Section 8

DEMERSAL SHELF ROCKFISH
STOCK ASSESSMENT AND FISHERY EVALUATION REPORT

By
Victoria O'Connell, David Carlile, and Cleo Brylinsky
Alaska Department of Fish and Game

November 2000

SUMMARY OF CHANGES IN THE DSR STOCK ASSESSMENT

Executive Summary

Relative to the December 1999 SAFE, the following substantive changes have been made:

Input Data: Yelloweye average weight and standard error data was updated using 1999 port samples. New age data from the 1998 and 1999 fishery was included and a discussion on fishery indicators was updated.

***Assessment Results*:**
The exploitable biomass estimate for yelloweye rockfish, based on the sum of the lower 90% confidence limit of biomass is 14,693 mt. This is a 3% decline over the 2000 estimate.

SSC Concerns Regarding Consistency in ABC Recommendations
Because of the continued uncertainty in estimation of yelloweye biomass due to difficulties in estimation of total area of rock habitat, we continue to advocate using the sum of the lower 90% confidence limits of biomass, by area, as the reference number for setting ABC. It is more appropriate to use the sum of the lower 90% confidence limits of biomass by area to estimate total biomass (instead of the overall estimate), because the fishery is managed based on these smaller areas and using the larger number could result in an overharvest of fish within an individual area.

8.1 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 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 s 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 8-1. These fishes all occur on the continental shelf, reside on bottom, and are generally associated with rugged, rocky habitat. For the purposes of this document, 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 (see section 8.3.1). 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.

DSR are classified as ovoviviparous although some species of *Sebastes* are viviparous (Boehlert and Yoklavich 1984, Boehlert et al. 1986). 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 an 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 8-1).

8.2 FISHERY

8.2.1 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 150 m and the 75 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 3 days after landed.

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 3. A winter fishery was requested by the directed fleet, as the ex-vessel 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 (reported and discard) in other fisheries.

8.2.3 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 1960's through the mid-1970's. DSR mortality during the halibut longline fishery continues to account for a significant portion of the total allowable catch (TAC). In 1999, the 114 mt of DSR landed in the halibut fishery, accounted for 31% of the total DSR landings.

Reported bycatch does not reflect true mortality rates as most rockfish suffer embolism mortality when caught and do not generally survive when released. Estimated unreported mortality has ranged between 130 mt to 355 mt annually. For the past several years we have estimated unreported mortality of DSR during the halibut fishery based on 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. Unreported mortality data has been more difficult to collect under the halibut IFQ fishery and appears to be less reliable than previous data.

The IPHC has provided us with bycatch statistics from their 1998 longline survey. Bycatch is estimated based on sampling the first 20 hooks of each skate of gear. We reviewed bycatch statistics for IPHC station locations in Southeast Alaska. Bycatch of yelloweye, expressed as the percent of yelloweye weight to halibut weight (for legal sized halibut) ranged from 0 to 189%, with area estimate means ranging from 5% in EYKT to 30% in CSEO. The overall average for the Southeast District was 10.9%, based on 109 longline sets (Figure 8-2). The combined average for the NSEO, CSEO, and SSEO areas was 15% (±7).

The allowable bycatch limit of DSR during halibut fishing is 10% of the halibut weight. Based on the 1998 landing data, it is estimated that approximately 37% of the 2C halibut quota and 1% 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 a 7% bycatch mortality in 3A. Estimated unreported mortality is the difference between the total and the reported bycatch. Based on the 1999 halibut quotas, the estimated total DSR mortality for the 1999 SEO halibut fishery is anticipated to be 184 mt.

Current federal regulations prevent fishermen from bringing in DSR above the bycatch limit of 10% of the target species (round pounds). The Secretary of Commerce is currently reviewing a regulation that would require fishermen to retain all DSR caught, forfeiting without penalty, the amount above the directed fishing standard. In February, 2000 the Board of Fisheries enacted a regulation requiring all DSR landed in state waters of Southeast 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.

8.2.3 Catch History

The history of domestic landings of DSR from SEO are shown in Table 8-2. 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 totaled 243 mt in 1999, bycatch landings totaled 105 mt, 90 mt of which were landed in the halibut fishery.

8.3 DATA

8.3.1 Fishery Data

In addition to catch data listed in Table 8-2, 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 accounts for 90%, by weight, of all DSR landed. 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 a slightly declining trend with overall CPUE generally higher for snap-on gear (figure 8-3) than for conventional longline gear (figure 8-4).

8.3.1.1 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 8-3). This number is similar to the estimate of Z from a small sample from CSEO in 1981 and also with Hoenig's geometric mean method for calculating Z (Hoenig 1983). 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 2 year intervals (to avoid zero counts) between the ages of 36 and 96.

8.3.1.2 Growth Parameters

Von Bertalanffy growth parameters for yelloweye are listed in Table 8-4 and length-weight parameters are listed in Table 8-5. These parameters were calculated using 1995 and 1996 port sample data. Because there are so few young fish in the commercial fisheries samples, we supplemented this data set with fish younger than 20 years from all years of port sampling data. A more detailed review of yelloweye age and growth is available in O'Connell and Funk (1986). A recent study by researchers at Moss Landing Marine Laboratory has validated break-and-burn ages for yelloweye using radiometric dating (Mounaix and Cailliet unpublished data). Estimated length and age at 50% maturity for yelloweye collected in CSEO in 1988 are 45 cm and 21 years for females and 50 cm and 23 years for males. 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.

8.3.1.3 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 1986). Sagittal otoliths are collected for aging. The break and burn technique is used for distinguishing annuli (Chilton and Beamish 1983). Researchers at Moss Landing Marine Laboratory (Mounaix and Cailliet, unpublished data), have recently validated this technique for yelloweye rockfish.

Age frequency data from the commercial catch differs somewhat by management area (Figure 8-5a-c). In EYAK, the 1999 age distribution is somewhat bimodal, the largest mode at 33 years, with a second, smaller mode at 43. Mean age of the 1999 sample is 44 years. There is no sign of strong incoming recruitment in this area. 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. The 1999 age data does not show a bimodal distribution and average age has increased by a few years, to 39. There is no sign of an incoming recruitment in these data. In SSEO the 1999 age data shows a strong mode between 18 and 22 years. The mean age has increased in this area as well, to 43 years.

8.3.2 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. However, ADF&G is continuing research to develop and improve a stock assessment approach for these fishes. As part of that research, a manned submersible, *Delta*, was used to conduct line transects to estimate rockfish density (Buckland et al. 1993, Burnham et al. 1980) on the Fairweather Ground in the EYKT section and in the CSEO subdistrict during 1990, 1994, 1995, and 1997 and in NSEO and SSEO in 1994. In 1999 line transects were conducted in EYKT and SSEO. A total of 444 line transects have been run since 1989, 65 of which were run in 1999 (Figure 8-6a-c). 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 therefore 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. Because this is an in-situ method for stock assessment, 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 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 5 minute time intervals and used the corresponding Differential Global Positioning (DPGS) fixes to determine line length.

8.6 ANALYTIC APPROACH

For each area yelloweye density was estimated as

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

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 3.05.0094 of the software program DISTANCE (Laake et al 1993) (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 1998 and 1999 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).

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.

Density Estimates

Changes in density were seen in both areas surveyed in 1999. The model did not fit the data as well in the EYKT area as it did in the SSEO area, most likely do to the lower sample size (Appendix 1).

In the SSEO area, which had not been surveyed since 1994, the estimated density of adult yelloweye increased 38%, from 1,173 adult yelloweye per km^2 to 1,879. Some of this increase may be attributable to the change in survey techniques since 1994 as well as the larger sample size in 1999 (table 8-6).

The EYKT density estimates dropped markedly from the 1997 survey estimates. In both years the EYKT transects occurred on the Fairweather Ground. Density declined 44% from 4,176 adult yelloweye per km^2 to 2, 323. More seafloor was covered in 1999 than in 1997 but less fish were seen and there was a 54% drop in the number of yelloweye per meter traversed (table 8-6).

Habitat Area Estimates

Area estimates of DSR habitat are based on the known distribution of rocky habitat inshore of the 100-fathom edge.

Sidescan Sonar

In 1996 we conducted a side-scan sonar/bathymetric survey for a 536 km^2 area in the CSEO section. The 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 current estimate (Figure 8-7).

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 1132 km^2 to 448 km^2 (Figure 8-8). Because of this great discrepancy, we conducted a sidescan sonar survey on the Fairweather Ground in August of 1998. 780 km^2 of seafloor were surveyed, primarily on the western bank of Fairweather. In the area sidescanned, 452 km^2 was rocky. Although the area surveyed did not cover the entire Fairweather Ground, it is possible to compare techniques by evaluating the difference between the west bank polygon we thought was rock in 1998 (279 km^2 in this polygon) to the sidescan data within that polygon, that documents 218 km^2 of rock habitat (Figure 8-8). The sidescan data, in conjunction with NOS data, submersible dives, and logbook data was used to re-estimate rock habitat for the EYKT area, now estimated at 617 km^2.

Area Estimates

Area estimates of DSR rock habitat were revised in 1999. Originally, an overlay grid was placed on the nautical charts for each region and squares within the grid were classified as either rocky or not rocky based on the available National Ocean Services (NOS) database or logbook information. Grids squares covered approximately 18 km$^{2.}$ The new estimates were based on sidescan sonar data, submersible dive observations, NOS data, and commercial logbook information. Areas of rock habitat were outlined and digitized for input into a GIS (Appendix 2). Changes were significant, and varied by area, with some areas showing an increase and some a decrease in estimated area of rock habitat. The overall change was down 46%, with 3,095 km^2 compared to 5,758 km^2 used in previous assessments (table 8-7). Area estimates will most likely change in the future as we collect more information on habitat.

8.7.1.1 EXPLOITABLE BIOMASS ESTIMATES

Estimates of exploitable biomass (adult yelloweye), with associated standard error, by year and area, are listed in Table 8-7. The only new information added this year was average weight and the standard error of the average weight data. Biomass estimates were down slightly in EYKT (-8%) and CSEO (-2%) and up slightly in SSEO (+3%). The total exploitable biomass for 2000 is estimated to be 14695 mt based on the sum of the lower 90% confidence limits of biomass estimates from each management area.

8.8 PROJECTIONS AND HARVEST ALTERNATIVES

8.8.1 ABC Recommendation

Demersal shelf rockfish are particularly vulnerable to overfishing given their longevity, late maturation, and sedentary and habitat-specific residency. Because of the continued uncertainty in estimation of yelloweye biomass due primarily to difficulties in estimation of total area of rock habitat, we continue to advocate using the sum of the lower 90% confidence limits of biomass by area as the reference number for setting ABC. This results in a biomass estimate of 14,695 mt. It is more appropriate to use the sum of the lower 90% confidence limits of biomass by area to estimate total biomass, as the fishery is managed based on these smaller units. Using the larger number could result in an overharvest of ABC within an individual area.

By applying F=M=0.02 to this biomass and adjusting for the 10% of other DSR species, the recommend 2000 ABC is 330 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.

8.8.2 Overfishing Definition

The overfishing level for DSR is 410 mt. This was derived by applying a fishing rate of F_{30}=0.0279 against the biomass estimate for yelloweye rockfish.

8.9 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 would suggest that we are taking 2% of the exploitable biomass per year and that this level is sustainable. However fishing effort tends to be concentrated in areas of best habitat and high density and it may be that locally, harvest rates exceed overfishing. 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.

The Pacific Fishery Management Council has recently recommended a harvest rate ppolicy 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 263 mt. This ABC would preclude a directed fishery for DSR because halibut bycatch is estimated at 200 to 300 mt annually.

8.10 Summary

M	0.02
2000 Biomass Estimate	14,695
F_{ofl} ($F_{30\%}$)	0.0279
Max F ($F_{40\%}$)	0.025
F_{abc}	0.02
F ($_{avg\ 94\text{-}98}$)	0.02
F ($_{50\%\ F\ max}$)	.019
Overfishing Level	410 mt
Recommended ABC Includes 10% for other DSR	330 mt

8.11 REFERENCES

Adams, P.B. 1980. Life history patterns in marine fishes and their consequences for fisheries management. Fish Bull. 78(1):1-12.

Archibald, C.P., W. Shaw, and B.M. Leaman. 1981. Growth and mortality estimates of rockfish (Scorpaenidae) from B.C. coastal waters. 1977-1979. Can. Tech. Rep. Fish. Aquat. Sc. No. 1048. 57p.

Boehlert, G.W. and M.M. Yoklavich. 1984. Reproduction, embryonic energetics, and the maternal-fetal relationship in the viviparous genus Sebastes. Biol. Bull. 167:354-370.

Boehlert, G.W., M. Kusakari, M. Shimizu, and J. Yamada. 1986. Energetics during embryonic development in kurosoi, Sebastes schlegeli Hilgendorf. J. Exp. Mar. Biol. Ecol. 101:239-256.

Bracken, B.E. and V.M. O'Connell. 1986a. Other rockfish. In R.L. Major (editor), Condition of groundfish resources in the Gulf of Alaska region as assessed in 1986. (Document submitted to the annual meeting of the International North Pacific Fisheries Commission, Anchorage, Alaska, October 1986.) U.S. Dept. Comm., Natl. Oceanic Atmospheric Adm., Natl. Mar. Fish. Ser., Northwest and Alaska Fisheries Center, 7600 Sand Point Way NE. BIN C15700,Bldg. 4, Seattle, WA 98115.

Bracken, B.E. and V.M. O'Connell. 1986b. Longline fisheries monitoring in the eastern Gulf of Alaska, 1980 - 1985. Ak. Dept. Fish and Game Info. Leaflet 258: 47 p.

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

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

Chilton, D.E. and R.J. Beamish. 1983. Age determination methods for fishes studied by the Groundfish Program in the Pacific Biological Station. Can. Spec. Publ. Fish. Aquat. Sci. 60. 102 pp.

Dorn, M. 2000. Advice on west coast rockfish harvest rates from Bayesian meta-analysis of *Sebastes* stock-recruit relationships. Proceedings of the 11th Western Groundfish Conference, Alaska Department of Fish and Game, Sitka, Alaska.

Francis, R.C. 1985. Fisheries Research and Its Application to West Coast Groundfish Management. In T. Frady (editor). Proceedings of the Conference on Fisheries Management: Issues and Options. p. 285-304. Alaska Sea Grant Report 85-2.

Gunderson, D.R. 1980. Using r-K selection theory to predict natural mortality. Can J. Fish. Aquat. Sci. 37:1522-1530.

Hayes, R.J. and S.T. Buckland. 1983. Radial distance models for the line transect method. Biometrics 39:29-42.

Hoenig, J.M. 1983. Empirical use of longevity data to estimate mortality rates. Fish. Bull. 82:898-903.

Leaman, B.M. 1991. Reproductive styles and life history variables relative to exploitation and management of Sebastes stocks. Env. Biol. Fishes. 30:253-271.

Leaman, B.M. and R.J. Beamish. 1984. Ecological and management implications of longevity in some northeast Pacific groundfishes. Int. North Pac. Fish. Comm., Bull. 42:85-97.

Love, M.S., P. Morris, M. McCrae, and R. Collins. 1990. Life History Aspects of 19 rockfish species (Scorpaenidae: Sebastes) from the southern California Bight. NOAA Tech. Rpt. NMFS 87: 38pp.

O'Connell, V.M. 1987. Reproductive seasons for some Sebastes species in Southeastern Alaska. AK. Dept. Fish and Game info. Leaflet 263: 21 p.

O'Connell, V.M. 1991. A preliminary examination of breakaway tagging for demersal rockfishes. Alaska Dept. Fish and Game, Comm. Fish. Div., Fish. Res. Bull. 91-06, 8 p.

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

O'Connell, V.M. and J.T. Fujioka. 1991. Demersal Shelf Rockfishes (Gulf of Alaska) IN Loh-Lee Low (editor). Status of Living Marine Resources off Alaska as assessed in 1991. NOAA Tech. Memo. NMFS F/NWC-211, 95 p.

O'Connell, V.M. and F.C. Funk. 1987. Age and growth of yelloweye rockfish (Sebastes ruberrimus) landed in Southeastern Alaska. In B.R. Melteff (editor). Proceedings of the International Rockfish Symposium. p 171-185. Alaska Sea Grant Report No. 87-2.

Ralston, S. 1998. The status of federally managed rockfish on the U.S. weest coast, pp 6-16. IN:M. Yoklavich (ed.), Marine Harvest Refugia for West Coast Rockfish: a Workshop. NOAA Tech. Memo. NMFS, NOAA-NM-NMFS-SWFCS-225.

Ralston, S., J. Bence, W. Clark, R. Conser, T. Jagielo, and T. Quinn II. 2000. West Coast Groundfish Harvest Rate Policy Workshop AFSC, Seattle, Washington: March 20-23, 2000. Panel Report to the Scientific and Statistical Committee of the Pacific Fishery Management Council.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382pp.

Rosenthal, R.J., L. Haldorson. L.J. Field, V.M. O'Connell, M. LaRiviere, J. Underwood, and M.C. Murphy. 1982. Inshore and shallow offshore bottomfish resources in the Southeastern Gulf of Alaska (1981-1982). Alaska Dept. Fish & Game, Juneau, Alaska. 166 pp.

Table 8-1. 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 8-3. 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

*Z approximately equal to M

Table 8-4. Growth parameters for yelloweye rockfish in Southeast Alaska from 1996 port samples (1996 data set supplemented with all years data for fish less than 20 years old).

Sex	L	K	t_0	N
Male	64.399	0.0512	-5.440	1112
Female	65.929	0.0372	-11.646	1091
Combined	64.403	0.0459	-7.565	2203

Table 8-5. Length-weight relationships (cm-kg) for yelloweye rockfish in Southeast Alaska ($W=aL^b$), from 1995 and 1996 port samples.

Sex	a	b	n
Male	.00013589	2.52061	2045
Female	.000064544	2.71707	2424

Table 8-2 Reported landings of demersal shelf rockfish (mt round weight from domestic fisheries in the Southeast Outside Subdistrict (SEO), 1982-1997[1].

		Directed Landings		Bycatch Landings		Total	
YEAR	Research Catch	AREA 65	AREA 68	AREA 65	AREA 68	SEO[2]	ABC[3]
1982		106	*	14	*	120	*
1983		161	*	15	*	176	*
1984		543	*	20	*	563	*
1985		388	*	100	1	488	*
1986		449	*	41	*	491	*
1987		726	77	47	5	858	*
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[1]	5	97	56	45	24	228	340

[1] Landings from ADF&G Southeast Region fishticket database and NMFS weekly catch reports through November 6, 2000.

[2] Estimated unreported DSR mortality associated with halibut fishery not reflected in totals: 1993= 271 mt, 1994=353 mt, 1995=130 mt, 1996=156 mt, 1997=204, 1998=214, 1999=324, 2000=207.

[3] Prior to 1993 TAC for FMP area 65 only.

Table 8-6. Sample size (transects), number of yelloweye observed, meters surveyed, and fish/line length for line transect surveys in EYKT, CSEO, and SSEO.

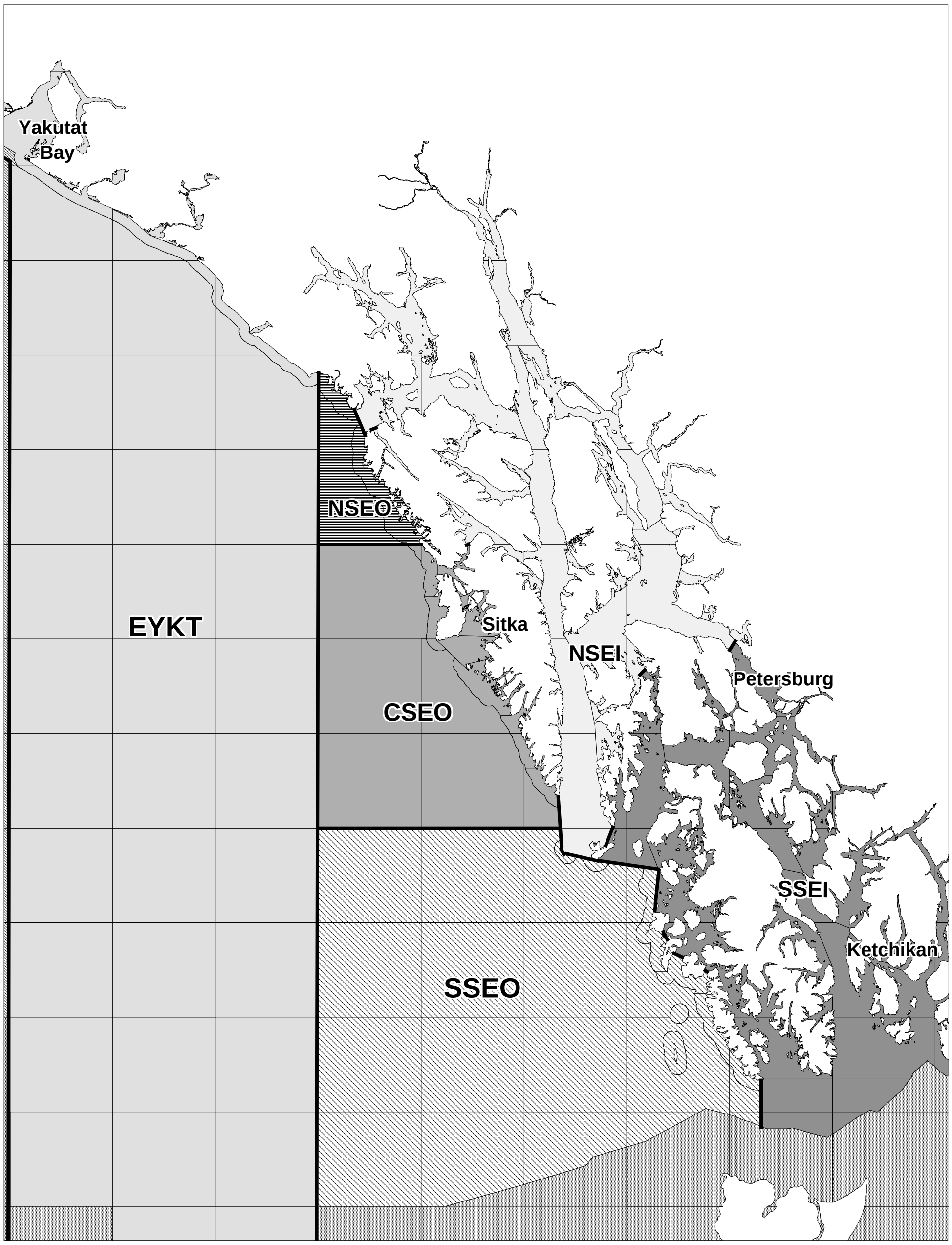
Area	Year	# transects (k)	# yelloweye	Meters surveyed	YE/M	Density
EYKT	1997	18	256	17238	.01485	4176
	1999	20	206	25646	.00803	2323
CSEO	1995	24	235	39368	.00597	2929
	1997	32	166	29176	.0057	2534
SSEO	1994	13	99	18991	.005213	1173
	1999	45	288	49663	.00579	1879

Table 8-7. Estimated Area of Rocky Habitat

Area	Total habitat inside 200 m 1999 estimate	Rock Habitat inside 200 m 1999 estimate	Previous estimate of rock habitat	Percent Change
EYKT	16,240	703	716	+ 2%
Fairweather	3,000	617	448	+27%
Other EYKT	13,200	86	268	-68%
NSEO	1,848	357	896	-60%
CSEO	4,141	1,184	1,997	-41%
SSEO	6,066	851	2,149	-60%
SEO total	28,255	3095	5,758	-46%

Table 8-8. 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)**
01	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**
00	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**
98/99	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	839	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**
96/97	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	839	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	1683	0.10	4.05	268	1686	1414
	EYKT total	1994			4.05	716	5829	4957
	CSEO	Revised 1994	1683	0.10	2.70	1997	9076	7583
	NSEO	Revised 1994	839	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**



.

Figure 8-1. 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

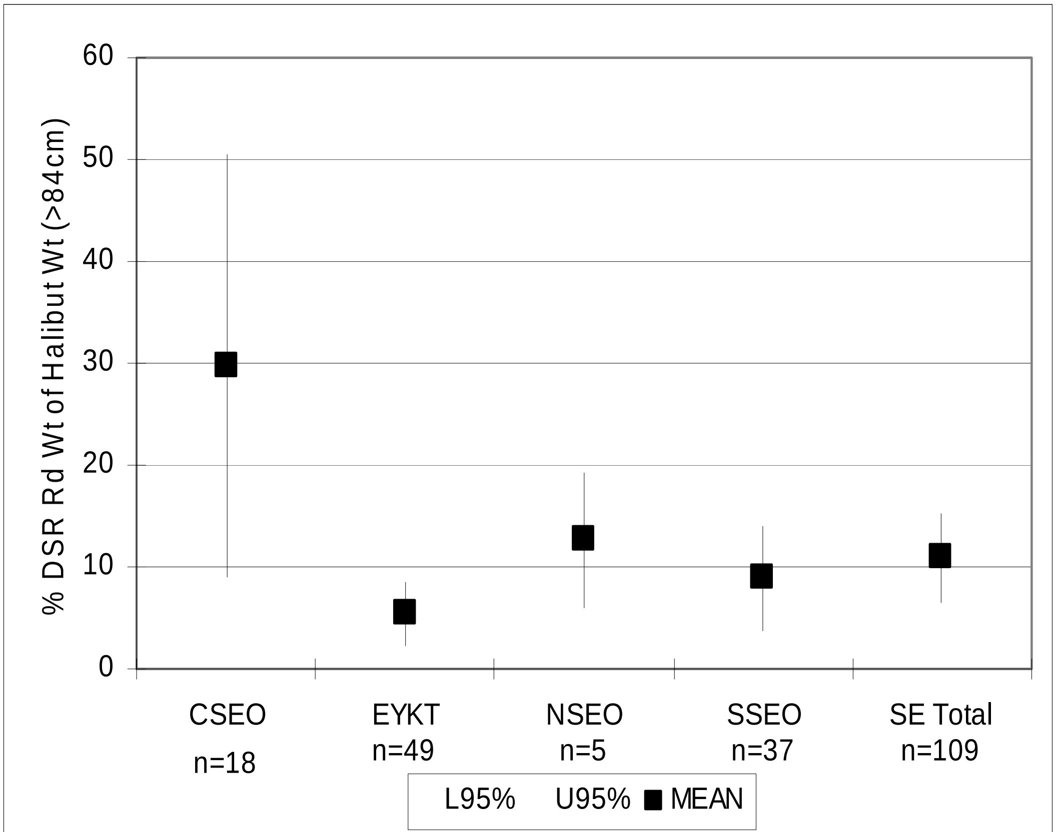


Figure 8-2. IPHC longline survey data: % yelloweye (rd weight)/halibut (legal fish, rd weight).

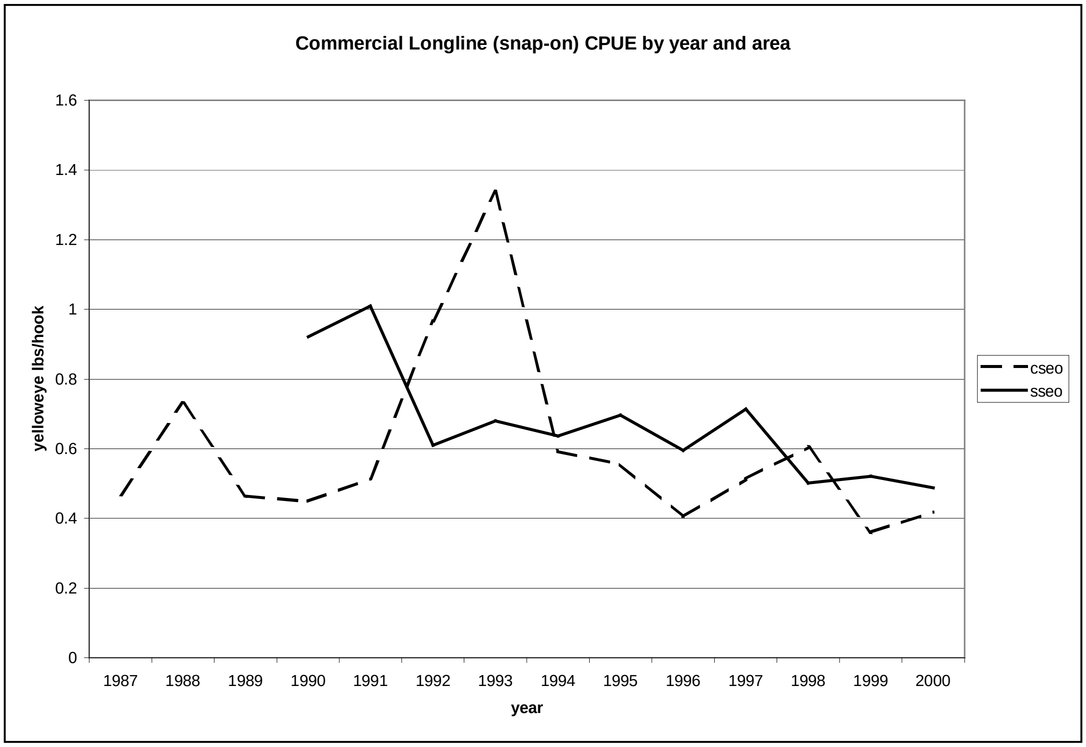


Figure 8-3. Commercial fishery catch per unit effort data, snap on longline gear for CSEO and SSEO, by year.

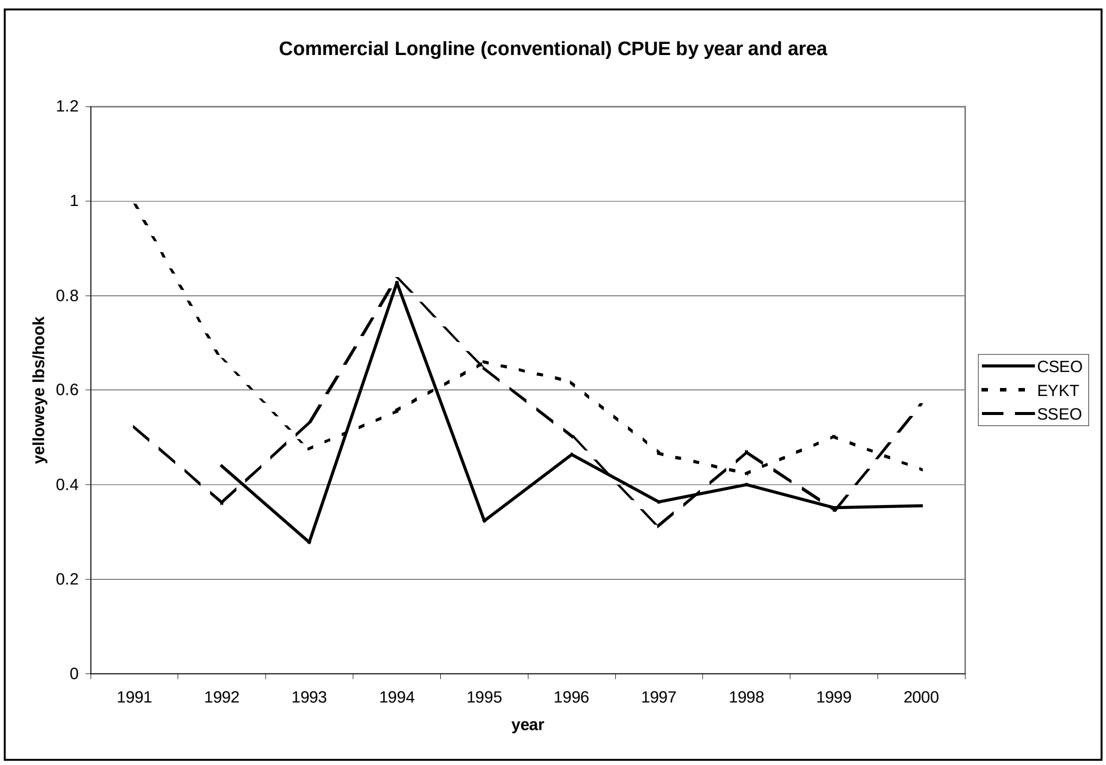


Figure 8-4. Commercial fishery catch per unit effort data, conventional longline gear, by area, and year.

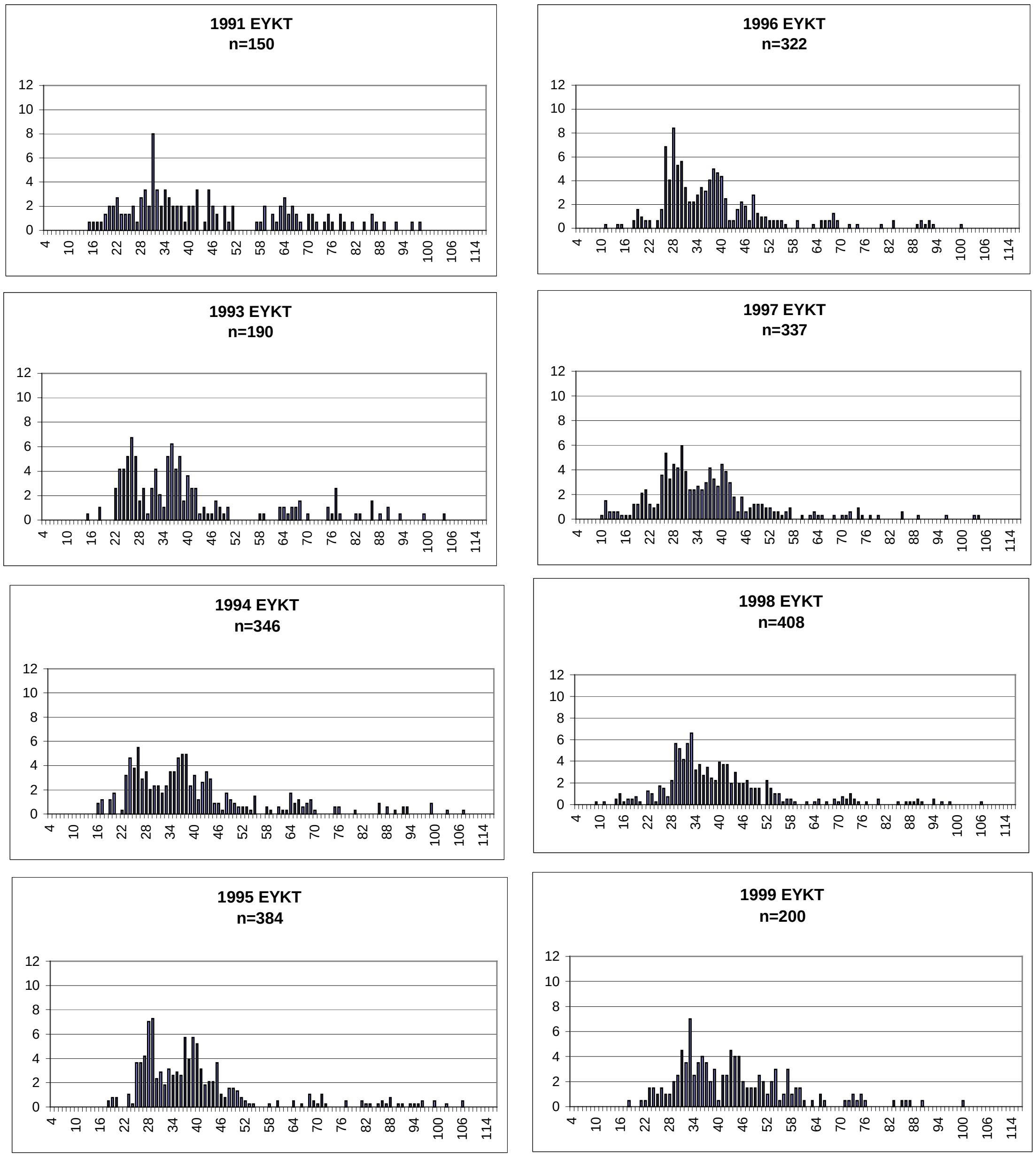


Figure 8-5a. Yelloweye rockfish age frequency distributions from EYKT commercial port samples.

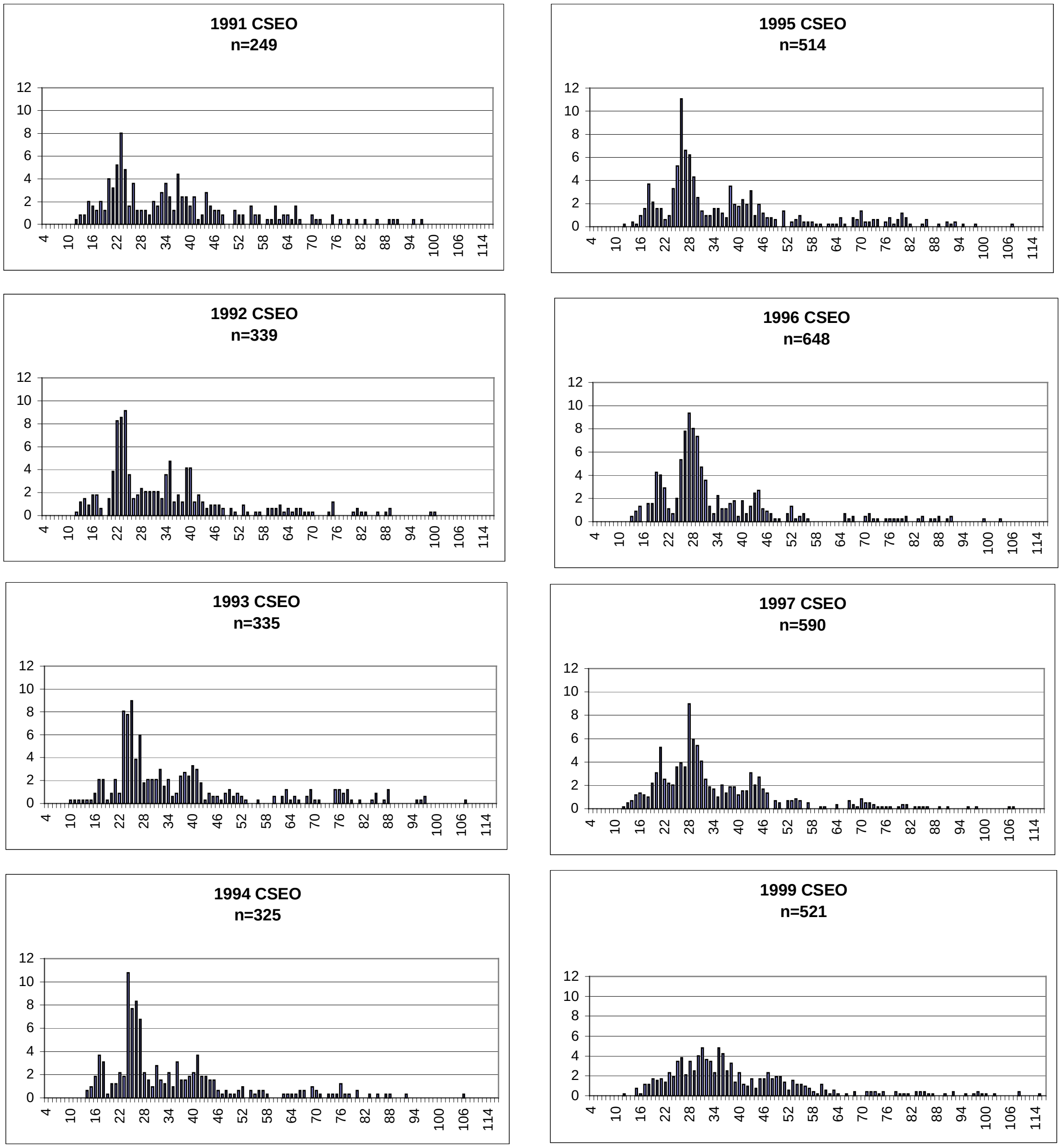


Figure 8-5(b). Yelloweye rockfish age frequency distributions from CSEO port samples.

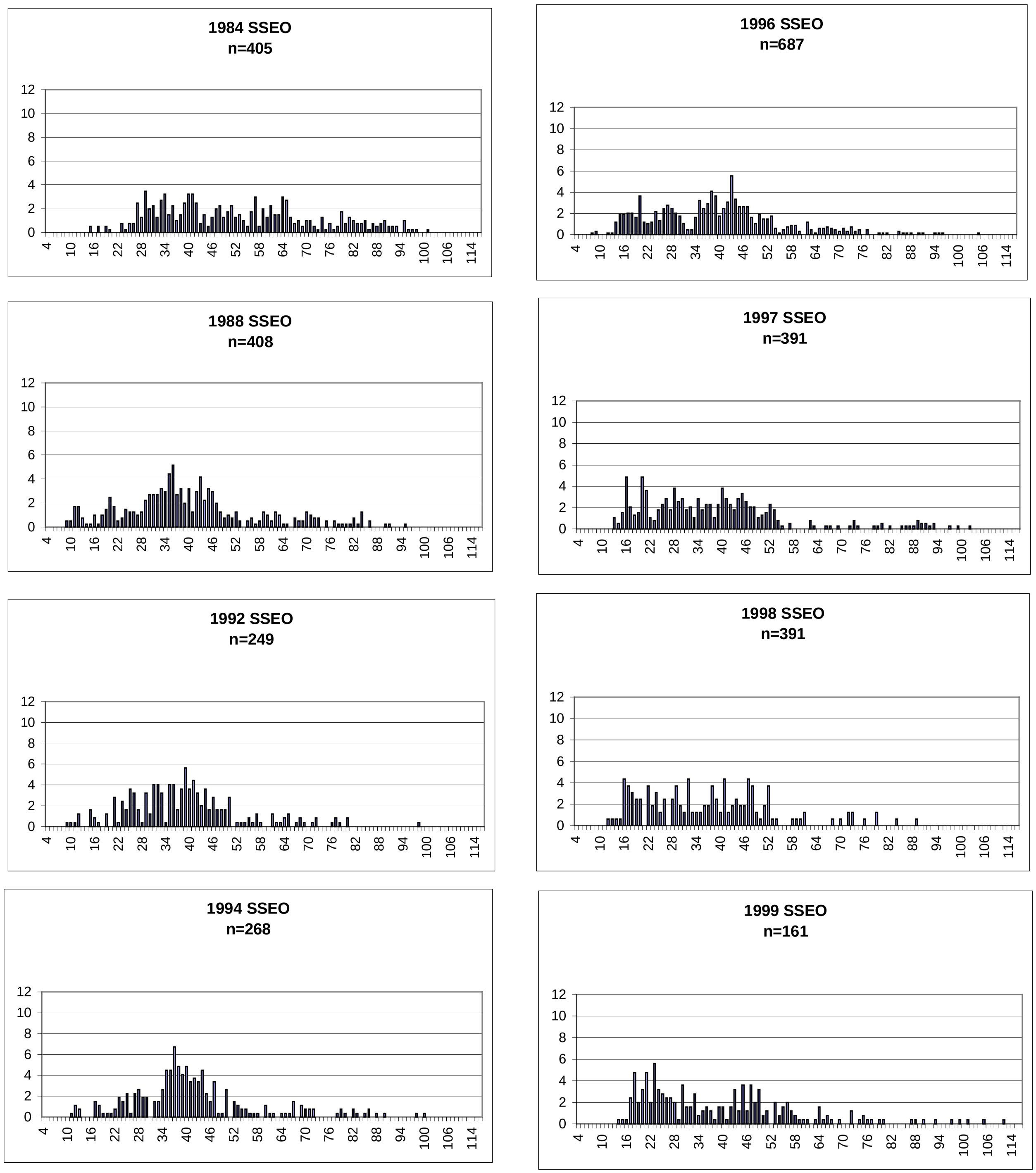


Figure 8-5c. Yelloweye rockfish age frequency distributons from SSEO commercial port samples.

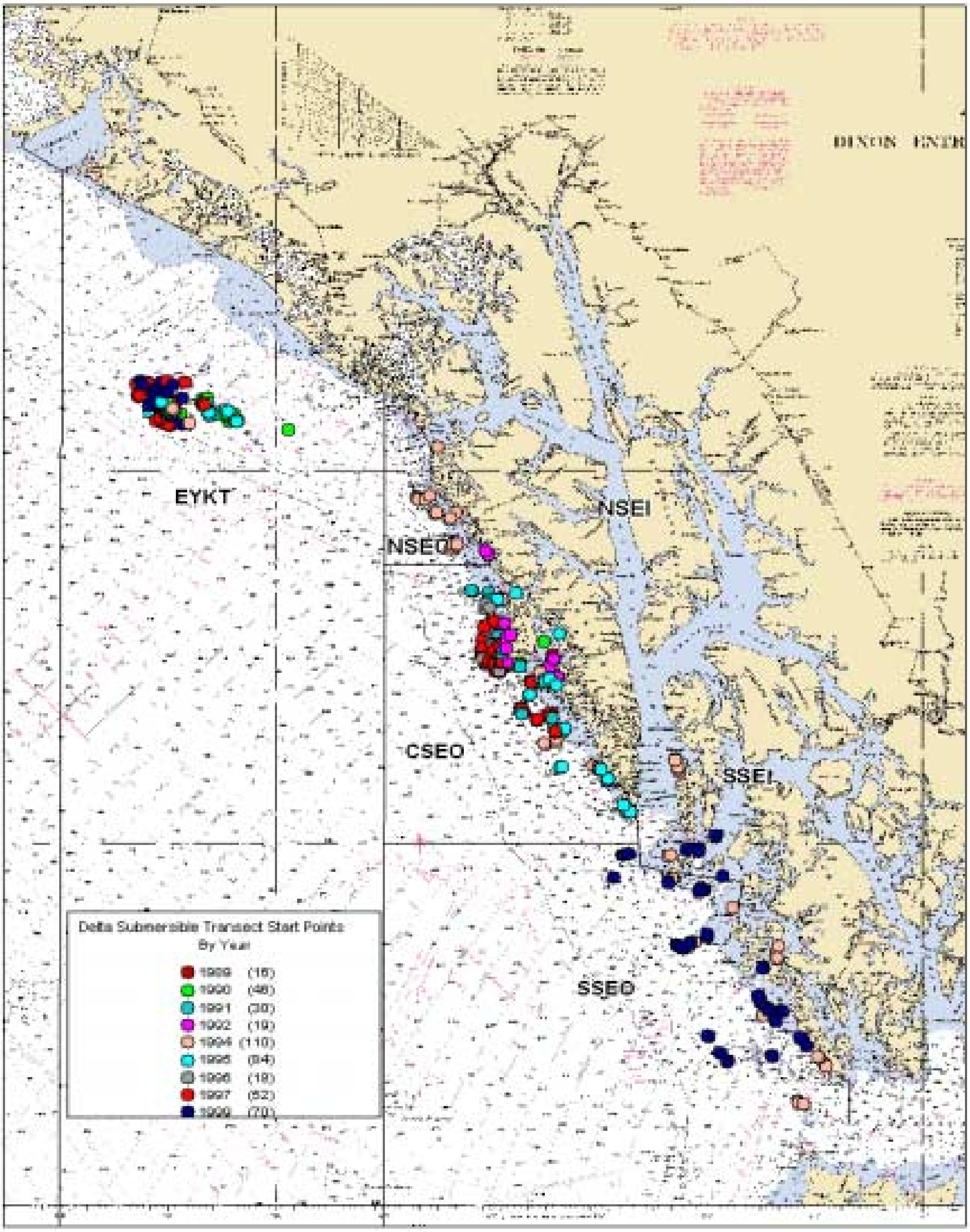


Figure 8-6a. Location of submersible live transects dives, Southeast Alaska 1990-1999.

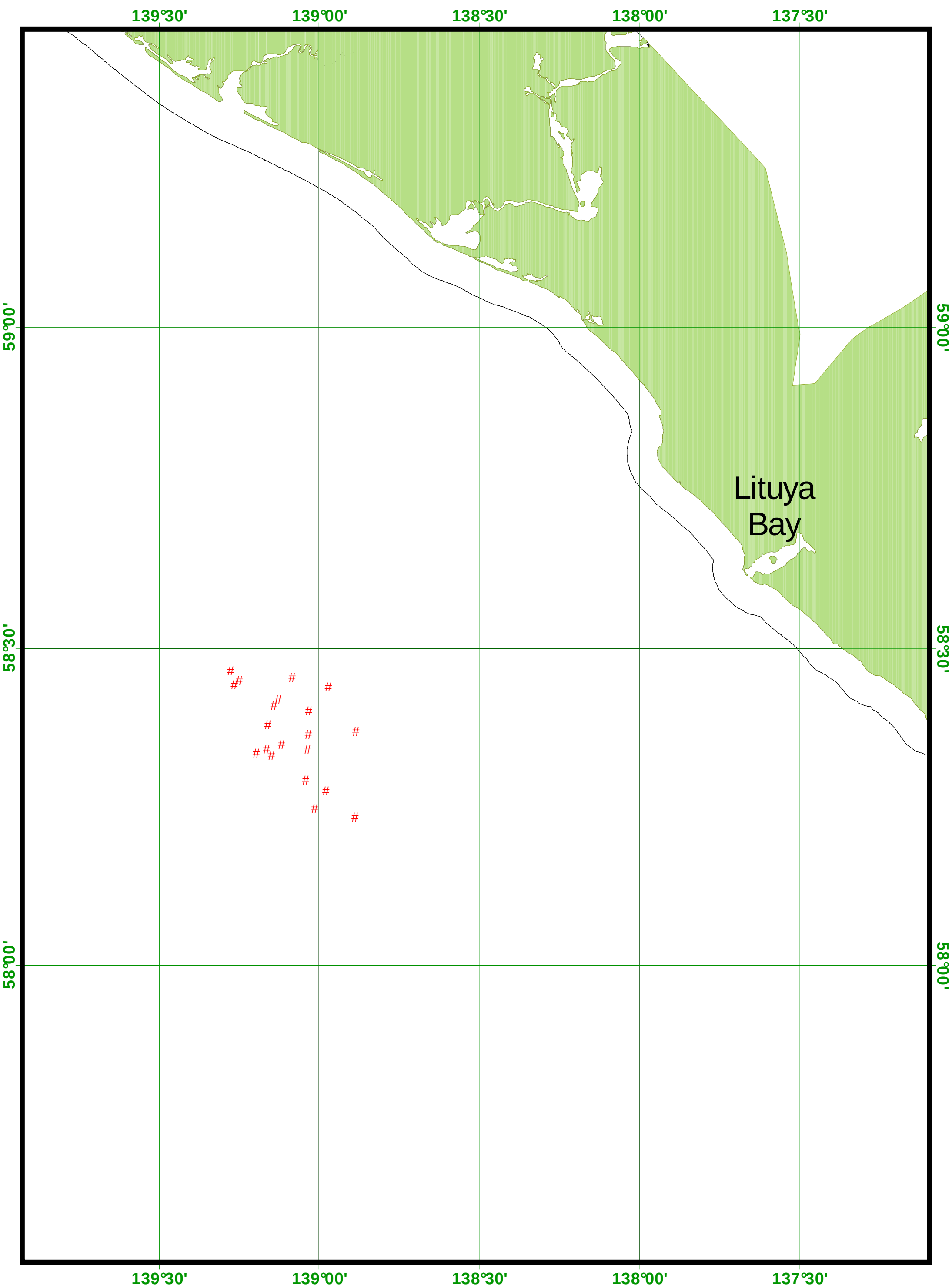


Figure 8-6b. Location of submersible transect dives, EYKT, 1999 survey.

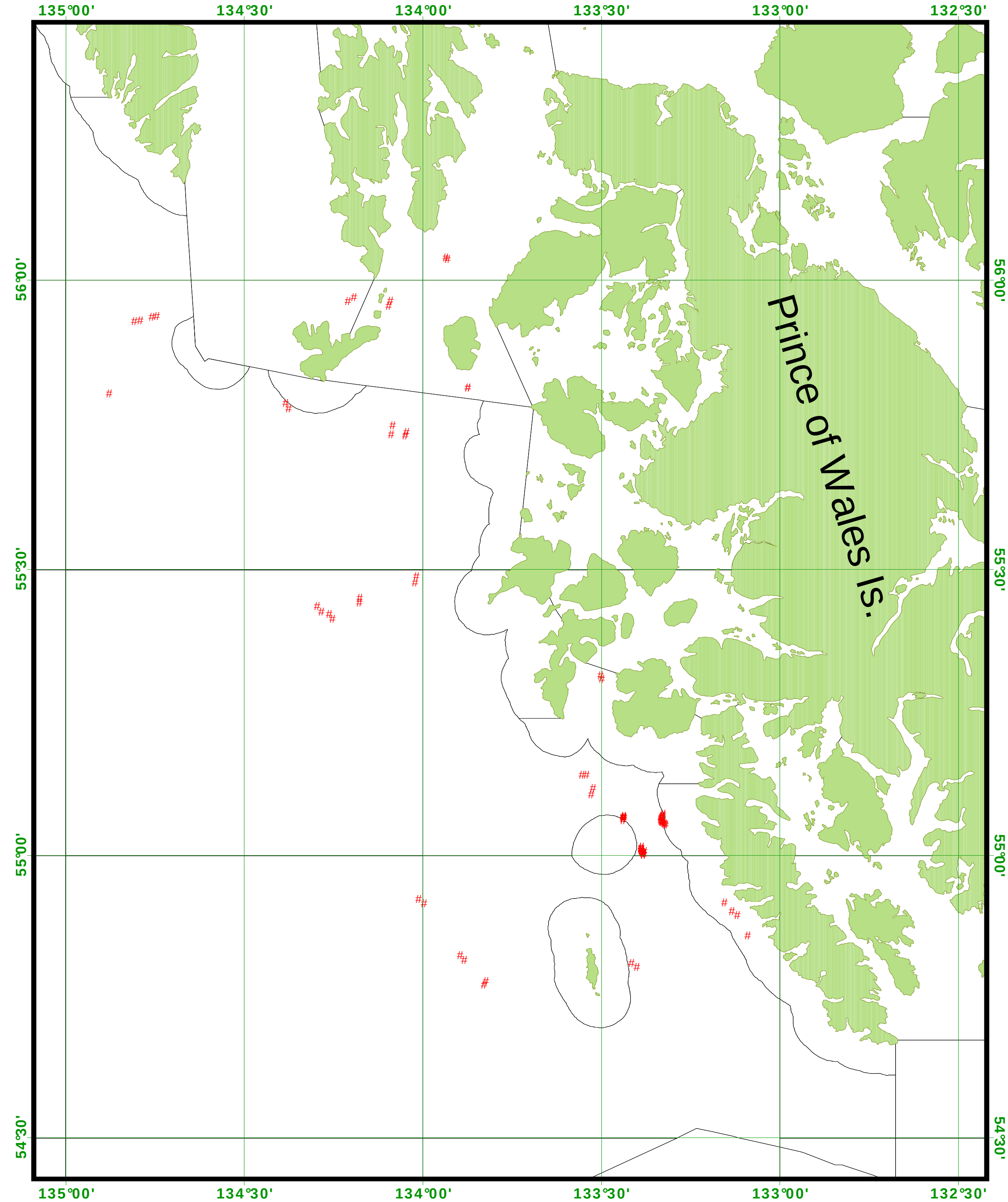


Figure 8-6c. Locations of submersible transect dives,SSEO, 1999 survey.

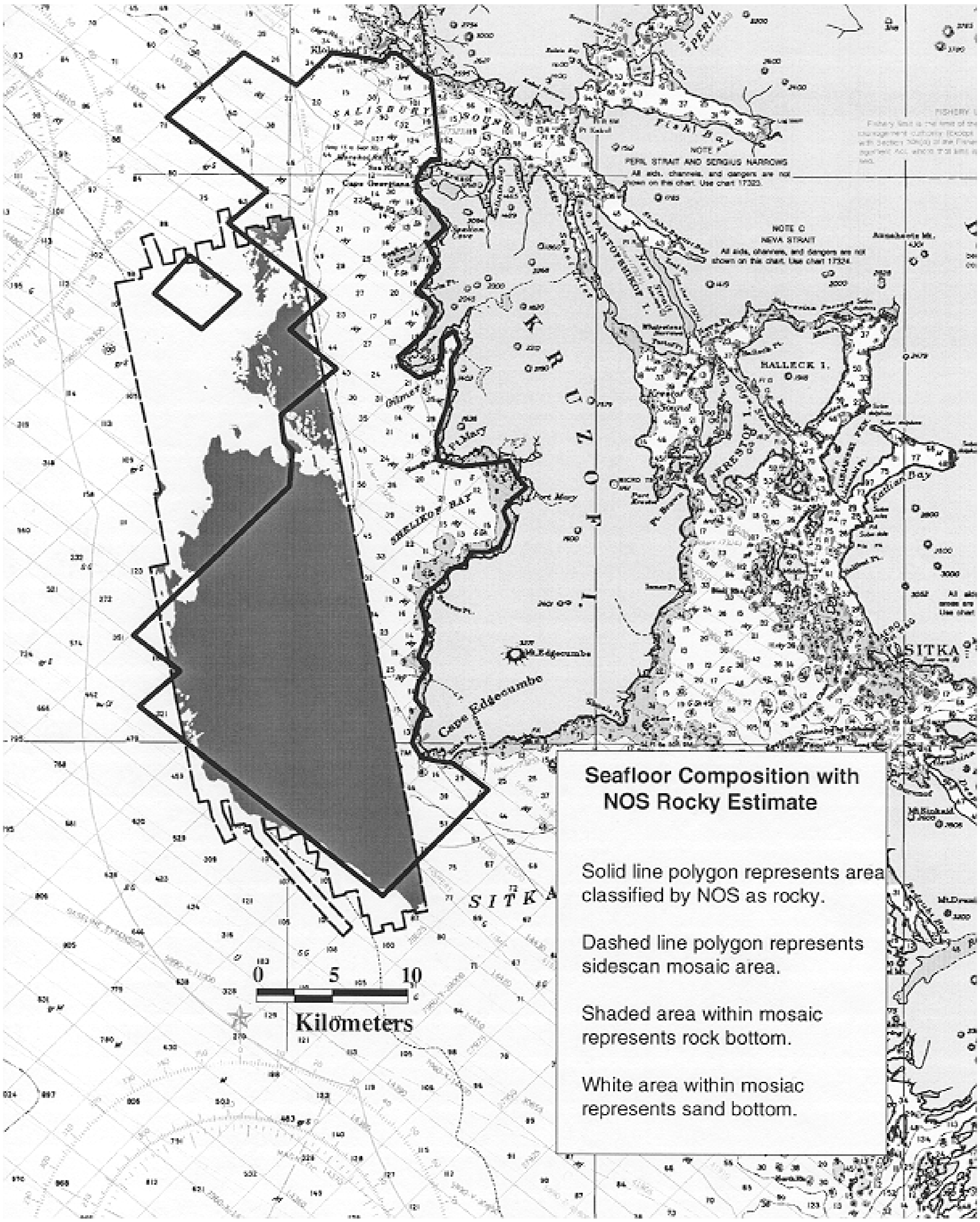


Figure 8-7. Comparison of area of rock habitat using NOS data versus geological interpretation using sidescan sonar data for a 536 sq. km are of seafloor off Kruzof Island.

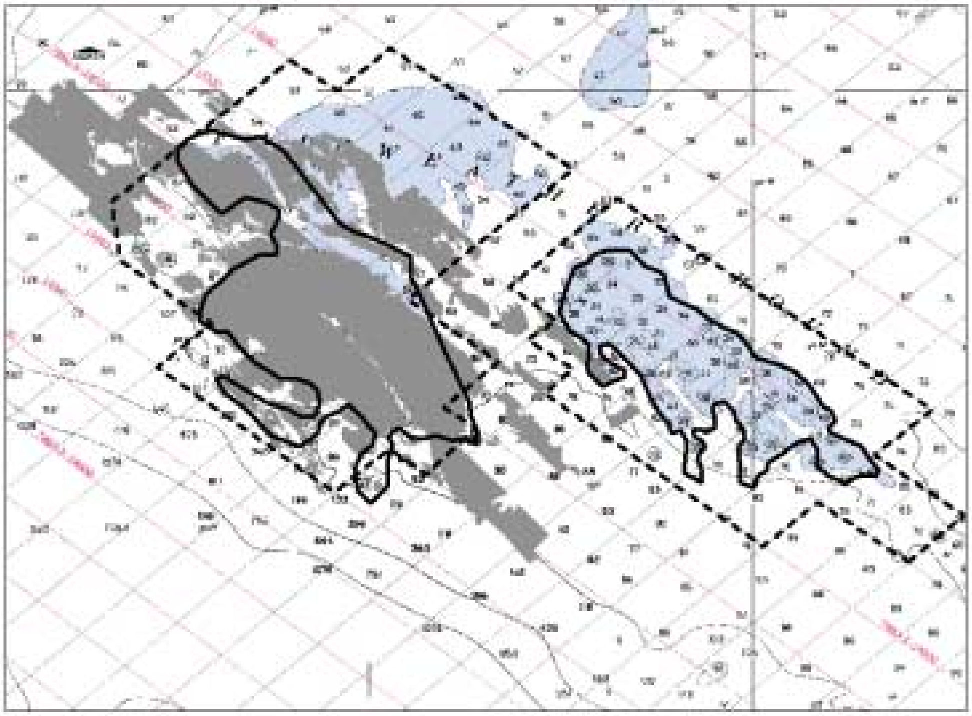
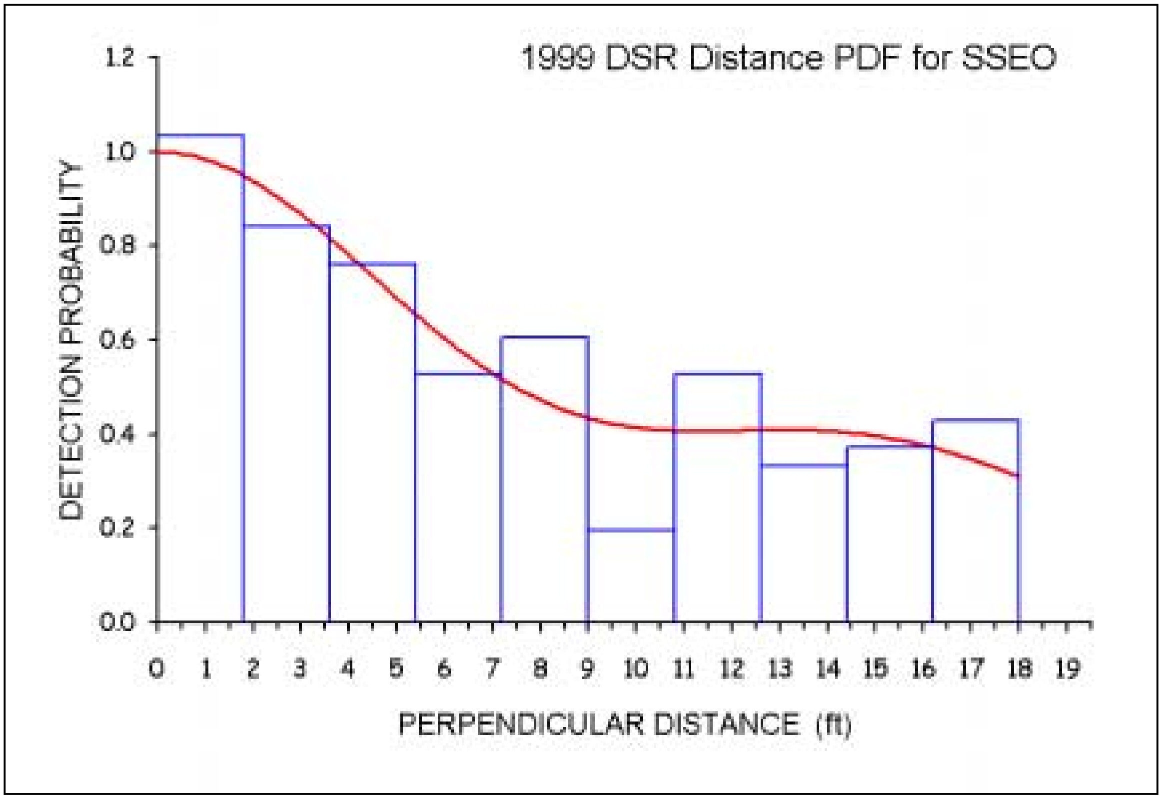
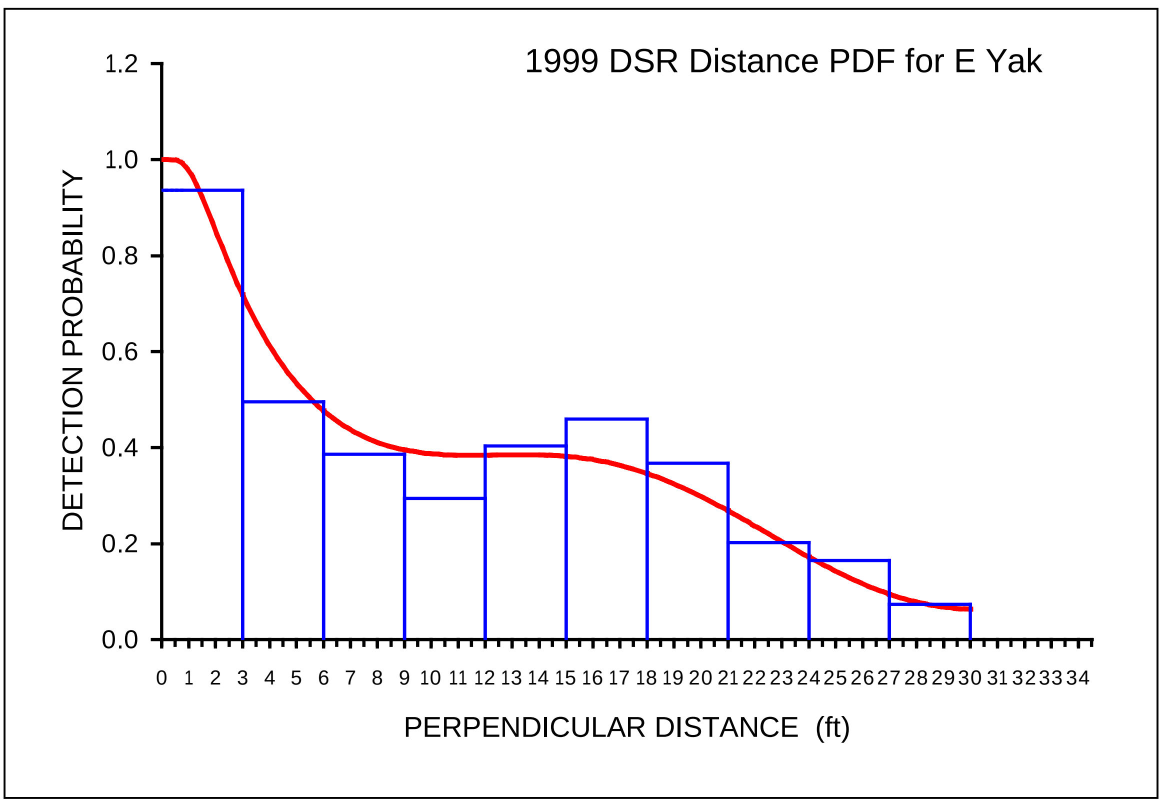
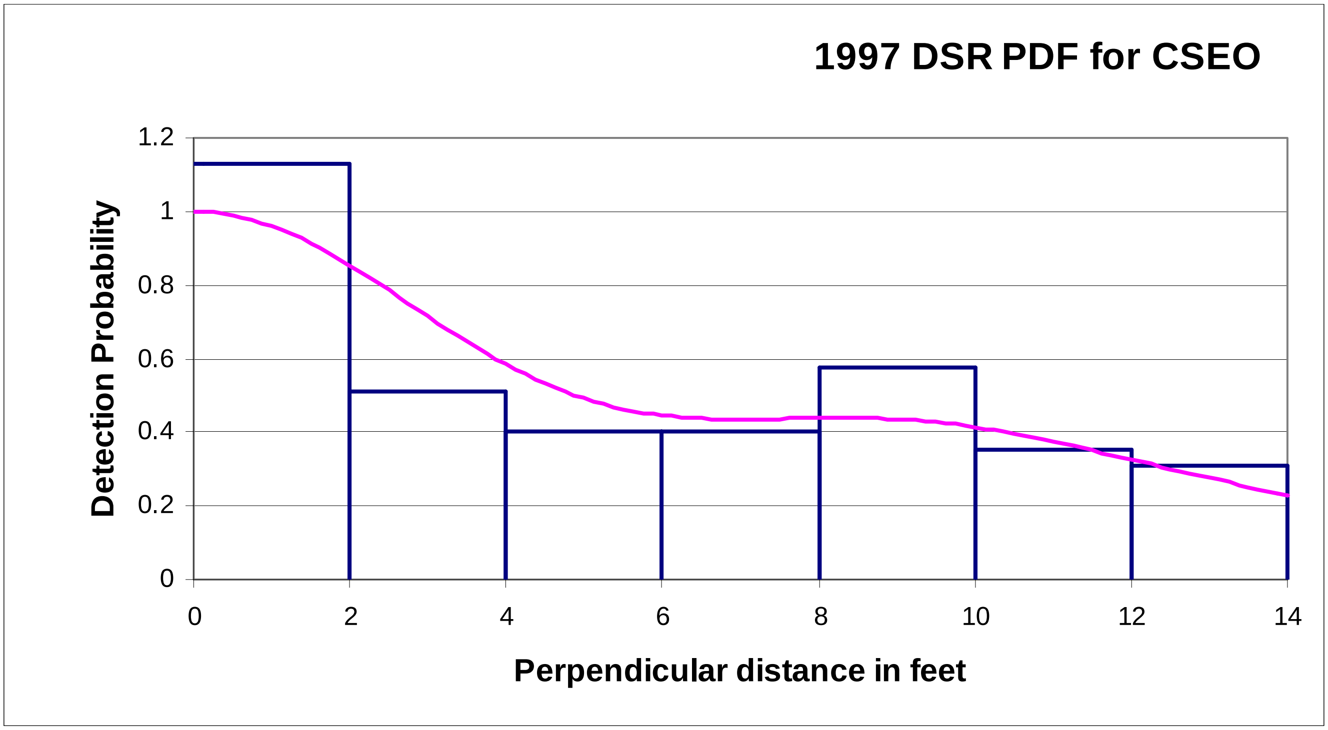


Figure 8-8. Comparison of delineation of rock habitat based on NOS data (dashed line) versus bottom recorder and submersible direct observation data (solid line) versus sidescan data (grey shaded area) for Fairweather Ground.

APPENDIX I. DISTANCE OUTPUT FOR 2001 ASSESSMENT






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

	November 2000: Distance Output for Yelloweye Rockfish	*From Program DISTANCE*									
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	0.0008654	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	**838.7**	233.02	0.2778	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.

1. Densities estimated using Version 2.01 of Program DISTANCE or 1999 windows-based version.
2. Log-based confidence intervals are used because the distribution of D is positively skewed & an interval with better coverage is obtained by assuming
that D is log-normally distributed. (Buckland et al. 1993. Distance sampling: Estimating abundance of biological

populations. Chapman & Hall)
3. Note, under 'Detection Function Description', that different detection functions were investigated with differing truncations, etc. The function judged to provide the
best fit to the DSR data was used in estimating biomass. This differs from the 1993 S.A.F.E. work, when hazard functions were used for all density estimates.
4. AIC (from Program DISTANCE output) is Akaike's Information Criterion. A lower AIC is better, indicating a better fit of the function to the data and fewer parameters
in the function.
5. Weights are from 1999 port sampling data (nseo data from 1996)

					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	
288	1847.0114	0.0837	0.1492252	74.9		1339.40	2635.72	1415.86	2493.37	
166	659.19946	0.1288	0.1547	81.00	Irregular; small shoulder; MARGINAL FIT @ ORIGIN	1705.69	3764.25	1819.90	3528.03	
39	116.11148	0.0293	0.2778	8.00	not available	447.21	1572.89	505.11	1392.60	
206	976.54069	0.2685	0.1516973	170.4		1281.08	4210.52	1410.85	3823.23	

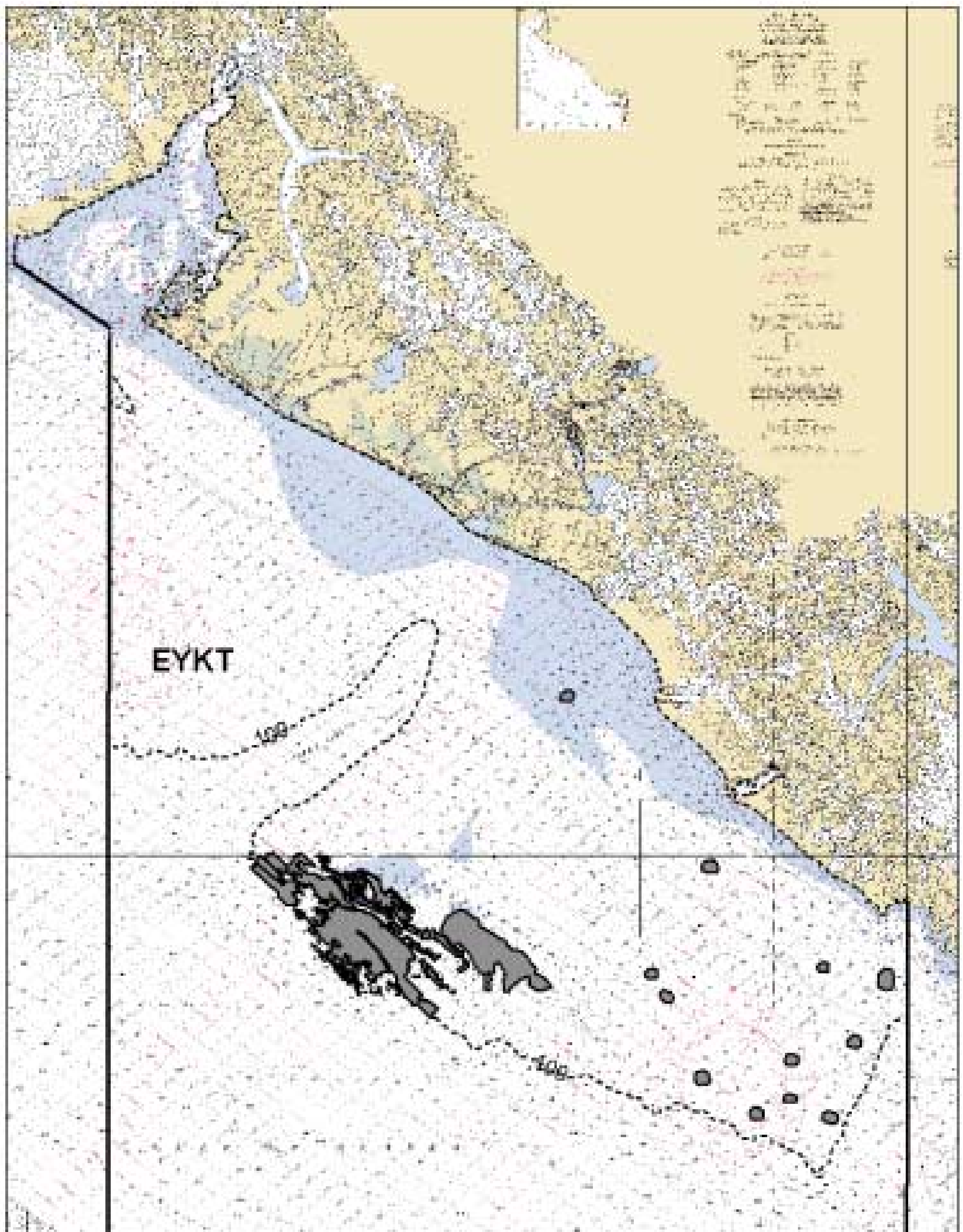
	1999 Mean Wt. (kg) [w]	1999 Std. Error Mean Wt. [s.e.(w)]	CV[w]	Area of Rocky Habitat (km^2) [A] (1999 estimate)	Biomass (kg) for Area [bk]	*Biomass (mt) for Area [bm]*	Var(biomass) for Area [Var(bk)]	CV(bk)	Lower 90% CL (kg) [l90]
Area	Formulae to the right indicate how parameters are estimated -->				= 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	3.14	*0.0697*	*0.0222*	*851.00*	*5020683.85*	*5020.68*	*737948013916.40*	*0.1711*	*3796708.70*
CSEO	3.050	0.0423	0.0139	1184.00	9,150,419.68	9150.42	3395522986438.26	0.2014	6591753.30
NSEO	*2.980*	*0.0953*	*0.0320*	*357.00*	892,259.38	892.26	62254087512.00	0.2796	568150.63
EYKT (All)	3.76	0.06	*0.0152*	*703.00*	6,139,017.80	6139.02	3593235475778.34	0.3088	3736864.94

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	*6639241.58*	*3796.71*	*6639.24*	75.934174	84.37130443
CSEO	12702262.44	6,591.75	12,702.26	131.83507	146.4834066
NSEO	1401260.10	568.15	1,401.26	11.363013	12.62556953
EYKT (All)	10085336.27	3,736.86	10,085.34	74.737299	83.04144317
	Totals, mt:	14693.48		293.86955	326.5217238

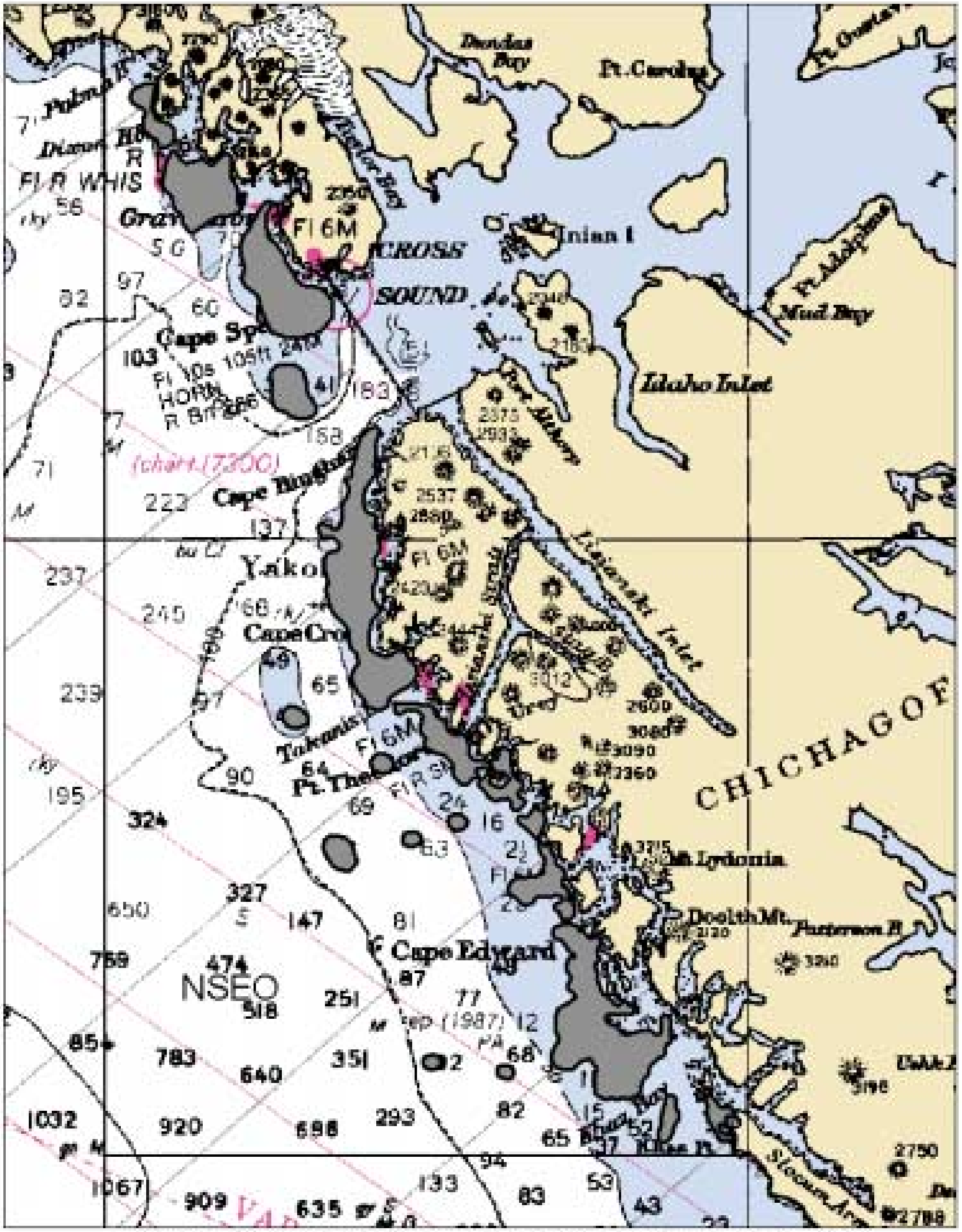
APPENDIX II.

CHARTS DELINEATING AREA OF ROCK HABITAT INSIDE THE 200 M CONTOUR, 1999 ESTIMATES

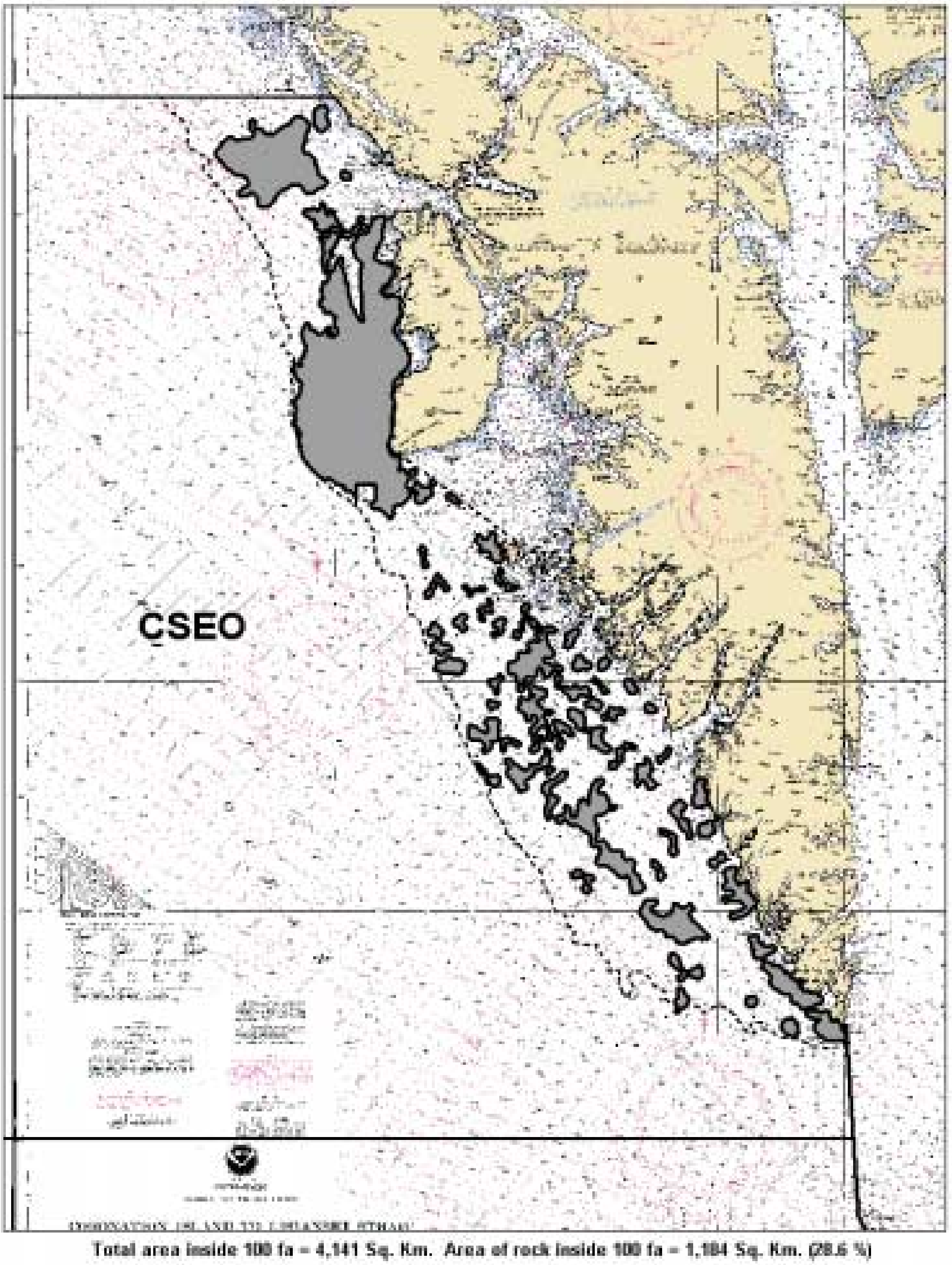


EYKTtotal area inside 100 fathoms:16,240 Sq. Km. Rocky area: 702.5 Sq.Km.

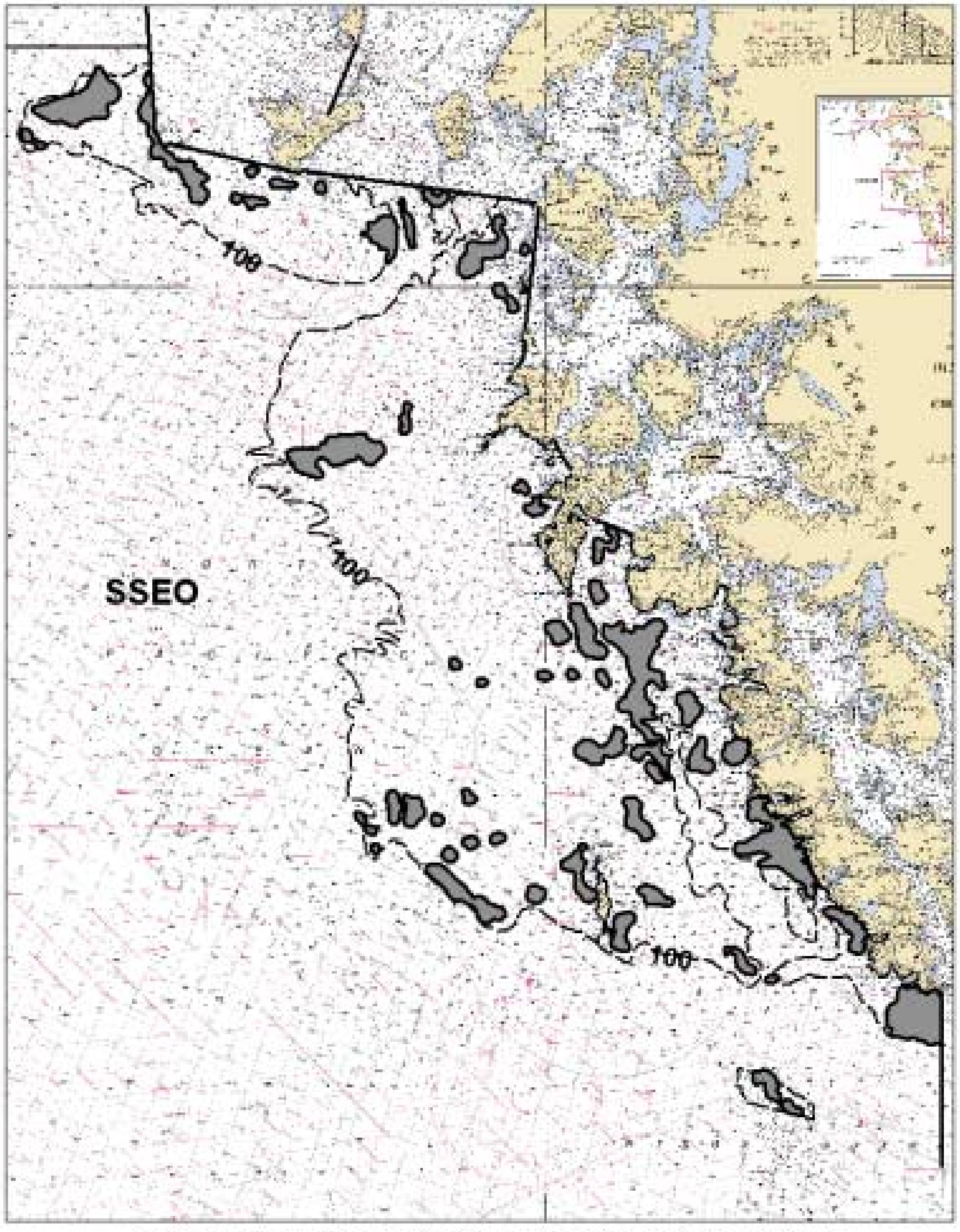
Figure i. Shaded area represents rock habitat.



Total area inside 100 Fa = 1,848 Sq. Km.   Total rock inside 100Fa = 356.7 Sq. Km. (19.3%)



Total area inside 100 fa = 4,141 Sq. Km. Area of rock inside 100 fa = 1,184 Sq. Km. (28.6 %)



Total area inside 100 fathoms = 6,066 Sq. Km. Area of rocky habitat is 851.4 Sq. Km.