CHAPTER 8: FLATHEAD SOLE

by

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Executive Summary

The following changes have been made to this assessment relative to the November 2004 SAFE:

Changes in the Input Data

1) The 2004 catch data was updated and the catch through 1 October, 2005 was included in the assessment.
2) The 2004 fishery length compositions were included in the assessment.
3) The 2004 survey biomass estimate was updated to incorporate the 2004 AI trawl survey biomass.
4) The age composition from the 2004 EBS trawl survey was added to the assessment.
5) Estimated survey biomass and standard error from the 2005 EBS trawl survey, as well as the length composition of the survey catch, were included in the assessment.

Changes in the Assessment Model

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

Changes in Assessment Results

1) The recommended ABC, based on an $F_{40\%}$ (0.296) harvest level, is 59,794 t for 2006 and 56,569 t for 2007.
2) The OFL, based on an $F_{35\%}$ (0.362) harvest level, is 71,764 t for 2006 and 67,907 t for 2007.
3) Projected female spawning biomass is 203,452 t for 2006 and 192,001 t for 2007.
4) Projected total biomass (age 3+) is 636,298 t for 2006 and 637,350 t in 2007.

A summary of the 2005 assessment recommended ABCs relative to the 2004 recommendations is as follows:

	2005 Assessment recommendations for the 2006 harvest	2004 Assessment recommendations for the 2005 harvest
ABC	59,794 t	58,458 t
Overfishing	71,764 t	70,189 t
F_{ABC}	$F_{40\%} = 0.30$	$F_{40\%} = 0.30$
$F_{overfishing}$	$F_{35\%} = 0.36$	$F_{35\%} = 0.37$

SSC Comments Specific to the Flathead Sole Assessment

No comments specific to flathead sole were made.

SSC Comments on Assessments in General

SSC comment: The SSC requested that "stock assessment authors exert more effort to address each item contained in" a previously-defined list of items to be included in each SAFE chapter at its December 2004 meeting

Author response: We have endeavored to incorporate the list of requested items in the current SAFE chapter.

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. The growth and distribution differences between the species were described by Walters and Wilderbuer (1997), who illustrated the possible ramifications of combining demographic information from the two species Bering flounder exhibited slower growth and smaller maximum size when compared with flathead sole, and fish of the same size could possibly be 3 years different in age for the two species. Although Bering flounder typically represent less than 2% of the total survey biomass for *Hippoglossoides* sp, combining the two species increases the uncertainty in estimates of life-history and population parameters. However, we feel there has been increasing accuracy during recent years. 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 17,317 t from 1990-2004 (Table 8.1).

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 (Tables 8.2-3). In 2005, as with most previous years, seasonal closures due to halibut bycatch constraints occurred in the first and second quarters, and the annual halibut allowance was reached in late summer. However, the fishery was not placed on bycatch or prohibited species status in 2005, as had occurred in 2004.

Substantial amounts of flathead sole are discarded overboard in various eastern Bering Sea target fisheries (Table 8.3). From the catch accounting system data, in 2003 approximately 28% of the catch was discarded, with 33% of the discards coming in the Pacific cod fishery, 23% in the flathead sole fishery, and 21% in the yellowfin sole fishery. The overall discard rate increased in 2004 to 31%, but decreased in 2005 to 24%.

The spatial distribution of annual flathead sole catch by bottom trawl gear in the Bering Sea is shown in Figure 8.1 for 2003-2005. Catches occur consistently in four principal areas on the shelf: an eastward-stretching band north of Unimak Island, east of the Pribilof Canyon on the shelf, northwest of the Pribilof Canyon 20-40 km inshore of the shelf break, and near the shelf edge east of St. Matthew Island.

In February 2006, the NPFMC will take final action on an amendment designed to address bycatch and non-AFA groundfish (Amendment 80). This amendment will allow a more rational use of bycatch allocations across fisheries and sectors. The implications of this action on the catch of flathead sole are difficult to predict. Fishing sectors may be able to fully utilize more valuable flatfish by reducing bycatch of flathead sole. Alternatively, more rational use of PSC limits may allow flatfish seasons to remain open, enabling full utilization of the flathead TAC.

Data

Fishery Catch and Catch-at-Age Data

This assessment uses fishery catches from 1977 through 1 October, 2005 (Table 8.1), estimates of the fraction of animals caught annually by length group and sex for the years 1977-1999 and 2002-2004 (Table 8.4), and estimates of the fraction of animals caught annually by age class for 2000 and 2001 (Table 8.5). The number of age and length samples from the fishery are shown in Table 8.6.

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. Bottom trawl surveys are conducted annually by NOAA Fisheries on the shelf in the Eastern Bering Sea using a fixed grid of stations. Survey data is also available from triennial/biennial surveys conducted by NOAA Fisheries in the Aleutian Islands (1980, ’83, ’86, ’91, ’94, ’97, 2000, ’02, and ’04).

This assessment uses survey estimates of total biomass for the years 1982-2005 (Figure 8.2 and Tables 8.7). Although surveys were conducted prior to 1982, the survey gear changed after 1981 and, as in previous assessments (Spencer et al. 2004), only the data from 1982 to the present are used. Additionally, a linear regression was used to predict the Aleutian Islands biomass in years in which an Aleutian Islands survey was not conducted. Since the early 1980s, estimated *Hippoglossoides* sp. biomass has approximately quadrupled to the 1997 peak estimate of 819,725 t (Figure 8.2). However, estimated biomass declined to 401,457 t in 1999 before increasing to 629,929 t in the 2004 survey. The estimated biomass level based on the 2005 survey was 620,381 t, a 2% decrease from 2004.

Survey length compositions by sex, the fraction of animals caught by length bin, are used for 1984-91, 1993-94, 1996-99, 2001-02 and 2005 (Table 8.8). Although survey length compositions are available from 1982-2005 without break, we do not use length compositions from the same year that age composition data is available, as this would be “double counting”. Survey age compositions by sex, the fraction of animals caught by age class, are used for 1982-841, 1992, 1995, 2000 and 2003-04 (Table 8.9). Sample sizes are shown in Table 8.10.

Assessments for other BSAI flatfish identified a relationship between bottom temperature and survey catchability (Wilderbuer et al. 2002). Bottom temperatures were hypothesized to affect survey catchability by affecting either stock distributions and/or the activity level of flatfish. The spatial distribution of flathead sole has been shown to shift location in conjunction with shifts in the location of the cold pool (Figure 8.3). This relationship was investigated in the previous assessment for flathead sole (Spencer et al., 2004) by using the annual temperature anomalies from data collected at all survey stations as a covariate of survey selectivity. Model results from that assessment indicated positive utility for this approach, and this approach is applied here, as well. Mean bottom temperatures from the Eastern Bering Sea shelf survey used in this assessment are shown in Figure 8.4 and Table 8.11.

Length, Weight and Age Information

Length, weight and age information were taken from the previous assessment (Spencer et al., 2004). In that assessment, sex-specific length-at-age curves were estimated from survey data using a procedure designed to reduce potential sampling-induced biases. Mean lengths-at-age had different temporal trends, so sex-specific von Bertalanffy growth curves were fit to mean length-at-age data using all available years (1982, '85, '92, '94, '95 and 2000; Figure 8.5). The parameters values are given in the following table:

	von Bertalanffy growth parameters		
Sex	t_0	L_∞	K
Male	-0.27	37.03	0.19
Female	-1.24	50.35	0.10

The L_∞ estimates of 37 cm and 50 cm for males and females, respectively, are somewhat lower than those obtained in previous assessments that used a potentially biased approach (40 cm and 55 cm, respectively; Spencer et al., 2003).

A length–weight relationship of the form $W = aL^b$ was fit to survey data from 1982-2004, with parameter estimates $a = 0.00326$ and $b = 3.3$ applying to both sexes (weight in g, length in cm). Application of the length-weight relationship to the predicted size at age from the von Bertalanffy relationships yielded weight-at-age relationships (Figure 8.6).

In summary, the data available for flathead sole are

1) Total catch weight, 1982-2005;
2) Fishery length composition, 1982-99, 2002-04;
3) Fishery age composition, 2000-01;
4) Survey biomass and standard error, 1982-2005;
5) Survey age composition 1982, 1985, 1992, 1995, 2000, and 2003-04;
6) Survey length composition, 1983-84,1986-91,1993-94,1996-99, 2001-02, and 2005.
7) Survey bottom temperature anomalies, 1982-2005.

Analytical Approach

Model Structure

The assessment model has a length-based formulation, which is underlain 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 is 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 is modeled as

$$N_{s,t,a} = N_{s,t-1,a-1} e^{-Z_{s,t-1,a-1}} \qquad 4 \le a < A, \quad 1977 \le t \le T$$

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 (2005). The numbers at age A are a "pooled" group consisting of fish of age A and older, and are estimated as

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

Numbers-at-age in the first year are modeled to be in equilibrium with an historical catch of 1500 t, requiring estimation of an historic recruitment parameter (R_{hist}) and an historic fishing mortality rate (f_{hist}).

Recruitment is taken as the number of age-3 fish entering the population. Recruits are modeled as

$$R_t = f(S_{t-a_r})e^{v_t}$$

where R is age 3 recruits, $f(S)$ is the form of the stock-recruitment function, S is spawning stock size, υ is random error, and a_r is the age of recruitment. The number of recruits is divided equally between males and females.

The efficacy of estimating productivity directly from the stock-recruitment data (as opposed to using an SPR proxy) was examined in the previous assessment by comparing results from fitting either the Ricker or Beverton-Holt forms of stock-recruit curves within the model (Spencer et al. 2004). Spencer et al. (2004) found that the Ricker form yielded a better fit to the data, and that form is used in this assessment. The functional form used for the Ricker stock recruitment curve is

$$R = \alpha\, S\, e^{-\beta S}$$

where α and β are parameters corresponding to density-dependent and density-independent processes, respectively. A convenient reparameterization expresses the original stock-recruitment curve as function of R_0 (the recruitment associated with and unfished stock, or S_0) and the dimensionless steepness parameter h (the proportion of R_0 attained when the stock size is 20% of S_0. For the Ricker curve, this reparameterization is achieved by the following substitutions for α and β:

$$\alpha = \frac{(5h)^{\frac{5}{4}}}{\varphi} \qquad \text{and} \qquad \beta = \frac{5\ln(5h)}{4\varphi R_0}$$

where φ is the spawner-per-recruit associated with no fishing, which is a constant dependent upon the size at age, proportion mature at age, and natural mortality. Wildebuer et al. (2002) found that the density dependence implicit in the Ricker model was statistically-significant for flathead sole in the Bering Sea when they fit stock-recruit models that included environmental terms. However, they also found that wind-driven advection to favorable nursery grounds corresponded to years of above average recruitment, and these years coincided with years of low spawning stock biomass. Thus, potential physical mechanisms influencing recruitment strength are confounded with potential density dependent mechanisms in the time series data for flathead sole. Consequently, although it is possible to estimate F_{msy} once a spawner-recruit relationship is given, we do not presently consider this estimate reliable given the confounding of competing mechanisms to drive recruitment success. As a result, flathead sole will remain in Tier 3 for setting ABC and status determination.

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, is 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 are 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 are 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 is 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.

The effect of temperature on survey catchability is modeled as

$$qsurv_t = e^{\alpha_q + \beta_q temp_t - \beta_q{}^2 \sigma_{temp}^2 / 2}$$

where the survey catchability in year *t* is a function of the temperature anomaly *temp* in year *t*, σ_{temp} is the standard deviation of the temperature anomalies, and the parameters α_q and β_q are potentially estimable within the model. The term $\beta_q^2\ \sigma_{temp}^2/2$ is subtracted in order to produce a mean survey selectivity of $\exp(\alpha_q)$. In practice, it has been found that α_q was not estimable from the data and is fixed at 0.0, corresponding to a mean survey selectivity of 1.0 (consistent with previous assessments).

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 the 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.

Estimation of maximum sustainable yield

F_{msy} for flathead sole is estimated using the Ricker stock recruitment curve based upon the post-1977 year classes. Briefly, a stock recruitment curve is fit to the available data, from which an equilibrium level of recruitment is solved for each level of fishing mortality. A yield curve (identifying equilibrium yield as a function of fishing mortality) is generated by multiplying equilibrium recruitment by yield-per-recruit (YPR), where each term in this product is a function of fishing mortality. The maximum sustainable yield is identified as the point where the derivative of the yield curve is zero, and the fishing mortality associated with MSY is F_{msy}.

The equilibrium recruitment, at a particular level of fishing mortality, for the Ricker curve is

$$R_{eq} = \frac{-\ln\left(\frac{1}{\alpha\phi}\right)}{\phi\beta}$$

where ϕ is the spawner-per-recruit (SPR) associated with a particular level of fishing mortality, and is a function of size at age, proportion mature-at-age, fishing selectivity, and fishing mortality. The sustainable yield for a level of fishing mortality is R_{eq}*YPR, where YPR is the yield per recruit. MSY and F_{msy} are then obtained by finding the fishing mortality rate where yield is maximized; this was accomplished by using the numerical Newton-Raphson technique to solve for the derivative of the yield curve. As noted above, we currently do not have confidence in the estimate of F_{msy} generated by this approach (Spencer et al. 2004).

Parameters Estimated Independently

The parameters estimated independently include the age error matrix, the transition matrix, individual weight-at-age, the mean survey selectivity α_q (as described above), natural mortality, and the proportion mature at age. The age error matrix was taken directly from the Stock Synthesis model used in assessments prior to 2004. The methodology for obtaining individual weights-at-age from the trawl survey data was described above. The natural mortality rate M was fixed at 0.2, consistent with previous assessments. The mean survey selectivity parameter α_q was fixed at 0.0, producing a mean value of survey selectivity of 1.0. The maturity curve for flathead sole was updated based upon the research in Stark (2004), which indicates a length at 50% maturity of 320.2 mm.

Parameters Estimated Conditionally

Parameter estimation was 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 was to assume that deviations between model estimates and observed quantities were attributable to observation error and could be described with statistical distributions. Each data component provided a contribution to a total log-likelihood function, and parameter values that minimized the log-likelihood were selected.

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

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

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. As in the previous assessment, σ was held fixed at 0.5.

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, was

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

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. The catch biomass was considered to be observed with higher precision than other variables, therefore 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 was

$$\begin{aligned}
&\lambda_1\left(\sum_t\left(\frac{(v_t+\sigma^2/2)^2}{2\sigma^2}\right)+n\ln(\sigma)\right)+\\
&\lambda_2\sum_t(\ln(obs_biom_t)-\ln(pred_biom_t))^2/2*cv_t^2+\\
&n_{f,s,t,l}\sum_{s,t,l}p_{f,s,t,l}\ln(\hat{p}_{f,s,t,l})-p_{f,s,t,l}\ln(p_{f,s,t,l})+\\
&n_{surv,s,t,a}\sum_{s,t,a}p_{surv,s,t,a}\ln(\hat{p}_{surv,s,t,a})-p_{surv,s,t,a}\ln(p_{surv,s,t,a})+.\\
&n_{surv,s,t,l}\sum_{s,t,a}p_{surv,s,t,l}\ln(\hat{p}_{surv,s,t,l})-p_{surv,s,t,l}\ln(p_{surv,s,t,l})+\\
&\lambda_3\sum_t(\ln(obs_cat_t)-\ln(pred_cat_t))^2
\end{aligned}$$

For the model run in this analysis, λ_1, λ_2, and λ_3 were assigned weights of 1,1, and 500, respectively, and n was set to 200 for the age and length composition data. 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)	29
3) recruitment mean	1
4) recruitment deviations (υ_t)	29
5) historic fishing mortality (f_{hist})	1
6) historic mean recruitment (R_{hist})	1
7) fishery selectivity parameters	2
8) survey selectivity parameters	2

9) survey catchability parameters	1
10) stock-recruitment parameters	2
Total parameters	69

Finally, a Markov Chain Monte Carlo (MCMC) algorithm was used to obtain estimates of parameter uncertainty (Gelman et al. 1995). As in the 2004 assessment, one million MCMC simulations were conducted, with every 1,000th sample saved for the sample from the posterior distribution. Ninety-five percent confidence intervals were produced as the values corresponding to the 5th and 95th percentiles of the MCMC evaluation. For this assessment, confidence intervals on total biomass, spawning biomass, and recruitment strength are presented.

Model evaluation

We considered two alternative models in this assessment. The first model was identical to the final model selected in the previous assessment. This model incorporated a temperature-dependent survey catchability coefficient and a Ricker stock-recruit function. The second model we considered did not incorporate temperature-dependent survey catchability; thus, $qsurv_t$ was fixed at 1 (α_q and β_q were set to 0) for all t.

The utility of temperature anomaly data in fitting the survey biomass trend can be seen in the Figure 8.7, which compares the survey fit both with and without use of the temperature data. An interesting feature of the model is that in many of the years before 1998 the direction of the yearly change in the in the predicted survey biomass using temperature-dependent catchability is opposite the direction of yearly change in the observed survey. However, modeling temperature-dependent catchability does provide a better fit to the relatively high biomass in 1998, the low biomass in 1999, and the higher biomasses from 2000-2005. As in the previous assessment, a significant reduction in the negative log-likelihood was achieved with the inclusion of the additional parameter to fit the temperature anomalies, and this model fit was used for the subsequent analyses.

The final model parameters are listed in Table 8.12. The Ricker spawner-recruit curve corresponding to the estimated parameters is shown in Figure 8.8. The fishery and survey selectivity curves corresponding to the estimated parameters are shown in Figure 8.9. The fishery shows little selectivity for flathead sole less that 30 cm.

Model Results

The model fit to reported catches is shown in Figure 8.10. The fit is nearly exact because of the high relative weight we applied to the catch likelihood.

The model provided a good fit to the survey size compositions for the past 10 years for females and males, as shown in Figures 8.11-12. Reasonable fits also resulted for fishery size composition observations (Figures 8.13-14) and the survey age compositions (Figures 8.15-16). The fits to the fishery age composition are shown in Figures 8.17-18. The best fit to the size and age composition data was achieved with the survey length compositions, which resulted in an average effective n of 286 and 197 for females and males, respectively, corresponding to input weights of 200. The survey male age composition data and the fishery female age composition data produced the lowest effective samples sizes of 89 and 69, respectively. The effective sample sizes for the remaining data types were near 100.

Estimated total biomass (ages 3+) increased from a low of 130,510 t in 1977 to a peak of 1,025,100 t in 1993 (Figure 8.19, Table 8.13). Since 1993, estimated total biomass has declined to an estimated value of 632,100 t for 2005. Female spawning biomass shows a similar trend, although the peak value (343,033 t) occurred in 1997 (Figure 8.19, Table 8.13).

The changes in stock biomass are primarily a function of recruitment, as fishing pressure has been relatively light. The estimated recruitment at age 3 has generally been higher during the early portion of the data series, averaging 1.1 billion for the 1974-1989 year classes, and 500 million for the 1997-2001 year classes (Figure 8.20, Table 8.13). These results remain consistent with Wilderbuer et al.'s (2002) hypothesis that shoreward-directed winds during spawning seasons in the 1980's led to enhanced recruitment via larval advection toward favorable nearshore settlement habitats, while seaward-blowing winds in the 1990's led to reduced recruitment by advecting larvae away from nearshore settlement habitats.

The fully-selected fishing mortality estimates remain small, and have averaged 0.046 from 1995 to 2004 (Figure 8.21). The time series of estimated fishing mortality rates and spawning stock biomass estimates relative to the harvest control rule is shown in Figure 8.22, which indicates that the flathead sole stock has been below its $F_{40\%}$ level, and above its $B_{40\%}$ level, since 1986.

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 $F_{40\%}$, $F_{35\%}$, and $SPR_{40\%}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from the 1977-2002 year classes estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{40\%}$ is calculated as the product of $SPR_{40\%}$ times the equilibrium number of recruits; this quantity is 123,656 t. The year 2005 spawning stock biomass is estimated as 233,850 t. Since reliable estimates of the 2005 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B > B_{40\%}$ (233,850 t > 123,656 t), flathead sole reference fishing mortality is defined in Tier 3a. For this tier, F_{ABC} is constrained to be $\leq F_{40\%}$, and F_{OFL} is defined to be $F_{35\%}$. The values of these quantities are:

2005 SSB estimate (B)	=	233,850 t
$B_{40\%}$	=	123,656 t
$F_{40\%}$	=	0.296
F_{ABC}	$\leq$	0.296
$F_{35\%}$	=	0.362
F_{OFL}	=	0.362

The estimated catch level for year 2006 associated with the overfishing level of F = 0.362 is 71,764 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 its upper bound; thus, the year 2006 recommended ABC associated with F_{ABC} of 0.296 is 59,794 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 2005 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2006 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2005. 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 2006, are as follows ("*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 2005 recommended in the assessment to the *max* F_{ABC} for 2005. (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 2000-2004 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 Table 8.14.

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 2006, then the stock is not overfished.)

Scenario 7: In 2006 and 2007, 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 2018 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that the BSAI flathead sole stock is neither overfished nor approaching an overfished condition. With regard to assessing the current stock level, the expected stock size in the year 2006 of scenario 6 is 201,952 t, 1.87 times larger than its $B_{35\%}$ value of 108,199 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 2018 of scenario 7 is 115,857, 1.07 times larger than $B_{35\%}$. Thus, the stock is not approaching an overfished condition.

Estimating an ABC and OFL for 2007 is somewhat problematic as these values depend on the catch that will be taken in 2006. Because the actual catch taken in the BSAI flathead sole fishery has been substantially smaller than the TAC for the past several years, we assumed that a reasonable estimate of the catch to be taken in 2006 is the average catch taken in the recent past—we used the average catch for 2000-2004 (15,767 t). Using this value and the estimated population size at the start of 2006 from the model, we projected the stock ahead through 2006 and calculated the ABC and OFL for 2007. The ABC for 2007 is estimated to be 56,569 t while the OFL is estimated to be 67,907. Total biomass for 2007 is estimated at 637,350 t, while female spawning biomass is estimated at 192,001.

Ecosystem Considerations

Ecosystem effects on the stock

Prey availability/abundance trends

Flathead sole feed upon a variety of species, including walleye pollock and other miscellaneous fish, brittlestars, polychaetes, and crustaceans. The proportion of the diet composed of fish appears to increase with flathead sole size (Lang et al., 2003). The population of walleye pollock has fluctuated but has remained relatively stable over the past twenty years. Information is not available to assess the abundance trends of the benthic infauna of the Bering Sea shelf. The original description of infaunal distribution and abundance by Haflinger (1981) resulted from sampling conducted in 1975 and 1976 and has not be re-sampled since.

Over the past 20 years many flatfish populations that occupy the middle shelf of the eastern Bering Sea have increased substantially in abundance, leading to concern regarding the action of potential density-dependent factors. Walters and Wilderbuer (2000) found density-dependent changes in mean length for age-3 northern rock sole during part of that stock's period of expansion, but similar trends in size have not been observed for flathead sole (Spencer et al., 2004). Most of the large populations of flatfish that have occupied the middle shelf of the Bering Sea over the past twenty years for summertime feeding do not appear to be food-limited. These populations have fluctuated due to variability in recruitment success—in which climatic factors or pre-recruitment density dependence may play important roles (Wilderbuer et al., 2002). However, this suggests that the primary infaunal food source has been at an adequate level to sustain the flathead sole resource.

McConnaughy and Smith (2000) compared the diet between areas with high survey CPUE to that in areas with low survey CPUE for a variety of flatfish species. For flathead sole, the diet in high CPUE areas consisted largely of echinoderms (59% by weight; mostly ophiuroids), whereas 60% of the diet in the low CPUE areas consisted of fish, mostly pollock. These areas also differed in sediment types, with the high CPUE areas consisting of relatively more mud than the low CPUE areas, and McConnaughy and Smith (2000) hypothesized that substrate-mediated food habits of flathead sole are influenced by energetic foraging costs.

Predator population trends

The dominant predators of flathead sole from 1993-1996 were Pacific cod and skates, with Pacific cod accounting for most of the predation upon flathead sole less than 5 cm (Lang et al. 2003); the maximum size of flathead sole observed as prey was 30 cm. Arrowtooth flounder, Greenland turbot, walleye pollock, and Pacific halibut comprised other predators. Flathead sole contributed a relatively minor portion of the diet of skates from 1993-1996, on average less than 2% by weight, although flatfish in general comprised a more substantial portion of skates greater than 40 cm. A similar pattern was seen with Pacific cod, where flathead sole generally contribute less than 1% of the cod diet by weight, although flatfish in general comprised up to 5% of the diet of cod greater than 60 cm. Based upon recent stock assessments, both Pacific cod and skate abundance have been relatively stable since the early 1990s.

There is some evidence of cannibalism for flathead sole. Stomach content data collected from 1990 indicate that flathead sole were the most dominant predator, and cannibalism was also noted in 1988 (Livingston et al. 1993).

Changes in habitat quality

The habitats occupied by flathead sole are influenced by temperature, which has shown considerable variation in the eastern Bering Sea in recent years. For example, the timing of spawning and advection to nursery areas are expected to be affected by environmental variation. Flathead sole spawn in deeper waters near the margin of the continental shelf in late winter/early spring and migrate to their summer distribution of the mid and outer shelf in April/May. The distribution of flathead sole, as inferred by summer trawl survey data, has been variable. In 1999, one of the coldest years in the eastern Bering Sea, the distribution was shifted further to the southeast than it was during 1998-2002.

Fishery effects on the ecosystem

Prohibited species catches in the flathead sole-directed fishery increased from 2003 to 2004 for halibut and salmon, but decreased for crabs (Table 8.15). Both the total prohibited species catch of halibut and the catch relative to that of flathead sole increased substantially from 2003 to 2004. In absolute terms, the catch of halibut increased from 223,673 t in 2003 to 632,041 t in 2004. The absolute catch of flathead sole in the fishery increased from 2003 to 2004, so the change in halibut catch was not as dramatic relative to the total catch of flathead sole in the directed fishery, increasing from 34 kg halibut per t of flathead sole in 2003 to 65 kg/t in 2004. The prohibited species catch of salmon also increased from 2003 to 2004 in both absolute and relative terms. In absolute terms, the catch of salmon increased by over a factor of 10 from 230 individuals to 2,867. In relative terms, the catch increased from 0.04 salmon/t flathead sole to 0.30. In contrast with halibut and salmon, the prohibited species catch of Tanner and king crabs declined substantially from 2003 to 2004, decreasing from 552,495 individuals in 2003 to 292,650 individuals in 2004. In relative terms, the catch of crab decreased from 85 individuals per ton of flathead sole in 2003 to 30 individuals per ton in 2004.

For non-prohibited species, the non-flathead sole species with the largest catch was pollock in both 2003 and 2004 (Table 8.16). The catch of pollock was 46% of the flathead sole catch in 2003 and 55% in 2004. Arrowtooth flounder was the next most-caught species (32% of the flathead sole catch in 2003 and 39% in 2004).

The flathead sole fishery is not likely to diminish the amount of flathead sole available as prey due to its low selectivity for fish less than 30 cm. Additionally, the fishery is not suspected of affecting the size-structure of the population due to the relatively light fishing mortality, averaging 0.06 over the last 5 years. It is not known what effects the fishery may have on the maturity-at-age of flathead sole.

Data gaps and research priorities

The amount of age data available for the fishery is minimal (2 years: 2000, 2001), and future assessments would undoubtedly benefit from more fishery age compositions. Several hundred individuals have generally been sampled by fishery observers each year for the past decade, but reading flathead otoliths has not been a priority task for the age readers at the Alaska Fisheries Science Center. Although the situation with survey age compositions is not quite so dire (7 years of data), it would also be desirable to have several more years of survey age data. Additional age data should improve future stock assessments by allowing improved estimates of individual growth and age-length transition matrices, and by filling in missing years with age composition data.

The current model includes one environmental covariate, mean survey bottom temperature, that affects survey catchability. The model should be enhanced to incorporate other types of environmental correlates and effects, such as predator biomass on natural mortality rates or oceanographic transport patterns on recruitment. Candidate correlates (e.g., arrowtooth flounder biomass) and population processes should be identified and evaluated.

Summary

In summary, several quantities pertinent to the management of the BSAI flathead sole are:

Tier	3a	
Reference mortality rates		
M	0.20	
$F_{35\%}$	0.362	
$F_{40\%}$	0.296	
Equilibrium female spawning biomass		
$B_{100\%}$	309,141 t	
$B_{40\%}$	123,656 t	
$B_{35\%}$	108,199 t	
Current biomass		
Year 2005 Total Biomass (age 3+)	639,304 t	
Year 2005 Spawning stock biomass	233,850 t	
Projected biomass	**2006**	**2007**
Female spawning biomass	203,452 t	192,001 t
Total biomass (age 3+)	636,298 t	637,350 t
Fishing rates		
F_{OFL}	0.362	
Maximum F_{ABC}	0.296	
Recommended F_{ABC}	0.296	
Harvest limits	**2006**	**2007**
OFL	71,764 t	67,907 t
ABC (maximum allowable)	59,794 t	56,569 t
ABC (recommended)	59,794 t	56,569 t

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Tables

Table 8.1. Harvest (t) of *Hippoglossoides* sp. from 1977-2005.

Year	Catch (t)
1977	7,909
1978	6,957
1979	4,351
1980	5,247
1981	5,218
1982	4,509
1983	5,240
1984	4,458
1985	5,636
1986	5,208
1987	3,595
1988	6,783
1989	3,604
1990	20,245
1991	14,197
1992	14,407
1993	13,574
1994	17,006
1995	14,713
1996	17,344
1997	20,681
1998	24,597
1999	18,555
2000	20,439
2001	17,809
2002	15,547
2003	13,792
2004	16,849
2005*	14,836

* NMFS Regional Office Catch Report through October 1, 2005.

Table 8.2. Restrictions on the flathead sole fishery from 1994 to 2005 in the BSAI 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; 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	1st seasonal halibut cap
	4/17 – 7/1	2nd seasonal halibut cap
	8/1 – 12/31	Annual halibut allowance
1996	2/26 – 4/1	1st seasonal halibut cap
	4/13 – 7/1	2nd seasonal halibut cap
	7/31 – 12/31	Annual halibut allowance
1997	2/20 – 4/1	1st seasonal halibut cap
	4/12 – 7/1	2nd seasonal halibut cap
	7/25 – 12/31	Annual halibut allowance
1998	3/5 – 3/30	1st seasonal halibut cap
	4/21 – 7/1	2nd seasonal halibut cap
	8/16 – 12/31	Annual halibut allowance
1999	2/26 – 3/30	1st seasonal halibut cap
	4/27 – 7/04	2nd seasonal halibut cap
	8/31 – 12/31	Annual halibut allowance
2000	3/4 – 3/31	1st seasonal halibut cap
	4/30 – 7/03	2nd seasonal halibut cap
	8/25 – 12/31	Annual halibut allowance
2001	3/20 – 3/31	1st seasonal halibut cap
	4/27 – 7/01	2nd seasonal halibut cap
	8/24 – 12/31	Annual halibut allowance
2002	2/22 – 12/31	Red King crab cap (Zone 1 closed)
	3/1 – 3/31	1st seasonal halibut cap
	4/20 – 6/29	2nd seasonal halibut cap
	7/29 – 12/31	Annual halibut allowance
2003	2/18 – 3/31	1st seasonal halibut cap
	4/1 – 6/21	2nd seasonal halibut cap
	7/31 – 12/31	Annual halibut allowance
2004	2/24 – 3/31	1st seasonal halibut cap
	4/16 – 6/30	2nd seasonal halibut cap
	7/31 – 9/3	Bycatch status
	9/4 – 12/31	Prohibited species status
2005	3/1 – 3/31	1st seasonal halibut cap
	4/22 – 6/4	2nd seasonal halibut cap
	8/18 – 12/31	Annual halibut allowance

Table 8.3. ABC's, TAC's, OFL's, and total, retained, and discarded *Hippoglossoides* sp. catch (t), 1995-2005.

Year	ABC	TAC	OFL	Total Catch	Retained	Discarded	Percent Retained
1995	138,000	30,000	167,000	14,713	7,520	7,193	51
1996	116,000	30,000	140,000	17,344	8,964	8,380	52
1997	101,000	43,500	145,000	20,681	10,859	9,822	53
1998	132,000	100,000	190,000	24,597	17,438	7,159	71
1999	77,300	77,300	118,000	18,555	13,757	4,797	74
2000	73,500	52,652	90,000	20,439	14,959	5,481	73
2001	84,000	40,000	102,000	17,809	14,436	3,373	81
2002	82,600	25,000	101,000	15,547	11,311	4,236	73
2003	66,000	20,000	81,000	13,792	9,926	3,866	72
2004	61,900	19,000	75,200	16,850	11,658	5,192	69
2005*	58,500	19,500	70,200	15,242	11,654	3,588	76
2006**	48,400	20,000	56,100				

*Regional Office Catch Accounting System data through Sept 24th, 2005.
**Biennial allocation set in 2004.

Table 8.4a. Fishery size composition for flathead sole females.

	Length cutpoints (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
1977	0.0000	0.0000	0.0000	0.0027	0.0082	0.0190	0.0494	0.0606	0.0492	0.0565	0.0876	0.1025	0.1309	0.1334	0.1128	0.0892	0.0597	0.0309	0.0046	0.0016	0.0005	0.0000	0.0000	0.0005
1978	0.0000	0.0000	0.0000	0.0009	0.0034	0.0095	0.0226	0.0473	0.0554	0.0590	0.0550	0.0629	0.0917	0.1315	0.1491	0.1235	0.0865	0.0758	0.0204	0.0045	0.0005	0.0004	0.0002	0.0000
1979	0.0000	0.0000	0.0000	0.0010	0.0079	0.0147	0.0334	0.0673	0.0802	0.0589	0.0524	0.0550	0.0555	0.0567	0.0848	0.1107	0.1146	0.1260	0.0596	0.0197	0.0014	0.0000	0.0000	0.0000
1980	0.0000	0.0000	0.0000	0.0000	0.0012	0.0062	0.0254	0.0538	0.0964	0.1385	0.1110	0.1028	0.0901	0.0753	0.0683	0.0751	0.0731	0.0626	0.0170	0.0025	0.0006	0.0002	0.0000	0.0000
1981	0.0000	0.0000	0.0000	0.0009	0.0014	0.0189	0.0312	0.0130	0.0069	0.0137	0.0435	0.1020	0.1500	0.1697	0.1309	0.0923	0.0823	0.0898	0.0427	0.0100	0.0009	0.0000	0.0000	0.0000
1982	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0025	0.0068	0.0234	0.0609	0.1243	0.2006	0.1785	0.1255	0.0652	0.0689	0.0905	0.0418	0.0105	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0012	0.0025	0.0012	0.0069	0.0006	0.0056	0.0131	0.0343	0.0636	0.0948	0.1621	0.2855	0.1983	0.0835	0.0293	0.0087	0.0081	0.0000
1984	0.0000	0.0000	0.0000	0.0014	0.0045	0.0071	0.0114	0.0324	0.0341	0.0247	0.0327	0.0520	0.0585	0.0747	0.1409	0.1826	0.1477	0.1247	0.0517	0.0165	0.0026	0.0000	0.0000	0.0000
1985	0.0000	0.0000	0.0000	0.0015	0.0017	0.0062	0.0064	0.0178	0.0310	0.0310	0.0354	0.0406	0.0490	0.0718	0.0966	0.1362	0.1523	0.1999	0.0778	0.0235	0.0107	0.0032	0.0052	0.0020
1986	0.0000	0.0000	0.0000	0.0000	0.0026	0.0153	0.0537	0.0486	0.0691	0.0486	0.0614	0.0895	0.0946	0.0818	0.0870	0.1100	0.1202	0.0767	0.0332	0.0077	0.0000	0.0000	0.0000	0.0000
1987	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0041	0.0035	0.0118	0.0242	0.0407	0.0572	0.0926	0.2188	0.2311	0.1604	0.1250	0.0242	0.0047	0.0012	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0002	0.0008	0.0026	0.0083	0.0115	0.0159	0.0335	0.0338	0.0666	0.1087	0.1499	0.1618	0.1419	0.1143	0.0979	0.0379	0.0123	0.0020	0.0002	0.0000	0.0000
1989	0.0000	0.0000	0.0000	0.0000	0.0004	0.0011	0.0036	0.0124	0.0270	0.0272	0.0302	0.0569	0.0799	0.1099	0.1263	0.1510	0.1406	0.1231	0.0671	0.0333	0.0097	0.0002	0.0000	0.0000
1990	0.0000	0.0000	0.0000	0.0000	0.0002	0.0007	0.0002	0.0025	0.0037	0.0050	0.0124	0.0154	0.0310	0.0429	0.0837	0.1263	0.1729	0.2346	0.1695	0.0803	0.0163	0.0021	0.0005	0.0000
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0006	0.0011	0.0028	0.0068	0.0148	0.0294	0.0430	0.0647	0.0881	0.1077	0.1667	0.2268	0.1599	0.0593	0.0219	0.0043	0.0017	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0053	0.0053	0.0184	0.0237	0.0789	0.1158	0.1447	0.1684	0.2237	0.1395	0.0526	0.0237	0.0000	0.0000	0.0000
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0011	0.0011	0.0098	0.0136	0.0212	0.0435	0.0642	0.0820	0.1149	0.1319	0.2491	0.1988	0.0537	0.0128	0.0023	0.0000	0.0000
1994	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0006	0.0008	0.0011	0.0028	0.0064	0.0108	0.0252	0.0416	0.0570	0.1191	0.1641	0.2508	0.1772	0.0848	0.0435	0.0104	0.0017	0.0019
1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0026	0.0037	0.0040	0.0068	0.0156	0.0251	0.0474	0.0648	0.0985	0.1157	0.2236	0.2383	0.1208	0.0289	0.0037	0.0004	0.0000
1996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0006	0.0008	0.0021	0.0041	0.0064	0.0155	0.0366	0.0787	0.1161	0.1336	0.2142	0.2383	0.1204	0.0266	0.0048	0.0010	0.0000
1997	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0006	0.0023	0.0066	0.0103	0.0205	0.0354	0.0515	0.0792	0.1152	0.1456	0.1985	0.1877	0.1121	0.0302	0.0039	0.0002	0.0000
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0009	0.0030	0.0056	0.0124	0.0260	0.0465	0.0742	0.1100	0.1326	0.2048	0.1918	0.1357	0.0492	0.0066	0.0003	0.0001
1999	0.0000	0.0000	0.0000	0.0000	0.0003	0.0002	0.0004	0.0001	0.0011	0.0024	0.0081	0.0146	0.0355	0.0573	0.0875	0.1106	0.1368	0.2210	0.1812	0.1014	0.0340	0.0049	0.0019	0.0006
2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0006	0.0012	0.0032	0.0087	0.0185	0.0436	0.0724	0.1082	0.1299	0.1230	0.1913	0.1527	0.1029	0.0362	0.0061	0.0009	0.0004
2001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0010	0.0019	0.0036	0.0073	0.0205	0.0242	0.0520	0.0821	0.1229	0.1339	0.2094	0.1872	0.1062	0.0385	0.0068	0.0014	0.0006
2002	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0004	0.0009	0.0018	0.0023	0.0045	0.0099	0.0200	0.0412	0.0844	0.1191	0.1569	0.2555	0.1715	0.0896	0.0338	0.0061	0.0018	0.0002
2003	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0002	0.0005	0.0007	0.0034	0.0099	0.0170	0.0299	0.0500	0.0831	0.1224	0.1496	0.2577	0.1778	0.0724	0.0201	0.0049	0.0000	0.0003
2004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0006	0.0014	0.0048	0.0123	0.0203	0.0345	0.0553	0.0788	0.1069	0.1161	0.1194	0.1887	0.1677	0.0735	0.0159	0.0028	0.0004	0.0000

Table 8.4b. Fishery size composition for flathead sole males.

	Length cutpoints (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
1977	0.0000	0.0000	0.0000	0.0024	0.0066	0.0168	0.0470	0.0459	0.0437	0.0893	0.1676	0.2201	0.1976	0.1111	0.0386	0.0068	0.0018	0.0029	0.0020	0.0000	0.0000	0.0000	0.0000	0.0000
1978	0.0000	0.0000	0.0000	0.0012	0.0074	0.0125	0.0331	0.0493	0.0703	0.0771	0.0828	0.1523	0.2224	0.1683	0.0859	0.0284	0.0067	0.0006	0.0000	0.0000	0.0008	0.0006	0.0002	0.0000
1979	0.0000	0.0000	0.0000	0.0024	0.0155	0.0267	0.0386	0.0741	0.0843	0.0532	0.0544	0.0795	0.1426	0.2015	0.1379	0.0615	0.0207	0.0060	0.0006	0.0002	0.0002	0.0000	0.0000	0.0000
1980	0.0000	0.0000	0.0000	0.0002	0.0004	0.0044	0.0166	0.0435	0.0923	0.1141	0.0863	0.0961	0.1871	0.2253	0.1090	0.0204	0.0031	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1981	0.0000	0.0000	0.0000	0.0018	0.0072	0.0341	0.0419	0.0109	0.0172	0.0338	0.0992	0.2214	0.2498	0.1747	0.0799	0.0181	0.0027	0.0045	0.0027	0.0000	0.0000	0.0000	0.0000	0.0000
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0052	0.0017	0.0087	0.0113	0.0295	0.0572	0.1525	0.2695	0.2409	0.1473	0.0485	0.0165	0.0052	0.0061	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0031	0.0131	0.0208	0.0664	0.1535	0.2276	0.2353	0.1721	0.0741	0.0208	0.0062	0.0023	0.0015	0.0015	0.0008	0.0008
1984	0.0000	0.0000	0.0000	0.0014	0.0028	0.0037	0.0102	0.0394	0.0464	0.0399	0.0691	0.1048	0.1164	0.2004	0.2036	0.1048	0.0450	0.0093	0.0019	0.0005	0.0000	0.0005	0.0000	0.0000
1985	0.0000	0.0000	0.0000	0.0006	0.0016	0.0052	0.0071	0.0292	0.0451	0.0577	0.0752	0.0859	0.1147	0.1319	0.1588	0.1514	0.0771	0.0324	0.0055	0.0032	0.0045	0.0045	0.0052	0.0029
1986	0.0000	0.0000	0.0000	0.0000	0.0031	0.0062	0.0217	0.0310	0.0588	0.1269	0.1610	0.1207	0.1362	0.1146	0.1238	0.0495	0.0402	0.0062	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	0.0000	0.0000	0.0000	0.0000	0.0008	0.0000	0.0017	0.0029	0.0080	0.0211	0.0333	0.0641	0.1032	0.2377	0.3030	0.1740	0.0455	0.0038	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0005	0.0036	0.0115	0.0166	0.0252	0.0541	0.0836	0.1301	0.2113	0.2370	0.1532	0.0548	0.0130	0.0050	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0066	0.0233	0.0386	0.0407	0.0798	0.1205	0.1594	0.1861	0.1776	0.1044	0.0386	0.0190	0.0040	0.0003	0.0005	0.0000	0.0000	0.0000
1990	0.0000	0.0000	0.0000	0.0000	0.0003	0.0013	0.0000	0.0059	0.0089	0.0132	0.0188	0.0351	0.0621	0.1135	0.1843	0.2256	0.1665	0.0973	0.0356	0.0234	0.0066	0.0015	0.0000	0.0000
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0010	0.0036	0.0068	0.0133	0.0225	0.0565	0.0808	0.1200	0.1849	0.2410	0.1682	0.0746	0.0155	0.0052	0.0042	0.0010	0.0002	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0057	0.0019	0.0246	0.0302	0.0378	0.0567	0.0681	0.1059	0.1493	0.1626	0.1664	0.1078	0.0813	0.0019	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0000	0.0000	0.0000	0.0000	0.0005	0.0014	0.0014	0.0005	0.0050	0.0115	0.0339	0.0710	0.0820	0.1402	0.2158	0.2194	0.1255	0.0646	0.0234	0.0041	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0002	0.0004	0.0022	0.0039	0.0071	0.0207	0.0418	0.0786	0.1303	0.1591	0.1785	0.1574	0.0898	0.0581	0.0241	0.0200	0.0155	0.0099	0.0017	0.0006
1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0021	0.0048	0.0088	0.0178	0.0428	0.0829	0.1428	0.2081	0.2234	0.1486	0.0722	0.0273	0.0151	0.0025	0.0000	0.0000	0.0000
1996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0007	0.0020	0.0050	0.0139	0.0285	0.0791	0.1591	0.2341	0.2291	0.1432	0.0736	0.0173	0.0077	0.0038	0.0023	0.0003	0.0004
1997	0.0000	0.0000	0.0000	0.0000	0.0002	0.0004	0.0013	0.0030	0.0058	0.0160	0.0449	0.0765	0.1212	0.1795	0.1994	0.1828	0.1116	0.0522	0.0052	0.0002	0.0000	0.0000	0.0000	0.0000
1998	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0007	0.0015	0.0036	0.0078	0.0181	0.0370	0.0792	0.1480	0.2184	0.2209	0.1621	0.0841	0.0144	0.0032	0.0005	0.0001	0.0000	0.0000
1999	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0003	0.0015	0.0041	0.0109	0.0244	0.0575	0.1030	0.1495	0.2028	0.1956	0.1418	0.0842	0.0170	0.0053	0.0009	0.0004	0.0003	0.0000
2000	0.0000	0.0002	0.0000	0.0000	0.0001	0.0003	0.0011	0.0011	0.0032	0.0082	0.0254	0.0530	0.1135	0.1744	0.2067	0.1785	0.1211	0.0733	0.0229	0.0100	0.0044	0.0016	0.0006	0.0005
2001	0.0000	0.0000	0.0002	0.0000	0.0003	0.0003	0.0009	0.0033	0.0040	0.0100	0.0169	0.0484	0.0846	0.1472	0.1979	0.2025	0.1514	0.0980	0.0188	0.0079	0.0034	0.0019	0.0014	0.0009
2002	0.0000	0.0000	0.0000	0.0004	0.0002	0.0009	0.0011	0.0026	0.0109	0.0144	0.0257	0.0431	0.0732	0.1400	0.1938	0.2191	0.1548	0.0902	0.0204	0.0067	0.0019	0.0006	0.0000	0.0000
2003	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0004	0.0012	0.0047	0.0124	0.0386	0.0512	0.0823	0.1206	0.1952	0.2216	0.1570	0.0869	0.0185	0.0069	0.0012	0.0008	0.0000	0.0000
2004	0.0000	0.0000	0.0000	0.0000	0.0002	0.0001	0.0010	0.0025	0.0060	0.0146	0.0332	0.0783	0.1192	0.1552	0.1797	0.1805	0.1389	0.0789	0.0092	0.0023	0.0003	0.0000	0.0000	0.0000

Table 8.5a. Fishery age composition for flathead sole females.

	Age bin																		
year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2000	0.0000	0.0000	0.0000	0.0187	0.0032	0.0432	0.0536	0.0656	0.0620	0.0715	0.1377	0.0630	0.0928	0.0674	0.0845	0.0726	0.0796	0.0278	0.0568
2001	0.0000	0.0000	0.0000	0.0000	0.0152	0.0159	0.0238	0.0542	0.0963	0.0789	0.0731	0.1037	0.0871	0.0925	0.0927	0.0544	0.0763	0.0445	0.0916

Table 8.5b. Fishery age compositions for flathead sole males.

	Age bin																		
year	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
2000	0.0000	0.0000	0.0000	0.0056	0.0317	0.0526	0.0724	0.0806	0.1362	0.0654	0.1227	0.0861	0.0854	0.0837	0.0483	0.0290	0.0397	0.0231	0.0375
2001	0.0000	0.0063	0.0000	0.0047	0.0237	0.0698	0.0702	0.0991	0.0721	0.0952	0.0806	0.1247	0.0591	0.0660	0.0277	0.0457	0.0558	0.0160	0.0833

Table 8.6a. Length and age composition sample sizes from the BSAI fishery for female flathead sole. The total number of collected otoliths is also listed. The "hauls" column under each data type refers to the number of hauls in which individuals were collected.

	--------Lengths--------		-----Ages------		Collected otoliths	
Year	**individuals**	**hauls**	**individuals**	**hauls**	**individuals**	**hauls**
1982	1625	44			166	
1983	1622	42			132	
1984	3522	55			183	
1985	4067	144			1157	
1986	391	48			995	
1987	1697	40			468	
1988	6596	158			514	
1989	5258	132				
1990	4499	120			369	55
1991	3509	123			91	26
1992	381	10				
1993	2646	59				
1994	4729	119	15	90	93	15
1995	5464	127	13	112	117	13
1996	7075	240				
1997	6388	150				
1998	14573	391	10	48	48	10
1999	9325	841	121		322	
2000	11290	2314	312	349	508	195
2001	7021	1598	244	353	366	238
2002	5562	1141	196		317	
2003	5964	1096	168		313	
2004	8515	1489	231	248	406	166

Table 8.6b. Male flathead sole sample sizes from the BSAI fishery. The total number of collected otoliths is also listed. The "hauls" column under each data type refers to the number of hauls in which individuals were collected.

	--------Lengths--------		-----Ages------		Collected otoliths	
Year	**individuals**	**hauls**	**individuals**	**hauls**	**individuals**	**hauls**
1982	1154	43			87	
1983	1306	43			68	
1984	2162	56			144	
1985	3105	140			877	
1986	323	43			686	
1987	2378	40			293	
1988	8377	158			430	
1989	3785	129				
1990	3975	117			261	54
1991	4976	114			63	19
1992	529	10				
1993	2183	59				
1994	4641	120	48	12	50	12
1995	4763	127	74	10	78	10
1996	7054	241				
1997	5388	150				
1998	15098	392	51	10	51	10
1999	9318	838			300	118
2000	8823	2139	215	133	348	235
2001	5815	1400	267	177	276	182
2002	5341	1009			241	136
2003	5076	1007			217	116
2004	9239	1398	248	161	395	195

Table 8.7. Estimated biomass (t) of *Hippoglossoides* sp. from the EBS and Aleutian Islands trawl survey, together with estimated biomass for flathead sole and Bering flounder separately. A linear regression was used to estimate AI biomass in years for which an AI survey did not exist. The "Fraction flathead" column gives the fraction of total EBS biomass that is accounted for by flathead sole.

Year	EBS Biomass	CV	AI Biomass	CV	Total	Bering flounder biomass	cv	Flathead sole biomass	cv	Fraction flathead
1975	100,700				103,747					
1979	104,900				107,998					
1980	117,500		3,300		120,800					
1981	162,900				166,706					
1982	191,988	0.09			196,148	0				
1983	269,419	0.10	1,500		270,919	18,359	0.20	191,988	0.09	1.00
1984	341,697	0.08			347,684	19,715	0.18	251,449	0.11	0.93
1985	276,350	0.07			281,540	16,059	0.09	323,877	0.09	0.95
1986	357,951	0.09	9,000		366,951	13,962	0.17	262,110	0.08	0.95
1987	394,758	0.09			401,392	14,194	0.14	343,989	0.09	0.96
1988	572,805	0.09			581,611	23,521	0.22	380,564	0.10	0.96
1989	536,433	0.08			544,796	18,794	0.20	549,284	0.09	0.96
1990	628,235	0.09			637,718	21,217	0.15	517,639	0.09	0.96
1991	544,893	0.08	6,885	0.20	551,778	27,412	0.22	607,049	0.09	0.97
1992	651,384	0.10			661,149	15,927	0.21	517,480	0.08	0.95
1993	610,259	0.07			619,522	22,323	0.21	635,458	0.10	0.98
1994	726,212	0.07	9,917	0.23	736,129	26,837	0.19	587,936	0.07	0.96
1995	593,412	0.09			602,470	15,476	0.01	699,375	0.07	0.96
1996	616,373	0.09			625,711	12,034	0.20	579,337	0.09	0.98
1997	807,825	0.22	11,540	0.24	819,365	14,641	0.19	604,339	0.09	0.98
1998	692,234	0.21			702,497	7,911	0.21	793,184	0.22	0.98
1999	394,822	0.09			401,457	13,229	0.18	684,324	0.21	0.99
2000	399,298	0.09	8,795	0.23	408,093	8,325	0.19	388,944	0.09	0.99
2001	515,275	0.10			523,380	11,419	0.21	390,974	0.09	0.98
2002	579,710	0.18	9,894	0.24	589,604	5,223	0.20	503,943	0.11	0.98
2003	529,188	0.11			537,462	5,799	0.22	573,953	0.18	0.99
2004	616,668	0.08	13,301	0.14	629,969	8,103	0.31	512,390	0.11	0.97
2005	611,123	0.09			620,381	7,288	0.28	606,625	0.09	0.98

Table 8.8a. Survey size composition for flathead sole females.

	Length cutpoints (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	0.0000	0.0000	0.0023	0.0308	0.0443	0.0363	0.0540	0.0860	0.0888	0.0885	0.0981	0.1229	0.1294	0.1014	0.0604	0.0248	0.0124	0.0160	0.0031	0.0007	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0007	0.0165	0.0511	0.0345	0.0602	0.0774	0.0734	0.0624	0.0697	0.0765	0.0845	0.1060	0.1089	0.0969	0.0446	0.0215	0.0126	0.0022	0.0006	0.0000	0.0000	0.0000	0.0000
1984	0.0000	0.0006	0.0064	0.0353	0.0618	0.0849	0.0664	0.0597	0.0758	0.0754	0.0765	0.0881	0.0879	0.0894	0.0890	0.0591	0.0285	0.0130	0.0013	0.0010	0.0000	0.0000	0.0000	0.0000
1985	0.0000	0.0018	0.0019	0.0121	0.0329	0.0504	0.0802	0.1192	0.1031	0.0762	0.0746	0.0810	0.0831	0.0858	0.0797	0.0524	0.0359	0.0220	0.0064	0.0015	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0006	0.0046	0.0163	0.0181	0.0236	0.0417	0.0634	0.0874	0.1014	0.0897	0.0819	0.0924	0.0954	0.1007	0.0746	0.0547	0.0412	0.0094	0.0027	0.0002	0.0000	0.0000	0.0000
1987	0.0000	0.0000	0.0053	0.0231	0.0339	0.0501	0.0509	0.0611	0.0568	0.0706	0.0835	0.0883	0.0900	0.0882	0.0989	0.0757	0.0587	0.0440	0.0173	0.0035	0.0001	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0020	0.0154	0.0577	0.0784	0.0732	0.0910	0.0640	0.0593	0.0621	0.0626	0.0629	0.0803	0.0830	0.0777	0.0554	0.0506	0.0207	0.0028	0.0011	0.0000	0.0000	0.0000
1989	0.0000	0.0001	0.0136	0.0380	0.0246	0.0350	0.0913	0.0908	0.0961	0.0674	0.0545	0.0595	0.0684	0.0595	0.0747	0.0796	0.0587	0.0573	0.0233	0.0070	0.0007	0.0000	0.0000	0.0000
1990	0.0000	0.0002	0.0017	0.0117	0.0523	0.0621	0.0430	0.0601	0.0810	0.0829	0.0727	0.0661	0.0588	0.0687	0.0639	0.0742	0.0716	0.0815	0.0353	0.0100	0.0021	0.0000	0.0000	0.0000
1991	0.0000	0.0007	0.0042	0.0040	0.0058	0.0265	0.0576	0.0795	0.0787	0.0866	0.0826	0.0741	0.0568	0.0643	0.0719	0.0638	0.0896	0.1037	0.0368	0.0122	0.0008	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0031	0.0238	0.0425	0.0330	0.0376	0.0587	0.0797	0.0953	0.0891	0.0885	0.0648	0.0612	0.0655	0.0659	0.0631	0.0733	0.0402	0.0128	0.0019	0.0001	0.0000	0.0000
1993	0.0000	0.0005	0.0043	0.0089	0.0173	0.0450	0.0528	0.0412	0.0634	0.0850	0.0872	0.0976	0.0954	0.0767	0.0661	0.0599	0.0527	0.0851	0.0441	0.0141	0.0026	0.0001	0.0000	0.0000
1994	0.0000	0.0003	0.0018	0.0106	0.0256	0.0377	0.0533	0.0449	0.0379	0.0597	0.0778	0.0944	0.1004	0.0902	0.0773	0.0622	0.0631	0.0825	0.0567	0.0205	0.0029	0.0003	0.0000	0.0000
1995	0.0000	0.0000	0.0013	0.0056	0.0172	0.0329	0.0419	0.0586	0.0544	0.0534	0.0668	0.0865	0.1051	0.0990	0.0870	0.0724	0.0643	0.0749	0.0547	0.0179	0.0060	0.0003	0.0000	0.0000
1996	0.0000	0.0002	0.0030	0.0187	0.0282	0.0430	0.0479	0.0615	0.0611	0.0662	0.0651	0.0642	0.0757	0.0880	0.0930	0.0810	0.0526	0.0727	0.0513	0.0233	0.0032	0.0003	0.0000	0.0000
1997	0.0000	0.0004	0.0015	0.0060	0.0130	0.0200	0.0268	0.0331	0.0375	0.0433	0.0541	0.0579	0.0735	0.0863	0.1025	0.0995	0.0894	0.1184	0.0989	0.0302	0.0072	0.0006	0.0000	0.0000
1998	0.0000	0.0006	0.0134	0.0251	0.0119	0.0219	0.0295	0.0433	0.0474	0.0499	0.0700	0.0757	0.0641	0.0797	0.0985	0.0931	0.0843	0.0917	0.0605	0.0260	0.0119	0.0015	0.0000	0.0000
1999	0.0000	0.0002	0.0037	0.0101	0.0252	0.0275	0.0256	0.0346	0.0495	0.0606	0.0713	0.0710	0.0758	0.0857	0.1118	0.1041	0.0789	0.0745	0.0483	0.0262	0.0134	0.0017	0.0003	0.0000
2000	0.0004	0.0007	0.0029	0.0083	0.0152	0.0300	0.0309	0.0360	0.0345	0.0496	0.0636	0.0685	0.0896	0.0986	0.1075	0.1160	0.0838	0.0859	0.0485	0.0214	0.0073	0.0009	0.0000	0.0000
2001	0.0002	0.0005	0.0041	0.0063	0.0107	0.0192	0.0364	0.0578	0.0607	0.0496	0.0497	0.0748	0.0835	0.0985	0.1109	0.1043	0.0752	0.0781	0.0490	0.0237	0.0054	0.0011	0.0001	0.0000
2002	0.0003	0.0008	0.0027	0.0064	0.0144	0.0184	0.0230	0.0334	0.0483	0.0532	0.0545	0.0634	0.0676	0.0946	0.1070	0.0865	0.0774	0.0846	0.0675	0.0566	0.0314	0.0067	0.0012	0.0000
2003	0.0005	0.0000	0.0027	0.0122	0.0151	0.0195	0.0251	0.0331	0.0394	0.0587	0.0815	0.0958	0.0878	0.0949	0.1019	0.0779	0.0822	0.0990	0.0548	0.0144	0.0032	0.0002	0.0000	0.0001
2004	0.0007	0.0029	0.0069	0.0202	0.0381	0.0418	0.0427	0.0456	0.0506	0.0608	0.0796	0.0919	0.0927	0.0825	0.0864	0.0620	0.0578	0.0774	0.0441	0.0146	0.0007	0.0000	0.0000	0.0000
2005	0.0000	0.0007	0.0061	0.0204	0.0239	0.0352	0.0471	0.0512	0.0512	0.0543	0.0641	0.0696	0.0812	0.0907	0.0924	0.0761	0.0537	0.0699	0.0629	0.0358	0.0122	0.0012	0.0000	0.0000

Table 8.8b. Survey size composition for flathead sole males.

year	Length cutpoints (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
1982	0.0005	0.0005	0.0025	0.0339	0.0535	0.0487	0.0588	0.0812	0.0961	0.1112	0.1478	0.1578	0.1269	0.0552	0.0182	0.0054	0.0010	0.0007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0007	0.0019	0.0240	0.0683	0.0400	0.0698	0.0937	0.0799	0.0710	0.0815	0.1013	0.1216	0.1173	0.0837	0.0336	0.0095	0.0019	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0008	0.0017	0.0117	0.0351	0.0647	0.1063	0.0817	0.0774	0.0898	0.0899	0.0981	0.1080	0.1038	0.0797	0.0383	0.0085	0.0040	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
1985	0.0000	0.0038	0.0061	0.0126	0.0336	0.0567	0.0868	0.1223	0.1070	0.0813	0.1000	0.1066	0.1151	0.0867	0.0553	0.0203	0.0047	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0006	0.0011	0.0098	0.0319	0.0235	0.0307	0.0519	0.0876	0.0998	0.1117	0.1135	0.0942	0.1179	0.1196	0.0666	0.0279	0.0093	0.0022	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
1987	0.0001	0.0003	0.0093	0.0296	0.0334	0.0543	0.0542	0.0660	0.0776	0.0982	0.0962	0.1120	0.1224	0.1203	0.0679	0.0353	0.0185	0.0047	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0005	0.0015	0.0047	0.0277	0.0692	0.0915	0.0664	0.0686	0.0581	0.0637	0.0675	0.0774	0.1038	0.1239	0.1083	0.0465	0.0159	0.0046	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0000	0.0013	0.0152	0.0613	0.0353	0.0380	0.1118	0.0899	0.0901	0.0638	0.0655	0.0667	0.0669	0.1124	0.1118	0.0516	0.0158	0.0026	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0000	0.0011	0.0039	0.0141	0.0604	0.0638	0.0526	0.0775	0.0933	0.0815	0.0790	0.0798	0.0895	0.1111	0.1080	0.0571	0.0225	0.0045	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.0001	0.0006	0.0106	0.0077	0.0091	0.0418	0.0808	0.1106	0.1047	0.0990	0.0983	0.0810	0.0895	0.0843	0.0946	0.0638	0.0188	0.0042	0.0004	0.0001	0.0000	0.0000	0.0000	0.0000
1992	0.0000	0.0000	0.0025	0.0323	0.0538	0.0330	0.0356	0.0660	0.0927	0.1155	0.1039	0.0856	0.0895	0.0976	0.0997	0.0640	0.0232	0.0047	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000
1993	0.0000	0.0008	0.0060	0.0117	0.0167	0.0504	0.0557	0.0528	0.0627	0.0948	0.1204	0.1200	0.1055	0.1114	0.1020	0.0596	0.0231	0.0061	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0000	0.0007	0.0038	0.0152	0.0329	0.0498	0.0664	0.0573	0.0519	0.0703	0.0961	0.1080	0.1190	0.1164	0.1093	0.0722	0.0240	0.0063	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000
1995	0.0000	0.0001	0.0018	0.0072	0.0178	0.0321	0.0411	0.0563	0.0655	0.0614	0.0997	0.1244	0.1427	0.1296	0.1119	0.0682	0.0299	0.0098	0.0005	0.0001	0.0000	0.0000	0.0000	0.0000
1996	0.0001	0.0006	0.0028	0.0174	0.0336	0.0315	0.0492	0.0610	0.0659	0.0688	0.0787	0.1025	0.1229	0.1287	0.1198	0.0750	0.0298	0.0109	0.0009	0.0000	0.0000	0.0000	0.0000	0.0000
1997	0.0001	0.0005	0.0029	0.0101	0.0121	0.0235	0.0294	0.0391	0.0518	0.0644	0.0716	0.0887	0.1389	0.1475	0.1413	0.0991	0.0519	0.0231	0.0023	0.0018	0.0000	0.0000	0.0000	0.0000
1998	0.0001	0.0012	0.0157	0.0316	0.0167	0.0241	0.0269	0.0343	0.0428	0.0638	0.0708	0.0865	0.1241	0.1476	0.1446	0.0979	0.0548	0.0137	0.0024	0.0004	0.0000	0.0000	0.0000	0.0000
1999	0.0000	0.0007	0.0041	0.0115	0.0318	0.0252	0.0279	0.0460	0.0490	0.0756	0.0935	0.1029	0.1249	0.1541	0.1295	0.0713	0.0331	0.0171	0.0016	0.0002	0.0000	0.0000	0.0000	0.0000
2000	0.0001	0.0006	0.0086	0.0123	0.0183	0.0388	0.0355	0.0410	0.0453	0.0692	0.1025	0.1041	0.1407	0.1411	0.1185	0.0789	0.0311	0.0123	0.0009	0.0004	0.0001	0.0000	0.0000	0.0000
2001	0.0000	0.0009	0.0058	0.0074	0.0195	0.0239	0.0430	0.0733	0.0693	0.0534	0.0687	0.1129	0.1389	0.1422	0.1217	0.0693	0.0356	0.0113	0.0022	0.0006	0.0000	0.0000	0.0000	0.0000
2002	0.0001	0.0006	0.0025	0.0083	0.0170	0.0228	0.0277	0.0455	0.0725	0.0755	0.0754	0.0950	0.1381	0.1475	0.1364	0.0801	0.0329	0.0158	0.0026	0.0038	0.0000	0.0000	0.0000	0.0000
2003	0.0000	0.0008	0.0053	0.0129	0.0153	0.0285	0.0352	0.0375	0.0518	0.0848	0.1039	0.1260	0.1391	0.1210	0.1071	0.0786	0.0393	0.0104	0.0026	0.0001	0.0000	0.0000	0.0000	0.0000
2004	0.0005	0.0031	0.0107	0.0223	0.0340	0.0480	0.0427	0.0520	0.0609	0.0816	0.1204	0.1379	0.1275	0.1201	0.0741	0.0460	0.0136	0.0041	0.0003	0.0001	0.0000	0.0000	0.0000	0.0000
2005	0.0000	0.0012	0.0084	0.0237	0.0276	0.0360	0.0484	0.0570	0.0590	0.0593	0.0847	0.1134	0.1378	0.1288	0.1013	0.0616	0.0337	0.0150	0.0016	0.0009	0.0008	0.0000	0.0000	0.0000

Table 8.9a. Survey age composition for flathead sole females.

year	Age bin 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1982	0.1262	0.1817	0.1069	0.1626	0.1117	0.0918	0.0891	0.0287	0.0178	0.0450	0.0235	0.0063	0.0089	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1985	0.0973	0.2213	0.1458	0.0898	0.1241	0.0527	0.0641	0.0615	0.0417	0.0564	0.0116	0.0028	0.0098	0.0164	0.0013	0.0000	0.0020	0.0000	0.0012
1992	0.0865	0.0295	0.1364	0.1330	0.1294	0.0546	0.1137	0.0625	0.0574	0.0983	0.0507	0.0211	0.0091	0.0084	0.0060	0.0024	0.0000	0.0000	0.0012
1995	0.0538	0.0660	0.0965	0.0594	0.1093	0.1776	0.0763	0.0825	0.0719	0.0548	0.0463	0.0347	0.0281	0.0184	0.0133	0.0074	0.0009	0.0000	0.0029
2000	0.0330	0.0964	0.0537	0.0730	0.0452	0.0683	0.1088	0.0957	0.0803	0.0521	0.0822	0.0510	0.0305	0.0309	0.0415	0.0170	0.0152	0.0075	0.0176
2003	0.0504	0.0583	0.1186	0.1093	0.1504	0.0453	0.0353	0.0864	0.0162	0.0493	0.0101	0.0468	0.0274	0.0700	0.0274	0.0487	0.0165	0.0062	0.0271
2004	0.1394	0.0418	0.1590	0.1597	0.0627	0.0705	0.0286	0.0258	0.0260	0.0256	0.0561	0.0315	0.0336	0.0048	0.0383	0.0278	0.0115	0.0000	0.0572

Table 8.9b. Survey age composition for flathead sole males.

year	Age bin 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1982	0.1301	0.1467	0.1907	0.1783	0.1085	0.0808	0.0229	0.0285	0.0431	0.0115	0.0245	0.0236	0.0023	0.0000	0.0014	0.0026	0.0000	0.0046	0.0000
1985	0.0980	0.2265	0.1138	0.1172	0.0848	0.0784	0.0831	0.0488	0.0620	0.0295	0.0238	0.0157	0.0125	0.0057	0.0000	0.0000	0.0000	0.0000	0.0000
1992	0.1047	0.0417	0.1807	0.0987	0.1744	0.0924	0.0844	0.0960	0.0407	0.0334	0.0398	0.0062	0.0000	0.0000	0.0070	0.0000	0.0000	0.0000	0.0000
1995	0.0376	0.1140	0.0766	0.1006	0.0511	0.1220	0.1085	0.1266	0.0819	0.0492	0.0074	0.0600	0.0385	0.0169	0.0027	0.0025	0.0000	0.0037	0.0000
2000	0.0365	0.1248	0.0999	0.0358	0.0642	0.1256	0.1472	0.0662	0.0386	0.0264	0.0722	0.0161	0.0393	0.0225	0.0112	0.0314	0.0068	0.0128	0.0224
2003	0.0570	0.1125	0.1007	0.1107	0.0979	0.0992	0.0620	0.0954	0.0263	0.0366	0.0113	0.1020	0.0113	0.0183	0.0119	0.0058	0.0058	0.0015	0.0337
2004	0.1358	0.0526	0.1304	0.1172	0.0676	0.0663	0.0265	0.0826	0.0642	0.0518	0.0564	0.0246	0.0196	0.0385	0.0092	0.0143	0.0159	0.0041	0.0223

Table 8.10. Flathead sole sample sizes from the EBS shelf survey. The hauls columns refer to the number of hauls from which either lengths or read otoliths were obtained.

	------Lengths------		------Ages------		Collected
Year	**# hauls**	**# individuals**	**# hauls**	**# individuals**	**otoliths**
1982	108	11029	15	390	390
1983	170	15727			
1984	152	14043			569
1985	189	13560	23	496	496
1986	259	13561			
1987	191	13878			
1988	202	14049			
1989	253	15509			
1990	256	15437			
1991	266	16102			
1992	273	15813	11	419	419
1993	288	17057	5	136	140
1994	277	16366	7	371	371
1995	263	14946	10	395	396
1996	290	19244			420
1997	281	16339			301
1998	315	21611			87
1999	243	14172			420
2000	277	15905	18	437	439
2001	286	16399			537
2002	281	16705			471
2003	276	17652	34	246	576
2004	274	18737	16	473	477
2005	284	16875			465

Table 8.11. Mean bottom temperature from Eastern Bering Sea shelf surveys.

Year	Bottom Temperature (deg C)
1982	2.269
1983	3.022
1984	2.333
1985	2.367
1986	1.859
1987	3.219
1988	2.352
1989	2.967
1990	2.448
1991	2.699
1992	1.928
1993	3.061
1994	1.571
1995	1.750
1996	3.425
1997	2.742
1998	3.275
1999	0.830
2000	2.161
2001	2.575
2002	3.250
2003	3.810
2004	3.384
2005	3.471

Table 8.12. Parameter estimates corresponding to the final model.

Fishery selectivity

slope	L_{50}
0.312	35.36

Survey selectivity

slope	L_{50}
0.094	29.59

Survey catchability

β_q	0.127

Historic parameters

f	0.064
ln(R0)	4.405

Fishing mortality

μ_f	-2.999					
ε_t	1976-1980:		1.711	1.611	1.052	0.999
	1981-1985:	0.667	0.189	0.047	-0.362	-0.336
	1986-1990:	-0.601	-1.138	-0.654	-1.413	0.212
	1991-1995:	-0.214	-0.264	-0.380	-0.197	-0.376
	1996-2000:	-0.224	-0.046	0.150	-0.102	0.035
	2001-2005:	-0.057	-0.143	-0.205	0.053	-0.017

Recruitment

$\ln(R_0)$	6.619					
h	1.988					
υ_t	1976-1980:		1.080	-0.958	0.531	-0.851
	1981-1985:	0.528	-0.264	0.942	1.055	-0.282
	1986-1990:	0.118	0.355	0.877	0.568	0.691
	1991-1995:	-0.045	-0.341	0.181	0.272	-0.577
	1996-2000:	-0.100	-1.041	-0.324	-0.317	-0.044
	2001-2005:	-0.424	-0.451	-0.318	-0.827	-0.032

Table 8.13. Estimated total biomass (ages 3+), female spawner biomass, and recruitment (age 3), with comparison to the 2004 SAFE estimates.

	Spawning stock biomass (t)		Total biomass (t)		Recruitment (thousands)	
	Assessment		Assessment		Assessment	
Year	2005	2004	2005	2004	2005	2004
1977	22,257	20,601	130,510	122,374	2,199,950	2,065,170
1978	20,023	18,375	166,480	155,800	286,485	266,255
1979	19,076	17,417	228,070	213,320	1,270,390	1,191,080
1980	20,294	18,549	278,760	260,791	318,898	301,169
1981	24,222	22,229	345,720	323,149	1,266,640	1,175,610
1982	33,791	31,205	400,430	374,358	573,690	546,599
1983	51,916	48,186	482,740	450,742	1,916,880	1,771,150
1984	77,655	72,249	584,290	544,820	2,146,040	1,990,010
1985	105,066	97,840	660,090	615,063	563,664	527,555
1986	130,219	121,267	726,300	676,156	840,251	777,450
1987	154,004	143,387	785,840	730,875	1,065,890	982,172
1988	179,253	166,835	856,710	795,658	1,794,770	1,644,020
1989	207,224	192,694	916,420	849,621	1,317,770	1,202,780
1990	238,689	221,706	978,670	905,651	1,491,440	1,356,070
1991	263,639	244,242	1,006,800	929,214	713,918	645,136
1992	283,034	261,712	1,019,900	939,356	531,445	484,731
1993	296,777	273,860	1,025,100	941,919	895,246	802,905
1994	310,127	285,517	1,024,900	939,196	980,929	871,460
1995	326,442	299,674	1,006,600	919,628	419,370	362,717
1996	337,613	309,068	980,870	893,333	675,659	594,643
1997	343,033	313,028	939,990	853,355	263,781	231,914
1998	337,225	306,564	893,120	808,062	540,034	486,084
1999	325,960	295,000	843,920	761,106	543,896	502,457
2000	313,110	282,188	803,540	723,162	715,153	654,990
2001	299,920	268,937	763,350	682,307	488,761	319,268
2002	285,321	254,601	726,540	642,873	475,668	303,196
2003	267,382	237,520	692,360	603,202	543,589	319,773
2004	250,206	221,359	658,150	577,628	326,739	739,328
2005	233,850		632,100		723,418	

Table 8.14. Projections of catch (t), spawning biomass (t), and fishing mortality rate for the seven standard projection scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 123,656 t and 108,199 t, respectively.

year	Catch (t) scenario 1	scenario 2	scenario 3	scenario 4	scenario 5	scenario 6	scenario 7
2005	14,836	14,836	14,836	14,836	14,836	14,836	14,836
2006	59,794	59,794	31,146	10,175	NA	71,764	71,764
2007	50,232	50,232	28,283	9,759	NA	58,294	58,294
2008	43,215	43,215	25,953	9,392	NA	48,834	48,834
2009	37,649	37,649	24,331	9,154	NA	37,817	37,817
2010	32,082	32,082	23,454	9,091	NA	32,490	32,490
2011	30,665	30,665	23,150	9,163	NA	31,553	31,553
2012	31,457	31,457	23,205	9,305	NA	32,958	32,958
2013	33,214	33,214	23,606	9,550	NA	35,399	35,399
2014	34,768	34,768	24,105	9,811	NA	37,542	37,542
2015	36,095	36,095	24,698	10,113	NA	39,212	39,212
2016	37,105	37,105	25,273	10,408	NA	40,352	40,352
2017	37,872	37,872	25,808	10,695	NA	41,057	41,057
2018	38,351	38,351	26,252	10,937	NA	41,452	41,452

year	Female spawning biomass (t) scenario 1	scenario 2	scenario 3	scenario 4	scenario 5	scenario 6	scenario 7
2005	221,452	221,452	221,452	221,452	221,452	221,452	221,452
2006	203,452	203,452	206,880	209,255	210,370	201,952	201,952
2007	167,238	167,238	186,309	200,735	207,872	159,496	159,496
2008	139,792	139,792	168,483	192,045	204,295	128,939	128,939
2009	120,536	120,536	154,638	184,944	201,456	108,813	108,813
2010	109,519	109,519	145,904	181,262	201,389	99,234	99,234
2011	106,372	106,372	142,566	181,769	204,996	97,202	97,202
2012	108,089	108,089	143,527	185,628	211,444	99,691	99,691
2013	112,327	112,327	147,770	192,664	220,992	104,240	104,240
2014	116,692	116,692	152,841	200,215	230,799	108,523	108,523
2015	120,520	120,520	158,168	208,217	241,142	111,902	111,902
2016	123,300	123,300	162,807	215,479	250,681	114,060	114,060
2017	125,172	125,172	166,701	221,999	259,480	115,274	115,274
2018	126,316	126,316	169,699	227,291	266,806	115,857	115,857

year	Fishing mortality scenario 1	scenario 2	scenario 3	scenario 4	scenario 5	scenario 6	scenario 7
2005	0.065	0.065	0.065	0.065	0.065	0.065	0.065
2006	0.296	0.296	0.148	0.047	NA	0.362	0.362
2007	0.296	0.296	0.148	0.047	NA	0.362	0.362
2008	0.296	0.296	0.148	0.047	NA	0.362	0.362
2009	0.288	0.288	0.148	0.047	NA	0.316	0.316
2010	0.261	0.261	0.148	0.047	NA	0.287	0.287
2011	0.253	0.253	0.148	0.047	NA	0.280	0.280
2012	0.256	0.256	0.148	0.047	NA	0.288	0.288
2013	0.264	0.264	0.148	0.047	NA	0.300	0.300
2014	0.270	0.270	0.148	0.047	NA	0.311	0.311
2015	0.275	0.275	0.148	0.047	NA	0.318	0.318
2016	0.277	0.277	0.148	0.047	NA	0.322	0.322
2017	0.279	0.279	0.148	0.047	NA	0.325	0.325
2018	0.280	0.280	0.148	0.047	NA	0.326	0.326

Table 8.15. Prohibited species catch in the flathead sole target fishery.

year	Flathead sole (t)	Halibut kg	Halibut kg/t	Crab #	Crab #/t	Salmon #	Salmon #/t
2003	6,525	223,673	34	552,495	85	230	0.04
2004	9,673	632,041	65	292,650	30	2,867	0.30

Table 8.16. Catch of non-prohibited species in the flathead sole target fishery. The percentage catch is relative to the catch of flathead sole in its target fishery.

	2004		2003	
species	Total (t)	percent	Total (t)	percent
Alaska plaice	494	5	657	10
Atka mackerel	6	0	5	0
arrowtooth flounder	3,789	39	2,079	32
miscellaneous flatfish	160	2	36	1
flathead sole	9,673	100	6,525	100
turbot (BSAI)	196	2	77	1
northern rockfish	1	0	2	0
all sharks, skates, squid, sculpin, and octopus	1,837	19	1,012	16
Pacific cod	2,816	29	1,790	27
pollock	5,293	55	2,990	46
POP	44	0	42	1
rougheye	2	0	0	0
other rockfish complex	52	1	15	0
rock sole	2,143	22	1,174	18
sablefish	33	0	3	0
squid	4	0	0	0
shortraker	1	0	0	0
yellowfin sole	2,432	25	2,493	38

Figures

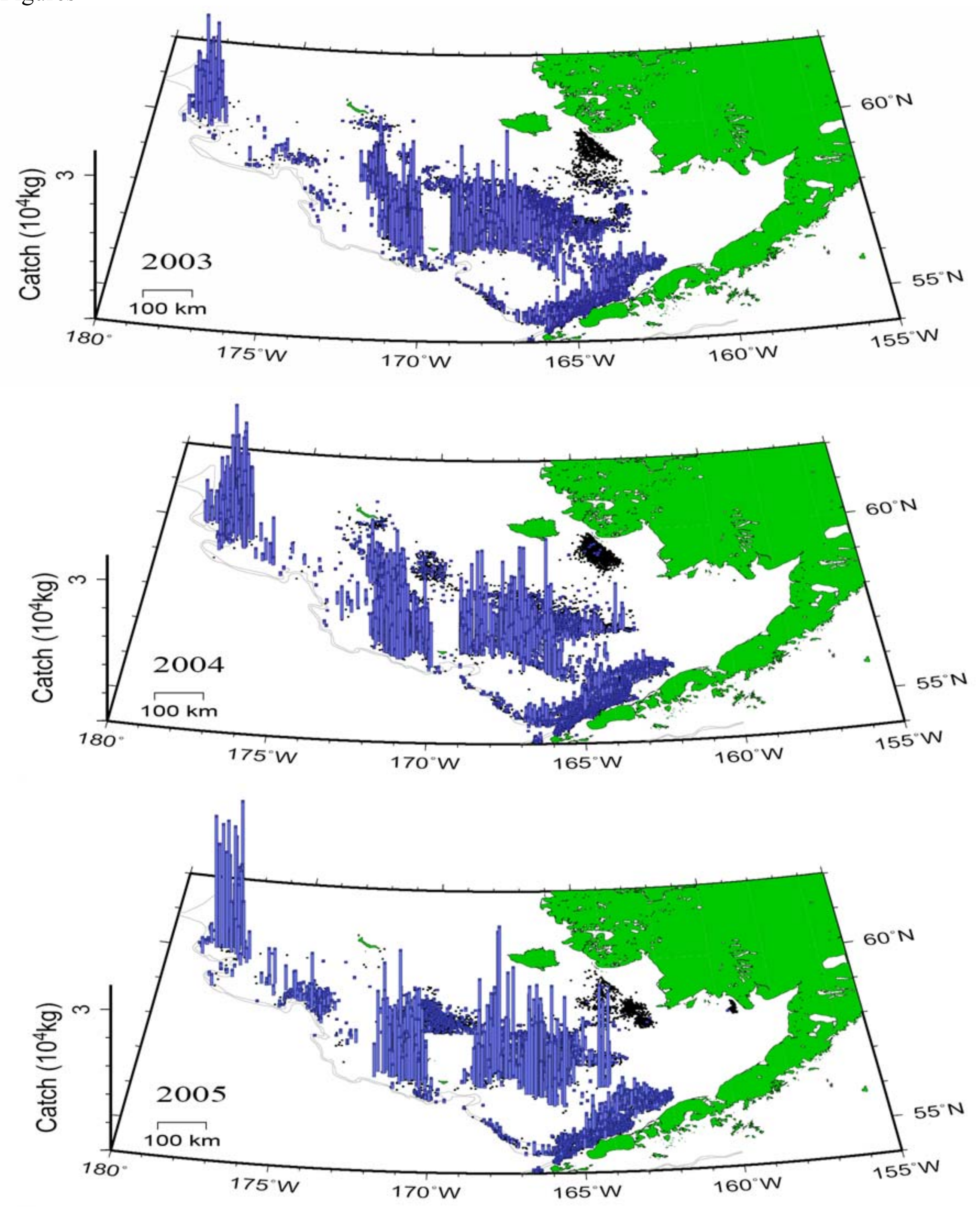

Figure 8.1. Spatial distribution of flathead sole catches, 2003-2005, from observer data. Black dots indicate hauls with no flathead sole catch.

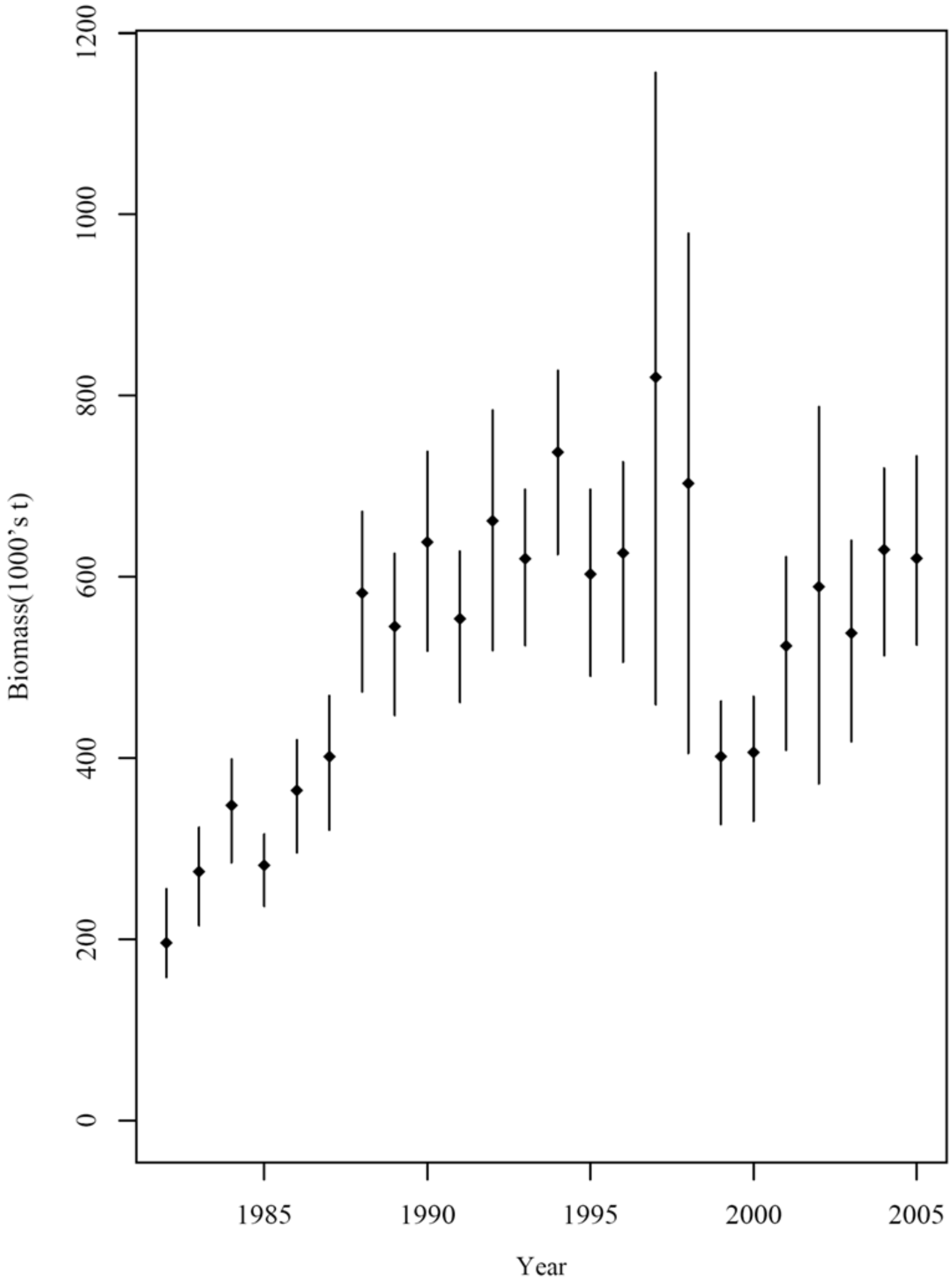

Figure 8.2. Estimated biomass for BSAI flathead sole from EBS and AI surveys. Bars represent 95% confidence intervals.

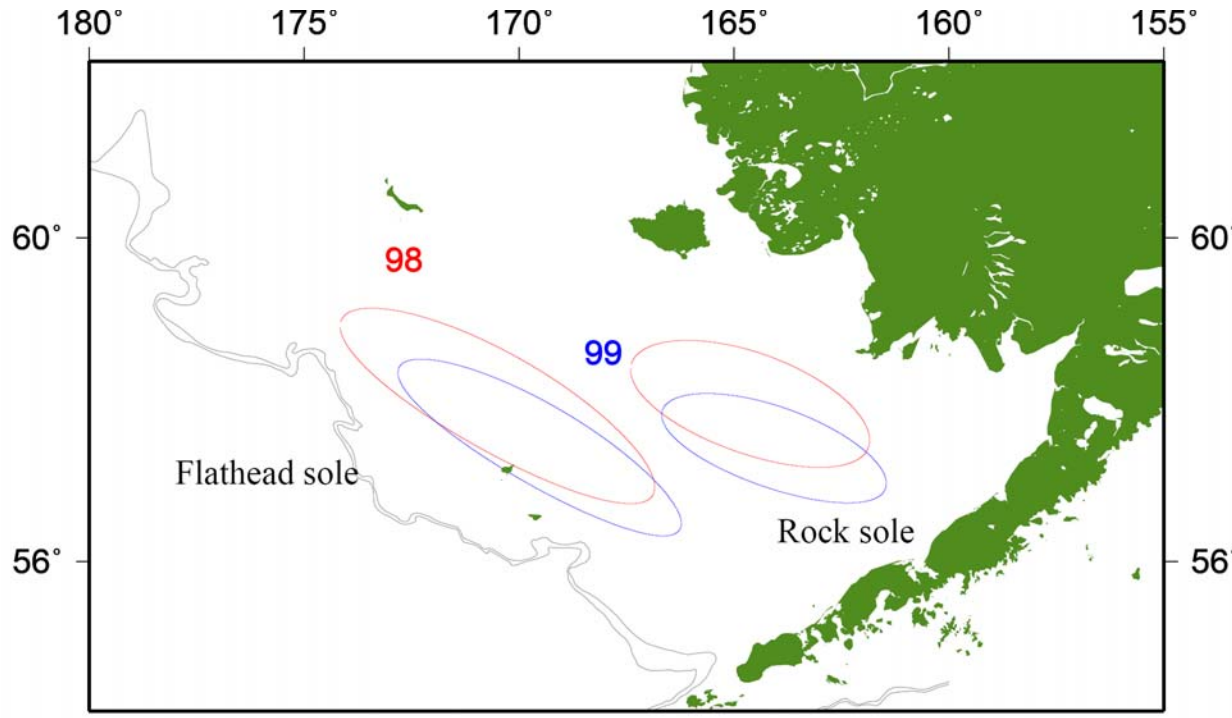

Figure 8.3. Centers of the cold pool (labeled by year), and the distributional ellipses encompassing a probability of 50% for a bivariate normal distribution (based upon EBS shelf survey CPUE data) for flathead sole and rock sole in 1998 (red) and 1999 (blue).

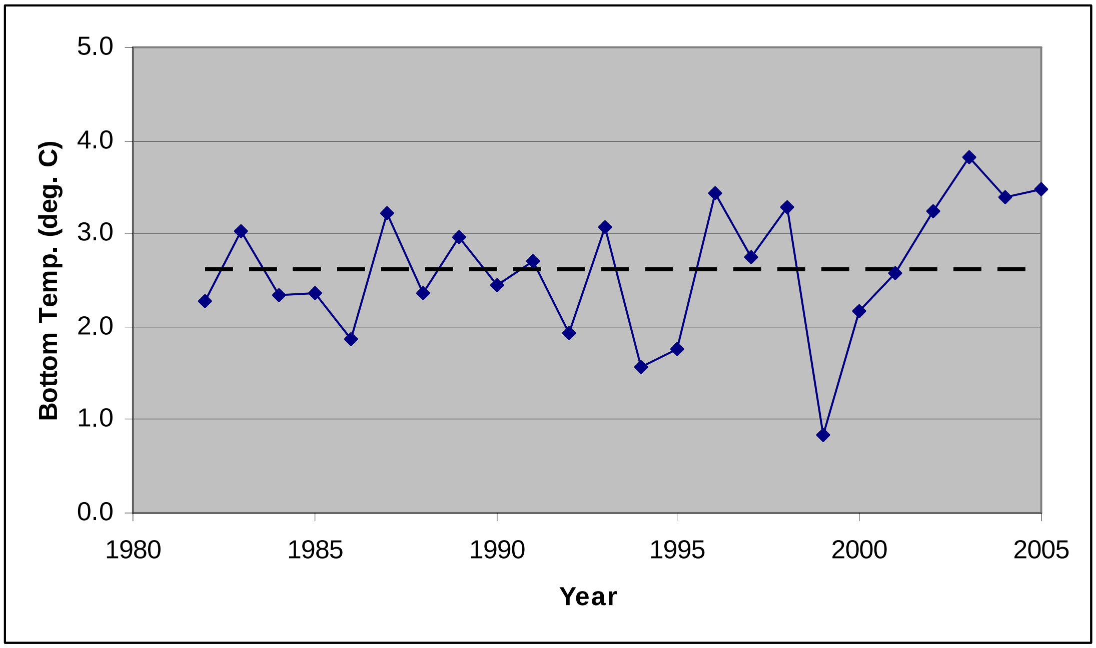

Figure 8.4. Mean bottom temperature from Eastern Bering Sea shelf survey. Observed values = solid line, mean value = dashed line.

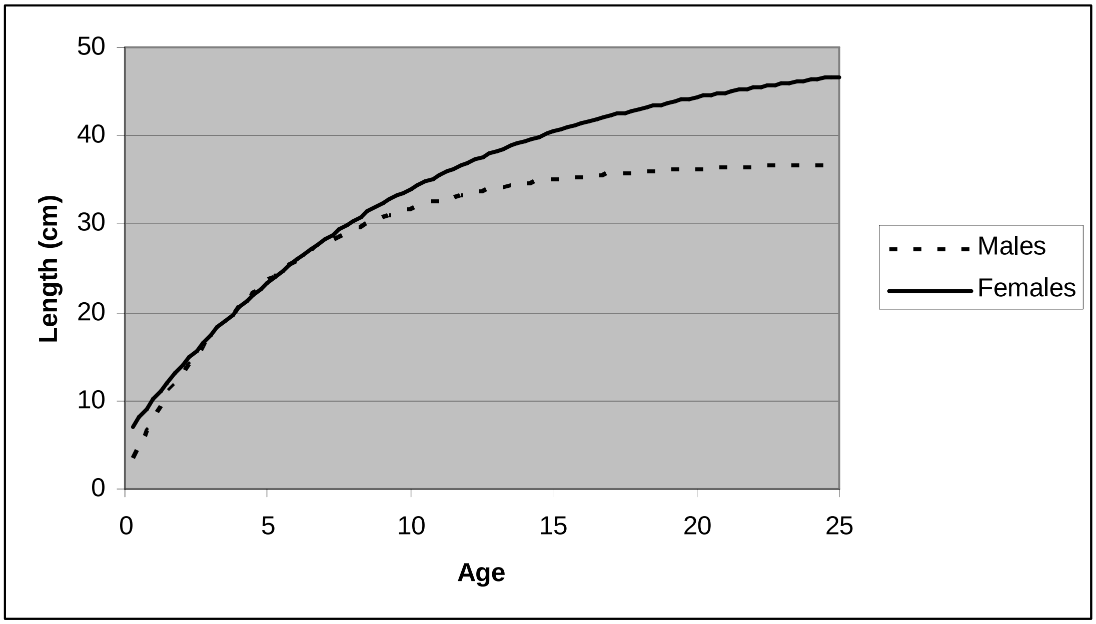

Figure 8.5. Flathead sole mean length at age for females (solid line) and males (dotted line) from NMFS summer surveys (same as the 2004 assessment).

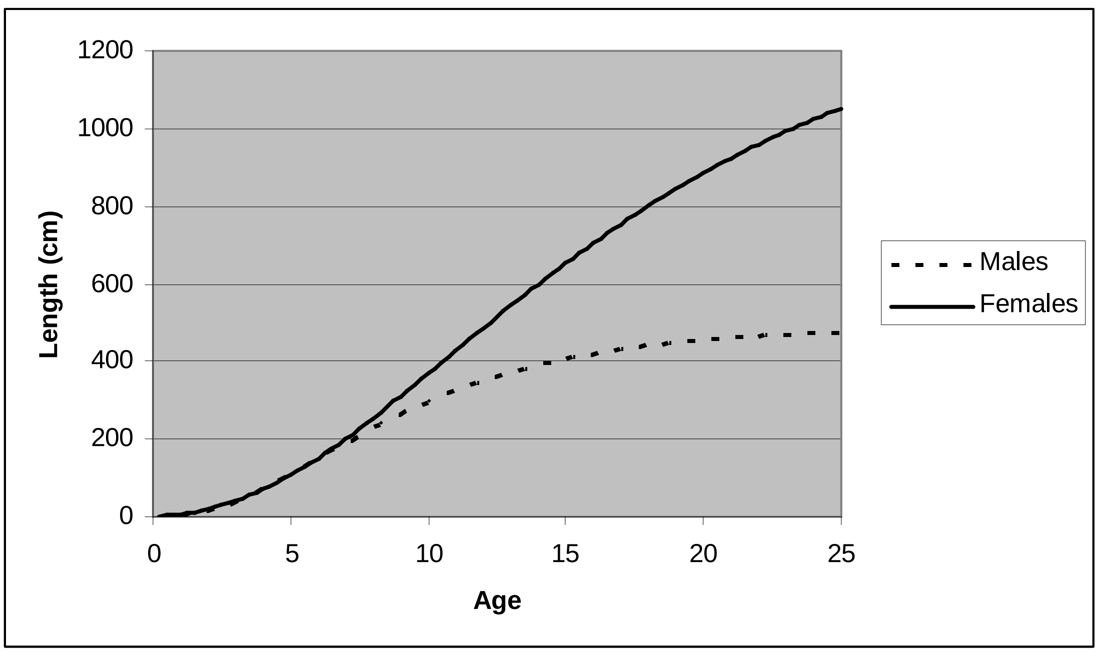

Figure 8.6. Weights at age used in the 2005 assessment (same as the 2004 assessment). Females = solid line, males = dotted line.

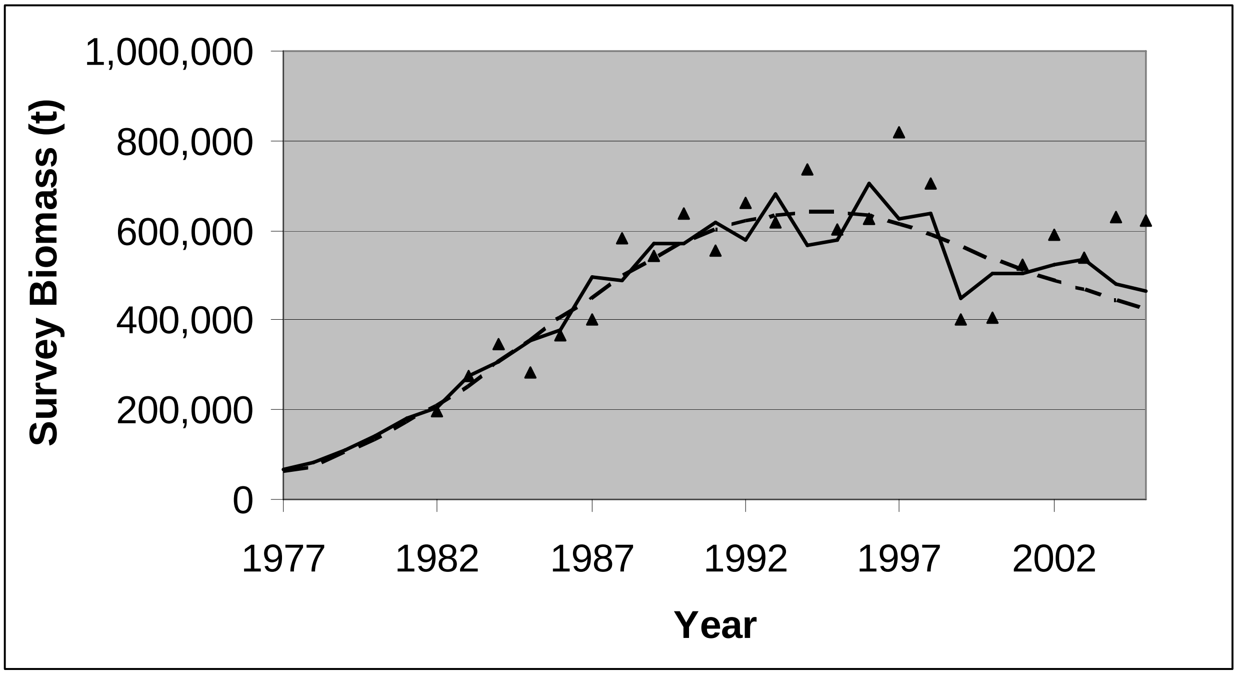

Figure 8..7. Model fits with temperature-dependent survey catchability (solid line) and temperature-independent survey catchability (dashed line) to survey biomass (triangles).

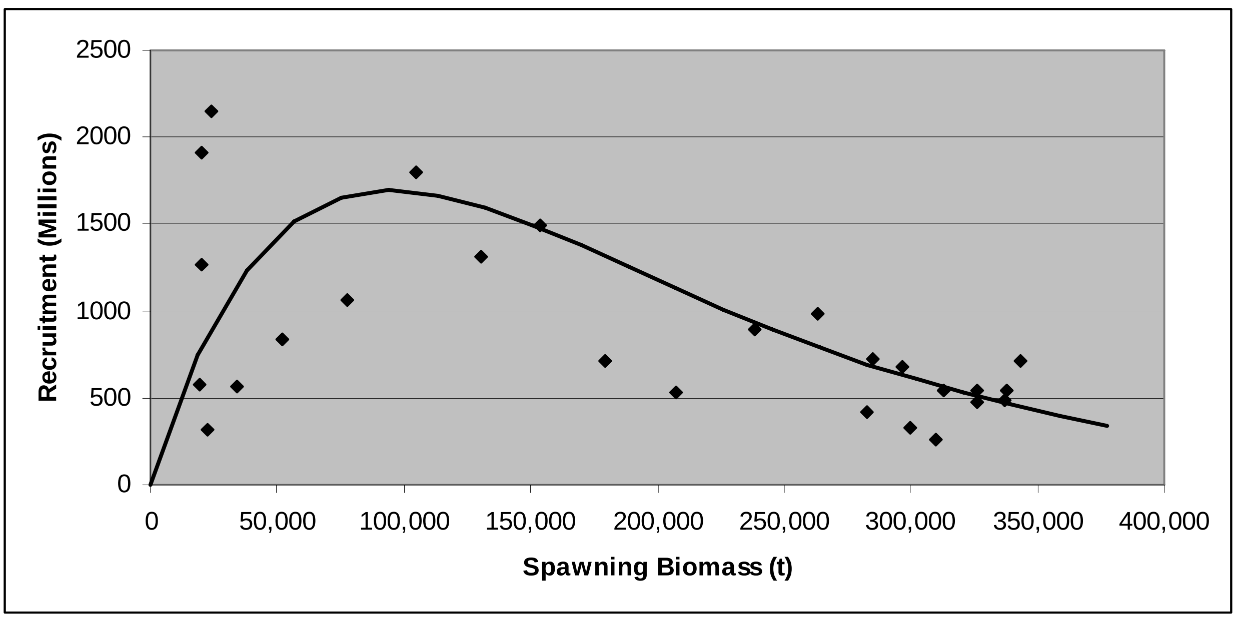

Figure 8.8. Estimated Ricker stock recruitment relationship for flathead sole using the year classes 1977 –2002.

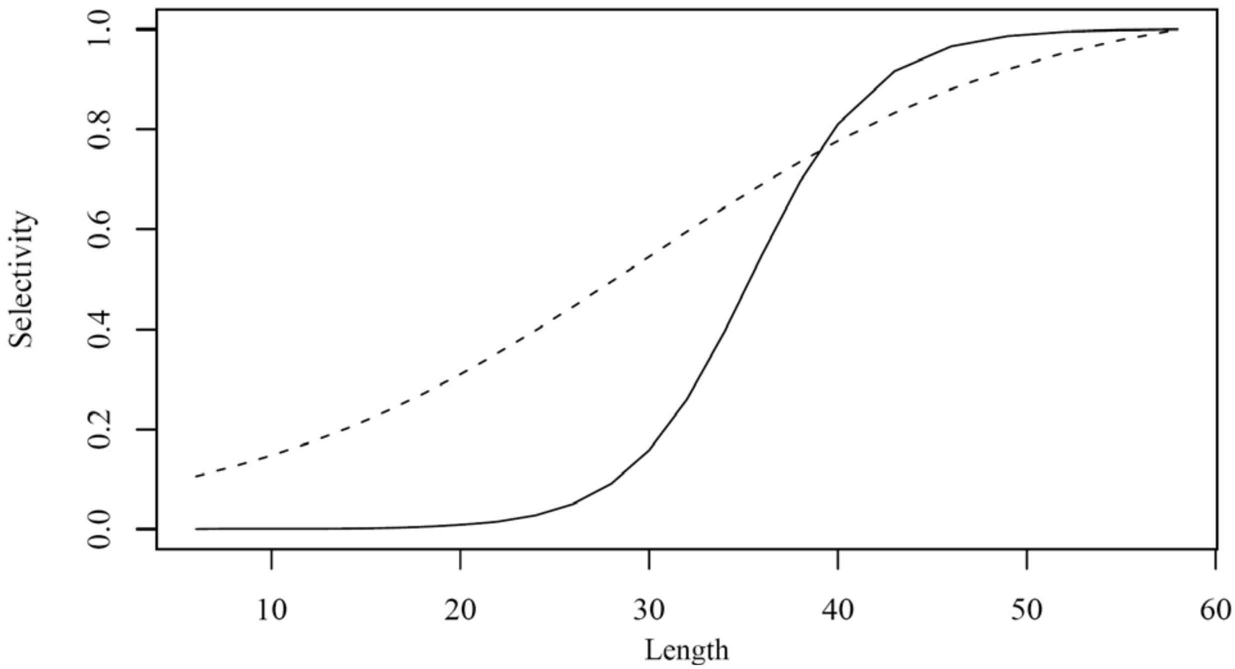

Figure 8.9. Estimated fishery (solid line) and survey (dashed line) selectivity-by-length curves.

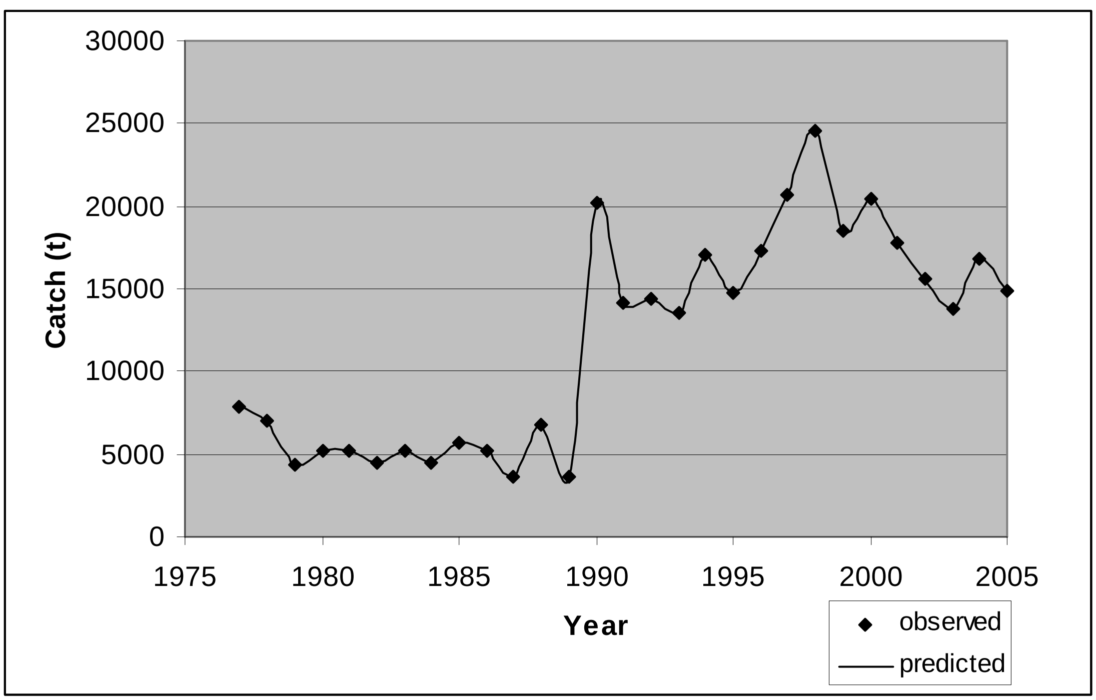

Figure 8.10. Predicted and observed fishery catches from 1977-2005. Predicted catch = solid line, reported catch = diamond symbols.

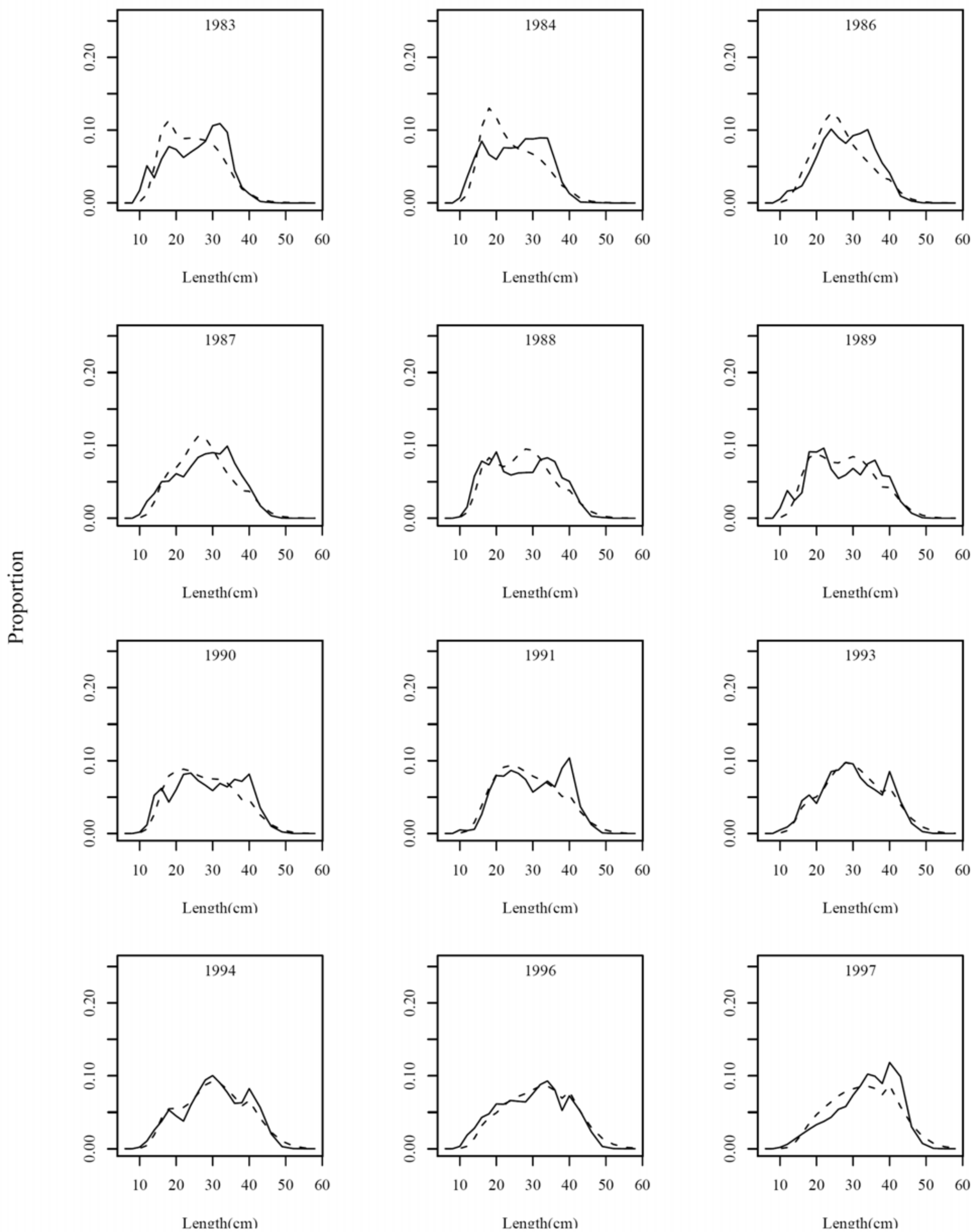

Figure 8.11. Model fit to female survey length composition by year. Solid line = observed length composition, dashed line = model fit.

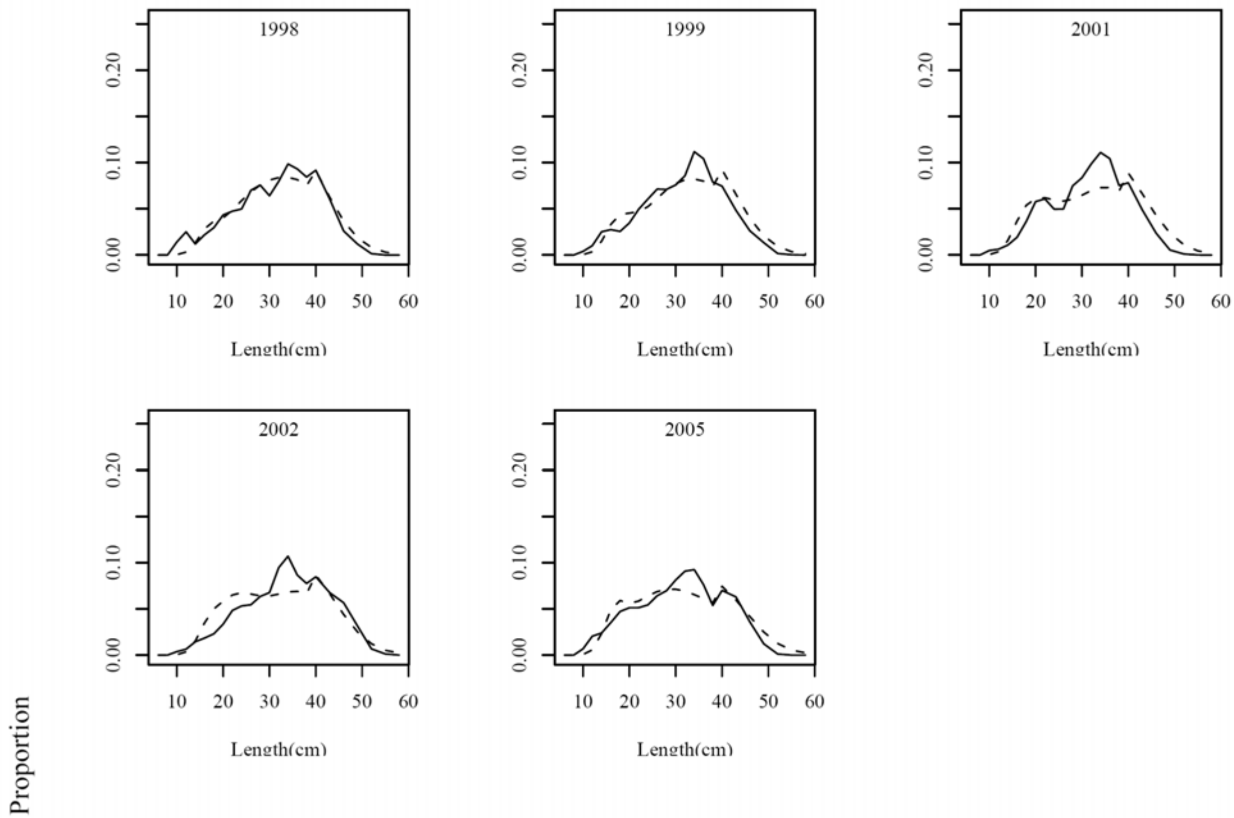

Figure 8.11 (cont.).

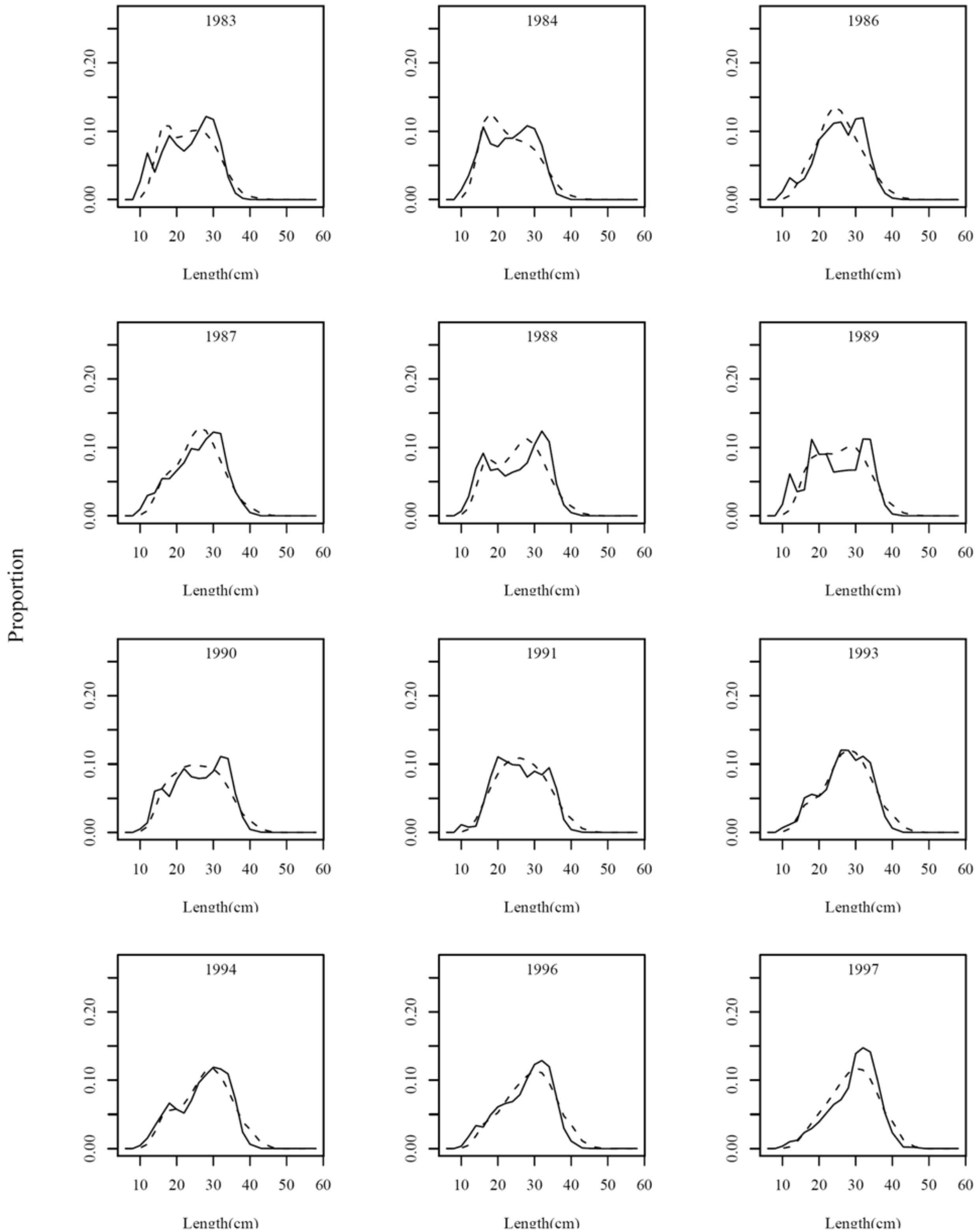

Figure 8.12. Model fit to male survey length composition by year. Solid line = observed length composition, dashed line = model fit.

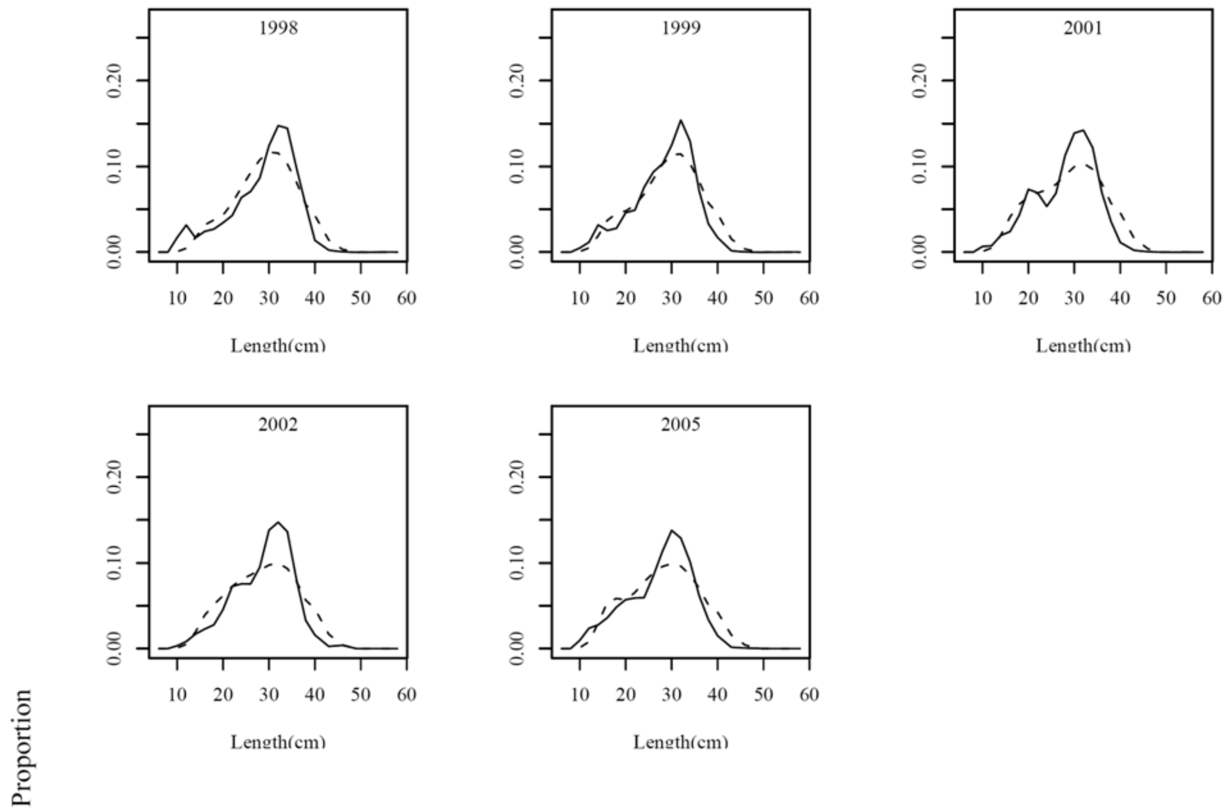

Figure 8.12 (cont.).

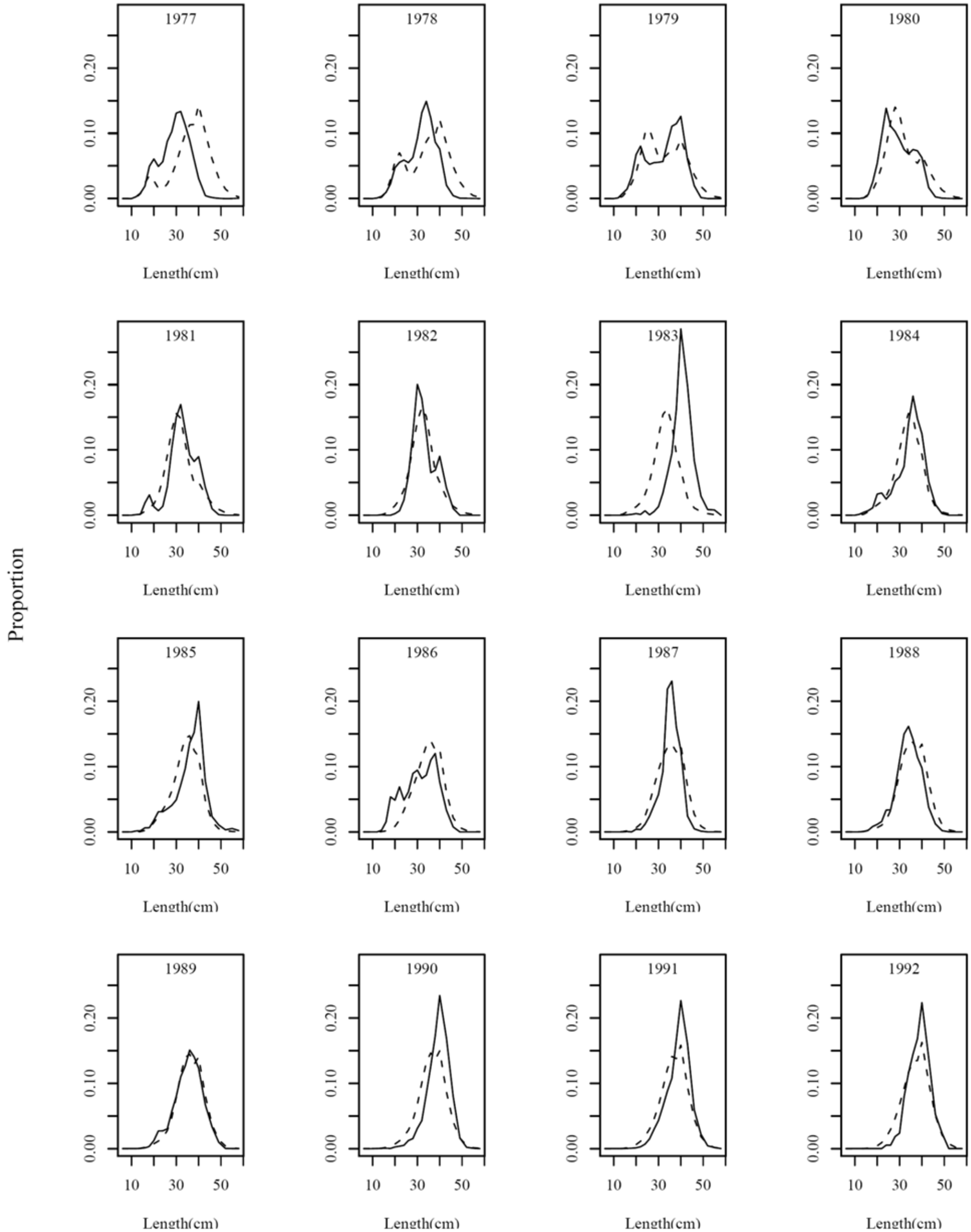

Figure 8.13. Model fit to female fishery length composition by year. Solid line = observed, dotted line = predicted.

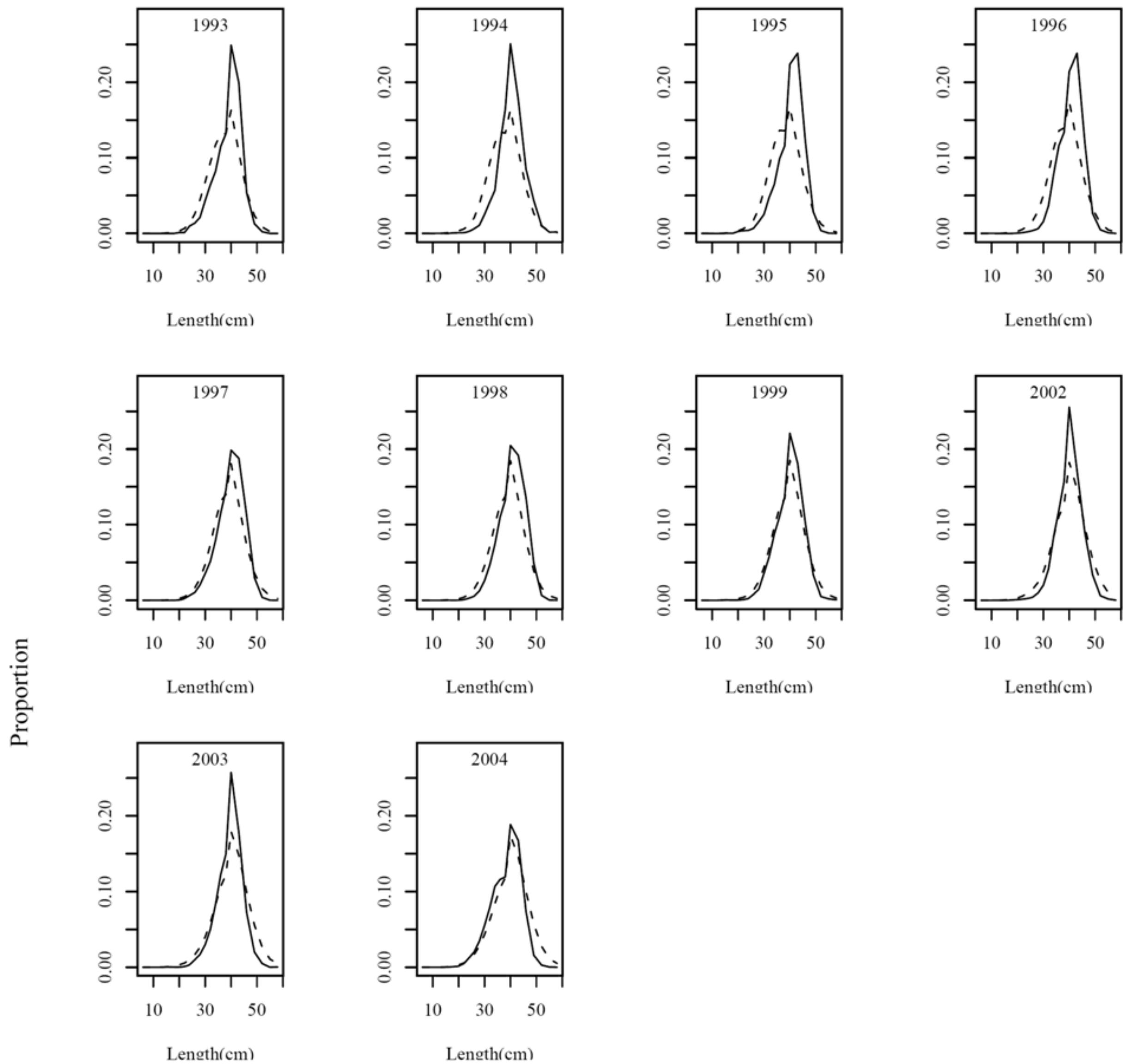

Figure 8.13 (cont.).

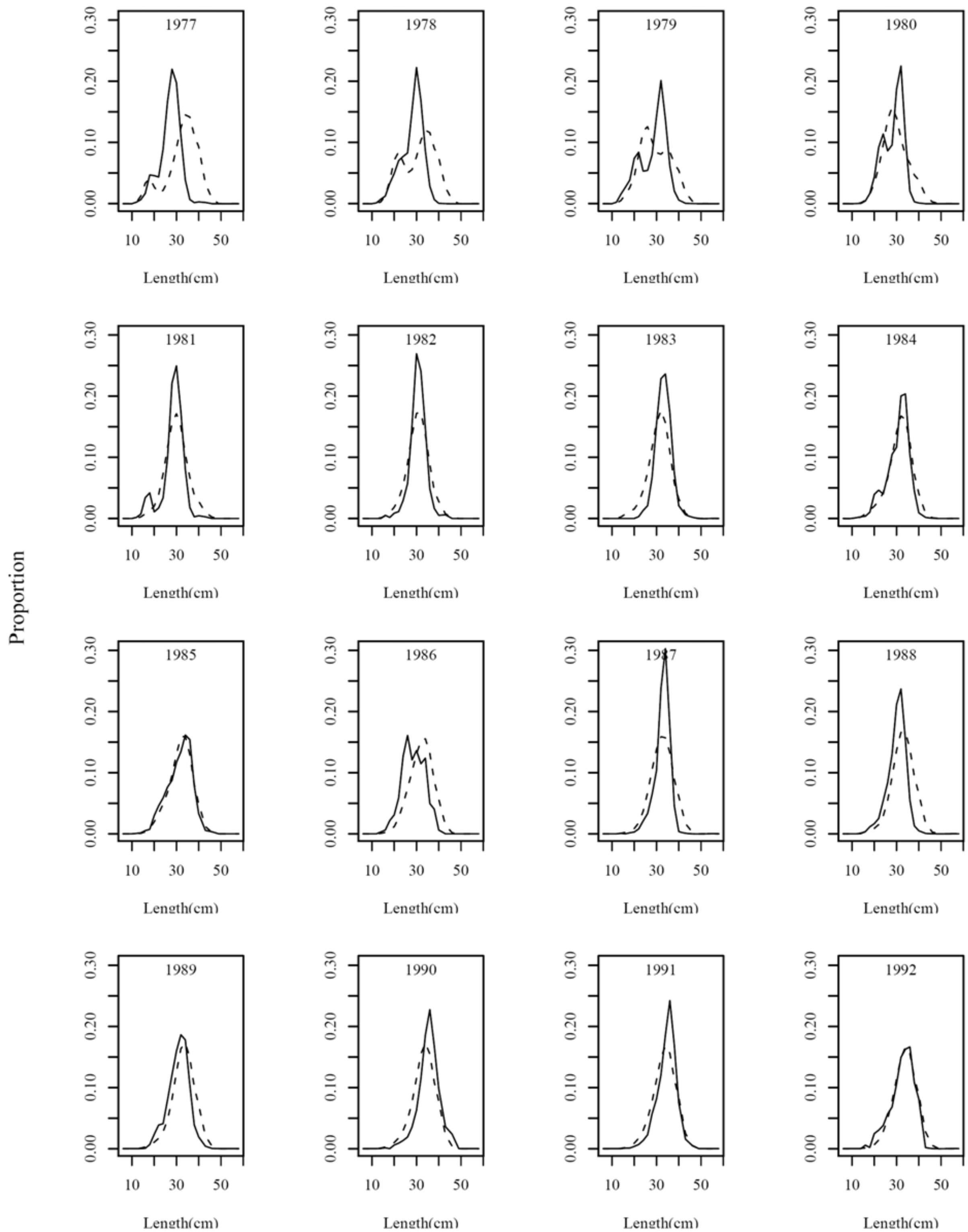

Figure 8.14. Model fit to male fishery length composition by year. Solid line = observed, dotted line = predicted.

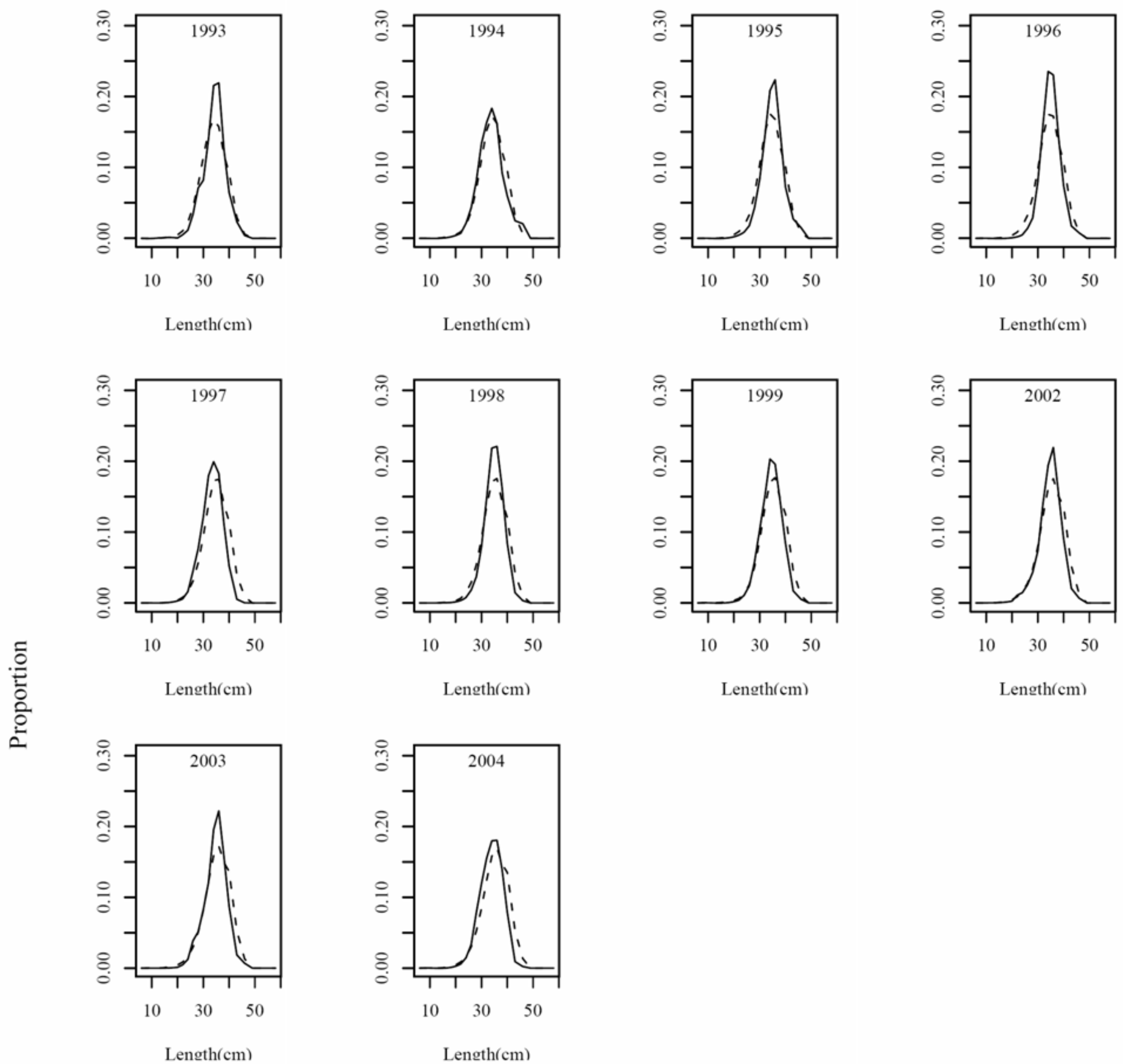

Figure 8.14 (cont.).

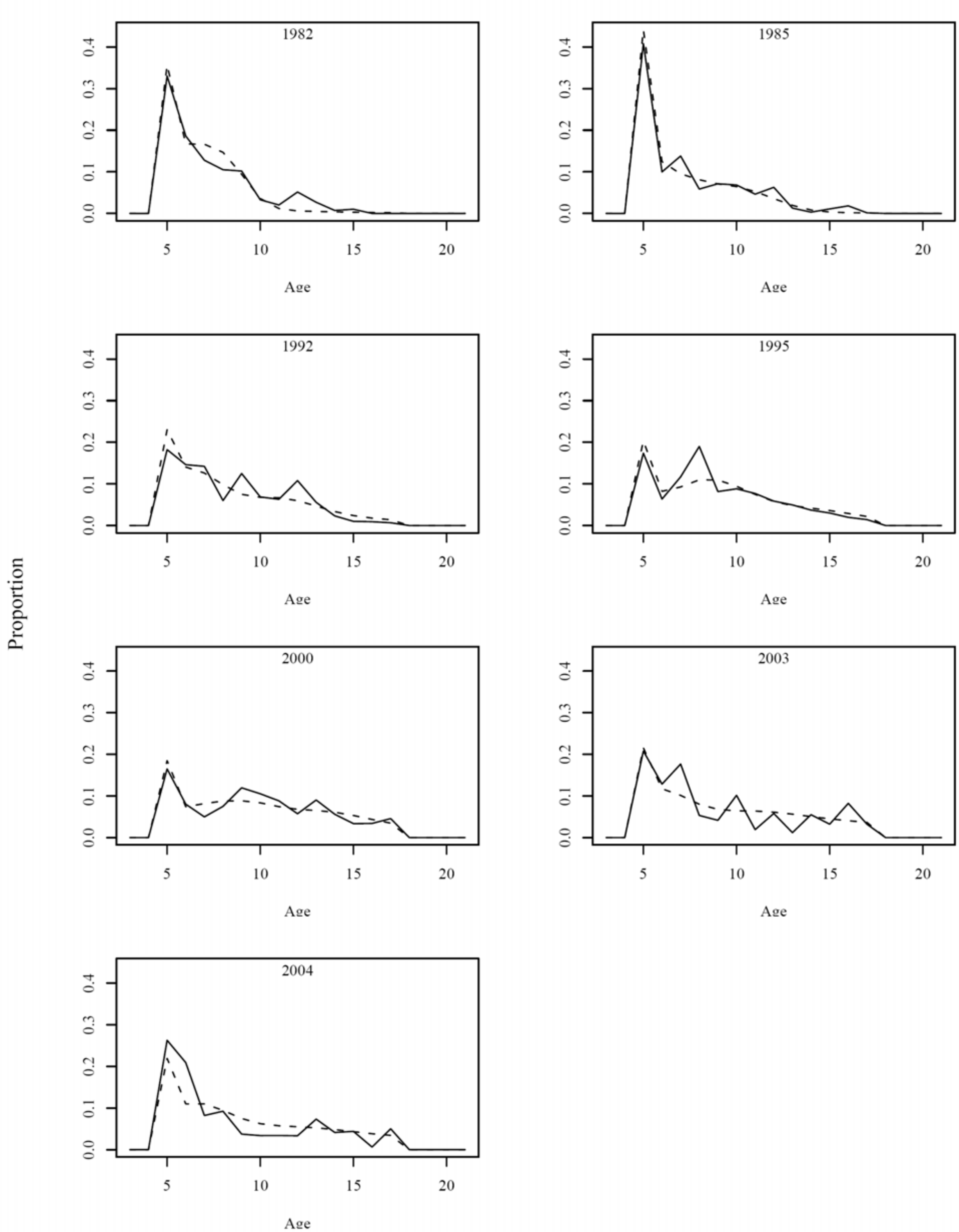

Figure 8.15. Model fit to female survey age compositions. Solid line = observed, dotted line = predicted.

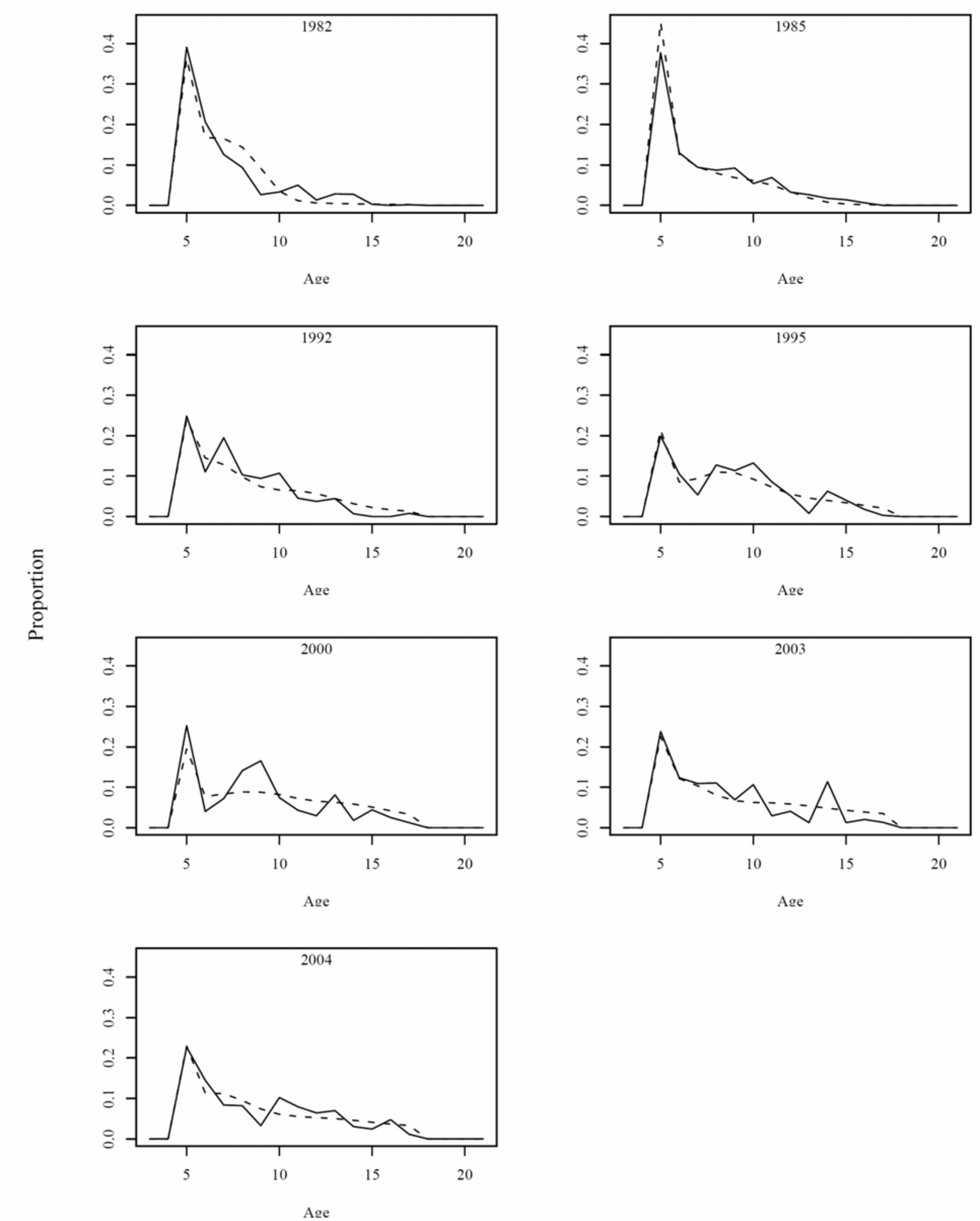

Figure 8.16. Model fit to male survey age compositions. Solid line = observed, dotted line = predicted.

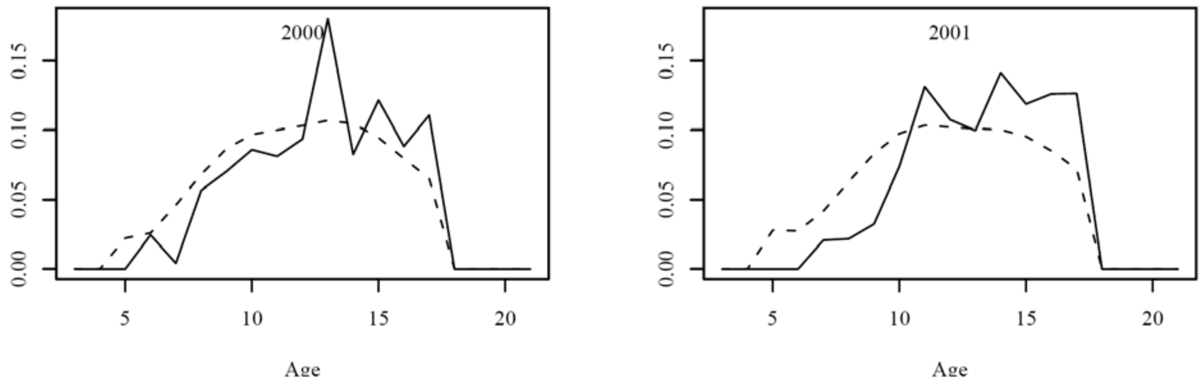

Figure 8.17. Model fit to female fishery age compositions. Solid line = observed, dotted line = predicted.

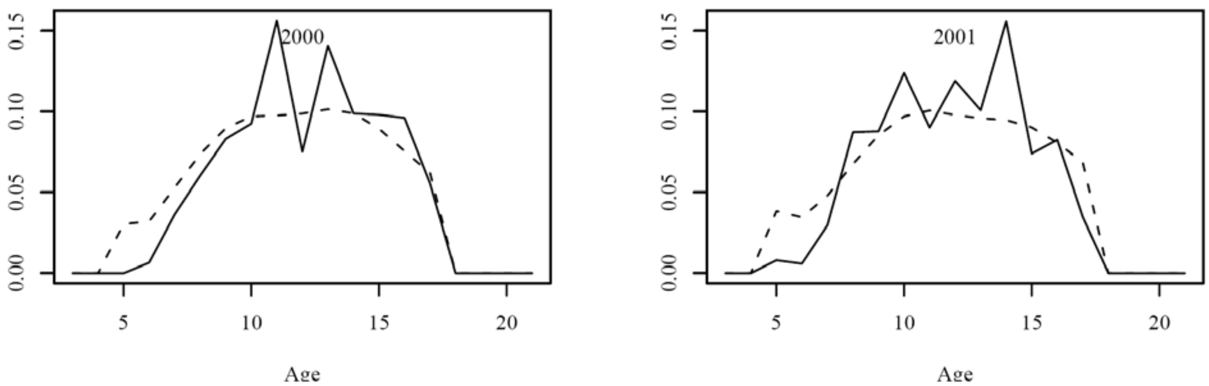

Figure 8.18. Model fit to male fishery age compositions. Solid line = observed, dotted line = predicted.

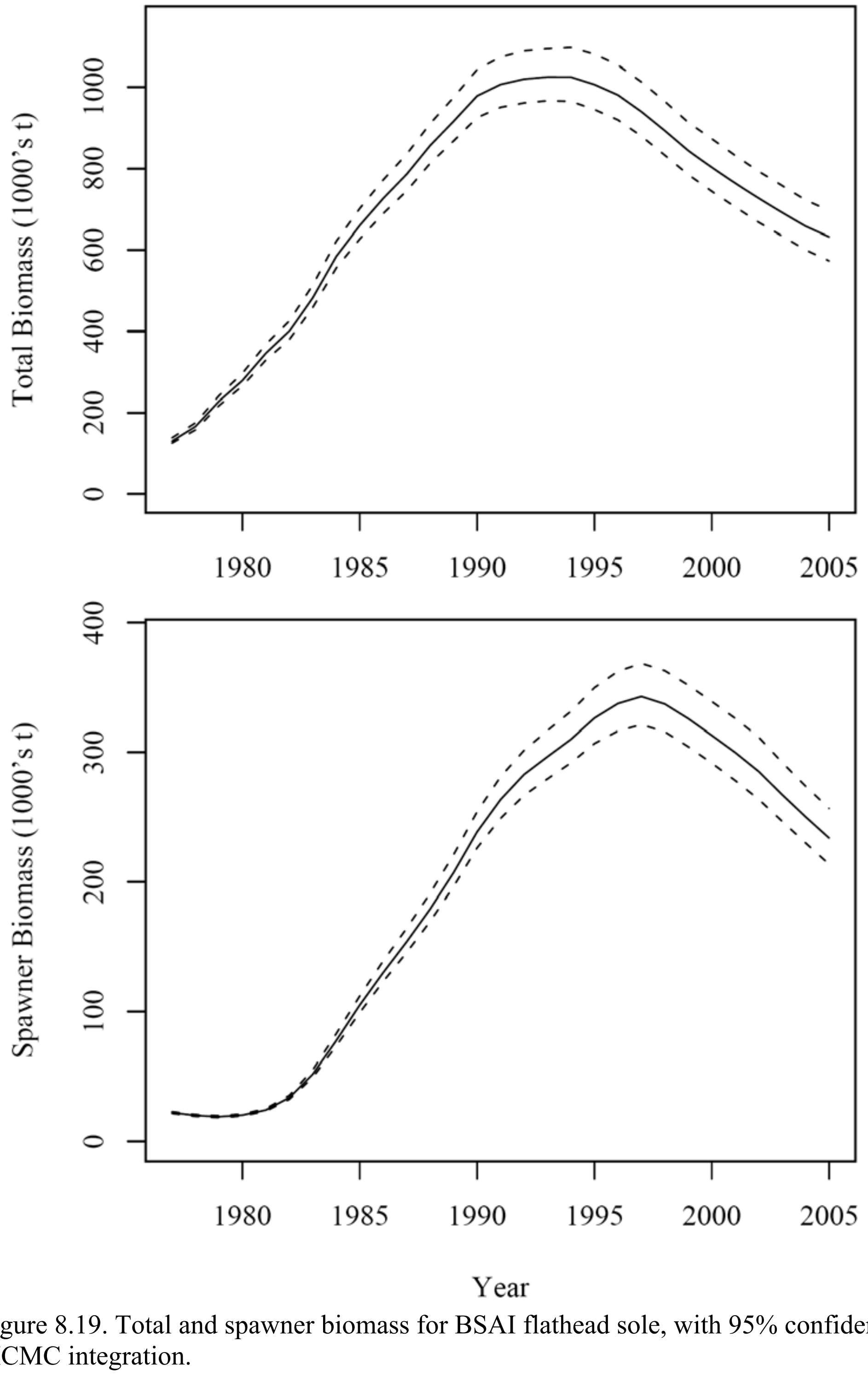

Figure 8.19. Total and spawner biomass for BSAI flathead sole, with 95% confidence intervals from MCMC integration.

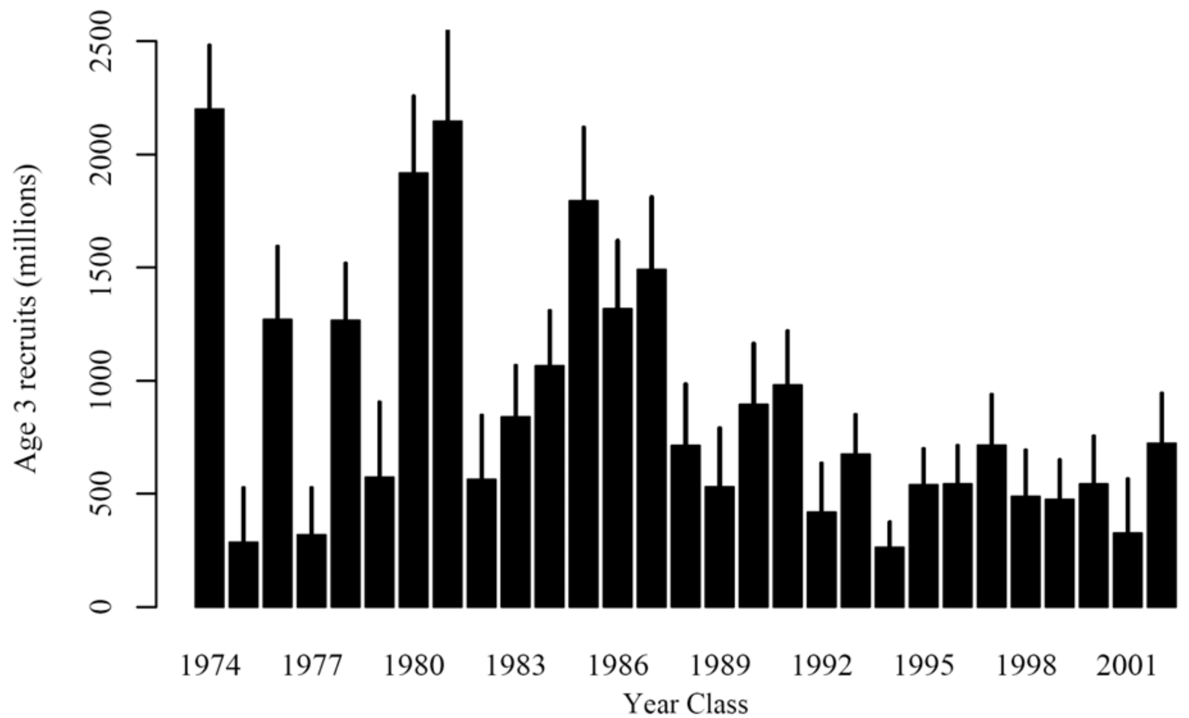

Figure 8.20. Estimated recruitment (age 3) of BSAI flathead sole, with 95% confidence intervals obtained from MCMC integration.

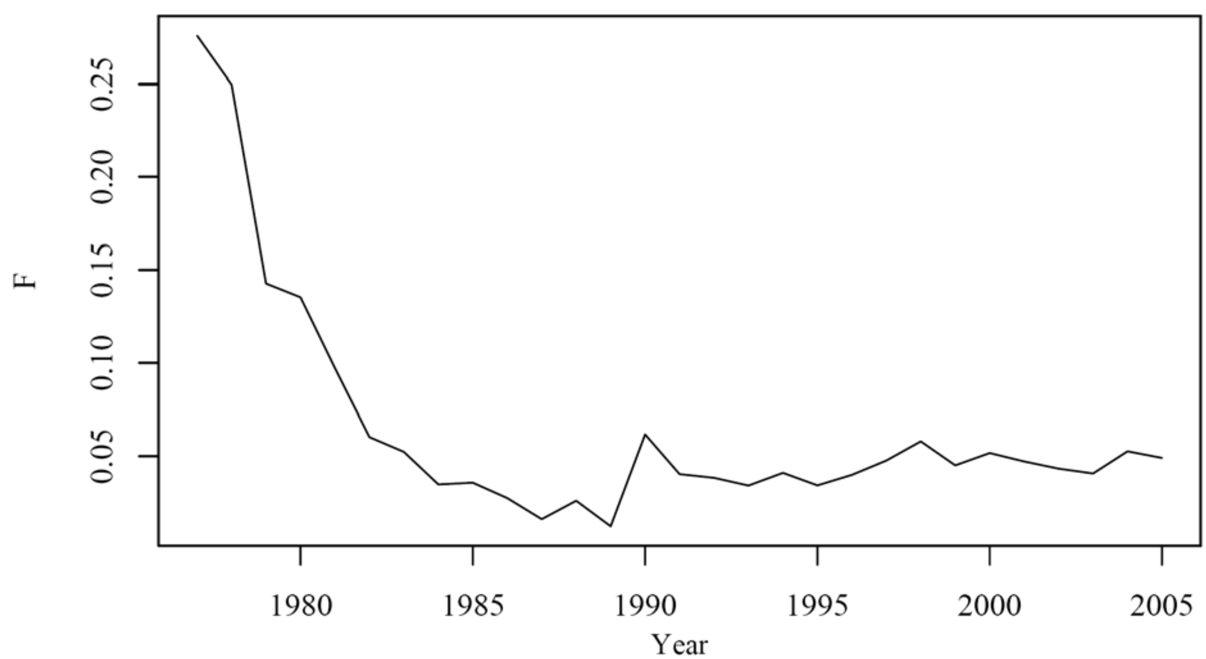

Figure 8.21. Estimated fully-selected fishing mortality rate for BSAI flathead sole.

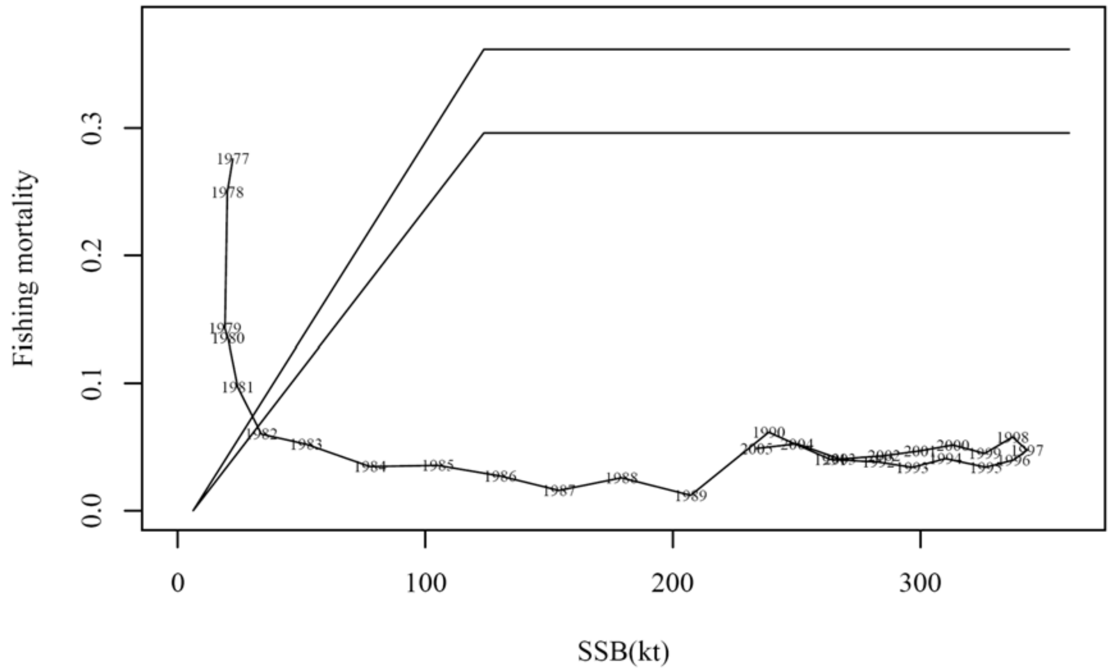

Figure 8.22. Estimated spawning stock biomass (SSB) and fully-selected fishing mortality of flathead sole in relation to ABC (lower line) and OFL (upper line) control rules.

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