Regional Operational Plan CF.1J.2017.02

Demersal Shelf Rockfish Remotely Operated Vehicle Stock Assessment Survey

by

Kristen Green

and

Jennifer Stahl

March 2017

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 figure 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 CF.1J.2017.02

DEMERSAL SHELF ROCKFISH REMOTELY OPERATED VEHICLE STOCK ASESSMENT SURVEY

by

Kristen Green

Alaska Department of Fish and Game, Division of Commercial Fisheries, Sitka

and

Jennifer Stahl
Alaska Department of Fish and Game, Division of Commercial Fisheries, Douglas

Alaska Department of Fish and Game
Division of Commercial Fisheries

March 2017

Kristen Green
Alaska Department of Fish and Game, Division of Commercial Fisheries,
304 Lake Street, Room 103, Sitka, Alaska 99835, USA
and
Jennifer Stahl
Alaska Department of Fish and Game, Division of Commercial Fisheries,
802 3rd Street, Douglas, Alaska 99824, USA

This document should be cited as follows:
Green, K., and J. Stahl. 2017. Demersal shelf rockfish remotely operated vehicle stock assessment survey. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF1J.2017.02, Anchorage.

SIGNATURE PAGE

Project Title:	Demersal Shelf Rockfish ROV Survey
Project leader(s):	Andrew Olson
Division, Region, and Area:	Commercial Fisheries, Southeast Alaska
Period Covered:	2014–2019
Field Dates:	May to August
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project leader	Andrew Olson		03/20/2016
Biometrician	Vacant		
Research Coordinator	Karla Bush		03/20/2016

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

Appendix **Page**

PURPOSE

The Federal Fishery Management Plan (FMP) for Groundfish in the Gulf of Alaska delegates management authority for demersal shelf rockfish (DSR) in the Southeast Outside Subdistrict (SEO) of the Eastern Gulf of Alaska to the Alaska Department of Fish and Game (ADF&G). Yelloweye rockfish compose, on average, over 96% of the DSR complex harvest. Yelloweye rockfish stock status is assessed in SEO using a remote operated vehicle (ROV). As funding allows, a survey will be conducted in one of the four management areas in SEO to collect data on yelloweye rockfish density and size composition to calculate a biomass estimate. Biomass estimates obtained for specific management areas will be used to update the SEO-wide biomass estimate, the acceptable biological catch (ABC), the total allowable catch (TAC) and the federal Stock Assessment and Fishery Evaluation (SAFE) report; all will be reviewed by the North Pacific Fishery Management Council (Council). The Council-approved TAC will be used to set the state-managed guideline harvest levels (GHL) for the commercial and recreational DSR fisheries in the SEO. Survey data, commercial fishery catch per unit effort (CPUE), and age, length, weight, and maturity information will be considered in management decisions. This regional operational plan (ROP) details the protocol for conducting the survey component only.

BACKGROUND

The demersal shelf rockfish (DSR) assemblage (comprised of canary, China, copper, quillback, rosethorn, tiger, and yelloweye rockfish (5 AAC 39.975 (34)) is a commercially important suite of rockfish species caught in commercial, recreational, and subsistence fisheries in Southeast Alaska. DSR are highly susceptible to over-exploitation due to their life history traits (slow growing, long lived, and late maturing); thus, careful management is necessary for this species complex.

The Groundfish FMP for the Gulf of Alaska delegates management of DSR to the State of Alaska. ADF&G began conducting a fishery-independent, habitat-based stock assessment for DSR using visual survey techniques (i.e. a submersible) to record DSR observations on line transects in rock habitat in 1988. In 1992, SEO was expanded from outside waters east of 137° W longitude to outside waters east of 140° W longitude. Currently, SEO includes the following management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) (Figure 1). The DSR stock assessment surveys have historically rotated among management areas on a biannual basis; it would be time and cost-prohibitive to survey the entire SEO in one field season due to the large size of the area. In recent years, surveys have occurred annually due to supplemental funding from the legislature. The most recent abundance estimate from a given management area is used to update the annual stock assessment for SEO, but four to six years may elapse between surveys in any one management area (Brylinsky et al. 2009). Prior to 2010, ADF&G assessed DSR biomass based on observations from a manned submersible. Between 1988 and 2010, density estimates derived from yelloweye rockfish counts from submersible video observations were extrapolated over the total yelloweye rockfish habitat. Average weight for yelloweye rockfish landed in the halibut and directed commercial fisheries was applied to the density estimate to obtain a biomass estimate for each management area (O'Connell and Carlile 1993, Brylinsky et al. 2009). A 2% harvest rate was applied to the lower 90% confidence interval for the biomass estimate in each management area to determine the overall ABC for yelloweye rockfish. The yelloweye rockfish biomass estimate was increased each year by 2 to 4% to account for the other species in the DSR complex (yelloweye rockfish typically compose >96% of the total DSR harvest). The DSR biomass estimate for the SEO was published in the annual Gulf of Alaska SAFE report (e.g. Brylinsky et al. 2009, Green et al. 2014) and forms the basis for the Council's TAC recommendation. Currently, a statistical age-structured model is being developed which will incorporate submersible and remote operated vehicle (ROV) yelloweye rockfish density estimates, commercial, sport, and subsistence fishery data, and International Pacific Halibut Commission (IPHC) survey data. This model will be used to project biomass estimates for yelloweye rockfish.

In 2012, ADF&G transitioned to using an ROV given the unavailability of an appropriate submersible. Although the survey vehicle changed, the stock assessment methods for the DSR complex remain similar. ROVs are low-cost and versatile tools that have been increasingly used to study marine habitats and organisms (e.g. Pacunski et al. 2008).

The purpose of the initial ROV survey in 2012 was to determine if accurate density estimates could be obtained using a ROV in lieu of a submersible, and if the assumptions of distance sampling could be satisfied (Buckland et al. 1993) using an alternative and unmanned underwater vehicle. For this pilot study, we conducted transects in the same locations as the 2007 sub survey, which allowed us to use the depth and habitat information from the previous survey in order to navigate the ROV in the rugged terrain. The 2007 data indicated we would encounter a sufficient number of yelloweye rockfish to estimate density in these dive locations. Data from the 2012 study indicated that the assumptions of distance sampling were not violated and resulted in a yelloweye rockfish density estimate with a coefficient of variation (CV) of 13%. Ralston et al. (2011) examined stock assessments for 17 data-rich groundfish and coastal pelagic species and found the mean CV for biomass estimate to be 18%. In this context, a CV of 13% is considered a high level of precision, a view supported by Robson and Regier (1964) and Seber (1982). Although we were not able to compare the ROV results directly with a submersible or account for natural changes in the yelloweye rockfish population between years, the ROV yelloweye rockfish density estimates are comparable to previous submersible estimates with a similar magnitude (Figure 2). The ROV has been successfully deployed in most weather conditions and 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).

Due to the success of the 2012 ROV pilot study, additional surveys were performed in 2013 and 2015 in the management areas of SSEO and EYKT, respectively. Dive locations for these surveys were selected by randomly placing dives within the habitat delineation for yelloweye rockfish. Future ROV surveys will be conducted using this protocol with the methods described in this report.

OBJECTIVES

1. Obtain a density estimate with a coefficient of variation (CV) ≤25% for yelloweye rockfish in rocky habitats in SEO management areas using distance sampling techniques[1];

[1] Other ROV and submarine surveys typically show CV levels between 15% and 30% when estimating species density (Yoklavish et al. 2007, Pacunski et al. 2008). We selected a conservative target for uncertainty given the long-lived nature of yelloweye and the associated susceptibility to over-harvesting even when catch levels remain constant.

2. Obtain total length measurements for yelloweye rockfish observed from line transects in the SEO management areas.

SECONDARY OBJECTIVES

1. Identify and enumerate other non-yelloweye rockfish DSR species, halibut, and lingcod. These observations will be recorded and archived for future data analyses (i.e. species composition);
2. Collect total length measurements for halibut and lingcod. These observations will be recorded and archived for future data analyses (i.e. length composition).

METHODS

SAMPLE DESIGN

Visual surveys are conducted in preferred yelloweye rockfish habitat, which we define as rock habitat generally inshore of the 100-fathom depth contour[2]. Seafloor is designated as "rock" based on information from sonar surveys, directed commercial fishery logbook data, and substrate information from NOAA charts. Only areas ≥35 fathoms and <100 fathoms are included in the habitat delineation, because 90% of yelloweye rockfish observed from the submersible occurred between these depths (submersible operations occurred from 2 to 144 fathoms). A total of 3,892 km^2 of yelloweye rockfish habitat has been estimated for SEO with 739 km^2 in EYKT, 1,661 km^2 in CSEO, 1,056 km^2 in SSEO, and 436 km^2 in NSEO.

Substrate information obtained from sonar surveys is considered the best information available on rock habitat. Of area designated as rocky habitat for stock assessment, 68% was derived from sonar in EYKT, 27% in CSEO, and 30% in SSEO. In NSEO, seafloor mapping was recently performed in 2015 but has not yet been analyzed. High resolution seafloor mapping has been performed across 3,058 km^2 of SEO with seafloor identified as hard substrate and considered "rock" for 322 km^2 of 832 km^2 surveyed area in CSEO, 500 km^2 of 1,072 km^2 in EYKT, and 322 km^2 of 1,154 km^2 in SSEO. All seafloor mapping performed in EYKT occurred in the Fairweather grounds.

For areas without sonar information, we delineated rocky habitat using directed commercial fishery logbook data or substrate information from NOAA charts when both sonar and fishery data are limited i.e. in NSEO management area (O'Connell and Carlile 1993, Brylinsky et al. 2009). Longline set locations where catch per unit effort is ≥0.04 yelloweye rockfish per hook are considered preferred yelloweye rockfish habitat. Sets with only start positions are buffered by 0.5 miles (this established buffer size was retained for consistency); whereas, sets with both start and end locations are buffered 0.5 km around the entire track based on the minimum range of travel of four tagged yelloweye rockfish (P. Rankin, Oregon Department of Fish and Wildlife, personal communication). Sets with both start and end positions constitute the majority of fishery data, because fishermen have been required to record both positions since 2003. Buffered

[2] Generally yelloweye rockfish habitat is within the 100-fathom contour, although some segments of habitat are included outside this line if they are adjacent to rock within the contour. In addition, two rock banks are included in SSEO that are well outside the 100-fathom line, but are within the operational depth of the ROV.

logbook sets are merged, and segments are included in the delineated habitat if ≥2,300 m in length (criteria originating from submersible surveys which required rocky segments long enough for two non-overlapping transects). Segments are considered "continuous" if no gaps >0.5 nm occur. Habitat derived from NOAA charts is included in the delineation if seafloor is designated as coral, rock, or hard; these "point" locations are buffered by 0.5 nm.

Random locations within the rock habitat were selected for each dive with a minimum distance of 1,900 m between each random point using ArcGIS[3] (Figure 3). The 1,900 m distance was selected to avoid overlap among transects and after considering logistics of vessel running time between points. Random locations were removed from the survey design if they were in depths ≥200 m, which is the maximum operating depth for the ROV.

Transect plan lines of 1-km length were mapped at each suitable random point with four possible orientations along the cardinal directions and crossing through the random point (Figure 4). In cases where a plan line is not completely within the rocky habitat delineation, the line is shifted through the random point until the greatest proportion is in rocky habitat but still includes the random point (Figure 4). In the field, the plan line is selected with the most preferable orientation relative to currents for ROV operation. The transect length of 1-km was selected after consideration of visual surveys conducted by other agencies, the encounter rate of yelloweye rockfish based on our previous surveys, and ROV pilot fatigue— at much longer transect lengths it becomes more difficult to maintain concentration.

The total length of line to be surveyed in an area is estimated based on the target coefficient of variation of the density estimate and analyses completed during past surveys. Buckland et al. (1993) recommends selecting a total transect line length sufficient to obtain 60–80 samples (individual fish observations) by:

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

where L_{target} = the target total transect length, cv_t = the target coefficient of variation of the density estimate $\hat{D}$, L_0 and n_0 = the line-length and observed animal numbers from a pilot study, respectively, and b = a dispersion parameter. For small-scale pilot surveys the dispersion parameter is difficult to estimate and a value between 2 and 4 is typically chosen. Once we have conducted an initial study in a management area, we will estimate b using the number of yelloweye rockfish observed (n) and the CV of the previous density estimate in that area ($cv(\hat{D})$) using the following equation from Buckland et al. (1993).

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

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

[3] This and subsequent product names are included for completeness and do not imply an endorsement by the Alaska Department of Fish and Game.

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

This provides the target total line transect length for a given area.

DATA COLLECTION

A Deep Ocean Engineering, Phantom HD2+2 ROV (property of ADF&G Division of Commercial Fisheries in Homer, AK) will be used as the survey vehicle. The ROV has four horizontal, one lateral, and one vertical thruster. There are two 250-watt halogen lamps to illuminate the viewing area. A GPS time code generator will be used to co-register video frames among multiple cameras and with acoustic tracking data. The ROV tether will be composed of fiber optic cables.

Navigation data will be obtained using Hypack software to perform ROV operations, including tracking the ROV and clump weight, and to estimate transect lengths. Information will be 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.

A pair of HD machine-vision stereo cameras will be used to record video data from line transects. The stereo camera data will be analyzed using SeaGIS software (SeaGIS Pty Ltd., EventMeasure version 3.50). SeaGIS is a measurement science software used to log and archive events occurring in digital imagery. Three additional cameras will be mounted to the ROV, the "main" camera, which is a wide-angle, color camera that the pilot will use to drive the ROV and a "forward-facing" camera, and a "belly" camera. Two scaling lasers, mounted 10 cm apart and in line with the camera housing, will be used as measurement reference for objects viewed in the non-stereo cameras, and measurement of objects viewed in the stereo cameras will be recorded using SeaGIS software.

Dive number, date, transect number, transect type, transect start and end times, and comments will be logged manually for each dive. All devices that keep time should be synchronized to Alaska Standard Time (AK Daylight Time). The ROV pilot will maintain a speed of about 0.5 knots and remain approximately 1 m off the bottom, if possible. Two science crew will be in the ROV shed during each dive (pilot and navigator) and three crew will be on deck during a ROV dive. The ROV will be deployed into the water using the vessel crane, and then the clump weight (a 250 lb weight attached to the tether approximately 10 m away from the ROV) will be 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 of the vessel crew will operate the winch for the clump weight, and two science or vessel crew will monitor the tether and clip the clump weight cable to the tether as the ROV descends.

DATA ANALYSIS

Transect Line Lengths

Transect line lengths will be estimated from navigation data after smoothing and removal of segments with poor video quality or problems with ROV operation. First tracking data will be filtered for outliers using Hypack® singlebeam editor and position errors will be removed.

Navigation data are generally recorded every two to three seconds; however, navigation data must be at one-second intervals to accurately match with video observations. As a result, navigation positions will be interpolated for each second. Navigation data will be smoothed in R statistical software using a smoothing spline. Video from the stereo left camera will be reviewed to determine which segments of video are of adequate quality and that the ROV is moving forward normally. Each video segment will be given a video quality code (Appendix A). Video will be coded as “poor visibility” and excluded from analysis only if fish cannot be identified on the transect line. An assumption of distance sampling is that there is 100% detection on the transect line; however, with distance the probability of detection declines and can be modeled. Video where the seafloor is not visible will be excluded, because yelloweye rockfish tend to be close to the seafloor and could be missed. Both smoothed and un-smoothed navigation data will be mapped in GIS, and ROV video quality segments will be overlaid smoothed navigation data using linear referencing. Mapped data will be examined for any problems (i.e. zigzags or loops); if problems are identified, then bad sections may need to be removed. If bad segments occur, then video data will be re-reviewed to determine if any problems occurred with the ROV during these segments and if these segments should be recoded that warrant excluding these segments from line length estimation. The total line length for each transect will be estimated only using the portion of the dives which are coded as “good going forward” indicating the ROV is moving forward normally, the seafloor is in view, and the visibility is good enough to view fish on the transect line.

Fish Video Review

Video will be reviewed to collect information on yelloweye rockfish in order to estimate their density and for other fish for species composition and length analyses. The video reviewer will identify and obtain fish location (i.e. x, y, and z position from transect line) for yelloweye rockfish, other DSR species, lingcod, and halibut, and as time allows, for other large-bodied fish (Appendix B). Fish total length (tip of the snout to the tip of the caudal fin) will be recorded for individual yelloweye rockfish, lingcod, and halibut. Fish behavior (Appendix C) and maturity stage will be recorded for yelloweye rockfish only. Coloration and other morphological characteristics will be used to identify maturity stage of yelloweye rockfish (Appendix D).

Stereo left and right cameras will be reviewed using Event Measure software to obtain 3D point measurements for fish, including perpendicular distance from the transect line. After the survey and prior to video review, a new measurement file will be created as a template for video review in Event Measure: information fields will need to be updated, the species names and codes table will need to be loaded, and the attribute field names (check ID, comment, and event time) will need to be edited using instructions in Appendix E. In addition, the computer registry will need to be edited to enable automatic number incrementing and to add fish behaviors and maturity stages (Appendix E). The digitized stereo videos will be loaded into Event Measure, along with calibration files for each camera, and left and right stereo videos will be synchronized (details on loading and synchronization are in Appendix F). Fish will be observed on and to the left and right of the transect line and marked in both the left and right stereo cameras to obtain a 3D point measurement with coordinates of x, y, and z; the perpendicular distance to the fish corresponds to “x” (Figure 5; details on collecting 3D point and length measurements are in Appendix F). The fish will be marked at the tip of the snout, if possible; otherwise the fish will be marked on another location on its body or tail (Figure 6). The video reviewer will record yelloweye rockfish at first observation on the video to minimize any effect of fish movement in response to the ROV as it moves closer to the animal. Yelloweye rockfish may be observed at distances as great as 8 m from the ROV; consequently, the video may need to be rewound to accurately record the *first* detection. The 3D measurement should be taken when the fish is "clear enough" to obtain a root mean square (RMS) error of the variance <10 mm. When this is not possible (e.g. if the fish is in the corner of the viewing screen and is blurry) the reviewer will note in the comments the reason for the poor RMS value. Other rockfish in the DSR complex, lingcod, and halibut will be recorded as early as possible, but accuracy at first detection is less critical; fish densities of these species will not be used in the DSR stock assessment. Any other species recorded will be used for species assemblage and not used for population estimates. In addition, to the stereo cameras, the camera attached to the "belly" of the ROV will be reviewed for yelloweye rockfish only to ensure all yelloweye rockfish on or near the transect line are observed, an essential assumption of distance sampling. For fish observed only in the belly camera or in one stereo camera (i.e. not in the overlapping field between the two stereo cameras), then a 3D point measurement cannot be generated, and perpendicular distance will be estimated using the two laser beams in the field of view. Care will be taken to not double-count fish that swim into the field of view more than once (this behavior is obvious, and based on our observations, rare for yelloweye rockfish).

The precision for a 3D point is a geometric function of the camera resolution, camera focal length, camera separation, camera distance from object (close is better precision) and object distance from center of field of view (center of field of view is more precise than at the edges). As a consequence, the precision of a 3D point is better when the fish is close to the camera and in the center of the field of view.

The best fish lengths will be obtained by measuring fish when they are close, straight (i.e. not curled), and parallel, relative to the cameras; the video reviewer will measure each fish in the best possible orientation and position and will attempt to obtain RMS <10 mm for both endpoints of the length measurement. The best possible horizontal direction will be obtained; the horizontal direction is the angle between the horizontal component of the measured length and the camera base and represents the degree to which a fish is turned away from the camera. For example, if a fish is parallel to the camera, then it has a horizontal direction of 0° and if a fish is facing directly toward or away from the camera, the horizontal direction is 90°. As the horizontal direction increases, the precision (standard deviation, σ_d) of a length measurement will also increase, because the Δz (the difference in the z coordinate between the snout and tail) becomes larger (Δz=0 when fish parallel) as:

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

(Seager 2008). Precision is expressed in terms of the difference between the x, y, and z coordinates for each endpoint of the length measurement (Δx, Δy, Δz), the standard deviation (precision) of x, y, and z (σ_x, σ_y, σ_z), and the length of the fish (d). The standard deviation of x and y is equivalent and small compared to the standard deviation of z. When a fish is parallel 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). We will attempt to obtain a horizontal direction <30° for each fish and a low precision value. The horizontal direction and the precision may be used to filter out less accurate length measurements. Fish that are not straight will not be measured. If a fish cannot be measured for any reason (i.e. a fish is under a rock, or in a crack) we will note that no length measurement was taken and explain why the measurement was not taken in the comments.

Density and Biomass Estimates

Yelloweye rockfish density will be estimated using DISTANCE 6.2 software (Thomas et al. 2010) which utilizes the following equations to estimate density with the principal function to estimate the probability of detection evaluated at the origin of the transect line ($\hat{f}(0)$):

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

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

where:

n = total number yelloweye rockfish adults and subadults >340 mm observed

$\hat{f}(0)$ = the probability density function evaluated at the origin of the transect line

L = total line length

μ = the effective width

w = width of line transect

P_a = probability of observing an object in the defined area

Yelloweye rockfish lengths and associated parameters, such as horizontal angle and RMS estimates, will be examined to determine which fish to include in the density estimate. Both adult and subadult yelloweye are included in the density estimates; however, we have set criteria to exclude small subadult yelloweye rockfish that are smaller than what are landed in the commercial fishery.

The best probability detection model will be selected in order to obtain a valid density estimate. Models will be explored with and without binning and truncation (i.e. at some predefined maximum distance) of distance data (Figure 7a) and with different key model functions and adjustment terms. The best model will be selected based on visual fit of model, the Akaike information criterion (*AIC*) value, X^2 goodness of fit test, and the CV for the density estimate ($cv_t(\hat{D})$). Probability detection functions will be visually examined to determine if the model fits the data well; it is most important to have a good fit at the origin (Figure 7a). In addition, the model will be examined to determine if the shape is biologically realistic, and if the model has the preferred "shoulder" at the origin of the transect line (Burnham et al. 1980).

Total yelloweye rockfish biomass will be estimated as the product of density, weight, and area of rocky habitat (O'Connell and Carlile 1993). In the past, the average weight of yelloweye rockfish sampled from the directed commercial fishery and from the halibut fishery has been used to expand density estimates to biomass for each management area. With the addition of the stereo cameras, fish can be measured using the SeaGIS software. We plan to explore the conversion of yelloweye rockfish lengths collected from the video observations to weight using length-weight relationships for yelloweye rockfish. We will determine if these weights derived from these length-weight relationships are appropriate for estimating biomass while considering the sample size of the length data obtained from the ROV.

Evaluation of Distance Sampling Assumptions

Distance sampling (Buckland et al. 1993) requires that three 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); (3) distances from the transect line to each object are measured accurately. Failure to satisfy these assumptions may result in biased density estimates. All assumptions were carefully evaluated and met during the 2012, 2013, and 2015 ROV surveys and will continue to be evaluated each successive survey.

To ensure the first assumption is met, we will examine the probability detection function and histograms of the distance data. If the detectability at the transect line is close to 100%, then the probability detection function will have a broad shoulder at the line that will drop off at some distance from the line (Figure 7a) (Buckland et al. 1993). In the past submersible surveys, the observer looked out the submersible port window to identify fish, so fish in close proximity to the submersible were sometimes missed by the observer and the main camera. As a consequence, a forward-facing camera was installed on the submersible to record fish directly on the transect line. The ROV stereo cameras are already oriented forward, so the video reviewer is able to easily detect fish on the transect line. A “belly” camera was added for the 2015 survey. Review of this camera indicated few fish are missed using the stereo cameras. Only two adult yelloweye were observed in the belly camera that were not observed during the dive in the stereo cameras. One of these fish was missed due to poor lighting but was in the field of view of the stereo cameras. The other was observed in the stereo cameras after the dive was completed but within the dive time with the belly camera.

The second assumption will be evaluated by examining the probability detection function (PDF) and the behavioral response of yelloweye rockfish to the ROV. The shape of the PDF may indicate if there is yelloweye rockfish movement response to the ROV. If the PDF has a high peak near the origin line, this may indicate animal attraction to the ROV. Whereas, if there are lower detections near the line and an increase in detection at some distance away from the origin of the line, this may indicate avoidance behavior by the animal (Figure 7b). Previous study results indicated that yelloweye rockfish were not moving in response to the ROV; generally yelloweye rockfish moved very little or slowly (on average 84%), with the majority (on average 71%) not indicating any directional movement (i.e. milling, resting on the bottom). These results are consistent with those observed in other ROV and submersible surveys and indicate that yelloweye rockfish move slowly relative to the speed of the survey vehicle. If undetected movements are random and slow relative to the speed of the ROV then this assumption will not be violated (Buckland et al. 1993). Byerly et al. (2005) found that yelloweye rockfish movement prior to detection by the ROV cameras was random.

The third assumption of distance sampling is met through the use of the SeaGIS software. The SeaGIS EventMeasure software in conjunction with the stereo camera videos allows us to obtain a precise and accurate measurement of distance to the fish (Seager 2008). In the submersible surveys, the observer estimated the perpendicular distance from the submersible to a fish by eye, which is subject to measurement error despite observer calibration before a dive using a hand-held sonar gun.

DATA MANAGEMENT

After the survey, data are loaded into trip, dive, and transect Oracle tables, and after video review, data are loaded into species and length Oracle tables. Transect length estimates are loaded into the transect table once complete. Tables are loaded using Benthic Software: Golden 6 and are accessible through OceanAK. Video data are stored on a server housed at ADF&G headquarters office and are accessible digitally.

SCHEDULE AND DELIVERABLES

Video review analysis will commence immediately after the survey.

Data collected on ROV surveys will be used to update annual stock assessments for demersal shelf rockfish that will be submitted to the Gulf of Alaska Plan Team for approval.

RESPONSIBILITIES

- Andrew Olson, Fishery Biologist III (Groundfish Project Leader)
- Jennifer Stahl, Fishery Biologist II (Data analyses, GIS support)
- Mike Byerly, Fishery Biologist II (ROV Pilot, technical support)
- Josh Mumm, GIS Analyst II (ROV Navigator, technical support)
- Aaron Baldwin, Fishery Biologist I (Video review)
- Asia Beder, Fishery Biologist I (Video review)
- Vacant, Biometrician III (Biometric review, modeler)

REFERENCES CITED

Buckland, S. T., D. R. Anderson, K. P Burnham, and J. L. Laake. 1993. Distance sampling: estimating abundance of biological populations. Chapman & Hall. London. 446 p.

Burnham, K. P., D. R. Anderson, and J. L. Laake. 1980. Estimation of density from line transect sampling of biological populations. Wildlife Monographs. 72: 3–202

Brylinsky, C., J. Stahl, and D. Carlile. 2009. Assessment of the demersal shelf rockfish stock for 2010 in the southeast outside district of the Gulf of Alaska. Chapter 14 in 2009 Stock Assessment and Fishery Evaluation Report for 2010. North Pacific Fishery Management Council, Anchorage, AK.

Green, K., D. Carlile, M. Jaenicke, and S. Meyer. 2014. Assessment of the demersal shelf rockfish stock for 2012 in the southeast outside district of the Gulf of Alaska. Chapter 14 in 2012 Stock Assessment and Fishery Evaluation Report for 2015. North Pacific Fishery Management Council, Anchorage, AK.

Green, K., J. Stahl, and M. Kallenberger. 2013. 2013 Demersal shelf rockfish remotely operated vehicle survey. Alaska Department of Fish and Game, Regional Operational Plan ROP.CF1J.2013.09. Anchorage.

O'Connell, V. M. and D. W. Carlile. 1993. Habitat-specific density of adult yelloweye rockfish Sebastes ruberrimus in the eastern Gulf of Alaska. Fishery Bulletin. 91: 304–309.

Pacunski, R. Palsson, W. Greene, G. Water and D. Gunderson. 2008. Conducting Visual Surveys with a Small ROV in Shallow Water. Alaska Sea Grant. University of Alaska Fairbanks

Ralston, S., Punt, E., Hamel, O., DeVore, J., and R. Conser. 2011. A meta-analytic approach to quantifying scientific uncertainty in stock assessments. Fishery Bulletin. 109: 217–231.

Seager, J. 2008. EventMeasure User Guide. SeaGIS Pty Ltd. June 2015 (version 4.12).

Thomas, L., S.T. Buckland, E.A. Rexstad, J. L. Laake, S. Strindberg, S. L. Hedley, J. R.B. Bishop, T. A. Marques, and K. P. Burnham. 2010. Distance software: design and analysis of distance sampling surveys for estimating population size. Journal of Applied Ecology 47: 5–14.

FIGURES

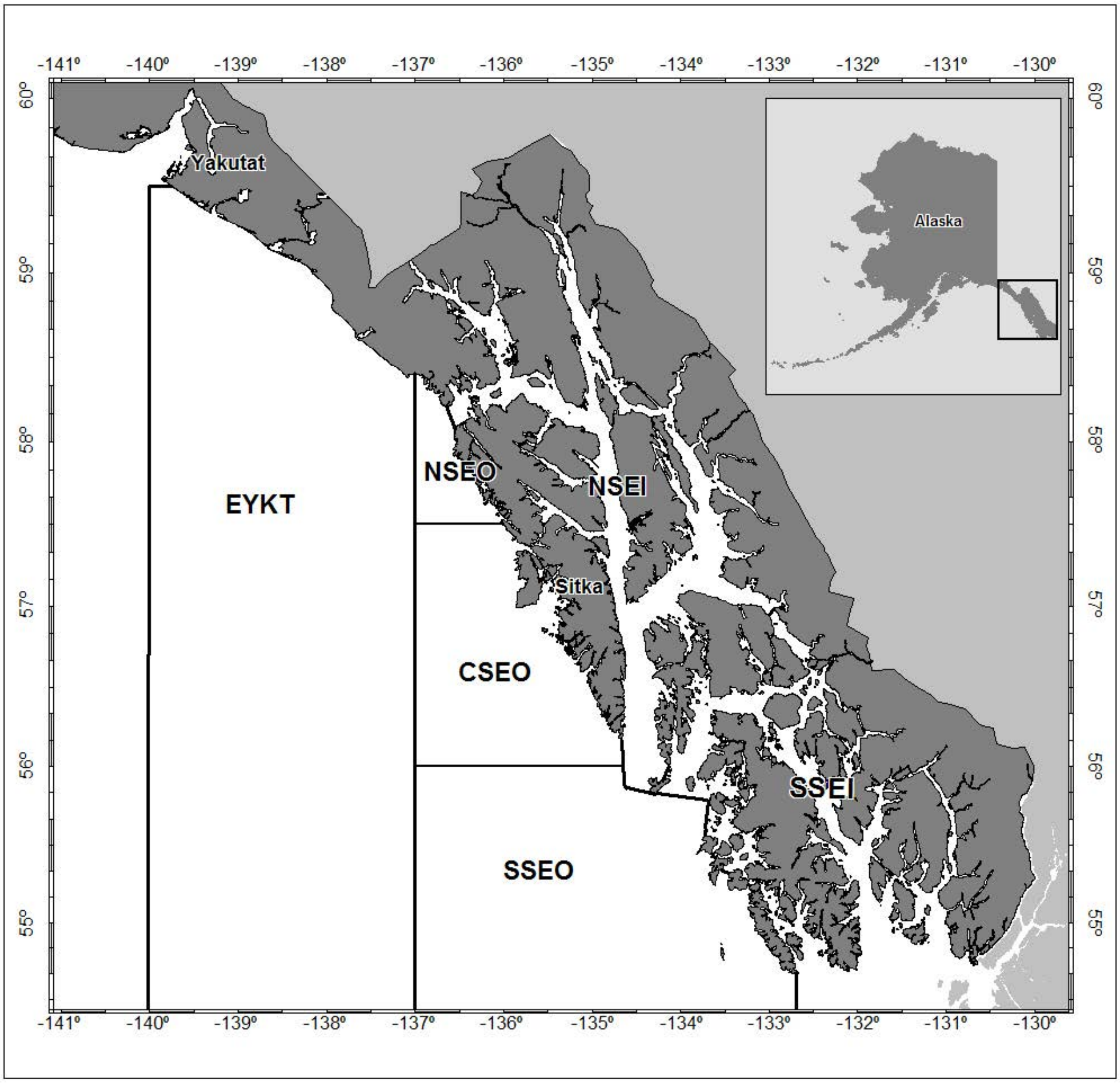

Figure 1.–Southeast Outside Subdistrict groundfish management areas in Southeast Alaska, including East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO).

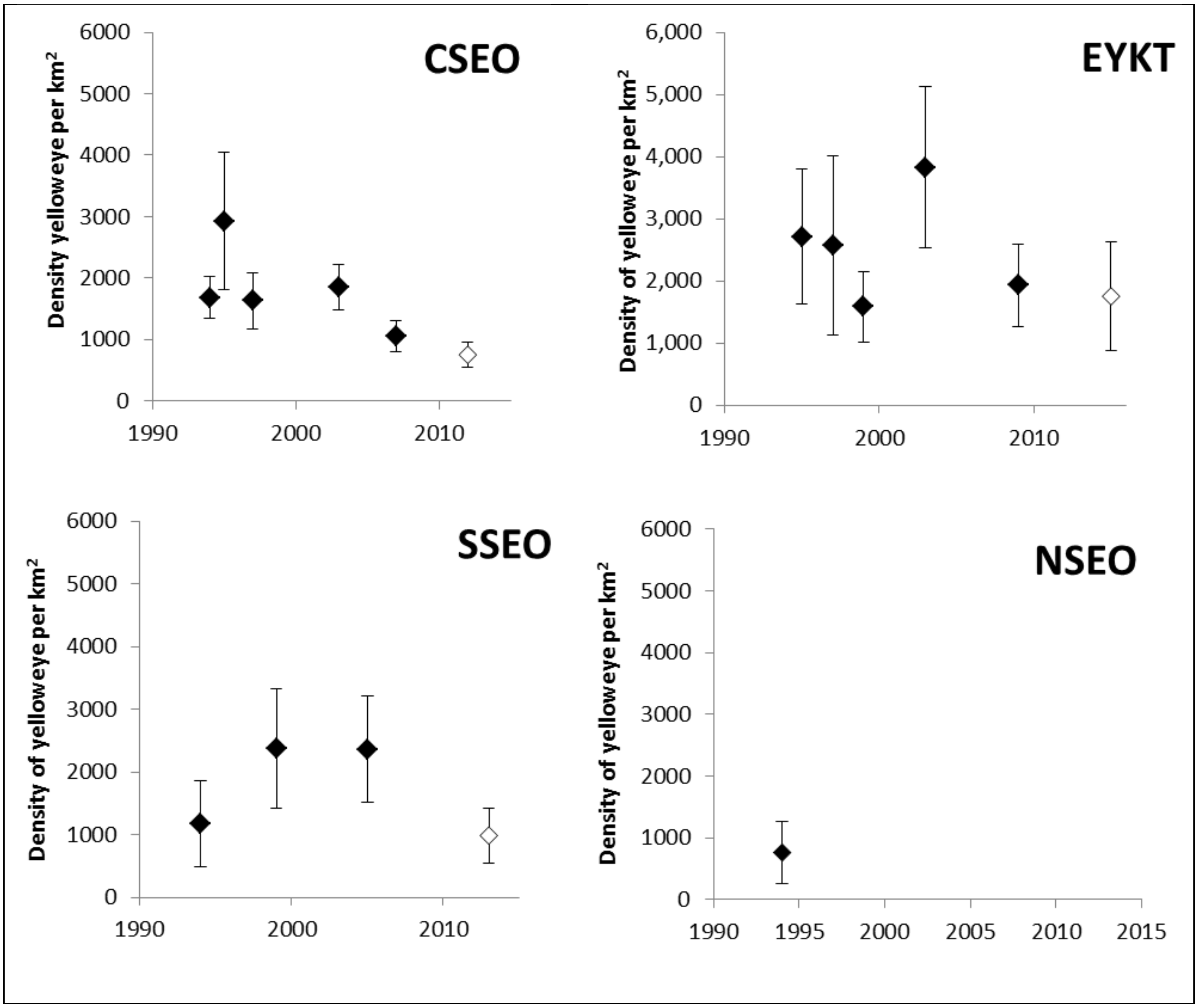

Figure 2.–Density of yelloweye rockfish by year and management area (Central Southeast Outside (CSEO), East Yakutat (EYKT), Southern Southeast Outside (SSEO), and Northern Southeast Outside (NSEO)). Error bars show two standard deviations for density estimates (diamonds).

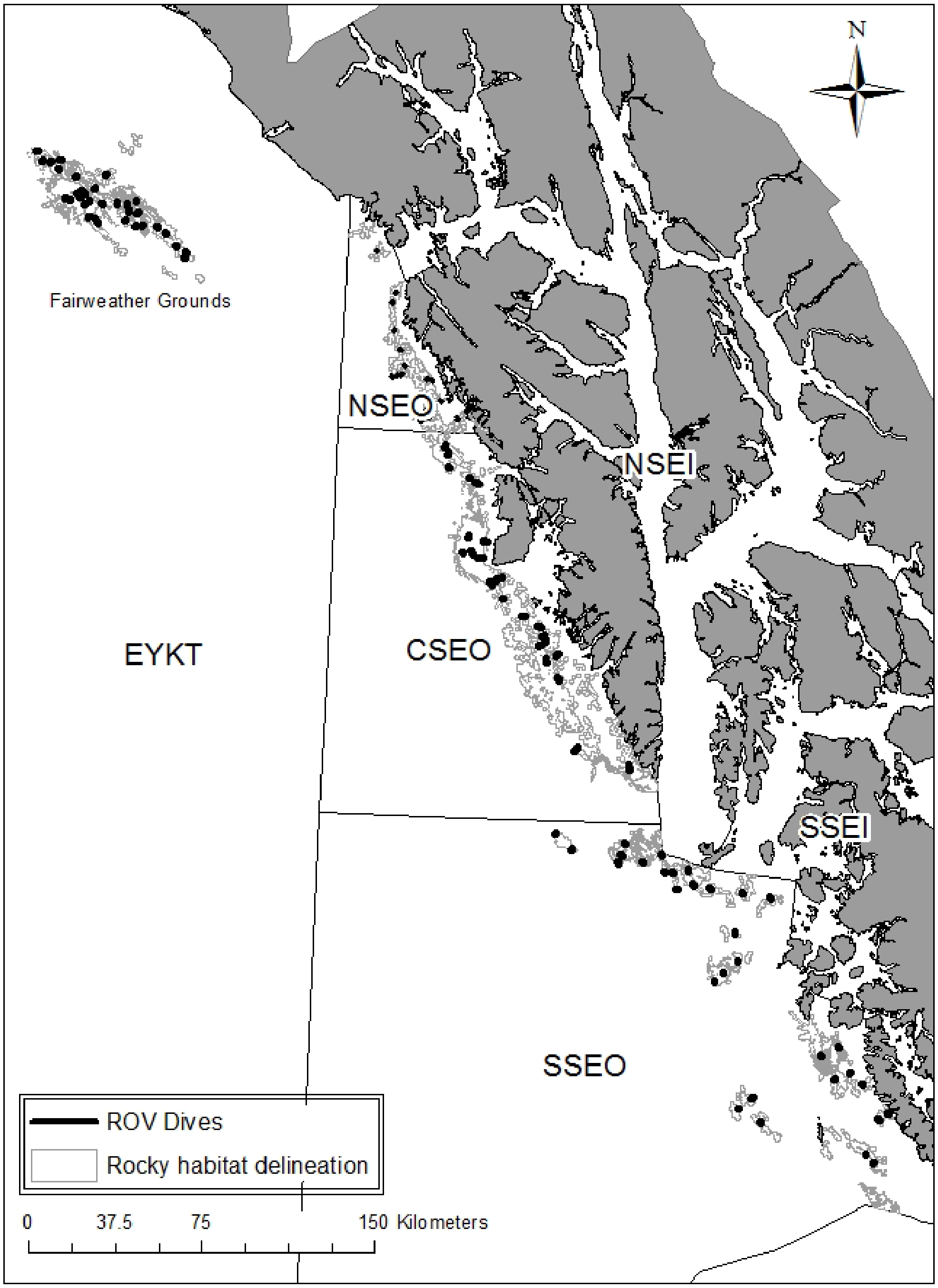

Figure 3.–Example dive locations (white circles) for ROV surveys in Southeast Outside Subdistrict (SEO) overlaid the habitat delineation for yelloweye rockfish.

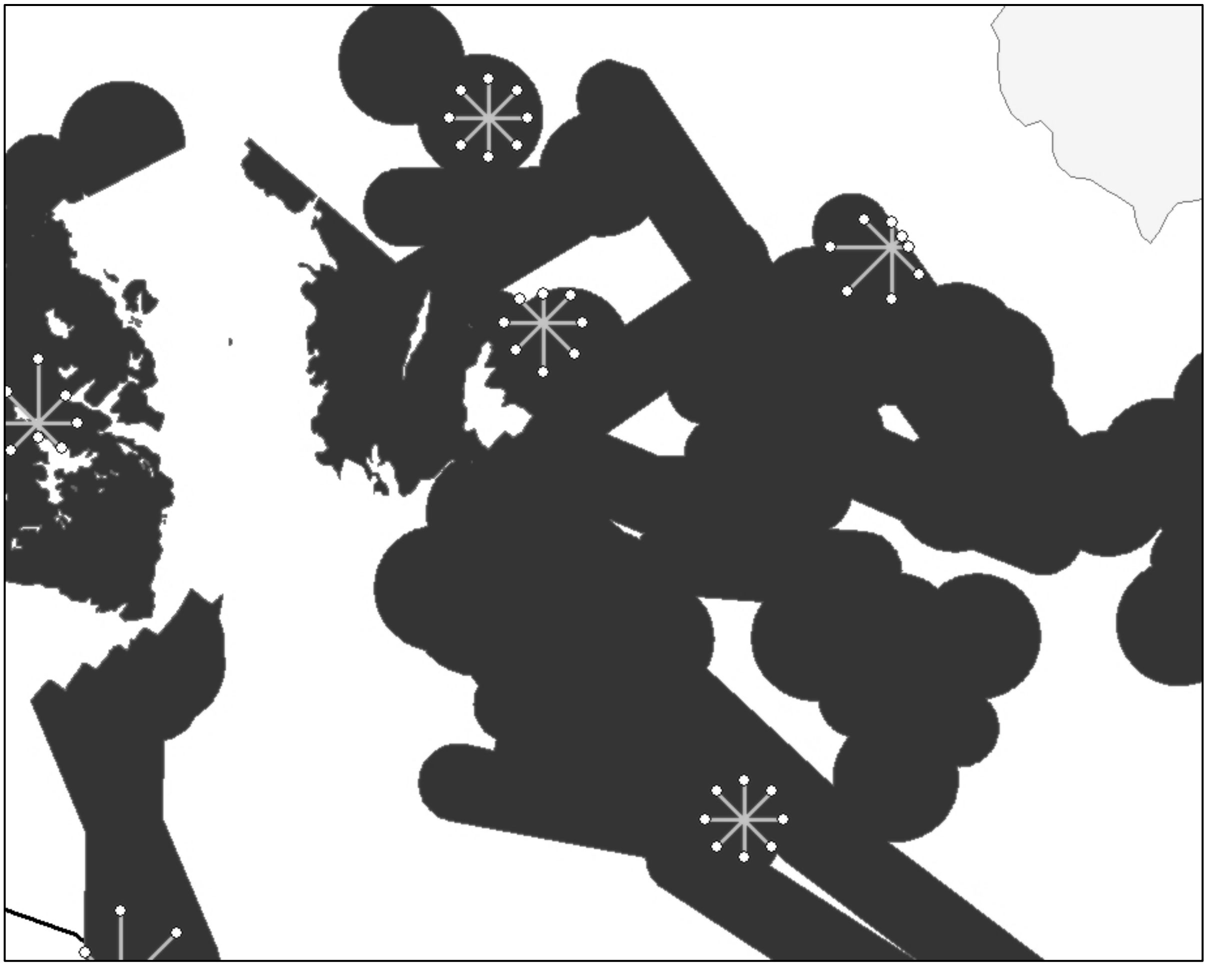

Figure 4.–Example of 1-km transect plan lines. Plan lines (star symbols) are adjusted in some cases to remain within the delineation of rocky habitat (solid dark grey polygons).

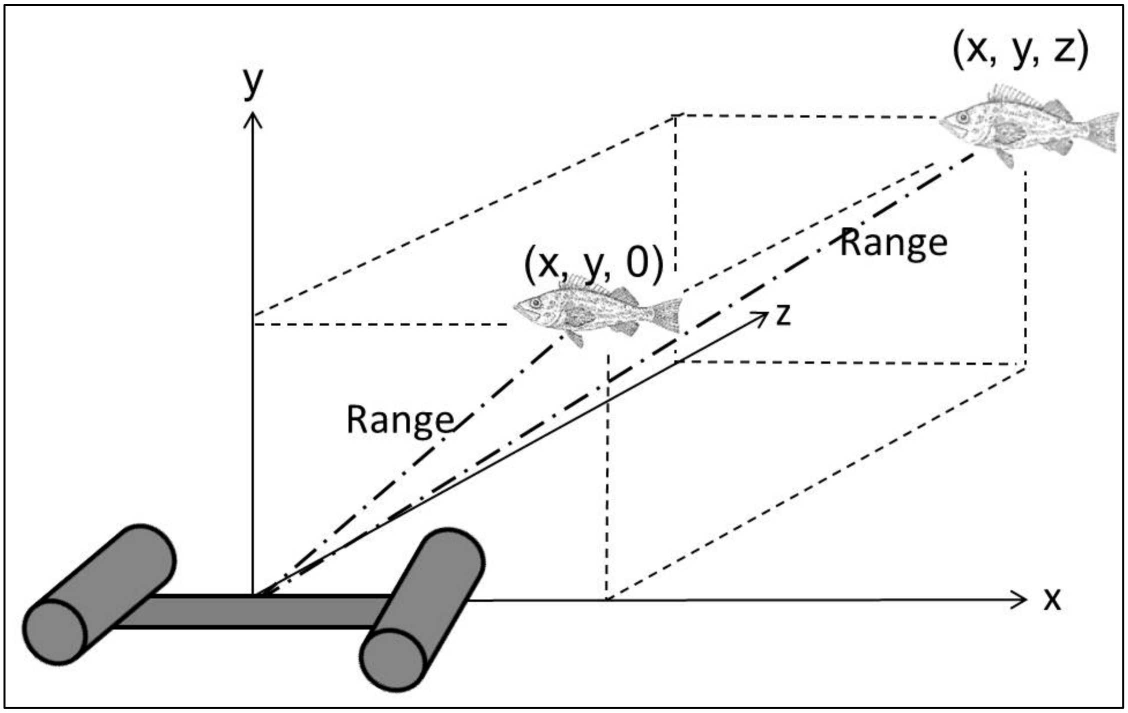

Figure 5.–The components of a 3D point measurement.

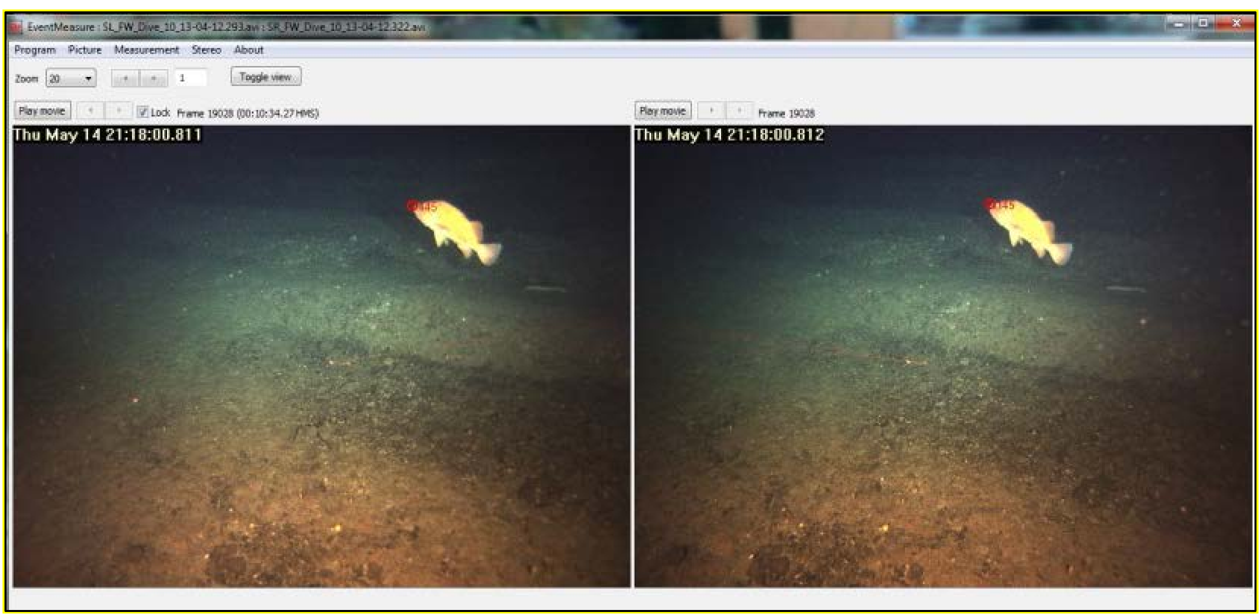

Figure 6.–Yelloweye rockfish marked in the overlapping field of view of the left and right stereo cameras in order to collect a 3D point measurement using SeaGIS Event Measure software.

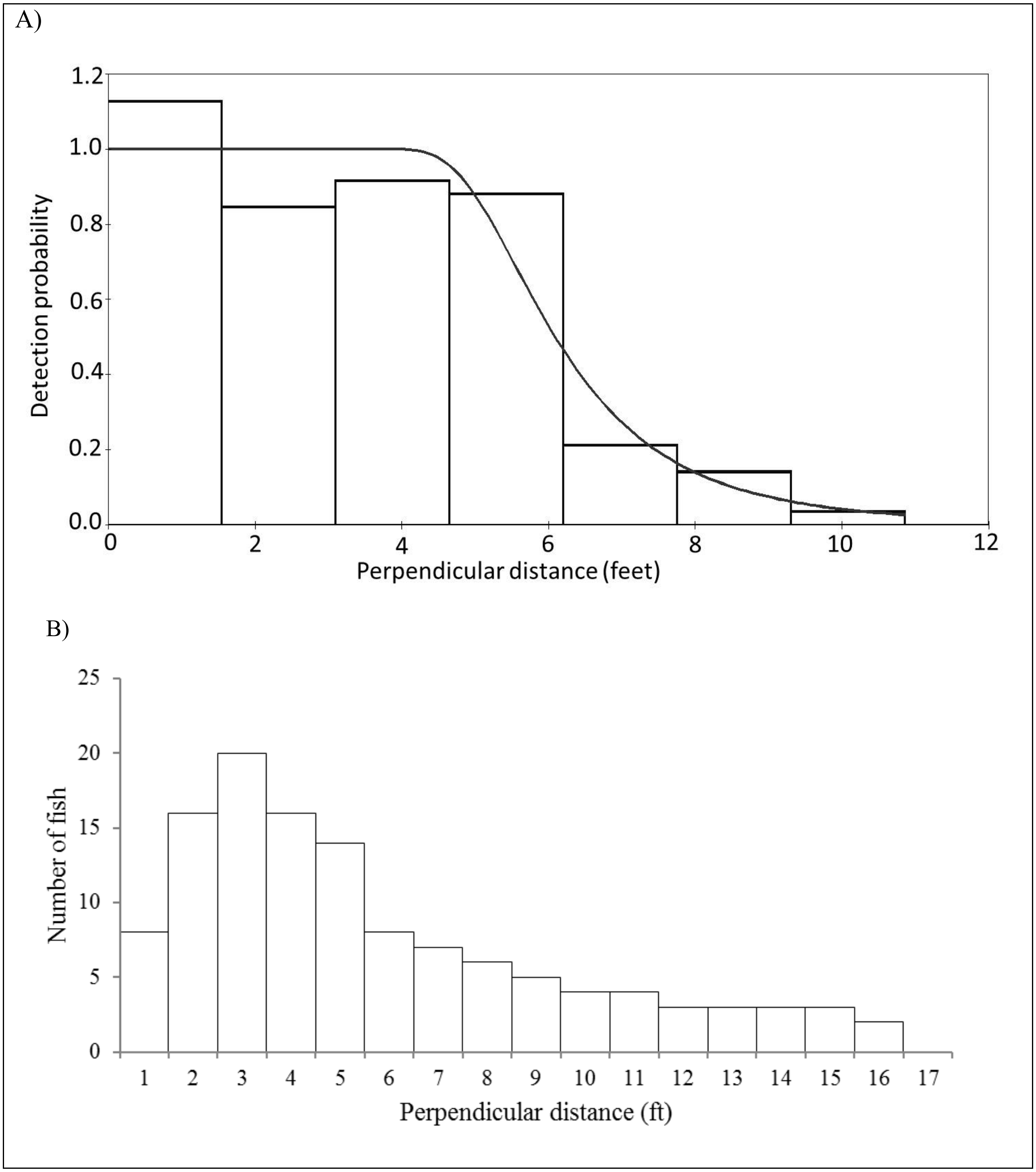

Figure 7.–An example of a probability detection function from the ROV survey which has a good "shoulder" at the origin, and no peaks away from the origin that would indicate avoidance behavior in response to the observer (A). Example histogram of perpendicular distance data, illustrating 'avoidance' behavior in which fish move away from the observer prior to detection (B).

APPENDICES

Appendix A.–Codes used to describe video quality and ROV movements in order to determine which portions of video to use for stock assessment.

Code	Description
GGF	good going forward
GRB	resting on bottom
GRBC	resting on bottom with close-up image
BDO	going over drop-off
BBS	bottom stir-up
BLB	lost bottom visual
BGB	going backwards
BRB	resting on bottom
BCF	bad camera focus
BLA	loitering in same area
BPV	poor visibility
BRP	repositioned

Appendix B.–Species and species class codes for rockfish and other fish and invertebrate species commonly observed on the 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 C.–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 D.–Maturity condition and codes for yelloweye rockfish used during video review.

Code	Maturity
AD	Adult
SU	Subadult
JV	Juvenile
YOY	Young of the year

Appendix E.–Instructions for creating a measurement file template and editing the computer registry for species review using Event Measure.

Setup for Species Review

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

1. *Create New Measurement File*
   - Measurement/ New Measurement File (.emobs)
2. *Set Information Field Names*
   - Click on *Measurement* | *Information Fields* | *Edit Field Names.* Will need to add field names of Year, Dive, and Transect number in fields 5, 6, and 7, respectively.
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 (adfg_species_table.txt").
4. *Edit Attribute Names*
   - Click on *Measurement* | *Attibutes* | *Attribute headers.* In the user defined attribute fields, add the field names of Check ID, Comment, and Event Time HH:MM:SS in attribute name of 8, 9, and 10, respectively.
5. Save Measurement File to use as Template
   - Measurement|Save. Now should only have to change dive and transect number for each new dive (i.e. Dive 9, Transect 1).
6. *Enable Automatic Number Incrementing*
   - Go to Start, 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 "Event Measure – Dive Review" for "Loading Files" (steps 1 through 7).
8. Perform one 3D point measurement in order to setup registry
   - Follow instructions in "Event Measure – Dive Review" for "Species Enumeration and Measurement" (steps 1 through 4).
9. *Edit Activity and Maturity codes*
   - You will need to first use the attribute editor at least once in Event Measure before editing registry. To do this, go through loading file instructions and create one 3D point measurement.
   - Start \search for 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. The following are the activities to add: *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 Event Measure that we use is *attracted*.
10. Use the template you created to perform species review for each dive using the instructions on "Event Measure – Dive Review".

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

Performing Species Review in Event Measure

Loading Files

1. Open EventMeasure (need license key plugged in)
2. Load measurement file template - ***Measurement | Open*, select .EMObs file & click *Open***
3. Load Camera Files
    - **a.** ***Stereo | Cameras | Left |Load camera file,* select stereo left .CAM file & click *Open***
    - **b.** ***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 need to be in the same folder)
5. Load left stereo camera video & set time
    - a. **Uncheck the *Lock Frame* box** (top left, click *Toggle View* if you do not see it)
    - b. ***Picture | Load Picture*, select stereo left file & click *Open***
    - c. ***Picture | Define movie Sequence***
    - d. ***Add file(s)*, select the left stereo video file & click *Open*** (First remove any videos listed).
    - e. 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 two 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, 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**
6. Load right stereo camera video.
    - **a.** ***Stereo | Picture | Load Picture*, select the right stereo video file & click *Open***
    - ***b.*** ***Stereo | Picture| Define movie sequence, Add file(s)*, select stereo right video, click *Open &* click *OK***
7. *Synchronize images*
    - *a.* **Match the time stamps on the stereo left and right video files** (frames do not necessarily match).
    - ***b.*** **Check the *Lock Frame* box**

Enter header information

1. Click on *Measurement | Information Fields | Edit Field Values*
2. Edit Tape Reader, Year, Dive number and Transect number. The depth and OpCode fields will need to be edited as well; the dummy value of "1" can be entered for the OpCode and "0" for the depth field. Transects will be "1" for dives with only one transect performed.

Species Enumeration and Measurement

1. Select 3D measurements for Data view
2. Review video by *Play movie* click play button. Can change speed of video with *Rate*.
3. Stop video at location of interest by *Close player and update position*
4. To record 3D point measurement & attributes
    - *a.* Double-check time stamps match for both cameras; if they do not, then unlock, adjust, and relock.
    - *b.* Click once on the nose of the fish or some other easy to locate point in both the left and right images. Check that RMS value in 3D point information box, which pops up. For yelloweye, lingcod, and halibut try to obtain an RMS value<10mm. If it is not possible, then include a comment. For yelloweye, take 3D measurement at earliest location in video as possible that an RMS<10mm can be obtained. Zoom function may assist in selecting same location in both images.

-continued-

- *c.* Right click on the left image and click *Add 3D point*
- *d.* *Add following attributes*
  - *Family, Genus, or Species* – Select species (by code from *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, remember to go back and fill in the species codes using the ADFG species table; Event Measure does not autofill species codes when common names are selected.
  - *Number* – Change to order specimens sequentially.
  - *Stage – Change to blank for non-yelloweye species. For yelloweye,* select *AD* (adult), *SU* (subadult), or *JV* (juvenile)
  - Activity – Change to blank for non-yelloweye species. For yelloweye choose fish behavior.
  - Check ID - type "Yes" if ID needs to be verified.
  - Comment - Type a short comment if needed. If a length can't be taken for yelloweye, lingcod, or halibut include comment as to why.
  - 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**

5. To record fish length (for yelloweye, halibut, and lingcod)
   - *a.* Select 3D point measurement row for fish that will be measured to autofill attributes.
   - b. Find the best orientation and clarity to capture fish length.
   - *c.* *Close player and update position*
   - *d.* Click on the **nose and fork of the fish** in the both the **left and right images** to take the measurement
   - *e.* Check 3D info. box to see that RMS<10mm for length endpoints and that horizontal angle<30, add comment if either cannot be achieved.
   - *f.* *Confirm correct species, specimen number, and stage are in attribute box*
   - *g.* Remove activity for length record
   - *h.* Add any needed comments, such as high RMS value or horizontal angle>30mm.
   - *i.* Click *OK*

6. Save Text and Measurement Files
   - *a.* *Measurement | Measurement Summaries|3D point and length measurements. File/save data to text file. Use naming convention* "Year_Dive_Dive Number".
   - *b.* *When close event measure will be prompted to save .EMObs measurement file. Click on "Yes".*

Appendix G.–Schedule of activities and deliverables for the 2017 ROV surveys.

Management area	Dates	Activity
EYKT	May 8–20, 2017	ROV survey in Fairweather grounds aboard R/V *Pandalus*
	August 1, 2017	Quality control video review completion
	September 1, 2017	Belly camera video review completion
	September 15, 2017	Transect length estimation
	October 1, 2017	Stereo camera video review
	October 15, 2017	Distance analysis and density estimation
	September 1, 2017	DSR stock assessment report draft to GOA Plan Team
	October 15, 2017	DSR stock assessment report completion
SSEO	August 10–25, 2017	ROV survey aboard R/V *Solstice*
	November 1, 2017	Quality control video review completion
	December 1, 2017	Belly camera video review completion
	December 1, 2017	Transect length estimation
	April 1, 2018	Stereo camera video review
	April 15, 2018	Distance analysis and density estimation
	September 1, 2018	DSR stock assessment report draft to GOA Plan Team
	October, 15 2018	DSR stock assessment report completion