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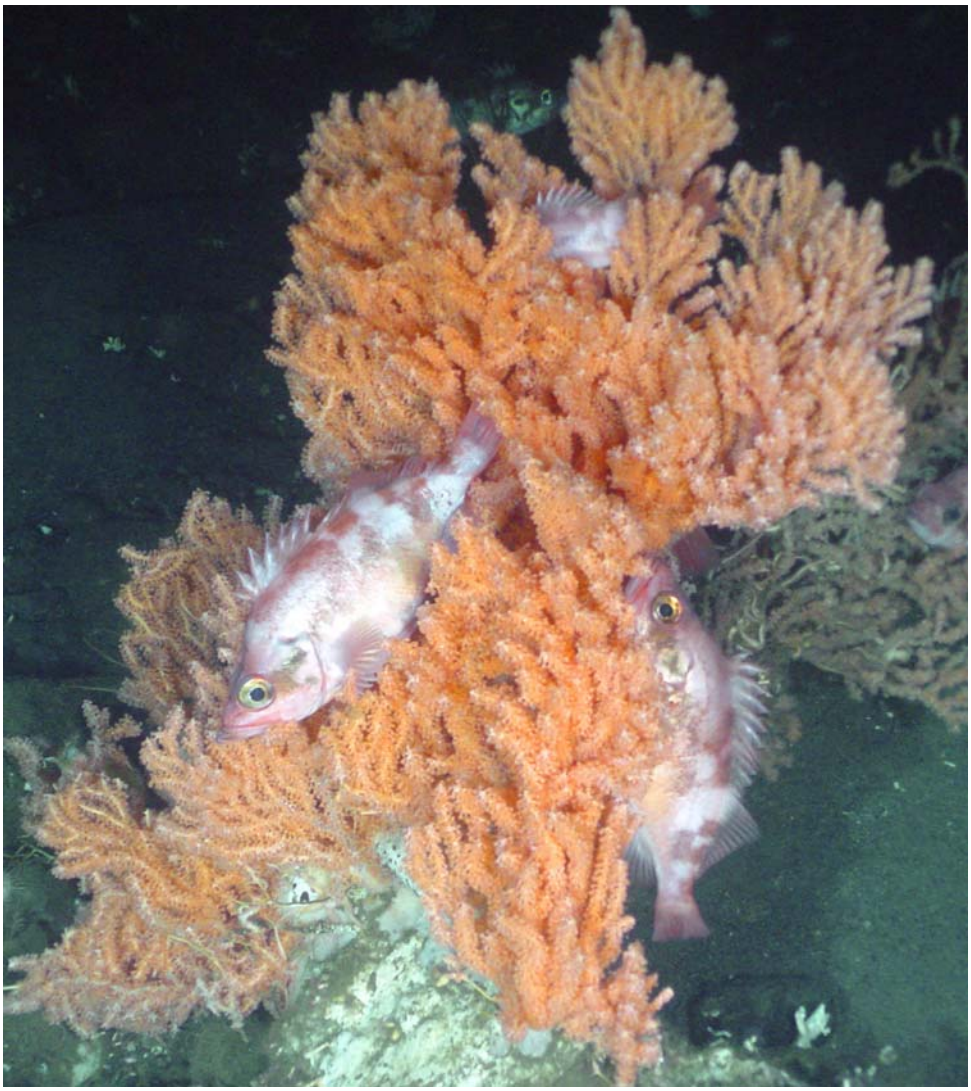

Observations of Deep Coral and Sponge Assemblages in Olympic Coast National Marine Sanctuary, Washington

Cruise Report: NOAA Ship *McArthur II* Cruise AR06-07/07

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
National Ocean Service
Office of Ocean and Coastal Resource Management
National Marine Sanctuary Program

July 2007

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Cruise Report: NOAA Ship *McArthur II* Cruise AR06-06/07

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COVER

Red tree coral, *Primnoa pacifica* with darkblotched and sharpchin rockfish. Photo credit: Olympic Coast National Marine Sanctuary, taken using the ROPOS ROV digital still camera.

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ABSTRACT

From May 22 to June 4, 2006, NOAA scientists led a research cruise using the ROPOS Remotely Operated Vehicle (ROV) to conduct a series of dives at targeted sites in the Olympic Coast National Marine Sanctuary (OCNMS) with the goal of documenting deep coral and sponge communities. Dive sites were selected from areas for which OCNMS had side scan sonar data indicating the presence of hard or complex substrate. The team completed 11 dives in sanctuary waters ranging from six to 52 hours in length, at depths ranging from 100 to 650 meters. Transect surveys were completed at 15 pre-selected sites, with additional observations made at five other sites. The survey locations included sites both inside and outside the Essential Fish Habitat (EFH) Conservation Area, known as Olympic 2, established by the Pacific Fishery Management Council, enacted on June 12, 2006. Bottom trawling is prohibited in the Olympic 2 Conservation Area for non-tribal fishermen. The Conservation Area covers 159.4 square nautical miles or about 15 percent of the sanctuary. Several species of corals and sponges were documented at 14 of the 15 sites surveyed, at sites both inside and outside the Conservation Area, including numerous gorgonians and the stony corals *Lophelia pertusa* and *Desmophyllum dianthus*, as well as small patches of the reef building sponge *Farrea occa*. The team also documented *Lophelia* sp. and *Desmophyllum* sp. coral rubble, dead gorgonians, lost fishing gear, and other anthropogenic debris, supporting concerns over potential risks of environmental disturbances to coral health.

KEY WORDS

Deep coral and sponges, marine sanctuary, ROV, rockfish, side scan sonar, *Lophelia*, gorgonians, coral distribution, EFH, Olympic 2 Conservation Area, seafloor disturbance.

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INTRODUCTION

The shelf and canyon habitats of the Olympic Coast National Marine Sanctuary (OCNMS) off the coast of Washington are areas of high primary productivity and biodiversity. They also support extensive groundfish fisheries, both commercial and tribal. However, only limited information is available on deep benthic habitats within the sanctuary. The present report provides preliminary results of a survey conducted in May-June 2006, using a remotely operated vehicle (ROV) equipped with digital video and still cameras, to learn more about the presence and condition of deep coral and sponge assemblages within the OCNMS and potential risks of environmental disturbances. The cruise is a follow-up to an earlier pilot survey conducted in June 2004 (Hyland et al. 2005).

Prior to this project, the distribution of corals and sponges in the OCNMS was much less known, limited to anecdotal reports by fishermen, coastal tribal members, scuba divers, previous submersible cruises undertaken by OCNMS, National Marine Fisheries Service trawl survey bycatch information, and some museum specimens collected by independent researchers. The most comprehensive peer-reviewed report that includes the OCNMS is a database compiled by researchers at the Marine Conservation Biology Institute (Etnoyer and Morgan 2003), which includes records from the Smithsonian National Museum of Natural History, National Oceanic and Atmospheric Administration (NOAA) Fisheries RACEBASE, Canadian Museum of Nature-Department of Fisheries and Oceans (CMN-DFO), California Academy of Science, among others. This latter report identified relatively few records on the continental shelf of the North American west coast, but this was thought to be an information gap largely reflecting research and reporting effort. Subsequent research in the Monterey Bay National Marine Sanctuary and along the coasts of Oregon, Washington, British Columbia, and Alaska have greatly increased the records of corals in these areas, though research effort is still limited due to lack of funds (Stein et al. 1992; Heifetz 2002; Cairns and Williams 2005; Conway et al. 2005; DeVogelaere et al. 2005; Jamieson et al. 2005; Whitmire and Clarke *In Press*).

Only one species of zoantharian coral in the family Antipathidae ("black corals"), i.e. *Bathypathes* sp., had been documented in the literature within OCNMS waters prior to the present project (Etnoyer and Morgan 2003; Etnoyer and Morgan 2005). OCNMS had unpublished data from its 2000-2004 surveys of benthic recovery along a fiber optic cable route (Brancato and Bowlby 2005), indicating the presence of the gorgonians *Paragorgia* sp., *Swiftia* sp., and an unidentified paramuriceid coral; the hydrocoral *Stylaster venustus; Balanophyllia* cup corals; plus numerous sponges. However, newly identified in the OCNMS, as a result of the 2004 pilot effort (Hyland et al. 2005; Bowlby et al. 2006), is the lithoherm[1]-forming scleractinian coral *Lophelia pertusa*. *Lophelia*

[1] Throughout this report, the term lithoherm is used as a general term for mounds of rubble and living *Lophelia pertusa* observed. Composition of the mounds has not been evaluated at this time to determine if they are compacted lithified sandy carbonate sediments forming a solid pavement or strictly mounds of rubble with some living polyps.

pertusa is common in the North Atlantic Ocean, forming extensive lithoherms. It has also been documented from southern California to British Columbia; but not as extensive lithoherms as in the north Atlantic (Cairns 1994; Conway et al. 2005; Jamieson et al. 2005; Whitmire and Clarke *In Press*). In OCNMS, most of the live *Lophelia pertusa* observed occurred on rock faces, with a lithoherm occurring at the base of the rock face. Also newly identified in OCNMS, as a result of the 2006 survey, are the scleractinian cup corals *Desmophyllum dianthus*, a potentially undescribed species of the hydrocoral *Stylaster*; and several other coral species. Corals were found at 14 of the 15 sites surveyed.

Although the 2006 cruise greatly increases our knowledge of coral distribution in the sanctuary, only a minor portion of the sanctuary has been photographically surveyed to date. Reliable information to help locate potential coral sites (e.g., using data derived from side scan sonar or multibeam bathymetry surveys) is currently only available for approximately 26 percent of the sanctuary (see Intelmann 2006; Intelmann et al. 2007). Within this mapped area, hard substrates existing within a specific depth criterion that may provide coral habitat have been identified at 48 sites. Quantitative ROV dive transects have been completed at 15 of these 48 sites. Because of the cost and logistical challenges associated with conducting acoustic surveys in deeper waters by towed array, the currently mapped areas within OCNMS using side scan sonar are primarily at depths < 400 m, yet some corals are found only in deeper areas. For instance, bamboo corals (family Isididae) and bubblegum corals (family Paragorgiidae) have been documented in deeper waters just outside sanctuary boundaries (Etnoyer and Morgan 2003).

The continental shelf in the sanctuary extends from 8 to 40 miles from the shore (Figure 1). Three submarine canyons cut into the shelf and slope within the sanctuary boundary: i.e., the Nitinat, Juan de Fuca, and Quinault canyons. The Juan de Fuca trough and canyon wind their way southwestward from the Strait of Juan de Fuca. 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. Many of our dive targets were located along the trough, consisting largely of glacial deposits; however, some sites included glacial erratics 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.

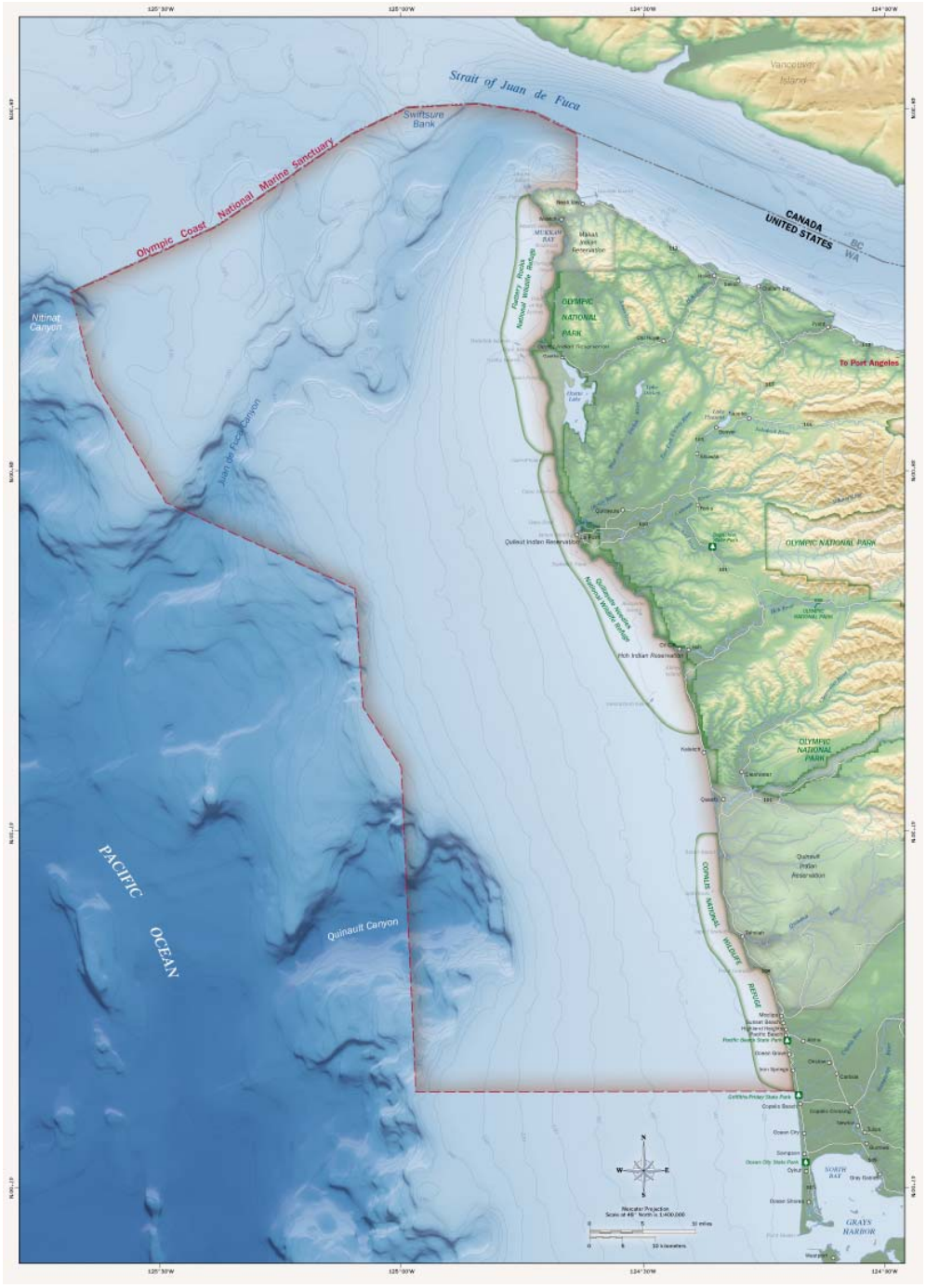

Figure 1. Map of the Olympic Coast National Marine Sanctuary showing shelf and canyon topography off the Washington coast of the United States.

OBJECTIVES

Overall study objectives and related research questions are presented below. Not all of these objectives can be addressed with a single year of data. This report primarily addresses objectives 1, 3 and 6. Additional analysis of existing video and photographs, plus the results from future cruises will be used to continue addressing the study objectives.

Objective 1: Locate coral and sponge assemblages in the sanctuary.

Objective 2: Define (map) the area of coverage of any "major" assemblages.

Objective 3: Identify to the lowest taxonomic level possible, the species providing biogenic structure.

Objective 4: Characterize the diversity, abundance and richness of species associated with coral-sponge habitat areas. Related research questions follow:

- Is the species diversity/abundance/richness of non-coral and sponge species different in coral/sponge areas than in adjacent areas without coral or sponges?

Objective 5: Document evidence of potential environmental disturbances that may present risks to deep coral and sponge health. Related research questions follow:

- Evaluate fishing/harvest pressures on coral-sponge assemblages and their associated fauna and how these vary due to fishing intensity.
- Is the condition of coral/sponges different in trawlable versus untrawlable habitats?
- Within trawlable habitats, is the condition of corals/sponges different between two levels of fishing intensity?
- Is the condition of coral/sponges different in closed areas than non-closed areas?

Objective 6: Document the substrate/habitat (and any other environmental features) the coral and sponge assemblages inhabit.

Objective 7: Collect and assess fish-habitat association information.

Objective 8: Monitor recovery of trawlable habitats within the Olympic 2 EFH Conservation Area to characterize changes in epifauna over time.

METHODS

Pre-Cruise Planning

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. Towed deep-water side scan sonar surveys were conducted in OCNMS off the *F/V Mystery Bay* in September 2002 (Intelmann and Cochrane 2006) and from the NOAA ship *McArthur II* in 2004, 2005 and 2006 (Intelmann 2006, Intelmann et al. 2007). These particular surveys were restricted to water depths < 400m to optimize the capabilities of the survey kits involved. The resulting side scan sonar imagery from these surveys covers approximately 11 percent of the sanctuary (Figure 2). Potential hard-bottom features were initially identified from side scan sonar mosaics for which habitat classification had not yet been conducted. Polygons were manually delineated using ArcGIS™ (Environmental Systems Research Institute (ESRI), Redlands, California). An example of this process is illustrated in Figure 3 using survey site 6. Shown in the figure is a manually delineated polygon (black outline) encompassing a candidate hard-bottom feature identified from side scan sonar imagery, the ROV navigation track lines showing the transect survey that was conducted within the polygon, and post-acoustic survey habitat classification results following the scheme of Greene et al. (1999). These hard-bottom approximations based on side scan data represented the population of known potential coral-sponge habitat in the sanctuary. Since only 21 percent of the sanctuary is currently mapped with side scan sonar, (26 percent with side scan or multibeam), we expect the population of known potential coral-sponge habitat in the sanctuary to increase over time. Because this cruise focused on a depth range of 80 to 1000 m, the high resolution side scan for OCNMS fitting this depth range was further limited to 11 percent of the sanctuary.

In addition to the side scan sonar imagery, multi-beam bathymetry was also queried for the purpose of limiting dive depths and evaluating bathymetric relief. Since only a small portion of the sanctuary has been mapped using high resolution multi-beam echosounders, a few areas of interest were evaluated by using dated single-beam soundings to create an interpolated surface through kriging. Hard bottom targets <80m were eliminated since the literature indicates that soft corals are generally found in waters >80m depth. Areas >1000m in depth were also removed from consideration because the dive limit of our ROV operations was 1000m.

Although the majority of the candidate ROV dive sites were chosen by reviewing acoustic derived data, some corals (e.g., black corals and bamboo corals) occur at depths much greater than our current acoustic data set spans. Thus, to supplement these data and expand the range of candidate ROV dive depths, we used additional information on locations of “untrawlable habitat” as defined by NOAA Fisheries (Zimmermann 2003) and/or Washington Department of Fish and Wildlife (WDFW, Jagielo et al. 2004) based on inaccessibility of scientific trawl survey methods. NOAA Fisheries and WDFW provided GIS layers illustrating what each have defined as untrawlable habitat. The assumption with untrawlable areas is that they represent hard, uneven substrate that may prevent trawl gear from operating effectively. So in theory they are untrawled areas, at

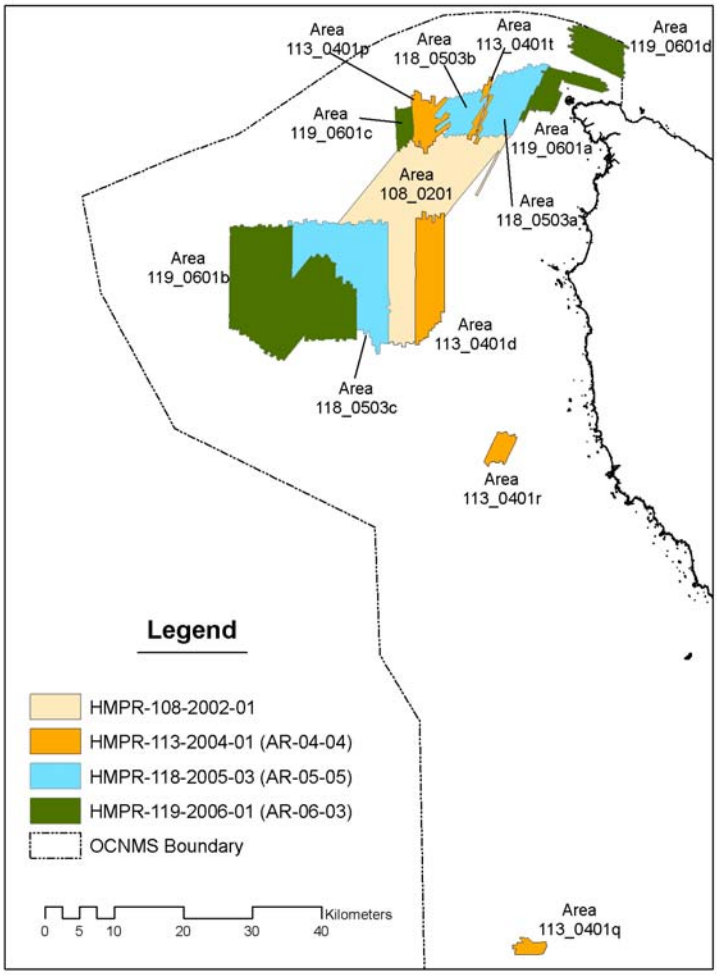

Figure 2. Areas of the Olympic Coast National Marine Sanctuary surveyed with high resolution side scan sonar off the *NOAA Ship McArthur II* (denoted by AR) and *F/V Mystery Bay*. Each color indicates an area surveyed during a particular cruise and year. These surveys cover only 11% of the sanctuary. (modified from Fig. 1 of Intelmann et al., 2007).

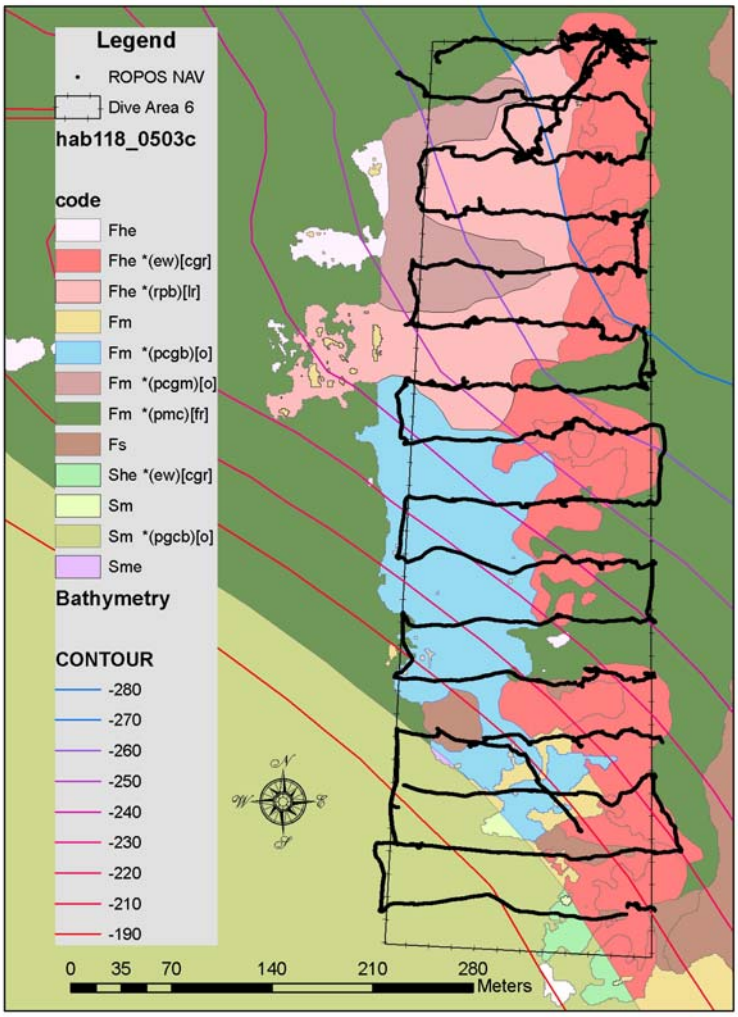

Figure 3. Survey site 6, illustrating the manually delineated polygon as drawn around mosaicked side scan sonar data, the ROV navigation track for the transects surveyed, and the segmented habitat classification polygons according to Greene et al. (1999). See below for key to codes.

Habitat Codes:

First letter = Megahabitat: based on depth, where >200m = Flank (F) and < 200 m = Shelf (S);

Second letter = Bottom Induration: where mixed (m) = mixed hard and soft substrates, and soft (s) = sediments such as mud, silt, clay, or sand;

Third letter = Meso/Macrohabitat: description relating to scale of features, where in this example exposed (e) =bedrock exposure;

Codes following asterisks relate to video observation of microhabitat, with codes as follows: encompassed by parentheses ( ) describes substrate where: e=exposed bedrock, w=sheer wall, p=pebble, g=gravel, c=cobble, b=boulder; in brackets [] describes biota where: f=flat fish, r=rockfish, c=coral, g=gorgonian, o=other sessile organisms, l=lingcod

Code Example: Fhe *(ew)[cgr] = Flank, hard exposed bedrock wall with corals, gorgonian and rock fish.

least avoided for scientific trawling purposes, however, not necessarily by commercial trawling, which may use small footrope roller gear to allow access to more substrate types. This hard, uneven substrate at appropriate depths also represents potential coral-sponge habitat. Information on the geographic extent of the untrawlable habitats were imported into GIS and overlays were created to allow both: (1) the delineation of additional deeper canyon sites for ROV dives, and (2) the classification of the various polygons generated from the side scan sonar data into trawlable versus untrawlable categories. The latter classifications provide an additional basis for evaluating differences in coral assemblages in relation to potential environmental controlling factors.

We also attempted to classify the sites by fishing intensity *a priori* using logbook trawl set-points; however, these data did not prove to be of high enough resolution for this purpose. Bycatch data from NOAA Fisheries were evaluated for the presence of corals and sponges, but because NOAA Fisheries staff (M.E. Clark and C. Whitmire pers. comm. 2006) indicated inconsistent reporting of bycatch by observers, this information was not used to prioritize potential dive sites.

Thus we identified 48 candidate ROV dive sites as the sample population, defined as the area of suspected coral and sponge habitat. We then overlaid the boundaries of the Olympic 2 EFH Conservation Area (NOAA Fisheries 2006) onto the map of the study sites. The Pacific Fisheries Management Council/NOAA Fisheries scheduled the Olympic 2 Conservation Area to go into effect on 12 June 2006, which was shortly after we completed the cruise. Olympic 2 is closed to bottom trawling for non-tribal fisheries. Tribal fishing occurs in the sanctuary since the sanctuary is located within the combined usual and accustomed (U&A) fishing areas of the four Washington coastal treaty tribes (Makah, Quileute, Hoh, and Quinault). The Tribes' treaty fishing rights are based on 1855 treaties with the United States and apply to fish species found within each Tribe's respective U&A area. Each tribe is responsible for managing the treaty fishing activities of its members and co-manages the resource with state and federal agencies. Tribal fishing allocation and management measures in federal waters are developed on a government-to-government basis within the Pacific Fishery Management Council process and then regulated by the individual tribal governments.

Because of the place-oriented nature of tribal fisheries, with each tribe limited to fishing within its U&A areas, as well as other legal standards established for treaty fisheries, restrictions such as rockfish conservation area closures or EFH closures do not apply to

tribal fisheries. To meet resource conservation needs, management measures for tribal fisheries are developed in consultation with NOAA Fisheries and adopted through PFMC as part of the annual Federal regulations.

With the overlay of the Olympic 2 EFH Conservation Area boundaries onto the map of the study sites, the 48 sites were divided into four strata: 1) *scientifically trawled and inside* the EFH Conservation Area; 2) *scientifically trawled and outside* the EFH Conservation Area; 3) *not scientifically trawled and inside* EFH Conservation Area; and 4) *not scientifically trawled and outside* the EFH Conservation Area (Figure 4).

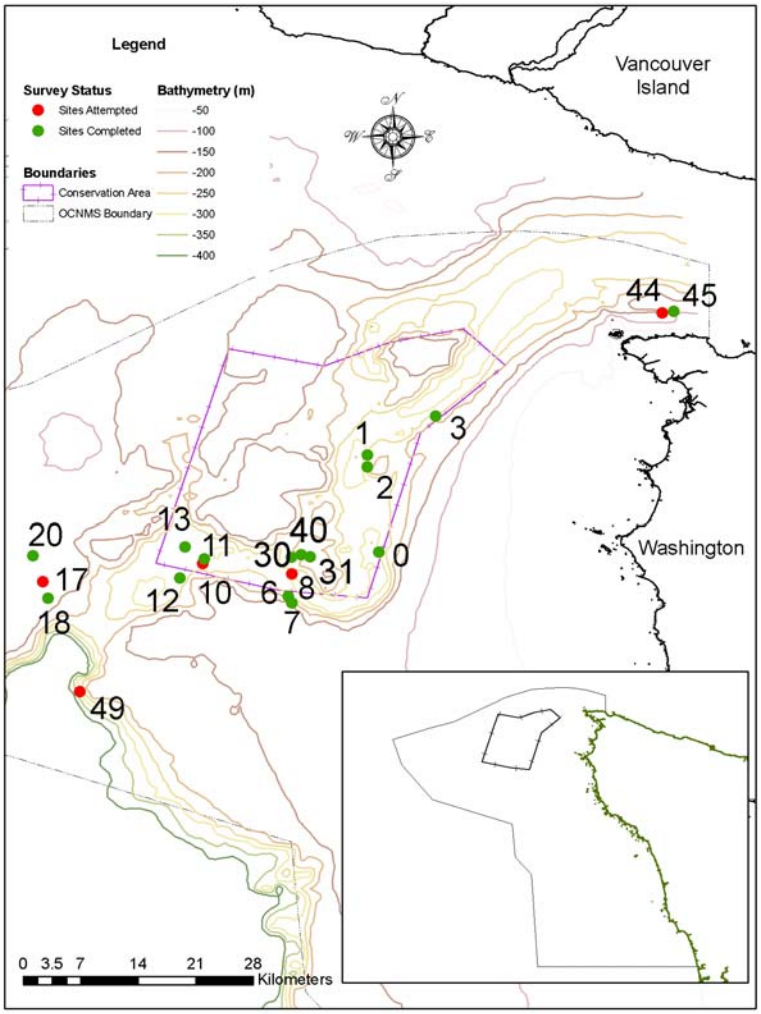

Figure 4. 2006 ROV dive sites in OCNMS and within the EFH Conservation Area Olympic 2.

In addition to the 48 core sites described above, sites within the Strait of Juan de Fuca were selected as "weather sites" to allow ROV dives to continue during any periods of high winds off the coast that prevented sampling of core sites. From previous submersible dives and review of side scan sonar data, OCNMS had documented that these sites met the depth and substrate criteria, and fishing intensity was known to be low

in these areas (open to tribal fishers only), though trawlable in terms of substrate. With these sites the number of potential dive sites totaled 55.

For the 2006 survey, half of the polygons within each of the three populated strata were then randomly selected by applying random number generation to the list of sites. About one third of these successfully surveyed during this cruise (Figure 5, Table 1). Our intention is to sample the remainder of the polygons in future years in order to meet overall project goals.

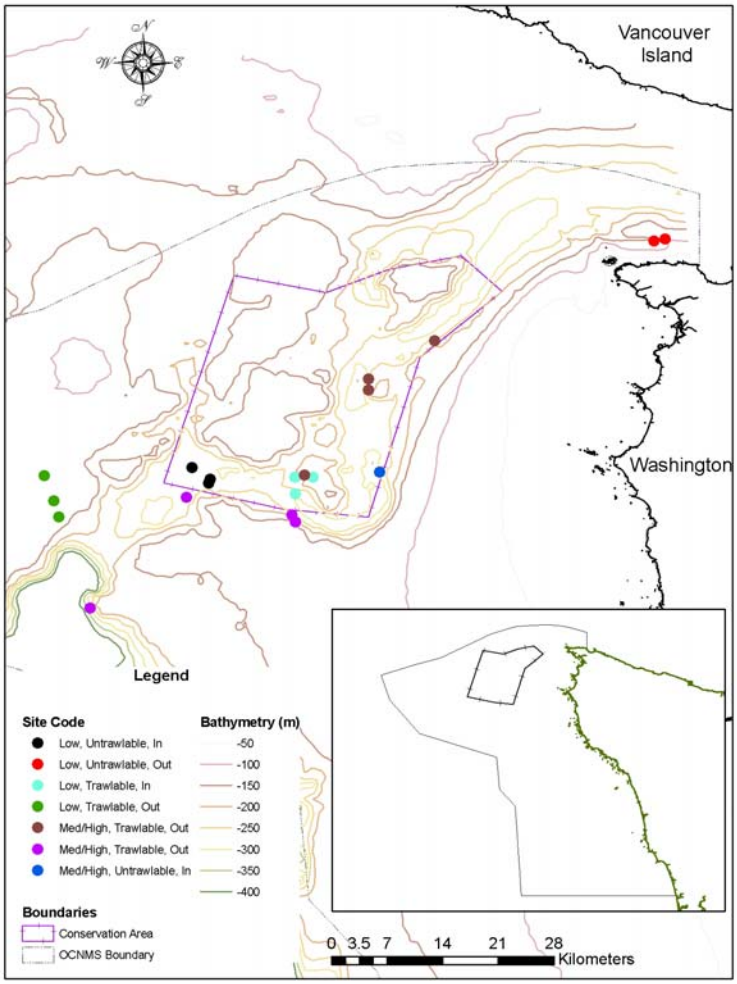

Figure 5. Dive sites classified in relation to trawl intensity (low or med/high), whether scientifically trawled and whether inside or outside the EFH Conservation Area Olympic 2 (in, out).

During the cruise we also had access to more detailed commercial trawl logbook data through participating NOAA Fisheries scientist Curt Whitmire. These catch data were used to develop a density algorithm for further classifying the dive sites into low versus medium-high trawl intensity. The levels of fishing intensity were assigned to the already randomly selected survey sites. In order to examine patterns in fishing effort in the vicinity of the randomly selected survey sites, fishing intensity (i.e., density of spatial effort) was calculated for the limited-entry groundfish trawl fishery. Logbook data were obtained from the states of California, Oregon and Washington and were queried for set and up points of trawl events. Logbook data were filtered to remove mid-water trawls and spurious data (e.g., trawls intersecting land). Trawl-set and up points were plotted in a GIS and converted to lines connecting set and up points. Line density (units = km/km^2) was calculated in ArcGIS™ software (ESRI, Redlands, California) using a 1-km search radius and cell size of 100 m. In other words, the total linear distance of all lines within a 1-km search radius was computed and assigned to a square cell (0.01 km^2) centered in the search radius. Density values were classified by quantiles of high, medium, and low fishing intensity. The ROV polygonal stations were attributed a fishing intensity based on which class constituted a majority of intersecting area.

Table 1. Sites Surveyed In OCNMS Selected Through Stratified Random Approach

Survey Site	Trawl Closure Area	Untrawlable[1]	Fishing Intensity
0	inside	No	medium
1	inside	Yes	medium
2	inside	Yes – Z	medium
3	inside	Yes	medium
6	outside	Yes – J	high
7	outside	Yes – J	high
11	inside	No	low
12	outside	Yes – Z	medium
13	inside	No	low
18	outside	Yes	low
20	outside	Yes	low
30	inside	Yes	medium
31	inside	Yes	low
40	inside	Yes – J	low
45	outside	No	low
Sites Attempted			
8	inside	Yes – J	low
10	inside	No	low
17	outside	Yes	low
44	outside	No	low
49	outside	Yes	high

[1]"Yes" indicates that both Zimmermann (2003) and Jagielo et al. (2004) illustrate the survey site as untrawlable using scientific survey methods. "No" indicates that both Zimmermann (2003) and Jagielo et al. (2004) illustrate the survey site as trawlable. Sites indicated as "Yes – Z" or "Yes – J", indicate that only one of the two, Zimmermann or Jagielo, respectively, indicated the area was untrawlable.

Dive Operations

From 22 May to 4 June 2006, ROV dives were conducted aboard the 224-foot NOAA ship *McArthur II*, Cruise AR06-06/07, using the ROPOS workclass ROV. In addition to the *McArthur II* crew and officers, 14 scientists and ROV staff participated using all berths available. Operations were conducted around the clock to maximize ROV dive time, with the scientists and ROV crew working 12-hour shifts. Although rough weather was forecasted, we only had to reposition twice due to weather — these were the two dives in the relatively calmer waters of the Strait of Juan de Fuca. The remaining nine dives were conducted along the outer coast up to 20 miles offshore, one of which was at the head of the Juan de Fuca Canyon. Dive plans were developed to take advantage of nearest neighbor dive sites to minimize launch and recovery operations, particularly during night operations when fewer ship crew were on active duty.

Figure 6. Launch/recovery of the ROPOS ROV off the NOAA Ship *McArthur II*.

To aid in conducting transects, the navigation screen for the ROV pilot included the polygons and evenly spaced transect lines. The obstacle avoidance sonar on the ROV was used throughout the dives to aid in locating hard substrates and trawl tracks. When trawl tracks were evident, the sonar was recorded to document the tracks.

The scientific party, in addition to eight ROV operators (from Canadian Scientific Submersible Facility), consisted of only six members due to berth limitations. Principal investigators were Ed Bowlby (OCNMS), Mary Sue Brancato (OCNMS) and Jeff Hyland (National Centers for Coastal Ocean Science). Additional scientists included Curt Whitmire (NOAA, Northwest Fisheries Science Center), Peter Etnoyer (then with Aquanautix Consulting), and Outreach and Education Coordinator Robert Steelquist (OCNMS).

Data Recording

The sites selected were surveyed by video transect and digital photography. Both a vertical and forward facing video camera were used along with a vertical digital camera. The video transects will be randomly or systematically sampled during post-cruise processing to address various research questions and the digital photographs are being reviewed as well to determine if they can be used for similar purposes. The sample units obtained during post-processing will include parameters such as the following: densities of megafauna, living/dead, broken/whole, size (area and height), and evidence of fishing activity (gear, tracks, etc.). The survey design provides a basis for addressing non-statistical objectives (e.g., locating coral and sponge assemblages in the sanctuary and looking for any evidence of environmental disturbances that may pose risks to coral health) as well as those of a more quantitative nature (e.g., is the species diversity/abundance/richness of non-coral species significantly different in coral areas than in adjacent areas without corals?).

More than 100 invertebrate samples were collected as vouchers and brought onboard the ship generally following the protocols of Etnoyer et al. (2005). Photos were taken of each organism *in situ* prior to collection and again once on deck. In some cases, higher-magnification images were obtained using a stereomicroscope. Tentative identifications were made on board whenever possible and the organisms preserved in 70 % isopropyl alcohol, ethanol, or 10 % buffered formalin depending on species. All samples were transferred to fresh fixative once on board and, depending on species, the fixative changed from formalin to alcohol.

The ROV was equipped with a Conductivity-Temperature-Depth (CTD) recorder with a dissolved oxygen (DO) sensor that recorded data during each dive from about 1m off the seafloor. The files were downloaded, filtered and trimmed with only the data for each survey site used in this report. Because the instrument was time-code linked to the navigation file, we were able to isolate the portion of the profile related to the bottom time at each site surveyed. CTD data are missing for a few of the sites because the instrument stopped recording due to battery failure. In future dives, the CTD was connected to the ROV power source, thus the reliance on batteries was alleviated. The mean values for salinity, temperature, DO and depth were calculated.

Current speeds encountered at the dive sites were estimated by the ROV pilot by turning the ROV into the current and applying forward speed and by observing the direction and speed of movement of marine snow while sitting stationary.

Post-Cruise Species Identifications and Evaluation

Coral samples from the 2006 survey were identified courtesy of three taxonomists: Dr. Stephen Cairns at the Smithsonian Institute; Dr. Beth Horvath at Santa Barbara Museum of Natural History/Westmont College; and Dr. Gary Williams at the California Academy of Sciences. A description of the potentially new species of the hydrocoral *Stylaster* may be undertaken at a later date by Drs. Stephen Cairns and Alberto Linder, when additional

samples are collected; only three specimens of this species were collected on this cruise. Genetics and molecular stress evaluation of the corals are currently underway at NOAA Fisheries (Dr. Ewann Berntson) and NCCOS (graduate student Sara Polson), respectively. Sponge identifications from the 2006 survey are currently underway by Dr. Henry Reiswig, Professor Emeritus, University of Victoria. Previous identifications of species observed again on the 2006 survey were made by Dr. Alberto Linder (then a graduate student at Duke University), Marine Taxonomic Services (led by Dr. Howard Jones, Corvallis, Oregon), and Drs. Henry Reiswig and Bill Austin (Marine Ecology Station, Nanaimo, British Columbia).

RESULTS

Fifteen sites were successfully surveyed, meaning sufficient number of transects were conducted to delineate the site for quantitative analysis (Table 2). Of these 15, six were outside the Closure Area and nine were inside. Three of the sites outside the Closure were within low fished areas and three were within moderately to highly fished areas. Four of the sites inside the Closure area were in low fished areas while five were within moderately to highly fished areas (Tables 1 and 2 and Figure 5).

Table 2. Sites Surveyed In OCNMS Within Each Stratified Category.

	Low Fishing Intensity, Trawlable	**Low Fishing Intensity, Untrawlable**	**Medium/High Fishing Intensity, Trawlable**	**Medium/High Fishing Intensity, Untrawlable**
Inside Conservation Area	31, 40,	11, 13	1, 2, 3, 30	0
Outside Conservation Area	18, 20	45	6, 7, 12[a]	none

[a] Survey site 12 was the only site for which no hard substrate was found.

At this point, work is still underway to quantify information from the transect surveys. Coral identifications are largely complete, while sponge and other invertebrate and fish identifications are still underway. Thus far, 18 corals have been identified in OCNMS from the 2006 survey, including scleractinids, gorgonians, and hydrocorals (Table 3).

Table 3. Coral Species Documented in OCNMS.

Class/Subclass	Order	Family	Genus species
Anthozoa/Hexacorallia	Scleractinia	Caryophylliidae	*Lophelia pertusa*
			Desmophyllum dianthus
			Balanophyllia elegans
			Caryophyllia alaskensis
Anthozoa/Octocorallia	Alcyonacea[a]	Alcyoniidae	*Anthomastus cf. ritteri*
		Primnoidae	*Plumarella longispina*
			Primnoa pacifica
		Plexauridae	*Swiftia pacifica*
			Swiftia beringi
			Swiftia spauldingi
			Muriceides sp.
		Paragorgiidae	*Paragorgia arborea pacifica*
	Pennatulacea	Halipteridae	*Halipteris cf. california*
		Virgulariidae	*Virgularia sp.*
		Umbellulidae	*Umbellula sp.*
		Anthoptilidae	*Anthoptilum grandiflorum*
Hydrozoa/Hydroidolina	Anthoathecatae[b]	Stylasteridae	*Stylaster sp. (potentially new species)*
			Stylaster venustus

cf = compared with

[a] Some taxonomists recognize the Order Gorgonacea as separate from the Order Alcyonacea. For this report we have not made a distinction.

[b] The Order containing lace corals (family Sterlasteridae) was previously called Filifera or Stylasterina.

More than 40 sponge species have been identified in OCNMS (Table 4).

Table 4. Sponge Species Documented in OCNMS (Partial).[1]

Class	Order	Family	Species
Calcarea			*Calcarea sp. Indet.*
	Clathrinida	Clathrinidae	*Clathrina sp. Indet.*
	Sycettida	Sycettidae	*Scypha sp.*
Demospongiae			*Demospongiae sp. 1*
			Demospongiae sp. 2
			Demospongiae sp. 3
			Demospongiae sp. 4
	Hadromerida	Suberitidae	*Prosuberites sp.*
			Suberites simplex
	Halichondrida	Halichondridae	*Halichondria sp. cf. fibrosa*
		Axinellidae	*Ceractinomorpha sp. Indet.*
			Axinellida sp. Indet.
	Poecilosclerida	Mycalidae	*Mycale sp. A*
			Mycale sp. B cf. bellebellensis
		Hamacanthidae	*Vomerula sp.*
		Guitarraidae	*Guitarra abbotti*
			Guitarra sp.
		Esperiopsidae	*Isodictya sp.*
		Myxillidae	*Iophon chelifer var. californiana*
			Lissodendoryx sp A
			Lissodendoryx sp B
			Myxilla sp.
		Tedaniidae	*Tedania gurjanovae*
			Tedania sp.
		Hymedesmiidae	*Acanthancora sp.*
			Hymedesanisochela rayae
			Hymedesmia sp.
			Phorbas sp.
			Stylopus sp.
		Clathriidae	*Microciona sp. cf. primitiva*
			Clathria sp.
	Haplosclerida	Chalinidae	*Haliclona sp. A*
			Haliclona sp. B
			Haliclona sp. C
			Haliclona sp. D
			Haliclona sp. E
			Orina sp. Indet.
		Adociidae	*Sigmadocia sp.*
Hexactinellida	Hexactinosa		*Scopularia sp. Indet.*
	Hexactinosa	Aphrocallistidae	*Aphrocallistes vastus*
			Heterochone calyx
		Farreidae	*Farrea occa*
	Lyssacinosa	Rossellidae	*Rhabdocalyptus dawsoni*

[1]Sponge samples are currently being worked up by Henry Reiswig. Those presented were identified by H. Reiswig in OCNMS on previous surveys and many were observed again in 2006.

At least 30 species of fish were observed during the 2006 survey (Table 5).

Table 5. Fish Species Documented in OCNMS (Partial).

Family	Scientific Name	Common Name
Scorpaenidae	*Sebastes helvomaculatus*	Rosethorn rockfish
	Sebastes zacentrus	Sharpchin rockfish
	Sebastes elongatus	Greenstriped rockfish
	Sebastes flavidus	Yellowtail rockfish
	Sebastes aurora	Aurora rockfish
	Sebastes ruberrimus	Yelloweye rockfish
	Sebastes babcocki	Redbanded rockfish
	Sebastes pinniger	Canary rockfish
	Sebastes crameri	Darkblotched rockfish
	Sebastes melanostomus	Blackgill rockfish
	Sebastolobus altivelis	Longspine thornyhead
	Sebastolobus alascanus	Shortspine thornyhead
Pleuronectidae	*Microstomus pacificus*	Dover sole
	Eopsetta jordani	Petrale sole
	Hippoglossus stenolepis	Pacific halibut
	Atheresthes stomias	Arrowtooth flounder
Paralichthyidae	*Citharichthys sordidus*	Pacific sanddab
Zoarcidae	Various species	Eelpouts
Agonidae	Various species	Poachers
Rajidae	*Raja binoculata*	Big skate
	Raja rhina	Longnose skate
Hexagrammidae	*Ophiodon elongatus*	Lingcod
Anoplopomatidae	*Anoplopoma fimbria*	Sablefish
Myxinidae	*Eptatretus stoutii*	Pacific hagfish
Chimaeridae	*Hydrolagus colliei*	Spotted ratfish
Cottidae	Undetermined species	Sculpins

Site Descriptions

Mean temperature, salinity and DO values varied little between sites, with the shallower sites being predictably slightly warmer, and with slightly higher DO than the deeper sites (Table 6). The mean depths of the sites surveyed ranged from 89 to 313m, with the majority of sites in the 200-300m range. Temperature ranged from 6.5 to 7.9 C, with shallower sites (89-131m depth) about one half degree warmer than deeper water sites. Salinity ranged from 32.0 to 34.0 psu, except at survey sites 30 and 40, at which the mean salinity was low, measuring 30.1 and 26.7 psu, respectively. Dissolved oxygen ranged from 2.2 to 4.6 mg/L (all sites included) and from 2.2 to 3.4 mg/L with the two shallowest sites excluded.

Table 6. OCNMS Survey Site Characteristics From ROV-Mounted CTD (Mean).

Survey Site	Dissolved Oxygen (mg/L)	Salinity (psu)	Temperature (°C)	Depth (meters)
0	3.0	32.0	6.9	313
1	3.3	33.9	6.8	249
2	ND[1]	ND	ND	276
3	3.0	33.2	7.0	245
6	2.9	33.8	6.9	232
7	3.4	33.8	7.2	193
11	2.9	33.6	6.5	280
12	2.2	34.0	6.5	289
13	2.6	33.7	6.7	247
18	4.5	33.7	7.7	131
20	ND	ND	ND	103
30	3.0	30.1	6.8	173
31	3.4	33.9	6.7	205
40	3.0	26.7	6.8	201
45	4.6	33.3	7.9	89
Sites Attempted				
8	ND	ND	ND	290
10	2.5	34.0	6.6	261
17	ND	ND	ND	107
44	3.7	33.8	7.2	121
49	2.7	34.0	6.5	318

[1]ND=no data.

A description of each of the sites surveyed and the predominant coral species found at each is provided below. For general location refer to Figure 4.

Survey Site 0

The first documentation of *Lophelia pertusa* in OCNMS was made at survey site 0 in 2004 on the companion pilot study survey. These colonies could not be located again in 2006, in spite of an extensive survey attempt. Rubble that appeared to be scleractinian skeletal material was located, as well as other live corals, including the hydrocoral *Stylaster* sp. and the gorgonians *Paragorgia arborea pacifica* and various *Swiftia* species. Survey site 0 is inside Olympic 2 Conservation Area. NOAA Fisheries bycatch data reviewed prior to the survey revealed sponges or corals near this site had been retrieved as bycatch. The site substrate was mainly cobble and pebbles with scattered boulders. Current speed was quite variable over the course of the approximate 16-hour dive at this site, ranging from 3/4 knot to 2 knots and changing directions several times, coming from the south, the west and then the south again. Depth at this site ranged from 254 to 372 meters. Lost fishing gear was documented at this site

Figure 7. Bubblegum coral colony *Paragorgia arborea pacifica* with extended polyps at survey site 0.

Figure 8. Bubblegum coral colony *Paragorgia arborea pacifica* with crinoids. The front lower branches of this colony appear to be broken off. The white lace coral *Stylaster* sp.can also be seen on the boulder in the fore and background at survey site 0. *Paragorgia arborea pacifica* colonies up to a meter tall were observed, while *Stylaster* sp. colonies were fairly consistently under 20 cm tall.

Survey Site 1

Numerous corals were observed at survey site 1, a site that included rock outcrop, boulders cobble and clay, and a steep, crumbly wall with benches. Corals at this highly diverse site included the gorgonians *Paragorgia arborea pacifica, Plumarella longispina, Primnoa pacifica,* various *Swiftia* species and *Muriceides* sp. The giant cup coral *Desmophyllum dianthus* was also located at this site, as well as the hydrocoral *Stylaster* sp. Survey site 1 is inside Olympic 2 Conservation Area. NOAA Fisheries bycatch data reviewed prior to the survey revealed sponges or corals near this site had been retrieved as bycatch historically. Current speed was minimal throughout the dive, never exceeding 0.75 knots and generally coming from the east or south throughout the 35 hours at this site. Visibility was good for Washington waters at about 5m. Depth ranged from 136 to 367 meters at this site. Lost fishing gear, particularly long line gear, was documented at this site that was classified as medium fishing intensity but is not inside the trawl closure area.

Figure 9. A bubblegum coral colony *Paragorgia arborea pacifica* that has been knocked over but is still alive with polyps extended at survey site 1.

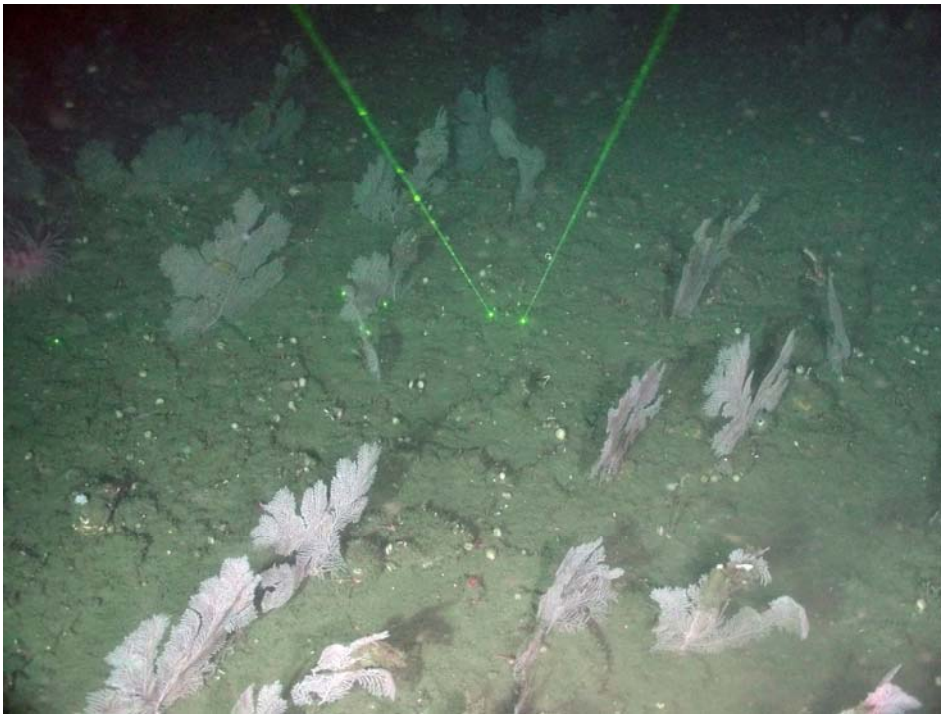

Figure 10. Colonies of gorgonian *Plumarella longispina* all oriented to take advantage of the currents at survey site 1. These colonies range in size from about 25 to 40 cm tall.

Figure 11. The giant cup coral *Desmophyllum dianthus* amidst the arms of crinoids *Florometra serratissima* at survey site 1. *Desmophyllum dianthus* corals were commonly 6 to 15 cm long.

Survey Site 2

Lophelia pertusa was documented at this site, as well as at least five other coral species, including large colonies of *Primnoa pacifica*. This site included a glacial erratic more than 8m tall amidst a seafloor of sand and clay with an occasional boulder. At the base of the glacial erratic, was a 7m wide *Lophelia* lithoherm, though with limited vertical relief. Often occurring at the same sites as *Lophelia pertusa*, was the giant cup coral *Desmophyllum dianthus.* NOAA Fisheries bycatch data reviewed prior to the survey revealed sponges or corals near this site had been retrieved as bycatch historically. Current speed was minimal throughout the dive, never exceeding 1 knot except for one 5 hour period of about 2 knots, and generally coming from the south or east but occasionally switching to come from the west or north over the course of the approximate 14 hour dive. Depth ranged from 195 to 328 meters. Lost long-line gear and trawl tracks were documented at this site, which is now located within the Olympic 2 Conservation Area.

Figure 12. Red tree coral colony *Primnoa pacifica* with crinoids adorning the branches at survey site 2. *Primnoa pacifica* colonies more than a meter tall were observed at this site and survey site 10.

Figure 13. Several giant cup corals *Desmophyllum dianthus* surrounded by a zoanthid anemone at survey site 2.

Figure 14. Scleratinian *Lophelia pertusa* colonies on a wall at the base of which is a lithoherm. Also in the photo is the giant cup coral *Desmophyllum dianthus* and a blackgill rockfish at survey site 2.

Survey Site 3

This low relief site had a muddy bottom with occasional cobble and boulders but it also included a rocky ledge forming a small wall. *Swiftia pacifica* and *Swiftia beringi* were the primary corals at this site but *Paragorgia arborea pacifica* was also observed. Survey site 3 is inside Olympic 2 Conservation Area. This site was surveyed for about 7 hours during which time the current speed remained steady at 2 to 2.5 knots from the south. Depth ranged from 200 to 270 meters.

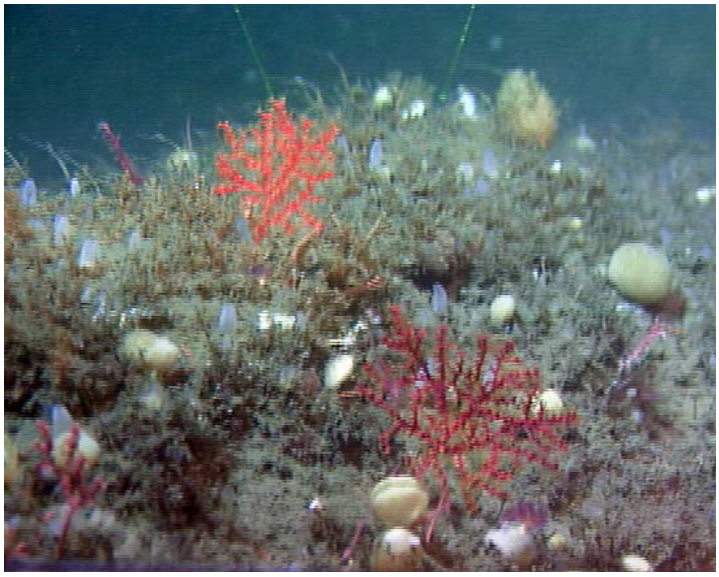

Figure 15. Small colonies of gorgonian *Swiftia pacifica* on a seafloor covered in hydroids, brachiopods and ball sponges at survey site 3. *Swiftia pacifica* colonies were generally no more than about 15 cm tall.

Figure 16. Bubblegum coral colony *Paragorgia arborea pacifica* with polyps extended at survey site 3. Another colony can be seen at the base of the slope.

Survey Site 6

This site included a long rock wall, steep on its eastern side and occasional boulders. Along the wall were visible slides of *Lophelia* rubble and live *Lophelia pertusa* on the vertical surfaces. This site also included at least five gorgonian coral species, including two *Swiftia* species, and the giant cup coral *Desmophyllum dianthus.* We surveyed this site for approximately 14 hours and encountered very little current throughout (less than 0.5 knots) though the direction changed over time from the northwest, to from the west and eventually from the south. Due to the wall and slope at this site, the depth range was considerable. At the top of the wall the depth below the surface was only 44 meters, while at the deepest part of the site it was 289 meters. Lost fishing gear was observed, including a good sized net and some line. This area is highly fished and located outside the Olympic 2 Conservation Area.

Figure 17. Rosethorn (left) and redbanded rockfish (right) at the base of a wall with scleractinian *Lophelia pertusa* and giant cup coral *Desmophyllum dianthus* at survey site 6. *Lophelia* can also be seen at the base of the wall in front of the rosethorn rockfish.

Figure 18. Two species of gorgonians *Swiftia, S. pacifica* (red) and *S. beringi* (white) at survey site 6. *Swiftia pacifica* and *S. beringi* colonies were generally no more than about 15 cm tall.

Survey Site 7

Survey site 7 was similar to site 6, with a smaller wall and less diverse biota, located outside the Olympic 2 Conservation Area and highly fished. The wall appeared to be clay pavement and was riddled with burrows. Hard rock outcrop also was evident. Cup corals and various *Swiftia* species, were evident as well as lost fishing gear. This site was a small site and only surveyed for about an hour. Currents remained less than 0.5 knots from the west. Depth ranged from 170 to 216 meters. No photos are included for this site because they are not publication quality.

Survey Site 11

This site was dominated by sand with occasional boulder patches. Currents were moderate throughout the 3.5 hours surveying this site, at about 1.25 knots from the northeast. The depth at this site ranged from 276 to 292 meters. This site included a considerable area of dead *Lophelia* sp. and *Desmophyllum* sp. and a broken *Paragorgia arborea pacifica* colony. In addition to the dead and damaged corals, at least three species of living corals were found at the site: *Plumarella longispina, Primnoa pacifica* and *Stylaster* sp. Survey site 11 is inside Olympic 2 Conservation Area.

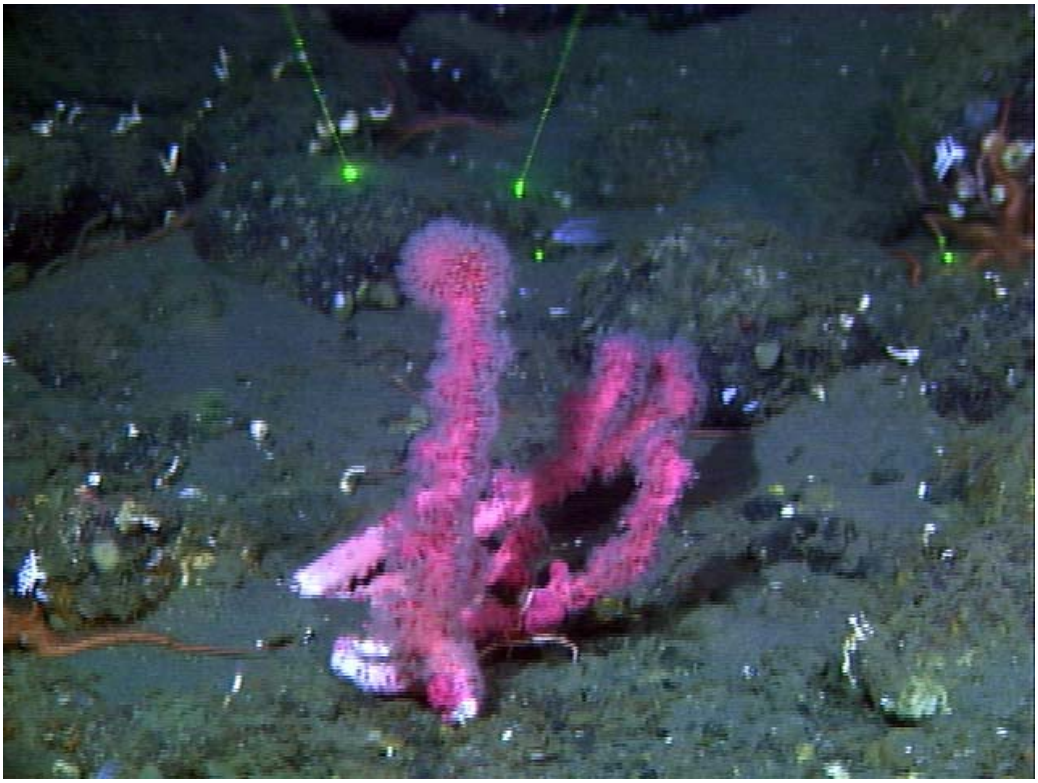

Figure 19. A damaged bubblegum coral colony *Paragorgia arborea pacifica* at survey site 11.

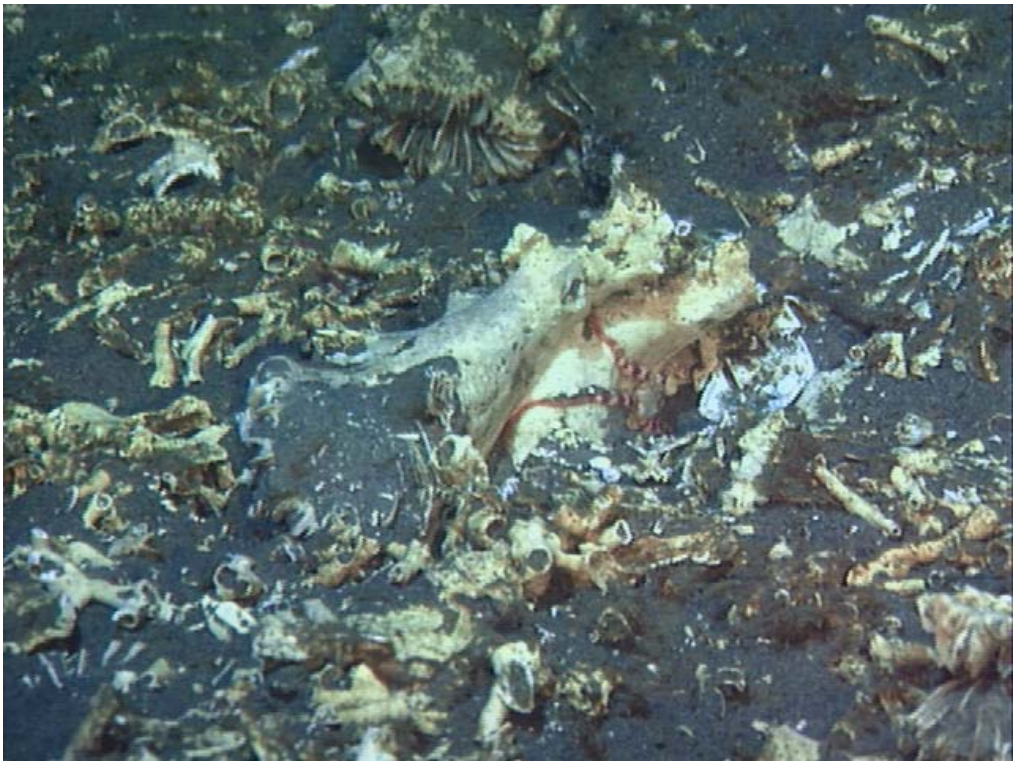

Figure 20. Skeletal remains of scleractinian *Lophelia pertusa* and giant cup coral *Desmophyllum* sp. at survey site 11.

Figure 21. Living colonies of the hydrocoral *Stylaster* sp. – possibly an undescribed species at survey site 11.

Survey Site 12

No hard substrate was located in survey site 12 – the only site for which this was the case. Post cruise review of the digital video along with the side scan imagery revealed that areas assumed to be relief pockets were actually soft sediment pockets. This was a featureless site consisting mostly of silt and gravel and no corals were observed over the course of the approximate 5 hour survey of this site. Survey site 12 is outside Olympic 2 Conservation Area. A partially incinerated waste pile was observed at this site (see Discussion). Currents were negligible at less than 0.5 knots and the direction varied. Depth ranged from 261 to 304 meters.

Survey Site 13

Site 13 was surveyed for about 5 hours during which the currents remained less than 0.5 knots with no direction defined. The depth ranged from 222 to 279 meters. This site included cobble and boulders on a silty seafloor and a small rock outcrop. Trawl tracks were evident at this site that is located outside Olympic 2 Conservation Area. At least four gorgonian corals, the cup coral *Desmophyllum dianthus* and the hydrocoral *Stylaster* sp. were present, as well as small patches of the reef building sponge *Farrea occa.*

Figure 22. A bubblegum coral colony *Paragorgia arborea pacifica* covered with brittlestars and a crinoid atop at survey site 13.

Survey Site 18

Site 18 consisted of a boulder field surrounded by cobble. We surveyed the site for about 7.5 hours during which time current speeds started at a high of about 1.25 knots, slowing to less than a knot after the first 1.5 hours and remaining low for the rest of the survey. Depth ranged from 118 to 207 meters. Lost fishing gear, netting and trawl tracks were evident at this site. At least one coral species was observed but not identified. Several sponges and sponge fragments were observed. Survey site 18 is outside Olympic 2 Conservation Area.

Figure 23. Possibly a crab pot, buoy and line at survey site 18.

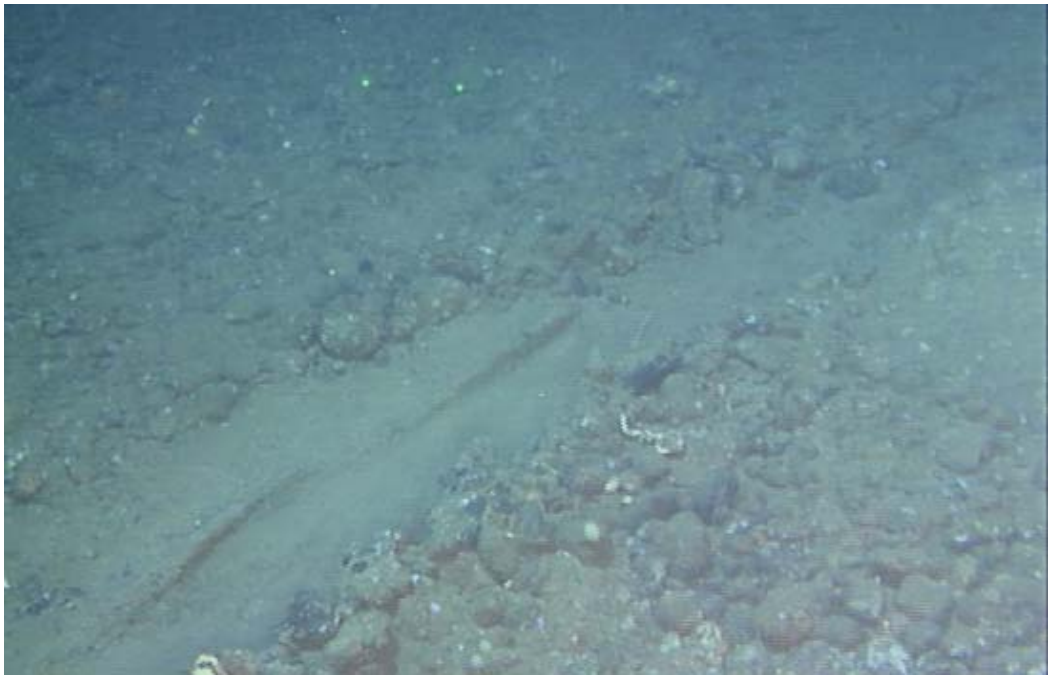

Figure 24. Trawl track at survey site 18.

Survey Site 20

At survey site 20, sea pens were documented. Survey site 20 is outside Olympic 2 Conservation Area. This was also a site near where the NOAA Fisheries bycatch data indicated sponges or corals had been brought up as bycatch. This site included boulders, cobble and areas with sand waves. We surveyed the site for about 2 hours during which currents were negligible. Depth ranged from 91 to 216 meters. No photos are included for this site because they are not publication quality.

Survey Site 30

The substrate at survey site 30 varied with pebble, cobble and boulders. This is another site near which the NOAA Fisheries bycatch database indicated sponges or corals were part of the bycatch. *Paragorgia arborea pacifica* was the predominant coral at this site, but various *Swiftia* species., *Plumarella longispina* and a hydrocoral were also documented. Dead or damaged *Paragorgia* was also found at this site. Survey site 30 is inside Olympic 2 Conservation Area. This site was surveyed for about four hours, encountering currents 1 knot or less, starting and ending from the north, but switching from the southeast in the middle. The depth at this site ranged from 153 to 191 meters. Relatively low average salinity (30.1 psu) was calculated at this site but the coral species did not appear to differ from those observed at other sites.

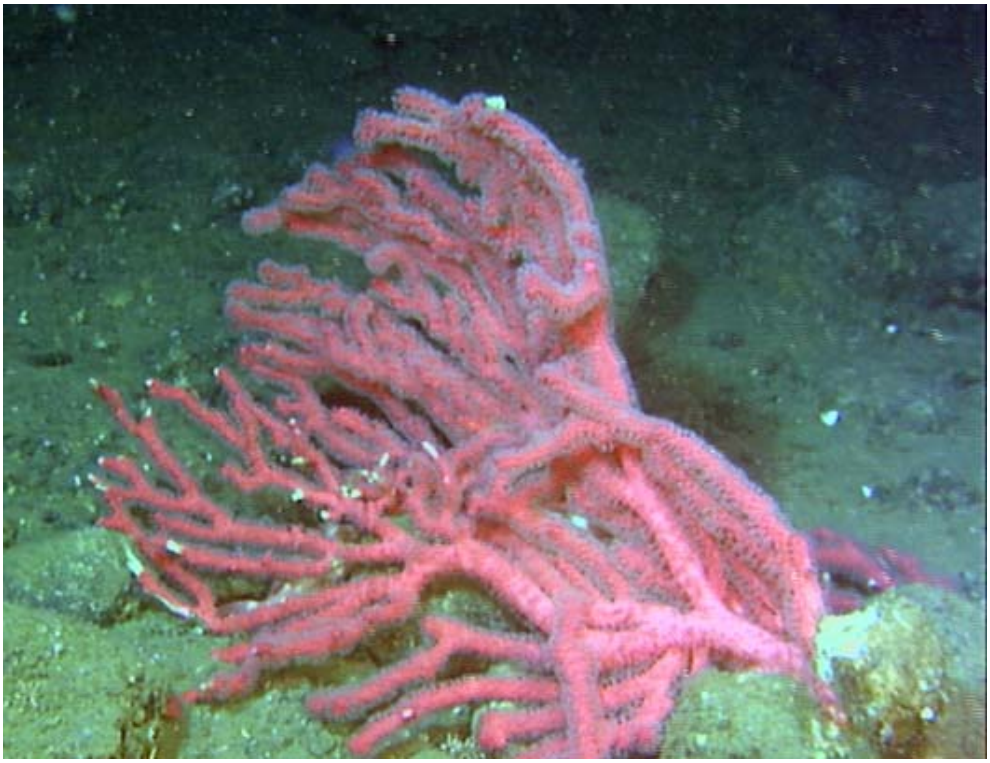

Figure 25. A bubblegum coral colony *Paragorgia arborea pacifica* on overturned cobble at survey site 30.

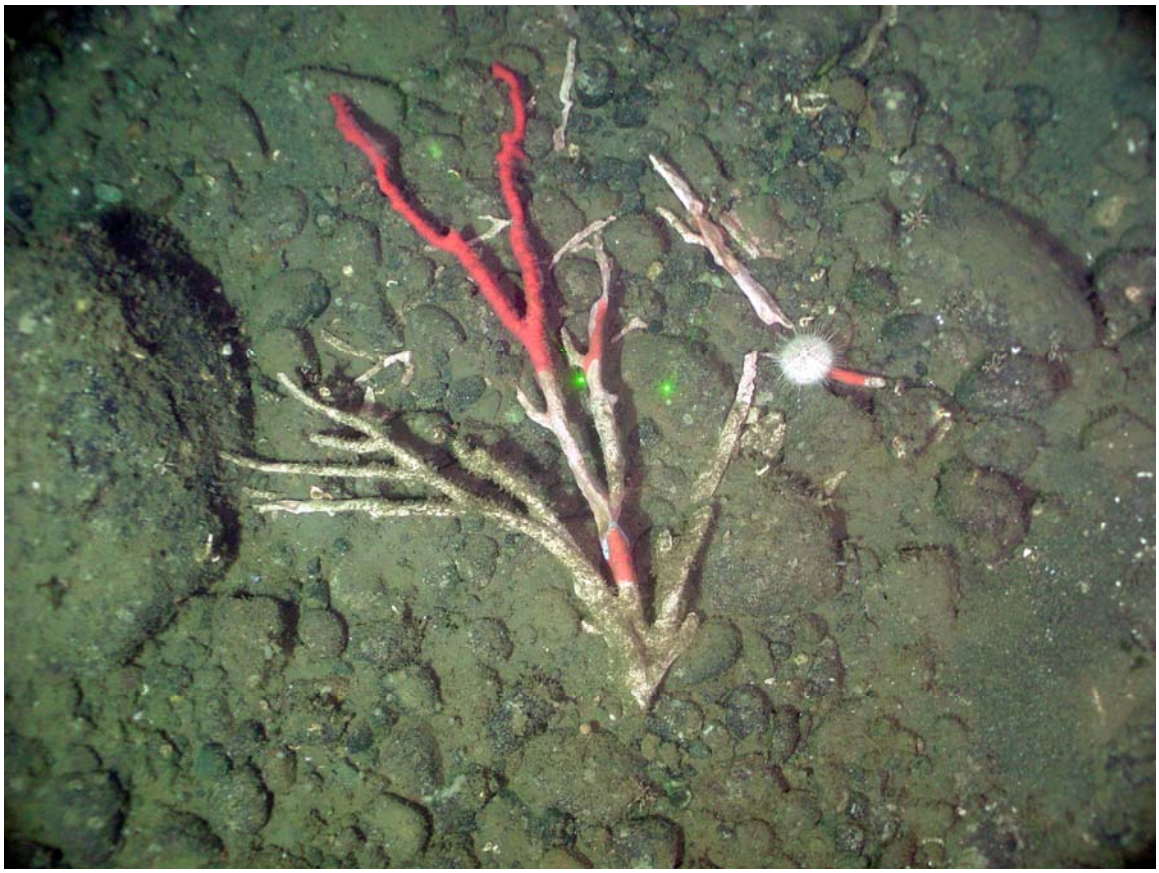

Figure 26. Mostly dead branches from a bubblegum coral colony *Paragorgia arborea pacifica* at survey site 30.

Survey Site 31

The substrate at survey site 31 was somewhat similar to 30 but with more mud in addition to the pebble, cobble and boulders. The site was surveyed for about 4 hours, encountering negligible currents (< 0.5 knots) mainly from the west. Depth ranged from 187 to 211 meters. Several gorgonians, including *Paragorgia arborea pacifica* were documented, as well as sea pens and hydrocorals. Survey site 31 is inside Olympic 2 Conservation Area. Lost fishing gear entangled on corals was observed at this site.

Figure 27. Bubblegum coral colony *Paragorgia arborea pacifica* with a hermit crab halfway up branch on left, at survey site 31.

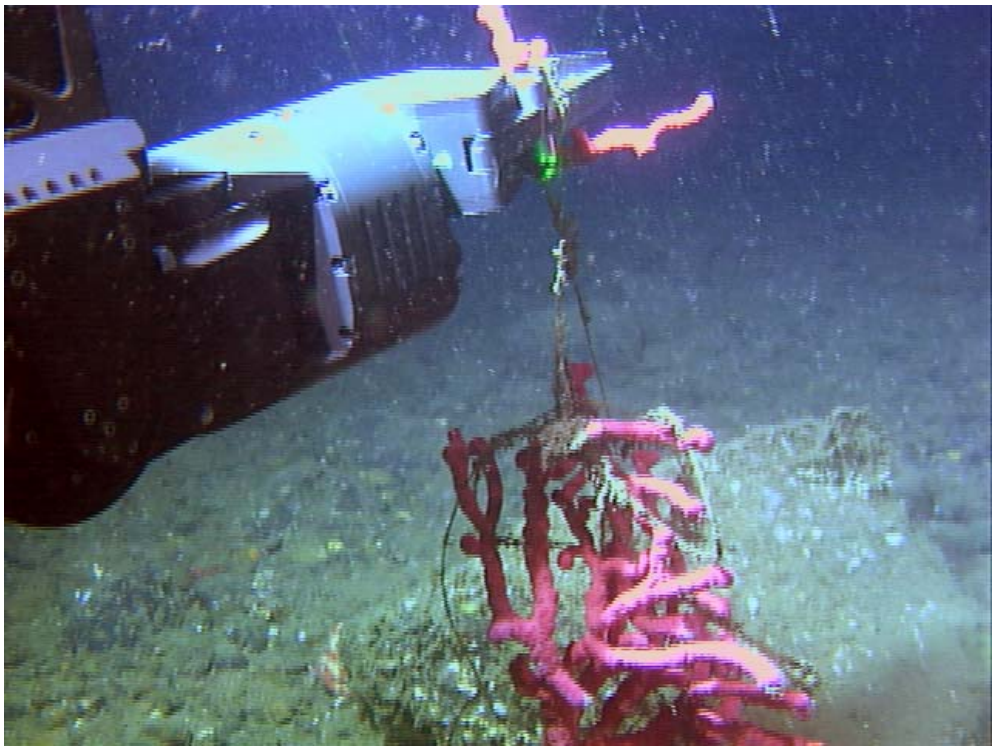

Figure 28. Fishing line entangled in a bubblegum coral colony *Paragorgia arborea pacifica* at survey site 31.

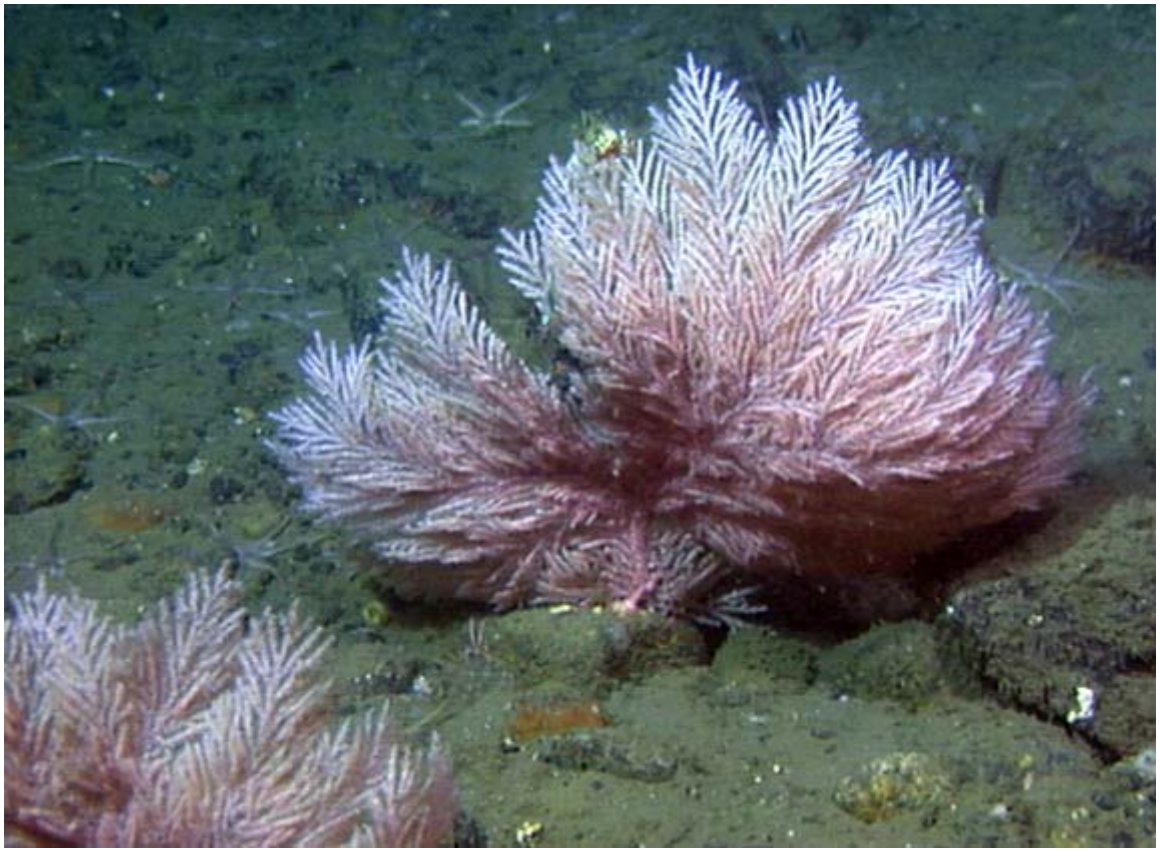
Figure 29. Gorgonian colonies *Plumarella longispina* at survey site 31.

Survey Site 40

Paragorgia arborea pacifica and various *Swiftia* species were documented at this muddy mixed substrate site of pebble and gravel with occasional boulders. Survey site 40 is inside Olympic 2 Conservation Area. This tiny site was surveyed for only about an hour in currents of only about 0.2 knots from the northeast. This site had the slightest change in depth over the survey area, ranging from 189 to 208 meters. Average salinity was low (26.7 psu) but this may be an artifact of the short dive time.

Figure 30. Gorgonian colony *Swiftia beringi* at survey site 40.

Survey Site 45

Approximately 9 hours were spent surveying this site in variable currents from 0.5 knots up to 3 knots, with current direction moving from the southwest, southeast, northeast, east, northwest and west over time. Depth ranged from 53 to 110 meters at this site. This site is at the entrance to the Strait of Juan de Fuca (Figure 4), explaining some of the high currents encountered and demonstrating their unpredictability in that surface tidal currents were dramatically different from conditions on the bottom. The substrate consisted of cobble with some boulders and rock outcrop. This site is inhabited by *Stylaster venustus*, the cup coral *Balanophyllia elegans*, and *Swiftia spauldingi*, among other species. Survey site 45 is outside Olympic 2 Conservation Area.

Figure 31. Gorgonian colony *Swiftia spauldingi* on a seafloor covered in hydroids and the bryozoan *Myriozoum* at survey site 45. This particular colony is only about 12 cm tall.

Other Attempted Sites

We attempted to survey five additional sites that we could not complete for a variety of reasons including prohibitive bottom currents, equipment problems, proximity to commercial fishing vessels, etc. However, such attempts were not totally unsuccessful. The largest *Primnoa pacifica* colonies recorded on this cruise were observed at one of these sites on the last day just before the dive was terminated to return to port. The branches of the colony shown in Figure 32 are adorned with rockfish.

Figure 32. Red tree coral *Primnoa pacifica* festooned with darkblotched rockfish at survey site 10.

DISCUSSION

New Records of Coral Species in OCNMS

OCNMS has unpublished data from its 2000-2004 surveys of benthic recovery along a fiber optic cable route (Brancato and Bowlby 2005), indicating the presence of the gorgonians *Paragorgia* sp., *Swiftia* spp., and an unidentified paramuriceid coral; the hydrocoral *Stylaster venustus;* plus numerous sponges. However, newly identified in the OCNMS, as a result of the 2004 pilot effort (Hyland et al. 2005; Bowlby et al. 2006), and documented again at three additional sites in our 2006 cruise is the lithoherm-forming scleractinian coral *Lophelia pertusa*. *Lophelia pertusa* is common in the North Atlantic Ocean, but rarely found in the Northeast Pacific off the coast of Washington state and British Columbia (Cairns 1994; Conway et al. 2005; Jamieson et al. 2005; Whitmire and Clarke *In Press).* Also newly identified in the OCNMS as a result of the 2006 survey are scleractinian cup corals, *Desmophyllum dianthus*, though these species have been documented in British Columbia waters to the north (Cairns 1994; Jamieson et al. 2005). A potentially undescribed species of the hydrocoral *Stylaster* (pers. comm.. S. Cairns 2007) was also documented at several sites in OCNMS. A variety of octocoral specimens were collected on the 2006 cruise as well, including nine families representing 12 species. In total, 18 species of coral recently have been identified thus far in OCNMS

to add to the one historic record. Because only a small area was surveyed and at a limited depth range, we expect we have just started developing the species list for OCNMS.

Observations of *Lophelia pertusa*

As mentioned above, *Lophelia pertusa* was located at four sites in 2006, but only two of these sites had what appeared to be live healthy colonies. The other two sites, including the one surveyed originally in 2004, consisted primarily of skeletal rubble. From our 2004 and 2006 surveys, we have noted *Lophelia* lithoherms (or bioherms) but nothing near as large as those documented in the North Atlantic. In OCNMS, the lithoherms observed thus far have been less than 1m in height, though fairly expansive (~7m) in width, and composed primarily of dead skeletal remains with a scattering of living polyps. The healthiest colonies appeared to be those living on verticals walls, underneath which were lithoherms of living and dead skeletal material. The 2004 survey site at which *Lophelia pertusa* was first documented in OCNMS (Hyland et al. 2005) was re-surveyed again in 2006 using an extensive search pattern. The lithoherm that was seen previously could not be relocated, though skeletal rubble of *Lophelia* was documented in the area.

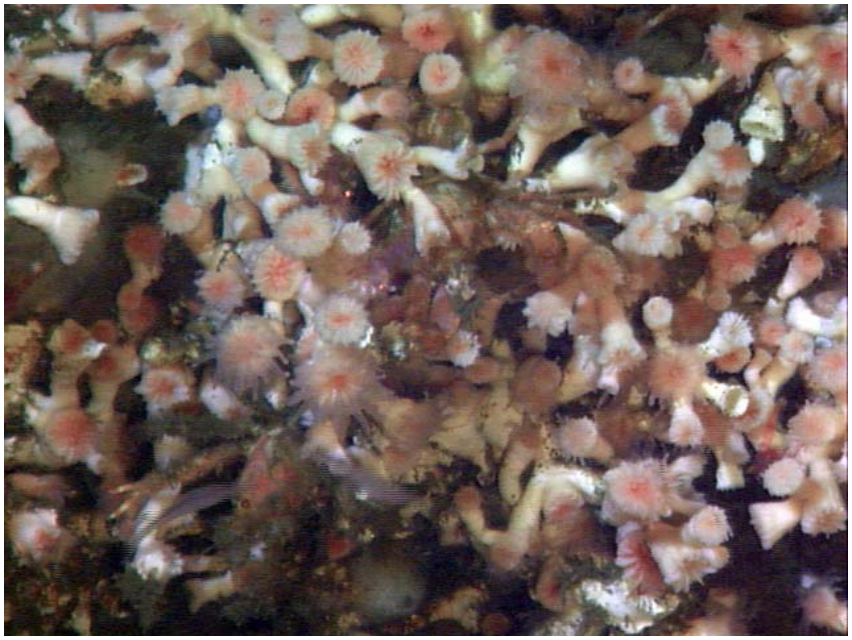

Figure 33. A colony of scleractinian *Lophelia pertusa* that appears healthy with polyps extended at survey site 6.

Corals Both Inside and Outside Conservation Area

Corals were documented at all but one of the sites surveyed in 2006, thus at five sites outside and nine sites inside the Olympic 2 Conservation Area (Figure 4) that went into effect just days after the 2006 cruise was completed. The two most diverse sites, Survey

Site 1 and Survey Site 6, are located inside and outside the Conservation Area, respectively. Survey Site 6 is one of the sites at which *Lophelia pertusa* was documented. The one site where we did not find corals, Survey Site 12, located outside the Conservation Area, was mistakenly interpreted as having hard substrate when reviewing the unprocessed side scan data. The use of hard substrate and depth as an indication of potential coral habitat worked well for this study and will be used again in the future. Classified polygon data are preferred to image mosaicks because the features can be finely delineated allowing for more focused use of ROV survey effort.

Evidence of Human Activity

Evidence of human activity was observed on the seafloor throughout the sanctuary, from occasional debris to cable trenching to rolled cobble and boulders (see Figure 25). Evidence of human disturbance was documented at sites both inside and outside the Conservation Area. Observations included trawl tracks, lost fishing gear (e.g., long-line), and other debris.

Lost long-line fishing gear, rolls of line, netting, and crab pots, were located at several sites, with line caught on bottom features at one site measuring more than 100m in length. Fishing line caught on corals was also documented, as shown above for Survey Site 31 and below at Survey Site 1 (Figures 28 and 34). Trawl tracks were also visible on the ROV's obstacle avoidance sonar and depending on the substrate, visible on the ROV's video monitors at several sites (see Figure 24). Other marine debris, usually cans and bottles, was evident as well. At one site there was a significant debris pile with partially incinerated waste, line, a plastic weave bag, and numerous cans still remaining. Discharges and waste dumping are not allowed in the sanctuary and such debris needless to say was disappointing to find. Surface laid cables, potentially no longer operational, were also seen, as was the cable trench for known buried cables. Due to their exposed structure and slow growth and recruitment rates, corals may be especially vulnerable to natural or human disturbance that result in physical disruption of the seafloor (Stone and Wing 2001; Andrews et al. 2002; Morgan et al. 2005; Morgan et al. 2006). Such disturbances could require very long periods for the coral communities to recover.

Figure 34. Long-line gear wrapped around the stalk of a dead gorgonian coral covered by an encrusting white sponge and brittle stars at survey site 1.

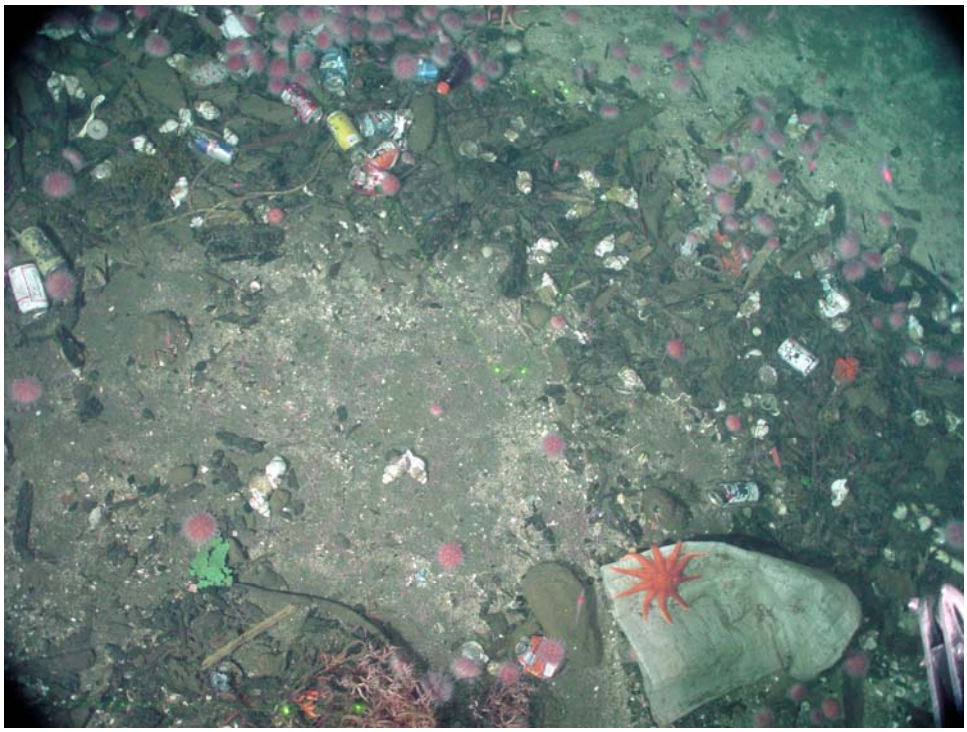

Figure 35. A partially incinerated waste dump with metal cans, line (bottom center) and a plastic weave bag still evident at survey site 12.

Fish and Invertebrate Associations with Corals and Sponges

The complex, three-dimensional structure of many corals and sponges makes them excellent habitat for other species, including commercially important fishes and invertebrates (Stein et al. 1992; Krieger and Wing 2002; Husebø et al. 2002; Auster 2005; Wang 2005). We observed corals and sponges associated with diverse assemblages of invertebrates and fish. Shark egg sacks were seen attached to both *Paragorgia arborea pacifica* and *Plumarella longispina* colonies and rockfish of various species were observed resting on branches of *Primnoa pacifica* and at the bases of several species. Crab, shrimp, and a diverse array of echinoderms were observed associated with the corals and sponges, and nudibranchs were observed foraging on them. The biogenic structure serves a variety of functions — a foraging platform for some organisms, allowing them access to currents higher in the water column; a safe refugium for escape from predators; a source of food; an anchor for egg attachment; and perhaps a nursery area for some species.

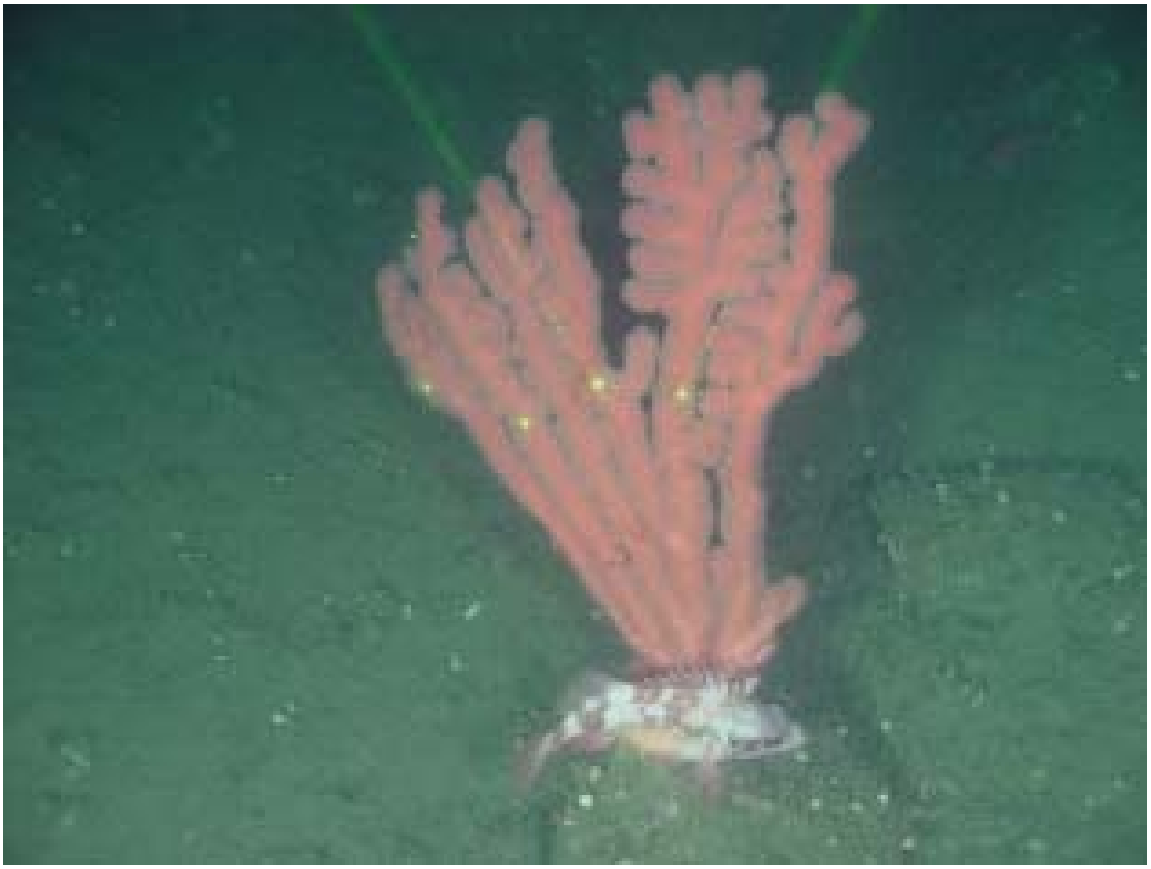

Figure 36. Bubble gum coral colony *Paragorgia arborea pacifica* with what appears to be a gravid sharpchin rockfish beneath it at survey site 2. The central lasers are 10cm apart.

Figure 37. Bubble gum coral colony *Paragorgia arborea pacifica* with 18 shark eggs cases, crinoids and a basket star attached at survey site 1.

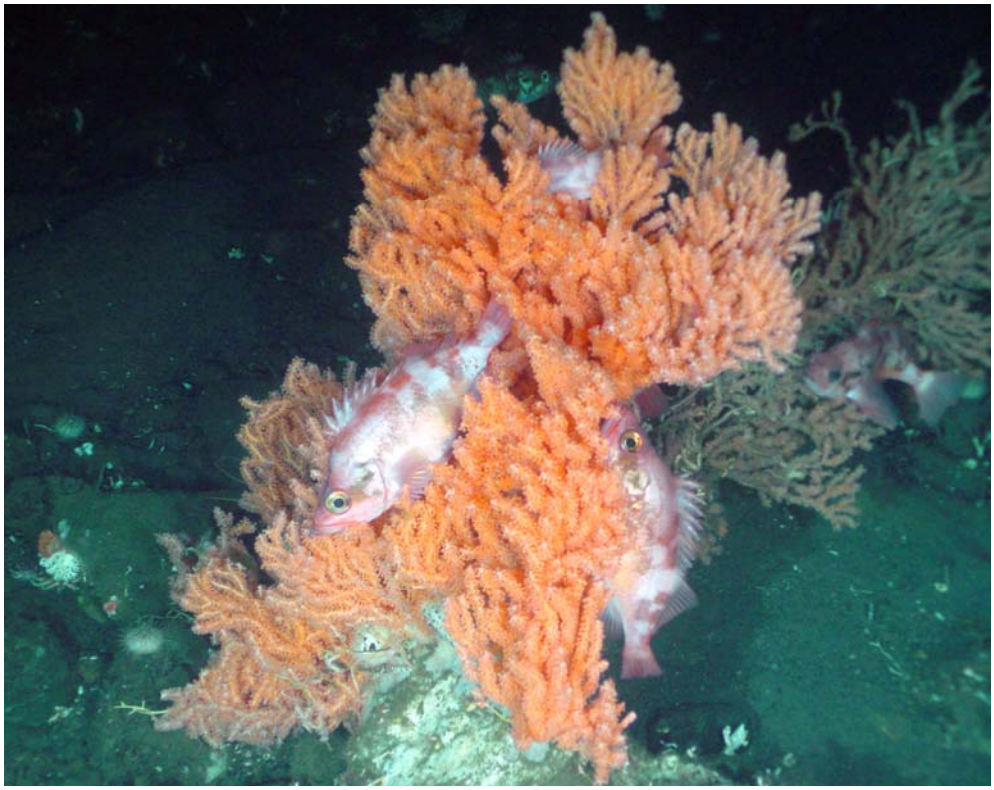

Figure 38. Red tree coral *Primnoa pacifica* with darkblotched and sharpchin rockfish resting in the branches at survey site 10.

Figure 39. An assemblage of cloud sponges with *Swiftia pacifica*, squat lobsters, bryozoans, brittlestars and other sponge species (photo taken by OCNMS in 2004).

Figure 40. An assemblage of cloud and boot sponges with a seastar, fish and several species of crustaceans in association (photo taken by OCNMS in 2004).

This research effort has done much to improve our knowledge of deep coral and sponge habitat, and of species composition and associations, in the Olympic Coast National Marine Sanctuary. These preliminary results will be supplemented with results from follow-up analyses of the video footage and digital-still photography obtained during the 2006 survey and by future efforts to survey the remaining sites in our sample population. As habitat mapping continues, we expect an increase of potential coral habitat and the species list to expand, particularly as we are able to move into deeper waters. Additional studies are required to further document the spatial extent of these habitats and changes to the existing study sites over time.

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