DEMERSAL SHELF ROCKFISH

STOCK ASSESSMENT

FOR 2003

by

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Regional Information Report[1] No. 1J02-44

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

December 2002

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ACKNOWLEDGEMENTS

The authors would like to thank Mike Vaughn, Kamala Carroll, Deidra Holum, Beverly Richardson, and Sue Domenowske for port sampling and data entry support. This work is supported under NOAA Grants NA16FN1273 and NA77FM0209.

DEMERSAL SHELF ROCKFISH STOCK ASSESSMENT FOR 2003

Executive Summary

Relative to the December 2001 Stock Assessment and Fishery Evaluation report (SAFE), the following substantive changes have been made:

Input Data

Yelloweye average weight and standard error data were updated using 2001 port samples. Estimates of yelloweye habitat were updated and the protocol for selecting areas described. New age data from the 2001 fishery are included and estimates of Z are calculated using catch curve analysis.

Assessment Results

The exploitable biomass estimate for yelloweye rockfish for 2003 is 17,510 mt. This is a 10% increase over the 2002 estimate due to change in the estimate of yelloweye habitat.

Scientific and Statistical Committee Concerns Regarding Consistency in Allowable Biological Catch Recommendations

The SSC concurred with the authors and Plan Team recommendation to use the sum of the individual management area TACs for establishing the Eastern Gulf TAC for DSR instead of the overall estimate. They requested that the authors compare the estimate of natural mortality for Southeast Alaska with other published natural mortality rates. This is addressed under the Natural Mortality section of this report.

ABC and Overfishing Levels

The ABC for Demersal Shelf Rockfish (DSR) is set using Tier IV definitions with F=M=0.02 and adjusting for the 10% of other species landed in the assemblage. The ABC was set at 390 mt. The overfishing level was set using $F_{35\%}$=0.0279= 540 mt.

INTRODUCTION

Rockfishes of the genus *Sebastes* are found in temperate waters of the continental shelf off North America. At least thirty-two species of *Sebastes* occur in the Gulf of Alaska (GOA). In 1988, the North Pacific Fisheries Management Council (NPFMC) divided the rockfish complex into three components for management purposes in the eastern Gulf: Demersal Shelf Rockfish (DSR), Pelagic Shelf Rockfish, and Slope Rockfish. These assemblages were based on species distribution and habitat, as well as commercial catch composition data. The species composition within each assemblage has changed over time as new information becomes available. The DSR assemblage is now comprised of the seven species of nearshore, bottom-dwelling rockfishes listed in Table 1. These fishes all occur on the continental shelf, reside on or near bottom, and are generally associated with rugged, rocky habitat. For purposes of this report, emphasis is placed on yelloweye rockfish *Sebastes ruberrimus*, as it is the dominant species in the DSR fishery.

All DSR are considered highly K selective, exhibiting slow growth and extreme longevity (Adams 1980, Gunderson 1980, Archibald et al. 1981). Estimates of natural mortality are very low. These types of fishes 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 1999).

DSR are classified as ovoviviparous although some species of *Sebastes* are viviparous (Boehlert and Yoklavich 1984, Boehlert et al. 1986, Yoklavich and Boehlert 1995). Rockfishes have internal fertilization with several months separating copulation, fertilization, and parturition. Within this species complex parturition occurs from February through September with the majority of species extruding larvae in late winter and spring. Yelloweye rockfish extrude larvae over an extended time period, with the peak period of parturition occurring in April and May (O'Connell 1987). Although some species of *Sebastes* have been reported to spawn more than once per year in other areas (Love et al. 1990), no incidence of multiple brooding has been noted in Southeast Alaska (O'Connell 1987).

Rockfishes have a closed swim bladder that makes them susceptible to embolism mortality when brought to the surface from depth. Therefore all DSR caught, including discarded bycatch in other fisheries, are usually fatally injured and should be counted against the TAC.

Prior to 1992, DSR was recognized as a Fishery Management Plan (FMP) assemblage only in the waters east of 137^{o} W. longitude. In 1992 DSR was recognized in the East Yakutat Section (EYKT) and management of DSR extended westward to 140^{o} W. longitude. This area is referred to as the Southeast Outside (SEO) Subdistrict and is comprised of four management sections: East Yakutat (EYKT), Northern Southeast Outside (NSEO), Central Southeast Outside (CSEO), and Southern Southeast Outside (SSEO). In SEO, DSR are managed jointly by the State of Alaska and the National Marine Fisheries Service. The two internal state water subdistricts, NSEI and SSEI, are managed entirely by ADF&G and are not included in this stock assessment (Figure 1).

FISHERY

Description of Fishery

The directed fishery for DSR began in 1979 as a small, shore-based hook and line fishery in Southeast Alaska. This fishery targeted on the nearshore, bottom-dwelling component of the rockfish complex, with fishing occurring primarily inside the 110 m contour. The early directed fishery targeted the entire DSR complex. The current fishery targets yelloweye rockfish, and fishes primarily between the 200 m and the 90 m contours. Yelloweye rockfish accounted for an average of 90% (by weight) of the total DSR catch over the past five years. Quillback rockfish accounted for 8% of the landed catch. 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 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.

The directed fishery is managed with seasonal allocations: 67 percent of the directed fishery quota is allocated between January 1 and March 15 and 33 percent is allocated between November 16 and December 31. A winter fishery was requested by the directed fleet as the exvessel price is highest at that time. The directed season is closed during the halibut IFQ season to prevent over-harvest of DSR. Directed fishery quotas are set by management area and are based on the remaining ABC after subtracting the estimated DSR bycatch (landed and discard) in other fisheries.

Bycatch and Discards

DSR have been taken as bycatch in domestic longline fisheries, particularly the halibut fishery, since the turn of the century. Some bycatch was also landed by foreign longline and trawl vessels targeting on slope rockfish in the eastern Gulf from the late 1960s through the mid-1970s. DSR mortality during the halibut longline fishery continues to account for a significant portion of the total allowable catch (TAC). In 2002, reported DSR bycatch in the halibut fishery accounted for over 40% of the total reported DSR landings in the SEO subdistrict.

The allowable bycatch limit of DSR during halibut fishing is 10% of the halibut weight. Current federal regulations prevent fishermen from bringing in DSR above the bycatch limit of 10% of the target species (round pounds). In 1998 the NPFMC passed an amendment to require full retention of DSR. This amendment would require fishermen to retain all DSR caught, forfeiting without penalty the amount above the directed fishing standard. This amendment is still under review at the Regional Office. In July of 2000 the State of Alaska enacted a regulation requiring all 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 fishery fund. The amount of yelloweye landed has significantly increased with this management action: in 2001 49,344 pounds of yelloweye were forfeited in southeast

Alaska compared to 13,767 in 2000. Of this 49,344 pounds, 8,944 pounds were retained for personal use by the permit holder.

Landed bycatch does not reflect the true mortality of bycatch as most rockfish suffer embolism mortality when caught and do not generally survive when released. Only a portion of bycatch is landed and reported on fishtickets. There is an inherent problem in estimating a rate of bycatch for DSR. DSR are habitat specific, and although their distribution overlaps with halibut, the distributions are not correlated. IPHC longline survey data indicates that bycatch of DSR is highly variable both inter-annually and within year, by area. There is no linear relationship between the catch of halibut and the catch of DSR (Figure 2). Until full retention of DSR is implemented in federal waters it will be difficult to discern whether the TAC has been met or exceeded.

The IPHC has provided us with data from recent longline surveys. Bycatch is estimated based on sampling the first 20 hooks of each skate of gear. There are obviously some problems in estimating total bycatch using this sampling approach. DSR tend to be contagiously distributed because they are habitat specific in their distribution. The 2001 IPHC survey bycatch of DSR, expressed as the percent of DSR weight to halibut weight (for legal sized halibut) ranged from 0% to well over 100%, with area estimate means ranging from 3% in EYKT (removing Fairweather stations) to 23% on Fairweather Ground. The overall rate ranged from 3% in EYKT and 16% in Fairweather Ground (Figure 3). The 2002 IPHC survey bycatch of DSR was lower, ranging from zero percent to 98% on individual sets, with area estimate means ranging from 1% in EYKT (removing Fairweather Stations) to 10% in CSEO (Figure 4).

Estimated total mortality of DSR in the halibut fishery has ranged between 130 mt to 355 mt annually. Before the implementation of the IFQ fishery, we estimated unreported mortality of DSR during the halibut fishery based on International Pacific Halibut Commission (IPHC) interview data. For example, the 1993 interview data indicates a total mortality of DSR of 13% of the June halibut landings (by weight) and 18% of the September halibut landings. This data has been more difficult to collect under the halibut IFQ fishery and appears to be less reliable than previous data. In recent years we have used IPHC catch statistics to determine the percent of the halibut catch taken in each of the four DSR management areas in the Southeast Outside district. In 2002 halibut bycatch mortality of DSR in the SEO was estimated at 250 mt and 138 mt have been landed as of October 10, 2002. Based on the 2001 landing data, it is estimated that approximately 47% of the 2C (IPHC Regulatory Area) halibut quota and 11% of the 3A halibut quota are taken in SEO (IPHC web page). Total bycatch mortality of DSR in the halibut fishery is estimated using a 10% bycatch mortality for DSR in 2C and IPHC statistical area 190 (Fairweather Ground) and a 7% bycatch mortality in the remaining portions of 3A east of 140^{o} . Based on the 2002 halibut quotas and the distribution of harvest in 2002, the estimated total DSR mortality for the 2003 SEO halibut fishery is anticipated to be 236 mt. There is some indication in the yelloweye biological data that we may be underestimating bycatch mortality, and consequently harvesting at a higher rate than intended.

Catch History

The history of domestic landings of DSR from SEO are shown in Table 2. The directed DSR catch in SEO increased from 106 mt in 1982 to a peak of 803 mt in 1987. Total landings exceeded 900 mt in 1993. Directed fishery landings have often been constrained by other fishery management actions. In 1992 the directed DSR fishery was allotted a separate halibut PSC and is therefore no longer effected when the

PSC is met for other longline fisheries in the GOA. In 1993 the fall directed fishery was cancelled due to an unanticipated increase in DSR bycatch during the fall halibut fishery.

Directed fishery landings from SEO totaled 172 mt in 2001, bycatch landings totaled 147 mt, 138 of which were landed in the halibut fishery.

DATA

Fishery Data

In addition to catch data listed in Table 2, catch per unit effort data is collected through a mandatory logbook program and biological information is collected through port sampling of the commercial catch. Species composition and length, weight, sex, and stage-of-maturity data are recorded and otoliths taken for aging. Yelloweye rockfish is the primary target of the directed fishery and accounted for 92%, by weight, of all DSR landed in the directed fishery during 2001. The following biological information is reported for yelloweye rockfish only.

Commercial fishery catch per unit effort (CPUE), expressed as round pounds of yelloweye rockfish per hook, shows an increase between 2000 and 2001 in EYKT and CSEO and a decrease in SSEO (Figure 6). Overall CPUE is generally higher for snap-on gear (Figure 5) than for conventional longline gear (Figure 6).

Mortality Estimates

An estimate of Z=0.0174 (± 0.0053) from a 1984 "lightly-exploited" stock in SSEO is used to estimate M=0.02 (Table 3). There is a distinct decline in the log frequency of fish after age 95. This may be due to increased natural mortality in the older ages, perhaps senescence. The M=0.02 is based on a catch curve analysis of age data grouped into two-year intervals (to avoid zero counts) between the ages of 36 and 96. This number is similar to the estimate of Z from a small sample from CSEO in 1981 and to the 0.0196 estimated for a lightly exploited stock of yelloweye on Bowie Seamount (Lynne Yamanaka, personal communication). Hoenig's geometric mean method for calculating Z yields estimates of 0.033 when using his fish parameters, and 0.038 when using his combined parameters, and a maximum age of 121 years (Hoenig 1983). Wallace (2001) set natural mortality equal to 0.04 in his stock assessment of west coast yelloweye. For the Northern California and Oregon data the model performed better when M was set constant until 50% maturity then increased linearly until age 70 (Wallace 2001).

Catch curve analysis of recent age data was run for each management area in SEO. The port sampling data from 2000–2002 were used and a line fit to the data between the majority of the ages (approximately 20–60 years). The estimate of Z is 0.03 for SSEO, 0.04 for EYKT, and 0.056 for CSEO (Table 3). Catch curves are problematic for fish with variable recruitment however these estimates would indicate that we may be exceeding our harvest policy of two percent in the CSEO area.

Growth Parameters

Von Bertalanffy growth parameters and length weight parameters for yelloweye are listed in Table 4. These parameters were calculated using 2000 to 2002 port sample data. Males attain a larger maximum size than females and there appears to be a slight trend in the data for increasing growth with increasing latitude (Table 4). Estimated length and age at 50% maturity for yelloweye collected in CSEO are 42 cm and 22 years for females and 43 cm and 18 years for males (Table 5). Rosenthal et al. (1982) estimated length at 50% sexual maturity for yelloweye from this area to be 52 cm for females and 57 cm for males.

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 is not a tight relationship between growth-zone-derived ages and radiometric ages, Andrews et al. conclude support for age that exceeds 100 years from their observation that as aged derived from growth zones approached and exceeded 100 years, the sample ratios measured approached equilibrium. 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.

Age frequency data from the commercial catch differs somewhat by management area (Figures 7a-f). In EYAK the 2001 age distribution is somewhat bimodal, the largest mode between 32 and 34 years, with a second, smaller mode at 44–45 years. Mean age of the 2001 samples is 42 years. There appears to be some recruitment in the 15- and 22-year age classes. Maximum age in EYKT was 110 years. In CSEO, the area with the longest catch history, a bimodal pattern has been present in the age distribution since 1992 and the older ages have declined in frequency over time. Maximum age for CSEO in 2001 is 110 and the average age is 36. There is a strong mode in the early thirties with the 32- and 33-year olds account for 18% of the sample. There is a second, smaller mode at 23–24 years. There is no sign of an incoming recruitment in these data and very few fish represented in the 60–70 year classes. In SSEO the 2001 age data has a bimodal distribution with a strong mode at 23 and a smaller mode at 44–45 years. Maximum age is 101 with very few fish older than 70, and an average age of 40 years. Year classes are more evenly distributed than in other areas, particularly between 17 and 60 years and there is some recruitment in the 18–20 year classes.

Survey Data

Traditional abundance estimation methods (e.g., area-swept trawl surveys, mark recapture) are not considered useful for these fishes given their distribution, life history, and physiology. ADF&G uses direct observation to collect density estimates and is continuing research to develop and improve a stock assessment approach for these fishes. As part of that research, a manned submersible, *Delta*, has been used to conduct line transects to estimate rockfish density (Buckland et al. 1993, Burnham et al. 1980). We have surveyed the Fairweather Ground in the EYKT section in 1990, 1994, 1995, 1997, and 1999; the CSEO section during 1990, 1994, 1995, and 1997; the NSEO section in 1994 and 2001; and the SSEO section in 1994 and 1999. A total of 452 line transects have been run since 1989 (Figure 8). Although line transect data is collected for four of the eight DSR species (yelloweye, quillback, tiger, rosethorn), and for juvenile as well as adult yelloweye, included here are density estimates for adult yelloweye rockfish only.

Density estimates are limited to adult yelloweye because it is the principal species targeted and caught in the fishery, and our ABC recommendations for the entire assemblage are keyed to adult yelloweye abundance. 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. Variance estimates can be calculated for the density and weight parameters but not for area. This is an in-situ method for stock assessment and we have made some changes in techniques each year in an attempt to improve the survey. Estimation of both line length for the transects and total area of rocky habitat are difficult and result in some uncertainty in the biomass estimates.

In a typical submersible dive, two transects were run per dive with each transect lasting 30 minutes. During each transect, the submersible's pilot attempted to maintain a constant speed of 0.5 kn and to remain within 1 m of the bottom, terrain permitting. A predetermined compass heading was used to orient each transect line.

The usual procedure for 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. Horizontal visibility was usually good, 5–15 m. All fish observed from the starboard port were individually counted and their perpendicular distance from the transect recorded (Buckland 1985). 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 "guard" the transect line promoting 100% detectability of yelloweye on the transect line, a critical assumption when employing line transects. The forward camera also enabled counts of fish that avoided the sub as the sub approached. Yelloweye rockfish have distinct coloration differences between juveniles and adults, so observations of the two were recorded separately.

A PISCES[2] data logger overlaid depth of the submersible and its distance from the bottom, time of day, and temperature onto the videotape at 1 second intervals. In addition to the video system, we used a Photosea 35-mm camera with strobe to photograph habitat and fish.

Hand-held sonar guns were used to calibrate observer estimates of perpendicular distances. It was not practical, and can be deleterious to accurate counts and distance estimates to make a sonar gun confirmation to every fish. We therefore calibrated observer distance estimates using the sonar gun at the beginning of each dive prior to running the transect. The sonar gun was also used during the transect when necessary to reconfirm distances. To verify the accuracy of this method, we confirmed sonar readings by positioning a scuba diver at intervals along a marked transect line.

Beginning in 1997, we positioned the support ship directly over the submersible at five-minute time intervals and used the corresponding Differential Global Positioning (DGPS) fixes to determine line length.

[2] Product names used in this publication are included for scientific completeness but do not constitute product endorsement.

ANALYTIC APPROACH

For each area yelloweye density was estimated as:

$$\hat{D}_{YE} = \frac{nf(0)}{L}, \qquad (1)$$

where:

n = total number yelloweye rockfish adults observed,
f (0) = probability density function of distance from a transect line, evaluated at zero distance,
L = total line length in meters.

A line transect estimator (Buckland et al. 1993) was calculated and the best fit model selected from several detection functions using Version 3.5 Release 6 of the software program DISTANCE (Laake et al. 1998, Thomas et al. 1999) (Appendix 1). A principal function of the DISTANCE software is to estimate f(0). The program can either be run with default and best fit settings or can be used with set sighting intervals and truncation of a portion of the right limb of the sighting data. Estimated probability detection functions (pdf) generally exhibited the "shoulder" (i.e., an inflection and asymptote in the pdf for perpendicular distances near 0) that Burnham et al. (1980) advocate as a desirable attribute of the pdf for estimation of f(0). Final models for the stock assessment were picked, by area, based on goodness of fit of model to data (judged by visual examination of plot and X^2 goodness of fit test (Appendix 1)). The sample size for the 2001 survey data is quite small (six transects, 30 yelloweye) and there is substantial variance around this estimate. Sample size, number of yelloweye observed, and meters surveyed is shown by area and year in Table 6.

For the 1993 SAFE (based on 1990 and 1991 data), to estimate the variance in biomass, we assumed a Poisson distribution for the sample size, n. The variance of n provides one component of the overall variance estimate of density. We used this approach because of the relatively small number of transects conducted in 1990 and 1991. Beginning in 1994 we substantially increased the numbers of transects conducted and now use an actual empirical estimate of the variance of n (see p. 88, Buckland et al. 1993).

Total yelloweye rockfish biomass is estimated for each management subdistrict as the product of density, mean weight, and areal estimates of DSR habitat (O'Connell and Carlile, 1993). For estimating variability in yelloweye biomass, we used log-based confidence limits because the distribution of density tends to be positively skewed and we assume density is log-normally distributed (Buckland et al. 1993).

In 1997, biomass was estimated for the EYKT area by separating the Fairweather and non-Fairweather areas of EYKT. Biomass was then calculated for the Fairweather section using the Fairweather density and weight data and added to the non-Fairweather biomass estimate which had been estimated using data from CSEO. This was done because the Fairweather area had exceedingly high density estimates, not typical of surrounding areas. However, in 1999, given the decline in density in the Fairweather area and the large reduction in estimated area of rock habitat in non-Fairweather portions of EYKT, we used Fairweather data for the entire EYKT area.

2002 Density Estimates

There were no density surveys conducted during 2002 therefore density for this stock assessment is based on the last best estimate. Density estimates range from 1,420 to 2,534 adult yelloweye per km^2 (Table 7). The EYKT and SSEO areas were last surveyed in 1999, CSEO was surveyed in 1997, and NSEO was surveyed in 2001. We intend to conduct line transects in CSEO area in June 2002.

Habitat

Area estimates of yelloweye habitat are based on the known distribution of rocky habitat inshore of 110 fathoms. Information used to identify these areas include NOS data, sidescan and multibeam data, direct observation from the submersible, and commercial logbook data from the directed DSR fishery. For this assessment we revised estimates of area of yelloweye habitat using the following protocol: In areas with multibeam and/or sidescan sonar data area of yelloweye habitat is delineated based on defined habitat types within the mapped area. For areas without these data sets we use the position data from 1993–2000 commercial logbooks, buffered to 0.05 mi from the start position. Longline sets must have at least a 0.04 yelloweye/hook catch rate to be included in the data. Prior to this assessment the commercial logbook data was not buffered and our estimate of yelloweye habitat was based on hand-drawing polygons encompassing set start locations as well as NOS habitat data. This change in protocol has resulted in changes in the area of rock habitat (Table 8). Habitat estimates increased for the EYKT, NSEO, and CSEO areas and decreased for the SSEO area. Because these data are based on confidential logbook information, charts are not available.

Sidescan Sonar

In 1996 we conducted a side-scan sonar/bathymetric survey for a 536 km^2 area in the CSEO section. The National Ocean Services (NOS) data from the area covered by the sidescan indicated that 216 km^2 of this area was rocky. Interpretation of the sidescan data, combined with direct observation from the submersible to groundtruth the interpretation, reveals that in fact, approximately 304 km^2 of the seafloor is rocky in this area, a 29% increase over the previous estimate (Figure 9).

Area estimates for the Fairweather portion of the East Yakutat Subdistrict were redefined during the 1997 survey. The support ship transected the bank in several sections using a paper-recording fathometer to determine gross bottom type. The “Delta” submersible was then used to groundtruth habitat characterization in several areas. Based on this survey the estimate of total area of rocky habitat on the Fairweather Ground was reduced from 1,132 km^2 to 448 km^2 (Figure 10). Because of this great discrepancy, we conducted a sidescan sonar survey on the Fairweather Ground in August of 1998. The area surveyed was 780 km^2 of seafloor, primarily on the western bank of Fairweather. In the area sidescanned, 403 km^2 was rocky.

Multibeam Sonar

In 2001 we conducted a multibeam survey for two areas in Southeast: a portion of CSEO off of Larch Bay and a portion of SSEO off of Hazy Islands (Figure 11). National Marine Fisheries Service Auke Bay Lab surveyed an adjacent area offshore of the Larch Bay site. Of the 293.7 km^2 surveyed offshore of Larch Bay, 112 km^2 were identified as yelloweye habitat based on interpretation of the multibeam data. A total of 385 km^2 were surveyed off Hazy Island, 105.5 km^2 of which was identified as yelloweye habitat.

Area Estimates

The estimates of yelloweye habitat are highly subjective. Although a defined protocol allows for a standard interpretation there is no way to estimate variance of this data. A comparison of fishing data with the habitat interpretation from multibeam is illustrative of the problem. In the Larch Bay multibeam site we had previously estimated the amount of yelloweye habitat to be 44.1 km^2 (Figure 12). The habitat interpretation yielded 112 km^2 of yelloweye habitat. However, placement of the commercial fishing data (start locations from 1993–2000) buffered to 0.05 mi, with set CPUE at least 0.04 fish/hook) yields an estimate of 65.6 km^2. This is a 41% difference in area. It appears from the fishing data that there is some difference in habitat within one of our habitat categories that is not resolvable from the multibeam data. We intend to survey these habitats during our submersible work to groundtruth the habitat interpretation.

In the Hazy Island multibeam area the differences were less severe (22%). In this area we had previously estimated the amount of yelloweye habitat to be 99 km^2. The interpretation of the multibeam data yields 105.5 km^2 of yelloweye habitat. The commercial fishing data yields an estimate of 135.7 km^2 (Figure 13).

Exploitable Biomass Estimates

Estimates of exploitable biomass (adult yelloweye), with associated standard error, by year and area, are listed in Table 7. New information added this year included 2001 average weight data and standard error of the average weight data for all areas, and revised estimates of the area of yelloweye habitat. The total exploitable biomass for 2002 is estimated to be 17,510 mt (based on the sum of the lower 90% confidence limits of biomass estimates from each management area), up 10% over the 2002 estimate.

PROJECTIONS AND HARVEST ALTERNATIVES

ABC Recommendation

Demersal shelf rockfish are particularly vulnerable to overfishing given their longevity, late maturation, and sedentary and habitat-specific residency. We recommend a harvest rate lower than the maximum allowed under Tier 4. By applying F=M=0.02 to this biomass and adjusting for the 10% of other DSR species, the recommended 2001 ABC is 390 mt. This rate is more conservative than would be obtained by using tier 4 under the new definitions for setting ABC, as F_{40}=0.025. Continued conservatism in managing this fishery is warranted given the life history of the species and the uncertainty of the biomass estimates.

Overfishing Definition

The overfishing level for DSR is 540 mt. This was derived by applying a fishing rate of $F_{35\%}$=0.0279 against the biomass estimate for yelloweye rockfish.

HARVEST SCENARIOS TO SATISFY REQUIREMENTS OF NPFMC'S AMENDMENT 56, NEPA, AND MSFCMA

Under tier 4 projections of harvest scenarios for future years is not possible. Yields for 2003 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 $F_{40\%}$. $F_{40\%}$ equals 0.025, corresponding to a yield of 480 mt (including the 10% other DSR).

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 390 mt.

Scenario 3: F equals the 5-year average F from 1995 to 1999. The true past catch is not known for this species assemblage so the 5 year average is estimated at F=0.02 (the proposed F in all 5 years), and the corresponding yield is 390 mt.

Scenario 4: F equals 50% of the maximum permissible F_{ABC} as specified in the ABC/OFL definitions. 50% of $F_{40\%}$ is 0.0125, and the corresponding yield is 240 mt.

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

OTHER CONSIDERATIONS

Although management of this stock has been conservative, the decline in the density estimates in the Fairweather Ground may be an indication that localized overfishing may be occurring. Harvest limits are set by management area based on density and habitat. Our harvest strategy suggests we are taking 2% of the exploitable biomass per year and this level is sustainable. However fishing effort tends to be concentrated in areas of best habitat and high density and it may be that local overfishing occurs. Anecdotal evidence also suggests that prime rockfish habitat in the Fairweather Ground has been fished more heavily by halibut fishermen since the implementation of IFQ. Yelloweye tend to be resident and tag return information would suggest that adult fish stay in the same area over years (O'Connell 1991).

Under the scenario outlined above, although our harvest policy is for a 2% annual rate of exploitation, on the Fairweather Ground the yelloweye occurring in prime habitat may actually be being harvested locally at a rate well in excess of the overfishing level for the population.

This year, for the second time, the directed fishery will be pre-empted by the halibut fishery in the EYKT area. IPHC catch data indicates that 10% of the 3A quota was taken in EYKT. If the 2003 halibut quota for 3A is similar to the 2002 quota, the associated DSR mortality is estimated to be 96 mt which is 94% of the 106 mt ABC for this management area. The Fairweather Ground is a portion of the EYKT section and has supported an important directed fishery for DSR in past years.

Catch curve analysis of age data from CSEO suggests that total mortality is approaching 6% (natural mortality is estimated at 2% annually). Catch curves are problematic for fish with variable recruitment however, catch curves from the SSEO and EYKT areas suggest harvest rate more in line with policy with Z estimated at less than 4%.

The Pacific Fishery Management Council has recently recommended a harvest rate policy of $F_{50\%}$ for rockfishes (Ralston et al. 2000). This recommendation is based largely on work presented by Ralston (1998) and Dorn (2000). The $F_{50\%}$ for yelloweye is F=0.016. This corresponds to an ABC of 300 mt (including 10% for other DSR species). This ABC would preclude a directed fishery for DSR because halibut bycatch is estimated at 276 mt for the 2003 fishery.

SUMMARY

M	0.02
2003 Biomass Estimate	17,510
F_{ofl} ($F_{35\%}$)	0.0279
Max F ($F_{40\%}$)	0.025
F_{abc}	0.020
F ($_{avg\ 94\text{-}98}$)	0.020
F ($_{50\%\ F\ max}$)	0.0125
Overfishing Level Includes 10% for other DSR	540 mt
Recommended ABC Includes 10% for other DSR	390 mt

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Table 1. Species included in the Demersal Shelf Rockfish assemblage.

Common name	Scientific Name
canary rockfish	*Sebastes 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 2. Reported landings of demersal shelf rockfish (mt round weight from domestic fisheries in the Southeast Outside Subdistrict (SEO), 1982–1997.[a]

	Research	Directed Landings		Bycatch Landings		Total	
YEAR	Catch	AREA 65	AREA 68	AREA 65	AREA 68	SEO[b]	ABC[c]
1982		106		14		120	
1983		161		15		176	
1984		543		20		563	
1985		388	7	100	4	499	
1986		449	2	41	2	494	
1987		726	77	47	5	855	
1988		471	44	29	8	552	660
1989		312	44	101	18	475	420
1990		190	17	100	36	379	470
1991		199	187	83	36	889	425
1992		307	57	145	44	503	550
1993	13	246	99	254	18	901	800
1994	4	174	109	128	26	441	960
1995	13	110	67	90	22	282	580
1996	6	248	97	62	23	436	945
1997	13	202	65	62	25	381	945
1998		176	65	83	34	363	560
1999		169	66	74	38	348	560
2000	5	126	57	70	24	282	340
2001	6	122	50	110	37	326	330
2002[b]	1	76	0	111	37	226	350

[a] Landings from ADF&G Southeast Region fishticket database and NMFS weekly catch reports through November 4, 2002.

[b] Estimated unreported DSR mortality associated with halibut fishery not reflected in totals.

[c] No ABC prior to 1987, 1988-1993 ABC for FMP area 65 only.

Table 3. Estimates of instantaneous mortality (Z) of yelloweye rockfish in Southeast Alaska.

AREA	YEAR	SOURCE	Z	n
SSEO	1984	Commercial Longline	.017*	1049
CSEO	1981	Research Jig	.020*	196
CSEO	1988	Research Longline	.042	600
EYKT	2000-2002	Commercial Longline ages 24-62	.04	295
CSEO	2000-2002	Commercial Longline Ages 20-60	0.056	514
SSEO	2000-2002	Commercial Longline (ages 24-67)	0.03	602
SE		Hoenigs equation max age 121 (parameters combined taxa)	0.038	
SE		Hoenig's equation max age 121 (fish parameters)	0.033	

* Z approximately equal to M as there was very little directed fishing pressure in these areas at that time (1981 for CSEO, 1984 for SSEO).

Table 4. Growth parameters (cm and kg) for yelloweye rockfish in Southeast Alaska from 2000-2002 port samples.

		Wt. Vs Length		Von Bertalanffy		
Sex	Area	a	b	L_{inf}	K	t_0
Female	EYKT	0.000008876	3.2113	71.0496	0.0327	-14.8832
	CSEO	0.000012	3.1346	65.8733	0.0342	-14.7556
	SSEO	0.000023	2.9689	67.4639	0.0236	-28.7107
	NSEI	0.000018	3.0248	68.5183	0.0314	-13.5622
	SSEI	0.000017	3.011	68.674	0.0196	-36.7438
Male	EYKT	0.000055	2.7441	72.0703	0.03	-18.9701
	CSEO	0.000037	2.8348	65.9722	0.05	-4.2473
	SSEO	0.000016	3.0397	63.112	0.0573	-4.4311
	NSEI	0.000008792	3.1884	63.3418	0.0367	-17.7907
	SSEI	0.000008189	3.1716	62.3299	0.0727	1.0032
Combined	Outside Areas	0.000014	3.0869	65.9619	0.0369	-13.0505

Table 5. Length and age at 50% sexual maturity for yelloweye rockfish, Southeast Alaska.

	m_8	?	?	Sum(dev.)	50%
Female length	0.98142	1.0813	41.79	0.08441	41.8
Female age	0.97801	0.283363	21.814	1.2330	22.0
Male length	1.004079	0.55547	43.128	0.2227	43.1
Male age	0.9942	0.3645	18.23	0.7134	18.3

Table 6. Sample size (transects), number of yelloweye observed, meters surveyed, and fish/line length for line transect surveys in EYKT, CSEO, SSEO, and NSEO.

Area	Year	# transects (k)	# yelloweye	Meters surveyed	YE/M	Density
EYKT	1997	18	256	17238	.01485	4176
	1999	20	206	25646	.00803	2323
CSEO	1995	24	235	39368	.00597	2929
	1997	32	166	29176	.0057	2534
SSEO	1994	13	99	18991	.005213	1173
	1999	45	288	49663	.00579	1879
NSEO	1994	9	39	9535	.00409	839
	2001	9	30	4474	.006	1420

Table 7. Adult yelloweye rockfish density, weight, habitat, and associated biomass estimates by year and management area.

Year	Mgt Area	Survey Year	Density (adults/km^2)	CV(D)	avg wt (kg.)	Habitat (km^2)	Point Est (mt)	**Biomass L 90% CL (mt)**
2003	EYKT	1999	2323	.3084	4.30	757	7560	4601
	CSEO	1997	2534	.2009	3.14	1414	11250	8093
	NSEO	2001	1420	.3144	2.98	472	1997	1205
	SSEO	1999	1879	.1711	3.47	732	4772	3609
	Total SEO					3375	24762	**17509**
2002	EYKT	1999	2323	.3084	4.04	703	6596	4208
	CSEO	1997	2534	.2009	3.3	1184	9690	6981
	NSEO	2001	1420	.3144	3.76	357	1511	411
	SSEO	1999	1879	.1711	3.48	851	5564	4015
	Total SEO					3095	23362	**15616**
2001	EYKT	1999	2323	0.3084	3.76	703	6645	3737
	CSEO	1997	2534	.2009	3.05	1184	9432	6592
	NSEO	Revised 1994	834	.2778	3.76	357	892	892
	SSEO	1999	1879	.1711	2.98	851	4858	3797
	TOTAL SEO					3095	21827	**14693**
2000	EYKT	1999	2323	0.3084	4.07	703	6645	4045
	CSEO	1997	2534	.2009	3.144	1184	9432	6701
	NSEO	Revised 1994	834	.2778	2.98	357	892	568
	SSEO	1999	1879	.1711	3.04	851	4858	3673
	TOTAL SEO					3095	21827	**15067**
1998/ 1999	Fairweather	1997	4176	0.18	3.87	448	7369	5443
	Other EYKT	CSEO '97	2534	0.20	3.87	268	2669	1921
	Total EYKT	1997			3.87	716	10039	7899
	CSEO	1997	2534	0.20	2.87	1997	14520	10453
	NSEO	Revised '94	834	0.28	2.98	896	2239	1428
	SSEO	Revised '94, '96 avg wt	1173	0.28	3.27	2149	8243	5253
	TOTAL SEO					5757	35041	**25031**
1996/ 1997	Fairweather	95 with 97 habitat	4805	0.16	3.74	448	8046	5759
	Other EYKT	CSEO 95	2929	0.19	3.74	268	2689	2158
	EYKT total	1995				716	11014	8492
	CSEO	1995	2929	0.19	3.10	1997	18117	13168
	NSEO	Revised 1994	834	0.28	2.98	896	2239	1426
	SSEO	Revised 1994	1173	0.28	3.88	2149	9781	6222
	TOTAL SEO					5757	41151	**29285**
1995	Fairweather	90 D, 97 habitat	2283	0.10	4.05	448	4143	2947
	Other EYKT	CSEO revised 1994	1683	0.10	4.05	268	1686	1414
	EYKT total				4.05	716	5829	4957
	CSEO	Revised 1994	1683	0.10	2.70	1997	9076	7583
	NSEO	Revised 1994	834	0.28	2.98	896	2239	1426
	SSEO	Revised 1994	1173	0.29	3.88	2149	9781	6222
	TOTAL SEO					5757	26925	**20188**
1994	Fairweather	90 D, 97 habitat	2283	0.10	4.05	448	4143	2947
	Other EYKT	1991 CSEO	2030	0.09	4.05	268	2199	1564
	EYKT total					716	6342	4924
	CSEO	1991	2030	0.09	2.93	1997	11892	15608
	NSEO	1991 CSEO	2030		3.73	896	6779	5124
	SSEO	1991 CSEO	2030		3.43	2149	14964	11344
	TOTAL SEO					5757	39976	**30453**

Table 8. Estimated area of rocky habitat.

Area	Rock Habitat inside 220 m 2002 estimate	Previous estimate of rock habitat	Percent Change
EYKT	757.4	703	+7.8
NSEO	472.0	357	+32
CSEO	1,413.8	1,184	+19.6
SSEO	732.0	851	-14.0
SEO total	5,597.2	3,095	

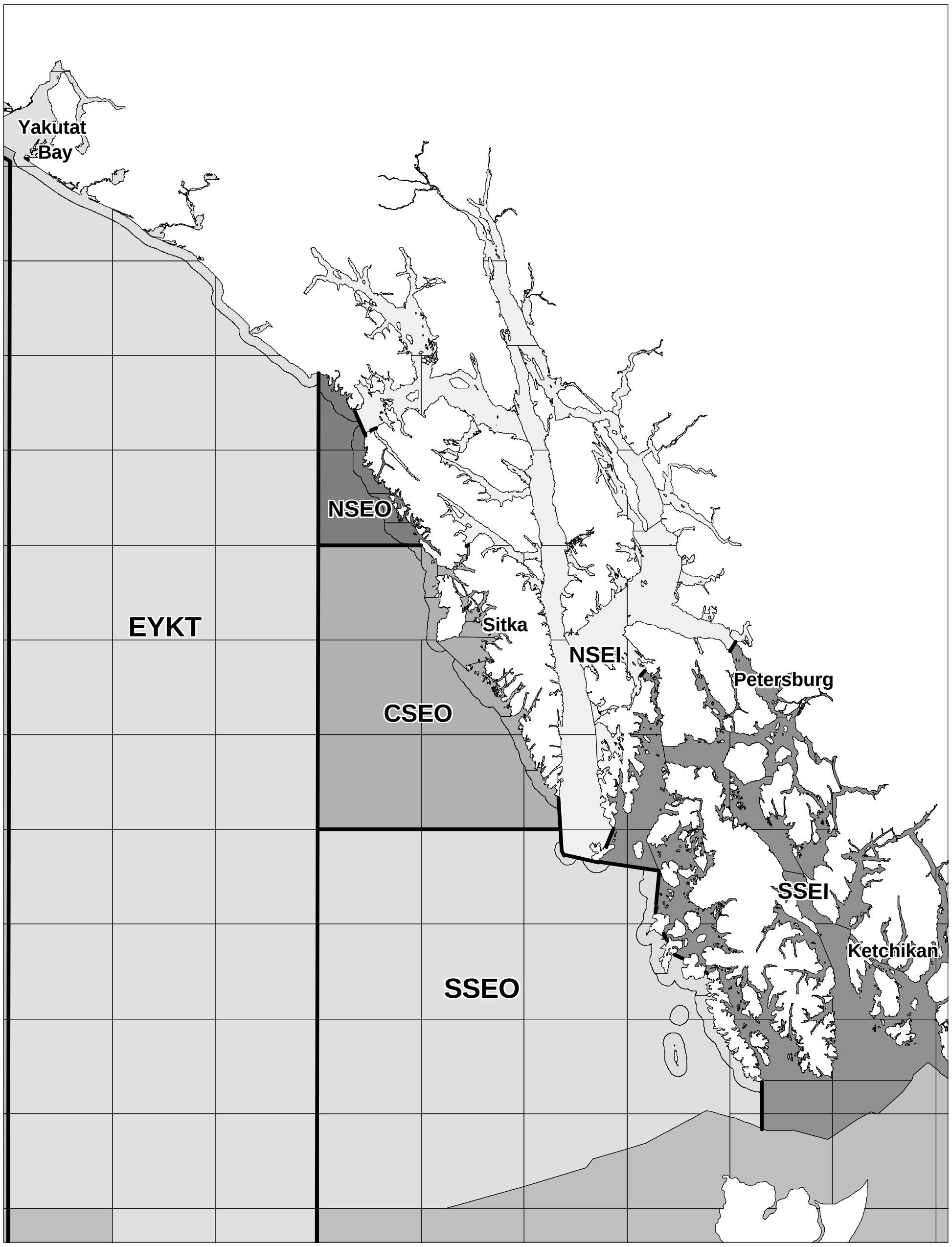


Figure 1. The Eastern Gulf of Alaska with Alaska Department of Fish and Game groundfish management areas: the EYKT, NSEO, CSEO, and SSEO sections comprise the Southeast Outside (SEO) Subdistrict.

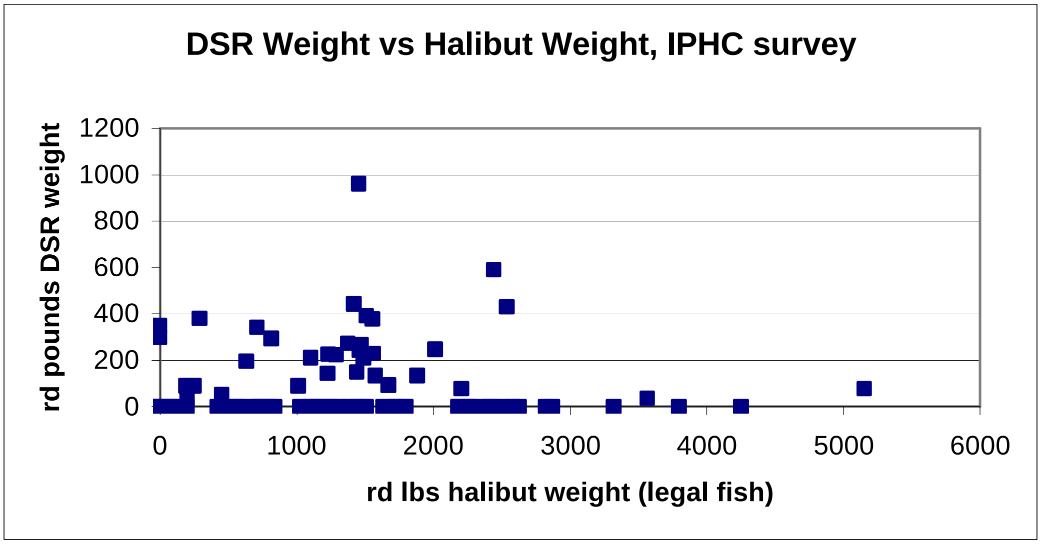


Figure 2. Catch of DSR (rd weight) versus halibut rd weight, legal fish) for 2000 IPHC longline survey.

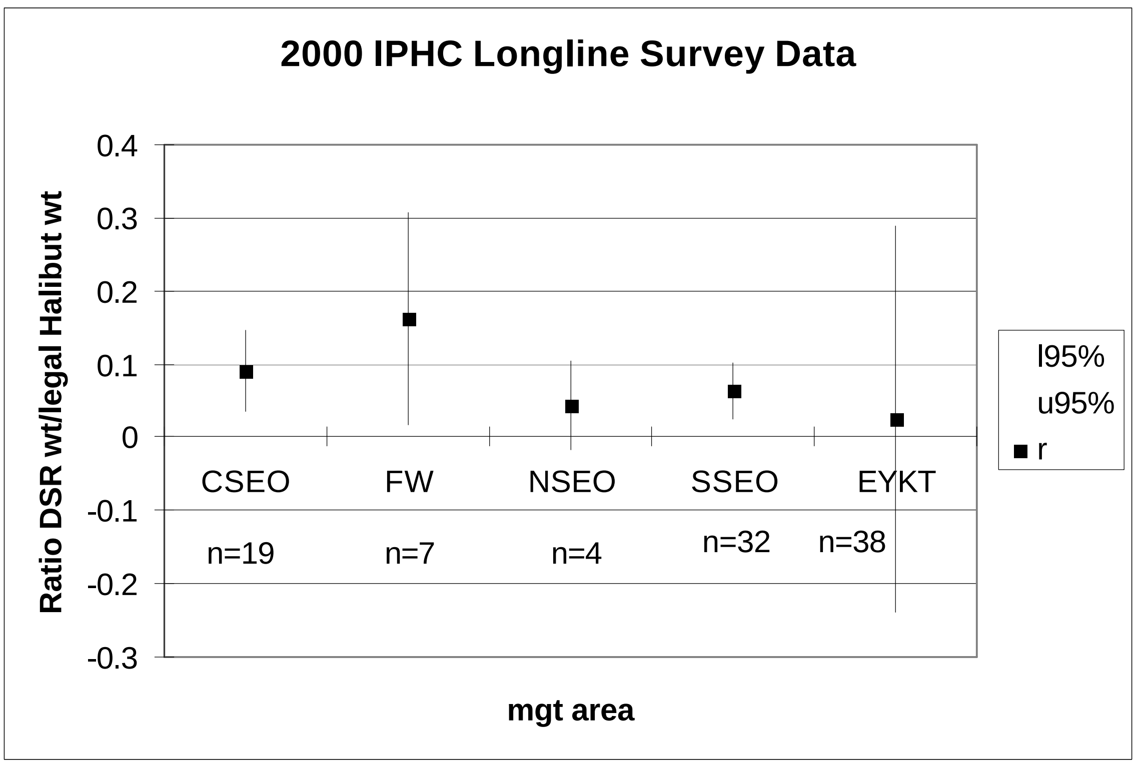


Figure 3. 2000 IPHC longline survey data, ratio of yelloweye (rd weight)/halibut (legal fish, rd weight).

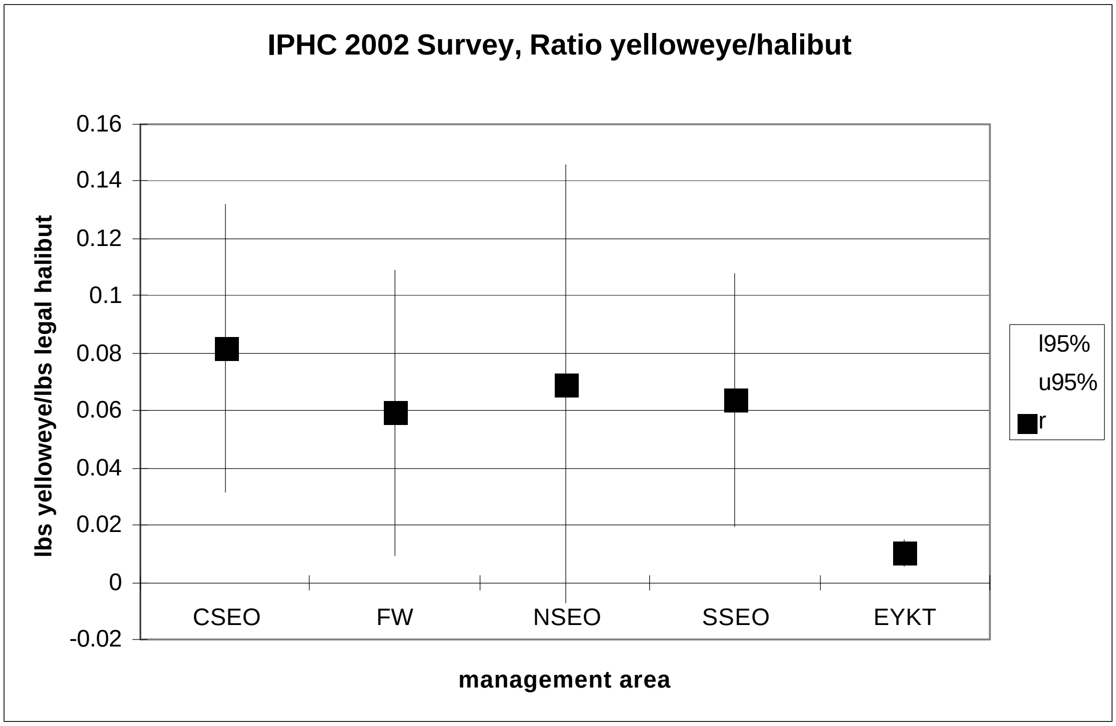


Figure 4. 2002 IPHC longline survey data, ratio of yelloweye (rd weight)/halibut (legal fish, rd weight).

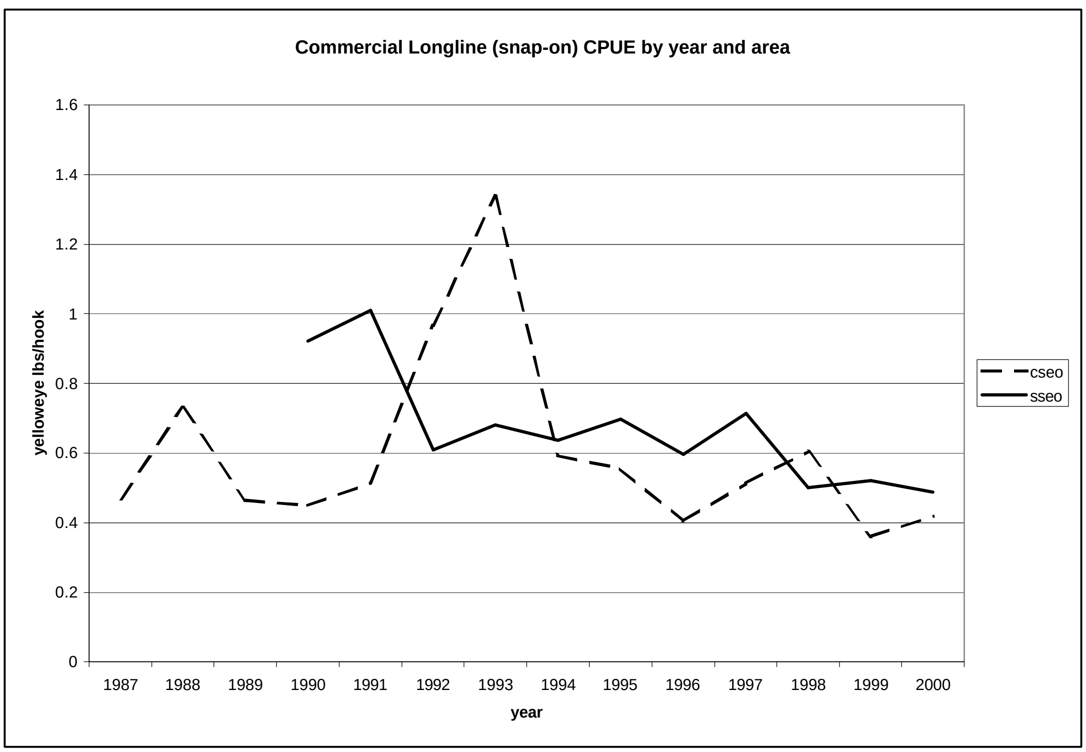


Figure 5. Commercial fishery catch per unit effort data, snap on longline gear for CSEO and SSEO, by year.

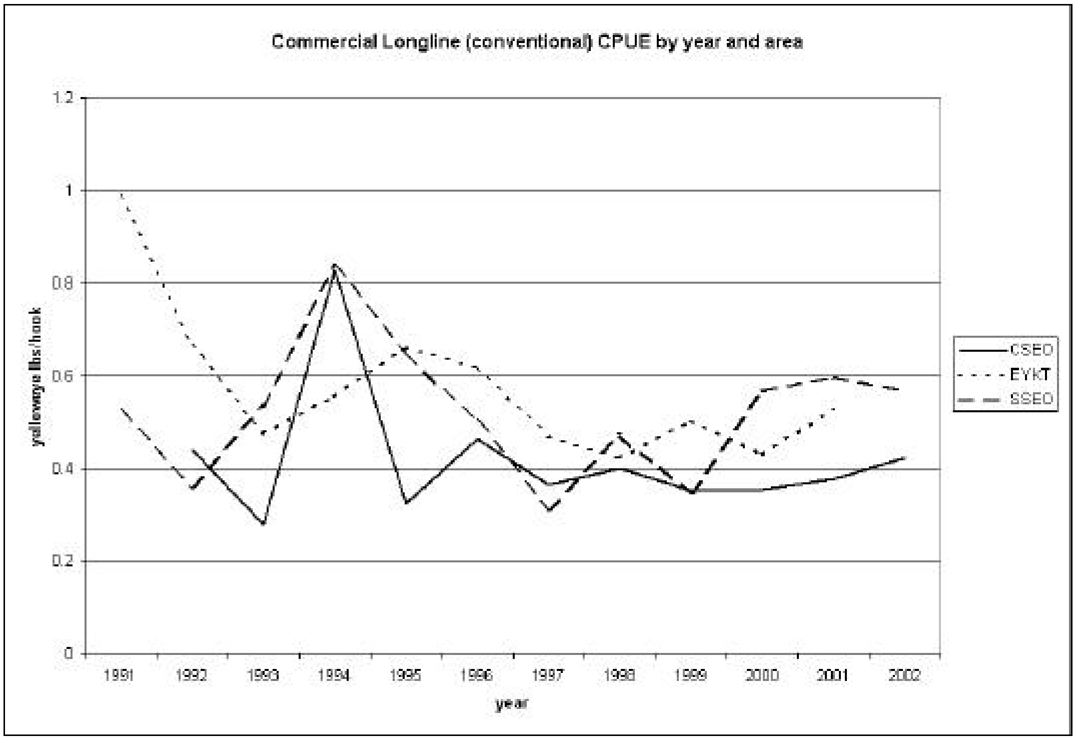


Figure 6. Commercial fishery catch per unit effort data, conventional longline gear, by area, and year.

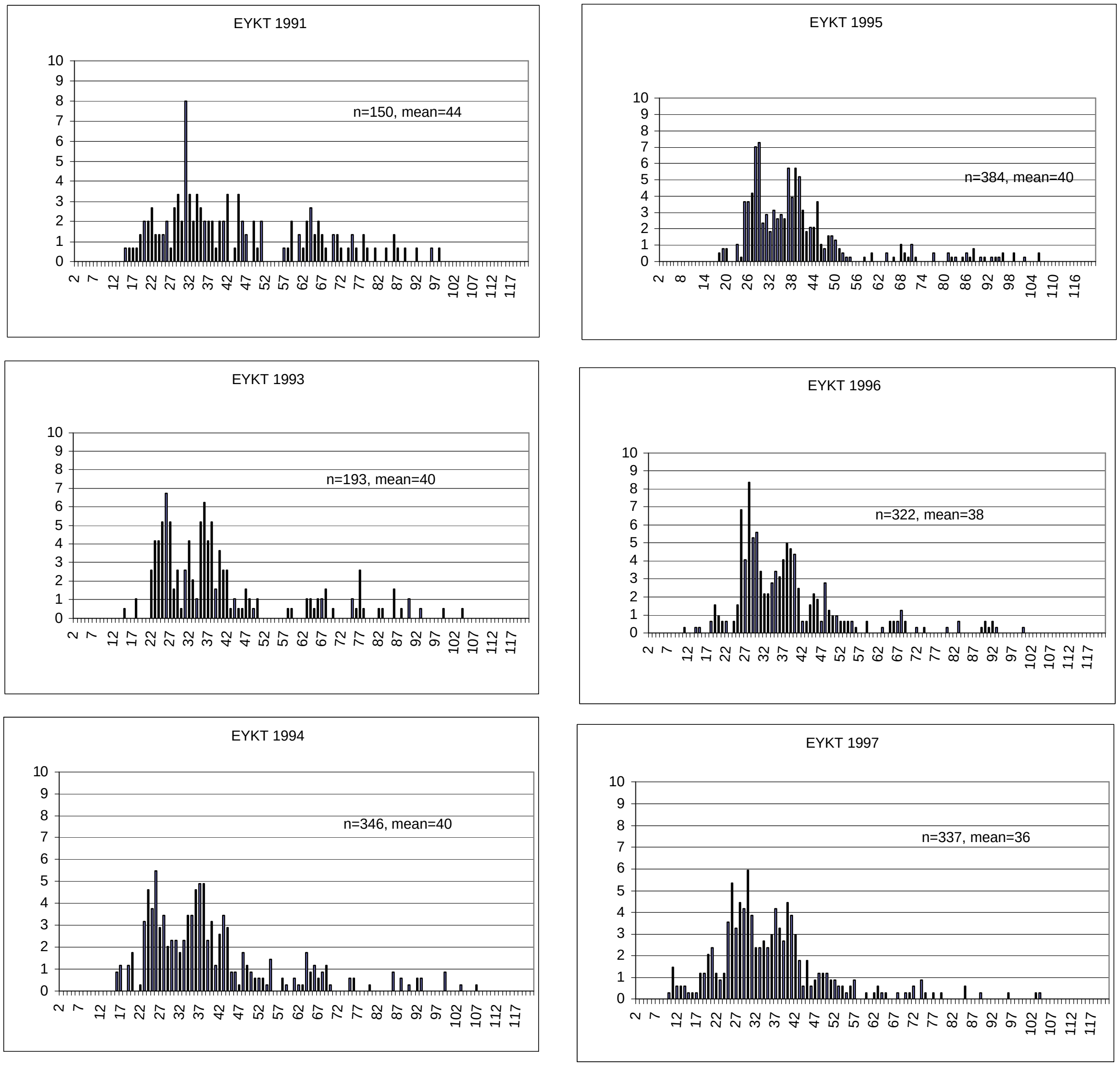


Figure 7a. Yelloweye rockfish age frequency distributions from EYKT commercial port samples, 1991–1997.

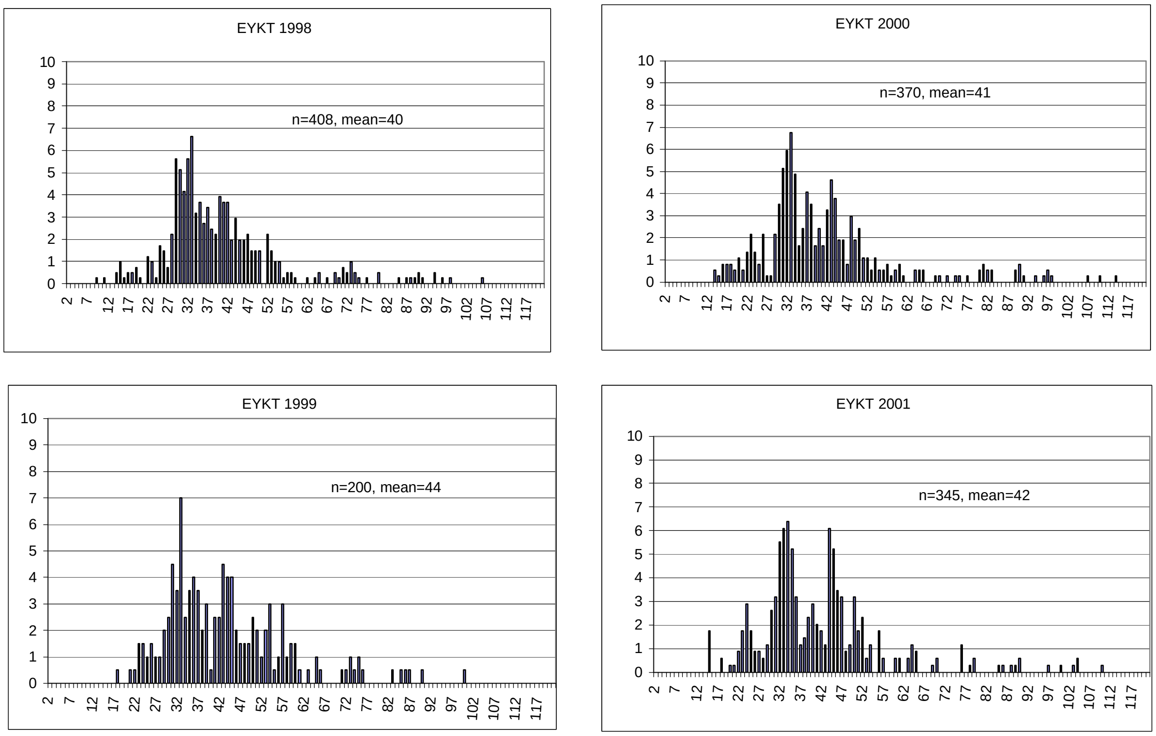


Figure 7b. Yelloweye rockfish age frequency distributions from EYKT commercial port samples, 1998–2001.

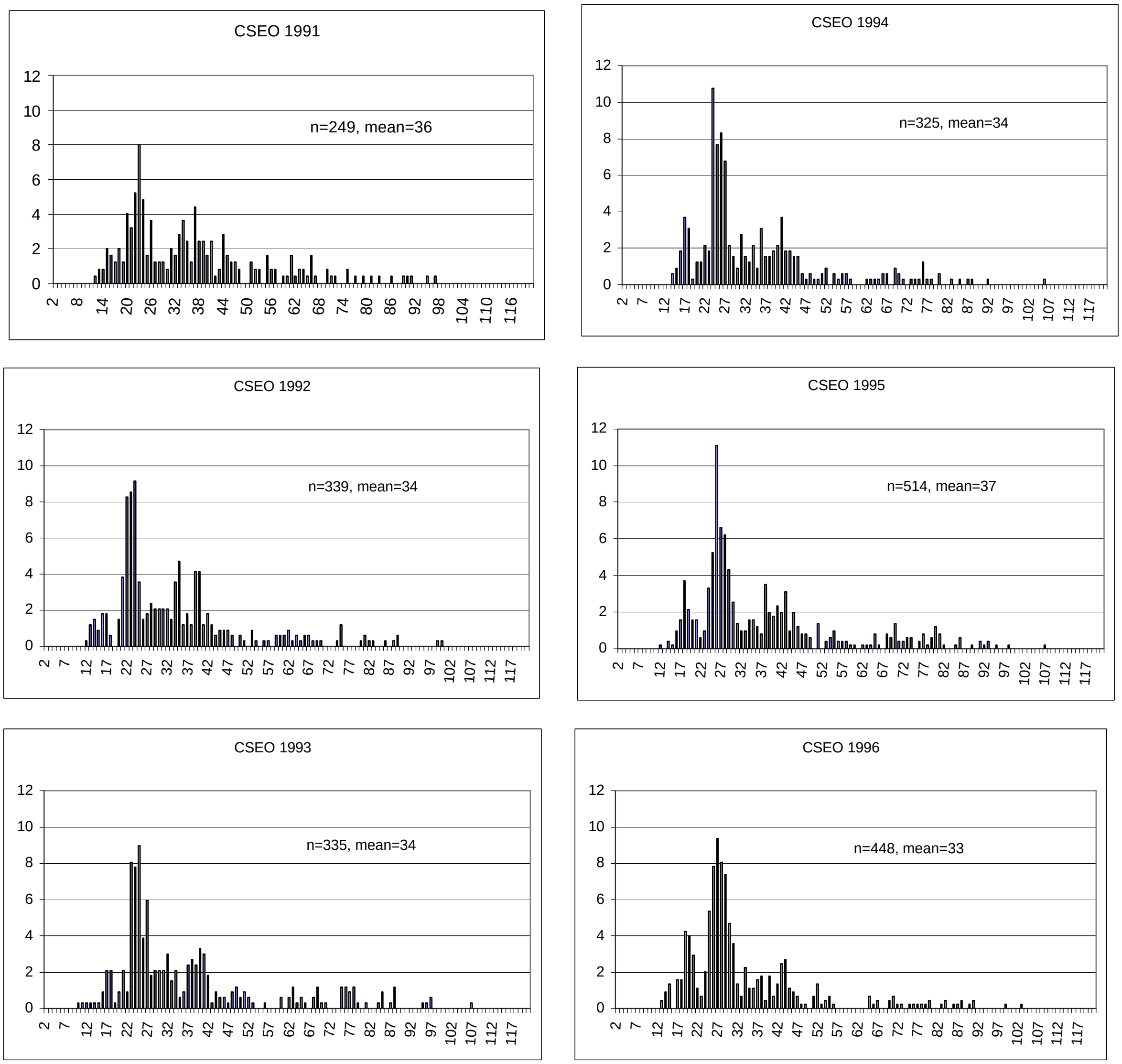


Figure 7c. Yelloweye rockfish age frequency distributions from CSEO port samples, 1991–1997.

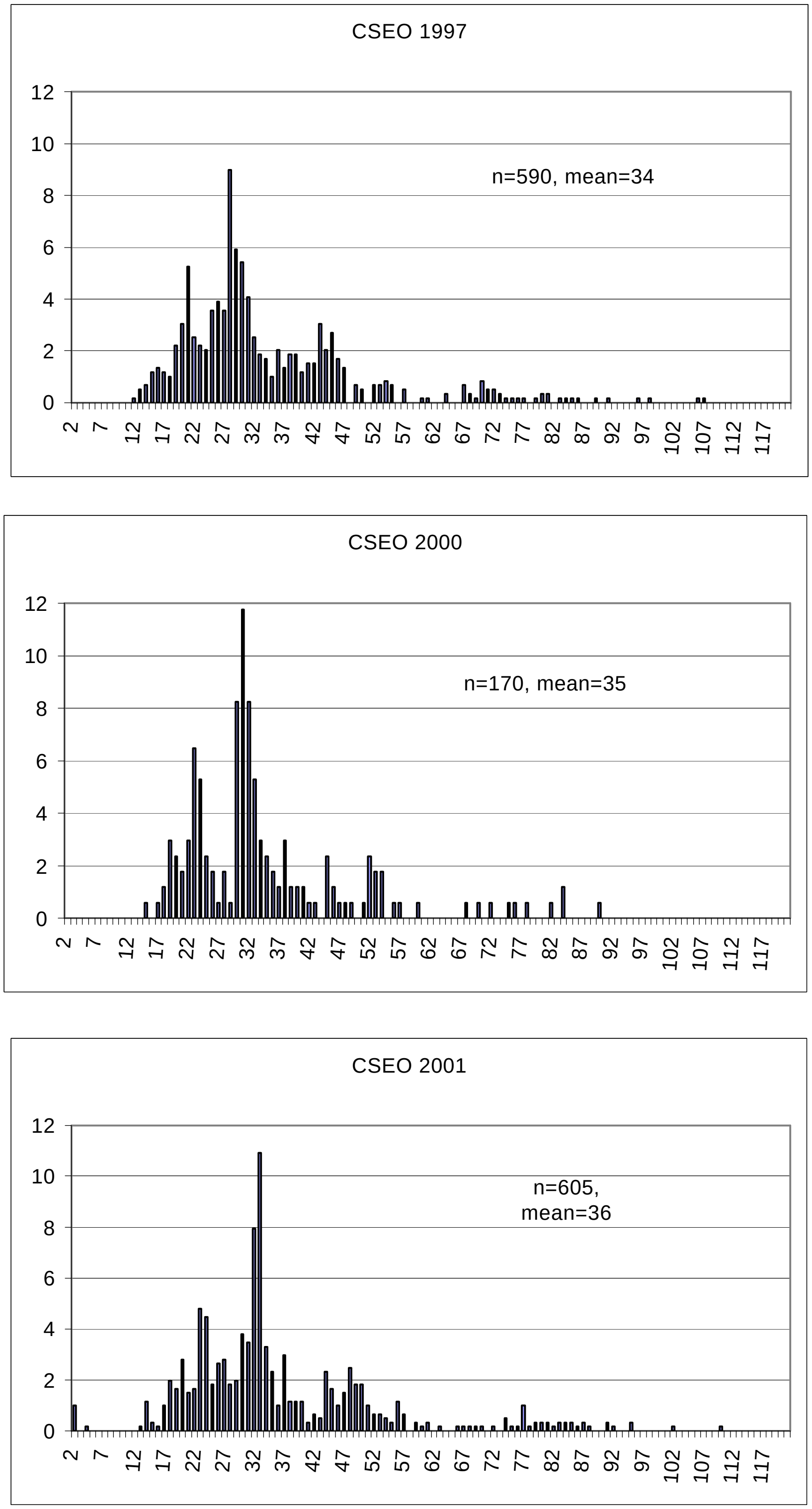


Figure 7d. Yelloweye rockfish age frequency distributons from CSEO commercial port samples, 1998–2001.

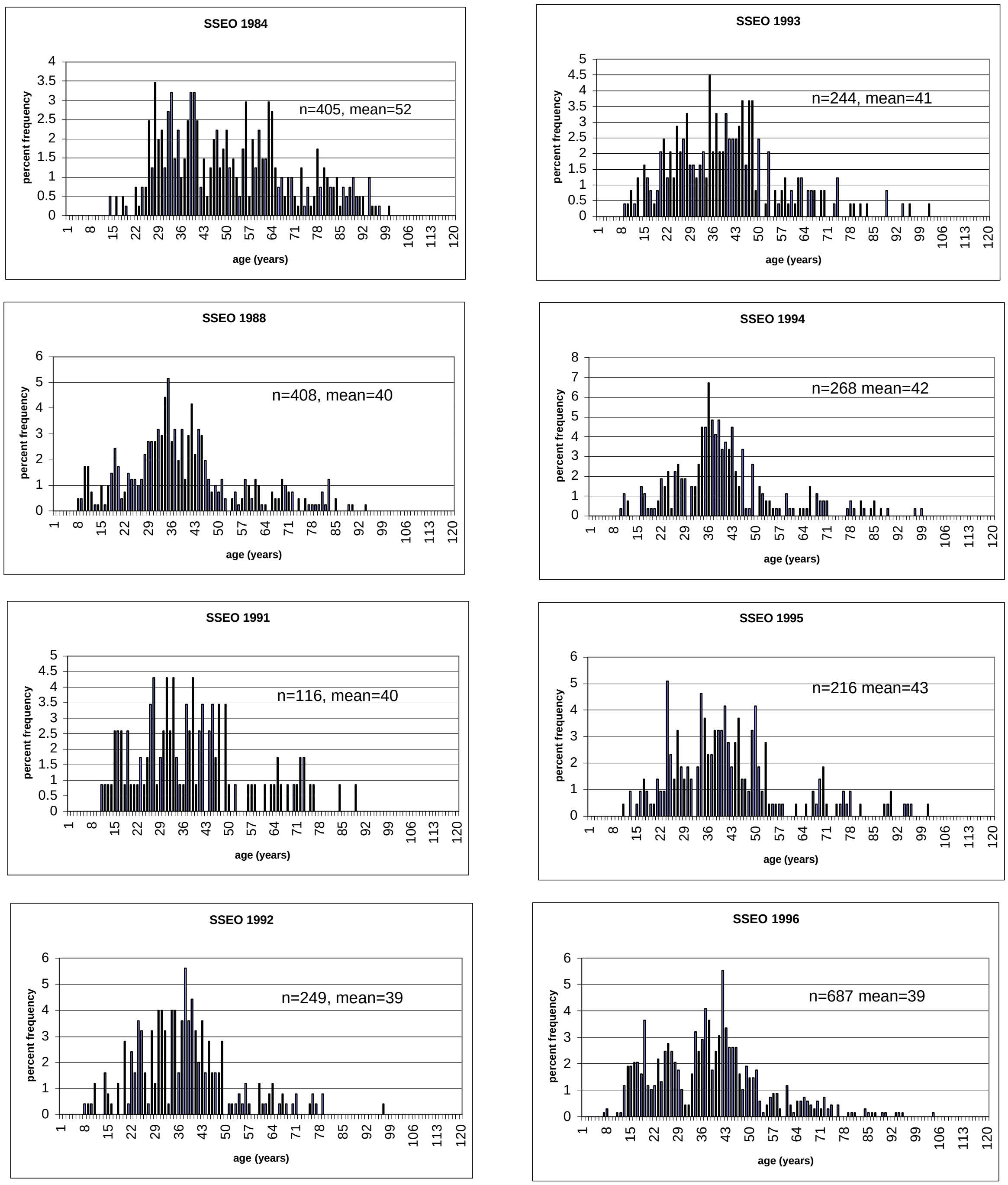


Figure 7e. Yelloweye rockfish age frequency distributons from SSEO commercial port samples, 1984–1996.

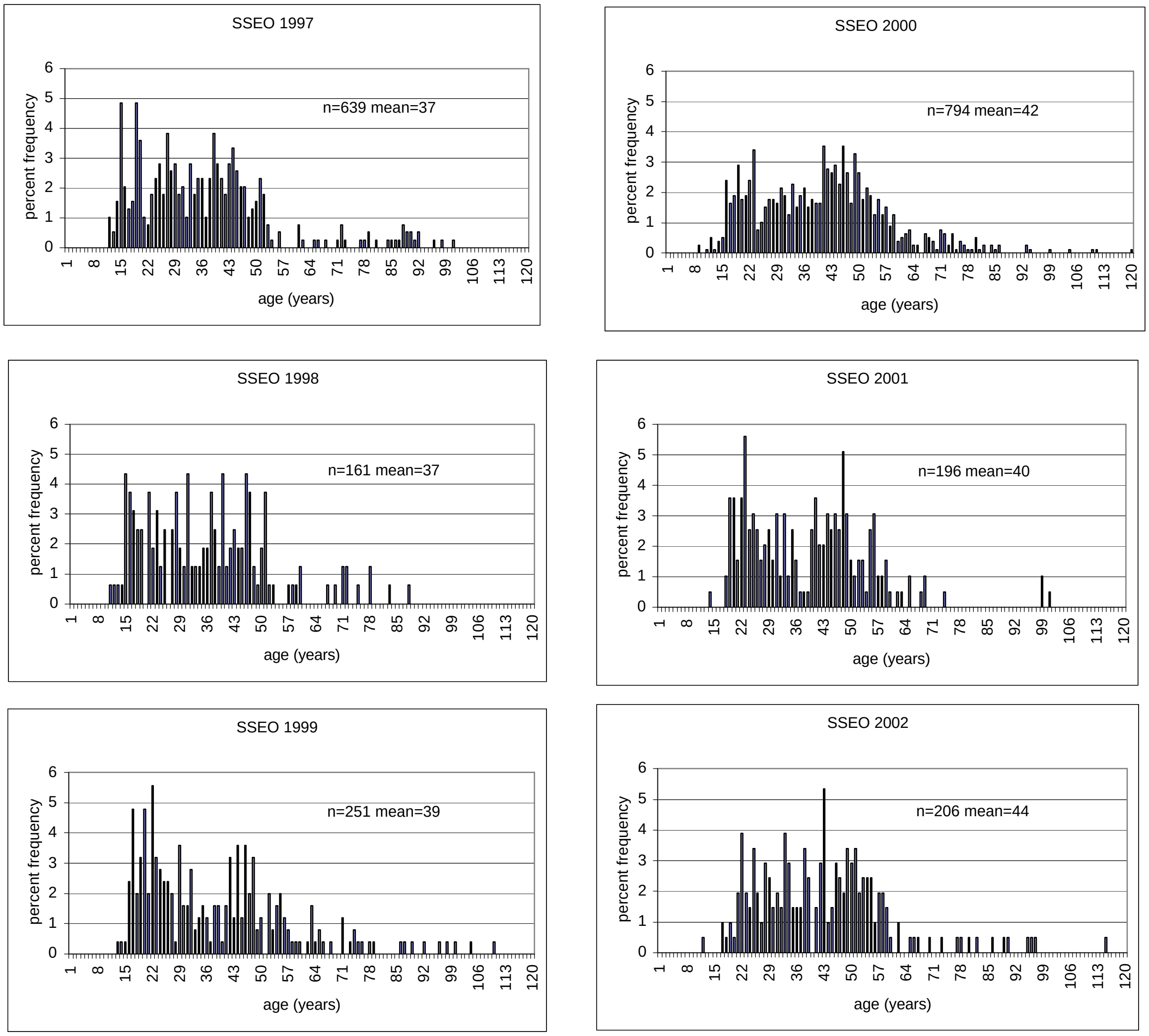


Figure 7f. Yelloweye rockfish age frequency distributons from SSEO commercial port samples, 1997–2002.

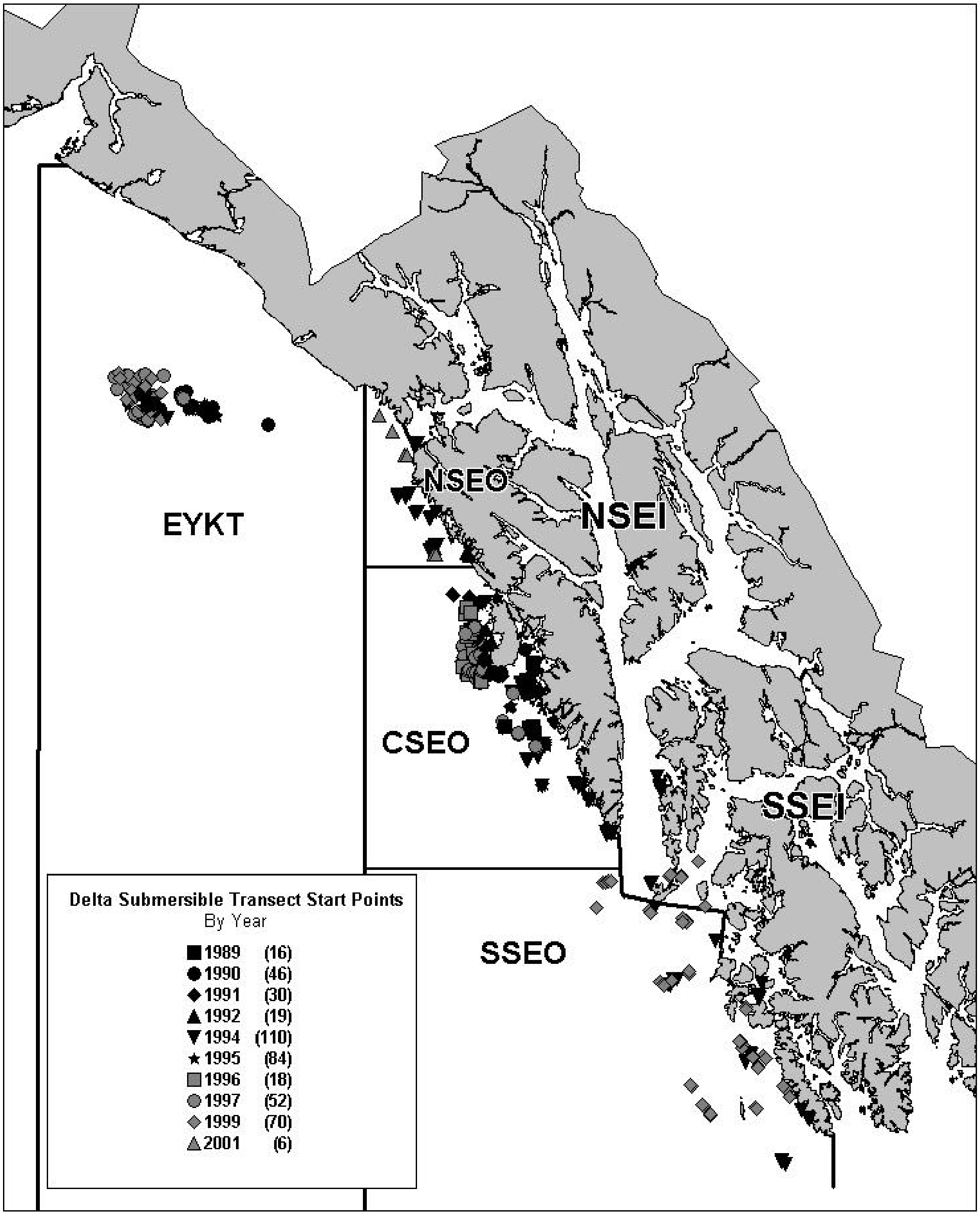


Figure 8. Location of submersible live transects dives, Southeast Alaska 1990–2001.

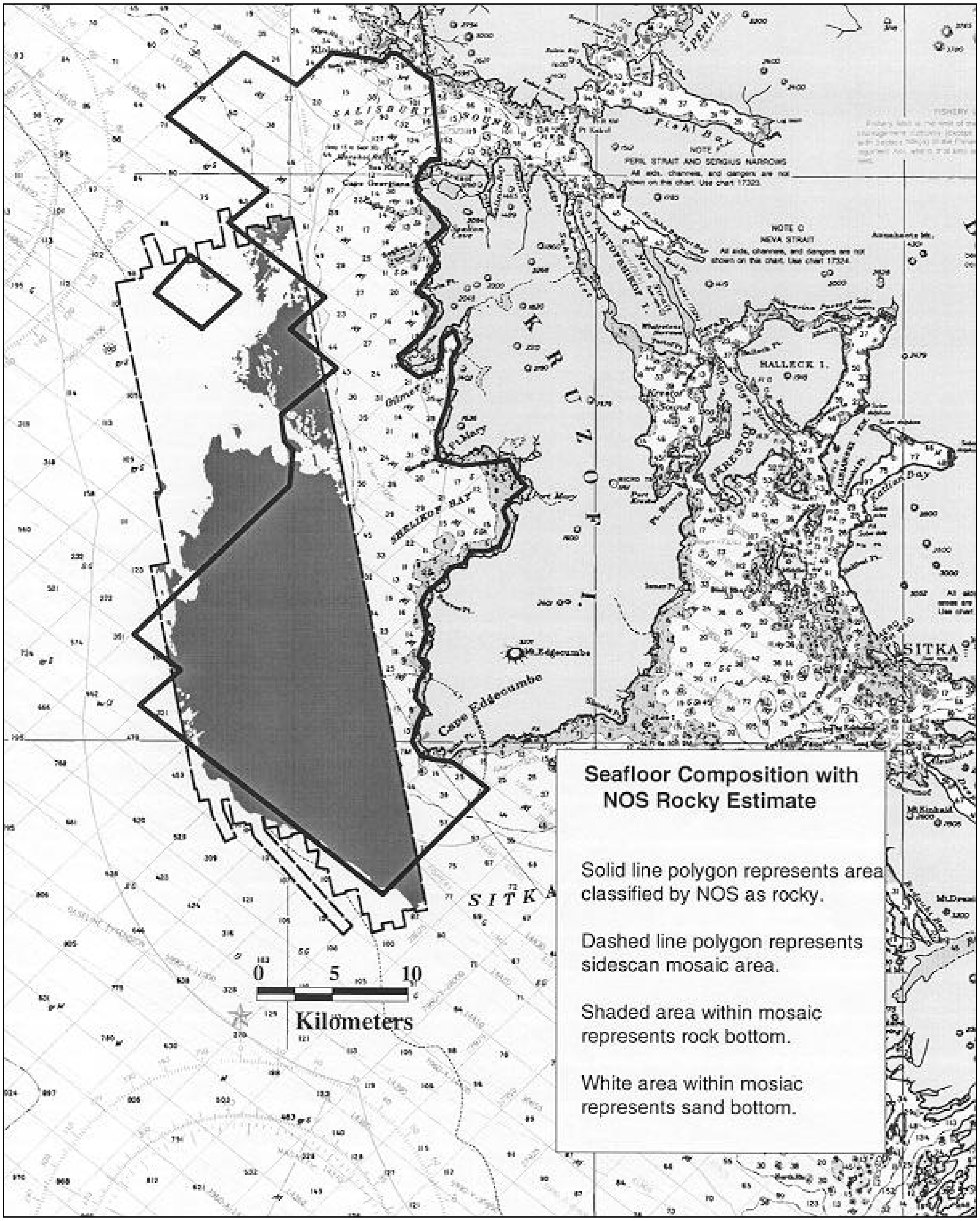


Figure 9. Comparison of area of rock habitat using NOS data versus geological interpretation using sidescan sonar data for a 536 sq. km are of seafloor off Kruzof Island.

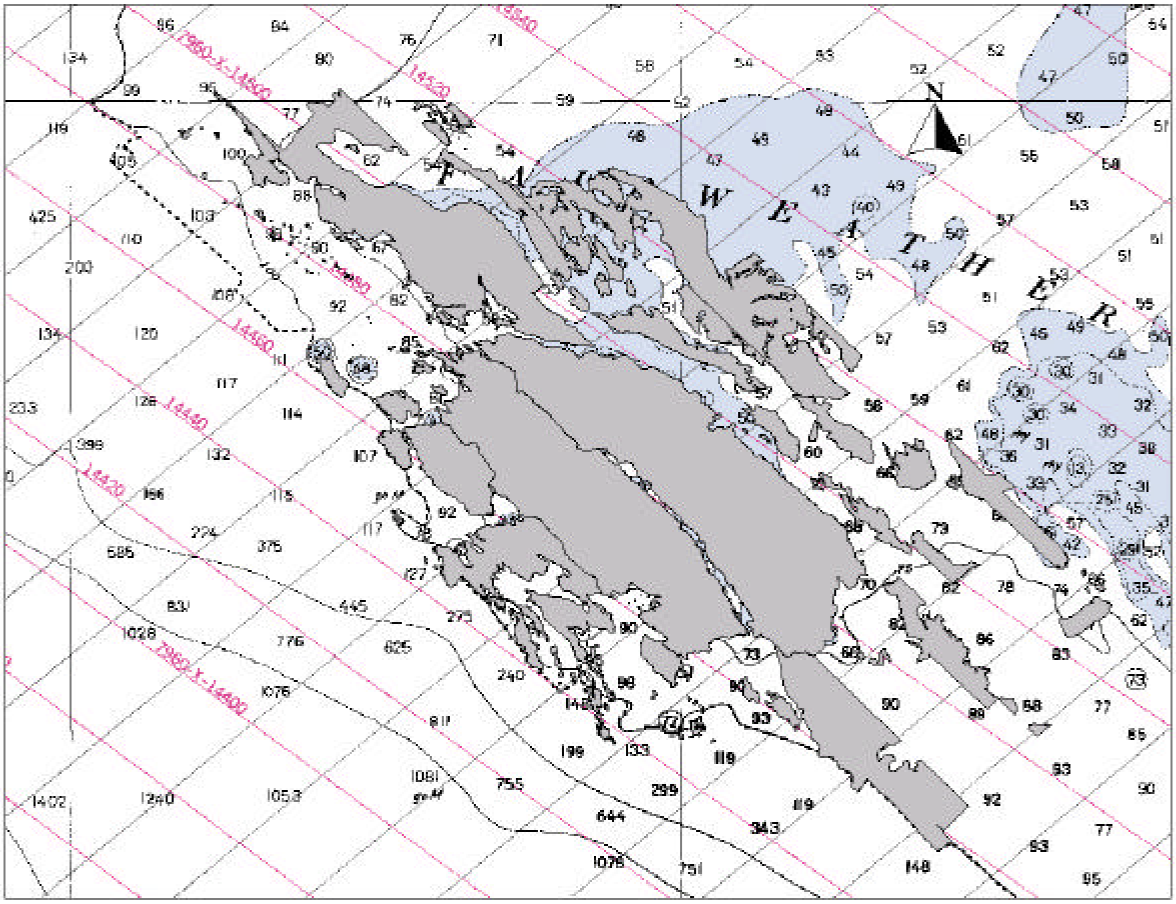


Figure 10. Area of rock habitat based on interpretation of sidescan data (gray shaded area) for west bank of Fairweather Ground.

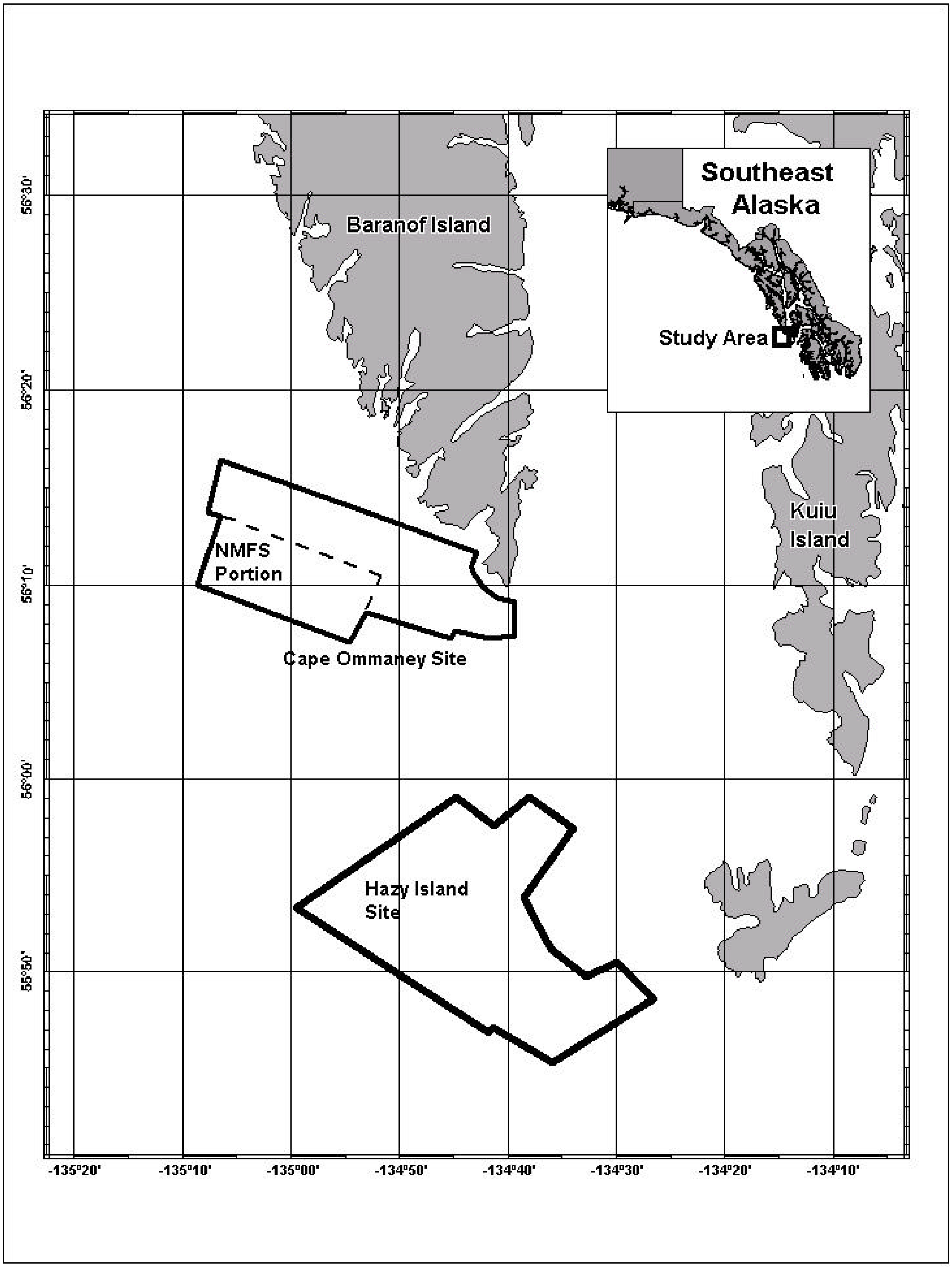


Figure 11. Locations of multibeam echo sounder surveys conducted in 2001. Cape Omaney site had a portion surveyed by NMFS Auke Bay in addition to the area surveyed by ADF&G.

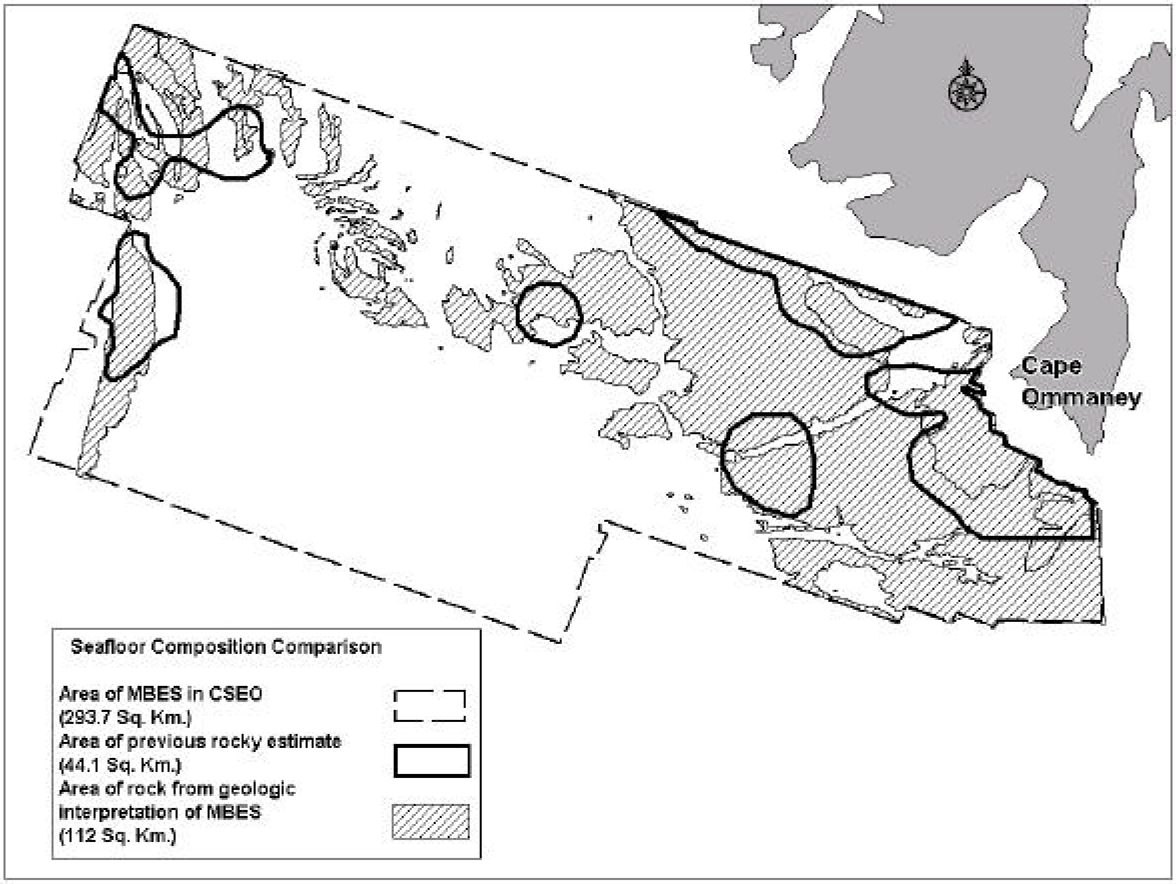


Figure 12. Comparison of habitat estimates for Cape Ommaney multibeam site.

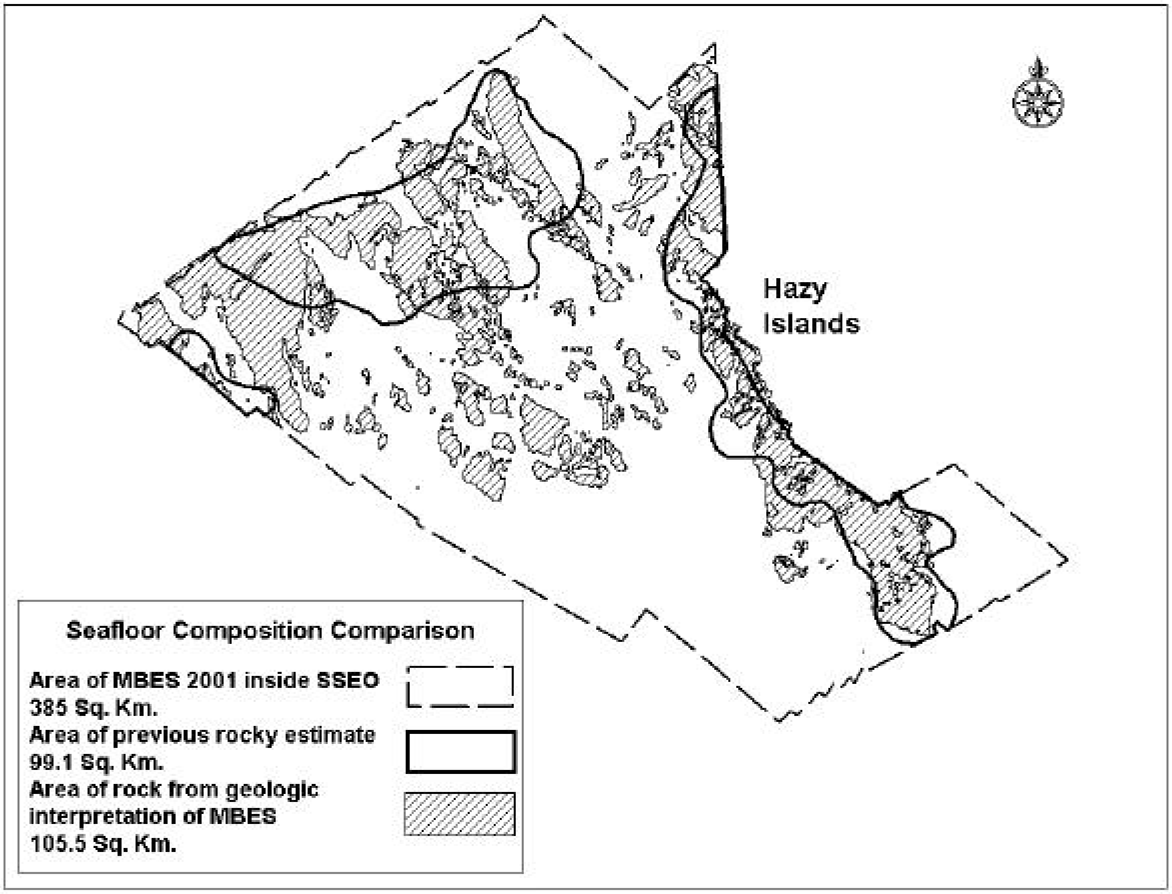
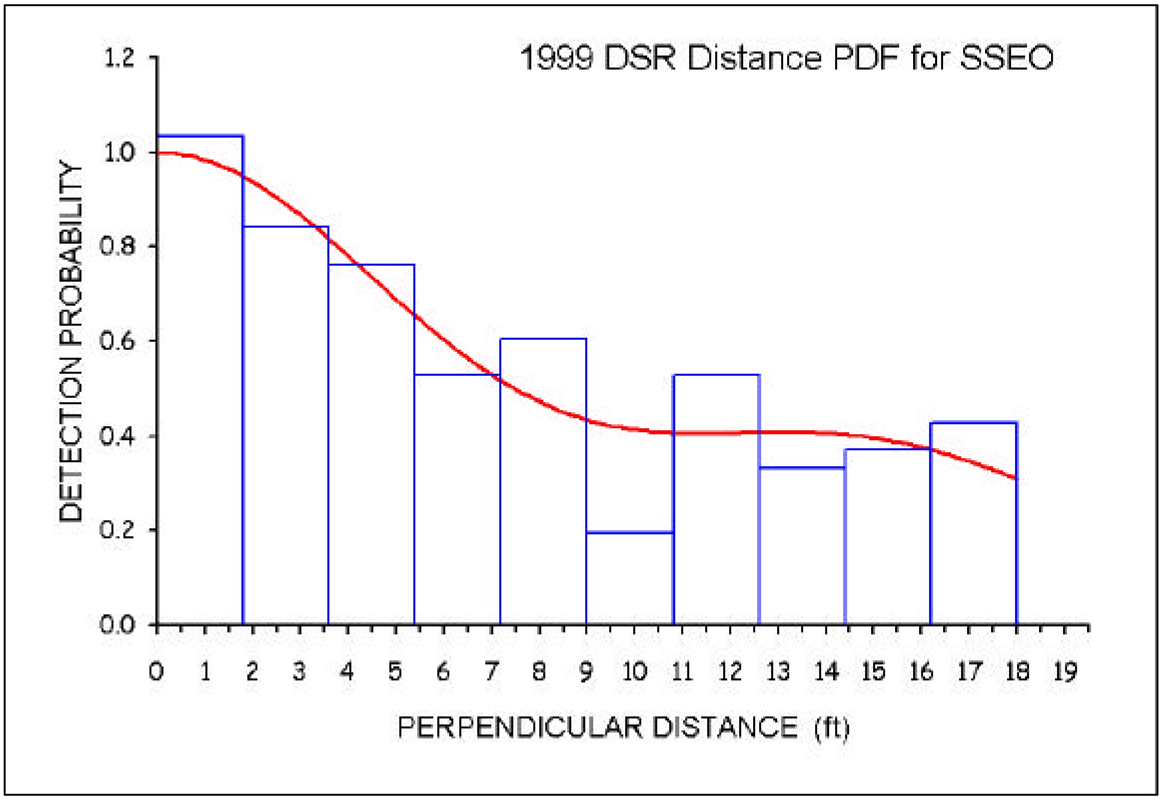
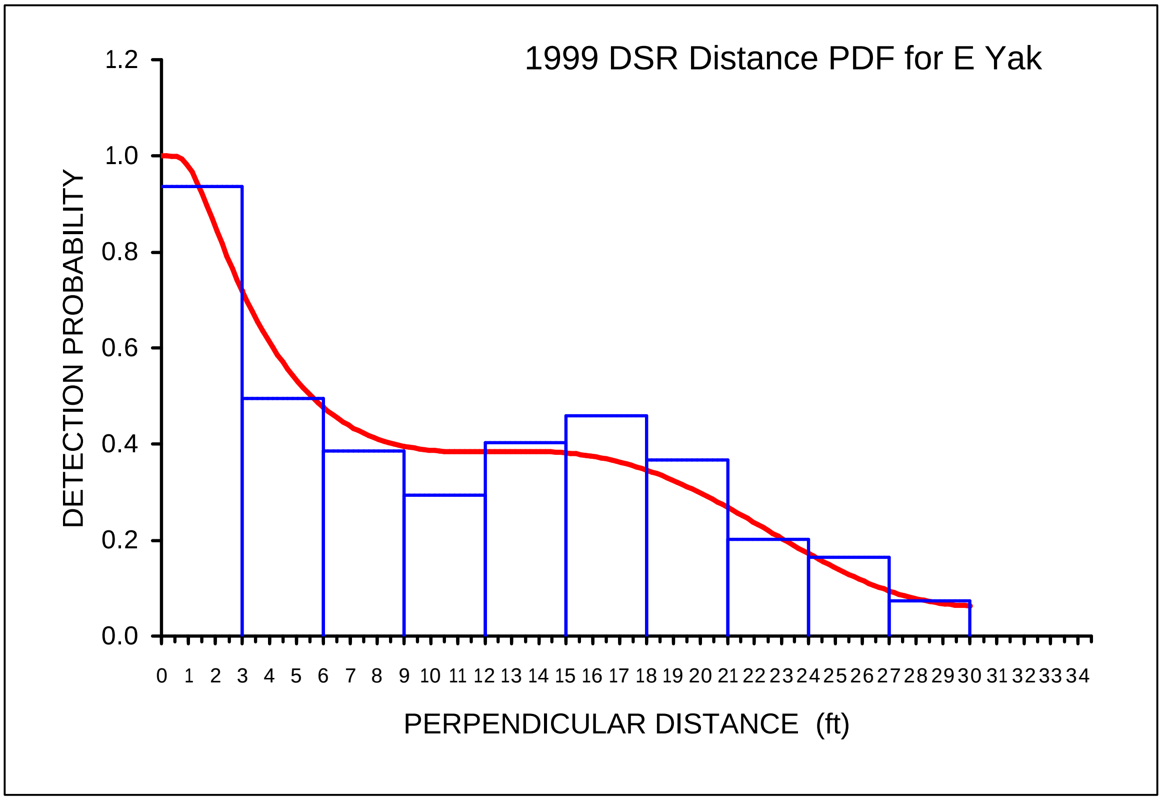
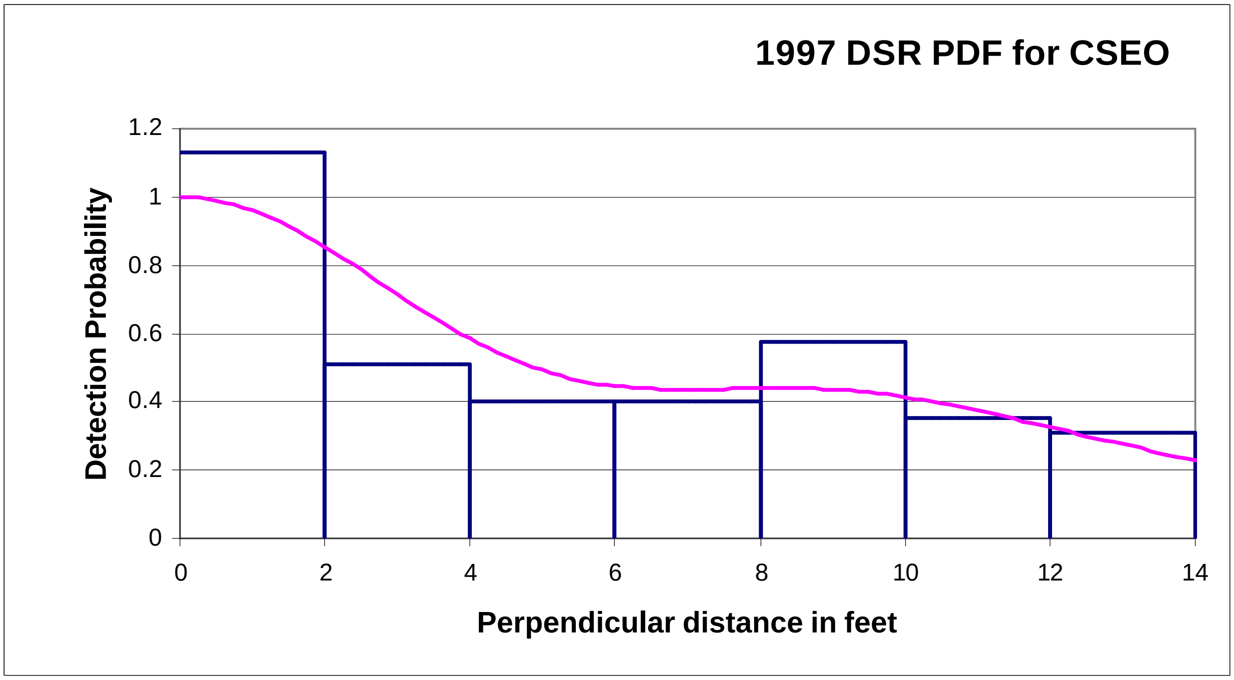


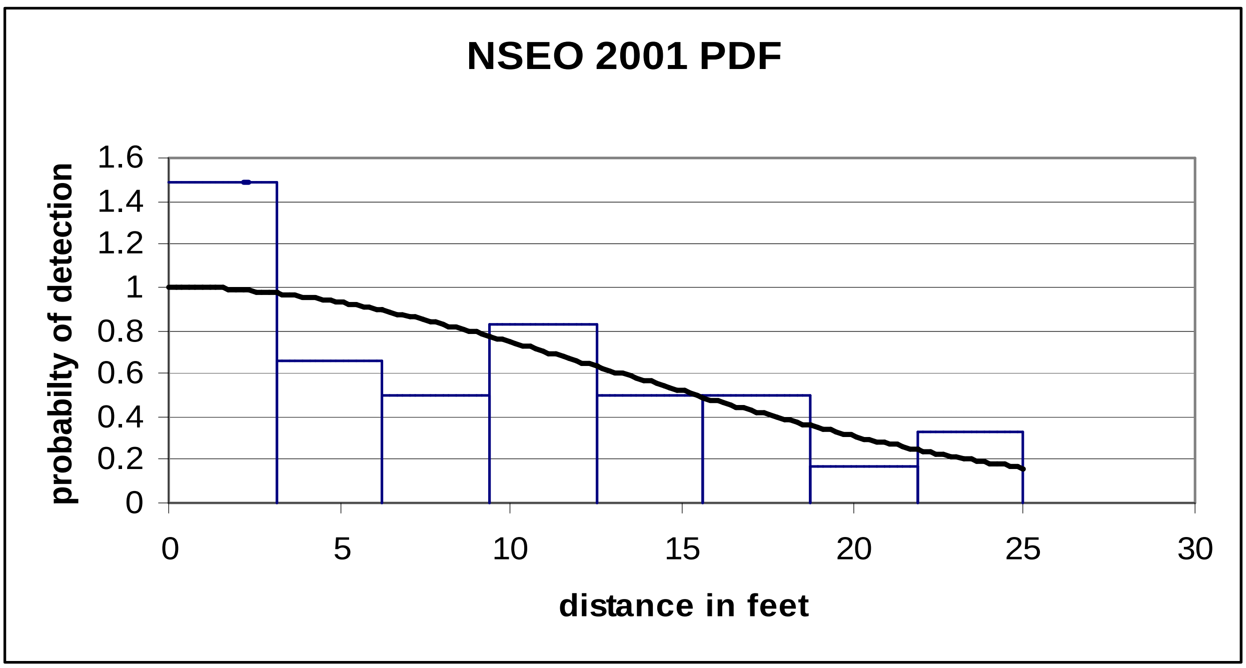
Figure 13. Comparison of habitat estimates for Hazy Island multibeam site.

APPENDIX I. DISTANCE OUTPUT FOR 2002 ASSESSMENT


1999 DSR Distance PDF for SSEO
DETECTION PROBABILITY
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
PERPENDICULAR DISTANCE (ft)


1999 DSR Distance PDF for E Yak
DETECTION PROBABILITY
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34
PERPENDICULAR DISTANCE (ft)


1997 DSR PDF for CSEO
Detection Probability
1.2
1
0.8
0.6
0.4
0.2
0
0
2
4
6
8
10
12
14
Perpendicular distance in feet


NSEO 2001 PDF
probabilty of detection
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
distance in feet

November 2002: Distance Output for Yelloweye Rockfish *(From Program DISTANCE)*.

November 2002: Distance Output for Yelloweye Rockfish

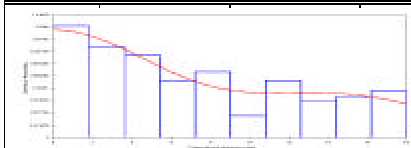
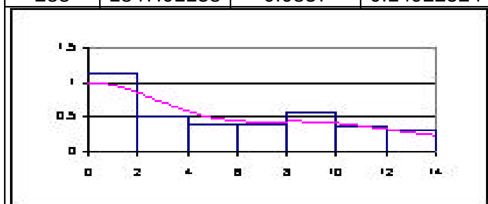
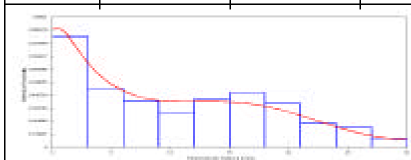
From Program DISTANCE new inputs are average weight and new estimates of habitat

Area	Detection Function Description	Density [D] (no./km^2)	s.e. [D]	CV(D)	AIC	Chi-square	k	L	n/L	s.e. n/L	f(0)
SSEO	1999: Intervals 0, 1.8, 3.6 to 18 & half norm/cosine vs. haz/cos vs. haz/herm models	**1878.9**	321.48	0.1711	1290.2	0.08992	45	49663	0.005799	0.00086537	0.098757
CSEO	1997: Intervals, 0,2,4,...,14; (Dave's run). 99 weights	**2533.9**	509.07	0.2009	625.5	0.05	32	29176	0.0057	880.0E-6	0.13574
NSEO	0,5,8,11...32	**1420**	233.02	0.3144	147.2999	0.46624	9	9535	0.0040902	1.1E-3	0.062
EYKT (All)	1999:Intervals 0, 3, 6 to 30 & Half Norm/Cosine, Haz/Cos, Haz/Herm	**2322.5**	716.17	0.3084	891.92	0.4625	20	25646	0.0080323	0.0012185	0.088131

Results chosen as best estimates, based on goodness of fit of model to data (judged by visual examination of plot and X2 goodness of fit test); visual examination of goodness of fit near the origin; the shape of the detection function [a regular shape with a shoulder is best]; and the CV of density, with a lower CV being better.

NOTE: Values in italics have been checked for correct computation and/or original value.

Log-based Confidence Intervals based on Replicate Transects

n	var(n)	cv[f(0)]	cv(n)	df (Buckland et al p 90)	Detection Function	95% Lower	95% Upper	90% Lower	90% Upper	
 [illegible]	[illegible]	[illegible]	[illegible]022524	74.9		1339.40	2635.72	1415.86	2493.37	SSEO
 [illegible]	[illegible]	[illegible]	[illegible]	81.00	Irregular; small shoulder; MARGINAL FIT @ ORIGIN	1705.69	3764.25	1819.90	3528.03	CSEO
39	116.111476	0.0293	0.2778	13.10	not available	998.50	2019.44	1063.94	1895.22	NSEO
 [illegible]	[illegible]	[illegible]	[illegible]169733	170.4		1281.08	4210.52	1410.85	3823.23	EYKT

Area	01 or 02 wt	2001/02 Std. Error Mean Wt. [s.e.(w)]	CV[w]	Area of Rocky Habitat (km^2) [A] (1999 estimate)	Biomass (kg) for Area [bk]	*Biomass (mt) for Area [bm]*	Var(biomass) for Area [Var(bk)]	CV(bk)	Lower 90% CL (kg) [l90]
Area	Formulae to the right indicate how parameters are estimated -->				= w*D*A	*=bk/ 1000*	=bk^2*(CV(d)^2 +CV(wt)^2)	=sqrt[Var(bk)]/ bk	=bk/ (exp(1.645*(ln(1+CV(bk)))^0.5))
SSEO	3.47	*0.0837*	*0.0241*	*732.00*	*4772481.16*	*4772.48*	*666789056733.62*	*0.1711*	*3609014.48*
CSEO	3.140	0.0738	0.0235	1414.00	11,250,414.64	11250.41	5178459808017.00	0.2023	8093008.22
NSEO	*2.980*	*0.0953*	*0.0320*	*472.00*	1,179,681.87	1179.68	108821682651.68	0.2796	751168.34
EYKT (All)	4.30	0.08	*0.0178*	*757.00*	7,559,969.75	7559.97	5454004203762.13	0.3089	4600834.67

2001 for eykt as no fishery there in 2002

Approximations for variance of a product of independent variables used. (Goodman, L.A. 1960. On the exact variance of products. J. Amer. Stat. Assoc. 55:708-713.)

	Upper 90% CL (kg) [u90]	*Lower 90% CL (mt)*	*Upper 90% CL (mt)*		
Area	=bk*(exp(1.645*(ln(1+ CV(bk)))^0.5))	*=l90/1000*	*=u90/1000*	yelloweye F=.02, mt	DSR TAC (ye/.9), mt
SSEO	*6311023.82*	*3609.01*	*6311.02*	72.18028969	80.20032188
CSEO	15639651.69	8,093.01	15,639.65	161.8601643	179.844627
NSEO	3309685.29	1,205.33	3,309.69	24.10663045	26.78514494
EYKT (All)	12422342.18	4,600.83	12,422.34	92.01669343	102.2407705
	Totals, mt:	17508.19		350.1637779	389.0708644

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