A REPORT TO
NOAA DEEP-SEA CORAL RESEARCH AND TECHNOLOGY PROGRAM
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A CHARACTERIZATION OF THE CORAL AND SPONGE COMMUNITY ON PIGGY BANK SEAMOUNT IN SOUTHERN CALIFORNIA FROM A SURVEY USING A REMOTELY OPERATED VEHICLE

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INTRODUCTION AND SCIENTIFIC OBJECTIVES

Offshore seafloor habitats in the Southern California Bight (SCB) are diverse compared to other areas of the Pacific coast, and include a number of rocky banks, seamounts, basins, and submarine canyons spanning about 75,000 km^2. SCB habitats also are influenced by a dynamic mixing of cold, nutrient-rich water from the California Current and warmer water from the south. Complexity in both the oceanographic and topographic aspects of habitat promotes highly varied assemblages of demersal organisms, which include overfished and ESA-listed species (Butler et al. 2006; Love et al. 2002; Love et al. 2009) and dense stands of deep-sea corals and sponges (DSC; Tissot et al. 2006; Bright 2007). The SCB is bordered by one of the most populated areas along the Pacific coast, with 10 million residents in the greater Los Angeles area alone. Waters of the SCB have been intensively fished both commercially and recreationally to depths over 300 m for at least 40 years; most fishing has been by lines and traps, with little trawling activities in the SCB. Competing activities and multiple stressors in this area necessitate effective spatial management of marine resources. In an effort to protect these valuable resources from harvest or damage, large conservation areas and habitat areas of particular concern have been established by the Pacific Fisheries Management Council. The State of California and NOAA's Channel Islands National Marine Sanctuary also have implemented a series of smaller marine protected areas that are closed to fishing around the Channel Islands.

As is the case worldwide, most aspects of the taxonomy, biology, and ecology of the DSC on rocky banks and seamounts in the SCB remain to be studied. Much of what we know about any of these DSC has come from chance collections during research cruises or from fisheries bycatch, and more recently from in situ observations made during visual surveys using manned submersibles and remotely operated vehicles (Tissot et al. 2006; Love et al. 2007). Such opportunities have provided new insight into the ecology of DSC and their association with valuable fisheries, and have even resulted in the discovery of new species of corals (e.g., the Christmas tree black coral [Opresko 2005; Yoklavich and Love 2005]).

In 2010, the NOAA Deep-Sea Coral Research and Technology Program (DSCRTP) initiated a three-year study to advance our understanding of 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). Our report provides a summary of the methods and results from underwater surveys of corals, sponges, and associated habitats, invertebrates, and fishes conducted during Leg 3 of the cruise using the ROV on a deep rocky seamount in the SCB. These surveys were a collaborative effort among researchers from the Southwest Fisheries Science Center (SWFSC), the University of California Santa Barbara, and the Monterey Bay Aquarium Research Institute.

The specific objectives of our research during Leg 3 were to:

1. collect baseline data on abundance, size, condition, and distribution of DSC on the Piggy Bank seamount;

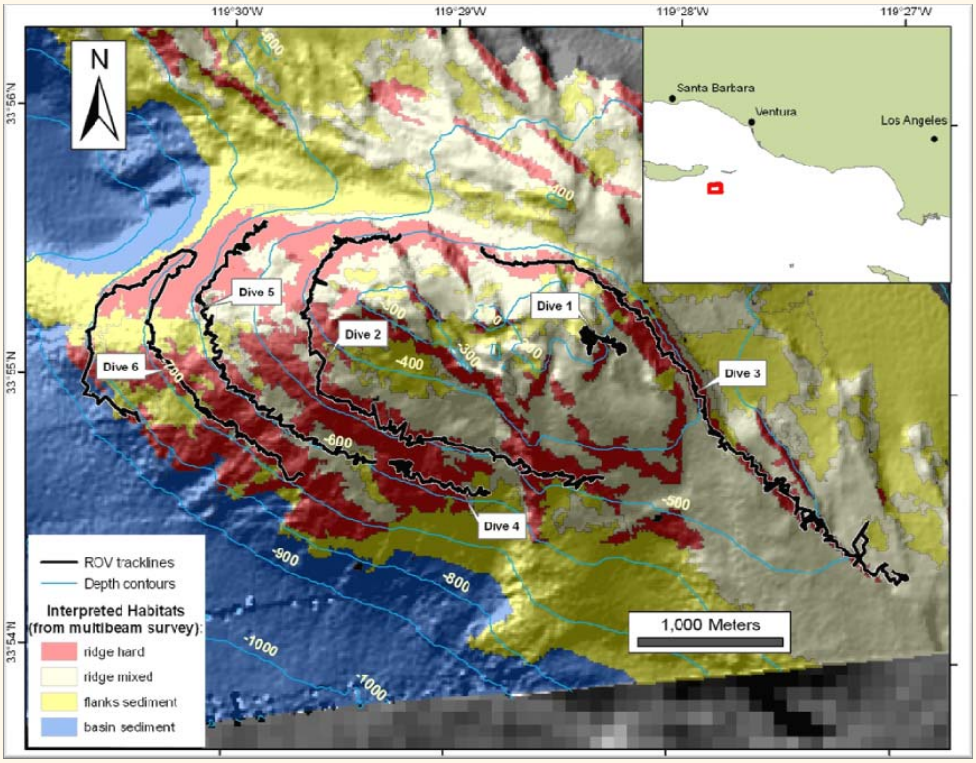
2. quantify fish and invertebrate associations with DSC to help understand the value of DSC as habitat;

3. document environmental conditions of DSC habitats, including depth, sea floor substratum types, and seawater temperature, salinity, pH, and dissolved oxygen to help understand habitat factors that influence DSC distribution; and

4. collect specimens of DSC and associated organisms for confirmation of taxonomic identifications and for genetic, reproductive, and stable isotope analyses.

STUDY SITE

The Piggy Bank seamount is located within the Channel Islands National Marine Sanctuary, in the general vicinity of 33°54.84' N and 119°28.35' W in the SCB. This seamount is about 30 km^2 in area, ranging in depth from 275 to 900 meters. It is designated as essential fish habitat (EFH) by NOAA Fisheries and the Pacific Fisheries Management Council and is within the Footprint Marine Reserve. This area is especially important because it represents extensive, deep, rocky habitats, which are uncommon within the Sanctuary, and is accessible from nearby ports and protected from adverse sea conditions (thereby improving the chance of success of this relatively short cruise).



The Piggy Bank seamount study site, located in the Southern California Bight. Six dive tracks are depicted from surveys of deep-sea coral communities using a remotely operated vehicle (ROV). Also included are habitat types interpreted from multibeam bathymetry collected prior to the visual surveys by Dartnell et al. (2005).

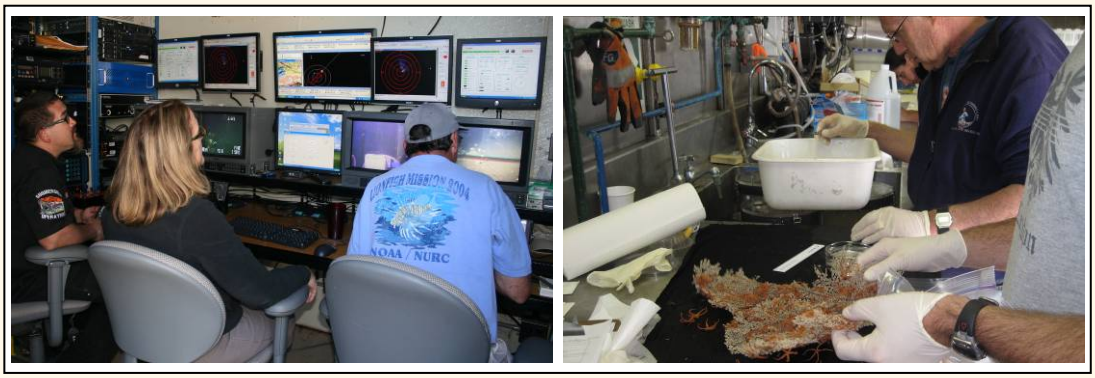
Underwater visual surveys were planned to span the entire depth range of the Piggy Bank, specifically in regions that had a high probability of comprising rocky substratum types and associated DSC communities. The shallowest parts of the Piggy Bank (275-360 meters) had been surveyed in previous years using *Delta* submersible, resulting in video tapes and still photographs of several taxa of DSC (e.g., *Lophelia* sp., *Antipathes dendrochristos*, *Paragorgia* sp.) as well as geo-referenced and mapped occurrence of demersal fishes and habitats along quantified dive tracks (Love et al. 2009). High-resolution maps of bathymetry and backscatter from multibeam acoustic surveys and associated interpreted maps of sea floor substratum types of this area also were available prior to our study (Dartnell et al. 2005; P. Dartnell, USGS unpublished data). These maps and dive information were critical in designing and locating our visual surveys.

FIELD SURVEY METHODS

Underwater surveys of corals, sponges, and associated habitats, invertebrates, and fishes were conducted using non-extractive transect methods and direct observations with University of Connecticut's *Kraken 2* ROV off of the NOAA ship *McArthur II*, 27 June – 01 July 2010. Video images were collected using a Kongsberg high-definition (HD) camera positioned forward on the ROV. Observers annotated the video images, both verbally and in a written log. The video data were captured on HD-DVCAM and HD mini-DV tapes, as well as digital files. Two parallel lasers were installed at 20 cm apart on either side of the Kongsberg HD video camera to estimate size of organisms in the images. A second video camera was positioned below the Kongsberg survey camera and was used to pilot the ROV; these video data were collected on SD-DVCAM tapes. A third video camera was used to document sample-collection activities; this footage was captured onto SD-DVCAM tapes. A digital still camera and associated strobes on the ROV were used to assist in documenting corals, sponges, and fishes. A hand-held video camera was used to document topside survey activities.

The ROV also was equipped with a Sea-Bird SBE19 CTD and associated sensors, which continuously recorded temperature, salinity, depth, pH, and oxygen concentration during the dives. Navigation data, including range and bearing from the ship to the ROV, were collected via an ORE Trackpoint II USBL system during each dive. These data were integrated with the ship's GPS using Fugro Pelagos WinFrog Version 2 software. Tracking data were provided to the science team as DAT files in ASCII format.

Biological samples were collected using a manipulator arm and suction device on the ROV, and stored in a 'bio box' onboard the ROV until completion of the dive. Immediately following the dive, these samples were processed, photographed, labeled, and stored in ethanol (or 10% buffered formalin for genetic samples), following protocols outlined in Etnoyer et al. (2006).



POST-DIVE DATA ANALYSES

The navigation data associated with the *Kraken 2* ROV contained a significant number of spurious data points, likely due to intermittent interference from the ship's fathometer, inadvertent changes to the rate of navigation output, and working in high-relief rock habitats in deep water. Consequently, we executed a series of steps to edit the navigation data and improve the accuracy of ROV location during the dives. Duplicate records were removed, and the data were filtered to remove records that exceeded the maximum possible distance (82.3 m) of the ROV from the ship and the maximum speed (1.3 m/s) of the ROV in survey mode. The edited dive tracks were plotted in ArcGIS, and additional spurious data points were removed based on the type of activities being performed by the ROV (e.g., attempting to collect specimens or being pulled off track by the ship) as noted in the dive logbook. The data then were linearly interpolated to 2-second intervals, which was the rate at which the original data generally were collected. Interpolated data were smoothed using a boxcar, running average with a 51-point window.

Varying numbers of 15-minute transects were identified from the video records of each dive. During these transects, the ROV maintained a relatively consistent speed and height off the sea floor. Quality and resolution of images from the Kongsburg HD video camera were excellent; these images were used to identify and quantify the organisms and habitats on each transect. The still camera and associated strobe that came with the ROV generally resulted in poor quality images. The length of each transect was estimated using ArcMap. The width of the survey track (i.e., field of view of the video camera) was estimated by comparing the measured distance between the laser points as observed on the video monitor to the known distance between the lasers (20 cm). Width was estimated each minute of the video because the laser distance on the monitor changed with the altitude of the ROV. The area of each transect was calculated as the product of length and average width.

Sea floor habitats were classified by type of substratum, in order of decreasing particle size and vertical relief (as described in Greene et al. 1999): rock ridge (R), boulder (B), cobble (C), flat rock (F), and mud (M). A two-character code was used to quantify patches of uniform substratum type along each transect (as described in Yoklavich et al. 2000). The primary character in the code represented the substratum type that accounted for at least 50% of the patch, and the secondary character represented the substratum type that accounted for at least 20% of the patch (e.g., CM represented a patch of at least 50% cobbles and at least 20% mud). The area of each habitat patch was estimated as the product of the transect width (measured from the paired laser dots in the field of view) and the length of the patch, as determined from the geographic position at the beginning and end of each patch.

Temperature, salinity, pH, and dissolved oxygen were processed, plotted, and analyzed using Sea-Bird Electronics' SBEDataProcessing-Win32 software. Large spikes in the data were edited with the 'window filter' module (median option), and when necessary, the 'wild edit' module.

Corals, sponges, and fishes were identified to the lowest possible taxonomic level and quantified along each 15-minute transect. Sponges were classified by general morphology (i.e., upright flat, foliose, mound, branching, barrel, and vase) because species identification generally is only possible by examination of spicules in collected specimens. Macro-invertebrates living on the corals and sponges also were identified to lowest possible taxon and classified as either mobile or sessile. Maximum width and height of each coral, height of each sponge, and total length of each fish were estimated using the set of paired lasers. Color and any physical damage to corals and sponges were noted. Distance was estimated between the fishes and the corals and sponges. Fishes were considered to be associated with corals and sponges if they were less than one body length away or in direct contact with a coral or sponge. The condition of each coral and sponge was determined to be healthy (<10% of organism is dead), dying (10-50% is dead), or dead (>50% of organism dead). Frequency and type of derelict fishing gear and other marine debris also were documented along the quantitative video transects. All collected specimens were sent to experts of the various taxonomic groups for identification.

All data, including navigation, environmental, habitat type, and information associated with the corals, sponges, and fishes, were entered into a geo-referenced, relational database in Microsoft Access. A photo database of many of the geo-referenced and annotated images of corals, sponges, and other organisms observed during this survey are available at http://swfsc.noaa.gov/DeepseaCoralImageDatabase/.

SUMMARY OF DIVES

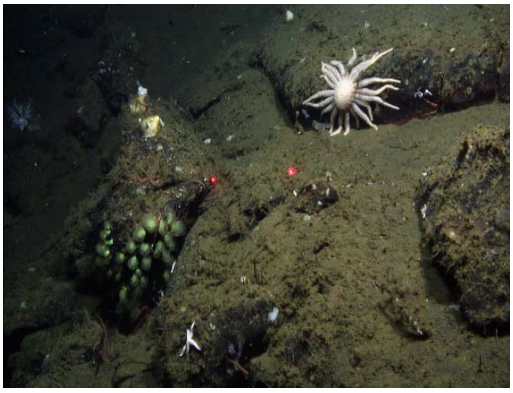
About 38 hours of video images were collected under essentially ideal sea conditions during daytime (est. 0700 - 1700) operations on six dives on the Piggy Bank seamount.

Date	PI	Dive #	Method	Start Time	End Time	Start Lat (N)	Start Long (W)	End Lat (N)	End Long (W)
27-Jun-10	M. Yoklavich	0001	ROV	14:45	19:09	33˚ 55.147’	119˚ 28.246’	33˚ 55.170’	119˚ 28.383’
28-Jun-10	M. Yoklavich	0002	ROV	09:27	16:30	33˚ 54.663’	119˚ 28.326’	33˚ 55.544’	119˚ 29.241’
29-Jun-10	M. Yoklavich	0003	ROV	08:07	16:56	33˚ 54.333’	119˚ 26.981’	33˚ 55.498’	119˚ 28.869’
30-Jun-10	M. Yoklavich	0004	ROV	08:16	10:33	33˚ 54.601’	119˚ 28.834’	33˚ 54.696’	119˚ 29.164’
30-Jun-10	M. Yoklavich	0005	ROV	11:33	17:01	33˚ 54.700’	119˚ 29.323’	33˚ 55.577’	119˚ 29.840’
01-Jul-10	M. Yoklavich	0006	ROV	08:41	17:00	33˚ 54.643’	119˚ 29.655’	33˚ 54.824’	119˚ 30.390’

A total of 21,237 m^2 of sea floor habitat was classified during the 48 quantitative transects. The original two-character-code habitat types were aggregated into three general categories for this analysis: the ‘hard’ category included rock ridge, boulder, cobble, and flat rock in various proportions; ‘mixed’ comprised rock ridge, boulder, cobble, or flat rock and mud; and ‘sediment’ was represented entirely by mud. About 30% of the surveyed area comprised hard habitat (i.e., combinations of rocks, boulders, and cobbles).

A mud sea floor (classified as sediment).

A rock ridge (classified as hard habitat).



Boulders (classified as hard habitat).

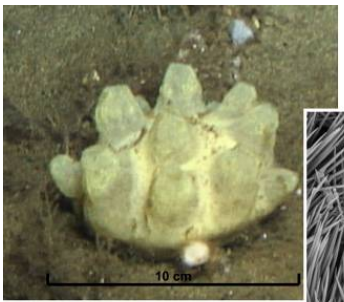
Mud and cobble (classified as mixed habitat).

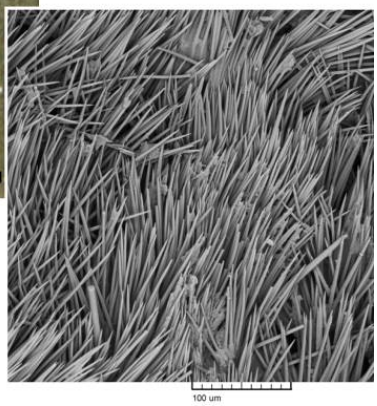
We identified 166 taxa of invertebrates and fishes from observations of the video footage during the 48 quantitative transects conducted on Piggy Bank seamount. We collected 34 specimens, including 14 corals, 13 sponges, and 7 other invertebrates (e.g., worms, tunicates, and nudibranchs), most of which have been identified by various experts. We did not routinely apply the identifications of these specimens to similar-looking organisms in the video transects. Genetic analyses remain underway on many of these samples. There were at least 26 taxa of corals quantified in the 48 transects. We observed at least 26 taxa of sponges in a variety of shapes, sizes (tiny encrusting types on rocks to those almost 3 m in height), and colors (porcelain white; pale yellow; dirty gray). Several of the sponges that we collected were sent to James Weaver (Harvard University, Cambridge, MA), from which he produced exceptional, high resolution scanning electron micrographs for identification purposes (images can be viewed at http://www.lovelab.id.ucsb.edu/corals/Cruise_Introduction). Invertebrates from 70 taxa other than corals and sponges also were quantified, many of these living on the corals and sponges. Fishes from 44 taxa were quantified on the transects.

A total of 3,160 corals, 16,153 sponges, and 2,190 fishes were enumerated along 48 transects. Densities of corals, sponges, and fishes were estimated by dividing abundance of each taxon by the area of transect. Overall densities were 95-536 corals/1000 m^2; 224–969 sponges/1000 m^2; and 77–185 fishes/1000 m^2. The most abundant corals (depending on depth) included Christmas tree black coral (*Antipathes dendrochristos*), mushroom coral (*Anthomastus ritteri*), several species of Primnoidae and Plexauridae (*Swiftia* spp.), dense stands of cup corals (*Lophelia pertusa* and *Desmophyllum dianthus*), and the sea pen (*Halipteris californica*; only on soft sediment). The most abundant sponges generally were mound, foliose, upright flat, vase, and barrel groups. The most abundant fishes were bank rockfish (*Sebastes rufus*) in rocky areas on top of the bank and thornyhead rockfish (both *Sebastolobus alascanus* and *S. altivelis*) at deeper depths largely on soft sediment. Only 148 of the 19,313 corals and sponges that were documented during the 48 transects on the six dives were associated with fishes (that is, <1% of the corals and sponges had fishes that were <1 body length away). Those fishes associated with the corals and sponges included thornyhead, aurora (*S. aurora*), and bank rockfishes, Dover sole (*Microstomus pacificus*), Pacific hagfish (*Eptatretus stoutii*), eelpouts (Zoarcidae), and catshark egg cases (Scyliorhinidae).

Below we present summaries, by dive, of the diversity and density of corals, sponges, and fishes and associated habitats observed in the 48 quantitative transects. We also present profiles of sea temperature, salinity, dissolved oxygen, and pH with depth during the dives. Health and condition of the corals and sponges are reported, along with incidence of marine debris on each dive.

This yellow, foliose sponge was collected on the Piggy Bank at 288 meters depth. Bill Austin (Khoyatan Marine Laboratory, Sidney, BC) identified it as *Polymastia* sp., noting that its occurrence is a new record for the NE Pacific and that it could be a new species. The black and white scanning electron micrograph of the sponge's spicules (produced by James Weaver, Harvard Medical School) could help in species identification.





Invertebrate and fish taxa observed from video surveys conducted with a remotely operated vehicle (ROV) on the *Piggy Bank* seamount in southern California, 27 June – 1 July 2010.

Scientific Name	Common Name	Taxon
Acanthogorgia spp.	Gold coral	Coral
Anthomastus ritteri	Mushroom coral	Coral
Anthoptilum grandiflorum	Feather boa sea pen	Coral
Antipathes dendrochristos	Christmas tree black coral	Coral
Caryophyllidae	Unidentified cup corals	Coral
Clavularia spp.	Soft coral	Coral
Desmophyllum dianthus	Cockscomb cup coral	Coral
Gorgonacea	Unidentified sea fans	Coral
Halipteris californica	Sea pen	Coral
Lophelia pertusa	White cup coral	Coral
Paracyathus spp.	Brown cup coral	Coral
Paragorgia arborea	Bubblegum coral	Coral
Paragorgia spp.	Sea fan (white w/ red polyps)	Coral
Paragorgia stephencairnsi	Sea fan (white w/ red polyps)	Coral
Parastenella ramosa	Primnoid	Coral
Pennatula phosphorea	Phosphorescent sea pen	Coral
Pennatulacea	Unidentified sea pen (thin)	Coral
Pennatulidae	Unidentified sea pen (thick)	Coral
Plexauridae #1	Swiftia type (red w/ white polyps)	Coral
Plexauridae #2	Swiftia type (red w/ yellow polyps)	Coral
Plexauridae #3	Swiftia type (red w/ unknown polyps)	Coral
Plumarella longispina	Primnoid	Coral
Swiftia pacifica	Sea fan (red w/ yellow polyps)	Coral
Umbellula lindahli	Droopy sea pen	Coral
Virgularia spp.	Sea pen	Coral
Zoantharia	Unidentified zooanthids	Coral
Asbestopluma spp. #1	Predatory pipecleaner sponge	Sponge
Asbestopluma spp. #2	Predatory sponge (clear)	Sponge
Crella spp.	Sponge	Sponge
Dragmacidon spp.	Sponge	Sponge
Farrea occa	Lace (or cloud) foliose sponge	Sponge
Heterochone calyx	Fingered goblet vase sponge	Sponge
Hexactinella spp.	Sponge (white)	Sponge
Mycale spp.	Upright flat sponge (yellow)	Sponge
Polymastia spp.	Nipple foliose sponge (yellow)	Sponge
Porifera	Unidentified barrel sponges	Sponge
Porifera	Unidentified branching sponges	Sponge
Porifera	Unidentified foliose sponges	Sponge
Porifera	Unidentified mound sponges	Sponge
Porifera	Unidentified puffball mound sponges	Sponge
Porifera	Unidentified shelf sponges	Sponge
Porifera	Unidentified sponge (blue/white)	Sponge
Porifera	Unidentified sponges	Sponge
Porifera	Unidentified tube sponges	Sponge
Porifera	Unidentified upright flat sponges	Sponge
Porifera	Unidentified vase sponges	Sponge
Staurocalyptus fasciculatus	Vase sponge (yellow)	Sponge
Staurocalyptus solidus	Vase sponge (yellow)	Sponge
Staurocalyptus spp.	Unidentified vase sponge (yellow)	Sponge
Stylocordyla spp.	Stalked sponge	Sponge
Tentorium spp.	Puffball mound sponge	Sponge
Thenea muricata	Foliose sponge (clear)	Sponge

(continued) Invertebrate and fish taxa observed from video surveys conducted with a remotely operated vehicle (ROV) on the *Piggy Bank* seamount in southern California, 27 June – 1 July 2010.

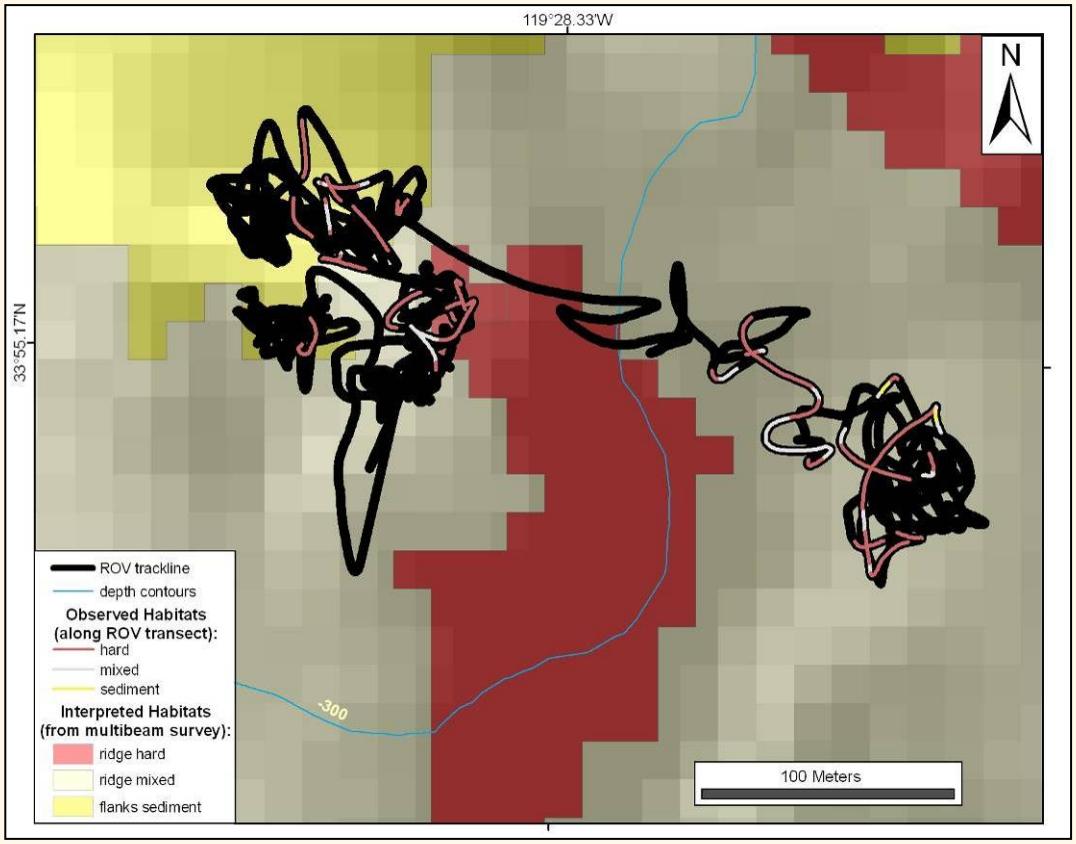
Scientific Name	Common Name	Taxon
Actinaria	Unidentified anemones	Anemone
Cerianthidae	Unidentified tube anemones	Anemone
Liponema brevicornis	Pom pom anemone	Anemone
Hirudinea	Leech	Annelid
Sabellidae	Feather duster worm	Annelid
Sabellidae (red)	Feather duster worm	Annelid
Serpulidae	Tube worm	Annelid
Terebellidae	Lanice worm	Annelid
Benthopectin spp.	Sea star	Asteroid
Brisingida	Sea star	Asteroid
Ceramaster spp.	Cushion sea star	Asteroid
Dipsacaster spp.	Sea star	Asteroid
Henricia spp.	Sea star	Asteroid
Hippasteria spp.	Sea star	Asteroid
Myxoderma sacculatum	Sea star	Asteroid
Poraniopsis inflata	Spiny sea star	Asteroid
Pterasteridae	Sea star	Asteroid
Rathbunaster californicus	Sea star	Asteroid
Solaster spp.	Sea star	Asteroid
Stylasterias forreri	Fish eating star	Asteroid
Bacterial mat (orange, white)	Bacteria	Bacteria
Asteronyx spp.	Brittle star	Brittle star
Gorgonocephalus eucnemis	Basket star	Brittle star
Ophiocanthidae	Brittle star	Brittle star
Ophiuroidea	Brittle star	Brittle star
Bryozoan	Bryozoan	Bryozoan
Dosidicus gigas	Humboldt squid	Cephalopod
Enteroctopus spp.	Giant octopus	Cephalopod
Gonatus spp.	Squid	Cephalopod
Octopus spp.	Octopus	Cephalopod
Polyplacophora	Chiton	Chiton
Acesta sphoni	Clam	Clam
Vesicomyidae	Vesicomyid clam	Clam
Chionoecetes spp.	Crab	Crab
Chorilia spp.	Decorator crab	Crab
Lithodidae	Crab	Crab
Munida spp.	Squat lobster	Crab
Florometra serratissima	Sea lily	Crinoid
Cydippida	Comb jelly	Ctenophore
Lobata	Lobate comb jelly	Ctenophore
Cucumariidae	Sea cucumber	Cucumber
Pannychia moselyi	Sea cucumber	Cucumber
Parastichopus californicus	California sea cucumber	Cucumber
Parastichopus spp.	Sea cucumber	Cucumber
Psolus squamatus	Sea cucumber	Cucumber
Calliostoma spp.	Top snail	Gastropod
Neptunea spp.	Whelk	Gastropod
Hydrozoa	Hydroid	Hydrozoa
Caprellidae	Skeleton shrimp	Amphipod
Aegina spp.	Jelly (clear)	jelly
Cnidaria	Jelly (dark red)	jelly
Poralia spp.	Jelly (red)	jelly
Mysidacea	Mysid	Mysid
Cladobranchia	Aeolid nudibranch	Nudibranch
Dendronotus spp.	Dendronotus nudibranch	Nudibranch
Tritonia diomedea	Giant orange nudibranch	Nudibranch
Tritonioidea	Nudibranch (orange)	Nudibranch
Polychaeta	Polychaete (purple)	Polychaete
Pandalopsis spp.	Shrimp	Shrimp
Apolemia spp.	Siphonophore	Siphonophore
Dromalia alexandri	Siphonophore	Siphonophore
Nanomia spp.	Siphonophore	Siphonophore
Aplidium spp. #1	Tunicate (fluorescent green)	Tunicate
Aplidium spp. #2	Tunicate (white)	Tunicate
Bathocordaeus spp.	Larvacean	Tunicate
Cnemidocarpa spp.	Red sea squirt	Tunicate
Corynascidia spp.	Tunicate (clear)	Tunicate
Megalodicpoia hians	Predatory tunicate	Tunicate
Tunicata	Tunicate (white, colonial)	Tunicate
Allocentrotus fragilis	Fragile urchin	Urchin

(continued) Invertebrate and fish taxa observed from video surveys conducted with a remotely operated vehicle (ROV) on the *Piggy Bank* seamount in southern California, 27 June – 1 July 2010.

Scientific Name	Common Name	Taxon	Scientific Name	Common Name	Taxon
Agonidae	Unidentified poachers	Fish	*Parophrys vetulus*	English sole	Fish
Alepocephalus tenebrosus	California slickhead	Fish	*Plectobranchus evides*	Bluebarred prickleback	Fish
Anoplopoma fimbria	Sablefish	Fish	Pleuronectiformes	Unidentified flatfishes	Fish
Bathyraja trachura	Black skate	Fish	*Raja rhina*	Longnose skate	Fish
Careproctus melanurus	Blacktail snailfish	Fish	Scyliorhinidae	Unidentified catsharks	Fish
Cottidae	Unidentified sculpins	Fish	Scyliorhinidae	Unidentified catshark egg cases	Fish
Embassichthys bathybius	Deepsea sole	Fish	*Sebastes aurora*	Aurora rockfish	Fish
Eptatretus stoutii	Pacific hagfish	Fish	*Sebastes diploproa*	Splitnose rockfish	Fish
Glyptocephalus zachirus	Rex sole	Fish	*Sebastes helvomaculatus*	Rosethorn rockfish	Fish
Hydrolagus colliei	Spotted ratfish	Fish	*Sebastes jordani*	Shortbelly rockfish	Fish
Icelinus spp.	Icelinid sculpins	Fish	*Sebastes melanostomus*	Blackgill rockfish	Fish
Leuroglossus stilbius	California smoothtongue	Fish	*Sebastes rufus*	Bank rockfish	Fish
Liparidae	Unidentified snailfishes	Fish	*Sebastes* spp.	Unidentified rockfishes	Fish
Lycenchelys crotalinus	Snakehead eelpout	Fish	*Sebastes* spp.	Young-of-the-year rockfishes	Fish
Lycodapus spp.	Unidentified eelpouts	Fish	*Sebastolobus alascanus*	Shortspine thornyhead	Fish
Melanostigma pammelas	Midwater eelpout	Fish	*Sebastolobus altivelus*	Longspine thornyhead	Fish
Merluccius productus	Pacific hake	Fish	*Sebastolobus* spp.	Unidentified thornyheads	Fish
Microstomus pacificus	Dover sole	Fish	Sebastomus	Unidentified rockfishes	Fish
Myctophidae	Unidentified lanternfishes	Fish	*Squalus acanthias*	Spiny dogfish	Fish
Nezumia liolepis	Smooth grenadier	Fish	Sternoptychidae	Undentified hatchetfishes	Fish
Nezumia stelgidolepis	California grenadier	Fish	*Torpedo californica*	Pacific electric ray	Fish
Osteichthyes	Unidentified fishes	Fish	Zoarcidae	Unidentified eelpouts	Fish

DIVE NUMBER: ROV 0001 *STUDY AREA: Piggy Bank*

GENERAL LOCATION AND DIVE TRACK



STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Yoklavich
Contact Information	NMFS, SWFSC, mary.yoklavich@noaa.gov
Purpose	Survey deep coral communities at Piggy Bank off southern CA
Vessel	NOAA Ship *McArthur II* Leg 3; *Kraken 2* ROV
Science Observers	L. Krigsman, T. Laidig, M. Love, L. Lundsten, A. Taylor
External Video Tapes	1 HD, 3 SD
Internal Video Tapes	n/a
Digital Still Photos	138
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	No
O_2 Sensor	No
pH Sensor	No
Specimens collected	Yes
Other	Logbook, Access database
Report Analyst	D. Watters
Date Compiled	11 May 2011

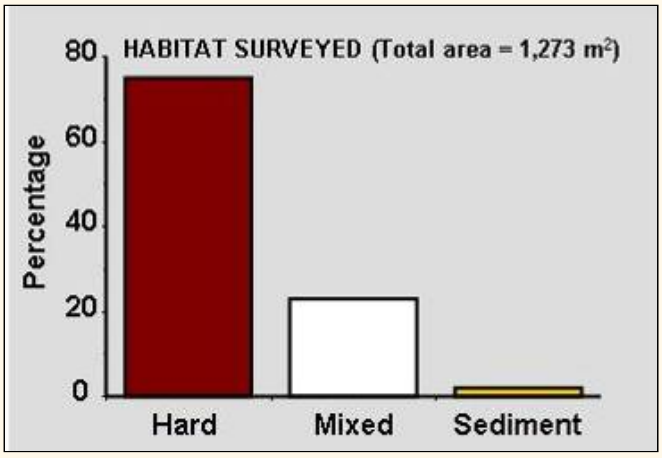
DIVE NUMBER: ROV 0001 *STUDY AREA: Piggy Bank*

DIVE DATA

Date	27 June 2010	Starting Latitude (N)	33° 55.147’
Minimum Bottom Depth (m)	275	Starting Longitude (W)	119° 28.246’
Maximum Bottom Depth (m)	322	Ending Latitude (N)	33° 55.170’
Start Bottom Time (PDT)	14:45	Ending Longitude (W)	119° 28.383’
End Bottom Time (PDT)	19:09	Surface Current	n/a
Number 15-min Transects	2	Bottom Current	Light, westerly

PHYSICAL ENVIRONMENT

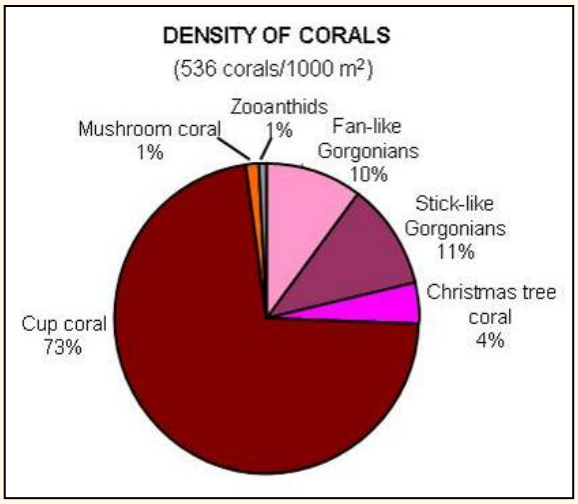
In total, 1,273 m^2 of sea floor were surveyed during 2 quantitative transects conducted during Dive 0001 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the top of seamount *Piggy Bank* off southern California. Habitat types were classified as (1) Hard (75% of the total area surveyed), which included large boulders, rock outcrops, and some cobbles; (2) Mixed (23% of the total area surveyed), including a combination of mud with boulder, cobbles, or rock; and (3) Sediment (2% of the total area surveyed), which consisted entirely of mud.



The ROV was not equipped with CTD, pH, or O_2 sensors during Dive 0001.

BIOLOGICAL ENVIRONMENT: CORALS

A total of 727 individual corals, comprising at least 14 taxa, were enumerated from 2 quantitative transects conducted during Dive 0001 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the top of seamount *Piggy Bank* off southern California. An overall density of 536 corals per 1,000 m^2 of sea floor was estimated. Cup corals accounted for 73% of the coral density on Dive 0001. The remaining coral density comprised fan-like gorgonians (10%, including *Acanthogorgia* spp., *Paragorgia* spp., *Plumarella longispina*, *Paragorgia arborea*, *Parastenella ramosa*), stick-like gorgonians (11%, including both *Swiftia* spp. and *Euplexaura* spp., which could not be distinguished reliably from the video footage alone), the Christmas tree black coral (4%, *Antipathes dendrochristos*), the mushroom coral (1%, *Anthomastus ritteri*), and unidentified zooanthids (1%). All of these corals occurred on either hard or mixed habitats.



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

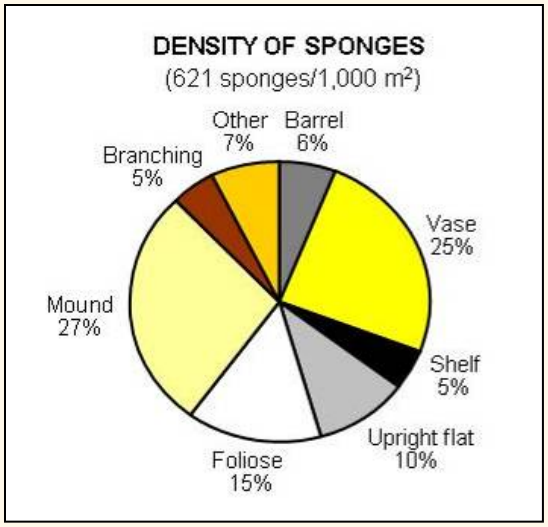
Scientific name	Common name	Number
Corals		
Acanthogorgia spp.[1]	Gold coral	1
Paragorgia arborea	Bubblegum coral	14
Paragorgia spp.	Sea fan (white w/ red polyps)	2
Parastenella ramosa	Primnoid	48
Plumarella longispina[1]	Primnoid	4
Plexauridae #1 (*Swiftia* type)	Sea fan (red w/ white polyps)	74
Plexauridae #2 (*Swiftia* type)	Sea fan (red w/ yellow polyps)	2
Swiftia pacifica[1]	Sea fan (red w/ yellow polyps)	1
Antipathes dendrochristos	Christmas tree black coral	28
Caryophyllidae	Unidentified cup corals	169
Desmophyllum dianthus[1]	Cockscomb cup coral	81
Lophelia pertusa[1]	White cup coral	288
Anthomastus ritteri	Mushroom coral	9
Zoantharia[1]	Unidentified zooanthids	6

[1]Specimen sent to experts for identification

Six coral specimens were collected during Dive 0001 and sent to experts for identification. Stephen Cairns (National Museum of Natural History, Smithsonian Institution, Washington DC) identified the golden primnoid (*Acanthogorgia* spp.), the pale pink primnoid (*Plumarella longispina*), and the cup corals (*Lophelia pertusa* and *Desmophyllum dianthus*). Beth Horvath (Westmont College, Santa Barbara, CA) identified the gorgonian (*Swiftia pacifica*); this specimen was red with yellow polyps. Specimens of a tan-colored zoanthid were sent to Tim Swain (Biodiversity Synthesis Center, Field Museum of Natural History, Chicago, IL), and we await his response.

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 776 individual sponges from at least 18 different taxa were enumerated from 2 quantitative transects conducted during Dive 0001 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the top of seamount *Piggy Bank* off southern California. An overall density of 621 sponges per 1,000 m^2 of sea floor was estimated. Mound sponges were most abundant (27% of the total density), followed by vase (25%, *Heterochone calyx* and others), foliose (15%, *Farrea* occa, *Polymastia* spp., *Thenea muricata*, and others), upright flat (10%, *Mycale* spp. and others), barrel (6%), branching (5%), and shelf (5%) sponges. The category 'Other' represented 7% of the total sponge density and included at least five taxa (i.e., the predatory sponge *Asbestopluma* spp. #1, *Stylocordyla* spp., and several unidentified sponges). Most of the sponges occurred on hard and mixed habitats.



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

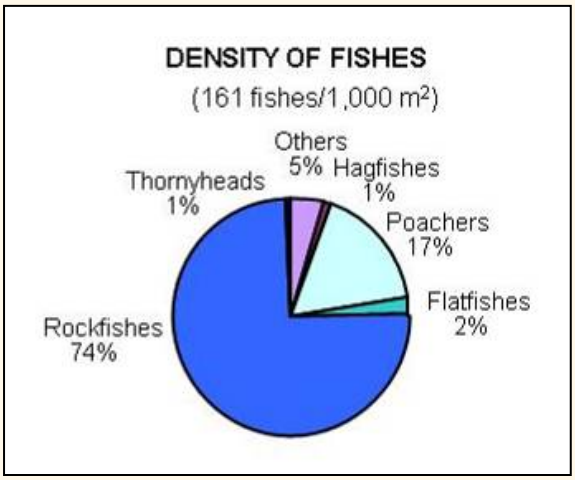
Scientific name	Common name	Number
Sponges		
Porifera	Unidentified barrel sponges	46
Heterochone calyx	Fingered goblet vase sponge	8
Porifera	Unidentified vase sponges	190
Porifera	Unidentified shelf sponges	36
Mycale spp.	Upright flat sponge (yellow)	20
Porifera	Unidentified upright flat sponges	61
Farrea occa	Lace (or cloud) foliose sponge	2
Polymastia spp.[1]	Nipple foliose sponge (yellow)	53
Thenea muricata	Foliose sponge (clear)	24
Porifera	Unidentified foliose sponges	34
Porifera	Unidentified mound sponges	192
Porifera	Unidentified puffball mound sponges	17
Porifera	Unidentified branching sponges	37
Asbestopluma spp. #1	Predatory pipecleaner sponge	19
Porifera	Unidentified tube sponges	3
Porifera	Unidentified sponge (blue/white)	23
Porifera	Unidentified sponges	8
Stylocordyla spp.[1]	Stalked sponge	3

[1]Specimen sent to experts for identification

Four Demospongia specimens were collected during Dive 0001 and sent to William Austin (Khoyatan Marine Laboratory, Sidney, BC) for identification. He has identified the yellow, foliose nipple sponge (*Polymastia* sp.), the stalked sponge (*Stylocordyla* spp.), a cream-colored *Crella* sp., and a cream-colored *Dragmacidon* sp.; the latter two taxa were collected off-transect and therefore not listed in the sponge table for Dive 0001. All of these are new records for the northeastern Pacific, and all likely are new species. These sponges also were sent to James Weaver (University California Santa Barbara, now at Harvard University); he has produced some exceptional, high resolution scanning electron micrographs for identification purposes.

BIOLOGICAL ENVIRONMENT: FISHES

At least 14 taxa of fishes were identified during Dive 0001 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on top of the seamount *Piggy Bank* off southern California. A total of 214 individual fishes were enumerated, and an overall density of 161 fishes per 1,000 m^2 of sea floor was estimated from 2 quantitative transects. At least five species of rockfishes (*Sebastes*) dominated by bank (*S. rufus*) comprised 74% of fish density. The remainder of the fish assemblage included poachers (17%), flatfishes (2%), hagfishes (1%, *Eptatretus stoutii*), and thornyheads (1%, *Sebastolobus* spp.). The category 'Others' represented 5% of the total fish density and included at least four taxa, including sculpins, lanternfishes, and the blue-barred prickleback (*Plectobranchus evides*).



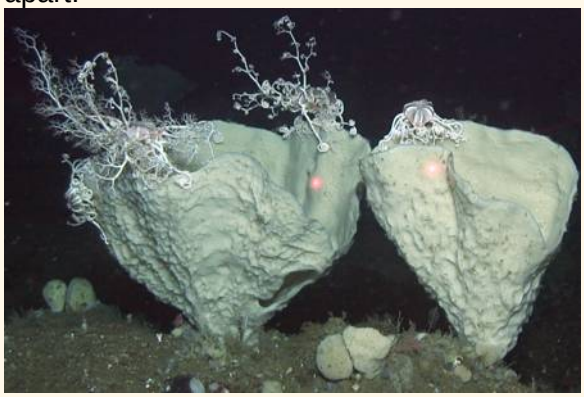
Colors in pie diagram match colors in list of fish taxa (below).

Only one of the 1,503 corals and sponges that were documented during the two transects on Dive 0001 was associated with a fish (i.e. a bank rockfish was resting on top of a shelf sponge).

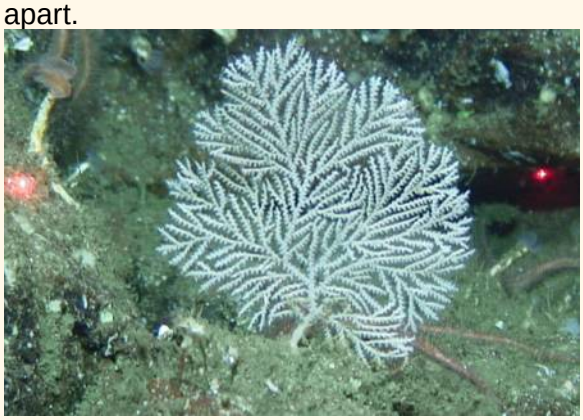
Scientific name	Common name	Number
Fishes		
Eptatretus stoutii	Pacific hagfish	2
Agonidae	Unidentified poachers	35
Microstomus pacificus	Dover sole	3
Pleuronectiformes	Unidentified flatfish	1
Sebastes diploproa	Splitnose rockfish	1
Sebastes rufus	Bank rockfish	134
Sebastes spp.	Unidentified rockfishes	5
Sebastes spp.	Young-of-the-year rockfish	1
Sebastomus	Unidentified rockfishes	22
Sebastolobus spp.	Unidentified thornyhead	1
Cottidae	Unidentified sculpins	3
Myctophidae	Unidentified lanternfish	1
Osteichthyes	Unidentified fish	1
Plectobranchus evides	Bluebarred prickleback	4

IMAGE GALLERY

Two unidentified vase sponges on rock outcrop at 286 m depth. Paired lasers (red dots) are 20 cm apart.

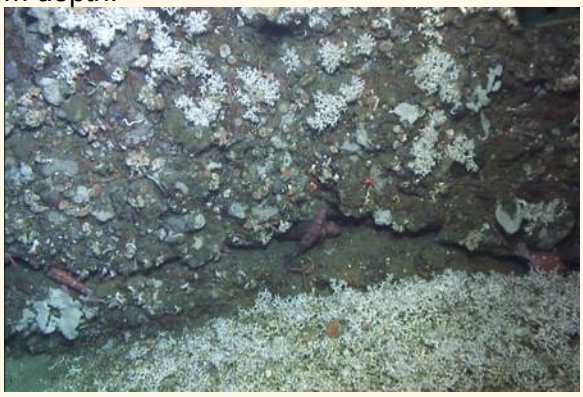


Plumarella longispina on large boulder at 318 m depth. Paired lasers (red dots) are 20 cm apart.



Lophelia pertusa (small white cup corals) and *Desmophyllum dianthus* (large peach cup corals) on rock outcrop at 348 m depth.

Lophelia pertusa on rock outcrop; piles of dead *L. pertusa* on mud at base of rock, with several bank rockfish (*Sebastes rufus*) at 348 m depth.



Plexauridae (*Swiftia* type, single red stalk with white polyps); *Swiftia pacifica* (red multi-branching with yellow polyps); and *Desmophyllum dianthus* (large cup corals) on rock at 238 m depth. Paired lasers (red dots) are 20 cm apart.

Swiftia pacifica on rock outcrop at 238 m depth.

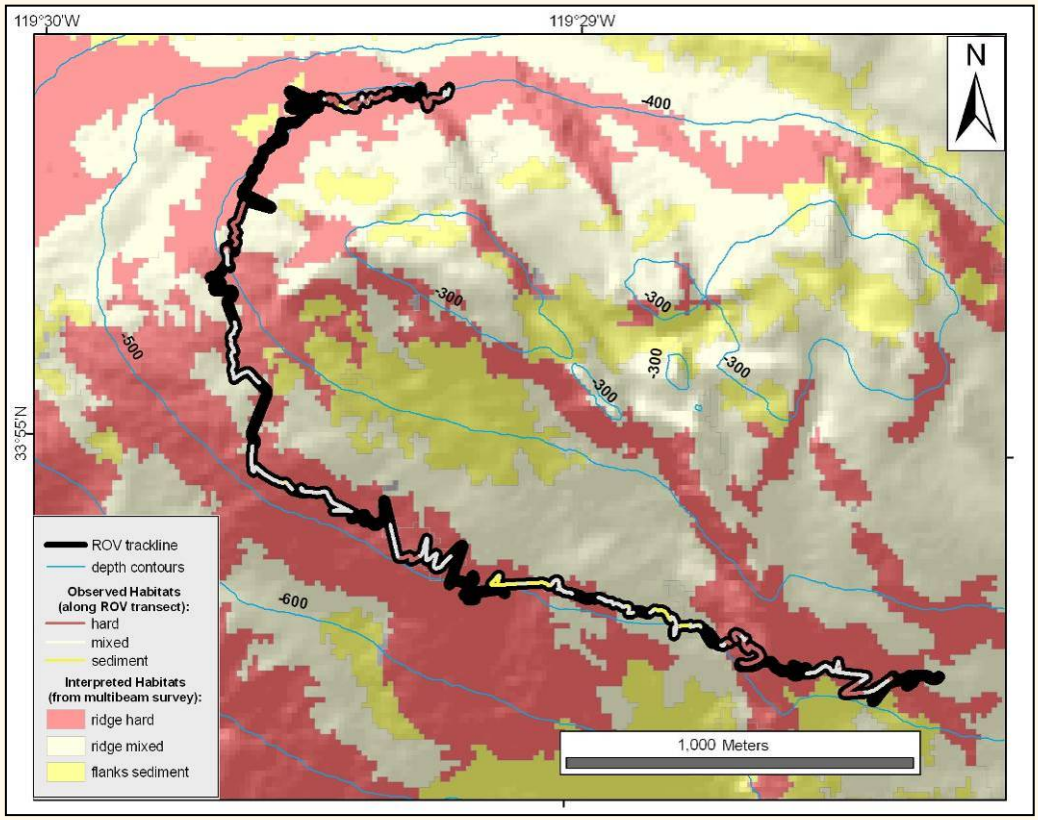
ADDITIONAL COMMENTS

One man-made debris item (a rope) was documented during the second transect of Dive 0001 in boulder habitat at 290 m depth. Invertebrates colonized the rope, and no damage potentially caused by this debris was evident.

Of the 727 individual corals that occurred on the two transects of Dive 0001, 103 appeared to be dead or dying. The majority of these were the cup coral (*Lophelia pertusa*; n=78), typically seen in piles of broken skeletons at the base of rock outcrops (see image gallery for example). Twelve cup corals (*Desmophyllum dianthus*) appeared dead, having bare white skeletons without polyps. Five bubblegum corals (*Paragorgia arborea*), four Christmas tree black corals (*Antipathes dendrochristos*), and the top-half of two sea fans (Plexauridae, *Swiftia*-type) appeared to be dead or dying, with discolored skeletons and no polyps. The dead corals often were covered with encrusting organisms and detritus. Only two sponges appeared to be dead. Additionally, 22 healthy sponges had missing parts or were knocked over.

DIVE NUMBER: ROV 0002 *STUDY AREA: Piggy Bank*

GENERAL LOCATION AND DIVE TRACK



STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Yoklavich
Contact Information	NMFS, SWFSC, mary.yoklavich@noaa.gov
Purpose	Survey deep coral communities at Piggy Bank off southern CA
Vessel	NOAA Ship *McArthur II* Leg 3; *Kraken 2* ROV
Science Observers	L. Krigsman, T. Laidig, M. Love, L. Lundsten, A. Taylor
External Video Tapes	3 HD, 4 SD
Internal Video Tapes	n/a
Digital Still Photos	301
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	Yes
O_2 Sensor	No
pH Sensor	No
Specimens collected	No
Other	Logbook, Access database
Report Analyst	D. Watters
Date Compiled	11 May 2011

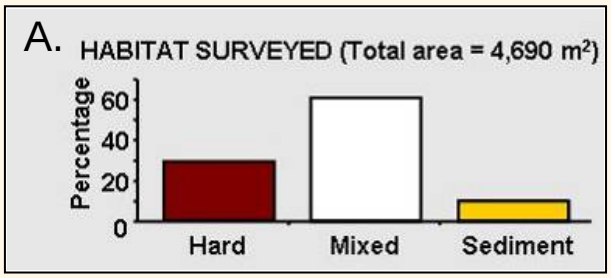
DIVE NUMBER: ROV 0002 *STUDY AREA: Piggy Bank*

DIVE DATA

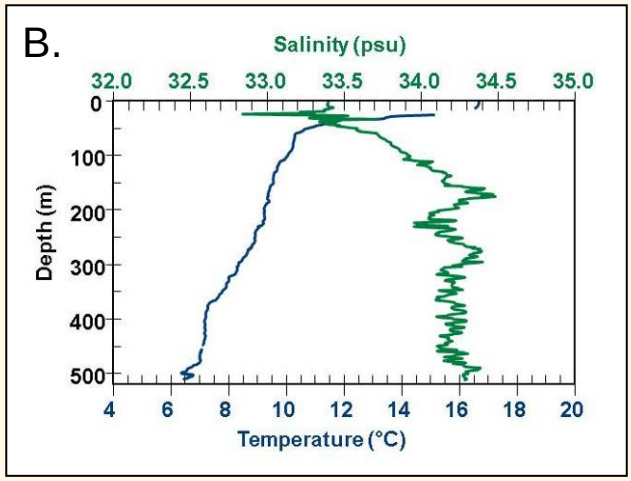
Date	28 June 2010	Starting Latitude (N)	33˚ 54.663’
Minimum Bottom Depth (m)	384	Starting Longitude (W)	119˚ 28.326’
Maximum Bottom Depth (m)	527	Ending Latitude (N)	33˚ 55.544’
Start Bottom Time (PDT)	9:27	Ending Longitude (W)	119˚ 29.241’
End Bottom Time (PDT)	16:30	Surface Current	n/a
Number 15-min Transects	13	Bottom Current	n/a

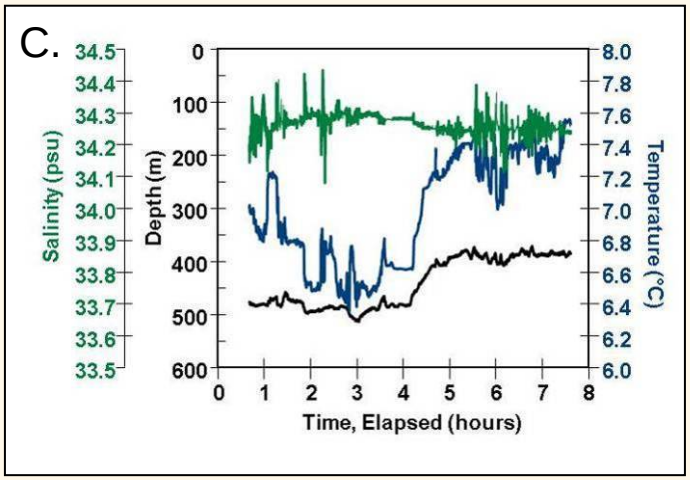
PHYSICAL ENVIRONMENT

In total, 4,690 m^2 of sea floor were surveyed during 13 quantitative transects conducted during Dive 0002 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California (A). Habitat types were classified as (1) Hard (29% of the total area surveyed), which included boulders, cobbles, and some rock; (2) Mixed (61% of the total area surveyed), including a combination of mud with boulder, cobbles, or rock; and (3) Sediment (10% of the total area surveyed), which consisted entirely of mud.



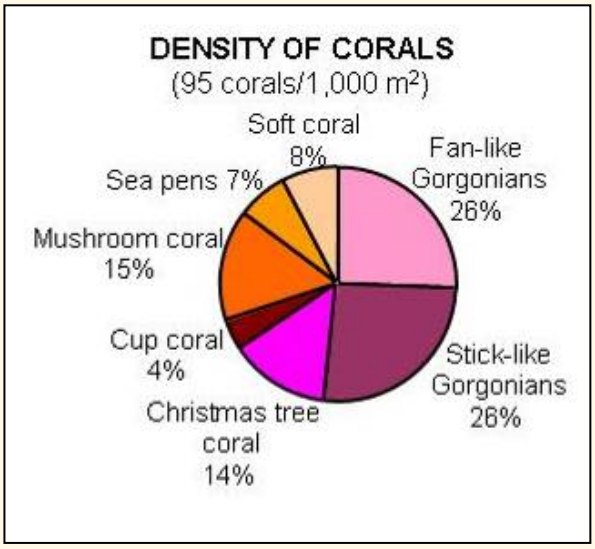
The ROV was equipped with a Sea-Bird SBE 19 CTD during Dive 0002, which collected data on depth, conductivity, and temperature during descent (B), and at depth along the track line (C). Temperature ranged from 16.7°C at the sea surface to 6.5°C on the sea floor at 512 m depth. During the dive, temperature fluctuated with depth along the track line (C). Salinity (as estimated from conductivity, temperature, and pressure) ranged from 33.4 psu at the sea surface to 34.3 psu on the sea floor. Salinity also varied with depth along the dive track line. The pH and O_2 sensors did not function during this dive.





BIOLOGICAL ENVIRONMENT: CORALS

A total of 416 individual corals, comprising at least 15 taxa, were enumerated from 13 quantitative transects conducted during Dive 0002 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 95 corals per 1,000 m^2 of sea floor was estimated. Fan- and stick-like gorgonians accounted for over 50% of the coral density. The stick-like gorgonians include both *Swiftia* spp. and *Euplexaura* spp., based on expert examination of photographs and specimens collected on other dives; these genera could not be distinguished reliably from the video footage alone. The mushroom coral (*Anthomastus ritteri*) comprised 15% of the total density of corals on the *Piggy Bank*, followed by the Christmas tree black coral, *Antipathes dendrochristos* (14%), the soft coral, *Clavularia* spp. (8%), sea pens (7%), and cup corals (4%). All of these corals occurred on either hard or mixed habitats, except for the sea pens on soft mud sediment.

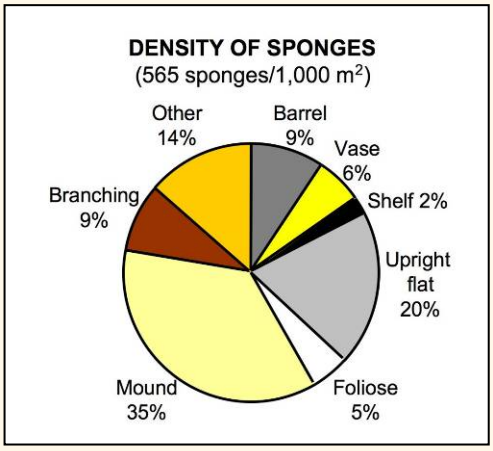


Colors in pie diagram match colors in the list of coral taxa (below).

Scientific name	Common name	Number
Corals		
Gorgonacea	Unidentified sea fan	1
Paragorgia spp.	Sea fan (white w/ red polyps)	28
Paragorgia arborea	Bubblegum coral	1
Parastenella ramosa	Primnoid	1
Plumarella longispina	Primnoid	81
Plexauridae #1 (*Swiftia* type)	Sea fan (red w/ white polyps)	97
Plexauridae #2 (*Swiftia* type)	Sea fan (red w/ yellow polyps)	4
Antipathes dendrochristos	Christmas tree black coral	61
Caryophyllidae	Unidentified cup corals	9
Desmophyllum dianthus	Cockscomb cup coral	7
Anthomastus ritteri	Mushroom coral	60
Anthoptilum grandiflorum	Feather boa sea pen	29
Pennatulacea	Unidentified sea pens (thin)	2
Umbellula lindahli	Droopy sea pen	1
Clavularia spp.	Soft coral	34

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 2,547 individual sponges from at least 19 different taxa were enumerated from 13 quantitative transects conducted during Dive 0002 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 565 sponges per 1,000 m^2 of sea floor was estimated. Mound sponges were most abundant (35% of the total density), followed by upright flat (20%, *Mycale* spp. and a few others), barrel (9%), branching (9%), vase (6%, *Heterochone calyx*, *Staurocalyptus* spp., and others), foliose (5%, *Farrea occa*, *Polymastia* spp., and others), and shelf (2%) sponges. The category 'Other' represented 14% of the total sponge density and included at least five taxa (i.e., the predatory sponges *Asbestopluma* spp. and several unidentified sponges). Most of the sponges occurred on mixed and hard habitats.



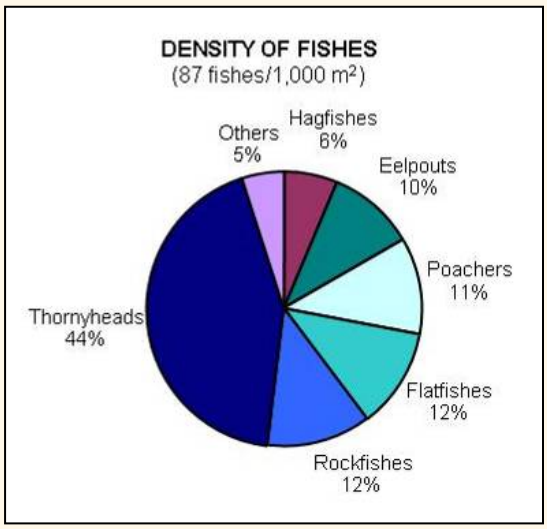
Colors in pie diagram match colors in the list of sponge taxa (below).

Scientific name	Common name	Number
Sponges		
Porifera	Unidentified barrel sponges	241
Heterochone calyx	Fingered goblet vase sponge	9
Porifera	Unidentified vase sponges	118
Staurocalyptus spp.	Unidentified vase sponge (yellow)	31
Porifera	Unidentified shelf sponges	49
Mycale spp.	Upright flat sponge (yellow)	533
Porifera	Unidentified upright flat sponges	22
Farrea occa	Lace (or cloud) foliose sponge	8
Porifera	Unidentified foliose sponges	76
Polymastia spp.	Nipple foliose sponge (yellow)	19
Thenea muricata	Foliose sponge (clear)	4
Porifera	Unidentified mound sponges	752
Porifera	Unidentified puffball mound sponges	129
Porifera	Unidentified branching sponges	222
Asbestopluma spp. #1	Predatory pipecleaner sponge	166
Asbestopluma spp. #2	Predatory sponge (clear)	9
Porifera	Unidentified sponge (blue/white)	20
Porifera	Unidentified tube sponges	71
Porifera	Unidentified sponges	68

BIOLOGICAL ENVIRONMENT: FISHES

At least 25 taxa of fishes were identified during Dive 0002 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. A total of 339 individual fishes were enumerated, and an overall density of 87 fishes per 1,000 m^2 of sea floor was estimated from 13 quantitative transects. Rockfishes (at least five species of *Sebastes*) and two species of thornyheads (*Sebastolobus alascanus* and *S. altivelis*) comprised 56% of total fish density. The remainder of the fish assemblage included a variety of flatfishes (12% of total density), poachers (11%), eelpouts (10%), hagfishes (6%), and other taxa that occurred primarily on soft sediments.

Only 18 (0.6%, four corals and 14 sponges) of the 2,963 corals and sponges that were documented during the transects on Dive 0002 were associated with fishes less than one body length away. Associated fishes were thornyheads (69%), aurora rockfish (23%), and unidentified rockfishes (8%).



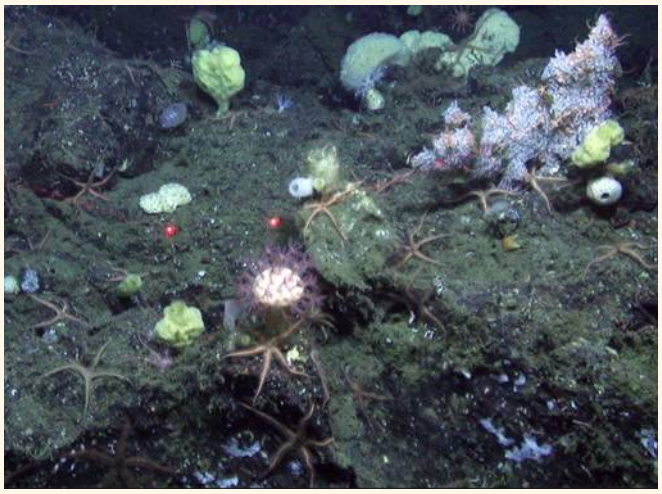
Colors in pie diagram match colors in the list of fish taxa (below).

Scientific name	Common name	Number
Fishes		
Eptatretus stoutii	Pacific hagfish	29
Zoarcidae	Unidentified eelpouts	33
Agonidae	Unidentified poachers	35
Embassichthys bathybius	Deepsea sole	1
Glyptocephalus zachirus	Rex sole	1
Microstomus pacificus	Dover sole	32
Pleuronectiformes	Unidentified flatfish	1
Sebastes aurora	Aurora rockfish	12
Sebastes diploproa	Splitnose rockfish	11
Sebastes melanostomus	Blackgill rockfish	1
Sebastes rufus	Bank rockfish	1
Sebastes spp.	Unidentified rockfishes	12
Sebastes spp.	Young-of-the-year rockfishes	2
Sebastomus	Unidentified rockfishes	4
Sebastolobus alascanus	Shortspine thornyhead	5
Sebastolobus altivelis	Longspine thornyhead	4
Sebastolobus spp.	Unidentified thornyheads	138
Careproctus melanurus	Blacktail snailfish	3
Cottidae	Unidentified sculpins	5
Merluccius productus	Pacific hake	1
Myctophidae	Unidentified lanternfishes	2
Nezumia stelgidolepis	California grenadier	3
Osteichthyes	Unidentified fish	1
Raja rhina	Longnose skate	1
Scyliorhinidae	Unidentified catshark	1

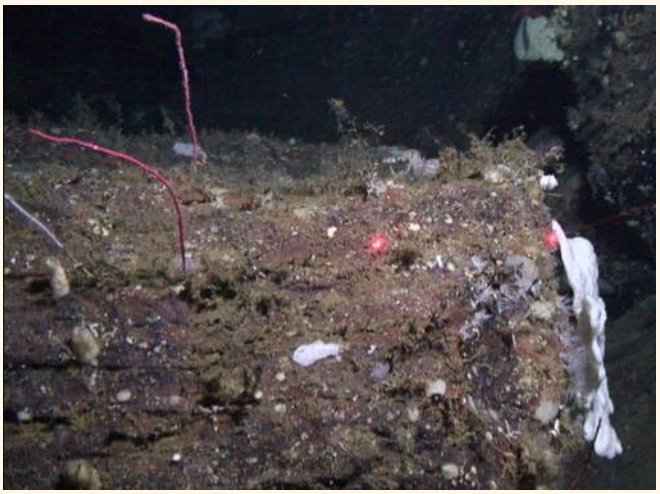
IMAGE GALLERY

Unidentified puffball mound sponge and *Mycale* spp. on mixed habitat (mud with cobble) at 482 m depth. Paired lasers (red dots) are 20 cm apart.

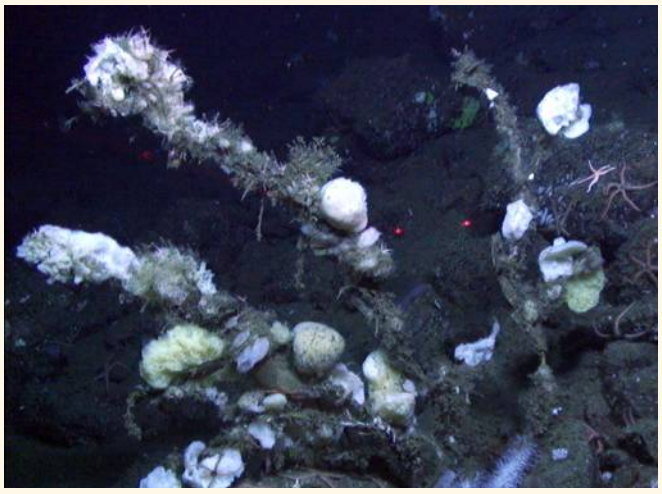
Unidentified puffball mound sponge, *Anthomastus ritteri*, *Parastenella ramosa*, and *Mycale* spp. on hard habitat (rock) at 489 m depth. Paired lasers (red dots) are 20 cm apart.



Plexauridae (S*wiftia*-type) coral with white polyps, *Clavularia* spp., and unidentified upright flat sponge on hard habitat (boulder) at 394 m depth. Paired lasers (red dots) are 20 cm apart.



Clavularia spp., *Mycale* spp., unidentified foliose sponges, and unidentified puffball mound sponges on a dead *Antipathes dendrochristos* in mixed habitat (mud with boulders) at 438 m depth. Paired lasers (red dots) are 20 cm apart.



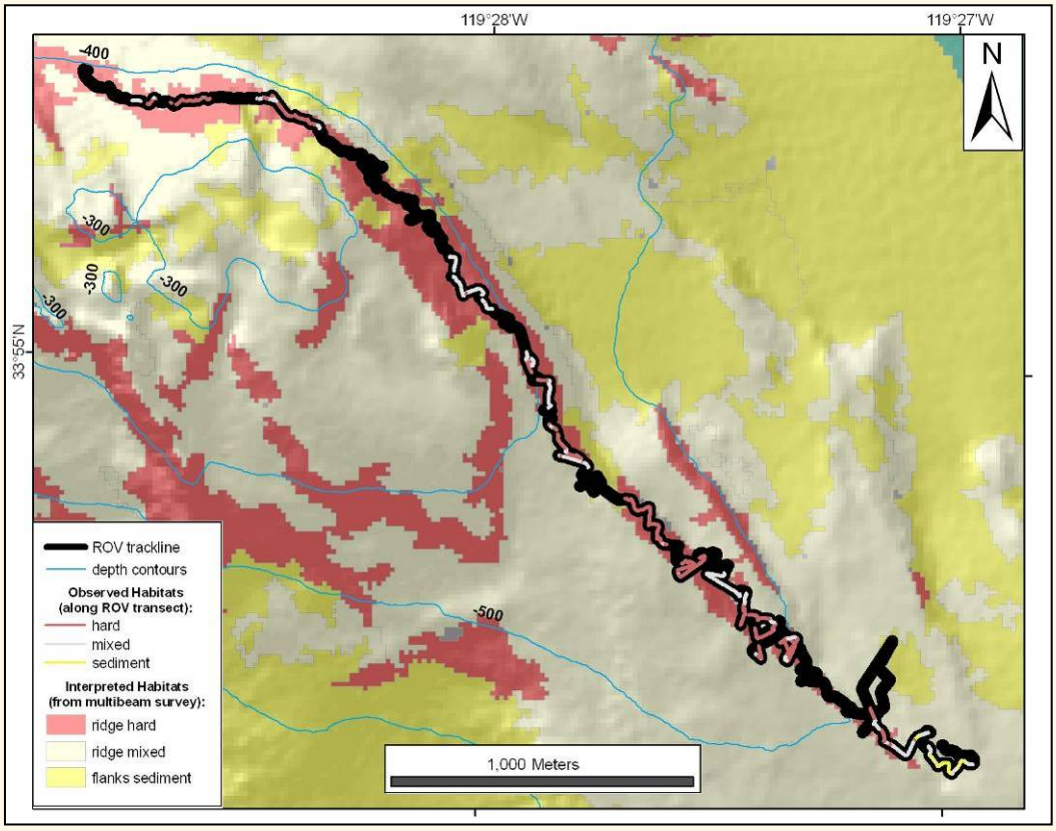
ADDITIONAL COMMENTS

Two man-made debris items were documented during transects on Dive 0002: an unidentified object (possibly a Frisbee®) was observed during transect 2 in boulder habitat at 492 m depth, and a rope was recorded during transect 9 in mud and cobble habitat at 450 m depth. No damage, potentially caused by either of these items, was evident.

Sixty-three of the 2,963 individual corals and sponges that occurred on the 13 transects during Dive 0002 appeared to be dead or dying. Thirty-four of these were corals (29 Christmas trees, 1 bubblegum, and 4 sea fans) with discolored skeletons and no polyps. Twenty-nine sponges of various types appeared to be dead. Almost all of these dead and dying sponges and corals were knocked over. Additionally, 73 healthy sponges were knocked over or had missing parts; 2 healthy corals were altered. Dead corals and sponges often were covered with encrusting organisms and detritus.

DIVE NUMBER: ROV 0003 *STUDY AREA: Piggy Bank*

GENERAL LOCATION AND DIVE TRACK



STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Yoklavich
Contact Information	NMFS, SWFSC, mary.yoklavich@noaa.gov
Purpose	Survey deep coral communities at Piggy Bank off southern CA
Vessel	NOAA Ship *McArthur II* Leg 3; *Kraken 2* ROV
Science Observers	L. Krigsman, T. Laidig, M. Love, L. Lundsten, A. Taylor
External Video Tapes	4 HD, 4 SD
Internal Video Tapes	n/a
Digital Still Photos	346
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	Yes
O_2 Sensor	Yes
pH Sensor	Yes
Specimens collected	Yes
Other	Logbook, Access database
Report Analyst	D. Watters
Date Compiled	11 May 2011

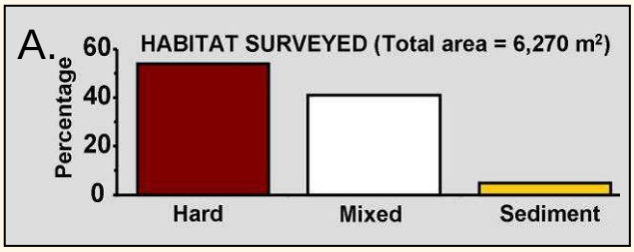
DIVE NUMBER: ROV 0003 *STUDY AREA: Piggy Bank*

DIVE DATA

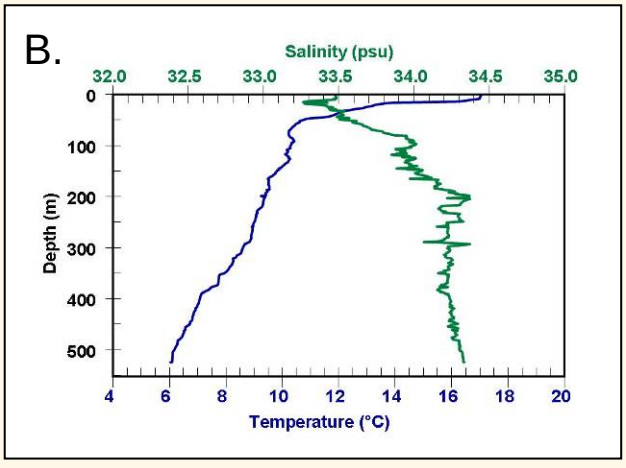
Date	29 June 2010	Starting Latitude (N)	33˚ 54.333’
Minimum Bottom Depth (m)	329	Starting Longitude (W)	119˚ 26.981’
Maximum Bottom Depth (m)	543	Ending Latitude (N)	33˚ 55.498’
Start Bottom Time (PDT)	08:07	Ending Longitude (W)	119˚ 28.869’
End Bottom Time (PDT)	16:56	Surface Current	n/a
Number 15-min Transects	12	Bottom Current	n/a

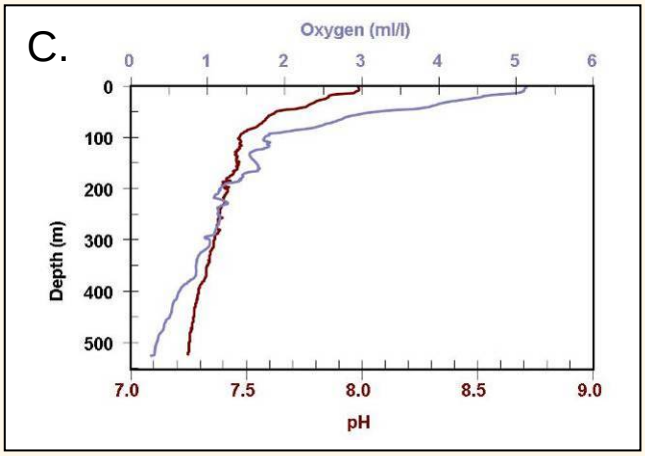
PHYSICAL ENVIRONMENT

In total, 6,270 m^2 of sea floor were surveyed during 12 quantitative transects conducted during Dive 0003 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California (A). Habitat types were classified as (1) Hard (54% of the total area surveyed), which included mostly boulders and high relief rock; (2) Mixed (41% of the total area surveyed), including a combination of mud with cobbles and boulders; and (3) Sediment (5% of the total area surveyed), which consisted entirely of mud.



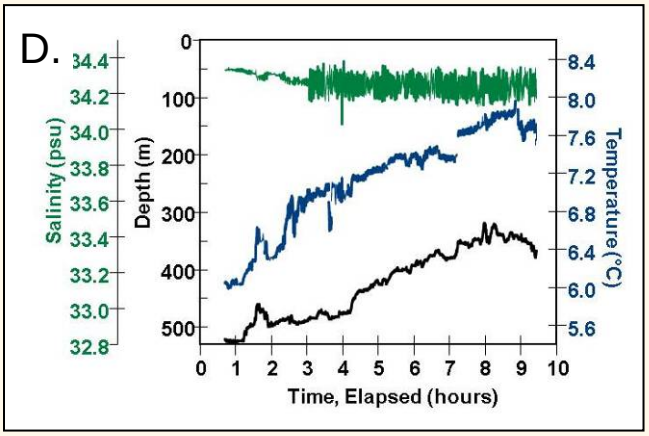
The ROV was equipped with a Sea-Bird SBE 19 CTD during Dive 0003, which collected data on depth, conductivity, temperature, pH, and oxygen during descent (B and C) and at depth along the track line (D and E).Temperature ranged from 17.0°C at the sea surface to 6.0°C on the sea floor at 526 m depth. Salinity (as estimated from conductivity, temperature, and pressure) ranged from 33.5 psu at the sea surface to 34.3 psu on the sea floor. The range in pH was from 8.0 at the sea surface to 7.2 on the sea floor, and oxygen ranged from 5.1 ml/l at the sea surface to 0.3 ml/l on the sea floor at 526 m. As the ROV dive continued from deep to shallow depths along the sea floor, temperature, salinity, pH, and oxygen all fluctuated with depth (D and E).



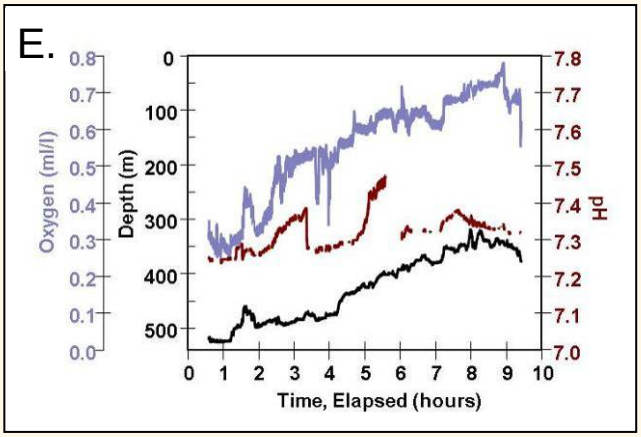


PHYSICAL ENVIRONMENT

D.

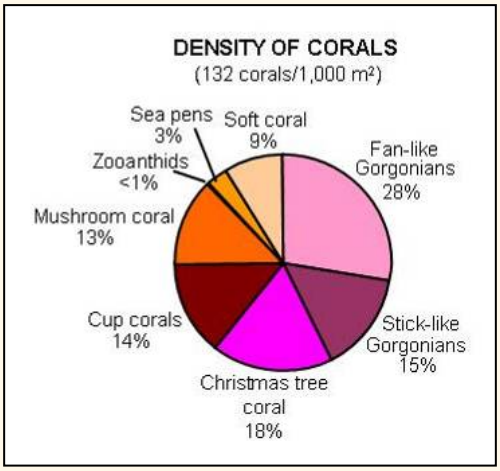


E.



BIOLOGICAL ENVIRONMENT: CORALS

A total of 755 individual corals, comprising at least 17 taxa, were enumerated from 12 quantitative transects conducted during Dive 0003 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 132 corals per 1,000 m^2 of sea floor was estimated. Fan- and stick-like gorgonians accounted for over 40% of the coral density. The stick-like gorgonians include both *Swiftia* spp. and *Euplexaura* spp., which could not be distinguished reliably from the video footage alone. The Christmas tree black coral (*Antipathes dendrochristos*) comprised 18% of the total density of corals, and occurred to a depth of 435 m. Cup corals (14%), the mushroom coral (13%, *Anthomastus ritteri*), the soft coral (9%,*Clavularia* spp.), sea pens (3%), and zooanthids (<1%) were observed on this dive. All of these corals occurred on either hard or mixed habitats, except for the sea pens on soft mud sediment.



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

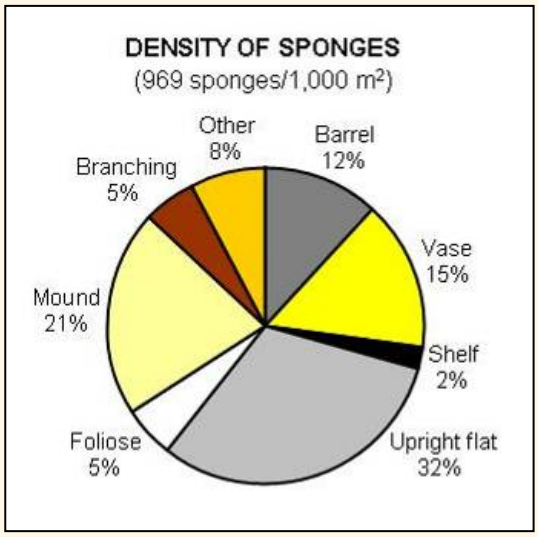
Scientific name	Common name	Number
Corals		
Acanthogorgia spp.$_1$	Gold coral	1
Paragorgia spp.	Sea fan (white w/ red polyps)	1
Paragorgia stephencairnsi$_1$	Sea fan (white w/ red polyps)	83
Paragorgia arborea	Bubblegum coral	11
Parastenella ramosa	Primnoid	2
Plumarella longispina$_1$	Primnoid	112
Plexauridae #1 (*Swiftia* type)	Sea fan (red w/ white polyps)	107
Plexauridae #2 (*Swiftia* type)	Sea fan (red w/ yellow polyps)	5
Antipathes dendrochristos	Christmas tree black coral	126
Caryophyllidae	Unidentified cup corals	96
Desmophyllum dianthus	Cockscomb cup coral	6
Anthomastus ritteri	Mushroom coral	107
Zoantharia	Unidentified zooanthids	2
Anthoptilum grandiflorum	Feather boa sea pen	22
Pennatulacea	Unidentified sea pens (thin)	2
Umbellula lindahli	Droopy sea pen	2
Clavularia spp.	Soft coral	70

$_1$Specimen sent to experts for identification

Three coral specimens were collected during Dive 0003 and sent to experts for identification. Stephen Cairns (National Museum of Natural History, Smithsonian Institution, Washington DC) identified the golden primnoid (*Acanthogorgia* spp.) and the pale pink primnoid (*Plumarella longispina*). Peter Etnoyer (NOAA, National Ocean Service, Silver Spring, MD) identified the white sea fan with red polyps (*Paragorgia stephencairnsi*).

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 6,318 individual sponges from at least 23 different taxa were enumerated from 12 quantitative transects conducted during Dive 0003 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 969 sponges per 1,000 m^2 of sea floor was estimated. Upright flat sponges (*Mycale* spp., and others) were most abundant (32% of the total density), followed by mound (21%, *Tentorium* spp., and others), vase (15%, *Heterochone calyx*, *Staurocalyptus* spp., and others), barrel (12%), branching (5%), foliose (5%, *Farrea occa*, *Polymastia* spp., *Thenea muricata,* and others), and shelf (2%) sponges. The category 'Other' represented 8% of the total sponge density and included at least six taxa (i.e., the predatory sponge *Asbestopluma* spp #1., the stalked sponge *Stylocordyla* spp., and several unidentified sponges). Most of the sponges occurred on mixed and hard habitats.



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

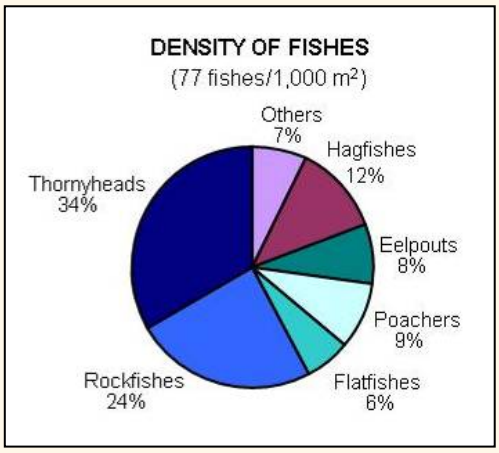
Nine specimens of sponges were collected during Dive 0003. Three Demospongia were sent to William Austin (Khoyatan Marine Laboratory, Sidney, BC). He identified the clear predatory sponge (*Asbestopluma* spp. #2) as being a new species and perhaps a new subgenus as well. Austin also identified the puffball sponge (*Tentorium* sp.), which likely is a new species, and the yellow upright flat sponge (*Mycale* spp.). Five specimens of vase sponges were sent to Henry Reiswig (Department of Biology, University Victoria, BC), which he identified as *Heterochone calyx*, *Staurocalyptus solidus,* and *S. fasciculatus*. Reiswig also was sent a tube sponge to be identified. All of these sponges also were sent to James Weaver (University California Santa Barbara, now at Harvard University, Cambridge, MA); he has produced some exceptional, high resolution scanning electron micrographs for identification purposes.

Scientific name	Common name	Number
Sponges		
Porifera	Unidentified barrel sponges	715
Heterochone calyx$_1$	Fingered goblet vase sponge	147
Porifera	Unidentified vase sponges	686
Staurocalyptus fasciculatus$_1$	Vase sponge	1
Staurocalyptus solidus$_1$	Vase sponge	3
Staurocalyptus spp.	Unidentified vase sponge (yellow)	151
Porifera	Unidentified shelf sponges	139
Mycale spp.$_1$	Upright flat sponge (yellow)	1,994
Porifera	Unidentified upright flat sponges	140
Farrea occa	Lace (or cloud) foliose sponge	22
Polymastia spp.	Nipple foliose sponge (yellow)	47
Thenea muricata	Foliose sponge (clear)	126
Porifera	Unidentified foliose sponges	105
Porifera	Unidentified mound sponges	1,055
Porifera	Unidentified puffball mound sponges	223
Tentorium spp.$_1$	Puffball mound sponge	1
Porifera	Unidentified branching sponges	324
Asbestopluma spp. #1	Predatory pipecleaner sponge	189
Asbestopluma spp. #2$_1$	Predatory sponge (clear)	10
Porifera$_1$	Unidentified tube sponges	119
Porifera	Unidentified sponge (blue/white)	68
Porifera	Unidentified sponges	51
Stylocordyla spp.	Stalked sponge	2

$_1$Specimen sent to experts for identification

BIOLOGICAL ENVIRONMENT: FISHES

At least 27 taxa of fishes were identified during Dive 0003 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. A total of 460 individual fishes were enumerated, and an overall density of 77 fishes per 1,000 m^2 of sea floor was estimated from 12 quantitative transects. Rockfishes (at least seven species of *Sebastes*) and two species of thornyheads (*Sebastolobus alascanus* and *S. altivelis*) comprised 58% of total fish density. The remainder of the fish assemblage included hagfishes (12% of total density), poachers (9%), eelpouts (8%), and flatfishes (*Microstomus pacificus* and others; 6%). The category 'Other' (7% of total density) comprised at least 10 taxa, including sablefish (*Anoplopoma fimbria*), blacktail snailfish (*Careproctus melanurus*), sculpins of the family Cottidae, the ratfish (*Hydrolagus colliei*), the California grenadier (*Nezumia stelgidolepis*), the longnose skate (*Raja rhina*), the Pacific electric ray (*Torpedo californica*) and other taxa occurring primarily on soft sediments.



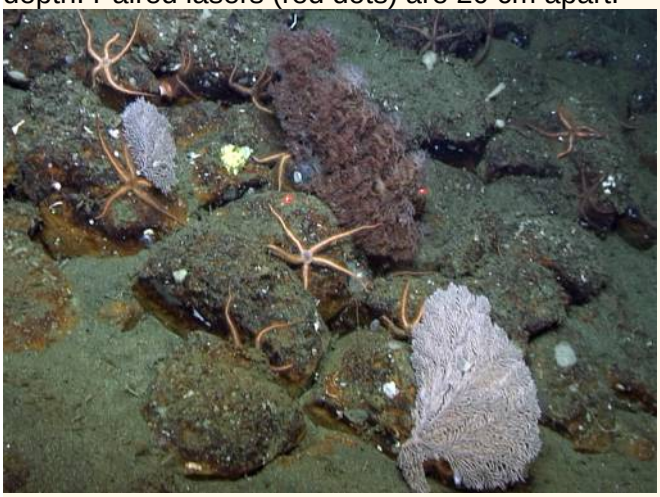
Colors in pie diagram match colors in list of fish taxa (below).

Only 35 (one coral and 34 sponges) of the 7,073 corals and sponges that were documented during Dive 0003 were associated with fishes (i.e., the fish was located less than one body length from the coral or sponge). The associated fishes were thornyheads (85%), unidentified rockfishes (9%), Dover sole (3%), and catshark egg cases (3%).

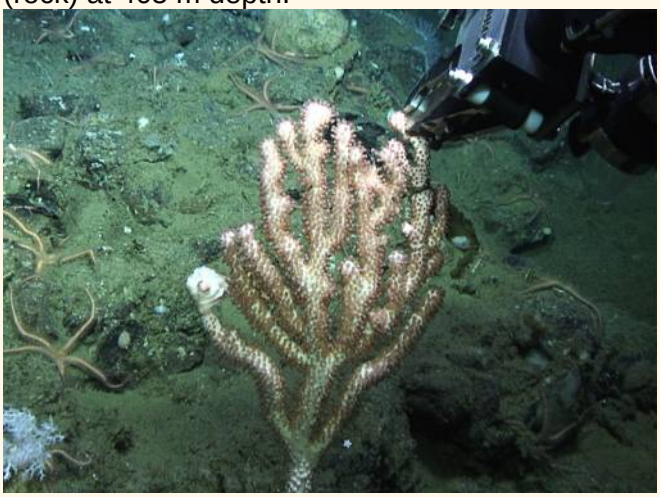
Scientific name	Common name	Number
Fishes		
Eptatretus stoutii	Pacific hagfish	56
Zoarcidae	Unidentified eelpouts	34
Agonidae	Unidentified poachers	39
Microstomus pacificus	Dover sole	17
Pleuronectiformes	Unidentified flatfish	10
Sebastes aurora	Aurora rockfish	15
Sebastes diploproa	Splitnose rockfish	21
Sebastes helvomaculatus	Rosethorn rockfish	6
Sebastes jordani	Shortbelly rockfish	2
Sebastes melanostomus	Blackgill rockfish	14
Sebastes spp.	Unidentified rockfishes	44
Sebastes spp.	Young-of-the-year rockfish	1
Sebastomus	Unidentified rockfishes	6
Sebastolobus alascanus	Shortspine thornyhead	12
Sebastolobus altivelis	Longspine thornyhead	5
Sebastolobus spp.	Unidentified thornyheads	142
Anoplopoma fimbria	Sablefish	1
Careproctus melanurus	Blacktail snailfish	2
Cottidae	Unidentified sculpins	6
Hydrolagus colliei	Spotted ratfish	2
Myctophidae	Unidentified lanternfishes	10
Nezumia stelgidolepis	California grenadier	3
Osteichthyes	Unidentified fishes	3
Raja rhina	Longnose skate	1
Scyliorhinidae	Unidentified catsharks	3
Scyliorhinidae	Unidentified catshark egg cases	4
Torpedo californica	Pacific electric ray	1

IMAGE GALLERY

A red Christmas tree black coral (*Antipathes dendrochristos*) and light pink sea fan (*Plumarella longispina*) on hard habitat (boulders) at 351 m depth. Paired lasers (red dots) are 20 cm apart.

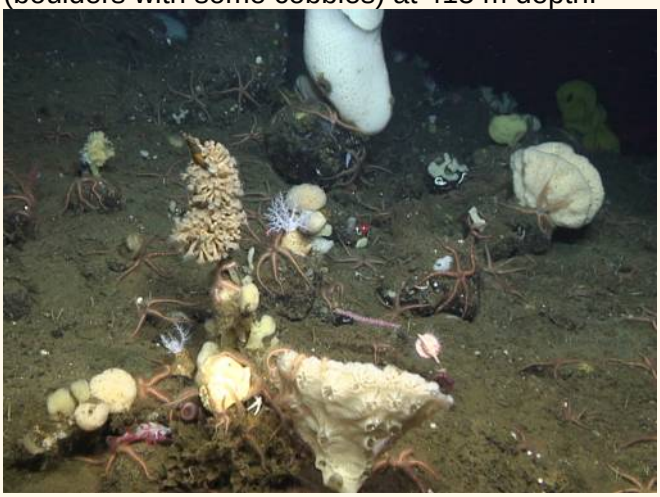


Collecting a small branch of a white sea fan with red polyps (*Paragorgia* spp.) on hard habitat (rock) at 405 m depth.



Fingered goblet vase sponge (*Heterochone calyx*), unidentified vase sponge, and upright flat sponge (*Mycale* spp.) on hard habitat (boulders) at 540 m depth. Paired lasers (red dots) are 20 cm apart.

Unidentified zooanthids growing on a dead Christmas tree black coral, Plexauridae (*Swiftia* type), unidentified vase sponge, unidentified puffball mound sponges, and an aurora rockfish (*Sebastes aurora*, lower left) on hard habitat (boulders with some cobbles) at 415 m depth.



ADDITIONAL COMMENTS

No man-made debris items were observed during the 12 quantitative transects conducted during Dive 0003.

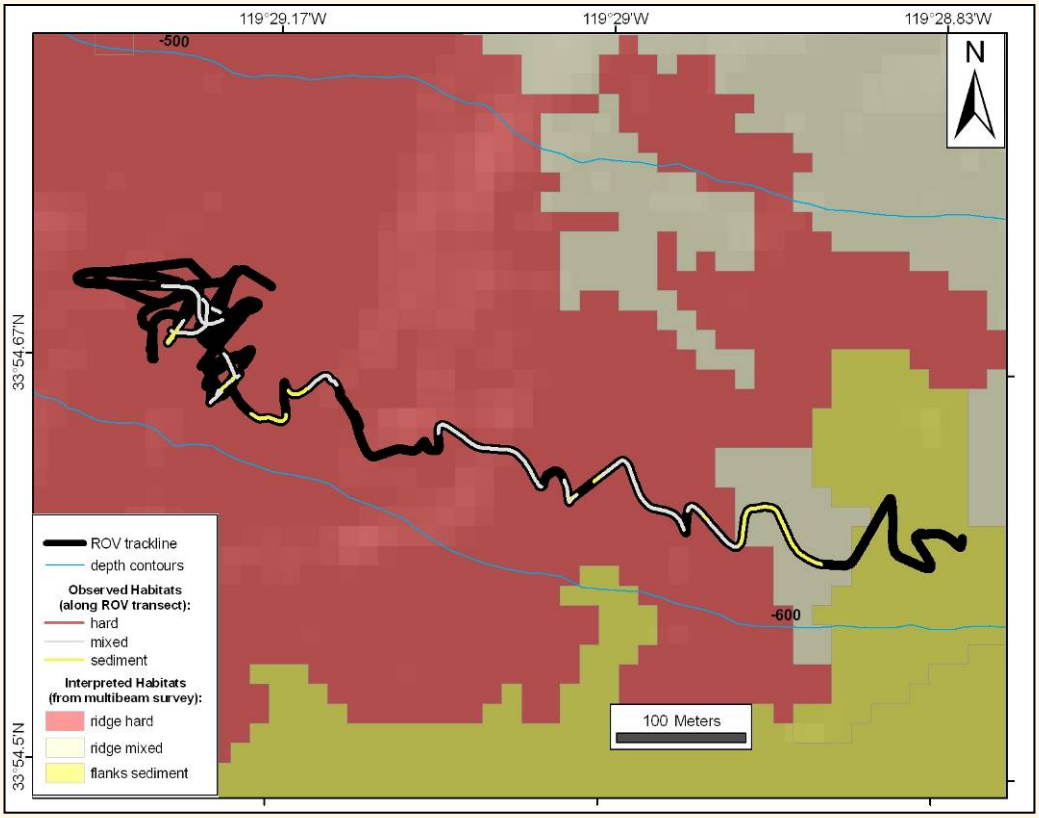
One hundred and thirty of the 7,073 individual corals and sponges that occurred on the 12 transects during Dive 0003 appeared to be dead or dying. Most of these were sponges (109). In addition, 12 Christmas tree black corals and 9 sea fans were dead/dying, with discolored skeletons and no polyps. Many (81%) of these sponges and corals were knocked over or had missing parts. Additionally, 92 healthy sponges were knocked over or had missing parts; 1 healthy *Paragorgia* was knocked over. Dead corals and sponges often were covered with encrusting organisms and detritus.

(Left) Two fingered goblet vase sponges (*Heterochone calyx*) on hard habitat (boulders and cobbles) at 490 m depth. The sponge in the foreground is alive, while the sponge in background appears dead and is covered with encrusting organisms and detritus.

(Right) Two tunicate specimens were collected during Dive 0003 and sent to Karen Sanamyan (Kamchatka Branch of Pacific Institute Geography, Russia). He identified these as *Aplidium* sp. 1 (initial color yellow-green fluorescent) and *Aplidium* sp. 2 (initial color white). These resemble *A. translucidum* from the north Pacific, but more time is needed to identify the species. These tunicates can be found on dead fingered

DIVE NUMBER: ROV 0004 *STUDY AREA: Piggy Bank*

GENERAL LOCATION AND DIVE TRACK



STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Yoklavich
Contact Information	NMFS, SWFSC, mary.yoklavich@noaa.gov
Purpose	Survey deep coral communities at Piggy Bank off southern CA
Vessel	NOAA Ship *McArthur II* Leg 3; *Kraken 2* ROV
Science Observers	L. Krigsman, T. Laidig, M. Love, L. Lundsten, A. Taylor
External Video Tapes	2 HD, 1 SD
Internal Video Tapes	n/a
Digital Still Photos	31
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	Yes
O_2 Sensor	Yes
pH Sensor	Yes
Specimens collected	Yes
Other	Logbook, Access database
Report Analyst	D. Watters
Date Compiled	11 May 2011

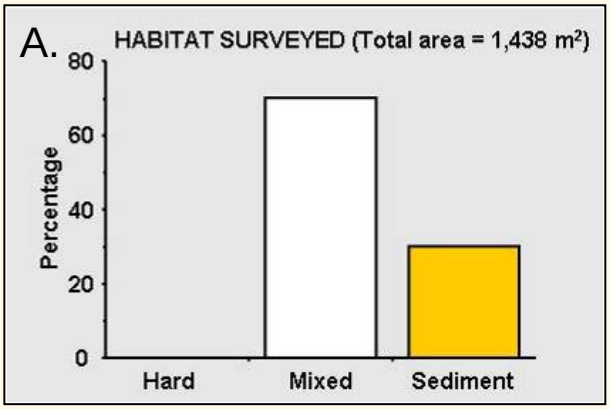
DIVE NUMBER: ROV 0004 *STUDY AREA: Piggy Bank*

DIVE DATA

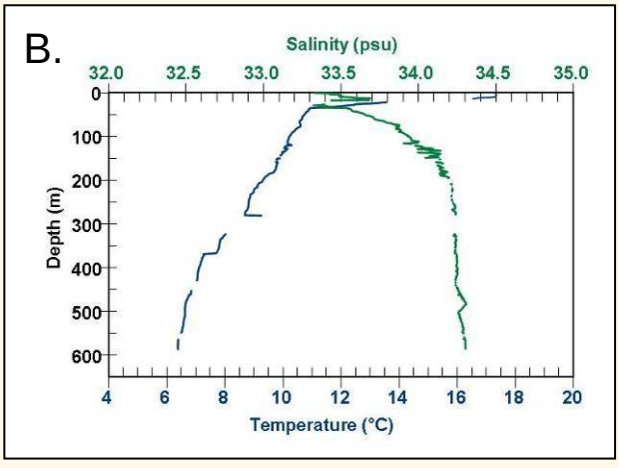
Date	30 June 2010	Starting Latitude (N)	33˚ 54.601’
Minimum Bottom Depth (m)	569	Starting Longitude (W)	119˚ 28.834’
Maximum Bottom Depth (m)	614	Ending Latitude (N)	33˚ 54.696’
Start Bottom Time (PDT)	08:16	Ending Longitude (W)	119˚ 29.164’
End Bottom Time (PDT)	10:33	Surface Current	n/a
Number 15-min Transects	2	Bottom Current	n/a

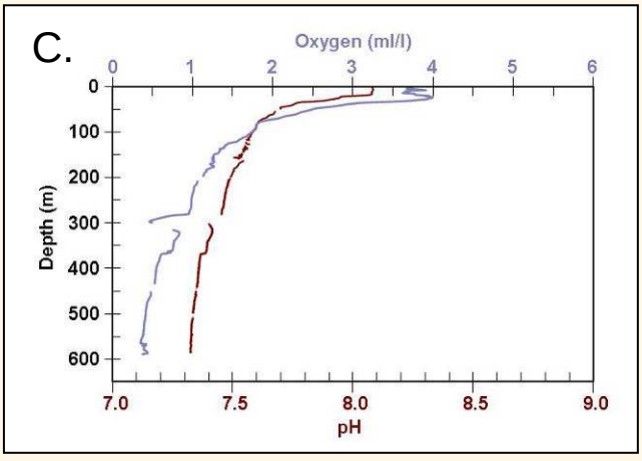
PHYSICAL ENVIRONMENT

A total area of 1,438 m^2 of sea floor was surveyed during two quantitative transects conducted during Dive 0004 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California (A). Habitat types were classified as (1) Mixed (70% of the total area surveyed), including a combination of mud with boulder, cobbles, or rock; and (2) Sediment (30% of the total area surveyed), which consisted entirely of mud. Hard substrata (boulders, cobbles, rock) were not present on the survey transects for Dive 0004.



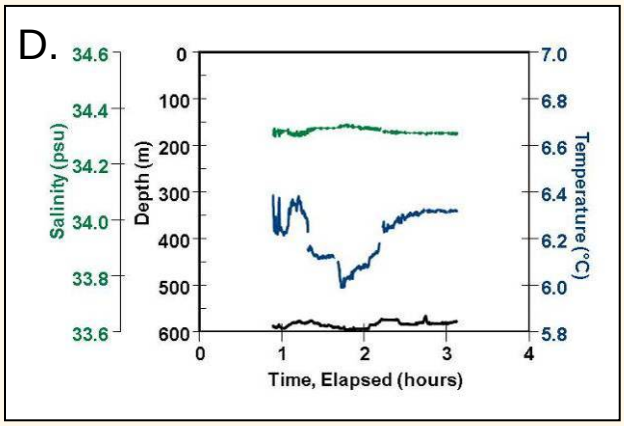
The ROV was equipped with a Sea-Bird SBE 19 CTD during Dive 0004, which collected data on depth, conductivity, temperature, pH, and oxygen during descent (B and C) and at depth along the track line (D and E).Temperature ranged from 17.3°C at the sea surface at the beginning of the dive to 6.3°C on the sea floor at 588 m depth. Salinity (as estimated from conductivity, temperature, and pressure) ranged from 33.3 psu at the sea surface to 34.3 psu on the sea floor. The range in pH was 8.1 at the sea surface to 7.3 on the sea floor, and oxygen ranged from 3.7 ml/l at the sea surface to 0.4 ml/l on the sea floor at 588 m. Temperature, pH, and oxygen all fluctuated as the ROV dive continued along the sea floor (D and E).



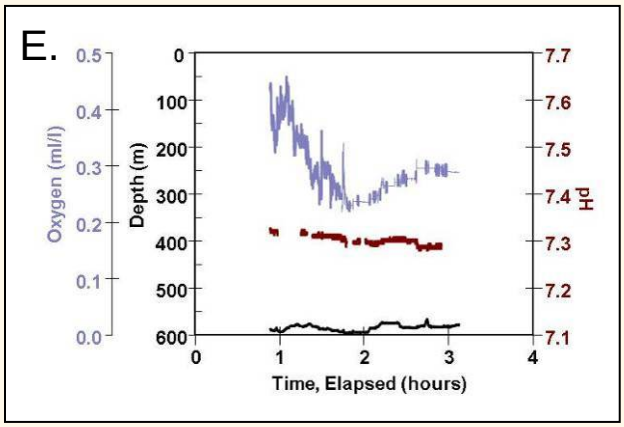


PHYSICAL ENVIRONMENT

D.



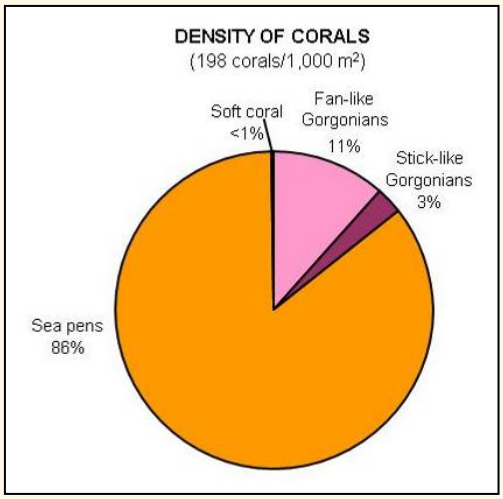
E.



BIOLOGICAL ENVIRONMENT: CORALS

A total of 247 individual corals, comprising at least eight taxa, were enumerated from 2 quantitative transects conducted during Dive 0004 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 198 corals per 1,000 m^2 of sea floor was estimated. Sea pens, which occur on soft mud sediment, accounted for 86% of the coral density on Dive 0004. Fan-like gorgonians (*Paragorgia* spp.) comprised 12% of coral density, followed by stick-like gorgonians (3%, Plexauridae #2; *Swiftia* type), and soft coral (<1%, *Clavularia* spp.). The gorgonians and soft corals occurred on mixed habitats.

One specimen of a sea pen with a white rachis and pink polyps was collected during Dive 0004. Gary Williams (California Academy of Sciences, San Francisco, CA) identified this specimen as *Halipteris californica*.



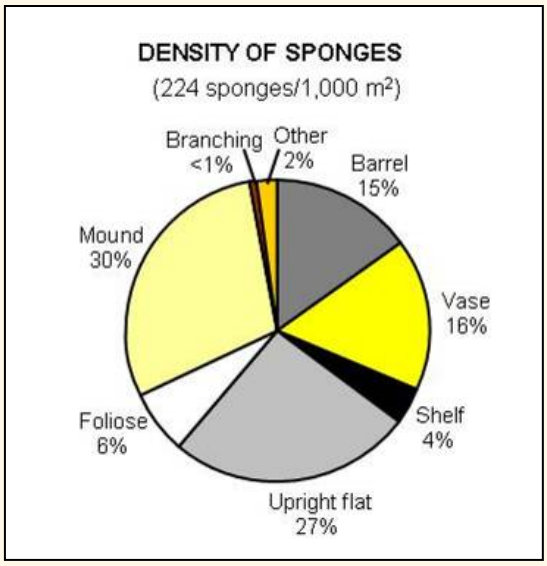
Colors in pie diagram match colors in list of coral taxa (below).

Scientific name	Common name	Number
Corals		
Paragorgia spp.	Sea fan (white w/ red polyps)	31
Plexauridae #2 (*Swiftia* type)	Sea fan (red w/ yellow polyps)	5
Anthoptilum grandiflorum	Feather boa sea pen	9
Halipteris californica[1]	Sea pen	60
Pennatulacea	Unidentified sea pens (thin)	82
Pennatulidae	Unidentified sea pens (thick)	35
Umbellula lindahli	Droopy sea pen	24
Clavularia sp.	Soft coral	1

[1]Specimen sent to experts for identification

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 281 individual sponges from at least 13 different taxa were enumerated from 2 quantitative transects conducted during Dive 0004 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 224 sponges per 1,000 m^2 of sea floor was estimated. Mound sponges were most abundant (30% of the total density), followed by upright flat (27%, *Mycale* spp.), vase (16%, *Heterochone calyx* and others), barrel (15%), foliose (6%, *Farrea occa* and *Thenea muricata*), shelf (4%), and branching (<1%) sponges. The category 'Other' represented 2% of the total sponge density and included at least two taxa (predatory sponges *Asbestopluma* spp. #1, and an unidentified sponge). Most of the sponges occurred on mixed habitats.



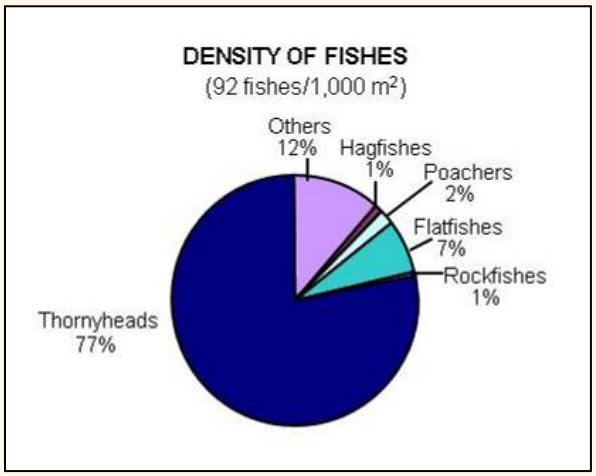
Colors in pie diagram match colors in list of sponge taxa (below).

Scientific name	Common name	Number
Sponges		
Porifera	Unidentified barrel sponges	45
Heterochone calyx	Fingered goblet vase sponge	5
Porifera	Unidentified vase sponges	37
Porifera	Unidentified shelf sponges	9
Mycale spp.	Upright flat sponge (yellow)	60
Porifera	Unidentified upright flat sponges	5
Farrea occa	Lace (or cloud) foliose sponge	1
Thenea muricata	Foliose sponge (clear)	12
Porifera	Unidentified mound sponges	90
Porifera	Unidentified puffball mound sponges	8
Porifera	Unidentified branching sponges	1
Asbestopluma spp. #1	Predatory pipecleaner sponge	7
Porifera	Unidentified tube sponges	1

BIOLOGICAL ENVIRONMENT: FISHES

At least 12 taxa of fishes were identified during Dive 0004 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. A total of 117 individual fishes were enumerated, and an overall density of 92 fishes per 1,000 m^2 of sea floor was estimated from 2 quantitative transects. Thornyheads (*Sebastolobus* spp.) accounted for 77% of the total fish density. The remaining fish assemblage consisted of the flatfish *Microstomus pacificus* (7%), poachers (2%), and hagfishes (1%). The category 'Others' (12% of total density) comprised at least 5 taxa, including sablefish (*Anoplopoma fimbria*), snailfishes (Liparidae), lanternfishes (Myctophidae), the California grenadier (*Nezumia stelgidolepis*), and a catshark (Scyliorhinidae). Fishes occurred primarily on soft sediments.

None of the 528 corals and sponges that were documented during Dive 0004 were associated with fishes (i.e., the fish was located less than one body length from the coral or sponge).

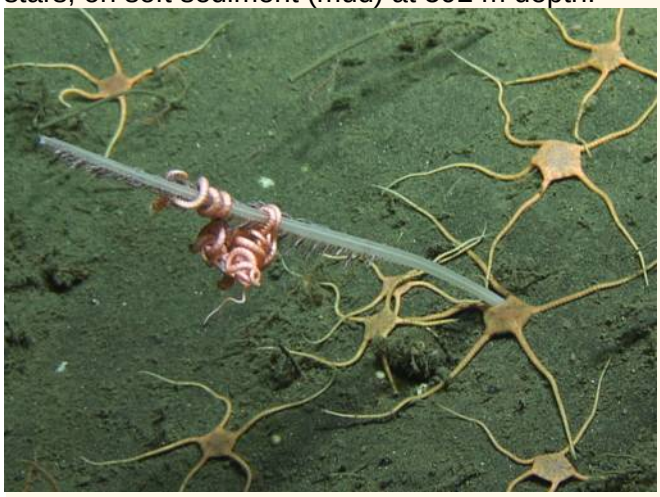


Colors in pie diagram match colors in list of fish taxa (below).

Scientific name	Common name	Number
Fishes		
Eptatretus stoutii	Pacific hagfish	2
Agonidae	Unidentified poachers	2
Microstomus pacificus	Dover sole	7
Sebastomus	Unidentified rockfish	1
Sebastolobus alascanus	Shortspine thornyhead	2
Sebastolobus altivelis	Longspine thornyhead	4
Sebastolobus spp.	Unidentified thornyheads	86
Anoplopoma fimbria	Sablefish	1
Liparidae	Unidentified snailfishes	3
Myctophidae	Unidentified lanternfishes	7
Nezumia stelgidolepis	California grenadier	1
Scyliorhinidae	Unidentified catshark	1

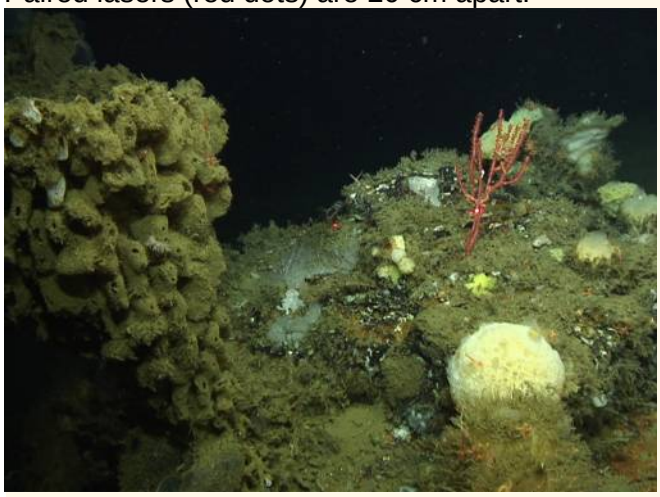
IMAGE GALLERY

The sea pen, *Halipteris californica*, with brittle stars, on soft sediment (mud) at 592 m depth.

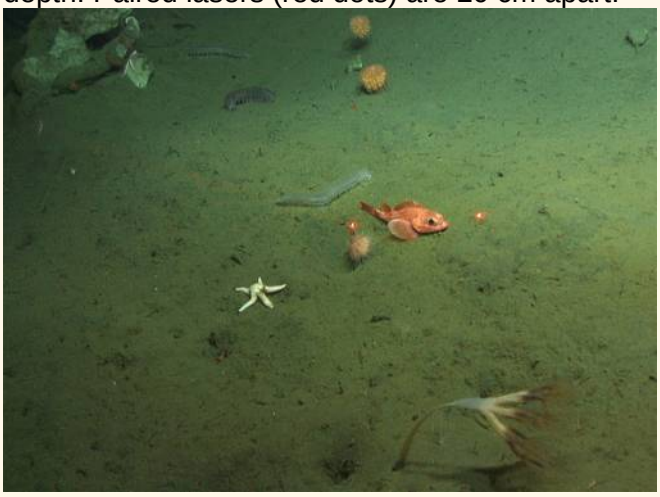


An unidentified sea pen on soft sediment (mud) at 608 m depth.

A dead, fingered goblet vase sponge, a red sea fan (Plexauridae; *Swiftia* type), soft coral (*Clavularia* spp.), and a variety of sponges on mixed habitat (mud with boulder) at 599 m depth. Paired lasers (red dots) are 20 cm apart.



The droopy sea pen (*Umbellula lindahli*; foreground), two peach-colored siphonophores (*Dromalia alexandri*; background), and a shortspine thornyhead rockfish (*Sebastolobus alascanus*) on soft sediment (mud) at 611 m depth. Paired lasers (red dots) are 20 cm apart.



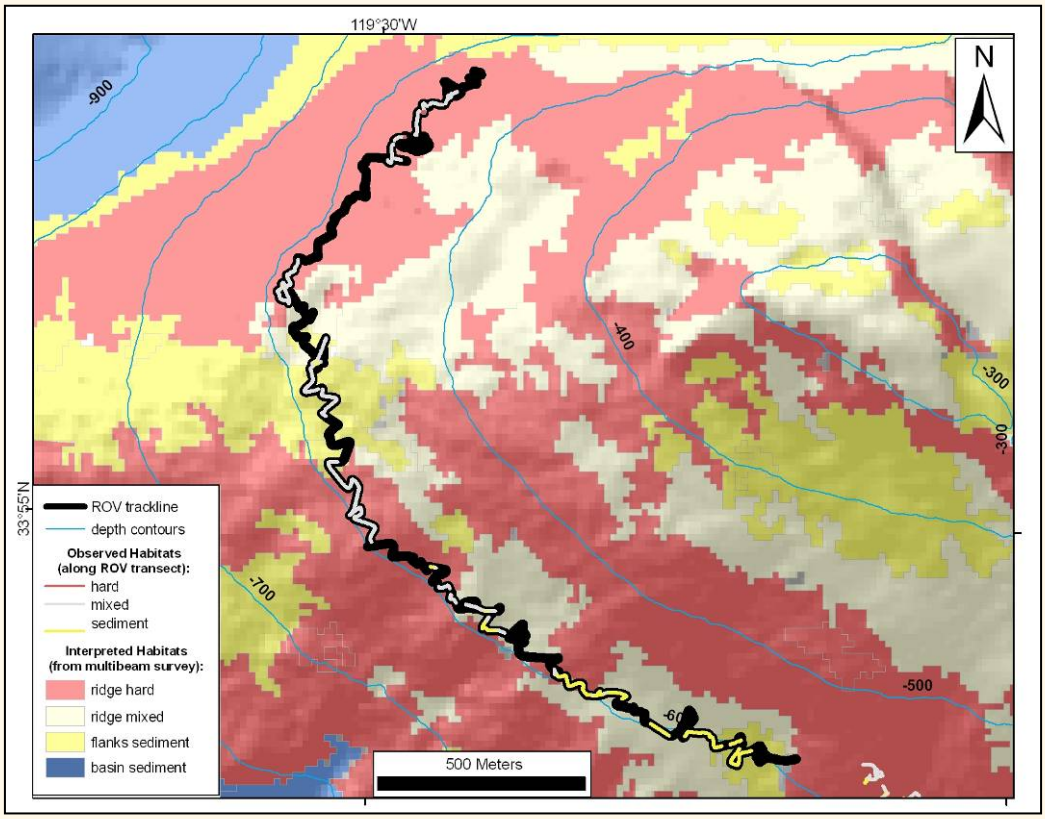
ADDITIONAL COMMENTS

No man-made debris items were observed during the two quantitative transects conducted during Dive 0004.

Four of the 528 individual sponges that occurred on the two transects of Dive 0004 were classified as dead or dying; three of these were knocked over. In addition, three healthy vase sponges were knocked over.

DIVE NUMBER: ROV 0005 *STUDY AREA: Piggy Bank*

GENERAL LOCATION AND DIVE TRACK



STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Yoklavich
Contact Information	NMFS, SWFSC, mary.yoklavich@noaa.gov
Purpose	Survey deep coral communities at Piggy Bank off southern CA
Vessel	NOAA Ship *McArthur II* Leg 3; *Kraken 2* ROV
Science Observers	L. Krigsman, T. Laidig, M. Love, L. Lundsten, A. Taylor
External Video Tapes	3 HD, 2 SD
Internal Video Tapes	n/a
Digital Still Photos	92
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	Yes
O_2 Sensor	Yes
pH Sensor	Yes
Specimens collected	Yes
Other	Logbook, Access database
Report Analyst	D. Watters
Date Compiled	11 May 2011

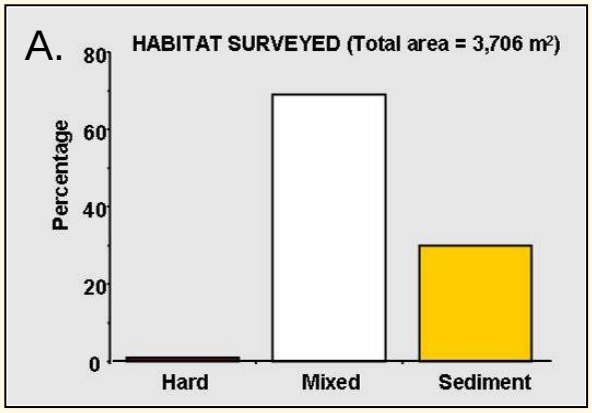
DIVE NUMBER: ROV 0005 *STUDY AREA: Piggy Bank*

DIVE DATA

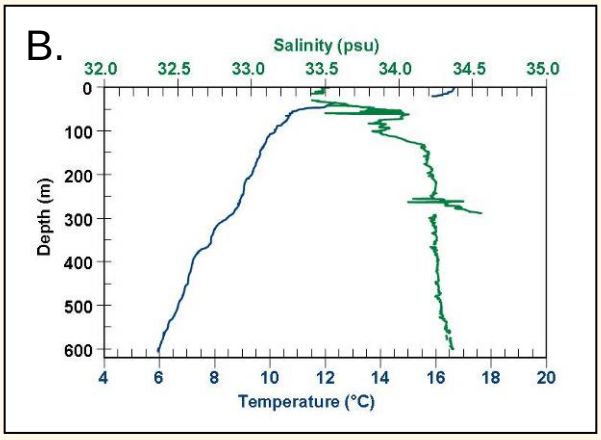
Date	30 June 2010	Starting Latitude (N)	33˚ 54.700’
Minimum Bottom Depth (m)	568	Starting Longitude (W)	119˚ 29.323’
Maximum Bottom Depth (m)	633	Ending Latitude (N)	33˚ 55.577’
Start Bottom Time (PDT)	11:33	Ending Longitude (W)	119˚ 29.840’
End Bottom Time (PDT)	17:01	Surface Current	n/a
Number 15-min Transects	7	Bottom Current	northwesterly

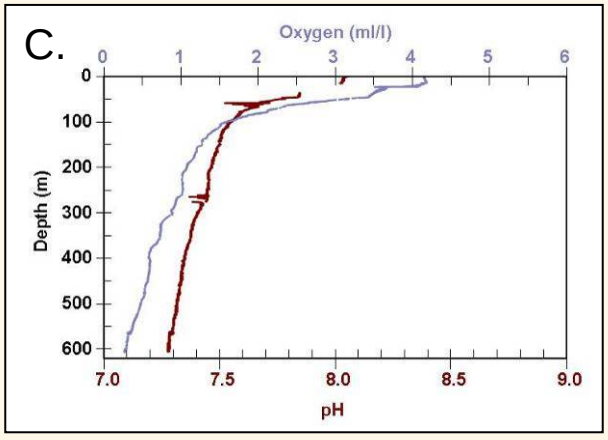
PHYSICAL ENVIRONMENT

In total, 3,706 m^2 of sea floor were surveyed during seven quantitative transects conducted during Dive 0005 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California (A). Habitat types were classified as (1) Hard (1% of the total area surveyed), which included mostly boulders; (2) Mixed (69% of the total area surveyed), including a combination of mud with cobbles and boulder; and (3) Sediment (30% of the total area surveyed), which consisted entirely of mud.



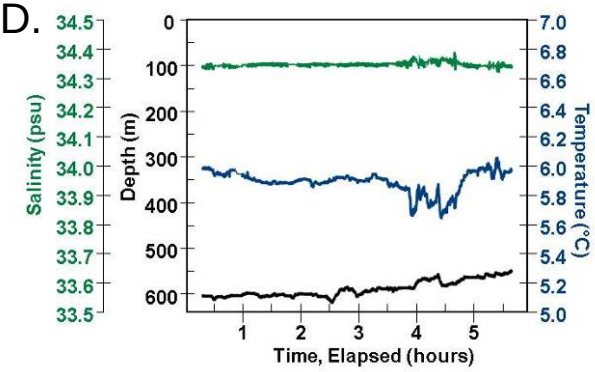
The ROV was equipped with a Sea-Bird SBE 19 CTD during Dive 0005, which collected data on depth, conductivity, temperature, pH, and oxygen during descent (B and C) and at depth along the track line (D and E).Temperature ranged from 16.6°C at the sea surface at the beginning of the dive to 6.0°C on the sea floor at 610 m depth. Salinity (as estimated from conductivity, temperature, and pressure) ranged from 33.5 psu at the sea surface to 34.3 psu on the sea floor. The range in pH was 8.0 at the sea surface to 7.3 on the sea floor, and oxygen ranged from 4.1 ml/l at the sea surface to 0.3 ml/l on the sea floor at 610 m. Temperature, pH, and oxygen fluctuated as the ROV dive continued along the sea floor (D and E).



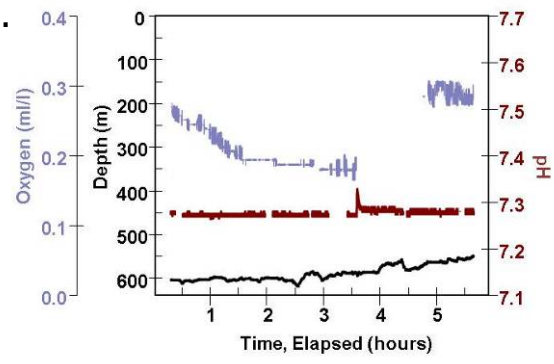


PHYSICAL ENVIRONMENT

D.



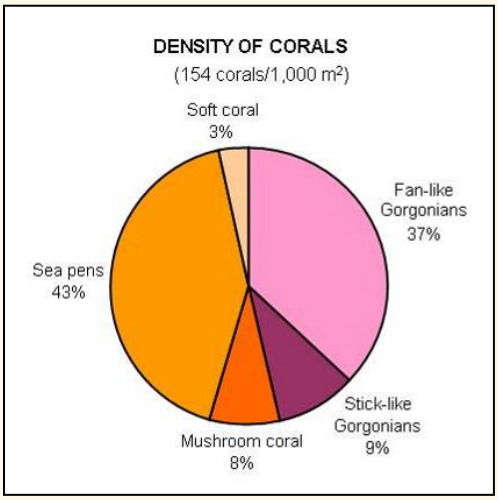
E.



BIOLOGICAL ENVIRONMENT: CORALS

A total of 599 individual corals, comprising at least ten taxa, were enumerated from seven quantitative transects conducted during Dive 0005 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 154 corals per 1,000 m^2 of sea floor was estimated. Sea pens, which occurred on soft mud sediment, accounted for 43% of the coral density on Dive 0005. Fan-like gorgonians (37%, Gorgonacea, *Paragorgia* spp., and *Parastenella ramosa*), stick-like gorgonians (9%, Plexauridae #2; *Swiftia* type), the mushroom coral (8%, *Anthomastus ritteri*), and soft coral (3%, *Clavularia* spp.) occurred mostly on mixed habitats.

Two coral specimens were collected during Dive 0005 and sent to experts for identification. Stephen Cairns (National Museum of Natural History, Smithsonian Institution, Washington DC) identified the primnoid (*Parastenella ramosa*). Gary Williams (California Academy of Sciences, San Francisco, CA) identified the sea pen (*Halipteris californica*).



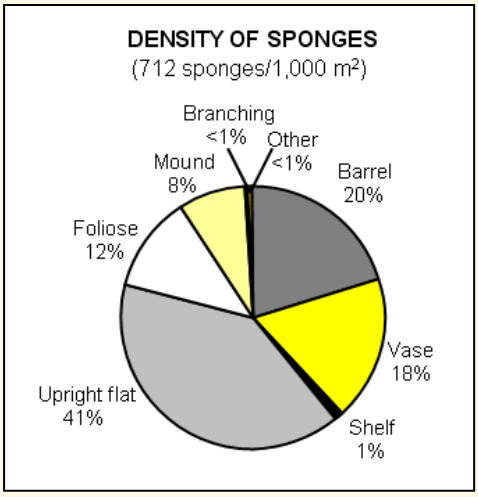
Colors in pie diagram match colors in list of coral taxa (below).

Scientific name	Common name	Number
Corals		
Gorgonacea	Unidentified sea fans	2
Paragorgia spp.	Sea fan (white w/ red polyps)	20
Parastenella ramosa[1]	Primnoid	205
Plexauridae #2 (*Swiftia* type)	Sea fan (red w/ yellow polyps)	54
Anthomastus ritteri	Mushroom coral	46
Anthoptilum grandiflorum	Feather boa sea pen	16
Halipteris californica[1]	Sea pen	111
Pennatulacea	Unidentified sea pens (thin)	61
Umbellula lindahli	Droopy sea pen	64
Clavularia spp.	Soft coral	20

[1]Specimen sent to experts for identification

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 2,682 individual sponges from at least 18 different taxa were enumerated from seven quantitative transects conducted during Dive 0005 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 712 sponges per 1,000 m^2 of sea floor was estimated. Upright flat sponges were most abundant (41% of the total density, *Mycale* spp. and others), followed by barrel (20%), vase (18%, *Heterochone calyx*, *Staurocalyptus* spp., and others), foliose (12%, *Farrea occa*, *Thenea muricata*, and others), mound (8%), shelf (1%), and branching (<1%) sponges. The category 'Other' represented <1% of the total sponge density and included at least five taxa (the predatory sponges *Asbestopluma* spp., *Hexactinella* sp., and unidentified sponges). Most of the sponges occurred on mixed habitats.



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

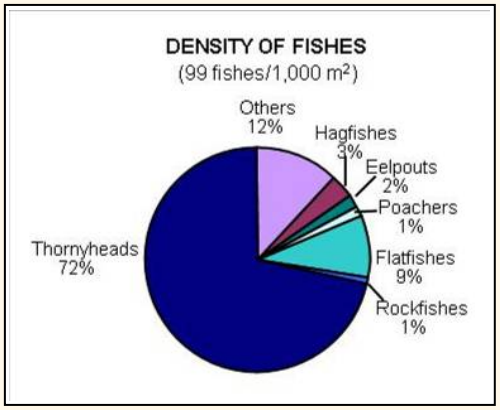
A mound-shaped, cream-colored sponge with multiple tubes originating from a central location was collected during Dive 0005. Henry Reiswig (Department of Biology, University Victoria, BC) identified this specimen as a glass sponge (*Hexactinella* sp.; see Image Gallery), and commented that this is almost certainly a new species. This sponge also was sent to James Weaver (University California Santa Barbara, now at Harvard University, Cambridge, MA); he has produced some exceptional, high resolution scanning electron micrographs for identification purposes.

Scientific name	Common name	Number
Sponges		
Porifera	Unidentified barrel sponges	553
Heterochone calyx	Fingered goblet vase sponge	37
Porifera	Unidentified vase sponges	423
Staurocalyptus spp.	Unidentified vase sponge (yellow)	8
Porifera	Unidentified shelf sponges	33
Mycale spp.	Upright flat sponge (yellow)	1,074
Porifera	Unidentified upright flat sponges	11
Farrea occa	Lace (or cloud) foliose sponge	1
Thenea muricata	Foliose sponge (clear)	286
Porifera	Unidentified foliose sponges	17
Porifera	Unidentified mound sponges	72
Porifera	Unidentified puffball mound sponges	145
Porifera	Unidentified branching sponges	9
Asbestopluma spp. #1	Predatory pipecleaner sponge	3
Asbestopluma spp. #2	Predatory sponge (clear)	2
Porifera	Unidentified sponges	3
Porifera	Unidentified tube sponges	3
Hexactinella sp.$_1$	Sponge (white)	2

$_1$Specimen sent to experts for identification

BIOLOGICAL ENVIRONMENT: FISHES

At least 20 taxa of fishes were identified during Dive 0005 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. A total of 354 individual fishes were enumerated, and an overall density of 99 fishes per 1,000 m^2 of sea floor was estimated from seven quantitative transects. Thornyheads (*Sebastolobus* spp.) accounted for 72% of the total fish density. The remaining fish assemblage consisted of flatfishes (9%, *Embassichthys bathybius*, *Microstomus pacificus*, *Parophrys vetulus*), the hagfish *Eptatretus stoutii* (3%), eelpouts (2%), poachers (1%), and rockfishes (1%). The category 'Others' (12% of total density) comprised at least nine taxa, including the blacktail snailfish (*Careproctus melanurus*), sculpins (Cottidae), the California smoothtongue (*Leuroglossus stilbius*), unidentified snailfishes (Liparidae), the California grenadier (*Nezumia stelgidolepis*), catsharks and a catshark egg case (Scyliorhinidae), lanternfishes (Myctophidae), and unidentified fishes.



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

Only 27 (0.8%; all sponges) of the 3,281 corals and sponges recorded on Dive 0005 were associated with fishes less than one body length away. The associated fishes were thornyheads (88%), unidentified rockfishes (6%), and Pacific hagfishes (6%).

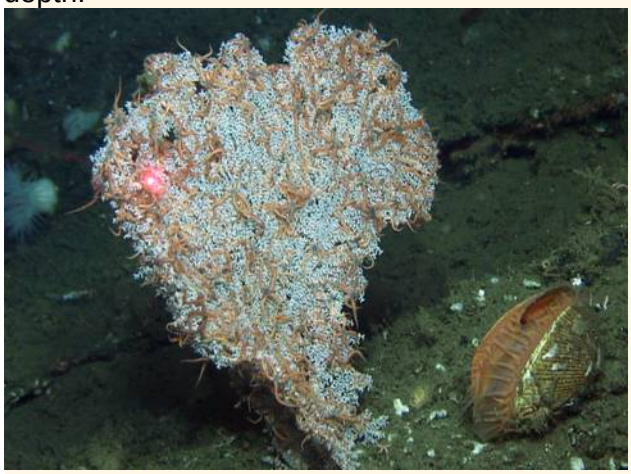
Scientific name	Common name	Number
Fishes		
Eptatretus stoutii	Pacific hagfish	12
Zoarcidae	Unidentified eelpouts	7
Agonidae	Unidentified poachers	4
Embassichthys bathybius	Deepsea sole	6
Microstomus pacificus	Dover sole	25
Parophrys vetulus	English sole	1
Sebastes aurora	Aurora rockfish	1
Sebastes spp.	Unidentified rockfishes	2
Sebastolobus alascanus	Shortspine thornyhead	1
Sebastolobus altivelis	Longspine thornyhead	5
Sebastolobus spp.	Unidentified thornyheads	245
Careproctus melanurus	Blacktail snailfish	1
Cottidae	Unidentified sculpins	3
Leuroglossus stilbius	California smoothtongue	6
Liparidae	Unidentified snailfish	10
Nezumia stelgidolepis	California grenadier	6
Osteichthyes	Unidentified fishes	2
Scyliorhinidae	Unidentified catsharks	7
Scyliorhinidae	Unidentified catshark egg case	1
Myctophidae	Unidentified lanternfishes	9

IMAGE GALLERY

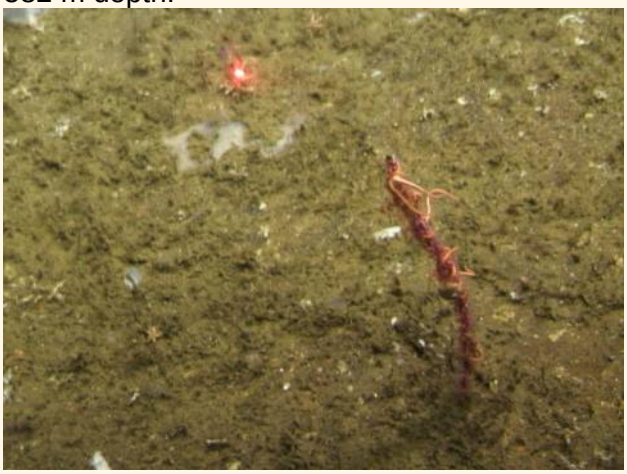
The droopy sea pen (*Umbellula lindahli*) and an unidentified sea pen on soft on soft mud sediment at 624 m depth.

A glass sponge, *Hexactinella* sp., on mixed habitat (large boulders with some mud) at 623 m depth.

The sea fan (*Parastenella ramosa*) with brittle stars, and mollusk (*Acesta sphoni*) on mixed habitat (large boulders with some mud) at 619 m depth.

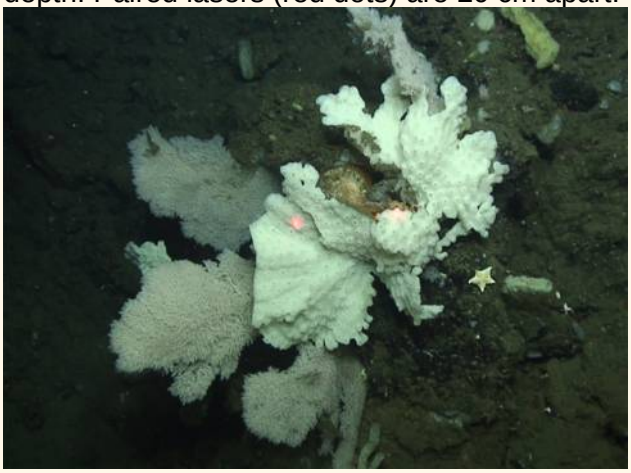


A brittle star wrapped around a red gorgonian (Plexauridae; Swiftia type) on hard rock habitat at 582 m depth.



Unidentified sculpin (Cottidae) on an unidentified sponge in hard rock habitat at 573 m depth.

Unidentified upright flat sponges and the sea fan (*Parastenella* spp.) on hard rock habitat at 307 m depth. Paired lasers (red dots) are 20 cm apart.

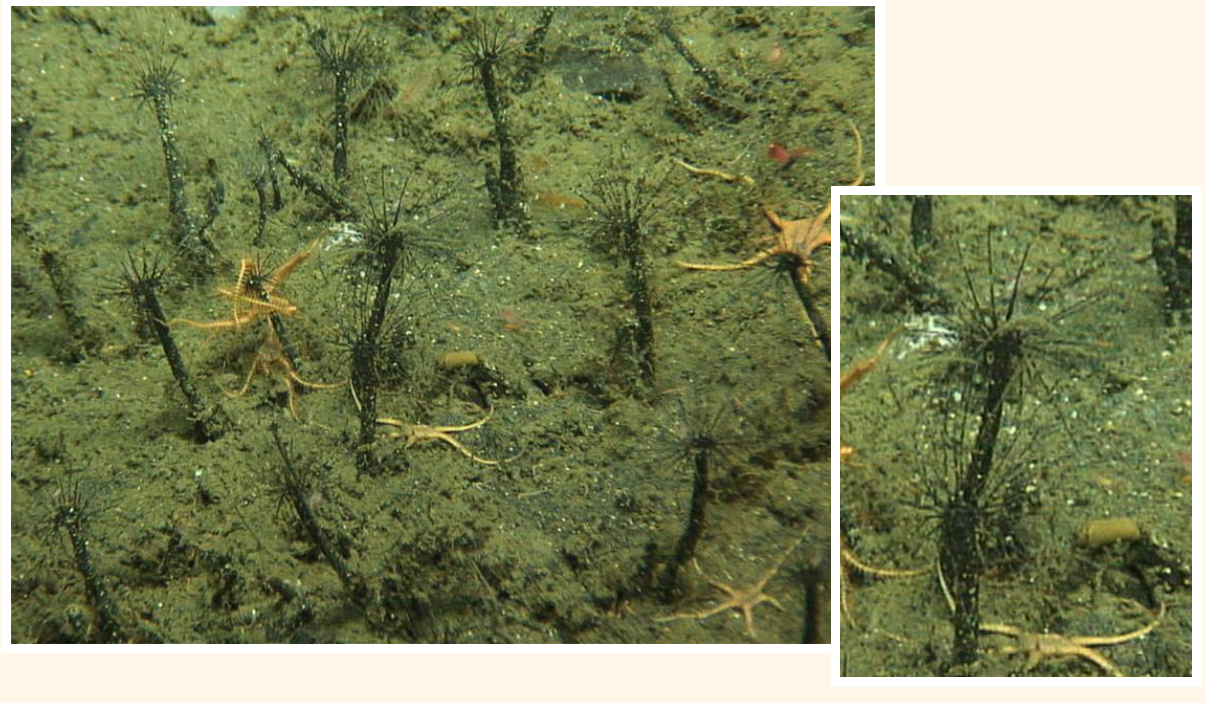


ADDITIONAL COMMENTS

Two man-made debris items (a beverage can in mud and rock habitat, and a larger can in cobble and mud habitat) occurred during the seven quantitative transects conducted during Dive 0005. Damage potentially caused by these two items was not observed.

Twenty-four of the 3,281 individual corals (two *Paragorgia* spp. and one *Halipteris californica*) and sponges (21 various types) that occurred on the seven transects during Dive 0005 appeared to be dead or dying. Many (70%) of these sponges and corals were knocked over or had missing parts. Additionally, 32 healthy sponges were knocked over or had missing parts. Dead corals and sponges often were covered with encrusting organisms and detritus.

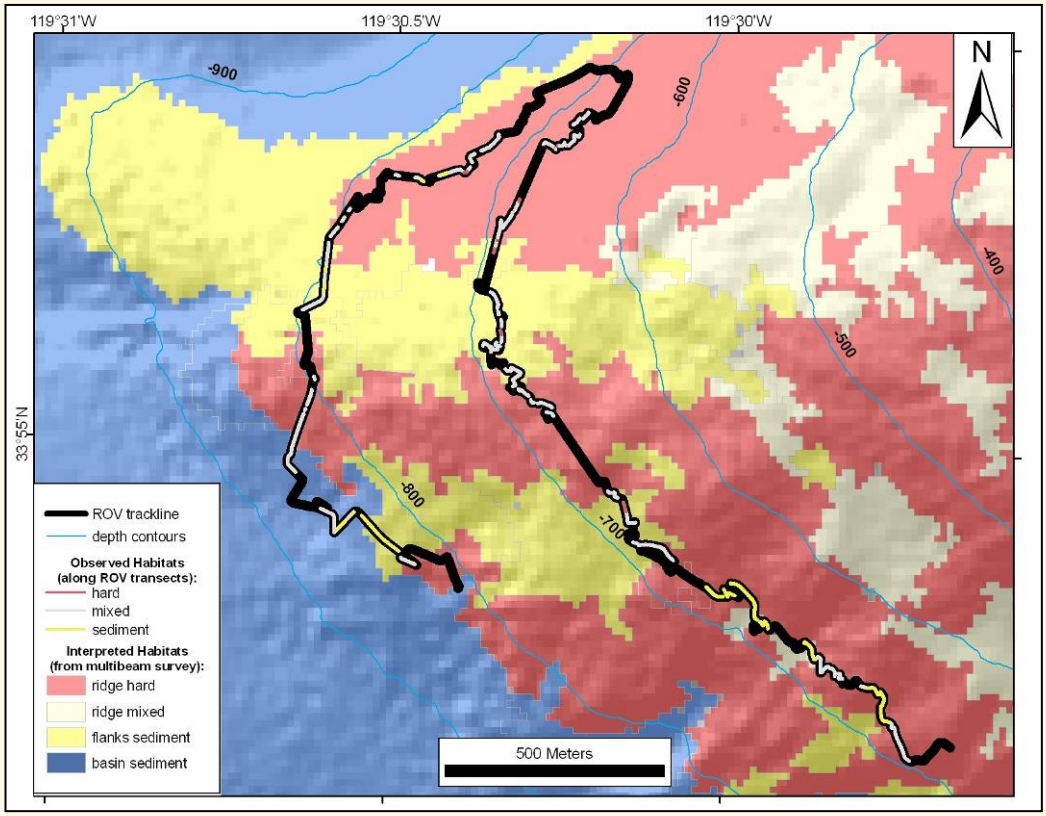
Several lanice polychaetes (family: Terebellidae) were collected during Dive 0005 and sent to Leslie Harris (Los Angeles County Natural History Museum). Harris comments that these specimens are members of an undescribed species, having “two kidney-shaped lobes at the tip of the tube, a single row of rays with black micro-pebbles, and each intact ray tipped with a piece of glass sponge spicule”. Harris says that “the worm uses its feeding tentacles to spread strings of mucus over the rays to create a web that catches drifting food particles. The tentacles remove individual particles and carry them to the mouth; periodically the worm will remove entire strings or the whole web, swallow them, then start the process all over again”.



Mat of lanice polychaetes (family: Terebellidae) in soft mud sediment at 605 m depth.

DIVE NUMBER: ROV 0006 *STUDY AREA: Piggy Bank*

GENERAL LOCATION AND DIVE TRACK



STATION OVERVIEW

Project	U.S. West Coast Deep Coral Cruise
Chief Scientist	M. Yoklavich
Contact Information	NMFS, SWFSC, mary.yoklavich@noaa.gov
Purpose	Survey deep coral communities at Piggy Bank off southern CA
Vessel	NOAA Ship *McArthur II* Leg 3; *Kraken 2* ROV
Science Observers	L. Krigsman, T. Laidig, M. Love, L. Lundsten, A. Taylor
External Video Tapes	5 HD, 3 SD
Internal Video Tapes	n/a
Digital Still Photos	22
Positioning System	Ship: GPS; ROV: USBL
CTD Sensors	Yes
O_2 Sensor	Yes
pH Sensor	Yes
Specimens collected	Yes
Other	Logbook, Access database
Report Analyst	D. Watters
Date Compiled	11 May 2011

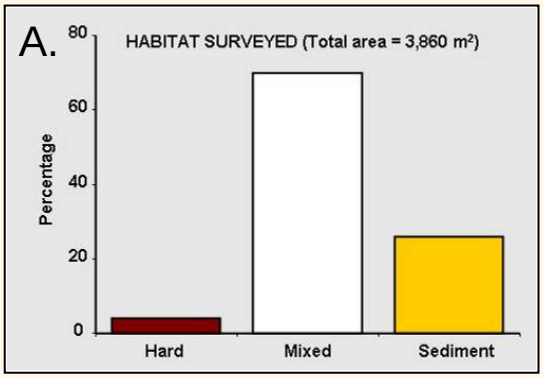
DIVE NUMBER: ROV 0006 *STUDY AREA: Piggy Bank*

DIVE DATA

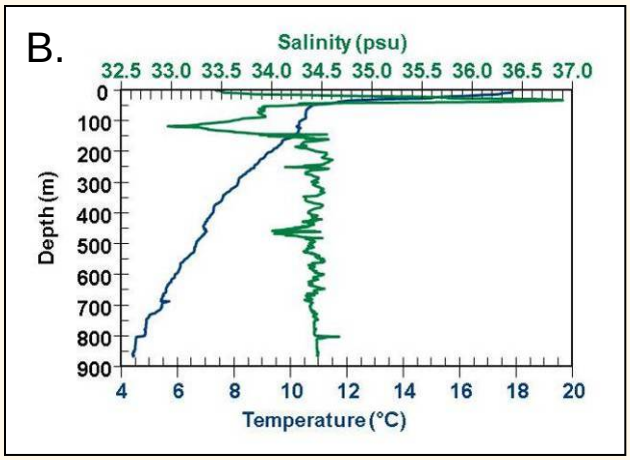
Date	1 July 2010	Starting Latitude (N)	33˚ 54.643’
Minimum Bottom Depth (m)	677	Starting Longitude (W)	119˚ 29.655’
Maximum Bottom Depth (m)	896	Ending Latitude (N)	33˚ 54.824’
Start Bottom Time (PDT)	08:41	Ending Longitude (W)	119˚ 30.390’
End Bottom Time (PDT)	17:00	Surface Current	n/a
Number 15-min Transects	12	Bottom Current	northwesterly

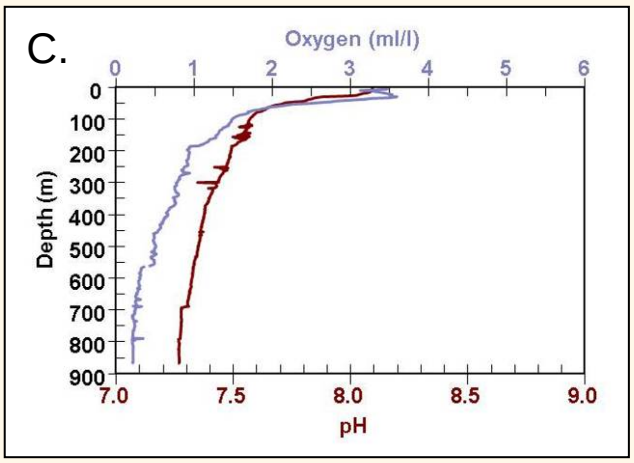
PHYSICAL ENVIRONMENT

In total, 3,860 m^2 of sea floor were surveyed during 12 quantitative transects conducted during Dive 0006 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California (A). Habitat types were classified as (1) Hard (4% of the total area surveyed), which included mostly rock and a mix of boulders and cobbles; (2) Mixed (70% of the total area surveyed), which included a combination of mud with mostly cobbles and boulders; and (3) Sediment (26% of the total area surveyed), which consisted entirely of mud.



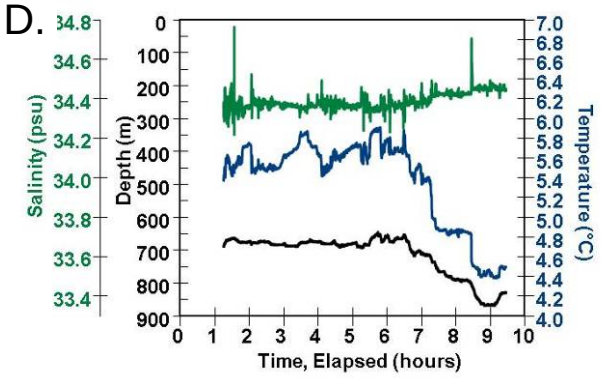
The ROV was equipped with a Sea-Bird SBE 19 CTD during Dive 0006, which collected data on depth, conductivity, temperature, pH, and oxygen during descent (B and C) and at depth along the track line (D and E).Temperature ranged from 17.9°C at the sea surface to 4.4°C on the sea floor at 868 m depth. Salinity (as estimated from conductivity, temperature, and pressure) ranged from 33.5 psu at the sea surface to 34.5 psu on the sea floor. Salinity varied widely in the top 200 meters of the water column. The range in pH was from 8.1 at the sea surface to 7.3 on the sea floor, and oxygen ranged from 3.5 ml/l at the sea surface to 0.2 ml/l on the sea floor at 868 m. As the ROV dive continued along the sea floor, temperature, salinity, pH, and oxygen all fluctuated with depth (D and E).



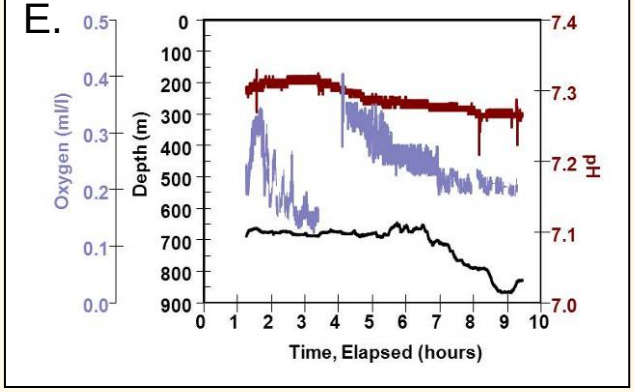


PHYSICAL ENVIRONMENT

D.



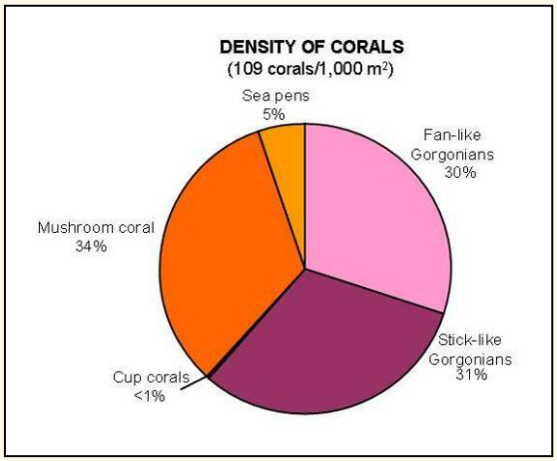
E.



BIOLOGICAL ENVIRONMENT: CORALS

A total of 416 individual corals, comprising at least 11 taxa, were enumerated from 12 quantitative transects conducted during Dive 0006 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 109 corals per 1,000 m^2 of sea floor was estimated. Fan- and stick-like gorgonians accounted for more than 60% of the coral density. The stick-like gorgonians likely include the genera *Swiftia* and *Euplexaura*, which could not be distinguished from the video footage alone. The mushroom coral (*Anthomastus ritteri*) comprised 34% of coral density, followed by sea pens (5%), and cup corals (<1%). All of these corals occurred on hard and mixed habitats, except for sea pens, which occurred on soft mud sediment.

Gary Williams (California Academy of Sciences, San Francisco, CA) identified a white-and-maroon-colored sea pen (*Pennatula phosphorea*) from the one coral specimen that was collected during Dive 0006.



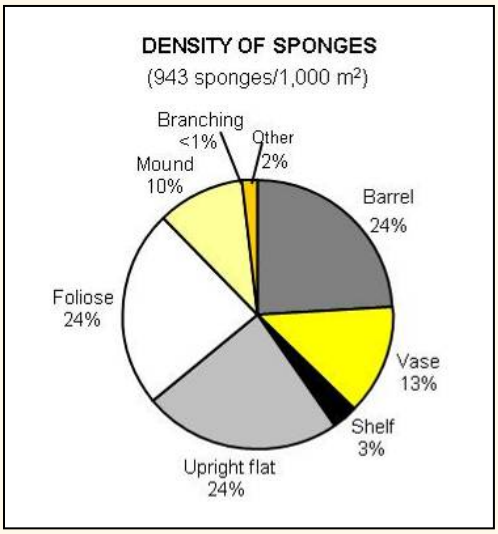
Colors in pie diagram match colors in list of coral taxa (below).

Scientific name	Common name	Number
Corals		
Paragorgia spp.	Sea fan (white w/ red polyps)	56
Parastenella ramosa	Primnoid	68
Plexauridae #1 (*Swiftia* type)	Sea fan (red w/ white polyps)	2
Plexauridae #2 (*Swiftia* type)	Sea fan (red w/ yellow polyps)	127
Caryophyllidae	Unidentified cup coral	1
Anthomastus ritteri	Mushroom coral	136
Halipteris californica	Sea pen	8
Pennatula phosphorea[1]	Phosphorescent sea pen	1
Pennatulacea	Unidentified sea pen (thin)	3
Pennatulidae	Unidentified sea pen (thick)	1
Umbellula lindahli	Droopy sea pen	13

[1]Specimen sent to experts for identification

BIOLOGICAL ENVIRONMENT: SPONGES

A total of 3,549 individual sponges from at least 20 different taxa were enumerated from 12 quantitative transects conducted during Dive 0006 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. An overall density of 943 sponges per 1,000 m^2 of sea floor was estimated. Barrel, upright flat (*Mycale* spp. and others), and foliose (*Farrea* occa, *Polymastia* spp., *Thenea muricata*, and others) sponges each accounted for 24% of the overall sponge density. Vase sponges (*Heterochone calyx*, *Staurocalyptus* spp., and others) represented 13% of the overall sponge density, followed by unidentified mound (10%), shelf (3%), and branching (<1%). The category 'Other' represented 2% of the total sponge density and included at least six taxa (the predatory sponges *Asbestopluma* spp., *Hexactinella* sp., and others). Sponges occurred on mixed and hard habitats.

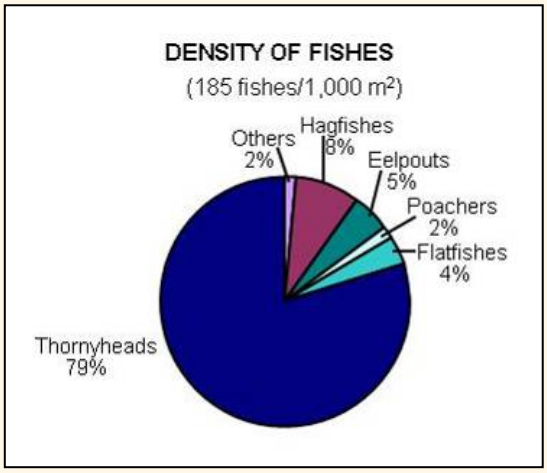


Colors in pie diagram match colors in list of sponge taxa (below).

Scientific name	Common name	Number
Sponges		
Porifera	Unidentified barrel sponges	875
Heterochone calyx	Fingered goblet vase sponge	55
Porifera	Unidentified vase sponges	395
Staurocalyptus spp.	Unidentified vase sponge (yellow)	23
Porifera	Unidentified shelf sponges	105
Mycale spp.	Upright flat sponge (yellow)	798
Porifera	Unidentified upright flat sponges	39
Farrea occa	Lace (or cloud) foliose sponge	21
Polymastia spp.	Nipple foliose sponge (yellow)	3
Thenea muricata	Foliose sponge (clear)	796
Porifera	Unidentified foliose sponges	7
Porifera	Unidentified mound sponges	357
Porifera	Unidentified puffball mound sponges	17
Porifera	Unidentified branching sponges	5
Asbestopluma spp. #1	Predatory pipecleaner sponge	6
Asbestopluma spp. #2	Predatory sponge (clear)	3
Porifera	Unidentified sponge (blue/white)	1
Porifera	Unidentified sponges	13
Porifera	Unidentified tube sponges	25
Hexactinella sp.	Sponge (white)	5

BIOLOGICAL ENVIRONMENT: FISHES

At least 15 taxa of fishes were identified during Dive 0006 using the *Kraken 2* ROV from NOAA vessel *McArthur II* on the seamount *Piggy Bank* off southern California. A total of 706 individual fishes were enumerated, and a total density of 185 fishes per 1,000 m^2 of sea floor was estimated from 12 quantitative transects. Thornyheads (*Sebastolobus* spp.) accounted for 79% of the total fish density and occurred in all habitats. The remaining fish assemblage consisted of hagfishes (8%, *Eptatretus stoutii*), eelpouts (5%, *Lycenchelys crotalinus* and others), flatfishes (4%, *Embassichthys bathybius and Microstomus pacificus*), and poachers (2%, Agonidae), which occurred primarily on soft mud sediment. The category 'Others' (2% of total density) comprised at least six taxa, including the California slickhead (*Alepocephalus tenebrosus*), unidentified sculpin (Cottidae), snailfish (Liparidae), and lanternfishes (Myctophidae), the California grenadier (*Nezumia stelgidolepis*), and an unidentified bony fish.



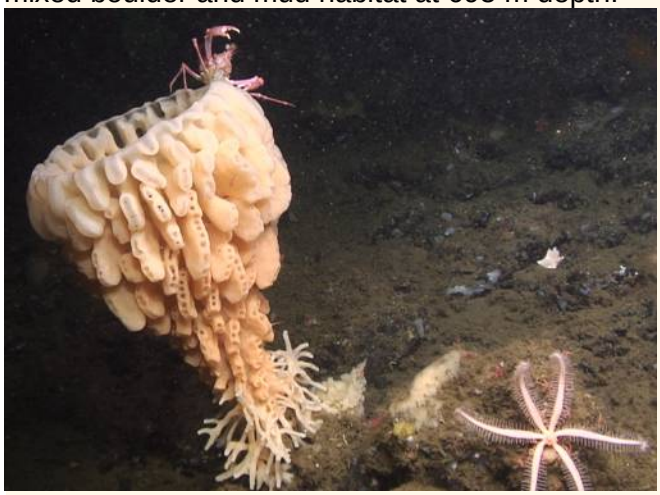
Colors in pie diagram match colors in list of fish taxa (below).

Only 67 (1.7%) of the 3,965 corals and sponges recorded on Dive 0006 were associated with fishes one body length or less away. Most of these fishes were thornyheads (89%); the remainder were hagfishes (9%), and eelpouts (2%).

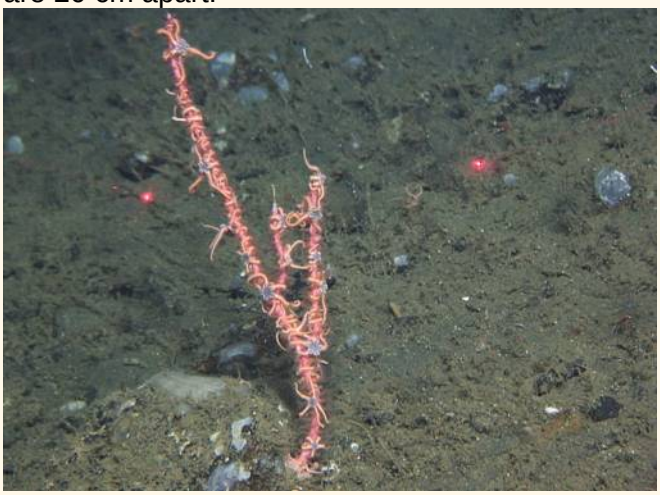
Scientific name	Common name	Number
Fishes		
Eptatretus stoutii	Pacific hagfish	58
Lycenchelys crotalinus	Snakehead eelpout	14
Zoarcidae	Unidentified eelpouts	22
Agonidae	Unidentified poachers	11
Embassichthys bathybius	Deepsea sole	4
Microstomus pacificus	Dover sole	21
Sebastolobus alascanus	Shortspine thornyhead	6
Sebastolobus altivelis	Longspine thornyhead	9
Sebastolobus spp.	Unidentified thornyheads	549
Alepocephalus tenebrosus	California slickhead	2
Cottidae	Unidentified sculpin	1
Liparidae	Unidentified snailfish	1
Myctophidae	Unidentified lanternfishes	6
Nezumia stelgidolepis	California grenadier	1
Osteichthyes	Unidentified fish	1

IMAGE GALLERY

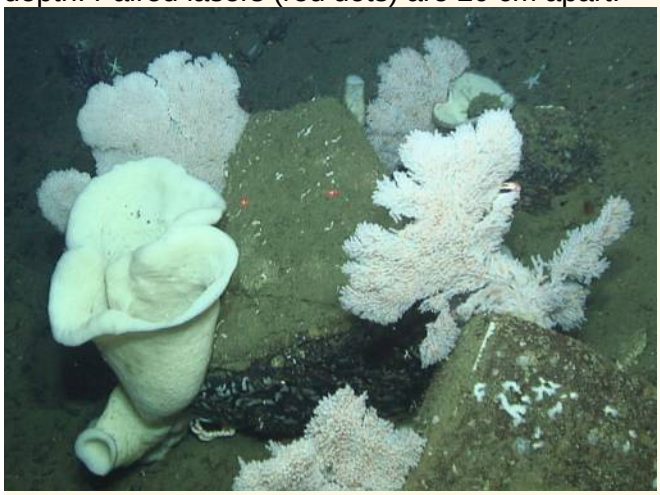
Fingered goblet vase sponge (*Heterochone calyx*), with *Chorilia* sp. crab, and a Brisingida sea star on mixed boulder and mud habitat at 695 m depth.



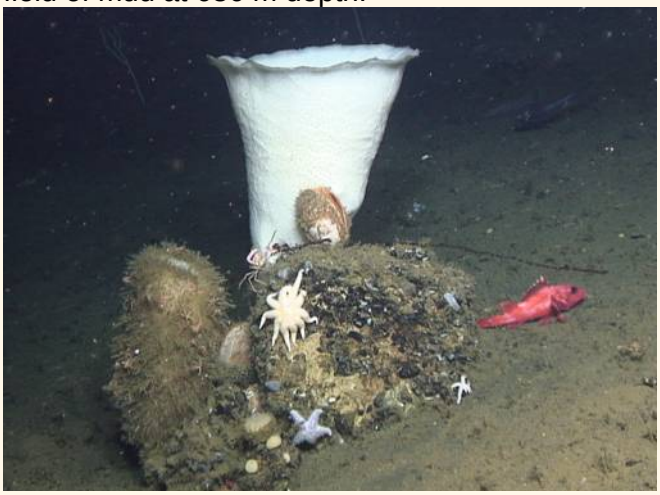
A red sea fan (Plexauridae; *Swiftia* type) covered with small brittle stars on mixed boulder and mud habitat at 695 m depth. Paired lasers (red dots) are 20 cm apart.



Unidentified vase sponges and Primnoid sea fans (*Parastenella ramosa*) on boulders at 686 m depth. Paired lasers (red dots) are 20 cm apart.



Unidentified barrel sponge, vase sponge, mollusk (*Acesta sphoni*), and unidentified thornyhead rockfish (*Sebastolobus* spp.) on a boulder in a field of mud at 686 m depth.



ADDITIONAL COMMENTS

No man-made debris items were observed during the twelve quantitative transects conducted during Dive 0006.

Fifty of the 3,965 individual corals (2 Plexauridae, *Swiftia*-type) and sponges (48 various types) that occurred on the 12 transects during Dive 0006 appeared to be dead or dying. Many (90%) of these sponges were knocked over or had missing parts; both dead/dying corals were altered. Additionally, 85 healthy sponges and three healthy corals were knocked over or had missing parts. Dead corals and sponges often were covered with encrusting organisms and detritus.

Tunicate specimens (clear organisms at center, bottom edge of this image) were collected during Dive 0006 and sent to Karen Sanamyan (Kamchatka Branch of Pacific Institute Geography, Russia). He identified these as *Corynascidia* sp., noting that they were very similar and may be identical to *Corynascidia vinogradovae* (Sanamyan 1998). These tunicates were commonly seen on dead fingered goblet vase sponges. Paired lasers (red dots) are 20 cm apart.

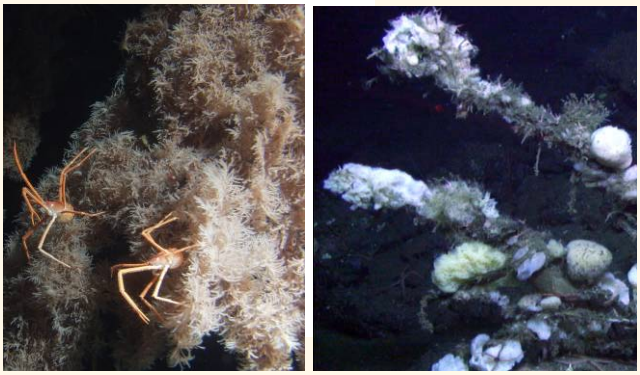
CORALS AND SPONGES AS BIOGENIC HABITATS

During our survey, we observed that Christmas tree black corals (*Antipathes dendrochristos*) and fingered goblet sponges (*Heterochone calyx)* often were colonized by other invertebrate taxa. Further, we hypothesized that occurrence and abundance of invertebrates was greater on dead or dying corals and sponges than on healthy ones. From additional analysis of the video footage, we assessed abundance and diversity of invertebrates on 225 corals and 275 sponges. These corals and sponges occurred in three conditions: healthy, dying, and dead.

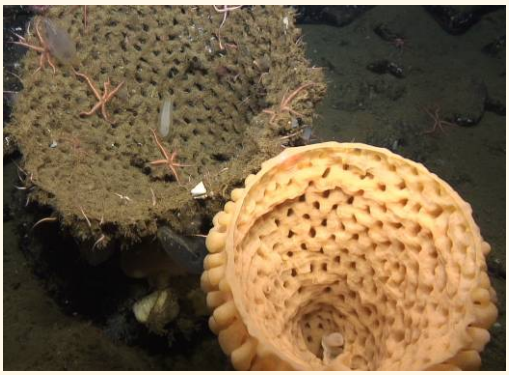
A greater number of invertebrates were found on dead corals ($\overline{X}$ = 5.3 organisms) and sponges ($\overline{X}$ = 9.2) than on living corals ($\overline{X}$ = 0.1 organisms) and sponges ($\overline{X}$ = 0.6). A two-sample *t*-test indicated a significant difference between living and dead hosts in both cases ($p<0.01$). The macrofauna observed on the corals and sponges were classified as either sessile or mobile. Sessile macrofauna did not colonize any living organisms, but rather colonized only dead hosts. This sessile group was dominated by sponges and tunicates, but also included anemones, corals, and bivalves. Mobile organisms, dominated by brittle stars, colonized both healthy and dead hosts, but were found in greater abundance on dead tissue. Other mobile organisms were basket stars, crinoids, crabs, sea stars, sea cucumbers, snails, and shrimps. We surmised that living biogenic hosts protect themselves from colonization either by having stinging nematocysts (Christmas tree black corals) or a microbial film (goblet sponges) that inhibit the settlement of the larvae. We suggest that these corals and sponges, especially dead and dying ones, can physically engineer the environment and aid in the sustainability of seafloor communities by providing habitat for demersal organisms.

Two dead fingered goblet sponges (*Heterochone calyx*) loaded with tunicates and brittle stars.

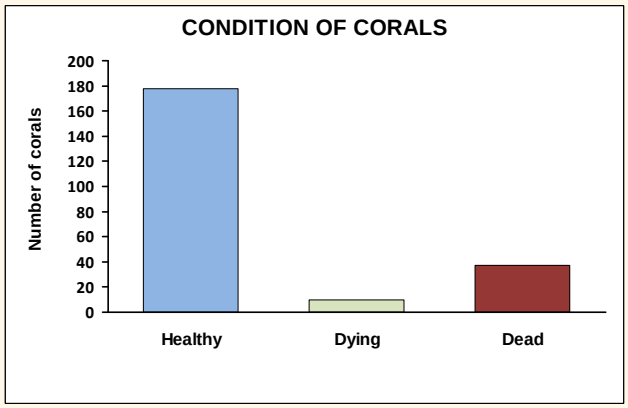
CORALS AND SPONGES AS BIOGENIC HABITATS

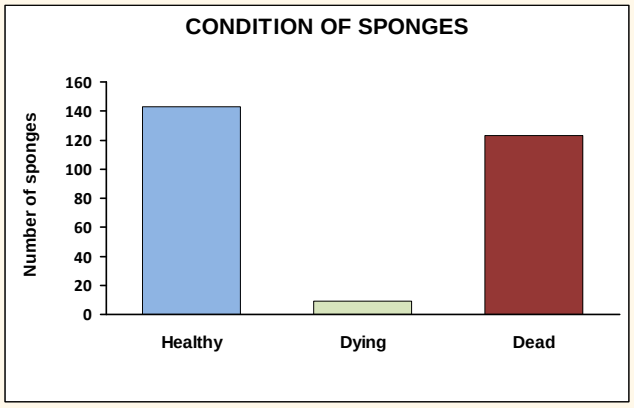


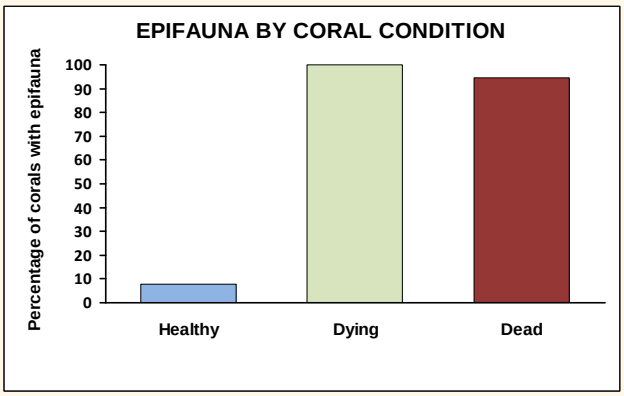
Healthy (left) and dead (right) Christmas tree black coral.

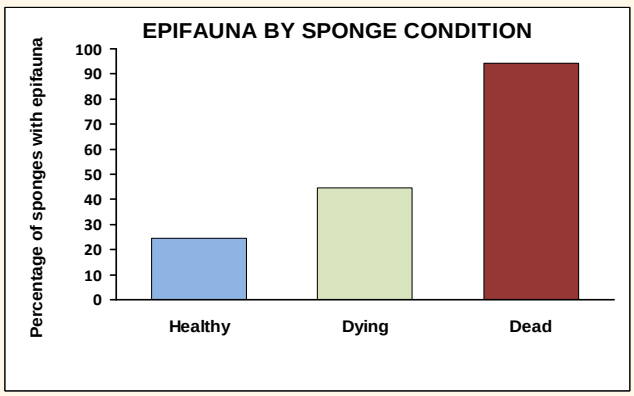


Healthy (right) and dead (left) fingered goblet sponges.









CONCLUSIONS AND NEXT STEPS

From this initial survey, we have found that the Piggy Bank seamount off southern California supports very high densities and an astounding diversity of deep-sea corals and sponges. At least 26 different taxa of corals and 26 different taxa of sponges occur on rocky, mixed, and soft sediment substrata of this seamount at depths from 275 to 900 m. Densities ranged from 95–536 corals/1000 m^2 and 224–969 sponges/1000 m^2; sizes of these organisms ranged from a few centimeters to 1.5 meters in height. By comparison, other recent surveys of DSC off the west coast resulted in much lower densities and diversity. For example, Stierhoff et al. (In Review) estimated 0–0.6 corals/ 1000 m^2 (from 7 taxa) and 0–0.1 unidentified sponges/1000 m^2 at five sites off California, Oregon, and Washington in hard, mixed, and soft substrata at 100–450 m depth during ROV surveys made in November 2010. From DSC surveys conducted west of Cordell Bank during Leg 2 of our *McArthur II* cruise in June 2010 (CBNMS 2011), estimated densities were 400 corals/1000 m^2 (4 taxa, primarily sea pens) and 10 sponges/1000 m^2 (at least 5 taxa) in mostly mixed rock and soft sediments at 167–497 m depth.

Densities of corals and sponges vary with habitat type (Tissot et al. 2006), but most of these organisms are found on rocky substrata. Species richness can depend on sample size (search area), habitat types, and depth range of the survey. Our survey covered the high-relief rocky pinnacles and boulder fields on top of Piggy Bank, as well as the mostly low-relief, mixed cobble and soft sediments along the sides of the seamount at deeper depths. The high densities and diversity of DSC on Piggy Bank could reflect the wide range of habitats and depths of our survey. In addition, the SCB comprises areas of high nutrients and broad temperature ranges, which also can result in the high diversity of corals and sponges observed on our survey.

One significant effect on the densities of deep-sea corals and sponges can be from the physical damage imparted by certain fishing gear types (e.g., bottom trawling specifically outfitted with roller gear). While most of the west coast shelf and slope has been intensely trawled for at least 40 years, this type of fishing was not as prevalent in southern California. On sites such as the Piggy Bank seamount, fishing largely was carried out with hook and line, longlines, and traps. This could explain the high densities of DSC on the Piggy Bank when compared to other regions along the west coast.

Whatever the reason, Piggy Bank will continue to receive protection from any type of fishing that impacts the seafloor inside the Footprint MPA and EFH Conservation Area. With such protection, the Piggy Bank seamount very likely will serve as a source of young corals and sponges that may repopulate surrounding rocky banks. Our characterization of the DSC community and associated habitats on the Piggy Bank provides the baseline for future monitoring of change to this community and for evaluation of the effectiveness of the new Footprint MPA and EFH Conservation Area to conserve biodiversity of habitats and assemblages.

This was an extraordinarily successful field study that was executed over a very short period of time (4.5 days at sea). The success of this cruise has instigated much discussion, leading to the identification of a number of topics for further investigation. For instance, we found few instances of corals and sponges associated with demersal fishes. In Alaska, however, researchers have found fish associations with corals and sponges to be common in some locations (Stone 2006). This discrepancy could be related to the types of species, densities, and sizes of corals, sponges and fishes at each location, as well as the extent and distribution of physical habitats available to the DSC and fishes. Critical evaluation of these data is needed to understand the role of corals and sponges as fish habitat.

We found many undescribed and recently described species of corals and sponges. Further study is warranted to determine depth and latitudinal ranges, associations, habitats, and community structure for these new species. Additionally, results from our survey on Piggy Bank seamount can be compared with findings of DSC on other offshore banks in the SCB (Tissot et al. 2006; Bright 2007) and central California (Graiff 2008; CBNMS 2011; McKelvey 2011). We also collected data on environmental conditions, including depth, temperature, substratum types, topography, pH, and dissolved oxygen. Further analyses and interpretation of these data can help us understand habitat factors that influence settlement and distribution of DSC. Our results of habitat types and distribution also will be used by USGS researchers to groundtruth and revise their seafloor habitat maps, which were interpreted from multibeam sonar surveys.

Data from the DSC survey on Piggy Bank are being added to our comprehensive database that includes geo-referenced information on identification, counts, sizes, and associated habitats (e.g., location, depth, substratum type, temperature) collected throughout the SCB. With these data, we are beginning to develop habitat-based models to predict the distribution and abundance of DSC associated with rocky areas off southern California. For this project, we will relate abundance of DSC to various components of habitat using predictive models and broad-scale seafloor maps. The resultant maps of DSC distributions from these predictive models will assist researchers and managers in understanding habitat requirements of DSC and in prioritizing areas for future field research.

Leg 3 of this coastwide cruise included multiple investigators of various disciplines and expertise, and several underwater survey tools. The partnerships developed among investigators on this cruise will facilitate our ability to share these research results with a broad group of constituents that are interested in deep-sea coral and sponge communities.

ACKNOWLEDGEMENTS

The captain (Greg Hubner), officers, and crew of the NOAA vessel *McArthur II* worked very hard and competently to make all aspects of our survey run smoothly and successfully. We thank the *Kraken 2* ROV team for their efforts in planning the survey, operating and maintaining the survey vehicle, and collecting the video images and biological specimens. We appreciate the planning and technical efforts of other members of our Leg-3 research team, particularly Elizabeth Clarke, Steve Katz, and Danielle Lipski. We also thank researchers from the Olympic Coast and Cordell Bank National Marine Sanctuaries for assistance in planning this survey. We are grateful for the assistance of the many experts in the identification of deep-sea corals and sponges; these researchers have been identified throughout the report. This research was supported by NOAA NMFS SWFSC and DSCRTP; we especially thank Tom Hourigan, Fan Tsao and the West Coast DSC Plan Team.

REFERENCES

Bright, J. 2007. Abundance and distribution of structure-forming invertebrates and their association with fishes at the Channel Islands "Footprint" off the southern coast of California. M.S. Thesis, Washington State University, Vancouver, WA. 66 p.

Butler, J., M. Neuman, D. Pinkard, R. Kvitek, and G. Cochrane. 2006. The use of multibeam sonar mapping techniques to refine population estimates of the endangered white abalone (*Haliotis sorenseni*). Fishery Bulletin 104:521-532.

CBNMS (Cordell Bank National Marine Sanctuary). 2011. Central California survey (Leg 2): June 2010. A report to the NOAA Deep-sea Coral Research and Technology Program. 19 p.

Dartnell, P., G. Cochrane, and M. E. Dunaway. 2005. Multibeam bathymetry and backscatter data: Northeastern Channel Islands region, Southern California. U.S. Geological Survey Open-File Report 05-1153, http://pubs.usgs.gov/of/2005/1153.

Etnoyer, P., S. D. Cairns, J. A. Sanchez, J. K. Reed, J. V. Lopez, W. W. Schroeder, S. D. Brooke, L. Watling, A. Baco-Taylor, G. C. Williams, A. Lindner, S.C. France, and A.W. Bruckner. 2006. Deep-Sea coral collection protocols. NOAA Technical Memorandum NMFS-OPR-28, Silver Spring, MD. 53 p.

Graiff, K. W. 2008. Abundance and distribution of megafaunal invertebrates in relation to fishing intensity off central California. M.S. Thesis. Washington State University, Vancouver, WA.

Greene, H. G., M. M. Yoklavich, R. M. Starr, V. M. O'Connell, W. W. Wakefield, D. E. Sullivan, J. E. McRea, and G. M. Cailliet. 1999. A classification scheme for deep seafloor habitats. Oceanologica Acta 22:663–678.

Love, M. S., M. M. Yoklavich, B. A. Black, and A. H. Andrews. 2007. Age of black coral (*Antipathes dendrochristos* Opresko, 2005) colonies, with notes on associated invertebrate species. Bulletin of Marine Science 80:391-400.

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.

Love, M. S., M. Yoklavich, and L. Thorsteinson. 2002. The Rockfishes of the Northeast Pacific. University of California Press, Berkeley and Los Angeles, CA. 405 p.

McKelvey, C. B. 2011. Abundance and distribution of megafaunal invertebrates in NE Pacifc submarine canyons and their ecological associations with demersal fishes. M.S. Thesis, School of Earth and Environmental Sciences, Washington State University, Vancouver, WA.

Opresko, D. 2005. A new species of antipatharian coral (Cnidaria: Anthozoa: *Antipatharia*) from the Southern California Bight. Zootaxa 852:1-10.

Sanamyan, K. 1998. Ascidians from the NW Pacific region. 5. Phlebobranchia. Ophelia 49:97-116.

Stierhoff, K. L., P. J. Etnoyer, D. W. Murfin, and J. L. Butler. A survey of deep-water coral and sponge habitats along the West Coast of the US using a remotely operated vehicle. In review for submission as a NOAA Technical Memorandum.

Stone, R. P. 2006. Coral habitat in the Aleutian Islands of Alaska: depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25:229-238.

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.

Yoklavich, M., and M. Love. 2005. Christmas tree corals: a new species discovered off southern California. Current: The Journal of Marine Education 21:27-30.

Yoklavich, M. M., H. G. Greene, G. M. Cailliet, D. E. Sullivan, R. N. Lea, and M. S. Love. 2000. Habitat associations of deep-water rockfishes in a submarine canyon: an example of a natural refuge. Fishery Bulletin 98:625-641.