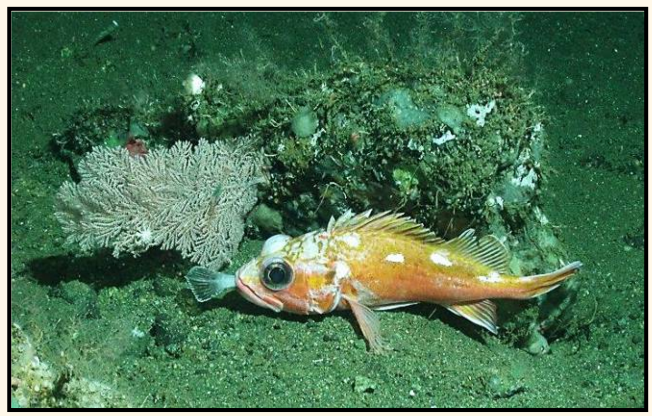
A REPORT TO NOAA DEEP-SEA CORAL RESEARCH
AND TECHNOLOGY PROGRAM
October 3, 2011

A CHARACTERIZATION OF DEEP-SEA CORAL AND SPONGE COMMUNITIES ON THE CONTINENTAL SLOPE WEST OF CORDELL BANK, NORTHERN CALIFORNIA USING A REMOTELY OPERATED VEHICLE

Kaitlin Graiff[1], Dale Roberts[1], Dan Howard[1], Peter Etnoyer[2],
Guy Cochrane[3], Jeff Hyland[2], Jan Roletto[4]

[1] NOAA, ONMS, Cordell Bank National Marine Sanctuary, Point Reyes Station, CA
[2] NOAA, NCCOS, Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC
[3] USGS, Pacific Coastal & Marine Science Center, Santa Cruz, CA
[4] NOAA, ONMS, Gulf of the Farallones National Marine Sanctuary, San Francisco, CA



BACKGROUND AND SCIENTIFIC RATIONALE

Interest in the conservation of deep-sea coral (DSC) and sponge communities has grown over the last decade. Increased awareness of the ecological importance of and threats to DSC has come about as nearshore fishing grounds have become depleted and fishers have moved into deeper water where DSC are often taken as bycatch. Advancement in deep water survey technologies, such as remotely operated vehicles and autonomous underwater vehicles, has also enhanced the ability to study DSC communities.

As the federal agency charged with managing the Nation's marine living resources, the responsibility for conserving DSC falls on the National Oceanic and Atmospheric Administration (NOAA) which has formed the Deep Sea Coral Research and Technology Program (DSCRTP). This program is now conducting targeted exploration and research to improve the understanding of DSC.

Research on DSC has revealed that they are often extremely long-lived, slow growing, fragile animals; characteristics that make them particularly vulnerable to physical disturbance such as bottom contact fishing gear (trawling), oil and gas exploration and extraction, or the laying of undersea cables.

The high biodiversity associated with the structurally complex morphology of DSC has shown potential value for commercially important fishes and other invertebrates as they rely on DSC as habitat for protection from predators and for enhanced feeding opportunities.

Despite scientific advances in the understanding of DSC, there is still very little known about their growth rates, reproductive cycles, their functional role as habitat for marine species, and their contribution to the biodiversity of the deep seas. Also, little is known about DSC distribution and abundance on the continental shelf and slope of United State's West Coast. To address some of these biological issues and to discover new regions which may be candidates for Essential Fish Habitat (EFH) protection, the DSCRTP initiated a three year program (2010-2012) to study West Coast DSC.

This report provides summary results from leg 2 (Central California) of the 2010 effort in which a Remotely Operated Vehicle (ROV) was deployed from the NOAA ship *McArthur II* to survey potential DSC habitat.

The specific objectives of our research during Leg 2 were to:

1. Survey and characterize the distribution, abundance, and condition of DSC communities in and adjacent to Cordell Bank (CBNMS) and Gulf of the Farallones (GFNMS) National Marine Sanctuaries;

2. Quantify fish and invertebrate associations with DSC to help understand the value of DSC as habitat;

3. Collect limited DSC specimens to confirm taxonomic identification;

4. Make visual observations of sea floor substratum to refine habitat classifications derived from multibeam sonar data.

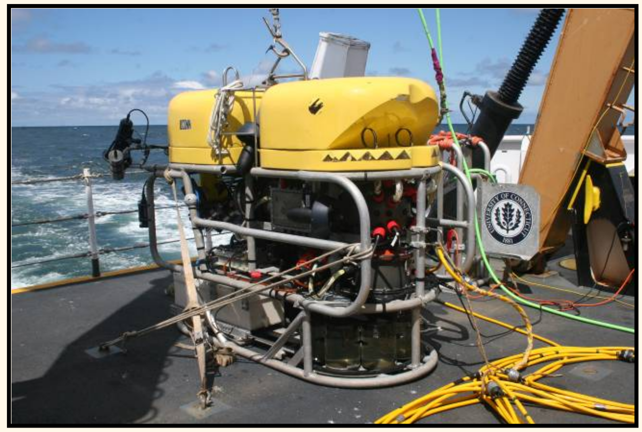
SURVEY OVERVIEW

Project	U.S. West Coast Deep-Sea Coral Cruise
Chief Scientist	D. Howard
Contact Information	NOAA,NOS,ONMS,CBNMS, dan.howard@noaa.gov
Purpose	Survey deep coral communities on the continental slope west of Cordell Bank, northern California
Vessel	NOAA Ship *McArthur II*, *Kraken 2* ROV
Science Observers	P. Etnoyer, K.Graiff, D. Howard, J. Hyland, D. Roberts, J. Roletto
External Video Tapes	3 HD, 4 SD
Internal Video Tapes	n/a
Digital Still Photos	147
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	Yes
O_2 Sensor	No
pH Sensor	No
Specimens collected	Yes
Other	Logbook, Access database
Report Analysts	K. Graiff, D. Roberts

DIVE OVERVIEW

Date	24 June 2010	Starting Latitude (N)	38˚ 2.186’
Minimum Bottom Depth (m)	167	Starting Longitude (W)	123˚ 31.340’
Maximum Bottom Depth (m)	497	Ending Latitude (N)	38˚ 2.174’
Start Bottom Time (PDT)	8:31	Ending Longitude (W)	123˚ 30.901’
End Bottom Time (PDT)	19:01		
Number Segments	9 quantitative 61 qualitative		

METHODS: FIELD SURVEY



ROV dive sites were planned in regions of the continental shelf and slope with the highest likelihood of having a substrate type and location most likely to support DSC communities. Substrate classification was performed by Guy Cochrane of the U. S. Geological Survey using numerical classification of multibeam sonar data collected on the NOAA R/V *Okeanos Explorer* to produce a seafloor character map (Cochrane, 2008). The character map consisted of three substrate classes: soft-flat, hard-flat, and hard-rugose bottom. The map is a raster dataset with the same resolution as the multibeam sonar data. Hard substrate areas and locations such as steep slopes and isolated bathymetric highs were considered suitable for DSC communities.

While surveys had been planned in both Cordell Bank National Marine Sanctuary (CBNMS) and Gulf of the Farallones National Marine Sanctuary (GFNMS), high winds and seas pre-empted all ROV operations with the exception of a single eleven hour dive on the continental slope just west of Cordell Bank (Figure 1a), on June 24, 2010. This site was chosen because it was believed to be the most likely of the proposed sites to support DSC based on characteristics of the substrate and slope (Figure 1b).

Operations were conducted aboard the NOAA ship *McArthur II*. Photographic images and biological specimens were collected by the *Kraken2* (*K2*) Remotely Operated Vehicle (ROV) which is owned and operated by the University of Connecticut. The ROV had two video cameras, one high definition “Kongsberg” camera and a second standard definition “Pilot” camera which provided a wider angle of view and better situational awareness for the ROV pilot than the Kongsberg. High definition video was recorded to video tapes and also to the hard disk of a Mac Pro computer running Apple ProRes 422 software. Standard definition video was recorded to video tape. The *K2* was also equipped with a “Scorpio” still camera and strobes for illumination of the stills. All three cameras were mounted on a pan and tilt head with a pair of lasers spaced 20 cm apart (for sizing objects viewed in images). Biological samples were collected with the *K2*’s manipulator arm and stored in an onboard ‘bio box’ until completion of the dive.

During the dive the *K2*’s position was tracked using an ORE Trackpoint II acoustic tracking system which provided bearing and range from the *McArthur II* to the *K2*. Trackpoint positions were integrated with the ship’s GPS using Fugro Pelagos WinFrog navigation software. Tracking data were provided to the science team as Winfrog .DAT files which were in ASCII format.

METHODS: STUDY SITE

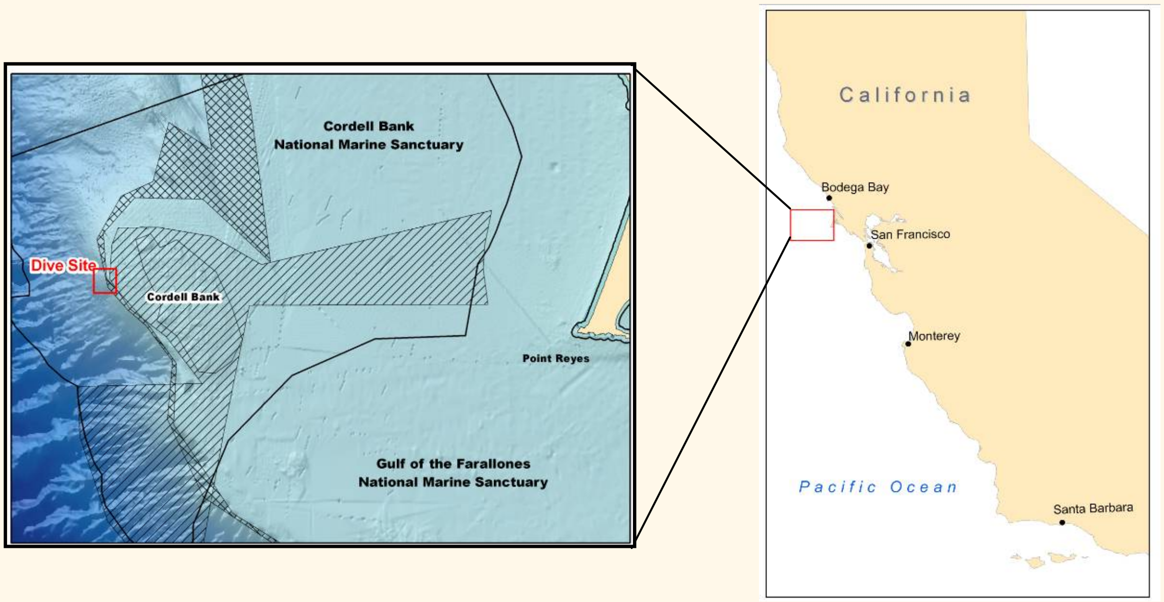


Figure 1(a). Location of ROV dive site on the continental slope west of Cordell Bank, northern California

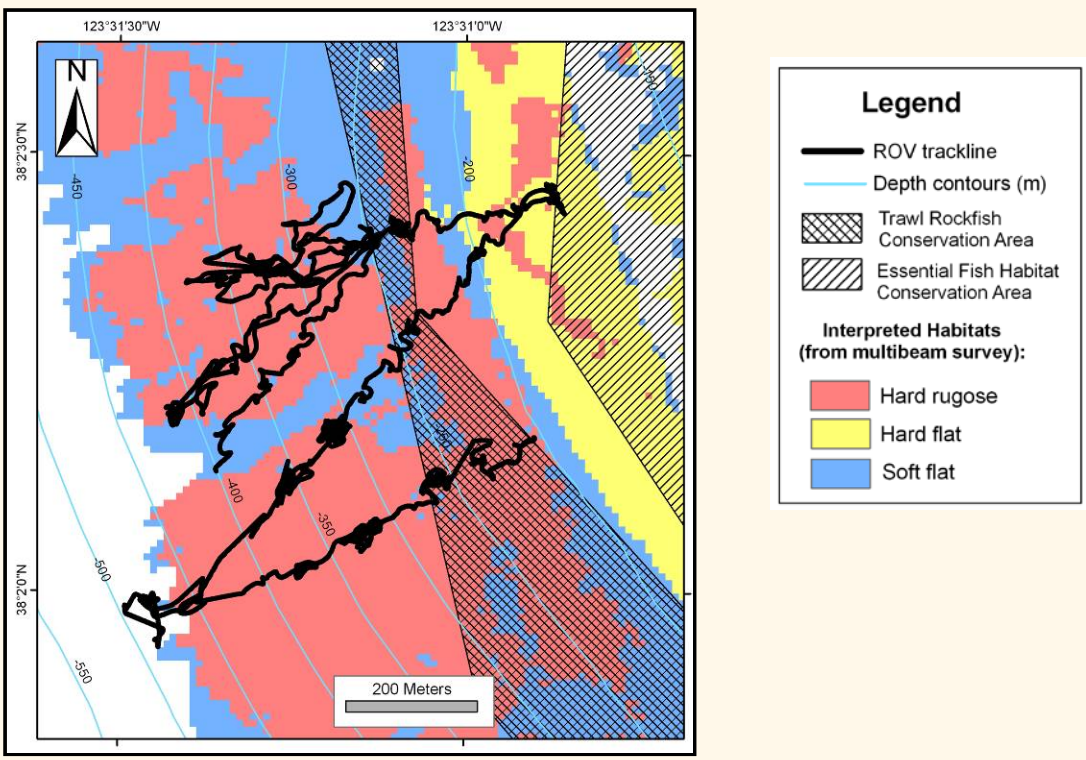


Figure 1(b). ROV trackline overlaid on interpreted habitats at dive site

METHODS: DATA PROCESSING AND VIDEO ANALYSIS

The tracking data received from the *K2* survey team contained a number of spurious data points likely owing to the depth of operations and the rough seas which introduced noise into the tracking data. To clean-up these data and more accurately determine the track of the *K2* during the dive, a series of processing steps were executed. Initial filtering was performed using a SAS program that removed points which were 120 meters from the preceding points and/or in which the speed from one point to the next was greater than 2.5 meters / second. The dive track was then plotted using Fugro Pelagos Ribbit software and additional spurious data points were identified and removed using the interactive editor.

Trackline data points were interpolated to 1 second intervals using the 'sample1d' routine of (Geographic Information Systems) GIS Generic Mapping Tools GIS software (http://www.soest.hawaii.edu/gmt/). Interpolated tracklines were then smoothed using the GMT routine 'filter1d' which applied a Gaussian filter over a 60 sample window.

The length of dive segments was measured by summing the distances 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 (20 cm) with that measured on the video screen to calculate the width of the field of view. Since this value changes as the altitude of the ROV changes the width estimate was made every minute with width estimates applied to the entire minute of the segment. The segment area was the product of transect length and width.

The quality of the video images taken from the ROV dive was variable owing to the difficulty encountered maintaining station in strong winds. When the *McArthur II* was unable to hold position, the *K2* became vulnerable to being dragged off course and into the water column by the umbilical cable which is attached to the ship. To eliminate bias introduced by combining data from good and bad quality video the dive was initially viewed and classified with regard to quality. The dive was broken into segments which were assigned one of three categories: A.) Highest quality 'quantitative' video in which the ROV maintained a consistent speed, course, and height off the bottom for a distance greater than 50 meters and the lasers were illuminated; B.) 'qualitative' video in which the seafloor was visible but ROV speed, course or altitude were not consistent or the lasers were switched off; C.) Dive segments not classified A or B. Nine dive segments were classified as quantitative and sixty-one were classified as qualitative (Figure 2).

Substratum types of quantitative and qualitative segments were classified using a combination of seven categories of substratum type described in Stein et al. (1992). Substratum categories, in order of decreasing particle size and vertical relief, were: rock ridge (R), boulder (B), cobble (C), pebble (P), gravel (G), sand (S), mud (M). A two-character code was used to quantify distinct changes in substratum type greater than or equal to four seconds in duration along a segment, thus establishing "habitat patches" of uniform substratum type. The primary character in the code represented the substratum type that accounted for at least 50% of the patch, and the secondary character represented the substratum type that accounted for at least 20% of the patch (e.g., "CS" represented a patch of at least 50% cobbles and at least 20% sand).

Invertebrates and fishes were identified to the lowest taxonomic level and enumerated within each habitat patch. Individual corals, sponges, and fishes were recorded by geographic position and maximum size was determined using the set of paired lasers. Sponges were classified by general morphology (i.e., flat, foliose, barrel, and vase sponges), because spicules are needed for confidence in sponge species identification. Invertebrates other than sponges and corals were enumerated continuously within the start and end of each habitat patch less than or equal to one minute in duration. If a habitat patch was greater in duration than one minute, the invertebrates were enumerated continuously at one minute intervals within the habitat patch. This method was determined best for the homogenous seafloor habitats surveyed in order to more accurately associate taxa to geographic location and depth. Associations of fish and small invertebrates with corals and sponges were recorded. An associated fish was located less than one body length away or in direct contact with a coral and sponge. Any invertebrate living on a coral or sponge was documented as an association. Frequency and type of derelict fishing gear also was documented from the video segments, and any damaged corals and sponges were noted.

ROV DIVE TRACKLINE

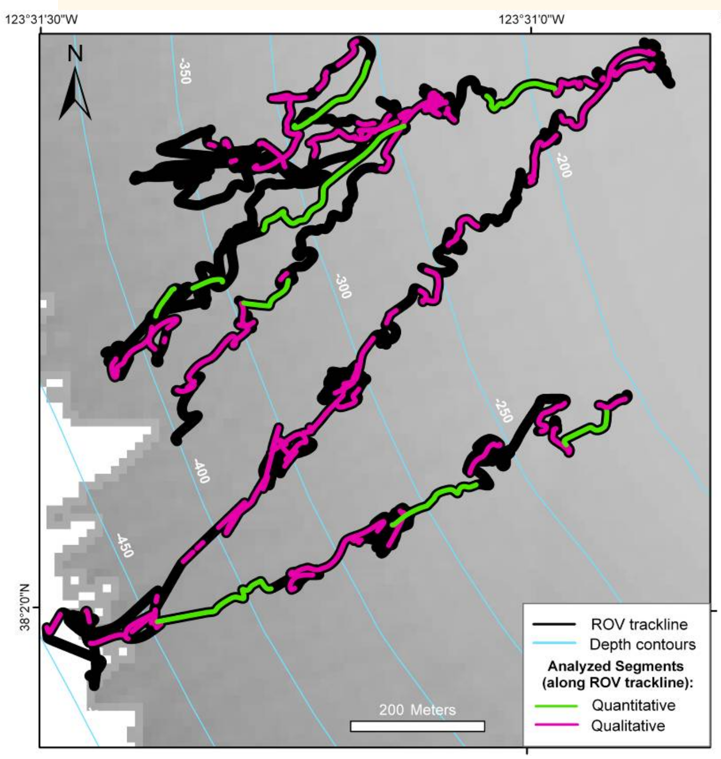


Figure 2. Segments analyzed along ROV trackline

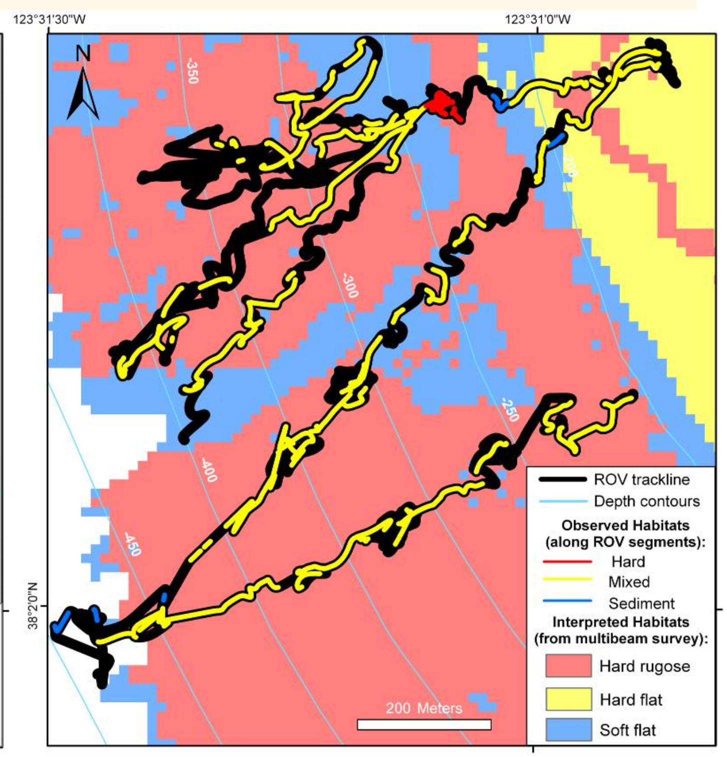


Figure 3. Habitat types observed along ROV segments

DATA SUMMARIES

The original seven primary substratum types were aggregated into three habitat categories for data analysis. These three categories were hard, mixed, and sediment (Figure 3). Taxa were analyzed separately in three groups: corals and sponges, small invertebrates, and fishes. For each of the biological groups separate data summaries were prepared for quantitative and qualitative segments.

Habitat results for quantitative data were expressed as area per m^2 while habitat results for qualitative dive segments were expressed as length per linear meter traveled because estimates of segment width could not be made due to the fact that the lasers were often turned off. Densities of invertebrates and fishes were estimated by dividing abundance of each taxa by the area of associated habitat of quantitative segments (number per $1000m^2$). Percent species composition of invertebrates and fishes was calculated for qualitative segments.

PHYSICAL ENVIRONMENT: HABITAT

A total area of 1,754 m^2 of sea floor was surveyed during 9 quantitative segments conducted during the dive (Figure 2). Habitat types were classified as (1) Hard (0% of the total area surveyed), (2) Mixed (97% of the total area surveyed), was primarily sand with cobbles and some areas of sand with boulders or pebbles; and (3) Sediment (3% of the total area surveyed), consisted of sand (Figure 4). Shell hash and often full scallop shells were occasionally observed mixed in with the sand patches among pebbles and cobbles.

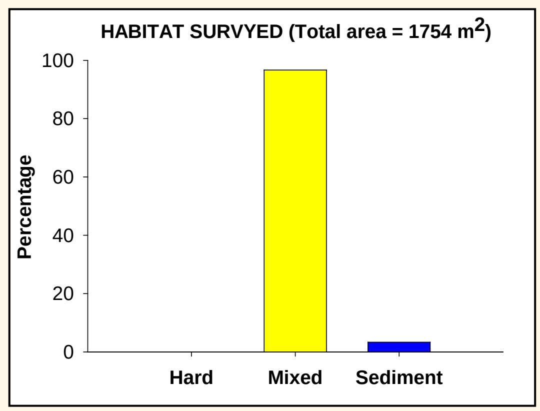


Figure 4. Percent habitat (hard, mixed, sediment) observed along quantitative segments.

A total distance of 4,277 m of sea floor was surveyed during 61qualitative segments (Figure 2). (1) Hard (8% of the total area surveyed), included mostly rock ridge, and some areas with ridge-boulders and cobbles-boulders; (2) Mixed (90% of the total area surveyed), was primarily sand and cobbles and pebbles, with some areas of sand with boulders and gravel; and (3) Sediment (2% of the total area surveyed), consisted of sand and sandy mud (Figure 5). As mentioned above, shell hash and often full scallop shells were sometimes observed mixed in with sand and among sand-pebble habitats.

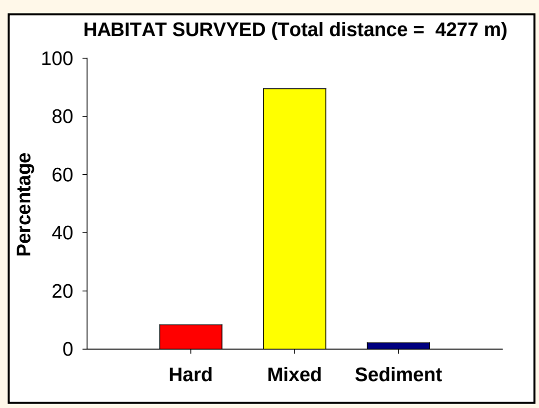
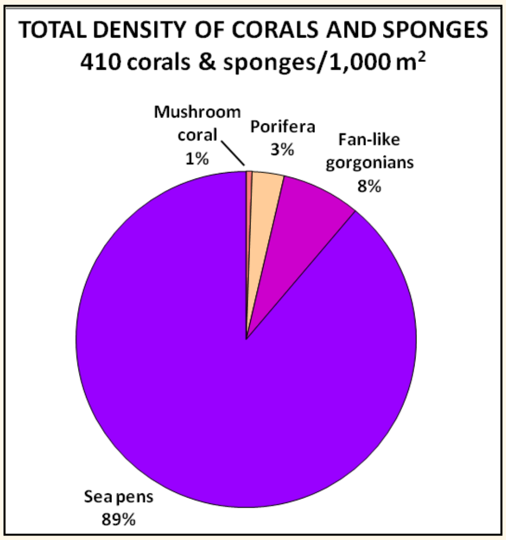


Figure 5. Percent habitat (hard, mixed, sediment) observed along qualitative segments.

BIOLOGICAL ENVIRONMENT: CORALS AND SPONGES

Findings from quantitative segments:

A total of 697 individual corals from 4 taxa and 22 individual sponges from at least 5 taxa were enumerated from 9 quantitative segments conducted during the dive. A density of 410 corals and sponges per 1,000 m^2 of sea floor were estimated. Sea pens in the family Virgulariidae accounted for 89% of overall density. Fan-like gorgonians (*Plumarella longispina* and *Paragorgia* sp.) accounted for 8% of total density which was primarily the primnoid, *Plumarella longispina*. Size range for the majority of fan-like gorgonians was 5-20 cm height. The mushroom coral (*Anthomastus ritteri)* comprised 1% of the total density. Sponges were identified by morphological features and comprised a total density of 3%. Some individual barrel sponges may be the boot sponge, *Rhabdocalyptus dawsoni.* One primnoid coral specimen was collected and sent to Beth Horvath (Westmont College, Santa Barbara, CA) and identified as *Plumarella longispina.* All of these corals and sponges were observed in mixed habitats.



Colors in pie diagram match colors in list of coral and sponge taxa (below).

Scientific name	Common name	Number
Corals and Sponges		
*Anthomastus ritteri**	Mushroom coral	4
Porifera	Unidentified upright flat sponge	1
Porifera	Unidentified vase sponge	1
Porifera	Unidentified mound sponge	4
Porifera	Unidentified leaf sponge	11
Porifera	Unidentified barrel sponge	5
Paragorgia sp.*	Bubblegum coral	1
*Plumarella longispina**	Primnoid	53
Virgulariidae*	Sea pen	639

* First verified observation in CBNMS

BIOLOGICAL ENVIRONMENT: CORALS AND SPONGES

Findings from qualitative segments:

A total of 1,783 individual corals from 5 taxa and 96 individual sponges from at least 7 taxa were enumerated from 61 qualitative segments observed during the dive. As reported for the quantitative segments, Virgulariidae sea pens accounted for the majority of observations (86% of total species composition). Observations of fan-like gorgonians included 154 primoids (*Plumarella longispina*), 4 bubble gum corals (*Paragorgia* sp.), and 1 red gorgonian ("*Swiftia* sp.") accounting for 8.5% of total coral and sponge composition. One small individual of *Paragorgia* sp. was noted to be broken at the base and the polyp colonies of half the individual "*Swiftia*" type red gorgonian were dead. Associations of amphipod mud tubes, skate egg cases and feather star crinoids (*Florometra serratissima*) were common on *Plumarella longispina*. The mushroom coral (*Anthomastus ritteri*) accounted for a small percentage of coral and sponge composition (0.5%). Total sponge abundance was 5% of the total coral and sponge composition. Foliose and shelf sponge morphologies that were not observed on the quantitative segments were documented on these qualitative segments. Some large barrel sponges were sized at 30-60 cm height.

Percent composition of corals and sponges documented on qualitative segments. Colors in table match colors in list of coral and sponge taxa (below).

Corals and sponges	% Composition
Mushroom coral	0.5
Porifera	5
Fan-like gorgonians	8.5
Sea pens	86

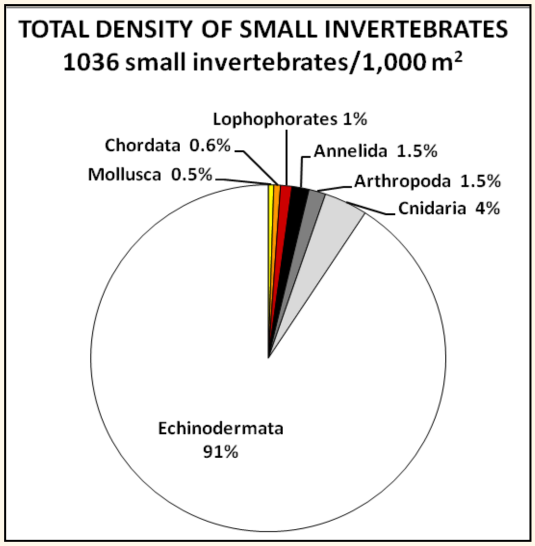
Scientific name	Common name	Number
Corals and Sponges		
*Anthomastus ritteri**	Mushroom coral	8
Porifera	Unidentified upright flat sponge	1
Porifera	Unidentified vase sponge	9
Porifera	Unidentified mound sponge	7
Porifera	Unidentified leaf sponge	43
Porifera	Unidentified foliose sponge	3
Porifera	Unidentified shelf sponge	1
Porifera	Unidentified barrel sponge	32
Paragorgia sp.*	Bubblegum coral	4
"*Swiftia* sp."	Red gorgonian	1
*Plumarella longispina**	Primnoid	154
Virgulariidae*	Sea pen	1616

* First verified observation in CBNMS

BIOLOGICAL ENVIRONMENT: SMALL INVERTEBRATES

Findings from quantitative segments:

A total of 1,819 small invertebrates from at least 32 different taxa were enumerated from 9 quantitative segments conducted during the dive. A total density of 1,036 small invertebrates per 1,000 m^2 of sea floor was estimated. Taxa within the phylum Echinodermata were the most abundant (91% of total density) due to the high abundance of fragile pink sea urchins (*Allocentrotus fragilis*), sessile sea cucumbers (*Psolus squamatus)* and vermillion sea stars (*Mediaster aequalis).* Species abundance in phylums Mollusca, Chorodata, Lophophorates, Annelida, Arthropoda and Cnidaria accounted for 9% of total density. All of these small invertebrate taxa occurred in mixed habitats.



Colors in pie diagram match colors in list of small invertebrate taxa (below).

Scientific name	Common name	Number
Small invertebrates		
Octopodidae	Unidentified octopus	3
Nudibranchia	Unidentified nudibranchs	1
Gastropoda	Unidentified gastropods	5
Urochordata	Unidentified solitary tunicate	4
Megalodicopia hians	Preditory tunicate	7
Laqueus californicus	Brachiopodes	19
Serpulidae	Unidentified serpulid worm	17
Spirobranchus spp.	Unidentified Christmas tree worm	11
Lopholithodes foraminatus	Brown box crab	6
Pandalus platyceros	Spot prawn	5
Paguridae	Unidentified hermit crabs	14
Munida quadrispina	Squat lobster	3
Metridium farcimen	Giant plumed anemone	1
Liponema brevicornis	Pom-pom anemone	3
Actiniaria	Unidentified anemone	4
Actiniaria	Unidentified small yellow anemone	60
Dromalia alexandri	Benthic siphonophore	1
Stomphia sp.	Orange and white anemone	1
Cerianthidae	Tube dwelling anemone	2
Allocentrotus fragilis	Fragile pink sea urchin	1071
Florometra serratissima	Feather star crinoid	6
Rathbunaster californicus	Deep-sea sun star	1
Mediaster aequalis	Vermilon sea star	165
Stylasterias forreri	Fish-eating seastar	6
Poraniopsis inflata	Spiny seastar	3
Hippasteria spp.	Spiny seastar	2
Henricia spp.	Blood seastar	6
Pteraster spp.	Seastars	2
Ceramaster spp.	Cookie shaped seastars	4
Asteroidea	Unidentified sea stars	4
Ophiuroidea	Unidentified brittle stars	77
Psolus squamatus	Sessile sea cucumber	305

BIOLOGICAL ENVIRONMENT: SMALL INVERTEBRATES

Findings from qualitative segments:

A total of 6,785 small invertebrates from at least 38 different taxa were enumerated from 61 qualitative segments conducted during the dive. Taxa within the phylum Echinodermata were the most abundant (80% of total species composition) due to the high abundance of fragile pink sea urchins (*Allocentrotus fragilis*) and sessile sea cucumbers (*Psolus squamatus).* Four additional sea star taxa that were not observed on the quantitative segments were documented on these qualitative segments.

Percent composition of small invertebrates documented on qualitative segments. Colors in table match colors in list of small invertebrate taxa (below).

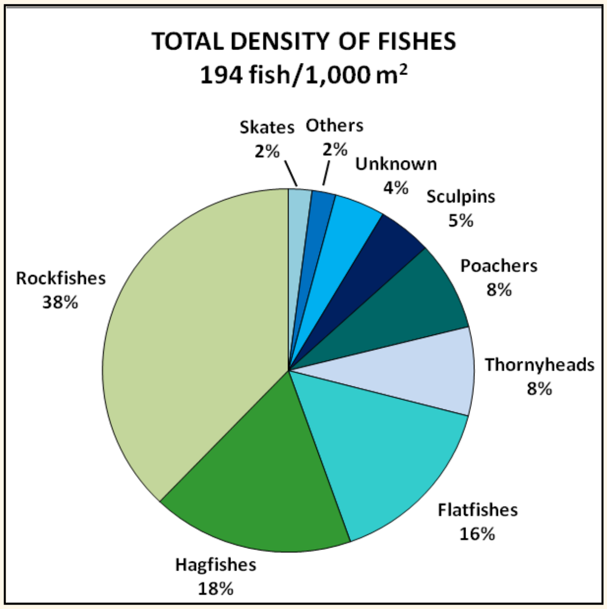
	Invertebrate Phylum	% Composition
Yellow	Mollusca	0.1
Orange	Chordata	0.2
Dark gray	Arthropoda	0.6
Black	Annelida	1
Light gray	Cnidaria	18
White	Echinodermata	80

	Scientific name	Common name	Number
Small invertebrates			
Yellow (Mollusca)	Octopodidae	Unidentified octopus	6
Yellow (Mollusca)	*Pleurobranchaea californica*	California sea slug	1
Orange (Chordata)	Urochordata	Unidentified solitary tunicate	3
Orange (Chordata)	*Megalodicopia hians*	Preditory tunicate	9
Black (Annelida)	Serpulidae	Unidentified serpulid worm	43
Black (Annelida)	*Spirobranchus* spp.	Unidentified Christmas tree worm	40
Dark gray (Arthropoda)	*Lopholithodes foraminatus*	Brown box crab	17
Dark gray (Arthropoda)	*Pandalus platyceros*	Spot prawn	7
Dark gray (Arthropoda)	Paguridae	Unidentified hermit crabs	5
Dark gray (Arthropoda)	*Munida quadrispina*	Squat lobster	8
Dark gray (Arthropoda)	Majidae	Decorating spider crabs	1
Dark gray (Arthropoda)	*Paralithodes californiensis*	California king crab	1
Dark gray (Arthropoda)	Brachyura	Unidentified true crabs	1
Light gray (Cnidaria)	*Metridium farcimen*	Giant plumed anemone	17
Light gray (Cnidaria)	*Liponema brevicornis*	Pom-pom anemone	7
Light gray (Cnidaria)	Actiniaria	Unidentified anemone	12
Light gray (Cnidaria)	Actiniaria	Unidentified small yellow anemone	992
Light gray (Cnidaria)	Zoantharia	Unidentified zoanthids	187
Light gray (Cnidaria)	*Dromalia alexandri*	Benthic siphonophore	2
Light gray (Cnidaria)	*Stomphia* spp.	Orange and white anemone	8
Light gray (Cnidaria)	Ceriantheidae	Tube dwelling anemone	11
White (Echinodermata)	*Allocentrotus fragilis*	Fragile pink sea urchin	3633
White (Echinodermata)	*Florometra serratissima*	Feather star crinoid	26
White (Echinodermata)	*Rathbunaster californicus*	Deep-sea sun star	8
White (Echinodermata)	*Mediaster aequalis*	Vermilon sea star	355
White (Echinodermata)	*Stylasterias forreri*	Fish-eating seastar	26
White (Echinodermata)	*Poraniopsis inflata*	Spiny seastar	2
White (Echinodermata)	*Pteraster militaris*	Wrinkled seastar	6
White (Echinodermata)	*Pteraster tesselatus*	Cushion seastar	1
White (Echinodermata)	*Henricia* spp.	Blood seastar	3
White (Echinodermata)	*Solaster* spp.	Sun seastars	5
White (Echinodermata)	*Ceramaster* spp.	Cookie shaped seastars	7
White (Echinodermata)	*Leptasterias* sp.	Six armed seastars	1
White (Echinodermata)	Asteroidea	Unidentified sea stars	13
White (Echinodermata)	Ophiuroidea	Unidentified brittle stars	13
White (Echinodermata)	Psolus squamatus	Sessile sea cucumber	1305
White (Echinodermata)	*Parastichopus johnsoni*	Johnson's sea cucumber	2
White (Echinodermata)	*Pannychia moseleyi*	Deep-sea cucumber	1

BIOLOGICAL ENVIRONMENT: FISHES

Findings from quantitative segments:

A total of 343 fishes from at least 28 different taxa were enumerated from 9 quantitative segments conducted during the dive. A total density of 194 fishes per 1,000 m^2 of sea floor was estimated. Rockfishes (at least 11 species of *Sebastes*) and at least 1 species of thornyheads (*Sebastolobus*) comprised 46% of total fish density. Hagfishes accounted for 18% of the total density and at least 2 species of flatfishes accounted for 16% of total density. The remainder of the fish assemblage included poachers (8%), sculpins (5%), fishes that could not be indentified (4%), skates (2%) and other taxa (2%). All fishes occurred in mixed habitats, except for four sculpins and two flatfishes that were observed in sediment habitats.



Colors in pie diagram match colors in list of fish taxa (below).

Scientific name	Common name	Number
Fishes		
Raja kincaidii	Sandpaper skate	2
Raja rhina	Longnose skate	5
Lycodes cortezianus	Bigfin eelpout	3
Ophiodon elongatus	Lingcod	1
Merluccius productus	Pacific hake	1
Hydrolagus colliei	Spotted ratfish	2
Osteichthyes	Unidentified fish	15
Cottidae	Unidentified sculpins	16
Agonidae	Unidentified poachers	28
Sebastolobus alascanus	Shortspine thornyhead	2
Sebastolobus spp.	Unidentified thornyheads	27
Pleuronectiformes	Unidentified flatfishes	5
Lyopsetta exilis	Slender sole	11
Microstomus pacificus	Dover sole	37
Eptatretus stoutii	Pacific hagfish	61
Sebastes melanostomus	Blackgill rockfish	3
Sebastes pinniger	Canary rockfish	6
Sebastes goodei	Chilipepper rockfish	9
Sebastes elongatus	Greenstriped rockfish	12
Sebastes jordani	Shortbelly rockfish	5
Sebastes zacentrus	Sharpchin rockfish	3
Sebastes diploproa	Splitnose rockfish	6
Sebastes saxicola	Stripetail rockfish	24
Sebastes chlorostictus	Greenspotted rockfish	3
Sebastes helvomaculatus	Rosethorn rockfish	8
Sebastes spp.	Unidentified rockfishes	45
Sebastes spp.	Young-of-the-year rockfishes	2
Sebastomus	Unidentified rockfishes	1

BIOLOGICAL ENVIRONMENT: FISHES

Findings from qualitative segments:

A total of 718 fishes from at least 44 different taxa were enumerated from 61 qualitative segments conducted during the dive. Rockfishes (*Sebastes*) and thornyheads (*Sebastolobus)* comprised 62% of total fish composition. Eight additional species of rockfishes (*Sebastes* spp.) that were not observed on the quantitative segments were documented on these qualitative segments. Specifically, large (>50 cm) bank, bocaccio, canary, cowcod, flag, vermillion, yelloweye, and widow rockfishes were observed in the hard rock habitat surveyed at the shallower portion of the dive.

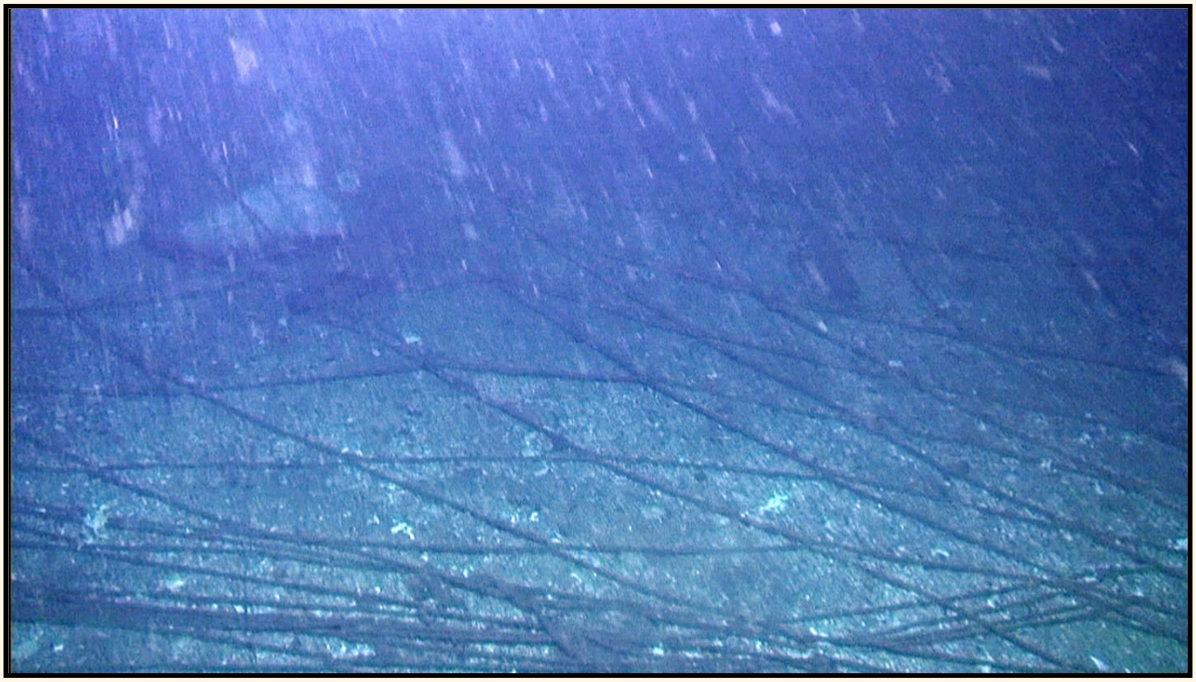
Percent composition of fishes documented on qualitative segments. Colors in table match colors in list of fish taxa (right).

Fishes	% Composition
Skates	1
Unknown	4
Others	5
Sculpins	5
Poachers	7
Thornyheads	7
Flatfishes	8
Hagfishes	8
Rockfishes	55

Scientific name	Common name	Number
Fishes		
Raja kincaidii	Sandpaper skate	3
Raja rhina	Longnose skate	1
Raja spp.	Unidentified skates	3
Lycodes cortezianus	Bigfin eelpout	15
Lyconema barbatum	Bearded eelpout	1
Ophiodon elongatus	Lingcod	3
Merluccius productus	Pacific hake	4
Hydrolagus colliei	Spotted ratfish	8
Plectobranchus evides	Bluebarred prickleback	1
Stichaeidae	Unidentified pricklebacks	1
Liparidae	Unidentified snailfishes	1
Torpedo Californica	Pacific electric ray	1
Osteichthyes	Unidentified fishes	28
Cottidae	Unidentified sculpins	39
Xeneretmus triacanthus	Blue spotted poacher	1
Agonidae	Unidentified poachers	52
Sebastolobus alascanus	Shortspine thornyhead	2
Sebastolobus spp.	Unidentified thornyheads	49
Pleuronectiformes	Unidentified flatfishes	7
Lyopsetta exilis	Slender sole	7
Microstomus pacificus	Dover sole	40
Glyptocephalus zachirus	Rex sole	2
Eptatretus stoutii	Pacific hagfish	57
Sebastes aurora	Aurora rockfish	5
Sebastes rufus	Bank rockfish	8
Sebastes melanostomus	Blackgill rockfish	3
Sebastes paucispinis	Bocaccio	21
Sebastes pinniger	Canary rockfish	22
Sebastes goodei	Chilipepper rockfish	22
Sebastes levis	Cowcod	2
Sebastes rubrivinctus	Flag rockfish	4
Sebastes elongatus	Greenstriped rockfish	30
Sebastes jordani	Shortbelly rockfish	8
Sebastes zacentrus	Sharpchin rockfish	9
Sebastes diploproa	Splitnose rockfish	19
Sebastes saxicola	Stripetail rockfish	28
Sebastes miniatus	Vermilion rockfish	1
Sebastes entomelas	Widow rockfish	6
Sebastes ruberrimus	Yelloweye rockfish	2
Sebastes chlorostictus	Greenspotted rockfish	17
Sebastes helvomaculatus	Rosethorn rockfish	9
Sebastes spp.	Unidentified rockfishes	158
Sebastes spp.	Young-of-the-year rockfishes	3
Sebastomus	Unidentified rockfishes	15

ADDITIONAL OBSERVATIONS

Anthropogenic marine debris was observed on 17 segments (2 quantitative, 13 qualitative). Debris items included eight rubbish items (cans, jars, metal pieces from fishing gear, etc.), four monofilament lines, three longlines, two lines not identified as longline or monofilament, one piece of trawl cable, and one trawl net.



Derelict trawl net stretched out over bottom at 206 meters.

ADDITIONAL OBSERVATIONS

The condition of the habitat and the presence of the derelict trawl net and cables raised questions about the level of bottom trawling effort at the dive site. Figure 6 depicts the total hours towed per 1 minute latitude x 1 minute longitude microblock over a 5 year period (1997-2001). Forty tow hours, an average of 13 hours per year, passed through the block sampled during the ROV dive (pers. comm. Janet Mason, NOAA-SWFSC).

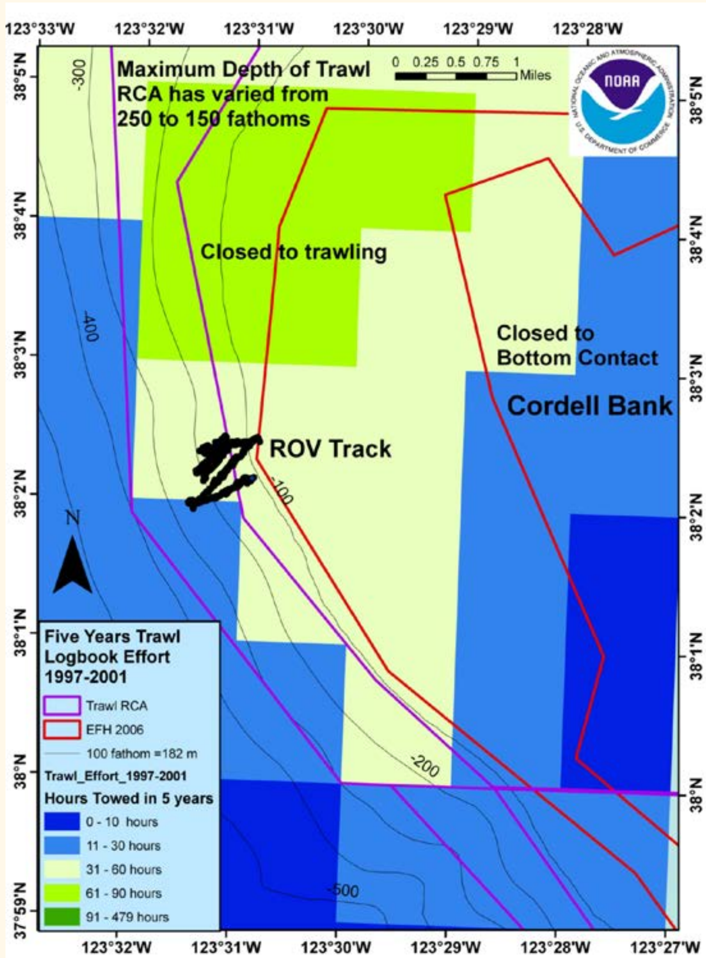


Figure 6. Total hours of bottom trawl tows, 1997-2001, per 1 minute^2 microblock

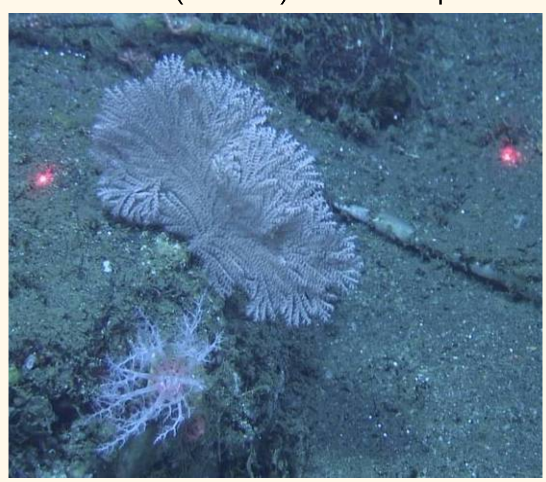
IMAGE GALLERY

The largest (25 cm) bubble-gum coral (*Paragorgia* sp.) observed on mixed habitat (sand with cobbles) at 304 m depth.

Mushroom coral (*Anthomastus ritteri*) and Aurora rockfish *(Sebastes aurora)* on mixed habitat (sand with small cobbles and pebbles) at 454 m depth.

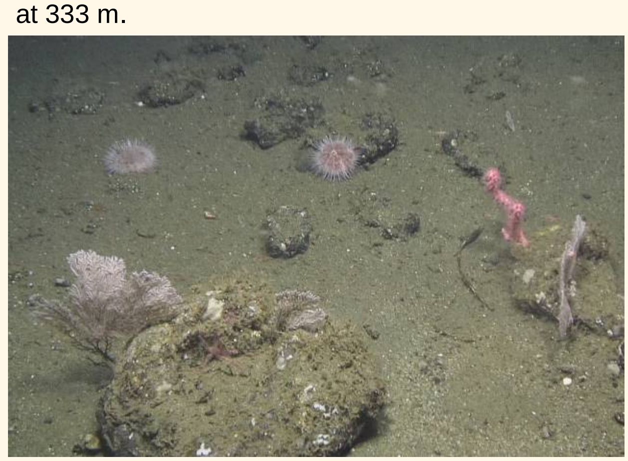
Barrel shaped ‘Boot sponge’ (tentative id: *Rhabdocalyptus dawsoni)* with associated brittle stars on mixed sand-boulder habitat at 392 m. Paired lasers (red dots) are 20 cm apart.

Primnoid (*Plumarella longispina*) and sessile sea cucumber (*Psolus squamatus)* on mixed habitat (sand with cobbles) at 350 m depth. Paired lasers (red dots) are 20 cm apart.



Unidentified vase sponge with associated crinoids (*Florometra serratissima)* on mixed habitat (sand with cobbles) at 376 m depth.

Primnoid coral (*Plumarella longispina),* bubble-gum coral *(Paragorgia* sp.) and fragile pink sea urchins (*Allocentrotus fragilis)* on mixed sand-cobble habitat at 333 m.



DISCUSSION

While the continental slope and shelf region targeted by this survey is well known to fishers and mariners, *in situ* observations are rare owing to the difficulty posed by the elements, depth, and distance from shore. This first glimpse of the continental slope region of CBNMS revealed some expected as well as some unexpected findings.

Analysis of multibeam sonar data collected in 2009 by the NOAA R/V *Okeanos Explorer* indicated that the selected dive site contained broad regions of hard-rugose bottom. This site was selected as the most likely of all candidate sites in the targeted region to provide habitat for DSC assemblages. However, ROV observations revealed that rather than rugose rocky bottom the substrate was primarily a mixture of sand with cobbles and some pebbles (Figure 3). Therefore, observed assemblages of corals, sponges, and fishes were not as diverse or abundant as predicted.

Summary observations of abundance patterns of invertebrates were similar in quantitative and qualitative dive segments. A higher number of taxa were observed on qualitative segments owing to the greater area searched by this class of observation. While twelve taxa of corals and sponges were observed, the category was dominated by a single species of sea pen in the family Virgulariidae, which made up 89% of the corals and sponges observed in the quantitative dive segments and 86% of the corals and sponges in the qualitative dive segments. The abundance of fan-like gorgonians was similar on quantitative and qualitative segments (8%), for which *Plumarella longisipina* was the dominant structure-forming coral species. The abundance of sponges was overall low, representing 3% of the quantitative dive segments and 5% of the qualitative segments. The small invertebrate group was dominated by echinoderms and a single species, the fragile pink sea urchin, *Allocentrotus fragilis,* represented 59% of the taxa observed on quantitative segments and 53% of the taxa observed on qualitative segments. Notably, 30 of the 32 feather star crinoids (*Florometra serratissima)* observed on all quantitative and qualitative segments were living on two vase sponges and twelve *P. longspina*.

Fishes observed during the dive exhibited higher diversity than the invertebrates. The single species dominance that was observed in the invertebrates was not seen in the fishes. The rockfish family (Sebastes) accounted for 38% of the fishes observed on quantitative dive segments and 55% of the fishes observed on qualitative segments. Eighteen species of rockfishes were identified during the dive. However, the numerically dominant single species was the hagfish *Eptatretus stoutii* which represented 18% of the fishes seen on quantitative dive segments and 8% of the fishes enumerated on qualitative dive segments. A few fish-invertebrate associations were documented; nine fish were located less than one body length from six individual corals and three individual sponges and two fish were hiding in a vase sponge.

The relatively low diversity of invertebrates which were dominated by just a few taxa (sea pens and sea urchins) may be a condition that was caused by bottom trawling which has been shown to lower the diversity and biomass of benthic communities (Jennings et al., 2005, Collie et al., 2000), including central California (De Marignac et al., 2009). Trawling has occurred in the region where the ROV dive occurred with an average of 13 hours per year between 1997 and 2001 (pers. comm. Janet Mason, NOAA-SWFSC). Since corals and sponges are slow growing and long lived, several passes of a trawl over these fragile species could significantly alter the benthic community structure. The slope area sampled in 2010 is proximate to areas closed to trawling but most of the continental slope region which was surveyed is not closed to bottom trawling (Figure 6).

The presence of some structure forming corals, some large sponges and the large number of sea pens is inconsistent with the hypothesis that coral and sponge communities have been altered by bottom trawling. However, it has been ten years since fishery closures (e.g. Rockfish Conservation Areas, established in 2002) drastically reduced landings at Bodega Bay (the closest port to CBNMS). This reduced trawl effort may be allowing corals and sponges in the region to recover.

In a trawl impacts study conducted in mud habitat off Oregon, Hixon and Tissot (2007) observed a dramatic contrast in the presence or absence of sea pens, in untrawled (sea pens present) vs. trawled (sea pens absent) study sites. The sea pens in the untrawled study sites, identified as *Stylatula spp.*, ranged in height from 20-50 cm. The Virgulariidae sea pens observed on the Cordell Bank slope were small and uniform in height (<10 cm). This suggests the Virgulariidae sea pens are of similar age and therefore recruited at about the same time namely, the time following the cessation of heavy trawling activity about 10 years ago. This theory correlates with the relatively slow growth rates and long-lived nature of sea pens (Wilson et al., 2002).

Similarly, assemblages of the gorgonian *P. longispina* may be recovering in this area and be of similar age because the majority of individuals ranged in height from 10-15 cm. While there is limited information on the growth rate of this species, they are in the same family (Primnoidae) as the gorgonian, *Primnoa resedaeformis,* of which individuals from southeast Alaska were determined to have growth rates of 1.6 to 2.3 cm/year in height (Andrews et al., 2002). Applying this growth rate to the size classes of *P. longispina* observed in this study area suggests that their recruitment started with the decline in bottom trawl effort in the region about 10 years ago. This hypothesis can also be applied to the small (3-25 cm) *Paragorgia* sp. observed in this study area. Andrews et al. (2005) estimated that an individual *Paragorgia* sp. that was 20 cm tall and growing on a cable submerged for 44 years grew at a minimum of 0.5 cm/year. Despite being slow growing, these gorgonian corals are long-lived and can reach large sizes. Observations of corals in similar habitat and depths off the coast of Washington found assemblages of *P. longispina* ranging from 25-40 cm in height and *Paragorgia arborea pacifica* up to 1 meter tall (Brancato et al., 2007).

Although very few sponges were documented in the study area, more than 5 individual barrel sponges (visually similar to the hexactinellid sponge, *Rhabdocalyptus dawsoni*) ranging in height from 30-60 cm, were observed. Leyes and Lauzon (1998) determined that the average growth rate of *R. dawsoni* in British Columbia, Canada was 2 cm per year. Like corals, slow growth rates and reaching a large size are not compatible with frequent physical disturbance. So it is likely that these few large barrel sponges inhabit a serendipitous refuge untouched by the trawl nets.

Virgulariidae sea pen

Fifty cm tall barrel sponge

We believe that the lack of consolidated rugose bedrock is limiting the DSC assemblages in the study region. Another factor which likely influenced DSC size and abundance was historic bottom trawling which may have degraded the habitat and removed many of the sponges and corals. A reduction in trawl effort (a consequence of fishery closures in the region enacted over a decade ago) has likely allowed the small DSC we observed to become established and grow. The few large sponges we observed likely inhabited a region not impacted by bottom trawls. Further exploration of this continental slope ecosystem needs to be conducted as we cannot confidently deduce from a single ROV dive that the overall low abundance of DSC disqualifies this region of the continental slope as significant habitat.

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