Marine Sanctuaries Conservation Series ONMS (ONMS-16-01)

Benthic Characterization of Deep-Water Habitat in the Newly Expanded Areas of Cordell Bank and Greater Farallones National Marine Sanctuaries

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of National Marine Sanctuaries

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About the Marine Sanctuaries Conservation Series

The Office of National Marine Sanctuaries, part of the National Oceanic and Atmospheric Administration, serves as the trustee for a system of 14 marine protected areas encompassing more than 170,000 square miles of ocean and Great Lakes waters. The 13 national marine sanctuaries and one marine national monument within the National Marine Sanctuary System represent areas of America's ocean and Great Lakes environment that are of special national significance. Within their waters, giant humpback whales breed and calve their young, coral colonies flourish, and shipwrecks tell stories of our maritime history. Habitats include beautiful coral reefs, lush kelp forests, whale migrations corridors, spectacular deep-sea canyons, and underwater archaeological sites. These special places also provide homes to thousands of unique or endangered species and are important to America's cultural heritage. Sites range in size from one square mile to almost 140,000 square miles and serve as natural classrooms, cherished recreational spots, and are home to valuable commercial industries.

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Cover

A sedimentary rock outcrop slope was a prominent feature at The Football and provided habitat for cup corals in the family Flabellidae, crinoids (*Florometra serratissima)*, brittle stars and many other invertebrate and rockfish species (not shown in picture).

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Abstract

A large area of the seafloor off northern California lies within the US National Marine Sanctuary System, but very little of the habitat has been explored and even less is characterized using visual survey techniques, especially deep-water habitats. Benthic surveys using a Phantom HD2 remotely operated vehicle (ROV) were conducted during September 2-7, 2014 off the coast of Sonoma County, northern California at dive targets near Bodega Canyon and on a rocky feature informally named “The Football.” The targeted sites are within the northern areas recently added to Cordell Bank and Greater Farallones National Marine Sanctuaries. Information was collected to establish a baseline characterization of these areas that could inform researchers and the sanctuaries’ managers to better understand these deep-water ecosystems. The goals of the ROV surveys were to characterize deep-water benthic habitats, ground truth predicted habitat classifications, ground truth predictive habitat suitability models for coral and fish occurrence, and contribute to education and outreach about deep-water habitats. The sampling scheme was designed to characterize three classes of habitat predicted by multibeam sonar data: 1) hard-rugose (high-relief, hard bottom), 2) hard-flat (low-relief, hard bottom), and 3) soft-flat (low relief, soft bottom). A total of 20 transects were conducted, 9 at the Bodega Canyon site and 11 at The Football site at depths ranging from 180 to 306 meters. Many species of fishes, corals and sponges were documented. At Bodega Canyon at least 30 taxa of fish, 6 coral taxa and 6 sponge taxa were observed. At The Football at least 34 taxa of fish, 5 coral taxa and 4 sponge taxa were observed. A large sedimentary rock outcrop slope with many ledges and overhangs providing an ideal habitat for invertebrates and hundreds of rockfish were observed on The Football transect HC-30. A sea whip commonly seen while surveying The Football was collected and determined to be a new species *Swiftia farallonesica*. Other interesting observations included large aggregations of catshark and skate egg cases at The Football. Derelict fishing gear was observed at both sites.

Key Words

California continental shelf, deep-water benthic habitats, corals, sponges, rockfishes, National Marine Sanctuaries, remotely operated vehicle (ROV)

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Introduction

In 2014, the National Oceanic and Atmospheric Administration (NOAA) proposed to expand the northern and western boundaries of Cordell Bank and Gulf of the Farallones National Marine Sanctuaries off the northern California coast. The proposal followed years of grass roots support starting in 2001, with Congressional legislation, research, and public comment in the intervening years. Support for this proposal resulted in NOAA's decision (announced in the Federal Register [FR]; 80 FR 13078) to expand Cordell Bank National Marine Sanctuary (CBNMS) and Greater Farallones National Marine Sanctuary[1] (GFNMS), effective June 9, 2015 (Figure 1).

The waters of CBNMS and GFNMS are influenced by the Point Arena upwelling center, which contributes to the highly productive waters (Halle and Largier 2011) that sustain rich and abundant underwater biological communities including a diversity of fishes and invertebrates such as deep-sea corals and sponges (Roberts et al. 2004, Anderson et al. 2009, Etnoyer et al. 2014). Deep-sea corals and sponges are long-lived, slow-growing animals with structurally complex morphologies that can provide biogenic habitat for commercially important fishes and other invertebrates (Krieger and Wing 2002, Costello et al. 2005). Previous seafloor characterizations on the continental shelf and slope within the original boundaries of CBNMS and GFNMS have documented numerous species of deep-sea corals, sponges and fishes (Graiff et al. 2011, Etnoyer et al. 2014). ROV surveys over unconsolidated sand bottom in GFNMS documented the sea pen *Halipteris californica* as the dominant epifauna macroinvertebrate (de Marignac et al. 2008). However, there has been limited seafloor exploration and characterization within the newly established northern boundaries of CBNMS and GFNMS. Benthic surveys were needed to characterize the habitat and species in this area to inform management of the resources in the expanded areas of the sanctuaries.

During September 2-7, 2014, scientists from CBNMS, GFNMS, the National Centers for Coastal Ocean Science (NCCOS), the US Geological Survey (USGS) and the California Academy of Sciences (CAS) teamed up to characterize the seafloor habitats, fishes and invertebrates (with special focus on deep-sea corals and sponges), using a remotely operated vehicle (ROV) near Bodega Canyon and a rocky feature to the north informally named "The Football" (and referred to as such hereafter in this report) within CBNMS and GFNMS, respectively. The surveys were made possible, in part, by mapping activities conducted by NOAA Ship *Okeanos Explorer* in 2009 which provided bathymetry and hardness of the underlying seafloor.

Bodega Canyon is a prominent submarine feature within CBNMS that cuts across the continental shelf and slope about 16 km north of Cordell Bank. The Canyon is about 20 km long and is over 1,600 m deep. Submarine canyons provide areas of high bathymetric complexity, support deep-water communities, and affect local and regional circulation patterns. Physical and biological processes associated with Bodega Canyon make this a dynamic oceanographic area. Previous surveys in Bodega Canyon using an Autonomous Underwater Vehicle (AUV) revealed mud-draped hard substrate on the canyon edges, deep-sea corals and sponges associated with the hard substrate and numerous fishes (Fruh et al. 2011). These AUV surveys within and near Bodega

[1]NOAA changed the name from Gulf of the Farallones National Marine Sanctuary to Greater Farallones National Marine Sanctuary to reflect the new jurisdiction on June 15, 2015 (80 FR 34047).

Canyon included just a small area of this vast and complex underwater feature, making this region a priority for further characterization.

Underwater rocky features provide habitat for corals, sponges and fishes. Rocky banks in CBNMS and GFNMS include Cordell Bank, the focal point of CBNMS, and Rittenburg Bank and Cochrane Bank within GFNMS. The Football is a rocky feature, approximately 180 to 250 meters deep, in northern GFNMS located on the continental shelf north of Bodega Canyon and approximately 33 km west of the Russian River. The Football was briefly explored with a ROV in 2010 (Stierhoff et al. 2011). The survey confirmed hard bottom habitat was present, and identified a moderate-relief (~1 m) sedimentary rock outcrop slope with many ledges, providing habitat for rockfish and cup corals. The extent of the feature was undetermined at the time, but multibeam bathymetry suggested the feature was semi-continuous. Scattered boulders and cobbles were also observed, supporting numerous rockfish species and invertebrates, however no habitat forming deep-sea corals were observed and only a few small sponges were documented (Stierhoff et al. 2011). Although The Football may not be as structurally complex as the banks to the south, The Football's rocky habitats can be considered important as the area is large, but the habitat is relatively uncommon. The rocky area is mostly surrounded by expanses of low relief, soft sediments (as predicted from multibeam sonar data). Therefore, it was deemed important to continue and expand upon the characterization of The Football, particularly for deep-sea corals and sponges.

The goals and priorities of benthic characterization aboard the R/V *Fulmar* in 2014 were: (1) to use the sanctuary-owned Phantom HD2 ROV to characterize deep-water benthic habitats within the northern areas of Cordell Bank and Greater Farallones National Marine Sanctuaries, including fishes, corals, sponges, and physical habitat; (2) to contribute to outreach, education, and public awareness of deep-water habitats; (3) to ground truth interpreted habitat classification from multibeam sonar data; and (4) to ground truth habitat suitability models for corals and fishes.

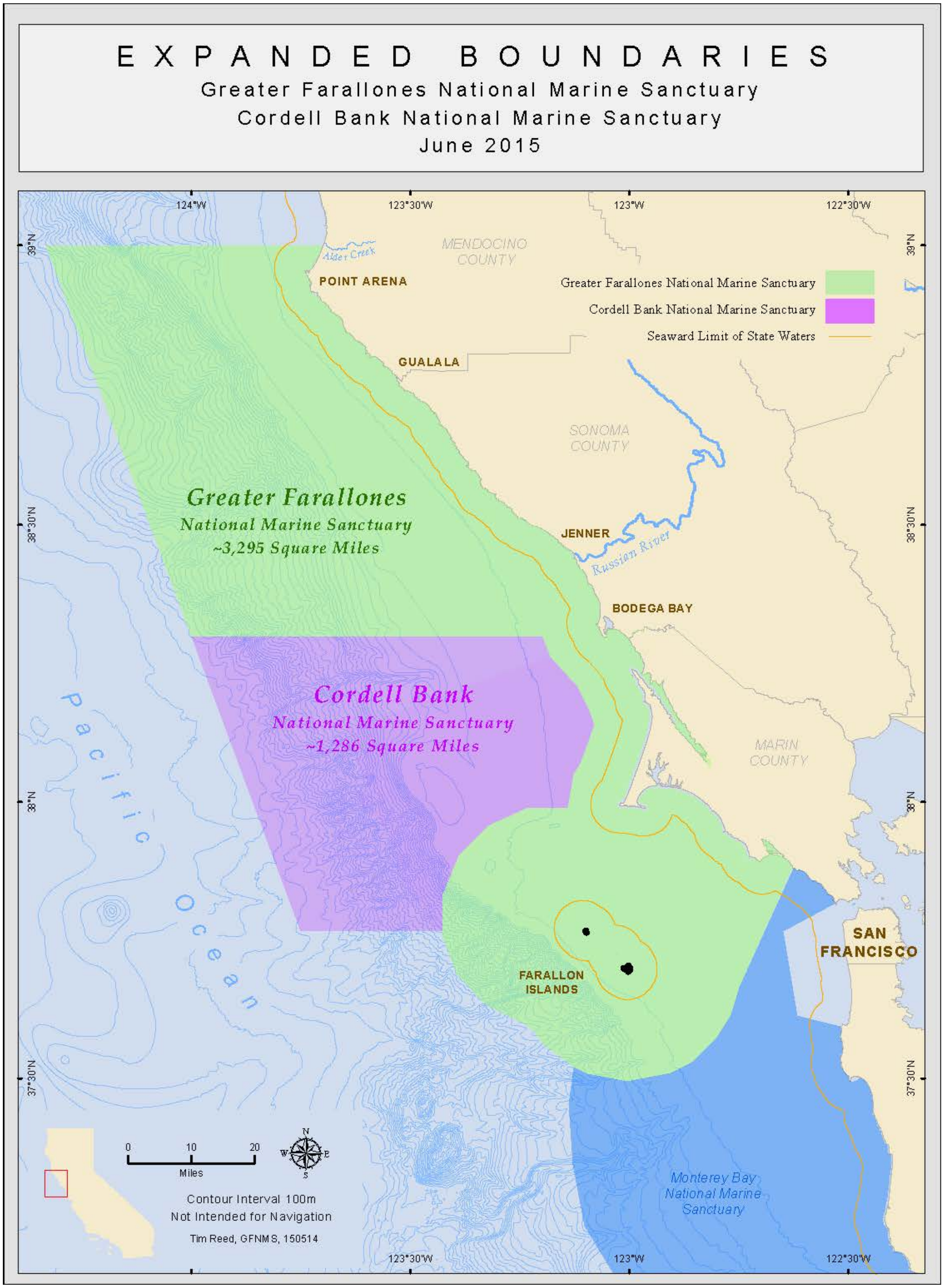

Figure 1. Expanded boundaries of Greater Farallones National Marine Sanctuary from approximately 1,282 sq. mi. to approximately 3,295 sq. mi., and Cordell Bank National Marine Sanctuary from approximately 529 sq. mi. to approximately 1,286 sq. mi. The northern area of Monterey Bay National Marine Sanctuary is shown in blue for reference but the boundaries of MBNMS were not expanded.

Methods

Site Selection

Two areas were selected for exploration, one within each sanctuary, based on the availability of multibeam data to interpret geology and the ability of the ROV to access these sites. The depth limit of the ROV was 310 meters. ROV dive sites at Bodega Canyon were selected on a projecting plateau to the south of the head of the canyon. This area was selected because it is in close proximately to the canyon which is oceanographically and geologically influential to CBNMS. The Football was selected for dive targets because a previous ROV dive revealed some relief and hard substrate (Stierhoff et al. 2011) (Figure 2).

Additionally, since one goal of the ROV surveys was to ground truth predictive fish and coral species models, some ROV transects were conducted in locations where the models predicted rockfish and coral species to occur. Some of these transects were completed during the vessel transit to Bodega Canyon and The Football. These transects are denoted by the “MV” in their identifier.

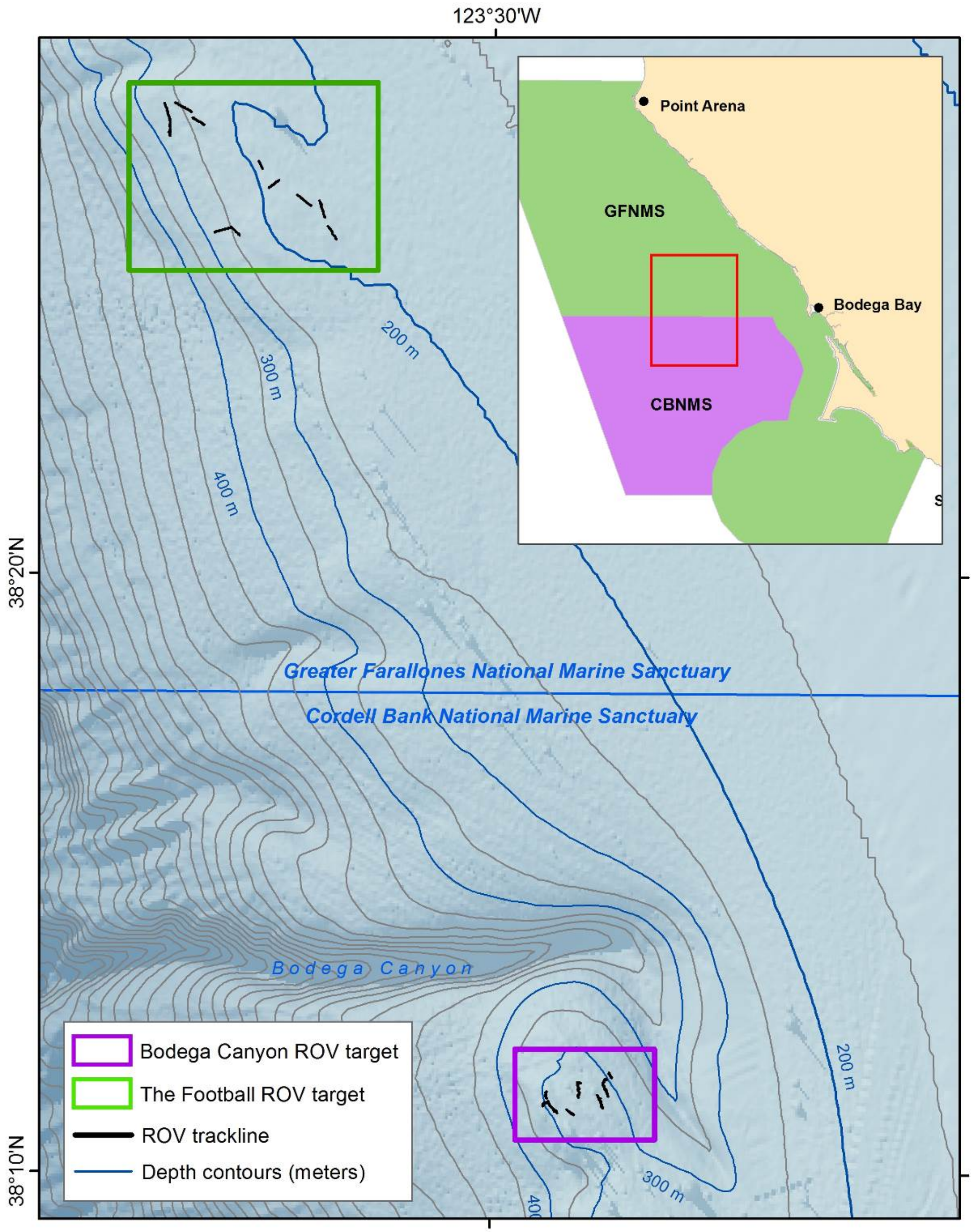

Figure 2. Locations of ROV dive targets near Bodega Canyon and The Football on the continental shelf within Cordell Bank National Marine Sanctuary (CBNMS) and Greater Farallones National Marine Sanctuary (GFNMS), northern California.

Field Survey

ROV dive sites were planned near Bodega Canyon and at The Football to ground truth multiple habitat types as predicted by multibeam sonar data collected in 2009 on the NOAA Ship *Okeanos Explorer* to produce a seafloor habitat characterization map. The sampling scheme targeted at least two transects in each of the three interpreted habitat categories: 1) hard-rugose (high-relief, hard bottom), 2) hard-flat (low-relief, hard bottom), and 3) soft-flat (low relief, soft bottom), at each of the two sites. In addition, transects were planned in areas to test habitat suitability models for corals and fishes. Planned transects were 500 to 750 meters in length and no deeper than 310 meters (maximum depth rating of the ROV).

Operations were conducted September 2-7, 2014 onboard the R/V *Fulmar* using the CBNMS Phantom HD2 ROV. The ROV was outfitted with three cameras to collect photographic and video images. A standard definition video camera (Deep Ocean Engineering) on a motorized tilt was mounted on the front center of the ROV to be forward-looking. During surveys the video camera angle was maintained at approximately 60 degrees from vertical. Standard definition (SD) video was continuously recorded to mini digital video (MiniDV) tapes. A pair of parallel lasers were used for scale, set 10 cm apart and positioned in the center of the video frame for sizing objects viewed in images. A high-definition still camera (Insite Pacific Scorpio Plus) on loan from the Undersea Vehicles Program at University of North Carolina at Wilmington was mounted on the top lateral bar of the ROV frame at an angle of approximately 60 degrees. Still images were manually captured approximately every 30 seconds using Insite Pacific custom user interface software on a topside laptop and stored on the camera's storage card until they were downloaded to a hard drive after the ROV was recovered. A strobe light (Insite Pacific) illuminated the camera field of view when the still camera was triggered and three other lights (Deep Sea Power and Light) provided lighting for the video cameras. In addition, a GoPro Hero 3 camera in a custom submersible housing was mounted facing forward on the lower front lateral bar of the ROV frame to capture wide angle high-definition video imagery for education and outreach.

Specimens of corals and other organisms of interest were collected as they were encountered using the ROV's manipulator arm with a two-fingered pincher. Samples were preserved dry and in 95% ethanol, labeled, and bagged in plastic. The ROV was not equipped with storage compartments so specimens were held in the manipulator arm until the ROV surfaced and recovered on the ship deck. Only one collection was made per dive.

The ROV dives each consisted of a series of pre-determined transects over a geological classification scheme with a series of transits to approach the start point(s) and maneuver between transects. While on transect, the ROV maintained a consistent height and speed from the bottom; about 1 meter off the bottom and at a speed of 0.5 to 1 knots. During the dive, the ROV position was tracked using an ORE Trackpoint II acoustic tracking system which provided bearing and range from the R/V *Fulmar* to the ROV. Trackpoint positions were integrated with the ship's GPS and relative to the planned transect lines using Hypack software (Hypack, Inc., Connecticut, USA).

Data Processing and Video Analysis

ROV and ship tracking data were recorded at one second intervals. The locations were smoothed with a filter over a 20 point sampling window. Positions with a distance greater than 0.1 degrees from the previous position were removed.

MiniDV tapes from the forward facing SD video camera were converted to digital MPG files using a Diamond Multimedia VC500 Video Capture Device and these files were used for analysis. Survey distance and duration varied among transects so the MPG files were reviewed to subsample 15-minute segments that met specific criteria: the seafloor was in focus with clear visibility and the ROV moved at a consistent height and speed over bottom. These 15-minute segments were used for species identification and counts, which were later converted into quantitative densities of fishes and invertebrates based on the area of the transect.

To estimate transect area, the length of the 15-minute segments was measured by summing the distance between successive UTM points in the segment. The width of the field of view of the video camera was estimated by measuring the distance between the laser points as they were observed on the video monitor and applying the ratio of the known laser distance (10 cm) with that measured on the video screen to calculate the width of the field of view. Since this value changed as the altitude of the ROV changed the width estimates were made every 30 seconds or when there was a large (> 1 m) change in ROV altitude and these estimates were applied to the entire 30 seconds of the segment. The total area of each 15-minute segment was the product of the total width measurements and total segment length.

Subject matter experts separately reviewed videos for substrate, fishes, and invertebrates and each data set was imported into a Microsoft Access relational database. ROV transects ranged in duration from 17 minutes to more than an hour. Data were analyzed for substrate, invertebrates, species associations of fishes with corals or sponges, and marine debris. Fishes were identified within the 15-minute subsampled segments only because of the significant processing time required to review video to identify fishes. Densities of corals, sponges and fishes were estimated for the area of the 15-minute quantitative segments. Relative percent composition of corals and sponges and other invertebrates from the remainder of each transect (referred to as qualitative transects in this report) was also calculated.

A fish was considered "associated" with a coral or sponge if it was located less than one body length away or in direct contact with a coral or sponge (Krieger and Wing 2002, Tissot et al. 2006). The type of association, the taxa with which the fish was associated, and the coordinates were recorded. Fishes were identified to the lowest taxonomic level, enumerated, sized using the paired lasers, and georeferenced. Elasmobranch egg cases were also enumerated when image resolution was satisfactory. Egg cases and egg bundles were identified as Scyliorhinidae (catshark) or Rajiformidae (skate), based on their morphology. Individual skate egg cases could be counted because they were large and discernible, but many of the catshark egg cases occurred in large aggregations or bundles. Counts of catshark egg cases in bundles were estimated from *in situ* images based on laboratory counts of shark eggs from a single bundle collected by the ROV.

Counts in images were estimates based on number of egg cases per unit volume from the collected shark egg bundle.

Macro invertebrates in the following categories were identified to the lowest taxonomic level, enumerated, and georeferenced: corals and sponges $\geq$ 10 cm, Flabellidae cup-corals (usually $<$ 10 cm), anemones larger than 10 cm, sea pens (*Halipteris* spp.), sea stars, urchins, and spot prawns (*Pandalus platyceros*). Some invertebrates were recorded as presence only. These included: small sea pens (possibly *Stylatula* sp. or *Virgularia* sp.), octopus, crabs, brittle stars, and crinoids. Corals and sponges were measured within categories as follows: 10-20 cm (Category 1); 21-50 cm (Category 2); and larger than 50 cm (Category 3). Specimen collections were identified and cataloged at the California Academy of Sciences (CAS), San Francisco; one elasmobranch sample, a juvenile catshark in an egg case bundle, was cataloged at College of Charleston for mitochondrial DNA analysis by Dr. Gavin Naylor.

Three classes of substratum types: 1) hard-rugose (high-relief, hard bottom), 2) hard-flat (low-relief, hard bottom), and 3) soft-flat (low relief, soft bottom) were used to quantify distinct changes in substratum types greater than or equal to 30 seconds in duration along the transect, thus establishing “habitat patches” of uniform substrate type. Marine debris was also identified and georeferenced.

The high-definition video collected by the GoPro camera was originally collected to be used for education and outreach. However, GoPro video and the high-definition still images were found to be useful in species detection and identification and were referenced alongside the lower quality SD video. The GoPro was battery powered and recorded *in situ* to a SD card so there were some instances when the GoPro would stop recording (battery died or SD card filled) before the end of the dive. Therefore, GoPro video does not exist for all transects or some portions of transects resulting in lower species detection and identification for those transects without GoPro video. All the GoPro video was made available to education staff at GFNMS and CBNMS to be used in education and outreach products.

Results

General Location and Dive Track – Bodega Canyon

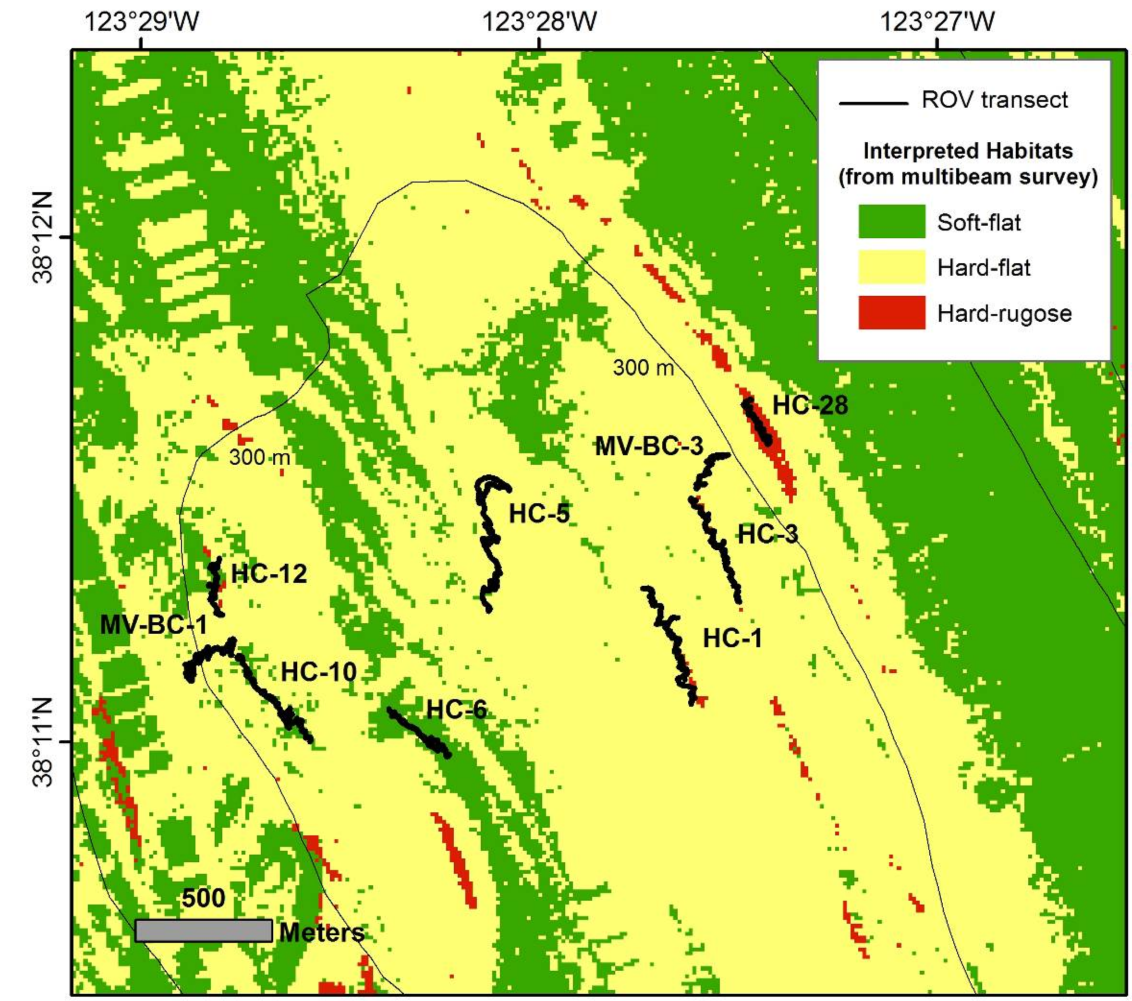

Figure 3. Bodega Canyon ROV transect track lines overlaid on interpreted habitat types predicted from multibeam data.

Transect Summary - Bodega Canyon

Total transects: 9 Depth range (m): 273 to 306

Table 1. Transects completed for Bodega Canyon area. Predicted habitat type refers to the substrate type that was anticipated from the interpreted habitat model displayed in Figure 3 and model type refers to the predictive species model that the survey was ground truthing.

Date	Dive	Transect	Transect duration	Area of 15-minute Segment (m^2)	Predicted Habitat or Model Type	Observed Habitat	Depth min (m)	Depth max (m)	Start Lat/Long	End Lat/Long
9/2/2014	1	HC-5	0:41:00	1,081	Hard-flat	Hard-flat	273	283	38.1915 -123.4689	38.1878 -123.4687
9/3/2014	2	HC-12	0:32:50	950	Hard-rugose	Hard-rugose Hard-flat	281	292	38.1894 -123.4799	38.1876 -123.4799
9/3/2014	2	MV-BC-1	0:33:00	n/a	Holaxonia model	Hard-flat	282	292	38.1859 -123.4813	38.1863 -123.4794
9/3/2014	2	HC-10	0:42:00	891	Soft-flat	Soft-flat Hard-flat	282	285	38.1862 -123.4792	38.1834 -123.4761
9/3/2014	2	HC-6	0:32:50	641	Soft-flat	Soft-flat Hard-flat	277	280	38.1845 -123.4728	38.1830 -123.4703
9/4/2014	3	HC-28	0:22:10	884	Hard-rugose	Hard-flat	301	306	38.1947 -123.4579	38.1933 -123.4570
9/4/2014	3	MV-BC-3	0:17:15	736	Sablefish and Thornyheads models	Hard-flat	287	291	38.1929 -123.4587	38.1918 -123.4599
9/4/2014	3	HC-3	0:29:15	714	Hard-flat	Hard-flat	283	289	38.1915 -123.4602	38.1881 -123.4581
9/4/2014	3	HC-1	0:41:00	914	Hard-rugose	Hard-rugose Hard-flat	274	278	38.1885 -123.4622	38.1847 -123.4601

Physical Habitat - Bodega Canyon

A total area of 6,811 m^2 of seafloor was surveyed during the eight 15-minute quantitative segments conducted in the Bodega Canyon area. Area for transect MV-BC-1 could not be calculated because the ROV's lasers were turned off and transect width could not be estimated. Habitat types were classified as (1) soft-flat (3% of the total area surveyed) comprised of sand and mud sediments were observed in small patches; (2) hard-flat (93% of the total area surveyed) comprised of sand mixed with cobbles, boulders or rocks, or a mix of cobbles, boulders and rocks; and (3) hard-rugose (4% of total area surveyed) rocky bottom was limited (Figure 4).

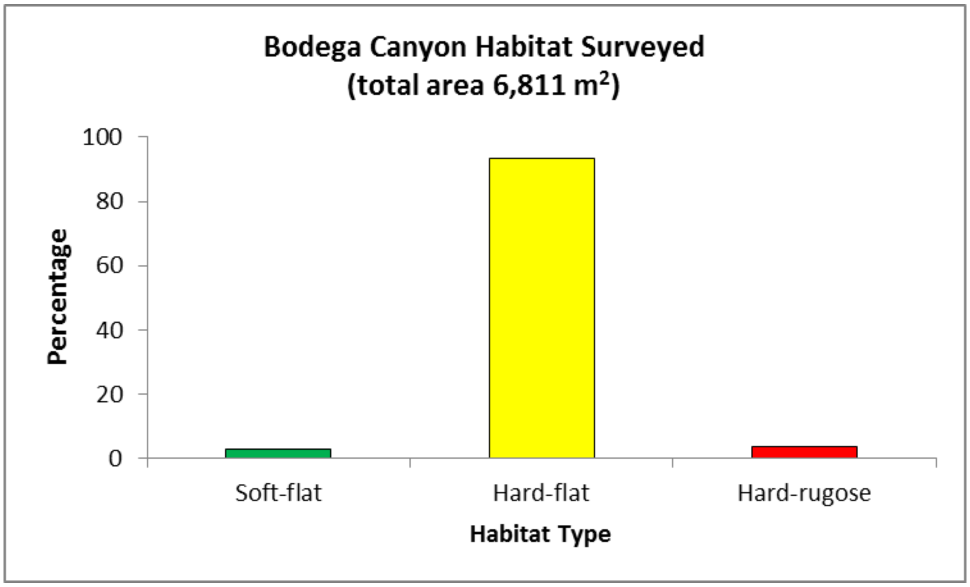

Figure 4. Percent of total habitat (soft-flat, hard-flat, hard-rugose) area observed along quantitative segments in the Bodega Canyon area

Biological Environment – Bodega Canyon

Fishes

A total of 589 fishes from at least 30 different taxa were enumerated from the eight 15-minute quantitative segments conducted in the Bodega Canyon region (Table 2). A total density of 79 fish per 1,000 m^2 of seafloor was estimated. No density estimates were available from transect MV-BC-1 because the ROV's lasers were turned off and transect area could not be calculated.

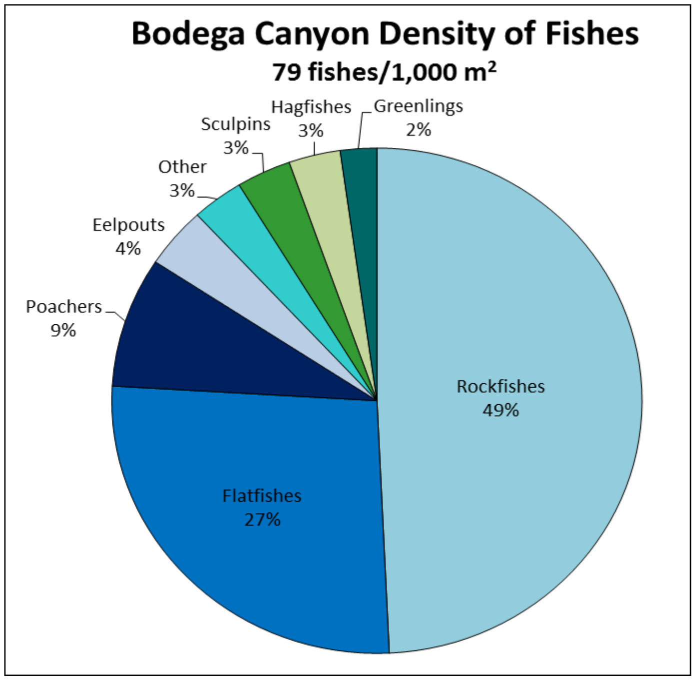

Figure 5. Percent composition of densities of fish groups from Bodega Canyon. Colors in pie diagram match colors in list of fish taxa (Table 2).

Rockfishes (at least 12 *Sebastes* species and at least 1 *Sebastolobus* species) comprised almost half (49%) of total fish density. Flatfishes (at least 5 species) accounted for 27% of the total density and many individuals could not be identified to the species level due to them being mostly covered in soft sediment. Poachers accounted for 9% of total density. The remainder of the fish assemblage included eelpouts (4%), other taxa (3%), sculpins (3%), Pacific hagfish (3%), and lingcod (2%) (Figure 5).

A small bundle of catshark egg cases was observed attached to a fishing net along transect HC-3. The total estimate was 13 catshark eggs. No catsharks were observed. Transect MV-BC-3 was designed to test a predictive model for sablefish *(Anoplopoma fimbria)* and thornyheads (*Sebastolobus* spp.). A total of 16 thornyheads were observed, but no sablefish.

Table 2. Abundance of fish taxa observed on Bodega Canyon transects. Colors in table match colors in pie diagram (Figure 5).

Scientific Name	Common Name	Number
Fishes		
Sebastes aurora	Aurora rockfish	1
Sebastes babcocki	Redbanded rockfish	1
Sebastes crameri	Darkblotched rockfish	6
Sebastes diploproa	Splitnose rockfish	5
Sebastes elongatus	Greenstriped rockfish	2
Sebastes goodei	Chilipepper rockfish	86
Sebastes helvomaculatus	Rosethorn rockfish	31
Sebastes pinniger	Canary rockfish	1
Sebastes rufus	Bank rockfish	11
Sebastes saxicola	Stripetail rockfish	9
Sebastes zacentrus	Sharpchin rockfish	1
Sebastes spp.	Unidentified rockfishes	42
Sebastolobus spp.	Unidentified thornyheads	66
Sebastomus subgenus	Unidentified rockfishes	25
Eopsetta jordani	Petrale sole	6
Glytocephalus zachirus	Rex sole	12
Lyopsetta exilis	Slender sole	9
Microstomus pacificus	Dover sole	43
Pleuronectiformes	Unidentified flatfishes	86
Agonidae	Unidentified poachers	56
Lycodes diapterus	Black eelpout	1
Lyconema barbatum	Bearded eelpout	20
Zoarcidae	Unidentified eelpouts	1
Hydrolagus colliei	Spotted ratfish	6
Merluccius productus	Pacific hake	8
Raja rhina	Longnose skate	4
Paricelinus hopliticus	Thornback sculpin	4
Cottidae	Unidentified sculpins	14
Eptatretus stoutii	Pacific hagfish	18
Ophiodon elongatus	Lingcod	14

Findings from Quantitative 15-Minute Segments:

A total of 25 individual corals from 4 taxa and 12 individual sponges from at least 5 taxa were enumerated from the eight 15-minute quantitative segments conducted in the Bodega Canyon region (Table 3). A total density of 5 corals and sponges per 1,000 m^2 of seafloor was estimated. No density estimates were available from transect MV-BC-1 because the ROV's lasers were turned off and transect area could not be calculated.

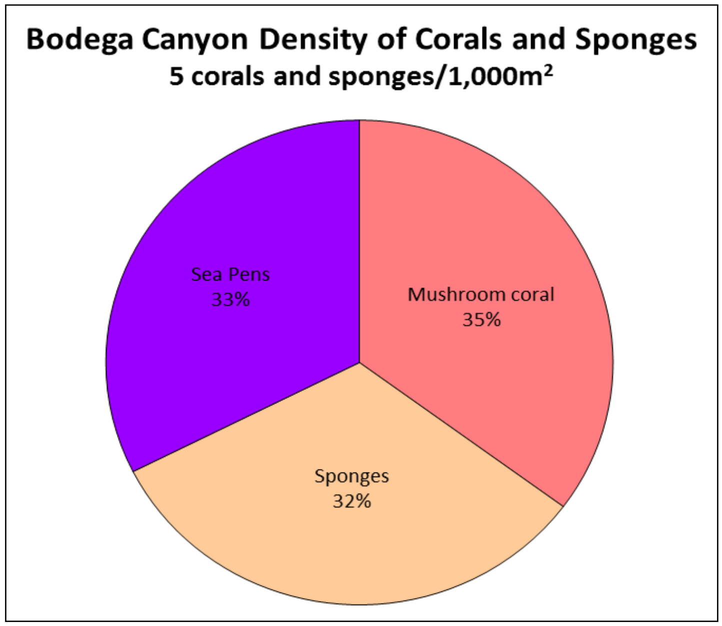

Figure 6. Percent composition of densities of corals and sponges from Bodega Canyon. Colors in pie diagram match colors in list of coral and sponge taxa (Table 3).

The mushroom coral (*Heteropolypus ritteri*) comprised 35% of the total density and sea pens accounted for 33% of the total density. Small sea pens (possibly *Stylatula* sp. or *Virgularia* sp.) were not enumerated but were present on 3 of the 10 transects. Also noteworthy is the one primnoid octocoral, *Plumarella* sp., observed on transect MV-BC-1 but not included in density estimates as previously stated. Sponges accounted for 32% of total density of sessile benthic invertebrates (Figure 6). The structure forming barrel/boot sponges, *Staurocalyptus* sp. were most conspicuous, and ranged in size from 10 – 20 cm tall.

Transect MV-BC-1 was designed to test a predictive model for Holaxonia gorgonian corals, however no corals in this suborder were observed on transect.

Table 3. Abundance of corals and sponges observed on Bodega Canyon transects. Colors in table match colors in pie diagram (Figure 6).

Scientific Name	Common Name	Number
Corals and Sponges		
Heteropolypus ritteri	Mushroom coral	13
Halipteris californica	Sea pen	8
Pennatulacea	Sea pen	2
Ptilosarcus gurneyi	Orange sea pen	2
Dysidea sp.	Gray sponge	1
Euplectella sp.	Glass sponge	2
Iophon sp.	White sponge	1
Polymastia sp.	Aggregated sponge	1
Staurocalyptus sp.	Barrel/boot sponge	7

Findings from qualitative segments:

A total of 41 individual sponges from at least 6 taxa and 66 individual corals from 3 taxa were enumerated from the remaining Bodega Canyon transects that were not part of the 15-minute quantitative segments (Table 4a). Sponges accounted for 38% of species composition of sessile benthic invertebrates. Observations of mushroom corals (*Heteropolypus ritteri)* comprised 36% of the total species composition. Sea pens comprised 26% of species composition (Table 4b). Small sea pens (possibly *Stylatula* sp. or *Virgularia* sp.) were not enumerated but were present on 1 of the 10 transects.

Table 4. (a) Abundance of corals and sponges documented on Bodega Canyon qualitative segments. (b) Percent composition of coral and sponge counts. Colors of corals and sponges in table (a) match colors in table (b).

a.	Scientific Name	Common Name	Number
Corals and Sponges			
	Dysidea sp.	Gray sponge	1
	Euplectella sp.	Glass sponge	5
	Iophon sp.	White sponge	2
	Mycale sp.	Yellow vase sponge	1
	Porifera	Unidentified sponges	7
	Staurocalyptus sp.	Barrel/boot sponge	25
	Heteropolypus ritteri	Mushroom coral	38
	Halipteris californica	Sea pen	23
	Pennatulacea	Sea pen	5

b.	Corals and Sponges	% Composition
	Sponges	38
	Mushroom coral	36
	Sea pens	26

Other Invertebrates

A total of 2,324 other invertebrates such as sea stars (*Ceramaster patagonicus*, *Rathbunaster californicus*, other Asteroidea); sea urchins (*Strongylocentrotus fragilis*); spot prawns (*Pandalus platyceros*); and anemones (*Corallimorphus pilatus*, other Actiniaria) were counted along Bodega Canyon transects and total percent composition is displayed in Figure 7. *Corallimorphus pilatus* accounted for over half of the total percent composition of these taxa.

Other invertebrates present in the Bodega Canyon area included unidentified octopus species, brachyurian crabs, brittle stars and crinoids (*Florometra serratissima*). Crinoids were commonly observed, and recorded as present on 9 of the 10 transects.

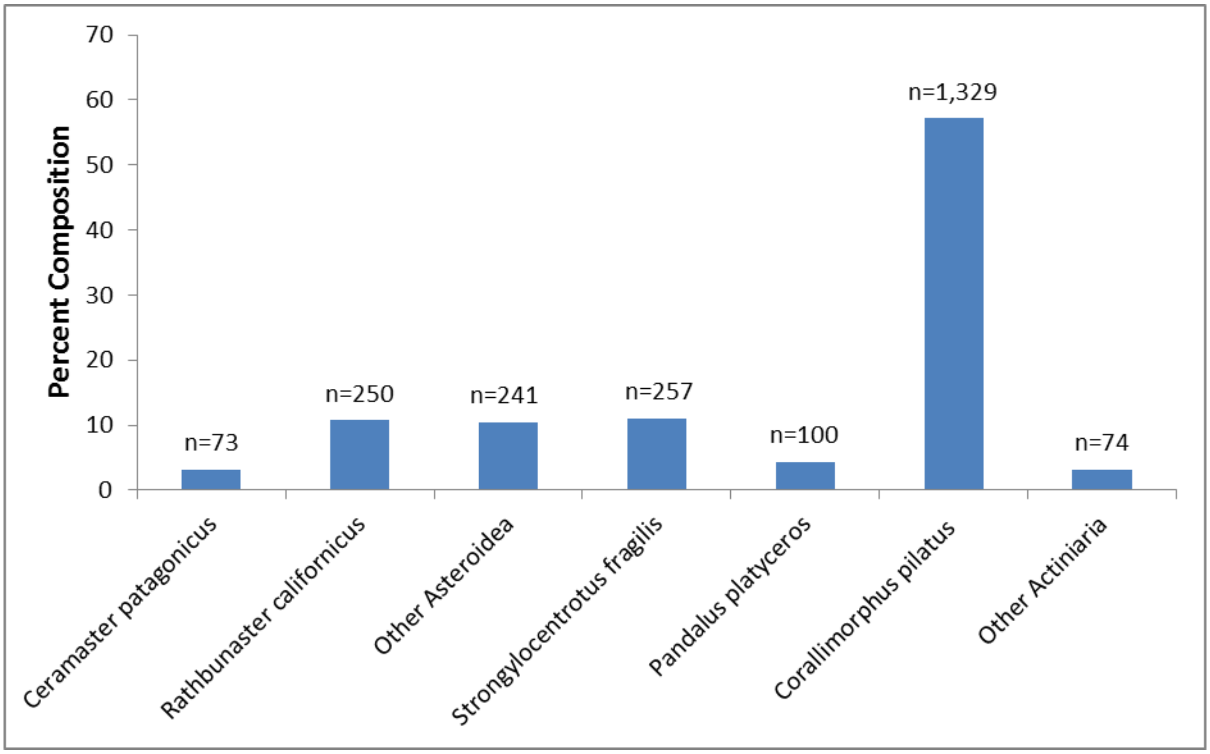

Figure 7. Total percent composition of other invertebrates from Bodega Canyon transects.

Other Observations – Bodega Canyon

Fish-Invertebrate Associations

There were 11 fishes associated with a coral or sponge in the Bodega Canyon region. Three fish were documented in direct contact with three individual sponges. Eight fishes were documented within one body length of the coral or sponge (Table 5).

Table 5. Associations of fish and invertebrates from Bodega Canyon transects. *Association code: 1 = fish in contact with coral or sponge; 2 = fish within 1 body length of coral or sponge.

Transect	Fish	Fish Count	Association Code*	Invertebrate	Latitude	Longitude
MV-BC-1	Agonidae	1	1	*Iophon* sp.	38.1864	-123.4801
MV-BC-1	*Ophiodon elongatus*	1	2	*Heteropolypus ritteri*	38.1855	-123.4811
MV-BC-1	*Lyconema barbatum*	1	2	*Heteropolypus ritteri*	38.1863	-123.4797
MV-BC-1	*Sebastes helvomaculatus*	1	1	*Staurocalyptus* sp.	38.1863	-123.4797
HC-6	*Sebastes goodei*	1	2	*Ptilosarcus gurneyi*	38.1832	-123.4710
HC-5	*Ophiodon elongatus*	1	1	*Staurocalyptus* sp.	38.1889	-123.4682
HC-12	*Hydrolagus colliei*	1	2	*Heteropolypus ritteri*	38.1885	-123.4802
HC-10	Unknown flatfish	1	2	*Heteropolypus ritteri*	38.1842	-123.4770
HC-1	*Sebastes rufus*	3	2	*Staurocalyptus* sp.	38.1849	-123.4600

Anthropogenic Items/Derelict Fishing Gear

There were three observations of anthropogenic materials from the Bodega Canyon region, including: one trawl net; one large metal cylinder with a hole in middle about 100 cm long with crinoids (*Florometra serratissima*) and other inverts and an associated darkblotched rockfish (*Sebastes crameri*); and one small pile of rope covered in sediment.

Collections

Table 6. Specimen collection from Bodega Canyon.

Specimen No.	Species	Date	Coordinates	Transect	Depth	CAS Cat. No.
S1	*Halipteris californica* (Sea Pen)	3-Sep-14	38.1818 -123.4707	HC6	282 m	196928

General Location and Dive Track –The Football

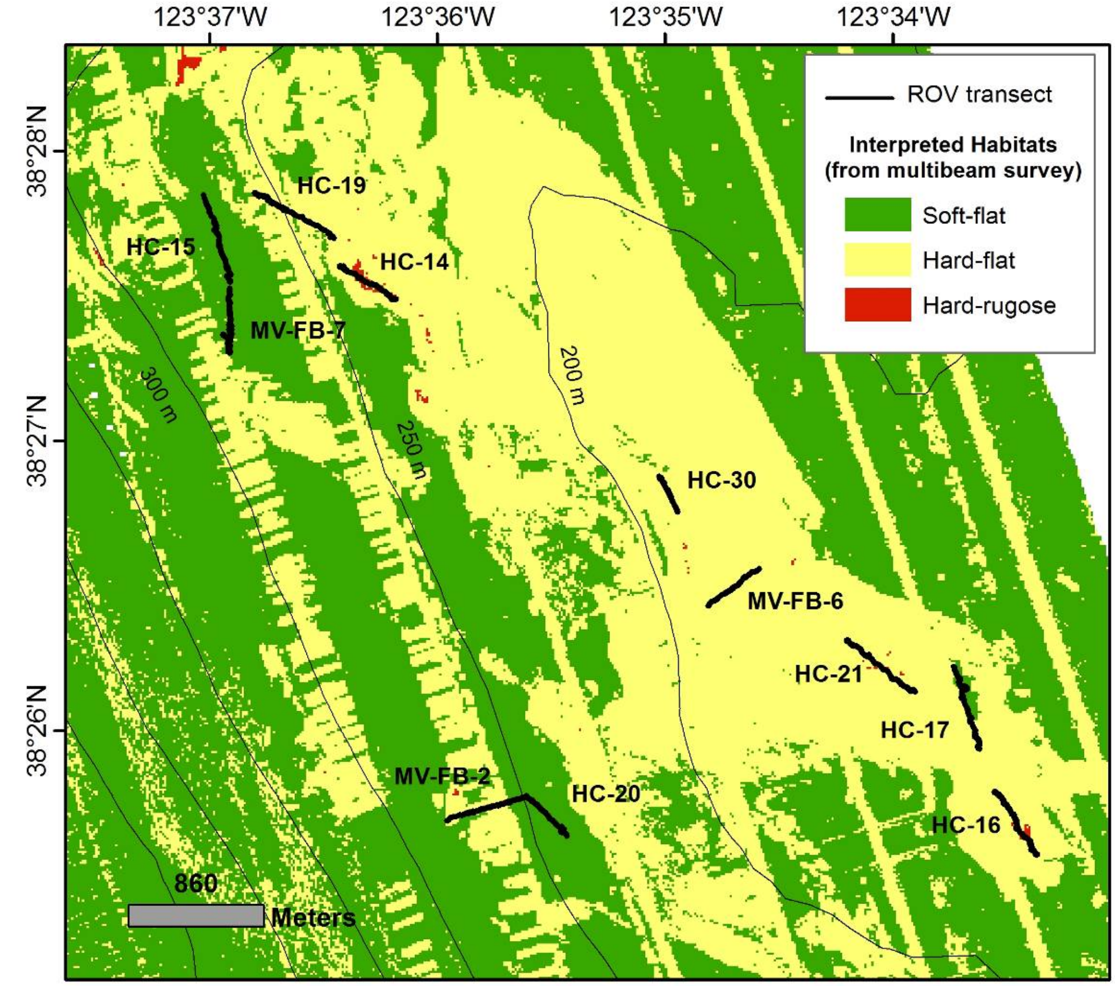

Figure 8. The Football ROV transect track lines overlaid on interpreted habitat types predicted from multibeam data. Quality of the multibeam data was compromised by rough sea conditions during the survey, therefore causing the striped appearance classified as hard-flat habitat. These habitats are more likely to be soft-flat based on the classification of the surrounding habitats.

Transect Summary - The Football

Total transects: 11 Depth range (m): 180 to 279

Table 7. Transects completed for The Football area. Predicted habitat type refers to the substrate type that was anticipated from the interpreted habitat model displayed on Figure 8 and model type refers to the predictive species model that the survey was ground truthing.

Date	Dive	Transect	Transect duration	Area of 15-minute Segment (m^2)	Predicted Habitat or Model Type	Observed Habitat	Depth min (m)	Depth max (m)	Start Lat/Long	End Lat/Long
9/5/2014	5	MV-FB-7	0:22:40	702	Darkblotch model	Soft-flat	268	279	38.4552 -123.6151	38.4589 -123.6150
9/5/2014	5	HC-15	0:35:40	598	Soft-flat	Soft-flat	262	269	38.4592 -123.6150	38.4642 -123.6170
9/5/2014	5	HC-19	0:51:00	305	Hard-flat	Hard-flat Soft-flat	235	251	38.4643 -123.6132	38.4617 -123.6074
9/5/2014	6	HC-14	1:06:50	397	Hard-rugose	Hard-rugose Hard-flat Soft-flat	223	240	38.4601 -123.6070	38.4583 -123.6028
9/6/2014	7	HC-16	0:57:00	630	Hard-rugose	Hard-rugose Hard-flat	181	189	38.4266 -123.5558	38.4301 -123.5589
9/6/2014	7	HC-17	0:35:45	627	Hard-flat	Hard-flat Soft-flat	185	186	38.4327 -123.5599	38.4374 -123.5619
9/6/2014	7	HC-21	0:35:42	893	Hard-rugose	Hard-rugose Hard-flat	180	184	38.4359 -123.5648	38.4388 -123.5698
9/6/2014	8	HC-30	0:33:30	388	Hard-flat	Hard-flat Hard-rugose	191	192	38.4482 -123.5836	38.4461 -123.5822
9/6/2014	8	MV-FB-6	0:25:00	523	Canary model	Hard-flat Hard-rugose	184	188	38.4408 -123.5799	38.4429 -123.5762
9/7/2014	9	MV-FB-2	0:40:40	283	Chilipepper model	Soft-flat Hard-flat	243	274	38.4283 -123.5989	38.4297 -123.5930
9/7/2014	9	HC-20	0:47:20	286	Soft-flat	Soft-flat Hard-flat Hard-rugose	234	245	38.4298 -123.5931	38.4275 -123.5901

Physical Habitat – The Football

A total area of 5,632 m^2 of seafloor was surveyed during the eleven 15-minute quantitative segments conducted in The Football area. Habitat types were classified as (1) soft-flat (40% of the total area surveyed) comprised completely of sand or sand with a few boulders primarily on transects to the west of The Football feature; (2) hard-flat (25% of the total area surveyed) comprised of sand mixed with cobbles, boulders or rocks, or a mix of cobbles, boulders and rocks; and (3) hard-rugose (35% of the total area surveyed) primarily composed of a mix of larger rocky substrata like boulders, rock, cobbles. A large sedimentary rock outcrop slope that was eroded, forming many rock ledges and overhangs, on transect HC-30 was originally predicted to be hard-flat habitat, was later included in hard-rugose category (Figure 9).

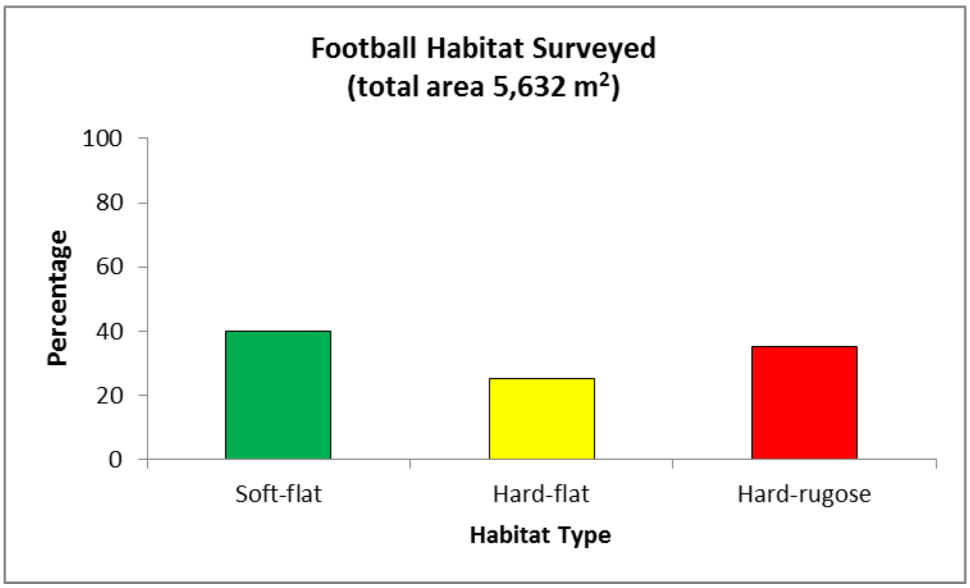

Figure 9. Percent of total habitat (soft-flat, hard-flat, hard-rugose) area observed along quantitative segments at The Football.

Biological Environment – The Football

Fishes

A total of 2,038 fishes from at least 34 different taxa were enumerated from the eleven 15-minute quantitative segments conducted on The Football (Table 8). A total density of 362 fish per 1,000 m^2 of seafloor was estimated.

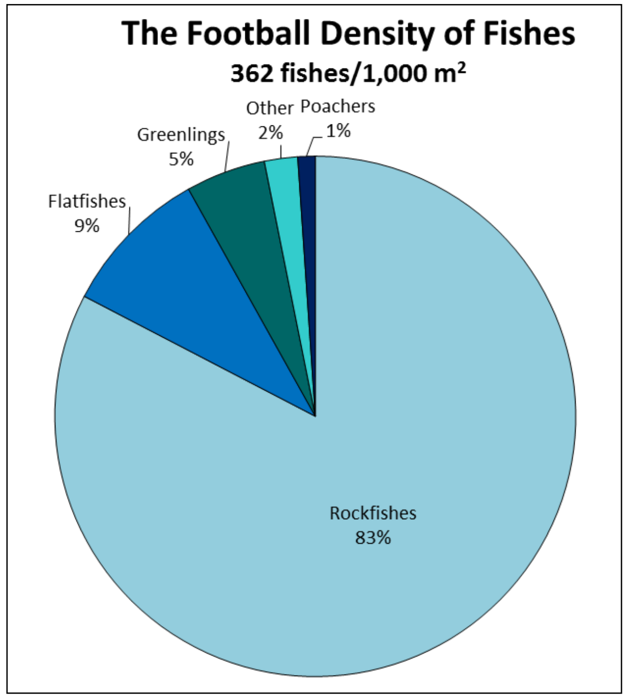

Figure 10. Percent composition of densities of fish groups from The Football. Colors in pie diagram match colors in list of fish taxa (Table 8).

Rockfishes (at least 16 *Sebastes* species and at least 1 *Sebastolobus* species) comprised 83% of total fish density. Flatfishes (from at least 6 species) accounted for 9% of total density and many individuals could not be identified to the species level because they were mostly covered in soft sediment. The remainder of the fish assemblage included lingcod (5%), other taxa (2%) and poachers (1%) (Figure 10).

Transects MV-FB-7 and MV-FB-2 were designed to test predictive models for darkblotched rockfish (*Sebastes crameri)* and chilipepper rockfish *(Sebastes goodei)* respectively, however neither of these species were observed on transect. Transect MV-FB-6 was designed to test a predictive model for canary rockfish (*Sebastes pinniger)*; two individuals were observed on transect.

A total of 986 catshark and skate egg cases were observed during surveys at The Football. A total of 254 skate egg cases were observed on transects HC-14 and HC-19. A large number of catshark egg cases were observed in beehive-shaped bundles attached to rocks on transects HC-14, HC-19 and HC-20. The total estimate was 732 catshark egg cases in a total of 11 bundles at The Football. Laboratory examination of one bundle revealed 164 egg cases of which 35% contained yolk sacs and 65% were empty (presumably hatched or predated). Egg cases with yolk sacs were exterior, empty egg cases were interior. One juvenile hatched on deck. Tissue samples revealed mDNA sequences suggesting the species to be *Apristurus brunneus* (brown catshark). This species of Scyliorhinid shark is common from Baja to southeastern Alaska (Flammang et at. 2008). No adult cat sharks were observed during quantitative transects.

Table 8. Abundance of fish taxa observed on The Football transects. Colors in table match colors in pie diagram (Figure 10).

	Scientific Name	Common Name	Number
Fishes			
	Sebastes chlorostictus	Greenspotted rockfish	79
	Sebastes elongatus	Greenstriped rockfish	35
	Sebastes entomelas	Widow rockfish	684
	Sebastes goodei	Chilipepper rockfish	2
	Sebastes helvomaculatus	Rosethorn rockfish	93
	Sebastes hopkinsi	Squarespot rockfish	8
	Sebastes jordani	Shortbelly rockfish	2
	Sebastes levis	Cowcod	3
	Sebastes paucispinis	Bocaccio	1
	Sebastes pinniger	Canary rockfish	3
	Sebastes ruberrimus	Yelloweye rockfish	15
	Sebastes rufus	Bank rockfish	7
	Sebastes saxicola	Stripetail rockfish	100
	Sebastes wilsoni	Pygmy rockfish	64
	Sebastes zacentrus	Sharpchin rockfish	93
	Sebastes spp.	Unidentified juvenile rockfish	90
	Sebastes spp.	Unidentified rockfishes	375
	Sebastolobus spp.	Unidentified thornyheads	2
	Sebastomus subgenus	Unidentified rockfishes	28
	Atheresthes stomias	Arrowtooth flounder	1
	Glyptocephalus zachirus	Rex sole	10
	Lyopsetta exilis	Slender sole	9
	Microstomus pacificus	Dover sole	32
	Parophrys vetulus	English sole	6
	Pleuronectiformes	Unidentified flatfishes	131
	Ophiodon elongatus	Lingcod	101
	Eptatretus stoutii	Pacific hagfish	3
	Hydrolagus colliei	Spotted ratfish	11
	Lyconema barbatum	Bearded eelpout	7
	Raja rhina	Longnose skate	5
	Raja sp.	Unidentified skate	7
	Ophidiidae	Unidentified cuskeel	1
	Cottidae	Unidentified sculpins	8
	Agonidae	Unidentified poachers	22

Findings from Quantitative 15-minute Segments:

A total of 22 individual corals from 4 taxa and 10 individual sponges from at least 4 taxa were enumerated from the eleven 15-minute quantitative segments conducted on The Football (Table 9). A density of 6 corals and sponges per 1,000 m^2 of seafloor was estimated. Flabellidae cup-corals accounted for 31% of overall density. All were observed on a single transect (HC-30) on the ledges and overhangs of the sedimentary rock outcrop slope. Sponges comprised 31% of total density. A new species of gorgonian sea whip, *Swiftia farallonesica*, was observed and comprised a quarter of the total density of corals and sponges. *Swiftia farallonesica* was observed on transects HC-16 and HC-21. Sea pens accounted for 13% of overall density (Figure 11). Small sea pens (possibly *Stylatula* sp. or *Virgularia* sp.) were not enumerated but were present on 1 of the 11 transects.

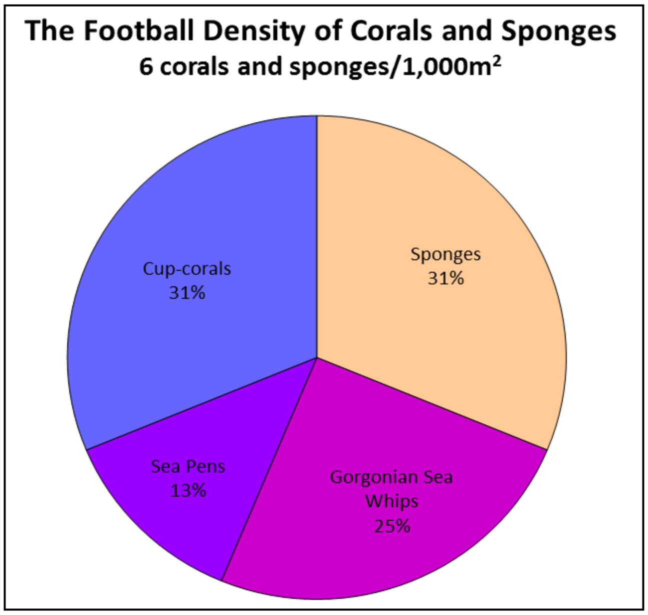

Figure 11. Percent composition of densities of coral and sponges from The Football. Colors in pie diagram match colors in list of coral and sponge taxa (Table 9).

Table 9. Abundance of corals and sponges observed on The Football transects. Colors in table match colors in pie diagram (Figure 11).

	Scientific Name	Common Name	Number
Corals and Sponges			
	Flabellidae	Cup-coral	10
	Swiftia farallonesica *	Gorgonian sea whip	8
	Pennatulacea	Sea pen	2
	Ptilosarcus gurneyi	Orange sea pen	2
	Dysidea sp.	Gray sponge	3
	Poecillastra sp.	Shelf sponge	4
	Porifera	Unidentified sponges	2
	Staurocalyptus sp.	Barrel/boot sponge	1

* new species

Findings from qualitative segments:

A total of 57 individual corals from 3 taxa and 32 individual sponges from at least 4 taxa were enumerated from transects that were not considered the 15-minute quantitative segments (Table 10a). The new species of gorgonian sea whip (*Swiftia farallonesica*) accounted for nearly half of the coral and sponge observations (48% of total species composition). Thirty-seven *S. farallonesica* individuals ranged in size from 10-20 cm and 6 individuals ranged in size from 21-50 cm. Sponges comprised 36% of species composition of the sessile structure forming fauna. The structure forming barrel/boot sponges, *Staurocalyptus* sp., ranged in size from 21-50 cm tall. The pennatulacean sea pen, *Halipteris californica*, made up 9% of coral and sponge species composition. Small sea pens (possibly *Stylatula* sp. or *Virgularia* sp.) were not enumerated but were present on 1 of the 11 transects. Flabellidae cup corals accounted for 7% of total species composition and were all observed on one transect (HC-30) at the sedimentary rock outcrop slope with many ledges and overhangs (Table 10b).

Table 10. (a) Abundance of corals and sponges documented on The Football qualitative segments. (b) Percent composition of coral and sponge counts. Colors of corals and sponges in table (a) match colors in table (b).

a.	Scientific Name	Common Name	Number
Corals and Sponges			
	Swiftia farallonesica *	Gorgonian sea whip	43
	Dysidea sp.	Gray sponge	7
	Poecillastra sp.	Shelf sponge	11
	Porifera	Unidentified sponges	9
	Staurocalyptus sp.	Barrel/boot sponge	5
	Halipteris californica	Sea pen	8
	Flabellum sp.	Cup-coral	6

* new species

b.	Corals and Sponges	% Composition
	Gorgonians	48
	Sponges	36
	Sea pens	9
	Cup-corals	7

Other Invertebrates

A total of 4,077 other invertebrates such as sea stars (*Ceramaster patagonicus*, *Rathbunaster californicus*, other Asteroidea); sea urchins (*Strongylocentrotus fragilis*); spot prawns (*Pandalus platyceros*); and anemones (*Corallimorphus pilatus*, *Metridium farcimen*, and other Actiniaria) were counted along The Football transects and total percent composition is displayed in Figure 12. *Strongylocentrotus fragilis* accounted for over half of the total percent composition of these taxa.

Other invertebrates present at The Football included unidentified octopus species, brachyurian crabs, dungeness crab (*Cancer magister*), brittle stars and crinoids (*Florometra serratissima*). Crinoids were commonly observed, and recorded as present on 9 of the 11 transects.

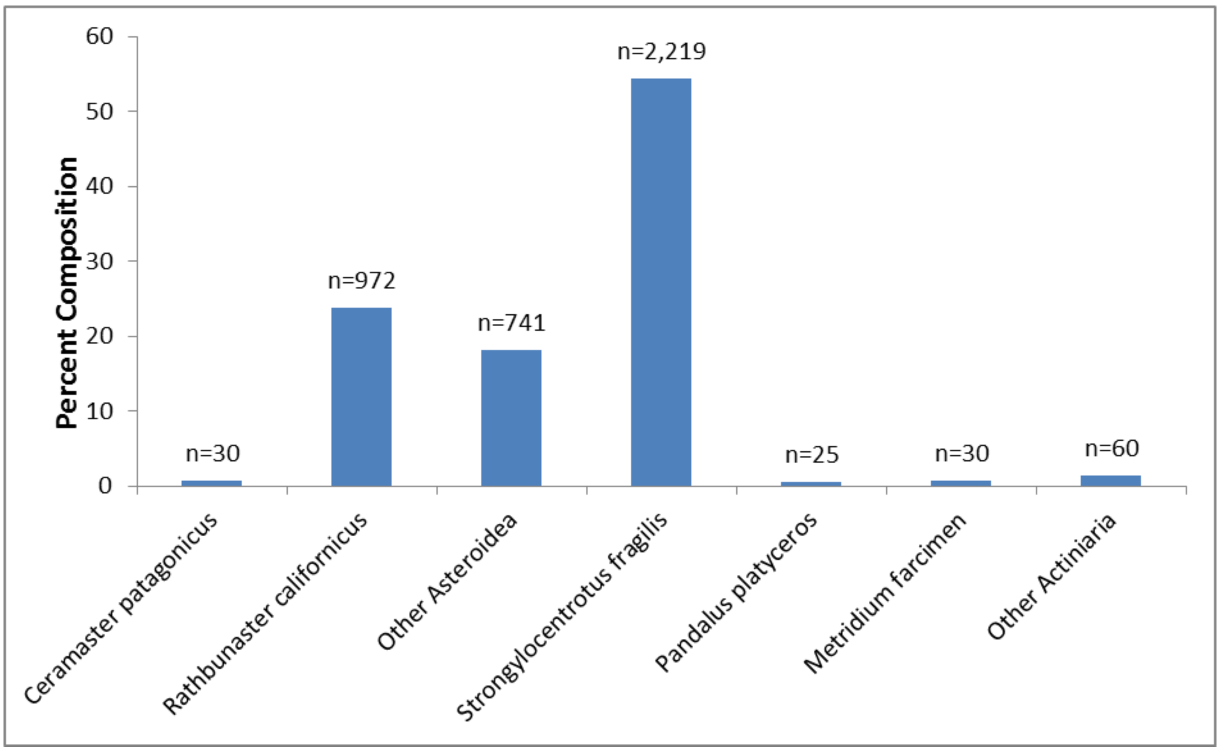

Figure 12. Total percent composition of other invertebrates from The Football transects.

Other Observations – The Football

Fish-Invertebrate Associations

There was one fish-invertebrate association observed, a rockfish (*Sebastes* sp.) darting into a barrel sponge (*Staurocalyptus* sp.) that was approximately 50 cm tall.

Anthropogenic Items/Derelict Fishing Gear

There were nine observations of anthropogenic materials documented at the Football, including: two lines, two nets (possibly gillnet or trawl net), four rubbish items (tire, glass bottle, etc.); and one derelict crab trap with many associated fish species, including a cowcod (*Sebastes levis)* resting on top of the trap.

Collections

Table 11. Specimen collections at The Football.

Specimen No.	Species	Date	Coordinates	Transect	Depth	CAS Cat. No.
S3	Sea Star Arm**	5-Sep-14	38.4553 -123.6150 38.4617 -123.6074	MVFB7, HC19	281-242 m	196927
S4	Cat shark egg cases***	5-Sep-14	38.4585 -123.6029	HC14	230 m	---
S4A	Brittle Star ****	5-Sep-14	(same as S4)	HC14	230 m	196921
S4B	Brittle Stars****	5-Sep-14	(same as S4)	HC14	230 m	196939
S4C	Polychaetes****	5-Sep-14	(same as S4)	HC14	230 m	196931
S4D	Decapod****	5-Sep-14	(same as S4)	HC14	230 m	196935
S4E	Gastropods****	5-Sep-14	(same as S4)	HC14	230 m	196925
S4F	Brachiopods****	5-Sep-14	(same as S4)	HC14	230 m	196937
S5	*Swiftia farallonesica* (Sea Whip)	6-Sep-14	38.4388 -123.5698	HC21	182 m	196930
S6	Cup Coral	6-Sep-14	38.4472 -123.5827	HC30	194 m	196940
S7	Holothurian (Sea Cucumber)**	7-Sep-14	38.4442 -123.5904	HC20	241 m	196938
S8	Decapod (Crab)**	7-Sep-14	38.4276 -123.5904	HC20	241 m	196933

** Hand collected off bottom rail of ROV
*** NOAA/College of Charleston material (not CAS)
**** Found in S4G egg case mass

<u>Cat shark egg cases (S4).</u> One juvenile hatched on deck. Tissue samples revealed mDNA sequences suggesting the species to be *Apristurus brunneus* (brown catshark) This species of Scyliorhinid shark is common from Baja to southeastern Alaska (Flammang et at. 2008)

Cup Coral (S6): A solitary hard coral in the family Flabellidae.

Brachiopod (S4F): *Terebratulina unquicula* (family Cancellothyrididae); known between 10 and 850 m in depth.

Holothurian (S7): A deep-sea sea cucumber (family Stichopodidae).

Swiftia farallonesica (S5): A new species of whip-like gorgonian coral described by Williams and Breedy (2016), California Academy of Sciences.

Education and Outreach

The high-definition video and still imagery collected from Bodega Canyon and The Football was used by West Coast sanctuaries education staff to create a classroom activity and accompanying poster about deep-sea habitats in all five West Coast National Marine Sanctuaries. The activity and poster are entitled “Deep Coral Communities: Sentinels of a Changing Ocean.” The unit allows high school students to explore species abundance and diversity in different habitats (rocky and soft bottom). Students also examine threats to deep-sea corals such as ocean acidification, harmful fishing methods, and marine debris/derelict fishing gear and discuss action items that individuals and communities can take part in to help mitigate the impacts. The activity is available online for free download (http://sanctuaries.noaa.gov/education/teachers/deep-coral-communities/) and it is estimated it may be used by over 50,000 students. The program meets National ‘Next Generation Science Standards’ (http://www.nextgenscience.org) as well as California State Science Standards and Washington State Science Standards. Additionally, an in-school outreach program, titled ‘Diving Deep: Exploration of Deep-Sea Coral Communities’ was developed from the video and still images collected from The Football. The target audience is 9th-12th grade students within the San Francisco Bay Area, reaching 1,000-2,000 students per year, and each program will be taught by a sanctuary educator. Additionally, some of the video footage was used to produce a narrated 5-minute video titled “Exploring Deep-Sea Coral Communities of West Coast National Marine Sanctuaries” that is available on the web for the general public (http://sanctuaries.noaa.gov/education/teachers/deep-coral-communities/). Future projects using the video and still images include: exhibits at partner institutions and/or sanctuary visitor centers, outreach presentations and social media.

Conclusions

The benthic characterization of Bodega Canyon and The Football provided details about the habitats and associated fish and invertebrate species in these areas, and revealed some expected and new findings. Collectively, a total of 12,443 m^2 of seafloor was surveyed for quantitative analysis at both sites, and more was surveyed for qualitative analysis. The quantitative surveys for both sites together enumerated 2,627 individual fishes, 47 corals, and 22 sponges. In the qualitative segments, a total of 123 corals, 73 sponges and 6,401 other invertebrates were recorded. The surveys also revealed skate and catshark nursery habitat, and a new species of octocoral. For further detailed analysis, we examined each of the two sites separately given the disparate qualities and distance separating the sites. The information will be used by CBNMS and GFNMS to establish a baseline characterization of the habitat and species present, and to evaluate management efforts to protect these areas which have been recently added to the sanctuaries' boundaries.

At Bodega Canyon, the sampling scheme was designed to sample transects in each of three pre-determined habitat categories (hard-rugose, hard-flat, and soft-flat) as predicted from multibeam sonar data. However, the observed habitat was primarily hard-flat with very little hard-rugose habitat. The observed assemblages of corals and sponges were not very diverse or abundant. All coral taxa, except for one observation of the primnoid, *Plumarella* sp., were soft bodied species such as mushroom coral (*Heteropolypus ritteri)* and small pennatulacean sea pens that can establish on soft bottom or low relief habitats of mixed rocks and soft sediments. The limited availability of rugose rocky habitat can also explain the few observations and low diversity of sponges. Although counts were relatively low, the most abundant sponge species was the barrel/boot sponge, *Staurocalyptus* sp., ranging in height from 10-50 cm, providing additional habitat and refuge for some fish species. Findings from a previous AUV survey in Bodega Canyon also found a relatively low abundance of corals and sponges, because the majority of habitat was soft sediment or when hard rock was present it was usually draped with mud (Fruh et al. 2011). The AUV surveys estimated a higher density of corals (mostly gorgonian octocorals - *Parastenella* spp., *Plumerella* spp. and *Swiftia* spp.) and sponges than our ROV surveys. The difference could be attributed to the availability of exposed rock such as boulders and cobbles and deeper depths (to 500 m) as the highest density of sponges and second highest density of corals were found during the deepest AUV dive (Fruh et al. 2011). These deeper habitats may be providing the corals and sponges with colder and more stable water temperatures, greater availably of prey, or a natural refuge from disturbances from bottom contact fishing gear than available in shallower water habitats.

Similarly, majority of fish species documented at Bodega Canyon were those that prefer mixed rock and soft sediment habitats. Rockfishes accounted for about half of the fishes observed, the majority were thornyheads (*Sebastolobus* spp.) and chillipepper (*Sebastes goodei*) resting on the seafloor. About a quarter of the fishes observed were flatfishes, many could not be identified to the species level because they were buried in sediment. The 2011 AUV surveys in Bodega Canyon also observed a high abundance of thornyheads and flatfishes; comprising over 75% of the total fish density. Species composition of other fishes observed by the AUV was very similar to those species observed by the ROV with the exception of a relatively high number of sablefish

(*Anoplopoma fimbria*) as this species is most common deeper than 600 m (Love 1996, Fruh et al. 2011).

Observations from The Football revealed habitat types consistent with the predicted habitats. The Football is a low-relief rocky feature (with some areas of hard-rugose habitat) surrounded by soft-flat sediments. The availability of rocky substrate provided habitat for Flabellidae cup corals, the only stony coral observed in our surveys, and numerous (n=51) gorgonian sea whips determined from a sample collection to be a new species *Swiftia farallonesica* (Williams and Breedy, 2016). Abundance of sponges on both quantitative and qualitative segments was about a third of the total sessile benthic invertebrate observations. A few large habitat-forming sponges were observed such as the shelf sponge (*Poecillastra* sp.) and barrel/boot sponge (*Staurocalyptus* sp.). As suggested by Stierhoff et al. (2011), the multiple ROV dives on The Football resulted in a greater density and diversity of corals and sponges than was observed during their one ROV dive in 2011. This survey confirms and better quantifies the hard substrate, and resulting growth and recruitment of habitat forming benthic invertebrates at this location.

Rockfishes at The Football were the most abundant group of fishes, mostly dominated by large schools of widow rockfish (*Sebastes entomelas*) swimming in the water column above rocky bottom. Widow rockfish was federally designated by NOAA as an "overfished" species in 2001 (which means that less than 25 percent of their estimated pre-fishery population existed), but was declared “rebuilt” (population at a biomass to support maximum sustainable yield) in 2011 (NMFS 2012). Numerous yelloweye rockfish (*S. ruberrimus*) were observed on transects and the stock is currently listed as overfished. A few canary rockfish (*S. pinniger*) were observed on transect and the stock was listed as overfished until 2015 when it was declared rebuilt (NMFS 2015). Bocaccio *(S. paucispinis)* and cowcod *(S. levis)* were observed on transects and both stocks had previously been listed as overfished and are currently in rebuilding phases (PFMC 2014). More than one hundred very large lingcod (*Ophiodon elongatus*) were observed on transects. Lingcod was once listed as overfished, but populations have now recovered and the species was declared rebuilt in 2005 (PFMC 2014). On one transect (HC-30) there was a large sedimentary rock outcrop slope with many ledges and overhangs providing an ideal habitat for invertebrates and hundreds of rockfishes including sharpchins *(S. zacentrus*) and other adult and juvenile rockfishes (*Sebastes* spp.). Many of the fishes taking refuge within the rock layers were so well hidden they could not be identified to species. Stierhoff et al. (2011) also observed this outcrop slope in their ROV survey transect at The Football in 2011. The high abundance and diversity of associated invertebrates and fishes highlights the value the rock outcrop serves as habitat.

Our research team made significant discoveries in the hundreds of skate egg cases on the seafloor, and in the many bundles of catshark egg cases attached to rocks. One of the catshark eggs hatched a juvenile *Apristurus brunneus*, but the identity of the other egg cases is still unverified. The Football location represents an unusual nursery area because, to our knowledge, catshark nurseries have not previously been reported in the same area as skate nurseries. Catshark nurseries have been identified among gorgonian octocorals in the deep Gulf of Mexico (Etnoyer and Warrenchuk 2007) and in *Lophelia pertusa* corals in the North Atlantic (Henry et al. 2013). Nursery grounds are also reported locally in Northern California (Flammang et al. 2008) and in Southern California (Cross 1988). No catsharks were observed in the vicinity of the catshark egg cases, but our surveys did observe five longnose skates (*Raja rhina*) and seven other skates in the vicinity of the skate egg cases at The Football. Abundance and diversity of skates tend to reach a peak at the continental shelf break. Several species of skates lay eggs in association with rocky substrates, including high-relief habitats (Bizarro et al. 2014). Migration patterns for skates are poorly understood, but may represent seasonal movements to the breeding grounds and/or egg deposition sites (Frisk 2010). The Football appears to be one of these breeding ground locations. This confers value on the habitat and supports the need for protection from anthropogenic bottom disturbance.

The discovery of a new species of coral *(Swiftia farallonesica*) is an indication that there is still much to be learned about these underexplored habitats (Williams and Breedy, 2016). In most cases it is not possible to make positive identifications of deep-sea invertebrates with images or video footage alone. It is necessary to examine collected specimens to make identifications, to acquire tissue samples for molecular analysis, and to preserve and properly curate specimens for future study. Several examples of this occurred during the 2014 survey. The white sea pen and white sea whip that were photographed and collected (*Halipteris californica* and *Swiftia farallonesica* respectively) could only be properly identified after examining the specimens that were collected by the ROV. Without specimens to study for identification purposes, deep-sea studies regarding biodiversity of the benthic fauna are necessarily limited in scope as well as scientific merit and importance. Therefore, all future ROV expeditions destined for deep-sea biodiversity studies should be equipped for the collection of benthic specimens.

There was evidence of human impacts on many of the transects at Bodega Canyon and The Football. Marine debris in the form of derelict fishing gear, included longlines, nets (gillnets and/or trawl nets) and other human rubbish was observed. In some cases, the derelict fishing gear provided additional habitat for fishes and invertebrates, however the initial loss of the gear most likely had negative impacts to the seafloor and associated species (particularly corals and sponges). Indeed, lost fishing gear presents hazards to habitat, wildlife, and humans. On the last day of the surveys the ROV became entangled in marine debris (pot and line) that we were observing, but was eventually successfully freed.

Data collected to inform model validation of corals and rockfishes were too limited for a complete analysis. When more observations of these species become available through other studies, data from our study can be combined to inform a more robust model validation.

The imagery collected was used in four education and outreach products to date. The curriculum and poster, available online, will reach thousands of high school students. The footage from the ROV is an exciting and novel tool for marine science education. It is visually engaging and represents a unique and important marine habitat that students otherwise know very little about. It provides the opportunity to learn about conducting marine research, and to talk about specific threats to habitats in National Marine Sanctuaries and realistic actions people can make to mitigate these threats. In addition, a large audience was informed about the ROV surveys and discovery of a new coral species, *Swiftia farallonesica,* through a press release in November 2014 that was widely distributed by news media in 431 outlets worldwide, providing over 80 million “media impressions” (opportunities to view the feature).

Planned upgrades to the CBNMS ROV including improved cameras and lighting will allow us to collect high definition still images and video to enhance our capabilities to detect and identify more species than was possible with the standard definition video collected on this cruise. Although one of this mission's goals was to use the CBNMS Phantom HD2 ROV, this class of ROV has depth, sampling and power limitations so a larger, deep depth rated 'science class' ROV is necessary to explore and characterize larger expanses of the deep-water habitats within CBNMS and GFNMS. Another needed upgrade is a suite of sensors to measure physical parameters. The ability to record environmental data concurrently with imagery through use of a Conductivity-Temperature-Depth (CTD) sensor mounted on the ROV would contribute to our knowledge of the physical environment species experience in the deep sea and how that affects their distribution and abundance.

One of the limitations to benthic surveys in CBNMS and GFNMS is lack of high quality multibeam sonar data necessary to produce reliable habitat maps for the sanctuary. Future benthic surveys in CBNMS and GFNMS are dependent on acquiring high quality continuous multibeam data and habitat maps and this will be a priority in the coming years. As this study has shown, reliable interpretations of these data depend upon supervised visual surveys in order to evaluate and ground truth habitat classes.

Based on the work presented in this report, recommendations for future missions include the equipment upgrades and new mapping data mentioned above so that surveys of other unexplored areas in the sanctuaries can be completed. Results from this work will assist in planning future surveys which should focus on data collection needed to inform analysis of initial characterization of new areas, as well as community composition, habitat-species associations, and changes to habitats and species over time and in response to stressors and protections.

Although the sites surveyed are a small portion of The Football and Bodega Canyon and more surveys are needed to comprehensively characterize the benthic habitat of the sanctuaries, overall the new information about species and habitats collected from this characterization of Bodega Canyon and The Football greatly expands our knowledge of the habitat and species present in these areas. This and future expeditions to CBNMS and GFNMS will assist researchers and the sanctuaries' managers to better understand and protect benthic habitats in the newly expanded Cordell Bank and Greater Farallones National Marine Sanctuaries.

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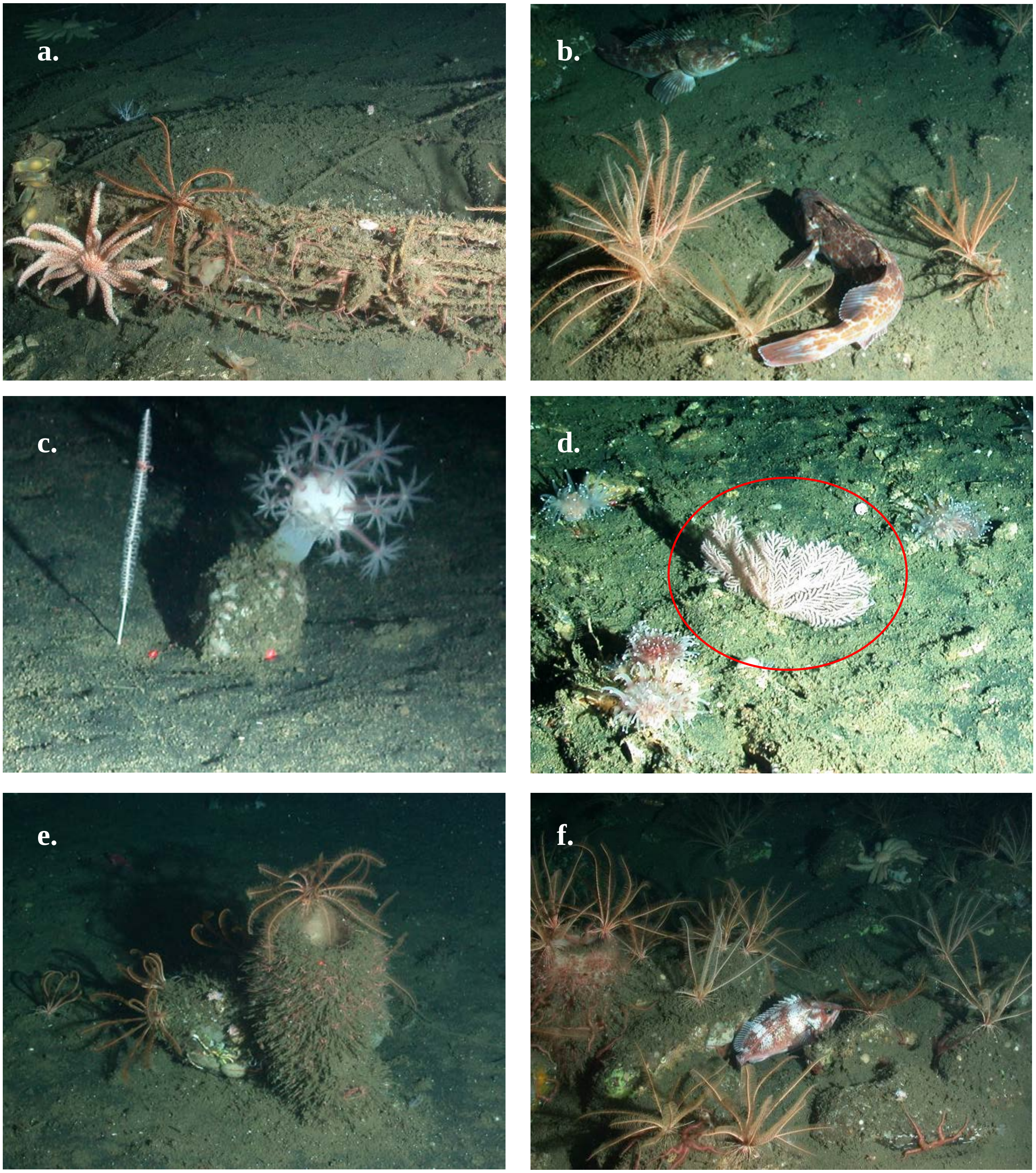
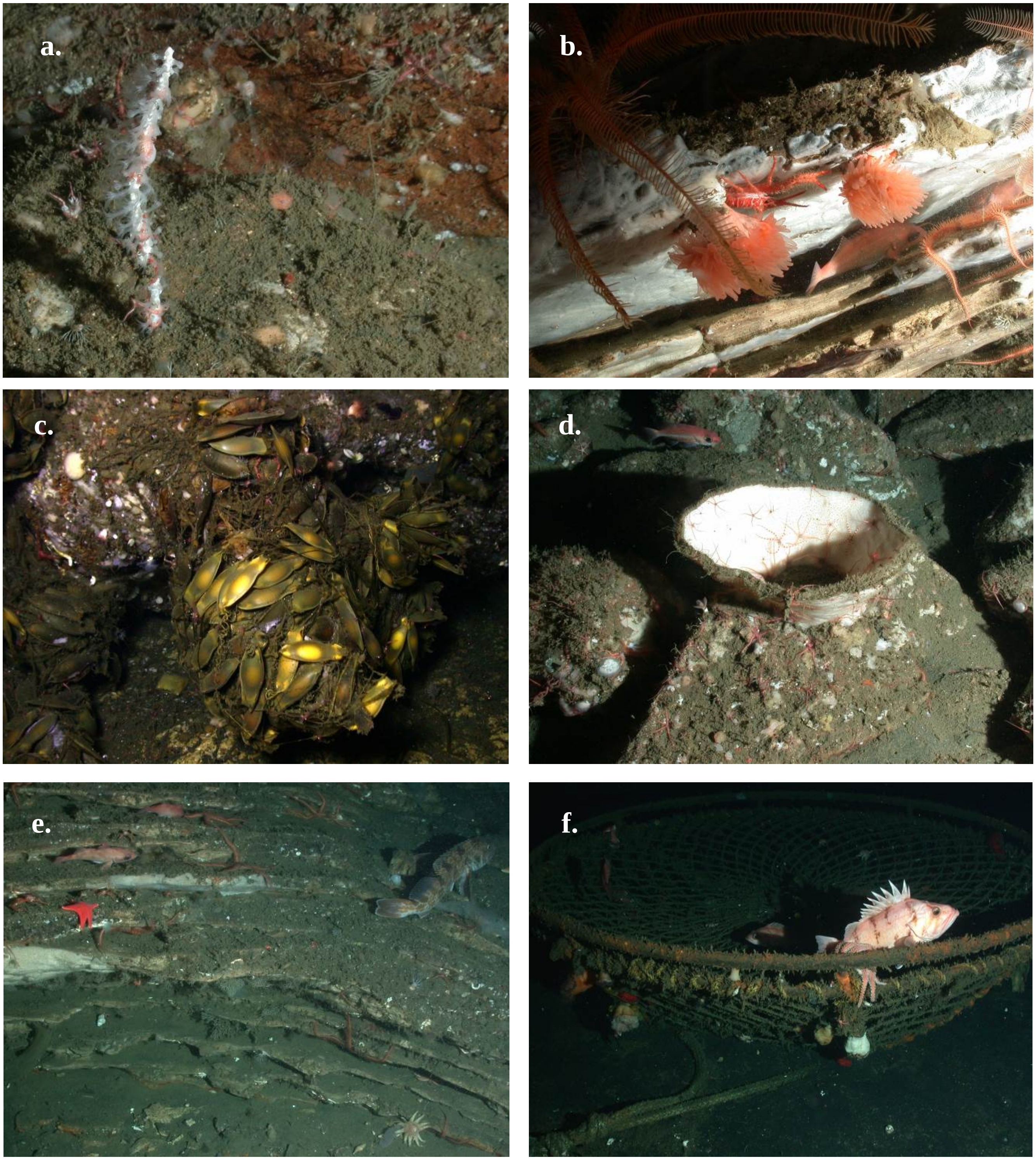
Appendix A – Bodega Canyon Image Gallery



a) Derelict fishing net with invertebrates and catshark egg cases; **b)** Lingcod (*Ophiodon elongatus*) and crinoids (*Florometra serratissima)* on mud-cobble habitat; **c)** Mushroom coral (*Heteropolypus ritteri*) and unknown sea pen; **d)** Primnoid octocoral *Plumarella* sp. (circled in red); **e)** Barrel sponge (*Staurocalyptus* sp.) with crinoids (*F. serratissima)* **f)** Cobble-mud habitat with bank rockfish (*Sebastes rufus*) and crinoids (*F. serratissima).*

Appendix B – The Football Image Gallery



a) New species of gorgonian: *Swiftia farallonesica*; **b)** Flabellidae cup corals on rock ledge; **c)** Catshark egg cases; **d)** *Poecillastra* sp. sponge with brittle stars **e)** rock ledge providing habitat for fishes and invertebrates; **f)** Cowcod *(Sebastes levi*s) perched on derelict trap.