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 triennial cycle, with a full stock assessment typically conducted every third 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). The results of a preliminary statistical age-structured assessment model (ASA) that incorporates submersible, and ROV yelloweye rockfish density estimates, commercial, sport, and subsistence fishery data, and International Pacific Halibut Commission (IPHC) survey data are not presented this year due to personnel changes. The ASA will be presented in full in 2020; updates to the assessment inputs are for the status quo methodology are presented here.

Summary of Changes in Assessment Inputs

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

Changes in the input data:
Catch information and the average weight of yelloweye rockfish caught in the commercial fishery were updated for 2018. The average weight of yelloweye rockfish from 2017 to 2018 increased from 3.87 ± 1.35 kg (n = 550) to 3.95 ± 1.56 kg (n = 560) in East Yakutat (EYKT), decreased from 3.71 ± 1.34 kg (n = 410) to 3.54 ± 1.28 kg (n = 378) in Northern Southeast Outside (NSEO), increased from 3.57 ± 1.14 kg (n = 560) to 3.63 ± 1.20 kg (n = 738) in Central Southeast Outside (CSEO), and in Southern Southeast Outside (SSEO) samples were limited for 2018, (n = 11) therefore, the most recent 5-year average weight of 3.55 ± 1.30 kg (n = 756) was used from 2013–2017 to provide a comparable sample size to other management areas.

Changes in the assessment methodology:
There were no changes in the assessment methodology due to personnel changes.

Summary of Results

The yelloweye rockfish biomass estimate increased from 11,508 t to 12,029 t from 2018 to 2019. The increase in abundance is driven by an increase in average weight of yelloweye sampled in the CSEO management area.

Yelloweye rockfish comprise the largest component of the DSR complex and are managed using the Tier 4 harvest rule. The maximum allowable ABC for DSR in 2018 is 333 t (313 t yelloweye + 20 t non-yelloweye). The ABC and OFL for non-yelloweye DSR are calculated based on the Tier 6 rules harvest rule, species and these are added to the Tier 4 values for yelloweye. The Tier 6 values for non-yelloweye DSR utilizes catch data from 2010–2014 as this is the only time period with data available from the commercial, sport, and subsistence. This time period was the only range when all three catch data sets (commercial, sport, and subsistence) overlapped (Table 14.1). The maximum allowable ABC for DSR for 2019 is 333 t (313 t yelloweye + 20 t non-yelloweye), which is 14 tons higher than the maximum allowable ABC for 2018. This increase can be attributed to our increase in average weight for yelloweye rockfish in NSEO and CSEO. The DSR complex is particularly vulnerable to overfishing given their longevity, late maturation, and habitat-specific residency. 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 261 t (241 t yelloweye + 20 t non-yelloweye DSR Tier 6) for 2019. The OFL is set using $F_{35\%}=0.032$; which is 411 t for 2019.

State of Alaska regulations at 5 AAC 28.160(c)(1)(A) dictate that subsistence DSR removals be deducted from the ABC prior to allocating the TAC to the commercial (84%) and sport (16%) fisheries. In the current assessment, 7 t were deducted from the ABC for DSR from the most recent subsistence harvest estimate from 2015 for a TAC of 254 t; 213 t is allocated to commercial fisheries and 41 t is allocated to sport fisheries for 2019.

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 *recommended this* year for: 2019	2020
M (natural mortality rate)		0.02	0.02
Tier		4	4
Yelloweye Biomass (t)		12,029	
$F_{OFL}=F_{35\%}$		0.032	0.032
$maxF_{ABC}$		0.026	0.026
F_{ABC}		0.020	0.020
DSR OFL (t)		411	411
DSR max ABC (t)		333	333
ABC (t)		261	261
Status		As determined this year for: 2017	2018
Overfishing		No	n/a

The non-yelloweye DSR ABCs and OFL are calculated using Tier 6 methodology. Non-yelloweye Tier 6 ABCs and OFL are added to Tier 4 yelloweye ABCs and OFL for total DSR values.

Quantity (Tier 6 for other DSR only)	As estimated or *specified last* year and *recommended this* year for: **2018**	**2019**
OFL (t)	**26**	**26**
ABC (t)	**20**	**20**

Area Apportionment

The ABC and OFL for DSR are for the Southeast Outside Subdistrict (SEO) 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 the SEO Subdistrict is at the discretion of the State. Commercial catch data (t) for DSR in the SEO Subdistrict is updated as of October 16, 2018 (NMFS Alaska Regional Office Catch Accounting System via the Alaska Fisheries Information Network (AKFIN) database), http://www.akfin.org (Table 14.2).

Responses to SSC and Plan Team Comments Specific to this Assessment

September 2018 Plan Team

The Plan Team recommended an examination of converting ROV determined lengths to weights in order to examine the similarities/differences between surveyed and harvested populations.

We compared length distributions of yelloweye rockfish collected from the ROV survey and the commercial fishery from 2012–2018. ROV survey lengths were used to estimate weights ($\hat{W}$) based upon an allometric length-weight relationship based upon commercial fishery yelloweye rockfish samples where:

$$\hat{W} = a * L^b$$

Yelloweye rockfish length distributions were compared using a Kruskal-Wallis test to determine if samples originated from the same distribution among management areas (α=0.05). Sampling distributions of length differed significantly among management areas for both the survey (chi-squared = 13.0, df = 3, $p < 0.05$) and fishery (chi-squared = 319.4, df = 3, p-value < 0.05). Survey length distributions varied among the EYKT (n=146, 34.3–71.1 cm), NSEO (n=47, 36.6–71.5 cm), CSEO (n=134, 35.7–77.7 cm), and SSEO (n=130, 34.0–78.1 cm) management areas (Figure 14.1a). Average length varied among management areas with the largest average length occurring in EYKT (54.0 ± 8.5 cm) followed by CSEO (51.6 ± 8.7 cm), NSEO (50.9 ± 10.4 cm), and SSEO (50.6 ± 9.21cm). Fishery lengths distributions also varied among the EYKT (n=4,360, 30–86 cm), NSEO (n=1,892, 30–81 cm), CSEO (n=4,297, 33–77 cm), and SSEO (n=1,068, 34–79 cm) management areas (Figure 14.1b). Average length was higher in the fishery compared to the survey with the largest averages occurring in EYKT (58.5 ± 7.1 cm) followed by NSEO (57.8 ± 7.1 cm), SSEO (56.2 ± 6.4 cm), and CSEO (56.0 ± 6.3 cm). Yelloweye length distributions varied between the survey and fishery with the survey observing a larger proportion of smaller individuals with a mode near 50 cm the fishery mode was near 60 cm (Figure 14.1c). Survey lengths were converted to weights by applying the L-W relationship from the fishery (Figure 14.1d) and varied minimally among management areas for the survey (Figure 14.1e) and fishery (Figure 14.1f), and were smaller than that of the fishery (Figure 14.1g).

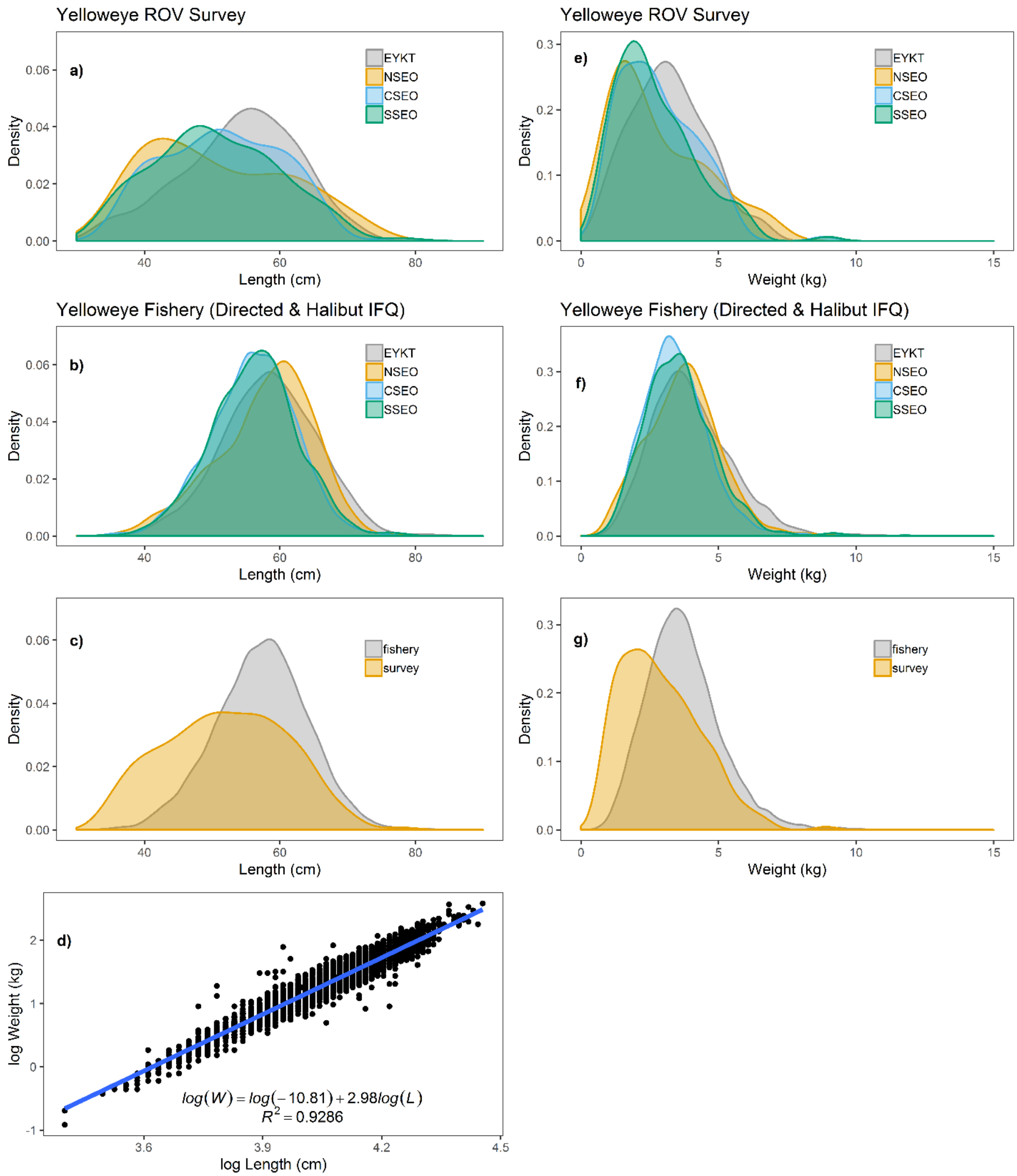

Figure 14.1.–EGOA yelloweye rockfish length (cm) and weight (kg) distributions from the ROV survey and commercial fishery (directed and halibut IFQ): a) ROV survey length distributions by management area, b) Commercial fishery length distributions for sampled catch from the directed and halibut IFQ fisheries, c) Comparison of length distributions for the survey and fishery, d) log transformed L-W 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 IFQ fisheries, and g) Comparison of estimated weight distributions for the survey and observed weights from the fishery.

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 14.3). 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).

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, but 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 the SEO Subdistrict. 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, like in Aleutian Islands blackspotted/rougheye rockfish (Spencer and Rooper 2016).

Life History

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). However, some species of *Sebastes* have been reported to brood multiple times within a year off the coast of California; 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) and begin recruiting to the commercial fishery at age 8 in Southeast Alaska.

Rockfishes of genus *Sebastes* are physoclistous (closed swim bladder) making them susceptible to embolism mortality when brought to the surface from depth. Full retention requirements for the commercial fisheries have been in regulation since 2005. Full retention of DSR had been required for the guided sport fishery, but beginning in the 2013 season, all charter operators in Southeast Alaska were required to possess and utilize deep-water release devices for releasing nonpelagic (i.e. DSR) rockfish. Historically, release mortality biomass has been estimated using the assumption that released rockfish experience 100% mortality (Green et al. 2013) and since 2013 the guided sport fishery assumes a release mortality rate of 20% for yelloweye rockfish (Hochhalter and Reed 2011, GMT 2014).

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 the East Yakutat management area (EYKT), and management of DSR extended westward to 140° W. longitude. This area is referred to as the Southeast Outside (SEO) Subdistrict and is comprised of four management sections: EYKT, Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO) (Figure 14.2). 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 (Figure 14.2). 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 (Table 14.1), 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 primarily between the 90 m and the 200 m depth contours. Over the past four years, yelloweye rockfish accounted for 95 to 97% (by weight) of the total DSR catch (Table 14.4). Quillback rockfish are the next most common species landed in the complex, accounting for approximately 2.3% of the landed catch between 2009 and 2018 (Table 14.4). The directed fishery is prosecuted almost exclusively by longline gear. Although snap-on longline gear was originally used in this fishery, most vessels now 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 will 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 5th (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 over-harvest of DSR), whichever comes first. The directed DSR fleet requested a winter fishery, as the ex-vessel price is highest at that time. Directed fisheries are opened by management area (EYKT, NSEO, CSEO, and/or SSEO) if there is sufficient commercial TAC remaining after subtracting the estimated DSR incidental catch in other fisheries. The catch by sector, including directed and incidental, are in Table 14.2.

Commercial Fishery Catch History

The DSR fishery has been active since the late 1979 and catch data prior to 1992 is 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 in 1992 for EYKT (Appendix A). Thus, the history of domestic landings of DSR from SEO is shown from 1992–2018 in Table 14.2, Figure 14.3 and 14.4. The directed DSR catch in SEO was above 350 t in the mid-1990s. Since 1998, landings have been below 250 t, and since 2005, directed landings have typically been less than 100 t. During the reported years total harvest peaked at 604 t in 1994, and directed harvest peaked at 381 t in 1994. Although directed landings were higher in the 1990s, since 2000, 58.7% of the DSR total reported catch is from incidental catch of DSR in the halibut fishery. It should be emphasized, however, that prior to 2005, unreported mortality from incidental catch of DSR associated with the halibut and other non-directed fisheries is unknown and may have been as great as a few hundred tons annually. This is due to full retention requirements that were passed by the NPFMC in 1998 did not go into effect until 2005 where fishermen are required to retain and report all DSR caught. 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. However, now the incidental catch must be projected because the directed fishery occurs before the Pacific halibut fishery, which starts in mid-March.

Directed commercial fisheries are held in the four management areas (EYKT, NSEO, SSEO, and CSEO) if there is sufficient quota available after the DSR mortality in other commercial fisheries (primarily the IFQ halibut fishery) is estimated. 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 sport 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 the SEO district as ADFG took action in two areas; one was to enact management measures to keep the catch of DSR in the sport fishery to the levels mandated by the Board of Fisheries (BOF), and the other was to further compare the estimations of incidental catch in the halibut fishery to the actual landings from full retention regulations in the commercial fishery in those years to see how closely our predicted incidental catch matched commercial landings. 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, and in 2018 only CSEO were open to directed fishing.

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%) (Figure 14.4).

In 1998 the NPFMC passed an amendment to require full retention of DSR in federal waters and the final rule went into effect in 2005 and fishermen are required to retain and report all DSR caught in federal waters; any poundage above the 10% incidental catch allowance 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.

Since the implementation of the state and federal full retention regulations for DSR, over 95% of the landed overages of DSR in the state and federal waters are now retained for personal use rather than being donated or sold. There appears to be increasing compliance with the full retention. In addition, the Alaska Longline Fishermen's Association has developed a database of rockfish "hotspots" so that halibut and sablefish longline fishermen can avoid making sets in these areas in an effort to reduce rockfish incidental catch.

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, we estimated the amount of DSR incidental catch in the halibut fishery 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, please see Brylinsky et al. (2009). Since 2012, we have calculated a ratio of DSR to halibut landed in the halibut fishery, by management area, and applied this 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 10% is added to the estimation preseason for unreported incidental catch.

Other Removals

Other removals (subsistence, sport, and research catch) are documented in Table 14.2. In July 2009, the ADF&G Division of Subsistence published the results of a study done to estimate the subsistence harvest of rockfish near 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 sport 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 sport 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.

Sport Fishery Removals

The Alaska Board of Fisheries currently allocates 16% of the DSR TAC for the Southeast Outside District to the sport fishery after deduction of the estimated subsistence harvest. The sport fishery allocation includes estimated harvest and release mortality (20% for charter sector and 100% for noncharter sector). Prior to 2006, the daily bag limit in the Southeast Alaska sport fishery for nonpelagic (DSR and slope/other) rockfish was 3 to 5 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 3 to 5 fish bag limit. Since then, the BOF has established management provisions that may be implemented by the department on an annual basis to manage the sport fishery within the allocation. Sport fishery regulations for the Southeast outside waters in 2018 were as follows:

1. For resident anglers, the daily bag and possession limit was one nonpelagic rockfish.
2. For nonresident anglers, the daily bag and possession limit was one nonpelagic rockfish. In addition, nonresidents were restricted to an annual limit of one yelloweye rockfish. Immediately upon harvesting a yelloweye rockfish, the angler was required to log the harvest in ink on the back of their fishing license or on a nontransferable harvest record.
3. All nonpelagic rockfish caught were required to be retained until the angler's daily bag limit was reached.
4. Guides and crew members were not allowed to retain nonpelagic rockfish when clients were on board the vessel.
5. Retention of nonpelagic rockfish was prohibited from August 1 through August 31 and all vessels in Southeast outside waters must have a functional deepwater release device on board while fishing (regardless of target species) and all nonpelagic rockfish must be released at depth of capture or at least 100 feet.

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

In addition, since January 1, 2013, all nonpelagic rockfish released from a charter vessel were required to be released with a deepwater 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 deepwater release device on board, have it readily available for use while anglers are fishing, and present it for inspection upon request by department or enforcement personnel.

Beginning January 1, 2020 all sport fishing vessels fishing in salt waters of Southeast Alaska will be required to have in possession, and utilize, a deepwater release mechanism to return and release nonpelagic rockfish to the depth it was hooked or at least 100 ft in depth. All vessels will be required to have at least one functioning deepwater release mechanism onboard while actively sport fishing in salt waters.

Data sources for the sport 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 anglers. 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 Sport Fish management areas.

Logbooks have been mandatory for the charter 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 angler. 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 sport-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.

Final estimates of sport fishery removals used a combination of data from the SWHS, creel survey, and charter logbook. The total removals were estimated as the sum of the mass of the harvest (retained catch) and release mortality. Harvest biomass *HB* was estimated for the outside waters portion of SWHS areas B, D, G, and H, which correspond roughly with the SSEO, CSEO, NSEO, and EYKT groundfish management districts, and summed:

$$HB = \sum_a \sum_c \sum_s \hat{H}_{ac} \hat{p}_{ac} \hat{\iota}_{acs} \hat{\hat{w}}_{acs}$$

where:

$\hat{H}_{ac}$ = the SWHS estimate of the number of rockfish (all species combined) harvested in SWHS area *a* by class *c* (charter or noncharter),

$\hat{p}_{ac}$ = the estimated proportion of harvest by class *c* from outside waters portion of area *a*,

$\hat{\iota}_{acs}$ = the estimated proportion of species *s* in the sport harvest of all rockfish by class *c* from the outside waters of area *a*, and

$\hat{\hat{w}}_{acs}$ = the estimated average round weight of species *s* in the sport harvest by class *c* from outside waters of area *a*.

Because the SWHS areas include inside waters, harvest estimates must be apportioned to obtain the outside waters harvest using $\hat{p}_{ac}$. Neither SWHS estimates nor creel survey interviews are adequate for this apportionment. SWHS reporting locations are not precise enough to identify outside waters, and many survey respondents are too unfamiliar with where they were fishing to report accurately. Creel survey data are precise, but surveys are only conducted in major ports and interviewed anglers may not accurately represent the spatial distribution of total harvest. Logbook data are mandatory and presumably represent a complete census of the charter harvest. Therefore, logbook data were used to apportion both charter and noncharter harvest to outside waters. This proportion is treated as a constant in calculation of variance.

Average weight was estimated for each species by applying species-specific length-weight relationships to length measurements of all harvested fish from outside waters in each SWHS area (Brylinsky et al. 2009).

Release mortality biomass (RB) was estimated by area and species for each class using different methods. For the noncharter sector, the mortality rate of all species of rockfish released was assumed to be 100 percent, and the average weight of released rockfish was assumed to equal the average weight of harvested rockfish for each species. Therefore, release mortality was estimated as a function of harvest biomass and the release rate by SWHS area for the noncharter sector:

$$RB_{Noncharter} = \sum_{a}\sum_{s}\left(\frac{\widehat{HB}_{as}}{1 - r_{as}} - \widehat{HB}_{as}\right)$$

where:

$\widehat{HB}_{as}$ = the estimated harvest biomass of species s in SWHS area a by noncharter anglers, and

r_{as} = the proportion of the catch of rockfish species s that was released in area a.

The release rate r_{as} for the noncharter and charter sectors was obtained using charter logbook data from outside waters. Logbook data were used for noncharter sector estimates because SWHS estimates are for all species combined and could not be apportioned to species for the noncharter sector. Creel survey interview data on noncharter fishery releases were spotty and incomplete. Given the similarity in resident (mostly noncharter) and nonresident (mostly charter) bag limits, logbook data were felt to provide a reasonable proxy for release rates in the noncharter fishery.

Starting in 2013, release biomass was estimated for the charter sector taking into account a higher survival rate due to mandatory use of deepwater release devices. There is now substantial evidence that survival of benthic rockfish species is dramatically increased when fish are released at depth (Jarvis and Lowe 2008, Hochhalter and Reed 2011, Hannah et al. 2012, GMT 2014). Point estimates of survival for yelloweye rockfish and other DSR species held in cages for two days ranged from 0.90 to 1.00 (Hannah et al. 2012, Hannah et al. 2014). Hochhalter and Reed (2011) estimated 17-day survival of fish caught and released in the wild at 0.988. The Pacific Fishery Management Council has adopted depth-specific mortality rates for yelloweye, canary rockfish, and cowcod. The mortality rates for yelloweye rockfish are based on 90% confidence limits and range from 0.22 to 0.27 for depths shallower than 91 m, and 0.57 for depths of 91–137 m (GMT 2014). Hochhalter and Reed (2011) captured yelloweye at depths of 18-72 m but were unable to discern an effect of depth of capture on survival.

Based on the above studies, we assumed a mortality rate of 20% for estimation of 2013 and 2014 charter release mortality for DSR species. This rate is higher than most scientific study results for yelloweye rockfish, but is precautionary in order to take into account the lack of depth information for sport-caught fish, expected variation in types of gear used, less than ideal handling, and potential noncompliance with the release requirement. The choice of 20% is somewhat arbitrary and will be adjusted if better information becomes available.

Release mortality biomass RB was estimated for the charter sector as:

$$RB_{Charter} = \sum_a \sum_s \hat{R}_{as} \widehat{MR} \hat{\bar{w}}_{as}$$

where:

$\hat{R}_{as}$ = the estimated number of rockfish of species *s* released in the outside waters of SWHS area a by charter anglers,

$\widehat{MR}$ = the assumed short-term mortality rate due to capture, handling, and release of demersal shelf rockfish (all species, all depths), and

$\hat{\bar{w}}_{as}$ = the estimated average round weight of species *s* released by charter anglers from outside waters of area a.

As noted above, the assumed mortality rate was 0.20, with a standard error of 0.03. The assumed standard error was "borrowed" from the Pacific Council adopted mortality rates for yelloweye rockfish (GMT 2014). The average weight of harvested rockfish was used as a proxy for the average weight of released rockfish because there are no size data available for rockfish released in the charter fishery. This is not an unreasonable proxy given the requirement that anglers must retain all rockfish until their bag limit is reached.

The number of rockfish released in each area in the equation above (R_{acs}) was estimated as:

$$\hat{R}_{as} = r_{as} \frac{\hat{H}_{as}}{(1 - r_{as})}$$

where $\hat{H}_{as}$ is the estimated charter harvest in SWHS area a of species s, and r_{as} is proportion of rockfish catch by charter anglers that was released, as described above.

As noted previously, SWHS estimates were used to calculate final estimates of the biomass of harvest and release mortality. However, SWHS estimates are not available until November of the year following harvest, therefore average harvest from the most recent 3-years will be used until final SWHS estimates are available.

Data

Fishery Age Compositions

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 1983). 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, generally agreement between growth-zone-derived ages and radiometric ages was good with a low coefficient of variation. In addition, Andrews et al. (2002) conclude 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. Maximum published age for yelloweye is 118 years (O'Connell and Funk 1987), but one specimen from the SSEO 2000 samples 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 14.2). Instead, the most recent abundance estimate from a management area is used to update the annual stock assessment, however four to six 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. We use a Phantom ROV (HD 2+2) "*Buttercup*" that is owned and operated by the ADF&G in Homer, AK. 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 (SeaGIS Pty Ltd., EventMeasure version 3.50). The SeaGIS software is a measurement science software used to log and archive events in digital imagery (Seager 2012).

The initial 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 with a coefficient of variation (CV) of 13% (Table 14.5; Figure 14.5). 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 we were not able to compare the ROV results directly with the submersible or account for natural changes in the yelloweye rockfish population between years, the ROV yelloweye rockfish density estimate for 2012 was comparable to previous submersible estimates with a similar magnitude. 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 for EYKT (2015 and 2017), NSEO (2016), CSEO (2012 and 2016), and SSEO (2013 and 2018) (Table 14.5). In 2018, 33 transects were successfully surveyed in SSEO in May and video is still being processed and from August 11–25 we surveyed the CSEO and NSEO management areas and plan to have updated density estimates for these management areas in 2020.

Analytic approach

Modelling 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, and our 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, we only counted fish 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 counts of fish that avoided the sub as the sub approached and removals of fish that swam into the transect from the left side because of interaction with the submersible. Yelloweye rockfish have distinct coloration differences between juveniles, subadults, and adults, so 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 selected in preferred yelloweye rockfish habitat using ArcGIS. Random locations were removed from the survey design if they were in depths ≥200 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 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 (personal communication, Robert Pacunski, WDFW, Mike Byerly, ADF&G), the encounter rate of yelloweye rockfish based on our previous surveys, and ROV pilot fatigue. The number of planned transects was based on yelloweye rockfish encounter rates from previous surveys and our targeted precision (CVs of less than 15%).

Transect Line Lengths–Submersible
Beginning in 1997, we positioned the support ship directly over the submersible at five-minute time intervals and used the corresponding Differential Global Positioning System (DGPS) fixes to determine line length. In 2003 the submersible tracking system was equipped with a gyro compass, enabling more accurate tracking of the submersible 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, we also collected position data every 2 seconds using the WinFrog tracking software provided by *Delta*. Outliers were identified in the WinFrog data by calculating the rate of travel between submersible locations. The destination record was removed if the rate of travel was greater than 2 meters per second. In 2007, a 9-point running average was used to smooth the edited WinFrog data and then smoothed data were visually examined in ArcGIS. If any additional irregularities in data were observed, such as loops or back tracks, then these anomalies were removed and the data 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 edited out of the line transect and the line transect data were 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 are “pre-reviewed” to remove

any video segments where poor visbility would obscure yelloweye rockfish observations or when the ROV was not moving forward (i.e. stalled, or stopped due to some logistical problem). Navigation data are mapped in ArcGIS after treatment with a smoothing spline and video quality segments are overlaid navigation data using linear referencing. The total line length for each transect is estimated using the good quality video segments only.

Video Review–Submersible
The side facing and forward-facing video from the submersible dives were reviewed post-dive while listening to the verbal recording made by the scientist-observer in the submersible. The audio transcript includes the scientist's observations of the species observed, and each individual fish's distance away from the submersible. These data are 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 is able to see farther out the window than the camera field of view, thus the verbal transcript is critical for data collection.

Video Review–ROV
Fish are recorded on the right and left side of the "center line" of the line transect when reviewing video within the SeaGIS EventMeasure software (Figure 14.9). The video reviewer will identify and enumerate yelloweye rockfish for density estimation, and other DSR, black rockfish, lingcod, halibut and other large-bodied fish, as time allows, for species composition. Fish total length will be recorded for individual yelloweye rockfish, lingcod, halibut, and black rockfish (2018). Fish behavior and maturity stage are recorded for yelloweye rockfish only.

For each fish, a perpendicular distance from the origin of the transect line to the fish will be obtained through the SeaGIS software. 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 will be 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 14.10). Fish that swim into the field of view more than once will not be double counted (this behavior is obvious, and based on our observations, rare for yelloweye rockfish).

Fish total length is recorded from the tip of the snout to the tip of the caudal fin. Length measurements are most accurate when fish are close, straight (i.e. not curled), and parallel, relative to the cameras; the video reviewer will measure each fish in the best possible orientation and position. The best possible horizontal direction will be obtained; the horizontal direction is the angle between the horizontal component of the measured length and the camera base and represents the degree to which a fish is turned away from the camera. For example, if a fish is parallel to the camera then it has a horizontal direction of 0° and if a fish is facing directly toward or away from the camera, the horizontal direction is 90°. As the horizontal direction increases, the precision 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

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

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

Yelloweye rockfish density is estimated using DISTANCE 7.2 software (Thomas et al. 2010) which utilizes the following equations to estimate density with the principal function to estimate the probability of detection evaluated at the origin of the transect line ($\hat{f}(0)$):

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

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

where:

n = total number yelloweye rockfish 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

Yelloweye rockfish lengths are examined to determine whether to exclude any small yelloweye rockfish identified as adults or subadults from the density model data. The best probability detection model is selected in order to obtain a valid density estimate. Models are explored with and without binning and truncation (i.e. at some predefined maximum distance) of distance data and with different key model functions and adjustment terms. The best model is selected based on visual fit of model, the Akaike information criterion (AIC) value, X^2 goodness of fit test, and the CV for the density estimate ($cv_t(\hat{D})$). Probability detection functions are visually examined to determine if the model fits the data well and has a good fit at the origin. In addition, the model is 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).

The average weight of yelloweye rockfish sampled from the directed commercial fishery and incidental catch from the halibut fishery 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 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 software (Seager 2012). 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

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 rocky habitat (O'Connell and Carlile 1993, Brylinsky et al. 2009). In NSEO management area, where no sonar surveys have been performed and commercial fishery logbook data are limited, yelloweye rockfish habitat was delineated by buffering locations designated as coral, rock, or hard seafloor on NOAA charts by 0.5 miles. Locations were only considered preferred yelloweye rockfish habitat if ≥ 64 m and < 183 m; 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; Figure 14.11). 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 CSEO management area, 832 km^2 have been surveyed with 442 km^2 of this area considered rocky habitat. A side scan survey covering 538 km^2 was performed west of Cape Edgecumbe (located on Kruzof

Island) in 1996, and in 2005, a high resolution 8 km^2 multibeam survey, which encompasses the Pinnacles Marine Reserve, was performed within the southern portion of the area originally side scanned. In 2001, a 294 km^2 area west of Cape Ommaney (located on the southern tip of Baranof Island) was surveyed.

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 rocky 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 SSEO management area, 1,154 km^2 have been multibeamed, with 322 km^2 considered rocky 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).

In the NSEO management area, 849 km^2 have been multibeamed, with 109 km^2 considered rocky habitat. A total of 3,217 km^2 was surveyed using a multibeam in Cross Sound in 2015.

For areas without seafloor mapping information, we delineate rocky habitat 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 are buffered by 0.5 miles (this established buffer size was retained for consistency). Starting in 2003, fishermen were required to include both start and end set positions; sets with both locations are buffered 0.5 km around the entire track. 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 ≥2,300 m in length (to ensure rocky segments were large enough for two non-overlapping submersible transects). To consider habitat segments as “continuous”, no gaps > 0.5 nautical miles 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; CSEO management area is composed of 1,661 km^2 rocky habitat with 27% from sonar; SSEO composed of 1,056 km^2 of rock with 30% from sonar; and NSEO with 442 km^2 of rocky habitat with 25% derived from sonar. Rock habitat not derived from sonar is defined based on fishery logbook data.

Density estimates

Overall density estimates have declined in all management areas in recent years with the exception of CSEO which saw an increase in 2016 (Table 14.5; Figure 14.5). CSEO exhibited a large decrease in density in 2012, but rebounded in 2016 after being closed to a directed commercial fishery for 4 years. In SSEO trends increased through 2003, and then declined. The EYKT density estimates are more variable and relatively stable through the survey time series, however, density estimates dropped in 2017. For a more complete description of previous submersible estimates, please see Brylinsky et al. (2009).

The initial 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 14.5; Figure 14.5). 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 we were not able to compare the ROV results directly with the submersible or account for natural changes in the yelloweye rockfish population between years, the ROV-based yelloweye rockfish density estimate for 2012 was comparable to previous submersible estimates with a similar magnitude. 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. 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 and 2017), NSEO (2016 and 2018), CSEO (2012, 2016, 2018), and SSEO (2013) (Table 14.5; Figure 14.5). Video from the NSEO, CSEO, and SSEO 2018 surveys is under review so density estimates are not available for those areas.

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 2019 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 333 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 261 t (including 20 t for other DSR species).

Scenario 3: F equals the 5-year average F from 2013 to 2018. 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 261 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 176 t (including 20 t for other DSR species).

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

Ecosystem Considerations

In general, ecosystem considerations for the DSR complex are limited. Table 14.7 consolidates information regarding ecosystem effects on the stock and the stocks effect on the ecosystem. Specific data to evaluate these effects are mostly lacking

Ecosystem Effects on the Stock

Prey availability
Like many rockfishes, the DSR complex is highly influenced by periodic abundant year classes. Zooplankton prey availability and favorable environmental conditions may affect the survivability of larval rockfishes. Yelloweye rockfish consume rockfishes, herring, sandlance, shrimps, and crabs and seasonally lingcod eggs, and changes in the abundance of these food sources could impact yelloweye rockfish abundance (Love et al. 2002).

Predator population trends
Many predators, including other rockfishes consume larval and juvenile yelloweye rockfish. Adult yelloweye rockfish have been found in the stomachs of longline caught lingcod and halibut but this may be opportunistic feeding as the yelloweye rockfish were caught on the fishing gear. A yelloweye rockfish was also found in the stomach of an orca whale (Love et al. 1990). Yelloweye rockfish are considered mid to high in trophic level (Kline et al. 2007). Predator effects, or an increase in predation on any one of the life stages of the DSR complex could have negative effects on the stock.

Changes in physical environment:
Strong year classes for many species of fish correlate with good environmental conditions. Black et al. (2011) documented seasonal (winter and summer modes) upwelling as an index for predicting rockfish productivity. For yelloweye rockfish, increased growth was associated with the winter upwelling mode but not summer upwelling in the California Current Ecosystem. Thorson et al. (2013) found that a multi-species approach to estimating recruitment may be promising for some species (e.g. for yelloweye rockfish, a shared index of cohort strength decreased coefficient of variation for recruitment for the modeled year by 40%). Thus, recruitment estimates for data poor species such as yelloweye rockfish may be improved by using multispecies recruitment indices.

Availability of physical bottom habitat would impact yelloweye rockfish at many different stages of life. Both juveniles and adults are associated with high relief rock habitat, as well as corals and sponges (O'Connell and Carlile 1993). Bottom trawling is not a legal gear type in the Eastern Gulf of Alaska so the effects of commercial fishing on the bottom habitat are minimal, although there is some removal of coral and sponges from non-trawl gear that comes in contact with the bottom (e.g. hook and line, dinglebar gear.)

Fishery Effects on the Ecosystem

Fishery specific contribution to HAPC biota
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, we have recorded many

observations of yelloweye rockfish in close association with corals and sponges. 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 lengths composition of yelloweye rockfish captured on the gear. The commercial directed fisheries landing data show that most fish are captured between 450 and 650 mm (Figures 14.12–14.15). 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 we are still exploring those differences.

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 14.16–14.19. The age at 50% maturity used in this stock assessment 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 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 management areas more frequently and consistently will 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.

There is limited information on yelloweye rockfish fecundity; a fecundity study specific to southeast Alaska would be useful. Little is known about the timing of parturition for yelloweye rockfish recruitment or post larval survival. A recruitment index for yelloweye rockfish would improve modeling estimates for total yelloweye rockfish biomass.

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Table 14.1.–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 14.2.–Catch (t) of demersal shelf rockfish from research, directed commercial, incidental commercial, sport and subsistence fisheries in the Southeast Outside Subdistrict (SEO), 1992–2018[a], ABC, OFL and TAC for commercial and sport sectors combined after estimated subsistence harvest is decremented. Commercial catch includes discards at sea and at the dock and catch retained for personal use.

Year	Research	Directed	Incidental[d,f]	Sport[b]	Subsistence[c]	Total[d]	ABC[e]	OFL	TAC
1992		351	119			478	550		550
1993	13	341	188			534	800		800
1994	4	383	219			604	960		960
1995	13	168	103			271	580		580
1996	11	350	85			436	945		945
1997	16	280	100			380	945		945
1998	2	241	120			361	560		560
1999	2	242	126			367	560		560
2000	8	187	107			295	340		340
2001	7	178	146			324	330		330
2002	2	136	149			285	350	480	350
2003	6	105	169			275	390	540	390
2004	2	173	155			329	450	560	450
2005	4	42	195			237	410	650	410
2006	2	0	203	75		280	410	650	410
2007	3	0	196	60		259	410	650	410
2008	1	42	152	68		263	382	611	382
2009	2	76	139	37		254	362	580	362
2010	7	30	131	52	8	228	295	472	287
2011	5	22	87	36	6	156	300	479	294
2012	4	105	76	46	7	238	293	467	286
2013	4	130	83	34	7	258	303	487	296
2014	5	33	63	40	7	148	274	438	267
2015	4	33	69	48	8	162	225	361	217
2016	4	34	77	48	7	170	231	364	224
2017	5	32	92	45	7	181	227	357	220
2018	4	51	72	47	7	181	250	394	243

[a]Landings from ADF&G Southeast Region fish ticket database and NMFS weekly catch reports through October 16, 2018.
[b]Sport catch (retained catch plus estimated discard) from 2006 to 2008 include EYKT and IBS. These data are not available prior to 2006. Estimate for 2018 is based on the most recent 3-year average (2015–2017)..
[c]Projected subsistence catch for the fishery year, i.e. 2010 is for the 2010 fishery. These data were not available or deducted from the ABC prior to 2009.
[d]Data are from reported landings. Full retention of DSR went into effect in 2005, and unreported DSR discard associated with the halibut fishery prior to 2005 is not reported in these totals.
[e]No ABC prior to 1988, 1988–1993 ABC for CSEO, NSEO, and SSEO only (not EYKT).
[f]Assignment of ADF&G groundfish management areas for DSR bycatch landed in the commercial salmon troll fishery began in 2015.

Table 14.3.–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 14.4.–Commercial landings (t) of demersal shelf rockfish by species in Southeast Outside Subdistrict from 2015–2018. Discards (at sea and at dock) and personal use included.

Species	**2015[a]**	**2016**	**2017**	**2018[b]**
Canary rockfish	0.30	0.41	0.47	2.49
China rockfish	0.02	0.05	0.03	0.04
Copper rockfish	0.01	0.12	0.10	0.08
Quillback rockfish	2.32	2.86	2.50	2.92
Rosethorn rockfish	0.02	0.01	0.08	0.13
Tiger rockfish	0.23	0.32	0.21	0.21
Yelloweye rockfish	99.1	107.0	121.0	117.3
Total (t)	102.0	110.8	124.4	123.4
% yelloweye	97.2%	96.6%	97.3%	95.1%

[a]Assignment of ADF&G groundfish management areas for DSR bycatch landed in the commercial salmon troll fishery began in 2015.

[b]Represents preliminary commercial catch data through October 16, 2018.

Table 14.5.–Submersible (1994–1995, 1997, 1999, 2003, 2005, 2007, 2009) and ROV (2012–2013, 2015–2017) 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.

Area	Year	# transects	# 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**
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**
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**
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**

[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 fish. The forward-facing camera was added after 1994, which ensures that fish are observed on the transect line.

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%
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%
NSEO	Cross Sound	849	109
Total Sonar		849	109
Total rock (Sonar & fishery)			442
Percentage rocky habitat from sonar			25%

Table 14.7.–Ecosystem effects on GOA DSR

Indicator	Observation	Interpretation	Evaluation
Prey availability or abundance trends			
Phytoplankton and Zooplankton	Important for larval and post larval survival but no information known	May help determine recruitment strength, no time series.	Possible concern if more information known
Predator population trends			
Marine mammals	Not commonly eaten by marine mammals	No effect	No concern
Birds	Stable, some increasing some decreasing	Affects young-of-year mortality	Probably no concern
Fish (Pollock, Pacific cod, halibut)	Stable	No effect	No concern
Changes in habitat quality			
Temperature regime	Higher recruitment after 1977 regime shift		No concern
Winter-spring environmental conditions	Affects pre-recruit survival	Different Phytoplankton bloom timing	Causes natural variability, rockfish have varying larval release to compensate
Production	Relaxed downwelling in summer brings nutrients to the Gulf	Some years highly variable, i.e. El Nino 1998	Probably no concern, contributes to high variability in rockfish recruitment

GOA DSR fishery effects on the ecosystem			
Prohibited species	Halibut are taken as incidental catch but released	Minor contribution to mortality, soak times are short for DSR gear, separate PSC cap for DSR	Little concern
Forage (including herring, Atka mackerel, cod, and pollock)	A small amount of cod incidental catch is taken in this fishery	Incidental catch levels small relative to forage biomass	No concern
HAPC biota	Low incidental catch levels of Primnoa coral, hard coral, and sponges.	Longline gear has some incidental catch but levels small relative to HAPC biota	Little concern
Marine mammals and birds	Minor take associated with longline gear, little impact	Data limited for discards, fishery has been largely unobserved until recently.	No concern
Sensitive non-target species	Likely minor impact	Data limited, likely to be harvested in proportion to their abundance.	No concern
Fishery concentration in space and time	Majority of catch is harvested during halibut IFQ season (March to November), the directed fishery is concentrated during the winter	Fishery does not hinder reproduction	Little concern
Fishery effects on amount of large size target fish	Fishery is catching primarily adults but difficult to target largest individuals over others	Large and small fish both occur in population	Little concern
Fishery contribution to discards and offal production	Discard rates low for DSR fishery but can include dogfish and skates	Data limited for discards, fishery has been largely unobserved until recently	Possible concern
Fishery effects on age-at-maturity and fecundity	Fishery is catching some immature fish but small proportion of total catch. Larger fish likely contribute more to spawning output via exponentially greater and higher quality larvae.	If increased could reduce spawning potential and yield	Possible concern

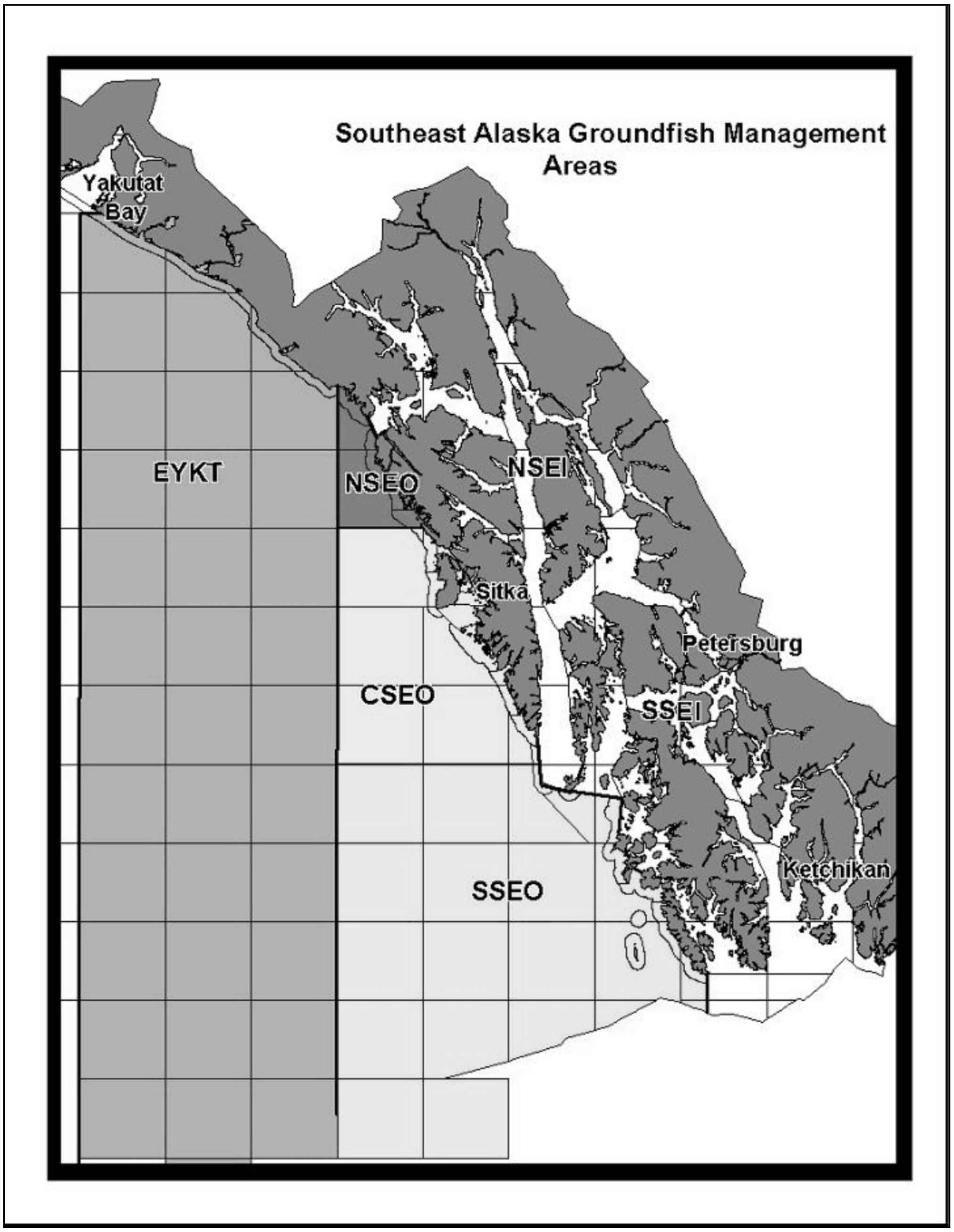

Figure 14.2.–The Southeast Outside (SEO) Subdistrict with the Alaska Department of Fish and Game groundfish management areas used for managing the demersal shelf rockfish fishery: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO).

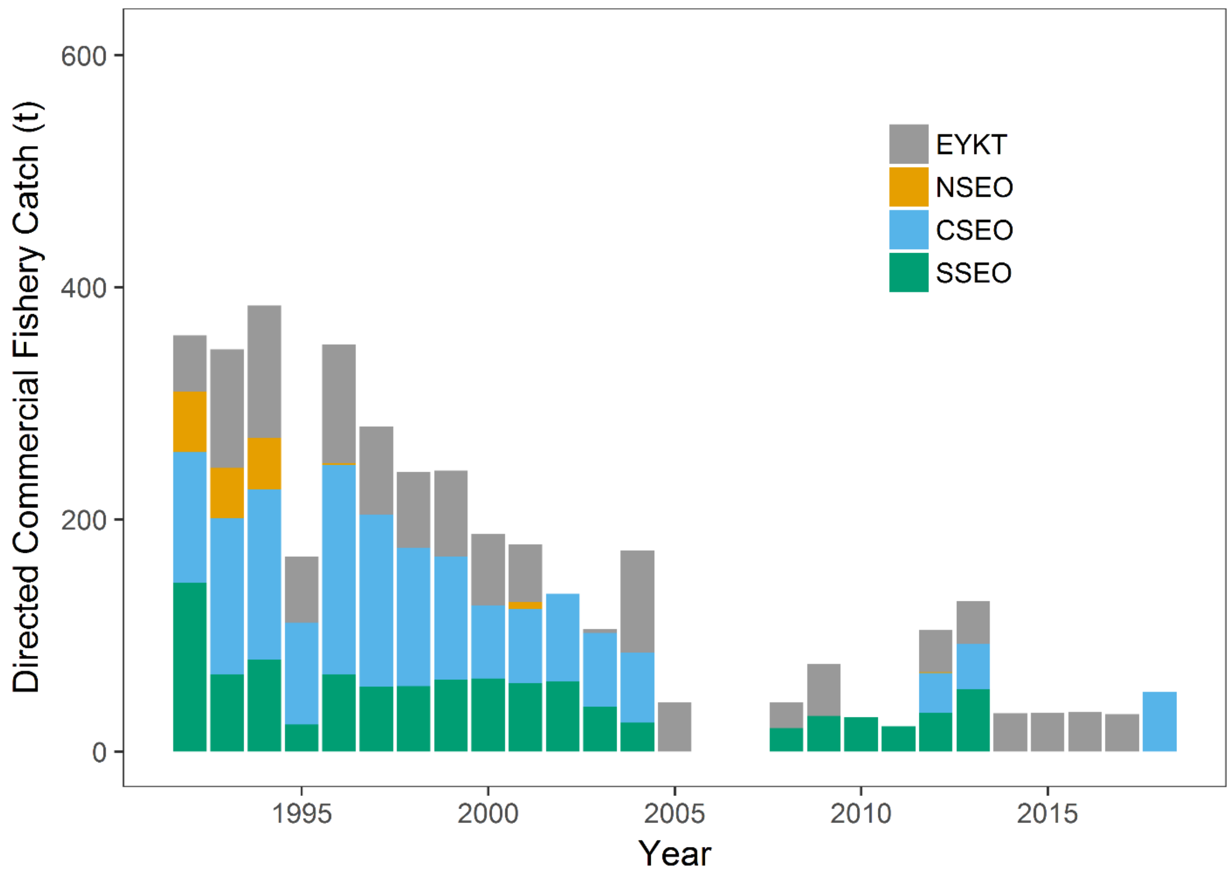

Figure 14.3.–1992–2018 directed commercial fishery catch (t) of DSR in the Southeast Outside (SEO) Subdistrict groundfish management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SEO).

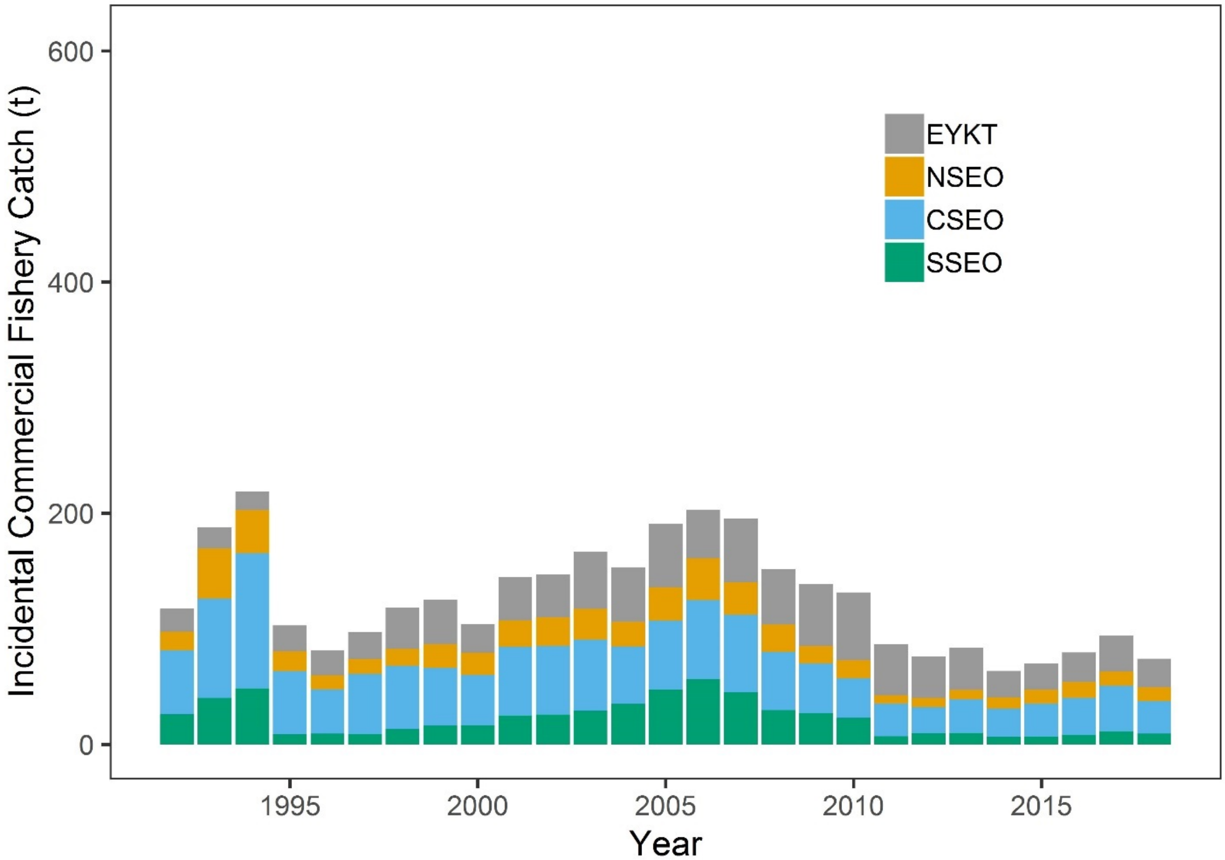

Figure 14.4.–1992–2018 incidental commercial fishery catch (t) of DSR in the for halibut, sablefish, lingcod, Pacific cod, and salmon fisheries (2015–2018) for Southeast Outside (SEO) Subdistrict groundfish management areas: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SEO).

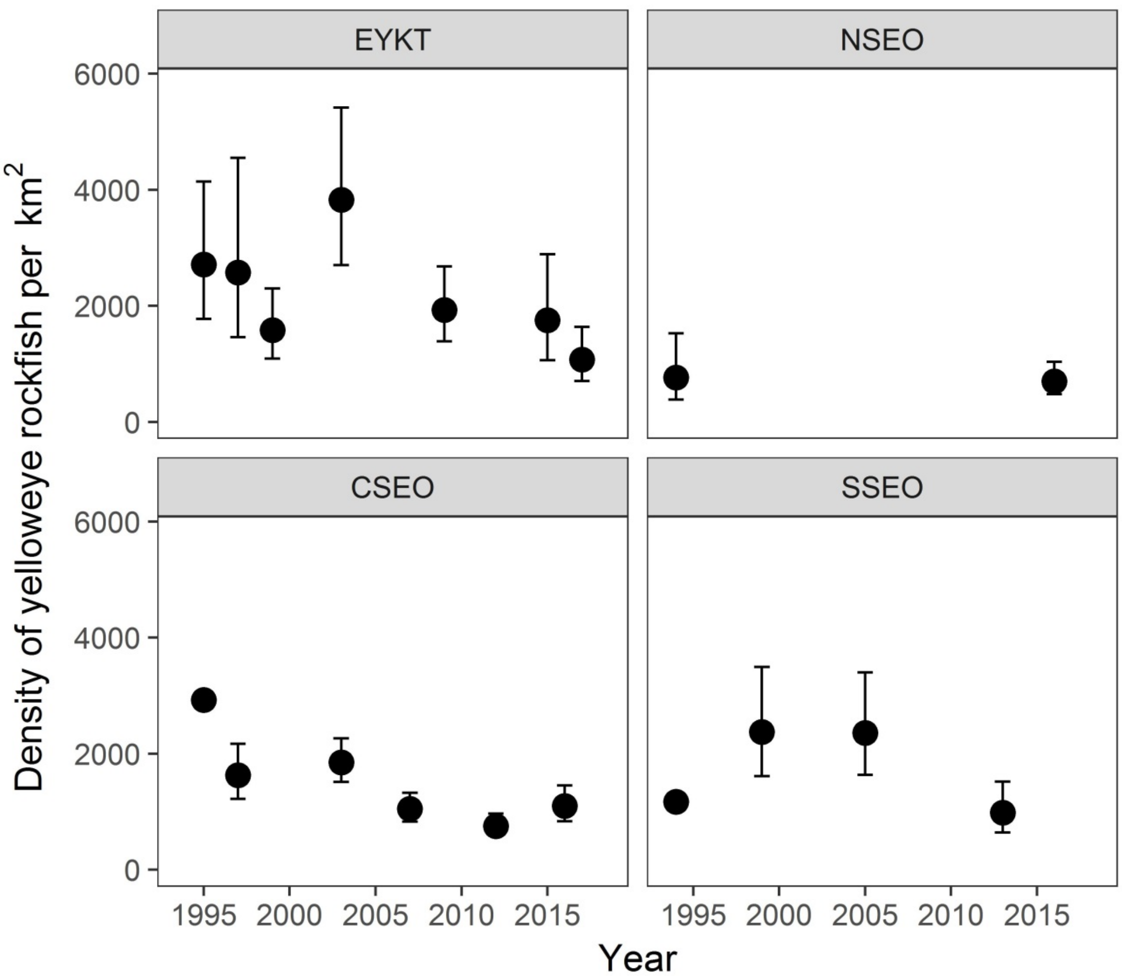

Figure 14.5.–Density of yelloweye rockfish predicted by DISTANCE (circles) +/- two standard deviations in each management area (Central Southeast Outside (CSEO), East Yakutat (EYKT), Southern Southeast Outside (SSEO), and Northern Southeast Outside (NSEO).

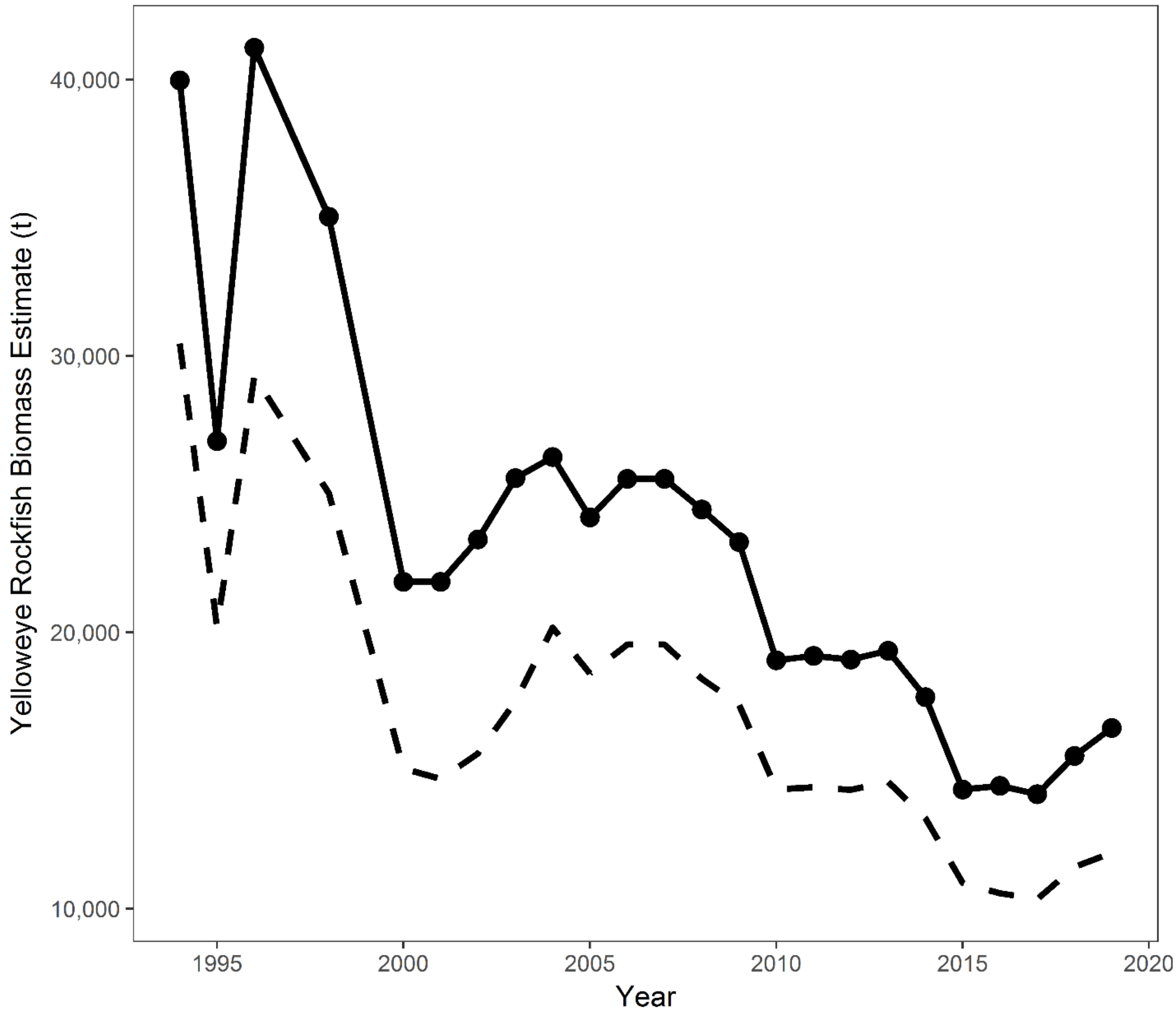

Figure 14.6.–1994–2018 yelloweye rockfish biomass estimate (t) (solid line) and 90% lower confidence interval (dashed line) for the Southeast Outside (SEO) Subdistrict.

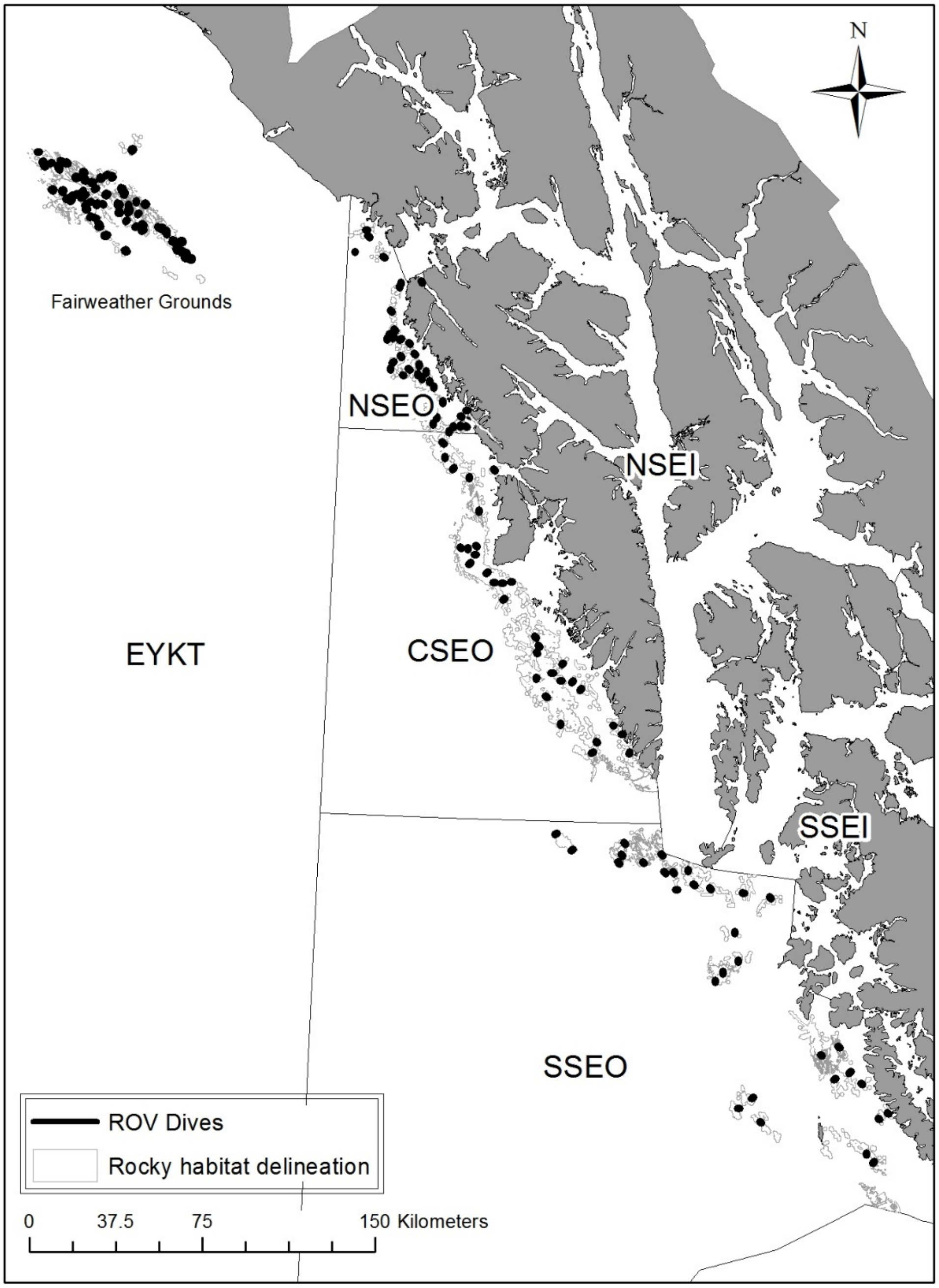

Figure 14.7.–ROV transects conducted in Northern Southeast Outside (NSEO) and Central Southeast Outside (CSEO) in 2016, and East Yakutat (EYKT) in 2017. Southern Southeast Outside (SSEO) was surveyed in May 2018.

Figure 14.8.–Example of 1-km transect plan lines for remote operated vehicle (ROV) dives. Plan lines have been adjusted in some cases to remain within the delineation of rocky habitat (solid gray).

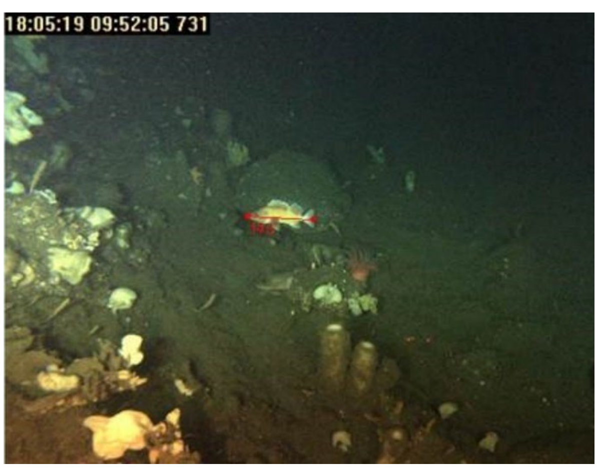

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Figure 14.9.–Yelloweye rockfish with a 3D point (red circle) and a total length (red line) measured in the stereo camera overlapping field of view in the SeaGIS EventMeasure software.

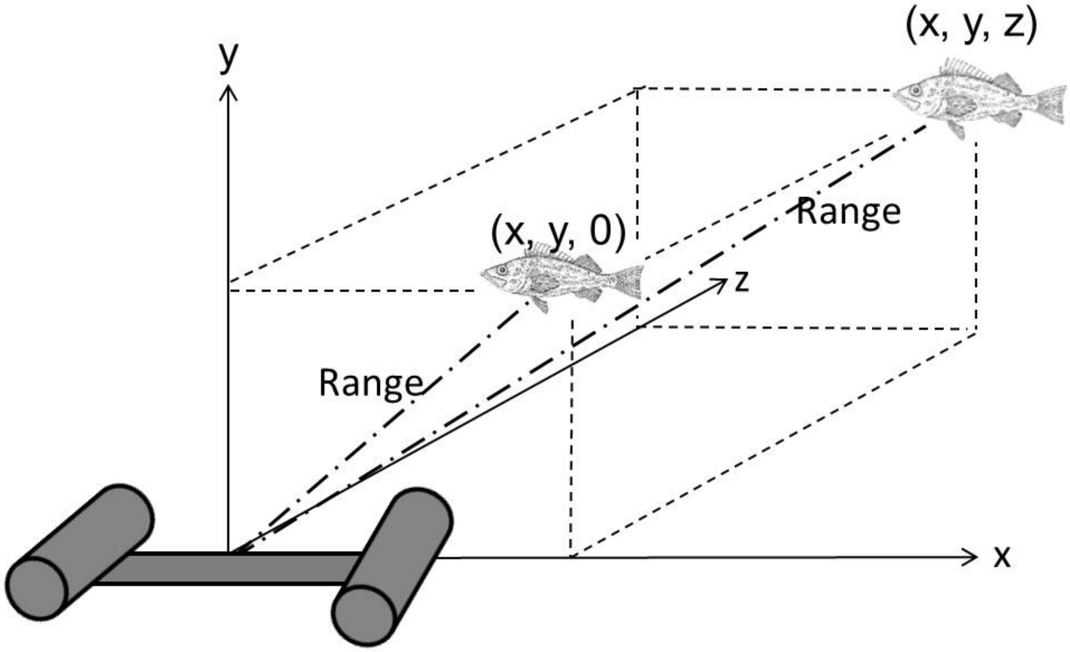

Figure 14.10.–The components of a 3D point measurement.

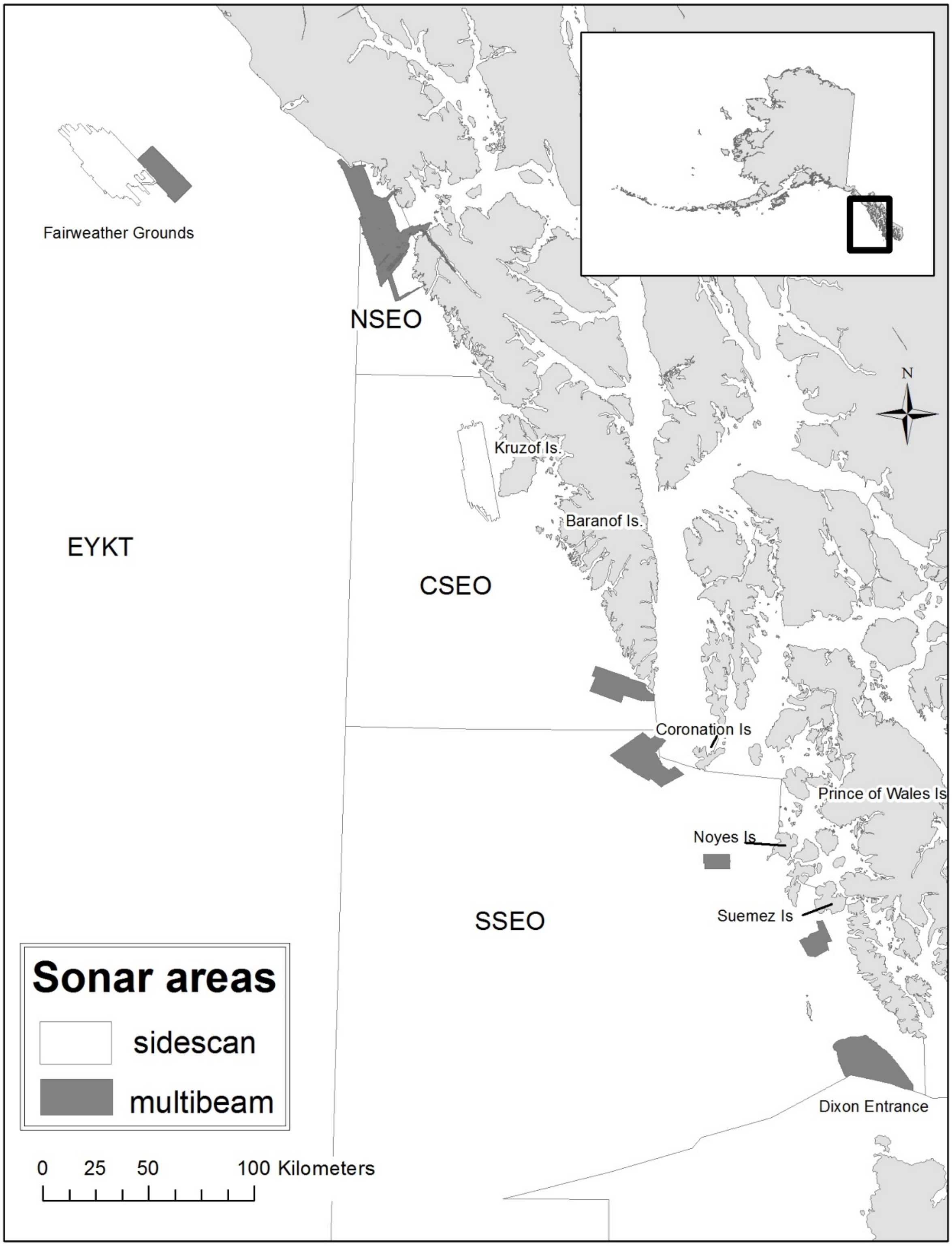

Figure 14.11.–Sonar surveys performed in southeast Alaska used to delineate yelloweye rockfish habitat.

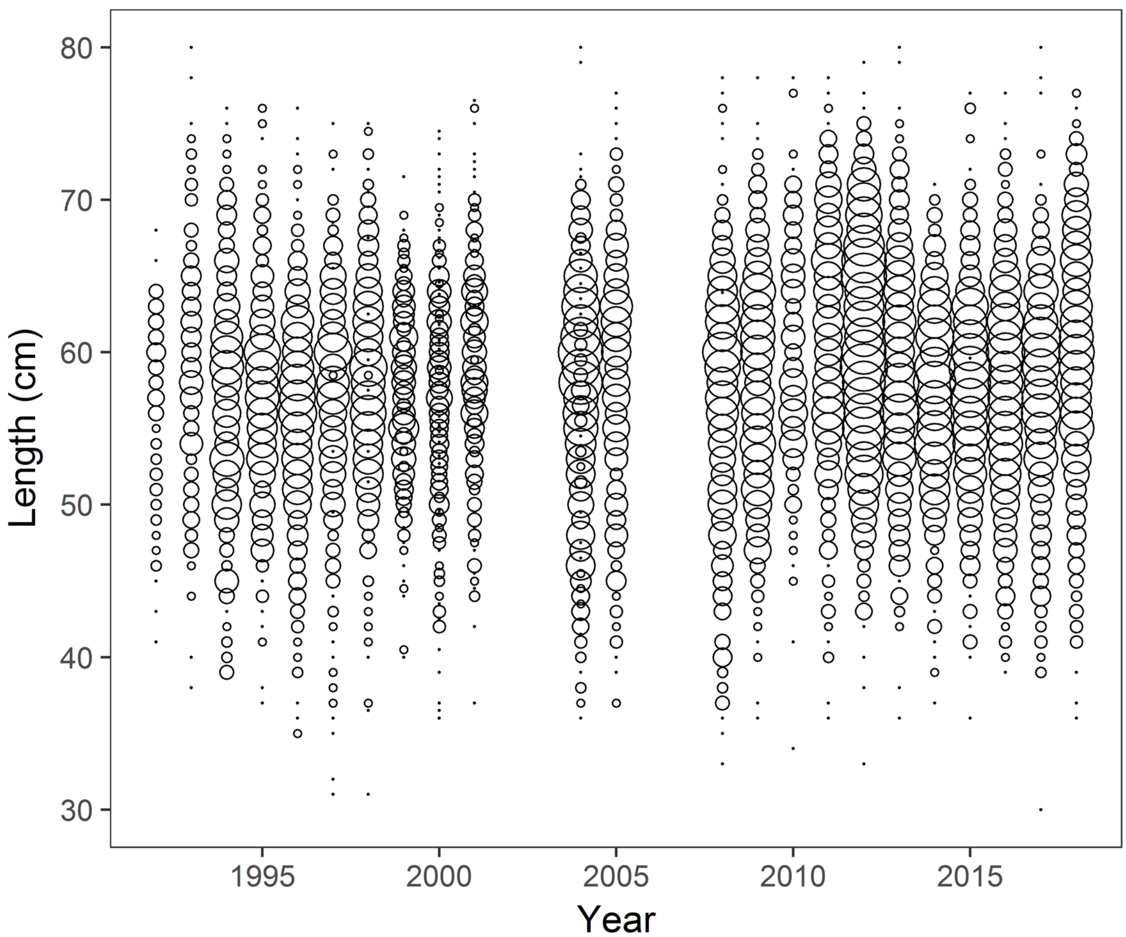

Figure 14.12.–1992–2018 yelloweye rockfish length compositions sampled in the East Yakutat management area (EYKT) from direct and incidental catch.

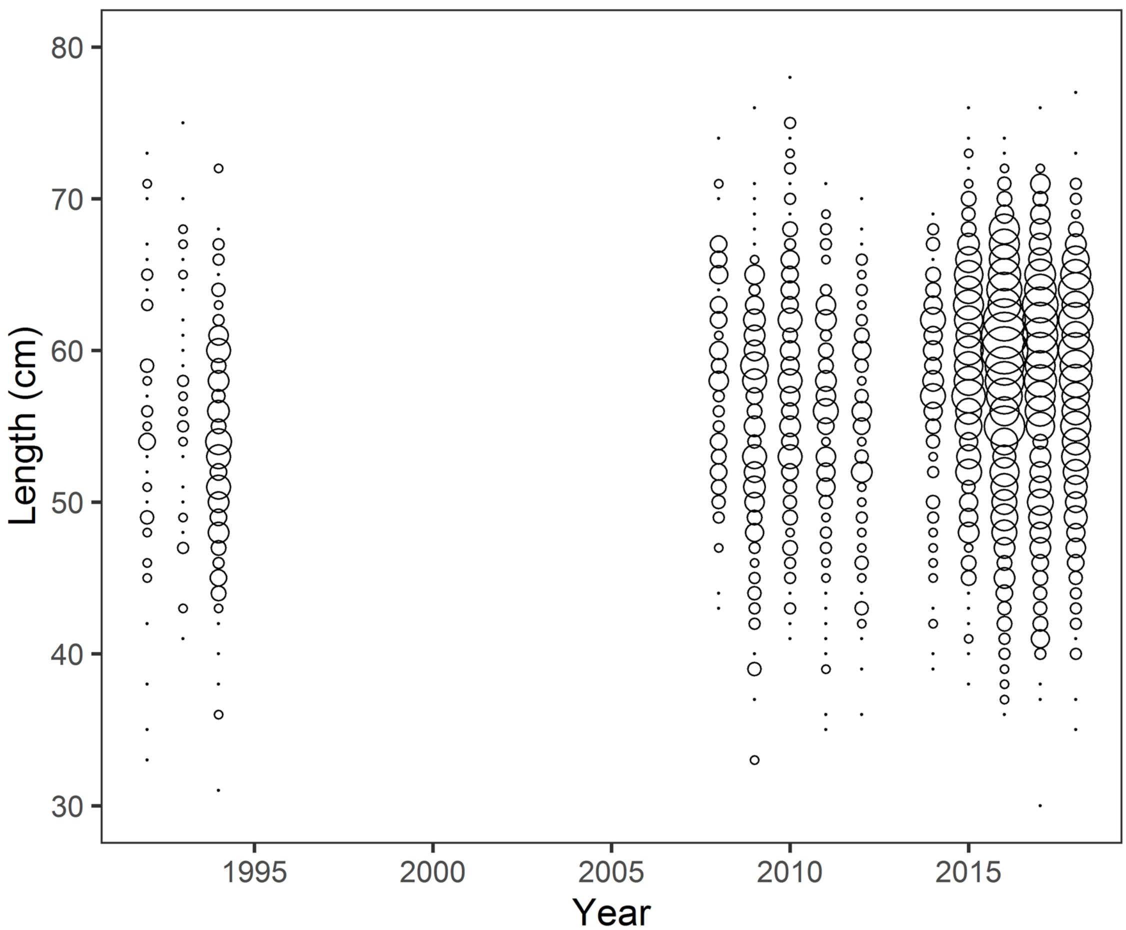

Figure 14.13.–1992–2018 yelloweye rockfish length compositions sampled in the Northern Southeast Outside management area (NSEO) from direct and incidental catch.

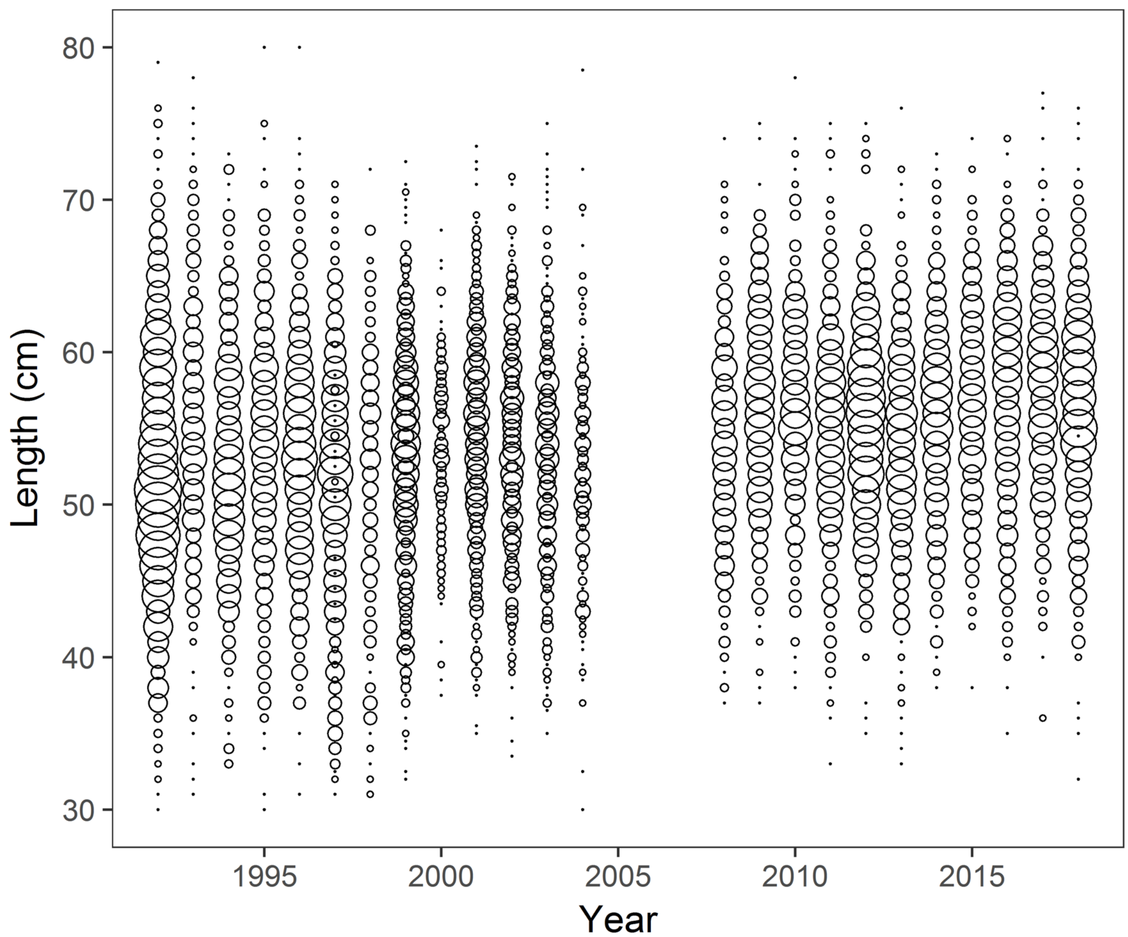

Figure 14.14.–1992–2018 yelloweye rockfish length compositions sampled in the Central Southeast Outside management area (CSEO) from direct and incidental catch.

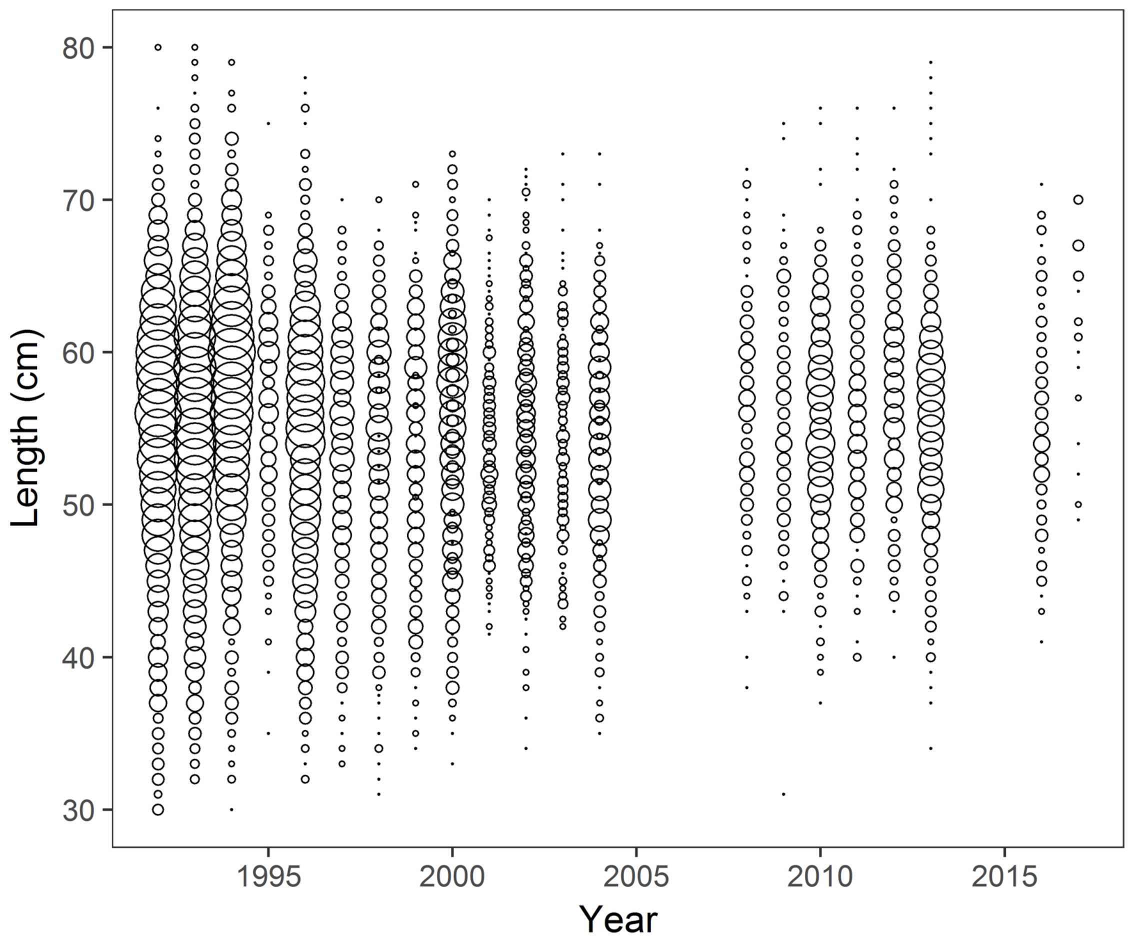

Figure 14.15.–1992–2018 yelloweye rockfish length compositions sampled in the Southern Southeast Outside management area (SSEO) from direct and incidental catch.

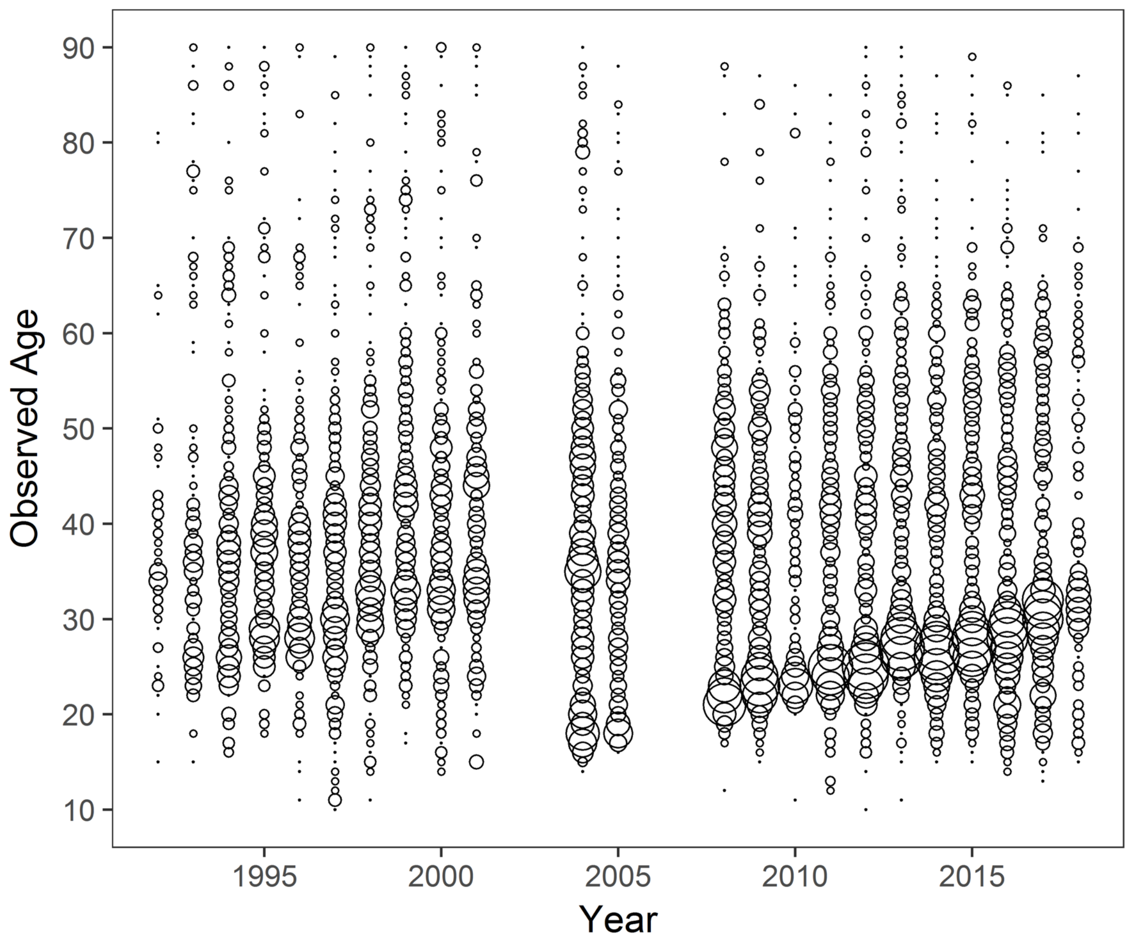

Figure 14.16.–1992–2018 yelloweye rockfish age compositions sampled in the East Yakutat management area (EYKT) from direct and incidental catch.

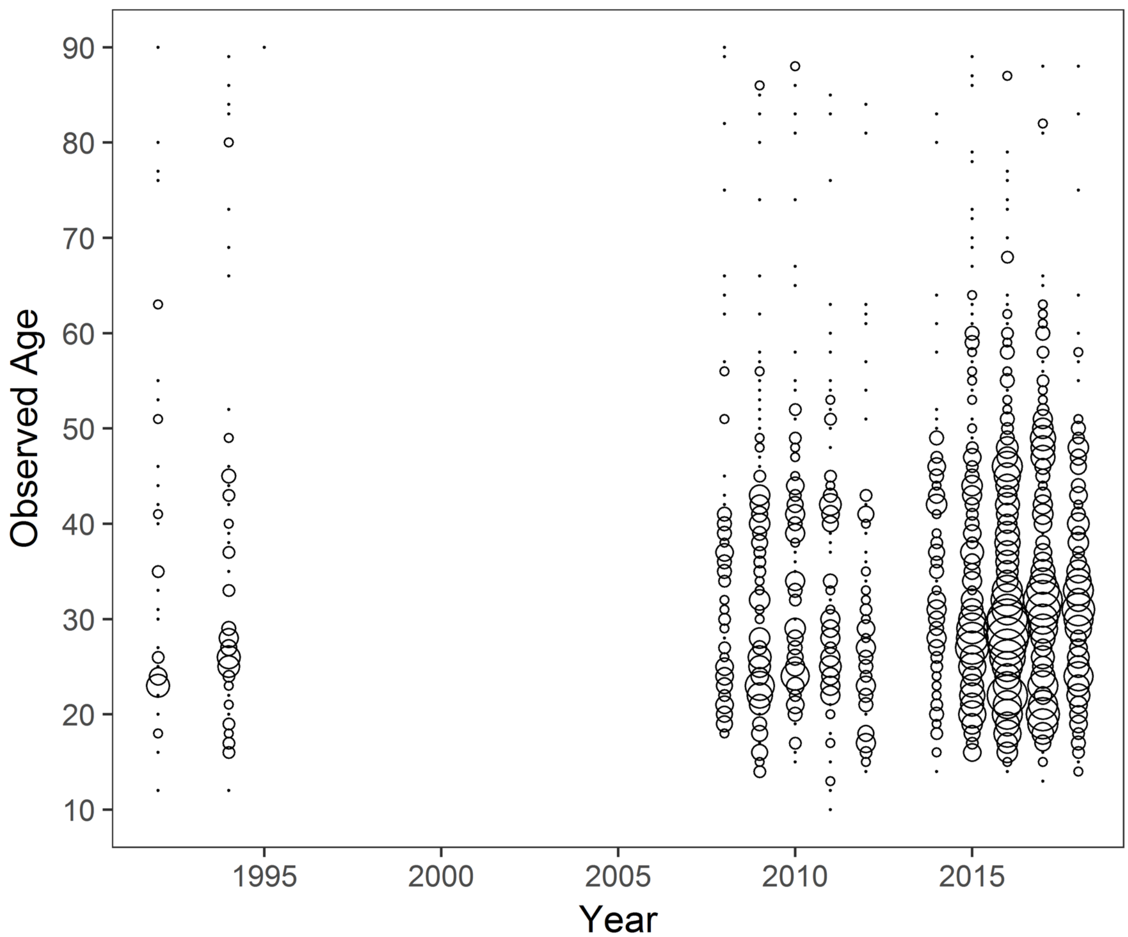

Figure 14.17.–1992–2018 yelloweye rockfish age compositions sampled in the Northern Southeast Outside management area (NSEO) from direct and incidental catch.

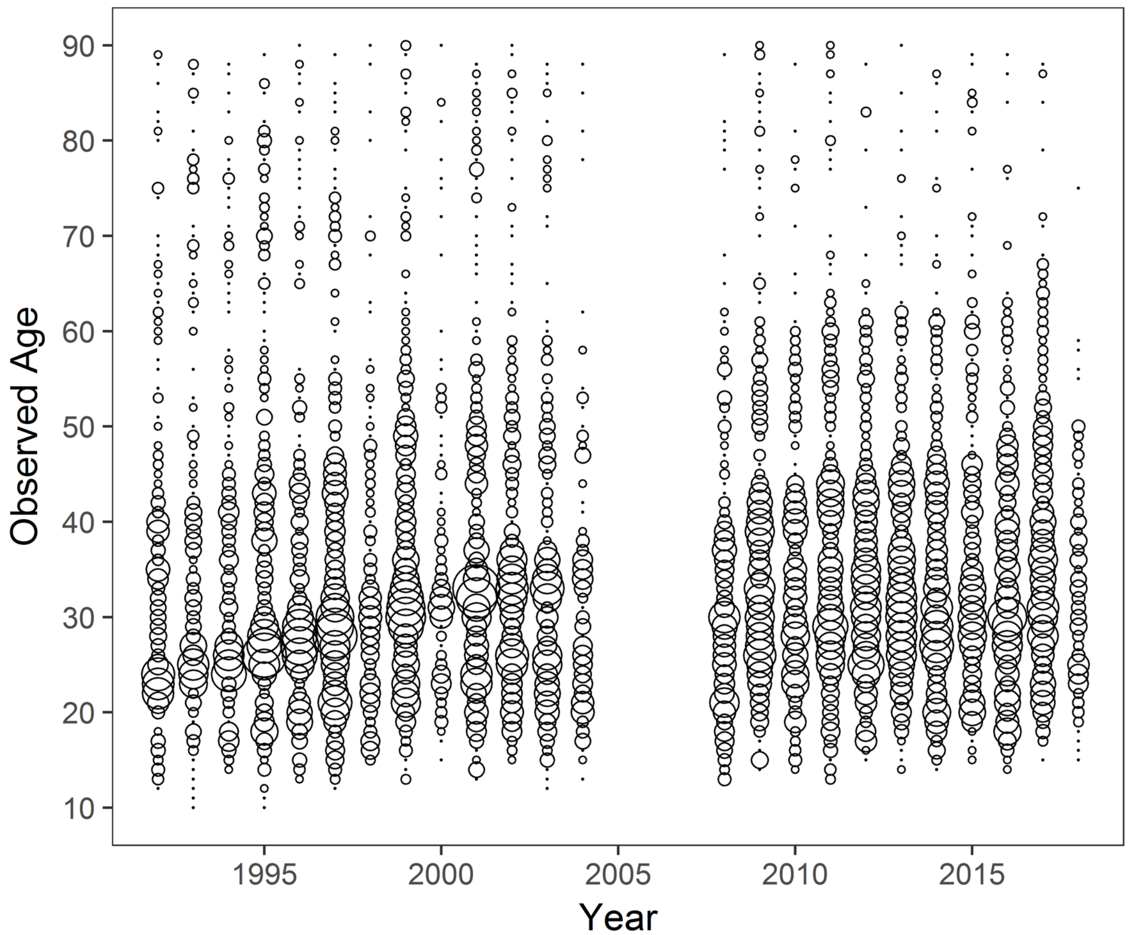

Figure 14.18.–1992–2018 yelloweye rockfish age compositions sampled in the Central Southeast Outside management area (CSEO) from direct and incidental catch.

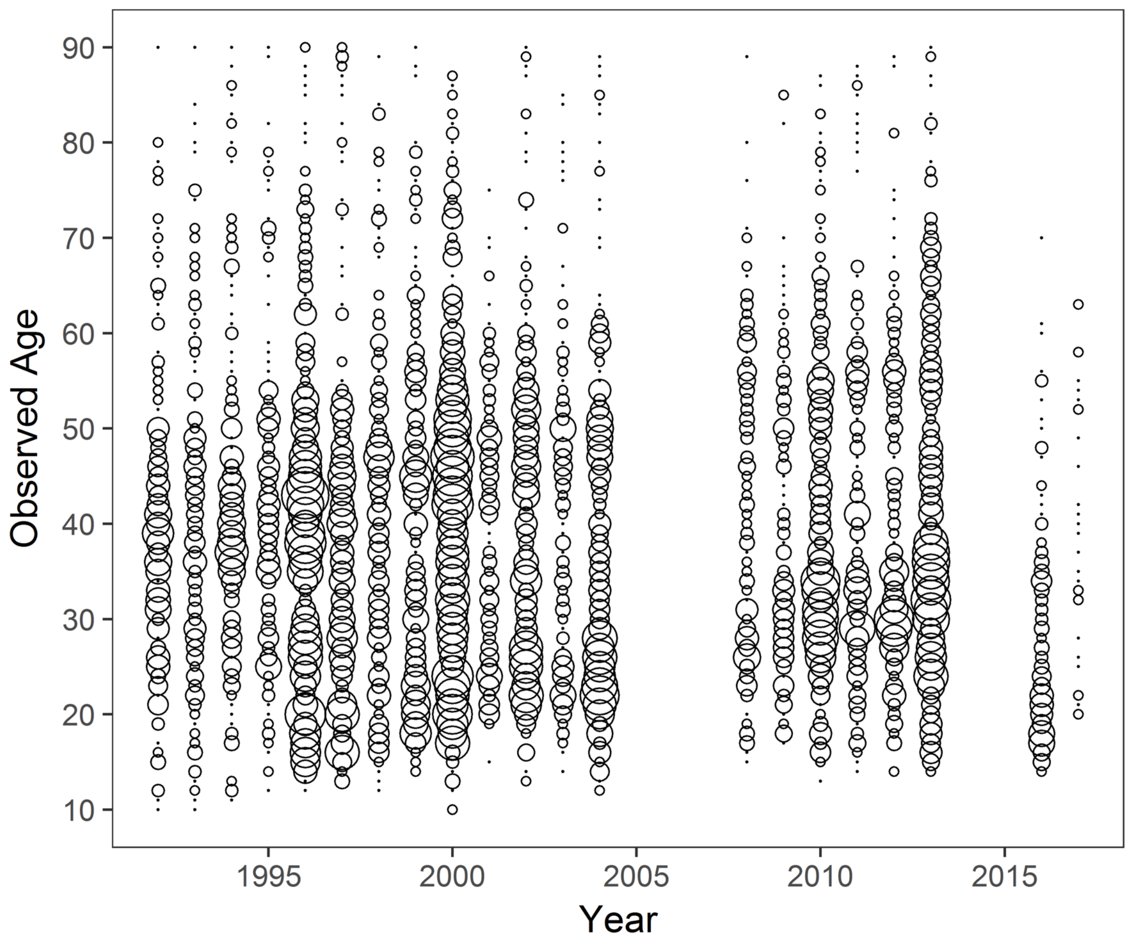

Figure 14.19.–1992–2018 yelloweye rockfish age compositions sampled in the Southern Southeast Outside management area (SSEO) from direct and incidental catch.

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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	Marine reserves recommended to BOF by ADF&G – rejected 600 t Guideline harvest limit for 10 species of DSR in CSEO directed fishery 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 imposes TAC of 470 t (catch history average) Industry working group 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	Directed permit card required for CSEO, SSEO, NSEO, NPFMC TAC of 470 t
1991	NPFMC TAC of 425 t. Change in assemblage to 8 species (removed silvergrey, bocaccio, redstripe added redbanded). Craig and Klawock closures implemented
1992	East Yakutat area included in SEO (NPFMC extends ADF&G mgt authority to 140^0) NPFMC TAC of 550 t. Directed fishery permit card required in EYKT. Submersible line transect data used to set ABC in EYKT
1993	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) NPFMC TAC of 800, yelloweye line transect data used to set TAC NPFMC institutes a separate halibut prohibited species cap (PSC) for DSR
1994	Trip limits reduced to 6,000 in SE and 12,000 lb trip limit implemented in EYKT NPFMC TAC 960 t line transect yelloweye plus 12% for other species. 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.
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 460 t, directed fishery reopened in EYKT, no directed fishery in NSEO.
2005	NPFMC Final rule to require full retention for all DSR landed incidentally in the commercial halibut fishery for federal waters.
2006	DSR TAC is allocated as follows: 84% to the commercial fishery, 16% to the sport fishery. SEO DSR restricted to winter fishery only and must close before the start of the halibut fishery. All directed fisheries closed.
2007	All directed fisheries closed.
2008	SSEO and EYKT directed fisheries opened. CSEO and NSEO closed.
2009	Subsistence catch to be deducted from the ABC before allocation of the TAC to the commercial and sport fish sectors. SSEO and EYKT directed fisheries opened. CSEO and NSEO closed.
2010	SSEO and EYKT directed fisheries opened. CSEO and NSEO closed.
2011	SSEO and EYKT directed fisheries opened. CSEO and NSEO closed.
2012	Rockfish release devices required on sport fish charter vessels. SSEO, CSEO and EYKT directed fisheries opened. NSEO closed.
2013	SSEO, CSEO and EYKT directed fisheries opened. NSEO closed.
2014	EYKT directed fishery opened. SSEO, CSEO, and NSEO remain closed.
2015	EYKT directed fishery opened. SSEO, CSEO, and NSEO remain closed.
2016	EYKT directed fishery opened. SSEO, CSEO, and NSEO remain closed.
2017	EYKT directed fishery opened. SSEO, CSEO, and NSEO remain closed.
2018	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 sport fish vessels in Southeast Alaska in 2020.