Section 10

PACIFIC OCEAN PERCH

by
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Executive Summary

Relative to last year's final BS/AI SAFE report, the following major changes have been made in the current draft of the Pacific ocean perch chapter:

Changes in 'the Input Data

(1) The 1998 harvest levels for Pacific ocean perch have been revised and harvests through September 25, 1999 have been included in the assessment.

(2) Age composition information from the 1994 and 1997 Aleutian Islands Triennial Surveys have now been included in the assessment

Changes in the Assessment Methodolow

(1) The stock synthesis model configuration and assessment methodology remains essentially unchanged from that used in last year's assessment.

(2) In accordance with the status determination criteria defined by Amendments 56, $F_{35\%}$ now replaces the $F_{30\%}$ rate as the basis of determining the overfishing level.

(3) Current biomass estimates for northern, rougheye, and shortraker rockfishes have been revised to include only the U.S. domestic trawl surveys (1988-1997).

Changes in the Assessment Results

(1) A summary of the 1999 ABC's relative to the 1998 recommendations is as follows:

	Eastern Bering Sea		Aleutian Islands	
	Last Year	This Year	Last Year	This Year
Pacific ocean perch	1,900 t	2,600 t	13,500 t	12,300 t
Northern/Sharpchin	537 t	34t	4,230 t	5,153 t
Rougheye/Shortraker	236 t	160t	965 t	646 t

(2) A summary of the 1999 OFL's relative to the 1998 recommendations is as follows:

	Eastern Bering Sea		Aleutian Islands	
	Last Year	This Year	Last Year	This Year
Pacific ocean perch	3,600 t	3,100 t	19,100 t	14,400 t
Northern/Sharpchin	716 t	45 t	5,639 t	6,870 t
Rougheye/Shortraker	315 t	214 t	1,287 t	1,180 t

INTRODUCTION

Pacific ocean perch (*Sebastes alutus*) inhabit the outer continental shelf and upper slope regions of the North Pacific Ocean and Bering Sea. The management of Pacific ocean perch in these areas has been divided into two geographic units corresponding to the eastern Bering Sea slope and the Aleutian Islands region. The management stock from the Aleutian Islands region is the larger of the two.

Pacific ocean perch, and four other associated species of rockfish (northern rockfish, *S. polyspinis*; rougheye rockfish, S. *aleutianus*; shortraker rockfish, *S. borealis*; and sharpchin rockfish, *S. zacentrus*) were managed as a complex in the two distinct areas from 1979 to 1990. Known as the POP complex, these five species were managed as a single entity with a single TAC (total allowable catch). In 1991, the North Pacific Fishery Management Council enacted new regulations that changed the species composition of the POP complex. For the eastern Bering Sea slope region, the POP complex was divided into two subgroups: 1) Pacific ocean perch, and 2) shortraker, rougheye, sharpchin, and northern rockfishes combined, also known as "other red rockfish." For the Aleutian Islands region, the POP complex was divided into three subgroups: 1) Pacific ocean perch, 2) shortraker/rougheye rockfishes, and 3) sharpchin/northern rockfishes. These subgroups were established to protect Pacific ocean perch, shortraker rockfish, and rougheye rockfish (the three most valuable commercial species in the assemblage) from possible overfishing. Each subgroup is now assigned an individual TAC.

Of the five species which comprise the POP complex, S. *alutus* has historically been the most abundant rockfish in this region and has contributed most to the commercial rockfish catch. Furthermore, the bulk of the research on rockfish has been concentrated on S. *alutus*; relatively little biological or assessment information is available for the other rockfish species. Consequently, this assessment deals primarily with Pacific ocean perch, S. *alutus*.

FISHERY

Pacific ocean perch were highly sought by Japanese and Soviet fisheries and supported a major trawl fishery throughout the 1960s. Catches in the eastern Bering Sea peaked at 47,000 (metric tons, t) in 196 1; the peak catch in the Aleutian Islands region occurred in 1965 at 109,100 t. Apparently, these stocks were not productive enough to support such large removals. Catches continued to decline throughout the 1960s and 1970s, reaching their lowest levels in the mid 1980s. With the gradual phase-out of the foreign fishery in the 200-mile U.S. Exclusive Economic Zone (EEZ), a small joint-venture fishery developed but was soon replaced by a domestic fishery by 1990. In 1990 the domestic fishery recorded the highest Pacific ocean perch removals since 1977. The history of *S. alutus* landings since implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) is shown in Table 10- 1. Catches of "other red rockfish" from the eastern Bering Sea since 1993 are shown in Table 10-2. Shortraker/rougheye and sharpchin/northern removals from the Aleutian Islands region for the same time period are also provided in this table.

Estimates of retained and discarded Pacific ocean perch from the fishery have been available since 1990. Table 1 O-3 sumarizes this information for *S. alutus* in both regions. The eastern Bering Sea region generally shows a higher discard rate than in the Aleutian Islands region. For the period from 1990 to 1999, the Pacific ocean perch discard rate in the eastern Bering Sea averaged about 22.0%; whereas, in the Aleutian Islands region, the discard rate for the same period averaged about 14.9%. Much higher discard rates are evident for the other species in the POP complex (Table 1 O-4). Of particular note are the high discard rates observed for the sharpchin/northern complex in the Aleutian Islands region. For the period from 1993 to 1999, the average discard rate for this complex amounted to about 80.3%.

DATA

Fisherv Data

Catch per unit effort (CPUE) data from Japanese trawl fisheries indicate that Pacific ocean perch stock abundance has declined to very low levels in the Aleutian Islands region (Ito 1986). By 1977, CPUE values had dropped by more than 90-95% from those of the early 1960s. Japanese CPUE data after 1977, however, is probably not a good index of stock abundance because most of the fishing effort has been directed to species other than Pacific ocean perch. Standardizing and partitioning total groundfish effort into effort directed solely toward Pacific ocean perch is extremely difficult. Increased quota restrictions, effort shifts to different target species, and rapid improvements in fishing technology undoubtedly affect our estimates of effective fishing effort. Consequently, we included CPUE data primarily to evaluate its consistency with other sources of information. We used nominal CPUE data for class 8 trawlers in the eastern Bering Sea and Aleutian Islands regions from 1968- 1979. During this time period these vessels were known to target on Pacific ocean perch (Ito 1982).

Otoliths collected by the NMFS domestic observer program in 1990 were analyzed for age composition estimates. Estimates of catch length frequency data from 1993 to 1996 were updated and added to the Aleutian Islands fishery data series. Updated length frequency data from the 1993 and 1994 eastern Bering Sea fishery were also included in the analysis. Within synthesis, fits to annual length-frequency data from the commercial fishery and surveys were weighted by the square root of sample size.

Survey Data

Biomass estimates of S. *alutus* in the eastern Bering Sea were derived from cooperative U.S.-Japan trawl surveys from 1979 to 1985. These estimates were based almost entirely on data collected by Japanese vessels sampling the continental slope (the area of greatest Pacific ocean perch abundance). In 1988, the U.S. vessel ***Miller Freeman*** sampled the continental slope for the first time. This vessel was again used to sample the continental slope during the 199 1 eastern Bering Sea survey. This complicates the comparison of the 1988 and 199 1 estimates with those from earlier years. To solve this problem, the Japanese provided a landbased trawler in 1988 to conduct side-by-side trawling operations with the ***Miller Freeman*** so that it would be possible to relate the ***Miller Freeman*** data to that of the Japanese vessels which sampled the slope in the past.

The 1988 and 1991 biomass estimates are not directly comparable with estimates from previous years because the area of the slope sampled by ***the Miller Freeman*** was less than that sampled by the Japanese ***vessels*** in 1979-85. The ***Miller Freeman*** sampled from 200-800 m whereas the Japanese vessels sampled from 200- 1,000 m in previous years. To better evaluate the trend in abundance of *S. alutus* as shown by the 1988 and 199 1 trawl data the biomass estimates for earlier years were recalculated using data only from the 200-800 m depth interval.

Biomass estimates for the 200-1,000 m depth interval in 1988 and 1991 were also calculated. These were derived by using the average of the ratios between the biomass estimates from the 200-800 m and 200-1,000 m depth intervals in 1982 and 1985 which was 0.7810. Applying this average to the 1988 biomass in the 200-800 m depth interval (28,882/0.7810) produced an estimate for the 200-l ,000 m depth interval of 36,981 t. For 1991, biomass was estimated at 14,562 t (11,373/0.7810). Biomass estimates of *S. alutus* for the 200-1,000 m depth interval from cooperative U.S.-Japan trawl surveys (1979-1985) and U.S. domestic trawl surveys (1988- 199 1) are shown in Table 1 O-5.

The biomass estimate for the eastern Bering Sea has two surveyed components--the eastern Bering Sea shelf-slope component and the Aleutian Islands component of Bering Sea statistical Area I. The eastern Bering Sea shelf-slope component increased between the 1979-82 and the 1985 surveys, reflecting the variability among the point estimates (Fig. 10- 1). For example, there is a sixfold increase from 1982 to 1985 while from 1985 to 1988, biomass appeared to only increase slightly from about 32,400 t in 1994 to approximately 37,000 t three years later in 1988. Then in 1991 biomass dropped by more than half to 14,465 t. The wide variability among survey estimates from the Aleutian Islands component of the EBS is also quite evident (Table 1 O-5).

The estimated biomass of Pacific ocean perch in the Aleutian Islands region (long. 170" E to 170° W) appears to be less variable. In this region there has been-a steady increase from 1980 to 1997. Biomass increased moderately from 1980 to 1983 and then increased substantially by 1986. The 1991 trawl survey produced a biomass estimate exceeding 405,300 t, representing more than 3.7 times the 1980 point estimate. The 1994 trawl survey produced a slightly higher biomass estimate of 423,045 t. The most recent trawl suvey of the Aleutian islands region occurred this year in 1997 and produced the largest biomass to date, 713,841 t. Optimism about this increasing trend in biomass, however, should be tempered with the general uncertainty about the ability to adequately estimate the absolute abundance of rockfish with trawl surveys. Also, the 1997 survey relied on 15 minute tows to estimate biomass, a significant departure from the 30 minute tows used in all previous surveys. In this year's assessment, we use the Aleutian Islands trawl survey biomass estimates in a relative sense rather than in an absolute sense. We allow the survey catchability (q) to be estimated in the model rather than fixing q at 1.0. Model fits to the survey biomass estimates were weighted by the inverse of their variances (Fig. IO- 1).

Biomass estimates were also calculated for the other rockfish species in the POP complex (Table 10-6). These estimates were based on the same trawl surveys and estimation methodology used to estimate Pacific ocean perch absolute abundance. In most cases, the variances about these point estimates were large, making it almost impossible to determine significant changes in biomass from one survey year to the next. Therefore, we thought it prudent to take an average of the survey point estimates to arrive at a recent biomass for each species in each region. In addition, we excluded the data from the cooperative U.S.-Japan trawl surveys (1979-86) from the averages, as these surveys were conducted with considerably different vessels and gear than the U.S. domestic trawl surveys (1988-1997) (Skip Zenger, National Marine Fisheries Service, Seattle, WA, personal communication). Using this approach we estimate the current biomass of northern, rougheye, and shortraker rockfish as follows (sharpchin rockfish biomass is insignificant in both regions):

	Eastern Bering Sea	**Aleutian Islands**
Northern rockfish	754	114,501
Rougheye rockfish	1,889	12,762
Shortraker rockfish	5,552	28,713
Sharpchin rockfish	***** Not common in either area *****	

Biological Data

The surveys produce large numbers of samples for age determination, length-weight relationships, sex ratio information, and for estimating the length distribution of the population. For the six Aleutian Islands surveys, age and length composition data were compiled and used in this assessment. Otoliths from the 1994 and 1997 surveys were read this year and are now included in the current assessment. The age compositions were determined by constructing age-length keys for each year and using them to convert the observed length frequencies from each year. The length frequency data were corrected to represent the entire catch of the surveys within a year. Because these age data were based on the break and bum method of ageing Pacific ocean perch, they were treated as unbiased but measured with error. Kimura and Lyons (199 1) give data on the percent agreement between otolith readers for Pacific ocean perch. The estimate of aging error was identical to that presented in Ianelli and Ito (199 1). Stock synthesis uses this information to create a transition matrix to convert the simulated "true" age composition to a form consistent with the observed but imprecise age data.

Assessments of Pacific ocean perch have significantly changed in the past decade because of improved methods of age determination. Previously, Pacific ocean perch age determinations were done using scales and surface readings from otoliths. These gave estimates of natural mortality of about 0.15 and a longevity of about 30 years (Gunderson 1977). Based on the now accepted break and burn method of age determination using otoliths, Chilton and Beamish (1982) determined the maximum age of *S. alutus* to be 90 years. Using similar information, Archibald et al. (198 1) concluded that natural mortality for Pacific ocean perch should be on the order of 0.05. The age at 50% recruitment to the fishery is estimated from previous cohort analyses to be about 7.25 yrs or about 28 cm. In the stock synthesis analyses presented below, we re-estimate the fishery selectivity pattern.

The length weight relationship for Pacific ocean perch was estimated using survey data by area from 1983 - 1989. The following equations were used in stock synthesis to model length at age and weight:

Aleutian Islands region:

$$L_{age} = 39.565\left(1 - e^{-0.1673(age + 0.907)}\right)$$

$$W_L = 1.224 \times 10^{-5} L^{3.0297}$$

Eastern Bering Sea region:

$$L_{age} = 39.962\left(1 - e^{-0.1348(age + 1.831)}\right)$$

$$W_L = 1.193 \times 10^{-5} L^{3.037}$$

where L = length in cm, W = weight in grams. Because stock synthesis uses this growth relationship to interpret length frequency data, an estimate of variability in length at age is also required. We used the variance in length at age reported in Ianelli and Ito (1991).

Sex ratio information was calculated from the trawl survey samples. The ratio of males to females varied slightly from year to year but was not significantly different from 1: 1 (Ianelli and Ito 1991). To calculate mature biomass a logistic function was used to describe the proportion of Pacific ocean perch that are mature at each age. This relationship was drawn from Chikuni's (1975) findings where about 50% of the population is mature at age seven, or around 29 cm, and no fish less than 32 cm or about nine years old were found to be immature. This maturation (PM) schedule as a function of age can be drawn using the following logistic equation (with the slope set to 2):

$$PM(age) = \frac{1}{\left(1 + e^{-2(age-7)}\right)}$$

ANALYTIC APPROACH

Previous stock assessments of Pacific ocean perch in the eastern Bering Sea and Aleutian Islands have relied in part on stock reduction analysis (SRA, Kimura et al. 1984; Kimura 1985, 1988) to provide historical biomass and exploitation trends in the fishery. One limitation of SRA is that the underlying age-structure of the population and other auxiliary information are not directly incorporated into the analysis. The stock synthesis (SS) model (Methot 1989, 1990) is a form of catch-at-age analysis that has been designed to incorporate age composition and a diversity of other information into a single computational framework. The main difference between the two models is that SRA does not keep track of abundance of fish at age. By explicitly tracking age structure, stock synthesis allows information on age and length composition to be used in the estimation process.

Stock synthesis functions by simulating both the dynamics of the population and the processes by which the population is observed. This simulation, which incorporates both imprecision and bias in the observations, is used to predict expected values for the observations. These expected values are then compared to the actual observations (data) from surveys and the fishery. Together, the comparisons between expected values given the simulation conditions and the observations are used to obtain a statistical likelihood value. This likelihood value is maximized via a numerical derivative "hill climbing" algorithm (Methot 1989) to update the simulation model parameters. The model proceeds with this updating process until no further improvements can be made by tuning the simulation.

Model parameters are estimated by maximizing the log likelihood (l) of the predicted observations given the data. Data are classified into different components. For example, age composition from a survey and catch per unit effort (CPUE) from a fishery are different components. The total l is a sum of the likelihoods for each component. The total l may also include a component for a stock-recruitment relationship (Methot 1990) and penalty functions to help stabilize parameter estimates (Ianelli and Ito 1991). The likelihood components may be weighted by an emphasis factor.

Likelihood components

The following table shows the main likelihood components by time period used in the stock synthesis mode1 for Pacific ocean perch in the eastern Bering Sea and Aleutian Islands region:

Component	Eastern Bering Sea	Aleutian Islands
Fishery catch	1960-97	1962-97
Fishery age composition	1964-72, 81-82, 90	1964-72, 90
Fishery size composition	1963-78, 90-92, 93, 94	1964-84, 86-96
Fishery CPUE	1968-79	1968-79
Survey age composition		1980, 83, 86, 91, 94, 97
Survey size composition	1979, 81, 82, 85, 88, 91	1980, 83, 86, 91, 94, 97
Survey biomass estimates	1979, 81, 82, 85, 88, 91	1980, 83, 86, 91, 94, 97
Stock-recruitment relationship	All years	All years

In principle, if all data types and model assumptions are consistent with each other, then the maximum of the sum of likelihood components should fall at or near the maximum of each individual component. In practice this is rarely true. Although stock synthesis accounts for many types of errors with the data it uses, it often remains for the practitioner to assign statistical weights to individual data types. Ideally these terms could be estimated directly, however, as pointed out by Foumier and Archibald (1982), there is typically not enough information in the data to determine the relative accuracies of the different data types.

For this analysis, the emphasis assigned to each likelihood component was based on our subjective interpretation of the relative adequacy of each data component. In several previous assessments, survey biomass was set to an emphasis of 3, the fishery size composition was assigned an emphasis of 2, and the fishery CPUE and biased age compositions were given a factor of 0.5 and 0.3, respectively (Ianelli and Ito 1996). All other likelihood components were set to an emphasis of 1.0. As was done in last year's assessment, all likelihood components were set to an emphasis of 1 .O with the exception of the fishery CPUE and biased age compositions, which remained the same. We made this change because we are no longer confident and have no compelling evidence that the trawl surveys and fishery size composition data sets represent a significantly better information source relative to the other likelihood components.

Catch data used in the stock synthesis model were from 1960 to 1999 for the eastern Bering Sea stock and from 1962 to 1999 for the Aleutian Islands stock. Catch data for the last ten years were adjusted to include discards. Discards were based on detailed catch information published by the NMFS Alaska Regional Office. Recent estimates of the retained catch and discards are provided in Tables 1 O-3 and 1 O-4. Catch data prior to 1990 were assumed to include discards in the total.

The stock synthesis model configuration used in this year's assessment is essentially the same as that used in last year's asssessment (Ito and Ianelli 1998). Biomass estimates from NMFS trawl surveys were used in the model, but in different ways depending on the region. For the eastern Bering Sea (EBS) model configuration, we collapsed the trawl survey biomass estimates into a single point. This was done to address some of the concerns regarding the perceived uninformative nature of the eastern Bering Sea survey biomass time series. There was concern by the review panel that the trawl surveys in this region may not adequately capture the population trends, especially given the large CV's often associated with the survey estimates. A single point biomass estimate was determined by summing the mean of the biomass estimates from the 1979-9 1 EBS slope surveys and the mean of the biomass estimates from that portion of the EBS region (Area I) covered during the 1980-97 Aleutian Islands surveys (Table 1 O-5). This resulted in a single point estimate of 50,359 t which was then used as the 1988 (1979-97 midpoint) "tuning" point for all subsequent EBS stock synthesis runs.

For the Aleutian Islands model configuration, the individual biomass estimates from the 1980-97 u-awl surveys were used. But rather than use these estimates as absolute, we chose to use them as relative indicies of abundance. We believe that the trawl surveys probably do a fairly good job of describing the general population trend of Pacific ocean perch in the Aleutian Islands region. It is still questionable, however, whether these surveys adequately estimate the absolute abundance of rockfish populations (e.g., Krieger and Sigler 1996). As such, we attempt to estimate the survey catchability coefficient (q) rather than keeping it fixed at 1.0. The sampling variance of survey biomass estimates was used to appropriately weight the individual survey observations.

Full-Selection Fishing Mortalitv Rates

In this report, full selection instantaneous fishing mortality rates (F) are used to calculate yield (Y) for given year as :

$$Y = \sum_{a=1}^{nages} W_a N_a F S_a \left(\frac{1 - e^{-Z_a}}{Z_a} \right)$$

$$Z_a = F S_a + M$$

where S, is the selectivity at age, M is natural mortality, W_a is the mean weight at age, and N_a is the number at age a in the beginning of the year. It is important to understand that other forms of reported F, e.g., the knife-edged selectivity version for the standard Baranov catch equation dealing with numbers of fish, are*not* identical to the above. Furthermore, a constant F fishing strategy does not imply a constant fraction of biomass removals; year-class variability will cause the biomass fraction of removals to vary.

The exploitation rate, reported here as the fraction of the exploitable biomass to be harvested, is calculated based on the ratio of the yield for a given (full-selection) F level. Two such reference F-levels will be used in this assessment: $F_{40\%}$ and $F_{35\%}$. These rates are estimated to be the fishing mortality at which the spawning biomass per recruit (SBPR) is reduced to 40% and 35% of the unfished level. Note that the actual value of F for these calculations is independent of any stock-recruitment relationship and depends solely on the schedules of age-specific weights, maturity, natural mortality, and fishery selectivity.

RESULTS

Biomass Trends

Figure 1 O-2 shows the trend in survey biomass as estimated by the stock synthesis modeling process. The trajectory of survey biomass estimated by stock synthesis shows that in 1962 the survey biomass in the Aleutian Islands region was over 1,148,000 tons, then declined to about 105,000 tons through the late 1970s and has rebuilt to the current level which is estimated to be around 470,000 tons. The reader should bear in mind that the survey point estimates are used in a relative sense rather than in an absolute sense, with a survey catchability estimated at 2.28 rather than fixed at 1 .O. In the eastern Bering Sea, the trajectory of the survey biomass begins at about 247,000 tons in 1960, declines to around 25,000 tons during 1976-82, and has increased to about 43,000 tons in recent years. The values for the survey biomass, along with available biomass (catch/full-selection F), female spawning biomass, and biomass of age 9 and older POP for the entire time series is given in Table 10-7. The estimated numbers at age for the eastern Bering Sea and Aleutian Islands region are provided in Tables 1 O-8 and 10-9, respectively.

As previously stated, the best estimates of exploitable biomass for the other rockfish species in the POP complex are:

	Eastern Bering Sea	Aleutian Islands
Northern rockfish	754 t	114,501 t
Rougheye rockfish	1,889 t	12,762 t
Shortraker rockfish	5,552 t	28,713 t
Sharpchin rockfish	*****Not common in either area *****	

Selectivity

Survey abundance estimates are highly dependent on the type of selectivity exhibited by the surveys. For example, absolute abundance can be much larger than the estimated abundance from the surveys if older fish are not selected or available to the gear. In this assessment, we chose to use an asymptotic selectivity function for the surveys. This assumption is based on the objective sampling design of the surveys which cover several depth strata. Survey abundance therefore reflects the abundance of fish old enough to be selected by the survey gear.

Pacific ocean perch appear to be available at earlier ages in the surveys than the early fishery (Fig. 1 O-3). This may be due to the fact that the surveys are carried out over a shallower range of depths than the fishery and Pacific ocean perch have been known to aggregate at certain depths at different ages (Ito 1982). For the recent fishery, the model predicts a decrease in selectivity with age. This may be due to older fish going to deeper depths, or moving into “refuge” areas or out of the area entirely. In a previous assessment (Ianelli and Ito 1992), an asymptotic selectivity pattern for the fishery was evaluated and was found to be inadequate in describing the observed data. The estimated current fishery selectivity-at-age values for the eastern Bering Sea and Aleutian Islands region are given in Table 1 O-10.

Fishing Mortality

The estimates for instantaneous fishing mortality on POP range from highs during the 1970’s to low levels in the 1980’s (Fig. 10-4). Relative to the estimated $F_{35\%}$ level, the stocks in both the eastern Bering Sea and Aleutian Islands were overfished during considerable portions of this period (Table 10- 11). Fishing mortality rates since the early 1980's, however, have moderated considerably due to the phase out of the foreign fleets and quota limitations imposed by the North Pacific Fishery Management Council.

Recruitment

For both. the eastern Bering Sea and Aleutian Islands, year class strength varies widely (Fig. 1 O-5). The relationship between spawning stock and recruitment also displays a high degree of variability (Fig. 1 O-6). This variability reflects the most fundamental difference between the stock synthesis approach and stock reduction analysis (SRA). Under SRA, the large removals of Pacific ocean perch in the 1960s was implicitly comprised of mostly old (>25yr) fish. Using explicit age structured information in stock synthesis has shown that the catches evidently comprised removals of relatively young fish representing strong year-classes.

PROJECTIONS AND HARVEST ALTERNATIVES

A constant age-structured exploitation rate **strategy** was employed to obtain an acceptable biological catch (ABC) for Pacific ocean perch, S. *alutus*. Several spawning-biomass per recruit (SBPR) fishing mortality rates were calculated based on the current age-structured estimates of fishery selectivity, individual weights, and proportion mature. At this time, such age-structured information is not available for the other rockfish species groups; therefore, alternative fishing mortality rates are only provided for Pacific ocean perch. The corresponding fishing mortality rates for *S. alutus* in 2000 are:

Quantity	Eastern Bering Sea	Aleutian Islands
F35%	0.0690	0.085 1
F40%	0.0574	0.0720

Projected Catch and Abundance

This year, a standard set of projections is required for each stock managed under Tiers 1, 2, or 3 of Amendment 56. This set of projections encompasses seven harvest scenarios designed to satisfy the requirements of Amendment 56, the National Environmental Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 1999 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2000 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 1999. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2000, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

> *Scenario* I: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
>
> *Scenario 2:* In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2000 recommended in the assessment to the max F_{ABC} for 2000. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

Scenario 3: In all future years, F is set equal to 50% of max F_{ABC}. (Rationale: This scenario provides a likely lower bound on F_{ABC} that still allows future harvest rates to be adjusted downward when stocks fall below reference levels.)

Scenario 4: In all future years, F is set equal to the 1994- 1998 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

Scenario 5: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, and five-year projections of the mean harvest and spawning stock biomass for the remaining four scenarios are shown in Tables 10- 12 to IO- 15. The projections of future harvest levels have relatively large confidence intervals due to high fishery selectivity values for ages 6-7 (the fourth and fifth ages in the model). In contrast, the confidence intervals on projected biomass are relatively small because the proportion mature at ages three through seven is small.

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether the Alaska plaice stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (for Tier 3 stocks, the MSY level is defined as $B_{35\%}$):

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above ½ of its MSY level in 2000 and above its MSY level in 2010 under this scenario, then the stock is not overfished.)

Scenario 7: In 2000 and 2001, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2012 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that the neither the Aleutian Islands or eastern Bering Sea Pacific ocean perch stock is overfished or approaching an overfished condition. With regard to assessing the current stock level, the expected Al stock size in the year 2000 of scenario 6 is 1.11 times its $B_{35\%}$ value of 87,74 1 t, and the expected EBS stock size is 1.08 times its $B_{35\%}$ value of 22,904 t. With regard to whether the stocks are likely to be in an overfished condition in the near future, the expected Aleutian Islands and eastern Bering Sea stock sizes in the year 20 12 of scenario 7 are 1.04 and 1.06 times, respectively, their $B_{35\%}$ values.

Acceptable Biological Catch

The results of our assessment for the Aleutian Islands stock indicate that current spawning biomass is about 2,500 t below its long-term average under an $F_{40\%}$ (=0.0720) harvest strategy. Our estimate of the year 2000 spawning biomass for this stock (SPB_{2000}) is about 97,800 mt; whereas, the long-term equilibrium spawning biomass ($SPB_{40\%}$) is about 100,300 mt. Similar to the guidelines established under tier 3b of Amendment 56, we calculate the F_{ABC} as $\{F_{40\%} \times (SPB_{2000}/SPB_{40\%} - 0.05)/(1-0.05)\}$. **This procedure produces an F_{ABC} of 0.0702 and an ABC estimate for the Aleutian Islands region of approximately 12,300** t. This ABC estimate represents about a 1,200 t decrease over last year's recommendation of 13,500 t..

For the eastern Bering Sea stock, the estimate of current spawning biomass is also below its long-term average. The current estimate of spawning biomass for this stock is at **about** 24,900 t and its long-term equilibrium spawning biomass is 26,200 t. We apply the same adjustment procedure to the eastern Bering Sea $F_{40\%}$ that was used to calculate the F_{ABC} for the Aleutian Islands stock. **This procedure produces and F_{ABC}** of 0.0544 **and an ABC estimate for the eastern Bering Sea region of approximately 2,600 t.** This ABC estimate represents about a 700 t increase over last year's recommendation.

ABCs for the other rockfish species in the complex were calculated based on the guidelines for calculating ABC (i.e., tier 5 of Amendment 56). The appropriate exploitation rate strategy is given as 75% of M (i.e., F_{ABC} = 0.75 x M). Estimates of M for rougheye, shortraker, and northern rockfish are from Heifetz and Clausen (1991). Applying 75% of these values as exploitation rates to the estimates of biomass gives ABCs as follows:

	M	E. Bering Sea	Aleutian Islands
Northern rockfish	0.060	34t	5,153 t
Rougheye rockfish	0.025	35t	239t
Shortraker rockfish	0.030	125t	646t
Sharpchin rockfish	*****Not common in either area *****		

Preliminary data suggest that the rougheye and shortraker rockfish occupy a distinctly different depth range than the other species in the complex and can be targeted on readily. Furthermore, there is an economic incentive to target on rougheye and shortraker rockfish because they command a much higher ex-vessel price than the other species in the complex. The ability and tendency of the commercial fishery to target on these two species poses a potential conservation concern. Currently, the eastern Bering Sea harvest is regulated by a single quota for the above four species combined; so theoretically, it is possible for this quota to be taken entirely from the rougheye and shortraker rockfish stocks only, resulting in a much higher than anticipated harvest of these species. Therefore, we recommend that northern/sharpchin rockfishes and rougheye/shortraker rockfishes be allocated separate TACs in the eastern Bering Sea region, as is the case in the Aleutian Islands region.

The following table summarizes our ABC recommendations for this year by species group and area :

	Eastern Bering Sea	Aleutian Islands
Pacific Ocean Perch	2,600 t	12,300 t
Northern/Sharpchin	34t	5,153 t
Rougheye/Shortraker	160t	885 t

<u>Overfishing Definitions</u>

Prevention of growth overfishing requires that fishing mortality, either intentional or incidental, be directed at fish that have reached ages where increases in biomass due to individual body growth is offset by motility in the population. Typically, management measures to prevent growth overfishing require implementation of mesh-size regulations or area closures. For Pacific ocean perch, growth in weight occurs relatively quickly; they reach about 80% of their maximum weight by age 12. As recruitment to the fishery is approximately 50% by age 8, the Pacific ocean perch does not appear to be in danger of growth overfishing. Should recruitment to the fishery begin at early ages, then area closures in shallow waters might be appropriate given that younger fish appear to reside at shallower depths (Heifetz and Clausen 1991).

Prevention of recruitment overfishing from a harvest management perspective requires information on the level of spawning biomass required to prevent recruitment failure. For Pacific ocean perch, low recruitment appears to have happened regularly, even before fishery removals became significant (Figures 1 O-5, 1 O-6). This suggests that environmental conditions and perhaps biological interactions may play an important role in the success of a year class. These characteristics plague estimation of recruitment productivity because of the large amount of process error driving inter-annual recruitment variability.

For both the eastern Bering Sea and Aleutian Islands stocks, the current SPB is below SPB,,. Under the guidelines established in the new overfishing definition, F,, is to be calculated as $F_{35\%}$ x $(SPB_{2000}/SPB_{40\%}$ - 0.05) / (l-0.05). The estimates of F,, for the Aleutian Islands stock is 0.0826 and 0.0653 for the eastern Bering Sea stock. These mortality levels translate to overfishing harvest levels of 14,400 mt and 3,100 mt, respectively. The overfishing mortality level for the other rockfish species was calculated as F_{OFL} = M. The overfishing levels for Pacific ocean perch and the other species in the complex are summarized by region below:

	Overfishing Level	
	Eastern Bering Sea	Aleutian Islands
Pacific ocean perch	3,100 t	14,400 t
Northern rockfish	45 t	6,870 t
Rougheye rockfish	47t	319t
Shortraker rockfish	167t	861 t
Sharpchin rockfish	******* Not common in either area *******	

OTHER CONSIDERATIONS

To distribute fishing effort throughout the Aleutian Islands region we recommend- that the ABC be apportioned based on the apparent distribution of the biomass. The three most recent trawl surveys (199 1, 1994, and 1997, Table 10- 12), indicate that the average POP biomass was distributed in the Aleutian Islands region as follows:

	Biomass (%)
Eastern subarea (54 1):	25.4%
Central subarea (542):	28.5%
Western subarea (543):	46.1%
Total	100%

The biomass trends produced by the stock synthesis model are highly dependent on the survey biomass estimates. The current trawl survey methods to assess rockfish absolute biomass, especially for the deeper water species such as shortraker and rougheye rockfish, have not been calibrated. Additionally, the effect of the fisheries on the ecosystem is not well understood. These concerns have prompted the Alaska Fisheries Science Center to develop a comprehensive working plan to improve stock assessments for rockfish stocks in waters off Alaska and to better understand the habitat in which they live. Research studies have been initiated and are currently ongoing to improve our understanding ofrockfish biology and distribution. Many of these studies hope to improve survey designs for the major rockfish species.

The catch of Pacific ocean perch taken in research surveys will be included in catch totals in future assessments; these catch levels are shown from 1979- 1988 in Table 10- 17.

SUMMARY

The management parameters for Pacific ocean perch as presented in this assessment are summarized as follows:

	Eastern Bering Sea	Aleutian Islands
M	0.05	0.05
Approximate recruitment age	8 yrs	6 yrs
$F_{35\%}$	0.0690	0.085 1
$F_{40\%}$	0.0574	0.0720
Equil. spawner biomass ($F_{40\%}$)	26,200	100,300
2000 spawner biomass	24,900	97,800
F_{abc} (adjusted)	0.0544	0.0702
ABC (adjusted $F_{40\%}$)	2,600	12,300
$F_{overfishing}$ (adjusted $F_{30\%}$)	0.0653	0.0826
Overfishing Level	3,100	14,400

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Table 10-l. Estimated removals of Pacific ocean perch (S. *alutus*, t) since implementation of the Magnuson Fishery Conservation and Management Act of 1976.

	Eastern Bering Sea				Aleutian Islands			
Year	Foreign	JVP	DAP	Total	Foreign	JVP	DAP	Total
1977	2,654		-	2,654	8,080	--		8,080
1978	2,221			2,221	5,286	--		5,286
1979	1,723			1,723	5,487		--	5,487
1980	1,050	47		1,097	4,700	Tr	-	4,700
1981	1,221	1		1,222	3,618	4	--	3,622
1982	212	3	9	224	1,012	2		1,014
1983	116	97	8	221	272	8		280
1984	156	134	1,279	1,569	356	273	2	631
1985	35	32	717	784	Tr	215	93	308
1986	16	117	427	560	Tr	160	126	286
1987	5	50	875	930	0	500	504	1,004
1988	0	51	996	1,047	0	1513	466	1,979
1989	0	31	2,929	2,960	0	Tr	2,706	2,706
1990	0	0	7,231	7,231	0	0	15,224	15,224
1991	0	0	5,339	5,339	0	0	2,831	2,831
1992	0	0	3,309	3,309	0	0	10,278	10,278
1993	0	0	3,746	3,746	0	0	13,330	13,330
1994	0	0	1,687	1,687	0	0	10,865	10,865
1995	0	0	1,207	1,207	0	0	10,303	10,303
1996	0	0	2,855	2,855	0	0	12,827	12,827
1997	0	0	817	817	0	0	12,648	12,648
1998	0	0	1,017	1,017	0	0	9,051	9,051
1999*	0	0	372	372	0	0	11,162	11,162

Tr = trace, JVP = Joint Venture Processing, DAP = Domestic Annual Processing.
Source: PacFIN, NMFS Observer Program, and NMFS Alaska Regional Office.
* Estimated removals through September 25, 1999.

Table 10-2. Estimated removals (t) of the "other red rockfish," **sharpchin/northern,** and **rougheye/shortraker** subgroups from the eastern Bering Sea and Aleutian Islands regions.

Eastern Bering Sea		1993	1994	1995	1996	1997	1998	**1999***
Other red rockfish		487 t	129t	344t	207 t	230 t	111 t	212t
Aleutian Islands		1993	1994	**1995**	i996	1997	1998	**1999***
Sharpchin/Northern		4,486 t	4,668 t	3,872 t	6,653 t	1,997 t	3,675 t	3,336 t
Rougheye/Shortraker		1,130 t	926 t	558 t	960 t	1,042 t	678 t	450 t

* Estimated removals through September 25, 1999.

Table 10-3. Estimated retained, discarded, and percent discarded of Pacific ocean perch from the eastern Bering Sea (EBS) and Aleutian Islands (AI) regions.

Area	Year	Catch Retained	Discard	Total	Discard Percentage
EBS	1990	5,779	1,452	7,231	20.1%
	1991	4,112	1,227	5,339	23.0%
	1992	2,784	525	3,309	15.9%
	1993	2,602	1,144	3,746	30.5%
	1994	1,281	406	1,687	24.1%
	1995	839	368	1,207	30.5%
	1996	2,522	333	2,855	11.7%
	1997	539	278	817	34.0%
	1998	821	201	1,022	19.7%
	1999*	242	130	372	34.9%
AI	1990	13,231	1,993	15,224	13.1%
	1991	1,851	980	2,831	34.6%
	1992	8,686	1,592	10,278	15.5%
	1993	11,438	1,892	13,330	14.2%
	1994	9,491	1,374	10,865	12.6%
	1995	8,603	1,700	10,303	16.5%
	1996	9,832	2,995	12,827	23.3%
	1997	10,855	1,793	12,648	14.2%
	1998	8,030	940	8,970	10.5%
	1999*	10,274	882	11,156	7.9%

* Estimated removals through September 25, 1999.
Source: NMFS Alaska Regional Office

Table 10-4. Estimated retained, discarded, and percent discarded of other red rockfiih (ORR), **sharpchin/northern (SC/NR),** and **shortraker/rougheye (SR/RE)** from the eastern Bering Sea (EBS) and Aleutian Islands (Al) regions.

Area	Species **Group**	Year	Catch Retained	Discard	Total	Discard Percentage
EBS	ORR	1993	390	97	**487**	19.9%
		1994	28	101	129	78.3%
		1995	273	71	344	20.66
		1996	58	149	207	72.0%
		1997	57	173	230	75.2%
		1998	41	71	112	63.4%
		1999*	66	146	212	68.9%
AI	**SC/NR**	1993	320	4,166	4,486	92.9%
		1994	798	3,870	4,668	82.9%
		1995	1,207	2,665	3,872	68.8%
		1996	2,269	4,384	6,653	65.9%
		1997	145	1,852	1,997	92.7%
		1998	459	3,289	3,748	87.8%
		1999*	458	2,879	3,337	86.3%
AI	**SR/RE**	1993	733	397	1,130	35.1%
		1994	700	224	924	24.2%
		1995	455	103	558	18.5%
		1996	752	208	960	21.7%
		1997	732	310	1,042	29.8%
		1998	449	235	684	34.4%
		1999*	287	162	449	36.1%

* Estimated removals through September **25, 1999.**
Source: NMFS Alaska Regional Office

Table 10-5. **Pacific** ocean perch estimated biomass in metric tons from the NMFS bottom trawl surveys.

	Eastern Bering Sea (EBS) Shelf and Slope	Aleutian Islands portion of EBS Area I	Aleutian Islands Region
1979	4,459		--
1980		6,003	109,022
1981	9,821		--
1982	5,505		--
1983	--	97,478	144,080
1984	--	--	--
1985	32,393		--
1986	--	49,562	220.6 14
1987			--
1988	36,981		--
1989			--
1990	--		--
1991	14,562	2,274	405,366
1992	--	--	
1993	--	--	
1994	--	25,147	423,045
1995	--	--	
1996	--		--
1997		17,972	713,841

Table 10-6. Estimated biomass (t) of rougheye, shortraker, and northern rockfishes from the NMFS bottom trawl surveys.

Eastern Bering Sea (EBS) Surveys

	Rougheye	Shortraker	Northern
1979	1,053	1,391	53
1981	818	3,571	23
1982	605	5,176	24
1985	1,716	4,010	
1988	876	1,260	4
1991	884	2,758	

Aleutian Islands portion of EBS Area I

	Rougheye	Shortraker	Northern
1980)	922	-1,020	341
1983	2,830	13,079	1,516
1986	3,511	6,478	67,394
1991	1,274	6,615	763
1994	1,186	1,791	1,193
1997	568	2,222	293

Aleutian Islands Surveys

	Rougheye	Shortraker	Northern
19801	21,865	15,963	43,312
1983	20,582	27,913	43,458
1986	48,843	19,345	133,662
1991	12,351	20,191	181,613
1994	13,732	27,286	81,183
1997	12,202	38,661	80,706

Table 10-7. Trajectory of different biomass estimates (beginning of the year) by area

Year	Age 9+ Biomass		Available Biomass		Spawner Biomass		Survey Biomass	
	AI	EBS	AI	EBS	AI	EBS	AI	EBS
60	--	247,133		150,237	--	128.601		246,847
61		245,903		148,711		121,825	--	223,046
62	453,846	204,115	373,369	113,796	246,310	103,954	1,148,180	195,276
63	490,097	188,282	385,086	101,973	252,326	94,738	1,159,469	176,409
64	487,761	166,768	375,458	86,667	237,361	83,463	1,067,359	154,451
65	406,611	144,029	305.35 1	70,562	193,458	72,739	866,036	136,326
66	303,704	129,512	2 19.730	6 1,765	148,029	64,724	667,405	120.287
67	228,570	110.901	155,868	5 1,025	114.152	55,835	540,451	103540
68	185,938	94.195	140,379	42083	94599	46.026	487,984	.81,500
69	152,524	66,549	144,425	27.827	90,627	36,252	455,984	65,657
70	13 1588	58,211	13 1,236	25.374	83,655	32,268	374,607	58,638
71	125,408	55,903	82,764	24,793	63,781	29.24 1	292,680	535 15
72	111,085	49,410	71,518	23,798	53.660	27513	243,914	50,546
73	83,108	46,467	53,200	26,058	42,769	27,952	207,981	50,544
74	74,444	51,691	54,425	29,460	39,189	26,762	187,171	46,404
75	59,665	43,472	44,318	= 23,204	33,312	21,942	156,920	39575
76	53.62 1	36,524	36,739	20,009	28,324	17,986	132,900	30,544
77	46,004	24,431	30,647	12.161	24,392	13,913	116,826	25359
78	41.413	25,083	29,163	12,665	22,707	13,411	110,239	24,530
79	40,058	24,958	29,790	12,848	22079	12,782	107,084	23,855
80	38,468	23,987	29,794	12,915	21,448	12,295	105,508	23556
81	38,477	23,334	3 1,536	13,461	21,201	12,154	110,120	23,719
82	38.30 1	22,559	38,171	14,607	22502	12,736	125,632	25,136
83	40,632	23,075	51.366	18,328	27,066	15.075	152,225	28,572
84	46,666	26,153	67,487	24,688	34,033	19,056	183,742	33,387
85	63,502	3350	82,356	3 1,946	41.939	22,850	2 15,493	39,219
86	78,875	46,112	95,738	39,490	49,164	25,760	250.641	45.5 19
87	101,051	51,590	115,613	45.63 1	55.88 1	28,049	292,673	50.883
88	106,280	55,960	124.5 13	59,428	65,675	29535	336,960	54.800
89	118,941	59,720	144,878	60,899	75,857	30,101	38 1,230	56.53 1
90	153,428	58,725	165.0 13	59.8 14	83,770	29,036	4 13,428	54.161
91	148,364	53,150	172,548	54,109	89,469	26,488	437,621	49,959
92	175,594	48,811	189.933	50,005	97,166	24,789	468,102	47,192
93	186,825	47,029	198,735	47,723	101,071	23,630	482,969	44,919
94	188.180	44,193	202,914	45,048	103,598	22513	492,266	43364
95	199.183	43,279	207,400	44,716	106,266	22,274	499,694	43,090
96	200,829	42845	209.602	45,451	107,692	22,346	498,628	42,580
97	206,983	41,007	205,900	45,111	106,026	22,462	489,173	42,765
98	202,135	43.115	200.212	47,033	103,717	23,447	479,868	
99	198,834	4'5,082	196,028	48,780	101,787	24,445	470,156	

Table 10-8. **Estimated** numbers **of** Pacificocean perch at age in **the** Easlern Bering Sea region.

Eastern Bering Sea
Age

Year	3	4	5	6	7	8	9	10	II	12	13	14	15	16	17	18	19	20	21	22	23	24	25t
60	24982	27850	27026	31637	31937	31111	17282	16439	15637	14875	14149	13459	12803	12178	11584	11019	10482	9971	9485	9022	8582	8163	159221
61	19518	23161	26481	25673	29959	30000	28851	15863	15021	14267	13565	12902	12272	11673	11104	10563	10047	9553	9091	8648	8226	7825	157774
62	23250	18548	22523	24885	23465	25489	22715	19999	10560	9866	9334	8865	8429	8017	7626	1254	6900	6563	6243	5939	5649	5374	145583
63	17729	22105	17612	21291	23190	21076	21591	18411	15834	8303	7742	7321	6951	6609	6286	5979	5688	5410	5146	4895	4657	4429	138064
64	35560	16852	20973	16605	19673	20340	17016	16317	13510	11507	6017	5606	5299	5032	4784	4550	4328	4117	3916	3725	3543	3370	128369
65	430Yo	33194	15978	19121	15222	16875	15699	12072	11150	9118	1138	4042	3765	3558	3379	3212	3055	2906	2764	2629	2501	2379	117107
66	18379	40960	32066	15067	18236	13368	13660	11908	8895	8138	6636	5621	2939	273-1	2587	2456	2335	2221	2113	2010	1912	1818	107974
67	14549	17465	381123	30126	13761	15482	10105	9411	1872	5801	5286	43%	3650	1906	1775	1678	1593	1514	1440	1370	1303	1240	97187
68	39944	13823	16542	36386	27295	11425	11188	6537	5795	4169	3498	3182	2591	2196	1147	1068	1010	959	911	867	824	784	86029
69	24851	37892	13023	15218	31013	19106	5847	4460	2331	1992	1622	1186	1078	877	744	388	362	342	325	309	293	279	68486
70	9045	23600	351133	12138	13542	24481	12473	3280	2338	1195	1015	824	602	548	446	378	I97	184	174	165	157	149	511473
71	10723	8593	22355	33591	11005	11265	17763	8111	2032	1425	725	615	499	365	332	270	229	119	III	105	100	95	51458
72	19961	10188	8139	20948	30419	9124	8116	11442	4970	1225	855	434	368	299	218	199	162	137	72	61	63	60	45172
73	11078	18980	9667	7616	19372	26140	7400	6173	8456	3639	894	624	317	268	218	159	145	118	100	52	4Y	46	41047
74	4626	10533	18029	9150	7184	17609	23207	6189	5078	6919	2973	730	509	259	219	178	130	118	96	82	43	40	38046
75	3262	4394	9964	16822	8169	5725	11712	13362	3342	2684	3635	1559	383	267	136	115	93	68	62	50	43	22	32603
76	3111	3099	4162	9343	15265	6813	4174	7671	8343	2054	1642	2221	952	234	163	83	70	51	42	38	31	26	28698
77	4241	2951	2918	3824	7929	10556	34m	1607	2631	2755	671	535	722	310	76	53	27	23	19	14	12	I0	22602
78	13047	4032	2801	2755	3545	7021	8688	2642	1216	1974	2061	501	400	540	231	57	40	20	17	14	I0	9	20613
19	21294	12404	3829	264%	2567	3186	5952	7032	2094	957	1551	1619	394	314	424	182	45	31	16	13	11	8	18963
80	50950	25953	11783	3625	2480	2339	2718	5011	5828	1727	788	1276	1332	324	25U	349	149	37	26	13	11	Y	17590
81	18268	48453	24667	11176	3415	2297	2108	2449	4316	5073	1502	685	1110	1158	282	224	303	130	32	22	II	I0	16476
82	15888	17372	46049	23391	10522	3157	2062	1849	2126	3784	4383	1297	592	958	1000	243	I94	262	112	28	IY	I0	15417
83	14677	15113	16523	43781	22212	9962	2914	1935	1732	1991	3544	4104	1214	554	897	936	228	181	245	105	26	18	14633
84	5493	13961	14374	15710	41590	21051	9406	28U0	1819	1628	1870	3329	3856	1141	521	843	uuo	214	170	230	YY	24	13906
85	5805	5224	13272	13643	14839	38786	19239	8459	2500	1621	1449	1664	2963	3431	1015	463	750	783	190	I52	205	88	13095
86	4437	5521	4968	12614	12943	14009	36336	17913	7854	2319	1503	1344	1543	2147	3182	941	430	696	126	177	141	190	12482
87	7456	4220	5251	4724	11980	12258	13209	34141	16804	7364	2174	1409	1260	1447	2575	2983	uu3	403	652	680	165	132	12021
88	5222	1092	4014	4992	4483	11325	11514	12344	31832	15656	6860	2025	1312	1173	1348	23Y9	2778	U22	315	607	634	154	11515
89	5100	4967	6741	3u0Y	4717	4213	10599	10759	11530	29733	14625	6408	1892	1226	IOY6	1260	2242	2597	769	351	568	593	10918
Yo	5225	4848	4114	6361	3556	4335	3829	9592	Y-726	10422	26881	13226	5191	1712	1110	YY3	1141	2032	2354	6Y7	318	515	10452
91	56YU	4962	4586	4404	5715	3095	3666	3202	1999	UIOY	U694	22441	11051	4848	1433	930	u33	958	1707	1979	587	268	Y254
92	13043	5413	4698	42YY	4031	5112	2677	3144	2739	6841	693U	1444	19228	Y476	4160	1231	79Y	716	U24	1470	1706	506	8223
Y3	12880	12396	5134	4426	3987	3657	4568	2378	2788	242Y	6069	6157	6609	17080	8421	36YY	1095	711	637	134	1310	1521	7190
Y4	12458	12239	11749	4828	4085	3584	3229	4005	2081	2439	2126	5314	5395	5794	14981	73Y0	3248	962	625	561	646	1154	820U
95	12148	11845	11623	11116	4528	3784	3293	2956	3664	1904	2232	1Y46	4864	4939	5306	13124	6772	2977	uu2	573	514	593	8594
96	11920	11551	11254	11014	10467	4226	3511	3048	2134	3389	1761	2065	1800	4502	4572	4913	12709	6272	2158	817	531	477	8518
97	11688	11329	10957	10608	10228	9520	3789	3130	2713	2434	3017	1569	1840	1605	4015	4080	4386	11351	5605	2465	731	475	8055
98	11636	11116	10769	10398	10030	9619	U922	3546	2928	2538	2217	2823	1468	1722	1502	3758	3819	4106	10628	5248	2309	684	7992
99	11652	11066	10563	10212	9811	93%	8968	8302	3298	2123	2361	2118	2626	1366	1602	1398	3499	3556	3824	9899	4889	2151	8086

Table 10-9. Estimated numbers of Pacific ocean perch by age in the Aleutian Islands **regio**

Aleutian Islands

Year	Age 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25+
62	92624	54829	27977	40393	60158	101028	109273	130891	22476	21379	20333	19326	18356	17431	16553	15719	14927	14175	13460	12782	12138	11526	221164
63	28648	88107	52155	26611	38413	57196	96049	103887	124439	21368	20325	19331	18374	17451	16572	15737	14944	14191	13476	12797	12152	11540	221311
64	32622	27249	83758	49360	24652	34747	51445	86328	93366	111835	19203	18267	17373	16513	15684	14894	14143	13431	12754	12111	11504	10945	218382
65	302019	31020	25842	77720	41249	18331	25128	37073	62187	67253	80556	13833	13158	12514	11894	11297	10728	10188	9674	9188	8735	8376	203658
66	55704	287133	29366	23635	60237	26578	11303	15409	22719	38106	41210	49362	8476	8063	7668	7288	6922	6574	6243	5929	5641	5444	181290
67	26898	52955	271680	26743	17911	37186	15626	6605	8997	13265	22248	24060	28820	4949	4701	4477	4255	4042	3838	3646	3469	3356	158172
68	21474	25573	50135	248619	20787	11604	23070	9641	4072	5547	8178	13717	14835	17769	3051	2902	2760	2624	2492	2367	2252	2175	138824
69	20503	20417	24227	46128	198770	14209	7641	15120	6316	2667	3634	5357	8985	9717	11639	1999	1901	1808	1719	1633	1553	1497	123015
70	54343	19496	19356	22415	37967	143591	9950	5330	10543	4403	1860	2533	3735	6264	6775	8115	1393	1325	1261	1198	1140	1096	110265
71	34452	51649	18408	17322	15510	19717	69645	4785	2560	5064	2115	893	1217	1794	3009	3254	3898	669	637	606	571	562	90598
12	19515	32759	48967	17041	14301	11269	13896	48896	3358	1797	3553	1484	627	854	1259	2111	2283	2735	470	447	426	410	80916
73	21242	18549	30960	44175	12294	8040	5970	7307	25690	1764	944	1867	780	329	449	661	1109	1200	1437	247	235	229	67614
74	16979	20200	17597	28804	37426	9383	5986	4431	5421	19058	1309	700	1385	578	244	333	491	823	890	1066	183	176	61005
75	20291	16141	19109	15997	21631	22711	5412	3430	2538	3104	10913	749	401	793	331	140	191	281	471	510	612	107	51894
16	13904	19291	15278	17455	12317	13763	13809	3272	2072	1533	1875	6593	453	242	479	200	85	115	170	285	309	376	44651
77	13831	13219	18258	13945	13388	7780	8301	8280	1960	1242	918	1124	3950	271	145	287	120	51	69	102	171	188	38540
78	22763	13151	12533	16906	11525	9747	5496	5841	5824	1379	873	646	790	2778"	191	102	202	84	36	49	72	122	34401
79	55274	21647	12483	11710	14649	9181	7611	4280	4548	4535	1074	680	503	615	2163	149	79	157	66	28	38	56	31384
80	46814	52565	20546	11659	10128	11627	7140	5903	3319	3527	3516	833	527	390	477	1677	115	62	122	51	22	30	28560
81	66270	44521	49907	19244	[illegible]	8264	9325	5714	4723	2655	2821	2813	666	422	312	382	1342	92	49	98	41	17	26156
82	14481	63028	42293	46952	17282	8723	6960	7840	4803	3970	2232	2372	2365	560	355	262	321	1128	77	41	82	34	24214
83	42251	13774	59936	40132	44093	16043	8076	6441	7256	4445	3674	2066	2195	2188	518	328	243	297	1044	72	38	76	22924
84	112647	40190	13102	56984	38075	41735	15176	7639	6092	6863	4205	3475	1954	2076	2070	490	310	230	281	987	68	36	21850
85	22459	107152	38226	12452	53963	35911	39325	14298	7197	5740	6466	3961	3274	1841	1956	1950	462	292	216	265	930	64	20774
86	95105	21364	101922	36349	11824	51157	34030	37264	13549	6820	5439	6127	3754	3103	1744	1854	1848	438	277	205	251	882	19804
81	63880	90466	20321	96924	34527	11217	48515	32271	35338	12848	6467	5158	5810	3560	2942	1654	1758	1752	415	263	194	238	19662
88	43106	60764	86045	19315	91814	32584	10576	45739	30424	33315	12113	6097	4863	5478	3356	2774	1560	1657	1652	391	248	183	18891
89	70277	40998	57775	81726	18293	86529	30578	9905	42811	28472	31175	11335	5705	4550	5126	3140	2596	1459	1551	1546	366	232	18076
90	38377	66839	38978	54859	77341	17211	81009	28562	9245	39948	26566	29088	10576	5323	4245	4783	2930	2422	1362	1447	1443	342	17337
91	63895	36478	63407	36742	50827	69565	15091	70194	24652	7970	34428	22893	25066	9113	4587	3658	4121	2525	2087	1173	1247	1248	16432
92	28641	60771	34682	60221	34792	47886	65254	14127	65667	23057	7454	32199	21410	23442	8523	4290	3421	3854	2361	1952	1097	1167	16744
93	25269	27232	57717	32819	56421	32046	43463	58824	12706	59022	20720	6698	28933	19239	21065	7659	3855	3074	3463	2122	1754	988	16790
94	25269	24024	25853	54545	30632	51553	28749	38661	52178	11261	52298	18358	5935	25635	17046	18663	6786	3415	2724	3069	1881	1559	16611
95	25269	24026	22817	24465	51111	28224	46814	25930	34793	46926	10126	47023	16506	5336	23049	15326	16780	6101	3071	2449	2760	1695	17025
96	25269	24027	22822	21600	22951	47203	25717	42390	23432	31421	42370	9143	42456	14903	4818	20810	13837	15151	5508	2773	2212	2497	17558
97	25269	24025	22815	21580	20196	21046	42570	23014	37838	20899	28019	37781	8152	37856	13288	4296	18555	12338	13509	4912	2473	1977	18727
98	25269	24025	22813	21573	20176	18517	18977	38087	20537	33739	18632	24977	33679	7267	33746	11846	3829	16541	10999	12043	4380	2210	19349
99	25269	24028	22823	21603	20256	18669	16921	17240	34533	18610	30569	16880	22629	30513	6584	30573	10732	3469	14986	9965	10913	3975	20234

Table 10- 10. Current trawl fishery selectivity values by area and age.

Age	Eastern Bering Sea Region	Aleutian Islands Region
3	0.01	0.01
4	0.04	0.03
5	0.14	0.09
6	0.36	0.27
7	0.68	0.57
8	0.89	0.82
9	0.98	0.94
10	1.00	0.98
11	1.00	1.00
12	1.00	1.00
13	73.99	1.00
14	0.98	1.00
15	0.98	1.00
16	0.97	1.00
17	0.96	1.00
18	0.96	1.00
19	0.95	1.00
20	0.94	1.00
21	0.94	1.00
22	0.93	1.00
23	0.92	0..96
24	0.92	0.73
25+	0.91	0.22

Table 10-l 1. Estimated full selection fishing mortality rate (F) for Pacific ocean perch by region 1960-99.

Year	Eastern Bering Sea Region	Aleutian Islands Region
1960	0.042	--
1961	0.376	--
1962	0.193	0.001
1963	0.273	0.057
1964	0.348	0.278
1965	0.269	0.440
1966	0.383	0.488
1967	0.458	0.434
1968	1.033	0.373
1969	0.627	0.311
1970	0.452	0.683
1971	8.463	0.304
1972	0.266	0.594
1973	0.153	0.249
1974	0.596	0.508
1975	0.443	0.454
1976	1.074	0.462
1977	0.241	0.302
1978	0.192	0.200
1979	0.145	0.204
1980	0.090	0.173
1981	0.097	0.124
1982	0.016	0.028
1983	0.012	0.006
1984	0.067	0.010
1985	0.025	0.004
1986	0.015	0.003
1987	0.021	0.009
1988	0.018	0.016
1989	0.051	0.019
1990	0.132	0.099
1991	0.106	0.017
1992	0.070	0.057
1993	0.084	0.071
1994	0.039	0.056
1995	0.028	0.052
1996	0.066	0.065
1997	0.017	0.065
1998	0.023	0.049
1999	0.007	0.065

Table 10- 12. Projections of future catch (t) of the Aleutian Island Pacific ocean perch under various harvest rates.

F level	YEAR 2000	2001	2002	2003	2004
F_{OFL}	14,380	12,731	11,428	10,466	10,034
90% CI	(14,378 - 14,383)	(12,722-12,745)	(11,386 - 11,494)	(10,296 - 10,740)	(9,502- 10,858)
F_{ABC}	12,279	11,113	10,162	9,449	9,166
90% CI	(12,277 - 12,281)	(11,106 - 11,125)	(10,126 - 10,220)	(9,300 - 9,689)	(8,694 - 9,896)
$F_{ABC}/2$	6,240	6,017	5,817	5,674	5,720
90% CI	(6,240 - 6,241)	(6,013 - 6,023)	(5,798 - 5,848)	(5,592 - 5,807)	(5,455 - 6,139)
Recent F level (F = 0.05736)	10,099	9,592	9,144	8,789	8,668
90% CI	(10,098 - 10,101)	(9,586 - 9,601)	(9,117 - 9,188)	(8,689 - 8,944)	(8,404 - 9,057)

Table 10-13. Projections of future spawning biomass (t) of the Aleutian Island Pacific ocean perch under various harvest rates. The estimated $B_{40\%}$ and $B_{35\%}$ values are 100,300 t and 87,741 t, respectively.

F level	YEAR 2000	2001	2002	2003	2004
F_{OFL}	97,506	93,101	89,368	86,407	84,812
90% CI	(97,506 - 97,506)	(93,097 - 93,107)	(89,325 - 89,442)	(86,048 - 87,006)	(83,045 - 87,644)
F_{ABC}	97,780	94,356	91,376	88,990	87,843
90% Cl	(97,780 - 97,780)	(94,352 - 94,362)	(91,332 - 91,450)	(88,629 - 89,592)	(86,062 - 90699)
F_{ABC} /2	98,553	98,011	97,451	97,089	97,656
90% CI	(98,553 - 98,553)	(98,007 - 98,017)	(97,407 - 97,526)	(96,722 - 97,700)	(95,828 - 100,591)
Recent F level (F = 0.05736)	98,061	95,635	93,341	91,395	90,518
90% Cl	(98,061 - 98,061)	(95,632 - 95,642)	(93,296 - 93,416)	(91,025 - 92,010)	(88,684 - 93,460)
F=O	99,332	101,868	104,259	106,701	109,954
90% CI	(99,332 - 99,332)	(101,864 - 101,874)	(104,214 - 104,335)	(106,328 - 107,324)	(108,067 - 112,988)

Table 10-14. Projections of future catch (t) of the eastern Bering Sea Pacific ocean perch under various harvest rates.

F level	YEAR 2000	2001	2002	2003	2004
F_{OFL}	3,106	3,074	3,040	3,008	2,984
90% CI	(3,104 - 3 106)	(3.071 - 3079)	(3,027 - 3,063)	(2,957 - 3,094)	(2,837 - 3220)
F_{ABC}	2,599	2,624	2,642	2,656	2,670
90% CI	(2,598 - 2,600)	(2.621 - 2,628)	(2,631 - 2,662)	(2,612 - 2,730)	(2,543 - 2,877)
$F_{ABC}/2$	1,316	1,396	1,464	1,500	1,535
90% CI	(1,315 - 1,316)	(1,395 - 1,398)	(1,459 - 1,473)	(1,482 - 1,530)	(1,493 - 1,599)
Recent F level (F = 0.03456)	1,665	1,702	1,739	1,773	1,807
90% CI	(1,665 - 1666)	(1,701 - 1,705)	(1,732 - 1,750)	(1,751 - 1,808)	(1,756 - 1,884)

Table **10-** 15. Projections of future spawning biomass (t) of the eastern Bering Sea Pacific ocean perch under various harvest rates. The estimated B,, and $B_{35\%}$ values are 26,176 t and 22,904 t, respectively.

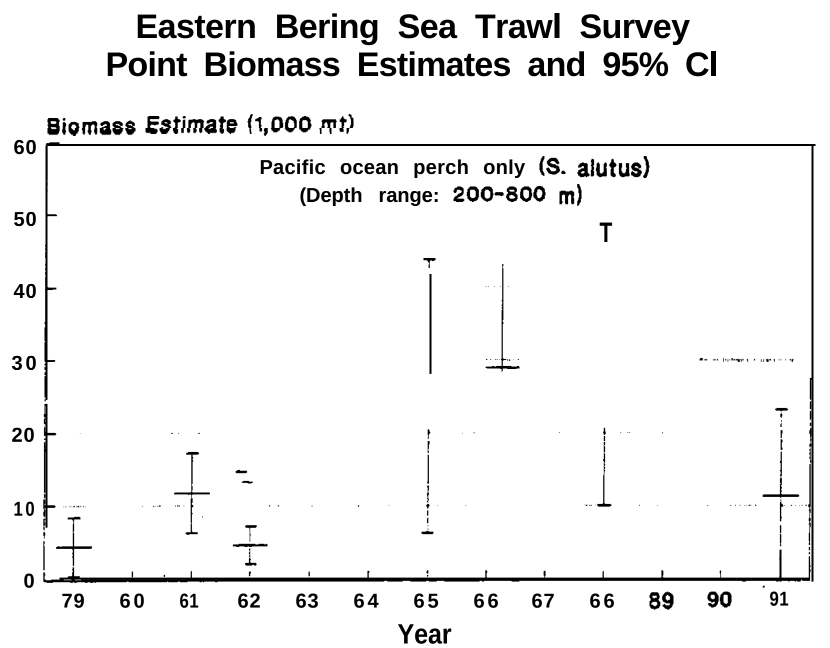
	YEAR				
F level	2000	2001	2002	0	2004 3
F_{OFL}	24,840	24,718	24,579	24,432	**24,3** 16
90% CI	(24,840 - 24,840)	(24,717 - 24,720)	(24,567 - 24,599)	(24,339 - 24,594)	(23,869 - 25,076)
F_{ABC}	24,904	25,025	25106	25,153	25,207
90% CI	(24,904 - 24,904)	(25,024 - 25,027)	(25,094 - 25,127)	(25,060 - **25,3** 16)	(24,755 - 25,974)
$F_{ABC}/2$	25,063	25,814	26,506	27,141	27,765
90% CI	(25,063 - 25,063)	(25,814 - 25,816)	(26,494 - 26,527)	(27,045 - 27,308)	(27,294 - 28,567)
Recent F level					
(F = 0.03456)	25,020	25,603	26,144	26,642	**27,13**1
90% CI	(25,020 - 25,020)	(25,602 - 25,605)	(26,132 - 26,165)	(26,546 - 26,809)	(26,662 - 27,930)
F=O	25,223	26,638	28,040	**29,4** 13	30,785
90% CI	(25,223 - 25,223)	(26,637 - 26,640)	(28,028 - 28,061)	(**29,3** 16 - 29,582)	(30,306 - 3 1,603)

Table 10-16. Pacific ocean perch biomass estimates (t) from the 1991, 1994, and 1997 triennial trawl surveys broken out by the three management sub-areas in the Aleutian Islands region.

	Aleutian Islands Management Sub-Areas			
	western	central	Eastern	Total
1991	226,409	112,766	66,188	405,363
1994	210,898	105,075	107,072	423,045
1997	273,303	222,396	218,141	713,840
Average	236,870 (46.1%)	146,756 (28.5%)	130,467 (25.4%)	514,093 (100.0%)

Table 10- 17. Catch of Pacific ocean perch (t) in Aleutian Island and Eastern Bering Sea trawl surveys

	Region	
Year	AI	EBS
1977		0.008
1978		0.144
1979		3.083
1980	71.471	0.002
1981		13.982
1982	0.239	12.088
1983	133.301	0.161
1984		0.000
1985		98.567
1986	164.536	0.004
1987		0.014
1988		10.428
1989		0.003
1990		0.031
1991	73.565	2.762
1992		0383
1993		0.011
1994	112.789	0.026
1995		0.023
19%		1.179
1997	177.940	0.880
1998		0.006
1999		0.001



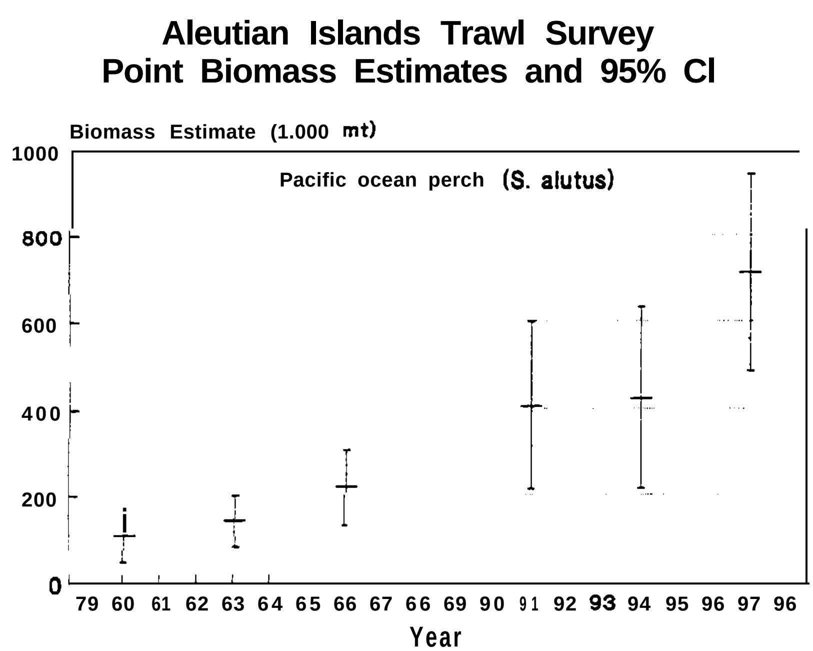
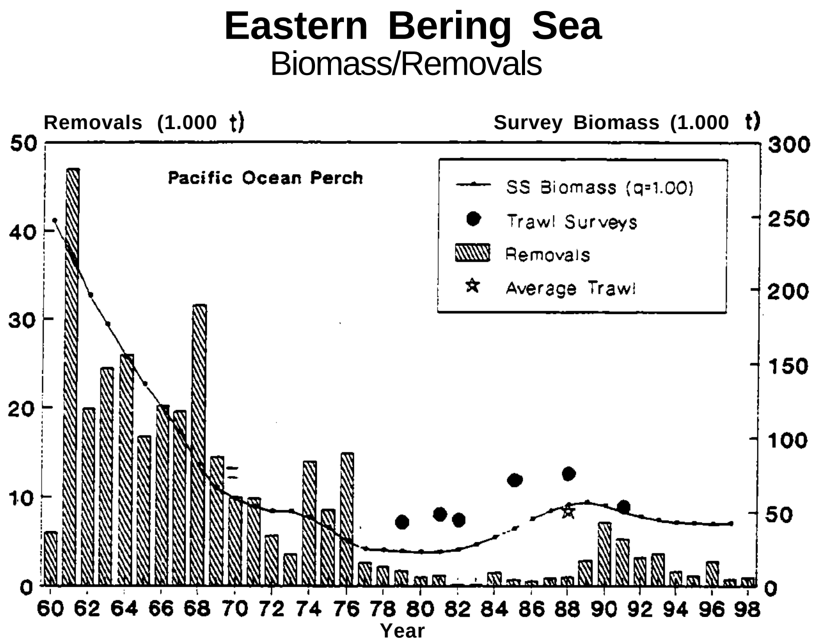


Figure 10-I. Estimated biomass and 95% confidence intervals by year and region.



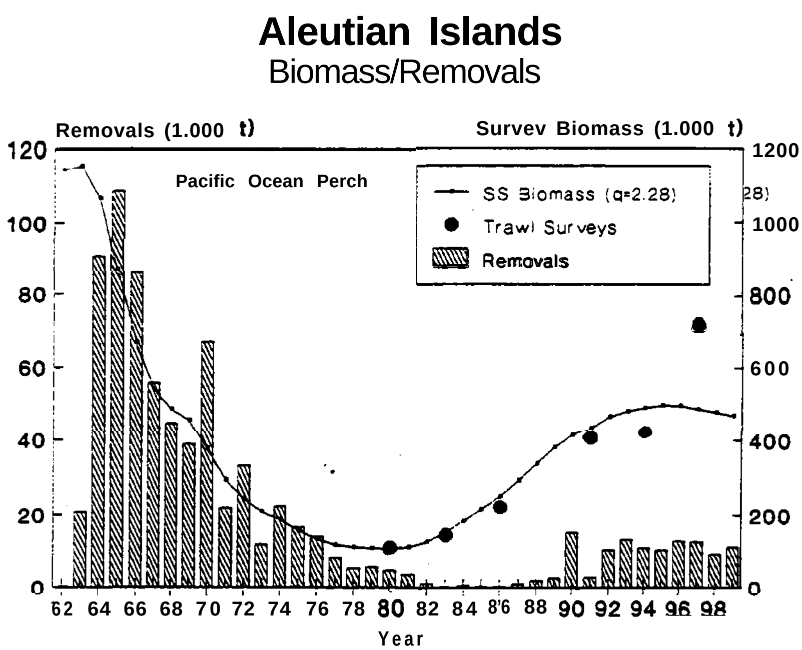
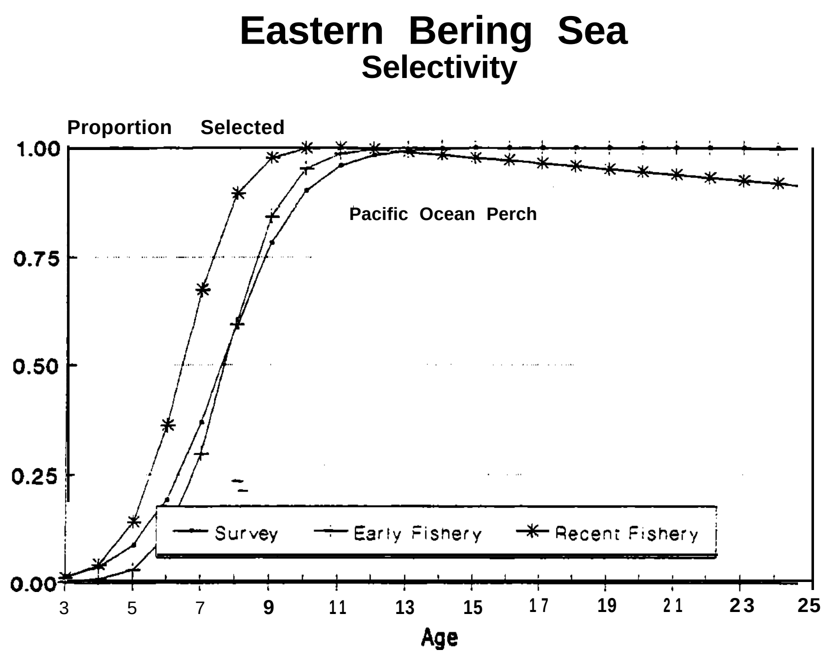


Figure 10-2. Estimated total removals and predicted and observed survey biomass trends for the eastern Bering Sea and Aleutian Islands region.



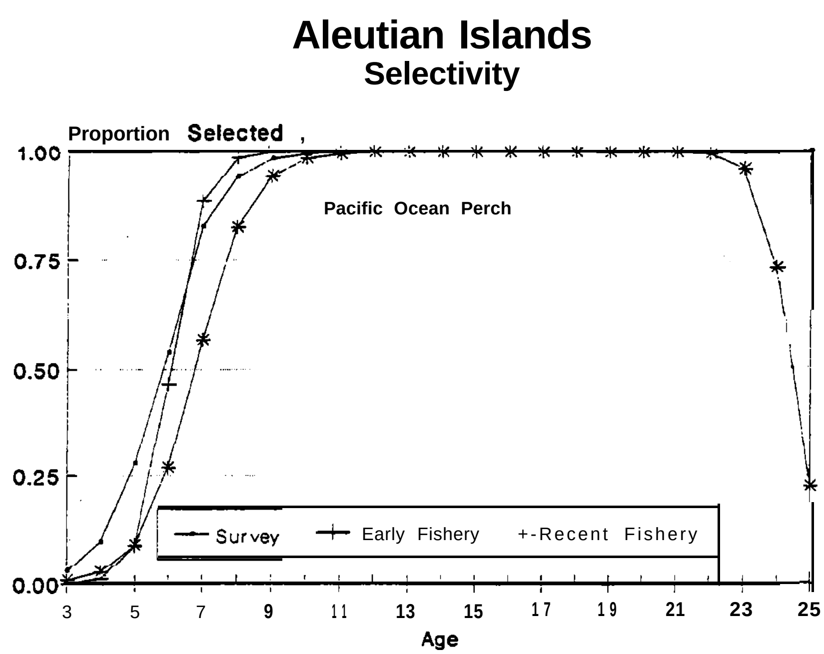
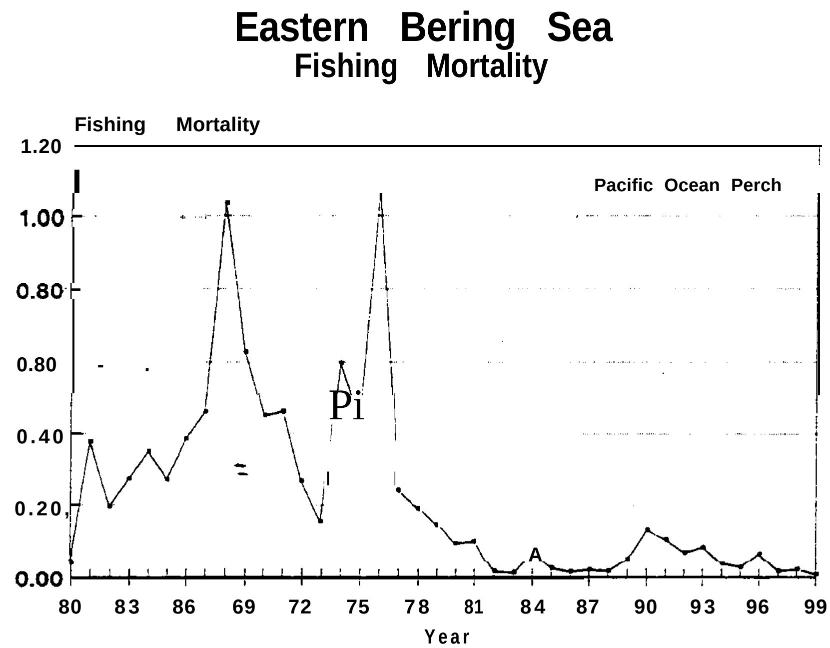


Figure 1 O-3. Selectivity patterns for the eastern Bering Sea and Aleutian Islands region for two different fishery periods and the surveys.



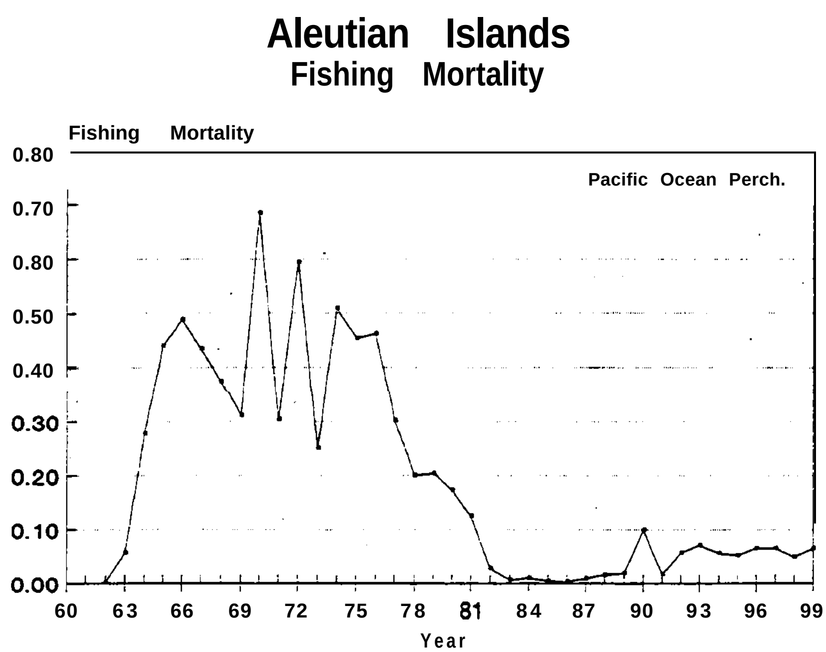


Figure 10-4. Estimated trajectory of full-selection fishing mortality rates for eastern Bering Sea and Aleutian Islands region.

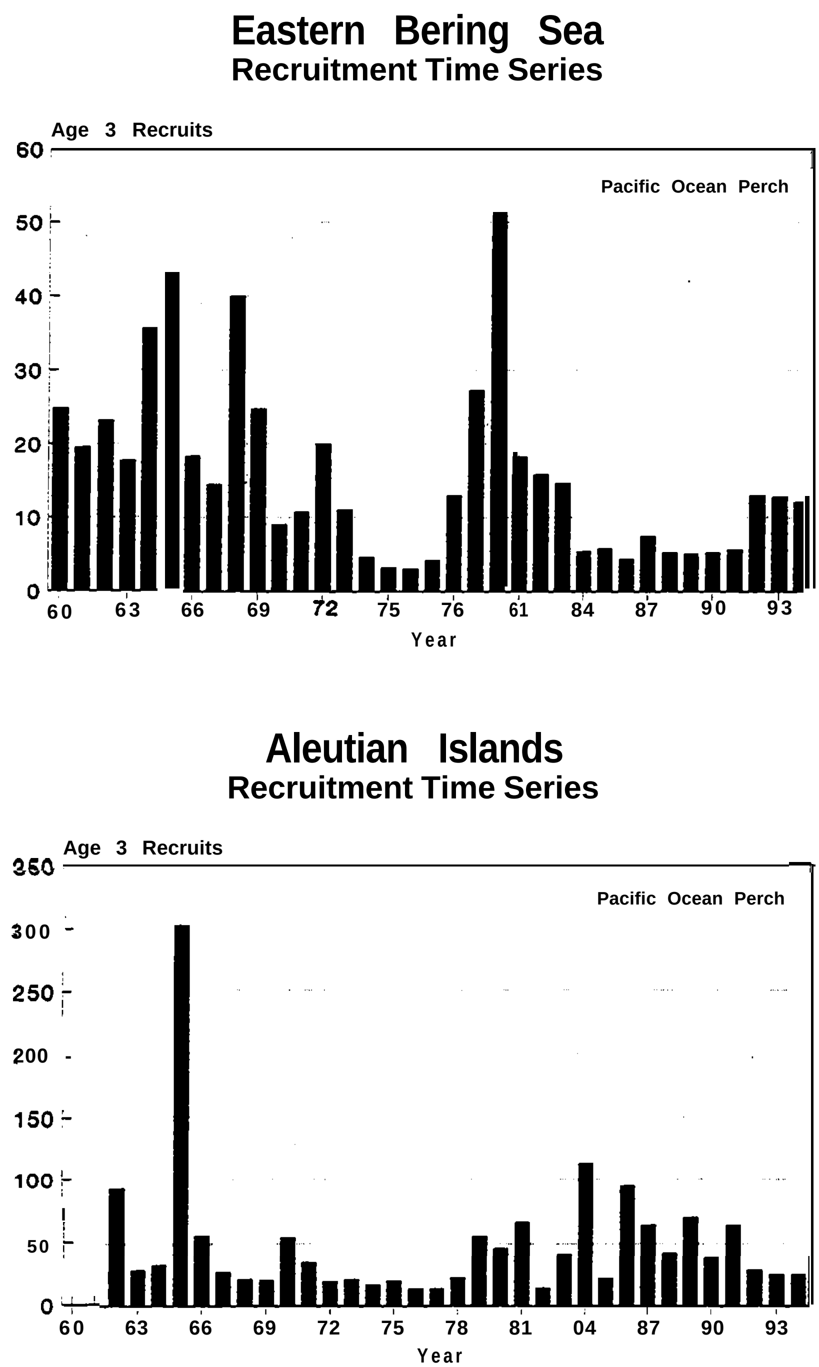
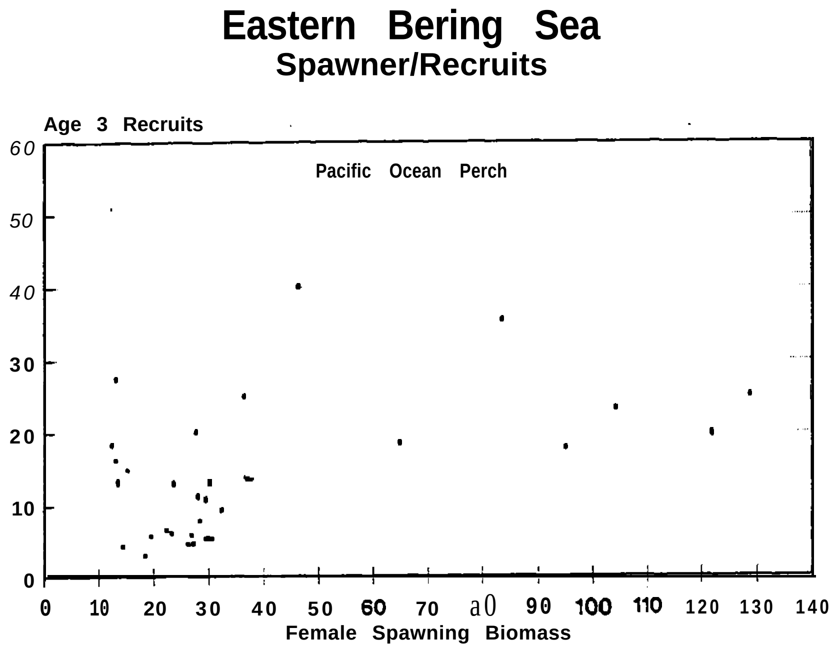


Figure 1 O-5. Estimated recruitment time series for the eastern Bering Sea and Aleutian Islands regions.



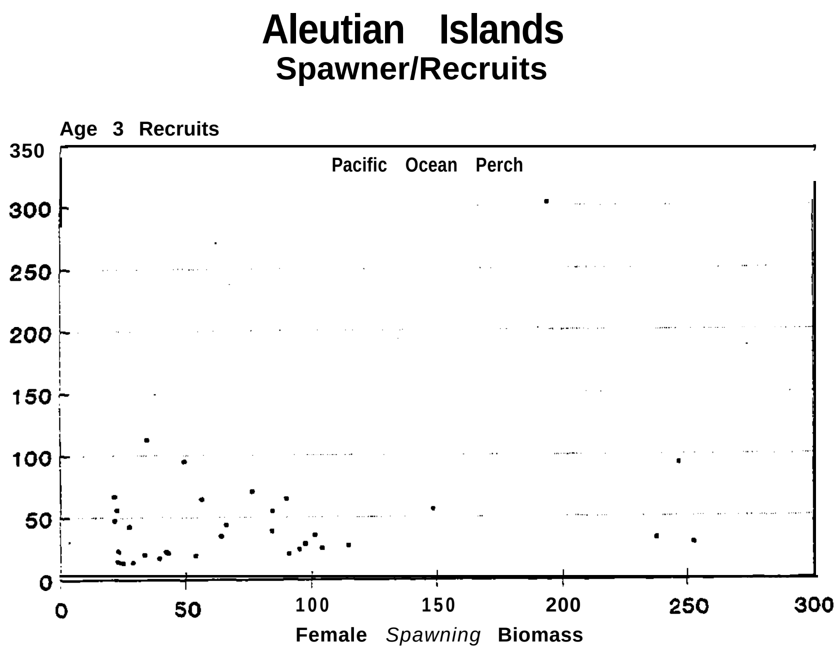


Figure 1 O-6. Estimated spawner-recruitment data for the eastern Bering Sea and Aleutian islands region.