The influence of bait and stereo video on the performance of a video lander as a survey tool for marine demersal reef fishes in Oregon waters

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Abstract

We evaluated how the use of bait as a fish attractant influenced the species and size composition of demersal fishes viewed with a stereo video lander, at 160 sampling sites at Stonewall Bank, a deepwater rocky reef complex in Oregon waters. We also studied the effectiveness of stereo video for generating estimates of fish length and distance from the cameras. Bait altered the species composition of fish encountered ($P<0.05$), increasing the mean counts (MaxN, see text) of demersal fishes by 47% ($P<0.01$), with increases of 135-250% for Rosethorn Rockfish *Sebastes helvomaculatus* ($P<0.05$), Northern Ronquil *Ronquilis jordani* ($P<0.05$) and Spotted Ratfish *Hydrolagus colliei* ($P<0.05$). Increases in the mean counts of 35-150% for unidentified sculpins (Cottidae) and Yelloweye Rockfish *S. ruberrimus* and Quillback Rockfish *S. maliger*, were non-significant ($P>0.05$). The calibrated stereo video lander provided acceptably precise estimates of fish length and distance (range of three replicate measurements less than 3 cm and 20 cm for length and distance, respectively) for 34.3% of the demersal fishes that were counted. The precision of length and distance estimates declined with increased distance, with acceptable estimates typical within 200 cm distance and infrequent beyond 500 cm. Bait reduced the mean distance at which acceptable estimates of demersal fish length and distance were obtained, from 264 cm to 200 cm ($P<0.01$), but had no effect on mean fish length for the three most frequently encountered demersal species ($P>0.05$). The combined effect of bait on demersal fish counts and mean distance from the cameras more than doubled the efficiency of the stereo video lander for generating fish length and distance estimates.

Introduction

The implementation of numerous no-take marine reserves on the U.S. west coast has led to increased interest in further development of visual survey methods, particularly for demersal fishes inhabiting rocky reefs that are too deep for diver surveys. Deepwater rocky reefs are environments that are very challenging to sample, as they often include many areas that cannot be effectively sampled with survey trawls (Zimmerman 2003; Williams et al. 2010). Visual surveys of deepwater rocky reefs on the U.S. west coast have typically been conducted with remotely operated or human-occupied vehicles (Stoner et al. 2008). Recently, video landers have been developed and tested as an alternative survey tool for these habitats (Hannah and Blume 2012; Easton 2013). A video lander is a simple rugged frame enclosing an underwater video system that can be dropped to the seafloor to record images at a fixed station for a fixed time period. Landers are low cost sampling devices designed to be used in very rugged rocky habitat, and can be deployed from vessels equipped with only a hydraulic block (Hannah and Blume 2012). They have been shown to be useful for distinguishing differences in fish abundance and species assemblages and also for identifying species-habitat relationships (Hannah and Blume 2012; Easton 2013). The video landers used on the U.S west coast operate similarly to the remote underwater video stations (RUVs) that have been used successfully, either with or without bait as a fish attractant, to study reef fish populations in the southern hemisphere (Willis and Babcock 2000; Willis et al. 2000; Harvey et al. 2007). Previous video lander research that has been conducted in waters off of Oregon has not used bait as a fish attractant (Hannah and Blume 2012); however bait has been shown to increase visual sampling efficiency for some species in other waters (Harvey et al. 2007). Our primary objective was to determine how the use of bait would influence the species composition of fishes viewed with a video lander on a temperate rocky reef.

Video landers used on the U.S. west coast to date have typically utilized single-camera systems, requiring a pair of calibrated lasers to generate modest amounts of fish length data. Single-camera lander systems, even with paired lasers, cannot provide accurate estimates of the distance of counted fish from the camera, a potential measure of the area being sampled. Calibrated stereo video systems have been shown to be effective for estimating these parameters in other areas and applications (Harvey et al. 2001; Harvey et al. 2004; Williams et al. 2010; Langlois et al. 2012), but have not been evaluated on a video lander for sampling temperate deepwater rocky reef fishes. Our second objective was to evaluate the effectiveness of a stereo video lander for generating precise fish length and distance estimates with a video lander. Stereo video capability facilitates the additional study objectives of evaluating the effect of bait on the size composition of demersal fishes viewed, as well as the effect of bait on the distance at which fish were being counted and measured.

Methods

Study area

This study was conducted at Stonewall Bank, a large (approximately 5 km east-west and 42 km north-south) rocky reef complex located off central Oregon (Figure 1). Stonewall Bank was chosen as a study site based on available information from prior video lander surveys (Hannah and Blume 2012). Prior surveys typically encountered acceptable water clarity and also provided data on habitat type at hundreds of locations, allowing some control for habitat type in selecting our sampling sites (Hannah and Blume 2012). The prior surveys also showed a wide variety of demersal fishes inhabiting this reef complex.

Study design

We selected sampling sites for this study from over 800 locations previously sampled with an unbaited video lander in 2009-2010 (Hannah and Blume 2012). We first systematically eliminated some of the possible sites to maintain a minimum distance of 400 m between all sites. This minimum distance was chosen to reduce the likelihood of viewing the same fish at two adjacent sites on the same day. Then we randomly selected 80 sites each for baited and unbaited video lander deployments, totaling 160 sampling sites, focusing on sites with complex habitat types such as bedrock outcrops, large boulders, crevices or vertical walls that we considered more likely to hold abundances of demersal fish. The 160 sampling sites were then divided, based on proximity, into 8 single-day surveys of 20 sites each, with sites evenly split between baited and unbaited deployments each day (Figure 1).

Stereo video lander system

Our stereo video lander used a frame (Figure 2) that was very similar to that described by Hannah and Blume (2012). It consisted of a tubular aluminum frame (32 mm OD tubing) enclosing the video equipment, lights and battery housing (Figure 2). The frame system similarly used a weighted, sacrificial base made of 13 mm diameter mild steel rod designed to break away if the lander became snagged in rocky habitat. The system also incorporated a series of “break away” attachment points designed to fail in a sequence to tilt and then rotate the lander as pulling force increased, to improve the probability of successful retrieval from rocky habitat.

Although our lander frame and bases were very similar to those described by Hannah and Blume (2012), our camera system was quite different. We used a pair of stereo-calibrated high-definition Canon Vixia® HFS21 video cameras instead of a single standard-definition Deep Sea Power and Light (DSPL) Multi-Seacam® 2060. The use of a calibrated stereo video system allowed us to estimate the total length (cm) of many of the fish viewed, as well as the distance of these fish from the camera system (cm). Each camera was equipped with a wide-angle adapter (DVP-WA50-58 Pro Digital 0.5X) to increase the field of view. The video cameras were set to "progressive scan" and 24 frames per second to provide crisp single-frame still images for use in estimating fish length and distance. Each camera was enclosed in an underwater housing, equipped with a dome port (Figure 2). The two camera housings were separated by 40.3 cm (measured between the centers of the camera housings) and were aimed inwards at a 4 degree angle to increase the overlap of the two video fields.

Our system illuminated the seafloor with two DSPL Sealite Spheres® (3000 lm, 6000 K) as opposed to the two DSPL Mini-Sealites® (850 lm, 6500 K) used by Hannah and Blume (2012). The more powerful lights were chosen because of the decreased low-light sensitivity of the high-definition video cameras in comparison to the DSPL Multi-Seacam® 2060.

Calibration of the stereo camera system was completed using the camera calibration toolbox for Matlab (version R2011a) available at http://www.vision.caltech.edu/bouguetj/calib_doc/ (Bouget 2008). Following initial calibration with a printed checkerboard grid, 49 underwater length measurements of known-size objects were taken in a seawater tank to determine the inherent accuracy of the calibrated stereo video system. Under these ideal conditions of lighting and water clarity, but within a distance limit inside the seawater tank of about 1.5 m, 42 of 49 length measurements were within 1 cm of the known length (Figure 3). The estimates were also slightly positively biased, with a mean measurement anomaly of 0.21 cm (mean 0.21 cm, SE±0.10 cm). Prior to final calibration, the cameras, camera mounting plates, housing ends and housing end-caps were all etched with fine, permanent alignment marks to ensure that the system could be disassembled to change camera batteries and then reassembled in the exact same physical orientation. To check for errors in length estimates from removing the cameras from the housings, the measurement of known-size objects was repeated before and after disassembly and reassembly of both housings, and the length estimates yielded very similar accuracy. We also filmed a digital stopwatch with both cameras simultaneously and compared frame counts at identical times at the start and after 10 minutes of filming to check for between-camera differences in clock "drift" and found none.

Field methods

Sampling was conducted between April and September, 2013. Sites for baited and unbaited lander deployments were sampled in an AABB pattern each day. To balance out any effects from time of day, 4 of the 8 surveys were started with baited deployments and four were started with unbaited deployments. A nominal duration of 12 minutes on the seafloor was used for both baited and unbaited deployments. This duration was chosen to allow as much time as possible for fishes to respond to the bait while still completing 20 sites per day and thus complete a total of 160 sites within 8 days of vessel time. For baited deployments, an orange mesh bait bag enclosing 0.9 kg of chopped Pacific Sardine (*Sardinops sagax*), chopped Pacific Herring (*Clupea* *harengus*) or a mixture of these species was suspended in front of the video cameras at the end of a 152 cm aluminum pole (Figures 2 and 3). For unbaited deployments, an identical empty bait bag, that had never been in contact with bait, was suspended in the same position. Although the mix of bait species varied some between survey days due to availability, the same mix of bait was used during each sampling day. Prior to each deployment, a running digital stopwatch showing hundredths of a second was held in full view of both cameras to allow later synchronization of the video feeds to the individual frame.

Video analysis

The video from each deployment was imported into Adobe Premiere Pro® CS5.5 so that it could be easily reviewed on a full size computer screen. Each deployment was scored for water clarity and the quality of the view of the surrounding habitat, using the criteria from Hannah and Blume (2012). Fish 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 (MaxN, Harvey et al. 2007). This approach resulted in conservative counts, but was necessary because it was often impossible 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 deployment, using the criteria from Hannah and Blume (2012) to verify that differences in habitat type were adequately controlled for between baited and unbaited deployments.

Each counted fish was next evaluated to determine if estimates of fish length (cm) and distance from the camera (cm) could be made. Estimates were made whenever a pair of synchronized frames could be identified in which the fish in view was known to be a unique individual, the nose and tip of the tail could be clearly seen on both video feeds and the fish's body was approximately straight, not bent. Length and distance were calculated from paired, synchronized video frames using a custom version of the Matlab program entitled Stereomeasure developed by the National Marine Fisheries Service (Williams et al. 2010). To evaluate measurement precision with the stereo video system, three separate measurements of each fish were taken by sequentially selecting the nose and tail of each fish in each paired image with a computer mouse, generating replicated estimates of length, as well as distance from the camera system to both the nose and tail of the fish. The distance measurements for the nose and tail were then averaged to generate a mean fish distance from the camera system. As an indicator of the precision of the length and distance measurements for each fish we used the range of the three replicate measurements.

Statistical analysis

Except for reporting simple totals, we restricted our analysis to the 13 most commonly encountered species in our study (sum of MaxN >10). However, some analysis was focused solely on demersal fish species. Semi-pelagic rockfishes, such as Widow Rockfish *Sebastes entomelas*, Blue Rockfish *S. mystinus* or Yellowtail Rockfish *S. flavidus*, can be abundant at Stonewall Bank, however they are often distributed tens of meters up into the water column, and therefore may not be effectively sampled for relative abundance or size composition with a video lander.

We evaluated how bait influenced the assemblage of species viewed using a one-way ANOSIM, as implemented in PAST 2.14 (Hammer et al. 2001). We tested if the presence of bait increased the mean MaxN per station using the nonparametric Wilcoxon test (1-tailed). To determine how bait influenced the time at which MaxN was measured, we compared the elapsed time (min) on the seafloor to the frame where MaxN was established, between baited and unbaited deployments, using the Wilcoxon test (2-tailed). To determine the effect of bait on fish length and distance, we first screened the mean length and distance estimates to eliminate ones that were not precisely estimated. We included fish mean length and distance estimates in which all three replicates differed by no more than 3 cm and 20 cm, respectively. We used the nonparametric Wilcoxon test to compare the mean distance from the stereo video lander, between baited and unbaited deployments, for all of the demersal fish that met the screening criteria, and for the 3 most frequent species in this group. For demersal fish species in which a total of at least 25 acceptably precise individual mean length and distance estimates were made, we compared mean length between baited and unbaited deployments using a single-factor ANOVA.

Results

All 160 planned sites were sampled with the stereo video lander. To achieve an acceptable view of the surrounding habitat, six sites had to be re-sampled, primarily due to the lander coming to rest with the cameras pointing straight down or directly at a large rock at close range. Water clarity was typically rated as “good” (157 of 160 sites, Figure 3) or “moderate” (3 sites). The quality of the view of surrounding habitat was rated as “good” at 144 sites and “moderate” at 16 sites. Only two of the sacrificial bases were lost in the process of sampling all 160 sites. Due to a variety of technical problems with one or more of the video cameras, synchronized, stereo video from which fish length and distance could be estimated was obtained for only 140 of the 160 stations. Twelve of the 20 stations for which synchronized stereo video was not obtained were unbaited deployments and eight were baited deployments. The primary and secondary habitats encountered at the 160 stations were generally similar for baited and unbaited lander deployments (Figure 4). Baited deployments encountered slightly less flat bedrock, bedrock outcrop and large boulder, and slightly more small boulder and cobble, as primary habitat types. Baited deployments encountered slightly less flat bedrock, small boulder and large boulder, and slightly more bedrock outcrop and cobble, as secondary habitat types (Figure 3).

In total (sum of maxN), 625 fish of 24 different species or groups were counted at the 160 sites, 415 in baited deployments and 210 in unbaited deployments. The most commonly encountered demersal fish was Canary Rockfish *Sebastes pinniger* (N=118) followed by Rosethorn Rockfish *S. helvomaculatus* (N=77), and Northern Ronquil *Ronquilus jordani* (N=75). Other demersal fishes that were encountered included Yelloweye Rockfish *S. ruberrimus* (N=47), Kelp Greenling *Hexagrammos decagrammus* (N=30), Lingcod *Ophiodon elongatus* (N=20), Spotted Ratfish *Hydrolagus colliei* (N=18), Quillback Rockfish *S. maliger* (N=18), unidentified sculpins (N=14, Cottidae) and Silvergray Rockfish *S. brevispinis* (N=11). A variety of semi-pelagic rockfishes, including Blue Rockfish (N=66), Widow Rockfish (N=65) and Yellowtail Rockfish (N=49) were also frequently encountered, and were very abundant at a few sites.

Bait effects on fish counts and time to MaxN

The presence of bait altered the species composition of fish counted with the stereo video lander (ANOSIM, $P<0.05$, $R=0.017$), increasing the mean counts for demersal fishes, as a group, by 47% (Table 1, $P<0.01$). Mean counts increased 135-250% for Rosethorn Rockfish, Northern Ronquil and Spotted Ratfish ($P<0.05$, Table 1). Mean counts of several other demersal fish species were increased by 35-150%, including unidentified sculpins and Yelloweye Rockfish and Quillback Rockfish, however these differences in mean count were non-significant (Table 1, $P>0.05$). Interestingly, mean counts of two common demersal species, Canary Rockfish and Kelp Greenling, were not increased by the presence of bait (Table 1). The very large, but non-significant, increase in the mean count of Blue Rockfish (Table 1) is probably not meaningful, as it resulted from a very large school of fish noted in a single baited lander deployment.

With bait as an attractant the mean elapsed time at which MaxN was reached was delayed by about 1.5 min, suggesting a gradual accumulation effect for demersal fishes as a group (Table 2, $P<0.05$). Time to MaxN was longer for most demersal species when bait was present, but not all (Table 2). Individual species comparisons indicated a statistically significant increase in elapsed time to maxN only for spotted ratfish (Table 2, $P<0.05$).

Effectiveness of stereo video

Initial length and distance estimates were generated for 206 fishes of the 13 most commonly encountered species (Table 1) from the 140 successful stereo video lander deployments. The precision in fish length and distance estimates measured with the stereo video system was influenced by the distance of fish from the camera system (Figure 5). Generally, whenever the mean distance of a fish was less than 200 cm, acceptably precise estimates of both length and distance were obtained (Figure 5). Between 200 and 500 cm from the camera system, the percentage of acceptably precise estimates of length and distance declined, and beyond 500 cm, they were infrequently obtained (Figure 5). After eliminating length and distance estimates with a range in three replicate measurements of more than 3 or 20 cm, respectively, a total of 151 fishes remained for which length and distance estimates were considered acceptable, or about 29% of those that we were able to identify and count (sum of MaxN = 521). Of the 55 pairs of length and distance estimates that were rejected, 51 (93%) were rejected based solely on the length precision criteria of 3 estimates with a range of less than 3 cm. Baited lander deployments accounted for 71.5% of the acceptable estimate pairs. For demersal fishes, the stereo video system performed somewhat better. Acceptable length and distance estimates were obtained for 122 demersal fishes from 140 lander deployments, or 34.3% of the 356 that we were able to count. Baited lander deployments accounted for 71.3% of these measurements.

Bait effects on fish length and distance estimates

The mean distance at which demersal fishes were measured was reduced by the presence of bait (P<0.01). When bait was not present, demersal fishes were measured at a mean distance of 264 cm, but when bait was present, this distance was reduced to 200 cm, a difference of 64 cm. The combined effect of bait on demersal fish counts and the distance at which they were measured resulted in baited lander deployments being much more efficient for generating precise length and distance data (Figure 6). From the 68 unbaited deployments that resulted in synchronized stereo video, 35 acceptable measurements of demersal fish length and distance were obtained, or 0.51 combined measurements per deployment. With bait present, this rate increased to 1.21 measurements of length and distance per deployment, an increase of 237%. This effect was most pronounced for Yelloweye Rockfish, Silvergray Rockfish, Canary Rockfish and Lingcod (Figure 6). Oddly, more acceptably precise estimates of length and distance were obtained for Spotted Ratfish when bait was absent (Figure 6).

At least 25 acceptably precise measurements of length and distance were obtained for just three demersal species, Canary Rockfish (N=32), Yelloweye Rockfish (N=27) and Rosethorn Rockfish (N=26). For these fishes, the presence of bait had no significant effect on mean fish length ($P>0.05$, Figure 7), but did decrease mean distance (Table 3) from the stereo lander for Canary Rockfish ($P<0.01$) and Rosethorn Rockfish ($P<0.05$) but not for Yelloweye Rockfish ($P>0.05$). However, it should be noted that statistical power is very limited with these small sample sizes.

Discussion

This study shows that the use of bait as a fish attractant improves the efficiency of a stereo video lander system as a survey tool for demersal reef fishes in Oregon waters in several ways. Counts of many demersal fish species were increased, an important improvement for surveying populations of less abundant species like Quillback Rockfish or overfished species like Yelloweye Rockfish. This finding was consistent with previous studies of the effect of bait to attract fishes to RUV stations (Harvey et al. 2007), which showed that some species were encountered in higher numbers when bait was present, while sampling of other species was still effective. In our study, bait was also shown to reduce the average distance at which fish length and distance measurements were taken, suggesting a general effect of bringing some species closer to the camera system, which should improve both the precision of length and distance measurements from paired images as well as the ability to identify species from video. Although these effects from bait are not surprising, it is interesting that they are not reflected in all of the demersal species. We saw no effect of bait on either Kelp Greenling or Canary Rockfish counts, even though they were two of the more common species encountered. Interestingly, bait did improve the ability to generate length and distance estimates for Canary Rockfish with the stereo video system, while not increasing mean counts.

Although bait improved the efficiency of our stereo video lander for many demersal species, adding bait as a fish attractant had the disadvantage of requiring longer seafloor deployment times. We used nominal 12-minute deployments of the lander system in this study to allow the bait plume to spread and attract fish. Because we restricted sampling to just daylight hours, this limited the number of sites that could be sampled per day to about 20. Much of the prior work with an unbaited lander system utilized 4-5 minute deployments, and also sampled only during daylight hours, allowing about 30-40 sites to be sampled per day (Hannah and Blume 2012; Easton 2013). This trade-off between maximizing demersal fish counts and the number of sites sampled per day can perhaps be optimized with a set of two video lander systems, deployed in an alternating manner. If the second lander system can be deployed at a nearby site while the first system is recording video on the seafloor, the number of sites sampled with a nominal 12-minute bottom time can probably be increased to about 30-35 per day, using just daylight hours.

Despite bait improving the ability of our stereo video system to generate fish length and distance estimates from video, our system was relatively inefficient at generating these data, especially in comparison with capture-based survey methods such as hook-and-line sampling. Only about 1.2

acceptably precise combined measurements of length and distance were generated per deployment of the baited lander system, equivalent to about 24 combined estimates per day of sampling, at 20 sites per day. Although the ability to catch fish with hook-and-line gear can be quite variable, it still seems likely that capture-based sampling would generate considerably more length data per day than our stereo video lander system. Although less efficient than capture-based methods, the stereo video lander system can generate some accurate length frequency data for areas in which capture-based survey methods cannot be used, such as some MPAs. Hook-and-line sampling in particular can also have size- and species-related biases. These biases can make it difficult to accurately characterize species assemblages or generate unbiased length-frequency data. The data from our study suggest that these biases may be reduced some with a baited stereo video lander. For example, hook-and-line sampling at Stonewall Bank typically does not yield catches of Northern Ronquil or Spotted Ratfish, both of which were shown with the video lander to be fairly common. With the stereo video lander system we were able to generate 15 combined length and distance estimates for these two species.

It may be possible to improve the efficiency of the stereo video lander at generating precise fish length and distance estimates. The seawater tank we used for calibration limited the distance at which calibration images could be collected to about 1.5 m from the cameras, possibly limiting the precision of fish length or distance estimates made at greater distances. Calibrating the system in a larger seawater tank could possibly help address this. Also, the Stereomeasure estimation program we used could be modified to increase the size of the images as viewed on a computer screen, or a larger computer screen could be used, potentially improving the repeatability of length estimates through more precise identification of the location of the edges of each fish.

However, there are also some inherent limitations for length estimation with a stereo video lander. To obtain length and distance estimates, the nose and tail of a fish must be fully visible on both video feeds, and readily distinguishable from the background. For some smaller species or those that blend in well with the substrate, this is simply not possible at times. This problem limited our ability to generate length and distance estimates for Northern Ronquil in particular. In other work with stereo video RUVs, a larger separation between the two cameras (1.4-1.5 m) yielded better performance at generating precise length estimates (Harvey and Shortis 1996; Harvey et al. 2001). For our lander system however, the baseline separation of the cameras was limited by the size of the lander frame (Figure 2), which must be small enough to be readily handled on deck and deployed repeatedly over the side of a vessel (Hannah and Blume 2012). Lander systems are also purpose-built for deployment into deep and very rugose rocky habitat. Retrieval of the lander system frequently resulted in dragging of the frame through rocky habitat, requiring that the camera housings be well inside the frame edges to be sufficiently protected, also limiting the camera separation that can be used. These limitations, the modest efficiency of the stereo video system at generating precise length and distance estimates, and the increased cost and complexity of a stereo video lander, suggest that adding stereo capabilities to a video lander will probably be worthwhile only for surveys in which length and distance estimates are considered critical.

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Table 1. Summary of mean number (standard error) of fish observed per station with a stereo video lander at Stonewall Bank, by species, with and without bait as a fish attractant, April through September, 2013. Also shown is the percentage increase in mean number observed with bait and the one-tailed P-value from a Wilcoxon test comparing mean abundance with and without bait.

Species	Mean number (standard error) observed per station		Percentage increase with bait	P-value in Wilcoxon test
	With bait	Without bait		
Blue Rockfish (N=66)	0.763 (0.546)	0.063 (0.063)	1120.0	0.087
Canary Rockfish[a] (N=118)	0.588 (0.155)	0.888 (0.328)	-33.8	decrease
Kelp Greenling[a] (N=30)	0.175 (0.050)	0.200 (0.048)	-12.5	decrease
Lingcod[a] (N=20)	0.150 (0.044)	0.100 (0.038)	50.0	0.162
Northern Ronquil[a] (N=75)	0.725 (0.152)	0.213 (0.049)	241.2	0.006
Quillback Rockfish[a] (N=18)	0.150 (0.044)	0.075 (0.035)	100.0	0.060
Rosethorn Rockfish[a] (N=77)	0.675 (0.123)	0.288 (0.062)	134.8	0.014
Silvergray Rockfish[a] (N=11)	0.088 (0.041)	0.050 (0.035)	75.0	0.130
Spotted Ratfish[a] (N=18)	0.175 (0.050)	0.050 (0.025)	250.0	0.017
Unidentified sculpin[a] (N=14)	0.125 (0.041)	0.050 (0.025)	150.0	0.073
Widow Rockfish (N=65)	0.625 (0.625)	0.188 (0.188)	233.3	0.496
Yelloweye Rockfish[a] (N=47)	0.338 (0.075)	0.250 (0.074)	35.0	0.077
Yellowtail Rockfish (N=49)	0.438 (0.279)	0.175 (0.092)	150.0	0.376
Demersal species combined (N=428)	3.188 (0.341)	2.163 (0.408)	47.3	0.002

[a] Demersal species

Table 2. Summary of mean elapsed time (min, standard error) to MaxN for all demersal fish species (Table 1) counted with a stereo video lander, with and without bait as a fish attractant, by species, April through September, 2013. Also shown is the two-tailed P-value from a Wilcoxon test comparing mean elapsed time to Max N with and without bait.

Species	Elapsed time to Max N (min, standard error)		P-value in Wilcoxon test
	With bait	Without bait	
Canary Rockfish (N=33)	9.25 (1.14)	8.63 (1.36)	0.7125
Kelp Greenling (N=27)	9.50 (1.60)	6.23 (1.14)	0.1184
Lingcod (N=18)	8.96 (1.62)	7.08 (2.03)	0.4414
Northern Ronquil (N=44)	8.12 (0.80)	6.37 (1.10)	0.1500
Quillback Rockfish (N=16)	8.42 (1.17)	11.19 (1.50)	0.1262
Rosethorn Rockfish (N=49)	8.00 (0.75)	8.29 (1.01)	0.9346
Silvergray Rockfish (N=7)	10.68 (1.98)	5.64 (3.97)	0.2453
Spotted Ratfish (N=16)	11.59 (1.15)	2.18 (0.77)	0.0153
Unidentified sculpin (N=12)	6.99 (1.69)	8.82 (2.18)	0.6104
Yelloweye Rockfish (N=32)	9.95 (1.03)	7.77 (1.20)	0.2429
Demersal species combined (N=254)	8.95 (0.37)	7.41 (0.46)	0.0101

Table 3. Summary of mean distance (cm, standard error) from the stereo video lander for Canary Rockfish, Rosethorn Rockfish and Yelloweye Rockfish with acceptably precise estimates of fish length and distance (see text), with and without bait as a fish attractant, April through September, 2013. Also shown is the two-tailed P-value from a Wilcoxon test comparing mean distance with and without bait.

Species	Mean distance from lander (cm, standard error)		P-value in Wilcoxon test
	With bait	Without bait	
Canary Rockfish (N=32)	225.0 (20.0)	328.4 (35.5)	0.0055
Rosethorn Rockfish (N=26)	168.5 (12.7)	274.5 (37.0)	0.0142
Yelloweye Rockfish (N=27)	186.3 (20.6)	215.5 (27.9)	0.3130

Figure Captions

Figure 1. The study area at Stonewall Bank, showing sampling sites and the 8 areas allocated 20 sites each, evenly divided between deployments with and without bait as a fish attractant.

Figure 2. The stereo video lander used in this study, showing the camera housings (A), the lights (B), the battery housing (C), the sacrificial base (D), the bait bag support pole (E) and the lander frame (F).

Figure 3. The view from one of the paired video cameras, showing typical “good” water clarity and a “moderate” view quality (partially obstructed) during this study at Stonewall Bank, with the orange bait bag hanging near the center of the view. Three Rosethorn Rockfish are on the right and a Yelloweye Rockfish is emerging from behind a rock on the left.

Figure 4. Percent composition of primary and secondary habitat types (see text) identified at sites sampled with a stereo video lander at Stonewall Bank, Oregon, with and without bait as a fish attractant, April through September, 2013.

Figure 5. Relationship between the range of 3 replicate measurements of a fish’s length (cm, upper panel) and distance (cm) from a stereo video lander and the mean estimated distance from the stereo video lander.

Figure 6. The percentage of fish, by species or group, for which acceptable length and distance estimates were generated (number of acceptable estimate pairs/sum of maxN) with the stereo video lander, with and without bait as a fish attractant.

Figure 7. Estimated total length (mean of 3 measurements, cm) of Canary Rockfish, Rosethorn Rockfish and Yelloweye Rockfish measured with a stereo video lander, with and without bait as a fish attractant.

Figure 1

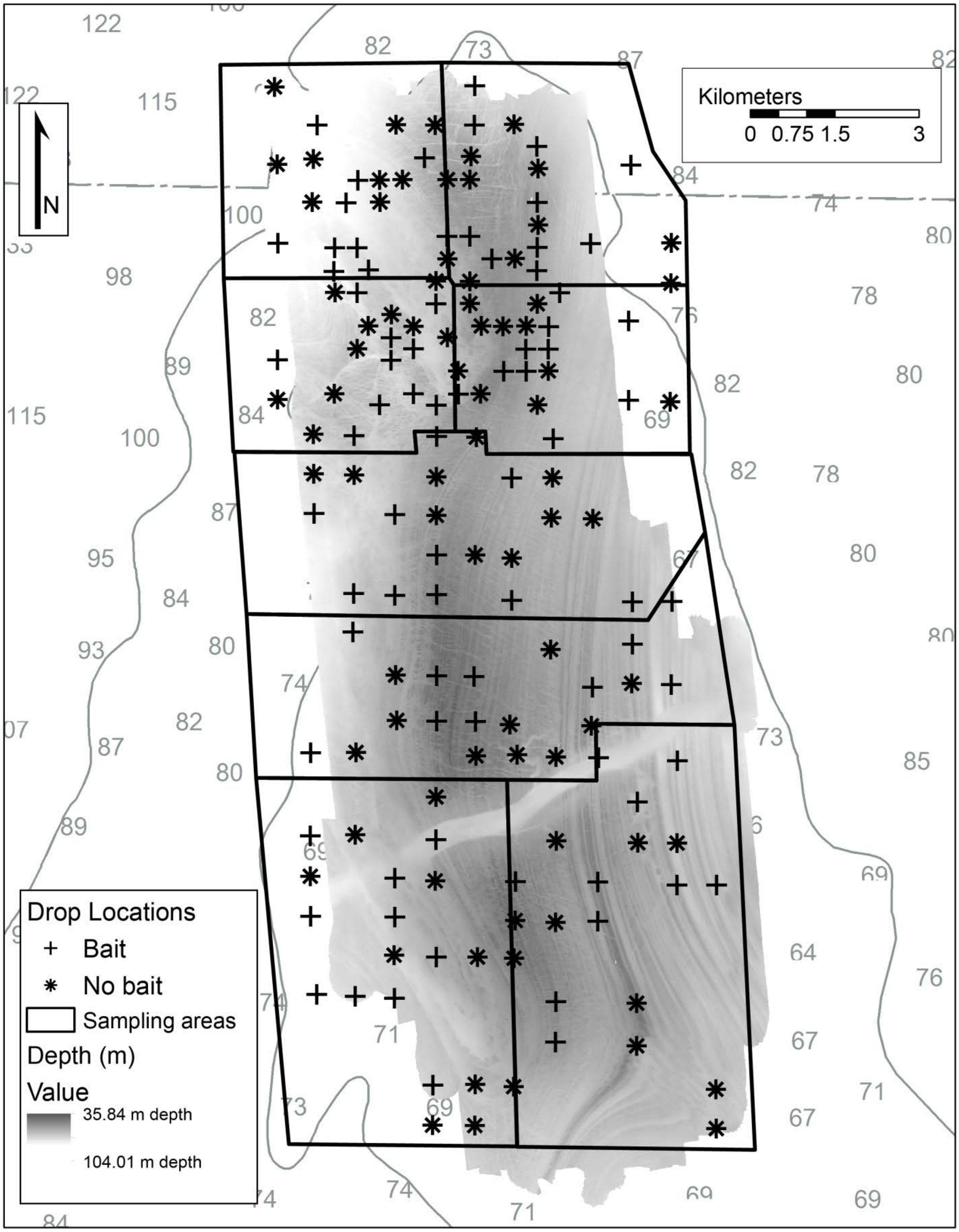

Kilometers
0 0.75 1.5 3
N
Drop Locations
+ Bait
✱ No bait
Sampling areas
Depth (m)
Value
35.84 m depth
104.01 m depth

Figure 2

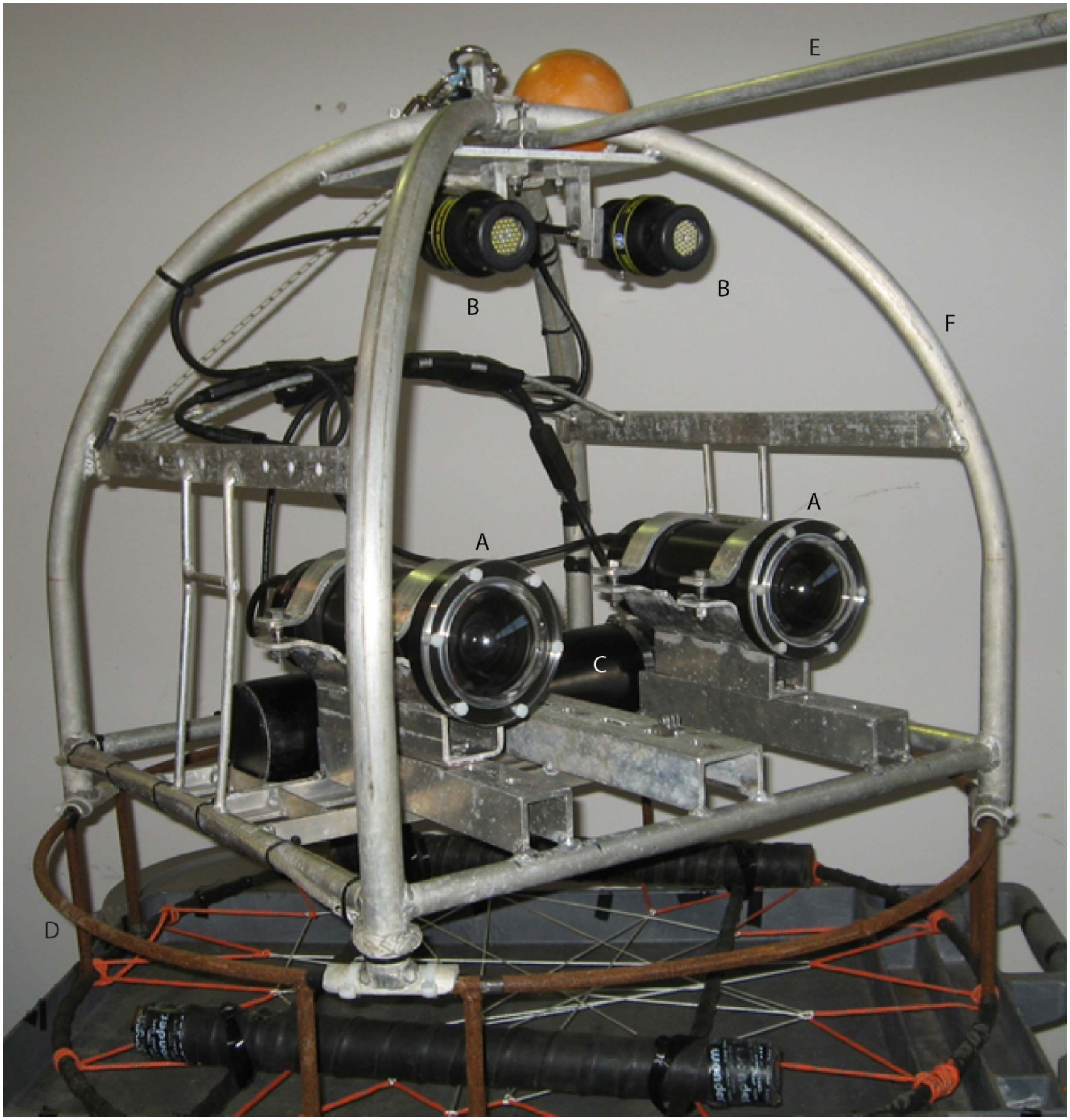


Figure 3

Figure 4

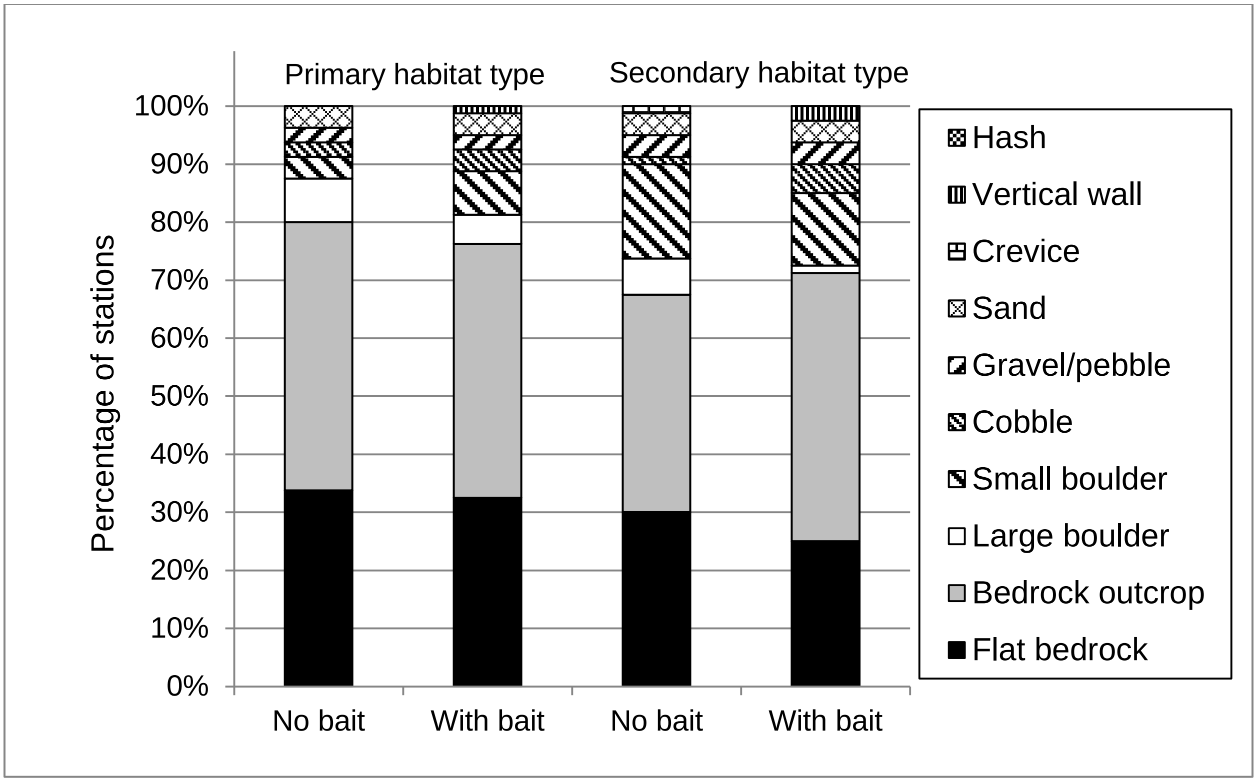

Primary habitat type
Secondary habitat type
Percentage of stations
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
No bait
With bait
No bait
With bait
Hash
Vertical wall
Crevice
Sand
Gravel/pebble
Cobble
Small boulder
Large boulder
Bedrock outcrop
Flat bedrock

Figure 5

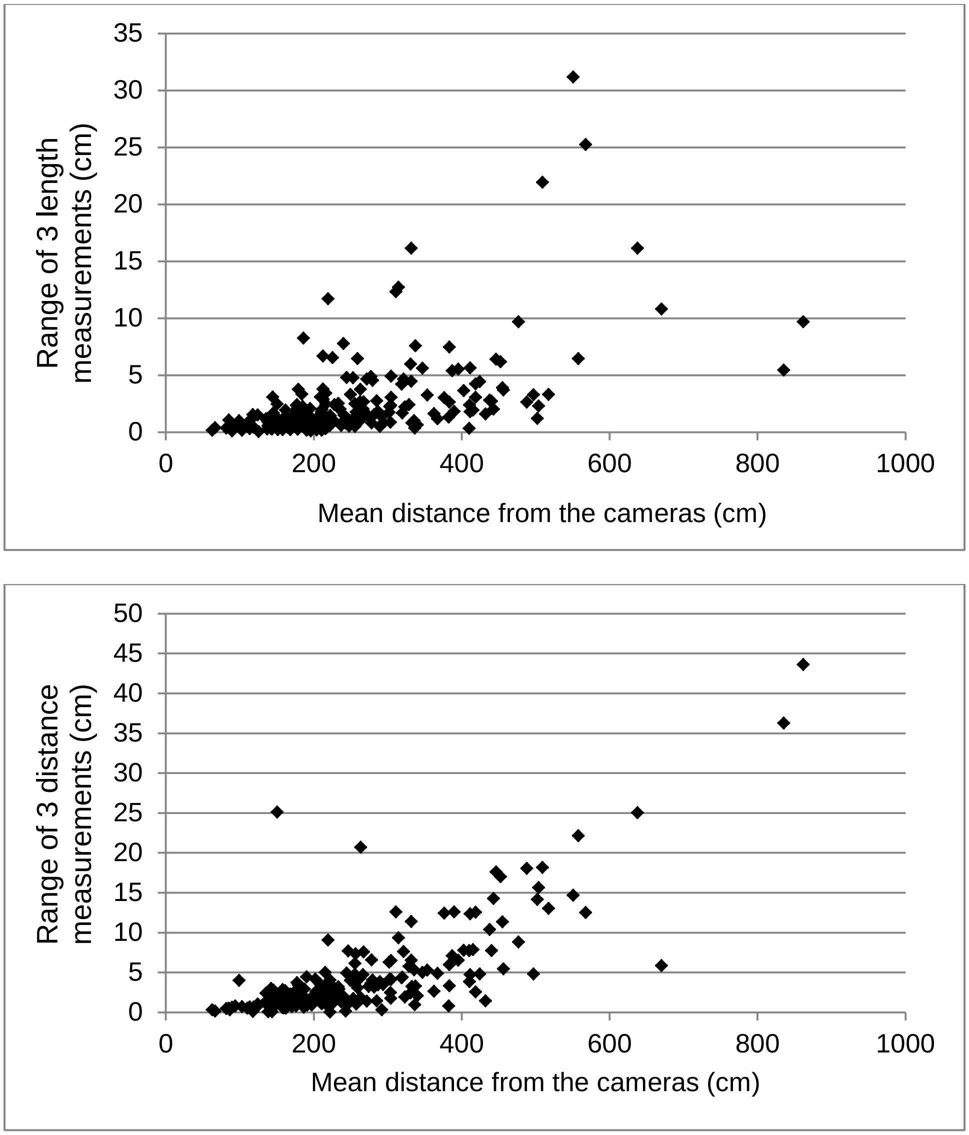

Range of 3 length measurements (cm)
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
Mean distance from the cameras (cm)
Range of 3 distance measurements (cm)
50
45
40
35
30
25
20
15
10
5
0
0
200
400
600
800
1000
Mean distance from the cameras (cm)

Figure 6

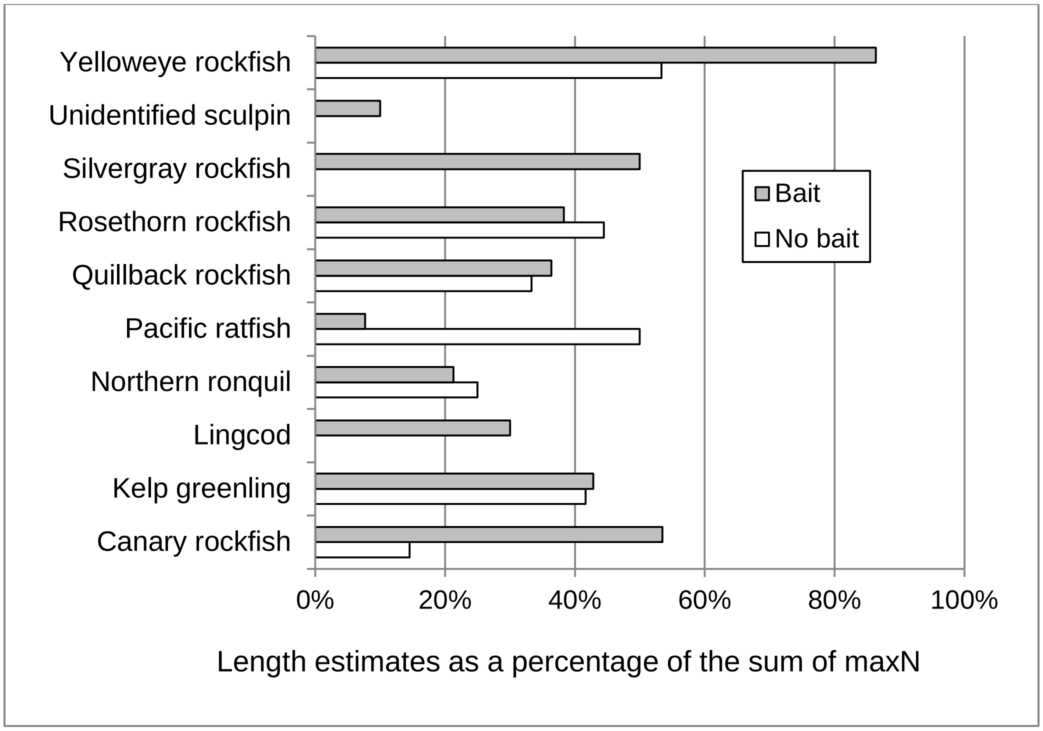
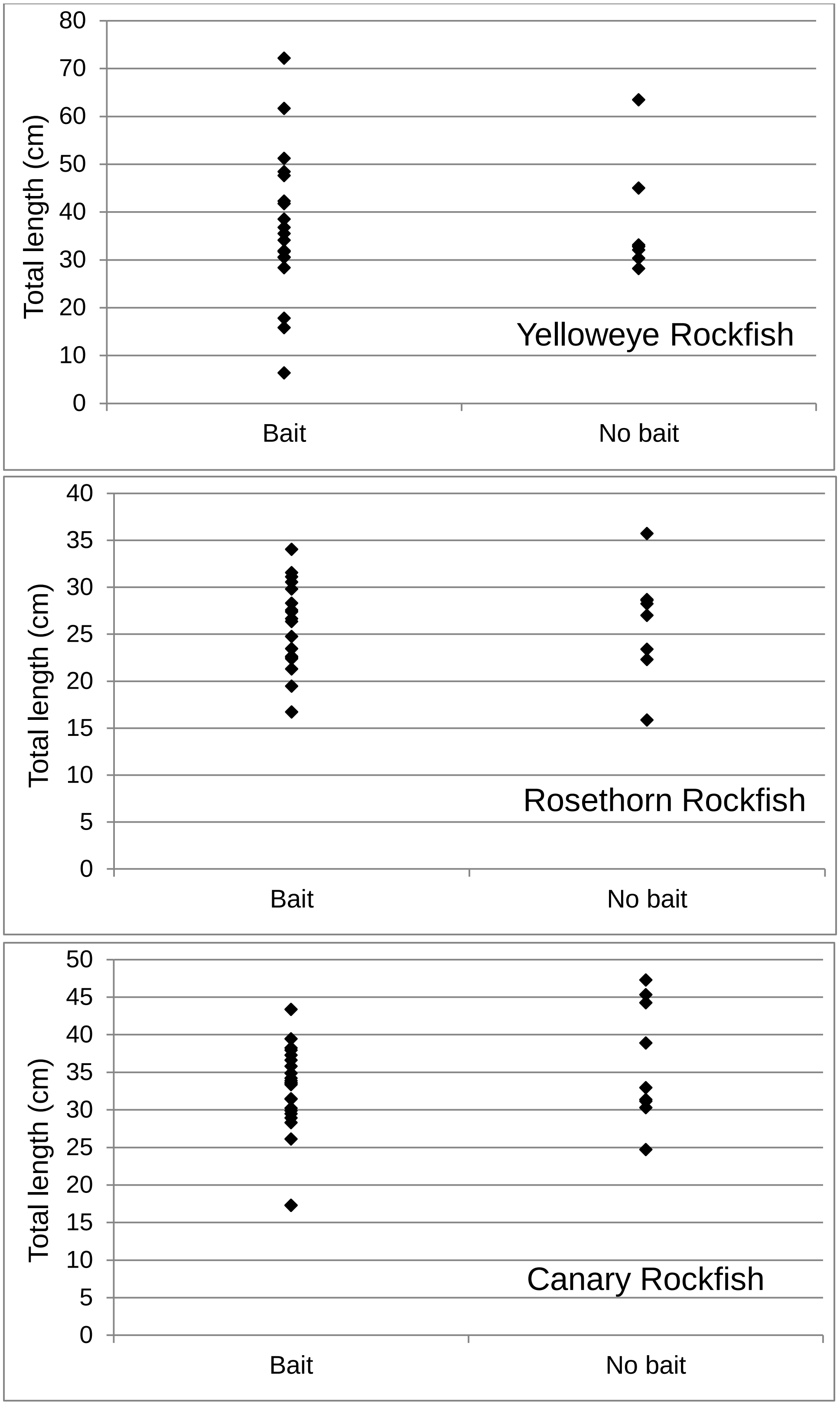

Yelloweye rockfish
Unidentified sculpin
Silvergray rockfish
Rosethorn rockfish
Quillback rockfish
Pacific ratfish
Northern ronquil
Lingcod
Kelp greenling
Canary rockfish
▨ Bait
☐ No bait
0%
20%
40%
60%
80%
100%
Length estimates as a percentage of the sum of maxN

Figure 7



Total length (cm)
80
70
60
50
40
30
20
10
0
Bait
No bait
Yelloweye Rockfish
Total length (cm)
40
35
30
25
20
15
10
5
0
Bait
No bait
Rosethorn Rockfish
Total length (cm)
50
45
40
35
30
25
20
15
10
5
0
Bait
No bait
Canary Rockfish