A CHARACTERIZATION OF THE DEEP-SEA CORAL AND SPONGE COMMUNITY IN BODEGA CANYON OFF THE COAST OF CALIFORNIA FROM A SURVEY USING AN AUTONOMOUS UNDERWATER VEHICLE

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INTRODUCTION AND SCIENTIFIC OBJECTIVES

In 2010, the NOAA Deep-Sea Coral Research and Technology Program (DSCRTP) initiated a three- year study to advance our understanding of deep-sea corals (DSC) off the west coast of the U.S. The following study was a part of this research.

A broad-scale characterization of deep-sea coral/sponge habitats and communities was conducted in Bodega Canyon during late summer of 2011 using still photo observations from an Autonomous Underwater Vehicle (AUV). This project was carried out as a joint effort between staff from NOAA Northwest Fisheries Science Center and Cordell Bank National Marine Sanctuary. The goal of this study was to provide information regarding this unexplored canyon system to compare with other well-studied canyons in the region (Figure 1). The area is currently open to trawling; however, fishing effort data suggest that it is an area of lower trawl intensity and may provide a good contrast to those areas with high trawling intensity. Bodega Canyon is outside the existing boundary of Cordell Bank National Marine Sanctuary but is included in the area proposed for Sanctuary expansion. Further information on the importance of the habitats and associated communities could assist in appropriately reviewing these areas for further protection as Essential Fish Habitat Conservation Areas or by an expansion of the National Marine Sanctuary.

There existed high-resolution multibeam data of this region from the NOAA Research Vessel *Okeanos Explorer*. Target locations were identified to focus on areas with the highest likelihood of corals, but also included a range of habitat types to acquire contrast in the data and provide data for ground-truthing the habitat maps (Figure 2).   The goal for 2011 was to use an Autonomous Underwater Vehicle to 1) assess the abundance, distribution, and habitat associations of corals and sponges, as well as associated fish and invertebrates, over a broad region of the Canyon; 2) understand environmental factors (e.g., depth, substratum, bottom

topography, and water properties) that influence coral and sponge distribution; 3) gather information to help understand the value of deep-sea corals and sponges as habitat for fish and other associated species. In addition, data from still images were used to ground-truth the multibeam data.
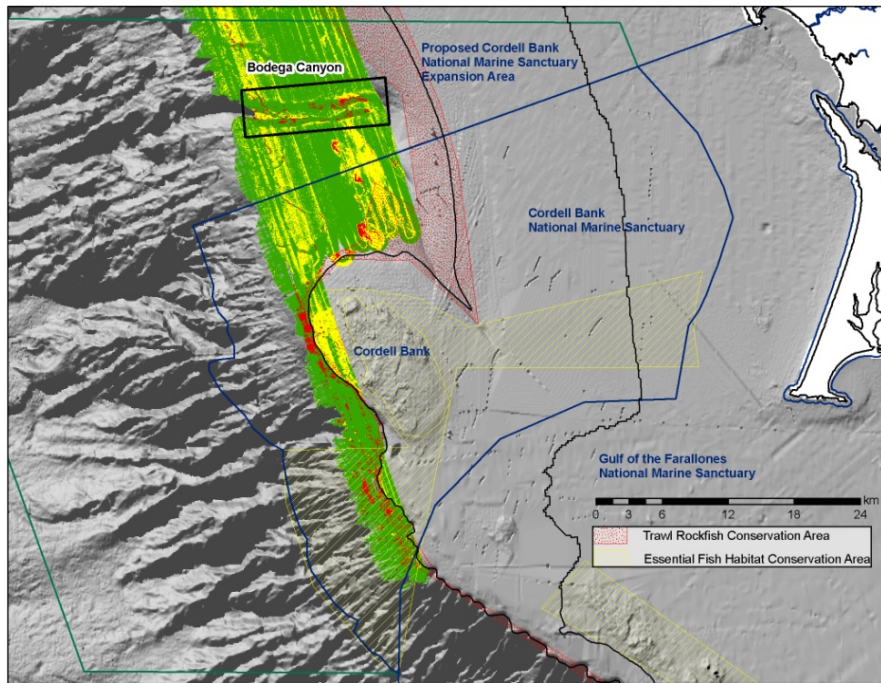

Figure 1. Location of Bodega Canyon, just north of Cordell Bank and within the proposed expansion area for Cordell Bank National Marine Sanctuary.
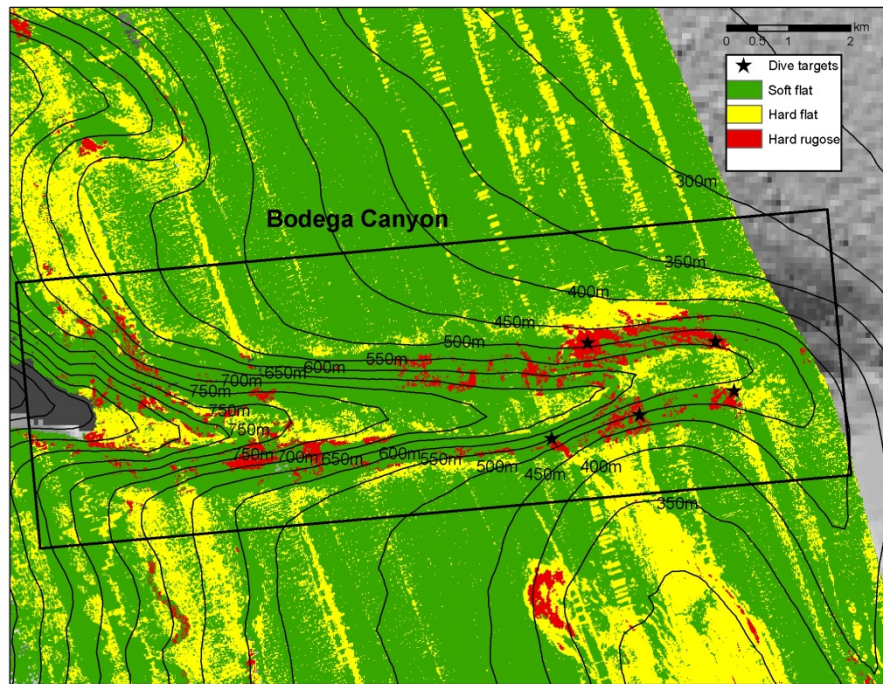
Figure 2. Detail of Bodega Canyon (habitat classes created from multibeam data collected on NOAA Research Vessel *Okeanos Explorer*, 2009 by Guy Cochrane, USGS, Santa Cruz) and AUV dive target locations.

Science operations included quantitative visual surveys of DSC and fishes with their associated habitats. The SeaBED AUV and associated cameras were used during daylight hours to quantitatively survey DSC and habitats particularly at depths beyond the capabilities of other oceanographic equipment.

This report provides a summary of the methods and results from underwater surveys of corals, sponges and associated habitats, and fishes using the SeaBED AUV in Bodega Canyon.

STUDY SITE

Bodega Canyon is located west of the California town of Bodega Bay, north of the Cordell Bank National Marine Sanctuary.

Figure 3. SeaBED AUV

Figure 4. NOAA Research Vessel *Fulmar*

FIELD SURVEY METHODS

Underwater surveys of DSC, sponges, habitats and associated fishes were conducted using the SeaBED class AUV *Lucille* (Figure 3) deployed from the NOAA Research Vessel *Fulmar* (Figure 4). Images of the seafloor were collected using two 5 megapixel, 12-bit dynamic range Prosilica GigE cameras. Dives were developed from transect surveys to conduct exploration in areas with the probable occurrence of DSC. Two cameras (a stereo pair) were mounted to look directly downward and the third camera was angled forward at 30°. Lighting was provided by a strobe synced with the cameras.

The AUV was equipped with two navigational sensors: the RDI 1200 kHz Doppler Velocity Log as the primary navigational sensor and the iXSea OCTANS gyrocompass and inertial motion sensor. The AUV was tracked using a Link Quest TrackLink 1500 USBL navigation system. Subsurface communication was provided by the WHOI 256008 acoustic micromodem and surface communication used a FreeWave FGR-115 RCRF radio modem. Depth was determined using a Paroscientific depth sensor. Salinity, temperature and pressure were collected using a Sea-Bird model 49 FastCat CTD mounted on the AUV.

Four dives were attempted over 5 days (Figure 5). Camera shutter trigger (interval between photos) and altitude varied by dive and within dives depending on the mission of the dive and the rugosity of the seafloor. Images were down-loaded at the end of each mission and each image was color-corrected. All non-overlapping color-corrected digital stills from the downward looking camera were reviewed following the cruise and invertebrates as well as associated fishes were identified and counted. Photos from the angled camera were used to assist in species identification only.

Figure 5. Locations of AUV Dives

POST-DIVE ANALYSIS

Location of the AUV during each dive was estimated using USBL range and bearing measurements relative to the ship, the X,Y coordinates of the vehicle position relative to its dive origin, and the GPS coordinates of the dive launch point.

All non-overlapping color-corrected digital images from the port downward looking camera were reviewed following the cruise. Corals, sponges and fishes were identified and counted from all images. The area of each image was estimated using the measured altitude off the bottom and the specified camera field of view. As the altitude maintained by the AUV changed, so did the image area. Marine debris and any evidence of anthropogenic effects were noted.

Seafloor habitats in each photograph were categorized using a two-character code (Table 1) The first character signified the primary habitat type that covered greater than 50% of the field of view, while the second character defined the secondary habitat type covering between 20% and 50%. If the primary habitat coverage exceeded 80%, that letter was denoted twice (e.g., CC).

Temperature and salinity were processed, plotted, and analyzed using Sea-Bird Electronics' data processing software. Large spikes in the data were edited by hand.

Table 1. Habitat types

Habitat Code	Description	Habitat Name
u	small particle size anywhere in grain size from finest mud to coarsest sand	Unconsolidated
m	small particle size; darker color than sand & generally deeper water	Mud
s	small particle size; white to light gray in color & generally in shallower water; > 0.0625 mm & < 4 mm	Sand/sediment
g	>4 mm & <2 cm	Gravel
p	>2 cm & <6.4 cm	Pebble
c	>6.4 cm & <25.6 cm; often rounded	Cobble
b	>25.6 cm; detached from outcrop of origin	Boulder
f	<1 m relief; slope angle,<30 deg; flat rock areas away from ridge	Flat Rock
r	generally >1 m relief consolidated rock; slope angle >30 deg & <60 deg	Ridge
t	>3 m relief; slope angle >60 deg	Pinnacle

SUMMARY OF DIVES

During this cruise, five AUV dives were attempted, but only four were completed. The AUV communications system had difficulties due to rough weather that cancelled launching for the fifth dive.

Date	PI	Dive #	Method	Start Time (UTC)	End Time (UTC)	Start Lat (N)	Start Long (W)	End Lat (N)	End Long (W)
24-Aug-11	M.E. Clarke	001	AUV	18:09	22:36	38°14.30'	123°29.52'	38°14.39'	123°29.28'
25-Aug-11	M.E. Clarke	002	AUV	17:51	21:51	38°13.07'	123°28.51'	38°13.25'	123°29.18'
26-Aug-11	M.E. Clarke	003	AUV	18:53	22:18	37°55.66'	123°26.86'	37°55.77'	123°27.68'
27-Aug-11	M.E. Clarke	004	AUV	19:57	23:03	38°11.63'	123°27.03'	38°12.03'	123°27.41'

A total of 14, 271m^2 of seafloor was classified during the 4 completed dives. The original two-character-code habitat types were aggregated into three general categories for this analysis: the 'hard' category included ridge, boulder, cobble and flat rock in various proportions; 'mixed' comprised one of the 'hard' classifications combined with mud or sand; and 'sediment' was represented by mud and sand or a combination of the two. The overall area surveyed by the AUV was approximately 90% sediment substrate.

We were able to identify 48 taxa of invertebrates and fishes by analyzing the still images during the 4 successful AUV dives in or near Bodega Canyon. We identified 9 taxa of sponges, 8 taxa of corals and anemones and 31 taxa of fishes. Identifications in question were moved up to the level of certainty, leading to family and order level groupings.

A total of 310 corals and anemones, 469 sponges and 2,166 fishes were enumerated during the 4 dives analyzed. Densities of corals, sponges, fishes and invertebrates were estimated by dividing the abundance of each taxon by the area covered during each dive. Area was determined using the constant altitude of the camera and known field of view for each image. Overall densities varied greatly by dive, the ranges were 2.1-34 corals and anemones/ 1,000m^2; 1.6-90 sponges/ 1,000m^2; and 40-383 fishes/ 1,000m^2. The most abundant corals and anemones encountered included the pom pom anemone (*Liponema brevicornis*) and unidentified anemones, mushroom corals (*Anthomastus ritteri*), and various fan-like gorgonians (*Parastenella* spp. and *Plumerella* spp.). The most abundant sponge morphotypes were other (including unidentified sponges and *Asbestopluma* spp.), branching and vase sponges. The most abundant fishes varied greatly by dive, with different dives favoring flatfish (Dover sole, *Microstomus pacificus* and slender sole, *Lyopsetta exilis*), thornyheads (*Sebastolobus* spp.) and rockfish (*Sebastes* spp.).

In the following pages we present summaries, by dive, of the diversity and density of corals and anemones, sponges, and fishes along with their associated habitats. We also present

profiles of sea temperature and salinity with depth during the AUV dives. Some notes on the health and condition of the corals and sponges are included, along with the occurrence of marine debris and evidence of fishing.

Table 2. Invertebrate taxa observed in still photos taken by AUV in the Bodega Canyon near the Cordell Bank National Marine Sanctuary, 24 August- 27 August, 2011.

	Scientific Name	**Common Name**
	Mud Covered	Unidentified species
	Porifera	Unidentified vase sponges
	Porifera	Unidentified barrel sponges
	Mycale spp.	Upright flat sponge (yellow)
	Porifera	Unidentified branching sponge
	Porifera	Unidentified mound sponges
	Asbestopluma spp. #2	Predatory sponge (clear)
	Asbestopluma spp. #1	Pipe cleaner Sponge
	Porifera	Unidentified sponges
	Parastenella spp.	Primnoid
	Plumerella spp.	Primnoid
	Swiftia spp.	Sea fan
	Anthomastus ritteri	Mushroom coral
	Pennatulacae	Unidentified sea pen
	Anthozoa	Unidentified coral
	Liponema brevicornis	Pom-pom anemone
	Actinidae	Unidentified anemone

Table 3. Fish taxa observed in still photos taken by AUV in the Bodega Canyon near the Cordell Bank National Marine Sanctuary, 24 August- 27 August, 2011.

| Scientific Name	Common Name
Myxinidae	Unidentified hagfish
Bathyraja kincaidii	Sandpaper skate
Hydrolagus colliei	Spotted ratfish
Raja rhina	Longnose skate
Scyliorhinidae	Unidentified catshark
Agonidae	Unidentified poachers
Anoplopoma fimbria	Sablefish
Cottidae	Unidentified sculpins
Liparidae	Unidentified snailfish
Lycodes cortezianus	Bigfin eelpout
Osteichthyes	Unidentified fishes
Zoarcidae	Unidentified eelpouts
Atheresthes stomias	Arrowtooth flounder
Embassichthys bathybius	Deepsea sole
Eopsetta jordani	Petrale sole
Glyptocephalus zachirus	Rex sole
Lyopsetta exilis	Slender sole
Microstomus pacificus	Dover sole
Parophrys vetulus	English sole
Pleuronectiformes	Unidentified flatfish
Sebastes babcocki	Redbanded rockfish
Sebastes chlorostictus	Greenspotted rockfish
Sebastes diploproa	Splitnose rockfish
Sebastes elongatus	Greenstriped rockfish
Sebastes melanostomus	Blackgill rockfish
Sebastes zacentrus	Sharpchin rockfish
Sebastes spp.	Chilipepper/ Shortbelly rockfish
Sebastes spp.	Rockfish Unid.
Sebastomus	Unidentified White-spotted RF
Sebastolobus alascanus	Shortspine thornyhead
Sebastolobus spp.	Unidentified thornyhead

DIVE NUMBER: AUV001

STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Elizabeth Clarke, Dan Howard
Contact Information	NMFS, NWFSC, elizabeth.clarke@noaa.gov
Purpose	Survey to find deep corals in Bodega Canyon
Vessel	NOAA Sanctuary Vessel *Fulmar*, *Lucille* AUV
Team	C. Whitmire, E. Fruh, J. Taylor
Digital Still Photos	4080
Positioning System	Ship: GPS; AUV: DVL, gyrocompass, USBL
CTD Sensor	Yes

DIVE DATA

Date	24 August 2011	Starting Latitude (N)	38°14.30'
Maximum Bottom Depth (m)	507	Starting Longitude (W)	123°29.52'
Start Time (UTC)	18:09	Ending Latitude (N)	38°14.39'
End Time (UTC)	22:36	Ending Longitude (W)	123°29.28'

GENERAL LOCATION AND DIVE TRACK
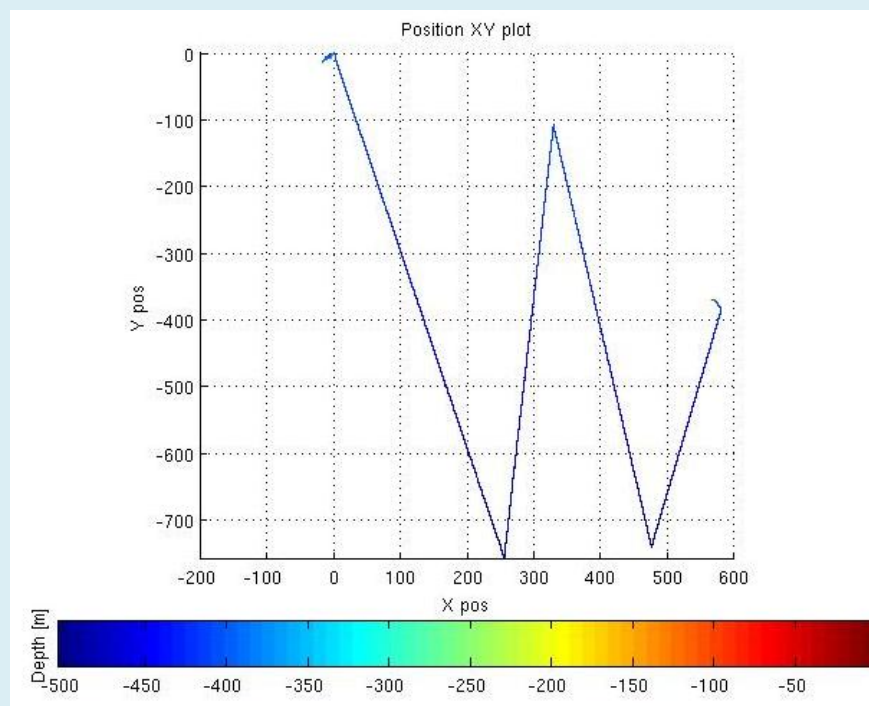
Survey pattern of dive AUV001.
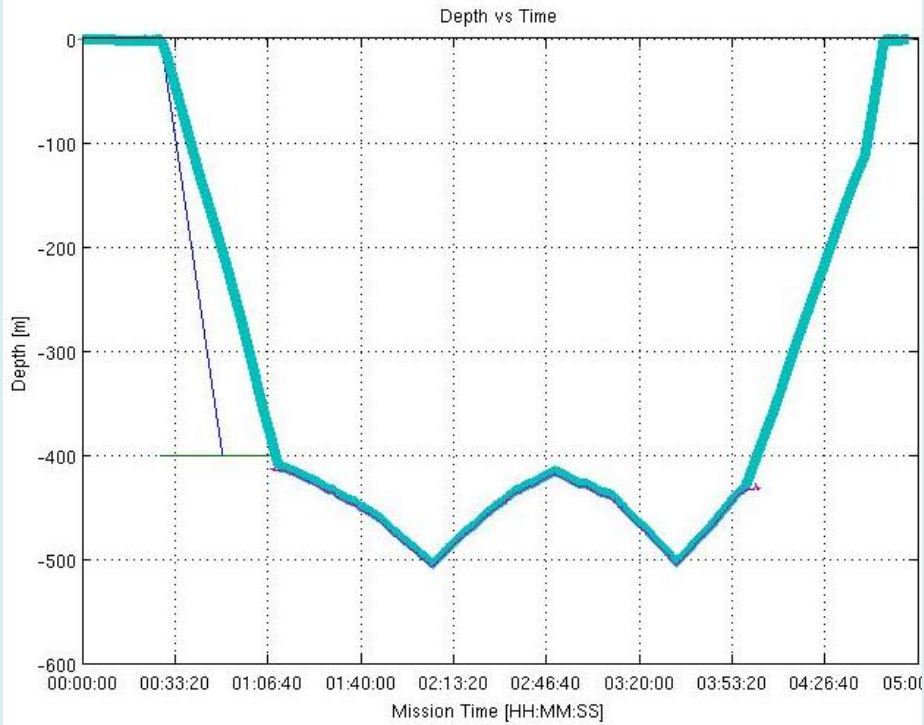
Depth track of dive AUV001 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

PHYSICAL ENVIRONMENT

The AUV was equipped with an onboard Sea-Bird model 49 FastCat CTD that collected temperature and salinity information throughout the AUV's descent as well as along the dive track. During the dive AUV001 descent, the temperature varied from 11.5 to 7.91°C and salinity varied from 33.96 to 34.12 (psu).

Dive AUV001 descent temperature and salinity profiles.
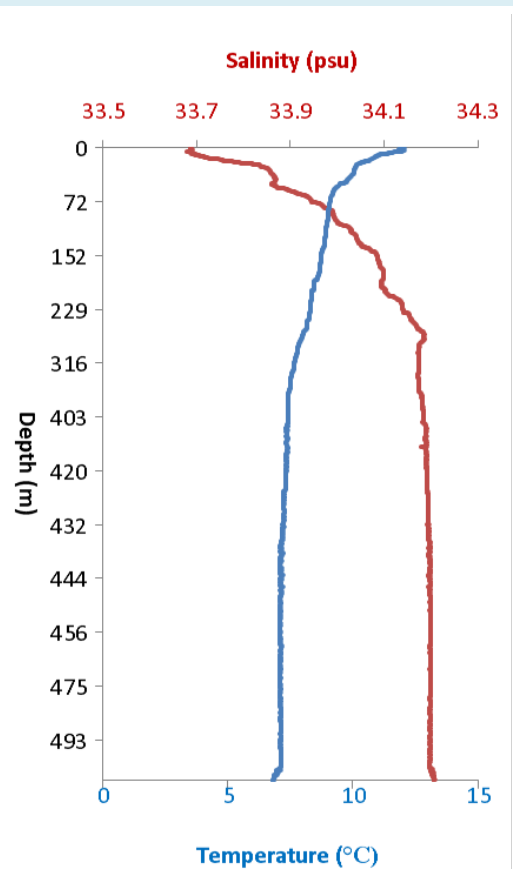
13

AUV001 Habitat Surveyed
(Total area= 4,318 m^2)
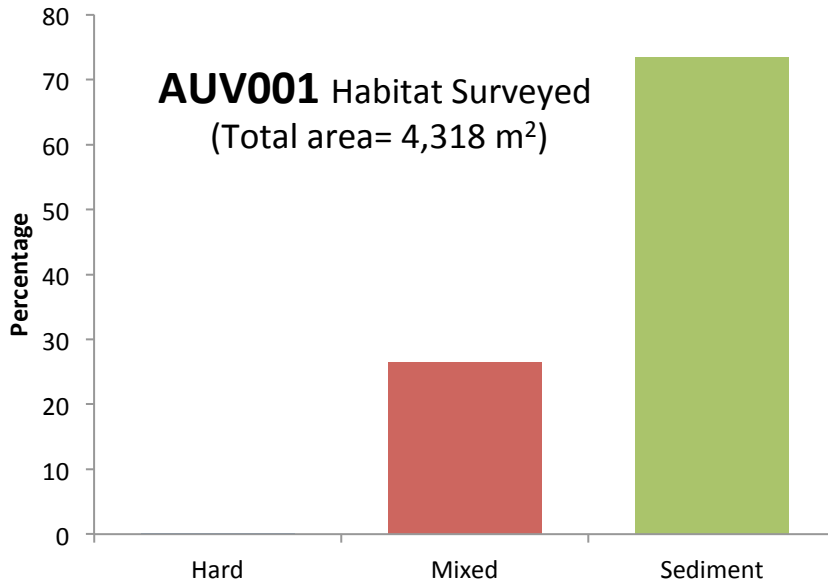
In total, 4,328 m^2 of seafloor were surveyed during dive AUV001 using the *Lucille* AUV deployed from the NOAA Sanctuary Vessel *Fulmar* in the Bodega Canyon. Habitat types were classified as (1) Hard (<1% of the total area surveyed), which included boulders and cobble; (2) Mixed (27% of the total area surveyed), which included mud appearing with boulder, cobble or rock; (3) Sediment (73% of the total area surveyed), which included mud substrate.

BIOLOGICAL ENVIRONMENT: CORALS

A total of 118 corals and anemones were enumerated from the 1004 frames sampled from dive AUV001 conducted in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. They represented 7 taxonomic groups. An overall density of 27 anthozoans per 1,000 m^2 of seafloor was estimated. Unidentified anemones and the pom-pom anemone (*Liponema brevicornis*) were the most abundant at 62% of the overall density. Mushroom corals (*Anthomastus ritteri*)accounted for the second highest density (20%). Fan-like (7%) and stick-like (2%) gorgonians together accounted for 9% of the overall density. These included the genera *Parastenella* spp., *Plumerella* spp. and *Swiftia* spp. The remaining 9% of coral density was made up of unidentified corals. Corals were encountered when boulders and cobble were present in the substrate. The colors in the pie diagram match the colors in the list of coral taxa.
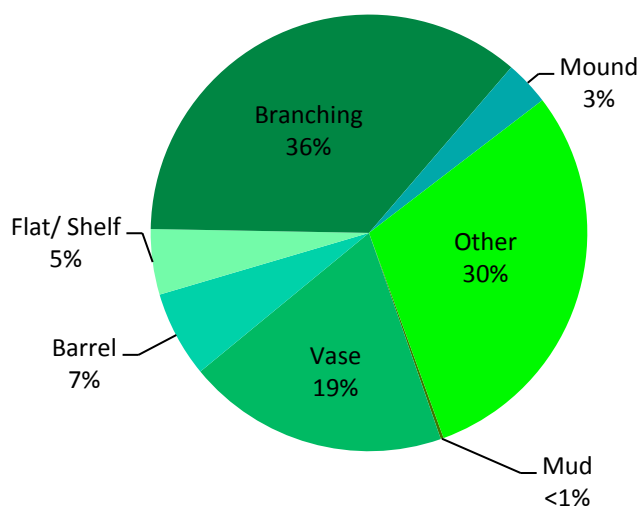
AUV001- Density of Corals
(27 anthozoans/ 1,000 m^2)

Anemones 62%

Fan-like Gorgonians 7%

Stick-like Gorgonians 2%

Mushroom coral 20%

Other 9%

	Scientific Name	Common Name	Count
	Parastenella spp.	Primnoid	6
	Plumerella spp.	Primnoid	2
	Swiftia spp.	Sea fan	2
	Anthomastus ritteri	Mushroom coral	24
	Anthozoa	Unidentified coral	11
	Liponema brevicornis	Pom-pom anemone	8
	Actinidae	Unidentified anemone	65

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 392 sponges were enumerated from the 1004 frames sampled from dive AUV001 conducted in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. Ten different taxonomic groups were represented. An overall density estimate of 90 sponges per 1,000 m^2 of seafloor was reached. Unidentified branching sponges were found to be the most abundant, representing 36% of the overall sponge density. The genera *Asbestopluma* spp. and other unidentified sponges were the second most abundant grouping at 30% of the overall density. Unidentified vase sponges accounted for 19% of the sponge density for this dive. Unidentified barrel sponges (7%), *Mycale* spp. and unidentified flat sponges (5%), mound sponges (3%) and mud covered sponges (<1%) were the other categories represented. The majority of the sponges occurred on hard and mixed habitats. Colors in the pie chart above match the list of sponge taxa following.

AUV001- Density of Sponges
(90 sponges/ 1,000 m^2)

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	Scientific Name	Common Name	Count
	Mud Covered	Unidentified species	1
	Porifera	Unidentified vase sponges	76
	Porifera	Unidentified barrel sponges	25
	Porifera	Unidentified upright flat sponges	9
	Mycale spp.	Upright flat sponge (yellow)	10
	Porifera	Unidentified branching sponge	141
	Porifera	Unidentified mound sponges	13
	Asbestopluma spp. #2	Predatory sponge (clear)	3
	Asbestopluma spp. #1	Pipe cleaner Sponge	8
	Porifera	Unidentified sponges	106

BIOLOGICAL ENVIRONMENT: FISHES

AUV001- Density of Fishes
(68 fishes/ 1,000 m²)
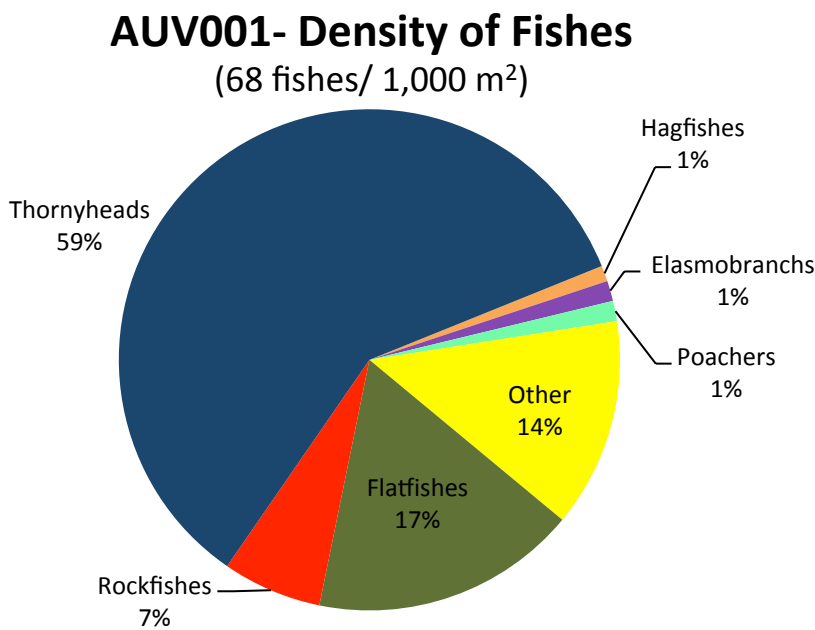
A total of 297 fishes were enumerated, representing 17 different taxonomic groupings during dive AUV001 in Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. An overall density of 68 fishes per 1,000 m² was estimated. The *Sebastolobus* spp. grouping, including *Sebastolobus alascanus*, made up 59% of the total density of fishes for dive AUV001. Flatfishes (17%, represented by Dover sole (*Microstomus pacificus*), deepsea sole (*Embassichthys bathybius*) and rex sole (*Glyptocephalus zachirus*)) were the next largest density. The other grouping, made up of sablefish (*Anoplopoma fimbria*), eelpouts (including bigfin, *Lycodes corezianus*), Cottidae and unidentified fishes represented 14% of the overall density. Rockfishes, including splitnose rockfish (*Sebastes diploproa*), blackgill rockfish (*Sebastes melanostomus*) and unidentified rockfish accounted for 7% of the fish density. The remaining categories represented included hagfish (1%), elasmobranchs (1%) (unidentified catshark and longnose skate, *Raja rhina*) and poachers from the family Agonidae. . The pie diagram colors match with the list of fish taxa below.

|	Scientific Name	Common Name	Count
	Myxinidae	Unidentified hagfish	3
	Raja rhina	Longnose skate	3
	Scyliorhinidae	Unidentified catshark	1
	Agonidae	Unidentified poachers	4
	Zoarcidae	Unidentified eelpouts	10
	Lycodes cortezianus	Bigfin eelpout	5
	Cottidae	Unidentified sculpins	1
	Glyptocephalus zachirus	Rex sole	1
	Microstomus pacificus	Dover sole	45
	Embassichthys bathybius	Deepsea sole	5
	Osteichthyes	Unidentified fishes	3
	Sebastes diploproa	Splitnose rockfish	1
	Sebastes melanostomus	Blackgill rockfish	3
	Sebastes spp.	Rockfish Unid.	15
	Sebastolobus alascanus	Shortspine thornyhead	26
	Sebastolobus spp.	Unidentified thornyhead	150
	Anoplopoma fimbria	Sablefish	21

IMAGE GALLERY- AUV001
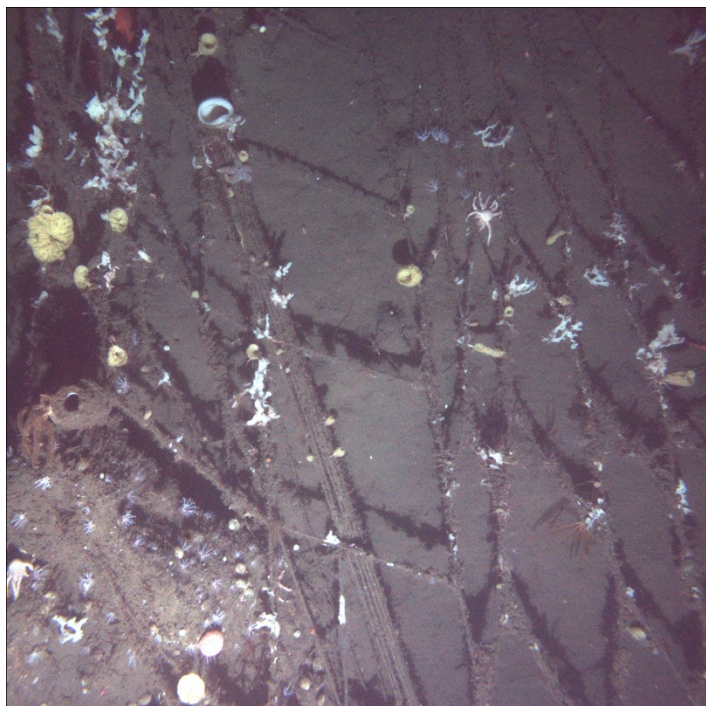
This image shows the remains of a midwater trawl net encountered on this dive. Although classified as persistent marine debris, the net provides shelter and substrate for sponges, fishes and invertebrates. Vase sponges, branching sponges, sea stars, crinoids and rockfish can be observed in this image.
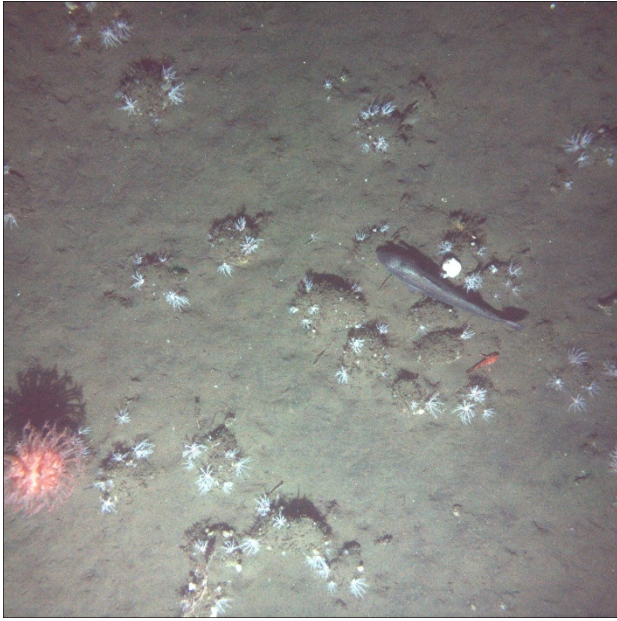
This image shows mixed substrate (cobble and mud), with a sablefish (*Anoplopoma fimbria*) and a thornyhead (*Sebastolobus* spp.). In the lower left of the image a mushroom coral (*Anthomastus ritteri*) with feeding tentacles extended can be seen.

The image to the right shows an unidentified catshark (Scyliorhinidae) and a Dover sole (*Microstomus pacificus*) over mixed substrate.
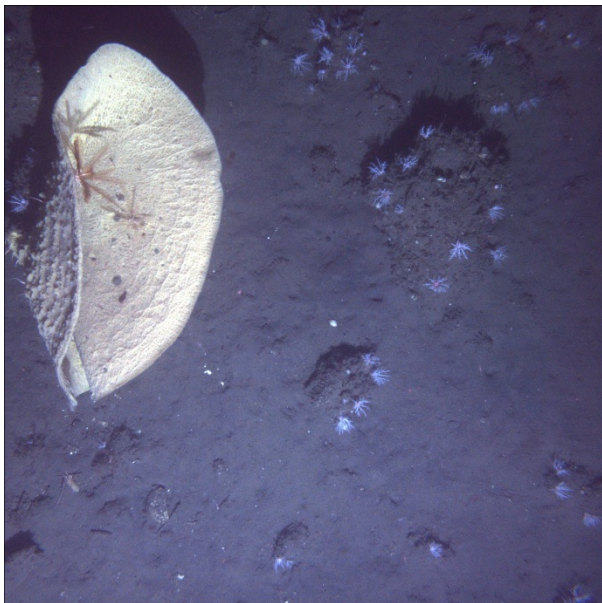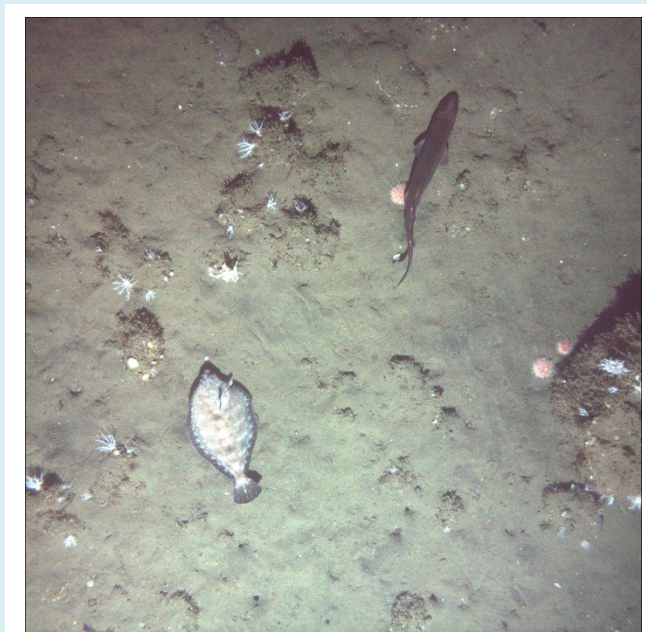
The image to the left shows a large vase sponge providing substrate for crinoids. The mixed substrate of mud and boulder also provides attachment sites for many sea cucumbers with feeding arms extended.

DIVE NUMBER: AUV002

STATION OVERVIEW

|	
Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Elizabeth Clarke, Dan Howard
Contact Information	NMFS, NWFSC, elizabeth.clarke@noaa.gov
Purpose	Survey to find deep corals in Bodega Canyon
Vessel	NOAA Sanctuary Vessel *Fulmar*, *Lucille* AUV
Team	C. Whitmire, E. Fruh, J. Taylor
Digital Still Photos	3930
Positioning System	Ship: GPS; AUV: DVL, gyrocompass, USBL
CTD Sensor	Yes

DIVE DATA

Date	25 August 2011	Starting Latitude (N)	38°13.07'
Maximum Bottom Depth (m)	408	Starting Longitude (W)	123°28.51'
Start Time (UTC)	17:51	Ending Latitude (N)	38°13.25'
End Time (UTC)	21:51	Ending Longitude (W)	123°29.18'

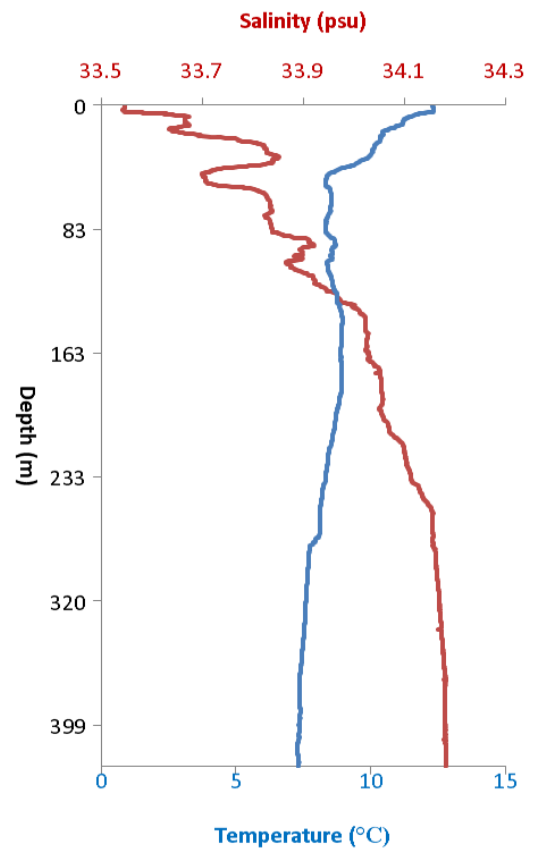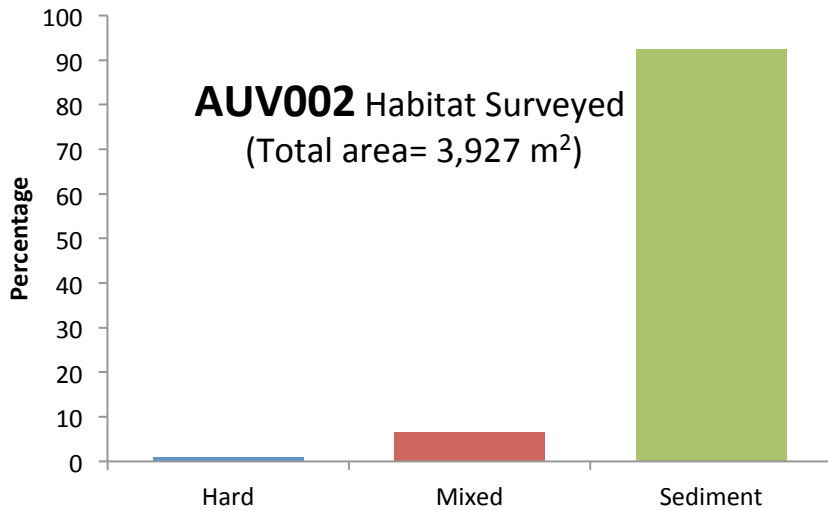**GENERAL LOCATION AND DIVE TRACK**
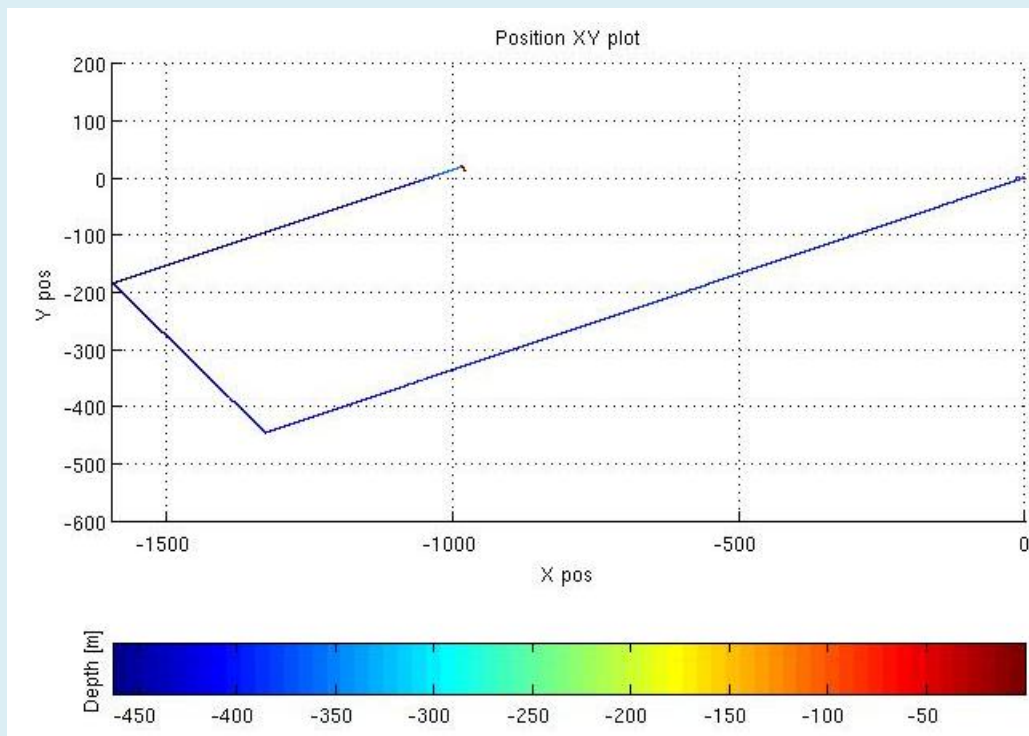
Survey track of dive AUV002.
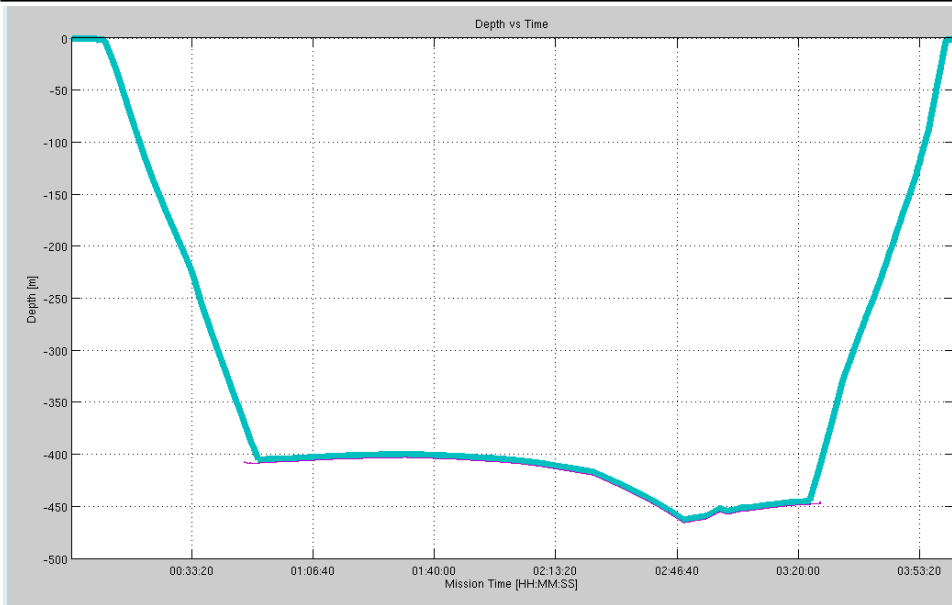
Depth track of dive AUV002 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

PHYSICAL ENVIRONMENT

The AUV was equipped with an onboard Sea-Bird model 49 FastCat CTD that collected temperature and salinity information throughout the AUV's descent as well as along the dive track. During the dive AUV002 descent, the temperature varied from 12.6 to 7.3°C and salinity varied from 33.56 to 34.2 (psu).
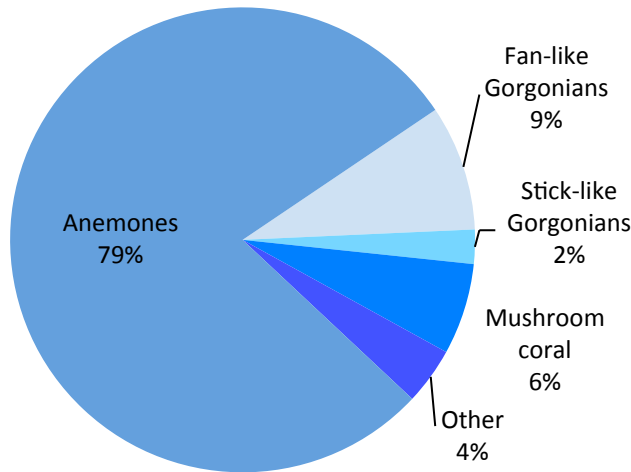
Dive AUV002 descent temperature and salinity profiles.

AUV002 Habitat Surveyed
(Total area= 3,927 m^2)

Percentage

100
90
80
70
60
50
40
30
20
10
0

Hard   Mixed   Sediment

In total, 3,927 m^2 of seafloor were surveyed during dive AUV002 using the Lucille AUV deployed from the NOAA Sanctuary vessel *Fulmar* in the Bodega Canyon. Habitat types were classified as (1) Hard (<1% of the total area surveyed); (2) Mixed (7% of the total area surveyed); and (3) Sediment (93% of the total area surveyed).

AUV002- Density of Corals
(13 corals/ 1,000 m^2)

Fan-like
Gorgonians
9%

Stick-like
Gorgonians
2%

Anemones
79%

Mushroom
coral
6%

Other
4%

BIOLOGICAL ENVIRONMENT: CORALS

A total of 49 corals and anemones were enumerated from the 910 frames sampled from dive AUV002 in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. They represented 6 taxonomic groupings. An overall density of 13 corals and anemones per 1,000 m^2 of seafloor was estimated. Unidentified anemones accounted for 79% of the overall density of corals and

anemones. Fan-like gorgonians were the second most abundant taxa at 9% of the overall density, including *Parastenella* spp. and *Plumerella* spp. Mushroom coral (*Anthomastus ritteri*) accounted for 6% of the coral density. Unidentified corals (4%) and stick-like gorgonians (*Swiftia* spp.) Two percent were the remaining groups encountered in this dive. Corals and anemones tended to be associated with the hard and mixed substrates when they were encountered. The colors in the pie diagram match the colors in the list of coral taxa.

	Scientific Name	Common Name	Count
	Parastenella spp.	Primnoid	3
	Plumerella spp.	Primnoid	1
	Swiftia spp.	Sea fan	1
	Anthomastus ritteri	Mushroom coral	3
	Anthozoa	Unidentified coral	2
	Actinidae	Unidentified anemone	39

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 64 individual sponges were identified in the 910 frames analyzed from dive AUV002 in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. They represented 7 taxonomic groupings. Unidentified and *Asbestopluma* spp. sponges were the most abundant taxa, representing 66% of the overall sponge density. Mud covered sponges accounted for 15% of the sponge density. Unidentified branching sponges (11%), unidentified mound sponges (5%) and unidentified barrel sponges (3%) comprised the remainder of the overall sponge density.   Sponges were encountered when harder substrates were encountered. The colors in the pie diagram match the colors in the list of sponge taxa.

AUV002- Density of Sponges
(16 sponges/ 1,000 m^2)

Mud 15%
Barrel 3%
Branching 11%
Other 66%
Mound 5%
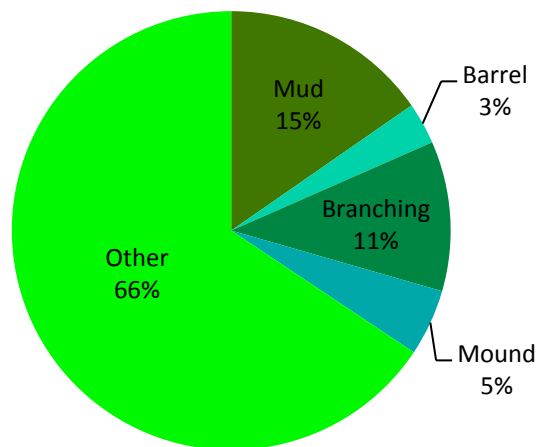
	Scientific Name	Common Name	Count
	Porifera	Unidientified vase sponges	10
	Porifera	Unidentified barrel sponges	2
	Porifera	Unidentified branching sponge	7
	Porifera	Unidentified mound sponges	3
	Asbestopluma spp. #2	Predatory sponge (clear)	1
	Asbestopluma spp. #1	Pipe cleaner Sponge	18
	Porifera	Unidentified sponges	23

BIOLOGICAL ENVIRONMENT: FISHES

### AUV002- Density of Fishes
(40 fishes/ 1,000 m^2)
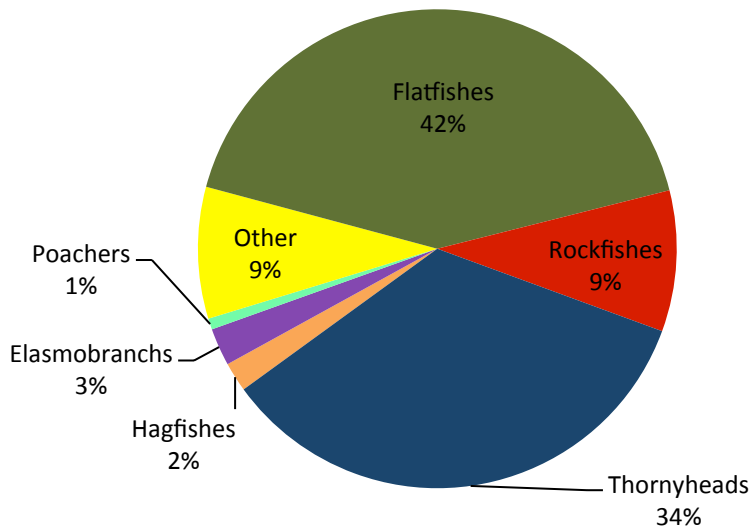
A total of 157 fishes, representing 16 different taxa were enumerated for dive AUV002 in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. The most abundant were the flatfishes (42%), including Dover sole (*Microstomus pacificus*), rex sole (*Glyptocephalus zachirus*), petrale sole (*Eopsetta jordani*) and arrowtooth flounder (*Atheresthes stomias*). Thornyheads (*Sebastolobus* spp.) were the next most abundant fishes comprising 34% of the overall density. Rockfishes (including blackgill rockfish (*Sebastes melanostomus*), sharpchin rockfish (*Sebastes zacentrus*) and unidentified rockfish) and other fishes (including sablefish (*Anoplopoma fimbria*) and bigfin eelpouts (*Lycodes cortezianus*)) each accounted for 9% of the overall fish density. The remaining fish density was comprised of elasmobranchs (3%, longnose skate (*Raja rhina*), sandpaper skate (*Bathyraja kincaidii*) and catsharks (Scyliorhinidae)), unidentified hagfishes (2%, family Myxinidae) and unidientified poachers (1%, family Agonidae). Fishes were found associated with all substrate types. The colors in the pie diagram match the colors in the list of fish taxa.

	Scientific Name	Common Name	Count
🟧	Myxinidae	Unidentified hagfish	3
🟪	*Raja rhina*	Longnose skate	1
	Bathyraja kincaidii	Sandpaper skate	2
	Scyliorhinidae	Unidentified catshark	1
🟩	Agonidae	Unidentified poachers	1
🟨	*Lycodes cortezianus*	Bigfin eelpout	3
🫒	*Glyptocephalus zachirus*	Rex sole	3
	Atheresthes stomias	Arrowtooth flounder	1
	Eopsetta jordani	Petrale sole	5
	Microstomus pacificus	Dover sole	57
🟥	*Sebastes zacentrus*	Sharpchin rockfish	1
	Sebastes melanostomus	Blackgill rockfish	5
	Sebastes spp.	Rockfish Unid.	9
🟦	*Sebastolobus alascanus*	Shortspine thornyhead	12
	Sebastolobus spp.	Unidentified thornyhead	42
🟨	*Anoplopoma fimbria*	Sablefish	11

IMAGE GALLERY- AUV002
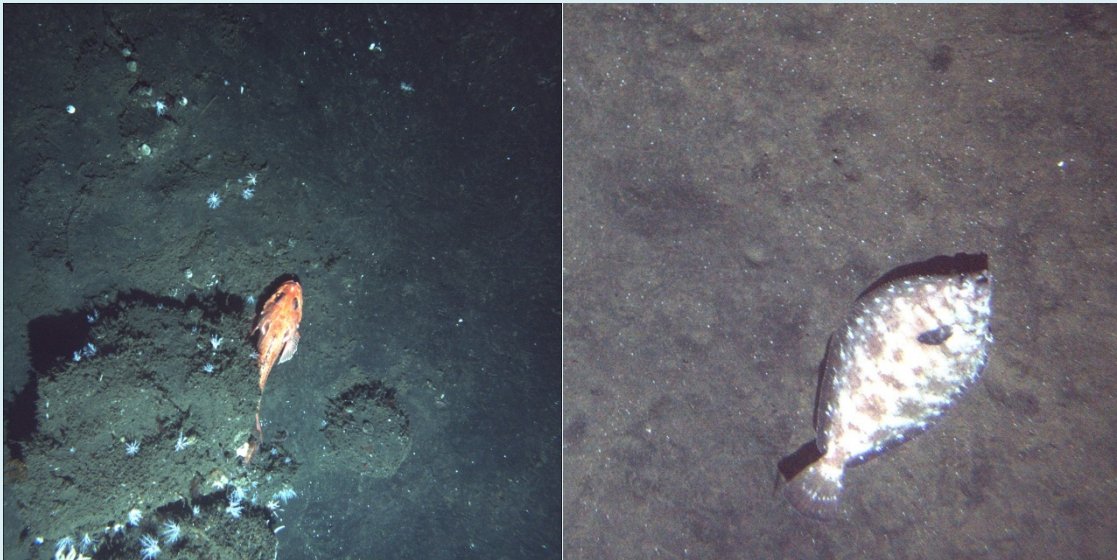
The left image shows a shortspine thornyhead (*Sebastolobus alascanus*) using a boulder as shelter. The image to the right, shows a Dover sole (*Microstomus pacificus*) on sediment substrate.

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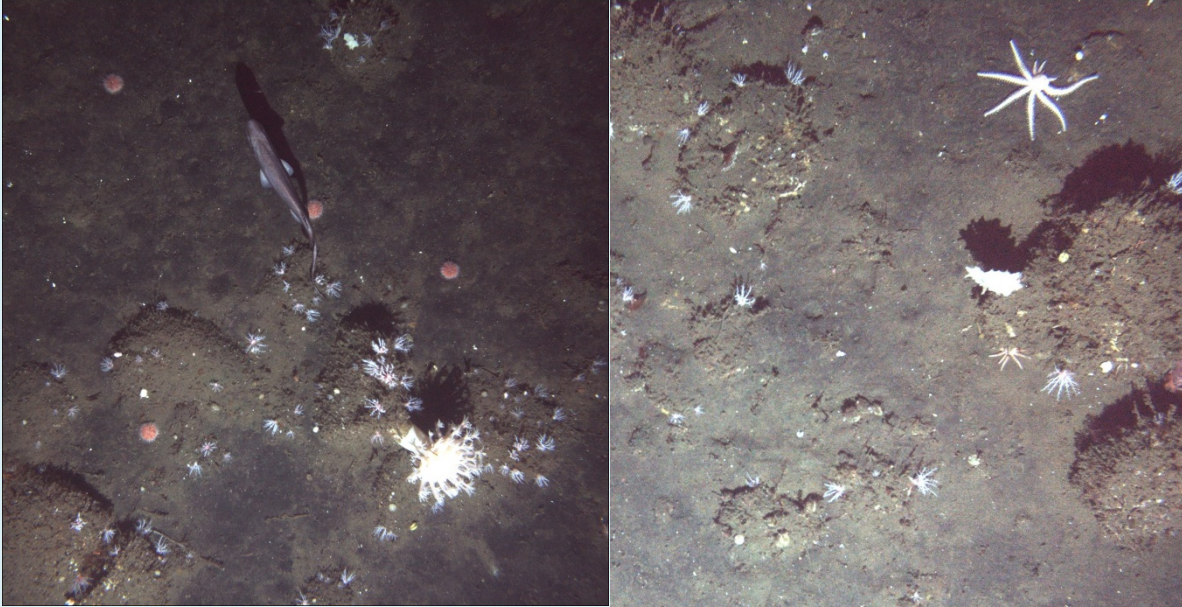
The image to the left shows an unidentified catshark (Scyliorhinidae) swims near a mushroom coral (*Anthomastus ritteri*). The image to the right shows a *Parastenella* spp. coral on boulder substrate.

The above image shows a coil of rope or cable debris serving as substrate for a vase sponge, and several sea stars. An unidentified hagfish swims in the upper left corner.

DIVE NUMBER: AUV003

STATION OVERVIEW

|	
Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Elizabeth Clarke, Dan Howard
Contact Information	NMFS, NWFSC, elizabeth.clarke@noaa.gov
Purpose	Survey to find deep corals in Bodega Canyon
Vessel	NOAA Sanctuary Vessel *Fulmar*, *Lucille* AUV
Team	C. Whitmire, E. Fruh, J. Taylor
Digital Still Photos	3381
Positioning System	Ship: GPS; AUV: DVL, gyrocompass, USBL
CTD Sensor	Yes

DIVE DATA

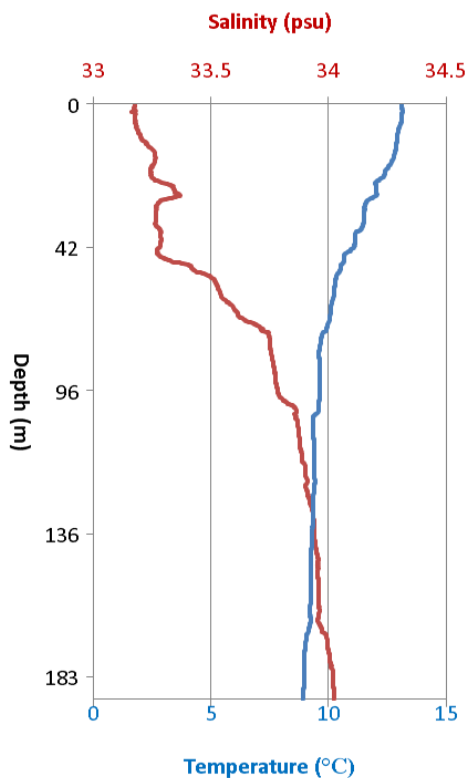|			
Date	26 August 2011	Starting Latitude (N)	37°55.66'
Maximum Bottom Depth (m)	388	Starting Longitude (W)	123°26.86'
Start Time (UTC)	18:53	Ending Latitude (N)	37°55.77'
End Time (UTC)	22:18	Ending Longitude (W)	123°27.68'

## GENERAL LOCATION AND DIVE TRACK
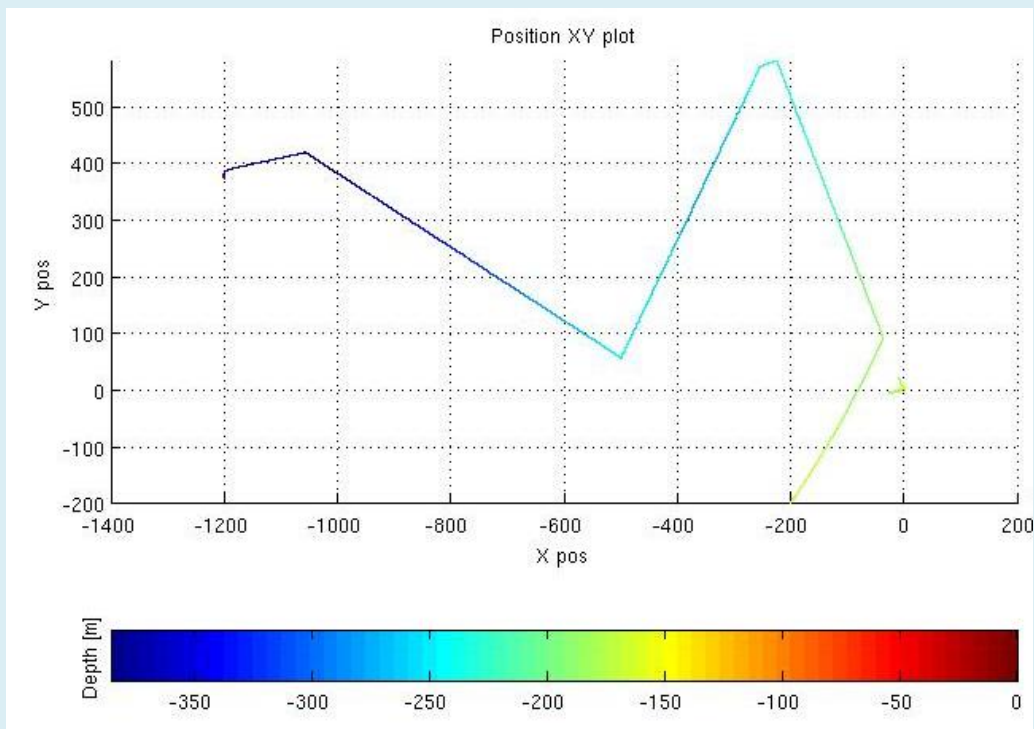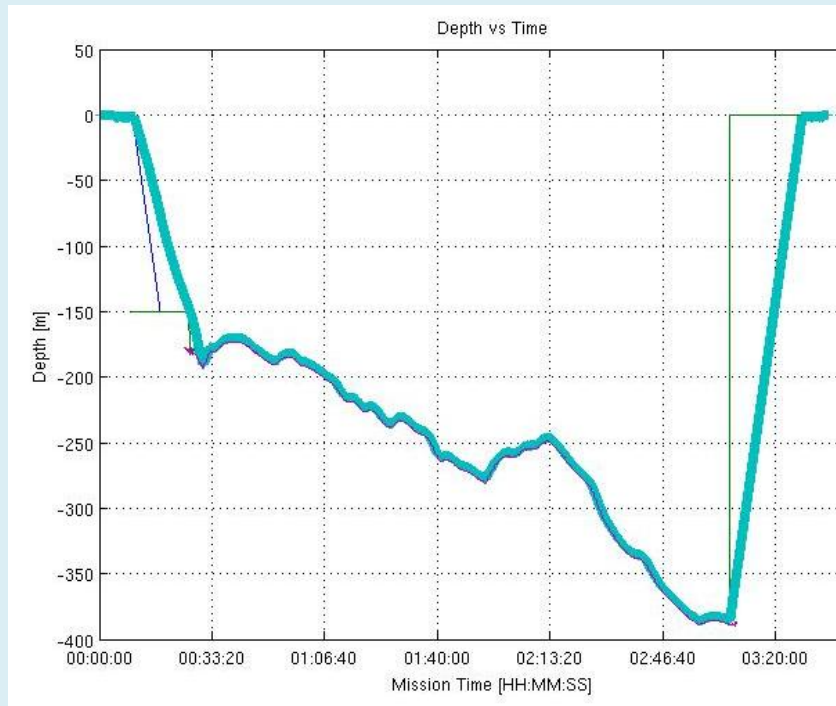
Survey track of dive AUV003.

Depth track of dive AUV003 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

PHYSICAL ENVIRONMENT

The AUV was equipped with an onboard Sea-Bird model 49 FastCat CTD that collected temperature and salinity information throughout the AUV's descent as well as along the dive track. During the dive AUV003 descent, the temperature varied from 13.1 to 8.9°C and salinity varied from 33.18 to 34.03 (psu).

Dive AUV003 descent temperature and salinity profiles.

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AUV003 Habitat Surveyed
(Total area= 4,108 m²)
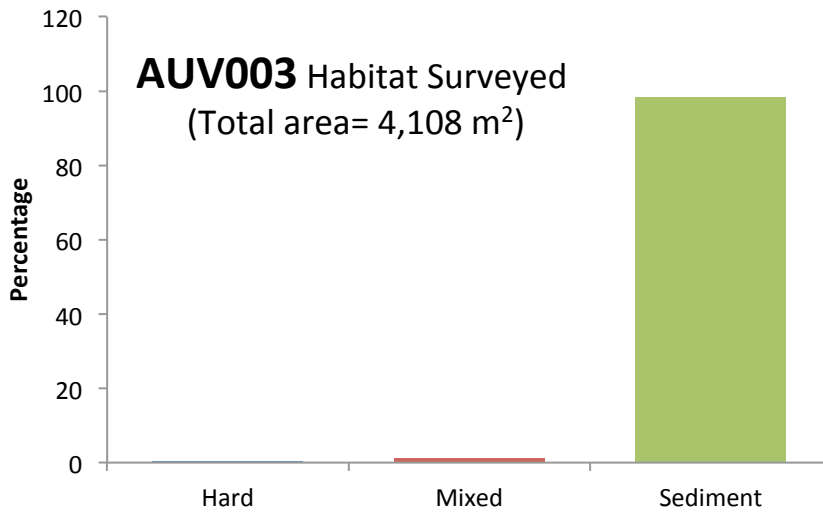
In total, 4,108 m² of seafloor were surveyed during dive AUV003 using the *Lucille* AUV deployed from the NOAA Sanctuary Vessel Fulmar on the slope southwest of Cordell Bank. Habitat types were classified as (1) Hard (<1% of the total area surveyed), which included boulders and cobble; (2) Mixed (just over 1% of the total area surveyed), which included mud appearing with boulder, cobble or rock; (3) Sediment (98% of the total area surveyed), which included mud substrate

BIOLOGICAL ENVIRONMENT: CORALS

AUV003- Density of Corals
(34 corals/ 1,000 m²)
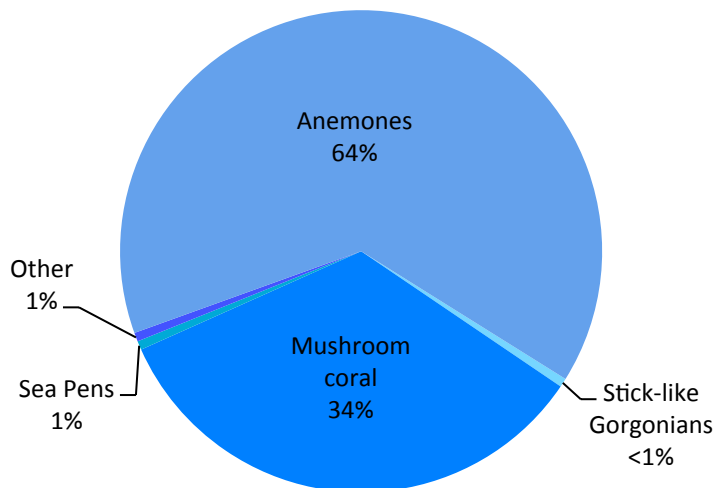
A total of 139 corals and anemones representing 5 taxa were encountered and identified from the 937 frames analyzed during dive AUV003 in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. An overall density of 34 corals and anemones per 1,000 m² of seafloor was estimated. Unidentified anemones accounted for 64% of the overall coral and anemone density. The second most abundant were mushroom corals (*Anthomastus ritteri*), which made up 34% of the overall density. Unidentified corals and unidentified sea pens were each represented by 1% of the coral and anemones density. Finally, stick-like gorgonians (*Swiftia* spp.) made up <1% of the overall density. Anemones were found on all substrate types, but the corals favored hard to mixed

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substrates. The colors in the pie diagram match the colors in the list of coral and anemone taxa.

	Scientific Name	Common Name	Count
	Swiftia spp.	Sea fan	1
	Anthomastus ritteri	Mushroom coral	47
	Anthozoa	Unidentified coral	1
	Pennatulacae	Unidentified sea pen	1
	Actinidae	Unidentified anemone	89

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 10 individual sponges were enumerated from the 937 frames sampled from dive AUV003 conducted in the Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. An overall sponge density of 2.5 sponges per 1,000 m^2 of seafloor was estimated. There was little variation in the sponge community from this dive. Two taxa were represented (unidentified Porifera and *Asbestopluma* spp.). They were grouped into the "other" category that accounted for 100% of the overall sponge density. The colors in the pie diagram match the colors in the list of sponge taxa.
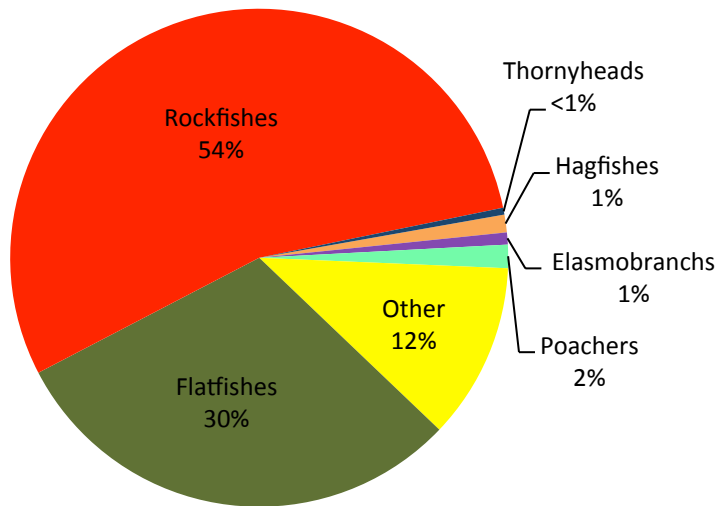
AUV003- Density of Sponges
(2.5 sponges/ 1,000 m^2)

Other
100%
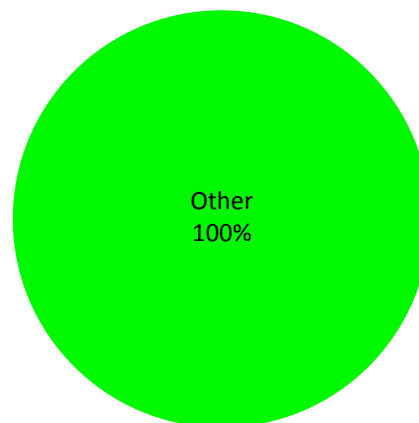
	Scientific Name	Common Name	Count
	Asbestopluma spp. #1	Pipe cleaner Sponge	4
	Porifera	Unidentified sponges	6

BIOLOGICAL ENVIRONMENT: FISHES

AUV003- Density of Fishes
(383 fishes/ 1,000 m^2)

A total of 1,571 fishes were counted representing 22 different taxonomic groupings during dive AUV003 in Bodega Canyon from the NOAA Sanctuary vessel *Fulmar*. An overall density of 383 fishes per 1,000 m^2 was estimated. Rockfishes (chilipepper/ shortbelly, greenspotted, greenstriped, Sebastomus and unidentified rockfish) represented 54% of the overall fish density. Large schools of chilipepper/ shortbelly rockfish were observed over sediment substrate. Flatfish were the next most abundant category at 30% of the overall density. These included Dover sole (*Microstomus pacificus*), slender sole (*Lyopsetta exilis*), rex sole (*Glyptocephalus zachirus*) and to a lesser degree arrowtooth flounder (*Atherestes stomias*), English sole (*Parophrys vetulus*) and unidentified flatfish. The other category (12% of overall fish density) included sablefish (*Anoplopoma fimbria*), unidentified fishes, eelpouts (Zoarcidae), sculpins (Cottidae) and snailfish (Liparidae). The remainder of the fish assemblage included poachers (2%, Agonidae), hagfishes (1%, Myxinidae), thornyheads (<1%, *Sebastolobus* spp.) and elasmobranchs (1%, *Hydrolagus colliei, Raja rhina* and *Bathyraja kincaidii*). The colors in the pie chart match the colors in the list of fish taxa.

|	Scientific Name	Common Name	Count
	Myxinidae	Unidentified hagfish	18
	Hydrolagus colliei	Spotted ratfish	2
	Raja rhina	Longnose skate	6
	Bathyraja kincaidii	Sandpaper skate	4
	Agonidae	Unidentified poachers	24
	Zoarcidae	Unidentified eelpouts	126
	Liparidae	Unidentified snailfish	1
	Cottidae	Unidentified sculpins	4
	Glyptocephalus zachirus	Rex sole	50
	Microstomus pacificus	Dover sole	109
	Parophrys vetulus	English sole	1
	Lyopsetta exilis	Slender sole	264
	Atheresthes stomias	Arrowtooth flounder	1
	Pleuronectiformes	Unidentified flatfish	50
	Osteichthyes	Unidentified fishes	41
	Sebastes chlorostictus	Greenspotted rockfish	1
	Sebastes elongatus	Greenstriped rockfish	11
	Sebastes spp.	Chilipepper/ Shortbelly rockfish	674
	Sebastes spp.	Rockfish Unid.	165
	Sebastomus	Unidentified White-spotted RF	4
	Sebastolobus spp.	Unidentified thornyhead	7
	Anoplopoma fimbria	Sablefish	8

IMAGE GALLERY- AUV003

This image shows one of the large schools of small rockfish encountered during this dive. The fish were identified as chilipepper/ shortbelly rockfish.
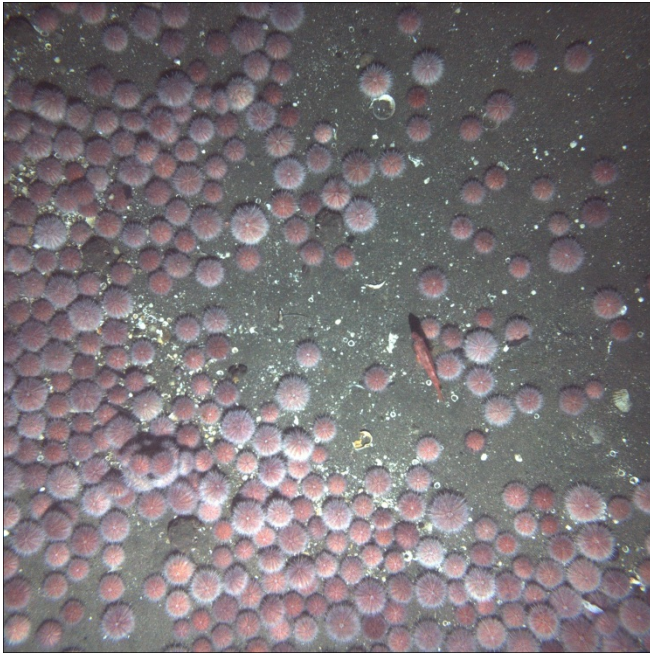
The image to the right shows an unidentified rockfish among a bed of urchins (*Allocentrotus fragilus*).
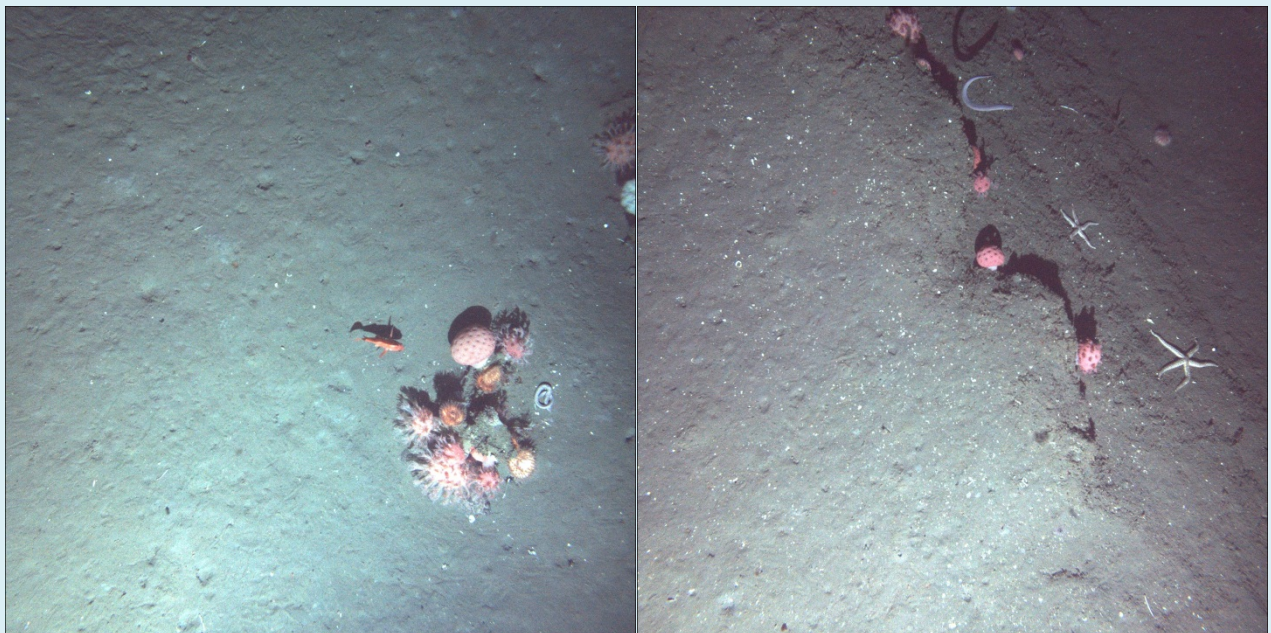
The image to the left shows an unidentified rockfish (*Sebastes* spp.) swimming near a stand of mushroom coral (*Anthomastus ritteri*) and unidentified anemones. A hagfish (Myxinidae) is curled nearby. The image on the right shows multiple mushroom corals (*Anthomastus ritteri*) attached to an exposed rock edge. Another hagfish (Myxinidae) swims near the top of the image.

DIVE NUMBER: AUV004

STATION OVERVIEW

|	
Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Elizabeth Clarke, Dan Howard
Contact Information	NMFS, NWFSC, elizabeth.clarke@noaa.gov
Purpose	Survey to find deep corals in Bodega Canyon
Vessel	NOAA Sanctuary Vessel *Fulmar*, *Lucille* AUV
Team	C. Whitmire, E. Fruh, J. Taylor
Digital Still Photos	2214
Positioning System	Ship: GPS; AUV: DVL, gyrocompass, USBL
CTD Sensor	Yes

DIVE DATA

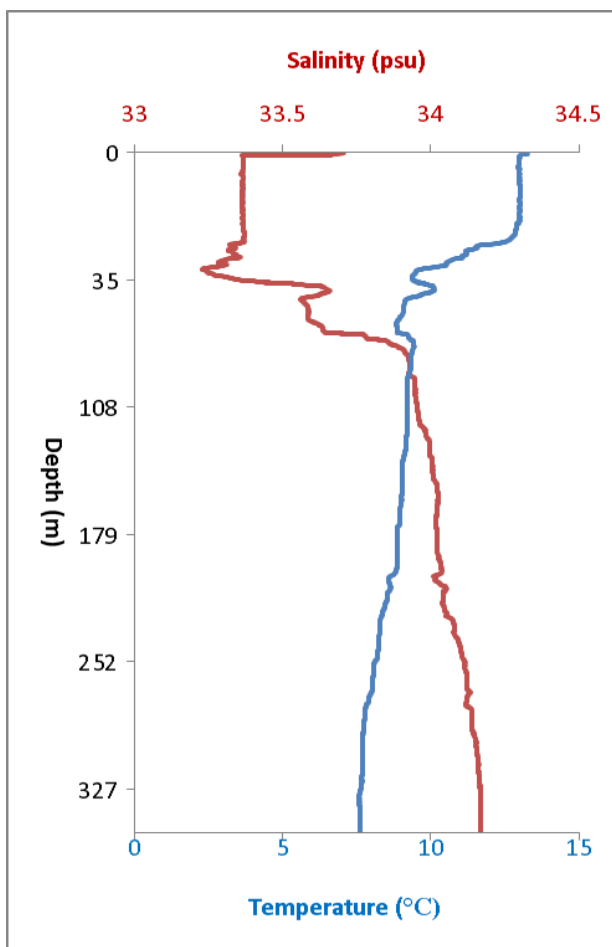|			
Date	27 August 2011	Starting Latitude (N)	38°11.63'
Maximum Bottom Depth (m)	331	Starting Longitude (W)	123°27.03'
Start Time (UTC)	19:57	Ending Latitude (N)	38°12.03'
End Time (UTC)	23:03	Ending Longitude (W)	123°27.41'

GENERAL LOCATION AND DIVE TRACK
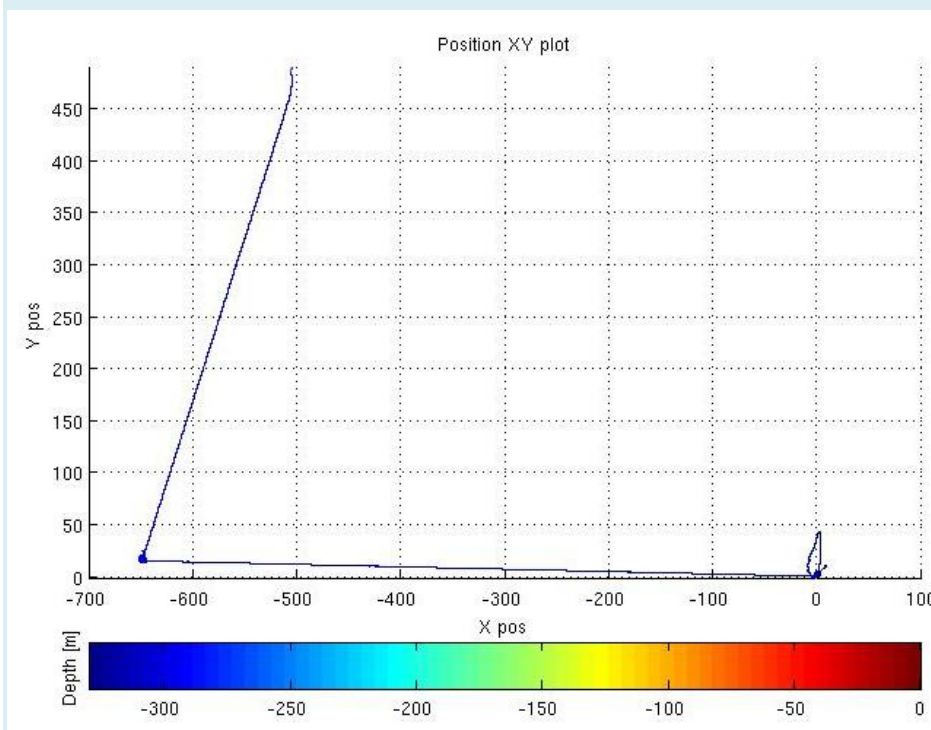
Survey track of dive AUV004.
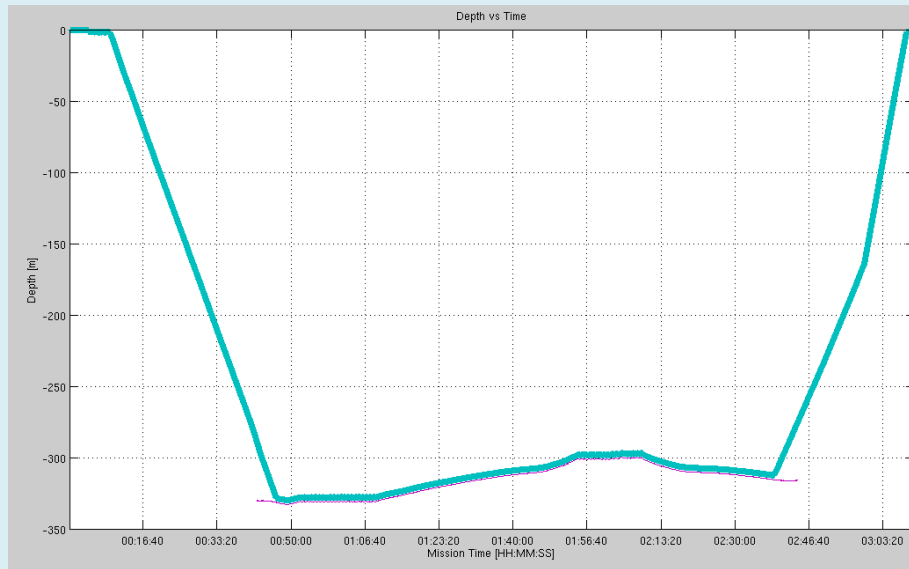
Depth track of dive AUV003 showing bottom in pink (—) and vehicle tracking bottom in teal (—).
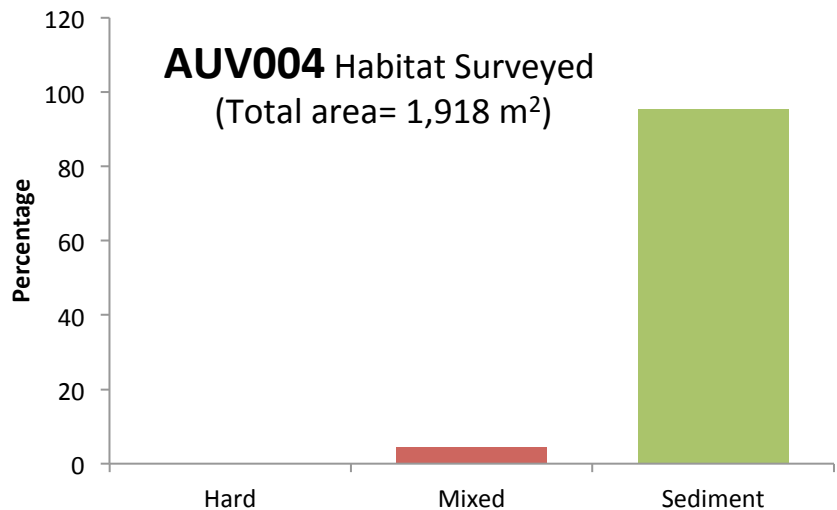

Dive AUV004 descent temperature and salinity profiles.

PHYSICAL ENVIRONMENT

The AUV was equipped with an onboard Sea-Bird model 49 FastCat CTD that collected temperature and salinity information throughout the AUV's descent as well as along the dive track. During the dive AUV004 descent, the temperature varied from 12.9 to 7.6°C and salinity varied from 33.4 to 34.2 (psu).
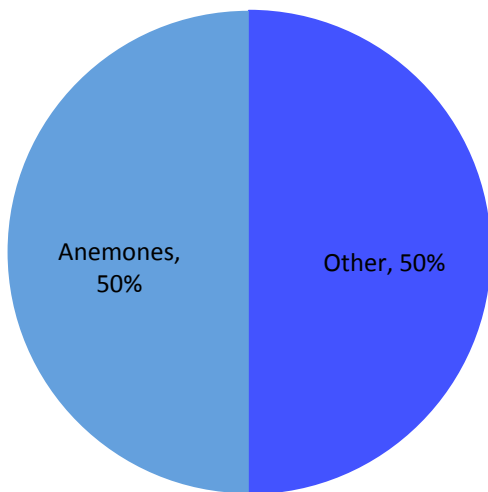
35

In total, 1,918 m^2 of seafloor were surveyed during dive AUV004 using the *Lucille* AUV deployed from the NOAA Sanctuary Vessel *Fulmar* on the shelf between Bodega Canyon and Cordell Bank. Habitat types were classified as (1) Hard (no hard substrate was encountered); (2) Mixed (4% of the total area surveyed), which included sand appearing with boulder or cobble; (3) Sediment (95% of the total area surveyed), which included sand and mud substrate.

AUV004 Habitat Surveyed
(Total area= 1,918 m^2)

(Bar chart: Percentage on y-axis (0 to 120); categories Hard, Mixed, Sediment on x-axis. Hard ≈ 0, Mixed ≈ 4, Sediment ≈ 95.)

BIOLOGICAL ENVIRONMENT: CORALS

AUV004- Density of Corals
(2.1 corals/ 1,000 m^2)

*(Pie chart: Anemones, 50%; Other, 50%.)*

A total of 4 corals and anemones were enumerated during dive AUV004 using the *Lucille* AUV deployed from the NOAA Sanctuary Vessel *Fulmar* in the Bodega Canyon. An overall coral and anemone density of 2.1 corals and anemones per 1,000 m^2 of seafloor was estimated. Unidentified corals and unidentified anemones each accounted for 50% of the overall density. The colors in the pie chart match the colors in the list of coral taxa.

	Scientific Name	Common Name	Count
	Anthozoa	Unidentified corals	2
	Actinidae	Unidentified anemone	2

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 3 sponges were enumerated during dive AUV004 using the *Lucille* AUV deployed from the NOAA Sanctuary Vessel *Fulmar* in the Bodega Canyon. An overall sponge density of 1.6 sponges per 1,000 m^2 of seafloor was estimated. Unidentified sponges and *Asbestopluma* spp. made up 100% of the sponge density.   The colors in the pie chart match the colors in the list of sponge taxa.
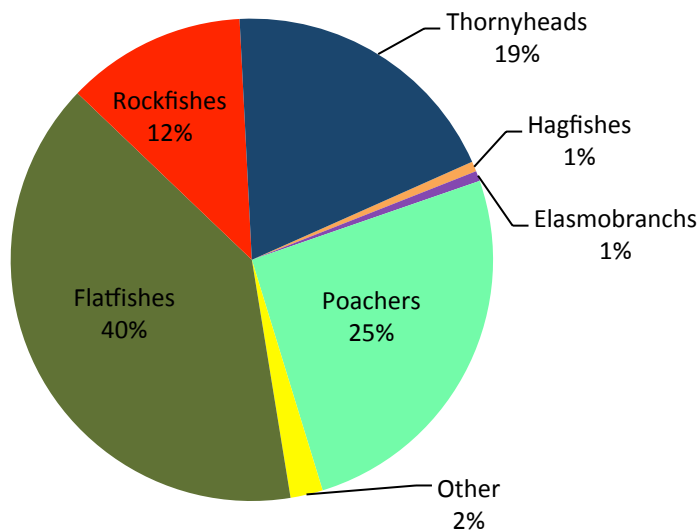
AUV004- Density of Sponges
(1.6 sponges/ 1,000 m^2)
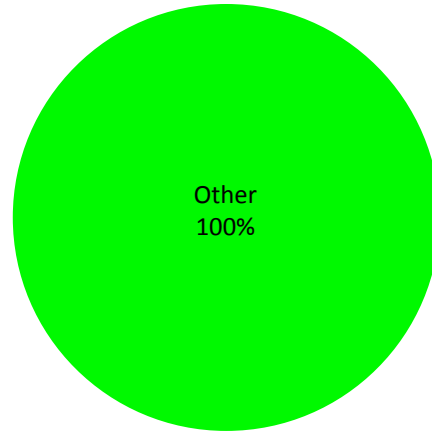
	Scientific Name	Common Name	Count
	Asbestopluma spp. #1	Pipe cleaner Sponge	2
	Porifera	Unidentified sponges	1

BIOLOGICAL ENVIRONMENT: FISHES

AUV004- Density of Fishes
(74 fishes/ 1,000 m^2)

A total of 141 fishes were enumerated during dive AUV004 with the *Lucille* AUV from the NOAA Sanctuary vessel *Fulmar*. An overall fish density of 74 per 1,000m^2 of seafloor was estimated. The most abundant fish in this dive fell into the flatfish category and included slender sole, Dover sole, rex sole and arrowtooth flounder. Flatfish represented 40% of the overall density. Poachers (family Agonidae) were the second most

abundant category, representing 25% of the overall fish density. Thornyheads (19%, *Sebastolobus* spp.) and rockfishes (12%, *Sebastes* spp., *Sebastes babcocki*, and Sebastomus) were both present during this dive. Other fishes (unidentified eelpouts) accounted for 2% of the overall density, while hagfishes and elasmobranchs (*Raja rhina*) each accounted for 1%. The colors in the pie chart match the colors in the list of fish taxa.

|	Scientific Name	Common Name	Count
⬛(orange)	Myxinidae	Unidentified hagfish	1
⬛(purple)	*Raja rhina*	Longnose skate	1
⬛(light green)	Agonidae	Unidentified poachers	36
⬛(yellow)	Zoarcidae	Unidentified eelpouts	3
⬛(dark green)	*Glyptocephalus zachirus*	Rex sole	21
	Microstomus pacificus	Dover sole	10
	Lyopsetta exilis	Slender sole	23
	Atheresthes stomias	Arrowtooth flounder	2
⬛(red)	*Sebastes babcocki*	Redbanded rockfish	2
	Sebastes spp.	Rockfish Unid.	13
	Sebastomus	Unidentified White-spotted RF	2
⬛(dark blue)	*Sebastolobus alascanus*	Shortspine thornyhead	1
	Sebastolobus spp.	Unidentified thornyhead	26

IMAGE GALLERY- AUV004
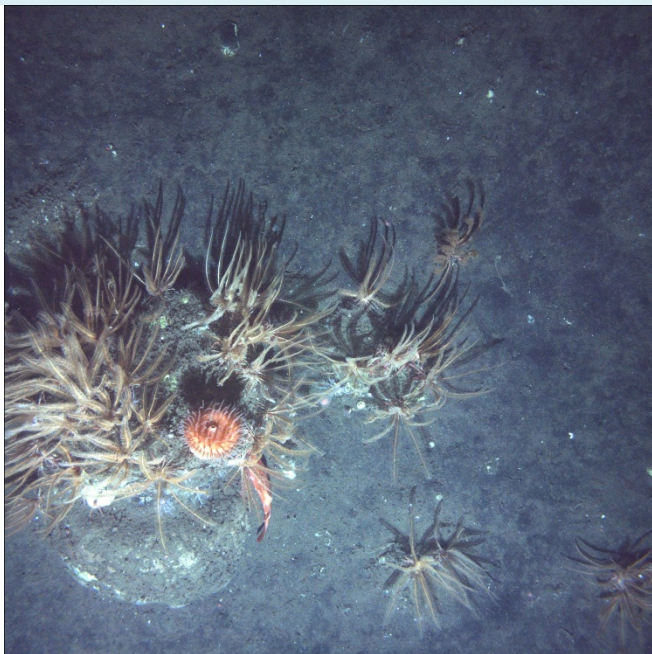
During dive AUV004, any hard substrate encountered was covered with crinoids. This boulder also provides substrate for an unknown anemone (Actinidae) and an unidentified rockfish (*Sebastes* spp.).

The majority of the substrate encountered during diva AUV004 was sediment. In the far left image, a longnose skate buries itself in the sand. The center image shows an eelpout (probably a Bigfin eelpout). The right image shows an arrowtooth flounder (*Atheresthes stomias*) blending in with the surroundings.
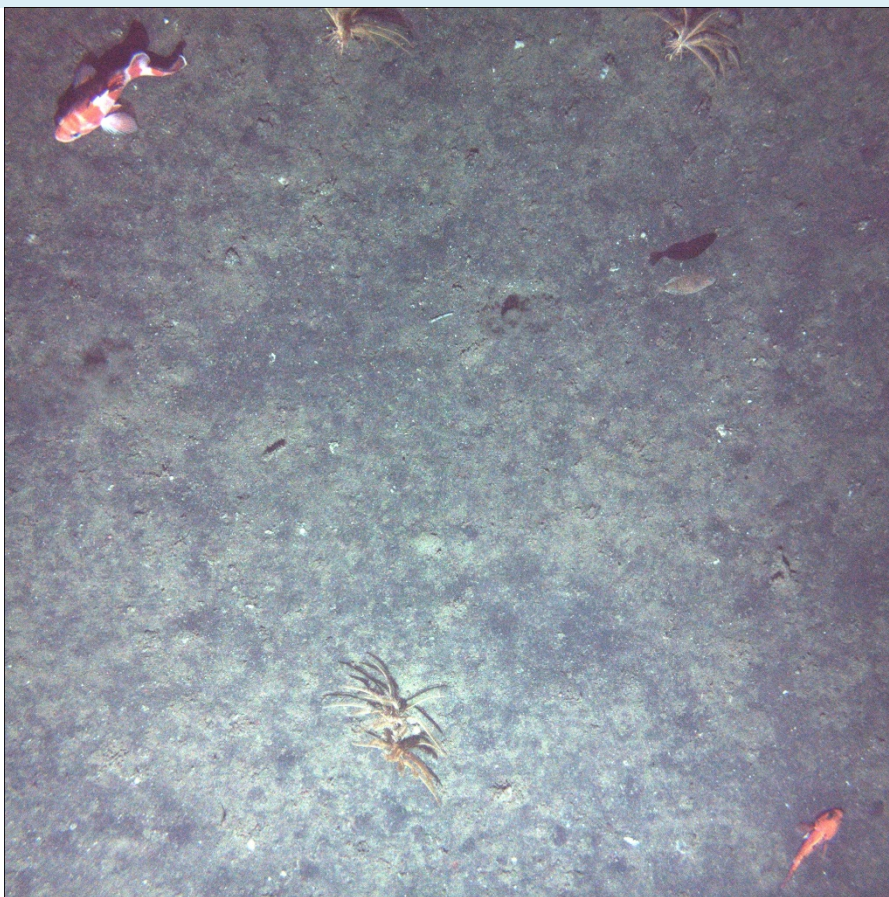
This image shows the sediment substrate with a thornyhead (*Sebastolobus* spp.), a swimming slender sole (*Lyopsetta exilis*) and a redbanded rockfish (*Sebastes babcocki*).

CONCLUSIONS

From these AUV dives we were able to establish the presence of 9 taxa of sponges, 8 taxa of corals, and 31 taxa of fishes, many of these identified to the species level. Most of the substrate sampled was sediment covered and in many cases these areas possibly were hard rock draped with mud. From earlier habitat mapping surveys we expected the bottom to be exposed bedrock that is likely habitat for the deep-sea corals we were investigating. The AUV returned with images revealing that the rock substrate was covered with a layer of mud. Few corals and sponges were seen in AUV images, with the exception of when exposed rock was available. It was apparent that the exposed hard substrate provided important habitat for corals and other invertebrates but that it was relatively rare in this area.

To the best of our knowledge, these are the first observations from the Bodega Canyon. The data that was collected has already been used to correct existing habitat maps. These updated maps better characterize the deep ocean floor on the U.S. west coast and will help to locate deep coral communities in the future.

The ecosystem in this area was not diverse, with low densities of deep-sea corals and sponges were encountered in all locations however, the Bodega Canyon (dives 1 and 2) has a higher diversity and abundance of corals and sponges than at the other two sites surveyed in dives 3 and 4. . Overall densities ranged from 2.1-34 corals/1,000 m^2 and 1.6-90 sponges/1,000 m^2.. The highest density of sponges and second highest density of corals and anemones were found during the deepest dive (AUV001). This area also had the highest percentage of mixed habitat. The highest density of fish was encountered during AUV003, this was due to the presence of large schools of chilipepper/ shortbelly rockfish, which occurred over the sediment substrate. The lowest abundance of fish was found during dive AUV004. At this site over 93% of the area was sediment. Coral abundance was dominated by mushroom corals (*Anthomastus ritteri*) at three of the dive sites.

There was evidence of human impacts at many of the sites. Marine debris in the form of derelict fishing gear (trawl net) was spotted during AUV001, and a coil of cable or rope was encountered during AUV002.