CHAPTER 8

ALASKA PLAICE

by

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EXECUTIVE SUMMARY

Assessment of Alaska plaice had previously been presented in the "other flatfish" chapter. Because the 2002 harvest specifications separated Alaska plaice from the other flatfish complex, the assessment of Alaska plaice has been presented as a separate chapter in this SAFE document. The assessment of the remaining other flatfish, excluding Alaska plaice, is presented in a separate chapter.

The following changes have been made to this assessment relative to the November 2001 SAFE:

<u>Changes in the input data</u>

1) The 2001 catch (total and discarded) was updated, and catch through 28, September 2002 were included in the assessment.

2) 2002 trawl survey biomass estimate and standard error for Alaska plaice was included in the assessment.

<u>Model results</u>

1) Estimated 1+ total biomass for 2003 is 1,082,690 t.
2) Projected female spawning biomass for 2003 is 255,676 t.
4) Recommended ABC for 2003 is 137,015 t based on an $F_{40\%}$ (0.28) harvest level.
5) 2002 overfishing level is 164,822 t based on a $F_{35\%}$ (0.34) harvest level.

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

	2001 Assessment recommendations for the 2002 harvest	2002 Assessment recommendations for the 2003 harvest
ABC	142,764 t	137,015
Overfishing	171,736 t	164,822
F_{ABC}	$F_{0.40} = 0.28$	$F_{0.40} = 0.28$
$F_{overfishing}$	$F_{0.35} = 0.34$	$F_{0.35} = 0.34$

INTRODUCTION

Prior to 2001, Alaska plaice (*Pleuronectes quadrituberculatus*) were managed as part of the "other species" complex. Flathead sole (*Hippoglossoides elassodon*) were part of the other flatfish complex until they were removed in 1995, but in recent years Alaska plaice was the dominant species of the complex and comprised 87% of both the 2000 catch and the estimated 2001 trawl survey biomass. Because more biological information exists for Alaska plaice than for the remaining species of other flatfish, an age-structured population model was used to assess this stock. In contrast, survey biomass estimates are the principal data source used to assess the remaining other flatfish. In 2002, Alaska plaice were managed separately from the other flatfish complex and removed from the other species complex. Given the differences in biological information, assessment techniques, and management, it is appropriate to separate the assessment of Alaska plaice from the remaining other flatfish. This chapter considers only the assessment of Alaska plaice; the remaining other flatfish are discussed in another chapter.

The distribution of Alaska plaice 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 Alaska plaice increased from approximately 1,000 t in 1971 to a peak of 62,000 t in 1988, the first year of joint venture processing (JVP) (Table 1). 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). With the cessation of joint venture fishing operations in 1991, Alaska plaice are 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 of Alaska plaice taken in research surveys from 1977 –2001 are shown in Table 2. The catch locations by quarter for 2001 for Alaska plaice fishery hauls (defined by Alaska plaice contributing at least 20% of the total catch) are shown in the Appendix.

Since implementation of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1977, Alaska plaice has been generally been lightly fished. However, the 2002 catch through 28 September of 11,400 t exceeds the total allowable catch of 10,200 t. Alaska plaice are grouped with the rock sole, flathead sole, and other flatfish 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, this group of fisheries has been closed prior to attainment of the TAC due to the bycatch of halibut (Table 3), and portion of the eastern Bering Sea has been closed to these fisheries in 2002 for exceeding the red king crab bycatch allowance.

Substantial amounts of Alaska plaice are discarded in various eastern Bering Sea target fisheries. Retained and discarded catches were reported for Alaska plaice for the first time in 2002, and indicate that of the 11,360 t caught only 360 t were retained, resulting in a retention rate of 3.2 %. The discarding estimates were produced by using observer estimates of discard rate applied to the “blend” estimate of observer and industry reported retained catch. Examination of the 2002 blend data revealed that over 9,400 t of discards could be attributed to the yellowfin sole fishery, primarily from March to early April and again from August from late September. Substantial rates of discarding also occurred in the rock sole, flathead sole, and Pacific cod fisheries.

DATA

Commercial Catch Data

Fishery Catch Biomass and Catch-at-Age Data

This assessment uses fishery catches from 1971 through 28 September, 2002 (Table 2), and estimates of number caught by age for the years 1971-79, 81-82, 1988, and 1995 (Table 5).

Survey Data

Survey Biomass

Because Alaska plaice 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 1979-2001 by NMFS. Survey estimates of total biomass and numbers at age are shown in Tables 4 and 5, 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 escapement or gains due to gear herding effects.

Trawl survey biomass estimates for Alaska plaice biomass increased dramatically from 1975 through 1982 and have remained at a high and stable level since (Table 4, Figure 1). The trawl gear was changed in 1982 from the 400 mesh eastern trawl to the 83-112 trawl, as the latter trawl has better bottom contact. This may contribute to the increase in Alaska plaice seen from 1981 to 1982, as increases between these years were noticed in other flatfish as well. However, large changes in Alaska plaice biomass between adjacent years have occurred without changes in trawl gear, such as the increase from 1980 to 1981 and the decrease from 1984 to 1985.

Although calibration between years with different trawl gear has not been accomplished, the survey data since 1982 does incorporate calibration between the two vessels used in the survey. Fishing Power Coefficients (FPC) were estimated with the methods of Kappenman (1992). The trend of the biomass estimates is the same as without the calibration between vessels, but 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 2002 estimate of 424,971 t is close to the 2000 estimate of 443,620 t, and is a 27% decrease from the 2001 estimate of 538,319 t. The interannual variation in estimated biomass appears to be relatively high since 1994.

Survey Growth Parameters

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 aging 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, 1971-2001;
2) Proportional catch number at age, 1971-79, 1981-82, 1988, 1995;
3) Survey biomass and standard error 1975, 1979-2001;
4) Survey age composition 1979, 1982, 1988, 1992-1995, 1998.

ANALTICAL APPROACH

Model Structure

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

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

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 is a function of the mean numbers at age, which was computed as:

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

The predicted survey biomass for a given year is

$$q\_srv * \sum_{a} sel\_srv_a (\overline{N}_a * wt_a)$$

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)	32
3) recruitment mean (*meanrec*)	1
4) recruitment deviations (ν)	32
5) initial year mean (*meaninit*)	1
6) initial year deviations (γ)	24
7) fishery selectivity patterns	2
8) survey selectivity patterns	2
Total parameters	95

RESULTS

Biomass trends

The model results show that estimated total Alaska plaice biomass (ages 1+) increased from a low of 447,726 t in 1971 to a peak of 1,462,360 t in 1984 (Figure 2, Table 6). Beginning in 1985, estimated total biomass has declined to 1,075,230 t in 1993, and has remained at approximately this level; the estimated 2002 total biomass is 1,076,720 t. The estimated survey biomass also shows a rapid increase to a peak biomass of 680,259 t in 1987, a subsequent decline to 488,175 t in 1996, and an increase to 515,861 t in 2002 (Figure 4). The fits to the trawl survey and fishery age compositions are shown in Figures 5 and 6, respectively.

Recruitment trends

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 0.08 in 1988, and have averaged 0.02 during 1971-2001 (Figure 7); the 2002 estimate is 0.021. Estimated age-1 recruitment has shown high levels from 1971-1982, averaging 2.4 x 10^9 (Figure 8, Table 9). From 1983-2002, estimated recruitment has declined, averaging 1.7 x 10^9. A particularly low period of recruitment apparently occurred from 1983-1987, 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 1977-2002 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 $SPR_{40\%}$ * equilibrium recruits, and this quantity is 130,888 t. The year 2003 spawning biomass is estimated as 255,676 t. Since reliable estimates of 2003 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B > B_{40\%}$ (255,676 t > 130,888 t), Alaska plaice reference fishing mortality is defined in tier 3a of Amendment 56. For this tier, F_{ABC} is constrained to be ≤ $F_{40\%}$, and F_{OFL} is defined as $F_{35\%}$. The values of these quantities are

2003 SSB estimate (B)	=	255,676 t
$B_{40\%}$	=	130,888 t
$F_{40\%}$	=	0.279
F_{ABC}	≤	0.279
$F_{35\%}$	=	0.344
F_{OFL}	=	0.344

Specification of OFL and Maximum Permissible ABC

The estimated catch level for year 2003 associated with the overfishing level of F = 0.344 is 164,822 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 the maximum permissible ; thus, the year 2003 recommended ABC associated with F_{ABC} of 0.279 is 137,015 t.

Standard Harvest and Recruitment Scenarios and Projection Methodology

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

For each scenario, the projections begin with the vector of 2002 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2002 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2002. 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 2003, 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 2003 recommended in the assessment to the *max* F_{ABC} for 2002. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

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

Scenario 4: In all future years, F is set equal to the 1997-2001 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 7.

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 2003 under this scenario, then the stock is not overfished.)

Scenario 7: In 2003 and 2004, 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 2005 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 2003 of scenario 6 is 2.2 times its $B_{35\%}$ value of 114,527 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 2005 of scenario 7 is 1.5 times its $B_{35\%}$ value.

OTHER CONSIDERATIONNS

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 2003 spawning stock biomass	255,676 t
F_{OFL}	0.344
Maximum F_{ABC}	0.279
Recommended F_{ABC}	0.279
OFL	164,822 t
Recommended ABC	137,015 t

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Table 1. Harvest (t) of Alaska plaice from 1977-2002

Year	Harvest
1977	2589
1978	10420
1979	13672
1980	6902
1981	8653
1982	6811
1983	10766
1984	18982
1985	24888
1986	46519
1987	18567
1988	61638
1989	14134
1990	10926
1991	18029
1992	18985
1993	14536
1994	9227
1995	19204
1996	16084
1997	20420
1998	13989
1999	13612
2000	14274
2001	8397
2002*	11360

*NMFS Regional Office Report through Sept 28, 2002

Table 2. Research catches (t) of Alaska plaice in the BSAI area from 1977 to 2002.

Year	Research Catch (t)
1977	4.28
1978	4.94
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	15.98
2001	20.45
2002	15.07

Table 3. Restrictions on the “other flatfish” fishery from 1994 to 2002 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
2001	3/20 – 3/31	First Seasonal halibut cap
	4/27 – 7/01	Second 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	First Seasonal halibut cap
	4/20 – 6/29	Second seasonal halibut cap
	7/29 – 12/31	Annual halibut allowance

Table 4. Estimated biomass and standard deviations (t) of Alaska plaice from the eastern Bering Sea trawl survey.

Year	Biomass estimate	Standard Deviation
1975	103,500	11,600
1979	277,200	31,100
1980	354,000	39,800
1981	535,800	60,200
1982	715,400	64,800
1983	743,000	65,100
1984	789,200	35,800
1985	580,000	61,000
1986	553,900	63,000
1987	564,400	57,500
1988	699,400	140,000
1989	534,000	58,800
1990	522,800	50,000
1991	529,000	50,100
1992	530,400	56,400
1993	515,200	50,500
1994	623,100	53,300
1995	552,292	62,600
1996	529,300	67,500
1997	643,400	73,200
1998	452,600	58,700
1999	546,522	47,000
2000	443,620	67,600
2001	538,319	30,700
2002	424,971	53,800

Table 5. 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 6. Estimated total biomass (ages 1+), female spawner biomass, and recruitment (age 1), with comparison to the 2001 SAFE estimates.

	Female Spawner Biomass (t)		Total Biomass (t)		Recruitment (Millions)	
	Assessment		Assessment		Assessment	
Year	2002	2001	2002	2001	2002	2001
1971	62941	62887	447726	447611	2401	2404
1972	69723	69671	573433	573374	1788	1791
1973	85841	85793	705367	705399	1380	1383
1974	112713	112674	824505	824671	1499	1503
1975	151741	151715	919065	919405	2674	2681
1976	196382	196376	992417	992973	3139	3144
1977	241615	241642	1056400	1057220	2579	2582
1978	278389	278467	1122390	1123480	3584	3586
1979	300316	300456	1187390	1188740	2287	2290
1980	311182	311400	1255230	1256790	2398	2401
1981	322053	322359	1327450	1329160	2274	2278
1982	335354	335753	1388060	1389880	2362	2367
1983	355325	355802	1436580	1438500	1201	1204
1984	376608	377143	1462360	1464350	924	927
1985	396719	397287	1454430	1456480	1458	1463
1986	406178	406762	1415430	1417530	1081	1086
1987	403950	404543	1335830	1337990	1330	1338
1988	404695	405301	1274560	1276800	2310	2327
1989	380143	380759	1170930	1173350	1713	1730
1990	368463	369094	1128840	1131590	2249	2280
1991	352961	353609	1103370	1106700	1693	1728
1992	330685	331363	1084270	1088500	2085	2158
1993	309338	310079	1075230	1080870	1790	1882
1994	296218	297082	1078750	1086630	1560	1648
1995	293281	294370	1089450	1100520	1562	1637
1996	289737	291408	1087460	1103030	1679	1737
1997	294248	296432	1085150	1104830	1762	1802
1998	295258	298187	1075420	1098900	1809	1840
1999	300941	305017	1071960	1098550	1857	1883
2000	302587	308035	1069780	1098460	1859	1883
2001	302471	309358	1069120	1098820	1859	1882
2002	302840		1076720		1859	

Table 7. 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 130,888 t and 114,527 t, respectively.

Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2002	276948	276948	276948	276948	276948	276948	276948
2003	255676	255676	266265	275225	277329	250852	255676
2004	209214	209214	242168	273419	281232	195538	209214
2005	178748	178748	224623	273002	285828	161285	175584
2006	159679	159679	212524	273845	290994	141035	150202
2007	148055	148055	204395	275437	296280	129515	135079
2008	141076	141076	198994	277326	301296	123688	126632
2009	136887	136887	195379	279178	305779	121438	122700
2010	134455	134455	192967	280870	309670	120726	121263
2011	133247	133247	191388	282374	313001	120645	120885
2012	132811	132811	190377	283676	315812	120772	120876
2013	132739	132739	189720	284761	318136	120915	120929
2014	132775	132775	189266	285628	320019	120990	120882
2015	132732	132732	188853	286213	321431	120927	120763
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2002	0.0205563	0.0205563	0.020557	0.0205563	0.0205571	0.0205563	0.0205569
2003	0.278651	0.278651	0.139326	0.0260277	0	0.344195	0.278651
2004	0.278651	0.278651	0.139326	0.0260277	0	0.344195	0.278651
2005	0.278651	0.278651	0.139326	0.0260277	0	0.344195	0.344195
2006	0.278651	0.278651	0.139326	0.0260277	0	0.344195	0.344195
2007	0.278651	0.278651	0.139326	0.0260277	0	0.340428	0.344195
2008	0.278651	0.278651	0.139326	0.0260277	0	0.324294	0.332097
2009	0.278645	0.278645	0.139326	0.0260277	0	0.318059	0.320797
2010	0.276659	0.276659	0.139326	0.0260277	0	0.31569	0.316178
2011	0.273872	0.273872	0.139326	0.0260277	0	0.314688	0.314502
2012	0.271885	0.271885	0.139326	0.0260277	0	0.314281	0.314098
2013	0.270991	0.270991	0.139326	0.0260277	0	0.314221	0.314138
2014	0.27064	0.27064	0.139326	0.0260277	0	0.314295	0.314022
2015	0.270671	0.270671	0.139326	0.0260277	0	0.314136	0.313807
Catch	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2002	11360.6	11360.6	11361	11360.6	11361.1	11360.6	11360.9
2003	137015	137015	72553.5	14217.4	0	164822	137015
2004	111629	111629	65811.5	14104.6	0	127810	111629
2005	95338.5	95338.5	61068.6	14093.4	0	105326	114843
2006	85346.1	85346.1	57891.6	14156.6	0	92281.7	98328
2007	79380.8	79380.8	55813.3	14259	0	84117.8	88647.5
2008	75822.7	75822.7	54440.4	14369.2	0	76852.4	80475.1
2009	73682.4	73682.4	53517	14471.1	0	74214.4	75623.5
2010	71953.8	71953.8	52890.3	14559.1	0	73410.6	73894.1
2011	70702.1	70702.1	52475.3	14634.9	0	73274.2	73430.6
2012	70061	70061	52214.4	14701.2	0	73357.9	73418.1
2013	69860.4	69860.4	52049.4	14757.1	0	73487.3	73514.1
2014	69835.6	69835.6	51941.2	14802.6	0	73591.5	73491.9
2015	69857	69857	51848.3	14835.1	0	73545.7	73334.5

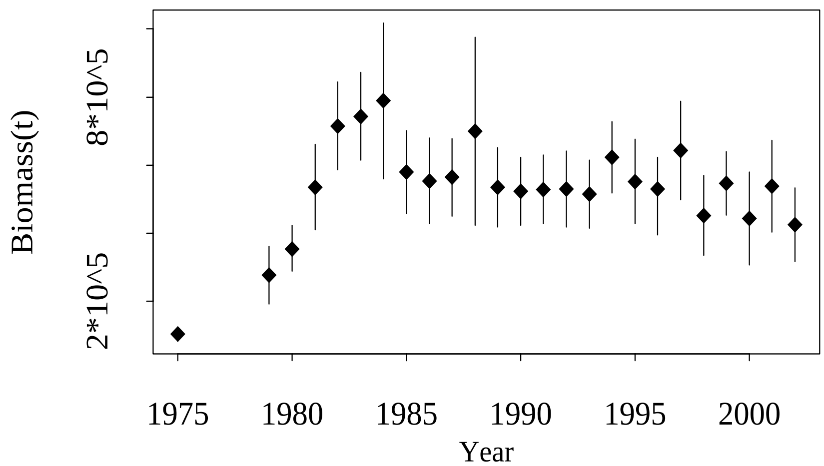


Figure 1. Estimated survey biomass and 95% CIs

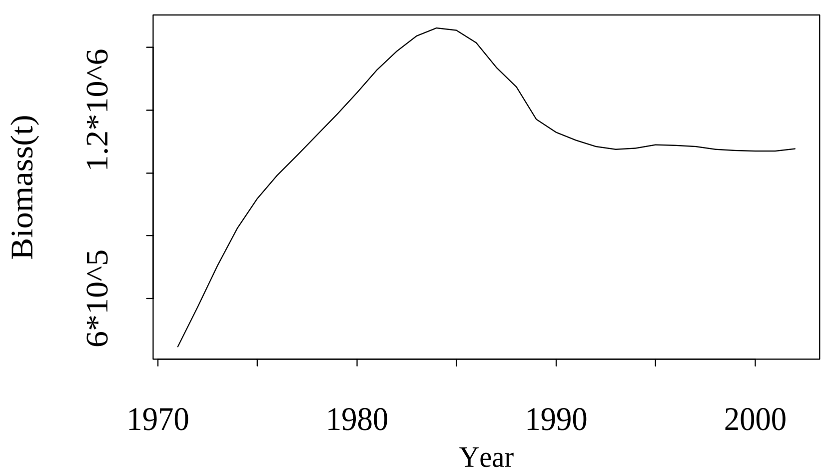
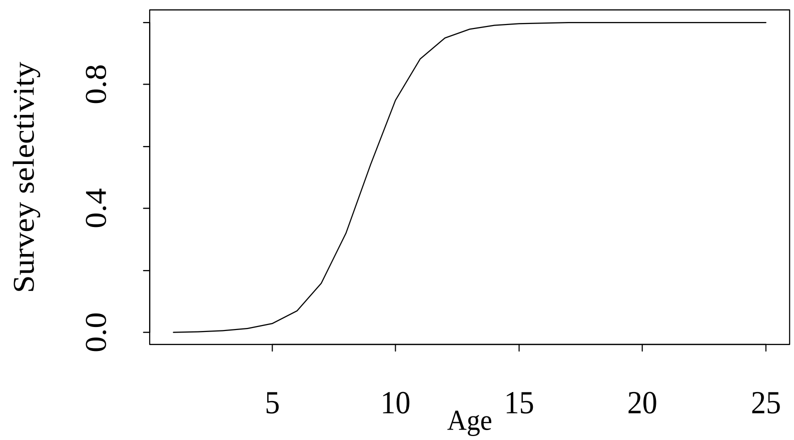


Figure 2. Estimated beginning year total biomass of Alaska plaice



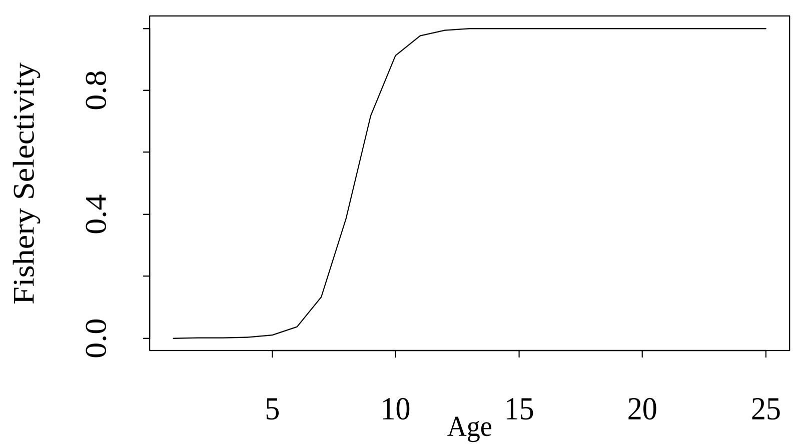


Figure 3. Estimated survey and fishery selectivity

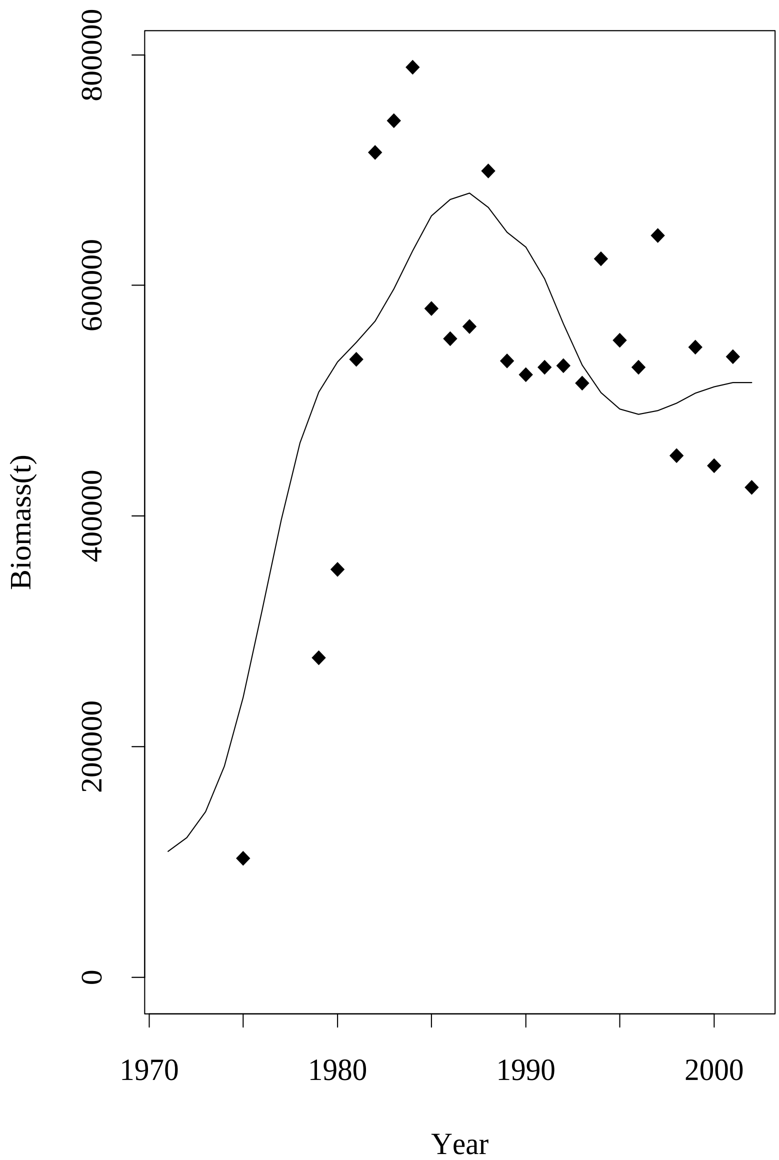


Figure 4. Observed (data points) and predicted (solid line) survey biomass of Alaska plaice

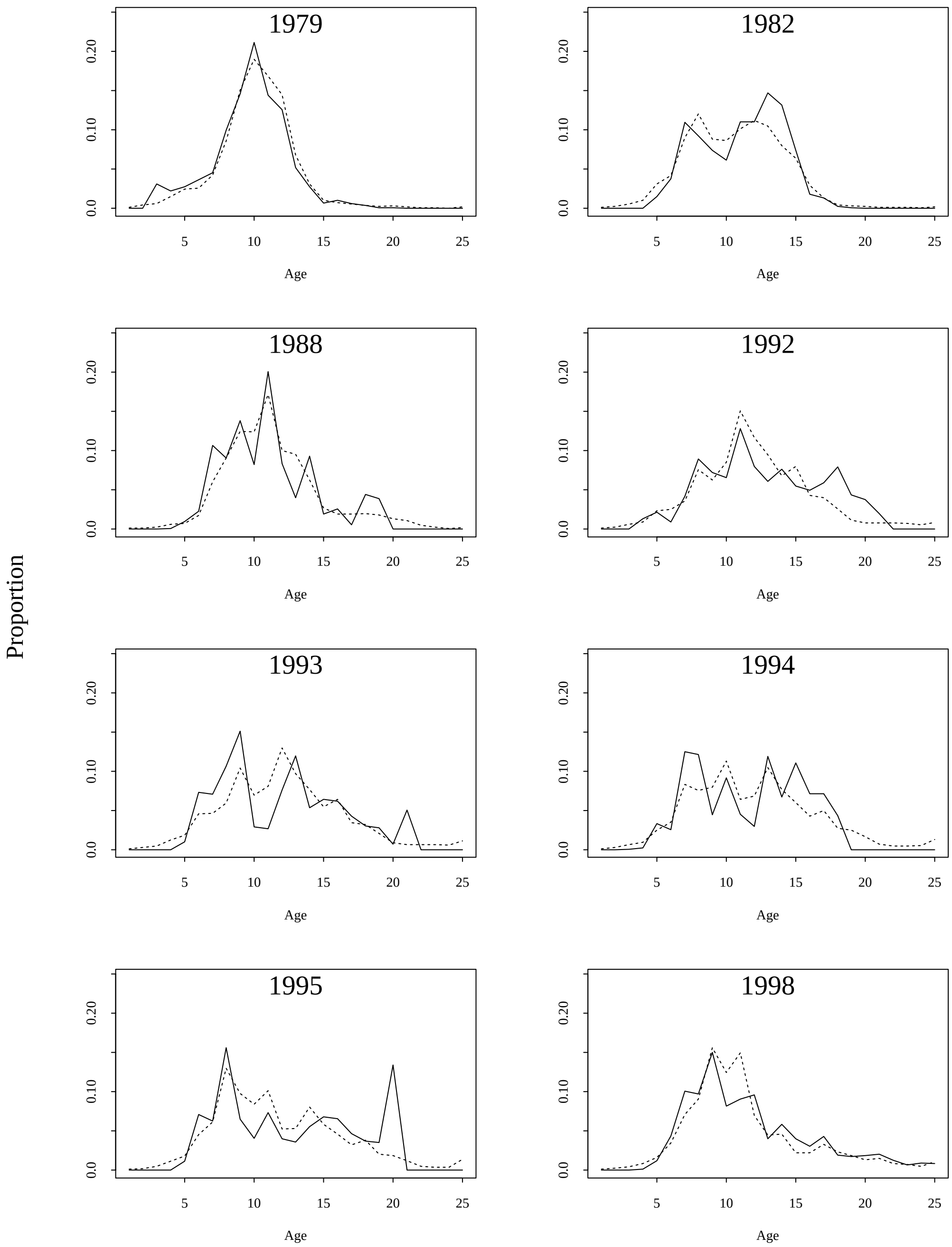


Figure 5. Survey age composition by year (solid line = observed, dotted line = predicted)

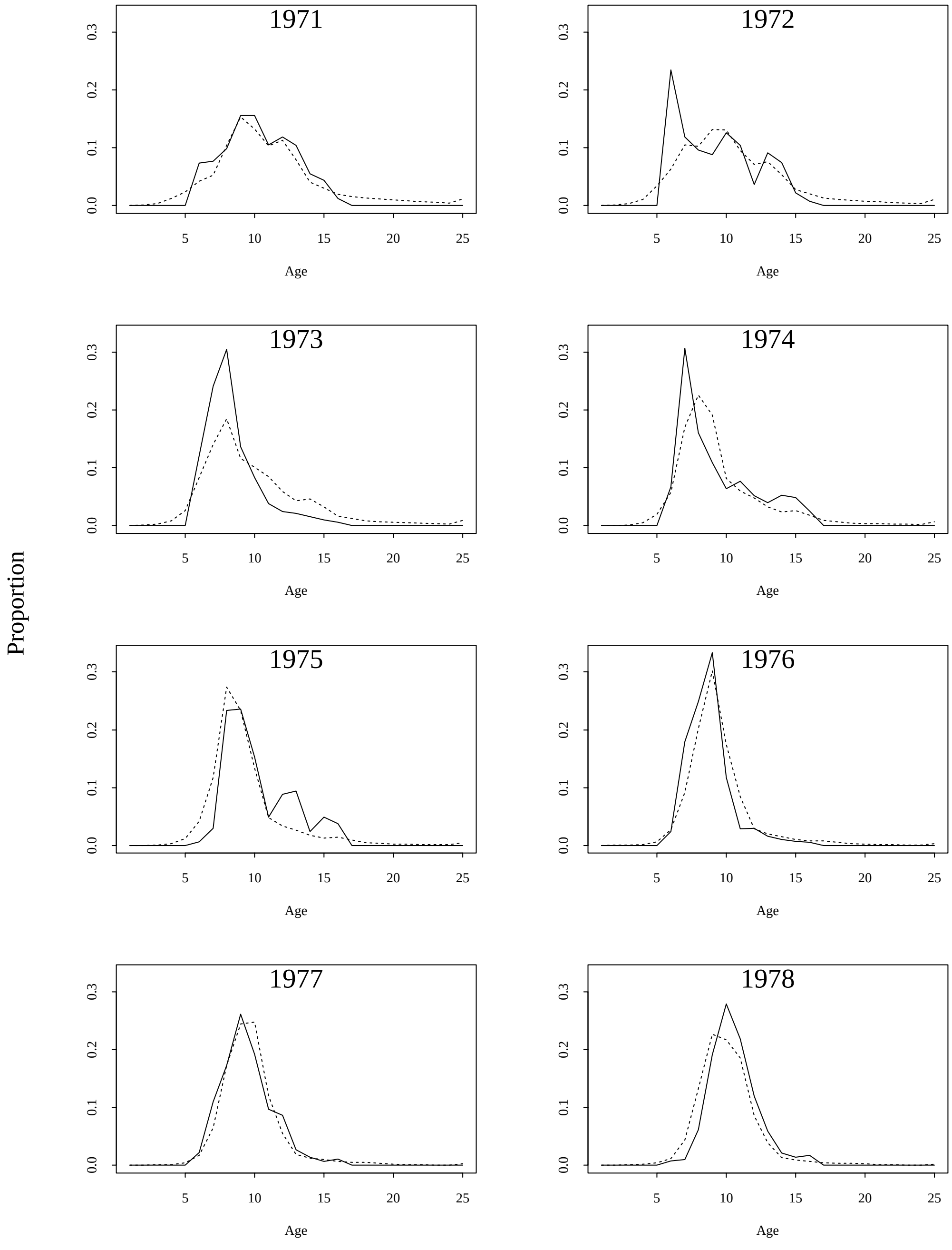


Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

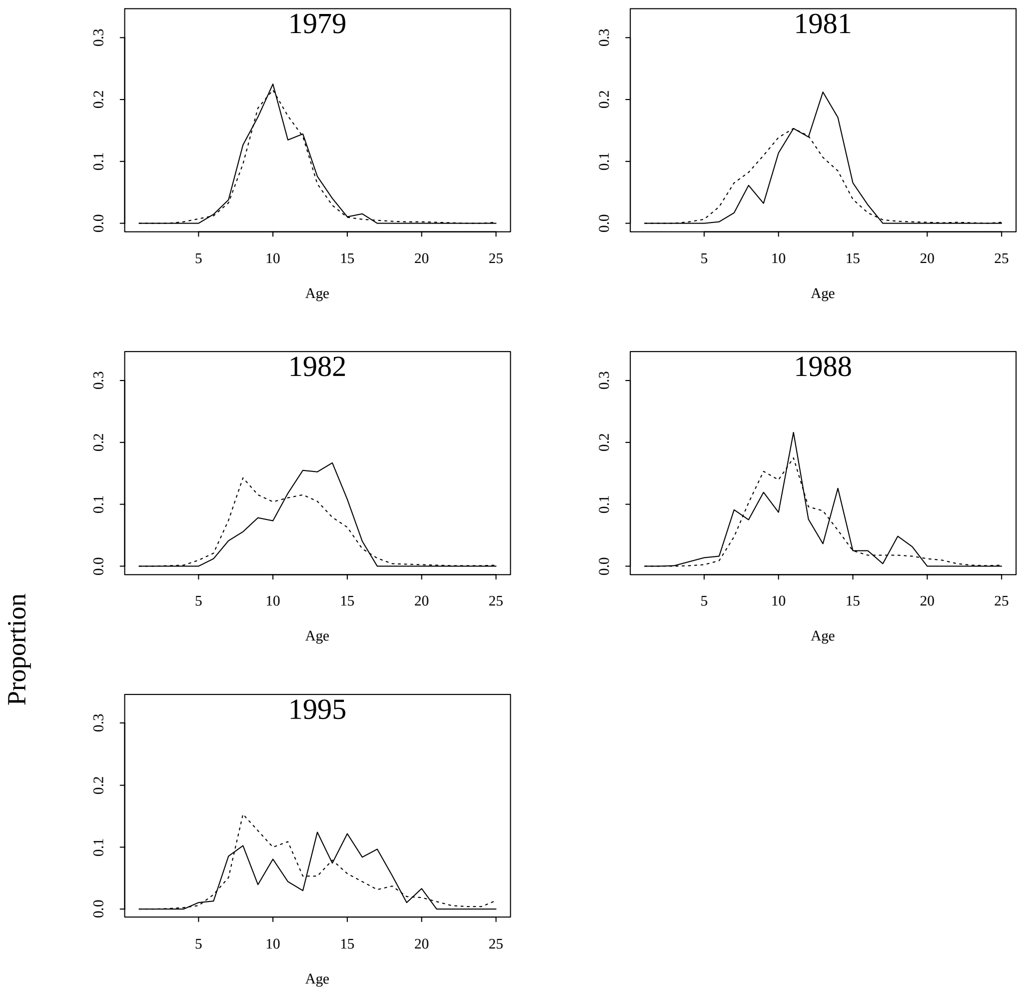


Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

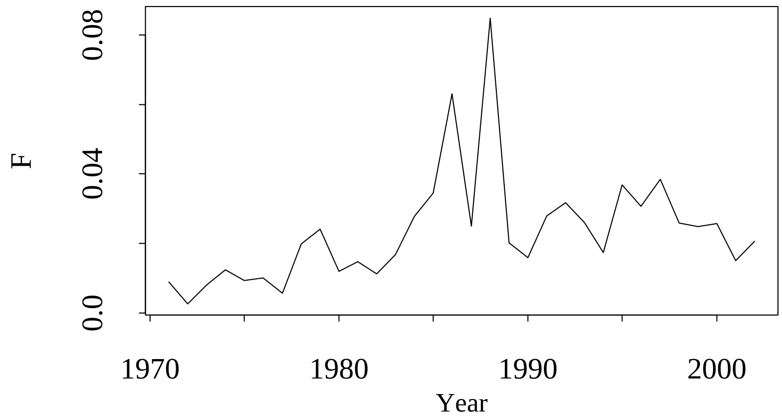


Figure 7. Estimated fully selected fishing mortality

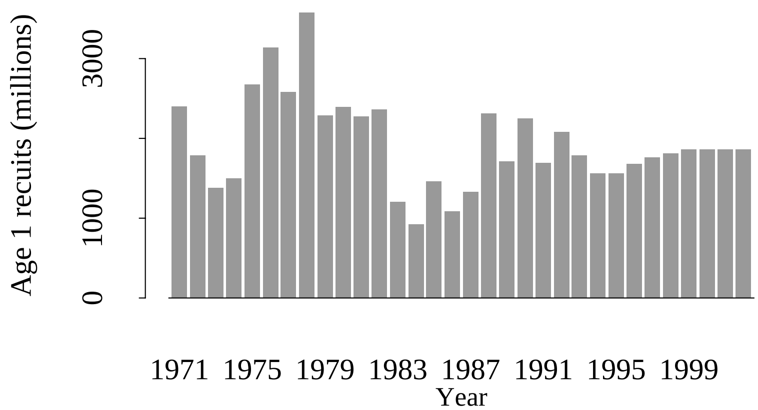


Figure 8. Estimated recruitment (age 1) of Alaska plaice

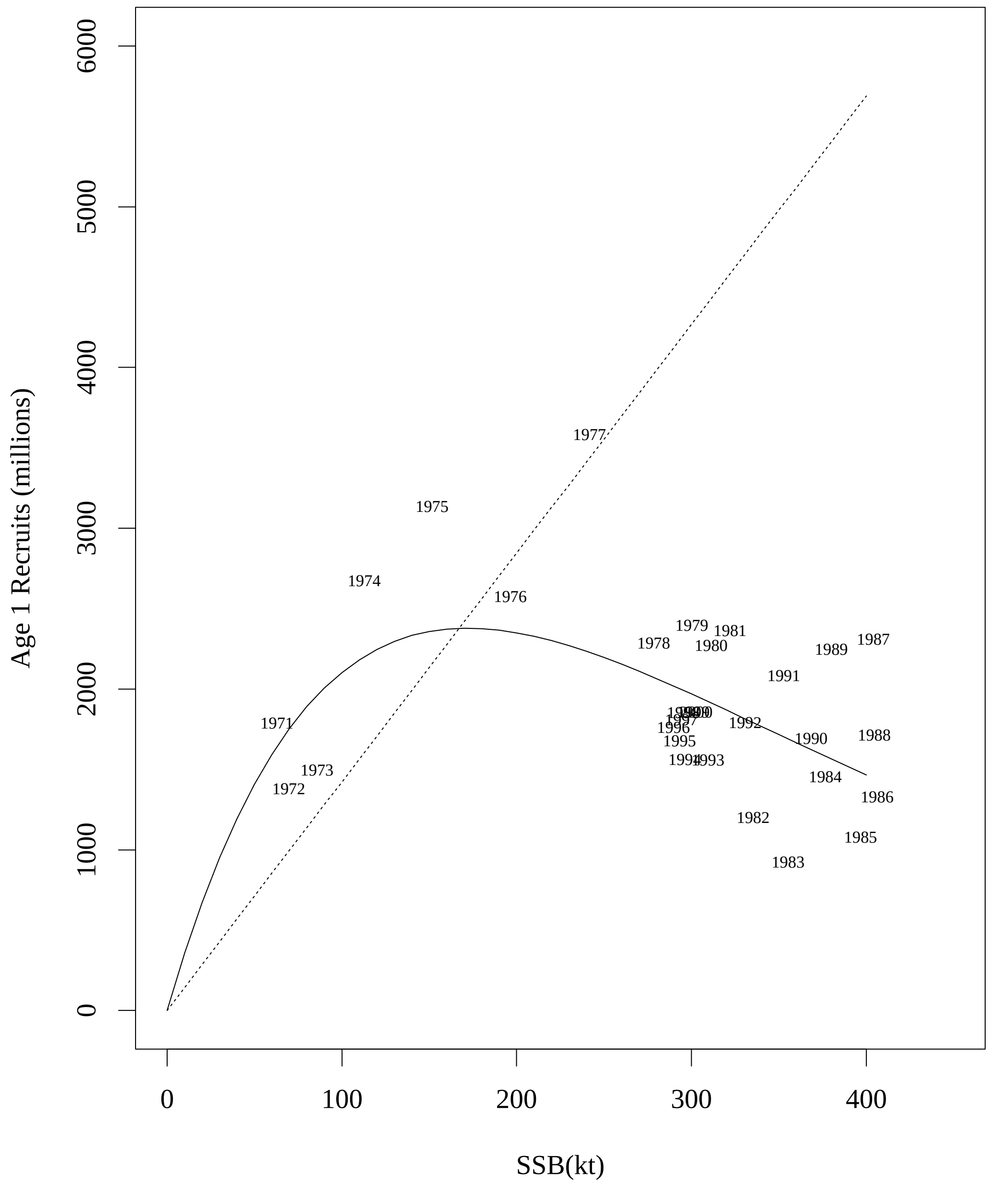
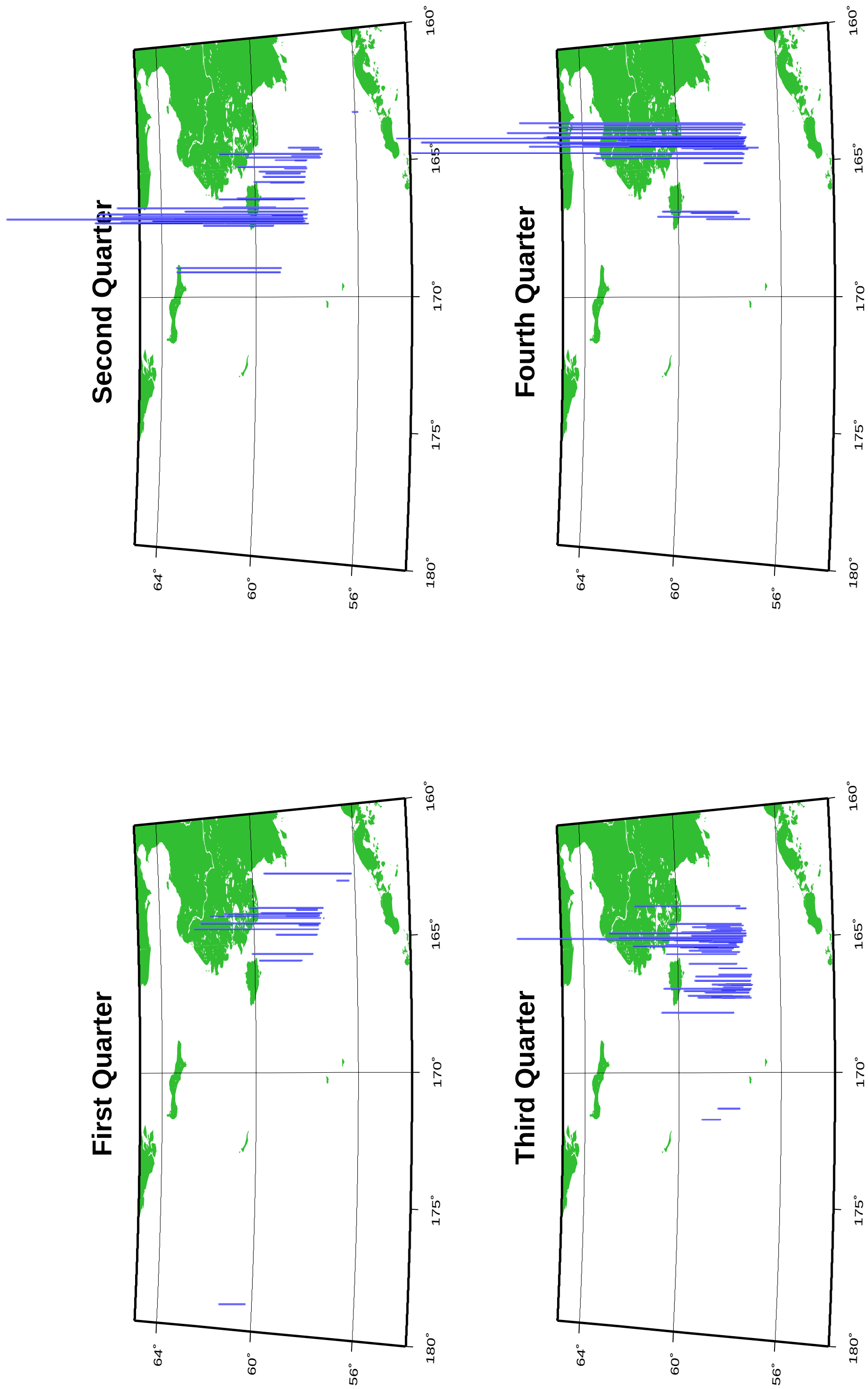


Figure 9. Estimated SSB and recruitment for Alaska plaice,
with fitted Ricker curve (solid line); labels are spawning year.
The replacement line (dashed line) is based upon an F40 value of 0.28



Appendix Figure 1. Alaska plaice fishery catch (relative biomass), by quarter, of hauls where more than 20 percent of the catch was Alaska plaice.