
Marine Resource Assessment for Marine Protected Areas
ROV-Based Deep Water Exploratory Survey
at Point Reyes National Seashore and Golden Gate National Recreation Area



Pacific States Marine Fisheries Commission



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INTRODUCTION

The state of California is in the process of implementing a network of Marine Protected Areas (MPAs) that are intended to protect marine ecosystems. Under the Marine Life Protection Act, monitoring is required to ensure that MPA networks meet the stated goals, facilitate adaptive management, and improve the understanding of marine ecosystems. In 2007, the central coast study region was the first of five statewide study regions to complete the Marine Life Protection Act planning and implementation process with the creation of 29 MPAs. In May 2010 the north central coast study region will become the second region, with the creation of 30 MPAs, extending from Alder Creek, near Point Arena in Mendocino County, south to Pigeon Point in San Mateo County.

The National Parks Service (NPS) at Point Reyes National Seashore (PORE) and Golden Gate National Recreation Area (GOGA) have received funding to promote collaborative MPA assessments that will aid in future MPA design and consideration, while providing insight to NPS and other agencies implementing MPAs in the future. The goal of this program is to produce a three-year baseline of finfish density and habitats both inside and outside of newly implemented MPAs in the north central region.

Funding provided by NPS to Pacific States Marine Fisheries Commission (PSMFC) over the three year period (2009-2011) will supplement a remotely operated vehicle (ROV)-based MPA monitoring program initiated at the northern Channel Islands in 2003 by the California Department of Fish and Game (Department), The Nature Conservancy, and Marine Applied Research and Exploration. Year one funding was used to support exploratory surveys of potential study areas from Tomales Point to Duxbury Point. Year two and three funding will support quantitative MPA baseline data collection within the north central region. Funding will specifically support survey efforts at selected sites in areas adjacent to PORE and GOGA.

Program overview

The Department purchased an ROV in 1997 in partnership with PSMFC to complete a deep water species inventory of Punta Gorda Ecological Reserve. The initial focus was the development of quantitative sampling techniques for collecting video and associated sensor data within nearshore rocky habitats. 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; Karpov et al. 2010). From these partnerships a ROV sampling program was established.

In 2003, a collaboration of local state and federal agencies as well as nongovernmental organizations began an MPA baseline assessment using an ROV at the northern Channel Islands. The goal was to monitor and track changes in finfish and invertebrate abundances, both inside and outside of newly formed MPAs. Initial exploratory surveys were conducted to evaluate potential study areas for monitoring. Based on results from exploratory surveys conducted from 2003 through 2004, six MPAs and four fished reference areas were selected for annual monitoring. In 2007, sampling was expanded to include MPAs in the central coast study region. Exploratory surveys of potential study areas within the central coast study region resulted in the selection of four MPAs and four fished reference areas for monitoring.

The ROV based study design requires an initial period of annual baseline data collection (3 to 5 years) within each MPA region, with re-sampling occurring at three to five year intervals thereafter. Within each study area, annual sampling levels are designed to produce a minimum of seventy-five 100m² transects over rocky habitat. Sampling area and design have been structured to complement the shallow water SCUBA protocols used by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) that target shallow nearshore rocky habitats. When feasible, ROV study sites are selected near PISCO shallow water SCUBA sites.

Within the different study regions, rocky substrates have been identified as the priority habitat for deep water assessments. In an effort to meet this monitoring priority, ROV based survey efforts have been focused on finfish associated with rocky habitat both inside and outside MPA boundaries. Since the majority of rocky habitat within California's waters is patchy, it has been extremely difficult to find multiple areas with similar substrate and habitat compositions. In order to achieve the goal of finding comparable areas of rocky habitat inside and outside of MPAs, potential study areas are selected for survey using multibeam and/or sidescan sonar maps. Each study area is chosen based on available rocky habitat, exposure and depth range. Following initial study area selection, exploratory surveys are conducted to evaluate habitat and sampling levels needed for baseline MPA monitoring.

Report Purpose

The purpose of this report is to present summarized post-processing results of data collected during exploratory surveys conducted near PORE and GOGA in 2009. Results are presented without detailed analysis and focus on evaluation of potential study areas for baseline MPA monitoring.

METHODS

ROV Equipment

The ROV used in this study was a Deep Ocean Engineering Phantom® HD 2+2. 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 (± 0.3 m) with minimal corrections. In addition, a forward cruise control was added to help the pilot maintain a constant forward velocity.

An ORE Offshore Trackpoint III® acoustic positioning system with ORE Offshore Motion Reference Unit (MRU) pitch and roll sensor was used to reference the ROV position relative to the ship's Wide Area Augmentation System Global Positioning System (WAAS GPS). WAAS GPS (Wilson unpublished <http://www.users.erols.com/dwilson/gpswaas.htm>) has an accuracy of 3.2 m. The ship's heading was determined using a Hemisphere® Crescent VS100 Series dual antennae compass. The Trackpoint III® calculated the XY position of the ROV at approximately two-second intervals. The position was recorded in meters as X and Y using the World Geodetic System (WGS)1984 Universal Transverse Mercator (UTM) coordinate system in both ARC VIEW® 9.2 and HYPACK® 6.2 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 HYPACK®.

The ROV was equipped with two forward-facing color cameras: one set approximately 20° below the horizon and the other pointing at approximately 35° . The two-camera system provided a continuous, slightly overlapping view. Digital video for both cameras was captured using SONY® DSR 45s and Pioneer DVR510s. Data collection protocols require seawater visibility to be 3m or greater. In addition to capturing biological and habitat observations, the forward video captured redundant onscreen recordings of time code, depth, temperature, range, forward camera angle 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 $1/30^{\text{th}}$ of a second. This method was improved by customizing HYPACK® navigational software to link all data collected in the field to the GPS time. ROV tracked position and sensor data were recorded directly by HYPACK® as a time-linked text file. A redundant one-second time code file of sensor data was also collected in the field using a custom built on screen display and operating system software with time code extracted from the system's internal clock.

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 Greenwich Mean Time (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

Exploratory ROV surveys of areas adjacent to PORE and GOGA were conducted by PSMFC staff from 6 October through 9 October, 2009. ROV operations were conducted off the FV Donna Kathleen, a 19-m fishing vessel owned and operated by Tim Maricich. Individual ROV dives were limited to approximately two hours (3 km) each. 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 the low light conditions of dawn and dusk that might affect finfish abundance measurements and underwater visibility.

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 range of 0.1–10 m 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 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 and 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

The boundaries of the eleven sites sampled in 2009 were selected based on habitat interpretations from multibeam and/or sidescan sonar maps (Figure 1). Areas determined to be predominantly rocky bottom and that showed potential as candidate study areas for MPA monitoring (both MPA and fished reference areas) were targeted for exploratory survey. Study sites were selected as 500 x 500 m wide squares with depths ranging from 10 m to 70 m, with the exception of PR-2, which was 500 x 1400 m.

Prior to field sampling, GIS-based track lines for the site were 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 the desired number of planned lines and then evenly distributing them across the site. Track lines were numbered according to the distance along the site boundary running from shallow to deep. The number of lines sampled at each site was determined in the field and was based on water conditions (visibility, current, depth, etc.), total rocky habitat, and the amount of survey time dedicated to each area.

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 m² 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 m² transects (four sequential useable 25 m² 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 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; habitat percentages are presented as the relative proportion of the track line that contained the specific habitat type. Substrate percentages represent the ratio of the track line that has a given substrate compared to the total track line and are not relative percentages.

Finfish Abundance

Finfish post-processing consisted of a single pass method in which finfish species were identified to the lowest classification level possible, grouped into a specific complex of species, or recorded as unidentified. All finfish species and groupings were based on taxonomic review of video prior to enumeration. Only finfish greater than or equal to 11 cm were recorded. Surfperches (except pile surfperch (*Damlichthys vacca*) and halfbanded rockfish (*Sebastes semicinctus*)) were not counted due to their small size. Olive rockfish (*S. serranoides*) and yellowtail rockfish (*S. flavidus*) are difficult to distinguish between when viewed in video and are put together into the olive/yellowtail rockfish complex. The Sebastomus rockfish complex may include rosy rockfish (*S. rosaceus*), starry rockfish (*S. constellatus*), and greenspotted rockfish (*S. chlorostictus*). Excluded finfish included: skates, flatfish, young of the year (YOY) rockfish, pelagic species, sculpins, except cabezon (*Scorpaenichthys marmoratus*), and painted greenling (*Oxylebius pictus*).

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. Finfish enumeration was limited to a maximum distance of 4 m. Using the sonar range value depicted on the screen as a gauge, the processor determined if a fish was within 4 m as it entered the viewing area. Finfish that entered the viewing area were only counted if more than half the finfish 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 finfish that were within 4 m, but swam away before they crossed the mid-screen line, time code entry was made when the location where the finfish had been observed reached the mid-screen point. All data entries were recorded in a Microsoft Access® database linked with the time code.

Spatial Data Maps

The eleven sites sampled were depicted with substrate types and finfish counts on tracked lines using ArcView® 9.1 software. Site maps produced for this report show the locations along the ROV track line of finfish, substrate, bathymetry, and topography. Map products include associated bathymetry and multibeam and/or sidescan sonar imagery with shaded relief. The background multibeam sonar bathymetry imagery was collected by California State University Monterey Bay Seafloor Mapping Lab.

Evaluation of Study Areas for MPA Monitoring

Each study site was evaluated as a potential site for future sampling using the ROV MPA monitoring sampling design approved by the California Department of Fish and Game. Surveyed sites were evaluated based on the total amount of target rocky habitat observed, the average depth, maximum seawater visibility of the site at the time of survey and the number of finfish species/groupings that had a density greater than 0.05/100 m². Selection criteria were based on the combined line data from each site.

Positive criteria for monitoring included at least 75% rocky habitat, average depth greater than 20 m, seawater visibility of greater than 3 m, and at least five finfish species/groupings with a density greater than 0.05/100 m². Sites that met all four of the above criteria were given a high potential, sites that met three criteria were given moderate potential and those with less than two were classified as low potential.

RESULTS

Survey Totals

A total of 18.3 km of habitat was video recorded and used for habitat determination across the eleven sites (Table 1). Of this total, 12.8 km were determined to be hard and/or mixed habitat, which accounted for 69.9% of the total usable data from all sites combined. The amount of hard and mixed habitat by site averaged 1.2 km, with a range of 2.9 to 0.4 km at PR-2 and PR-4, respectively. The number of track lines processed from each site ranged from one at PR-4, DP-1, and DP-2 to seven at PR-2, with an average of 3.1 track lines per site.

The number of transects compiled from usable track line segments varied by site and was dependent on the number of lines surveyed. A total of two hundred and twenty 100 m² transects were generated from the 34 lines sampled. The number of transects generated by line averaged 6.5, with a range from 0 to 10.3 at PR-4 and TP-1 respectively; the Tomales Point study area had the greatest average number of transects per line (9.5).

Table 1. Processed tracked distances for survey lines, hard and/or mixed habitat amounts and transects generated for the eleven sites sampled in 2009.

Study Area	Site	No. of lines	Total km	Hard and/or mixed Habitat		No. of transects 100 m ²
				Km	Area (ha)	
Tomales Point						
	TP-1	4	2.1	2.0	0.53	41
	TP-2	4	2.2	2.0	0.46	36
	TP-3	3	1.7	1.6	0.35	28
Point Reyes Headland						
	PR-2	7	3.9	2.9	0.65	48
	PR-4	1	0.5	0.1	0.01	0
	PR-6	4	2.1	0.7	0.23	14
	PR-7	3	1.8	0.8	0.30	15
	PR-8	4	2.0	1.1	0.26	21
	PR-9	2	0.8	0.4	0.05	3
Duxbury Point						
	DP-1	1	0.5	0.5	0.10	7
	DP-2	1	0.5	0.5	0.09	7
Totals		34	18.3	12.8	3.02	220

Site Descriptions

Although rocky areas were targeted, substrate and habitat percentages varied considerably among the sites. Rock and sand substrate coverage for all sites combined averaged 69% and 42%, respectively, and are not mutually exclusive (Table 2). There were differences in the percentages of rock and sand among sites; PR-4 had the least rock (12%) and the most sand (85%), while DP-2 had the most rock (99%) and the least amount of sand (0%). Boulder and cobble were the least observed substrates, with an average of 3% and 5%, respectively per site. Outliers were at PR-2, where 18% of the site had boulder substrate; and at TP-3, where cobble covered 26 of the site.

Table 2. Percentages of substrates and habitats for all track lines post-processed at each of the eleven sites sampled in 2009.

Study Area	Site	Percentage by substrate				Percentage by habitat		
		Rock	Boulder	Cobble	Sand	Hard	Mixed	Soft
Tomales Point								
	TP-1	96	1	12	13	77	20	3
	TP-2	92	4	9	24	71	23	6
	TP-3	97	4	26	13	67	32	1
Point Reyes Headland								
	PR-2	74	18	3	57	40	36	24
	PR-4	12	0	0	85	11	1	88
	PR-6	34	4	0	69	31	3	66
	PR-7	46	2	0	52	45	4	51
	PR-8	56	5	0	65	35	22	44
	PR-9	52	0	0	79	21	31	48
Duxbury Point								
	DP-1	97	0	0	1	99	1	1
	DP-2	99	0	0	6	94	5	0
Average		69	3	5	42	54	16	30

The percent composition of mixed habitat averaged 16% for all sites combined and ranged from 1% at PR-4 and DP-1 to 36% at PR-2. Hard and soft habitat averaged 54% and 30% respectively, with the Duxbury Point sites being most notably different, averaging 97% hard and 1% soft habitat combined.

Finfish Biological Data

Of the 875 finfish observed from all sites combined, blue rockfish, kelp greenling and unidentified rockfish accounted for 60% of the total (Table 3). Rockfish represented 68% of the total finfish observed with unidentified rockfish accounting for 21% of the total rockfish. When unidentified rockfish are excluded, seven rockfish species/groupings (black, blue, canary, gopher,

olive/yellowtail, Sebastomus, and vermilion) accounted for 91% of the total rockfish observed. A total of 282 non-rockfish were observed, with kelp greenling accounting for 63% of the non-rockfish total. The locations of the nine most abundant finfish species relative to the surveyed track lines are displayed in Figures 2-12.

Table 3. Common and scientific names of quantified finfish in 2009.

Common Name	Scientific Name	Total Count
Blue rockfish	<i>Sebastes mystinus</i>	219
Kelp greenling	<i>Hexagrammos decagrammus</i>	178
Unidentified rockfish	<i>Sebastes sp.</i>	126
Canary rockfish	<i>Sebastes pinniger</i>	45
Lingcod	<i>Ophiodon elongatus</i>	43
Sebastomus rockfish complex	<i>Sebastomus</i>	42
Unidentified surfperch	<i>Embiotocidae sp.</i>	37
Black rockfish	<i>Sebastes melanops</i>	33
Vermilion rockfish	<i>Sebastes miniatus</i>	32
Olive/Yellowtail rockfish complex	<i>Sebastes serranoides/S. flavidus</i>	31
Gopher rockfish	<i>Sebastes carnatus</i>	21
Pile surfperch	<i>Rhacochilus vacca</i>	21
China rockfish	<i>Sebastes nebulosus</i>	12
Quillback rockfish	<i>Sebastes maliger</i>	10
Brown rockfish	<i>Sebastes auriculatus</i>	5
Copper rockfish	<i>Sebastes caurinus</i>	5
Flag rockfish	<i>Sebastes rubrivinctus</i>	4
Halfbanded rockfish	<i>Sebastes semicinctus</i>	2
Rock greenling	<i>Hexagrammos lagocephalus</i>	2
Tiger rockfish	<i>Sebastes nigrocinctus</i>	2
Treefish	<i>Sebastes sericeus</i>	2
Yelloweye rockfish	<i>Sebastes ruberrimus</i>	2
Spotted ratfish	<i>Hydrolagus coliei</i>	1
Total		875

Species densities by site for all quantified finfish are shown in Table 4. Of the twenty-three finfish taxa/groupings identified from the video, twenty were observed within transects generated from all sites combined. The site with the most observed finfish taxa/groupings was PR-2, where eighteen taxa were quantified. Sites PR-9 and DP-1 had the fewest observed taxa/ groupings, with only three finfish taxa quantified within transects generated.

Table 4. Descriptive statistics for 20 finfish from transects (100m²) at each site during exploratory ROV surveys in 2009. Mean - mean density; SD - standard deviation; %FO - percent frequency of occurrence

Site	TP-1 (n=41)			TP-2 (n=36)			TP-3 (n=28)			PR-2 (n=48)			PR-6 (n=14)		
Taxon	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO
Black rockfish													0.36	0.84	21
Blue rockfish	0.12	0.56	5	0.50	2.21	6	0.04	0.19	4	2.29	8.22	29	0.79	1.85	36
Brown rockfish	0.10	0.37	7	0.11	0.40	8	0.14	0.45	11	0.06	0.24	6	0.14	0.53	7
Canary rockfish				0.03	0.17	3				0.56	1.82	23			
China rockfish										0.17	0.43	15			
Copper rockfish				0.06	0.23	6				0.02	0.14	2	0.07	0.27	7
Flag rockfish				0.00	0.00	0				0.04	0.20	4			
Gopher rockfish	0.10	0.37	7	0.11	0.40	8	0.14	0.45	11	0.02	0.14	2	0.14	0.53	7
Kelp greenling	0.49	0.75	37	0.44	0.69	33	0.71	0.94	46	0.23	0.69	15	1.43	1.70	57
Lingcod	0.02	0.16	2	0.14	0.42	11	0.21	0.50	18	0.25	0.48	23	0.00	0.00	0
Olive/Yellowtail rockfish										0.25	0.53	21	0.14	0.53	7
Pile surfperch										0.02	0.14	2	0.29	0.83	14
Quillback rockfish										0.13	0.33	13	0.07	0.27	7
Rock greenling															
Sebastomus rockfish complex										0.67	1.12	35			
Tiger rockfish										0.02	0.14	2			
Treefish				0.03	0.17	3				0.02	0.14	2			
Unidentified rockfish	0.05	0.22	5	0.11	0.40	8	0.07	0.26	7	0.71	0.99	42	0.07	0.27	7
Unidentified surfperch							0.14	0.76	4	0.13	0.44	8	0.21	0.58	14
Vermilion rockfish							0.11	0.42	7	0.31	0.75	21	0.07	0.27	7

Table 4 continued.

Site	PR-7 (n=15)			PR-8 (n=21)			PR-9 (n=3)			DP-1 (n=7)			DP-2 (n=7)		
Taxon	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO	Mean	SD	%FO
Black rockfish	1.27	2.91	33	0.14	0.65	5									
Blue rockfish	2.00	4.64	20	0.52	1.25	19									
Brown rockfish	0.27	0.59	20	0.10	0.30	10									
Canary rockfish															
China rockfish	0.07	0.26	7												
Copper rockfish															
Flag rockfish															
Gopher rockfish	0.20	0.41	20	0.05	0.22	5									
Kelp greenling	1.53	1.25	73	0.76	1.09	48				0.71	0.49	71	0.43	0.79	29
Lingcod	0.20	0.41	20	0.14	0.36	14	0.33	0.58	33	0.29	0.49	29	0.43	0.79	29
Olive/Yellowtail rockfish															
Pile surfperch	0.47	1.25	13	0.05	0.22	5									
Quillback rockfish															
Rock greenling				0.05	0.22	5									
Sebastes rockfish complex							0.33	0.58	33	0.14	0.38	14			
Tiger rockfish															
Treefish															
Unidentified rockfish	0.20	0.56	13	0.14	0.48	10	1.33	1.53	67				0.14	0.38	14
Unidentified surfperch	0.20	0.56	13	0.05	0.22	5									
Vermilion rockfish	0.33	0.62	27										0.14	0.38	14

Evaluation of Study Areas for MPA Monitoring

Six of the eleven sites surveyed showed moderate to high potential as future monitoring sites (Table 5). All three sites sampled at Tomales Point showed high potential and both sites surveyed at Duxbury Point showed low potential for MPA monitoring. Sites surveyed near Point Reyes headland had varied potential, with three sites showing moderate potential and three sites showing low potential for MPA monitoring.

Water visibility and number of finfish taxa with a minimum density of 0.05 /100m² were the two leading factors in a site being evaluated as having low potential. Five of the six sites evaluated as low potential failed to meet minimum requirements in these two categories. Habitat minimum criteria were not met at three of the six poor potential sites and depth criteria at only one site.

Table 5. PORE and GOGA 2009 exploratory survey sites by location showing the average percent rocky habitat, average depth, maximum seawater visibility (m), number of finfish taxa with a mean density greater than 0.05 /100m² and site potential for future monitoring.

Study Area	Site	% Rocky Habitat	Average Depth	Max Seawater Visibility (m)	# Finfish Taxa > 0.05	Monitoring Potential (High, Moderate, Low)
Tomales Point						
	TP-1	97	25.3	4.3	5	High
	TP-2	94	34.0	3.4	7	High
	TP-3	99	41.9	3.5	7	High
Point Reyes Headland						
	PR-2	76	59.6	2.2	12	Moderate
	PR-4	12	48.5	0.6	0	Low
	PR-6	34	30.9	3.2	12	Moderate
	PR-7	49	20.8	3.4	11	Moderate
	PR-8	56	17.4	2.1	10	Low
	PR-9	52	39.0	0.7	3	Low
Duxbury Point						
	DP-1	99	23.6	0.9	3	Low
	DP-2	100	24.4	0.9	4	Low

DISCUSSION

Survey Totals

The number of lines completed at each site varied by area and was most affected by seawater visibility. The number of planned lines surveyed was decided in the field and was based on the minimum visibility needed to make accurate species identifications and to safely pilot the ROV through rocky habitat. Seven of the sites had sufficient seawater visibility that allowed for safe piloting and finfish identification; however, four of the eleven sites surveyed (PR-4, PR-9, DP-1 and DP-2), had only one planned line completed due to insufficient seawater visibility. An additional diagonal line segment was added in the field at site PR-9 so that the ROV could survey deeper water habitats similar to those surveyed during the line completed at site PR-4.

Based on the total number of lines surveyed and the total available rocky habitat, the number of 100m² transects generated varied by site. The Tomales Point study area generated the most transects per line, partly due to the large amount of rocky habitat. Other less rocky sites produce far less transects per line. The number of transects generated per line is an important factor when considering the costs associated with monitoring. Annual survey goals target 75 transects per study area. Sites that have little or no rocky habitat require higher sampling levels to meet the minimum transect goal.

Site Description

Study sites surveyed in 2009 varied considerably in the complexity and amount of rocky habitats observed. At Tomales Point, hard and/or mixed habitat accounted for more than 96% of the total habitats surveyed. Tomales Point also had the most complex habitats, with boulder and cobble observed at all three sites. The Point Reyes Headland sites (PR-2, PR-6, PR-7, and PR-8) were observed to have moderate amounts of rocky habitat, averaging over 50% rocky substrates. The PR-2 site was observed to have the most complexity of these sites. PR-2 is also a deep site and is the most distant from the shallower PR-6, PR-7, and PR-8 sites.

The PR-4 and PR-9 sites had little rocky habitat, with large amounts of fine sediment and sand. PR-9 was observed to have significantly rockier habitat than PR-4, but the amount of rock only was still less than all other sites. Both the Duxbury Point sites (DP-1 and DP-2) had the highest amount of hard habitat, but fine sediment covered all surfaces and the seawater visibility was poor. Based on the levels of fine sediments covering all rocky surfaces, it is anticipated that water visibility is often less than the minimum needed to conduct ROV based assessments.

Finfish Biological Data

The finfish abundances at these north central coast sites showed some similarities and differences when compared to other regions. The seven species/groupings of rockfish, which accounted for the majority of the total finfish, are also abundantly observed at the northern Channel Islands and within the central coast study region. The tiger rockfish, however, was observed for the first time during the 2009 survey at site PR-2. In addition, kelp greenling comprised a much greater percentage of the total finfish observed (20%) at the north central coast study sites but was much less abundant at the northern Channel Islands (0.09%) and within the central coast study region (1.8%).

Evaluation of Study Areas for MPA Monitoring

The results within this document do not support or preclude any study area from MPA monitoring. The evaluation of study areas results provided within this report will be submitted to Department managers for internal review. Following Department review, permanent study sites will be randomly selected within priority study areas of the north central coast study region.

REFERENCES

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, M. Bergen, J.J. Geibel, P.M. Law, C.F. Valle, and D. Fox. 2010 (*In Press*). Prospective (*a priori*) power analysis for detecting changes in density when sampling with strip transects. *California Fish and Game*. 96 (1).

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.

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.