Tests of an experimental unbaited video lander as a marine fish survey tool for high-relief deepwater rocky reefs

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Abstract

We describe the development and practical field testing of a rugged, unbaited video lander as a visual survey tool for fishes inhabiting structurally complex, high-relief, deepwater rocky reefs. Our autonomous, high-resolution, low-light, color video lander system utilized a smooth frame design that incorporated a series of breakaway attachments and inexpensive sacrificial steel bases to maximize the potential for camera system recovery from complex rocky habitats. Initial field tests at five reef complexes off Oregon (n=421) and a larger study evaluating the western boundary of Oregon's Yelloweye Rockfish Conservation Area (YRCA, n=527) showed that the video lander could be deployed and reliably retrieved from high-relief rocky habitat without damage to the camera system and with minimal losses of sacrificial bases. Acceptable visibility for counting fish from the lander video was common at offshore reefs like Stonewall Bank, but less so at nearshore reef complexes. The video lander system was effective for discriminating differences in fish species assemblages at the various reefs surveyed (one-way ANOSIM, P<0.001) and for identifying seafloor habitat types and species-habitat associations for yelloweye rockfish (*Sebastes ruberrimus*) at Stonewall Bank (P<0.05). The video lander data showed that the area outside and to the west of the YRCA enclosed similar quantities of yelloweye rockfish and their preferred habitats in comparison with the area inside the YRCA (0.179 yelloweye rockfish/station outside, versus 0.144 yelloweye rockfish/station inside, Wilcoxon test, P=0.417). Our visual survey data also showed that the current western YRCA boundary is not optimal for protecting yelloweye rockfish at Stonewall Bank from fishery harvest.

1.0 Introduction

A variety of tools have been developed for conducting visual surveys of marine fish populations inhabiting rocky reefs. The various tools have different biases (e.g. St. John et al. 1990, Willis et al. 2000, Harvey et al. 2007, Stoner et al. 2008) but all offer the benefit of non-extractive sampling, which can be important for sampling in marine reserves, marine protected areas (MPAs) and untrawlable habitats. Baited and unbaited underwater video stations and direct visual and video surveys by scuba divers have all been used successfully to survey fish populations on shallow-water (approximately ≤ 20 m) reefs (e.g. Willis and Babcock 2000, Watson et al. 2005, Langlois et al. 2010). Baited and unbaited video stations or “landers” have also been used with success in much deeper waters (e.g. Ellis and DeMartini 1995, Harvey et al. 2007).

Visual fish surveys of structurally complex, high-relief deepwater reefs have also been conducted, usually with more expensive and technically sophisticated equipment such as remotely operated vehicles (ROVs) or human occupied vehicles (HOVs, O’Connel and Carlile 1993, Yoklavich et al. 2007, Stoner et al. 2008). In addition to being expensive to purchase or lease, these vehicles require highly skilled operators. The ships that are needed to safely deploy all but the smallest of these types of survey vehicles can also be prohibitively expensive for small-scale surveys. Recently, very heavily constructed towed stereo-camera sleds have been used with some success to survey these deep, rugose habitats with less costly equipment (Williams et al. 2010). We report here on the development and extensive field testing of another type of relatively inexpensive visual survey tool for these structurally-complex habitats, specifically an unbaited video lander that was purpose-built for deployment into very rugged habitats. The objectives of our study were to:

1) Develop a design for a video lander that could be deployed and reliably retrieved, without damage, from high-relief, deepwater rocky reefs.

2) Determine, through field testing at a variety of reefs and across different conditions, if a video lander could be effectively used to gather data on differences in reef fish species assemblages in U.S. Pacific northwest marine waters.

3) Evaluate the video lander further by using it in an applied, large-scale field study to measure spatial differences in the relative abundance of fishes.

2.0 Methods

2.1 *Lander design*

Our autonomous, high-resolution, low-light, color video lander system was purpose-built for grid-based visual surveys of very high-relief rocky habitat (Figure 1). It was designed to be deployed and retrieved from vessels equipped with just a hydraulic crab block, and to be very portable, to facilitate use during brief periods of good ocean conditions. The concept we worked from was to have a relatively inexpensive system with no video feed to the surface, designed to be deployed to the bottom for a fixed time interval at a series of sites in a sequence, much like launching and retrieving a crab pot. We chose not to use bait with our video system so that fish presence/absence data could be used to analyze species-habitat associations. Baited underwater video systems (BUVs) have been shown to improve statistical power of survey data for some species due to the fact that they attract more fish, presumably from a greater distance (Harvey et al. 2007). However, this effect is also likely to bias species-habitat associations.

Our design for the frame and buoy line incorporated several features to increase the likelihood of recovery of the system in the event the lander became stuck in rocky habitat. The frame was constructed to be very smooth in shape to avoid hangups on rock ledges and strong enough to survive contact with rock surfaces without damage (Figure 1). The frame was constructed in a cage-like shape to provide protection for the camera, lights, and pressure housing containing the batteries and recording device (Figure 1). It incorporated an inexpensive sacrificial base constructed of 13 mm diameter mild steel rod, designed to break away if necessary, freeing the upper portion of the lander and the video equipment to return to the surface. The sacrificial base was weighted with one or two (more weight was used in deeper water) 9.1 kg, 61 mm lengths of 51 mm diameter mild steel rod to help maintain a vertical orientation during descent to the seafloor. The bottom of the base was covered with lightweight netting material to keep pointed rocks from protruding up into the lander frame and contacting the video equipment. The buoy line to the surface was constructed mostly of floating line to minimize fouling in rocks. A 4.5 m length of abrasion-resistant 9.5 mm line was used at the terminal end of the buoy line to limit abrasion by rocks and debris. On the lander frame a “breakaway” line constructed of 8 mm Spectra® was attached in a way such that as increased pulling force was applied to the line, several “weak links” would break sequentially, causing the lander to tip, and then rotate, to hopefully free it from any obstructions that it was hung up on (Figure 1). Fully assembled, as shown in Figure 1, our video lander weighed 42.6 kg.

2.2 *Video camera system*

We chose a Deep Sea Power and Light (DSPL) color video camera, paired (Multi-SeaCam® 2060) with two DSPL LED Mini-SeaLites® (850 lm, 6500º K) for illumination (Table 1). A color camera was chosen to aid in species identification. Video was captured using a SONY® DCR-TRV11 digital camcorder. The system utilized a pressure housing constructed from 10.2 cm ID aluminum tube to enclose the batteries and camcorder. Systems utilizing high-quality, consumer-level high-definition camcorders can also be built for a similar total cost (Table 1). Our system was powered by two 13.2 volt rechargeable NiMH battery packs, wired in parallel (Table 1). The system was activated at depth by a pressure-activated switch located on the end of the pressure housing. When the switch was activated, a programmable micro-controller circuit board conveyed power to the camera, lights and camcorder, and issued LANC (Local Application Control Bus System) control commands to the camcorder to initiate video recording.

Deployment and retrieval of the video lander was straightforward. Upon reaching each station, the lander was simply tossed over the side of the vessel and allowed to sink to the bottom. The float for the buoy line was also immediately thrown overboard and the vessel drifted away from the site. After enough time had elapsed for a pre-determined duration of video recording on the seafloor, the floating buoy was retrieved and the lander was hauled to the surface with the vessel's hydraulic crab block.

2.3 *Initial field tests*

We field tested the video lander to determine if it was reliably retrievable, to evaluate the frequency with which acceptable visibility and unobstructed views were obtained and to see if fish noticeably avoided or were attracted to it. To accomplish this, we deployed it at a variety of different reef complexes (Figure 2) encompassing a range of depths and across many different months of the year. A pre-designed set of stations (mostly following a rectangular grid) was utilized for most surveys although some experimental deployments or "drops" (hereafter drops) at small sites known to harbor demersal fish were also conducted. All surveys were conducted during daylight hours, avoiding crepuscular periods during which many demersal fish are known to move off bottom (Engås and Soldal 1992, Hannah et al. 2005). At Cape Perpetua, where the amount of rocky reef habitat is small and surrounded by expanses of sand and gravel, we conformed the station layout to fit the contours of the reefs. For all the pre-designed surveys, we chose a minimum distance between stations of at least 100 m to be sure that the same fish was not counted at adjacent stations. After initial testing with a range of bottom times, we chose a standardized bottom time of 4-5 minutes. This bottom interval was chosen based on several factors. First, a review of the initial video deployments showed that this was usually enough time for any disturbed sediment to clear. Also, review of the video footage from preliminary drops showed that after about 4 minutes, enough fish had frequently been seen such that additional specimens could not be confidently counted as fish that had not already been observed. This shorter interval also allowed for more drops to be completed in a day, with a larger total area surveyed.

2.4 *Video analysis*

The video footage from each deployment or “drop” was first imported into Adobe Premiere Pro® so that it could be easily reviewed on a full size computer screen. Each drop was scored for visibility and the quality of the view of the surrounding habitat, following the criteria shown in Table 2. Fish that were observed at each station, and that could be positively identified to species or a species group, were counted based on a maximum count of that species or group in any single video frame, following Harvey et al. (2007). This approach resulted in conservative counts, but is necessary because it was not possible to tell if a fish newly entering the frame was a different individual than one seen seconds or minutes before. The primary habitat (most common habitat in the view) and secondary habitat (second most common habitat type in the view) types were classified for each drop, based on the criteria shown in Table 3.

2.5 *Species assemblages*

To evaluate the effectiveness of the video lander system for studying differences in fish species assemblages, we compared the species composition at different reefs using a one-way ANOSIM, as implemented in PAST 2.14 (Hammer et al. 2001). Prior to statistical analysis, the count data were standardized to percentages to reduce effects from varying numbers of stations at different reefs (Somerfield 2008) and the analysis was restricted to just the 16 most abundant species across all surveys. With the exception of unidentified juvenile rockfish (*Sebastes* spp.), unidentified fish were excluded from the analysis. We used pairwise ANOSIMS as post-hoc tests and adjusted these for multiple comparisons using a step-down sequential Bonferroni correction. The degree of difference in species composition between specific reef surveys was measured using the Bray-Curtis dissimilarity index (BCDI, Bray and Curtis 1957), as implemented in the SIMPER routine in PAST 2.14.

2.6 *Large-scale field test*

To further test the utility of our video lander for quantitative fish surveys, we employed it in a large-scale field experiment to compare the relative abundance of selected fish species in two areas. As our question of interest, we chose to evaluate the boundaries of an MPA that was established to help rebuild depleted populations of yelloweye rockfish (*Sebastes ruberrimus*, PFMC 2011). Specifically, we chose to determine if the current western boundary of the northern portion of Oregon's Yelloweye Rockfish Conservation Area at Stonewall Bank (YRCA, Figure 3) had been chosen well to minimize fishery impacts on yelloweye rockfish. The YRCA is closed to recreational fishing for Pacific halibut (*Hippoglossus stenolepis*), much of which is centered around Stonewall Bank, where yelloweye rockfish can be a common bycatch species. At the time the boundaries of the YRCA were first developed, very little information on the spatial distribution of yelloweye rockfish or their preferred habitats at Stonewall Bank was available. Due to this lack of information, the boundaries were chosen to simply enclose a large portion of the shallowest parts of Stonewall Bank. The long-term effectiveness of the YRCA will be determined by how completely it encloses the locations at Stonewall Bank that are routinely inhabited by yelloweye rockfish. We chose the northwestern portion of the YRCA for further study because of reports by some anglers that they encountered yelloweye rockfish in the area immediately outside and west of the YRCA. Our goal was to measure yelloweye rockfish relative abundance on both sides of the current western

YRCA boundary to evaluate whether the current boundary was optimal, or if a different boundary, farther west, would better protect yelloweye rockfish.

We chose a sampling design with a grid spacing of 200 m to allow very intensive sampling of the study sites (Figure 3) but still maintain the independence of adjacent fish counts, and again used a bottom time of 4-5 minutes. To control for differences between sampling days in visibility or other environmental conditions, each day of sampling was divided roughly in half between stations within and outside of the YRCA (Figure 3). Video footage was reviewed in the field whenever possible and stations with an obstructed view of surrounding habitat were repeated as soon as possible.

Since an optimal revision of the YRCA western boundary requires a knowledge of both the distribution of yelloweye rockfish and their preferred habitats, we evaluated the distribution of habitat types and the relative abundance of yelloweye rockfish between the two areas as well as the association of yelloweye rockfish with the primary and secondary habitat types observed. For the latter analysis we used Fisher's exact test, applied to presence/absence data for yelloweye rockfish. We compared the relative abundance (maximum count per station) of yelloweye rockfish between the two study sites using the nonparametric Wilcoxon test. Although our primary focus was on yelloweye rockfish, we also present relative abundance data and Wilcoxon tests for four other common demersal fish species from these two study sites to illustrate the approximate differences in relative abundance that we were able to differentiate with video lander data at this reef.

3.0 Results

3.1 *Initial Field Tests*

Between October 2009 and September 2010, we deployed the video lander in pre-designed or exploratory surveys at five different reef complexes (Figure 2), usually sampling between 30 and 40 stations per day. In the course of 421 initial drops, the video system was never lost or damaged. During four drops, the sacrificial base broke free and was lost after the lander became badly stuck in rocky habitat, showing the benefit of this element of our design. The breakaway attachments on the buoy line were also frequently broken when the lander got temporarily stuck, suggesting that this element of the design also contributed to successful retrieval of the video system from rocky reef habitats. Strong currents at Stonewall Bank also sank the surface buoy on one occasion; however, we were able to successfully grapple for the buoy line and retrieve it. The addition of a 3 m section of line with a trailing buoy attached to the primary surface buoy resolved this problem.

3.2 *Effectiveness for visual surveys*

The video lander system was mostly very effective at obtaining video footage of the survey stations at the five reef complexes initially sampled. On a few drops, the pressure-activated switch failed to initiate video recording, a problem that was fixed with some simple adjustments. Excluding drops that produced no video footage (n=16), moderate or good visibility (Table 2) for counting fish was encountered in 89% of drops. At offshore stations like Stonewall Bank, good visibility was typical, with only 1.7% of drops rated as poor. On some days at Stonewall Bank, visibility was so good that significant amounts of surface light reached the seafloor, causing increased detection distance for fish, but also shifting the video to a bluish shade. At nearshore stations, visibility was more frequently rated as poor and was much more variable, especially at sites closer to shore. For the four nearshore reef areas, 18.2% and 53.3% of video drops were scored as having poor or moderate visibility, respectively. A completely obstructed or partially obstructed video view (Figure 4) was obtained in 4.8% and 5.7%, respectively, of the lander drops. Obstructed views were easily remedied by simply resampling those stations while still in the field, however, poor visibility sometimes required the video lander surveys to be halted and rescheduled for a later date.

3.3 *Species Assemblages*

Fish counts from the initial pre-designed video lander surveys (Table 4) showed distinct differences in species assemblages between reef areas ($P<0.001$, one-way ANOSIM, Table 4). One survey site, located in the northwest portion of Siletz Reef (not shown), was determined from the video lander footage to be mostly sand habitat intermixed with a few small patches of rocky reef, and was excluded from further analysis. Interestingly, this area was chosen for a survey because it had been identified as probable rock habitat based on interpretation of bathymetric and other available data by Romsos et al. (2007). The most distinct difference in species assemblages between reefs was found for Stonewall Bank in comparison with the Eastern Siletz site (Figure 2, BCDI= 91.9, $P<0.05$, Table 4), areas with very different mean depths. The difference in assemblages was driven mostly by differences in the relative abundance of canary rockfish (*S. pinniger*) and kelp greenling *(Hexagrammos decagrammus)*. The species assemblage at Seal Rocks reef was distinct from all other sites (BCDI> 85.1, $P<0.05$), due primarily to the strong dominance of black rockfish (*S. melanops*) and relatively low abundance of blue (*S. mystinus*) and canary rockfish observed at this site (Table 4). The repeat surveys at Cape Perpetua reef produced roughly similar species assemblages (BCDI=78.1, P>0.05), that differed sharply from the assemblage at Eastern Siletz reef (BCDI>89.7, P<0.05) primarily due to a higher percentage of canary rockfish and a lower percentage of blue rockfish at Cape Perpetua (Table 4). The species assemblage observed at the Western Siletz site was also distinct from that found at Stonewall Bank (BCDI>77.3, P<0.05) and Eastern Siletz (BCDI=87.1, P<0.05) due primarily to differences in the relative abundance of canary rockfish, but also to differences in abundance of blue rockfish and kelp greenling (Table 4).

3.4 *Fish behavior*

The large number and diversity of fish observed at the surveyed reefs (Table 4) showed that most of the rocky-reef species of interest in this study did not strongly avoid the video lander. Notably however, cryptic species like cabezon (*Scorpaenichthys marmoratus*) were rarely observed (Table 4). Our observations at some stations also indicated that some fish species may be attracted to the video lander. At several stations, yelloweye, quillback (*S. maliger*) and copper rockfish (*S. caurinus*) were sometimes observed approaching the lander from a distance.

3.5 *Large-scale field test*

We sampled 527 stations with the video lander at Stonewall Bank over 14 days of sampling between April 19 and August 15, 2011, losing only two of the sacrificial bases and with no damage to the lander or video system (Figure 3). These video lander surveys also generally encountered good water clarity and unobstructed views. A total of 34 stations had to be sampled twice to obtain acceptable video footage for all stations.

More yelloweye rockfish were observed in the area immediately west of the YRCA than in the YRCA (47 versus 38, Table 5, Figure 3). The mean number of yelloweye rockfish observed was 0.179 yelloweye rockfish per station in the area west of the YRCA and 0.144 yelloweye rockfish per station inside the YRCA, a difference of about 24%. This difference, however, was not statistically significant ($P = 0.417$, Wilcoxon test), suggesting that the area outside of the YRCA to the west has an abundance of yelloweye rockfish that is similar to the area enclosed within the YRCA. Lingcod (*Ophiodon elongatus*) were about 50% less abundant ($P<0.01$) in the area to the west of the YRCA than inside it. The other differences we noted in demersal fish relative abundance were not statistically significant with our sampling design (Table 5).

The frequency of primary habitat types was similar between the two sites at Stonewall Bank, but did show a few key differences (Figure 5). Flat bedrock and crevice habitats were more common inside the YRCA, while large and small boulder, gravel/pebble and cobble habitats were more frequently observed outside the YRCA (Figure 5). Secondary habitats showed a similar pattern, except that small boulder and bedrock outcrop were less frequently encountered outside of the YRCA (Figure 5).

Primary and secondary habitat types were useful predictors of the presence/absence of yelloweye rockfish as measured with the video lander at Stonewall Bank. Bedrock outcrop as a primary habitat type was negatively associated with yelloweye rockfish ($P>0.01$). Conversely, crevice as a primary habitat type was strongly positively associated with the presence of yelloweye rockfish ($P<0.001$). Similarly, bedrock outcrop as a secondary habitat type was negatively associated with yelloweye rockfish (P<0.01), as was cobble (P<0.05). Large boulder as a secondary habitat type was positively associated with yelloweye rockfish presence (P<0.001).

4.0 Discussion

The general utility of fixed underwater video stations for describing fish species assemblages and measuring differences in relative abundance is well established (Willis and Babcock 2000, Watson et al. 2005, Harvey et al. 2007, Langlois et al. 2010). The results from our study suggest that, with a proper frame design, those capabilities can also be utilized for some deepwater, highly rugose rocky reef habitats, without unacceptable risk of loss or damage to the camera system. Studies comparing different visual census methods for reef fishes generally recognize some bias in all techniques and suggest that the choice of technique for surveys should consider the known behaviors of the species of interest and the biases inherent in the technique (Willis and Babcock 2000, Watson et al. 2005). Our video lander system worked well for our primary species of interest at Stonewall Bank, yelloweye rockfish, for several reasons. Yelloweye rockfish are a large rockfish, have distinct coloration and body shape, are strongly demersally oriented and are believed to be fairly sedentary, making them readily identifiable with a benthic video lander employing a color camera (Love et al. 2002, Hannah and Rankin 2011). Although small fish are generally harder to accurately identify from video footage, juvenile yelloweye rockfish have very distinctive striped markings (Figure 4) that greatly alleviate this problem (Love et al. 2002). Our observations also suggest that yelloweye rockfish and most other demersal fishes inhabiting the areas we sampled did not appear to avoid the video lander and that some have at least a moderate tendency to approach it, potentially improving sampling efficiency for some species. However, although mild attraction may increase sampling efficiency for some species, it may also bias information on species composition.

Our data on yelloweye rockfish relative abundance, distribution and habitat associations at Stonewall Bank provided convincing evidence that a relocation of the western boundary of the YRCA further west would provide improved protection for yelloweye rockfish from fishery impacts (Figure 5). The positive association we demonstrated between the presence of yelloweye rockfish and crevice and large boulder habitat is consistent with the findings of O’Connel and Carlile (1993) for yelloweye rockfish in the eastern Gulf of Alaska. Similarly, the negative association found for this species with bedrock outcrops at Stonewall Bank is consistent with the very low densities of yelloweye rockfish they report for continuous rock bottom habitat (O’Connel and Carlile 1993). Given that yelloweye rockfish are currently considered overfished and at relatively low population levels in waters off the U.S west coast (PFMC 2011), the choice of an optimal new western boundary for the YRCA should consider the spatial distribution of both observed yelloweye rockfish and their preferred habitats at Stonewall Bank (Figure 6).

The video lander system developed here adds to the tools available for studying deepwater rocky reef fishes, however, due to the very limited amount of habitat viewed in a single deployment, it is unlikely to supplant more technically sophisticated survey tools like ROVs and HOVs. Our study suggests that it is not a good survey tool for cryptic fishes like cabezon, although this may be typical for stationary underwater video platforms used in complex habitat (Watson et al. 2005). Additionally, it is unknown how our use of artificial lighting may have influenced the numbers of fish of different species that we observed, although some prior studies suggest that lighting from stationary HOVs does not seem to have observable effects on many common demersal species found in the U.S. Pacific northwest, including many rockfishes (Hixon et al. 1991, Stein et al. 1992). Despite these limitations, our video lander system may have some advantages for specific sampling situations. Our type of system might be very useful for surveying marine habitats that are risky for larger ROVs or HOVs due to shallow depth, extreme topography or strong currents. We successfully sampled reef systems that are nearshore, but also beyond the depth ranges that are most amenable to scuba surveys. In these habitats, we encountered highly variable visibility, a factor that may typically complicate surveys of these habitats in marine waters of the U.S. Pacific northwest. The smaller vessels that can deploy the video lander, along with its simplicity and portability make mobilizing a survey quick and inexpensive in comparison with most ROVs and HOVs. This should facilitate attempting visual surveys of rocky habitat across a wider range of marine conditions (different days, tidal stages, etc.), increasing the likelihood of encountering favorable conditions and completing a survey in the nearshore environment. This ease of deployment also makes the video lander an excellent choice for very broad-scale surveys of demersal fish distribution, benthic habitat types or species-habitat associations: situations in which broad spatial coverage may be more important than viewing a large amount of seafloor in a single deployment, as is more typical for ROVs and HOVs.

The reliable retrievability of the video lander frame system suggests the possibility of adapting it for other visual sampling tools. It can be modified to carry other types of equipment, such as still cameras or high-definition video systems or different types of lights. The potential also exists for equipping the lander frame with a calibrated stereo-video or stereo-camera system (e.g. Williams et al. 2010) to estimate the lengths of the fish observed. For the reefs we surveyed, it's also possible that the efficiency of visual data collection with a video lander could be improved for some species of interest (e.g yelloweye rockfish) by using bait as an attractant, an approach that has been shown to very effective in other areas for some species (Willis and Babcock 2000, Watson et al. 2005, Harvey et al. 2007, Langlois et al. 2010). This is a topic that warrants additional investigation.

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Figure Captions

Figure 1. The video lander, showing the location of sequential break-away connections (arrows), camera (A), lights (B), pressure housing containing batteries and camcorder (C), sacrificial (breakaway) base (D) and steel weight (E).

Figure 2. Map showing the 5 reef complexes surveyed in initial field tests of the video lander, October 2009 through September 2010.

Figure 3. Sampling stations (small dots) and the number of yelloweye rockfish (maximum number in a single videof rame) observed (fish symbols) during the 2011 survey of the northern portion of Stonewall Bank.

Figure 4. Still image from video lander footage at Stonewall Bank, Oregon, showing a view that is partially obstructed on the right by nearby rock with a yellowtail rockfish (*Sebastes flavidus*) visible in the left foreground and a yelloweye rockfish visible below it in association with crevice habitat.

Figure 5. Percent composition of primary and secondary habitat types (see text) identified at stations inside and outside of the Yelloweye Rockfish Conservation Area at Stonewall Bank (Figure 3), Oregon, April through August, 2011.

Figure 6. Spatial distribution of habitat types preferred by yelloweye rockfish (crevice as a primary habitat type and large boulder as a secondary habitat type) at Stonewall Bank, Oregon, April through August 2011. One possible alternative western

boundary for the Yelloweye Rockfish Conservation Area is also shown (heavy hatched line).

Table 1. Design, manufacturer and approximate cost (U.S. dollars) for a video lander camera system with four sacrificial bases.

Component	Design or model number	Manufacturer	Number	Total Cost
Lander frame	32 mm OD aluminum tubing	Local manufacture	1	$620
Sacrificial base	13 mm diameter mild steel rod	Local manufacture	4	$450
Base weights	51 mm diameter mild steel rod, 61 cm long	Local manufacture	4	$47
Camera	Multi-SeaCam® 2060	Deep Sea Power and Light	1	$2,250
Lights	LED Mini-Sealite®	Deep Sea Power and Light	2	$2,600
Pressure housing	102 mm ID aluminum, anodized	The Sexton Company LLC	1	$1,714
Batteries	13.2 volt, 4.0 Amp-h X 2, NiMH	Energy Sales	4	$712
Battery chargers	CCC-3029, temperature controlled	Energy Sales	2	$450
Camcorder	TRV11	Sony	1	$599
Pressure-activated switch	PSW-3	The Sexton Company LLC	1	$380
LANC controller board	Micro controller circuit board	Mac Marine Instruments	1	$250
Underwater cable and connectors	-	Teledyne Impulse	5	$702
Total				$10,774

Table 2. Criteria used to classify visibility and the quality of the view from video lander footage of Oregon rocky reef survey sites, October 2009 to August 2011.

Category	Class	Description
Visibility	Poor	View of surrounding substrate completely obscured by turbidity or marine snow
	Moderate	View of surrounding substrate is not obscured but viewing distance is limited by variable turbidity and /or marine snow
	Good	View of surrounding substrate is clear to the limit of the lighted area
View quality	Poor	Camera is facing a rock in close proximity, looking straight down at the substrate or up into open water
	Moderate	View is at acceptable angle, substrate can be seen, however a portion of the view is blocked by nearby habitat
	Good	View is at an acceptable angle and view is unobstructed.

Table 3. Criteria used to classify primary and secondary habitat types viewed with the video lander at the rocky reef survey sites, Oregon, October 2009 through August 2011.

Primary and secondary habitat types	Description
Flat bedrock	Rock with little to no relief
Bedrock outcrop	Solid rock with some relief extending across the view
Large boulder	Boulders approximately 1-3 m in diameter (includes angular blocks of broken bedrock)
Small boulder	Boulders approximately 0.25-1 m diameter
Cobble	Cobble approximately 6-25 cm diameter
Gravel/pebble	Gravel or pebble approximately 2-60 mm diameter
Sand	Sand with grain size 0.06-2 mm diameter
Crevice	Crevices in rock up to 1 m high by 1-3 m wide
Vertical wall	Rock wall higher than 2 m and greater than 80 degrees to the horizontal
Hash	Small broken bits of shell

Table 4. Total numbers (percentage) of fish observed (sum of maximum counts across stations for the 16 most abundant species or groups) in selected visual fish surveys with an experimental video lander, by species or group and survey area, October 2009 through September 2010 (n denotes number of stations sampled).

Fish species	Cape Perpetua reef (February, n=30)	Cape Perpetua reef (July, n=30)	Seal Rocks reef (n=43)	East Siletz reef (n=36)	West Siletz reef (n=30)	Stonewall Bank (n=173)	Total
Rockfish							
Black rockfish *Sebastes melanops*	62 (15.4)	72 (21.1)	182 (48.3)	15 (5.5)	11 (6.7)	0 (0.0)	342 (15.1)
Blue rockfish *S. mystinus*	2 (0.5)	1 (0.3)	18 (4.8)	187 (68.3)	47 (28.5)	54 (7.6)	309 (13.6)
Brown rockfish *S. auriculatus*	3 (0.8)	1 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (0.2)
Canary rockfish *S. pinniger*	173 (43.0)	156 (45.8)	47 (12.5)	18 (6.6)	74 (44.9)	202 (28.4)	670 (29.5)
Copper rockfish *S. caurinus*	6 (1.5)	2 (0.6)	5 (1.3)	0 (0.0)	0 (0.0)	0 (0.0)	13 (0.6)
Unidentified juvenile	7 (1.7)	47 (13.8)	56 (14.9)	3 (1.1)	0 (0.0)	281 (39.5)	394 (17.4)

rockfish *Sebastes spp.*							
Quillback rockfish *S.maliger*	9 (2.2)	8 (2.4)	6 (1.6)	2 (0.7)	3 (1.8)	1 (0.1)	29 (1.3)
Rosethorn rockfish *S. helvomaculatus*	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	18 (2.5)	18 (0.8)
Yellowtail rockfish *S. flavidus*	44 (11.0)	14 (4.1)	18 (4.8)	2 (0.7)	5 (3.0)	95 (13.4)	178 (7.8)
Yelloweye rockfish *S. ruberrimus*	3 (0.8)	0 (0.0)	1 (0.3)	6 (2.2)	3 (1.8)	22 (3.1)	35 (1.5)
Other species							
Cabezon *Scorpaenichthys marmoratus*	2 (0.5)	3 (0.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.2)
Kelp greenling *Hexagrammos decagrammus*	14 (3.5)	18 (5.3)	23 (6.1)	16 (5.8)	8 (4.9)	13 (1.8)	92 (4.1)
Lingcod *Ophiodon elongatus*	8 (2.0)	7 (2.1)	15 (4.0)	23 (8.4)	12 (7.3)	13 (1.8)	78 (3.4)
Pacific halibut *Hippoglossus stenolepis*	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	8 (1.1)	8 (0.4)

Pile perch *Damalichthys vacca*	68 (16.9)	11 (3.2)	6 (1.6)	0 (0.0)	2 (1.2)	0 (0.0)	87 (3.8)
Unidentified sculpin Cottidae	1 (0.3)	1 (0.3)	0 (0.0)	2 (0.7)	0 (0.0)	4 (0.6)	8 (0.4)
Total	402	341	377	274	165	711	2,270
Mean station depth (m)	51.3	51.3	30.7	33.6	40.4	54.3	

Table 5. Summary of mean number of fish observed per station for five demersal fish species surveyed with a video lander at Stonewall Bank, inside and outside (to the west) of the Yelloweye Rockfish Conservation Area, April through August 2011 (Figure 3). Also shown is the percentage difference in abundance outside the YRCA and the P-value from a Wilcoxon test comparing mean abundance inside and outside the YRCA.

Species	Mean number (1SE) observed per station		Percentage difference outside YRCA	P-value in Wilcoxon test
	Inside YRCA	Outside YRCA		
Canary rockfish	0.561 (0.140)	0.631 (0.140)	+12.5	0.320
Kelp greenling	0.144 (0.022)	0.114 (0.020)	-20.8	0.303
Lingcod	0.148 (0.028)	0.072 (0.020)	-51.4	0.007
Rosethorn rockfish	0.318 (0.046)	0.228 (0.040)	-28.3	0.093
Yelloweye rockfish	0.144 (0.028)	0.179 (0.032)	+24.3	0.417

Fig. 1

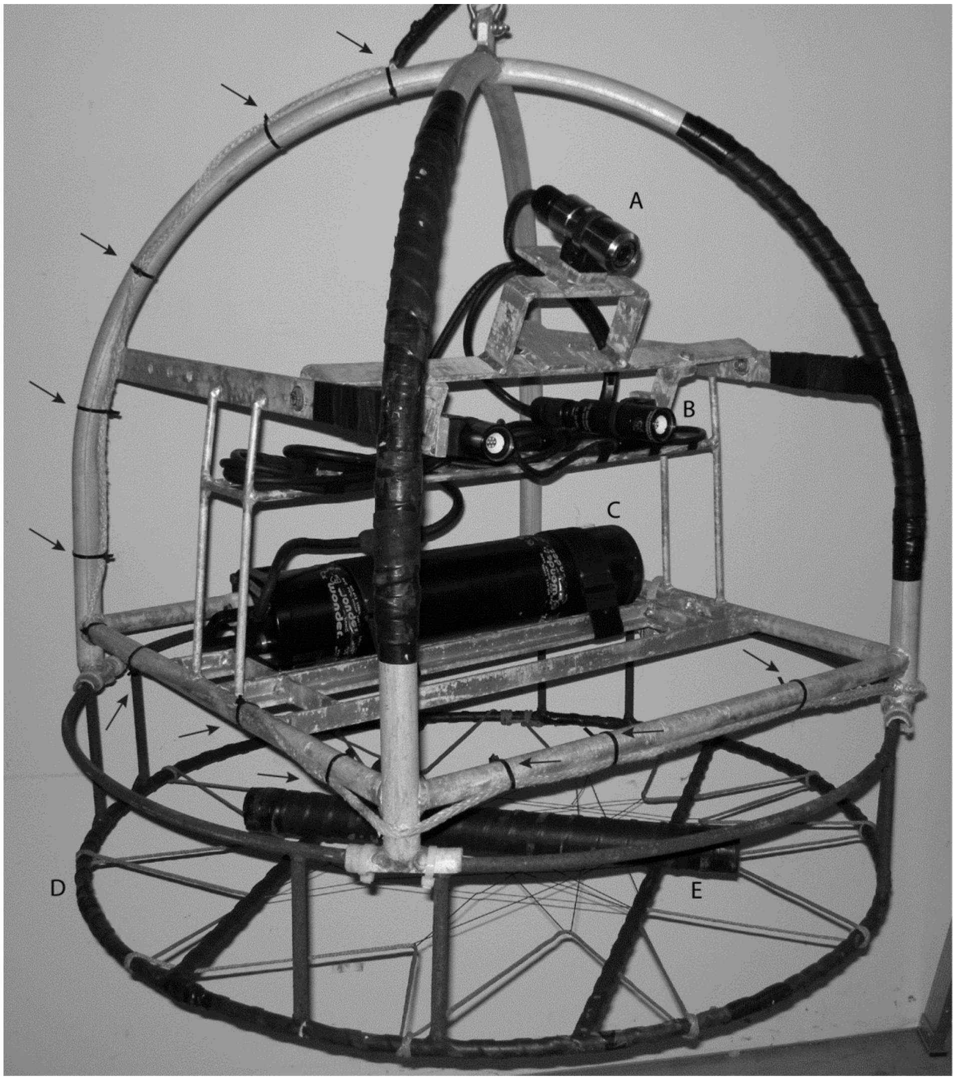


Fig. 2

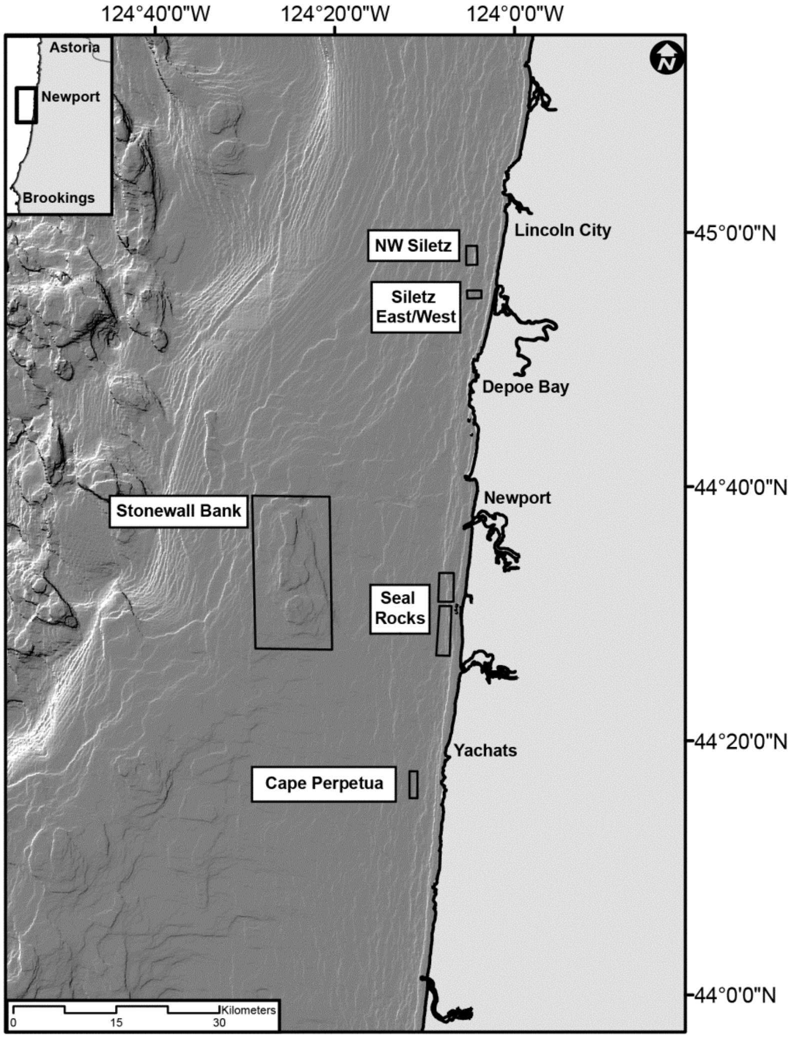
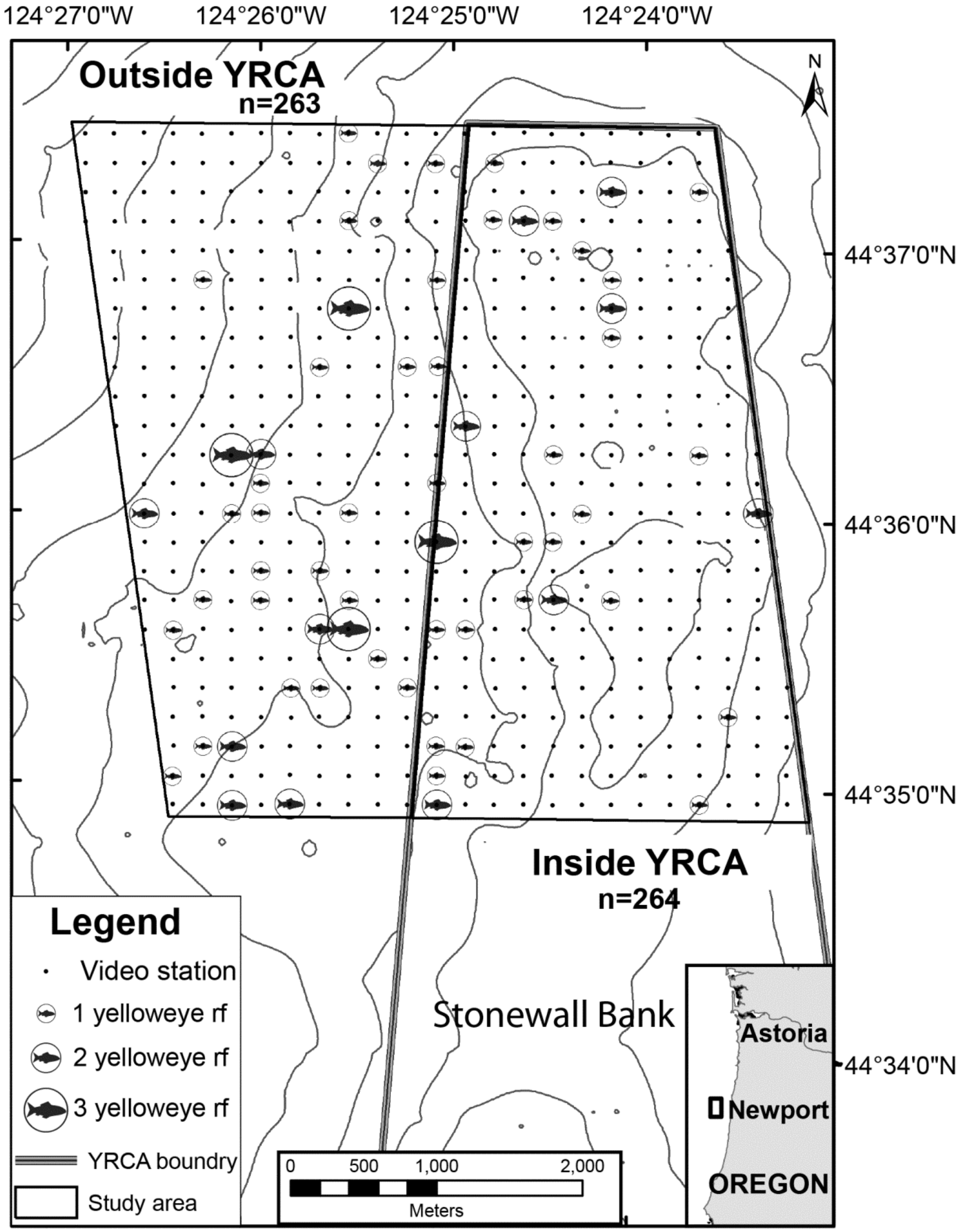
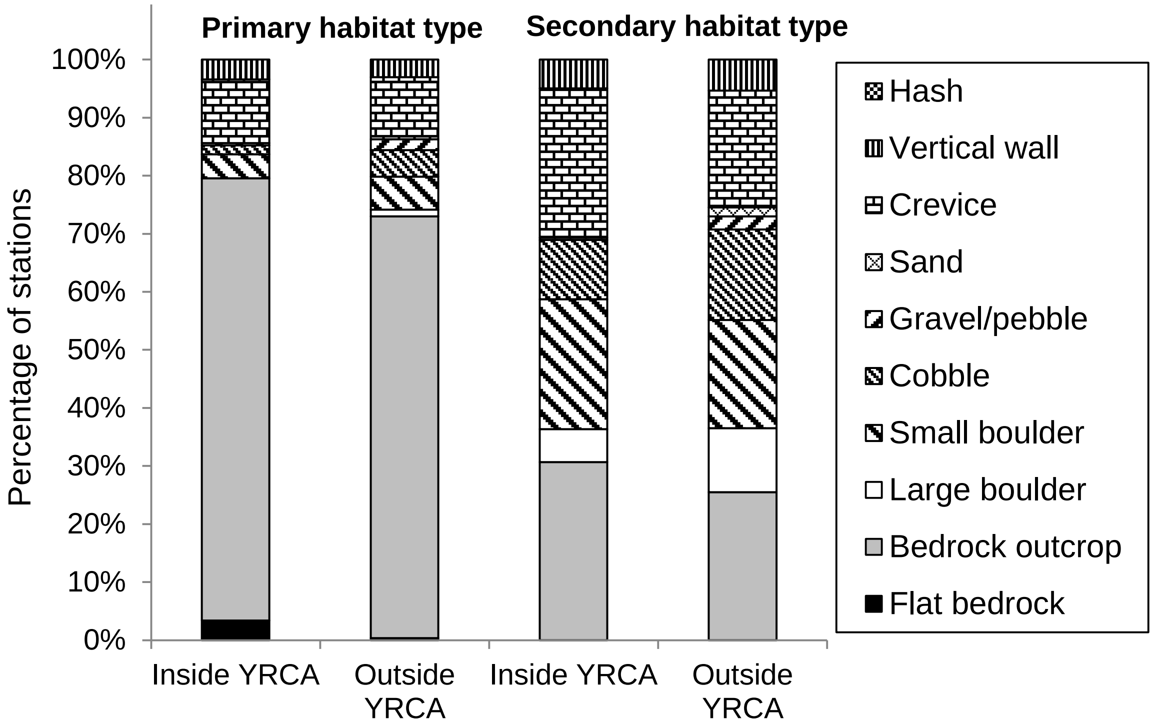

124°40'0"W
124°20'0"W
124°0'0"W
Astoria
Newport
Brookings
45°0'0"N
44°40'0"N
44°20'0"N
44°0'0"N
Lincoln City
NW Siletz
Siletz East/West
Depoe Bay
Newport
Stonewall Bank
Seal Rocks
Yachats
Cape Perpetua
0
15
30
Kilometers
N

Fig. 3



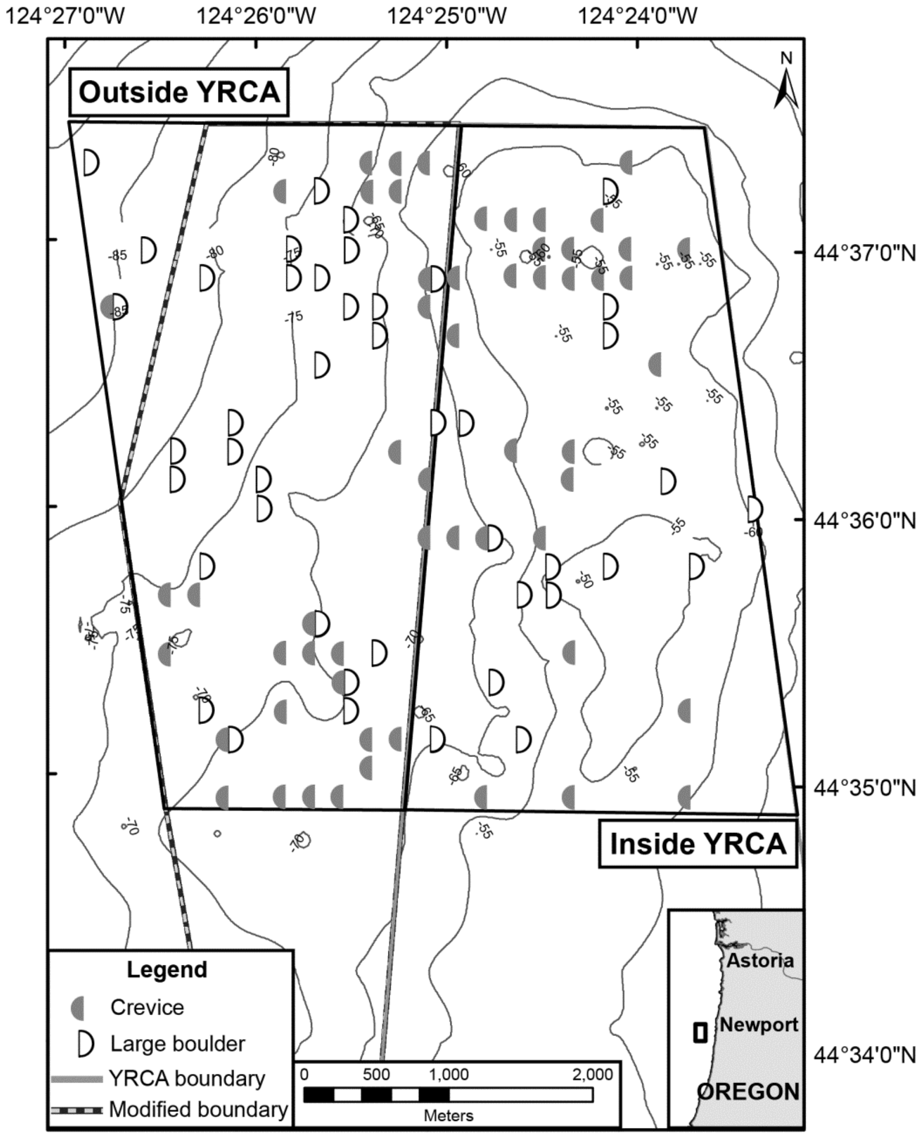
124°27'0"W
124°26'0"W
124°25'0"W
124°24'0"W
Outside YRCA
n=263
N
44°37'0"N
44°36'0"N
44°35'0"N
44°34'0"N
Inside YRCA
n=264
Stonewall Bank
Legend
Video station
1 yelloweye rf
2 yelloweye rf
3 yelloweye rf
YRCA boundry
Study area
0
500
1,000
2,000
Meters
Astoria
Newport
OREGON

Fig. 5



Primary habitat type
Secondary habitat type
Percentage of stations
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Inside YRCA
Outside YRCA
Inside YRCA
Outside YRCA
Hash
Vertical wall
Crevice
Sand
Gravel/pebble
Cobble
Small boulder
Large boulder
Bedrock outcrop
Flat bedrock

Fig. 6


124°27'0"W
124°26'0"W
124°25'0"W
124°24'0"W
44°37'0"N
44°36'0"N
44°35'0"N
44°34'0"N
Outside YRCA
Inside YRCA
N
-85
-80
-75
-70
-65
-60
-55
-50
Legend
Crevice
Large boulder
YRCA boundary
Modified boundary
0
500
1,000
2,000
Meters
Astoria
Newport
OREGON