Section 8

OTHER FLATFISH

by

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Executive Summary

The following changes have been made to this assessment relative to the November 1999 SAFE:

Changes in the input data

1) 2000 total catch and discards through 16 September, 2000; catch was partitioned among species according the proportions observed in the 1999 hauls sampled by NMFS observers.
2) 2000 trawl survey biomass estimate and standard error for Alaska plaice, and 2000 trawl survey biomass estimates of miscellaneous flatfish.
3) Estimate of the retained and discarded portions of the 1999 catch.
4) The Alaska plaice trawl survey biomass estimates and standard deviations from 1982-1999 were recomputed to correct a suspiciously uniform time series of coefficient of variation (CV).

Changes to assessment methodology
1) The CV for each Alaska plaice survey biomass estimate was used in the survey likelihood function.

Model results (Alaska plaice)

1) Estimated 2+ total biomass for 2000 is 865,146 t.
2) Projected female spawning biomass for 2001 is 217,357 t.
4) Recommended ABC for 2001 is 121,975 t based on an $F_{40\%}$ (0.29) harvest level.
5) 2001 overfishing level is 147,167 t based on a $F_{35\%}$ (0.36) harvest level.

The following summarizes our recommendations for Alaska plaice and other flatfish fisheries conservation measures.

	1999 Assessment recommendations for the 2000 harvest	2000 Assessment recommendations for the 2001 harvest
Alaska plaice		
ABC	101,913 t	121,975
Overfishing	122,659 t	147,167
F_{ABC}	$F_{0.40} = 0.28$	$F_{0.40} = 0.29$
$F_{overfishing}$	$F_{0.35} = 0.35$	$F_{0.35} = 0.36$
"Miscellaneous" species		
Exploitable biomass (as estimated from NMFS groundfish survey)	69,730 t	79,786 t
ABC	15,506 t	18,394 t
Overfishing	18,772 t	21,716 t
F_{ABC}	$F_{0.40} = 0.28$	$F_{0.40} = 0.30$
$F_{overfishing}$	$F_{0.35} = 0.35$	$F_{0.35} = 0.38$

Introduction

The other flatfish species complex has been managed as a unit and is currently made up of the flatfish species listed in Table 1. Prior to 1995, flathead sole (*Hippoglossoides elassodon*) were included in this complex; however, a change in the Bering Sea/Aleutian Islands directed fishing standards necessitated that flathead sole be managed separately was subsequently removed from the “other flatfish” management category. Alaska plaice (*Pleuronectes quadrituberculatus*) is the dominant species of the complex and comprised 89% of the 1999 catch and 86% of the estimated 2000 trawl survey biomass. Thus, the primary focus of this chapter is the quantitative assessment of Alaska plaice.

The distribution of most species in the “other flatfish” category is mainly on the Eastern Bering Sea continental shelf, with only small amounts found in the Aleutian Islands region. In particular, the summer distribution of Alaska plaice is generally confined to depths < 110 m, with larger fish predominately in deep waters and smaller juveniles (<20 cm) in shallow coastal waters (Zhang et al., 1998). The Alaska plaice distribution overlaps with rock sole (*Lepidopsetta bilineata*) and yellowfin sole (*Limanda aspera*), but the center of the distribution is north of these two species.

Catch History

Catches of these species, including flathead sole, increased from about 25,000 t in the 1960s to a peak of 52,000 t in 1971. Part of this apparent increase was due to better species identification and reporting of catches in the 1970s. Because of the overlap of the Alaska plaice distribution with that of yellowfin sole, much of the Alaska plaice catch during the 1960s was likely caught as bycatch in the yellowfin sole fishery (Zhang et al., 1998). After 1971, catches of the “other flatfish” category declined to less than 20,000 t in the mid-1970s. Besides Alaska plaice, the catch composition of the other flatfish category in recent years has been primarily composed of starry flounder, rex sole, and butter sole (Table 2); these estimates were obtained by applying the species proportions obtained from observer sampling to the total “other flatfish” group. The first year of joint venture processing (JVP), 1988, produced the largest catch of Alaska plaice since 1963 (Zhang et al., 1998). With the cessation of joint venture fishing operations in 1991, the other flatfish catch is now harvested exclusively by domestic vessels. Catch data from 1980-89 by its component fisheries (JVP, non-U.S., and domestic) are available in Wilderbuer and Walters (1990). The catch locations by quarter for 1999 of “other flatfish” hauls (defined as hauls where flatfish catch is greater than any other species group and other flatfish is the largest component of the flatfish catch) is shown in the Appendix.

Since implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977, the “other flatfish” complex has been lightly fished. This trend continued in 2000, with the catch through 16 September totaling only 17% of the 2000 total allowable catch of 83,813 t. The other flatfish complex is grouped with the rock sole and flathead sole fisheries in a single prohibited species class (PSC) classification, with seasonal and total annual allowances of prohibited bycatch applied to the classification. In recent years, the “other flatfish” fishery has been closed prior to attainment of the TAC due to the bycatch of halibut (Table 3).

Substantial amounts of flatfish in the “other flatfish” category 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).

Data

Fishery Catch and Catch-at-Age Data

This assessment uses fishery catches from 1971 through 16 September, 2000 (Table 2), and estimates of number caught by age for the years 1971-79, 81-82, 1988, and 1995 (Table 5).

Survey Data

Because "other flatfishes" are usually taken incidentally in target fisheries for other species, CPUE from commercial fisheries is considered unreliable information for determining 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 survey of the Eastern Bering Sea continental shelf have been conducted in 1975 and 1979-2000 by NMFS. Survey estimates of total biomass and numbers at age are shown in Tables 6 and 7, respectively. It should be recognized that the resultant biomass estimates are point estimates from an "area-swept" survey. As a result, they carry the uncertainty inherent in the technique. It is assumed that the sampling plan covers the distribution of the fish and that all fish in the path of the trawl are captured. That is, there are no losses due to escape or gains due to gear herding effects. Trawl survey estimates of Alaska plaice biomass increased dramatically from 1975 through 1982 and have remained at a high and stable level since (Table 6, Figure 1). The increase from 1981 to 1982 was high for a number of bottom-tending species such as flatfishes; for example, the increase in biomass was particularly large for Alaska plaice (535,800 to 715,400 t). These higher 1982 estimates may have been due in part to better bottom contact or greater herding effects of the trawls used in 1982 compared with those used in 1981 and earlier years. The biomass estimates have remained high in succeeding years, suggesting that the new rigging has increased the efficiency of the trawls for flatfish and plays some part in the increased levels seen in recent years.

During 1992, a reevaluation of the time series of survey data was performed using new estimates of the Fishing Power Coefficient (FPC). These coefficients estimate the calibration factor between the two vessels used in the survey. The new method (Kappenman 1992) yields more realistic values for these coefficients and as a result, we feel the survey estimates are more accurate. The reevaluation was performed for the survey data from 1982 (the time of the gear change) to the present, and the survey biomass estimates are shown in Table 6.. The trend of the biomass estimates is the same as before. However, the magnitude of the change in 1988 was markedly reduced. In 1988, one vessel had slightly smaller and lighter trawl doors which may have affected the estimates for several species. With the exception of the 1988 estimate, Alaska plaice has shown a relatively stable trend since 1985, although abundance was higher in the 1994 and 1997 surveys. The 2000 estimate of 433,620 t represents a high level of biomass but is the lowest level in 20 years, and is a 19% decline from the 1999 estimate of 546,522 t. The interannual variation in estimated biomass appears to be relatively high since 1994.

For the miscellaneous species of the other flatfish management category, individual species biomass from the 1997 and 2000 Aleutian Islands and 1997-2000 Bering Sea shelf trawl surveys are shown in Table 8. The biomass of the miscellaneous species in the "other flatfish" complex has been relatively stable since 1983. The 2000 estimate of 79,786 t is similar to the levels estimated in recent years.

Information on length at age, and weight at length, for Alaska plaice are also available from the bottom trawl survey. The values for the parameters in the von Bertalanffy age-length relationship were found from ageing data collected in 1995.

	L_{inf}(cm)	k	t_o
Alaska plaice			
males	39.1	0.1593	-0.5349
females	49.5	0.1162	-0.7715

A length (cm) – weight (g) relationship of the form $W = aL^b$ was also fit to data obtained from the 1995 trawl survey, with the estimated values of of a = 0.0088 and b = 3.11 applying to both sexes.

In summary, the data available for Alaska plaice are

1) Total catch weight, 1971-2000;
2) Proportional catch number at age, 1971-79, 1981-82, 1988, 1995;
3) Survey biomass and standard error 1975, 1979-2000;
4) Survey age composition 1979, 1982, 1988, 1992-1995, 1998.

Analytical Approach

Model Structure

Due to a lack of information on most of the various species that comprise the other flatfish group, an age-structured population assessment is conducted only on the Alaska plaice stock. For the remainder of the species in the other flatfish group, the ABC and OFL recommendations are derived from applying the $F_{40\%}$ and $F_{35\%}$ values, respectively, to the total 1999 survey biomass of these miscellaneous flatfish species.

A catch-at-age population dynamics model was used to obtain estimates of several population variables of the Alaska plaice stock, including recruitment, population size, and catch. This catch at age model was developed with the software program AD Modelbuilder. Population size in numbers at age a in year t was modeled as

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

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

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

The numbers of age 1 fish over all years are estimated as parameters in the model, as are the numbers at all ages in the first year. The number of age 1 fish over all years is modeled with a lognormal distribution

$$N_{t,1} = e^{(meanrec+\nu_t)}$$

where *meanrec* is the mean and ν is a time-variant deviation. The numbers at age in the first year are modeled in a similar manner

$$N_{1,a} = e^{(meaninit+\gamma_a)}$$

where *meaninit* is the mean and γ is an age-variant deviation.

Catch in numbers at age in year t ($C_{t,a}$) and total biomass of catch each year were modeled as

$$C_{t,a} = \frac{F_{t,a}}{Z_{t,a}}\left(1 - e^{-Z_{a,t}}\right)N_{t,a}$$

$$Y_t = \sum_{a=1}^{A} C_{t,a} w_a$$

where w_a is the mean weight at age for plaice.

Estimating certain parameters in different stages enhances the estimation of large number of parameters in nonlinear models. For example, the fishing mortality rate for a specific age and time ($F_{t,a}$) is modeled as the product of an age-specific selectivity function (sel_a) and a year-specific fully-selected fishing mortality rate. The fully selected mortality rate is modeled as the product of a mean (μ) and a year-specific deviation (ϵ_t), thus $F_{t,a}$ is

$$F_{t,a} = sel_a * e^{(\mu + \varepsilon_t)}$$

In the early stages of parameter estimation, the selectivity coefficients are not estimated. As the solution is being approached, selectivity was modeled with the logistic function:

$$sel_a = \frac{1}{1 + e^{(-slope(a - fifty))}}$$

where the parameter *slope* affects the steepness of the curve and the parameter *fifty* is the age at which sel_a equals 0.5. The selectivity for the survey is modeled in a similar manner.

Parameters Estimated Independently

The parameters estimated independently include the natural mortality (M) and survey catchability (*q_srv*). Most studies assume $M = 0.20$ for these species on the basis of their longevity. Fish from both sexes have frequently been aged as high as 25 years from samples collected during the annual trawl surveys. Zhang (1987) determined that the natural mortality rate for Alaska plaice is variable by sex and may range from 0.195 for males to 0.27 for females. Natural mortality was fixed at 0.25 for this assessment from the result of a previous assessment (Wilderbuer and Walters 1997, Table 8.1) where M was profiled over a range of values to explore the effect it has on the overall model fit and to the individual data components. The survey catchability was fixed at 1.0.

Parameters Estimated Conditionally

Parameter estimation is facilitated by comparing the model output to several observed quantities, such as the age compositions of the fishery and survey catches, the survey biomass, and the fishery catches. 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 maximize the log-likelihood are selected.

The log-likelihoods of the age compositions were modeled with a multinomial distribution. The log of the multinomial function (excluding constant terms) is

$$n\sum_{t,a} p_{t,a} \ln(\hat{p}_{t,a})$$

where n_t is the number of fish aged, and p and $\hat{p}$ are the observed and estimated age proportion at age.

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

$$\lambda_2 \sum_t (\ln(obs\_biom_t) - \ln(pred\_biom_t))^2 / 2 * cv(t)^2$$

where obs_biom_t and $pred\_biom_t$ are the observed and predicted survey biomass at time t, $cv(t)$ is the coefficient of variation of observed biomass in year t, and λ_2 is a weighting factor. The predicted survey biomass for a given year is

$$q\_srv * \sum_a sel\_srv_a (N_a * wt_a)$$

where sel_srv_a is the survey selectivity at age and wt_a is the population weight at age.

The log-likelihood of the catch biomass were 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 is given a very high value (hence low variance in the total catch estimate) 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 likelihood function (excluding the catch component) is

$$\lambda_1 \left(\sum_t \varepsilon_t + \sum_a \gamma_a \right) + n \sum_{t,a} p_{t,a} \ln(\hat{p}_{t,a}) + \lambda_2 \sum_t (\ln(obs\_biom_t) - \ln(pred\_biom_t))^2 / 2 * cv(t)^2$$

For the model run in this analysis, λ_1, λ_2, and λ_3 were assigned weights of 1,1, and 500, respectively. The value for age composition sample size, n, was set to 200. The likelihood function was maximized by varying the following parameters:

Parameter type	Number
1) fishing mortality mean (μ)	1
2) fishing mortality deviations (ϵ_t)	30
3) recruitment mean (*meanrec*)	1
4) recruitment deviations (ν)	30
5) initial year mean (*meaninit*)	1
6) initial year deviations (γ)	24
7) fishery selectivity patterns	2
8) survey selectivity patterns	2
Total parameters	91

Model Results (Alaska plaice)

The model results show that estimated total Alaska plaice biomass (ages 2+) increased from a low of 361,054 t in 1971 to a peak of 1,326,660 t in 1984 (Figure 2, Table 9). Beginning in 1985, estimated total biomass has declined to 865,146 t in 2000. The estimated survey biomass also shows a rapid increase to a peak biomass of 699,540 t in 1986, a subsequent decline to 480,691 t in 1996, and an increase to 501,470 t in 2000 (Figure 4). The fits to the trawl survey and fishery age compositions are shown in Figures 5 and 6, respectively.

The changes in stock biomass are primarily a function of recruitment variability, as fishing pressure has been relatively light. The fully selected fishing mortality estimates, although trending upward, show a maximum value of 0.10 in 1988, and have averaged 0.03 during 1971-2000 (Figure 1); the 2000 estimate is 0.028. Estimated age-2 recruitment has shown high levels from 1971-1983, averaging 1.70 x 10^9 (Figure 8, Table 9). From 1984-2000, estimated recruitment has declined, averaging 1.05 x 10^9. A particularly low period of recruitment apparently occurred from 1984-1988, which interestingly coincided with the peak in spawning biomass production. This is revealed in the spawning stock biomass-recruitment plot (Figure 9), which suggests that exceptional year classes have not occurred in the past when SSB has been greater than approximately 250,000 t.

Projections and Harvest Alternatives

The reference fishing mortality rate for Alaska plaice 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 $F_{40\%}$, $F_{40\%}$, and $SPR_{40\%}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from 1977-1999 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 $SPR_{40\%}$ * equilibrium recruits, and this quantity is 110,649 t. The year 2001 spawning biomass is estimated as 217,357 t. Since reliable estimates of 2001 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B>B_{40\%}$ (217,357 t > 110,649 t), Alaska plaice reference fishing mortality is defined in tier 3a of Amendment 56. For this tier, F_{ABC} is constrained to be $\leq F_{40\%}$, and F_{OFL} is defined as $F_{35\%}$. The values of these quantities are

2000 SSB estimate (B)	=	217,357 t
$B_{40\%}$	=	110,649 t
$F_{40\%}$	=	0.294
F_{ABC}	$\leq$	0.294
$F_{35\%}$	=	0.365
F_{OFL}	=	0.365

The estimated catch level for year 2001 associated with the overfishing level of F = 0.365 is 147,167 t. Because the Alaska plaice 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 2000 recommended ABC associated with F_{ABC} of 0.294 is 121,975 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 Protection Act, and the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

For each scenario, the projections begin with the vector of 2000 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2001 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2000. 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 2001, 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 2001 recommended in the assessment to the *max* F_{ABC} for 2001. (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 1995-1999 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 Alaska plaice harvest and spawning stock biomass for the remaining four scenarios are shown in Table 10.

The ABC and OFL levels for the other miscellaneous species in the other flatfish group are obtained from applying (using the catch equation) the $F_{40\%}$ and $F_{35\%}$ levels estimated from this years (2000) flathead sole assessment to the 2000 survey biomass of miscellaneous flatfish (79,539 t). The 2000 estimates of $F_{40\%}$ and $F_{35\%}$ for flathead sole are 0.302 and 0.378, respectively. The ABC and OFL, and the catch associated with the F_{ABC}/2 level of 0.140, are shown below:

F level (value)	Projected yield for year 2001
F_{ABC}/2 (0.15)	9,579 t
F_{ABC} (0.30)	18,394 t
F_{OFL} (0.38)	21,716 t

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether the Alaska plaice stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as 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 2001 under this scenario, then the stock is not overfished.)

Scenario 7: In 2001 and 2002, 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 2003 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that the Alaska plaice are neither overfished or approaching an overfished condition. With regard to assessing the current stock level, the expected stock size in the year 2001 of scenario 6 is 2.2 times its $B_{35\%}$ value of 96,818 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 2003 of scenario 7 is 1.4 times its $B_{35\%}$ value.

Other considerations

The catch of Alaska plaice taken in research surveys will be included in the catch totals in future assessments; these catch levels are shown from 1979 –2000 in Table 11.

Trophic studies indicate that Alaska plaice feed primarily on polychaetes, amphipods and echiurids. Groundfish predators include Pacific halibut, yellowfin sole , beluga whales and fur seals.

Summary

In summary, several quantities pertinent to the management of the Alaska plaice are listed below.

Quantity	Value
M	0.25
Year 2001 Spawning stock biomass	217,357 t
F_{OFL}	0.365
Maximum F_{ABC}	0.294
Recommended F_{ABC}	0.294
OFL	147,167 t
Recommended ABC	121,975 t

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Table 1. Flatfish species of the Bering Sea/Aleutian Islands “other flatfish” management complex.

Common Name	Scientific Name	Occurrence
Alaska plaice	*Pleuronectes quadrituberculatus*	common
Arctic flounder	*Liopsetta glacialis*	55 identified from slope surveys
butter sole	*Isopsetta isolepis*	common
curlfin sole	*Pleuronectes decurrens*	1 identified from 1981 shelf survey
deepsea sole	*Embassichths bathybus*	66 identified from slope surveys
Dover sole	*Microstomus pacificus*	common
English sole	*Parophrys vetulus*	9 identified from 1975 shelf survey
longhead dab	*Limanda proboscidea*	common
Pacific sanddab	*Citharichthys sordidus*	common
petrale sole	*Eopsetta jordani*	identified in observer samples
rex sole	*Glyptocephalus zachirus*	common
roughscale sole	*Clidodoerma asperrimum*	3 identified from slope surveys
sand sole	*Psettichthys melanostictus*	13 from shelf surveys and International Pacific Halibut Commission
slender sole	*Lyopsetta exilis*	1 identified from the 1980 shelf survey
starry flounder	*Platichthys stellatus*	common
Sakhalin sole	*Pleuronectes sakhalinensis*	identified in observer samples

Table 2. Harvest (t) of Alaska plaice and other flatfish from 1977-2000

		Miscellaneous Flatfish					
Year	Alaska Plaice	Starry Founder	Rex Sole	Butter Sole	Other Flatfish	Total Misc. Flatfish	Total
1977	2589					981	3570
1978	10420					340	10760
1979	13672					233	13905
1980	6902					650	7558
1981	8653					536	9189
1982	6811					645	7456
1983	10766					830	11596
1984	18982					2096	21078
1985	24888					2977	27865
1986	46519					1118	47637
1987	18567					1950	20517
1988	61638					5787	67425
1989	14134					1493	15636
1990	10926					964	11890
1991	18029					1040	19069
1992	18985					678	19963
1993	14536					873	15409
1994	9227					4763	13990
1995	18612					1618	20231
1996	16106	1180	972	243	76	2471	18579
1997	20493	1197	590	494	97	2378	22871
1998	14003	330	779	213	13	1335	15338
1999	13615	757	655	212	13	1637	15252
2000*	12554						14064

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Table 3. Restrictions on the "other flatfish" fishery from 1994 to 1999 in the Bering Sea – Aleutian Islands management area. Note that in 1994, the other flatfish category included flathead sole. 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

Table 4. Total retained and discarded "other flatfish", 1987-1999.

Year	Total Catch	Retained	Discarded	Percent Retained
1993	29072	9935	19137	34.2
1994	29160	10907	18253	37.4
1995	20231	8466	11765	41.8
1996	18579	5902	12677	31.8
1997	22872	6114	16758	26.7
1998	15367	3464	11903	22.5
1999	15252	2305	12947	15.1
2000*	14064	2630	11434	18.7

*NMFS regional office report through September 16, 2000

Table 5. Estimated biomass (t) of Alaska plaice and other flatfish from the eastern Bering Sea and Aleutian Islands trawl survey.

Year	Area	Alaska Plaice	Others	Total
1975	EBS	103,500	22,200	125,700
1979	EBS	277,200	50,900	328,100
1980	EBS	354,000	56,500	410,500
	Aleut.	0	2,700	2,700
1981	EBS	535,800	88,000	623,800
1982	EBS	715,400	104,700	820,100
1983	EBS	743,000	53,000	796,000
	Aleut.	0	2,700	2,700
1984	EBS	789,200	51,500	840,700
1985	EBS	580,000	32,900	612,900
1986	EBS	553,900	38,800	592,700
	Aleut.	0	6,100	6,100
1987	EBS	564,400	47,700	612,100
1988	EBS	699,400	48,000	747,400
1989	EBS	534,000	49,400	583,400
1990	EBS	522,800	46,600	569,400
1991	EBS	529,000	73,900	602,900
	Aleut.	0	3,700	3,700
1992	EBS	530,400	50,100	580,500
1993	EBS	515,200	87,200	602,400
1994	EBS	623,100	54,100	677,200
	Aleut.	0	6,710	6,710
1995	EBS	552,292	37,787	590,079
1996	EBS	529,300	60,200	589,500
1997	EBS	643,400	70,300	713,700
	Aleut.		9,500	9,500
1998	EBS	452,600	73,947	526,543
1999	EBS	546,522	69,730	616,252
2000	EBS	443,620	70,539	514,159
	Aleut		9,247	9,247

Table 6. Alaska plaice population numbers at age estimated from the NMFS eastern Bering Sea groundfish surveys and age readings of sampled fish.

Number at age (millions)

Age

Year	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16+**
79	0.00	0.00	12.00	15.00	20.00	25.00	55.00	83.00	120.00	81.00	72.00	29.00	14.00	4.00	11.00
82	0.06	0.49	0.20	22.47	57.35	163.21	135.31	105.38	90.14	161.59	161.69	215.11	192.95	108.58	53.20
88	0.00	0.00	0.38	7.75	18.38	86.98	73.76	111.32	66.18	167.50	74.89	32.59	109.00	15.28	248.41
92	0.00	0.00	5.31	22.44	6.15	31.98	64.97	52.11	43.04	81.70	50.18	37.56	45.89	33.39	247.04
93	0.00	0.00	0.00	8.41	51.74	44.97	67.64	97.52	20.87	20.13	59.56	85.71	32.73	50.91	242.20
94	0.00	0.18	2.00	21.34	27.90	102.78	100.33	36.71	75.39	37.85	26.09	112.62	58.78	81.05	257.04
95	0.00	0.00	0.00	10.00	10.00	59.90	53.19	131.74	55.17	34.31	62.18	33.89	30.20	47.18	300.48
98	0.00	0.00	1.17	8.77	31.89	73.60	71.29	109.75	59.98	66.31	70.21	29.14	42.74	29.46	136.93

Table 7 --Estimated biomass (t) for the miscellaneous species of the "other flatfish" management complex in the Aleutian Islands and Bering Sea surveys.

	Species						
Survey	Dover Sole	Rex Sole	longhead dab	Sakhalin sole	starry flounder	butter sole	English sole
1997 AI	442	7956	--	--	614	463	14
1997 BS	--	8233	18003	--	41018	2884	--
1998 BS	41	7588	14737	34	49605	1942	--
1999 BS	16	8020	12087	63	43375	4152	--
2000 BS	11	9348	13511	145	45810	1713	--
2000 AI	615	7381	--	--	763	402	86

Table 8. Estimated total biomass (ages 1+), female spawner biomass, and recruitment (age 2), with comparison to the 1999 SAFE estimates.

	Female Spawner Biomass (t)		Total Biomass (t)		Recruitment (Millions)	
	Assessment		Assessment		Assessment	
Year	2000	1999	2000	1999	2000	1999
1971	42338	49597	361054	389693	2051	1979
1972	48680	56197	478640	505549	1629	1510
1973	63597	71606	602153	624075	1248	1112
1974	88492	97030	713613	727311	935	805
1975	124810	133535	801977	804681	1036	858
1976	166527	174462	871134	859652	1964	1617
1977	208912	214787	932708	903586	2290	2024
1978	243208	245767	997365	949254	1835	1773
1979	263690	261951	1061110	996293	2570	2579
1980	273644	266636	1127150	1050720	1609	1599
1981	284475	271378	1197190	1114740	1705	1647
1982	297964	278468	1255670	1171410	1615	1529
1983	317927	293382	1302350	1218630	1661	1555
1984	338887	311388	1326660	1244520	781	716
1985	358179	330160	1317740	1237750	570	508
1986	366913	340168	1278320	1200400	974	845
1987	363936	339053	1198810	1122290	693	590
1988	364402	340904	1138030	1061700	888	742
1989	339615	317193	1035260	956945	1651	1365
1990	328130	306139	994215	910968	1181	986
1991	312855	291002	969860	879021	1605	1341
1992	290875	268762	951649	851302	1126	938
1993	269906	246860	943252	832663	1501	1271
1994	257186	232151	947145	826696	1201	1051
1995	254682	226530	956454	828165	830	747
1996	251624	220164	949370	816534	722	656
1997	256318	220945	935395	801690	845	767
1998	257160	218897	908790	777400	976	886
1999	262222	221612	885947	758894	1071	969
2000	261456		865146		1209	

Table 9. 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 110, 649 t and 96818 t, respectively.

Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2000	238705	238705	238705	238705	238705	238705	238705
2001	217357	217357	226938	234398	236968	212879	217358
2002	170148	170148	199555	225283	234755	157706	170148
2003	137296	137296	176957	215756	230985	122051	134603
2004	117298	117298	160915	208221	227939	102656	109772
2005	107525	107525	151601	204168	227299	95477.9	98623.3
2006	104893	104893	147819	203750	229535	95128.8	96497.5
2007	105612	105612	147338	205733	233709	96995.6	97602.9
2008	107414	107414	148675	209191	239080	99141.7	99404.6
2009	109048	109048	150438	212925	244536	100589	100733
2010	110324	110324	152187	216545	249728	101447	101495
2011	111169	111169	153613	219699	254310	101856	101841
2012	111672	111672	154692	222331	258224	102006	101931
2013	111907	111907	155439	224427	261449	102000	101903
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2000	0.0267688	0.0267688	0.0267684	238705	0.0267684	0.0267688	0.0267682
2001	0.29401	0.29401	0.147005	234398	0	0.365114	0.29401
2002	0.29401	0.29401	0.147005	225283	0	0.365114	0.29401
2003	0.29401	0.29401	0.147005	215756	0	0.365114	0.365114
2004	0.29401	0.29401	0.147005	208221	0	0.337389	0.362102
2005	0.285268	0.285268	0.147005	204168	0	0.31243	0.323363
2006	0.277905	0.277905	0.147005	203750	0	0.311215	0.315972
2007	0.279576	0.279576	0.147005	205733	0	0.317703	0.319357
2008	0.281369	0.281369	0.147005	209191	0	0.32452	0.324268
2009	0.281981	0.281981	0.147005	212925	0	0.327998	0.327319
2010	0.281918	0.281918	0.147005	216545	0	0.329431	0.328995
2011	0.281964	0.281964	0.147005	219699	0	0.330001	0.329769
2012	0.282177	0.282177	0.147004	222331	0	0.330208	0.330178
2013	0.282475	0.282475	0.147003	224427	0	0.330353	0.330241
Catch	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2000	12554.9	12554.9	12554.8	12555	12554.8	12554.9	12554.7
2001	121975	121975	64815.9	17102.6	0	147167	121976
2002	94455.2	94455.2	56552.2	16344	0	107682	94455.3
2003	74799.7	74799.7	49425.3	15466.6	0	81586.2	90323
2004	62951.9	62951.9	44453.1	14796.4	0	62514.9	71801.5
2005	55673	55673	41692.9	14461	0	53632.9	57333.9
2006	52976.6	52976.6	40672.4	14440.7	0	53338.5	54905.2
2007	54036.6	54036.6	40749.2	14641.3	0	55946.5	56644.9
2008	55599.9	55599.9	41270.7	14934.2	0	58740.1	58994.5
2009	56788	56788	41866.2	15235.5	0	60490.1	60559.3
2010	57555.5	57555.5	42396.8	15509.5	0	61391.8	61408.9
2011	58074.1	58074.1	42821.7	15744.3	0	61808.3	61794
2012	58415.4	58415.4	43138.2	15937.1	0	61968.5	61923.7
2013	58609.1	58609.1	43353.4	16088.6	0	61992.6	61873.8

Table 10. Research catches (t) of Alaska plaice in the BSAI area from 1979 to 2000.

Year	Research Catch (t)
1979	17.15
1980	12.02
1981	14.31
1982	26.77
1983	43.27
1984	32.42
1985	23.24
1986	19.66
1987	19.74
1988	39.42
1989	31.10
1990	32.29
1991	29.79
1992	15.14
1993	19.71
1994	22.48
1995	28.47
1996	18.26
1997	22.59
1998	17.17
1999	18.95
2000	15.92

Appendix

Figures showing the distribution of other flatfish hauls sampled by fishery observers in 1998, by quarters. Other flatfish hauls are defined as those hauls where the flatfish catch is greater than any other species group and other flatfish is the largest flatfish group in the catch.

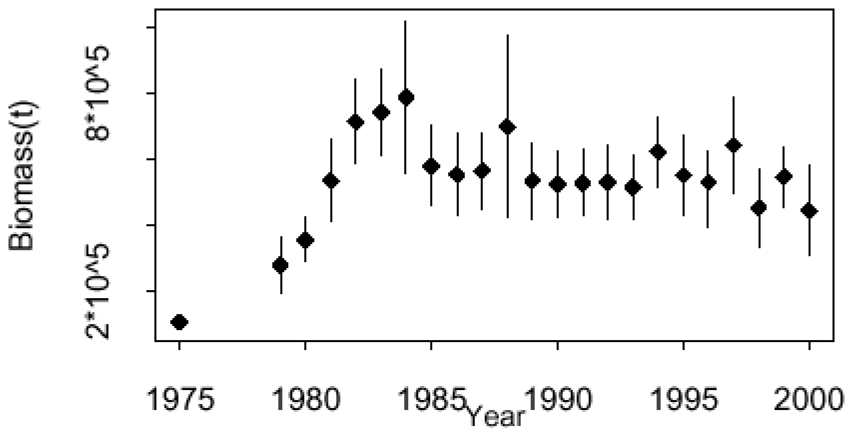

Figure 1. Estimated survey biomass and 95% CIs

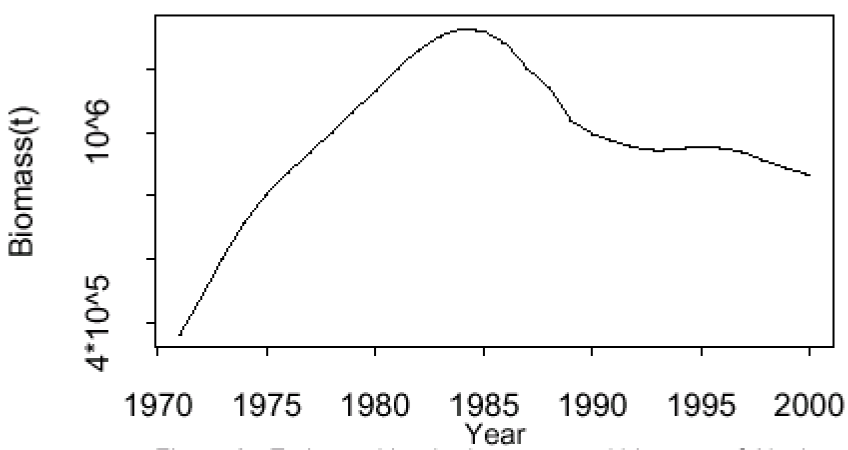

Figure 2. Estimated beginning year total biomass of Alaska plaice

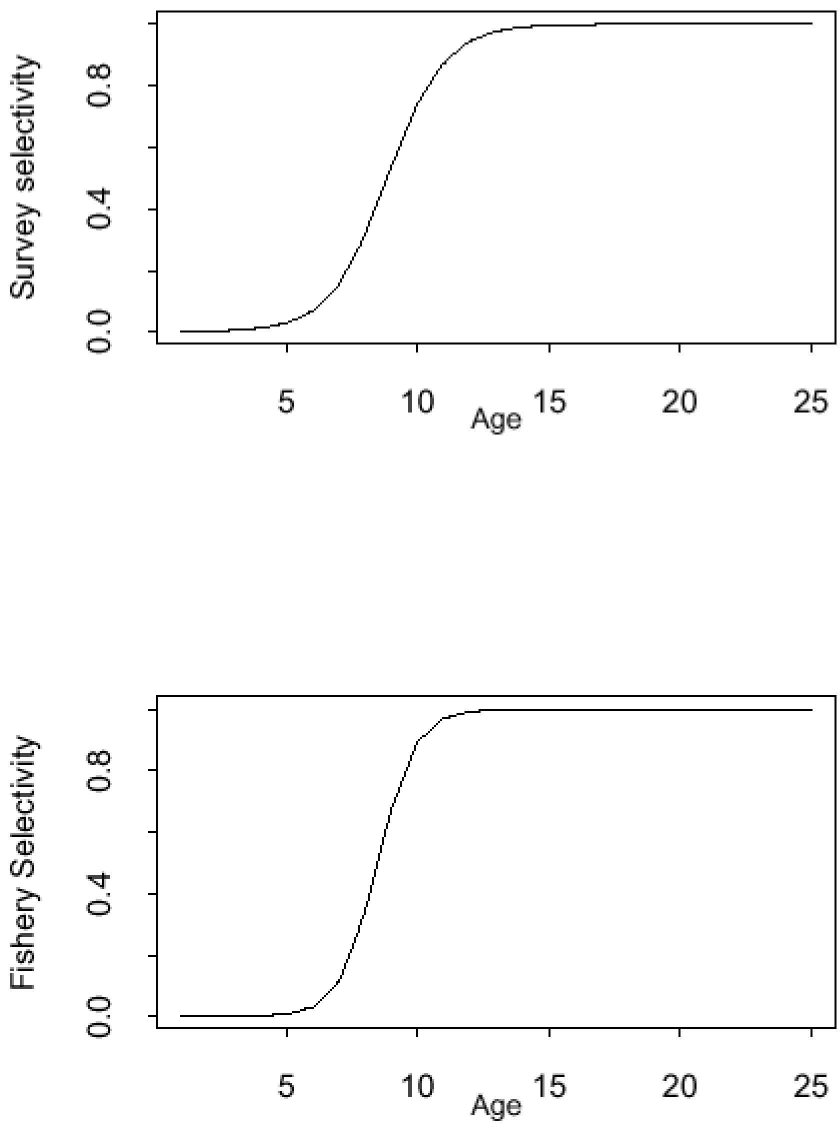

Figure 3. Estimated survey and fishery selectivity

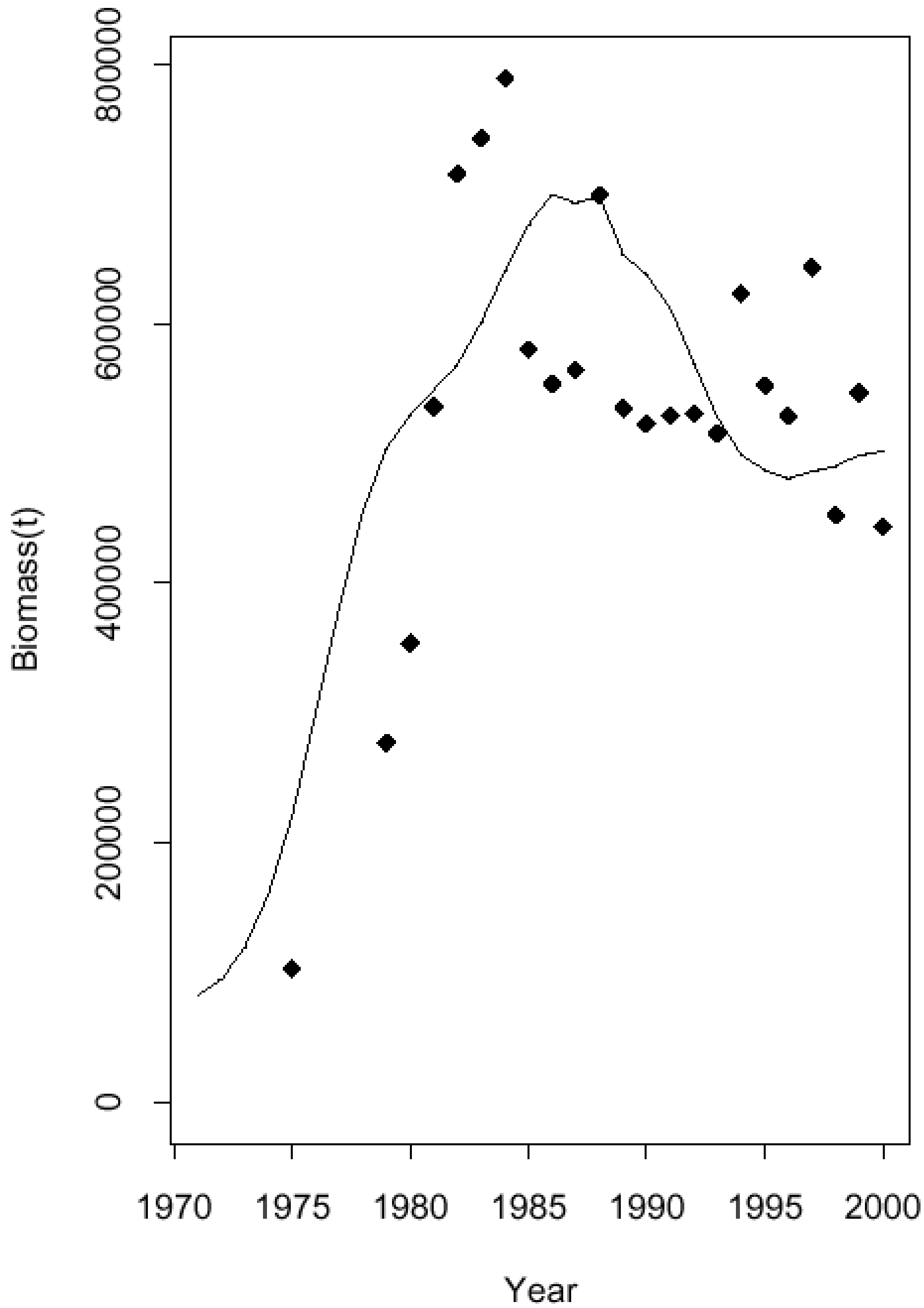

Figure 4. Observed (data points) and predicted (solid line) survey biomass of Alaska plaice

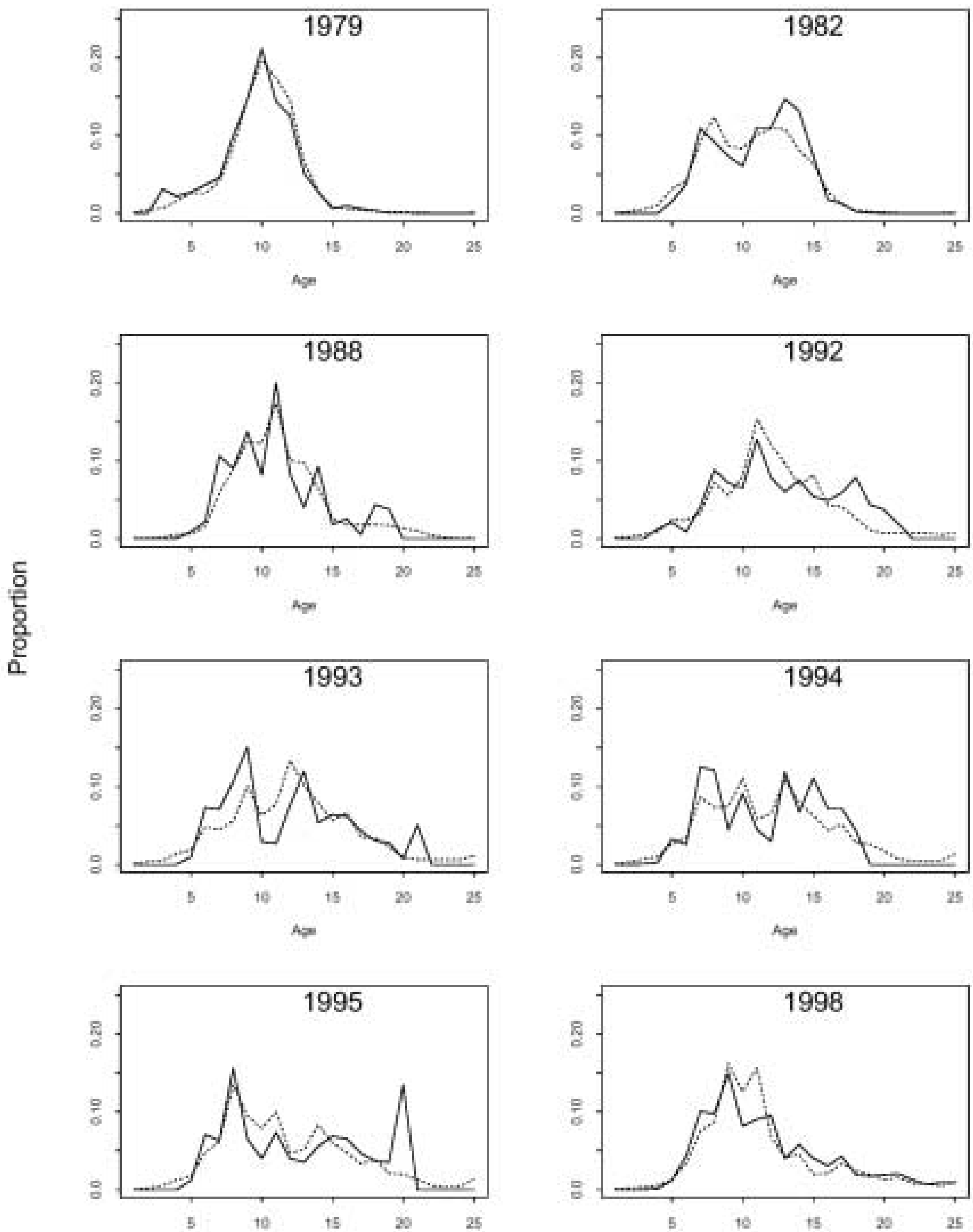

Figure 5. Survey age composition by year (solid line = observed, dotted line = predicted)

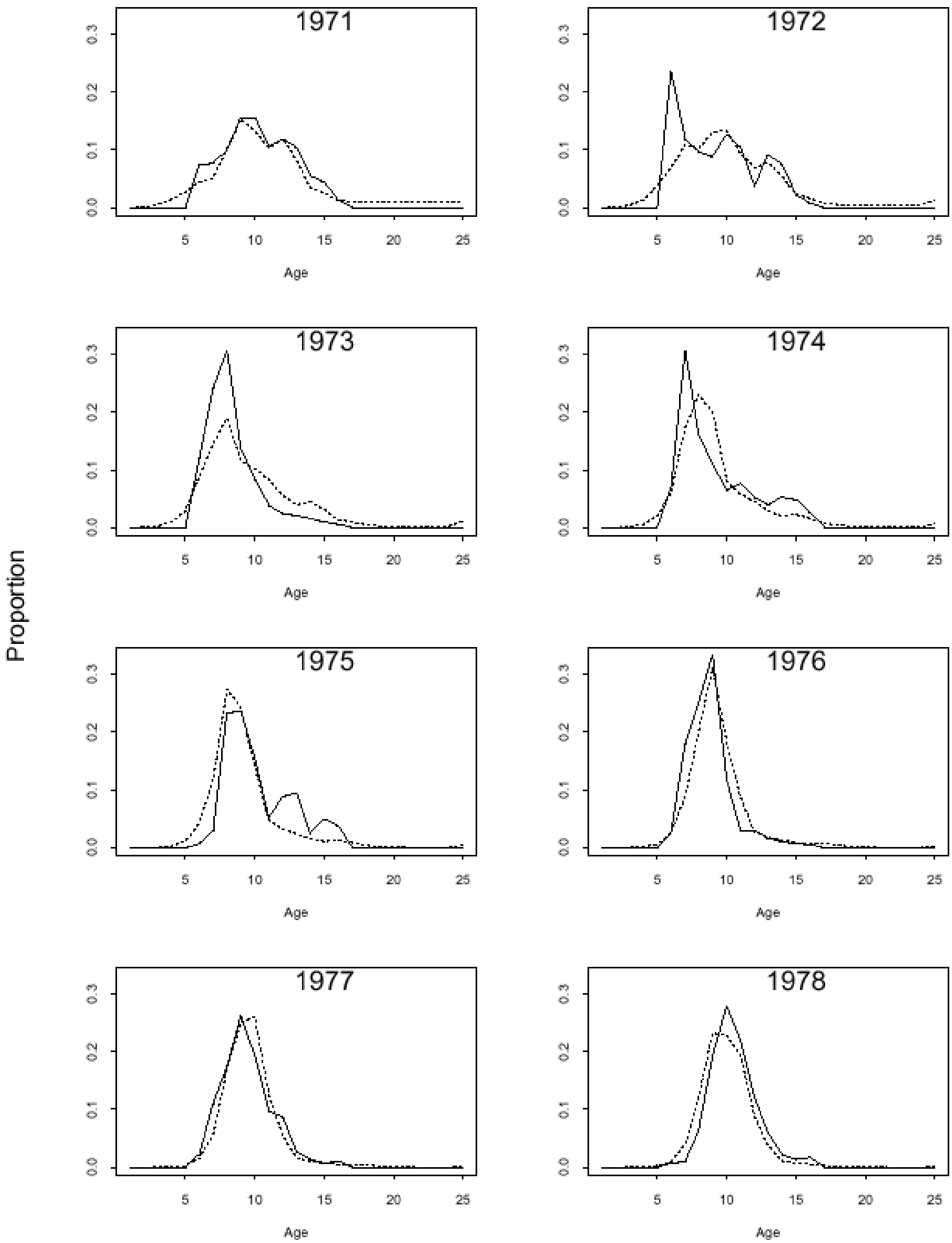

Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

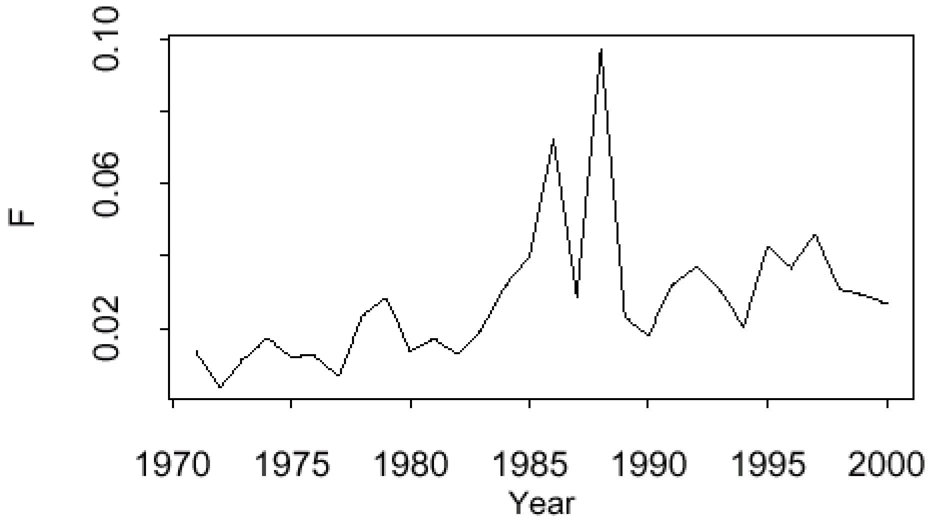

Figure 7. Estimated fully selected fishing mortality

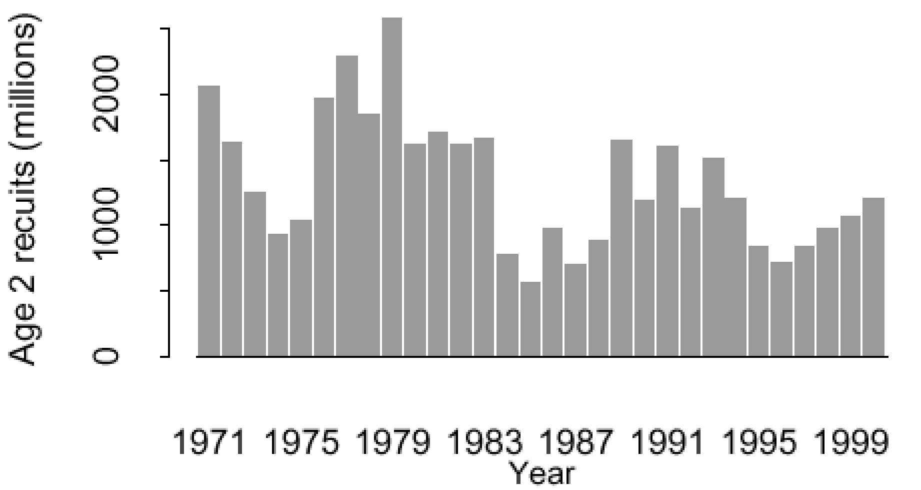

Figure 8. Estimated recruitment (age 2) of Alaska plaice

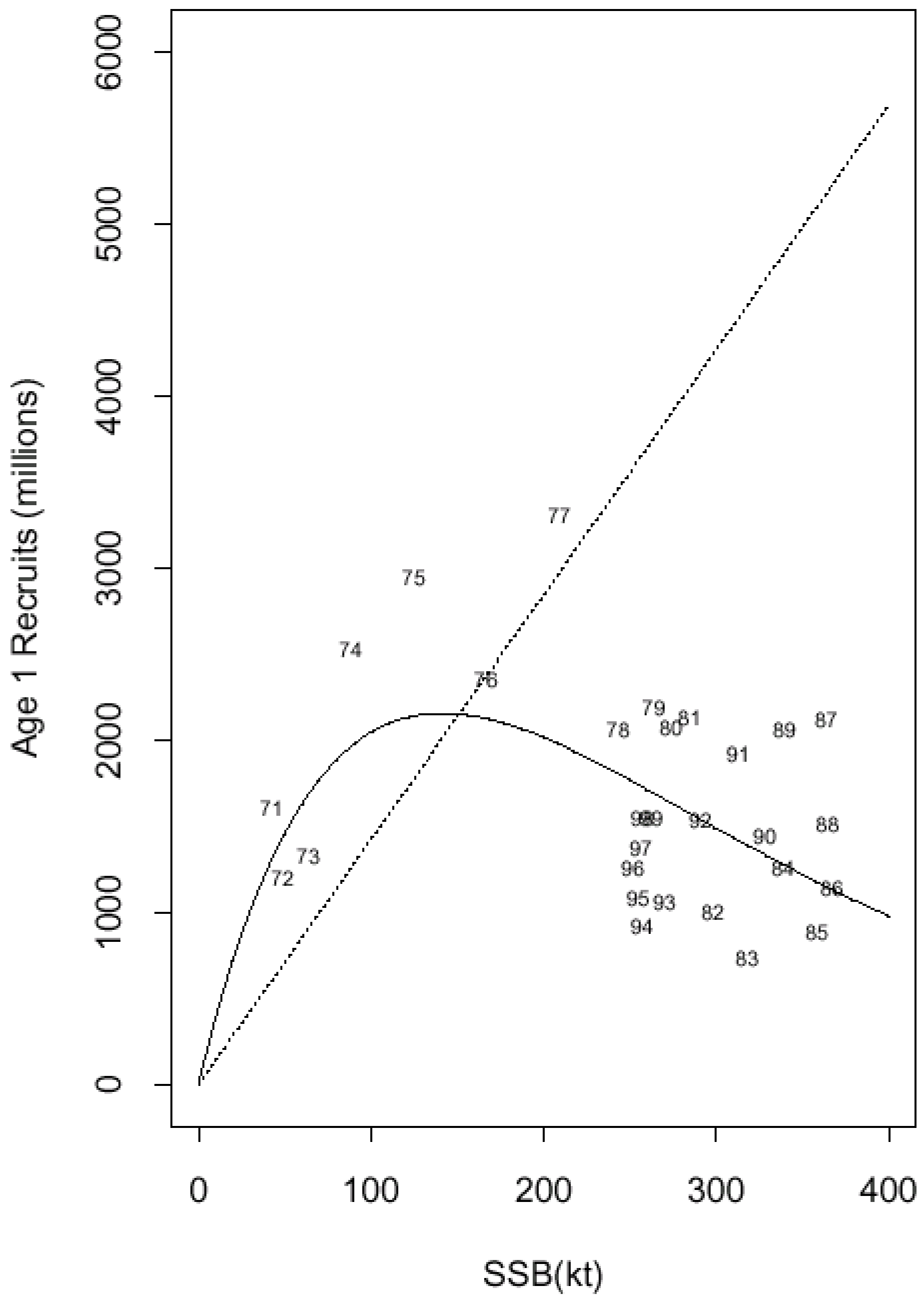

Figure 9. Estimated SSB and recruitment for Alaska plaice,
with fitted Ricker curve (solid line); labels are spawning year.
The replacement line (dashed line) is based upon an F40 value of 0.29