Coastal Zone Management Section 309 Grant:

2001 Nearshore Rocky Reef Assessment
ROV Survey

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Prepared by

Mark Amend
David Fox
Chris Romsos

Oregon Department of Fish and Wildlife
Marine Habitat Project
Marine Program

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1. Introduction

Oregon continues to face increased pressure to utilize living marine resources of nearshore subtidal rocky reef areas. Much of the increase has resulted from a shift toward nearshore reef fisheries due, initially, to the dramatic decrease in traditional salmon harvest, and now to a reduction of traditional groundfish fishing opportunities. The live-fish fishery and the sport bottomfish fishery focus effort in this rocky reef habitat, and the effect these fisheries have on fish populations within this limited space has not been fully assessed.

Nearshore rocky reef environments comprise an area where fishing pressure continues to increase, stocks appear to be declining, and we have little information upon which to base management decisions. Resource managers and scientists need to develop this information for making sound resource management decisions. The Oregon Department of Fish and Wildlife (ODFW) Marine Habitat Project initiated a nearshore rocky reef research project in 1995 to begin gathering information necessary for managing nearshore reefs. This report represents work completed during 2001, continuing this effort.

The use of rocky reefs as habitat by nearshore finfish is generally well accepted. How size and shape of habitat, time of year, month, or day, factor into our understanding of fish distribution on a species-by-species basis is poorly understood. Previous work examining rocky reef patch size and fish species abundance indicated species-specific relationships with available habitat exist (Fox, et al. 2000). Kelp greenling (*Hexagrammos decagrammus*), for example, occupied all ranges of rocky patch size, and increased their relative abundance with decreasing patch size. Many of the benthic rockfish species did not appear on the smallest rock patches.

Our first year (2000) using a remotely-operated vehicle (ROV) for nearshore sampling was primarily for the purpose of developing our capabilities and to address the hypothesis that available fish habitat is a limiting factor in both abundance and species composition (Fox, et al. 2000). Section 2 of this report describes the ROV operations and data collection techniques that have evolved from that initial work. Section 3 covers a comparison of fish utilization of the same small rocky reef patches sampled in 2000 (Figure 1.1.1)

Most of Oregon's nearshore remains unexplored by underwater observational means. One key role of the ROV is in obtaining reconnaissance information about a region for gross-scale descriptions and for planning future research. Section 4 of this report describes one of these exploratory ROV surveys of an unmapped reef near the mouth of the Siletz River in August 2001 (Figure 1.1.1). The ability of the ROV to sample unknown reef areas was tested and the methodological aspects of this are presented.

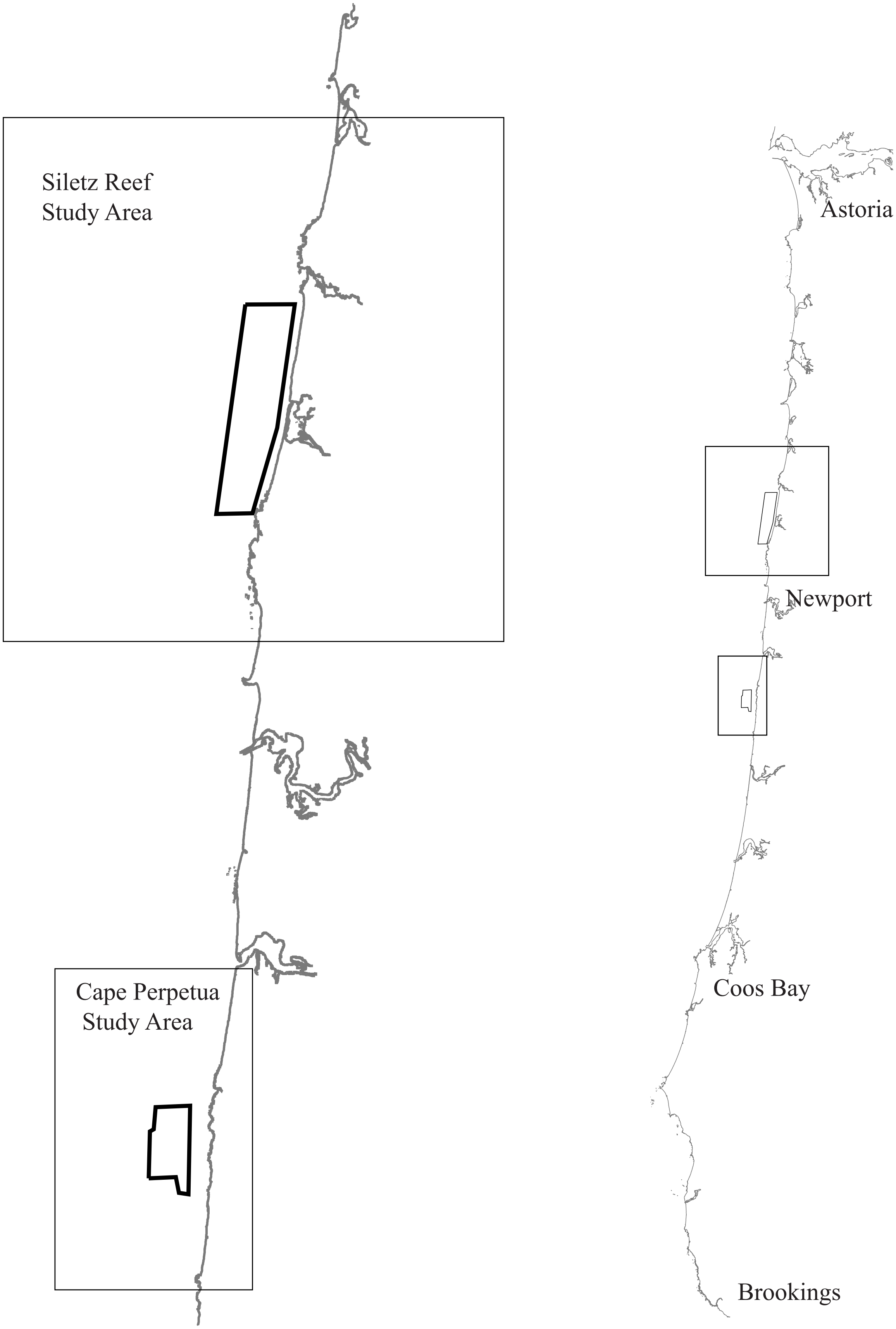

Figure 1.1.1 2001 ROV survey sites. Section 3 of the report covers a year-to-year comparison of finfish habitat preferences on small rock patches near Cape Perpetua while Section 4 covers an exploratory survey of Siletz Reef.

2. Remotely Operated Vehicle Procedures

2.1 Background

The Oregon Department of Fish and Wildlife's Marine Resources Program purchased a small remotely operated vehicle (ROV) in 1999. Our previous work in nearshore *in-situ* sampling was built upon SCUBA, restricted to safe diving depths (less than 30m). The nearshore is defined here as the area along the coastline out to about 50m depth. The ROV enables us to go deeper that we would have been able to dive, more safely enables us to sample remote areas, and gives us the luxury of spending more time underwater.

A ROV provides new opportunities and challenges to our work. Ground truthing sonar maps, collecting finfish abundance information, and investigating community diversity along the coast are some of the uses of this equipment. The basic design of a camera, lights, and propulsion, gives us the chance to ask questions we would have not had the resources to address before.

The challenges we have faced over the last two years in accepting this technology as a research tool have mostly been overcome. While operations are by no means a simple process, they have become facilitated by experience. We are currently working with the California Department of Fish and Game to develop standardized sampling techniques for small ROVs. The variables that affect the usefulness of an ROV as an ecological sampling tool are being discussed through this process. We feel a detailed description of our operations at this point is timely. The equipment, deployment, navigation, and retrieval of information, are presented in the following subsections.

2.2 Equipment Configuration

The Phantom HD2 ROV (Deep Ocean Engineering) is equipped with minimum propulsion for the currents and conditions of the Oregon coast (Photo 2.2.1). Two horizontal thrusters, two lateral thrusters, and one vertical thruster are controlled by the operator via a remote control unit. Also controlled on this remote unit are the lights, camera focus and angle, and auxillary components if present.

The minimal components of our ROV are: a Sony EVI-330 video camera, two Deep Sea Power and Light 250-watt halogen lights, two Deep Ocean Engineering 15mW lasers, a depth pressure sensor, a fluxgate compass, an On-Screen Display video overlay (OSD-379, Deep Ocean Eng.), and an Offshore Research Equipment 4330B Multibeacon. For optimal quantification of benthic attributes (organism counts, area of coverage), the forward-looking video camera is set at a fixed downward angle of 30° below horizontal. A video monitor on the survey vessel provides a live feed from the video camera, useful for ROV piloting and interpretation. Time, ROV depth, and ROV heading, are overlaid on the video and are used in pilot navigation and post-processing. A Panasonic DV-2000 MiniDV VCR records the video image onto MiniDV cassettes (up to 60 minutes of footage at a time). Tape changes mid-dive are made while keeping the ROV stationary on the bottom. The laser pair is mounted on top of the camera housing and are aligned parallel at approximately 10 cm apart to provide a 10 cm scale of reference in the video images. The ORE 4330B acts as a responder for acoustic navigation (Section 2.4).

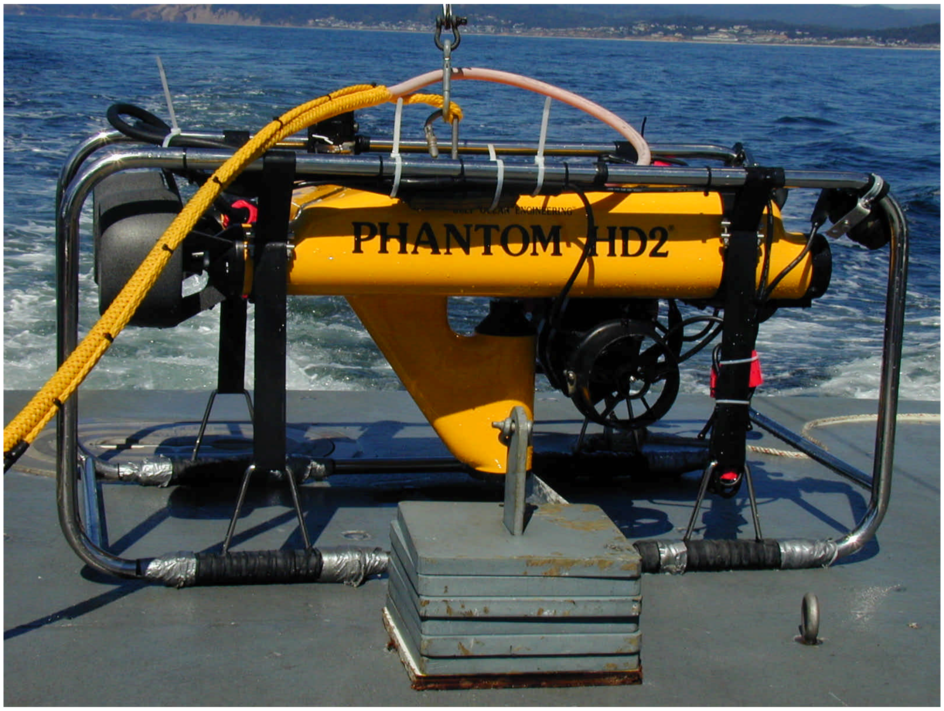

Photo 2.2.1 *Phantom ROV aboard the R/V Elakha, shown with clump weight.*

2.3 Deployment / Retrieval

We typically charter a support vessel that allows for the safe deployment, operation, and retrieval of the ROV. Vessel qualifications are generally related to electrical requirements, deck space, and cabin space. At a minimum, the basic requirements enable us to deploy and retrieve the ROV. Deployment follows the same protocol developed in our 2000 field season:

1) The support vessel is positioned upwind of the desired transect start location.
2) The ROV is attached to the winch cable and lowered into the water.
3) The ROV is run out astern of the vessel until about 50 m of umbilical is paid out (the umbilical has gangion clips at 50 m and every 4 m thereafter to secure the umbilical to the vessel’s winch cable). During this procedure, a small subsurface float is attached to the umbilical at the 25 m mark.

4) A 280 lb. “clump weight” is attached to the winch cable and lowered off the A-frame or davit to about 2 m under the water surface.
5) A survey crew member clips the first umbilical gangion clip to the winch cable.
6) The clump weight is lowered about 4 m and the second umbilical gangion clip is clipped to the winch cable. The lowering and clipping process is repeated until the clump weight is approximately 6 m above the seafloor.

Retrieval follows these steps in reverse order.

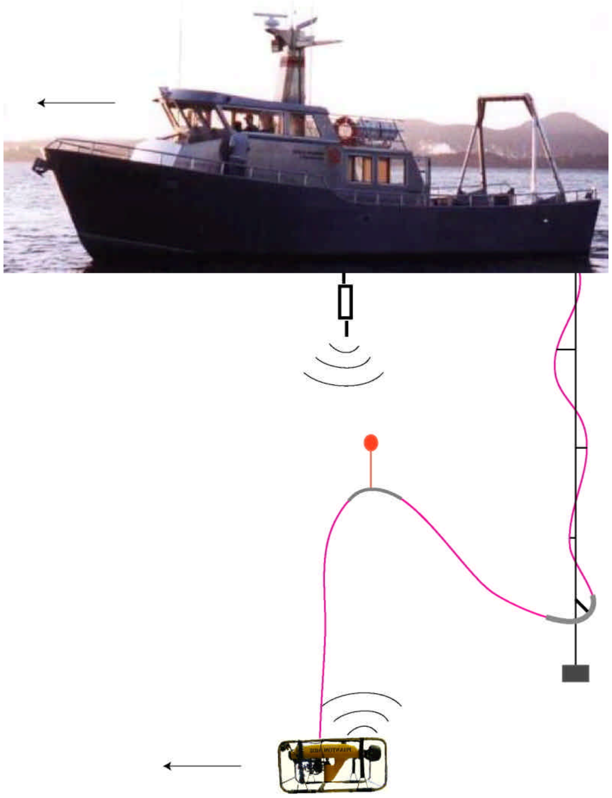

Figure 2.3.1 *A simplified illustration of our ROV live-boat configuration.*

This deployment method, modified from methods used by Norcross and Mueter (1999) and Stewart and Auster (1989), allows the ROV to maneuver along the bottom within a 50 m radius of the vessel while eliminating most of the drag on the umbilical due to water currents and vessel drift (Figure 2.3.1). The float at the umbilical’s 25 m mark is intended to keep the umbilical from snagging on the seafloor.

2.4 Navigation

Navigation of the ROV is achieved through a combinaton of acoustic and GPS data acquisition. The Trackpoint II (ORE) acoustic positioning system consists of a pole-mounted hydrophone, a beacon, a processing unit, and an external compass. The hydrophone pole is bracketed to the vessel via a custom-built swivel joint. The hydrophone, mounted on the end of this pole, extends vertically below the keel of the vessel. The beacon is attached to the ROV, mounted upright. The processing unit is located in the vessel cabin and controls and filters the transmitted and received acoustic signals (2 seconds/pulse). The slant range, bearing, and depth (input from the ROV's depth sensor data) signals are used to calculate the ROV's position relative to the hydrophone. Smoothing, ROV velocity threshold, and time gating filters are applied to the signals to remove errant echo returns. For nearshore work, we have been using the following filter settings with a high degree of success: Filter Level: LOW, Smoothing: ON, Threshold: MED-LO. The calculated relative ROV position and the magnetic heading (supplied by an external fluxgate compass) are finally sent as serial data to the navigation computer.

Hypack MAX Survey (©Coastal Oceanographics, Inc.) software is used for navigation, data acquisition, and processing of ROV position data. A Garmin GPS76/GBR21 Differential GPS is mounted on the support vessel, providing 1-2m accuracy of the vessel's position. The data string is sent to the navigation computer (Dell Inspiron laptop, 800MHz Pentium III, 256MB RAM, Quatech multi-port serial PCMCIA card), where it is displayed and logged. The vessel position data are then used by Hypack to interpret the ROV data sent by Trackpoint. A calculated geographic position of the ROV is then displayed and logged simultaneously.

The ROV pilot uses both the live video feed and the laptop's navigation screen to complete a dive. Attention is paid to ROV heading to keep consistent with the planned transect line. A second computer monitor displaying Hypack is situated in the vessel wheelhouse for use by the captain. Instructions on live-boat vessel navigation are given to keep the vessel and the ROV within the tether radius of the umbilical cable running out from the clump weight. Communication with the captain is essential to completing a safe and effective dive.

2.5 ROV Navigation Data Processing

The acoustic navigation data collected by Hypack MAX Survey needs to be "cleaned up" before it is used for any kind of spatial analyses. This step is standard for acoustic data from Trackpoint II (Susan Merle, pers. comm.). Positional errors beyond a reasonable amount, not captured by the Trackpoint unit's filtering, need to be removed from the dataset.

Hypack includes a Single Beam Editor program that, while primarily designed for bathymetric surveys, applies well to our ROV data. Criteria for position (x,y) and depth (z) outliers can be selected to pick out errant points. At this time, we are using a 2m radius for x,y, and +/-1m for depth. The editing program uses these criteria as it scans each raw navigation file (transect). The scan stops when one location differs from the previously scanned location by one of the criteria (either location, depth, or both). The user can then (1) average the outlier using the adjacent points (good for isolated outliers), or (2) remove the outlier (typical if outliers are persistent for several seconds).

For geographic position to be “tied in” to video review observations (i.e. where and when was this organism seen), we use a relational database to match ROV navigation data to video interpretation data. Trackpoint navigation data are typically one position every two seconds. However, video data are recorded with accuracy to one second. The navigation data, after removing outliers, is run through Generic Mapping Tools sample1d program (GMT©, Paul Wessel and Walter H. F. Smith) which interpolates the points using an akima spline, generating a 1-second interval output navigation file. The two final 1-second files can then be related by time and joined in a database for data query and analysis.

2.6 Video Review

Video footage recorded during surveys is the most important unit of ROV data. We use MiniDV format to record the video. This format captures the resolution of the Sony camera mounted on the ROV, 460(H) x 350(V) lines. Review of the video is performed in our Newport office using the recording deck, a Panasonic DV2000P DV/MiniDV VCR. Frame-by-frame advance with an editing wheel allows for detailed identification of organisms, measurements, and habitat interpretation. We use a Panasonic 14” CT-1383Y video monitor as the primary display for video review. The On-Screen Display unit overlays time, depth, and heading on the recorded video. The time record obtained during review of the video (the OSD’s internal clock) is later matched to GPS time by applying a correction factor obtained from the OSD’s measured linear time drift of -0.365 seconds per day.

Initial Video Assessment

Typically, post-processing of ROV navigation data and video data begin at the same time. Thus, a video quality check is made while navigation data are also being checked. An initial run-through of ROV dive video seeks to identify sections that contain footage not considered usable for quantitative counts of organisms, laser spread measurement, and habitat identification . This assessment also identifies “Start” and “Stop” times of the sampling unit (in our case, a transect).

The judgment of footage usability is framed by the study design. For example, our transect-based study design requires “distance traveled” to be calculated from ROV navigation data. If the ROV is pulled by the support vessel during live-boat operations, the distance traveled during the pull may be significant enough to distort the cumulative distance covered. This length of time is then removed from the ROV navigation data prior to smoothing and interpolation described in Section 2.5.

Another important data component is bottom coverage. If the need arises to rest the ROV on the bottom for a cassette change or a close-up, consideration must be given to the duration of this footage. Our post-processing involves sampling the video at periodic intervals and one to several of these sampling intervals may fall within this stationary footage time frame. During a close-up, an organism or bottom type may dominate the video, disproportionately representing itself in relative time. The “removal” of this footage consists of noting start and stop times, and then later *not collecting* visually interpreted review data during these times. Distance traveled is not significant during these sections, so the removal of unusable data from the cleaned ROV navigation data is not necessary.

The beginning and end of the video sampling unit also need to be identified prior to quantitative video review. Similar to usable video, these endpoints are also dependent upon study design. For our work at Cape Perpetua (Fox, et al. 2000), we sampled rock patches with cross-patch transects. The “start” of a transect was at the first indications of the rock patch, and the “end” was after we had clearly come to the end of the patch. For exploratory work, a predetermined length (e.g. 1 km transects) might be more appropriate for endpoints. In this case, once the ROV is at the “beginning” of a planned line (Section 2.4) the transect starts and then ends once the ROV reaches the “end” of the line.

Finfish Enumeration

The digital video record of each transect is reviewed to record time, fish taxa, fish count, schooling behavior, bottom habitat characteristics, and general notes (Fox, et al. 2000). Only fish that can be identified as present in the lower 80% of the video screen are counted. This accounts for an unrealistic extension of the top of the camera’s field of view beyond the practical limits of visibility.

All fish are counted and identified to species when possible. Unidentifiable species of rockfish (due to poor image quality) are counted and recorded as unknown. Juvenile rockfish are counted as accurately as possible, often by averaging two to three consecutive counts, and recorded without a reference to their species. Rockfish that appear to be larger than young-of–the-year, but identifiable to species, are noted as midsize fish in the database. Flatfish are also counted, though not identified to genus or species. It is probable that some very small fishes, smaller than juvenile rockfish, go unrecorded and unidentified.

Each fish or group of fish has a time record attributed to it in the database. Time is obtained from the OSD overlay when each fish is encountered. Fish count / time data also contain an "instantaneous" interpretation of benthic habitat type that describes the habitat in the immediate vicinity of the fish.

Transect Area Estimation

An important piece of information needed to quantify benthic attributes is the area of a transect. For example, fish count data are standardized by converting counts to densities. This step requires estimating seafloor surface area sampled in the video. We estimate dimensions of the video images following the perspective grid method described in Wakefield and Genin (1987), and elaborated below.

As the ROV moves closer to the seafloor, the spread of the terminal laser points on the video appears to widen. The width of the transect viewable on the video can be calculated using the measure of laser spread. We measure this variable once every thirty seconds on a transect. Occasionally the lasers cannot be detected when the ROV is too far off the bottom or the ROV is oriented at some oblique angle. In this situation, we measure and report the next available laser separation distance. Linear interpolation methods are used to construct a database with laser measurements at every second between the start and end of a transect, similar to those mentioned in Section 2.5.

Using camera declination angle, horizontal and vertical view angles, and laser separation distance in the image, the perspective grid method allows computation of depth and width of the video image, surface area of the seafloor in the image, and height of the camera above the bottom. Camera declination angle is fixed during our surveys. Camera horizontal and vertical view angles are computed by correcting the factory view angle specifications by the air to seawater diffraction index of 1.34 (Newmann and Pierson 1966; Jerlow 1976). Laser separation distance measurements are corrected for the horizontal laser offset from the camera’s center of view because the lasers are mounted 6.8 cm above the camera. A vertical offset correction is made to adjust for the lasers slight lift of 1.7° above the camera axis angle. All computations assume a flat seafloor and a stable camera platform (i.e., no ROV pitch or roll), and do not consider distortion effects of the camera and lenses (Li, et al. 1997), thus we consider our computations to be estimates. We use the transect width calculated for the top of our view area (upper 80% mark, Figure 2.6.1) and transect length estimated from the habitat segment data to determine the total area sampled on each transect.

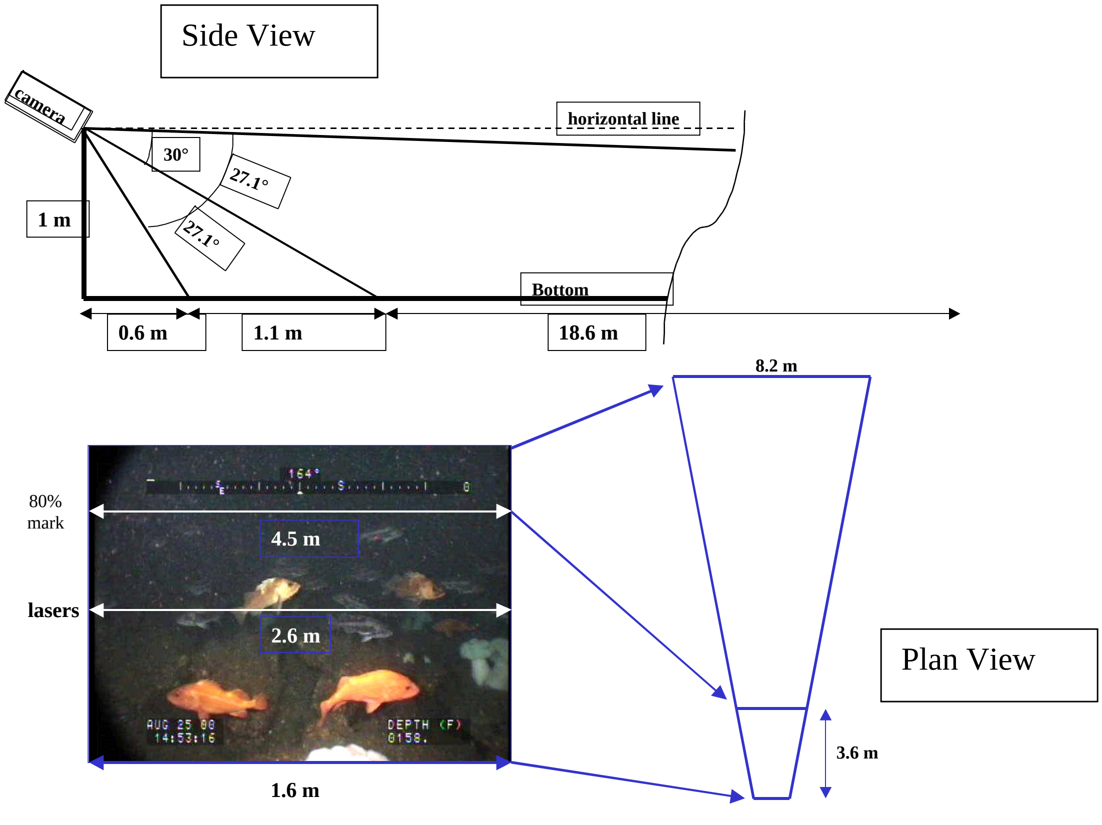

Figure 2.6.1. Schematic representations of the ROV camera's field of view. The Side View shows the vertical view angles (for the Sony EVI-330 in an underwater housing) and the distances extending along the bottom in the field of view, based on a camera height of 1 m above the bottom. Note that the top of the view extends out 18.6 m from the camera, explaining why we chose to disregard the top 20% of the video's view. The Plan View shows the area encompassed by the field of view and the calculated widths of the video image at the bottom of the view, at the point where the lasers appear in the view, and at the top of 80% of the view area. The view area is a trapezoid with a lower base of 1.6 m, and upper base of 4.5 m, a height of 3.6 m, and a surface area of 11 m^2. In this example, we use 4.5 m as the transect width.

Although it may seem obvious that there is a start and end to each transect and that each transect is geographically described, the estimated length of a transect using ROV position data alone is an overestimate due to the subtle variability of acoustic positioning. Currently, we account for this using only geographic position data from the endpoints of habitat segments. This simplifies both the substrate representation and the path of the ROV in a GIS. The end result is a polyline that is less jointed than a polyline constructed of 1-second interval data. The length of this polyline is then the estimated transect length used with calculated transect width to estimate area swept on the transect. This length works well for heterogeneous habitats and short overall transect lengths. Smoothing algorithms or habitat segment length criteria would be more appropriate for longer (e.g. 1 km) transects or homogeneous habitats.

Habitat Classification and Segmentation

We use a substrate classification system described in Fox, et al. (1998), with the addition of a relief code modifier described by Karpov, et al. (2001)(Table 2.6.1). While both systems parallel each other, there are a few subtle differences. At this time, we are using *both* schemes during video review for later comparison and analysis.

Habitats are segmented along a transect in a method adapted from Hixon, et. al (1991), Stein, et. al (1992), Yoklavich, et. al (1999), and Karpov, et. al (2001), by which a continuous habitat described by a primary and secondary component defines the beginning and end of a segment. This substrate must be continuous for a period of at least ten seconds. We define primary habitat to be the habitat in greatest abundance (> 50%) during the length of the segment (continuous or scattered). The relief code modifier applies to the primary habitat. Secondary habitat is defined as the component of the substrate that covers between 20 to 50% of the segment area.

Table 2.6.1. Description of primary substrate categories and corresponding relief qualifiers applied to substrate classification.

Fox et al. (1998)				Karpov et al. (2001)		
Substrate	Code	Interpretation	Microrelief Modifiers	Substrate	Relief Code	Interpretation
"Level" rock	F	0-45°	L (low), H (high)	Bedrock	1	low relief (<1m)
					2	medium relief (1-3m)
"Sloping" rock	R	>45°	L (low), H (high)		3	high relief (>3m)
Sm. Boulder	B	0.25-1m		Boulder	1	diameter 0.25-1m
Lg. Boulder	L	1m- 3m			2	diameter 1-3m
					3	diameter >3m
Cobble	C	64-250 mm		Cobble		64-250 mm
*				Pebble*		4-64 mm
Gravel	G	2-64 mm		Gravel		2-4mm
Sand	S	0.06-2mm		Sand	1	wave height < 10cm
					2	wave height 10 - 100cm
					3	wave height >100cm

**Pebble is not used as a individual substrate type and is considered "Gravel".*

3. Cape Perpetua Rock Patch Survey

3.1 Methods

Following methods outlined in Section 2, we attempted to duplicate sampling completed in 2000. Twelve rock patches previously mapped with side scan sonar and sampled for fish abundance were again sampled at a similar time of year. Sampling operations occurred on June 6 and 8, 2001. Planned line transects across the long axis of the rock patches were created in Hypack and used for vessel and ROV navigation.

GIS data layers of side scan mosaics were available in Hypack as GeoTIFF formatted files, while rocky patches digitized from the mosaics were displayed as DXF polygons. Polygons were found to be the most effective for ROV navigation, providing the ROV pilot with clear and effective outlines of the generalized rock structure. Patches previously defined as “tiny” were excluded from this survey (Fox et al, 2000).

ROV operations and video analysis followed procedures detailed in Section 2 of this report. The support vessel was the R/V Elakha (Oregon State University), based out of Yaquina Bay.

Cape Perpetua fish and habitat data were analyzed to compare fish species abundance between summer of 2000 and 2001, and to examine fish-habitat associations. Interannual comparison included a graphical examination of species composition and a comparison of species densities using paired t-tests. Transects sampled in both 2000 and 2001 surveys formed the pairs in the t-tests. Species densities were log-normally distributed and were log-transformed ($\ln(x+1)$) to meet normality assumptions of the t-tests.

Patterns of association among species and habitat classes were examined using hierarchical cluster analysis. Six habitat classes used in the cluster analysis (Table 3.1.1) were developed by recombining the seafloor habitat descriptions recorded from the video review (Table 2.6.1), including the creation of a transitional or edge habitat category between sand and rock. The habitat class constituted the basic sampling unit. Within the sampling units, species-specific densities were standardized to represent the proportional contribution of that species to each habitat class. Only species contributing more than 1% of the total species composition were used in the analysis. The clustering technique used the unweighted pair-group average linkage and Euclidean distance as the measure of distance between clusters (Statsoft 2001). A dissimilarity of 50% or more was considered a major division among clusters. After the clustering was completed, differences in mean log-transformed species densities among the clusters were examined using analysis of variance.

Table 3.1.1. Relationship between video review seafloor habitat descriptions and habitat classes used in the cluster analysis.

		Video review habitat codes (see Table 2.6.3.1)		
Habitat type used in the cluster analysis	Code for cluster analysis habitat	Primary habitat	Secondary habitat	Relief
low relief rock	RL	FL,FH,B,L,RL,RH	any	1
high relief rock	RH	FL,FH,B,L,RL,RH	any	2 or 3
sediment	S	S,G,C	any	any
sediment edge	ES	First 5 m of S, G, or C after the rock sediment interface	any	any
rock edge	ER	First 5 m of rock after the rock sediment interface	any	any
other edge types	EO	S,G,C	FL,FH,B,L,RL,RH	any

3.2 Results

Fish densities by transect, sampled area, and rock patch area are listed in Table 3.2.1. Figure 3.2.1 compares species composition between 2000 and 2001, with the exclusion of the juvenile rockfish category for clarity. Of the schooling rockfish species, black and canary rockfish occurred in higher proportions in 2000 compared to 2001, and yellowtail and blue rockfish occurred in higher proportions in 2001 compared to 2000. Quillback, copper, and yelloweye rockfish occurred in approximately the same proportions between the two years. Kelp greenling also occurred in approximately the same proportions between the two years. Lingcod showed a higher proportion in 2001 (Figure 3.2.1).

Table 3.2.2 summarizes the results of the paired t-tests comparing species densities from 2000 and 2001. Only canary rockfish exhibited significantly different density values at the 95% significance level (p=0.002), displaying approximately a two-fold difference in density between the two years. Power analysis applied to other species observed on the transects indicated that sample means would need to differ by 50% to 150% in order to detect statistically significant differences at the 95% level (based on a sample size of 12).

Table 3.2.1 Fish densities (# / 100 sq. m.) from 2001 and (2000) surveys. Fish categories are those used during video review. Rock patch size increases to the right.

RockPatch_ID	**1.4g**	**3b**	**1.4t**	**1.4v**	**1.1d**	**1.3a**	**1.1c**	**1.1k**	**3a**	**1.4a**	**2a**	**1.3b**
Patch Area (m^2)	**164.1**	**178.1**	**243.3**	**296.2**	**695.0**	**769.4**	**843.1**	**1102.9**	**2392.4**	**4798.3**	**4911.3**	**16106.8**
Transec t Area (m2)	66.4	93.5	119.8	170.6	225.4	351.1	246.0	468.6	311.0	548.8	1014.9	1026.9
	(109.0)	(59.9)	(84.0)	(151.2)	(176.0)	(325.4)	(244.7)	(376.9)	(685.4)	(961.8)	(841.3)	(1260.8)
BLACK	1.5			12.3	0.4	0.9		0.4	1.6	2.2	2.2	7.3
Sebastes melanops		(70.3)	(1.4)					(0.3)	(7.8)	(5.2)	(8.1)	(0.6)
BLUE							2.8			2.0		0.9
S. mystinus										(0.1)		
BROWN							1.2					0.1
S. auriculatus		(2.0)			(0.7)			(0.6)	(0.2)		(0.1)	
CABEZON												
Scorpaenichthys marmoratus												
CANARY			8.3	11.1	9.8	1.1	7.3	2.8	0.3	1.5	0.7	0.9
S. pinniger	(1.1)	(2.0)	(34.1)	(16.4)	(8.4)	(6.5)	(7.5)	(9.5)	(0.3)	(4.9)	(3.5)	(0.8)
CHINA												
S. nebulosus	(1.1)				(1.3)						(0.1)	
COPPER			2.5	2.3		0.3	1.6			0.4	0.1	0.5
S. caurinus			(10.9)	(1.6)	(0.7)	(0.4)	(0.5)	(0.6)	(0.7)	(0.8)	(0.3)	(0.2)
EELPOUT												
Zoarcidae												
UNK_FISH	1.5	3.2	1.7	1.8		0.3	0.8	0.4	2.3	1.1	0.7	0.5
UNK_FLATFSH				0.6							0.3	
HALIBUT												
Hippoglossus stenolepis												
JUV_ROCK					10.2	0.9	23.2	1.5		12.2	4.4	14.7
Sebastes spp.		(36.2)			(6.4)	(0.4)		(5.4)	(3.5)	(26.0)	(1.5)	(0.1)
K_GREEN	3.0		4.2	2.9	4.0	0.3	0.8	0.4	3.5	1.3	1.7	1.1
Hexagrammos decagrammus	(6.3)	(1.0)	(2.7)	(9.4)	(4.5)	(1.1)	(0.9)	(0.9)	(1.8)	(1.9)	(1.9)	(0.6)
LING	10.5		1.7	5.3	2.2	0.9	2.0	0.4	1.6	1.6	0.4	1.2
Ophiodon elongatus		(2.0)	(1.4)		(0.7)	(1.4)	(0.5)	(1.8)	(0.5)	(0.5)	(0.8)	(0.4)
P_GREEN										0.2		
Oxylebius pictus												
QUILLBACK	4.5				1.3	0.6	5.3	1.1	0.6	1.1	0.9	1.9
S. maliger			(4.1)	(1.6)	(5.2)	(0.4)	(0.9)	(3.0)	(0.7)	(2.5)	(1.5)	(1.4)
RATFISH										1.1		0.8
Hydrolagus colliei									(0.3)		(0.1)	(0.5)
UNK_ROCKFSH											0.2	
Sebastes spp.												
SCULPIN												
Cottidae												
SF_PERCH					0.4						1.1	0.1
Embiotocidae												
SKATE												
Rajidae												
TIGER												0.3
S.nigrocinctus												
VERMILLION												
S. miniatus												
WOLF_EEL							0.4					
Anarrhichthys ocellatus									(0.3)		(0.3)	(0.1)
YELLOWEYE							0.8		0.3			0.7
S. ruberrimus				(1.6)	(1.9)					(0.4)	(0.3)	(0.2)
YELLOWTAIL			19.2	1.2	0.4	0.3	4.9		4.5	1.3		1.8
S. flavidus	(1.1)	(8.0)			(14.8)	(0.4)		(1.5)		(0.4)	(0.1)	(0.4)

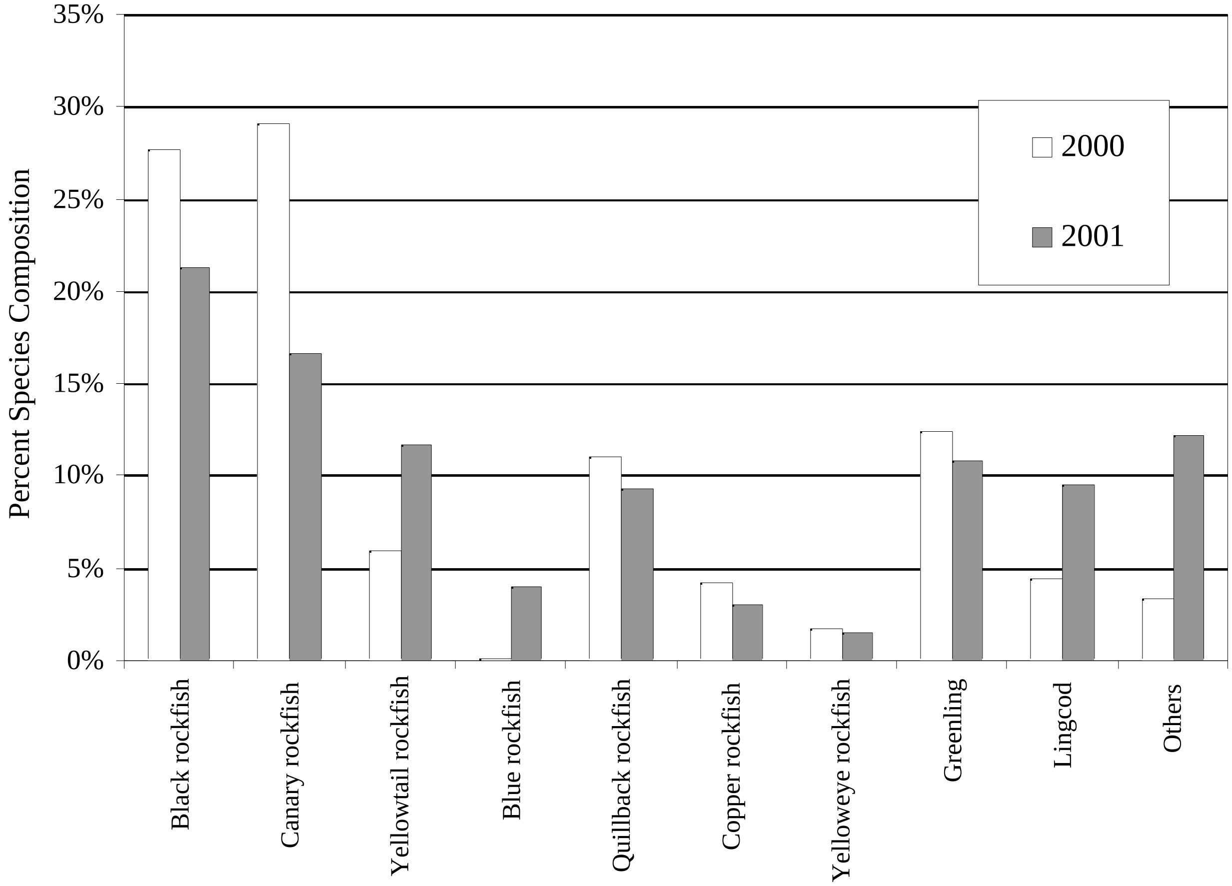

Figure 3.2.1. Percent species composition comparing 2000 with 2001 surveys.

Table 3.2.2. Mean densities (back transformed from log-transformed data) and p values for paired t-tests comparing 2000 and 2001 data by species or groups.

Species or Groups	2000 back-transformed mean density (#/100m^2)	2001 back-transformed mean density (#/100m^2)	p
Total Fish	22.72	17.95	0.569
Total Adult Fish	19.11	13.85	0.373
Total Adult Rockfish	14.59	7.94	0.209
Black Rockfish	1.74	1.35	0.761
Canary Rockfish	4.82	2.12	0.002*
Copper Rockfish	0.73	0.45	0.218
Kelp Greenling	2.62	1.56	0.142
Juvenile Rockfish	2.10	2.25	0.926
Lingcod	0.71	1.62	0.134
Quillback Rockfish	1.36	1.03	0.581
Yelloweye Rockfish	0.25	0.12	0.447
Yellowtail Rockfish	0.89	1.25	0.715

Cluster analysis grouped the habitats into four clusters (Figure 3.2.2). Percent species composition by habitat cluster revealed the dominant species by habitat (Figure 3.2.2). Juvenile rockfish were abundant in all clusters, and were the clear dominant in edge-rock. Adjusted for habitat area, nearly 50% of all juvenile rockfish observed were in the edge-rock cluster. Lingcod also appear proportionally higher in edge-rock than in other habitat clusters. Black rockfish and juvenile rockfish were the dominant species in the rock habitat types. Black rockfish schools were often observed in association with rocky areas of high topographic relief. Adjusted for habitat area, approximately 66% of all black rockfish observed were in the rock habitat cluster. Yellowtail rockfish were the dominant species on the sediment habitat type, followed by juvenile rockfish and kelp greenling. The apparent dominance of yellowtail rockfish was heavily influenced to one large school (37 fish) observed over the sediment habitat type. Canary rockfish were the clear dominant in edge-sediment habitat cluster, followed by kelp greenling. Most of the canary rockfish observed were relatively small and young and often occurred in schools. We often observed the schools over sand immediately adjacent to rock outcroppings. The edge-sediment habitat cluster accounted for about 56% of the canary rockfish observed.

Habitat cluster differences were further supported by an analysis of variance of species' densities in the habitat clusters (Table 3.2.3). Of the species contributing more that 1% to the species composition, black, juvenile, quillback, copper, and yellowtail rockfish, and lingcod exhibited significant differences in mean densities among the four

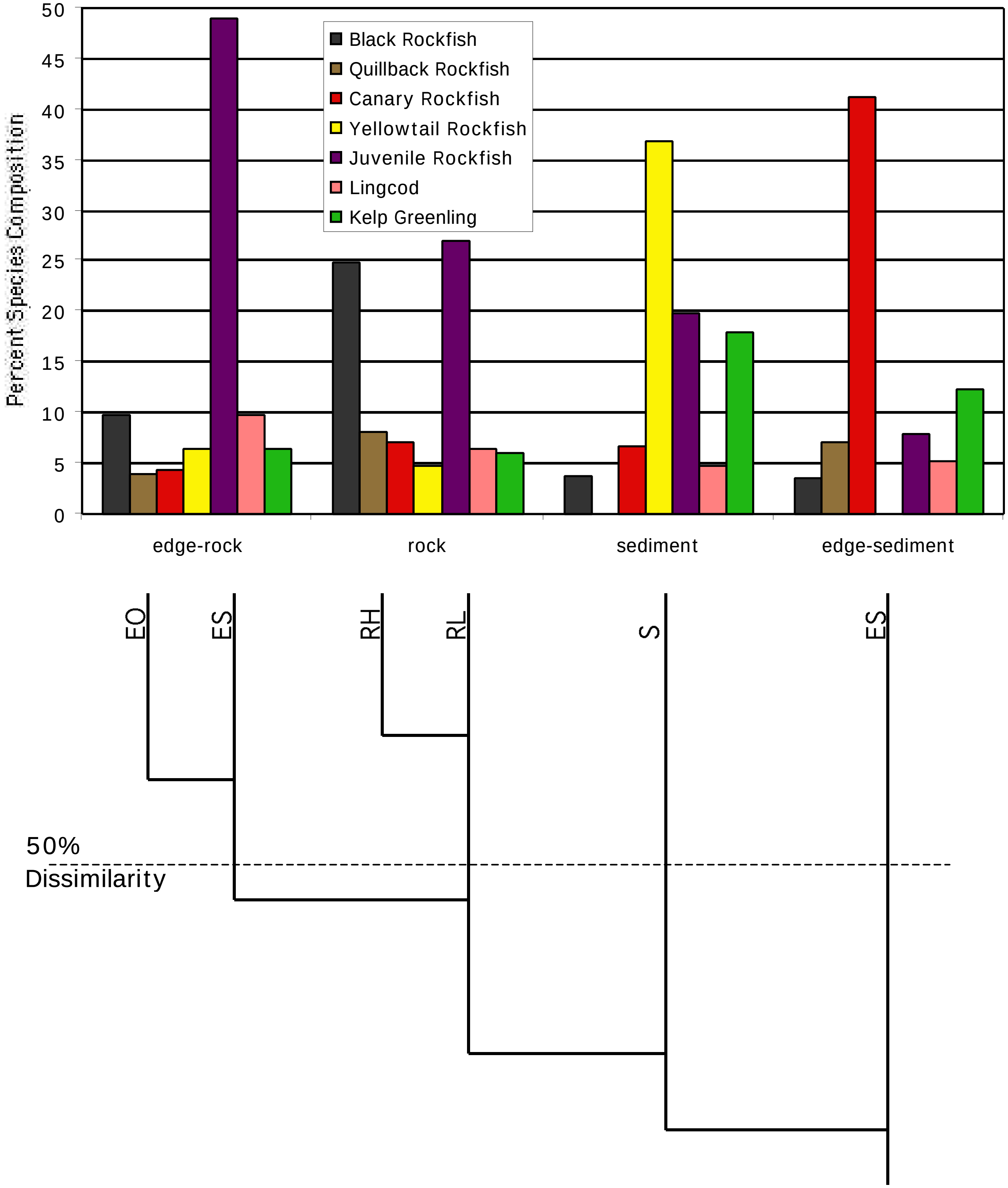

Figure 3.2.2. Dendrogram from cluster analysis of six habitat types (letter codes explained in Table 3.1.2), and percent species composition in each of the four resulting clustered habitat classes.

habitat clusters (Table 3.2.3). These results were generally consistent with the species composition of the cluster groupings. For example, black and quillback rockfish were significantly more dense in the rock than sediment and edge clusters. Lingcod and juvenile rockfish were significantly more dense in rock and edge-rock than edge-sediment (Table 3.2.3)

Figures 3.2.3, 3.2.4, and 3.2.5 show distribution of observations of selected species with respect to rock, sand, and edge habitat. This provides an alternate method of examining species-habitat relations. The occurrence of black rockfish over the rock habitat and canary rockfish on edge habitat can be clearly seen on some of the transects (Figure 3.2.3). For the most part, black and canary rockfish schools were spatially separated from each other (Figure 3.2.3). Juvenile rockfish appeared on both rock and edge habitats, with the largest schools over rock (Figure 3.2.4). Lingcod and kelp greenling were distributed throughout the transects, but a preponderance of individuals appeared to associate with edge habitat (Figure 3.2.5).

Table 3.2.3. Pair-wise comparisons of mean fish density differences between clustered habitat clusters. One asterisk (*) refers to significant differences at the 95% level and two asterisks (**) refer to significant differences at the 99% level. Results are based on analysis of variance and Scheffe post-hoc tests to compare mean densities among the four clustered habitat clusters.

Pair-wise comparison	Total Fish	Total Rockfish	Black Rockfish	Juvenile Rockfish	Lingcod	Quillback Rockfish	Copper Rockfish	Yellowtail Rockfish
Rock - Sed.	**	**	*			**		
Rock - Edge Sed.	**	**	**	*	**	**		**
Rock - Edge Rock		*	*			**	*	
Edge Sed. - Sed.								
Edge Sed. - Edge Rock	**			*	**			
Edge Rock - Sed.	*							

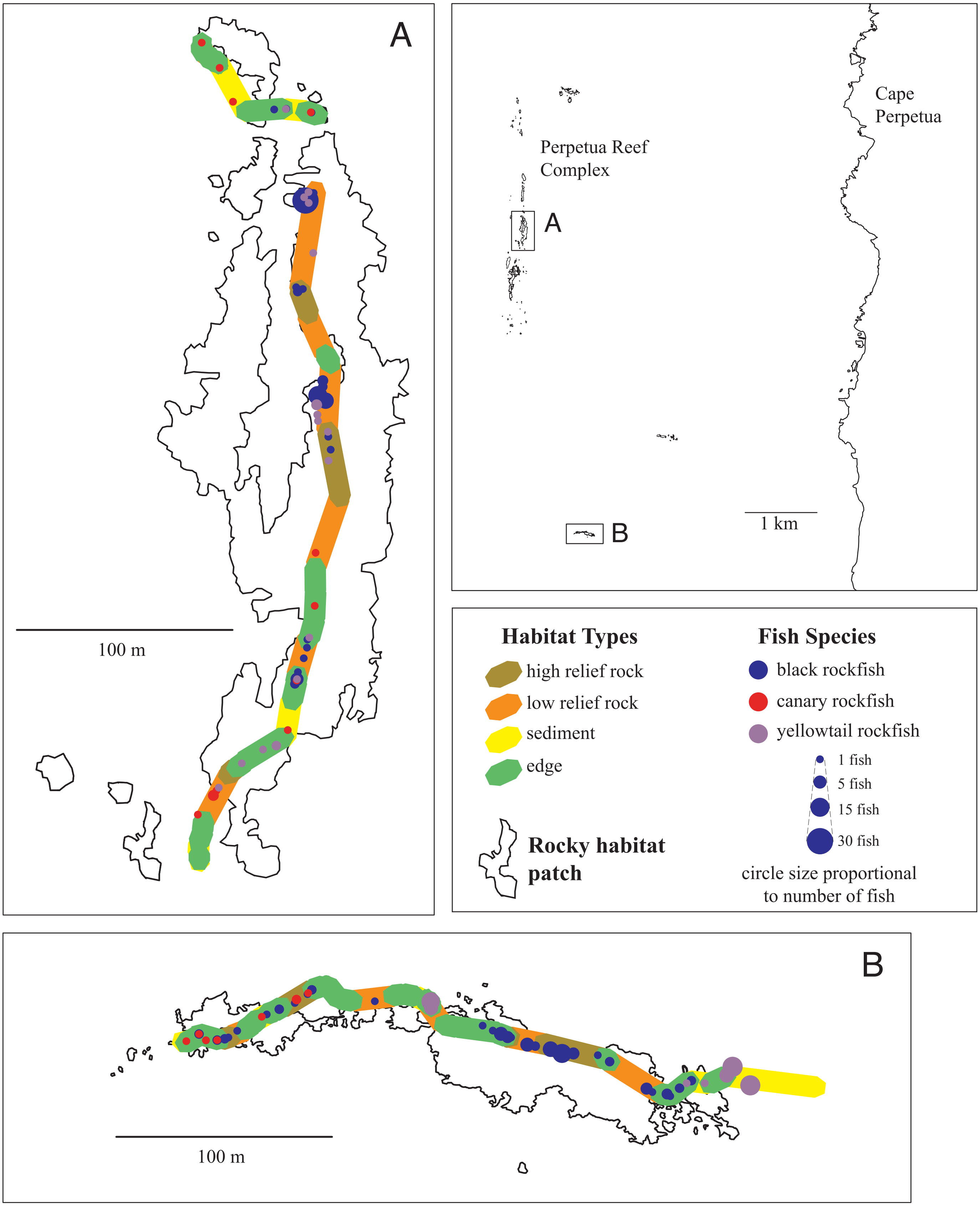

Figure 3.2.3. Cape Perpetua reef complex showing bottom habitat types along three example transects and the distribution of black, canary, and yellowtail rockfish observations.

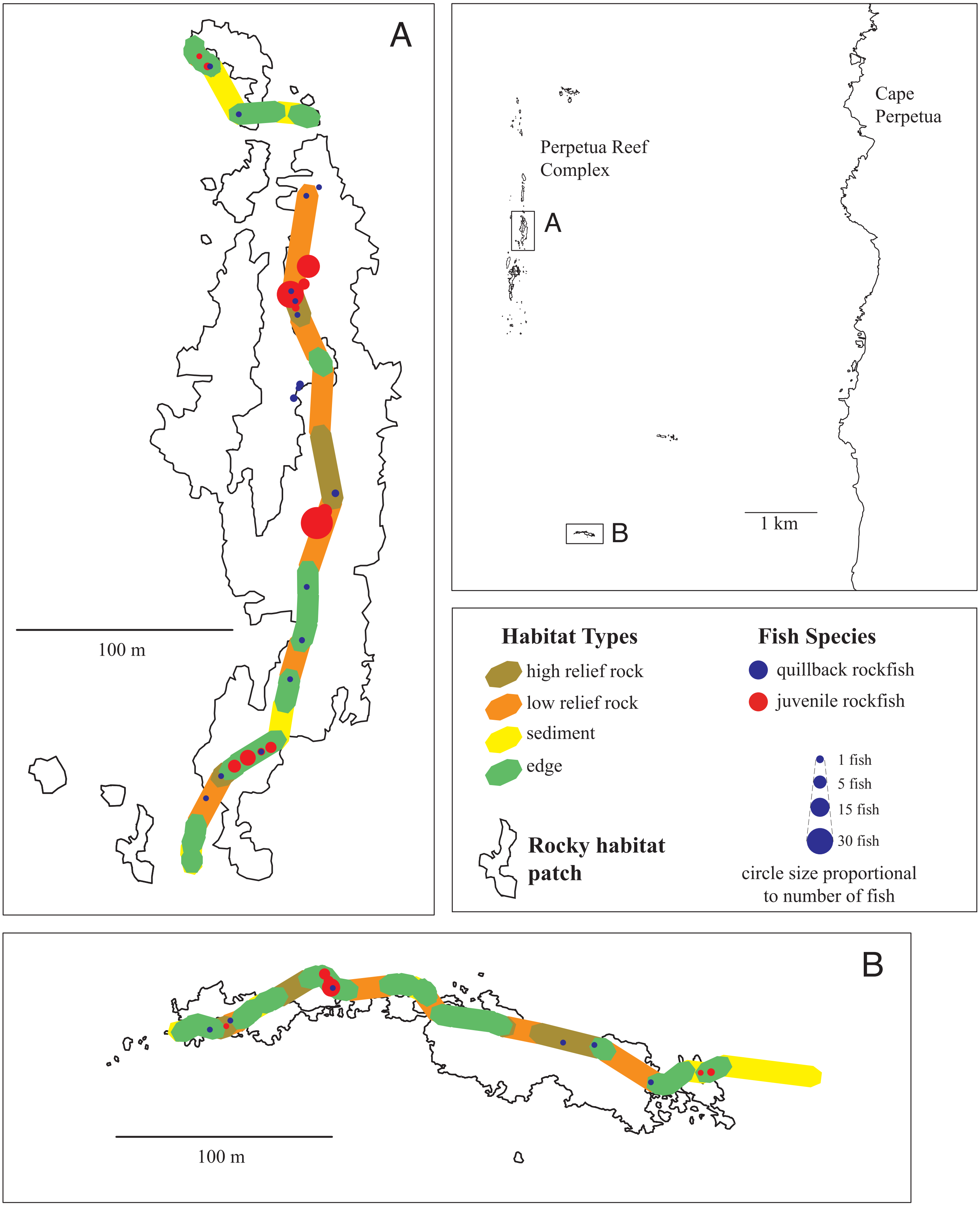

Figure 3.2.4. Cape Perpetua reef complex showing bottom habitat types along three example transects and the distribution of quillback and juvenile rockfish observations.

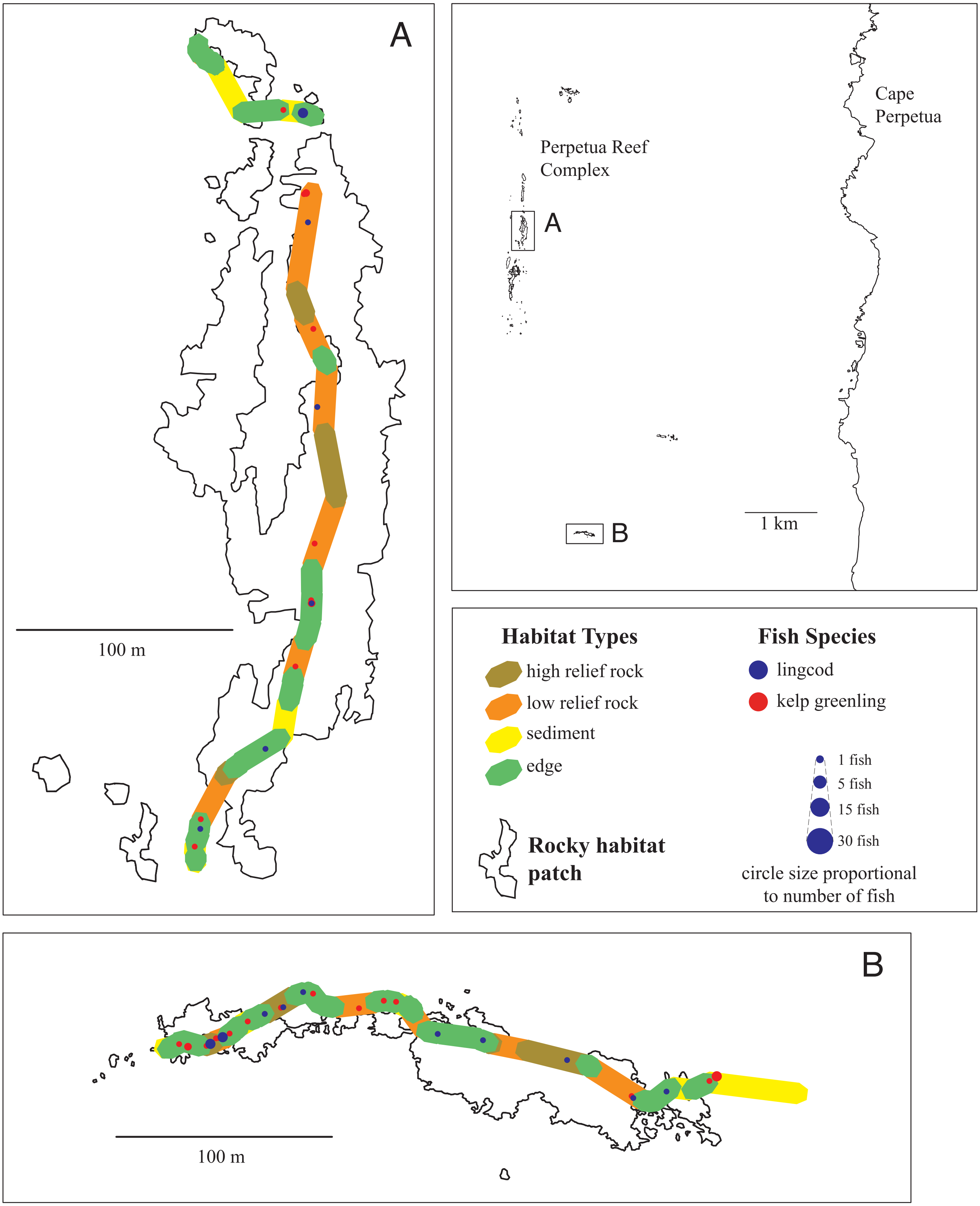

Figure 3.2.5. Cape Perpetua reef complex showing bottom habitat types along three example transects and the distribution of lingcod and kelp greenling observations.

3.3 Discussion

The comparison of two years of Cape Perpetua surveys was our first effort at understanding temporal variation of nearshore reef rockfish using ROV data. Understanding the persistence of species from year to year and variation on shorter time scales is essential to developing ROV techniques in surveying fish abundance on reefs. The similarity in species composition between the years suggests that even on the relatively small reef patches of Cape Perpetua, use of the habitat by rockfish and other species is persistent. Only the schooling species with known high mobility varied between the years, with only one species, canary rockfish exhibiting statistically significant differences. Canary and yellowtail rockfish generally occupy the depths typical of Cape Perpetua only as young fish, and move offshore to deeper waters as they age and grow (Lea, et al. 1999). Future work will examine seasonal variation on reefs and sampling variation on shorter time scales such as day to day or tidal to more fully understand both the temporal variation in habitat use, and types of variation inherent in ROV sampling.

Several researchers have used visual fish survey methods to examine fish-habitat associations (Hixon, et al. 1991; Stein, et al. 1992; O'Connell and Carlile 1993; Richards 1986; Matthews 1990a; Matthews 1990b; Krieger 1992a; Krieger 1992b; Murie, et al. 1994; Yoklavich, et al. 1999; Karpov, et al. 2001). Recent work using submersibles and ROV's on the west coast, including our surveys, has used a system of habitat classification based on seafloor composition and morphology (Hixon, et al. 1991; Stein, et al. 1992; Yoklavich, et al. 1999; Karpov, et al. 2001; Fox, et al. 1996; Fox, et al. 1998; Fox, et al. 2000). Although this system provides an excellent description of the seafloor, and there are some statistically definable associations among fish and bottom characteristics, there are other physical seafloor characteristics not included in the classification that appear to influence fish distribution. For example, using data derived from multibeam sonar in 1999, we found a relationship between rockfish abundance and high relief habitat patches defined in terms of patch surface area and density (Fox, et al. 1999). At Cape Perpetua, a reef area consisting of numerous small disjunct rocky patches scattered among a sand and gravel seafloor, we found a relationship between habitat patch size and rockfish species composition and abundance (Fox, et al. 2000). Although both of these studies represent site-specific findings and need to be tested in other areas, they do point to the need to examine spatial seafloor characteristics beyond a simple description of bottom composition and morphology.

A spatial attribute of habitats not usually included in the traditional classification system is the transition or edge between seafloor types. In our previous observations, we have noticed certain fish species appear to be associated with the interface between rock and sand. Hixon (1991), using a submersible in deeper waters off of Oregon, found that greenstripe rockfish are associated with rock-mud interfaces. We used Cape Perpetua reef to test if certain species in nearshore reefs are associated with habitat edges. We found a clear association of canary rockfish to the rock-sand interface, appearing most often over the sand, rather than rock (Figures 3.2.2 and 3.2.3). Lingcod also showed an increased abundance at the interface (Figures 3.2.2 and 3.2.5). Although present in all habitats, juvenile rockfish also showed increased frequency at the interface (Figures 3.2.2 and 3.2.4). Black rockfish, on the other hand, appeared to favor the interior portions of rock habitat (Figures 3.2.2 and 3.2.3). Our notion of examining edge environments came from observations we made while conducting transects. This underscores the value of visual observation data in formulating hypotheses and examining relationships that would not be apparent with non-visual sampling techniques.

4. Siletz Reef Exploratory Survey

4.1 Methods

Using procedures described in Section 2, we sampled a heavily used sport fishing nearshore area on the central Oregon coast near Lincoln City using the ROV aboard the R/V Elakha. Recreational charter and private boats fish in this area (hereafter called “Siletz Reef”), located between Government Point to the south and Cascade Head to the north. This rocky reef is believed to consist of a few fairly large continuous rock structures and a wide extent of smaller structures (Perry York, pers. comm.).

Placement of ROV transects was iteratively determined by examining the extent of “likely” rocky structures in an interpolated bathymetric map (Figure 4.2.1a, National Ocean Service Hydrographic Survey Data, 50 m gridded bathymetry), on a nautical chart of the region (Figure 4.2.1b, NOS chart no. 18520) and by reconnaissance using the vessel’s echosounder. Planned line transects were centered on these structures.

4.2 Results and Discussion

A total of nearly 30 km of ROV footage was collected over 5 days off of Siletz River (June 7; July 13; Aug 17, 19, and 20). Completed transect tracklines are illustrated in Figure 4.2.1c. Sixteen discrete transects varying from 800 m to 4 km in length were completed, totaling over 19 hours of benthic footage. Transects were surveyed in a northward direction to head into the prevailing wind-driven currents typical of the season. Video review of these transects has not been finished as of December 2001. Only preliminary impressions are described here, as we plan on completing the analysis of the Siletz survey in early 2002.

Visibility was variable, ranging from 3 m to approximately 20 m in the shallow regions. Low visibility was mostly due to dense swarms of zooplankton (unidentified, Order Mysidacea?), whereas high visibility primarily occurred in the shallow regions due to ambient light. The most shallow transects proved challenging to maneuver, causing the deck crew to respond quickly to keep the clump weight from catching the bottom. Once the skipper noticed the depth changing abruptly, the clump weight was raised to keep it above bottom. The ROV was so shallow at one point (10 m), that the float buoy was seen on the surface. Shallow dives also present difficulties in video review. One noticeable effect was the saturation of the video with the blue hue caused by ambient light. This light makes both presence/absence and identification of fish difficult.

Overall, depths ranged from 10 m to 45 m. Relief at the northern Siletz Reef area was more dramatic in some spots than originally anticipated. Massive structures (20m vertically, 10’s of meters across) covered with the white rocky reef anenome *Metridium*

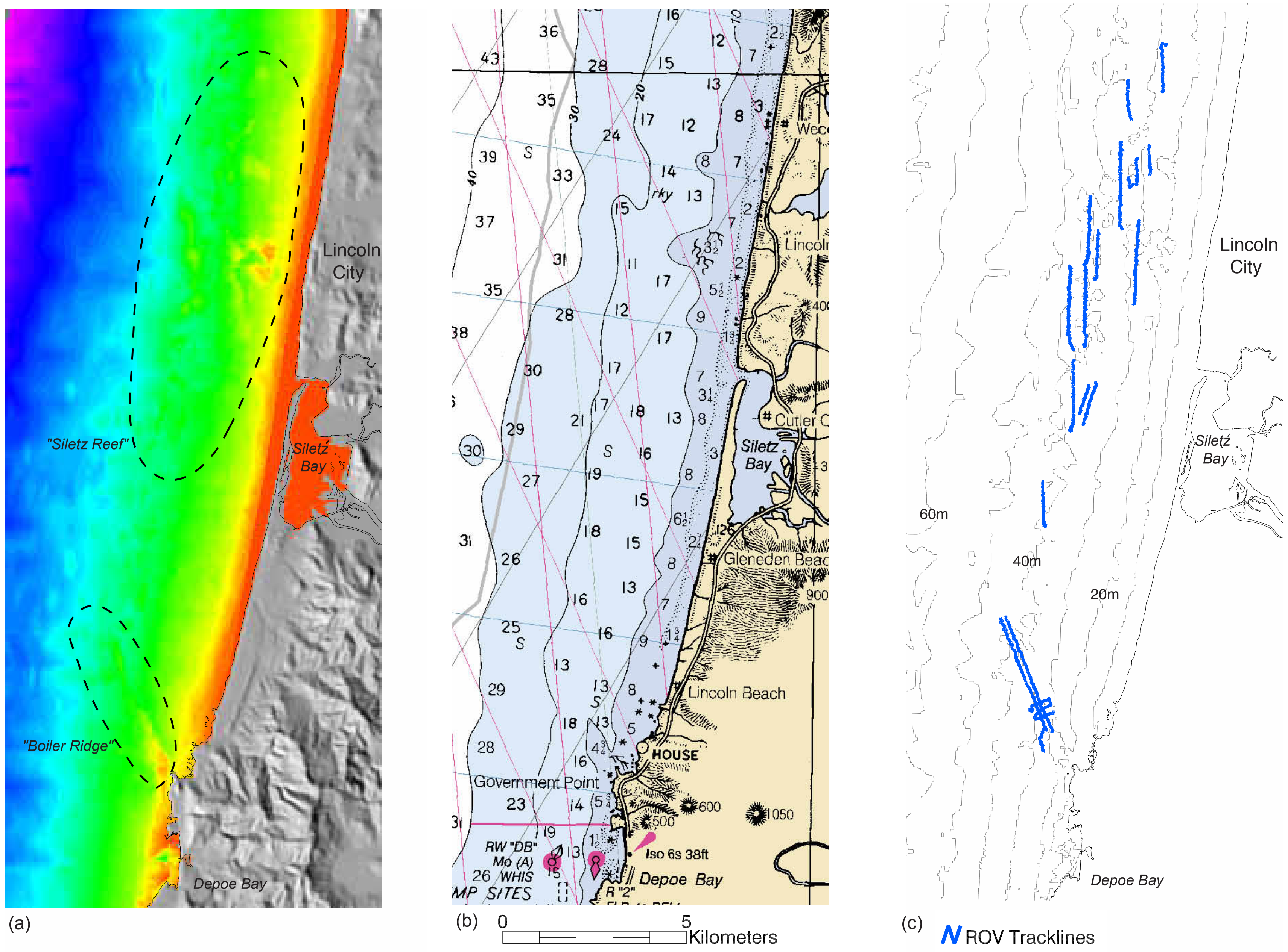

Figure 4.2.1 (a) 50m gridded NOS bathymetry/USGS elevation composite of Siletz Reef region. Note presence of shallow structures along Boiler Ridge and Siletz Reef. (b) NOS Nautical Chart 18520 section of study area. (c) 10m bathymetric contours and completed ROV dives.

giganteum were abundant in the shallow area known locally as “Tacklebuster Reef” (Photo 4.1). The outer portions of the survey area contained repeating ridges that ran from the southwest to the northeast, probably eroded bedforms similar to McKenzie’s Reef near Port Orford (Fox, et al. 1999).

Photo 4.2.1 High relief shallow region known as “Tacklebuster Reef”. Note the visual dominance of ambient light.

Of the transects reviewed at this time of this report (11), counts of finfish are lower than expected for the amount of available habitat. Further research at this site planned for 2002 will investigate this in detail. Invertebrate cover is dense and fairly “clean” on the high relief surfaces, unlike the Seal Rock region south of Newport (Fox, et al. 1998) which has signs of sediment scour along rock edges and a “coating” of detritus similar to our Cape Perpetua study site. These invertebrates primarily include filter feeding organisms (both encrusting and solitary forms) such as tunicates, sponges, clonal anemones, and corals. Aggregations of basket stars (*Gorgonocephalus eucnemis*) were frequent, with densities as high as 1/ sq. m. on some transects (Photo 4.2). The presence of this variety of filter feeding taxa suggests a productive and current-dominated region. The lower relief regions appeared similar to those at the Cape Perpetua site, with asteroids and deposit feeders such as holothuroids in fair abundance.

The ridge extending off of Government Point (hereafter called "Boiler Ridge") was surveyed with two transects parallel to its length, and 1 meandering transect crossing at 3 locations towards its shallow end. The ridge extends out to the northwest several kilometers. Shallow areas (~20m) towards Boiler Bay primarily contained black rockfish, juvenile rockfish, and kelp greenling. This site was intended to extend some shallow water reconnaissance SCUBA work performed early in the summer by researchers from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO). While many of the typical finfish were seen along Boiler Ridge in fair abundance, the most abundant was the spotted ratfish, *Hydrolagus colliei*, observed on the top portion of the ridge. Extremely thick schools of what appear to be mostly females were aggregated halfway along the transect at 40-45 m depth. These fish are typically found in deeper waters on the continental shelf and slope in this part of their range. A shallow water aggregation seems unusual, and deserves further investigation.

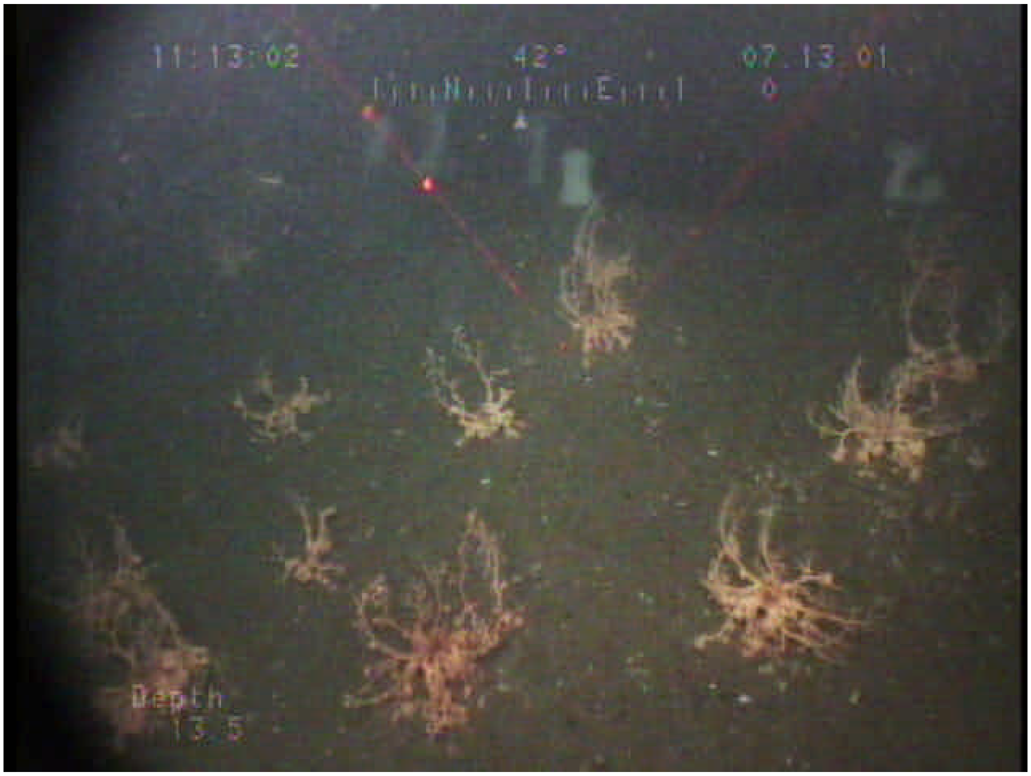

Photo 4.2.2 Aggregation of *Gorgonocephalus eucnemis* seen on the outer portions of the Siletz Reef survey area.

With regards to the logistical aspects of this exploratory survey, we feel that performing an ROV survey on an unknown reef area is possible and, indeed, recommended. Even though this survey was primarily for reconnaissance purposes, this does not preclude a study design for hypotheses testing. The available hydrographic data used to create crude “habitat” maps, adequately represents the extent of rock structures for such a survey. Once initial transects were planned, we watched the echosounder as the vessel then ran across the transect, allowing us to further narrow the transect to encompass likely rock structure. Once this step is taken, the ability to “sample” rock reefs is vastly improved because you can then efficiently run the ROV across the region, maximizing bottom time across the habitat of interest. Sand is an obvious dominant habitat in the ocean, so if we can create an outline of rock habitat through reconnaissance, then a sampling design can emerge.

Photo 4.2.3 Dense school of spotted ratfish, *Hydrolagus colliei,* seen on Boiler Ridge.

We have plans for 2002 to run a sonar survey across this region, defined by both our initial planning maps (Figure 4.2) and by ROV video data yet to be processed. The resulting map will give us a more detailed representation of Siletz Reef’s configuration and extent. Once this sonar survey is performed, we hope to sample the reef in a manner that will provide a comparable data set to other reefs on the west coast. This study design will likely emerge from an ongoing cooperative effort with the California Department of Fish and Game to establish common protocols to nearshore ROV research.

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