Section 8

OTHER FLATFISH

by

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Executive Summary

The following changes have been made to this assessment relative to the November 1998 SAFE:

Changes in the input data

1) 1999 total catch and discards through 2 October, 1999; catch was partitioned among species according the proportions observed in the 1998 hauls sampled by NMFS observers.
2) 1999 trawl survey biomass estimate and standard error for Alaska plaice, and 1999 trawl survey biomass estimates of miscellaneous flatfish.
3) 1998 age composition of the survey abundance for Alaska plaice.
4) Estimate of the retained and discarded portions of the 1998 catch.

Changes to assessment methodology

1) Change in the implementation software for the Alaska plaice assessment from the stock synthesis model to the Stock Assessment Model (SAM), which was developed with AD Modelbuilder.
2) Use of $F_{35\%}$ as the overfishing fishing rate, in accordance with Amendment 56 of the fishery management plan for the groundfish fishery of the Bering Sea/Aleutian Islands.
3) Baranov's catch equation was used to estimate ABC and OFL for the miscellaneous species.

Model results (Alaska plaice)

1) Estimated 2+ total biomass for 1999 is 758,894 t.
2) Projected female spawning biomass for 2000 is 186,880 t.
4) Recommended ABC for 2000 is 101,9 13 t based on an $F_{40\%}$ (0.28) harvest level.
5) 1999 overfishing level is 122,659 t based on a $F_{35\%}$ (0.35) harvest level.

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

	1998 Assessment recommendations for the 1999 harvest	1999 Assessment recommendations for the 2000 harvest
Alaska plaice		
ABC	142,500 t	101,913 t
Overfishing	230,900 t	122,659 t
F_{ABC}	$F_{0.40} = 0.29$	$F_{0.40} = 0.28$
$F_{overfishing}$	$F_{0.30} = 0.47$	$F_{0.35} = 0.35$
"Miscellaneous" species		
Exploitable biomass (as estimated from NMFS groundfish survey)	73,900 t	69,730 t
ABC	11,800 t	15,506 t
Overfishing	17,000 t	18,772 t
F_{ABC}	$F_{0.40} = 0.16$	$F_{0.40} = 0.28$
$F_{overfishing}$	$F_{0.30} = 0.23$	$F_{0.35} = 0.35$

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 most dominant species of the complex and comprised 91% of the 1998 catch and 89% of the estimated 1999 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. At least 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 flaffish" 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 composed primary 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 199 1, 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 1998 of "other flatfish" hauls (defined as hauls where flatfish compose more than 50% of the catch biomass and where 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 1999, with the catch through 2 October totaling only 11% of the 1999 total allowable catch of 130,900 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 2 October, 1999 (Table 2), and estimates of number caught by age for the years 1971-79, 8 l-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 1979-1999 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 198 1 to 1982 was substantially higher than from the 198 1 survey 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 198 1 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. 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 1998 value of 452,600 t indicates a high level of biomass but is the lowest estimate in the past 18 years. The 1999 value of 546,522 t represents an increase of 20.8% from the 1998 level.

For the miscellaneous species of the other flatfish management category, individual species biomass from the 1997 Aleutian Islands and 1997-99 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 1999 estimate of 69,730 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, 197 l-99;
2) Proportional catch number at age, 197 l-79, 198 l-82, 1988, 1995;
3) Survey biomass and standard error 1975, 1979-99;
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.

An 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

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

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,,) and total biomass of catch each year were modeled as

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

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

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:

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

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 A4 = 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 A4 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 cat&ability was fixed at 1 .O.

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, andp 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:

$$\lambda_2 \sum (\ln(obs\_biom_t) - \ln(pred\_biom_t))^2$$

where obs_biom_t and $pred\_biom_t$ are the observed and predicted survey biomass at time t, and λ_2 is a weight relates to the inverse of the assumed variance of the observations. 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:

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

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

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

For the model run in this analysis, λ_1, λ_2, and λ_3 were assigned weights of 1,20, 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)	29
3) recruitment mean *(meanrec)*	1
4) recruitment deviations (ν)	29
5) initial year mean *(meaninit)*	1
6) initial year deviations (y)	24
7) fishery selectivity patterns	2
8) survey selectivity patterns	2
Total parameters	89

Model Results (Alaska plaice)

The model results show that estimated total Alaska plaice biomass (ages 2+) increased from a low of 389,683 t in 1971 to a peak of 1,244,520 tin 1984 (Figure 2, Table 9). Beginning in 1985, estimated total biomass has declined to 758,894 t in 1999. The estimated biomass over much of the time series is decreased somewhat from the 1998 assessment (Table 9). This decrease is explained by a slight increase in the estimated survey selectivity (Figure 3), which is associated with the use of new implementation software, AD Modelbuilder. For example, the estimated age of 50% selection in the survey was younger age relative to the 1998 assessment (8.68 yrs compared to 9.17 yrs), and the slope has also increased; thus, the selection at age has increased for most ages. The estimated survey biomass also shows a rapid increase to a peak biomass of 682,260 t in 1986, and a subsequent decline to 441,740 t in 1999 ('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 1971-1999 (Figure 1); the 1999 estimate is 0.036. Estimated age-2 recruitment has shown high levels from 1971-1983, averaging 1.58 x 10^9 (Figure 8, Table 9). From 1984-99, estimated recruitment has declined averaging 9.0 x 10^8, and recruitment for any year since 1983 has not exceeded the minimum level estimated during 1976-83. 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 500,000 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 $F_{0.40}$, $F_{0.35}$, and $SPR_{0.40}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from 1977-1998 year classes estimated in this assessment represents a reliable estimate of equilibrium recruitment, then an estimate of $B_{0.40}$ is calculated as the product of $SPR_{0.40}$ * equilibrium recruits, and this quantity is 99,958 t. The year 2000 spawning biomass is estimated as 186,880 t. Since reliable estimates of 2000 spawning biomass (B), $B_{0.40}$, $F_{0.40}$, and $F_{0.35}$ exist and $B>B_{0.40}$ (186,880 t > 99,958 t), Alaska plaice reference fishing mortality is defined in tier 3a of Amendment 56. For this tier, F_{ABC} is constrained to be ≤ $F_{0.40}$, and F_{OFL} is defined as $F_{0.35}$. The values of these quantities are

2000 SSB estimate (B)	=	186,880 t
$B_{0.40}$	=	99,958 t
$F_{0.40}$	=	0.280
F_{ABC}	≤	0.280
$F_{0.35}$	=	0.346
F_{OFL}	=	0.346

The estimated catch level for year 2000 associated with the overfishing level of F = 0.346 is 122,659 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 0.280 is 101,913 t.

This year, 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 1999 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2000 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 1999. 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 2000, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

Scenario I: 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 2000 recommended in the assessment to the *max* F_{ABC} for 2000. (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 1994- 1998 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 Tables 10 and 11, respectively. The projections of future harvest levels have small confidence intervals due to small fishery selectivity values for ages 2-5. In contrast, the confidence intervals on projected biomass levels are zero because the proportion mature at ages 1-5 is zero.

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 (1999) flathead sole assessment to the 1999 survey biomass of miscellaneous flatfish (69,730 t). The 1999 estimates of F_{40} and F_{35} for flathead sole are 0.280 and 0.351, respectively. Note that these fishing mortality rates differ from the F_{40} and F_{30} values used in the 1998 other flatfish assessment, which were the 1997 estimates for F_{40} and F_{30} for flathead sole. The estimates of flathead sole reference fishing moralities increased substantially in the 1998 assessment and are comparable to the estimates in the 1999 flathead sole assessment. The ABS 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 2000
$F_{ABC}/2$ (0.14)	8,276 t
F_{ABC} (0.28)	15,506 t
F_{OFL} (0.35)	18,772 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 ½ of its MSY level in 2000 and above its MSY level in 20 10 under this scenario, then the stock is not overfished.)

Scenario 7: *In 2000* and 200 1, 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 20 12 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 2000 of scenario 6 is 2.1 times its $B_{35\%}$ value of 87,463 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 20 12 of scenario 7 is 1.05 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 -1998 in Table 12.

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 2000 Spawning stock biomass	186,880 t
F_{OFL}	0.346
Maximum F_{ABC}	0.280
Recommended F_{ABC}	0.280
OFL	122,659 t
Recommended ABC	101.913 t

References

Kappenman, R. F. 1992. Estimation of the fishing power correction factor. Processed Report 92-01, 10 p. Alaska Fish. Sci. Center, Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle, WA 98115.

Methot, R D. 1990. Synthesis model: An adaptable framework for analysis of diverse stock assessment data. INPFC Bull. 50:259-277. Symposium on application of stock assessment techniques to Gadoids.

Walters, G. E., and T. K. Wilderbuer. 1990. Other flatfish. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Bering Sea/Aleutian Islands Region as Projected for 1991, p.129-141. North Pacific Fishery Management Council, P.O. Box 103136, Anchorage Alaska 995 10.

Wilderbuer, T. K., and G. E. Walters. 1997. Other flatfish. In Stock Assessment and Fishery Evaluation Document for Groundfish Resources in the Bering Sea/Aleutian Islands Region as Projected for 1998, p.271-296. North Pacific Fishery Management Council, P.O. Box 103 136, Anchorage Alaska 995 10.

Zhang, C. I. 1987. Biology and population dynamics of Alaska plaice, Pleuronectes auadrituberculatus, in the eastern Bering Sea. Ph. D. dissertation, University of Washington: l-225.

Zhang, C. I., T.K. Wilderbuer, and G.E. Walters. 1998. Biological characteristics and fishery assessment of ***Alaska*** plaice, ***Pleuronectes quadrituberculatus***, in the Eastern Bering Sea. Marine Fisheries Review 60(4), 16-27.

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 198 1 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	*Lyopse tta exilis*	1 identified from the 1980 shelf survey
starry flounder	*Platichthys stellatus*	common
Sakhalin sole	*Pieuronectes sakhalinensis*	identified in observer samples

Table 2. Harvest (t) of Alaska plaice and other flatfish from 1977-1999

		Miscellaneous Flaffish					
Year	Alaska Plaice	starry Founder	Rex Sole	Butter Sole	Other Flaffish	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	2023 1
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*	13476						14785

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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, 5 12, and 5 16, whereas zone 2 consists of areas 5 13, 5 17, 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

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	2023 1	8466	11765	41.8
1996	18579	5902	12677	31.8
1997	22872	6114	16758	26.7
1998	15367	3464	11903	22.5
1999*	14785	2255	12530	15.2

*NMFS regional office report through October 2, 1999

Table 5. Alaska plaice numbers at age (millions) in the fishery, as estimated by total catch biomass, mean weight at age, and proportion at age (from NMFS observers).

	Age																			
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	IS	16	17	18	19	20
71	0.00	000	0.00	000	0.00	005	0.05	0.06	0.10	0 IO	007	0.08	007	0.04	003	001	0.00	0.00	000	0 00
72	000	0.00	0.00	0.00	000	064	032	0.26	0.24	0.34	028	0.10	0.25	020	006	002	000	0.00	000	0.00
73	0.00	0.00	0.00	0.00	0.00	0.79	1.58	2.00	0.90	0.55	02s	016	0 14	0 IO	006	004	000	000	000	0.00
74	000	0.00	0.00	000	0.00	039	1.78	093	0.63	037	045	030	0.23	031	028	0.14	0.00	0.00	0.00	000
75	000	0.00	0.00	0.00	0.00	0.05	0.21	1.68	170	1.10	0.36	0.64	0.68	0.17	0.36	0.27	0.00	0.00	0.00	0.00
76	000	000	0.00	0.00	0.W	0.15	1.17	1.62	2.16	076	0.19	0 19	0.10	007	0.05	004	0.00	0.00	000	000
77	000	000	000	0.00	0.00	0 50	1.54	3.99	6.05	44s	2.24	2.00	0.62	033	0.15	025	0.00	000	000	0.00
78	000	0.00	0.00	000	0.00	0.20	025	1.60	4.97	7.25	5.68	3.11	153	0.54	036	045	0.00	0.00	0.00	0.00
79	000	0.00	0.00	0.00	0.00	0.20	0.52	1.70	2.31	3.03	1.81	194	1.03	0.54	014	021	000	0.00	0.00	0.00
81	0.00	000	0.00	0.00	0.00	003	0 19	067	0.35	1.24	1.66	1.51	230	1.86	072	033	0.00	000	0.00	0.00
82	000	000	0.00	000	0.00	021	071	096	1.36	1 28	204	2.69	264	291	1.88	0 70	0.00	0.00	000	0.00
88	0.00	0.00	0.03	0.18	0.36	0.41	2.31	1.90	3.02	2.21	546	192	0.93	3 17	0.63	0.63	0.10	1.23	0 80	0.00
95	0.00	0.00	000	0.00	0.25	031	2.11	253	0.97	1.99	1 10	074	3 08	1.84	3.01	208	239	1.34	025	0 81

Table 6. Estimated biomass (t) of Alaska plaice and other flaffish 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.	0	9,500	9,500
1998	EBS	452,600	73,947	526,543
1999	EBS	546.522	69.730	616.252

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	9752	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						
Survev	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	--

Table 9. Estimated total biomass (ages l+), female spawner biomass, and recruitment (age 2), with comparison to the 1998 SAFE estimates.

	Female Spawner Biomass (t)		Total Biomass (t)		Recruitment (Millions)	
	Assessment		Assessment		Assessment	
Year	1999	1998	1999	1998	1999	1998
71	49597	49747	389693	459908	1979	2556
72	56197	56684	505549	607400	1510	2056
73	71606	72800	624075	761676	1112	1427
74	97030	100057	727311	897858	805	858
75	133535	140950	804681	1001091	858	1178
76	174462	187989	859652	1076715	1617	2279
77	214787	236162	903586	1135786	2024	1837
78	245767	273039	949254	1186338	1773	1701
79	261951	294206	996293	1230781	2579	2954
80	266636	303660	1050720	1278360	1599	1866
81	271378	309429	1114740	1335311	1647	2011
82	278468	315635	1171410	1388188	1529	1885
83	293382	324718	1218630	1434928	1555	1879
84	311388	336245	1244520	1461941	716	846
85	330160	348185	1237750	1453593	508	567
86	340168	351851	1200400	1411511	845	1090
87	339053	355523	1122290	1328984	590	788
88	340904	351388	1061700	1262328	742	919
89	317193	336747	956945	1150256	1365	2107
90	306139	327013	910968	1108052	986	1336
91	291002	310956	879021	1084004	1341	1510
92	268762	288958	851302	1059515	938	364
93	246860	269166	832663	1025955	1271	57
94	232151	257362	826696	978921	1051	55
95	226530	253689	828165	912143	747	52
96	220164	249492	816534	823586	656	52
97	220945	245636	801690	728333	767	48
98	218897	230717	777400	627557	886	331
99	**221612**		**758894**		**969**	

Table 10. Projections of future catch (t) under various harvest rates.

F level	Year 2000	2001	2002	2003	2004
F_{35} (F=0.346)	122,659	94,293	73,333	55,469	45,647
90% CI	(122,659 – 122,659)	(94,293 - 94,293)	(73,331 - 73,336)	(55,456 - 55,489)	(45,575 -45,753)
F_{40} (F=0.280)	101,913	82,465	66,877	55,968	47,407
90% CI	(101,913 - 101,913)	(82,464 - 82,465)	(66,876-66,880)	(55,956 - 55,986)	(47,341 - 47,505)
$F_{40}/2$(F=0.140)	53,955	48,765	43,475	39,042	36,185
90% CI	(53,955 - 53,955)	(48,765 -48,765)	(43,474-43,762)	(39,036 - 39,051)	(36,151 - 36,237)
Recent F level (F=0.0394)	15,847	15,532	14,889	14,196	13,727
90% CI	(15.847 - 15.847)	(15.532 - 15,532)	(14,889 - 14.889)	(14,194 - 14,198)	(13.717 - 13,742)

Table 11. Projections of future spawning biomass (t) under various harvest rates. Confidence intervals (not shown) are zero for these five-year projections because the proportion mature at ages l-5 is zero.

	Year				
F level	2000	2001	2002	2003	2004
F_{35} (F=0.346)	183,342	140,999	110,826	92,299	84,099
F_{40} (F=0.280)	186,880	151,202	123,823	105,098	94,702
$F_{40}/2$ (F=O. 140)	194,623	175,715	157,962	143,595	133,880
Recent F level (F=0.0394)	200,398	196,071	189,381	182,618	177,617
F = O	202.7 11	204.755	203.619	201.344	199.747

Table 12. Research catches (t) of Alaska plaice in the BSAI area from 1979 to 1998

Year	Research Catch (t)
1979	17.15
1980	12.02
1981	14.3 1
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

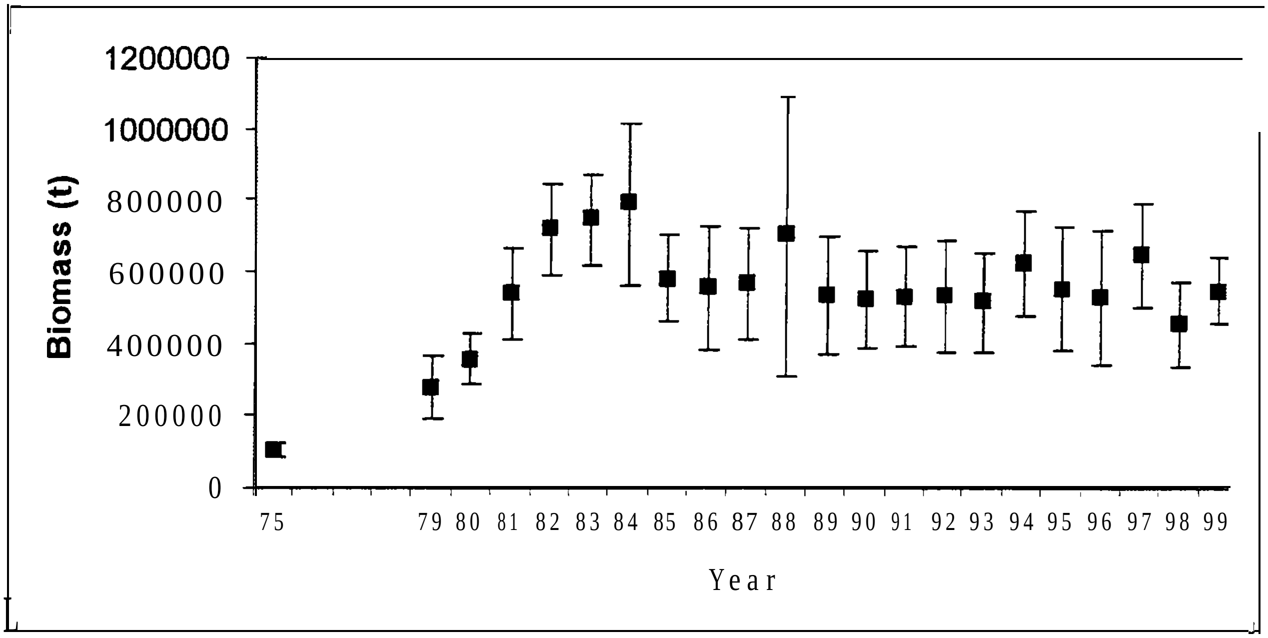


Figure 1. Estimated survey biomass (and 95% confidence intervals) of Alaska plaice)

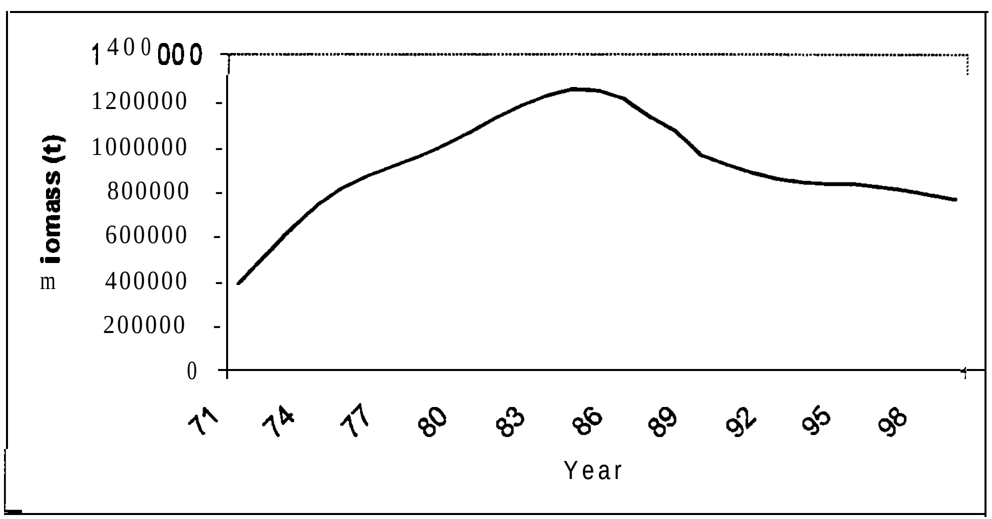
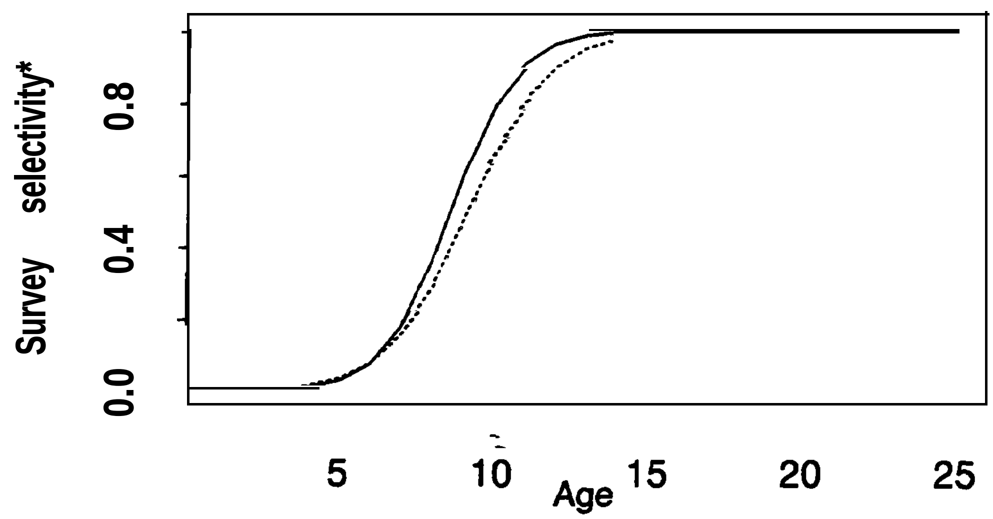


Figure 2. Estimated beginning year total biomass of Alaska Plaice



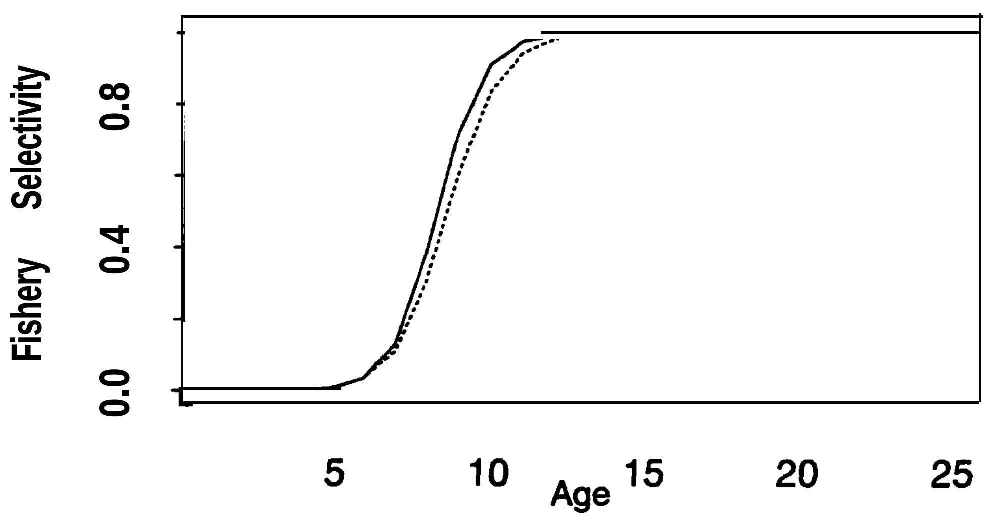


Figure 3. Estimated survey and fishery selectivity for the 1999 (solid line) and 1998 (dotted) assessments

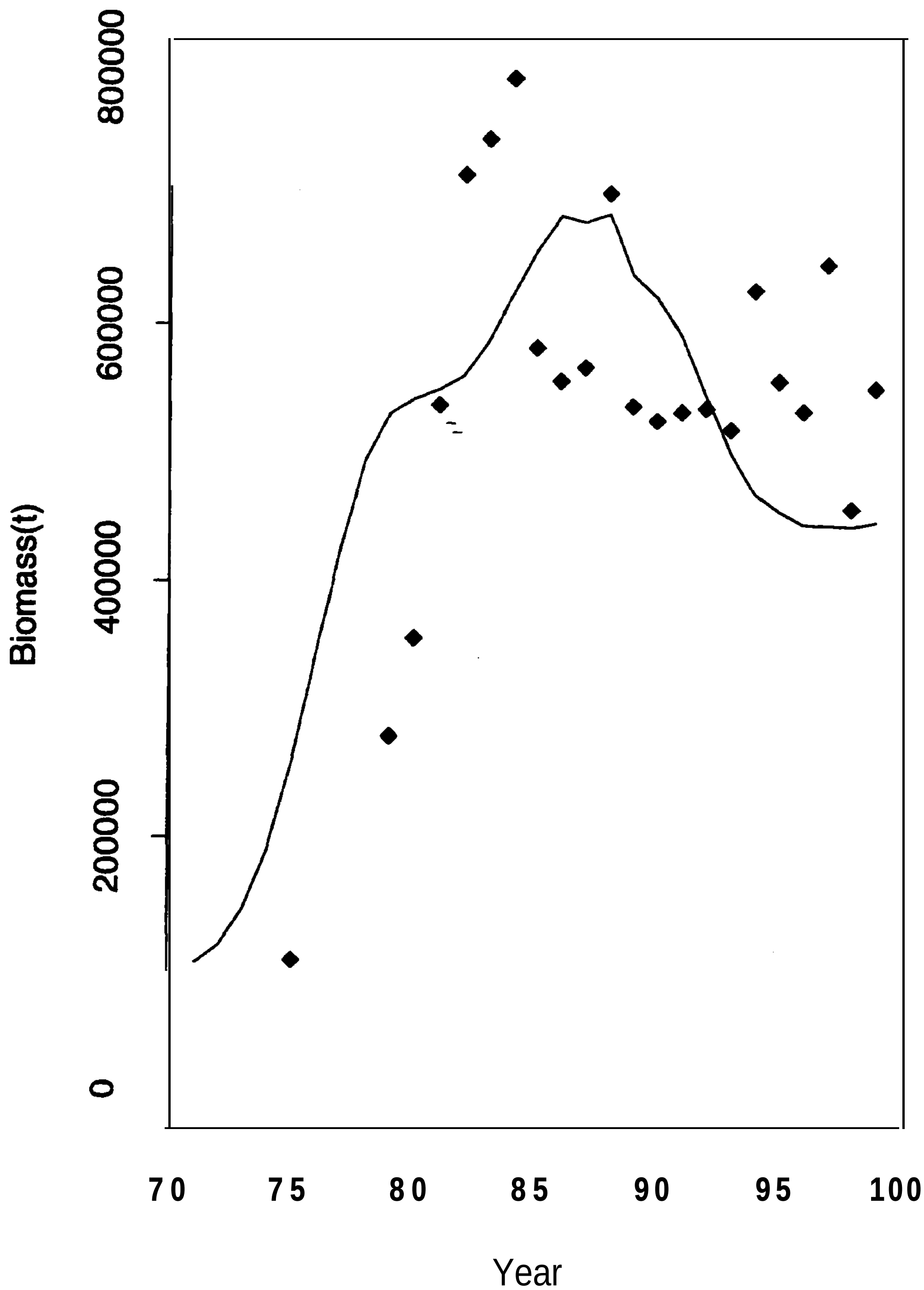


Figure 4. Observed (data points) and predicted (solid line) survey biomass of Alaska plaice

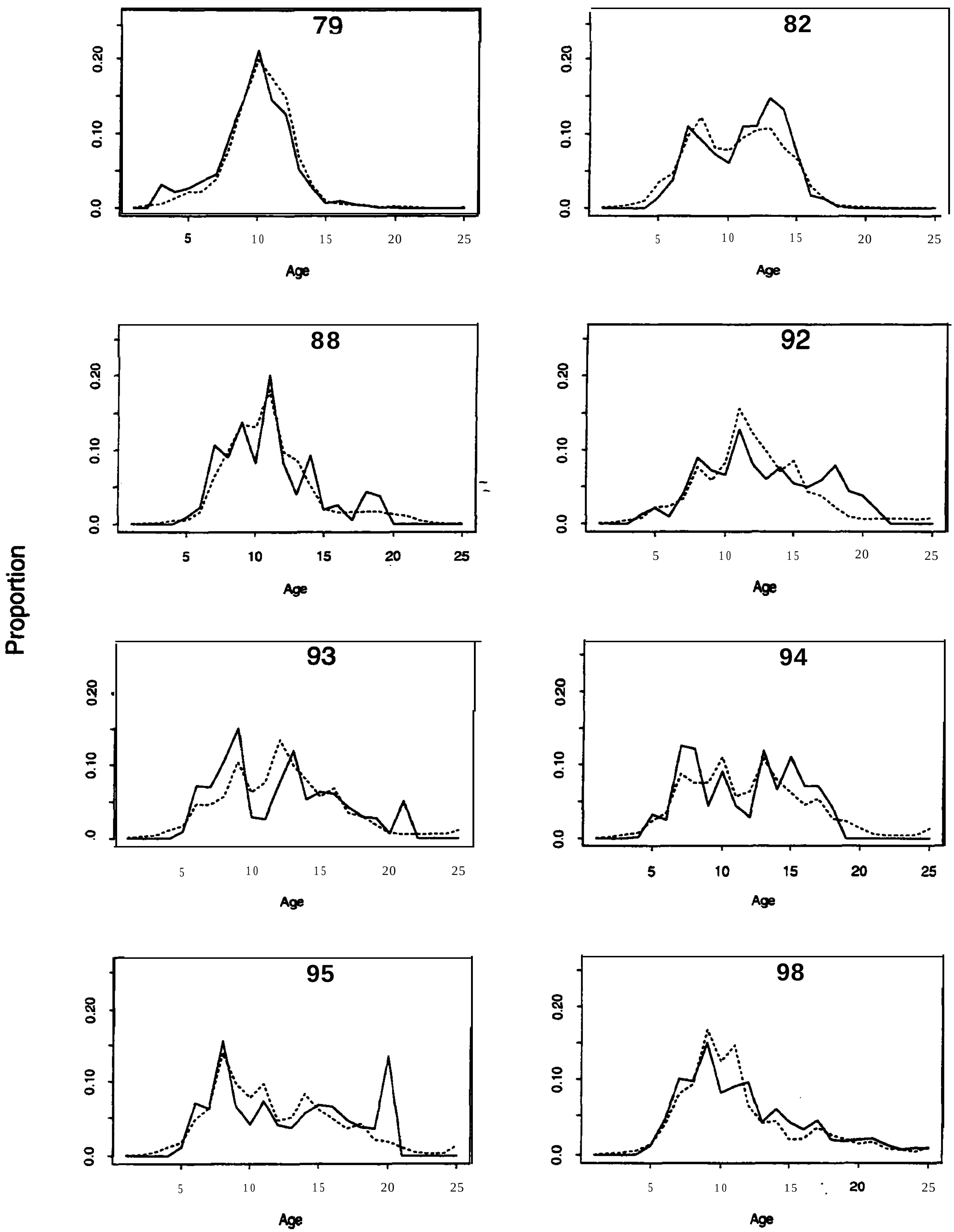


Figure 5. Survey age composition by year (solid line = observed, dotted line = predicted)

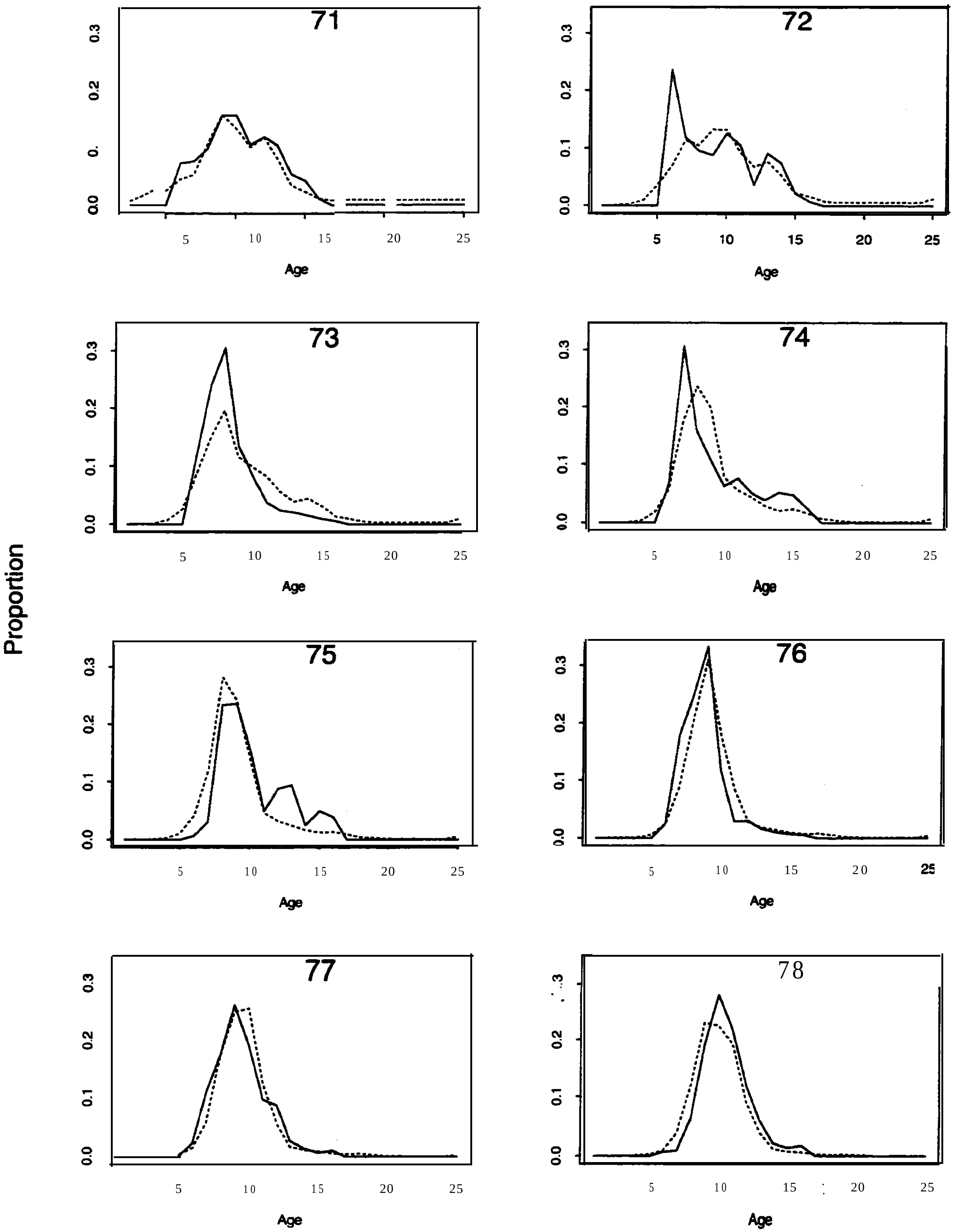


Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

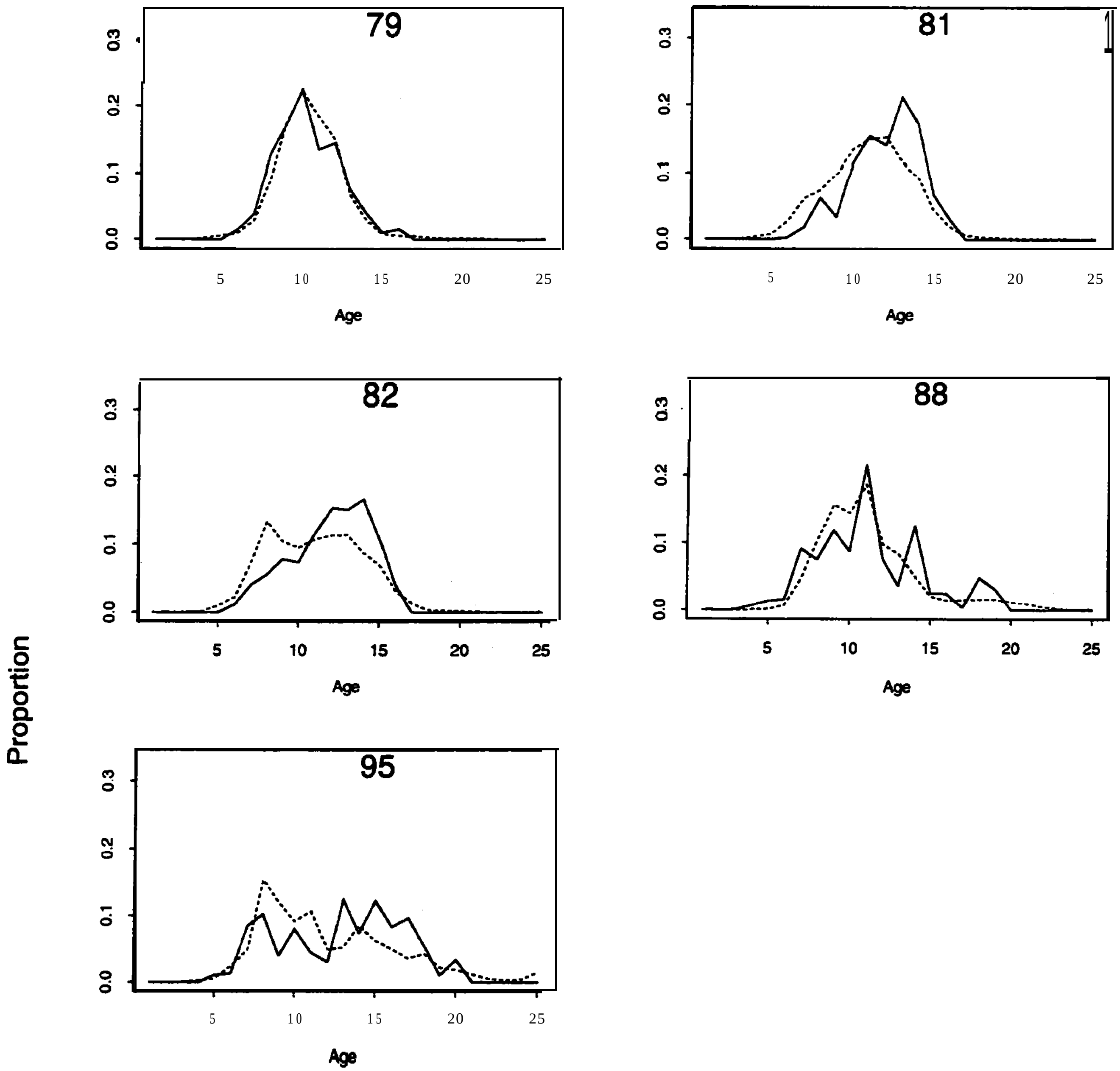


Figure 6. Fishery age composition by year (solid line = observed, dotted line = predicted)

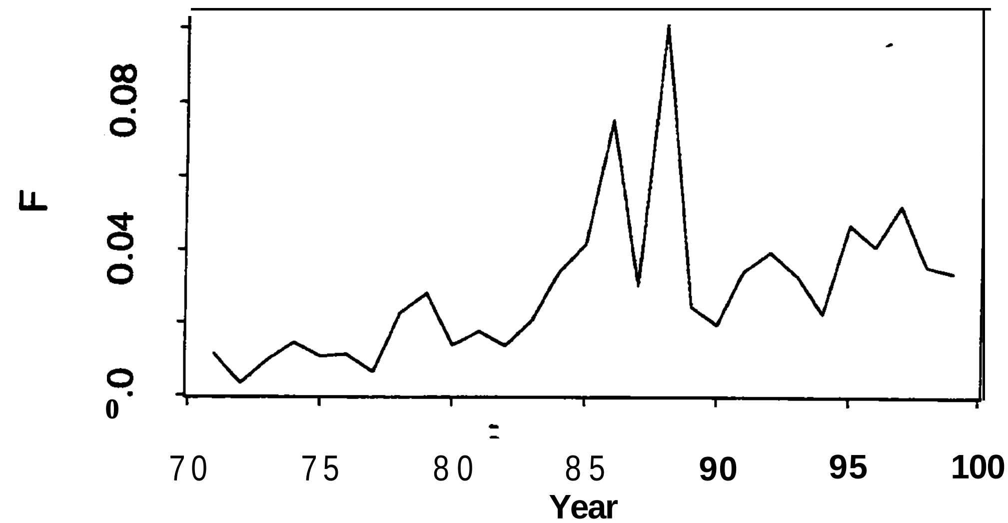


Figure 7. Estimated fully selected fishing mortality

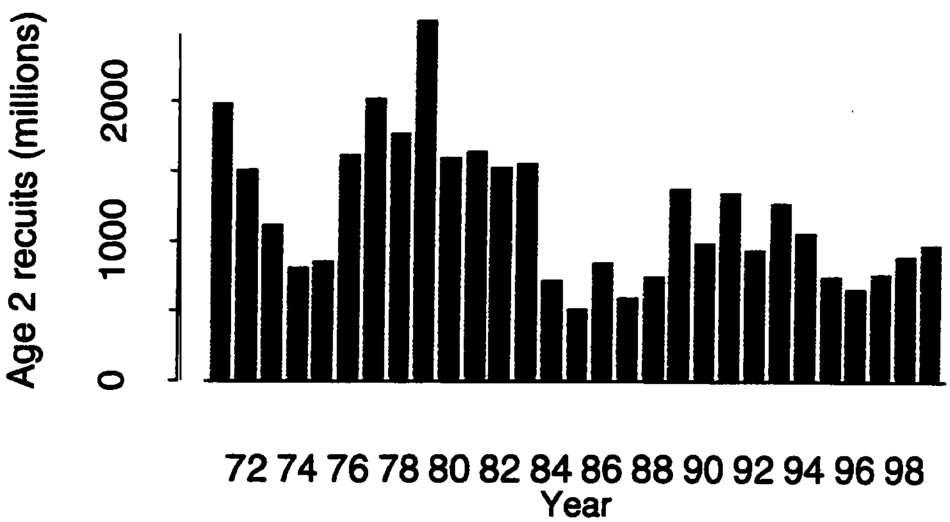


Figure 8. Estimated recruitment (age 2) of Alaska plaice

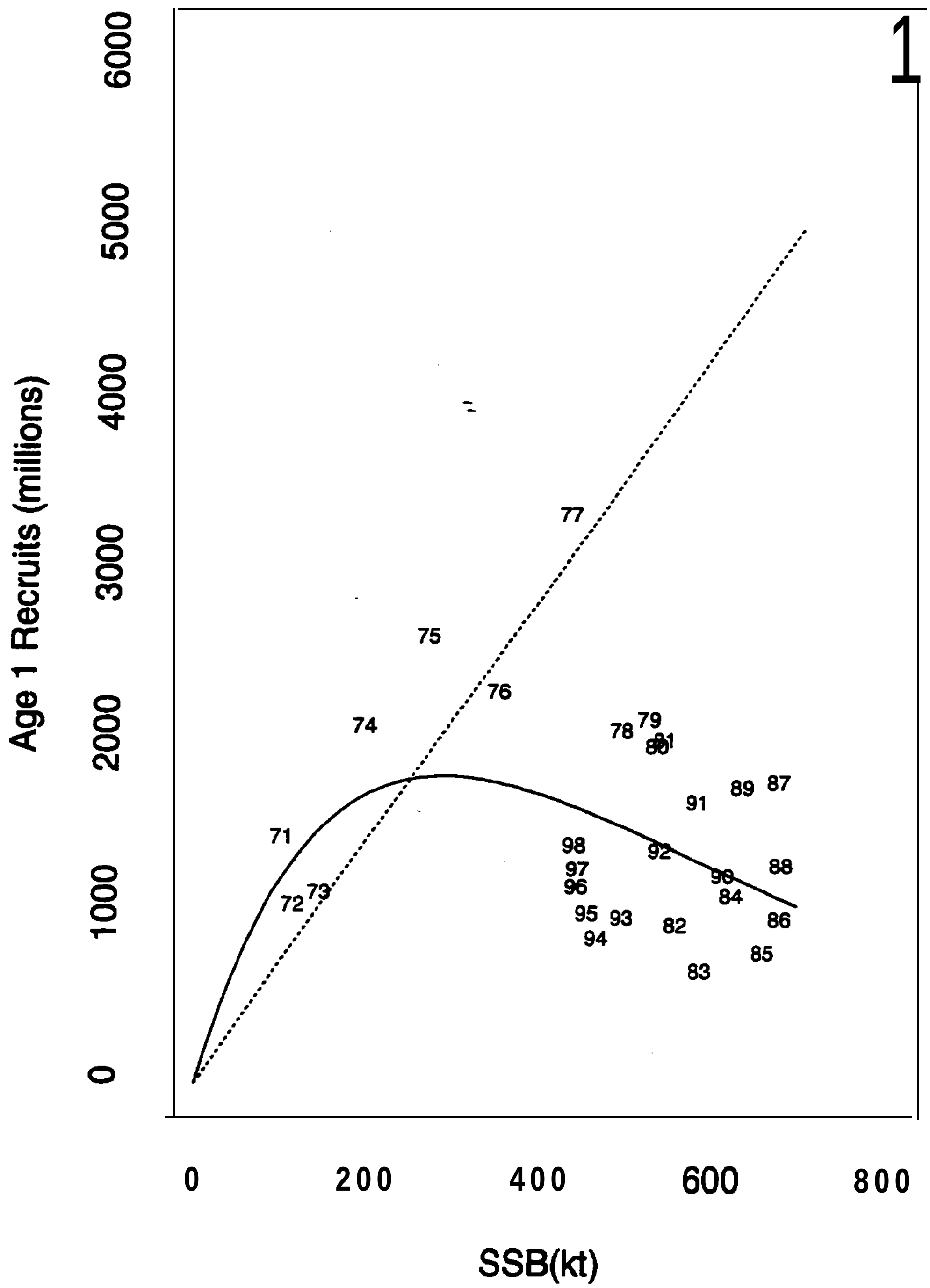


Figure 9. Estimated SSB and recruitment for Alaska plaice, with fitted Ricker curve (solid line); labels are spawning year. The replacement line (dashed line) is based upon an F40 value of 0.28

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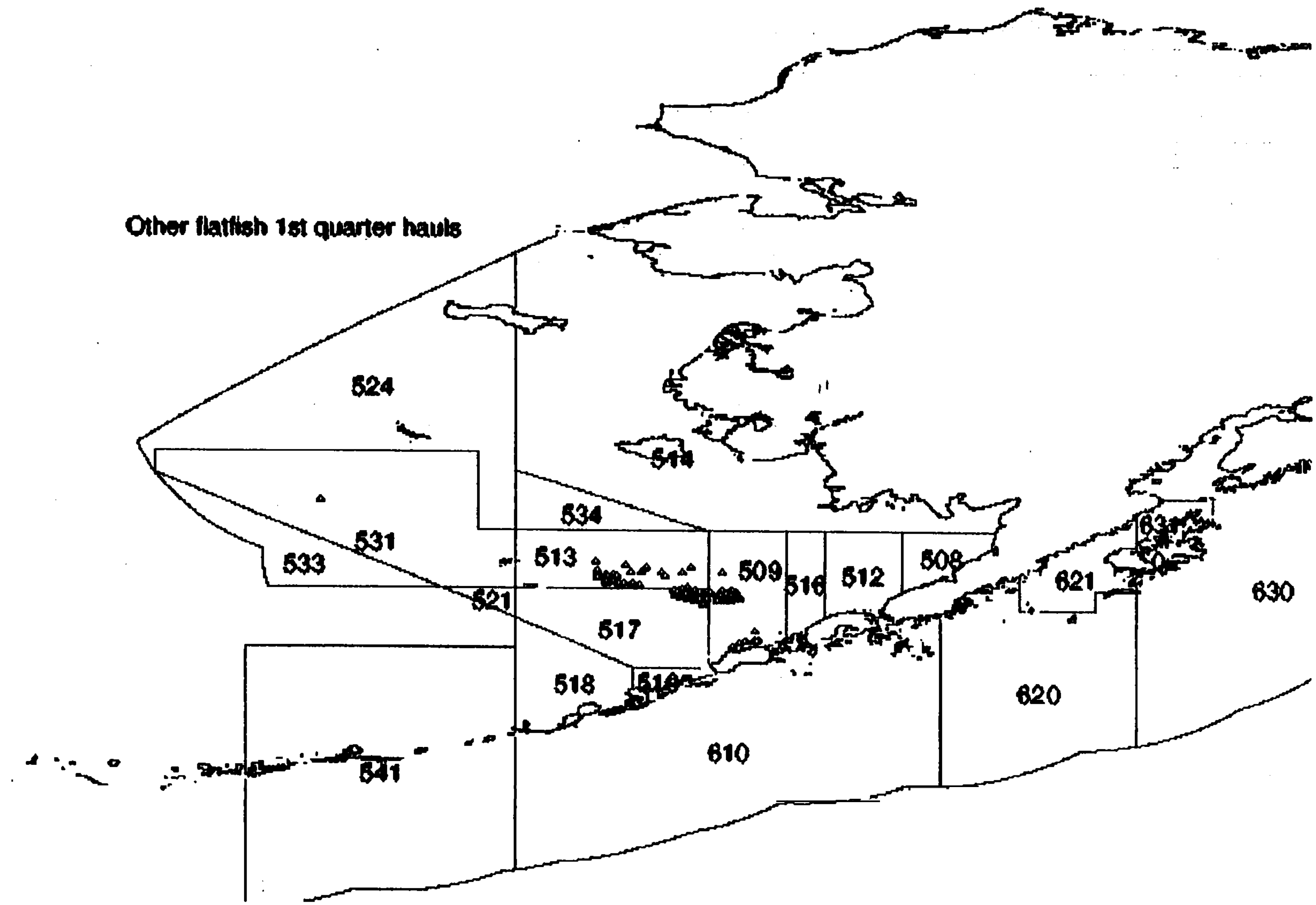
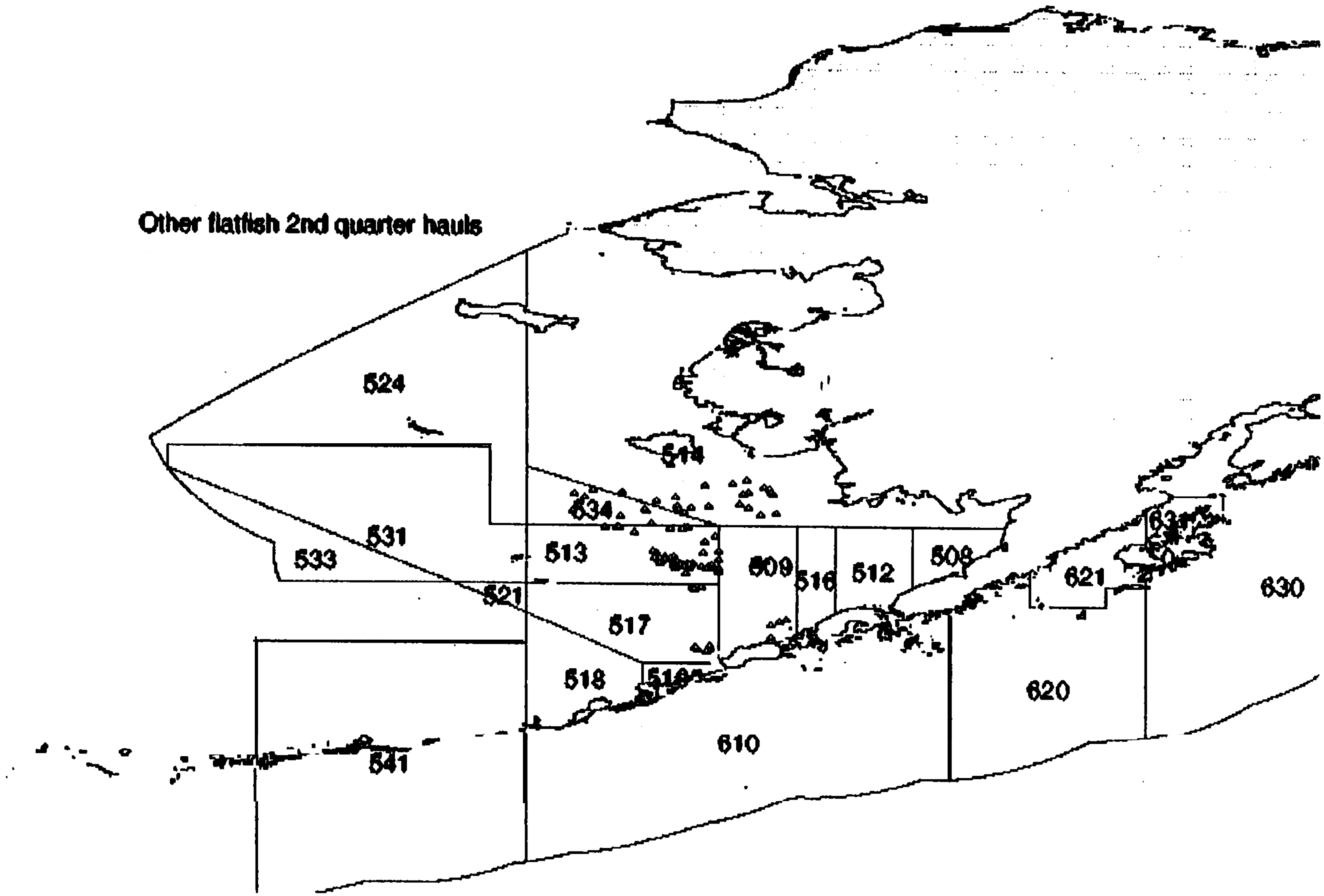
Appendix

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 other flatfish comprise greater than 50% of the catch and are the largest flatfish group in the catch

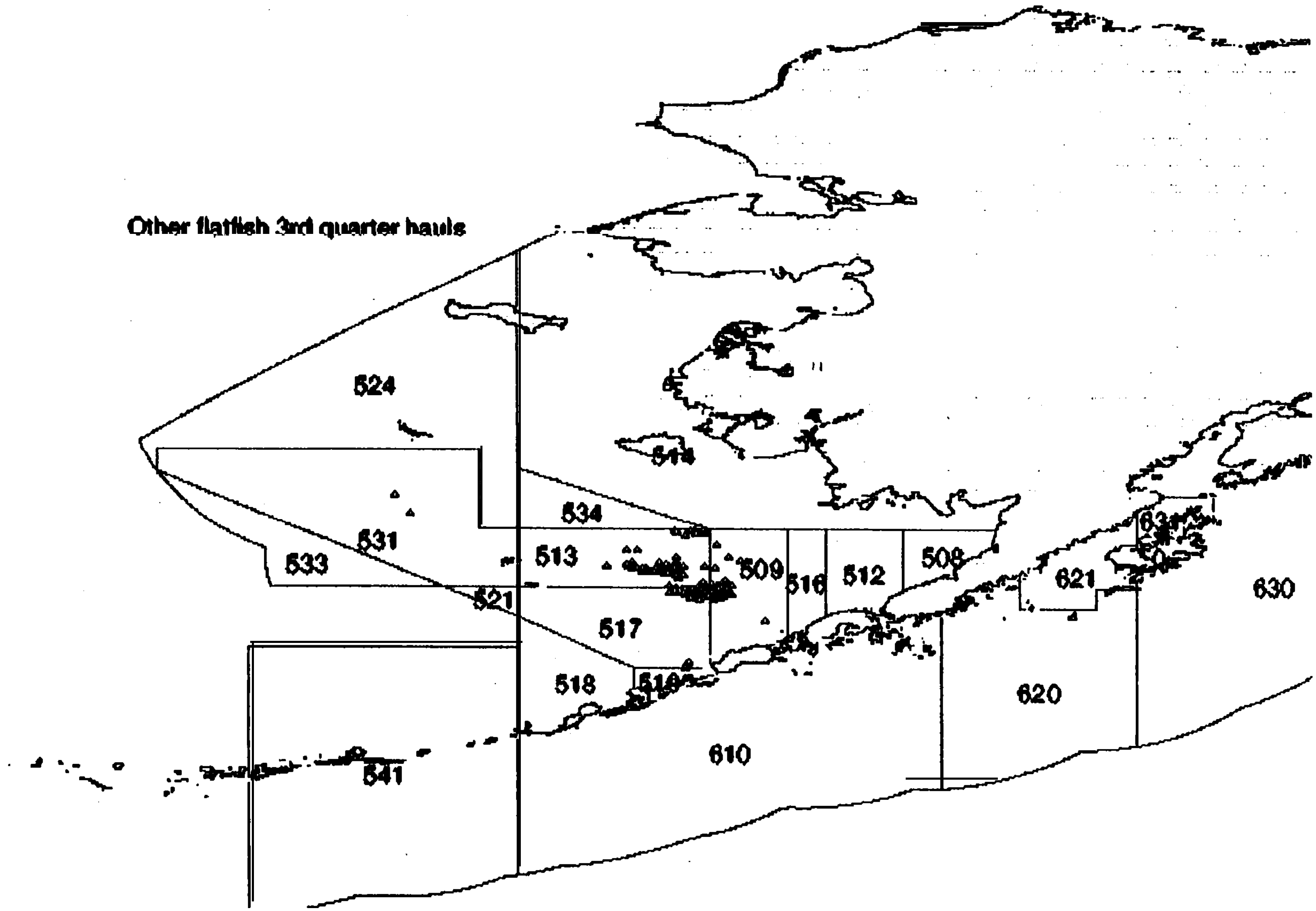
Other flatfish 1st quarter hauls



Other flatfish 2nd quarter hauls



Other flatfish 3rd quarter hauls



Other flatfish 4th quarter hauls