FLATHEAD SOLE

by

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Executive Summary

The following changes have been made to this assessment relative to the November 2000 SAFE:

Changes in the input data

1) 2001 total catch and discards through 6 October, 2001.
2) 2001 trawl survey biomass estimate and standard error.
3) 2001 length composition of the survey abundance.
4) 2000 length composition of the fishery catch.
5) 2000 age composition of the survey abundance.
6) Re-estimated age-length transition matrices, based upon survey length at age data.

Model results

1) Estimated 3+ total biomass for 2001 is 612,337 t.
2) Projected female spawning biomass for 2002 is 262,402 t.
3) Recommended ABC for 2002 is 82,572 t based on an $F_{40\%}$ (0.30) harvest level.
4) 2002 overfishing level is 100,770 t based on a $F_{35\%}$ (0.38) harvest level.

The following summarizes our recommendations for flathead sole fisheries conservation measures.

	2000 Assessment recommendations for the 2001 harvest	2001 Assessment recommendations for the 2002 harvest
ABC	83,964 t	82,572 t
Overfishing	102,485 t	100,770 t
F_{ABC}	$F_{0.40} = 0.30$	$F_{0.40} = 0.30$
$F_{overfishing}$	$F_{0.35} = 0.38$	$F_{0.35} = 0.38$

Introduction

The flathead sole (*Hippoglossoides elassodon*) is distributed from northern California, off Point Reyes, northward along the west coast of North America and throughout Alaska (Hart 1973). In the northern part of its range it overlaps with the related and morphologically similar Bering Flounder (*Hippoglossoides robustus*) whose range extends north to the Chukchi Sea and into the western Bering Sea. The two species are very similar morphologically and at-sea identification is extremely difficult on the production schedule of the annual trawl survey. However, we feel there has been increasing accuracy during recent years. The growth and distribution differences between the species were described in Walters and Wilderbuer (1997), which illustrated the possible ramifications of combining information. For the purposes of this section, these two species are combined under the heading, *Hippoglossoides* sp.

Hippoglossoides sp. are managed as a unit stock in the Bering Sea and Aleutian Islands and were formerly a constituent of the "other flatfish" SAFE chapter. In June 1994, the Council requested the Plan Team to assign a separate ABC for flathead sole (*Hippoglossoides* sp.) in the BSAI, rather than combining flathead sole (*Hippoglossoides* sp.) with other flatfish as in past assessments. This request was based on a change in the directed fishing standards to allow increased retention of flatfish.

Catch History

Prior to 1977, catches of *Hippoglossoides* sp. were combined with the species of the "other flatfish" category, which increased from around 25,000 t in the 1960s to a peak of 52,000 t in 1971. At least part of this apparent increase was due to better species identification and reporting of catches in the 1970s. After 1971, catches declined to less than 20,000 t in 1975. Catches from 1977-89 averaged 5,286 t increasing to an annual average of 17,946 t from 1990-2000 (Table 1). The resource remains lightly harvested as the 2001 catch through 6 October is only 47% of the 2001 TAC of 34,000 t. The catch of flathead sole taken in research surveys from 1979-2001 are shown in Table 2. The catch locations by quarter for 2000 for flathead sole hauls (defined by flathead sole contributing at least 20% of the total catch) are shown in the Appendix.

Although flathead sole (*Hippoglossoides* sp.) receive a separate ABC and TAC they are still managed in the same PSC classification as rock sole and "other flatfish" and receive the same apportionments and seasonal allowances of bycaught prohibited species. In recent years, the flathead sole fishery has been closed prior to attainment of the TAC due to the bycatch of halibut (Table 3).

Substantial amounts of flathead sole are discarded overboard in various eastern Bering Sea target fisheries. Retained and discarded amounts are estimated for recent years using observer estimates of discard rate applied to the “blend” estimate of observer and industry reported retained catch (including flathead sole prior to 1995) (Table 4). A substantial portion of the discards in 2000 occurred in the Pacific cod, pollock, and rock sole fisheries.

Data

Fishery Catch and Catch-at-age Data

This assessment uses fishery catches from 1977 through 6 October, 2001 (Table 1), and estimates of number caught by length group and sex for the years 1977-2000 (Tables 5-6).

Survey Data

Because *Hippoglossoides* sp. are often taken incidentally in target fisheries for other species, CPUE from commercial fisheries seldom reflect trends in abundance for these species. It is therefore necessary to use research vessel survey data to assess the condition of these stocks.

Large-scale bottom trawl surveys of the Eastern Bering Sea continental shelf have been conducted in 1975 and 1979-2001 by NMFS. Information on length at age for flathead sole are available from the 1982, 1985, 1992, 1994, 1995 and 2000 surveys. An evaluation of growth rates was made for each of the survey years above, as these rates form the basis of transition matrices that convert numbers at age to numbers at length. This examination of growth rates was motivated by the finding of temporal variability in growth for some flatfish species, such as rock sole and Pacific halibut. The von Bertalanffy growth parameters (L_{inf}, t_0, and K) and σ_g (the standard deviation of length at age on a log scale) were estimated by minimizing the negative log-likelihood of the observed flathead sole size at age data. The Akaike Information Criterion (AIC), defined as the negative log likelihood plus twice the number of parameters (Hilborn and Mangel 1997), was used to evaluate two models for each sex: a "combined" model in which the size at age data for all years was fit with a single growth model, and a "separate year" model, in which a separate growth curve was fit for each year. The results (shown below) suggest the use of the separate year model, although the difference in AIC between the two models is not large (especially for males).

	"Separate Year" Model (24 parameters)		Combined model (4 parameters)	
Sex	**- ln like**	**AIC**	**- ln like**	**AIC**
Male (n=1148)	-1873.62	-1825.62	-1830.42	-1822.42
Female (n=1371)	-2302.87	-2254.86	-2253.20	-2245.21

Although the AIC analysis suggests basing the transition matrix upon the most recent survey data, the estimated growth curves and observed size at age are similar between years up to age 10 (Figure 1). Beyond age 10, the growth curves began to deviate as the size at age data becomes more sparse in several years. The similarity in the size at age data led to the conclusion that there is no practical difference in growth rates. The transition matrices were estimated from the growth curve derived from the "combined" model; the coefficient of variation (CV) of growth was assumed to increase from 0.08 at age 3 to 0.10 at age 21.

A length (cm) – weight (g) relationship of the form $W = aL^b$ was also fit to *Hippoglossoides* sp., with the estimated parameters of a = 0.003965 and b = 3.25912 applying to both sexes.

Survey estimates of total biomass and numbers by length group and sex for the years 1982-2001 are shown in Tables 7-9 and Figure 2. The survey gear changed after 1981, and as in previous assessments (Spencer et al. 1999) only the data from 1982 to the present are used. Since the early 1980s, estimated *Hippoglossoides* sp. biomass has approximately quadrupled to the 1997 peak estimate of 807,800 t (Figure 2). However, estimated biomass declined to 394,822 t in 1999 and 399,023 t in 2000, respectively, and increased to 514,023 t in the 2001 survey.

In summary, the data available for flathead sole are

1) Total catch weight, 1977-2001;
2) Proportional catch numbers by length group, 1977-2000;
3) Survey biomass and standard error, 1982-2001;
4) Survey age composition 1982, 1985, 1992, 1995, and 2000;
5) Proportional survey numbers by length group, 1982-2001.

Analytical Approach

Model Structure

The assessment model has a length-based formulation, which is underlaid by an age-based model. A transition matrix (**TR**) is used to convert the selectivity at length to selectivity at age, and to convert the predicted catch and numbers at age to catch and numbers at length.

An age-structured, split-sex population dynamics model was used to obtain estimates of recruitment, numbers at age, and catch at age for each sex. Population size in numbers at age a in year t for sex s was modeled as

$$N_{s,t,a} = N_{s,t-1,a-1} e^{-Z_{s,t-1,a-1}} \qquad 4 \le a < A, \quad 2 \le t \le T$$

where Z is the sum of the instantaneous fishing mortality rate ($F_{s,t,a}$) and the natural mortality rate (M_s), A is the maximum number of ages in the population, and T is the terminal year of the analysis (2001). The numbers at age A are a “pooled” group consisting of fish of age A and older, and are estimated as

$$N_{s,t,A} = N_{s,t-1,A-1} e^{-Z_{s,t-1,A-1}} + N_{t-1,A} e^{-Z_{s,t-1,A}}$$

The total numbers of age 3 fish over all years are estimated as parameters in the model, and modeled with a lognormal distribution

$$N_{t,3} = e^{(\mu_R + \nu_t)}$$

where ν is a time-variant deviation. The number of recruits is divided equally between males and females. The numbers at age in the first year are modeled to be in equilibrium with an historical catch of 1500 t, and requires estimation of a historic recruitment parameter (R_0) and a historic fishing mortality rate (f_{hist}).

The fishing mortality rate for a specific age and time ($F_{t,a}$) is modeled as the product of a fishery age-specific selectivity function (*fishasel*) and a year-specific fully-selected fishing mortality rate *f*. The fully selected mortality rate is modeled as the product of a mean (μ_f) and a year-specific deviation (ϵ_t), thus $F_{t,a}$ is

$$F_{t,a} = fishasel_a * f_t \equiv fishasel_a * e^{(\mu_f + \varepsilon_t)}$$

The fishery selectivity at age is obtained from the selectivity at length and the transition matrix $\mathbf{TR_s}$, where the transition matrix $\mathbf{TR_s}$ indicates the proportion of each age (rows) in each length group (columns) for each sex; the sum across each age is equal to one. Because of growth differences between the sexes, there is a separate transition matrix and age –based selectivity vector for each sex; these matrices were computed as described above. The selectivity at age vector is computed from the fishery selectivity at length vector (**fishlsel**) as

$$\mathbf{fishasel_s} = \mathbf{TR_s} * \mathbf{fishlsel}$$

Finally, the selectivity at length vector, assumed identical for each sex, was modeled as

$$fishlsel_l = \frac{1}{1 + e^{-slope(l - fifty)}}$$

where the parameter *slope* affects the steepness of the curve and the parameter *fifty* is the length at which $fishlsel_l$ equals 0.5. There are 24 length bins ranging from 6 to 58 cm, and 19 age groups ranging from 3 to 21+. The age- and length-based selectivity for the survey is modeled in a similar manner.

The mean numbers at age for each year and sex were computed as

$$\overline{N}_{s,t,a} = N_{s,t,a} * (1 - e^{-Z_{s,t,a}}) / Z_{s,t,a}$$

The transition matrix and vector of mean numbers at age were used to compute the vector of mean numbers at length, by sex and year, as

$$\overline{\mathbf{NL}}_{s,t} = \overline{\mathbf{NA}}_{s,t} * \mathbf{TR}_s^{\mathbf{T}}$$

The vector of mean numbers at length was used to compute the catch as

$$C_{l,s,t} = \overline{NL}_{l,s,t} * fishlsel_l * f_t$$

$$pred\_cat_t = \sum_{l,s} C_{l,s,t} * FW_{l,s}$$

where $FW_{l,s}$ is the fishery weights by length and sex, and *pred_cat* is the predicted catch from the model. Similarly, the predicted survey biomass (*pred_biom*) is computed as

$$pred\_biom_t = qsurv \sum_{l,s} \left(\overline{NL}_{l,s,t} * survlsel_l * PW_{l,s} \right)$$

where $PW_{l,s}$ is the population weight by length and sex, and *qsurv* is the trawl survey catchability.

Finally, age composition data are assumed to be unbiased, but with some aging error. The distribution of read ages around the "true" age is assumed to be normal with a variance of 0.02 times the true age, resulting in a coefficient of variation of 0.14. The vector of mean number of fish by age available to the survey is multiplied by the aging error matrix in order to produce the observed survey age compositions.

Parameters Estimated Independently

The parameters estimated independently include the age error matrix, the transition matrix, individual weight at length, natural mortality, and survey catchability (*q_srv*). The age error matix was taken directly from the stock synthesis model used in previous assessments. The individual weights at age were obtained from trawl survey data, whereas *qsurv* and *M* were fixed at 1.0 and 0.2, respectfully, consistent with recent assessments.

Parameters Estimated Conditionally

Parameter estimation is facilitated by comparing the model output to several observed quantities, such as the age compositions of the survey, length composition of the fishery and survey catches, the survey biomass, and the catch biomass. The general approach is to assume that deviations between model estimates and observed quantities are attributable to observation error and can be described with statistical distributions. Each data component provides a contribution to a total log-likelihood function, and parameter values that minimize the log-likelihood are selected.

The log-likelihood of the initial recruitments were modeled with a lognormal distribution

$$\lambda_1 \sum_t \frac{\left(v_t + \frac{\sigma^2}{2}\right)^2}{2\sigma^2} + n\ln(\sigma)$$

where σ is a parameter representing the standard deviation of recruitment, respectively, on a log scale. The adjustment of adding $\sigma^2/2$ to the deviation was made to correct for bias and produce deviations from the mean, rather than the median, recruitment.

The log-likelihoods of the fishery and survey age and length compositions were modeled with a multinomial distribution. The log of the multinomial function (excluding constant terms) for the fishery length composition data, with the addition of a term that scales the likelihood, is

$$n_{f,s,t,l} \sum_{s,t,l} p_{f,s,t,l} \ln(\hat{p}_{f,s,t,l}) - p_{f,s,t,l} \ln(p_{f,s,t,l})$$

where *n* is the number of fish aged, and $p_{f,s,t,l.}$ and $\hat{p}_{f,s,t,l}$ are the observed and estimated proportion at length in the fishery by sex, year and length. The likelihood for the age and length proportions in the survey, $p_{surv,s,t,a}$ and $p_{surv,s,t,l}$, respectively, follow similar equations.

The log-likelihood of the survey biomass was modeled with a lognormal distribution:

$$\lambda_2 \sum_t (\ln(obs\_biom_t) - \ln(pred\_biom_t))^2 / 2cv_t^2$$

where obs_biom_t is the observed survey biomass at time *t*, cv_t is the coefficient of variation of the survey biomass in year *t*, and λ_2 is a weighting factor.

The log-likelihood of the catch biomass was modeled with a lognormal distribution:

$$\lambda_3 \sum_t (\ln(obs\_cat_t) - \ln(pred\_cat_t))^2$$

where obs_cat_t and $pred\_cat_t$ are the observed and predicted catch. Because the catch biomass is generally thought to be observed with higher precision that other variables, λ_3 was given a very high weight so as to fit the catch biomass nearly exactly. This can be accomplished by varying the F levels, and the deviations in F are not included in the overall likelihood function. The overall negative log-likelihood function (excluding the catch component) is

$$\lambda_1\left(\sum_t\left(\frac{(v_t+\sigma^2/2)^2}{2\sigma^2}\right)+n\ln(\sigma)\right)+$$

$$\lambda_2\sum_t(\ln(obs\_biom_t)-\ln(pred\_biom_t))^2/2*cv_t^2+$$

$$n_{f,s,t,l}\sum_{s,t,l}p_{f,s,t,l}\ln(\hat{p}_{f,s,t,l})-p_{f,s,t,l}\ln(p_{f,s,t,l})+$$

$$n_{surv,s,t,a}\sum_{s,t,a}p_{surv,s,t,a}\ln(\hat{p}_{surv,s,t,a})-p_{surv,s,t,a}\ln(p_{surv,s,t,a})+$$

$$n_{surv,s,t,l}\sum_{s,t,a}p_{surv,s,t,l}\ln(\hat{p}_{surv,s,t,l})-p_{surv,s,t,l}\ln(p_{surv,s,t,l})+$$

$$\lambda_3\sum_t(\ln(obs\_cat_t)-\ln(pred\_cat_t))^2$$

For the model run in this analysis, λ_1, λ_2, and λ_3 were assigned weights of 1,2, and 500, respectively, and n was set to 200. The likelihood function was minimized by varying the following parameters:

Parameter type	Number
1) fishing mortality mean (μ_f)	1
2) fishing mortality deviations (ϵ_t)	25
3) recruitment mean (μ_r)	1
4) recruitment standard deviation (σ)	1
4) recruitment deviations (v_t)	25
5) historic recruitment (R_0)	1
6) historic fishing mortality (f_{hist})	1
7) fishery selectivity parameters	2
8) survey selectivity parameters	2
Total parameters	59

Model Results

The model results show that estimated total biomass (ages 3+) increased from a low of 227,194 t in 1977 to a peak of 897,867 t in 1991 (Figure 2, Table 10). Since 1991, estimated total biomass has declined to an estimated value of 612,337 t for 2001. Female spawning biomass shows a similar trend, although the peak value (388,974 t) occurred in 1995 (Figure 3). The estimated survey biomass shows an increase from 1982 to the peak level of 567,695 t in 1993, and a subsequent decline to 418,152 t in 2001 (Figure 4). The model fits the survey biomass time-series well during the period of increasing biomass, but provides a poor fit to the 1994, 1997 and 1998 estimates, when it indicates a population decline while survey biomass estimates remain high and relatively stable. The continued trend of declining estimated biomass since the early 1990s results in the estimated 1999 and 2000 survey biomass matching the observed biomass more closely than the estimated 2001 biomass matches the observed biomass (Figure 4). The model provided a good fit to the survey size compositions for the past 10 years for males and females as shown Figures 5 and 6. Reasonable fits also resulted for fishery size composition observations (Figures 7 and 8) and the survey age composition (Figure 9).

The changes in stock biomass are primarily a function of recruitment, as fishing pressure has been relatively light. The fully selected fishing mortality estimates remain small, and have averaged 0.05 from 1990 to 2001 (Figure 10), and the fishery shows little selectivity for flathead sole less that 30 cm (Figure 11). Estimated recruitment at age 3 has generally been higher during the early portion of the data series, averaging 8.8×10^8 for the 1975-1988 year classes, and 4.1×10^8 for the 1989-98 year classes (Figure 12). The scattterplot of stock and recruitment data reveals a decreasing trend in recruitment with an increasing trend in spawner biomass (Figure 13). The survey size composition from 1994-2000 indicates that the proportion of fish at smaller sizes is reduced from the high recruitment years of the 1980s, leading to the decline in estimated biomass.

The extent to which the density-dependence observed in the scatterplot of spawer-recruit data (Figure 13) is affected by environmental conditions is unresolved. For example, a series of high spawner stock biomasses and low recruitments were observed for the post-1988 year classes, coinciding with changes in the environmental indices such as the Aleutian low pressure index (Hare and Mantua 2000). Stock-recruitment analyses that consider this environmental variability are a priority for future flathead sole research.

Projections and Harvest Alternatives

The reference fishing mortality rate for flathead sole is determined by the amount of reliable population information available (Amendment 56 of the Fishery Management Plan for the groundfish fishery of the Bering Sea/Aleutian Islands). Estimates of $F_{0.40}$, $F_{0.35}$, and $SPR_{0.40}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from the 1977-1998 year classes estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{0.40}$ is calculated as the product of $SPR_{0.40}$ * equilibrium recruits, and this quantity is 141,930 t. The year 2002 spawning stock biomass is estimated as 262,402 t. Since reliable estimates of the 2002 spawning biomass (B), $B_{0.40}$, $F_{0.40}$, and $F_{0.35}$ exist and $B > B_{0.40}$ (262,402 t > 141,930 t), flathead sole reference fishing mortality is defined in tier 3a. For this tier, F_{ABC} is constrained to be $\leq F_{0.40}$, and F_{OFL} is defined to be $F_{0.35}$. The values of these quantities are

2002 SSB estimate (B) = 262,402 t
$B_{0.40}$ = 141,930 t
$F_{0.40}$ = 0.300
$F_{ABC} \leq$ 0.300
$F_{0.35}$ = 0.375
F_{OFL} = 0.375

The estimated catch level for year 2002 associated with the overfishing level of $F = 0.375$ is 100,770 t. Because the flathead sole stock has not been overfished in recent years and the stock biomass is relatively high, it is not recommended to adjust F_{ABC} downward from it upper bound; thus, the year 2002 recommended ABC associated with F_{ABC} of 0.300 is 82,572 t.

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 2001 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2002 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2001. 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 2002, 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 2002 recommended in the assessment to the *max* F_{ABC} for 2002. (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 1996-2000 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)

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

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, and five-year projections of the mean harvest and spawning stock biomass for the remaining four scenarios are shown in Tables 11.

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

Scenario 6: In all future years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is overfished. If the stock is expected to be above its MSY level in 2002, then the stock is not overfished.)

Scenario 7: In 2002 and 2003, 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 2004 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that the flathead sole are neither overfished or approaching an overfished condition. With regard to assessing the current stock level, the expected stock size in the year 2002 of scenario 6 is 2.09 times its $B_{35\%}$ value of 124,189 t. With regard to whether the stock is likely to be in an overfished condition in the near future, the expected stock size in the year 2004 of scenario 7 is 1.29 times its $B_{35\%}$ value.

Other considerations

Trophic studies indicate that flathead sole feed mainly on ophiuroids, tanner crab, osmerids, bivalves and polychaetes. Groundfish predators include Pacific cod, Pacific halibut, arrowtooth flounder and also cannibalism by large flathead sole, mostly on fish less than 20 cm standard length.

Summary

In summary, several quantities pertinent to the management of the flathead sole are listed below.

Quantity	Value
M	0.20
Year 2001 Spawning stock biomass	262,402 t
F_{OFL}	0.375
Maximum F_{ABC}	0.300
Recommended F_{ABC}	0.300
OFL	100,770 t
Recommended ABC	82,572 t

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Table 1. Harvest (t) of flathead sole from 1977-2001

Year	Catch Biomass
1977	7909
1978	6957
1979	4351
1980	5247
1981	5218
1982	4509
1983	5240
1984	4458
1985	5636
1986	5208
1987	3595
1988	6783
1989	3604
1990	20245
1991	15602
1992	14239
1993	13664
1994	18455
1995	14707
1996	17344
1997	20704
1998	24397
1999	17842
2000	19983
2001	16131*

*NMFS Regional Office Report through October 6, 2001

Table 2. Research catches (t) of flathead sole in the BSAI area from 1979 to 2001.

Year	Research Catch (t)
1979	11.85
1980	6.19
1981	11.23
1982	20.36
1983	13.86
1984	13.51
1985	44.83
1986	13.79
1987	12.97
1988	29.86
1989	24.60
1990	26.76
1991	35.92
1992	18.92
1993	21.86
1994	30.23
1995	26.52
1996	20.87
1997	30.31
1998	23.02
1999	16.82
2000	19.09
2001	18.50

Table 3. Restrictions on the flathead sole fishery from 1994 to 2001 in the Bering Sea – Aleutian Islands management area. Unless otherwise indicated, the closures were applied to the entire BSAI management area. Zone 1 consists of areas 508, 509, 512, and 516, whereas zone 2 consists of areas 513, 517, and 521.

Year	Dates	Bycatch Closure
1994	2/28 – 12/31	Red King crab cap (Zone 1 closed)
	5/7 – 12/31	Bairdi Tannner crab (Zone 2 closed)
	7/5 – 12/31	Annual halibut allowance
1995	2/21 – 3/30	First Seasonal halibut cap
	4/17 – 7/1	Second seasonal halibut cap
	8/1 – 12/31	Annual halibut allowance
1996	2/26 – 4/1	First Seasonal halibut cap
	4/13 – 7/1	Second seasonal halibut cap
	7/31 – 12/31	Annual halibut allowance
1997	2/20 – 4/1	First Seasonal halibut cap
	4/12 – 7/1	Second seasonal halibut cap
	7/25 – 12/31	Annual halibut allowance
1998	3/5 – 3/30	First Seasonal halibut cap
	4/21 – 7/1	Second seasonal halibut cap
	8/16 – 12/31	Annual halibut allowance
1999	2/26 – 3/30	First Seasonal halibut cap
	4/27 – 7/04	Second seasonal halibut cap
	8/31 – 12/31	Annual halibut allowance
2000	3/4 – 3/31	First Seasonal halibut cap
	4/30 – 7/03	Second seasonal halibut cap
	8/25 – 12/31	Annual halibut allowance
2001	3/20 – 3/31	First Seasonal halibut cap
	4/27 – 7/01	Second seasonal halibut cap
	8/24 – 12/31	Annual halibut allowance

Table 4. Total retained and discarded flathead sole, 1995-2001.

Year	Total Catch	Retained	Discarded	Percent Retained
1995	14707	7521	7186	51
1996	17344	8964	8380	52
1997	20704	10871	9833	53
1998	24397	17208	7189	70
1999	17892	13282	4610	74
2000	19983	14730	5253	74
2001*	16131	13204	2927	82

[*] NMFS regional office report through October 6, 2000

Table 5. Eastern Bering Sea flathead sole male catch at length group (millions)

Year	Length Group (cm) 6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	43	46	49	52	55	58
1977	0.00	0.00	0.00	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.04	[illegible]	4.04	[illegible]	[illegible]	0.71	[illegible]	[illegible]	[illegible]	0.04	0.00	0.00	0.00	0.00	0.00
1978	0.00	0.00	0.00	[illegible]	0.10	[illegible]	0.47	0.70	1.00	1.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.41	[illegible]	0.01	0.00	0.00	0.01	0.01	0.00	0.00
1979	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.70	0.44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	0.00	0.00	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.00	[illegible]	[illegible]	0.40	[illegible]	1.00	[illegible]	1.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	0.00	0.00	0.00	0.00	0.00	0.00
1981	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	0.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00
1982	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.77	[illegible]	[illegible]	[illegible]	0.04	0.04	0.00	0.00	0.00	0.00	0.00
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	[illegible]	0.14	0.44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.14	0.04	[illegible]	0.01	0.01	0.01	[illegible]
1984	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	0.07	[illegible]	[illegible]	[illegible]	[illegible]	0.74	[illegible]	1.41	[illegible]	0.74	[illegible]	0.07	0.01	0.00	0.00	0.00	0.00	0.00
1985	0.00	0.00	0.00	0.00	0.01	0.04	[illegible]	[illegible]	[illegible]	0.44	[illegible]	[illegible]	[illegible]	1.01	[illegible]	1.10	[illegible]	[illegible]	0.04	[illegible]	[illegible]	[illegible]	0.04	[illegible]
1986	0.00	0.00	0.00	0.00	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.04	0.10	0.10	[illegible]	[illegible]	[illegible]	1.47	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.01	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.77	[illegible]	[illegible]	0.00	0.01	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.04	[illegible]	[illegible]	[illegible]	0.11	[illegible]	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.01	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.14	[illegible]	0.00	0.00
1991	0.00	0.00	0.00	0.00	0.00	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.14	[illegible]	[illegible]	[illegible]	[illegible]	0.07	[illegible]	0.00	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.11	0.04	0.40	[illegible]	0.70	[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.00	0.00	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.01	[illegible]	[illegible]	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	[illegible]	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.41	[illegible]	[illegible]	0.04	[illegible]
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.01	[illegible]	[illegible]	0.14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.14	0.07	0.04	0.01	[illegible]
1997	0.00	0.00	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	0.41	1.17	[illegible]	[illegible]	4.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0.04	0.10	[illegible]	[illegible]	1.00	[illegible]	[illegible]	[illegible]	[illegible]	4.40	[illegible]	[illegible]	[illegible]	0.01	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.01	[illegible]	[illegible]	[illegible]	[illegible]	1.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.70	[illegible]	0.11	[illegible]	0.01	0.01	0.00
2000	0.00	0.01	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	0.07	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.01	[illegible]	[illegible]	[illegible]	[illegible]	0.10	0.04	0.01	[illegible]

Table 6. Eastern Bering Sea flathead sole female catch at length group (millions)

Year	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	43	46	49	52	55	58
	Length Group (cm)																							
1977	0.00	0.00	0.00	0.04	0.11	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	0.01	0.00	0.00	[illegible]
1978	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.01	0.00	0.00	0.00
1979	0.00	0.00	0.00	[illegible]	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	0.11	0.01	0.00	0.00	0.00
1980	0.00	0.00	0.00	0.00	0.01	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	0.01	0.00	0.00	0.00
1981	0.00	0.00	0.00	[illegible]	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	[illegible]	[illegible]	[illegible]	[illegible]	0.01	0.00	0.00	0.00
1982	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00
1983	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.11	[illegible]	[illegible]	0.00
1984	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	0.00	0.10	[illegible]	[illegible]	0.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	[illegible]	[illegible]	0.01	0.00	0.00	0.00
1985	0.00	0.00	0.00	[illegible]	0.01	[illegible]	[illegible]	[illegible]	0.10	0.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.41	[illegible]	0.00	[illegible]	[illegible]	[illegible]
1986	0.00	0.00	0.00	0.00	[illegible]	0.11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0.01	0.04	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.10	[illegible]	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.01	[illegible]	0.10	0.10	0.11	[illegible]	[illegible]	0.40	0.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	[illegible]	0.00	0.04	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	0.00
1991	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00
1992	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00
1993	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.10	0.14	[illegible]	0.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.14	[illegible]	0.00	0.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.04	[illegible]	0.14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	[illegible]	0.04	0.04	[illegible]	0.10	[illegible]	[illegible]	0.00	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.04	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.01	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.11	0.01	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	[illegible]	0.10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.00	[illegible]	[illegible]
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.01	[illegible]

Table 7. Estimated biomass of flathead sole from the EBS and Aleutian Islands Trawl survey.

Year	Area	Biomass Estimate
1975	EBS	100,700
1979	EBS	104,900
1980	EBS	117,500
	Aleut.	3,300
1981	EBS	162,900
1982	EBS	191,988
1983	EBS	269,419
	Aleut.	1,500
1984	EBS	341,697
1985	EBS	276,350
1986	EBS	357,951
	Aleut.	9,000
1987	EBS	394,758
1988	EBS	572,805
1989	EBS	536,433
1990	EBS	628,235
1991	EBS	544,893
	Aleut.	6,885
1992	EBS	651,384
1993	EBS	610,259
1994	EBS	726,212
	Aleut.	9,917
1995	EBS	593,412
1996	EBS	616,373
1997	EBS	807,825
	Aleut.	11,540
1998	EBS	692,234
1999	EBS	394,822
2000	EBS	399,298
2000	Aleut	8,970
2001	EBS	514,023

Table 8. Eastern Bering Sea flathead sole male numbers at length group (millions) estimated from the NMFS trawl surveys

	Length Group (cm)																							
Year	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	43	46	49	52	55	58
1982	0.27	0.30	1.42	19.37	30.56	27.81	33.61	46.44	54.95	63.58	84.48	90.19	72.52	31.55	10.41	3.08	0.59	0.42	0.00	0.00	0.00	0.00	0.00	0.00
1983	0.47	1.36	16.88	47.98	28.14	49.06	65.83	56.16	49.88	57.29	71.20	85.44	82.41	58.81	23.63	6.70	1.37	0.12	0.00	0.00	0.00	0.00	0.00	0.00
1984	0.72	1.50	10.41	31.20	57.55	94.49	72.63	68.82	79.83	79.91	87.22	96.03	92.24	70.87	34.05	7.58	3.57	0.12	0.00	0.14	0.00	0.00	0.00	0.00
1985	0.03	2.70	4.28	8.83	23.65	39.88	61.01	86.03	75.21	57.16	70.29	74.92	80.93	60.96	38.86	14.30	3.33	0.78	0.00	0.00	0.00	0.00	0.00	0.00
1986	0.47	0.83	7.25	23.71	17.42	22.83	38.52	65.07	74.08	82.94	84.31	69.95	87.56	88.82	49.43	20.70	6.90	1.66	0.11	0.00	0.00	0.00	0.00	0.00
1987	0.06	0.21	7.51	24.00	27.07	44.09	43.98	53.56	63.01	79.70	78.04	90.86	99.30	97.64	55.07	28.65	14.99	3.82	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.54	1.63	5.23	30.89	77.10	101.89	73.97	76.37	64.69	70.87	75.18	86.13	115.63	137.93	120.56	51.74	17.67	5.16	0.26	0.00	0.00	0.00	0.00	0.00
1989	0.00	1.54	17.37	70.04	40.33	43.44	127.71	102.70	102.99	72.95	74.82	76.26	76.47	128.41	127.72	58.91	18.03	3.02	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	1.30	4.75	17.32	74.03	78.17	64.41	94.99	114.40	99.89	96.77	97.86	109.67	136.15	132.40	69.94	27.55	5.46	0.50	0.00	0.00	0.00	0.00	0.00
1991	0.10	0.70	12.03	8.80	10.32	47.57	91.91	125.85	119.07	112.65	111.83	92.10	101.78	95.91	107.64	72.53	21.39	4.77	0.45	0.06	0.00	0.00	0.00	0.00
1992	0.00	0.02	3.46	44.85	74.84	45.93	49.48	91.69	128.81	160.50	144.34	119.00	124.41	135.70	138.54	88.97	32.19	6.55	0.32	0.02	0.18	0.00	0.00	0.00
1993	0.00	0.91	6.95	13.50	19.31	58.28	64.41	61.04	72.45	109.60	139.13	138.74	121.89	128.75	117.83	68.84	26.74	7.10	0.24	0.00	0.00	0.00	0.00	0.00
1994	0.00	0.89	4.97	20.10	43.45	65.78	87.74	75.73	68.50	92.89	126.88	142.66	157.12	153.69	144.32	95.41	31.71	8.37	0.39	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.12	1.97	7.68	19.00	34.32	43.99	60.15	70.08	65.63	106.64	133.01	152.53	138.54	119.62	72.88	31.93	10.52	0.50	0.14	0.00	0.00	0.00	0.00
1996	0.07	0.63	3.15	19.70	38.02	35.65	55.73	69.11	74.66	77.90	89.21	116.17	139.29	145.85	135.79	85.00	33.76	12.38	1.01	0.00	0.00	0.03	0.00	0.00
1997	0.06	0.48	3.01	10.40	12.46	24.23	30.26	40.34	53.39	66.34	73.81	91.47	143.20	152.03	145.64	102.15	53.45	23.84	2.37	1.85	0.00	0.00	0.00	0.00
1998	0.06	1.26	17.18	34.49	18.23	26.35	29.32	37.45	46.66	69.57	77.23	94.44	135.44	161.08	157.74	106.86	59.75	14.97	2.64	0.44	0.00	0.00	0.00	0.00
1999	0.00	0.46	2.61	7.34	20.22	16.06	17.74	29.29	31.18	48.08	59.45	65.48	79.45	98.03	82.37	45.35	21.04	10.86	1.04	0.10	0.00	0.00	0.00	0.00
2000	0.06	0.36	5.35	7.63	11.38	24.17	22.09	25.56	28.20	43.09	63.81	64.82	87.61	87.90	73.77	49.16	19.36	7.65	0.58	0.24	0.03	0.00	0.00	0.00
2001	0.00	0.74	5.02	6.55	16.95	20.75	37.24	63.50	59.97	46.26	59.54	97.84	120.11	122.74	105.09	59.81	30.72	9.79	1.89	0.56	0.02	0.02	0.00	0.00

Table 9. Eastern Bering Sea flathead sole female numbers at length group (millions) estimated from the NMFS trawl surveys

	Length Group (cm)																							
Year	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	43	46	49	52	55	58
1982	0.00	0.00	1.23	16.77	24.10	19.75	29.37	46.82	48.32	48.18	53.37	66.87	70.42	55.20	32.85	13.48	6.75	8.71	1.67	0.40	0.00	0.00	0.00	0.00
1983	0.00	0.48	11.91	36.92	24.91	43.47	55.95	53.01	45.10	50.33	55.24	61.04	76.61	78.66	70.04	32.20	15.53	9.07	1.57	0.47	0.00	0.00	0.00	0.00
1984	0.00	0.61	6.07	33.44	58.49	80.38	62.89	56.56	71.80	71.37	72.40	83.43	83.20	84.64	84.32	56.00	26.95	12.30	1.26	0.92	0.03	0.00	0.00	0.00
1985	0.00	1.18	1.24	7.94	21.60	33.11	52.72	78.33	67.73	50.09	49.00	53.25	54.64	56.40	52.35	34.41	23.56	14.47	4.18	1.01	0.00	0.00	0.00	0.00
1986	0.00	0.47	3.44	12.09	13.38	17.44	30.88	46.88	64.65	75.02	66.41	60.58	68.37	70.62	74.52	55.19	40.46	30.46	6.97	2.00	0.18	0.00	0.00	0.00
1987	0.00	0.00	4.26	18.41	26.98	39.89	40.57	48.68	45.24	56.28	66.52	70.32	71.67	70.27	78.82	60.34	46.75	35.05	13.75	2.78	0.10	0.00	0.00	0.00
1988	0.00	0.00	2.50	19.33	72.66	98.75	92.24	114.64	80.63	74.65	78.18	78.82	79.20	101.09	104.48	97.85	69.78	63.72	26.02	3.48	1.34	0.00	0.00	0.00
1989	0.00	0.14	15.55	43.40	28.12	39.99	104.40	103.79	109.92	77.05	62.33	67.97	78.15	68.05	85.35	91.01	67.13	65.48	26.59	7.98	0.81	0.00	0.00	0.00
1990	0.00	0.20	1.95	13.16	59.00	70.08	48.57	67.86	91.46	93.57	82.06	74.66	66.36	77.56	72.18	83.78	80.79	91.95	39.88	11.28	2.42	0.00	0.00	0.00
1991	0.00	0.84	5.00	4.75	6.97	31.83	69.33	95.63	94.66	104.16	99.36	89.17	68.35	77.35	86.47	76.83	107.87	124.83	44.33	14.63	0.96	0.00	0.00	0.00
1992	0.00	0.00	3.99	30.73	54.87	42.64	48.51	75.78	102.93	123.14	115.07	114.32	83.74	79.04	84.58	85.11	81.45	94.70	51.89	16.50	2.48	0.13	0.00	0.00
1993	0.04	0.53	4.80	9.93	19.37	50.29	59.06	46.11	70.87	95.05	97.50	109.18	106.75	85.77	73.98	67.04	58.95	95.20	49.32	15.80	2.88	0.09	0.00	0.00
1994	0.00	0.41	2.31	13.29	31.96	47.10	66.62	56.17	47.42	74.66	97.27	118.08	125.57	112.85	96.71	77.87	78.94	103.18	70.94	25.65	3.59	0.32	0.00	0.00
1995	0.00	0.00	1.18	5.24	15.94	30.57	38.90	54.44	50.61	49.62	62.06	80.36	97.65	92.04	80.90	67.28	59.77	69.60	50.84	16.61	5.56	0.25	0.00	0.00
1996	0.00	0.18	3.04	18.72	28.21	43.06	47.93	61.57	61.11	66.25	65.12	64.30	75.83	88.04	93.11	81.05	52.62	72.78	51.34	23.32	3.15	0.28	0.00	0.00
1997	0.00	0.49	1.61	6.57	14.30	21.96	29.35	36.26	41.09	47.46	59.36	63.51	80.61	94.61	112.36	109.09	98.04	129.84	108.43	33.09	7.92	0.61	0.00	0.00
1998	0.00	0.58	12.84	23.99	11.43	20.98	28.26	41.44	45.34	47.69	66.99	72.37	61.31	76.22	94.19	89.04	80.66	87.72	57.85	24.88	11.34	1.39	0.00	0.00
1999	0.00	0.14	2.12	5.82	14.45	15.77	14.68	19.89	28.42	34.79	40.97	40.77	43.54	49.23	64.20	59.79	45.34	42.79	27.76	15.04	7.70	0.95	0.17	0.00
2000	0.25	0.40	1.71	4.95	9.06	17.91	18.47	21.53	20.59	29.62	38.01	40.90	53.51	58.93	64.24	69.28	50.05	51.29	28.99	12.80	4.39	0.53	0.00	0.00
2001	0.16	0.41	3.25	5.06	8.55	15.44	29.09	46.11	48.49	39.58	39.80	59.62	66.61	78.40	88.21	82.83	59.78	62.02	38.83	18.80	4.30	0.86	0.07	0.00

Table 10. Estimated total biomass (ages 3+), female spawner biomass, and recruitment (age 3), with comparison to the 2000 SAFE estimates

	Spawning stock biomass (t)		Total biomass (t)		Recruitment (thousands)	
	Assessment		Assessment		Assessment	
	2001	2000	2001	2000	2001	2000
1977	65311.1	65538.3	227194	229565		
1978	61171.7	61397.7	249219	251985	179074	170181
1979	58209	58437.9	290029	292328	597397	559669
1980	58979.4	59256.6	340857	350480	706972	944349
1981	69519.1	70090.4	406862	405273	1322300	865743
1982	95417.1	96589.4	458190	455299	941226	980363
1983	129963	131817	534569	530695	1339020	1394580
1984	158964	161617	611331	600345	1370640	1222600
1985	185201	187860	663933	652434	490698	614671
1986	214167	214892	715510	702050	769511	691817
1987	244811	241851	767380	750382	1110880	1069740
1988	280053	274243	818046	798440	1197110	1162070
1989	312100	304792	854307	833911	885244	874994
1990	339399	330815	897161	873396	1043330	997652
1991	348064	339340	897867	871356	362549	271401
1992	357550	348188	896629	874157	507167	681006
1993	369442	359137	890830	864999	623039	482185
1994	380168	369214	878997	850651	635981	537987
1995	388974	377169	855431	826528	322793	309134
1996	385633	373469	827276	797011	450196	419204
1997	374645	362585	786227	754366	206765	201993
1998	358020	346657	742433	710281	384467	329751
1999	339155	325786	698009	660285	438230	291376
2000	321697	307305	655716	618284	293801	332540
2001	301404		612337		264979	

Table 11. Projections of spawning biomass, catch, fishing mortality rate, and catch for each of the several scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 141,930 t and 124,189 t, respectively.

Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	262402	262402	289671	289671	289671	289671	289671
2002	203715	203715	267432	270655	272566	259925	262402
2003	162124	162124	230638	249648	261622	191595	203714
2004	133399	133399	201317	231711	252014	145954	160648
2005	115612	115612	178338	216703	243835	116850	126341
2006	108670	108670	160787	204386	236959	102141	107186
2007	110235	110235	150147	196690	233311	97460.5	100244
2008	115817	115817	147711	195913	235735	100537	102043
2009	122896	122896	150220	198675	240566	107050	107777
2010	129552	129552	156060	204900	248731	114370	114660
2011	134666	134666	163100	212766	258558	120706	120772
2012	138245	138245	169739	220628	268396	125140	125109
2013	140841	140841	175379	227527	276974	127929	127867
2014	138292	138292	180459	234373	285804	129711	129651
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	0.0509811	0.0509811	0.0509809	0.0509806	0.0509809	0.0509812	0.0509839
2002	0.300318	0.300318	0.150159	0.05555	0	0.375421	0.300318
2003	0.300318	0.300318	0.150159	0.05555	0	0.375421	0.300318
2004	0.300318	0.300318	0.150159	0.05555	0	0.375421	0.375421
2005	0.281317	0.281317	0.150159	0.05555	0	0.305591	0.332019
2006	0.241699	0.241699	0.150159	0.05555	0	0.264636	0.278682
2007	0.226236	0.226236	0.149883	0.05555	0	0.251603	0.259352
2008	0.229455	0.229455	0.146941	0.05555	0	0.260112	0.264287
2009	0.240518	0.240518	0.145973	0.05555	0	0.277465	0.279452
2010	0.253569	0.253569	0.146648	0.05555	0	0.296154	0.296935
2011	0.264354	0.264354	0.14761	0.05555	0	0.311533	0.311717
2012	0.271759	0.271759	0.148296	0.05555	0	0.32145	0.321396
2013	0.276264	0.276264	0.148838	0.05555	0	0.327417	0.327292
2014	0.279302	0.279302	0.149298	0.05555	0	0.33109	0.330969
Catch	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2001	16131.4	16131.4	16131.4	16131.3	16131.4	16131.5	16132.3
2002	82572	82572	43360	16554.7	0	100770	82571.9
2003	65488.3	65488.3	37872	15388	0	76238.6	65488.2
2004	52910.9	52910.9	33332.6	14344.5	0	59173.2	64635.3
2005	41273.5	41273.5	29643.9	13428.4	0	39452.5	45897.3
2006	31113.1	31113.1	26814.5	12677	0	30173.4	33219.4
2007	27054.2	27054.2	24753.7	12095.1	0	26943.9	28563.4
2008	26860.8	26860.8	23257.8	11783.6	0	27608	28517.6
2009	28470.4	28470.4	22779.7	11646	0	30110	30592.5
2010	31044.1	31044.1	23224.9	11771.9	0	33466.4	33696.3
2011	33658.3	33658.3	24089.3	12066.5	0	36698.9	36785.6
2012	35886.4	35886.4	25082.1	12451.8	0	39225.1	39240.3
2013	37554.8	37554.8	26030.5	12839	0	41005.3	40989.8
2014	38858.1	38858.1	26950.8	13253.4	0	42269.6	42246.4

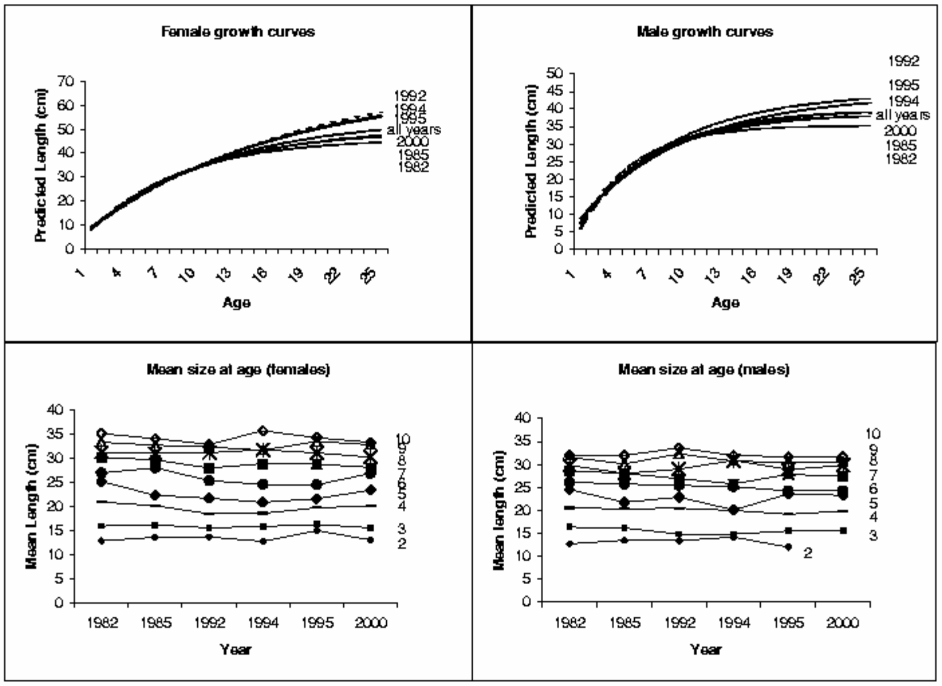


Figure 1. Estimated growth curves and mean length at age for Bering Sea/Aleutian Islands flathead sole.

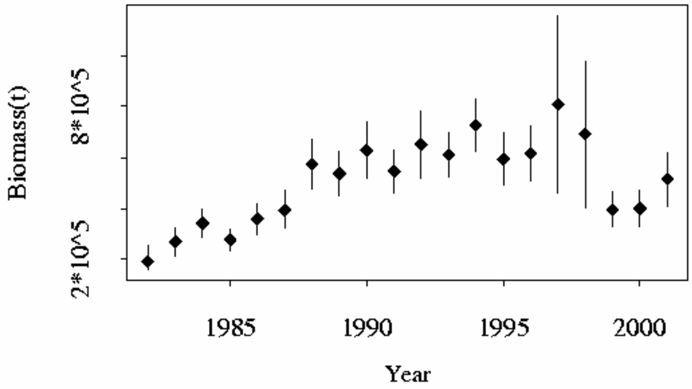


Figure 2. Estimated survey biomass and 95% CIs

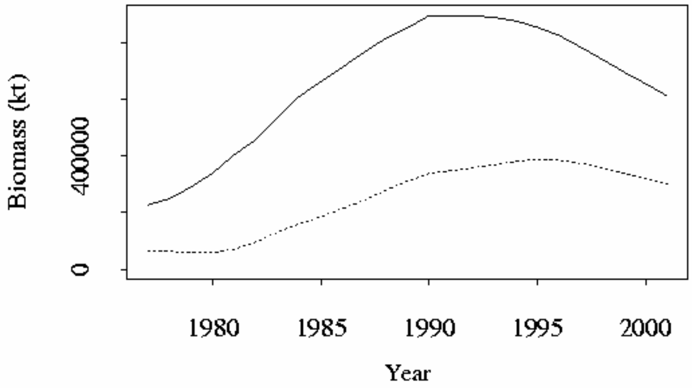


Figure 3. Estimated total (solid line) and spawner (dashed line) biomass

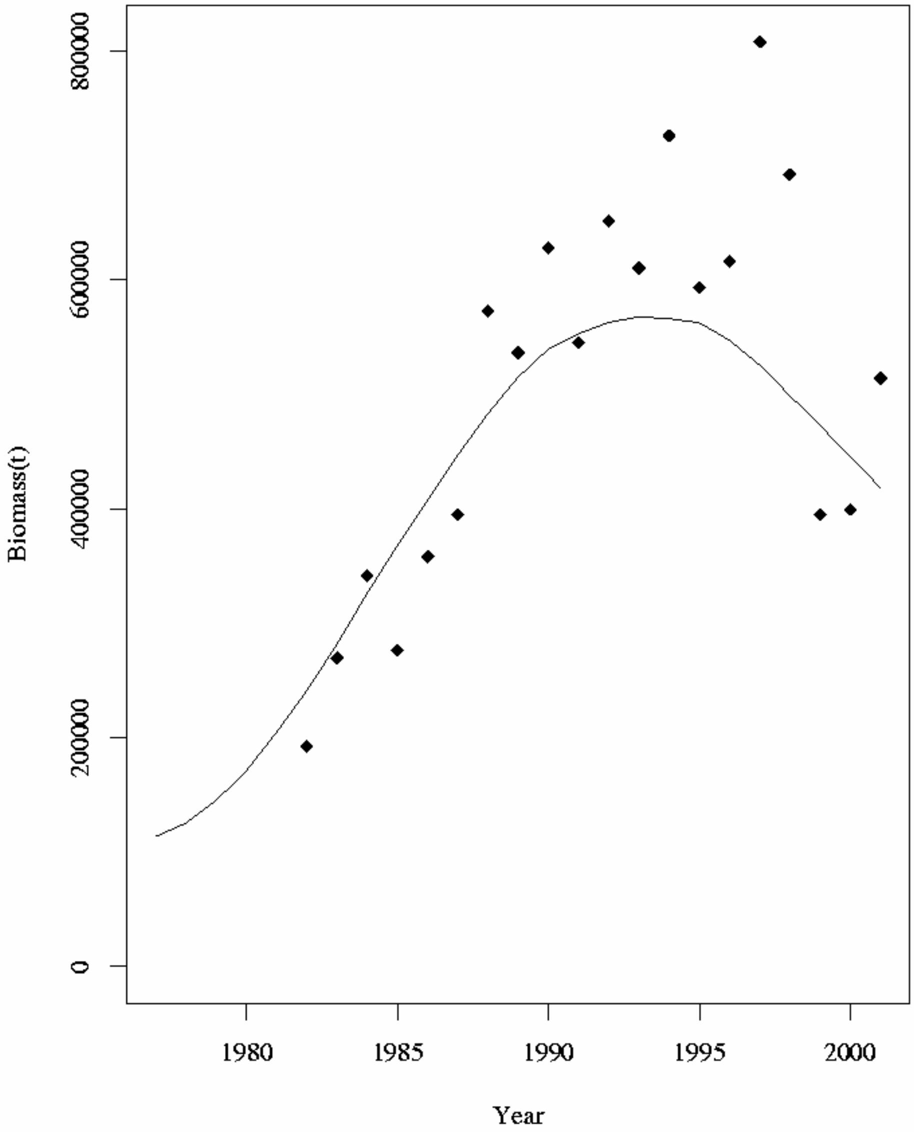


Figure 4. Estimated survey biomass of flathead sole
with observed survey biomass

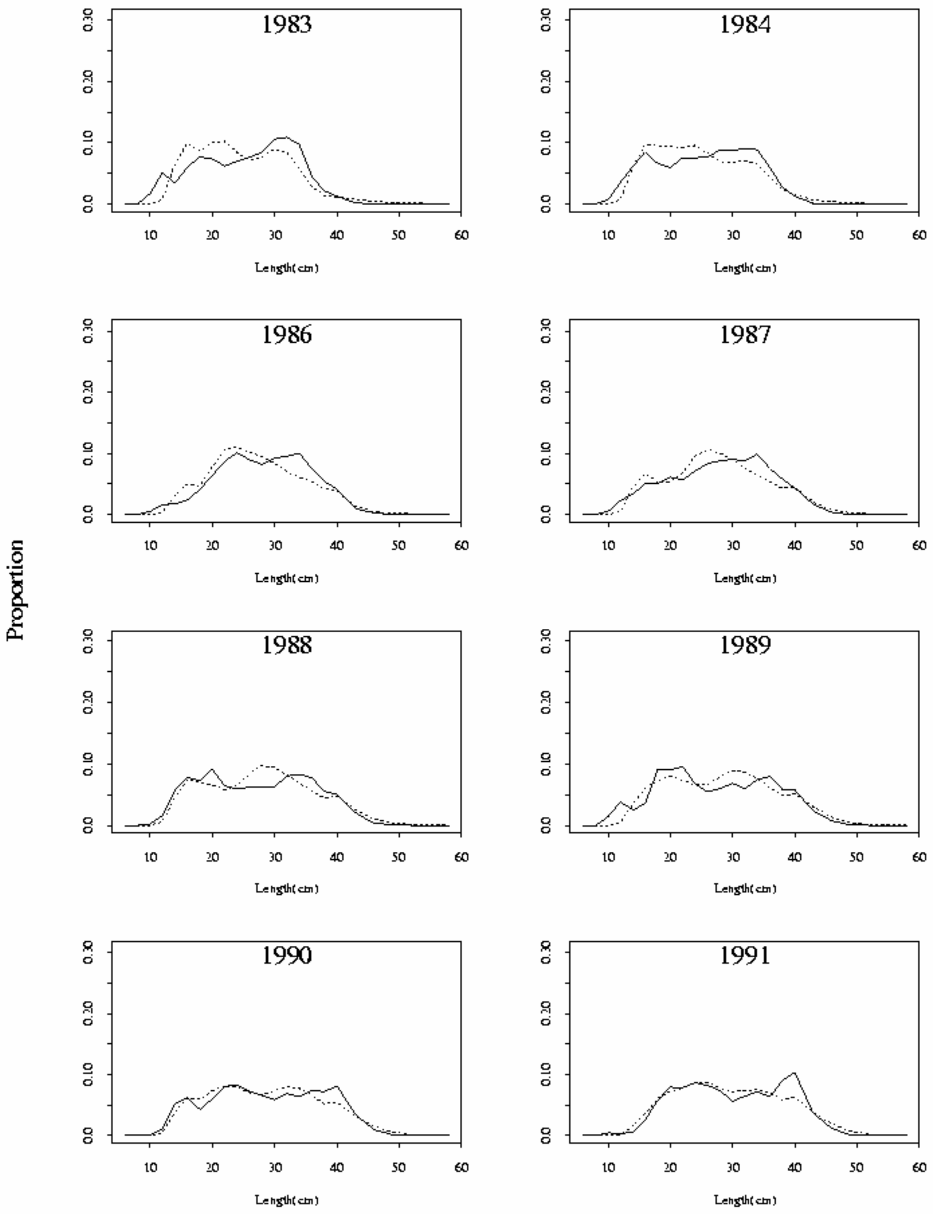


Figure 5. Female survey length composition by year (solid line = observed, dotted line = predicted)

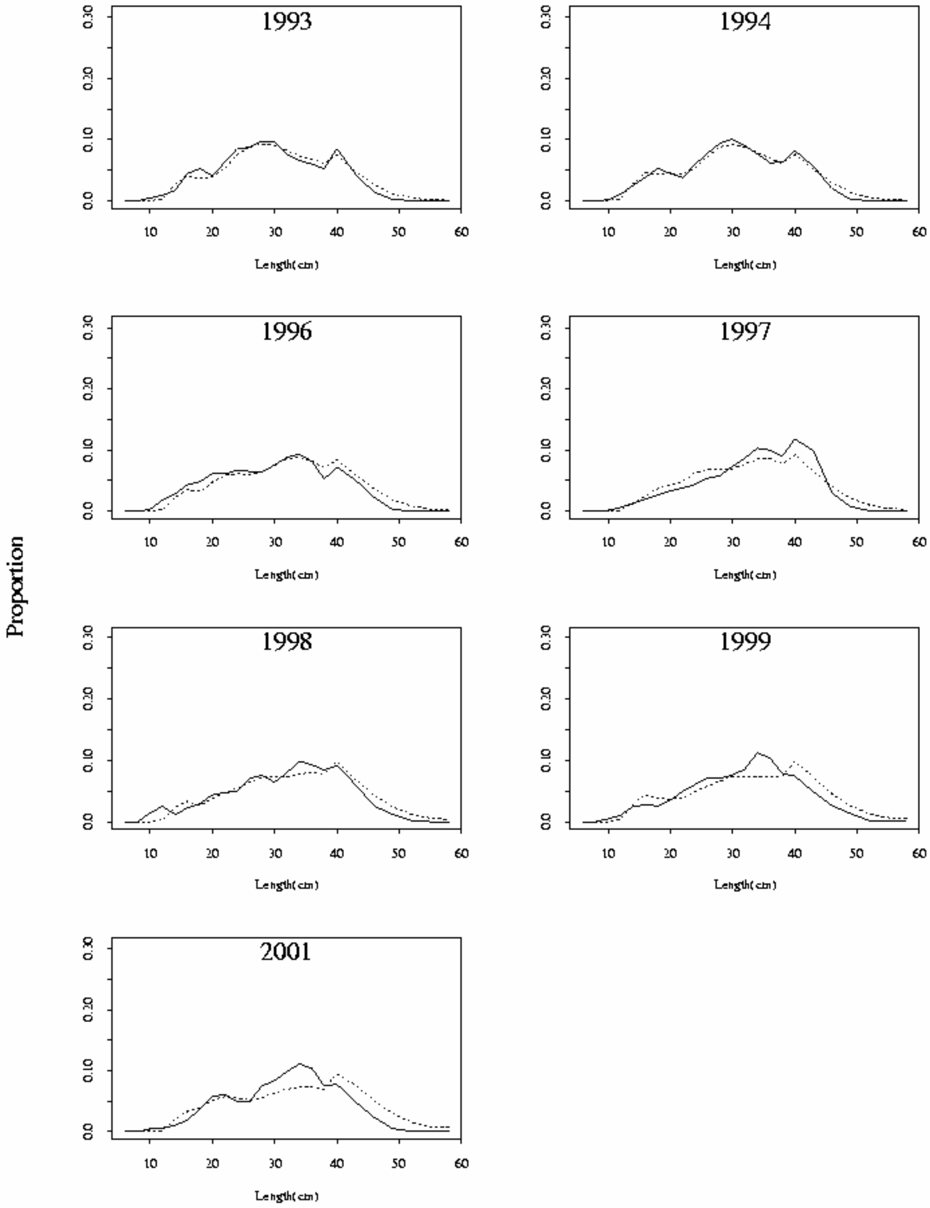


Figure 5. Female survey length composition by year (solid line = observed, dotted line = predicted)

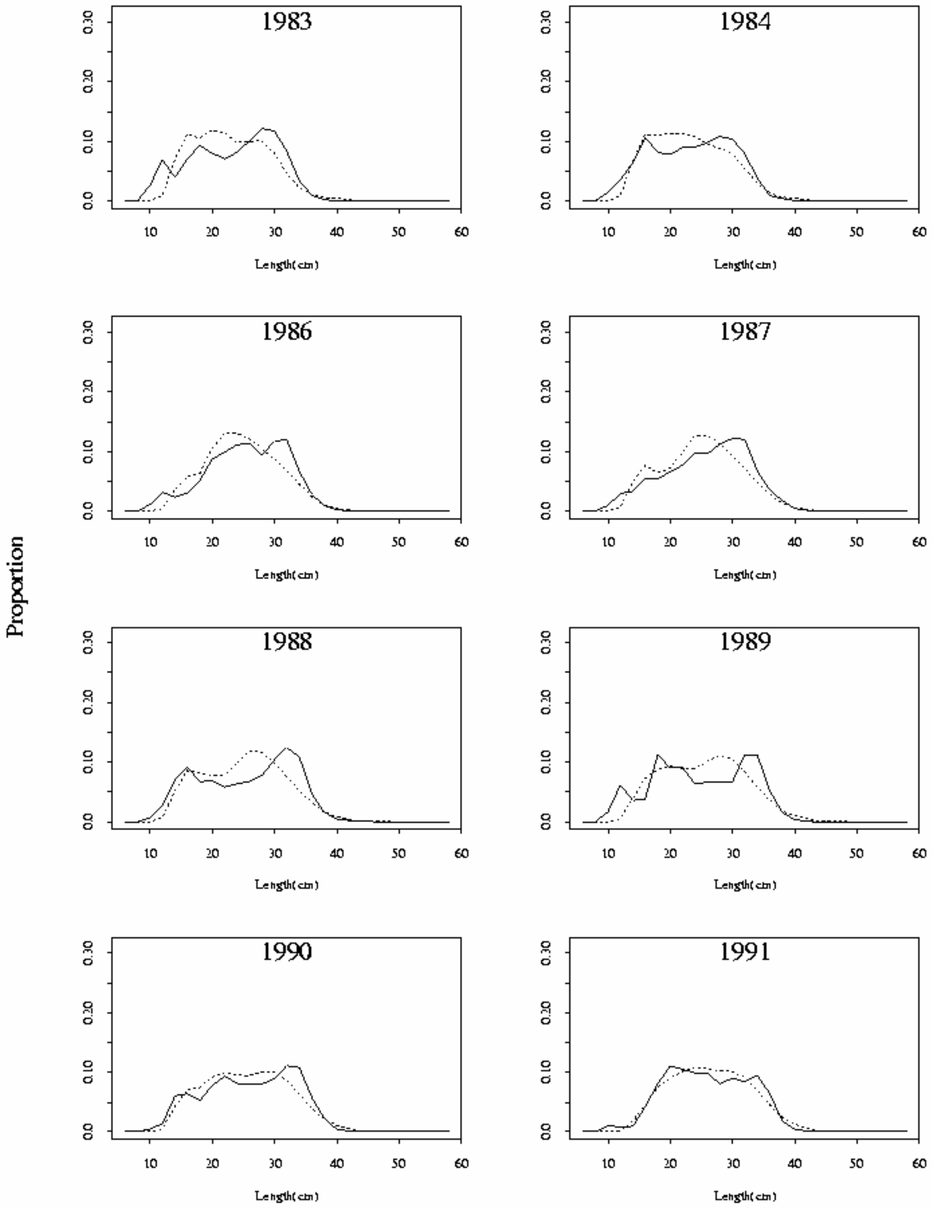


Figure 6. Male survey length composition by year (solid line = observed, dotted line = predicted)

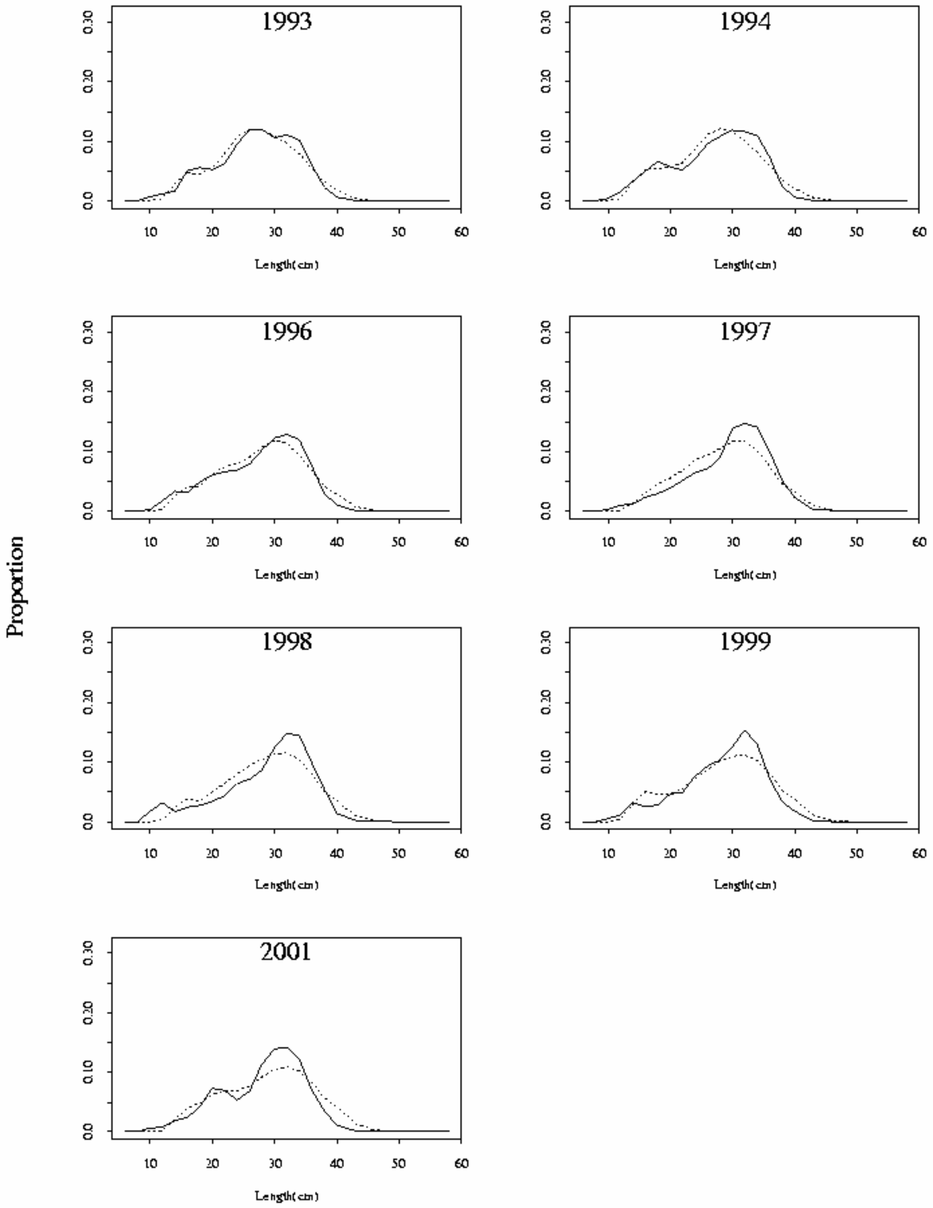


Figure 6. Male survey length composition by year (solid line = observed, dotted line = predicted)

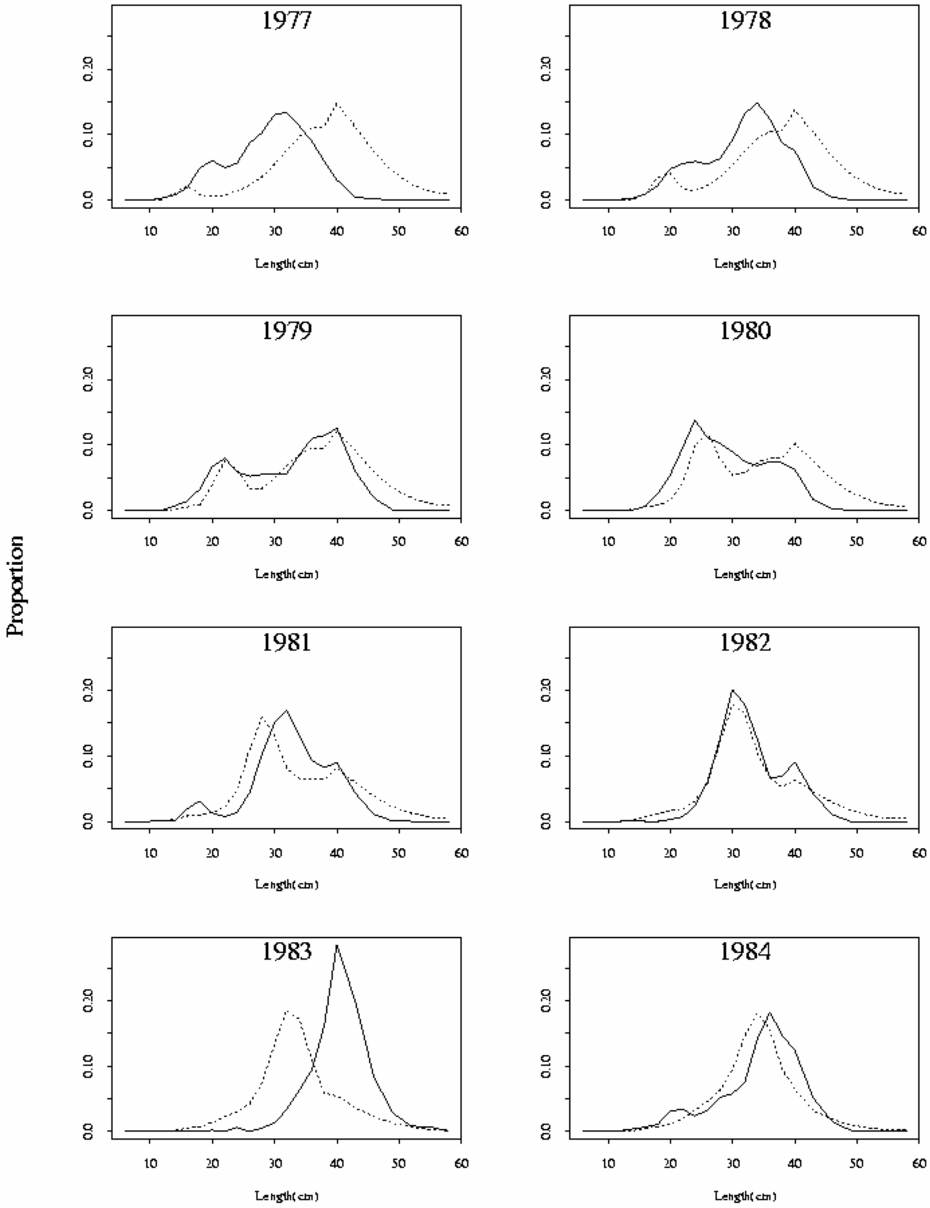


Figure 7. Female fishery length composition by year (solid line = observed, dotted line = predicted)

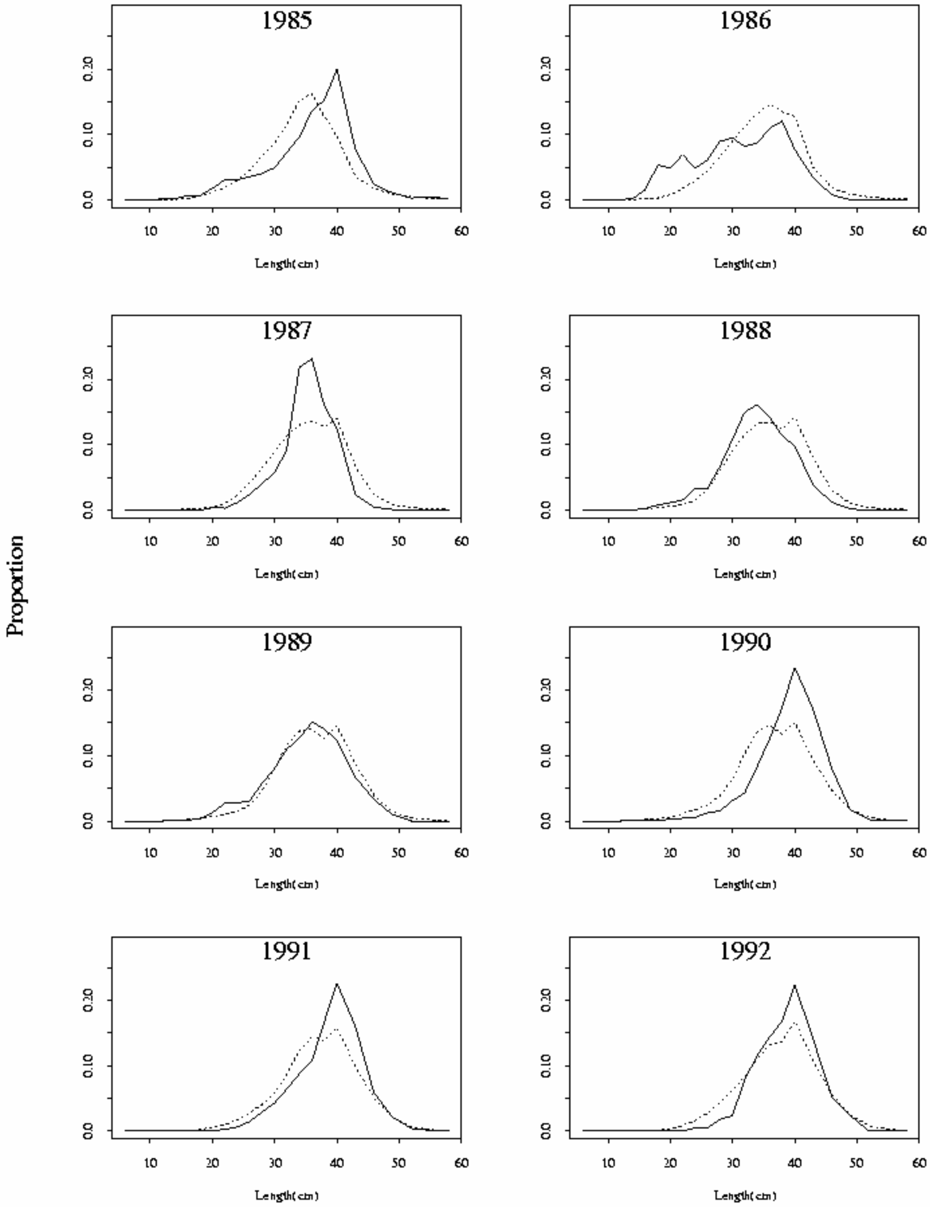


Figure 7. Female fishery length composition by year (solid line = observed, dotted line = predicted)

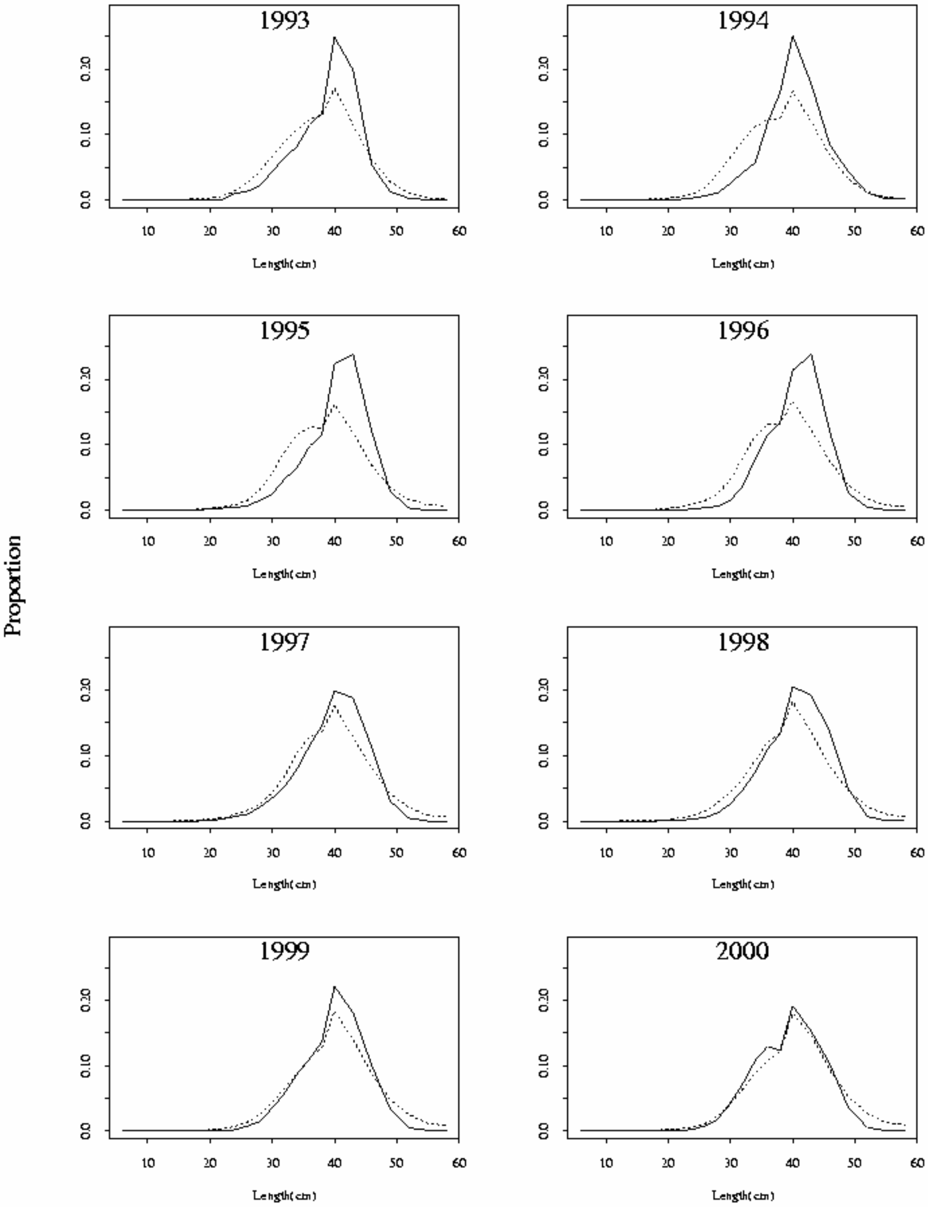


Figure 7. Female fishery length composition by year (solid line = observed, dotted line = predicted)

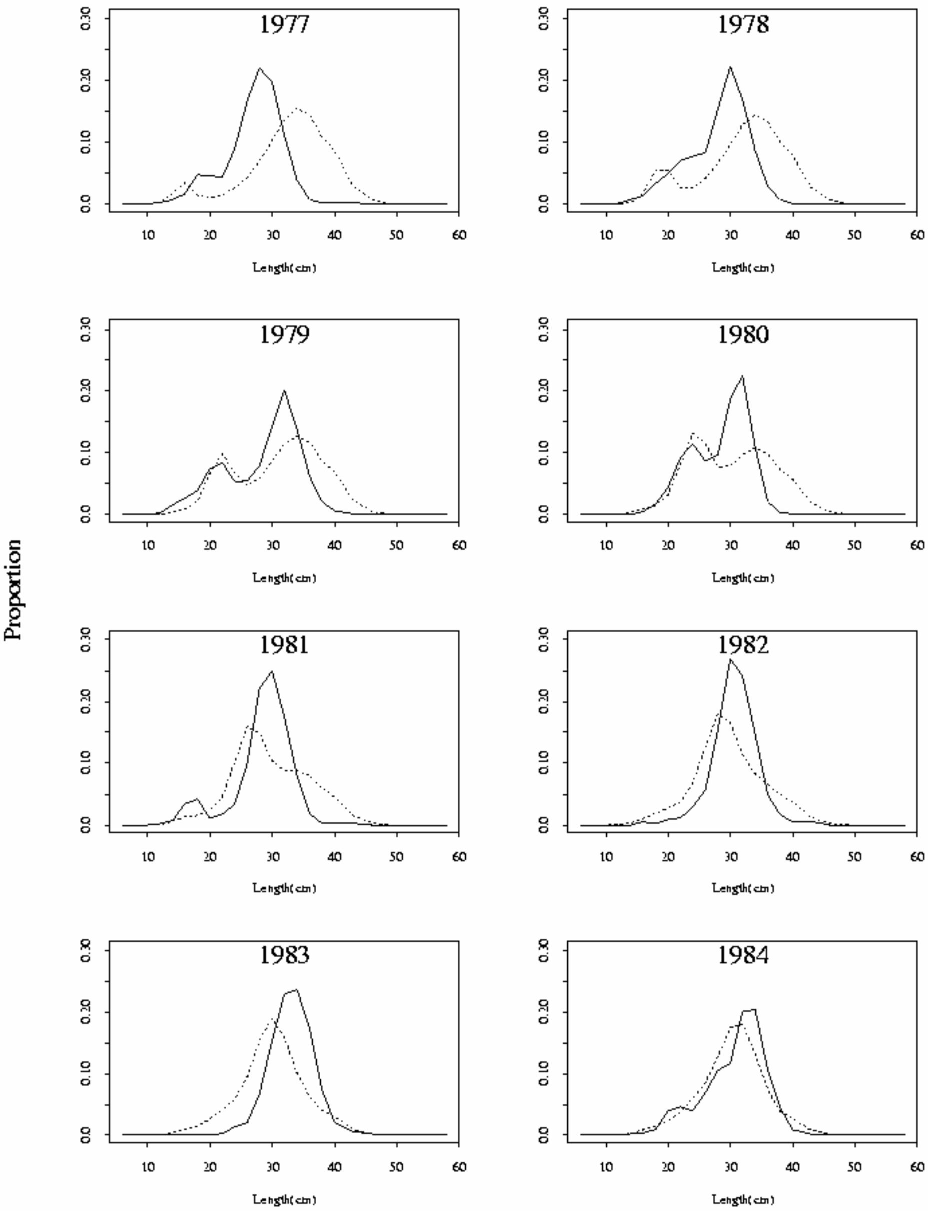
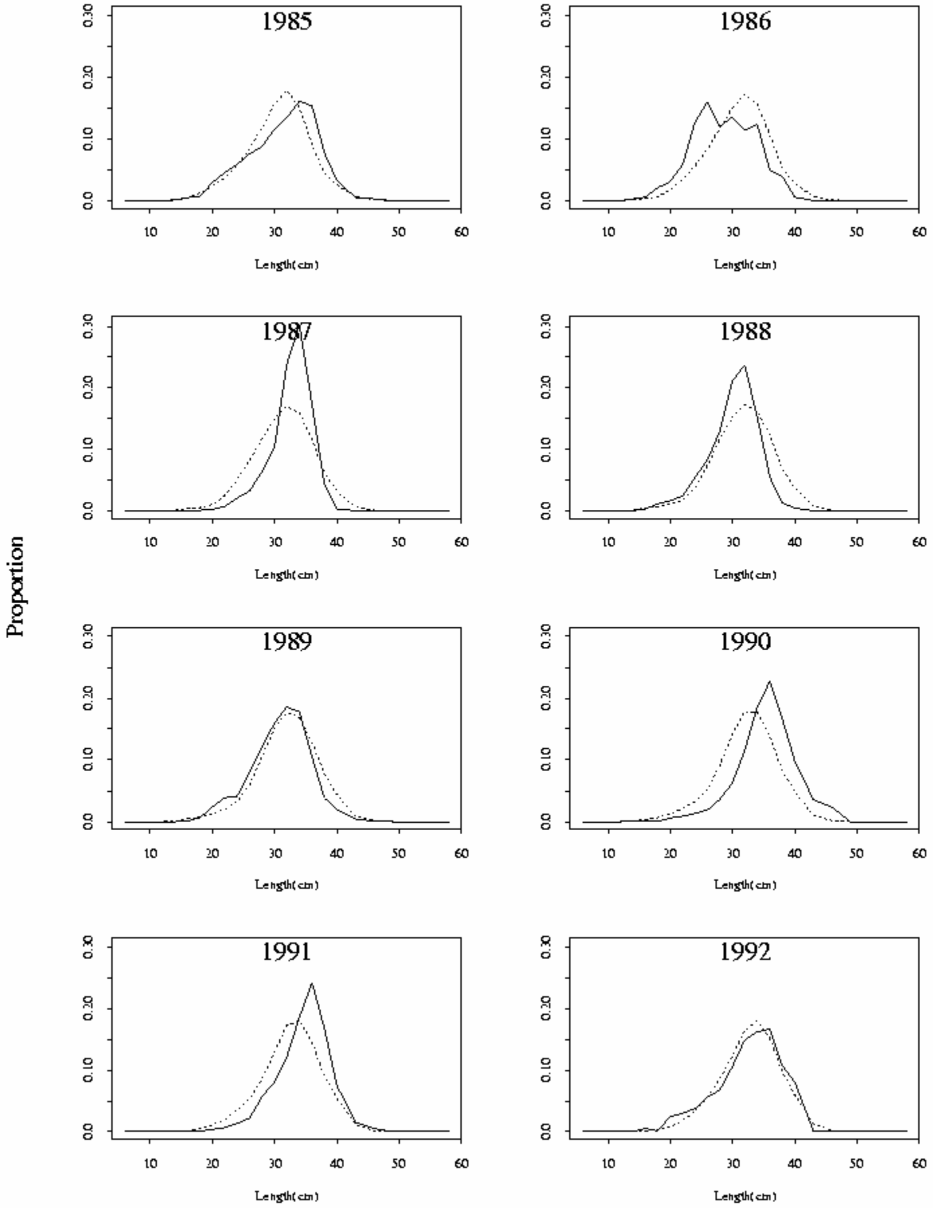


Figure 8. Male fishery length composition by year (solid line = observed, dotted line = predicted)



1985

1986

1987

1988

1989

1990

1991

1992

Figure 8. Male fishery length composition by year (solid line = observed, dotted line = predicted)

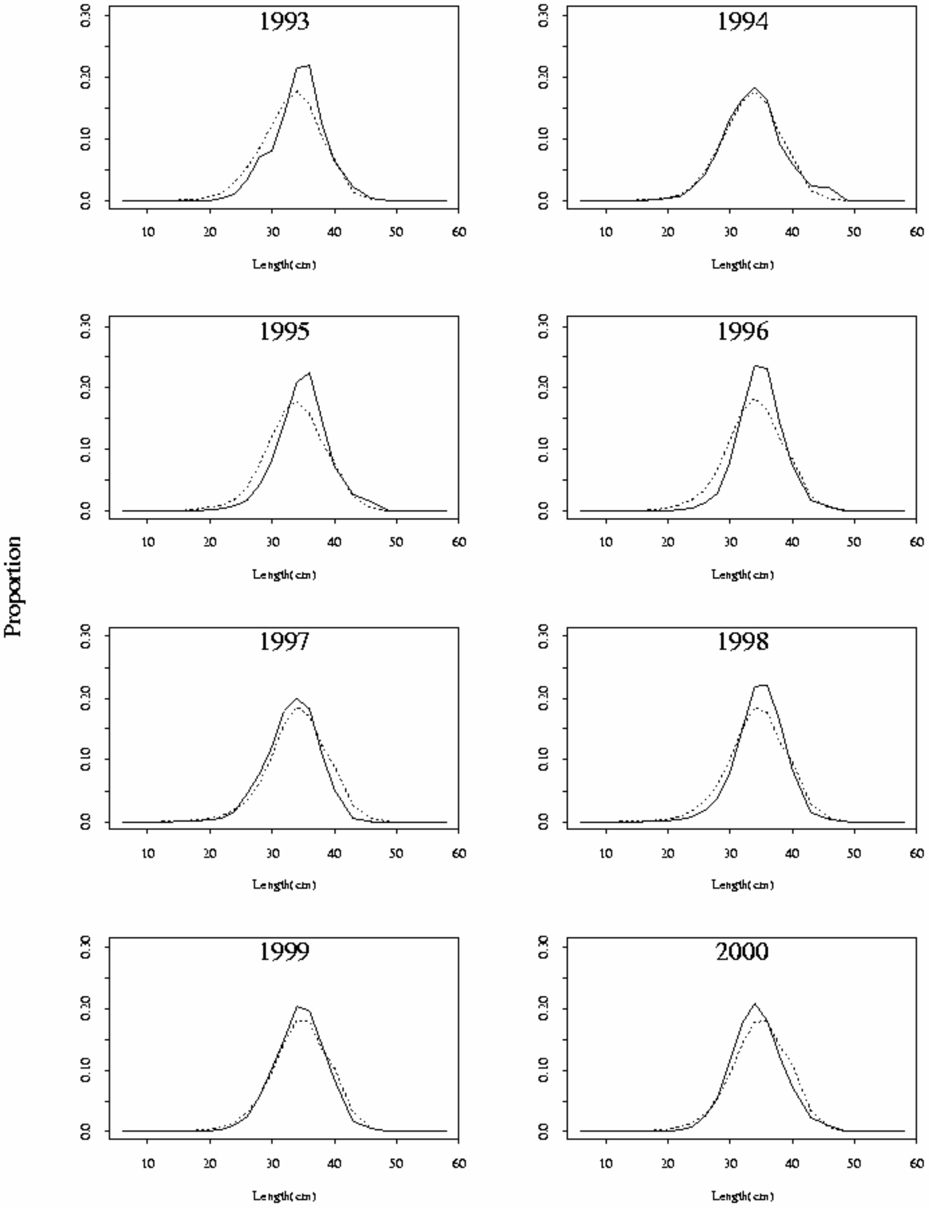


Figure 8. Male fishery length composition by year (solid line = observed, dotted line = predicted)

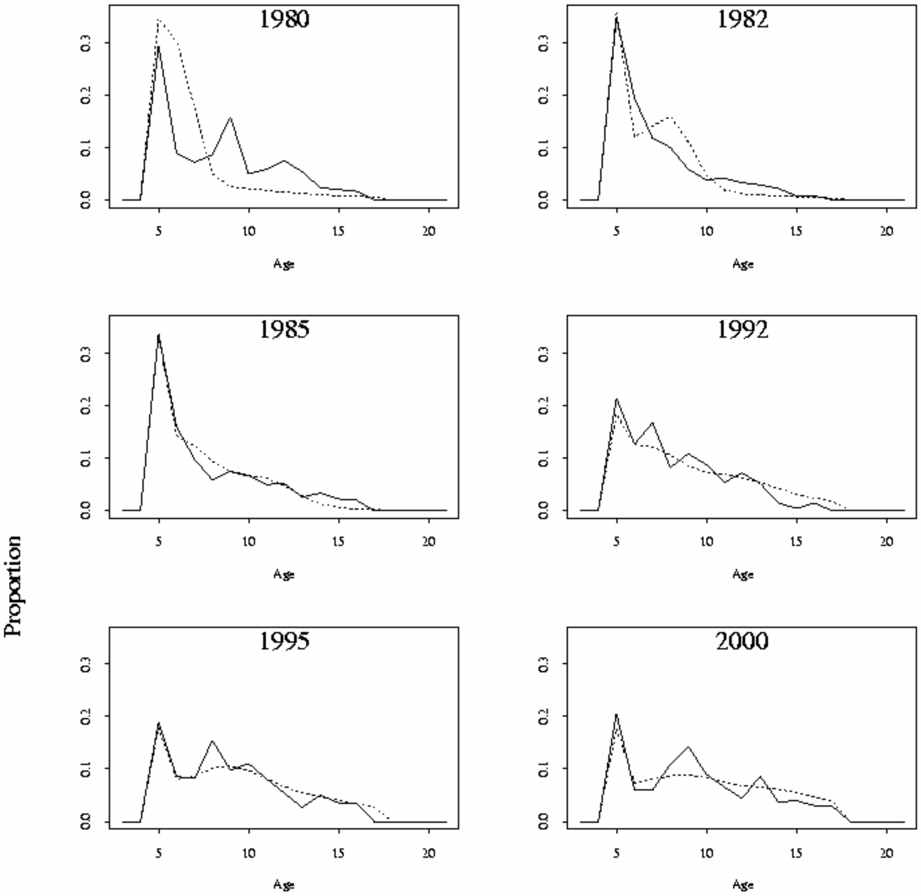


Figure 9. Survey age composition by year (solid line = observed, dotted line = predicted)

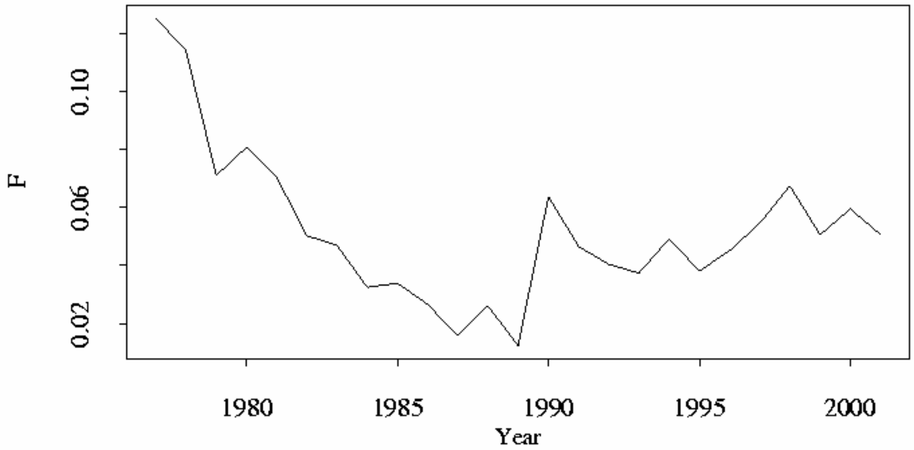


Figure 10. Estimated fishing mortality rate of flathead sole

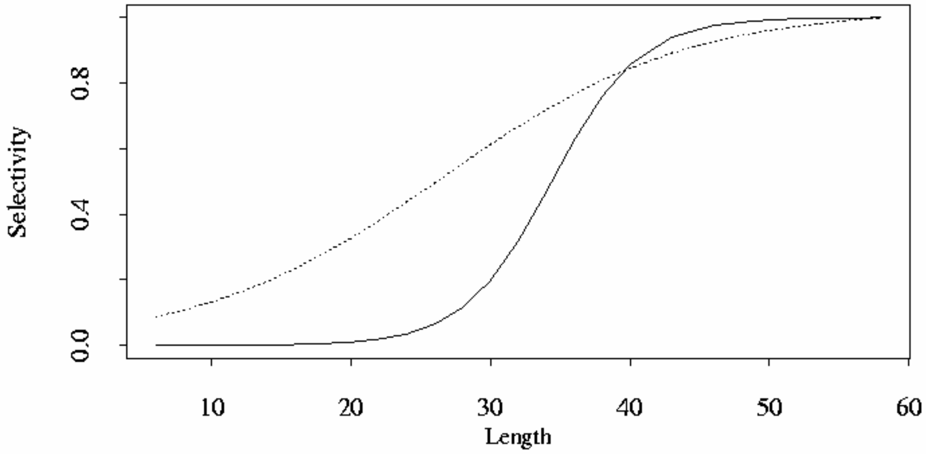


Figure 11. Estimated fishery (solid line) and survey (dashed line) selectivity curve by length

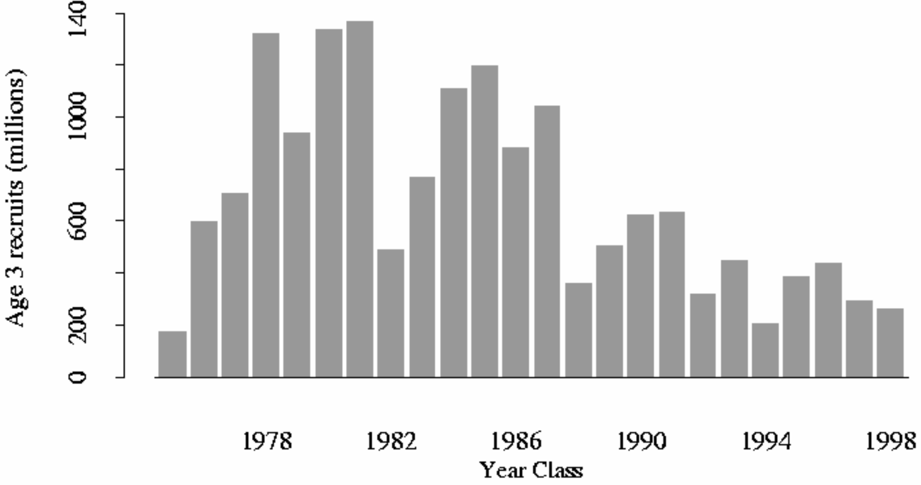


Figure 12. Estimated recruitment (age 3) of flathead sole

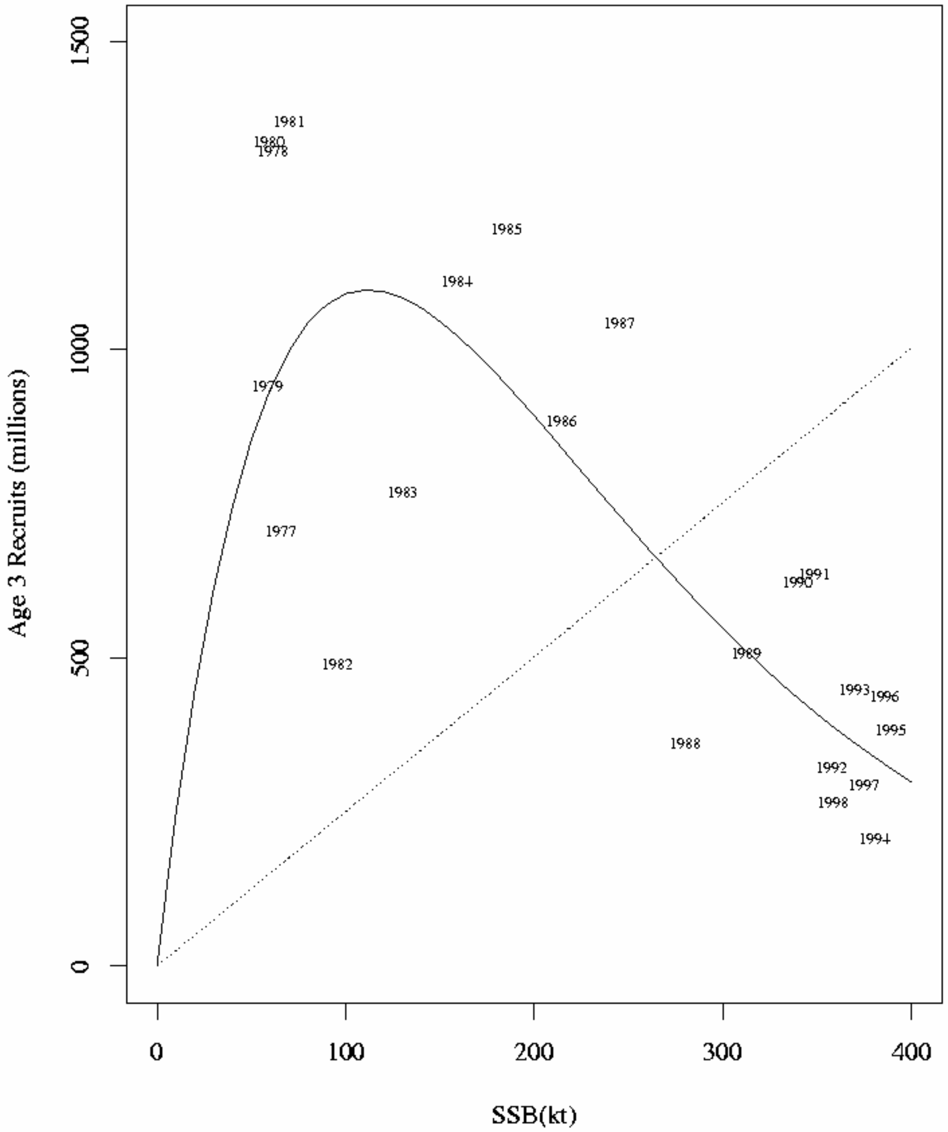
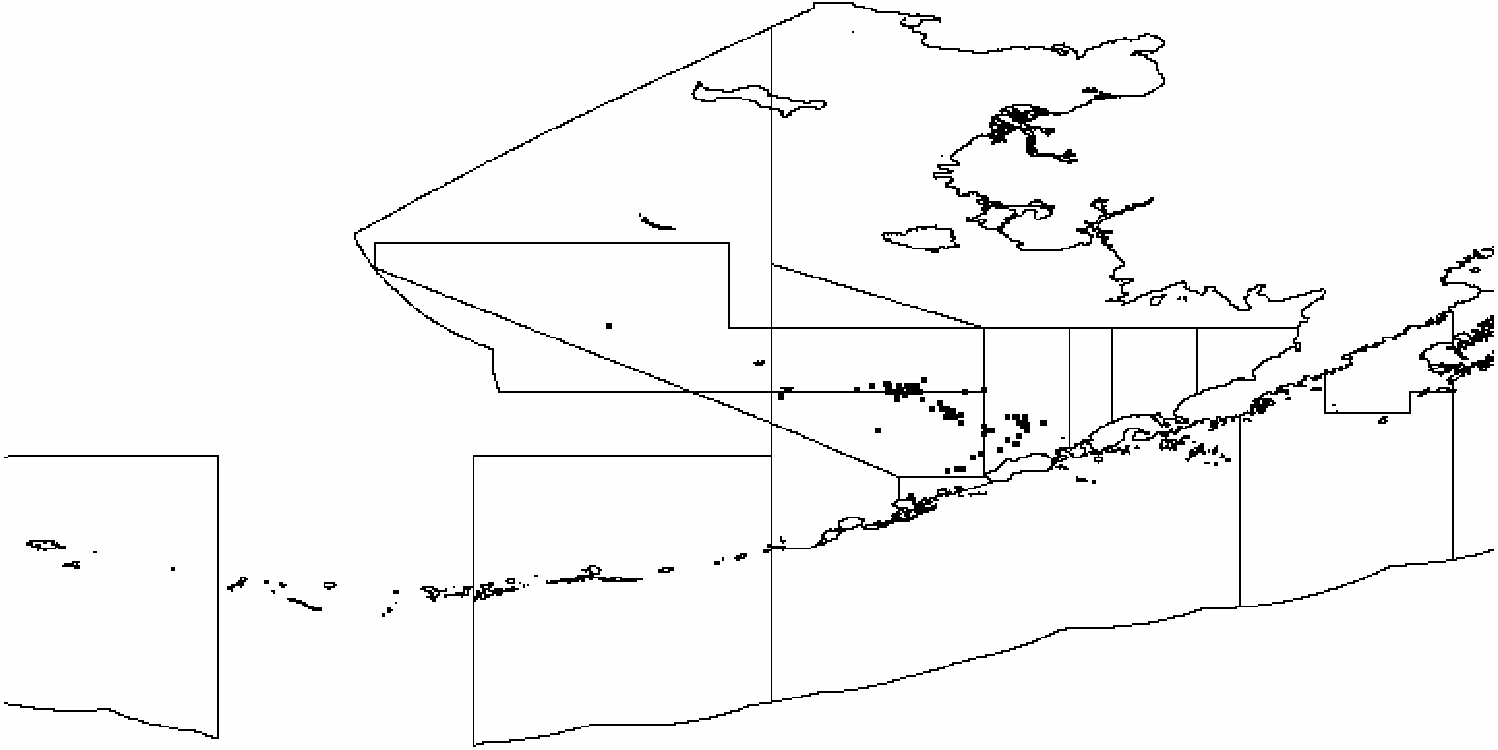


Figure 13. Estimated female SSB and recruitment of flathead sole, labeled by year class, with a fitted Ricker curve (solid line).
The replacement line is based on an F40% value of 0.30

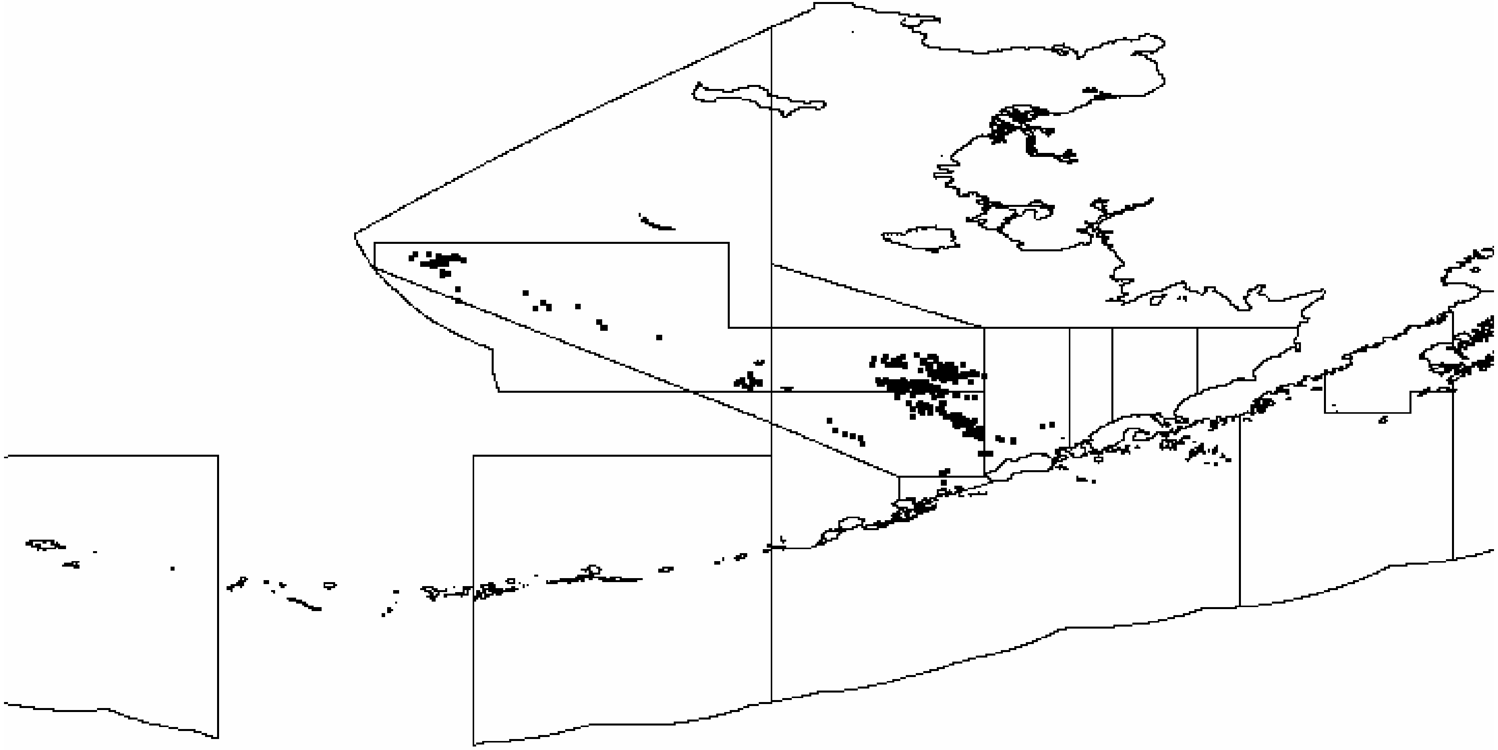
Appendix

Figures showing the distribution of flathead sole hauls sampled by fishery observers in 2000, by quarters. Flathead sole hauls are defined as having at least 20% of the total catch consisting of flathead sol

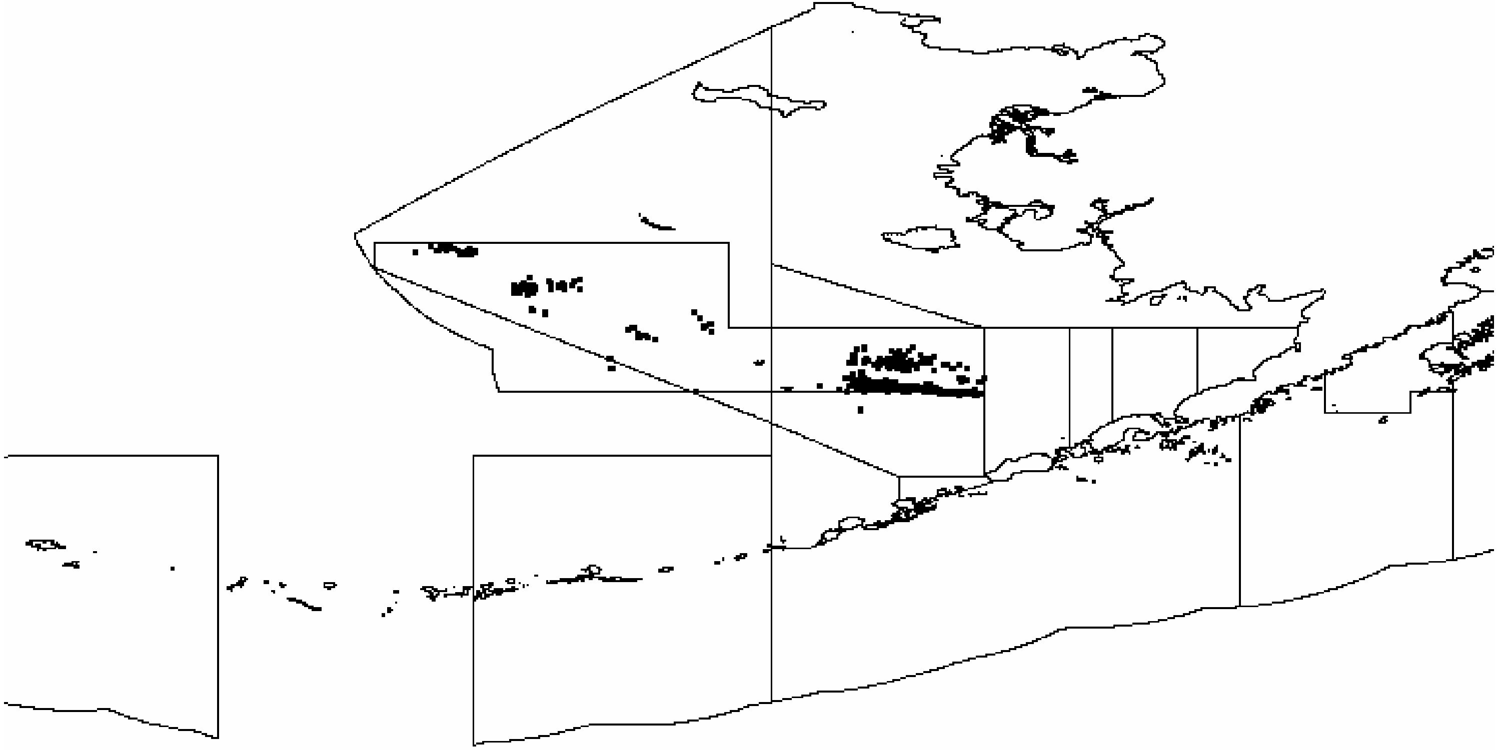


Flathead sole, Quarter 1, 2000

Flathead sole, Quarter 2, 2000



Flathead sole, Quarter 3, 2000



Flathead sole, Quarter 4, 2000