Coastal Zone Management Section 309 Grant:

2000 Nearshore Rocky Reef Assessment

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1. Introduction

Oregon is facing increasing 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. Emerging or proposed marine resource uses include the live-fish fishery, expansion of open access hook and line fisheries, kelp (*Nereocystis luetkeana*) harvest, propagation or enhancement of sea urchins, abalone, and other species, and increased and diversified recreational uses.

Because nearshore reefs are in state waters, Oregon is responsible for managing these living resources and habitats to sustain their long-term use and productivity. In addition, the West Coast groundfish fishery is currently in a state of crisis. This crisis manifests itself differently in different segments of the fishery. Nearshore rocky reef environments comprise an area where fishing pressure continues to increase rapidly, stocks appear to be declining, and we have little information upon which to base management decisions. Public pressure to obtain the necessary information and establish credible conservation policy is growing rapidly. 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 summarizes work completed during 2000. Our principal project during the 2000 field season was examining rockfish utilization of small rocky reef habitat patches. This work included surveying and mapping bottom habitat using side-scan sonar and estimating fish abundance using a Remotely Operated Vehicle (ROV). Section 2, below, presents the results of this work. During 2000, we also contracted with Seavisual, Inc., to conduct a multibeam bathymetry survey on the rocky reef off of Bandon (Section 3). Section 4 of the report discusses how the results of the 2000 work contribute to nearshore reef management. During summer of 2000 we also completed the field data collection portion of the kelp biomass analysis, but did not analyze the data to produce a biomass estimate. This work will be completed and presented in a future report.

2. Habitat and Fish Survey at Cape Perpetua

Over the past five years, our nearshore reef studies have focused on large, contiguous rocky reef habitats. These are known areas of rockfish abundance. During a fish sampling and habitat mapping project in 1998, we found substantial quantities of fish off of Cape Perpetua but were not able to detect rocky reef areas using a single beam sonar survey tool (Fox, et al. 1998). Fishermen have long known that small patches of rock are present off of Cape Perpetua between 30 and 60 m water depth, and these harbor rockfish and other groundfish species. During 2000, we returned to the Cape Perpetua area to conduct a full survey of bottom habitat and examine fish utilization of small habitat patches. If the small habitat patches prove important to rockfish, they need to be sampled along with the large contiguous reefs to fully understand nearshore rockfish abundance and distribution on the coast.

Our overall objective of the study was to examine nearshore rockfish use of small disjunct rocky habitat patches. The primary research questions included:

- What are the spatial patterns of nearshore rockfish distribution on small disjunct rocky habitat patches?
- What is the minimum size of isolated rocky habitat patches utilized by nearshore rockfish?

A second major objective was to test the sampling effectiveness of our newly-acquired ROV and develop methods for quantitative fish sampling.

Data collection methods for this project included side scan sonar surveys to identify and map bottom habitats and ROV video transects to count and identify fish. Section 2.1 discusses the side-scan sonar survey and Section 2.2 discusses the fish survey.

2.1 Side Sonar Survey

2.1.1 Methods

Side scan sonar equipment used in the survey included an Edgetech DF-1000 100/500 kHz towfish and digital control unit (DCU), Triton Elics ISIS sonar software for acquisition and production, an Ashtech BR2G differential GPS, and a Coda Technologies Hydrotrac 200kHz echosounder. The survey vessel was the commercial fishing vessel, *F/V Nesika*. Prior to the survey, we developed 100% coverage survey lines with Hypack hydrographic software. During the survey, these were placed on a helm display for accurate vessel navigation of the tracklines.

Performing the survey involved steering along parallel tracklines while towing the sonar towfish astern of the vessel. The towfish was lowered behind the vessel to fly safely above the seafloor (10-20m altitude). The ISIS software computed the distance between the vessel and towfish, or "layback", using the amount of cable paid out behind the vessel and the depth underneath the vessel. The software then combines the layback with the geographic position of the vessel and depth of the towfish to calculate the position of the towfish. Backscatter quality changes due to internal and external noise were monitored and adjusted using standard procedures (Fish and Carr 1990). The vessel ran with and into the alongshore current, and we did not notice any obvious sideward drag on the cable. A reasonable estimate of layback position uncertainty with respect to the vessel is ± 5 m. The first portion of the survey, (July 17-19) was run at a low frequency to identify the gross scale geology of the region (100kHz, 200m range, 5-6 kts, 20m altitude). During data acquisition, careful attention was paid to the output screen and rocky areas were noted. The second portion (July 19 to 20) was surveyed at a higher frequency to discern the small rock patches (500kHz, 50m range, 3-4 kts, 10m altitude) noted during the low frequency run-through.

Trackline sonar data collected during the survey were stored in XTF format on CD-R media at the end of each survey day. Position and depth data were stored in Hypack format. Standard adjustments to the clarity of the sonar data (time-varied gain, vessel speed, altitude) were made prior to mosaic production in Triton Elics DelphMap software. Because we were able to achieve 100% coverage, mosaics were created using a best-coverage overlaying approach, choosing the trackline with the clearest backscatter image for the visible top layer. Mosaics from each portion (low and high frequency) of the survey were stored in GeoTIFF format and then burned to CD-R. High resolution portions of the survey data were then imported into Hypack navigation software to develop ROV groundtruth and fish sampling transects (Section 2.2).

Rock patches visible in the 500kHz mosaics were classified by relative size into "tiny", "small", "medium" and "large" classes. Line transects across these patches were then created and used for ROV navigation with Hypack software. Surface areas of the rock polygons were estimated using GIS software and used in the ROV data analysis.

2.1.2 Results and Discussion

The survey area covered approximately 32 km^2 (Figure 2.1.1). There were very few difficulties encountered during the survey, other than two occasions when crab pot buoy lines tangled with the survey gear and broke the signal connection at the towfish. The low frequency (100 kHz) mosaic is shown in Figure 2.1.2. Darker areas represent a lower backscatter return (softer surfaces) while lighter areas are higher backscatter values (harder surfaces). The area consists of a large region of sand and mud mixture (dark) with large curving expanses of gravel and coarse sand. Both the northern- and southernmost expanses of gravel / coarse sand are likely deposits from the Yachats River (north) and Tenmile Creek (south). At the scale of the low frequency mosaic, rock patches are not readily visible. The detail of the rock patches becomes apparent in the high frequency (500 kHz) data at a magnified scale. Examples of rock patches seen in the high frequency data are shown in Figure 2.1.3. We encountered approximately 60 fairly low vertical relief rock patches. Patch composition was variable, ranging from 1.6 ha benches to boulder-like fields to isolated 1 m^2 rocks.

Rocky habitat patches are shown in Figure 2.1.1. The relative size to the survey area contextually illustrates the small and isolated nature of this type of rocky habitat. The estimated total area of rock patches within the survey area was 0.07 sq. km.

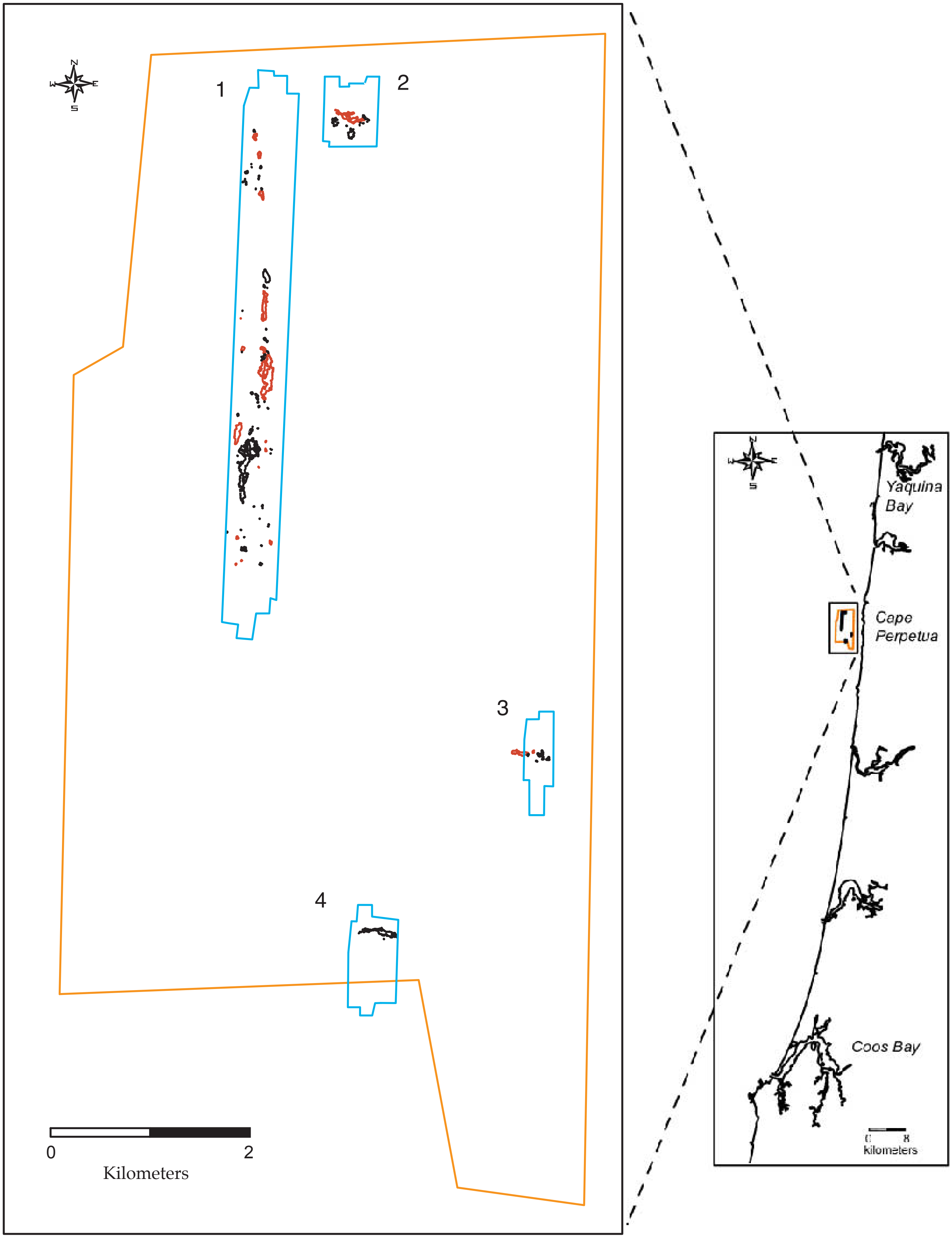


Figure 2.1.1. Map of side scan sonar survey areas off Cape Perpetua. Low resolution (100 kHz) survey area is in orange. High resolution (500 kHz) survey areas are in blue and shows rocky habitat patches. Habitat patches sampled for fish abundance using ROV-video are shown in red.

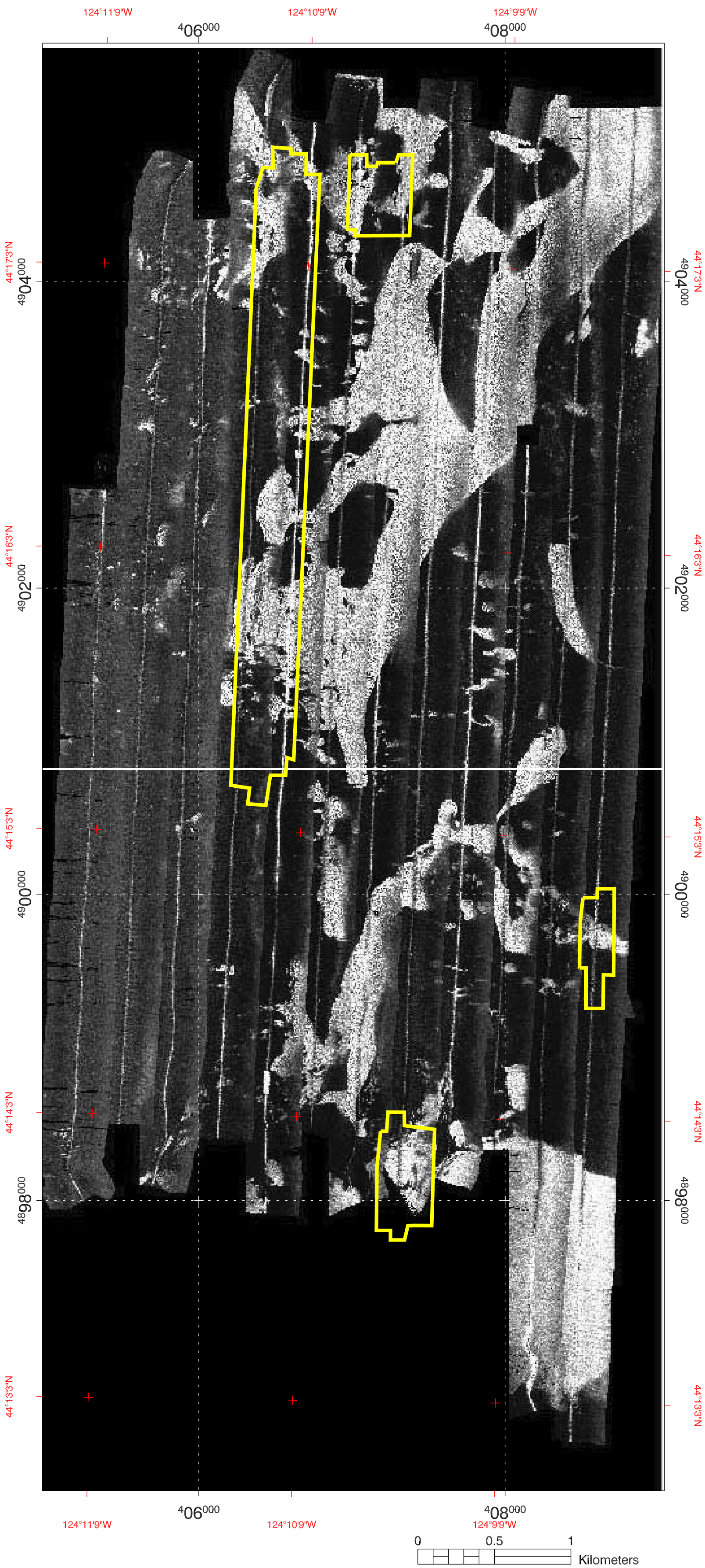
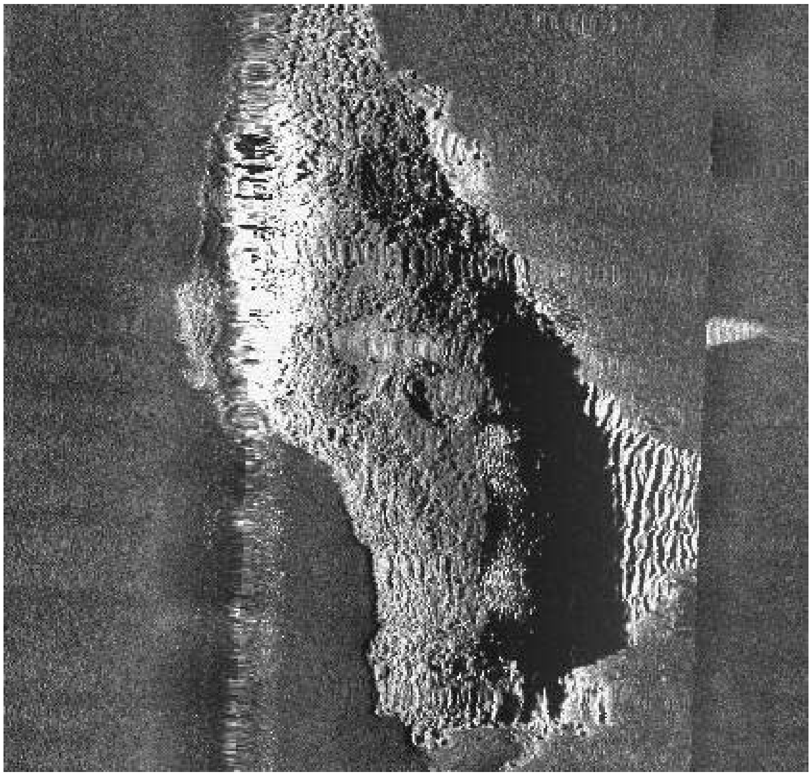
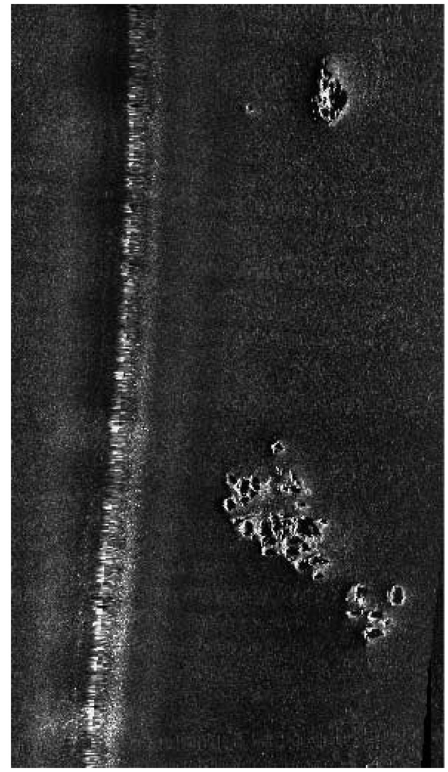


Figure 2.1.2. 100kHz side scan sonar mosaic of Cape Perpetua study area. Outlined areas were later surveyed at 500kHz.



(a)



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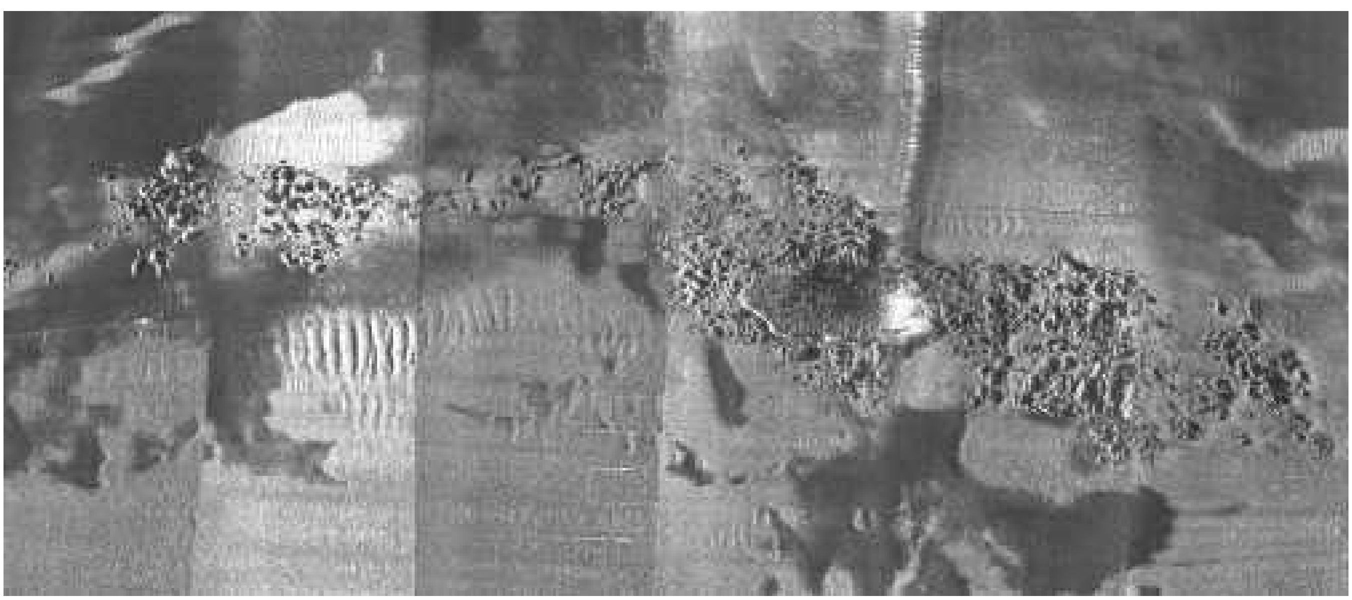


(c)

Figure 2.1.3. Examples of 500kHz mosaic rock patches. (a) Fairly large slabs of rocky substrate were common, dimensions (x,y) 30m x 100m. (b) Small and isolated boulders, each ~2m x 2m. (c) Expansive boulder field, dimensions 250m x 20m.

2.2 Fish Survey

2.2.1 Methods

Survey Equipment, Sampling Design, and Data Collection

The fish sampling method consisted of video strip transects conducted with a Deep Ocean Engineering Phantom HD-2 ROV. ROV equipment included a Sony EVI-330 video camera, a second Deep Sea Power and Light (DSPL) Micro SeaCam 2050 video camera, two DSPL 250 watt halogen lights, and four DSPL SeaLaser 15mW lasers. During sampling, the main Sony video camera was aimed to view ahead of the vehicle at a downward angle of 30° below horizontal. The second DSPL camera was placed at various positions on the ROV to test its utility for ROV navigation and alternate fish viewing angles. A monitor on the survey vessel provided a live feed from the ROV video. A Canon ZR1 digital video camera / VCR recorded the video image. The lasers were all mounted parallel to each other to provide a scale of reference in the video images. The mounting pattern consisted of two lasers on top of the video camera housing 10 cm apart, and two under the ROV's forward end caps 53.7 cm apart.

The fish transect sampling design focused on examining the effect of habitat patch size on fish species composition and density. Rocky habitat patches appearing on the side scan sonar mosaics were examined and classified by size, apparent composition, and approximate vertical relief. We grouped the habitat patches into four size categories based on natural breaks in their size distribution, and randomly selected 5 patches from each category to sample (Figure 2.1.1). Each ROV transect crossed an entire habitat patch, and generally ran along the longest dimension of each patch. Of the 20 transects sampled, one was discarded due to poor quality. In addition to the transects randomly selected in the four size categories, we ran 16 groundtruth transects on rocky habitat patches of interest and on seafloor areas consisting of sand and gravel. Data from these transects were recorded but are not reported in this analysis.

The *R/V Elahka*, a 54' research vessel owned and operated by Oregon State University, provided the platform for the ROV survey. The ROV was launched and recovered from the stern of the vessel using an A-frame and winch as follows:

1) The vessel was positioned upwind of the desired transect location.
2) The ROV was attached to the winch cable and lowered into the water.
3) The ROV was run out astern of the vessel until about 50 m of umbilical was paid out (the umbilical had gangion clips at 50 m and every 4 m thereafter, to secured the umbilical to the vessel's winch cable). During this procedure, a small subsurface float was attached to the umbilical at the 25 m mark.
4) A 200 lb. weight (depression weight) was attached to the winch cable and lowered off the A-frame to about 2 m under the water surface.
5) A survey crew member clipped the first umbilical gangion clip to the winch cable.
6) The depression weight was lowered about 4 m and the second umbilical gangion clip was clipped to the winch cable. The lowering and clipping process was repeated until the depression weight was approximately 6 m above the seafloor.

This deployment method, modified from methods used by Norcross and Mueter (1999) and Stewart and Auster (1989), allowed 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. The float at the umbilical's 25 m mark kept the umbilical from snagging on the seafloor.

We tracked and recorded the position of the ROV using an ORE Trackpoint LXT during the first 3 days of sampling and a Trackpoint II Plus during the last day of sampling. We switched tracking systems between survey legs because the survey demands were beyond the LXT's capabilities. A laptop computer loaded with Hypack software integrated the Trackpoint system's output with the vessel's differential GPS to compute and record both ROV and vessel positions. The tracking data, displayed as an overlay on the side scan sonar mosaics, provided navigation information to the ROV pilot. A second computer screen, set up in view of the vessel skipper, helped the skipper maneuver to the transect location and maintain the vessel near the ROV. After sampling, the tracking data were processed to provide transect position and length.

We examined the video record of the transects to record time, fish taxa, fish count, schooling behavior, bottom habitat characteristics, and general notes. Most of the larger fish were identified to species. Young-of-the-year rockfish were grouped into a single category as "juvenile rockfish". A fish school was defined as three or more individuals of the same fish species grouped together. The classification system and techniques for describing bottom habitat matched those described in Fox, et al. (1998), and are similar to those used in previous submersible studies off Oregon (Hixon, et al. 1991; Stein, et al. 1992).

Comparison of Video Review Methods

Three different methods were employed to extract fish count data from the video in order to test their relative utility. First, we recorded data while watching the videos during field sampling. We termed this method "boat review". The second method, termed "video review", involved viewing each of the video tapes again, taking time to pause and carefully review the images to ensure complete data collection. Under this method fish were only counted in the bottom 80% of the video screen. On average that portion of the screen showed views of the bottom from just in front of the ROV out to an average distance of 4.5 m (range: 2.5 – 11 m). Beyond that point counts could not be consistent within and between transects due to variations in visibility, light penetration, and terrain. The third method involved recording data from randomly selected video frames on each transect. We termed this method "frame review". We sampled frames by dividing each transect into approximate 5 m segments and randomly selecting one frame per segment for viewing. As with the above counts, we only included the bottom 80% of the image. In addition to the data described above, we also measured the distance between parallel laser points on the seafloor to estimate bottom surface area sampled in each frame. Frames where laser points were not visible or where the points appeared on seafloor surfaces widely differing in elevation were rejected and alternate random frames sampled. The random sampling and frame viewing routine was repeated five times on 10 of the transects to examine within-transect variation of the frame sampling method. We compared the three video sampling methods using

Analysis of Variance (ANOVA). We also used ANOVA to compare within-transect replicates of the frame sampling data.

All data were standardized by converting fish counts to fish density estimates (fish / $100m^2$). This required estimating seafloor surface area sampled in the video. We estimated dimensions of the video images following the perspective grid method described in Wakefield (1987). Using camera declination angle, horizontal and vertical view angles, and laser separation distance in the image, this 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. The 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 used transect width estimated from the frame review and transect length estimated from the tracking data to determine the total area sampled on each transect.

Fish-Habitat Associations

We examined the relationship between fish density and rocky habitat patch size using ANOVA and linear regression. Patch size was expressed as both area and perimeter / area ratio to provide two alternate representations of patch "size". There were four patch surface area categories for the ANOVA: "large", "medium", "small", and "tiny" (see Section 2.1.1). Relationships between fish densities and patch perimeter / area ratio were examined with linear regression only. All statistical analyses were performed on fish density data from the video review method that were log-transformed ($\ln(x+1)$) to normalize the otherwise highly skewed untransformed data.

Optimal Sample Size Estimation

We conducted statistical power analyses based on between and within-transect variance to estimate optimal transect sample sizes, video frame subsample sizes, and optimal transect lengths. The procedure for determining optimal transect sample size involved examining statistical precision (represented by 95% confidence intervals) of various transect sample size scenarios. The 95% confidence intervals were based on variance by species and groups in the longest 10 transects. Data were first log-transformed to estimate the variances and confidence intervals, and then back-transformed to report the results. We used bootstrapping to estimate the optimal number of video frames per transect. The bootstrapping technique randomly resampled the fish density data from the video frames within a transect to generate 95% confidence intervals for various sample size scenarios. We applied the technique to the five transects that were sampled with the greatest number of video frames. We also used the bootstrapping method to estimate optimal transect lengths based on the transect video review data. We divided transects into one-minute segments and performed the resampling procedure on the total fish count data from each one-minute segment. The procedure computed 95% confidence intervals and converted total transect minutes to transect length based on the elapsed time / length ratio of each transect.

Comparison of ROV Video Sampling with Jig Fishing Methods

During 1998, ODFW's recreational fishery management group engaged in a bottomfish assessment study at several nearshore reefs, including the reef off Cape Perpetua, using a jig fishing sampling method (Bodenmiller and Miller 2000). The sampling sites in the bottomfish study approximated the sampling sites in the ROV survey, allowing comparison of how each method characterized species composition of reef fish. Since we did not design and execute a study with this analysis in mind, statistical comparison of the data was not possible. In addition, the bottomfish study targeted black rockfish, potentially biasing any analysis. Our approach was to graphically compare species composition by examining the relative proportion of each species sampled by the two methods.

The detail and accuracy of the sampling locations recorded during the jig and ROV sampling differed between the two studies. ROV transects were recorded using differential GPS and were recorded continuously during each transect. Jig fishing drift locations were recorded using LORAN-C and recorded only a single point during each drift. Due to the lack of detail and potential error in the jig fishing locations, we spatially pooled data to derive the species composition for all transects and drifts that occurred in general proximity of one another. A large geographic break in the sampling locations allowed for two areas to be pooled and examined independently.

2.2.2 Results and Discussion

Sampling Completed and ROV Performance

We completed a total of 36 ROV transects on August 24, 25, 26 and September 13, 2000, varying in length from 4 to 226 m. The ROV and vessel performed well under the conditions encountered. We were able to navigate the ROV to very small habitat patches (< 5 m across) and, provided the vessel could maintain position, we were able to run uninterrupted transects for over 40 minutes. Only when the vessel could not maintain fine position control (usually due to wind) and moved beyond the 50 m maneuvering radius of the ROV did we have problems with running transects. In these instances, the vessel would drag the ROV through the water, making it necessary to wait for the vessel to regain position and re-run the transect. We found that the *R/V Elahka* could usually maintain adequate positional control in winds up to 15-18 knots.

Relative variation in ROV height above the bottom provided a test of the consistency of transect sampling width and video image surface area among the transects. The laser separation distance is proportional to the height of the ROV off the bottom. Using the laser measurements from the frame review data we found no significant difference in laser separation among small, medium, and large transects (ANOVA, $P = 0.13$). We eliminated tiny transects from the ANOVA because they had a sample size of only one to three frames each. Based on the laser separation distance the average height of the ROV off the bottom (measured at the camera) on the transects was 1.2 m ± 0.03 m (95% ci) and the average seafloor surface area in video frame images was 17.7 m^2 ± 0.9 m^2 (95% ci).

Comparison of Video Review Methods

The three video fish counting methods produced significantly different mean fish densities (ANOVA, $P = 0.0013$). Post-hoc Scheffe tests showed that the total fish density was significantly higher using the video review method over either the boat review or frame review methods. The boat review and frame review methods did not differ significantly from each other. The fish counts from the boat review methods were incomplete because we often could not keep up with data recording during the transects due to the speed at which fish appeared on the video. This did not pose a problem during the video review method due the ability to pause and rewind the tape. Data from the boat review method were excluded from further analysis.

The frame review method was intended to provide a representative subsample of the video review data. If subsampling were adequate, we would expect no difference in fish densities between the two methods; however, our results did show significant differences. An examination of the degree of correlation between fish densities computed under the two methods could reveal if the sub-sampling error was systematic. Although total densities were not significantly correlated ($r = 0.43$, $P = 0.067$), densities of schooling species were significantly correlated (black rockfish (*Sebastes melanops*) $r = 0.96$, $P < 0.001$; canary rockfish (*S. pinniger*) $r = 0.89$, $P < 0.001$). The systematic sampling error for schooling species can be explained by the effects of either double counting fish in the video review method due to difficulty in tracking individual fish in a school, undersampling in the frame review method due to small sample sizes underrepresenting highly patchy species distributions, or a combination of the two. There was no independent sampling to determine which method contributed most to the error; however, staff reviewing the videos were confident that double counting fish was minimal. Although the results are inconclusive, evidence suggests that subsampling the transect in the frame review sampling method did not adequately represent the very patchy schooling species. However, replicate frame subsamples within transects did not produce significantly different total fish densities (separate ANOVA's on 10 transects, p values ranging from 0.27 to 0.99), indicating that the subsampling is consistent and does an adequate job at representing less patchy species.

Fish-Habitat Associations

The analysis of fish density by reef size revealed patterns of fish abundance and distribution among the habitat patches. Table 2.2.1 summarizes the patch areas, perimeter/area ratio and fish densities for the four patch size categories. There were some statistically significant differences in densities among the four patch size classes for the various species and groupings of fish, including total adult rockfish ($P = 0.035$), total non-schooling rockfish ($P = 0.002$), and quillback rockfish (*S. maliger*) ($P = 0.020$). Non-schooling rockfish is this study include all rockfish species observed except black, canary, and juvenile rockfish. In each of the species/groups exhibiting significant differences, densities in the "tiny" patch category were significantly lower that the other three categories and the other three categories did not differ from each other. Small patches appear to have relatively high densities of canary and black rockfish (Table 2.2.1), though not significantly higher than the larger patches. The high density values result from individual fish schools on the patches that span much of the patch, thus cover much of the ROV transect. The apparent higher densities on smaller patches

Table 2.2.1. Mean and standard deviation (S.D.) values for habitat patch size parameters and fish densities of the top 15 species observed for the four patch size categories (untransformed data).

	Large Transects		Medium Transects		Small Transects		Tiny Transects	
Variable	mean	S.D.	mean	S.D.	mean	S.D.	mean	S.D.
Rocky Habitat Patches								
Area (m^2)	6608	5415	783	219	220	61	48	26
Perimeter (m)	971	617	193	66	73	17	29	9
Perimeter / area ratio	0.17	0.08	0.24	0.04	0.34	0.04	0.71	0.28
Fish (# / $100m^2$)								
Total fish	18.3	11.9	29.3	25.2	47.6	43.8	29.8	30.1
Total adult fish	12.4	4.8	22.7	16.6	40.0	30.3	23.9	21.7
Total rockfish	10.0	4.3	18.1	12.4	33.3	29.0	9.5	21.1
Black rockfish	3.8	3.4	3.2	7.1	14.9	29.0	0.0	0.0
Blue rockfish	0.0	0.1	1.3	2.8	0.0	0.0	0.0	0.0
Brown rockfish	0.1	0.1	0.5	0.6	0.4	0.8	0.0	0.0
Cabezon	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.8
Canary rockfish	3.3	3.3	6.5	1.5	11.6	13.5	9.5	21.1
China rockfish	0.0	0.1	0.2	0.5	0.2	0.5	0.0	0.0
Copper rockfish	0.6	0.4	0.4	0.2	2.7	4.6	0.0	0.0
Kelp greenling	1.3	0.5	1.9	1.5	6.0	2.7	11.5	16.0
Juvenile rockfish	5.9	9.4	6.6	9.1	7.5	15.0	6.0	11.8
Lingcod	0.7	0.5	1.7	1.8	0.7	0.8	2.5	3.3
Quillback rockfish	1.6	0.9	2.0	1.7	1.2	1.7	0.0	0.0
Ratfish	0.2	0.2	1.0	2.1	0.0	0.0	0.0	0.0
Wolf eel	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Yelloweye rockfish	0.3	0.3	1.0	1.4	0.3	0.7	0.0	0.0
Yellowtail rockfish	0.2	0.1	2.9	5.7	1.9	3.2	0.0	0.0

suggests that many small patches can harbor more schooling rockfish than a single large patch of similar total area. This observation warrants further study.

Linear regression results comparing species densities with patch area were non-significant. However, linear regressions between the species' densities and perimeter / area ratios were statistically significant for total non schooling rockfish (r^2 = 0.35, P = 0.0076), quillback rockfish (r^2 = 0.37, P = 0.0060), and kelp greenling (*Hexagrammos decagrammus*) (r^2 = 0.29, P = 0.019) (Figure 2.2.1). Both significant (Figure 2.2.1a, b) and non-significant plots of density against either area or perimeter / area ratio showed a similar pattern for all species except kelp greenling. The scatter of data points on these plots appear to follow a threshold pattern rather than continuously increasing or decreasing linear density values with patch size. In the typical pattern, fish densities on all but the smallest patches (small patches have high perimeter / area ratios) appear

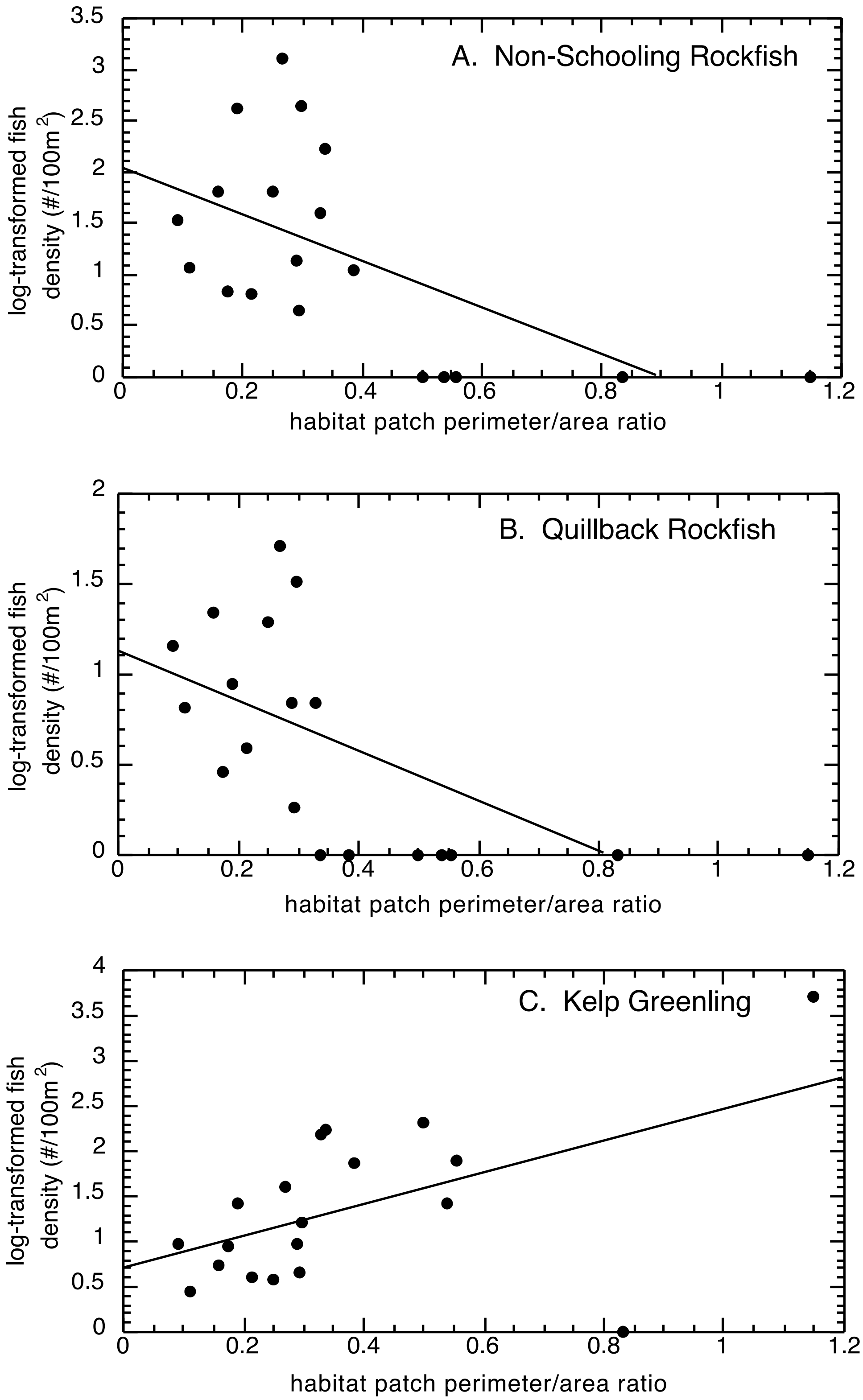


Figure 2.2.1. Linear regression plots of rockfish density versus habitat patch perimeter / area ratio.

unrelated to patch size, while the smallest patches have zero or very low fish density values (e.g., Figure 2.2.1a, b). Kelp greenling appear to follow a more progressive linear relationship with patch perimeter / area ratio, with densities increasing as perimeter / area ratio increases. This is consistent with our observation of relatively larger numbers of kelp greenling on the smaller patches (higher perimeter / area ratio).

The analyses summarized above demonstrated some patterns of fish abundance, distribution, and species composition relative to the size of isolated reef patches. All of the patches sampled would be considered small compared with large contiguous rocky substrates at Orford Reef, Seal Rock, and many other areas along the coast. The data clearly show that these relatively small reef patches off Cape Perpetua hold high densities and diversity of fish. All of the patches sampled had fish on them and all but the smallest patches had several species of rockfish, often with several fish schools. In addition to the quantitative analysis presented above, several qualitative observations provide insight into the patterns of fish distribution. The benthic non-schooling rockfish species, including quillback and copper rockfish (*S. caurinus*) appeared to be more associated with relatively larger patches. Rockfish that appeared on the smaller patches included schooling black, canary, and juvenile rockfish. All of the canary rockfish observed on the video were relatively small, young fish that are often found at the 30 – 50 m water depths of this survey. There appeared to be an increase in fish densities at habitat patch edges (interface between rock and sand) but we were not able to demonstrate that statistically. Of the species observed, lingcod (*Ophiodon elongatus*) and canary rockfish appeared to have the greatest affinity for patch edges. Kelp greenling was the most ubiquitous species, appearing on all but one patch sampled.

Optimal Sample Size Estimation

The power analyses based on between and within-transect variances suggested optimal sample sizes for future studies. A sample size of 20 transects would provide 95% confidence intervals within 20 – 40% of mean densities for total fish, and for copper rockfish, kelp greenling, and quillback rockfish individually (Figure 2.2.2, Table 2.2.2). Canary rockfish and lingcod would require a sample size of 30 for similar statistical precision (Table 2.2.2). Patchy schooling species such as black rockfish would only reach that level of statistical precision with sample sizes exceeding 60 (Figure 2.2.2). The bootstrapping analysis based on within-transect variance of the frame data suggested an optimal sample size of about 40 video frames per transect (Figures 2.2.3). The bootstrapping analysis of one minute transect segments (converted to transect length) suggested an optimal transect length ranging from 100 to 300 m (Figure 2.2.4). Because reefs off of Cape Perpetua consist of small isolated patches, these analyses may not represent large contiguous reefs. Also, the Cape Perpetua transects were unequal in length, possibly affecting the variances used in the analysis.

Comparison of ROV Video Sampling with Jig Fishing Methods

In the comparison of species composition between the ROV-video and jig fishing methods, the ROV sampled more species and sizes of fish. In Area 1 (Figure 2.2.5), a total of 14 species plus juvenile rockfish were observed using the ROV, while 10 species and no juvenile rockfish were caught by jig fishing (Figure 2.2.6). With the ROV, the most abundant species in descending order, were canary rockfish (30%), juvenile rockfish (21%), black rockfish (12%) and kelp greenling (11%). Although jig fishing targeted on black rockfish, the most abundant species was blue rockfish (*S. mystinus*) (44%), followed by black rockfish (22%), yellowtail rockfish (*S. flavidus*) (14%) and canary rockfish (11%). In Area 2 (Figure 2.2.5), a total of 10 species plus juvenile rockfish were observed using the ROV, while 7 species and no juvenile rockfish were caught by jig fishing (Figure 2.2.7). The predominant species observed with the ROV was black rockfish (65%), followed by juvenile rockfish (33%) and kelp greenling (10%). The predominant species caught by jig fishing was black rockfish (58%), followed by blue rockfish (28%) and yellowtail rockfish (9%).

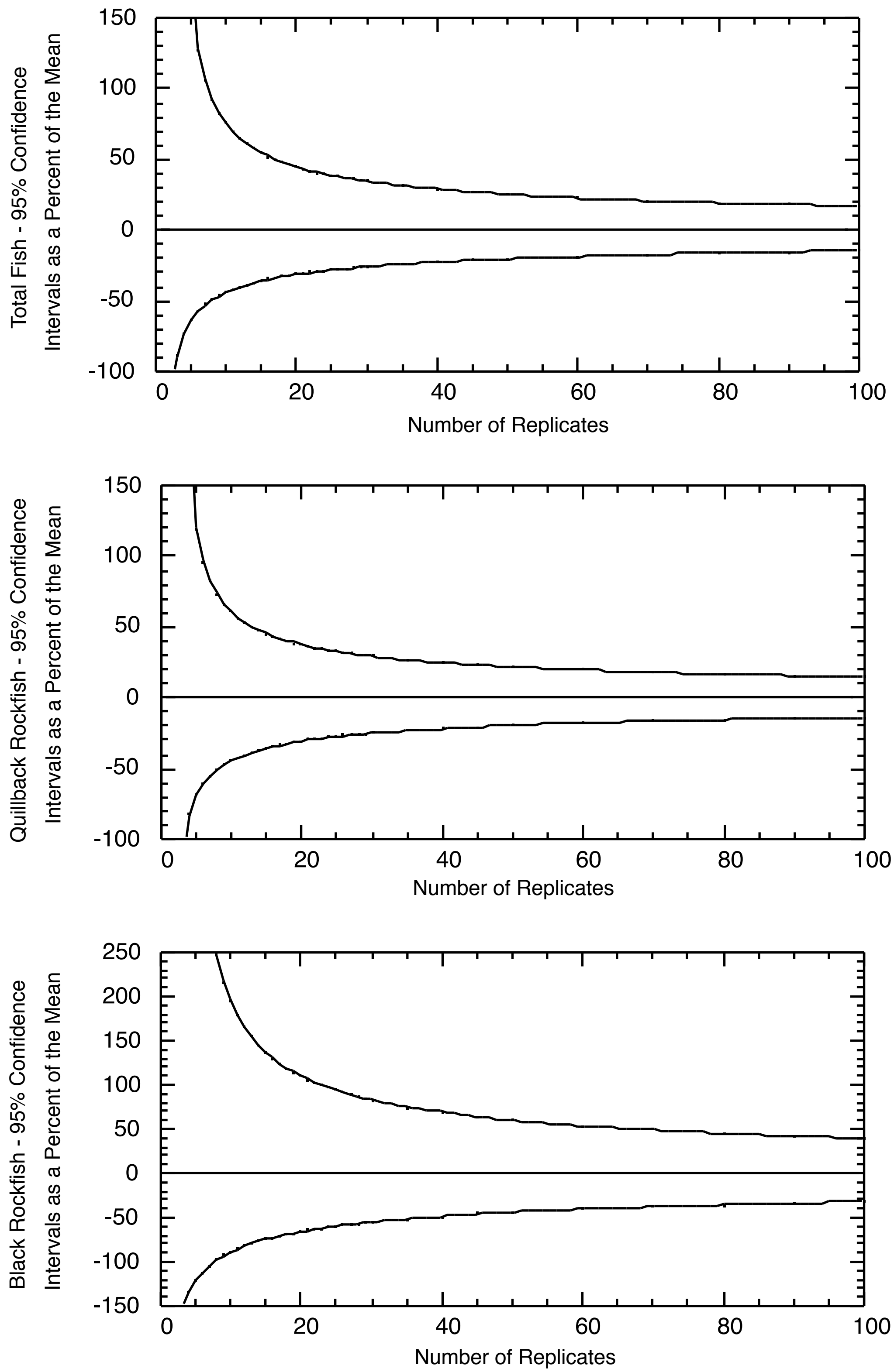


Figure 2.2.2. Estimated 95% confidence intervals expressed as a percent of the mean as a function of transect sample size.

Table 2.2.2. 95% confidence intervals (CI) expressed as a percent of the mean for three sample size scenarios.

Species or Group	95% CI as % of mean for n = 10		95% CI as % of mean for n = 20		95% CI as % of mean for n = 30	
	upper	lower	upper	lower	upper	lower
Total Fish	75	44	45	31	34	26
Total Adult Fish	59	38	36	27	28	22
Total Adult Rockfish	61	39	37	28	29	23
Total Non-Schooling Adult Fish	79	47	47	33	36	28
Total Schooling Adult Rockfish	56	38	34	26	26	21
Total Non-Schooling Adult Fish	101	56	59	40	45	33
Black Rockfish	195	89	110	66	83	55
Canary Rockfish	81	49	48	35	37	29
Copper Rockfish	54	47	34	31	27	25
Kelp Greenling	52	40	33	27	26	22
Juvenile Rockfish	170	75	95	56	72	47
Lingcod	78	57	48	39	38	32
Quillback Rockfish	61	44	38	31	29	25
Yelloweye Rockfish	139	98	86	68	67	55
Yellowtail Rockfish	212	119	125	86	96	71

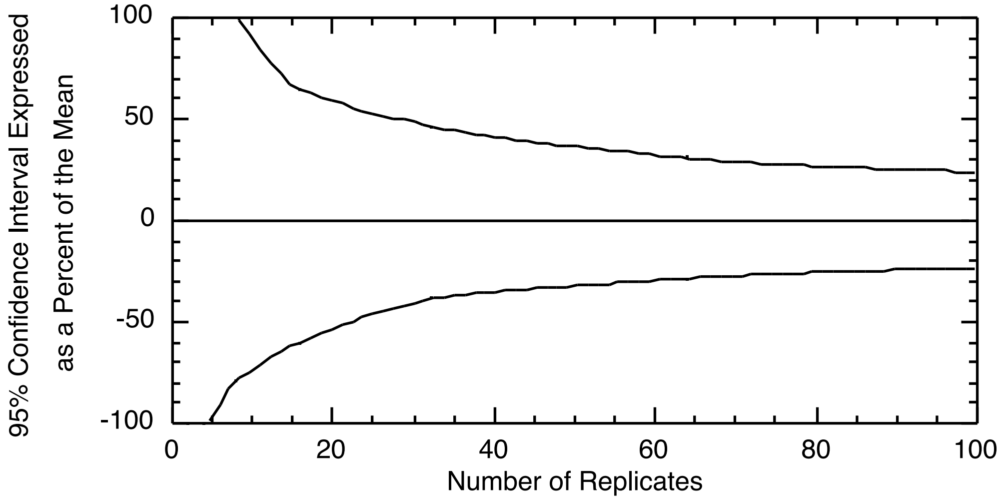


Figure 2.2.3. Estimated 95% confidence intervals expressed as a percent of the mean as a function of video frame sample size. Based on total fish in transect 1.3b.

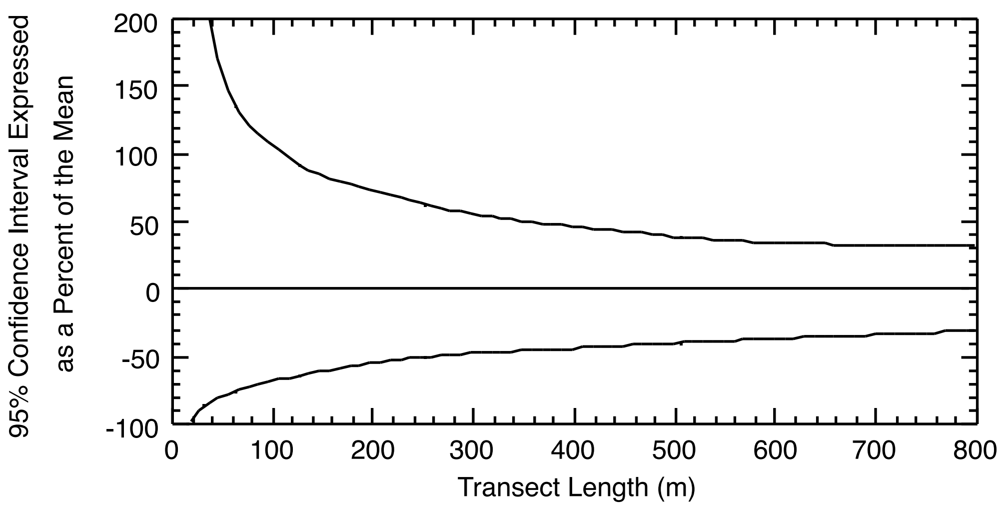


Figure 2.2.4. Estimated 95% confidence intervals expressed as a percent of the mean as a function of transect length. Based on total fish in transect 2a.

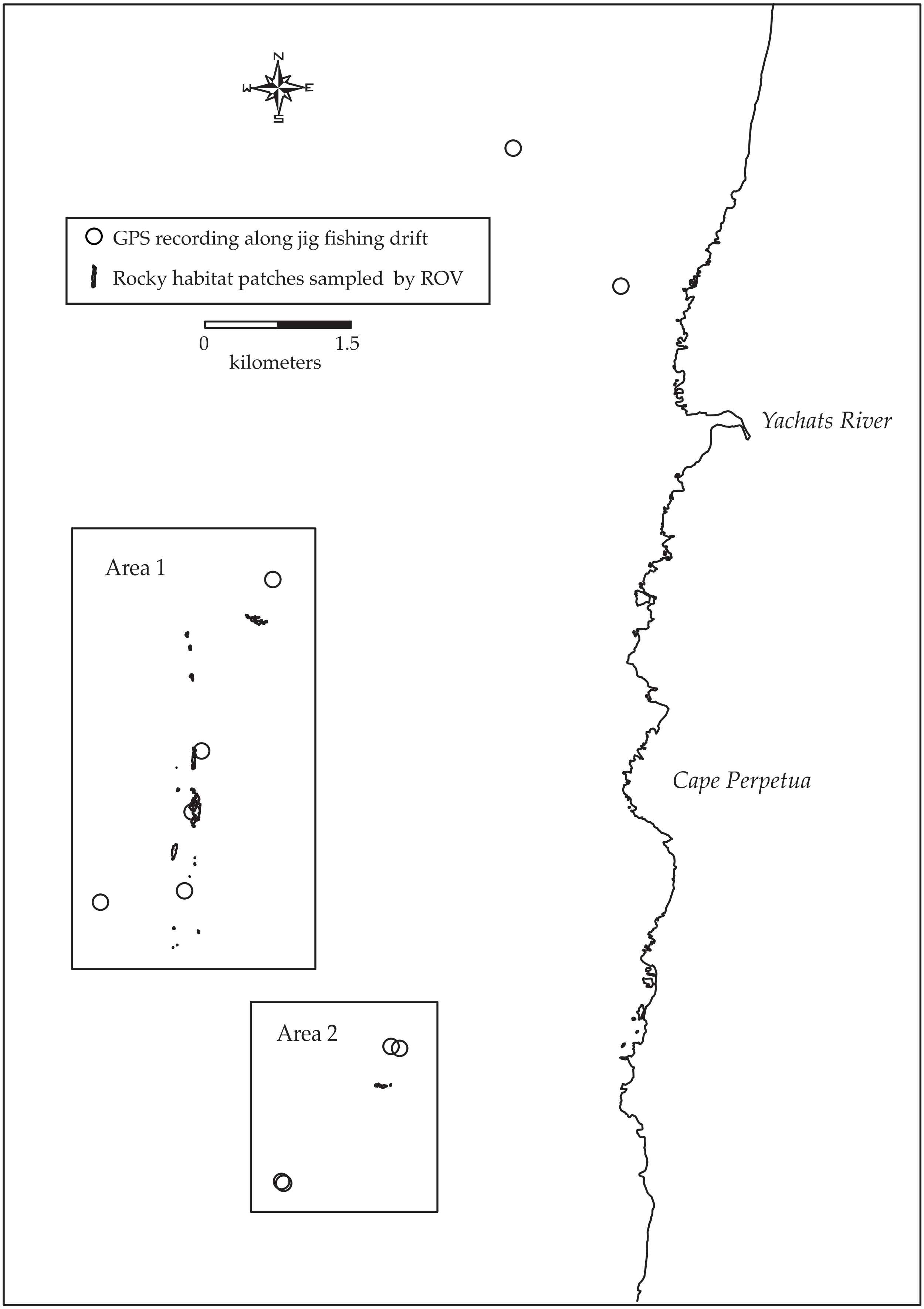
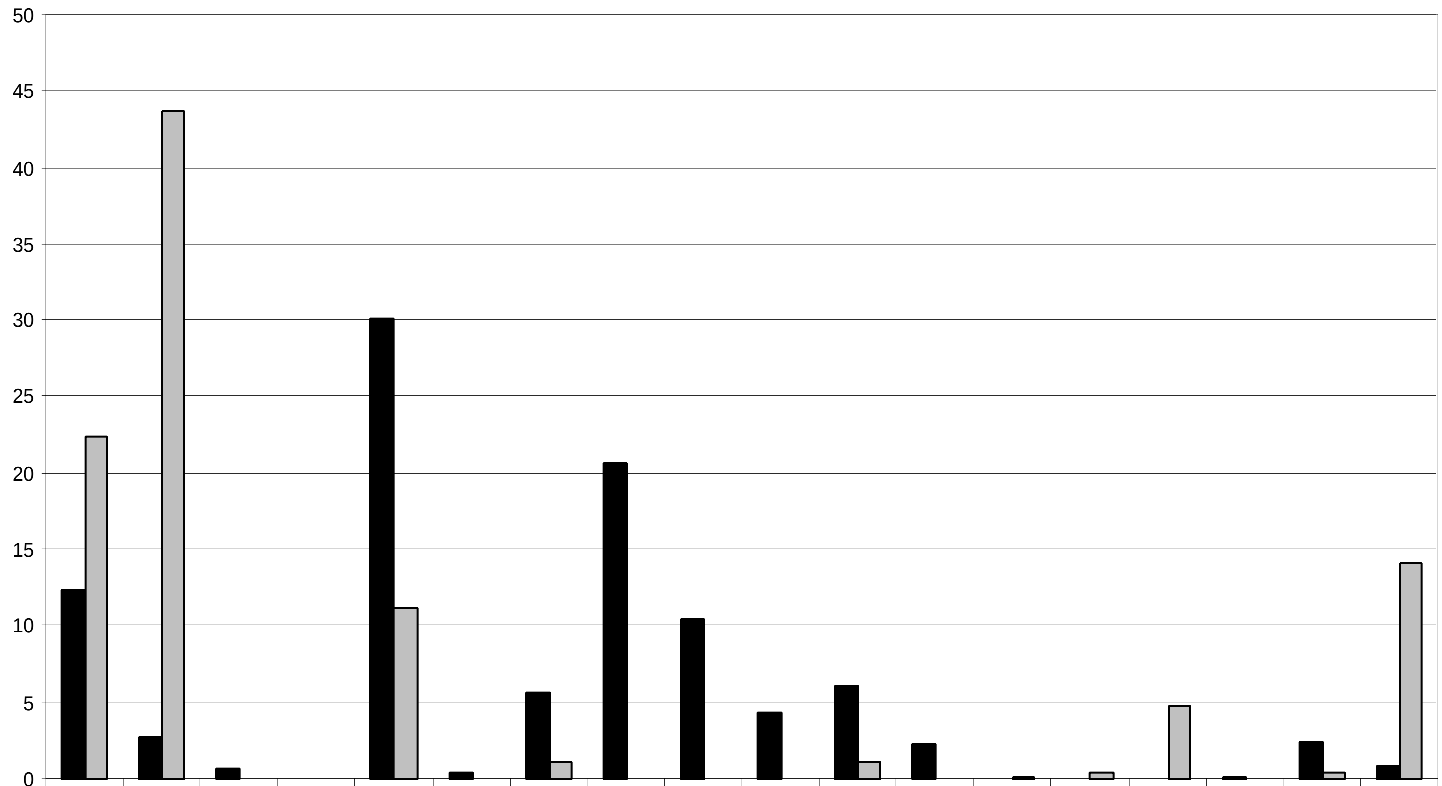
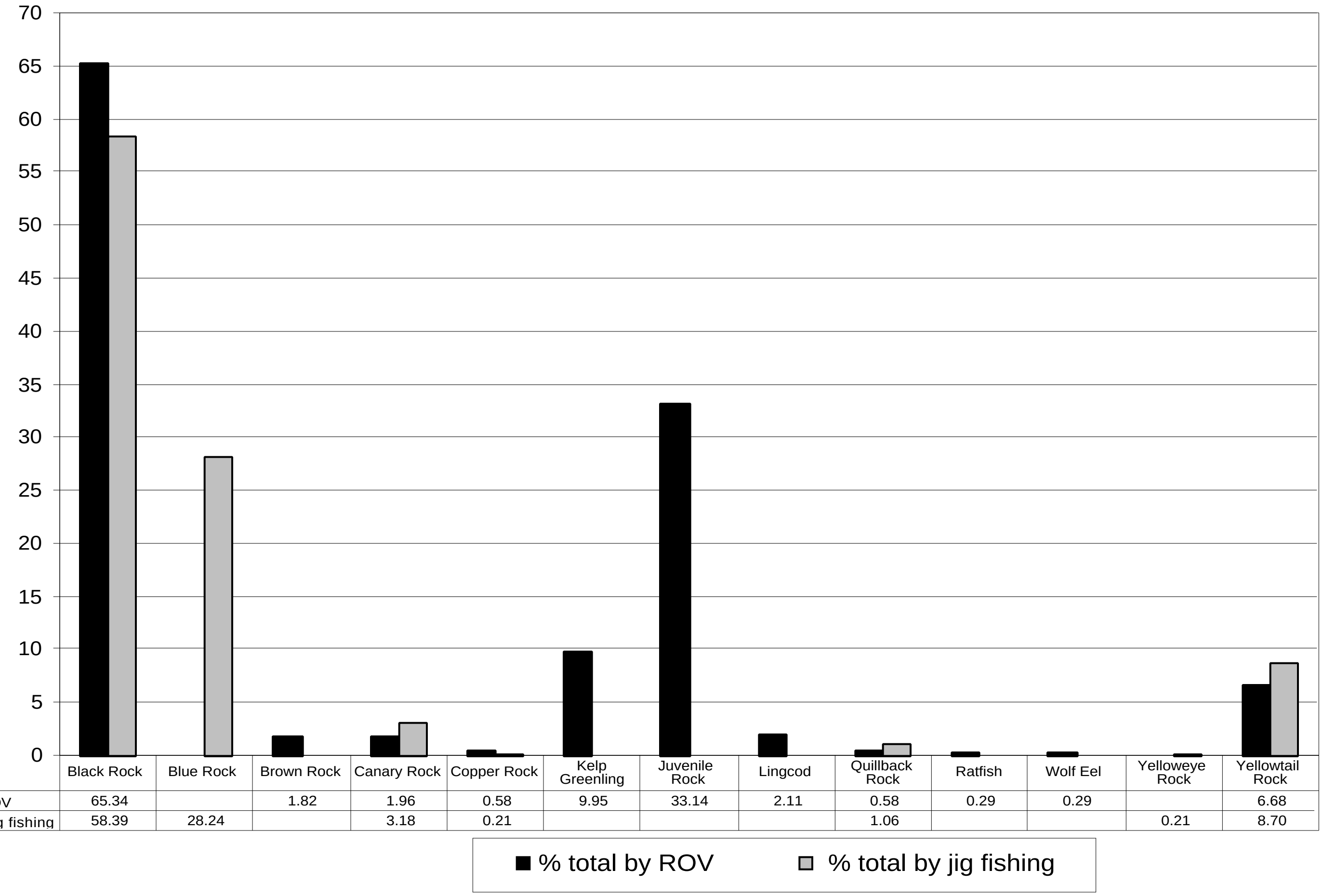


Figure 2.2.5. Nearshore sampling sites for jig fishing and ROV transects.



	Black Rock	Blue Rock	Brown Rock	Cabezon	Canary Rock	China Rock	Copper Rock	Juvenile Rock	Kelp Greenling	Lingcod	Quillback Rock	Ratfish	Stripetail Rock	Vermillion Rock	Widow Rock	Wolf Eel	Yelloweye Rock	Yellowtail Rock
% total by ROV	12.46	2.77	0.80	0.04	30.13	0.44	5.65	20.77	10.52	4.35	6.07	2.39				0.14	2.52	0.91
% total by jig fishing	22.38	43.71			11.26		1.19				1.19		0.13	0.40	4.77		0.40	14.17

Figure 2.2.6. Comparison of species composition in Area 1 for ROV and jig fishing methods.



	Black Rock	Blue Rock	Brown Rock	Canary Rock	Copper Rock	Kelp Greenling	Juvenile Rock	Lingcod	Quillback Rock	Ratfish	Wolf Eel	Yelloweye Rock	Yellowtail Rock
% total by ROV	65.34		1.82	1.96	0.58	9.95	33.14	2.11	0.58	0.29	0.29		6.68
% total by jig fishing	58.39	28.24		3.18	0.21				1.06			0.21	8.70

Figure 2.2.7. Comparison of species composition in Area 2 for ROV and jig fishing methods.

3. Multibeam Bathymetry Survey at Bandon

During the early portion of the 2000 field season, a charter-vessel bottom fishing survey was performed by ODFW in the Bandon and Cape Arago region of the southern coast. The intent of this survey was to collect biological data on black rockfish as a contribution to the current stock assessment being performed by the PFMC. The Marine Habitat Project collaborated with this survey in two ways: (1) collecting real-time geographic positioning while simultaneously collecting species catch information, and (2) designing a multibeam bathymetry survey area based on fishing locations.

3.1 Methods

3.1.1 Fish Catch Locations

The charter survey was structured as a drift-based sampling scheme targeting areas where black rockfish were known to exist. Approximately 15 volunteer anglers were aboard the vessel (*F/V Betty Kay*) on each day. The Bandon region was fished for 3 days, sampling approximately 15 "spots". The location of a "spot" was determined by the boat captain. The vessel would set itself upwind of an area, turn off the engine, and drift downwind through a potential fish-bearing site. Anglers had three hooks for each line, using a standard lure on each hook (Bodenmiller 2000). The drift was completed when either the fish “bite” was continually low or the captain decided we were off the targeted site. During fishing activity, vessel position was constantly recorded with the hydrographic/ navigation software Hypack, connected to the vessel's GPS. When a fish was pulled out of the water, the type and number of fish caught was logged while at the same time a geographic position was marked. One observer performed these tasks from a central point within the boat’s cabin and therefore 100% coverage of fishing activity was not feasible. The middle to rear sections of the vessel received the most attention. Monitoring of fishers from the front of the vessel was limited by viewing angle from within the cabin.

Each fish caught was considered a "sample" for the charter fishing survey. Unfortunately, the resulting biological data collected from each sample was not tied to the logged position. The extent of the information collected at each logged geographic position consisted of observations of species and number of fish. A comparison of the observed catch versus the actual catch sampled will address the effectiveness of single-person observations and data logging.

Upon completion of the charter fishing survey, an areal polygon was developed around the fishing locations. This polygon was used as the boundary for the contracted multibeam survey. Existing bathymetric data from within that polygon was also extracted from the National Geophysical Data Center, National Ocean Service (NOS), NOAA hydrographic database to examine coverage of potential rocky habitat.

3.1.2 Multibeam Survey

The multibeam bathymetry survey was conducted in August 2000, using methods similar to those used in the 1999 survey of Orford Reef (Fox et. al, 1999). An exception to the methodology was the installation of a tide gauge at the Port of Bandon. The nearest tide gauge to the region was in Charleston, 26 km away. Seavisual Consulting, Inc. conducted the survey, chartering the *F/V Mad Dog* as the survey vessel. A Reson Seabat 8101 Multibeam Sonar was used to collect soundings in the designated survey area . The final product (2m gridded bathymetry model) was delivered on CD-R media. We developed bathymetric models using methods similar to those described in Fox, et al. (1999).

3.2. Results and Discussion

3.2.1 Fish Catch Locations

A summary of the drift catch information is shown in Table 3.2.1. The overall coverage of fish observed for position logging (n = 717) was 84% of the total fish caught (n = 854). The limitations of both having one observer and having to remain indoors (to keep the data-logging computer dry) account for this disparity. With the exception of blue, yellowtail, and China rockfish (S. nebulosus), at least 90% of each individual species caught were observed for position logging. Blue rockfish were often caught in high numbers, and logging all individuals' positions was impossible. Both yellowtail and China rockfish were not as high in abundance, so an overlooked sample may have a large effect on overall percent coverage.

Table 3.2.1. Comparison of fish catch observed during geographic position monitoring and fish samples collected.

Species	# Positions	# Fish Observed	# Fish Caught	Coverage (%)
Black	202	343	366	93.72
Blue	133	326	436	74.77
Canary	11	12	13	92.31
Yellowtail	8	9	15	60.00
China	3	3	4	75.00
Quillback	1	1	1	100.00
Vermillion	9	9	9	100.00
Greenling	9	9	10	90.00
Lingcod	5	5	0	-
Combined	381	717	854	83.96

Fish catch locations are shown in Figure 3.2.1. Catch location of black rockfish and blue rockfish where the catch was greater than 2 fish is shown to represent dense schools of these fish. The spatial distribution of black rockfish (>2) catch is slightly different from blue rockfish (>2) catch, occurring in the most nearshore drifts. Other species were so low in catch abundance that their spatial distribution could not be determined

Further analysis of this type of data may provide a better understanding of the distribution of fishing effort across a reef. Geographic coverage of fishing effort on charter boats is a useful way to gather habitat boundary information. Suitable fish habitat can be expected to occur where fishing effort occurs. The polygon developed for the multibeam survey (Figure 3.2.1) encompasses this particular fishing effort, targeting black rockfish.

3.2.2 Multibeam Survey

Pre-existing NOS bathymetric data within our multibeam survey region are shown in Figure 3.2.2. The highest density of soundings occurs in the shallowest regions, because the intent of the original surveys was to develop charts for safe navigation. Rocky areas are evident in the area of dense survey data points, and can be interpolated to illustrate this even further. However, in the area of sparse data points, it is impossible to discern any kind of bottom structure. The extent of the fish catch information (Section 3.2.1) would suggest that the available rocky habitat extends further out to the points of lowest density, to the north and south of the Coquille Point area.

A 2m x 2m resolution gridded bathymetry model based on our multibeam survey data is shown in shaded relief color in Figure 3.2.3. As expected from the fishing "spots", there is rock structure throughout the survey area. A very large uplifted and convoluted section of the seafloor surrounds a mostly flat section of sediment for the length of the area. The inshore washrocks and islands around Coquille Point extend into the center as subsurface pinnacles and isolated rock patches.

The presence of such striking geology over an area where nautical charts suggest a somewhat regular bottom illustrates the lack of habitat information that exists for the nearshore. This example will continue to repeat over and over again as we begin to develop more detailed maps of Oregon's nearshore rocky reefs.

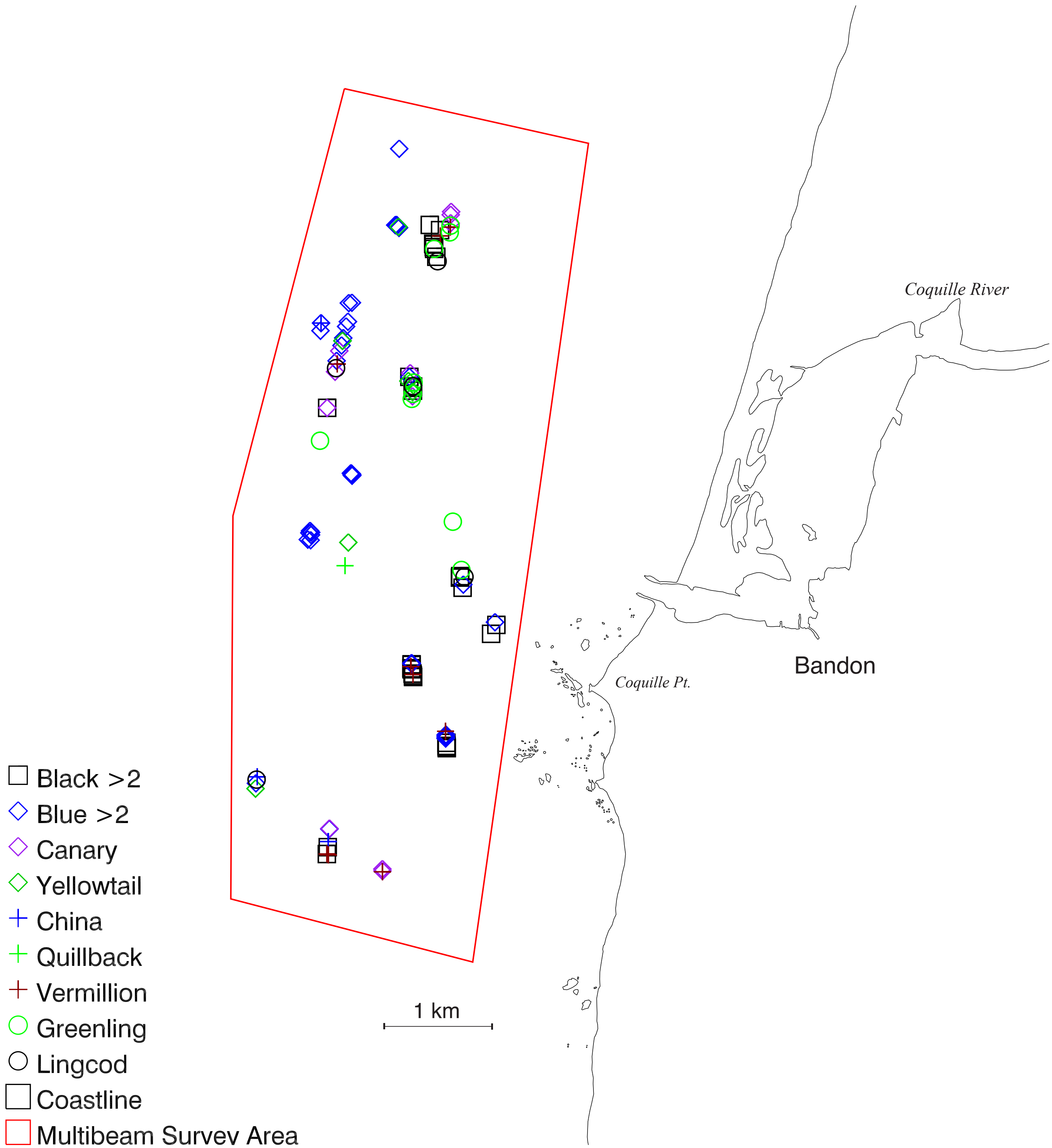


Figure 3.2.1. Individual fish catch locations from ODFW 2000 Nearshore Charter Survey. With the exception of Black Rockfish and Blue Rockfish, each location represents no more than 2 fish caught. The multibeam survey area was constructed to encompass these locations.

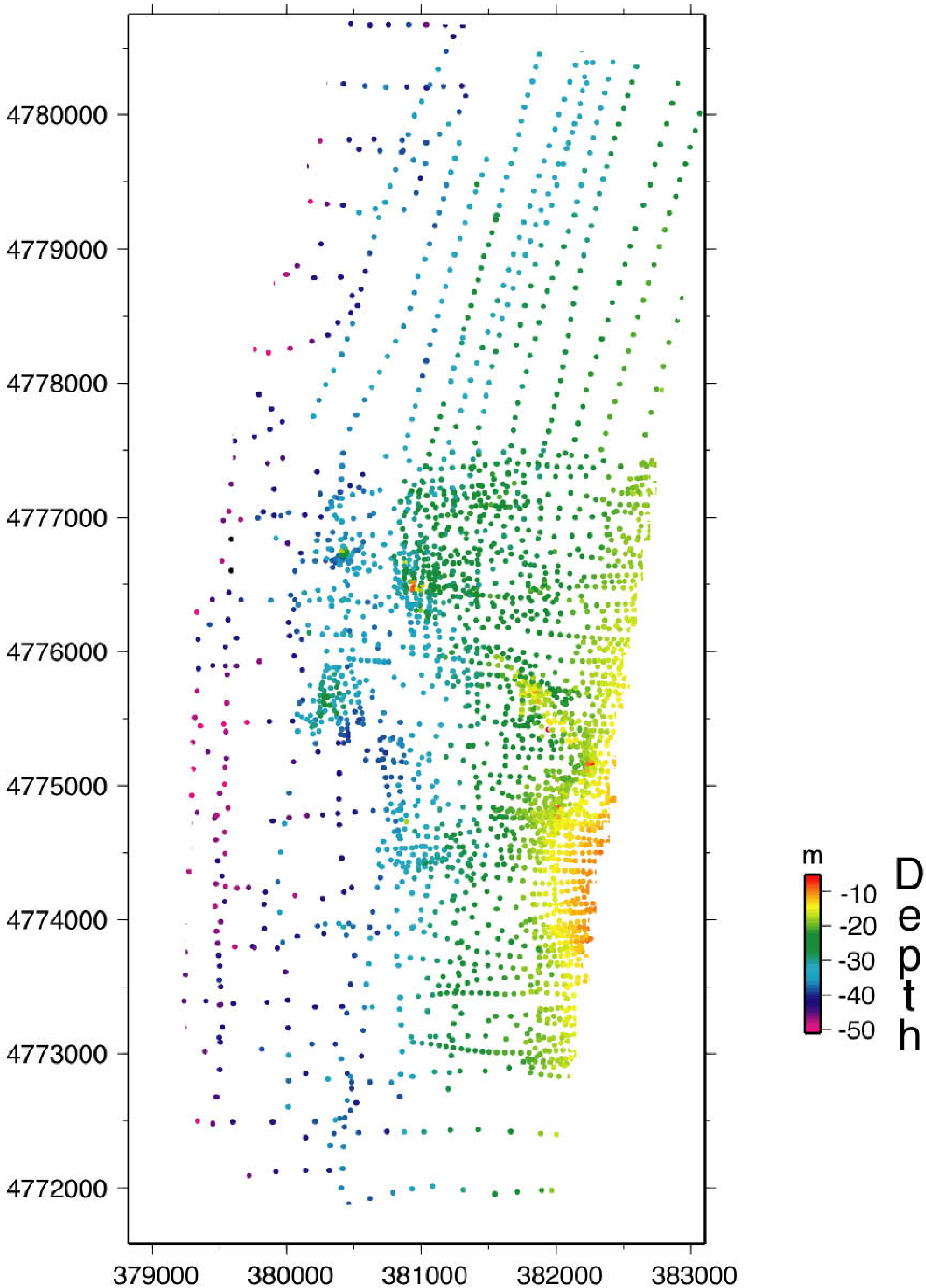


Figure 3.2.2 Existing National Ocean Service hydrographic data within the multibeam survey area. Coordinates are in meters (UTM Projection, WGS-84). Note: data point radius ~40 m.

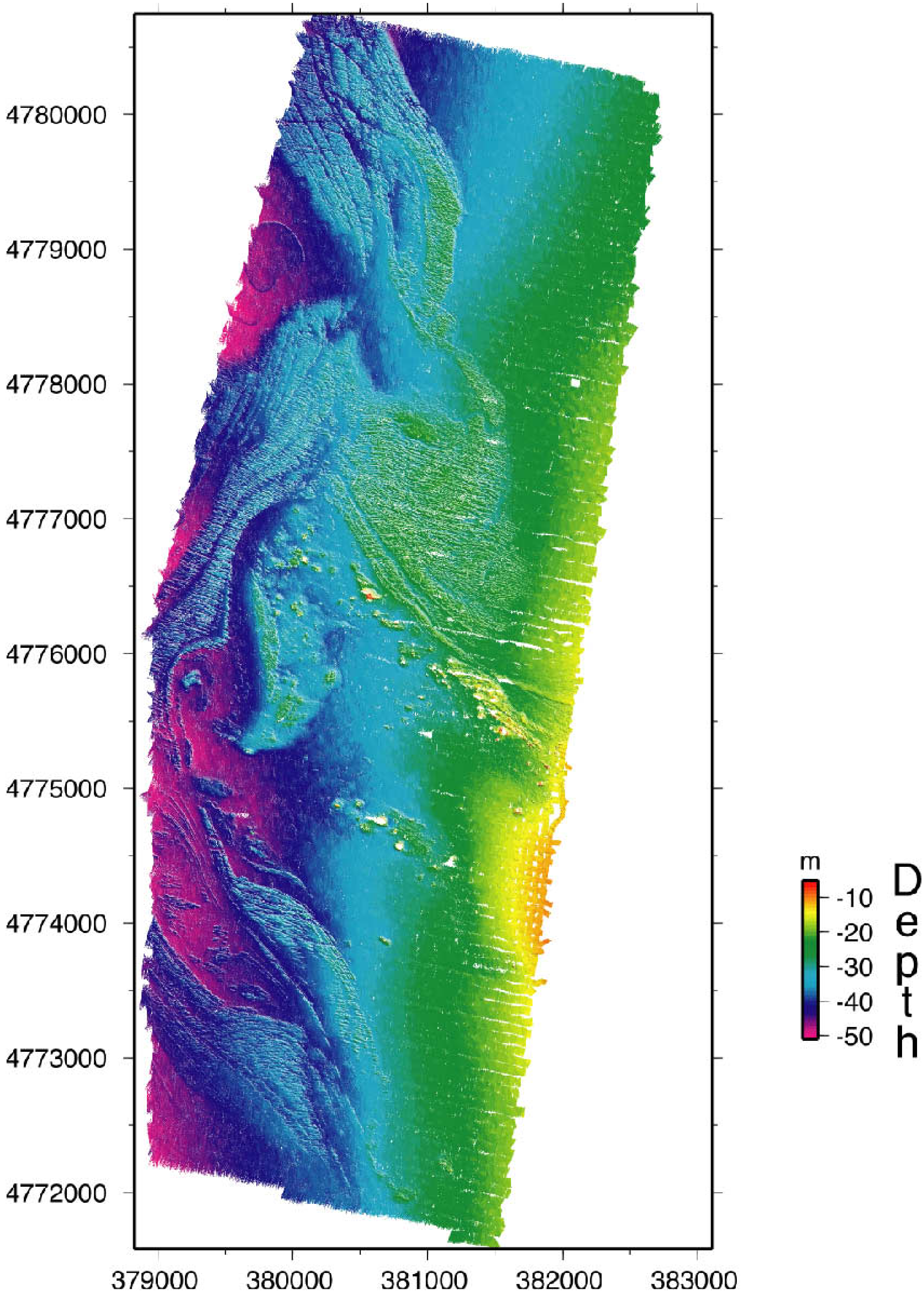


Figure 3.2.3. 2m gridded bathymetry model, resampled for presentation, generated from the multibeam survey. Coordinates are in meters (UTM projection, WGS-84)

4. Management Analysis

4.1 Background

In January 2000, NMFS declared a commercial fishery failure in the West Coast groundfish fishery. This is known in the fishing community and media as the "Groundfish Crisis". Much of the crisis results from a lack of information for making prudent management decisions. Innovative solutions are now needed to recover from the crisis. The lack of scientific information available to address current management needs is particularly evident for nearshore reefs. Data gaps occur at the population, species, and ecosystem levels. Examples of missing information include:

- stock assessments on most species of nearshore fish,
- adequate maps of the location, extent, and composition of reefs,
- reef-specific and coastwide demographic information on many of the harvested fish species,
- fishery monitoring on a reef-specific basis,
- fishery-independent population estimates, and
- a management model that accounts for both the biological and socio-economic characteristics of the nearshore reef fisheries.

Clearly, an integrated research effort is needed to develop information required to meet new management challenges. The information gaps listed above cover a broad spectrum of data types including populations statistics, habitat inventories, fishery-dependent information, fishery-independent information, economic data, and social information. ODFW's Marine Resources Program is developing a nearshore management and research plan to begin addressing these information needs. The Marine Habitat Project is currently addressing the habitat component of information gathering, and is working with other Marine Resource Program projects to develop new fish inventory tools.

Two high priority information needs in the nearshore include assessing the status of fish stocks and developing marine protected area policy. Both of these have significant habitat inventory components. Work accomplished during 2000 continues to address these needs, as described below.

4.2 Assessing Fish Stocks

Most nearshore rocky reef fish species are not formally assessed in the PMFC fishery management process. Managers, therefore, have no estimates of stock status to support management actions. Stock assessments require a suite of information, including data on fish removals and population demographics. One key piece of information required is fishery-independent population estimates, used to tune and verify population models. The continental shelf and slope fisheries rely on large-scale NMFS trawl surveys to develop fishery-independent population estimates. No such survey exists for the nearshore area. In addition, rocky reefs are particularly difficult to sample because of limitations to the type of fish sampling gear that can be used on rugged seafloor environments. Alternative survey options include hook and line sampling, visual surveys, and, for some species, hydroacoustic surveys.

We have been exploring visual and hook and line survey techniques. This report summarizes our first field season using an ROV to quantitatively sample fish. The ROV performed well and could prove an efficient sampling tool. During 2000, a separate group within the ODFW Marine Resources Program performed a pilot project to test fish sampling effectiveness with longline and cable gear. Although the data have not yet been analyzed, these gear types will probably also prove to be efficient sampling tools. The visual ROV methods appear to adequately sample non-cryptic species that generally stay within about 2 m of the bottom. We consider visual data for these species to be more representative of actual abundances than hook and line sampling because the visual data are not subject to size and feeding behavior selectivity characteristic of hook and line gear. However, cryptic species such as cabezon (*Scorpaenichthys marmoratus*) are poorly sampled with visual techniques, but appear to be well sampled with hook and line gear. Species that tend to school above the bottom, such as black rockfish, may be better sampled with hydroacoustic gear or an indirect technique. Both visual and hook and line survey techniques can be used to monitor trends in relative fish abundance over time. Visual techniques can provide fish density estimates, whereas, density computations are difficult with hook and line data because of difficulty in determining fish catchability. Using rocky reef habitat and surface area data, the density values from visual data can be expanded to population estimates. It is likely that a combination of all gear types will provide the best estimates of nearshore rocky reef fish population abundance.

4.3 Information for Marine Protected Area Policy

Management entities considering Marine Protected Areas (MPA) have supported the principle that designation of protected areas should be guided by specific goals and be based on scientific information. Designing a MPA program for nearshore reefs will entail reviewing the entire pool of reef areas along the coast and selecting candidates based on selection criteria designed to achieve stated goals. To accomplish this, reef areas need to be classified, compared, and contrasted based on biological, physical, and socio-economic information.

The primary categories of information needed for MPA development include:

1) location, extent, and physical structure of the reefs,
2) biological characteristics of reefs,
3) oceanographic influences on the reefs,
4) biological linkages among reefs and other ocean areas,
5) fishery uses,
6) non-fishery uses,
7) human impacts of reefs, and
8) social and economic characteristics of individuals and coastal communities utilizing the reefs.

Each of these categories encompasses a number of data types, and the total range of data types covers a broad spectrum of availability, format, and accessibility. Some of the data types can be developed using existing information, while others require gathering new information. For example, existing fishery information can be synthesized to describe fishery use on nearshore reefs. Some of the biological characteristics of reefs, such as location of kelp beds, have already been described, while others, such as characteristics of fish and invertebrate communities require collection of new data in the field.

The Marine Habitat Project is currently mapping nearshore reefs and developing information on reef physical and biological characteristics, mostly on a small scale. The 2000 project answered questions about the use of small isolated rocky reefs by rockfish. Future nearshore reef survey efforts need to be expanded to cover the entire Oregon coast. We are currently involved in developing collaborative efforts with Department of Land Conservation and Development, Oregon Ocean Policy Advisory Council, Oregon State University, and NOAA to expand our nearshore reef characterization efforts.

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