ROV-based Deep Water Monitoring of the Northern Channel Islands Marine Protected Areas Annual Report - 2008

California Department of Fish and Game

California Department of Fish and Game
Marine Region Administrative Report No. 09–02

June 30, 2009

June 30, 2009

Marine Resources Administrative Report Series

These internal documents provide a quick way to disseminate diverse material such as preliminary research results, fishery status reports, and reports to contributing agencies, the Legislature, the Fish and Game Commission, and Department headquarters. The source data described in this report is maintained by Department of Fish and Game. The series is authored by Department personnel and is not subject to peer review

This report will be posted on the Department web page: http://www.dfg.ca.gov

Table of Contents

List of Tables

List of Figures

Appendices

ROV-based Deep Water Monitoring of the Northern Channel Islands Marine Protected Areas Annual Report - 2008

California Department of Fish and Game
Marine Region Administrative Report No. 09–02

June 30, 2009

Abstract

Research cruises were conducted in August-October 2008 to complete the fourth 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 2008, the amount of soft-only substrate on the 139 track lines surveyed was estimated in real-time in order to target rocky habitat. These real-time estimates of hard and mixed substrate for all ten sites averaged 58%, 1% more than the post-processed average of 57%. Surveys generated 77 km of usable transects for use in finfish density calculations, with target rocky habitat accounting for 55% (39.9 km) for all sites combined. The amount of rocky habitat sampled by site averaged 4.0 km and ranged from 3.3 km sampled at South Point, a State Marine Reserve (SMR) off Santa Rosa Island, to 4.6 km at both East Point and Rodes Reef. 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 70 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 appeared to be more abundant at the state marine reserves relative to fished areas when densities were averaged across the 2005 to 2008 period. One of the species that appeared to be more abundant in fished areas was señorita, a relatively small prey species that is not a commercial or recreational target.

ACKNOWLEDGEMENTS

We wish to thank the following agencies and institutions for their help and contributions in support of this project (listed in alphabetical order):

- The California State Coastal Conservancy for financial contributions
- Channel Islands National Marine Sanctuary for RV *Shearwater* vessel and staffing support
- National Fish and Foundation for financial contributions
- Marine Applied Research and Exploration for field staffing and financial contributions
- The Nature Conservancy for financial contributions
- The Ocean Protection Council for financial contributions
- Pacific State Marine Fisheries Commission for staffing and equipment support
- Sportfish Restoration Act for financial contributions supporting Department of Fish and Game staffing and operations or financial contributions and field assistance

INTRODUCTION

Project Overview

Over the past eleven 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; Karpov et al. 2006).

Beginning in 2003, the Department and PSMFC were joined by Marine Applied Research and Exploration (MARE), the National Oceanic and Atmospheric Administration (NOAA) Channel Islands National Marine Sanctuary (CINMS) and The Nature Conservancy (TNC), to help expand the Department'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 vessel (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 data for fisheries management. Under the Channel Islands MPA monitoring plan (CDFG 2004), rocky 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.

[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.

The exploratory phase was developed to find study areas around the northern Channel Islands that had similar amounts of rocky habitat at similar depth 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 SMR 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 to allow for comparisons with shallower areas. 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 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 (100 m^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.

[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. *California Fish and Game.*

Starting in 2005, a time based estimate was used to monitor the total amount (km) of rocky substrate sampled at each site. This method is now 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 2006, the real-time method estimated habitat within 1% 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 2005–2008. SMR (State Marine Reserve), SMCA (State Marine Conservation Area).

Island			Kilometers surveyed				
Site Name	SMR Site Pair	Location code	Sep 2004	Aug -Oct 2005	Aug - Oct 2006	Aug 2007	Aug 2008
San Miguel Island							
Harris Pt. SMR	Harris Point	SMI-1	--	15	8	7	7
Castle Rock		SMI-2	--	10	5	4	4
Santa Rosa Island							
Carrington Pt. SMR	Carrington Point	SRI-2	12	7	8	7	7
Rodes Reef		SRI-3	12	6	8	6	7
Cluster Pt.	South Point	SRI-7	--	10	9	6	6
South Pt. SMR		SRI-8	--	13	8	8	9
East Pt.	Gull Island	SRI-6	12	12	11	9	10
Santa Cruz Island							
Gull Island SMR		SCI-2	12	13	11	11	12
Anacapa Island							
Anacapa SMR	Anacapa Island	AI-3	--	19	8	9	8
Anacapa SMCA		AI-1	9	12	9	7	8
Totals			57	117	85	71	77

Report Purpose

The purpose of this report is to present the 2008 data collected, methods used and summarized post-processing results. The effectiveness of real-time habitat typing is assessed, and habitat and fish abundances for 2008 are reported. Fish densities are also reported as a time series spanning the quantitative survey period from 2004 through 2008. These results are presented as preliminary without detailed statistical analysis or interpretation.

Blank Page

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. Individual ROV samples were limited to approximately two hours (3 km) each. ROV samples were limited by DVD recording time, and new samples were initiated often while the ROV remained on the seafloor. Surveys were conducted between the hours of 0800 and 1700 PST to avoid the low light conditions of dawn and dusk that might affect fish abundance measurements and underwater visibility.

To reduce the risk of under or over sampling a given site, a real-time protocol was used that monitors 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 (in linear km) for each site. These target goals reflect the minimum amount of track lines 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 2008 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 consist of a site within an SMR along with a site in a nearby fished reference area. 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 and commercial take of lobster. The study sites were selected as 500-m wide rectangles that 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

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

Anacapa Island SMCA and Gull Island SMR due to the available rocky habitat, which precludes enough lines to be drawn with 20-m spacing. At these two sites, 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 an 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). Rock included any igneous, metamorphic or sedimentary substrate that appeared to be fixed in location. Boulder was defined as any rock material between 0.25 and 3.0 m in diameter, which was clearly detached from the base substrate. Cobble included rock material that was between 6 and 25 cm in diameter, which was clearly

detached from base substrate. Sand was defined as any granular material with a diameter less than 6 cm and may include mud, organic debris, such as shell or bone, gravel or pebble.

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 again 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.

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 2005–2008 period was calculated for four SMRs and four fished reference areas combined excluding the Anacapa Island MPAs (Figures 25 to 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 rigorous statistical testing.

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

Table 2. Scientific and common names for major finfish taxa sampled from 2005 through 2008. 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.

Scientific Name	Common Name	Density (No. per 100 m^2)	
		SMR	Fished
Chromis punctipinnis	Blacksmith	1.167	0.293
Ophiodon elongatus	Lingcod	0.038	0.009
Oxyjulis californica	Señorita	0.337	0.777
Paralabrax clathratus	Kelp bass	0.002	0.003
Rhacochilus vacca	Pile perch	0.086	0.312
Sebastes carnatus	Gopher rockfish	0.081	0.031
S. caurinus	Copper rockfish	0.178	0.074
S. miniatus	Vermilion rockfish	0.498	0.236
S. mystinus	Blue rockfish	1.523	1.362
S. serranoides	Olive rockfish	0.165	0.222
S. serriceps	Treefish	0.031	0.004
Sebastomus	Sebastomus	0.298	0.270
Semicossyphus pulcher	California sheephead	0.226	0.168

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.

RESULTS

Real-time vs. Post-processed Substrate Estimates

Ten sites were successfully surveyed in 2008. A total of 139 track lines was 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 58%, only 1% more than the post-processed average of 57% (Table 2). These results were identical to those obtained in 2006 and 2007 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 2008.

Site	Zone	No. lines sampled	Percent hard or mixed substrate		
			Real-time (a)	Processed (b)	Difference (a - b)
Harris Point	1	9	46	51	-5
SMR	2	4	64	66	-2
Castle Rock	1	3	80	81	-1
	2	5	98	96	2
Carrington Point	1	6	56	49	7
SMR	2	7	65	55	10
Rodes Reef	1	6	82	83	-1
	2	6	57	53	4
Cluster Point	1	9	68	69	-1
	2	2	65	65	0
South Point	1	7	35	46	-11
SMR	2	8	41	37	4
East Point	1	6	42	36	6
	2	6	54	53	1
	3	4	47	60	-13
	4	2	NA	NA	NA
Gull Island SMR	1	21	33	34	-1
Anacapa Island	1	8	76	65	11
SMR	2	9	47	38	9
Anacapa Island	1	11	46	50	-4
SMCA	2	2	55	59	-4
Averages			58	57	1

Survey Totals

A total of 77.3 km of habitat was video recorded and used for habitat determination across the ten sites (Table 4). Of this total, 73.9 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 57% of total usable data from all sites combined. The amount of hard and mixed habitat sampled by site averaged 3.9 km, with a range of 3.3 km sampled at South Point SMR to 4.6 km at East Point and Rodes Reef. 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 2008.

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	6.9	6.8	3.8	1.2	99
Castle Rock	8	4.4	4.1	3.8	1.3	100
Carrington Point SMR	13	6.8	6.8	3.6	1.1	88
Rodes Reef	12	6.5	6.5	4.6	1.5	122
Cluster Point	11	6.4	6.0	4.2	1.4	105
South Point SMR	15	8.8	8.0	3.3	1.0	79
East Point	18	9.7	9.3	4.6	1.2	99
Gull Island SMR	21	11.9	11.1	4.0	1.3	102
Anacapa Island SMR	14	8.2	7.8	4.0	1.2	91
Anacapa Island SMCA	14	7.7	7.5	4.0	1.2	96
Totals	139	77.3	73.9	39.9	12.4	981

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 5). The average number of transects produced from all sites combined was 98 per site. Transect numbers ranged from 79 at South Point SMR to 122 at Rodes Reef.

Descriptive statistics for all 100-m^2 transects by site are shown in Table 5. The average transect depth was 37.7 m, with the shallowest average depth at East Point (25.4 m) and the deepest at Castle Rock (49.6). Transect width for all sites averaged 3.4 m and ranged from 3.1 m at both East Point and Anacapa Island SMR to 3.7 m at Castle Rock. Usable transect length, excluding sections of the line that were not within sampling criteria, averaged 31.4 m with a range of 28.9 at Castle Rock to 34.1 at East Point. The overall length of transects, including portions outside sampling criteria, averaged 33.0 m and ranged from 30.5 m at Rodes Reef to 35.6 at East Point. 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 2008.

Site	No. of transect	Depth (m)				Velocity (m/s)		Transect length (m)				Transect width	
								Sampled		Overall			
		Mean	SE	Min.	Max.	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Harris Point SMR	99	44.8	0.8	42.5	47.2	0.7	0.1	30.5	0.4	31.1	0.4	3.4	0.0
Castle Rock	100	49.6	0.9	47.5	51.9	0.7	0.1	28.9	0.4	31.0	0.9	3.7	0.1
Carrington Point SMR	88	32.2	0.5	30.0	34.4	0.8	0.1	31.8	0.6	31.9	0.6	3.3	0.1
Rodes Reef	122	28.3	0.4	26.2	30.4	0.8	0.1	30.3	0.3	30.5	0.3	3.4	0.0
Cluster Point	105	37.8	1.0	35.5	40.3	0.7	0.1	30.8	0.4	33.8	1.3	3.4	0.1
South Point SMR	79	44.1	1.5	37.6	49.8	0.7	0.1	32.5	0.6	34.9	0.8	3.3	0.1
East Point	99	25.4	0.4	22.3	27.8	0.8	0.1	34.1	0.5	35.6	0.7	3.1	0.1
Gull Island SMR	102	46.5	0.9	19.4	54.9	0.7	0.1	30.4	0.4	34.1	1.7	3.5	0.1
Anacapa Island SMR	91	39.5	1.9	35.0	43.9	0.6	0.1	33.4	0.6	34.7	0.8	3.1	0.1
Anacapa Island SMCA	96	29.0	0.8	14.3	34.6	0.7	0.1	31.3	0.5	32.1	0.5	3.4	0.1
Average	98	37.7	0.9	31.0	41.5	0.7	0.1	31.4	0.5	33.0	0.8	3.4	0.1

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 55% and 72%, 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 (34%) and the most sand (88%). Boulder and cobble were the least observed substrates, with an average of 6% and 8%, respectively per site. Outliers were at Castle Rock, where boulder substrate covered 34% of the lines surveyed; and at Carrington Point SMR, where cobble covered 29%.

The percent composition of mixed habitat was consistent among sites, with an average of 30% for all sites and a range of 22% at South Point SMR and Gull Island SMR to 39% at Rodes Reef. Hard and soft habitat averaged 27% and 44%, respectively, with Castle Rock being most notably different with 60% hard and 10% soft habitat. Overall, half of the site pairs were similar in their habitat composition. The greatest disparity occurred at Gull Island where the amounts of hard and soft substrate had a range of 12% and 66%, respectively.

Table 6. Sampling substrates and habitats for all track lines post-processed at each of the ten sites sampled in 2008.

Site	Pecentage by substrates				Percentage by habitat		
	Rock	Boulder	Cobble	Sand	Hard	Mixed	Soft
Harris Point SMR	55	6	11	71	27	29	44
Castle Rock	87	34	13	34	60	30	10
Carrington Point SMR	51	4	29	75	18	34	47
Rodes Reef	70	2	6	67	32	39	29
Cluster Point	68	4	2	64	36	32	32
South Point SMR	40	0	2	82	18	22	60
East Point	49	0	4	78	22	27	51
Gull Island SMR	34	3	4	88	12	22	66
Anacapa Island SMR	49	5	4	78	21	29	50
Anacapa Island SMCA	51	4	2	79	21	31	48
Average	55	6	8	72	27	30	44

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 2008 shows that 72% of the total area sampled contained sand (44% soft-only and 30% mixed rock and sand) (Table

6). The amount of sand ranged from 34% at Castle Rock to 88% at Gull Island SMR. Soft habitat was more variable and ranged from 10% at Castle Rock to 66% 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 (84-96%), with the other substrate components (boulder, cobble, and sand) varying more notably. Sand substrate was comparable at nine of the ten sites (47-67%), with Castle Rock the most different at 26%.

Table 7. Sampling substrates and habitats for 100 m^2 at each of the ten sites sampled in 2008.

Site	Pecentage by substrates				Percentage by habitat		
	Rock	Boulder	Cobble	Sand	Hard	Mixed	Soft
Harris Point SMR	94	10	18	50	47	47	6
Castle Rock	96	38	14	26	68	32	1
Carrington Point SMR	92	6	28	63	34	60	6
Rodes Reef	93	2	6	56	43	51	5
Cluster Point	95	6	2	47	52	43	5
South Point SMR	86	0	3	61	39	47	14
East Point	93	1	6	56	44	49	7
Gull Island SMR	84	7	8	67	32	53	15
Anacapa Island SMR	89	10	5	57	40	49	10
Anacapa Island SMCA	91	7	3	60	39	53	8
Average	91	9	9	54	44	48	8

Transects consisted of relatively low amounts of soft habitat at all ten sites (1–15%), 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 2008 (Table 8). Fish locations in 2008 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 2008. When the years were combined the group-mean density was greater for nine 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, lingcod, gopher rockfish, copper rockfish, vermilion rockfish and treefish.

Table 8. Finfish descriptive statistics for 100-m^2 transects at each site sampled in 2008. (Mean: mean density, SD: standard deviation, %FO: percent frequency of occurrence).

Site	Harris Pt. SMR			Castle Rock			Carrington Pt. SMR			Rodes Reef			Cluster Pt.		
Taxon	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO
Blacksmith	3.31	16.17	8	0.19	1.90	1	0.58	2.46	8	0.11	0.69	3	0.24	1.42	3
Blue rockfish	1.35	3.16	32	2.09	8.50	23	0.74	1.97	19	0.51	1.54	16	2.03	8.29	27
Ca. sheephead	0.14	0.47	10	0.02	0.14	2	0.13	0.40	10	0.25	0.59	19	0.11	0.40	10
Copper rockfish	0.33	0.61	26	0.05	0.22	5	0.11	0.38	9	0.15	0.46	11	0.03	0.17	3
Gopher rockfish	0.13	0.37	12	0.03	0.17	3	0.03	0.18	3	0.00	0.00	0	0.10	0.38	7
Kelp bass	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0	0.00	0.00	0
Lingcod	0.04	0.20	4	0.01	0.10	1	0.01	0.11	1	0.01	0.09	1	0.01	0.10	1
Pile perch	0.08	0.34	6	0.20	0.94	6	0.10	0.86	2	0.41	3.41	4	0.32	2.64	7
Sebastomus	0.40	0.78	26	0.85	1.21	46	0.05	0.21	5	0.00	0.00	0	0.21	0.60	14
Señorita	0.06	0.60	1	0.00	0.00	0	0.08	0.35	6	0.64	3.49	11	0.00	0.00	0
Treefish	0.09	0.29	9	0.00	0.00	0	0.01	0.11	1	0.02	0.13	2	0.00	0.00	0
Vermilion rockfish	0.76	0.86	54	0.30	0.63	23	0.25	0.59	18	0.34	0.84	21	0.22	0.50	18
Yellowtail/Olive	0.33	0.70	23	0.43	0.74	32	0.01	0.11	1	0.02	0.13	2	0.36	1.33	18
Average	0.54	1.89	16	0.32	1.12	11	0.16	0.59	6	0.19	0.87	7	0.28	1.22	8

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	0.00	0.00	0	0.63	2.92	12	0.78	3.93	10	5.28	14.42	33	8.35	26.84	38
Blue rockfish	1.16	2.87	28	0.82	2.87	22	2.83	6.34	51	0.05	0.27	4	0.97	3.89	17
Ca. sheephead	0.22	0.59	16	0.29	0.73	18	0.42	0.99	25	0.19	0.49	14	0.53	0.88	34
Copper rockfish	0.13	0.40	10	0.07	0.29	6	0.14	0.40	12	0.04	0.21	4	0.05	0.22	5
Gopher rockfish	0.09	0.33	8	0.00	0.00	0	0.07	0.25	7	0.04	0.21	4	0.02	0.14	2
Kelp bass	0.00	0.00	0	0.01	0.10	1	0.01	0.10	1	0.31	0.73	19	0.47	0.95	26
Lingcod	0.05	0.22	5	0.01	0.10	1	0.05	0.29	3	0.02	0.15	2	0.05	0.27	4
Pile perch	0.10	0.41	8	0.31	2.72	5	0.06	0.50	2	0.09	0.61	2	0.03	0.23	2
Sebastomus	0.08	0.38	5	0.02	0.14	2	0.67	1.12	37	0.10	0.34	9	0.02	0.14	2
Señorita	1.18	9.08	4	2.47	8.30	18	0.03	0.30	1	0.00	0.00	0	3.12	13.44	13
Treefish	0.01	0.11	1	0.00	0.00	0	0.01	0.10	1	0.02	0.15	2	0.01	0.10	1
Vermilion rockfish	0.46	0.80	32	0.08	0.27	8	0.53	0.88	33	0.05	0.27	4	0.16	0.49	11
Yellowtail/Olive	0.14	0.42	11	0.08	0.27	8	0.18	0.48	14	0.00	0.00	0	0.08	0.31	7
Average	0.28	1.20	10	0.37	1.44	8	0.44	1.21	15	0.48	1.37	8	1.07	3.69	13

Blank Page

Discussion

Real-time vs. Post-processed Substrate Estimates

Based on four 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 hard and mixed habitat surveyed provides a metric to gauge progress while at sea. From 2006 to 2008, 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 while at sea and targeting 4 km of rocky substrate, the goal of monitoring 75-m transects can be achieved real-time. Given the ability to calculate targeted substrate so closely, precautionary over-sampling can be minimized, reducing costs 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 used 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.

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 and acoustic sizing using a multibeam sonar. 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 2008 (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 2008 has been very successful in both meeting and exceeding the sampling goal (Table 9). Only three sites sampled in the past five years 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 2008.

Site	Years Sampled				
	2004	2005	2006	2007	2008
Harris Pt. SMR		109	111	89	99
Castle Rock		134	104	98	100
Carrington Pt. SMR	139	74	131	87	88
Rodes Reef	145	59	147	92	122
East Pt.	54	95	116	94	105
Gull Island SMR	59	94	86	95	79
Cluster Pt.		105	132	104	99
South Pt. SMR		110	91	79	102
Anacapa Island SMR		119	101	101	91
Anacapa Island SMCA		115	91	92	96
Average	99	101	111	93	98

Based on the results from this and previous year's surveys, it is estimated that 70 km of sampling (140 lines) should produce 75 transects per site.

Site Description

Data collected in 2008 show 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 density within SMRs relative to fished areas does not imply that significance has been thoroughly tested. 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.

References

Bergen, M., S. Holz, K. Karpov, A. Lauermann, C. Pattison, M. Prall, and D. Rosen. 2006. Quantitative Monitoring of Channel Islands Marine Protected Areas using a Remotely Operated Vehicle – A Cooperative Study with the Department of Fish and Game, Channel Islands National Marine Sanctuary, and Marine Applied Research and Exploration. Department of Fish and Game. Cruise Report 05-S-1. February 2006. 30p.

Bergen, M., M. Connell, S. Holz, K. Karpov, A. Lauermann, C. Pattison, M. Prall, D. Rosen, and C. Valle. 2005. Final September 2004 Project Report - Quantitative Finfish Abundance and Exploration of Santa Barbara Channel Islands Marine Protected Areas – A Cooperative Remote Operated Vehicle Study with the Department of Fish and Game, Channel Islands National Marine Sanctuary, and Marine Applied Research and Exploration. Department of Fish and Game. Unpublished Report. June 2005. 39p.

CDFG. 2004. Channel Islands Marine Protected Areas Monitoring Plan. http://www.dfg.ca.gov/mlpa/pdfs/mp041307section3.pdf.

Cochrane, Guy. United States Geological Survey, Menlo Park. http://mrib.usgs.gov/

Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E. Sullivan, J.E. McRea Jr., and G.M. Cailliet. 1999. A classification scheme for deep seafloor habitats: Oceanologica Acta 22(6):663–678.

Karpov, K., A. Lauermann, M. Bergen, and M. Prall. 2006. Accuracy and Precision of Measurements of Transect Length and Width Made with a Remotely Operated Vehicle. Marine Technical Science Journal 40(3):79–85.

Karpov, K.A., D. Rosen, A. Lauermann, M. Prall, M. Bergen, and C. Pattison. 2005a. Exploration and Inventory of Santa Barbara Channel Islands Marine Protected Areas – A Cooperative Remote Operated Vehicle Study with the Department of Fish and Game, Channel Islands National Marine Sanctuary, and Marine Applied Research and Exploration. Department of Fish and Game. Cruise Report 04-S-1. January 2005. 71p.

Karpov, K.A., A. Lauermann, M. Prall, and C. Pattison. 2005b. Quantitative Finfish Abundance and Exploration of Santa Barbara Channel Islands Marine Protected Areas – A Cooperative Remote Operated Vehicle Study with the Department of Fish and Game, Channel Islands National Marine Sanctuary, and Marine Applied Research and Exploration. Department of Fish and Game. Cruise Report 04-S-2. April 2005. 20p.

Karpov, K.A., D. Sweetnam, M. Prall, V. Kirby, A. Lauermann, J. DeMartini, P. Iampierto, R. Villa, D.A. Powers, D. Albin, M. Patyten, R. Kvitek, C.K. Bretz, F. Shaughnessy, P. Veisze, J. Geibel, P. Buttolph, C. Malzone. 1996-2000. Quantitative Inventory of Habitat and Species of Management Concern at Punta Gorda Ecological Reserve. MERRP Sea Grant Project PG-1. January 2001. 182p.

Rikk Kvitek. California State University Monterey Bay. Sea Floor Mapping Lab. http://seafloor.csumb.edu/SFMLwebDATA.htm

Veisze, P. and K. Karpov. 2002. Geopositioning a Remotely Operated Vehicle for Marine Species and Habitat Analysis. Pages 105–115 *in* Undersea with GIS. Dawn J. Wright, Editor. ESRI Press.