OTHER FLATFISH

by

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Executive Summary

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

Changes in the input data

1) 2001 total catch and discards through 15 September, 2001; catch was partitioned among species according the proportions observed in the 2001 hauls sampled by NMFS observers.
2) 2001 trawl survey biomass estimate and standard error for Alaska plaice, and 2001 trawl survey biomass estimates of miscellaneous flatfish.
3) Estimate of the retained and discarded portions of the 2001 catch.

Changes in assessment methodology

1) The mean numbers at age were used to compute predicted survey biomass estimates, differing from recent assessments in which the beginning numbers at age were used.

Model results (Alaska plaice)

1) Estimated 1+ total biomass for 2001 is 1,098,820 t.
2) Projected female spawning biomass for 2002 is 264,838 t.
4) Recommended ABC for 2002 is 142,764 t based on an $F_{40\%}$ (0.28) harvest level.
5) 2002 overfishing level is 171,736 t based on a $F_{35\%}$ (0.34) harvest level.

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

	2000 Assessment recommendations for the 20001 harvest	2001 Assessment recommendations for the 2002 harvest
Alaska plaice		
ABC	121,975 t	142,764
Overfishing	147,167 t	171,736
F_{ABC}	$F_{0.40} = 0.29$	$F_{0.40} = 0.28$
$F_{overfishing}$	$F_{0.35} = 0.36$	$F_{0.35} = 0.34$
"Miscellaneous" species		
Exploitable biomass (as estimated from NMFS groundfish survey)	79,786 t	78,293 t
ABC	18,394 t	18,065 t
Overfishing	21,716 t	21,832 t
F_{ABC}	$F_{0.40} = 0.30$	$F_{0.40} = 0.30$
$F_{overfishing}$	$F_{0.35} = 0.38$	$F_{0.35} = 0.38$

Introduction

The 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 87% of both the 2000 catch and the estimated 2001 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 of Alaska plaice taken in research surveys from 1977 –2001 are shown in Table 3. The catch locations by quarter for 2000 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, the "other flatfish" complex has been lightly fished. This trend continued in 2001, with the catch through 15 September totaling only 29% of the 2001 total allowable catch of 23,800 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 4).

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 5). Substantial discarding occurred in the yellowfin sole, flathead sole, and rock sole fisheries in 2000.

Data

Fishery Catch and Catch-at-Age Data

This assessment uses fishery catches from 1971 through 15 September, 2001 (Table 2), and estimates of number caught by age for the years 1971-79, 81-82, 1988, and 1995.

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 1979-2001 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 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 2001 estimate of 538,319 t is very close to the 1999 estimate of 546,522 t, and is a 23% increase from the 2000 estimate of 443,620 t. The interannual variation in estimated biomass appears to be relatively high since 1994.

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, 1971-2001;
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.

For the miscellaneous species of the other flatfish management category, individual species biomass from the 1997 and 2000 Aleutian Islands and 1997-2001 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 2001 estimate of 78,293 t is similar to the levels estimated in recent years. Interestingly, the biomass of rex sole in the Aleutian Islands survey has been approximately the same size as that in the EBS shelf survey in 1997 and 2000; other flatfish species generally show much smaller populations in the Aleutian Islands. Exploitation rates for starry flounder and rex sole have been low, not exceeding 0.10 from 1997 to 2001 (Table 9). In contrast, exploitation rates for butter sole have been slightly higher, exceeding 0.15 in 1997, 2000, and 2001.

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 2001 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

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

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)	31
3) recruitment mean (*meanrec*)	1
4) recruitment deviations (ν)	31
5) initial year mean (*meaninit*)	1
6) initial year deviations (γ)	24
7) fishery selectivity patterns	2
8) survey selectivity patterns	2
Total parameters	93

Model Results (Alaska plaice)

The model results show that estimated total Alaska plaice biomass (ages 1+) increased from a low of 447,611 t in 1971 to a peak of 1,464,350 t in 1984 (Figure 2, Table 10). Beginning in 1985, estimated total biomass has declined to 1,080,870 t in 1993, and increased slightly to 1,098,820 t in 2001. The estimated survey biomass also shows a rapid increase to a peak biomass of 680,678 t in 1987, a subsequent decline to 490,523 t in 1996, and an increase to 527,594 t in 2001 (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 0.08 in 1988, and have averaged 0.02 during 1971-2001 (Figure 7); the 2001 estimate is 0.009 Estimated age-1 recruitment has shown high levels from 1971-1982, averaging 2.4 x 10^9 (Figure 8, Table 9). From 1983-2001, 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 1977-2000 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 132,856 t. The year 2002 spawning biomass is estimated as 264,838 t. Since reliable estimates of 2002 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B>B_{40\%}$ (264,838 t > 132,856 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

2002 SSB estimate (B)	=	264,838 t
$B_{40\%}$	=	132,856 t
$F_{40\%}$	=	0.279
F_{ABC}	$\leq$	0.279
$F_{35\%}$	=	0.344
F_{OFL}	=	0.344

The estimated catch level for year 2002 associated with the overfishing level of F = 0.344 is 171,736 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 2002 recommended ABC associated with F_{ABC} of 0.279 is 142,764 t.

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 (2001) flathead sole assessment to the 2001 survey biomass of miscellaneous flatfish (78,293 t). Application of the catch equation the 2001 survey biomass estimates assumes that the survey biomass estimates are an estimate of the beginning year biomass for 2002, and that natural mortality and size at age do not change within 2002. The 2001 estimates of $F_{40\%}$ and $F_{35\%}$ for flathead sole are 0.300 and 0.375, respectively. The ABC and OFL, and the catch associated with the $F_{ABC}/2$ level of 0.150, are shown below:

F level (value)	Projected yield for year 2002
$F_{ABC}/2$ (0.15)	9,680 t
F_{ABC} (0.30)	18,065 t
F_{OFL} (0.38)	21,832 t

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

For each scenario, the projections begin with the vector of 2001 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2002 using the schedules of natural mortality and selectivity described in the assessment

and the best available estimate of total (year-end) catch for 2001. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TAC for 2002, are as 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 2002 recommended in the assessment to the *max* F_{ABC} for 2002. (Rationale: When F_{ABC} is set at a value below *max* F_{ABC}, it is often set at the value recommended in the stock assessment.)

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

Scenario 4: In all future years, *F* is set equal to the 1996-2000 average *F*. (Rationale: For some stocks, TAC can be well below ABC, and recent average *F* may provide a better indicator of F_{TAC} than F_{ABC}.)

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

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

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 2002 under this scenario, then the stock is not overfished.)

Scenario 7: In 2002 and 2003, F is set equal to $max\ F_{ABC}$, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2004 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that the 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 2002 of scenario 6 is 2.2 times its $B_{35\%}$ value of 116,249 t. With regard to whether the stock is likely to be in an overfished condition in the near future, the expected stock size in the year 2004 of scenario 7 is 1.5 times its $B_{35\%}$ value.

Other considerations

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 2002 Spawning stock biomass	264,838 t
F_{OFL}	0.344
Maximum F_{ABC}	0.279
Recommended F_{ABC}	0.279
OFL	171,736 t
Recommended ABC	142,764 t

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

Common Name	Scientific Name
Alaska plaice	*Pleuronectes quadrituberculatus*
Arctic flounder	*Liopsetta glacialis*
butter sole	*Isopsetta isolepis*
curlfin sole	*Pleuronectes decurrens*
deepsea sole	*Embassichths bathybus*
Dover sole	*Microstomus pacificus*
English sole	*Parophrys vetulus*
longhead dab	*Limanda proboscidea*
Pacific sanddab	*Citharichthys sordidus*
petrale sole	*Eopsetta jordani*
rex sole	*Glyptocephalus zachirus*
roughscale sole	*Clidodoerma asperrimum*
sand sole	*Psettichthys melanostictus*
slender sole	*Lyopsetta exilis*
starry flounder	*Platichthys stellatus*
Sakhalin sole	*Pleuronectes sakhalinensis*

Table 2. Harvest (t) of Alaska plaice and other flatfish from 1977-2001

		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	14287	1012	749	350	5	2116	16403
2001*	5355	805	512	256	5	1578	6933

*NMFS Regional Office Report through Sept 15, 2001

Table 3. Research catches (t) of Alaska plaice in the BSAI area from 1977 to 2001.

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

Table 4. Restrictions on the "other flatfish" fishery from 1994 to 2001 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

Table 5. Total retained and discarded "other flatfish", 1993-2001.

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	16403	2919	13484	17.8
2001*	6933	791	6142	11.4

*NMFS regional office report through September 15, 2001

Table 6. 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
2001	EBS	538,319	78,293	616,612

Table 7. 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 8 --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
2001 BS	16	21660	12764	31	43026	796	--

Table 9. Estimated exploitation rates of rex sole, starry flounder and butter sole from 1997 to 2001.

	Rex sole			Starry Flounder			Butter sole		
Year	Biomass (t)	Harvest (t)	Exp. Rate	Biomass (t)	Harvest (t)	Exp. Rate	Biomass (t)	Harvest (t)	Exp. Rate
1997	16189	590	0.04	41632	1197	0.03	3347	494	0.15
1998	7588	779	0.10	49605	330	0.01	1942	213	0.11
1999	8020	655	0.08	43375	757	0.02	4152	212	0.05
2000	16689	749	0.04	46573	1013	0.02	2115	350	0.17
2001	21660	512	0.02	43026	805	0.02	796	256	0.32

Table 10. Estimated total biomass (ages 1+), female spawner biomass, and recruitment (age 1), with comparison to the 2000 SAFE estimates.

	Female Spawner Biomass (t)		Total Biomass (t)		Recruitment (Millions)	
	Assessment		Assessment			
Year	2001	2000	2001	2000	2001	2000
1971	62887	42338	447611	361054	2404	2091
1972	69671	48680	573374	478640	1791	1602
1973	85793	63597	705399	602153	1383	1200
1974	112674	88492	824671	713613	1503	1330
1975	151715	124810	919405	801977	2681	2521
1976	196376	166527	992973	871134	3144	2941
1977	241642	208912	1057220	932708	2582	2356
1978	278467	243208	1123480	997365	3586	3300
1979	300456	263690	1188740	1061110	2290	2066
1980	311400	273644	1256790	1127150	2401	2189
1981	322359	284475	1329160	1197190	2278	2074
1982	335753	297964	1389880	1255670	2367	2133
1983	355802	317927	1438500	1302350	1204	1003
1984	377143	338887	1464350	1326660	927	732
1985	397287	358179	1456480	1317740	1463	1251
1986	406762	366913	1417530	1278320	1086	890
1987	404543	363936	1337990	1198810	1338	1140
1988	405301	364402	1276800	1138030	2327	2120
1989	380759	339615	1173350	1035260	1730	1517
1990	369094	328130	1131590	994215	2280	2061
1991	353609	312855	1106700	969860	1728	1446
1992	331363	290875	1088500	951649	2158	1928
1993	310079	269906	1080870	943252	1882	1542
1994	297082	257186	1086630	947145	1648	1066
1995	294370	254682	1100520	956454	1637	927
1996	291408	251624	1103030	949370	1737	1085
1997	296432	256318	1104830	935395	1802	1253
1998	298187	257160	1098900	908790	1840	1375
1999	305017	262222	1098550	885947	1883	1553
2000	308035	261456	1098460	865146	1883	1553
2001	309358		1098820		1882	

Table 11. Projections of spawning biomass, catch, fishing mortality rate, and catch for each of the several scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 132,856 t and 116,249 t, respectively.

Sp. Biomass	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	283843	283843	283843	283843	253648	283843	283843
2002	264838	264838	275840	287335	257139	259824	264838
2003	216189	216189	250546	291286	261103	201929	216189
2004	183392	183392	231125	294891	264697	165235	180121
2005	162617	162617	217321	298762	268499	143356	152881
2006	150084	150084	208046	302946	272567	131099	136844
2007	142699	142699	201960	307151	276631	125076	128081
2008	138430	138430	198035	311132	280472	122901	124199
2009	136036	136036	195484	314688	283901	122292	122864
2010	134934	134934	193878	317823	286920	122306	122571
2011	134594	134594	192887	320529	289523	122496	122633
2012	134612	134612	192286	322828	291730	122691	122722
2013	134703	134703	191881	324700	293530	122792	122696
2014	134700	134700	191520	326138	294916	122746	122584
F	*Scenario 1*	*Scenario 2*	*Scenario 3*	*Scenario 4*	*Scenario 5*	*Scenario 6*	*Scenario 7*
2001	0.0093993	0.0093993	0.0093992	0.0093989	0.0093991	0.0093993	0.0093991
2002	0.278822	0.278822	0.139411	0.0289	0	0.344426	0.278822
2003	0.278822	0.278822	0.139411	0.0289	0	0.344426	0.278822
2004	0.278822	0.278822	0.139411	0.0289	0	0.344426	0.344426
2005	0.278822	0.278822	0.139411	0.0289	0	0.344426	0.344426
2006	0.278822	0.278822	0.139411	0.0289	0	0.339674	0.344426
2007	0.278822	0.278822	0.139411	0.0289	0	0.323226	0.331132
2008	0.27881	0.27881	0.139411	0.0289	0	0.317285	0.320088
2009	0.27647	0.27647	0.139411	0.0289	0	0.315214	0.315759
2010	0.273661	0.273661	0.139411	0.0289	0	0.314438	0.314279
2011	0.271731	0.271731	0.139411	0.0289	0	0.314148	0.314053
2012	0.270941	0.270941	0.139411	0.0289	0	0.31422	0.314192
2013	0.270641	0.270641	0.139411	0.0289	0	0.314366	0.31415
2014	0.270703	0.270703	0.139411	0.0289	0	0.31427	0.31397
Catch	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
2001	5355.53	5355.53	5355.48	5355.29	5355.45	5355.53	5355.44
2002	142764	142764	75607.5	16422.4	0	171736	142764
2003	115659	115659	68275.1	16195.9	0	132345	115659
2004	97850.1	97850.1	62866.3	16048.2	0	107945	117856
2005	86855.7	86855.7	59165	15995.8	0	93733.3	100015
2006	80368.2	80368.2	56752.3	16016.9	0	84799.1	89692.9
2007	76642.5	76642.5	55217.5	16079.9	0	77368.7	81058.9
2008	74486.1	74486.1	54227.1	16155.5	0	74865.1	76314.8
2009	72703.5	72703.5	53577.1	16228.7	0	74206.1	74728.8
2010	71504.6	71504.6	53161.1	16296.7	0	74185.3	74369.2
2011	70930.9	70930.9	52910.8	16360.2	0	74339.9	74435.4
2012	70797.1	70797.1	52760.5	16416.3	0	74526.7	74582.1
2013	70818.4	70818.4	52669.3	16463.4	0	74669	74589.7
2014	70869.4	70869.4	52591.4	16497.9	0	74647.7	74441.3

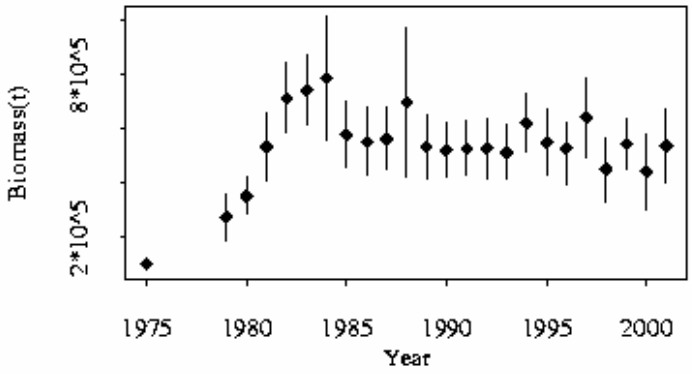


Figure 1. Estimated survey biomass and 95% CIs

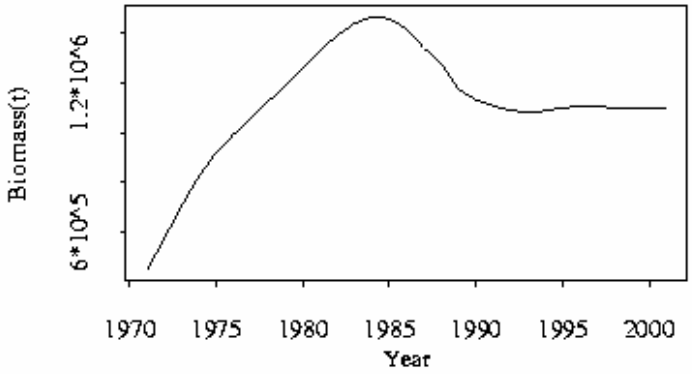


Figure 2. Estimated beginning year total biomass of Alaska plaice

Figure 3. Estimated survey and fishery selectivity

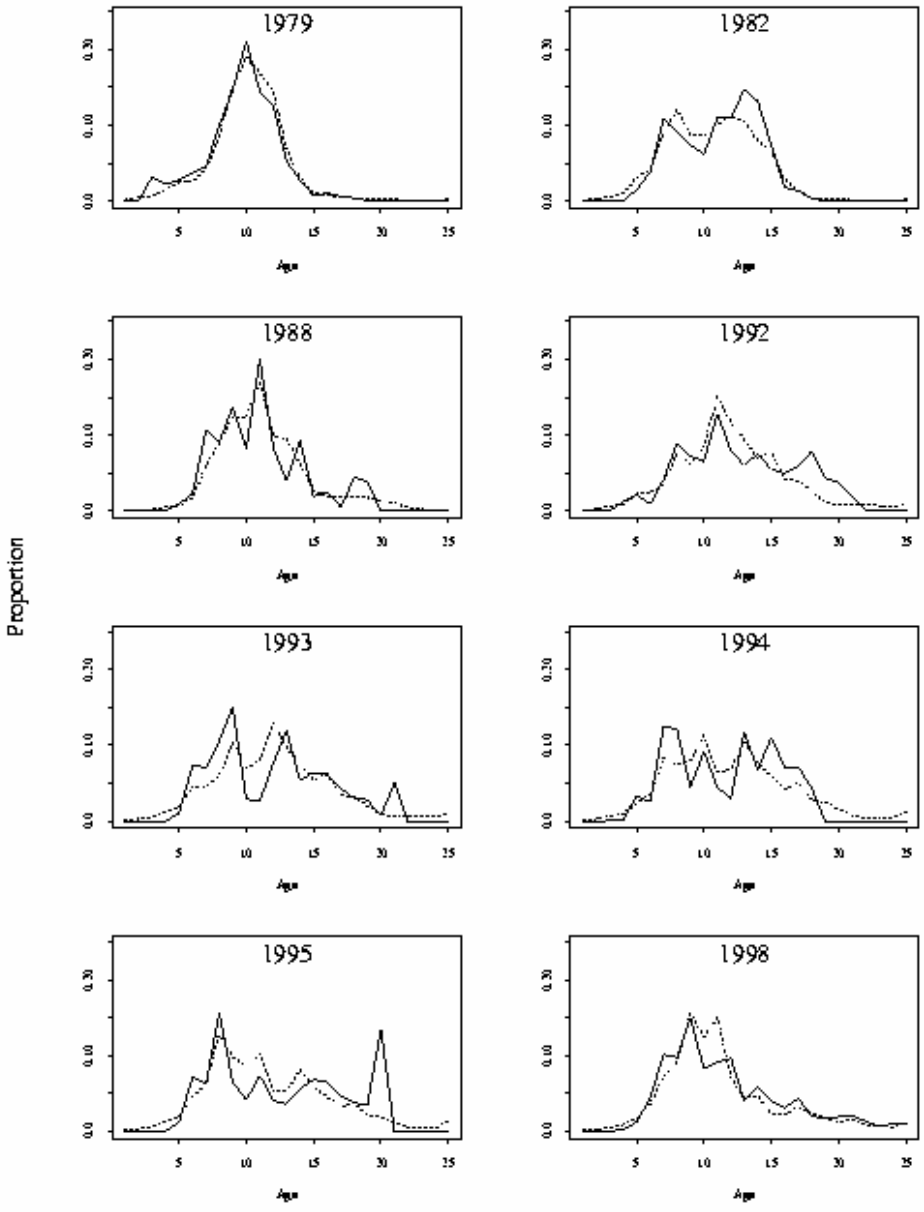


Figure 5. Survey age composition by year (solid line = observed, dotted line = predicted)

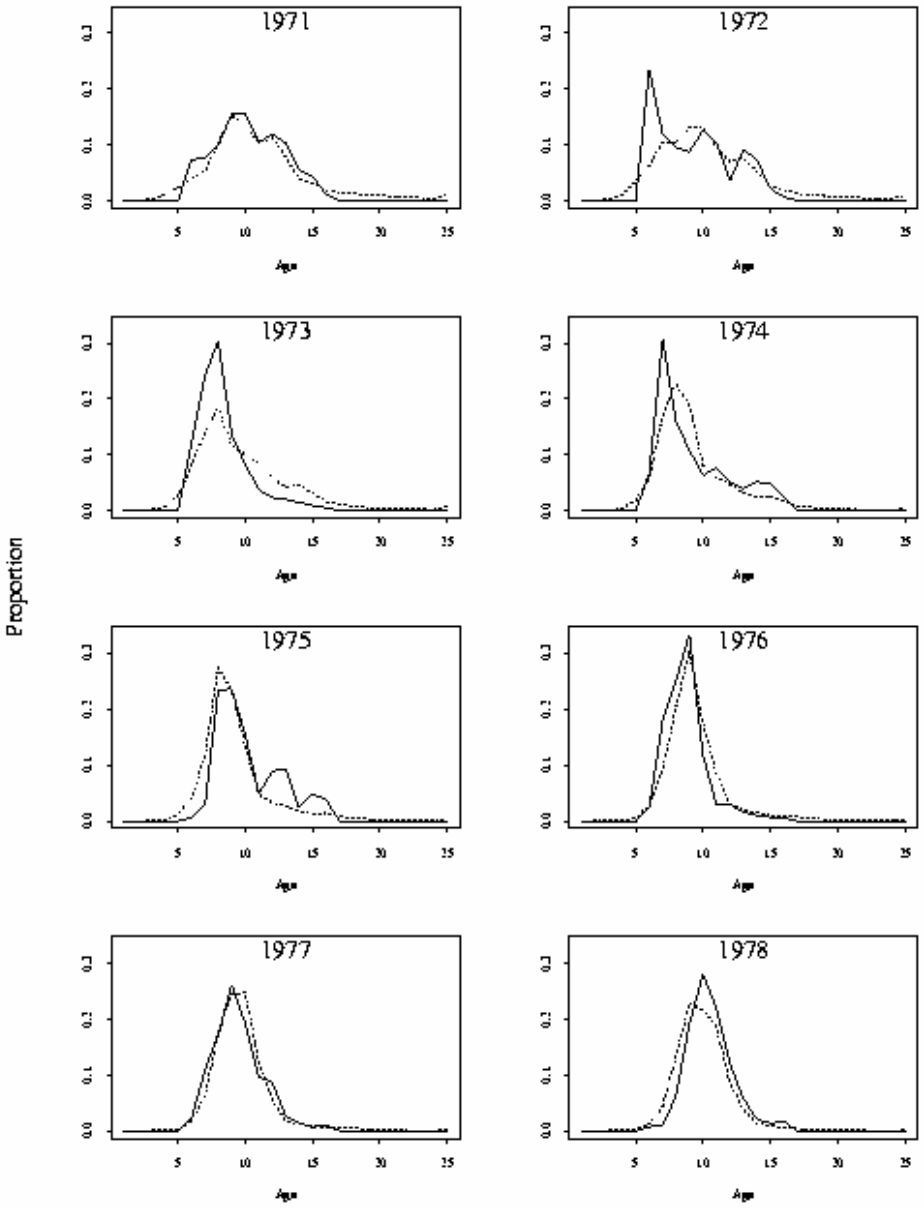


Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

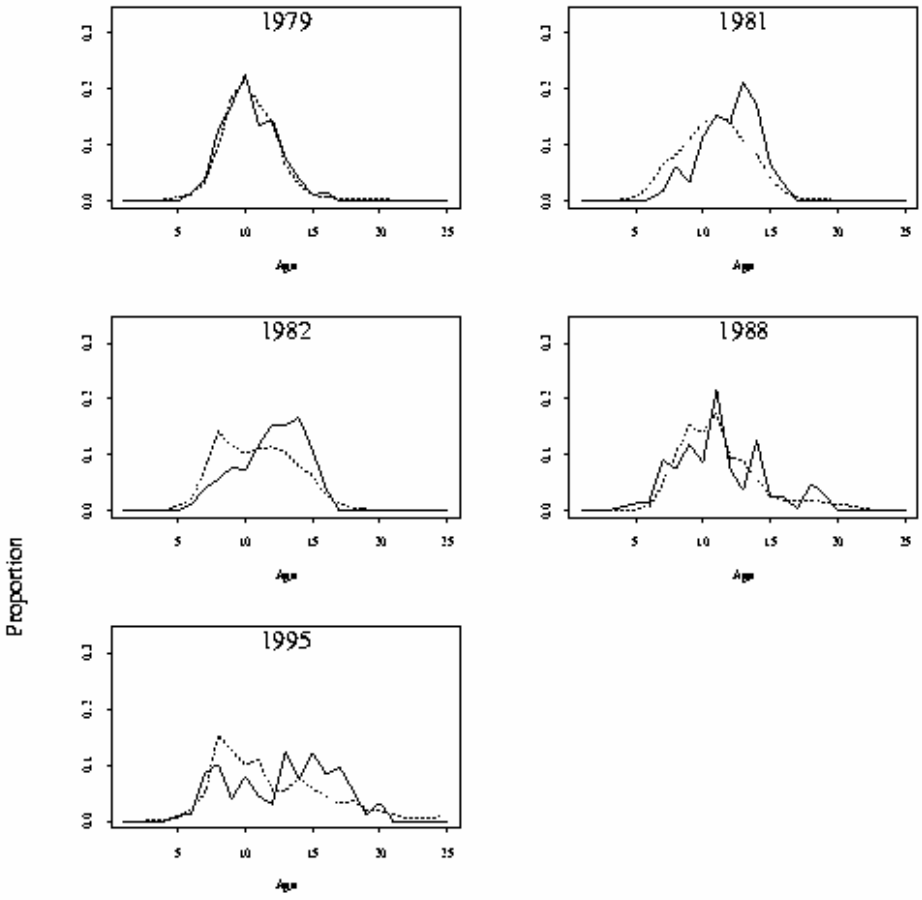


Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

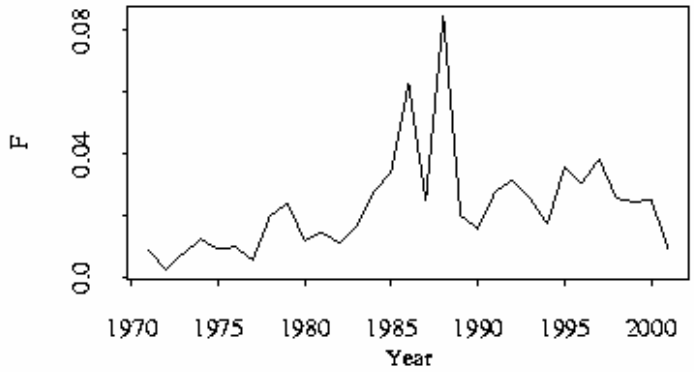


Figure 7. Estimated fully selected fishing mortality

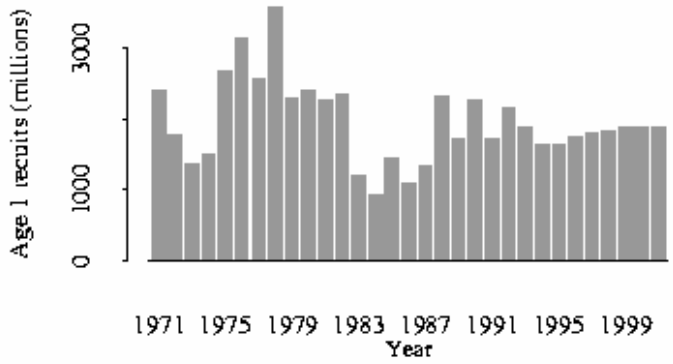


Figure 8. Estimated recruitment (age 1) of Alaska plaice

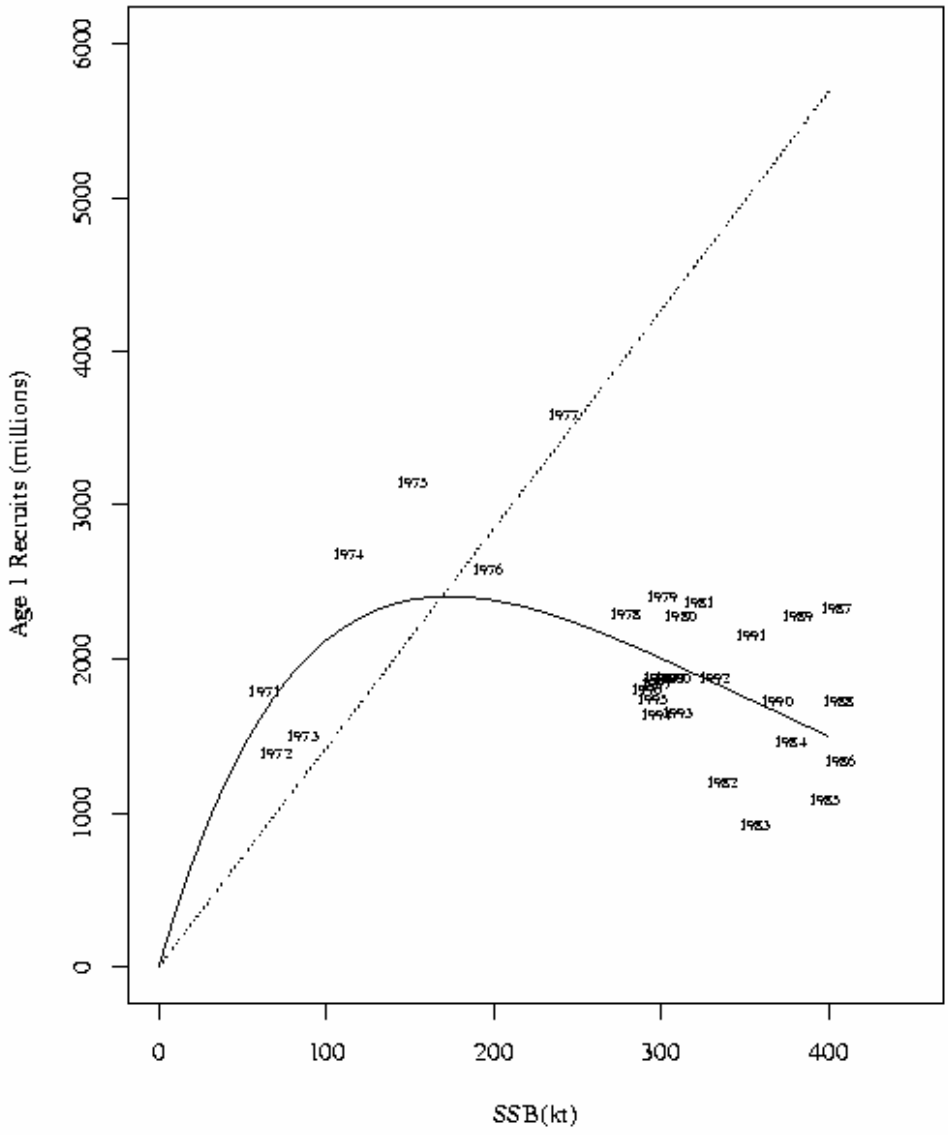
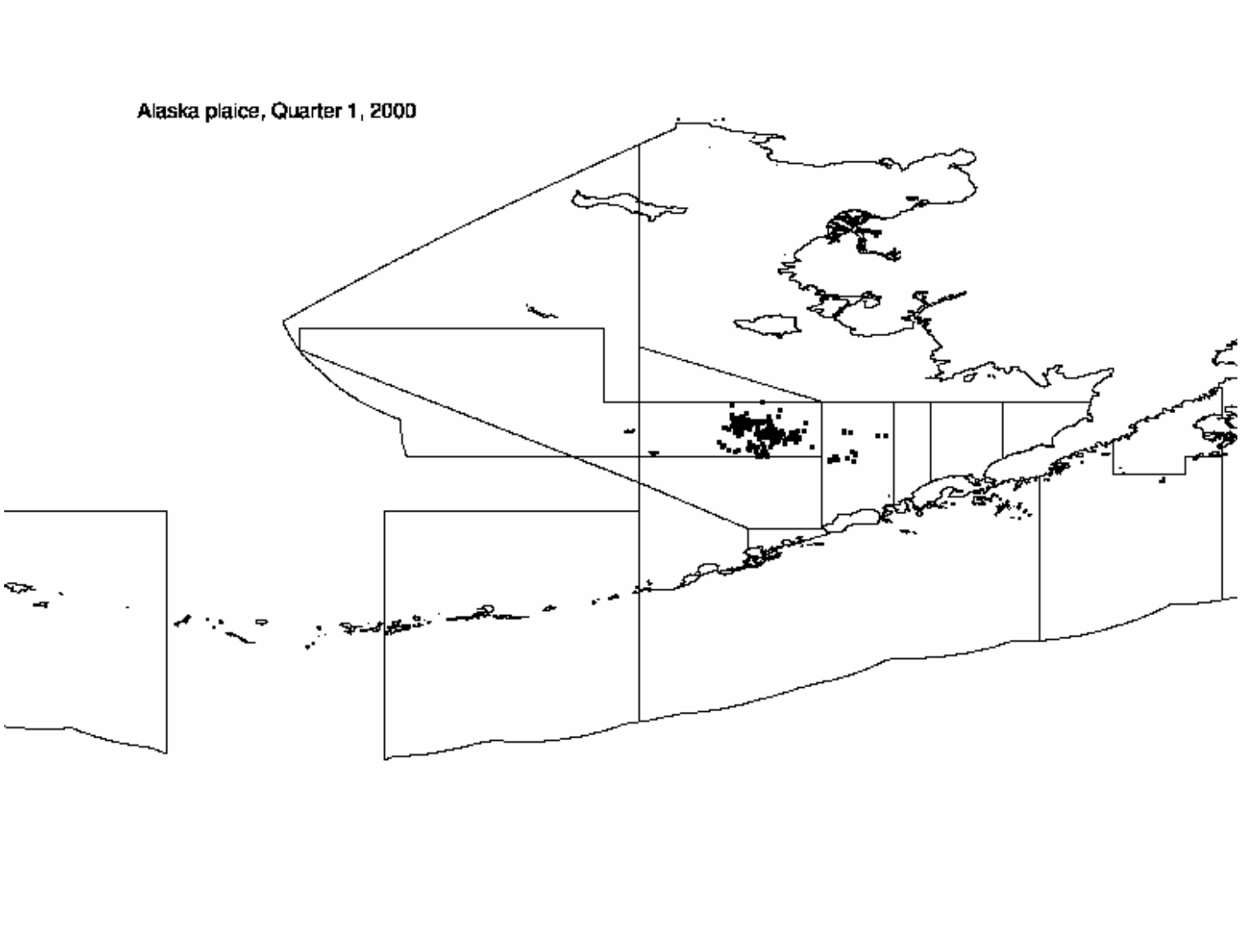
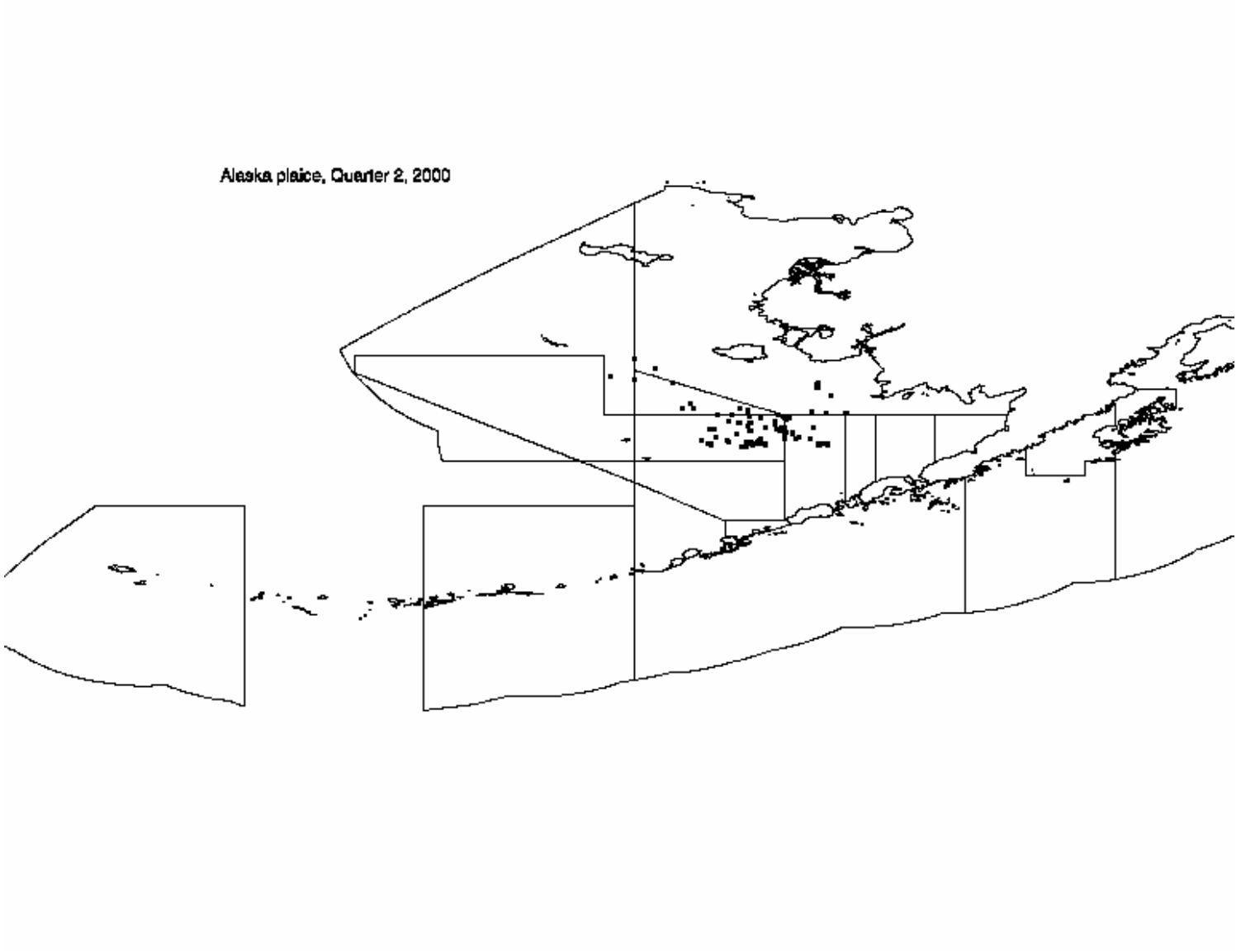


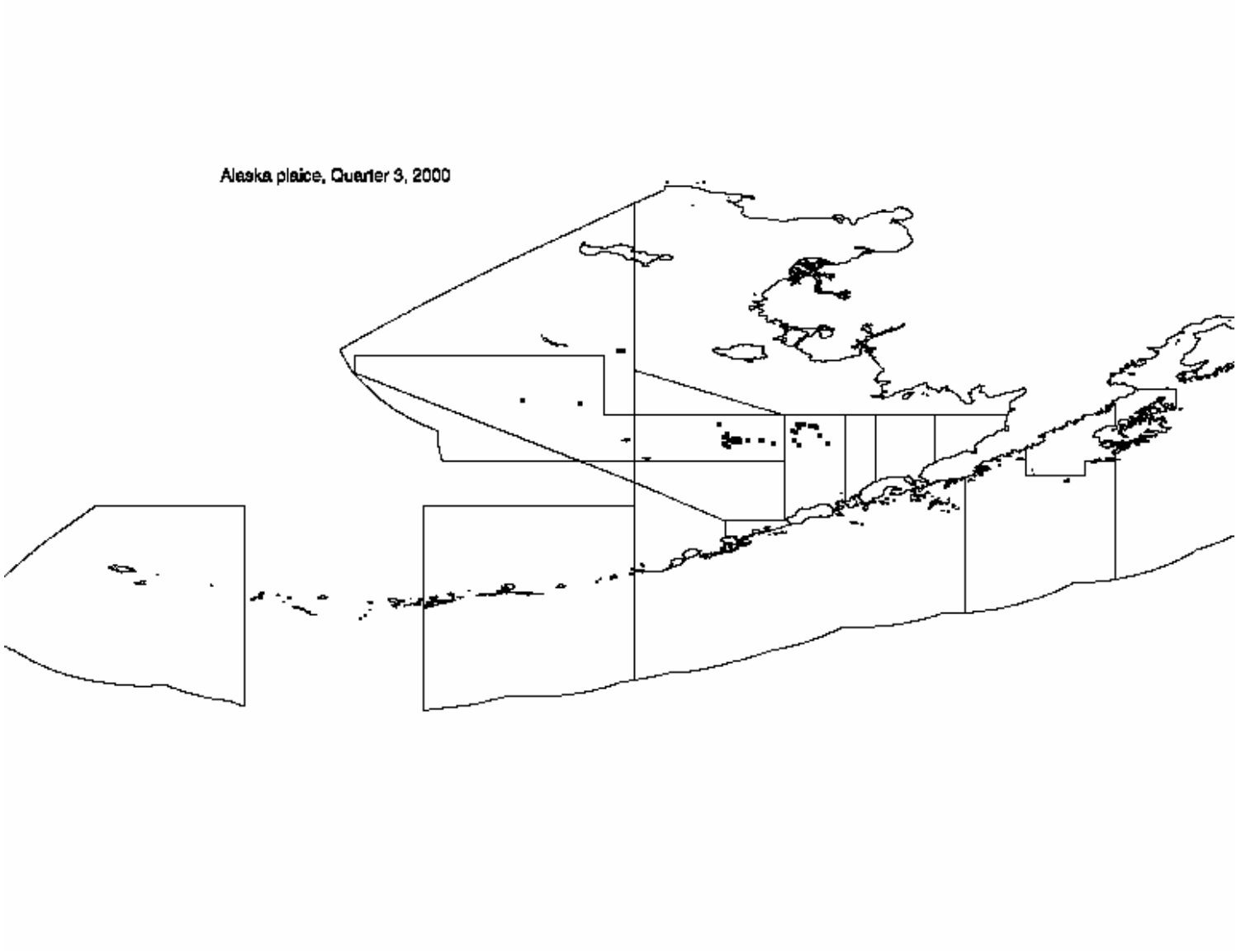
Figure 9. Estimated SSB and recruitment for Alaska plaice, with fitted Ricker curve (solid line); labels are spawning year. The replacement line (dashed line) is based upon an F40 value of 0.30

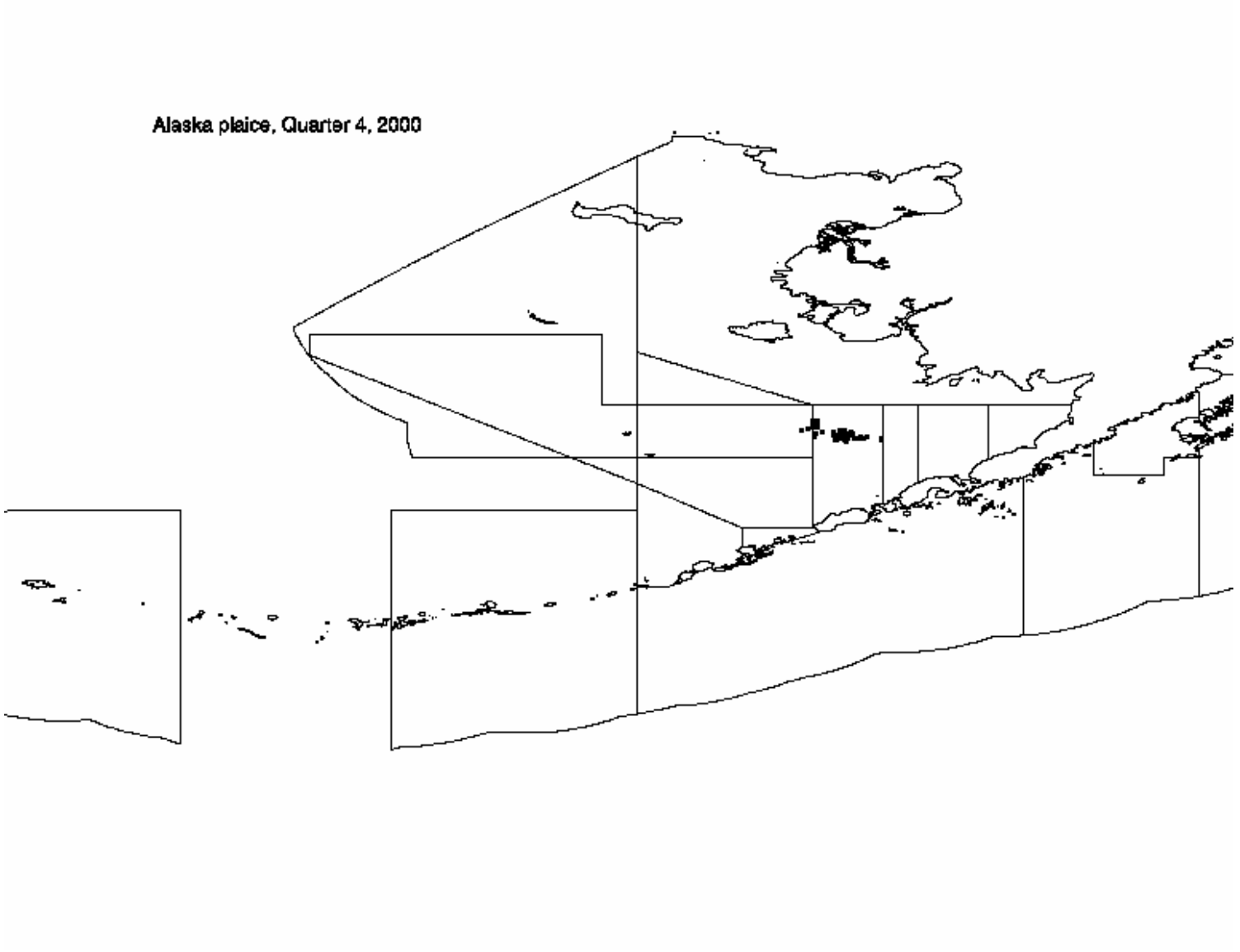
Appendix

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


Alaska plaice, Quarter 1, 2000


Alaska plaice, Quarter 2, 2000


Alaska plaice, Quarter 3, 2000


Alaska plaice, Quarter 4, 2000