# CHAPTER 2: ASSESSMENT OF THE PACIFIC COD STOCK IN THE EASTERN BERING SEA AND ALEUTIAN ISLANDS AREA

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## EXECUTIVE SUMMARY

### Summary of Major Changes

Relative to the November edition of last year's BSAI SAFE report, the following substantive changes have been made in the Pacific cod stock assessment.

Changes in the Input Data

1) Size composition data from the 2002 and January-September 2003 commercial fisheries were incorporated into the model.
2) Catch data for 2003 were incorporated and catch data for 1991-2002 were recompiled.
3) Size composition data from the 2003 EBS bottom trawl survey were incorporated.
4) The biomass estimate from the 2003 EBS bottom trawl survey was incorporated (the 2003 estimate of 605,681 t was down about 2% from the 2002 estimate).

Changes in the Assessment Model

No changes were made to the structure of the assessment model.

Changes in Assessment Results

1) The estimated 2004 female spawning biomass for the BSAI stock is 435,000 t, up about 3% from last year's estimate for 2003 and down about 1% from last year's $F_{ABC}$ projection for 2004.
2) The estimated 2004 total age 3+ biomass for the BSAI stock is 1,660,000 t, down about 1% from last year's estimate for 2003 and down about 3% from last year's $F_{40\%}$ projection for 2004.
3) The recommended 2004 ABC for the BSAI stock is 223,000 t, identical to both the 2002 and 2003 ABC.
4) The estimated 2004 OFL for the BSAI stock is 350,000 t, up about 8% from last year's estimate for 2003.

Responses to Comments of the Scientific and Statistical Committee (SSC)

SSC Comments Specific to the Pacific Cod Assessments

From the December, 2002 minutes: *"The SSC appreciates the authors attention to SSC comments from the December 2001 minutes with respect to model configuration for selectivity and retrospective analyses, and looks forward to future developments of spawner-recruit relationships for BS/AI cod."* As in the last two assessments, a provisional stock-recruitment relationship is described in the "Recruitment" subsection of the "Results" section. Additional research, not described in this assessment, has been conducted in support of a new assessment model capable of calculating a statistically valid spawner-recruit relationship for this stock.

SSC Comments on Assessments in General

There were no SSC comments on assessments in general during the last year.

## INTRODUCTION

Pacific cod (*Gadus macrocephalus*) is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34° N latitude, with a northern limit of about 63° N latitude. Pacific cod is distributed widely over the eastern Bering Sea (EBS) as well as in the Aleutian Islands (AI) area. The resource in these two areas (BSAI) is managed as a single unit. Tagging studies (e.g., Shimada and Kimura 1994) have demonstrated significant migration both within and between the EBS, AI, and Gulf of Alaska (GOA), and genetic studies (e.g., Grant et al. 1987) have failed to show significant evidence of stock structure within these areas. Pacific cod is not known to exhibit any special life history characteristics that would require it to be assessed or managed differently from other groundfish stocks in the EBS or AI areas.

## FISHERY

During the early 1960s, a Japanese longline fishery harvested BSAI Pacific cod for the frozen fish market. Beginning in 1964, the Japanese trawl fishery for walleye pollock (*Theragra chalcogramma*) expanded and cod became an important bycatch species and an occasional target species when high concentrations were detected during pollock operations. By the time that the Magnuson Fishery Conservation and Management Act went into effect in 1977, foreign catches of Pacific cod had consistently been in the 30,000-70,000 t range for a full decade. Catches of Pacific cod taken in the EBS, AI, and BSAI since 1978 are shown in Tables 2.1a, 2.1b, and 2.1c, respectively. (For this assessment, catch data for 1991-2002 were recompiled, meaning that some entries in Tables 2.1a-c may not match the values shown in previous SAFE reports.) The catches in Tables 2.1a-c are broken down by management area, year, fleet sector, and gear type. In 1981, a U.S. domestic trawl fishery and several joint venture fisheries began operations in the BSAI. The foreign and joint venture sectors dominated catches through

1988, but by 1989 the domestic sector was dominant and by 1991 the foreign and joint venture sectors had been displaced entirely. Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including trawl, longline, pot, and jig components. Figure 2.1 shows areas in which sampled hauls for each of the three main gear types (trawl, longline, and pot) were concentrated during 2002. To create this figure, the EEZ off Alaska was divided into 10 km × 10 km squares. A square is shaded if more than two hauls containing Pacific cod were sampled in it during 2002. In the upper panel, the shaded cells represent 89% of the total BSAI/GOA trawl catch; in the middle panel, the shaded cells represent 64% of the total BSAI/GOA longline catch; and in the lower panel, the shaded cells represent 46% of the total BSAI/GOA pot catch.

The history of acceptable biological catch (ABC) and total allowable catch (TAC) levels is summarized and compared with the time series of aggregate (i.e., all-gear, combined area) commercial catches in Table 2.2. From 1980 through 2003, TAC averaged about 76% of ABC, and aggregate commercial catch averaged about 87% of TAC. In 8 of these 24 years (33%), TAC equaled ABC exactly, and in 4 of these 24 years (17%), catch exceeded TAC. Changes in ABC over time are typically attributable to three factors: 1) changes in resource abundance, 2) changes in management strategy, and 3) changes in the stock assessment model. For example, from 1980 through 2005, five different assessment models were used (Table 2.2), though the present model has remained unchanged since 1997 (except for the addition of a new fishery selectivity era beginning in 2000). Historically, the great majority of the BSAI catch has come from the EBS area. During the most recent five-year period (1997-2001), the EBS accounted for an average of about 82% of the BSAI catch.

Current regulations specify that the BSAI Pacific cod TAC will be allocated initially according to gear type as follows: the trawl fishery will be allocated 47%, the fixed gear (longline and pot) fishery will be allocated 51%, and the jig fishery will be allocated 2%; of the fixed gear allocation, the longline fishery will be allocated 80.3% (not counting catcher vessels less than 60 ft LOA), the pot fishery will be allocated 18.3% (not counting catcher vessels less than 60 ft. LOA), and fixed-gear catcher vessels less than 60 ft. LOA will be allocated 1.4%. Typically, as the harvest year progresses, it becomes apparent that one or more gear types will be unable to harvest their full allotment(s) by the end of the year. This is addressed by reallocating TAC between gear types in September of each year. Most often, such reallocations shift TAC from the trawl, jig, and sometimes pot components of the fishery to the longline catcher/processors. The longline catcher-processors typically receive 15,000-20,000 t per year through such transfers.

An analysis of recent trends in Pacific cod catches by three-digit statistical area, gear, and month is presented in Appendix 2A.

The catches shown in Tables 2.1a-c and 2.2 include estimated discards. Discard rates of Pacific cod in the various EBS and AI target fisheries are shown for each year 1991-2002 in Table 2.3.

## DATA

This section describes data used in the current assessment. It does not attempt to summarize all available data pertaining to Pacific cod in the BSAI.

## Commercial Catch Data

### Catch Biomass

Catches (including estimated discards) taken in the EBS since 1978 are shown in Table 2.4, broken down by the three main gear types and intra-annual periods consisting of the months January-May, June-August, and September-December. This particular division, which was suggested by participants in the EBS fishery, is intended to reflect actual intra-annual differences in fleet operation (e.g., fishing operations during the spawning period may be different than at other times of year). In years for which estimates of the distribution by gear or period were not available, proxies based on other years' distributions were used.

### Catch Size Composition

Fishery size compositions are presently available, by gear, for the years 1978 through the first part of 2003. As in all assessments since 1997, size composition data from trawl catches sampled on shore were not included in the set of input data, because a comparison of cruises for which both at-sea and shoreside size composition samples were available showed that, in the case of trawl catches, the shoreside data typically contained a smaller proportion of small fish than the at-sea data, indicating that these data may reflect post-discard landings rather than the entire catch. For ease of representation and analysis, length frequency data for Pacific cod can usefully be grouped according to the following set of 25 intervals or "bins," with the upper and lower boundaries shown in cm:

| Bin Number: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lower Bound: | 9 | 12 | 15 | 18 | 21 | 24 | 27 | 30 | 33 | 36 | 39 | 42 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 | 105 |
| Upper Bound: | 11 | 14 | 17 | 20 | 23 | 26 | 29 | 32 | 35 | 38 | 41 | 44 | 49 | 54 | 59 | 64 | 69 | 74 | 79 | 84 | 89 | 94 | 99 | 104 | 115 |

Total length sample sizes for each year, gear, and period are shown in Table 2.5. The collections of relative length frequencies are shown by year, period, and size bin for the pre-1989 trawl fishery in Table 2.6, the pre-1989 longline fishery in Table 2.7, the post-1988 trawl fishery in Tables 2.8a-b, the post-1988 longline fishery in Tables 2.9a-b, and the pot fishery in Tables 2.10a-b.

## Survey Data

### EBS Shelf Trawl Survey

The relative size compositions from trawl surveys of the EBS shelf conducted by the Alaska Fisheries Science Center since 1979 are shown in Table 2.11, using the same length bins defined above for the commercial catch size compositions. Information regarding the absolute numbers of fish measured at each length are available only for the years 1986-1987 and 1990-2003. For all other years, only relative numbers of measured fish are available. The total sample sizes from the years 1986-1987 and 1990-2003 are shown below:

| Year: | 1986 | 1987 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|
| Sample Size: | 15376 | 10609 | 5628 | 7228 | 9601 | 10404 | 13922 | 9216 |

| Year: | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|
| Sample Size: | 9348 | 9169 | 9583 | 11699 | 12564 | 19750 | 12238 | 12360 |

Estimates of total abundance (both in biomass and numbers of fish) obtained from the trawl surveys are shown in Table 2.12, together with the standard errors and upper and lower 95% confidence intervals (CI) for the biomass estimates. Survey results indicate that biomass increased steadily from 1978 through 1983, then remained relatively constant from 1983 through 1989. The highest biomass ever observed by the survey was the 1994 estimate of 1,368,109 t. Following the high observation in 1994, the survey biomass estimate declined steadily through 1998. The survey biomass estimates remained in the 520,000-620,000 t range from 1998 through 2003, except for 2001, when the estimate was 830,479 t. The 2003 estimate was 605,681 t.

In terms of numbers (as opposed to biomass), the record high was observed in 1979, when the population was estimated to include over 1.5 billion fish. The 1994 estimate of population numbers was the second highest on record. After the peak in 1994, numerical declines were observed through 1997, paralleling the biomass time trend. The survey estimate of population numbers remained in the 480-570 million fish range from 1997 through 2003, except for 2001, when the estimate was 980 million fish. The 2003 estimate was 510 million fish.

Both the biomass and numerical abundance estimates from the 2001 survey appear likely to be overestimates, given the magnitudes of the implied increases relative to the 2000 survey (57% and 104%, respectively) and the fact that the 2002-2003 estimates were much more in line with the preceding estimates.

Aleutian Trawl Survey

Biomass estimates for the Aleutian Islands region were derived from U.S.-Japan cooperative trawl surveys conducted during the summers of 1980, 1983, and 1986, and by U.S. trawl surveys of the same area in 1991, 1994, 1997, 2000, and 2002. These surveys covered both the Aleutian management area (170 degrees east to 170 degrees west) and a portion of the Bering Sea management area ("Southern Bering Sea") not covered by the EBS shelf surveys. The time series of biomass estimates from both portions of the Aleutian survey area are shown together with their sum below (all figures are in t):

| Year | Aleutian Management Area | Southern Bering Sea | Aleutian Survey Area |
|---|---|---|---|
| 1980 | 52,070 | 74,373 | 126,443 |
| 1983 | 113,148 | 45,624 | 158,772 |
| 1986 | 172,625 | 42,298 | 214,923 |
| 1991 | 180,904 | 8,286 | 189,190 |
| 1994 | 153,026 | 31,084 | 184,109 |
| 1997 | 72,674 | 10,742 | 83,416 |
| 2000 | 126,918 | 9,157 | 136,075 |
| 2002 | 73,252 | 9,601 | 82,853 |

As in previous assessments of Pacific cod in the BSAI, a weighted average formed from EBS and

Aleutian survey biomass estimates is used in the present assessment to provide a conversion factor which can be used to translate model projections of EBS catch and biomass into BSAI equivalents. Because the assessment model is configured to represent the portion of the Pacific cod population inhabiting the EBS survey area (as opposed to the more extensive EBS *management* area), it seems appropriate to use the biomass estimates from the entire Aleutian survey area (as opposed to the less extensive Aleutian *management* area) to inflate model projections of EBS catch and biomass. Weighted averages of the biomass estimates from the entire Aleutian survey area and their EBS survey area counterparts indicate that, on average, the ratio of Pacific cod biomass in the combined BS and AI management areas to that in the EBS survey area is about 1.17. Because the 83-112 net (with no roller gear) used in the EBS survey generally tends the bottom better than the polyethylene Noreastern net (with roller gear) used in the AI survey, this ratio should tend to err on the conservative side.

### Length at Age, Weight at Length, and Maturity at Length

The set of reliable length at age data for BSAI Pacific cod has been small for the past several years and such data are used only sparingly in this assessment. The otoliths examined from fish sampled during EBS shelf trawl surveys provide the following data regarding the relationship between age and length and the amount of spread around that relationship (lengths, in cm, were measured during summer, and ages are back-dated to January 1):

| Age group: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average length: | 19 | 29 | 37 | 48 | 57 | 65 | 73 | 79 | 82 | 84 | 86 | 89 |
| St. dev. of length: | 3.5 | 5.3 | 5.0 | 4.9 | 4.2 | 3.7 | 4.0 | 5.4 | 7.4 | 5.8 | 7.4 | 7.7 |

Although the supply of reliable length at age data has been severely limited in the past, it now appears likely that such data will become much more available in the future. Studies at the Alaska Fisheries Science Center have resulted in an ageing methodology for Pacific cod that gives reliable age determinations, and production ageing of this species has recently begun (Delsa Anderl, pers. commun.).

Weight measurements taken during summer bottom trawl surveys since 1975 yield the following data regarding average weights (in kg) at length, grouped according to size composition bin (as defined under "Catch Size Composition" above):

| Bin Number: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ave. weight: | 0.0 | 0.0 | 0.0 | 0.1 | 0.1 | 0.2 | 0.2 | 0.3 | 0.4 | 0.6 | 0.7 | 0.9 | 1.2 | 1.6 | 2.2 | 2.9 | 3.5 | 4.6 | 5.6 | 7.0 | 8.4 | 10.1 | 11.8 | 11.0 | 15.0 |

From 1984 through 1994, assessments of EBS Pacific cod used a maturity schedule based on a logistic function with an inflection at about 61 cm. This schedule was based on a survey sample of fish taken during the 1981-1982 field seasons (see review provided by Thompson and Methot 1993). To update the maturity schedule for Pacific cod, a sampling program was conducted in 1993-1994, using commercial fishery observers. The resulting data consist of observers' visual determinations regarding the spawning condition of 2312 females taken in the EBS fishery. Of these 2312 females, 231 were smaller than 42 cm (the lower boundary of length bin 12). None of these sub-42 cm fish were mature. The observed proportions of mature fish in the remaining length bins, together with the numbers of fish sampled in those length bins, are shown below (bins are defined under "Catch Size Composition" above):

| Bin number: | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prop. mature: | 0.03 | 0.05 | 0.14 | 0.19 | 0.28 | 0.53 | 0.69 | 0.82 | 0.89 | 0.94 | 0.94 | 0.91 | 0.89 | 1.00 |
| Sample size: | 39 | 122 | 226 | 313 | 295 | 300 | 320 | 177 | 103 | 70 | 50 | 35 | 19 | 12 |

## ANALYTIC APPROACH

### Model Structure

This year's base model structure is identical to the base model structure used in all assessments of the EBS Pacific cod stock since 1997 (Thompson and Dorn 1997). Beginning with the 1993 SAFE report (Thompson and Methot 1993), a length-structured Synthesis model (Methot 1986, 1989, 1990, 1998) has formed the primary analytical tool used to assess the EBS Pacific cod stock. Synthesis is a program that uses the parameters of a set of equations governing the assumed dynamics of the stock (the “model parameters”) as surrogates for the parameters of statistical distributions from which the data are assumed to be drawn (the “distribution parameters”), and varies the model parameters systematically in the direction of increasing likelihood until a maximum is reached. The overall likelihood is the product of the likelihoods for each of the model components. Each likelihood component is associated with a set of data assumed to be drawn from statistical distributions of the same general form (e.g., multinomial, lognormal, etc.). Typically, likelihood components are associated with data sets such as catch size (or age) composition, survey size (or age) composition, and survey biomass.

The Synthesis program permits each data time series to be divided into multiple segments, or “eras,” resulting in a separate set of parameter estimates for each era. In the base model for the EBS Pacific cod assessment, for example, the survey size composition and survey biomass time series have traditionally been split into pre-1982 and post-1981 eras to account for the effects of a change in the trawl survey gear that occurred in 1982. Also, to account for possible differences in selectivity between the mostly foreign (also joint venture) and mostly domestic fisheries, the fishery size composition time series in the base model has traditionally been split into pre-1989 and post-1988 eras. A minor modification of the base model was suggested by the SSC in 2001, namely, that consideration be given to dividing the domestic era into pre-2000 and post-1999 segments. This modification was tested in the 2002 assessment (Thompson and Dorn 2002) and was found to result in a statistically significant improvement in the model’s ability to fit the data. Therefore, the present assessment treats the post-1999 fisheries separately from the 1978-1988 and 1989-1999 fisheries.

Symbols used in the stock assessment model are listed in Table 2.13 (note that this list applies to the stock assessment model only, and does not include all symbols used elsewhere in this document). Synthesis uses a total of 16 dimensional constants, special values of indices, and special values of continuous variables, all of which are listed on the first page of Table 2.13. The values of these quantities are not estimated statistically, in the strict sense, but are typically set by assumption or as a matter of structural specification. The values of these constants, indices, and variables are listed in Table 2.14, with a brief rationale given for each value used. In contrast to the quantities whose values are specified in Table 2.14, Synthesis uses a large number of parameters that are estimated statistically (though the estimation itself may not necessarily take place within Synthesis). For ease of reference, capital Roman letters are used to designate such “Synthesis parameters,” which are listed on the second page of Table 2.13. Functional representations of population dynamics are given in Appendix 2A of the 2002 stock assessment (Thompson and Dorn 2002).

Parameters Estimated Independently

Table 2.15 divides the set of Synthesis parameters into two parts, the first of which lists those parameters that were estimated independently (i.e., outside of Synthesis), and the second of which lists those parameters that were estimated conditionally (i.e., inside of Synthesis). This section describes the estimation of parameters in the first part of Table 2.15.

Natural Mortality

The natural mortality rate was estimated independently of other parameters at a value of 0.37. This value was used in the present assessment for the following reasons: 1) it was derived as the maximum likelihood estimate of *M* in the 1993 BSAI Pacific cod assessment (Thompson and Methot 1993), 2) it has been used to represent *M* in all BSAI Pacific cod assessments since 1993 and in all GOA Pacific cod assessments except one since 1994, 3) it was explicitly accepted by the SSC for use as an estimate of *M* in the GOA Pacific cod assessment (SSC minutes, December, 1994), and 4) it lies well within the range of previously published estimates of *M* shown below:

| Area | Author | Year | Value |
|---|---|---|---|
| Eastern Bering Sea | Low | 1974 | 0.30-0.45 |
| | Wespestad et al. | 1982 | 0.70 |
| | Bakkala and Wespestad | 1985 | 0.45 |
| | Thompson and Shimada | 1990 | 0.29 |
| | Thompson and Methot | 1993 | 0.37 |
| Gulf of Alaska | Thompson and Zenger | 1993 | 0.27 |
| | Thompson and Zenger | 1995 | 0.50 |
| British Columbia | Ketchen | 1964 | 0.83-0.99 |
| | Fournier | 1983 | 0.65 |

Trawl Survey Catchability

The trawl survey catchability coefficient was estimated independently of other parameters at a value of 1.0. This value was used in the present assessment mostly because it has been used in all previous assessments. Also, preliminary results of recent experimental work conducted in the EBS by the Alaska Fisheries Science Center's Resource Assessment and Conservation Engineering Division tend to confirm that this is a reasonable value (David Somerton, pers. commun.).

Weight at Length

Parameters (Table 2.13) governing the relationship between weight and length were estimated by log-log regression from the available data (see "Data" above), giving the following values (weights are in kg, lengths in cm): $W_1 = 4.36 \times 10^{-6}$, $W_2 = 3.242$.

Length at First Age of Survey Observation

Assuming that the first age at which Pacific cod are seen in the trawl survey ($\alpha_1$, Table 2.13) is approximately 1.5 years, the length at this age ($L_1$, Table 2.13) as estimated to be 15.8 cm by averaging the lengths corresponding to the first mode greater than or equal to 14 cm (bin 2) from each of the five most recent survey size compositions.

Variability in Length at Age

Parameters (Table 2.13) governing the amount of variability surrounding the length-at-age relationship were estimated directly from the observed standard deviations in the available length-at-age data (see "Data" above), giving the following values (in cm): $X_1$ = 3.5, $X_2$ = 7.7. Estimation of these two parameters constituted the only use of age data in the present assessment.

Maturity at Length

Maximum likelihood estimates of the parameters (Table 2.13) governing the female maturity-at-length schedule were obtained using the method described by Prentice (1976), giving the following values: $P_1$ = 0.142, $P_2$ = 67.1 cm. The variance-covariance matrix of the parameter estimates gave a standard deviation of 0.006 for the estimate of $P_1$, a standard deviation of 0.39 cm for the estimate of $P_2$, and a correlation of -0.154 between the estimates of the two parameters.

Parameters Estimated Conditionally

Those Synthesis parameters that are estimated internally are listed in the second part of Table 2.15. The estimates of these parameters are conditional on each other, as well as on those listed in the first part of the table and discussed in the preceding section (i.e., those Synthesis parameters that are estimated independently).

Likelihood Components

As noted in the "Model Structure" section, Synthesis is a likelihood-based framework for parameter estimation which allows several data components to be considered simultaneously. In this assessment, four fishery size composition likelihood components were included: the January-May ("early") trawl fishery, the June-December ("late") trawl fishery, the longline fishery, and the pot fishery. In addition to the fishery size composition components, likelihood components for the size composition and biomass trend from the bottom trawl survey were included in the model.

The Synthesis program allows the modeler to specify "emphasis" factors that determine which components receive the greatest attention during the parameter estimation process. As in previous assessments, each component was given an emphasis of 1.0 in the present assessment.

Use of Size Composition Data in Parameter Estimation

Size composition data are assumed to be drawn from a multinomial distribution specific to a particular year, gear/fishery, and time period within the year. In the parameter estimation process, Synthesis weights a given size composition observation (i.e., the size frequency distribution observed in a given year, gear/fishery, and period) according to the emphasis associated with the respective likelihood component and the sample size specified for the multinomial distribution from which the data are assumed to be drawn. In developing the model upon which Synthesis was originally based, Fournier and Archibald (1982) suggested truncating the multinomial sample size at a value of 400 in order to compensate for contingencies which cause the sampling process to depart from the process that gives rise to the multinomial distribution. As in previous assessments, the present assessment uses a multinomial sample size equal to the square root of the true sample size, rather than the true sample size itself. Given the true sample sizes observed in the present assessment, this procedure tends to give values somewhat below 400 while still providing the Synthesis program with usable information regarding the appropriate effort to devote to fitting individual samples. Multinomial sample sizes derived by this procedure for the commercial fishery size compositions are shown in Table 2.16. In the case of survey size composition data, the square root assumption was also used, except that it was necessary to assume a true sample size for the years 1979-1985 and 1988-1989, years for which such measures are unavailable (see “Trawl Survey Data” above). For those years, a true sample size of 10,000 fish was assumed (giving a multinomial sample size of 100), which approximates the average of the 10 known true sample sizes from the years 1986-1997. For the years 1986-1987 and 1990-2003, the square roots (SR) of the true survey sample sizes are shown below:

| Year: | 1986 | 1987 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|
| SR(sample size): | 124 | 103 | 75 | 85 | 98 | 102 | 118 | 96 |

| Year: | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
|---|---|---|---|---|---|---|---|---|
| SR(sample size): | 97 | 96 | 98 | 108 | 112 | 141 | 111 | 111 |

Use of Survey Biomass Data in Parameter Estimation

Each year’s survey biomass datum is assumed to be drawn from a lognormal distribution specific to that year. The model’s estimate of survey biomass in a given year serves as the geometric mean for that year’s lognormal distribution, and the ratio of the survey biomass datum’s standard error to the survey biomass datum itself serves as the distribution’s coefficient of variation.

## MODEL EVALUATION

### Evaluation Criteria

Three criteria were used to evaluate the stock assessment model: 1) the effective sample sizes of the size composition data, 2) the root mean squared error (RMSE) of the fit to the survey biomass data, and 3) the overall reasonableness of the results.

Effective Sample Size

Once maximum likelihood estimates of the model parameters have been obtained, Synthesis computes an “effective” sample size for the size composition data specific to a particular year, gear/fishery, and time period within the year. Roughly, the effective sample size can be interpreted as the multinomial sample size that would typically be required in order to produce the given fit. More precisely, it is the sample size that sets the sum of the marginal variances of the proportions implied by the multinomial distribution equal to the sum of the squared differences between the sample proportions and the estimated proportions (McAllister and Ianelli 1997). As a function of a multinomial random variable, the effective sample size has its own distribution. The harmonic mean of the distribution is equal to the true sample size in the multinomial distribution. Thus, if the effective sample size is less than the true sample size in the multinomial distribution, it is reasonable to conclude that the fit is not as good as expected. The following table shows the average of the input sample sizes and the average effective sample sizes for each of the size composition components in the two models (in each column, the average is computed with respect to all years and periods present in the respective time series):

| Size composition likelihood component | Average effective sample size | Average input sample size | Ratio (effective divided by input) |
|---|---|---|---|
| Early-season trawl fishery | 273 | 197 | 1.39 |
| Late-season trawl fishery | 84 | 46 | 1.83 |
| Longline fishery | 322 | 192 | 1.68 |
| Pot fishery | 228 | 111 | 2.05 |
| Pre-1982 survey | 85 | 100 | 0.85 |
| Post-1981 survey | 165 | 103 | 1.59 |
| All | 229 | 137 | 1.67 |

Note: True sample sizes for the survey are available only for the years 1986-1987 and 1990-2003. For all other years, a value of 10,000 (square root = 100) was assumed.

The model produces average effective sample sizes considerably larger than the average input values for all components except the pre-1982 survey component. However, the result for the pre-1982 survey component is not particularly meaningful because the true sample sizes for those years are unknown.

Observed and estimated size compositions in the January-May fisheries in 2001, 2002, and 2003 are compared in Figures 2.2, 2.3, and 2.4, respectively. Observed and estimated size compositions from the three most recent bottom trawl surveys are compared in Figure 2.5.

Fit to Survey Biomass Data

The root-mean-squared value of the lognormal “sigma” parameter in the survey biomass data is 0.097. The log-scale RMSE from the model is 0.198, about twice the value of the root-mean-squared-sigma. The inability of the model to achieve a log-scale RMSE close to the root-mean-squared-sigma may indicate that simple haul-to-haul sampling variability underestimates the true variability of the survey biomass data.

Overall Reasonableness of Results

The model’s estimates of length-at-age parameters $K$ and $L_2$ ($L_1$ was estimated independently) are shown below:

| Parameter | Estimate |
|---|---|
| $K$ | 0.216 |
| $L_2$ | 93.7 |

Model estimates of fishing mortality rates $F_{g,y,i}$, recruitments $R_y$ and initial numbers at age $N_a$, and selectivity parameters $S_{1\text{-}7,g,e(y|g)}$ are shown in Tables 2.17, 2.18, and 2.19, respectively.

Model estimates of age 3+ biomass, spawning biomass, and survey biomass are shown in Table 2.20 and Figure 2.6.

All of the above appear reasonable, with the possible exception of the relationship between age 3+ biomass and survey biomass (Table 2.20, Figure 2.6). On average, the model's estimate of age 3+ biomass exceeds the observed survey biomass by about 112%. While this result is biologically possible, there is no obvious reason why it should be expected.

### Schedules Defined by Parameter Estimates

Lengths at age defined by the final parameter estimates are shown below (lengths are in cm and are evaluated at the mid-point of each age group):

| Age group: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average length: | 15 | 32 | 46 | 57 | 66 | 73 | 79 | 83 | 87 | 90 | 93 | 97 |

The distribution of lengths at age (measured in mid-year) defined by the final parameter estimates is shown in Table 2.21.

Weights at length and maturity proportions at length defined by the final parameters are shown in Table 2.22, and selectivities at length defined by the final parameter estimates are shown in Table 2.23.

## RESULTS

### Definitions

The biomass estimates presented here will be defined in three ways: 1) age 3+ biomass, consisting of the biomass of all fish aged three years or greater in January of a given year; 2) spawning biomass, consisting of the biomass of all spawning females in March of a given year; and 3) survey biomass, consisting of the biomass of all fish that the model estimates should have been observed by the survey in July of a given year. The recruitment estimates presented here will be defined in two ways: 1) as numbers of age 3 fish in January of a given year and 2) as the recruitment parameter $R_y$, which represents numbers at age 1 in January of year *y*. The fishing mortality rates presented here will be defined as full-selection, instantaneous fishing mortality rates expressed on a per annum scale.

### Biomass

The model's estimate of the recent history of the stock (EBS portion only) is shown in Table 2.24, together with estimates provided in last year's final SAFE report (Thompson and Dorn 2002). The biomass trends estimated in the present assessment are also shown in Figure 2.6. The model's estimated time series of "survey" biomass parallels the biomass trend from the actual survey reasonably well, particularly given the occasional volatility of the survey time series. The model's estimate of survey biomass is within two standard deviations of the survey point estimate in 17 out of 25 years. Exceptions occur with respect to the 1982, 1985, 1991, and 1992 estimates, where the model's estimates are more than two standard deviations above the data, and with respect to the 1979, 1994, 1995, and 2001 estimates, where the model's estimates are more than two standard deviations below the data.

Figure 2.7 compares this year's estimate of the survey biomass time series with those from all other assessments since 1997 (the year in which the base model was standardized). These annual estimates have been remarkably consistent. If each assessment's estimate of the survey biomass time series had been used to predict the next assessment's estimate of the same time series, the $R^2$ would have ranged from a low of 0.989 (using the 2000 estimates to predict the 2001 estimates) to a high of 0.998 (using the 1998 estimates to predict the 1999 estimates and using the 2002 estimates to predict the 2003 estimates) . There is no obvious time trend in the survey biomass estimates between assessments.

The model's estimated age 3+ biomass shows a near-continual decline from 1987 through 2001, but an upward trend in each of the last two years. Similarly, the model's estimated spawning biomass shows a continual decline from 1987 through 2000, with an upward trend in each of the last three years. These recent upturns notwithstanding, the model's estimates of 2000-2003 spawning biomass are the four lowest points in the time series since 1981.

Figure 2.8 compares this year's estimate of the age 3+ biomass time series with those from all other assessments since 1997. Like the estimates of survey biomass, these annual estimates have been remarkably consistent. If each assessment's estimate of the age 3+ biomass time series had been used to predict the next assessment's estimate of the same time series, the $R^2$ would have ranged from a low of 0.942 (using the 1998 estimates to predict the 1999 estimates) to a high of 0.999 (using the 2002 estimates to predict the 2003 estimates). Unlike the annual estimates of the survey biomass time series, there does appear to be a slight time trend in the age 3+ biomass estimates between assessments. To measure this trend, the relative change in each year's age 3+ biomass estimate as assessed between each pair of successive assessments was computed (e.g., the relative change in the estimated value of age 3+ biomass for 1985 as assessed in, say, the 2000 and 2001 assessments), then the relative changes were averaged for each pair of successive assessments. The average relative change between the 1997 and 1998 assessments was negative, but for all other pairs of successive assessments the average relative change was either zero or slightly positive, as shown in the table below:

| | | | | | | |
|---|---|---|---|---|---|---|
| First assessment year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| Second assessment year | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
| Average relative change in age 3+ biomass | -0.033 | 0.076 | 0.072 | 0.006 | 0.000 | 0.003 |

Assuming that the assessments have become more accurate over time, the above table indicates that recent assessments have tended to err on the conservative side (i.e., they tend to underestimate age 3+ biomass).

Figure 2.9 plots the trajectory of fishing mortality and female spawning biomass from 1978 through 2003, overlaid with the current harvest control rules. The entire trajectory lies underneath both harvest control rules except for the years 1978 and 1979 (note that the current harvest control rules did not go into effect until 1999). In other words, fishing mortality rates have been well within the current limits throughout the period in which those limits have been in effect.

## Recruitment

Numbers at Age 3

Traditionally, recruitment strengths for Pacific cod have been assessed at age 3, because this is the approximate age of first significant recruitment to the fishery and because model estimates of relative year class strength tend to stabilize by this age. The model's estimated time series of age 3 recruitments is shown in Table 2.25, together with the estimates provided in last year's final SAFE report (Thompson and Dorn 2002). The model's recruitment estimates are also plotted in Figure 2.10. The current time series has a mean value of 244 million fish, a coefficient of variation of 59%, and an autocorrelation coefficient of -0.030.

One possible means of assigning a qualitative ranking to each year class within this time series is as follows: an "above average" year class can be defined as one in which numbers at age 3 are at least 120% of the mean, an "average" year class can be defined as one in which numbers at age 3 are less than 120% of the mean but at least 80% of the mean, and a "below average" year class can be defined as one in which numbers at age 3 are less than 80% of the mean. These criteria give the following classification of year class strengths:

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Above average: | 1977 | 1978 | 1979 | 1982 | 1984 | 1992 | 2000 | | | | | | | |
| Average: | 1980 | 1985 | 1989 | 1990 | 1996 | 1999 | | | | | | | | |
| Below average: | 1975 | 1976 | 1981 | 1983 | 1986 | 1987 | 1988 | 1991 | 1993 | 1994 | 1995 | 1997 | 1998 | |

Except for the addition of the 2000 year class to the "above average" category, these results are identical to those presented in last year's SAFE report (Thompson and Dorn 2002). The 2000 year class currently ranks as the sixth largest in the time series, and the largest since the 1984 year class.

Numbers at Age 1

The model's estimated time series of age 1 recruitments is shown in Table 2.18. This time series has a mean value of 520 million fish, a coefficient of variation of 58%, and an autocorrelation coefficient of -0.004. The qualitative rankings of year class strengths at age 1 naturally parallel the rankings at age 3, except that estimates for the 1975 and 1976 year classes do not exist at age 1 and the 2001 and 2002 year classes are added to the time series. The 2001 year class appears to be well below average, while the 2002 year class appears to be average. The model's estimate of age 1 recruitment from the 2001 year class is the lowest in the time series, although it should be noted that this estimate is based almost entirely on the 2002 and 2003 survey size composition data.

The present assessment model is not configured to estimate a stock-recruitment relationship. Estimation of stock-recruitment relationships is a notoriously difficult exercise in the field of stock assessment, because both the stock data and the recruitment data are measured with error and because the errors in the stock-recruitment data are autocorrelated (Walters and Ludwig 1981). Also, if the stock and recruitment data are generated by a model which assumes that no stock-recruitment relationship exists, these data will be biased. Nevertheless, the stock-recruitment relationship is potentially such an important component of stock dynamics that it seems prudent to provide some kind of investigation, albeit provisional, as to its possible shape. In addition, the SSC has requested that the assessment include a stock-recruitment relationship (SSC minutes, December, 2000; December, 2001; and December, 2002). To this end, the following analysis was conducted (use of symbols in this description does not necessarily follow Table 2.13, which pertains to the Synthesis assessment model only):

1) Age 1 recruitment $R$ in year $y$+1 was assumed to be related to spawning biomass $S$ in year $y$ by the Ricker (1954) stock-recruitment relationship subject to lognormal error:

$$R_{y+1} = S_y \exp\left(-\alpha - \beta S_y + \varepsilon_y\right),$$

where $\alpha$ and $\beta$ are parameters and the $\varepsilon_y$ are drawn from a normal distribution with mean 0 and variance $\sigma^2$.
2) The estimates of spawning biomass generated by Synthesis were treated as known constants (i.e., it was assumed that they are measured without error).
3) Parameters were estimated by the method of maximum likelihood.
4) The covariance of the parameter estimates was assumed to equal the inverse of the Hessian matrix.

The point estimates of the parameters were $\alpha$ = -1.629, $\beta$ = 0.003237, and $\sigma$ = 0.598. The 95% confidence interval of the stock-recruitment parameters is shown in the upper panel of Figure 2.11. One of the attractive features of the method described above is that it implies that the stock-recruitment relationship $r(S) = S\exp(-\alpha-\beta S)$ is itself a lognormal random variable with parameters that are functions of stock size. The coefficient of variation for the relationship is minimized at the mean of the stock data. The lower panel of Figure 2.11 shows the data (solid squares), the stock-recruitment relationship defined by the point estimates of the parameters (thick curve), and the 95% confidence interval around the stock-recruitment relationship (thin curves). This analysis is useful mostly because it indicates a considerable level of uncertainty regarding the shape of the stock-recruitment relationship. Moreover, this description of uncertainty should be regarded as an underestimate because of the problems noted in the paragraph above. The estimates given here are not recommended for use in estimating maximum sustainable yield. It should also be noted that this analysis pertains only to the EBS portion of the stock.

### Exploitation

The model's estimated time series of the ratio between EBS catch and age 3+ biomass is shown in Table 2.26, together with the estimates provided in last year's final SAFE report (Thompson and Dorn 2002). The average value of this ratio over the entire time series is about 0.088. The estimated values exceed the average for every year after 1990 except 1993, whereas none of the estimated values exceed the average in any year prior to 1991 except 1978.

## PROJECTIONS AND HARVEST ALTERNATIVES

### Amendment 56 Reference Points

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines the "overfishing level" (OFL), the fishing mortality rate used to set OFL ($F_{OFL}$), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC ($F_{ABC}$) may be less than this maximum permissible level, but not greater. Because reliable estimates of reference points related to maximum sustainable yield (MSY) are currently not available but reliable estimates of reference points related to spawning per recruit are available, Pacific cod in the BSAI are managed under Tier 3 of Amendment 56. Tier 3 uses the following reference points: $B_{40\%}$, equal to 40% of the equilibrium spawning biomass that would be obtained in the absence of fishing; $F_{35\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the level that would be obtained in the absence of fishing; and $F_{40\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing. The following formulae apply under Tier 3:

*3a)* *Stock status:* $B/B_{40\%} > 1$
$F_{OFL} = F_{35\%}$
$F_{ABC} \leq F_{40\%}$
*3b)* *Stock status:* $1/20 < B/B_{40\%} \leq 1$
$F_{OFL} = F_{35\%} \times (B/B_{40\%} - 1/20) \times 20/19$
$F_{ABC} \leq F_{40\%} \times (B/B_{40\%} - 1/20) \times 20/19$
*3c)* *Stock status:* $B/B_{40\%} \leq 1/20$
$F_{OFL} = 0$
$F_{ABC} = 0$

Estimation of the $B_{40\%}$ reference point used in the above formulae requires an assumption regarding the equilibrium level of recruitment. In this assessment, it is assumed that the equilibrium level of recruitment is equal to the post-1976 average (i.e., the arithmetic mean of all estimated recruitments from year classes spawned in 1977 or later). Other useful biomass reference points which can be calculated using this assumption are $B_{100\%}$ and $B_{35\%}$, defined analogously to $B_{40\%}$. These reference points are estimated as follows:

| Reference point: | $B_{35\%}$ | $B_{40\%}$ | $B_{100\%}$ |
|---|---|---|---|
| EBS: | 316,000 t | 361,000 t | 906,000 t |
| BSAI: | 370,000 t | 422,000 t | 1,060,000 t |

For a stock exploited by multiple gear types, estimation of $F_{35\%}$ and $F_{40\%}$ requires an assumption regarding the apportionment of fishing mortality among those gear types. The current allocation formula (see "Fishery" section) was integrated into calculation of reference points in this assessment as follows: First, to simplify the analysis, it was assumed that the 1.4% of the fixed-gear allocation that is reserved for catcher vessels less than 60 ft. LOA would be taken in the longline fishery. Second, since available data are insufficient to estimate selectivities for the jig fishery, the jig fishery was merged into the other commercial fisheries. Third, total fishing mortality was apportioned between gear types (early trawl, late trawl, longline, and pot) at a ratio of 441:57:389:113. These proportions result in a 2004 catch composition that matches both the 47:51 trawl:fixed allocation, the 817:183 longline:pot allocation and the recent (2000-2002) average distribution of catches between the early and late trawl fisheries. It should be noted that this apportionment scheme is generally consistent with existing Steller sea lion protection measures. This apportionment results in the following estimates of $F_{35\%}$ and $F_{40\%}$:

| $F_{35\%}$ | $F_{40\%}$ |
|---|---|
| 0.47 | 0.39 |

## Specification of OFL and Maximum Permissible ABC

BSAI spawning biomass for 2004 is estimated at a value of 430,000 t (EBS value = 368,000 t). This is about 2% above the BSAI $B_{40\%}$ value of 422,000 t (EBS value = 361,000 t), thereby placing Pacific cod in sub-tier "a" of Tier 3. Given this, the model estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2004 as follows:

| | Overfishing Level | Maximum Permissible ABC |
|---|---|---|
| EBS catch: | 299,000 t | 254,000 t |
| BSAI catch: | 350,000 t | 297,000 t |
| Fishing mortality rate: | 0.47 | 0.39 |

The age 3+ biomass estimates for 2004 are 1,660,000 t and 1,420,000 t for the BSAI and EBS, respectively.

## ABC Recommendation

It is important to remember that the maximum permissible ABC computed under the stock assessment model is only a point estimate, around which there is significant uncertainty. Pacific cod ABCs for the years 1998-2002 were based on an explicit attempt to account for part of this uncertainty, namely the uncertainty surrounding the natural mortality rate and the survey catchability coefficient. Last year, however, the BSAI Groundfish Plan Team and the SSC recommended a different approach to incorporate the effects of assessment uncertainty into the ABC. This approach was simply to set the 2003 ABC equal to the 2002 ABC. Because this approach met with Team, SSC, and Council approval last year and because it would result in a 2004 ABC at least as conservative as the one that would be obtained using the previous approach, a "constant catch" approach is recommended for setting the 2004 ABC. It should be emphasized, however, that this recommendation pertains to the ABC for 2004 only, and should not be considered as an endorsement of the "constant catch" approach as a long-term management strategy. The "constant catch" approach gives a 2004 ABC of 223,000 t (EBS value = 191,000 t), corresponding to a fishing mortality rate of 0.29. The ratio of this fishing mortality rate to the maximum permissible $F_{ABC}$ is 0.73.

## Area Allocation of Harvests

At present, ABC of BSAI Pacific cod is not allocated by area. Pacific cod is something of an exception in this regard. The same multiplier (1.17) that is currently used to expand the results of the EBS assessment model into BSAI-wide amounts could be used to apportion the Pacific cod ABC between the EBS and AI management areas. If the 2004 ABC is set at 223,000 t, the EBS and AI portions under this approach would be 191,000 t and 32,000 t, respectively. An AI ABC of 32,000 t would be higher than the 2002 AI catch of 30,801 t and thus would not be expected to result in significant new constraints on the existing fishery. However, it would help to constrain future expansion in a precautionary manner until such time as a more rigorous apportionment methodology can be developed.

Standard Harvest and Recruitment Scenarios and Projection Methodology

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 Policy Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2003 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2004 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2003. 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 2004, are as follow ("*max* $F_{ABC}$" refers to the maximum permissible value of $F_{ABC}$ under Amendment 56):

*Scenario 1*: 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 2004 recommended in the assessment to the *max* $F_{ABC}$ for 2004. (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 1998-2002 average $F$, which was 0.20. (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.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a 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 1) above its MSY level in 2004 or 2) above ½ of its MSY level in 2004 and above its MSY level in 2014 under this scenario, then the stock is not overfished.)

*Scenario 7*: In 2004 and 2005, $F$ 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 2016 under this scenario, then the stock is not approaching an overfished condition.)

## Projections and Status Determination

Table 2.27 defines symbols used to describe projections of spawning biomass, fishing mortality rate, and catch corresponding to the seven standard harvest scenarios. These projections are shown in Tables 2.28-34.

Harvest scenarios #6 and #7 are intended to permit determination of the status of a stock with respect to its minimum stock size threshold (MSST). Any stock that is below its MSST is defined to be *overfished*. Any stock that is expected to fall below its MSST in the next two years is defined to be *approaching* an overfished condition. Harvest scenarios #6 and #7 are used in these determinations as follows:

*Is the stock overfished?* This depends on the stock's estimated spawning biomass in 2004:

a) If spawning biomass for 2004 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b) If spawning biomass for 2004 is estimated to be above $B_{35\%}$, the stock is above its MSST.
c) If spawning biomass for 2004 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest scenario #6 (Table 2.33). If the mean spawning biomass for 2014 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

*Is the stock approaching an overfished condition?* This is determined by referring to harvest scenario #7 (Table 2.34):

a) If the mean spawning biomass for 2006 is below ½ $B_{35\%}$, the stock is approaching an overfished condition.
b) If the mean spawning biomass for 2006 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c) If the mean spawning biomass for 2006 is above ½ $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2016. If the mean spawning biomass for 2016 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

In the case of BSAI Pacific cod, spawning biomass for 2004 is estimated to be above $B_{35\%}$. Therefore, the stock is above its MSST and is not overfished. Mean spawning biomass for 2006 in Table 2.34 is above $B_{35\%}$. Therefore, the stock is not approaching an overfished condition.

# ECOSYSTEM CONSIDERATIONS

## Ecosystem Effects on the Stock

A primary ecosystem phenomenon affecting the BSAI Pacific cod stock seems to be the occurrence of periodic "regime shifts," in which central tendencies of key variables in the physical environment change on a scale spanning several years to a few decades (Livingston, ed., 2002). One well-documented example of such a regime shift occurred in 1977, and shifts occurring in 1989 and 1999 have also been suggested (e.g., Hare and Mantua 2000).

The prey and predators of Pacific cod have been described or reviewed by Albers and Anderson (1985), Livingston (1989, 1991), and Westrheim (1996). In terms of percent occurrence, the most important items in the diet of Pacific cod in the BSAI and GOA are polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, the most important dietary items are euphausids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, the most important dietary items are walleye pollock, fishery offal, and yellowfin sole. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include halibut, salmon shark, northern fur seals, Steller sea lions, harbor porpoises, various whale species, and tufted puffin. Major trends in the most important prey or predator species could be expected to affect the dynamics of Pacific cod to some extent.

## Fishery Effects on the Ecosystem

Potentially, fisheries for Pacific cod can have effects on other species in the ecosystem through a variety of mechanisms, for example by relieving predation pressure on shared prey species (i.e., species which serve as prey for both Pacific cod and other species), by reducing prey availability for predators of Pacific cod, by altering habitat, by imposing bycatch mortality, or by "ghost fishing" caused by lost fishing gear.

### Bycatch of Nontarget and "Other" Species

The methods described by Gaichas (2002) were used to estimate the bycatch imposed by the BSAI Pacific cod fisheries on various nontarget species and members of the "other species" group. Tables 2.35a-f show these estimates in terms of both absolute bycatch amounts (metric tons or number of individuals, depending on the species group) and proportions of the total bycatch for each species group. Tables 2.35a-c show estimates for the EBS trawl, longline, and pot fisheries, respectively and Tables 2.35d-f show estimates for the AI trawl, longline, and pot fisheries, respectively.

It is not clear how much bycatch of a particular species constitutes "too much" in the context of ecosystem concerns. As a first step toward possible prioritization of future investigation into this question, it might be reasonable to focus on those species groups for which a Pacific cod fishery had a bycatch in excess of 100 t and accounted for more than 10% of the total bycatch in at least half of the six most recent years. This criterion results in the following list of impacted species groups (an "x" indicates that the criterion was met for that area/species/gear combination).

| Area | Species group | Trawl | Longline | Pot |
|---|---|---|---|---|
| EBS | sculpins | x | x | |
| EBS | skates | | x | |
| EBS | sleeper shark | | x | |
| EBS | octopus | | | x |
| EBS | “other fish” | x | | |
| EBS | anemones | | x | |
| AI | sculpins | x | x | |
| AI | skates | | x | |

Steller Sea Lions

Sinclair and Zeppelin (2002) showed that Pacific cod was one of the four most important prey items of Steller sea lions in terms of frequency of occurrence averaged over years, seasons, and sites, and was especially important in winter. Pitcher (1981) and Calkins (1998) also showed Pacific cod to be an important winter prey item in the GOA and BSAI, respectively. Furthermore, the size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery operates to some extent in the same geographic areas used by Steller sea lion as foraging grounds (Livingston, ed., 2002).

Seabirds

The following is a summary of information provided by Livingston (ed., 2002): In both the BSAI and GOA, the northern fulmar (*Fulmarus glacialis*) comprises the majority of seabird bycatch, which occurs primarily in the longline fisheries, including the longline fishery for Pacific cod (Tables 2.35b and 2.35e). Shearwater (*Puffinus* spp.) distribution overlaps with the Pacific cod longline fishery in the Bering Sea, and with trawl fisheries in general in both the Bering Sea and GOA. Black-footed albatross (*Phoebastria nigripes*) is taken in much greater numbers in the GOA longline fisheries than the Bering Sea longline fisheries, but is not taken in the trawl fisheries. The distribution of Laysan albatross (*Phoebastria immutabilis*) appears to overlap with the longline fisheries in the central and western Aleutians. The distribution of short-tailed albatross (*Phoebastria albatrus*) also overlaps with the Pacific cod longline fishery along the Aleutian chain, although the majority of the bycatch has taken place along the northern portion of the Bering Sea shelf edge (in contrast, only two takes have been recorded in the GOA). Some success has been obtained in devising measures to mitigate fishery-seabird interactions. For example, on vessels larger than 60 ft. LOA, paired streamer lines of specified performance and material standards have been found to reduce seabird incidental take significantly.

Fishery Usage of Habitat

The following is a summary of information provided by Livingston (ed., 2002): The longline and trawl fisheries for Pacific cod each comprise an important component of the combined fisheries associated with the respective gear type in each of the three major management regions (BS, AI, and GOA). Looking at each gear type in each region as a whole (i.e., aggregating across all target species) during the period 1998-2001, the total number of observed sets was as follows:

| Gear | BS | AI | GOA |
|---|---:|---:|---:|
| Trawl | 240,347 | 43,585 | 68,436 |
| Longline | 65,286 | 13,462 | 7,139 |

In the BS, both longline and trawl effort was concentrated north of False Pass (Unimak Island) and along the shelf edge represented by the boundary of areas 513, 517 (in addition, longline effort was concentrated along the shelf edge represented by the boundary of areas 521-533). In the AI, both longline and trawl effort was dispersed over a wide area along the shelf edge. The catcher vessel longline fishery in the AI occurred primarily over mud bottoms. Longline catcher-processors in the AI tended to fish more over rocky bottoms. In the GOA, fishing effort was also dispersed over a wide area along the shelf, though pockets of trawl effort were located near Chirikof, Cape Barnabus, Cape Chiniak and Marmot Flats. The GOA longline fishery for Pacific cod generally took place over gravel, cobble, mud, sand, and rocky bottoms, in depths of 25 fathoms to 140 fathoms.

### Data Gaps and Research Priorities

Understanding of the above ecosystem considerations would be improved if future research were directed toward closing certain data gaps. Such research would have several foci, including the following: 1) ecology of the Pacific cod stock, including spatial dynamics, trophic and other interspecific relationships, and the relationship between climate and recruitment; 2) behavior of the Pacific cod fishery, including spatial dynamics; 3) determinants of trawl survey selectivity; 4) ecology of species taken as bycatch in the Pacific cod fisheries, including estimation of biomass, carrying capacity, and resilience; and 5) ecology of species that interact with Pacific cod, including estimation of biomass, carrying capacity, and resilience.

## SUMMARY

The major results of the Pacific cod stock assessment are summarized in Table 2.36.

## ACKNOWLEDGMENTS

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Table 2.1a--Summary of catches (t) of Pacific cod by management area, fleet sector, and gear type. All catches since 1980 include discards. LLine = longline, Subt. = sector subtotal. Catches for 2003 are through September. Catches by gear are not available prior to 1981.

**Eastern Bering Sea Only:**

| Year | Foreign | | | Joint Venture | | Domestic Annual Processing | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trawl | LLine | Subt. | Trawl | Subt. | Trawl | LLine | Pot | Other | Subt. | |
| 1978 | | | 42512 | | 0 | | | | | 31 | 42543 |
| 1979 | | | 32981 | | 0 | | | | | 780 | 33761 |
| 1980 | | | 35058 | | 8370 | | | | | 2433 | 45861 |
| 1981 | 30347 | 5851 | 36198 | 7410 | 7410 | 12884 | 1 | 0 | 14 | 12899 | 56507 |
| 1982 | 23037 | 3142 | 26179 | 9312 | 9312 | 23893 | 5 | 0 | 1715 | 25613 | 61104 |
| 1983 | 32790 | 6445 | 39235 | 9662 | 9662 | 45310 | 4 | 21 | 569 | 45904 | 94801 |
| 1984 | 30592 | 26642 | 57234 | 24382 | 24382 | 43274 | 8 | 0 | 205 | 43487 | 125103 |
| 1985 | 19596 | 36742 | 56338 | 35634 | 35634 | 51425 | 50 | 0 | 0 | 51475 | 143447 |
| 1986 | 13292 | 26563 | 39855 | 57827 | 57827 | 37646 | 48 | 62 | 167 | 37923 | 135605 |
| 1987 | 7718 | 47028 | 54746 | 47722 | 47722 | 46039 | 1395 | 1 | 0 | 47435 | 149903 |
| 1988 | 0 | 0 | 0 | 106592 | 106592 | 93706 | 2474 | 299 | 0 | 96479 | 203071 |
| 1989 | 0 | 0 | 0 | 44612 | 44612 | 119631 | 13935 | 145 | 0 | 133711 | 178323 |
| 1990 | 0 | 0 | 0 | 8078 | 8078 | 115493 | 47114 | 1382 | 0 | 163989 | 172067 |
| 1991 | 0 | 0 | 0 | 0 | 0 | 129392 | 76734 | 3343 | 0 | 209469 | 209469 |
| 1992 | 0 | 0 | 0 | 0 | 0 | 77259 | 80174 | 7512 | 33 | 164978 | 164978 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 81790 | 49295 | 2098 | 2 | 133185 | 133185 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 84931 | 78566 | 8037 | 730 | 172264 | 172264 |
| 1995 | 0 | 0 | 0 | 0 | 0 | 110956 | 97665 | 19275 | 599 | 228496 | 228496 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 91910 | 88882 | 28006 | 267 | 209064 | 209064 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 93924 | 117008 | 21493 | 173 | 232598 | 232598 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 60780 | 84323 | 13232 | 192 | 158526 | 158526 |
| 1999 | 0 | 0 | 0 | 0 | 0 | 51902 | 81463 | 12399 | 100 | 145865 | 145865 |
| 2000 | 0 | 0 | 0 | 0 | 0 | 53815 | 81640 | 15849 | 68 | 151372 | 151372 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 35655 | 90360 | 16385 | 52 | 142452 | 142452 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 51065 | 100269 | 15051 | 166 | 166552 | 166552 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 44662 | 80490 | 17399 | 155 | 142706 | 142706 |

Table 2.1b--Summary of catches (t) of Pacific cod by management area, fleet sector, and gear type. All catches since 1980 include discards. LLine = longline, Subt. = sector subtotal. Catches for 2003 are through September. Catches by gear are not available prior to 1981.

**Aleutian Islands Region Only:**

| Year | Foreign | | | Joint Venture | | Domestic Annual Processing | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trawl | LLine | Subt. | Trawl | Subt. | Trawl | LLine | Pot | Other | Subt. | |
| 1978 | | | 0 | | 0 | | | | | 0 | 0 |
| 1979 | | | 0 | | 0 | | | | | 0 | 0 |
| 1980 | | | 0 | | 86 | | | | | 0 | 86 |
| 1981 | 2680 | 235 | 2915 | 1749 | 1749 | 2744 | 26 | 0 | 0 | 2770 | 7434 |
| 1982 | 1520 | 476 | 1996 | 4280 | 4280 | 2121 | 0 | 0 | 0 | 2121 | 8397 |
| 1983 | 1869 | 402 | 2271 | 4700 | 4700 | 1459 | 0 | 0 | 0 | 1459 | 8430 |
| 1984 | 473 | 804 | 1277 | 6390 | 6390 | 314 | 0 | 0 | 0 | 314 | 7981 |
| 1985 | 10 | 829 | 839 | 5638 | 5638 | 460 | 0 | 0 | 0 | 460 | 6937 |
| 1986 | 5 | 0 | 5 | 6115 | 6115 | 784 | 1 | 1 | 0 | 786 | 6906 |
| 1987 | 0 | 0 | 0 | 10435 | 10435 | 2662 | 22 | 88 | 0 | 2772 | 13207 |
| 1988 | 0 | 0 | 0 | 3300 | 3300 | 1698 | 137 | 30 | 0 | 1865 | 5165 |
| 1989 | 0 | 0 | 0 | 6 | 6 | 4233 | 284 | 19 | 0 | 4536 | 4542 |
| 1990 | 0 | 0 | 0 | 0 | 0 | 6932 | 602 | 7 | 0 | 7541 | 7541 |
| 1991 | 0 | 0 | 0 | 0 | 0 | 3414 | 3203 | 3180 | 0 | 9797 | 9797 |
| 1992 | 0 | 0 | 0 | 0 | 0 | 14558 | 22108 | 6317 | 84 | 43068 | 43068 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 17312 | 16860 | 0 | 33 | 34204 | 34204 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 14382 | 7009 | 147 | 0 | 21539 | 21539 |
| 1995 | 0 | 0 | 0 | 0 | 0 | 10574 | 4935 | 1024 | 0 | 16534 | 16534 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 21179 | 5819 | 4611 | 0 | 31609 | 31609 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 17349 | 7151 | 575 | 89 | 25164 | 25164 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 20531 | 13771 | 424 | 0 | 34726 | 34726 |
| 1999 | 0 | 0 | 0 | 0 | 0 | 16437 | 7874 | 3750 | 69 | 28130 | 28130 |
| 2000 | 0 | 0 | 0 | 0 | 0 | 20362 | 16183 | 3107 | 33 | 39684 | 39684 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 15826 | 17817 | 544 | 19 | 34207 | 34207 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 27929 | 2865 | 7 | 0 | 30801 | 30801 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 27706 | 942 | 1 | 0 | 28649 | 28649 |

Table 2.1c--Summary of catches (t) of Pacific cod by management area, fleet sector, and gear type. All catches since 1980 include discards. LLine = longline, Subt. = sector subtotal. Catches for 2003 are through September. Catches by gear are not available prior to 1981.

**Eastern Bering Sea and Aleutian Islands Region Combined:**

| Year | Foreign | | | Joint Venture | | Domestic Annual Processing | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Trawl | LLine | Subt. | Trawl | Subt. | Trawl | LLine | Pot | Other | Subt. | |
| 1978 | | | 42512 | | 0 | | | | | 31 | 42543 |
| 1979 | | | 32981 | | 0 | | | | | 780 | 33761 |
| 1980 | | | 35058 | | 8456 | | | | | 2433 | 45947 |
| 1981 | 33027 | 6086 | 39113 | 9159 | 9159 | 15628 | 27 | 0 | 14 | 15669 | 63941 |
| 1982 | 24557 | 3618 | 28175 | 13592 | 13592 | 26014 | 5 | 0 | 1715 | 27734 | 69501 |
| 1983 | 34659 | 6847 | 41506 | 14362 | 14362 | 46769 | 4 | 21 | 569 | 47363 | 103231 |
| 1984 | 31065 | 27446 | 58511 | 30772 | 30772 | 43588 | 8 | 0 | 205 | 43801 | 133084 |
| 1985 | 19606 | 37571 | 57177 | 41272 | 41272 | 51885 | 50 | 0 | 0 | 51935 | 150384 |
| 1986 | 13297 | 26563 | 39860 | 63942 | 63942 | 38430 | 49 | 63 | 167 | 38709 | 142511 |
| 1987 | 7718 | 47028 | 54746 | 58157 | 58157 | 48701 | 1417 | 89 | 0 | 50207 | 163110 |
| 1988 | 0 | 0 | 0 | 109892 | 109892 | 95404 | 2611 | 329 | 0 | 98344 | 208236 |
| 1989 | 0 | 0 | 0 | 44618 | 44618 | 123864 | 14219 | 164 | 0 | 138247 | 182865 |
| 1990 | 0 | 0 | 0 | 8078 | 8078 | 122425 | 47716 | 1389 | 0 | 171530 | 179608 |
| 1991 | 0 | 0 | 0 | 0 | 0 | 132806 | 79937 | 6523 | 0 | 219266 | 219266 |
| 1992 | 0 | 0 | 0 | 0 | 0 | 91818 | 102282 | 13829 | 117 | 208046 | 208046 |
| 1993 | 0 | 0 | 0 | 0 | 0 | 99102 | 66155 | 2098 | 35 | 167389 | 167389 |
| 1994 | 0 | 0 | 0 | 0 | 0 | 99313 | 85575 | 8184 | 730 | 193802 | 193802 |
| 1995 | 0 | 0 | 0 | 0 | 0 | 121530 | 102600 | 20299 | 599 | 245029 | 245029 |
| 1996 | 0 | 0 | 0 | 0 | 0 | 113089 | 94701 | 32617 | 267 | 240673 | 240673 |
| 1997 | 0 | 0 | 0 | 0 | 0 | 111273 | 124159 | 22068 | 262 | 257762 | 257762 |
| 1998 | 0 | 0 | 0 | 0 | 0 | 81310 | 98094 | 13657 | 192 | 193253 | 193253 |
| 1999 | 0 | 0 | 0 | 0 | 0 | 68339 | 89337 | 16150 | 169 | 173995 | 173995 |
| 2000 | 0 | 0 | 0 | 0 | 0 | 74177 | 97823 | 18956 | 101 | 191056 | 191056 |
| 2001 | 0 | 0 | 0 | 0 | 0 | 51482 | 108177 | 16929 | 71 | 176659 | 176659 |
| 2002 | 0 | 0 | 0 | 0 | 0 | 78994 | 103134 | 15058 | 166 | 197352 | 197352 |
| 2003 | 0 | 0 | 0 | 0 | 0 | 72368 | 81432 | 17399 | 155 | 171354 | 171354 |

Table 2.2--History of Pacific cod ABC, TAC, total BSAI catch, and type of stock assessment model used to recommend ABC. Catch for 2003 is current through September.

| Year | ABC | TAC | Catch | Stock Assessment Model |
|---|---|---|---|---|
| 1980 | 148,000 | 70,700 | 45,947 | projection of 1979 survey numbers at age |
| 1981 | 160,000 | 78,700 | 63,941 | projection of 1979 survey numbers at age |
| 1982 | 168,000 | 78,700 | 69,501 | projection of 1979 survey numbers at age |
| 1983 | 298,200 | 120,000 | 103,231 | projection of 1979 survey numbers at age |
| 1984 | 291,300 | 210,000 | 133,084 | projection of 1979 survey numbers at age |
| 1985 | 347,400 | 220,000 | 150,384 | projection of 1979-1985 survey numbers at age |
| 1986 | 249,300 | 229,000 | 142,511 | separable age-structured model |
| 1987 | 400,000 | 280,000 | 163,110 | separable age-structured model |
| 1988 | 385,300 | 200,000 | 208,236 | separable age-structured model |
| 1989 | 370,600 | 230,681 | 182,865 | separable age-structured model |
| 1990 | 417,000 | 227,000 | 179,608 | separable age-structured model |
| 1991 | 229,000 | 229,000 | 219,266 | separable age-structured model |
| 1992 | 182,000 | 182,000 | 208,046 | age-structured Synthesis model |
| 1993 | 164,500 | 164,500 | 167,389 | length-structured Synthesis model |
| 1994 | 191,000 | 191,000 | 193,802 | length-structured Synthesis model |
| 1995 | 328,000 | 250,000 | 245,029 | length-structured Synthesis model |
| 1996 | 305,000 | 270,000 | 240,673 | length-structured Synthesis model |
| 1997 | 306,000 | 270,000 | 257,762 | length-structured Synthesis model |
| 1998 | 210,000 | 210,000 | 193,253 | length-structured Synthesis model |
| 1999 | 177,000 | 177,000 | 173,995 | length-structured Synthesis model |
| 2000 | 193,000 | 193,000 | 191,056 | length-structured Synthesis model |
| 2001 | 188,000 | 188,000 | 176,659 | length-structured Synthesis model |
| 2002 | 223,000 | 200,000 | 197,352 | length-structured Synthesis model |
| 2003 | 223,000 | 207,500 | 171,354 | length-structured Synthesis model |

Table 2.3–Pacific cod discard rates by area, target species/group, and year. The discard rate is the ratio of discarded Pacific cod catch to total Pacific cod catch for a given area/target/year combination. An empty cell indicates that no Pacific cod were caught in that area/target/year combination. Note that the absolute amount of discards may be small even if the discard rate is large.

**Eastern Bering Sea**

| Target species/group | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arrowtooth flounder | 0.61 | 0.00 | 0.94 | | 0.66 | 0.08 | 0.07 | 1.00 | 1.00 | 0.99 | 1.00 | 0.22 |
| Atka mackerel | 1.00 | | 0.70 | 1.00 | | 0.23 | | 0.51 | 0.00 | 0.00 | 1.00 | |
| Flathead sole | | | | | 0.39 | 0.58 | 0.10 | 0.75 | 0.87 | 0.75 | 0.00 | 1.00 |
| Greenland turbot | 0.01 | 0.00 | 0.12 | 0.04 | 0.35 | 0.09 | 0.03 | 0.04 | 0.13 | 0.10 | 0.01 | 0.18 |
| Other flatfish | 0.63 | 0.31 | 0.47 | 0.88 | 0.22 | 0.28 | 0.91 | 0.28 | 0.33 | 0.32 | 0.00 | 0.00 |
| Other species | 0.04 | 0.99 | 0.38 | | 1.00 | 1.00 | 0.01 | 0.95 | 0.07 | 0.92 | 0.08 | 0.00 |
| Pacific cod | 0.03 | 0.04 | 0.08 | 0.06 | 0.07 | 0.04 | 0.03 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 |
| Pollock | 0.70 | 0.85 | 0.73 | 0.68 | 0.21 | 0.41 | 0.24 | 0.42 | 0.49 | 0.68 | 0.84 | 0.52 |
| Rock sole | 1.00 | 0.00 | 0.08 | 0.87 | 0.25 | 0.90 | | 1.00 | 0.02 | 0.16 | 1.00 | 1.00 |
| Rockfish | 1.00 | 0.00 | 0.89 | 0.01 | 0.84 | 0.69 | 0.16 | | 0.00 | 0.03 | 0.00 | 0.00 |
| Sablefish | 0.00 | 0.12 | 0.42 | 0.40 | 0.96 | 0.94 | 0.78 | 0.93 | 0.61 | 0.98 | 0.12 | 0.48 |
| Unknown | 0.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.49 | 0.04 | 0.02 | | |
| Yellowfin sole | | 0.74 | 0.72 | 0.50 | 0.08 | 1.00 | 0.24 | 0.77 | 0.50 | 0.60 | 0.39 | 0.77 |
| Grand Total | 0.03 | 0.04 | 0.08 | 0.06 | 0.07 | 0.04 | 0.03 | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 |

**Aleutian Islands**

| Target species/group | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arrowtooth flounder | 1.00 | | | | | | | | | | 0.00 | 0.00 |
| Atka mackerel | | | | | | | | 1.00 | | 1.00 | 1.00 | 1.00 |
| Flathead sole | | 0.35 | | | | | | | | | | |
| Greenland turbot | 0.11 | 0.00 | 0.73 | 0.58 | 0.40 | 0.89 | 0.04 | 0.01 | 0.18 | 0.40 | 0.00 | 0.00 |
| Other species | | 1.00 | | | 0.00 | | | | 0.14 | 0.08 | 0.00 | 0.06 |
| Pacific cod | 0.02 | 0.03 | 0.12 | 0.09 | 0.04 | 0.04 | 0.05 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 |
| Pollock | 0.76 | 0.00 | 0.29 | 0.00 | 0.47 | 0.74 | 0.75 | 0.61 | 0.00 | | | |
| Rock sole | | | 0.00 | | | | | | | | | |
| Rockfish | 0.83 | | 0.75 | 0.28 | 0.18 | 0.80 | 0.91 | 1.00 | 0.64 | 0.12 | 0.22 | 0.03 |
| Sablefish | 1.00 | 0.04 | 0.49 | 0.52 | 0.97 | 0.53 | 0.70 | 0.88 | 0.51 | 0.31 | 0.06 | 0.76 |
| Unknown | 0.09 | | | | 1.00 | 1.00 | | 0.03 | | 1.00 | 1.00 | |
| Grand Total | 0.04 | 0.03 | 0.12 | 0.09 | 0.12 | 0.04 | 0.06 | 0.02 | 0.02 | 0.02 | 0.01 | 0.02 |

Table 2.4–EBS catch (t) of Pacific cod by year, gear, and period. Catch for 2003 is complete through September. Distribution of catch for 1978-1980 by gear and period was estimated from other years' data.

| Year | Trawl | | | Longline | | | Pot | | |
|---|---|---|---|---|---|---|---|---|---|
| | Period 1 | Period 2 | Period 3 | Period 1 | Period 2 | Period 3 | Period 1 | Period 2 | Period 3 |
| 1978 | 10424 | 11288 | 18021 | 1371 | 1032 | 1856 | 0 | 0 | 0 |
| 1979 | 10397 | 12587 | 10403 | 1371 | 699 | 547 | 0 | 0 | 0 |
| 1980 | 9452 | 9007 | 17039 | 1106 | 206 | 4230 | 0 | 0 | 0 |
| 1981 | 15067 | 14087 | 21486 | 1286 | 624 | 3942 | 0 | 0 | 0 |
| 1982 | 21742 | 18151 | 16348 | 363 | 475 | 2308 | 0 | 0 | 0 |
| 1983 | 40757 | 24300 | 22705 | 2941 | 748 | 2756 | 0 | 0 | 0 |
| 1984 | 48237 | 24964 | 25045 | 5012 | 2128 | 19508 | 0 | 0 | 0 |
| 1985 | 55673 | 28673 | 22310 | 13703 | 1710 | 21379 | 0 | 0 | 0 |
| 1986 | 59786 | 26598 | 22382 | 8895 | 438 | 17278 | 0 | 0 | 0 |
| 1987 | 64413 | 15604 | 21462 | 20947 | 723 | 26752 | 0 | 0 | 0 |
| 1988 | 127470 | 25662 | 47166 | 444 | 646 | 1385 | 90 | 51 | 160 |
| 1989 | 127459 | 16986 | 19798 | 3810 | 4968 | 5157 | 33 | 63 | 49 |
| 1990 | 101645 | 11402 | 10524 | 13171 | 16643 | 17299 | 0 | 986 | 395 |
| 1991 | 107979 | 15549 | 5863 | 25470 | 21472 | 29792 | 12 | 1042 | 2288 |
| 1992 | 59460 | 11840 | 5959 | 49696 | 24201 | 6276 | 2622 | 4632 | 258 |
| 1993 | 67148 | 5362 | 9280 | 49244 | 27 | 23 | 2073 | 24 | 0 |
| 1994 | 61009 | 5806 | 18115 | 57968 | 13 | 20585 | 4923 | 0 | 3113 |
| 1995 | 90366 | 8543 | 12047 | 68458 | 26 | 29180 | 12484 | 3469 | 3322 |
| 1996 | 78194 | 3126 | 10590 | 62011 | 26 | 26845 | 18143 | 6401 | 3462 |
| 1997 | 81313 | 3927 | 8684 | 70676 | 43 | 46290 | 14584 | 3576 | 3333 |
| 1998 | 45008 | 5603 | 10169 | 54234 | 18 | 30071 | 9022 | 2779 | 1432 |
| 1999 | 44904 | 3312 | 3686 | 55180 | 1923 | 24360 | 9346 | 1001 | 2052 |
| 2000 | 44508 | 4578 | 4730 | 40180 | 1375 | 40086 | 15742 | 0 | 107 |
| 2001 | 22849 | 7025 | 5781 | 38368 | 6700 | 45291 | 11645 | 442 | 4298 |
| 2002 | 37008 | 9554 | 4503 | 50024 | 12132 | 38113 | 10852 | 401 | 3799 |
| 2003 | 32111 | 9808 | 2744 | 52879 | 11026 | 16586 | 12633 | 0 | 4766 |

Table 2.5--Pacific cod length sample sizes from the commercial fisheries. Data for 2003 are complete through September.

| Year | Trawl Fishery | | | Longline Fishery | | | Pot Fishery | | |
|---|---|---|---|---|---|---|---|---|---|
| | Per. 1 | Per. 2 | Per. 3 | Per. 1 | Per. 2 | Per. 3 | Per. 1 | Per. 2 | Per. 3 |
| 1978 | 646 | 0 | 3161 | 2885 | 4886 | 2514 | 0 | 0 | 0 |
| 1979 | 1667 | 0 | 748 | 11410 | 2514 | 2662 | 0 | 0 | 0 |
| 1980 | 1359 | 73 | 327 | 2600 | 1389 | 2932 | 0 | 0 | 0 |
| 1981 | 132 | 0 | 1540 | 2253 | 1276 | 1300 | 0 | 0 | 0 |
| 1982 | 592 | 226 | 1643 | 2910 | 1203 | 5078 | 0 | 0 | 0 |
| 1983 | 12386 | 1231 | 14577 | 18800 | 4119 | 9610 | 0 | 0 | 0 |
| 1984 | 10246 | 4482 | 4477 | 6853 | 6004 | 82103 | 0 | 0 | 0 |
| 1985 | 30171 | 1556 | 3051 | 0 | 4561 | 134469 | 0 | 0 | 0 |
| 1986 | 28566 | 1813 | 2548 | 18588 | 200 | 104142 | 0 | 0 | 0 |
| 1987 | 46360 | 6674 | 20923 | 70273 | 0 | 165124 | 0 | 0 | 0 |
| 1988 | 103453 | 0 | 2897 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 58575 | 612 | 669 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1990 | 64143 | 9807 | 250 | 18900 | 74534 | 62550 | 0 | 1506 | 5772 |
| 1991 | 88727 | 2083 | 0 | 54671 | 70808 | 91693 | 0 | 10701 | 11243 |
| 1992 | 79286 | 0 | 0 | 152152 | 134263 | 20129 | 17289 | 48569 | 5147 |
| 1993 | 81637 | 0 | 0 | 154337 | 0 | 0 | 10557 | 0 | 0 |
| 1994 | 103839 | 0 | 0 | 172585 | 0 | 45350 | 25950 | 0 | 6436 |
| 1995 | 68575 | 0 | 0 | 144739 | 392 | 74766 | 47660 | 16786 | 13741 |
| 1996 | 104295 | 1139 | 3473 | 164051 | 156 | 75385 | 76393 | 23063 | 11199 |
| 1997 | 106847 | 275 | 0 | 184741 | 109 | 144489 | 43859 | 11760 | 11760 |
| 1998 | 108187 | 2790 | 2974 | 162821 | 62 | 190555 | 26595 | 8899 | 4522 |
| 1999 | 44845 | 228 | 1136 | 84227 | 10095 | 51065 | 22634 | 1875 | 8922 |
| 2000 | 47085 | 304 | 67 | 71413 | 9960 | 97697 | 26040 | 0 | 512 |
| 2001 | 26124 | 2787 | 1304 | 84559 | 27431 | 102235 | 15985 | 447 | 8447 |
| 2002 | 38042 | 4583 | 2362 | 75151 | 31360 | 85824 | 11155 | 367 | 6250 |
| 2003 | 43321 | 4985 | 877 | 95445 | 20056 | 3370 | 12251 | 0 | 407 |

Table 2.6–Length frequencies of Pacific cod in the pre-1989 trawl fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1978 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 5 | 22 | 29 | 88 | 233 | 112 | 44 | 32 | 36 | 15 | 11 | 9 | 1 | 1 | 2 | 0 | 0 |
| 1978 | 3 | 0 | 0 | 0 | 0 | 0 | 6 | 35 | 79 | 37 | 21 | 19 | 5 | 62 | 387 | 999 | 882 | 337 | 159 | 81 | 37 | 13 | 2 | 0 | 0 | 0 |
| 1979 | 1 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 21 | 46 | 94 | 206 | 319 | 346 | 100 | 149 | 161 | 152 | 48 | 11 | 4 | 5 | 1 | 1 | 0 | 0 |
| 1979 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 24 | 74 | 150 | 220 | 78 | 38 | 47 | 58 | 31 | 14 | 4 | 0 | 0 | 0 | 1 | 1 |
| 1980 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 34 | 84 | 186 | 295 | 462 | 192 | 49 | 19 | 14 | 8 | 3 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1980 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 16 | 45 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1980 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 9 | 17 | 37 | 79 | 70 | 55 | 32 | 8 | 9 | 6 | 3 | 0 | 1 | 0 | 0 |
| 1981 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 28 | 43 | 34 | 16 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1981 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 3 | 8 | 26 | 122 | 336 | 373 | 301 | 194 | 120 | 32 | 13 | 7 | 2 | 0 | 0 |
| 1982 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 21 | 22 | 9 | 13 | 48 | 61 | 94 | 133 | 84 | 69 | 20 | 8 | 3 | 1 | 0 | 0 | 0 |
| 1982 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 7 | 21 | 14 | 21 | 41 | 43 | 33 | 16 | 13 | 4 | 6 | 4 | 1 | 0 |
| 1982 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 4 | 27 | 70 | 143 | 215 | 196 | 302 | 346 | 215 | 90 | 18 | 9 | 5 | 1 | 0 |
| 1983 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 20 | 99 | 286 | 284 | 275 | 467 | 1113 | 1272 | 1978 | 2477 | 1982 | 1193 | 584 | 202 | 72 | 35 | 22 | 13 | 7 |
| 1983 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 3 | 10 | 4 | 7 | 31 | 95 | 204 | 289 | 249 | 187 | 85 | 30 | 11 | 8 | 6 | 7 | 3 |
| 1983 | 3 | 0 | 0 | 0 | 0 | 1 | 15 | 24 | 26 | 15 | 8 | 35 | 205 | 421 | 508 | 1451 | 1999 | 2487 | 2441 | 2235 | 1563 | 767 | 284 | 66 | 21 | 5 |
| 1984 | 1 | 0 | 1 | 1 | 1 | 0 | 7 | 121 | 251 | 222 | 132 | 66 | 148 | 439 | 503 | 758 | 1394 | 2027 | 1873 | 1278 | 639 | 263 | 96 | 16 | 9 | 1 |
| 1984 | 2 | 0 | 1 | 0 | 0 | 5 | 18 | 14 | 5 | 10 | 55 | 93 | 118 | 241 | 284 | 403 | 612 | 638 | 620 | 481 | 411 | 313 | 110 | 42 | 7 | 1 |
| 1984 | 3 | 0 | 0 | 0 | 0 | 0 | 7 | 21 | 15 | 114 | 434 | 370 | 188 | 137 | 124 | 254 | 396 | 576 | 614 | 483 | 376 | 224 | 99 | 32 | 13 | 0 |
| 1985 | 1 | 0 | 0 | 2 | 0 | 4 | 0 | 2 | 39 | 116 | 262 | 733 | 1768 | 2246 | 1088 | 1415 | 2474 | 5067 | 5635 | 4340 | 2649 | 1402 | 608 | 229 | 69 | 23 |
| 1985 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 24 | 77 | 70 | 119 | 425 | 356 | 116 | 59 | 70 | 88 | 73 | 35 | 20 | 8 | 9 | 3 | 1 |
| 1985 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 9 | 79 | 170 | 533 | 322 | 195 | 126 | 288 | 424 | 374 | 296 | 152 | 78 | 4 | 0 | 0 |
| 1986 | 1 | 0 | 4 | 16 | 8 | 34 | 62 | 118 | 249 | 636 | 761 | 683 | 788 | 2229 | 3564 | 3293 | 2108 | 2647 | 3498 | 3377 | 2446 | 1346 | 456 | 168 | 58 | 17 |
| 1986 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 4 | 2 | 4 | 5 | 9 | 26 | 95 | 130 | 195 | 285 | 481 | 352 | 128 | 48 | 30 | 8 | 4 | 0 |
| 1986 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 1 | 15 | 17 | 28 | 26 | 86 | 169 | 288 | 405 | 520 | 406 | 265 | 136 | 93 | 59 | 22 | 4 | 5 |
| 1987 | 1 | 0 | 0 | 3 | 13 | 15 | 58 | 194 | 446 | 516 | 640 | 1250 | 2235 | 4300 | 3164 | 3663 | 6190 | 6238 | 5028 | 4338 | 3669 | 2326 | 1255 | 510 | 234 | 75 |
| 1987 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 5 | 9 | 6 | 10 | 29 | 135 | 241 | 422 | 837 | 1294 | 1344 | 889 | 574 | 397 | 252 | 133 | 68 | 25 |
| 1987 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 13 | 68 | 76 | 263 | 1095 | 1809 | 2177 | 2736 | 3204 | 2732 | 2087 | 1946 | 1549 | 802 | 306 | 53 |
| 1988 | 1 | 1 | 0 | 1 | 1 | 6 | 30 | 93 | 605 | 1533 | 2081 | 2311 | 4634 | 11994 | 11361 | 10890 | 9690 | 10862 | 13124 | 11333 | 6319 | 3330 | 1855 | 913 | 380 | 106 |
| 1988 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 13 | 52 | 257 | 326 | 284 | 348 | 348 | 373 | 332 | 305 | 166 | 56 | 20 | 6 | 6 |

Table 2.7–Length frequencies of Pacific cod in the pre-1989 longline fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1978 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 23 | 124 | 623 | 812 | 435 | 269 | 216 | 160 | 110 | 58 | 36 | 7 | 7 | 0 | 0 |
| 1978 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 40 | 240 | 574 | 1226 | 994 | 716 | 566 | 330 | 133 | 44 | 12 | 2 | 1 | 0 |
| 1978 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 62 | 366 | 736 | 788 | 306 | 124 | 66 | 35 | 19 | 8 | 2 | 0 | 0 |
| 1979 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 83 | 377 | 683 | 436 | 375 | 1303 | 2454 | 2711 | 1575 | 679 | 380 | 208 | 87 | 36 | 8 | 7 | 0 |
| 1979 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 14 | 49 | 90 | 155 | 102 | 327 | 646 | 660 | 315 | 86 | 43 | 17 | 5 | 3 | 0 | 0 |
| 1979 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 | 47 | 233 | 249 | 174 | 387 | 683 | 599 | 216 | 41 | 10 | 9 | 2 | 0 | 0 |
| 1980 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 15 | 66 | 212 | 591 | 604 | 320 | 182 | 199 | 244 | 111 | 36 | 11 | 4 | 0 | 0 | 0 |
| 1980 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 29 | 169 | 334 | 293 | 185 | 148 | 140 | 67 | 17 | 4 | 2 | 0 | 0 | 0 |
| 1980 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 18 | 235 | 558 | 679 | 652 | 350 | 194 | 138 | 76 | 25 | 5 | 0 | 1 | 0 |
| 1981 | 1 | 0 | 0 | 0 | 0 | 5 | 18 | 7 | 7 | 10 | 0 | 18 | 48 | 285 | 503 | 453 | 340 | 198 | 153 | 89 | 70 | 36 | 9 | 4 | 0 | 0 |
| 1981 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 8 | 29 | 88 | 160 | 265 | 292 | 228 | 108 | 35 | 32 | 24 | 3 | 1 | 0 | 0 |
| 1981 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 86 | 230 | 318 | 300 | 220 | 89 | 29 | 15 | 2 | 0 | 1 | 0 |
| 1982 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 14 | 22 | 30 | 215 | 381 | 520 | 550 | 468 | 298 | 167 | 100 | 78 | 47 | 13 | 3 | 2 |
| 1982 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 43 | 17 | 102 | 208 | 164 | 211 | 164 | 133 | 80 | 48 | 11 | 7 | 3 | 3 | 0 |
| 1982 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 15 | 35 | 107 | 270 | 512 | 830 | 1195 | 1101 | 639 | 240 | 82 | 35 | 9 | 4 | 2 |
| 1983 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 21 | 51 | 178 | 1231 | 1673 | 2160 | 2944 | 3606 | 3254 | 2018 | 876 | 390 | 220 | 117 | 48 | 9 |
| 1983 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 18 | 24 | 118 | 414 | 454 | 580 | 676 | 704 | 520 | 368 | 154 | 55 | 19 | 10 | 0 |
| 1983 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 4 | 28 | 129 | 459 | 1163 | 1262 | 1550 | 1779 | 1565 | 993 | 477 | 148 | 37 | 9 | 6 |
| 1984 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 11 | 21 | 22 | 20 | 191 | 414 | 614 | 1188 | 1473 | 1370 | 833 | 400 | 177 | 60 | 31 | 20 | 3 |
| 1984 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 3 | 10 | 8 | 54 | 232 | 468 | 960 | 1290 | 1095 | 774 | 524 | 374 | 158 | 36 | 11 | 3 |
| 1984 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 12 | 53 | 250 | 643 | 1558 | 2738 | 6857 | 12095 | 15376 | 15438 | 12475 | 8243 | 4156 | 1555 | 465 | 143 | 43 |
| 1985 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 25 | 221 | 348 | 177 | 346 | 628 | 849 | 710 | 526 | 392 | 216 | 96 | 21 | 2 |
| 1985 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 5 | 28 | 167 | 756 | 5832 | 16308 | 14473 | 11108 | 18384 | 25332 | 19838 | 11750 | 6227 | 2938 | 1006 | 252 | 64 |
| 1986 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 | 23 | 51 | 84 | 278 | 1093 | 1464 | 1354 | 1181 | 2186 | 3783 | 3595 | 2082 | 911 | 360 | 107 | 26 | 3 |
| 1986 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 | 29 | 47 | 23 | 21 | 32 | 14 | 9 | 3 | 3 | 0 | 0 |
| 1986 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 154 | 610 | 2194 | 5080 | 14156 | 23223 | 20331 | 10705 | 10312 | 8875 | 4920 | 2286 | 869 | 324 | 85 |
| 1987 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 10 | 38 | 291 | 983 | 3411 | 3420 | 5818 | 10732 | 12540 | 10019 | 9453 | 7603 | 3871 | 1490 | 422 | 145 | 26 |
| 1987 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 0 | 2 | 7 | 26 | 130 | 511 | 4041 | 17126 | 27487 | 22822 | 24411 | 26687 | 19727 | 10159 | 6334 | 3638 | 1480 | 399 | 134 |

Table 2.8a–Length frequencies of Pacific cod in the 1989-1999 trawl fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1989 | 1 | 0 | 0 | 3 | 3 | 1 | 0 | 29 | 217 | 497 | 799 | 721 | 961 | 3128 | 4368 | 4678 | 5713 | 7070 | 8599 | 8291 | 6310 | 3853 | 1882 | 917 | 391 | 144 |
| 1989 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 3 | 20 | 68 | 109 | 136 | 142 | 79 | 39 | 9 | 1 | 0 | 1 | 0 | 0 |
| 1989 | 3 | 0 | 0 | 0 | 0 | 1 | 6 | 7 | 13 | 32 | 53 | 49 | 33 | 90 | 54 | 36 | 83 | 92 | 88 | 22 | 6 | 4 | 0 | 0 | 0 | 0 |
| 1990 | 1 | 0 | 0 | 3 | 4 | 14 | 85 | 312 | 710 | 953 | 888 | 715 | 539 | 1148 | 2576 | 4417 | 7339 | 9969 | 10306 | 9376 | 6405 | 4195 | 2266 | 1280 | 480 | 163 |
| 1990 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 6 | 6 | 17 | 106 | 377 | 772 | 1048 | 1631 | 1566 | 1623 | 1221 | 655 | 457 | 206 | 80 | 32 |
| 1990 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 14 | 42 | 13 | 30 | 17 | 16 | 49 | 17 | 19 | 16 | 10 | 0 | 2 | 0 | 2 |
| 1991 | 1 | 0 | 1 | 5 | 6 | 15 | 71 | 452 | 1230 | 1329 | 1232 | 1288 | 1713 | 5172 | 6133 | 6560 | 9202 | 12298 | 12683 | 10962 | 7771 | 5103 | 2937 | 1517 | 766 | 281 |
| 1991 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 7 | 9 | 16 | 32 | 25 | 27 | 103 | 129 | 216 | 251 | 300 | 319 | 219 | 200 | 136 | 62 | 18 | 1 | 6 |
| 1992 | 1 | 0 | 3 | 9 | 15 | 21 | 67 | 200 | 631 | 1310 | 1664 | 2488 | 4704 | 9607 | 7198 | 6648 | 6782 | 8239 | 8016 | 7777 | 5712 | 3853 | 2326 | 1291 | 517 | 208 |
| 1993 | 1 | 0 | 0 | 5 | 8 | 23 | 56 | 254 | 1164 | 1666 | 1780 | 4496 | 7742 | 11709 | 10367 | 9951 | 7408 | 5314 | 4343 | 3901 | 3540 | 3128 | 2163 | 1472 | 806 | 341 |
| 1994 | 1 | 0 | 1 | 5 | 5 | 24 | 106 | 610 | 2149 | 3791 | 3227 | 1938 | 2981 | 9909 | 14285 | 14434 | 11718 | 11710 | 9933 | 6337 | 4075 | 2739 | 1764 | 1161 | 623 | 314 |
| 1995 | 1 | 0 | 0 | 12 | 28 | 46 | 160 | 306 | 448 | 495 | 707 | 2597 | 5806 | 9110 | 5979 | 7066 | 8171 | 8721 | 7021 | 4381 | 2782 | 1824 | 1195 | 772 | 540 | 408 |
| 1996 | 1 | 1 | 6 | 13 | 25 | 29 | 51 | 382 | 1066 | 1319 | 1118 | 1145 | 2429 | 8755 | 14699 | 13711 | 9877 | 10959 | 11919 | 9647 | 6868 | 4308 | 2875 | 1607 | 911 | 575 |
| 1996 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 5 | 10 | 11 | 35 | 112 | 164 | 186 | 106 | 125 | 97 | 160 | 107 | 16 | 0 | 0 | 1 | 0 |
| 1996 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 13 | 51 | 132 | 149 | 275 | 322 | 292 | 287 | 305 | 436 | 454 | 388 | 220 | 104 | 40 |
| 1997 | 1 | 1 | 4 | 17 | 80 | 97 | 65 | 326 | 1261 | 2372 | 2398 | 1778 | 2027 | 7423 | 8553 | 11653 | 16352 | 16489 | 12167 | 7909 | 5444 | 4105 | 2800 | 1846 | 1060 | 620 |
| 1997 | 2 | 0 | 1 | 0 | 4 | 5 | 1 | 4 | 4 | 8 | 8 | 12 | 13 | 31 | 42 | 38 | 34 | 20 | 24 | 15 | 8 | 2 | 0 | 0 | 1 | 0 |
| 1998 | 1 | 0 | 1 | 7 | 4 | 7 | 114 | 744 | 1464 | 1423 | 1113 | 969 | 1398 | 5031 | 6020 | 6694 | 10192 | 14965 | 16533 | 10659 | 5972 | 3531 | 2880 | 2293 | 1631 | 1107 |
| 1998 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 31 | 61 | 71 | 47 | 110 | 242 | 298 | 270 | 195 | 125 | 83 | 36 | 12 | 9 | 5 | 10 | 6 |
| 1998 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 12 | 37 | 60 | 135 | 172 | 249 | 177 | 190 | 211 | 258 | 270 | 160 | 74 | 68 | 46 | 22 |
| 1999 | 1 | 4 | 0 | 1 | 6 | 5 | 10 | 108 | 421 | 412 | 382 | 1039 | 2515 | 5006 | 3143 | 3270 | 3992 | 5218 | 5560 | 4722 | 3617 | 2327 | 1295 | 818 | 592 | 382 |
| 1999 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 31 | 31 | 32 | 30 | 21 | 9 | 15 | 12 | 15 | 10 | 5 | 6 | 5 |
| 1999 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 2 | 18 | 51 | 114 | 164 | 145 | 144 | 121 | 96 | 88 | 82 | 53 | 36 | 14 | 5 |

Table 2.8b–Length frequencies of Pacific cod in the post-1999 trawl fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 2000 | 1 | 0 | 0 | 0 | 2 | 2 | 7 | 63 | 187 | 173 | 236 | 559 | 1075 | 3035 | 4364 | 4870 | 4763 | 4839 | 5349 | 4673 | 3869 | 3230 | 2655 | 1546 | 952 | 636 |
| 2000 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 2 | 4 | 13 | 18 | 41 | 76 | 67 | 34 | 22 | 8 | 5 | 6 | 2 | 1 | 0 | 0 | 0 |
| 2000 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 13 | 20 | 12 | 8 | 6 | 3 | 0 | 1 | 1 | 0 | 0 | 0 |
| 2001 | 1 | 0 | 0 | 2 | 1 | 3 | 4 | 22 | 43 | 111 | 176 | 112 | 173 | 922 | 1483 | 2119 | 3376 | 4045 | 4026 | 2853 | 2193 | 1618 | 1195 | 840 | 531 | 276 |
| 2001 | 2 | 0 | 0 | 5 | 12 | 10 | 14 | 5 | 10 | 23 | 57 | 93 | 79 | 212 | 506 | 433 | 394 | 352 | 247 | 137 | 62 | 58 | 31 | 30 | 15 | 2 |
| 2001 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 8 | 12 | 8 | 21 | 33 | 80 | 109 | 200 | 199 | 202 | 175 | 109 | 68 | 33 | 15 | 14 | 10 | 5 |
| 2002 | 1 | 0 | 0 | 0 | 6 | 12 | 26 | 79 | 333 | 541 | 550 | 535 | 642 | 1780 | 2107 | 2215 | 3692 | 5123 | 5676 | 4771 | 3635 | 2621 | 1579 | 952 | 736 | 431 |
| 2002 | 2 | 0 | 0 | 0 | 6 | 8 | 3 | 12 | 68 | 201 | 263 | 306 | 288 | 417 | 596 | 747 | 529 | 399 | 253 | 195 | 147 | 69 | 42 | 20 | 10 | 4 |
| 2002 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 9 | 9 | 60 | 141 | 240 | 249 | 339 | 259 | 229 | 236 | 205 | 180 | 114 | 52 | 25 | 11 | 3 |
| 2003 | 1 | 0 | 0 | 2 | 5 | 1 | 3 | 9 | 103 | 314 | 388 | 427 | 770 | 2187 | 2306 | 2620 | 3458 | 4766 | 5660 | 4866 | 4568 | 4209 | 3135 | 1892 | 1084 | 548 |
| 2003 | 2 | 0 | 1 | 0 | 1 | 1 | 3 | 8 | 24 | 42 | 120 | 180 | 196 | 474 | 624 | 538 | 587 | 630 | 506 | 430 | 330 | 178 | 76 | 21 | 10 | 5 |
| 2003 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 17 | 45 | 80 | 70 | 89 | 91 | 102 | 117 | 115 | 81 | 45 | 16 | 3 | 1 |

Table 2.9a–Length frequencies of Pacific cod in the 1989-1999 longline fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1990 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 12 | 163 | 784 | 1700 | 2796 | 3536 | 3080 | 2490 | 1599 | 1216 | 728 | 480 | 219 | 93 |
| 1990 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 6 | 24 | 56 | 136 | 238 | 794 | 2391 | 5893 | 10108 | 12945 | 12636 | 10237 | 7314 | 5084 | 3262 | 2200 | 889 | 315 |
| 1990 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 1 | 12 | 18 | 56 | 348 | 1644 | 5170 | 9453 | 11864 | 11121 | 8939 | 6057 | 3593 | 2102 | 1291 | 598 | 279 |
| 1991 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 14 | 30 | 114 | 306 | 1052 | 2487 | 5075 | 8929 | 11159 | 9547 | 6917 | 4040 | 2444 | 1331 | 780 | 311 | 130 |
| 1991 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 9 | 19 | 35 | 143 | 773 | 2130 | 4733 | 8310 | 10823 | 12060 | 10930 | 8769 | 6004 | 3203 | 1778 | 793 | 291 |
| 1991 | 3 | 0 | 0 | 0 | 1 | 3 | 18 | 33 | 39 | 62 | 127 | 207 | 467 | 1723 | 4038 | 7030 | 10634 | 13041 | 14086 | 13443 | 10791 | 7589 | 4290 | 2527 | 1104 | 440 |
| 1992 | 1 | 0 | 0 | 0 | 2 | 0 | 3 | 5 | 42 | 90 | 312 | 1253 | 3300 | 10451 | 14863 | 15640 | 19126 | 23004 | 20775 | 15837 | 11594 | 7556 | 4380 | 2455 | 1057 | 407 |
| 1992 | 2 | 0 | 0 | 0 | 0 | 3 | 2 | 3 | 21 | 66 | 174 | 574 | 1325 | 6719 | 13151 | 13754 | 15857 | 17833 | 16704 | 14043 | 11802 | 8990 | 6331 | 4035 | 2045 | 831 |
| 1992 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 6 | 19 | 52 | 154 | 765 | 2375 | 2564 | 2390 | 2741 | 2404 | 1939 | 1595 | 1267 | 888 | 565 | 298 | 106 |
| 1993 | 1 | 0 | 0 | 1 | 0 | 1 | 6 | 16 | 76 | 186 | 450 | 1482 | 3328 | 10312 | 20462 | 27089 | 23370 | 17302 | 14383 | 12020 | 9965 | 6845 | 3850 | 1953 | 926 | 314 |
| 1994 | 1 | 0 | 0 | 0 | 3 | 3 | 12 | 23 | 40 | 91 | 223 | 551 | 1472 | 7088 | 17414 | 29142 | 38186 | 32928 | 19177 | 9869 | 6051 | 4280 | 3011 | 1766 | 930 | 325 |
| 1994 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 8 | 12 | 57 | 145 | 268 | 952 | 3070 | 5831 | 8261 | 9569 | 7327 | 4226 | 2341 | 1425 | 914 | 505 | 296 | 141 |
| 1995 | 1 | 0 | 0 | 0 | 2 | 5 | 6 | 13 | 24 | 60 | 186 | 1059 | 3031 | 8219 | 14024 | 23789 | 30478 | 28823 | 18233 | 8432 | 3841 | 1961 | 1172 | 730 | 445 | 206 |
| 1995 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 10 | 33 | 55 | 79 | 56 | 29 | 37 | 38 | 27 | 15 | 9 | 0 | 0 |
| 1995 | 3 | 0 | 0 | 1 | 0 | 0 | 1 | 2 | 21 | 25 | 50 | 219 | 522 | 2929 | 7080 | 8279 | 9857 | 12273 | 11397 | 8717 | 5585 | 3365 | 2040 | 1402 | 714 | 287 |
| 1996 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 20 | 73 | 192 | 604 | 1794 | 9116 | 19703 | 26399 | 29777 | 28680 | 21120 | 12783 | 6741 | 3465 | 1691 | 992 | 518 | 382 |
| 1996 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 27 | 23 | 27 | 17 | 15 | 15 | 14 | 6 | 3 | 0 | 0 | 0 |
| 1996 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 4 | 15 | 83 | 182 | 404 | 1626 | 5549 | 11617 | 14477 | 11224 | 8332 | 7296 | 5950 | 4217 | 2391 | 1149 | 562 | 306 |
| 1997 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 18 | 92 | 224 | 571 | 1700 | 8606 | 17788 | 30652 | 40069 | 35267 | 21243 | 12004 | 7165 | 4417 | 2557 | 1322 | 651 | 389 |
| 1997 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 4 | 6 | 18 | 18 | 15 | 16 | 5 | 8 | 6 | 4 | 4 | 3 | 0 |
| 1997 | 3 | 0 | 0 | 1 | 2 | 3 | 13 | 20 | 89 | 160 | 288 | 621 | 1673 | 4814 | 9408 | 15198 | 20854 | 26965 | 25031 | 17322 | 8992 | 6074 | 3767 | 1977 | 853 | 364 |
| 1998 | 1 | 0 | 0 | 0 | 0 | 1 | 9 | 19 | 94 | 224 | 414 | 957 | 2524 | 8417 | 13159 | 18857 | 27872 | 30580 | 24229 | 13821 | 7243 | 4858 | 3787 | 2748 | 1747 | 1261 |
| 1998 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 22 | 4 | 9 | 7 | 4 | 1 | 2 | 3 | 0 | 2 | 0 | 0 | 0 |
| 1998 | 3 | 1 | 0 | 0 | 1 | 32 | 23 | 46 | 45 | 93 | 370 | 1928 | 4087 | 9736 | 15515 | 22466 | 26645 | 30947 | 28225 | 21358 | 13610 | 7212 | 3900 | 2469 | 1211 | 635 |
| 1999 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 4 | 22 | 60 | 220 | 1263 | 3731 | 8701 | 8787 | 10336 | 12449 | 12238 | 10724 | 7083 | 4170 | 2019 | 1037 | 624 | 408 | 347 |
| 1999 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 13 | 44 | 135 | 981 | 1548 | 1315 | 1398 | 1400 | 1230 | 816 | 573 | 328 | 175 | 77 | 42 | 14 |
| 1999 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 10 | 27 | 61 | 115 | 371 | 707 | 3684 | 7968 | 7048 | 6468 | 6890 | 6175 | 4308 | 3091 | 1886 | 1110 | 554 | 359 | 231 |

Table 2.9b–Length frequencies of Pacific cod in the post-1999 longline fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 2000 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 5 | 16 | 50 | 189 | 679 | 1627 | 6534 | 10526 | 11488 | 9991 | 8549 | 6638 | 4465 | 3133 | 2504 | 1923 | 1339 | 957 | 797 |
| 2000 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 10 | 27 | 248 | 654 | 1256 | 1910 | 1616 | 1240 | 891 | 701 | 500 | 397 | 250 | 156 | 100 |
| 2000 | 3 | 1 | 8 | 0 | 0 | 0 | 1 | 3 | 7 | 15 | 71 | 431 | 1300 | 4358 | 10130 | 16501 | 21226 | 16982 | 10164 | 6387 | 4077 | 2569 | 1573 | 881 | 569 | 443 |
| 2001 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 5 | 27 | 117 | 363 | 581 | 1283 | 5348 | 10260 | 14341 | 16442 | 13783 | 8606 | 4957 | 2958 | 1878 | 1393 | 955 | 705 | 552 |
| 2001 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 10 | 26 | 103 | 211 | 407 | 1449 | 3133 | 4343 | 4736 | 4615 | 3548 | 1825 | 1100 | 597 | 408 | 322 | 332 | 264 |
| 2001 | 3 | 0 | 0 | 0 | 1 | 4 | 0 | 5 | 21 | 56 | 236 | 1040 | 2147 | 6079 | 10320 | 16069 | 18724 | 18097 | 13810 | 6921 | 3436 | 1789 | 1248 | 960 | 679 | 593 |
| 2002 | 1 | 1 | 2 | 5 | 5 | 7 | 14 | 20 | 90 | 198 | 346 | 1104 | 2778 | 6505 | 7619 | 10662 | 14937 | 13802 | 9000 | 4165 | 1962 | 900 | 502 | 330 | 124 | 73 |
| 2002 | 2 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 27 | 74 | 189 | 328 | 637 | 2568 | 4552 | 5151 | 5247 | 5129 | 3579 | 2091 | 942 | 415 | 229 | 114 | 68 | 14 |
| 2002 | 3 | 2 | 0 | 0 | 0 | 0 | 2 | 17 | 49 | 164 | 428 | 1068 | 2283 | 7508 | 12276 | 13901 | 13729 | 12909 | 10164 | 5968 | 2954 | 1297 | 589 | 261 | 135 | 120 |
| 2003 | 1 | 0 | 0 | 2 | 0 | 3 | 1 | 9 | 40 | 233 | 529 | 1471 | 3631 | 10895 | 15804 | 16379 | 15184 | 13322 | 9589 | 4865 | 2173 | 800 | 322 | 125 | 54 | 14 |
| 2003 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 8 | 48 | 144 | 398 | 1565 | 3027 | 3964 | 3604 | 2904 | 2172 | 1139 | 611 | 274 | 110 | 57 | 18 | 8 |
| 2003 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14 | 50 | 307 | 575 | 634 | 575 | 469 | 359 | 224 | 99 | 44 | 15 | 3 | 1 | 1 |

Table 2.10a–Length frequencies of Pacific cod in the 1989-1999 pot fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1990 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 7 | 42 | 74 | 141 | 230 | 293 | 220 | 229 | 138 | 81 | 45 | 3 | 2 |
| 1990 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 10 | 116 | 512 | 1149 | 1146 | 1360 | 701 | 391 | 260 | 109 | 11 | 3 |
| 1991 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 39 | 240 | 572 | 1106 | 1700 | 2050 | 1874 | 1636 | 875 | 414 | 155 | 35 | 5 |
| 1991 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 29 | 163 | 406 | 790 | 1444 | 2084 | 2236 | 1810 | 1218 | 637 | 290 | 101 | 29 |
| 1992 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 8 | 7 | 24 | 174 | 380 | 731 | 1875 | 3807 | 3583 | 2710 | 1776 | 1160 | 590 | 324 | 99 | 39 |
| 1992 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 5 | 36 | 103 | 438 | 2186 | 3592 | 4075 | 5205 | 6914 | 7708 | 7212 | 5139 | 3268 | 1601 | 710 | 261 | 113 |
| 1992 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 22 | 73 | 145 | 590 | 869 | 749 | 599 | 526 | 406 | 327 | 306 | 200 | 151 | 79 | 48 | 55 |
| 1993 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 | 28 | 320 | 824 | 1448 | 1968 | 1869 | 1621 | 1062 | 640 | 384 | 233 | 93 | 41 | 18 |
| 1994 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 19 | 125 | 727 | 2791 | 4384 | 4660 | 4567 | 3529 | 2371 | 1284 | 706 | 409 | 238 | 112 | 27 |
| 1994 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 10 | 25 | 152 | 576 | 1095 | 1255 | 1050 | 808 | 601 | 364 | 229 | 136 | 71 | 39 | 17 |
| 1995 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 45 | 242 | 1203 | 3094 | 6944 | 10101 | 9099 | 6435 | 3950 | 2408 | 1608 | 1394 | 826 | 222 | 84 |
| 1995 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 56 | 443 | 841 | 1540 | 2499 | 2682 | 2128 | 1816 | 1425 | 1139 | 1007 | 520 | 449 | 236 |
| 1995 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 16 | 275 | 821 | 1444 | 2240 | 2490 | 2142 | 1563 | 1158 | 787 | 449 | 201 | 125 | 29 |
| 1996 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 5 | 11 | 14 | 39 | 89 | 268 | 2272 | 6731 | 10936 | 13049 | 13395 | 10997 | 7115 | 4724 | 2883 | 1910 | 1123 | 588 | 241 |
| 1996 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 6 | 43 | 389 | 1293 | 2879 | 3807 | 3552 | 2788 | 2147 | 1939 | 1517 | 1126 | 771 | 513 | 291 |
| 1996 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 12 | 174 | 464 | 953 | 1766 | 1923 | 1526 | 1088 | 991 | 929 | 668 | 400 | 218 | 84 |
| 1997 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 3 | 15 | 38 | 82 | 647 | 2100 | 5113 | 9620 | 10616 | 6855 | 3690 | 1963 | 1239 | 838 | 530 | 311 | 197 |
| 1997 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 7 | 22 | 164 | 454 | 973 | 1685 | 2434 | 2523 | 1440 | 704 | 477 | 393 | 270 | 143 | 69 |
| 1997 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 7 | 22 | 164 | 454 | 973 | 1685 | 2434 | 2523 | 1440 | 704 | 477 | 393 | 270 | 143 | 69 |
| 1998 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 4 | 17 | 93 | 695 | 1363 | 2166 | 4743 | 6257 | 5386 | 3157 | 1369 | 579 | 372 | 213 | 118 | 60 |
| 1998 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 12 | 159 | 524 | 934 | 1372 | 1824 | 1709 | 1051 | 520 | 280 | 210 | 131 | 111 | 57 |
| 1998 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 8 | 10 | 70 | 257 | 405 | 605 | 730 | 788 | 587 | 396 | 247 | 147 | 130 | 72 | 66 |
| 1999 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 6 | 17 | 106 | 918 | 1497 | 2389 | 3677 | 3882 | 3557 | 2484 | 1586 | 958 | 656 | 392 | 332 | 172 |
| 1999 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 7 | 58 | 123 | 151 | 239 | 239 | 257 | 198 | 170 | 148 | 116 | 72 | 51 | 44 |
| 1999 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 12 | 21 | 53 | 305 | 793 | 1153 | 1122 | 1255 | 1086 | 835 | 696 | 585 | 442 | 249 | 202 | 109 |

Table 2.10b–Length frequencies of Pacific cod in the post-1999 pot fishery by year, period, and length bin.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 2000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 2 | 12 | 112 | 934 | 2545 | 4019 | 4085 | 3753 | 3482 | 2412 | 1715 | 1125 | 882 | 487 | 256 | 216 |
| 2000 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 39 | 87 | 134 | 149 | 62 | 25 | 8 | 0 | 2 | 1 | 0 | 0 | 0 |
| 2001 | 1 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 13 | 234 | 796 | 2200 | 4015 | 4021 | 2277 | 1046 | 485 | 316 | 232 | 168 | 78 | 96 |
| 2001 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 | 45 | 77 | 103 | 93 | 61 | 33 | 5 | 7 | 4 | 6 | 1 |
| 2001 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 4 | 4 | 14 | 155 | 618 | 1313 | 1543 | 1768 | 1322 | 674 | 438 | 267 | 156 | 93 | 48 | 25 |
| 2002 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 | 16 | 131 | 605 | 1564 | 2847 | 2848 | 1789 | 768 | 297 | 134 | 78 | 39 | 20 | 14 |
| 2002 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 20 | 45 | 72 | 65 | 62 | 41 | 32 | 9 | 12 | 2 | 0 | 1 |
| 2002 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 26 | 165 | 580 | 1244 | 1352 | 1026 | 728 | 485 | 314 | 144 | 107 | 43 | 19 | 11 |
| 2003 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 6 | 54 | 267 | 766 | 1391 | 2203 | 2788 | 2360 | 1328 | 655 | 259 | 97 | 41 | 19 | 9 |
| 2003 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 92 | 95 | 84 | 42 | 31 | 14 | 10 | 10 | 1 | 0 | 0 | 0 |

Table 2.11–Length frequencies of Pacific cod in the trawl survey by year (all surveys take place in period 2). Numbers shown are survey estimates of population numbers at length, rescaled so that the sum equals the total size of the actual survey length sample.

| | | Length Bin | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Yr. | Per | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| 1979 | 2 | 0 | 5 | 44 | 186 | 374 | 457 | 694 | 1764 | 2393 | 1884 | 1171 | 618 | 202 | 70 | 44 | 51 | 29 | 8 | 0 | 3 | 1 | 1 | 0 | 0 | 0 |
| 1980 | 2 | 0 | 6 | 85 | 241 | 82 | 42 | 224 | 687 | 929 | 1320 | 1542 | 2062 | 1364 | 893 | 333 | 100 | 33 | 31 | 19 | 6 | 2 | 0 | 0 | 0 | 0 |
| 1981 | 2 | 0 | 20 | 156 | 330 | 278 | 32 | 100 | 330 | 653 | 724 | 511 | 1063 | 1396 | 1746 | 1215 | 812 | 398 | 156 | 39 | 27 | 13 | 1 | 0 | 0 | 0 |
| 1982 | 2 | 16 | 84 | 205 | 132 | 35 | 27 | 124 | 384 | 732 | 718 | 391 | 769 | 1179 | 1256 | 1232 | 1135 | 821 | 450 | 192 | 80 | 26 | 8 | 3 | 0 | 0 |
| 1983 | 2 | 278 | 996 | 939 | 460 | 109 | 23 | 100 | 264 | 405 | 294 | 163 | 483 | 891 | 1024 | 1069 | 891 | 700 | 514 | 247 | 111 | 22 | 14 | 3 | 1 | 0 |
| 1984 | 2 | 43 | 88 | 66 | 120 | 252 | 762 | 1380 | 1426 | 858 | 389 | 200 | 291 | 361 | 481 | 708 | 783 | 713 | 478 | 320 | 152 | 83 | 36 | 10 | 1 | 0 |
| 1985 | 2 | 88 | 325 | 573 | 893 | 1004 | 387 | 179 | 362 | 544 | 580 | 703 | 1194 | 815 | 392 | 282 | 322 | 408 | 401 | 294 | 148 | 69 | 24 | 10 | 4 | 0 |
| 1986 | 2 | 91 | 286 | 320 | 99 | 75 | 452 | 1163 | 1257 | 1040 | 711 | 359 | 396 | 573 | 869 | 776 | 406 | 268 | 296 | 244 | 171 | 79 | 48 | 13 | 8 | 0 |
| 1987 | 2 | 18 | 72 | 248 | 385 | 258 | 179 | 413 | 847 | 729 | 580 | 600 | 1231 | 1089 | 768 | 551 | 604 | 581 | 378 | 193 | 151 | 61 | 45 | 15 | 6 | 0 |
| 1988 | 2 | 9 | 53 | 80 | 91 | 109 | 236 | 282 | 393 | 666 | 627 | 493 | 987 | 1102 | 1310 | 1086 | 833 | 559 | 414 | 293 | 234 | 75 | 33 | 28 | 7 | 0 |
| 1989 | 2 | 17 | 137 | 316 | 224 | 69 | 37 | 92 | 102 | 147 | 350 | 347 | 565 | 709 | 1218 | 1308 | 1138 | 941 | 800 | 632 | 326 | 234 | 146 | 87 | 59 | 0 |
| 1990 | 2 | 203 | 491 | 689 | 357 | 132 | 124 | 263 | 303 | 323 | 277 | 174 | 160 | 169 | 224 | 349 | 408 | 276 | 262 | 170 | 123 | 82 | 33 | 25 | 10 | 1 |
| 1991 | 2 | 141 | 408 | 447 | 381 | 228 | 262 | 595 | 867 | 912 | 611 | 349 | 249 | 259 | 327 | 260 | 226 | 211 | 181 | 108 | 107 | 49 | 20 | 22 | 7 | 1 |
| 1992 | 2 | 18 | 468 | 451 | 565 | 514 | 455 | 891 | 1092 | 872 | 560 | 462 | 889 | 699 | 564 | 244 | 233 | 186 | 108 | 101 | 91 | 54 | 38 | 30 | 15 | 1 |
| 1993 | 2 | 114 | 924 | 1087 | 981 | 677 | 213 | 247 | 614 | 847 | 666 | 489 | 845 | 842 | 665 | 398 | 267 | 230 | 85 | 62 | 49 | 36 | 21 | 24 | 15 | 6 |
| 1994 | 2 | 18 | 145 | 291 | 361 | 327 | 446 | 957 | 1924 | 2082 | 1121 | 443 | 685 | 1051 | 964 | 1058 | 920 | 565 | 288 | 92 | 46 | 33 | 60 | 15 | 22 | 8 |
| 1995 | 2 | 29 | 74 | 135 | 208 | 77 | 172 | 460 | 691 | 580 | 705 | 1064 | 1575 | 1017 | 617 | 434 | 484 | 326 | 253 | 133 | 84 | 41 | 27 | 18 | 9 | 3 |
| 1996 | 2 | 14 | 65 | 164 | 198 | 110 | 103 | 357 | 699 | 677 | 526 | 499 | 744 | 1477 | 1404 | 908 | 499 | 288 | 237 | 148 | 109 | 71 | 25 | 16 | 7 | 3 |
| 1997 | 2 | 91 | 472 | 601 | 728 | 507 | 140 | 215 | 481 | 628 | 451 | 407 | 399 | 918 | 809 | 842 | 583 | 436 | 215 | 105 | 60 | 40 | 26 | 10 | 4 | 1 |
| 1998 | 2 | 30 | 262 | 334 | 74 | 46 | 311 | 1151 | 1837 | 1396 | 655 | 379 | 367 | 659 | 458 | 378 | 391 | 333 | 244 | 132 | 64 | 33 | 29 | 9 | 10 | 1 |
| 1999 | 2 | 71 | 335 | 286 | 113 | 141 | 415 | 760 | 874 | 667 | 719 | 1169 | 1648 | 1854 | 768 | 493 | 447 | 337 | 252 | 130 | 89 | 62 | 37 | 24 | 7 | 2 |
| 2000 | 2 | 175 | 918 | 1310 | 505 | 54 | 141 | 488 | 785 | 604 | 564 | 749 | 958 | 1720 | 1419 | 894 | 537 | 266 | 188 | 99 | 79 | 57 | 33 | 19 | 3 | 0 |
| 2001 | 2 | 95 | 640 | 1815 | 2110 | 1011 | 407 | 903 | 1994 | 2550 | 1618 | 706 | 486 | 1193 | 1278 | 1080 | 819 | 515 | 257 | 123 | 71 | 34 | 22 | 14 | 4 | 5 |
| 2002 | 2 | 31 | 192 | 374 | 352 | 105 | 207 | 662 | 1456 | 1446 | 1004 | 791 | 1216 | 1579 | 880 | 611 | 546 | 368 | 209 | 104 | 49 | 19 | 16 | 15 | 3 | 2 |
| 2003 | 2 | 19 | 283 | 635 | 774 | 682 | 489 | 182 | 255 | 705 | 837 | 974 | 1188 | 1969 | 1213 | 767 | 513 | 338 | 259 | 141 | 86 | 35 | 14 | 2 | 1 | 0 |

Table 2.12--Biomass, standard error, 95% confidence interval (CI), and population numbers of Pacific cod estimated by NMFS' annual bottom trawl survey of the EBS shelf. All figures except population numbers are expressed in metric tons. Population numbers are expressed in terms of individual fish.

| Year | Biomass | Standard Error | Lower 95% CI | Upper 95% CI | Numbers |
|---|---|---|---|---|---|
| 1979 | 754,314 | 97,844 | 562,539 | 946,089 | 1,530,429,650 |
| 1980 | 905,344 | 87,898 | 733,063 | 1,077,624 | 1,084,147,540 |
| 1981 | 1,034,629 | 123,849 | 791,885 | 1,277,373 | 794,619,624 |
| 1982 | 1,020,550 | 73,392 | 876,701 | 1,164,399 | 583,715,089 |
| 1983 | 1,176,305 | 121,606 | 937,958 | 1,414,651 | 725,351,369 |
| 1984 | 1,001,940 | 64,127 | 876,251 | 1,127,629 | 636,948,300 |
| 1985 | 961,050 | 51,453 | 860,203 | 1,061,896 | 800,070,473 |
| 1986 | 1,134,106 | 71,813 | 993,353 | 1,274,858 | 843,460,794 |
| 1987 | 1,142,450 | 71,439 | 1,002,430 | 1,282,468 | 754,269,021 |
| 1988 | 959,544 | 76,284 | 810,028 | 1,109,060 | 509,336,483 |
| 1989 | 960,436 | 69,157 | 824,888 | 1,095,984 | 339,719,445 |
| 1990 | 708,551 | 53,728 | 603,245 | 813,857 | 435,856,535 |
| 1991 | 532,590 | 41,678 | 450,902 | 614,279 | 496,841,261 |
| 1992* | 546,707 | 45,754 | 457,030 | 636,383 | 577,416,832 |
| 1993 | 690,524 | 54,934 | 582,853 | 798,196 | 851,866,426 |
| 1994 | 1,368,109 | 254,435 | 869,416 | 1,866,802 | 1,237,760,162 |
| 1995 | 1,003,046 | 92,677 | 821,400 | 1,184,692 | 757,576,445 |
| 1996 | 890,793 | 120,522 | 652,160 | 1,129,426 | 609,304,214 |
| 1997 | 604,881 | 69,250 | 466,382 | 743,380 | 487,429,700 |
| 1998 | 534,141 | 42,942 | 449,116 | 619,166 | 514,321,475 |
| 1999 | 583,259 | 50,622 | 483,028 | 683,490 | 500,692,872 |
| 2000 | 528,466 | 43,037 | 443,253 | 613,679 | 481,358,109 |
| 2001 | 830,479 | 75,675 | 679,130 | 981,829 | 980,493,794 |
| 2002 | 616,923 | 69,586 | 477,750 | 756,096 | 564,115,880 |
| 2003 | 605,681 | 63,601 | 478,479 | 732,882 | 510,187,323 |

*During the 1992 field season, 18 stations were omitted from the standard survey grid due to severe weather and vessel problems. In 1989, 1990, and 1991, these 18 stations represented, on average, 2.2% and 2.8% of the total Pacific cod biomass and numbers, respectively. The 1992 point estimates and confidence interval shown above have been adjusted upward proportionately.

Table 2.13–Symbols used in the Synthesis assessment model for Pacific cod (page 1 of 2).

| Indices | |
|---|---|
| $a$ | age group |
| $g$ | gear type |
| $i$ | time interval |
| $j$ | size bin |
| $y$ | year |

| Dimensions | |
|---|---|
| $a_{min}$ | age of youngest group |
| $a_{max}$ | age of oldest group |
| $g_{max}$ | number of gear types |
| $i_{max}$ | number of time intervals in each year |
| $j_{max}$ | number of size bins |
| $y_{max}$ | number of years |

| Special Values of Indices | |
|---|---|
| $a_{rec}$ | index of age group used to assess recruitment strength |
| $g_{sur}$ | index of survey gear type |
| $i_{spa}$ | index of time interval during which spawning occurs |
| $i_{sur}$ | index of time interval during which survey occurs |

| Operators | |
|---|---|
| $e(y\|g)$ | returns the era containing year $y$ given gear type $g$ |
| $l_{mid}$ | returns the length corresponding to the midpoint of bin $j$ |
| $l_{min}$ | returns the smallest length contained in bin $j$ |
| $t_{dur}$ | returns the duration (in years) of time interval $i$ |

| Continuous Variables | |
|---|---|
| $\alpha$ | age |
| $\lambda$ | length |
| $\tau$ | time |

| Special Values of Continuous Variables | |
|---|---|
| $\alpha_1$ | first reference age used in length-at-age relationship (in years) |
| $\alpha_2$ | second reference age used in length-at-age relationship (in years) |
| $\lambda_{\text{min}}$ | minimum length used in assessment |
| $\lambda_{\text{max}}$ | maximum length used in assessment |
| $\tau_{spa}$ | annual time of spawning (in years) |
| $\tau_{sur}$ | annual time of survey (in years) |

Table 2.13–Symbols used in the Synthesis assessment model for Pacific cod (page 2 of 2).

Functions of Age or Length

| | |
|---|---|
| $h(\lambda \mid \alpha)$ | probability density function describing distribution of length, conditional on age |
| $l(\alpha)$ | length at age |
| $p(\lambda)$ | proportion mature at length |
| $s(\lambda \mid g, y)$ | selectivity at length, conditional on gear type and year |
| $w(\lambda)$ | weight at length |
| $x(\alpha)$ | standard deviation associated with the length-at-age relationship, as a function of age |

Arrays Generated by Synthesis

| | |
|---|---|
| $b_y$ | biomass of population aged $a \geq a_{rec}$ at start of year $y$ |
| $c_y$ | spawning biomass at time of spawning in year $y$ |
| $d_y$ | survey biomass at time of survey in year $y$ |
| $n_{a,y,i}$ | population numbers at age $a$, year $y$, and time interval $i$ |
| $u_{a,y}$ | population numbers at time of spawning at age $a$ and year $y$ |
| $v_{a,y}$ | population numbers at time of survey at age $a$ and year $y$ |
| $z_{a,i,j}$ | proportion of length distribution falling within size bin $j$ at age $a$ and time interval $i$ |

Parameters Used by Synthesis

| | |
|---|---|
| $F_{g,y,i}$ | instantaneous fishing mortality rate at each gear $g$, year $y$, and time $i$ for which catch>0 |
| $K$ | Brody's growth parameter |
| $L_1$ | length at age $\alpha_1$ |
| $L_2$ | length at age $\alpha_2$ |
| $M$ | instantaneous natural mortality rate |
| $N_a$ | initial population numbers at each age $a > a_{min}$ |
| $P_1$ | length at point of inflection in maturity schedule |
| $P_2$ | relative slope at point of inflection in maturity schedule |
| $Q$ | survey catchability |
| $R_y$ | recruitment at age $a_{min}$ in year $y$ |
| $S_{1,g,e(y \mid g)}$ | selectivity at minimum length in gear type $g$ and era $e$ |
| $S_{2,g,e(y \mid g)}$ | length at inflection in ascending part of selectivity schedule in gear type $g$ and era $e$ |
| $S_{3,g,e(y \mid g)}$ | relative slope at inflection in ascending part of selectivity schedule in gear type $g$ and era $e$ |
| $S_{4,g,e(y \mid g)}$ | length at maximum selectivity in gear type $g$ and era $e$ |
| $S_{5,g,e(y \mid g)}$ | selectivity at maximum length in gear type $g$ and era $e$ |
| $S_{6,g,e(y \mid g)}$ | length at inflection in descending part of selectivity schedule in gear type $g$ and era $e$ |
| $S_{7,g,e(y \mid g)}$ | relative slope at inflection in descending part of selectivity schedule in gear type $g$ and era $e$ |
| $W_1$ | weight-length proportionality |
| $W_2$ | weight-length exponent |
| $X_1$ | standard deviation of length evaluated at age $\alpha_1$ |
| $X_2$ | standard deviation of length evaluated at age $\alpha_2$ |

Table 2.14–Dimensions and special values of indices and variables used in the Pacific cod assessment. Symbols are defined in Table 2.13.

Dimensions

| Term | Value | Comments/Rationale |
|---|---|---|
| $a_{min}$ | 1 | assumed minimum age group observed in the trawl survey |
| $a_{max}$ | 12 | a convenient place to insert an "age-plus" category |
| $g_{max}$ | 6 | early trawl, late trawl, longline, pot, pre-1982 survey, post-1981 survey |
| $i_{max}$ | 3 | January through March, June through August, September through December |
| $j_{max}$ | 25 | bin boundaries are given in the "Data" section of the text |
| $y_{max}$ | 26 | 1978 through 2003 |

Special Values of Indices

| Term | Value | Comments/Rationale |
|---|---|---|
| $a_{rec}$ | 3 | age traditionally used to indicate first significant recruitment to the fishery |
| $g_{sur}$ | 6 | index of post-1981 survey gear type |
| $i_{spa}$ | 1 | March (see $\tau_{spa}$ below) falls within the first intra-annual time period |
| $i_{sur}$ | 2 | July (see $\tau_{sur}$ below) falls within the second intra-annual time period |

Special Values of Continuous Variables

| Term | Value | Comments/Rationale |
|---|---|---|
| $\alpha_1$ | 1.5 | assumed age of youngest fish seen in the trawl survey |
| $\alpha_2$ | 12.0 | set equal to the lower bound of the age-plus group for convenience |
| $\lambda_{min}$ | 9 | close to the length of the smallest fish seen by the survey in a typical year |
| $\lambda_{max}$ | 115 | close to the length of the largest fish seen by the survey in a typical year |
| $\tau_{spa}$ | (3-1)/12 | March appears to be the month of peak spawning in the observer data |
| $\tau_{sur}$ | (7-1)/12 | July is the approximate mid-point of the June-August trawl survey season |

Table 2.15–Partitioning the list of parameters used in the Synthesis model of Pacific cod into those that are estimated independently (i.e., outside) of Synthesis and those that are estimated conditionally (i.e., inside of Synthesis).

| Parameters Estimated Independently | |
|---|---|
| $L_1$ | length at age $\alpha_1$ |
| $M$ | instantaneous natural mortality rate |
| $P_1$ | length at point of inflection in maturity schedule |
| $P_2$ | relative slope at point of inflection in maturity schedule |
| $Q$ | survey catchability |
| $W_1$ | weight-length proportionality |
| $W_2$ | weight-length exponent |
| $X_1$ | standard deviation of length evaluated at age $\alpha_1$ |
| $X_2$ | standard deviation of length evaluated at age $\alpha_2$ |

| Parameters Estimated Conditionally | |
|---|---|
| $F_{g,y,i}$ | instantaneous fishing mortality rate at each gear *g*, year *y*, and time *i* for which catch>0 |
| $K$ | Brody's growth parameter |
| $L_2$ | length at age $\alpha_2$ |
| $N_a$ | initial population numbers at each age $a > a_{min}$ |
| $R_y$ | recruitment at age $a_{min}$ in year *y* |
| $S_{1,g,e(y\|g)}$ | selectivity at minimum length in gear type *g* and era *e* |
| $S_{2,g,e(y\|g)}$ | length at inflection in ascending part of selectivity schedule in gear type *g* and era *e* |
| $S_{3,g,e(y\|g)}$ | relative slope at inflection in ascending part of selectivity schedule in gear type *g* and era *e* |
| $S_{4,g,e(y\|g)}$ | length at maximum selectivity in gear type *g* and era *e* |
| $S_{5,g,e(y\|g)}$ | selectivity at maximum length in gear type *g* and era *e* |
| $S_{6,g,e(y\|g)}$ | length at inflection in descending part of selectivity schedule in gear type *g* and era *e* |
| $S_{7,g,e(y\|g)}$ | relative slope at inflection in descending part of selectivity schedule in gear type *g* and era *e* |

Table 2.16–Pacific cod commercial fishery length sample sizes used in the multinomial distribution. (These values correspond to the square roots of the true sample sizes shown in Table 2.5.)

| Year | Trawl Fishery | | | Longline Fishery | | | Pot Fishery | | |
|---|---|---|---|---|---|---|---|---|---|
| | Per. 1 | Per. 2 | Per. 3 | Per. 1 | Per. 2 | Per. 3 | Per. 1 | Per. 2 | Per. 3 |
| 1978 | 25 | 0 | 56 | 54 | 70 | 50 | 0 | 0 | 0 |
| 1979 | 41 | 0 | 27 | 107 | 50 | 52 | 0 | 0 | 0 |
| 1980 | 37 | 9 | 18 | 51 | 37 | 54 | 0 | 0 | 0 |
| 1981 | 11 | 0 | 39 | 47 | 36 | 36 | 0 | 0 | 0 |
| 1982 | 24 | 15 | 41 | 54 | 35 | 71 | 0 | 0 | 0 |
| 1983 | 111 | 35 | 121 | 137 | 64 | 98 | 0 | 0 | 0 |
| 1984 | 101 | 67 | 67 | 83 | 77 | 287 | 0 | 0 | 0 |
| 1985 | 174 | 39 | 55 | 0 | 68 | 367 | 0 | 0 | 0 |
| 1986 | 169 | 43 | 50 | 136 | 14 | 323 | 0 | 0 | 0 |
| 1987 | 215 | 82 | 145 | 265 | 0 | 406 | 0 | 0 | 0 |
| 1988 | 322 | 0 | 54 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1989 | 242 | 25 | 26 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1990 | 253 | 99 | 16 | 137 | 273 | 250 | 0 | 39 | 76 |
| 1991 | 298 | 46 | 0 | 234 | 266 | 303 | 0 | 103 | 106 |
| 1992 | 282 | 0 | 0 | 390 | 366 | 142 | 131 | 220 | 72 |
| 1993 | 286 | 0 | 0 | 393 | 0 | 0 | 103 | 0 | 0 |
| 1994 | 322 | 0 | 0 | 415 | 0 | 213 | 161 | 0 | 80 |
| 1995 | 262 | 0 | 0 | 380 | 20 | 273 | 218 | 130 | 117 |
| 1996 | 323 | 34 | 59 | 405 | 12 | 275 | 276 | 152 | 106 |
| 1997 | 327 | 17 | 0 | 430 | 10 | 380 | 209 | 108 | 108 |
| 1998 | 329 | 53 | 55 | 404 | 8 | 437 | 163 | 94 | 67 |
| 1999 | 212 | 15 | 34 | 290 | 100 | 226 | 150 | 43 | 94 |
| 2000 | 217 | 17 | 8 | 267 | 100 | 313 | 161 | 0 | 23 |
| 2001 | 162 | 53 | 36 | 291 | 166 | 320 | 126 | 21 | 92 |
| 2002 | 195 | 68 | 49 | 274 | 177 | 293 | 106 | 19 | 79 |
| 2003 | 208 | 71 | 30 | 309 | 142 | 58 | 111 | 0 | 20 |

Table 2.17–Estimates of Pacific cod fishing mortality rates, expressed on an annual time scale. Empty cells indicate that no catch was recorded.

| Year | Trawl | | | Longline | | | Pot | | |
|---|---|---|---|---|---|---|---|---|---|
| | Per. 1 | Per. 2 | Per. 3 | Per. 1 | Per. 2 | Per. 3 | Per. 1 | Per. 2 | Per. 3 |
| 1978 | 0.11 | 0.23 | 0.25 | 0.02 | 0.02 | 0.03 | | | |
| 1979 | 0.07 | 0.16 | 0.09 | 0.01 | 0.01 | 0.00 | | | |
| 1980 | 0.03 | 0.06 | 0.07 | 0.01 | 0.00 | 0.02 | | | |
| 1981 | 0.03 | 0.05 | 0.05 | 0.00 | 0.00 | 0.01 | | | |
| 1982 | 0.03 | 0.05 | 0.03 | 0.00 | 0.00 | 0.00 | | | |
| 1983 | 0.05 | 0.05 | 0.04 | 0.00 | 0.00 | 0.00 | | | |
| 1984 | 0.06 | 0.05 | 0.04 | 0.01 | 0.00 | 0.03 | | | |
| 1985 | 0.07 | 0.06 | 0.04 | 0.02 | 0.00 | 0.04 | | | |
| 1986 | 0.07 | 0.06 | 0.04 | 0.01 | 0.00 | 0.03 | | | |
| 1987 | 0.08 | 0.03 | 0.03 | 0.03 | 0.00 | 0.05 | | | |
| 1988 | 0.16 | 0.05 | 0.08 | 0.00 | 0.00 | 0.00 | | | |
| 1989 | 0.16 | 0.03 | 0.03 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |
| 1990 | 0.14 | 0.02 | 0.02 | 0.02 | 0.05 | 0.04 | | 0.00 | 0.00 |
| 1991 | 0.17 | 0.04 | 0.01 | 0.05 | 0.08 | 0.09 | 0.00 | 0.00 | 0.01 |
| 1992 | 0.11 | 0.04 | 0.01 | 0.12 | 0.11 | 0.02 | 0.01 | 0.02 | 0.00 |
| 1993 | 0.14 | 0.02 | 0.02 | 0.13 | 0.00 | 0.00 | 0.01 | 0.00 | |
| 1994 | 0.12 | 0.02 | 0.04 | 0.14 | 0.00 | 0.06 | 0.01 | | 0.01 |
| 1995 | 0.18 | 0.03 | 0.03 | 0.17 | 0.00 | 0.09 | 0.03 | 0.01 | 0.01 |
| 1996 | 0.16 | 0.01 | 0.03 | 0.15 | 0.00 | 0.08 | 0.05 | 0.03 | 0.01 |
| 1997 | 0.18 | 0.01 | 0.02 | 0.18 | 0.00 | 0.16 | 0.04 | 0.02 | 0.01 |
| 1998 | 0.11 | 0.02 | 0.03 | 0.16 | 0.00 | 0.12 | 0.03 | 0.01 | 0.01 |
| 1999 | 0.12 | 0.01 | 0.01 | 0.19 | 0.01 | 0.10 | 0.03 | 0.01 | 0.01 |
| 2000 | 0.17 | 0.02 | 0.02 | 0.12 | 0.01 | 0.15 | 0.06 | | 0.00 |
| 2001 | 0.09 | 0.03 | 0.02 | 0.11 | 0.03 | 0.16 | 0.04 | 0.00 | 0.02 |
| 2002 | 0.14 | 0.04 | 0.01 | 0.14 | 0.06 | 0.14 | 0.04 | 0.00 | 0.02 |
| 2003 | 0.12 | 0.04 | 0.01 | 0.14 | 0.05 | 0.13 | 0.04 | | 0.01 |

Table 2.18–Estimates of Pacific cod recruitment at age 1 and initial numbers at age (in millions of fish).

| Year | Recruitment at age 1 |
|---|---|
| 1978 | 1485 |
| 1979 | 670 |
| 1980 | 767 |
| 1981 | 603 |
| 1982 | 197 |
| 1983 | 1098 |
| 1984 | 330 |
| 1985 | 883 |
| 1986 | 539 |
| 1987 | 334 |
| 1988 | 192 |
| 1989 | 250 |
| 1990 | 599 |
| 1991 | 582 |
| 1992 | 340 |
| 1993 | 649 |
| 1994 | 318 |
| 1995 | 260 |
| 1996 | 250 |
| 1997 | 556 |
| 1998 | 368 |
| 1999 | 327 |
| 2000 | 521 |
| 2001 | 654 |
| 2002 | 219 |
| 2003 | 484 |

| Age | Numbers at age |
|---|---|
| 2 | 259 |
| 3 | 93 |
| 4 | 103 |
| 5 | 0 |
| 6 | 11 |
| 7 | 3 |
| 8 | 0 |
| 9 | 0 |
| 10 | 0 |
| 11 | 1 |
| 12 | 0 |

Table 2.19–Estimates of Pacific cod selectivity parameters. The first column lists the parameter families for which the remaining columns contain era-specific estimates.

| Trawl (Jan-May) | 1978-88 | 1989-99 | 2000-03 |
|---|---|---|---|
| $S_{1,g,e(y\|g)}$ | 0 | 0 | 0 |
| $S_{2,g,e(y\|g)}$ | 52.10 | 53.67 | 73.73 |
| $S_{3,g,e(y\|g)}$ | 0.16 | 0.15 | 0.12 |
| $S_{4,g,e(y\|g)}$ | 86.80 | 85.74 | 112.24 |
| $S_{5,g,e(y\|g)}$ | 0.50 | 0.71 | 1.00 |
| $S_{6,g,e(y\|g)}$ | 92.78 | 86.39 | 113.55 |
| $S_{7,g,e(y\|g)}$ | 0.29 | 0.21 | 4.79 |
| Trawl (Jun-Dec) | 1978-88 | 1989-99 | 2000-03 |
| $S_{1,g,e(y\|g)}$ | 0 | 0 | 0 |
| $S_{2,g,e(y\|g)}$ | 60.05 | 53.20 | 52.96 |
| $S_{3,g,e(y\|g)}$ | 0.17 | 0.20 | 0.18 |
| $S_{4,g,e(y\|g)}$ | 85.53 | 98.46 | 93.06 |
| $S_{5,g,e(y\|g)}$ | 0.87 | 0.85 | 0.47 |
| $S_{6,g,e(y\|g)}$ | 85.53 | 98.46 | 93.54 |
| $S_{7,g,e(y\|g)}$ | 0.53 | 0 | 0.11 |
| Longline | 1978-88 | 1989-99 | 2000-03 |
| $S_{1,g,e(y\|g)}$ | 0 | 0 | 0 |
| $S_{2,g,e(y\|g)}$ | 59.49 | 57.67 | 54.77 |
| $S_{3,g,e(y\|g)}$ | 0.25 | 0.27 | 0.28 |
| $S_{4,g,e(y\|g)}$ | 84.47 | 76.42 | 85.53 |
| $S_{5,g,e(y\|g)}$ | 0.32 | 0.44 | 0.51 |
| $S_{6,g,e(y\|g)}$ | 85.14 | 77.42 | 86.18 |
| $S_{7,g,e(y\|g)}$ | 0.12 | 0.12 | 0.88 |
| Pot | 1978-88 | 1989-99 | 2000-03 |
| $S_{1,g,e(y\|g)}$ | n/a | 0 | 0 |
| $S_{2,g,e(y\|g)}$ | n/a | 61.44 | 60.45 |
| $S_{3,g,e(y\|g)}$ | n/a | 0.27 | 0.31 |
| $S_{4,g,e(y\|g)}$ | n/a | 78.64 | 78.43 |
| $S_{5,g,e(y\|g)}$ | n/a | 0.56 | 0.41 |
| $S_{6,g,e(y\|g)}$ | n/a | 79.44 | 79.23 |
| $S_{7,g,e(y\|g)}$ | n/a | 0.15 | 0.24 |
| Survey | 1978-81 | 1982-03 | |
| $S_{1,g,e(y\|g)}$ | 0 | 0.12 | |
| $S_{2,g,e(y\|g)}$ | 29.52 | 20.68 | |
| $S_{3,g,e(y\|g)}$ | 0.20 | 0 | |
| $S_{4,g,e(y\|g)}$ | 46.31 | 44.83 | |
| $S_{5,g,e(y\|g)}$ | 0.33 | 0.08 | |
| $S_{6,g,e(y\|g)}$ | 47.34 | 45.74 | |
| $S_{7,g,e(y\|g)}$ | 0.13 | 0.05 | |

Table 2.20–Time series of EBS Pacific cod age 3+ biomass, spawning biomass, and survey biomass as estimated by the assessment model. The biomass time series obtained by the survey is shown in the right-hand column for comparison. All biomass figures are in 1000s of t.

| Year | Age 3+ | Spawning | Survey (est) | Survey (obs) |
|---|---|---|---|---|
| 1978 | 324 | 48 | n/a | n/a |
| 1979 | 480 | 80 | 558 | 754 |
| 1980 | 1066 | 138 | 921 | 905 |
| 1981 | 1593 | 257 | 1062 | 1035 |
| 1982 | 2073 | 440 | 1208 | 1021 |
| 1983 | 2410 | 620 | 1135 | 1176 |
| 1984 | 2450 | 742 | 1094 | 1002 |
| 1985 | 2608 | 786 | 1122 | 961 |
| 1986 | 2573 | 789 | 1108 | 1134 |
| 1987 | 2647 | 793 | 1127 | 1142 |
| 1988 | 2640 | 789 | 1033 | 960 |
| 1989 | 2482 | 775 | 866 | 960 |
| 1990 | 2223 | 744 | 710 | 709 |
| 1991 | 1938 | 672 | 648 | 533 |
| 1992 | 1746 | 568 | 694 | 547 |
| 1993 | 1698 | 493 | 728 | 691 |
| 1994 | 1674 | 475 | 746 | 1368 |
| 1995 | 1694 | 458 | 732 | 1003 |
| 1996 | 1600 | 440 | 650 | 891 |
| 1997 | 1466 | 422 | 554 | 605 |
| 1998 | 1274 | 387 | 537 | 534 |
| 1999 | 1256 | 354 | 574 | 583 |
| 2000 | 1255 | 335 | 585 | 528 |
| 2001 | 1241 | 337 | 607 | 830 |
| 2002 | 1289 | 341 | 670 | 617 |
| 2003 | 1393 | 343 | 695 | 606 |

Table 2.21–Distribution of Pacific cod lengths (in cm) at age (mid-year) as defined by final parameter estimates. Lengths correspond to lower bounds of size bins. Columns sum to 1.0.

| Len. | Age Group | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ |
| 105 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.001 | 0.006 | 0.020 | 0.046 | 0.167 |
| 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0.001 | 0.007 | 0.030 | 0.068 | 0.114 | 0.179 |
| 95 | 0 | 0 | 0 | 0 | 0 | 0 | 0.007 | 0.040 | 0.103 | 0.170 | 0.221 | 0.224 |
| 90 | 0 | 0 | 0 | 0 | 0 | 0.004 | 0.041 | 0.129 | 0.217 | 0.264 | 0.271 | 0.202 |
| 85 | 0 | 0 | 0 | 0 | 0.001 | 0.029 | 0.137 | 0.248 | 0.281 | 0.254 | 0.209 | 0.134 |
| 80 | 0 | 0 | 0 | 0 | 0.010 | 0.116 | 0.262 | 0.283 | 0.221 | 0.152 | 0.102 | 0.064 |
| 75 | 0 | 0 | 0 | 0.001 | 0.063 | 0.254 | 0.288 | 0.192 | 0.106 | 0.056 | 0.031 | 0.022 |
| 70 | 0 | 0 | 0 | 0.012 | 0.198 | 0.306 | 0.182 | 0.077 | 0.031 | 0.013 | 0.006 | 0.006 |
| 65 | 0 | 0 | 0 | 0.079 | 0.321 | 0.202 | 0.066 | 0.019 | 0.006 | 0.002 | 0.001 | 0.001 |
| 60 | 0 | 0 | 0.004 | 0.243 | 0.266 | 0.073 | 0.014 | 0.003 | 0.001 | 0 | 0 | 0 |
| 55 | 0 | 0 | 0.046 | 0.349 | 0.113 | 0.014 | 0.002 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0.210 | 0.233 | 0.025 | 0.002 | 0 | 0 | 0 | 0 | 0 | 0 |
| 45 | 0 | 0.003 | 0.380 | 0.072 | 0.003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 42 | 0 | 0.019 | 0.191 | 0.009 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | 0 | 0.072 | 0.109 | 0.002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | 0 | 0.172 | 0.044 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 33 | 0 | 0.261 | 0.013 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0.248 | 0.003 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27 | 0.002 | 0.150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 24 | 0.016 | 0.057 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 21 | 0.088 | 0.014 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | 0.238 | 0.002 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 15 | 0.329 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 12 | 0.230 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0.098 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2.22–Schedules of Pacific cod weight (kg) and maturity proportions at length (cm) as defined by final parameter estimates. Lengths correspond to lower bounds of size bins.

| Bin | Length | Weight | Maturity |
|---:|---:|---:|---:|
| 1 | 9 | 0.010 | 0.000 |
| 2 | 12 | 0.021 | 0.001 |
| 3 | 15 | 0.040 | 0.001 |
| 4 | 18 | 0.068 | 0.001 |
| 5 | 21 | 0.107 | 0.002 |
| 6 | 24 | 0.160 | 0.003 |
| 7 | 27 | 0.229 | 0.004 |
| 8 | 30 | 0.317 | 0.006 |
| 9 | 33 | 0.425 | 0.010 |
| 10 | 36 | 0.556 | 0.015 |
| 11 | 39 | 0.713 | 0.023 |
| 12 | 42 | 0.898 | 0.035 |
| 13 | 45 | 1.201 | 0.061 |
| 14 | 50 | 1.659 | 0.117 |
| 15 | 55 | 2.225 | 0.210 |
| 16 | 60 | 2.912 | 0.347 |
| 17 | 65 | 3.735 | 0.514 |
| 18 | 70 | 4.705 | 0.678 |
| 19 | 75 | 5.838 | 0.808 |
| 20 | 80 | 7.146 | 0.894 |
| 21 | 85 | 8.645 | 0.945 |
| 22 | 90 | 10.348 | 0.972 |
| 23 | 95 | 12.271 | 0.986 |
| 24 | 100 | 14.428 | 0.993 |
| 25 | 105 | 15.566 | 0.995 |

Table 2.23–Schedules of Pacific cod selectivities as defined by final parameter estimates. Lengths (cm) correspond to lower bounds of size bins.

| Bin | Len. | Trawl (Jan.-May) | | | Trawl (Jun.-Dec.) | | | Longline | | | Pot | | Survey | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 78-88 | 89-99 | 00-03 | 78-88 | 89-99 | 00-03 | 78-88 | 89-99 | 00-03 | 89-99 | 00-03 | 78-81 | 82-03 |
| 1 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| 2 | 12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.20 |
| 3 | 15 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.28 |
| 4 | 18 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.13 | 0.37 |
| 5 | 21 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.22 | 0.45 |
| 6 | 24 | 0.02 | 0.02 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.35 | 0.53 |
| 7 | 27 | 0.04 | 0.04 | 0.01 | 0.01 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.51 | 0.62 |
| 8 | 30 | 0.06 | 0.06 | 0.01 | 0.02 | 0.03 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.66 | 0.70 |
| 9 | 33 | 0.09 | 0.09 | 0.02 | 0.03 | 0.05 | 0.06 | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.80 | 0.79 |
| 10 | 36 | 0.14 | 0.13 | 0.02 | 0.05 | 0.09 | 0.11 | 0.01 | 0.01 | 0.02 | 0.01 | 0.00 | 0.89 | 0.87 |
| 11 | 39 | 0.21 | 0.19 | 0.03 | 0.07 | 0.15 | 0.17 | 0.03 | 0.03 | 0.05 | 0.01 | 0.01 | 0.96 | 0.95 |
| 12 | 42 | 0.31 | 0.28 | 0.05 | 0.12 | 0.23 | 0.26 | 0.05 | 0.07 | 0.11 | 0.03 | 0.02 | 1.00 | 0.97 |
| 13 | 45 | 0.42 | 0.38 | 0.07 | 0.18 | 0.35 | 0.37 | 0.11 | 0.13 | 0.22 | 0.06 | 0.05 | 0.88 | 0.89 |
| 14 | 50 | 0.62 | 0.56 | 0.12 | 0.34 | 0.59 | 0.59 | 0.29 | 0.37 | 0.54 | 0.19 | 0.19 | 0.69 | 0.77 |
| 15 | 55 | 0.79 | 0.74 | 0.20 | 0.55 | 0.79 | 0.78 | 0.58 | 0.70 | 0.82 | 0.48 | 0.54 | 0.55 | 0.65 |
| 16 | 60 | 0.89 | 0.86 | 0.32 | 0.74 | 0.91 | 0.90 | 0.83 | 0.90 | 0.95 | 0.79 | 0.85 | 0.45 | 0.55 |
| 17 | 65 | 0.95 | 0.94 | 0.47 | 0.88 | 0.96 | 0.96 | 0.95 | 0.98 | 0.99 | 0.95 | 0.97 | 0.40 | 0.45 |
| 18 | 70 | 0.98 | 0.98 | 0.62 | 0.96 | 0.99 | 0.98 | 0.99 | 0.95 | 1.00 | 1.00 | 1.00 | 0.37 | 0.37 |
| 19 | 75 | 1.00 | 1.00 | 0.76 | 0.99 | 1.00 | 0.99 | 1.00 | 0.80 | 1.00 | 0.87 | 0.73 | 0.35 | 0.30 |
| 20 | 80 | 0.93 | 0.91 | 0.86 | 0.91 | 1.00 | 1.00 | 0.83 | 0.66 | 0.59 | 0.74 | 0.53 | 0.34 | 0.24 |
| 21 | 85 | 0.72 | 0.80 | 0.92 | 0.87 | 1.00 | 0.94 | 0.64 | 0.57 | 0.51 | 0.65 | 0.45 | 0.34 | 0.19 |
| 22 | 90 | 0.57 | 0.75 | 0.96 | 0.87 | 0.98 | 0.77 | 0.50 | 0.51 | 0.51 | 0.60 | 0.42 | 0.34 | 0.15 |
| 23 | 95 | 0.52 | 0.72 | 0.99 | 0.87 | 0.93 | 0.62 | 0.40 | 0.47 | 0.51 | 0.57 | 0.41 | 0.33 | 0.11 |
| 24 | 100 | 0.50 | 0.72 | 1.00 | 0.87 | 0.88 | 0.51 | 0.34 | 0.45 | 0.51 | 0.56 | 0.41 | 0.33 | 0.09 |
| 25 | 105 | 0.50 | 0.71 | 1.00 | 0.87 | 0.85 | 0.47 | 0.32 | 0.44 | 0.51 | 0.56 | 0.41 | 0.33 | 0.08 |

Table 2.24–Time series of EBS Pacific cod age 3+ biomass, spawning biomass, and survey biomass as estimated in last year's and this year's assessments.

| Year | Age 3+ Biomass | | Spawning Biomass | | Survey Biomass | |
|---|---|---|---|---|---|---|
| | Last Year | This Year | Last Year | This Year | Last Year | This Year |
| 1978 | 320 | 324 | 48 | 48 | n/a | n/a |
| 1979 | 474 | 480 | 79 | 80 | 555 | 558 |
| 1980 | 1053 | 1066 | 136 | 138 | 917 | 921 |
| 1981 | 1576 | 1593 | 254 | 257 | 1063 | 1062 |
| 1982 | 2052 | 2073 | 435 | 440 | 1206 | 1208 |
| 1983 | 2388 | 2410 | 615 | 620 | 1135 | 1135 |
| 1984 | 2429 | 2450 | 736 | 742 | 1090 | 1094 |
| 1985 | 2587 | 2608 | 780 | 786 | 1120 | 1122 |
| 1986 | 2553 | 2573 | 783 | 789 | 1105 | 1108 |
| 1987 | 2627 | 2647 | 788 | 793 | 1126 | 1127 |
| 1988 | 2621 | 2640 | 784 | 789 | 1033 | 1033 |
| 1989 | 2465 | 2482 | 770 | 775 | 866 | 866 |
| 1990 | 2209 | 2223 | 739 | 744 | 709 | 710 |
| 1991 | 1927 | 1938 | 669 | 672 | 646 | 648 |
| 1992 | 1736 | 1746 | 565 | 568 | 694 | 694 |
| 1993 | 1690 | 1698 | 490 | 493 | 730 | 728 |
| 1994 | 1669 | 1674 | 473 | 475 | 749 | 746 |
| 1995 | 1692 | 1694 | 457 | 458 | 738 | 732 |
| 1996 | 1601 | 1600 | 439 | 440 | 657 | 650 |
| 1997 | 1471 | 1466 | 423 | 422 | 562 | 554 |
| 1998 | 1282 | 1274 | 390 | 387 | 545 | 537 |
| 1999 | 1267 | 1256 | 357 | 354 | 585 | 574 |
| 2000 | 1270 | 1255 | 339 | 335 | 594 | 585 |
| 2001 | 1251 | 1241 | 343 | 337 | 620 | 607 |
| 2002 | 1315 | 1289 | 346 | 341 | 717 | 670 |
| 2003 | n/a | 1393 | n/a | 343 | n/a | 695 |

Notes: Spawning biomass is computed as the sum of March female numbers at age times population weight at age times fraction mature at age.

"Survey biomass" is the model's estimate of what the actual survey should have observed.

All biomass figures are in 1000s of t.

Table 2.25–Time series of EBS Pacific cod age 3 recruitment as estimated in last year's and this year's assessments.

| Year | Recruitment (millions of age 3 fish) | |
|---|---|---|
| | Last Year | This Year |
| 1978 | 92 | 93 |
| 1979 | 175 | 177 |
| 1980 | 698 | 705 |
| 1981 | 316 | 319 |
| 1982 | 362 | 365 |
| 1983 | 286 | 287 |
| 1984 | 93 | 94 |
| 1985 | 518 | 523 |
| 1986 | 157 | 157 |
| 1987 | 417 | 420 |
| 1988 | 255 | 257 |
| 1989 | 158 | 158 |
| 1990 | 91 | 91 |
| 1991 | 119 | 119 |
| 1992 | 283 | 285 |
| 1993 | 276 | 277 |
| 1994 | 162 | 162 |
| 1995 | 309 | 308 |
| 1996 | 153 | 151 |
| 1997 | 125 | 123 |
| 1998 | 120 | 118 |
| 1999 | 269 | 264 |
| 2000 | 177 | 175 |
| 2001 | 145 | 155 |
| 2002 | 275 | 248 |
| 2003 | n/a | 311 |

Table 2.26–Time series of EBS Pacific cod catch divided by age 3+ biomass as estimated in last year's and this year's assessments (the last entry in each column is based on partial catches for the respective year, because the year was/is still in progress at the time of the assessment).

| Year | EBS Catch Divided by Age 3+ Biomass | |
|---|---|---|
| | Last Year | This Year |
| 1978 | 0.13 | 0.13 |
| 1979 | 0.07 | 0.07 |
| 1980 | 0.04 | 0.04 |
| 1981 | 0.04 | 0.04 |
| 1982 | 0.03 | 0.03 |
| 1983 | 0.04 | 0.04 |
| 1984 | 0.05 | 0.05 |
| 1985 | 0.06 | 0.06 |
| 1986 | 0.05 | 0.05 |
| 1987 | 0.06 | 0.06 |
| 1988 | 0.08 | 0.08 |
| 1989 | 0.07 | 0.07 |
| 1990 | 0.08 | 0.08 |
| 1991 | 0.11 | 0.11 |
| 1992 | 0.10 | 0.09 |
| 1993 | 0.08 | 0.08 |
| 1994 | 0.10 | 0.10 |
| 1995 | 0.14 | 0.13 |
| 1996 | 0.13 | 0.13 |
| 1997 | 0.16 | 0.16 |
| 1998 | 0.13 | 0.12 |
| 1999 | 0.12 | 0.12 |
| 2000 | 0.12 | 0.12 |
| 2001 | 0.11 | 0.11 |
| 2002 | 0.09 | 0.13 |
| 2003 | n/a | 0.10 |

Table 2.27–Definitions of symbols and terms used in the Pacific cod projection tables.

| Symbol | Definition |
|---|---|
| SPR | Equilibrium spawning per recruit, expressed as a percentage of the maximum level |
| L90%CI | Lower bound of the 90% confidence interval |
| Median | Point that divides projection outputs into two groups of equal size (50% higher, 50% lower) |
| Mean | Average value of the projection outputs |
| U90%CI | Upper bound of the 90% confidence interval |
| St. Dev. | Standard deviation of the projection outputs |

Table 2.28–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that $F = max\ F_{ABC}$ in 2004-2016, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 430 | 430 | 430 | 430 | 0.00 |
| 2005 | 415 | 416 | 416 | 416 | 0.24 |
| 2006 | 390 | 393 | 394 | 401 | 3.64 |
| 2007 | 364 | 382 | 386 | 423 | 19.42 |
| 2008 | 342 | 388 | 396 | 475 | 43.86 |
| 2009 | 329 | 398 | 408 | 521 | 62.34 |
| 2010 | 326 | 407 | 419 | 549 | 72.33 |
| 2011 | 329 | 413 | 426 | 558 | 76.85 |
| 2012 | 329 | 417 | 430 | 575 | 78.29 |
| 2013 | 331 | 418 | 431 | 586 | 78.91 |
| 2014 | 333 | 417 | 433 | 581 | 79.49 |
| 2015 | 331 | 418 | 434 | 573 | 79.58 |
| 2016 | 334 | 419 | 435 | 588 | 78.84 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0.39 | 0.39 | 0.39 | 0.39 | 0.000 |
| 2005 | 0.39 | 0.39 | 0.39 | 0.39 | 0.000 |
| 2006 | 0.36 | 0.36 | 0.36 | 0.37 | 0.004 |
| 2007 | 0.34 | 0.35 | 0.36 | 0.39 | 0.016 |
| 2008 | 0.31 | 0.36 | 0.36 | 0.39 | 0.027 |
| 2009 | 0.30 | 0.37 | 0.36 | 0.39 | 0.032 |
| 2010 | 0.30 | 0.38 | 0.36 | 0.39 | 0.033 |
| 2011 | 0.30 | 0.38 | 0.37 | 0.39 | 0.033 |
| 2012 | 0.30 | 0.39 | 0.37 | 0.39 | 0.033 |
| 2013 | 0.30 | 0.39 | 0.37 | 0.39 | 0.033 |
| 2014 | 0.31 | 0.39 | 0.37 | 0.39 | 0.032 |
| 2015 | 0.30 | 0.39 | 0.37 | 0.39 | 0.031 |
| 2016 | 0.31 | 0.39 | 0.37 | 0.39 | 0.031 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 297 | 297 | 297 | 297 | 0.00 |
| 2005 | 277 | 278 | 278 | 278 | 0.28 |
| 2006 | 242 | 247 | 249 | 260 | 6.22 |
| 2007 | 208 | 237 | 244 | 310 | 31.47 |
| 2008 | 183 | 249 | 256 | 348 | 54.19 |
| 2009 | 172 | 262 | 267 | 382 | 66.06 |
| 2010 | 169 | 273 | 275 | 389 | 71.13 |
| 2011 | 172 | 278 | 281 | 393 | 72.52 |
| 2012 | 170 | 285 | 283 | 408 | 72.87 |
| 2013 | 174 | 283 | 284 | 409 | 73.15 |
| 2014 | 176 | 285 | 285 | 406 | 72.95 |
| 2015 | 174 | 285 | 286 | 404 | 72.43 |
| 2016 | 177 | 285 | 287 | 410 | 71.87 |

Table 2.29–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that the ratio of *F* to *max* $F_{ABC}$ in 2004-2016 is fixed at a value of 0.73, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 435 | 435 | 435 | 435 | 0.00 |
| 2005 | 446 | 447 | 447 | 447 | 0.25 |
| 2006 | 438 | 441 | 442 | 449 | 3.86 |
| 2007 | 416 | 436 | 440 | 481 | 21.06 |
| 2008 | 392 | 442 | 452 | 542 | 49.92 |
| 2009 | 376 | 456 | 468 | 601 | 73.80 |
| 2010 | 370 | 468 | 483 | 643 | 87.88 |
| 2011 | 371 | 479 | 495 | 659 | 94.85 |
| 2012 | 373 | 488 | 503 | 678 | 97.66 |
| 2013 | 374 | 493 | 507 | 693 | 99.01 |
| 2014 | 376 | 497 | 510 | 693 | 99.78 |
| 2015 | 378 | 496 | 512 | 687 | 99.81 |
| 2016 | 382 | 501 | 514 | 697 | 98.98 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0.29 | 0.29 | 0.29 | 0.29 | 0.000 |
| 2005 | 0.29 | 0.29 | 0.29 | 0.29 | 0.000 |
| 2006 | 0.29 | 0.29 | 0.29 | 0.29 | 0.000 |
| 2007 | 0.28 | 0.29 | 0.29 | 0.29 | 0.003 |
| 2008 | 0.26 | 0.29 | 0.28 | 0.29 | 0.009 |
| 2009 | 0.25 | 0.29 | 0.28 | 0.29 | 0.013 |
| 2010 | 0.25 | 0.29 | 0.28 | 0.29 | 0.014 |
| 2011 | 0.25 | 0.29 | 0.28 | 0.29 | 0.014 |
| 2012 | 0.25 | 0.29 | 0.28 | 0.29 | 0.014 |
| 2013 | 0.25 | 0.29 | 0.28 | 0.29 | 0.014 |
| 2014 | 0.25 | 0.29 | 0.28 | 0.29 | 0.013 |
| 2015 | 0.25 | 0.29 | 0.28 | 0.29 | 0.012 |
| 2016 | 0.26 | 0.29 | 0.28 | 0.29 | 0.012 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 223 | 223 | 223 | 223 | 0.00 |
| 2005 | 224 | 224 | 224 | 224 | 0.10 |
| 2006 | 216 | 219 | 220 | 226 | 3.17 |
| 2007 | 196 | 218 | 221 | 255 | 18.54 |
| 2008 | 174 | 224 | 226 | 290 | 36.72 |
| 2009 | 161 | 231 | 234 | 319 | 48.30 |
| 2010 | 157 | 238 | 241 | 329 | 53.62 |
| 2011 | 160 | 243 | 246 | 336 | 55.46 |
| 2012 | 161 | 246 | 249 | 350 | 56.09 |
| 2013 | 165 | 246 | 251 | 352 | 56.54 |
| 2014 | 166 | 247 | 253 | 347 | 56.33 |
| 2015 | 165 | 250 | 254 | 348 | 55.85 |
| 2016 | 169 | 252 | 255 | 353 | 55.26 |

Table 2.30–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that $F$ = ½ *max* $F_{ABC}$ in 2004-2016, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 439 | 439 | 439 | 439 | 0.00 |
| 2005 | 475 | 475 | 475 | 476 | 0.25 |
| 2006 | 487 | 491 | 492 | 499 | 3.87 |
| 2007 | 480 | 500 | 505 | 546 | 21.39 |
| 2008 | 461 | 516 | 526 | 621 | 52.62 |
| 2009 | 443 | 537 | 549 | 693 | 81.34 |
| 2010 | 436 | 555 | 570 | 749 | 100.32 |
| 2011 | 435 | 571 | 586 | 776 | 110.73 |
| 2012 | 435 | 585 | 598 | 800 | 115.62 |
| 2013 | 439 | 591 | 605 | 820 | 118.01 |
| 2014 | 442 | 597 | 610 | 824 | 119.17 |
| 2015 | 450 | 600 | 614 | 820 | 119.20 |
| 2016 | 451 | 603 | 617 | 829 | 118.17 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2005 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2006 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2007 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2008 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2009 | 0.20 | 0.20 | 0.20 | 0.20 | 0.002 |
| 2010 | 0.20 | 0.20 | 0.20 | 0.20 | 0.002 |
| 2011 | 0.20 | 0.20 | 0.20 | 0.20 | 0.003 |
| 2012 | 0.20 | 0.20 | 0.20 | 0.20 | 0.003 |
| 2013 | 0.20 | 0.20 | 0.20 | 0.20 | 0.003 |
| 2014 | 0.20 | 0.20 | 0.20 | 0.20 | 0.003 |
| 2015 | 0.20 | 0.20 | 0.20 | 0.20 | 0.003 |
| 2016 | 0.20 | 0.20 | 0.20 | 0.20 | 0.003 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 157 | 157 | 157 | 157 | 0.00 |
| 2005 | 165 | 166 | 166 | 166 | 0.07 |
| 2006 | 166 | 168 | 168 | 173 | 2.18 |
| 2007 | 160 | 171 | 174 | 197 | 12.21 |
| 2008 | 152 | 178 | 182 | 226 | 23.93 |
| 2009 | 147 | 186 | 190 | 250 | 32.77 |
| 2010 | 145 | 192 | 196 | 261 | 37.86 |
| 2011 | 145 | 196 | 201 | 268 | 40.26 |
| 2012 | 146 | 199 | 204 | 279 | 41.30 |
| 2013 | 148 | 201 | 206 | 285 | 41.93 |
| 2014 | 150 | 202 | 207 | 280 | 42.02 |
| 2015 | 151 | 203 | 208 | 281 | 41.85 |
| 2016 | 152 | 205 | 209 | 286 | 41.40 |

Table 2.31–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that *F* = the 1998-2002 average in 2004-2016, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 439 | 439 | 439 | 439 | 0.00 |
| 2005 | 474 | 474 | 474 | 475 | 0.25 |
| 2006 | 485 | 489 | 489 | 497 | 3.87 |
| 2007 | 477 | 497 | 502 | 543 | 21.38 |
| 2008 | 458 | 513 | 523 | 618 | 52.53 |
| 2009 | 440 | 534 | 546 | 689 | 81.12 |
| 2010 | 433 | 551 | 566 | 744 | 100.03 |
| 2011 | 432 | 567 | 582 | 771 | 110.45 |
| 2012 | 431 | 581 | 594 | 796 | 115.39 |
| 2013 | 434 | 587 | 600 | 815 | 117.82 |
| 2014 | 437 | 593 | 605 | 818 | 118.98 |
| 2015 | 446 | 595 | 609 | 814 | 119.00 |
| 2016 | 447 | 598 | 612 | 824 | 117.96 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2005 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2006 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2007 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2008 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2009 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2010 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2011 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2012 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2013 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2014 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2015 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |
| 2016 | 0.20 | 0.20 | 0.20 | 0.20 | 0.000 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 160 | 160 | 160 | 160 | 0.00 |
| 2005 | 168 | 168 | 168 | 168 | 0.07 |
| 2006 | 168 | 170 | 171 | 175 | 2.22 |
| 2007 | 162 | 173 | 176 | 200 | 12.41 |
| 2008 | 154 | 181 | 184 | 229 | 24.30 |
| 2009 | 149 | 188 | 192 | 253 | 33.02 |
| 2010 | 147 | 194 | 198 | 264 | 37.94 |
| 2011 | 147 | 198 | 203 | 271 | 40.25 |
| 2012 | 148 | 201 | 206 | 282 | 41.25 |
| 2013 | 150 | 204 | 208 | 288 | 41.91 |
| 2014 | 152 | 204 | 210 | 283 | 42.11 |
| 2015 | 152 | 206 | 211 | 284 | 41.94 |
| 2016 | 154 | 207 | 212 | 289 | 41.49 |

Table 2.32–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that *F* = 0 in 2004-2016, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 449 | 449 | 449 | 449 | 0.00 |
| 2005 | 545 | 545 | 545 | 545 | 0.25 |
| 2006 | 619 | 623 | 623 | 631 | 3.88 |
| 2007 | 665 | 686 | 691 | 733 | 21.95 |
| 2008 | 687 | 747 | 758 | 862 | 57.45 |
| 2009 | 697 | 805 | 820 | 990 | 95.96 |
| 2010 | 705 | 855 | 874 | 1099 | 127.16 |
| 2011 | 718 | 899 | 920 | 1172 | 148.72 |
| 2012 | 728 | 935 | 956 | 1235 | 162.25 |
| 2013 | 733 | 961 | 979 | 1287 | 170.66 |
| 2014 | 748 | 979 | 1000 | 1322 | 175.67 |
| 2015 | 764 | 994 | 1015 | 1334 | 178.09 |
| 2016 | 776 | 1011 | 1026 | 1336 | 178.04 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 0 | 0 | 0 | 0 | 0 |
| 2011 | 0 | 0 | 0 | 0 | 0 |
| 2012 | 0 | 0 | 0 | 0 | 0 |
| 2013 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 0 | 0 | 0 | 0 | 0 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 0 | 0 | 0 | 0 | 0 |
| 2006 | 0 | 0 | 0 | 0 | 0 |
| 2007 | 0 | 0 | 0 | 0 | 0 |
| 2008 | 0 | 0 | 0 | 0 | 0 |
| 2009 | 0 | 0 | 0 | 0 | 0 |
| 2010 | 0 | 0 | 0 | 0 | 0 |
| 2011 | 0 | 0 | 0 | 0 | 0 |
| 2012 | 0 | 0 | 0 | 0 | 0 |
| 2013 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 0 | 0 | 0 | 0 | 0 |

Table 2.33–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that $F = F_{OFL}$ in 2004-2016, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 426 | 426 | 426 | 426 | 0.00 |
| 2005 | 394 | 395 | 395 | 395 | 0.24 |
| 2006 | 362 | 366 | 366 | 373 | 3.62 |
| 2007 | 336 | 354 | 358 | 394 | 19.04 |
| 2008 | 316 | 360 | 367 | 444 | 41.47 |
| 2009 | 305 | 370 | 378 | 479 | 56.43 |
| 2010 | 303 | 378 | 386 | 498 | 63.59 |
| 2011 | 305 | 380 | 391 | 504 | 66.40 |
| 2012 | 304 | 385 | 393 | 515 | 66.82 |
| 2013 | 307 | 383 | 393 | 520 | 67.01 |
| 2014 | 308 | 384 | 394 | 518 | 67.40 |
| 2015 | 307 | 383 | 395 | 516 | 67.51 |
| 2016 | 307 | 384 | 395 | 522 | 66.70 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0.47 | 0.47 | 0.47 | 0.47 | 0.000 |
| 2005 | 0.44 | 0.44 | 0.44 | 0.44 | 0.000 |
| 2006 | 0.40 | 0.41 | 0.41 | 0.42 | 0.004 |
| 2007 | 0.37 | 0.39 | 0.40 | 0.44 | 0.022 |
| 2008 | 0.35 | 0.40 | 0.40 | 0.47 | 0.039 |
| 2009 | 0.33 | 0.41 | 0.41 | 0.47 | 0.046 |
| 2010 | 0.33 | 0.42 | 0.42 | 0.47 | 0.048 |
| 2011 | 0.34 | 0.42 | 0.42 | 0.47 | 0.048 |
| 2012 | 0.33 | 0.43 | 0.42 | 0.47 | 0.049 |
| 2013 | 0.34 | 0.43 | 0.42 | 0.47 | 0.048 |
| 2014 | 0.34 | 0.43 | 0.42 | 0.47 | 0.047 |
| 2015 | 0.34 | 0.43 | 0.42 | 0.47 | 0.047 |
| 2016 | 0.34 | 0.43 | 0.42 | 0.47 | 0.047 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 350 | 350 | 350 | 350 | 0.00 |
| 2005 | 299 | 299 | 299 | 300 | 0.32 |
| 2006 | 251 | 257 | 259 | 272 | 6.91 |
| 2007 | 213 | 245 | 254 | 326 | 36.84 |
| 2008 | 188 | 259 | 270 | 389 | 65.00 |
| 2009 | 178 | 274 | 284 | 421 | 77.63 |
| 2010 | 176 | 282 | 293 | 430 | 82.50 |
| 2011 | 177 | 286 | 297 | 433 | 83.68 |
| 2012 | 176 | 293 | 299 | 445 | 83.71 |
| 2013 | 180 | 287 | 299 | 448 | 83.90 |
| 2014 | 180 | 292 | 300 | 443 | 83.69 |
| 2015 | 180 | 290 | 301 | 438 | 83.44 |
| 2016 | 182 | 290 | 302 | 442 | 82.92 |

Table 2.34–Equilibrium reference points and projections for BSAI Pacific cod spawning biomass (1000s of t), fishing mortality, and catch (1000s of t) under the assumption that $F = max\ F_{ABC}$ in each year 2004-2005 and $F = F_{OFL}$ thereafter, where future recruitment is drawn from a distribution based on estimated recruitments spawned during the period 1977-2002. See Table 2.27 for symbol definitions.

**Equilibrium Reference Points**

| SPR | Spawning Biomass | Fishing Mortality | Catch |
|---|---|---|---|
| 100% | 1,056 | 0 | 0 |
| 40% | 422 | 0.39 | 294 |
| 35% | 370 | 0.47 | 313 |

**Spawning Biomass Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 430 | 430 | 430 | 430 | 0.00 |
| 2005 | 415 | 416 | 416 | 416 | 0.24 |
| 2006 | 387 | 390 | 391 | 397 | 3.61 |
| 2007 | 347 | 365 | 369 | 405 | 18.97 |
| 2008 | 320 | 364 | 371 | 448 | 41.34 |
| 2009 | 306 | 370 | 379 | 480 | 56.41 |
| 2010 | 303 | 378 | 386 | 497 | 63.60 |
| 2011 | 305 | 380 | 391 | 504 | 66.40 |
| 2012 | 303 | 385 | 393 | 515 | 66.81 |
| 2013 | 307 | 382 | 393 | 520 | 66.99 |
| 2014 | 307 | 384 | 394 | 518 | 67.39 |
| 2015 | 307 | 383 | 395 | 516 | 67.50 |
| 2016 | 307 | 384 | 395 | 522 | 66.70 |

**Fishing Mortality Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 0.39 | 0.39 | 0.39 | 0.39 | 0.000 |
| 2005 | 0.39 | 0.39 | 0.39 | 0.39 | 0.000 |
| 2006 | 0.43 | 0.44 | 0.44 | 0.44 | 0.004 |
| 2007 | 0.38 | 0.41 | 0.41 | 0.45 | 0.021 |
| 2008 | 0.35 | 0.40 | 0.41 | 0.47 | 0.038 |
| 2009 | 0.34 | 0.41 | 0.41 | 0.47 | 0.046 |
| 2010 | 0.33 | 0.42 | 0.42 | 0.47 | 0.048 |
| 2011 | 0.33 | 0.42 | 0.42 | 0.47 | 0.048 |
| 2012 | 0.33 | 0.43 | 0.42 | 0.47 | 0.049 |
| 2013 | 0.34 | 0.43 | 0.42 | 0.47 | 0.048 |
| 2014 | 0.34 | 0.43 | 0.42 | 0.47 | 0.047 |
| 2015 | 0.34 | 0.43 | 0.42 | 0.47 | 0.047 |
| 2016 | 0.34 | 0.43 | 0.42 | 0.47 | 0.047 |

**Catch Projections**

| Year | L90%CI | Median | Mean | U90%CI | St. Dev. |
|---|---|---|---|---|---|
| 2004 | 297 | 297 | 297 | 297 | 0.00 |
| 2005 | 277 | 278 | 278 | 278 | 0.28 |
| 2006 | 283 | 289 | 291 | 305 | 7.31 |
| 2007 | 226 | 259 | 267 | 341 | 37.06 |
| 2008 | 193 | 264 | 275 | 391 | 64.52 |
| 2009 | 179 | 275 | 285 | 421 | 77.41 |
| 2010 | 175 | 282 | 293 | 429 | 82.49 |
| 2011 | 177 | 285 | 297 | 433 | 83.71 |
| 2012 | 176 | 293 | 299 | 445 | 83.72 |
| 2013 | 180 | 287 | 299 | 447 | 83.91 |
| 2014 | 180 | 292 | 300 | 443 | 83.70 |
| 2015 | 180 | 290 | 301 | 438 | 83.44 |
| 2016 | 182 | 290 | 302 | 442 | 82.92 |

Table 2.35a–Bycatch of nontarget and "other" species taken in the EBS Pacific cod trawl fishery. The first part of the table ("Bycatch in...") shows the amount (metric tons or individuals, as appropriate) of each species group taken as bycatch in the EBS Pacific cod trawl fishery, broken down by year. The second part of the table ("Proportion of...") shows the same quantity expressed relative to the total EBS catch (taken in all target categories with all gears) of that species group in that year. An empty cell in the second part of the table indicates that no catch of that group was observed in the EBS during that year.

| | Bycatch in EBS Pacific cod trawl fishery | | | | | | Proportion of total EBS catch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| sculpin | 1508 | 1365 | 893 | 1280 | 749 | 925 | 0.22 | 0.26 | 0.20 | 0.23 | 0.12 | 0.12 |
| skates | 678 | 676 | 946 | 981 | 583 | 1303 | 0.04 | 0.04 | 0.07 | 0.06 | 0.03 | 0.05 |
| shark | 0 | 0 | 0 | 9 | 2 | 3 | 0.00 | 0.00 | 0.00 | 0.15 | 0.09 | 0.08 |
| salmonshk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| dogfish | 0 | 0 | 0 | 0 | 0 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.08 |
| sleepershk | 8 | 33 | 4 | 0 | 12 | 10 | 0.03 | 0.10 | 0.01 | 0.00 | 0.02 | 0.01 |
| octopus | 29 | 19 | 17 | 68 | 17 | 30 | 0.14 | 0.13 | 0.13 | 0.19 | 0.09 | 0.08 |
| squid | 7 | 1 | 0 | 2 | 4 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| smelts | 1 | 0 | 1 | 0 | 0 | 0 | 0.03 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| gunnel | 0 | 0 | 0 | 0 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 |
| sticheidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.03 | 0.00 | 0.00 | 0.01 | 0.00 |
| sandfish | 0 | 0 | 3 | 0 | 0 | 1 | 0.27 | 0.08 | 0.91 | 0.02 | 0.05 | 0.36 |
| lanternfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sandlance | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | 0.00 | 0.00 | 0.90 | 0.01 |
| grenadier | 1 | 6 | 0 | 3 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| otherfish | 231 | 232 | 195 | 302 | 220 | 157 | 0.16 | 0.21 | 0.20 | 0.24 | 0.18 | 0.14 |
| crabs | 10 | 6 | 5 | 8 | 3 | 6 | 0.03 | 0.03 | 0.05 | 0.06 | 0.02 | 0.04 |
| starfish | 133 | 63 | 83 | 109 | 57 | 98 | 0.02 | 0.02 | 0.03 | 0.03 | 0.01 | 0.02 |
| jellyfish | 948 | 213 | 416 | 413 | 112 | 93 | 0.11 | 0.03 | 0.06 | 0.04 | 0.03 | 0.05 |
| invertunid | 1 | 9 | 3 | 11 | 1 | 51 | 0.00 | 0.02 | 0.02 | 0.01 | 0.00 | 0.05 |
| seapen/whip | 0 | 0 | 0 | 0 | 0 | 0 | 0.10 | 0.09 | 0.01 | 0.06 | 0.00 | 0.00 |
| sponge | 73 | 34 | 39 | 28 | 9 | 13 | 0.23 | 0.09 | 0.22 | 0.30 | 0.05 | 0.08 |
| anemone | 14 | 5 | 18 | 10 | 6 | 9 | 0.08 | 0.05 | 0.11 | 0.03 | 0.03 | 0.03 |
| tunicate | 6 | 10 | 0 | 67 | 5 | 1 | 0.00 | 0.01 | 0.00 | 0.06 | 0.00 | 0.00 |
| benthinv | 25 | 18 | 11 | 23 | 6 | 12 | 0.04 | 0.03 | 0.05 | 0.06 | 0.01 | 0.03 |
| snails | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 0.00 | 0.00 |
| echinoderm | 13 | 4 | 13 | 13 | 20 | 14 | 0.31 | 0.20 | 0.54 | 0.33 | 0.50 | 0.46 |
| coral | 0 | 0 | 0 | 4 | 0 | 0 | 0.02 | 0.01 | 0.04 | 0.37 | 0.00 | 0.00 |
| shrimp | 0 | 0 | 0 | 0 | 0 | 0 | 0.07 | 0.03 | 0.01 | 0.00 | 0.01 | 0.00 |
| birds | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 2.35b–Bycatch of nontarget and "other" species taken in the EBS Pacific cod longline fishery. The first part of the table ("Bycatch in...") shows the amount (metric tons or individuals, as appropriate) of each species group taken as bycatch in the EBS Pacific cod longline fishery, broken down by year. The second part of the table ("Proportion of...") shows the same quantity expressed relative to the total EBS catch (taken in all target categories with all gears) of that species group in that year. An empty cell in the second part of the table indicates that no catch of that group was observed in the EBS during that year.

| | Bycatch in EBS Pacific cod longline fishery | | | | | | Proportion of total EBS catch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| sculpin | 706 | 931 | 821 | 801 | 1142 | 1383 | 0.11 | 0.18 | 0.18 | 0.14 | 0.19 | 0.18 |
| skates | 12961 | 12808 | 9178 | 11578 | 11932 | 17507 | 0.77 | 0.70 | 0.69 | 0.68 | 0.66 | 0.66 |
| shark | 27 | 48 | 18 | 47 | 17 | 22 | 0.50 | 0.40 | 0.11 | 0.78 | 0.70 | 0.48 |
| salmonshk | 0 | 1 | 1 | 0 | 1 | 10 | 0.00 | 0.05 | 0.04 | 0.01 | 0.05 | 0.22 |
| dogfish | 4 | 5 | 5 | 8 | 11 | 8 | 1.00 | 0.90 | 0.99 | 0.98 | 0.83 | 0.92 |
| sleepershk | 67 | 114 | 99 | 114 | 240 | 250 | 0.24 | 0.34 | 0.35 | 0.33 | 0.37 | 0.30 |
| octopus | 15 | 15 | 13 | 29 | 15 | 76 | 0.07 | 0.10 | 0.10 | 0.08 | 0.08 | 0.19 |
| squid | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| smelts | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| gunnel | 0 | 0 | 0 | 0 | 0 | 0 | | 0.60 | 0.00 | 0.80 | 0.00 | 0.00 |
| sticheidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.56 |
| sandfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| lanternfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sandlance | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| grenadier | 437 | 604 | 356 | 364 | 162 | 336 | 0.15 | 0.12 | 0.08 | 0.09 | 0.07 | 0.06 |
| otherfish | 43 | 27 | 38 | 38 | 71 | 122 | 0.03 | 0.03 | 0.04 | 0.03 | 0.06 | 0.11 |
| crabs | 1 | 0 | 0 | 1 | 1 | 3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| starfish | 136 | 141 | 250 | 132 | 319 | 384 | 0.02 | 0.04 | 0.08 | 0.04 | 0.08 | 0.08 |
| jellyfish | 5 | 7 | 24 | 2 | 2 | 5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| invertunid | 10 | 12 | 1 | 6 | 10 | 11 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 |
| seapen/whip | 2 | 2 | 4 | 3 | 6 | 41 | 0.83 | 0.79 | 0.87 | 0.63 | 0.79 | 0.95 |
| sponge | 1 | 1 | 2 | 1 | 0 | 5 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.03 |
| anemone | 76 | 58 | 123 | 200 | 115 | 195 | 0.42 | 0.51 | 0.73 | 0.58 | 0.55 | 0.59 |
| tunicate | 1 | 1 | 0 | 2 | 0 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| benthinv | 7 | 5 | 10 | 11 | 12 | 12 | 0.01 | 0.01 | 0.04 | 0.03 | 0.02 | 0.03 |
| snails | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 1.00 | 0.00 |
| echinoderm | 1 | 0 | 3 | 0 | 0 | 0 | 0.02 | 0.00 | 0.11 | 0.00 | 0.00 | 0.01 |
| coral | 1 | 0 | 0 | 3 | 1 | 2 | 0.07 | 0.02 | 0.04 | 0.30 | 0.01 | 0.03 |
| shrimp | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| birds | 26 | 33 | 17 | 24 | 13 | 13 | 0.98 | 0.86 | 0.81 | 0.97 | 0.88 | 0.96 |

Table 2.35c–Bycatch of nontarget and "other" species taken in the EBS Pacific cod pot fishery. The first part of the table ("Bycatch in...") shows the amount (metric tons or individuals, as appropriate) of each species group taken as bycatch in the EBS Pacific cod pot fishery, broken down by year. The second part of the table ("Proportion of...") shows the same quantity expressed relative to the total EBS catch (taken in all target categories with all gears) of that species group in that year. An empty cell in the second part of the table indicates that no catch of that group was observed in the EBS during that year.

| | Bycatch in EBS Pacific cod pot fishery | | | | | | Proportion of total EBS catch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| sculpin | 351 | 267 | 438 | 494 | 315 | 384 | 0.05 | 0.05 | 0.10 | 0.09 | 0.05 | 0.05 |
| skates | 1 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| shark | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| salmonshk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| dogfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sleepershk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| octopus | 79 | 95 | 80 | 199 | 140 | 254 | 0.38 | 0.65 | 0.64 | 0.56 | 0.75 | 0.65 |
| squid | 0 | 0 | 0 | 0 | 1 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| smelts | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| gunnel | 0 | 0 | 0 | 0 | 0 | 0 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sticheidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sandfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| lanternfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sandlance | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 |
| grenadier | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| otherfish | 27 | 44 | 32 | 12 | 48 | 23 | 0.02 | 0.04 | 0.03 | 0.01 | 0.04 | 0.02 |
| crabs | 1 | 1 | 4 | 2 | 1 | 2 | 0.00 | 0.00 | 0.04 | 0.01 | 0.01 | 0.01 |
| starfish | 64 | 14 | 15 | 35 | 31 | 11 | 0.01 | 0.00 | 0.01 | 0.01 | 0.01 | 0.00 |
| jellyfish | 11 | 1 | 16 | 0 | 6 | 2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| invertunid | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| seapen/whip | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sponge | 0 | 0 | 0 | 0 | 0 | 1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| anemone | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| tunicate | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| benthinv | 8 | 3 | 4 | 11 | 4 | 9 | 0.01 | 0.01 | 0.02 | 0.03 | 0.01 | 0.02 |
| snails | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 0.00 | 0.00 |
| echinoderm | 1 | 0 | 0 | 2 | 1 | 0 | 0.02 | 0.02 | 0.02 | 0.04 | 0.02 | 0.01 |
| coral | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| shrimp | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| birds | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |

Table 2.35d–Bycatch of nontarget and "other" species taken in the AI Pacific cod trawl fishery. The first part of the table ("Bycatch in...") shows the amount (metric tons or individuals, as appropriate) of each species group taken as bycatch in the AI Pacific cod trawl fishery, broken down by year. The second part of the table ("Proportion of...") shows the same quantity expressed relative to the total AI catch (taken in all target categories with all gears) of that species group in that year. An empty cell in the second part of the table indicates that no catch of that group was observed in the AI during that year.

| | Bycatch in AI Pacific cod trawl fishery | | | | | | Proportion of total AI catch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| sculpin | 107 | 146 | 131 | 257 | 102 | 131 | 0.14 | 0.14 | 0.14 | 0.18 | 0.06 | 0.12 |
| skates | 37 | 95 | 38 | 72 | 49 | 97 | 0.04 | 0.08 | 0.05 | 0.04 | 0.02 | 0.14 |
| shark | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 |
| salmonshk | 0 | 0 | 0 | 4 | 0 | 0 | 0.00 | 0.00 | 0.00 | 1.00 | 0.00 | |
| dogfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sleepershk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| octopus | 2 | 2 | 9 | 2 | 1 | 9 | 0.06 | 0.05 | 0.04 | 0.03 | 0.03 | 0.38 |
| squid | 1 | 0 | 0 | 1 | 2 | 4 | 0.01 | 0.01 | 0.01 | 0.07 | 0.30 | 0.25 |
| smelts | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.95 | 0.00 | 1.00 | 1.00 | 0.00 |
| gunnel | 0 | 0 | 0 | 0 | 0 | 0 | | | 1.00 | | 1.00 | |
| sticheidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | | 0.00 | | |
| sandfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | | 0.00 | | |
| lanternfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | | | | |
| sandlance | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 0.00 | 0.00 |
| grenadier | 0 | 0 | 0 | 0 | 0 | 9 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| otherfish | 6 | 38 | 29 | 25 | 26 | 15 | 0.04 | 0.14 | 0.09 | 0.12 | 0.11 | 0.07 |
| crabs | 1 | 1 | 0 | 0 | 1 | 2 | 0.13 | 0.44 | 0.27 | 0.22 | 0.42 | 0.88 |
| starfish | 2 | 3 | 5 | 5 | 5 | 5 | 0.12 | 0.15 | 0.29 | 0.20 | 0.17 | 0.46 |
| jellyfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.17 | 0.00 | 0.99 | 0.01 | 0.44 |
| invertunid | 0 | 2 | 3 | 6 | 2 | 0 | 0.00 | 0.03 | 0.34 | 0.40 | 0.36 | 0.02 |
| seapen/whip | 0 | 0 | 0 | 0 | 0 | 0 | 0.85 | 0.23 | 0.54 | 0.33 | 0.08 | 0.16 |
| sponge | 4 | 52 | 15 | 15 | 13 | 28 | 0.02 | 0.47 | 0.10 | 0.21 | 0.18 | 0.16 |
| anemone | 0 | 0 | 1 | 0 | 0 | 0 | 0.09 | 0.08 | 0.41 | 0.17 | 0.05 | 0.17 |
| tunicate | 0 | 0 | 0 | 0 | 1 | 0 | 0.63 | 0.75 | 0.08 | 0.58 | 0.40 | 0.07 |
| benthinv | 4 | 3 | 1 | 2 | 3 | 6 | 0.90 | 0.68 | 0.16 | 0.73 | 0.76 | 0.92 |
| snails | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| echinoderm | 0 | 1 | 1 | 1 | 1 | 2 | 0.16 | 0.26 | 0.23 | 0.35 | 0.44 | 0.75 |
| coral | 2 | 8 | 2 | 8 | 3 | 11 | 0.07 | 0.48 | 0.03 | 0.24 | 0.15 | 0.52 |
| shrimp | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.05 | 0.00 | 0.11 | 0.19 | 0.10 |
| birds | 0 | 1 | 0 | 0 | 0 | 0 | 0.02 | 0.11 | 0.02 | 0.04 | 0.01 | 0.16 |

Table 2.35e–Bycatch of nontarget and "other" species taken in the AI Pacific cod longline fishery. The first part of the table ("Bycatch in...") shows the amount (metric tons or individuals, as appropriate) of each species group taken as bycatch in the AI Pacific cod longline fishery, broken down by year. The second part of the table ("Proportion of...") shows the same quantity expressed relative to the total AI catch (taken in all target categories with all gears) of that species group in that year. An empty cell in the second part of the table indicates that no catch of that group was observed in the AI during that year.

| | Bycatch in AI Pacific cod longline fishery | | | | | | Proportion of total AI catch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| sculpin | 334 | 597 | 356 | 662 | 1004 | 214 | 0.43 | 0.55 | 0.37 | 0.47 | 0.63 | 0.19 |
| skates | 338 | 727 | 473 | 1397 | 2184 | 246 | 0.39 | 0.64 | 0.59 | 0.77 | 0.87 | 0.35 |
| shark | 0 | 1 | 0 | 0 | 0 | 0 | 0.78 | 0.04 | 0.05 | 0.03 | 0.00 | 0.00 |
| salmonshk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | |
| dogfish | 0 | 0 | 0 | 0 | 1 | 0 | 0.96 | 0.55 | 0.84 | 0.85 | 0.31 | 0.54 |
| sleepershk | 0 | 0 | 1 | 0 | 1 | 2 | 0.00 | 0.00 | 0.02 | 0.00 | 0.03 | 0.49 |
| octopus | 10 | 21 | 9 | 13 | 21 | 8 | 0.27 | 0.47 | 0.05 | 0.20 | 0.51 | 0.32 |
| squid | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| smelts | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| gunnel | 0 | 0 | 0 | 0 | 0 | 0 | | | 0.00 | | 0.00 | |
| sticheidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | | 0.00 | | |
| sandfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | | 0.00 | | |
| lanternfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | | | | |
| sandlance | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 0.00 | 0.00 |
| grenadier | 397 | 83 | 215 | 151 | 6 | 88 | 0.14 | 0.05 | 0.07 | 0.05 | 0.00 | 0.03 |
| otherfish | 2 | 5 | 2 | 6 | 10 | 3 | 0.02 | 0.02 | 0.01 | 0.03 | 0.04 | 0.01 |
| crabs | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.01 | 0.01 | 0.01 | 0.04 | 0.00 |
| starfish | 3 | 7 | 4 | 13 | 16 | 3 | 0.22 | 0.41 | 0.28 | 0.51 | 0.59 | 0.25 |
| jellyfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| invertunid | 0 | 1 | 0 | 1 | 0 | 0 | 0.00 | 0.01 | 0.02 | 0.06 | 0.08 | 0.02 |
| seapen/whip | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.21 | 0.44 | 0.54 | 0.92 | 0.56 |
| sponge | 0 | 4 | 3 | 11 | 4 | 1 | 0.00 | 0.04 | 0.02 | 0.15 | 0.06 | 0.00 |
| anemone | 0 | 0 | 1 | 1 | 0 | 1 | 0.34 | 0.57 | 0.32 | 0.59 | 0.47 | 0.69 |
| tunicate | 0 | 0 | 0 | 0 | 0 | 0 | 0.01 | 0.00 | 0.00 | 0.24 | 0.00 | 0.00 |
| benthinv | 0 | 0 | 0 | 0 | 0 | 0 | 0.02 | 0.00 | 0.02 | 0.06 | 0.04 | 0.03 |
| snails | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| echinoderm | 0 | 0 | 0 | 0 | 0 | 0 | 0.10 | 0.04 | 0.00 | 0.09 | 0.04 | 0.02 |
| coral | 0 | 1 | 2 | 6 | 3 | 1 | 0.02 | 0.03 | 0.04 | 0.17 | 0.16 | 0.03 |
| shrimp | 0 | 0 | 0 | 0 | 0 | 0 | 0.09 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| birds | 2 | 2 | 2 | 2 | 1 | 0 | 0.75 | 0.45 | 0.55 | 0.66 | 0.48 | 0.16 |

Table 2.35f–Bycatch of nontarget and “other” species taken in the AI Pacific cod pot fishery. The first part of the table (“Bycatch in...”) shows the amount (metric tons or individuals, as appropriate) of each species group taken as bycatch in the AI Pacific cod pot fishery, broken down by year. The second part of the table (“Proportion of...”) shows the same quantity expressed relative to the total AI catch (taken in all target categories with all gears) of that species group in that year. An empty cell in the second part of the table indicates that no catch of that group was observed in the AI during that year.

| | Bycatch in AI Pacific cod pot fishery | | | | | | Proportion of total AI catch | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Species group | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
| sculpin | 7 | 12 | 221 | 211 | 42 | 0 | 0.01 | 0.01 | 0.23 | 0.15 | 0.03 | 0.00 |
| skates | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| shark | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| salmonshk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| dogfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| sleepershk | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| octopus | 24 | 18 | 182 | 47 | 17 | 0 | 0.62 | 0.40 | 0.90 | 0.75 | 0.41 | 0.00 |
| squid | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| smelts | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| gunnel | 0 | 0 | 0 | 0 | 0 | 0 | | | 0.00 | | 0.00 | |
| sticheidae | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | | 0.00 | | |
| sandfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | | | 0.00 | | |
| lanternfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | | | | |
| sandlance | 0 | 0 | 0 | 0 | 0 | 0 | | | | | 0.00 | 0.00 |
| grenadier | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| otherfish | 0 | 0 | 7 | 1 | 4 | 0 | 0.00 | 0.00 | 0.02 | 0.01 | 0.02 | 0.00 |
| crabs | 0 | 0 | 1 | 1 | 0 | 0 | 0.00 | 0.06 | 0.51 | 0.61 | 0.31 | 0.00 |
| starfish | 0 | 0 | 1 | 1 | 0 | 0 | 0.00 | 0.00 | 0.05 | 0.05 | 0.00 | 0.00 |
| jellyfish | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| invertunid | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| seapen/whip | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.07 | 0.00 | 0.00 |
| sponge | 0 | 0 | 0 | 4 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 |
| anemone | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| tunicate | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| benthinv | 0 | 0 | 1 | 0 | 0 | 0 | 0.00 | 0.01 | 0.09 | 0.12 | 0.00 | 0.00 |
| snails | 0 | 0 | 0 | 0 | 0 | 0 | | | | | | |
| echinoderm | 0 | 0 | 1 | 1 | 0 | 0 | 0.01 | 0.00 | 0.20 | 0.18 | 0.00 | 0.00 |
| coral | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| shrimp | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| birds | 0 | 0 | 0 | 0 | 0 | 0 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |

Table 2.36--Summary of major results for the stock assessment of Pacific cod in the BSAI region.

| | |
|---|---|
| Tier | 3a |
| Reference mortality rates | |
| $M$ | 0.37 |
| $F_{40\%}$ | 0.39 |
| $F_{35\%}$ | 0.47 |
| Equilibrium spawning biomass | |
| $B_{35\%}$ | 370,000 t |
| $B_{40\%}$ | 422,000 t |
| $B_{100\%}$ | 1,060,000 t |
| Projected biomass for 2004 | |
| Spawning (at *max* $F_{ABC}$) | 435,000 t |
| Age 3+ | 1,660,000 t |
| ABC for 2004 | |
| $F_{ABC}$ (maximum permissible) | 0.39 |
| $F_{ABC}$ (recommended) | 0.29 |
| ABC (maximum permissible) | 297,000 t |
| ABC (recommended) | 223,000 t |
| Overfishing level for 2004 | |
| Fishing Mortality | 0.47 |
| Catch | 350,000 t |

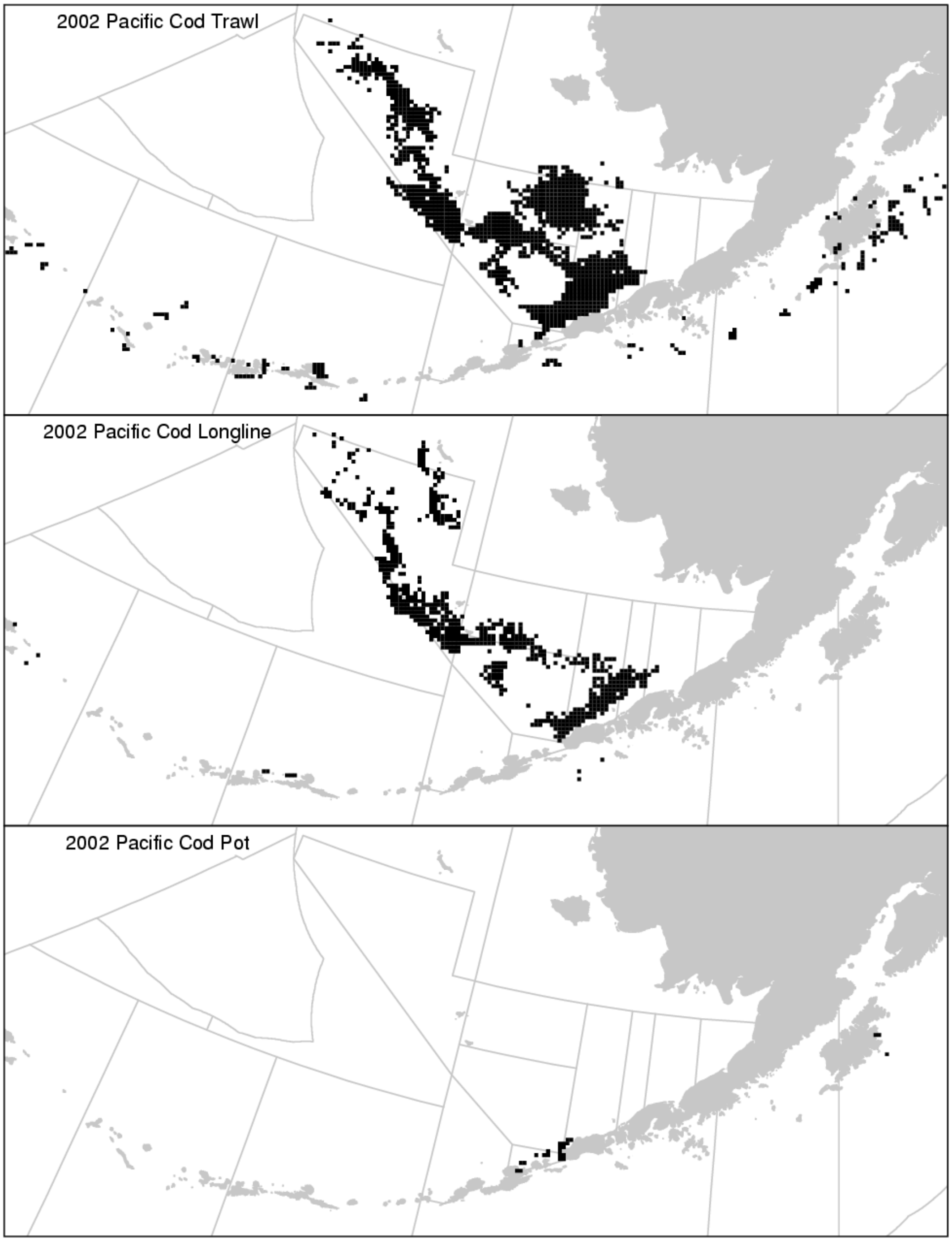
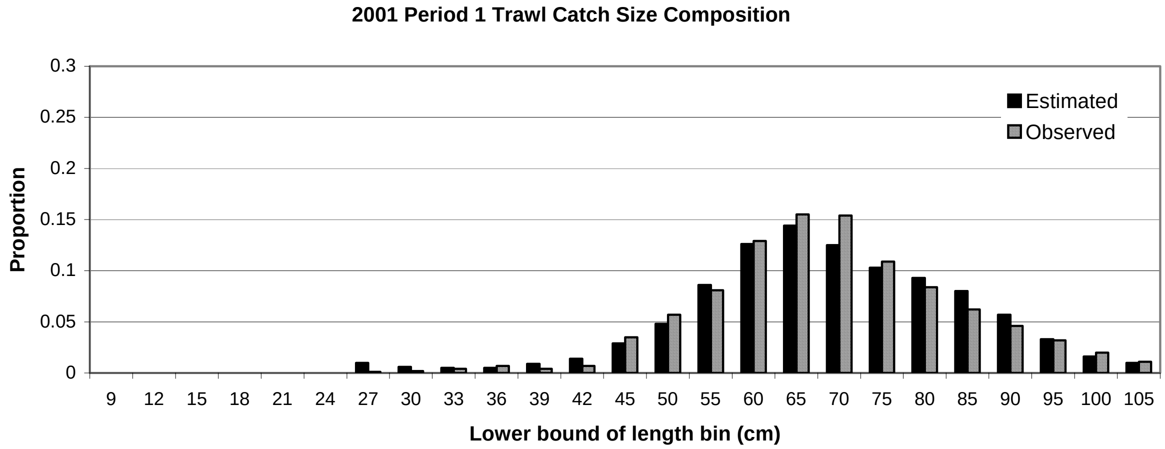
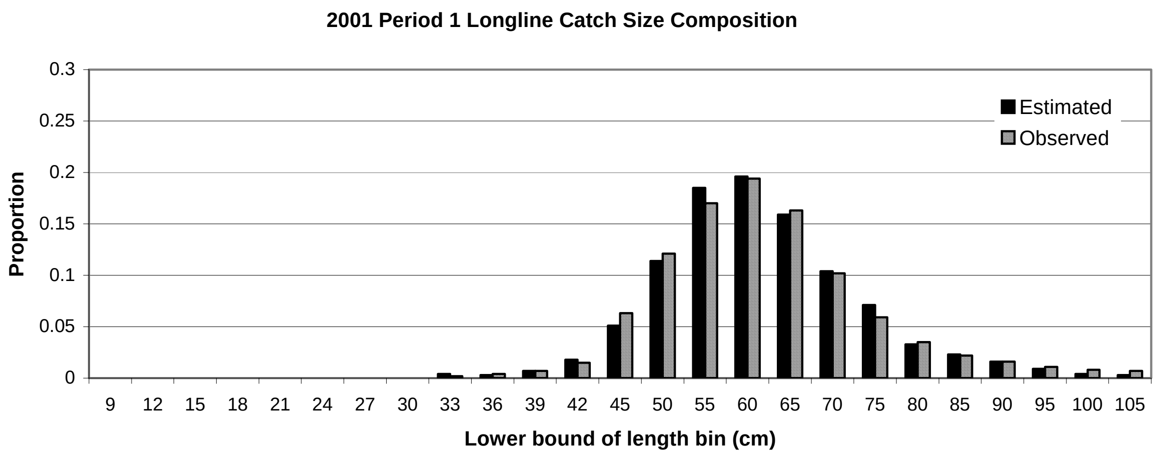
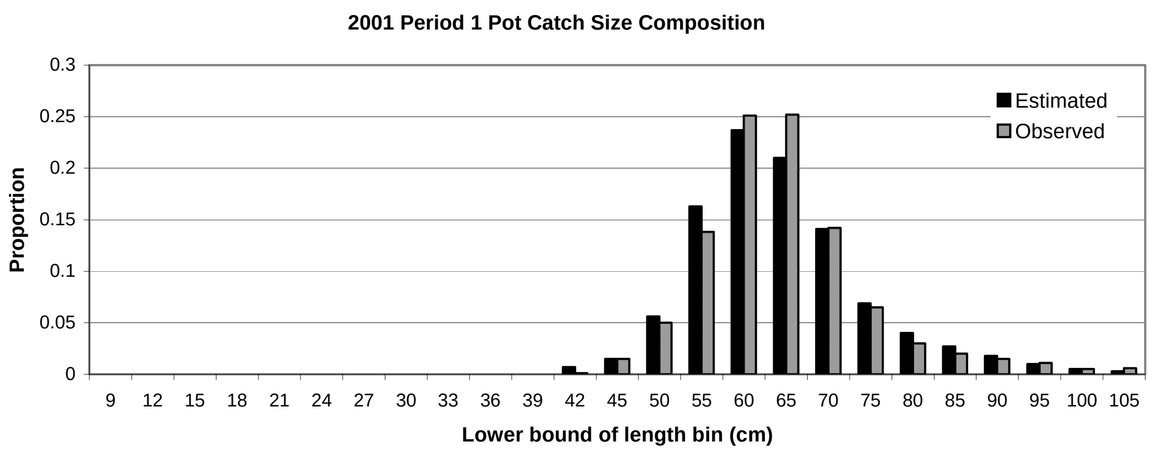


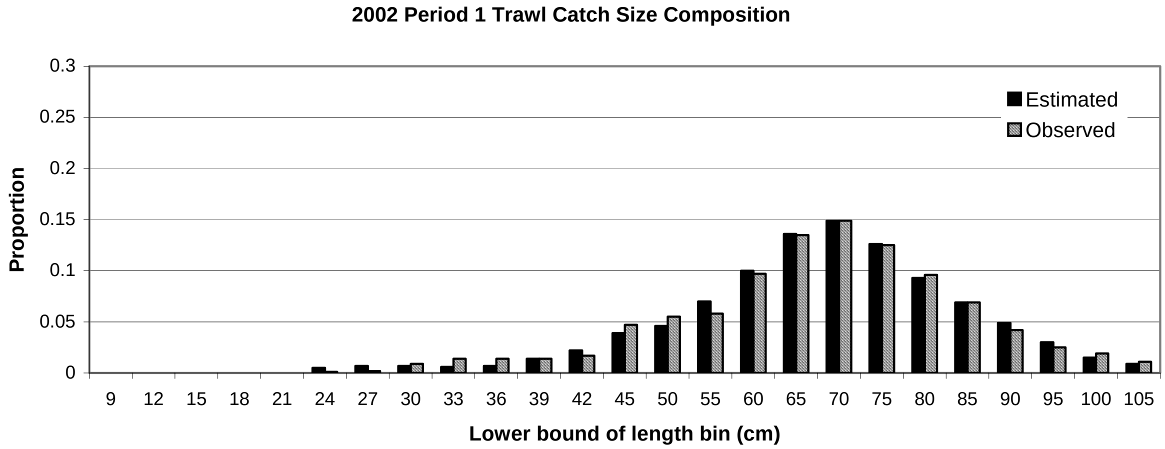

Figure 2.1. Maps showing each 10 km × 10 km square with at least 3 observed hauls/sets containing Pacific cod in 2002, by gear type.

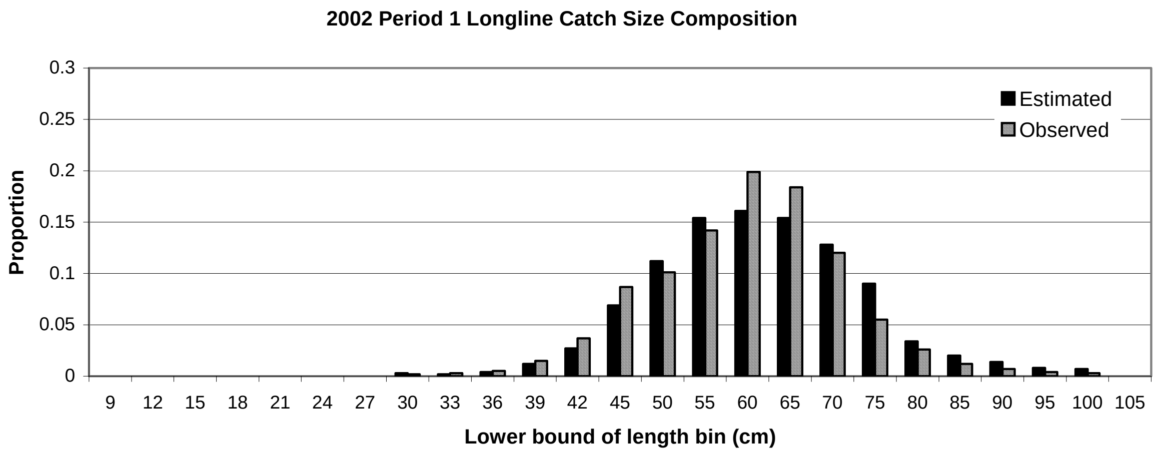



Fi
gure 2.2–Estimated and observed size compositions from the 2001 period 1 fisheries.



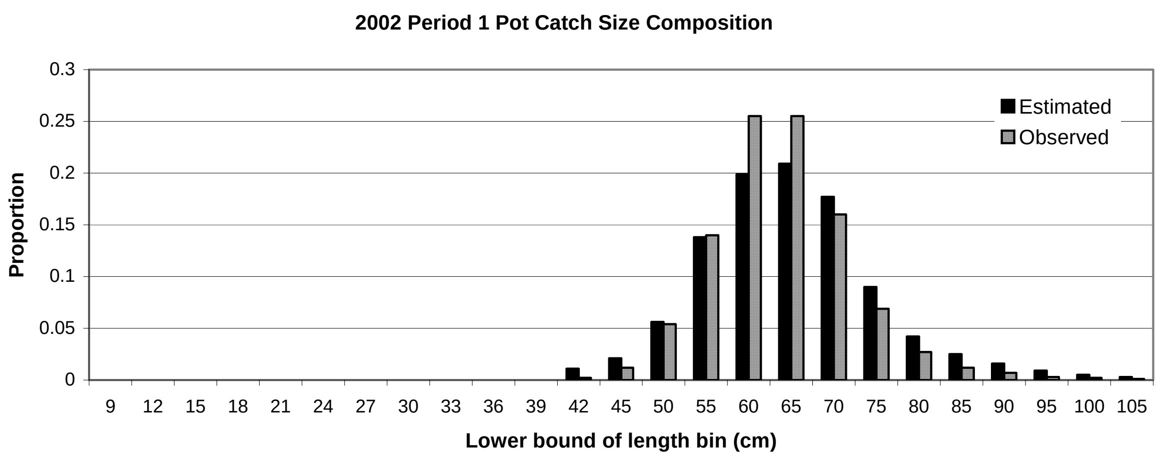




Figure 2.3–Estimated and observed size compositions from the 2002 period 1 fisheries.

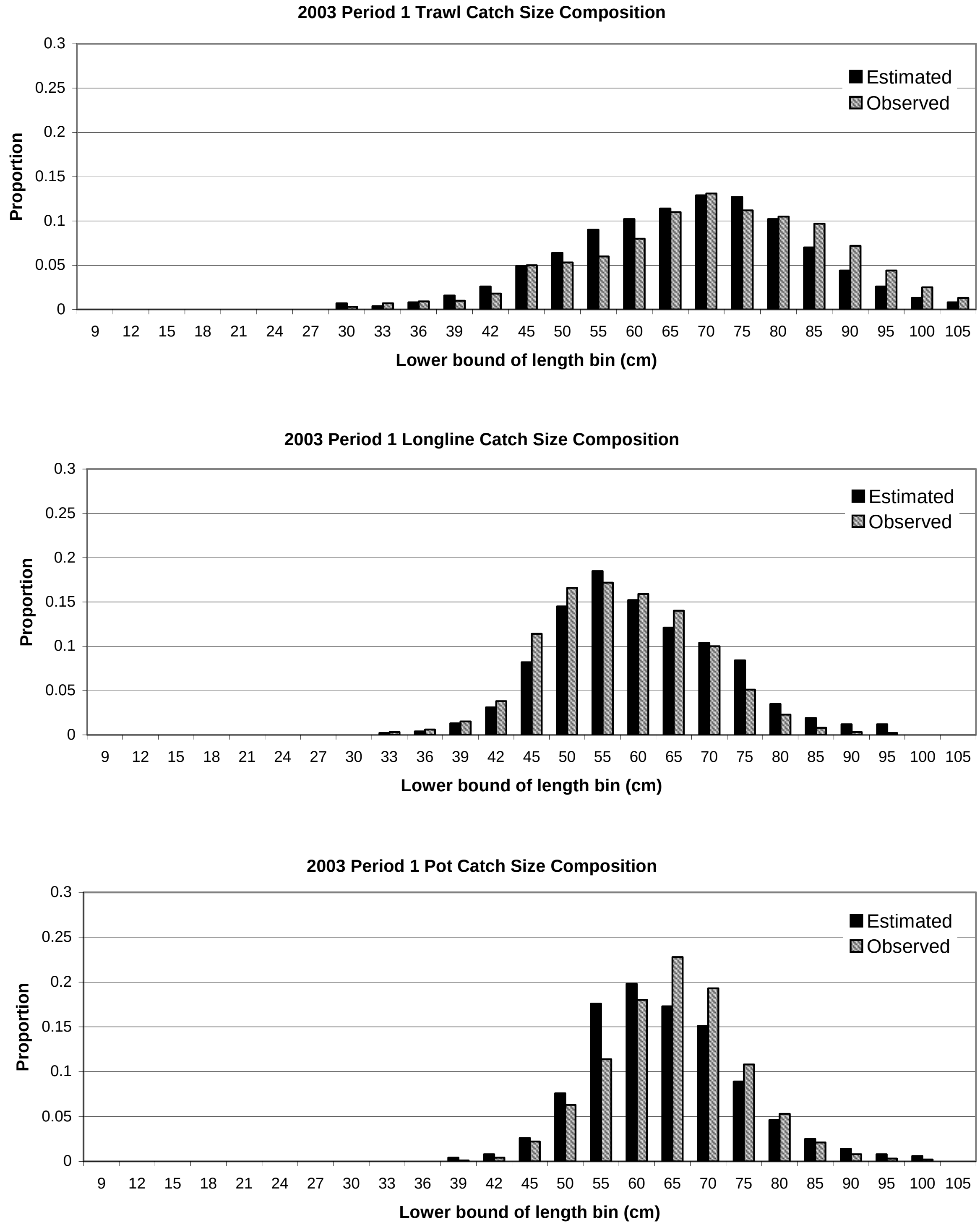
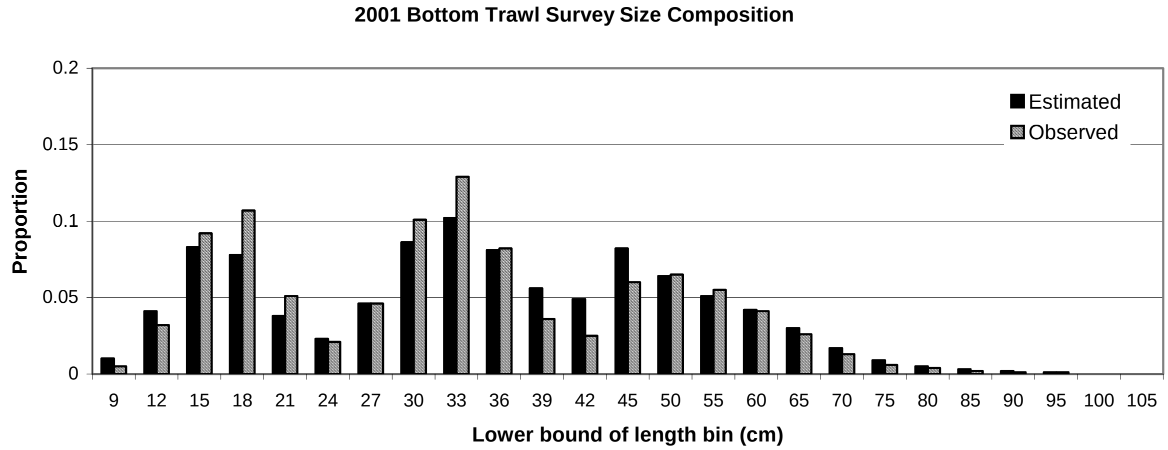
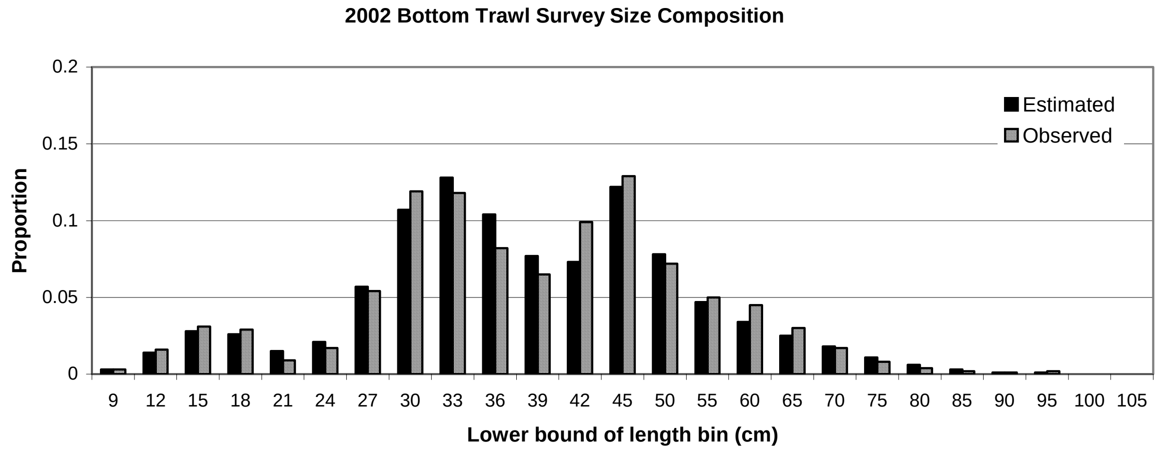
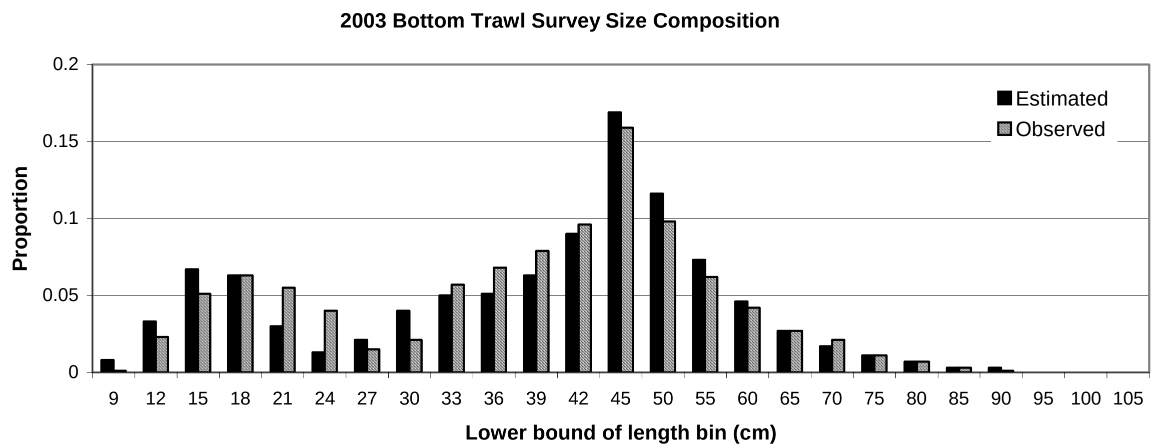



Figure 2.4–Estimated and observed size compositions from the 2003 period 1 fisheries.




Fi
gure 2.5–Estimated and observed size compositions from the 3 most recent surveys.

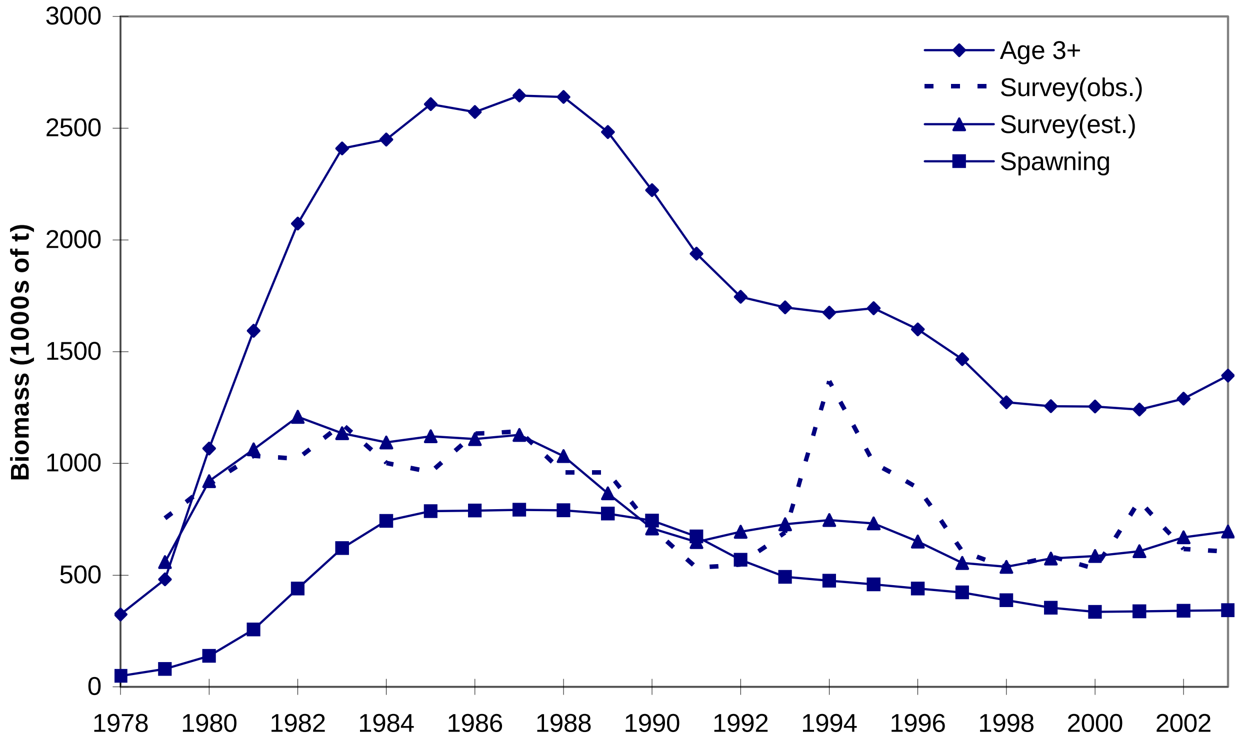



Figure 2.6–Time series of biomass estimates.

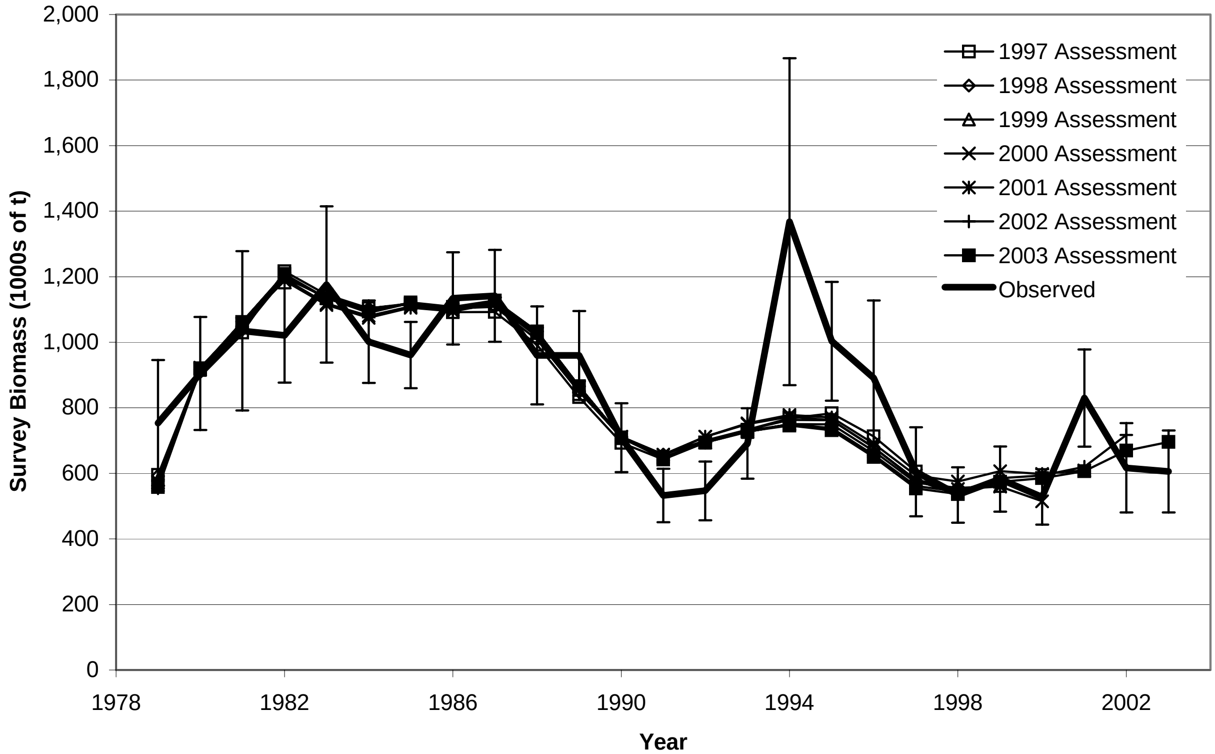



Figure 2.7–Retrospective analysis of estimated survey biomass, 1997-present. The vertical error bars around the observed survey biomass represent 1.96 standard deviations on either side of the mean.

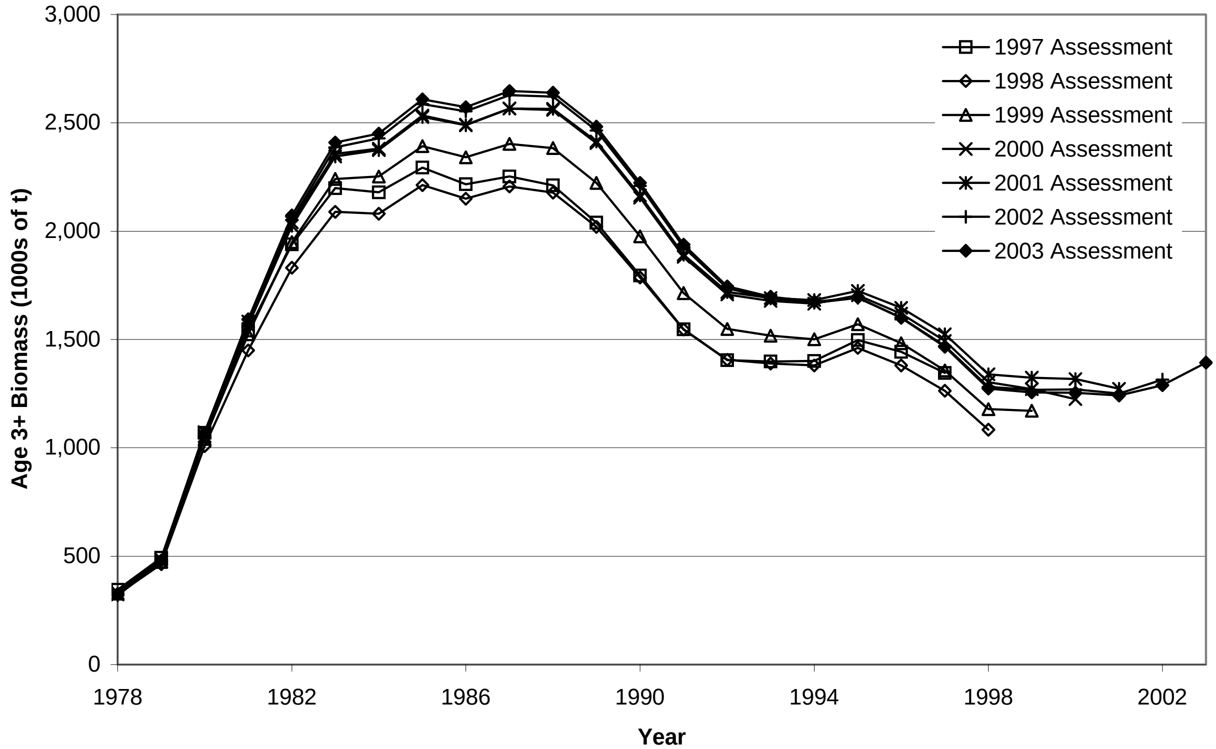



Figure 2.8–Retrospective analysis of estimated age 3+ biomass, 1997-present.

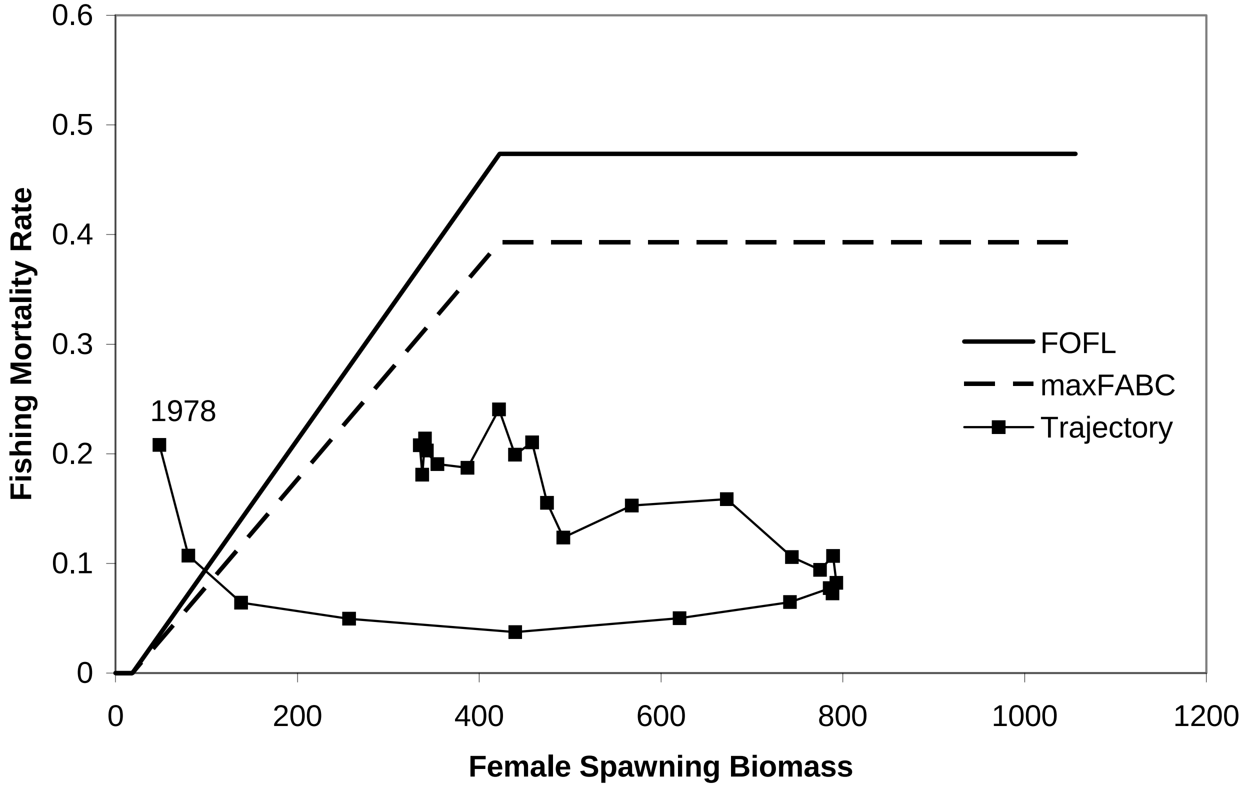



Figure 2.9–Trajectory of fishing mortality and female spawning biomass, 1978-present.

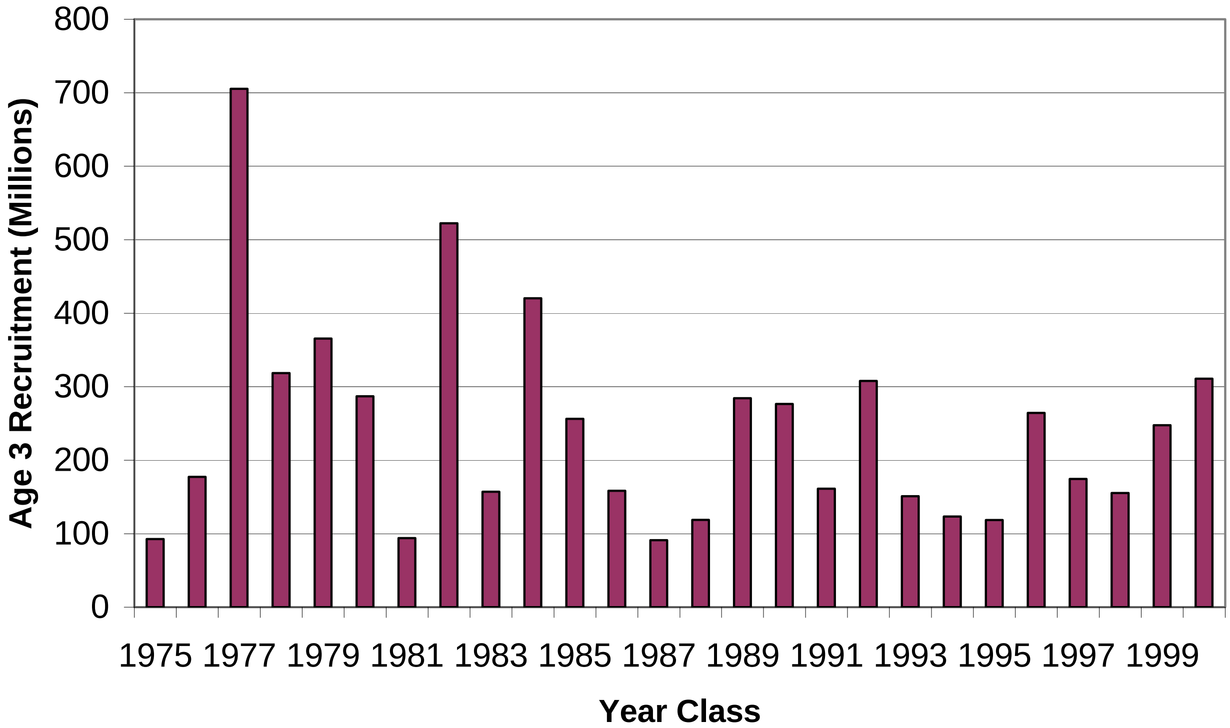



Figure 2.10–Pacific cod recruitment at age 3 (EBS only) as estimated by the stock assessment model.

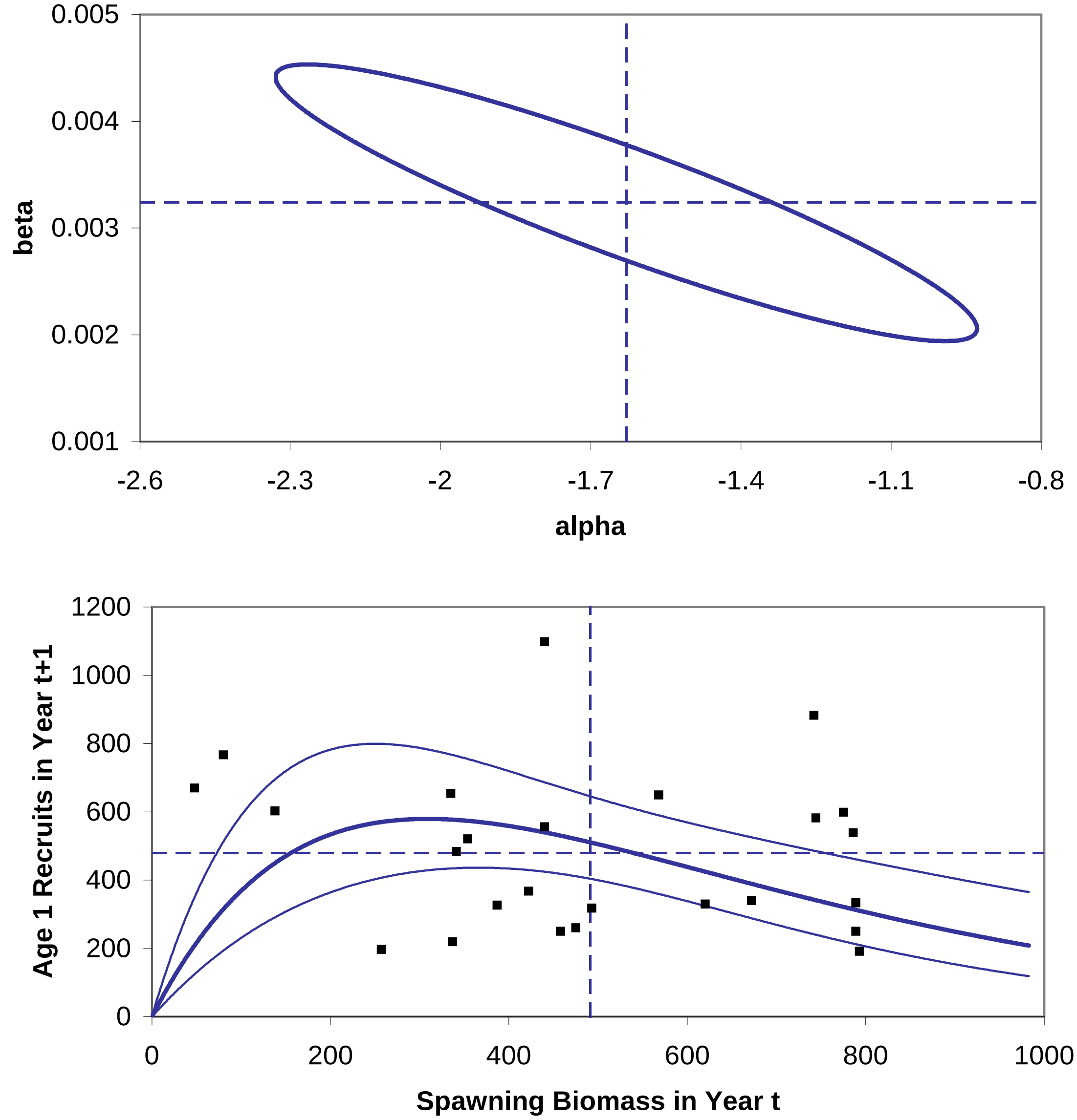



Figure 2.11–Some aspects of uncertainty surrounding the stock-recruitment relationship. The upper panel shows a 95% confidence ellipse for the estimated parameters of the stock-recruitment relationship, with dashed lines indicating the location of the point estimates. The lower panel shows the data (small squares), the estimated relationship (bold curve), and the 95% confidence interval around the curve (thin curves), with dashed lines indicating the locations of the data means. See text for details and caveats.

## Appendix 2A: Recent changes in patterns of fishing for Pacific cod

### 1. Introduction

At its April 2003 meeting, the Council requested that the following questions be addressed in this year's SAFE reports:

1) Has the pattern of fishing for Pacific cod in the BSAI changed in recent years with respect to catch location, concentrations, timing, amount of catch by area, and number and type of vessels?
2) What seems to be driving these changes (environmental conditions, economics of fishing, location of facilities, etc.)?
3) Do these changes have conservation impacts for Pacific cod, other species like rockfish, or habitats?
4) Do these changes and conservation issues have management implications for TAC setting, seasons, gear, or allocations?

Following the meeting, Council staff requested that similar consideration be given to GOA Pacific cod.

### 2. Methods

The "blend" database was used to address the Council's questions. This database is limited to some extent by the fact that it cannot address questions relating to the number of vessels, but it can address questions relating to the number of processors, which can be shore plants, motherships, or catcher/processors. The blend database is also limited to some extent by the fact that it does not include catches from the State-managed fishery for Pacific cod.

The Council did not define what it meant by the term "recent years." The years 1998-2002 were chosen as a reasonable interpretation (complete 2003 data were not available at the time of this analysis).

Data were obtained by querying the blend database for number of processors and amount of catch taken in each combination of three-digit statistical area, gear, and month for the years 1998-2002. This resulted in a total of 2,159 records, with an average (across years) total catch of 240,761 t. Two problems arose with these data. First, most of the records were associated with very small catches. For example, 57% of the records were associated with catches less than 100 t apiece, while the remaining 43% of the records accounted for 98% of the total catch. Second, 36% of the records were associated with fewer than three processors. Confidentiality restrictions preclude displaying such records directly or in a way that would permit them to be reconstructed by a reader. With some data sets, it might be possible to deal with this problem simply by eliminating all records associated with fewer than three processors. Because the present exercise evaluates whole time series of individual records, however, deletion of individual records in this manner can cause other problems. Instead, the data were purged of all records pertaining to any area-gear-month category for which the number of processors was less than three in *any* of the years 1998-2002. This left 740 records which accounted for 186,271 t (77%) of the average total catch.

In their raw form, the data describe the number of processors and amount of catch in each year for a series of area-gear-month categories. The data describing processor numbers cannot be aggregated beyond this point, because the same processor can participate in more than one area, gear, or month, meaning that summing the data across factors would tend to overestimate the number of processors. The catch data, on the other hand, *can* be aggregated, because each fish can be caught only once. The catch data were therefore aggregated at various levels to guard against the possibility of significant trends being masked by an inappropriate choice of resolution. The raw data describe a three-factors-at-a-time resolution, which is the highest resolution possible with these data. The next lower level of resolution is achieved by aggregating across one of the factors (area, gear, or month) to achieve a two-factors-at-a-time resolution (area-and-gear, area-and-month, or month-and-gear). The lowest level of resolution is achieved by aggregating across two of the factors (gear and month, area and month, or area and gear) to achieve a one-factor-at-a-time resolution (area, gear, or month).

The data in each aggregation and category were tested for the presence of statistically significant trends in three ways. First, a linear relationship was regressed through each time series and the slope was tested to determine whether it was significantly different from zero. Second, each time series was split into two portions, the first consisting of the years 1998-1999 and the second consisting of the years 2000-2002, then the difference between the means of the two portions was computed, and finally this difference was tested to determine whether it was significantly different from zero. The third test was the same as the second, except that the partitions consisted of the years 1998-2000 and 2001-2002. For all three tests, a 5% significance level was used.

It should be noted that conventional measures of statistical significance can be misleading in analyses of this type. Ideally, a test of significance should be applied to a single hypothesis. Use of a 5% significance level means that there is no more than a 5% chance of accepting a particular hypothesis if that hypothesis is actually false. Here, on the other hand, *many* hypotheses are being tested. If all the hypotheses are false, use of a 5% significance level means that one would expect to accept 5% of them anyway. Therefore, "significant" here should be interpreted heuristically rather than statistically. To emphasize this caveat, "significant" will be used hereafter with quotation marks.

## 3. Results

The results are described in order of resolution, proceeding from lowest to highest. In this section, the term "data" refers to the set of records remaining after all confidentiality-precluded records were eliminated, and the term "average total catch" refers to the average total catch associated with the remaining records (186,271 t).

### *3.1. One Factor at a Time*

#### 3.1.1. Area

A total of 16 reporting areas (ten in the BSAI and six in the GOA) were represented in the data. Eight (50%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.1a). These eight areas represent 44% of the average total catch. The catch trends in all eight of these areas were negative.

#### 3.1.2. Gear

A total of three gears (longline, pot, and trawl) were represented in the data. Only one of these (pot) was also associated with "significant" results for at least one of the three tests (Table 2A.1b). This gear represents 4% of the average total catch. The catch trend for this gear was negative.

#### 3.1.3. Month

A total of 12 months were represented in the data. Five (42%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.1c). These five months represent 52% of the average total catch. The catch trends in three (60%) of these months were negative.

*3.2. Two Factors at a Time*

3.2.1. Area and Gear

A total of 28 area-and-gear categories were represented in the data. Nine (32%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.2a). These nine categories represent 25% of the average total catch. The catch trends in eight (89%) of these categories were negative.

3.2.2. Area and Month

A total of 108 area-and-month categories were represented in the data. Twenty-five (23%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.2b). These 25 categories represent 21% of the average total catch. The catch trends in 19 (76%) of these categories were negative.

3.2.3. Gear and Month

A total of 26 gear-and-month categories were represented in the data. Seven (27%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.2c). These seven categories represent 23% of the average total catch. The catch trends in five (71%) of these categories were negative.

*3.3. Three Factors at a Time*

3.3.1. Catch

A total of 148 area-gear-month categories were represented in the data. Thirty (20%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.3a). These 30 categories represent 20% of the average total catch. The catch trends in 25 (83%) of these categories were negative.

3.3.2. Number of Unique Processors

A total of 148 area-gear-month categories were represented in the data. Twenty-eight (19%) of these were also associated with "significant" results for at least one of the three tests (Table 2A.3b). The processor trends in 19 (68%) of these categories were negative.

## 4. Discussion

The Council's request was framed as a set of four questions, addressed in order below. (Note: The following responses consider both the BSAI and GOA fisheries.)

*4.1. Has the pattern of fishing for Pacific cod in the BSAI changed in recent years with respect to catch location, concentrations, timing, amount of catch by area, and number and type of vessels?*

For most categories, the available data do not demonstrate "significant" changes in fishing patterns for Pacific cod with respect to area, gear, or month. Of those categories that *do* show "significant" changes, the trend is most often negative. The preceding statements are true regardless of whether trends are measured in terms of catch or number of processors. In terms of catch (Tables 2A.1-

2A.3a), the proportion of categories showing "significant" positive trends varied from 0% to 17%, with an average of 5%. In terms of processor numbers (Table 2A.3b), only 6% of the categories showed a "significant" positive trend.

A number of caveats should be applied to the above, however. First, the data do not include catches from the State-managed fishery or records which were omitted because of confidentiality considerations. Second, although consideration was given here to three levels of resolution and every possible combination of three factors within these three levels, it is conceivable that "significant" trends might exist with respect to other (presumably finer) levels of resolution or other factors. Third, the fact that a given trend did not qualify as "significant" in this analysis does not mean that the trend does not exist or, if such a trend does exist, that it is unimportant. This is one of the fundamental difficulties involved with attempts to detect "recent" trends: When the time series is short, the trend either has to be very strong or very consistent to qualify as "significant."

*4.2. What seems to be driving these changes (environmental conditions, economics of fishing, location of facilities, etc.)?*

Just as it is difficult to find "significant" trends on the basis of only a few years of data, it is also difficult (perhaps more so) to find "significant" correlations between these trends and exogenous factors such as environmental conditions. For short time series such as those considered in this analysis, effort is probably better spent toward identifying exogenous factors with known, direct relationships to catches of Pacific cod. One obvious choice is TAC. Given that catch is often limited by TAC, that TACs have been declining recently, and that most of the "significant" catch trends are negative, it is reasonable to conclude that declining TACs have been one of the driving factors in recent catch trends. Identification of other causative factors may be possible in the future.

*4.3. Do these changes have conservation impacts for Pacific cod, other species like rockfish, or habitats?*

Because is unlikely that negative trends in either catch or processor numbers will adversely impact stocks of Pacific cod, other species, or habitats, it is appropriate that the answer to the above question be focused on those few categories for which "significant" positive trends were demonstrated. The positive catch trends from Tables 2A.1-2A.3a have been consolidated and summarized in Table 2A.4. As noted in Section 4.1, the proportion of categories in Tables 2A.1-2A.3a showing "significant" positive trends in catch varied from 0% to 17%, with an average of 5%. In terms of processor numbers (Table 2A.3b), only 6% of the categories showed a "significant" positive trend. Because relatively few positive trends have been demonstrated, it is unlikely that they would have major conservation impacts unless they were very large. However, as Table 2A.4 shows, the increases within a particular aggregation never sum to more than about 4% of the average total catch. Therefore, based on the evidence presented here, it appears unlikely that recent changes in patterns of fishing for Pacific cod have had major conservation impacts.

*4.4. Do these changes and conservation issues have management implications for TAC setting, seasons, gear, or allocations?*

The information presented here does not suggest that recent changes in patterns of fishing for Pacific cod have management implications. Because measures such as TAC allocation are determined in part by policy considerations, however, it is possible that some management implications may exist but are outside the scope of this study. Another consideration outside the scope of this study has to do with the relationship between the spatiotemporal distribution of the fisheries and that of the stock. Regardless of whether fishing patterns have *changed*, it may be important to understand how the *patterns themselves* interact with the stock. Research designed to increase the spatiotemporal resolution of the Pacific cod assessments is underway.  Once this research has been completed, it may be easier to determine whether changes in overall TAC or TAC allocation are likely to be beneficial.

Table 2A.1a. Three-digit reporting areas in which “significant” catch trends were detected. Key: “slope” = slope of linear fit through the time series of catches, “dif1” = average 2000-2002 catch minus average 1998-1999 catch, “dif2” = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a “significant” result at the 5% level.

| | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|
| Area | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| 517 | 40,038 | 38,512 | 43,951 | 21,860 | 31,599 | -3,353 | -6,805 | **-14,104** |
| 543 | 121 | 65 | 63 | 43 | 16 | **-23** | -52 | -53 |
| 610 | 18,036 | 19,060 | 16,769 | 10,719 | 10,332 | -2,375 | -5,941 | **-7,430** |
| 620 | 9,901 | 6,546 | 3,999 | 3,350 | 4,074 | -1,485 | **-4,416** | -3,104 |
| 630 | 30,397 | 31,293 | 25,122 | 21,688 | 18,379 | **-3,364** | **-9,115** | **-8,904** |
| 640 | 10 | 11 | 1 | 6 | 5 | -2 | **-7** | -2 |
| 650 | 70 | 33 | 24 | 12 | 8 | **-14** | -36 | -32 |
| 659 | 210 | 142 | 95 | 56 | 20 | **-46** | -119 | -110 |

Table 2A.1b. Gear types in which “significant” catch trends were detected. Key: “slope” = slope of linear fit through the time series of catches, “dif1” = average 2000-2002 catch minus average 1998-1999 catch, “dif2” = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a “significant” result at the 5% level.

| | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|
| Gear | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| POT | 8,258 | 10,182 | 10,550 | 2,931 | 2,060 | -1,965 | -4,040 | **-7,168** |

Table 2A.1c. Months in which“significant” catch trends were detected. Key: “slope” = slope of linear fit through the time series of catches, “dif1” = average 2000-2002 catch minus average 1998-1999 catch, “dif2” = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a “significant” result at the 5% level.

| | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|
| Month | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| 1 | 25,480 | 24,868 | 26,674 | 14,345 | 19,868 | -2,175 | -4,878 | **-8,568** |
| 2 | 50,124 | 49,992 | 52,930 | 30,824 | 39,726 | -3,996 | -8,898 | **-15,741** |
| 4 | 19,162 | 21,286 | 19,898 | 11,750 | 12,030 | -2,380 | -5,665 | **-8,225** |
| 6 | 132 | 132 | 84 | 714 | 1,311 | 294 | 571 | **896** |
| 9 | 7,682 | 9,454 | 15,207 | 16,760 | 14,664 | 2,127 | **6,976** | 4,931 |

Table 2A.2a. Area-and-gear categories in which "significant" catch trends were detected. Key: "LGL" = longline, "POT" = pot, "TWL" = trawl, "slope" = slope of linear fit through the time series of average catches, "dif1" = average 2000-2002 catch minus average 1998-1999 catch, "dif2" = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a "significant" result at the 5% level.

| Category | | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|---|
| Area | Gear | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| 509 | LGL | 10,376 | 12,704 | 14,413 | 14,174 | 16,593 | **1,390** | 3,520 | 2,886 |
| 543 | TWL | 121 | 65 | 63 | 43 | 16 | **-23** | -52 | -53 |
| 610 | TWL | 14,715 | 15,074 | 11,976 | 6,698 | 5,435 | **-2,693** | -6,858 | **-7,855** |
| 620 | POT | 2,437 | 3,352 | 1,912 | 794 | 656 | -612 | -1,774 | **-1,842** |
| 630 | POT | 5,821 | 6,830 | 8,637 | 2,138 | 1,404 | -1,353 | -2,266 | **-5,325** |
| 630 | TWL | 18,641 | 18,159 | 9,985 | 13,883 | 10,608 | -2,034 | **-6,908** | -3,350 |
| 640 | LGL | 10 | 11 | 1 | 6 | 5 | -2 | **-7** | -2 |
| 650 | LGL | 70 | 33 | 24 | 12 | 8 | **-14** | -36 | -32 |
| 659 | LGL | 210 | 142 | 95 | 56 | 20 | **-46** | -119 | -110 |

Table 2A.2b. Area-and-month categories in which "significant" catch trends were detected. Key: "slope" = slope of linear fit through the time series of catches, "dif1" = average 2000-2002 catch minus average 1998-1999 catch, "dif2" = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a "significant" result at the 5% level.

| Category | | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|---|
| Area | Month | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| 509 | 6 | 21 | 12 | 30 | 650 | 1,259 | 311 | 630 | **933** |
| 509 | 9 | 1,418 | 789 | 2,130 | 2,815 | 3,388 | 597 | **1,674** | 1,656 |
| 513 | 3 | 553 | 1,597 | 1,405 | 2,033 | 2,855 | **504** | 1,022 | 1,259 |
| 513 | 11 | 441 | 562 | 905 | 799 | 1,155 | **167** | 452 | 341 |
| 513 | 12 | 488 | 347 | 265 | 121 | 75 | **-105** | -264 | -269 |
| 517 | 4 | 6,349 | 6,543 | 4,923 | 1,652 | 2,841 | -1,191 | -3,308 | **-3,692** |
| 517 | 5 | 312 | 577 | 71 | 62 | 113 | -91 | **-362** | -233 |
| 521 | 4 | 5,593 | 6,475 | 2,176 | 3,139 | 2,833 | -886 | **-3,318** | -1,762 |
| 521 | 7 | 355 | 498 | 677 | 744 | 1,029 | **159** | 390 | 376 |
| 541 | 1 | 352 | 352 | 210 | 26 | 8 | **-101** | **-270** | **-288** |
| 541 | 4 | 2,478 | 4,163 | 3,748 | 239 | 1,203 | -647 | -1,590 | **-2,741** |
| 543 | 7 | 121 | 65 | 63 | 43 | 16 | **-23** | -52 | -53 |
| 610 | 2 | 12,351 | 9,934 | 9,789 | 6,108 | 6,266 | **-1,600** | -3,755 | **-4,505** |
| 620 | 3 | 6,390 | 3,795 | 910 | 468 | 672 | -1,477 | **-4,410** | -3,129 |
| 630 | 1 | 3,557 | 4,545 | 4,453 | 1,969 | 1,570 | -655 | -1,387 | **-2,416** |
| 630 | 3 | 8,826 | 10,304 | 3,619 | 2,414 | 6,142 | -1,326 | **-5,507** | -3,305 |
| 630 | 6 | 43 | 54 | 21 | 31 | 25 | -6 | **-23** | -11 |
| 630 | 9 | 80 | 103 | 28 | 1,121 | 1,055 | 297 | 643 | **1,017** |
| 650 | 6 | 12 | 13 | 3 | 5 | 6 | -2 | **-8** | -4 |
| 659 | 3 | 51 | 36 | 28 | 18 | 2 | **-12** | -27 | -28 |
| 659 | 4 | 49 | 23 | 16 | 5 | 2 | **-11** | -28 | -26 |
| 659 | 6 | 10 | 16 | 6 | 3 | 4 | -2 | **-9** | -7 |
| 659 | 9 | 13 | 7 | 8 | 3 | 1 | **-3** | -6 | -7 |
| 659 | 10 | 8 | 10 | 8 | 1 | 0 | -2 | -6 | **-8** |
| 659 | 11 | 14 | 22 | 2 | 3 | 1 | -5 | **-16** | -11 |

Table 2A.2c. Gear-and-month categories in which "significant" catch trends were detected. Key: "LGL" = longline, "POT" = pot, "TWL" = trawl, "slope" = slope of linear fit through the time series of catches, "dif1" = average 2000-2002 catch minus average 1998-1999 catch, "dif2" = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a "significant" result at the 5% level.

| Category | | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|---|
| Gear | Month | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| LGL | 4 | 8,459 | 8,375 | 1,672 | 2,882 | 2,417 | -1,758 | **-6,093** | -3,519 |
| LGL | 6 | 110 | 120 | 54 | 64 | 52 | -17 | **-59** | -37 |
| LGL | 9 | 3,833 | 7,785 | 12,663 | 13,221 | 12,291 | 2,235 | **6,916** | 4,662 |
| POT | 1 | 1,879 | 2,696 | 2,425 | 345 | 224 | -566 | -1,289 | **-2,049** |
| TWL | 1 | 4,788 | 3,554 | 4,488 | 1,095 | 1,625 | -878 | -1,768 | **-2,916** |
| TWL | 2 | 27,491 | 27,650 | 27,588 | 14,765 | 18,283 | -3,130 | -7,358 | **-11,052** |
| TWL | 6 | 21 | 12 | 30 | 650 | 1,259 | 311 | 630 | **933** |

Table 2A.3a. Area-gear-month categories in which “significant” catch trends were detected. Key: “LGL” = longline, “POT” = pot, “TWL” = trawl, “slope” = slope of linear fit through the time series of catches, “dif1” = average 2000-2002 catch minus average 1998-1999 catch, “dif2” = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a “significant” result at the 5% level.

| Category | | | Catch | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Area | Gear | Month | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| 509 | LGL | 9 | 95 | 457 | 1,082 | 2,142 | 3,317 | **813** | 1,905 | **2,185** |
| 509 | TWL | 6 | 21 | 12 | 30 | 650 | 1,259 | 311 | 630 | **933** |
| 513 | LGL | 11 | 441 | 562 | 905 | 799 | 1,155 | **167** | 452 | 341 |
| 513 | LGL | 12 | 488 | 347 | 265 | 121 | 75 | **-105** | -264 | -269 |
| 517 | LGL | 4 | 1,446 | 1,723 | 267 | 167 | 29 | -439 | **-1,430** | -1,047 |
| 517 | LGL | 10 | 3,217 | 2,766 | 2,797 | 1,727 | 1,897 | -368 | -851 | **-1,114** |
| 517 | TWL | 1 | 2,587 | 1,544 | 2,886 | 443 | 446 | -538 | -807 | **-1,895** |
| 517 | TWL | 4 | 4,903 | 4,821 | 4,656 | 1,485 | 2,811 | -752 | -1,878 | **-2,645** |
| 517 | TWL | 5 | 312 | 577 | 71 | 62 | 113 | -91 | **-362** | -233 |
| 521 | LGL | 4 | 5,197 | 4,712 | 721 | 2,607 | 2,104 | -829 | **-3,144** | -1,188 |
| 521 | TWL | 7 | 355 | 498 | 677 | 744 | 1,029 | **159** | 390 | 376 |
| 541 | LGL | 4 | 1,752 | 1,895 | 629 | 90 | 266 | -478 | **-1,495** | -1,247 |
| 541 | TWL | 1 | 352 | 352 | 210 | 26 | 8 | **-101** | **-270** | **-288** |
| 543 | TWL | 7 | 121 | 65 | 63 | 43 | 16 | **-23** | -52 | -53 |
| 610 | LGL | 1 | 1,180 | 1,159 | 1,216 | 1,726 | 1,416 | 104 | 283 | **386** |
| 610 | TWL | 2 | 10,431 | 8,000 | 7,094 | 4,026 | 3,539 | **-1,776** | -4,329 | **-4,726** |
| 620 | POT | 2 | 1,412 | 1,472 | 1,408 | 564 | 284 | -317 | -690 | **-1,007** |
| 620 | POT | 3 | 1,025 | 1,880 | 505 | 229 | 372 | -296 | **-1,084** | -836 |
| 630 | LGL | 6 | 43 | 54 | 21 | 31 | 25 | -6 | **-23** | -11 |
| 630 | LGL | 10 | 37 | 25 | 20 | 9 | 6 | **-8** | -19 | -20 |
| 630 | POT | 1 | 1,879 | 2,696 | 2,425 | 345 | 224 | -566 | -1,289 | **-2,049** |
| 630 | TWL | 2 | 5,472 | 5,171 | 3,923 | 3,496 | 2,963 | **-669** | **-1,861** | -1,626 |
| 630 | TWL | 3 | 6,723 | 6,726 | 1,903 | 1,798 | 4,188 | -1,000 | **-4,095** | -2,125 |
| 650 | LGL | 6 | 12 | 13 | 3 | 5 | 6 | -2 | **-8** | -4 |
| 659 | LGL | 3 | 51 | 36 | 28 | 18 | 2 | **-12** | -27 | -28 |
| 659 | LGL | 4 | 49 | 23 | 16 | 5 | 2 | **-11** | -28 | -26 |
| 659 | LGL | 6 | 10 | 16 | 6 | 3 | 4 | -2 | **-9** | -7 |
| 659 | LGL | 9 | 13 | 7 | 8 | 3 | 1 | **-3** | -6 | -7 |
| 659 | LGL | 10 | 8 | 10 | 8 | 1 | 0 | -2 | -6 | **-8** |
| 659 | LGL | 11 | 14 | 22 | 2 | 3 | 1 | -5 | **-16** | -11 |

Table 2A.3b. Area-gear-month categories in which “significant” trends in the number of processors were detected. Key: “LGL” = longline, “POT” = pot, “TWL” = trawl, “slope” = slope of linear fit through the time series of processor numbers, “dif1” = average 2000-2002 catch minus average 1998-1999 catch, “dif2” = average 2001-2002 catch minus average 1998-2000 catch. Bold font indicates a “significant” result at the 5% level.

| Category | | | Processors | | | | | Measure of Trend | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Area | Gear | Month | 1998 | 1999 | 2000 | 2001 | 2002 | slope | dif1 | dif2 |
| 509 | LGL | 9 | 7 | 4 | 13 | 18 | 15 | 3.0 | **9.8** | 8.5 |
| 509 | TWL | 3 | 32 | 27 | 39 | 40 | 36 | 2.1 | **8.8** | 5.3 |
| 509 | TWL | 6 | 4 | 3 | 5 | 8 | 10 | **1.7** | 4.2 | **5.0** |
| 513 | TWL | 7 | 10 | 11 | 14 | 14 | 15 | **1.3** | **3.8** | 2.8 |
| 513 | TWL | 9 | 35 | 29 | 31 | 23 | 23 | -3.0 | -6.3 | **-8.7** |
| 514 | TWL | 5 | 10 | 8 | 9 | 3 | 5 | -1.5 | -3.3 | **-5.0** |
| 517 | LGL | 4 | 12 | 14 | 5 | 5 | 3 | -2.7 | **-8.7** | -6.3 |
| 517 | LGL | 10 | 23 | 21 | 21 | 19 | 19 | **-1.0** | -2.3 | -2.7 |
| 517 | TWL | 4 | 23 | 22 | 26 | 19 | 18 | -1.3 | -1.5 | **-5.2** |
| 517 | TWL | 9 | 35 | 34 | 31 | 31 | 27 | **-1.9** | -4.8 | -4.3 |
| 519 | TWL | 7 | 3 | 4 | 6 | 8 | 6 | 1.0 | **3.2** | 2.7 |
| 521 | LGL | 4 | 20 | 19 | 6 | 9 | 7 | -3.6 | **-12.2** | -7.0 |
| 521 | LGL | 9 | 22 | 22 | 19 | 25 | 26 | 1.1 | 1.3 | **4.5** |
| 521 | TWL | 7 | 5 | 11 | 16 | 22 | 24 | **4.9** | **12.7** | 12.3 |
| 523 | LGL | 10 | 8 | 6 | 4 | 4 | 3 | **-1.2** | **-3.3** | -2.5 |
| 541 | TWL | 3 | 26 | 21 | 15 | 11 | 14 | -3.4 | **-10.2** | -8.2 |
| 542 | TWL | 2 | 7 | 5 | 7 | 9 | 11 | 1.2 | 3.0 | **3.7** |
| 610 | TWL | 3 | 16 | 10 | 10 | 6 | 6 | **-2.4** | -5.7 | -6.0 |
| 610 | TWL | 10 | 5 | 4 | 4 | 10 | 9 | 1.4 | 3.2 | **5.2** |
| 620 | TWL | 2 | 11 | 9 | 8 | 7 | 7 | **-1.0** | -2.7 | -2.3 |
| 620 | TWL | 10 | 15 | 12 | 4 | 7 | 8 | -1.9 | **-7.2** | -2.8 |
| 630 | LGL | 7 | 18 | 21 | 12 | 7 | 7 | -3.6 | **-10.8** | -10.0 |
| 630 | LGL | 10 | 16 | 15 | 13 | 9 | 10 | **-1.8** | -4.8 | **-5.2** |
| 630 | TWL | 3 | 11 | 13 | 8 | 9 | 7 | -1.2 | **-4.0** | -2.7 |
| 630 | TWL | 7 | 19 | 17 | 13 | 13 | 12 | **-1.8** | **-5.3** | -3.8 |
| 630 | TWL | 10 | 12 | 12 | 9 | 8 | 7 | **-1.4** | **-4.0** | -3.5 |
| 659 | LGL | 5 | 9 | 10 | 10 | 7 | 5 | -1.1 | -2.2 | **-3.7** |
| 659 | LGL | 6 | 11 | 10 | 11 | 8 | 8 | -0.8 | -1.5 | **-2.7** |

Table 2A.4. Summary of "significant" positive catch trends. The first part of the table lists months with positive trends, the second part lists area-and-gear categories with positive trends, the third part lists area-and-month categories with positive trends, the fourth part lists gear-and-month categories with positive trends, and the fifth part lists area-gear-month categories with positive trends. Each positive trend is reported in terms of tons and as a percentage of the average total catch (186,271 t). In cases where the "slope" measure of trend was "significant", the change in tons is shown as twice the slope, to make this statistic comparable to "dif1" and "dif2" (see Tables 2A.1-2A.3). In cases where more than one measure of trend was "significant," the measure with the largest magnitude is used here.

| Month | Change (t) | Change (%) |
|---|---|---|
| 6 | 896 | 0.5 |
| 9 | 6,976 | 3.7 |
| Total | 7,872 | 4.2 |

| Area | Gear | Change (t) | Change (%) |
|---|---|---|---|
| 509 | LGL | 2,781 | 1.5 |
| | Total | 2,781 | 1.5 |

| Area | Month | Change (t) | Change (%) |
|---|---|---|---|
| 509 | 6 | 933 | 0.5 |
| 509 | 9 | 1,674 | 0.9 |
| 513 | 3 | 1,008 | 0.5 |
| 513 | 11 | 333 | 0.2 |
| 521 | 7 | 319 | 0.2 |
| 630 | 9 | 1,017 | 0.5 |
| | Total | 5,285 | 2.8 |

| Gear | Month | Change (t) | Change (%) |
|---|---|---|---|
| LGL | 9 | 6,916 | 3.7 |
| TWL | 6 | 933 | 0.5 |
| | Total | 7,850 | 4.2 |

| Area | Gear | Month | Change (t) | Change (%) |
|---|---|---|---|---|
| 509 | LGL | 9 | 2,185 | 1.2 |
| 509 | TWL | 6 | 933 | 0.5 |
| 513 | LGL | 11 | 333 | 0.2 |
| 521 | TWL | 7 | 319 | 0.2 |
| 610 | LGL | 1 | 386 | 0.2 |
| | | Total | 4,157 | 2.2 |