14: ASSESSMENT OF THE DEMERSAL SHELF ROCKFISH STOCK COMPLEX IN THE SOUTHEAST OUTSIDE SUBDISTRICT OF THE GULF OF ALASKA

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Executive Summary

The demersal shelf rockfish (DSR) complex (yelloweye, quillback, copper, rosethorn, China, canary, and tiger rockfish) is assessed on a biennial cycle, with a full stock assessment conducted every second year. Historically, the stock assessment was based on relative abundance estimates from a manned submersible (*Delta*) and transitioned to a remote operated vehicle (ROV) in 2012. The recommended acceptable biological catch (ABC) and overfishing level (OFL) for this year's assessment are based on the most recent ROV density estimates of yelloweye rockfish in each management area using the methodology described in Brylinsky et al. (2009).

Summary of Changes in Assessment Inputs

The following updates have been made to last year's assessment:

<u>Changes in the input data:</u>
Management region specific catch information and commercial fishery average weights were updated for 2021. Relative abundance estimates from the ROV survey were updated for the Southern Southeast Outside (SSEO) Section. In addition, upon biometric review, it was found that the R code used from the 2018 and 2019 density estimates for SSEO, Central Southeast Outside (CSEO), and Northern Southeast Outside (NSEO) Sections did not exclude yelloweye rockfish that were attracted to the ROV; therefore, the adjusted density estimates were reduced due to less specimens contributing to the final density and biomass estimates.

Catch information and the average weight of yelloweye rockfish caught in the commercial fishery were updated for 2021 (Tables 14.1 and 14.2).

<u>Changes in the assessment methodology:</u>
Other than including a risk table for the Gulf of Alaska yelloweye rockfish stock, there are no major changes to the assessment methodology data from the previous habitat-based assessment using ROV density estimates as the primary survey data. A model-averaging procedure was used to account for model uncertainty and derive density estimates, rather than selecting a single "best" model as in past assessments.

Summary of Results

Yelloweye rockfish comprise the largest component of the DSR complex and are managed under Tier 4 of the North Pacific Fishery Management Council (NPFMC) harvest rules, where maximum allowable $F_{ABC} \leq F_{40\%}$ and $F_{OFL}=F_{35\%}$. The estimated yelloweye rockfish biomass increased from 10,648 metric tons (t) to 12,388 t from 2021 to 2022. The increase in abundance is driven by an increase in the estimated density of yelloweye rockfish sampled from the ROV survey in the SSEO management area in 2020. The Tier 6 values for non-yelloweye DSR utilize catch data from 2010–2014, as this is the only time period with overlapping data available from the commercial, recreational, and subsistence fisheries (Table 14.3).

The ABC and OFL for non-yelloweye DSR are calculated based on the Tier 6 harvest rule and are added to the Tier 4 yelloweye rockfish ABCs and OFL for total DSR values.

The maximum allowable ABC for DSR for 2022 is 342 t (322 t yelloweye + 20 t non-yelloweye DSR), which is 14 t higher than the maximum allowable ABC for 2021. The DSR complex is particularly vulnerable to overfishing given their longevity, late maturation, and habitat-specific residency. In addition, there is increased concern for Southeast Outside (SEO) Subdistrict yelloweye rockfish, as described in the risk table. Therefore, as in previous years, we recommend a harvest rate lower than the maximum allowed under Tier 4; $F=M=0.02$. This results in an author's recommended ABC of 268 t (248 t yelloweye + 20 t non-yelloweye DSR Tier 6) for 2022. The OFL is set using $F_{35\%}=0.032$; which is 422 t for 2022.

State of Alaska regulations (5 AAC 28.160(c)(1)(A)) dictate that subsistence DSR removals be deducted from the ABC prior to allocating the total allowable catch (TAC) to the commercial (84%) and recreational (16%) fisheries. Using the most recent subsistence harvest estimate from 2015, 7 t were deducted from the ABC for DSR resulting in a TAC of 261 t. Thus, 219 t is allocated to commercial fisheries, and 42 t is allocated to recreational fisheries for 2022.

Reference values for DSR are summarized in the following table, with the recommended ABC and OFL values. The stock was not subjected to overfishing last year.

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
	2021	2022	2022	2023
M (natural mortality rate)	0.02	0.02	0.02	0.02
Tier	4	4	4	4
Yelloweye Biomass (t)	10,648		12,388	
$F_{OFL}=F_{35\%}$	0.032	0.032	0.032	0.032
$maxF_{ABC}$	0.026	0.026	0.026	0.026
F_{ABC}	0.020	0.020	0.020	0.020
DSR OFL (t)	**405**	**405**	**422**	**422**
DSR max ABC (t)	328	328	342	342
Recommended ABC (t)	**257**	**257**	**268**	**268**
Status	As determined last year for:		As determined this year for:	
	2019	2020	2020	2021
Overfishing	No	n/a	No	n/a

Quantity (Tier 6 for non-yelloweye DSR only)	As estimated or *specified last* year and *recommended this* year for:	
	2021	**2022**
OFL (t)	26	26
ABC (t)	20	20

The summarized results of the risk table for this stock are in the table below. The overall level of 2 suggests there is a continued need to set the ABC below the maximum permissible. Further details for each category of this risk table are provided in the *Harvest Recommendations* section.

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*	*Overall score (highest of the individual scores)*
Level 2: Substantially increased concerns	**Level 2:** Substantially increased concerns	**Level 1:** Normal	**Level 2:** Substantially increased concerns	**Level 2:** Substantially increased concerns

Area Apportionment

The ABC and OFL are set for DSR in the SEO area of the Eastern Gulf of Alaska (EGOA). The State of Alaska manages DSR in the EGOA regulatory area with Council oversight and any further apportionment within SEO is at the discretion of the State. Commercial catch data (t) for DSR in SEO have been updated as of October 26, 2021, using ADF&G fish ticket data (Table 14.2).

Summaries for Plan Team

Species	Year	Biomass[1]	OFL	ABC	TAC[2]	Commercial catch[3]	Recreational harvest[4]	Total catch[5]
DSR	2019	10,592	411	261	254	145	59	221
	2020	10,620	375	238	231	111	5	129
	2021	10,648	405	257	250	108	6	121
	2022	12,388	422	268	261	-	-	-

[1] Biomass estimates were adjusted for 2019 to 2021 due to a coding error in the past analyses. The historic OFL, ABC, and TAC remain unchanged.
[2] TAC is for the commercial and recreational fisheries and is calculated after the subsistence estimated harvest is deducted from the ABC.
[3] Commercial catch data are updated through October 26, 2021.
[4] Updated recreational harvest for SEO is for release mortality estimate only, as retention of DSR in 2020 and 2021 was prohibited. This information was updated through September 17, 2021. The recreational harvest for all years has been updated in 2021 using a new methodology (Howard et al. 2020) described in the recreational fishery removals section of this document.
[5] Total catch is from the commercial (incidental, directed, and estimated unreported catch from commercial halibut fishery), recreational, subsistence, and research fisheries.

A comparison of the lower 90% confidence interval of the DSR biomass estimate to the biomass point estimate and OFL, recommended ABC, and TAC from 2020 to 2022. The 2020 biomass estimate has been updated this year due to a coding error.

Species	Year	Biomass Lower 90% CI	Biomass Point Estimate	OFL Lower 90% CI	OFL Point Estimate	ABC Lower 90% CI	ABC Point Estimate	TAC[1] Lower 90% CI	TAC[1] Point Estimate
DSR	2020	10,620	15,782	375	509	238	322	231	315
	2021	10,648	15,800	405	560	257	354	250	347
	2022	12,388	17,273	422	579	268	365	261	358

[1]TAC is for the commercial and recreational fisheries and is calculated after the subsistence estimated harvest is deducted from the ABC.

Responses to SSC and Plan Team Comments Specific to this Assessment

As in past years, in December 2020, the SSC agreed with the authors and the Gulf of Alaska Groundfish Plan Team (GOA GPT) that precaution is necessary due to the long-term decline in the biomass estimate, though the stable biomass since 2015 is encouraging. The SSC endorsed the GOA GPT's and authors' recommended ABC and OFL for demersal shelf rockfish in the SEO District for 2021 and 2022. DSR management is deferred to the state of Alaska; any further apportionment within SEO is at the discretion of the state.

In the full assessment this year, the SSC looked forward to seeing alternatives for setting OFLs and ABCs that are more in line with current practice (i.e., using point estimates instead of lower 90% confidence intervals and incorporating uncertainty with the risk table rather than in the biomass estimates). The assessment authors created a risk table for SEO yelloweye rockfish, which is the most abundant species within the DSR complex. Overall, there are moderate concerns for yelloweye rockfish in most categories in the risk table; thus, the assessment authors recommend an ABC below the maximum ABC. As in past years, the assessment authors utilize the lower 90% confidence interval biomass estimate to determine the recommended ABC given uncertainty associated with the assessment. Although the stock appears to be moving in an upward trend, it is still considered to be in a depressed state. Until uncertainty can be addressed, the authors continue using the lower 90% confidence interval along with a risk table.

The SSC also agreed with the authors and GOA GPT that an age-structured assessment is desirable for this stock, and the SSC continued to encourage its development. The ADF&G Groundfish Project has recently hired a new biometrician, who is becoming familiar with the current yelloweye rockfish assessment. The department hopes to present a preliminary age-structured assessment for review in 2022.

Introduction

Biology and Distribution

Rockfishes of the genus *Sebastes* are found in temperate waters of the continental shelf off North America. At least thirty-five species of *Sebastes* occur in the Gulf of Alaska. The demersal shelf rockfish complex is comprised of the seven species of nearshore, bottom-dwelling rockfishes (yelloweye, quillback, copper, rosethorn, canary, China, and tiger rockfish; Table 14.4). These fish are located on the continental shelf, reside on or near the bottom, and are generally associated with rugged, rocky habitat. For purposes of this report, emphasis is placed on yelloweye rockfish, as it is the dominant species harvested in the DSR fishery (O'Connell and Brylinsky 2003).

Rockfishes of genus *Sebastes* are physoclistous (closed swim bladder) making them susceptible to embolism mortality when brought to the surface from depth. All DSR are considered highly K-selective, exhibiting slow growth, late maturity, and extreme longevity (Archibald et al. 1981, Haldorson and Love

1991, Love et al. 2002). Estimates of natural mortality are very low. These species of fish are very susceptible to over-exploitation and are slow to recover once driven below the level of sustainable yield (Leaman and Beamish 1984, Francis 1985). An acceptable exploitation rate is assumed to be very low (Dorn 2000).

Stock Structure

Siegle et al. (2013) detected subtle population genetic structure in yelloweye rockfish from the outer British Columbia coast and inner waters, and a lack of genetic structure on the outer coast (between the Bowie Seamount and other coastal locations in British Columbia). These data suggest that due to the long pelagic larval duration for *Sebastes* spp. (several months to one year) there is not significant genetic stock structure for the DSR complex in SEO. However, additional life history data analyses at finer spatial scales are needed to evaluate DSR stock structure in the EGOA and internal waters. In addition, the limited movements of yelloweye rockfish can lead to serial depletion of localized areas if overharvest occurs, as in Aleutian Islands blackspotted/rougheye rockfish (Spencer and Rooper 2016).

Life History Information

Rockfishes are considered viviparous although different species have different maternal contribution (Boehlert and Yoklavich 1984, Boehlert et al. 1986, Love et al. 2002). Rockfishes are iteroparous and have internal fertilization with several months separating copulation, fertilization, and parturition. Within the DSR complex, parturition occurs from February through September with most species extruding larvae in spring. Yelloweye rockfish extrude larvae over an extended time period, with the peak period of parturition occurring in April and May in Southeast Alaska (O’Connell 1987). Some species of *Sebastes* have been reported to brood multiple times within a year off the coast of California, though no incidence of multiple brooding has been noted in Southeast Alaska (Love et al. 1990, O’Connell 1987). Early life history for yelloweye rockfish and other DSR species is poorly understood; however, juveniles are typically found in areas of high relief with vertical walls, algal and kelp-ridden, and nearshore (Love et al. 2002, Love 2011) Yelloweye rockfish from British Columbia reach size- and age-at-50% maturity at 54 cm and 22 years for males and 46 cm and 19 years for females (Love et al. 2002). Research from Arthur (2020) showed that female yelloweye rockfish reach age-at-50% maturity at 16 years and 15 years for males for both Prince William Sound (PWS) and Northern Gulf of Alaska (NGOA). Female yelloweye rockfish in the NGOA reached length-at-50% maturity at 46.7 cm and reached 41.1 cm in PWS. Male yelloweye rockfish reached length-at-50% maturity at 44.0 cm in the NGOA and males in PWS reached 40.8 cm. In Southeast Alaska, yelloweye rockfish begin recruiting to the commercial fishery at age 8.

Fishery

Management Units

Prior to 1992, the DSR complex was recognized in the Fishery Management Plan (FMP) only in the waters east of 137° W. longitude. In 1992, the DSR complex was recognized in East Yakutat (EYKT and management of DSR extended westward to 140° W. longitude. This area is referred to as SEO and is comprised of four management sections: EYKT, NSEO, CSEO, and SSEO (Figure 14.1). In SEO, the State of Alaska and the National Marine Fisheries Service (NMFS) manage DSR jointly. The two internal state water Subdistricts, Northern Southeast Inside (NSEI) and Southern Southeast Inside (SSEI) are managed entirely by the State of Alaska and are not included in this stock assessment. See Appendix A for a more complete description of historical DSR management changes.

Description of Directed Commercial Fishery

The directed commercial fishery for DSR began in 1979 as a small, shore-based, hook and line fishery in Southeast Alaska. This fishery was prosecuted nearshore, with fishing occurring primarily inside the 110 m depth contour. The early directed fishery targeted the entire DSR complex, which at that time also included silvergray, bocaccio, and redstripe rockfish (Appendix A). In more recent years, the hook and line fishery evolved into a longline fishery primarily targeting yelloweye rockfish and fished between the 90 m and the 200 m depth contours. Over the past ten years, yelloweye rockfish accounted for 95 to 97% (by weight) of the total DSR catch (Table 14.5). Quillback rockfish are the next most common species landed in the complex, accounting for approximately 3.6% of the landed catch, by weight, between 2012 and 2021 in SEO (Table 14.5). The directed fishery is prosecuted almost exclusively by longline gear. Although snap-on longline gear was originally used in this fishery, most vessels use conventional (fixed-hook) longline gear. Markets for this product are domestic fresh markets and fish are generally brought in whole, bled, and iced. Processors typically do not accept fish delivered more than three days after being caught. In SEO, regulations stipulate one season only for directed fishing for DSR, opening January 5 (unless closed by emergency order) and continuing until the allocation is landed or until the day before the start of the individual fishing quota (IFQ) halibut season to prevent overharvest of DSR, whichever comes first. The directed DSR fleet requested a winter fishery, as the ex-vessel price is highest at that time.

Directed DSR fisheries are opened only if there is sufficient quota available after estimating DSR mortality in other commercial fisheries. The directed fishery in NSEO has been closed since 1995; the total allocation for this management area has not been sufficient to prosecute an orderly fishery. The directed commercial DSR fisheries in the CSEO and SSEO management areas were not opened in 2005 because it was estimated that total mortality in the recreational fishery was significant and combined with the directed commercial fishery would likely result in exceeding the TAC. No directed fisheries occurred in 2006 or 2007 in SEO as ADF&G took action in two areas; one, to enact management measures to keep the catch of DSR in the recreational fishery to the levels mandated by the Board of Fisheries (BOF), and two, to compare the estimations of predicted incidental catch in the halibut fishery to the actual commercial landings in the halibut fishery under full retention regulations. From 2008–2014, there was sufficient quota to hold directed commercial fisheries in at least two of the four SEO management areas. From 2015–2017, only EYKT was opened, in 2018 only CSEO, and in 2019 only SSEO was open to directed fishing. The directed DSR fishery was closed to harvest in all management areas in 2020 and 2021 due to stock health concerns.

Directed commercial fishery landings have often been constrained by other fishery management actions. In 1992, the directed DSR fishery was allotted a separate halibut prohibited species cap (PSC) and is therefore no longer affected when the PSC is met for other longline fisheries in the GOA. In 1993, the directed fishery was closed early due to an unanticipated increase in DSR incidental catch during the halibut fishery. Since then, the annual incidental catch of DSR has been projected because the directed fishery occurs before the Pacific halibut fishery, which typically starts in mid-March.

DSR Mortality in Other Fisheries

DSR have been taken as incidental catch in domestic longline fisheries, particularly the halibut fishery, for over 100 years. Some incidental catch was also landed by foreign longline and trawl vessels targeting slope rockfish in the EGOA from the late 1960s through the mid-1970s. Other sources of DSR incidental commercial catch occur in the lingcod, Pacific cod, sablefish, and salmon fisheries; however, the halibut longline fishery is the most significant contributor to the incidental mortality of DSR (94.1%). Full retention requirements in which fishermen area required to retain and report all DSR caught were passed by the North Pacific Fishery Management Council (NPFMC) in 1998; however, these requirements did not go into effect until 2005. Under the full retention regulation, fishermen are required to retain and report all DSR caught in federal waters; any poundage above the 10% incidental catch allowance for DSR may be donated or kept for personal use but may not enter commerce. The intention was to create a disincentive for catching DSR incidentally in other fisheries. In July of 2000, the State of Alaska enacted a parallel regulation requiring DSR landed in state waters of Southeast Alaska to be retained and reported on fish tickets. Proceeds from the sale of DSR in excess of legal sale limits are forfeited to the State of Alaska.

The DSR mortality anticipated in the halibut fishery is deducted from the total commercial TAC before a directed fishery can be prosecuted. From 2006 to 2011, the amount of DSR incidental catch in the halibut fishery was estimated using the IPHC stock assessment survey data to determine the weight ratio of yelloweye rockfish to halibut by depth and area. The yelloweye/halibut weight ratio by strata was applied to the IPHC halibut catch limit by strata. For a complete description of estimating the incidental catch of DSR in the halibut fishery prior to 2011, refer to Brylinsky et al. (2009). Since 2012, a ratio of DSR to halibut landed in the halibut fishery is calculated, by management area, and applied to the estimated halibut quota to project DSR incidental mortality. The results of this analysis showed that on an annual basis, the commercial fleet incidental catch rate was consistent (8 to 10%) over a five-year period, while the IPHC survey incidental catch rate was highly variable by strata and year (ranging from 3 to 20%). An additional percentage is added to the estimation preseason for unreported incidental catch.

Commercial Fishery Catch History

Catch data prior to 1992 are problematic due to changes in the DSR species assemblage, as well as the lack of a directed fishery harvest card prior to 1990 for CSEO, SSEO, and NSEO, and prior to 1992 for EYKT (Appendix A). Thus, the history of domestic landings of DSR from SEO is shown from 1992–2021 in Table 14.2 and Figures 14.2–14.5. The directed DSR catch in SEO was above 350 t in the early 1990s. Since 1998, directed landings have been below 250 t, and since 2005, have been less than 130 t. During the years reported, total harvest peaked at 980 t in 1994, and directed harvest peaked at 383 t in 1994. Although directed landings were higher in the 1990s, since 2000, 44.0% of the DSR total reported catch is from incidental catch of DSR in the halibut fishery. Unreported mortality from incidental catch of DSR associated with the halibut and other non-directed fisheries is unknown; however, unreported incidental catch discard mortality in the halibut fishery was broadly estimated in 2021 and is now included in Table 14.2. These estimates will be refined for the 2022 assessment report.

Other Removals

Other removals (subsistence, research, and recreational) are documented in Table 14.2. In July 2009, the ADF&G Division of Subsistence published the results of a study that estimated the subsistence harvest of rockfish in four Alaskan communities, one of which was Sitka (Turek et al. 2009). ADF&G Subsistence Division conducted a call-out survey of “high harvesting households” to obtain additional information on the species composition of subsistence-caught rockfish. This survey revealed that 58% of the rockfish harvested are nonpelagic species, predominantly quillback rockfish (52%). These “high harvesting households” fished predominantly in the Sitka Local Area Management Plan (LAMP) area. The nonpelagic subsistence harvest is reported in numbers of fish by location (northern southeast, southern southeast, and the Sitka LAMP area); these data are converted to weight using the average weights provided from creel sampled recreational harvest. For 2015 estimates, the voluntary mail survey indicated 9,116 rockfish (not defined by species) had been taken in the EGOA subsistence fisheries.[1] No mail surveys have been conducted since 2015 due to lack of funding; therefore, average harvest from 2010–2015 was utilized as an estimate of total anticipated harvest from 2016–present (7 t), which is deducted from the ABC prior to allocating TACs for the commercial and recreational fisheries.

Small research catches of yelloweye rockfish occur during the annual IPHC longline survey (Table 14.2). Research catch data are based on yelloweye rockfish reported on fish tickets from the IPHC survey due to full retention requirements. These are deducted, by management area, from the TAC prior to the opening of the directed commercial fishery.

Recreational Fishery Removals

Regulation currently allocates 16% of the DSR TAC for SEO to the recreational fishery after deduction of the estimated subsistence harvest. The recreational fishery allocation includes estimated harvest and release mortality. Release mortality was estimated at 90% for guided and unguided fishermen prior to the required use of a deep-water release device, which was implemented for guided fishermen in 2013. From 2013 to 2016, unguided release mortality was reduced to 80% due to a small percentage of fishermen following suit of the guided deep water release mandate. For 2017, 2018, and 2019 release mortality was stepped down to 70%, 60% and 50% respectively as the practice of deep-water releasing rockfish became more prevalent. Release mortality has been estimated at 20% for the guided sector since 2013 and unguided sector since 2020, at which time the use of a deep-water release device became required for all fishermen (and all species of rockfish) (Hochhalter and Reed 2011, GMT 2014, Chadwick et al. *In prep*). Prior to 2006, the daily bag limit in the Southeast Alaska recreational fishery for nonpelagic (DSR and slope/other) rockfish was three to five fish, depending upon the area fished, and there were no annual limits on any rockfish species. Additional restrictions also limited the number of yelloweye rockfish that could be retained as part of the three to five fish bag limit. Since then, the BOF has established management provisions that may and have been implemented by the department on an annual basis to manage the recreational fishery to stay within the allocation. This has resulted in more restrictive rockfish regulations over time, which culminated in a closure to DSR harvest in 2020 and 2021. Recreational fishery regulations for DSR in Southeast outside waters in 2021 were as follows:

1) Retention of demersal shelf rockfish was prohibited for all fishermen.
2) Guides and crew members were not allowed to retain DSR rockfish when clients were on board the vessel.
3) All recreational fishing vessels in Southeast outside waters were required to have in possession, and utilize, a deep-water release device to return and release rockfish to the depth it was hooked or to at least 30.5 m (100 ft) in depth.

In addition, since January 1, 2013, all nonpelagic rockfish released from a charter vessel were required to be released with a deep-water release device at the depth of capture or at a depth of at least 100 feet. All charter vessels were required to have at least one functional deep water release device on board, have it

[1] With the exception of the fish reported from the Sitka LAMP area, it cannot be determined how many DSR were caught in SEO versus internal state waters.

readily available for use while fishermen are fishing, and present it for inspection upon request by department or enforcement personnel.

Beginning January 1, 2020, all recreational fishing vessels fishing in salt waters of Southeast Alaska have been required to have in possession, and utilize, a deep-water release device to return and release rockfish to the depth it was captured or at least 30.5 m (100 ft) in depth. All vessels are required to have at least one functioning deep-water release device onboard while recreational fisheries are taking place in salt waters.

Data sources for the recreational fishery include the ADF&G statewide harvest survey (SWHS), mandatory charter logbooks, and interview and biological sampling data from dockside surveys in major ports throughout Southeast Alaska. The SWHS is an annual mail survey sent to a stratified random sample of approximately 45,000 households containing resident and nonresident licensed fishermen. The survey provides estimates of harvest and catch (kept plus released) in numbers of fish, for all rockfish species combined. Up to three questionnaires may be mailed to unresponsive households. Responses are coded by mailing, which allows adjustments for nonresponse bias. Estimates are provided for SWHS reporting areas, which closely mirror ADF&G recreational management areas.

Logbooks have been mandatory for the charter (guided) fishery since 1998. Before 2006, charter logbook data were reported for pelagic and nonpelagic rockfish assemblages. Since 2006 logbooks have required reporting of the numbers of pelagic rockfish, yelloweye rockfish, and all other nonpelagic species (non-yelloweye DSR and slope species) kept and released by each individual fisherman. Charter operators are also required to report the primary ADF&G statistical area for each boat trip.

Creel survey sampling is conducted at public access sites in major ports throughout Southeast Alaska. There is also some sampling of fish landed at private docks and lodges. Prior to 2006, there were no biological data collected by creel samplers beyond species composition of recreational-caught rockfish. Length and weight data were collected in 2006 and 2007 to estimate length-weight functions for each species. Only species composition and length have been collected since 2008. The numbers of rockfish kept and released per boat-trip have been collected by DSR species since 2006. The creel survey interviews also include reporting of the primary statistical area fished for each boat trip.

The method of estimating recreational removals for Southeast Alaska was changed in 2021 from the prior method utilizing the SWHS guided and unguided harvest estimates, and release rates from charter logbook guided fishermen as a surrogate for unguided fishermen.

Final estimates of DSR recreational fishery removals used a combination of data from the SWHS, Southeast Alaska Marine Harvest Studies program creel survey, and charter logbook. Prior to 2021, the SWHS estimates of total rockfish harvest by guided and unguided by area was used as the baseline harvest estimate to apportion out via species composition information from onsite creel surveys. The new method/approach was retrospectively applied to the time series of 1999 to current and involves utilizing the ADF&G charter logbook harvest and release data as the guided total rockfish removal estimate, and then estimating the total rockfish removals for each CFMU by increasing the guided estimate by the ratio of SWHS guided versus total SWHS harvest and release (Howard et al. 2020). DSR removals for each CFMU are apportioned out via species composition information from the Marine Harvest Studies creel survey (Howard et al. 2020; Jaenicke et al. 2019), which is also the sole source of estimates of average weight. Species compositions of releases are assumed to be the same as for harvests.

To assign average weights by DSR species (yelloweye rockfish and the other six DSR species) by fishery type by year and by area, the following decision tree for pooling data was utilized:

Time period from 2006 to 2019 (DSR harvest prohibited for 2020 and 2021):

1) If a sufficient sample size of at least 50 lengths were collected by species by year by area by fishery type, then that average weight was utilized.
2) If there were less than 50 sampled lengths by year by area by fishery type, then a pooling of estimated weight data for the period for 2006 to 2019 by fishery type or by all fishermen combined was conducted to reach the 50 fish minimum sample size.

Time period from 1999 to 2005 (prior to the collection of biological data):

1) The average weights from 2006 to 2010 were pooled by fishery type by area if the sample size was at least 50 lengths.
2) If there were less than 50 sampled lengths by year by area by fishery type, then the pooling of estimated weight data for the period for 2006 to 2019 by all fishermen combined was done to reach the 50 fish minimum sample size.

Biological Fishery Data

Fishery Biological Data

Samples are collected from directed and incidental commercial fishery landings at port to obtain life history information such as length, weight, sex, and age (Carlile 2005). Length frequency distributions are not particularly useful in identifying individual strong year classes because individual growth levels off at about age 30 (O'Connell and Funk 1987). Sagittal otoliths are collected for aging. The break and burn technique is used for distinguishing annuli (Chilton and Beamish 1982). Radiometric age validation has been conducted for yelloweye rockfish otoliths collected in Southeast Alaska (Andrews et al. 2002). Radiometry of the disequilibrium of ^{210}Pb and ^{226}Ra was used as the validation technique. Although there was some subjectivity in these techniques, general agreement between growth-zone-derived ages and radiometric ages was good with a low coefficient of variation. In addition, Andrews et al. (2002) concluded strong support for age that exceeds 100 years from their observation that as growth-zone-derived ages approached and exceeded 100 years, the sample ratios of ^{210}Pb and ^{226}Ra approached equilibrium with a ratio equal to 1. The maximum published age for yelloweye rockfish is 118 years (O'Connell and Funk 1987), but one specimen sampled from SSEO in 2000 was aged at 121 years.

Submersible and ROV surveys

ADF&G began conducting a fishery-independent, habitat-based stock assessment for DSR using visual survey techniques to record yelloweye rockfish observations on line transects in rocky habitat in 1988. The DSR stock assessment surveys have historically rotated among management areas on a quadrennial 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 (Figure 14.1). Instead, the most recent abundance estimate from a management area is used to update the annual stock assessment; however, several years may lapse between surveys in a given management area. 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).

In 2012, ADF&G transitioned to using an ROV for visual surveys given the unavailability of a cost-effective and appropriate submersible. ROVs are a low-cost and versatile tool that have been increasingly used to study marine habitats and organisms (Pacunski et al. 2008). Although the survey vehicle has changed, the basic methodology to perform the stock assessment for the DSR complex remains unchanged. A Deep Ocean Engineering[2], Phantom HD2+2 ROV (property of ADF&G Division of Commercial Fisheries in Homer, AK) is used as the survey vehicle. The ROV is outfitted with a pair of high-definition machine-vision stereo cameras that are used to record video data from line transects. Two additional cameras are mounted to the ROV, the "main" camera, which is a wide-angle, color camera that the pilot uses to drive the ROV, and a "forward-facing" camera. Two scaling lasers, mounted 10 cm apart and in line with the camera housing, are used as a measurement reference for objects viewed in the non-stereo cameras. However, objects viewed in the stereo cameras are most accurately measured during video review in the stereo camera software viewing package. All stereo camera video data are reviewed and analyzed using SeaGIS software (Seager 2012; SeaGIS Pty Ltd., EventMeasure version 5.32). The SeaGIS software is a measurement science software used to log and archive events in digital imagery (Seager 2012).

Analytic Approach

Modeling Approach

Distance sampling methodology is used to estimate yelloweye rockfish density from ROV and submersible surveys. Density estimates are limited to adult and subadult yelloweye rockfish, the principal species targeted and caught in the directed DSR fishery. The ABC recommendations for the entire assemblage are based on adult yelloweye biomass. Biomass of adult yelloweye rockfish is derived as the product of estimated density, the estimate of rocky habitat within the 200 m contour, and average weight of fish for each management area. Variances are estimated for the density and weight parameters, but not for area. Estimation of both transect line lengths and total area of rocky habitat are difficult and contribute to the uncertainty in the biomass estimates. As a result of this uncertainty in the habitat area estimation, the lower 90% confidence interval of the biomass estimate is used to calculate the ABC (Figure 14.6).

Yelloweye Rockfish Density Estimates from Submersible Surveys (1988–2009)

In a typical submersible dive, two transects were completed per dive with each transect lasting 30 minutes. During each transect, the submersible pilot attempted to maintain a constant speed of 0.5 km and to remain within 1 m of the bottom, terrain permitting. A predetermined compass heading was used to orient each transect line. Line transect sampling entails counting objects on both sides of a transect line. Due to the configuration of the submersible, with primary view ports and imaging equipment on the starboard side, fish were only counted on the right side of the line. All fish observed from the starboard port were individually counted and their perpendicular distance from the transect line recorded (Buckland et al. 1993). An externally mounted video camera was used on the starboard side to record both habitat and audio observations. In 1995, a second video camera was mounted in a forward-facing position. This camera was used to ensure 100% detectability of yelloweye rockfish on the transect line; a critical assumption when using line transect sampling to estimate density. The forward camera also enabled the counting of fish that avoided the submersible as the vehicle approached, as well as removing the count of fish that swam into the transect from the left side because of interaction with the submersible. Yelloweye

[2] Product names appearing in this document are included for completeness, and do not imply an endorsement by the Alaska Department of Fish and Game.

rockfish have distinct coloration differences between juveniles, subadults, and adults, therefore these observations were recorded separately.

Hand-held sonar guns were used to calibrate observer estimates of perpendicular distances. It was not practical to make a sonar gun confirmation for every fish. Observers calibrated their eye to making visual estimates of distance using the sonar gun to measure the distance to stationary objects (e.g., rocks) at the beginning of each dive prior to running the transect and between transects.

Yelloweye Rockfish Density Estimates from ROV Surveys (2012–present)
Random dive locations for line transects (Figure 14.7) are created in preferred yelloweye rockfish habitat using ArcGIS. Random locations were removed from the survey design if they were in depths ≥180 m, which is the maximum operating depth for the ROV. Transects of 1-km length were mapped at each suitable random point with four possible orientations along the cardinal and intercardinal directions and crossing through the random point (Figure 14.8). A transect length of 1-km was selected after consideration of visual surveys conducted by other agencies or ADF&G groups (Robert Pacunski, Washington Department of Fish and Wildlife, personal communication, Mike Byerly, ADF&G, personal communication, Yoklavich et al. 2013), the encounter rate of yelloweye rockfish based on previous submersible surveys, and ROV pilot fatigue and inability to maintain concentration for extended periods. The number of planned transects was based on yelloweye rockfish encounter rates from previous surveys and our targeted precision (CVs of less than 25%).

Transect Line Lengths–Submersible
Beginning in 1997, the support ship was positioned directly over the submersible at five-minute time intervals and the corresponding Differential Global Positioning System (DGPS) fixes to determine line length was used. In 2003, the submersible tracking system was equipped with an SG Brown Meridian Gyro® compass, enabling more accurate tracking without positioning the vessel over the submersible. In 2007 and 2009, in addition to collecting the position of the submersible using five-minute time intervals, position data was also every two seconds using the WinFrog® tracking software provided by *Delta*. Outliers were identified in the WinFrog® tracking software data by calculating the rate of travel between submersible locations. The destination record was removed if the rate of travel was greater than two meters per second. In 2007, a 9-point running average was used to smooth the edited WinFrog® tracking software data, and then smoothed data were visually examined in ArcGIS. If any additional irregularities in data were observed, such as loops or back tracks, these anomalies were removed, and the data was resmoothed. After a 27-point smoother was applied to the data, these smoothed line transects were examined in ArcGIS. If any irregularities still existed in the line transects that were thought to be misrepresentations of the actual submersible movements, then these anomalies were removed from the line transect and resmoothed.

Transect Line Lengths–ROV
Transect line length is estimated by editing ROV tracking data generated from Hypack® software. Tracking data are filtered for outliers using Hypack® singlebeam editor (positioning errors are removed and data are filled in to one second intervals using linear interpolation). Video data undergo a quality review to remove any video segments where poor visibility would obscure yelloweye rockfish observations or when the ROV was not moving forward (i.e., stalled, or stopped due to logistical issues). Navigation data are mapped in ArcGIS after being smoothed with a spline in R (R Core Team 2020).

Image quality segments are then joined with the navigation data in ArcGIS using linear referencing. The total line length for each transect is estimated using the good quality image segments only.

Video Review–Submersible
The side facing and forward-facing video from the submersible dives were reviewed post-dive while listening to verbal recordings made by the observer in the submersible. The audio transcript included remarks regarding the species observed, and each individual fish's distance away from the submersible. These data were recorded in the database, as well as any additional yelloweye rockfish seen in either video camera that the observer may have missed while underwater. The observer was able to see farther out the window than the camera field of view, thus the verbal transcript was critical for data collection.

Video Review–ROV
Fish are recorded on the left and right side of the "center line" of the line transect when reviewing video within the SeaGIS EventMeasure software (Seager 2012; SeaGIS Pty Ltd., EventMeasure version 5.42) (Figure 14.9). The video reviewer identifies and enumerates yelloweye rockfish for density estimation, and other DSR, black rockfish, lingcod, halibut, and other large-bodied fish as time allows for species composition. Fish lengths are recorded for individual yelloweye rockfish, lingcod, halibut, and black rockfish. Fish behavior and life-stage are recorded for yelloweye rockfish only.

For each fish, a perpendicular distance from the origin of the transect line to the fish is obtained through the SeaGIS EventMeasure software (Seager 2012; SeaGIS Pty Ltd., EventMeasure version 5.42). The precision of 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). Fish are 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 14.9). Fish that swim into the field of view more than once are not double counted; this behavior is obvious, and based on previous survey observations, rare for yelloweye rockfish.

Fish length is recorded from the tip of the snout to the tip of the caudal fin (Figure 14.10). Length measurements are most accurate when fish are close, straight (i.e., not curled), and parallel, relative to the stereo cameras; the video reviewer measures each fish in the best possible orientation and position. The best possible horizontal direction is obtained, which 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 of a length measurement decreases because the Δz (the difference in the z coordinate between the snout and tail) becomes larger (Δz=0 when fish parallel) as

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

for which σ_d = the standard deviation of a given length measurement (Seager 2012). 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 $\Delta z = 0$ 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).

Density and Biomass Estimates

Analyses are conducted in R (R Core Team 2020) and yelloweye rockfish density is estimated using the R package *Distance*[3] (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 ($\hat{f}(0)$):

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

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

where:

n = total number yelloweye rockfish included in the density estimate

$\hat{f}(0)$ = 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

A suite of density models are examined using a variety of key model functions and adjustment terms, with and without truncation of the distance data, and with the inclusion of two covariates (yelloweye rockfish life-stage and survey depth). Models are evaluated 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 ($cv_t(\hat{D})$). In addition, the models are 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). To deal with uncertainty in model selection when estimating density, the best models (as determined by AICc and goodness of fit tests) are averaged in a bootstrap procedure as recommended by Thomas et al. (2010).

The average weight of yelloweye rockfish sampled from the directed commercial fishery and incidental catch from the halibut fishery, as well as the estimated area of habitat, has been used to expand density estimates to biomass for each management area.

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

[3] https://CRAN.R-project.org/package=Distance

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 ROV and submersible surveys.

To ensure that (1) all objects on the transect line are detected with certainty, the probability detection function and histograms of the distance data are examined. 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 (Buckland et al. 1993). In the past submersible surveys, the observer looked out the side window for fish identification, and fish under or in close proximity to the submersible were sometimes missed by the observer and the main camera prior to installing a “forward-facing” camera in 1995 to record fish on or close to the transect line. The ROV stereo cameras are already oriented forward, so the video reviewer can easily detect fish on the transect line. Additionally, a camera was added to the underside (“belly”) of the ROV in 2015 to verify that no fish were being missed on transect lines.

The second assumption (2) that yelloweye rockfish are detected at their initial location and are not moving in response to the vehicle (submersible or ROV) prior to detection in the video is evaluated by examining the probability detection function and the behavioral response of yelloweye rockfish to the vehicle. The shape of the probability detection function may indicate if there is yelloweye rockfish movement response to the vehicle. If the probability detection function has a high peak near the origin line, this may indicate an attraction. 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. Yelloweye rockfish behaviors during the 2012 survey indicate that yelloweye rockfish are not moving in response to the ROV; generally, yelloweye rockfish moved very little or slowly (85%), with the majority (76%) 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 vehicle 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: (3) distances from the transect line to the fish are recorded accurately is met through the use of the stereo cameras in conjunction with the SeaGIS EventMeasure software (SeaGIS Pty Ltd., EventMeasure version 5.42). In the submersible surveys, the observer visually estimated the perpendicular distance from the submersible to a fish, which is subject to measurement error despite observer calibration before a dive using a hand-held sonar gun.

Results

Average Weight

Yelloweye rockfish weights are obtained from biological sampling of directed and incidental fishery landings and the average of these annual weights for each management area are used in combination with the annual density estimate and estimated area of suitable habitat in each management area to determine the biomass estimate each year. If there is an insufficient number of samples for the current year to obtain an adequate average for the biomass estimate, an average weight from multiple years will be used.

Habitat

Visual surveys are conducted only in yelloweye rockfish habitat, which is defined as rock habitat inshore of the 100-fathom depth contour. Seafloor is designated as "rock" based on information from sonar surveys, directed commercial fishery logbook data, and substrate information from NOAA charts. Substrate information obtained from sonar surveys is considered the best information available on rock habitat. In the absence of sonar data, directed commercial fishery logbook data are considered a proxy for rock habitat (O'Connell and Carlile 1993, Brylinsky et al. 2009). In the NSEO management area, where no sonar surveys have been performed and commercial fishery logbook data are limited, yelloweye rockfish habitat was delineated by buffering features designated as coral, rock, or hard seafloor on NOAA charts by 0.8 km in ArcGIS. Locations were only considered preferred yelloweye rockfish habitat if it lies between ≥ 64 m and < 180 m deep; this criterion was based on observations from the submersible that indicated that 90% of yelloweye rockfish were recorded between those depths.

Seafloor mapping has been performed across 3,907 km^2 of SEO (Table 14.6). Backscatter data have been collected during side scan and multibeam surveys and comprehensive bathymetry data during multibeam surveys with some limited bathymetric soundings collected during side scan surveys. Seafloor has been classified into habitat type by Moss Landings Marine Laboratories' Center for Habitat Studies using bathymetry, backscatter, and direct observations from the *Delta* submersible and reduced to substrate induration of soft, mixed, or hard (Greene et al. 1999). Seafloor identified as hard substrate is considered yelloweye rockfish habitat.

In the EYKT management area, 1,072 km^2 have been surveyed on the Fairweather grounds with 500 km^2 of this area composed of rock habitat. A total of 784 km^2 were side scanned on the west bank in 1998 and 288 km^2 multibeamed on the east bank in 2002 and 2004. In the NSEO management area, 849 km^2 have been multibeamed, with 109 km^2 considered rock habitat. In the CSEO management area, 832 km^2 have been surveyed with 442 km^2 of this area considered rock habitat. A side scan survey covering 538 km^2 was performed west of Cape Edgecumbe (located on Kruzof Island) in 1996. In 2001, a 294 km^2 area west of Cape Ommaney (located on the southern tip of Baranof Island) was surveyed. In the SSEO management area, 1,154 km^2 have been multibeamed, with 322 km^2 considered rock habitat. Multibeam surveys have been performed around the Hazy Islands west of Coronation Island in 2001 (400 km^2), west of Cape Addington on Noyes Island in 2006 (84 km^2), at Learmonth Bank in Dixon Entrance in 2008 (530 km^2), and south of Cape Felix on Suemez Island in 2010 (140 km^2).

For areas without seafloor mapping information, rock habitat was delineated using directed commercial fishery logbook data. Locations where catch per unit effort is ≥ 0.04 yelloweye rockfish per hook are considered preferred yelloweye rockfish habitat. Longline sets with only start positions were buffered by 0.8 km; this established buffer size was retained for consistency in ArcGIS. Starting in 2003, fishermen were required to include both start and end set positions; sets with both locations were buffered by 0.8 km around the entire line in ArcGIS. This buffering criterion was based on the minimum range of travel of four yelloweye rockfish tagged with transmitters in Oregon (P. Rankin, Oregon Department of Fish and Wildlife, personal communication). Buffered logbook sets were merged, and segments were included in the delineated habitat if ≥ 2.3 km in length to ensure rocky segments were large enough for two non-overlapping submersible transects. To consider habitat segments as "continuous," no gaps > 0.9 km were allowed.

Total yelloweye rockfish habitat is estimated for SEO at 3,892 km^2. The Fairweather grounds in EYKT management area composes 739 km^2 of rocky habitat with 68% derived from sonar; NSEO with 442 km^2 of rocky habitat with 25% derived from sonar; CSEO management area is composed of 1,661 km^2 rocky habitat with 27% from sonar; and SSEO composed of 1,056 km^2 of rock with 30% from sonar. Rock habitat not derived from sonar is defined based on fishery logbook data (Table 14.7).

Density estimates

Overall density estimates have declined in most management areas in recent years (Table 14.7; Figure 14.11). The EYKT density estimates have shown a substantial decline since 2003 and. NSEO has continued to decline in density despite long-term directed fishery closures for the area. The CSEO area has also exhibited a large decrease in density since 2003 and experienced a slight rebound in 2016 after being closed to a directed commercial fishery for four years but dropped again in 2018. SSEO has experienced a decline in density since 1999, with a drastic drop determined in 2013. There was an increase estimated from the 2018 survey, with this trend slightly increasing with estimates from the 2020 survey. For a more complete description of previous submersible estimates, refer to Brylinsky et al. (2009).

The first ROV survey was conducted in 2012 in the CSEO management area. Forty-six transects were conducted, and the resulting yelloweye rockfish density estimate was 752 fish/km^2 (CV= 13%) (Table 14.6; Figure 14.6). Ralston et al. (2011) examined stock assessments for 17 data-rich groundfish and coastal pelagic species and found the mean CV for biomass estimates to be 18%. In this context, a CV of 13% was considered a high level of precision, a view supported by Robson and Regier (1964) and Seber (1982). Although ROV results could not be compared directly to the submersible nor could natural changes in the yelloweye rockfish population between years be accounted for, the ROV-based yelloweye rockfish density estimate for 2012 was comparable to previous submersible estimates with a similar magnitude (Green et al. 2013). 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). Since 2012, all management areas have been surveyed for yelloweye rockfish densities with surveyed areas rotating each year due to funding limitations which include EYKT (2015, 2017, 2019), NSEO (2016, 2018), CSEO (2012, 2016, 2018), and SSEO (2013, 2018, 2020) (Table 14.6, Figure 14.6). Due to weather limitations, the CSEO and NSEO areas were not surveyed in August 2021 but will be in the spring of 2022 with the analyses being completed later that year; EYKT will be surveyed in August of 2022.

Harvest Recommendations

Amendment 56 Reference Points

Amendment 56 to the GOA Groundfish Fishery Management Plan defines the “overfishing level” (OFL), the fishing mortality rate used to set the OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set the ABC (F_{ABC}) may be less than this maximum permissible level but not greater. DSR are managed under Tier 4 because reliable estimates of spawning biomass and recruitment are not available. Demersal shelf rockfish are particularly vulnerable to overfishing given their longevity, late maturation, and habitat-specific residency. We recommend a harvest rate lower than the maximum allowed under Tier 4: F=M=0.02. This rate is more conservative than would be obtained by using Tier 4 definitions for setting the maximum permissible F_{ABC} as $F_{40\%}$ ($F_{40\%}$=0.026). Continued conservatism in managing this fishery is warranted given the life history of the species and the uncertainty of the biomass estimates.

Specification of F_{OFL} and the maximum permissible ABC
Under Tier 4, projections of harvest scenarios for future years is not possible. Yields for 2022 are computed for scenarios 1-5 as follows:

Scenario 1: *F* equals the maximum permissible F_{ABC} as specified in the ABC/OFL definitions. For Tier 4 species, the maximum permissible F_{ABC} is $F_{40\%}$=0.026, corresponding to a yield of 341 t (including 20 t for other DSR species).

Scenario 2: *F* equals the stock assessment author's recommended F_{ABC}. In this assessment, the recommended F_{ABC} is F=M=0.02, and the corresponding yield is 267 t (including 20 t for other DSR species).

Scenario 3: *F* equals the 5-year average *F* from 2017 to 2021. The true past catch is not known for this species complex, so the 5-year average is estimated at *F*=0.02 (the proposed F in all 5 years), and the corresponding yield is 255 t (including 20 t for other DSR species).

Scenario 4: *F* equals 50% of the maximum permissible F_{ABC} as specified in the ABC/OFL definitions; 50% of $F_{40\%}$ is 0.013, and the corresponding yield is 171 t (including 20 t for other DSR species).

Scenario 5: *F* equals 0. The corresponding yield is 0 t.

Should the ABC be reduced below the maximum permissible ABC?
The SSC in its December 2020 minutes recommended that the assessment authors utilize the point biomass estimates and incorporate uncertainty with a risk table when determining whether to recommend an ABC lower than the maximum permissible, rather than utilizing the lower 90% confidence intervals. The following template was used to complete the risk table:

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators.

Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types.
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented. More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock. Potential for cascading effects on other ecosystem components.	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock.

The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. Assessment considerations—data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data; model fits: poor fits to fits to fishery or survey data, inability to simultaneously fit multiple data inputs; model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds; estimation uncertainty: poorly-estimated but influential year classes; retrospective bias in biomass estimates.
2. Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.
3. Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.
4. Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings.

<u>Assessment considerations:</u>
There is no age-structured assessment available for SEO DSR and/or yelloweye rockfish. The department continues to work towards such an assessment but has lacked the technical staff to do so. Yelloweye

rockfish biomass is currently assessed using estimates of yelloweye rockfish density, the estimated area of yelloweye habitat, and the average weight of yelloweye rockfish caught in commercial fisheries. The amount of yelloweye habitat in each management area was estimated from commercial longline data and NOAA survey data and currently has no variance component associated with it. Furthermore, each management area is surveyed only once every three or four years. Because there is currently no way to assess uncertainty in the amount of habitat available, the true precision and bias of the biomass estimate remains unknown. Given the lack of an age-structured assessment and the uncertainty regarding the precision and bias of the biomass estimates, this category is rated as Level 2.

Population dynamics considerations:
Yelloweye rockfish comprises over 95% of the DSR commercial harvest and is the primary target compared to the six other DSR species (quillback, copper, rosethorn, canary, China, and tiger rockfish). DSR are particularly vulnerable to overexploitation and are slow to recover once fished below sustainable levels given their longevity, slow growth, late maturation, and high site-fidelity, with yelloweye rockfish reaching an estimated maximum age of 122 years and maturing at 18–22 years. Biomass estimates of yelloweye rockfish derived from submersible and ROV surveys demonstrate a 60% decline since 1994, despite conservative management over the last decade. In addition to the decline in biomass, annual trends in biological data (length, weight, and age by sex) reveal truncation of age classes, thus reducing reproductive potential and increasing uncertainty for future recruitment of juveniles. The lack of an age-structured assessment further limits our ability to examine recruitment. Given the data and assessment limitations for yelloweye rockfish, this category is rated Level 2, as stock trends are unusual with biomass estimates decreasing over time.

Environmental/Ecosystem considerations:
This category was scored as level 1 (normal concern) given limited and mixed information on the abundance of prey, predators, and competitors, and a lack of a mechanistic understanding for the direct and indirect effects of environmental change on the survival and productivity of demersal shelf rockfish.

The demersal shelf rockfish (DSR) stock complex includes seven species (canary, China, copper, quillback, rosethorn, tiger, and yelloweye rockfish) found in the SEO region (east of the 140 W˚ longitude, NMFS Area 650). This summary of environmental considerations for the stock complex is based on representatives of the dominant species (yelloweye rockfish, accounts for approximately 95% of the total biomass) and of the minor species accounting for a low percentage of harvest, with little data to assess population status (canary, China, copper, rosethorn, tiger, rosethorn, and quillback), described in Baskett et al. (2006), Love et al. (2002), and Yoklavich et al. (2002).

It is reasonable to expect that the 2021 and predicted 2022 average deeper ocean temperatures will provide good spawning habitat and average to cooler surface temperatures contribute to good pelagic conditions for age-0 rockfish during a time when they are growing to a size that promotes over winter survival. Adult yelloweye are found in depths of 90 to 180 m, in rocky, high relief crevices, pinnacles, and overhangs (Love 2002). Their temperature range extends as low as 4.7℃. The adults of the minor group are found at depths of 30 to 300 m among boulder fields, high relief rock, caves, crevices, pinnacles, kelp beds, and areas of high rugosity. Their optimal temperature ranges from 4.1℃ to 12.2℃. The 2021 summer surface waters over the EGOA shelf (Bottom Trawl Survey: 13.4 °C; Laman 2021) cooled from 2019 to approximately the long-term average. The surface waters of Icy Strait (located in internal state waters) remained just below the long-term average, at 8.9 °C, for a second year. At ~ 200 m depth, EGOA shelf summer temperatures were cooler than the previous surveys (Longline Survey: 5.5 °C, Siwicke 2021, and Bottom Trawl Survey: 5.9 °C) but still slightly warmer than survey-specific long-term averages. Additional GOA-wide epifauna habitat data show a continued decline in sponges since 2015, particularly the Shumagin and Kodiak areas (AFSC Bottom Trawl Survey; Palsson 2021) and no change in relative abundance of soft corals (AFSC Bottom Trawl Survey; Palsson 2021).

The prey base for yelloweye rockfish and the minor group is potentially average to good, with limited prey- and region-specific information. The primary prey of yelloweye rockfish are primarily rockfish and then herring. The minor group prey on crab, shrimp, and smaller rockfish. Herring spawning stock biomass continues a multi-year increase in southeast Alaska, particularly the Craig and Sitka - ocean influenced populations (Hebert 2021). Shrimp have been increasing around Yakutat and southeastern GOA regions over the past 5 years (Bottom Trawl Survey, Palsson 2021) and Tanner crab around Kodiak (EGOA crab status is not known) have been increasing (ADF&G trawl survey, Worton 2021). Western GOA spring larval surveys (no eastern GOA data available) observed lower than average age-0 rockfish, potential indicative of reduced prey for the minor group of demersal shelf rockfish (EcoFOCI spring survey, Deary 2021).

There is no cause to suspect increased predation pressure on larval or adult demersal shelf rockfish. Predators of yelloweye rockfish include salmon and orcas. Predators of the minor group include lingcod, shore birds, and larger rockfish. SEAK salmon returns in 2021 (as indicated by commercial catch) rebounded from a low in 2019, largely driven by large returns of pink salmon (primary prey are zooplankton and squid) and a slight increase in chum salmon (Murphy 2021). Little is known about the population status of orcas, lingcod, and shore birds.

The main competitors of juvenile yelloweye rockfish are other rockfish, and are unknown for the minor group.

<u>Fishery performance:</u>
With the closure of the directed DSR commercial fishery and prohibition of DSR retention in the recreational and personal use fisheries, DSR rockfish may only be retained in subsistence fisheries and as bycatch in commercial fisheries. Commercial fishery bycatch harvest of yelloweye rockfish has increased over the last three years, primarily in the halibut IFQ longline fishery, indicating that halibut fishermen may be finding it more difficult to avoid catching DSR rockfish or may be fishing more heavily in areas where DSR rockfish are more abundant. Preliminary results from directed DSR fishery CPUE analyses showed a contrasting pattern (increasing or staying the same) from the biomass trend (declining) and shifts in spatial distribution of fishery effort was observed in maps created using logbook set data. Harvest reconstruction of yelloweye rockfish mortality showed OFL and ABC levels were exceeded in several years, previously believed to be under the ABC. Given the recent fishery closures, conservation concerns, and increases in bycatch harvest, this category is rated as Level 2.

Other Ecosystem Considerations

Fishery Effects on the Ecosystem

<u>Fishery-specific contribution to HAPC biota:</u>
HAPC biota such as corals and sponges are associated with some of the same habitats that yelloweye and other demersal shelf rockfish inhabit. On ROV and submersible dives, many observations of yelloweye rockfish in close association with corals and sponges have been recorded. However, as described above, bottom trawling is prohibited in the EGOA, so contact with the bottom and therefore biogenic habitat removal is limited to primarily hook and line and dinglebar gear. The expanded observer program should provide additional data on invertebrate incidental catch in the DSR directed and halibut fisheries.

Fishery specific concentration of target catch in space and time relative to predator needs in space and time (if known) and relative to spawning components:
Insufficient research exists to determine yelloweye rockfish catch relative to predator needs in time and space. Yelloweye rockfish are winter/spring spawners, with a peak period of parturition in April and May in Southeast Alaska (O'Connell 1987). The directed fishery, if opened, occurs between late January and early March, but the bulk of the mortality for the DSR complex is taken as incidental catch in the halibut longline fishery. Reproductive activities do overlap with the fishery, but since parturition takes place over a protracted period, there should be sufficient spawning potential relative to fishery mortality.

Fishery-specific effects on amount of large size target fish:
Full retention of the DSR complex is required in the EGOA, therefore high grading should be minimized in the reported catch and lengths sampled in port should be representative of length composition of yelloweye rockfish captured on the gear. The commercial directed fisheries landing data show that most fish are captured between 450 and 700 mm depending on the management area (Figures 14.12 to 14.15). There are some differences in the length compositions of yelloweye rockfish from the commercial fishery compared with the measurements of yelloweye rockfish derived from the ROV survey; however, those differences are still being explored (Figure 14.16).

Fishery contribution to discards and offal production:
Full retention requirements of the DSR complex became regulation in 2000 in state waters and 2005 in federal waters of the EGOA, thus making discard at sea of DSR illegal. There may be some unreported discard in the fishery. Data from the observer restructuring program may shed additional light on the magnitude of unreported catch.

Fishery-specific effects on age-at-maturity and fecundity of the target fishery:
Fishery effects on age-at-maturity and fecundity are unknown. Age composition of the fishery, by management area, is shown in Figures 14.17 to 14.20. The age at 50% maturity for yelloweye rockfish in Southeast Alaska is 17.6 years. This age is based on a maturity-at-age curve for males and females combined and was derived from directed DSR commercial fishery data from 1992–2013 from all four management areas. Most yelloweye rockfish are captured at ages greater than the length at 50% maturity.

Fishery-specific effects on essential fish habitat (EFH) living and non-living substrate:
Effects of the DSR fishery on non-living substrates are minimal since no trawl gear is used in the fishery. Occasionally fishing gear is lost in the fishery, so longline and anchors may end up on the bottom. There is likely minimal damage to EFH living substrate as the gear used in the fishery is set on the bottom but does not drag along the bottom.

Data Gaps and Research Priorities

Surveying SEO management areas more frequently and consistently would allow for more accurate biomass estimates. In the absence of a survey, the latest density estimate for a management area is used in determining biomass estimates for SEO, which can be misleading in areas where fishery catch has occurred. In addition, utilizing a habitat suitability model to determine better estimates of yelloweye rockfish habitat would help reduce uncertainty in the assessment.

There is limited information on yelloweye rockfish fecundity and maturity. Little is known about the timing of parturition for yelloweye rockfish recruitment or post larval survival. A fecundity and maturity project is currently underway to provide updated life history parameter estimates for yelloweye rockfish for each management area. A recruitment index for yelloweye rockfish would improve modeling estimates for total yelloweye rockfish biomass. In addition, a yelloweye rockfish age-structured assessment would also improve modeling estimates.

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Table 14.1. The average weights (kg), number sampled, and the standard deviation of weights for yelloweye rockfish from East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) Sections, 1984–September 2021.

Year	EYKT			NSEO			CSEO			SSEO		
	Average Weight	# YE	SD	Average Weight	# YE	SD	Average Weight	# YE	SD	Average Weight	# YE	SD
1984	-	-	-	-	-	-	5.40	124	0.82	-	-	-
1985	-	-	-	-	-	-	-	-	-	4.58	191	1.00
1986	-	-	-	-	-	-	-	-	-	-	-	-
1987	-	-	-	-	-	-	-	-	-	2.96	30	1.51
1988	-	-	-	3.45	425	1.57	3.17	2,663	1.43	3.37	4,130	1.46
1989	-	-	-	3.15	160	0.98	3.20	1,743	1.44	3.53	323	1.23
1990	-	-	-	-	-	-	3.12	790	1.56	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	3.15	316	1.79
1993	-	-	-	-	-	-	-	-	-	2.90	145	1.39
1994	-	-	-	-	-	-	-	-	-	4.37	215	1.59
1995	3.44	200	0.98	-	-	-	3.14	446	1.35	3.68	222	1.18
1996	3.47	350	1.19	-	-	-	3.12	609	1.23	3.37	794	1.41
1997	3.80	398	1.31	-	-	-	2.72	518	1.26	3.14	230	1.23
1998	4.04	429	1.39	-	-	-	2.79	217	1.38	3.00	281	1.14
1999	3.78	260	1.03	-	-	-	3.02	603	1.20	3.03	253	1.26
2000	3.56	130	1.01	-	-	-	3.14	120	0.93	3.51	591	1.30
2001	4.54	108	1.39	-	-	-	3.40	266	1.24	3.34	171	1.12
2002	-	-	-	-	-	-	3.23	347	1.22	3.43	444	1.25
2003	-	-	-	-	-	-	3.03	278	1.16	3.45	73	1.33
2004	3.74	556	1.35	-	-	-	3.11	151	1.20	3.33	325	1.14
2005	4.30	274	1.59	-	-	-	-	-	-	-	-	-
2006[a]	-	-	-	-	-	-	-	-	-	-	-	-
2007[a]	-	-	-	-	-	-	-	-	-	-	-	-
2008	3.86	250	1.59	4.02	100	1.36	3.20	369	1.24	3.73	180	1.33
2009	4.18	265	1.60	3.35	183	1.34	3.53	517	1.20	3.53	171	1.32
2010	4.24	260	1.62	4.02	147	1.75	3.49	435	1.25	3.34	327	1.19
2011	4.41	413	1.58	3.43	129	1.18	3.14	513	1.18	3.53	214	1.29
2012	3.38	967	1.61	3.24	94	1.26	3.48	671	1.14	3.68	312	1.25
2013	4.19	455	1.54	-	-	-	3.25	466	1.15	3.52	429	1.33
2014	3.67	421	1.10	3.71	123	1.12	3.37	418	1.16	-	-	-
2015	4.00	375	1.44	3.95	312	1.39	3.47	455	1.18	-	-	-
2016	3.83	452	1.44	3.94	377	1.29	3.47	509	1.21	3.32	155	1.22
2017	3.87	572	1.35	3.71	410	1.35	3.57	560	1.14	4.59	31	1.31
2018	3.95	560	1.56	3.54	378	1.28	3.63	739	1.20	4.97	11	0.90
2019	4.08	182	1.67	3.37	40	1.20	3.49	493	1.23	3.49	553	1.25
2020[a]	4.17	55	1.22	3.86	85	1.24	3.43	84	1.05	-	-	-
2021[a]	4.17	304	1.50	3.43	63	1.24	3.50	175	1.09	3.95	32	1.14

[a] The commercial directed demersal shelf rockfish fishery was closed to harvest in all management areas; average weights, if available, were obtained from bycatch in the halibut fishery.

Table 14.2.–Catch (t) of demersal shelf rockfish from research, directed commercial, incidental commercial, estimated unreported discards from the halibut fishery, recreational, subsistence, and total catch from all fisheries in the Southeast Outside (SEO) Subdistrict, 1992–October 2021. Also included are allowable biological catch (ABC), overfishing level (OFL), and total allowable catch (TAC) for 1992–2022. Commercial catch includes redbanded rockfish from 1992–1996 and also include discards at sea/at the dock and catch retained for personal use.

Year	Research	Directed	Incidental	Unreported Discards	Recreational[b]	Subsistence[c]	Total	ABC[d]	OFL[d]	TAC[d]
1992	0	362	168	191	16	8	745	550	-	550
1993	15	342	230	267	20	8	882	800	-	800
1994	4	383	268	283	34	8	980	960	-	960
1995	14	155	123	72	25	8	398	580	-	580
1996	12	345	94	135	28	8	622	945	-	945
1997	16	267	105	217	38	8	651	945	-	945
1998	2	241	119	175	47	8	592	560	-	560
1999	2	240	125	175	33	8	584	560	-	560
2000	8	183	105	150	53	8	507	340	-	340
2001	7	173	145	113	49	8	495	330	-	330
2002	2	136	148	128	47	8	469	350	480	350
2003	6	102	168	95	48	8	427	390	540	390
2004	2	174	155	170	60	8	568	450	560	450
2005	4	42	192	157	72	8	475	410	650	410
2006[e]	2	0	204	49	87	8	348	410	650	410
2007[e]	3	0	196	48	82	8	336	410	650	410
2008	1	42	152	36	81	8	319	382	611	382
2009	2	76	140	34	47	8	306	362	580	362
2010	7	30	133	31	63	8	268	295	472	287
2011	5	22	88	12	50	6	182	300	479	294
2012	4	105	77	10	55	7	257	293	467	286
2013	4	129	84	11	47	7	279	303	487	296
2014	5	33	64	8	47	7	163	274	438	267
2015	4	33	70	9	57	8	181	225	361	217
2016	4	34	79	10	51	7	185	231	364	224
2017	5	32	94	12	54	7	204	227	357	220
2018	6	51	80	10	53	7	205	250	394	243
2019	10	45	89	11	59	7	219	261	411	254
2020[e]	6	0	99	12	5	7	131	238	375	231
2021[a,e]	6	0	90	12	6	7	102	257	405	250
2022	-	-	-	-	-	-	-	268	422	261

[a] Landings from ADF&G fish ticket database, updated through October 26, 2021.

[b] Recreational harvest for 1992–1998 referenced from Table 1 in Chadwick et al. 2017; recreational harvest for 1999–2021 include retained harvest plus estimated release mortality discard.

[c] Projected subsistence catch for the fishery year. These data were not available or deducted from the ABC prior to 2009. Harvest interviews have not been conducted since 2015 but were estimated for all years to account for subsistence harvest that occurred.

[d] ABC for CSEO, NSEO, and SSEO only (not EYKT) in 1993. ABC, OFL, and TAC based on lower 90% confidence interval.

[e] The directed commercial demersal shelf rockfish fishery was closed to harvest in SEO.

Table 14.3.–Catch data for Tier 6 calculations for non-yelloweye demersal shelf rockfish (DSR). These catch data represent for each species, the highest year (maximum sum) of commercial, subsistence, and recreational catch during 2010–2014. The 2010–2014 time period is used because the three-time series of catch data (commercial, recreational, and subsistence) overlap.

Species	**Max catch (t) 2010–2014**	**OFL (t)**	**ABC (t)**
Canary rockfish	5.6	5.6	4.2
China rockfish	1.4	1.4	1.1
Copper rockfish	4.4	4.4	3.3
Quillback rockfish	13.9	13.9	10.4
Rosethorn rockfish	0.0	0.0	0.0
Tiger rockfish	0.8	0.8	0.6
Sum Tier 6 (t)		**26.1**	**19.6**

Table 14.4.–Species included in the demersal shelf rockfish assemblage.

Common name	**Scientific Name**
canary rockfish	*S. pinniger*
China rockfish	*S. nebulosus*
copper rockfish	*S. caurinus*
quillback rockfish	*S. maliger*
rosethorn rockfish	*S. helvomaculatus*
tiger rockfish	*S. nigrocinctus*
yelloweye rockfish	*S. ruberrimus*

Table 14.5.–Commercial landings (t) of demersal shelf rockfish by species in Southeast Outside (SEO) Subdistrict, 2012–October 2021. Discards (at sea and at dock) and personal use included.

Species	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021[a]**
Canary	3.35	3.21	0.55	0.69	1.17	0.82	2.94	1.12	0.69	0.64
China	0.03	0.05	0.03	0.02	0.11	0.05	0.06	0.08	0.15	0.04
Copper	0.04	0.04	0.03	0.02	0.15	0.13	0.09	0.06	0.09	0.15
Quillback	4.30	4.07	2.15	2.75	3.43	3.05	3.40	5.76	3.86	2.81
Rosethorn	0.03	0.04	0.01	0.03	0.17	0.28	0.17	0.07	0.20	0.09
Tiger	0.42	0.32	0.26	0.23	0.33	0.22	0.22	0.14	0.12	0.49
Yelloweye	183.97	217.05	102.55	108.83	118.57	133.59	135.01	137.84	106.27	97.86
Total (t)	192.14	224.78	105.57	112.56	123.94	138.14	141.88	145.07	111.38	102.08
Percent Yelloweye	95.75	96.56	97.14	96.68	95.67	96.71	95.16	95.02	95.42	95.87

[a] Preliminary commercial data from ADF&G fish ticket database, updated through October 26, 2021.

Table 14.6.–Area estimates for sonar locations and rocky habitat by management area in Southeast Alaska.

	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)			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
	Learmouth Bank	530	77
Total sonar		1,154	322
Total rock (sonar & fishery)			1,056
Percentage rocky habitat from sonar			30%

Table 14.7.–Submersible (1994–1995, 1997, 1999, 2003, 2005, 2007, 2009) and ROV (2012–2013, 2015–2020) yelloweye rockfish density estimates with 95% confidence intervals (CI) and coefficient of variation (CV) by year and management area. The number of transects, yelloweye rockfish (YE), and meters surveyed included in each model are shown, along with the encounter rate of yelloweye rockfish. Values in bold were used for this stock assessment. Density estimates from 2018 and 2019 were updated with new estimates this year due to a coding error found in the analyses.

Area	Year	Number transects	Number YE[b]	Meters surveyed	Encounter rate (YE/m)	Density (YE/km^2)	Lower CI (YE/km^2)	Upper CI (YE/km^2)	CV
EYKT[a]	1995	17	330	22,896	0.014	2,711	1,776	4,141	0.20
	1997	20	350	19,240	0.018	2,576	1,459	4,549	0.28
	1999	20	236	25,198	0.009	1,584	1,092	2,298	0.18
	2003	20	335	17,878	0.019	3,825	2,702	5,415	0.17
	2009	37	215	29,890	0.007	1,930	1,389	2,682	0.17
	2015	33	251	22,896	0.008	1,755	1,065	2,891	0.25
	2017	35	134	33,960	0.004	1,072	703	1,635	0.21
	2019	**33**	**288**	**33,653**	**0.009**	**1,397**	**850**	**2,286**	**0.27**
NSEO	1994[c]	13	62	17,622	0.004	765	383	1,527	0.33
	2016	36	125	34,435	0.004	701	476	1,033	0.20
	2018	**30**	**95**	**29,792**	**0.003**	**637**	**395**	**969**	**0.59**
CSEO	1994[c]	-	-	-	-	1,683	-	-	0.10
	1995	24	235	39,368	0.006	2,929	-	-	0.19
	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**	**910**	**675**	**1,216**	**0.14**
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	1,582	1,013	2,439	0.20
	2020	**33**	**349**	**32,828**	**0.011**	**1,949**	**1,459**	**2,604**	**0.15**

[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.

Table 14.8.–Ecosystem effects on Gulf of Alaska (GOA) demersal shelf rockfish (DSR).

Indicator	***Observation***	***Interpretation***	***Evaluation***
ECOSYSTEM EFFECTS ON STOCK			
Prey availability or abundance trends			
Phytoplankton and zooplankton	Important for larval and post larval survival but no information known	May help determine recruitment strength	Possible concern
Predator population trends			
Marine mammals	Not common	No effect	No concern
Birds	Fluctuating	Affects young-of-year mortality	Probably no concern
Fish (pollock, Pacific cod, halibut)	Fluctuating	No effect	No concern
Changes in habitat/environmental quality			
Temperature regime	Higher recruitment after 1977 regime shift	May affect rockfish	Possible concern
Winter-spring environmental conditions	Affects pre-recruit survival but rockfish have varying larval release to compensate; some natural variability	Different phytoplankton bloom timing	Possible concern
Production	Relaxed downwelling in summer brings nutrients to the Gulf; contributes to high variability in rockfish recruitment	Some years highly variable (e.g., El Nino 1998)	Probably no concern
FISHERY EFFECTS ON ECOSYSTEM			
Fishery contribution to bycatch			
Prohibited species	Halibut incidental catch but released	Minor contribution to mortality	Little concern
Forage (herring, Atka mackerel, cod, pollock)	A small amount of cod incidental catch is taken	Incidental catch small relative to forage biomass	No concern
HAPC biota (seapens/whips, corals, sponges, anemones)	Low incidental catch levels of Primnoa coral, hard coral, and sponges.	Some incidental catch; levels small relative to HAPC biota	Little concern
Marine mammals and birds	Minor take associated with longline gear	Data limited for discards; fishery largely unobserved until recently	No concern
Sensitive non-target species	Likely minor impact	Data limited	No concern
Fishery concentration in space and time	Majority is harvested in halibut IFQ season; directed fishery occurs during the winter	Data limited on reproductive behavior in rockfishes	Possible concern
Fishery effects on amount of large size target fish	Catch is primarily adults; difficult to target largest individuals over others	Large and small fish both occur in population	Little concern
Fishery contribution to discards/offal production	Discard rates may be high for dogfish and skates	Data limited for discards	Possible concern
Fishery effects on age-at-maturity and fecundity	Few small fish caught; larger fish contribute more to spawning output	Could reduce spawning potential and yield	Possible concern

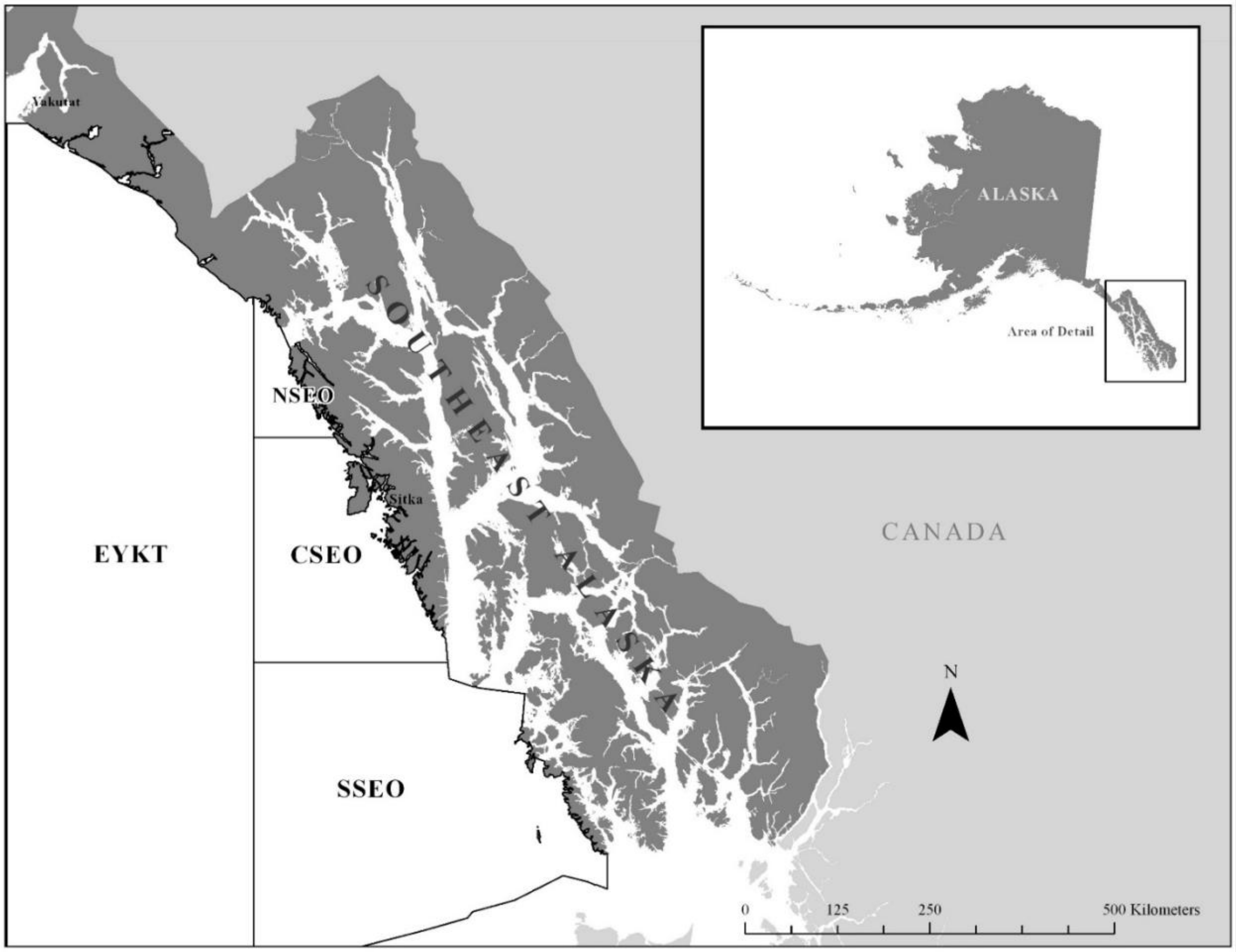

Figure 14.1.–The Southeast Outside (SEO) Subdistrict with the Alaska Department of Fish and Game groundfish management areas used for managing the demersal shelf rockfish fishery: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) Sections.

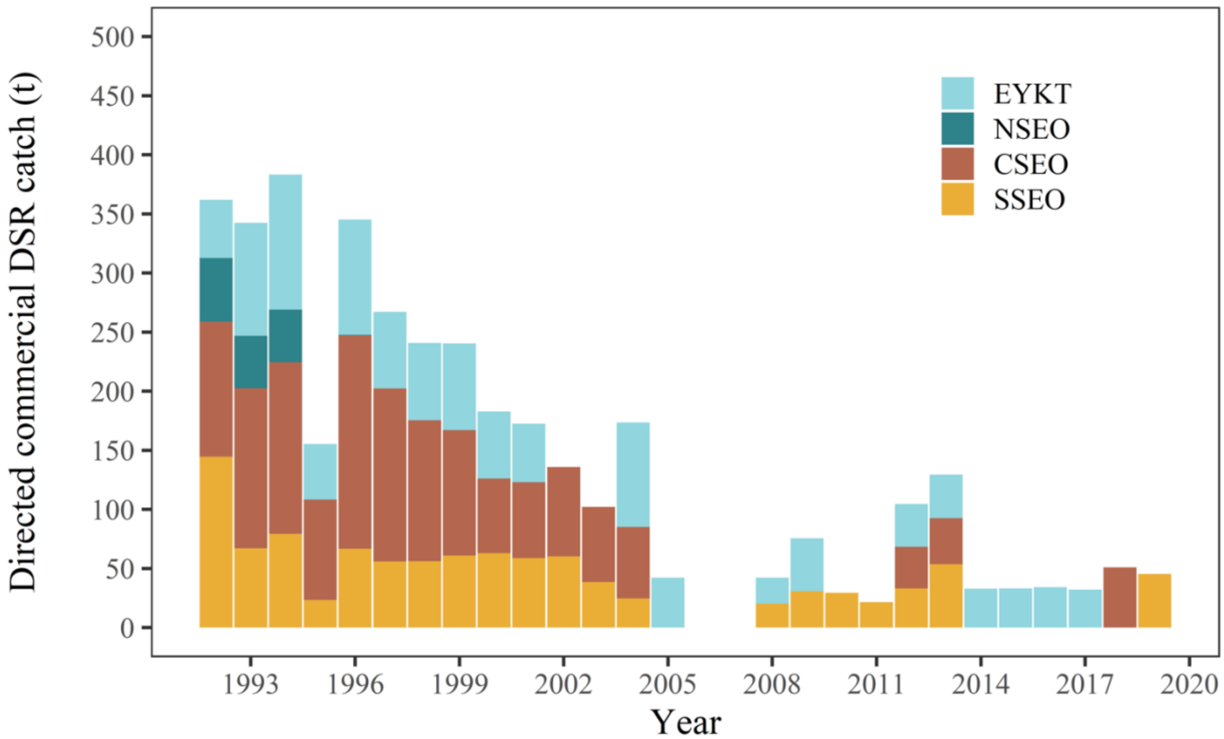

Figure 14.2.–Directed commercial demersal shelf rockfish (DSR) fishery catch (t) in the Southeast Outside (SEO) Subdistrict groundfish management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) Sections, 1992–2021. The directed commercial fishery was closed in SEO in 2006, 2007, 2020, and 2021.

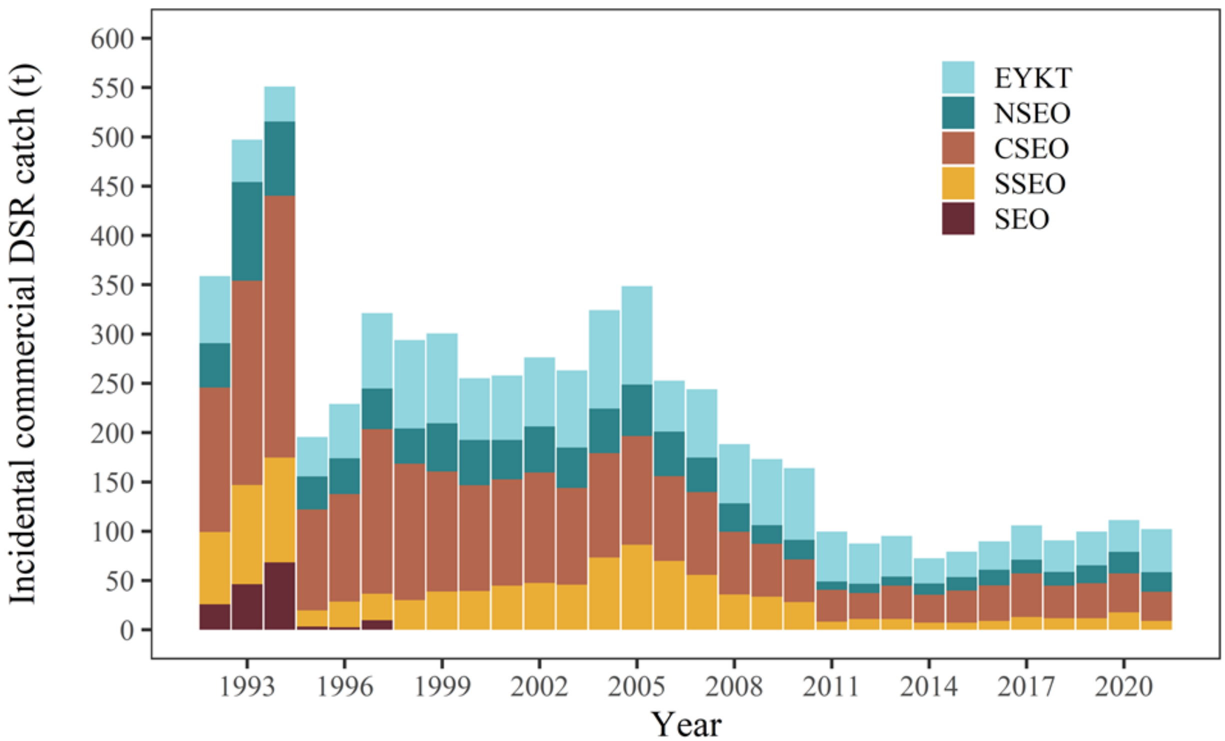

Figure 14.3.–Incidental commercial fishery catch (t) of demersal shelf rockfish (DSR) in the halibut, sablefish, lingcod, Pacific cod, miscellaneous finfish, and salmon fisheries for Southeast Outside (SEO) Subdistrict groundfish management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) Sections, 1992–2021. Harvest in the SEO area could not be assigned to a management area due to fish ticket data limitations.

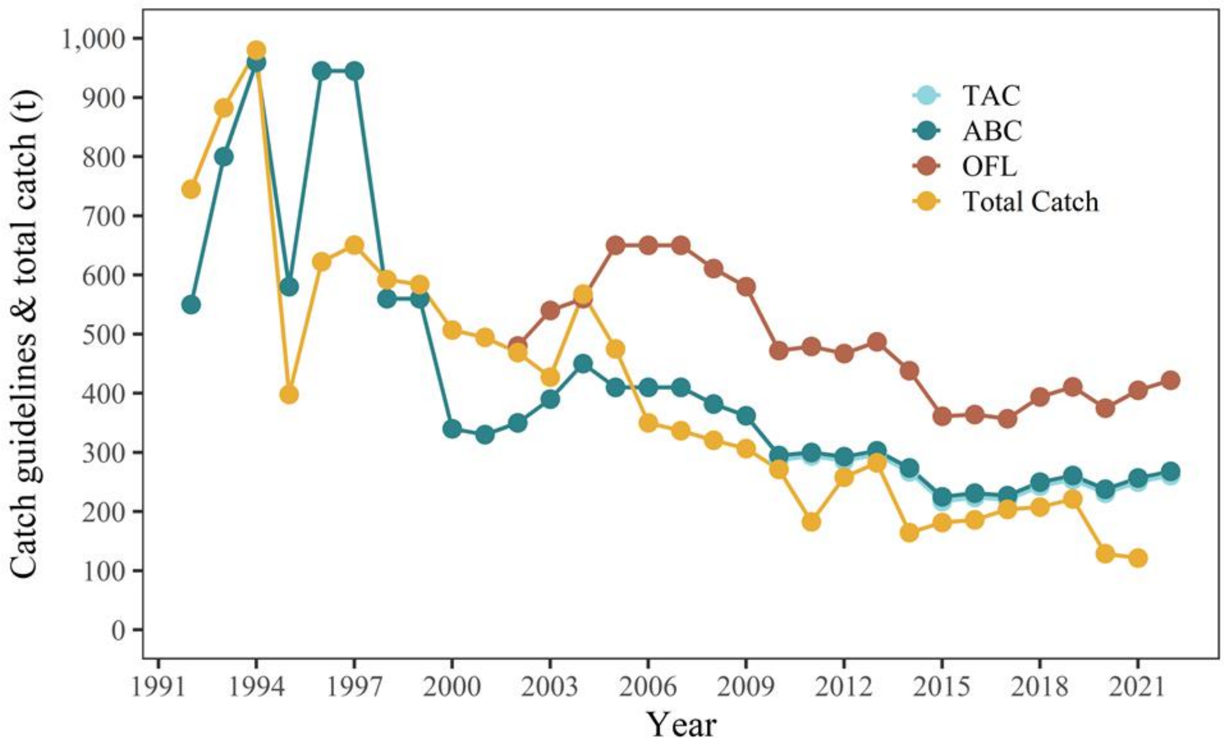

Figure 14.4.–Demersal shelf rockfish (DSR) catch guidelines: overfishing level (OFL), allowable biological catch (ABC), total allowable catch (TAC), and total catch for the Southeast Outside (SEO) Subdistrict, 1992–2022. The directed commercial fishery was closed in SEO in 2006, 2007, 2020, and 2021. The recreational fishery was closed to the retention of DSR in all Southeast Alaska management areas in 2020 and 2021; however, 2020 and 2021 recreational fishery catch include the estimated release mortality.

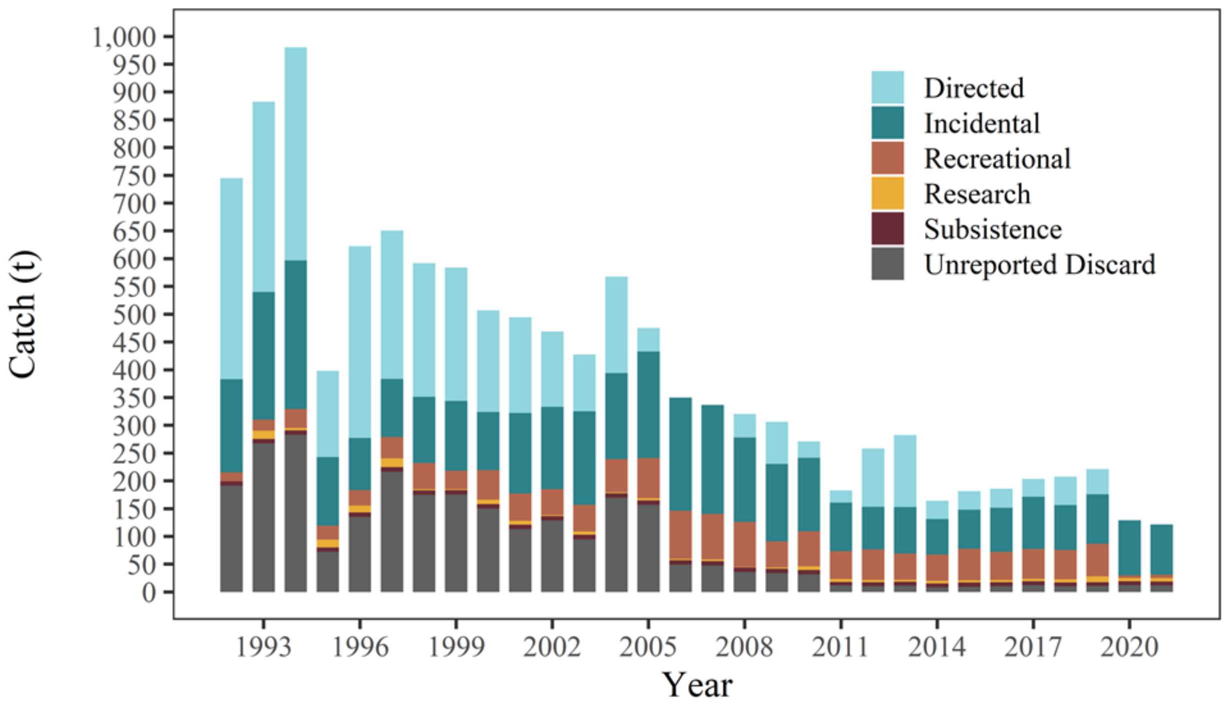

Figure 14.5.–Demersal shelf rockfish (DSR) catch (t) by fishery type: commercial (directed, incidental, and estimated unreported discards from the halibut longline fishery), recreational, research, and subsistence for the Southeast Outside (SEO) Subdistrict, 1992–2021. The directed DSR commercial and recreational fisheries were closed in SEO in 2006, 2007, 2020, and 2021; however, 2020 and 2021 recreational fishery catch include the estimated release mortality.

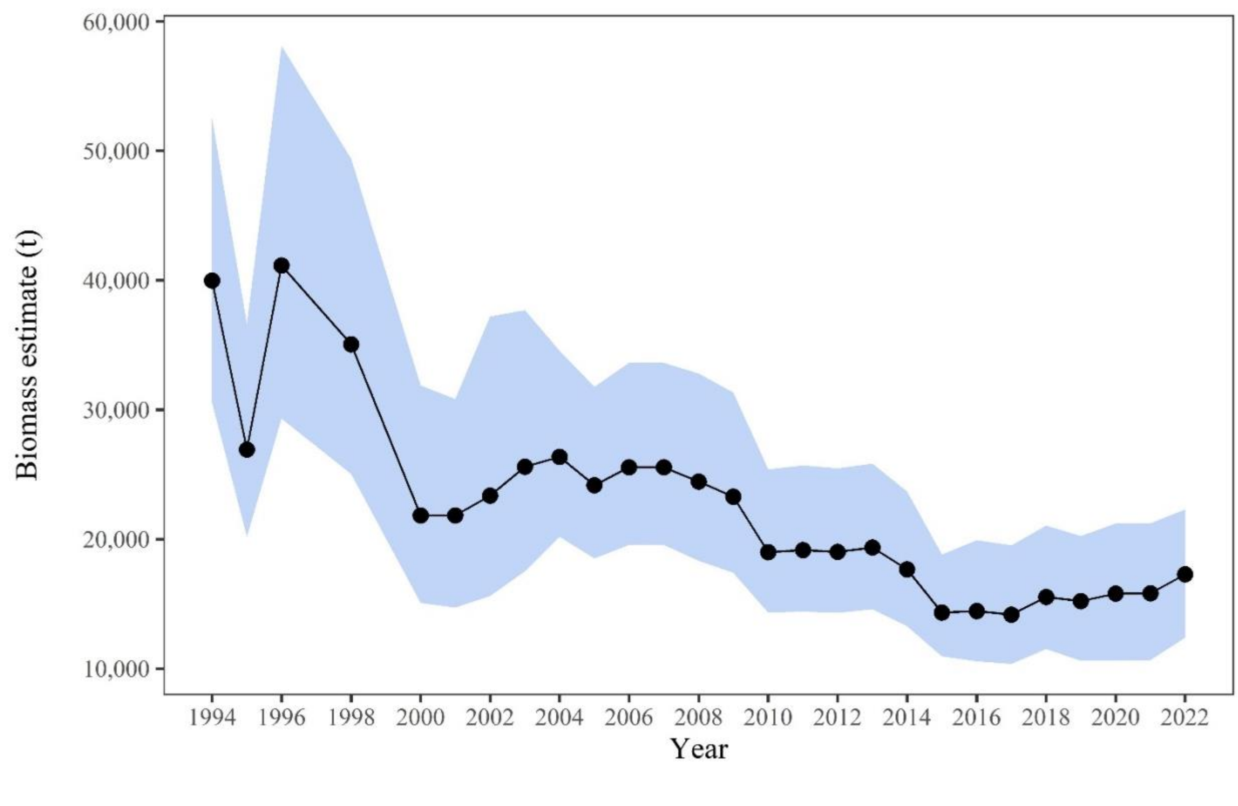

Figure 14.6.–Yelloweye rockfish biomass estimate (t) (solid line) and 90% lower and upper confidence intervals (blue shaded area) for the Southeast Outside (SEO) Subdistrict, 1994–2022.

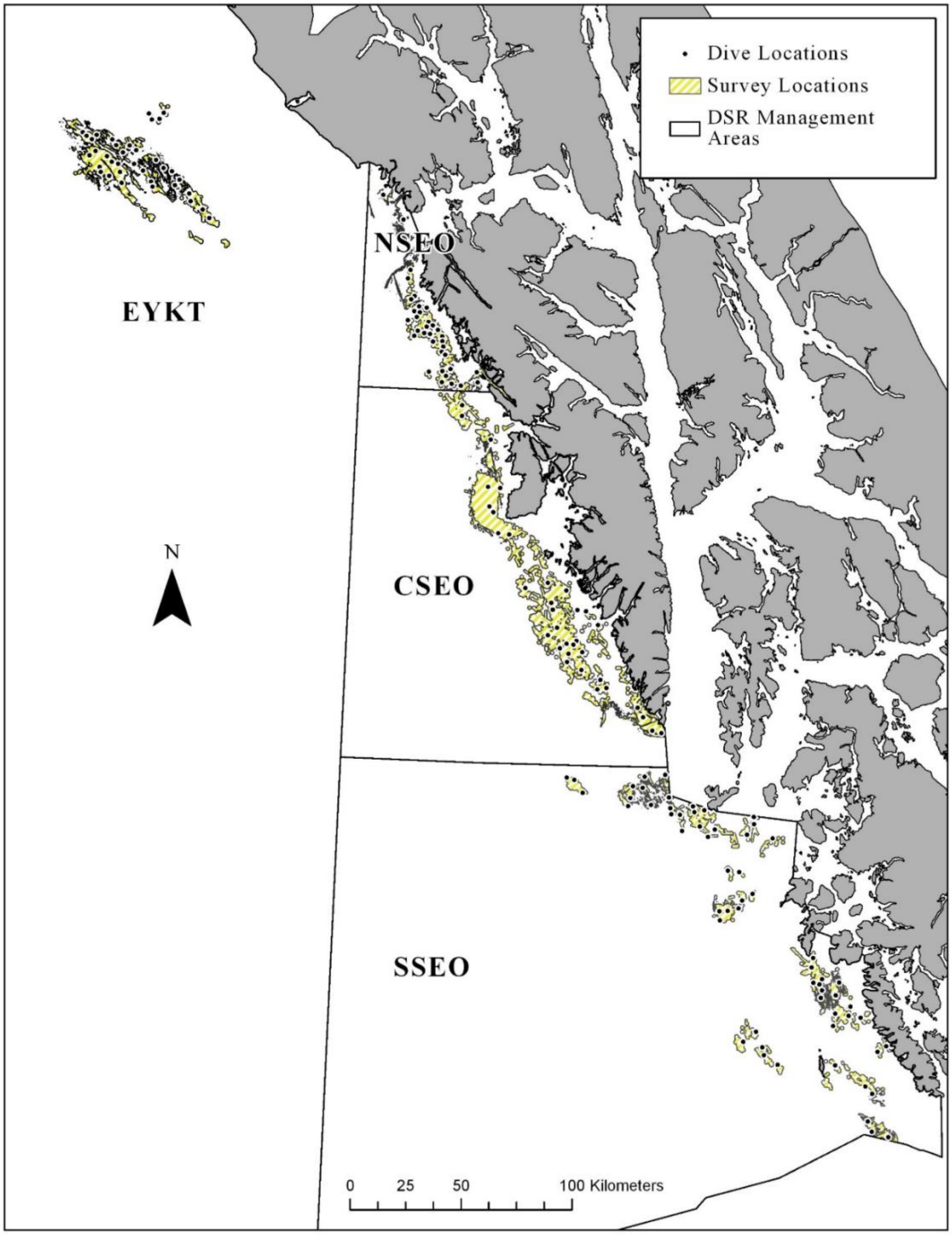

Figure 14.7.–Example dive locations (black circles) within survey locations (yellow hatching) for remote operated vehicle (ROV) surveys in Southeast Outside (SEO) Subdistrict.

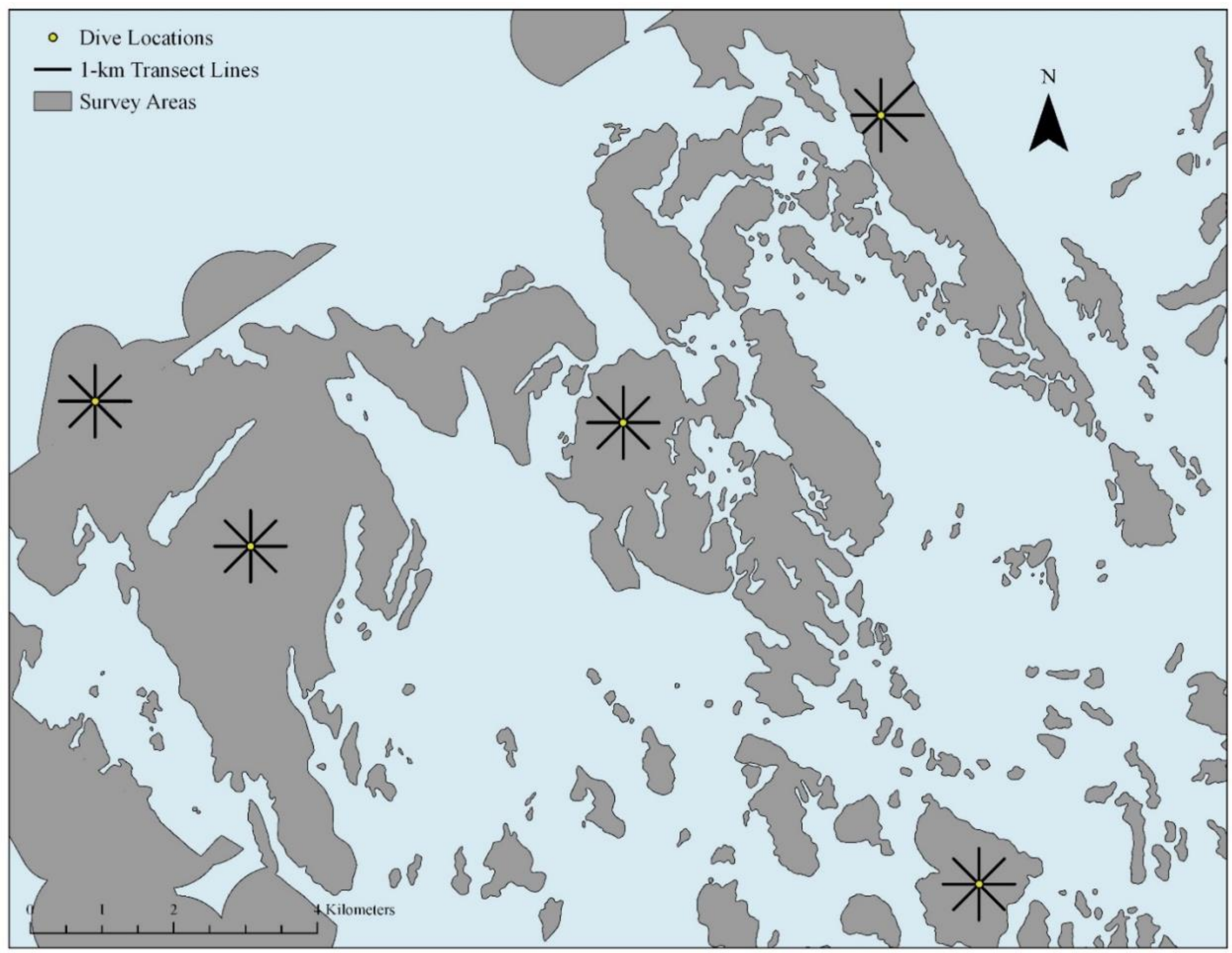

Figure 14.8.–Example of 1-km transect lines. Transect lines (star symbols) are adjusted around dive locations (yellow circles) in some cases to remain within the delineation of survey areas (grey polygons).

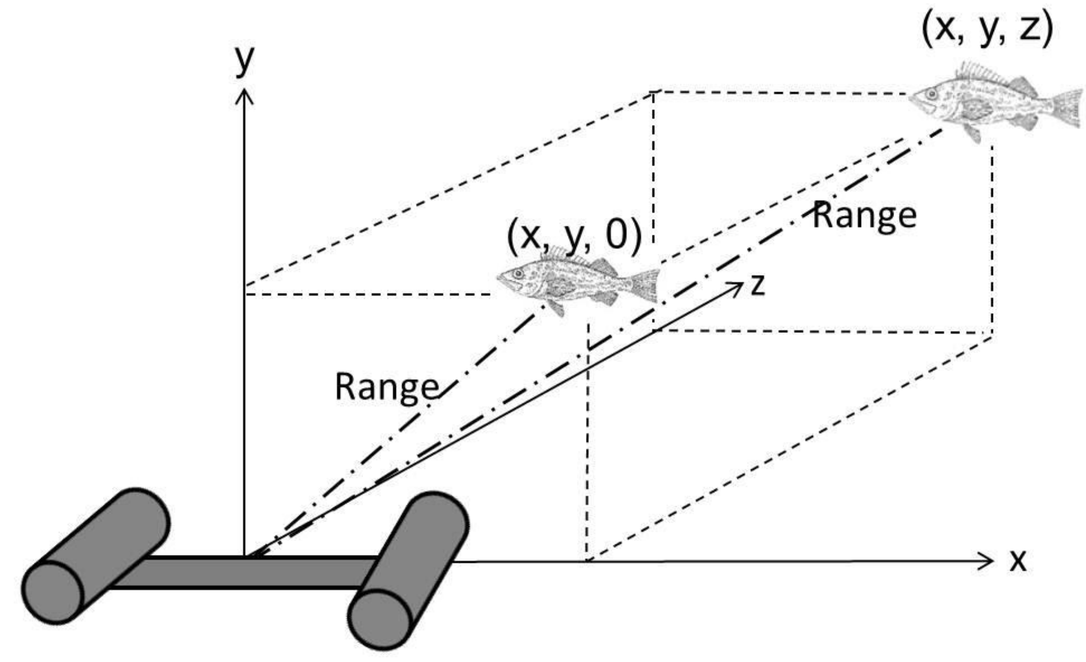

Figure 14.9.–The components of a 3D point measurement.

Figure 14.10table.–Yelloweye rockfish with a 3D point (red circle) and a total length (red line) measured in the stereo camera overlapping field of view in the SeaGIS EventMeasure software.

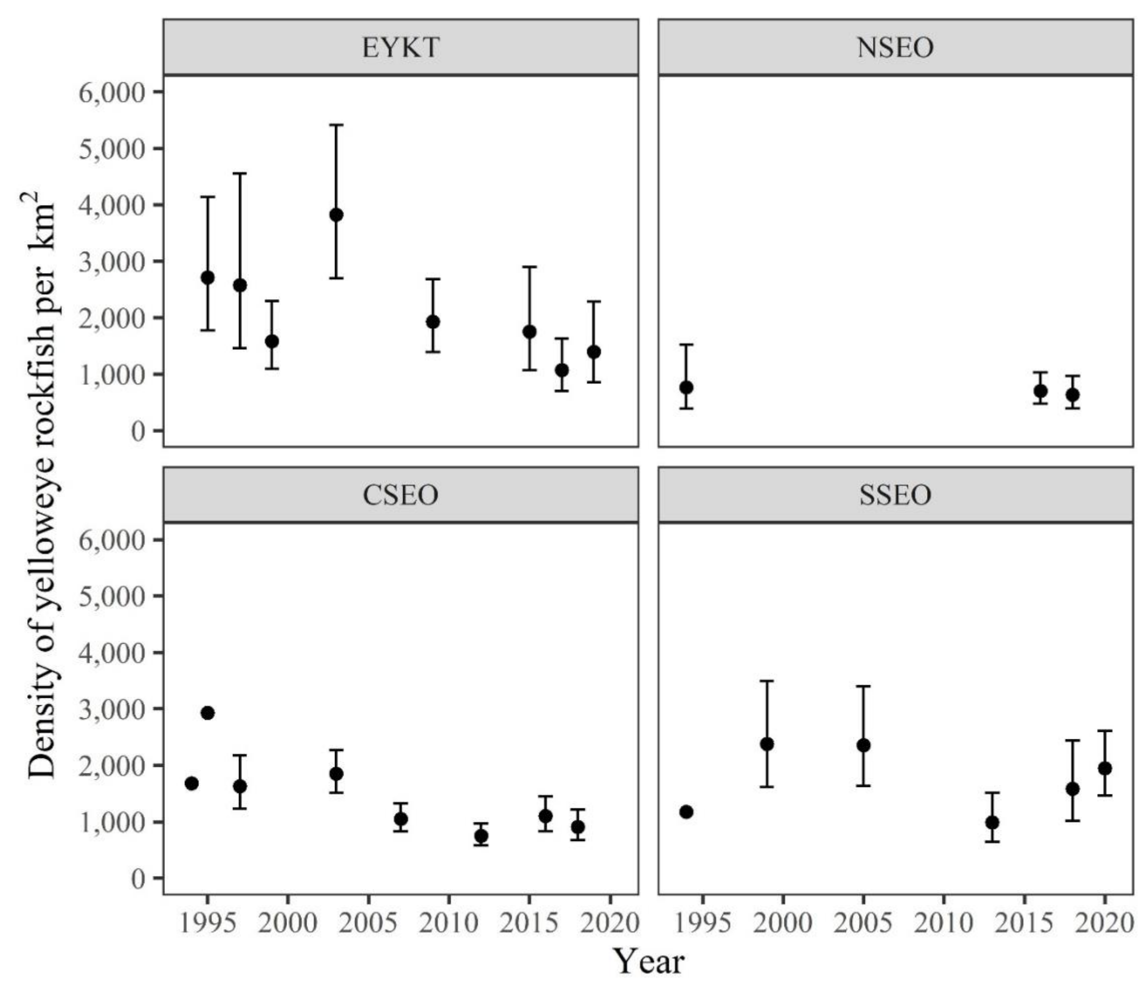

Figure 14.11.–Density of yelloweye rockfish predicted by DISTANCE (circles) +/- two standard deviations in each management area: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) Sections, 1994–2020.

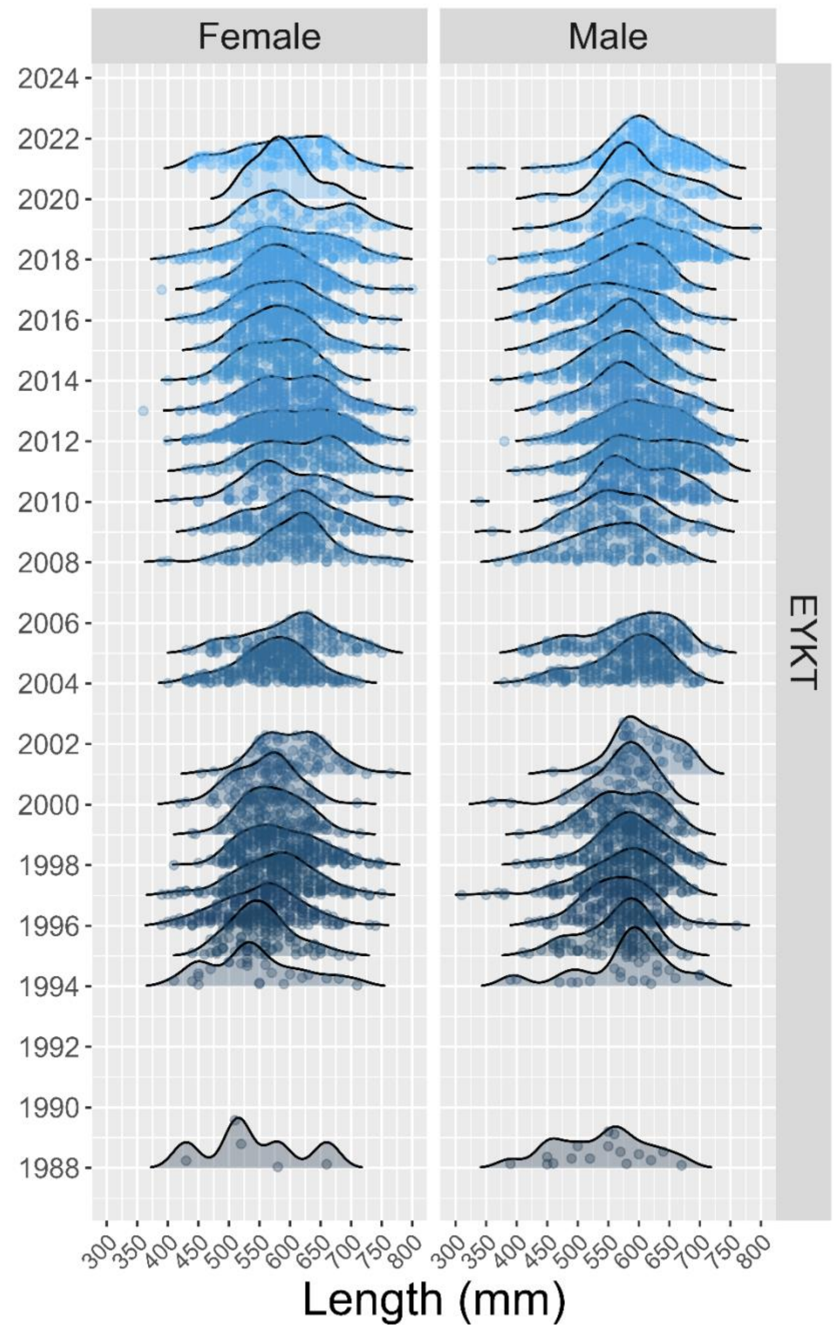

Figure 14.12–Yelloweye rockfish length compositions sampled in the East Yakutat (EYKT) Section obtained from directed and incidental catch, 1988–2021. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

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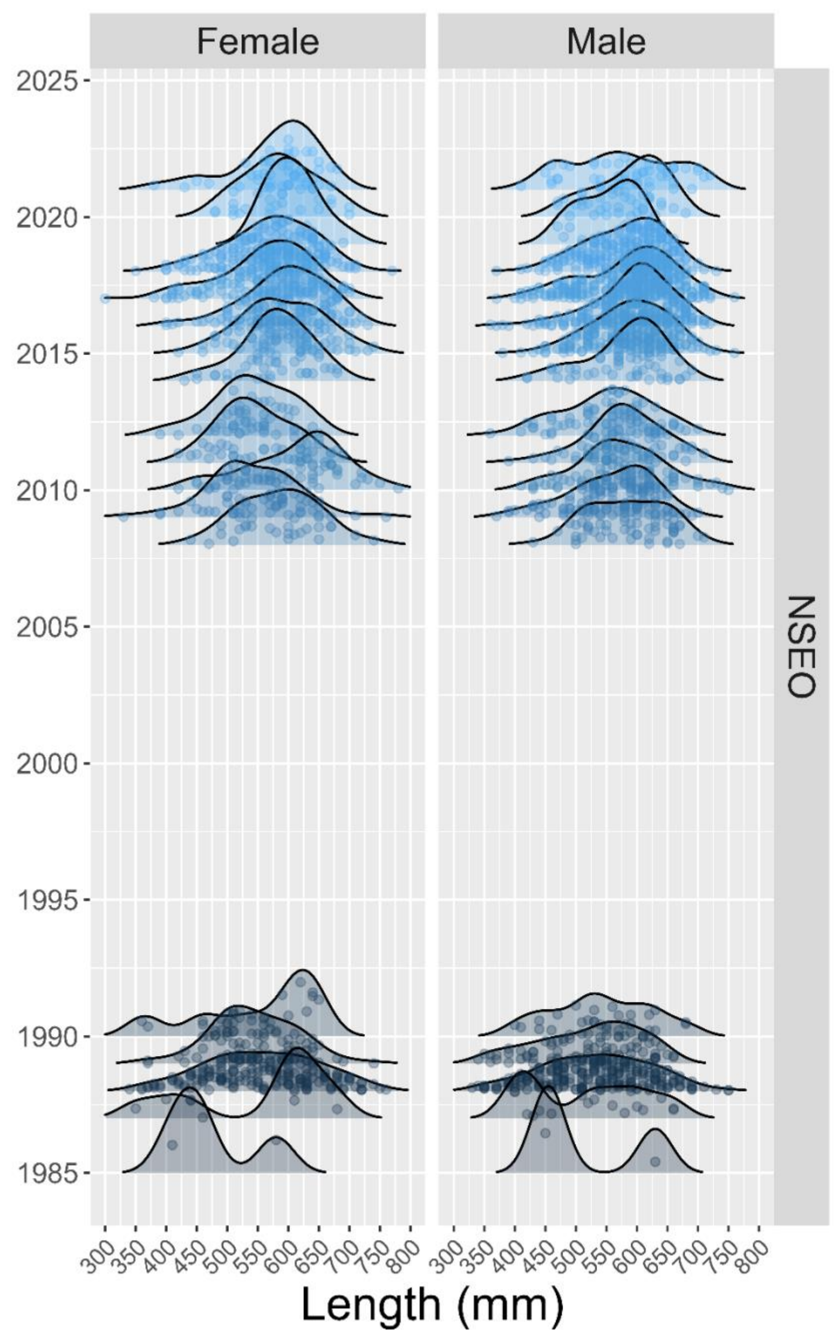

Figure 14.13–Yelloweye rockfish length compositions sampled in the Northern Southeast Outside (NSEO) Section obtained from directed and incidental catch, 1985–2021. The directed commercial demersal shelf rockfish fishery in NSEO has been closed since 1994, and fishery biological data in recent years are from halibut incidental fisheries, when available.

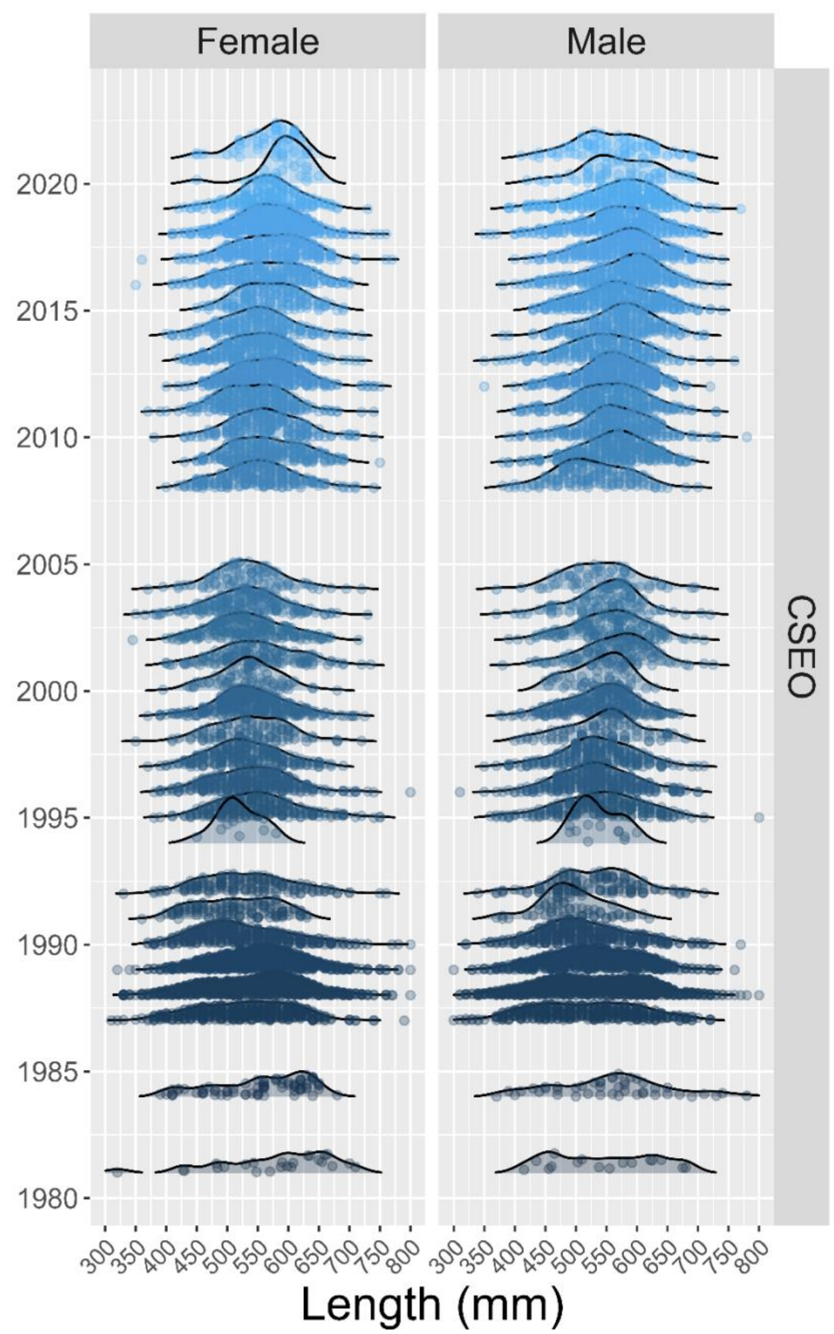

Figure 14.14.–Yelloweye rockfish length compositions sampled in the Central Southeast Outside (CSEO) Section obtained from directed and incidental catch, 1981–2021. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

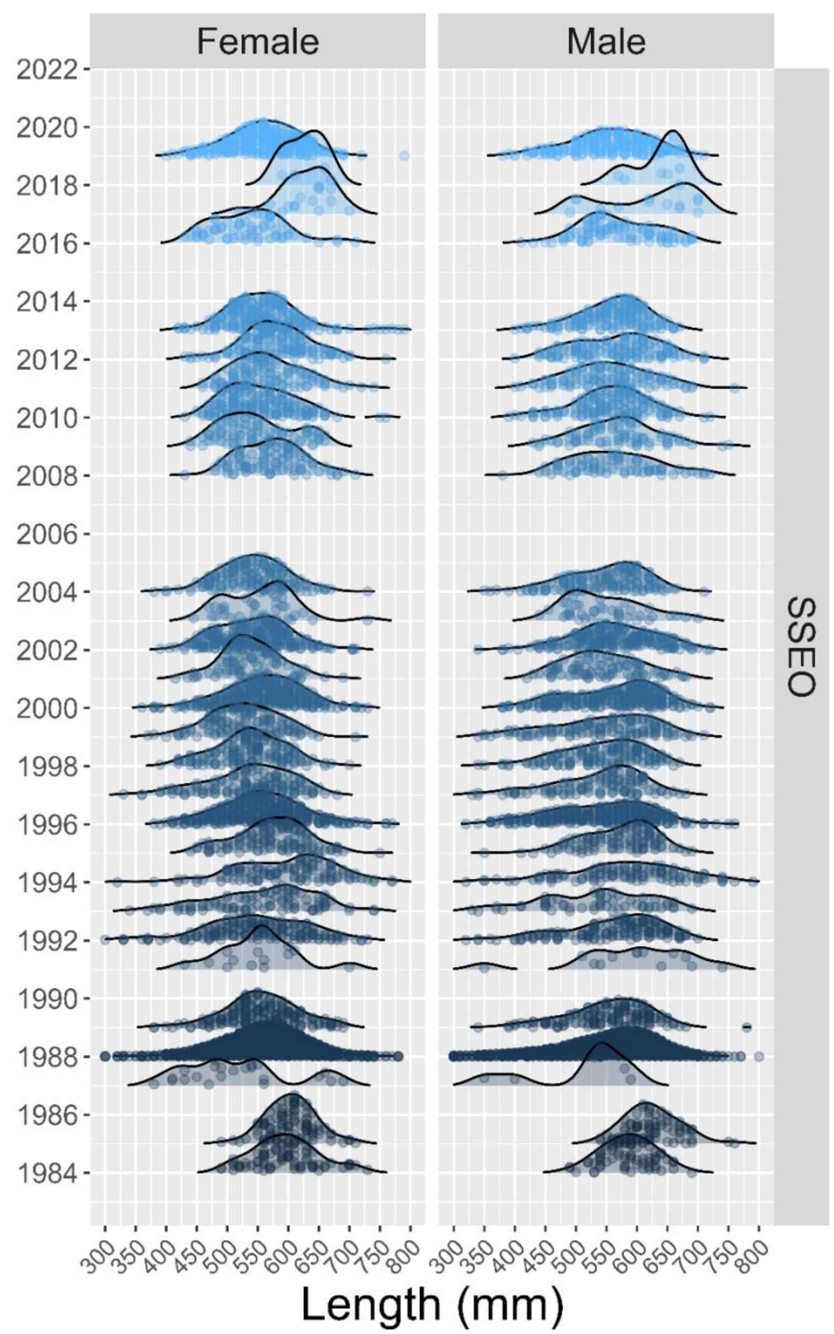

Figure 14.15.–Yelloweye rockfish length compositions sampled in the Southern Southeast Outside (SSEO) Section obtained from directed and incidental catch, 1984–2021. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

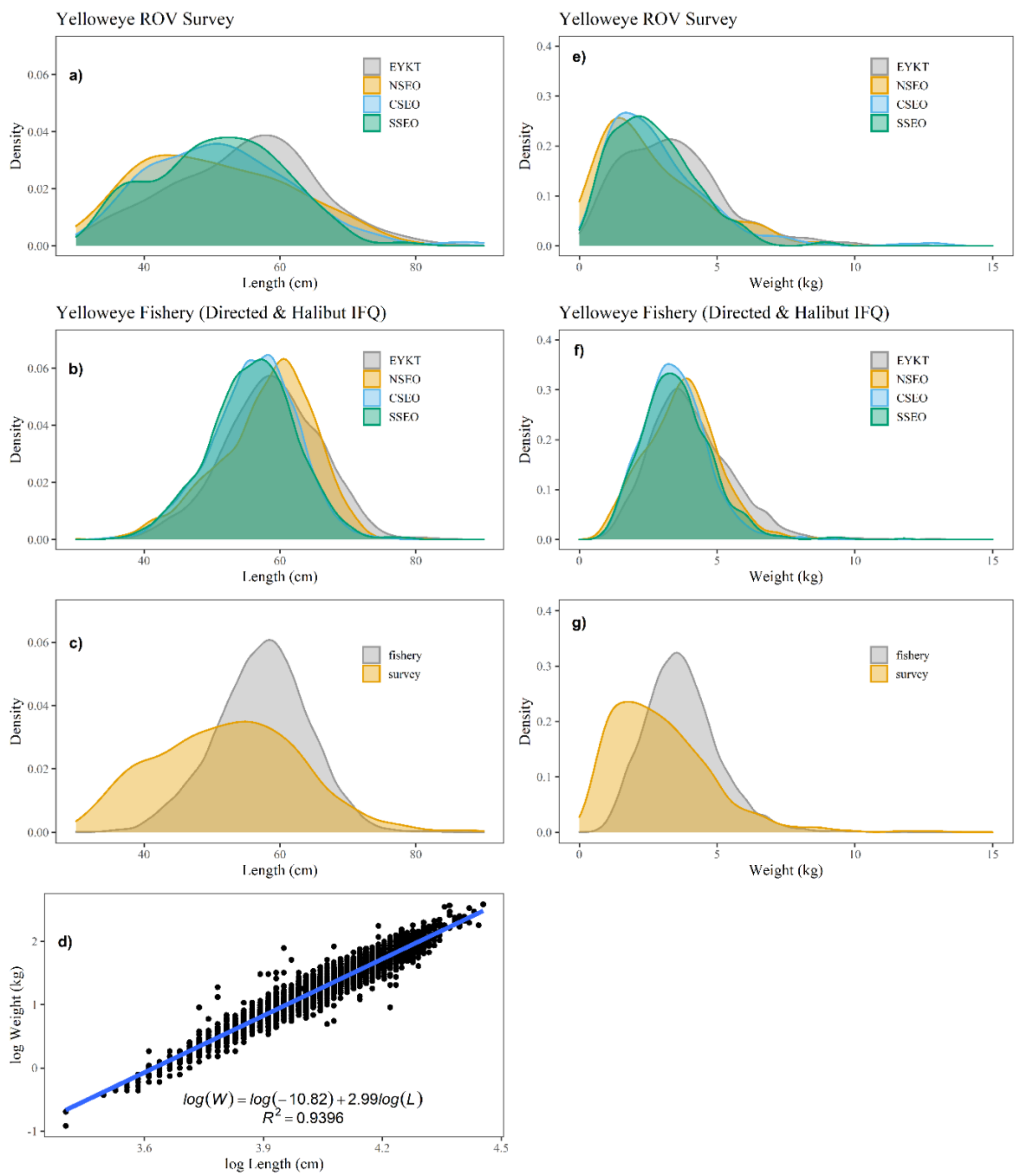

Figure 14.16.–Yelloweye rockfish length (cm) and weight (kg) distributions from the remote operated vehicle (ROV) survey and commercial fishery (directed and halibut incidental) port sampling data for the Southeast Outside (SEO) Subdistrict: a) ROV survey length distributions by management area, b) commercial fishery length distributions for sampled catch from the directed and halibut incidental fisheries, c) comparison of length distributions for the survey and fishery, d) log transformed length-weight relationship for the commercial fishery, e) ROV survey estimated weight distributions by management area, f) commercial fishery weight distributions for sampled catch from the directed and halibut incidental fisheries, and g) comparison of estimated weight distributions for the survey and observed weights from the fishery. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

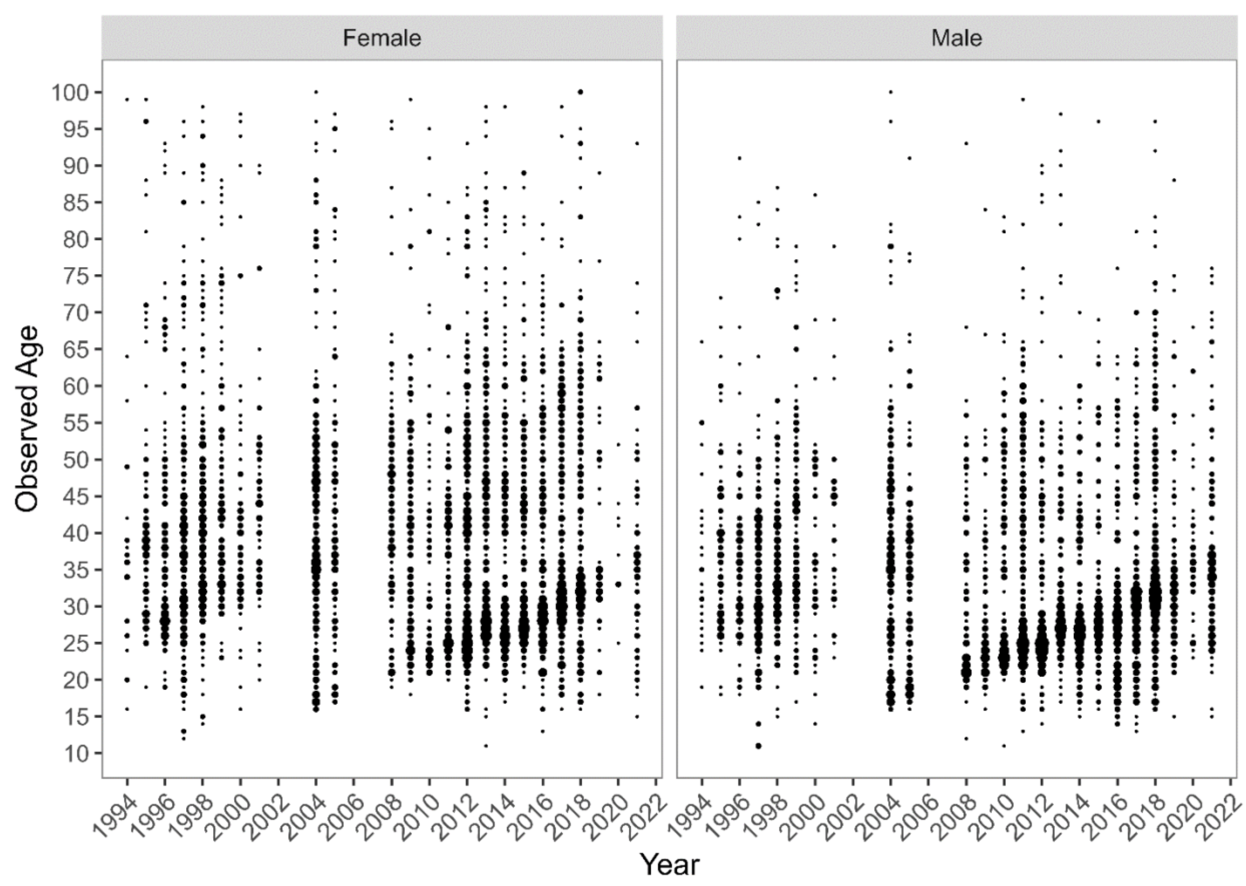

Figure 14.17.–Yelloweye rockfish age compositions sampled in the East Yakutat (EYKT) Section obtained from directed and incidental catch, 1994–2021. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

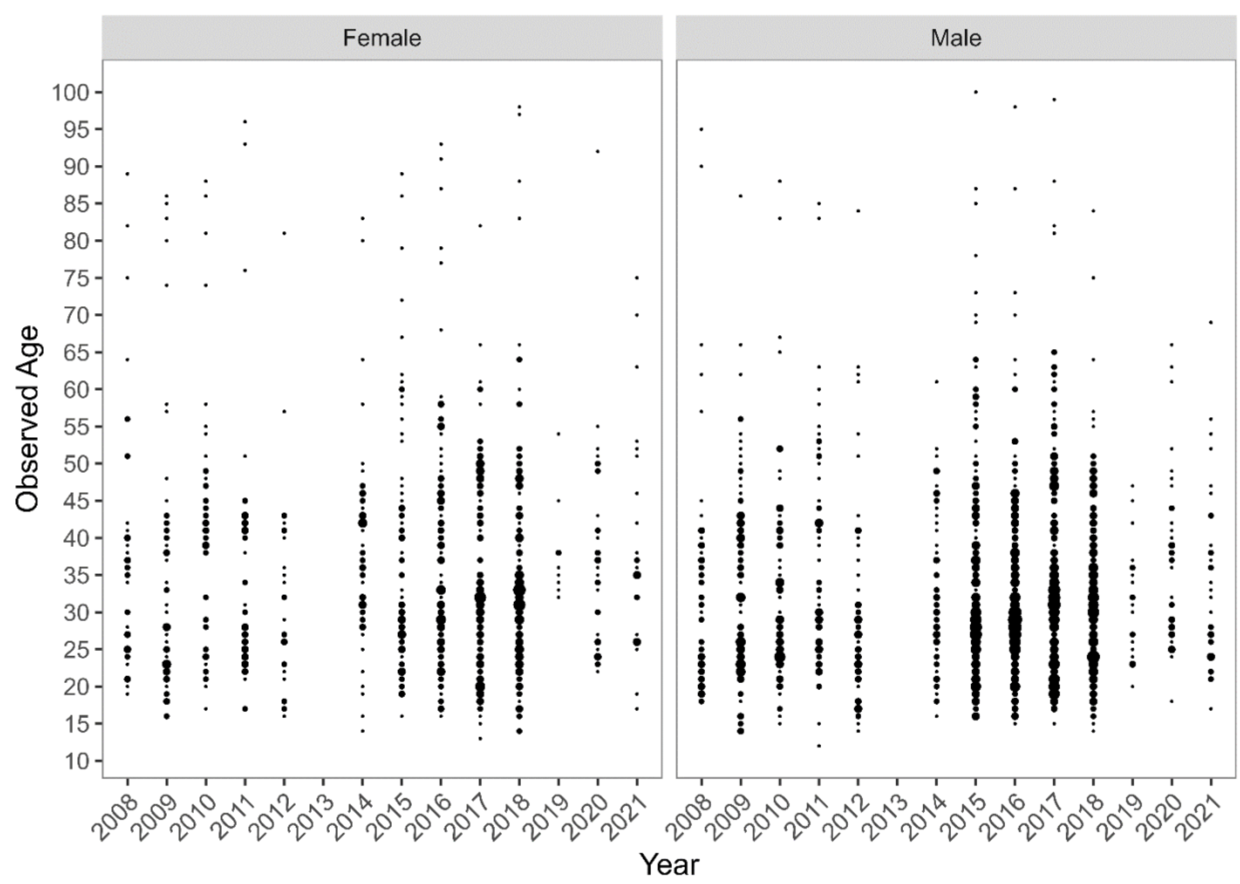

Figure 14.18.–Yelloweye rockfish age compositions sampled in the Northern Southeast Outside (NSEO) Section obtained from directed and incidental catch, 2008–2021. The directed commercial demersal shelf rockfish fishery in NSEO has been closed since 1994, and fishery biological data in recent years are from halibut incidental fisheries, when available.

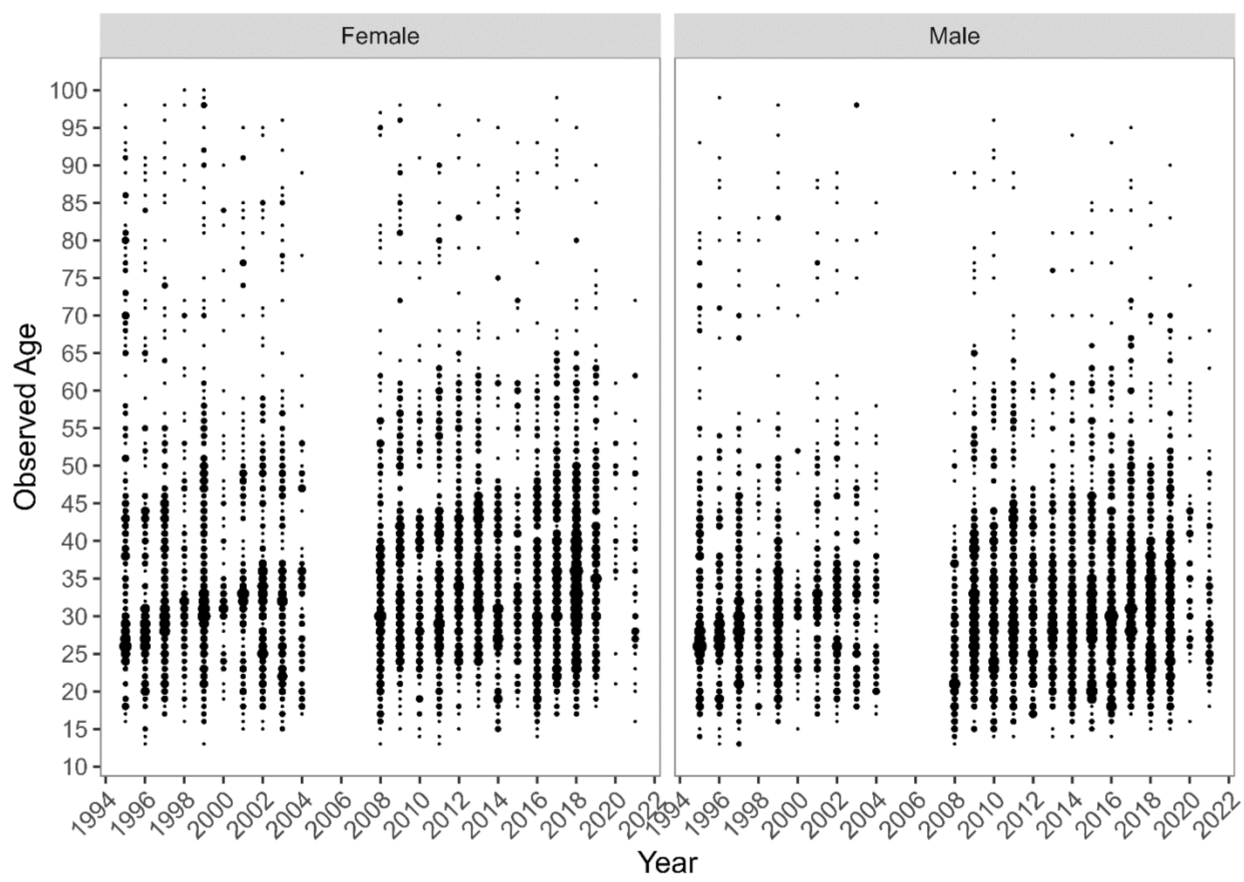

Figure 14.19.–Yelloweye rockfish age compositions sampled in the Central Southeast Outside (CSEO) Section obtained from directed and incidental catch, 1992–2021. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

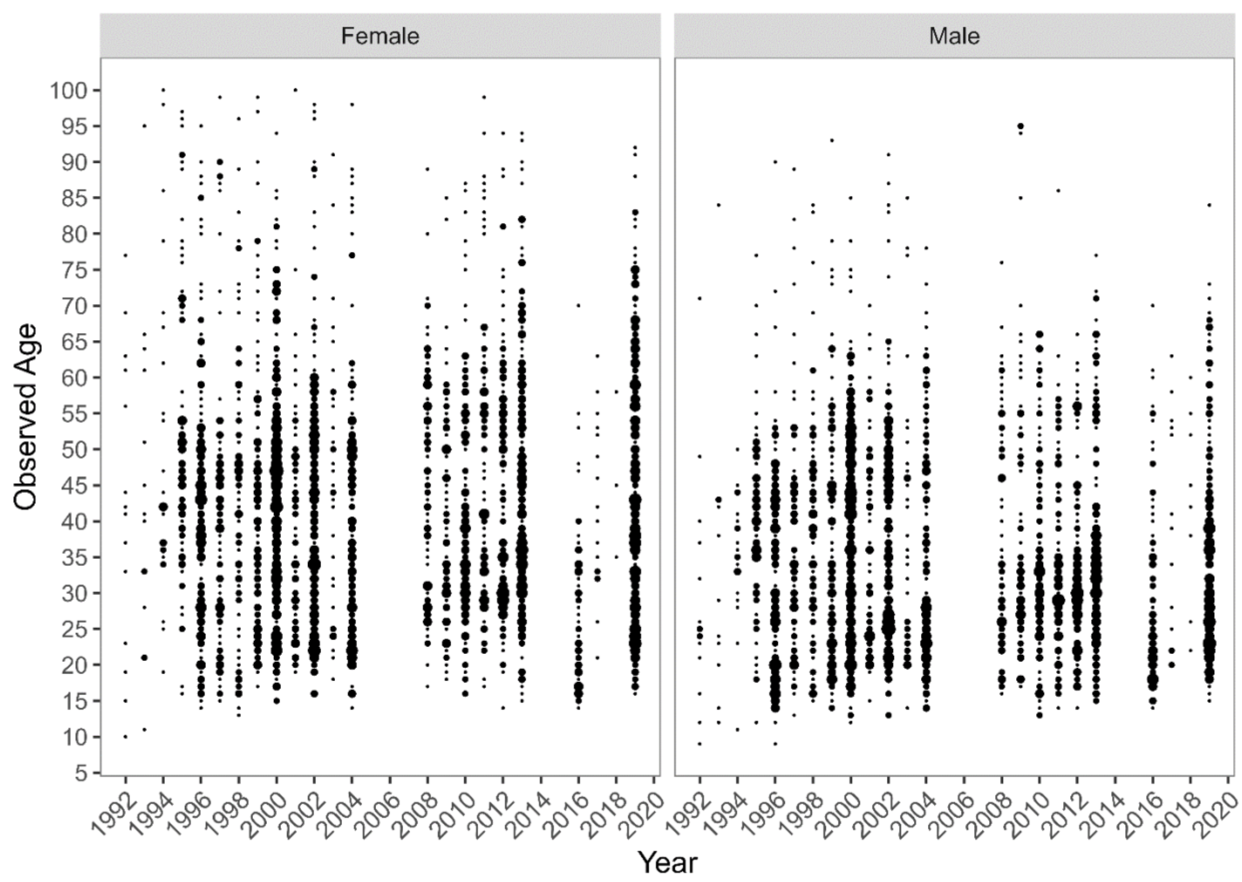

Figure 14.20.–Yelloweye rockfish age compositions sampled in the Southern Southeast Outside (SSEO) Section obtained from directed and incidental catch, 1992–2021. The directed commercial demersal shelf rockfish fishery was closed in 2006, 2007, 2020, and 2021, and fishery biological data from these years are from halibut incidental fisheries, when available.

Appendix A.–History of demersal shelf rockfish (DSR) management action, Board of Fisheries (BOF), North Pacific Management Council (NPFMC) and Alaska Department of Fish and Game (ADF&G).

Year	Management Action
1984	600 t guideline harvest limit for 10 species of DSR in CSEO directed fishery. Marine reserves recommended to BOF by ADF&G – rejected. NPFMC defines 10 species assemblage as DSR (yelloweye, quillback, China, copper, canary, rosethorn, tiger, silvergrey, bocaccio, redstripe). October 1-Sept 30 accounting year.
1986	ADF&G restricts gear for rockfish in the Southeast Region to hook and line only. NPFMC gives ADF&G management authority for DSR to 137^0 W long. (Southeast Outside SEO). Guideline harvest limit (GHL) for directed fishery reduced to 300 t (CSEO). GHL for directed fishery set for SSEO (250 t), SSEI (225 t), NSEO (75 t), and NSEI (90 t).
1987	Sitka Sound closed to commercial fishing for DSR.
1988	NPFMC implements 660 t total allowable catch for all fisheries (TAC) for SEO.
1989	NPFMC TAC of 470 t (catch history average). Industry working group (IWG) discusses ITQ options with NPMFC (rejected). IWG recommends 7,500 lb trip limits, mandatory logbooks, and seasonal allocations (10/1-11/31 43%, 12/1-5/15 42%, 7/1-9/30 15%). Ketchikan area closure implemented. GHL for directed fishery reduced in all areas (CSEO 150 t, SSEO 170 t, NSEO 50 t).
1990	NPFMC TAC of 470 t. Directed permit card required for CSEO, SSEO, NSEO.
1991	NPFMC TAC of 425 t. Change in assemblage to 8 species (removed silvergrey, bocaccio, redstripe and added redbanded). Craig and Klawock closures implemented.
1992	NPFMC TAC of 550 t. East Yakutat (EYKT) area included in SEO (NPFMC extends ADF&G mgt authority to 140^0). Directed fishery permit card required in EYKT. Submersible line transect data used to set ABC in EYKT.
1993	NPFMC TAC of 800, yelloweye rockfish line transect data used to set TAC, NPFMC institutes a separate halibut prohibited species cap (PSC) for DSR, BOF changes seasonal allocation to calendar year: 1/1-5/15 (43%), 7/1-9/30 15%, and 10/1-12/31 (42%), DSR opened for 24-hour halibut opening 6/10 (full retention).
1994	NPFMC TAC 960 t using line transect yelloweye rockfish plus 12% for other species, trip limits reduced to 6,000 in SE and 12,000 lb trip limit implemented in EYKT, last time a directed fishery in NSEO was held.
1995	NPFMC TAC 580 t.
1996	NPFMC TAC 945 t.
1997	NPFMC TAC 945 t. Redbanded removed from assemblage definition.
1998	NPFMC TAC 560 t. Revised estimates of rock habitat in EYKT, 10% included for other species. Directed fishery season changed to prevent overlap with IFQ fishery 1/1-3/14 (67%), 11/16-12/31 (33%).
1999	NPFMC TAC 560 t.
2000	NPFMC TAC 340 t. Revised estimates of rock habitat in SEO. Regulation to require full retention for all DSR landed incidentally in the commercial halibut fishery was adopted for state waters.
2001	NPFMC TAC 330 t. Fall directed fishery season initially 24 hours in CSEO and SSEO due to small quota then re-opened 11/26 until quotas taken, no directed fishery NSEO.
2002	NPFMC TAC 350 t. No directed fishery in EYKT due to changes in estimated incidental mortality in that area, no directed fishery in NSEO.

Year	Management Action Cont.
2003	NPFMC TAC 390 t. No directed fishery in EYKT or NSEO. Protocol for classifying habitat revised resulting in changes in TAC. Registration required before participating in directed fishery.
2004	NPFMC TAC 450 t. Directed fishery reopened in EYKT, no directed fishery in NSEO.
2005	NPFMC TAC 437 t. NPFMC final rule to require full retention for all DSR landed incidentally in the commercial halibut fishery for federal waters.
2006	NPFMC TAC 407 t. BOF decision to allocate DSR TAC as follows: 84% to the commercial fishery, 16% to the recreational fishery. SEO DSR restricted to winter fishery only and must close before the start of the halibut fishery. All management areas remain closed to the directed fishery due to stock health concerns; EYKT, NSEO, CSEO, and SSEO.
2007	NPFMC TAC 410 t. All management areas remain closed to the directed fishery due to stock health concerns; EYKT, NSEO, CSEO, and SSEO.
2008	NPFMC TAC 382 t. SSEO and EYKT directed fisheries opened; CSEO and NSEO remain closed.
2009	NPFMC TAC 362 t. Subsistence catch to be deducted from the ABC before allocation of the TAC to the commercial and recreational sectors. SSEO and EYKT directed fisheries opened; CSEO and NSEO remain closed.
2010	NPFMC TAC 295 t. SSEO and EYKT directed fisheries opened; CSEO and NSEO remain closed.
2011	NPFMC TAC 294 t. SSEO and EYKT directed fisheries opened; CSEO and NSEO remain closed.
2012	NPFMC TAC 286 t. Rockfish release devices required on recreational charter vessels. SSEO, CSEO and EYKT directed fisheries opened; NSEO remained closed.
2013	NPFMC TAC 293 t. SSEO, CSEO and EYKT directed fisheries opened; NSEO remained closed.
2014	NPFMC TAC 267 t. EYKT directed fishery opened; SSEO, CSEO, and NSEO remain closed.
2015	NPFMC TAC 217 t. EYKT directed fishery opened; SSEO, CSEO, and NSEO remain closed.
2016	NPFMC TAC 224 t. EYKT directed fishery opened; SSEO, CSEO, and NSEO remain closed, decision to alternate opening each management area every three to four years depending on stock health in management area was made.
2017	NPFMC TAC 220 t. EYKT directed fishery opened; SSEO, CSEO, and NSEO remain closed.
2018	NPFMC TAC 243 t. CSEO directed fishery opened; EYKT, SSEO, and NSEO remain closed, BOF decision reduced the trip limit of DSR in the EYKT management area from 5.4 t to 3.6 t, clarified the language for trip limit amounts for all management areas in SEO, and rockfish release devices will be required for all recreational vessels in Southeast Alaska in 2020.
2019	NPFMC TAC 254 t. SSEO directed fishery opened; EYKT, NSEO, and CSEO remained closed.
2020	NPFMC TAC 231 t. Other than the subsistence and bycatch fisheries, all management areas remain closed to all fishery types due to stock health concerns; EYKT, NSEO, CSEO, and SSEO. Rockfish release devices are required for all recreational vessels in Southeast Alaska starting this year.
2021	NPFMC TAC 250 t. Other than the subsistence and bycatch fisheries, all management areas remain closed to all fishery types due to stock health concerns; EYKT, NSEO, CSEO, and SSEO.