
**A survey of deep-water coral and sponge habitats along the West Coast
of the US using a remotely operated vehicle**

**NOAA Fisheries Survey Vessel (*FSV*) *Bell M. Shimada*
November 1-5, 2010**



Report date: October 2011



NOAA Technical Memorandum NOS NCCOS 138

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A survey of deep-water coral and sponge habitats along the West Coast of the US using a remotely operated vehicle

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Introduction

Survey overview

Survey Objectives:

Remotely operated vehicle (ROV) surveys were conducted from NOAA's state-of-the-art Fisheries Survey Vessel (FSV) *Bell M. Shimada* during a six-day transit November 1-5, 2010 between San Diego, CA and Seattle, WA. The objective of this survey was to locate and characterize deep-sea coral and sponge ecosystems at several recommended sites in support of NOAA's Coral Reef Conservation Program. Deep-sea corals and sponges were photographed and collected whenever possible using the Southwest Fisheries Science Center's (SWFSC) Phantom ROV '*Sebastes*' (Fig. 1).

The surveyed sites were recommended by National Marine Sanctuary (NMS) scientists at Monterey Bay NMS, Gulf of the Farallones NMS, and Olympic Coast NMS (Fig. 2). The specific sites were: Sur Canyon, The Football, Coquille Bank, and Olympic Coast NMS. During each dive, the ROV collected digital still images, video, navigation, and along-track conductivity-temperature-depth (CTD), and optode data. Video and high-resolution photographs were used to quantify abundance of corals, sponges, and associated fishes and invertebrates to the lowest practicable taxonomic level, and also to classify the seabed by substrate type. A reference laser system was used to quantify area searched and estimate the density of benthic fauna.

Survey Summary:

Five ROV transect surveys were conducted between San Diego, CA and Seattle, WA. The total submerged time of 9 hours 45 minutes. The total seafloor distance surveyed was ~5.1 kilometers (km). The depth range of observations was from 110-400 meters (m) (Table 1). Many deep-sea octocorals, cup corals, and sponges were observed throughout the survey. The ROV's single function manipulator was used to collect four deep-sea coral specimens for molecular and morphological taxonomy plus three serendipitous samples of invertebrates associated with those corals. Samples consisted of: (1) *Dendrophyllia* sp., (2) brittle stars, (2) *Euplexaura markii*, (~20) amphipods associated with *E. markii*, and (1) *Swiftia pacifica* (see Appendix 1).

Table 1. Navigation summary for ROV deep-sea coral surveys.

Dive name	Site name	Duration (h)	Start		End		Avg. Depth (m)	Total distance (m)
			Latitude	Longitude	Latitude	Longitude		
10-306A	Sur Canyon	2:44	36.232	-121.914	36.236	-121.911	-401	1025
10-307A	The Football	1:03	38.449	-123.582	38.446	-123.583	-192	566
10-308A	Coquille Bank	1:51	42.907	-124.859	42.909	-124.854	-237	858
10-309A	OCNMS Site 1	1:57	48.167	-125.360	48.177	-125.362	-111	1503
10-309B	OCNMS Site 2	2:10	48.155	-125.112	48.163	-125.114	-244	1212

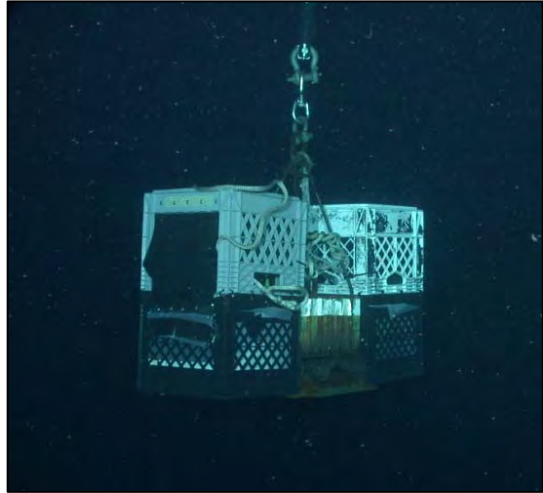
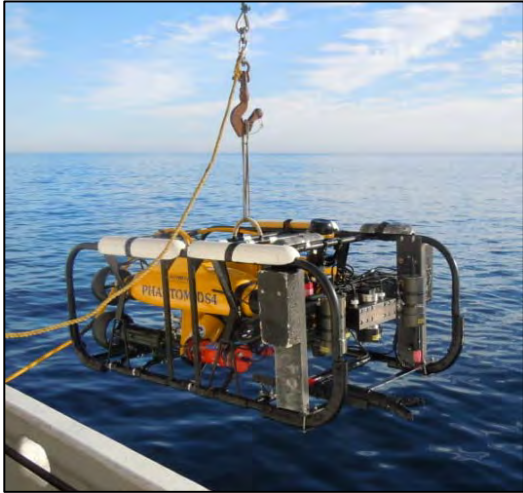


Figure 1: Photos of the SWFSC Phantom ROV 'Sebastes' (top left), the collection baskets attached to the clump weight (top right), and the FSV *Bell M. Shimada* (bottom).

Survey Method:

The ROV (Deep Ocean Engineering, Inc. Phantom DS4) was equipped with a CTD sensor (Citadel CTD, Teledyne RDI), an oxygen optode, a Doppler velocity log (DVL, for precisely measuring speed and distance, Workhorse Navigator, Teledyne RDI), a scanning sonar, a single-function manipulator, a digital still camera (Insite Pacific, Inc. Scorpio with Nikon Coolpix 995), a video camera (Sony FCB-IX47C with 468x720 lines of resolution and an 18x optical zoom), a reference laser system, and an ultra-short baseline (USBL) tracking system (LinkQuest). The ROV's down weight was equipped with collection baskets for holding coral specimens. The FSV *Shimada* was equipped with an azimuthal bow thruster and dynamic-positioning (DP) system that provided precise control over the ship's course, heading, and speed. These tools allowed the ROV to survey and navigate to precise coordinates and change course while underway. A live-feed of the ROV's real-time tracking system to the bridge aided communications among the helm, deck crew and ROV operations. Navigation data from the ship and ROV were logged at 2-second intervals using the WinFrog integrated navigation system software (Fugro-Pelagos, Inc.).

During each dive, the ROV collected digital still images, video, navigation data (e.g. latitude/longitude, speed, and depth), and along-track CTD-optode (CTD-O) data. Video and high-resolution photographs were reviewed post-cruise to quantify the abundance of all observed organisms to the lowest practicable taxonomic level. Distance was calculated every 2-seconds using the speed of the ROV. Video and the reference laser system were used to quantify total area searched at 2-second intervals using the 3Beam© Quantitative Measurement System (QMS) software (Pinkard et al. 2005, Stierhoff et al. In prep.). Habitat types were classified following the classification system of Greene et al. (1999), but were subsequently summarized into broader habitat classes (hard, soft, mixed) for ease of comparison (Table 2). The total area searched within each broad habitat type was also calculated to estimate habitat-specific densities of each organism at each dive site.

Table 2. Habitat classification criteria for ROV surveys, from Greene et al. (1999).

Broad class	Habitat type	Habitat description
Soft	Mud	Mud (clay to silt, <0.06mm)
	Sand	Sand (0.06-2mm)
Mixed	Pebble	Pebble (2-64mm)
	Cobble	Cobble (64-256mm)
Hard	Low-relief reef	Consolidated low-relief reef (e.g. pavement)
	Boulder	Boulder (0.25-3m)
	High-relief	Consolidated high-relief reef
	Vertical rock	Vertical rock (approaching 90 degrees)
Water column	Water column	ROV off-bottom

Detailed information is provided in this report. Additional images are available here: <http://picasaweb.google.com/peter.etnoyer/WestCoastShakedownExpedition#>

An interactive map, including virtual tours from each ROV dive is available here: <http://swfsc.noaa.gov/ShimadaDeepcoralCruise2010/>

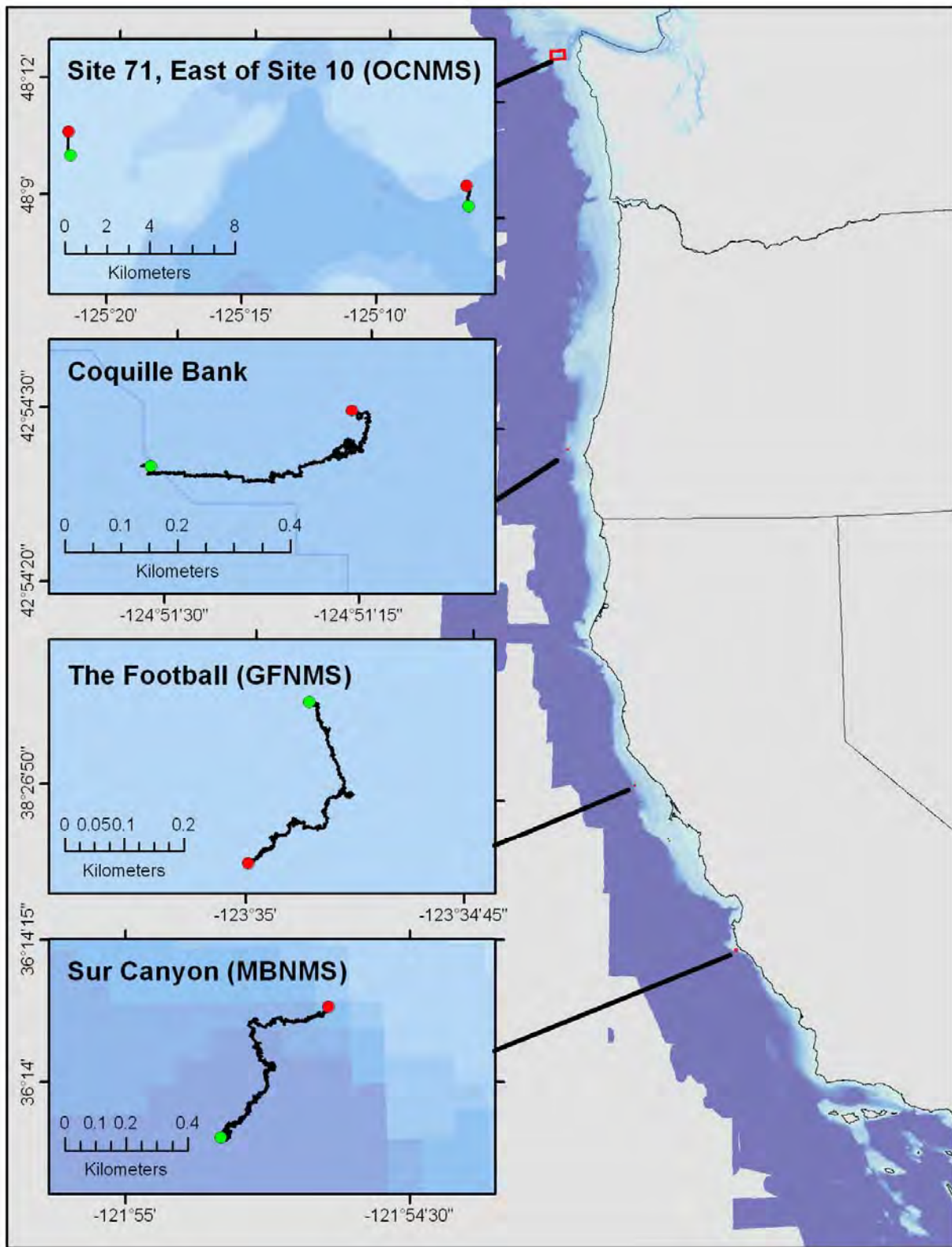


Figure 2. Overview map showing the location of remotely operated vehicle (ROV) dives between San Diego, CA and Seattle, WA. Green and red points indicate the start and end of each ROV transect, respectively.

Site characterizations

Sur Canyon (Dive 10-306A) – 11/02/2010

Physical environment

The Sur Canyon (Fig. 3) is an unexplored area of the MBNMS. It is being considered as a potential "Unique and Rare Area" in an Ecosystem Based Management Initiative due to the unique canyon morphology. Surveys of deep coral and sponges are necessary to inform this initiative. Moreover, a north/south deep-sea cable route was planned to cross this area in the past, and the proposal may be resubmitted in the future. A characterization of canyon fauna is important for assessing environmental impacts from potential cables (*pers. comm.*, A. DeVogelaeare, MBNMS). The canyon site is located ~6 km offshore of the Big Sur Coast, south of Monterey Bay.

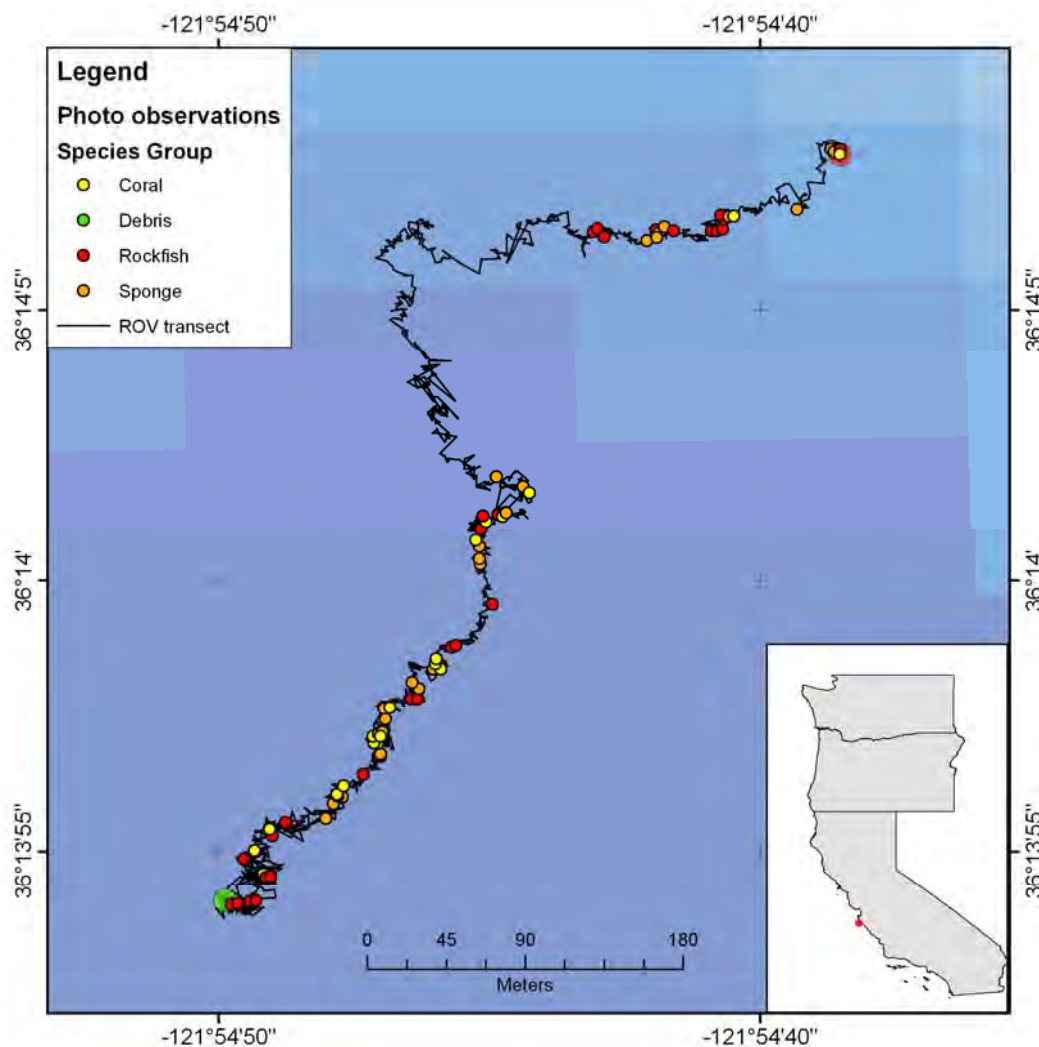


Figure 3. Map of the dive site at Sur Canyon (Dive 10-306A). Points indicate observations from still photographs. Green and red points indicate the start and end of each ROV transect, respectively. Inset map indicates the location along the coast.

A water column profile was collected using the CTD-O, but the collection of data did not begin until the ROV reached 50 m (Fig. 4). The temperature was 11 °C at 50m and continually decreased to 6 °C at ~480 m. Salinity also decreased continually from 33.8 PSU to 34.3 PSU between 50 m and the sea floor. Dissolved oxygen dropped from 5 mg O₂ l⁻¹ at the sea surface to ~1 mg O₂ l⁻¹ (~10% saturation) at depth.

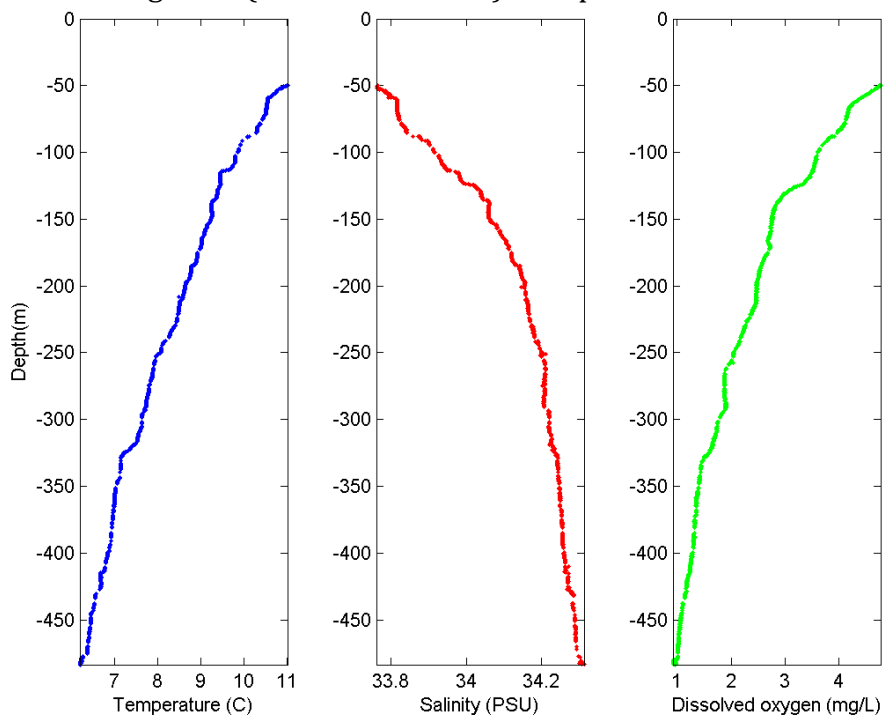


Figure 4. Water column profiles of temperature (blue), salinity (red), and dissolved oxygen (green) at Sur Canyon (10-306A).

The ROV was deployed in challenging conditions: the wind speed was ~10 knots and the seas were 3-4m. This 4-hour dive targeted the steep eastern wall of Sur Canyon, covering approximately 1 km of seafloor at an average depth of 400m (Table 1). The steepest part of the canyon wall was near the transect line, but this particular part of the canyon was avoided to minimize the risk of damage to the ROV. The slope was moderate to steep, composed primarily of hard (low- and high-relief reef, 59% total area) and soft substrate (mostly mud, 34% total area), and punctuated by intermittent boulders (Fig. 5).

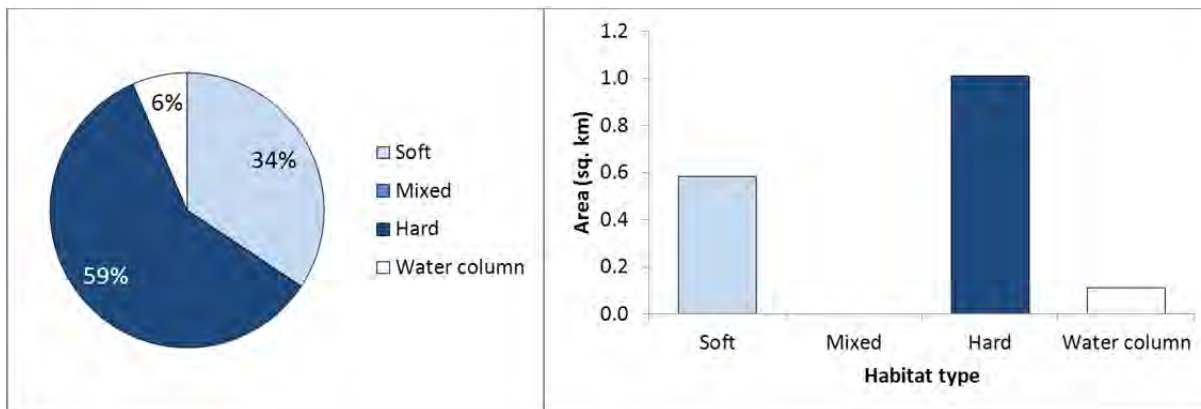


Figure 5. Percent and total area of habitat surveyed at Sur Canyon (10-306A).

Biological environment

Corals and anemones

The predominant corals were the soft coral *Anthomastus ritteri* and the large cup coral *Desmophyllum* sp. (Fig. 6a, Table 3). *Swiftia beringi* and *Euplexaura marki* were present, but relatively uncommon (Table 3). Several unidentified sea pens (Pennatulacea) were also observed. Almost all observations occurred on hard substrate. Coral density across all habitat types was estimated to be ~36 colonies per km². Photos of several representative species are shown in Fig. 7.

Sponges

The sponge assemblage was fairly diverse. Fan-shaped, vase-shaped, plate-shaped (bracket sponges), barrel-shaped and whip-like colonies were observed (Fig. 6b, Table 3). Large boot sponges (~30 cm height) and yellow vase sponges (~20 cm diameter) were the predominant habitat forming benthic invertebrates. Numerous whip-like colonies of *Asbestopluma* sp. (identified by Lonny Lundsten, Monterey Bay Aquarium Research Institute) were observed. Sponge density across all habitat types was estimated to be ~80 colonies per km². Almost all observations occurred on hard substrate, where sponges were attached to boulders. Photos of several representative species are shown in Fig. 7.

Fishes

Shortspine thornyheads (*Sebastolobus alascanus*) were the most common fishes observed (~32 per km², Figure 6c), and were mostly observed over soft substrate (Table 3). Other notable Scorpaenid fishes included bank rockfish (*Sebastes rufus*), aurora rockfish (*S. aurora*), and blackgill rockfish (*S. melanostomus*, Fig. 6c). Dover sole (*Microstomus pacificus*), California rays (*Raja inornata*) and several sablefish (*Anoplopoma fimbria*) were also observed.

Echinoderms, Arthropods and Mollusks

Numerous Humboldt squid (*Dosidicus gigas*) were observed feeding amidst a mid-water aggregation of *Diaphus* sp. (likely *Diaphus theta*, California headlightfish) near 400 m depth during the descent. Deep-sea sun stars (*Rathbunaster californicus*) were highly abundant over the hard substrate (Fig. 6d, Table 3). Several other unidentified sea stars, feather stars (crinoids), and suspension-feeding sea cucumbers were also observed. Two brittle stars were collected inadvertently in the sample basket.

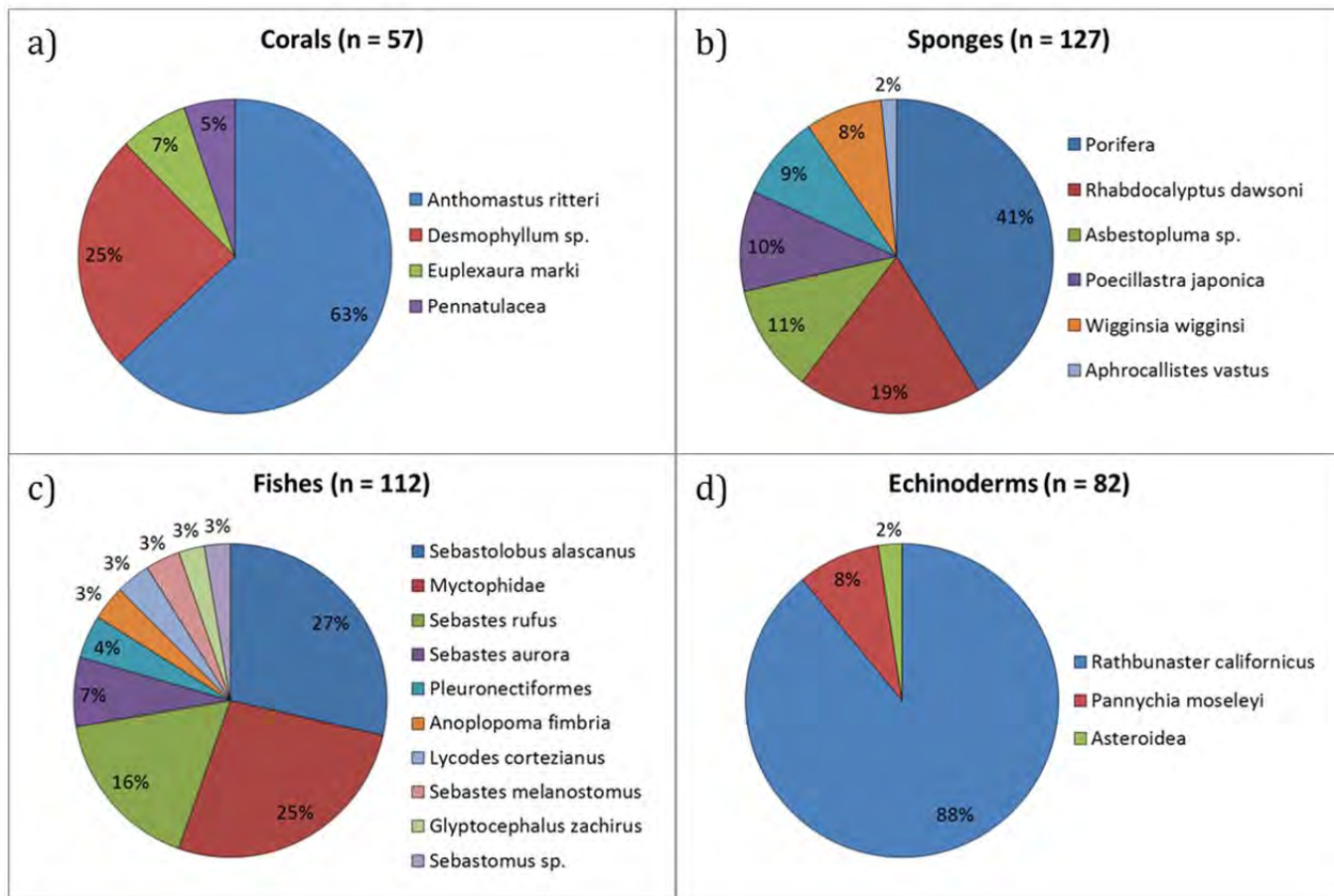


Figure 6. Relative abundance of the predominant taxa at Sur Canyon (10-306A). The total number of colonies (for corals and sponges) or individuals (for fishes and echinoderms) is indicated on each panel.

Table 3. Abundance (total number) and density (number per km²) of fish and benthic megafauna in each major habitat type at Sur Canyon (10-306A).

Species by group		Abundance by habitat type (total number)				Density by habitat type (number per km ²)			
Scientific name	Common name	Soft	Mixed	Hard	All	Soft	Mixed	Hard	All
Cnidarians (Cnidaria)		9		48	57	15		48	36
Anthozoa		9		48	57	15		48	36
<i>Anthomastus ritteri</i>	Mushroom soft coral	8		28	36	14		28	23
<i>Desmophyllum sp.</i>	Large cup coral			14	14			14	9
<i>Euplexaura marki</i>	Red sea whip			4	4			4	3
Pennatulacea	Sea pen-unidentified	1		2	3	2		2	2
Sponges (Porifera)		12		115	127	21		114	80
Demospongiae		2		46	48	3		46	30
<i>Asbestopluma sp.</i>	Asbestopluma (white whip sponge)			14	14			14	9
<i>Poecillastra japonica</i>	Poecillastra (yellow bracket sponge)			13	13			13	8
<i>Amphilectus sp.</i>	Amphilectus (yellow vase sponge)			11	11			11	7
<i>Wigginsia wigginsi</i>	Wigginsia (tall white sponge)	2		8	10	3		8	6
Hexactinellida		3		24	27	5		24	17
<i>Rhabdocalyptus dawsoni</i>	Boot sponge	2		22	24	3		22	15
<i>Aphrocallistes vastus</i>	Aphrocallistes (yellow sponge)	1		1	2	2		1	1
Acanthascinae	Glass sponge-unidentified			1	1			1	1
Unknown		7		45	52	12		45	33
Porifera	Sponge-unidentified	7		45	52	12		45	33
Fishes (Chordata)		76		44	120	130		44	75
Actinopterygii		75		42	117	128		42	73
<i>Sebastolobus alascanus</i>	Shortspine thornyhead	20		12	32	34		12	20
Myctophidae	Myctophid-unidentified	30			30	51			19
<i>Sebastes rufus</i>	Bank rockfish	2		17	19	3		17	12
<i>Sebastes aurora</i>	Aurora rockfish	4		4	8	7		4	5
Pleuronectiformes	Flatfish-unidentified	1		4	5	2		4	3
<i>Anoplopoma fimbria</i>	Sablefish	4			4	7			3
<i>Lycodes cortezianus</i>	Bigfin eelpout	2		2	4	3		2	3
<i>Sebastes melanostomus</i>	Blackgill rockfish	4			4	7			3
<i>Glyptocephalus zachirus</i>	Rex Sole	3			3	5			2
<i>Sebastomus sp.</i>	Rosy-group rockfish	1		2	3	2		2	2
Agonidae	Poacher-unidentified	1			1	2			1
<i>Merluccius productus</i>	Pacific hake	1			1	2			1
<i>Microstomus pacificus</i>	Dover sole	1			1	2			1
<i>Sebastes sp.</i>	Rockfish-unidentified			1	1			1	1
<i>Sebastolobus sp.</i>	Thornyhead-unidentified	1			1	2			1
Chondrichthyes		1		1	2	2		1	1
<i>Raja inornata</i>	California skate			1	1			1	1
<i>Raja sp.</i>	Skate-unidentified	1			1	2			1
Myxini				1	1			1	1
Myxinidae	Hagfish-unidentified			1	1			1	1
Echinoderms (Echinodermata)		25		58	83	43		58	52
Asteroidea		17		58	75	29		58	47
<i>Rathbunaster californicus</i>	Deep-sea sun star	15		58	73	26		58	46
Asteroidea	Sea star-unidentified	2			2	3			1
Crinoidea		1			1	2			1
<i>Florometra serratissima</i>	Common feather star	1			1	2			1
Holothuroidea		7			7	12			4
<i>Pannychia moseleyi</i>	Sea cucumber	7			7	12			4
Mollusks (Mollusca)		2		1	3	3		1	2
Cephalopoda		1			1	2			1
<i>Dosidicus gigas</i>	Giant squid	10			1	17			1
Gastropoda		1		1	2	2		1	1
<i>Pleurobranchaea californica</i>	Bubble snail	1		1	2	2		1	1
Grand Total		124		266	390	212		264	245

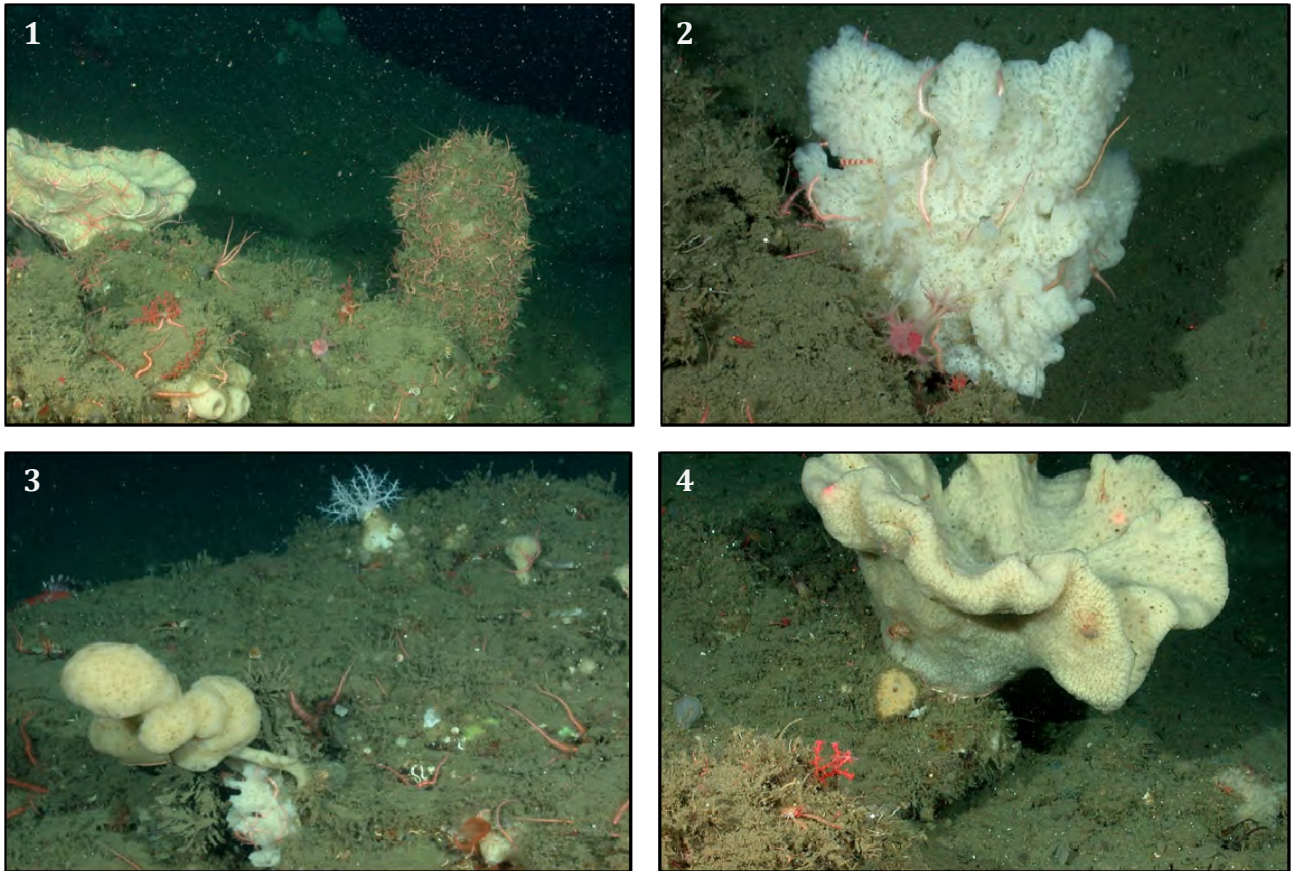


Figure 7a. Select photos of structure forming corals and sponges from the dive site at Sur Canyon (10-306A): 1) A large vase sponge (left) and boot sponge (*Rhabdocalyptus dawsoni*, right), 2) a fan sponge (*Amphilectus* sp. center) and *Anthomastus Ritteri* (bottom center), 3) a stalked sponge (lower left) and a fan sponge (lower left), 4) a vase sponge *Amphilectus* sp. Sponge identifications were provided by Drs. Bill Austin and Henry Resiwig, from photos. Red lasers = 20 centimeters.

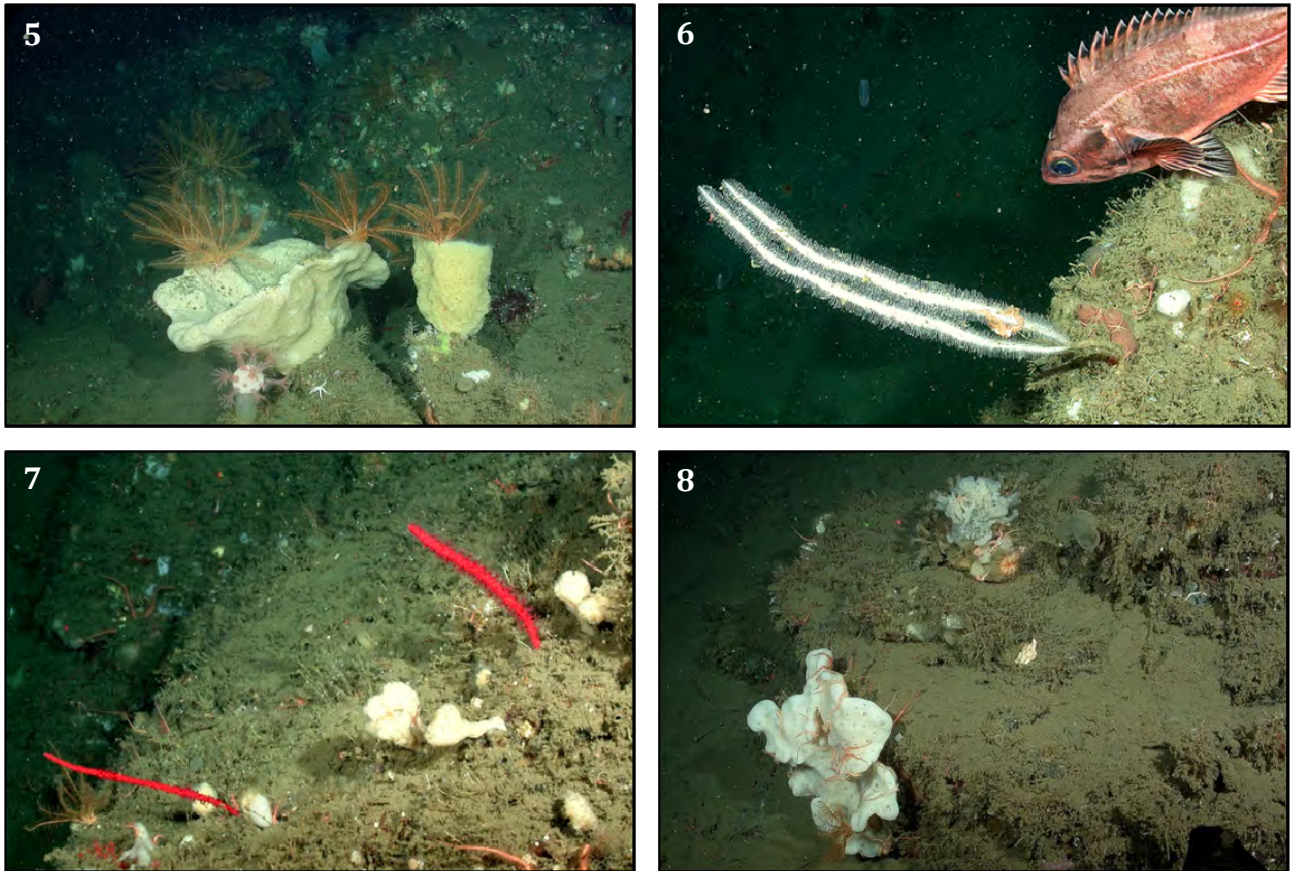


Figure 7b. Select photos of structure forming corals and sponges from the dive site at Sur Canyon (10-306A): 5) large vase sponges with *Anthomastus ritteri* at the base, 6) an *Asbestopluma* sp. sponge and a bank rockfish (*Sebastes rufus*), 7) red whip corals (*Euplexaura marki*), and 8) a plate sponge (lower left) with *Desmophyllum* sp. (top center).

'The Football' (Dive 10-307A) - 11/03/2010

Physical environment

'The Football' (Fig. 8) is a proposed GFNMS expansion site located northwest of San Francisco. The dive site was recommended by Jan Roletto of the Gulf of the Farallones National Marine Sanctuary (GFNMS). 'The Football' The ROV covered approximately 600m of the seafloor at an average depth of 200m over the course of a 1-hour dive (Table 1).

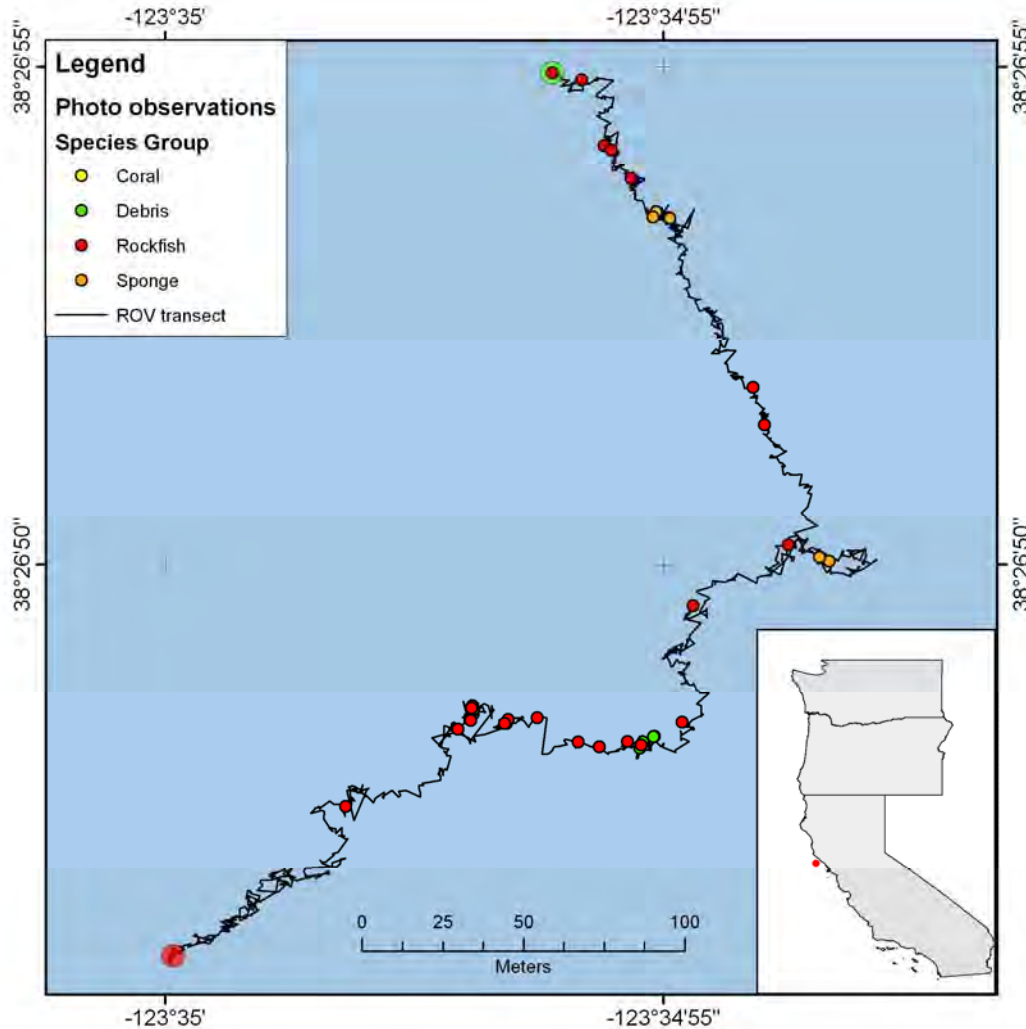


Figure 8. Map of the dive site at 'The Football' (10-307A). Points indicate observations of various species groups from still photographs. Green and red points indicate the start and end of each ROV transect, respectively. Inset map indicates the location along the coast.

A water column profile was collected using the CTD-O (Fig. 9). The profile indicated surface temperatures of 13 °C in the first 10 m of the water column, dropping to a uniform temperature near 8 °C below 100 m depth. Salinity was relatively low, increasing slightly from 33 PSU at the surface to 34 PSU below 100 m depth. Dissolved oxygen dropped from 9 mg O₂ l⁻¹ at the sea surface to 2.7 mg O₂ l⁻¹ (~30% saturation) at ~190 m depth.

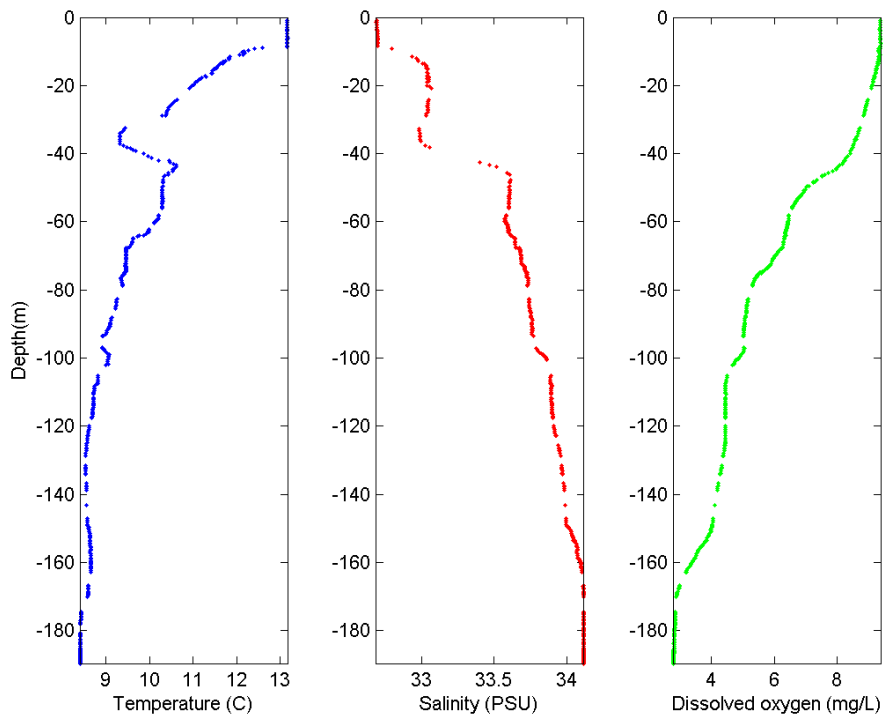


Figure 9. Water column profiles of temperature (blue), salinity (red), and dissolved oxygen (green) at ‘The Football’ (10-307A).

The dive began at the north end of the feature, moving towards the south before altering course towards the west into slightly deeper water. The seafloor was a moderate to steep incline covered with fine sediment and intermittent large boulders overlying the dominant low-relief reef substrate (i.e. hard pavement, Fig. 10). Light-colored worm tubes were attached to the boulders. As the ROV moved to the west into deeper water, we observed a sedimentary scarp feature with many rockfish taking refuge. Geological features were photographed to aid interpretation of multibeam echosounder data collected by the NOAA Ship *Okeanos Explorer*.

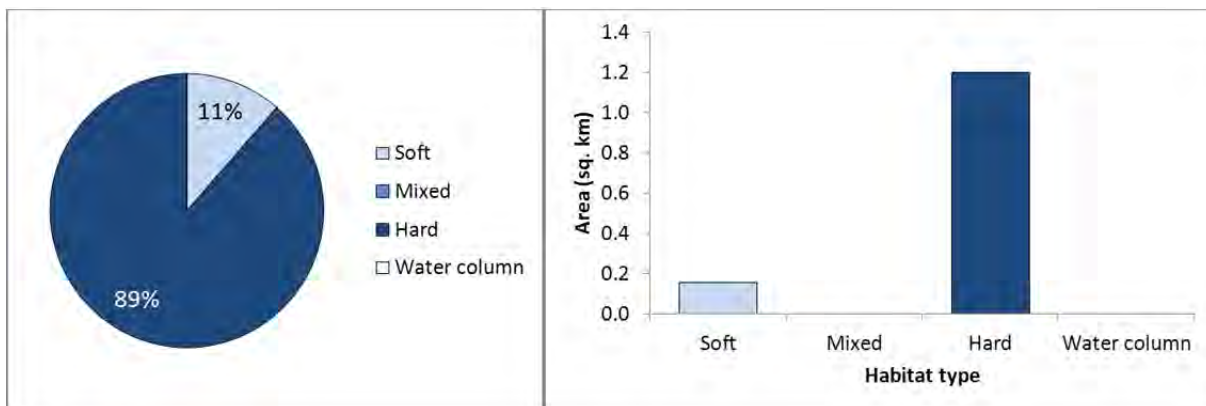


Figure 10. Percent and total area of habitat surveyed at ‘The Football’ (10-307A).

Biological environment

Corals and anemones

No large habitat-forming corals were observed, and there were no samples collected by the ROV. The overall density of corals and anemones at this site was relatively low (~7 colonies per km², Table 4). Several *Desmophyllum* sp. cup corals (Fig. 11a) were observed hanging down from a sedimentary scarp, and several unidentified anemones (*Urticina* sp.) were observed on hard substrate. Photos of several representative species are shown in Fig. 12.

Sponges

Few large habitat-forming sponges were observed. Some smaller unidentified sponge colonies were observed over hard substrate (Fig. 11b). The overall density of sponges at this site was also relatively low (~22 colonies per km², Table 4). Photos of several representative species are shown in Fig. 12.

Fishes

Several rockfishes (*Sebastes* sp.) were observed, but greenspotted rockfish (*S. chlorostictus*) and greenstriped rockfish (*S. elongatus*) were most common (Figure 11c, Table 4). Other noteworthy sightings included one cowcod (*S. levis*), one yelloweye rockfish (*S. ruberrimus*), and one sharpchin rockfish (*S. zacentrus*). Numerous unidentified poachers (Agonidae) and flatfishes were also observed. Two Pacific hagfishes (*Eptatretus stoutii*) were observed. Almost all fish observations occurred over hard substrate.

Echinoderms, Arthropods and Mollusks

High densities of echinoderms were observed throughout the hard substrate (~185 per km², Table 4). Fragile urchins (*Allocentrotus* sp.) were most abundant, with numerous other sun stars (Solasteridae) and sea stars (Asteroidea) present (Fig. 11d). Several brachyuran crabs (most likely spiny king crabs, *Paralithodes californiensis*) were also observed. Very few mollusks were present.

Other observations

Several pieces of marine debris were observed, all of which appeared to be submarine cable (Fig. 12).

Additional comments

Our preliminary impression of the habitat on the northern part of the Football was that hard substrate was readily available, but growth and/or recruitment of habitat-forming benthic invertebrates were limited. However, the Football is a large hard-bottom feature, and we surveyed only a small portion, so one cannot necessarily expect these results to apply to the entire bank. More ROV dives on other parts of 'The Football' may be necessary to confirm this generalization. We recommend that future ROV dives on 'The Football' approach the feature from the west, in order to take advantage of the perspective gained by moving uphill along the gentle slope and slightly terraced topography.

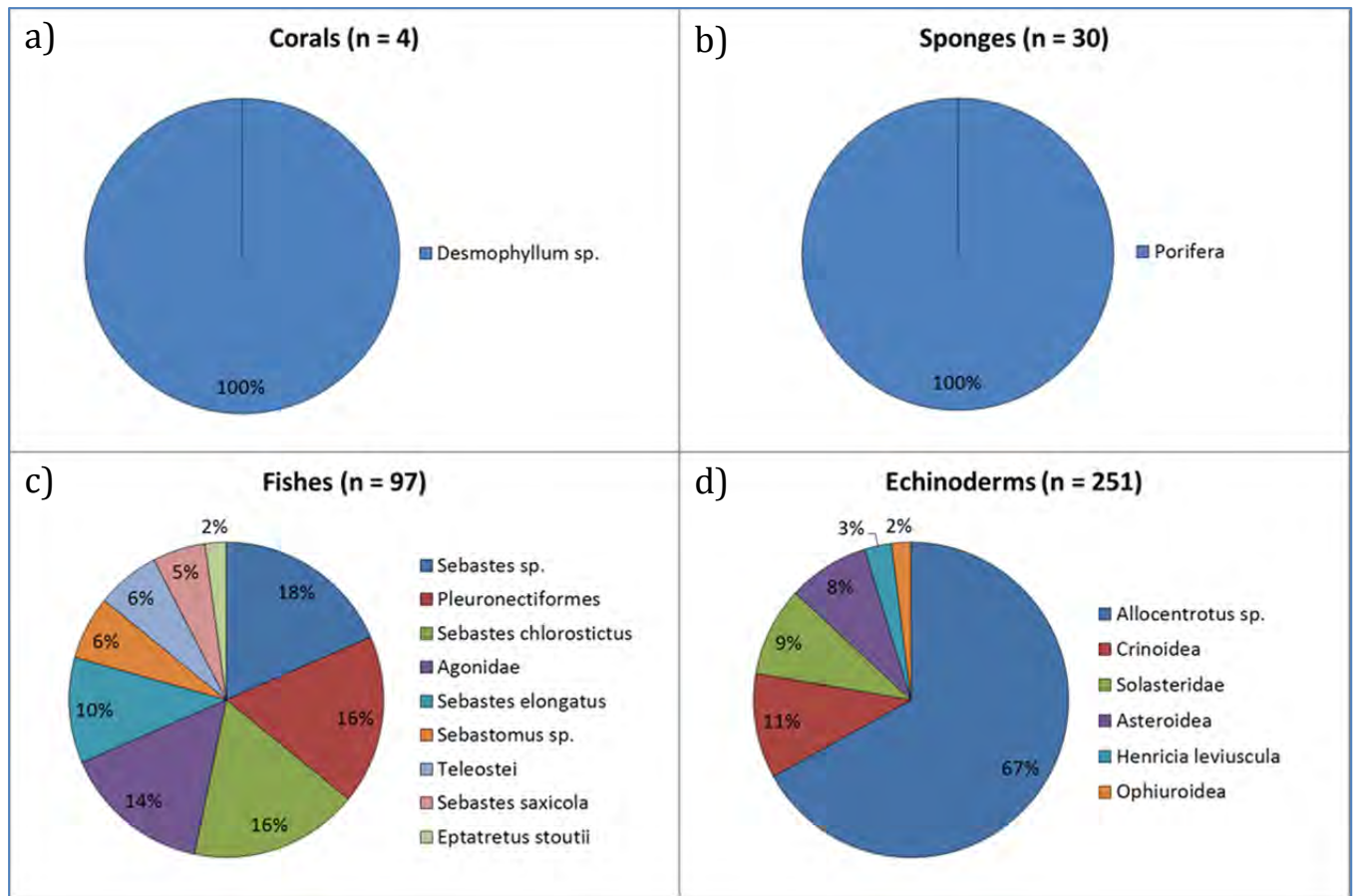


Figure 11. Relative abundance of predominant taxa at 'The Football' (10-307A). The total number of colonies (for corals and sponges) or individuals (for fishes and echinoderms) is indicated on each panel.

Table 4. Abundance (total number) and density (number per km²) of all organisms (grouped by Phylum and Class) in each major habitat type at ‘The Football’ (Dive 10-307A).

Species by group		Abundance by habitat type (total number)				Density by habitat type (number per km ²)			
Scientific name	Common name	Soft	Mixed	Hard	All	Soft	Mixed	Hard	All
Cnidarians (Cnidaria)					9	9		7	7
Anthozoa					9	9		7	7
<i>Urticina cf. coriacea</i>	Stubby rose anemone				5	5		4	4
<i>Desmophyllum sp.</i>	Large cup coral				4	4		3	3
Sponges (Porifera)					30	30		25	22
Unknown					30	30		25	22
Porifera	Sponge-unidentified				30	30		25	22
Fishes (Chordata)		14		83	97	90		69	72
Actinopterygii		14		83	97	90		69	72
<i>Sebastes sp.</i>	Rockfish-unidentified				17	17		14	13
<i>Pleuronectiformes</i>	Flatfish-unidentified	4			12	16	26	10	12
<i>Sebastes chlorostictus</i>	Greenspotted rockfish	3			13	16	19	11	12
Agonidae	Poacher-unidentified	2			12	14	13	10	10
<i>Sebastes elongatus</i>	Greenstripe rockfish				10	10		8	7
<i>Sebastes sp.</i>	Rosy-group rockfish				6	6		5	4
Teleostei	Fish-unidentified	3			3	6	19	2	4
<i>Sebastes saxicola</i>	Stripetail rockfish				5	5		4	4
<i>Eptatretus stoutii</i>	Pacific hagfish				2	2		2	1
<i>Icelinus borealis</i>	Northern sculpin	1				1	6		1
<i>Microstomus pacificus</i>	Dover sole	1				1	6		1
<i>Sebastes levis</i>	Cowcod				1	1		1	1
<i>Sebastes ruberrimus</i>	Yelloweye rockfish				1	1		1	1
<i>Sebastes zacentrus</i>	Sharpchin rockfish				1	1		1	1
Echinoderms (Echinodermata)					251	251		209	185
Echinoidea					168	168		140	124
<i>Allocentrotus sp.</i>	Urchin-unidentified				168	168		140	124
Asteroidea					51	51		42	38
Solasteridae	Sun star-unidentified				23	23		19	17
Asteroidea	Sea star-unidentified				21	21		17	15
<i>Henricia leviuscula</i>	Blood star				7	7		6	5
Crinoidea					27	27		22	20
Crinoidea	Crinoids-unidentified				27	27		22	20
Ophiuroidea					5	5		4	4
Ophiuroidea	Brittle star-unidentified				5	5		4	4
Arthropods (Arthropoda)					7	7		6	5
Malacostraca					7	7		6	5
Brachyura	Crab-unidentified				6	6		5	4
Paguroidea	Hermit crab-unidentified				1	1		1	1
Mollusks (Mollusca)					4	4		3	3
Unknown					3	3		2	2
Mollusca	Mollusk-unidentified				3	3		2	2
Cephalopoda					1	1		1	1
<i>Octopus sp.</i>	Octopus-unidentified				1	1		1	1
Other					9	9		7	7
Unknown					9	9		7	7
Debris	Marine debris				5	5		4	4
Shark egg cases	Eggs				4	4		3	3
Grand Total		14		393	407	90		327	300

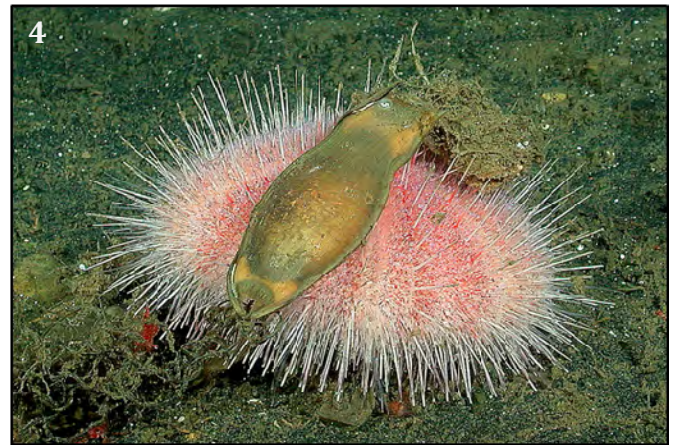


Figure 12. Select photos from the dive at the ‘The Football’ (10-307A, From top left to bottom right): 1) an unidentified sponge, 2) a boot sponge and section of submarine cable, and 3) *Desmophyllum* cup coral (upper left) with a greenspotted rockfish (*Sebastes chlorostictus*) and a cowcod (*S. levis*), and 4) a catshark egg case on a fragile urchin (*Allocentrotus fragilis*).

Coquille Bank (Dive 10-308A) - 11/04/2010

Physical environment

This site on the southern portion of Coquille Bank (Fig. 13) has been reported as having a high abundance of gorgonians (Strom 2006). The primary objectives of this dive were to characterize the gorgonian assemblage and to collect voucher specimens for species level taxonomy. The secondary objective was to ground-truth existing substrate maps from Strom (2006) that were geo-referenced and plotted using the ROV navigation system. The intention was to verify the utility of existing substrate maps for repeat surveys.

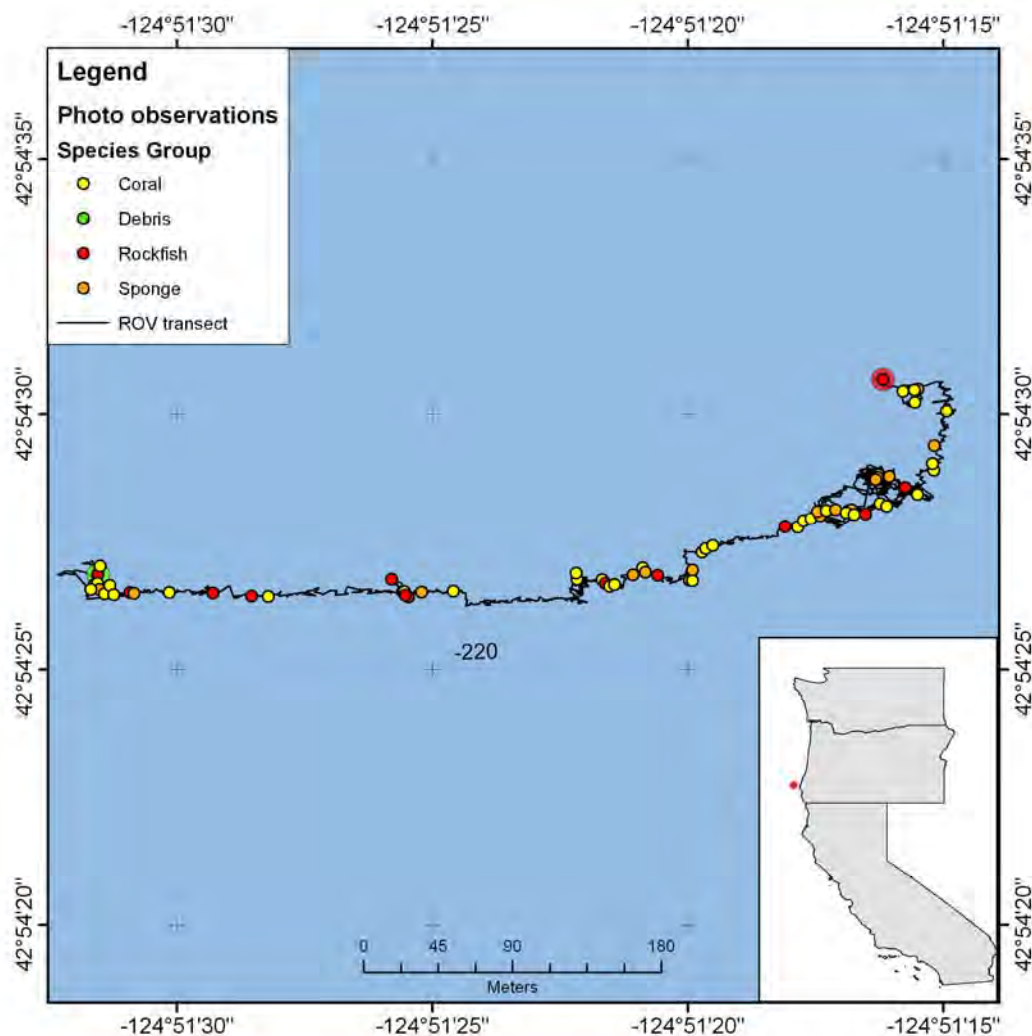


Figure 13. Map of the dive site at Coquille Bank (10-308A). Points indicate observations of various species groups from still photographs. Green and red points indicate the start and end of each ROV transect, respectively. Inset map indicates the location along the coast.

A water column profile was collected using the CTD-O (Fig.14). The profile indicated surface temperatures of approximately 11.5 °C within the first 20 m of the water column, dropping to a uniform temperature of 7°C below 180 m depth. Salinity was relatively low, increasing slightly from 33 PSU at the surface to 34 PSU below 100 m depth. Dissolved

oxygen dropped from 9 mg O₂ l⁻¹ at the sea surface to 3 mg O₂ l⁻¹ (~30% saturation) at 220 m depth.

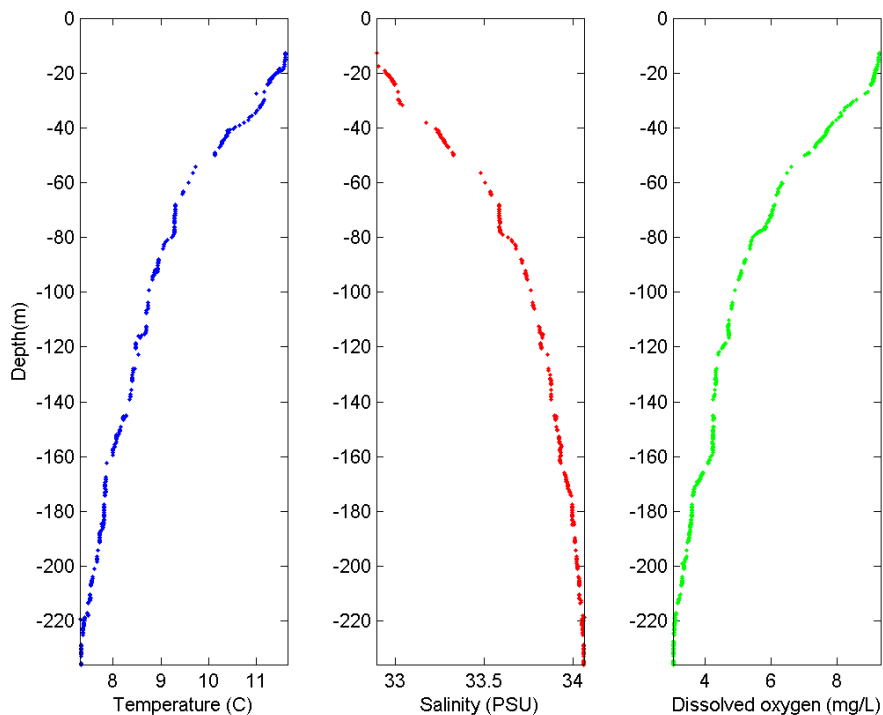


Figure 14. Water column profiles of temperature (blue), salinity (red), and dissolved oxygen (green) at Coquille Bank (10-308A).

During the 2-hour survey, the ROV covered over 850 m of thickly sedimented habitat on Coquille Bank at an average depth of ~240 m (Table 1). The seabed was almost entirely composed of soft substrate (i.e. mud, Fig. 15). A portion of the dive was spent in the water column above the seabed (~40%). The sea state was excellent, but visibility on the bottom was limited by moving sediment. The dive started at the south end of the feature, moving northeast, then changed course toward north in order to replicate the general trajectory of a dive by the *Delta* submersible (dive number 3688) in 1993, as described in Strom (2006).

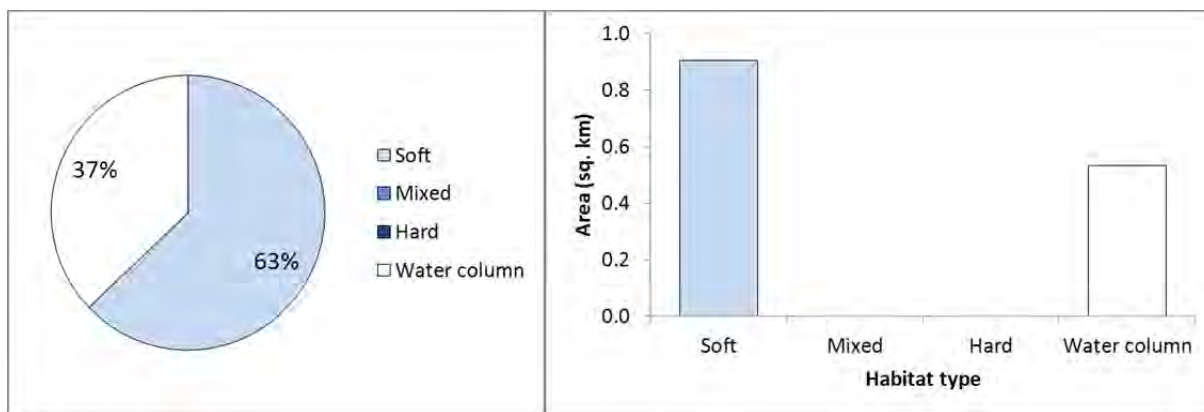


Figure 15. Percent and total area of habitat surveyed at Coquille Bank (10-308A).

Biological environment

Corals and anemones

Dense colonies of red sea whips (*Euplexaura marki*, ~624 colonies per km²) were observed throughout the soft substrate during the dive (Fig. 16a, Table 5), which was consistent with the presence of gorgonians indicated Strom (2006). Two voucher specimens were collected for genetic and morphological identification (samples sent to Beth Horvath, Westmont College, Santa Barbara, CA for morphology; and Ewann Berntson, NOAA NWFSC, Seattle, WA for genetics). Vouchers were firmly attached to buried substrate, and not easily collected using the manipulator on the ROV, which suggested that hard substrate lay underneath the soft sediment. The larger of the two samples of *E. marki* had several amphipods. Amphipods were collected and preserved along with the specimen. The size distribution of the amphipods was bimodal, and the larger individuals appeared to be ovigerous with bright red egg masses. Several very colorful anemones (*Urticina* sp.) were observed when some rocks were present. Photos of representative species are shown in Fig. 17.

Sponges

Moderate densities of unidentified sponges were observed (~35 colonies per km², Fig. 16b, Table 5). One piece of white sponge was collected, but this specimen was flushed from the basket on retrieval. Photos of representative species are shown in Fig. 17.

Fishes

Unidentified flatfishes, most likely slender (*Lyopsetta exilis*) and Dover soles (*Microstomus pacificus*), were the most abundant fishes (Fig. 16c, Table 5). Other noteworthy fishes included numerous shortspine thornyheads (*Sebastolobus alascanus*), several aurora (*S. aurora*) and greenstriped rockfishes (*S. elongatus*), and one redbanded rockfish (*S. babcocki*). Several Pacific hagfishes (*E. stoutii*) were also observed.

Echinoderms, Arthropods, and Mollusks

Unidentified sea cucumbers (Holothuroidea) were the most abundant (~86 per km²; Fig. 16d, Table 5), with numerous other unidentified sea stars (Asteroidea), sun stars (Solasteridae), and one large basket star (*Gorgonocephalus eucnemis*). Photos of representative species are shown in Fig. 17.

Other observations

Two catshark egg cases were observed on gorgonians, and one catshark egg case was attached to a white sponge.

Additional comments

Substrate maps from Strom (2006) were generally consistent with our observations. We observed soft sediment where Strom indicated 'mud' and we observed rocks where Strom indicated 'rocks with sediment' Therefore, the primary and secondary objectives for this dive were accomplished.

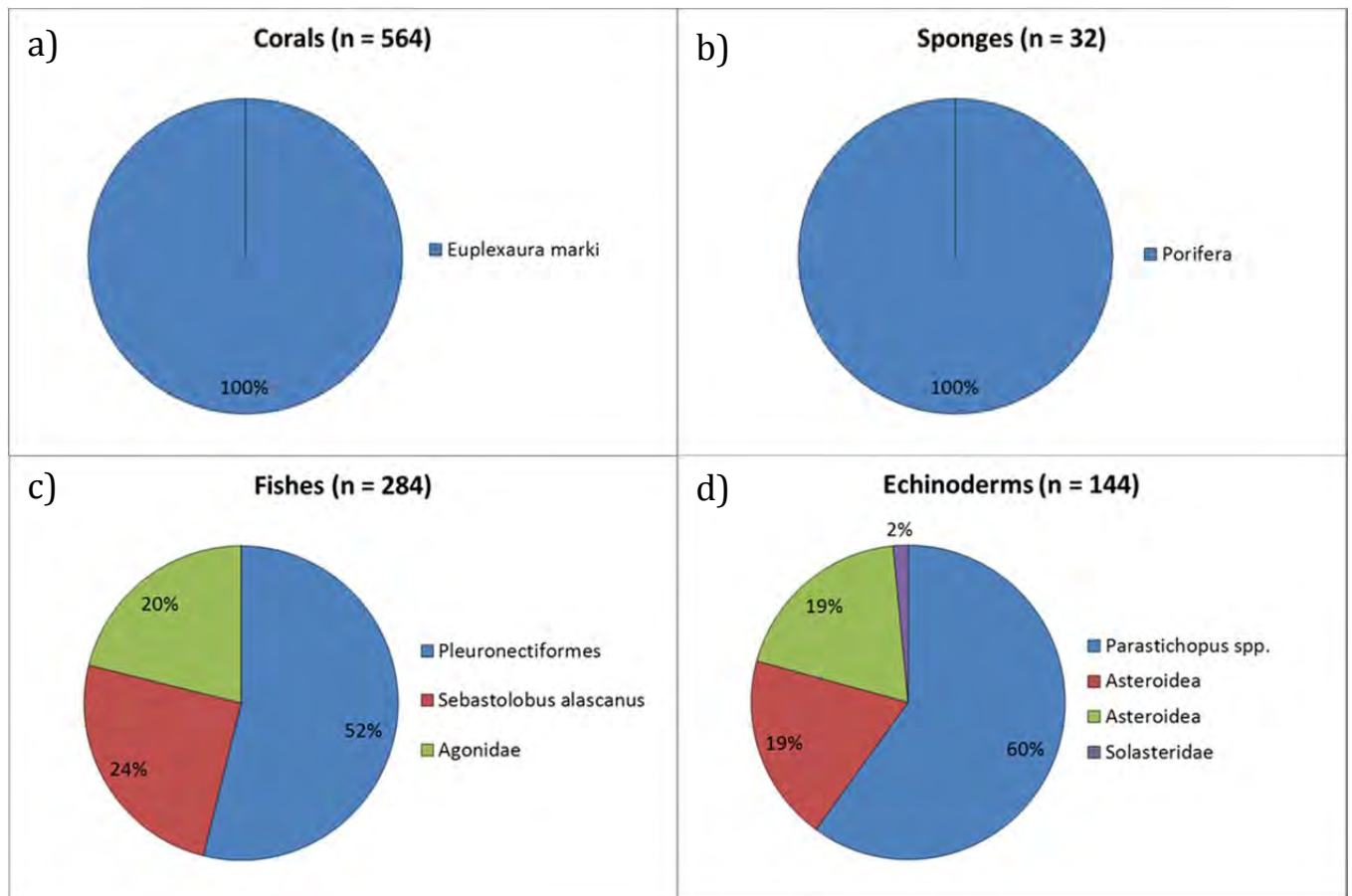


Figure 16. Relative abundance of predominant taxa at Coquille Bank (Dive 10-308A). The total number of colonies (for corals and sponges) or individuals (for fishes and echinoderms) is indicated on each panel.

Table 5. Abundance (total number) and density (number per km²) of benthic megafauna and fish in each major habitat type at Coquille Bank (Dive 10-308A).

Species by group		Abundance by habitat type (total number)				Density by habitat type (number per km ²)			
Scientific name	Common name	Soft	Mixed	Hard	All	Soft	Mixed	Hard	All
Cnidarians (Cnidaria)		564			564	624			624
Anthozoa		564			564	624			624
<i>Euplexaura marki</i>	Red sea whip	554			554	613			613
<i>Urticina cf. coriacea</i>	Stubby rose anemone	10			10	11			11
Sponges (Porifera)		32			32	35			35
Unknown		32			32	35			35
Porifera	Sponge-unidentified	32			32	35			35
Fishes (Chordata)		296			296	327			327
Actinopterygii		296			296	327			327
Pleuronectiformes	Flatfish-unidentified	153			153	169			169
<i>Sebastolobus alascanus</i>	Shortspine thornyhead	71			71	79			79
Agonidae	Poacher-unidentified	60			60	66			66
<i>Eptatretus stoutii</i>	Pacific hagfish	4			4	4			4
<i>Sebastes sp.</i>	Rockfish-unidentified	3			3	3			3
<i>Sebastes aurora</i>	Aurora rockfish	2			2	2			2
<i>Sebastes elongatus</i>	Greenstripe rockfish	2			2	2			2
<i>Sebastes babcocki</i>	Redbanded rockfish	1			1	1			1
Echinoderms (Echinodermata)		131			131	145			145
Holothuroidea		78			78	86			86
<i>Parastichopus spp.</i>	Sea cucumber-unidentified	78			78	86			86
Asteroidea		51			51	56			56
Asteroidea	Sea star-unidentified	25			25	28			28
Solasteridae	Sun star-unidentified	25			25	28			28
<i>Gorgonocephalus eucnemis</i>	Basket star	1			1	1			1
Echinoidea		2			2	2			2
<i>Allocentrotus sp.</i>	Urchin-unidentified	2			2	2			2
Arthropods (Arthropoda)		1			1	1			1
Malacostraca		1			1	1			1
Brachyura	Crab-unidentified	1			1	1			1
Mollusks (Mollusca)		1			1	1			1
Gastropoda		1			1	1			1
Nudibranchia	Nudibranch-unidentified	1			1	1			1
Other		5			5	6			6
Unknown		5			5	6			6
Shark egg cases	Eggs	5			5	6			6
Grand Total		1030			1030	1139			1139

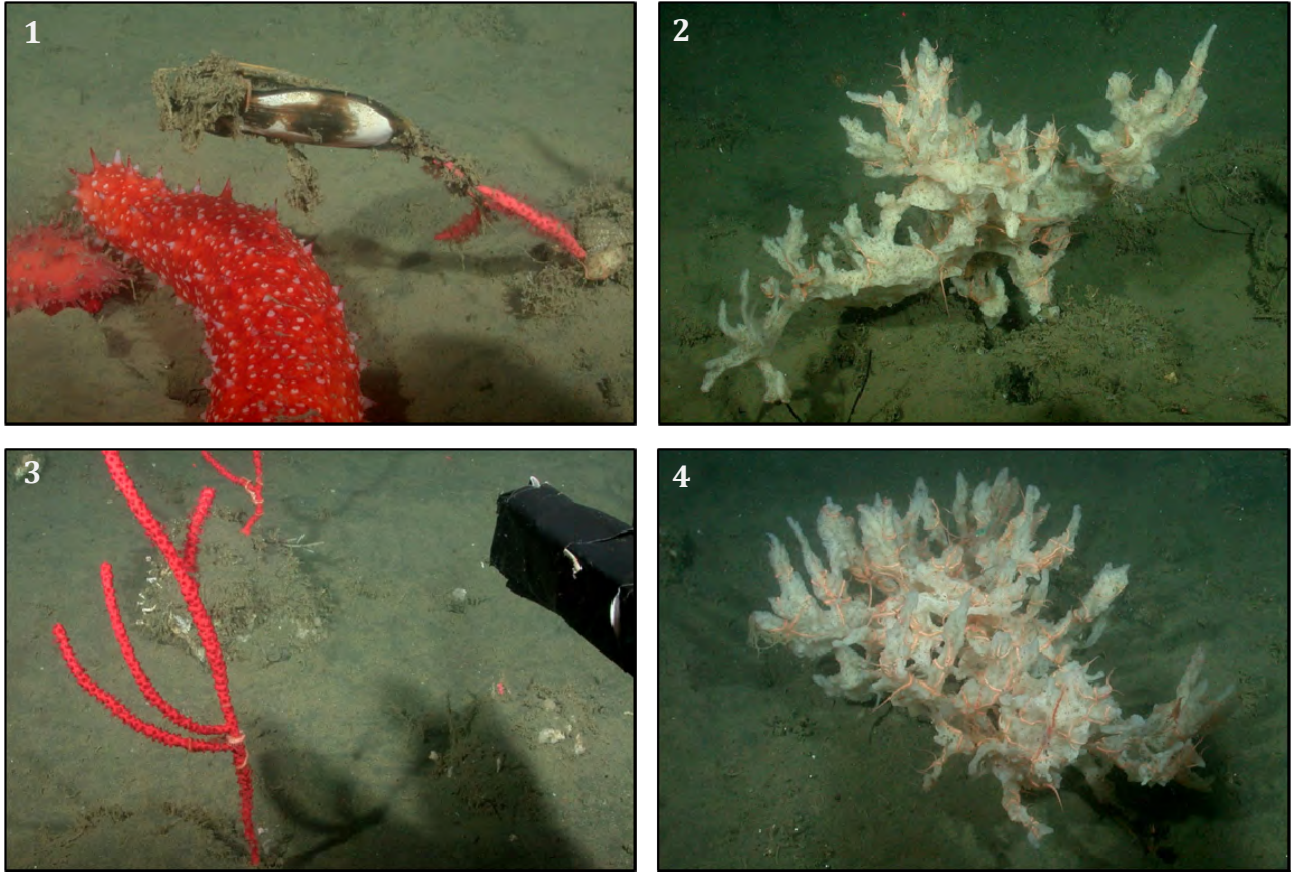


Figure 17. Selected photos from Coquille Bank (Dive 10-308A): 1) red whip coral (*Euplexaura marki*, right) with an attached egg case, and a Johnson's sea cucumber (*Parastichopus johnsoni*, left) 2) a fan sponge with many brittle stars, 3) several colonies of red whip coral (*E. marki*), and 4) another fan sponge with brittle stars.

OCNMS-Site 1 (Dive 10-309A) - 11/05/2010

Physical environment

This dive site was recommended by Ed Bowlby, Research Coordinator of OCNMS to supplement ongoing work since 2000 to characterize benthic seafloor communities and to establish essential fish habitat (EFH) in the sanctuary. The survey was conducted within OCNMS Site 72 (herein called OCNMS-Site 1, Fig. 18). During this 2-hour survey, the ROV traversed 1.5 km of boulder habitat with intermittent sand at an average depth of 110m (Table 1). The transect started at the south end of the site and moved toward the north at a speed of 0.3-0.5 knots.

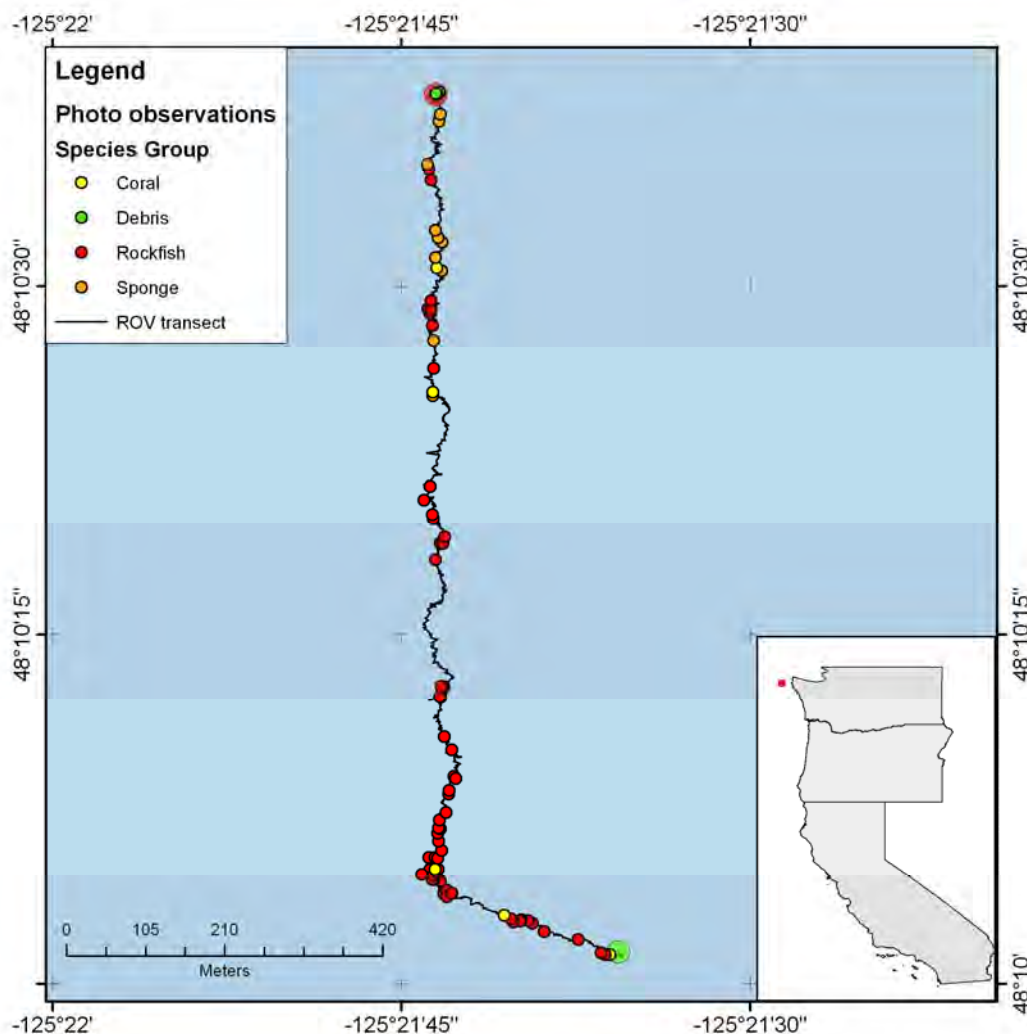


Figure 18. Map of the dive site at the OCNMS-Site 1 (Dive 10-309A). Points indicate observations from still photographs. Inset map indicates the location along the coast. The depth range for the entire transect ranged from 106-116m.

A water column profile from the CTD-0 indicated a well-mixed surface layer with uniform surface temperature, salinity, and oxygen within the first 60 m of the water column (Fig. 19). A sharp thermocline was evident at 60 m depth. Salinity was lower than other sites, increasing slightly from 32 PSU at the surface to 34 PSU below 115 m depth.

Dissolved oxygen dropped from 9 mg O₂ l⁻¹ at 60 m depth to 4.2 mg O₂ l⁻¹ (~43% saturation) at 115 m depth.

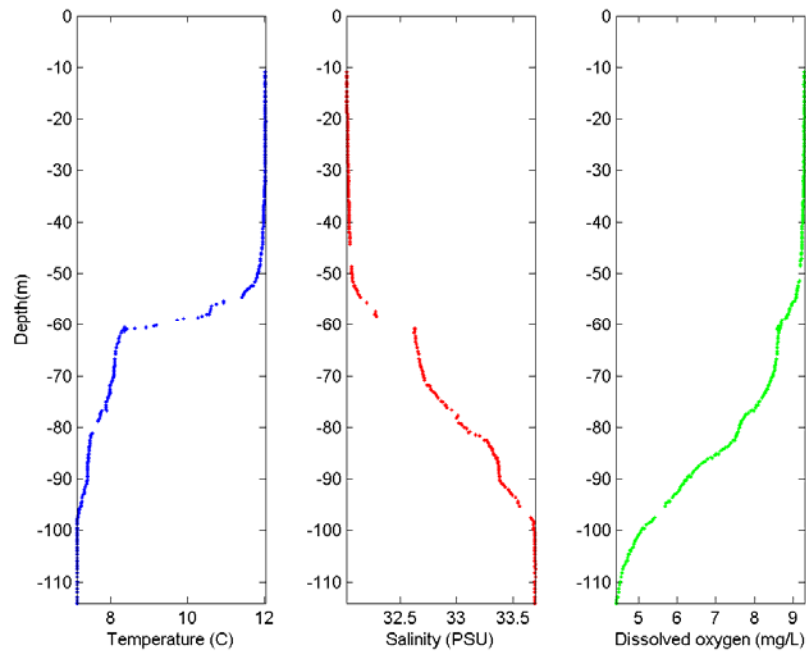


Figure 19. Water column profiles of temperature (blue), salinity (red), and dissolved oxygen (green) at OCNMS-Site 1 (Dive 10-309A).

The seabed was mostly hard substrate composed of large boulders (~57% total area) interspersed with sand (17% total area), pebbles (~22% total area), and cobble (~5% total area, Fig. 20). The boulders appeared to be mostly bare except for some encrusting organisms and a few small octocoral colonies (see below).

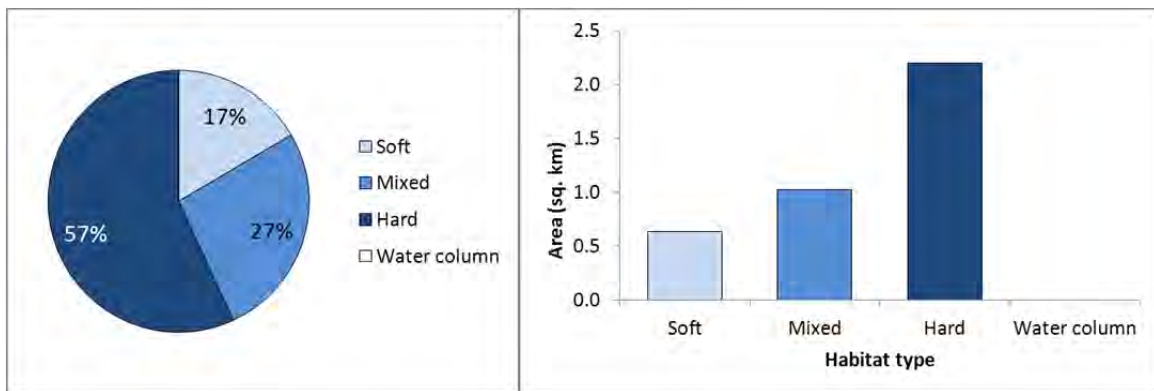


Figure 20. Percent and total area of habitat surveyed at OCNMS-Site 1 (Dive 10-309A).

Biological environment

Corals and anemones

Relatively few colonies of corals were observed at this site (~4 colonies per km²; Fig. 21a, Table 6). Several colonies of white *Swiftia* (*S. beringi*) were observed on mixed and hard substrate. A few Fernald brooding anemones (*Cribrinopsis fernaldi*) and one *Urticina* sp. anemone were also observed. Photos of representative species are shown in Fig. 22.

Sponges

The density of sponges (all presently unidentified) was relatively high at this site (~33 colonies per km², Table 6, Figure 21b). The density of sponges was greatest on mixed (~57 colonies per km²) and hard substrates (~30 colonies per km²). Photos of representative species are shown in Fig. 22.

Fishes

Rockfishes were abundant and diverse (Figure 21c), including many aggregations of yellowtail (*Sebastes flavidus*), rosethorn (*S. helvomaculatus*), redstripe (*S. proriger*), yelloweye (*S. ruberrimus*), greenstripe (*S. elongatus*), and tiger rockfishes (*S. nigrocinctus*) (Table 6). Puget Sound rockfish (*S. emphaeus*), Pygmy rockfish (*S. wilsoni*), canary (*S. pinniger*), and rougheye rockfishes (*S. aleutianus*) were also present. Several lingcod (*Ophiodon elongatus*) and eight unidentified hagfishes (Myxinidae) were also observed.

Echinoderms, Arthropods, and Mollusks

Unidentified crinoids (likely *Florometra serratissima*) were very dense on boulders (331 per km²), and to a lesser extent on mixed substrate (27 per km²) (Fig. 21d, Table 6). Several thorny stars (*Poraniopsis inflata*) and a few individuals of other sea stars were observed on mixed and hard substrate. Numerous unidentified sea cucumbers (Holothuroidea) were also observed.

Additional comments

A large abandoned trawl net (mesh size of ~15-20cm) was observed at the northern endpoint of the transect (Fig. 22). The net was not heavily fouled, suggesting that it may have been recently lost.

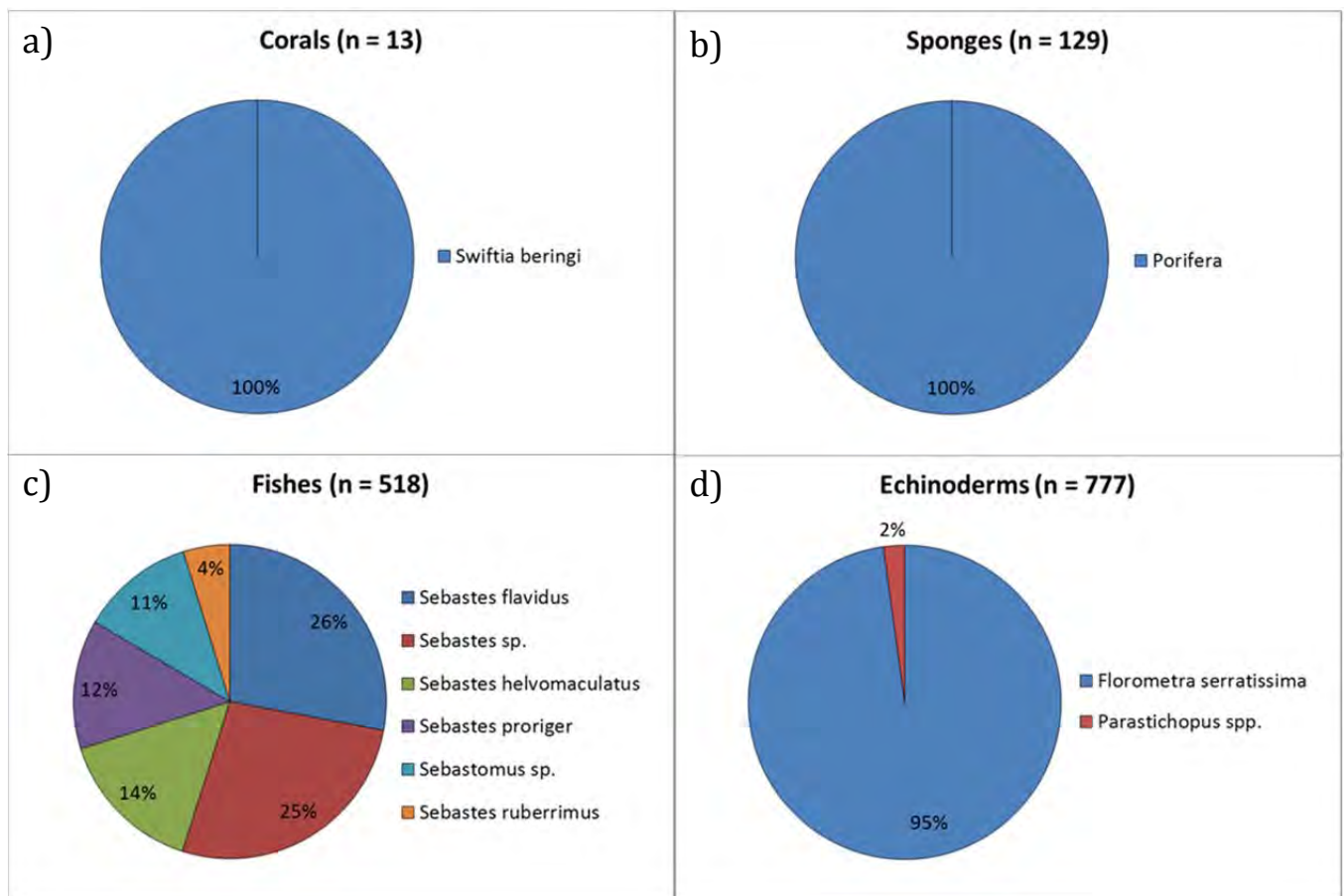


Figure 21. Relative abundance of predominant taxa at OCNMS-Site 1 (Dive 10-309A). The total number of colonies (for corals and sponges) or individuals (for fishes and echinoderms) is indicated on each panel.

Table 6. Abundance (total number) and density (number per km²) of benthic megafauna and fish in each major habitat type at OCNMS-Site 1 (Dive 10-309A).

Species by group		Abundance by habitat type (total number)				Density by habitat type (number per km ²)			
Scientific name	Common name	Soft	Mixed	Hard	All	Soft	Mixed	Hard	All
Cnidarians (Cnidaria)			7	10	17		7	5	4
Anthozoa			7	10	17		7	5	4
<i>Swiftia beringi</i>	White Swiftia		5	8	13		5	4	3
<i>Cribrinopsis fernaldi</i>	Fernald brooding anemone		2	1	3		2	0.5	1
<i>Urticina cf. coriacea</i>	Stubby rose anemone			1	1			0.5	0.3
Sponges (Porifera)		5	59	65	129	8	57	30	33
Unknown		5	59	65	129	8	57	30	33
Porifera	Sponge-unidentified	5	59	65	129	8	57	30	33
Fishes (Chordata)		18	38	507	563	28	37	230	145
Actinopterygii		18	38	499	555	28	37	227	143
<i>Sebastes flavidus</i>	Yellowtail rockfish			145	145			66	37
<i>Sebastes sp.</i>	Rockfish-unidentified	4	19	117	140	6	18	53	36
<i>Sebastes helvomaculatus</i>	Rosethorn rockfish	1	4	74	79	2	4	34	20
<i>Sebastes proriger</i>	Redstripe rockfish	3	1	65	69	5	1	30	18
<i>Sebastomus sp.</i>	Rosy-group rockfish	3		58	61	5		26	16
<i>Sebastes ruberrimus</i>	Yelloweye rockfish		9	16	25		9	7	6
<i>Sebastes nigrocinctus</i>	Tiger rockfish			8	8			4	2
Gobiidae	Goby-unidentified	3	1	3	7	5	1	1	2
<i>Sebastes elongatus</i>	Greenstripe rockfish	3	3		6	5	3		2
<i>Sebastes wilsoni</i>	Pygmy rockfish			4	4			2	1
<i>Ophiodon elongatus</i>	Lingcod			3	3			1	1
<i>Sebastes emphaeus</i>	Puget Sound rockfish			2	2			1	1
<i>Icosteus aenigmaticus</i>	Ragfish			1	1			0.5	0.3
Pleuronectiformes	Flatfish-unidentified	1			1	2			0.3
<i>Polylepion sp. Novum</i>	Wrasse-undescribed			1	1			0.5	0.3
<i>Sebastes aleutianus</i>	Rougheye rockfish			1	1			0.5	0.3
Teleostei	Fish-unidentified		1		1		1		0.3
<i>Theragra chalcogramma</i>	Alaska pollock			1	1			0.5	0.3
Myxini				8	8			4	2
Myxinidae	Hagfish-unidentified			8	8			4	2
Echinoderms (Echinodermata)		6	35	760	801	9	34	345	207
Crinoidea		4	28	728	760	6	27	331	196
<i>Florometra serratissima</i>	Feather star	4	28	728	760	6	27	331	196
Asteroidea		2	5	17	24	3	5	8	6
Asteroidea	Sea star-unidentified	1	1	9	11	2	1	4	3
<i>Poraniopsis inflata</i>	Thorny star	1	3	5	9	2	3	2	2
<i>Pteraster sp.</i>	Sea star-unidentified			2	2			1	1
<i>Henricia leviuscula</i>	Blood star			1	1			0.5	0.3
<i>Pteraster tessellatus</i>	Cushion sea star		1		1		1		0.3
Holothuroidea			2	15	17		2	7	4
<i>Parastichopus spp.</i>	Sea cucumber-unidentified		2	15	17		2	7	4
Arthropods (Arthropoda)		351			351	548			91
Malacostraca		351			351	548			91
Euphausiacea	Euphausiids	350			350	547			90
Brachyura	Crab-unidentified	1			1	2			0.3
Mollusks (Mollusca)			1	2	3		1	1	1
Unknown			1	1	2		1	0.5	1
Shell	Mollusk shell-unidentified		1	1	2		1	0.5	1
Gastropoda				1	1			0.5	0.3
<i>Haliotis fulgens</i>	Green abalone			1	1			0.5	0.3
Other			1	1	2		1	0	1
Unknown			1	1	2		1	0	1
Debris	Marine debris		1		1		1		0.3
Shark egg cases	Eggs			1	1			0.5	0.3
Grand Total		380	141	1345	1866	593	137	611	482

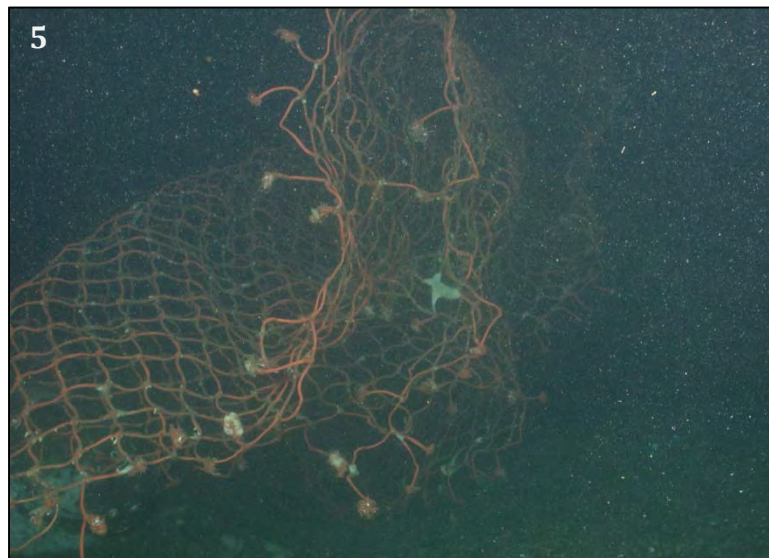


Figure 22. Selected photos from OCNMS-Site 1 (Dive 10-309A): 1) sponges on a boulder, 2) a fan sponge (top center) and *Swiftia beringi* (left of center) with several squat lobsters, 3) *Swiftia beringi*, 4) a mixed sponge assemblage on cobble substrate, and 5) a derelict fishing net.

OCNMS Site 2 (Dive 10-309B) - 11/05/2010

Physical environment

The final ROV survey of the expedition was an opportunistic dive conducted east of Site 10 within the OCNMS (herein called OCNMS-Site 2, Fig. 23). The site was selected based upon proximity to the transit route towards shore and topographic slope. The ROV traversed 250 m of flat bottom sandy habitat at an average depth of 240 m, heading north towards a 50 m rise.

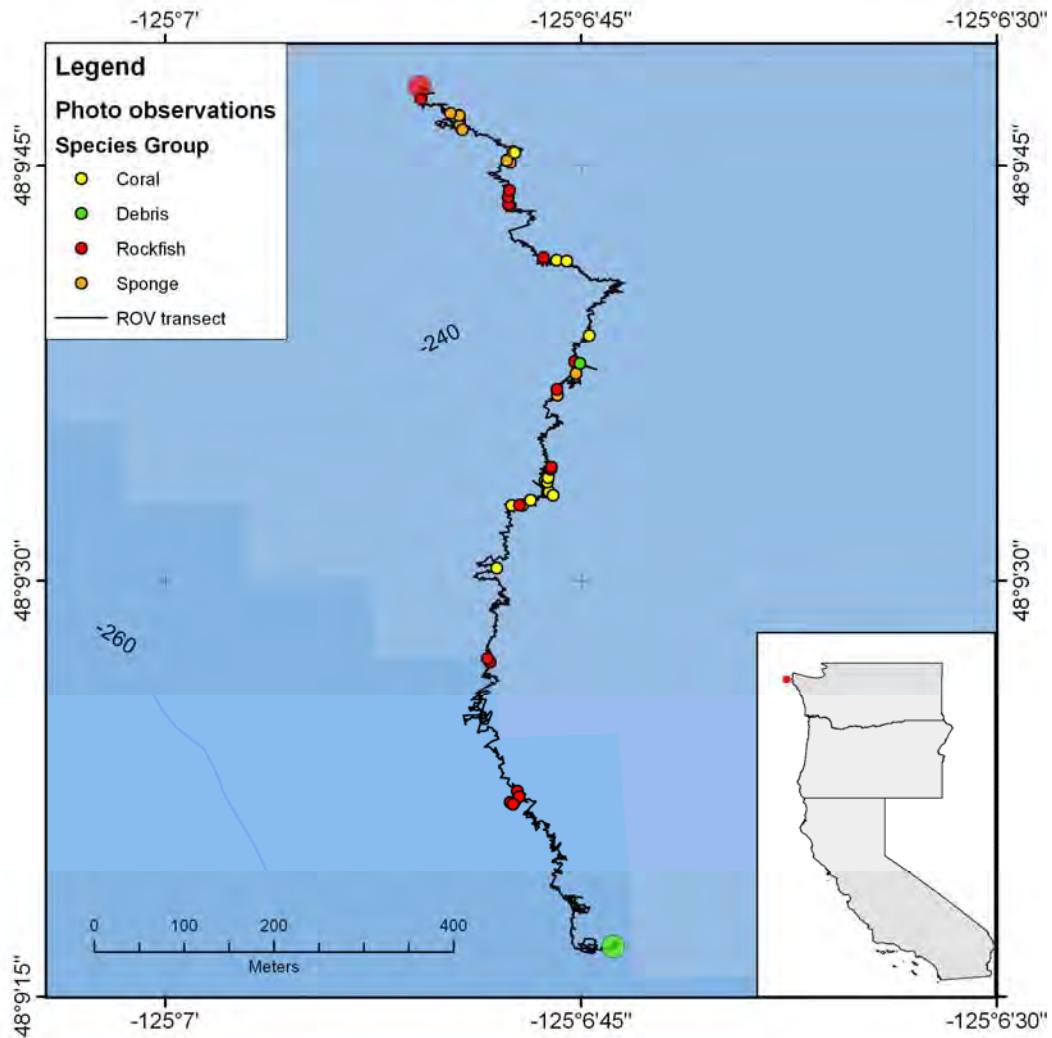


Figure 23. Map of dive site at OCNMS-Site 2 (Dive 10-309B). Points indicate observations of various species groups from still photographs. Inset map indicates the location along the coast.

A water column profile was collected using the CTD-O (Fig. 24). No data was available for the first 40 m of the descent. The profile below 50 m indicated uniform temperatures between 7 and 8 °C down to 265 m. Salinity increased slightly from 33 PSU at 50 m depth to 34 PSU below 100 m depth. Dissolved oxygen dropped from 9 mg O₂ l⁻¹ at 30 m depth to 3.0 mg O₂ l⁻¹ (~31% saturation) at 265 m depth.

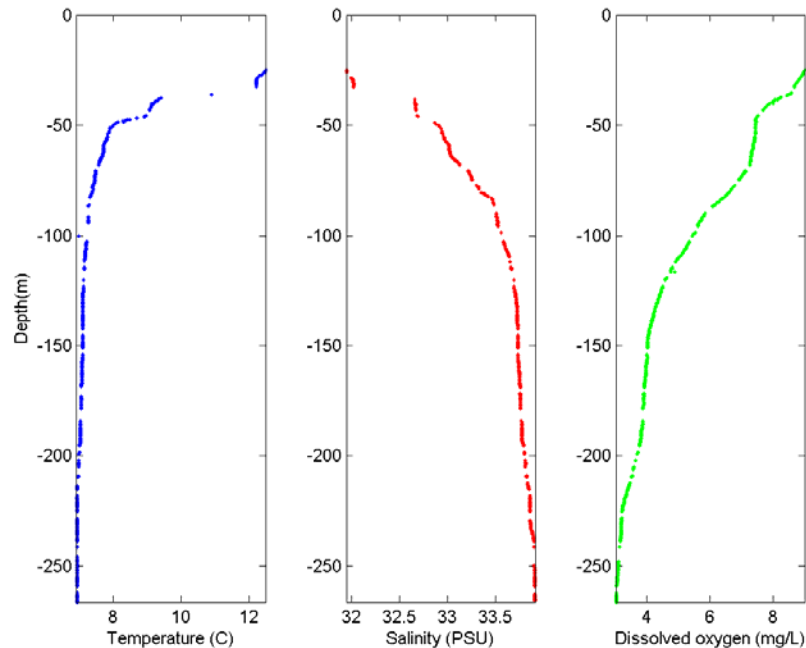


Figure 24. Water column profiles of temperature (blue), salinity (red), and dissolved oxygen (green) at OCNMS-Site 2 (Dive 10-309B).

The seabed was mostly composed of mixed (cobble, ~59% total area) and soft substrate (mud, ~41% total area, Fig. 25). As the ROV approached the gentle slope, the substrate turned to cobble with a soft sediment veneer.

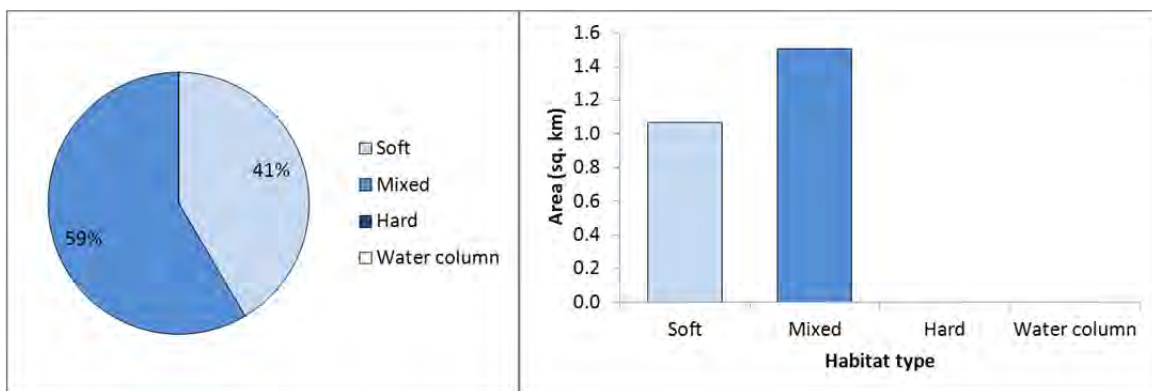


Figure 25. Percent and total area of habitat surveyed at OCNMS-Site 2 (Dive 10-309B).

Biological environment

Corals and anemones

The overall density of coral colonies at this site was relatively low (~10 colonies per km², Table 7). The coral community was mostly composed of branched octocoral, including *Swiftia beringi*, *S. pacifica*, *Euplexaura marki*, and one colony of *Plumarella longispina* with abundant crustaceans on the colonies (Figure 26a). Photos of representative sea fan species are shown in Fig. 27.

Sponges

Very few unidentified sponges were observed on mixed substrate (~2 colonies per km², Table 7, Figure 26b). A photo of a small vase sponge is shown in Fig. 27.

Fishes

The overall density of fishes was relatively low at this site (~27 per km², Table 7). The fish community at this site was composed mostly of flatfishes, and primarily Dover sole (*Microstomus pacificus*, Fig. 26c). Pacific halibut (*Hippoglossus stenolepis*), rex sole (*Glyptocephalus zachirus*), slender sole (*Lyopsetta exilis*), and a few other unidentified flatfishes were most common on soft and mixed substrates. Several other notable fishes observed during the survey included shortspine thornyheads (*Sebastolobus alascanus*), Pacific ocean perch (*Sebastes alutus*), sablefish (*Anoplopoma fimbria*), redbanded rockfish (*S. babcocki*), aurora rockfish (*S. aurora*), spotted ratfish (*Hydrolagus coliei*), and sandpaper skate (*Bathyraja interrupta*).

Echinoderms, Arthropods, and Mollusks

The seabed was almost entirely covered with unidentified brittle stars (Ophiuroidea, ~884 per km²), spot prawns (*Pandalus platyceros*, ~203 per km²), and fragile urchins (*Allocentrotus sp.*, ~190 per km²; Fig. 26d, Table 7). These three species occupied nearly 80% of the visible seafloor on soft substrate. Squat lobsters (*Munida quadrispina*) were commonly observed on or near octocoral colonies (Fig. 27). Several other unidentified sea stars (Asteroidea), sea cucumbers (Holothuroidea), and one sunflower star (*Pycnopodia sp.*) were also observed.

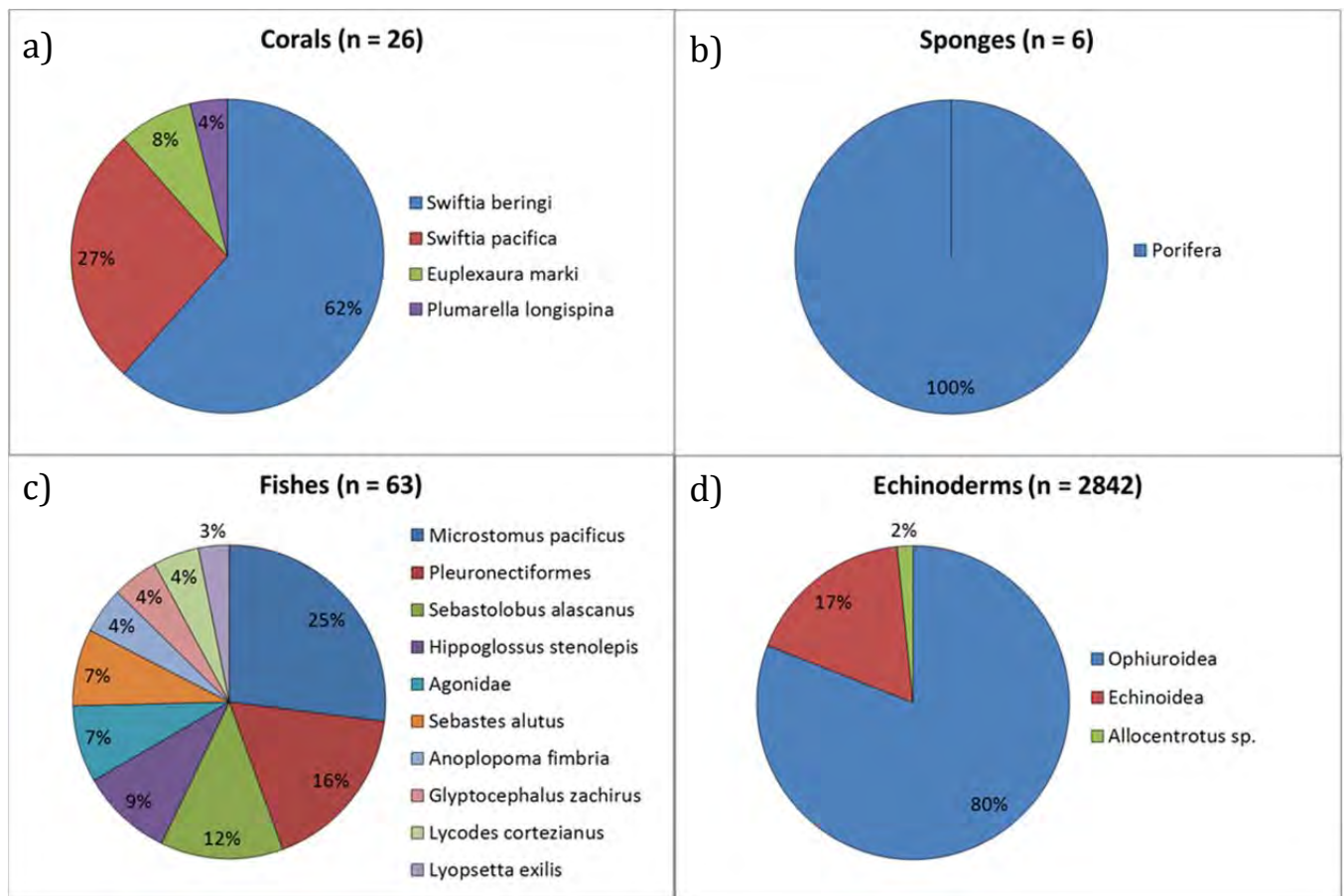


Figure 26. Relative abundance of predominant taxa at OCNMS-Site 2 (10-309B). The total number of colonies (for corals and sponges) or individuals (for fishes and echinoderms) is indicated on each panel.

Table 7. Abundance (total number) and density (number per km²) of benthic megafauna and fish in each major habitat type at OCNMS-Site 2 (Dive 10-309B).

Species by group		Abundance by habitat type (total number)				Density by habitat type (number per km ²)			
Scientific name	Common name	Soft	Mixed	Hard	All	Soft	Mixed	Hard	All
Cnidarians (Cnidaria)			26		26		17		10
Anthozoa			26		26		17		10
<i>Swiftia beringi</i>	White Swiftia		16		16		11		6
<i>Swiftia pacifica</i>	Red Swiftia		7		7		5		3
<i>Euplexaura marki</i>	Red sea whip		2		2		1		1
<i>Plumarella longispina</i>	Plumarella soft coral		1		1		1		0.4
Sponges (Porifera)			6		6		4		2
Unknown			6		6		4		2
Porifera	Sponge-unknown		6		6		4		2
Fishes (Chordata)			48		69		32		27
Actinopterygii			20		47		19		31
<i>Microstomus pacificus</i>	Dover sole	9	8		17	8	5		7
Pleuronectiformes	Flatfish-unknown		11		11		7		4
<i>Sebastolobus alascanus</i>	Shortspine thornyhead		8		8		5		3
<i>Hippoglossus stenolepis</i>	Pacific halibut	1	5		6	1	3		2
Agonidae	Poacher-unknown	1	4		5	1	3		2
<i>Sebastes alutus</i>	Pacific ocean perch	4	1		5	4	1		2
<i>Anoplopoma fimbria</i>	Sablefish	2	1		3	2	1		1
<i>Glyptocephalus zachirus</i>	Rex Sole		3		3		2		1
<i>Lycodes corteziianus</i>	Bigfin eelpout		3		3		2		1
<i>Lyopsetta exilis</i>	Slender sole	2			2	2			1
<i>Sebastes aurora</i>	Aurora rockfish	1			1	1			0.4
<i>Sebastes babcocki</i>	Redbanded rockfish		1		1		1		0.4
<i>Sebastes sp.</i>	Rockfish-unknown		1		1		1		0.4
Teleostei	Fish-unknown		1		1		1		0.4
Chondrichthyes			1		2		1		1
<i>Bathyraja interrupta</i>	Sandpaper skate	1			1	1			0.4
<i>Hydrolagus colliei</i>	Spotted ratfish		1		1		1		0.4
Echinoderms (Echinodermata)			339		2842		225		1104
Ophiuroidea			46		2276		31		884
Ophiuroidea	Brittle star-unknown	2230	46		2276	2088	31		884
Echinoidea			219		490		145		190
<i>Allocentrotus sp.</i>	Urchin-unknown	271	219		490	254	145		190
Asteroidea			45		47		30		18
Asteroidea	Sea star-unknown	2	44		46	2	29		18
<i>Pycnapodia sp.</i>	Sunflower star-unknown		1		1		1		0.4
Holothuroidea			29		29		19		11
<i>Parastichopus spp.</i>	Sea cucumber-unknown		29		29		19		11
Arthropods (Arthropoda)			167		643		111		250
Malacostraca			167		643		111		250
<i>Pandalus platyceros</i>	Spot prawn	449	73		522	420	48		203
<i>Munida quadrispina</i>	Squat lobster		94		94		62		37
Euphausiacea	Euphausiids	27			27	25			10
Mollusks (Mollusca)			29		29		19		11
Unknown			29		29		19		11
Mollusca	Mollusk-unknown		29		29		19		11
Algae (Phaeophyta)			2		2		1		1
Phaeophyceae			2		2		1		1
Laminariaceae	Kelp-unknown		2		2		1		1
Other			3		3		2		1
None			3		3		2		1
Debris	Marine debris		3		3		2		1
Grand Total			3000		620		3620		2809
							412		1406

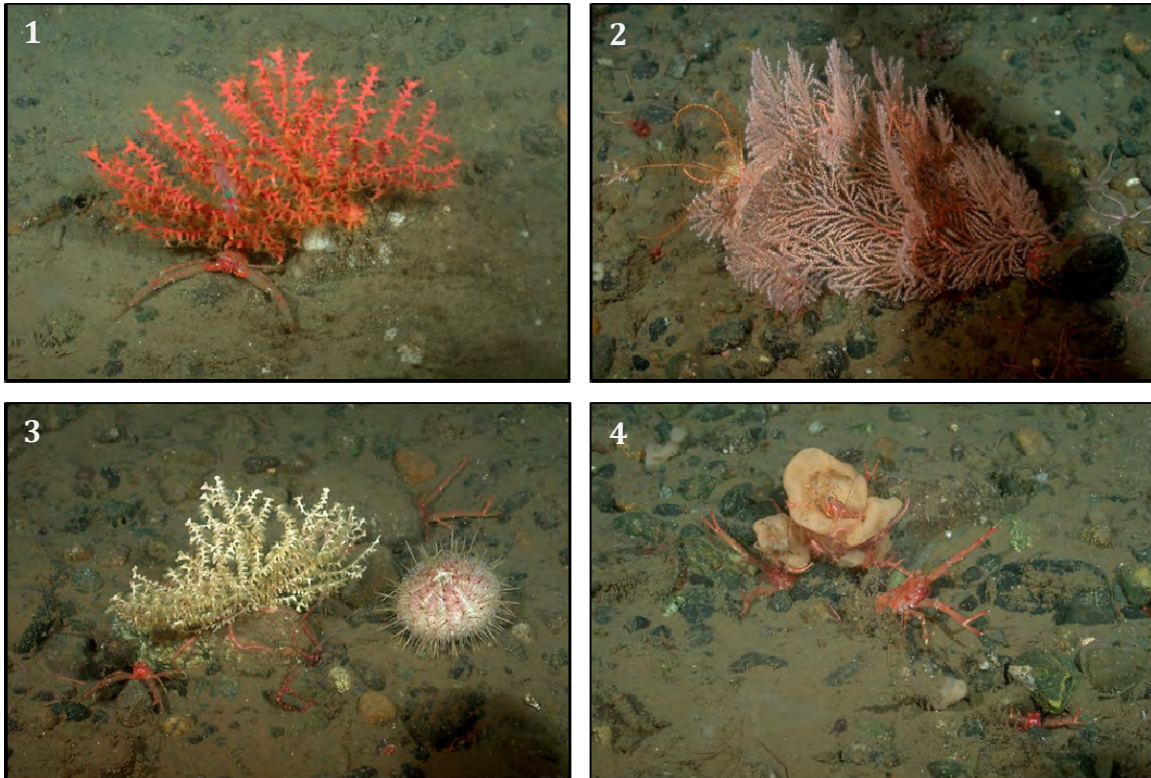


Figure 27. Select photos from OCNMS-Site 2 (10-309B):1) *Swiftia pacifica*, 2) *Plumarella sp.*, 3) *Swiftia beringi* (left) with a sea urchin (*Allocentrotus fragilis*, right) and squat lobsters, and 4) a small vase sponge with squat lobsters.

Additional Comments on ROV Operations:

Phantom ROV operations from the FSV *Bell M. Shimada* were extremely successful. The 'permanent' installation of the USBL transceiver on the ship's centerboard greatly reduced the time required to deploy the ROV and also improved the quality of tracking information by reducing acoustic interference from bubbles originating from the ship's propeller during normal operations. New launch and recovery methods suggested by the ship's deck crew improved the overall ROV operation. The ship's DP was an invaluable asset that 1) enabled us to precisely return to geo-located positions on the seafloor for biological sampling, and 2) greatly improved ROV survey capabilities by enabling the ship to precisely follow a survey line for a specified distance at a chosen course and speed. The new FSV platforms are proving to be the most effective vessels for ROV surveys available on the West Coast.

Appendix 1. Log of coral samples collected by or relevant to this cruise.

Number	Collection date	Sample Number	Species ID	Authority	Site	Latitude	Longitude	Depth (m)	Disposition
001	10/29/10	BS 2010 001	<i>Dendrophyllia</i> sp.	Butler	43 Fathom Bank SW	32.65500	-117.97167	78	Berntson
002	11/04/10	BS 2010 004	<i>Euplexaura markii</i>	Horvath	Coquille Bank	42.90777	-124.85535	257	Berntson
003	11/04/10	BS 2010 005	<i>Euplexaura markii</i>	Horvath	Coquille Bank	42.90777	-124.85535	250	Berntson
004	11/05/10	BS 2010 007	<i>Swiftia pacifica</i>	Horvath	OCNMS	48.16467	-125.23077	230	Berntson
005	06/24/10	M2 2010 001	<i>Plumarella longispina</i>	Horvath	Cordell Bank slope	38.03949	-123.52154	328	Berntson

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Left to right: Kevin Stierhoff, Scott Mau, John Butler, David Murfin, and Peter Etnoyer

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