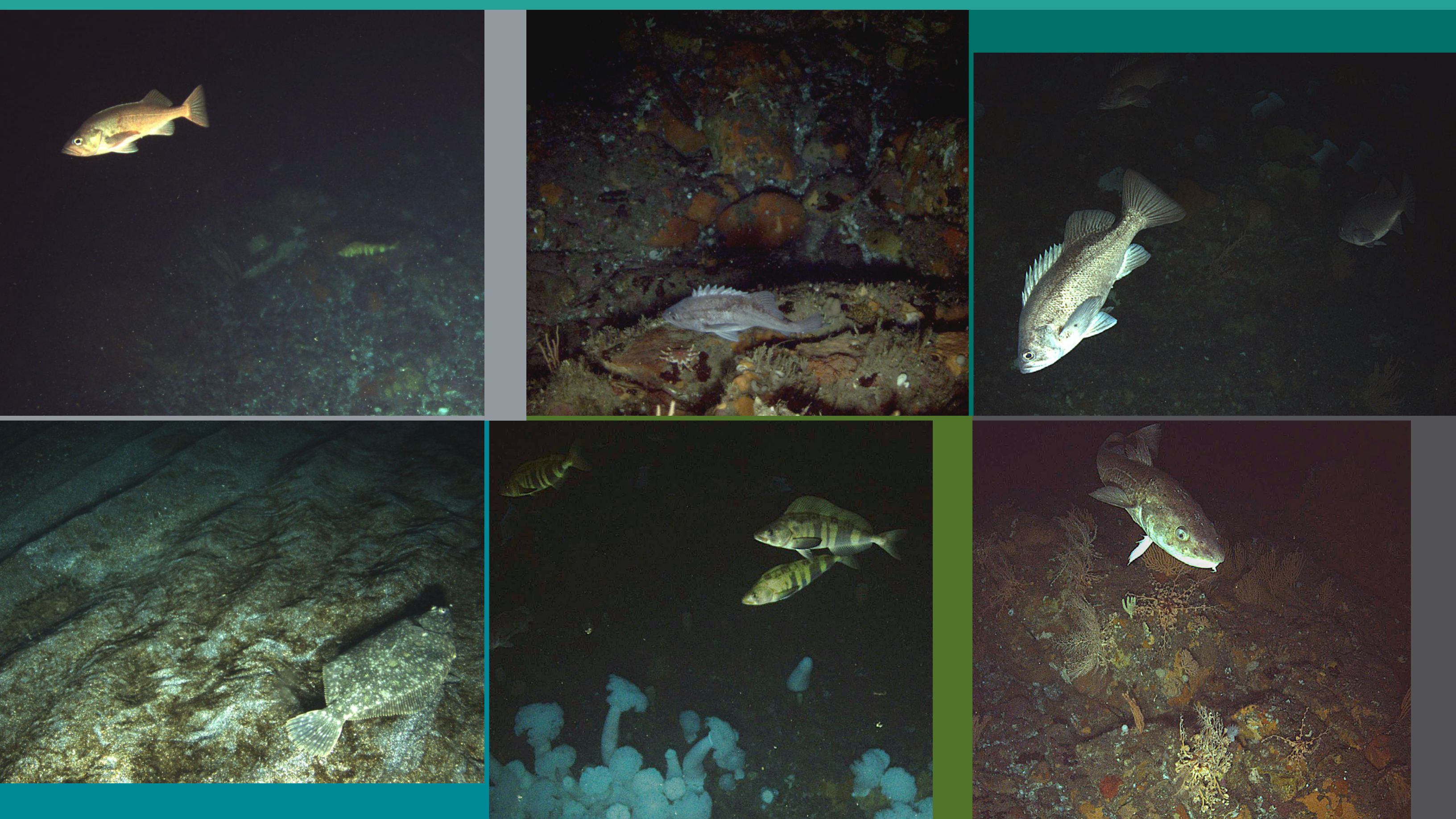
NOAA Technical Memorandum NMFS-AFSC-381

Results of the 2016 and 2017 Central and Western Aleutian Islands Underwater Camera Survey of Steller Sea Lion Prey Fields

by

D. R. Bryan, M. Levine, and S. McDermott



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ABSTRACT

Recent satellite tagging efforts indicate that foraging areas of endangered adult female Steller sea lions (SSL) in the central and western Aleutian Islands include shallow, nearshore regions. However, prey availability in these regions remains poorly understood because traditional bottom trawl surveys either cannot sample or lack precision on the rocky, nearshore habitats where sea lions forage. We attempted to overcome these sampling challenges by opportunistically deploying a towed underwater stereo-camera system near SSL rookeries and haulouts during the National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center, Marine Mammal Laboratory's ship-based population surveys of SSL in 2016 and 2017. A total of 63, 15-minute transects were conducted in depths ranging from 20 to 100 m. Fish and associated habitat were identified, quantified, and measured along transects. While stereo-image quality did not allow for the identification of all fish to the species level, it did allow for identification of many prey species (i.e., Atka mackerel (*Pleurogrammus monopterygius*), Pacific cod (*Gadus macrocephalus*)) and species groups (i.e., rockfishes, flatfishes, and sculpins) that are consumed by SSL during the summer. Camera transects encompassed substrates ranging from sand to high-relief boulder fields, and greater fish abundance was associated with rockier terrain. Substrates and associated fish abundances varied widely over small (10-100 m) spatial scales, suggesting that nearshore survey activities should be structured to account for extreme spatial variability. The relatively low cost of our camera system, combined with its ability to be deployed quickly during available vessel time, make it a promising tool for future fish surveys of nearshore and untrawlable habitat.

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INTRODUCTION

The remote location and frequently harsh weather conditions throughout the central and western Aleutian Islands greatly limits the research and monitoring of marine species. This area is home to the endangered western population of Steller sea lions (SSL) and supports multiple productive commercial fisheries. The primary source of data on fish populations in this region comes from the Alaska Fisheries Science Center's (AFSC) biennial bottom trawl survey, which does not include rocky areas close to shore where SSL are thought to feed during the summer. In this report, we share our findings from two research cruises in the central and western Aleutian Islands, where we used a towed stereo-camera system to survey the nearshore fish communities adjacent to SSL rookeries and haulouts.

Steller sea lions are an integral component of the Aleutian Islands ecosystem as both predator and prey (Sinclair and Zeppelin 2002, Williams et al. 2004, Tollit et al. 2017). During the 1970s and 1980s, their population declined precipitously, compelling the National Marine Fisheries Service to list them as threatened under the Endangered Species Act in 1990 (Loughlin et al. 1992), then as endangered for the western population in 1997. After declines continued until 2000, populations in the Gulf of Alaska and the eastern Aleutian Islands have stabilized or increased, but in the western Aleutians, their numbers have remained depressed (Fritz et al. 2014). The cause of the population decline and its consistency in the western Aleutians is unknown, but several hypotheses suggest that it involves a lack or degradation in quality of food sources (Merrick et al. 1997, Trites and Donnelly 2003).

Steller sea lions can travel large distances between haulouts and rookeries to forage and reproduce (Raum-Suryan et al. 2002). Yet, during the early pup-rearing period in summer months, female SSL tend to stay close to their rookeries and forage within nearshore waters (Merrick and Loughlin 1997, Waite et al. 2012). Juvenile SSL typically develop their foraging skills in water depths less than 100 m and can mostly be found diving nearshore during the summer as part of their foraging behavior (Fadely et al. 2005, Lander et al. 2011). In the western Aleutians, these nearshore waters are often comprised of rocky habitat that is inaccessible to the AFSC's bottom trawl survey, which currently provides the only large-scale, fishery-independent estimate of fish biomass in the Aleutian Islands and has been important in modeling prey availability for SSL (Hui et al. 2015, von Szalay et al. 2017). These rocky, untrawlable habitats are essential for numerous species including Atka mackerel (*Pleurogrammus monopterygius*), Irish lords (*Hemilepidotus* sp.), and rockfishes (Sebastidae) that are major components of SSL diets (Sinclair and Zeppelin 2002, Stone 2006, Lauth et al. 2007, Tollit et al. 2017). Because the AFSC's biennial bottom trawl survey does not sample these habitats and since there is no other dedicated sampling programs, there is a lack of information on fish assemblages and densities in these nearshore areas.

An alternative sampling method to trawl gear for rocky habitats is optical surveys (Williams et al. 2010). For this report, we used two different stereo-camera systems to quantify fish density in nearshore areas adjacent to SSL rookeries. Similar systems were used by the AFSC in both the Bering Sea and the Aleutian Islands to quantify benthic fauna (Goddard et al. 2016, Goddard et al. 2017, Boldt et al. 2018). The relatively inexpensive and small camera systems allow for surveys to be conducted off a variety of research platforms. For this study, we were able to take advantage of vessel time during AFSC's Marine Mammal Laboratory (MML) SSL research charters to survey nearshore habitats and associated fish assemblages that are primarily inaccessible to the bottom trawl survey. These data provide a better understanding of the prey fields available to SSL near their rookeries during summer months.

METHODS

Study Area

The Aleutian Islands chain extends 1,900 km from the Alaska Peninsula towards the Kamchatka Peninsula in Russia. The waters surrounding these volcanic islands support a diverse and productive ecosystem including marine mammals, birds, fishes, and marine invertebrates. The continental shelf along the Aleutians is narrow and often includes a steep drop-off close to shore with rocky habitat. A total of 63 underwater towed camera transects were conducted near 14 islands in the Aleutians with prominent SSL rookeries (Fig. 1). The majority of transects were conducted in the western Aleutians, however two transects were conducted in the Western Gulf of Alaska at Ugamak (Fox Islands), and seven in the central Aleutians near Gramp Rock, Ulak, and Tag (Delarof Islands). In the western Aleutians, 26 transects were conducted in the Rat Islands (near Semisopochnoi, Hawadax Island (formerly Rat Island), Kiska, and Amchitka), 2 transects were conducted at Buldir, and 17 transects were conducted in the Near Islands (Shemya, Alaid, Ingenstrem Rocks, Agattu, and Attu). The starting point of each transect was randomly chosen and included all habitat types available from 20 to 100 m.

Camera Systems

2016

The 2016 stereo-camera system was designed and tested as part of NOAA's Advanced Sampling Technology Working Group project "Creating a low-cost towed stereo-camera system using GoPro cameras for routine use in stereo-camera surveys". It included two GoPro HERO3 cameras that were synched and controlled through an Arduino microcontroller and software program. The paired cameras were enclosed in a custom-built anodized aluminum housing (Sexton Co.) rated to 500 m depth. Live video from the system was transmitted via an armored coaxial cable through a winch to a monitor onboard the vessel. Lighting was provided by a series of three Underwater Kinetics Aqualite Pro LED lights emitting up to 750 lumens each at 20° angles. The camera system and lights were mounted on a protective aluminum cage (Fig. 2).

2017

In 2017, this project was continued as part of NMFS National Cooperative Research Grant project "Using underwater stereo-cameras to describe nearshore Steller sea lion prey fields in untrawlable habitats near rookeries and haulouts". The GoPro camera system was replaced with two machine vision cameras (FLIR Chameleon3 3.2 MP with Arecont 4 mm fixed lens) controlled by a single-board computer (ODROID-XU4) and custom-built control board and microprocessor. This camera system was developed at the AFSC's Resource Assessment and Conservation Engineering Division (RACE) by Rick Towler and Kresimir Williams and is being used by RACE for several other monitoring and research projects (Goddard et al. 2016, Goddard et al. 2017). For our study, the cameras were programmed to synchronously capture eight frames per second which was transmitted through a media converter to an armored coaxial cable that ran to the winch onboard the vessel. The digital signal was then converted from the coaxial cable to an ethernet cable and run through a router to provide real time viewing at a control center. Lighting for the cameras was provided by two high-efficiency LED strobes that were triggered by the control board in synchronization with the cameras. The cameras, computer system, and strobes were all powered by an enclosed 24 volt battery pack. The cameras, computer, media converter, control board and microprocessor were all enclosed in an anodized aluminum housing (Sexton Co.) rated to 500 m in depth. The battery pack and strobes were also rated down to 500 m.

Survey Design and Field Methods

The survey was conducted off of the U.S. Fish and Wildlife's RV *Tiĝlâx* during AFSC's Marine Mammal Laboratory (MML) SSL research charters. Camera tows were opportunistically conducted as vessel time allowed. Sampling areas were selected based on proximity to SSL rookeries or haulouts. When telemetry data were available, the core use areas of adult female SSL, as indicated by the movements of tagged individuals, were used to further refine sampling areas (M. Lander, AFSC-MML, pers. comm.). The starting point for each transect was randomly chosen. In 2016, the sampling areas were divided using a minute-longitude by minute-latitude grid. Grid cells were randomly selected and we attempted to sample at three depth strata (25-50 m, 50-75 m, and 75-100 m) within each sampling area. In 2017, a 1 km by 1 km grid was created for the entire Aleutian Islands. Three grids were randomly selected within each sampling area irrespective of depth and the coordinates for the center point of the corresponding grid was supplied to the captain as the starting point for each transect.

Once at the randomly chosen starting location, the camera system was lowered to the bottom. Each transect was 15 minutes long with a targeted towing speed between 1 and 1.5 knots. In most cases the vessel generally drifted with prevalent current direction. The distance of camera to the seafloor was controlled using the live camera feed and winch control from the vessel. The camera was held approximately 1 to 2 m above the substrate with the cameras pointed slightly downward at an angle of approximately 35° off parallel to the seafloor. The position of the camera throughout the deployment was assumed to be the same as the position obtained from vessel-mounted GPS-sensor. The deployment cable was held as near vertical as possible to improve positional accuracy and to allow for faster adjustments of camera altitude in relation to the seafloor.

Image Analysis

In 2016, the GoPro system captured 1080 HD video at 60 frames per second. These synchronized video files were parsed into synchronized still images at a 1-second interval using routines developed in the Python programming language. In 2017, paired still images were recorded at a rate of 1 per second. Image analysis for still images for both years was performed with SEBASTES software by a single reviewer (Williams et al. 2016). The substrate type for each frame was classified based on a commonly used scheme (Stein et al. 1992, Yoklavich et al. 2000). A primary substrate with > 50% coverage of the seafloor bottom and a secondary substrate with 20–49% coverage of the seafloor was recorded. Six possible substrate types were used: sand, pebble (diameter < 6.5 cm), cobble (diameter 6.5–25.5 cm), boulder (diameter > 25.5 cm), exposed low-relief bedrock and exposed high-relief bedrock and rock ridges. When necessary, the size of substrate particles was measured directly using the SEBASTES software. All fish species were enumerated and identified to the lowest possible taxonomic level. Image quality did not always allow identification to species; in those instances, fish were identified to species groups (i.e., ‘rockfish unidentified’). Care was taken to not double-count fish that may have appeared in consecutive frames. If the head and tail of a fish was clearly visible in both the left and right frames of an image pair with no curves in its body, a total length measurement was made using stereo geometry. To compute range and size information, the cameras were calibrated to correct for image distortion due to the lens and viewport optics, and to solve for the epipolar geometry between the two cameras (Williams et al. 2010, Williams et al. 2016). Once calibrated, the three-dimensional coordinates of corresponding points identified in stereo-image pairs could be determined in SEBASTES using a stereo-triangulation function.

Density and Occurrence Calculations

The area swept (defined as the path width * path length of each camera tow) was calculated to estimate fish density. The path width (swath) was calculated using methods from Rooper et al. (2016). For each identified fish, the distance from the camera to the fish (range) was recorded. The median range was calculated for each tow and assumed to be the distance from the camera in which 100% of fish could be detected. The swath covered by the camera was calculated by multiplying the median range by the combined field of view for both cameras:

$$swath = range \times (\tan(radians\left(\frac{A}{2}\right)) + \tan(radians\left(\frac{A}{2}\right)) + baseline ,$$

range = median range for tow,

A = field of view for camera, 2016 = 94.4°, 2017 = 84.7°, and

baseline = distance between cameras (15.5 cm).

The path length was estimated as length of the tow adjusted for the amount of time spent on bottom. The tow length was estimated from the vessel GPS. The time and coordinates when the camera touched the bottom was recorded along with coordinates every 5 minutes during the tow. After 15 minutes, the camera system was retrieved and the coordinates were recorded. The distance between each 5-minute segment was calculated and added together to provide the tow length. In some cases, the position of the camera system (either too far above the seafloor or too close) did not provide images that could be used to identify fish. The distance over which these images occurred was subtracted from the tow length to provide the path length by assuming that the camera system speed was constant within each transect. With this assumption, each frame represents the same horizontal distance along transect, so the distance lost is estimated as the number of frames that are not useable for identification multiplied by the distance per frame. On average, the length of transects were reduced by 18.0 % (± 17.2 SD) due to poor images. Finally, this path length was multiplied by the swath to provide an estimated area swept for each tow (m^2). The total number of fish by species or species group in each transect was then divided by the area swept to generate a density estimate (fish/m^2).

A generalized linear model was used to investigate the influence of substrate type and depth on fish density. The six primary substrate types were combined into two classifications: rocky (boulder, low bedrock, and high bedrock) and unconsolidated (sand, pebble, and cobble). The percent of frames per tow that were classified as rocky was used as the predictor variable for substrate and the average depth during the tow was used as the predictive variable for depth. P-values were used to test for statistical significance. Substrata and depth were also categorized to explore possible stratification schemes. If a transect had greater than 10% of frames classified as rocky, it was considered a rocky tow, otherwise it was categorized as unconsolidated. Two depth categories were created: less than 75 m (shallow), and greater than 75 m (deep). Student t-tests were used to compare survey-wide estimates of density between rocky and unconsolidated transects and between the two depth categories.

The occupancy rate (percent occurrence) of individuals was calculated by dividing the number of transects in which they were present by the total number of transects. Confidence intervals (95%) for percent occurrence were approximated with the Wilson score interval.

RESULTS

In 2016, 47 transects were conducted near 17 islands and in 2017, 16 transects were conducted near 17 islands (Appendix I). Across both survey years, depths ranged from 22.0 to 98.8 m and a variety of habitats were encountered ranging from sand to high relief rocky ridges. A total of 29 different species and species groups were identified in 2,548 individual fish observations. Survey-wide, the five most common species group were rockfishes, Atka mackerel, flatfishes, Irish lords, and Pacific cod (*Gadus macrocephalus*) (Fig. 3). Distinct external morphological characteristics such as color and body shape make the visual identification of some species such as Atka mackerel and Pacific cod easier than others such as rockfishes or flatfishes. In addition, both the distance from the camera and the size of the fish had an effect on identification. In 2017, unidentified fish were significantly smaller (22.4 cm) (t-test, $p = 0.001$) and further away from the camera (300.3 cm) (t-test, $p = 0.009$) than those that were identified to a species or species group (38.0 cm and 262.9 cm, respectively). Furthermore, the ability to identify rockfishes and flatfishes to species was also affected by their distance from the camera (Fig. 4). The mean length of unidentified rockfishes in 2017 was statistically similar to those that were identified to species, but unidentified flatfishes were significantly smaller (24.4 cm) (t-test, $p = 0.007$) than those that were identified (37.9 cm).

A majority of rockfishes could not be identified to species, but of those that could, northern rockfish (*Sebastes polyspinis*) were the most common (Table 1). Similarly, most flatfishes could not be identified to species, but of those identified to species, northern rock sole (*Lepidopsetta polyxystra*) were the most common (Table 1). Eighty-three percent of Irish lords were yellow Irish lords (*Hemilepidotus jordani*), 9.8% were red Irish lords (*Hemilepidotus hemilepidotus*), and the remaining were unidentified. Forty-three percent of greenlings

(*Hexagrammos* sp.) were kelp greenlings (*Hexagrammos decagrammus*), 7.6% were rock greenlings (*Hexagrammos lagocephalus*) and the remaining were unidentified.

Fish occurrence and density varied by substrate type and depth. With the exception of flatfishes, sculpins and skates, most fishes had a higher percent occurrence on transects classified as rocky. Rockfishes, Atka mackerel, and Irish lords were each observed in over 70% of rocky transects (Fig. 3). The cumulative average fish density was also more than three times greater on rocky substrates than on unconsolidated substrates (Fig. 5). Substrate was a significant factor in our generalized linear model for 6 out of 11 species, while depth was only significant for one species (Table 2). Atka mackerel, Irish lords, greenlings, ronquils, and unidentified fishes had a significant higher density on rocky substrates (Table 2 and Fig. 6). Flatfishes and skates had higher densities on transects that were greater than 90% unconsolidated substrates (Table 2 and Fig. 6). Within the relatively narrow depth range surveyed, there were significantly more ronquils (Bathymasteridae) and skates in deep transects (> 75 m) (Figs. 7 and 8). No ronquils or skates were observed in shallow (< 75 m) waters. The density of other species or groups was not significantly different due to depth. However, the combined cumulative density of all species was slightly higher at depths greater than 75 m (Fig. 7).

In 2017, 32% of the 741 fishes observed were successfully measured. Average length and standard error for the top five most common species/species groups was calculated. The average length of Pacific cod was the greatest followed by Atka mackerel and rockfishes (Table 3 and Fig. 9).

The most common primary habitat type encountered during the surveys was sand constituting 40% of frames analyzed. Sand was followed by boulders (20%), pebbles (16%), high-relief bedrock (12%), low-relief bedrock (6%) and cobble (6%). Both corals and sponges were more common on the high-relief habitats than low-relief substrates (Fig. 10). Corals were found in 50% and 39% of high-relief bedrock and low-relief bedrock frames, respectively. Sponges were present 73% and 56% of high relief bedrock and low relief bedrock frames, respectively.

Island Groups

The Delarof Islands had the highest percentage of high relief bedrock (25%) and density of fish (0.044 fish m^{-2}) of the nearshore habitats sampled (Figs. 11 and 12). The high number of fish was largely driven by a single transect in Ulak, where a large school of Atka mackerel were encountered (Fig. 11). The Near Islands had the second highest fish density (0.03 fish m^{-2}) comprised primarily of rockfishes (0.013 fish m^{-2}), Atka mackerel (0.007 fish m^{-2}), and flatfishes (0.004 fish m^{-2}). No rocky tows were encountered near Buldir and fish density (0.007 fish m^{-2}) was below the islands' group average (0.02 fish m^{-2} ± 0.007 SE). In Ugamak, fish density was also low (0.007 fish m^{-2}), despite the occurrence of rocky substrates in transects. This low density is likely an artifact of the small sample size (n = 2).

A more detailed description of each transect, including primary habitat types, biotic coverage, and fish densities are included in the Island Summaries section listed in Appendix I.

CONCLUSIONS

Our towed stereo-camera system was successful in surveying the fish communities associated with nearshore rock environments throughout the remote central and western Aleutian Islands. These areas are not typically visited by the AFSC biennial bottom trawl survey but are important to foraging SSL during the summer months. We found that several species or species groups had a significantly higher density on transects that included at least 10% rock bottom. These include Atka mackerel, Irish lords, and greenlings. Tollit et al. (2017) ranked these species as 1st, 5th, and 10th most important items in SSL diets, respectively. Other species groups that we encountered, but not in significant abundance, were also key components of SSL diets: Pacific cod (2nd) and rockfishes (6th). Flatfishes and sculpins, which were more common over unconsolidated substrates in our survey, were ranked 13th and 11th, respectively. These results highlight the importance of surveying nearshore rocky habitats to better understand SSL prey fields. Furthermore, the stereo-camera system provided total length estimates for roughly 30% of all observed fish. This is an encouraging result and suggests that a more rigorous probabilistic survey design with a larger sample size could prove a mechanism for tracking and comparing the nearshore biomass of key SSL prey items over time and space.

However, there are still some limitations and potential biases with optical surveys that require additional research. For example, we found that the distance from the camera system at which a fish was observed affected our ability to identify it to species. This is important as artificial lights and vessel noise can elicit behavioral responses, such as the attraction or avoidance of the camera gear, which differ among species and thus leads to varying levels of detectability (Stoner et al. 2008, De Robertis and Handegard 2012, Rooper et al. 2015). Instead of using a constant area swept for all species, distance sampling estimation techniques (Buckland et al. 1993) that incorporate detection ranges for individual species may be more appropriate for density estimates and requires additional research. In addition, a method for estimating volumetric density from stationary cameras that takes into account detectability has been developed at the AFSC and may also work for towed cameras (Williams et al. in review). As with most fisheries-independent surveys, size selectivity of the gear can create a bias when generating population estimates and needs to be resolved for our towed camera system (Harley and Myers 2001, Lauth et al. 2004, Kotwicki et al. 2017). In the future, species-specific selectivity curves for towed camera gear can be constructed as more data are collected.

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CITATIONS

Boldt, J. L., K. Williams, C. N. Rooper, R. H. Towler, and S. Gauthier. 2018. Development of stereo camera methodologies to improve pelagic fish biomass estimates and inform ecosystem management in marine waters. Fish. Res. 198:66-77.

Buckland, S. T., D. R. Anderson, K. P. Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London.

De Robertis, A., and N. O. Handegard. 2012. Fish avoidance of research vessels and the efficacy of noise-reduced vessels: a Review. ICES J. Mar. Sci. 70:34-45.

Fadely, B. S., B. W. Robson, J. T. Sterling, A. Greig, and K. A. Call. 2005. Immature Steller sea lion (*Eumetopias jubatus*) dive activity in relation to habitat features of the eastern Aleutian Islands. Fish. Oceanogr. 14:243-258.

Fritz, L. W., R. Towell, T. S. Gelatt, D. S. Johnson, and T. R. Loughlin. 2014. Recent increases in survival of western Steller sea lions in Alaska and implications for recovery. Endanger. Species Res. 26:13-24.

Goddard, P., R. Wilborn, C. N. Rooper, K. Williams, R. H. Towler, M. Sigler, and P. Malecha. 2016. Results of the 2014 underwater camera survey of the eastern Bering Slope and Outer Shelf. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-313, 304 p.

Goddard, P., R. E. Wilborn, C. N. Rooper, K. Williams, and R. H. Towler. 2017. Results of the 2012 and 2014 underwater camera surveys of the Aleutian Islands. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-351, 505 p.

Harley, S. J., and R. A. Myers. 2001. Hierarchical Bayesian models of length-specific catchability of research trawl surveys. Can. J. Fish. Aquat. Sci. 58:1569-1584.

Hui, T. C., R. Gryba, E. J. Gregr, and A. W. Trites. 2015. Assessment of competition between fisheries and Steller sea lions in Alaska based on estimated prey biomass, fisheries removals and predator foraging behaviour. PLOS ONE 10:e0123786.

Kotwicki, S., R. R. Lauth, K. Williams, and S. E. Goodman. 2017. Selectivity ratio: a Useful tool for comparing size selectivity of multiple survey gears. Fish. Res. 191:76-86.

Lander, M. E., D. S. Johnson, J. T. Sterling, T. S. Gelatt, and B. S. Fadely. 2011. Diving behaviors and movements of juvenile Steller sea lions (*Eumetopias jubatus*) captured in the central Aleutian Islands, April 2005. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-218, 62 p.

Lauth, R., J. Ianelli, and W. W. Wakefield. 2004. Estimating the size selectivity and catching efficiency of a survey bottom trawl for thornyheads, *Sebastolobus* spp. using a towed video camera sled. Fish. Res. 70:27-37.

Lauth, R. R., S. W. McEntire, and H. H. Zenger Jr. 2007. Geographic distribution, depth range, and description of Atka mackerel *Pleurogrammus monopterygius* nesting habitat in Alaska. Alaska Fish. Res. Bull. 12:165-186.

Loughlin, T. R., A. S. Perlov, and V. A. Vladimirov. 1992. Range-wide survey and estimation of total number of Steller sea lions in 1989. Mar. Mammal Sci. 8:220-239.

Merrick, R. L., M. K. Chumbley, and G. V. Byrd. 1997. Diet diversity of Steller sea lions (*Eumetopias jubatus*) and their population decline in Alaska: a Potential relationship. Can. J. Fish Aquat. Sci. 54:1342-1348.

Merrick, R. L., and T. R. Loughlin. 1997. Foraging behavior of adult female and young-of-the-year Steller sea lions in Alaskan waters. Can. J. Zool. 75:776-786.

Raum-Suryan, K. L., K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Mar. Mammal Sci. 18:746-764.

Rooper, C. N., M. F. Sigler, P. Goddard, P. Malecha, R. Towler, K. Williams, R. Wilborn, and M. Zimmermann. 2016. Validation and improvement of species distribution models for structure-forming invertebrates in the eastern Bering Sea with an independent survey. Mar. Ecol. Prog. Ser. 551:117-130.

Rooper, C. N., K. Williams, A. De Robertis, and V. Tuttle. 2015. Effect of underwater lighting on observations of density and behavior of rockfish during camera surveys. Fish. Res. 172:157-167.

Sinclair, E. H., and T. K. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). J. Mammal. 83:973-990.

Stein, D. L., B. N. Tissot, M. A. Hixon, and W. Barss. 1992. Fish-habitat associations on a deep reef at the edge of the Oregon continental shelf. Fish. Bull., U.S. 90:540-551.

Stone, R. 2006. Coral habitat in the Aleutian Islands of Alaska: Depth distribution, fine-scale species associations, and fisheries interactions. Coral Reefs 25:229-238.

Stoner, A. W., C. H. Ryer, S. J. Parker, P. J. Auster, and W. W. Wakefield. 2008. Evaluating the role of fish behavior in surveys conducted with underwater vehicles. Can. J. Fish. Aquat. Sci. 65:1230-1243.

Tollit, D., L. Fritz, R. Joy, K. Miller, A. Schulze, J. Thomason, W. Walker, T. Zeppelin, and T. Gelatt. 2017. Diet of endangered Steller sea lions in the Aleutian Islands: New insights from DNA detections and bio-energetic reconstructions. Can. J. Zool. 95:853-868.

Trites, A., and C. Donnelly. 2003. The decline of Steller sea lions *Eumetopias jubatus* in Alaska: a review of the nutritional stress hypothesis. Mammal Rev. 33:3-28.

von Szalay, P. G., N. W. Raring, C. N. Rooper, and E. A. Laman. 2017. Data Report: 2016 Aleutian Islands bottom trawl survey. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-349, 161 p.

Waite, J. N., S. J. Trumble, V. N. Burkanov, and R. D. Andrews. 2012. Resource partitioning by sympatric Steller sea lions and northern fur seals as revealed by biochemical dietary analyses and satellite telemetry. J. Exp. Mar. Biol. Ecol. 416:41-54.

Williams, K., C. N. Rooper, A. D. Robertis, M. Levine, and R. H. Towler. In review. A method for computing volumetric fish density using stereo cameras. J. Exp. Mar. Biol. Ecol.

Williams, K., C. N. Rooper, and R. Towler. 2010. Use of stereo camera systems for assessment of rockfish abundance in untrawlable areas and for recording pollock behavior during midwater trawls. Fish. Bull., U.S. 108:352-362.

Williams, K., R. H. Towler, P. Goddard, R. Wilborn, and C. N. Rooper. 2016. SEBASTES stereo image analysis software. AFSC Processed Rep. 2016-03, 42 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Williams, T. M., J. A. Estes, D. F. Doak, and A. M. Springer. 2004. Killer appetites: Assessing the role of predators in ecological communities. Ecology 85:3373-3384.

Yoklavich, M. M., H. G. Greene, G. M. Cailliet, D. E. Sullivan, R. N. Lea, and M. S. Love. 2000. Habitat associations of deep-water rockfishes in a submarine canyon: an Example of a natural refuge. Fish. Bull., U.S. 98:625-641.

Table 1. -- Species composition as a percent of number observed for the rockfish and flatfish species groups.

Rockfishes	**Number observed**	**%**
Rockfish spp.	661	79%
Northern rockfish (*Sebastes polyspinis*)	93	11%
Dusky rockfish (*Sebastes variabilis*)	38	5%
Pacific ocean perch (*Sebastes alutus*)	26	3%
Dark rockfish (*Sebastes ciliatus*)	21	3%
Total	**839**	
Flatfishes	**Number observed**	**%**
Flatfish spp.	235	85%
Northern rock sole (*Lepidopsetta polyxystra*)	35	13%
Halibut (*Hippoglossus stenolepis)*	3	1%
Arrowtooth/Kamchatka flounder (*Atheresthes stomias/A. evermanni*)	2	1%
Rex sole (*Glyptocephalus zachirus*)	1	0%
Flathead sole (*Hippoglossoides elassodon*)	1	0%
	277	

Table 2. -- Results from a generalized linear model (Density ~ Substrate + Depth). Significance is highlighted in yellow. (+) indicates a positive relationship between density and % rocky substrate or depth and (-) indicates a negative relationship.

Species / Species group	Substrate		Depth	
	p-value	Effect	p-value	Effect
Rockfishes	0.078	+	0.801	+
Atka mackerel	0.001	+	0.190	+
Flatfishes	0.000	-	0.100	-
Unidentified fishes	0.000	+	0.204	+
Pacific cod	0.060	+	0.949	-
Irish lords	0.007	+	0.361	+
Sculpins	0.603	-	0.446	+
Greenlings	0.004	+	0.791	-
Ronquils	0.002	+	0.000	+
Prowfish	0.281	+	0.895	-
Skates	0.171	-	0.200	+

Table 3. -- The number and percentage measured of the most common species/species groups in 2017 along with the mean length, standard error, and minimum length.

Species / Species group	Number of measurements	Total fish observed	Percent measured	Mean length (cm)	SE	Min. length (cm)
Rockfishes	82	234	35.0%	36.12	1.30	15.36
Atka mackerel	36	174	20.7%	41.33	1.23	28.96
Flatfishes	47	76	61.8%	33.66	2.46	3.92
Irish lords	8	43	18.6%	36.24	2.56	29.60
Pacific cod	12	38	31.6%	62.30	9.98	20.15

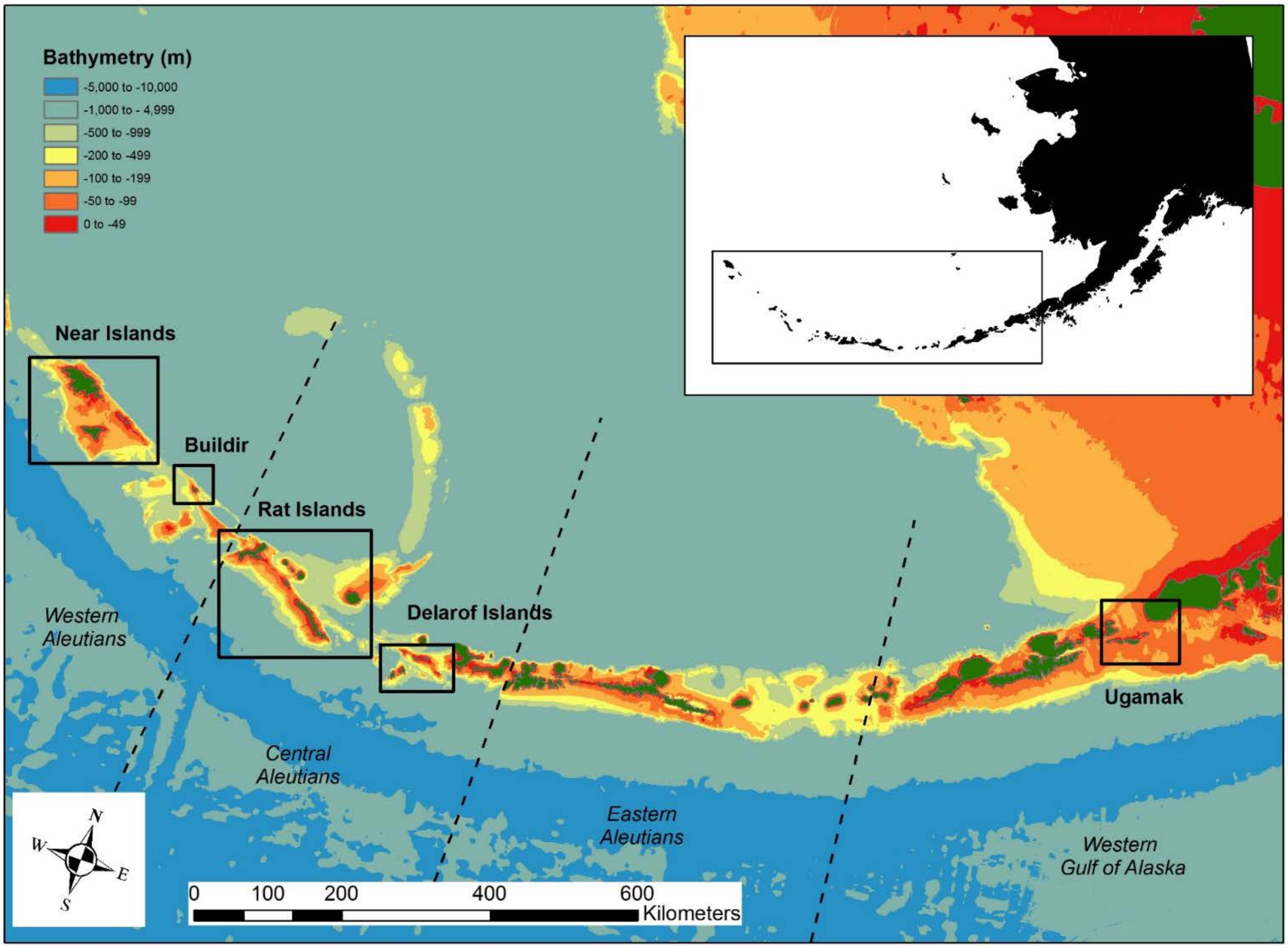


Figure 1. -- Map of the Aleutian Islands and areas sampled during the 2016 and 2017 survey.

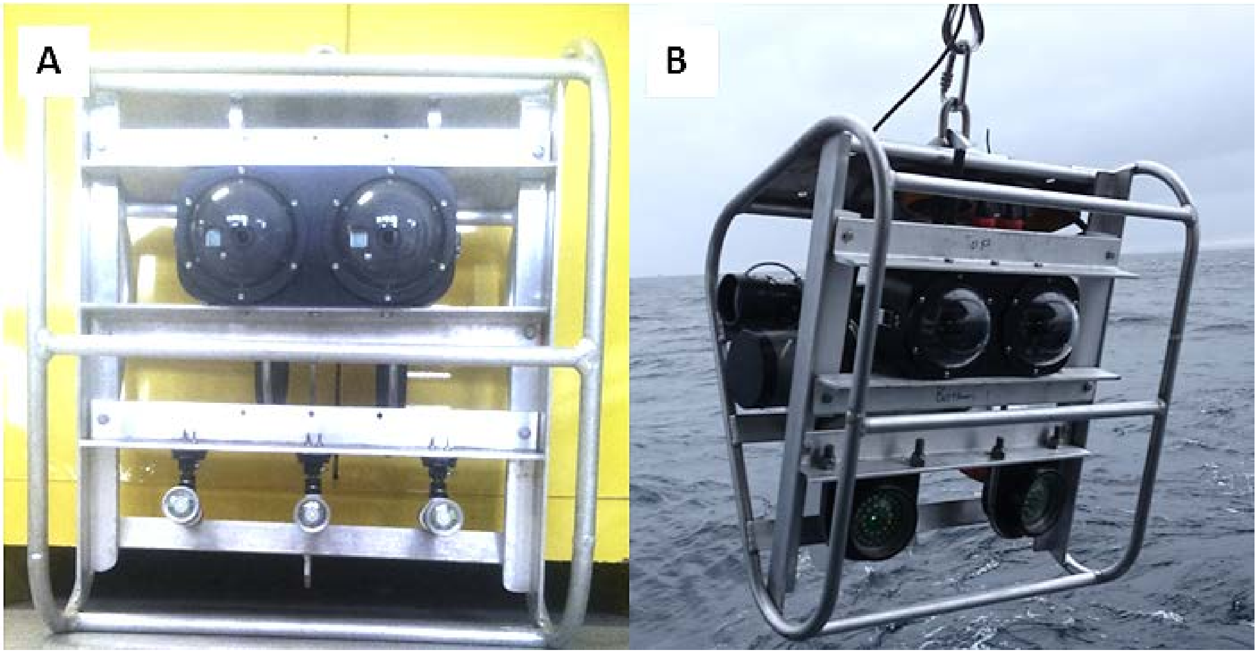


Figure 2. -- Stereo-camera system used in 2016 (A) included a protective aluminum cage with stereo GoPro cameras in a black anodized aluminum housing rated to 500 m and three 750 lumens LED dive lights. In 2017 (B), a protective aluminum cage was also used along with enclosed stereo machine vision cameras, computer and processor in the same model camera housing, two high-efficiency strobes, and a separate 24 volt battery system to power the cameras and strobes.

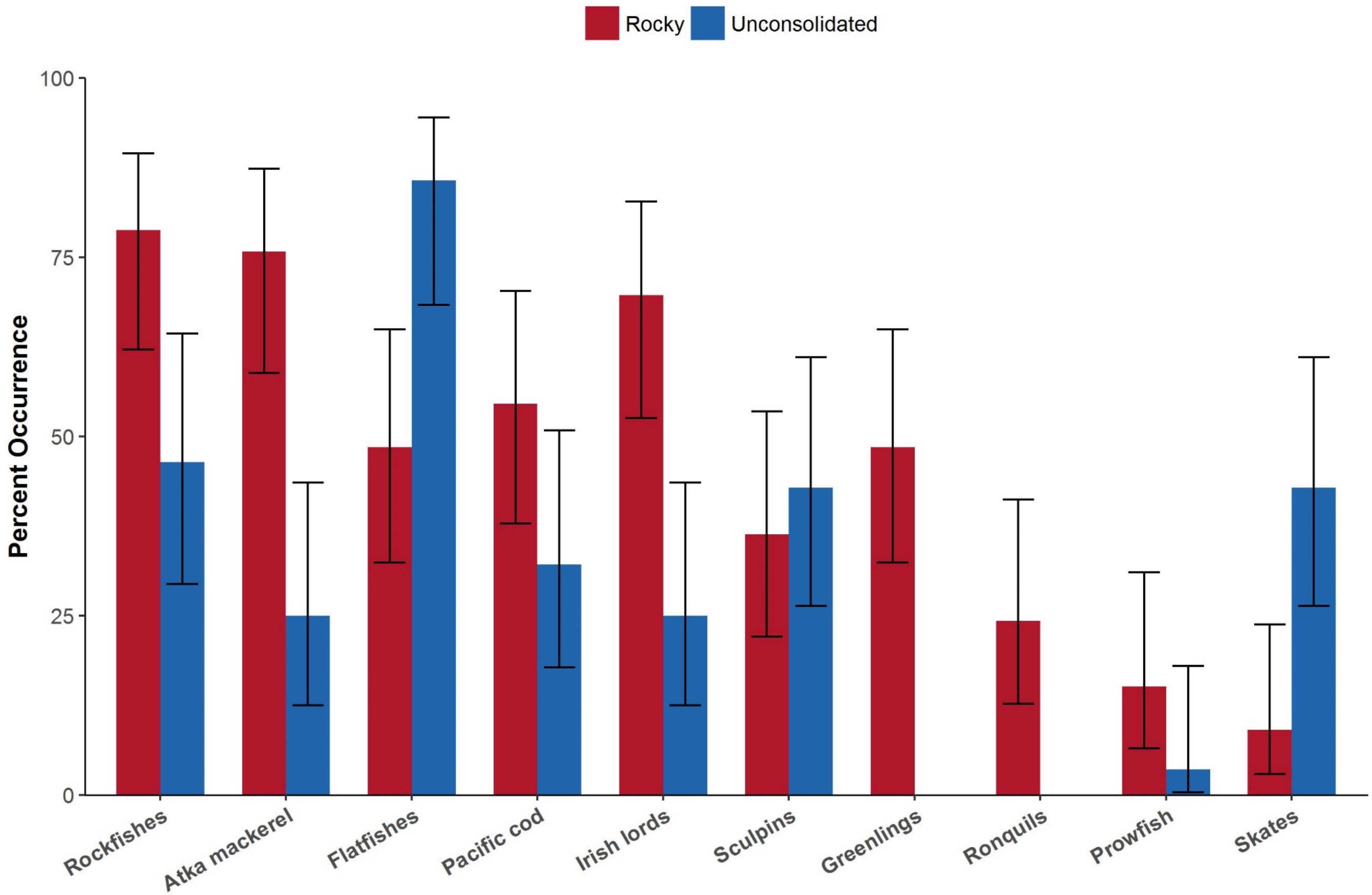


Figure 3. -- Percent occurrence of 10 most common species/ species groups by substrate type. Lines represent 95% confidence intervals.

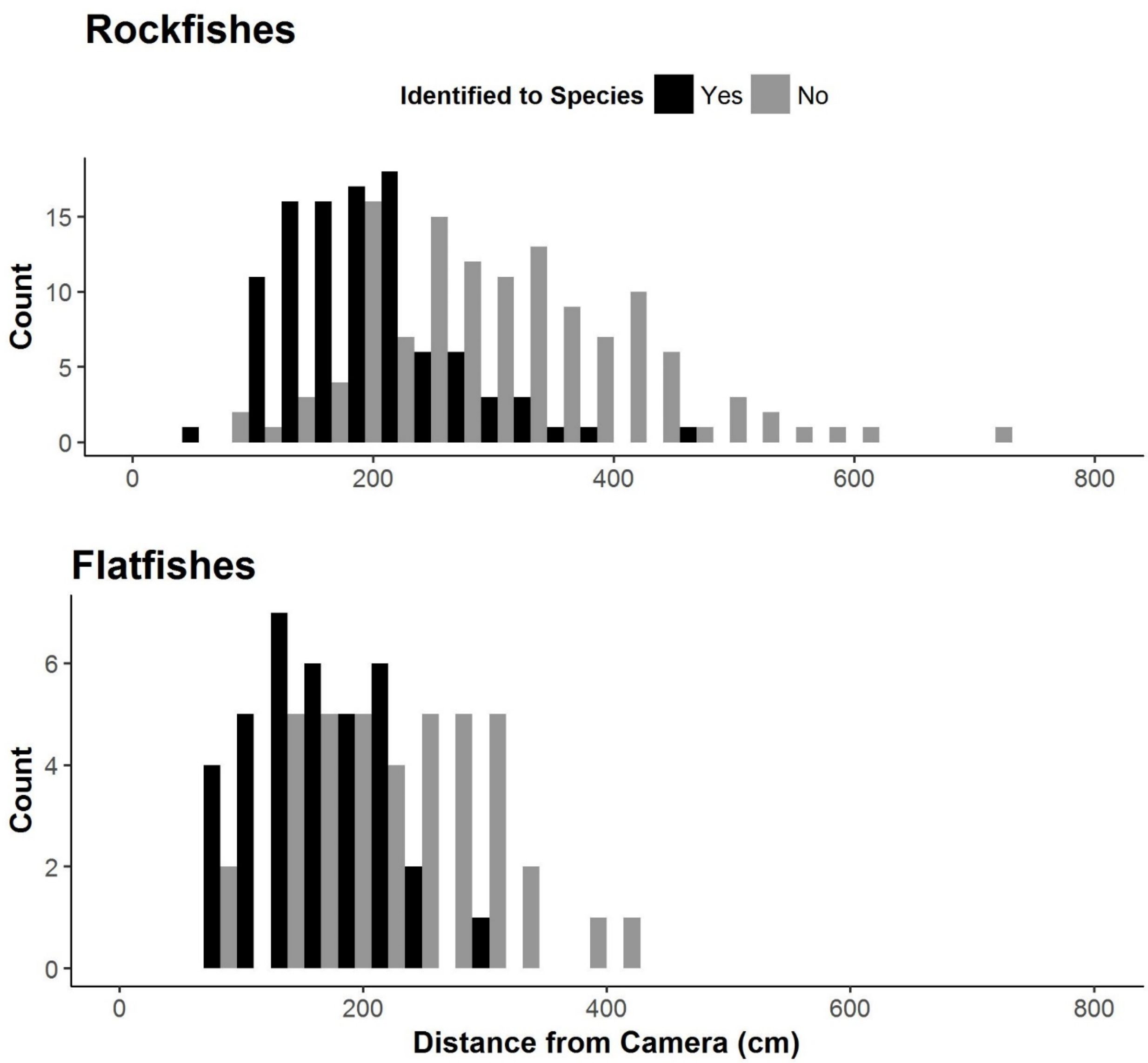


Figure 4. -- The number of rockfishes and flatfishes that were identified to species in 2017 compared to their distance from the towed camera.

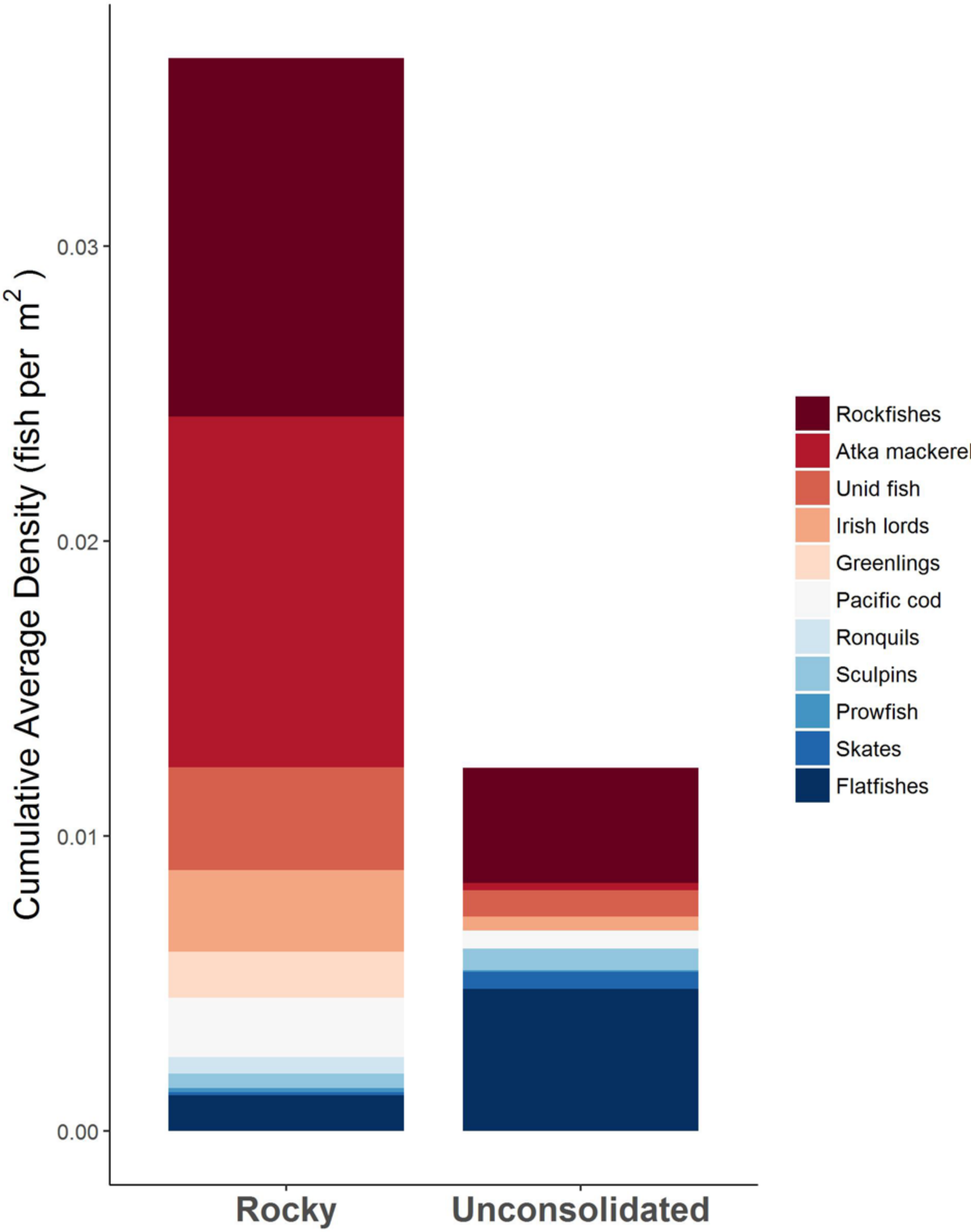


Figure 5. -- Stacked bar plot of cumulative average fish density (fish per m^2) for 11 species groups in rocky and unconsolidated video transects.

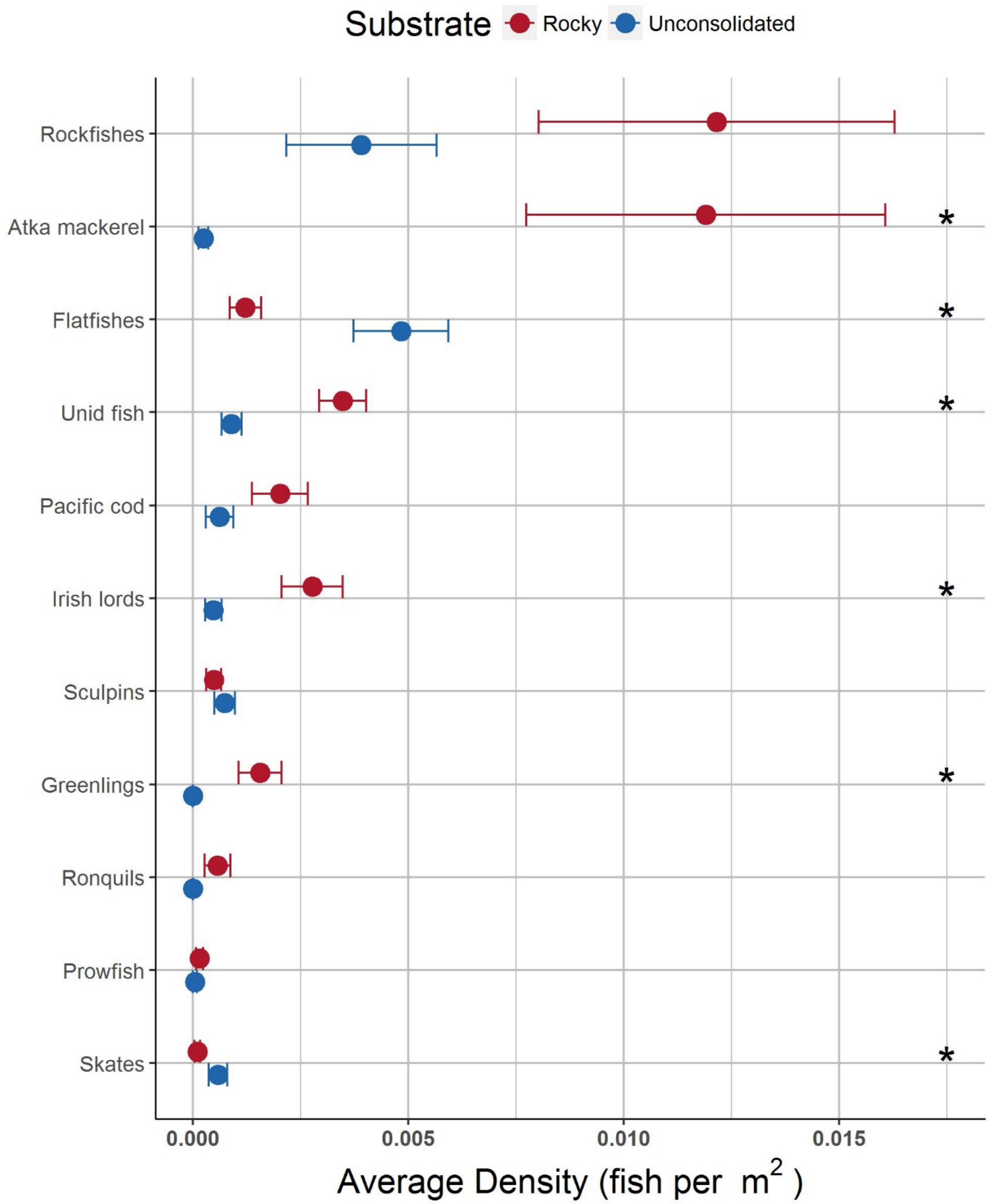


Figure 6. -- Average fish density (± SE) per m^2 from rocky and unconsolidated video transects. Asterisk (*) represents a significant difference (t-test, p ≤ 0.05).

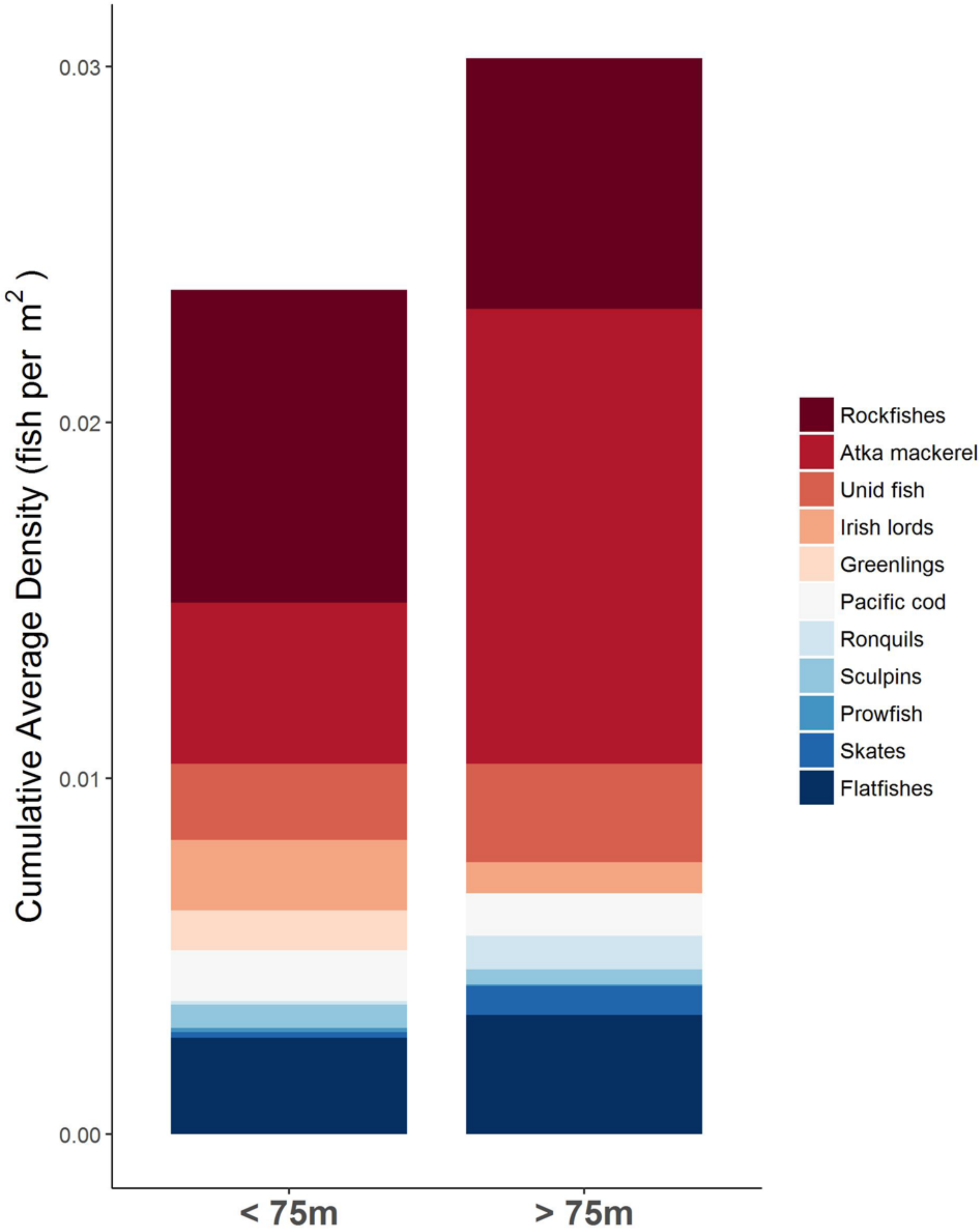


Figure 7. -- Stacked bar plot of the cumulative average fish density (fish per m^2) of 11 species groups at two different depth categories.

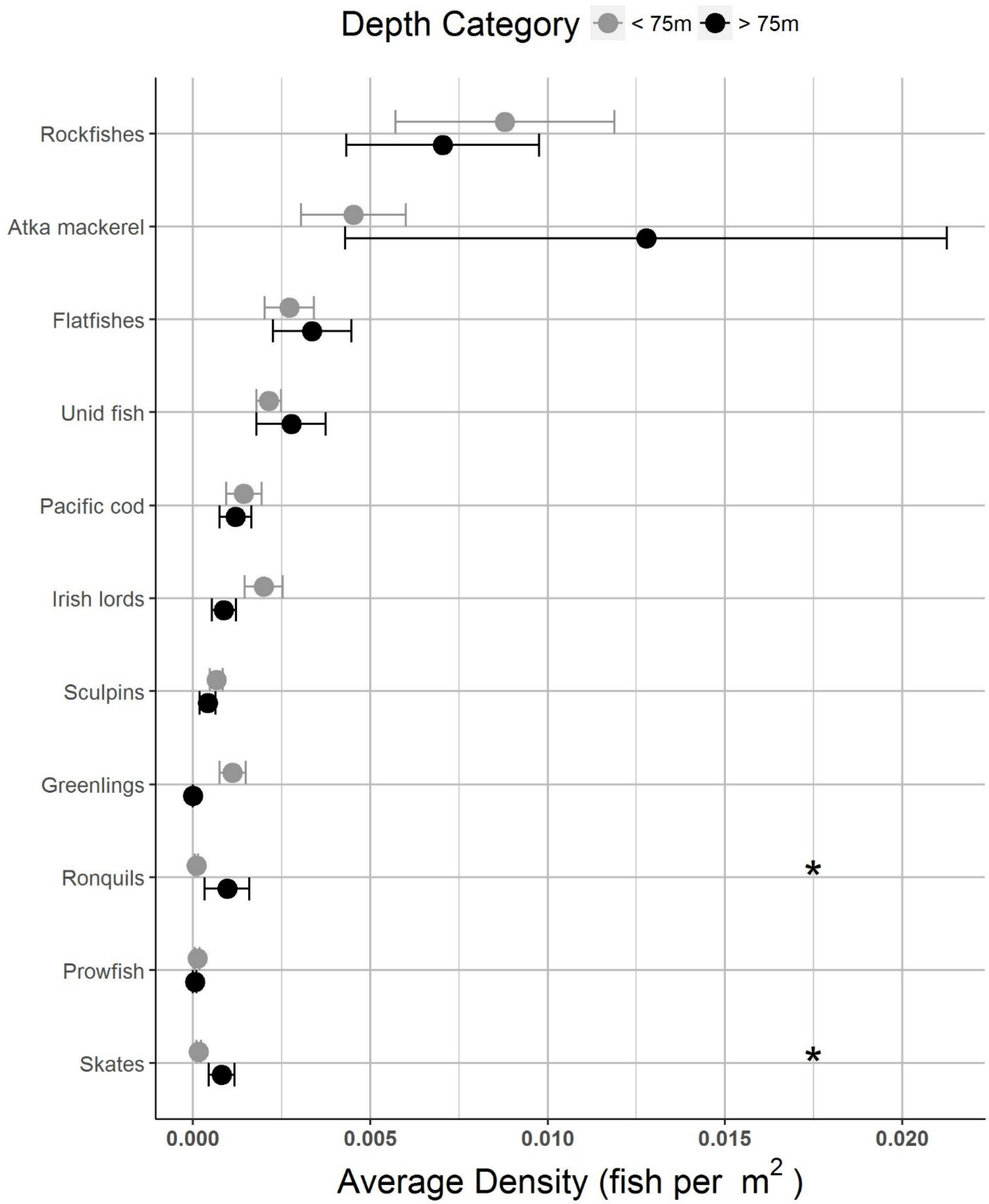


Figure 8. -- Average fish density (± SE) per m^2 by depth category (< 75 m and > 75 m). Asterisk (*) represents a significant difference (t-test, p ≤ 0.05).

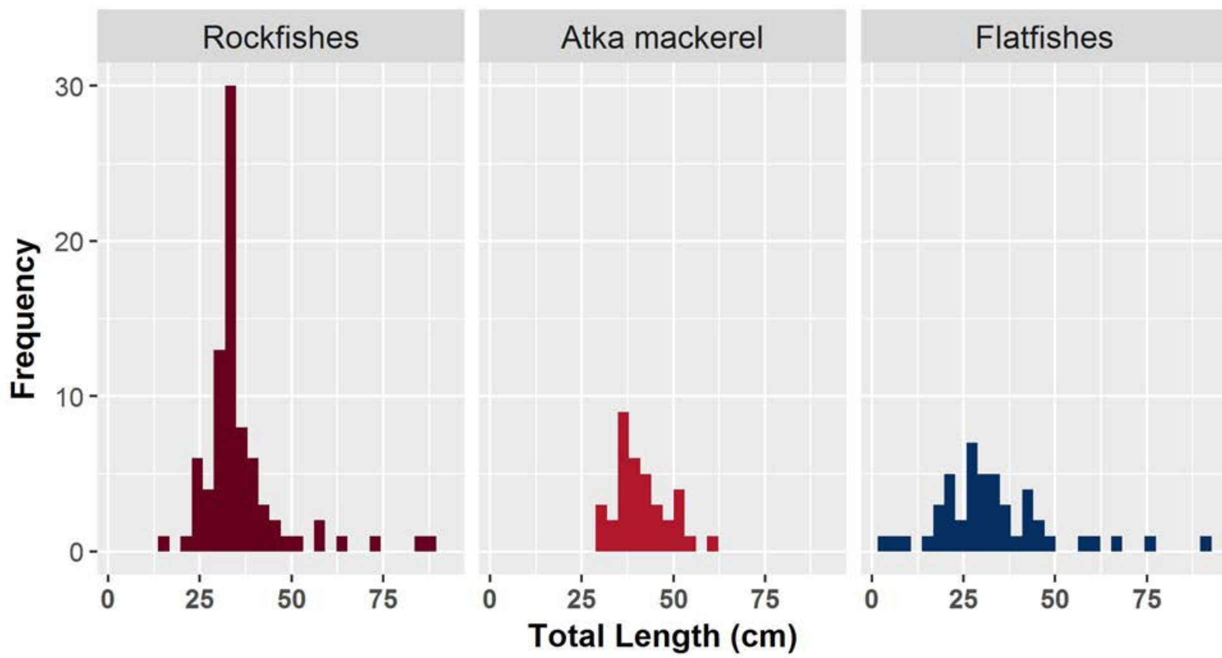


Figure 9. -- Length frequency of rockfishes, Atka mackerel, and flatfishes from the 2017 survey.

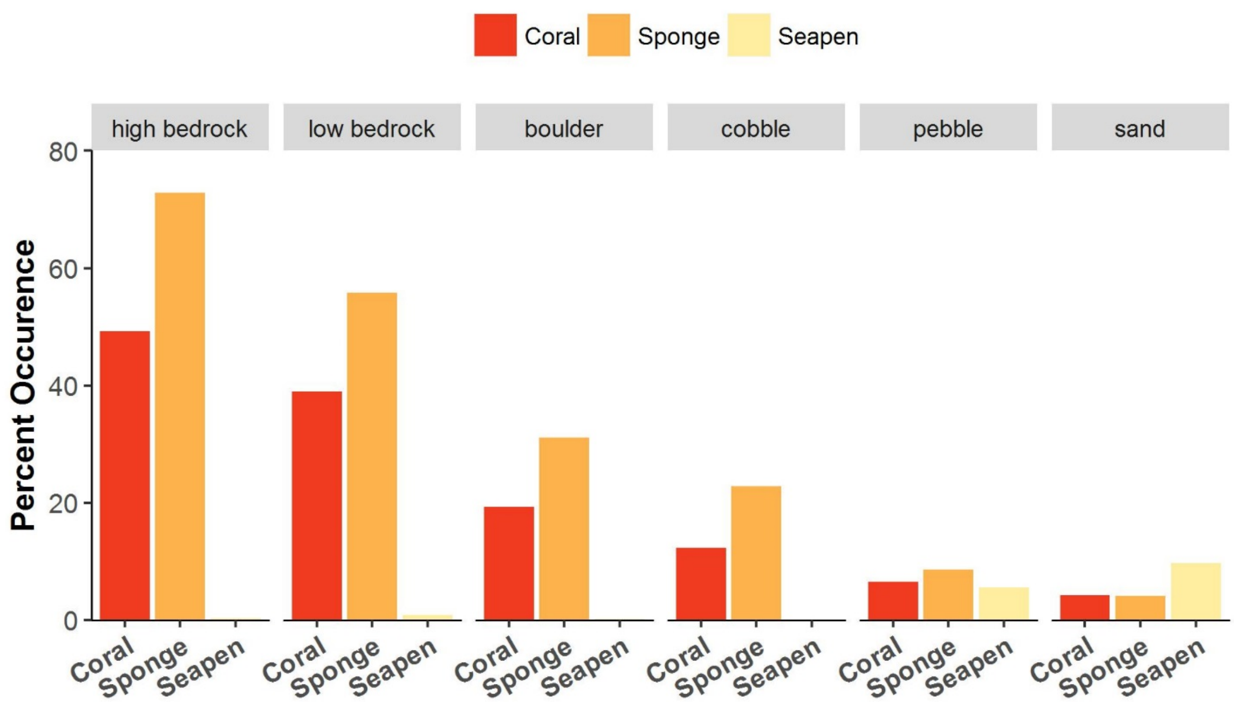


Figure 10. -- Percent occurrence of corals, sponges, and sea pens in each frame by primary habitat type.

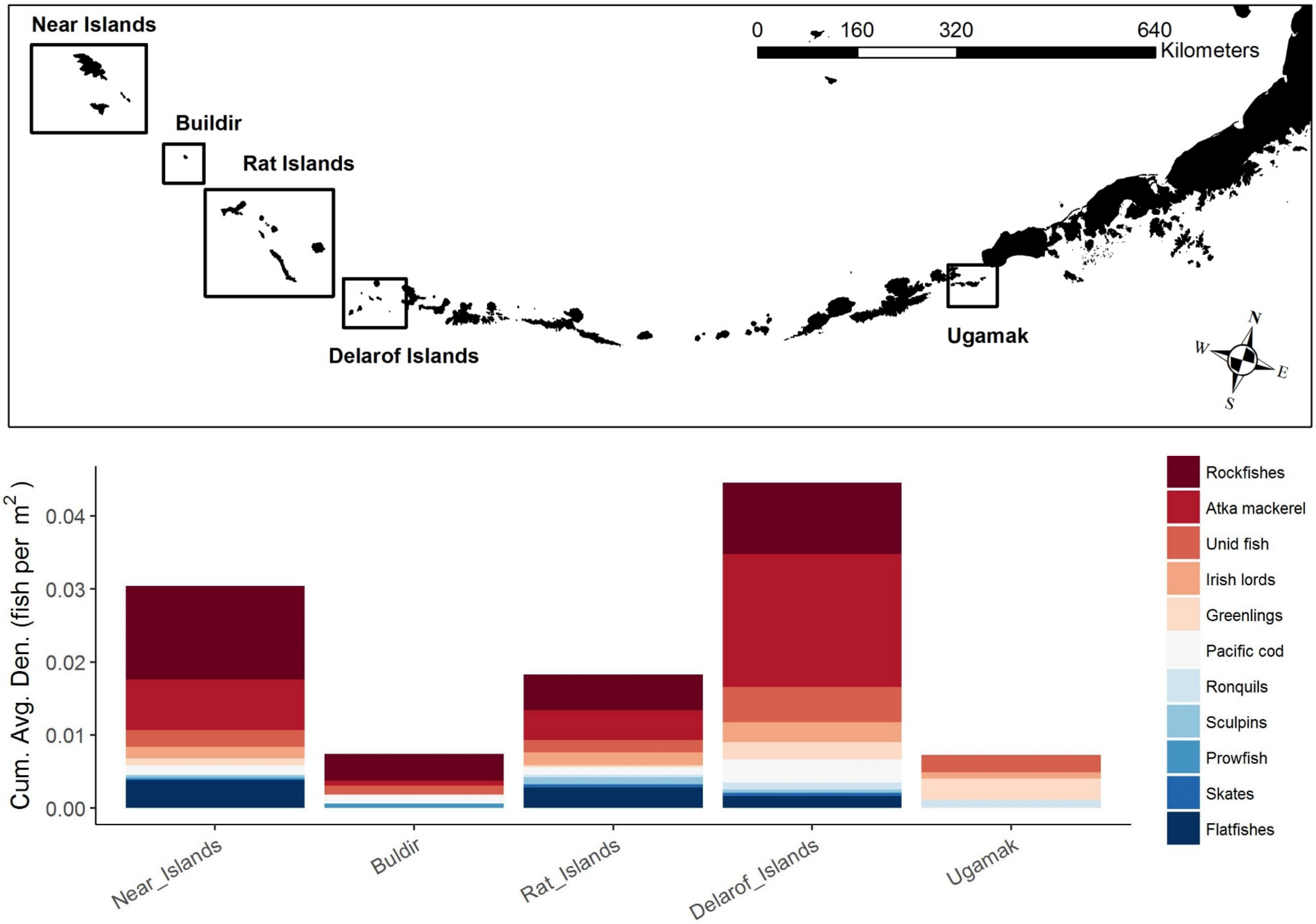


Figure 11. -- Map of Aleutian archipelago showing the major island groups surveyed and stacked bar plots of the cumulative average density (fish per m^2) of the 11 most common species/species groups by island group.

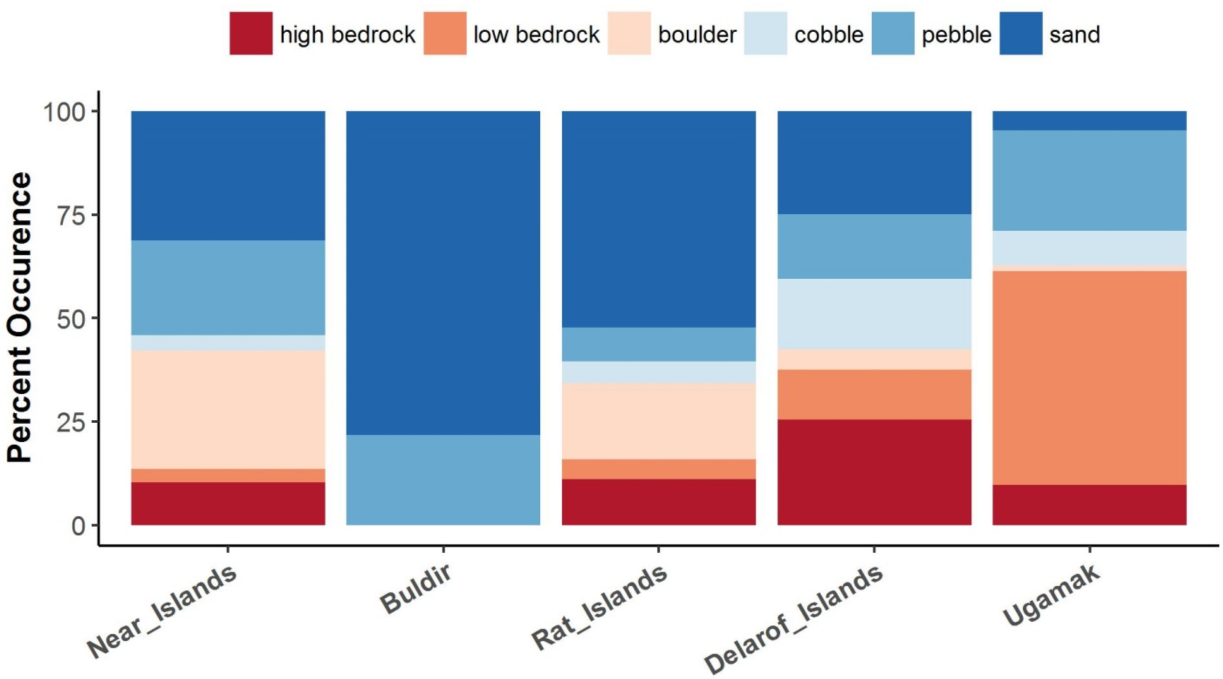
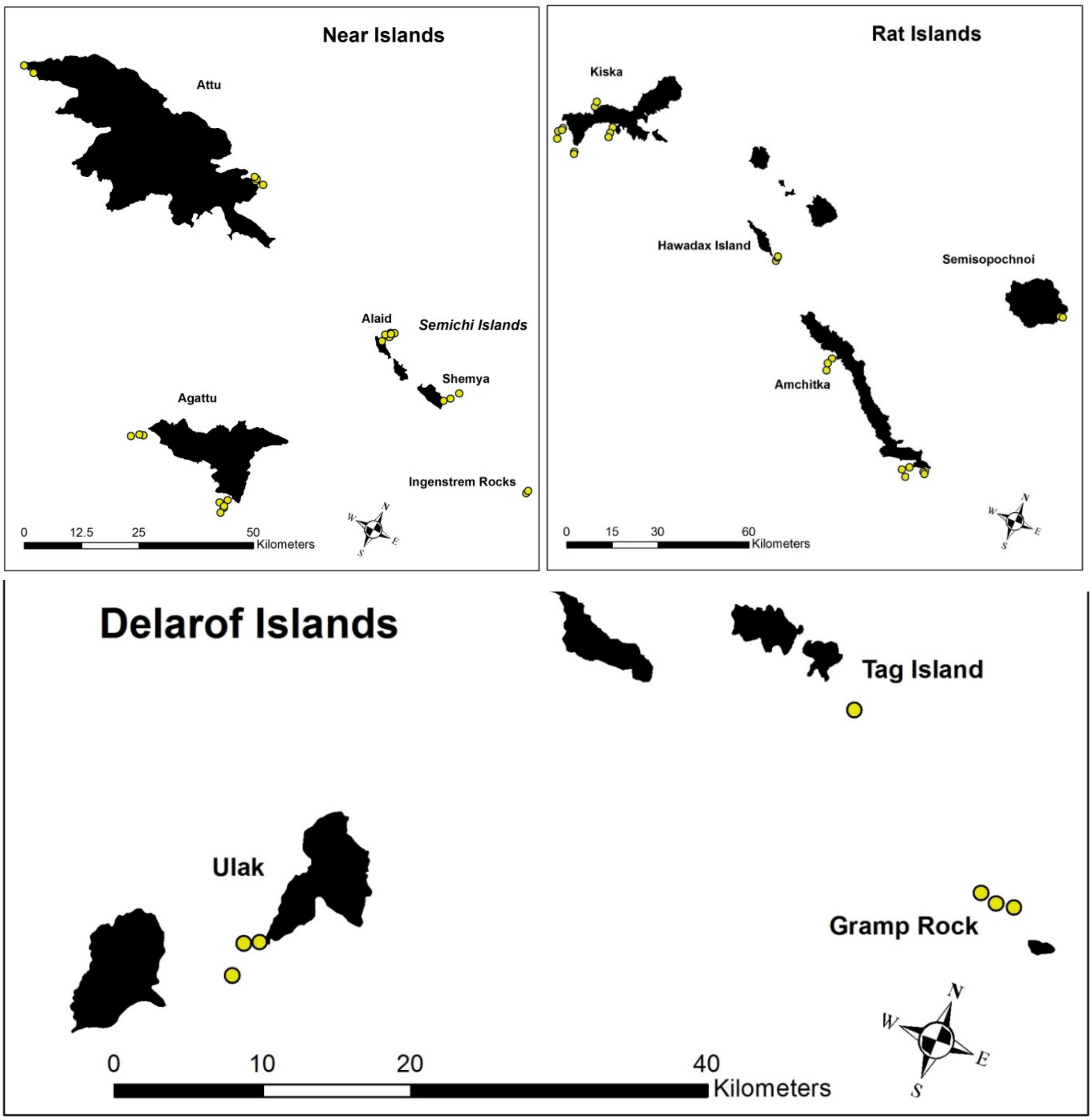


Figure 12. -- The percentage of primary habitat types survey in each island group.

APPENDICES

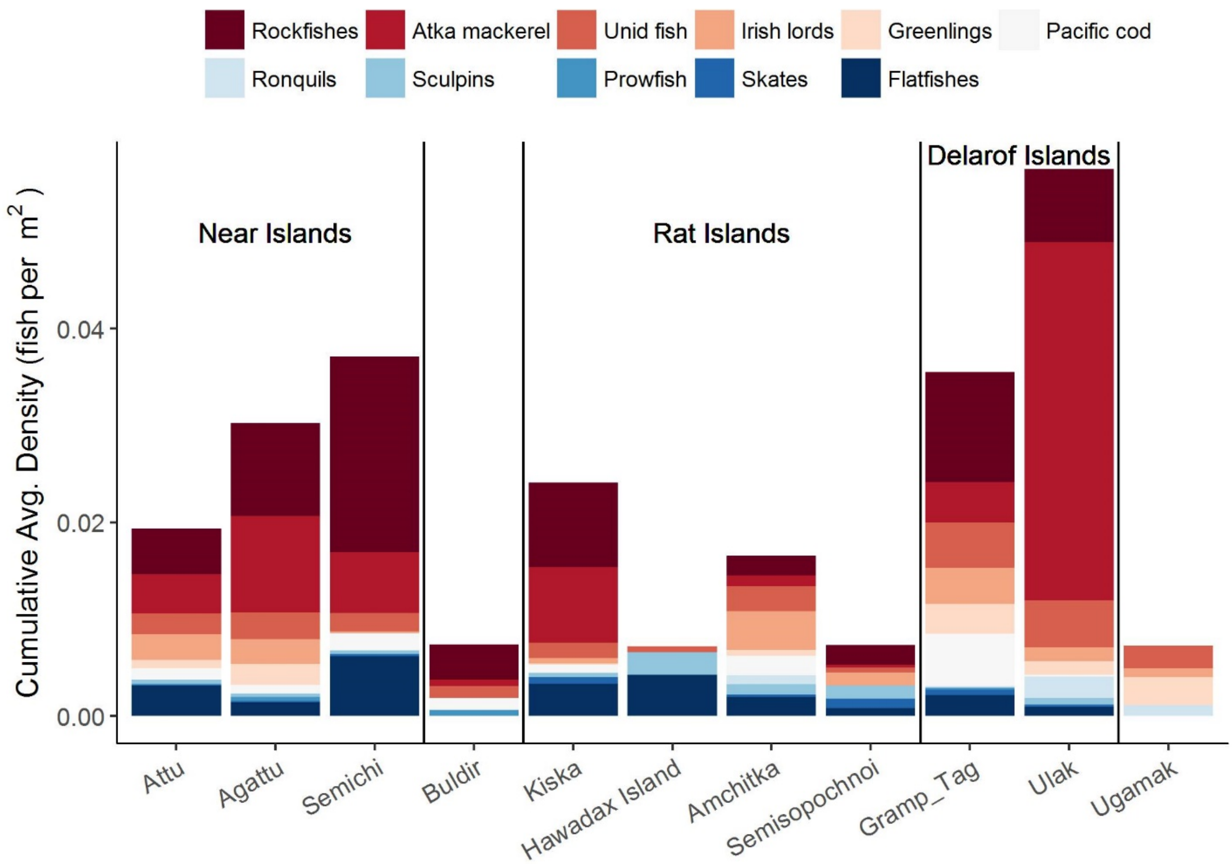
Island Summaries

The following section provides a detailed summary of each transect organized into 11 islands as part of five major areas within the Aleutian Islands. In the Near Islands, this included Attu, Agattu and the Semichi Islands. In the Rat Islands, this included Kiska, Hawadax Island, Amchitka, and Semisopochnoi. In the Delarof Islands, this included Ulak and Tag Island and Gramp Rock. Buldir and Ugamak were stand-alone islands surveyed.



Appendix Figure 1. -- Maps and locations of transects in the Near, Rat, and Delarof Islands.

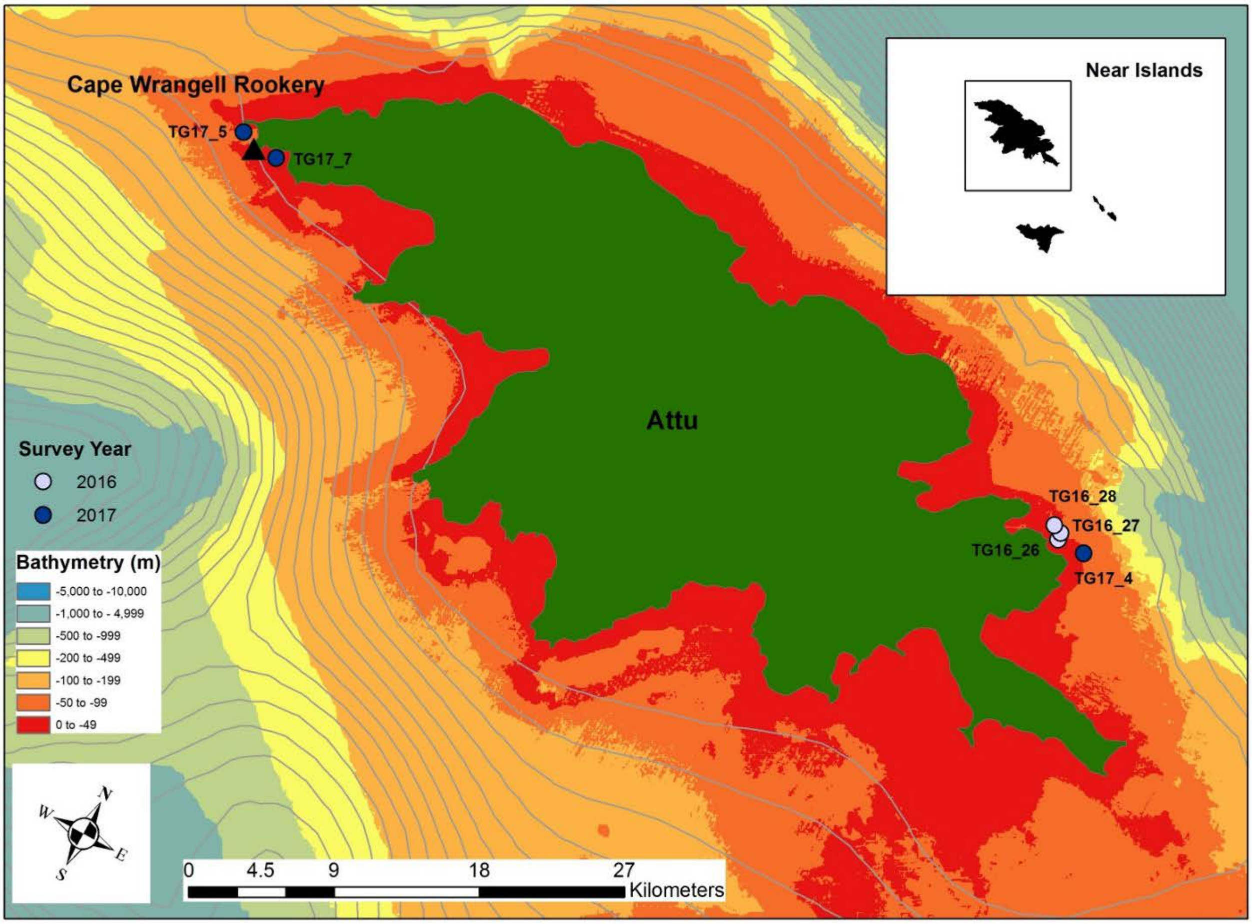
Island Summaries



Appendix Figure 2. -- Stacked bar plot of cumulative average fish density (fish per m^2) by island

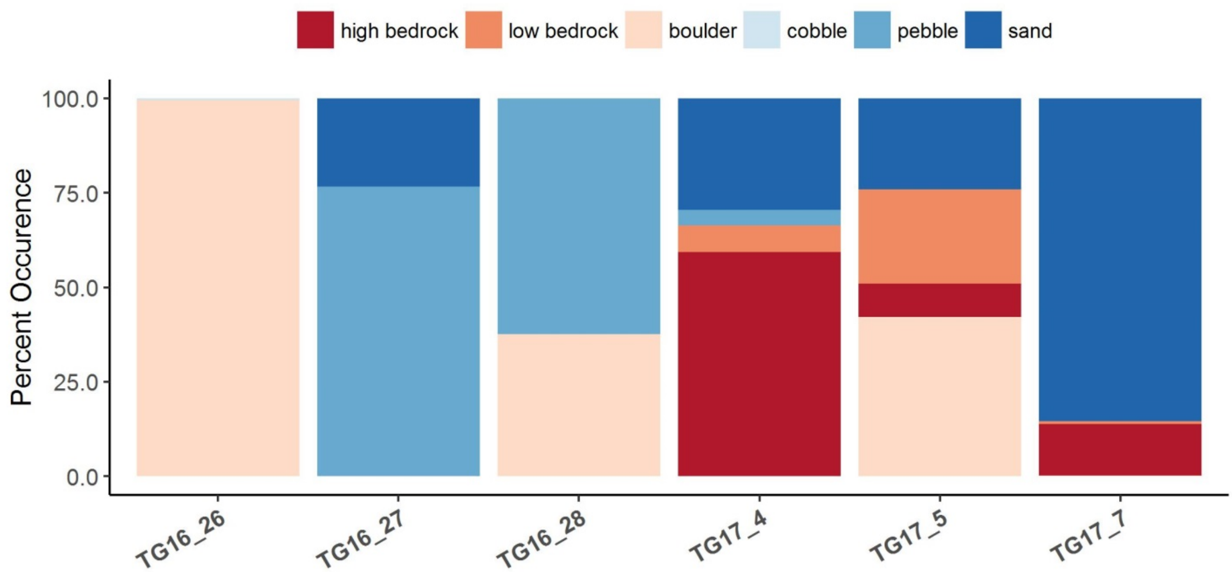
Appendix Figure 3. --The US Fish and Wildlife RV Tiglax in the Delarof Islands offshore of Ulak during 2017 survey.

Near Islands

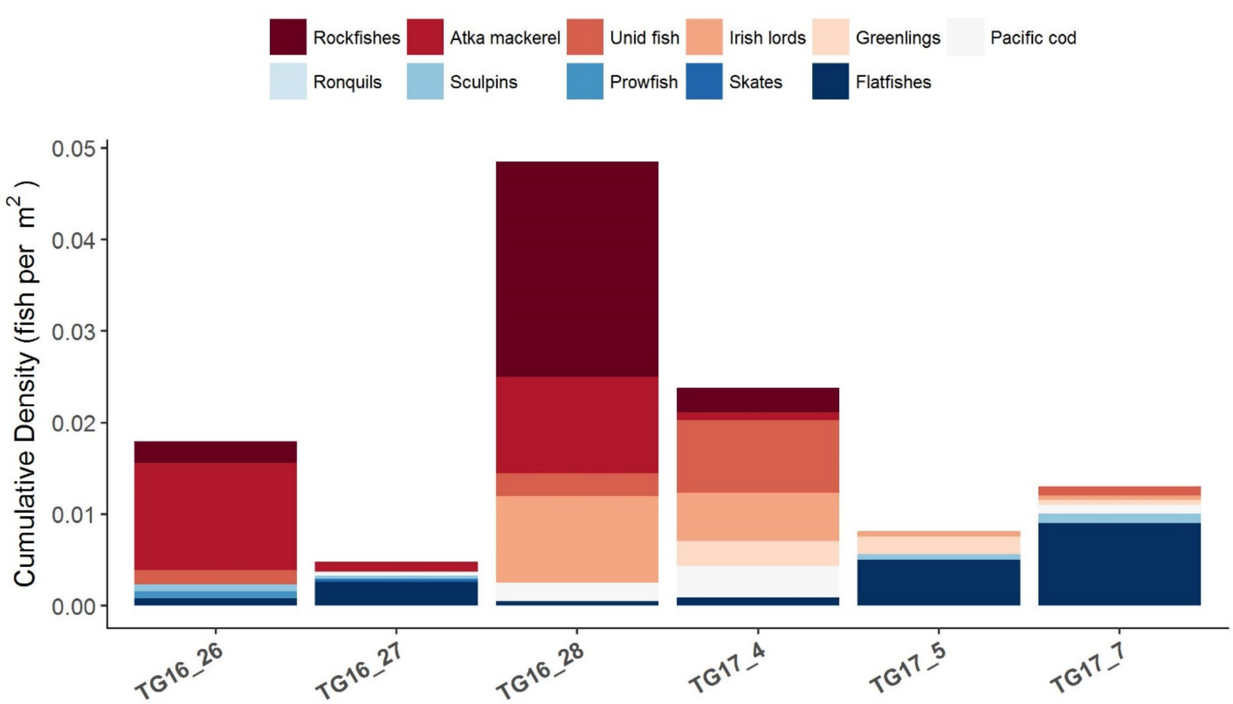


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m²)	Average Depth (m)	Frames Analyzed
TG16_26	6/28/2016	52.93	173.29	247	5.18	1280.5	32.3	588
TG16_27	6/28/2016	52.94	173.28	635	4.26	2708.0	55.3	733
TG16_28	6/28/2016	52.94	173.28	380	5.26	2001.2	53.5	529
TG17_4	6/25/2017	52.93	173.31	323	3.52	1135.3	52.3	776
TG17_5	6/25/2017	52.92	172.45	364	4.38	1593.0	21.8	733
TG17_7	6/25/2017	52.91	172.49	537	3.71	1992.7	28.8	782

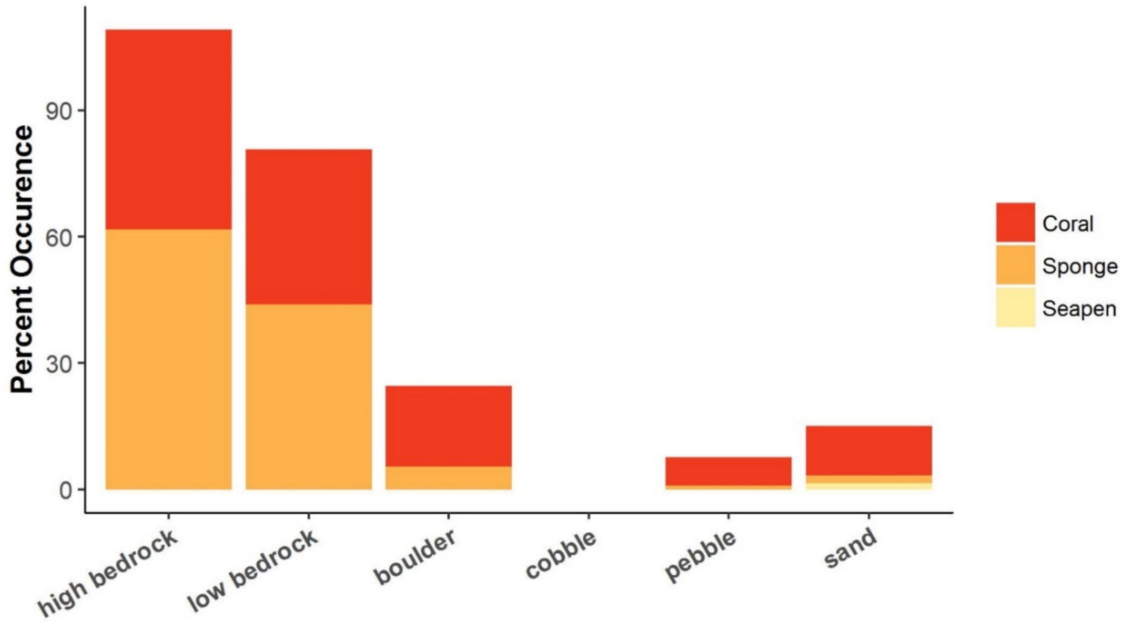
Description: Three transects were conducted in 2016 near a SSL haulout on the north eastern area of Attu. In 2017, a single transect was conducted in the same area and two were completed near the Cape Wrangell rookery. The most common primary habitat types during a transect ranged from mostly boulders (TG16_26) to pebbles and sand (TG16_27). Corals were observed in 47% of frames on high relief bedrock and 37% of frames on low relief bedrock. Sponges were also common on high and low relief bedrock (62% and 44%, respectively). Rockfishes (0.0047 ind m^{-2}) and Atka mackerel (0.0040 ind m^{-2}) were the most common fish species observed.



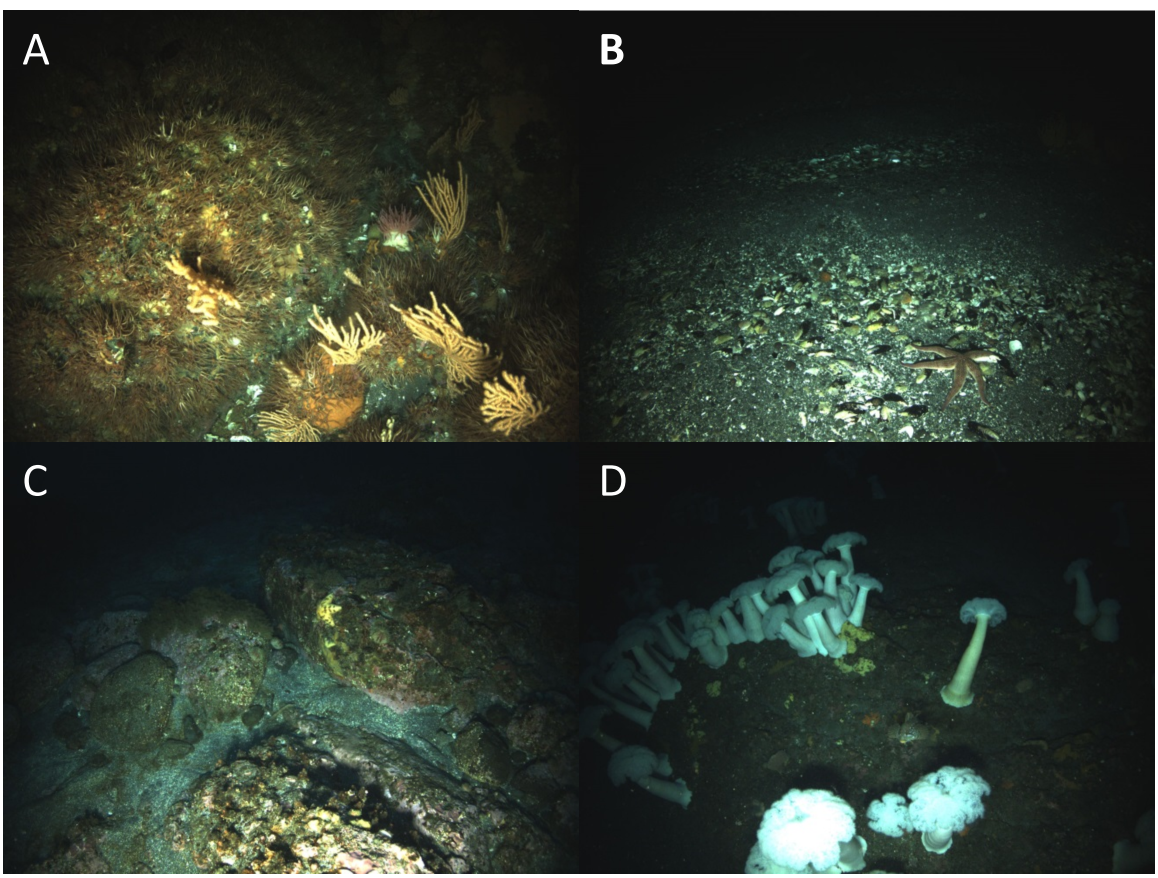
Appendix Figure 4. -- Percent occurrence of primary habitat type by transect.



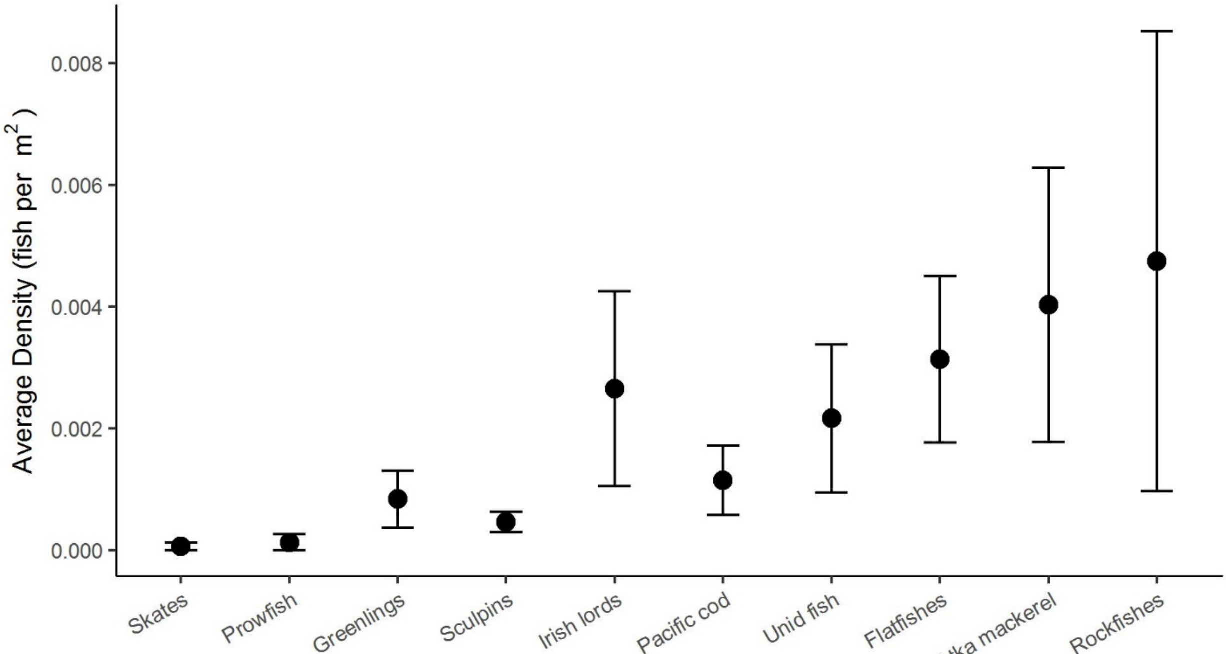
Appendix Figure 5. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



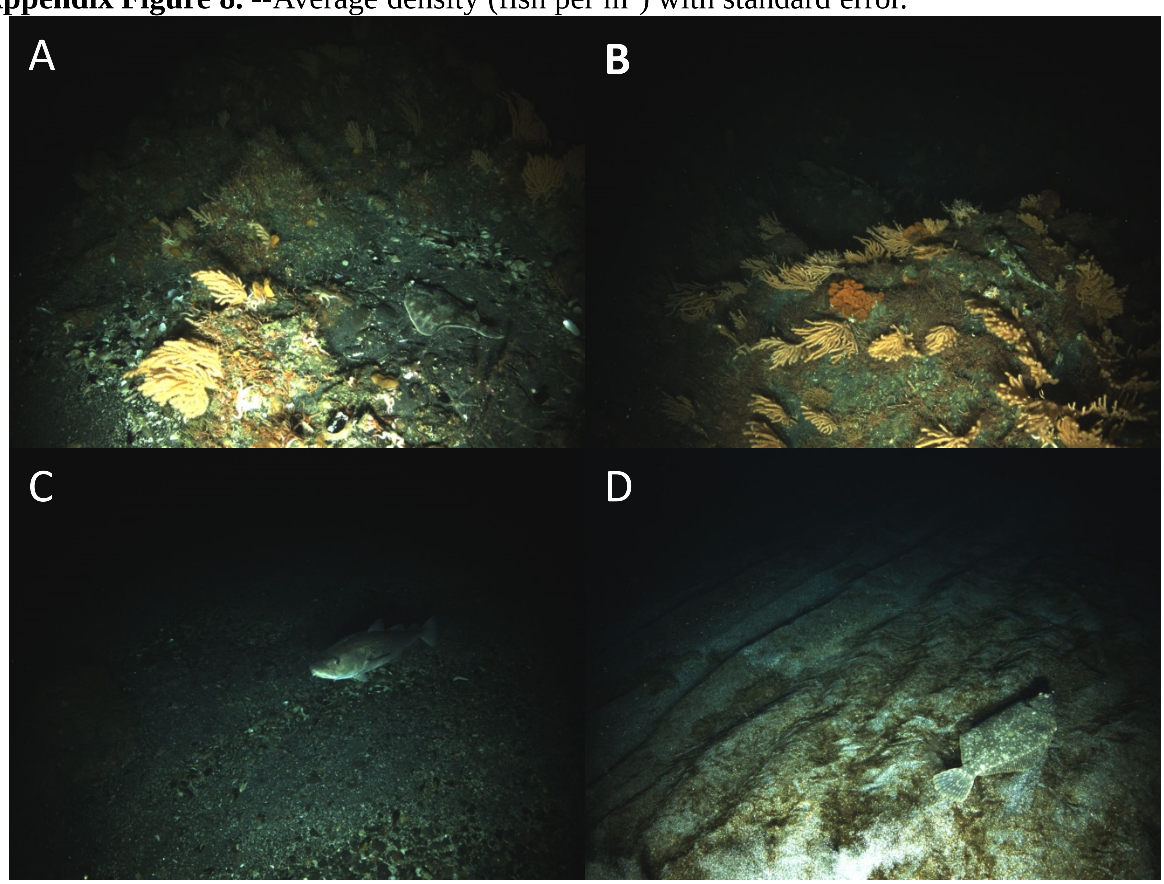
Appendix Figure 6. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



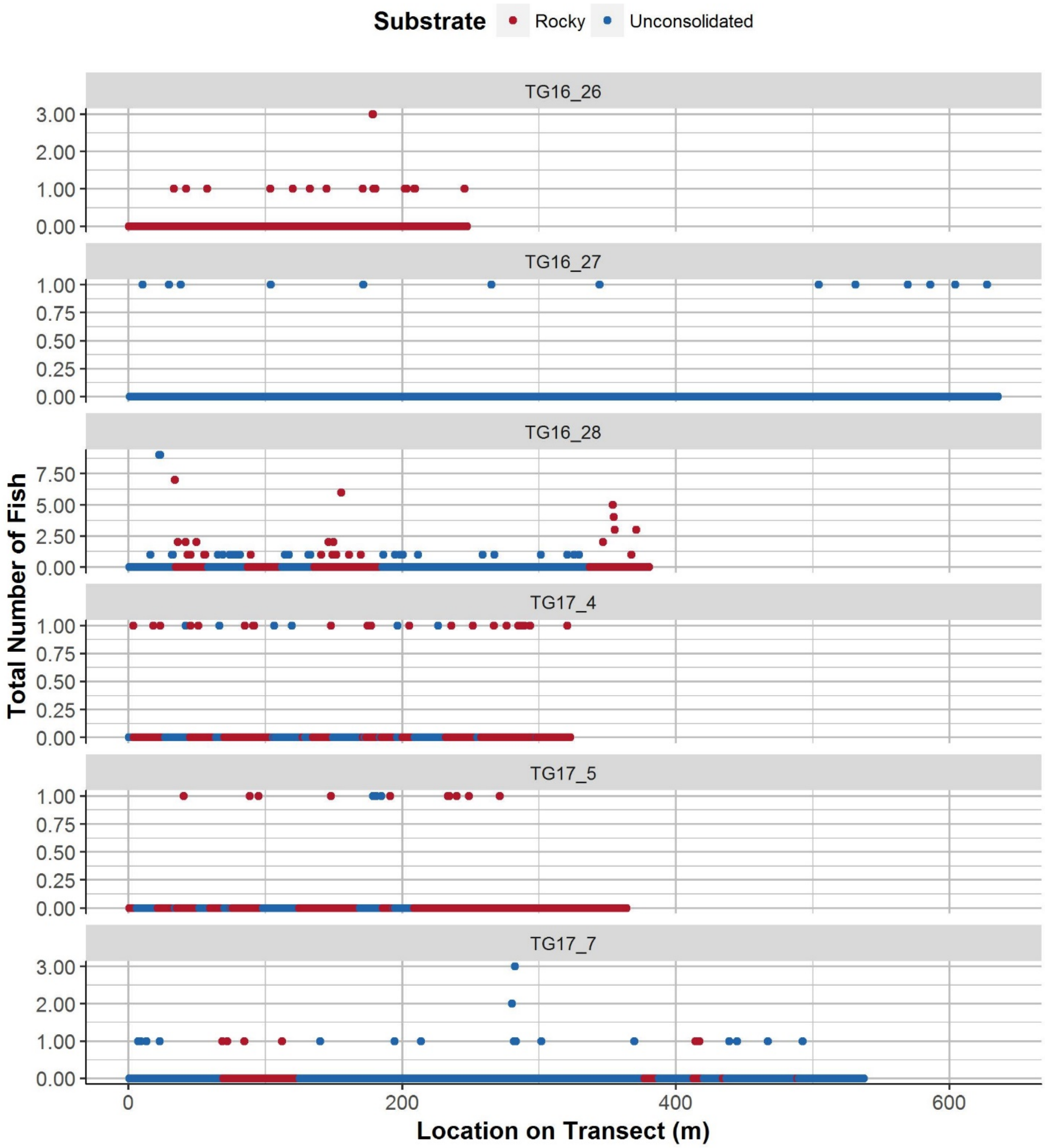
Appendix Figure 7. -- Habitat images of (A) high relief bedrock on transect TG17_4, (B) pebbles on transect TG17_4, (C) boulders on transect TG17_5, and (D) high relief bedrock on transect TG17_7.



Appendix Figure 8. --Average density (fish per m^2) with standard error.

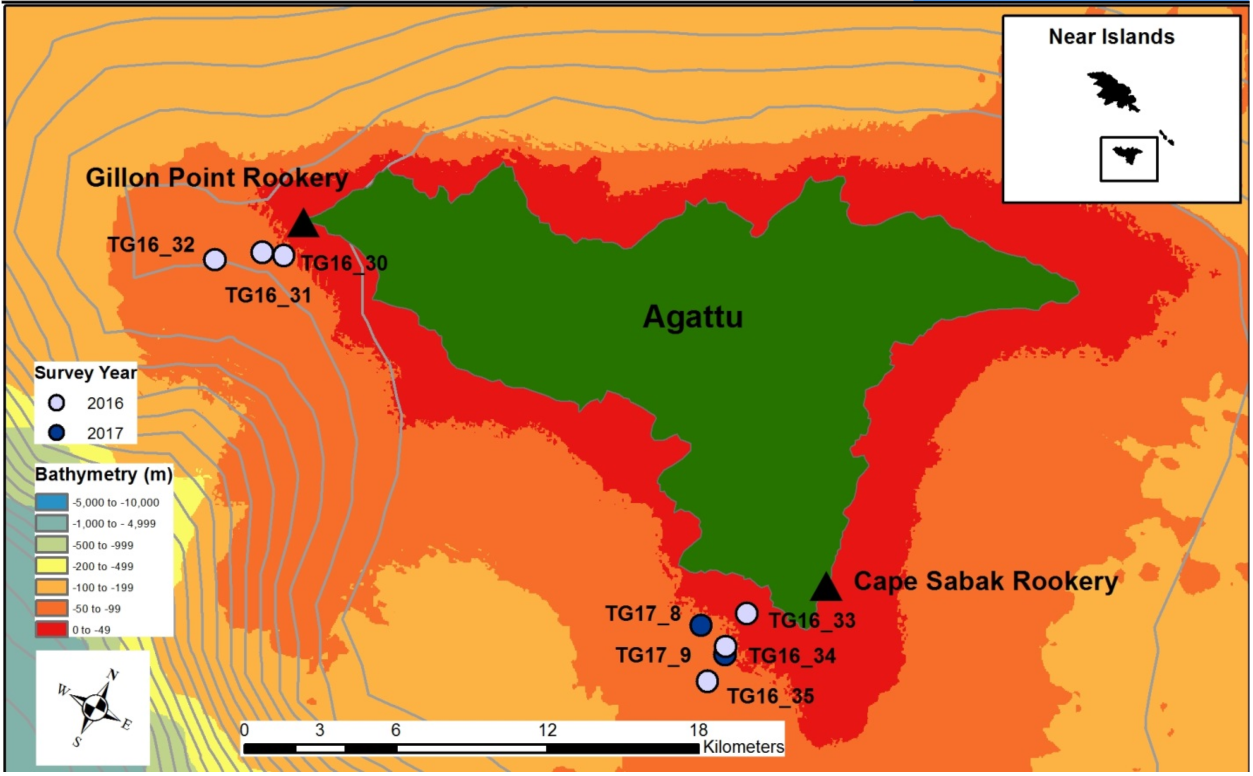


Appendix Figure 9. -- Images of (A) northern rocksole on transect TG17_4, (B) yellow Irish lord on transect TG17_4, (C) a Pacific cod on transect TG17_5, and (D) a northern rocksole on transect TG17_7.



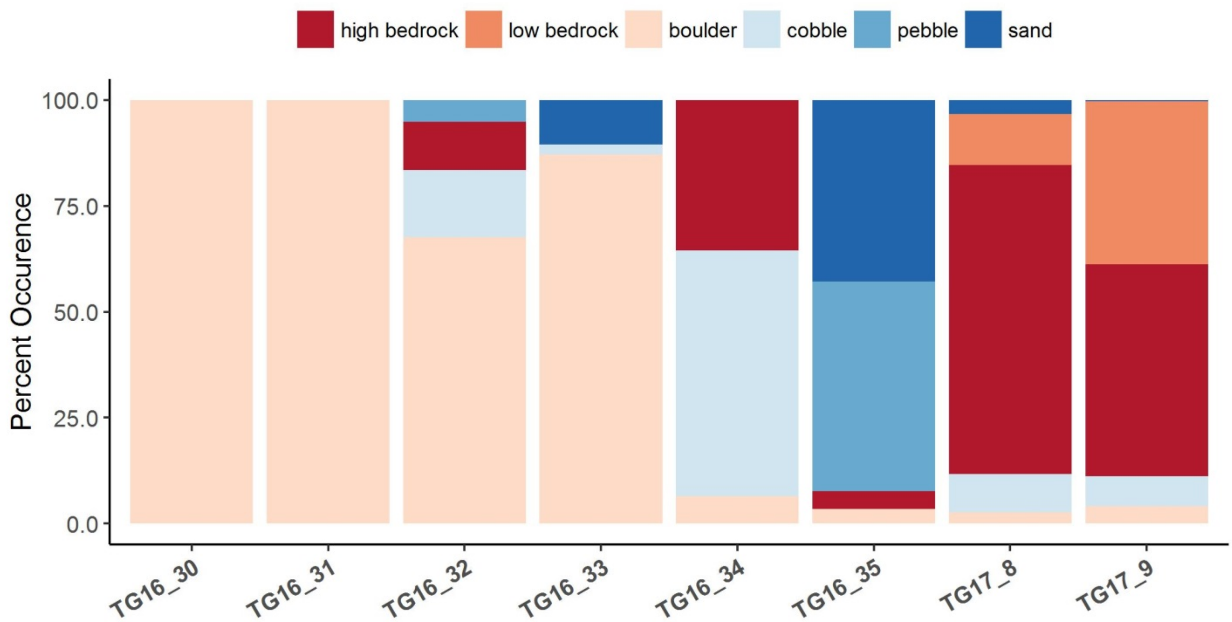
Appendix Figure 10. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

Near Islands | Agattu

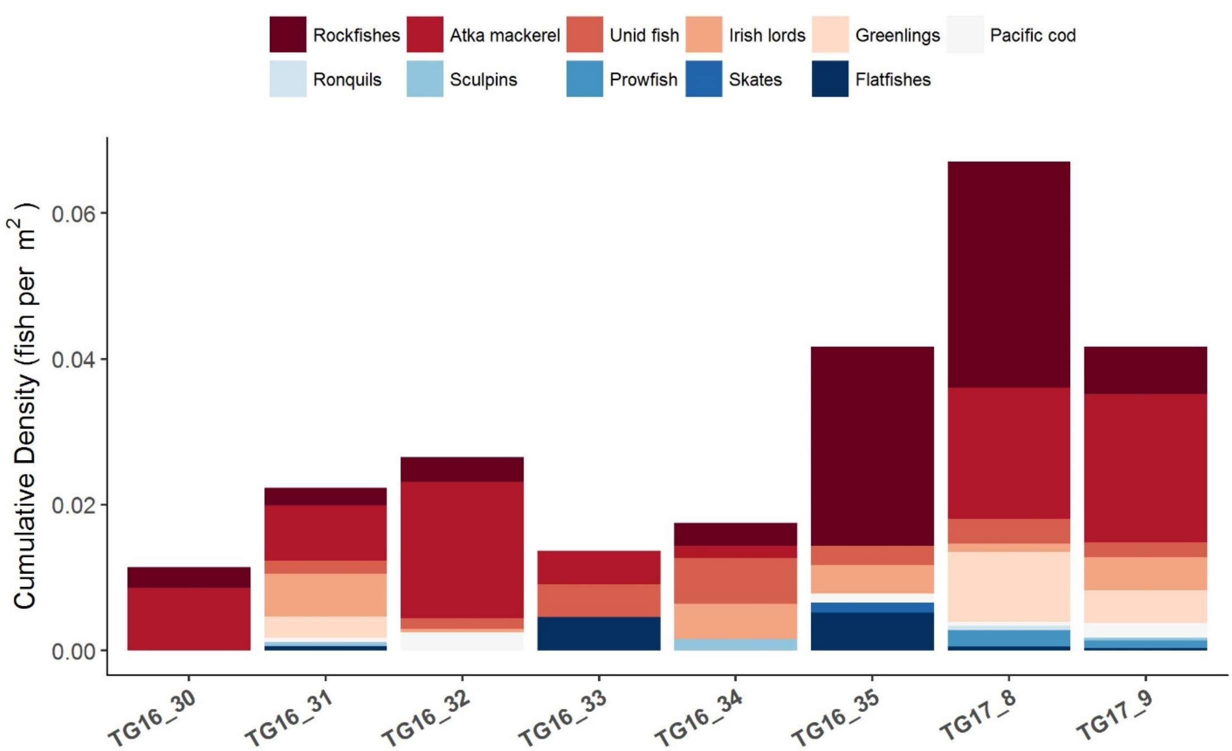


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed
TG16_30	6/30/2016	52.39	173.35	58	6.1	350.9	22	98
TG16_31	6/30/2016	52.39	173.34	254	6.7	1705.0	57.25	429
TG16_32	6/30/2016	52.38	173.32	275	7.4	2033.8	72	558
TG16_33	6/30/2016	52.35	173.69	108	2.0	219.5	29.75	257
TG16_34	6/30/2016	52.34	173.69	206	3.1	628.3	46.75	402
TG16_35	6/30/2016	52.33	173.69	187	4.1	767.5	75.25	488
TG17_8	6/26/2017	52.34	173.69	412	4.3	1774.9	52.625	774
TG17_9	6/26/2017	52.34	173.67	596	4.9	2900.5	47	852

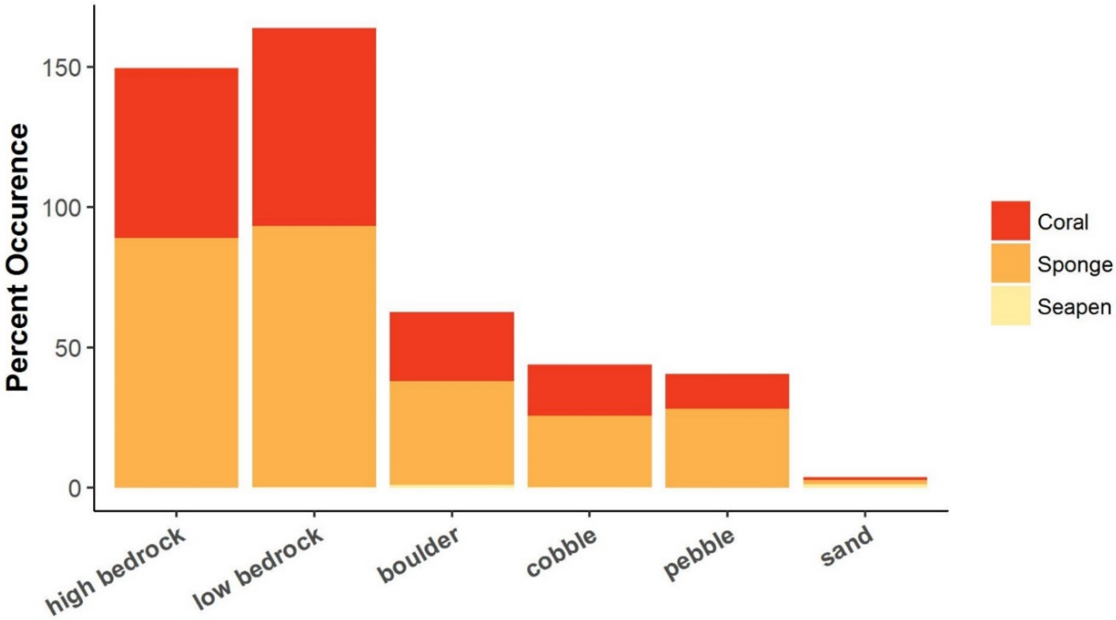
Description: In 2016, three transects were conducted near the Gillon Point rookery and three near the Cape Sabak rookery. All transects except TG16_35 were over rocky substrate. The occurrence of corals was greater than 50% on low and high relief bedrock and sponges occurred in 89% and 93% of low and high relief bedrock frames, respectively. Rockfishes and Atka mackerel were the dominant fish species observed over these rocky transects. Greenlings and Irish lords were relatively common.



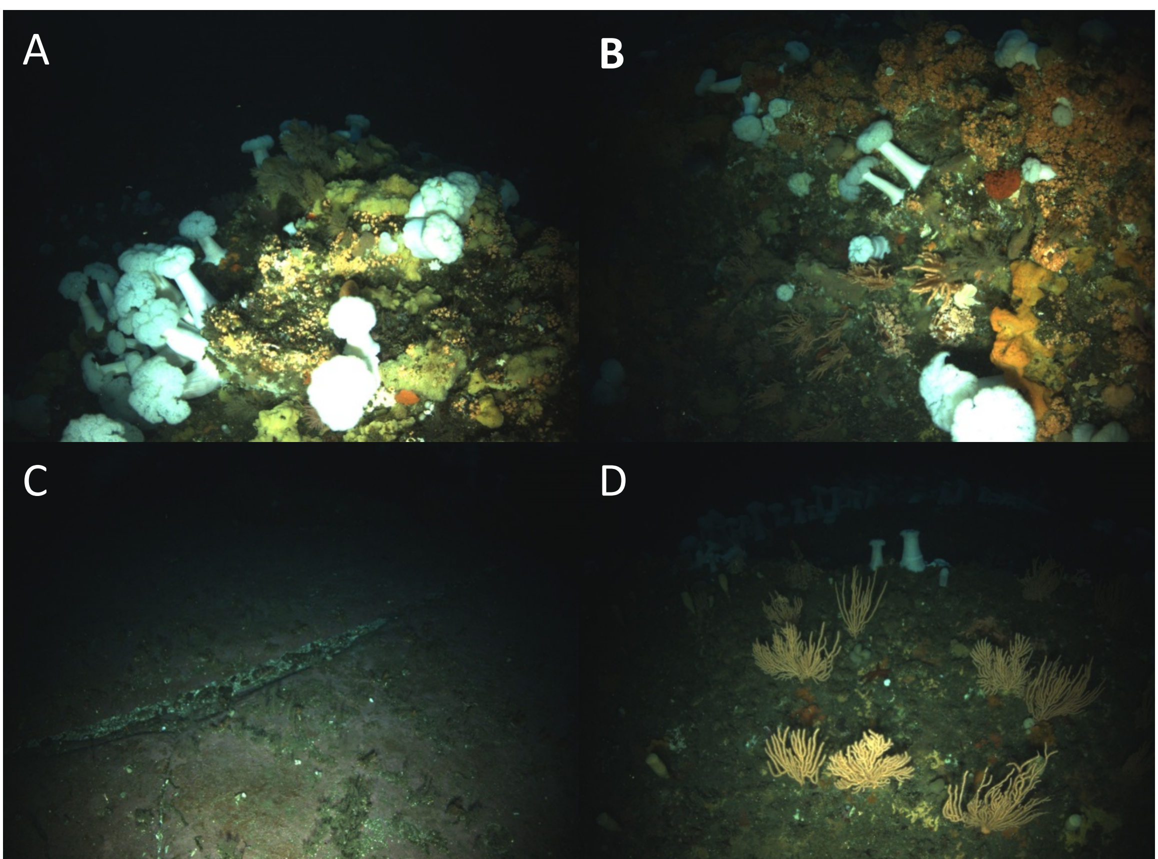
Appendix Figure 11. -- Percent occurrence of primary habitat type by transect.



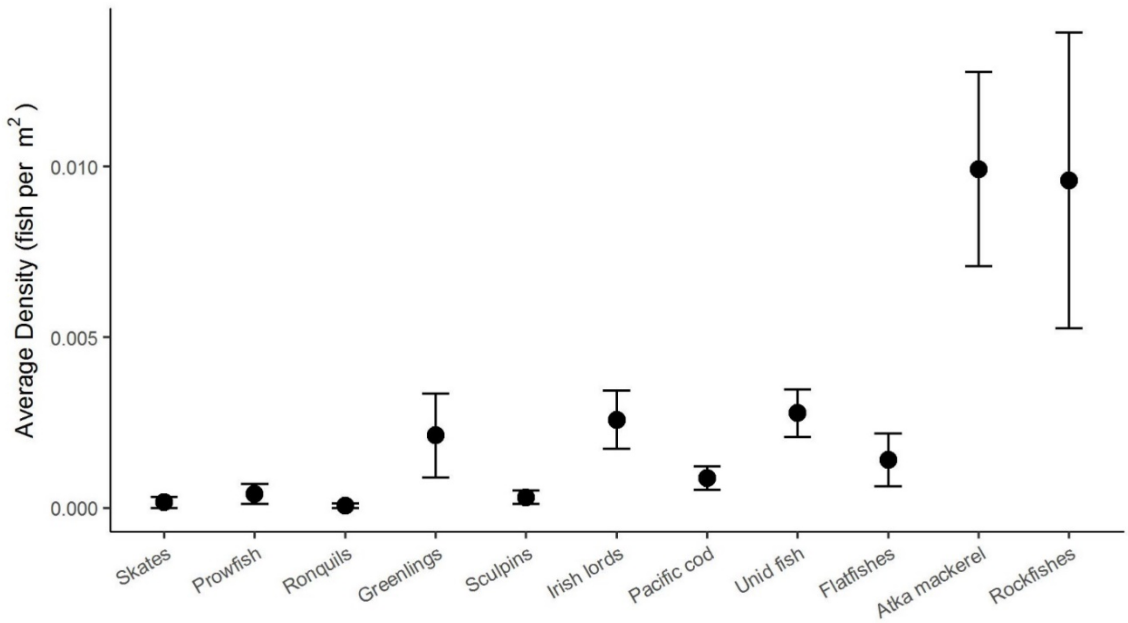
Appendix Figure 12. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



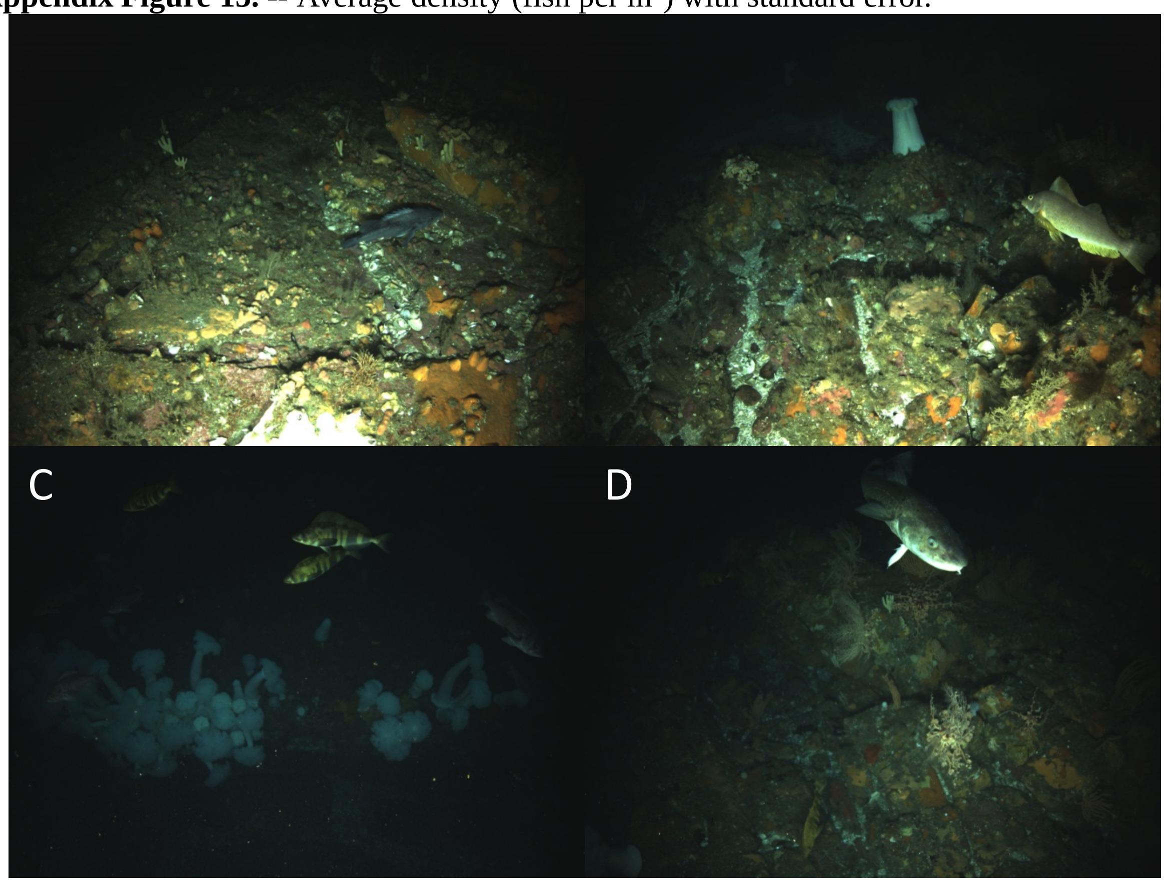
Appendix Figure 13. --Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



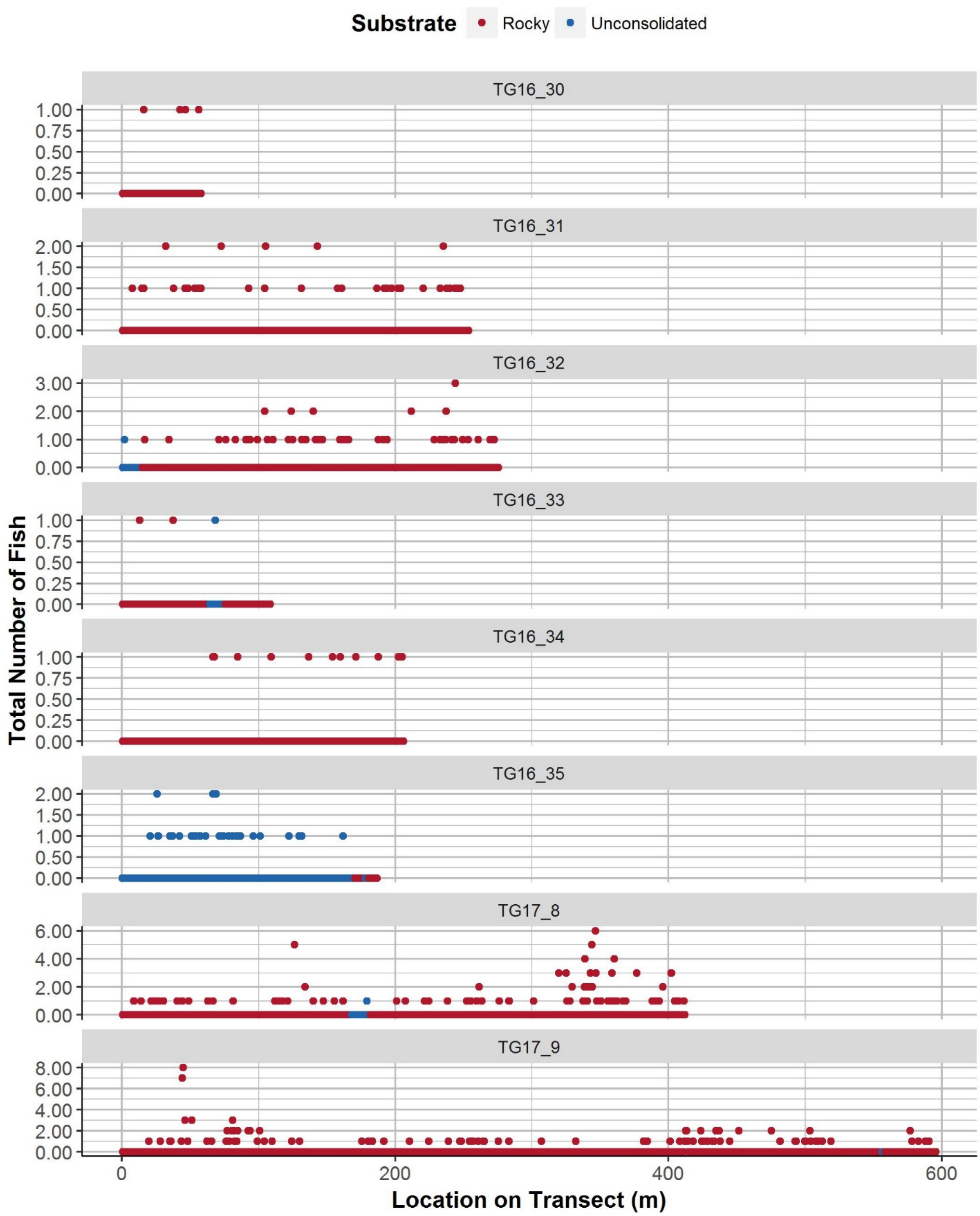
Appendix Figure 14. -- Habitat images of (A & B) high relief bedrock on transect TG17_8, (C) low relief bedrock on transect TG17_8, and (D) high relief bedrock on transect TG17_9.



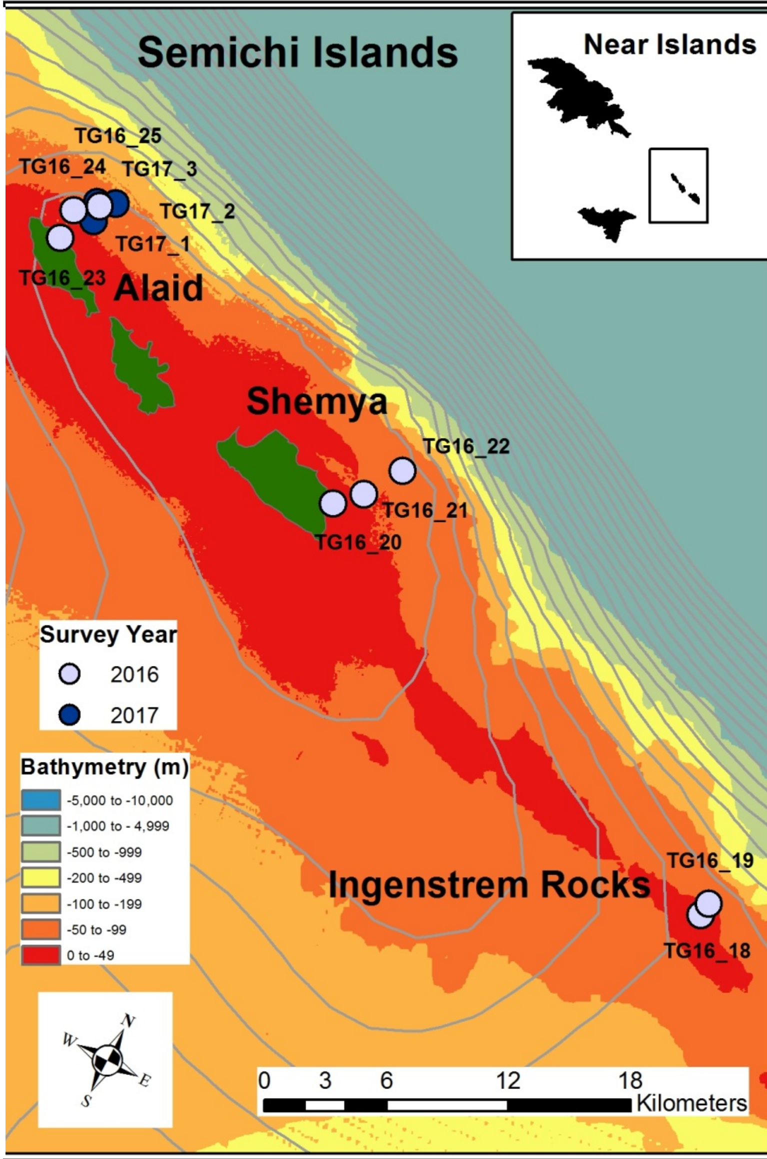
Appendix Figure 15. -- Average density (fish per m^2) with standard error.



Appendix Figure 16. -- Images of (A) dark rockfish on transect TG17_8, (B) kelp greenling on transect TG17_8, (C) Atka mackerel on transect TG17_9, and (D) a Pacific cod on transect TG17_9.

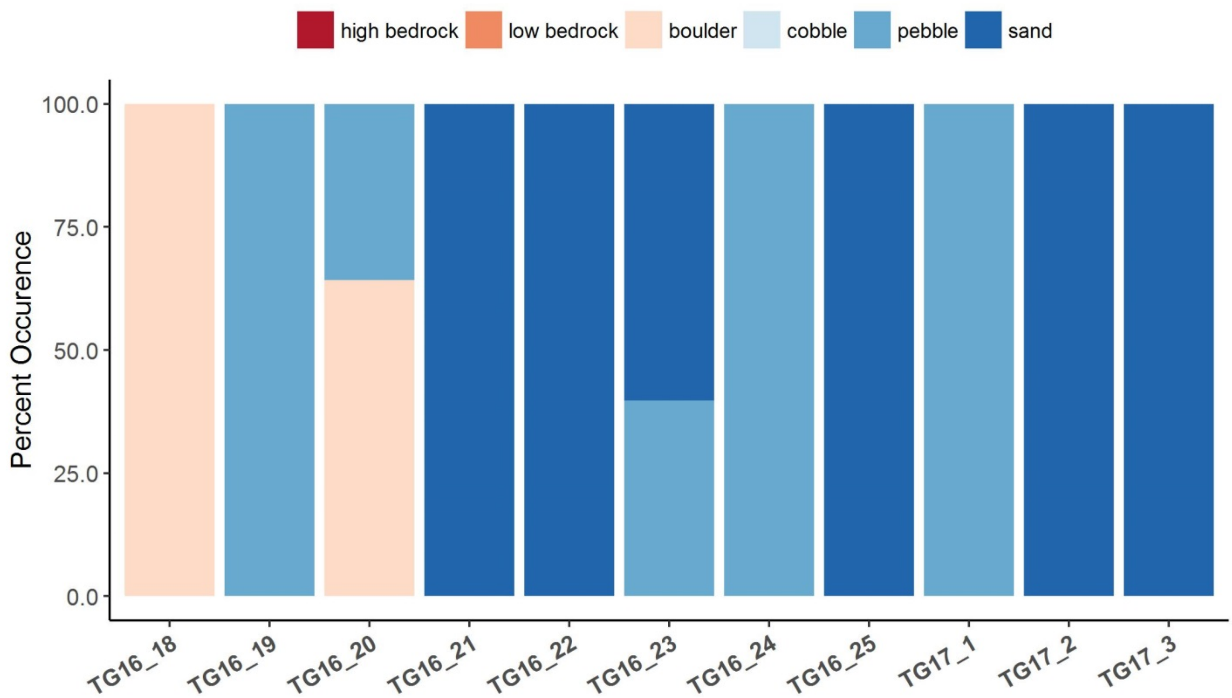


Appendix Figure 17. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

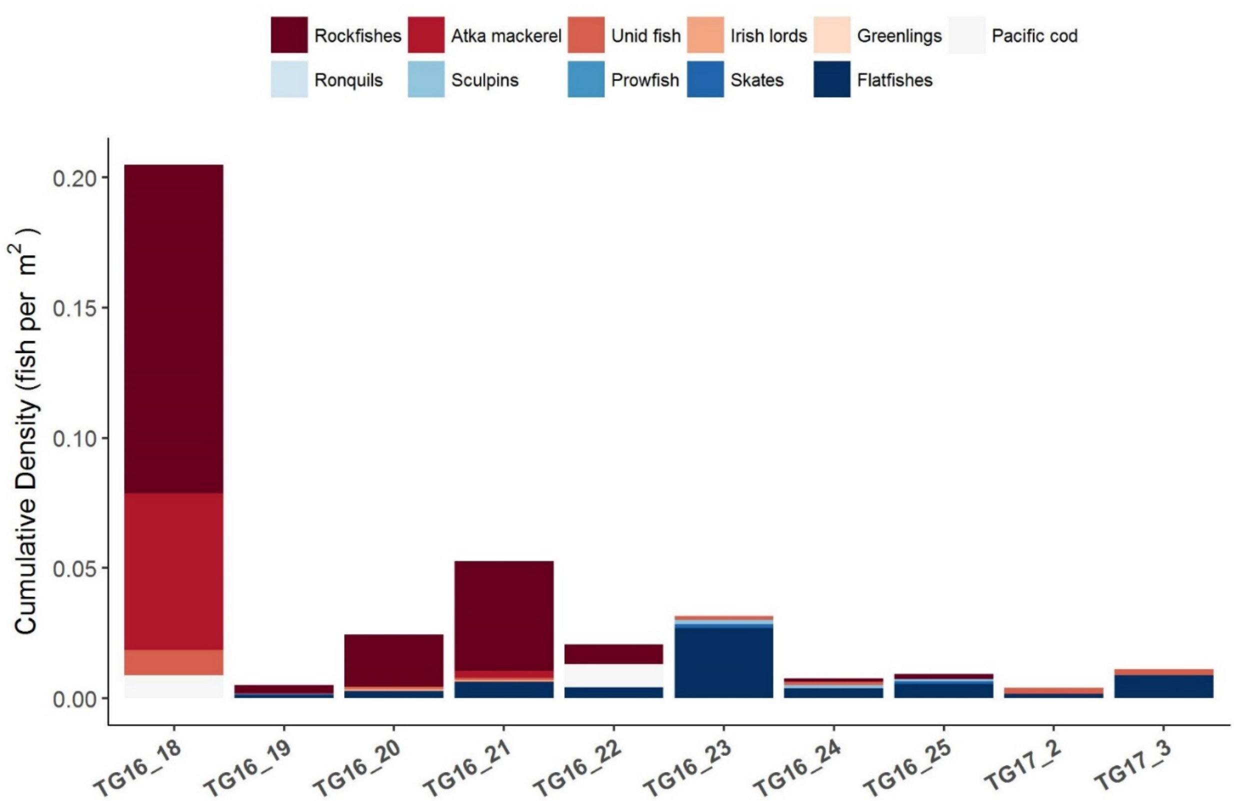


Description: In the Semichi Islands surveys were conduced near Alaid in 2016 and 2017 and near Shemya and Ingenstrem Rocks in 2016. Most of the transects in the area were over unconsolidated substrate where flatlfishes were common (0.0063 ind m^{-2} ±0.002 SE). An exception was TG16_18, off Ingenstrem Rocks, where a large school of rockfishes (170 fish) and Atka mackerel (81 fish) were observed over the boulder habitat.

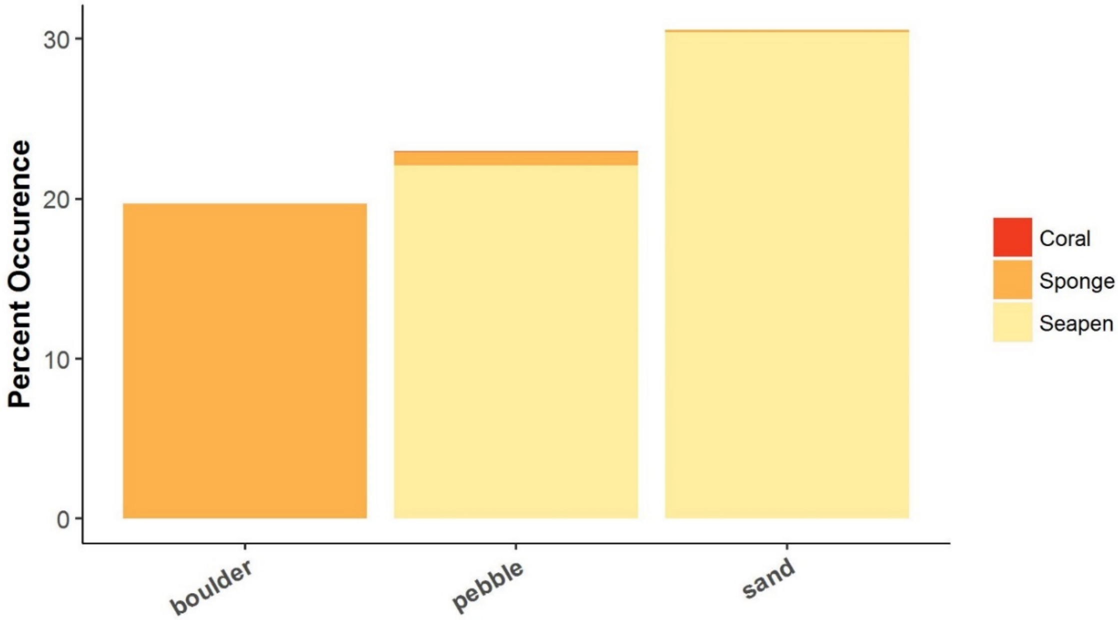
Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m²)	Average Depth (m)	Frames Analyzed
TG16_18	6/27/2016	52.64	174.53	237	5.7	1346.7	42.5	433
TG16_19	6/27/2016	52.64	174.53	577	5.4	3122.5	79	876
TG16_20	6/28/2016	52.72	174.15	297	3.7	1103.9	25.75	578
TG16_21	6/28/2016	52.73	174.17	476	3.0	1424.1	51.5	915
TG16_22	6/28/2016	52.75	174.19	317	4.6	1450.7	74.25	837
TG16_23	6/28/2016	52.77	173.89	314	2.1	666.6	39.25	777
TG16_24	6/28/2016	52.79	173.89	232	3.4	796.6	68.75	484
TG16_25	6/28/2016	52.79	173.90	300	3.6	1078.4	93.25	644
TG17_1	6/24/2017	52.79	173.90	524	3.9	2030.8	65	800
TG17_2	6/24/2017	52.79	173.90	440	3.9	1707.5	88.25	647
TG17_3	6/24/2017	52.80	173.91	574	3.1	1799.6	96.75	608



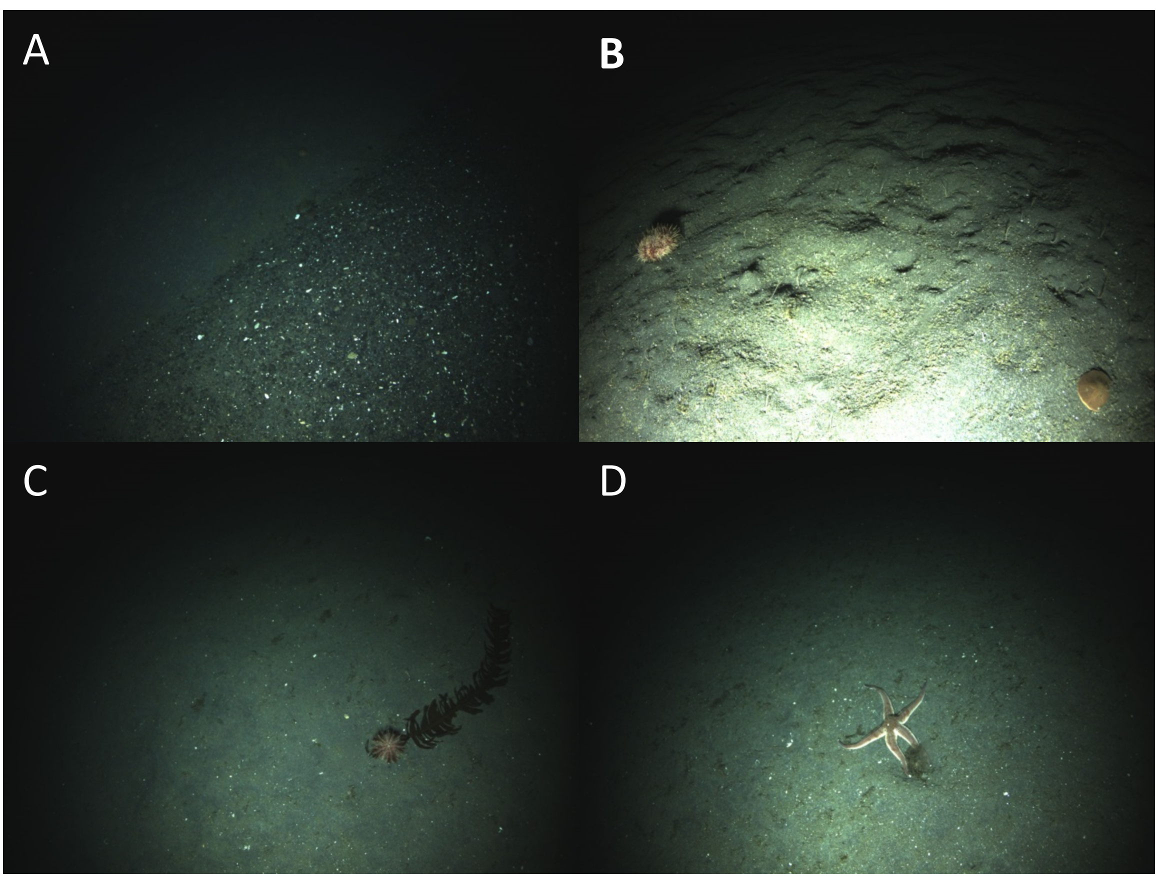
Appendix Figure 18. -- Percent occurrence of primary habitat type by transect.



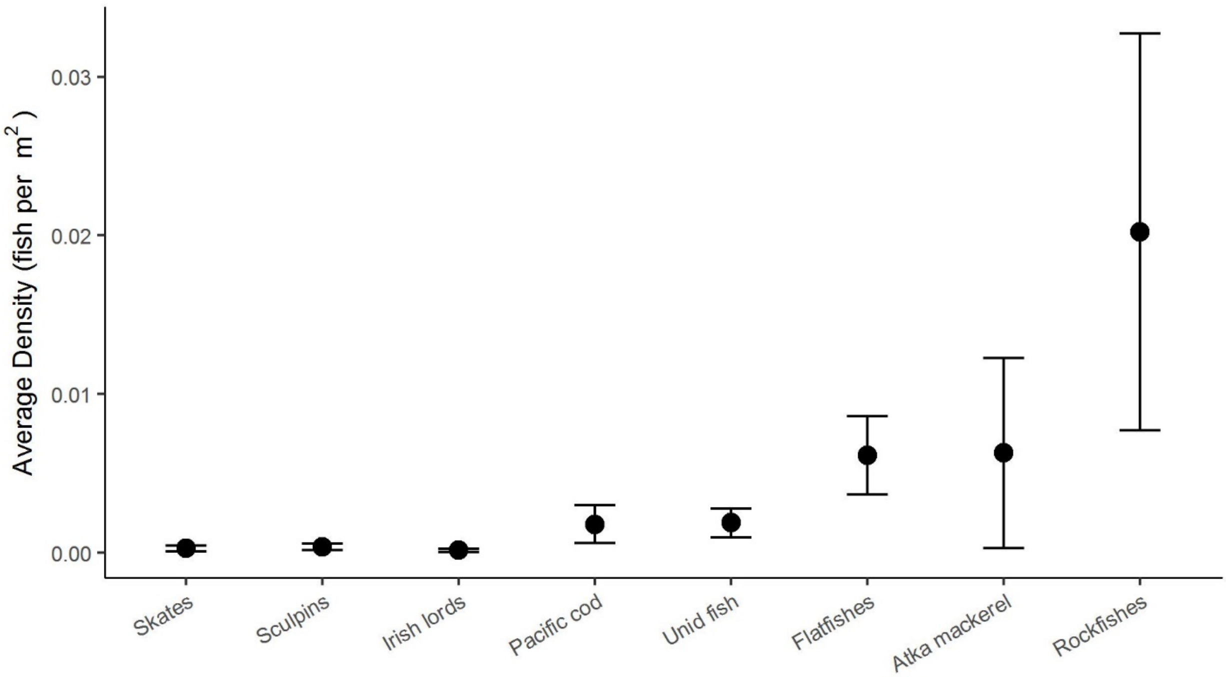
Appendix Figure 19. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



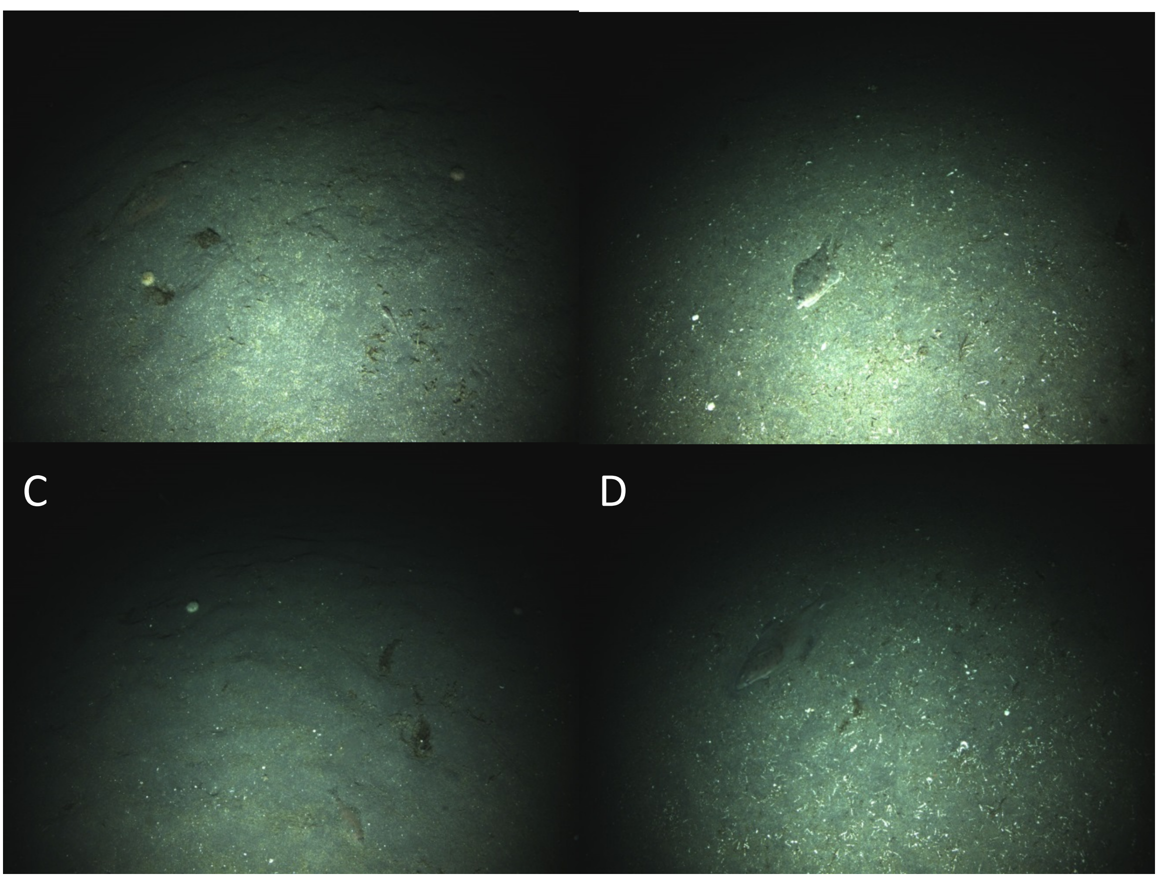
Appendix Figure 20. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



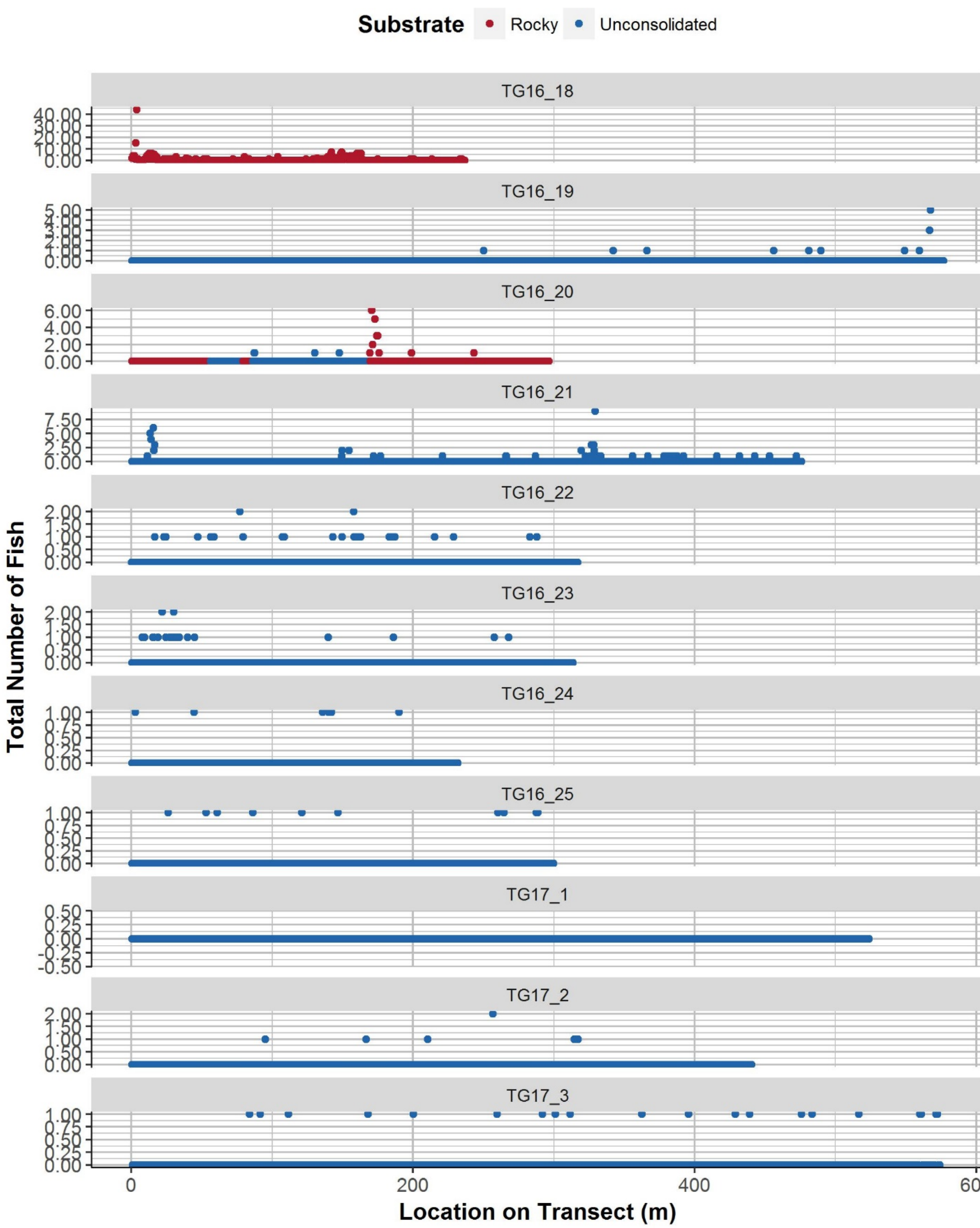
Appendix Figure 21. -- Habitat images of (A) pebbles on transect TG17_1, (B) sand on transect TG17_2, and (C & D) sand on transect TG17_3.



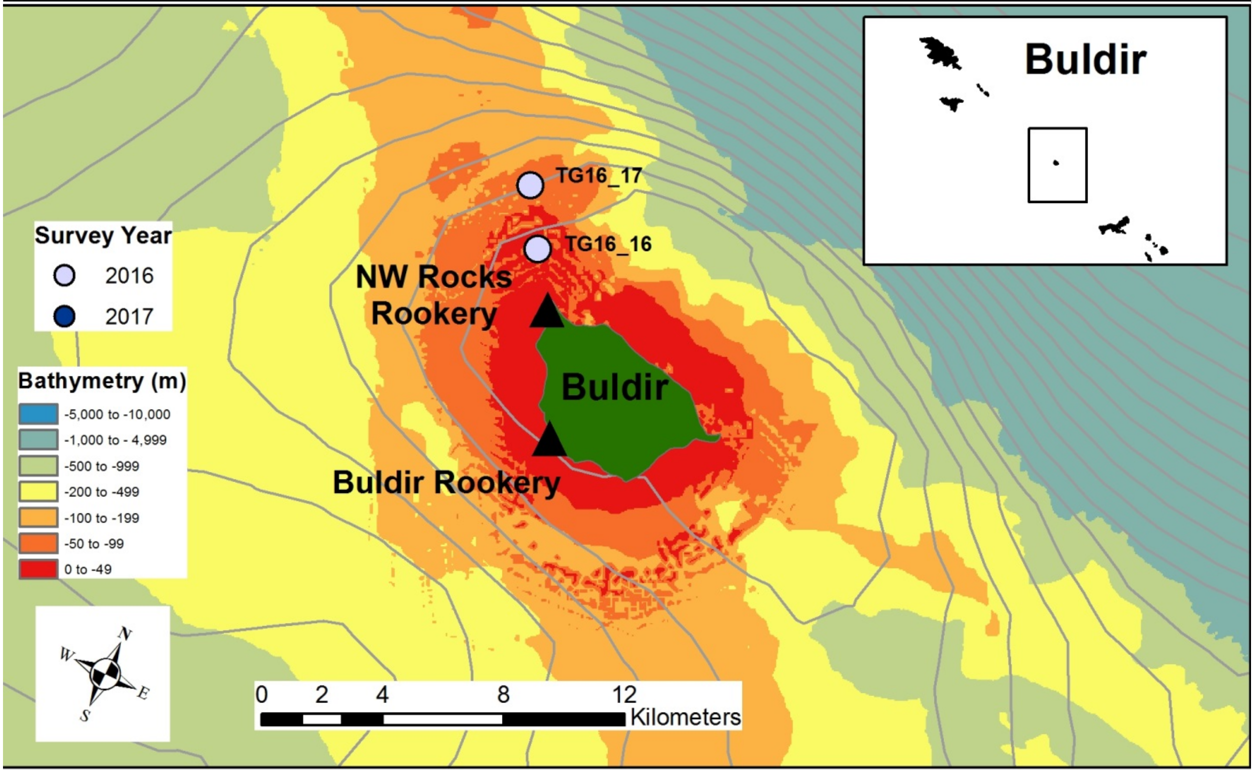
Appendix Figure 22. -- Average density (fish per m^2) with standard error.



Appendix Figure 23. -- Images of (A) a rex sole, (B) northern rocksole, (C) arrowtooth flounder, and (D) a halibut on transect TG17_3.

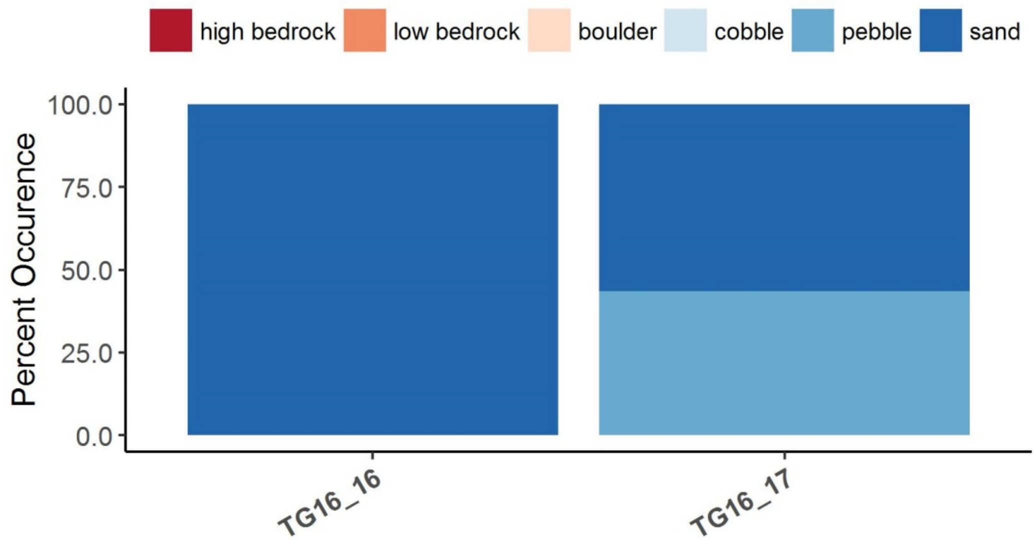


Appendix Figure 24. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

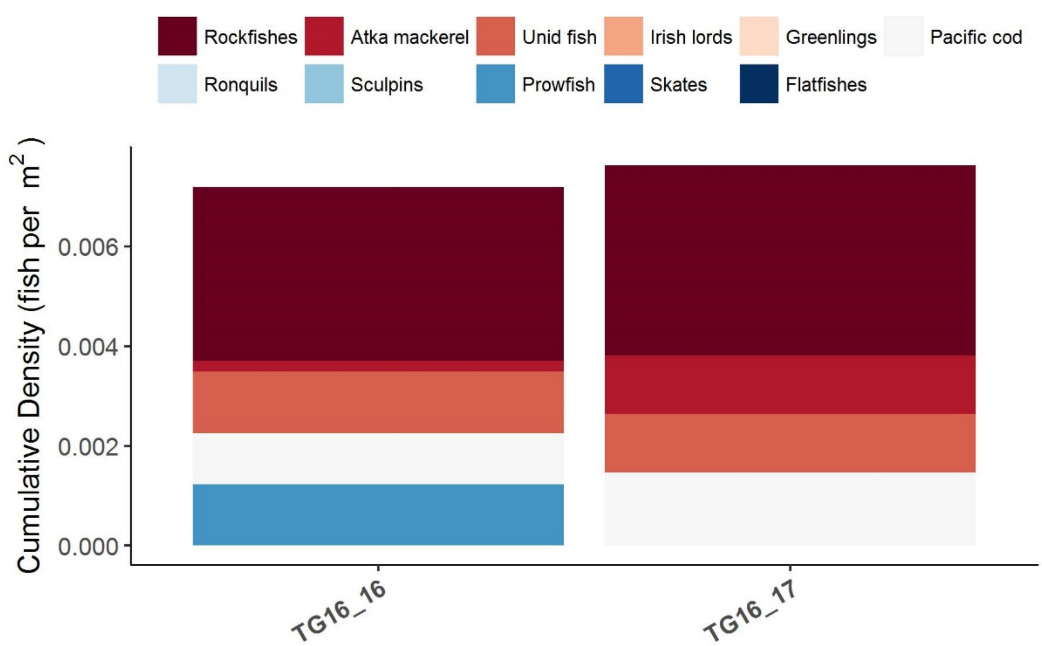


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed
TG16_16	6/27/2016	52.39	175.86	877	5.6	4870.3	32.25	708
TG16_17	6/27/2016	52.40	175.84	889	7.7	6825.1	80.5	758

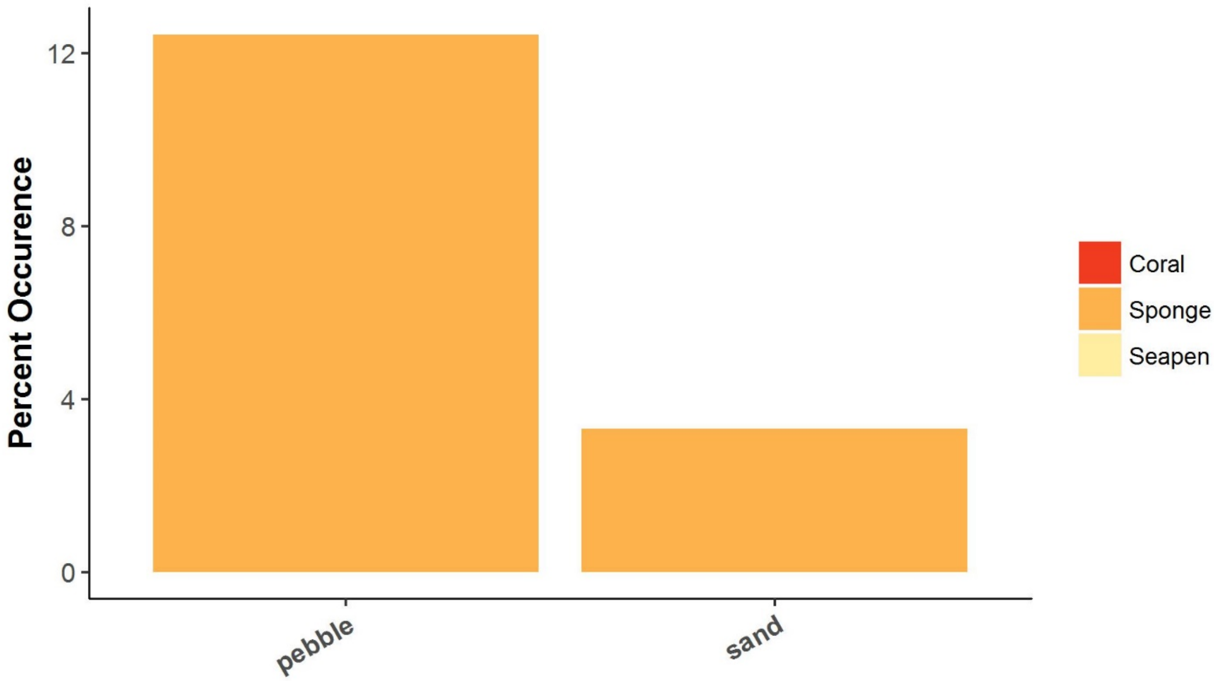
Description: The solitary island Buldir is located between the Near Islands and Rat Islands in the Western Aleutian Islands. Two transects were conducted on the northwestern side of the island in 2016. Both transects were conducted over unconsolidated substrate and total fish densities were among the lowest for any island surveyed. Interestingly no flatfishes were observed over unconsolidated substrate.



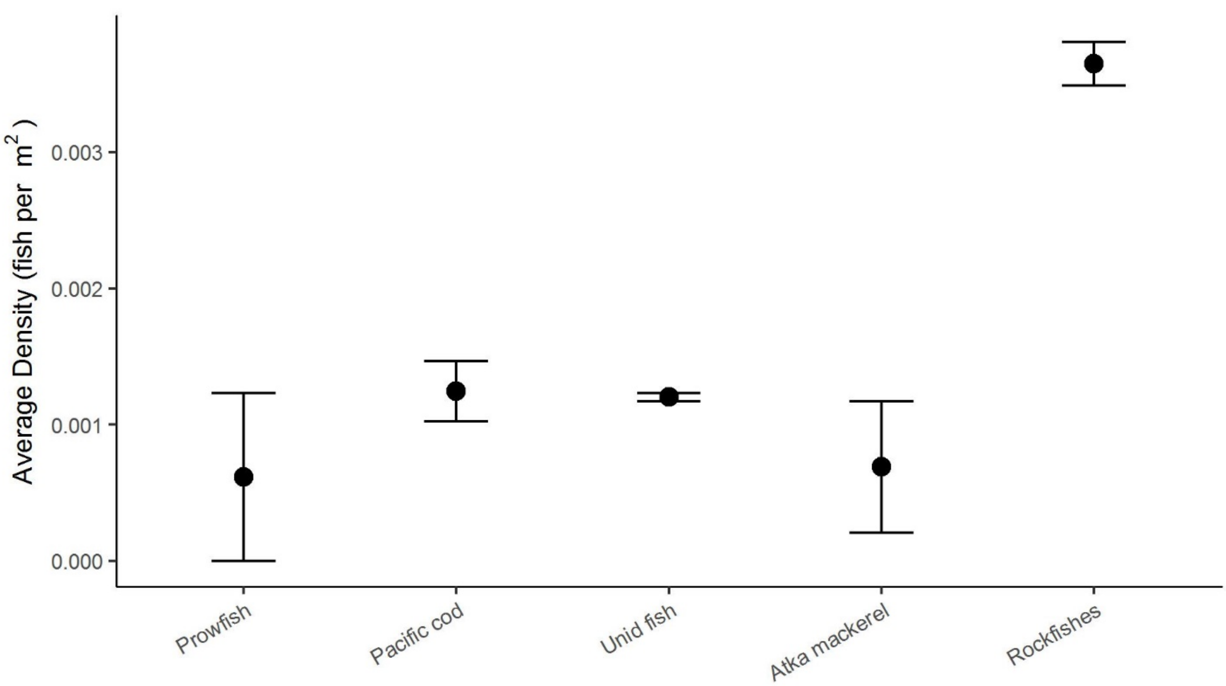
Appendix Figure 25. -- Percent occurrence of primary habitat type by transect.



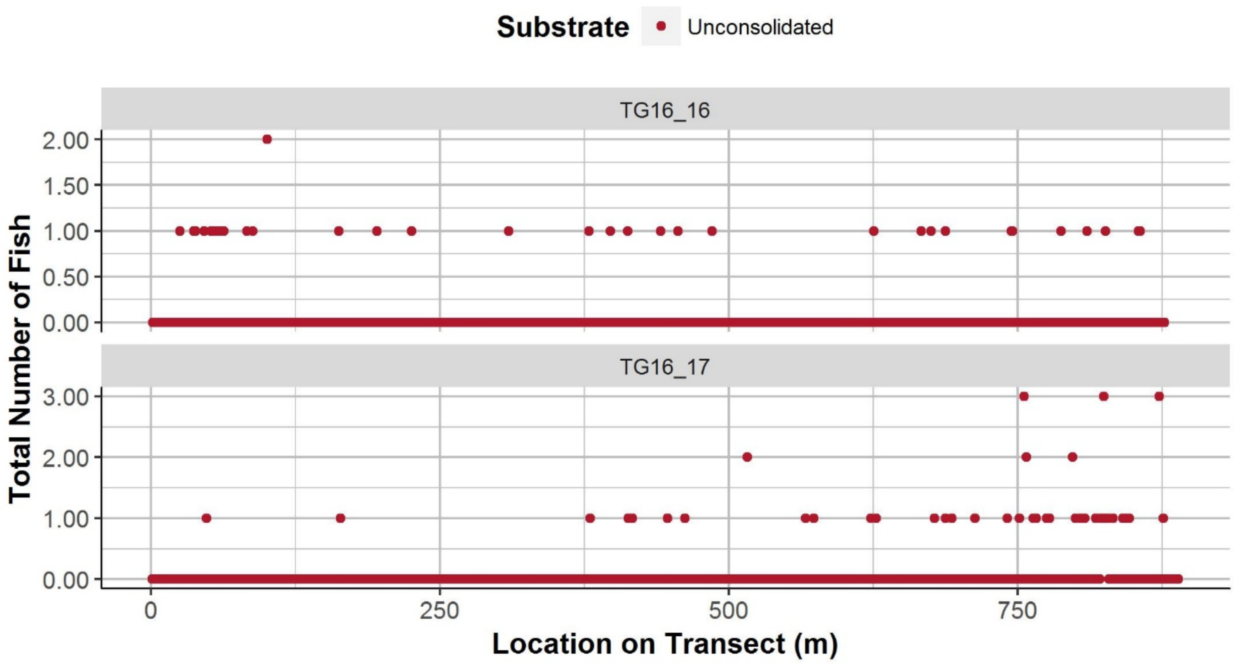
Appendix Figure 26. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



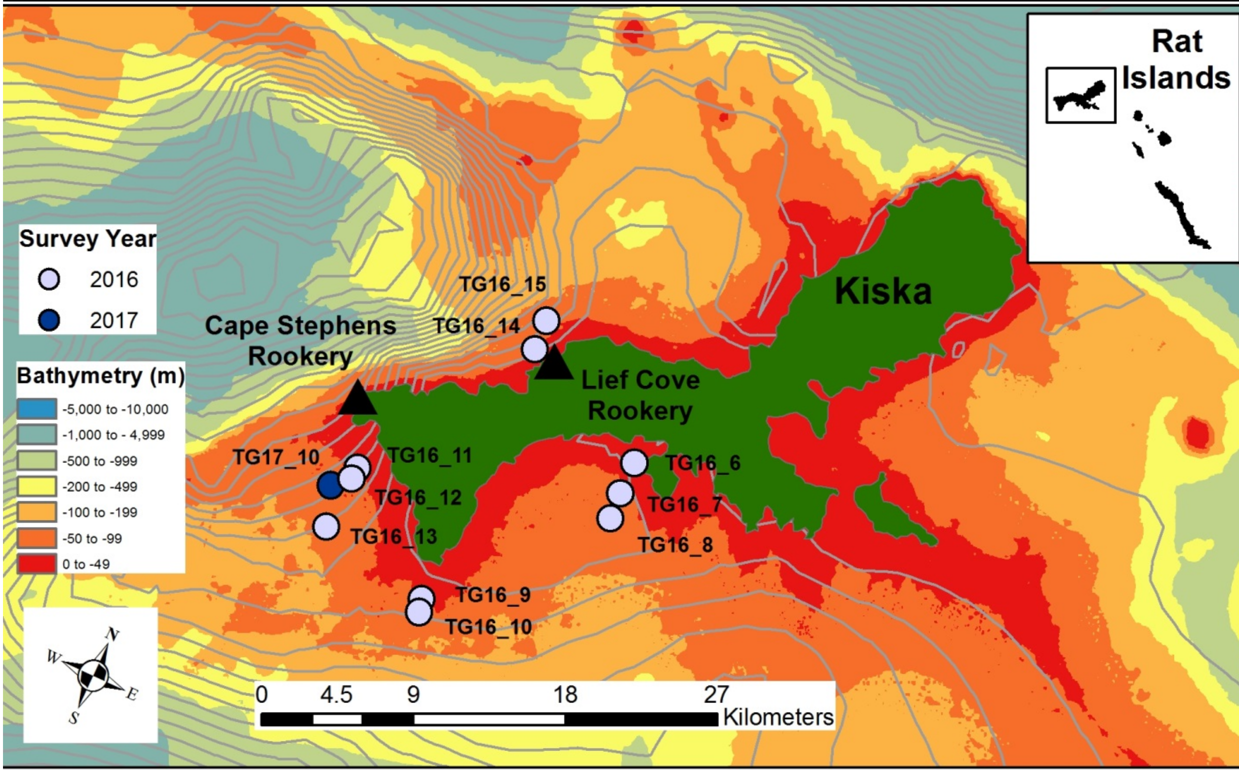
Appendix Figure 27. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



Appendix Figure 28. -- Average density (fish per m^2) with standard error.

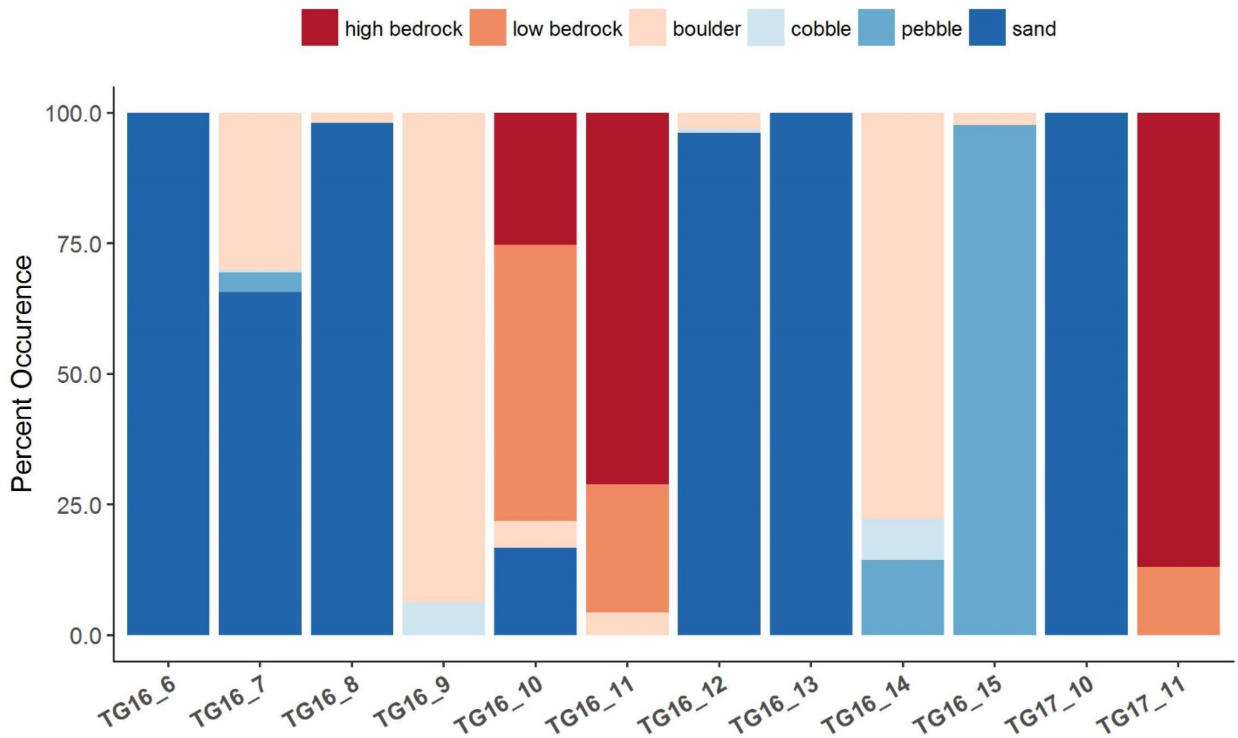


Appendix Figure 29. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

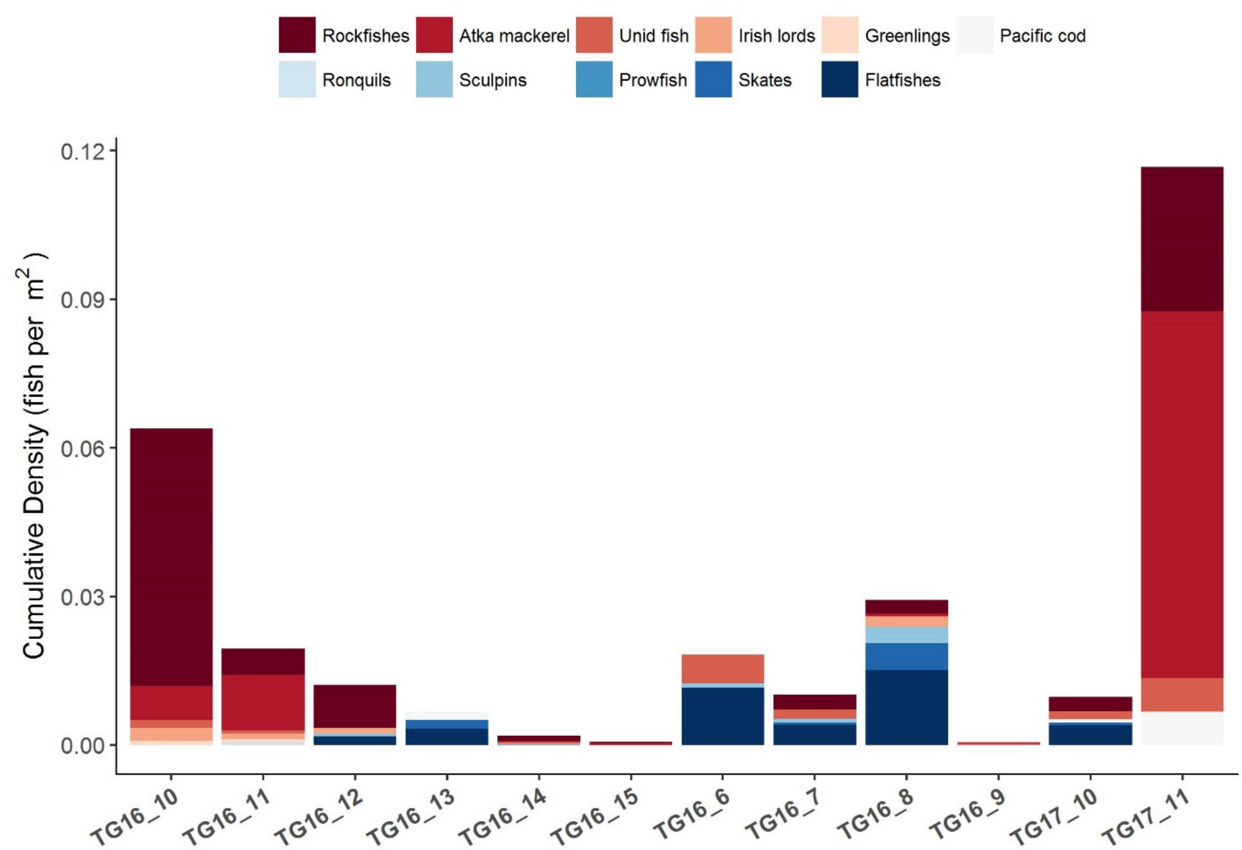


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m²)	Average Depth (m)	Frames Analyzed
TG16_6	6/26/2016	51.92	177.44	552	6.5	3612.3	33	789
TG16_7	6/26/2016	51.90	177.44	454	5.9	2656.8	59.5	789
TG16_8	6/26/2016	51.89	177.44	445	4.1	1847.2	75.75	767
TG16_9	6/26/2016	51.81	177.32	441	7.9	3489.2	32.25	608
TG16_10	6/26/2016	51.80	177.32	229	5.1	1173.9	57	787
TG16_11	6/26/2016	51.86	177.23	247	6.8	1692.1	25.25	810
TG16_12	6/26/2016	51.85	177.22	361	4.8	1725.9	58.5	803
TG16_13	6/26/2016	51.82	177.22	82	7.3	596.6	82	373
TG16_14	6/26/2016	51.95	177.32	937	8.4	7837.2	46.25	850
TG16_15	6/26/2016	51.97	177.32	963	7.4	7102.2	70.5	807
TG17_10	6/28/2017	51.84	177.21	582	3.0	1749.4	67.5	739
TG17_11	6/28/2017	NA	NA	72	6.2	445.3	NA	115

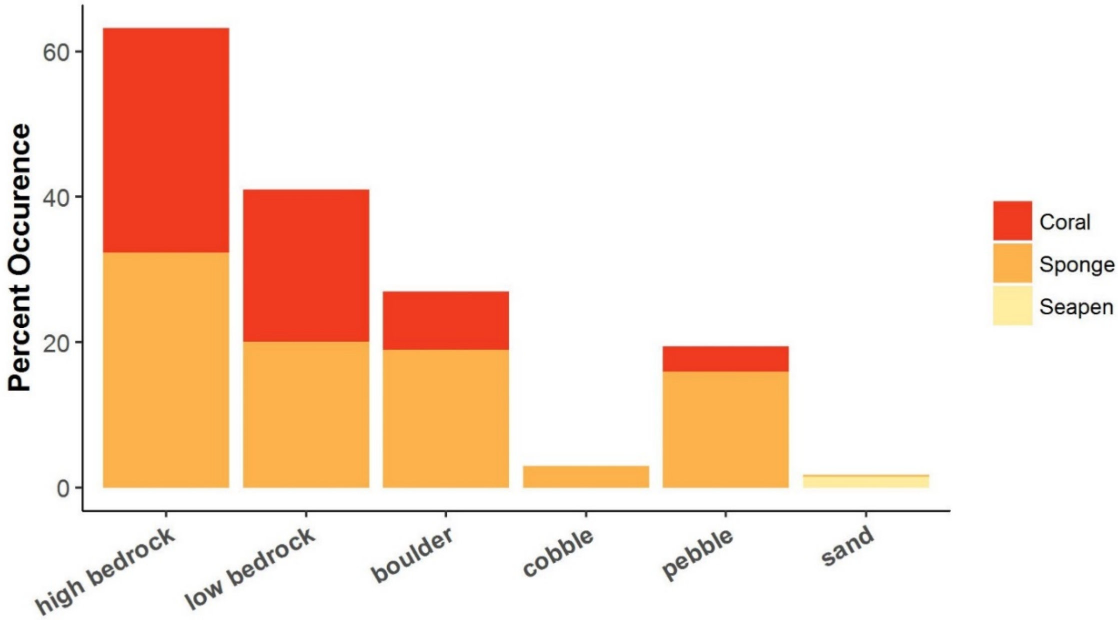
Description: Ten transects were conducted around Kiska in 2016 and two in 2017. Transects were conducted over a range of habitat types. On rocky substrates, rockfishes and Atka mackerel were common while flatfishes were observed on unconsolidated substrates. The highest total fish density in the Rat Islands was recorded around Kiska. A large patch of 61 rockfishes were recorded during transect TG16_10. In 2017, a 33 Atka mackerel and 13 rockfishes were recorded during a shortened transect (TG17_11) resulting in high density estimate. Corals and sponges occurred in ~30% of frames and high relief bedrock which was considerably lower than Attu and Agattu in the Near Islands.



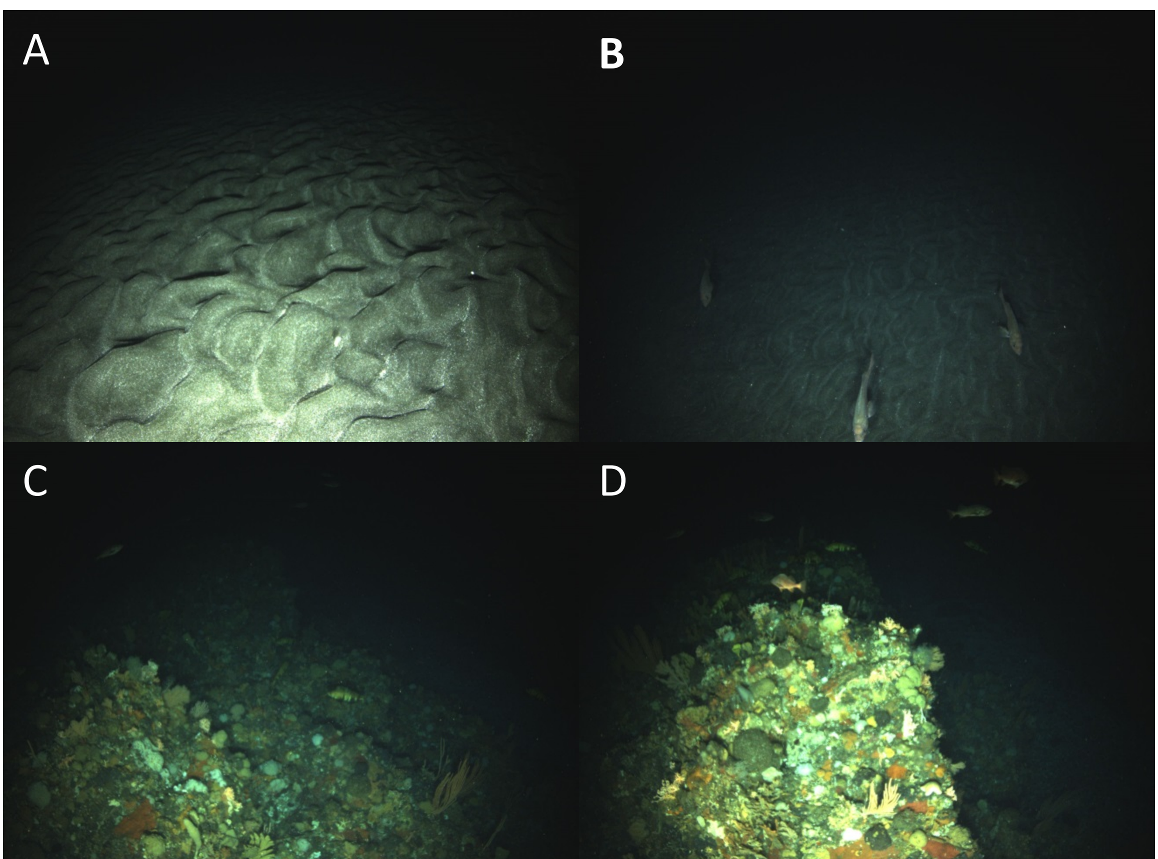
Appendix Figure 30. -- Percent occurrence of primary habitat type by transect.



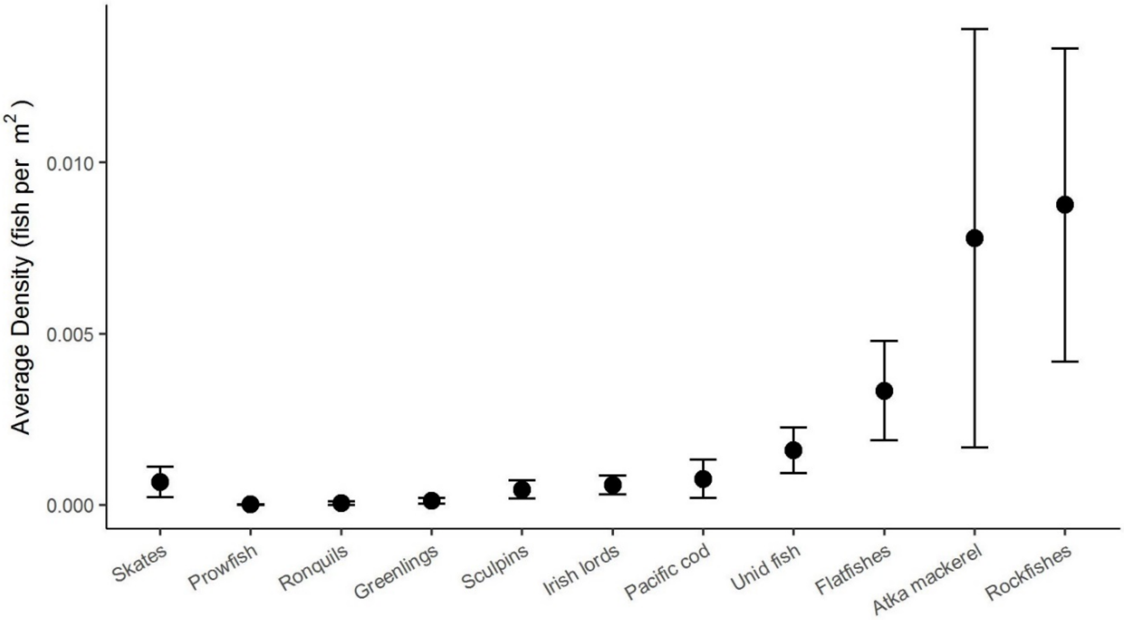
Appendix Figure 31. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



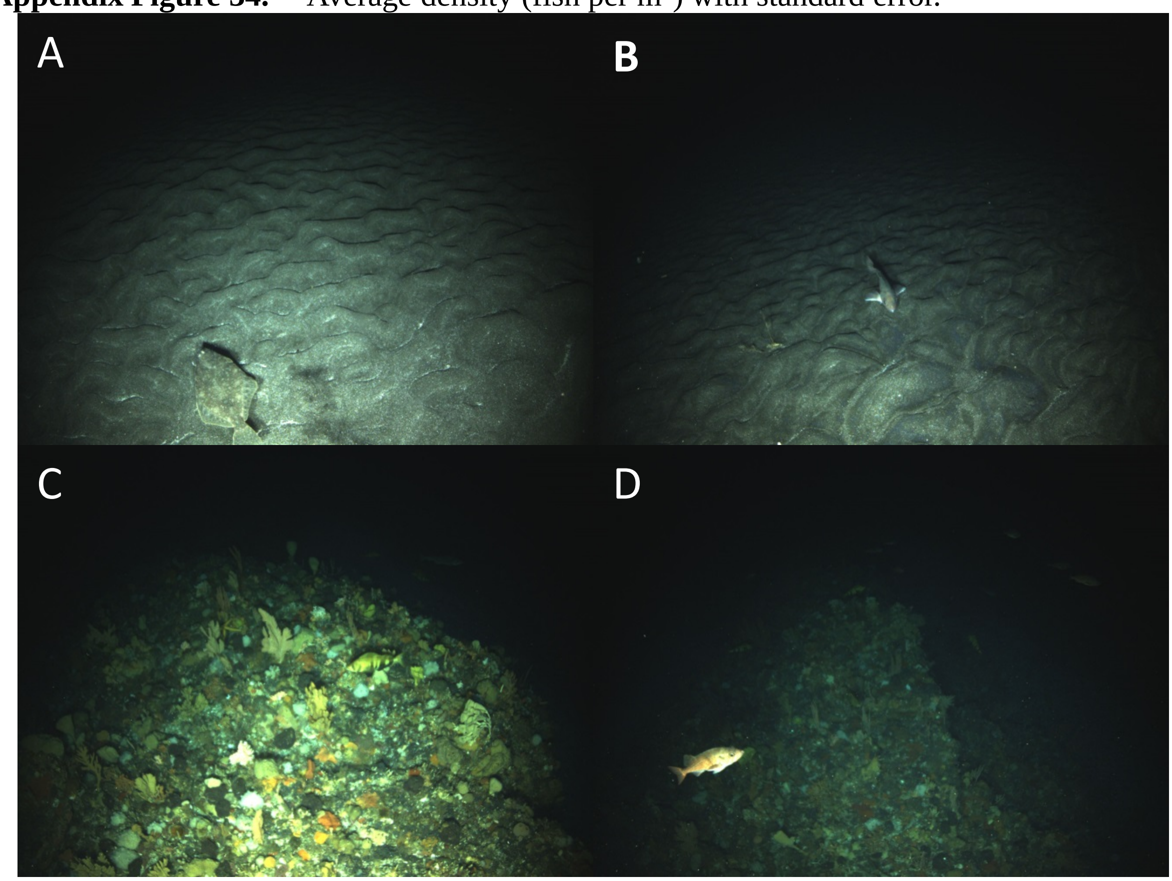
Appendix Figure 32. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



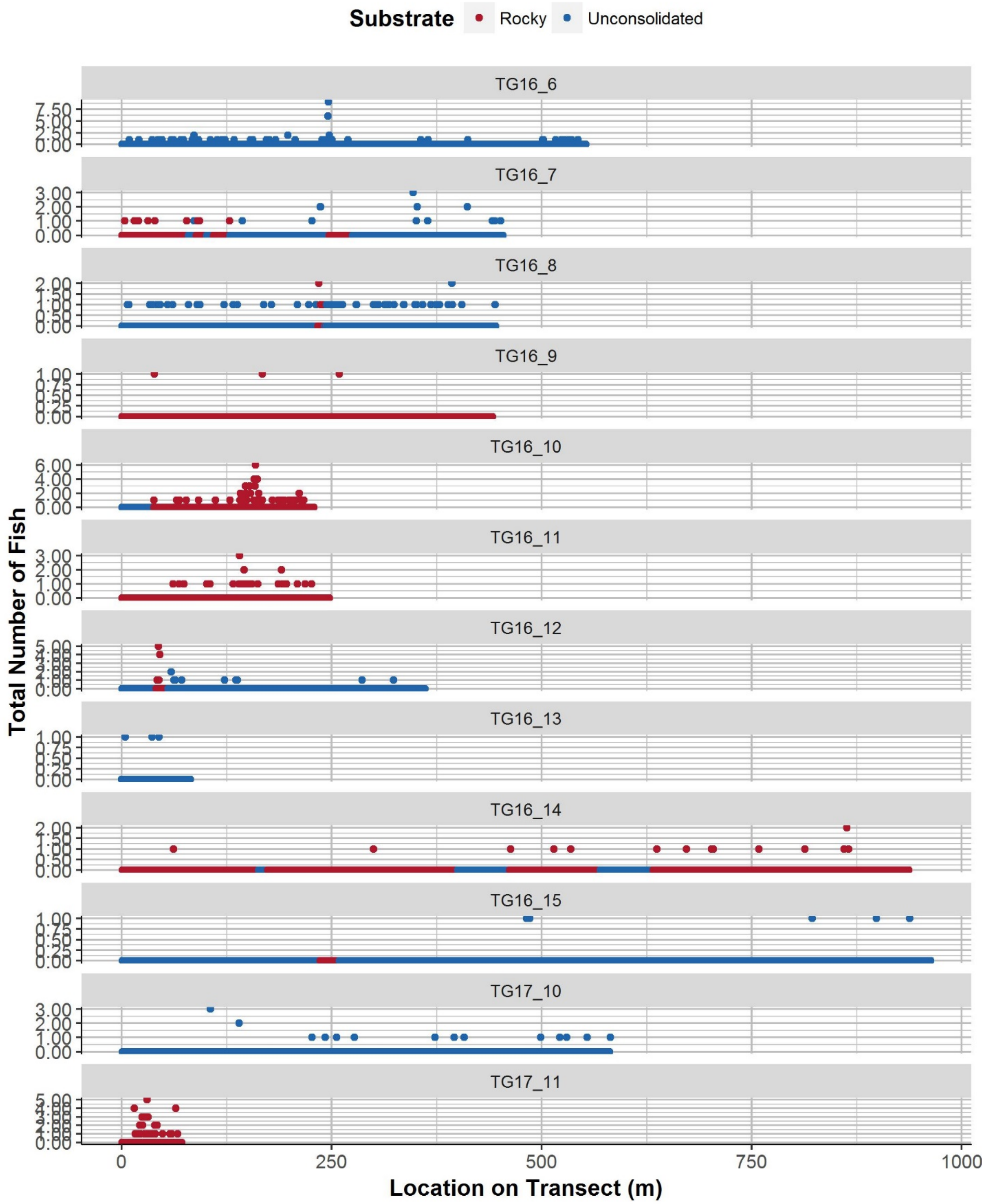
Appendix Figure 33. -- Habitat images of (A & B) sand on transect TG17_10 and (C & D) high relief bedrock on transect TG17_11.



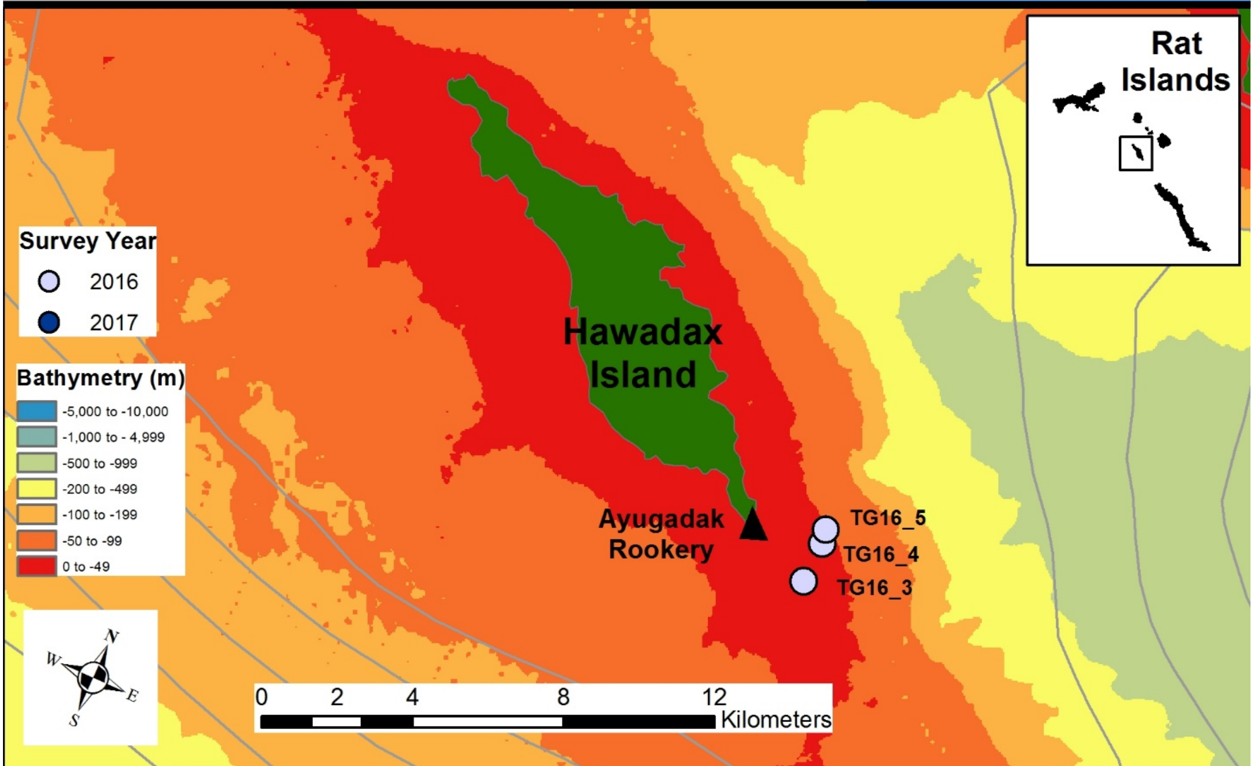
Appendix Figure 34. -- Average density (fish per m^2) with standard error.



Appendix Figure 35. -- Images of (A) a northern rocksole and a northern rockfish on transect TG17_10 and (C) an Atka mackerel, and (D) a northern rockfish on transect TG17_11.

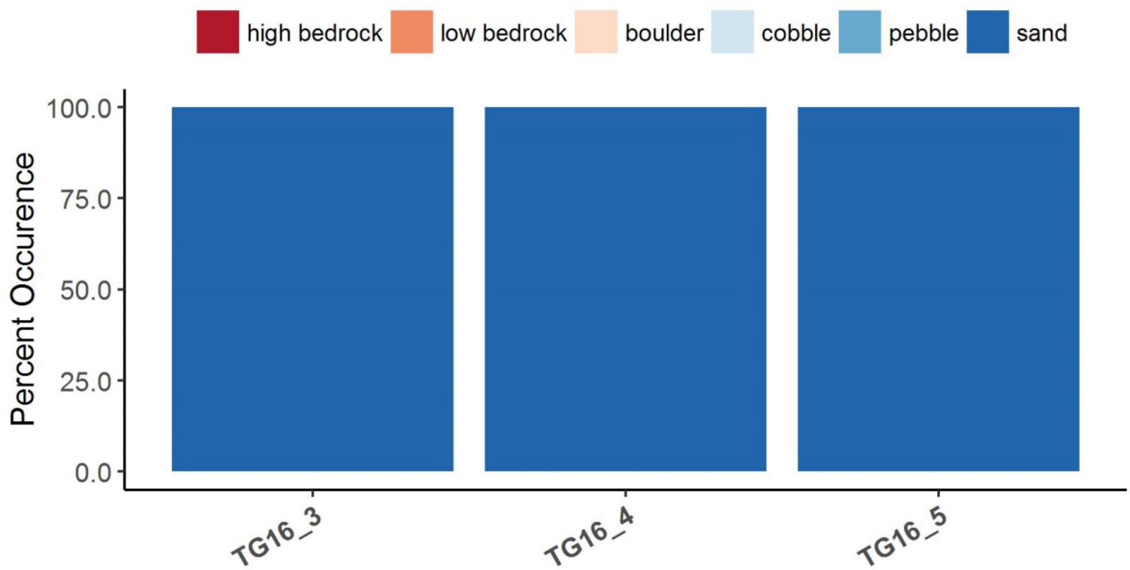


Appendix Figure 36. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

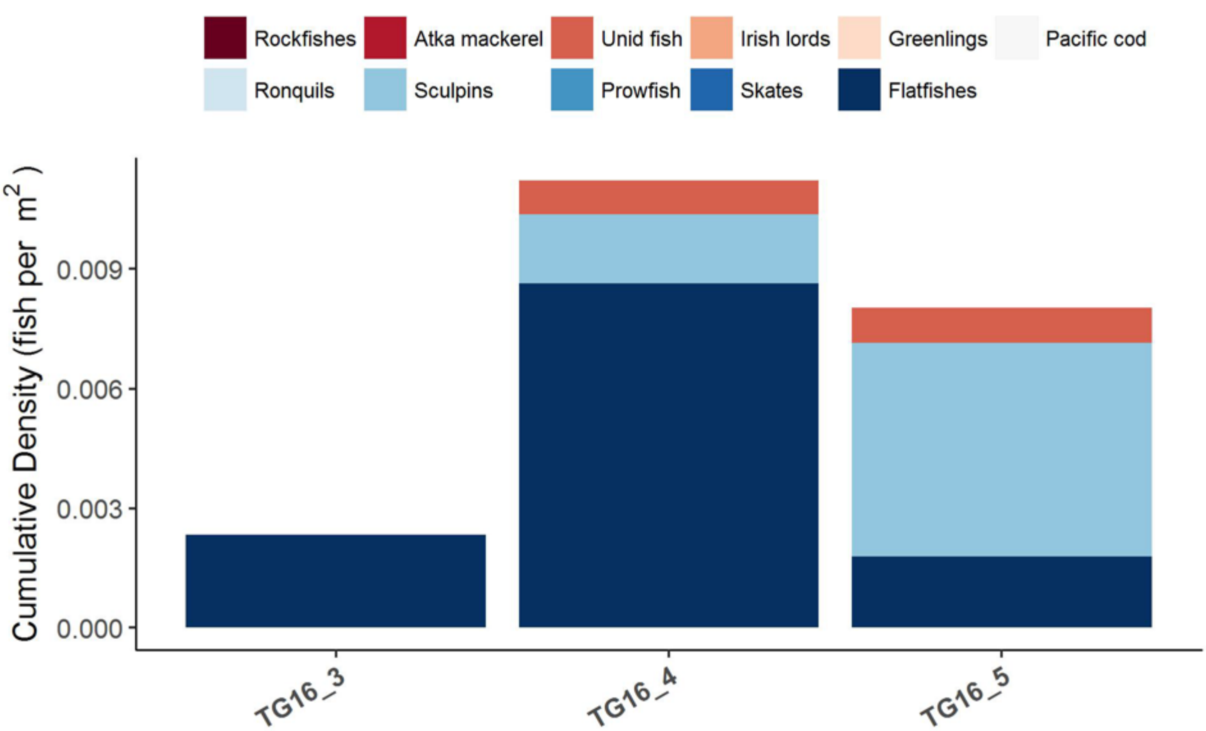


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed
TG16_3	6/25/2016	51.76	178.41	436	3.9	1709.6	27	910
TG16_4	6/25/2016	51.77	178.41	409	2.8	1158.2	49.5	918
TG16_5	6/25/2016	51.77	178.41	320	3.5	1120.7	75	760

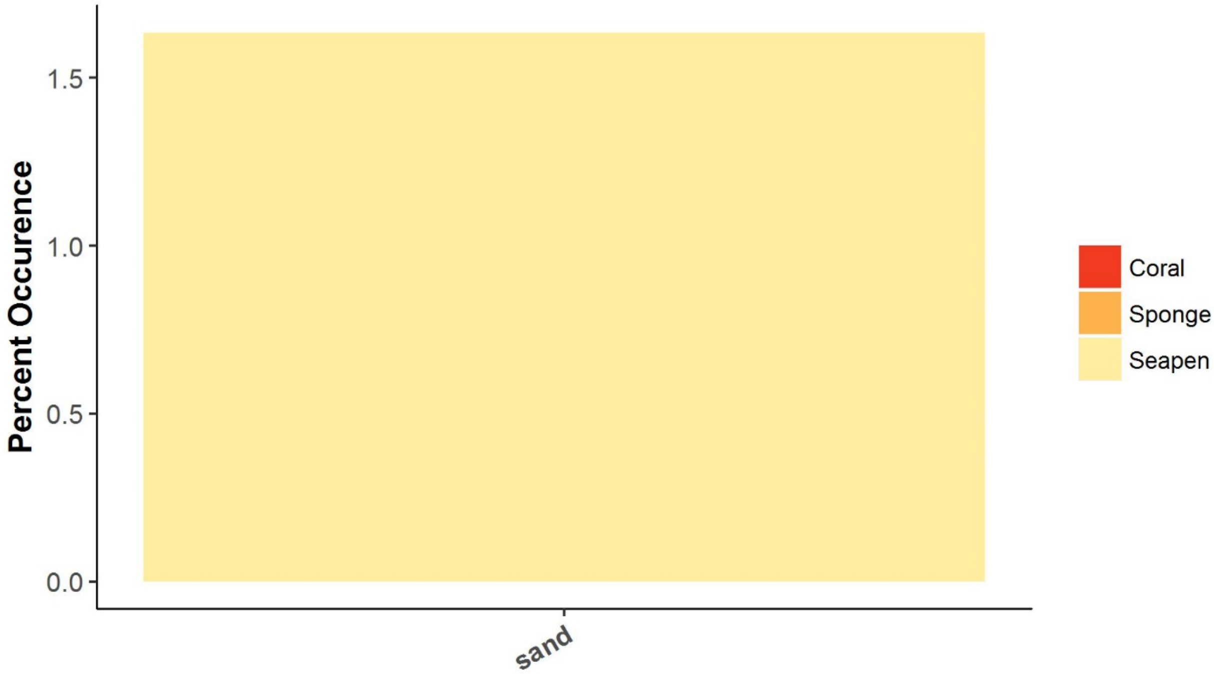
Description: Three transects were conducted over sand in the eastern end of Hawadax Island (formerly Rat Island) near the Ayugadek rookery. Of the three species groups observed, flatfishes were the most common (0.0043 ind m^{-2} ± 0.002 SE).



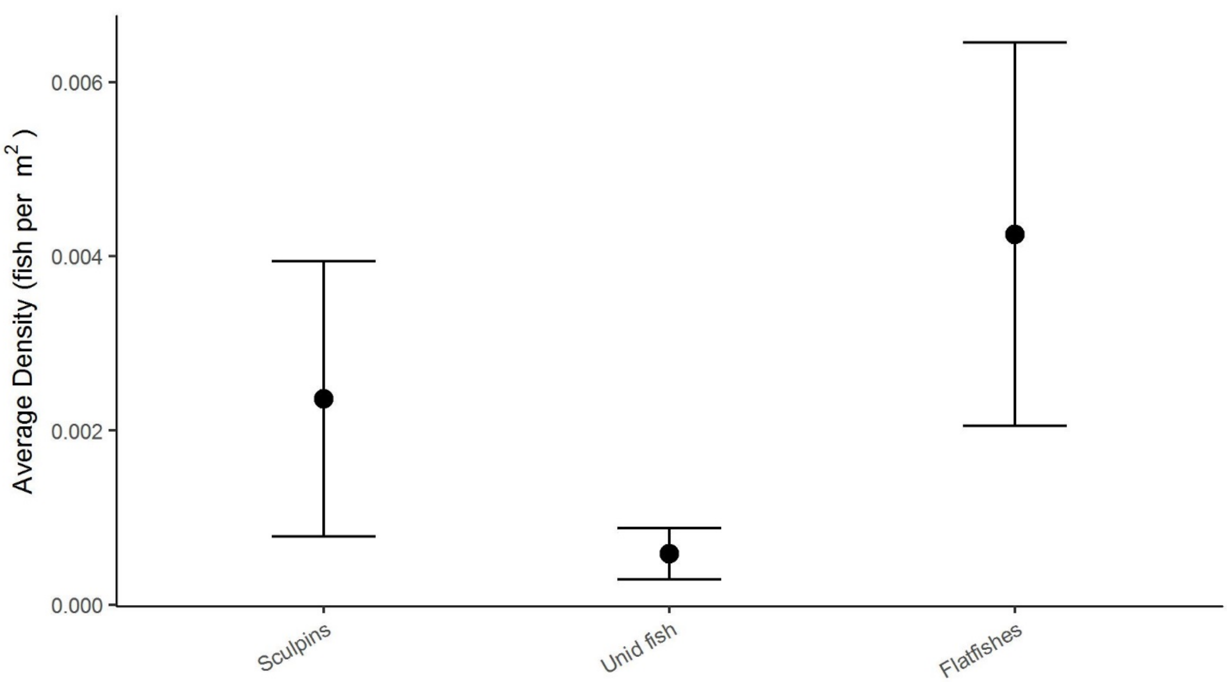
Appendix Figure 37. -- Percent occurrence of primary habitat type by transect.



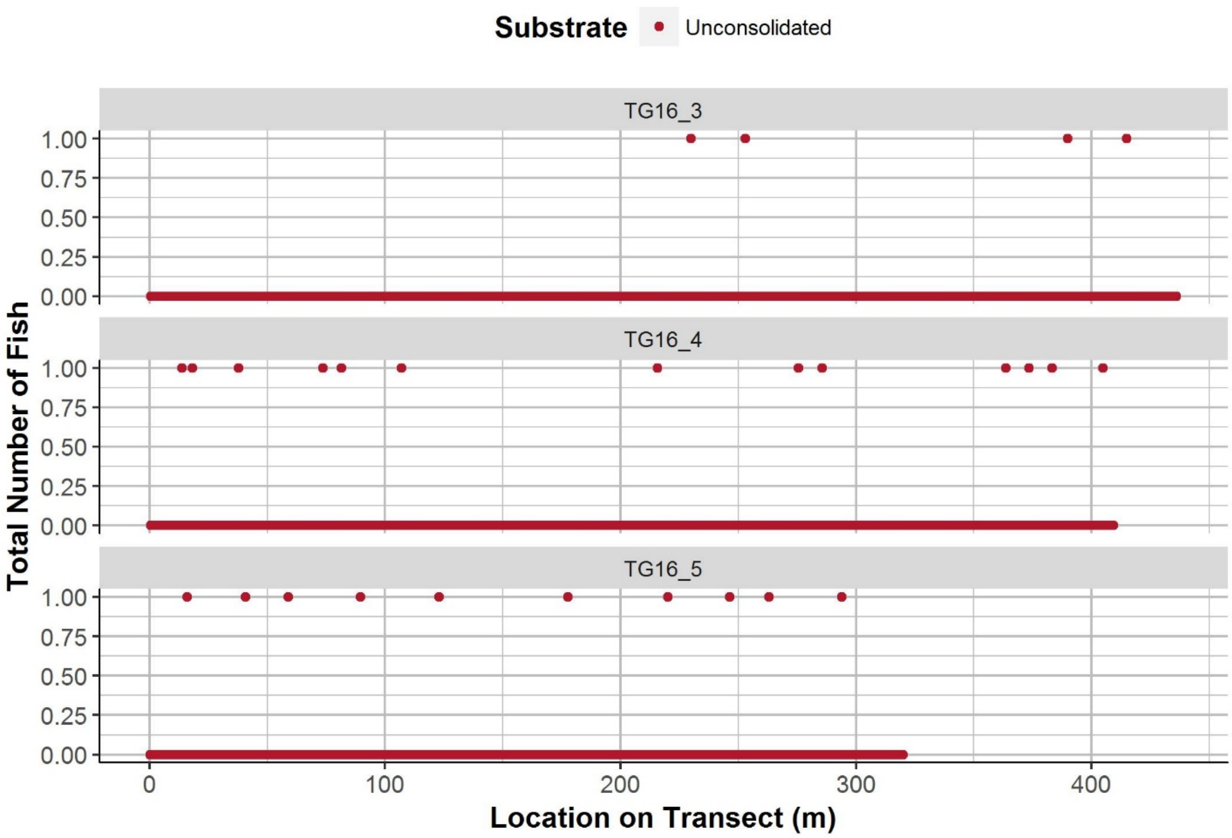
Appendix Figure 38. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



Appendix Figure 39. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.

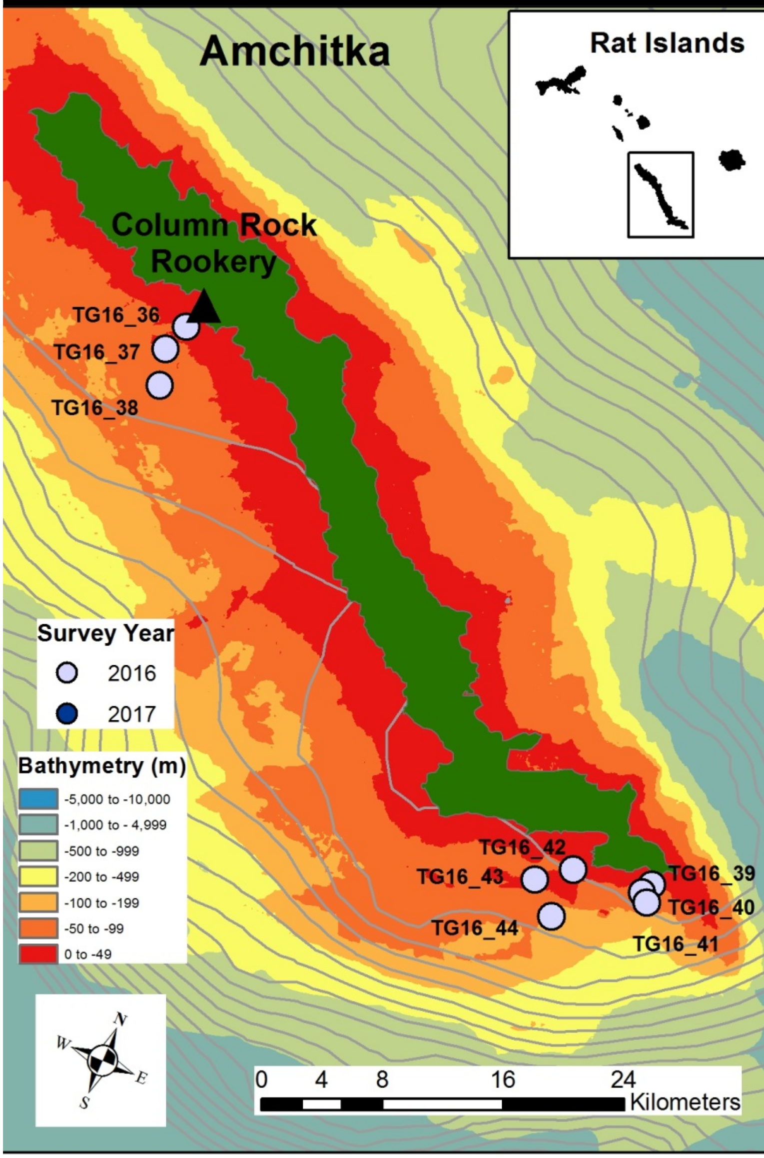


Appendix Figure 40. -- Average density (fish per m^2) with standard error.



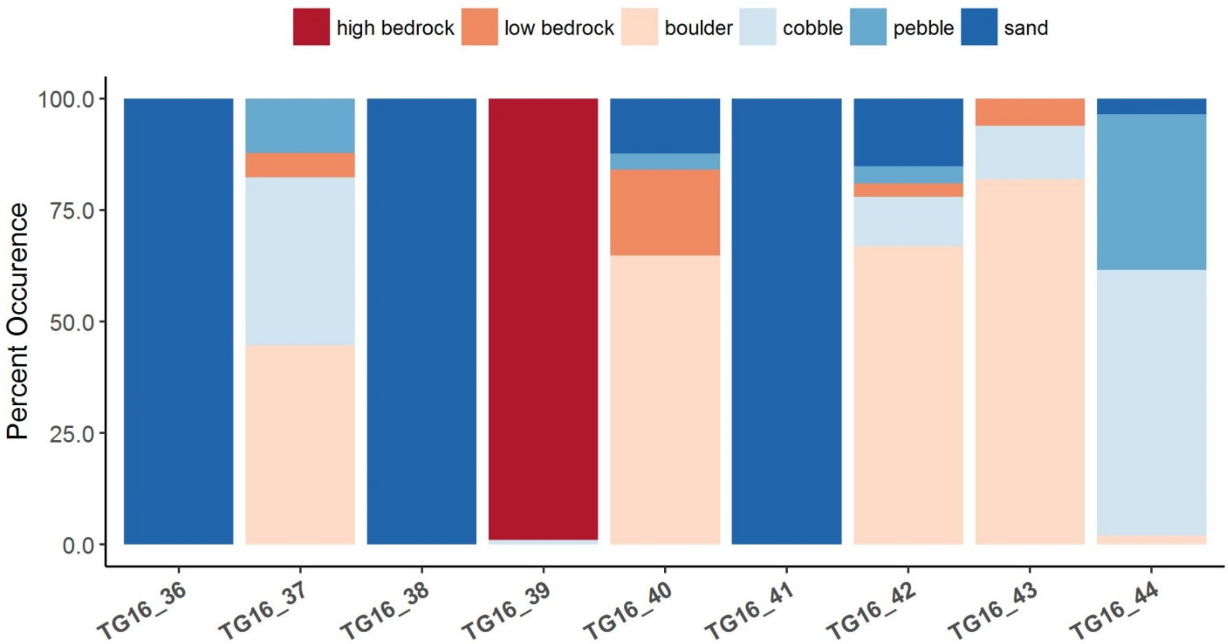
Appendix Figure 41. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

Rat Islands | Amchitka

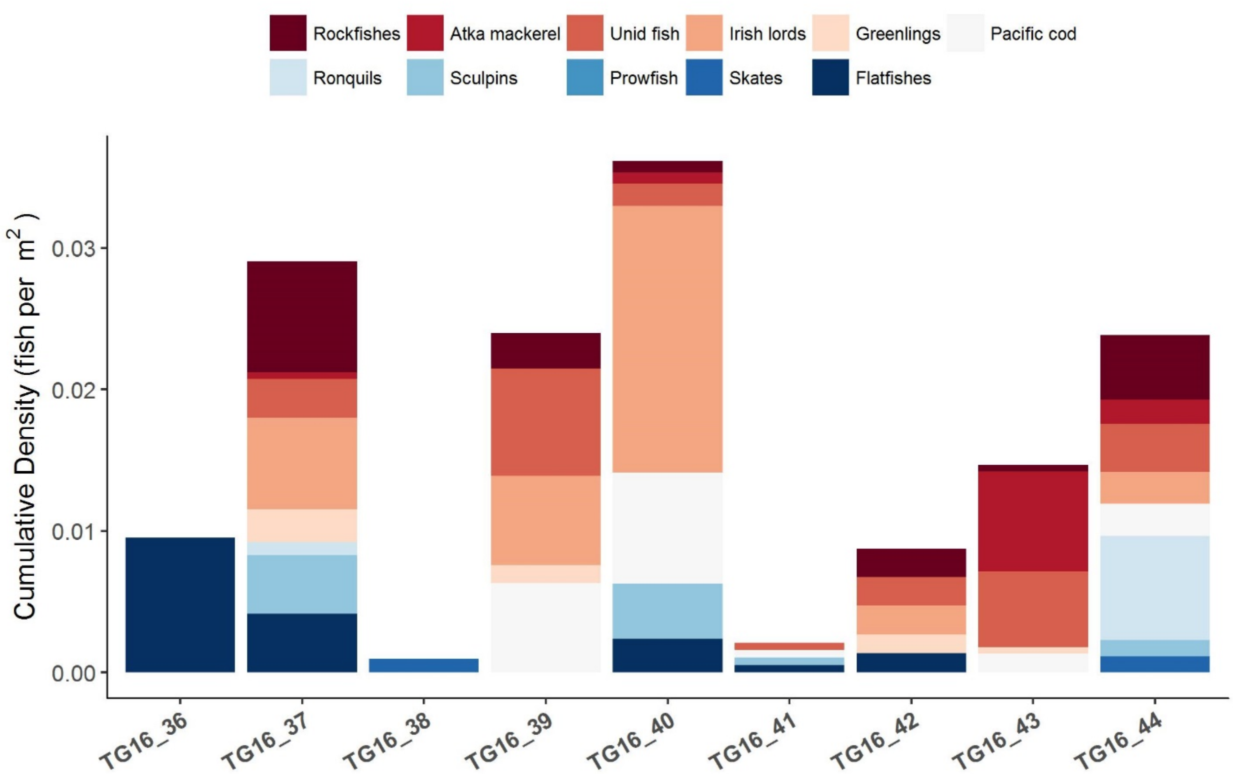


Description: Nine transects were conducted over mixed habitat around Amchitka in 2016. Irish lords were the most common species group recorded (0.004 ind m^{-2} ± 0.002 SE). Atka mackerel were relatively rare (0.001 ind m^{-2} ± 0.0007 SE). Corals were observed in less than 20% of frames in all rocky substrates. Sponges were more common with greater than 25% occurrence in high and low relief bedrock.

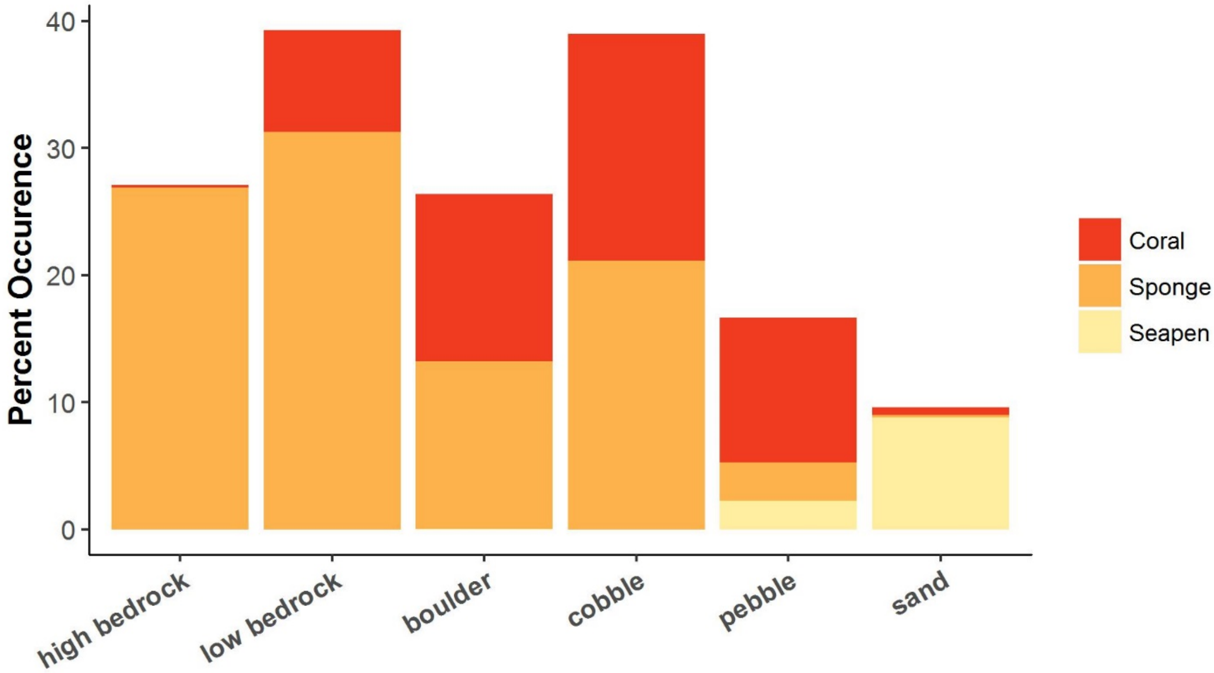
Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m²)	Average Depth (m)	Frames Analyzed
TG16_36	7/1/2016	51.56	178.83	324	2.3	736.4	29.5	646
TG16_37	7/1/2016	51.54	178.83	493	4.4	2168.6	54.5	733
TG16_38	7/1/2016	51.52	178.83	262	4.0	1046.1	75.25	184
TG16_39	7/2/2016	51.36	179.45	136	5.8	791.5	32.5	496
TG16_40	7/2/2016	51.35	179.44	195	6.5	1273.8	53.25	654
TG16_41	7/2/2016	51.35	179.45	306	6.2	1908.8	77	763
TG16_42	7/2/2016	51.35	179.37	366	4.1	1487.9	46.5	899
TG16_43	7/2/2016	51.34	179.34	338	6.7	2252.8	36.25	830
TG16_44	7/2/2016	51.32	179.37	470	3.8	1763.6	98.75	885



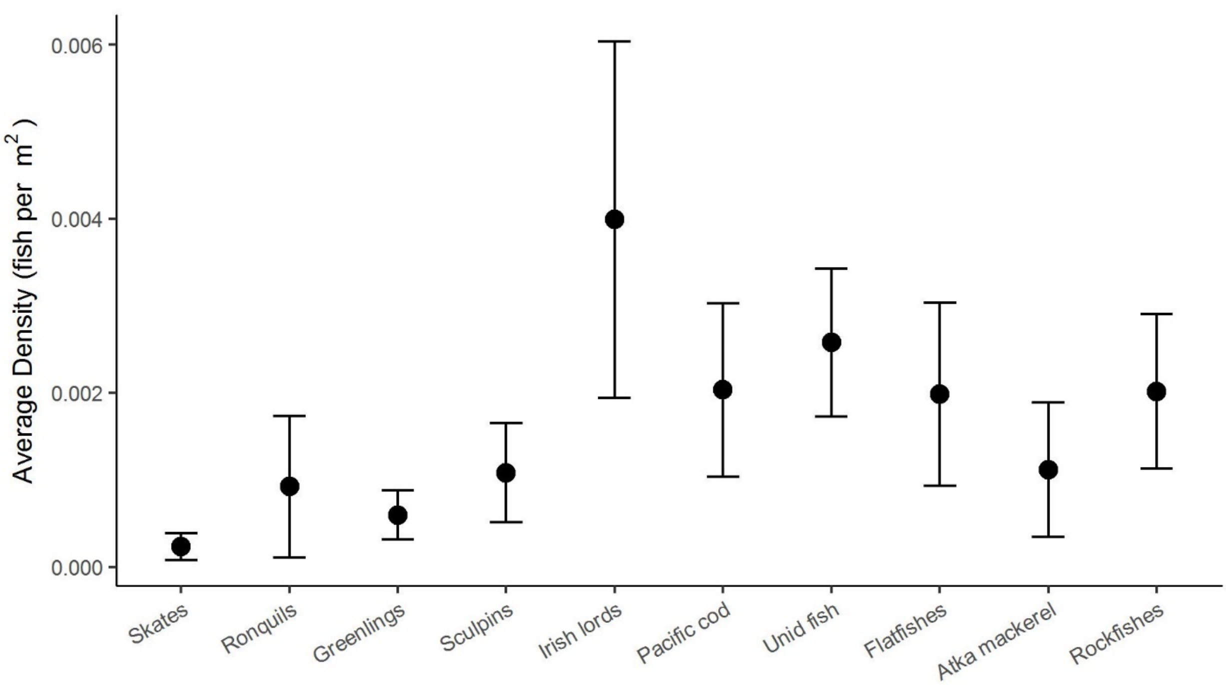
Appendix Figure 42. -- Percent occurrence of primary habitat type by transect.



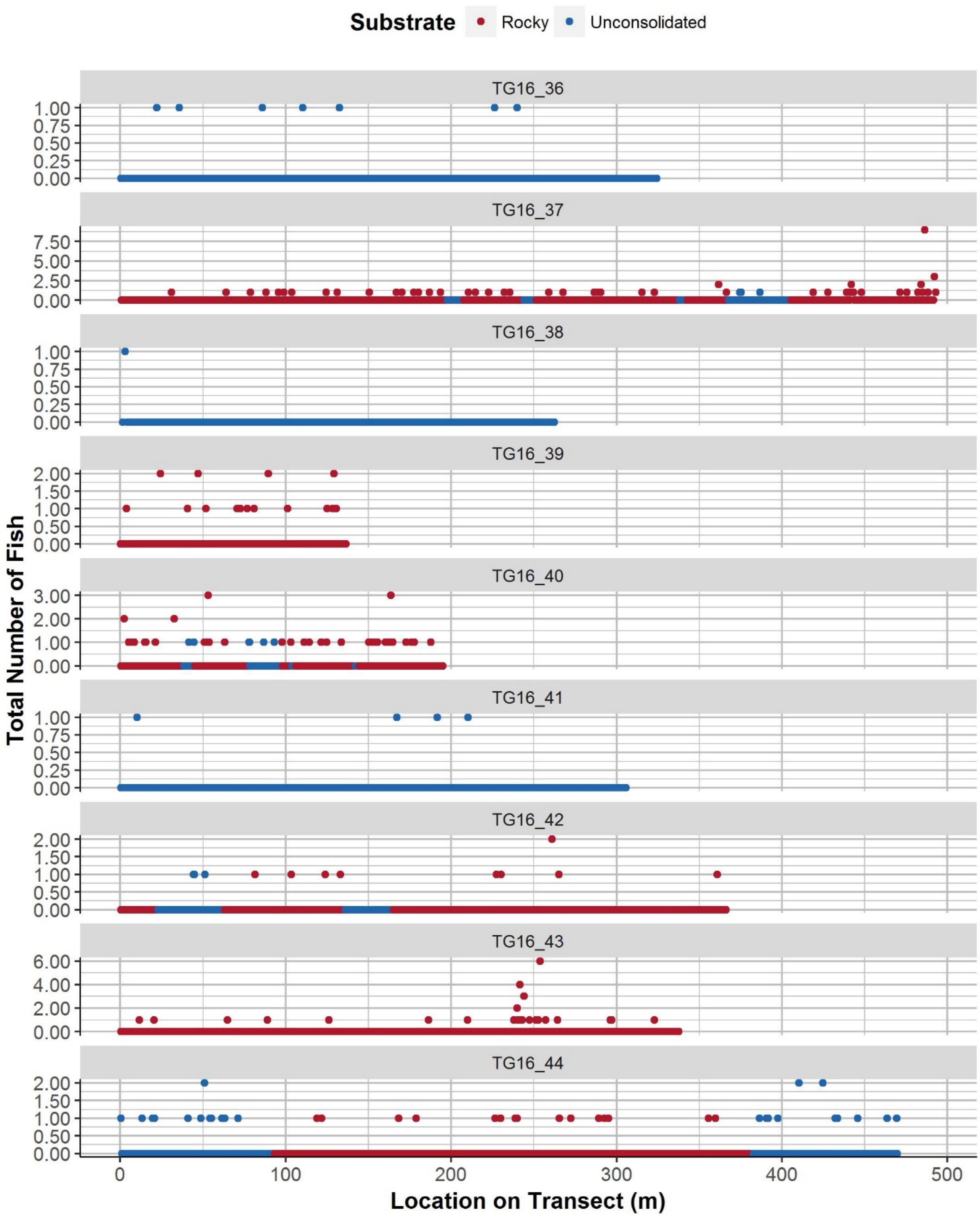
Appendix Figure 43. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



Appendix Figure 44. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.

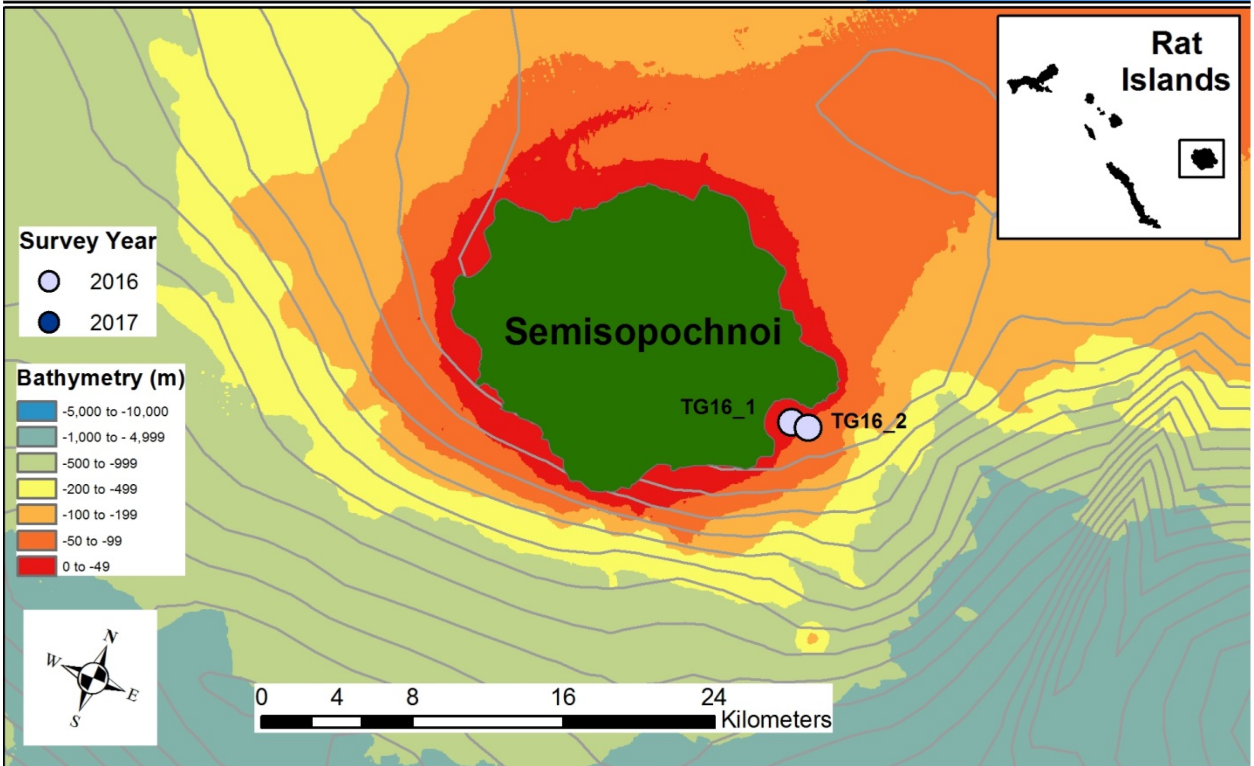


Appendix Figure 45. -- Average density (fish per m^2) with standard error.



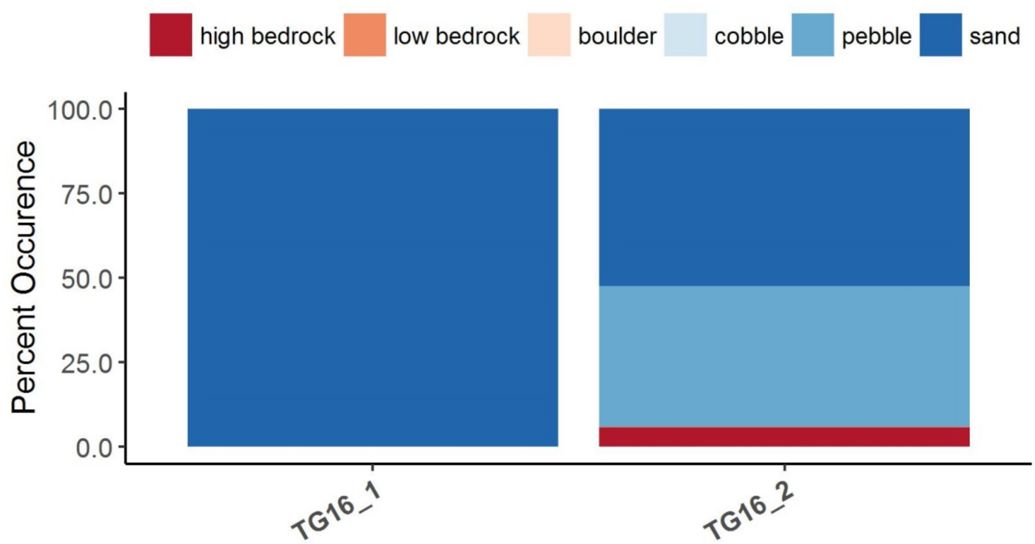
Appendix Figure 46. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

Rat Islands

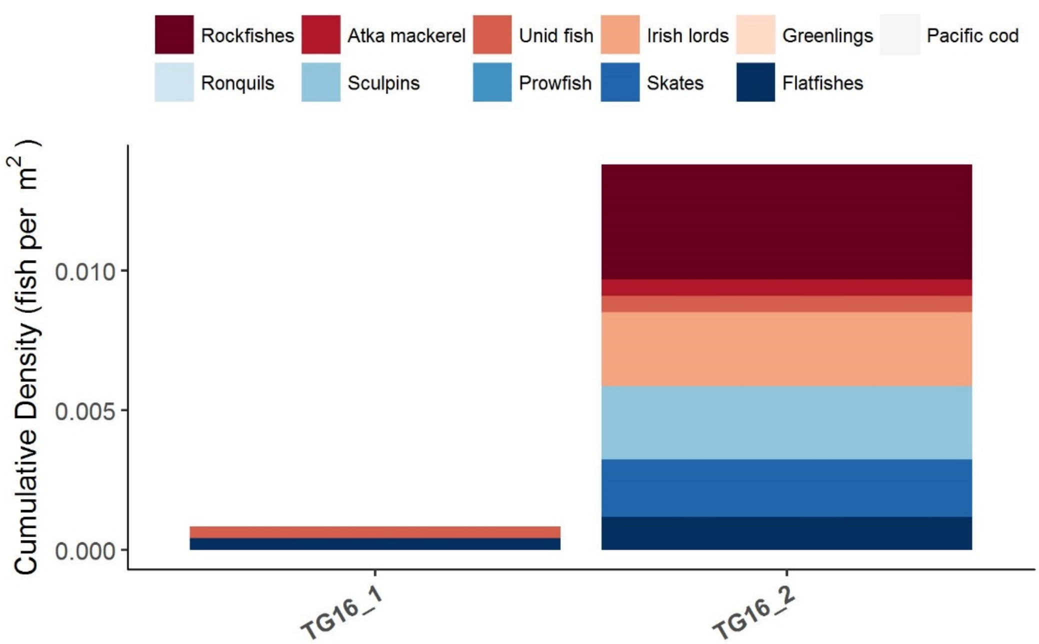


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed
TG16_1	6/24/2016	51.94	179.75	492	9.6	4709.9	27.3	902
TG16_2	6/24/2016	51.94	179.77	702	4.8	3401.1	57.5	972

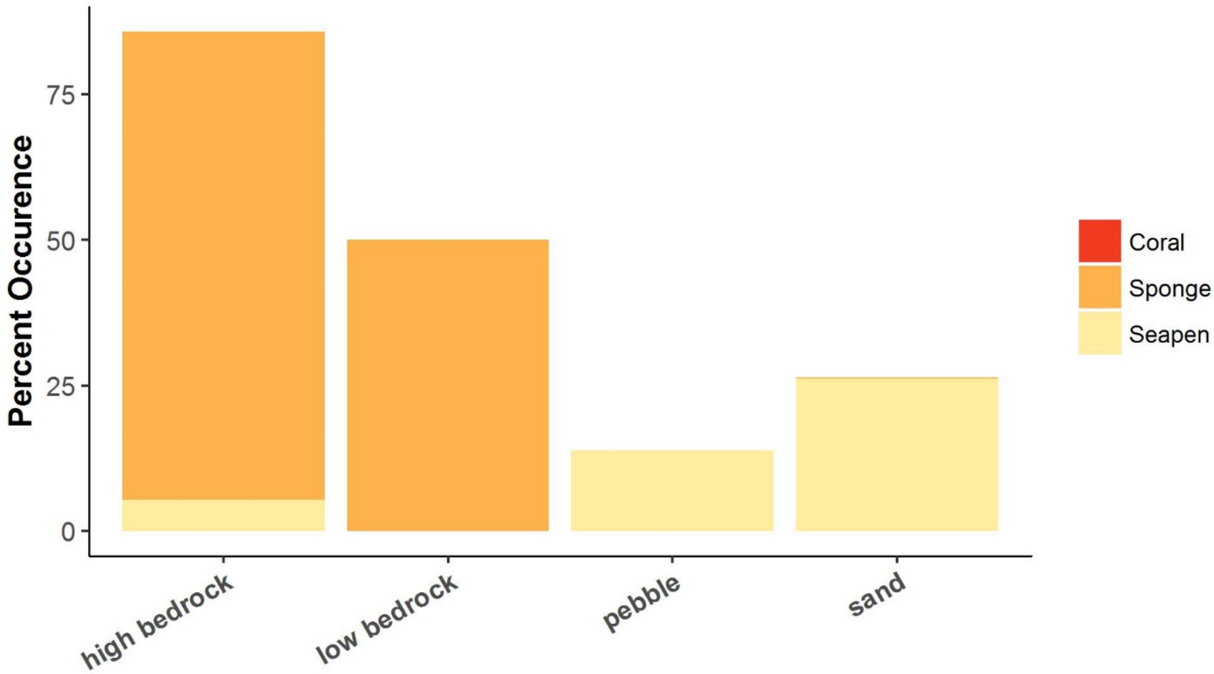
Description: Two transects were conducted near Semisopochnoi in 2016. Transect TG16_1 was over sand and only four fish were recorded. A mix of rockfishes (14), Irish lords (9), sculpins (9), and skates (7) were the most common fish dispersed throughout transect TG16_2. No corals were observed, yet sponges were present in more than 50% of high and low relief bedrock frames.



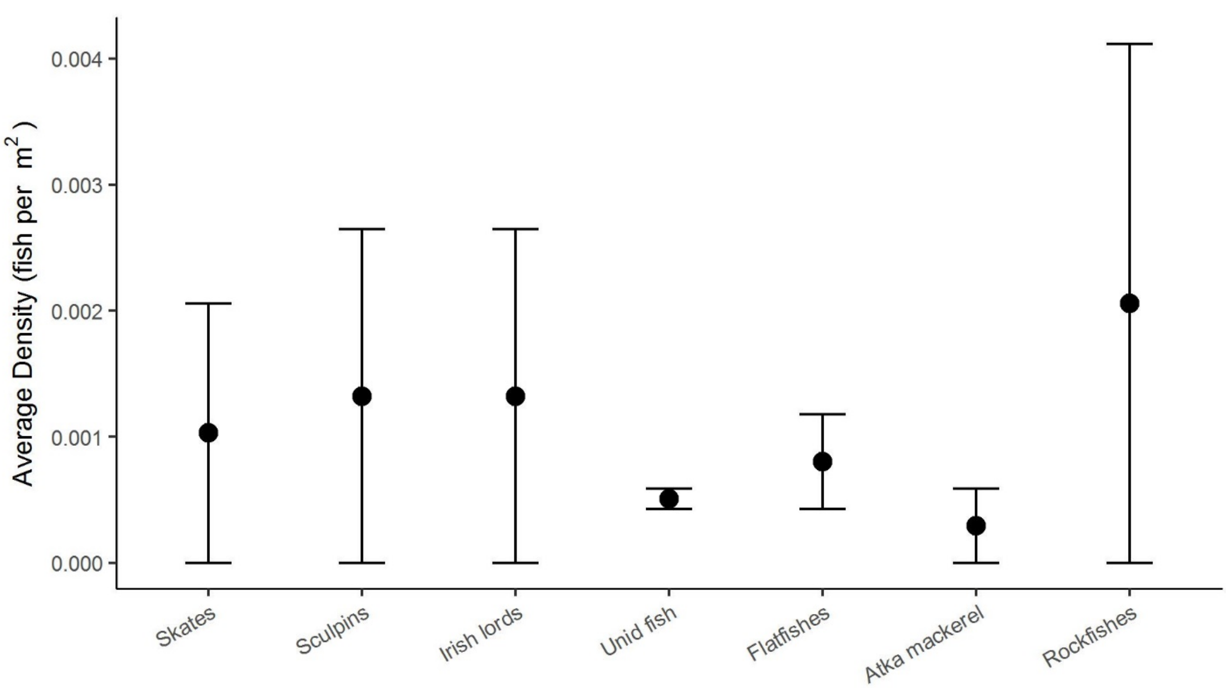
Appendix Figure 47. -- Percent occurrence of primary habitat type by transect.



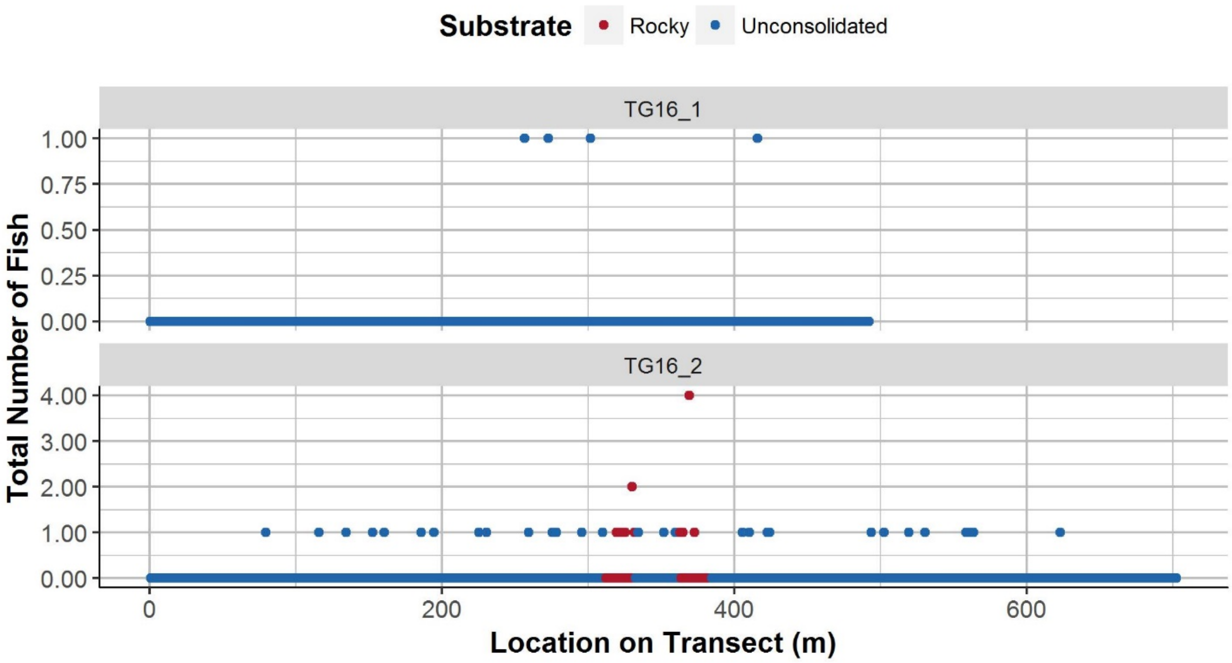
Appendix Figure 48. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



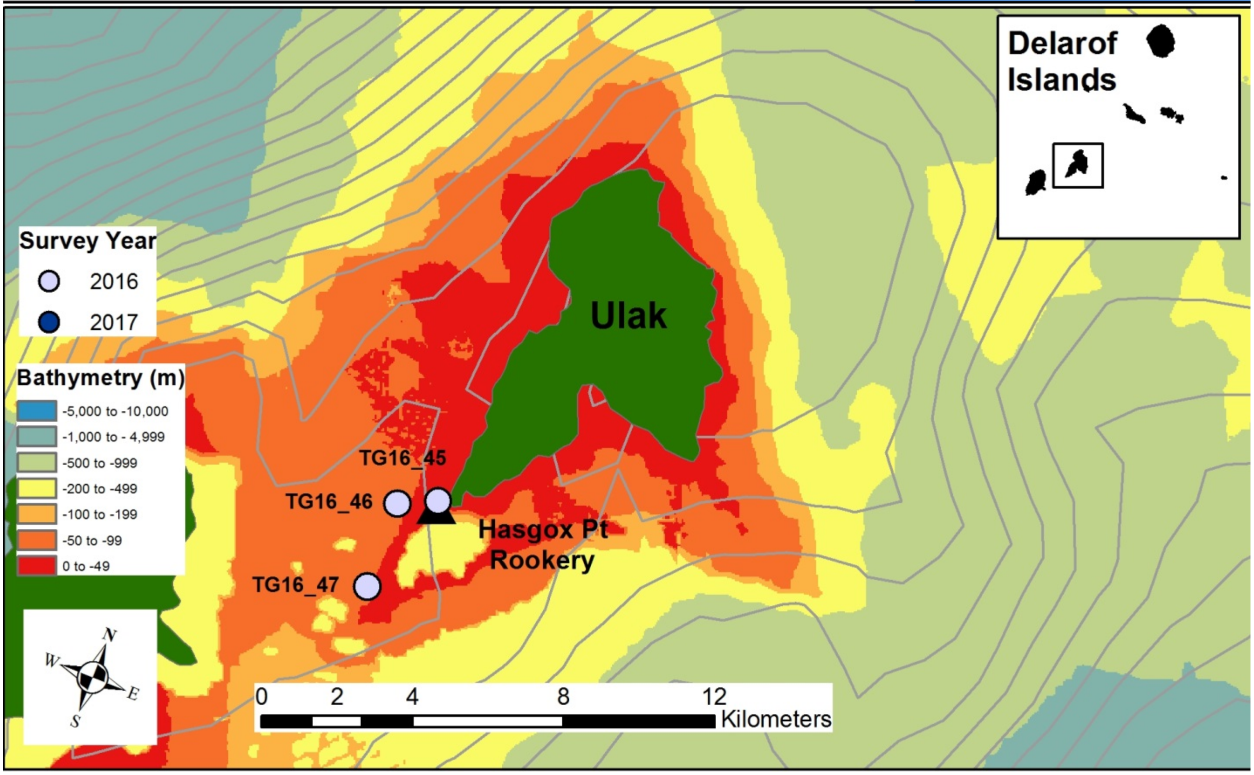
Appendix Figure 49. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



Appendix Figure 50. -- Average density (fish per m^2) with standard error.

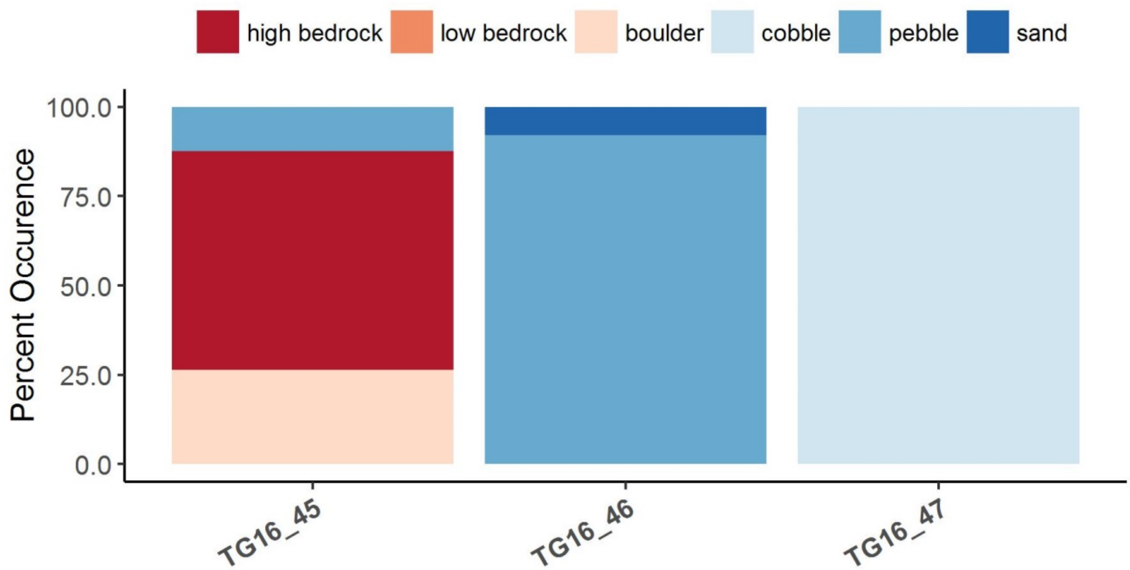


Appendix Figure 51. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

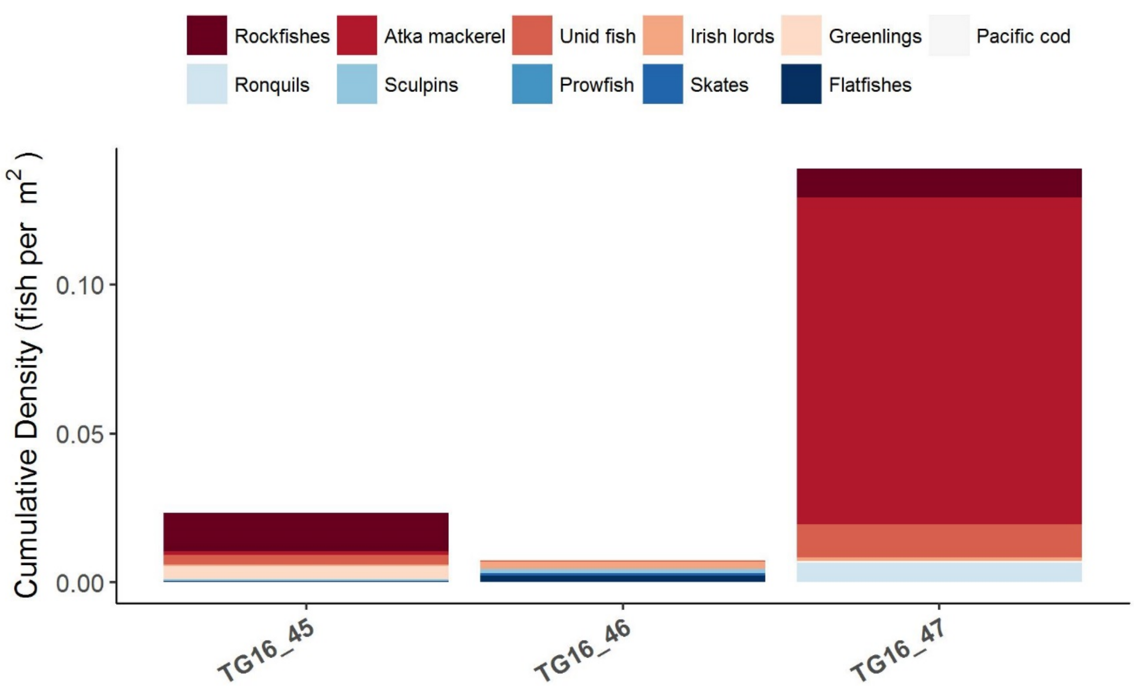


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m²)	Average Depth (m)	Frames Analyzed
TG16_45	7/3/2016	51.31	-178.99	267	6.9	1841.4	43	765
TG16_46	7/3/2016	51.31	-179.01	381	6.9	2614.0	74.5	896
TG16_47	7/3/2016	51.28	-179.00	313	7.3	2268.4	97.5	685

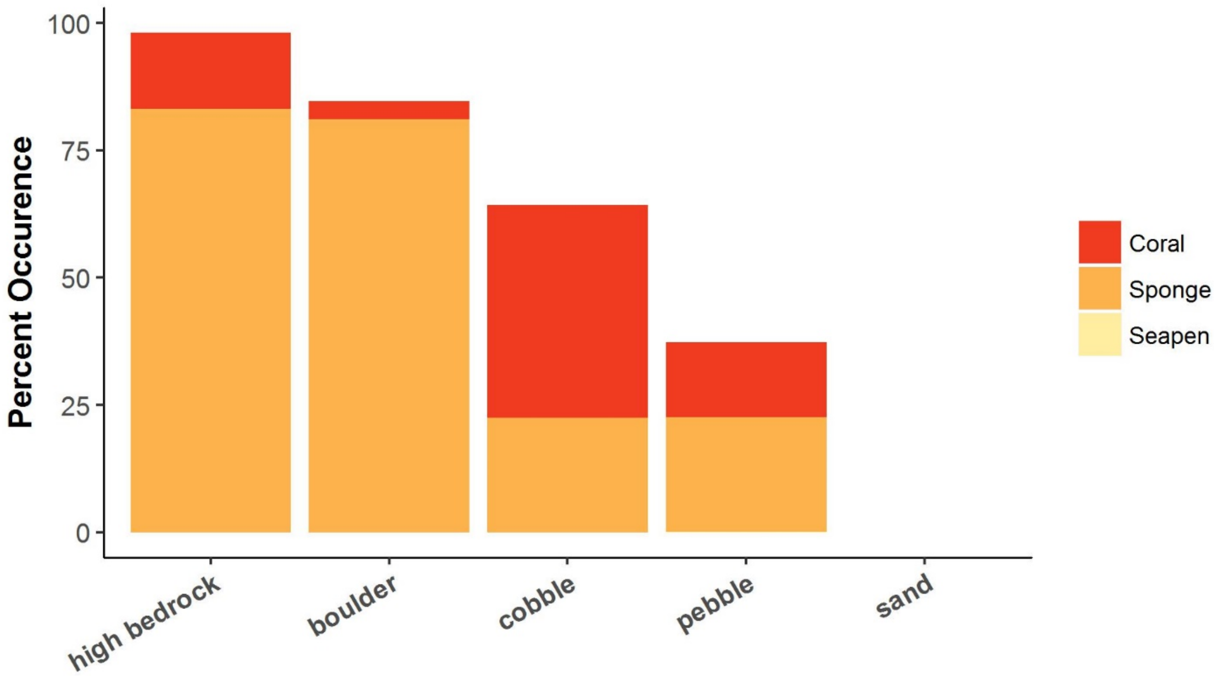
Description: Three transects were conducted off the southwestern side of Ulak near the Hasgox Point SSL rookery. Transect T16_47 was noteworthy, as 249 Atka mackerel were counted over the 100% cobble substrate. Most of these fish were observed in one patch. This cobble transect also had a higher than average percent occurrence of corals (41%). Sponges were common on high relief bedrock and boulders, 83% and 81%, respectively.



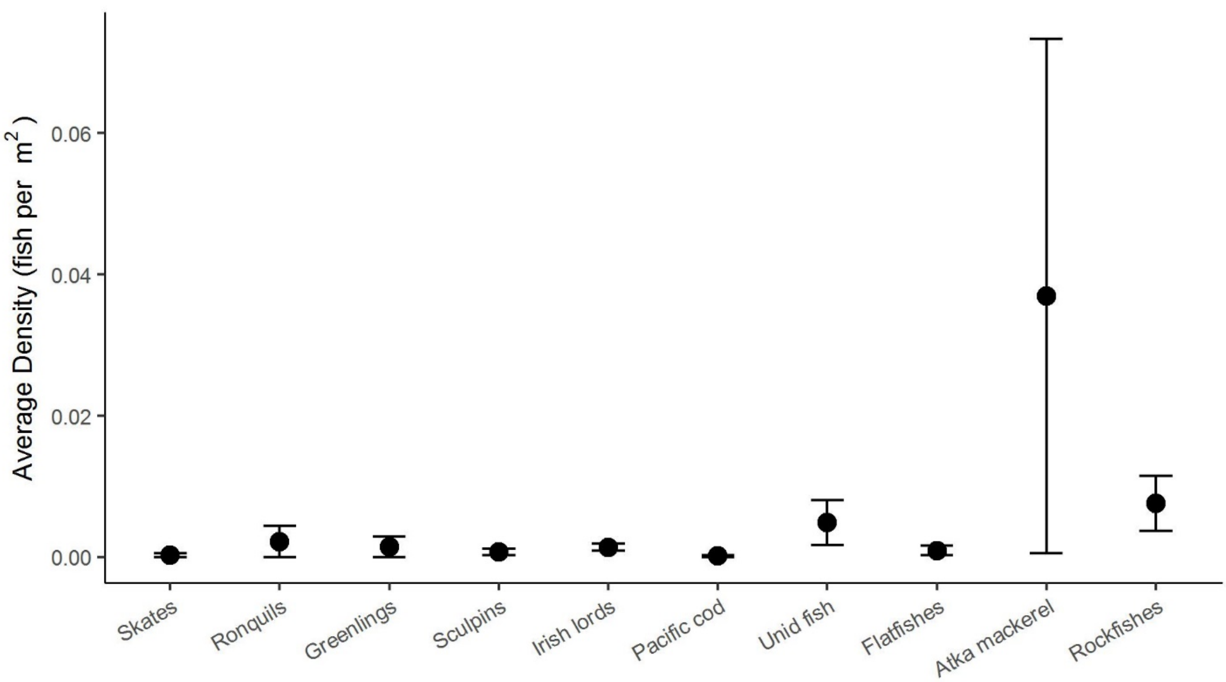
Appendix Figure 52. -- Percent occurrence of primary habitat type by transect.



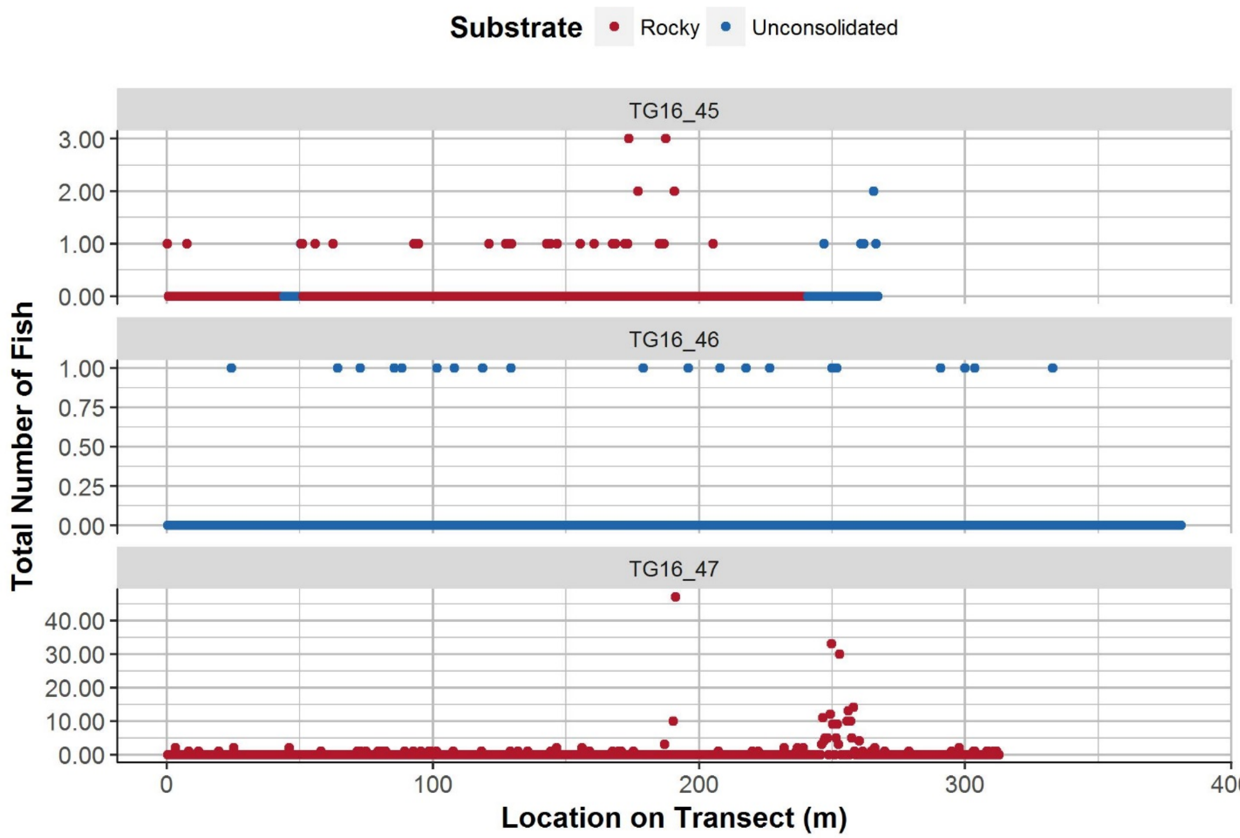
Appendix Figure 53. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



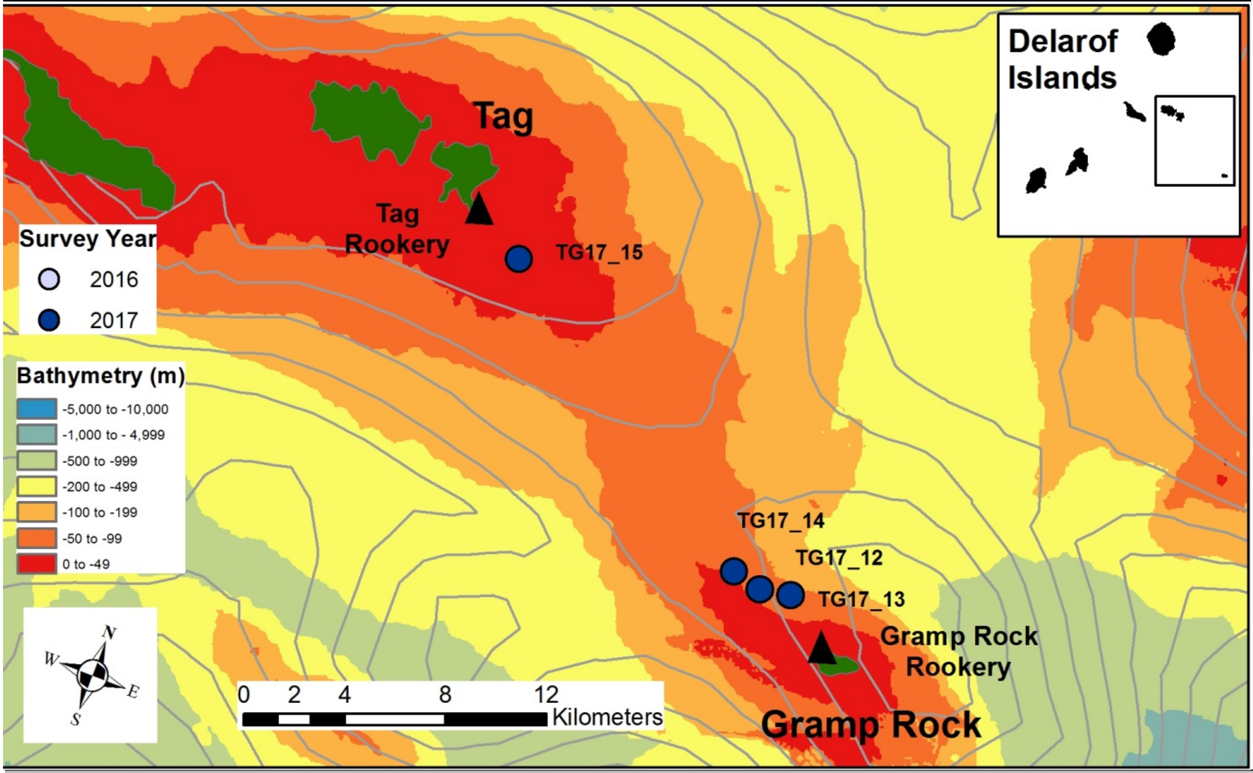
Appendix Figure 54. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



Appendix Figure 55. -- Average density (fish per m^2) with standard error.

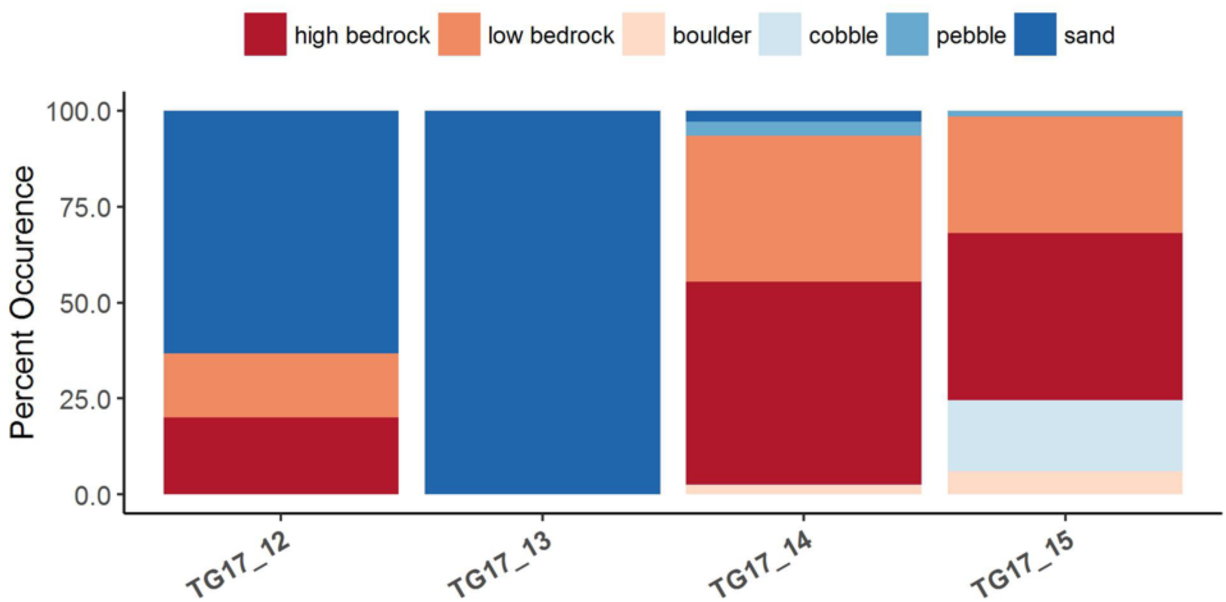


Appendix Figure 56. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

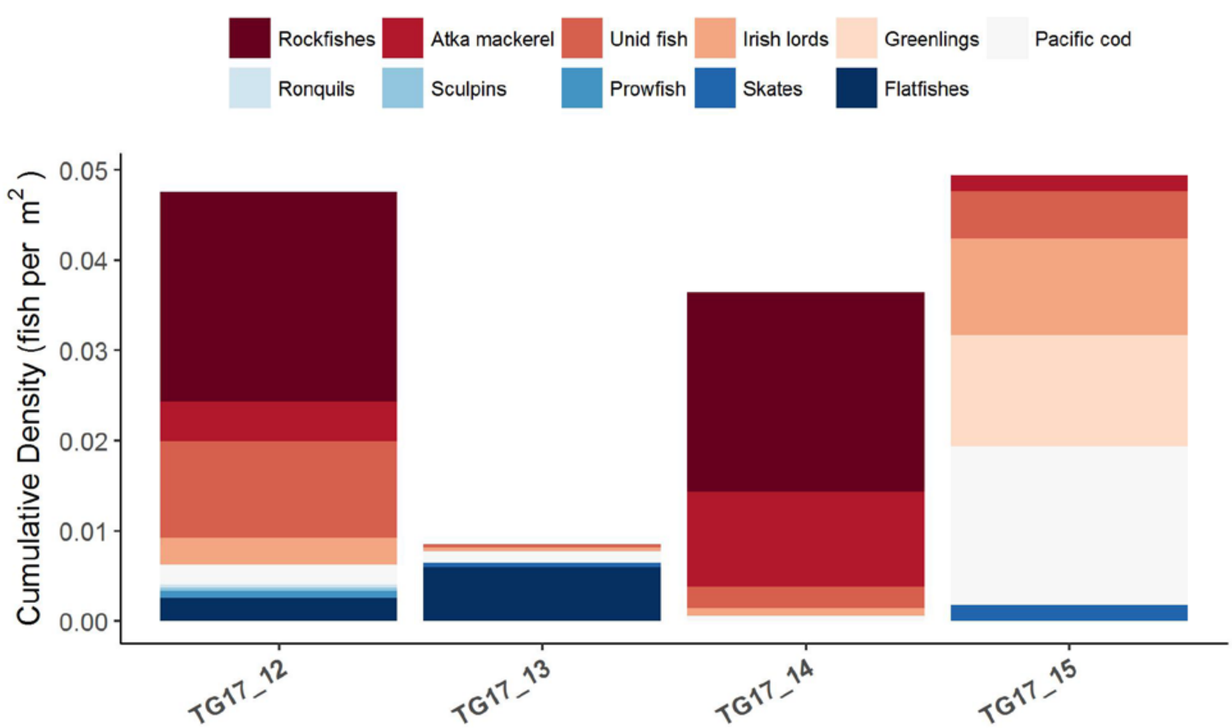


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed
TG17_12	6/30/2017	51.49	-178.34	547	5.0	2709.5	75.5	890
TG17_13	6/30/2017	51.50	-178.33	468	5.0	2328.3	79.5	857
TG17_14	6/30/2017	51.50	-178.36	653	5.3	3427.7	69	723
TG17_15	7/1/2017	51.57	-178.54	169	3.4	567.0	35.5	738

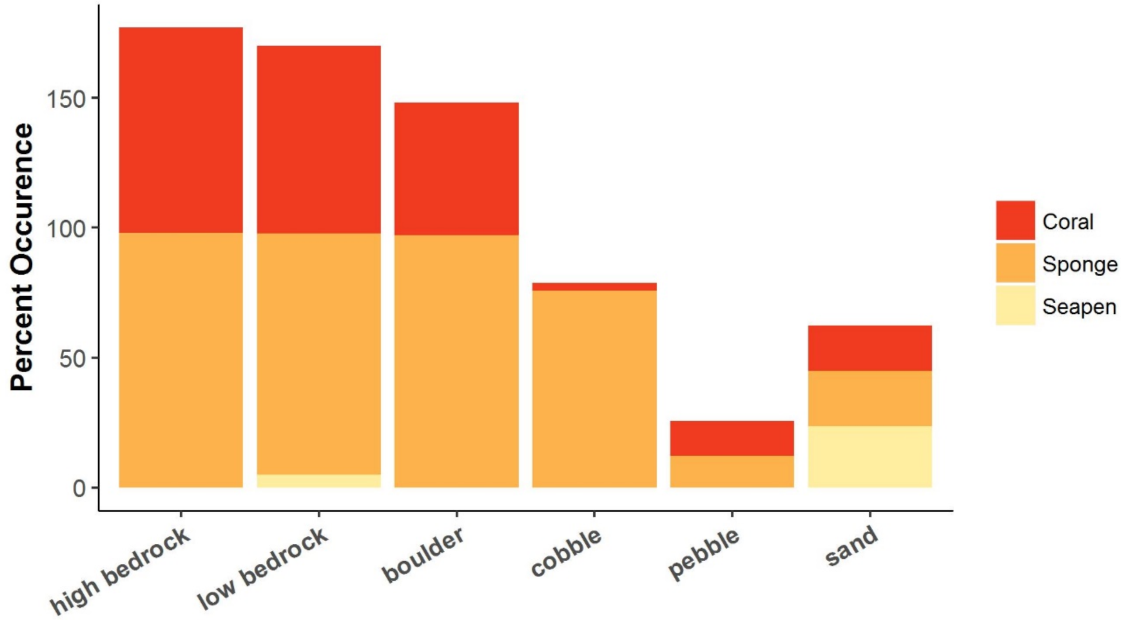
Description: A single transect near the Tag rookery was combined with three transects near Gramp Rock for this section. The area had the third highest total fish density. Rockfishes were common (0.01 ind m^{-2} ± 0.007 SE) especially on transects TG17_12 and TG17_14. Ten pacific cod were counted on transect TG17_15 which translated into an above average density of 0.017 ind m^{-2}). Corals and sponges were common (> 50%) on high and low relief bedrock as well as boulders.



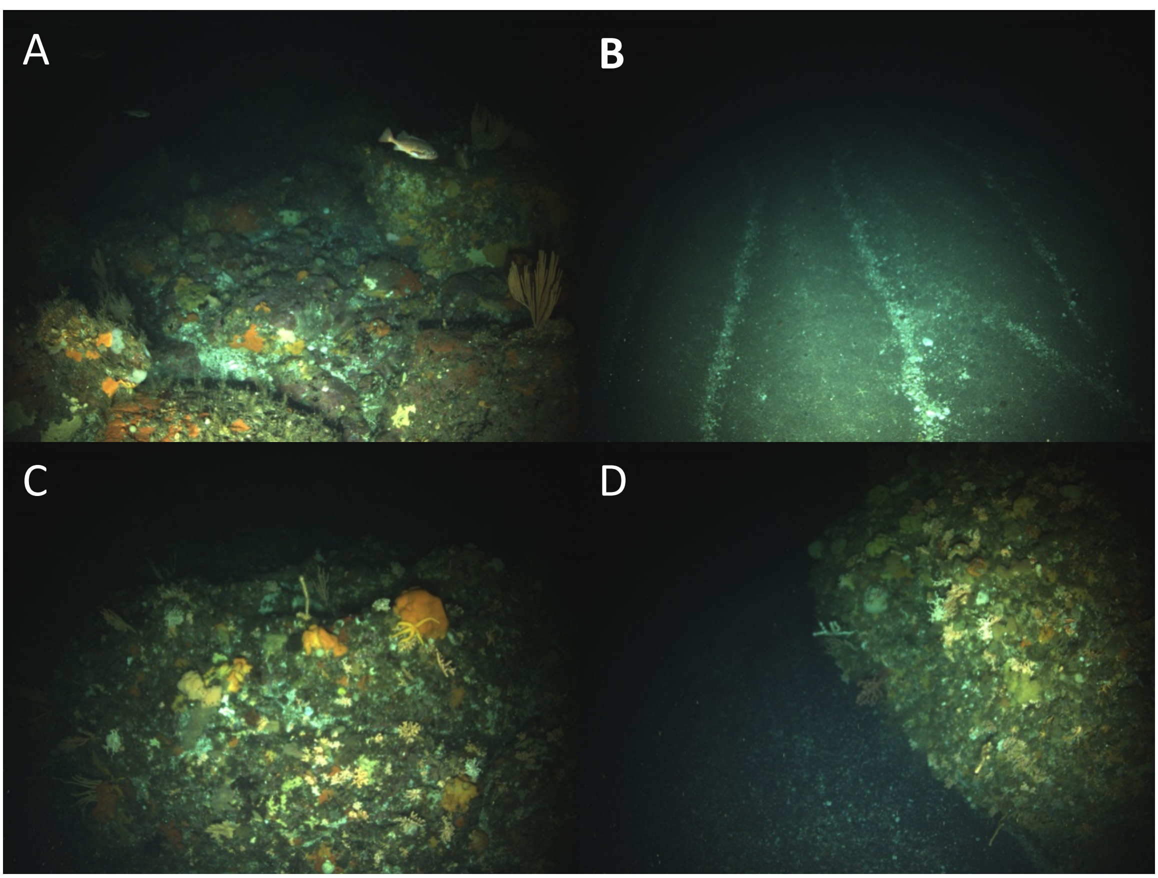
Appendix Figure 57. -- Percent occurrence of primary habitat type by transect.



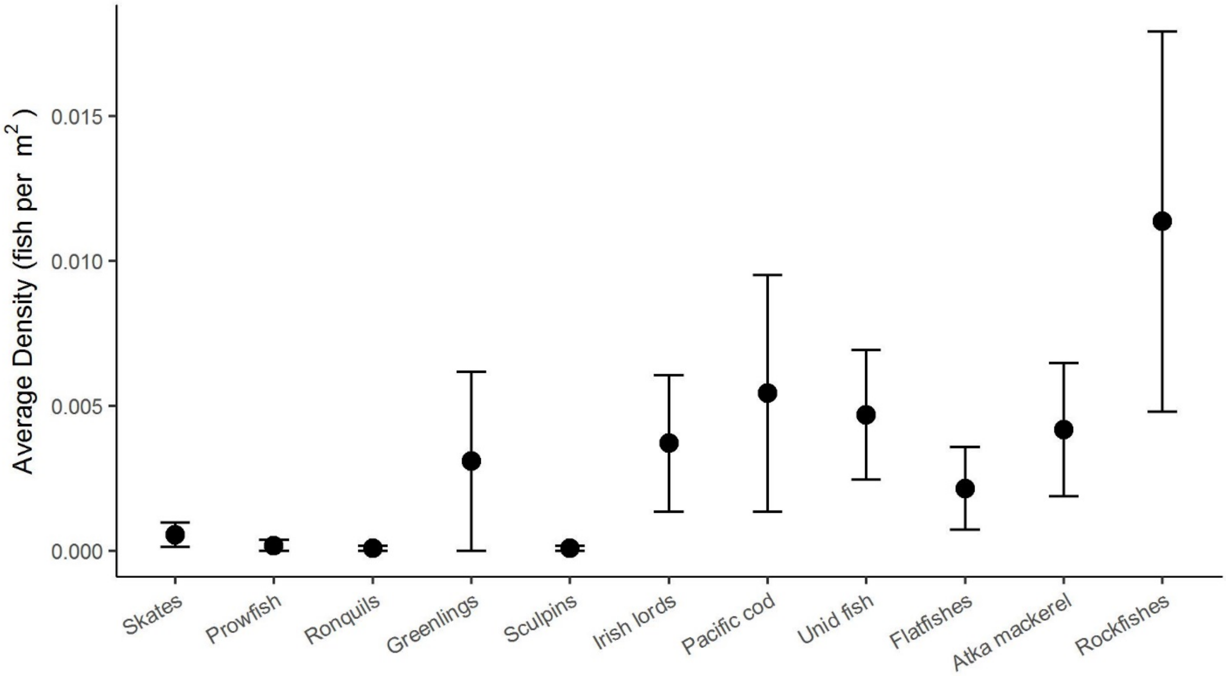
Appendix Figure 58. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



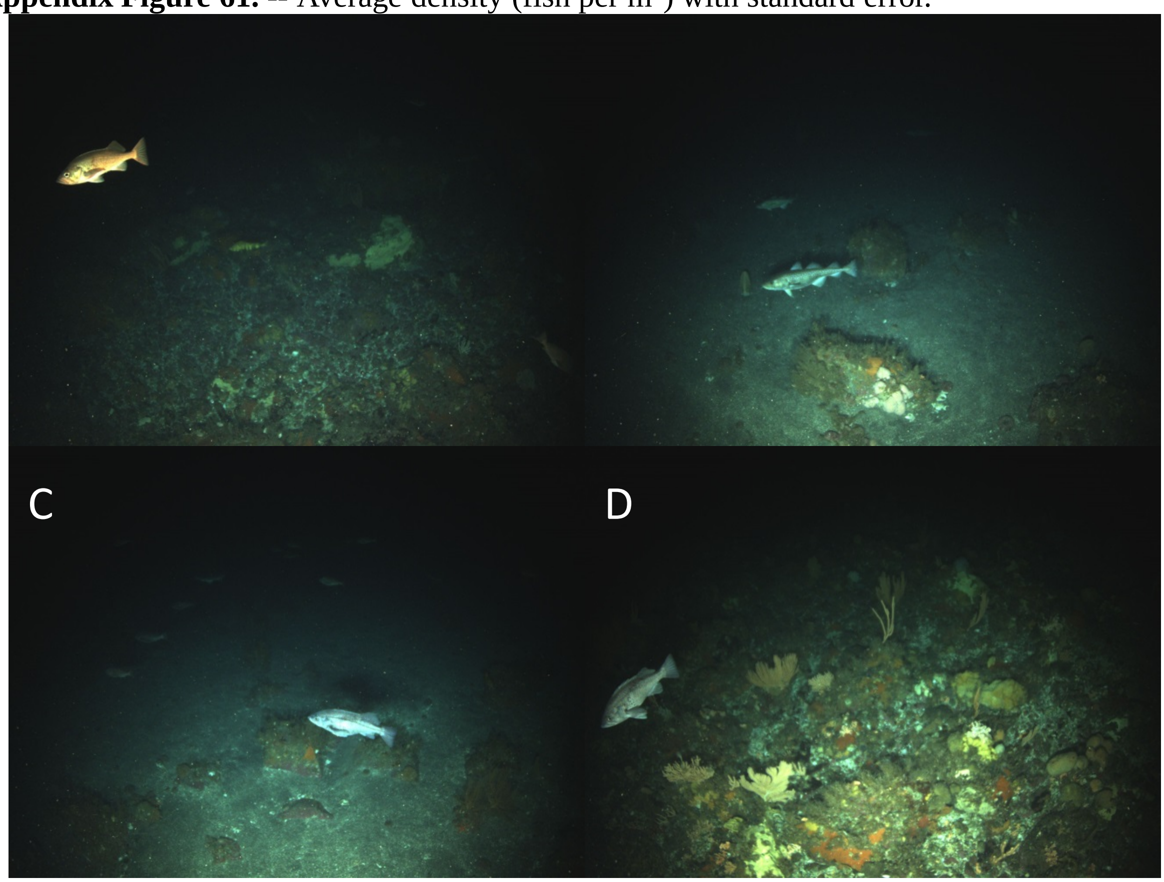
Appendix Figure 59. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



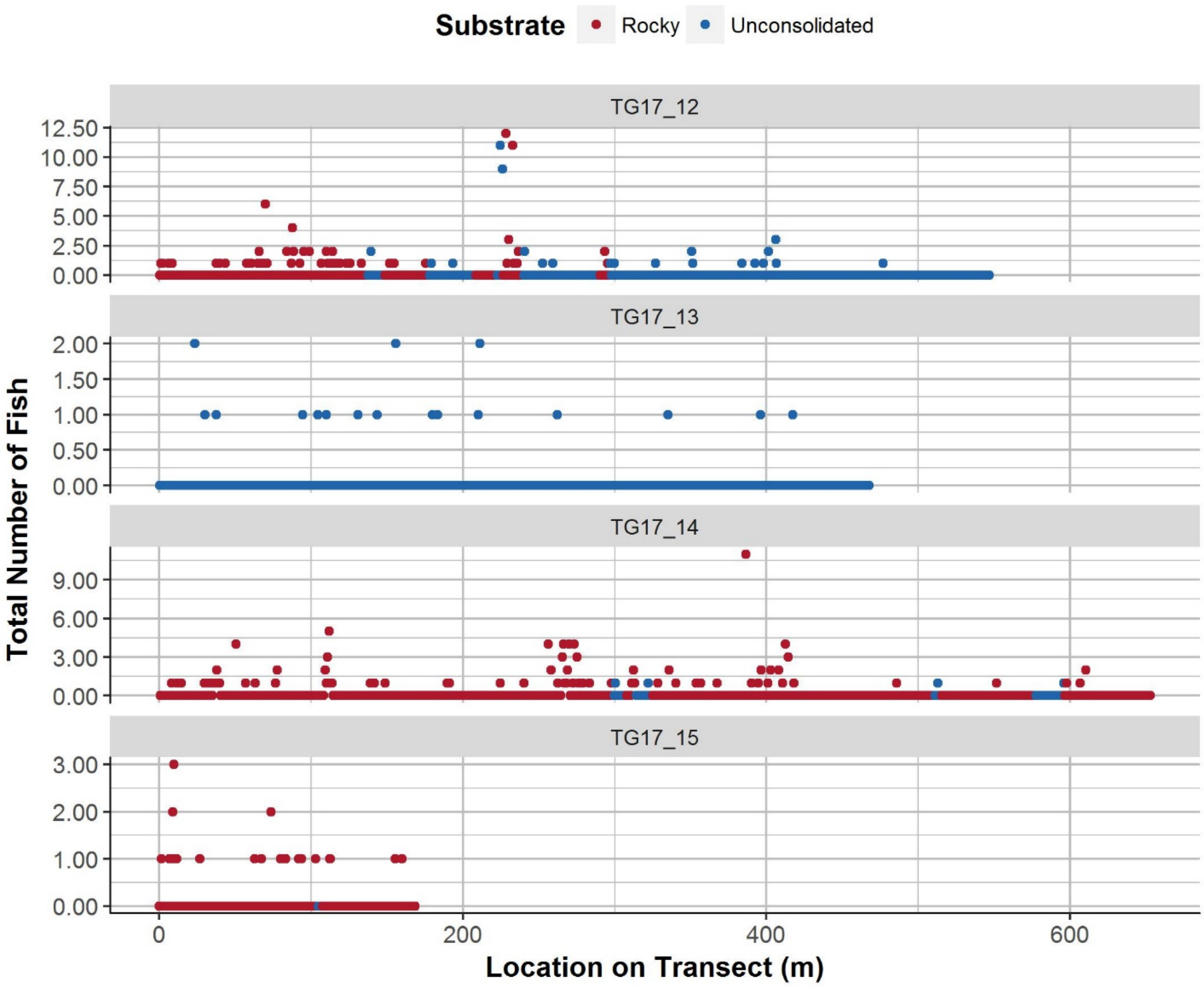
Appendix Figure 60. -- Habitat images of (A) high relief bedrock on transect TG17_12, (B) sand on transect TG17_13, and (C & D) high relief bedrock on transect TG17_14.



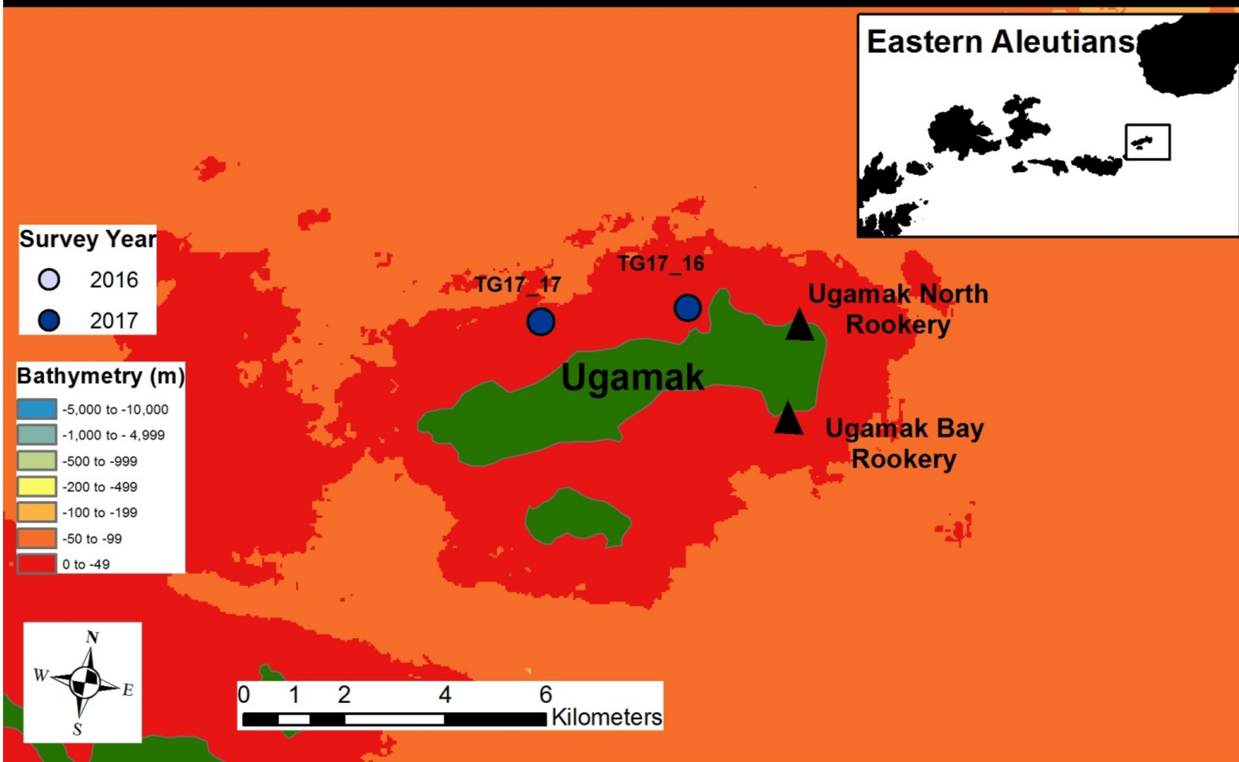
Appendix Figure 61. -- Average density (fish per m^2) with standard error.



Appendix Figure 62. -- Images of (A) a northern rockfish, (B) Pacific cod and (C) dusky rockfish on transect TG17_12 and and a dusky rockfish on transect TG17_14.

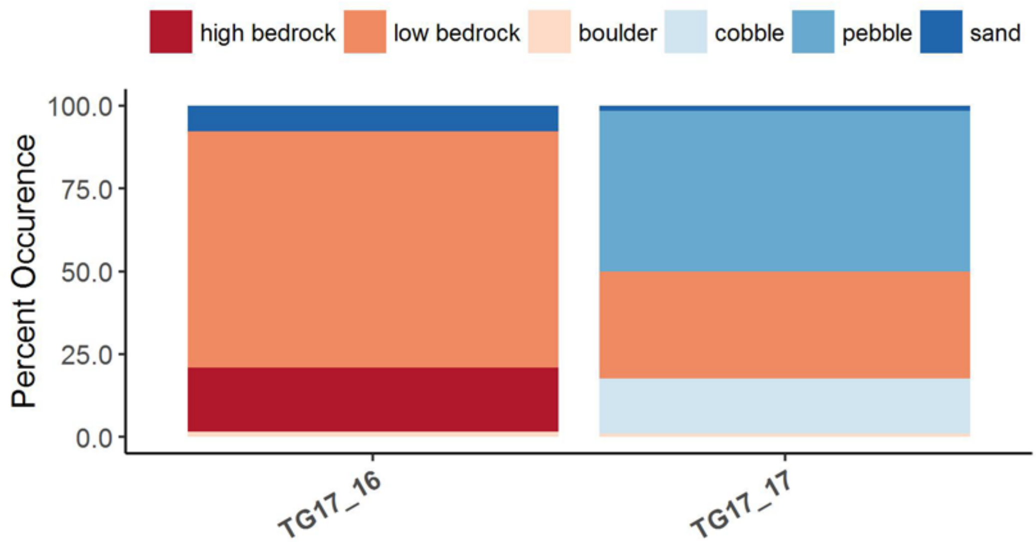


Appendix Figure 63. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

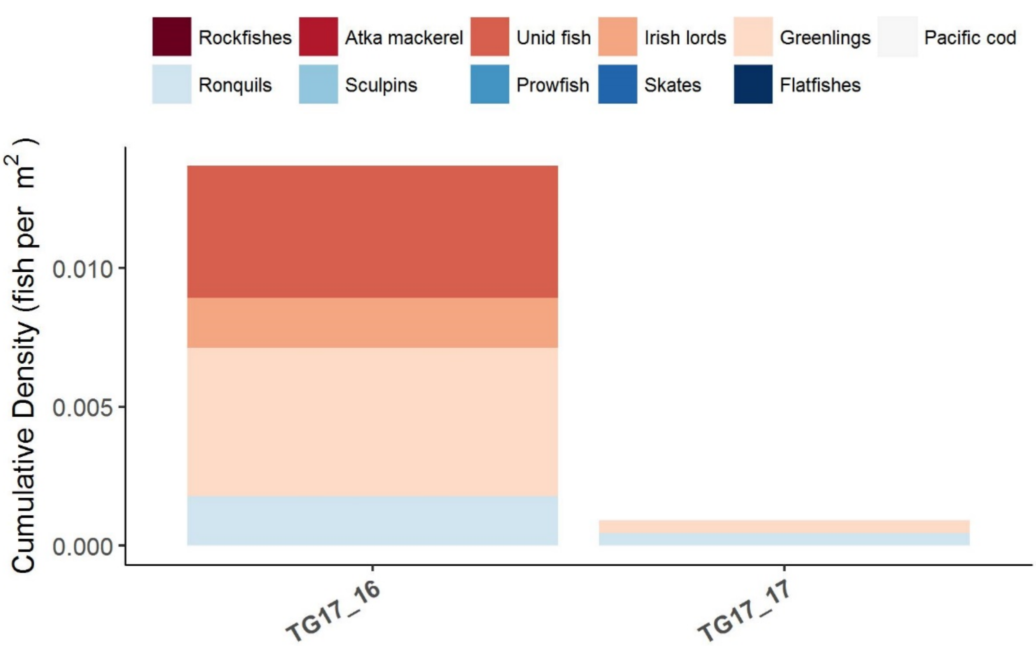


Transect ID	Date	Lat	Long	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed
TG17_16	7/6/2017	54.23	-164.81	456	3.7	1682.2	30.5	865
TG17_17	7/6/2017	54.22	-164.85	562	3.9	2177.9	47.75	879

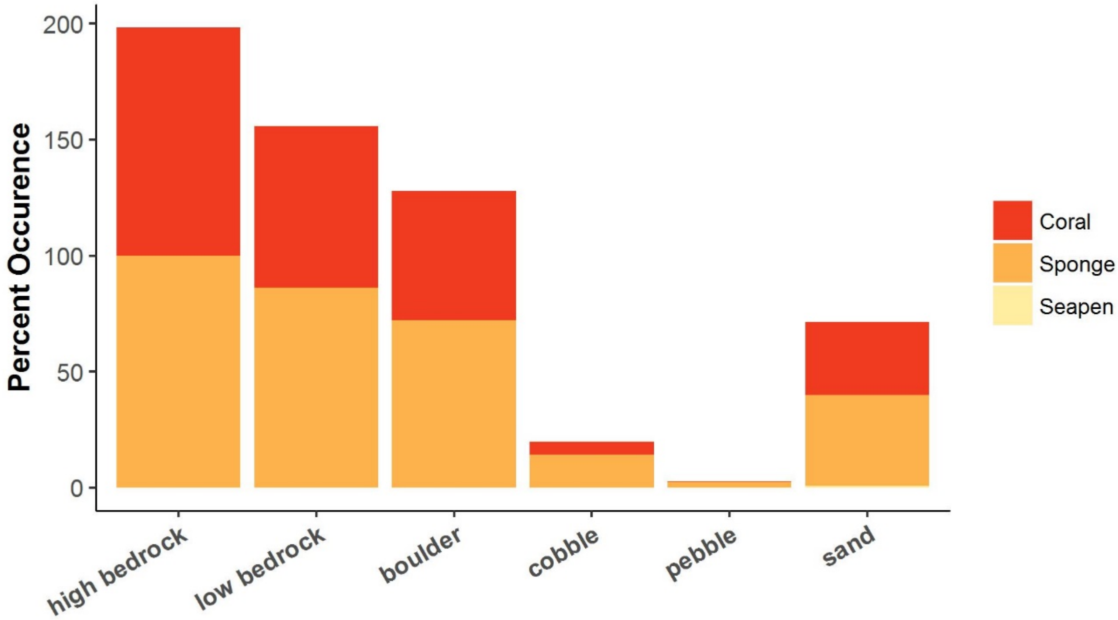
Description: Two shallow transects were conducted off the north side of Ugamak in 2017. Only two fish (greenling and sculpin) were observed during transect TG17_17. Nine Pacific cod and 8 unidentified fish made up the majority of fish observed on transect TG17_16. Corals and sponges were common (> 50%) on high and low relief bedrock as well as boulders.



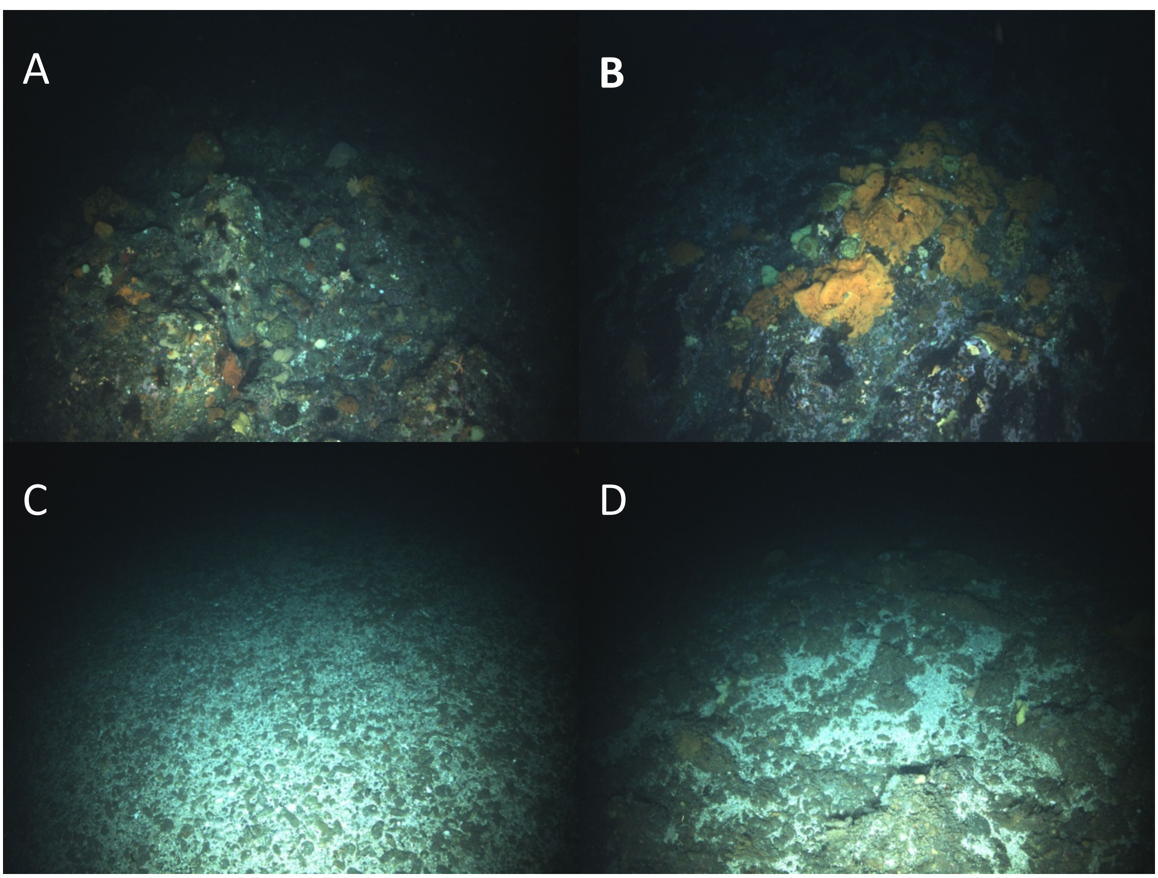
Appendix Figure 64. -- Percent occurrence of primary habitat type by transect.



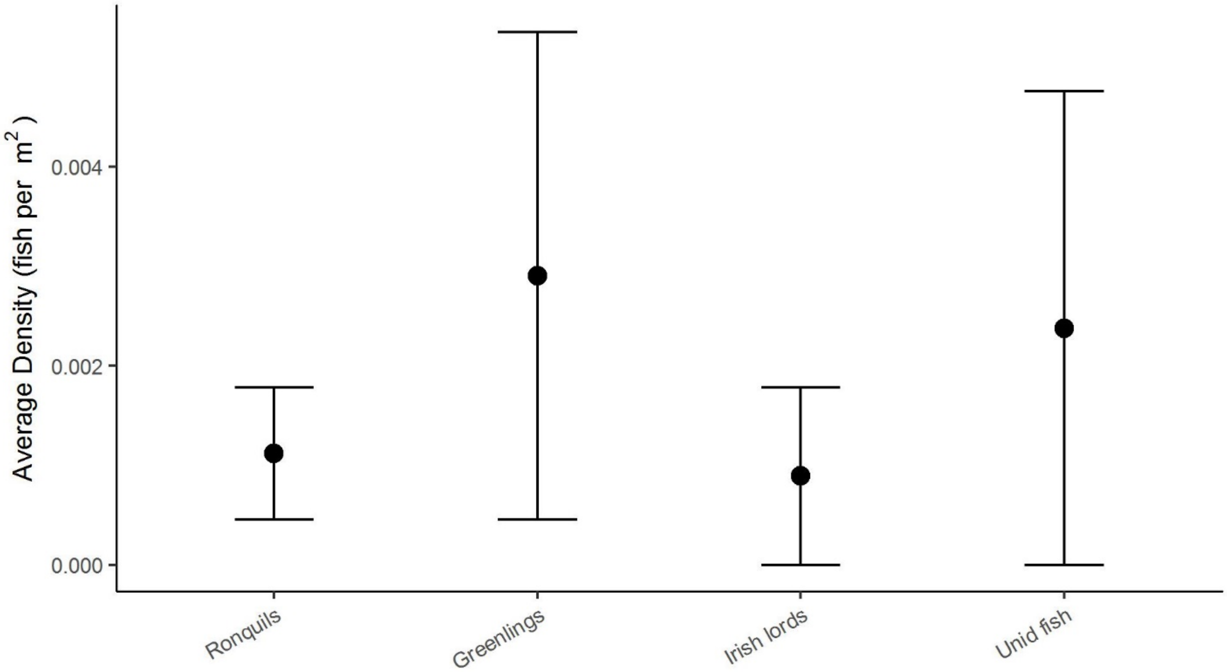
Appendix Figure 65. -- Stacked bar plot of cumulative density (fish per m^2) by transect.



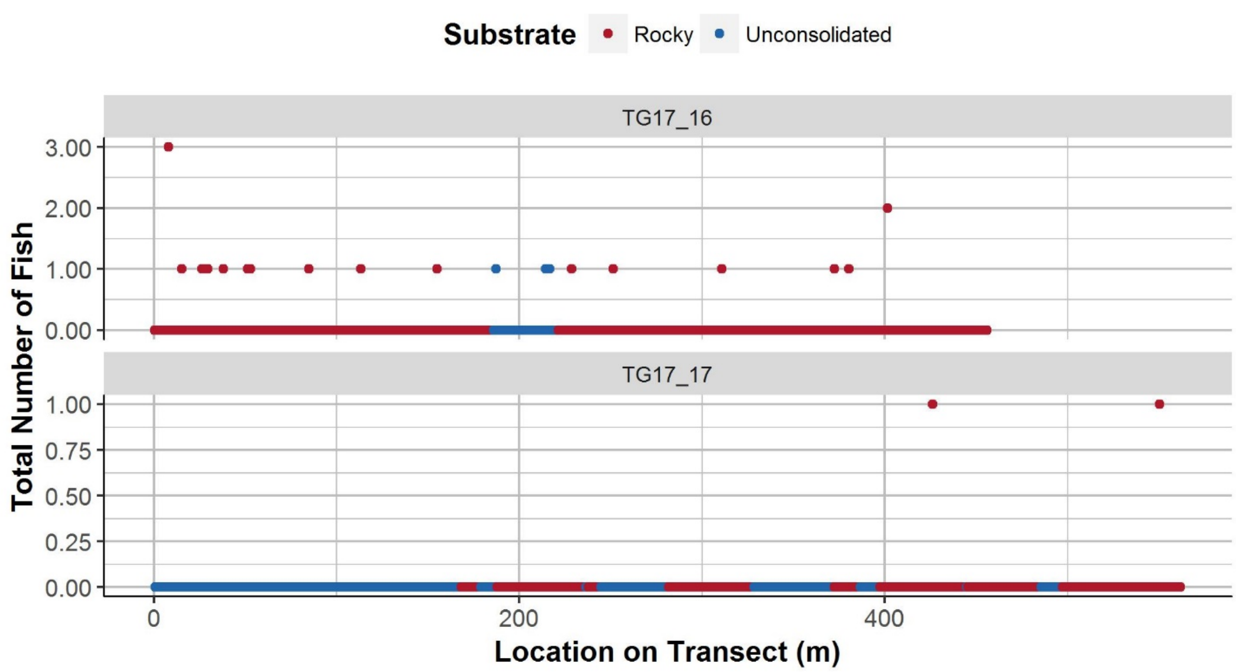
Appendix Figure 66. -- Stacked bar plot of the percent occurrence of coral, sponges and seapens by primary habitat type.



Appendix Figure 67. -- Habitat images of (A) low relief bedrock and (B) high relief bedrock on transect TG17_16 and (C) pebble and (D) low relief bedrock on transect TG17_17.



Appendix Figure 68. -- Average density (fish per m^2) with standard error.



Appendix Figure 69. -- Total number of fish observed at each frame along a transect. The substrate for each frame is colored red for rocky and blue for unconsolidated. The y axis scale is different for each transect.

Appendix II. Transect summary information including location, area swept, average depth, number of frames analyzed, and percent substrate type.

Island Group	Island	Transect ID	Date	Latitude	Longitude	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed	Substrate % Rocky	Substrate % Unconsolidated
Rat Islands	Semisopochnoi	TG16_1	6/24/2016	51.94	179.75	492	9.57	4709.9	27.3	902	0	100
Rat Islands	Semisopochnoi	TG16_2	6/24/2016	51.94	179.77	702	4.84	3401.3	57.5	972	6	94
Rat Islands	Hawadax Island	TG16_3	6/25/2016	51.76	178.41	436	3.92	1709.6	27.0	910	0	100
Rat Islands	Hawadax Island	TG16_4	6/25/2016	51.77	178.41	409	2.83	1158.2	49.5	918	0	100
Rat Islands	Hawadax Island	TG16_5	6/25/2016	51.77	178.41	320	3.50	1120.7	75.0	760	0	100
Rat Islands	Kiska	TG16_6	6/26/2016	51.92	177.44	553	6.54	3618.3	33.0	789	0	100
Rat Islands	Kiska	TG16_7	6/26/2016	51.90	177.44	454	5.86	2660.6	59.5	789	31	69
Rat Islands	Kiska	TG16_8	6/26/2016	51.89	177.44	445	4.15	1847.9	75.8	767	2	98
Rat Islands	Kiska	TG16_9	6/26/2016	51.81	177.32	441	7.90	3489.2	32.3	608	100	0
Rat Islands	Kiska	TG16_10	6/26/2016	51.80	177.32	231	5.13	1184.1	57.0	787	83	17
Rat Islands	Kiska	TG16_11	6/26/2016	51.86	177.23	247	6.84	1692.6	25.3	810	100	0
Rat Islands	Kiska	TG16_12	6/26/2016	51.85	177.22	361	4.78	1727.3	58.5	803	4	96
Rat Islands	Kiska	TG16_13	6/26/2016	51.82	177.22	82	7.31	596.6	82.0	373	0	100
Rat Islands	Kiska	TG16_14	6/26/2016	51.95	177.32	937	8.36	7837.4	46.3	850	86	14
Rat Islands	Kiska	TG16_15	6/26/2016	51.97	177.32	963	7.38	7102.2	70.5	807	2	98
Buldir	Buldir	TG16_16	6/27/2016	52.39	175.86	877	5.55	4871.6	32.3	708	0	100
Buldir	Buldir	TG16_17	6/27/2016	52.40	175.84	891	7.68	6840.5	80.5	758	0	100
Near Islands	Ingenstrem Rocks	TG16_18	6/27/2016	52.64	174.53	282	5.69	1602.9	42.5	433	100	0
Near Islands	Ingenstrem Rocks	TG16_19	6/27/2016	52.64	174.53	577	5.41	3124.4	79.0	876	0	100
Near Islands	Shemya	TG16_20	6/28/2016	52.72	174.15	299	3.72	1113.1	25.8	578	64	36
Near Islands	Shemya	TG16_21	6/28/2016	52.73	174.17	476	2.99	1424.1	51.5	915	0	100
Near Islands	Shemya	TG16_22	6/28/2016	52.75	174.19	317	4.58	1450.7	74.3	837	0	100
Near Islands	Alaid	TG16_23	6/28/2016	52.77	173.89	314	2.12	666.9	39.3	777	0	100
Near Islands	Alaid	TG16_24	6/28/2016	52.79	173.89	232	3.44	796.6	68.8	484	0	100
Near Islands	Alaid	TG16_25	6/28/2016	52.79	173.90	300	3.60	1078.4	93.3	644	0	100
Near Islands	Attu	TG16_26	6/28/2016	52.93	173.29	248	5.18	1283.0	32.3	588	100	0
Near Islands	Attu	TG16_27	6/28/2016	52.94	173.28	635	4.26	2708.0	55.3	733	0	100
Near Islands	Attu	TG16_28	6/28/2016	52.94	173.28	387	5.26	2038.4	53.5	529	38	62

Appendix II. Transect summary information including location, area swept, average depth, number of frames analyzed, and percent substrate type.

											Substrate %	
Island Group	Island	Haul #	Date	Latitude	Longitude	Camera Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth	Frames Analyzed	Rocky	Unconsolidated
Near Islands	Agattu	TG16_30	6/30/2016	52.39	173.35	58	6.06	350.9	22.0	98	100	0
Near Islands	Agattu	TG16_31	6/30/2016	52.39	173.34	255	6.72	1713.7	57.3	429	100	0
Near Islands	Agattu	TG16_32	6/30/2016	52.38	173.32	276	7.39	2040.9	72.0	558	95	5
Near Islands	Agattu	TG16_33	6/30/2016	52.35	173.69	108	2.03	219.5	29.8	257	89	11
Near Islands	Agattu	TG16_34	6/30/2016	52.34	173.69	206	3.05	628.3	46.8	402	100	0
Near Islands	Agattu	TG16_35	6/30/2016	52.33	173.69	187	4.11	768.8	75.3	488	8	92
Rat Islands	Amchitka	TG16_36	7/1/2016	51.56	178.83	324	2.27	736.4	29.5	646	0	100
Rat Islands	Amchitka	TG16_37	7/1/2016	51.54	178.83	493	4.40	2168.9	54.5	733	88	12
Rat Islands	Amchitka	TG16_38	7/1/2016	51.52	178.83	262	3.99	1046.1	75.3	184	0	100
Rat Islands	Amchitka	TG16_39	7/2/2016	51.36	179.45	137	5.81	794.3	32.5	496	100	0
Rat Islands	Amchitka	TG16_40	7/2/2016	51.35	179.44	195	6.54	1276.6	53.3	654	84	16
Rat Islands	Amchitka	TG16_41	7/2/2016	51.35	179.45	306	6.24	1908.8	77.0	763	0	100
Rat Islands	Amchitka	TG16_42	7/2/2016	51.35	179.37	366	4.06	1488.0	46.5	899	81	19
Rat Islands	Amchitka	TG16_43	7/2/2016	51.34	179.34	338	6.67	2255.6	36.3	830	100	0
Rat Islands	Amchitka	TG16_44	7/2/2016	51.32	179.37	470	3.75	1763.6	98.8	885	62	38
Delarof Islands	Ulak	TG16_45	7/3/2016	51.31	-178.99	267	6.89	1843.3	43.0	765	88	12
Delarof Islands	Ulak	TG16_46	7/3/2016	51.31	-179.01	381	6.86	2614.0	74.5	896	0	100
Delarof Islands	Ulak	TG16_47	7/3/2016	51.28	-179.00	327	7.25	2374.1	97.5	685	100	0
Near Islands	Alaid	TG17_1	6/24/2017	52.79	173.90	524	3.88	2030.8	65.0	800	0	100
Near Islands	Alaid	TG17_2	6/24/2017	52.79	173.90	440	3.88	1707.5	88.3	647	0	100
Near Islands	Alaid	TG17_3	6/24/2017	52.80	173.91	574	3.13	1799.6	96.8	608	0	100
Near Islands	Attu	TG17_4	6/25/2017	52.93	173.31	323	3.52	1135.3	52.3	776	66	34
Near Islands	Attu	TG17_5	6/25/2017	52.92	172.45	364	4.38	1593.0	21.8	733	76	24
Near Islands	Attu	TG17_6	6/25/2017	52.91	172.49	537	3.71	1992.7	28.8	782	14	86
Near Islands	Aggatu	TG17_7	6/26/2017	52.34	173.69	412	4.31	1774.9	52.6	774	97	3
Near Islands	Aggatu	TG17_8	6/26/2017	52.34	173.67	596	4.87	2900.5	47.0	852	100	0

Appendix II. Transect summary information including location, area swept, average depth, number of frames analyzed, and percent substrate type.

											Substrate %	
Island Group	Island	Transect ID	Date	Latitude	Longitude	Distance (m)	Swath (m)	Area Swept (m^2)	Average Depth (m)	Frames Analyzed	Rocky	Unconsolidated
Rat Islands	Kiska	TG17_9	6/28/2017	51.84	177.21	582	3.01	1749.4	67.5	739	0	100
Rat Islands	Kiska	TG17_10	6/28/2017	NA	NA	72	6.21	445.3	NA	115	100	0
Delarof Islands	Gramp Rock	TG17_11	6/30/2017	51.49	-178.34	547	4.96	2709.5	75.5	890	37	63
Delarof Islands	Gramp Rock	TG17_12	6/30/2017	51.50	-178.33	468	4.98	2328.3	79.5	857	0	100
Delarof Islands	Gramp Rock	TG17_13	6/30/2017	51.50	-178.36	653	5.25	3427.7	69.0	723	94	6
Delarof Islands	Tag Island	TG17_14	7/1/2017	51.57	-178.54	169	3.36	567.0	35.5	738	99	1
Ugamak	Ugamak	TG17_15	7/6/2017	54.23	-164.81	456	3.69	1682.2	30.5	865	92	8
Ugamak	Ugamak	TG17_16	7/6/2017	54.22	-164.85	562	3.88	2177.9	47.8	879	50	50

Appendix III. Fish density (per m^2) by transect.

Transect ID	Island	Rockfishes	Atka mackerel	Unid fish	Irish lords	Greenlings	Pacific cod	Gadids	Ronquils	Sculpins	Prowfish	Skates	Poachers	Flatfishes
TG16_1	Semisopochnoi			0.0004										0.0004
TG16_2	Semisopochnoi	0.0041	0.0006	0.0006	0.0026					0.0026		0.0021		0.0012
TG16_3	Hawadax Island													0.0023
TG16_4	Hawadax Island			0.0009						0.0017				0.0086
TG16_5	Hawadax Island			0.0009						0.0054				0.0018
TG16_6	Kiska			0.0058						0.0008				0.0116
TG16_7	Kiska	0.0030		0.0019						0.0008		0.0004		0.0041
TG16_8	Kiska	0.0027	0.0005		0.0022					0.0032		0.0054		0.0152
TG16_9	Kiska		0.0003	0.0003										
TG16_10	Kiska	0.0520	0.0068	0.0017	0.0026	0.0009								
TG16_11	Kiska	0.0053	0.0112	0.0006	0.0012	0.0006			0.0006					
TG16_12	Kiska	0.0087			0.0012					0.0006				0.0017
TG16_13	Kiska						0.0017					0.0017		0.0034
TG16_14	Kiska	0.0011	0.0001	0.0004			0.0001				0.0001			
TG16_15	Kiska	0.0003	0.0004											
TG16_16	Buldir	0.0035	0.0002	0.0012			0.0010				0.0012			
TG16_17	Buldir	0.0038	0.0012	0.0012			0.0015							
TG16_18	Semichi	0.1262	0.0601	0.0097			0.0089							
TG16_19	Semichi	0.0032		0.0003								0.0003		0.0013
TG16_20	Semichi	0.0199		0.0009	0.0009									0.0027
TG16_21	Semichi	0.0421	0.0028	0.0007	0.0007									0.0063
TG16_22	Semichi	0.0076					0.0090							0.0041
TG16_23	Semichi			0.0015						0.0015		0.0015		0.0270
TG16_24	Semichi	0.0013		0.0013						0.0013				0.0038
TG16_25	Semichi	0.0019								0.0009		0.0009		0.0056
TG16_26	Attu	0.0023	0.0117	0.0016						0.0008	0.0008			0.0008
TG16_27	Attu		0.0011				0.0004			0.0004		0.0004		0.0026
TG16_28	Attu	0.0235	0.0105	0.0025	0.0095		0.0020							0.0005
TG16_30	Agattu	0.0028	0.0085											

Appendix III. Fish density (per m^2) by transect.

Transect ID	Island	Rockfishes	Atka mackerel	Unid fish	Irish lords	Greenlings	Pacific cod	Gadids	Ronquils	Sculpins	Prowfish	Skates	Poachers	Flatfishes
TG16_31	Agattu	0.0023	0.0076	0.0018	0.0059	0.0029	0.0006			0.0006				0.0006
TG16_32	Agattu	0.0034	0.0187	0.0015	0.0005		0.0025							
TG16_33	Agattu		0.0046	0.0046										0.0046
TG16_34	Agattu	0.0032	0.0016	0.0064	0.0048					0.0016				
TG16_35	Agattu	0.0274		0.0026	0.0039		0.0013					0.0013		0.0052
TG16_36	Amchitka													0.0095
TG16_37	Amchitka	0.0078	0.0005	0.0028	0.0065	0.0023			0.0009	0.0042				0.0042
TG16_38	Amchitka											0.0010		
TG16_39	Amchitka	0.0025		0.0076	0.0063	0.0013	0.0063							
TG16_40	Amchitka	0.0008	0.0008	0.0016	0.0188		0.0079			0.0039				0.0024
TG16_41	Amchitka			0.0005			0.0005			0.0005				0.0005
TG16_42	Amchitka	0.0020		0.0020	0.0020	0.0013								0.0013
TG16_43	Amchitka	0.0004	0.0071	0.0053		0.0004	0.0013							
TG16_44	Amchitka	0.0045	0.0017	0.0034	0.0023		0.0023		0.0074	0.0011		0.0011		
TG16_45	Ulak	0.0130	0.0011	0.0033	0.0005	0.0043				0.0005				0.0005
TG16_46	Ulak			0.0004	0.0023					0.0015		0.0008		0.0023
TG16_47	Ulak	0.0097	0.1098	0.0110	0.0013		0.0004		0.0066					
TG17_1	Semichi													
TG17_2	Semichi			0.0023									0.0006	0.0018
TG17_3	Semichi			0.0022										0.0089
TG17_4	Attu	0.0026	0.0009	0.0079	0.0053	0.0026	0.0035							0.0009
TG17_5	Attu				0.0006	0.0019				0.0006				0.0050
TG17_7	Attu			0.0010	0.0005	0.0005	0.0010			0.0010				0.0090
TG17_8	Agattu	0.0310	0.0180	0.0034	0.0011	0.0096	0.0006	0.0028	0.0006		0.0023			0.0006
TG17_9	Agattu	0.0066	0.0203	0.0021	0.0045	0.0045	0.0021			0.0003	0.0010			0.0003
TG17_10	Kiska	0.0029		0.0017			0.0006					0.0006		0.0040
TG17_11	Kiska	0.0292	0.0741	0.0067			0.0067							

Appendix III. Fish density (per m^2) by transect.

Transect ID	Island	Rockfishes	Atka mackerel	Unid fish	Irish lords	Greenlings	Pacific cod	Gadids	Ronquils	Sculpins	Prowfish	Skates	Poachers	Flatfishes
TG17_12	Gramp_Tag	0.0233	0.0044	0.0107	0.0030		0.0022	0.0015	0.0004	0.0004	0.0007			0.0026
TG17_13	Gramp_Tag			0.0004	0.0004		0.0013					0.0004		0.0060
TG17_14	Gramp_Tag	0.0222	0.0105	0.0023	0.0009		0.0006							
TG17_15	Gramp_Tag		0.0018	0.0053	0.0106	0.0123	0.0176	0.0018				0.0018		
TG17_16	Ugamak			0.0048	0.0018	0.0054		0.0006	0.0018					
TG17_17	Ugamak					0.0005			0.0005					

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AFSC-

380 SEUNG, C. K., and S. MILLER. 2018. Regional economic analysis for North Pacific fisheries, 86 p. NTIS number pending.

379 GANZ, P., S. BARBEAUX, J. CAHALAN, J. GASPER, S. LOWE, R. WEBSTER, and C. FAUNCE. 2018. Deployment performance review of the 2017 North Pacific Observer Program, 68 p. NTIS number pending.

378 M. M. MUTO, V. T. HELKER, R. P. ANGLISS, B. A. ALLEN, P. L. BOVENG, J. M. BREIWICK, M. F. CAMERON, P. J. CLAPHAM, S. P. DAHLE, M. E. DAHLHEIM, B. S. FADELY, M. C. FERGUSON, L. W. FRITZ, R. C. HOBBS, Y. V. IVASHCHENKO, A. S. KENNEDY, J. M. LONDON, S. A. MIZROCH, R. R. REAM, E. L. RICHMOND, K. E. W. SHELDEN, R. G. TOWELL, P. R. WADE, J. M. WAITE, and A. N. ZERBINI. 2018. Alaska marine mammal stock assessments, 2017, 272 p. NTIS number pending.

377 RICHWINE, K. A., K. R. SMITH, and R. A. MCCONNAUGHEY. 2018. Surficial sediments of the eastern Bering Sea continental shelf: EBSSED-2 database documentation, 48 p. NTIS No. PB2018-101013.

376 DORN, M. W., C. J. CUNNINGHAM, M. T. DALTON, B. S. FADELY, B. L. GERKE, A. B. HOLLOWED, K. K. HOLSMAN, J. H. MOSS, O. A. ORMSETH, W. A. PALSSON, P. A. RESSLER, L. A. ROGERS, M. A. SIGLER, P. J. STABENO, and M. SZYMKOWIAK. 2018. A climate science regional action plan for the Gulf of Alaska, 58 p. NTIS No. PB2018-100998.

375 TESTA, J. W. (editor). 2018. Fur seal investigations, 2015-2016, 107 p. NTIS No. PB2018-100966.

374 VON SZALAY, P. G., and N. W. RARING. 2018. Data Report: 2017 Gulf of Alaska bottom trawl survey, 266 p. NTIS No. PB2018-100892

373 ROONEY, S., C. N. ROOPER, E. LAMAN, K. TURNER, D. COOPER, and M. ZIMMERMANN. 2018. Model-based essential fish habitat definitions for Gulf of Alaska groundfish species, 370 p. NTIS No. PB2018-100826.

372 LANG, C. A., J. I. RICHAR, and R. J. FOY. 2018. The 2017 eastern Bering Sea continental shelf and northern Bering Sea bottom trawl surveys: Results for commercial crab species, 233 p. NTIS No. PB2018-100825.

371 RODGVELLER, C. J., K. B. ECHAVE, P-J. F. HULSON, and K. M. COUTRÉ. 2018. Age-at-maturity and fecundity of female sablefish sampled in December of 2011 and 2015 in the Gulf of Alaska, 31 p. NTIS No. PB2018-100824.

370 GUTHRIE, C. M. III, HV. T. NGUYEN, A. E. THOMSON, K. HAUCH, and J. R. GUYON. 2018. Genetic stock composition analysis of the Chinook salmon bycatch samples from the 2016 Gulf of Alaska trawl fisheries, 226 p. NTIS number pending.