ROV-based Deep Water Monitoring of the Northern Channel Islands Marine Protected Areas Annual Report - 2007

California Department of Fish and Game

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Marine Region Administrative Report No. 09–01

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Abstract

Research cruises were conducted in August-October 2007 to complete the third annual remotely operated vehicle (ROV)-based assessments of nearshore rocky bottom finfish at ten sites in the northern Channel Islands. Annual surveys at the Channel Islands have been conducted since 2004 at four sites and were expanded to ten sites in 2005 to monitor potential marine protected area (MPA) effects on baseline fish density. Six of the ten sites are in MPAs and four in nearby fished reference areas. In 2007 the amount of soft-only substrate on the 141 track lines surveyed was again estimated in real-time in order to target rocky bottom habitat. These real-time estimates of hard and mixed substrate for all ten sites averaged 57%, 1% more than the post-processed average of 56%. Surveys generated 69.9 km of usable video for use in finfish density calculations, with target rocky bottom habitat accounting for 56% (39.1 km) for all sites combined. The amount of rocky habitat sampled by site averaged 3.8 km and ranged from 3.3 km sampled at South Point, a State Marine Reserve (SMR) off Santa Rosa Island, to 4.7 km at Anacapa Island SMR. A sampling goal of 75 transects at all 10 sites was met using real-time habitat estimates combined with precautionary over-sampling by 10%. A total of seventy kilometers of sampling is projected to produce at least seventy-five 100 m^2 transects per site. Thirteen of 26 finfish taxa observed were selected for quantitative evaluation over the time series based on a minimum criterion of abundance (0.05/100 m^2). Ten of these 13 finfish appear to be more abundant at the state marine reserves relative to fished areas when densities were averaged across the 2005 to 2007 period. One of the species that appears to be more abundant in fished areas was señorita, a relatively small prey species that is not a commercial or recreational target.

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INTRODUCTION

Project Overview

Over the past ten years, the California Department of Fish and Game (Department) and various partners have been developing the use of a Remotely Operated Vehicle (ROV) as a quantitative visual sampling tool for the deep subtidal environment. The Department's ROV research program was initiated in 1997 when the ROV was purchased in partnership with the Pacific States Marine Fisheries Commission (PSMFC) to complete a deep water species inventory of Punta Gorda Ecological Reserve using Sea Grant funding (Karpov et al. 2001). Since that time, numerous partners have collaborated on research efforts to further develop the efficiency and value of this technology (Veisze and Karpov 2002 and Karpov et al. 2006).

Beginning in 2003, the Department and PSMFC were joined by Marine Applied Research and Exploration (MARE), the Channel Islands National Marine Sanctuary (CINMS) and The Nature Conservancy (TNC), to help expand the Department program's deep water sampling (>20 m) of then newly formed Marine Protected Areas (MPAs) off the northern Channel Islands[1]. MARE and TNC obtained additional support and funding for equipment and operations, while the CINMS provided its research vessel (*RV Shearwater*) to complement the Department's vessels (*PB Swordfish*) in field operations.

The primary objective of this collaborative research program is to evaluate the effectiveness of state marine reserves (SMRs) at the Channel Islands, while also providing critical data for fisheries management. Under the Channel Islands MPA monitoring plan (CDFG 2004), rocky bottom substrates were identified as the priority habitat for deep water assessments. In an effort to meet this monitoring priority, the Department has focused survey efforts on finfish associated with rocky habitat both inside and outside SMR boundaries. While finfish associated with rocky substrates are the current focus, video data collected may also be used to assess invertebrate and habitat changes.

The predominant habitat around the northern Channel Islands consists of sand and/or cobble with patchy rock outcroppings. The scarcity of rocky habitat made early efforts to find similar study sites extremely difficult. The use of sonar imagery proved helpful, but with little ground truth data available, determination of habitat composition was not feasible. In order to achieve a goal of locating comparable areas of rocky habitat both inside and outside of SMR boundaries, research was conducted in two phases: exploratory and quantitative.

The exploratory phase was developed to find study areas around the northern Channel Islands that had similar amounts of rocky habitat at similar depth

[1] Two types of MPAs were sampled in the study and are henceforth referred to as State Marine Reserves (SMRs) and State Marine Conservation Areas (SMCAs) in this publication.

ranges, while developing the sampling protocols to be used during the quantitative phase. Potential study areas were selected using multibeam or sidescan sonar mapping provided by Dr. Rikk Kvitek (California State University, Monterey Bay) and Dr. Guy Cochrane (United States Geological Survey). The study areas were then explored using the ROV to find comparable habitats and depths both inside and outside reserve boundaries.

The primary objective during the exploratory phase was to find site pairs; one site inside a reserve and another far enough outside to serve as an independent fished reference area. Selection criteria included habitat composition, depth, oceanographic exposure and proximity to the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) SCUBA survey sites. The paired site design was used in order to more equally distribute sampling across similar habitats for both reserve and reference areas. This approach was not always practical due to habitat availability and ultimately resulted in the pairing of two MPA sites near Anacapa Island. The exploratory phase spanned 2003-2005, and resulted in the survey of 18 potential study areas (Appendix 1). Of the 18 explored areas, only ten (five site pairs) met selection criteria for annual quantitative surveys (Table 1, Figure 1).

The quantitative phase began in 2004 with four sites and expanded to ten sites in 2005 (Table 1). The goal of the quantitative phase is to complete annual surveys within each study area targeting a fixed amount of rocky substrate. During this phase, annual surveys at each site will be continued as long as is practical, monitoring SMR effects on baseline density, size, and biomass of finfishes relative to fished reference areas.

One early design question was to determine the area to be sampled each year at each of the ten sites. A corollary to this question was the size of strip transects to use in analyzing the data. Power analysis of data collected during 2003-2004 exploratory surveys suggested that smaller transects ($100m^2$ or less) were optimal for detecting changes in density. The selected sample size was subsequently corroborated in a more rigorous statistical analysis[2].

Collecting the minimum number of transects at each site proved problematic because each site differs in the proportion of hard substrate available. This is compounded by the fact that the number of transects captured is not fully known until after analysis (post-processing) of the data has occurred. Since post-processing occurs after each research cruise, a new field method was used to determine “real-time” if sampling goals had been met at each site.

Starting in 2005, a time based estimate was used to monitor the total amount (km) of rocky substrate sampled at each site. This innovative method is now

[2] Karpov, K. A., M. Bergen, J. J. Geibel, P. M. Law, C.F. Valle, and D. Fox (In Review). Prospective (A Priori) power analysis for detecting changes in density between sites when sampling with strip transects. *Department of Fish and Game.*

used to focus survey effort and reduce under sampling at each site. This method also reduces over sampling and the costs associated with both data collection and post-processing. In 2005, this real-time method estimated habitat within 5% of the actual post-processed habitat percentages, which allowed collection of the minimum number of transects at all ten sites.

Table 1. Ten sites by island, site name, location codes, and kilometers of track line captured during surveys in September 2004 and August to October 2005-2007. SMR (State Marine Reserve), SMCA (State Marine Conservation Area).

Island / Site Name	SMR Site Pair	Location code	Kilometers surveyed Sep 2004	Aug -Oct 2005	Aug - Oct 2006	Aug 2007
San Miguel Island						
Harris Pt. SMR	Harris Point	SMI-1	--	15	8	7
Castle Rock		SMI-2	--	10	5	4
Santa Rosa Island						
Carrington Pt. SMR	Carrington Point	SRI-2	12	7	8	7
Rodes Reef		SRI-3	12	6	8	6
Cluster Pt.	South Point	SRI-7	--	10	9	6
South Pt. SMR		SRI-8	--	13	8	8
East Pt.	Gull Island	SRI-6	12	12	11	9
Santa Cruz Island						
Gull Island SMR		SCI-2	12	13	11	11
Anacapa Island						
Anacapa SMR	Anacapa Island	AI-3	--	19	8	9
Anacapa SMCA		AI-1	9	12	9	7
Totals			57	117	85	71

Report Purpose

The purpose of this report is to present the 2007 data collection, methods used, and summarized post-processing results. The effectiveness of real-time habitat typing is assessed, and habitat and fish abundances for 2007 are reported. Fish densities are also reported as a time series spanning the quantitative survey period from 2004 through 2007. These results are presented as preliminary without detailed statistical analysis or interpretation.

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METHODS

The ROV model used in this study was a Deep Ocean Engineering Phantom® HD 2+2[3], with auto heading and speed trim. Key methods linking Global Positioning System (GPS) time code to position and visual observations are described by Veisze and Karpov (2002). Since that study, navigation and tracking precision of strip transects has been greatly improved and are described in detail by Karpov et al. (2006). A more detailed technical description for some of the following methods is also provided in Appendix 2.

ROV Sampling Operations

ROV operations were conducted off the *RV Shearwater*, a 19 m catamaran owned and operated by NOAA's CINMS. Individual ROV dives were limited to approximately two hours (3 km) each. ROV dives were limited by DVD recording time, and new dives were initiated often while the ROV remained on the seafloor. Surveys were conducted between the hours of 0800 and 1700 PST to avoid twilight conditions that might affect fish abundance measurements and underwater visibility.

In order to reduce the risk of under or over sampling a given site, a real-time protocol was implemented that monitored the total kilometers of rocky substrate sampled at each site. Prior to data collection, percentages of rocky habitat, along with the potential number of transects generated per km of survey, were used to generate a survey goal (km) for each site. These target goals reflect the minimum amount (km) of track lines that are needed to generate seventy-five 100 m^2 transects per site.

Site and Track Line Description

The boundaries of the ten sites (five site pairs) sampled in 2007 were made permanent in 2005 (Table 1, Figure 1). Four of the sites (two site pairs) were also sampled in 2004. These paired sites were selected based on exploratory surveys conducted during the 2003 through 2005 survey years (Karpov et al. 2005). Site pairs consisted of a site within an SMR along with a site in a nearby fished (reference) area. Where possible, sites were selected offshore of PISCO sites sampled by SCUBA. The reference sites were chosen based upon comparable criteria which included: distance to port, exposure to prevailing wind and waves, habitat (rocky substrate) and depth range. Four of the five reference sites are unrestricted areas that are open to all types of fishing. The fifth reference site (AI-1) is located within the boundaries of Anacapa Island State Marine Conservation Area, which only allows recreational take of lobster and pelagic finfish. The study sites were selected as 500 m wide rectangles that

[3] Use of trade names does not indicate an endorsement of any product by the California Department of Fish and Game.

varied in length from 1.2 km to 3.5 km moving offshore, with depths ranging from 11 m to 71 m.

Prior to field sampling, 500 m long track lines were randomly chosen within each site with a minimum spacing of 20 m (Appendix 2). An exception was made at Anacapa Island SMCA and Gull Island SMR where a 10 m minimum spacing was used. To ensure that the sampling was distributed across the entire depth range each site was divided into one to four zones established in 2005 (Bergen et al. 2005). The total number of track lines selected within each zone was dependent on the zone's area and the anticipated proportion of hard habitat (Appendix 2). An additional 10% buffer was added to the target goal to allow for sampling errors, such as the ROV missing part of a planned track line or being pulled off the planned line by the topside vessel.

During random line selection, areas determined to be mostly sand were excluded. These areas were defined from existing multibeam sonar data (Kvitek unpublished), or by sidescan sonar (Cochrane unpublished) and also by overlaying data from exploratory ROV surveys completed in 2003 through 2005 (Karpov et al. 2005a). When real-time estimates of rocky habitat sampled fell below the level needed to produce a minimum of seventy-five 100 m^2 transects, additional randomly selected lines (alternate lines) were prepared and surveyed. In order to track habitat changes over time (i.e. such as reefs being sanded over) a minimum number of random lines has been set as a annual sampling goal for each site.

Post-processing

Positional data collected for each line was processed to produce the final track lines. Positional information was filtered for outliers and smoothed using a 21-point running mean (Karpov et al. 2006). Gaps in the tracking data that occurred due to deviations from quantitative protocols were removed from the data prior to transect computation.

Planar length per second was combined with sonar width to calculate tracked area per second, which was used to create transects of fixed area for density determination. Usable portions of the track line were divided into 25 m^2 subunits, which typically ranged 8 to 10 m in length. Subunits with less than 50% hard and/or mixed habitat were then removed. The remaining subunits were used to generate 100 m^2 transects (four consecutive usable 25 m^2 subunits) for use in density calculations. A spacer subunit was discarded between each to avoid bias of contiguous transects. This method has allowed a focus on rocky substrate without the loss of rock/sand interface habitat.

Substrate and Habitat

The video record was reviewed and substrate types encountered were classified independently as rock, boulder, cobble, or sand. Substrate classification used during post-processing was simplified from Green et al. (1999).

A transparency film placed on the video monitor screen was used during review of a video record with guidelines that approximated a 1.5 m wide swath. Each of the substrate types were recorded as discrete segments with a beginning and ending GPS time code. Each substrate layer was considered continuous until a break of 2 m or greater occurred or the substrate dropped below 20% of the total combined substrates for a distance of at least 3 m. After processing, the substrates were combined to create three habitat types: hard, (rock and/or boulder), mixed (rock and/or boulder with either cobble and/or sand), or soft (cobble and/or sand).

Fish Abundance, Transects, and Descriptive Statistics

A single-pass method was used to identify observed fish to one of the following levels: species, complex, family, or unidentified (Appendix 3). At the inception of this study in 2003, fish species and groupings were selected based on taxonomic review of video prior to enumeration. Fish observations recorded were limited to a size greater than 11 cm with the exception of señorita (*Oxyjulis californica*), surf perch, and blacksmith (*Chromis punctipinnis*). Several fish species were excluded: skates, flatfish, young of the year (YOY) rockfish, pelagic species, painted greenling (*Oxylebius pictus*) and sculpins (except cabezon [*Scorpaenichthys marmoratus*]).

During post-processing, a screen overlay was used to approximate the transect width and serve as a guide for determining if a fish fell within the ROV transect. Fish enumeration was limited to a distance of approximately 4 m (Karpov et al. 2006). In addition, fish that entered the viewing area were only counted if more than half the fish crossed the overlay guidelines.

Table 2. Scientific and common names for major finfish taxa sampled from 2005 through 2007. Average densities are presented for four combined SMR and four fished reference sites, excluding both the Anacapa SMR and SMCA. Densities are group means for combined sites and years.

		Density (No. per 100m^2)	
Scientific Name	Common Name	SMR	Fished
Chromis punctipinnis	Blacksmith	0.792	0.398
Ophiodon elongatus	Lingcod	0.073	0.044
Oxyjulis californica	Señorita	0.304	0.574
Paralabrax clathratus	Kelpbass	0.002	0.010
Rhacochilus vacca	Pile perch	0.275	0.195
Sebastes carnatus	Gopher rockfish	0.085	0.029
S. caurinus	Copper rockfish	0.155	0.076
S. miniatus	Vermilion rockfish	0.664	0.249
S. mystinus	Blue rockfish	1.448	0.719
S. serranoides	Olive rockfish	0.289	0.221
S. serriceps	Treefish	0.056	0.024
Sebastomus	Sebastomus	0.272	0.176
Semicossyphus pulcher	California sheephead	0.145	0.150

Fish species were counted from the video using protocols described in Bergen et al. (2005). Results of fish density presented are limited to a subset of quantified taxa (from 2005 survey) that had a minimum of 0.05 fish per 100 m^2. Thirteen of the 26 taxa (Table 2) enumerated met this minimum density criterion. Density and variance were also calculated for each fish at each site (Table 7 and Appendix 4). The average fish[4] density for each year by site is shown in figures 12 to 24. Average density by year and for the combined 2005 to 2007 period was calculated for four SMRs and four fished reference areas combined excluding the Anacapa Island MPAs (Figures 25 – 26). The average densities were group means without descriptive statistics to avoid bias from uneven sampling by site for any year. All biological descriptions presented in this report were based on general observations of the data and not subjected to statistical testing.

The ten sites sampled were depicted with habitat types and fish counts on tracked lines, excluding areas consisting of kelp or predominantly soft-only substrate using ArcView® 9.1 software. Two types of maps were produced for this report: hard copy overview site maps and a map with a detailed interactive data display of fish, habitat, bathymetry, and topography on compact disc (CD) available from the Department. Both map products include associated bathymetry and multibeam or sidescan sonar imagery with shaded relief.

[4]The 13 taxa include Sebastomus and 12 fish identified to the species level. The term fish is used henceforth in place of taxa.

RESULTS

Real-time vs. Post-processed Substrate Estimates

Ten sites were successfully surveyed in 2007. A total of 141 track lines were surveyed, all of which were post-processed for subsequent analysis (Table 3; Figures 2-11).

The real-time average of hard and mixed substrate for all ten sites averaged 57%, only 1% more than the post-processed average of 56% (Table 2). These results were identical to those obtained in 2006 when the difference between real-time and post-processed estimates was also 1%.

Table 3. Real-time and post-processed percentage of hard or mixed substrate by zone for the ten sites sampled in 2007.

Site	Zone	No. lines sampled	Percent hard or mixed substrate		
			Real-time (a)	Processed (b)	Difference (a - b)
Harris Point	1	9	45	50	-5
SMR	2	4	65	73	-8
Castle Rock	1	3	97	94	4
	2	5	96	96	1
Carrington Point	1	6	56	53	3
SMR	2	7	63	56	7
Rodes Reef	1	6	78	76	2
	2	6	52	47	5
Cluster Point	1	9	76	75	2
	2	2	50	49	1
South Point	1	7	59	51	7
SMR	2	8	46	37	9
East Point	1	6	39	25	14
	2	6	48	47	1
	3	4	67	61	6
	4	2	50	36	13
Gull Island SMR	1	21	33	36	-3
Anacapa Island	1	8	53	67	-15
SMR	2	9	30	37	-6
Anacapa Island	1	11	48	56	-8
SMCA	2	2	54	64	-10
Averages			57	56	1

Survey Totals

A total of 71.7 km of habitat was video recorded and used for habitat determination across the ten sites (Table 4). Of this total, 69.9 km was determined to be usable based on transect quality criteria and range values within target goals. The targeted hard and mixed habitat accounted for 56% of total usable data from all sites combined. The amount of target habitat sampled by site averaged 3.8 km, with a range of 3.3 km sampled at South Point SMR to 4.7 km at Anacapa Island SMR. The number of track lines processed from each site ranged from 8 at Castle Rock to 21 at Gull Island SMR, with an average of 14 lines per site.

Table 4. Processed tracked distances for survey lines, hard or mixed substrate amounts, and transects generated by zone for the ten sites sampled in 2007.

Site	No. of lines	Track line (km)		Hard or mixed		No. of transects
		Total	Usable	Km	Area (ha)	100 m^2
Harris Point SMR	13	6.1	5.9	3.4	1.1	89
Castle Rock	8	4.0	3.9	3.8	1.3	99
Carrington Point SMR	13	6.4	6.3	3.5	1.1	87
Rodes Reef	12	6.0	6.0	3.7	1.1	92
Cluster Point	11	5.7	5.5	4.0	1.4	104
South Point SMR	15	7.6	7.1	3.3	1.1	79
East Point	18	9.1	9.0	3.9	1.2	94
Gull Island SMR	21	10.7	10.4	3.8	1.2	96
Anacapa Island SMR	17	9.3	9.1	4.7	1.2	101
Anacapa Island SMCA	13	6.7	6.7	3.8	1.1	92
Totals	141	71.7	69.9	38.1	11.9	933

Transect Description

The goal of completing at least seventy-five 100 m^2 transects per site was met at all ten of the sites (Table 4). The average number of transects produced from all sites combined was 93 per site. Transect numbers ranged from 79 at South Point SMR to 104 at Cluster Point.

Descriptive statistics for all 100 m^2 transects by site are shown in Table 4. The average transect depth was 37.6 m, with the shallowest average depth at Rodes Reef (28.2 m) and the deepest at Gull Island SMR (50.5 m). Transect width for all sites averaged 3.1 m and ranged from 2.6 m at Anacapa Island SMR to 3.5 m at both Castle Rock and Cluster Point. Usable transect length, excluding sections of the line that were not within sampling criteria, averaged 31.6 m with a range of 29.2 m at Cluster Point to 36.5 m at Anacapa Island SMR. The overall length of transects, including portions outside sampling criteria, averaged 32.8 m and ranged from 30.0 m at Castle Rock to 36.8 m at Anacapa Island SMR.

Velocity of the ROV along the track lines remained constant, averaging 0.7 m/sec (± 0.02 SE).

Table 5. Sampling statistics for 100 m^2 transects for each of the ten sites sampled in 2007.

Site	No. of transect	Depth (m)				Velocity (m/s)	
		Mean	SE	Min.	Max.	Mean	SE
Harris Point SMR	89	42.0	0.7	25.5	56.4	0.8	0.01
Castle Rock	99	44.8	0.8	24.2	58.2	0.8	0.01
Carrington Point SMR	87	29.3	0.5	17.6	40.0	0.7	0.02
Rodes Reef	92	28.2	0.6	18.5	45.2	0.6	0.01
Cluster Point	104	36.2	0.9	20.0	58.4	0.7	0.02
South Point SMR	79	41.8	1.5	17.8	70.7	0.6	0.02
East Point	94	28.9	0.7	15.3	52.7	0.7	0.02
Gull Island SMR	96	50.5	0.9	30.6	66.8	0.6	0.02
Anacapa Island SMR	101	42.9	1.8	16.8	67.4	0.8	0.02
Anacapa Island SMCA	92	31.8	0.9	11.5	50.0	0.7	0.02
Average	93	37.6	0.9	19.8	56.6	0.7	0.02

Table 5 continued.

Site	No. of transect	Transect length (m)				Transect width	
		Sampled		Overall			
		Mean	SE	Mean	SE	Mean	SE
Harris Point SMR	89	30.5	0.4	31.6	0.5	3.3	1.2
Castle Rock	99	29.6	0.4	30.0	0.4	3.5	1.2
Carrington Point SMR	87	31.5	0.5	32.0	0.5	3.2	0.9
Rodes Reef	92	32.5	0.4	32.6	0.4	2.9	0.7
Cluster Point	104	29.2	0.4	30.3	0.5	3.5	2.2
South Point SMR	79	29.9	0.4	34.7	1.9	3.3	1.6
East Point	94	31.1	0.5	32.4	0.5	3.2	1.2
Gull Island SMR	96	31.6	0.5	33.5	1.1	3.1	1.2
Anacapa Island SMR	101	36.5	0.6	36.8	0.7	2.6	1.0
Anacapa Island SMCA	92	33.3	0.5	33.7	0.5	2.8	1.0
Average	93	31.6	0.5	32.8	0.7	3.1	1.2

Site Description

Substrate and habitat composition for all lines processed are presented in Tables 6 and 7 and Figures 2-11. Habitat percentages are presented as the relative proportion of the line or transect that contained the habitat type. Percent by component substrates represent the ratio of the line or transect that has a given substrate compared to the total line and are not relative percentages.

Rock and sand substrate coverage for all sites combined averaged 57% and 77%, respectively, and are not mutually exclusive. Lines may have sections in which rock and sand are observed concurrently. There were differences in the percentages of rock or sand among sites; Gull Island SMR had the least rock (35%) and the most sand (90%). Boulder and cobble were the least observed substrates, each with an average of 7% per site. Outliers were at Castle Rock, where boulder substrate covered 27% of the lines surveyed; and at Carrington Point SMR, where cobble covered 22%.

The percent composition of mixed habitat was consistent among sites, with an average of 35% for all sites and a range of 25% at East Point to 46% at Rodes Reef. Hard and soft habitat averaged 22% and 43%, respectively, with Castle Rock being most notably different with 55% hard and 5% soft habitat. Overall, half of the site pairs were similar in their habitat composition. The greatest disparity occurred at the Gull Island where the amounts of hard and soft substrate had a range of 9% and 64%, respectively.

Table 6. Sampling substrates and habitats for all track lines post-processed at each of the ten sites sampled in 2007.

Site	Pecentage by substrates				Percentage by habitat		
	Rock	Boulder	Cobble	Sand	Hard	Mixed	Soft
Harris Point SMR	57	7	7	76	23	34	43
Castle Rock	95	27	17	35	55	40	5
Carrington Point SMR	54	8	22	83	16	39	45
Rodes Reef	62	2	3	84	16	46	38
Cluster Point	71	3	7	72	27	44	29
South Point SMR	44	1	1	85	15	29	56
East Point	42	2	4	83	17	25	58
Gull Island SMR	35	3	4	90	9	27	64
Anacapa Island SMR	51	13	3	86	14	37	49
Anacapa Island SMCA	57	5	3	77	23	34	43
Average	57	7	7	77	22	35	43

Analysis of substrate data showed that sand was a major component at all sites, even though sand-only areas identified from acoustic sonar maps were excluded from sampling (Bergen et al. 2005, Karpov et al. 2005a, and Karpov et al. 2005b). The average for all ten sites sampled in 2007 shows that 77% of the total area sampled contained sand (43% soft-only and 35% mixed rock and sand) (Table 6). The amount of sand ranged from 35% at Castle Rock to 90% at Gull Island SMR. Sand-only habitat (soft) was more variable and ranged from 5% at Castle Rock to 64% at Gull Island SMR.

When transects from each site were compared, there were fewer differences between grouped site pairs (Table 7). The proportion of rock substrate was similar for all ten sites (84-98%), with the other substrate components (boulder, cobble, and sand) varying more notably. Sand substrate was comparable at nine of the ten sites (59-75%), with Castle Rock the most diverse at 33%.

Table 7. Sampling substrates and habitats for 100 m^2 at each of the ten sites sampled in 2007.

Site	Pecentage by substrates				Percentage by habitat		
	Rock	Boulder	Cobble	Sand	Hard	Mixed	Soft
Harris Point SMR	93	10	10	60	38	55	7
Castle Rock	98	28	17	33	58	41	1
Carrington Point SMR	92	13	22	70	30	64	7
Rodes Reef	92	2	4	75	25	67	8
Cluster Point	95	3	8	60	38	57	4
South Point SMR	89	1	2	66	34	55	11
East Point	91	3	4	59	40	51	8
Gull Island SMR	84	8	7	75	23	61	14
Anacapa Island SMR	92	23	4	71	28	64	7
Anacapa Island SMCA	94	8	2	60	39	55	6
Average	92	10	8	63	35	57	7

Transects consisted of relatively low amounts of soft habitat at all ten sites (1-14%), and varying amounts of hard and mixed habitat (Table 6). Hard and mixed habitat varied most between the Harris Point SMR and Gull Island SMR site pairs. All other site pairs had comparable percentages of hard and mixed habitat.

Finfish Biological Data

Descriptive statistics were provided for each of the 13 fish by sites sampled in 2007 (Table 8). Fish locations in 2007 relative to the random lines are displayed on the accompanying Interactive CD.

Figures 12 through 24 depict the time series of density for all 13 fish at each of four sites in 2004 and ten sites in 2005 through 2007. When the years were combined the group mean density was greater for ten of thirteen fish for the four combined SMRs relative to the four fished areas (Table 2, Figures 25 and 26). Señorita was one of only three species more common on fished areas relative to the SMRs. Differences were double the average density for six of the species including blacksmith, gopher rockfish, copper rockfish, vermilion rockfish, blue rockfish, and treefish.

Table 8. Finfish descriptive statistics for 100 m^2 transects at each site sampled in 2007. (Mean: mean density, SD: standard deviation, %FO: percent frequency of occurrence).

Site	Harris Pt. SMR			Castle Rock			Carrington Pt. SMR			Rodes Reef			South Pt. SMR		
Taxon	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO
Blacksmith	0.02	0.21	1	0.03	0.22	2	0.98	4.47	11	0.03	0.23	2	1.42	9.29	9
Blue rockfish	0.76	2.33	21	0.50	1.76	14	1.10	3.40	17	0.40	1.11	17	2.76	7.26	28
Ca. Sheephead	0.05	0.26	3	0.09	0.32	8	0.06	0.28	5	0.04	0.21	4	0.19	0.58	13
Copper rockfish	0.19	0.40	19	0.04	0.20	4	0.22	1.03	10	0.12	0.42	10	0.08	0.27	8
Gopher rockfish	0.17	0.41	16	0.02	0.14	2	0.03	0.18	3	0.03	0.18	3	0.08	0.27	8
Kelp Bass	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Lingcod	0.09	0.29	9	0.01	0.10	1	0.02	0.15	2	0.04	0.25	3	0.04	0.19	4
Pile perch	0.08	0.31	7	0.04	0.40	1	0.03	0.18	3	0.15	1.17	3	0.06	0.29	5
Sebastomus	0.50	0.82	37	0.55	0.83	40	0.02	0.15	2	0.03	0.23	2	0.13	0.41	10
Senorita	0.23	2.13	1	0.02	0.20	1	0.03	0.32	1	0.31	1.63	11	0.96	3.52	13
Treefish	0.08	0.27	8	0.03	0.17	3	0.01	0.11	1	0.01	0.10	1	0.03	0.16	3
Vermillion rockfish	1.13	1.57	58	0.21	0.50	18	0.41	1.18	21	0.40	1.27	13	0.45	0.83	32
Yellowtail/Olive	0.31	0.65	22	0.35	1.47	19	0.13	0.45	9	0.08	0.31	7	0.17	0.59	10
Average	0.30	0.80	17	0.16	0.53	10	0.25	0.99	7	0.14	0.59	6	0.53	1.97	12

Table 8 continued.

Site	South Pt. SMR			East Pt.			Gull Island SMR			Anacapa Island SMR			Anacapa Island SMCA		
Taxon	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO
Blacksmith	1.35	9.23	9	2.06	8.24	19	1.42	5.65	14	1.24	4.52	23	5.48	12.03	35
Blue rockfish	2.26	6.07	27	1.46	4.37	27	0.62	1.93	20	0.06	0.37	3	0.16	0.56	10
Ca. Sheephead	0.12	0.36	10	0.28	0.60	21	0.18	0.53	13	0.21	0.52	17	0.18	0.46	13
Copper rockfish	0.08	0.27	8	0.02	0.21	1	0.05	0.22	5	0.05	0.22	5	0.05	0.23	5
Gopher rockfish	0.08	0.27	8	0.01	0.10	1	0.04	0.20	4	--	--	--	0.02	0.15	2
Kelp Bass	--	--	--	0.01	0.10	1	--	--	--	0.20	0.60	15	0.08	0.27	7
Lingcod	0.04	0.19	4	0.03	0.18	3	0.05	0.22	5	--	--	--	0.04	0.21	4
Pile perch	0.05	0.27	4	0.06	0.29	5	0.17	1.16	4	--	--	--	0.01	0.10	1
Sebastomus	0.13	0.41	10	--	--	--	0.59	1.09	31	0.13	0.39	12	0.09	0.35	6
Senorita	0.71	2.80	13	1.74	9.88	10	0.19	1.45	4	0.01	0.10	1	--	--	--
Treefish	0.03	0.16	3	--	--	--	0.12	0.32	11	0.01	0.10	1	0.04	0.21	4
Vermillion rockfish	0.45	0.83	32	0.14	0.52	7	0.72	1.22	41	0.15	0.54	10	0.18	0.49	12
Yellowtail/Olive	0.15	0.58	9	0.05	0.23	5	0.24	0.63	18	--	--	--	0.02	0.15	2
Average	0.45	1.79	11	0.53	2.25	9	0.37	1.22	14	0.23	0.82	10	0.53	1.27	8

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Discussion

Real-time vs. Post-processed Substrate Estimates

Based on three years of sampling results, the real-time sampling method has been shown to be a reliable tool for monitoring sampling goals during quantitative surveys. Using real-time data to project the amount of target habitat surveyed provides a metric to gauge progress while at sea. In 2006 and 2007, real-time estimates were within 1% of post-processed data, substantiating this method as an accurate means of determining the types and amount of substrate sampled.

By assessing the amount of usable substrate surveyed at sea, the goal of gathering 4 km of hard substrate data needed for analysis can be monitored. Given the ability to calculate targeted substrate so closely, precautionary over-sampling can be minimized, reducing costs both in the field and during post-processing.

Costs could be further cut in future surveys by using more extensive and improved sonar maps while concurrently performing exploratory and quantitative sampling. The quality and extent of sonar map interpretations by both Cochrane and Kvitek can greatly enhance the ability to pre-select sample sites while eliminating soft-only areas from the sample frame. Work in the northern Channel Islands was often based on draft maps not yet interpreted by the authors, which consumed a considerable amount of exploratory survey time.

During early exploratory surveys (Karpov et al. 2005a) a zigzag pattern was run across areas that were poorly mapped or difficult to interpret. This approach was not randomized in track line deployment and often overestimated the amount of hard substrate due to subjective bias in line placement across a site. The zone-based methods developed for this quantitative survey, combined with real-time estimates of captured habitat, bypass the need for independent exploratory habitat truthing. By using real-time estimates with quality map interpretations, appropriate sampling areas may be selected which immediately provide useful data.

Fish and invertebrate sizing methods are currently being developed. Experiments completed over the last two years have been directed at fish models sized using an ROV with paired lasers and a ranging altimeter. Once sizing has been determined to be accurate, it may be added to sampling protocols. MPA effects on size and biomass may then be determined.

Survey Totals and Transect Compilation

The precautionary measure of over-sampling by 10% in 2007 (Bergen et al. 2006) facilitated meeting a sampling goal of 75 transects at all sites. Modifications made following the 2005 survey to exclude soft-only areas increased efficiency and resulted in a slight over-sampling in 2006. In general, the time series of sampling spanning 2004 through 2007 has been very

successful in both meeting and exceeding the sampling goal (Table 9). Only three sites sampled did not reach the goal of 75 transects; two in 2004 and one in 2005.

Table 9. Number of 100 m^2 transects sampled for each site by year from 2004 through 2007

	Years Sampled			
Site	2004	2005	2006	2007
Harris Pt. SMR		109	111	89
Castle Rock		134	104	98
Carrington Pt. SMR	139	74	131	87
Rodes Reef	145	59	147	92
East Pt.	54	95	116	94
Gull Island SMR	59	94	86	95
Cluster Pt.		105	132	104
South Pt. SMR		110	91	79
Ancapa Island SMR		119	101	101
Ancapa Island SMCA		115	91	92
Average	99	101	111	93

Based on the results of this year's survey, 70 km of future sampling (140 lines) should produce 75 transects per site

Site Description

Data collected in 2007 showed that site pairs were similar in habitat composition, with the exception of the Harris Point SMR and Castle Rock site pair. Noticeably different amounts of sand were present at the Harris Point SMR site when compared to the mostly rocky substrate found at Castle Rock.

Finfish Biological Data

The observed higher fish densities within SMRs relative to fished areas should not be interpreted to imply significance. This report intentionally excluded confidence bounds to avoid inference of statistical significance. Project staff are preparing a review to evaluate these density differences spanning 2004 through 2008. This review applies statistical analysis intended to clarify if observed differences are significant by treatment (within or outside MPAs) and across time.

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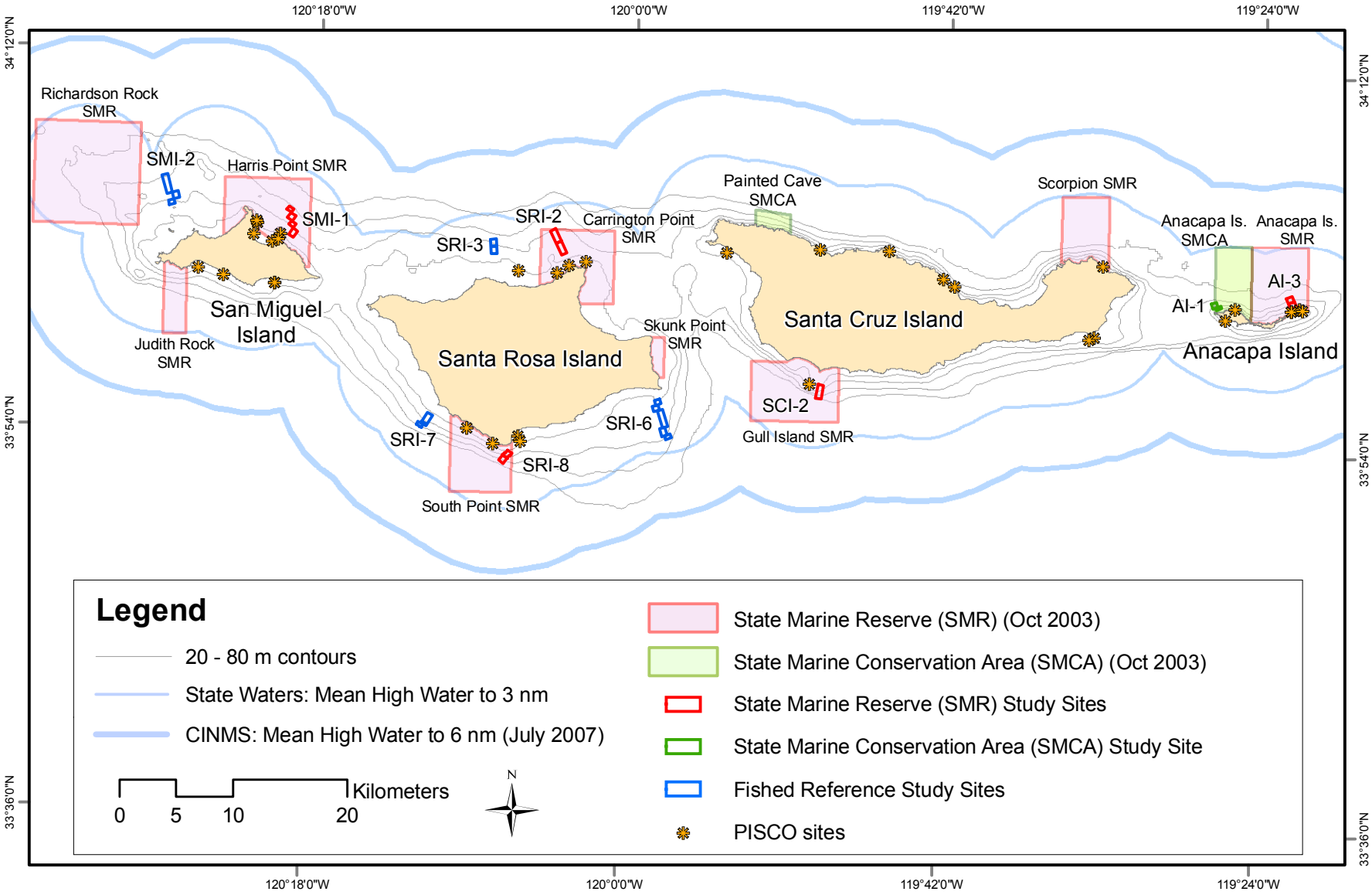

Figure 1. Location codes for sites surveyed in 2005, 2006 and 2007 relative to the five State Marine Reserves, the one State Marine Conservation Area and locations of PISCO SCUBA survey sites.

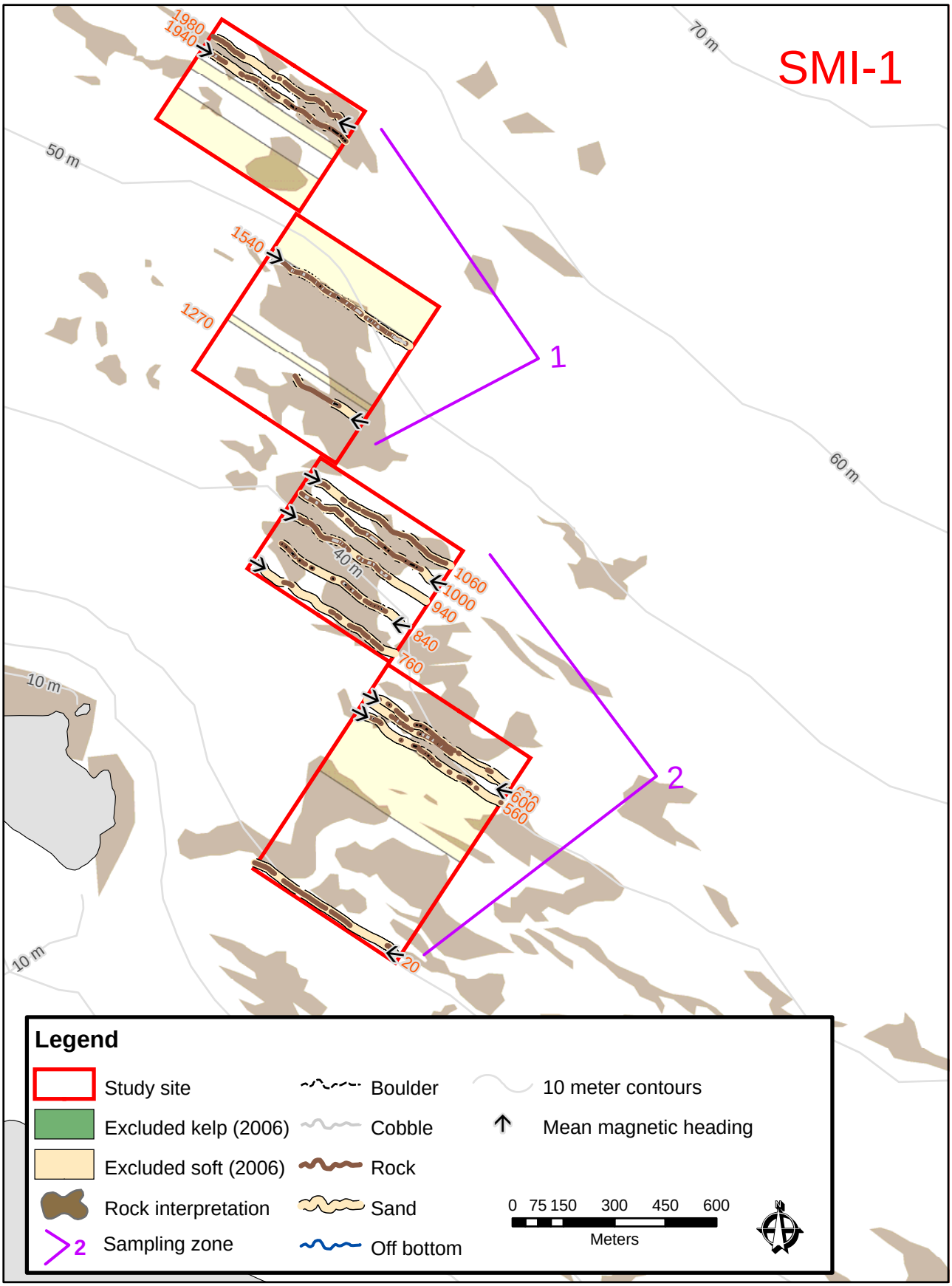

Figure 2. The Harris Point State Marine Reserve site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from USGS sidescan sonar mapping.

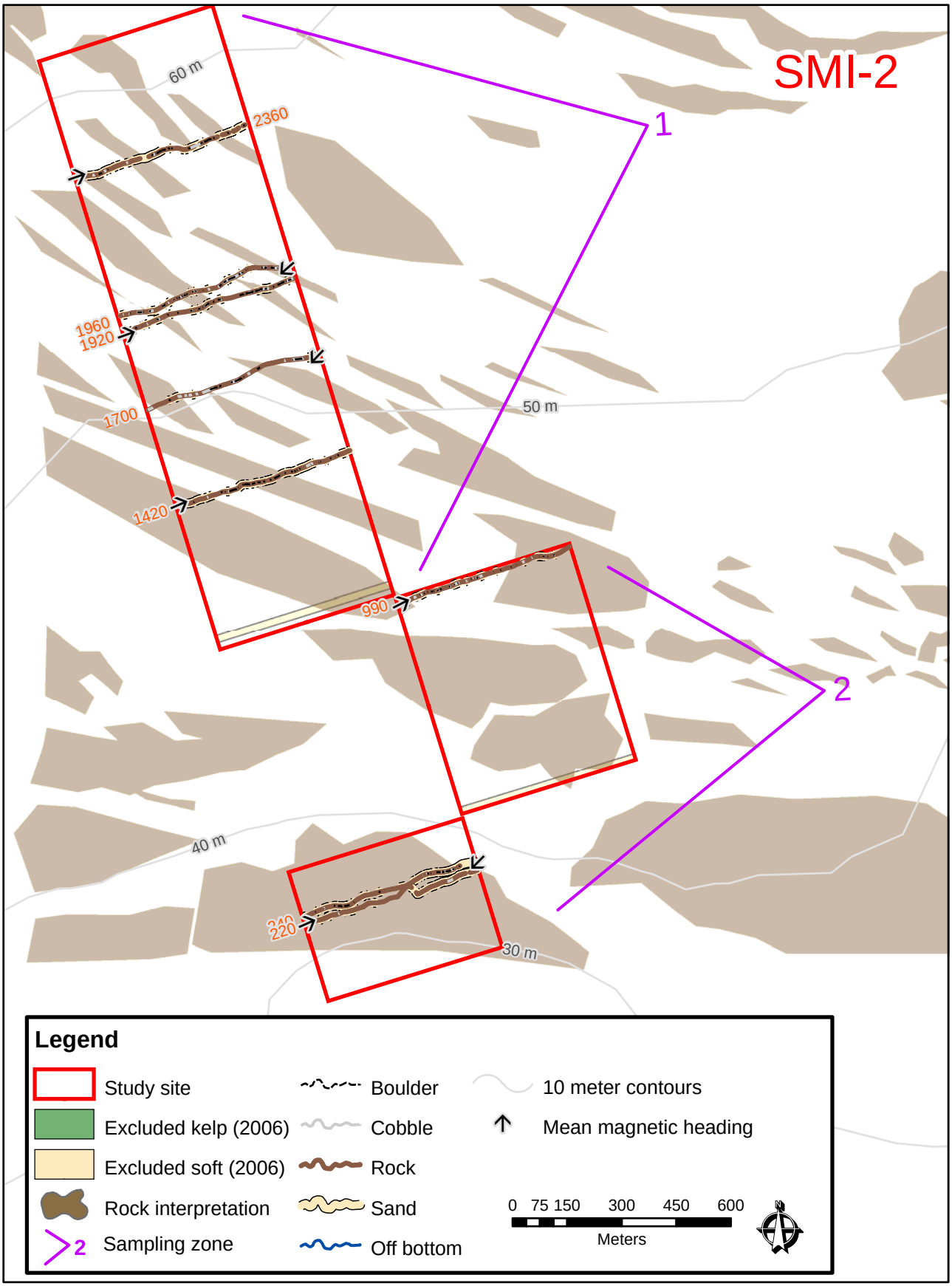

Figure 3. Castle Rock site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from USGS sidescan sonar mapping.

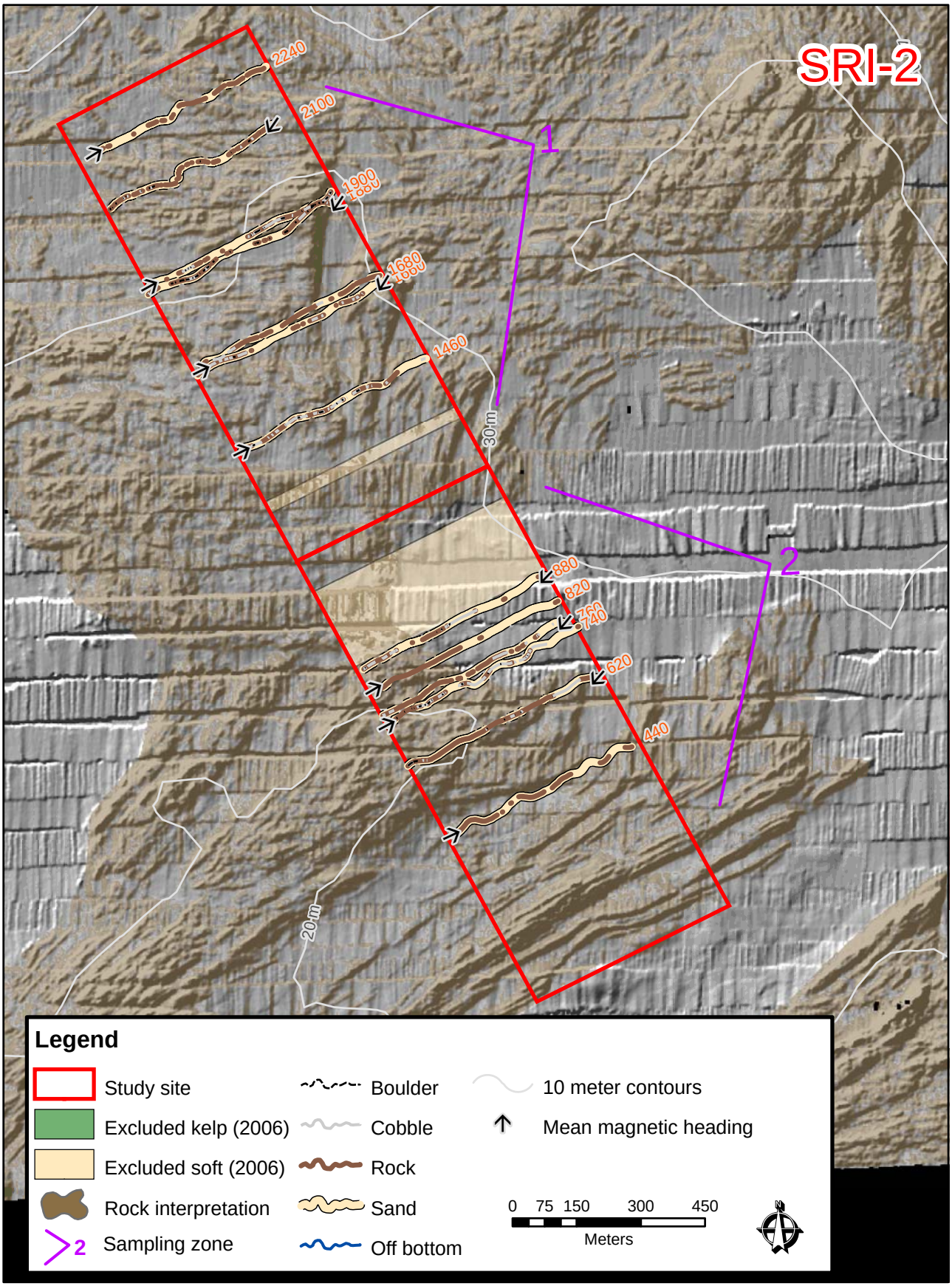

Figure 4. Carrington Point State Marine Reserve site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from CSUMB multibeam sonar mapping.

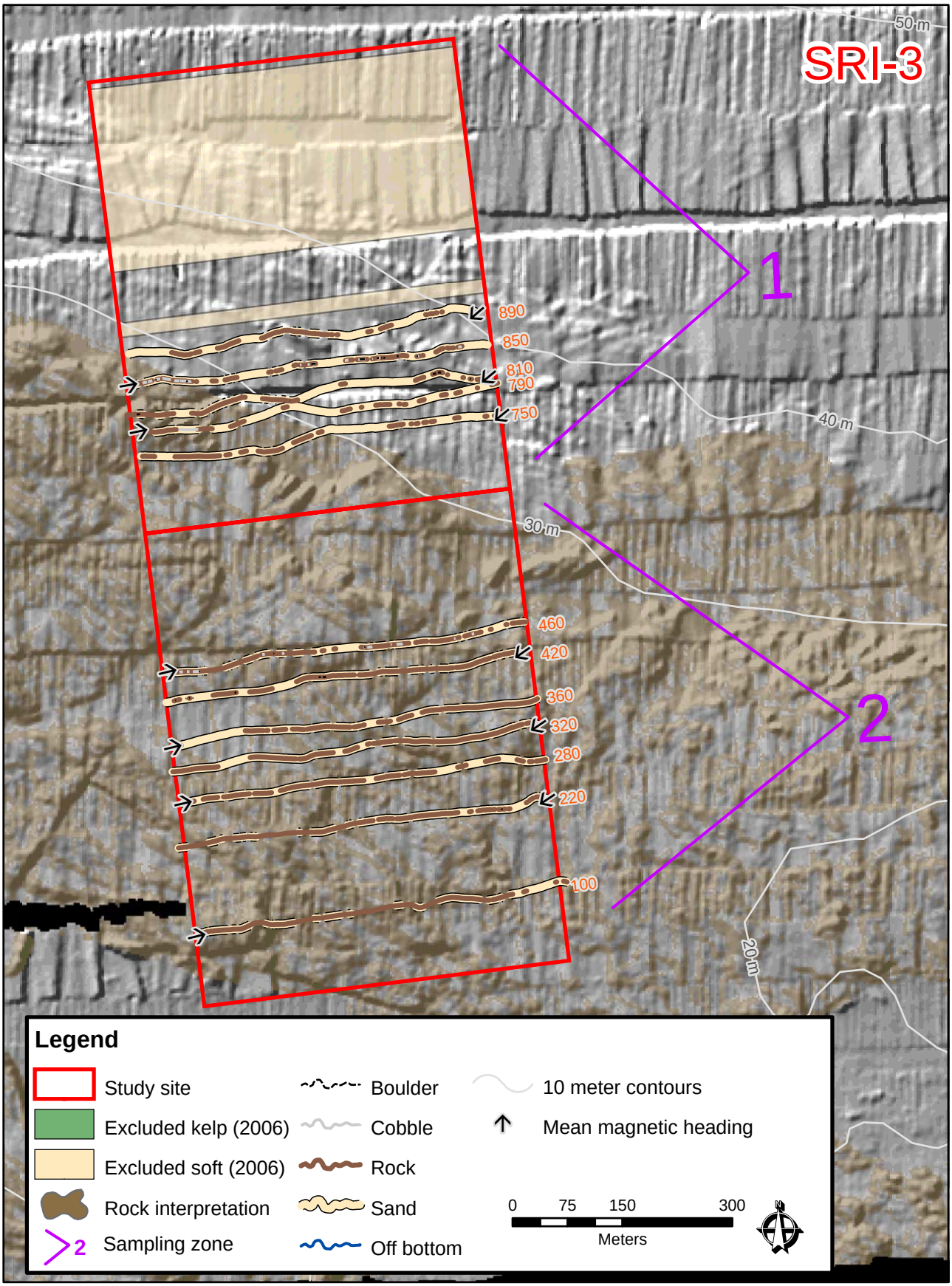

Figure 5. Rodes Reef site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from CSUMB multibeam sonar mapping.

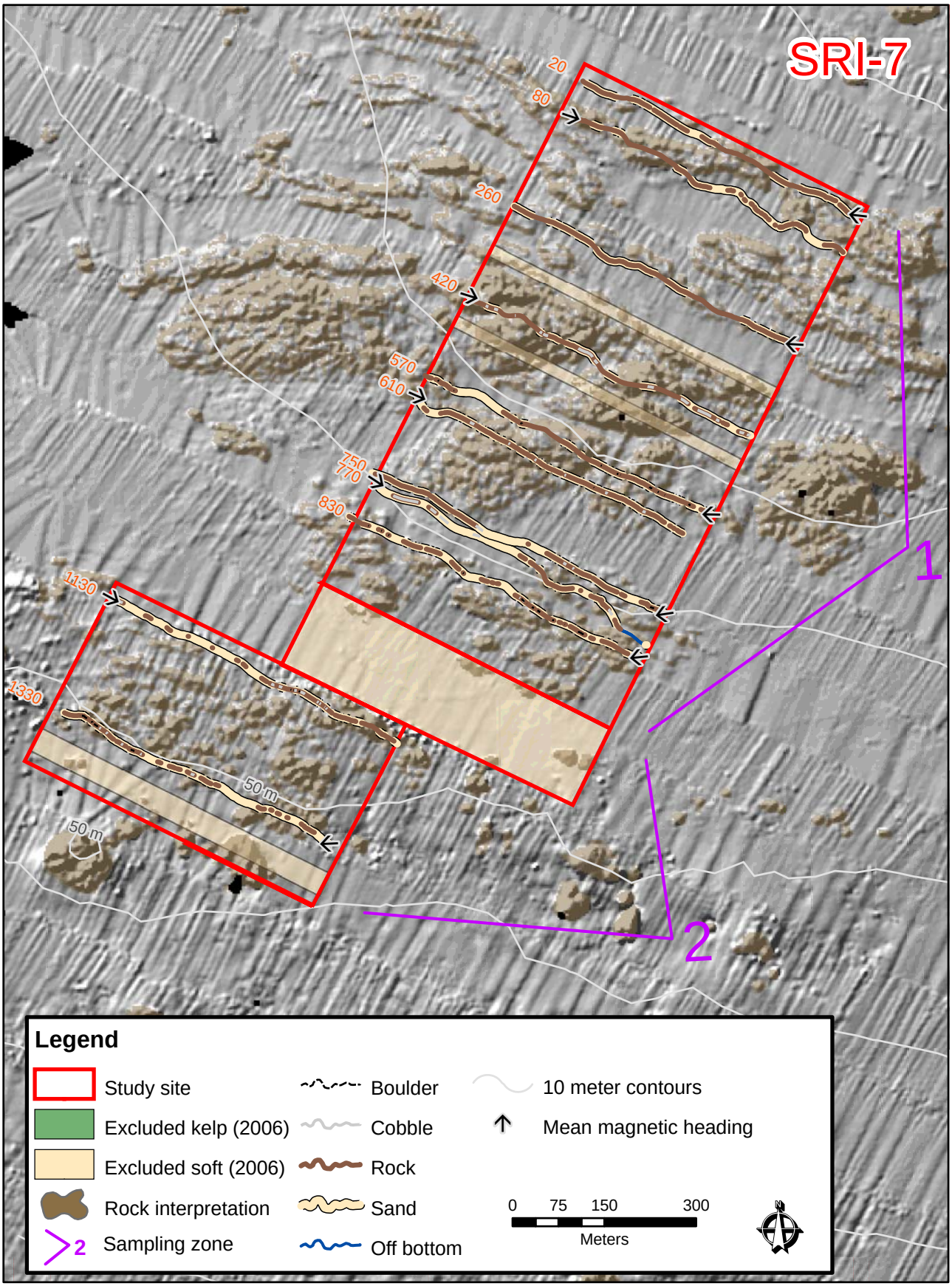

Figure 6. Cluster Point site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from CSUMB multibeam sonar mapping.

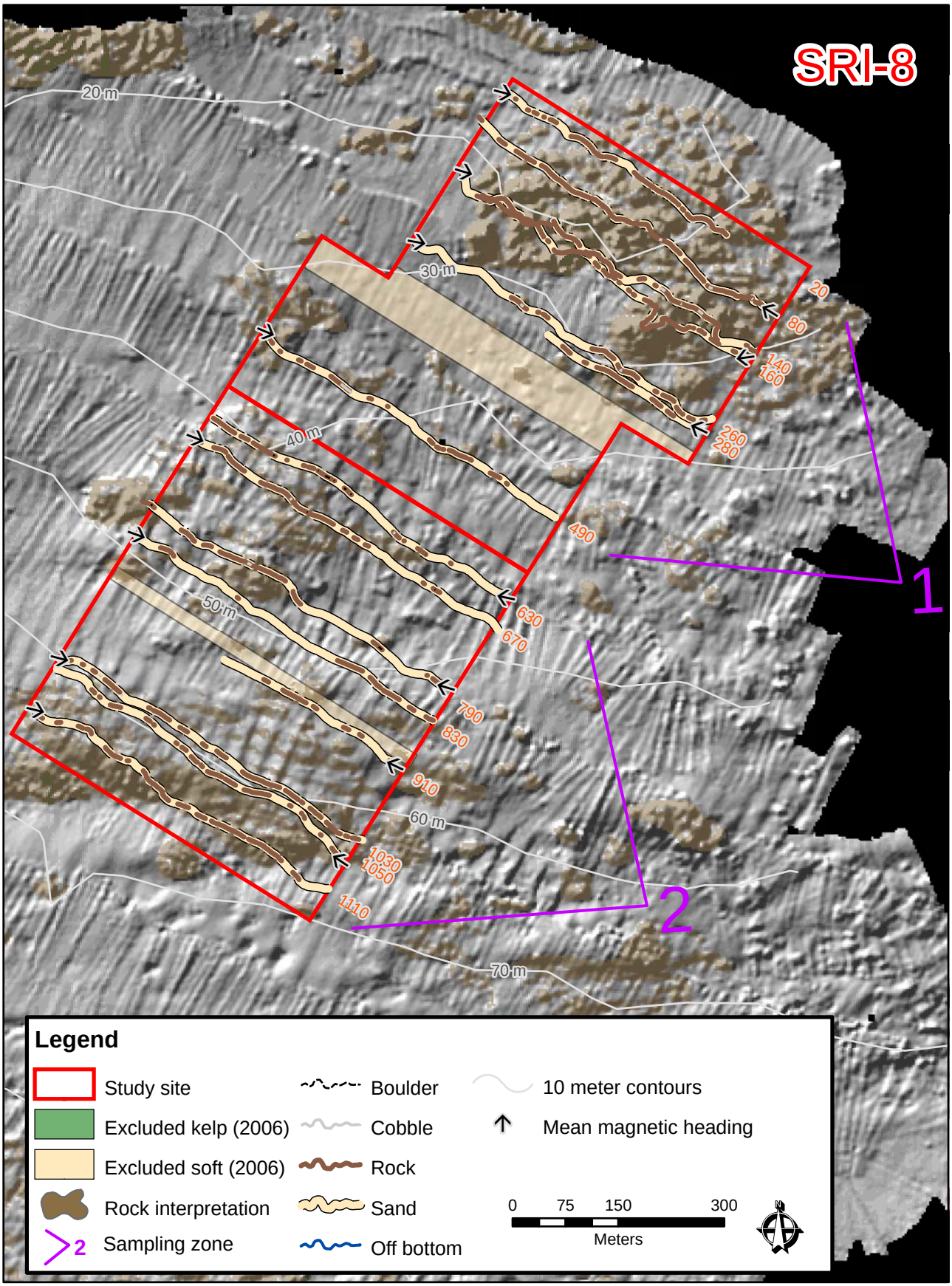

Figure 7. South Point State Marine Reserve site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from CSUMB multibeam sonar mapping.

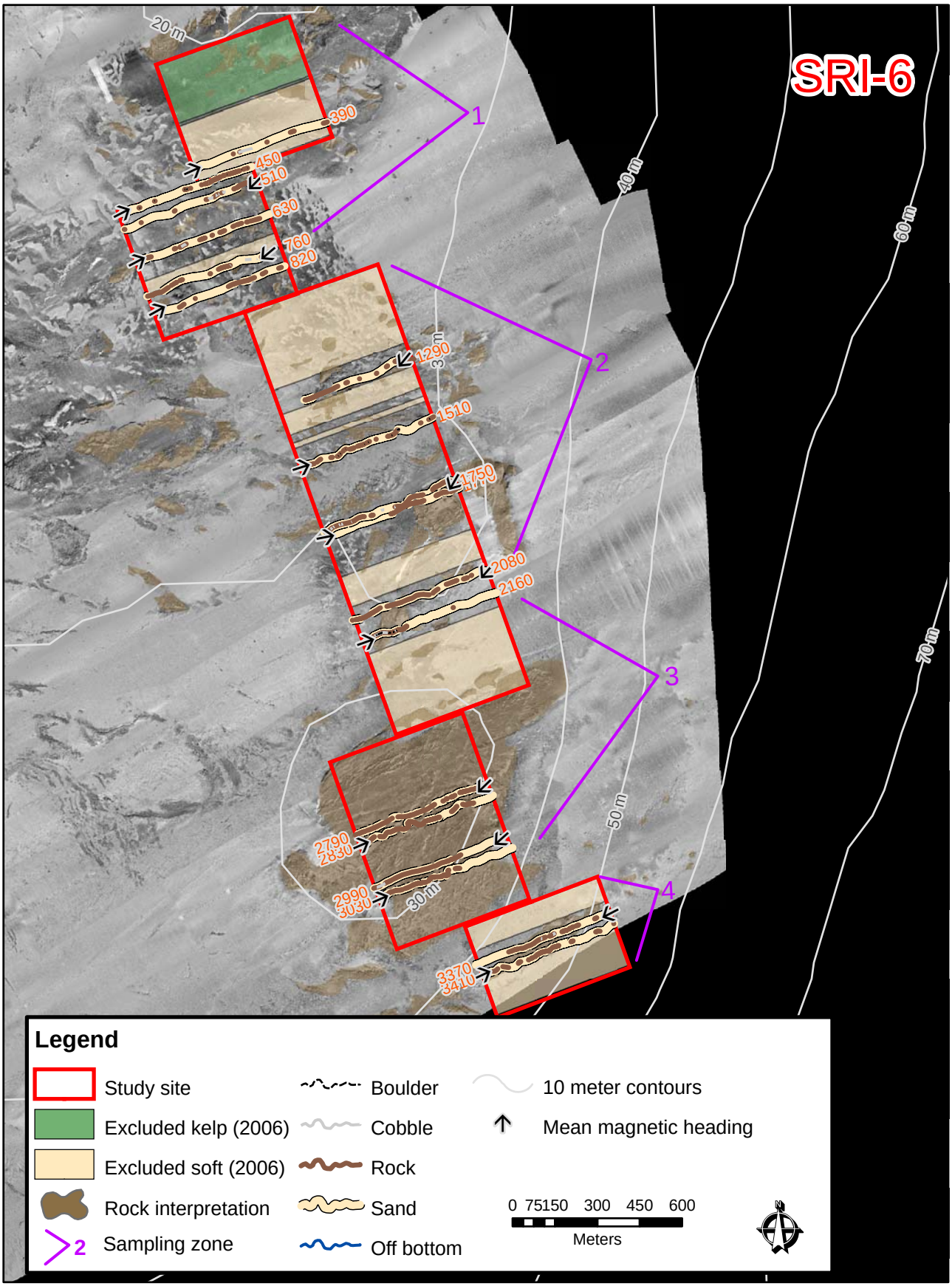

Figure 8. East Point site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from USGS sidescan sonar mapping.

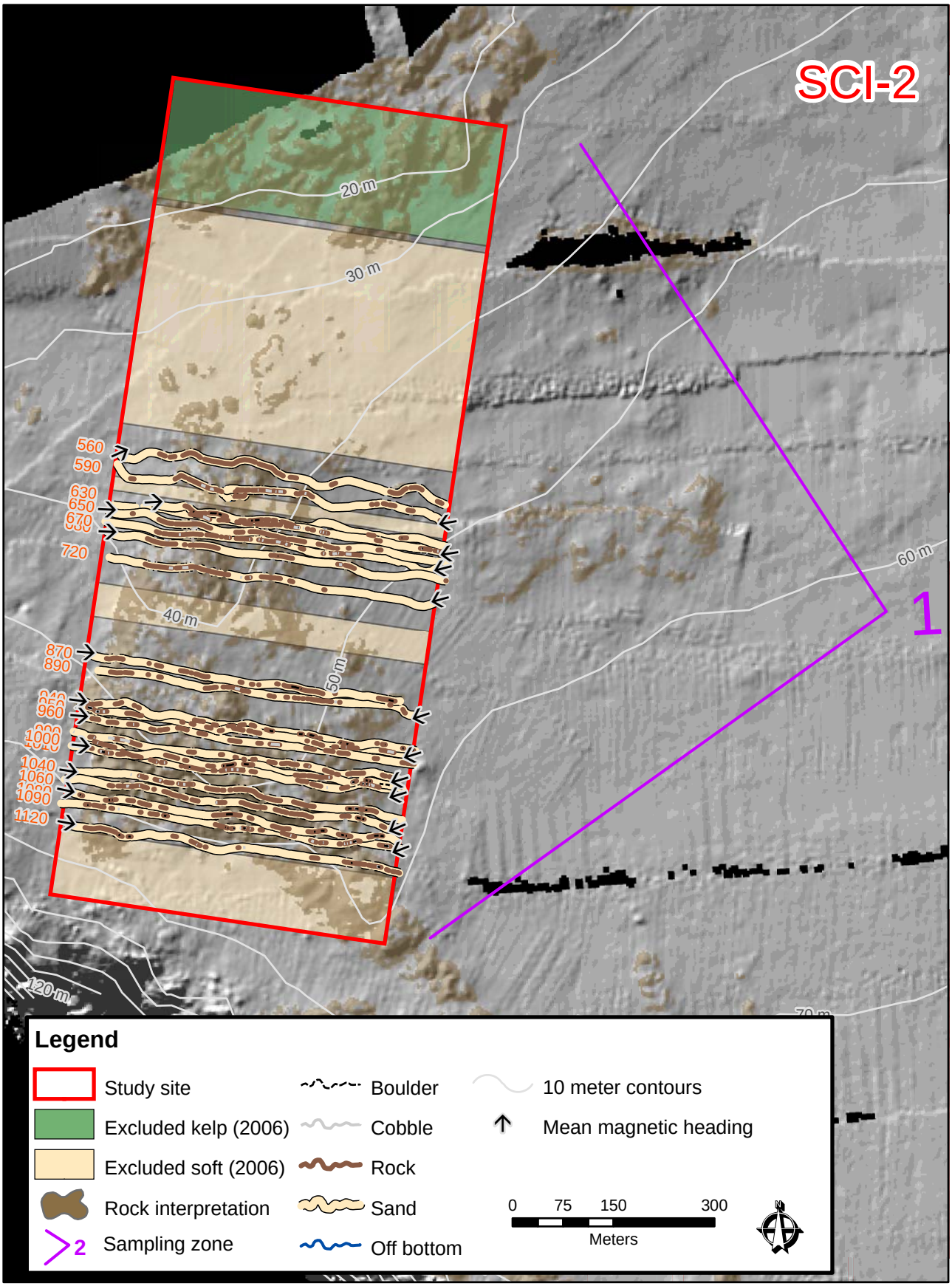

Figure 9. Gull sland State Marine Reserve site boundary, sampling zone, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from CSUMB multibeam sonar mapping.

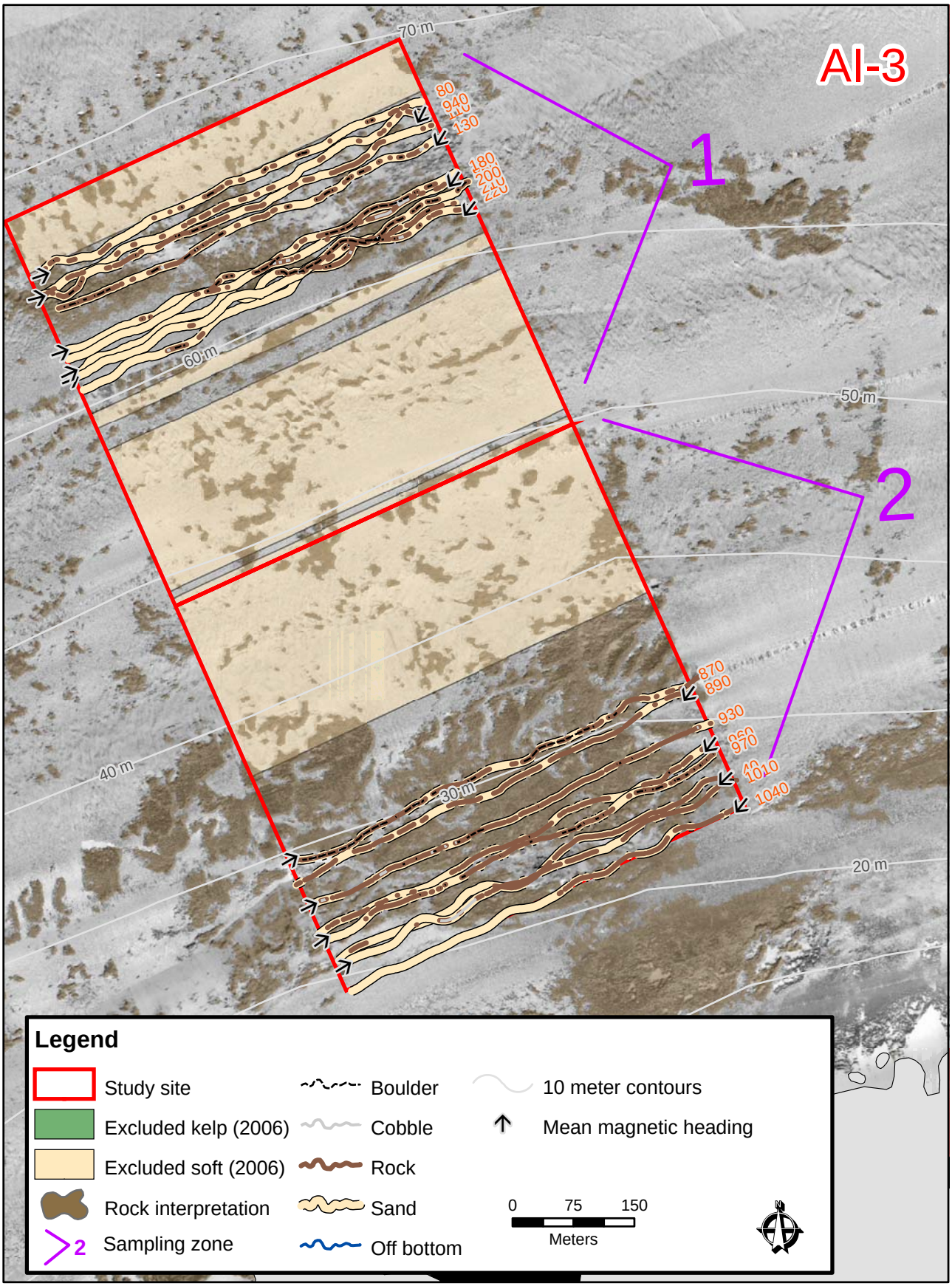

Figure 10. Anacapa Island State Marine Reserve site boundary, sampling zones, and track lines 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from USGS sidescan sonar mapping.

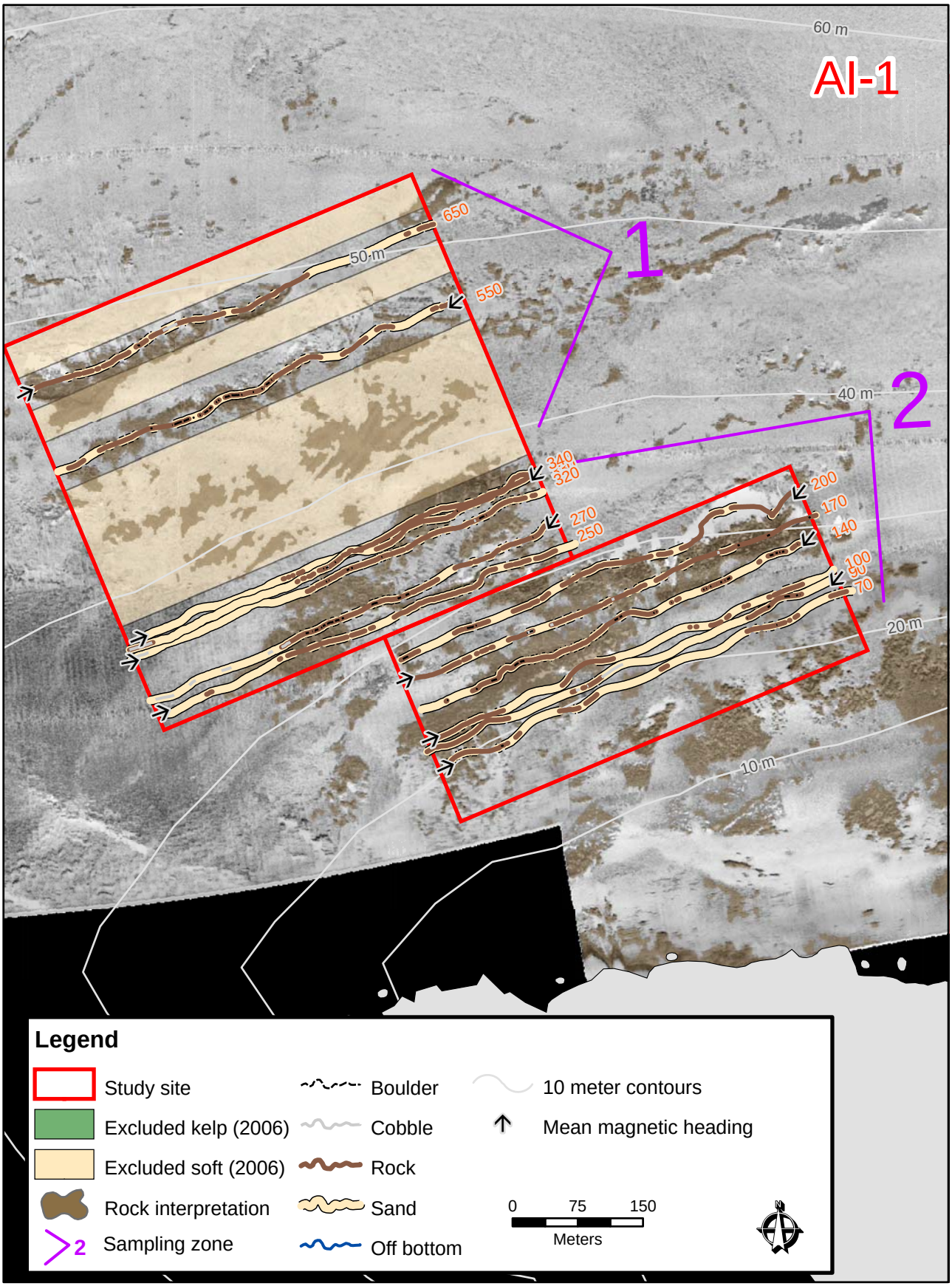

Figure 11. Anacapa Island State Marine Conservation Area site boundary, sampling zones, and track lines for 2007. The amount of boulder, cobble, rock, and sand are estimates from ROV video. The background rock is interpreted from USGS sidescan sonar mapping.

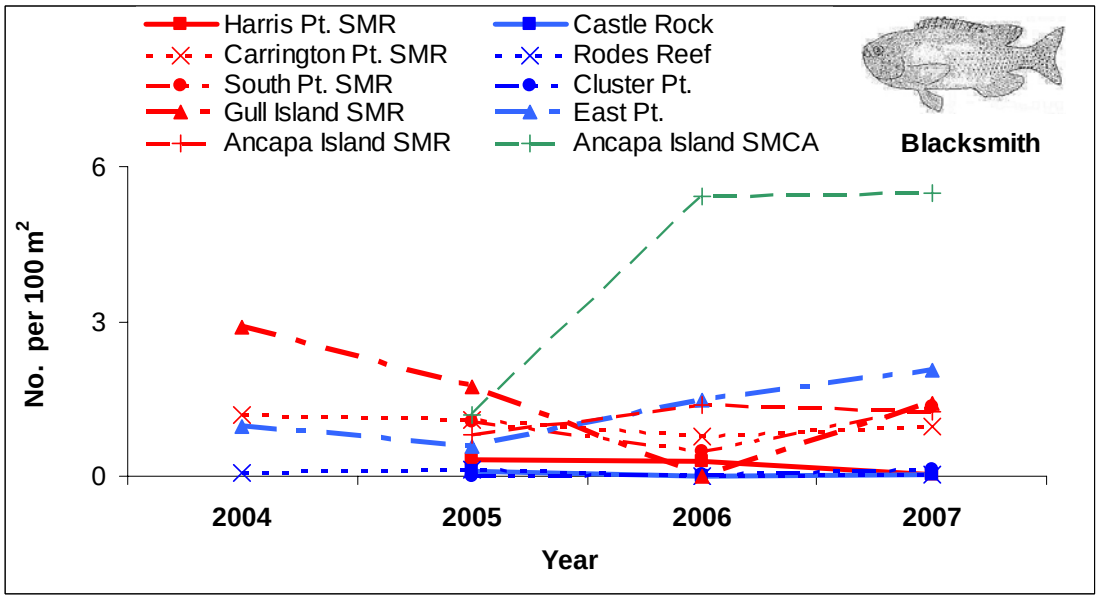

Figure 12. Density of blacksmith sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

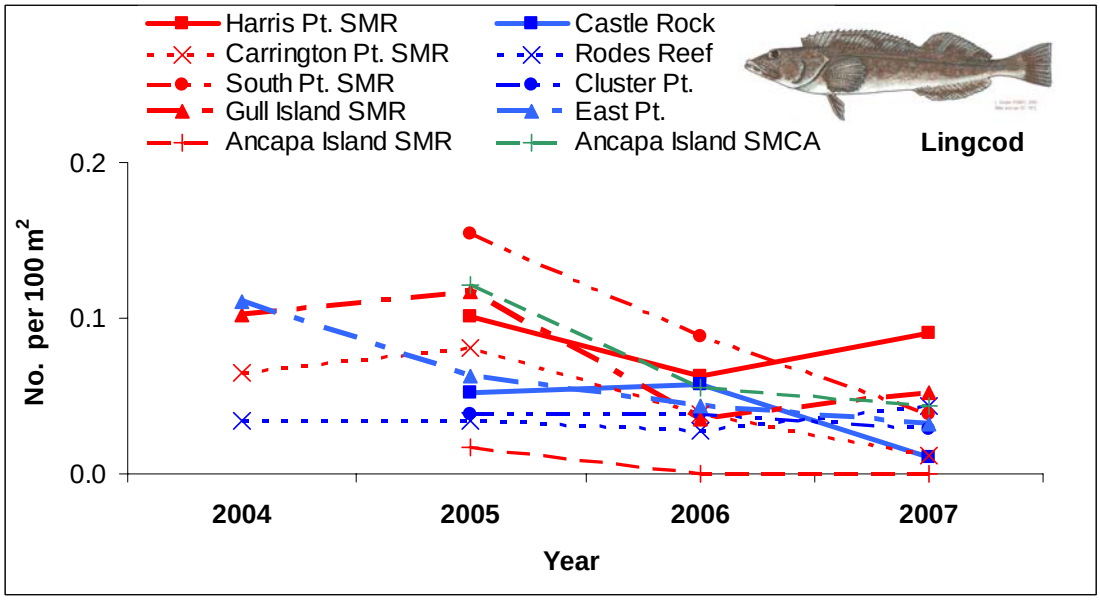

Figure 13. Density of lingcod sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

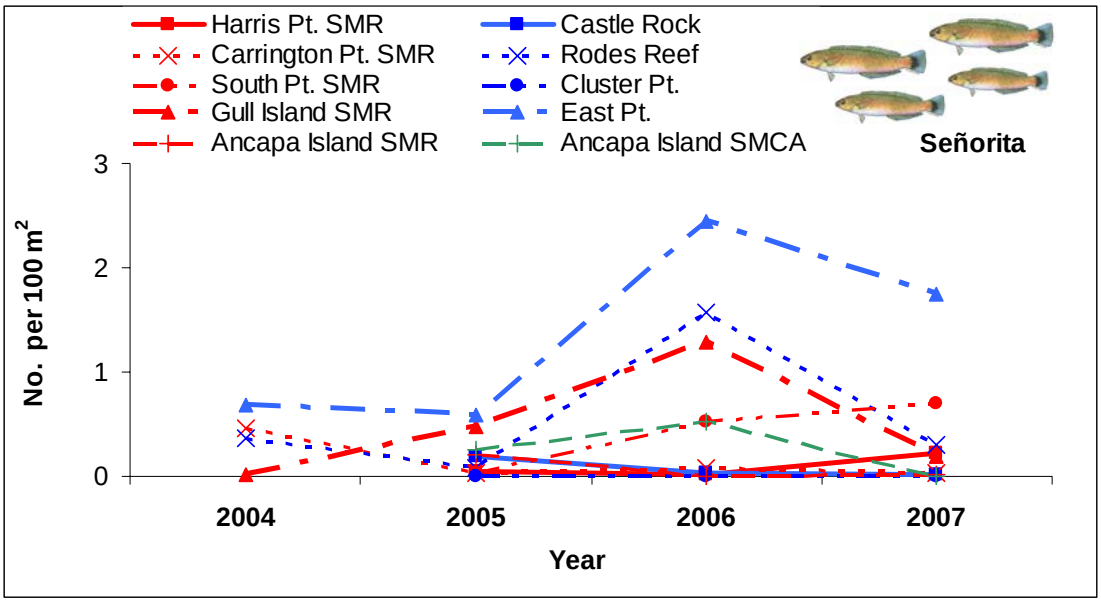

Figure 14. Density of señorita sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

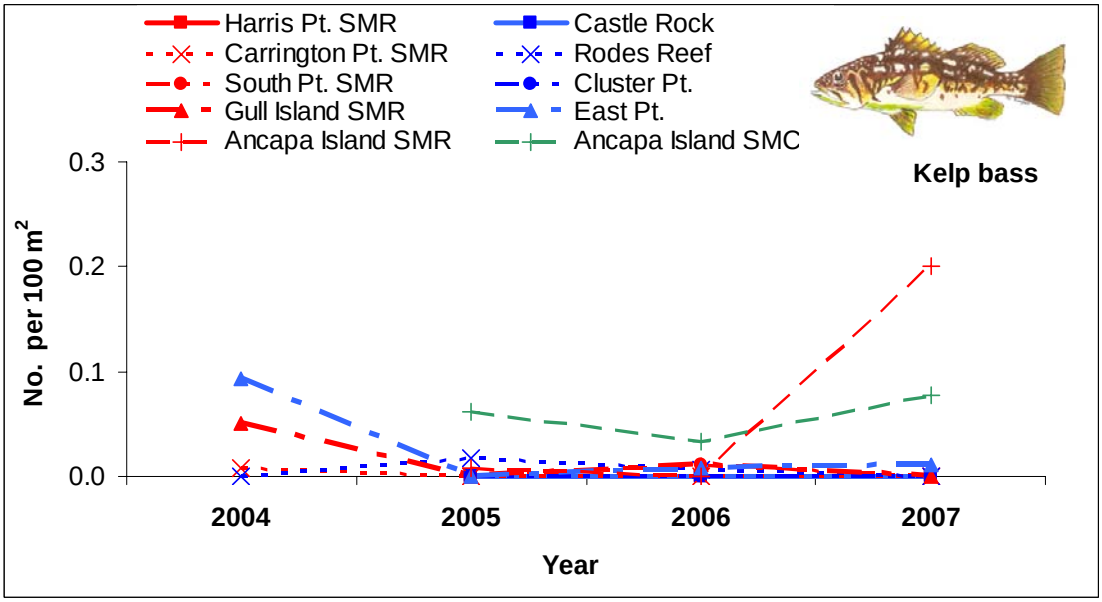

Figure 15. Density of kelp bass sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

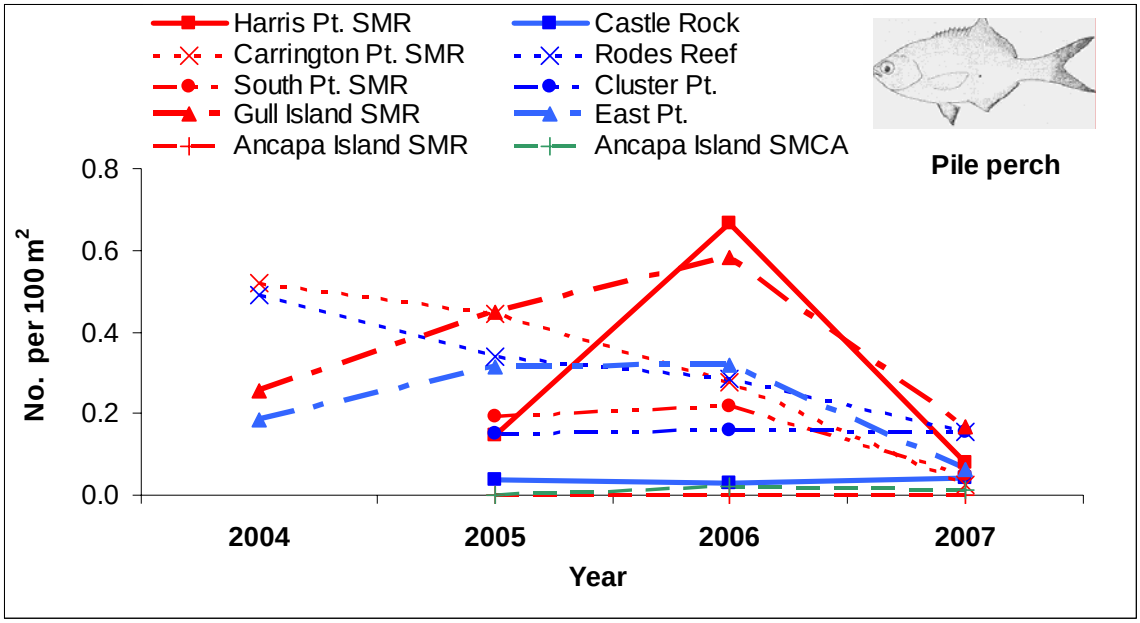

Figure 16. Density of pile perch sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

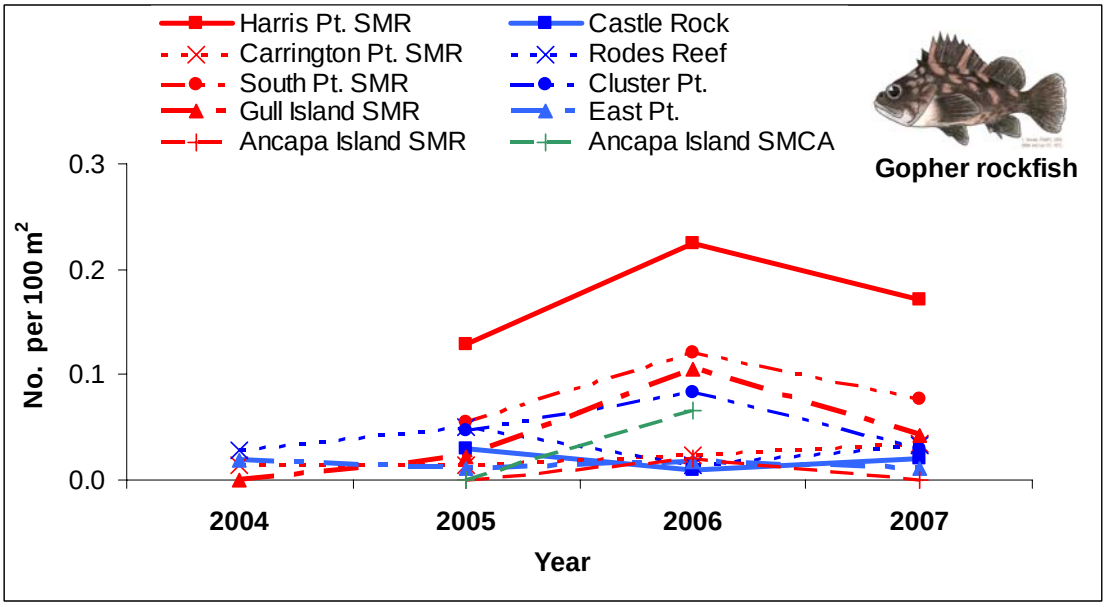

Figure 17. Density of gopher rockfish sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

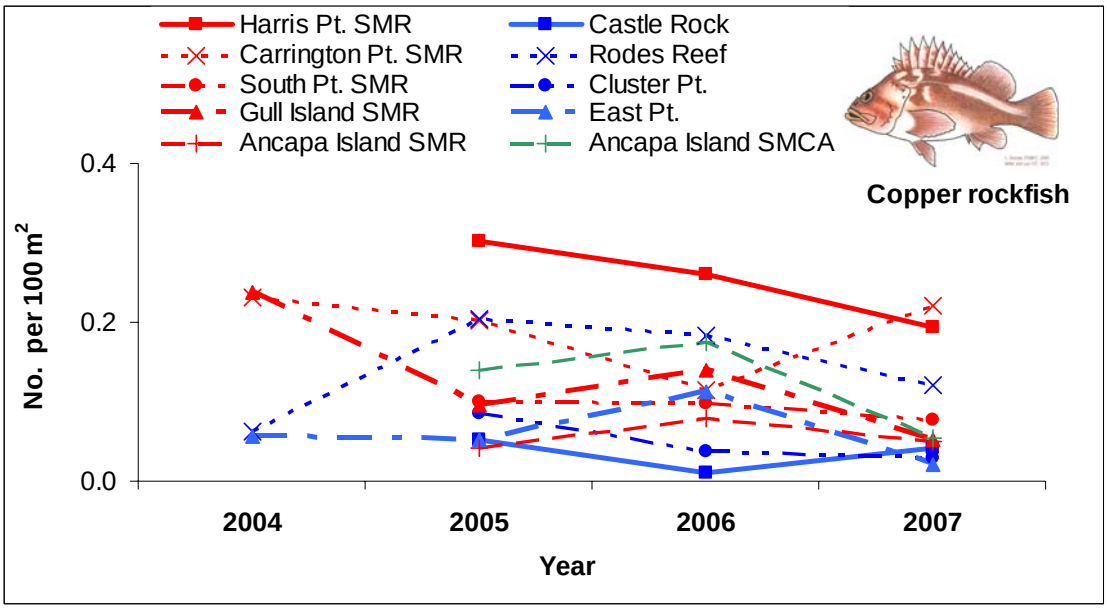

Figure 18. Density of copper rockfish sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

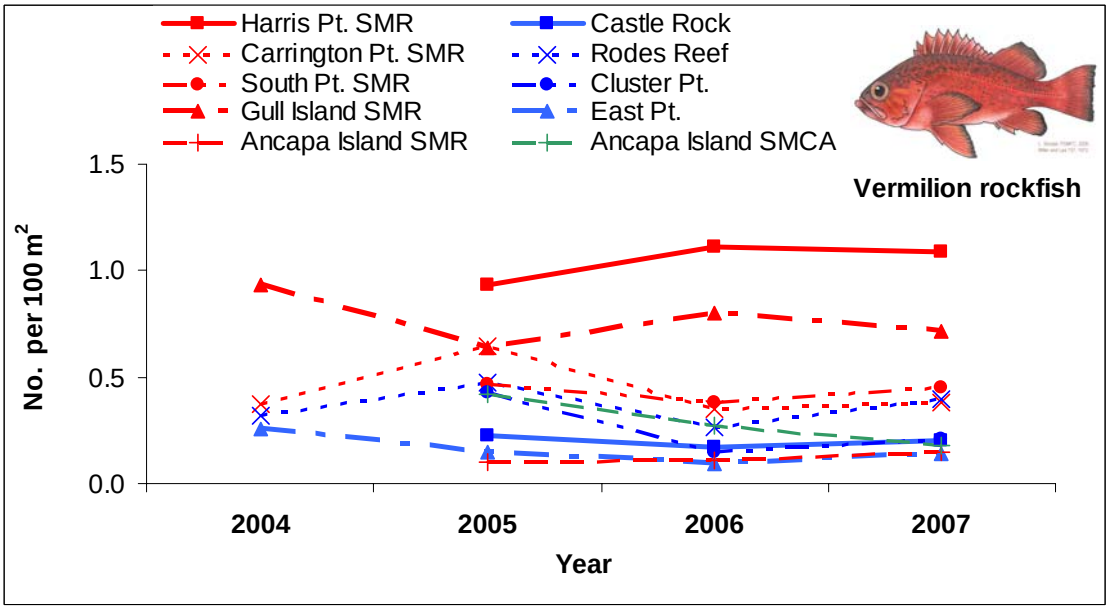

Figure 19. Density of vermilion rockfish sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

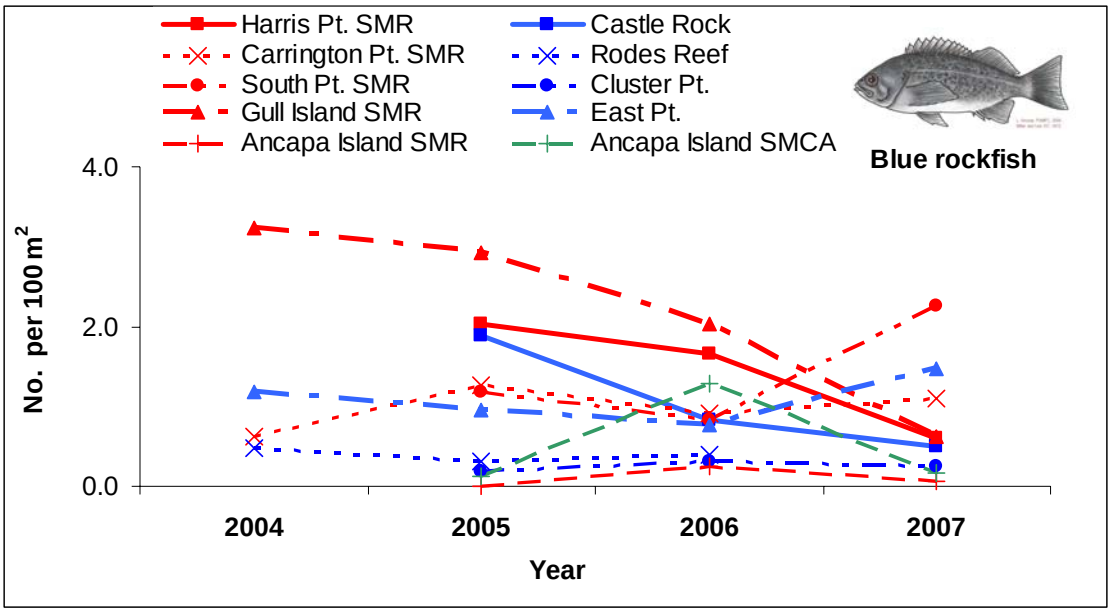

Figure 20. Density of blue rockfish sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

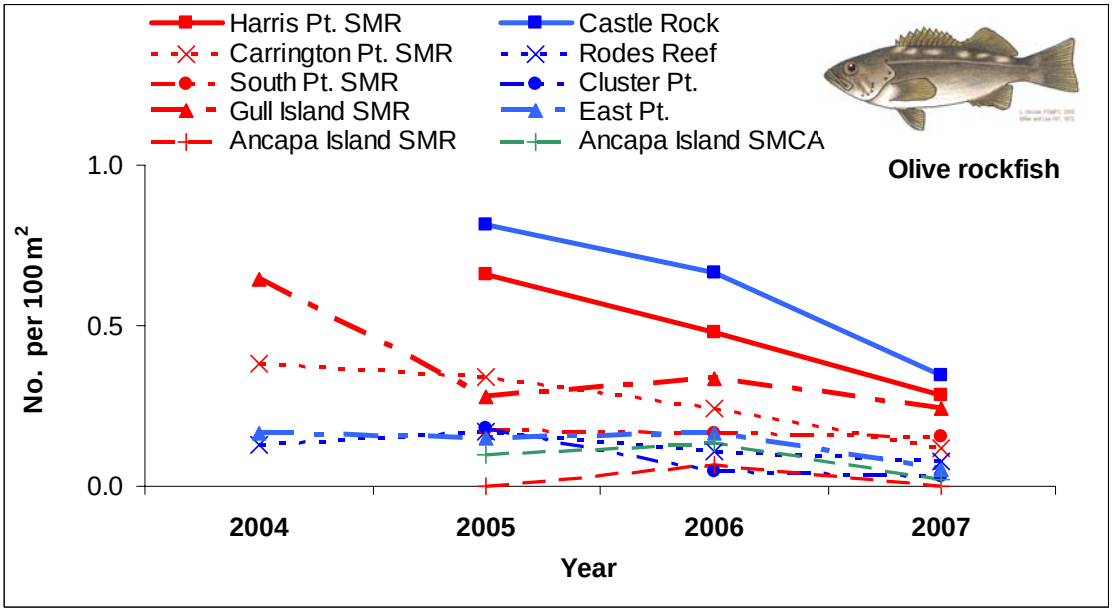

Figure 21. Density of olive rockfish sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

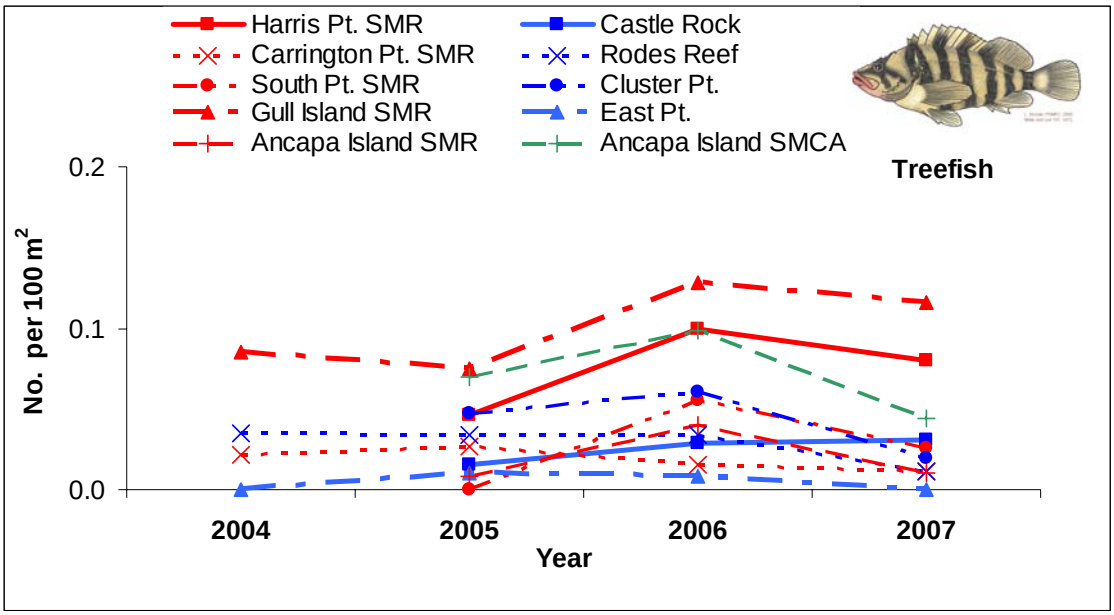

Figure 22. Density of treefish sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

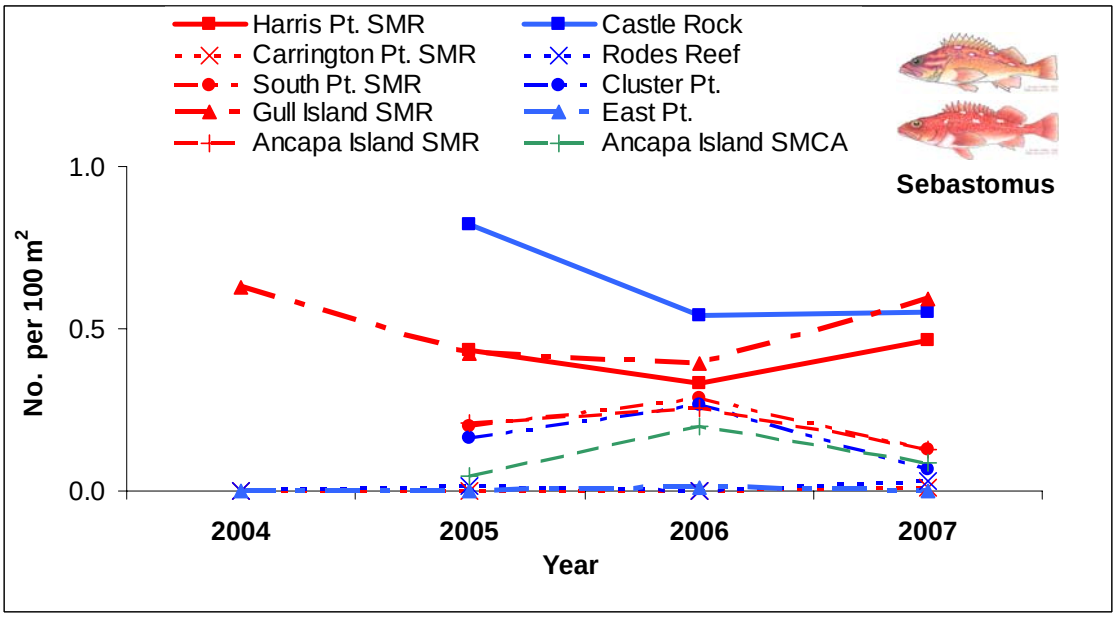

Figure 23. Density of sebastomus sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

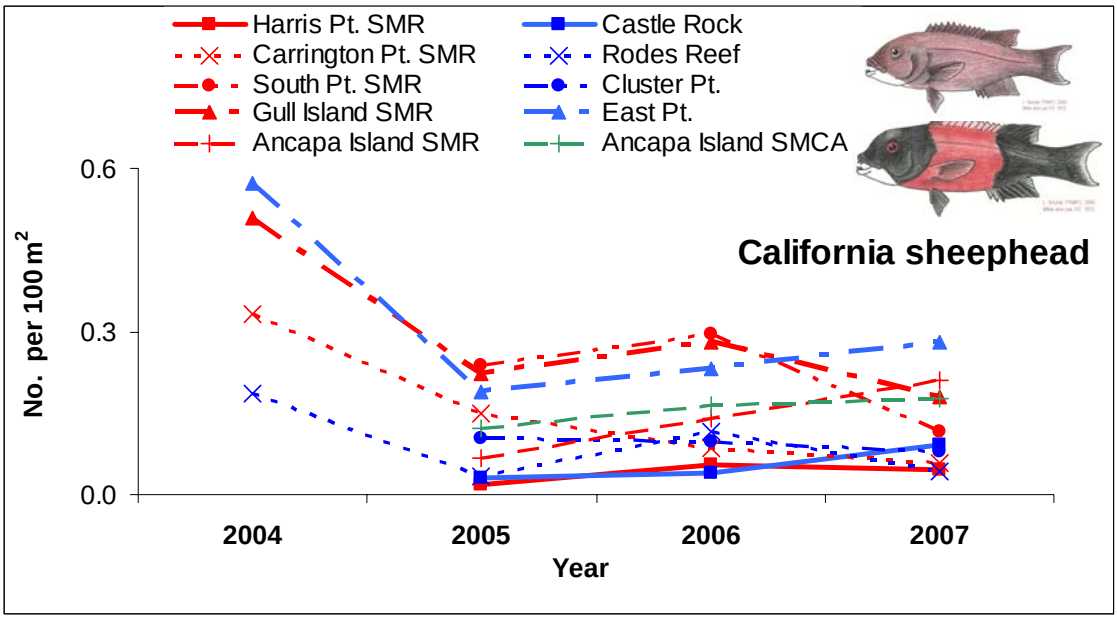

Figure 24. Density of California sheephead sampled from 2004 through 2007 by site. Only four of the ten sites were sampled in 2004. State Marine Reserves are **red**, fished **blue** and the State Marine Conservation Area **green.**

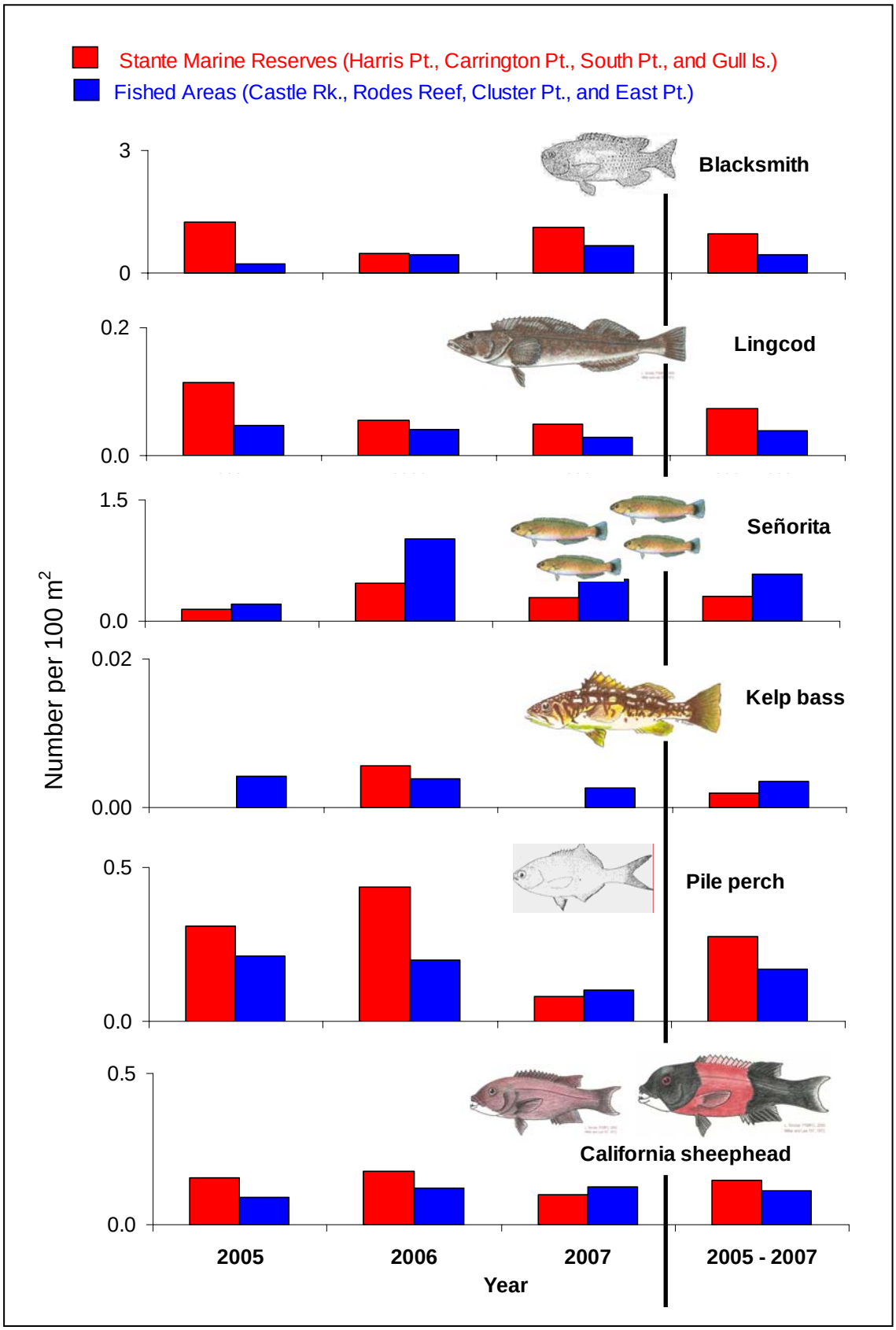

Figure 25. Average density of six finfish by year from 2005 through 2007 for combined sites. State Marine Reserves are **red** and fished areas in **blue.** Anacapa Island sites are not included.

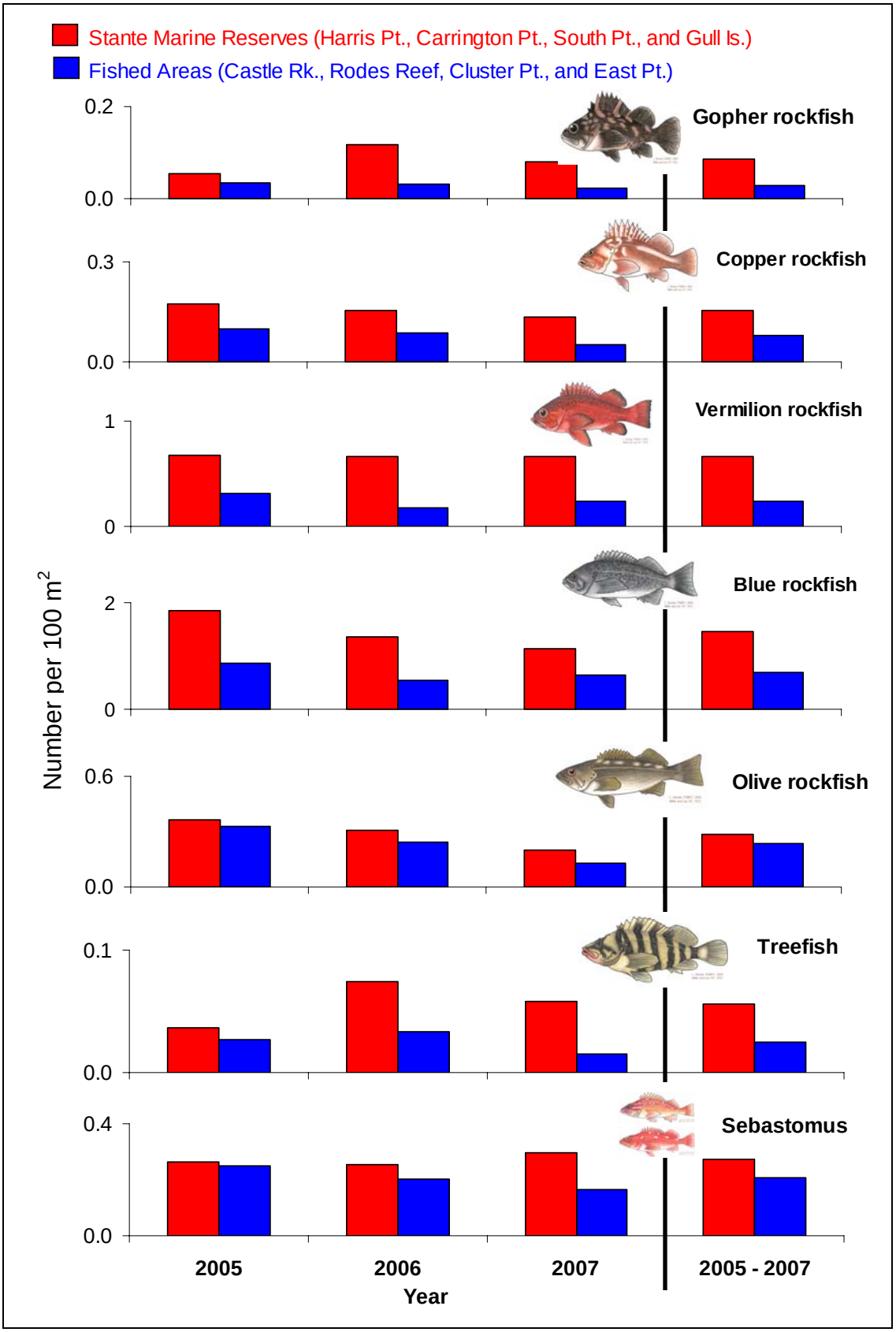

Figure 26. Average density of seven rockfish taxa by year from 2005 through 2007 for combined sites. State Marine Reserves are **red** and fished areas in **blue.** Anacapa Island sites are not included.

Appendix 1. Kilometers surveyed by the ROV at both exploratory and quantitative sites from 2003 to 2007.

Island Site Name	Site Code	Nov 2003	May 2004	Sep 2004	Aug-Oct 2005	Aug-Oct 2006	Aug-Oct 2007
San Miguel Island							
Harris Point SMR	SMI-1	--	--	--	15	8	7
Castle Rock	SMI-2	--	--	--	10	5	4
Santa Rosa Island							
Carrington Point SMR	SRI-1	2	--	--	--	--	--
Carrington Point SMR	SRI-2	2	--	12	7	8	7
Rodes Reef	SRI-3	2	--	12	6	8	6
Cluster Point	SRI-4	1	--	--	--	--	--
South Point SMR	SRI-5	1	--	--	--	--	--
East Point	SRI-6	--	4	12	12	11	9
Cluster Point	SRI-7	--	--	--	10	9	6
South Point SMR	SRI-8	--	--	--	13	8	8
Santa Cruz Island							
Gull Island SMR	SCI-1	4	--	--	--	--	
Gull Island SMR	SCI-2	4	--	12	13	11	11
Bowen Point	SCI-3	2	--	--	--	--	--
Blue Banks Arch	SCI-4	--	3	--	--	--	--
Anacapa Island							
Anacapa SCA	AI-1	--	3	9	12	9	7
Anacapa SMR	AI-2	--	3	--	--	--	--
Anacapa SMR	AI-3	--	3	--	19	8	9
Arch Rock	AI-4	--	3	--	--	--	--
	Total	18	18	57	117	85	74

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Appendix 2. ROV data collection and post-processing complete methods for 2007.

ROV Equipment

The basic ROV equipment used was similar to that described by Veisze and Karpov (2002) with some improvements. The ROV used in this study was a Deep Ocean Engineering model Phantom® HD 2+2[1]. The ROV was equipped with a three-axis autopilot including a rate gyro-damped compass card. Together, these allowed the pilot to maintain a constant heading (± 1 degree) and constant depth (± 0.3m) with minimal corrections. In addition, a forward cruise control was added to help the pilot maintain a constant forward velocity.

A Trackpoint II® acoustic positioning system was used to reference the ROV position relative to the ship's Wide Area Augmentation System GPS (WAAS GPS). WAAS GPS has an accuracy of 3.2 m (Wilson unpublished http://www.users.erols.com/dlwilson/gpswaas.htm). The Trackpoint II® calculated the XY position of the ROV at approximately two-second intervals. The position was recorded in meters as X and Y using the WGS 1984 UTM coordinate system in both ARC VIEW® 8.4 and HYPAC® navigational software. Measurements of ROV heading and depth, water temperature, camera tilt, and sonar distance both forward and downward to the substrate were averaged over a one-second period and recorded by HYPAC®.

The ROV was equipped with two color cameras, one facing forward and set approximately 20^{o} below the horizon and the other pointing downwards at 85^{o}. The two-camera system provided a continuous, slightly overlapping view forward and downward. Digital video for both the forward and down facing cameras was captured using SONY® DSR 45s and Pioneer DVR510s. Data collection protocols require a minimum of 3 m of water visibility. In addition to capturing biological and habitat observations, the forward video captured redundant onscreen recordings of time code, depth, temperature, range, forward camera angel, and heading.

GPS time was used to provide a basis for linking position, field data, and video observations (Veisze and Karpov 2002). A Horita® GPS3 and WG-50 were used to generate on screen displays of GPS time, as well as output audio time code data for capture on SONY® DSR audio tracks at an interval of 1/30th of a second. This method was improved by customizing HYPAC® navigational software to link all data collected in the field to the GPS time. ROV tracked position and sensor data was recorded directly by HYPAC® as a time-linked text file. A redundant one-second time code file of sensor data was also collected in the field using Deep Oceans HD2 OSD® operating system software with time code extracted from the system's internal clock.

[1] Use of trade names does not indicate an endorsement of any product by the California Department of Fish and Game.

All data collected by the ROV, along with subsequent observations extracted during post-processing of the video, were linked in a Microsoft Access® database using GPS time. Data management software was developed to expand all data records to one second of GMT time code. During video post-processing, a Horita® Time Wedge (model number TCW50) was used in conjunction with a computer to record the audio time code in a Microsoft Access® database.

ROV Sampling Operations

Individual ROV dives were limited to approximately 2 hours (3 km) each due to DVD recording capability. When 2 hours of DVD recording was reached, a new dive was initiated, often while the ROV remained on the seafloor. Surveys were conducted between the hours of 0800 and 1700 PST to avoid twilight conditions that might affect fish abundances.

At each site, the ROV was flown along pre-planned track lines, targeting ± 10 m of the line. GPS time was recorded on each video frame (1/30th sec) and on an audio track using methods developed by Veisze and Karpov (2002). ROV sensor data for water depth, temperature, ROV heading, ranging sonar, and camera tilt angle were also recorded. A pair of Tritech® 500 kHz ranging sonars, which measure distance across a 0.1–10 m range using a 6° conical transducer, was added in 2003 to replace paired lasers as the primary method for measuring transect width. The ranging sonars were secured to both the forward and downward facing cameras and measured the distance from the camera to the sea floor. Readings from these sonars were averaged five times per second and recorded at a one-second interval with all other sensor data.

The ROV was flown off the vessel's stern using a "live boat" technique that employed a 227 kg (600 lb) clump weight. Using this method, all but 40 m of the ROV umbilical was secured from current-induced drag by coupling it with the clump weight cable and suspending the clump weight at least 10 m off the bottom. The 40 m tether allowed the ROV pilot to maintain a constant speed (0.5 to 0.75 m/sec) and a straight course down the planned line by using the location of the ship, the ROV and its calculated speed, and the track line displayed on shipboard monitors. The ship's captain also used the displays to maintain the position of the ship within 30 m of the ROV. Three ridged foam floats were affixed to the 40 m tether to help keep the umbilical off the ocean floor and prevent snagging in high relief areas.

Track line width on the forward camera was calculated using the ranging sonar fixed below and parallel to the camera between two forward-facing red lasers spaced 110 mm apart. Measurements of transect width using a ranging sonar are accurate to ± 0.1 m (Karpov et al. 2006). The ROV pilot used the sonar reading to sustain a transect width between 2 and 4 m by maintaining the distance from the camera to the substrate (at the screen horizontal mid-point)

between 1.5 to 3 m. Transect width was computed each second based on the camera field of view as 1.3 times the ranging sonar distance.

Site and Track Line Selection

With the aid of acoustic survey maps (sidescan and multibeam), study areas were selected inside and outside of marine reserves. Each area located within marine reserves was paired with a reference area located outside but not immediately adjacent to the reserve boundaries. Where possible, sites were selected offshore of Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) sites sampled by SCUBA. The reference sites were chosen based upon comparable criteria which included: distance to port, exposure, habitat (rocky substrate) and depth range. In order to cover patchy rock outcroppings, some sites were broken into adjoining 500 m wide rectangular zones.

Within each zone, GIS-based track lines for the site were randomly selected and placed across the width of each site parallel to the prevailing depth contour and bathymetry. The locations of the track lines were chosen by selecting random numbers, rounded to the nearest 10 m, from zero to the total length of the site in meters from shallow to deep. Numbers that did not produce line spacing of ≥ 20 m were rejected. This approach avoids overlapping of adjacent lines that are typically navigable within ± 10 m (Karpov et al. 2006). Track lines were numbered according to the distance along the site boundary running from shallow to deep.

To ensure that the sampling was distributed across the entire depth range, each site was divided into zones. Zones were structured depending on the site's depth and habitat composition. The total number of track lines selected within each zone was dependent on the size of the zone.

The number of 500 m lines selected at each site was determined based on available habitat data and a 10% buffer was added to allow for sampling losses (e.g., being pulled off course by the boat, flying too high off the bottom, temporary equipment failure, etc.). In case the amount of hard and mixed substrate was underestimated, additional auxiliary lines were randomly pre-selected and sequentially labeled. Thus, if the number of transects needed to be increased, a subset of the randomly selected lines could be added to each zone.

Areas determined to be mostly sand were excluded during the placement of random transect lines. These areas were defined from existing multibeam or sidescan sonar data and also by overlaying data from previous ROV surveys completed within the study site (Karpov et al. 2005a).

Two approaches were adopted to assess the amount of usable substrate and track line while at sea. First, a technique was applied to estimate in real-time the amount of soft-only substrate for track lines while sampling (Bergen et al. 2006).

During the survey of each line, the data officer recorded the total time spent over soft-only substrate, which was divided by the total time to survey the entire track line. Assuming constant velocity, this approximated post-processed estimates based on actual tracked distance. Real-time estimates allowed us to adjust the number of track lines surveyed by site to meet our sampling goals. The second approach adopted was to review the tracking data at the end of each sampling day for content and quality. If the quality was compromised, lines were repeated later in the survey.

Post-Processing

Following the survey, positional data was post-processed to produce the final track lines. Positional information, in the form of XY metric coordinates, was filtered for outliers and smoothed using a 21-point running mean (Karpov et al. 2006). The distance formula was used to calculate planar length tracked per second and combined with width to calculate area tracked per second. Gaps in the tracking data that occurred due to deviations from quantitative protocols, such as pulls (ROV pulled back by tension on the 40 m tether), stops (ROV stops to let the boat catch up which affects tracking) or backsides of high relief structures (visual loss of 4 m target distance for more than 6 seconds which typically occurs on the downward slope of high relief habitat) were removed from the data prior to transect computation.

The remaining usable portions of the line were then divided into 25 m^2 segments (subunits). Component subunits were typically 8 to 10 m in length with a transect width averaging approximately 3 m. Each subunit's total percent hard and/or mixed habitat was then calculated and those with percentages below 50% were removed. The remaining subunits were concatenated into 100 m^2 transects (four sequential useable 25 m^2 subunits) for use in density calculations. A spacer subunit was discarded between each to avoid bias of contiguous transects. Using this method for generating transects has allowed us to focus on rocky substrate without the loss of rock/sand interface habitat.

Substrate and Habitat

Substrate classification used during post-processing was simplified from Green et al. (1999). The video record was reviewed and substrate types encountered were classified independently as rock, boulder, cobble, or sand. Rock was defined as any igneous, metamorphic, or sedimentary substrate; boulder as rounded rock material that is between 0.25 and 3.0 m in diameter and clearly detached from the base substrate; cobble as rounded rock material that is between 6 and 25 cm in diameter and clearly detached; and sand as any granular material with a diameter less than 6 cm (may include mud, organic debris such as shell or bone, gravel, or pebble).

During review of a video record, a transparency film overlay with guidelines approximating a 1.5 m wide swath was placed over a monitor screen. Each of the substrate types are independent of each other and were recorded as discrete

segments with a beginning and ending GPS time code, thus the total available substrate often exceeds 100%. A substrate layer was considered continuous until a break of 2 m or greater occurred or the substrate dropped below 20% of the total combined substrates for a distance of at least 3 m.

After processing, the substrates were combined to create three independent habitat types: hard (rock and/or boulder), mixed (rock and/or boulder with either cobble and/or sand), or soft (cobble and/or sand). These habitat types combined total 100% of the available habitat.

Fish Abundance, Transects, and Descriptive Statistics

Fish processing consisted of reviewing the video records in a single-pass method in which observed fish were identified to one of the following levels: species, complex, family, or unidentified (Appendix 3). Fish observations recorded were limited to a size greater than 11 cm with the exception of señorita (*Oxyjulis californica*), surf perch, and blacksmith (*Chromis punctipinnis*). Several fish species were excluded: skates, flatfish, young of the year (YOY) rockfish, pelagic species, painted greenling (*Oxylebius pictus*) and sculpins (except cabezon [*Scorpaenichthys marmoratus*]).

A screen overlay was also used during fish quantification to approximate the transect width, calculated by the ranging sonar, at mid-screen (Karpov et al. 2006). The overlay served as a guide for determining if a fish was in or out of the ROV transect. Fish enumeration was limited to a distance of approximately 4 meters, the lower working visibility of the ROV based on analysis by Karpov et al. (2006). Using the sonar range value depicted on the screen as a gauge, the processor determined if a fish was within 4 meters as it entered the viewing area. Fish that entered the viewing area were only counted if more than half the fish crossed the overlay guidelines.

In order to match the location of the fish with the habitat, time code entry was made when the fish crossed the mid-screen line. For fish that were within 4 meters, but swam away before they crossed the mid-screen line, time code entry was made when the location where the fish had been observed reached the mid-screen point. All data entries were recorded in a Microsoft Access® database linked with the time code.

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Appendix 3. Scientific and common names for quantified finfish in 2007.

Taxa	Scientific Name
Ocean whitefish	*Caulolatilus princeps*
Blacksmith	*Chromis punctipinnis*
Unidentified surfperch	*Embiotocidae*
Rock wrasse	*Halichoeres semicinctus*
Kelp greenling	*Hexagrammos decagrammus*
Lingcod	*Ophiodon elongatus*
Señorita	*Oxyjulis californica*
Kelp bass	*Paralabrax clathratus*
Pile perch	*Rhacochilus vacca*
California scorpionfish	*Scorpaena guttata*
Unidentified rockfish	Sebastes 1
Gopher/Copper complex	Sebastes 2
Canary/Vermilion complex	Sebastes 3
Olive/Yellowtail complex	Sebastes 4
Sebastomus complex	Sebastes 5
Kelp rockfish	*Sebastes atrovirens*
Gopher rockfish	*Sebastes carnatus*
Copper rockfish	*Sebastes caurinus*
Vermilion rockfish	*Sebastes miniatus*
Blue rockfish	*Sebastes mystinus*
Bocaccio	*Sebastes paucispinis*
Canary rockfish	*Sebastes pinniger*
Flag rockfish	*Sebastes rubrivinctus*
Treefish	*Sebastes serriceps*
California sheephead	*Semicossyphus pulcher*
Giant sea bass	*Stereolepis gigas*

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Appendix 4. Finfish abundances and sample size of 100 m^2 transects for all ten sites surveyed in 2007.

	SMI-1			SMI-2			SRI-2			SRI-3			SRI-7		
Common Name	Ave	SD	%FO	Ave	SD	%FO	Ave	SD	%FO	Ave	SD	%FO	Ave	SD	%FO
Black perch															
Blacksmith	0.02	0.21	1	0.03	0.22	2	0.97	4.45	11	0.03	0.23	2	0.12	1.09	2
Blue rockfish	0.60	2.11	18	0.50	1.76	14	1.10	3.40	17	0.40	1.11	17	0.25	0.75	14
Ca. Sheephead	0.05	0.26	3	0.09	0.32	8	0.06	0.28	5	0.04	0.21	4	0.08	0.17	3
Canary/Vermillion complex	0.02	0.15	2												
Copper rockfish	0.19	0.40	19	0.04	0.20	4	0.22	1.03	10	0.12	0.42	10	0.03	0.14	2
Gopher rockfish	0.17	0.41	16	0.02	0.14	2	0.03	0.18	3	0.03	0.18	3	0.03	0.17	3
Gopher/Copper complex	0.01	0.11	1	0.01	0.10	1				0.03	0.23	2			
Kelp bass															
Kelp greenling	0.01	0.11	1							0.01	0.10	1	0.01	0.29	6
Kelp rockfish							0.01	0.11	1						
Lingcod	0.09	0.29	9	0.01	0.10	1	0.01	0.11	1	0.04	0.25	3	0.03	0.17	3
Oceanwhite	0.01	0.11	1				0.02	0.22	1						
Pile perch	0.08	0.31	7	0.04	0.40	1	0.02	0.15	2	0.15	1.17	3	0.16	0.10	1
Sebastomus	0.47	0.74	36	0.55	0.83	40	0.01	0.11	1	0.03	0.23	2	0.07	0.17	3
Senorita	0.23	2.13	1	0.02	0.20	1	0.03	0.32	1	0.31	1.63	11			
Treefish	0.08	0.27	8	0.03	0.17	3	0.01	0.11	1	0.01	0.10	1	0.02	0.25	7
Unidentified perch	0.27	1.10	8	0.23	1.55	6	0.06	0.39	2	0.11	0.48	5	0.11	0.27	8
Unidentified rockfish	0.20	0.59	13	0.03	0.17	3	0.03	0.18	3	0.04	0.21	4	0.07	0.46	19
Vermillion rockfish	1.09	1.53	58	0.20	0.50	17	0.38	1.17	20	0.40	1.27	13	0.21	0.48	6
Yellowtail/Olive complex	0.28	0.61	21	0.35	1.47	19	0.12	0.45	8	0.08	0.31	7	0.03	0.76	8
Average	0.22	0.64	12	0.14	0.54	8	0.19	0.79	5	0.12	0.51	6	0.09	0.38	6

Appendix 4 continued.

	SRI-8			SRI-6			SCI-2			AI-3			AI-1		
Common Name	Ave	SD	%FO	Ave	SD	%FO	Ave	SD	%FO	Ave	SD	%FO	Ave	SD	%FO
Black perch				0.01	0.10	1									
Blacksmith	1.35	9.23	9	2.06	8.24	19	1.42	5.65	14	1.24	4.52	23	5.48	12.03	35
Blue rockfish	2.26	6.07	27	1.46	4.37	27	0.62	1.93	20	0.06	0.37	3	0.16	0.56	10
Ca. Sheephead	0.12	0.27	8	0.28	0.60	21	0.18	0.53	13	0.21	0.52	17	0.18	0.46	13
Canary/Vermillion complex															
Copper rockfish	0.08	0.16	3	0.02	0.21	1	0.05	0.22	5	0.05	0.22	5	0.05	0.23	5
Gopher rockfish	0.08	0.11	1	0.01	0.10	1	0.04	0.20	4				0.02	0.15	2
Gopher/Copper complex	0.01	0.27	8	0.01	0.10	1									
Kelp bass				0.01	0.10	1				0.20	0.60	15	0.08	0.27	7
Kelp greenling															
Kelp rockfish				0.01	0.10	1				0.01	0.10	1			
Lingcod	0.04	0.55	9	0.03	0.18	3	0.05	0.22	5				0.04	0.21	4
Oceanwhite				0.01	0.10	1			0	0.02	0.14	2			
Pile perch	0.05	0.19	4	0.06	0.29	5	0.17	1.16	4				0.01	0.10	1
Sebastomus	0.13	0.58	9				0.59	1.09	31	0.13	0.39	12	0.09	0.35	6
Senorita	0.71	0.41	10	1.74	9.88	10	0.19	1.45	4	0.01	0.10	1			
Treefish	0.03	2.80	13				0.12	0.32	11	0.01	0.10	1	0.04	0.21	4
Unidentified perch	0.82	0.36	10	0.43	0.99	21	0.45	1.31	18	0.26	1.57	7	0.68	2.10	18
Unidentified rockfish	0.14	0.83	32	0.05	0.23	5	0.14	0.48	9	0.13	0.84	5	0.08	0.31	6
Vermillion rockfish	0.45	3.12	24	0.14	0.52	7	0.72	1.22	41	0.15	0.54	10	0.18	0.49	12
Yellowtail/Olive complex	0.15	0.27	4	0.05	0.23	5	0.24	0.63	18				0.02	0.15	2
Average	0.43	1.68	11	0.38	1.55	8	0.36	1.17	13	0.19	0.77	8	0.51	1.26	9

Appendix 5. Percentage of soft only substrate determined at sea and during post-processing by line number from ten northern Channel Islands sites sampled in 2007. Beginning line numbers are listed for one to four zones per site.

Harris Point SMR			Castle Rock			Carrington Pt. SMR			Rodes Reef			Cluster Point		
	% Soft Only			% Soft Only			% Soft Only			% Soft Only			% Soft Only	
Line	At Sea	Post	Line	At Sea	Post	Line	At Sea	Post	Line	At Sea	Post	Line	At Sea	Post
20	50	36	220	8	4	440	55	44	100	20	13	20	18	12
560	75	67	240	0	12	620	8	18	220	21	18	80	21	28
600	73	70	990	0	0	740	36	59	280	27	31	260	0	0
620	64	57	Zone 2			760	43	41	320	17	19	420	8	10
760	73	71				820	64	50	360	20	34	570	20	21
840	60	51	1420	0	1	880	57	67	420	27	27	610	17	16
940	42	40	1700	0	0	Zone 2			Zone 2			750	33	34
1000	27	31	1920	0	2							770	50	52
1060	33	31	1960	0	1	1460	20	43	460	33	28	830	46	42
Zone 2			2360	18	17	1660	50	55	750	47	58	Zone 2		
						1680	27	35	790	36	66			
1270	73	24				1880	50	39	810	57	53	1130	50	50
1540	9	18				1900	33	54	850	53	51	1330	50	50
1940	27	27				2100	27	29	890	63	61			
1980	31	34				2240	50	51						

Appendix 5 continued.

South Pt. SMR			Gull Island SMR			East Point			Anacapa Island SMCA			Anacapa Island SMR		
Line	% Soft Only		Line	% Soft Only		Line	% Soft Only		Line	% Soft Only		Line	% Soft Only	
	At Sea	Post		At Sea	Post		At Sea	Post		At Sea	Post		At Sea	Post
20	38	37	560	50	55	390	92	93	70	60	60	0	55	57
80	22	20	590	47	56	450	64	71	90	64	60	30	64	42
140	32	31	630	57	71	510	54	79	100	58	56	40	45	38
160	32	30	640	67	67	630	45	72	140	54	37	70	55	30
260	75	69	650	75	61	760	50	61	170	23	17	80	45	40
280	40	78	670	73	64	820	60	68	200	36	24	110	38	12
490	50	72	680	69	72	Zone 2			250	54	44	150	50	30
Zone 2			720	82	68				270	47	43	170	27	16
			870	77	64	1290	42	56	320	50	49	Zone 2		
630	73	64	890	75	70	1510	67	62	330	64	46			
670	60	59	940	71	70	1750	33	33	340	60	51	820	78	67
790	25	58	950	73	66	1770	54	60	Zone 2			830	75	74
830	13	74	960	69	64	2080	36	37				840	54	63
910	80	83	990	73	69	2160	80	70	550	50	33	850	80	68
1030	54	52	1000	64	60	Zone 3			650	42	38	860	67	57
1050	64	66	1010	64	60							910	50	45
1110	60	47	1040	65	54	2790	18	28				930	62	45
			1060	54	54	2830	22	34				940	85	75
			1080	62	60	2990	40	42				960	77	75
			1090	79	66	3030	53	49						
			1120	71	68	Zone 4								
						3370	30	64						
						3410	71	63						

Appendix 6. ROV dive data for Harris Point SMR surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SMI-1													
8/25/2007	1	370	20	22:01:36	22:13:20	193319.35	3773041.00	192922.04	3773333.51	0.7	2.8	25.5	32.0	28.6
			560	21:32:48	21:44:06	193257.57	3773752.35	193655.64	3773466.16	0.7	3.1	32.6	41.0	38.1
			600	21:19:05	21:29:32	193669.46	3773500.51	193280.10	3773790.56	0.8	2.8	34.6	42.6	38.4
			620	21:04:54	21:15:47	193291.50	3773796.61	193315.40	3773789.12	0.7	3.1	34.9	41.1	38.3
			760	20:45:00	20:55:42	192983.04	3774206.96	193321.07	3773947.65	0.8	3.4	34.3	43.0	38.7
			840	20:31:26	20:40:11	193394.20	3774003.77	193055.73	3774263.29	0.8	3.6	35.9	45.1	40.1
		369	940	20:11:56	20:22:47	193080.83	3774349.57	193133.32	3774321.53	0.7	3.8	29.8	45.9	41.1
			1000	19:58:56	20:08:44	193511.06	3774120.64	193123.36	3774406.11	0.8	3.1	40.8	48.9	45.0
			1060	19:42:47	19:54:01	193157.81	3774451.07	193549.31	3774168.51	0.7	3.2	40.1	50.0	46.5
	2		1270	19:17:23	19:22:35	193307.09	3774607.76	193124.28	3774751.39	0.8	3.6	40.3	46.8	43.7
			1540	18:55:11	19:05:17	193084.82	3775105.68	193465.99	3774818.62	0.8	3.5	39.5	54.4	46.5
			1940	18:31:41	18:41:47	192914.38	3775722.86	193314.66	3775428.78	0.8	3.7	36.5	55.5	50.4
			1980	18:16:19	18:28:43	193321.47	3775475.98	192942.71	3775759.27	0.7	3.1	43.6	56.4	52.3

Appendix 6. ROV dive data for Castle Rock surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SMI-2													
8/25/2007	1	368	220	16:59:41	17:11:53	182419.99	3776147.55	182895.78	3776266.01	0.7	3.7	24.2	41.3	33.2
			240	16:45:23	16:56:00	182898.27	3776287.65	182409.95	3776165.70	0.8	3.9	27.9	42.6	34.1
			990	16:16:23	16:27:02	182728.84	3777006.53	183200.80	3777135.97	0.8	3.2	39.5	47.6	43.7
	2		1420	15:55:06	16:05:50	182136.67	3777312.84	182613.46	3777434.39	0.8	3.0	42.7	49.0	46.1
			1700	15:37:05	15:47:11	182539.27	3777697.72	182400.73	3777683.99	0.8	3.7	45.7	51.2	48.4
			1920	15:19:02	15:29:14	182019.69	3777786.29	182486.00	3777914.50	0.8	3.6	47.4	54.5	50.4
			1960	15:04:53	15:15:53	182471.17	3777943.17	182449.83	3777945.41	0.7	3.5	48.6	53.4	50.4
			2360	14:45:02	14:55:35	181909.33	3778227.33	182351.16	3778328.13	0.8	3.4	51.8	58.2	54.6

Appendix 6. ROV dive data for Carrington Point SMR surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SRI-2													
8/24/2007	1	367	440	23:13:21	23:23:41	216750.97	3771892.05	217184.25	3772073.57	0.8	3.5	24.0	29.6	26.8
			620	22:53:29	23:05:05	217114.74	3772238.70	216892.77	3772154.95	0.7	2.8	17.6	31.0	23.5
			740	22:36:53	22:47:53	216615.05	3772156.88	216701.34	3772197.92	0.8	3.8	19.8	31.6	25.7
			760	22:21:39	22:34:29	217045.60	3772370.92	217032.19	3772372.18	0.6	3.2	20.1	32.4	26.3
			820	22:03:21	22:16:47	216589.16	3772242.53	216854.21	3772351.16	0.6	3.1	21.0	31.3	27.0
			880	21:45:59	21:58:47	217009.37	3772481.64	216984.19	3772481.18	0.6	2.9	21.4	33.0	27.4
8/23/2007	2	364	1460	22:24:31	22:34:31	216314.52	3772812.96	216757.68	3773004.91	0.8	3.1	24.2	32.8	28.5
			1660	22:09:59	22:19:47	216669.50	3773187.45	216582.43	3773148.05	0.8	2.9	25.0	34.5	30.5
			1680	21:56:31	22:06:31	216231.20	3773007.46	216661.17	3773204.16	0.8	3.4	26.1	34.7	30.3
			1880	21:35:19	21:44:55	216573.70	3773378.57	216118.58	3773191.29	0.9	3.2	24.9	35.3	31.1
			1900	21:21:01	21:32:19	216121.84	3773210.07	216481.70	3773361.19	0.7	3.1	25.7	34.4	30.7
			2100	21:01:47	21:16:06	216432.36	3773569.27	216408.87	3773557.17	0.5	3.3	0.0	38.6	34.5
			2240	20:40:05	20:53:46	216010.63	3773525.08	216088.40	3773558.60	0.6	3.2	32.7	40.0	36.9

Appendix 6. ROV dive data for Rodes Reef surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SRI-3													
8/23/2007	1	363	100	18:28:01	18:42:59	210745.10	3771693.43	211253.44	3771737.76	0.6	3.4	19.6	24.6	22.6
			220	18:04:11	18:17:59	211233.41	3771852.19	210727.31	3771815.14	0.6	3.3	18.5	25.3	22.9
			280	17:46:29	18:00:31	210736.98	3771875.37	211234.15	3771905.88	0.6	3.4	19.8	25.1	23.2
			320	17:26:49	17:42:01	211227.18	3771953.08	210724.96	3771919.13	0.6	3.1	19.8	26.0	23.1
			360	17:09:19	17:23:43	210727.37	3771952.29	210780.94	3771962.46	0.6	2.9	21.4	25.9	23.7
			420	16:50:49	17:05:35	211211.50	3772052.89	210722.27	3772013.69	0.6	3.0	21.2	27.5	24.2
	2	362	460	16:34:10	16:45:01	210726.56	3772054.66	211218.10	3772094.21	0.8	2.8	21.4	27.9	24.4
			750	16:10:49	16:25:31	210880.94	3772346.16	210707.31	3772350.15	0.6	2.6	26.9	38.6	32.8
			790	15:53:49	16:06:46	210706.38	3772384.09	210737.12	3772382.00	0.6	2.7	26.0	39.8	33.6
			810	15:37:22	15:50:52	210941.91	3772420.17	210691.69	3772407.26	0.6	2.6	25.1	39.8	33.9
			850	15:20:07	15:34:25	210793.15	3772447.06	210735.48	3772453.00	0.6	2.7	28.3	42.0	35.5
			890	15:00:19	15:16:25	211101.16	3772518.81	210978.12	3772499.96	0.5	2.4	32.5	45.2	37.4

Appendix 6. ROV dive data for Cluster Point surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SRI-7													
8/26/2007	1	372	20	17:59:08	18:09:20	205317.67	3757546.52	205097.32	3757670.65	0.8	3.5	20.0	27.4	24.2
			80	17:41:44	17:55:32	205073.96	3757614.53	205097.67	3757605.03	0.6	2.9	21.4	28.2	25.0
			260	17:21:59	17:34:20	205100.85	3757399.55	205039.13	3757441.26	0.7	3.4	23.3	31.2	27.2
			420	17:04:56	17:15:48	204891.36	3757331.75	205336.78	3757078.19	0.8	4.4	22.6	32.8	28.6
		371	570	16:41:20	16:55:25	205265.49	3756953.50	204812.50	3757207.07	0.6	3.5	30.1	38.4	34.8
			610	16:27:20	16:37:55	204797.45	3757175.09	205155.20	3756965.09	0.8	3.2	30.7	40.5	35.9
			750	16:11:13	16:22:31	205180.61	3756796.99	204717.08	3757053.43	0.8	3.5	33.7	42.0	39.2
			770	15:54:23	16:04:47	204722.07	3757040.17	205147.86	3756747.78	0.9	3.1	36.3	43.4	40.3
			830	15:38:07	15:50:50	205134.33	3756728.94	204675.08	3756985.23	0.7	3.4	39.6	45.8	41.9
	2		1130	15:16:59	15:26:17	204279.31	3756875.61	204723.56	3756618.28	0.9	4.0	43.6	52.6	49.1
			1330	14:59:05	15:10:17	204612.03	3756455.27	204192.42	3756693.54	0.7	3.8	47.4	58.4	54.6

Appendix 6. ROV dive data for South Point SMR surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SRI-8													
8/24/2007	1	366	20	19:01:05	19:13:53	212134.21	3754344.99	212379.91	3754165.17	0.5	3.2	18.1	25.2	21.7
			80	18:38:16	18:56:20	212494.98	3754014.09	212209.79	3754215.07	0.5	3.3	18.8	32.3	24.8
			140	18:14:41	18:32:52	212072.46	3754237.19	212420.88	3754000.21	0.5	3.8	22.0	36.7	28.0
			160	17:53:38	18:10:11	212456.54	3753950.97	212097.57	3754202.24	0.5	3.8	17.8	36.8	27.2
			260	17:27:35	17:43:26	211999.82	3754141.84	212403.92	3753867.58	0.5	3.1	29.1	40.8	34.8
			280	17:15:17	17:24:53	212384.87	3753853.59	211985.29	3754139.21	0.8	2.3	0.0	42.0	35.8
			490	16:50:08	17:03:40	211778.90	3754027.54	212173.99	3753740.89	0.6	3.0	34.4	46.4	42.1
	2		630	16:35:02	16:45:04	212097.81	3753631.83	211992.46	3753696.43	0.8	3.5	38.3	51.6	44.7
		365	670	16:14:11	16:28:53	211670.40	3753883.57	212051.67	3753611.66	0.6	3.6	39.6	53.7	46.5
			790	15:58:35	16:09:44	212005.56	3753510.18	211984.57	3753526.28	0.8	3.3	39.9	53.5	48.4
			830	15:40:29	15:54:59	211579.19	3753751.21	211881.16	3753543.80	0.6	3.2	47.2	53.7	50.5
			910	15:26:50	15:36:51	211927.06	3753403.79	211623.30	3753626.34	0.8	3.0	48.8	56.2	52.4
			1030	15:09:29	15:22:23	211460.41	3753582.60	211874.75	3753301.40	0.7	3.2	54.5	64.7	58.0
			1050	14:56:59	15:06:41	211841.89	3753273.72	211814.64	3753313.35	0.9	3.3	55.9	66.6	59.1
			1110	14:38:41	14:53:39	211421.95	3753512.04	211631.05	3753361.35	0.6	3.8	58.5	70.7	64.5

Appendix 6. ROV dive data for East Point surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SRI-6													
8/27/2007	1	373	390	23:07:05	23:17:53	225145.06	3758332.52	225167.53	3758344.03	0.8	2.4	21.9	27.8	24.7
			450	22:46:19	22:59:17	224887.24	3758197.71	224916.99	3758206.56	0.6	2.3	21.4	27.1	25.2
			510	22:29:59	22:41:46	225365.36	3758277.88	225329.55	3758278.01	0.7	3.0	15.3	27.5	24.2
			630	22:14:01	22:24:11	224929.91	3758024.19	225410.92	3758165.43	0.8	3.2	22.7	26.1	24.5
			760	21:56:19	22:08:01	225396.76	3758026.70	225378.25	3758017.53	0.7	3.2	18.9	27.0	24.5
			820	21:41:01	21:50:25	224991.56	3757846.66	225451.41	3757978.62	0.9	3.0	22.1	26.9	25.4
8/29/2007	2	378	1290	18:27:03	18:38:39	225854.82	3757625.54	225867.68	3757624.48	0.7	3.2	20.5	31.9	27.1
			1510	18:01:52	18:13:22	225468.04	3757265.11	225945.45	3757417.49	0.8	3.3	25.0	31.6	28.7
			1750	17:41:10	17:52:40	226004.24	3757184.50	225535.63	3757032.42	0.7	3.1	19.8	31.4	27.0
			1770	17:24:34	17:36:36	225538.59	3757014.49	225900.45	3757126.05	0.7	3.3	15.5	31.8	26.0
			2080	17:02:10	17:12:22	226102.58	3756862.46	225668.63	3756729.13	0.8	3.1	24.1	32.6	28.6
			2160	16:42:54	16:57:42	225659.08	3756639.17	225812.71	3756688.43	0.6	3.0	22.4	34.4	30.1
	3	377	2790	16:08:16	16:19:18	226049.29	3756107.32	225844.23	3756037.68	0.7	3.4	19.0	31.6	23.5
			2830	15:47:39	16:04:40	225599.56	3755922.72	225892.34	3756009.43	0.5	3.9	16.5	32.5	24.0
			2990	15:30:24	15:39:36	226099.09	3755917.93	225637.02	3755769.38	0.9	3.7	20.2	37.2	26.7
			3030	15:11:00	15:27:06	225655.52	3755729.18	226135.70	3755883.50	0.5	3.4	21.8	39.5	30.9
	4		3370	14:48:10	14:59:39	226467.07	3755632.92	226177.86	3755536.52	0.7	2.8	37.3	52.1	43.5
			3410	14:28:24	14:44:36	226001.73	3755441.07	226111.66	3755463.67	0.5	3.5	37.9	53.1	44.5

Appendix 6. ROV dive data for Gull Island SMR surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	SCI-2													
8/28/2007	1	375	720	18:54:44	19:04:44	239797.17	3759339.32	239310.24	3759429.83	0.8	3.3	34.6	55.5	45.7
			870	18:33:34	18:45:41	239267.53	3759291.38	239536.92	3759228.54	0.7	2.9	42.3	57.3	48.6
			890	18:18:47	18:30:17	239758.97	3759168.57	239538.67	3759210.70	0.7	2.8	42.2	62.0	49.5
			940	18:01:26	18:15:02	239252.07	3759221.32	239285.08	3759214.45	0.6	3.0	46.4	60.8	51.2
			950	17:44:20	17:58:23	239743.22	3759111.29	239266.88	3759209.50	0.6	2.8	46.2	61.2	51.3
			960	17:25:59	17:41:47	239252.56	3759198.63	239733.65	3759099.54	0.5	2.7	46.2	61.9	52.5
			990	17:06:14	17:20:26	239721.45	3759076.28	239245.22	3759174.67	0.6	3.1	48.1	62.6	53.4
		376	560	20:50:27	21:05:42	239335.12	3759582.70	239344.87	3759574.32	0.6	2.2	30.6	49.3	39.2
			590	20:29:51	20:47:42	239815.30	3759452.08	239443.29	3759534.21	0.6	2.8	30.7	51.3	37.4
			630	20:13:09	20:24:33	239380.64	3759507.06	239811.15	3759416.04	0.7	3.2	33.7	50.8	41.9
			640	19:55:54	20:06:56	239814.87	3759406.23	239606.27	3759454.76	0.8	2.7	36.6	52.3	45.2
			650	19:41:09	19:52:47	239311.35	3759500.33	239590.12	3759438.36	0.7	3.1	32.0	54.1	42.9
			670	19:27:27	19:38:23	239804.32	3759384.65	239659.85	3759414.41	0.8	3.0	35.4	55.2	43.4
			680	19:11:21	19:24:05	239310.08	3759468.28	239310.01	3759468.32	0.7	3.2	33.3	56.1	44.2
		374	1000	16:46:36	16:59:40	239251.58	3759154.70	239507.02	3759110.30	0.6	3.4	48.1	62.8	53.8
			1010	16:30:09	16:43:00	239717.94	3759053.93	239341.89	3759130.99	0.6	3.2	47.9	62.3	54.4
			1040	16:12:08	16:25:16	239231.05	3759118.14	239615.93	3759040.19	0.6	3.7	47.9	63.4	56.1
			1060	15:56:32	16:08:45	239714.12	3759005.34	239294.35	3759091.79	0.7	3.3	51.9	63.2	58.0
			1080	15:40:45	15:53:27	239225.98	3759089.77	239713.34	3758984.12	0.7	3.9	56.4	64.5	60.3
			1090	15:23:33	15:37:44	239717.37	3758973.18	239540.82	3759008.19	0.6	3.1	56.6	65.5	61.0
			1120	15:06:41	15:20:35	239223.94	3759041.46	239487.69	3758988.86	0.6	3.7	55.4	66.8	62.6

Appendix 6. ROV dive data for Anacapa Island SMR surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	AI-3													
8/30/2007	1	381	0	19:51:14	20:01:59	281433.15	3766896.93	281251.20	3766821.94	0.8	2.2	16.8	25.0	21.9
			30	19:37:41	19:48:32	280933.34	3766728.11	281315.26	3766884.88	0.8	2.3	19.3	25.7	22.9
			40	19:24:32	19:35:02	281415.64	3766931.36	280928.20	3766736.13	0.9	2.2	20.0	25.5	23.1
			70	19:09:29	19:21:29	280908.37	3766761.22	281074.95	3766825.32	0.7	2.0	21.0	26.6	24.1
			80	18:55:41	19:06:20	281399.42	3766973.39	281046.16	3766821.52	0.8	2.8	20.7	28.1	24.2
			110	18:39:11	18:51:29	280895.55	3766804.32	281401.43	3766999.59	0.7	3.0	20.4	27.7	24.9
			150	18:22:14	18:36:01	281376.86	3767037.49	280974.29	3766873.20	0.7	2.7	22.9	29.8	26.6
			170	18:04:20	18:18:37	280875.21	3766862.44	281301.98	3767032.65	0.7	3.0	23.3	30.5	27.3
8/31/2007	2	382	820	16:34:51	16:43:48	281142.70	3767647.20	280656.20	3767452.56	1.0	2.1	55.9	63.0	58.5
			830	16:21:06	16:32:45	280640.75	3767465.47	281087.80	3767645.14	0.8	2.6	55.6	62.4	58.8
			840	16:45:55	16:58:13	280639.95	3767473.69	280959.16	3767596.77	0.8	2.6	55.9	64.0	59.3
			850	16:08:37	16:18:15	281125.90	3767683.84	280639.80	3767490.99	0.9	2.4	56.3	63.7	59.2
			860	15:55:06	16:06:55	280629.96	3767499.37	281126.34	3767690.56	0.8	2.3	55.4	63.8	59.1
			910	15:41:12	15:51:09	281112.49	3767735.16	280908.58	3767660.10	0.9	3.2	54.5	63.6	59.3
			930	15:26:37	15:39:00	280605.45	3767567.95	281067.86	3767742.52	0.7	2.8	56.6	64.5	60.5
			940	15:12:33	15:24:57	281090.56	3767764.93	280707.80	3767617.45	0.7	2.9	57.3	66.7	62.0
			960	14:58:09	15:10:21	280611.84	3767595.44	281039.23	3767764.15	0.7	2.4	58.0	67.4	62.9

Appendix 6. ROV dive data for Anacapa Island SMCA surveyed in 2007.

Date	Zone	Dive	Line Number	Beginning time (GMT)	Ending time (GMT)	Begin X	Begin Y	End X	End Y	Avg velocity (m/s)	Avg Width (m)	Min depth (m)	Max depth (m)	Avg depth (m)
	AI-1													
8/30/2007	1	380	70	17:16:53	17:26:14	274424.61	3766654.71	274496.17	3766678.18	0.9	2.7	11.5	25.2	20.5
			90	17:01:41	17:12:18	274885.88	3766845.06	274404.59	3766674.47	0.8	2.5	14.3	26.3	21.3
			100	16:47:56	16:59:14	274409.16	3766688.47	274620.25	3766767.39	0.8	2.4	14.9	28.0	22.2
			140	16:32:24	16:44:32	274856.22	3766892.44	274479.03	3766749.89	0.7	2.6	16.2	30.2	23.9
			170	16:16:05	16:27:56	274384.00	3766757.75	274866.05	3766918.51	0.7	3.2	19.2	31.6	24.9
			200	15:59:05	16:12:42	274848.90	3766946.08	274622.78	3766876.62	0.6	3.5	22.4	32.3	28.4
			250	15:38:23	15:50:26	274102.24	3766736.82	274588.34	3766902.33	0.7	2.8	26.8	38.7	34.0
		379	270	15:17:17	15:31:37	274564.50	3766929.41	274532.24	3766910.04	0.6	2.4	27.6	39.2	34.8
			320	15:00:32	15:13:44	274070.59	3766797.27	274554.84	3766963.94	0.7	2.6	32.2	41.4	37.0
			330	14:44:20	14:57:38	274549.24	3766985.44	274371.46	3766913.19	0.6	2.7	32.8	41.9	37.5
			340	14:32:04	14:41:19	274082.31	3766823.04	274550.80	3766988.13	0.9	2.9	33.8	41.4	38.3
	2		550	14:12:43	14:24:11	274468.17	3767186.50	274320.19	3767132.58	0.7	3.0	37.2	44.2	41.1
			650	13:56:25	14:08:02	273968.20	3767110.92	274058.31	3767136.15	0.7	3.5	37.8	50.0	45.1

Appendix 7. ROV substrate and habitat summary data for Harris Point SMR surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SMI-1											
	20	497.7	64	0	0	97	0	3	60	36	0
	560	499.0	33	11	1	88	2	12	21	67	0
	600	493.1	30	2	7	84	1	14	16	70	0
	620	483.6	43	7	0	82	0	18	25	57	0
	760	494.9	29	0	0	91	3	9	20	71	0
	840	432.5	49	16	8	87	4	13	37	51	0
	940	490.7	60	0	16	72	5	24	36	40	0
	1000	493.6	69	10	11	71	3	29	40	31	0
	1060	492.6	69	0	0	78	4	22	47	31	0
	1270	236.9	74	16	8	49	0	51	25	24	0
	1540	482.9	82	9	34	47	3	44	38	18	0
	1940	502.6	73	21	3	61	3	39	34	27	0
	1980	489.1	66	0	0	73	5	27	39	34	0

Appendix 7. ROV substrate and habitat summary data for Castle Rock surveyed in 2007.

Site	Line Number	Length (m)	Percentage of substrate on each line					Percentage of habitat on each line			
			Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SMI-2											
	220	517.4	94	0	4	38	8	59	35	4	2
	240	513.0	87	24	6	54	4	46	41	12	0
	990	495.9	100	20	19	20	2	72	28	0	0
	1420	499.8	99	38	6	57	0	43	56	1	0
	1700	494.3	100	29	37	10	0	57	43	0	0
	1920	492.0	98	42	20	24	1	68	29	2	0
	1960	490.1	99	37	35	14	0	59	40	1	0
	2360	494.6	83	29	12	64	3	36	46	17	0

Appendix 7. ROV substrate and habitat summary data for Carrington Point SMR surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SRI-2											
	440	499.3	56	0	0	100	0	0	56	44	0
	620	499.4	82	8	27	69	1	31	51	18	0
	740	527.7	38	13	53	82	5	17	24	59	0
	760	487.0	59	0	17	80	1	20	39	41	0
	820	484.0	49	0	0	73	0	27	23	50	0
	880	487.8	31	5	32	93	0	7	26	67	0
	1460	494.6	52	14	51	84	0	15	42	43	0
	1660	495.0	44	2	28	96	3	3	41	55	1
	1680	483.1	65	0	15	75	3	25	40	35	0
	1880	509.4	60	31	19	89	1	10	51	39	0
	1900	487.2	44	18	37	86	3	12	34	54	0
	2100	469.4	70	12	7	77	3	22	48	29	1
	2240	465.9	49	0	0	79	4	21	28	51	0

Appendix 7. ROV substrate and habitat summary data for Rodes Reef surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SRI-3											
	100	519.3	87	1	0	59	0	41	46	13	0
	220	513.2	82	0	0	68	0	32	50	18	0
	280	501.6	69	0	0	91	0	9	59	31	0
	320	510.2	81	0	0	90	0	10	71	19	0
	360	505.9	66	0	0	92	0	8	58	34	0
	420	495.0	73	4	0	86	0	14	60	27	0
	460	496.7	72	1	12	76	0	24	48	28	0
	750	503.4	42	0	0	98	2	2	40	58	0
	790	501.4	34	0	6	90	0	10	24	66	0
	810	507.3	47	5	0	82	0	18	29	53	0
	850	494.9	49	7	22	90	0	9	41	51	0
	890	489.5	39	0	0	89	0	11	29	61	0

Appendix 7. ROV substrate and habitat summary data for Cluster Point surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SRI-7											
	20	507.6	88	0	0	65	3	35	53	12	0
	80	525.1	72	0	0	59	0	41	31	28	0
	260	519.1	100	0	0	62	3	38	62	0	0
	420	526.2	90	0	27	53	9	44	46	10	0
	570	527.6	79	9	0	61	2	39	39	21	0
	610	499.1	84	1	6	75	0	24	60	16	0
	750	536.4	66	1	5	90	4	10	55	34	0
	770	541.2	40	0	19	79	10	12	28	52	9
	830	535.2	58	10	1	78	1	22	37	42	0
	1130	531.7	50	2	9	78	4	20	31	50	0
	1330	492.0	50	7	5	89	5	11	38	50	0

Appendix 7. ROV substrate and habitat summary data for South Point SMR surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SRI-8											
	20	391.9	63	0	0	76	2	24	39	37	0
	80	522.8	80	0	3	65	5	34	46	20	1
	140	565.9	66	0	4	62	32	35	31	31	3
	160	525.3	70	0	0	53	20	47	24	30	0
	260	516.7	31	0	2	94	2	6	25	69	0
	280	497.1	22	0	0	96	0	4	18	78	0
	490	499.7	28	0	4	98	2	2	25	72	0
	630	495.3	36	6	1	89	1	11	25	64	0
	670	520.3	41	1	1	90	3	10	31	59	0
	790	520.6	42	2	1	89	2	11	31	58	0
	830	507.2	26	0	0	95	0	5	21	74	0
	910	506.8	17	0	0	94	0	6	11	83	0
	1030	513.5	48	0	2	90	1	10	37	52	0
	1050	502.9	34	0	0	97	2	3	31	66	0
	1110	511.4	53	0	0	81	4	19	34	47	0

Appendix 7. ROV substrate and habitat summary data for East Point surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SRI-6											
	390	510.7	7	0	10	100	0	0	7	93	0
	450	491.5	29	4	1	91	0	9	21	71	0
	510	500.4	21	0	9	90	0	10	11	79	0
	630	503.8	28	0	4	97	0	3	24	72	0
	760	463.9	39	0	6	83	2	17	22	61	0
	820	482.8	31	1	0	88	0	12	20	68	0
	1290	519.9	44	0	0	71	1	29	15	56	0
	1510	519.1	36	9	2	93	2	7	32	62	0
	1750	510.9	67	0	9	77	1	23	44	33	0
	1770	512.4	40	0	0	70	2	30	10	60	0
	2080	518.5	63	0	0	82	0	18	44	37	0
	2160	506.8	30	13	15	92	5	8	22	70	0
	2790	496.0	72	0	0	56	5	44	28	28	0
	2830	547.9	66	0	0	61	8	39	27	34	0
	2990	489.3	58	0	7	85	0	15	43	42	0
	3030	535.9	50	0	0	75	4	24	26	49	1
	3370	515.8	35	0	3	93	0	6	30	64	1
	3410	521.8	37	0	0	87	4	13	24	63	0

Appendix 7. ROV substrate and habitat summary data for Gull Island SMR surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
SCI-2											
	560	520.3	45	0	0	95	0	4	41	55	1
	590	634.4	36	0	6	82	8	10	26	56	8
	630	451.6	29	8	0	95	1	5	25	71	0
	640	507.9	31	1	7	92	0	5	26	67	2
	650	521.4	38	0	0	90	3	8	30	61	1
	670	515.1	36	0	9	95	1	5	31	64	0
	680	515.5	28	0	1	91	0	9	19	72	0
	720	504.0	32	0	5	85	0	15	18	68	0
	870	478.0	36	6	0	96	0	4	32	64	0
	890	491.3	30	0	3	97	2	3	26	70	0
	940	517.9	30	8	0	95	0	5	26	70	0
	950	499.4	34	2	6	91	0	8	26	66	0
	960	506.9	36	0	3	94	1	6	29	64	0
	990	496.0	31	0	7	92	3	8	22	69	0
	1000	494.3	35	13	2	89	1	11	29	60	0
	1010	499.6	40	3	9	87	1	12	28	60	0
	1040	508.1	46	3	5	84	5	16	30	54	0
	1060	506.8	46	2	2	82	1	18	28	54	0
	1080	507.2	40	12	0	82	7	18	22	60	0
	1090	516.3	34	6	7	89	0	10	25	66	0
	1120	509.6	32	4	2	93	2	7	25	68	0

Appendix 7. ROV substrate and habitat summary data for Anacapa Island SMR surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
AI-3											
	0	541.3	43	0	0	79	0	21	22	57	0
	30	551.4	58	1	10	75	0	25	33	42	0
	40	543.2	62	0	0	83	0	17	45	38	0
	70	542.3	70	22	0	69	0	31	39	30	0
	80	543.2	60	1	0	72	0	28	32	40	0
	110	546.9	88	10	6	74	0	26	62	12	0
	150	544.3	70	0	0	71	0	29	42	30	1
	170	563.9	80	51	6	63	0	36	48	16	0
	820	545.5	33	11	3	96	0	4	29	67	0
	830	543.3	26	4	1	98	8	2	25	74	0
	840	579.0	37	35	1	98	6	2	35	63	0
	850	529.8	32	0	11	100	0	0	32	68	0
	860	546.0	42	33	2	96	0	4	38	57	0
	910	522.5	55	26	3	92	5	8	47	45	0
	930	547.0	55	10	0	93	0	7	48	45	0
	940	538.1	25	0	0	99	1	1	25	75	0
	960	526.0	24	9	0	99	2	1	24	75	0

Appendix 7. ROV substrate and habitat summary data for **Anacapa** Island SMCA surveyed in 2007.

			Percentage of substrate on each line					Percentage of habitat on each line			
Site	Line Number	Length (m)	Rock	Boulder	Cobble	Sand	Backsides	Hard	Mixed	Soft	Off Transect
AI-1											
	70	521.4	40	1	0	83	0	17	23	60	0
	90	518.9	40	4	7	98	0	2	37	60	0
	100	512.4	44	0	0	85	1	15	29	56	0
	140	498.8	63	16	0	84	1	16	48	37	0
	170	512.2	83	5	4	42	1	56	27	17	0
	200	526.8	75	4	0	62	2	37	38	24	0
	250	523.0	55	0	0	86	1	13	42	44	1
	270	514.9	57	11	13	73	0	27	31	43	0
	320	519.6	50	4	5	80	1	20	30	49	0
	330	523.1	54	2	6	85	0	15	39	46	0
	340	502.1	49	0	0	92	0	8	41	51	0
	550	510.0	65	16	0	71	0	29	38	33	0
	650	514.1	62	1	4	63	0	37	24	38	0