

# A REPORT TO NOAA DEEP-SEA CORAL RESEARCH AND TECHNOLOGY PROGRAM

## A CHARACTERIZATION OF THE DEEP-SEA CORAL AND SPONGE COMMUNITY ON PIGGY BANK IN SOUTHERN 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. During the first year of this study, a coast-wide survey of the distribution and abundance of DSC from Washington to southern California was conducted during three legs of a cruise aboard the NOAA ship *McArthur II* using the *Kraken 2* remotely operated vehicle (ROV) operated by the University of Connecticut and the SeaBED autonomous underwater vehicle (AUV) operated by Northwest Fisheries Science Center and collaborators.

The final leg of this cruise focused on documenting the biology and ecology of the deep-sea coral community and habitats on Piggy Bank, a deep offshore bank in the southern California Bight. Individual habitats can be distinct based on the substrate, the influence of local currents and outside influences, such as fishing. It is located within the Channel Islands National Marine Sanctuary and is designated as Essential Fish Habitat (EFH). The Piggy Bank study site is about 30 km<sup>2</sup>. This area contains deep, rocky habitats that support dense stands of deep-sea corals (Tissot et al. 2006) as well as diverse assemblages of fishes (Love et al. 2009).

The goals of this project were:

- (1) to characterize the distribution and abundance of DSC on Piggy Bank.
- (2) to understand factors (e.g. depth, substratum type) that influence their distribution and to assess the condition of DSC assemblages in relation to potential anthropogenic or environmental disturbances.
- (3) to evaluate the function of DSC as fish and invertebrate habitat.

Science operations included quantitative visual surveys of DSC and fishes with their associated habitats. The *Kraken II* ROV was used during the daylight hours and for the collection of coral samples. The SeaBED AUV and associated cameras were used during the night hours to quantitatively survey DSC and habitats particularly at depths beyond the capabilities of the ROV.

This report provides a summary of the methods and results from underwater surveys of corals, sponges and associated habitats, invertebrates, and fishes the using the SeaBED AUV on Piggy Bank.



NOAA Ship *McArthur II*

## STUDY SITE

Piggy Bank is located within the Southern California Bight (SCB), more specifically in the Channel Islands National Marine Sanctuary (CINMS) generally in the area of 33°54.84' N and 119°28.35'W. Piggy Bank ranges in depth from 275 to 900 meters and is about 30km<sup>2</sup> in area. It is designated as essential fish habitat (EFH) by the Pacific Fisheries Management Council (PFMC) and by NOAA Fisheries, and it is located within the Footprint Marine Reserve. The Footprint Reserve is home to some of the largest areas of rocky habitat within the CINMS.

## FIELD SURVEY METHODS

Underwater surveys of DSC, sponges, habitats and associates fishes and invertebrates were conducted using the SeaBED class AUV *Lucille* (Figure 1) deployed from the NOAA Ship *McArthur II*. Images of the seafloor were collected using two 5 megapixel, 12-bit dynamic range Prosilica GigE cameras. One camera was mounted to look directly downward and the second camera was angled forward at 30°. Lighting was provided by a strobe synced with the cameras. Dives varied and included straight line transect surveys, zig-zag surveys, and a grid survey designed to collect detailed photographic and multibeam information in a limited area

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.

Eight dives were attempted over 5 days (Figure 2). 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 1. The NWFSC *Lucille* SeaBED AUV.

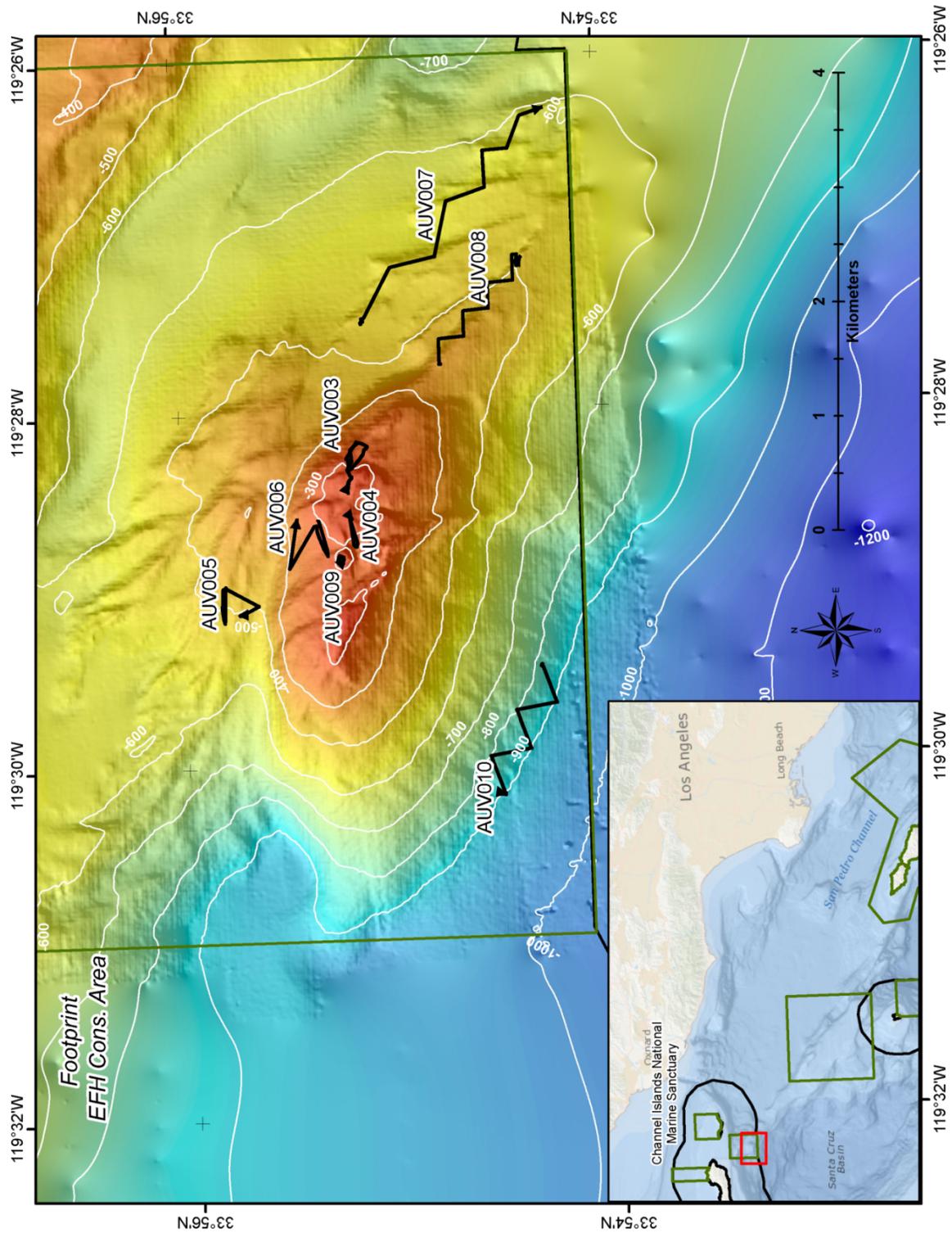


Figure 2. This map shows the bathymetry of Piggy Bank and the projected dive tracks of each of the AUV dives. Dive 4 was not completed due to the AUV encountering extremely rough terrain.

**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 downward looking camera were reviewed following the cruise. Corals, sponges and other invertebrates as well as associated 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. Dives flown at higher altitudes to avoid bottom obstacles produced pictures with larger fields of view and some additional difficulty in identifying organisms. 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 section of the cruise, eight AUV dives were attempted, but only seven were completed. The AUV ran into significant bottom relief during AUV004 and was unable to continue bottom tracking and complete the dive.

Date	PI	Dive #	Method	Start Time (UTC)	End Time (UTC)	Start Lat (N)	Start Long (W)	End Lat (N)	End Long (W)
28-Jun-10	M.E. Clarke	003	AUV	05:33	07:09	33°55.18'	119°28.17'	33°55.21'	119°28.46'
29-Jun-10	M.E. Clarke	005	AUV	05:16	06:48	33°55.79'	119°28.99'	33°55.74'	119°29.13'
29-Jun-10	M.E. Clarke	006	AUV	09:51	12:03	33°55.36'	119°28.61'	33°55.53'	119°28.69'
30-Jun-10	M.E. Clarke	007	AUV	05:05	09:11	33°55.14'	119°27.39'	33°54.16'	119°26.40'
1-Jul-10	M.E. Clarke	008	AUV	03:55	06:43	33°54.77'	119°27.76'	33°54.28'	119°26.99'
1-Jul-10	M.E. Clarke	009	AUV	10:08	12:45	33°55.28'	119°28.86'	33°55.25'	119°28.85'
2-Jul-10	M.E. Clarke	010	AUV	03:22	08:06	33°54.39'	119°29.44'	33°54.53'	119°30.19'

A total of 17,173m<sup>2</sup> of seafloor was classified during the 7 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 30% hard substrate.

We were able to identify 99 taxa of invertebrates and fishes by analyzing the still images during the 7 successful AUV dives on Piggy Bank. We identified 21 taxa of sponges, 16 taxa of corals, 40 taxa of invertebrates and 22 taxa of fishes. Identifications in question were moved back up to the level of certainty, leading to family and order level groupings.

A total of 5,619 corals, 9,312 sponges and 35,944 invertebrates were enumerated during the 7 dives analyzed (Tables 2 and 3). We also counted 1,518 fishes. 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 from the altitude of the camera and known field of view for each image. Overall densities varied greatly by dive, the ranges were 28-1595 corals/ 1,000m<sup>2</sup>; 182-1852 sponges/ 1,000m<sup>2</sup>; 411-4486 invertebrates/ 1,000m<sup>2</sup> and 40-193 fishes/ 1,000m<sup>2</sup>. The most abundant corals encountered included cup corals (*Lophelia pertusa* and unidentified cup corals), Christmas tree black coral (*Antipathes dendrochristos*), and the droopy sea pen (*Umbellula lindahli*) in sediment areas. The most abundant sponge morphotypes were mound, foliose (*Thenea muricata*) and vase sponges. The most abundant invertebrates included the fragile sea urchin (*Allocentrotus fragilis*), the sea cucumber

(*Pannychia mosleyi*), and basket stars (*Gorgonocephalus eucnemis*) in the more shallow dives. The most abundant fishes were poachers (family Agonidae) and rockfish (genus *Sebastes*), with thornyheads (genus *Sebastolobus*) becoming the dominant species in the deeper areas.

In the following pages we present summaries, by dive, of the diversity and density of corals, sponges, invertebrates 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 on the Piggy Bank in the Channel Islands National Marine Sanctuary, 28 June-02 July, 2010.

Scientific Name	Common Name
Mud Covered	
Porifera	Unidentified vase sponges
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)
<i>Heterochone calyx</i>	Fingered goblet vase sponge
Porifera	Unidentified barrel sponges
Porifera	Unidentified upright flat sponges
Porifera	Unidentified shelf sponges
<i>Mycale</i> spp.	Upright flat sponge (yellow)
Porifera	Unidentified branching sponges
Porifera	Unidentified branching sponge
Porifera	Unidentified foliose sponges
<i>Polymastia</i> spp.	Nipple foliose sponges
<i>Thenea muricata</i>	Foliose Sponge (clear)
<i>Farrea occa</i>	Lace (or cloud) foliose sponge
Porifera	Unidentified pipe organ sponge ( <i>Oceanapia</i> spp.?)
Porifera	Unidentified small mound sponges
Porifera	Unidentified mound sponges
Porifera	Unidentified sponges (blue/white)
<i>Asbestopluma</i> spp. #2	Predatory sponge (clear)
<i>Asbestopluma</i> spp. #1	Pipe cleaner Sponge
Porifera	Unidentified sponges
Unidentified Gorgonian	Unidentified Gorgonian
<i>Paragorgia</i> spp.	Sea fan
<i>Parastenella</i> spp.	Primnoid
<i>Plumerella</i> spp.	Primnoid
Plexauridae	Sea fan
<i>Swiftia</i> spp.	Sea fan

Scientific Name	Common Name
<i>Antipathes dendrochristos</i>	Christmas tree black coral
<i>Lopheila</i> spp.	White cup coral
Caryophyllidae	Unidentified cup corals
<i>Anthomastus ritteri</i>	Mushroom coral
Zoantharia	Unidentified zooanthids
<i>Clavularia</i> spp.	Soft coral
<i>Pennatula</i> spp.	Deep-sea sea pen
<i>Anthoptilum grandiflorum</i>	Feather boa sea pen
<i>Umbellula lindahli</i>	Droopy sea pen
Anthozoa	Unidentified coral/ sea pen
Actinidae	Unidentified anemone
<i>Liponema brevicornis</i>	Tentacle shedding anemone
Asteroidea	Unidentified Sea star
<i>Gorgonocephalus eucnemis</i>	Basket Star
Ophiocanthidae	Unidentified brittlestar
<i>Rathbunaster californicus</i>	Deep-sea sunflower star
<i>Ceramaster</i> spp.	Cookie star
<i>Pteraster</i> spp.	Slime star
<i>Henricia</i> spp.	Henricia star
<i>Thrissacanthius penicillatus</i>	Carpet star
Asteroidea	<i>Nearchaster/Cheiraster</i> spp.
Asteroidea	<i>Myxoderma platycanthum</i> -like
<i>Solaster</i> spp.	Deep-sea sunstar
<i>Crossaster/ Heterozonias</i> spp.	Unidentified deep-sea sunstar
<i>Crossaster papposus</i>	Rose star
<i>Hippasteria</i> spp.	Unidentified spiny star
<i>Zoroaster evermanni</i>	Slender star
<i>Stylasterias forreri</i>	Fish-eating star
<i>Poraniopsis</i> spp.	Thorny star
<i>Brisingella</i> spp.	Lacy-armed star
<i>Dipsacaster eximius</i>	Broad sand star
Asteroidea	Unidentified mud star ( <i>Ctenodiscus</i> spp.?)
Galatheoidea	Unidentified Galtheid crab
<i>Chorilia longipes</i>	Long-horned decorator crab
Decapoda	Unidentified shrimp
Decapoda	Unidentified crab
<i>Psolus squamatus</i>	White-scaled cucumber
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber
<i>Pannychia moseleyi</i>	Sloppy cucumber
Holothuroidea	Unidentified sea cucumber
<i>Brisaster</i> spp./ <i>Brissopsis</i> spp.	Unidentified mud urchin
<i>Allocentrotus fragilis</i>	Fragile red sea urchin
<i>Florometra serratissima</i>	Feather star crinoid

Scientific Name	Common Name
Tunicata	Unidentified tunicates
Unidentified invertebrate	Unidentified invertebrate
Cephalopoda	Unidentified octopus
Opisthobranchia	Unidentified nudibranch
<i>Pleurobranchaea californica</i>	California sea slug
<i>Acesta sphoni</i>	Sphon's giant file clam
<i>Dromalia alexandri</i>	Benthic siphonophore

Table 3. Fish taxa observed in still photos taken by AUV on the Piggy Bank in the Channel Islands National Marine Sanctuary, 28 June-02 July, 2010.

Scientific Name	Common Name
Myxinidae	Unidentified hagfish
<i>Hydrolagus colliei</i>	Spotted ratfish
<i>Raja rhina</i>	Longnose skate
Scyliorhinidae	Unidentified catshark
Agonidae	Unidentified poachers
Zoarcidae	Unidentified eelpouts
Alepocephalidae	Unidentified slickheads
Macrouridae	Unidentified grenadiers
Liparidae	Unidentified snailfish
Cottidae	Unidentified sculpins
<i>Glyptocephalus zachirus</i>	Rex sole
<i>Microstomus pacificus</i>	Dover sole
<i>Embassichthys bathybius</i>	Deepsea sole
Pleuronectiformes	Unidentified flatfish
Osteichthyes	Unidentified fishes
<i>Sebastes diploproa</i>	Splitnose rockfish
<i>Sebastes rufus</i>	Bank rockfish
<i>Sebastes melanostomus</i>	Blackgill rockfish
<i>Sebastes</i> spp.	Rockfish Unid.
Sebastomus	Unidentified White-spotted RF
<i>Sebastolobus alascanus</i>	Shortspine thornyhead
<i>Sebastolobus</i> spp.	Unidentified thornyhead

**DIVE NUMBER: AUV003**

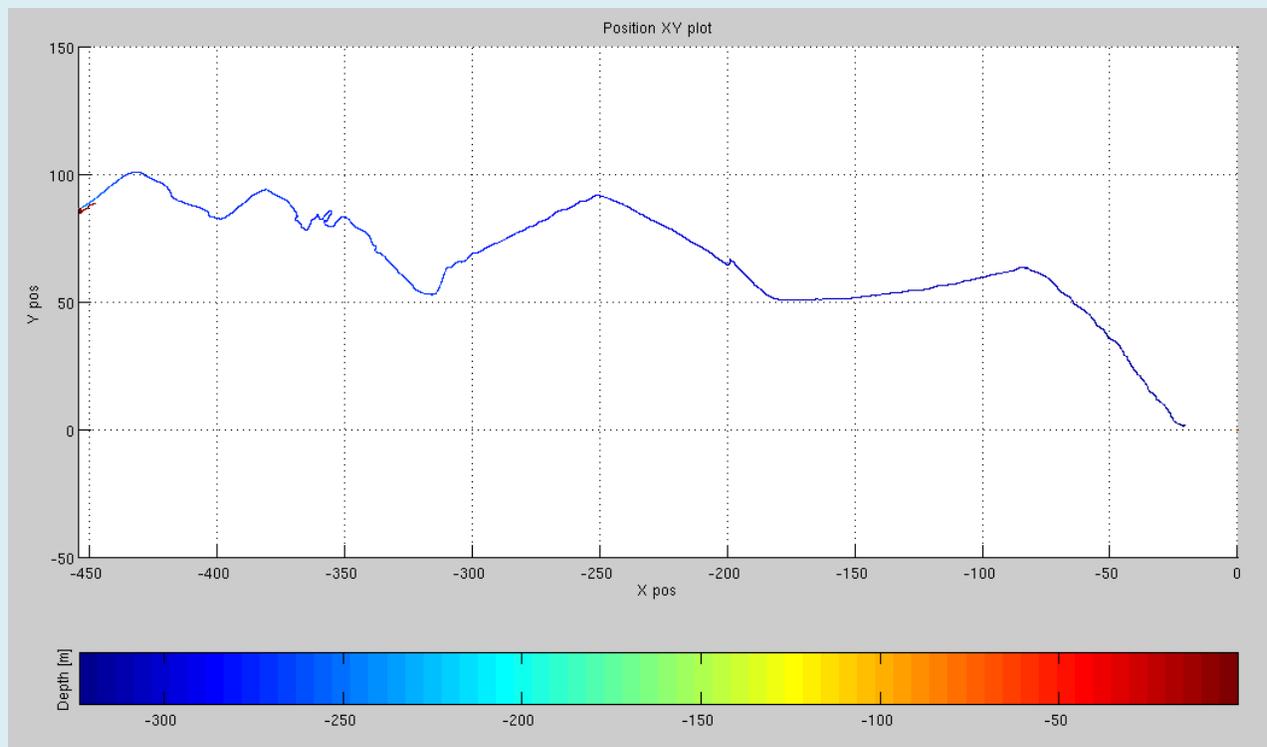
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	3019
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

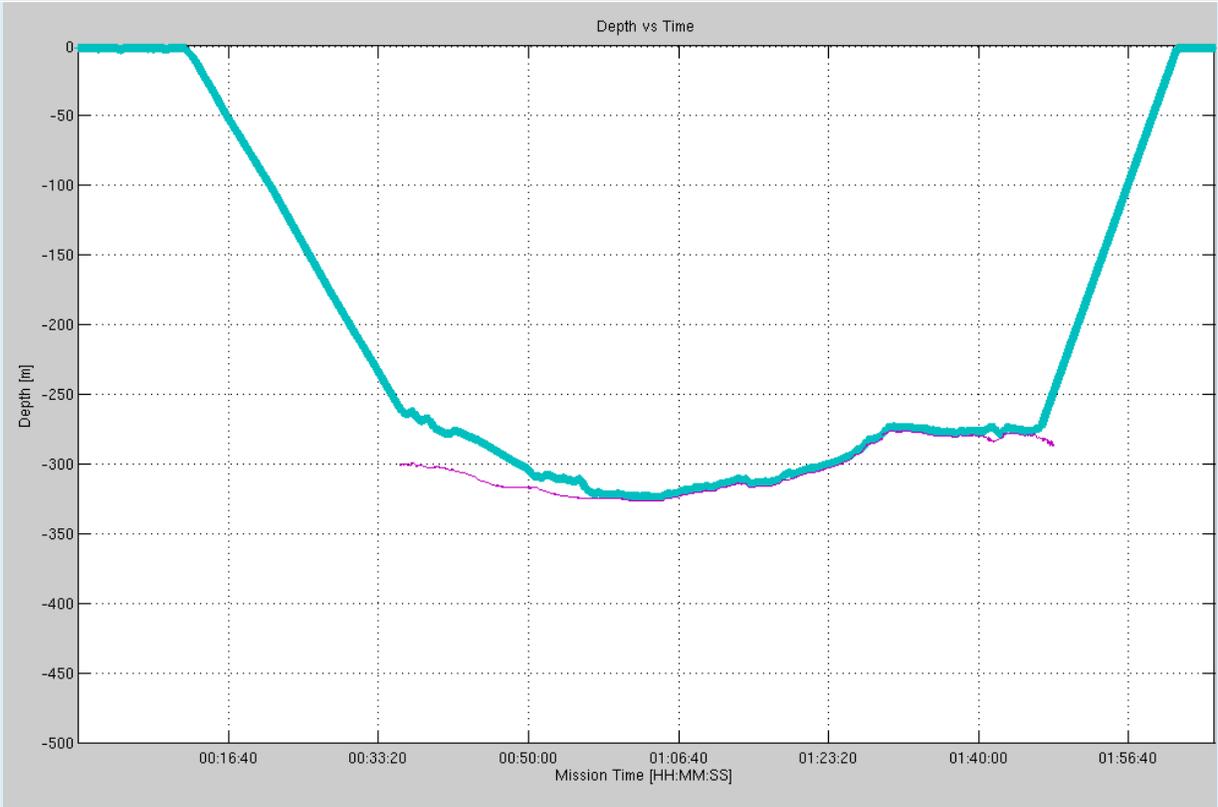
**DIVE DATA**

Date	28 June 2010	Starting Latitude (N)	33°55.21'
Maximum Bottom Depth (m)	325	Starting Longitude (W)	119°28.17'
Start Time (UTC)	05:33	Ending Latitude (N)	33°55.21'
End Time (UTC)	07:09	Ending Longitude (W)	119°28.46'

**GENERAL LOCATION AND DIVE TRACK**



Survey pattern of dive AUV003.

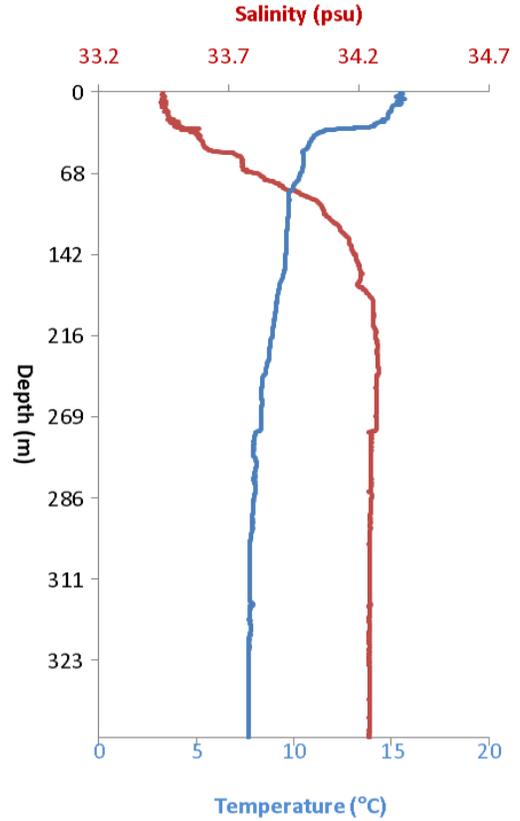


Depth track of dive AUV003 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

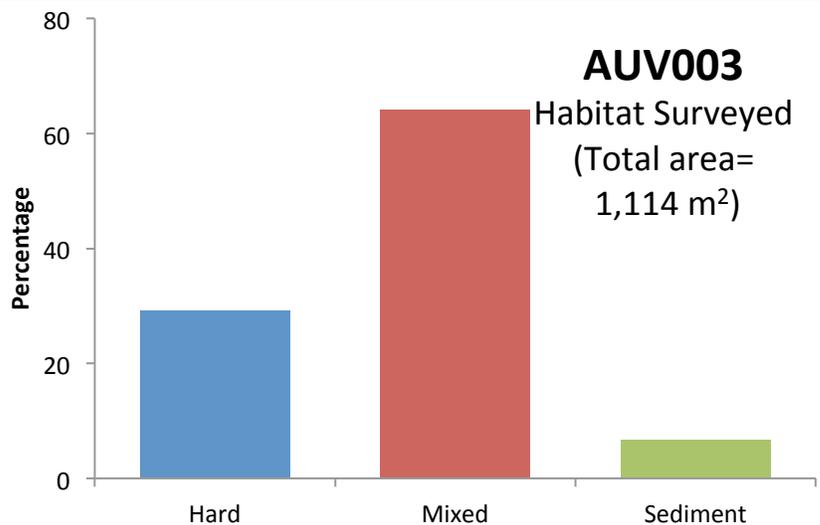
**PHYSICAL ENVIRONMENT**

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 15.5 to 7.68°C and salinity varied from 33.45 to 34.24 (psu).

Dive AUV003 descent temperature and salinity profiles.



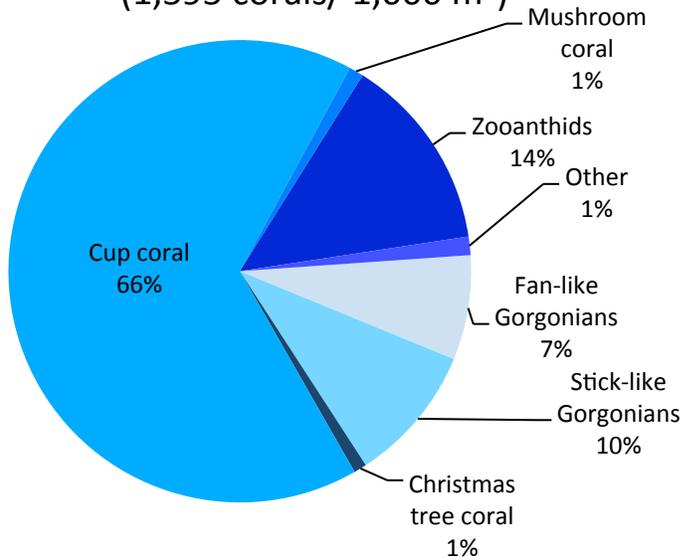
In total, 1,114 m<sup>2</sup> of seafloor were surveyed during dive AUV003 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (29% of the total area surveyed), which included boulders, rock ridges and cobble; (2) Mixed (64% of the total area surveyed), which included mud appearing with rock, boulder or cobble; and (3) Sediment (7% of the total area surveyed), which consisted of mud and/or sand.



BIOLOGICAL ENVIRONMENT: CORALS

**AUV003- Density of Corals**

(1,595 corals/ 1,000 m<sup>2</sup>)

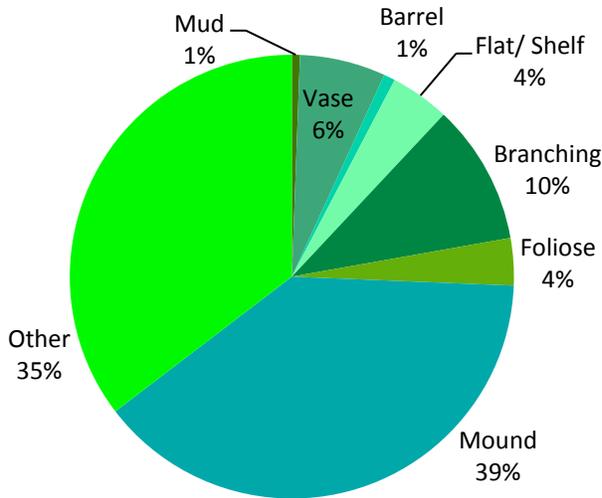


A total of 1,776 individual corals were enumerated from the 240 frames sampled from dive AUV003 conducted on the Piggy Bank from the NOAA vessel *McArthur II*. They represented 11 taxonomic groups. An overall density of 1,595 corals per 1,000 m<sup>2</sup> of seafloor was estimated. Unidentified cup corals and *Lophelia pertusa* combined to make up the highest density of corals (66%). Zooanthids accounted for the second highest density at 14%. Stick- and fan-like gorgonians accounted for a combined density of 17%, these included the genera *Paragorgia* spp., *Plumerella*

spp., *Swiftia* spp. and the family Plexauridae. *Anthomastus ritteri*, *Antipathes dendrochristos* and other unidentified corals were each represented at 1% of the total density of corals. All of these corals occurred on the hard or mixed substrates. The colors in the pie diagram match the colors in the list of coral taxa.

Scientific Name	Common Name	Count
Unidentified Gorgonian	Unidentified Gorgonian	16
<i>Paragorgia</i> spp.	Sea fan	8
<i>Plumerella</i> sp.	Primnoid	106
Plexauridae	Sea fan	118
<i>Swiftia</i> spp.	Sea fan	53
<i>Antipathes dendrochristos</i>	Antipathes sp.	16
<i>Lopheila</i> spp.	White cup coral	68
Caryophyllidae	Unidentified cup corals	1107
<i>Anthomastus ritteri</i>	Anthomastus sp.	18
Zoantharia	Unidentified zooanthids	243
Anthozoa	Unidentified coral/ sea pen	23

**AUV003- Density of Sponges**  
(1,852 sponges/ 1,000 m<sup>2</sup>)



**BIOLOGICAL ENVIRONMENT:  
SPONGES**

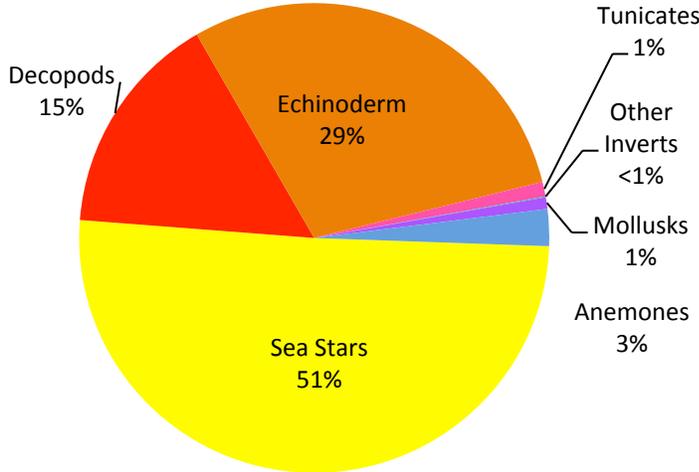
A total of 2,063 individual sponges from 16 different taxonomic classifications were observed during the 240 frames sampled from dive AUV003 on Piggy Bank from the NOAA vessel *McArthur II*. An overall density of 1,852 sponges per 1,000 m<sup>2</sup> of seafloor was estimated. Mound sponges were found to be the most abundant accounting for 39% of the total density. Other and unidentified sponges, including *Asbestopluma* spp. and an unidentified spotted sponge accounted for 35% of the overall density. Branching sponges (10%), vase (6%), foliose (4%, including *Farrea occa* and *Polymastia* spp.), flat/ shelf sponges (4%), barrel (1%) and mud covered (1%) comprised the remaining sponge density. The majority of the sponges occurred on hard and mixed habitats. Colors in the pie chart above match the list of sponge taxa following.

vase (6%), foliose (4%, including *Farrea occa* and *Polymastia* spp.), flat/ shelf sponges (4%), barrel (1%) and mud covered (1%) comprised the remaining sponge density. The majority of the sponges occurred on hard and mixed habitats. Colors in the pie chart above match the list of sponge taxa following.

Scientific Name	Common Name	Count
Mud Covered		12
Porifera	Unidentified vase sponges	126
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)	3
Porifera	Unidentified barrel sponges	17
Porifera	Unidentified shelf sponges	16
Porifera	Unidentified upright flat sponges	73
Porifera	Unidentified branching sponges	2
Porifera	Unidentified branching sponge	209
<i>Farrea occa</i>	Lace (or cloud) foliose sponge	35
<i>Polymastia</i> sp.	Nipple foliose sponges	36
Porifera	Unidentified small mound sponges	87
Porifera	Unidentified mound sponges	717
Porifera	Unidentified sponges (blue/white)	146
<i>Asbestopluma</i> spp. #2	Predatory sponge (clear)	4
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	70
Porifera	Unidentified sponges	510

**AUV003- Density of Other Invertebrates**

(1,349 inverts/ 1,000 m<sup>2</sup>)



**BIOLOGICAL ENVIRONMENT:  
OTHER INVERTEBRATES**

A total of 1,502 invertebrates representing 26 taxa were counted for dive AUV003 from the NOAA vessel *McArthur II* on the Piggy Bank. An overall density of 1,349 invertebrates per 1,000m<sup>2</sup> of seafloor was estimated. Sea stars were the most abundant invertebrate representing 51% of the overall density. This number did not include individuals from the family Ophiocanthidae, which were too numerous to accurately count. The sea star grouping was made up of 14 genera or species pairings, including *Rathbunaster*

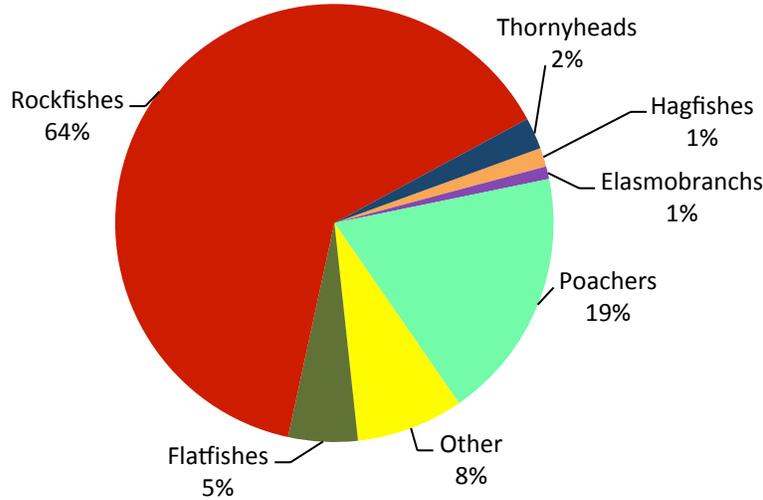
*californicus*, *Gorgonocephalus eucnemis* and an unidentified mud star, possibly *Ctenodiscus* spp. Echinoderms represented 29% of the invertebrate density including *Psolus squamatus*, and *Parastichopus* spp. Decapods, comprised of galatheid crabs (squat lobsters) accounted for 15% of the invertebrate density. Other groups represented included anemones (3%), mollusks (1%, unidentified octopus and nudibranchs), tunicates (1%) and other unidentified invertebrates (<1%). Invertebrates were distributed throughout all habitat types. The pie diagram colors match with the list of invertebrate taxa below.

Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	249
<i>Gorgonocephalus eucnemis</i>	Basket Star	161
Ophiocanthidae	Unidentified brittlestar	
<i>Rathbunaster californicus</i>	Deep-sea sunflower star	72
<i>Ceramaster</i> spp.	Cookie star	8
<i>Pteraster</i> spp.	Slime star	3
<i>Henricia</i> spp.	Henricia star	8
<i>Thrissacanthius penicillatus</i>	<i>Carpel star</i>	1
Asteroidea	<i>Nearchaster/Cheiraster</i> spp.	115
Asteroidea	<i>Myxoderma platycanthum</i> -like	3
<i>Solaster</i> spp.	Deep-sea sunstar	4
<i>Crossaster papposus</i>	Rose star	1
<i>Stylasterias forreri</i>	Fish-eating star	3
<i>Poraniopsis</i> spp.	Thorny star	5
Asteroidea	Unidentified mud star ( <i>Ctenodiscus</i> spp.?)	128
Galatheoidea	Unidentified Galtheid crab	232
<i>Psolus squamatus</i>	White-scaled cucumber	279
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber	142
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	22
<i>Liponema brevicornis</i>	Tentacle shedding anemone	9
Actinidae	Unidentified anemone	29
Tunicata	Unidentified tunicates	15
Unidentified invertebrate	Unidentified invertebrate	1
Cephalopoda	Unidentified octopus	7
Opisthobranchia	Unidentified nudibranch	2
<i>Pleurobranchaea californica</i>	California sea slug	3

**BIOLOGICAL ENVIRONMENT: FISHES**

A total of 215 fishes were counted representing 11 different taxonomic groupings during dive

**AUV003- Density of Fishes**  
(193 fishes/ 1,000 m<sup>2</sup>)

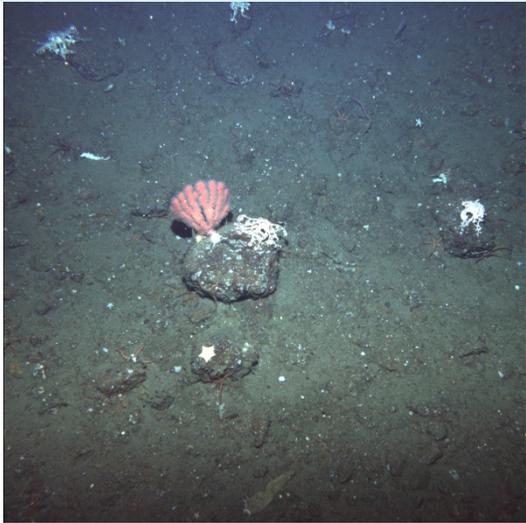


AUV003 on Piggy Bank from the NOAA ship McArthur II. An overall density of 193 fishes per 1,000 m<sup>2</sup> was estimated. Rockfishes (bank, splitnose, Sebastomus and unidentified rockfish) represented 64% of the overall fish density. Poachers were the next most abundant category at 19% of the overall density. The remainder of the fish assemblage included flatfishes (5%, Dover sole

(*Microstomus pacificus*)), hagfishes (Myxinidae) (1%), thornyheads (*Sebastolobus* spp.) (2%), elasmobranchs (*Hydrolagus colliei*) (1%) and other (8%, including Cottids, and unidentified fishes). The colors in the pie chart match the colors in the list of fish taxa.

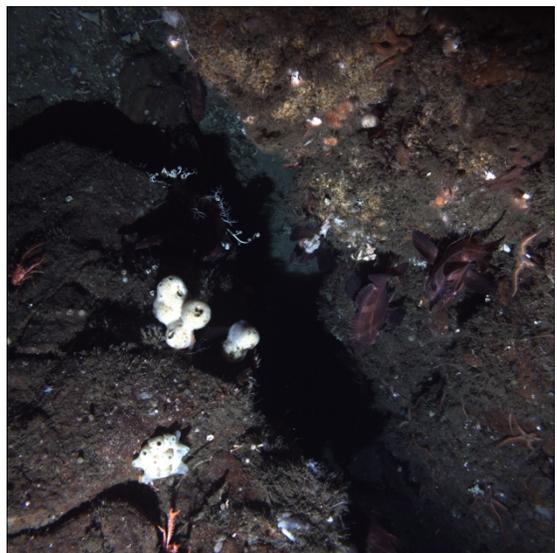
Scientific Name	Common Name	Count
Myxinidae	Unidentified hagfish	3
<i>Hydrolagus colliei</i>	Spotted ratfish	2
Agonidae	Unidentified poachers	40
<i>Microstomus pacificus</i>	Dover sole	11
Cottidae	Unidentified sculpins	10
Osteichthyes	Unidentified fishes	7
<i>Sebastes diploproa</i>	Splitnose rockfish	5
<i>Sebastes rufus</i>	Bank rockfish	47
<i>Sebastes</i> spp.	Rockfish Unid.	49
Sebastomus	Unidentified White-spotted RF	36
<i>Sebastolobus</i> spp.	Unidentified thornyhead	5

IMAGE GALLERY- AUV003



*Paragorgia* spp., *Gorgonocephalus eucnemis* and a *Ceramaster* spp. on mixed habitat (cobble and mud).

*Polymastia* spp., and unidentified mound sponges on rock ridge habitat (hard). Cup corals (*Caryophyllidae*), basket stars (*Gorgonocephalus eucnemis*), galatheid crabs and bank rockfish (*Sebastes rufus*) are also in the frame.



*Parastenella* spp., *Plumerella* spp. and *Parastichopus* spp. in mixed habitat (cobble and mud). To the bottom right there is an unidentified mound sponge.

**DIVE NUMBER: AUV005**

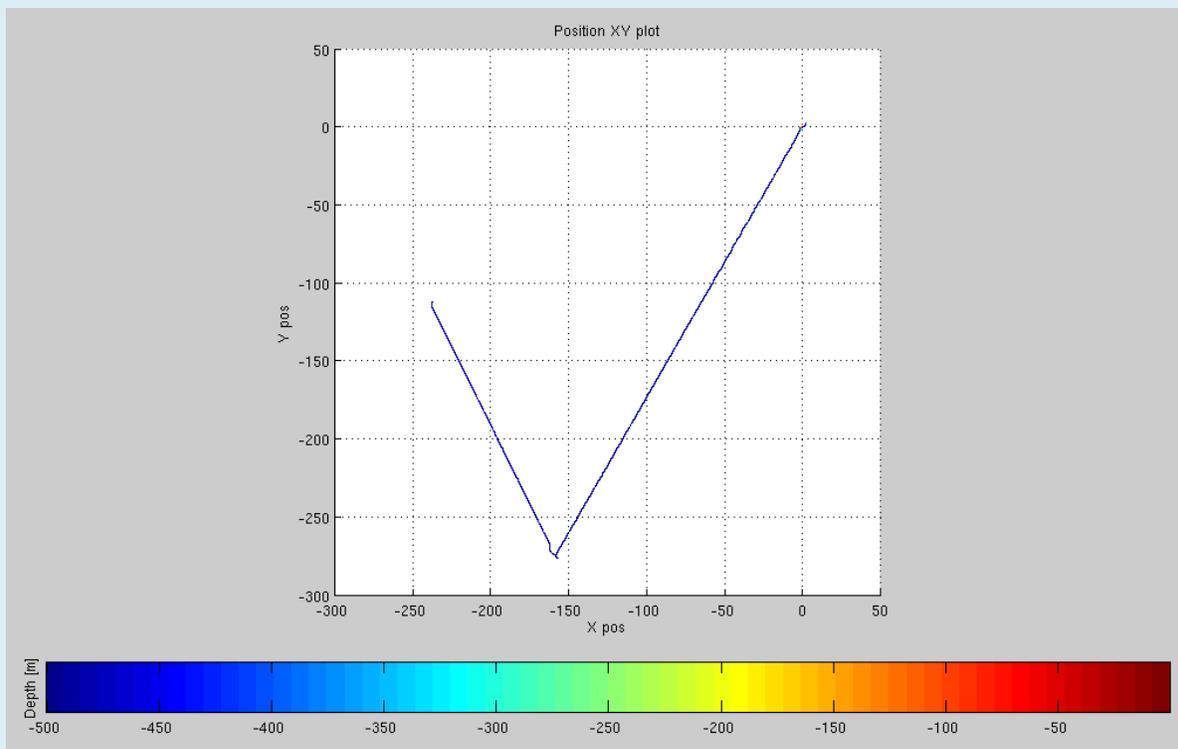
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	1219
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

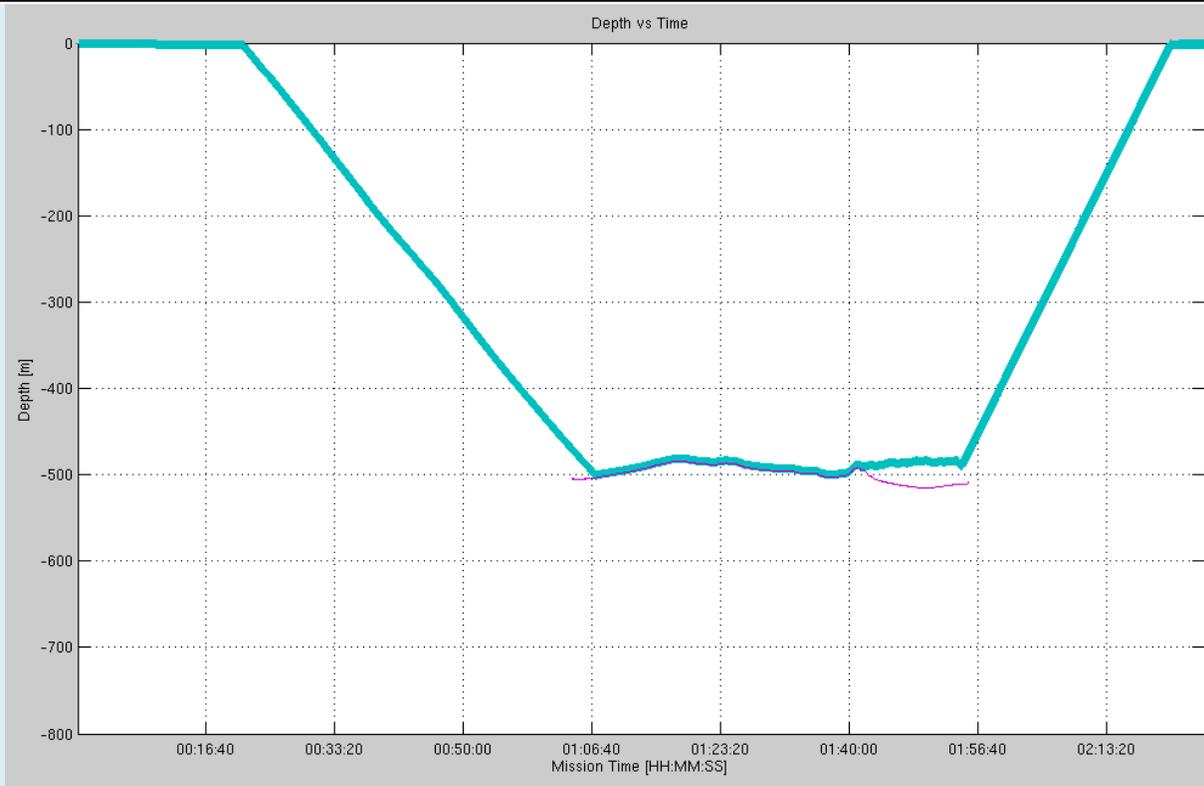
**DIVE DATA**

Date	29 June 2010	Starting Latitude (N)	33°55.79'
Maximum Bottom Depth (m)	504	Starting Longitude (W)	119°28.99'
Start Time (UTC)	05:16	Ending Latitude (N)	33°55.74'
End Time (UTC)	06:48	Ending Longitude (W)	119°29.13'

**GENERAL LOCATION AND DIVE TRACK**

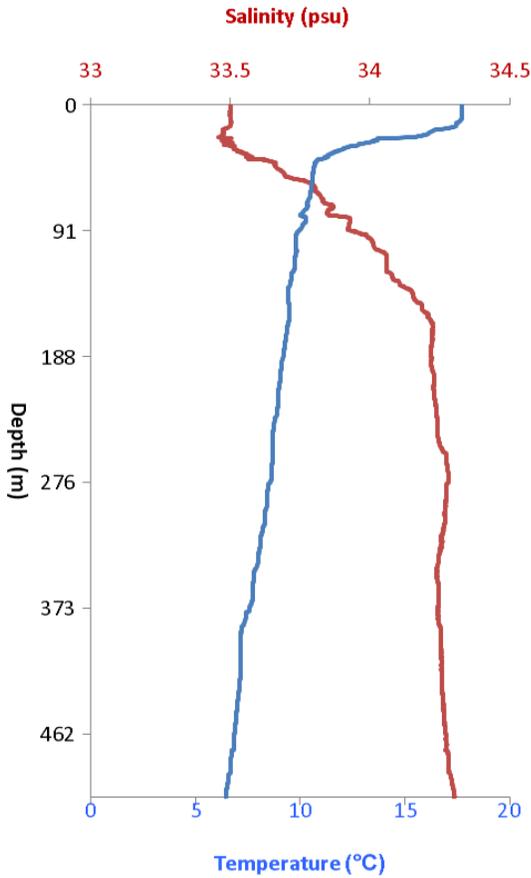


Survey track of dive AUV005.



Depth track of dive AUV005 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

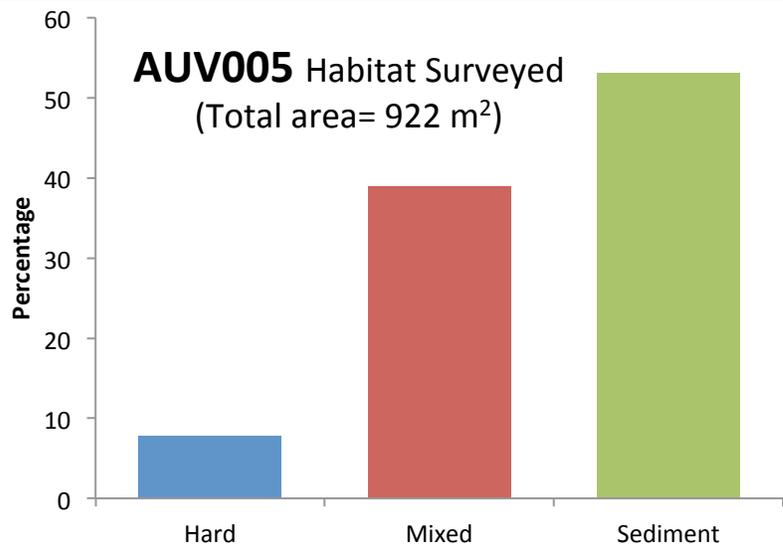
**PHYSICAL ENVIRONMENT**



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 AUV005 descent, the temperature varied from 17.71 to 7.45°C and salinity varied from 33.5 to 34.3 (psu).

Dive AUV005 descent temperature and salinity profiles.

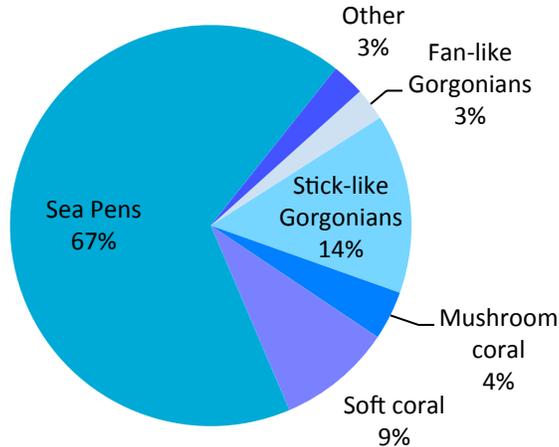
In total, 922 m<sup>2</sup> of sea floor were surveyed during dive AUV005 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (8% of the total area surveyed), which included boulders and cobble; (2) Mixed (39% of the total area surveyed), which included mud appearing with rock, boulder or cobble; and (3) Sediment (53% of the total area surveyed), which consisted of mud.



BIOLOGICAL ENVIRONMENT: CORALS

**AUV005- Density of Corals**

(82 corals/ 1,000 m<sup>2</sup>)

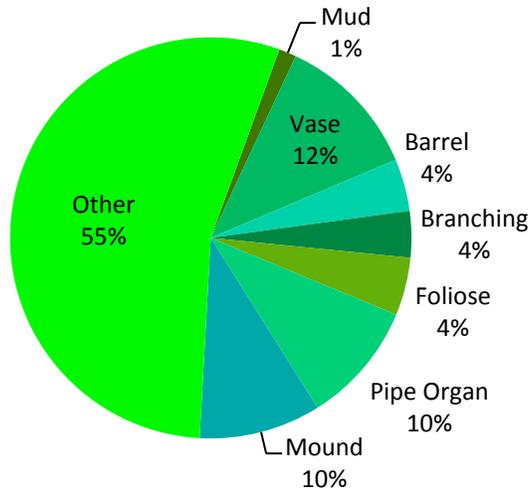


A total of 76 individual corals were enumerated from the 205 frames sampled from dive AUV005 conducted on the Piggy Bank from the NOAA vessel *McArthur II*. They represented 8 taxonomic groups. An overall density of 82 corals per 1,000 m<sup>2</sup> of seafloor was estimated. Unidentified sea pens, *Umbellula lindahli*, and *Anthoptilum grandiflorum* combined to make up the highest density of corals (67%). Stick-like gorgonians (*Swiftia* spp. and the family Plexauridae) accounted for the second highest density at 14%. Soft corals (*Clavularia* spp.) made up 9% of the overall coral

density. Fan-like gorgonians and *Anthomastus ritteri* accounted for 3% and 4% respectively. Other unidentified corals were represented at 3% of the total density of corals. The sea pens were all found on sediment, while the rest of the corals occurred on the hard or mixed substrates. The colors in the pie diagram match the colors in the list of coral taxa.

Scientific Name	Common Name	Count
Unidentified Gorgonian	Unidentified Gorgonian	2
<i>Swiftia</i> spp.	Sea fan	3
Plexauridae	Sea fan	8
<i>Anthomastus ritteri</i>	Mushroom coral	3
<i>Clavularia</i> spp.	Soft coral	7
<i>Anthoptilum grandiflorum</i>	Feather boa sea pen	42
<i>Umbellula lindahli</i>	Droopy sea pen	9
Anthozoa	Unidentified coral/ sea pen	2

**AUV005- Density of Sponges**  
(232 sponges/ 1,000 m<sup>2</sup>)



**BIOLOGICAL ENVIRONMENT:  
SPONGES**

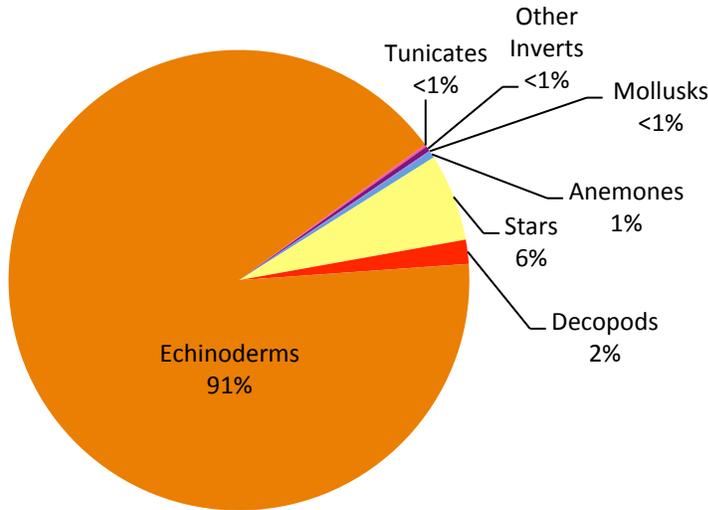
A total of 214 individual sponges from 12 different taxonomic classifications were observed during the 205 frames sampled from dive AUV005 on Piggy Bank from the NOAA vessel *McArthur II*. An overall density of 232 sponges per 1,000 m<sup>2</sup> of seafloor was estimated. Unidentified and other sponges were found to be the most abundant, accounting for 55% of the total density. Vase, mound and pipe organ (possibly *Oceanapia* spp.) sponges accounted for 12%, 10% and 10% respectively, of the total sponge density. Branching sponges, foliose

and barrel sponges each accounted for 4% of the overall density. Mud covered sponges made up 1% of the overall sponge density. The majority of the sponges occurred on hard and mixed habitats. Colors in the pie chart above match the list of sponge taxa following.

Scientific Name	Common Name	Count
Mud Covered		3
Porifera	Unidentified vase sponges	24
<i>Heterochone calyx</i>	Fingered goblet vase sponge	1
Porifera	Unidentified barrel sponges	9
Porifera	Unidentified branching sponge	8
<i>Thenia muricata</i>	Foliose Sponge (clear)	10
Porifera	Unidentified pipe organ sponge	21
Porifera	Unidentified mound sponges	20
Porifera	Unidentified small mound sponges	1
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	14
Porifera	Unidentified sponges (blue/white)	1
Porifera	Unidentified sponges	102

### AUV005- Density of Other Invertebrates

(4,486 invertebrates/ 1,000 m<sup>2</sup>)



### BIOLOGICAL ENVIRONMENT: OTHER INVERTEBRATES

A total of 4,137 invertebrates representing 21 taxa were enumerated for dive AUV005 from the NOAA vessel *McArthur II* on the Piggy Bank. An overall density of 4,486 invertebrates per 1,000 m<sup>2</sup> of seafloor was estimated.

Echinoderms (mostly the urchins, *Alloctrotus fragilis* and *Brisaster* spp./ *Brissopsis* spp.) were the most abundant invertebrate representing 91% of the overall density. The sea star grouping was made up of 7 genera or species pairings, including *Rathbunaster californicus*, *Nearchaster* spp./ *Cheiraster* spp. and other unidentified stars, and

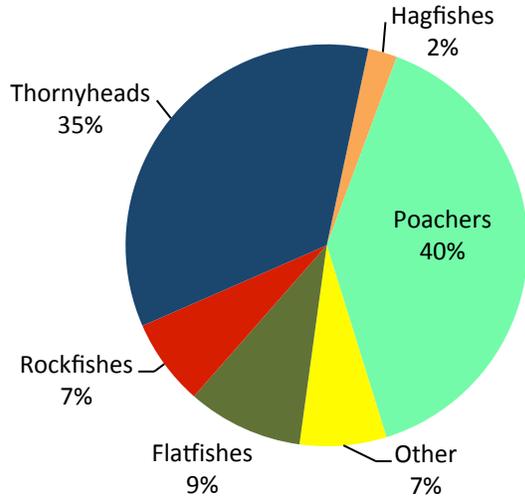
represented 6% of the overall invertebrate density. This percentage did not include individuals from the family Ophiocanthidae, which we were unable to accurately count. Decapods, comprised of galatheid crabs (squat lobsters) and unidentified shrimp accounted for 2% of the invertebrate density. Other groups represented included anemones (1%), mollusks (<1%, unidentified octopus and nudibranchs), tunicates (<1%) and other unidentified invertebrates (<1%, the benthic siphonophore, *Dromalia alexandri*). Invertebrates were distributed throughout all habitat types. The pie diagram colors match with the list of invertebrate taxa below.

Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	130
<i>Ophiocanthidae</i>	Unidentified brittlestar	
<i>Rathbunaster californicus</i>	Deep-sea sunflower star	43
<i>Pteraster</i> spp.	Slime star	7
<i>Thrissacanthius penicillatus</i>	Carpet star	2
Asteroidea	<i>Nearchaster/Cheiraster</i> spp.	55
Asteroidea	<i>Myxoderma platycanthum</i> -like	7
<i>Crossaster</i> spp./ <i>Heterozonius</i> spp.	Unidentified deep-sea sunstar	10
Galatheoidea	Unidentified Galtheid crab	31
Decapoda	Unidentified shrimp	39
<i>Psolus squamatus</i>	White-scaled cucumber	31
<i>Pannychia moseleyi</i>	Sloppy cucumber	161
Holothuroidea	Unidentified sea cucumber	2
<i>Brisaster</i> spp./ <i>Brissopsis</i> spp.	Unidentified mud urchin	302
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	3270
<i>Florometra serratissima</i>	Feather star crinoid	3
<i>Liponema brevicornis</i>	Tentacle shedding anemone	3
Actinidae	Unidentified anemone	17
Tunicata	Unidentified tunicates	7
Unidentified invertebrate	Unidentified invertebrate	3
Cephalopoda	Unidentified octopus	2
<i>Dromalia alexandri</i>	Benthic siphonophore	12

**BIOLOGICAL ENVIRONMENT: FISHES**

**AUV005- Density of Fishes**

(93 fishes/ 1,000 m<sup>2</sup>)

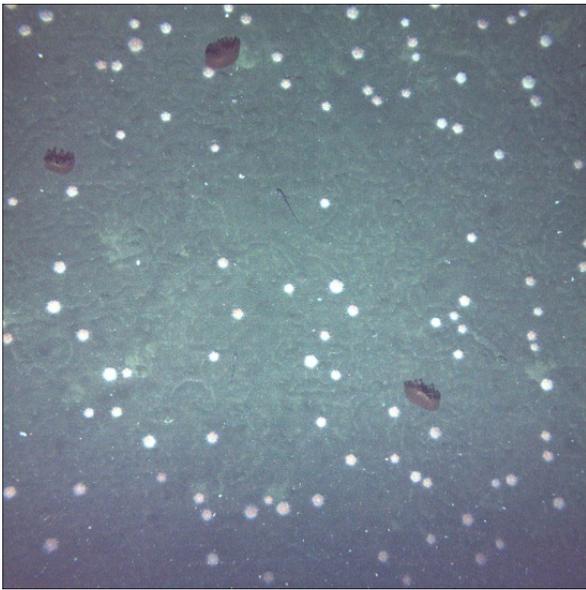


A total of 86 fishes were enumerated, representing 8 different taxonomic groupings during dive AUV005 on Piggy Bank from the NOAA ship *McArthur II*. An overall density of 93 fishes per 1,000 m<sup>2</sup> was estimated. Unidentified poachers from the family Agonidae were the most abundant fish encountered at 40% of the overall density. Unidentified thornyheads, grouped as *Sebastolobus* spp., represented 35% of the total fish density. Flatfishes (9%, represented by Dover sole, *Microstomus pacificus*), rockfishes (7%, *Sebastes* spp. and *Sebastes melanostomus*),

and Other (7%, included Liparidae and unidentified fishes) were the next largest densities. Hagfishes (Myxinidae) made up the last 2% in overall density of fishes. The colors in the pie chart match the colors in the list of fish taxa below.

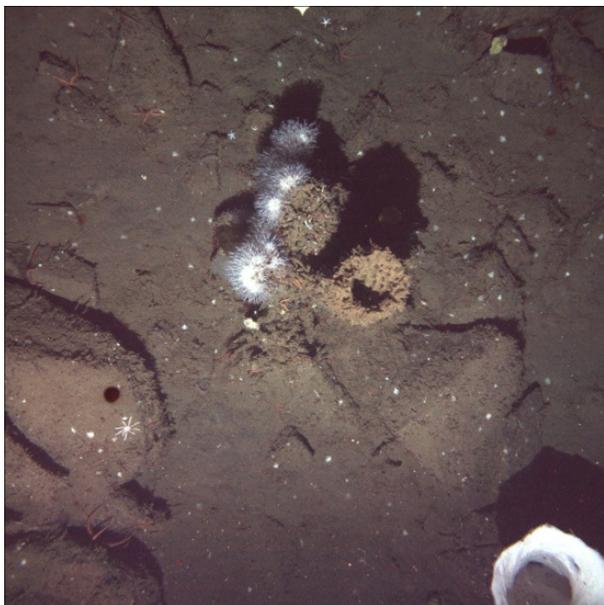
Scientific Name	Common Name	Count
Myxinidae	Unidentified hagfish	2
Agonidae	Unidentified poachers	34
Liparidae	Unidentified snailfish	3
<i>Microstomus pacificus</i>	Dover sole	8
Osteichthyes	Unidentified fishes	3
<i>Sebastes</i> spp.	Rockfish Unid.	1
<i>Sebastes melanostomus</i>	Blackgill rockfish	5
<i>Sebastolobus</i> spp.	Unidentified thornyhead	30

IMAGE GALLERY- AUV005



To the left, we see sediment habitat with *Allocentrotus fragilis* sea urchins and *Anthoptilum grandiflorum* sea pens. There are also unidentified poachers in this image.

To the right, we see mixed habitat with a blackgill rockfish (*Sebastes melanostomus*), unidentified sea stars and *Anthomastus ritteri*, (mushroom coral).



This image shows mixed habitat with an unidentified vase sponge and mud covered *Heterochone calyx*. Also present is the soft coral, *Clavularia* spp.

**DIVE NUMBER: AUV006**

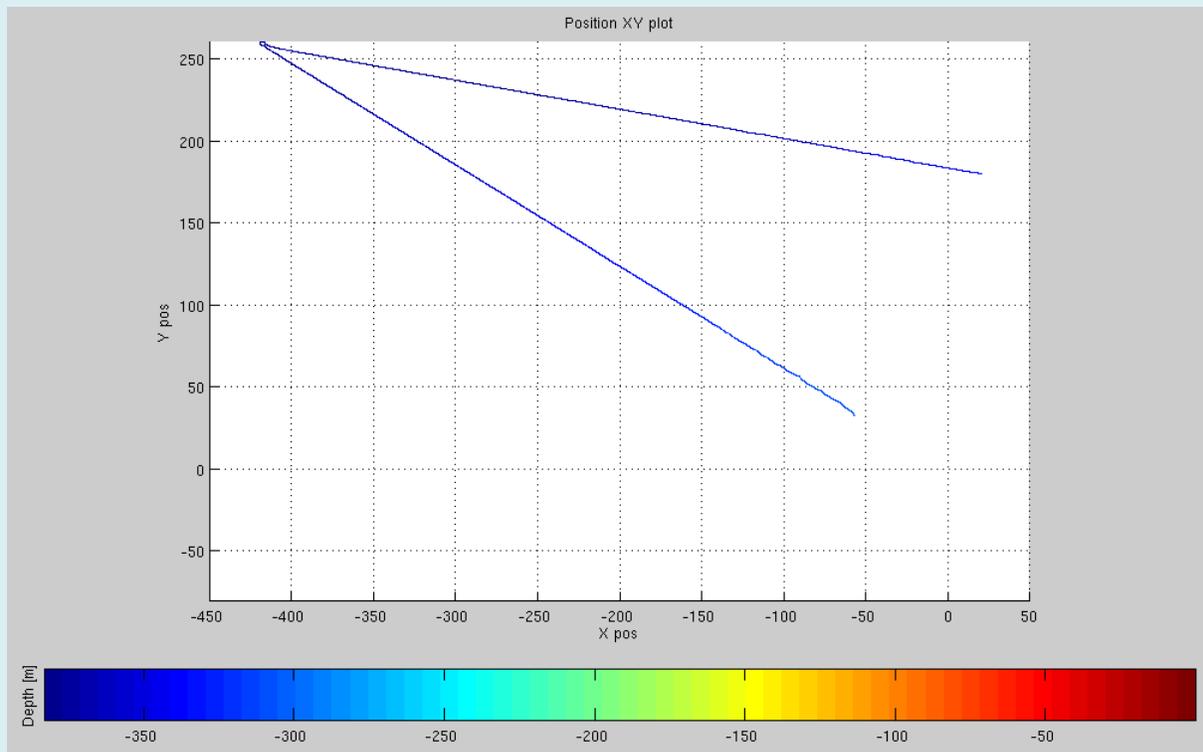
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	1003
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

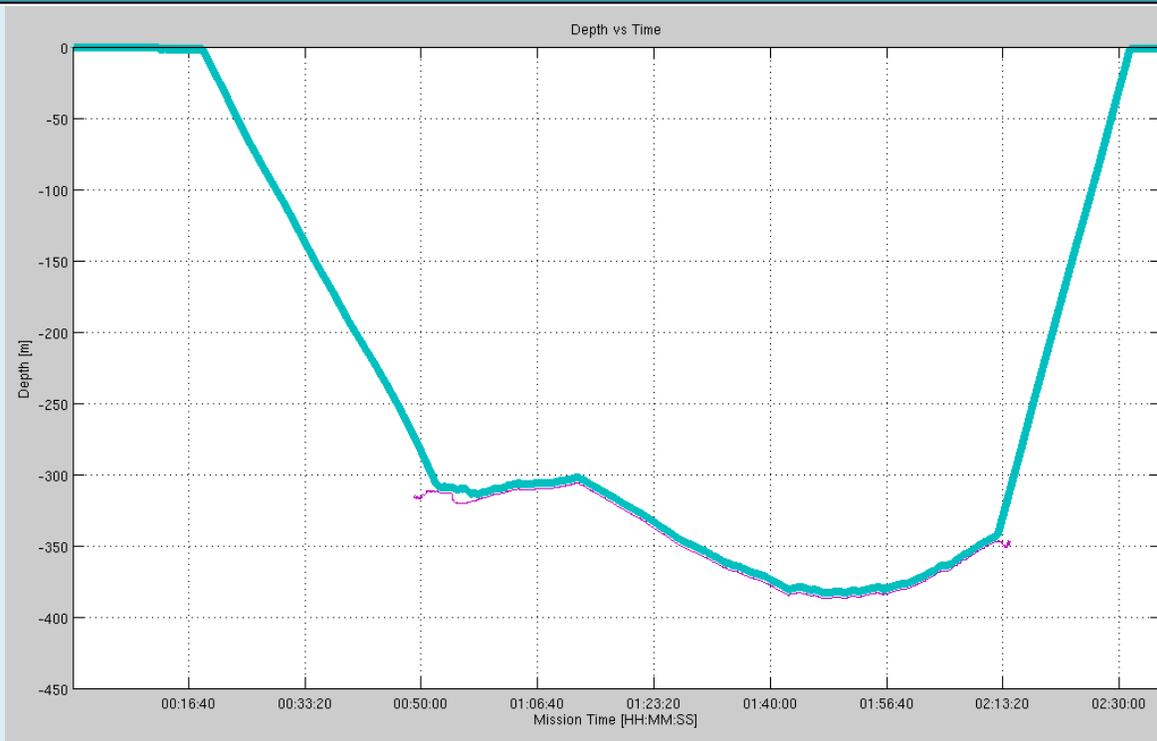
**DIVE DATA**

Date	29 June 2010	Starting Latitude (N)	33°55.36'
Maximum Bottom Depth (m)	315	Starting Longitude (W)	119°28.61'
Start Time (UTC)	09:51	Ending Latitude (N)	33°55.53'
End Time (UTC)	012:03	Ending Longitude (W)	119°28.69'

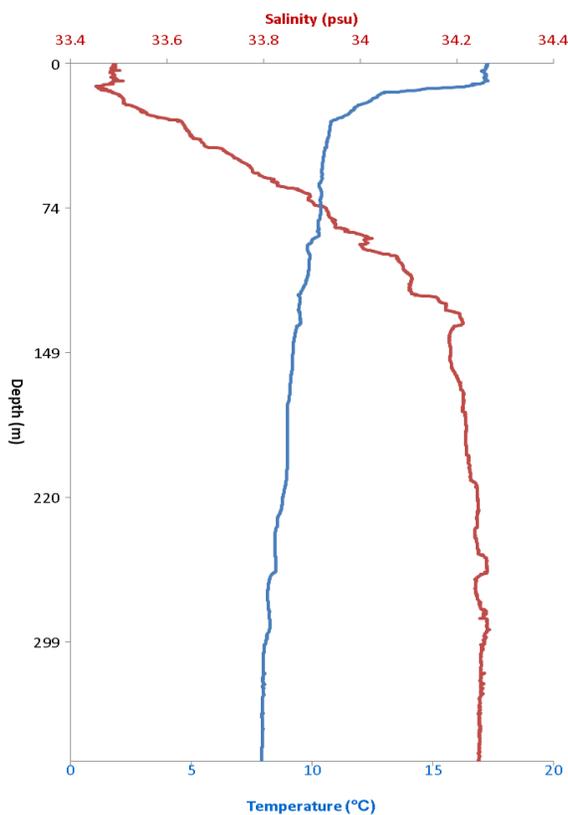
**GENERAL LOCATION AND DIVE TRACK**



Survey track of dive AUV006.



Depth track of dive AUV006 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

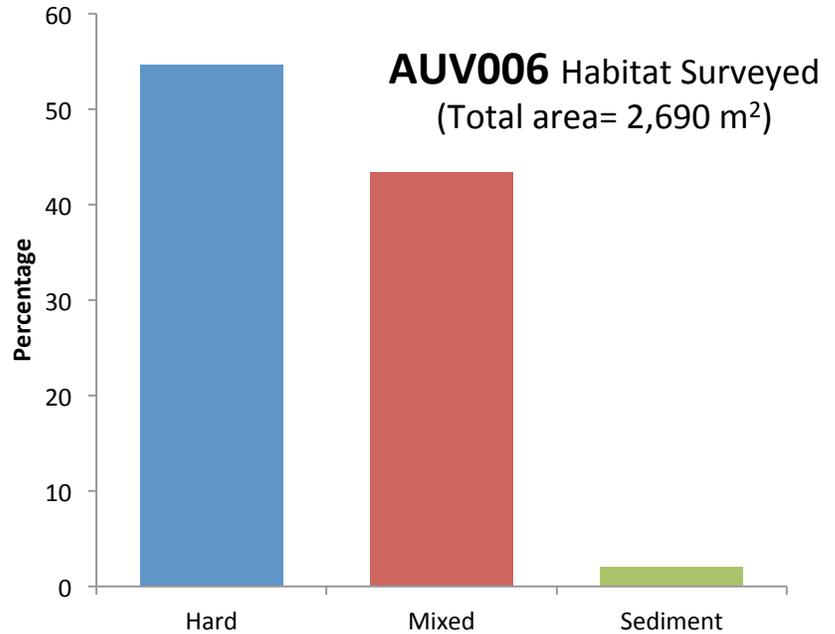


**PHYSICAL ENVIRONMENT**

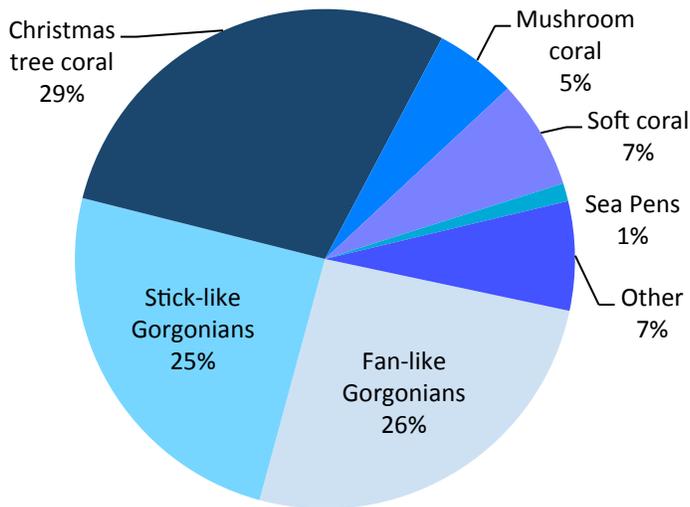
The AUV was equipped with an onboard Sea-Bird model 49 FastCat CTD that collected temperature and salinity information throughout the AUV’s descent as well as along the dive track. During the dive AUV006 descent, the temperature varied from 17.3 to 7.91°C and salinity varied from 33.5 to 34.25 (psu).

Dive AUV006 descent temperature and salinity profiles.

In total, 2,690 m<sup>2</sup> of sea floor were surveyed during dive AUV006 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (55% of the total area surveyed), which included boulders, flat rock and cobble; (2) Mixed (43% of the total area surveyed), which included mud appearing with rock, boulder or cobble; and (3) Sediment (2% of the total area surveyed), which consisted of mud. This mission was flown at a higher altitude (4m), which increased the area of each image.



**AUV006- Density of Corals**  
(63 corals/ 1,000 m<sup>2</sup>)



**BIOLOGICAL ENVIRONMENT: CORALS**

A total of 170 individual corals were enumerated from the 337 frames sampled from dive AUV006 conducted on the Piggy Bank from the NOAA vessel *McArthur II*. They represented 10 taxonomic groups. An overall density of 63 corals per 1,000 m<sup>2</sup> of seafloor was estimated. Christmas tree black corals (*Antipathes dendrochristos*) were the most abundant species during this dive at 29% of the overall density. Fan-like (26%, *Paragorgia* spp., *Parastenella* spp. and *Plumerella* spp.) and stick-like (25%, *Plexuridae* and *Swiftia* spp.)

gorgonians combined to account for 51% of the overall coral density. Unidentified corals (Anthozoa) and soft corals (*Clavularia* spp.) each made up 7% of the overall coral density. *Anthomastus ritteri* accounted for 5% and sea pens (*Anthoptilum grandiflorum*) represented 1% of the total density of corals. The majority of the corals occurred on the hard or mixed substrates. The colors in the pie chart match the colors in the list of coral taxa below.

Scientific Name	Common Name	Count
<i>Paragorgia</i> spp.	Sea fan	4
<i>Parastenella</i> spp.	Primnoid	3
<i>Plumerella</i> spp.	Primnoid	37
Plexauridae	Sea fan	41
<i>Swiftia</i> spp.	Sea fan	1
<i>Antipathes dendrochristos</i>	Christmas tree black coral	49
<i>Anthomastus ritteri</i>	Mushroom coral	9
<i>Clavularia</i> spp.	Soft coral	12
<i>Anthoptilum grandiflorum</i>	Feather boa sea pen	2
Anthozoa	Unidentified coral/ sea pen	12

**BIOLOGICAL ENVIRONMENT: SPONGES**

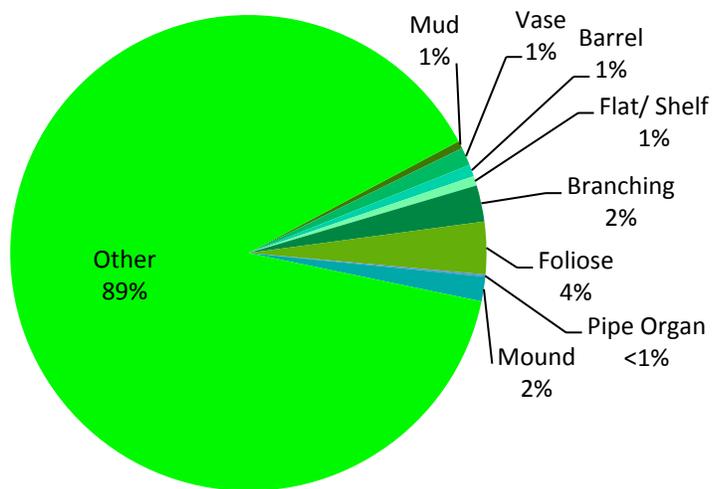
A total of 1,377 individual sponges from 16 different taxonomic classifications were observed during the 337 frames sampled from dive AUV006 on Piggy Bank from the NOAA vessel *McArthur II*. An overall density of 512 sponges per 1,000 m<sup>2</sup> of seafloor was estimated.

Unidentified and other (including *Asbestopluma* spp.) sponges were found to be the most abundant, accounting for 89% of the total density.

Foliose sponges (*Thenea muricata*, *Polymastia* spp. and *Farrea occa*) made up 4% of the overall sponge density. Branching and mound sponges each accounted for 2% of the sponge density.

Vase, mud covered, barrel, flat/shelf and pipe organ (possibly *Oceanapia* spp.) sponges accounted for ≤1% each of the total sponge density in dive AUV006. All of the sponges occurred on hard and mixed habitats. Colors in the pie chart above match the list of sponge taxa following.

**AUV006- Density of Sponges**  
(512 sponges/ 1,000 m<sup>2</sup>)



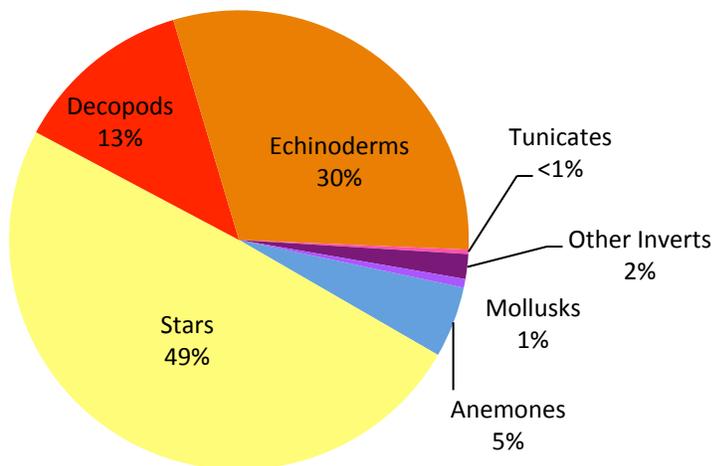
Scientific Name	Common Name	Count
Mud Covered		7
Porifera	Unidentified vase sponges	16
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)	1
Porifera	Unidentified barrel sponges	11
Porifera	Unidentified upright flat sponges	9
Porifera	Unidentified branching sponge	34
<i>Polymastia</i> sp.	Nipple foliose sponges	23
<i>Thenea muricata</i>	Foliose Sponge (clear)	22
<i>Farrea occa</i>	Lace (or cloud) foliose sponge	4
Porifera	Unidentified pipe organ sponge	2
Porifera	Unidentified small mound sponges	6
Porifera	Unidentified mound sponges	17
Porifera	Unidentified sponges (blue/white)	17
<i>Asbestopluma</i> spp. #2	Predatory sponge (clear)	4
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	53
Porifera	Unidentified sponges	1151

**BIOLOGICAL ENVIRONMENT: OTHER INVERTEBRATES**

A total of 1,317 invertebrates representing 25 taxa were enumerated for dive AUV006 from the NOAA vessel *McArthur II* on the Piggy Bank. An overall density of 490 invertebrates per 1,000

**AUV006- Density of Other Invertebrates**

(490 invertebrates/ 1,000 m<sup>2</sup>)



m<sup>2</sup> of seafloor was estimated. The sea star grouping was made up of 11 genera or species pairings, including *Rathbunaster californicus*, *Nearchaster* spp./ *Cheiraster* spp. and other unidentified stars, and represented 49% of the overall invertebrate density. Echinoderms (mostly sea cucumbers, *Psolus squamatus* and *Parastichopus* spp.) were the next most abundant invertebrate representing 30% of the overall density. Decapods, comprised of galatheid crabs (squat lobsters) and unidentified crab species accounted for 13% of the

invertebrate density. Other groups represented included anemones (5%, *Liponema brevicornis* and unidentified anemones), mollusks (1%, unidentified octopus and nudibranchs), tunicates (<1%) and other unidentified invertebrates (2%, including the benthic siphonophore, *Dromalia alexandri*). Invertebrates were distributed throughout all habitat types. The pie diagram colors match with the list of invertebrate taxa below

Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	280
<i>Gorgonocephalus eucnemis</i>	Basket Star	8
<i>Rathbunaster californicus</i>	Deep-sea sunflower star	49
<i>Ceramaster</i> spp.	Cookie star	4
<i>Pteraster</i> spp.	Slime star	1
<i>Thrissacanthius penicillatus</i>	Carpet star	67
Asteroidea	<i>Nearchaster/Cheiraster</i> spp.	220
<i>Solaster</i> spp.	Deep-sea sunstar	17
<i>Crossaster</i> spp./ <i>Heterozonius</i> spp.	Unidentified deep-sea sunstar	3
<i>Hippasteria</i> spp.	Unidentified spiny star	1
<i>Stylasterias forreri</i>	Fish-eating star	1
Galatheoidea	Unidentified Galtheid crab	165
Decapoda	Unidentified crab	1
<i>Psolus squamatus</i>	White-scaled cucumber	111
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber	175
<i>Pannychia moseleyi</i>	Sloppy cucumber	2
Holothuroidea	Unidentified sea cucumber	1
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	109
<i>Florometra serratissima</i>	Feather star crinoid	1
<i>Liponema brevicornis</i>	Tentacle shedding anemone	20
Actinidae	Unidentified anemone	46
Tunicata	Unidentified tunicates	4
Cephalopoda	Unidentified octopus	6
Opisthobranchia	Unidentified nudibranch	2
<i>Dromalia alexandri</i>	Benthic siphonophore	23

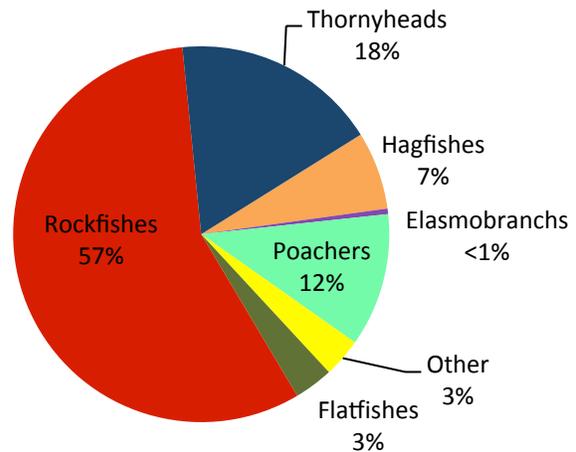
**BIOLOGICAL ENVIRONMENT: FISHES**

A total of 209 fishes were enumerated, representing 12 different taxonomic groupings during dive AUV006 on Piggy Bank from the NOAA ship *McArthur II*. An overall density of 78 fishes per 1,000 m<sup>2</sup> was estimated.

Unidentified rockfishes, *Sebastes melanostomus*, *Sebastes diploproa* and the Sebastomus grouping made up 57% of the total fish density. The *Sebastolobus* spp. grouping made up 18% of the total density for dive AUV006. Poachers (family Agonidae) from accounted for 12% of the overall density.

Hagfishes (family Myxinidae) represented 7% of the observed fish density. Flatfishes (3%, represented by Dover sole (*Microstomus pacificus*) and rex sole (*Glyptocephalus zachirus*), and Other (3%, including Cottidae and unidentified fishes) were the next largest densities. Elasmobranchs (represented by *Hydrolagus colliei*, spotted ratfish) made up <1% in the overall density of fishes. The colors in the pie chart match the colors in the list of fish taxa below.

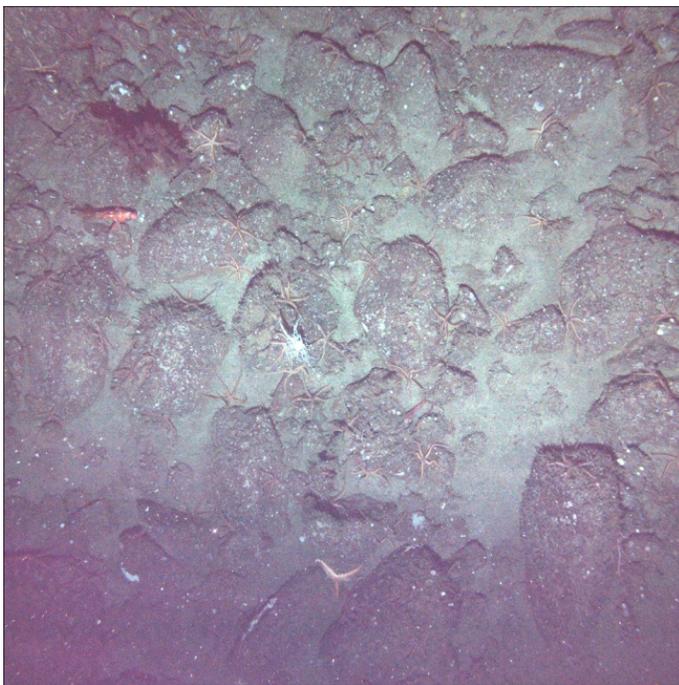
**AUV006- Density of Fishes**  
(78 fishes/ 1,000 m<sup>2</sup>)



Scientific Name	Common Name	Count
Myxinidae	Unidentified hagfish	14
<i>Hydrolagus colliei</i>	Spotted ratfish	1
Agonidae	Unidentified poachers	24
Cottidae	Unidentified sculpins	4
<i>Glyptocephalus zachirus</i>	Rex sole	1
<i>Microstomus pacificus</i>	Dover sole	6
Osteichthyes	Unidentified fishes	3
<i>Sebastes diploproa</i>	Splitnose rockfish	6
<i>Sebastes melanostomus</i>	Blackgill rockfish	5
<i>Sebastes spp.</i>	Rockfish Unid.	97
Sebastomus	Unidentified White-spotted RF	11
<i>Sebastolobus spp.</i>	Unidentified thornyhead	37

**IMAGE GALLERY- AUV006**

To the right, we see boulder / cobble (hard) habitat with two poachers (Agonidae), a basket star (*Gorgonocephalus eucnemis*) and two Plexuridae coral. We also see an unidentified octopus, sea stars and fragile urchins (*Allocentrotus fragilis*).

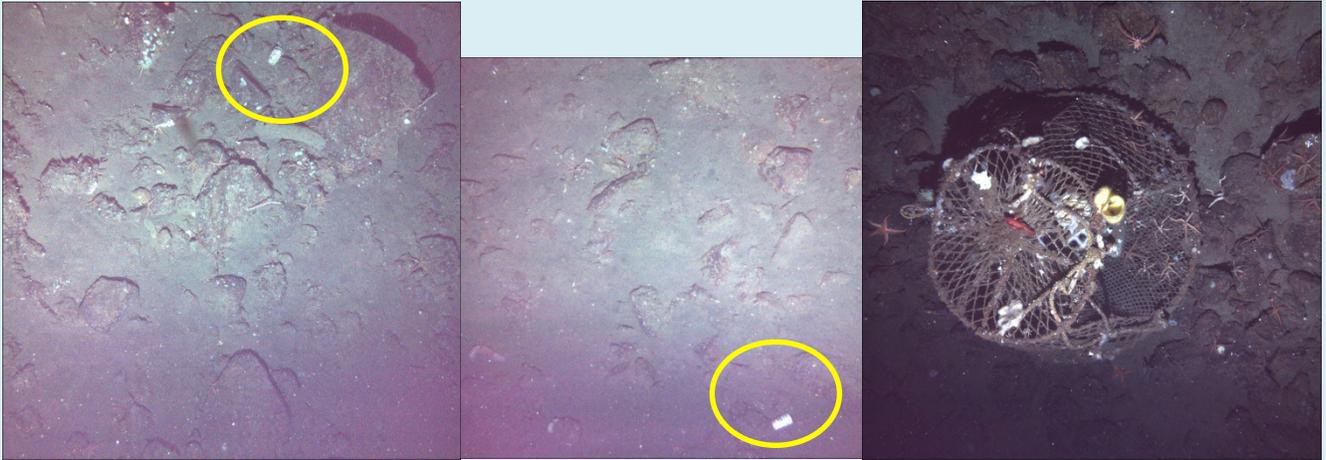


This photo shows Christmas tree black coral (*Antipathes dendrochristos*), a Sebastomus rockfish, and a basket star (*Gorgonocephalus eucnemis*) on boulder/ cobble (hard) habitat. Note the presence of Ophiocanthidae in large numbers.

This image shows mixed habitat (cobble and mud) with unidentified rockfish, an unidentified vase sponge, an *Asbestopluma* spp. (sponge), galatheid crab and a Christmas tree black coral (*Antipathes dendrochristos*).



These images below show anthropogenic marine debris in the form of aluminum cans and pot fishing gear.



**DIVE NUMBER: AUV007**

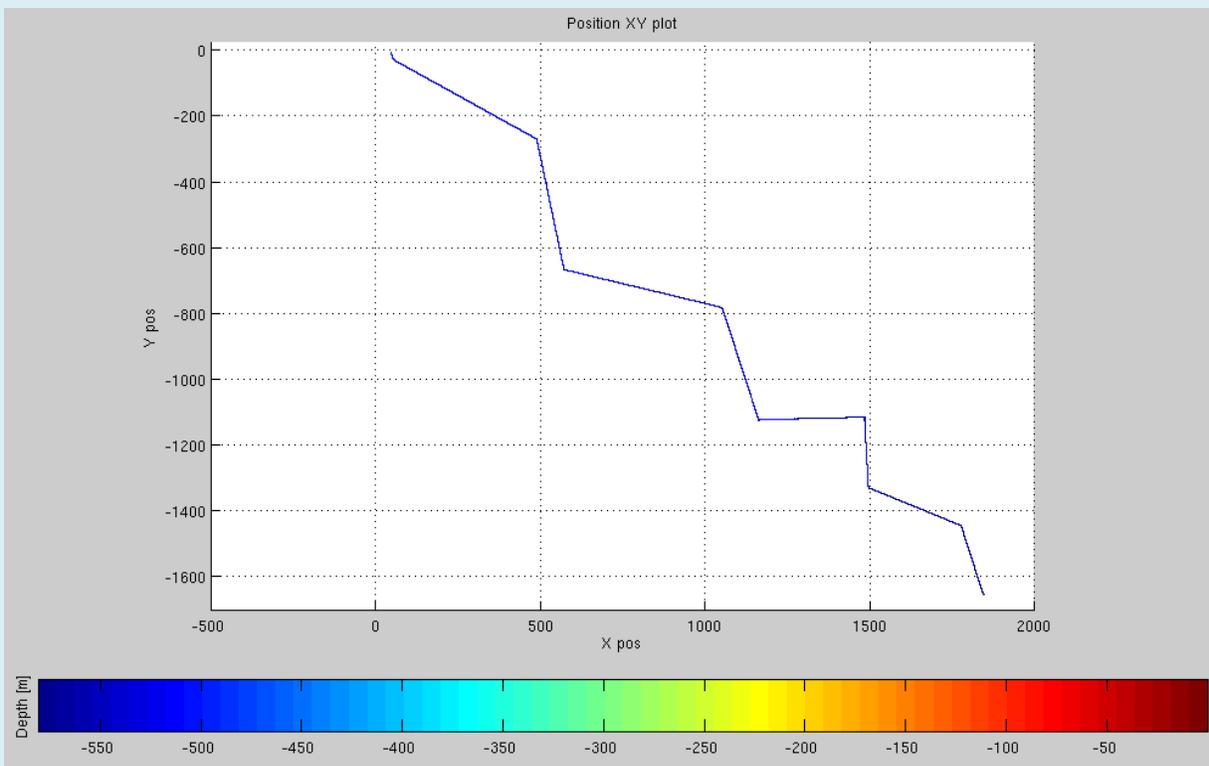
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	2360
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

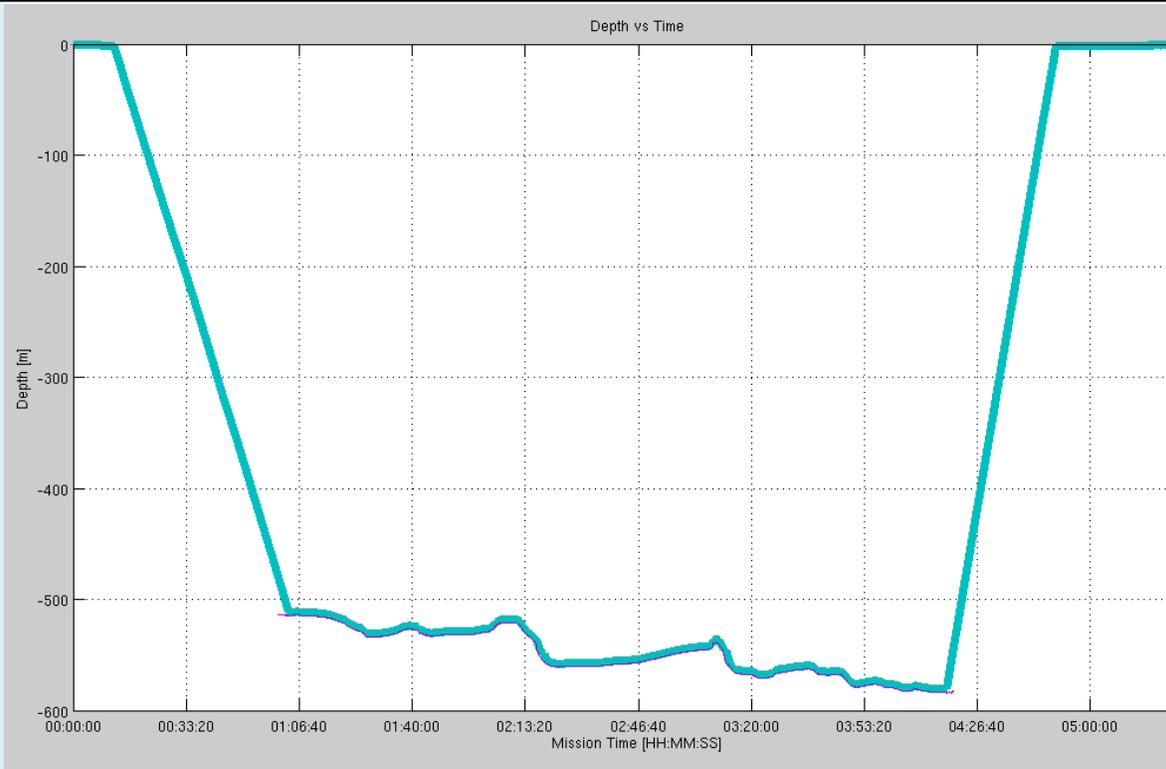
**DIVE DATA**

Date	30 June 2010	Starting Latitude (N)	33°55.14'
Maximum Bottom Depth (m)	585	Starting Longitude (W)	119°27.39'
Start Time (UTC)	05:05	Ending Latitude (N)	33°54.16'
End Time (UTC)	09:11	Ending Longitude (W)	119°26.40'

**GENERAL LOCATION AND DIVE TRACK**



Survey track of dive AUV007.

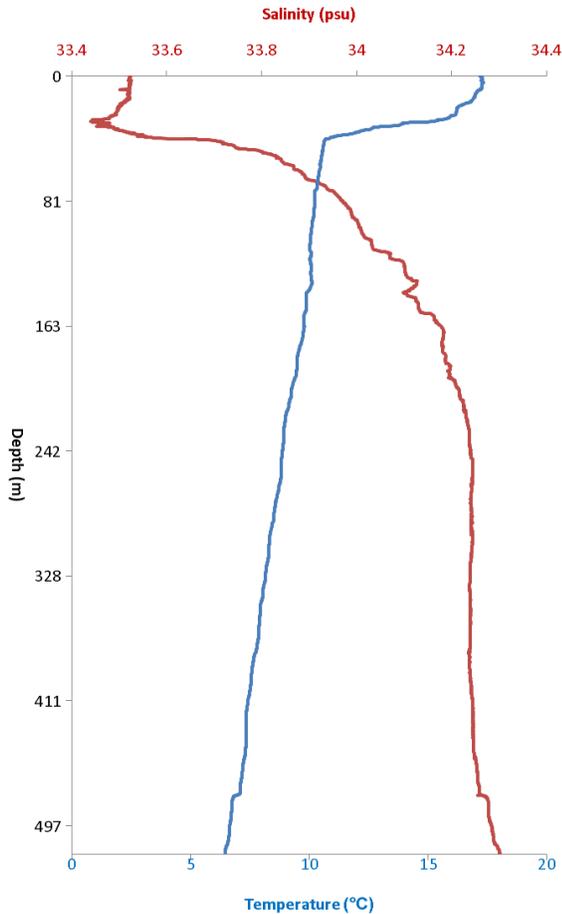


Depth track of dive AUV007 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

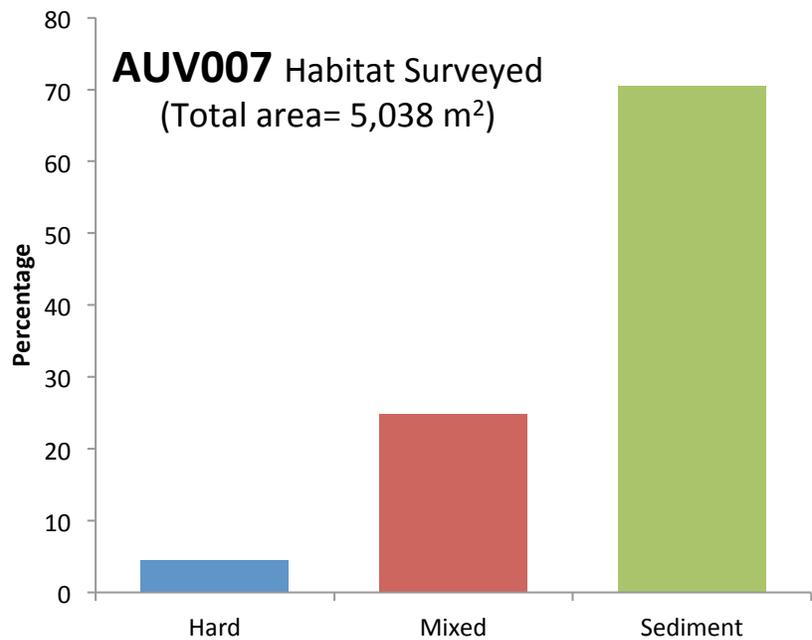
**PHYSICAL ENVIRONMENT**

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 AUV007 descent, the temperature varied from 17.21 to 6.47°C and salinity varied from 33.5 to 34.3 (psu).

Dive AUV007 descent temperature and salinity profiles.



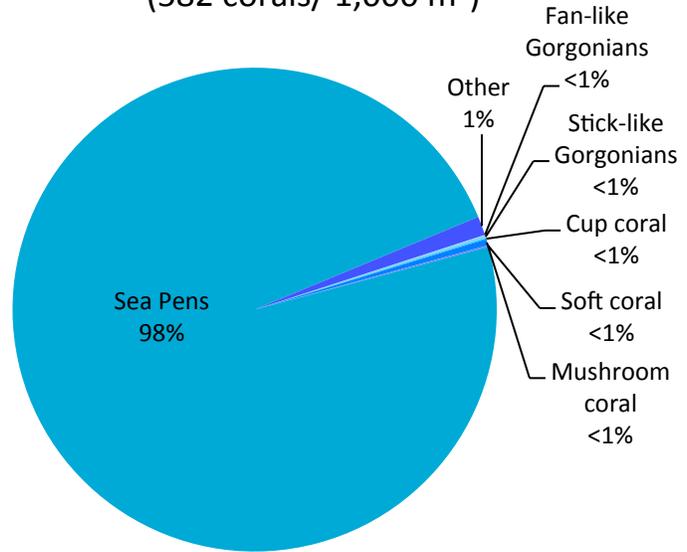
In total, 5,038 m<sup>2</sup> of sea floor were surveyed during dive AUV007 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (5% of the total area surveyed), which included boulders, ridge and cobble; (2) Mixed (25% of the total area surveyed), which included mud appearing with rock, boulder or cobble; and (3) Sediment (70% of the total area surveyed), which consisted of mud. This mission was flown at an altitude of 3 meters.



**BIOLOGICAL ENVIRONMENT: CORALS**

A total of 2,933 individual corals were enumerated from the 1,124 frames sampled from dive AUV007 conducted on the Piggy Bank from the NOAA vessel *McArthur II*. They represented 10 taxonomic groups. An overall density of 582 corals per 1,000 m<sup>2</sup> of seafloor was estimated. Sea pens accounted for 98% of the overall coral density during this dive, and was predominantly an unidentified stick-like sea pen found on mud substrate. The sea pen category also contained *Umbellula lindahli*, *Anthoptilum grandiflorum*, and *Pennatula* spp. The other category, comprised of unidentified corals, accounted for 1% of the overall coral density. Fan-like gorgonians, stick-like gorgonians, cup corals, soft corals and *Anthomastus ritteri* each accounted for <1% of the overall coral density. These groups occurred on mixed or hard substrates.

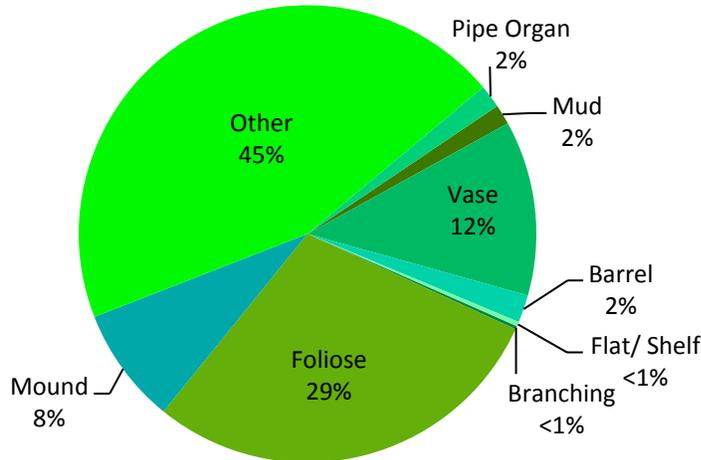
**AUV007- Density of Corals**  
(582 corals/ 1,000 m<sup>2</sup>)



Scientific Name	Common Name	Count
<i>Paragorgia</i> spp.	Sea fan	1
Plexauridae	Sea fan	6
<i>Anthomastus ritteri</i>	Mushroom coral	12
Caryophyllidae	Unidentified cup corals	2
<i>Clavularia</i> spp.	Soft coral	3
<i>Pennatula</i> spp.	Deep-sea sea pen	80
Pennatulacea	Unidentified sea pen	2352
<i>Anthoptilum grandiflorum</i>	Feather boa sea pen	68
<i>Umbellula lindahli</i>	Droopy sea pen	372
Anthozoa	Unidentified coral	37

**BIOLOGICAL ENVIRONMENT: SPONGES**

**AUV007- Density of Sponges**  
(182 sponges/ 1,000 m<sup>2</sup>)



A total of 921 individual sponges from 15 different taxonomic classifications were observed during the 1,124 frames sampled from dive AUV007 on Piggy Bank from the NOAA vessel *McArthur II*. An overall density of 182 sponges per 1,000 m<sup>2</sup> of seafloor was estimated. Unidentified and other (including *Asbestopluma* spp.) sponges were found to be the most abundant, accounting for 45% of the total density. Foliose sponges (including *Thenea muricata* and *Farrea occa*) made up 29% of the overall sponge density. Vase sponges, including *Heterochone calyx* and *Staurocalyptus* spp., accounted for

12% of the total density. Unidentified mound sponges (8%), unidentified pipe organ sponges (2%), mud covered sponges (2%) and barrel sponges (2%) were the next most abundant taxa. Unidentified flat/ shelf sponges and branching sponges each accounted for <1% of the overall density. Colors in the pie chart above match the list of sponge taxa following.

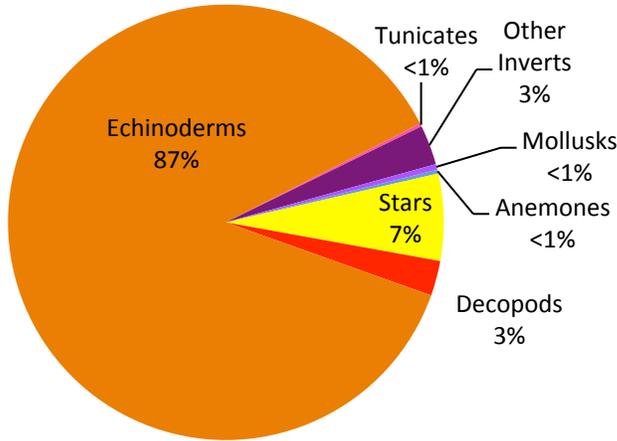
Scientific Name	Common Name	Count
	Mud Covered	13
Porifera	Unidentified vase sponges	96
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)	2
<i>Heterochone calyx</i>	Fingered goblet vase sponge	16
Porifera	Unidentified barrel sponges	18
Porifera	Unidentified upright flat sponges	3
Porifera	Unidentified branching sponge	2
Porifera	Unidentified foliose sponges	6
<i>Thenea muricata</i>	Foliose Sponge (clear)	257
<i>Farrea occa</i>	Lace (or cloud) foliose sponge	4
Porifera	Unidentified pipe organ sponge	15
Porifera	Unidentified small mound sponges	27
Porifera	Unidentified mound sponges	49
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	93
Porifera	Unidentified sponges	320

**BIOLOGICAL ENVIRONMENT: OTHER INVERTEBRATES**

A total of 18,901 invertebrates representing 32 taxa were enumerated for dive AUV007 from the NOAA vessel *McArthur II* on the Piggy Bank. An overall density of 3,741 invertebrates per 1,000m<sup>2</sup> of seafloor was estimated. Echinoderms (the urchins, *Allocentrotus fragilis* and

**AUV007- Density of Other Invertebrates**

(3,741 invertebrates/ 1,000 m<sup>2</sup>)



*Brisaster* spp./ *Brissopsis* spp. and the cucumber *Pannychia moseleyi*) were the most abundant invertebrates representing 87% of the overall density. The sea star grouping was made up of 14 genera or species pairings, including *Ceramaster* spp., a *Myxoderma platycanthum*-like star and *Brisengella* spp., and represented 7% of the overall invertebrate density. This percentage did not include individuals from the family Ophiocanthidae, which we were unable to accurately count. Decapods, comprised of galatheid crabs (squat lobsters), unidentified

crabs and unidentified shrimp accounted for 3% of the invertebrate density. The other group, which included the abundant benthic siphonophore, *Dromalia alexandri*, accounted for 3% of the overall density. Anemones (<1%, including *Liponema brevicornis*), mollusks (<1%, *Acesta sphoni* (a deepwater clam), unidentified octopus and nudibranchs), and tunicates (<1%) were the remaining groupings encountered in this dive. Invertebrates were distributed throughout all habitat types. The pie diagram colors match with the list of invertebrate taxa below.

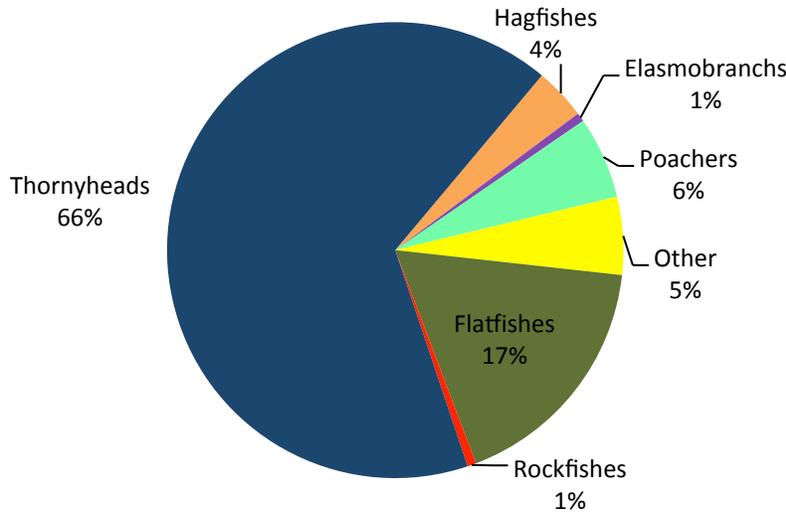
# Characterization of Deep-sea Coral Communities

Area: Piggy Bank

Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	596
<i>Gorgonocephalus eucnemis</i>	Basket Star	1
<i>Rathbunaster californicus</i>	Deep-sea sunflower star	15
<i>Ceramaster</i> spp.	Cookie star	79
<i>Pteraster</i> spp.	Slime star	19
<i>Thrissacanthius penicillatus</i>	Carpet star	24
Asteroidea	Nearchaster/Cheiraster spp.	1
Asteroidea	<i>Myxoderma platycanthum</i> -like	385
<i>Crossaster</i> spp./ <i>Heterozonius</i> spp.	Unidentified deep-sea sunstar	1
<i>Hippasteria</i> spp.	Unidentified spiny star	31
<i>Zoroaster evermanni</i>	Slender star	1
<i>Brisingella</i> spp.	Lacy-armed star	57
<i>Dipsacaster eximius</i>	Broad sand star	4
Asteroidea	Unidentified mud star ( <i>Ctenodiscus</i> spp.?)	3
Galatheoidea	Unidentified Galtheid crab	35
Decapoda	Unidentified shrimp	442
Decapoda	Unidentified crab	12
<i>Psolus squamatus</i>	White-scaled cucumber	122
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber	8
<i>Pannychia moseleyi</i>	Sloppy cucumber	4194
Holothuroidea	Unidentified sea cucumber	2
<i>Brisaster</i> spp./ <i>Brissopsis</i> spp.	Unidentified mud urchin	1062
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	11009
<i>Florometra serratissima</i>	Feather star crinoid	11
<i>Liponema brevicornis</i>	Tentacle shedding anemone	26
Actinidae	Unidentified anemone	28
Tunicata	Unidentified tunicates	43
Unidentified invertebrate	Unidentified invertebrate	8
<i>Acesta sphoni</i>	Sphon's giant file clam	52
Cephalopoda	Unidentified octopus	4
Opisthobranchia	Unidentified nudibranch	23
<i>Dromalia alexandri</i>	Benthic siphonophore	549

BIOLOGICAL ENVIRONMENT: FISHES

**AUV007- Density of Fishes**  
(65 fishes/ 1,000 m<sup>2</sup>)



A total of 326 fishes were enumerated, representing 12 different taxonomic groupings during dive AUV007 on Piggy Bank from the NOAA ship *McArthur II*. An overall density of 65 fishes per 1,000 m<sup>2</sup> was estimated. The *Sebastolobus* spp. grouping, including *Sebastolobus alascanus*, made up 66% of the total density of fishes for dive AUV007. Flatfishes (17%, represented by Dover sole (*Microstomus pacificus*) and

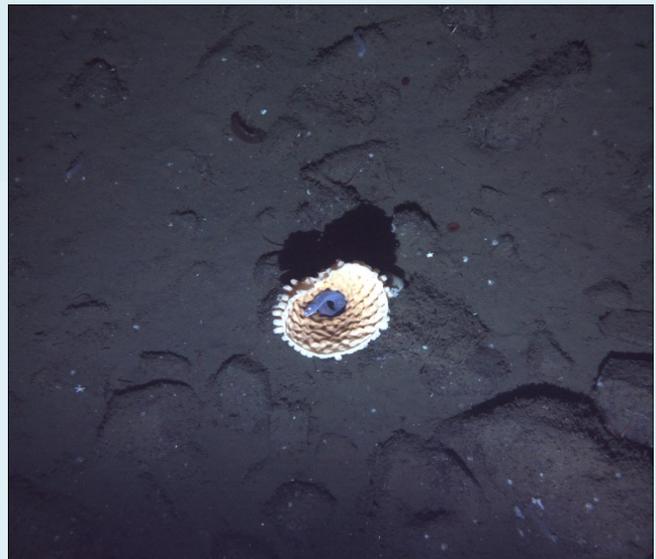
rex sole (*Glyptocephalus zachirus*)) were the next largest density. Poachers (6%, family Agonidae), other (5%, including Liparidae, Macrouridae and unidentified fishes) and hagfishes (4%, Myxinidae) from accounted for portions of the overall density. Rockfishes (*Sebastes melanostomus*) and elasmobranchs (*Raja rhina* and Scyliorhinidae) each accounted for 1% of the overall density. The pie diagram colors match with the list of fish taxa below.

Scientific Name	Common Name	Count
Myxinidae	Unidentified hagfish	12
<i>Raja rhina</i>	Longnose skate	1
Scyliorhinidae	Unidentified catshark	1
Agonidae	Unidentified poachers	19
Macrouridae	Unidentified grenadiers	4
Liparidae	Unidentified snailfish	8
<i>Glyptocephalus zachirus</i>	Rex sole	1
<i>Microstomus pacificus</i>	Dover sole	56
Osteichthyes	Unidentified fishes	6
<i>Sebastes melanostomus</i>	Blackgill rockfish	2
<i>Sebastolobus alascanus</i>	Shortspine thornyhead	3
<i>Sebastolobus</i> spp.	Unidentified thornyhead	213

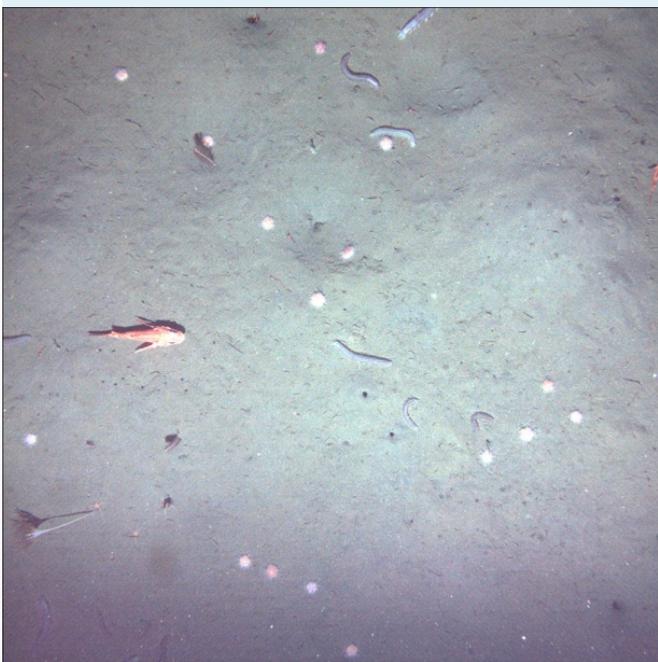
IMAGE GALLERY- AUV007



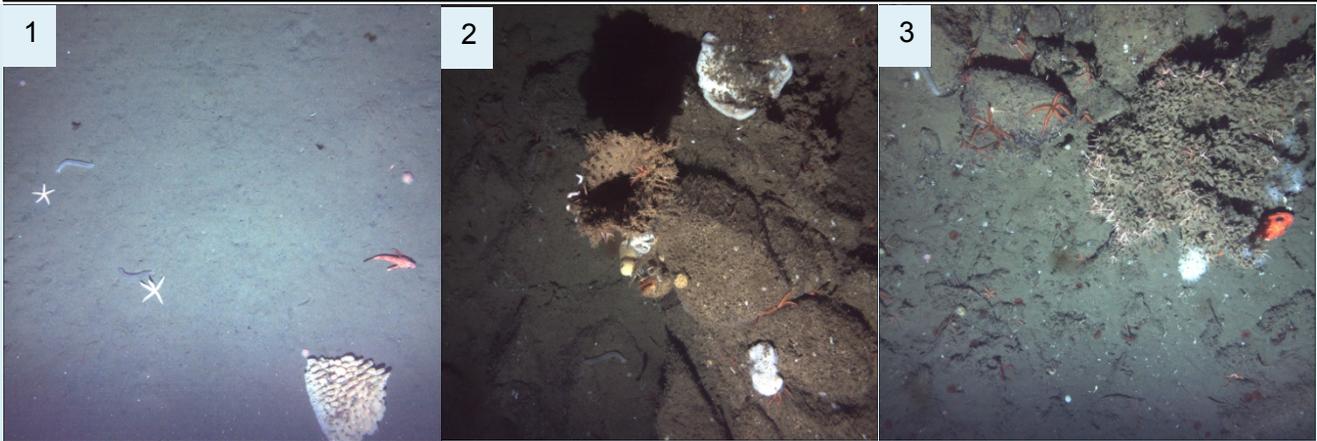
This photo shows vase sponges, barrel sponges and *Umbellula lindahli* on sediment substrate. You can also find a benthic siphonophore (*Dromalia alexandri*), tunicates and *Pannychia moseleyi* sea cucumbers. A thornyhead, *Sebastolobus* spp. rests near the sponges.



This photo shows a sponge, *Heterochrone calyx*, with a hagfish (Myxinidae) taking shelter in the cone. On the mixed substrate (boulder and mud), one can also observe a sea pen (*Anthoptilum grandiflorum*) and sea cucumbers (*Pannychia moseleyi*).



This image shows the unidentified stick-like sea pen that was prevalent throughout AUV007. Also found on the sediment substrate were *Umbellula lindahli*, *Pannychia moseleyi*, *Allocentrotus fragilis* and a shortspine thornyhead (*Sebastolobus alascanus*).



The three images above all show dead or dying sponges. The first photo shows a broken section of *Heterochone calyx*. The second shows a mud covered sponge. The third shows a mostly dead *Farrea occa*, but it still provided shelter for a shortspine thornyhead.

**DIVE NUMBER: AUV008**

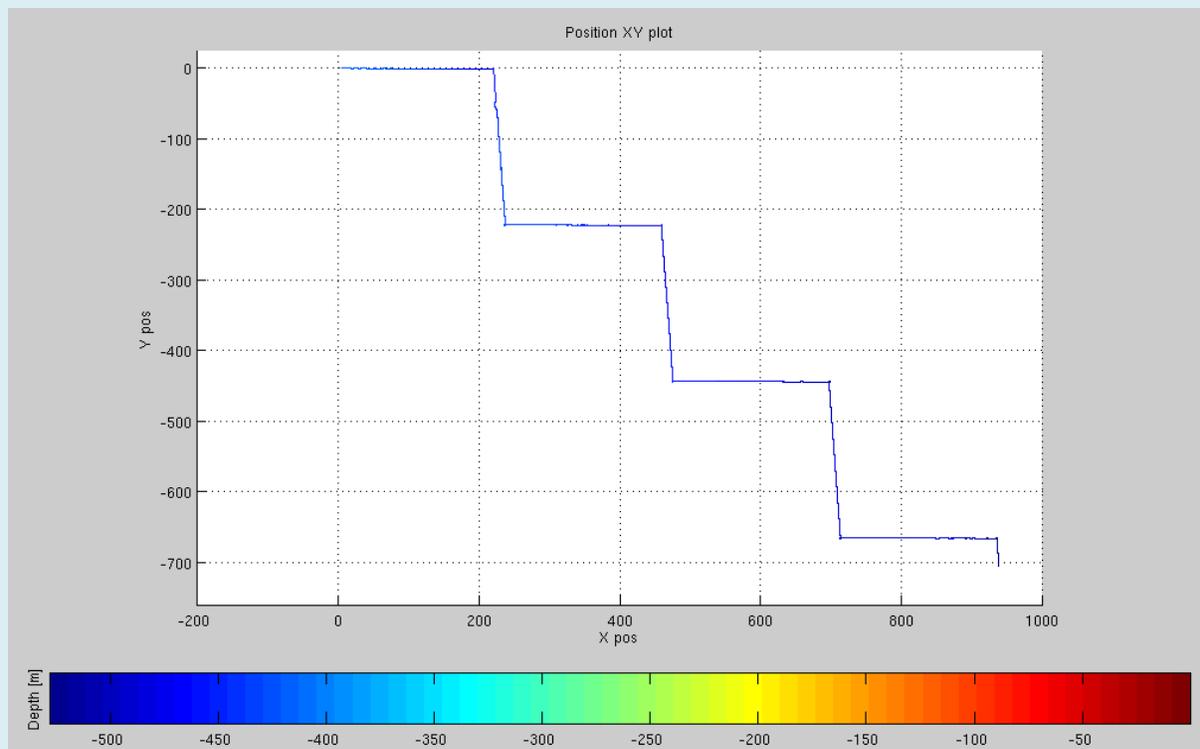
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	2056
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

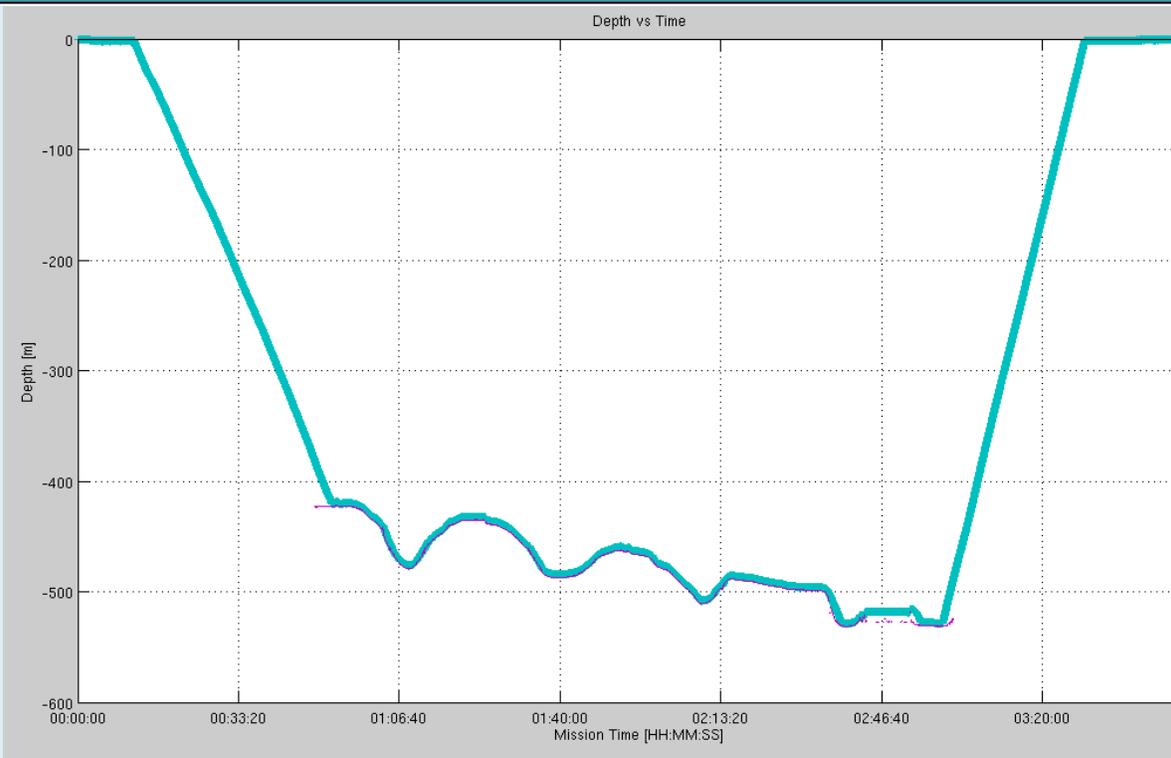
**DIVE DATA**

Date	01 July 2010	Starting Latitude (N)	33°54.77'
Maximum Bottom Depth (m)	532	Starting Longitude (W)	119°27.76'
Start Time (UTC)	03:55	Ending Latitude (N)	33°54.28'
End Time (UTC)	06:43	Ending Longitude (W)	119°26.99'

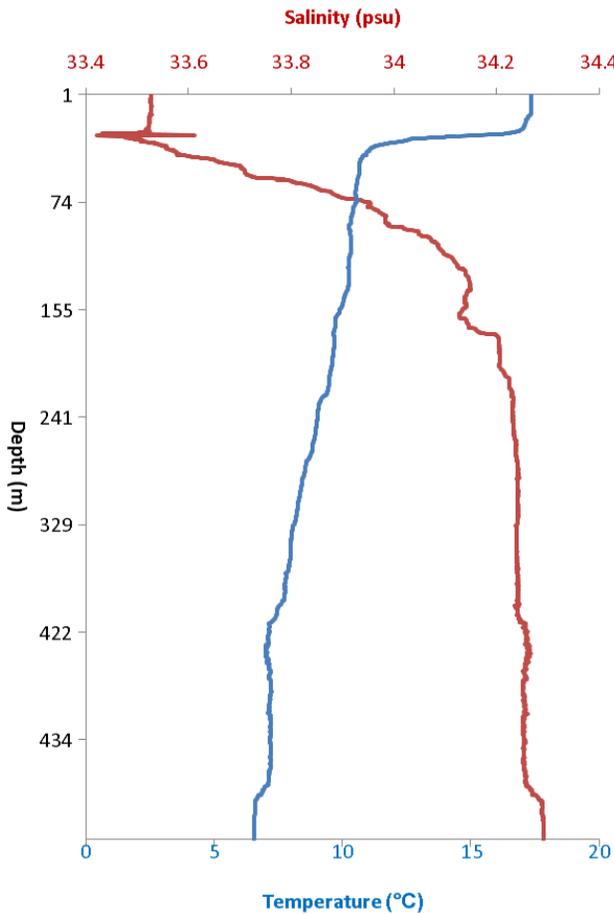
**GENERAL LOCATION AND DIVE TRACK**



Survey track of dive AUV008.



Depth track of dive AUV008 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

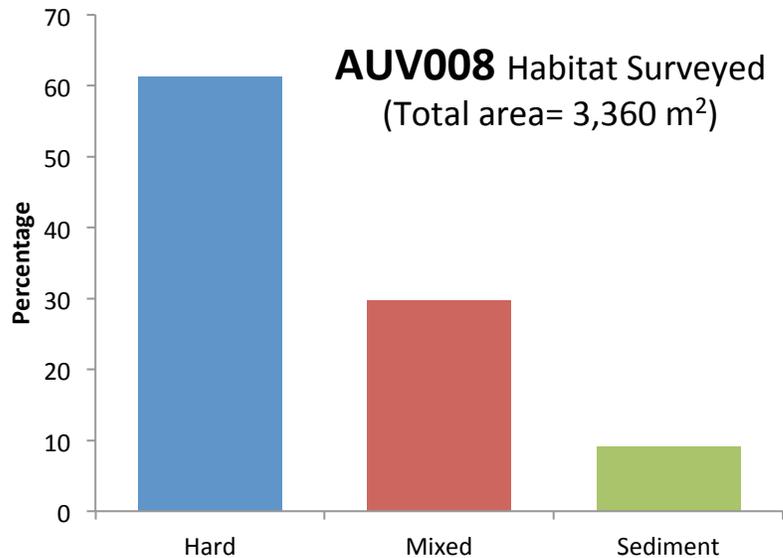


**PHYSICAL ENVIRONMENT**

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 AUV008 descent, the temperature varied from 17.36 to 6.6°C and salinity varied from 33.5 to 34.3 (psu) (Figure x).

Dive AUV008 descent temperature and salinity profiles.

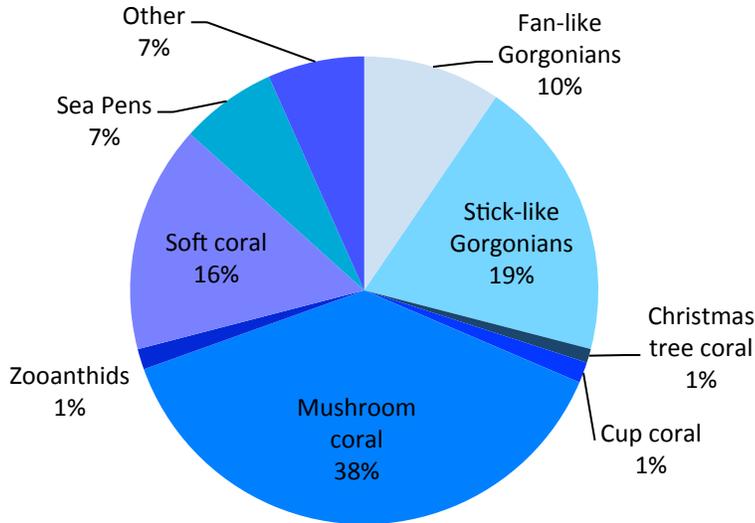
In total, 3,360 m<sup>2</sup> of sea floor were surveyed during dive AUV008 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (61% of the total area surveyed), which included boulders, flat rock, ridge and cobble; (2) Mixed (30% of the total area surveyed), which included mud appearing with rock, boulder or cobble; and (3) Sediment (9% of the total area surveyed), which consisted of mud. This mission was flown at an altitude of 3 meters.



**BIOLOGICAL ENVIRONMENT: CORALS**

**AUV008- Density of Corals**

(63 corals/ 1,000 m<sup>2</sup>)



A total of 210 individual corals were enumerated from the 750 frames sampled from dive AUV008 conducted on the Piggy Bank from the NOAA vessel *McArthur II*. They represented 13 taxonomic groups. An overall density of 63 corals per 1,000 m<sup>2</sup> of seafloor was estimated. Mushroom corals (*Anthomastus ritteri*) accounted for 38% of the overall coral density. Stick-like gorgonians (19%, Plexuridae and *Swiftia* spp.) and soft corals (16%, *Clavularia* spp.) were the next most abundant groupings. Fan-like gorgonians (*Paragorgia* spp., *Parastenella* spp., and *Plumerella*

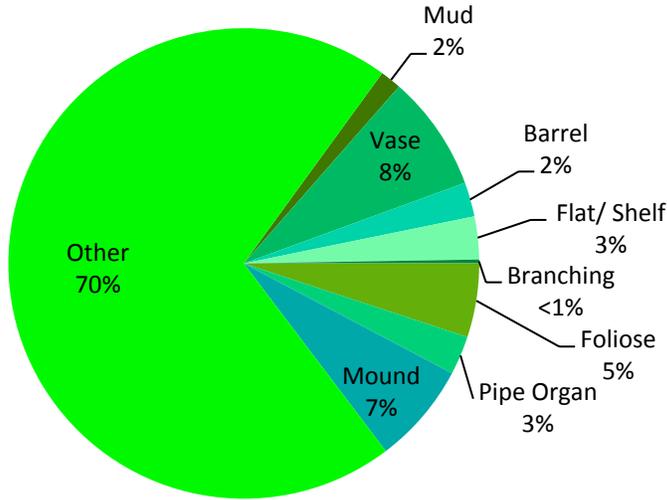
spp.) accounted for 10% of the overall coral density. Sea pens (*Anthoptilum grandiflorum*) and other unidentified corals each accounted for 7% of the total density. Zooanthids, cup corals (*Lophelia* spp., and Caryophyllidae) and Christmas tree black coral (*Antipathes dendrochristos*) each made up 1% of the overall coral density. Other than sea pens, these coral groups occurred on mixed or hard substrates. Colors in the pie chart above match the list of coral taxa following.

Scientific Name	Common Name	Count
<i>Paragorgia</i> spp.	Sea fan	11
<i>Parastenella</i> spp.	Primnoid	6
<i>Plumerella</i> spp.	Primnoid	3
Plexauridae	Sea fan	37
<i>Swiftia</i> spp.	Sea fan	4
<i>Antipathes dendrochristos</i>	Christmas tree black coral	2
<i>Lopheila</i> spp.	White cup coral	2
Caryophyllidae	Unidentified cup corals	1
<i>Anthomastus ritteri</i>	Mushroom coral	80
Zoantharia	Unidentified zooanthids	3
<i>Clavularia</i> spp.	Soft coral	33
<i>Anthoptilum grandiflorum</i>	Feather boa sea pen	14
Anthozoa	Unidentified coral/ sea pen	14

**BIOLOGICAL ENVIRONMENT: SPONGES**

A total of 3,563 individual sponges from 19 different taxonomic classifications were observed during the 750 frames sampled from dive AUV008 on Piggy Bank from the NOAA vessel *McArthur II*. An overall density of 1,060 sponges per 1,000 m<sup>2</sup> of seafloor was estimated.

**AUV008- Density of Sponges**  
(1,060 sponges/ 1,000 m<sup>2</sup>)



Unidentified and other (including *Asbestopluma* spp.) sponges were found to be the most abundant, accounting for 70% of the total density. Vase sponges (including *Staurocalyptus* spp. and *Heterochone calyx*) made up 8% of the overall sponge density. Unidentified mound sponges accounted for 7% of the total density. Foliose sponges (5%, including *Thenea muricata* and *Farrea occa*), unidentified pipe organ sponges (3%, possibly *Oceanapia* spp.), and Flat/ shelf sponges (2%, including *Mycale* spp.), mud covered sponges

(2%) and barrel sponges (2%) were the next most abundant taxa. Branching sponges accounted for <1% of the overall density. Colors in the pie chart above match the list of sponge taxa following.

Scientific Name	Common Name	Count
Mud Covered		52
Porifera	Unidentified vase sponges	225
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)	12
<i>Heterochone calyx</i>	Fingered goblet vase sponge	47
Porifera	Unidentified barrel sponges	84
Porifera	Unidentified upright flat sponges	12
Porifera	Unidentified shelf sponges	5
<i>Mycale</i> spp.	Upright flat sponge (yellow)	88
Porifera	Unidentified branching sponges	2
Porifera	Unidentified branching sponge	7
<i>Thenea muricata</i>	Foliose Sponge (clear)	164
<i>Farrea occa</i>	Lace (or cloud) foliose sponge	17
Porifera	Unidentified pipe organ sponge	95
Porifera	Unidentified small mound sponges	6
Porifera	Unidentified mound sponges	242
Porifera	Unidentified sponges (blue/white)	84
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	100
<i>Asbestopluma</i> spp. #2	Predatory sponge (clear)	6
Porifera	Unidentified sponges	2315

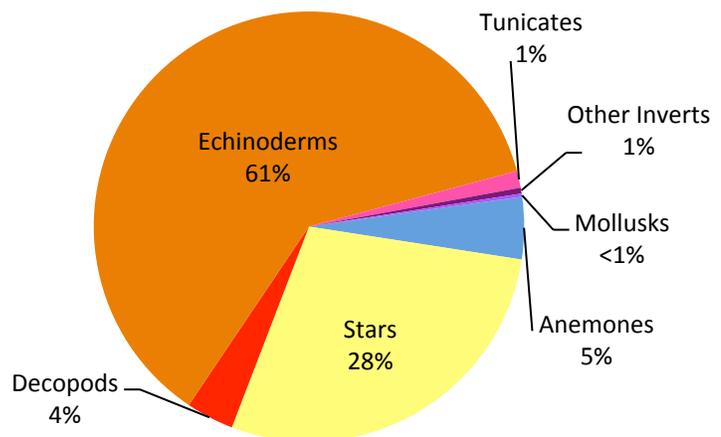
**BIOLOGICAL ENVIRONMENT: OTHER INVERTEBRATES**

A total of 5,179 invertebrates representing 29 taxa were enumerated for dive AUV008 from the NOAA vessel *McArthur II* on the Piggy Bank. An overall density of 1,541 invertebrates per 1,000 m<sup>2</sup> of seafloor was estimated. Echinoderms (the urchins, *Allocentrotus fragilis* and *Brisaster* spp./ *Brissopsis* spp. and the cucumbers *Psolus squamatus* and *Pannychia moseleyi*) were the most abundant invertebrates representing 61% of the overall density. The sea star grouping was made up of 12 genera or species pairings, including

*Rathbunaster californicus*, *Thrissacanthius penicillatus* and *Nearchaster/Cheiraster* spp.; and represented 28% of the overall invertebrate density. This percentage did not include individuals from the family Ophiocanthidae, which were present, but we were unable to get an

**AUV008- Density of Other Invertebrates**

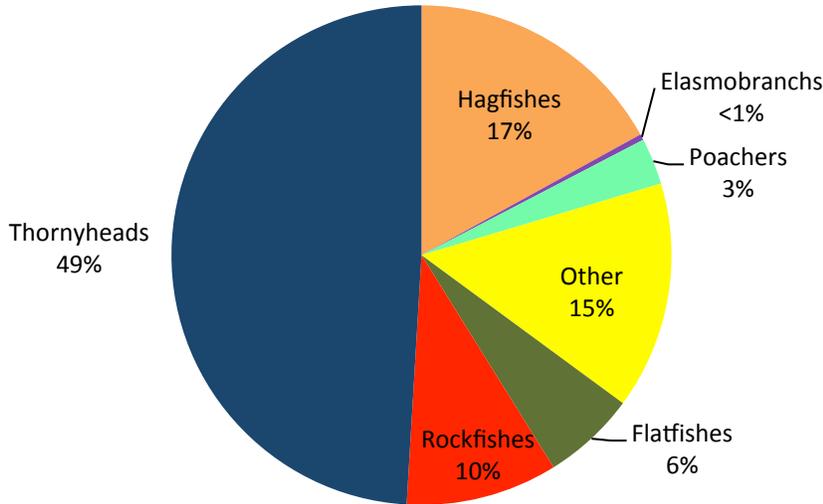
(1,541 invertebrates/ 1,000 m<sup>2</sup>)



accurate count. Decapods, comprised of galatheid crabs (squat lobsters), unidentified crabs and unidentified shrimp accounted for 4% of the invertebrate density. Anemones (5%, including *Liponema brevicornis*), mollusks (<1%, unidentified octopus and nudibranchs), and tunicates (1%) were groupings encountered in this dive. The other group, which included the benthic siphonophore, *Dromalia alexandri*, accounted for 1% of the overall density. Invertebrates were distributed throughout all habitat types. The pie diagram colors match with the list of invertebrate taxa below.

Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	835
<i>Rathbunaster californicus</i>	Deep-sea sunflower star	220
<i>Ceramaster</i> spp.	Cookie star	3
<i>Pteraster</i> spp.	Slime star	23
<i>Thrissacanthius penicillatus</i>	Carpet star	134
Asteroidea	<i>Nearchaster/Cheiraster</i> spp.	202
<i>Solaster</i> spp.	Deep-sea sunstar	4
<i>Crossaster</i> spp./ <i>Heterozonius</i> spp.	Unidentified deep-sea sunstar	23
<i>Hippasteria</i> spp.	Unidentified spiny star	4
<i>Zoroaster evermanni</i>	Slender star	2
<i>Brisingella</i> spp.	Lacy-armed star	1
Asteroidea	Unidentified mud star ( <i>Ctenodiscus</i> spp.?)	19
Galatheoidea	Unidentified Galatheid crab	164
Decapoda	Unidentified crab	3
Decapoda	Unidentified shrimp	19
<i>Psolus squamatus</i>	White-scaled cucumber	401
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber	164
<i>Pannychia moseleyi</i>	Sloppy cucumber	555
Holothuroidea	Unidentified sea cucumber	5
<i>Brisaster</i> spp./ <i>Brissopsis</i> spp.	Unidentified mud urchin	494
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	1504
<i>Florometra serratissima</i>	Feather star crinoid	58
<i>Liponema brevicornis</i>	Tentacle shedding anemone	74
Actinidae	Unidentified anemone	168
Tunicata	Unidentified tunicates	65
Unidentified invertebrate	Unidentified invertebrate	9
Cephalopoda	Unidentified octopus	7
Opisthobranchia	Unidentified nudibranch	5
<i>Dromalia alexandri</i>	Benthic siphonophore	14

**AUV008- Density of Fishes**  
(79 fishes/ 1,000 m<sup>2</sup>)



**BIOLOGICAL ENVIRONMENT: FISHES**

A total of 26 fishes were enumerated, representing 9 different taxonomic groupings during dive AUV008 on Piggy Bank from the NOAA ship *McArthur II*. An overall density of 78 fishes per 1,000 m<sup>2</sup> was estimated. The *Sebastolobus* spp. grouping made up 49% of the total density of fishes for dive AUV008. Hagfishes (17%) and other unidentified fishes (15%, including family

Cottidae) were the next most abundant groupings. Rockfishes, including *Sebastes melanostomus*, accounted for 10% of the overall fish density. Flatfishes (6%, represented by Dover sole (*Microstomus pacificus*), and deep-sea sole (*Embassichthys bathybius*)), poachers (3%, family Agonidae) and elasmobranchs (<1%, represented by *Raja rhina*) were the remaining fish groupings. The pie diagram colors match with the list of fish taxa below.

Scientific Name	Common Name	Count
Myxinidae	Unidentified hagfish	45
<i>Raja rhina</i>	Longnose skate	1
Agonidae	Unidentified poachers	8
Cottidae	Unidentified sculpins	1
<i>Microstomus pacificus</i>	Dover sole	14
Osteichthyes	Unidentified fishes	38
<i>Sebastes melanostomus</i>	Blackgill rockfish	9
<i>Sebastes spp.</i>	Rockfish Unid.	17
<i>Sebastolobus spp.</i>	Unidentified thornyhead	130

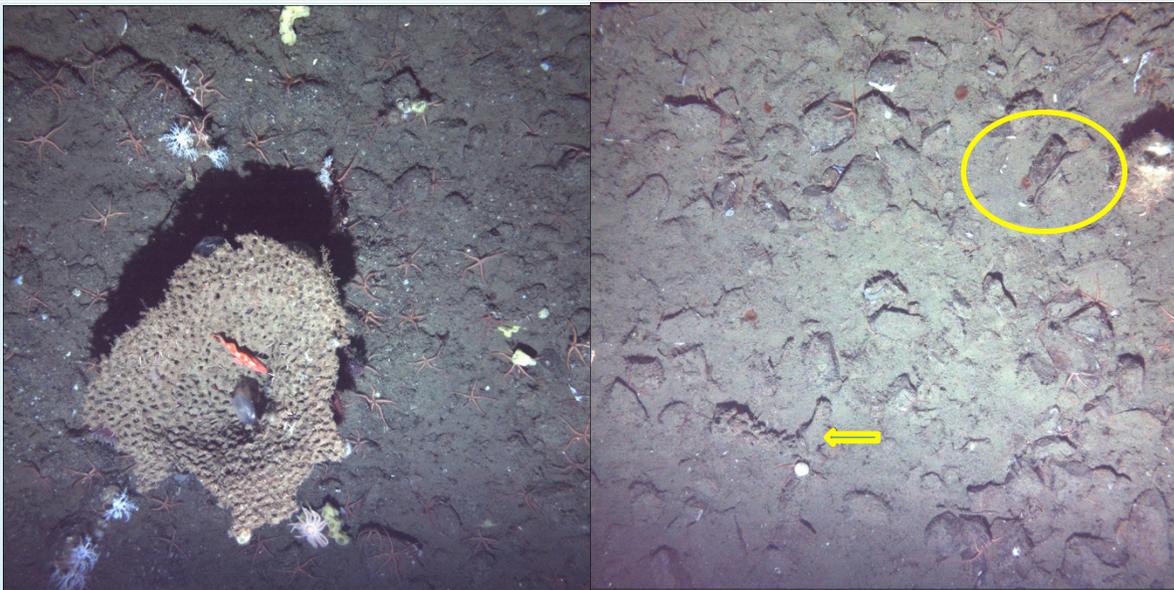
IMAGE GALLERY- AUV008



The image to the left shows ridge and cobble (hard) habitat, offering an attachment for *Farrea occa*, unidentified sponges and unidentified anemones. The rocks are also providing shelter for a blackgill rockfish (*Sebastes melanostomus*).

The image to the right shows *Mycale* spp. sponges, unidentified vase sponges and mound sponges. A Dover sole (*Microstomus pacificus*) and a deep-sea sole (*Embassichthys bathybius*) take cover among the sponges. *Psolus squamatus* cucumbers and *Rathbunaster californicus* sea stars are also present.





These images show stresses in the Piggy Bank environment, the left image shows a mud covered vase sponge that is possibly dead or dying. The right image shows a brown glass bottle and the broken bottom of a vase sponge.

**DIVE NUMBER: AUV009**

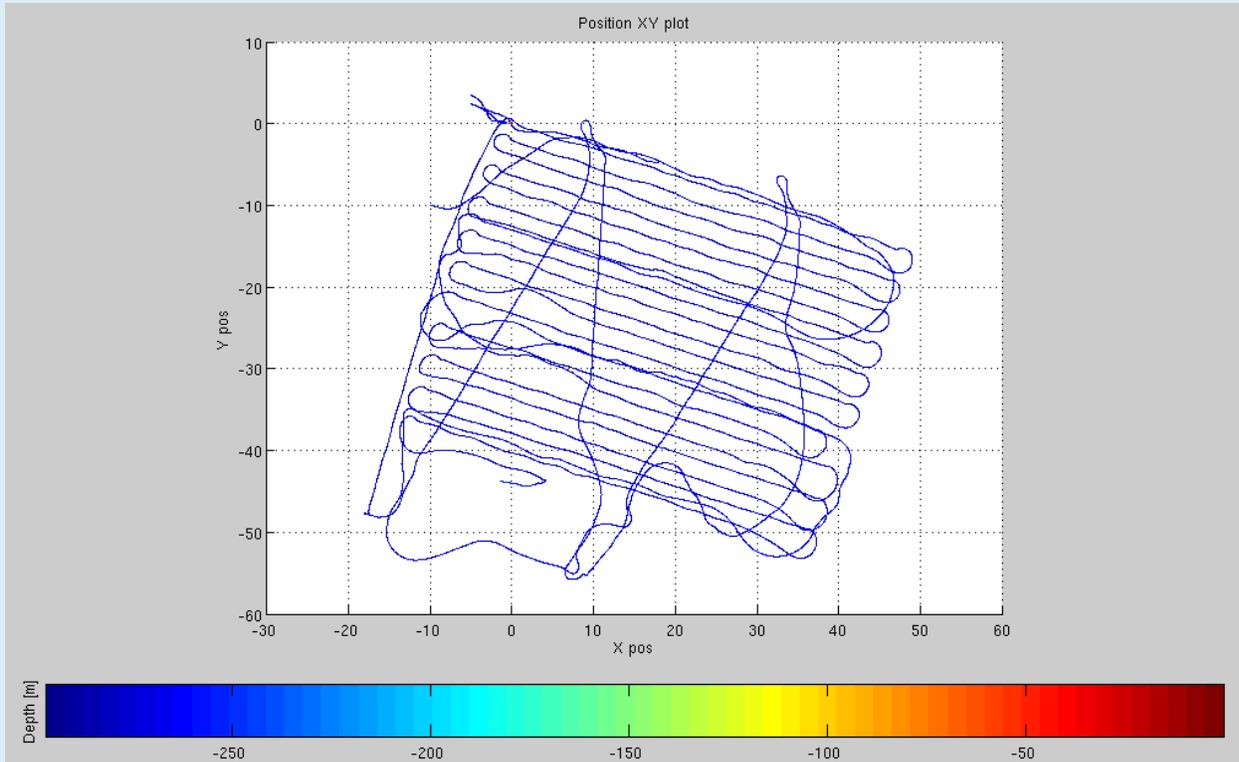
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	2529
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

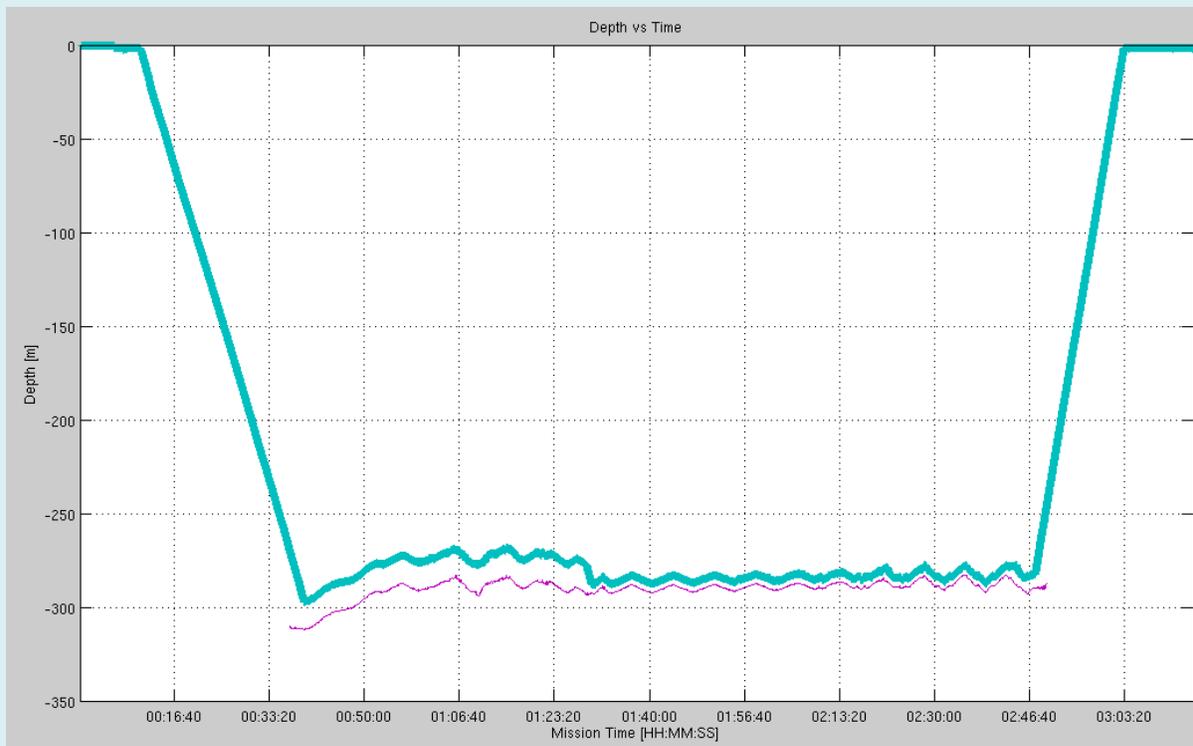
**DIVE DATA**

Date	01 July 2010	Starting Latitude (N)	33°55.28'
Maximum Bottom Depth (m)	298	Starting Longitude (W)	119°28.86'
Start Time (UTC)	10:08	Ending Latitude (N)	33°55.25'
End Time (UTC)	12:45	Ending Longitude (W)	119°28.85'

GENERAL LOCATION AND DIVE TRACK



Survey track for dive AUV009. This dive included a multibeam survey and a photo-mosaic.

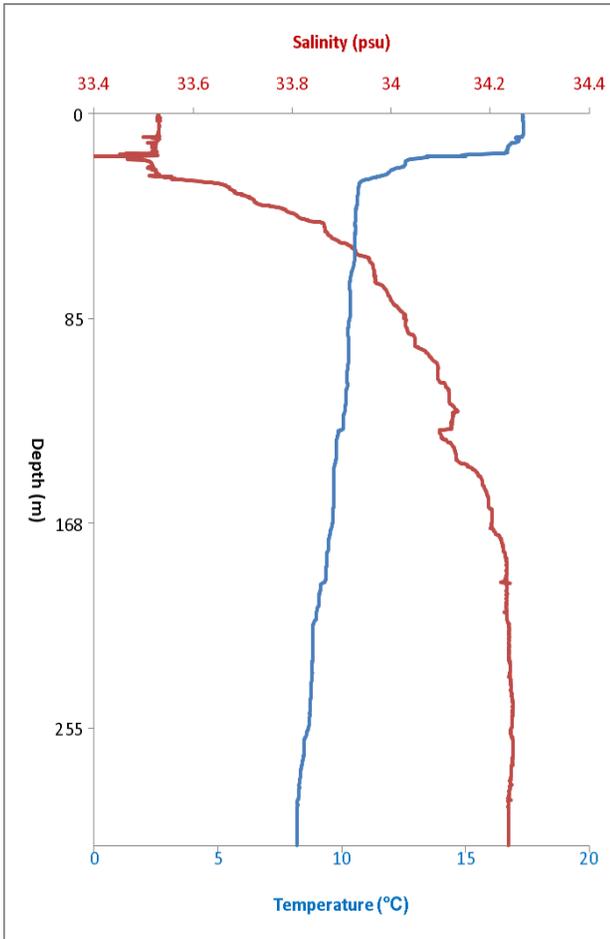


Depth track of dive AUV009 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

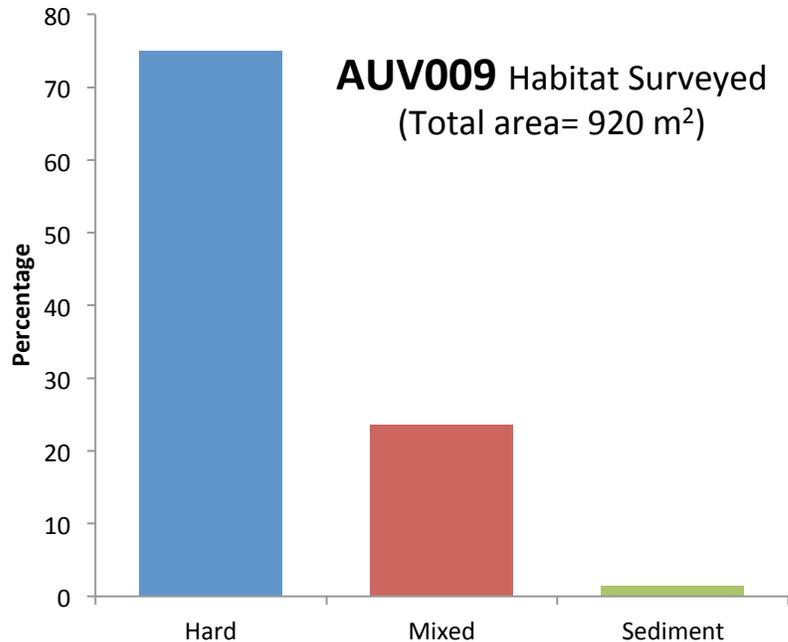
**PHYSICAL ENVIRONMENT**

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 AUV009 descent, the temperature varied from 17.32 to 8.2°C and salinity varied from 33.5 to 34.2 (psu) (Figure x).

Dive AUV009 descent temperature and salinity profiles.

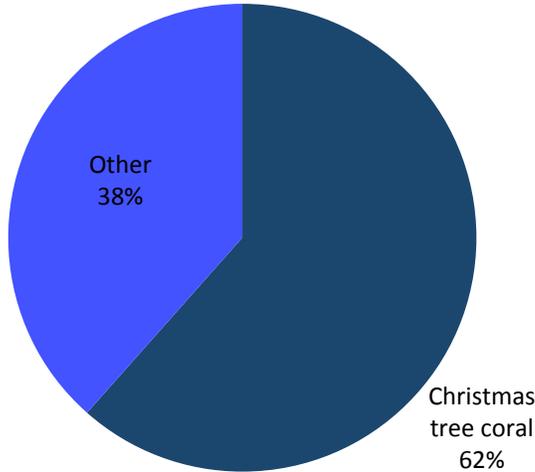


In total, 920 m<sup>2</sup> of sea floor were surveyed during dive AUV009 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (75% of the total area surveyed), which included boulders, ridge and cobble; (2) Mixed (24% of the total area surveyed), which included mud appearing with rock, boulder or cobble; and (3) Sediment (1% of the total area surveyed), which consisted of mud. This mission was flown at an altitude of 5 m.



**BIOLOGICAL ENVIRONMENT: CORALS**

**AUV009- Density of Corals**  
(28 corals/ 1,000 m<sup>2</sup>)



A total of 26 individual corals were enumerated from the 72 frames sampled from dive AUV009 conducted on the Piggy Bank from the NOAA ship *McArthur II*. This mission was conducted at an altitude of 5 meters above the seafloor. This distance did not allow for the precise level of identification of individual organisms found with the other dives. Corals were counted, allowing us to estimate a coral density of 28 corals per 1,000 m<sup>2</sup>. The taxa encountered were Christmas tree black coral (*Antipathes dendrochristos*), which comprised 62% of the overall density, and unidentified corals, which accounted for 38% of the

overall density. Cup corals (Caryophyllidae) were observed in two frames from this dive and their presence was noted, however, enumeration proved impossible due to the altitude. The pie diagram colors match with the list of coral taxa below.

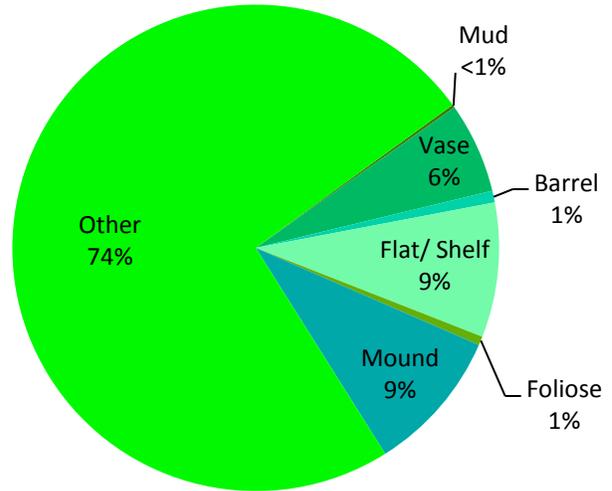
Scientific Name	Common Name	Count
<i>Antipathes dendrochristos</i>	Christmas tree black coral	16
Caryophyllidae	Unidentified cup corals	presence
Anthozoa	Unidentified coral/ sea pen	10

Dive AUV009 was designed to include both a multi-beam survey at 15 m altitude and a dense photographic survey at 5 m altitude. We counted the fauna in a non-overlapping subset from the photo mosaic portion of the dive. This altitude was not ideal for species enumeration, but allowed for gross identification and classification of habitat, invertebrates and fishes.

**BIOLOGICAL ENVIRONMENT:  
SPONGES**

A total of 514 individual sponges were enumerated from the 72 frames sampled from dive AUV009 conducted on the Piggy Bank from the NOAA ship *McArthur II*. This allowed us to estimate an overall sponge density of 558 sponges per 1,000 m<sup>2</sup>. This mission was conducted at an altitude of 5 meters above the seafloor. This distance did not allow for the same level of identification of individual organisms found with the other dives. Unidentified sponges (including *Asbestopluma* spp.) accounted for

**AUV009- Density of Sponges**  
(558 sponges/ 1,000 m<sup>2</sup>)



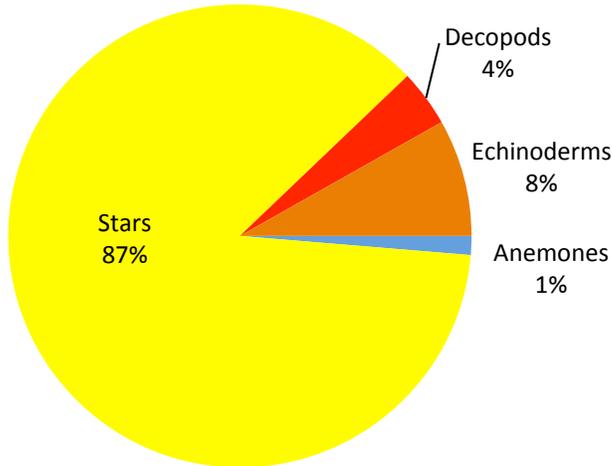
74% of the overall sponge density. Mound sponges and flat/ shelf sponges each accounted for 9% of the overall sponge density. Vase sponges (including *Staurocalyptus* spp.) comprised 6% of the density. Barrel sponges (1%), foliose sponges (1%, *Farrea occa* and *Polymastia* spp.), and mud covered sponges (<1%) complete the remaining taxa identified. The pie diagram colors match with the list of sponge taxa below.

Scientific Name	Common Name	Count
Mud Covered		1
Porifera	Unidentified vase sponges	30
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)	1
Porifera	Unidentified barrel sponges	4
Porifera	Unidentified upright flat sponges	46
<i>Polymastia</i> sp.	Nipple foliose sponges	2
<i>Farrea occa</i>	Lace (or cloud) foliose sponge	1
Porifera	Unidentified small mound sponges	2
Porifera	Unidentified mound sponges	47
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	3
Porifera	Unidentified sponges	377

**BIOLOGICAL ENVIRONMENT: OTHER INVERTEBRATES**

**AUV009- Density of Other Invertebrates**

(411 invertebrates/ 1,000 m<sup>2</sup>)



A total of 374 individual invertebrates were enumerated from the 72 frames sampled from dive AUV009 conducted on the Piggy Bank from the NOAA ship *McArthur II*. This allowed us to calculate an overall invertebrate density of 411 invertebrates per 1,000 m<sup>2</sup>. Sea stars comprised 87% of the overall invertebrate density and dominated by basket stars, *Gorgonocephalus eucnemis*. Echinoderms made up 8% of the invertebrate density; primarily sea cucumbers (*Parastichopus* spp., and *Holothuroidea*). Decapods, represented by galatheid crabs

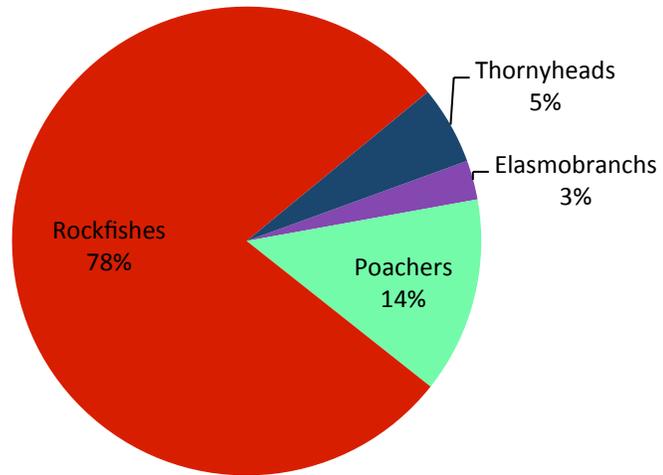
(squat lobsters) made up 4% of the overall density. *Liponema brevicornis* and other unidentified anemones made up the final 1% of the invertebrate density. The pie diagram colors match with the list of invertebrate taxa below.

Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	60
<i>Gorgonocephalus eucnemis</i>	Basket Star	231
<i>Rathbunaster californicus</i>	Deep-sea sunflower star	36
<i>Solaster</i> spp.	Deep-sea sunstar	1
Galatheoidea	Unidentified Galatheid crab	15
<i>Psolus squamatus</i>	White-scaled cucumber	1
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber	15
<i>Pannychia moseleyi</i>	Sloppy cucumber	1
Holothuroidea	Unidentified sea cucumber	10
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	4
<i>Liponema brevicornis</i>	Tentacle shedding anemone	1
Actinidae	Unidentified anemone	4

**BIOLOGICAL ENVIRONMENT: FISHES**

A total of 37 fishes were identified from the 72 frames sampled from dive AUV009 conducted on the Piggy Bank from the NOAA ship *McArthur II*. This allowed us to estimate an overall fish density of 40 fishes per 1,000 m<sup>2</sup>. Rockfishes, both unidentified and *Sebastomus* (unidentified whitespotted rockfish) made up 78% of the overall fish density. The rockfish were primarily encountered over hard substrate. Poachers (family Agonidae) comprised 14% of the overall fish density, and were found over sediment or mixed substrates. Unidentified and shortspine thornyheads accounted for 5% of fish density. Elasmobranchs (family Scyliorhinidae; unidentified catshark) made up 3% of the overall density of fishes. The pie diagram colors match with the list of fish taxa below.

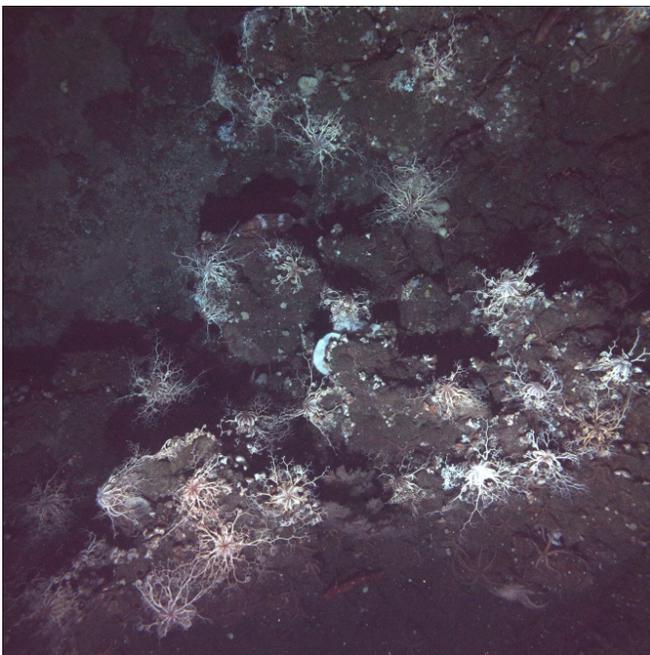
**AUV009- Density of Fishes**  
(40 fishes/ 1,000 m<sup>2</sup>)



Unidentified and shortspine thornyheads accounted for 5% of fish density. Elasmobranchs (family Scyliorhinidae; unidentified catshark) made up 3% of the overall density of fishes. The pie diagram colors match with the list of fish taxa below.

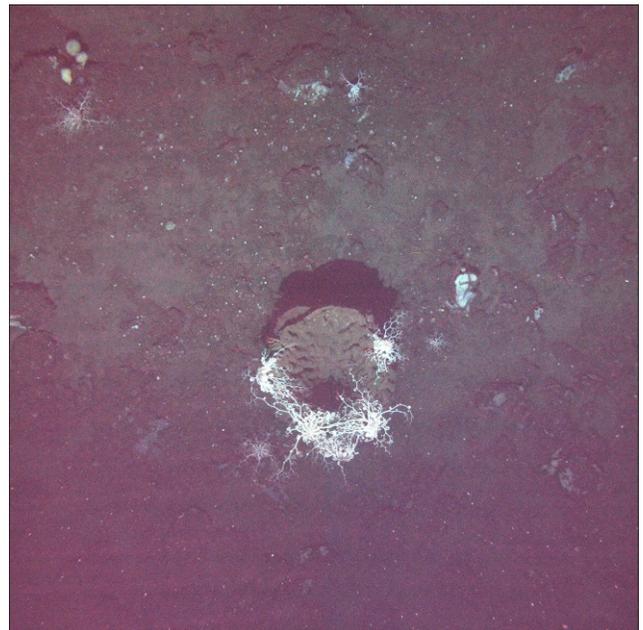
Scientific Name	Common Name	Count
Scyliorhinidae	Unidentified catshark	1
Agonidae	Unidentified poachers	5
<i>Sebastes spp.</i>	Rockfish Unid.	2
<i>Sebastomus</i>	Unidentified White-spotted RF	27
<i>Sebastolobus alascanus</i>	Shortspine thornyhead	1
<i>Sebastolobus spp.</i>	Unidentified thornyhead	1

IMAGE GALLERY- AUV009



This image shows the prevalence of the basket star, *Gorgonocephalus eucnemis*. The habitat in this image was classified as hard substrate. Whitespotted and unidentified rockfish can also be seen in this photo.

This image shows a mud covered sponge on mixed substrate. Mound sponges, galatheid crabs and basket stars (*Gorgonocephalus eucnemis*) can also be identified.



This image shows an unidentified vase sponge, basket stars (*Gorgonocephalus eucnemis*) and an unidentified thornyhead (*Sebastolobus* spp.). There are also two stands of Christmas tree black coral (*Antipathes dendrochristos*) found here on mixed substrate.



This image shows marine debris on a boulder substrate. It is an aluminum beverage can.

**DIVE NUMBER: AUV010**

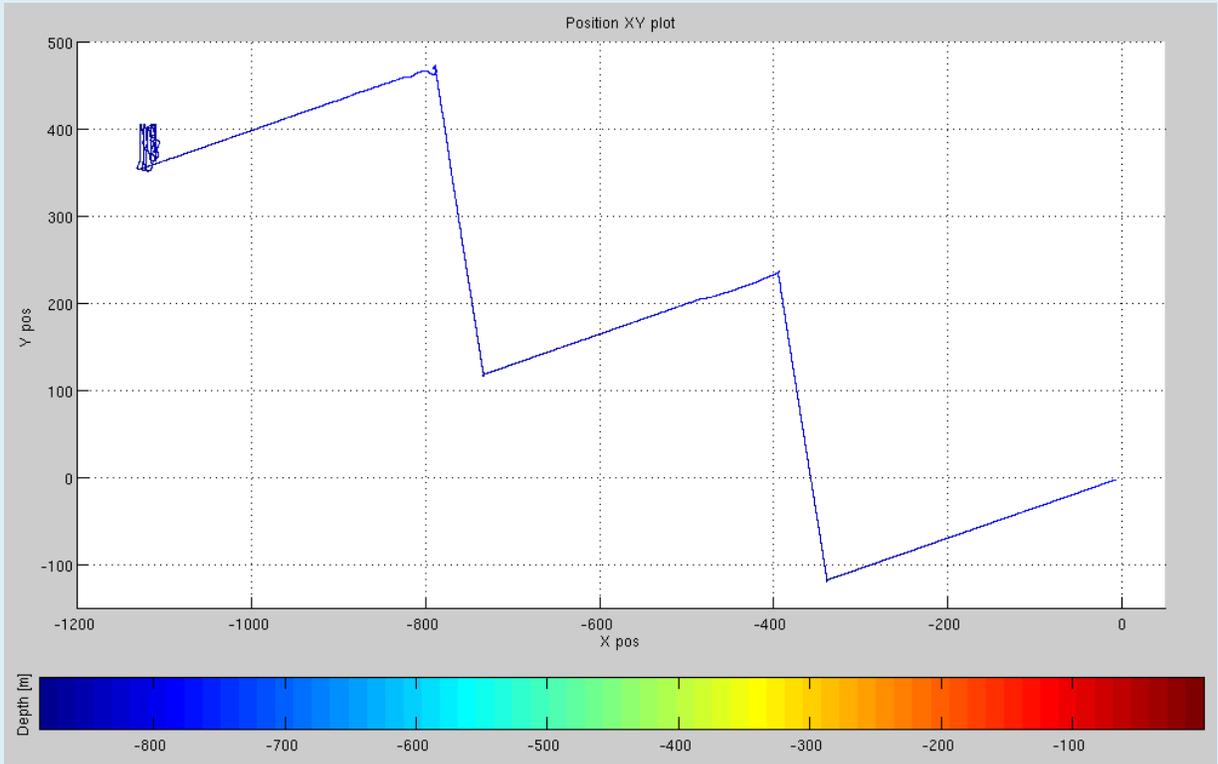
**STATION OVERVIEW**

<b>Project</b>	U.S. West Coast Deep Coral Cruise
<b>Chief Scientist</b>	M. Elizabeth Clarke
<b>Contact Information</b>	NMFS, NWFSC, elizabeth.clarke@noaa.gov
<b>Purpose</b>	Survey deep coral communities as Piggy Bank in the CINMS
<b>Vessel</b>	NOAA Ship <i>McArthur II</i> , Leg 3; <i>Lucille</i> AUV
<b>Team</b>	C. Whitmire, E. Fruh, J. Anderson, J. Taylor
<b>Digital Still Photos</b>	4181
<b>Positioning System</b>	Ship: GPS; AUV: DVL, gyrocompass, USBL
<b>CTD Sensor</b>	Yes

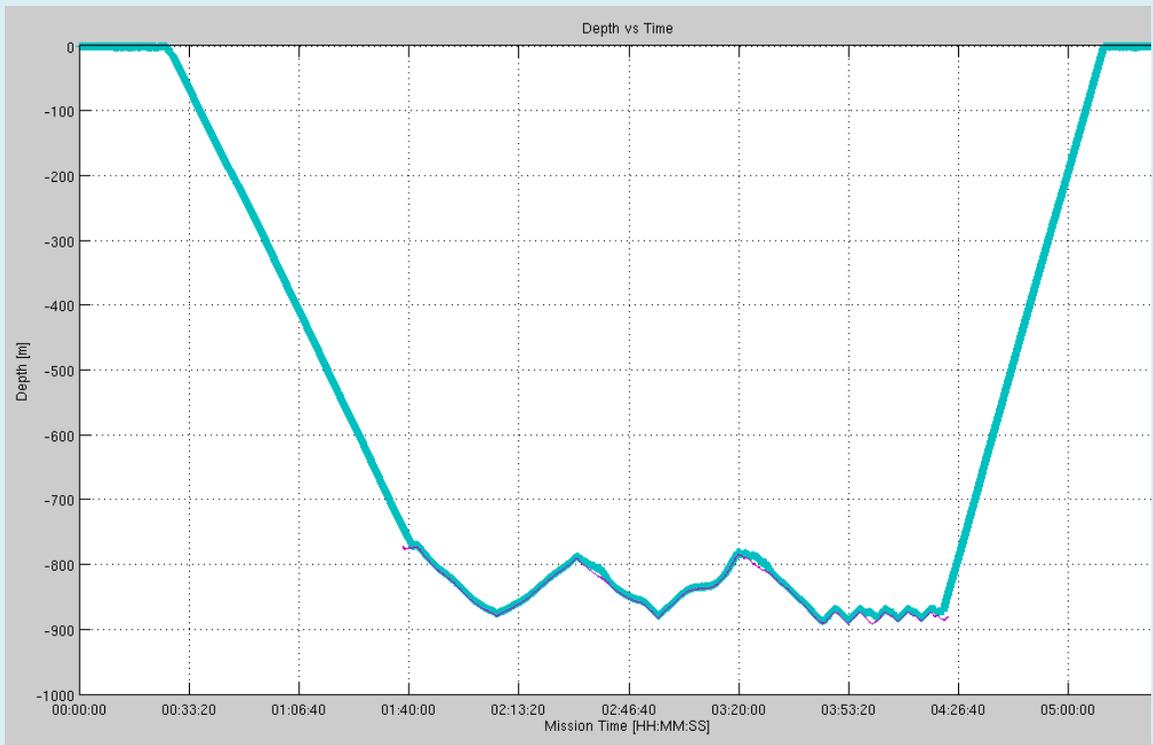
**DIVE DATA**

Date	02 July 2010	Starting Latitude (N)	33°54.39'
Maximum Bottom Depth (m)	884	Starting Longitude (W)	119°29.44'
Start Time (UTC)	03:22	Ending Latitude (N)	33°54.53'
End Time (UTC)	08:06	Ending Longitude (W)	119°30.19'

GENERAL LOCATION AND DIVE TRACK

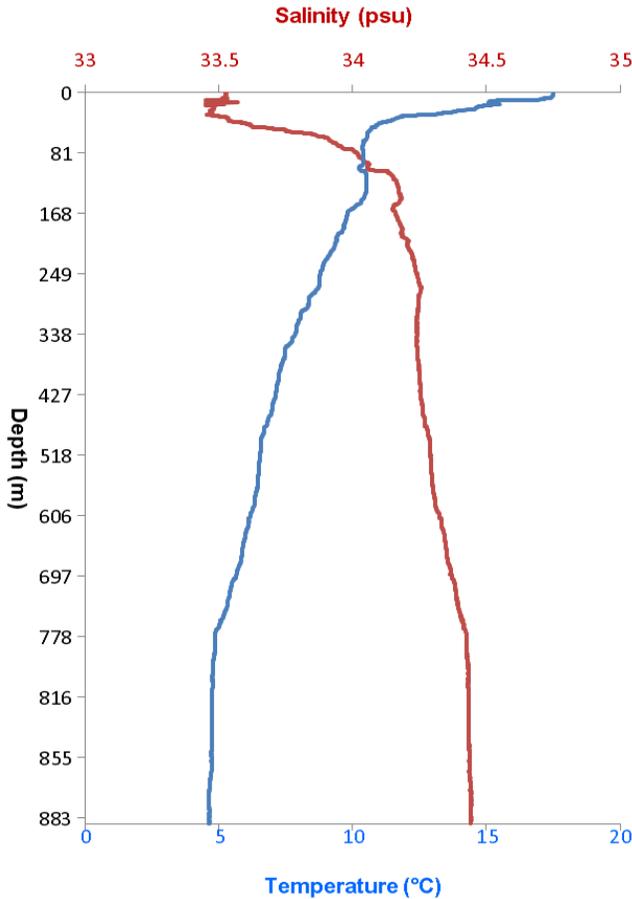


Survey track for dive AUV010. This dive went to a new depth maximum of 884 meters.



Depth track of dive AUV010 showing bottom in pink (—) and vehicle tracking bottom in teal (—).

**PHYSICAL ENVIRONMENT**

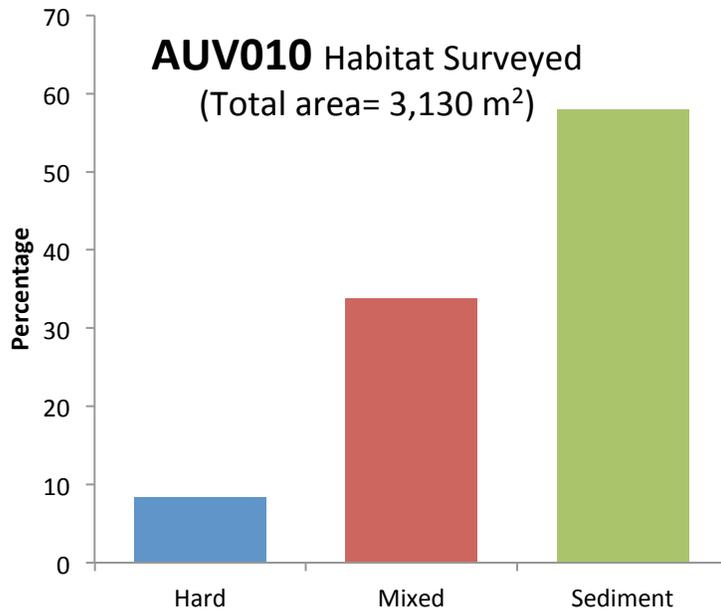


The AUV was equipped with an onboard Sea-Bird model 49 FastCat CTD that collected temperature and salinity information throughout the AUV's descent as well as along the dive track. During the dive AUV010 descent, the temperature varied from 17.5 to 4.65°C and salinity varied from 33.5 to 34.4 (psu) (Figure x).

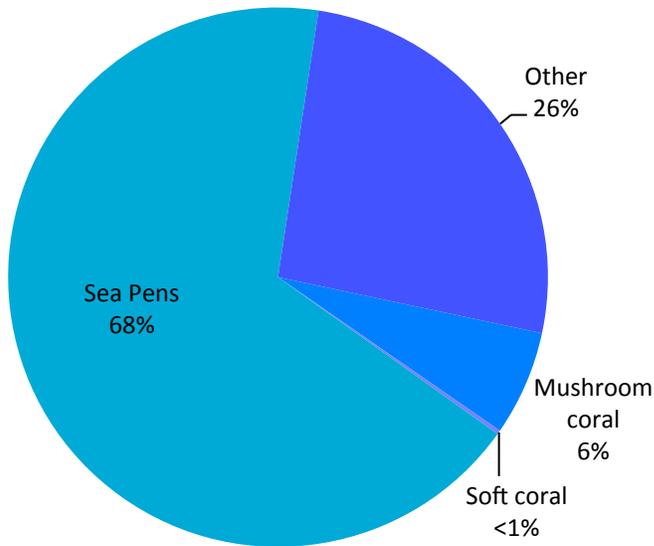
Dive AUV010 descent temperature and salinity profiles.

In total, 3,129 m<sup>2</sup> of sea floor were surveyed during dive AUV010 using the *Lucille* AUV deployed from the NOAA ship *McArthur II* on the Piggy Bank off southern California. Habitat types were classified as (1) Hard (8% of the total area surveyed), which included boulders, ridge and cobble; (2) Mixed (34% of the total area surveyed), which included mud or sand appearing with rock, boulder or cobble; and (3) Sediment (58% of the total area surveyed), which consisted of mud and/or sand. This mission was flown at an altitude of 3 meters.

**AUV010 Habitat Surveyed**  
(Total area= 3,130 m<sup>2</sup>)



**AUV010- Density of Corals**  
(137 corals/ 1,000 m<sup>2</sup>)



**BIOLOGICAL ENVIRONMENT:  
CORALS**

A total of 428 individual corals were enumerated from the 703 frames sampled from dive AUV010 conducted on the Piggy Bank from the NOAA ship *McArthur II*. This mission was conducted at an altitude of 3 meters above the seafloor. Corals were counted, allowing us to estimate a coral density of 137 corals per 1,000 m<sup>2</sup>. The taxa encountered were sea pens, comprised of Pennatulacea (unidentified sea pens), *Pennatula* spp, and *Umbellula* spp. making up 68% of the overall coral density. Other unidentified corals made up 26% of the coral density. Mushroom coral, *Anthomastus ritteri* made up 6% of the overall coral density and one occurrence of *Clavularia* spp. accounted for the final <1% of the overall density. The pie diagram colors match with the list of coral taxa below.

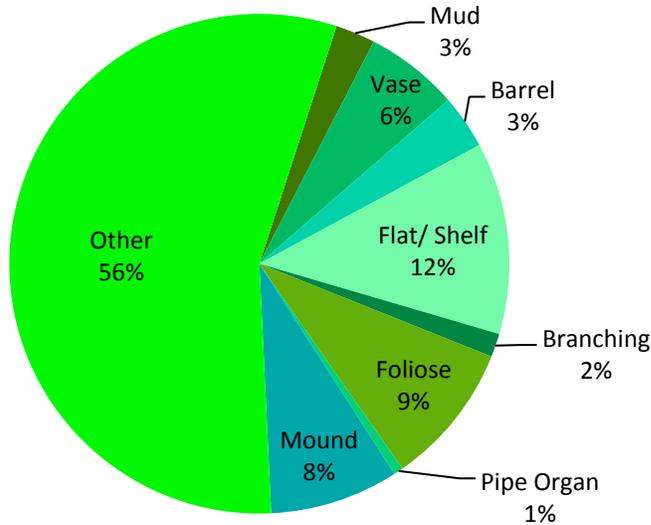
*Anthomastus ritteri* made up 6% of the overall coral density and one occurrence of *Clavularia* spp. accounted for the final <1% of the overall density. The pie diagram colors match with the list of coral taxa below.

Scientific Name	Common Name	Count
<i>Anthomastus ritteri</i>	Mushroom coral	27
<i>Clavularia</i> spp.	Soft coral	1
Pennatulacea	Unidentified sea pen	193
<i>Pennatula</i> spp.	Deep-sea sea pen	1
<i>Umbellula lindahli</i>	Droopy sea pen	95
Anthozoa	Unidentified coral	111

**BIOLOGICAL ENVIRONMENT: SPONGES**

**AUV010- Density of Sponges**

(211 sponges/ 1,000 m<sup>2</sup>)



A total of 660 individual sponges from 14 different taxonomic classifications were observed during the 703 frames sampled from dive AUV010 on Piggy Bank from the NOAA vessel *McArthur II*. An overall density of 211 sponges per 1,000 m<sup>2</sup> of seafloor was estimated. Unidentified and other (including *Asbestopluma* spp.) sponges were found to be the most abundant, accounting for 56% of the total density. Flat/ shelf type sponges were the second most numerous, accounting for 12% of the sponge density. Foliose sponges (9%, consisting of *Thenea muricata*), unidentified mound sponges (8%), and

vase sponges (6%, including *Staurocalyptus* spp. and *Heterochone calyx*) were the next most abundant taxa. Mud covered sponges (3%), barrel sponges (3%), branching sponges (2%) and unidentified pipe organ sponges (1%, possibly *Oceanapia* spp.) accounted for the remaining total density. Sponges were found on all substrate types, but increased with the presence of hard or mixed substrate. Colors in the pie chart above match the list of sponge taxa following.

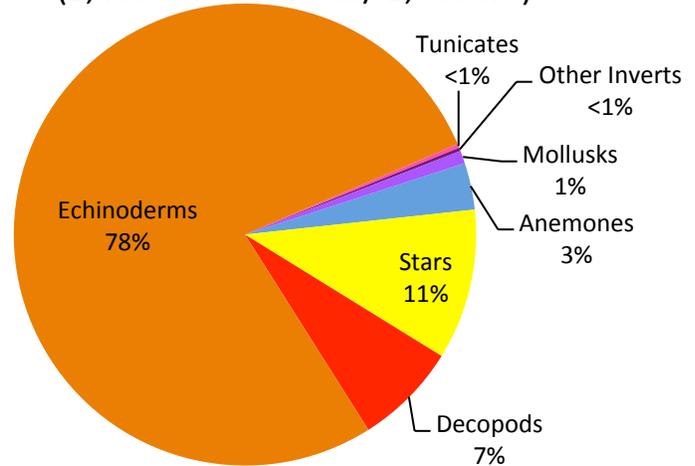
Scientific Name	Common Name	Count
Mud Covered		17
Porifera	Unidentified vase sponges	36
<i>Staurocalyptus</i> spp.	Unidentified vase sponge (yellow)	2
<i>Heterochone calyx</i>	Fingered goblet vase sponge	2
Porifera	Unidentified barrel sponges	23
Porifera	Unidentified upright flat sponges	81
Porifera	Unidentified shelf sponges	1
Porifera	Unidentified branching sponge	10
<i>Thenea muricata</i>	Foliose Sponge (clear)	61
Porifera	Unidentified pipe organ sponge	4
Porifera	Unidentified small mound sponges	33
Porifera	Unidentified mound sponges	22
<i>Asbestopluma</i> spp. #1	Pipe Cleaner Sponge	16
Porifera	Unidentified sponges	352

**BIOLOGICAL ENVIRONMENT: OTHER INVERTEBRATES**

In total, 4,583 invertebrates were enumerated during dive AUV010. This gave us an invertebrate density estimate of 1,465 invertebrates per 1,000 m<sup>2</sup>. The abundance of the fragile urchin, *Allocentrotus fragilis*, and brittlestars (Ophiocanthidae) was noted, but the individuals proved too numerous for specific counts. Other Echinoderms, comprised mostly of the sea cucumbers *Pannychia moseleyi* and *Psolus squamatus*, made up 78% of the overall invertebrate density. Sea stars accounted for 11% of the total invertebrate density. The most abundant were unidentified Asteroidea and *Brisengella* spp.

**AUV010- Density of Other Invertebrates**

(1,465 invertebrates/ 1,000 m<sup>2</sup>)



Decapods, including *Chorilia longipes* and galatheid crabs (squat lobsters) made up 7% of the total invertebrate density. Liponema brevicornis and other unidentified anemones accounted for 3% of the total density. Mollusks (1%, primarily *Acesta sponi* and unidentified nudibranchs), tunicates (<1%), and other inverts (<1%) were the remainder of the overall invertebrate density. Colors in the pie chart above match the list of invertebrate taxa following.

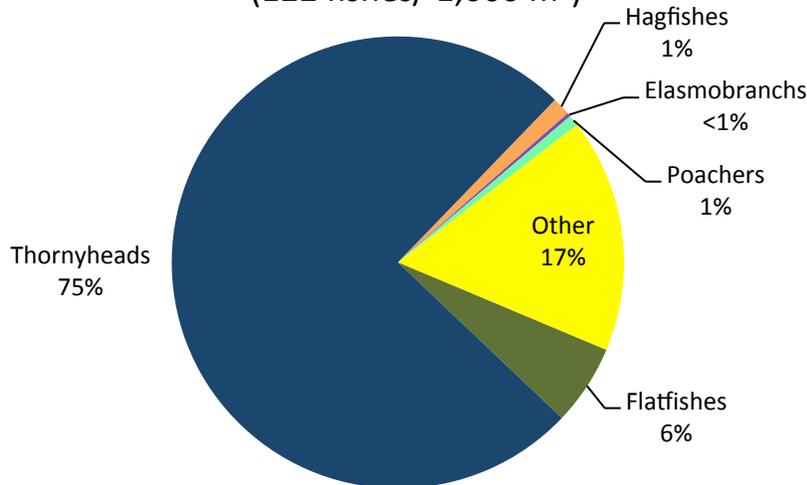
Scientific Name	Common Name	Count
Asteroidea	Unidentified Sea star	296
Ophiocanthidae	Unidentified brittlestar	presence
<i>Ceramaster</i> spp.	Cookie star	13
<i>Pteraster</i> spp.	Slime star	14
<i>Thrissacanthius penicillatus</i>	Carpet star	22
Asteroidea	Myxoderma platycanthum-like	6
<i>Hippasteria</i> spp.	Unidentified spiny star	5
<i>Zoroaster evermanni</i>	Slender star	15
<i>Dipsacaster eximius</i>	Broad sand star	9
<i>Brisingella</i> spp.	Lacy-armed star	102
Asteroidea	Unidentified mud star	1
Galatheoidea	Unidentified Galtheid crab	88
<i>Chorilia longipes</i>	Long-horned decorator crab	235
Decapoda	Unidentified shrimp	6
Decapoda	Unidentified crab	2
<i>Psolus squamatus</i>	White-scaled cucumber	31
<i>Parastichopus</i> spp.	Giant Orange/Giant California cucumber	8
<i>Pannychia moseleyi</i>	Sloppy cucumber	3493
Holothuroidea	Unidentified sea cucumber	2
<i>Brisaster</i> spp./ <i>Brissopsis</i> spp.	Unidentified mud urchin	8
<i>Allocentrotus fragilis</i>	Fragile red sea urchin	presence
<i>Florometra serratissima</i>	Feather star crinoid	13
<i>Liponema brevicornis</i>	Tentacle shedding anemone	12
Actinidae	Unidentified anemone	138
Tunicata	Unidentified tunicates	12
Unidentified invertebrate	Unidentified invertebrate	4
<i>Acesta sphoni</i>	Sphon's giant file clam	36
Opisthobranchia	Unidentified nudibranch	5
<i>Dromalia alexandri</i>	Benthic siphonophore	7

**BIOLOGICAL ENVIRONMENT: FISHES**

A total of 382 fishes were enumerated for dive AUV010. This provided an estimated fish

density of 122 fishes per 1,000 m<sup>2</sup>. The most abundant fish taxa were the thornyheads, representing 75% of the overall fish density. This is most likely due to the depth of this dive and prevalence of sediment as a habitat type. The category made up of other taxa accounted for 17% of the total fish density. This group consisted of Zoaracidae (unidentified eelpouts), Liparidae (unidentified snailfish),

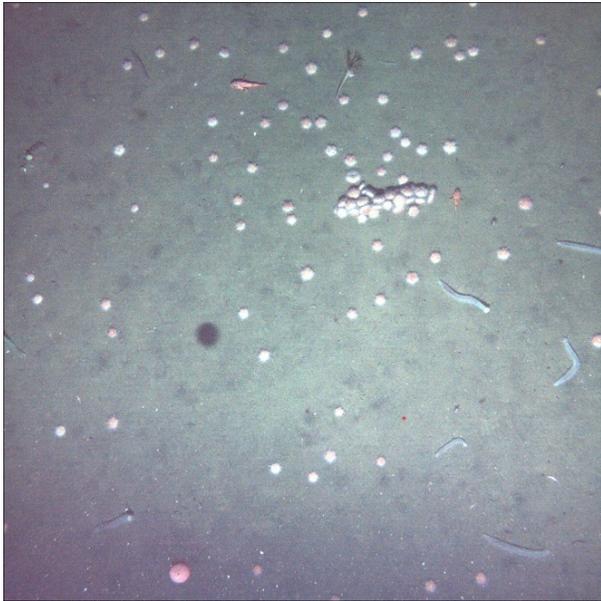
**AUV010- Density of Fishes**  
(122 fishes/ 1,000 m<sup>2</sup>)



Alepocephalidae (unidentified slickheads) and other unidentified Osteichthyes. Flatfishes, including *Microstomus pacificus* (Dover sole) and *Embassichthys bathybius* (deep-sea sole), made up 6% of the total fish density. Myxinidae (hagfishes) accounted for 1% and elasmobranchs (unidentified catsharks) accounted for the remaining <1% of the overall fish density. Colors in the pie chart above match the list of fish taxa following.

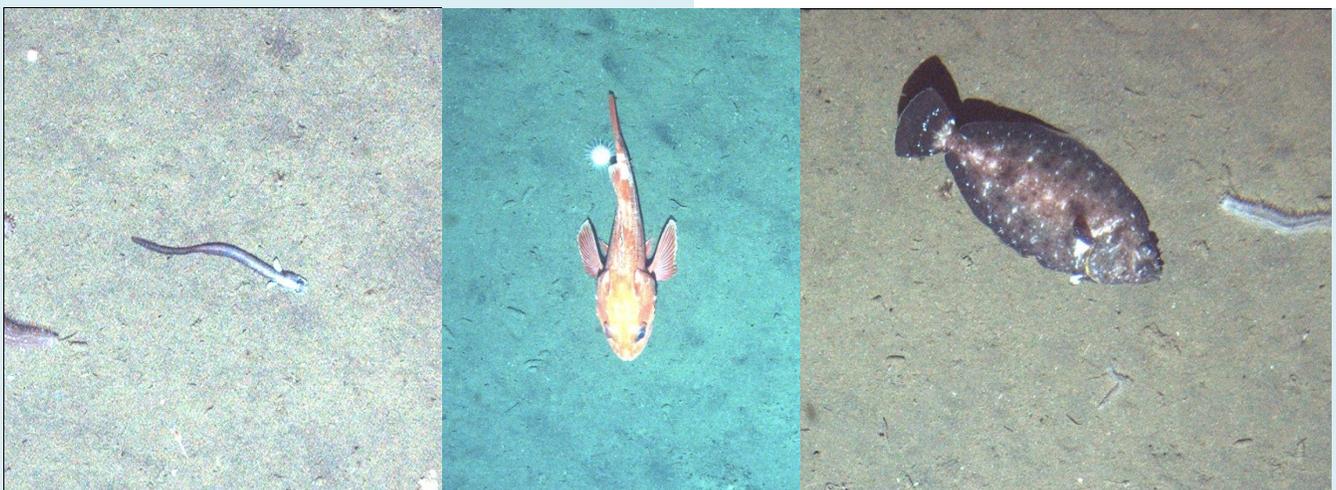
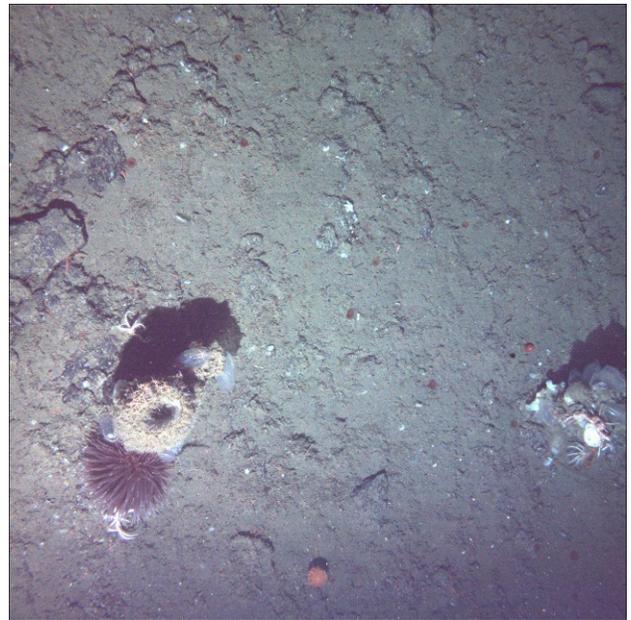
Scientific Name	Common Name	Count
Myxinidae	Unidentified hagfish	5
Scyliorhinidae	Unidentified catshark	1
Agonidae	Unidentified poachers	3
Zoaracidae	Unidentified eelpout	34
Liparidae	Unidentified snailfish	2
Alepocephalidae	Unidentified slickheads	5
Osteichthyes	Unidentified fishes	23
<i>Embassichthys bathybius</i>	Deep-sea sole	2
<i>Microstomus pacificus</i>	Dover sole	20
<i>Sebastolobus alascanus</i>	Shortspine thornyhead	38
<i>Sebastolobus</i> spp.	Unidentified thornyhead	249

IMAGE GALLERY- AUV010

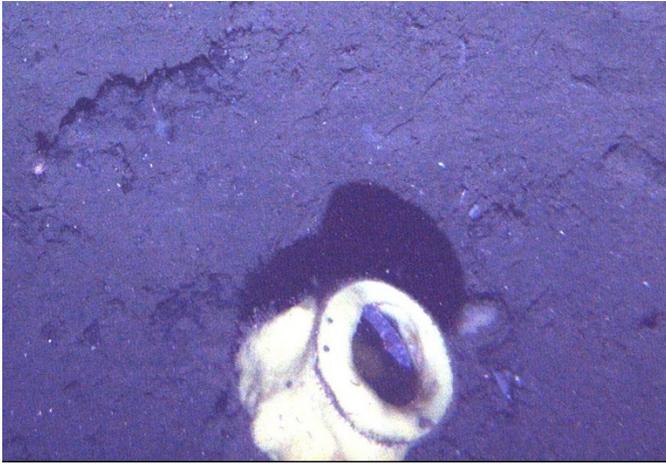


This image shows the prevalence of *Allocentrotus fragilis* urchins. Also in the image are *Pannychia moseleyi* (sloppy sea cucumbers), *Umbellula lindahli* (droopy sea pen), and *Sebastolobus* spp. (thornyheads). This image shows a typical example of the sediment habitat encountered throughout this dive.

This image shows mixed substrate with an unidentified barrel sponge, a *Liponema brevicornis* anemone, and multiple tunicates. In the bottom of the frame you will notice a benthic siphonophore (*Dromalia alexandri*). There are also several *Brisingella* spp. sea stars and a *Chorilia longipes* decorator crab in this frame.



These images show some of the more abundant fish taxa from dive AUV010. They include, from left to right, an unidentified eelpout (family Zoarcidae), a shortspine thornyhead (*Sebastolobus alascanus*) and a Dover sole (*Microstomus pacificus*), all of these fishes are shown on soft sediment substrate.



This image shows an unidentified hagfish (Myxinidae) taking shelter in a *Staurocalyptus* spp. vase sponge.

This image shows the deep water clam, *Acesta sphoni* (Sphon's giant file clam) on mixed substrate.



## CONCLUSIONS

From these AUV dives we were able to establish the presence of 21 taxa of sponges, 16 taxa of corals, 40 taxa of invertebrates and 22 taxa of fishes, many of these identified to the species level. The ecosystem in this area was diverse, with high densities of deep-sea corals and sponges in some locations. Densities ranged from 28-1,595 corals/1,000m<sup>2</sup> and 182-1,852 sponges/1,000m<sup>2</sup>. However, densities and species of both corals and sponges varied between sites. The highest densities of coral, sponges and fish were at one of the shallowest dive sites (AUV003). This area also had the highest percentage of mixed habitat. The coral community was characterized by a high density of cup corals. However, a slightly shallower dive (AUV009) had the lowest density of fish and coral. At this site a very high percentage of the area (75%) was categorized as rock. This dive was also unique since the extent track of this dive was very limited. This dive was designed to conduct detailed multibeam mapping in combination with a photographic survey of a limited area. The next lowest abundance of fish was found during dive AUV007. At this site over 75% of the area was sediment. Coral abundance was still quite high because the prevalence of sea pens. Ninety-eight percent of the corals were sea pens. Christmas tree corals were present at several sites but were the predominate species only at dive site AUV006.

There was evidence of human impacts at many of the sites. Marine debris included beverage cans and derelict fishing gear. There was also evidence of broken sponges and corals in some areas.

## CITATIONS

Love, M. S., M. Yoklavich, and D. M. Schroeder. 2009. Demersal fish assemblages in the Southern California Bight based on visual surveys in deep water. *Environmental Biology Fishes* 84:55-68.

Tissot, B., M. Yoklavich, M. Love, K. York and M. Amend. 2006. Benthic invertebrates that form habitat on deep banks off southern California, with special reference to deep-sea coral. *Fishery Bulletin* 104:167-181.