Coastal Zone Management Section 309 Grant:

2002 Nearshore Rocky Reef Assessment ROV Survey

Final Report for 2002 Grant
Cooperative Agreement [1-1149C]

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Marine Program

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Acknowledgements

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1. Introduction

For several years Oregon's nearshore environment and the living marine resources that inhabit it have received steady pressure from a myriad of sources. Declining offshore fisheries continue to contribute to the increase in fishing pressure on nearshore species. New fishery regulations have closed extensive offshore areas to trawling and that pressure will undoubtedly shift to the nearshore environment where rocky reef habitats are vulnerable to degradation. Declines in nearshore fisheries, such as the salmon and urchin fisheries, and the addition of the new and expanding live-fish fishery also increase demands on nearshore rockfish populations. Non-fishery pressures, such as dredge material disposal, mineral and gas exploration and extraction, and oil spills compromise the health and viability of the nearshore ecosystem. Oregon must work to conserve the state's resources by balancing harvest yields, habitat altercations and environmental uses with ecosystem health and functionality.

Of primary concern is the rocky reef environment where pressures are most notable and habitat is not only limited, but vulnerable to degradation. Since the early 1990's, Oregon Department of Fish and Wildlife (ODFW) has been gathering information about rocky reef habitats and the fish, invertebrate and plant species that reside there. The importance of habitat to reef species cannot be over-stated and is now widely accepted in the scientific community and is the focus of major research efforts in other Pacific coastal states. The degree to which species-habitat relationships is understood by resource managers is essential to protecting critical habitat, developing population indices for species at risk, and maintaining a healthy and productive sustainable system.

The ODFW, Marine Habitat Project has spent the last 8 years working in cooperation with scientists and other resource agencies to develop methods for classifying and mapping nearshore rocky reefs habitats off Oregon. To date, eight reefs have been surveyed and mapped with sidescan and/or multibeam bathymetry at a resolution indicative of fish habitat. ODFW has also been developing non-extractive fish survey techniques to describe fish-habitat associations and estimate fish abundance at the habitat and reef scale. As fish-habitat relationships become better understood it is presumable that we can extrapolate this knowledge to less familiar nearshore reefs and ultimately develop fish abundance estimates for all nearshore rocky reefs in Oregon.

In 2002, we conducted the third annual ROV survey at Cape Perpetua Reef and a second ROV survey at Siletz Reef. This report summarizes work at Siletz Reef. Also in 2002, under a companion grant, we conducted a sidescan sonar survey of Siletz Reef. The resulting map facilitated the sampling design of this study's ROV survey. In 2003 we will contract a high-resolution multi-beam sonar survey of Siletz Reef. Habitat information collected in the ROV survey will aid in ground-truthing the multibeam sonar data.

2. Methods

2.1 ROV Survey

ROV surveys at Siletz Reef were completed on July 13, August 26, 27 and 28, and October 4, 5 and 6, 2002. A total of 39 ROV transects 500 meters in length were stratified by two parameters; depth range and bottom relief, with each parameter having two levels. Depth range was classified as either deep (30-60 meters) or shallow (5-30 meters). Bottom relief was classified as either high or low relief as determined by side scan sonar imagery. A sidescan sonar survey was conducted on Siletz Reef in 2002 following methods similar to those described in Amend, et al. (2001) with minor differences. The Siletz sidescan sonar survey was conducted at a frequency of 10 kH_2 and was conducted aboard the R/V *Elakha*. A map of the survey area is presented in Figure 1.

The ROV video survey, including data retrieval and processing followed procedures described in Fox, et al. (2000 and 2001). The ROV survey consisted of continuous video coverage along a transect. Fish and habitat data observation and recording methods also followed methods described in Fox, et al. (2001). 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 species grouped together. The classification system and techniques for describing bottom habitat are described in Fox, et al. (2001). Two additional habitat types, vertical and crevice, were added in this year’s study. In total, eleven habitat types were identified in the survey. Data feeds from the ROV to the video included time and geographic position. Data recorded during video review were fish taxa, fish count, bottom habitat type, and schooling behavior. All data were synchronized by time.

2.2 Data Analysis

For the analyses presented here video fish counts were converted to fish density (no. fish/100m^2). Habitat area (100 m^2) was calculated in the same manner as described in Fox, et al. (2000).

Analyses of these data occurred at two habitat scales, referred to as “coarse scale” and “fine scale”. The coarse scale analysis compares fish density at high and low relief and is based on the sidescan sonar imagery. The fine scale analysis compares fish density among eleven discrete habitat types and is based on video observations. For comparative purposes, large boulder, sloping-high relief bedrock, level-high relief bedrock, sloping-low relief bedrock, and crevice habitats equate to high relief habitat in the coarse scale analyses. Small boulder, cobble, gravel and level-low relief bedrock equate to low relief habitat in the coarse scale analysis. Statistical analyses were performed on coarse scale data only. Fine scale analyses consist of graphical and geospatial analysis.

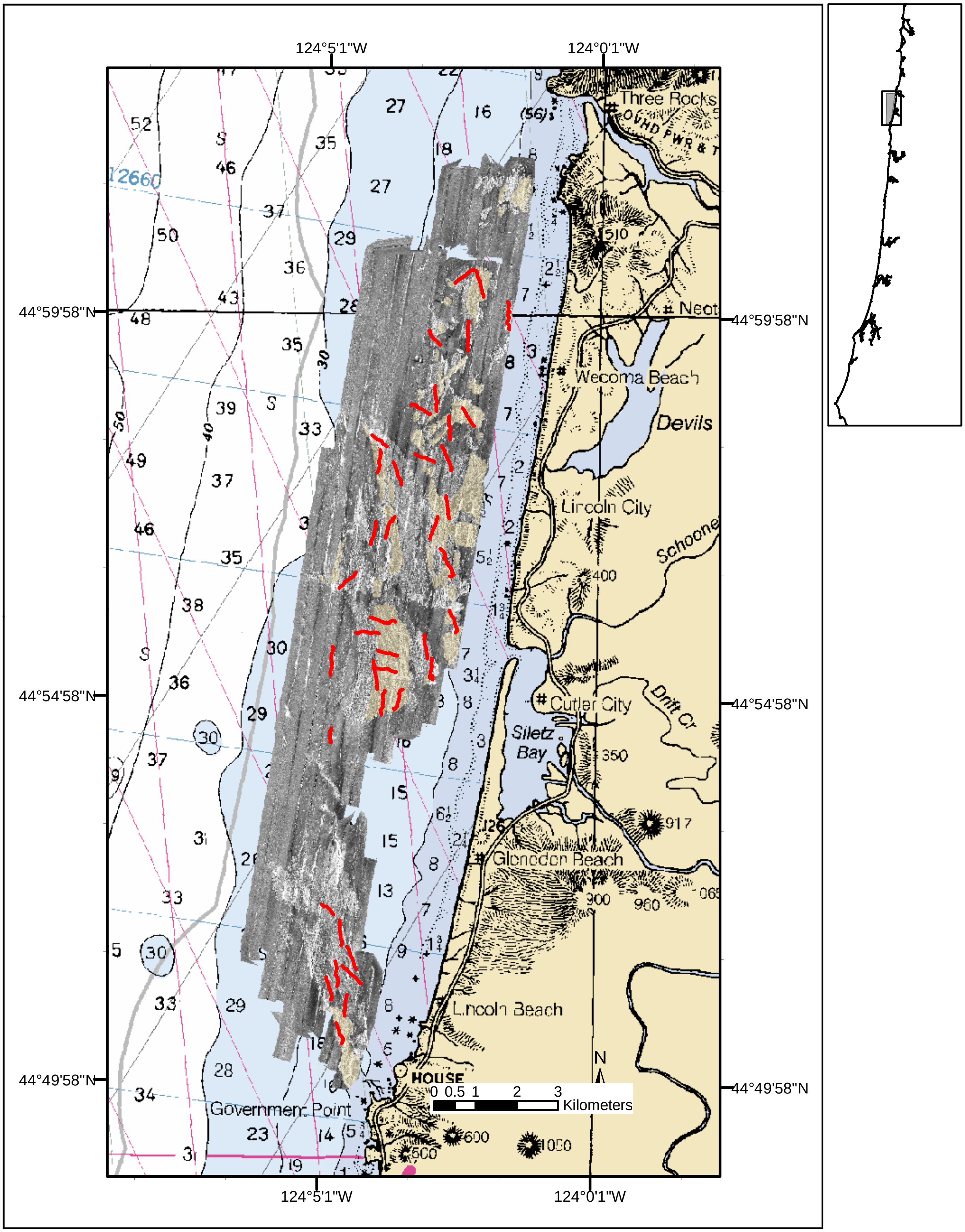

Figure 1. Map of Siletz Reef study area with sidscan sonar survey of reef (gray area). The sidescan image displays rock substrate as light gray or white. Shaded areas represents high relief habitat interpreted from the sidescan image. Red lines represent ROV video transects.

The effect of depth and bottom relief on species density was examined using analysis of variance (ANOVA) on log-transformed densities. Species that did not meet the assumption of normality for ANOVA were tested using the non-parametric, Mann-Whitney U test. Species or groups tested with ANOVA are black rockfish, kelp greenling, lingcod, schooling rockfish, and benthic rockfish. Species or groups tested with Mann Whitney-U test are blue rockfish, canary rockfish, yelloweye rockfish, yellowtail rockfish and juvenile rockfish.

2.3 Transect reclassification

As mentioned above transects were stratified for relief based on sidescan sonar imagery. During data processing it was apparent that for seven of the 39 transects the sidescan sonar classification of relief was not consistent with the relief observed in the video. The video enabled us to see all the actual habitat types that occurred along a transect and for these seven transects, the actual habitat types did not coincide with the sidescan interpretation of relief. In these seven cases we re-classified transects to represent the dominant relief type (>50%). Three transects initially classified as high relief actually had a greater percentage of low relief habitat, and were reclassified accordingly. Conversely, four transects initially classified as low relief had a greater percentage of high relief habitat and were reclassified as high relief. One transect was eliminated from the analyses of relief because it contained equal amounts of high and low relief habitat. This resulted in 19 high relief transects and 19 low relief transects. The reclassification only affected the coarse scale analysis for relief. Analysis of relief on species density was performed on both the original and reclassified data.

3. Results

3.1 Coarse Scale Analysis

The reclassification of seven transects for habitat relief resulted in minor differences in the results of the analysis. The interactive effect of depth and relief was significantly different for black rockfish for the original transects, but not significantly different for the re-classified transects. No other species showed a difference in these results, however, mean densities and standard deviations varied slightly for all species. The absence of any real affect of reclassifying transects on statistical analyses may be explained by the fact that even though seven transects were reclassified, the resulting number of high relief transects only decreased by one and the resulting number of low relief transects remained the same. Although differences were minor, the resolution at which habitat relief is delineated for the purpose of designing habitat-dependent fish surveys should be considered in the planning of future ROV surveys. In this survey, the coarse scale habitat delineation was valid for survey design.

The most abundant species in the survey was black rockfish making up 23% of the total fish abundance. Blue rockfish, kelp greenling and juvenile rockfish followed at

14%. Canary rockfish and lingcod each made up approximately 9%, with yellowtail rockfish at 3%. Other species that occurred only rarely and less than 3% of the total are China rockfish, copper rockfish, yelloweye rockfish, quillback rockfish, skates, sculpins, ratfish and flatfish. These rarely occurring species were excluded from the analyses, with the exception of yelloweye rockfish.

The interactive effect of depth and relief was not significant for the species tested. When testing for only depth, black rockfish was the only species that showed a significant difference ($p=0.0044$) (Figure 2). Descriptive statistics for fish density by depth are presented in Table 1.

The effect of bottom relief was much more notable. Fish density was significantly higher in high relief habitats for blue rockfish, kelp greenling, juvenile rockfish, total rockfish and schooling fish, ($p<0.05$) (Figure 3). Canary rockfish, yelloweye rockfish and yellowtail rockfish had higher densities in low relief habitat than in high relief habitat, though not significant. Descriptive statistics for fish density by relief are presented in Table 2.

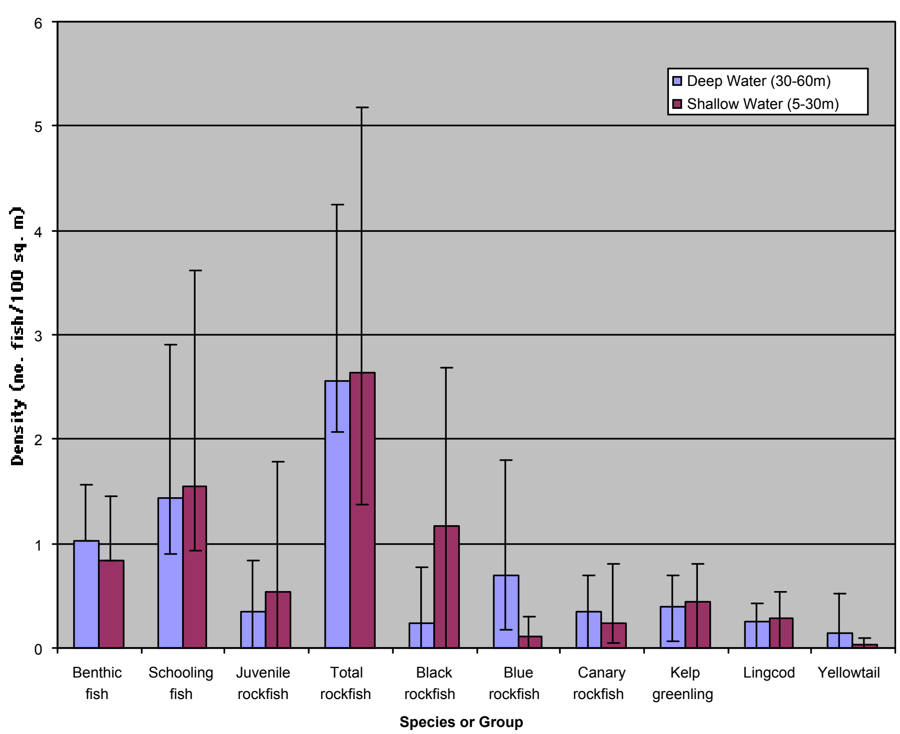

Figure 2. Graph of densities in deep and shallow water on Siletz Reef. Error bars denote standard deviation.

Table 1. Descriptive statistics for fish species and groups in deep (30-60 m) and shallow (5-30 m) water.

	Deep Water (n=21)		*Shallow Water (n=18)*		
Fish Species or Group	*Mean Density (no. fish / 100m²)*	*Std. Dev.*	*Mean Density (no. fish / 100m²)*	*Std. Dev.*	*p- value*
Benthic fish	1.034	0.532	0.839	0.614	
Schooling fish	1.439	1.463	1.553	2.066	
Total fish	2.908	1.842	3.165	3.395	
Juvenile rockfish	0.352	0.483	0.529	1.258	
Total rockfish	2.556	1.689	2.636	2.549	
Black rockfish	**0.239**	**0.529**	**1.172**	**1.505**	**0.0054**
Blue rockfish	0.697	1.106	0.116	0.184	
Canary rockfish	0.355	0.335	0.234	0.569	
China rockfish	0.003	0.012	0.01	0.031	
Copper rockfish	0.036	0.058	0	0	
Kelp greenling	0.397	0.293	0.441	0.36	
Lingcod	0.251	0.178	0.285	0.251	
Quillback	0.042	0.074	0.003	0.013	
Yelloweye	0.003	0.012	0.0015	0.041	
Yellowtail	0.148	0.377	0.031	0.06	

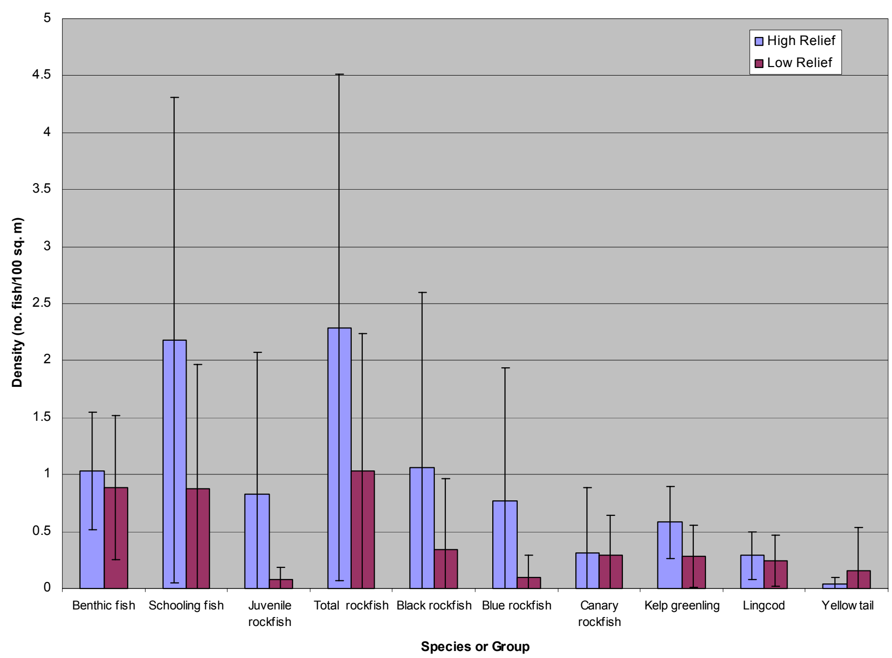

Figure 3. Graph of fish densities in high and low bottom relief on Siletz Reef. Error bars denote standard deviation.

Table 2. Descriptive statistics for fish species and groups at high and low bottom relief. Bold type indicates significant difference between high and low relief at $p < 0.05$.

	High Relief (n=18)		*Low Relief (n=18)*		
Fish Species or Group	*Mean Density (no. fish /100m²)*	*Std. Dev.*	*Mean Density (no. fish / 100m²)*	*Std. Dev.*	*p-value*
Benthic fish	0.993	0.527	0.915	0.634	
Schooling fish	**2.111**	**2.089**	**0.874**	**1.115**	**0.022**
Total fish	4.116	3.149	1.956	1.517	
Juvenile rockfish	**0.786**	**1.223**	**0.080**	**0.111**	**0.001**
Total rockfish	**2.227**	**2.180**	**1.026**	**1.240**	**0.038**
Black rockfish	**1.037**	**1.494**	**0.339**	**0.624**	**0.048**
Blue rockfish	**0.741**	**1.136**	**0.087**	**0.194**	**0.009**
Canary rockfish	0.297	0.558	0.302	0.356	
Kelp greenling	**0.552**	**0.329**	**0.292**	**0.277**	**0.012**
Lingcod	0.284	0.204	0.247	0.230	
Yelloweye	0.006	0.018	0.011	0.038	
Yellowtail	0.036	0.13	0.157	0.396	

3.2 Fine Scale Analysis

Graphical comparison of total fish density by habitat type shows the relative importance of different habitats for the reef fish community as a whole (Fig 4). The highest total fish density occurred in crevice habitat at 57 fish / 100m^2 and was dominated by schooling species. It was not unexpected that fish density in crevices would be inflated merely due to the limited space within a crevice and the resulting small area (m^2) by which density is calculated. Large boulder habitat and sloping high relief habitat had the next highest total fish densities at 7 fish/100 m^2 and 6 fish / 100m^2, respectively. Small boulder, cobble, gravel and level high relief had similar fish densities ranging from 1.8 and 2.4 fish /100m^2. Sand and low relief/level bedrock had the lowest fish densities at < 1 fish/100m^2.

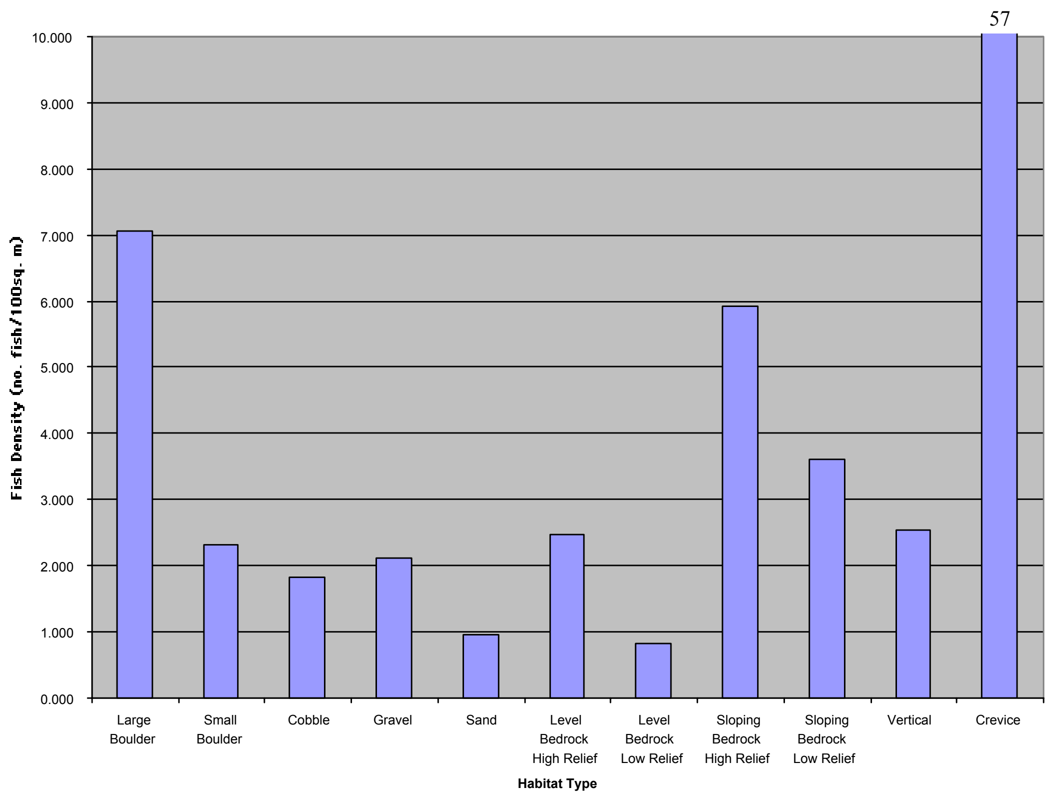

Figure 4. Total fish density by habitat type. Fish density for crevice habitat exceeds scale of graph at 57 fish/100 m^2.

Graphing individual species by habitat type provides a unique look at species diversity within a habitat. The greatest number of species occurred in high relief habitats (Figure 5). Some species were more prevalent than others in a given habitat. Large boulder habitat was dominated by black rockfish at 46 % of the total fish. Small boulder habitat was dominated by kelp greenling at 28%. Cobble habitat was dominated by canary rockfish at 50%. Gravel habitat was dominated by black rockfish and lingcod at 54 % and 23 %, respectively. Sand habitat was dominated by canary rockfish at 45 %. Level bedrock-low relief was dominated by lingcod and kelp greenling at 37% and 27%, respectively. Slope bedrock-high relief was dominated by blue rockfish and black rockfish at 38% and 30%, respectively. Crevice habitat was dominated by black rockfish and blue rockfish at 61% and 22%, respectively.

We also examined habitat selectivity and habitat diversity for each species (Figure 6). This was a qualitative approach and not supported by statistical analyses. Some species densities were notably different between habitats, while others show relatively little difference. For example, black rockfish, blue rockfish and juvenile rockfish

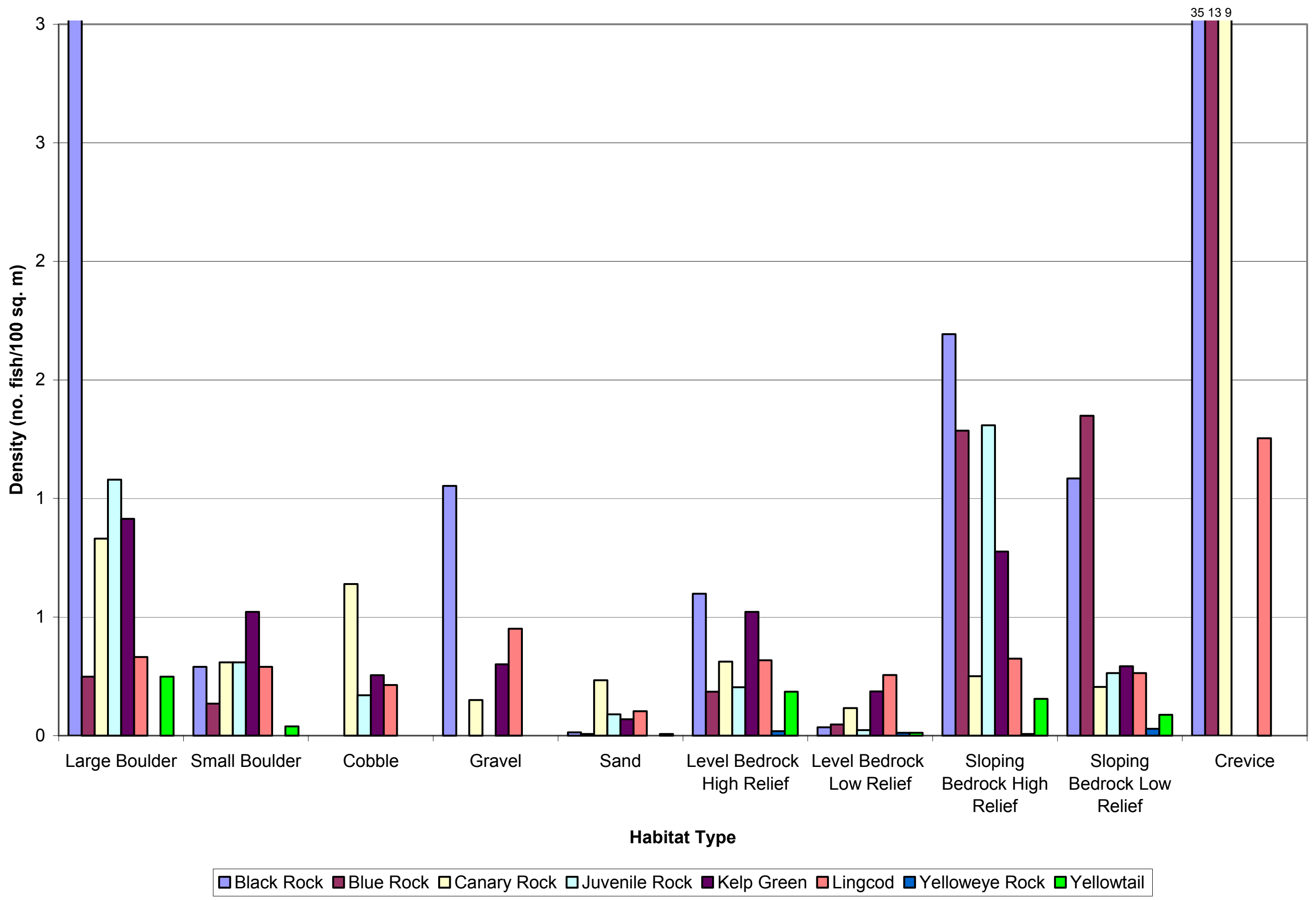

Figure 5. Graph of species densities within habitat types on Siletz Reef. Density values beyond extent of Y-axis are noted.

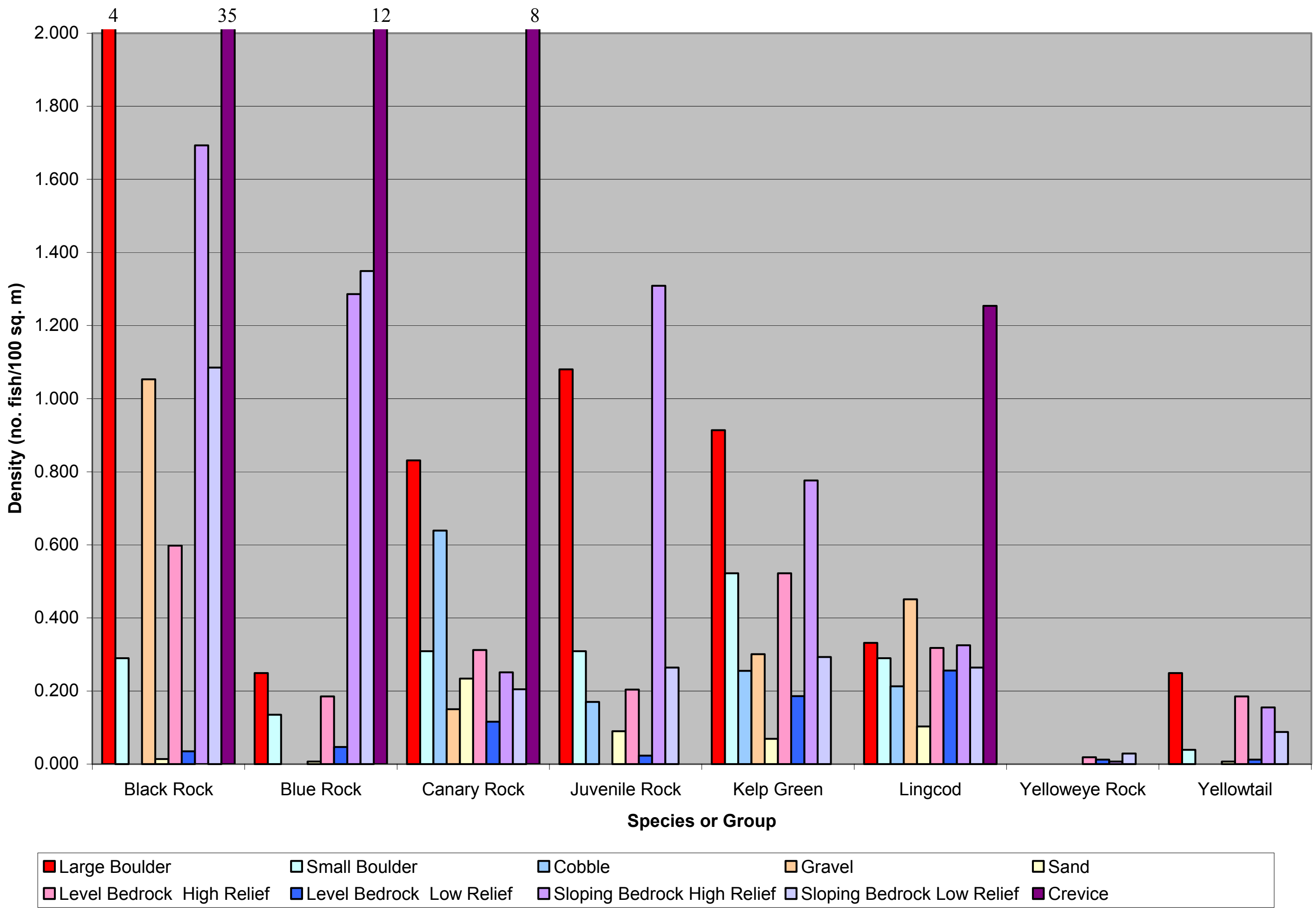

Figure 6. Graph showing fish densities of species or group by habitat type. Density values beyond the Y-axis are noted where appropriate.

densities showed the greatest difference between habitat types, while kelp greenling and lingcod were more evenly distributed among habitat types. Black rockfish density was at least twice as high (3 fish/100 m^2) in large boulder habitat than other habitat types, and relatively high in sloping bedrock-high relief habitat (1.7 fish/100 m^2). Little or no black rockfish were observed in the low relief habitats of cobble, sand or level bedrock-low relief. Blue rockfish density was remarkably high in crevice habitat (13 fish/100 m^2), though inflated by the low area for crevice habitat, as discussed earlier. Blue rockfish densities were notably higher (1.3 fish/100 m^2) in both high and low relief slope bedrock compared to other habitats. No blue rockfish were found in the low relief habitats of cobble, gravel or sand. Canary rockfish were found in all habitat types and densities were not markedly different between habitats, though they were highest in large boulder and cobble habitats (0.8 and 0.3 fish/100m^2). Juvenile rockfish densities were notably high in large boulder and slope bedrock- high relief habitats (1.0 and 1.3 fish/100 m^2, respectively). Juveniles were low by comparison in low relief habitats. Kelp greenling densities did not vary greatly among most habitats, though large boulder and slope bedrock-high relief had the highest densities. Lingcod occurred in all habitat types and densities were fairly consistent. Yelloweye rockfish occurred on the 4 bedrock habitats, though densities were very low. Yelloweye rockfish did not occur on other habitats. Yellowtail densities were low throughout but occurred primarily in high relief habitat types.

Spatial distribution of species among habitat types is presented in Figures 7 through 13. Canary rockfish exhibit a spatial distribution similar to that described in previous surveys at Perpetua Reef (Fox, et al. 2000, Fox et al., 2001). Canary rockfish are know to be a schooling species and this is apparent upon visual examination of their spatial distribution along transect lines (Figure 7). It was not uncommon to see up to 4 fish within a one-second observation frame or to see several fish consecutively along the transect. Also similar to previous findings is canary rockfish's affinity toward habitat edges. In the map, canary rockfish are shown frequently occurring at or near the transition point between two habitat types, with cobble being the predominant habitat type.

Black rockfish are also a schooling species, and in this survey there were more individuals in a school of black rockfish than a school of canary rockfish. The spatial distribution of black rockfish clearly shows their tendency to school. Black rockfish display a strong association to boulder and high relief-sloping habitats (Figure 8.) Blue rockfish, also a schooling species is shown associated with both high and low relief sloping bedrock (Figure 9).

Lingcod were fairly evenly dispersed across multiple habitat types (Figure 10). In the 2002 survey at Perpetua Reef lingcod showed preference for the habitat rock-sand interface. Although some lingcod in this study were observed at the rock-sediment interface, it does not appear to be the prevailing spatial distribution. Kelp greenling displayed the most spatial separation between individuals of all species, about one fish every few meters (Figure 11).

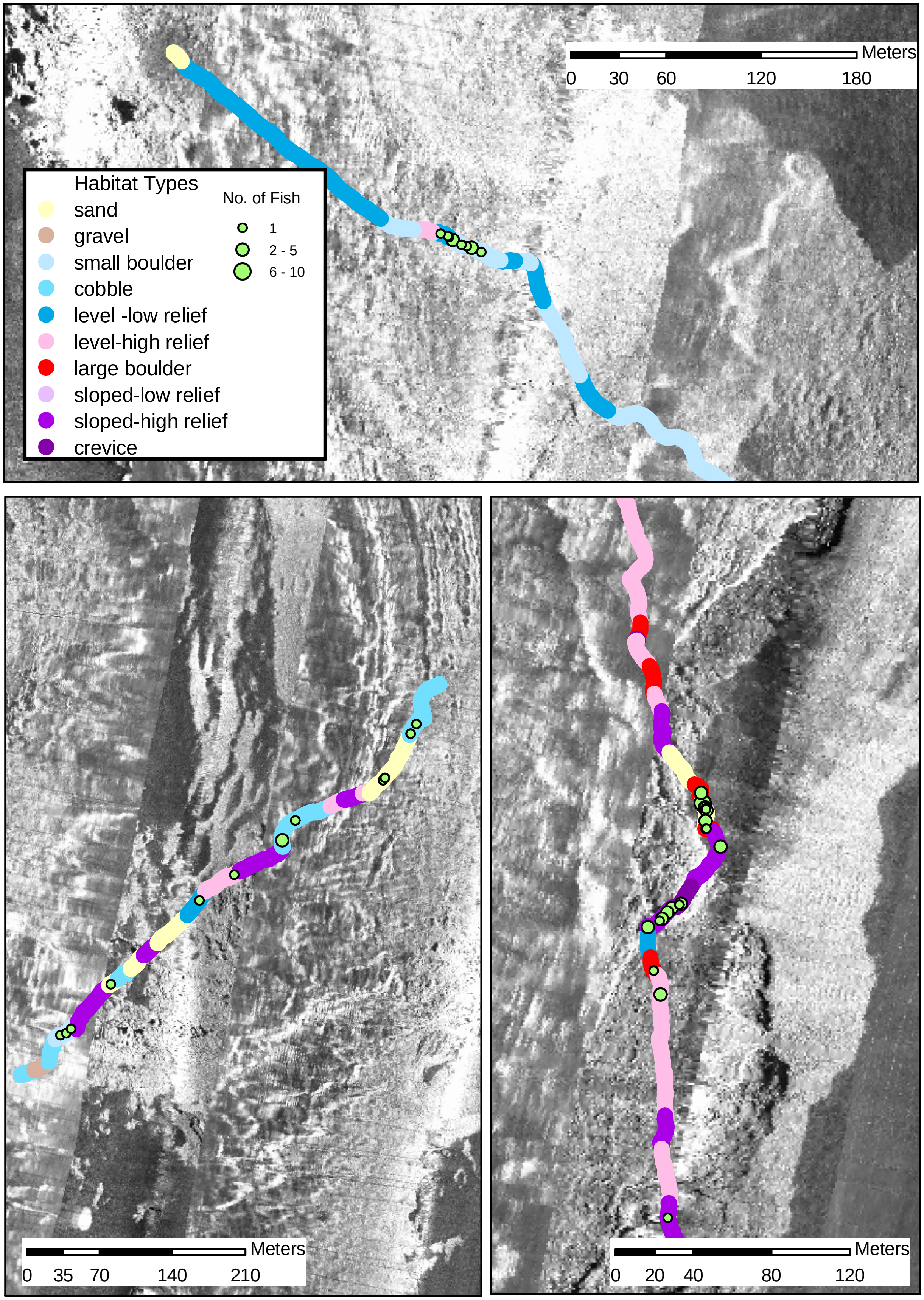

Figure 7. Spatial distribution of **canary rockfish** and bottom habitat features along ROV video transects on Siletz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

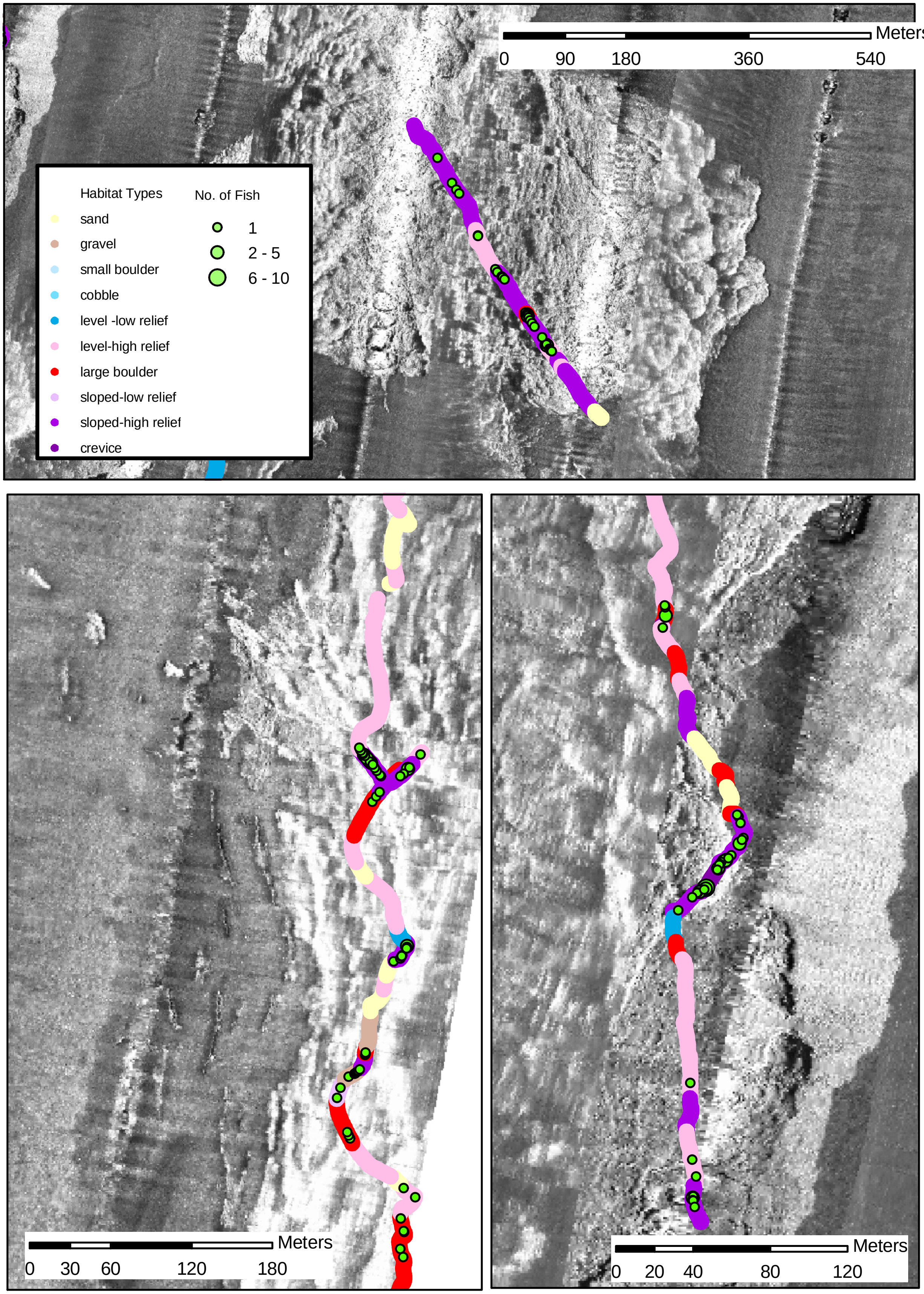

Figure 8. Spatial distribution of **black rockfish** and bottom habitat features along ROV video transects on Slietz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

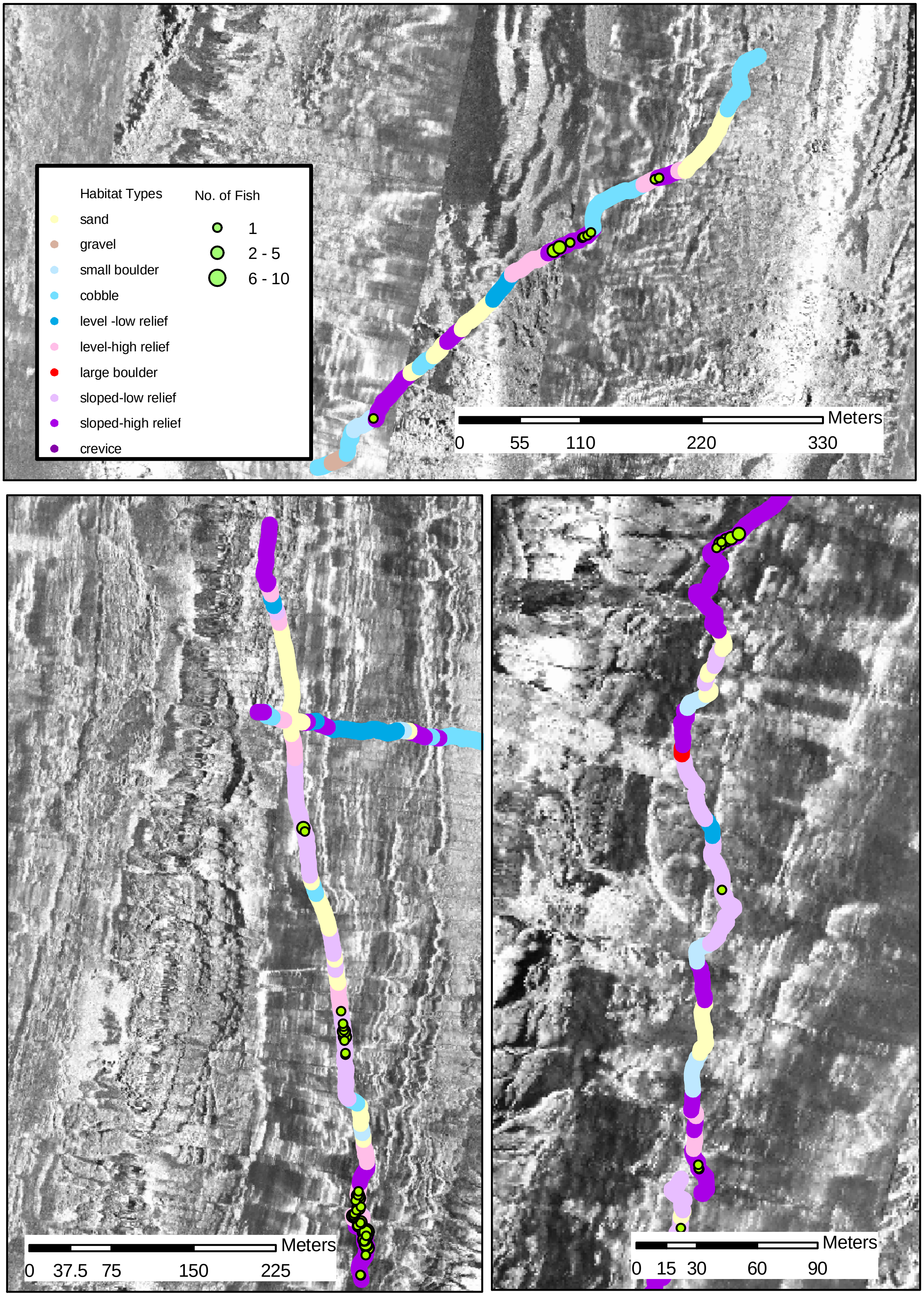

Figure 9. Spatial distribution of **blue rockfish** and bottom habitat features along ROV video transects on Slietz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

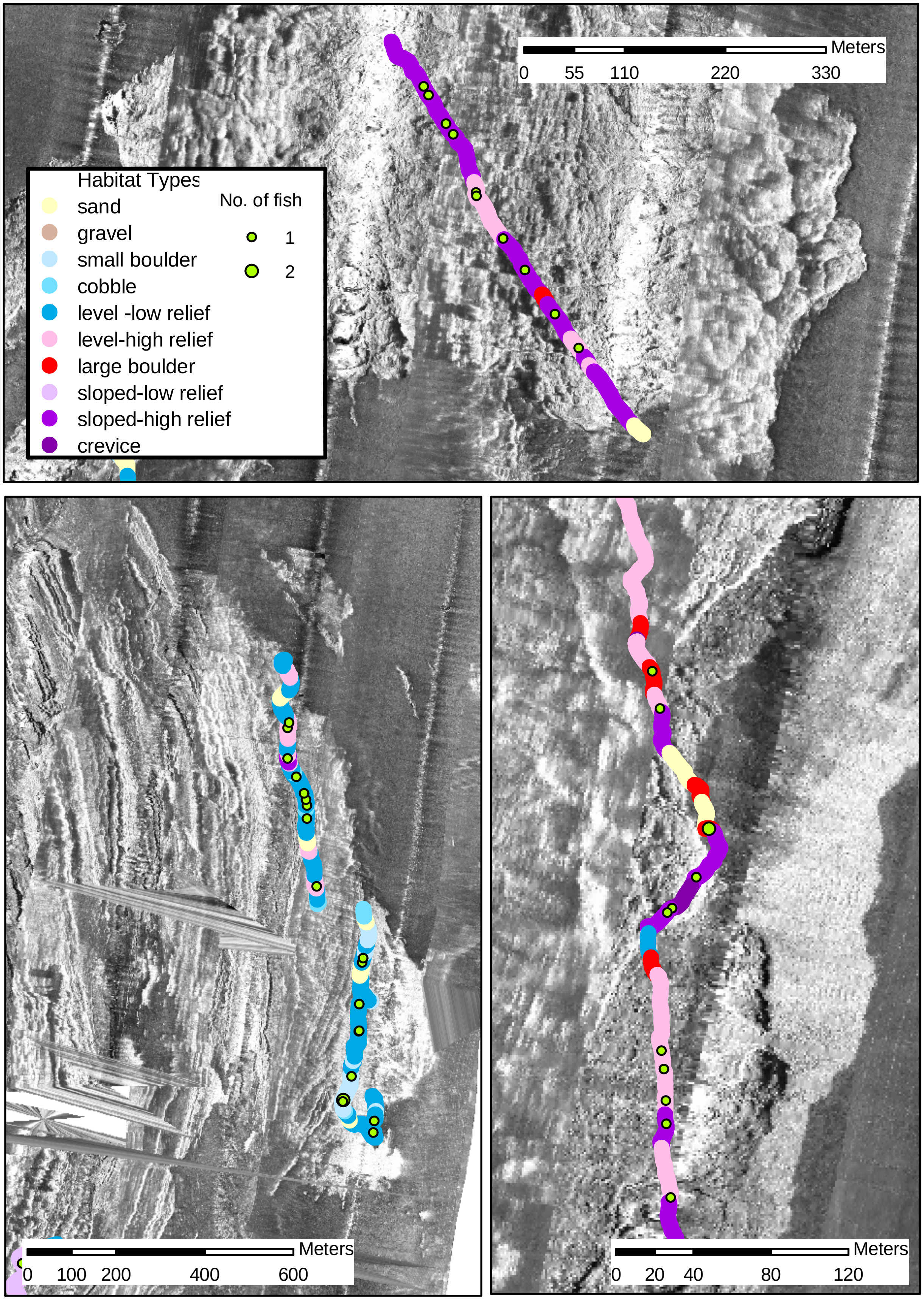

Figure 10. Spatial distribution of **lingcod** and bottom habitat features along ROV video transects on Slietz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

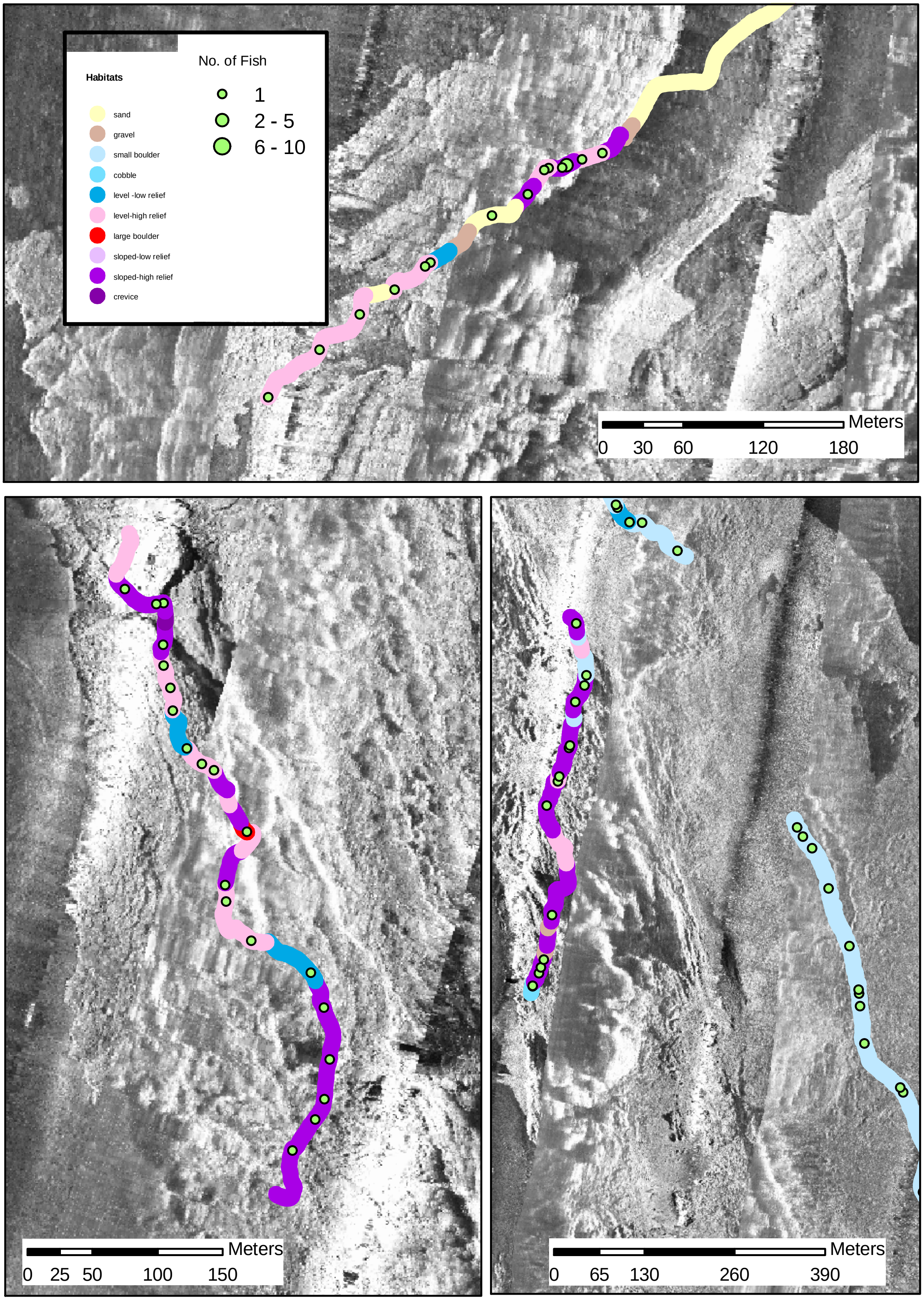

Figure 11. Spatial distribution of **kelp greenling** and bottom habitat features along ROV video transects on Slietz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

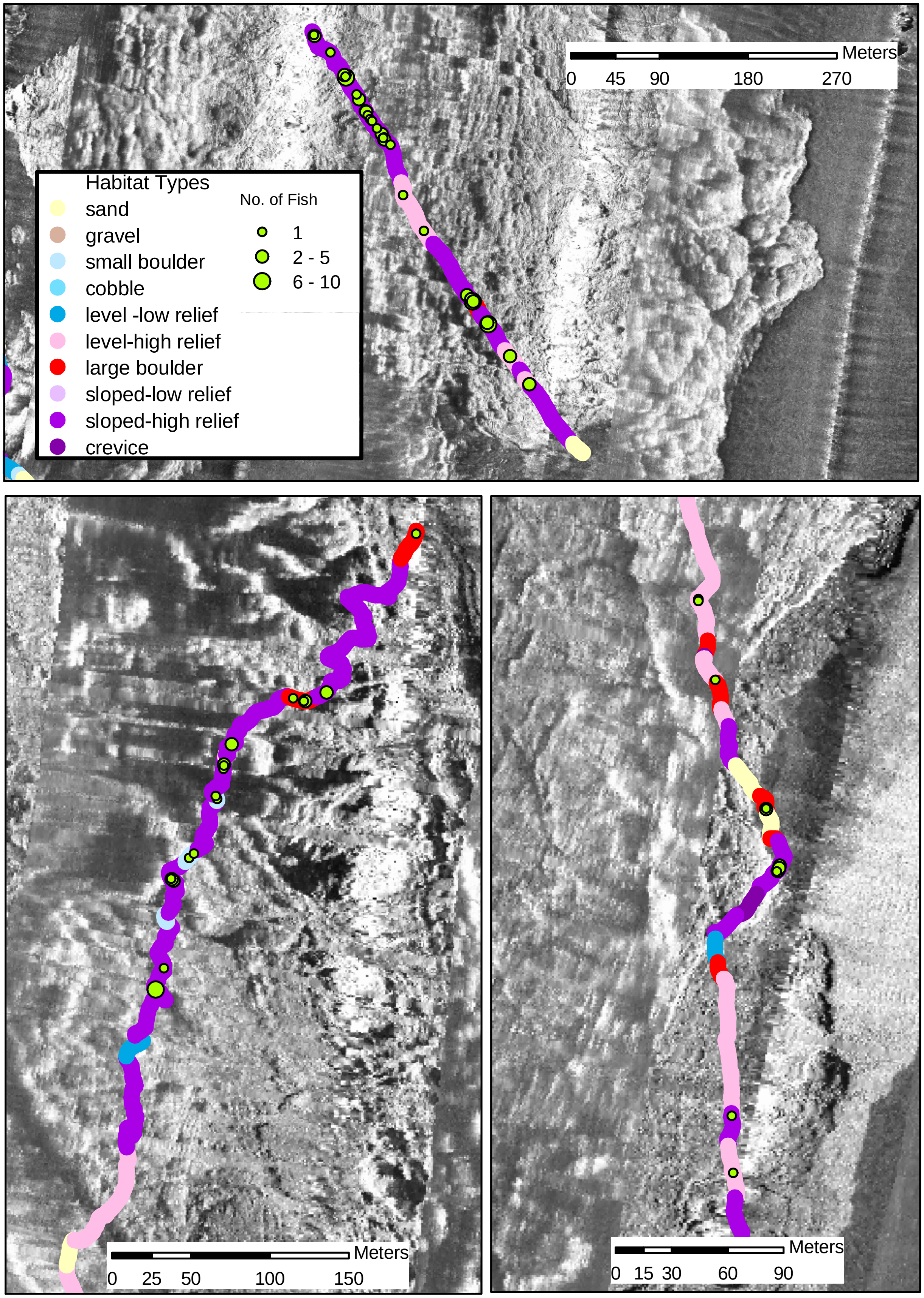

Figure 12. Spatial distribution of **juvenile rockfish** and bottom habitat features along ROV video transects on Slietz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

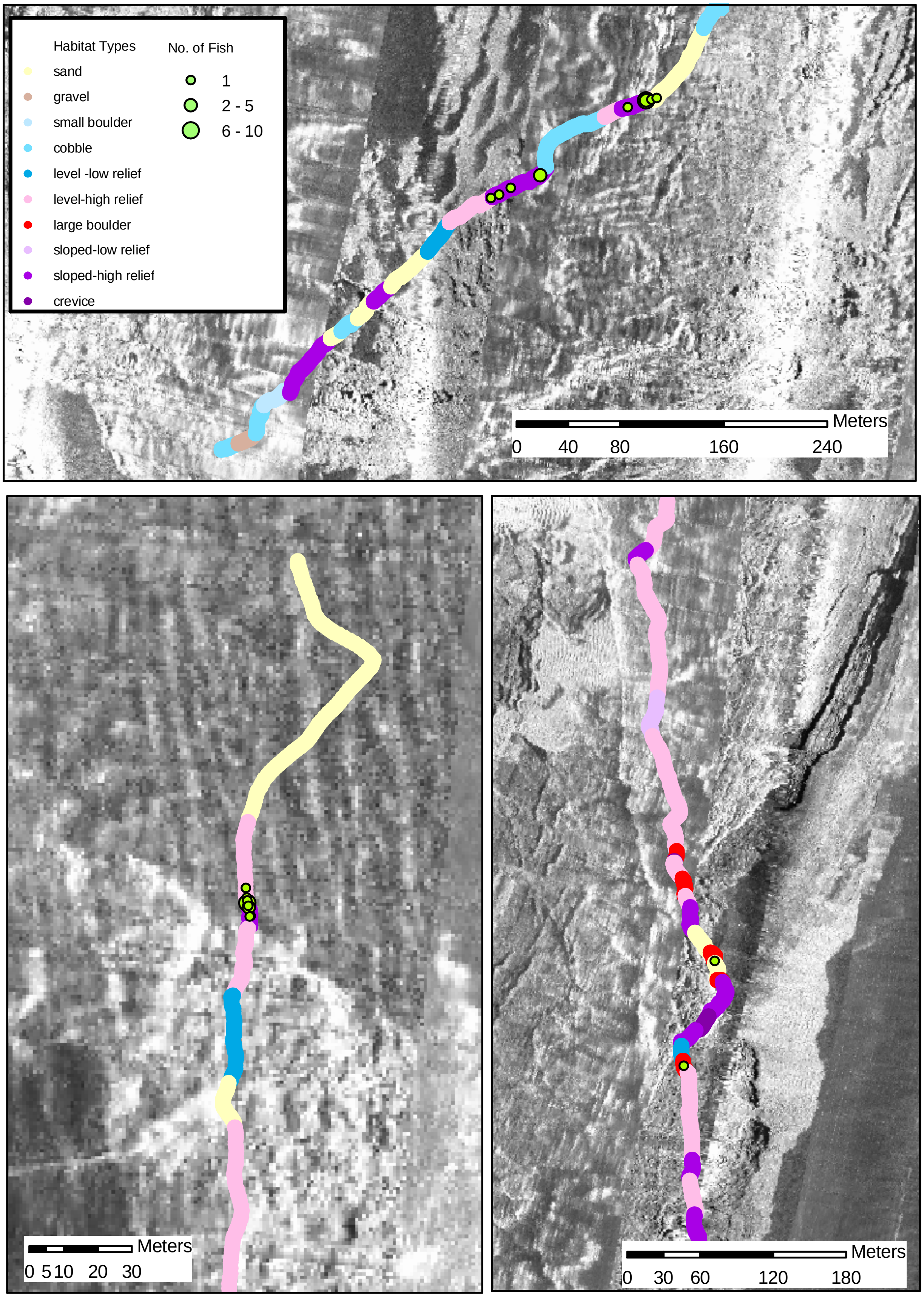

Figure 13. Spatial distribution of **yellowtail rockfish** and bottom habitat features along ROV video transects on Slietz Reef. Number of fish represent count per second of video observation. Transects are overlayed upon sidescan image of Siletz Reef.

Juvenile rockfish were relatively abundant on a few transects and much less so on most other transects (Figure 12). Where they were in high abundance, their spatial distribution was often clustered. From this map it appears that juveniles are associated with large boulder and sloping high relief habitats.

Yellowtail rockfish appeared to be fairly clustered along transects (Figure 13). A few large schools are responsible for the majority of yellowtail rockfish in this survey.

4. Discussion

Fish-habitat associations were examined at two habitat scales or resolutions, the coarser scale being based on topographic relief and the finer scale being based on specific substrate types. Associations between fish species and habitats can be discerned by either approach but with obviously different results.

The coarse scale analysis showed that black rockfish, blue rockfish, juvenile rockfish and kelp greenling were more strongly associated with high relief habitats than low relief habitats. This was clearly supported by the fine scale analysis for all but kelp greenling. Black rockfish, blue rockfish and juvenile rockfish had notably high densities in the 6 fine scale high relief habitat types (large boulder, crevice, vertical and 3 of the 4 bedrock habitats) and comparatively low densities in most or all low relief habitat types (small boulder, cobble, gravel, etc.) For kelp greenling, however, the fine scale analysis did not clearly demonstrate that these fish were not also associated with low relief habitats. Kelp greenling exhibited somewhat more uniform distribution across several habitat types than the other high relief species mentioned above.

Results for yellowtail rockfish are somewhat misleading. The coarse scale analysis resulted in no significant difference between high and low relief habitats, with slightly higher mean density in low relief habitat. But in the fine scale analysis, it is apparent that more fish and higher fish densities occur in the habitat types synonymous with high relief. This disparity may be partially explained by the fact that some low relief transects have sections of high relief, Though this only amounts to a small percentage of the transect area it can profoundly affect the results for a schooling species associated with high relief habitats. In fact, upon visual examination of low relief transects we see yellowtail rockfish congregating on these small sections of high relief habitat. Fish density would then be high for that transect. This disparity may also be an artifact of the sampling design which relied on a lower resolution of habitat delineation to classify habitat relief and would be true for other species as well. The fact that yellowtail rockfish were less abundant (60 fish total) than other species, may also influence the results.

Canary rockfish were not shown to be significantly different between high and low relief habitats in the coarse scale analysis. But the fine scale analysis reveals that some habitat types are more important than others. Canary rockfish showed a strong association with large boulder as well as cobble habitats, high and low relief, respectively. For this species, the rock structure itself may be more important than whether bottom relief is high or low. Statistical analysis is needed to more confidently assess any correlation, but nevertheless, this type of information would be useful in a habitat-based management decision for canary rockfish.

There are advantages to discerning habitat features at both coarse and fine resolutions. The coarse scale approach offers the ability for quick reconnaissance of reef habitats and facilitates general predictions about how fish species might be distributed among reefs. It also facilitates planning fish surveys in the general areas desired. The fine scale approach provides a very detailed look at how fish species are associated with micro-habitat features and the relative importance of those habitats to each species. With additional ROV fish and habitat surveys, it may be possible to develop abundance estimates of fish by habitat type. And delineating habitat types using both coarse and fine scale approaches will allow for quantifying habitats. These two important pieces of information can then be applied to modeling species distribution and abundance on other nearshore reefs and providing managers with a very powerful tool for managing nearshore reef fish.

5. Management Analysis

For years Oregon Department of Fish and Wildlife has recognized the need for a nearshore management program to specifically address over-utilization of nearshore fish stocks. Until recently the opportunity to develop such a program has been limited by funding and staff shortages. In spite of these limitations, increased demands on nearshore fish stocks have launched the Department fully into a nearshore management planning effort. The timing of the Department's involvement coincides with a statewide comprehensive wildlife management effort that is under the auspices of a U.S. Fish and Wildlife Service initiative. This initiative offers funding to all 50 states for the development and implementation of a wildlife management plan. Parallel to this federal interest is encouragement from NOAA Fisheries for coastal states to have a larger role in nearshore fisheries management. Oregon has long recognized the need for a state-lead nearshore management effort and with this federal support, Oregon can now meet this challenge.

The Department has been working over the past few years to develop ways of assessing fish stocks in the nearshore. Two key pieces of needed information is fishery-independent population estimates and fish habitat information. The Marine Habitat Project is working toward developing this information. To date, we have developed high resolution habitat maps for eight nearshore reefs that will enable us to describe and quantify important fish habitat. In addition, we have continued to refine methods for quantifying fish on nearshore reefs using non-lethal, fishery-independent means with the ROV.

In 2000 and 2001 many of the sampling protocols and biases were addressed. In 2002 we launched our first complete sampling effort in which we fully tested the approach of using habitat information to design and conduct a fish survey with quantifiable results. Our analyses show that it is possible to develop density estimates for fish at various resolutions of habitat. Fish density estimates can then be expanded to other reefs where habitats have been mapped and quantified. Ultimately, fish density information could be expanded to population estimates for all known nearshore reefs off Oregon. Additional analyses of data gathered from multiple years at Cape Perpetua Reef and Siletz Reef will shed light on the annual variability within fish populations at these reefs.

We intend to conduct a winter fish survey at Siletz Reef to examine the effects of season on fish distribution and abundance. Additional ROV surveys and habitat mapping efforts are anticipated in the coming year.

6. Literature Sited

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