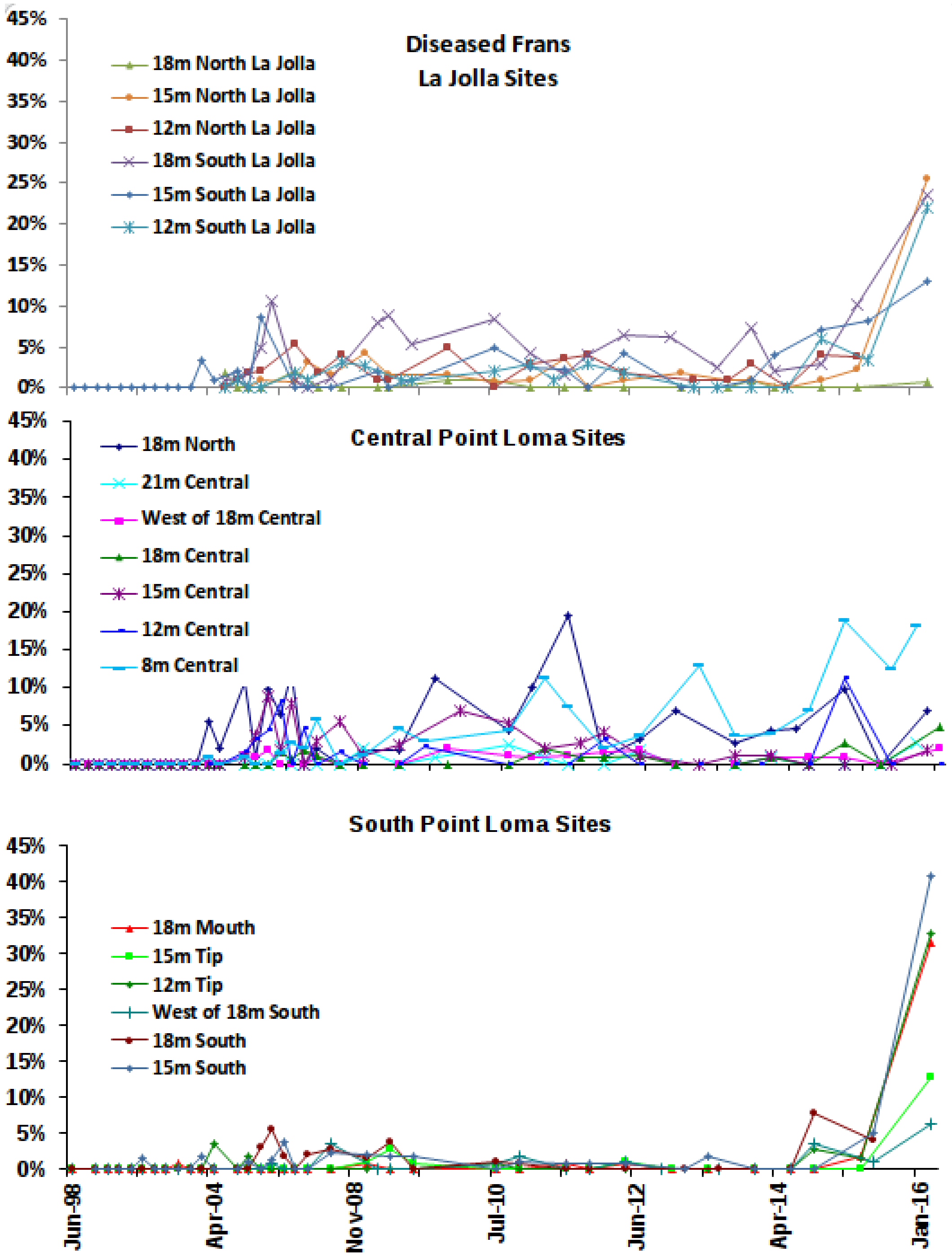

Figure 18. Time series of the percentage of diseased red sea urchins (*S. franciscanus*) observed during size frequency sampling.

3 Current Status of the Kelp Ecosystem off San Diego County

The kelp forests off San Diego are greatly impacted by warm water El Niño events. The most recent large El Niño on record appears as the large warming event that occurred in 1997 (see Fig. 5). That El Niño event caused the virtual disappearance of kelp canopy throughout San Diego County due to a combination of prolonged depleted nutrient conditions and repeated large storm swell. Ocean climate conditions in the intervening period have been generally conducive for giant kelp growth and reproduction until just recently. Bottom temperatures during the fall of 2014 and the beginning of winter 2015 were anonymously warm, warming to the highest temperatures observed in the entire time series dating back to 1984. This more recent warming was not associated with El Niño, but rather large scale changes in wind patterns across the NE Pacific in which winds have been weaker than their climatic averages. This weakening led to decreased mixing of surface waters downward resulting in increased near-surface temperatures. This large warm pool of water has been coined ‘the Blob’. Southward advection of ‘the Blob’ and entrainment into the California Current System (CCS) brought anonymously warm waters to the shelf margin of southern Caifornia. Presently, ‘the Blob’ appears to be weakening but has been followed by the onset of the strongest El Niño on record since the 1982/1983 El Niño. Unlike the warm water associated nutrient stress associated with ‘the Blob’, the current El Niño, which is predicted to dissipate late this spring, has been associated with six large winter storm events. Therefore, the kelp forests of San Diego County have been nutrient stressed since the fall of 2014 and have been subjected to strong wave disturbances this past winter (2015/2016) that have resulted in giant kelp losses in the kelp forests off San Diego.

Several bouts of giant kelp recruitment, maturation, and reproduction have occurred since the 1997 El Nino (Fig. 10) at most of the sites. This has contributed to the growth of several new cohorts of *Macrocystis pyrifera* off San Diego County, many of which have continued to survive through the previous reporting period (winter 2015). However, densities of giant kelp gradually decreased at all sites during this intervening period, with the exception of the two shallow central Point Loma sites (8 and 12 meter sites), where giant kelp has been mainly absent due to the high densities of competing understory kelps and turf algae. Giant kelp densities at all study sites except Pt. Loma central 12m have decreased significantly during this reporting period due to the warm water and wave disturbances. The spring 2015 giant kelp recruitment cohort observed at most stations has not survived either. The understory kelps, *Laminaria farlowii* and *Pterygophora californica* (Figs. 11 and 12) have also declined during this period at all study sites, and in some cases, exhibit the lowest densities observed since 2010. A synopsis of the declines for both understory kelps and giant kelp off La Jolla is presented in Fig. 13 where the slow decline in giant kelp can be seen as the densities and percent cover of the understory kelps increased through canopy competitive exclusion and how both canopies have declined beginning in 2015 with the persistent warm water stress.

Red and purple sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus*) experienced decreased recruitment rates (Figs. 15 and 16) and severe disease (Fig. 18) and mortality in the latter half of 2015. This is common during periods of warm water stress and is likely due to a combination of food limitation (lack of drift algae) stress and warm temperatures which increase bacterial growth rates. The loss of sea urchins has been so severe in some areas including central Pt. Loma where there are very few red sea urchins left. As of February 2016, there were no red sea urchins at the 8 m and 12 m sites off central Pt. Loma, and only a few dozen purple sea urchins were available for size frequency measurements. The level of disease over the past year has exceeded all of our personal observational time scales which range as early as the 1980's. This sea urchin mortality should bode well for the kelps as the current El Niño dissipates and with the onset of a La Niña (characterized by cool temperatures, high nutrient conditions, and good kelp growth conditions) which is predicted to develop in late spring of this year. High levels of giant and understory kelp recruitment and recovery will be likely if the La Niña prediction is accurate.

Recent observations of colonization in several areas within the La Jolla and Pt. Loma kelp forests by the invasive alga, *Sargassum horneri*, may however decrease or inhibit the recovery of kelps this year. This invasive alga from Asia was first spotted in Long Beach Harbor in 2003 and quickly spread to Santa Catalina Island and many estuaries, lagoons, and bays within southern California. *Sargassum horneri* now dominates the kelp forests on the mainland side of Catalina Island and covers large swathes of giant kelp habitat in the Northern Channel Islands near Santa Barbara and Ventura. It was thought the higher energy open coastlines of Orange and San Diego counties would limit its spread, but we have observed it in open coastal waters off San Diego at an accelerated pace in 2015. We have observed it forming short growth (<1m) reproductive patches within or near several or our study sites. These include the 15 m and 18 m sites of central Pt. Loma, both 15-m sites off south Pt. Loma, the 18 m site off North Pt. Loma, the 15 m site off northern La Jolla, and the Solana Beach study site. *S. horneri* has an annual growth and reproductive cycle in which growth occurs during spring when it can recruit and cover the bottom quickly. Therefore, it will likely outcompete giant and understory kelp recovery in several areas off San Diego.

In summary, giant and understory kelps have declined dramatically over the last year due to the persistent warm water conditions from 'the Blob' followed by an intense El Niño associated with six large storm events. At the same time, sea urchin mortality has been high in most areas of the San Diego kelp forests due to the persistent warm water conditions and associated disease. We anticipate rapid recovery and recruitment of kelps off San Diego due to the combination of: (1) the dissipation of the current intense El Nino (2) the continuing gradual dissipation of 'the Blob' followed by (3) the onset of good kelp growth conditions expected with the onset of a La Nina predicted for late spring/early summer, and (4) recently observed sea urchin disease and mortality. However, the unprecedented invasion by the invasive competitive algae, *Sargassum horneri*, in San Diego kelp forests could inhibit or fully exclude kelp recovery in many areas, including our study sites. The kelp forests could be permanently altered by the presence of this invasive seaweed.

4 Baited Fish Camera Surveys

Fish surveys were conducted using baited fish video surveys to develop baselines of fish sizes and abundances within the kelp forests off San Diego. The prime motivation for this aspect of the study was to track changes to fish populations within the La Jolla and Pt. Loma kelp forests as a result of the implementation of no-take marine protected areas that were established in 2012. Recreational and commercial fishing has been intense within the kelp forests of southern California dating back to the turn of the 20th century. As a result, many residential finfish species have been reduced both in terms of size and abundance. For our study, four study sites having similar topographic compositions and depth were established that were stratified by equal numbers of sites within and outside the marine protected areas (Table 1, and Figs. 19 and 20).

Table 1. Table listing dates, sampling bout names used in reporting figures, and the status and locations within marine protected areas. 'SMR' indicates State Marine Reserves which are areas of absolute no-take of any biological resources.

Study Site	Date	Sampling Bout Name	Kelp Forest	MPA Status
SDLJER	9/18/2015	SDLJER	La Jolla	Matlahauyl SMR
Mia's Reef	2/17/2015	MiasReef1	La Jolla	Non-MPA
Mia's Reef	10/9/2015	MiasReef2	La Jolla	Non-MPA
Inside Marbles	2/4/2015	InsideMarbles1	La Jolla	South La Jolla SMR
Inside Marbles	10/9/2015	InsideMarbles2	La Jolla	South La Jolla SMR
Urchin Feed Line	2/7/2015	UrchinFeedLine1	Pt. Loma	Non-MPA
Urchin Feed Line	9/25/2015	UrchinFeedLine2	Pt. Loma	Non-MPA

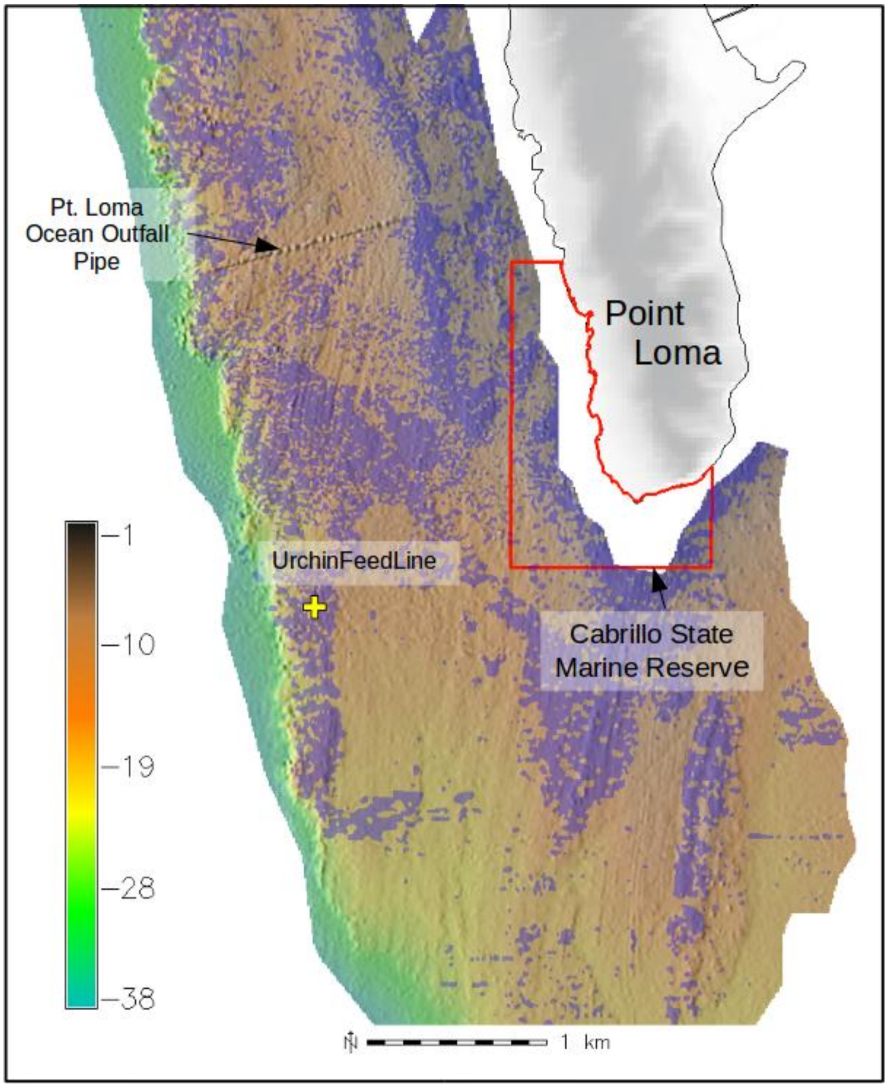

Figure 19. Map of baited fish video study site within the Pt. Loma kelp forest. Locations of the Cabrillo State Marine Reserve and the Pt. Loma Ocean Outfall pipe are also indicated. Kelp coverage is indicated by blue shading and the legend indicates depth color map in meters.

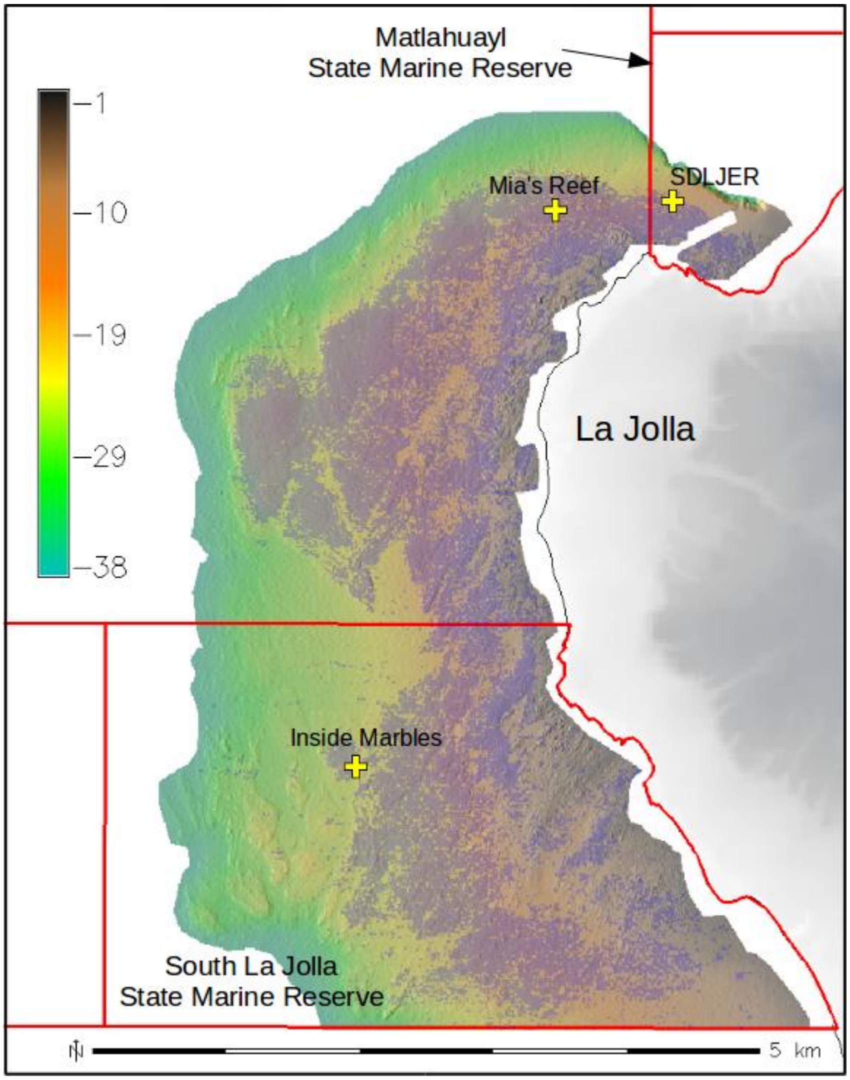

Figure 20. Map of baited fish video study sites within the La Jolla kelp forest. Locations of the South La Jolla and Matlahuayl State Marine Reserves are also shown. Kelp coverage is indicated by blue shading and the legend indicates depth color map in meters.

Preliminary results indicate that the effect of protection is not presently clear, and local conditions such as the nesting of small scale topography within the larger scale seascape, which together importantly define habitat but are difficult to match among study sites in MPA stratified studies, may be more important (see Figs. 21-30) than protection. The most important recreationally fished species include the California Sheephead (*Semicossyphus pulcher*), kelp bass (*Paralabrax clathratus*), barred sand bass (*Paralabrax nebulifer*), and rockfish in the genus *Sebastes* spp. (see Table 2 for a full list of species observed). The greatest effect of protection was observed for California sheephead (Figs. 23 and 24) which were observed in marginally higher numbers inside the Matlahyual and the South La Jolla State Marine Reserves. However, the effects of protection on fish sizes were not evident. In fact, size distributions were larger outside protected areas than inside (Figs. 26-30). Species richness (number of species observed) was greater inside the MPA's than outside (Table 2). These baseline data will serve as a good comparison for the trajectories of fish sizes and abundance through time as fishing pressure will likely continue to increase outside the MPA's. It should also be noted here that the lack of a clear protection effect may be due to poaching which is observed during all of our visits to the various study sites off La Jolla.

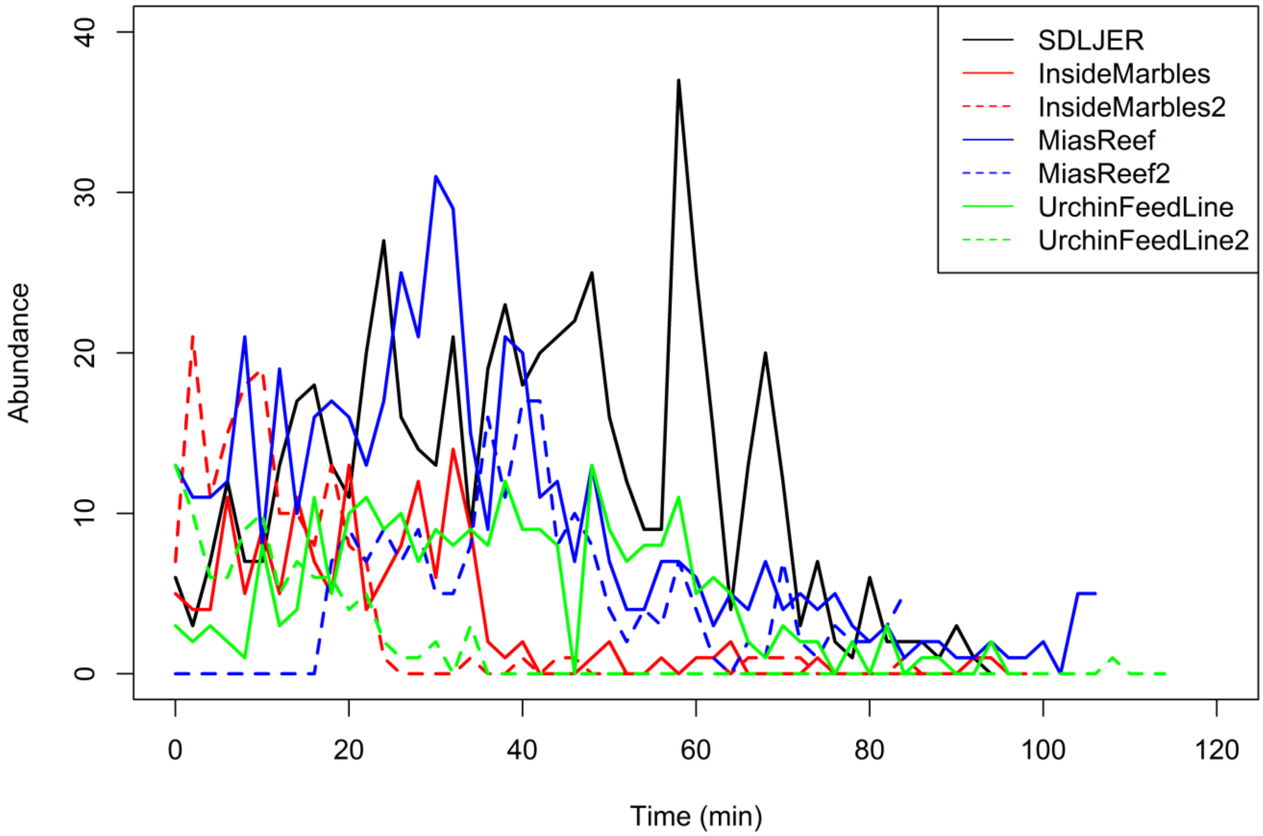

Figure 21. Observed abundance of Kelp Bass (*Paralabrax clathratus*) as a function of time (in minutes) since bait introduction. Line types and colors (see legend) indicate baited underwater video (BUV) deployment and location.

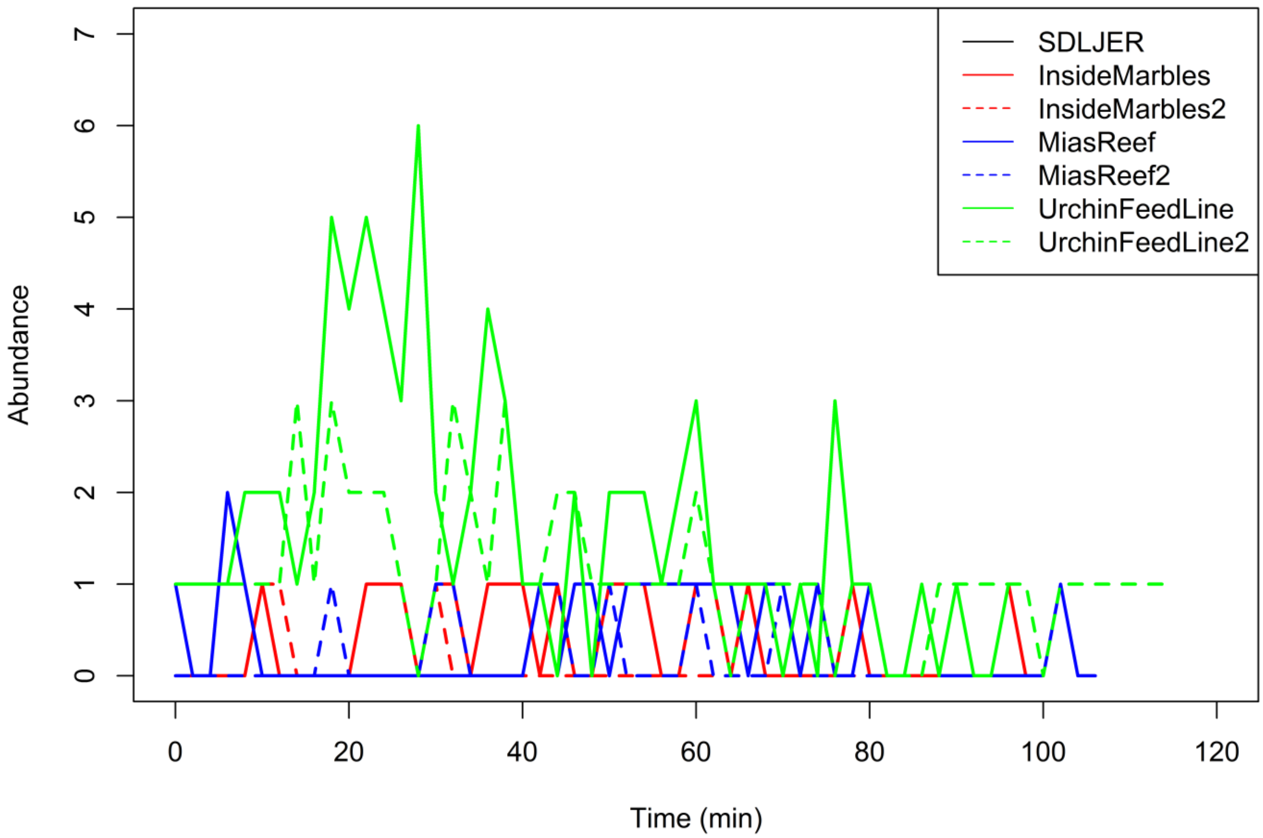

Figure 22. Observed abundance of Barred Sand Bass (*Paralabrax nebulifer*) as a function of time (in minutes) since bait introduction. Line types and colors (see legend) indicate baited underwater video (BUV) deployment and location.

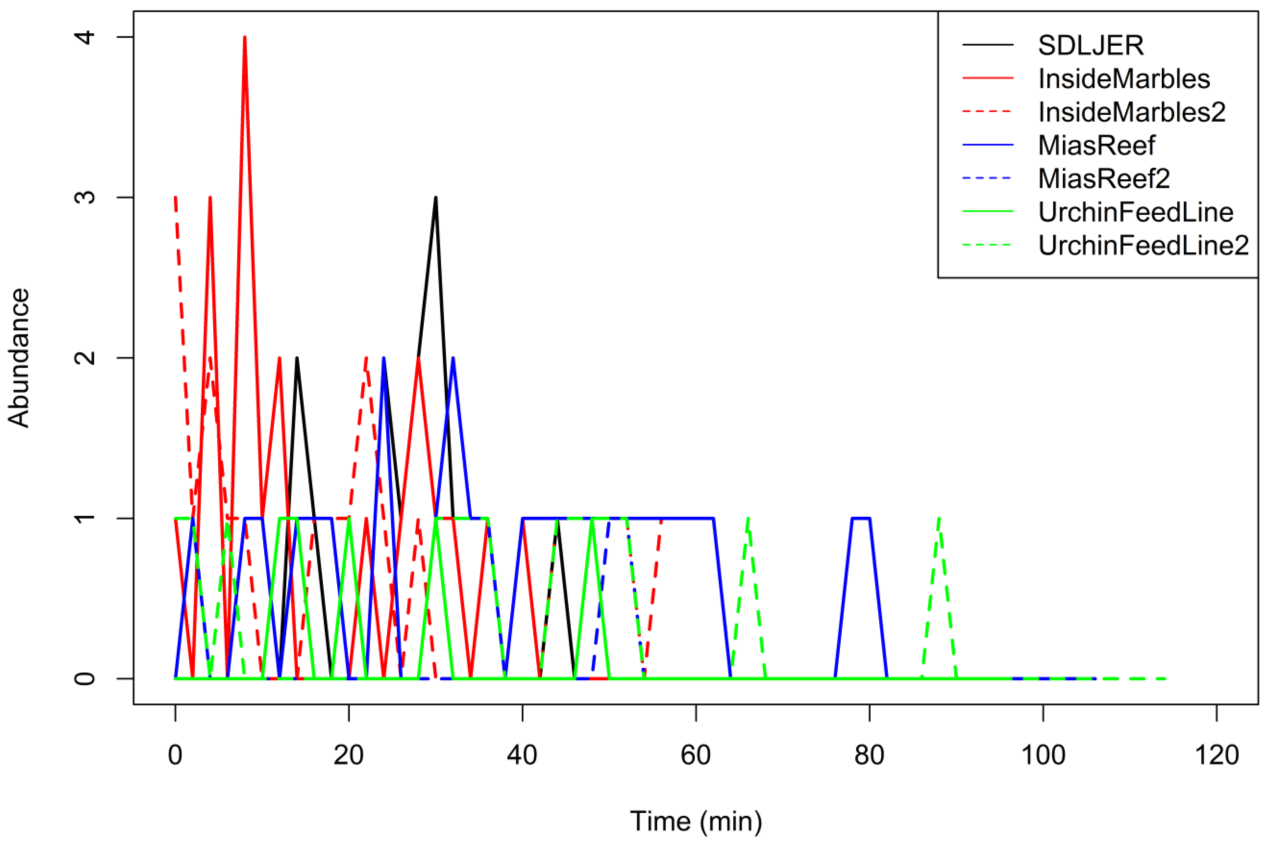

Figure 23. Observed abundance of male California Sheephead (*Semicossyphus pulcher*) as a function of time (in minutes) since bait introduction. Line types and colors (see legend) indicate baited underwater video (BUV) deployment and location.

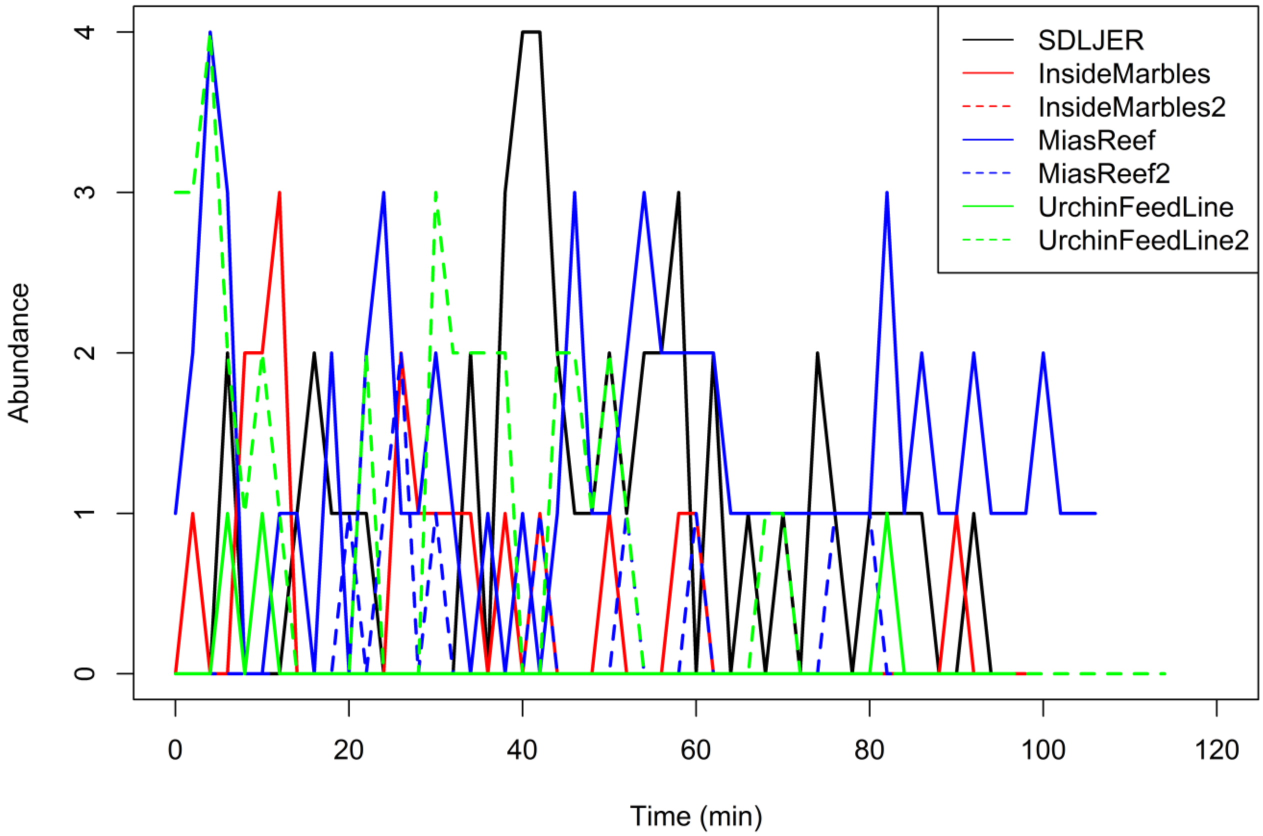

Figure 24. Observed abundance of female California Sheephead (*Semicossyphus pulcher*) as a function of time (in minutes) since bait introduction. Line types and colors (see legend) indicate baited underwater video (BUV) deployment and location.

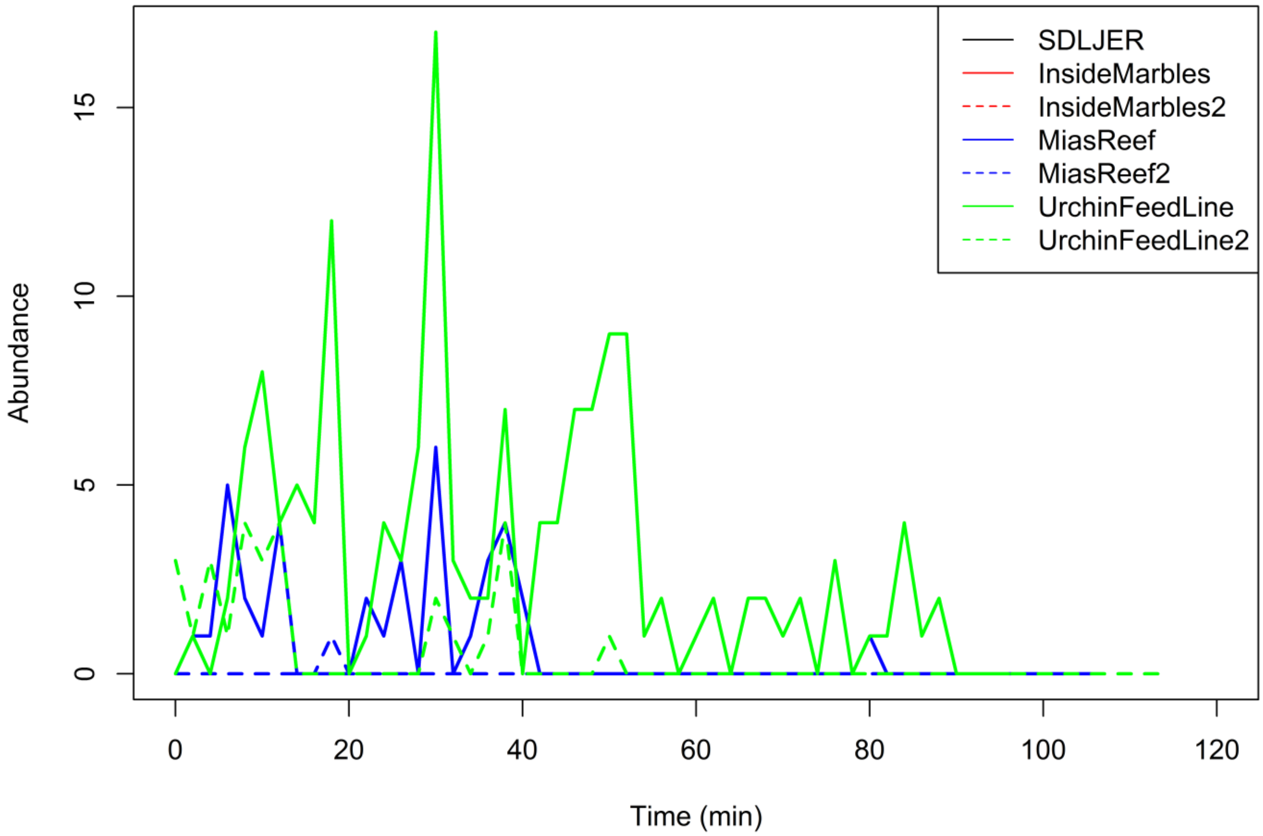

Figure 25. Observed abundance of Blacksmith (*Chromis punctipinnis*) as a function of time (in minutes) since bait introduction. Line types and colors (see legend) indicate baited underwater video (BUV) deployment and location.

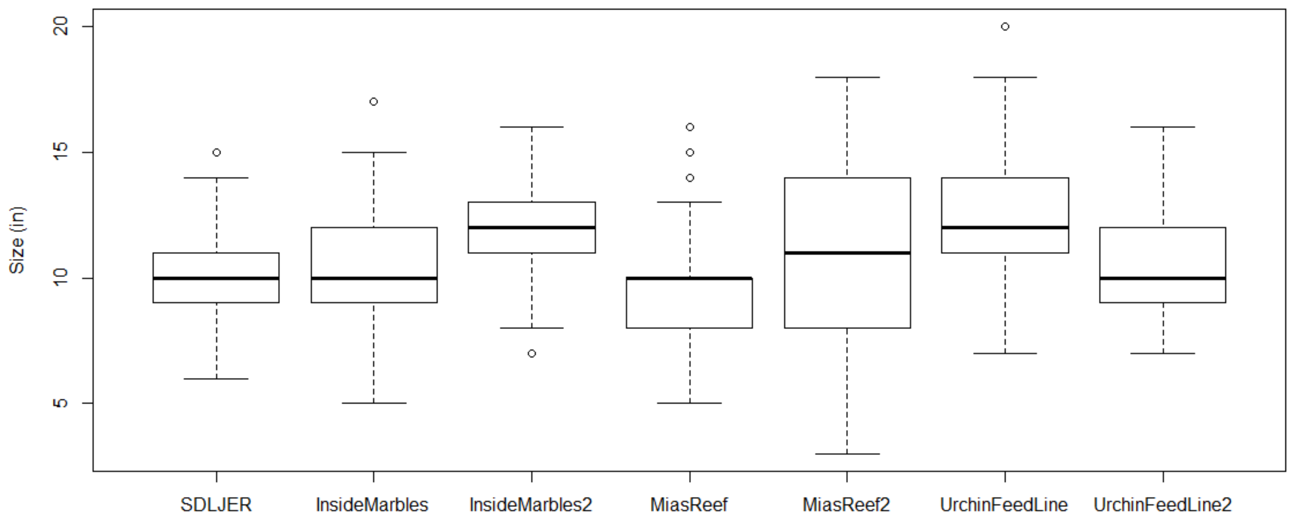

Figure 26. Boxplots indicating size distribution (in inches) of Kelp Bass (*Paralabrax clathratus*) by baited underwater video (BUV) deployment and location. Boxes indicate 25th and 75th percentiles, whiskers indicate 5th and 95th percentiles, dark horizontal lines indicate medians, and circles indicate significant outliers.

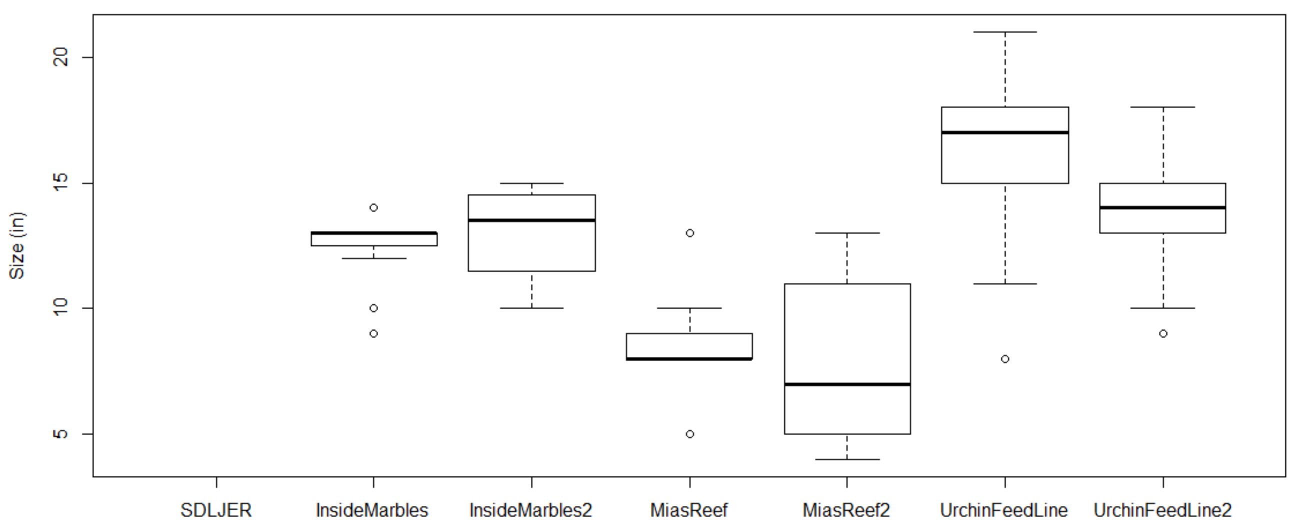

Figure 27. Boxplots indicating size distribution (in inches) of Barred Sand Bass (*Paralabrax nebulifer*) by baited underwater video (BUV) deployment and location. There were no observations of Barred Sand Bass in the San Diego La Jolla Ecological Reserve (SDLJER).

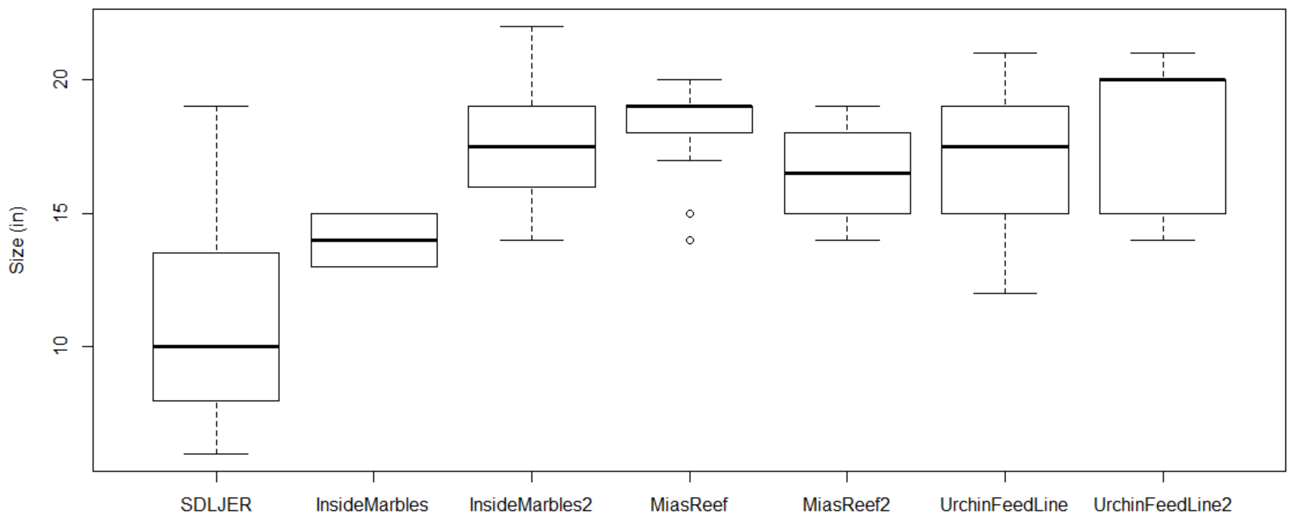

Figure 28. Boxplots indicating size distribution (in inches) of male California Sheephead (*Semicossyphus pulcher*) by baited underwater video (BUV) deployment and location.

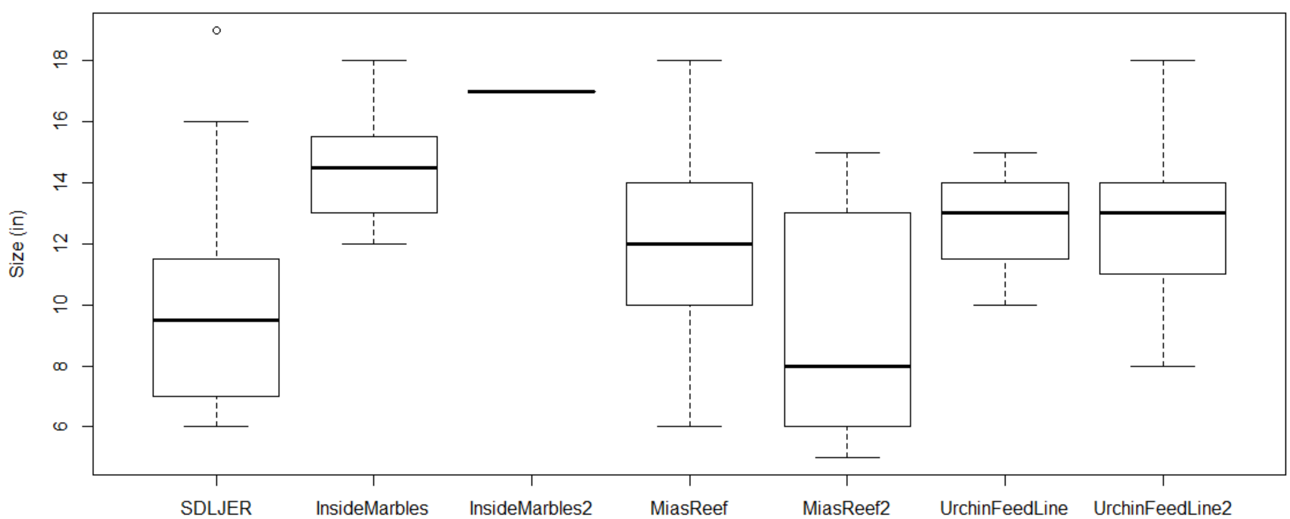

Figure 29. Boxplots indicating size distribution (in inches) of female California Sheephead (*Semicossyphus pulcher*) by baited underwater video (BUV) deployment and location.

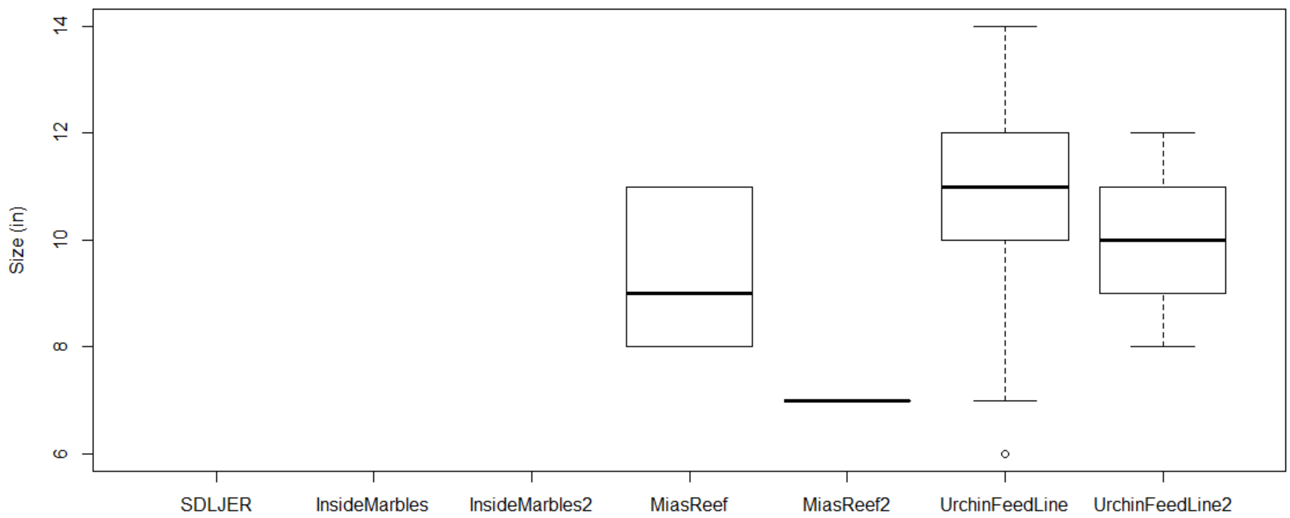

Figure 30. Boxplots indicating size distribution (in inches) of Blacksmith (*Chromis punctipinnis*) by baited underwater video (BUV) deployment and location. There were no observations of Blacksmith in the San Diego La Jolla Ecological Reserve (SDLJER) or Inside Marbles (on either of two deployment).

Table 2. Species observed in underwater baited fish videos. Sample dates are provided in Table 1.

	Inside Marbles 1	Inside Marbles 2	Mia's Reef 1	Mia's Reef 2	Urchin Barren 1	Urchin Barren 2	SDLJER
Carangidae							
Seriola lalandi	0	0	1	0	0	0	0
Trachurus symmetricus	0	0	0	1	0	0	1
Cottidae							
Scorpaenichthys marmoratus	1	0	0	0	0	0	0
Embiotocidae							
Embiotoca jacksoni	1	1	1	1	1	1	0
Rhacochilus toxotes	0	0	1	0	1	0	1
Gobiidae							
Rhinogobiops nicholsii	1	0	0	0	0	1	1
Haemulidae							
Anisotremus davidsonii	0	0	0	0	0	0	1
Hexagrammidae							
Ophiodon elongatus	1	0	1	0	0	0	0
Oxylebius pictus	1	0	0	0	0	0	0
Kyphosidae							
Girella nigricans	0	1	0	1	1	0	1
Medialuna californiensis	0	1	1	1	1	0	1
Labridae							
Halichoeres semicinctus	1	0	0	1	0	0	1
Oxyjulis californica	0	1	1	1	0	1	1
Semicossyphus pulcher	1	1	1	1	1	1	1
Muraenidae							
Gymnothorax mordax	0	0	0	1	0	0	1
Notorynchus							
Notorynchus cepedianus	1	0	0	0	1	0	0
Polyprionidae							

Sterolepis gigas	0	0	0	0	0	0	1
Pomacentridae							
Chromis punctipinnus	1	1	1	0	1	1	0
Hypsypops rubicundus	1	1	1	1	1	1	1
Serranidae							
Paralabrax clathratus	1	1	1	1	1	1	1
Paralabrax nebulifer	1	1	1	1	1	1	0
Scorpaenidae							
Sebastes atrovirens	1	1	0	0	0	0	1
Sebastes auriculatus	1	0	0	0	0	0	0
Sebastes carnatus	1	1	1	1	0	0	1
Sebastes serriceps	0	0	1	1	0	0	0
Triakidae							
Galeorhinus galeus	0	1	0	0	0	0	0
Species Richness	15	12	13	13	10	8	15