Regional Operational Plan No. ROP.1J.2026.04

Yelloweye Rockfish Remotely Operated Vehicle (ROV) Stock Assessment Survey in the Southeast Outside (SEO) Subdistrict

by

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figures or figure captions.

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	′
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	″
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN NO. ROP.CF.1J.2026.04

YELLOWEYE ROCKFISH REMOTELY OPERATED VEHICLE (ROV) STOCK ASSESSMENT SURVEY IN THE SOUTHEAST OUTSIDE (SEO) SUBDISTRICT

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SIGNATURE PAGE

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Project leader	Rhea Ehresmann		
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PURPOSE

This regional operational plan (ROP) details the protocol for conducting the remotely operated vehicle (ROV) survey and yelloweye rockfish density estimation in the Southeast Outside (SEO) Subdistrict of the Eastern Gulf of Alaska (Figure 1). In SEO, yelloweye rockfish account for more than 95% of the commercial harvest of the demersal shelf rockfish (DSR) complex based on the 2019–2023 five-year average landed weight. The federal fishery management plan (FMP) for groundfish in the Gulf of Alaska delegates management authority for the DSR complex in SEO to the Alaska Department of Fish and Game (ADF&G). Yelloweye rockfish stock status is assessed in SEO using a ROV. When funding allows, a ROV survey is conducted annually in at least one of the 4 SEO management areas, collecting data used to estimate yelloweye rockfish density, size composition, and biomass. Biomass estimates for specific management areas are used to update the SEO biomass estimate, which is used in calculation of the acceptable biological catch (ABC) and presented in the federal Stock Assessment and Fishery Evaluation (SAFE) report. The SAFE is reviewed by the North Pacific Fishery Management Council (Council), which sets the total allowable catch (TAC). The TAC is used to set the state guideline harvest levels (GHL) for the commercial, subsistence and sport DSR fisheries in SEO. Survey data, commercial fishery logbook catch per unit effort (CPUE), and age, length, and weight data from commercial port samples are also considered when making management decisions.

Keywords: remotely operated vehicle, yelloweye rockfish, demersal shelf rockfish, biomass estimate.

BACKGROUND

The demersal shelf rockfish (DSR) complex is composed of 7 nearshore, bottom-dwelling species and includes: yelloweye *Sebastes ruberrimus*, quillback *S. maliger*, tiger *S. nigrocinctus*, China *S. nebulosus*, canary *S. pinniger*, copper *S. caurinus*, and rosethorn *S. helvomaculatus* rockfish (5 AAC 39.975 (34)) and is an important suite of rockfish species caught in commercial, sport, and subsistence fisheries in Southeast Alaska. Demersal shelf rockfish are highly susceptible to over-exploitation as they are slow-growing, long-lived, and late-maturing, thus requiring careful management (Archibald et al. 1981; Leaman 1991).

In 1986, the Gulf of Alaska Pacific Coast Groundfish Fishery Management Plan (FMP) delegated management of DSR in the Southeast Outside (SEO) Subdistrict to the State of Alaska (ADF&G 1986). The Alaska Department of Fish and Game (ADF&G or the department) began conducting an annual fishery-independent, habitat-based survey for yelloweye rockfish in 1989 using visual survey techniques (i.e., line transects from a submersible vehicle) in rocky habitat to record yelloweye rockfish observations and subsequently estimate density (Appendix A). In 1992, the SEO area was expanded from outside waters east of 137° W longitude to outside waters east of 140° W longitude. This area includes 4 management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO; Figure 1).

From 1989–2009, the Alaska Department of Fish and Game (ADF&G) assessed yelloweye rockfish density based on observations from the manned submersible vehicle *Delta*. These surveys rotated among the 4 management areas, with each management area surveyed approximately once every 4 years as possible under time and budget constraints (Brylinsky et al. 2009). ADF&G surveyed the Fairweather Grounds in the EYKT section in 1990, 1994, 1995, 1997, 1999, 2003, and 2009; the CSEO section during 1990, 1991, 1994, 1995, 1996, 1997, 2003, and 2007; the NSEO section in 1994 and 2001; and the SSEO section in 1994, 1999, and 2005 (Figure 2, Appendix A). Although *Delta* could operate to a maximum depth of 365 m (Yoklavich and O'Connell 2008), the maximum depth at which a yelloweye rockfish was recorded during a submersible survey was 264 m. No surveys were conducted in 2010–2011 due to a lack of an available submersible.

In 2012, ADF&G transitioned to using a remotely operated vehicle (ROV) named *Buttercup* given the ongoing unavailability of an appropriate manned submersible. Remotely operated vehicles are low-cost and versatile tools that have been used to study marine habitats and organisms (Pacunski et al. 2008). *Buttercup* was successfully deployed in most weather conditions and was able to navigate the seafloor and currents in the preferred direction and orientation for the majority of the planned dive transects (Green et al. 2013; Green and Stahl 2017). While *Buttercup* was rated to 300 m, the functional depth that it could safely and reliably survey was 200 m (Mike Byerly, former Division of Commercial Fisheries Fishery Biologist, ADF&G, Homer, February 21, 2025, email communication). ADF&G surveyed each management area with the ROV approximately once every 2 to 4 years, depending on time and funding availability. ADF&G surveyed the Fairweather Grounds in the EYKT section in 2015, 2017, 2019, and 2023; the CSEO section in 2012, 2016, 2018, and 2022; the NSEO section in 2016, 2018, and 2022; and the SSEO section in 2013, 2018, and 2020 (Figure 2, Appendix A). No surveys were completed in 2014 and 2021 due to unfavorable weather conditions. Due to reduced funding and a lack of a capable ROV, ROV surveys were not conducted in 2024 or 2025.

Although the survey vehicle has changed, the survey methods for yelloweye rockfish have remained similar. Dive locations for surveys are selected by randomly placing transects within yelloweye rockfish habitat (Figure 3). Yelloweye rockfish are counted along the transect, and their density is estimated using distance methodology (Buckland et al. 1993, 2015). The biomass of adult and subadult yelloweye rockfish is calculated per management area as the product of estimated density, estimated yelloweye rockfish habitat area, and the average weight of yelloweye rockfish landed in directed DSR commercial fisheries and as bycatch (O'Connell and Carlile 1993; Brylinsky et al. 2009).

Prior to 2022, the acceptable biological catch (ABC) for yelloweye rockfish in SEO was calculated by applying an assumed natural mortality rate (0.02) to the lower 90% confidence interval of the survey biomass estimate (Wood et al. 2021). Since 2022, biomass has been estimated using a spatially stratified, two-survey random effects (REMA) model fit to the ROV-based biomass estimates and estimated catch per unit effort (CPUE) for yelloweye rockfish in the International Pacific Halibut Commission (IPHC) longline survey in SEO (Joy et al. 2022; Stern et al. 2024). As before, the overfishing limit (OFL) is calculated by multiplying the biomass estimate by an assumed natural mortality rate, and the ABC is calculated as 75% of the OFL. The yelloweye rockfish biomass estimate for SEO is published annually in the Gulf of Alaska Stock Assessment and Fishery Evaluation (SAFE) report (e.g., Brylinsky et al. 2009; Green et al. 2015; Wood et al. 2021; Joy et al. 2022; Stern et al. 2024) and forms the basis for the North Pacific Fishery Management Council's (NPFMC or Council) total allowable catch (TAC) recommendation for the DSR complex. Since 2016, the ABC for the DSR complex has been calculated by adding the ABC for yelloweye rockfish to the ABC of the non-yelloweye DSR. Between 2010 and 2014, the ABC for non-yelloweye DSR has been calculated as the sum of the maximum catch, including commercial, sport, and subsistence fisheries (Green et al. 2015).

OBJECTIVES

PRIMARY OBJECTIVES

1. Obtain a density estimate with a CV ≤ 25% for adult and subadult yelloweye rockfish in rocky habitats in SEO management areas using distance sampling techniques[1].
2. Obtain fork length measurements (mm from the tip of the snout to the fork of the tail) for yelloweye rockfish, including juveniles, observed from line transects in the SEO management areas.

SECONDARY OBJECTIVES

1. Identify and enumerate other non-yelloweye DSR species, black rockfish, halibut, and lingcod. These observations are recorded and archived for future analyses (i.e., species composition).
2. Collect fork length (mm) measurements for black rockfish, halibut, and lingcod. These observations are recorded and archived for future analyses (i.e., length composition).

METHODS

OVERVIEW

Distance sampling methods were used to estimate adult and subadult yelloweye rockfish densities in designated yelloweye rockfish habitat. The yelloweye rockfish habitat within each management area, termed the *delineated yelloweye rockfish habitat (*DYRH; Figure 3), is defined and quantified below. The planned 1-km ROV dive transects were designed to provide a simple random sample of the DYRH within each management area. During video review of each transect, yelloweye rockfish were enumerated, and the distance of the rockfish from the transect line (m) as well as the fork length (mm) of the rockfish were measured. Yelloweye rockfish observations from transects were modeled in R[2] using the *Distance* package to estimate detection probabilities and estimate density within the DYRH (Miller et al. 2019). The density estimates were used to estimate biomass by multiplying the density by the area of the DYRH and the average weight of yelloweye rockfish from commercial fishery port samples.

SAMPLE DESIGN

DYRH Delineation: Yelloweye rockfish are generally found in rocky habitat (O'Connell 1993); thus, the DYRH is defined as rocky habitat inshore of the 100-fathom (183 m) depth contour[3]. The DYRH was established based on characteristics of known yelloweye rockfish habitat from the literature, ADF&G sonar data, spatial data from the directed DSR commercial fishery, and National Ocean Service (NOS) habitat data on National Oceanic and Atmospheric Administration (NOAA) charts. Geophysical data from sidescan and multibeam sonar surveys are considered the most reliable estimates of yelloweye rockfish habitat because these methods provide detailed

[1] Other ROV and submarine surveys typically show CV levels between 15% and 30% when estimating species density (Pacunski et al. 2008). A conservative target was selected for uncertainty given the long-lived nature of yelloweye and the associated susceptibility to over-harvesting even when catch levels remain constant.

[2] R Core Team. 2024. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from https://www.R-project.org/.

[3] Two rock banks in SSEO (i.e., Learmonth Bank and a bank west of Hazy Islands) are well outside the 100-fathom contour but are within the operational depth of the ROV (200 m; 109 fathoms) and are included in the DYRH.

seafloor maps. Seafloor mapping has been performed across 3,907 km^2 of SEO (Table 1, Figure 4; Brothers et al. 2016; Fugro Pelagos, Inc. 2004, 2005; Greene et al. 2007; McRea et al. 1999; Olson et al. 2018; TerraSond Ltd. 2010; Thales GeoSolutions [Pacific] Inc. 2001a, 2001b, 2002). The surveyed seafloor has been classified into habitat type by the Moss Landing Marine Laboratories' Center for Habitat Studies using bathymetry, backscatter, and direct observations from the Delta submersible, and reduced to substrate induration (i.e., hardness) categories of soft, mixed, or hard (Greene et al. 1999). Seafloor identified as a hard substrate was considered a rocky habitat and served as the basis of the DYRH designation (Table 1; O'Connell and Carlile 1993; O'Connell et al. 2007).

For areas without geophysical data, longline set locations from the directed DSR fishery with CPUE ≥ 0.04 yelloweye rockfish per hook were included. When set locations were only noted by their start positions, the point was buffered by 0.8 km in ArcGIS Pro[4] to create a circular polygon. This buffer distance was originally established by comparing logbook set start locations to mapped sidescan sonar data in the Edgecumbe area. Both 0.8 km and 1.6-km buffers were evaluated, and it was found that the 0.8-km buffer more closely aligned with the boundaries of known rocky habitat (C. Brylinsky, Former Division of Commercial Fisheries Fishery Biologist, ADF&G, Sitka, unpublished protocol). To maintain consistency with this previous methodology, the 0.8-km buffer continues to be used for start-only positions. A single buffered set is represented as a circular polygon with a 1.6 km diameter. When both start and end locations of the commercial set were noted (as was required starting in 2002), a polygon was created by buffering the entire set by 0.5 km. This buffering distance was chosen based on observed travel of 4 tagged yelloweye rockfish in Oregon (Brylinsky et al. 2009). The buffered polygons determined by the commercial fishery data were considered continuous and merged with neighboring polygons if < 0.9 km apart. Of those designated areas, those that were ≥ 2.3 km in length (the minimum size necessary to allow two, non-overlapping transects) were included in the DYRHs.

The NSEO section is the only management area where NOS data are used because commercial fishery logbook data were more limited (i.e., 1993–1996) than in the other management areas. Features designated as coral, rock, or hard seafloor on NOAA charts were buffered by 0.8 km in ArcGIS Pro[4] and were included in the DYRH if the depth was between 60 to 183 m (33 to 100 fathoms). This depth range was used because submersible surveys conducted from 1994–2009 showed that 90% of yelloweye rockfish were observed within this range (K. Green, Former Division of Commercial Fisheries Fishery Biologist, ADF&G, Sitka, August 30, 2011, email communication).

The area of the DYRH in each management area has evolved and improved over time as new sonar surveys have been conducted and new data collected. The most recent DYRH estimates were incorporated in the biomass estimates for CSEO in 2013, EYKT and SSEO in 2014, and NSEO in 2017, reflecting updates from new sonar surveys and data collection. The total area of each DYRH varies by management area, with a portion derived from sonar-based mapping (Figure 4, Table 1). The DYRH has been estimated for SEO at 3,898 km^2. The Fairweather Grounds DYRH in EYKT section is comprised of 739 km^2, 68% of which is derived from sonar; the DYRH in NSEO is 442 km^2 with 25% derived from sonar; the DYRH in CSEO is 1,661 km^2 with 27% derived from sonar; and the DYRH in SSEO is 1,056 km^2 with 30% derived from sonar (Figure 4, Table 1).

[4] Esri Inc. 2022. ArcGIS Pro (Version 3.0.0). https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview.

Sample Size and Design: The number of transects to be conducted in each survey is based on yelloweye rockfish encounter rates from the previous survey in that management area and the targeted precision goal (CV ≤ 25%). Individual transects are 1 km in length, and the total number of transects is determined by calculating the total survey distance necessary to obtain sufficient fish observations with a minimum of 20 individual transects (Buckland et al. 1993). Buckland et al. (1993) recommend selecting a total transect line length (i.e., the sum of all transect lines) long enough to obtain 60–80 samples (individual fish observations) such that:

$$L_{target} = \left(\frac{b}{\{cv_t(\hat{D})\}^2}\right)\left(\frac{L_0}{n_0}\right) \quad (1)$$

where L_{target} is the target total transect length, cv_t is the target coefficient of variation of the density estimate $\hat{D}$, L_0 and n_0 are the line-length and observed animal numbers from the previous survey in the management area, respectively, and b is a dispersion parameter. The dispersion parameter, b, is estimated using the number of yelloweye rockfish observed (n) and the CV of the previous density estimate in that area ($cv(\hat{D})$) such that

$$\hat{b} \cong n \cdot \{cv(\hat{D})\}^2 \quad (2)$$

Substituting eq (2) for *b* into eq (1) resolves to

$$L_{target} = \frac{L\{cv(\hat{D})\}^2}{\{cv_t(\hat{D})\}^2} \quad (3)$$

This provides the target total line transect length for a given management area in a given year which is then divided into 1-km transects (Buckland et al. 1993).

To determine the location of survey transects, random points were selected within the bounds of the DYRH such that there is a minimum distance of 1.9 km (EYKT and SSEO) or 2.0 km (CSEO and NSEO) between each set of points. This selection was done using ArcGIS Pro and ET GeoWizards software[5] ArcGIS (Appendix B). These random points served as the midpoint for the 1-km transects. The minimum distance criteria were selected to prevent overlap among transects while also accounting for vessel transit time between stations. Moreover, a 1.9-km minimum distance was used in EYKT and SSEO because the DYRH in EYKT is not large enough to accommodate all required transects at greater spacing, and in SSEO, additional points are needed to ensure adequate sampling coverage due to the high proportion of deep habitat. Random point locations were removed from the survey design if they were in depths ≥200 m, the functional operating depth for the ROV.

Transect lines of 1-km length were centered at each random point with 4 possible orientations along the cardinal and ordinal directions (Figure 5). This step was included to accommodate logistical constraints in the field and to allow the crew to choose a single transect at each point based on currents and winds at the time of the survey. In cases where a transect line was not completely within the DYRH, the line was shifted through the random point until the greatest proportion was in the DYRH while still including the random point (Figure 5).

[5] ET Spatial Techniques. 2017. ET GeoWizards (Version 12). https://www.ian-ko.com.

DATA COLLECTION

A Deep Ocean Engineering Phantom HD2+2 ROV was used as the survey vehicle (property of ADF&G Division of Commercial Fisheries in Homer, AK; Figure 6). The ROV was fitted with a pair of high-definition machine-vision stereo cameras (right and left) and a *belly* camera that recorded video data from the line transects (Figure 7). The ROV was also equipped with the main camera, which is a wide-angle, color camera that the pilot used to navigate the ROV and a forward-facing camera that recorded black and white video. Footage from the main and forward-facing cameras were not used for analysis. Two pairs of scaling lasers, mounted in line with the main camera and the belly camera, were used as measurement reference for objects viewed in the non-stereo cameras. The ROV was tethered to the vessel and computers on board by fiber optic cables. Dive number, date, transect number, transect type, transect start and end times, and comments were logged manually for each dive (Appendix C). Navigation data were obtained using Hypack singlebeam editor software to perform ROV operations, including tracking the ROV and estimating transect lengths. Information was recorded on the position of the vessel and the ROV, including heading, pitch, and roll. The ROV's position was calculated using an ultra-short baseline (USBL) tracking system and vessel position from global positioning system (GPS). Survey operations are further detailed in Appendix D.

DATA ANALYSIS

Transect Line Length Correction

Transect length is a critical component of both sample size determination and density estimation. Although transects were planned to be 1 km in length, the actual surveyed length often differed because transect segments were only retained for final analysis when the ROV was moving normally at a constant speed of 0.5 knots as conditions allowed, the seafloor was in view approximately 1 m off the bottom, and visibility was clear enough to view fish on the transect line. These criteria are required because a key assumption of distance sampling is that all fish on the transect line are detected. Each video segment was assigned a video quality code (Appendix E) using SeaGIS EventMeasure software[6] (SeaGIS Pty Ltd., EventMeasure v6.42, hereafter referred to as SeaGIS EventMeasure). Video from the left stereo camera was reviewed to assign video quality codes. 3D measurements are not recorded during quality review, so video from the right camera is not used during this analysis. Segments were only assigned a *poor visibility* code when fish could not be identified on the transect line. Video segments designated as *good going forward* were retained for final analysis.

Navigation data were recorded every 2–3 seconds; however, navigation data must be documented at 1-second intervals to accurately match with video observations. To achieve this, positions were interpolated to 1-second intervals. The navigation data were then smoothed using a smoothing spline function in R[7], filtered to remove outliers using the Hypack singlebeam editor, and position errors were removed. Both smoothed and un-smoothed navigation data were mapped in ArcGIS Pro[8]and video quality segments were overlaid with smoothed navigation data using linear referencing.

[6] Seager, J. 2023. EventMeasure user guide. SeaGIS Pty Ltd, November 2023 (Version 6.42).

[7] R Core Team. 2024. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available from https://www.R-project.org/.

[8] Esri Inc. 2022. ArcGIS Pro (Version 3.0.0). https://www.esri.com/en-us/arcgis/products/arcgis-pro/overview.

The mapped transects were reviewed for any anomalies (e.g., zigzags or loops), which are removed as necessary. Actual transect line lengths were estimated from the cleaned navigation data. Despite these corrections, transect lengths rarely deviate significantly from the targeted 1-km length and were usually greater than 950 m.

Fish Video Review: Enumeration, Estimation of Distance from Transect Line, and Calculation of Fish Length

Survey transect videos from the stereo and belly cameras are reviewed and annotated by staff in the office using SeaGIS EventMeasure. Video review for yelloweye rockfish includes enumerating fish, documenting fish behavior (Appendix F), and estimating maturity stage using coloration and other morphological characteristics (Appendices G and H). Non-yelloweye DSR species, black rockfish, lingcod, and halibut are enumerated for species composition and measured for length analyses only. When time allows, other species are also enumerated (Appendix I). Care is taken to avoid double-counting fish that swim into the field of view more than once, though this behavior is rare for yelloweye rockfish. The camera attached to the belly of the ROV is also reviewed for yelloweye rockfish to ensure all yelloweye rockfish on or near the transect line are observed, an essential assumption of distance sampling.

Video review also includes estimating fork length (mm) and calculating the distance (m) of the fish from the transect line using stereoscopic methodology. These measurements are estimated by SeaGIS EventMeasure using an x, y, z coordinate system that describes a point in space relative to the ROV and transect line (Figure 8). The x measurement is the perpendicular distance to the fish and is the data used in the distance analysis to model the probability detection function. The video reviewer begins by recording the fish at 1st observation on the stereo camera video to minimize any effect of fish movement in response to the ROV as it moves closer to the animal. The 3D point measurement is taken when the fish is visually well defined enough to produce quality estimates, defined as the root mean square (RMS) error of the variance <10 mm (Figure 9). The precision of a 3D point is best when the fish is close to the camera and in the center field of view. Yelloweye rockfish may be observed at distances as great as 8 m from the ROV.

Once the optimal fish image is selected (i.e., earliest view, prior to the fish reacting to the camera, and when best oriented to view length), the reviewer will generate coordinates in SeaGIS EventMeasure for the tip of the snout (x_1, y_1, z_1) and the fork of the tail (x_2, y_2, z_2). The distance of the fish from the transect line is generated by estimating the x component from the midpoint of the line connecting the fish snout and tail (i.e., the average of x_1 and x_2). Fish length is estimated by calculating the difference between the snout and tail coordinates to generate Δx (difference between x_1 and x_2), Δy, and Δz and thus the length of the fish, d, is

$$d = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}$$

and the standard deviation of fish length is

$$\sigma_d = \frac{1}{d}\sqrt{2(\Delta x^2\sigma_x^2 + \Delta y^2\sigma_y^2 + \Delta z^2\sigma_z^2)} \quad (4)$$

where σ_x, σ_y, and σ_z are the standard deviations of Δx, Δy, and Δz and are estimated by SeaGIS EventMeasure. The standard deviations of x and y are generally equivalent and small compared to the standard deviation of z. When a fish is parallel to the transect line Δz=0, and there is no contribution to the error from Δz, but as a fish turns away from the camera, Δz increases, resulting in a decrease in precision (σ_d). Obtaining a horizontal direction of <30° for each fish and a high precision value is attempted. The horizontal direction and precision may be used to filter out less accurate length measurements.

Fish that are not oriented well enough to generate a length measurement or can only be partially viewed (i.e., a fish is partially under a rock, or in a curled position) are enumerated but not measured for length. If a fish cannot be measured for any reason, a note is made in the comments explaining why the measurement was not taken. If the fish is not oriented well enough to generate a length measurement, the video reviewer will use the x component from a single point near the center of the body. When a 3D point measurement cannot be generated due to fish only being observed in the ROV's belly camera or in 1 stereo camera, the perpendicular distance is estimated using the 2 laser beams in the field of view. The species review template setup and procedures are further detailed in Appendices J and K.

Evaluation of Distance Sampling Assumptions

Distance sampling (Buckland et al. 1993, 2015) requires that 3 major assumptions are met to achieve reliable estimates of density from line transect sampling: (1) objects on the line must be detected with certainty (i.e., every object on the line must be detected), (2) objects must be detected at their initial location (i.e., animals do not move toward or away from the transect line in response to the observer before distances are measured), and (3) distances from the transect line to each object are measured accurately. Failure to satisfy these assumptions may result in biased density estimates. These assumptions are carefully evaluated during each survey analysis.

To ensure the 1st assumption is met, the probability detection function and histograms of the distance data were examined. If the detectability at the transect line was close to 100%, then the probability detection function shape has a broad shoulder at the origin line that drops off as distance from the line increases (Figure 10A; Buckland et al. 1993). In earlier submersible surveys, the observer looked out of the submersible port window to identify fish, and fish near the submersible were sometimes missed by the observer and the main camera. To improve detection on the line, a forward-facing camera was added in 1995. In contrast, the ROV's stereo cameras are forward-facing, allowing reviewers to more effectively detect fish on the transect line. Since 2015, a belly camera has been used in all surveys to further minimize missed detections. Review of footage from the belly camera confirms that fish near the transect line are successfully recorded using the stereo cameras.

The 2nd assumption was evaluated by examining the probability detection function shape and the behavioral response of yelloweye rockfish to the ROV. If fish movements are random and slow relative to the speed of the ROV, the assumption is considered valid (Buckland et al. 1993). Certain probability detection function shapes may indicate behavioral responses to the ROV: a peak near the origin line could suggest attraction to the ROV, while a dip near the origin line followed by an increase in detection at some distance away from the line may indicate avoidance (Figure 10B). However, Byerly et al. (2015) found that yelloweye rockfish typically exhibit random movement prior to detection. Consistent with those findings, survey data since the adoption of the ROV in 2012 show that approximately 74% of all yelloweye rockfish displayed minimal or slow movement. Of these, about 69% showed no directional response (i.e., they were milling or resting on the bottom). These results suggest that yelloweye rockfish move slowly enough, relative to the speed of the survey vehicle, to meet this assumption during surveys (Byerly et al. 2015).

The 3rd assumption of distance sampling precision was met by using the SeaGIS EventMeasure, as previously described in the methodology section. During submersible surveys, the observer visually estimated the perpendicular distance from the submersible to a fish, which introduced potential measurement error, even with pre-dive calibration using a hand-held sonar gun. In contrast, the ROV provides 3D point measurements (x, y, z coordinates; Figure 8) from video footage processed with SeaGIS EventMeasure. The ability to reverse, replay, and slow down footage improves measurement precision.

Density and Biomass Estimates

The density of yelloweye rockfish in the DYRH was estimated by fitting a probability detection function to the data (the distance of each fish from the transect line) that described the probability a fish was observed given the fish's distance from the transect line. The probability detection function was used to estimate the density of fish within the width of the transect strip that was determined by the maximum distance that fish were observed from the transect line. Because the transects were simple random samples of the DYRH, the density estimated within the transect strips was considered an unbiased estimate of fish density within the DYRH (Buckland et al. 2015). Yelloweye rockfish density was estimated using the package *Distance*[9] in R, based on the following equations:

$$\widehat{D} = \frac{n\hat{f}(0)}{2L} \quad (5)$$

and the probability of detection evaluated at the origin of the transect line ($\hat{f}(0)$) is

$$\hat{f}(0) = \frac{1}{\mu} = \frac{1}{wP_a} \quad (6)$$

where n is the number of subadult and adult yelloweye rockfish observed, L is the total transect line length, μ is the effective width of the transect strip, w is the width of the transect strip, and P_a is the probability of observing an object in the defined area. Only adult and subadult yelloweye rockfish were included in the density estimate; juveniles were excluded due to differing detection probabilities and life history considerations.

For a given management area, several candidate models were fit to the distance data using the *Distance* package in R. These models included different detection functions (uniform, half-normal, and hazard rate) with various adjustment terms (cosine, simple polynomial, and Hermite polynomial adjustments) that describe the probability of a fish being detected based on its distance from the transect line. Additionally, 2 covariates, life stage (adult or subadult) and depth, were tested to determine whether they affect detection probabilities and should be included in the model (Thomas et al. 2010). All models were run with the full dataset and with a truncated dataset that excludes the 5% of observations farthest from the transect line. Truncation often results in a better fit by eliminating long tails in the detection function that can reduce model precision or require unnecessary adjustments (Thomas et al. 2010). The decision to truncate was based on goodness-of-fit tests (e.g., chi-squared tests) and visual inspection of the fit between the detection function and distance histograms. If truncation improved model fit with minimal loss of data, it was preferred.

[9] Miller, D. L., E. Rexstad, L. Thomas, L. Marshall, and J. L. Laake. 2019. Distance sampling in R. Journal of Statistical Software 89(1): 1–28.

Once a determination was made regarding the truncation of data, models were ranked based on Akaike Information Criterion (AIC) value where the best fit results in the lowest AIC value (and thus a ΔAIC value of 0). If 1 model clearly outperformed the others (ΔAIC of the 2nd best model > 4), density estimates from that model were selected. Multiple models having similar AIC scores (ΔAIC < 6) and goodness-of-fit as described by χ^2 tests indicated uncertainty in the shape of the true detection function. If density estimates from the best models were similar regardless of the detection function, the best model was used. However, in 2022, the density estimates varied among competing models, so a model averaging procedure was used to account for uncertainty in selecting the best detection function (Thomas et al. 2010; Joy et al. 2022).

To average the suite of best models as determined by AIC scores (ΔAIC < 6), a bootstrap procedure was used (Williams and Thomas 2009; Thomas et al. 2010; Joy et al. 2022). In this procedure, the transects represent the sampling unit and the bootstrap was performed by resampling the transects (as a whole) with replacement. For each bootstrap replicate, the best candidate models (ΔAIC < 6 and good fit) were fit to the data, the best model was selected based on AIC rankings and the density calculated. Estimates of density were taken as the mean of the bootstrap resample estimates (Williams and Thomas 2009; Thomas et al. 2010; Joy et al. 2022). Coefficients of variation (CVs) were calculated as the standard deviation of the bootstrap estimates divided by the mean, and the percentile method is used to obtain confidence intervals (Williams and Thomas 2009; Joy et al. 2022).

Biomass of adult and subadult yelloweye rockfish is derived as the product of estimated density, the estimate of DYRH area, and the average weight of fish for each management area (O'Connell and Carlile 1993). This was also calculated for each bootstrap resample estimate of density to produce non-parametric estimates of biomass in 2022 (Joy et al., 2022). The average weight of yelloweye rockfish sampled from the directed commercial fishery and from bycatch in the halibut fishery was used to expand density estimates to biomass for each management area. The resulting biomass estimate was used as 1 of the data inputs for the REMA model for the stock assessment (Joy et al. 2022; Stern et al. 2024). Once results were finalized, the code and outputs associated with the analysis were submitted to GitHub in accordance with reproducible research policies.

SCHEDULE AND DELIVERABLES

Dates	Activity
May/June 2022, August 2023	Created and provided vessel captain and ROV pilot with survey dive locations and supporting materials.
May/June 2022, August 2023	Conducted ROV dive survey of SEO management areas (CSEO/NSEO–2022, EYKT–2023).
July/September 2022, 2023	ROV pilot and navigator edited and sent completed video and other supporting files to Fishery Biologist II for review.
July 2022, August 2023, July 2024	Stereo ROV video reviewed by Fishery Biologist II for various rockfish and other important species. Quality review and ROV belly camera review was conducted by Fishery Biologist I.
November 2022, 2023, 2024	Survey results and DSR stock assessment were submitted by Fishery Biologist II and designated biometrician and reviewed by the Gulf of Alaska Plan Team for approval.
January 2023, 2024, 2025	All video review was completed and saved as .csv files from SeaGIS software (EventMeasure) in the folder labeled "ROVSurvey" on the

	Groundfish network drive (M:\ROVSurvey). All video hard drives were mailed and archived at Network Services in Juneau.
February 2023, 2024, 2025	Data analyses were completed in R and results reviewed by the Project Leader. Once results were finalized, the code associated with the analysis was submitted to GitHub for biometric review.

Responsibilities

Fisheries Biologist III: Groundfish project leader, supervises Project Fishery Biologist II and reviews results prior to biometric review.
Fisheries Biologist II: Scientific crew leader, responsible for generating dive locations, delivering navigation files to vessel and ROV crew prior to surveys, assisting with deployment and retrieval of ROV during survey and makes survey design decisions when needed. Conducts post survey stereo video review and responsible for density estimate analyses. This position is also the contact for the data associated with this survey.
Fisheries Biologist II: ROV pilot, responsible for conducting survey dives and ROV technical support. Edits, copies, and sends dive videos and supporting materials to the Project Fisheries Biologist II for video review.
Research Analyst II: ROV navigator, responsible for navigating the ROV, pilot, and vessel along the dive transects, recording video, and noting technical aspects of each dive.
Fisheries Biologist I: Conducts quality video and/or belly camera review for missed species from stereo video review. Scientific crew leader on ROV dive surveys.
Fisheries Biologist I: May conduct quality video and/or belly camera review for missed species from stereo video review.
Biometrician II: Reviews data analyses, provides modeling, and biometric support.

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TABLES

Table 1.–Area estimates for sonar locations and rocky habitat by data source and management area in Southeast Alaska: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), Southern Southeast Outside (SSEO) Sections.

	Sonar location	Sonared area (km^2)	Area rocky habitat (km^2)
EYKT	Fairweather West Bank	784	402
	Fairweather East Bank	288	98
Total sonar		1,072	500
Total rock (sonar & fishery)			739
Percentage rocky habitat from sonar			68%
NSEO	Cross Sound	849	109
Total sonar		849	109
Total rock (sonar, fishery & NOAA chart)			442
Percentage rocky habitat from sonar			25%
CSEO	Cape Edgecumbe	538	328
	Cape Ommaney	294	114
Total sonar		832	442
Total rock (sonar & fishery)			1,661
Percentage rocky habitat from sonar			27%
SSEO	Hazy Islands	400	120
	Addington	84	47
	Cape Felix	140	78
	Learmonth Bank	530	77
Total sonar		1,154	322
Total rock (sonar & fishery)			1,056
Percentage rocky habitat from sonar			30%

FIGURES

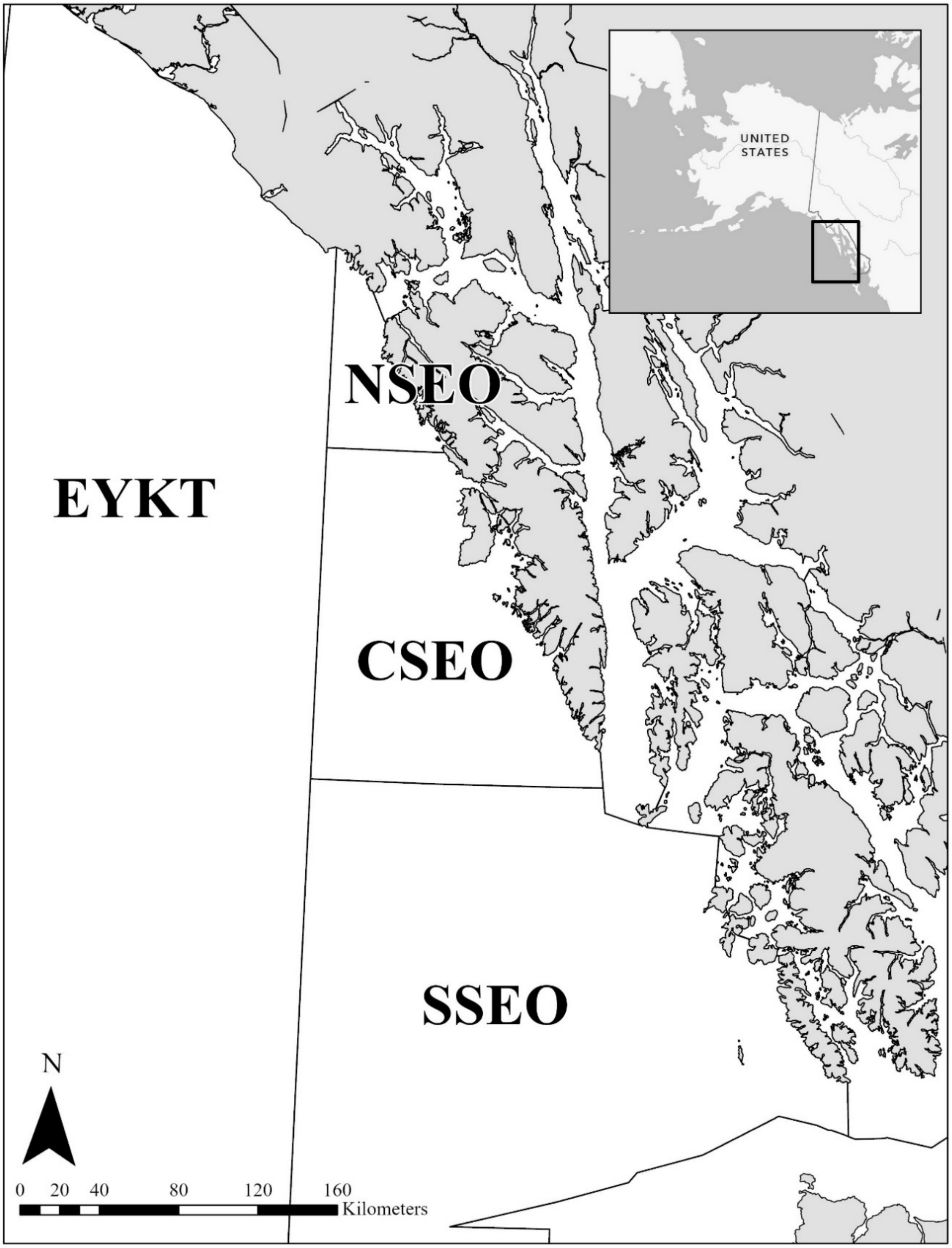


Figure 1.–Southeast Outside (SEO) Subdistrict demersal shelf rockfish management areas in Southeast Alaska, including East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) Sections.

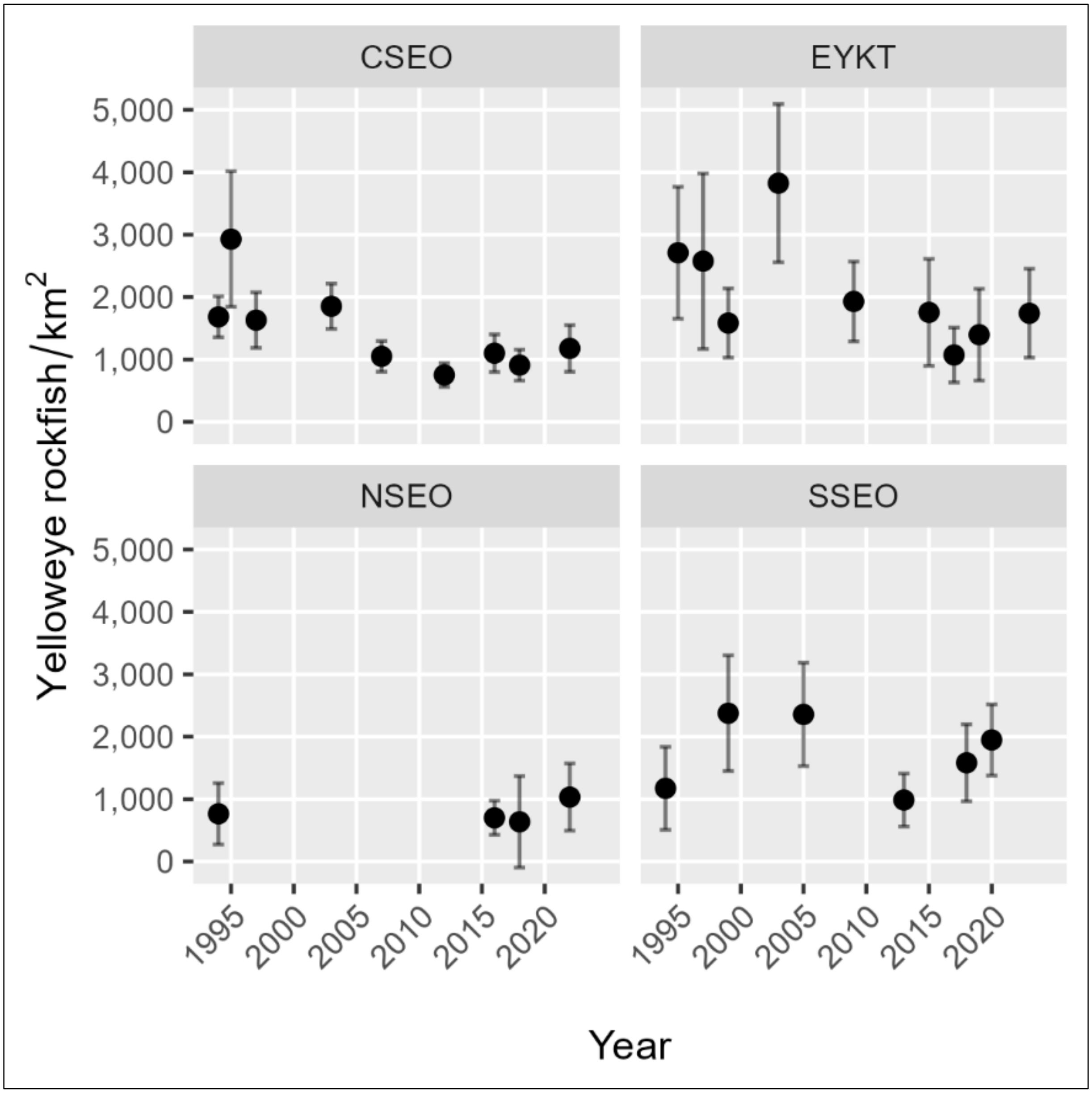


Figure 2.–Density of adult and subadult yelloweye rockfish per km^2 by survey year and management area: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), Southern Southeast Outside (SSEO) Sections, 1994–2023. Error bars show upper and lower confidence intervals for density estimates (black circles).

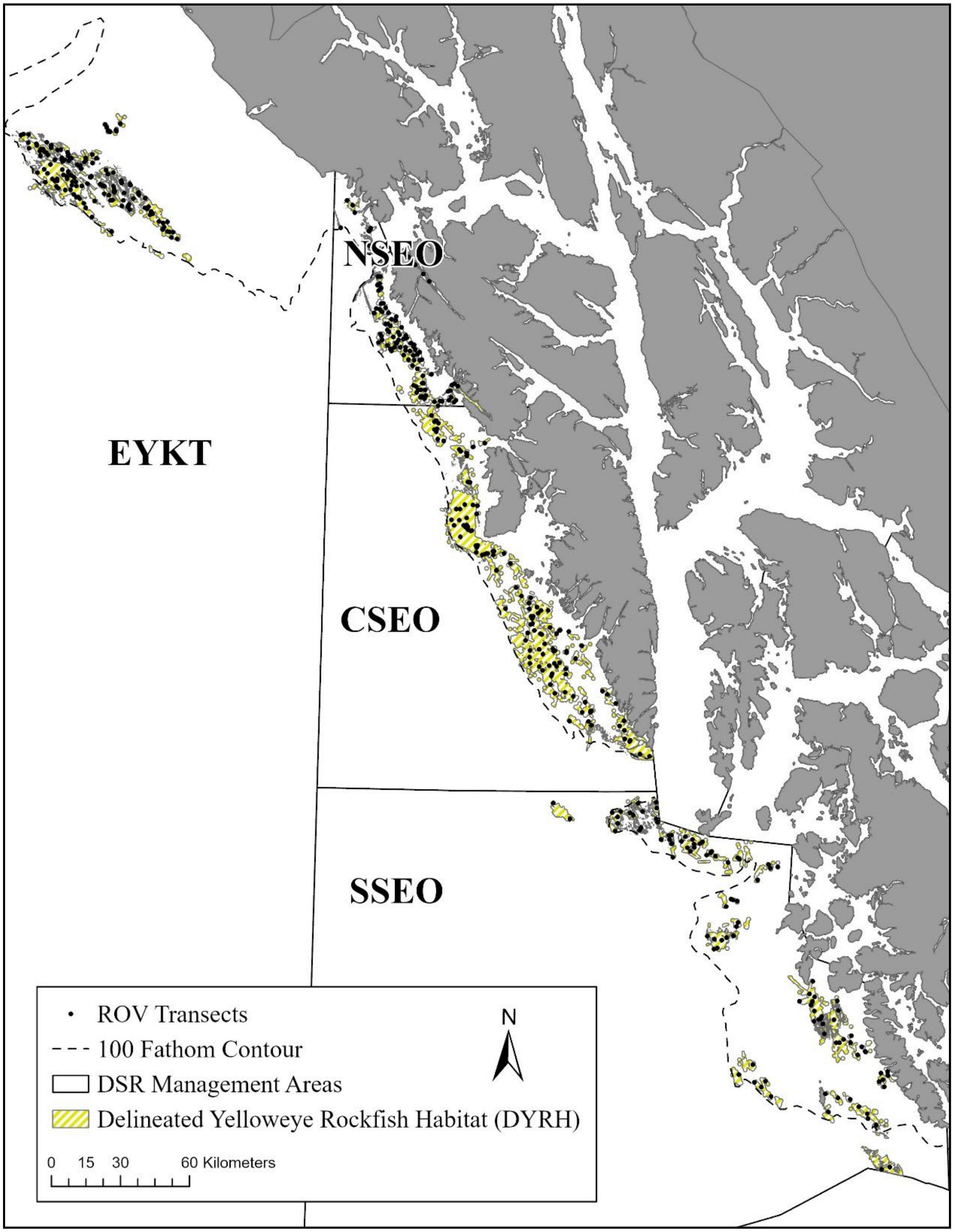


Figure 3.–Remotely Operated Vehicle (ROV) transect locations (black circles) within the delineated yelloweye rockfish habitat (DYRH; yellow hatching) for ROV surveys in the Southeast Outside (SEO) Subdistrict.

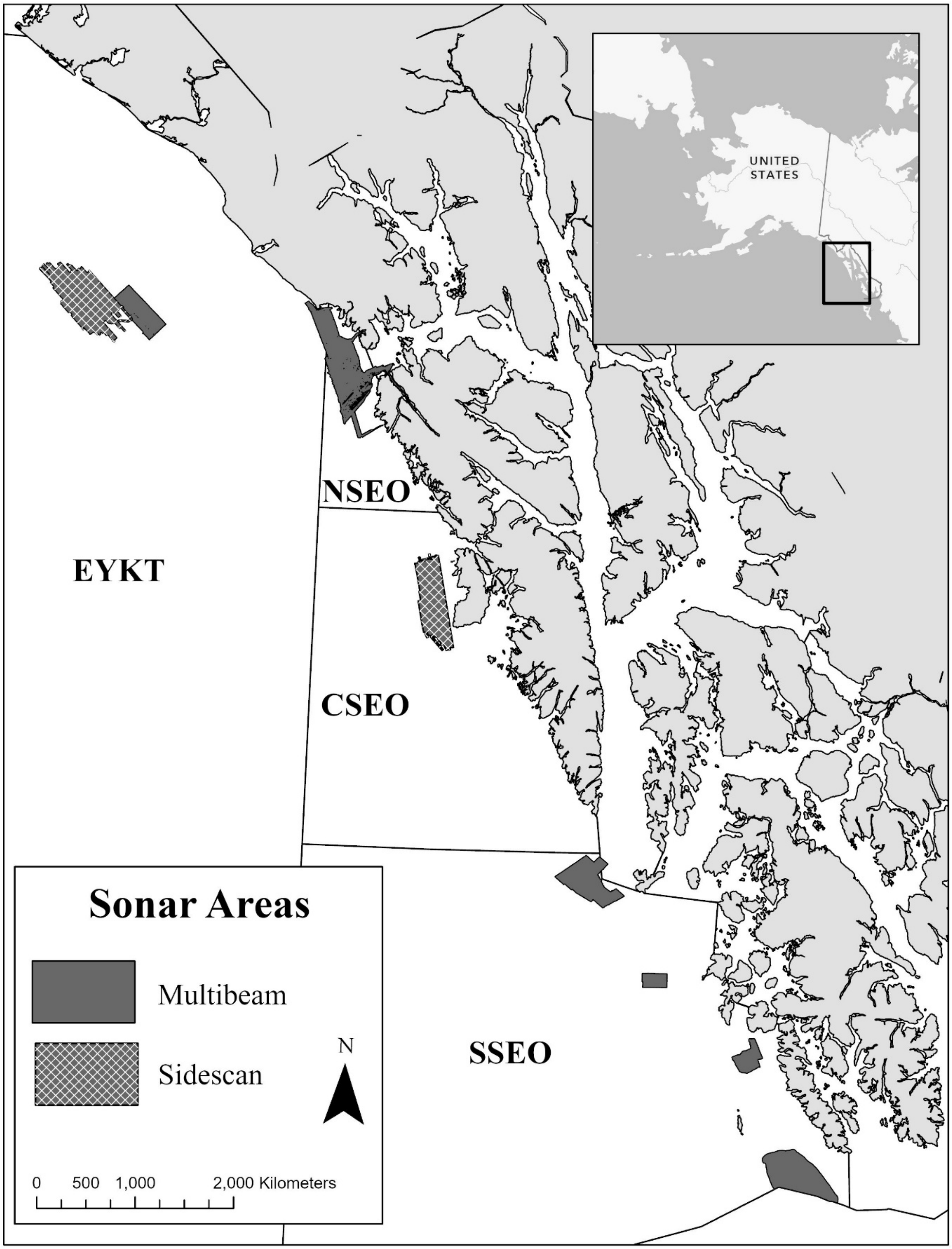


Figure 4.–Multibeam (gray polygons) and sidescan (hatched gray polygons) performed in Southeast Alaska used to delineate yelloweye rockfish habitat.

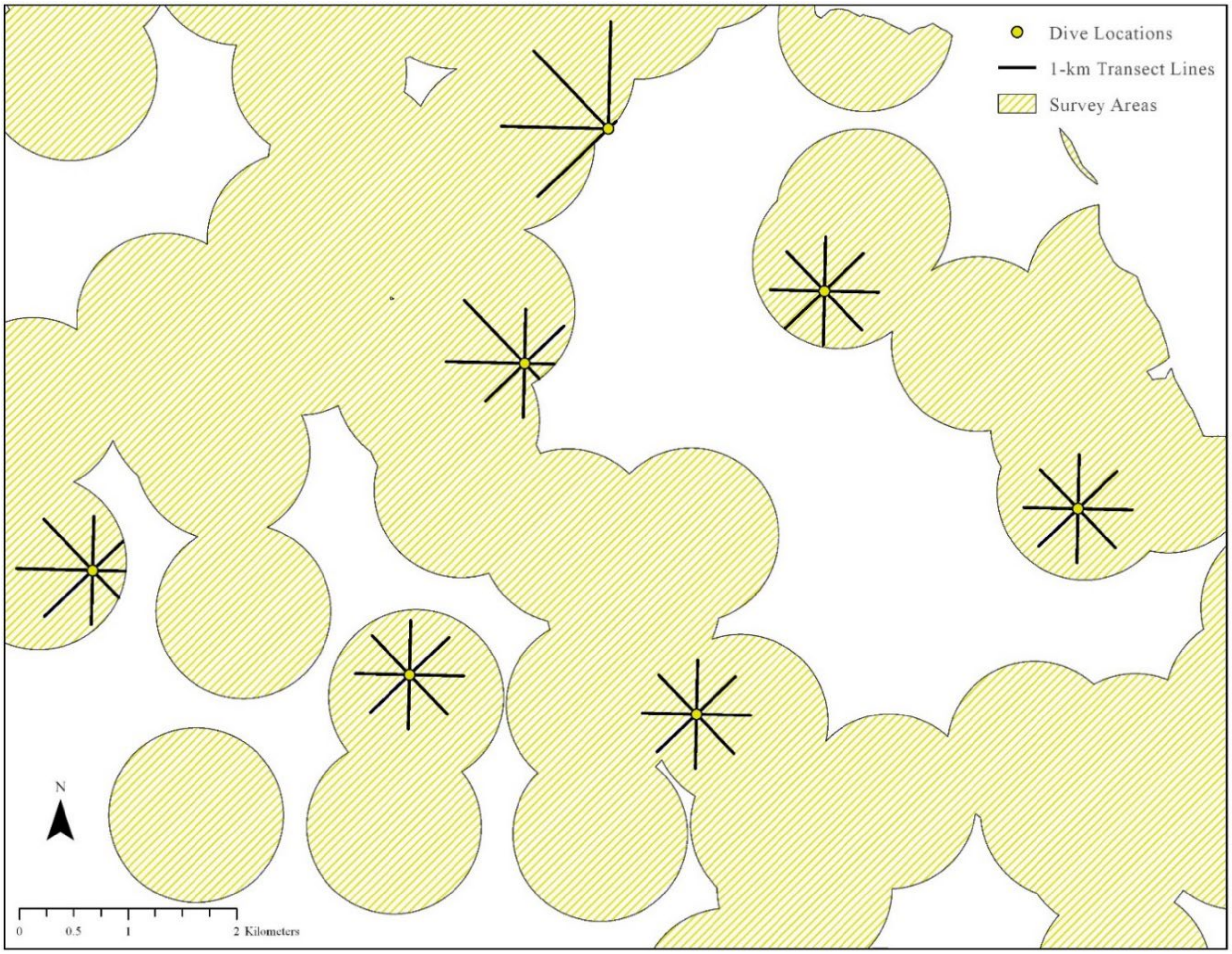


Figure 5.–Example of 1-km transect lines. Transect lines (star symbols) are adjusted around dive locations (yellow dots) in some cases to remain within the delineation of survey areas (yellow hatched polygons). Yellow dots represent random points from within the delineated yelloweye rockfish habitat (DYRH) and black lines represent options for transect lines at each point. Only 1 transect line is run per point and is chosen based on currents and winds at the time of surveying.

Figure 6.–Deep Ocean Engineering Phantom HD2+2 remotely operated vehicle (ROV) *Buttercup* used for the survey.

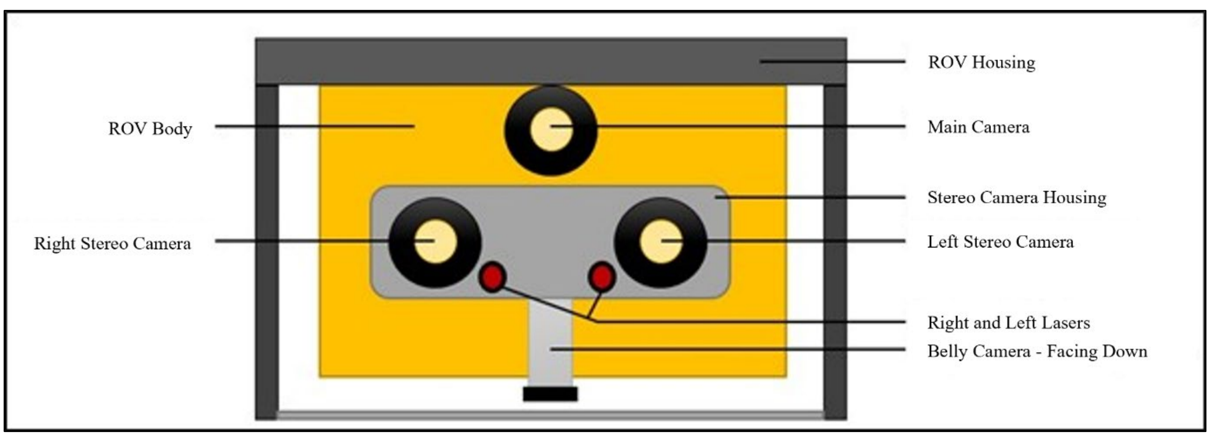


Figure 7.–Remotely operated vehicle (ROV) face showing the locations of the lasers and the main, belly, and stereo cameras. The forward-facing camera is not pictured.

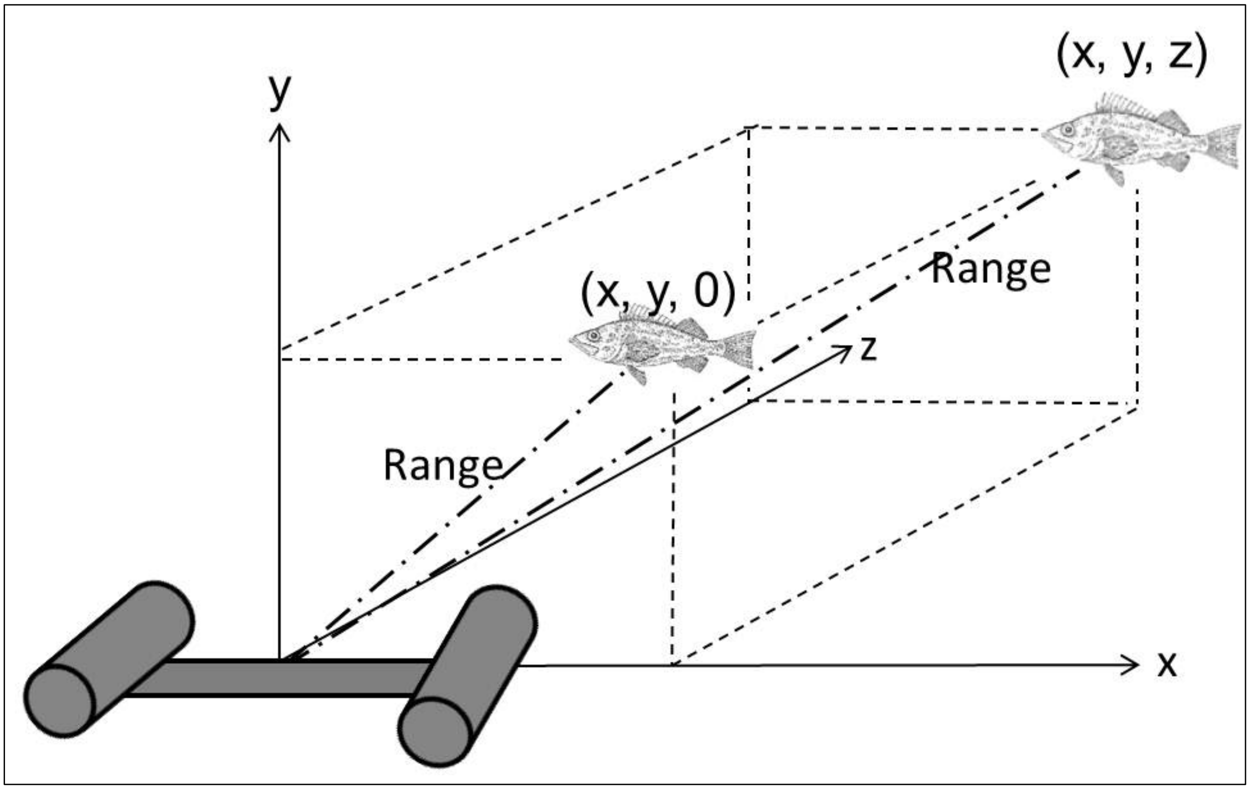


Figure 8.–Components of a 3D point measurement. Z represents the direction of travel along the transect, y represents the vertical distance from the transect, and x represents the perpendicular and horizontal distance from the transect. The x measurement is the data used in the distance analysis to determine rockfish density in the study area.

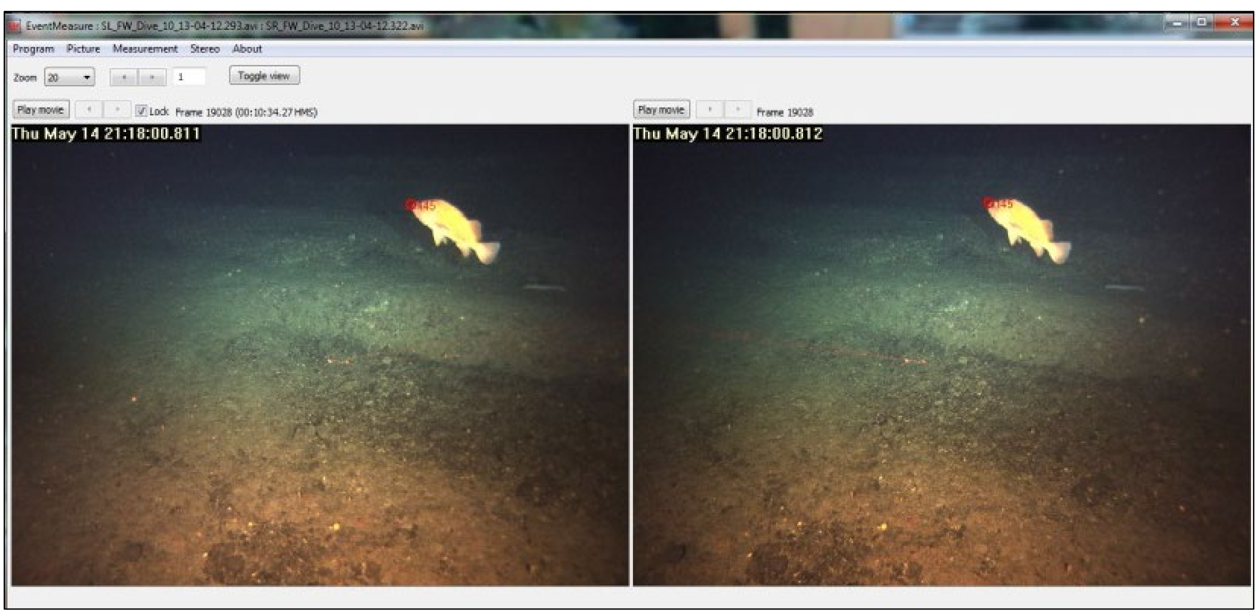


Figure 9.–Yelloweye rockfish marked in the overlapping field of view of the left and right stereo cameras to collect a 3D point measurement using SeaGIS EventMeasure software.

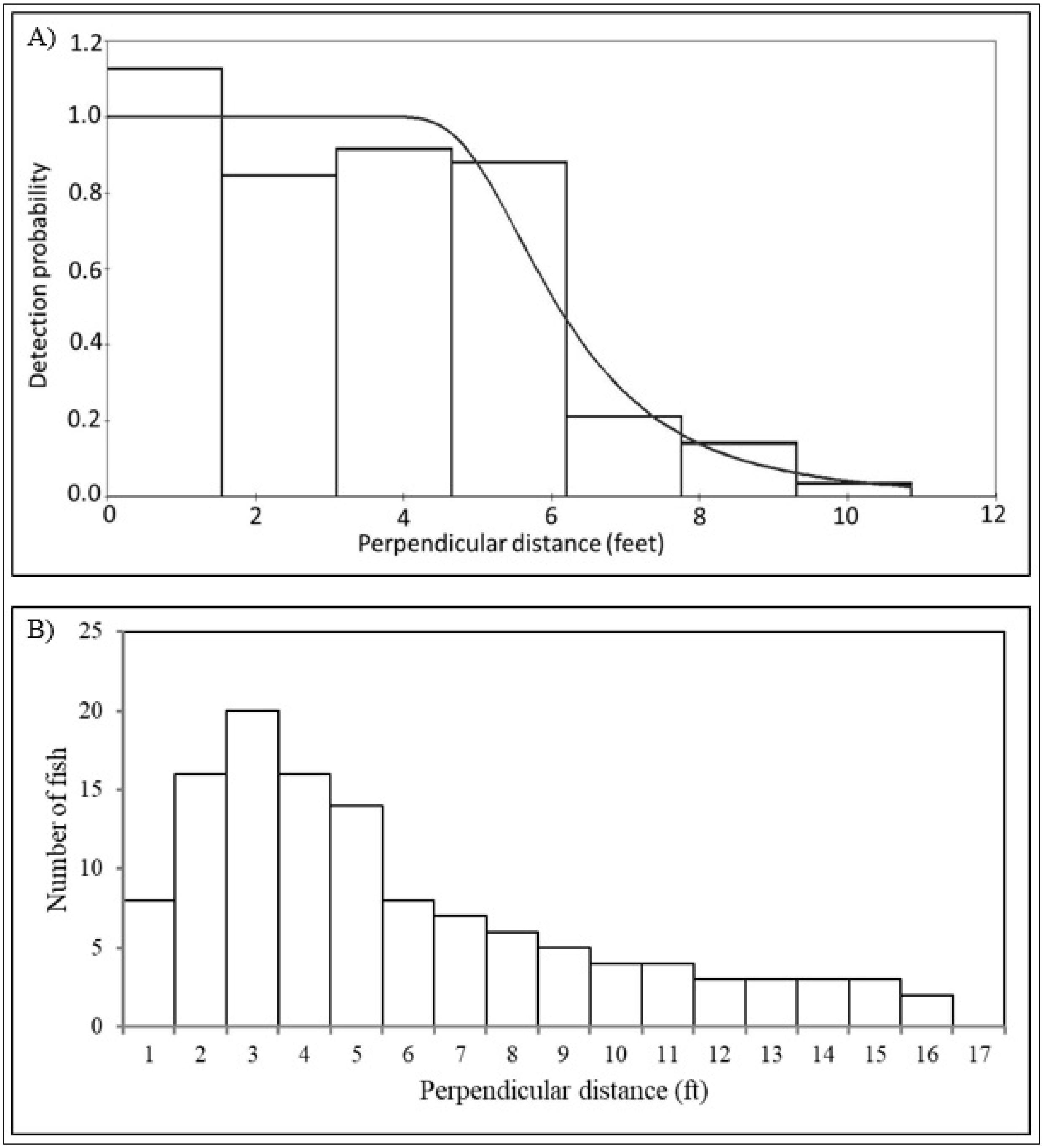


Figure 10.–Probability detection function from the remotely operated vehicle (ROV) survey which has a *shoulder* at the origin, and no peaks away from the origin that would indicate avoidance behavior in response to the ROV (A panel). Histogram of perpendicular distance data, illustrating avoidance behavior in which fish move away from the ROV prior to detection (B panel).

APPENDICES

Appendix A.–Submersible (1994, 1995, 1997, 1999, 2003, 2005, 2007, 2009) and remotely operated vehicle (ROV) (2012, 2013, 2015–2020, 2022, 2023) yelloweye rockfish (YE) density estimates with 95 percent confidence intervals (CI) and coefficient of variation (CV) by year and Southeast Outside (SEO) Subdistrict management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO). YE encounter rates and the number of transects, YE, and meters surveyed are shown.

Survey Area	Survey Year	Number transects	Number YE[b] observed	Area surveyed (m)	Yelloweye encounter rate (YE/m)	Yelloweye density (YE/km²)	Lower CI (YE/km²)	Upper CI (YE/km²)	CV
EYKT[a]	1990[c,d]	26	–	–	–	–	–	–	–
	1994[c,d]	4	–	–	–	–	–	–	–
	1995	17	330	22,896	0.014	2711	1776	4141	0.20
	1997	20	350	19,240	0.018	2576	1459	4549	0.28
	1999	20	236	25,198	0.009	1584	1092	2298	0.18
	2003	20	335	17,878	0.019	3825	2702	5415	0.17
	2009	37	215	29,890	0.007	1930	1389	2682	0.17
	2015	33	251	22,896	0.008	1755	1065	2891	0.25
	2017	35	134	33,960	0.004	1072	703	1635	0.21
	2019	33	288	33,653	0.009	1562	951	2566	0.25
	2023	22	189	21,032	0.009	1741	1134	2672	0.21
NSEO	1994[c]	13	62	17,622	0.004	765	383	1527	0.33
	2001[d]	8	–	–	–	–	–	–	–
	2016	36	125	34,435	0.004	701	476	1033	0.20
	2018	30	95	29,792	0.003	553	388	788	0.16
	2022	34	146	32,810	0.004	1033	729	1604	0.27
CSEO	1990[c,d]	18	–	–	–	–	–	–	–
	1991[c,d]	27	–	–	–	–	–	–	–
	1994[c,d]	44	–	–	–	1,683	–	–	–
	1995	24	235	39,368	0.006	2,929	–	–	0.19
	1996[d]	17	–	–	–	–	–	–	–

-continued-

Survey Area	Survey Year	Number transects	Number YE[b] observed	Area surveyed (m)	Yelloweye encounter rate (YE/m)	Yelloweye density (YE/km^2)	Lower CI (YE/km^2)	Upper CI (YE/km^2)	CV
CSEO	1997	32	260	29,273	0.009	1,631	1,224	2,173	0.14
	2003	101	726	91,285	0.008	1,853	1,516	2,264	0.10
	2007	60	301	55,640	0.005	1,050	830	1,327	0.12
	2012	46	118	38,590	0.003	752	586	966	0.13
	2016	32	160	30,726	0.005	1,101	833	1,454	0.14
	2018	35	193	33,700	0.006	898	672	1,199	0.14
	2022	32	153	27,428	0.006	1,178	824	1,535	0.16
SSEO	1994[c]	13	99	18,991	0.005	1,173	–	–	0.29
	1999	41	360	41,333	0.009	2,376	1,615	3,494	0.20
	2005	32	276	28,931	0.010	2,357	1,634	3,401	0.18
	2013	31	118	30,439	0.004	986	641	1,517	0.22
	2018	32	345	31.073	0.011	1,624	988	2,667	0.25
	2020	33	349	32,828	0.011	2,027	1,437	2,859	0.17

Note: Data in this table is subject to change as we continue to resolve discrepancies in the raw historical data. An en dash (–) indicates that raw historical data is not currently available to calculate missing fields.

[a] Estimates for EYKT management area include only the Fairweather Grounds, which is composed of a west and an east bank. In 1997, only 2 of 20 transects - and in 1999, no transects, were performed on the east bank that were used in the model. In other years, transects performed on both the east and west bank were used in the model.

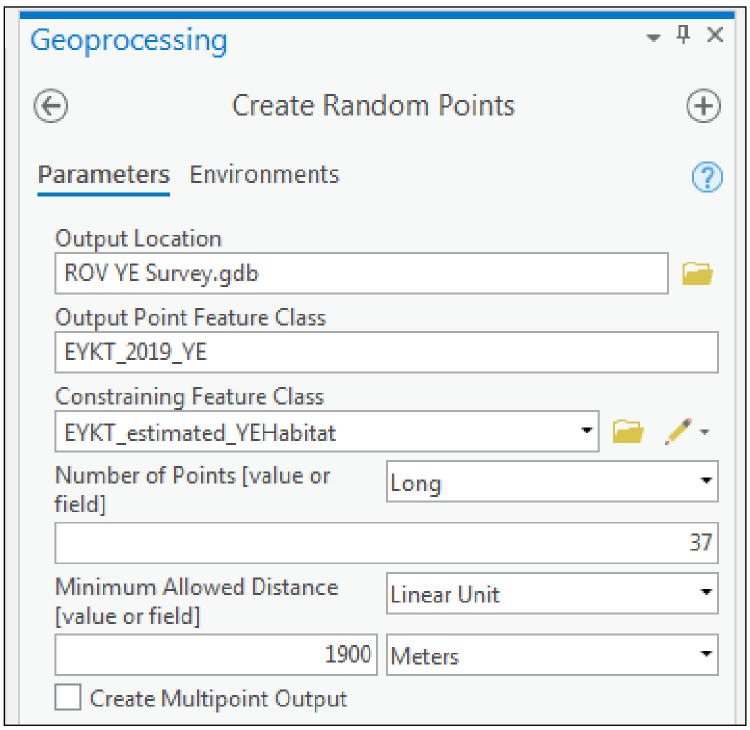
[b] Subadult and adult yelloweye rockfish were included in the analyses to estimate density. A few small subadult yelloweye rockfish were excluded from the 2012 and 2015 models based on size; length data were only available for the ROV surveys (not submersible surveys). Data were truncated at large distances for some models; as a consequence, the number of yelloweye rockfish included in the model does not necessarily equal the total number of yelloweye rockfish observed on the transects.

[c] Only a side-facing camera was used in 1994 and earlier years to video record fish. The forward-facing camera was added after 1994, which ensures that fish are observed on the transect line.

[d] Transects were completed but data collected could not produce a reliable yelloweye rockfish count or density estimate.

Appendix B.–Instructions on how random points for the survey are created.

1. **Determine Number of Transects**
   - Enter previous survey information into appropriate locations on spreadsheet: *ROV_Survey_EstimatedNumberofTransects*
   - File Location (Groundfish Drive – Sitka): ROVSurvey\Survey Prep
   - This will help to determine number of transects to create for the current year.
2. **Create Random Points**
   - Open ArcGIS Pro → "Add Data" → Add *Estimated YE Habitat for survey area*.
   - File Location (Groundfish Drive – Sitka): ROVSurvey\Survey Prep\Habitat Polygons for Random Points
   - Make sure the projection is: NAD 1983 UTM Zone 8N (Use 7N for EYKT).
   - Click on "Analysis" → "Tools" → Type in *search:* "Create Random Points."
   - Fill in the following fields:



   - Number of Points: Long and number is based on spreadsheet from 1st step.
   - Minimum Allowed Distance: Linear Unit
     - EYKT/SSEO: 1900 m (1.9 km)
     - CSEO/NSEO: 2000 m (2.0 km)
   - Run
   - Add a field (column) in the attribute table with dive number (open attribute table → add field) and number random points from north to south and west to east.
   - Add XY Coordinates to the random points (Analysis → Tools → type in "Add XY Coordinates"). This might need to be done in ArcCatalog.

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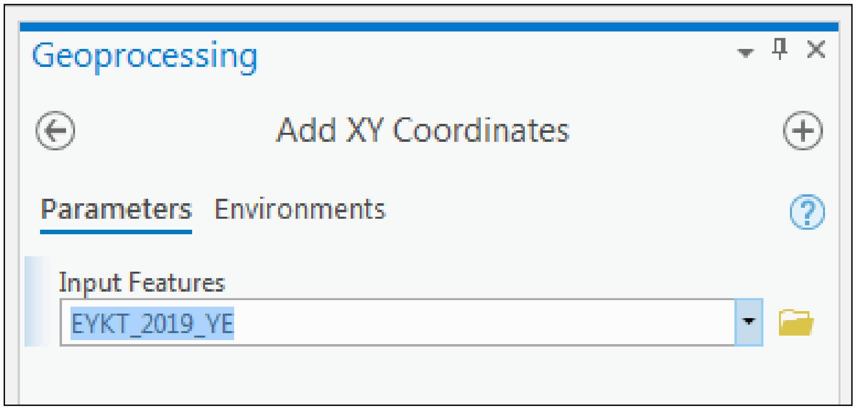
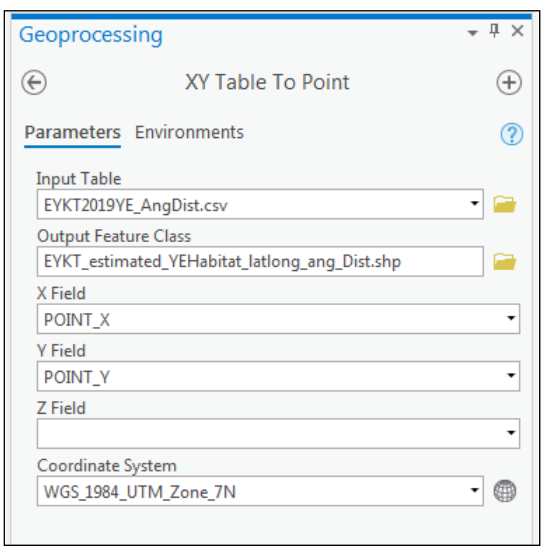


- If coordinates are not in decimal degrees, add 2 new fields to your attribute table: “Longitude” and “Latitude” and make sure “Float” is selected for both.
  - For each new field Right Click → Calculate Geometry
  - Field: Latitude or Longitude
  - Property: Latitude (Point y-coordinate), Longitude (Point x-coordinate)
  - Coordinate Format: Decimal Degrees
  - Coordinate System: Same as the random point file.

3. **Create Transect Plan Lines**
   - Export attribute table as a .csv file and open it in Microsoft Excel.
   - Set up data to create 4 plan lines for each random point along the cardinal directions to allow for alternative routes due to the currents.
   - Make 8 copies of each random point and add t columns for angle and distance to create lines for the cardinal and ordinal directions.
   - Distance: 500 m for each, which will make a total plan line of 1000 m (1-km).
   - Add the following angles for each dive: 0, 180, 270, 90, 315, 135, 225, 45.
   - Import back into ArcGIS Pro, using projection WGS84 UTM Zone 7N (EYKT) or 8N (all others).



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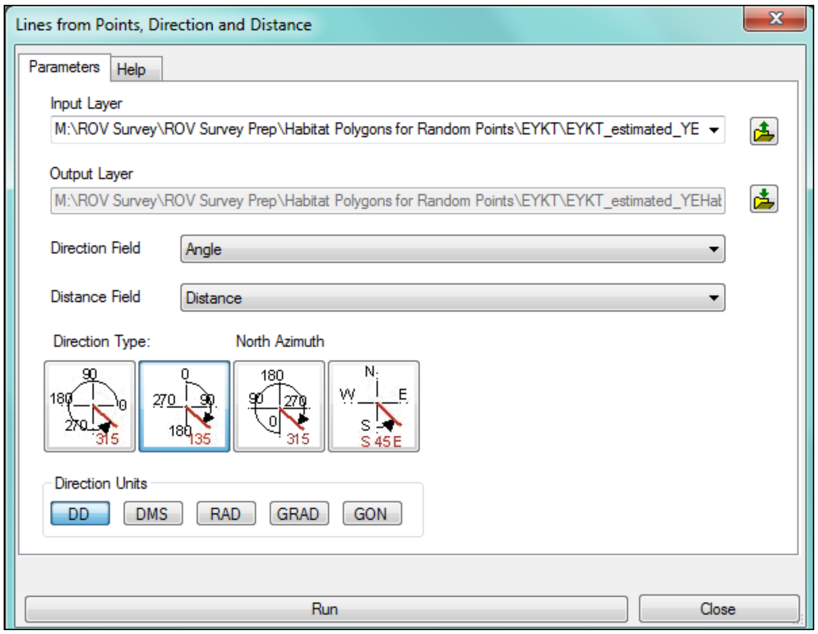
- Export points to feature class
- Right-click on points in Table of Contents
- Data →Export Features.
- Calculate geometry attributes in attribute table to get latitude and longitude from Point-X and Point-Y.
- Use ET GeoWizards (https://www.ian-ko.com/) to create <u>transect lines</u> from random points.
- ET GeoWizards → *Miscellaneous* → *Lines from Points, Direction and Distance*.
- Use the North Azimuth (2nd picture with 270 in W location) and DD as Direction Units.



- Alternatively: ArcCatalog → Data Management → Features → Bearing Distance to Line. Add the dive number under optional ID.

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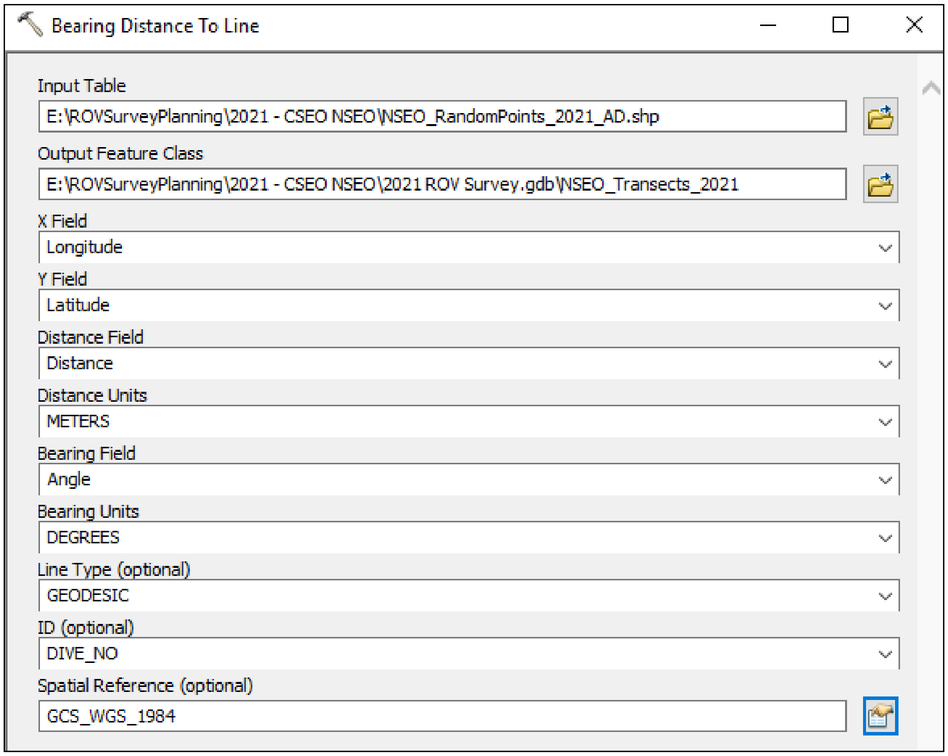

- Transects will need to be merged so that there are 4 plan lines for each transect instead of 8.
- Add transect file to ArcGIS Pro.
- Export the features for the 2 coordinating angles together in ArcGIS Pro.
- Select each row in the attribute table with the following combinations and export each group as a separate feature (after rows are selected → Right-click on shapefile in Table of Contents → Data → Export Features). Do this until there are 4 new features. The combinations are as follows:
  - 0 & 180
  - 270 & 90
  - 315 & 135
  - 225 & 45

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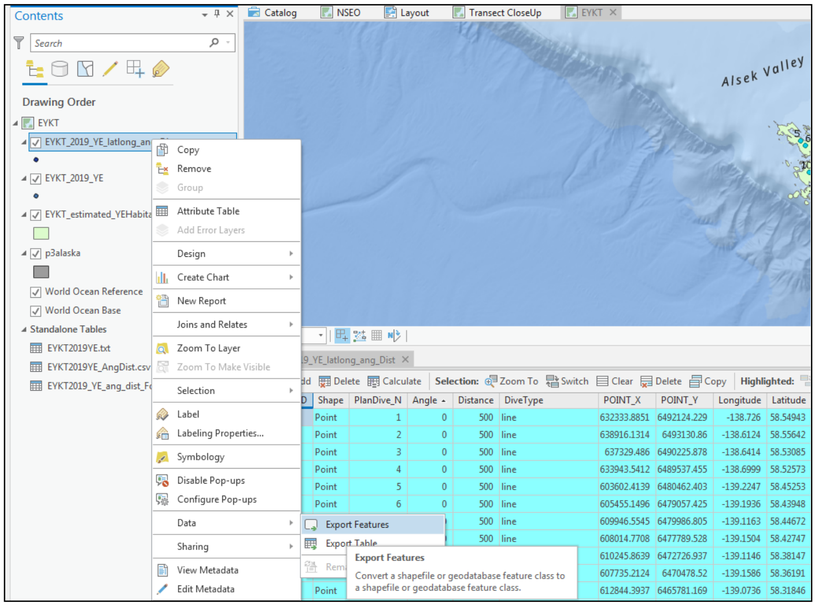

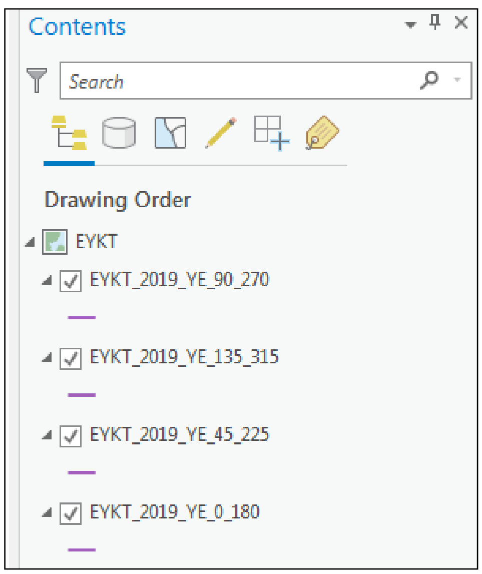

- Merge lines using ET GeoWizards (might have to export 4 shapefiles from geodatabase to another folder as shapefiles – ET GeoWizards cannot read geodatabase files.). Do this procedure with all 4 files.
  - Polyline → Clean Pseudo Nodes.
  - Input Layer: 1 of the 4 transect shapefiles (i.e., 0_180).
  - Output Layer: New merged file
  - Dissolve Field: Dive Number or Plan Dive Number
  - PlanDive_N: Minimum
  - Angle: Minimum
  - Distance: Sum

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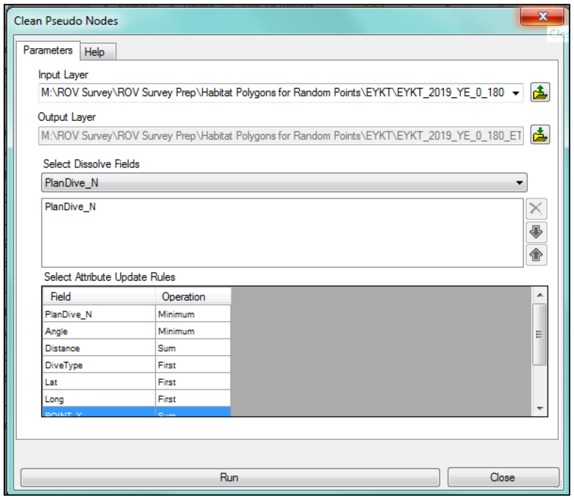
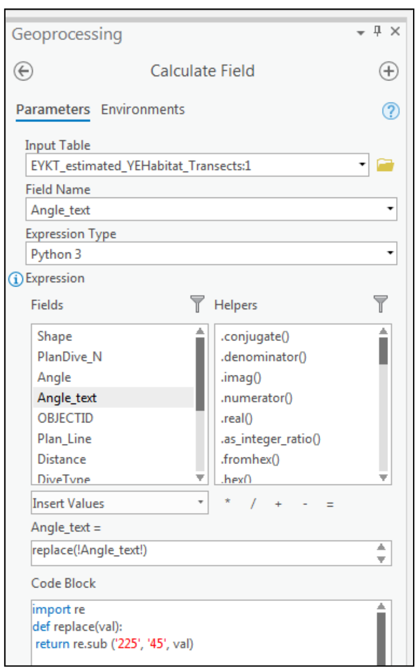


- Import shapefiles into ArcGIS Pro to make sure they draw correctly and that the angles are 0, 45, 90, and 135. If they are not, open their attribute tables and change them using "Calculate Field" (must create a column in attribute table, transfer angle column to new column and save as a text).



- Merge all 4 files together ArcGIS Pro (Analysis → Tools → Search "Merge").

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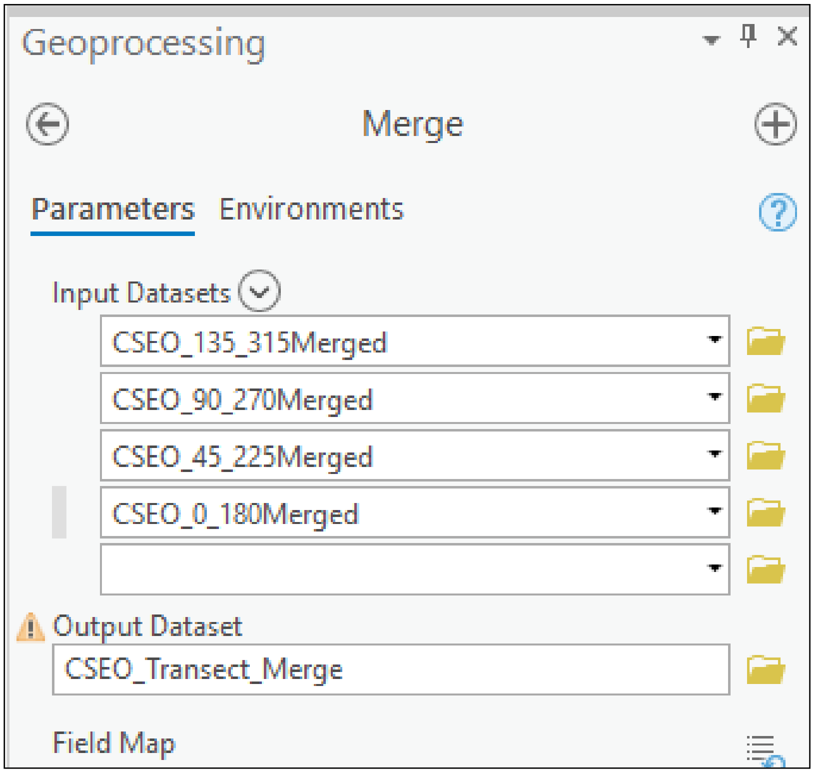

4. **Adjusting Plan Lines**
    - Some transects must be adjusted to fit within the borders of the estimated yelloweye rockfish habitat polygons by sliding the transect into the polygons across its midpoint while maintaining the original orientation of the transect. Zoom into the center to get the line on the point while editing.
5. **Navigation information**
    - The random point locations (original point file) need to be provided for the vessel to have a general idea of where to navigate to for each dive.
    - XY coordinates are added to the random point attribute table by:
        - Opening ArcCatalog
        - ArcToolbox → Data Management Tools → Features → Add XY Coordinates. This puts the random points in UTMs.
        - Add 3 columns:
            - Easting
            - Northing
            - UTM (as a TEXT)
        - Right-click on Easting Column → Calculate Field
        - Reference Point_X for Easting and Point_Y for Northing

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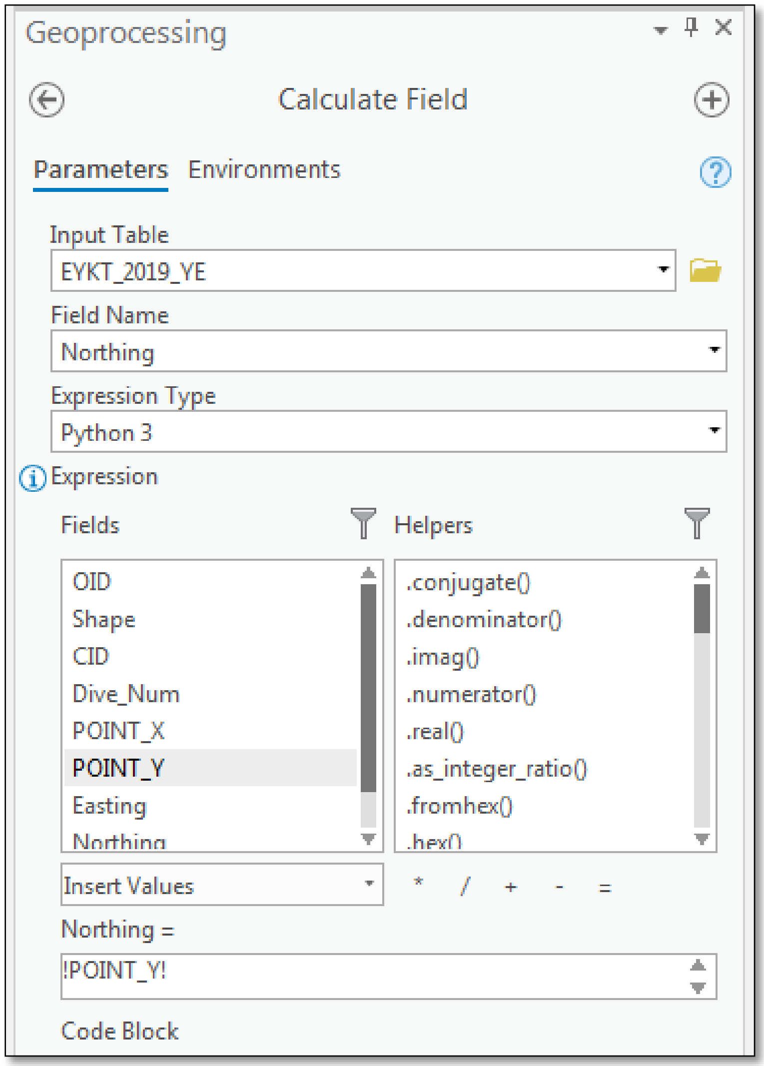

- The UTMs need to be converted to DD using the following:
  - Open file in ArcGIS Pro
  - ArcToolbox → Search "Convert Coordinate Notation."
  - In order for this tool to work, put both easting (x) and northing (y) in the same field with the following format:
    - Easting, Northing, 8N (7N for EYKT). (These can be combined into 1 column in Excel using "&" between column names (i.e., =F2&","&G2&","&H2)
  - Use this combined field as the X in the conversion tool.
  - Input file is UTM bands and Output Coordinate Format is DD_2. (Troubleshoot: May need to export the file into a geodatabase for the conversion tool to work. The default file output should be a geodatabase.)

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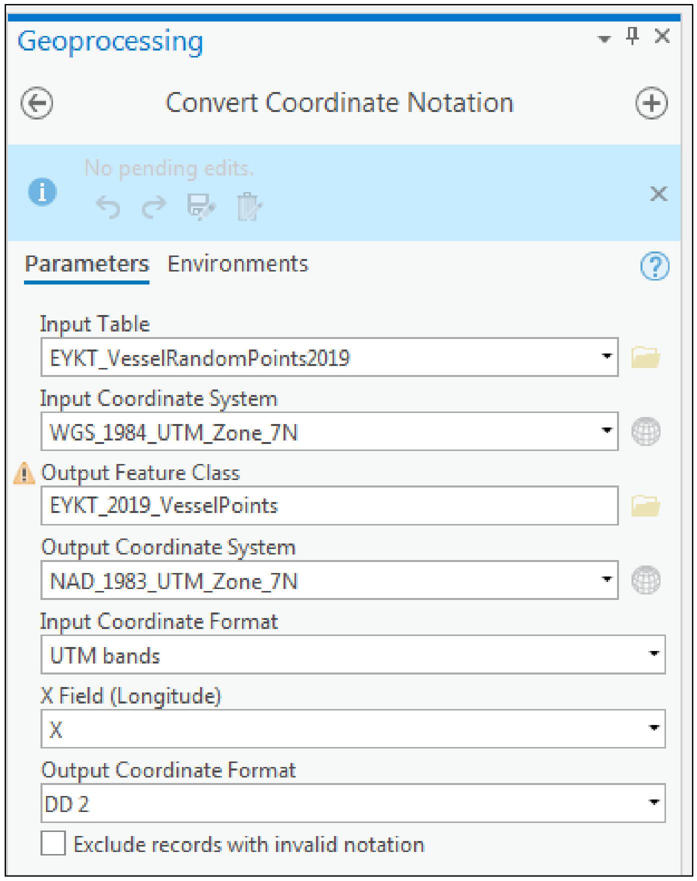

- Export feature class table as text and import into Microsoft Excel.

- Dive Location file for Vessel: Create a .csv file that shows the random dive points to load into the vessel navigation system.
  - The CSV file for the vessel should have no headings and fields for dive number, latitude, longitude, and any color codes to display the location of the dives in the navigation software. (A column of "3"s is used to display dive locations as red squares in navigation software.)

6. **Endpoints**
   - Create endpoints for transects by (if merged transect is in a geodatabase, you will need to export it as a shapefile into another folder – ET GeoWizards cannot read files in a geodatabase):
   - Open ET GeoWizards
     - Polyline → Export Nodes.
     - Use original file that had all the directions/angles listed (eight rows for each dive).
     - Export all node types.
     - Select a link field: use the dive number field

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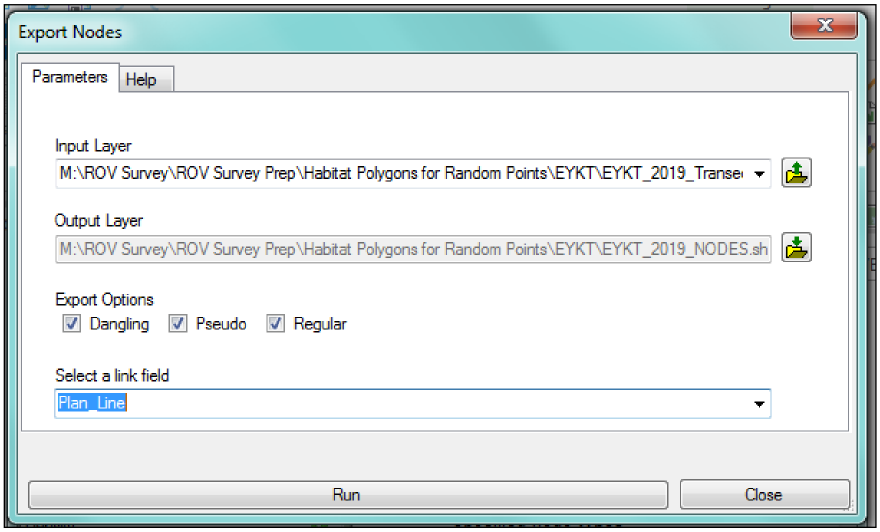

  - First, a unique identifier field was created by concatenating the dive number and the plan line angle together. Export all node types and make sure have the correct number of records. May need to edit any regular nodes that occur due to adjusting the plan lines all the way through to the random point. Slide back through the random point a bit and should fix issue.
- XY coordinates were added to the endpoint attribute table by using ArcCatalog → Data Management Tools → Features → Add XY Coordinates. This puts the endpoints in UTMs (if there are problems with ET GeoWizards, then get endpoints by creating fields in attribute table for X_start, Y_start, X_end, Y_end. Right-click field and calculate geometry for these values).
- The UTMs need to be converted to DD using the following: Data Management → Projections and Transformations → Convert Coordinate Notation.
- In order for this tool to work, both easting (x) and northings (y) in the same field with the following format: easting, northing, 8N (7N for FW).
- Then use this field as the X in the conversion tool with the designation UTM zone as the input coordinate notation.
- Use DD_2 as output coordinate notation and WGS84 as the output projection. (Troubleshoot: may need to export the file into a geodatabase for the conversion tool to work. The default file output should be a geodatabase).
- Export feature class table as text and import into Microsoft Excel, which the ROV pilot and navigator can load into the ROV navigational software, Hypack.

7. **Bathymetric Files**
   - All bathymetric data was mosaicked into 1 file and a hillshade was created in ArcGIS Pro.
   - To create the geotiffs, the hillshade or sidescan were exported in world view (not layout) as a .tif file with 1600 dpi.
   - Only display hillshade or sidescan in ArcGIS Pro (i.e., turn off the charts and other layers).
   - The box to "Write World File" needs to be checked in order for Hypack to read the GeoTiff.
   - Check "write geotiff tags" under format.
   - Make sure data frame is projected and in the correct projection in order to get the geotiff in correct format.

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- Converting the bathymetric grid file to a TIFF does not create this world file and although can be read and georeferenced in GIS it cannot be read by Hypack.
- Grid Files of bathymetric data to use in ArcGIS Pro were provided to allow for determination of depth information for locations. One can use the *identify tool* to click on a location and acquire the depth information.
- The interpretation shapefiles for the sidescan and multibeam areas were provided to be used in ArcGIS Pro.

8. Charts

- Charts are provided to the captain, and to hang in the ROV shack.
- A 30” x 25” chart is a good size to hang in the shack and is a sufficient resolution of the area to be surveyed.
- The charts include dive midpoints and number, bathymetric data, sonar data, and outline for the estimated yelloweye rockfish habitat.
- A thicker and brighter line should be used for the yelloweye rockfish habitat polygon, as the ROV shack is dark.

Appendix C.–Sample dive log used to record the dive number, date, transect number, transect type, transect start and end times, and comments.

ROV Survey Dive Log: Aug. 2019, R/V Solstice, ROV "Buttercup", Pilot Mike Byerly, EYKT									
Date	Actual Dive #	Planned Dive #	Transect #	Transect Direction	Transect Type	Starting Depth	Alaska Time		Comments
							Start Time	End Time	
		1			Line				
		2			Line				
		3			Line				
		4			Line				
		5			Line				
		6			Line				
		7			Line				
		8			Line				
		9			Line				
		10			Line				
		11			Line				
		12			Line				
		13			Line				
		14			Line				
		15			Line				
		16			Line				
		17			Line				
		18			Line				
		19			Line				
		20			Line				
		21			Line				
		22			Line				

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Appendix D.–Remotely operated vehicle (ROV) operations specifics.

Type of remotely operated vehicle (ROV) used: Deep Ocean Engineering, Phantom HD2+2 ROV (property of ADF&G Division of Commercial Fisheries in Homer, AK).

Specifications:

- Four horizontal, 1 lateral, and 1 vertical thruster.
- Two 4,500 lumen halogen and four 5,000 lumen LED halogen lamps to illuminate the viewing area.
- A GPS time server co-registers video frames among multiple cameras and with acoustic tracking data.
- The ROV tether is composed of fiber optic cables.

Navigation data:

- Obtained using Hypack software to perform ROV operations, including tracking the ROV and clump weight and estimating transect lengths.
- Information is recorded on the vessel and ROV positions, including heading, pitch, and roll.
- ROV x, y, z position is calculated from an ultra-short-base-line (USBL) tracking system and vessel position from GPS.

Cameras:

- The ROV is fitted with a pair of HD machine-vision stereo cameras and a belly camera that record video data from the line transects.
- Two additional cameras are mounted to the ROV: the "main" camera, which is a wide-angle, color camera that the pilot uses for navigation and a "forward-facing" camera. The "forward-facing" camera was originally used to look out ahead of the "main" camera to assess fish reaction (Byerly et al. 2015) but is not used for data collection for the yelloweye rockfish stock assessment survey.
- Two scaling lasers, mounted 10 cm apart and in line with the main camera housing, and another pair mounted 11.1 cm apart and in line with the belly camera, are used as measurement reference for objects viewed in the non-stereo cameras.
- Measurement of objects viewed in the stereo cameras is recorded using SeaGIS software.

Data recorded:

- Dive number, date, transect number, transect type, transect start and end times, and comments are logged manually for each dive (Appendix C), and all devices that keep time are synchronized to Alaska Standard Time (AK Daylight Time).

Deployment activities:

- Two science crew are in the ROV shed (pilot and navigator) and 3 crew are on deck during each ROV dive.
- The ROV is deployed into the water using the vessel crane, and the clump weight (a 113.4 kg weight attached to the tether approximately 10 m away from the ROV) is deployed after the ROV is in the water.
- The clump weight is used to manage the tether by monitoring its location and maintaining it at some distance from the ROV, which reduces the drag from the tether.
- One vessel crew operates the winch for the clump weight, 1 vessel crew monitors the tether and clips the clump weight cable to the tether as the ROV descends, and the 3rd person (science crew) helps uncoils the fiber optic umbilical, ensuring the umbilical does not get pinched as it descends with the ROV. The 3rdas person also coils the umbilical, alternating between an overhand and underhand loop as the ROV ascends at the end of the transect.

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- While operating the ROV, the pilot maintains a speed of approximately 0.5 knots and remains approximately 1 meter off the bottom, if possible.
- The captain monitors the Hypack software navigation software for the ROV depth and bottom depth, and lets the crew know when to raise and lower the clump weight in order to adjust the depth of the clump weight. The captain may also adjust the vessel speed to adjust the clump weight location.
    - The ROV tracking is performed using Hypack software navigation software. A display screen with the Hypack software navigation software is in the wheelhouse for the captain to observe along with a display screen in the ROV shack for the ROV driver and the ROV navigator to use for ROV navigation. A track pole is attached to the vessel on the port side with a transponder to track the vessel. In addition, transponders are attached to the ROV and to the clump weight.
- The ROV driver watches the main video camera coming from the ROV, as well as the ROV, clump weight, and vessel position.
- The ROV navigator monitors the ROV and clump weight depths, the vessel, clump weight, and ROV positions relative to each other, and updates the ROV operator with this information. The ROV navigator also acts as communication between the vessel captain and the ROV driver. In addition, the navigator logs dives with time codes for start and stop of transects and notes any times where the ROV sits on the bottom or has to reposition. These times are important for adjusting line lengths. In addition, the ROV navigator starts and stops the Horita time code machine and videotapes and enters the header information on each video camera overlay.
- The ROV driver steers the ROV in a way to try to maintain a distance of 10 m between the ROV and the clump weight with the ROV deeper than the clump weight.

Appendix E.–Codes used to describe video quality and remotely operated vehicle (ROV) movements to determine which portions of video to use for stock assessment.

Code	Description	Explanation
GGF	good going forward	ROV moving forward at normal speed with good video quality at or near transect line.
GRB	resting on bottom	ROV on bottom to look at something. May cause fish attraction.
GRBC	resting on bottom with close-up image	ROV on bottom and zooming in on organism or habitat. May cause fish attraction.
BDO	going over drop-off	Seafloor is not visible in either stereo or belly camera at or near transect line.
BBS	bottom stir-up	Silt reduces visibility so that the seafloor and/or fish are not visible in either the stereo or belly camera at or near the transect line.
BLB	lost bottom visual	Seafloor is not visible in either stereo or belly camera at or near transect line. May be note in dive log if technical problem.
BGB	going backwards	ROV is being dragged backwards by the vessel or clump weight pulling on the tether, may occur in high current. May be noted in dive log. May cause double-counting, or attraction to the ROV. Do not use this code if the ROV is backing up to move around an obstacle.
BRB	resting on bottom	This may occur if the ROV is waiting for the boat or clump weight to catch up or due to technical issues. May be note in dive log. Fish may become attracted to ROV.
BCF	bad camera focus	Very bad focus that may cause fish to be missed or unidentifiable on or near the transect line.
BLA	loitering in same area	May occur when ROV is waiting for boat or clump weight to catch up or other technical issues. May be note in dive log. Fish may become attracted to ROV.
BPV	poor visibility	Poor lighting or marine debris reduces visibility in stereo left and belly camera to point where fish may be missed or unidentifiable at or near the center of the transect line. Double-check if lighting may be improved in "Playback mode" by adjusting video codec.
BRP	repositioned	This may occur if there is a problem due to current or drag from the vessel or clump weight pulling on the tether. May also occur if the ROV is off the transect line and needs to reposition to get back onto the transect line. There may be a "headshake" to indicate a problem, a note in the dive log, or may be noticeable if ROV is traveling faster than normal "GGF" speed and then appears to turn. Fish attraction or double-counting may result.

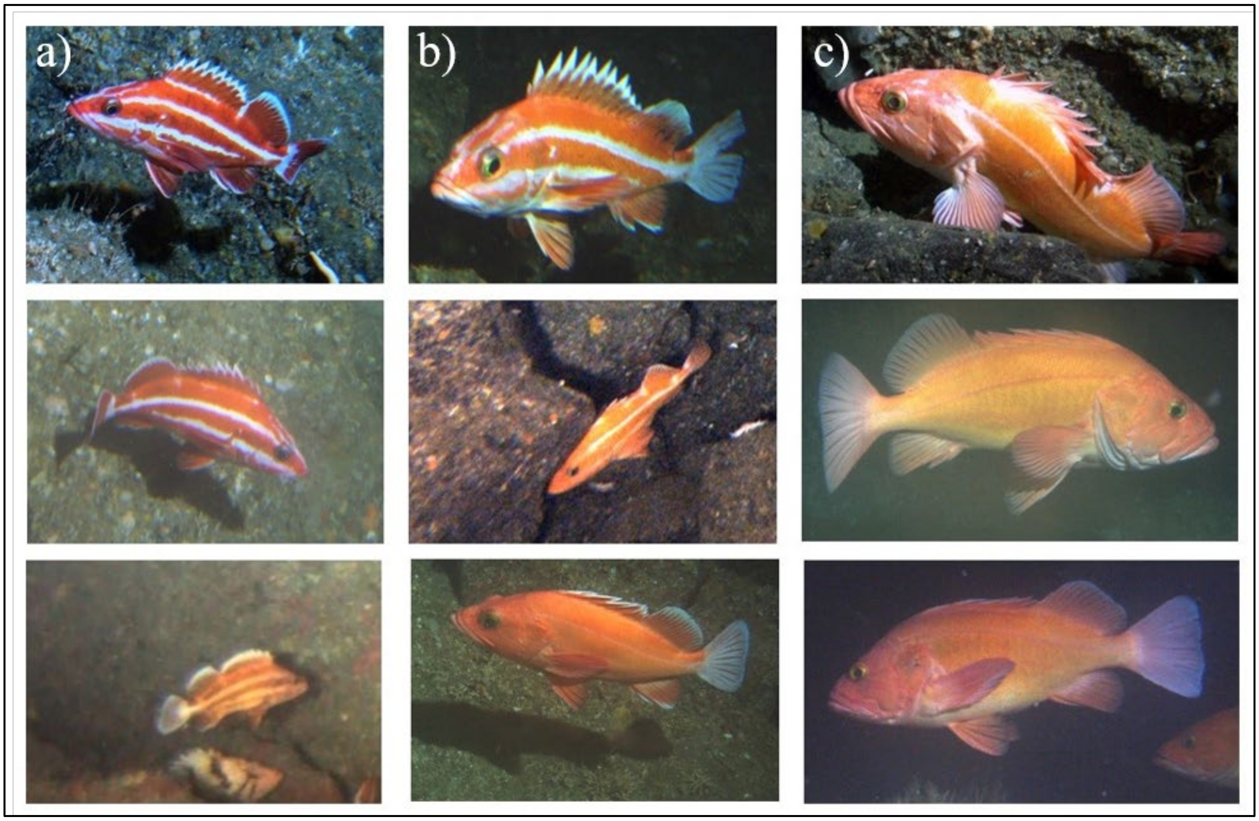
Appendix F.–Yelloweye rockfish behaviors and codes recorded during video review.

Code	Behavior
01	Fish milling/hovering
02	Fish resting on bottom
08	Fish seeking cover
05	Fish chasing other fish
09	Fish being chased
12	Attracted
03	Fish actively swimming in frame
04	Fish moving slowly into frame
06	Fish moving quickly into frame
07	Fish moving slowly out of frame
16	Fish moving quickly out of frame

Appendix G.–Maturity codes, condition, and morphology descriptions for yelloweye rockfish used during video review.

Maturity code	Maturity condition	Morphology description
JV	Juvenile	Body is typically dark red-orange and has 2 bright horizontal stripes on each side of the lateral line. Fins may show black or white fringe and have a white vertical band on the caudal peduncle and white patches along base of dorsal fin.
SU	Subadult	Body is a lighter orange than the juvenile and may have lost the lower juvenile stripe. The lower white stripe may still be visible but is less pronounced. Typically possesses bright, all white caudal fin and partially bright, white anal, spiny and soft dorsal fin.
AD	Adult	Body has a light to dark orange coloration depending on habitat and typically has 1 prominent white dorsal stripe on each side of the lateral line. Adults have muted white or all orange fins and spiny dorsal fin.

Appendix H.– Images of yelloweye rockfish at various maturity stages: a) juvenile yelloweye rockfish, b) subadult yelloweye rockfish, and c) adult yelloweye rockfish.



Appendix I.–Species and species class codes for rockfish and other fish and invertebrate species commonly observed on the remotely operated vehicle (ROV) survey.

Species code	Species class	Common name	Latin name
10058	Finfish	unknown	Unknown
10024	Rockfish	unknown	Unknown
145	Rockfish	yelloweye	*Sebastes ruberrimus*
147	Rockfish	quillback	*Sebastes maliger*
146	rockfish	canary	*Sebastes pinniger*
149	rockfish	China	*Sebastes nebulosus*
138	rockfish	copper	*Sebastes caurinus*
150	rockfish	rosethorn	*Sebastes helvomaculatus*
148	rockfish	tiger	*Sebastes nigrocinctus*
157	rockfish	silvergray	*Sebastes brevispinis*
156	rockfish	widow	*Sebastes entomelas*
142	rockfish	black	*Sebastes melanops*
155	rockfish	yellowtail	*Sebastes flavidus*
137	rockfish	bocaccio	*Sebastes paucispinis*
172	rockfish	dusky	*Sebastes variabilis*
135	rockfish	greenstripe	*Sebastes elongatus*
153	rockfish	redbanded	*Sebastes babcocki*
158	rockfish	redstripe	*Sebastes proriger*
10007	greenling	unknown	Unknown
194	greenling	kelp greenling	*Hexagrammos decagrammus*
130	greenling	lingcod	*Ophiodon elongatus*
10006	flatfish	unknown	Unknown
121	flatfish	arrowtooth flounder	*Atheresthes stomias*
124	flatfish	Dover sole	*Microstomus pacificus*
200	halibut	halibut	*Hippoglossus stenolepis*
701	skate	longnose skate	*Raja rhina*
700	skate	skate	Unknown
702	skate	big	*Raja binoculata*
9991	cod	unknown	Unknown
714	ratfish	ratfish	*Hydrolagus colliei*
10027	ronquil	ronquil	Unknown
160	sculpin	sculpin	Unknown
870	octopus	octopus	Unknown
9992	coral	unknown	Unknown
10001	coral	red tree coral	*Primnoa pacifica*
901	crab	unknown	Unknown
900	crab	box crab	*Lopholithodes foraminatus*
931	crab	Tanner	*Chionoecetes bairdi*

Appendix J.–Instructions for creating a measurement file template and editing the computer registry for species review using EventMeasure.

Setup for Species Review

Note- This setup will need to be done only once for each survey, prior to video review in EventMeasure

1. **Create New Measurement File**
   - *Measurement* → *New Measurement File* (. EMObs)
2. **Set Information Field Names**
   - Click on *Measurement* → *Information Fields* → *Edit Field Names.*
   - Add field names: "Year," "Dive," and "Transect" in fields 5, 6, and 7.
3. **Load Species Table**
   - Measurement-Attributes-Edit/Load Species files. Double-click "Species file" under the attribute header and you can navigate to a text file with the species information. The species table needs to be set up as a tab delimitated text file that contains the species codes (Species_Table_update.txt).
4. **Edit Attribute Names**
   - Click on *Measurement* → *Attributes* → *Attribute headers.*
   - In the user defined attribute fields, add the field names: "Check ID," "Comment," and "Event Time HH:MM:SS" in attribute name of 8, 9, and 10.
5. **Save Measurement File to use as Template**
   - *Measurement* → *Save*. Changes only need to be made for dive, transect number and depth for each new dive (i.e., Dive 9, Transect 1).
6. **Enable Automatic Number Incrementing**
   - On computer, click on *Start* and type in the search window "regedit".
   - In left hand panel of registry editor, navigate to HKEY_CURRENT_USER → Software → SeaGIS → EventMeasure → Number attribute.
   - Double click on "auto increment number for points" and select "1" to enable automatic incrementing.
7. **Load Files for Species Review**
   - Follow instructions in document " ROV Species Review Instructions_Updated2022" for "Loading Files".
   - File Location (Groundfish Drive – Sitka): ROVSurvey\Video Review Instructions\1. Species Review ROV\Species Review Instructions_Updated2022
8. **Perform One 3D Point Measurement to Setup Registry**
   - Follow instructions in document "ROV Species Review Instructions_Updated2022" for "Species Enumeration and Measurement".
     - File Location (Groundfish Drive – Sitka): ROVSurvey\Video Review Instructions\1. Species Review\ROV Species Review Instructions_Updated2022
9. **Edit Activity and Maturity Codes**
   - The attribute editor must be used at least once in EventMeasure before editing registry. To do this, complete loading file instructions and create one 3D point measurement.
   - Start → type in the search window "regedit".
   - In left hand panel of registry editor, navigate to HKEY_CURRENT_USER → Software → SeaGIS → EventMeasure → Custom attributes
   - Double click on Activity or Stage. Add the activity or stages and separate each with a comma & click OK.

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- Add these activities: Fish milling/hovering, Fish resting on bottom, Fish actively swimming in frame, Fish moving slowly into frame, Fish chasing other fish, Fish moving quickly into frame, Fish moving slowly out of frame, Fish seeking cover, Fish being chased, and Fish moving quickly out of frame. Note that the only existing activity in EventMeasure that we use is attracted.

10. Use previous created template to perform species review for each dive using the instructions on "ROV Species Review Instructions_Updated2022"
  - *Note*: In 2020, a species review template was created using the above steps. File Location (Groundfish Drive – Sitka): ROVSurvey\EventMeasure Templates\UseThisSpeciesReviewTemplate.EMObs

Appendix K.–Instructions on performing species review using EventMeasure software, including details on loading and synchronizing files and collecting 3D point and length measurements.

Performing Species Review in EventMeasure

1. **Open EventMeasure (license key must be plugged in).**
2. **Load Measurement File Template**:
   - *Measurement → Open → select .EMObs file → click "Open"*
3. **Load Camera Files**
   - *Stereo → Cameras → Left → Load camera file → select stereo left .CAM file → click "Open"*
   - *Stereo → Cameras → Right → Load camera file → select stereo right .CAM file → click "Open"*
4. **Set Picture Directory**
   - *Picture → Set Picture Directory → navigate to folder with stereo camera videos (both left and right stereo videos must be in the same folder)*
5. **Load Left Stereo Camera Video and Set Time**
   - Uncheck the "Lock Frame" box (top left, click "Toggle View" if you do not see it)
   - *Picture → Load Picture → select "stereo left" file → click "Open"*
   - *Picture → Define movie sequence*
   - *Add file(s) → select the "stereo left" video file → click "Open" (remove any previous videos listed).*
   - Set the Sequence Start Time
     - Type the time stamp from video overlay in the "Sequence Start Time" field. Enter HH:MM:SS. Do **not** enter the milliseconds (only need first 2 digits of :ss). Do **not** include leading zeros for single digits.
     - Change "Time Format" from "Decimal Minutes" to "HH:MM:SS.ss"
     - *Click OK*
     - **Verify time stamp on video matches time above image next to the lock box for HH:MM:SS**
     - If there is a problem with the time (i.e., video stopped and restarted) then the time for each 3D point and length will need to be entered in "Event Time" field in HH:MM:SS
6. **Load Right Stereo Camera Video**
   - *Stereo → Picture → Load Picture → select "stereo right" video file → click "Open"*
   - *Stereo → Picture → Define movie sequence →Add file(s) → select "stereo right" video → click "Open" → click OK*
7. **Synchronize Images**
   - Match the time stamps on the stereo left and right video files (frames do not necessarily match)
   - Check the "Lock Frame" box
8. **Enter header information**
   - Click on *Measurement → Information Fields → Edit Field Values*
   - Fill in information for: "Tape Reader," "Year," "Dive," "Depth" (starting depth), and "Transect".
9. **Species Enumeration and Measurement**
   - Select "3D Measurements for Data View"
   - Review video by *Play movie* → click "play" button. Change speed of video with "Rate."
   - Stop video at location of interest by clicking "Close player and update position."
   - Record 3D point measurement and attributes:
     - Double-check time stamps match for both cameras; if they do not, unlock, adjust, and relock.
     - Click once on the nose of the fish or other easy to locate point in both the left and right images. Check the RMS value in 3D point information box (pop up box). For yelloweye rockfish, lingcod, black rockfish, and halibut, obtain an RMS value < 10mm. If not possible, include a comment.

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- For yelloweye rockfish, take 3D measurement at earliest location in video as possible that an RMS < 10mm can be obtained. Zoom function (control button and click on image) may assist in selecting same location in both images.
- Right click on the left image and click “Add 3D point”.
- Add following attributes:
  - **Family, Genus, or Species**: Select species (by “Code,” by “Species” or by common name from “Genus”) if known or select broader group (by code from “Species” or by common name from “Genus” or “Family”). If species are known, fill in the species codes using the ADFG species table. EventMeasure does not autofill species codes when common names are selected.
  - **Number**: Change to order specimens sequentially.
  - *Stage:* Change to blank for non-yelloweye DSR species. For **yelloweye rockfish**, select *AD* (adult), *SU* (subadult), or *JV* (juvenile).
  - **Activity**: Change to blank for non-yelloweye DSR species. For **yelloweye rockfish**, choose appropriate behavior.
  - **Check ID**: Type “Yes” if ID needs to be verified.
  - **Comment**: Type short comment if needed. If a length cannot be taken for yelloweye rockfish, black rockfish, lingcod, or halibut, include comment (i.e., Partial view, Poor visibility, etc.).
  - **Event Time**: If there is a problem with the time, such as from the video stopped and restarted, then the time for each 3D point and length will need to be entered in Event Time field in HH:MM:SS.
- To record fish length (for yelloweye rockfish, lingcod, black rockfish, and halibut):
  - Select 3D point measurement row for fish that will be measured to autofill attributes.
  - Find the best orientation and clarity to capture fish length.
  - Click on “Close player and update position” button.
  - Click on the **nose and fork of the fish** in both the **left and right images** to take the measurement.
  - Check 3D information pop up box to see that **RMS <10mm** for length endpoints and that **horizontal angle <30** and **add comment if either cannot be achieved.**
  - Confirm correct species, specimen number, and stage are in attribute box.
  - Click *OK*

10. Save Text and Measurement Files

- *Measurement → Measurement Summaries →3D point and length measurements.*
- *File → Save data to .csv file.* Use naming convention “Location_Year_Dive Number_Transect Number.”
- Save. EMObs measurement file.