A REPORT TO NOAA DEEP-SEA CORAL RESEARCH AND TECHNOLOGY PROGRAM
November 30, 2011

A CHARACTERIZATION OF DEEP-SEA CORAL AND SPONGE COMMUNITIES ON THE CONTINENTAL SHELF OF OLYMPIC COAST NATIONAL MARINE SANCTUARY, NORTHERN WASHINGTON USING A REMOTELY OPERATED VEHICLE IN JUNE 2010

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INTRODUCTION AND SCIENTIFIC OBJECTIVES

Deep-sea corals, particularly structure forming corals, are biogenic habitats and are recognized as slow-growing, long-lived and fragile, making them and their associated organisms vulnerable to human-induced impacts, particularly from physical disturbances (NRC 2002; Hourigan et al. 2007; NOAA 2010a). The extent of habitat degradation resulting from these threats is largely unknown although there is increasing information on significant impacts in some areas. Activities that can directly impact deep coral communities include fishing using bottom-tending fishing gear, deep coral harvesting, oil and gas and mineral exploration and production, and submarine cable/pipeline deployment. Invasive species, climate change and ocean acidification represent additional serious threats.

Deep-sea sponges also provide important three dimensional structures to benthic habitats, and are thought to play ecological roles similar to deep-sea corals. In some areas, sponge-dominated habitats may be more widespread than coral-dominated habitats. For example, in the northeast Pacific Ocean, glass sponges (Class: Hexactinellida) form unique sponge reefs up to 19 m high and many kilometers long (Leys et al. 2004). Hexactinellida sponges have been documented in OCNMS although not forming these types of sponge reefs (Hyland et al. 2005; Brancato et al. 2007). Although much less is known about deep-sea sponges, they have been identified as habitat for managed fish stocks in certain regions (Cook et al. 2008) and face many of the same threats as deep-sea corals.

Submersible and ROV surveys for deep-sea habitats in OCNMS started in the year 2000 to investigate potential impacts to the benthic habitat caused by trenching operations to lay fiber optic cable in OCNMS (Brancato and Bowlby 2005). The stony coral *Lophelia pertusa* was discovered in the sanctuary in 2004 (Hyland et al. 2005). Large gorgonian coral patches were identified in 2006 during a more extensive research cruise dedicated to observing deep-sea corals (Brancato et al. 2007) and similar distribution/abundance patterns were recorded for a 2008 survey (Bowlby et al. in prep).

In 2010, the NOAA Deep-Sea Coral Research and Technology Program (DSCRTP) initiated a three year study to advance our understanding of deep-sea corals (DSC) off the west coast of the U.S. The status of DSC along the west coast had been previously summarized by Whitmire and Clarke (2007). 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* (K2), a science-class remotely operated vehicle (ROV), operated by the University of Connecticut and the *Seabed* autonomous underwater vehicle (AUV) operated jointly by the Northwest Fisheries Science Center (NWFSC) and the Pacific Islands Fisheries Science Center (PIFSC). This report provides a summary of the methods and results from underwater surveys of corals, sponges, and associated habitats, invertebrates, and fishes conducted during Leg 1 of the cruise using the ROV to survey hard bottom substrates previously mapped with side-scan sonar and/or multibeam bathymetry in the Olympic Coast National Marine Sanctuary (OCNMS or Sanctuary) that had high likelihood of suitable habitats for DSC communities. These ROV surveys were a collaborative effort among researchers from the OCNMS, the National Centers for Coastal Oceans Science (NCCOS), Washington State University (WSU), and the Makah Tribal Fisheries (MTF).

DSC surveys in OCNMS were ranked the highest priority for west coast efforts in FY2010 by the West Coast DSC Planning Team (NOAA 2010b) since it would also address groundfish Essential Fish Habitat (EFH) information needs linked to a proposal to the Pacific Fishery Management Council (PFMC) to expand the boundaries and increase protective measures for a EFH Conservation Area known as Olympic 2.

The Olympic 2 Conservation Area was created in 2006 as part of West Coast groundfish EFH areas (http://www.pcouncil.org/wp-content/uploads/EFH_maps.pdf), partially based on DSC data. Olympic 2 covers approximately 159 square nautical miles, or about 7 percent of OCNMS. The 2004 discovery of the stony coral *Lophelia pertusa* in the sanctuary (Hyland et al. 2005) was a contributing factor in the Council's decision on some boundaries of the Conservation Area.

These EFH closed areas were identified by PFMC and are intended to minimize to the extent practicable the adverse effects of fishing on groundfish EFH. New information on the locations, densities, and condition of DSCs and their role as EFH within these proposed conservation areas would not only help to fill scientific data gaps, but would provide new information pertinent to pending management considerations (via provisions of Magnuson-Stevens Act and/or the National Marine Sanctuaries Act). EFH Conservation Areas are closed to specific types of fishing. For Olympic 2 bottom trawling is prohibited for all non-treaty fisheries.

The specific objectives of our research during Leg 1 were to:

1. Survey and characterize the distribution, abundance, and condition of deep-sea coral and sponge communities in OCNMS, specifically in new areas proposed for bottom fishing closures;

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

3. Collect limited DSC and sponge specimens to confirm taxonomic identification;

4. Make visual observations of sea floor substratum to ground-truth and to refine habitat classifications derived from side scan and/or multibeam sonar data.

STUDY SITE

The study area is located in OCNMS, which is off the western coast of Washington state (Figure 1). The Sanctuary boundary follows the international border with Canada in the north, an offshore boundary approximating the 200m bathymetric contour, and the southern boundary northwest of Grays Harbor. OCNMS therefore covers most of the continental shelf in northern Washington. The offshore boundaries, which extend seaward 40 to 70 km (24 to 45 miles), also cross the heads of three major submarine canyons, in places reaching a maximum depth of over 1,400 meters (4,500 feet). OCNMS spans 8,259 square kilometers (3,198 square miles) of marine waters off Washington.

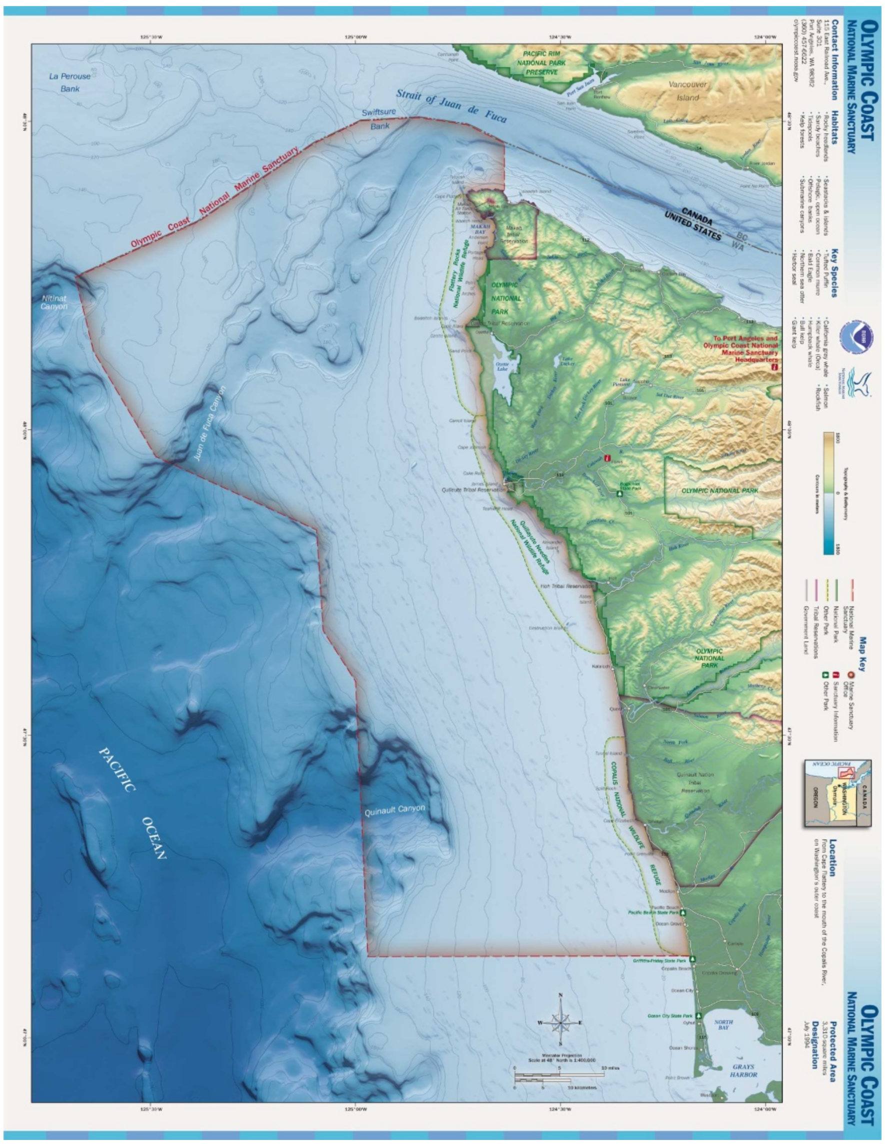


Figure 1. Map of the Olympic Coast National Marine Sanctuary showing shelf and canyon bathymetric relief off the Washington coast of the United States.

Because gorgonian and stony corals generally recruit to hard substrates, side scan sonar data were reviewed by OCNMS scientists to delineate potential hard-bottom substrates to serve as ROV dive targets (Intelmann et al. 2007). Potential hard-bottom features were initially identified from side scan sonar mosaics for which habitat classification had not yet been conducted. These hard-bottom approximations based on side scan data represented the population of known potential coral-sponge habitat in the sanctuary.

In addition to the side scan sonar imagery, multibeam bathymetry and backscatter was also queried for the purpose of limiting dive depths and evaluating bathymetric relief. However only small portions of the sanctuary have been mapped using high resolution multibeam since multibeam surveys off the Washington coast had been restricted, until recently, due to Navy classified areas (Intelmann et al. 2007).

We used these acoustic maps of hard bottom areas to select 48 candidate ROV dive sites as areas of potential coral and sponge habitat for the 2006 DSC survey. Some of the sites were surveyed in 2006 (Brancato et al. 2007), and some in 2008 (Bowlby et al. in prep). Remaining hard bottom sites that had not been surveyed and that were located in the proposed boundary expansion areas for Olympic 2 Conservation Area were prioritized for 2010 (Figure 2).

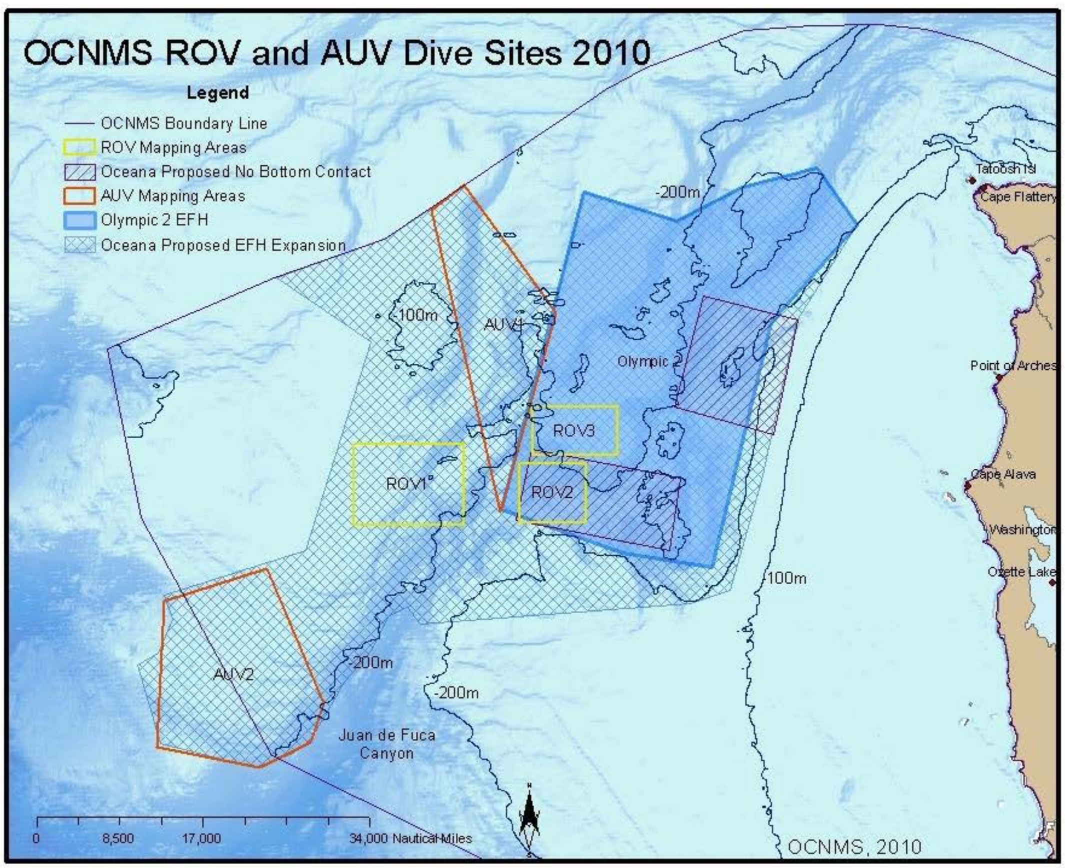


Figure 2. Targeted 2010 dive sites for ROV and AUV surveys in Olympic Coast National Marine Sanctuary off the coast of Washington state.

The Juan de Fuca trough and canyon revealed many of the hard bottom features we looked for. They wind their way southwestward from the Strait of Juan de Fuca (Figure 2). The upper part of this feature – the Juan de Fuca Trough – is a complex, glacially carved, underwater fjord-like system. Farther offshore the trough becomes the Juan de Fuca Canyon that cuts across the outer continental shelf and slope, terminating in deep water at the base of the continental slope. Most of our dive targets were located along the Juan de Fuca Trough, consisting largely of glacial deposits; some sites included glacial erratic boulders left either by the retreat of the Cordilleran ice sheet from Canada and the Olympic Peninsula, or carried to their location by icebergs from the sheet and deposited on the primarily sand or silt shelf substrate.

Analysis of seafloor substrate data used for groundfish EFH designation in 2006, limited as it was, indicated that approximately six percent of OCNMS was hard substrate with potential to host biologically structured habitat. Of this estimated hard substrate, 29 percent was within the Olympic 2 EFH conservation area (Figure 3, from NOAA 2011). More recent surveys by OCNMS researchers with ROV and acoustic surveys have documented corals and other biologically-structured habitat in additional areas (Brancato et al. 2007), which indicates that this preliminary analysis may underestimate the historic or current distribution of biogenic habitat.

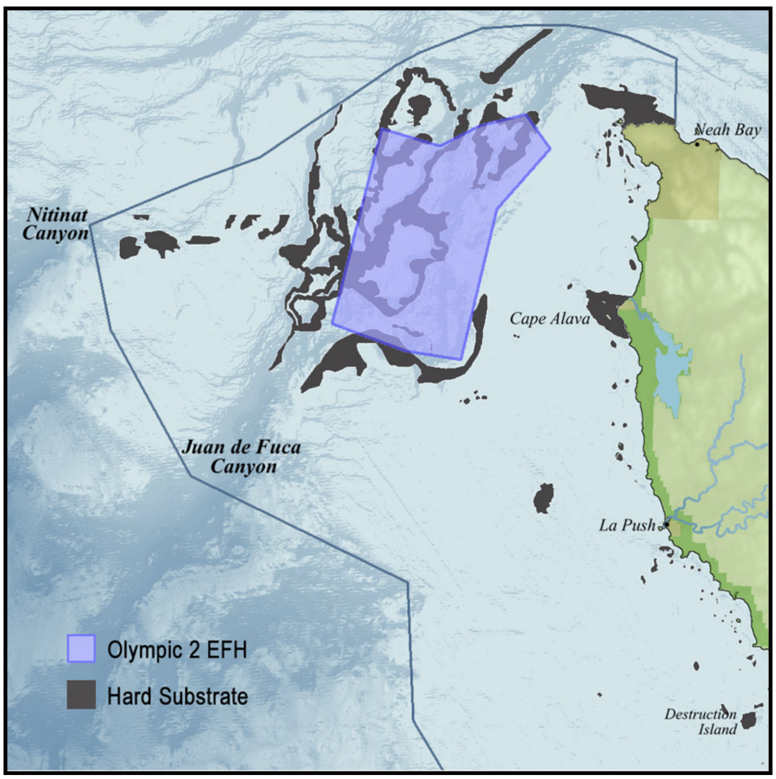
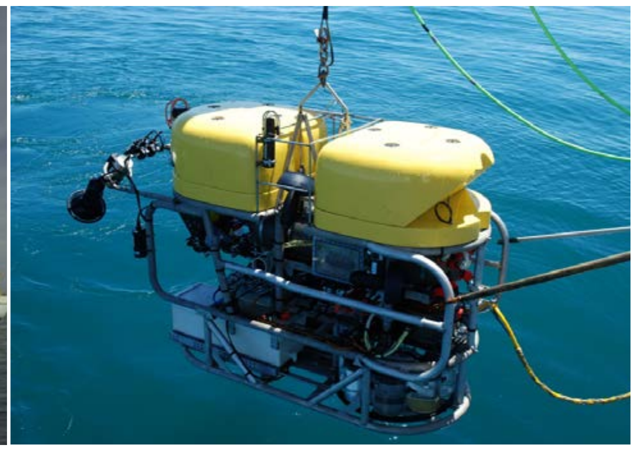


Figure 3. Potential historic distribution of biologically structured habitat associated with hard substrate overlaid on Olympic 2 EFH Conservation Area (data from Curt Whitmire, NOAA, as recorded in NOAA 2011).

The proposed 2010 ROV dive sites at OCNMS are indicated as ROV1, ROV2 and ROV3 in order of priority (Figure 2). ROV1 was highest priority due to being in the proposed expansion area of Olympic 2 and to the fact that it was near DSC sites that had been documented in 2006 (Brancato et al. 2007). ROV2 was next highest priority due to it being located in an area proposed for prohibition of all bottom contact fishing gear versus just bottom trawling restrictions. Although ROV3 was already located in the Olympic 2 Conservation Area, it had not been surveyed to date and additional DSC information would be helpful for long-term management. The AUV sites (AUV1 and AUV2) were selected based on information needs in the proposed expansion areas that had little or no acoustic substrate maps, which limited the usefulness of ROV surveys. However the cruise plan allowed flexibility to the ROV priorities, so if an AUV survey revealed significant biogenic habitats, the ROV could change its priority away from ROV1-3 to conduct more detailed investigations.

FIELD SURVEY METHODS



ROV surveys were conducted during daylight hours, while the alternating nighttime shift focused on AUV surveys, which are reported on separately. The ROV survey followed scientific protocols previously established by OCNMS and NCCOS (Hyland et al. 2005; Brancato et al. 2007). Pre-selected transect lines spaced 40m apart were developed for each of the sites in order for the K2 ROV to run quantitative video surveys, generally operating at depths between 100-150 meters. Protocol included limited sampling of portions of coral colonies that would confirm taxonomic identification, genetics, and for use in aging studies. Post-processing of video records would characterize distribution and abundance of coral and sponge species across substratum types and to determine species associations.

Video images were collected using a Kongsberg high-definition (HD) camera positioned forward on the ROV. Observers annotated the video images, both on audio tape and with programmable x-keys on laptops. The video data were captured on DVCAM and mini-DV tapes, as well as HD 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 and for area calculations post dive. 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 digital still camera and

associated strobes on the ROV were used to assist in documenting corals, sponges, and fishes. A hand-held digital video camera and a digital still camera were used to document topside survey activities and were combined with the ROV photos for public outreach and education elements of the cruise (http://sanctuaries.noaa.gov/missions/2010coral_west/welcome.html).

The ROV was equipped with a Sea-Bird SBE19 CTD and associated sensors to continuously record temperature, salinity, depth, pH, and oxygen concentration; however, the instrument caused continual ground-faults on the ROV. The instrument was subsequently removed, and no oceanographic data was collected during this leg.

The ROV was equipped with a robotic arm to collect coral and/or sponge specimens; however, during the single dive conducted on this leg, coral and sponge cover was limited, and the only species observed had been collected during previous research cruses. As a result no specimens were collected.

ROV transects were spaced 80m apart versus planned 40m due to time constraints to complete coverage of Site 63. Lasers on the ROV were measured at 20cm apart. Equipment issues included operational problems with the ROV. But the most significant limitation was due to heavy seas and wind conditions encountered during most of the field days.

POST-DIVE VIDEO ANALYSIS AND DATA PROCESSING

The Winfrog navigational files from the K2 ROV needed a general cleaning of noisy data points. OCNMS dove on relatively shallow and low relief sites attributing to possibly less noise than other sites. After removing a few outlying points in GIS, the navigational files were smoothed in Generic Mapping Tools (GMT) GIS software (http://www.soest.hawaii.edu/gmt/). In GMT, the data was filtered into 5 second intervals, using a boxcar filter1d command of 51 points with the following command: filter1d – Fb51 – E –T202209369/202209379/5 –N8/0 –v sorttime.txt > filt.txt.

Actual lasers were measured on screen to determine width of the quantifiable area surveyed. Laser measurements were sampled by micro habitat segments with at least 1 minute intervals. Each habitat segment was then averaged for a mean laser measurement and any unusable video segments were not used. The mean of the laser measurements for the habitat types throughout the entire site were used for segment widths with no viewable lasers. This accounts for any bias that may occur due to different heights of the ROV from the sea floor due to habitat type. Each segment was then calculated for field of view applying the ratio of the known laser distance (20 cm). In GIS, the consecutive points for each habitat segment was converted to polylines and summed in UTM for length. Area was calculated for each habitat segment using the product of length and width.

For post-cruise video analysis, OCNMS primarily used the Monterey Bay Aquarium Research Institute's Video Annotation Reference System (VARS) for processing and annotation. Videos were generally reviewed in at least two if not more passes. The first pass recorded macro- and microhabitats following a slightly modified version of Greene et al. 1999. Habitat was classified using a two letter code to indicate a primary ($\geq$ 50 percent of field of view) and secondary ($\geq$ 20 percent of field of view) where two letters are always used to identify substrate. In addition geological attributes were noted (e.g., boulder, cobble, etc.). Habitat characterizations were not classified for less than 10 seconds of video while at survey speed, generally around 0.5 knots. A survey activity code (e.g., on transect or off effort) was also recorded on the first pass.

The second pass was for coral and sponge identification, including size, number, color and confidence level of identification. The bottom half of the video view, with the lasers generally central in the view, was the portions of the video annotated. Identifications are made to the lowest taxonomic level *possible* with assurance. For some sponges, the families or classes were easy to distinguish on video, but many were not, thus the combination of identification terms that include morphologies (morphs) and descriptive terms were used (e.g., vase, ball, branching, etc.). Any corals or sponges over 5 cm tall were measured for height and width. Condition of corals and sponges were also noted (e.g., broken, missing branches, etc.).

The third pass was for quantifying fish distribution and relative abundance, although qualitative fish information was also summarized on the second pass. Additional information includes recording organism behavior, condition, associations and/or anthropogenic observations.

Our sponge morphologies and defining terms come from a variety of sources, including historical terms used by sponge taxonomist Henry Reiswig participating on previous cruises (personal communication), macroscopical features and surface characters in Boury-Esnault and Rutzler (1997) and a guide to sponges in Alaska (Stone et al. 2011).

All data, including navigation, environmental, habitat type, and information associated with 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 will be available at http://olympiccoast.noaa.gov/.

SUMMARY OF DIVES

Mobilization of the K2 ROV and the scientific contingent aboard the NOAA ship *McArthur II* took place in Seattle from June 7-10, including one extra day due to early access to the ship. As equipment was secured and tested, it was discovered that during shipment of the K2 from the east coast the tether cable had apparently been compromised. Approximately one day was spent locating and repairing the problem and its functionality was restored before the ship left the pier.

A scheduled test dive of the ROV in Puget Sound following mobilization in Seattle was not completely successful due to equipment problems but was deemed solvable, so the cruise continued as scheduled.

Of the scheduled five survey days in the study area, the first day had favorable sea and wind conditions, but the ROV experienced equipment problems which precluded a dive. However the AUV was able to conduct its first evening survey. With a forecast predicting improving weather trends, the ship remained on site. Unfortunately during the subsequent days at sea we experienced high seas and winds with 11-12 ft. swell and winds gusting over 30 kts which precluded safe launching for most of the remaining days at sea.

On day three, with the seas and winds preventing launches in the survey area, the ship ran back to the protected waters off Cape Flattery (outside of the study area) for more shake-down dives for the ROV and to provide the ship's crew and ROV team more experience at launch/recovery of the vehicle in protected waters before returning to the more challenging open seas. The ROV equipment problems were resolved and the deck crew gained more experience at launch and recovery. The ship returned to the study area in the evening, and the AUV was able to be safely launched for its second survey.

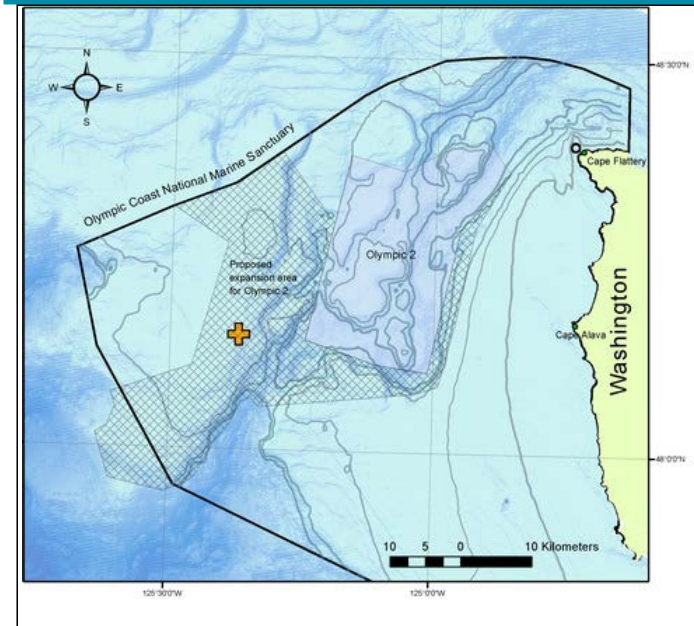
On day four, after the AUV was recovered, the ROV was able to dive on one of its priority survey sites, Site #63. However winds and seas were increasing during the day and the AUV was unable to conduct an evening dive.

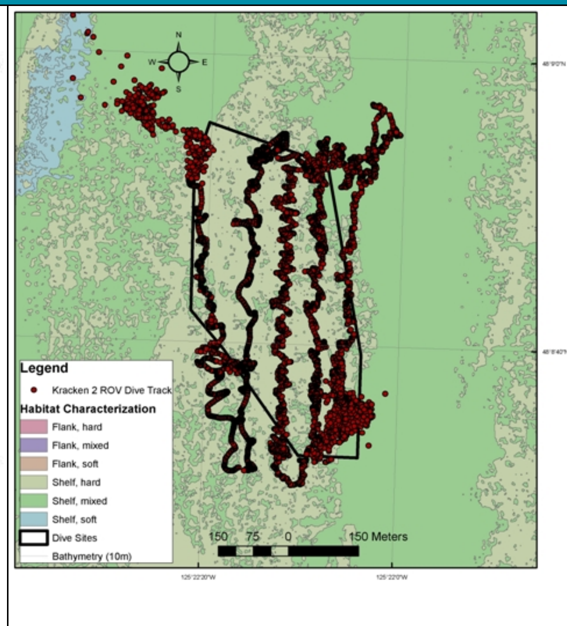
On day five, the last scheduled survey day, the ship's officers and chief scientist agreed that the high seas and wind conditions precluded safe launches for the day and with a forecast for increasing severe weather, the cruise was terminated early. The ship's captain requested a different demob location since the direction of the high swells precluded safe approaches to the scheduled primary demob location (Grays Harbor, WA) and even the backup alternate (Astoria, OR). Instead the ship was diverted to the protected waters of Port Angeles (WA) for demobilization of leg 1. Arrangements were made for science party for leg 2 to alter their location accordingly.

In summary, due to initial ROV equipment problems, followed by high seas, only one priority survey site was surveyed. However the AUV was able to survey two sites (reported elsewhere). No biological samples were collected

DIVE NUMBER: OC10004 SURVEY AREA: 63

GENERAL LOCATION AND DIVE TRACK





SITE OVERVIEW

Project	2010 Deep Sea Coral Research Cruise, Olympic Coast National Marine Sanctuary
Chief Scientist	Ed Bowlby
Contact Info	ed.bowlby@noaa.gov Olympic Coast National Marine Sanctuary 115 E Railroad Ave. Suite 301, Port Angeles, WA, 98362
Purpose	Locate coral and sponge assemblages in OCNMS, Olympic 2 EFH Conservation Area and/or proposed boundary expansion of Olympic 2. Characterize the diversity, distribution, abundance and richness of species associated with corals and sponges. Characterize substrates/habitats of coral and sponge communities. Collect and assess fish-habitat association information.
Vehicle	NOAA Ship McArthur II, UCONN Kracken 2 ROV
Science Observers	J. Bright, P. Etnoyer, S. Rooney, C. Brady, E. Bowlby
Forward View HD File Hrs	9
Forward View Tape Count	4
Digital Still Images	77
Oxygen mg/L (Avg)	unavailable
Salinity (Avg)	unavailable
Temp C (Avg)	unavailable
# of Samples Collected	no samples collected
Date Compiled	11/4/2011 12:43:58 PM
Acknowledgements	NOAA CRCP, OCNMS, ONMS, NOAA/NCCOS, NOAA Fisheries, UCONN, WSU, Makah Tribe
Report Analysts	J. Bright, K. Brenkman

DIVE NUMBER: OC10004 SURVEY AREA: 63

SITE DATA

Start Date	15-Jun-10	Start Latitude	N 48° 8' 38.88"
End Date	16-Jun-10	Start Longitude	W 125° 22' 6.192"
Minimum Bottom Depth (m)	-100.48	End Latitude	N 48° 8' 53.052"
Maximum Bottom Depth (m)	-137.5	End Longitude	W 125° 22' 20.544"
Start Bottom (GMT)	19:24	Bottom Current (Kts)	1 (estimated)
End Bottom (GMT)	3:13	Bottom Current Direction:	N

IMAGE GALLARY

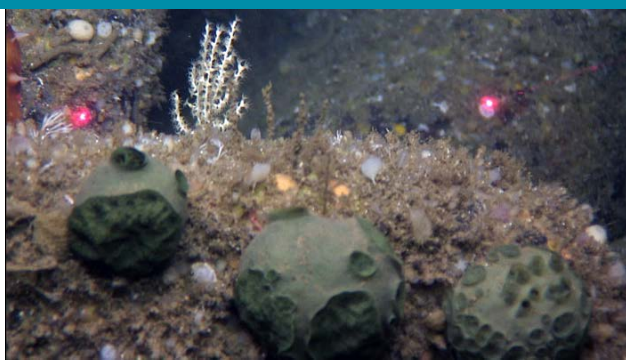


IMAGE A: *Swiftia beringi* with green lunar sponge *(Latrunculia sp.)*
N 48° 8' 36.798", W 125° 22' 8.712"

IMAGE B: Yellowtail rockfish *(Sebastes flavidus)* in boulder habitat
N 48° 8' 44.9874", W125° 22' 20.661"

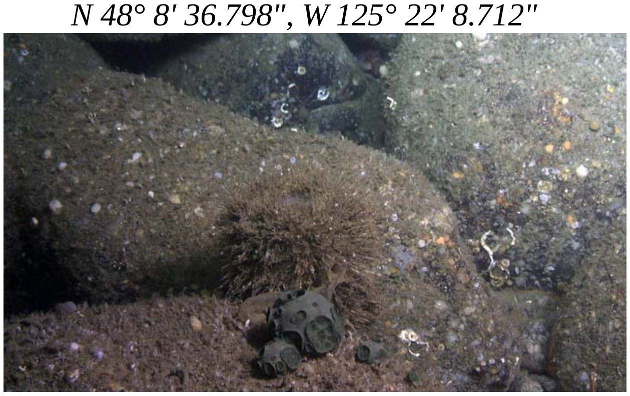
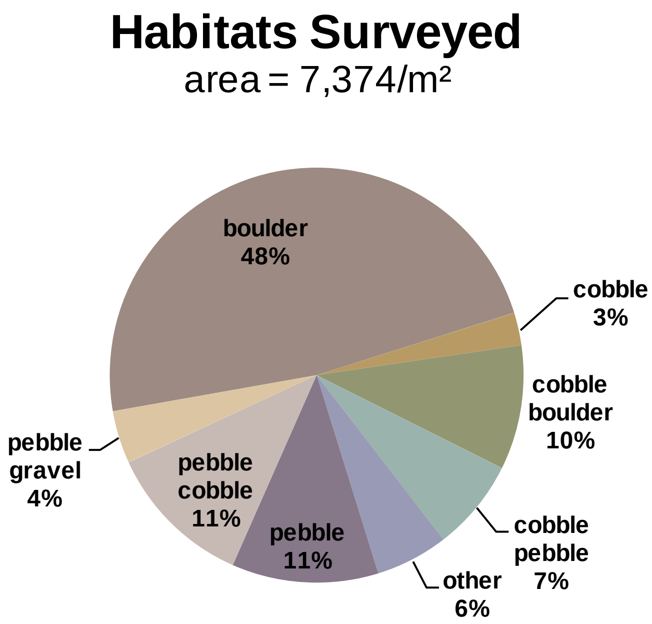


IMAGE C: Boulder habitat
N 48° 8' 36.714", W 125° 22' 8.31"

IMAGE D: Mud pebble habitat
N 48° 8' 44.934", W 125° 22' 12.762"

DIVE NUMBER: OC10004 SURVEY AREA: 63

PHYSICAL ENVIRONMENT



Habitats

The total area surveyed at site 63 was 7,374/m². The dive crossed several different geological habitat types, including cobble (10% of total area), pebble (11%), pebble cobble (11%), but boulder fields were the dominant habitat type (48%). Most fish species were observed either resting or swimming in the water column along the boulder fields.

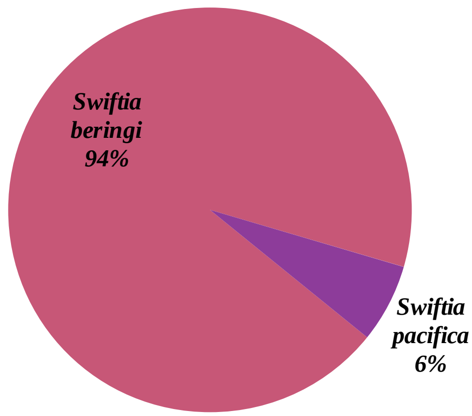
Corals

The site was dominated by areas of large boulders where *Swiftia beringi*, the primary coral species, occurred.

A total of 241 individual corals were seen on 5 transects covering 7,374/m²An average density of 33 corals per 1000/m² was estimated. The *Swiftia beringi* dominated the coral observations at 94% of the total density.

Density of Corals

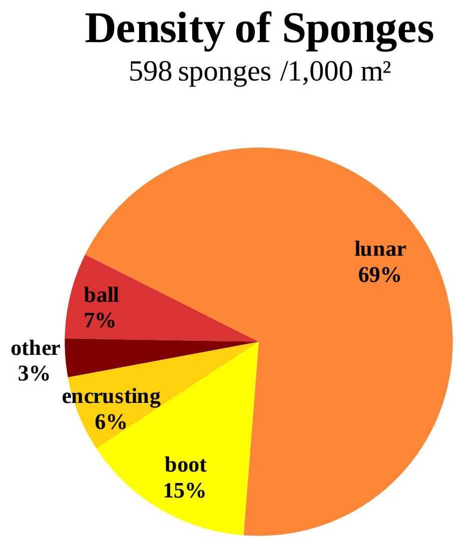
33 corals /1,000 m²



Color Bar	Coral Groups	Counts
	Swiftia beringi	226
	Swiftia pacifica	15

Sponges

The lunar sponge morph (*Latrunculia* sp.) was the most abundant sponge at 69% of the total density primarily found on boulders. In areas of pebble and gravel key sponge species observed consisted of small boot sponges (*Rhabdocalyptus dawsoni*). The other sponge category includes multi tube, short tube, single tube, finger, groove and lattice morphological structures.



A total of 4362 individual sponges were seen on 5 transects covering 7298/m² from 12 different sponge morphs. An average density of 598 sponges per 1000/m² was estimated.

Other invertebrate species observed in the boulder patches were crinoids (*Florometra serratissima*), squat lobsters (*Munida sp.)*, sea cucumbers (*Parastichopus leukothele* and *californicus*), *Zoanthid sp*., red *Ophiuroid* brittle stars and a few sea stars (*Poraniopsis sp*., *Pteraster tesselatus*, *Henricia sp*., and *Solaster paxillatus*).

Color Bar	Class	Structural Morphs	Count
	Demosponges	lunar	3003
	Hexactinellids	boot	633
	Demosponges	ball	311
	Hexactinellids	encrusting	275
	Demosponges	organ pipe	70
	Hexactinellids	cloud	40
	Demosponges	short tube	14
	Demosponges	multi tube	8
	Demosponges	finger	4
	Demosponges	lattice	2
	Demosponges	groove	1
	Demosponges	single tube	1

DIVE NUMBER: OC10004 SURVEY AREA: 63

BIOLOGICAL ENVIRONMENT

Fishes

Rockfish species observed during the dive were rosethorn (*Sebastes helvomaculatus),* yellowtail *(Sebastes flavidus),* yelloweye *(Sebastes ruberrimus)*, canary (*Sebastes pinniger)*, tiger (*Sebastes nigrocinctus)* and Puget Sound *(Sebastes emphaeus)*. A few rockfish were possibly gravid. Other fish species observed consisted of lingcod (*Ophiodon elongatus)*, spotted ratfish *(Hydrolagus colliei),* Pacific halibut *(Hippoglossus stenolepis)*, and kelp greenling (*Hexagrammos decagrammus).* There were many small fish yet to be identified.

Scientific Name	Common Name
Sebastes helvomaculatus	rosethorn rockfish
Sebastes flavidus	yellowtail rockfish
Sebastes ruberrimus	yelloweye rockfish
Sebastes pinniger	canary rockfish
Sebastes nigrocinctus	tiger rockfish
Sebastes emphaeus	Puget Sound rockfish
Ophiodon elongatus	lingcod
Hydrolagus colliei	spotted ratfish
Hippoglassus strenolepis	Pacific Halibut
Hexagrammos decagrammus	kelp greenling
	Unidentified small fish

ADDITIONAL COMMENTS

ROV transects were spaced 80m apart vs. planned 40m due to time constraints to complete coverage of Site 63. Red lasers on the ROV were measured at 20cm apart. The NMFS AUV *(Lucille)* surveyed nearby areas on alternating 12 hr. shifts during this cruise and is reported elsewhere. Equipment issues included the CTD sensor not working during dive and some ROV problems.

DISCUSSION

Leg 1 was challenging, both in terms of equipment issues and poor sea conditions. So the entire leg could even be considered a shake-down test for the remaining legs of this west coast mission.

Initial ROV equipment problems followed by continued poor sea conditions limited survey opportunity during the cruise to only 1 ROV dive and 2 AUV dives.

During our one ROV dive on Site 63, we ground-truthed the acoustic map that had been interpreted as hard bottom. Our photo and video documentation of boulder fields and cobble-pebble patches confirmed the presence of hard-bottom substrate at the site. Most corals, sponges and fishes were observed along these boulder fields.

The average depth during the dive was 119m. Along the transects we encountered small (averaging 12cm high, 10cm wide) and dispersed coral colonies, for a total of 241 individuals along 5 quantifiable transects covering an area of 7,374m^2. The average coral density was 33 corals per 1,000 m^2. The majority of corals were octocorals in the genus *Swiftia* (Plexauridae) on boulders, with *S. beringi* clearly predominating at 94%, and *S. pacifica* considerable less common at 6% of the total. No large gorgonian corals were observed at this site, a similar pattern to documentation of nearby sites in 2008 (Bowlby et al *in prep*,) and 2011 (Stierhoff et al. 2011). This new information helps to improve our understanding of coral distribution/abundance patterns across a range of different substrate types, depths, and other physical parameters. This information is critical for the development of predictive habitat models for deep-sea corals. We did not observe any larger dead corals, such as broken bases attached to boulders that would indicate historical occurrences.

Sponges were more frequently encountered with an overall density of 598 sponges/1,000m^2. The green lunar-looking ball sponge (*Latrunculia* sp.) was the dominant sponge accounting for 69% of all sponges, occurring predominately on boulders. A total of 4,362 individual sponges were recorded, including 12 different sponge morphs, along the 5 transects.

Most fishes observed were rockfish (*Sebastes* spp.) along the boulder fields, including rosethorn (*S. helvomaculatus),* yellowtail *(S. flavidus),* yelloweye *(S. ruberrimus),* canary (*S. pinniger),* tiger (*S. nigrocinctus)* and Puget Sound *(S. emphaeus).* A few rockfish appeared gravid. Other fish species encountered were lingcod (*Ophiodon elongatus),* spotted ratfish *(Hydrolagus colliei),* Pacific halibut *(Hippoglossus stenolepis)*, and kelp greenling (*Hexagrammos decagrammus).* Quantification of fish densities will be reported elsewhere.

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REFERENCES

Boury-Esnault, N, and Klaus Rutzler (editors). 1997. Thesaurus of Sponge Morphology. *Smithsonian Contributions to Zoology*, number 596.

Bowlby, C.E., M.S. Brancato, J.A. Boutillier, J. Bright, and K. Brenkman. Observations of Deep Coral and Sponge Assemblages in Olympic Coast National Marine Sanctuary during a 2008 ROV survey. In prep.

Brancato, M.S. and C.E. Bowlby. 2005. Survey of fishing gear and fiber optic cable impacts to benthic habitats in the Olympic Coast National Marine Sanctuary. Pages 629-630 in P.W. Barnes and J.P. Thomas, editors. Benthic habitats and the effects of fishing. American Fisheries Society,

Symposium 41, Bethesda, Maryland.

Brancato, M.S., C.E. Bowlby, J. Hyland, S.S. Intelmann, and K. Brenkman. 2007. Observations of Deep Coral and Sponge Assemblages in Olympic Coast National Marine Sanctuary, Washington. Cruise Report: NOAA Ship *McArthur II* Cruise AR06-06/07. Marine Sanctuaries Conservation Series NMSP-07-03. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. 48 pp. http://sanctuaries.noaa.gov/science/conservation/bowlby.html

Cook, S.E., B. Burd, and K.W. Conway. 2008. Status of the glass sponge reefs in the Georgia Basin. Mar Environ Res 66:S80–S86.

Greene, H.G., M.M. Yoklavich, R.M. Starr, V.M. O'Connell, W.W. Wakefield, D.E. Sullivan, J.E. McRea Jr, and G.M. Cailliet. 1999. A classification scheme for deep seafloor habitats. Marine benthic habitats and their living resources: monitoring, management and applications to Pacific Island countries. *Oceanologica Acta* 22:663-678.

Hourigan, TF, SE Clarke, G Dorr, AW Bruckner, S Brooke, and RP Stone. 2007. Deep Coral Ecosystems of the United States: Introduction and National Overview, pp. 1-64. In: SE Lumsden, Hourigan TF, Bruckner AW and Dorr G (eds.) The State of Deep Coral Ecosystems of the United States. NOAA Technical Memorandum CRCP-3. Silver Spring, MD 365 pp. http://coris.noaa.gov/activities/deepcoral_rpt/

Hyland, J., C. Cooksey, E. Bowlby, M.S. Brancato, and S. Intelmann. 2005. A Pilot Survey of Deepwater Coral/Sponge Assemblages and their Susceptibility to Fishing/Harvest Impacts at the Olympic Coast National Marine Sanctuary (OCNMS). Cruise Report for NOAA Ship McARTHUR II Cruise AR-04-04: Leg 2. NOAA Technical Memorandum NOS NCCOS 15. NOAA/NOS Center for Coastal Environmental Health and Biomolecular Research, Charleston, SC. 13 p. http://www.coastalscience.noaa.gov/documents/ar0404leg2.pdf

Intelmann, S.S., G.R. Cochrane, C.E. Bowlby, M.S. Brancato, and J. Hyland. 2007. Survey report of NOAA Ship McArthur II cruises AR-04-04, AR-05-05 and AR-06-03: Habitat classification of side scan sonar imagery in support of deep-sea coral/sponge explorations at the Olympic Coast National Marine Sanctuary. Marine Sanctuaries Conservation Series MSD-07-01. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Sanctuary Program, Silver Spring, MD. 50 pp. http://sanctuaries.noaa.gov/science/conservation/mcarthur.html

Leys, S.P., K. Wilson, C. Holeton, H.M. Reiswig, W.C. Austin, and V. Tunnicliffe. 2004. Patterns of glass sponge (Porifera, Hexactinellida) distribution in coastal waters of British Columbia. Canada. *Mar. Ecol. Prog. Ser.*, 283:133-149

National Oceanic and Atmospheric Administration (NOAA). 2010a. NOAA Strategic Plan for Deep-Sea Coral and Sponge Ecosystems: Research, Management, and International Cooperation. Silver Spring, MD: NOAA Coral Reef Conservation Program. NOAA Technical Memorandum CRCP 11. 67 pp. http://coris.noaa.gov/activities/deepsea_coral/

National Oceanic and Atmospheric Administration (NOAA). 2010b. NOAA Deep-Sea Coral FY2010 Science Plan for the U.S. West Coast.

National Oceanic and Atmospheric Administration (NOAA). 2011. Olympic Coast National Marine Sanctuary Final Management Plan and Environmental Assessment. Office of National Marine Sanctuaries. Silver Spring, MD.

National Research Council (NRC). 2002. Effects of trawling and dredging on seafloor habitat. National Academy Press, Washington, D.C. 136 pp.

Stierhoff, K.L., P.J. Etnoyer, D.W. Murfin, and J.L. Butler. 2011. A survey of deep-water coral and sponge habitats along the West Coast of the U.S. using a remotely operated vehicle. NOAA Technical Memorandum NOS NCCOS 138. NOAA Centers for Coastal Environmental Health and Biomolecular Research, Charleston, SC. 38 pp. http://www2.coastalscience.noaa.gov/publications/ccehbr/detail.aspx?resource=xyYY8+Vs2IWyXc8n343Z0pYibphi/R2GuAhSXhxDU1E=

Stone, R.P., H. Lehnert, and H. Reiswig. 2011. A guide to the deep-water sponges of the Aleutian Island Archipelago. NOAA Professional Paper 12:1-216.

Whitmire, C.E. and M.E. Clarke. 2007. State of the U.S. Deep Coral Ecosystems in the United States Pacific Coast: California to Washington, pp. 109-154. In: SE Lumsden, Hourigan TF, Bruckner AW and Dorr G (eds.) The State of Deep Coral Ecosystems of the United States. NOAA Technical Memorandum CRCP-3. Silver Spring, MD 365 pp.