10. Assessment of the Alaska Plaice stock in the Bering Sea and Aleutian Islands

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Executive Summary

The following changes have been made to this assessment relative to the November 2013 SAFE:

Summary of Changes Assessment Inputs

1) The 2013 catch data was updated, and the 2014 catch was estimated from Alaska Region total catch through September 15, 2014, in consideration of the recent weekly catch pattern for Alaska plaice.
2) The 2013 and 2014 shelf survey biomass estimates and standard errors, and the 2014 survey length composition were included in the assessment.
3) The 2012 and 2013 survey ages were read and their respective survey age compositions were added to the assessment.
4) The 2013 fishery length composition was added as a data component.
5) A new maturity schedule estimated from histological analysis of samples collected in 2012 was implemented in the assessment model.
6) The current assessment does not incorporate 1975, and 1979-1981 survey biomass data.

Changes to the Assessment Methodology

No modifications were made for this assessment.

Summary of Results

1) Estimated 3+ total biomass for 2015 is 471,500 t.
2) Projected female spawning biomass for 2015 is 215,300 t.
3) Recommended ABC for 2015 is 44,900 t based on an $F_{40\%}$ = 0.143 harvest level.
4) 2015 overfishing level is 54,000 t based on a $F_{35\%}$ (0.175) harvest level.

Quantity/Status	Last year 2014	2015	This year **2015**	2016
M (natural mortality)	0.13	0.13	**0.13**	0.13
Specified/recommended Tier	3a	3a	**3a**	3a
Projected biomass (ages 3+)	576,300	572,900	**471,500**	462,600
Female spawning biomass (t)				
Projected	250,600	246,300	**215,300**	201,300
$B_{100\%}$	380,100		**355,250**	
$B_{40\%}$	152,000		**142,100**	
$B_{35\%}$	133,000		**124,300**	
F_{OFL}	0.19	0.19	**0.175**	**0.175**
$maxF_{ABC}$ (maximum allowable = F40%)	0.158	0.151	**0.143**	**0.143**
Specified/recommended F_{ABC}	0.158	0.151	**0.143**	**0.143**
Specified/recommended ABC (t)	55,100	54,700	**44,900**	42,900
Specified/recommended OFL (t)	66,800	66,300	**54,000**	51,600
Is the stock being subjected to overfishing?	No	No	No	No
Is the stock currently overfished?	No	No	No	No
Is the stock approaching a condition of being overfished?	No	No	No	No

Responses to SSC and Plan Team Comments on Assessments in General

December 2013 SSC Comments:
The SSC noted that different stock assessment scientists often use different methods for catch estimation to estimate catches between late October and December 31 of the current assessment year, as well as catches to be taken during the following two years for use in the catch specification process. The SSC understands that Dana Hanselman will compile the various methods in use. The SSC looks forward to Plan Team advice on the merits of the various alternatives.

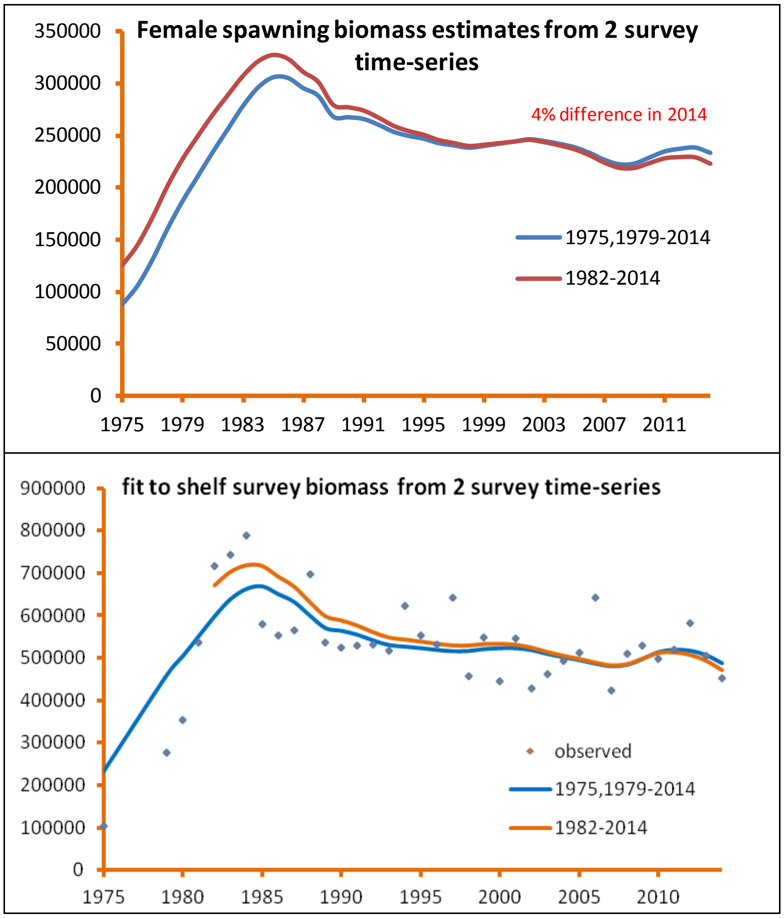
Authors' response: This is described under fisheries data.

The SSC also requested that authors include two years of projections in the phase plane diagram. For example, in 2014, projected values for 2015 and 2016 should be included.

Responses to SSC and Plan Team Comments Specific to this Assessment

SSC Comments from December 2013: ***In last year's assessment, the authors indicated a desire to remove pre-1982 survey data from the assessment, given changes in catchability associated with the switch in survey gears. The SSC looks forward to an alternative assessment with this modified dataset and reminds the authors to retain a model fit with the full data so that the effect of this change can be evaluated. The SSC also looks forward to any new insights into how best to address the situation that a significant portion of the Alaska plaice biomass resides in the northern Bering Sea.***

Authors' response: Both models were run and model output compared in the following figures. Results of estimated female spawning biomass and fit to surveys indicate a small difference (4%) in estimates from the early part of the time series when 4 extra data points were fit in 2014 estimates. Both models produce the same population trends. Given the unknown differences in catchability between the 2 survey trawls (estimates are all treated the same), the current assessment proceeds without the 1975, and 1979-1981 survey estimates (as do most other BSAI flatfish assessments).



Introduction

Alaska plaice (*Pleuronectes quadrituberculatus*) are primarily distributed 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 northern rock sole (*Lepidopsetta polyxystra*) and yellowfin sole (*Limanda aspera*), but the center of the distribution is north of the center of the other two species and seems to be positioned further north in warm years and more southern in cold years. Substantial amounts of Alaska plaice were also found between St. Matthew and St. Lawrence Islands in the 2010 northern expansion of the annual Bering Sea shelf trawl survey.

There has been no research on stock structure in this species.

Fishery

Since implementation of the Fishery Conservation and Management Act (FCMA) in 1977, Alaska plaice have been lightly harvested in most years as no major commercial target fishery exists for them. In 2013 68% of the Alaska plaice catch occurred in the yellowfin sole fishery. In 2011, most of the annual TAC for Alaska plaice was harvested by late winter and early spring as bycatch in the yellowfin sole fishery (at levels well-below ABC). This pattern changed in 2012 with much lower catch rates in the early part of the year but higher catch rates (over 1,000 t per week) in September. The majority of the 2013 catch was also taken early in the year. The 2014 catch is estimated at 19,000 t (less than half the ABC) based on the current catch history (detailed in Table 10.1).

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 10.1). Part of this apparent increase was due to increased 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).

Alaska plaice are grouped with the rock sole, flathead sole, and other flatfish fisheries under a common prohibited species catch (PSC) limit, with seasonal and total annual allowances of prohibited species bycatch by these flatfish fisheries applied to the fisheries within the group. Prior to 2008, these fisheries were closed prior to attainment of the TAC due to the bycatch of halibut (Table 10.2), and typically were also closed during the first quarter due to a seasonal bycatch cap. Since the implementation of Amendment 80 in 2008 where catch and bycatch shares were assigned to groups of fishing vessels (cooperatives), these fisheries have not been subjected to time and area closures, although there was a rock sole target closure in 2010 (http://www.afsc.noaa.gov/REFM/Docs/2013/BSAIrocksole.pdf).

Substantial amounts of Alaska plaice were discarded in various eastern Bering Sea target fisheries in past years due to low market interest. Retained and discarded catches were reported for Alaska plaice for the first time in 2002, and indicated that of the 12,176 t caught only 370 t were retained, resulting in a retention rate of 3.0% (Table 10.3). Similar patterns were observed for 2003 - 2005 (4%, 5% and 6%, respectively). The discard patterns have now changed, with increased retention each year. The amount of Alaska plaice retained in 2013 was 62%. Examination of the discard data by fishery indicates that 81% - 87% of the discards in 2002 - 2013 can be attributed to the yellowfin sole fishery. Discarding also occurred in the rock sole, flathead sole, Pacific cod and bottom pollock fisheries. The locations where Alaska plaice were caught, by month, in 2014 are shown in Figure 10.1.

Prior to 2002, Alaska plaice were managed as part of the “other flatfish” complex. Since then an age-structured model has been used for the stock assessment allowing Alaska plaice to be managed separately from the “other flatfish” complex as a single species.

Data

In summary, the data available for Alaska plaice are:

Source	Data	Years
NMFS Eastern Bering Sea shelf survey	Survey biomass and standard error	1983-2014
	Age Composition (by sex)	1982, 1988, 1992-1995, 1998, 2000-2002, 2005-2013
	Length Composition (by sex)	1983-1987, 1989-1991, 1996-1997, 1999, 2003, 2004, 2014
Fisheries	Catch	1971-2014
	Age Composition (by sex)	2000, 2002 and 2003
	Length Composition (by sex)	1978-89, 1995, 2001 and 2008-2012

1) Total catch weight, 1971-2014;
2) Proportional fishery catch number at age, 2000, 2002-2003
3) Proportional fishery catch number at length, 1978-89, 1995, 2001, 2008-2012
4) Survey biomass and standard error 1982-2012;
5) Survey age composition, 1982, 1988, 1992-1995, 1998, 2000-2002, 2005-2013
6) Survey length composition, 1983-1987, 1989-1991, 1996-1997, 1999, 2003, 2004, 2014

Fishery:

This assessment uses fishery catches from 1971 through 2014 (Table 10.1). Fishery length compositions from 1978-89, 1995, 2001 and 2008-2012 for each sex were also used, as well as sex-specific age compositions from 2000, 2002 and 2003. The number of ages and lengths sampled from the fishery are shown in Table 10.4.

The catch of Alaska plaice taken in scientific surveys, subsistence fishing, recreational fishing, fisheries managed under other FMPs from 1977 –2014 is shown in Table 10.5.

From August 24-September 30, 2014 the Alaska plaice catch averaged 750 t per week. Yellowfin sole catch is still well below the TAC and fishing is ongoing. Alaska plaice are usually caught as bycatch in the yellowfin sole fishery. Since the fishery was continuing at a good pace, it seemed reasonable to assume that Alaska plaice would continue to be caught at a similar rate to the previous 5 weeks. The catch at Sept. 30 was 16,922 with a TAC of 20,000 t. It was therefore estimated that the Alaska plaice catch could reach 19,000 t for the 2014 fishing season.

Survey:

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 surveys of the Eastern Bering Sea continental shelf have been conducted in 1975 and 1979-2014 by NMFS. Survey estimates of total biomass and numbers at age are shown in Tables 10.6 and 10.7, 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.

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. Due to the differences in catchability between these two survey trawls, this assessment only uses the survey estimates from 1982-2014.

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 following the methods of Kappenman (1992) for 1982-2005. 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 a high 1988 estimate, Alaska plaice has shown a relatively stable trend since 1985, although abundance was higher in the 1994, 1997 and 2006 surveys (Figure 10.2, Table 10.6). The 2012 estimate of 581,900 t was the highest observed in the five previous years. The past two surveys in 2013 and 2014 have decreased to 505,600 t and 451,600 t, respectively.

Assessments for other BSAI flatfish have suggested a relationship between bottom temperature and survey catchability (Wilderbuer et al. 2002), where bottom temperatures are hypothesized to affect survey catchability by affecting either stock distributions and/or the activity level of flatfish relative to the capture process. Temperature was not expected to affect Alaska plaice catchability since they are a “cold loving” species with an anti-freeze protein that inhibits ice formation in their blood (Knight et al. 1991). This relationship was investigated for Alaska plaice by using the annual temperature anomalies from surveys conducted from 1982 to 2014. Examination of the residuals from the model fit to the bottom trawl survey relative to the annual bottom temperature anomalies did not indicate a correlation between the two data series (Figure 10.3). This was also the result from a past assessment (Spencer et al. 2004) where a fit with a LOWESS smoother indicated that little correspondence exists between the two time series, and the cross-correlation coefficient (-0.17) was not significant at the 0.05 level. Thus, the relationship between bottom temperature and survey catchability was not pursued further.

In 2010 the Alaska Fisheries Science Center had the opportunity to extend the annual bottom trawl survey to the northern Bering Sea past St. Lawrence Island by the additional sampling of 142 stations. Substantial amounts of Alaska plaice were encountered in the northern area with a total biomass estimate of 311,900 t (Figure 10.4). This indicated that for 2010, the combined eastern and northern Bering Sea Alaska plaice biomass was estimated at 810,000 t, of which 38% occurred north of the standard survey area. Since the northern Bering Sea has only been surveyed one time with no plan to repeat the survey and also because the area is closed to fishing, biomass estimates from only the standard survey area are used in this assessment (Table 10.6) and the northern Bering Sea is not included in the assessment.

In this assessment, the estimated population numbers at length from the trawl survey were multiplied by the age-length key in order to produce a matrix of estimated population numbers by age and length, from which an unbiased average length for each age can be determined. These population estimates by length and sex were used to fit the model for years when age composition data were not available. The numbers of age and length samples obtained from the surveys are shown in Table 10.8.

Analytic Approach

Model Structure

This catch at age model was developed with the software program Automatic Differentiation Model Builder (ADMB; Fournier et al. 2012). The age-structured assessment model is configured to accommodate the sex-specific aspects of the population dynamics of Alaska plaice, because the sex-specific weight-at-age diverges after the age of maturity (about age 10 for 50% of the stock) with females growing larger than males (Table 10.9). The model is coded to allow for the input of sex-specific estimates of fishery and survey age composition and weight-at-age and provides sex-specific estimates of population numbers, fishing mortality, selectivity, fishery and survey age composition and allows for the estimation of sex-specific natural mortality and catchability. The 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. Population size in numbers at age *a* in year *t* was modeled as

$$N_{t,a} = N_{t-1,a-1}e^{-Z_{t-1,a-1}} \qquad 3 \le a < A, \quad 3 \le t \le T$$

where Z is the sum of the instantaneous fishing mortality rate ($F_{t,a}$) and the natural mortality rate (M), A is the maximum modeled age 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

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

Recruitment was modeled as the number of age 3 fish. The efficacy of estimating productivity directly from the stock-recruitment data (as opposed to using an SPR proxy) was examined in a past assessment (Wilderbuer et al. 2008) by comparing results from fitting either the Ricker or Beverton-Holt forms within the model and choosing different time-periods of stock-recruitment productivity. This analysis is described in more detail in the 2008 assessment.

The numbers at age in the first year are modeled with a lognormal distribution

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

where *meaninit* is the mean of the recruitments that made up the initial age comp and γ is an age-variant deviation.

The mean numbers at age within each year were computed as

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

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

$$C_{t,a} = F_{t,a}\overline{N}_{t,a}$$

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

where w_a is the mean weight at age for Alaska plaice.

A conversion matrix was derived from the von Bertalanffy growth relationship, and used to convert the modeled numbers at age into modeled numbers at length. There are 51 length bins ranging from 10 to 60 cm, and 23 age groups ranging from 3 to 25+. For each modeled age, the transition matrix (TR) consists of a probability distribution of numbers at length, with the expected value equal to the predicted length-at-age from the von Bertalanffy relationship. The variation around this expected value was derived from a linear regression of coefficient of variation (CV) in length-at-age against age, where the CV were obtained from the sampled specimens over all survey years. The estimated linear relationship predicts a

CV of 0.14 at age 3 and a CV of 0.10 at age 25. The conversion matrix, vector of mean numbers at age, and survey selectivity by age were used to compute the estimated survey length composition, by year, as

$$\overline{\mathbf{NL}}_t = (\boldsymbol{srvsel} * \overline{\mathbf{NA}}_t) * \mathbf{TR}^{\mathbf{T}}$$

where ***srvsel*** is a vector of survey selectivity by age.

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 ($fishsel_a$) 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

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

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:

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

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*). 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. In past assessments natural mortality was fixed at 0.25 based on an earlier analysis of natural mortality (Wilderbuer and Walters 1997, Table 8.1).

In the 2010 assessment, the natural mortality rate of Alaska plaice was re-estimated using 3 methods from the literature based on the life history characteristics of maximum life span (Hoenig 1983), average age (Chapman and Robson 1960) and the relationship between growth and maximum length (Gislason et al. 2008). The results are summarized below and suggest a range of natural mortality values from 0.08 to 0.13 for males and 0.08 to 0.29 for females.

Method	Males	Females
Hoenig (1983)	0.11	0.11
Chapman and Robson (1960)	0.08	0.08
Gislason et al. 2008	0.12	0.29
Model profiling	0.13	0.13

In this assessment, the model was again run for different combinations of male and female M to discern what value provides the best fit to the data components in terms of –log(likelihood). The best fit to the observable population characteristics occurred at M = 0.13 for both sexes (Figure 10.5). This value of natural mortality is close to those estimated from the other three methods and also is consistent with the natural mortality used in other assessments of Bering Sea shelf flatfish which have similar life histories, growth and maximum ages. Therefore a value of M = 0.13 was used to model natural mortality for both males and females in this assessment.

Herding experiments in the eastern Bering Sea have demonstrated that many of the flatfish encountered in the area between the outer end of the footrope and where the bridles contact the sea floor (outside the trawl path) are herded into the path of the bottom trawl in varying degrees (Somerton and Munro 2001). Although Alaska plaice were not among the seven species that were explicitly studied, it is assumed that their behavior is similar to the other studied species which all exhibited herding behavior. The mean herding effect from all seven species combined resulted in a bridle efficiency of 0.234. This assessment incorporates a herding effect into the stock assessment model by fixing survey catchability (q) at 1.2, close to the mean value from the combined flatfish species in the herding experiment.

Alaska plaice exhibit sex-specific dimorphic growth after the age of sexual maturity with females attaining a larger size than males. The von Bertalanffy parameters fit to the population length at age and the length-weight relationship of the form $W = aL^b$ were estimated as:

	Length at age fit			Length-weight fit		
	L_{inf}(cm)	k	t_o	a	b	n
males	49.9	0.06	-4.02	0.1249	2.98	866
females	50.1	0.127	0.35	0.0055	3.23	1,381

The combination of the length-weight relationship and the von Bertalanffy growth curve produces an estimated weight-at-age relationship that is similar to that used in previous Alaska plaice assessments. The sex-specific weight-at-age relationship calculated from the average population mean length at age and the length-weight relationship, by sex, are shown in Figure 10.6.

A new maturity schedule is available for this assessment from samples obtained in 2012. These histologically determined estimates of proportion mature at age (TenBrink and Wilderbuer in review) replace the previously used anatomically-derived estimates (Zhang 1987). Both studies estimated similar results differing in estimated 2013 female spawning biomass by only 4%.

Parameters Estimated Conditionally

Parameter estimation is facilitated by comparing the model output to several observed quantities, such as the age compositions of the fishery and survey catches, the survey biomass, and the fishery catches. The general approach is to assume that deviations between model estimates and observed quantities are attributable to observation error and can be described with statistical distributions. Each data component provides a contribution to a total log-likelihood function, and parameter values that maximize the log-likelihood are selected.

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

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

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

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

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

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

$$q\_srv * \sum_a selsrv_a (\overline{N}_a * wt_a)$$

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

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

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

where obs_cat_t and $pred\_cat_t$ are the observed and predicted catch. Because the catch biomass is generally thought to be observed with higher precision than 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 for surveys and 50 for the fishery. 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)	40
3) recruitment mean	1
4) recruitment deviations (ν_t) including initial yr	61
5) fishery selectivity patterns both sexes	4
8) survey selectivity patterns both sexes	4
Total parameters	111

Finally, a Monte Carlo Markov Chain (MCMC) algorithm was used to obtain estimates of parameter uncertainty (Gelman et al. 1995). One and a half million MCMC simulations were conducted, with every 1,000th sample saved for the sample from the posterior distribution. Ninety-five percent confidence intervals were produced as the values corresponding to the 5th and 95th percentiles of the MCMC evaluation. For this assessment, confidence intervals on female spawning biomass, total biomass and age 3 recruitment are presented.

Results

Modeling the Alaska plaice population with M set at 0.13 for both sexes results in population estimates that are 30-40% of the values derived from previous assessments which used M = 0.25. The values of $F_{40\%}$ and $F_{35\%}$ estimated at the reduced natural mortality level (0.143 and 0.195, respectively) are much more consistent with the other Bering Sea flatfish assessments than those that result from the M=0.25 estimates and produce a better fit to the observable population information.

Using the survey catchability value of 1.2, the model results estimate that the total Alaska plaice biomass (ages 3+) increased from 461,300 t in 1975 to a peak of 765,700 t in 1984 (Figure 10.7, Table 10.10). Beginning in 1984, the total biomass steadily declined to 535,600 t by 2003 before increasing again to 558,500 t in 2008. The model estimates a slow decrease thereafter to 484,600 t in 2014. The estimated survey biomass also shows a slow decline since a peak value estimated in 1984 (Figure 10.7). The female spawning biomass has also been very stable since a peak in 1985 and is projected at 215,300 t in 2015, well-above the $B_{40\%}$ value of 142,000 t. The recent increase from 2008-2013 is the result of above average year classes spawned in 2001 and 2002 that contributed to the mature biomass. The female spawning biomass trend is similar to the total biomass trend with a peak level estimated in 1985 and a slow decline thereafter until 2008 after which the spawning stock is estimated to be increasing (Figure 10.9).

As in past assessments, fitting fishery observations was de-emphasized by lowering the input sample sizes from 200 to 50. This contributed in part to producing estimates of 50% fishery selectivity at about 10 years for females and 9 for males (Figure 10.10). The fits to the trawl survey age and length compositions are shown in Figures 10.11 and 10.12 and the fit to the fishery age and length compositions are shown in Figures 10.13 and 10.14.

The modest changes in stock biomass are primarily a function of recruitment variability, as fishing pressure has been light. The fully selected fishing mortality estimates show a maximum value of 0.14 in 1988, and have averaged 0.04 from 1975-2014 (Figure 10.15). Estimated age-3 recruitment indicates high levels from the 1971-1976 year classes which built the stock to its peak level in 1982 (Figure 10.7, Figure 10.16, 10.10). Estimated numbers-at-age are shown in Table 10.11. From 1981-1997 the estimated recruitment declined, averaging 220 million fish. Recruitment is estimated have improved since 1997 with above average recruitment strength in 1998 and exceptionally strong recruitment in 2001 and 2002. These fish have contributed to a high level of female spawning biomass in 2008-2013.

Harvest Recommendations

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 $B_{40\%}$, $F_{40\%}$, and $SPR_{40\%}$ were obtained from a spawner-per-recruit analysis. Assuming that the average recruitment from 1972-2008 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 (=142,100 t). The 2015 spawning biomass is estimated at 215,300 t. Since reliable estimates of 2015 spawning biomass (B), $B_{40\%}$, $F_{40\%}$, and $F_{35\%}$ exist and $B>B_{40\%}$ (215,300 t > 142,100 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:

2015 SSB estimate (B)	=	215,300 t
$B_{40\%}$	=	142,100 t
$F_{40\%}$	=	0.143
F_{ABC}	=	0.143
$F_{35\%}$	=	0.175
F_{OFL}	=	0.175

The estimated catch level for year 2015 associated with the overfishing level of F = 0.175 is 54,000 t. **The 2015 recommended ABC associated with F_{ABC} of 0.143 is 44,900 t.** Projections of Alaska plaice female spawning biomass (described below) at a harvest rate equal to the average fishing mortality rate of the past five years indicate that the stock could increase to a female spawning biomass in 2027 of over 235,000 t (Fig. 10.17).

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 2014 numbers at age estimated in the assessment. This vector is then projected forward to the beginning of 2015 using the schedules of natural mortality and selectivity described in the assessment and the best available estimate of total (year-end) catch for 2014. 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 2015, 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 2015 recommended in the assessment to the *max* F_{ABC} for 2015. (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 2010-2014 average F. (Rationale: For some stocks, TAC can be well below ABC, and recent average F may provide a better indicator of F_{TAC} than F_{ABC}.)
>
> *Scenario 5*: In all future years, F is set equal to zero. (Rationale: In extreme cases, TAC may be set at a level close to zero.)

The recommended F_{ABC} and the maximum F_{ABC} are equivalent in this assessment, and five-year projections of the mean Alaska plaice harvest and spawning stock biomass for the remaining four scenarios are shown in Table 10.13.

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 2015 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2015 and 2016, 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 2027 under this scenario, then the stock is not approaching an overfished condition.)

The results of these two scenarios indicate that Alaska plaice are neither overfished nor approaching an overfished condition. With regard to assessing the current stock level, the expected stock size in the year 2013 of scenario 6 is well above its $B_{35\%}$ value of 124,300 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 2027 of scenario 7 is also greater than its $B_{35\%}$ value. Figure 10.18 shows the relationship between the estimated time-series of female spawning biomass and fishing mortality and the tier 3 control rule for Alaska plaice.

In addition to the seven standard harvest scenarios, Amendments 48/48 to the BSAI and GOA Groundfish Fishery Management Plans require projections of the likely OFL two years into the future. While Scenario 6 gives the best estimate of OFL for 2015, it does not provide the best estimate of OFL for 2016, because the mean 2016 catch under Scenario 6 is predicated on the 2015 catch being equal to the 2015 OFL, whereas the actual 2015 catch will likely be less than the 2015 ABC. Therefore, the projection model was re-run with the 2016 catch fixed at the 2015 level.

Year	Catch	ABC	OFL
2015	19,000	44,900	54,000
2016	19,000	42,900	51,600

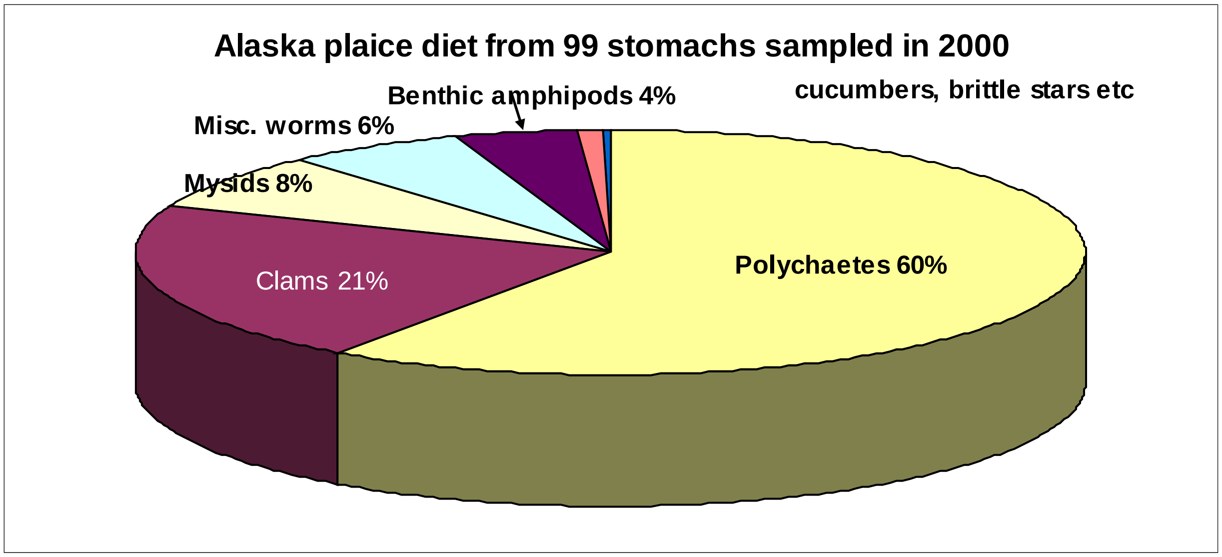
Ecosystem considerations

Ecosystem Effects on the stock

1) Prey availability/abundance trends

The feeding habits of juvenile Alaska plaice are relatively unknown, although the larvae are relatively large at hatching (5.85 mm) with more advanced development than other flatfish (Pertseva-Ostroumova 1961).

For adult fish, Zhang (1987) found that the diet consisted primarily of polychaetes and amphipods regardless of size. For fish under 30 cm, polychaetes contributed 63% of the total diet with sipunculids (marine worms) and amphipods contributing 21.7% and 11.6%, respectively. For fish over 30 cm, polychaetes contributed 75.2% of the total diet with amphipods and echiurans (marine worms) contributing 6.7% and 5.7%, respectively. Similar results were in stomach sampling from 1993-1996, with polychaetes and marine worms composing the majority of the Alaska plaice diet (Lang et al. 2003). McConnaughy and Smith (2000) contrasted the food habits of several flatfish between areas of high and low CPUE, using aggregated data from 1982 to 1994. For Alaska plaice, the diets were nearly identical with 76.5% of the diet composed of polychaetes and unsegmented coelomate worms in the high CPUE areas as compared to 83.1% in the low CPUE areas.



2) Predator population trends

Alaska plaice contribute a relatively small portion of the diets of Pacific cod, Pacific halibut, and yellowfin sole as compared with other flatfish. Total consumption estimates of Alaska plaice from 1993 to 1996 ranged from 0 t in 1996 to 574 t in 1994 (Lang et al. 2003). Consumption by yellowfin sole is upon fish < 2 cm whereas consumption by Pacific halibut is upon fish > 19 cm (Lang et al. 2003).

3) Changes in habitat quality

The habitats occupied by Alaska plaice are influenced by temperature, which has shown considerable variation in the eastern Bering Sea in recent years. For example, the timing of spawning and advection to nursery areas are expected to be affected by environmental variation. Musienko (1970) reported that spawning occurs immediately after the ice melt, with peak spawning occurring at water temperatures from -1.53 to 4.11. In 1999, one of the coldest years in the eastern Bering Sea, the distribution was shifted further to the southeast than it was during 1998-2002. However, in 2003, one of the warmest years in the EBS, the distribution was shifted further to the southeast than observed in 1999.

Fishery effects on the ecosystem

Alaska plaice are not a targeted species and are harvested in a variety of fisheries in the BSAI area. Since 2002, when single-species management for Alaska plaice was initiated, harvest estimates by fishery are available. Most Alaska plaice are harvested by the yellowfin sole fishery, accounting for over 80% of the Alaska plaice catch since 2002. Flathead sole, rock sole, and Pacific cod fisheries make up the remainder of the catch. The ecosystem effects of the yellowfin sole fishery can be found with the yellowfin sole assessment in this SAFE document.

Due to the minimal consumption estimates of Alaska plaice (Lang et al. 2003) by other groundfish predators, the yellowfin sole fishery does not have a significant impact upon those species preying upon Alaska plaice. Additionally, the relatively light fishing mortality rates experienced by Alaska plaice are not expected to have significant impacts on the size structure of the population or the maturity and fecundity at age. It is not known what effects the fishery may have on the maturity-at-age of Alaska plaice. The yellowfin sole fishery, however, does contribute substantially to the total discards in the EBS, as indicated by the discarding of Alaska plaice discussed in this assessment, and general discards within this fishery discussed in the yellowfin sole assessment.

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Tables

Table 10.1. Harvest (t) of Alaska plaice from 1977-2014.

Year	Harvest
1977	2,589
1978	10,420
1979	13,672
1980	6,902
1981	8,653
1982	6,811
1983	10,766
1984	18,982
1985	24,888
1986	46,519
1987	18,567
1988	61,638
1989	14,134
1990	10,926
1991	15,003
1992	18,074
1993	13,846
1994	10,882
1995	19,172
1996	16,096
1997	21,236
1998	14,296
1999	13,997
2000	14,487
2001	8,685
2002	12,176
2003	9,978
2004	7,888
2005	11,194
2006	17,318
2007	19,522
2008	17,376
2009	13,944
2010	16,165
2011	23,656
2012	16,612
2013	23,523
2014*	19,000

* From August 24-September 30, 2014 the Alaska plaice catch averaged 750 t per week. Yellowfin sole catch is still well below the TAC and fishing is ongoing. Alaska plaice are usually caught as bycatch in the yellowfin sole fishery. Since the fishery was continuing at a good pace, it seemed reasonable to assume that Alaska plaice would continue to be caught at a similar rate to the previous 5 weeks. The catch at Sept. 30 was 16,922 with a TAC of 20,000 t. **It was therefore estimated that the Alaska plaice catch could reach 19,000 t for the 2014 fishing season.**

Table 10.2. Restrictions on the “other flatfish” fishery from 1995 to 2007 in the Bering Sea – Aleutian Islands management area. Unless otherwise indicated, the closures were applied to the entire BSAI management area. Zone 1 consists of areas 508, 509, 512, and 516, whereas zone 2 consists of areas 513, 517, and 521. Since 2008 no management restrictions have occurred.

Year	Dates	Bycatch Closure
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	¾ – 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
2003	2/18 – 3/31	First Seasonal halibut cap
	4/1 – 6/21	Second seasonal halibut cap
	7/31 – 12/31	Annual halibut allowance
2004	2/24 – 3/31	First Seasonal halibut cap
	4/10 – 12/31	Bycatch status
2005	3/1 - 3/31	First Seasonal halibut cap
	4/22-6/30	Second Seasonal halibut cap
	5/9-12/31	Bycatch status, TAC attained
2006	2/21 - 3/31	First Seasonal halibut cap
	4/5 – 12/31	Red King crab cap (Zone 1 closed)
	4/12 – 5/31	Second seasonal halibut cap
	5/26	TAC attained, 7,000 t reserve released
	8/7 – 12/31	Annual halibut allowance
2007	2/17-3/31	First seasonal halibut cap
	4/1-6/21	Second seasonal halibut cap
	7/31-12/31	Annual halibut allowance

Table 10.3 Discarded and retained BSAI Alaska plaice catch (t) for 2002-2013, from NMFS Alaska regional office ‘blend” (2002) and catch accounting system (2003 - 2014) data.

year	Discard	Retained	Total	Proportion discarded
2002	11,806	370	12,176	0.97
2003	9,428	350	9,778	0.96
2004	7,193	379	7,572	0.95
2005	10,293	786	11,079	0.93
2006	14,746	2,564	17,310	0.85
2007	15,481	3,946	19,427	0.8
2008	9,330	8,046	17,376	0.54
2009	5,061	8,882	13,945	0.36
2010	5,845	10,322	16,166	0.36
2011	7,197	16,459	23,656	0.30
2012	3,589	13,023	16,611	0.22
2013	9,053	14,470	23,523	0.38

Table 10.4. Alaska plaice sample sizes from the BSAI fishery. The hauls columns refer to the number of hauls where either lengths or aged otoliths were obtained.

Year	Total Hauls with AK Plaice	Haul Count -- Lengths collected	Number of Lengths	Haul Count -- Otoliths collected	Number of Otoliths	Number of Aged Otoliths
2008	11741	1641	7494	329	381	0
2009	9176	1950	8795	412	443	0
2010	9743	1810	8781	344	398	0
2011	9914	2800	14328	545	686	0
2012	9782	2962	13611	548	600	0
2013	11026	3469	16646	649	787	0
2014	8217	1900	8852	373	456	0

Table 10.5. Research catches (t) of Alaska plaice in the BSAI area from 1977 to 2014.

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
2003	15.39
2004	18.03
2005	22.52
2006	28.50
2007	18.80
2008	17.50
2009	18.40
2010	17.30
2011	17.82
2012	19.26
2013	17.18
2014	15.35

Table 10.6. Estimated biomass and standard deviations (t) of Alaska plaice from the eastern Bering Sea shelf trawl survey, 1982-2014.

Year	Biomass estimate	Standard Deviation
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	540,458	68,600
2002	428,519	53,800
2003	467,326	97,400
2004	488,217	63,800
2005	503,861	55,698
2006	636,971	81,547
2007	421,765	37,831
2008	509,382	47,431
2009	529,729	50,359
2010	498,104	46,867
2011	519,578	72,781
2012	581,894	83,432
2013	505,583	65,596
2014	451,624	48,850

Table 10.7. Alaska plaice population numbers at age (millions) estimated from the NMFS Bering Sea groundfish surveys and age readings of sampled fish.

	females												
Year	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1982	0.41	0.37	22.53	41.28	269	172.3	90.15	57.82	181.37	152.84	337.25	231.75	117.71
1988	0	0.21	3.85	11.7	47.27	35.98	62.44	32.87	62.31	55.98	25.55	77.65	0
1992	0	0	4.21	4.88	7.67	32.47	28.58	20.72	35.2	24.66	16.18	25.8	22.36
1993	0	0	5.45	14.86	30.17	42.06	53.67	5.63	2.43	25.19	42.68	26.55	38.77
1994	0	0	7.69	14.8	45.16	38.83	21.56	45.23	16.55	11.28	55.34	11.75	50.02
1995	0	0	10	31.4	32.78	47.14	34.28	16.81	23.35	16.56	10.15	30.11	30.32
1998	0	0.87	3.72	9.78	35.71	37.29	58.62	28.49	40.13	43.26	17.83	24.84	14.62
2000	0	0.1	3.94	3.86	22.18	27.15	53.22	26.88	33.92	18.95	21.06	15.94	13.8
2001	0	0	4.11	9.46	13.63	48.23	21.59	85.08	30.82	44.56	15.27	16.01	10.5
2002	0	0.04	1.38	13.85	20.02	14.87	31.56	22.2	37.67	15.24	31.42	13.78	22.86
2005	0.86	2.07	13.32	23.35	34.58	31.89	31.31	28.52	24.17	28.67	33.18	19.61	22.53
2006	0.26	4.43	47.24	24.28	54.33	51.8	38.45	27.34	20.18	11.78	31.92	19.4	28.33
2007	0	4.02	43.49	56.53	35.95	24.59	20.18	27.42	29.71	16.8	17.94	16.9	8.71
2008	0	0	12.28	46.14	60.05	42.37	23.47	33.67	32.77	24.79	10.82	13.96	25.29
2009	0	0.55	9.92	14.33	89.06	61.3	24.44	36.06	26.58	17.58	15.89	12.03	18.55
2010	0	0	4.59	10.4	16.1	85.19	55.96	28.89	29.6	26.81	13.44	13.31	17.39
2011	0	0.03	0.61	21.03	34.45	31.66	73.68	60.28	24.6	16.22	26.19	8.6	9.66
2012	0	0	1.35	9.97	19.64	37.37	39.03	63.35	57.44	40.12	22.53	29.85	10.64
2013	0	0	3.47	8.83	12.58	37.11	33.53	22.53	48.73	38.42	42.84	28.05	14.08

Table 10.7 (continued).

Year	males 3	4	5	6	7	8	9	10	11	12	13	14	15
1982	0.58	0	22.23	73.69	58.78	95.64	113.81	126.18	144.63	170.99	93.5	155.86	99.64
1988	0	0.14	3.66	6.49	37.64	36.15	47.49	32.31	102.5	17.23	6.35	28.89	15.16
1992	0	5.31	16.81	1.29	22.86	29.62	19.29	22.23	46.34	25.41	21.31	19.97	10.93
1993	0	0	2.94	36.76	14.75	25.43	43.65	15.2	17.67	34.2	42.85	6.14	12.04
1994	0.18	2	13.65	13.11	57.64	61.53	15.17	30.2	21.32	14.81	57.29	47.05	31.05
1995	0	0	0	28.54	20.44	84.71	20.96	17.54	38.87	17.38	20.09	17.17	27.44
1998	0	0.3	5.05	22.12	37.94	34.11	51.34	31.63	26.46	27.3	11.56	18.07	15.01
2000	0	0	9.04	0.98	20.94	20.93	75.64	44.57	27.81	30.16	21.56	16.45	3.35
2001	0	0	1.68	17.13	6.41	70.21	46.7	64.95	26.29	52.48	23.07	69.35	5.37
2002	0	1.01	2.18	13.73	15.76	21.47	30.88	45.28	37.32	20.83	32.13	13.55	32.91
2005	0.64	4.19	10.18	32.27	23.25	50.37	14.58	43.1	18.7	32.76	41.25	21.95	10.57
2006	0.09	9.84	46.73	29.28	60.61	61.64	46.65	29.81	24.25	25.34	23.38	55.71	31.55
2007	1.64	3.98	39.18	63.35	46.71	18.93	21.23	41.58	36.97	6.87	12.81	20.21	20.92
2008	0	0	6.71	87.18	60.27	14.47	29.59	52.29	13.51	32.08	15.63	18.74	23.65
2009	0	2.88	6.06	12.58	93.08	83.7	71.81	39.87	23.12	25.57	11.52	39.2	19.17
2010	0	0.48	6.62	17.02	31.68	61.44	65	40.38	48.41	35.67	30.19	24.47	10.99
2011	0	1.08	1.4	17.47	47.71	26.43	56.99	63.27	22.49	33.17	31.88	11.36	13.32
2012	0	0	7.33	3.57	39.68	66.94	25.25	85.81	49.72	33.23	20.86	12.86	9.19
2013	0	0	1.3	7.11	21.61	46.81	35.16	26.77	51.47	72.59	31.89	16.53	19.41

Table 10.7 (continued).

	females													
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16+**
1982	0.41	0.37	22.53	41.28	269	172.3	90.15	57.82	181.37	152.84	337.25	231.75	117.71	0
1988	0	0.21	3.85	11.7	47.27	35.98	62.44	32.87	62.31	55.98	25.55	77.65	0	104.15
1992	0	0	4.21	4.88	7.67	32.47	28.58	20.72	35.2	24.66	16.18	25.8	22.36	134.69
1993	0	0	5.45	14.86	30.17	42.06	53.67	5.63	2.43	25.19	42.68	26.55	38.77	99.41
1994	0	0	7.69	14.8	45.16	38.83	21.56	45.23	16.55	11.28	55.34	11.75	50.02	128.93
1995	0	0	10	31.4	32.78	47.14	34.28	16.81	23.35	16.56	10.15	30.11	30.32	157.67
1998	0	0.87	3.72	9.78	35.71	37.29	58.62	28.49	40.13	43.26	17.83	24.84	14.62	83.19
2000	0	0.1	3.94	3.86	22.18	27.15	53.22	26.88	33.92	18.95	21.06	15.94	13.8	137.91
2001	0	0	4.11	9.46	13.63	48.23	21.59	85.08	30.82	44.56	15.27	16.01	10.5	134.68
2002	0	0.04	1.38	13.85	20.02	14.87	31.56	22.2	37.67	15.24	31.42	13.78	22.86	105.04
2005	0.86	2.07	13.32	23.35	34.58	31.89	31.31	28.52	24.17	28.67	33.18	19.61	22.53	100.02
2006	0.26	4.43	47.24	24.28	54.33	51.8	38.45	27.34	20.18	11.78	31.92	19.4	28.33	145.96
2007	0	4.02	43.49	56.53	35.95	24.59	20.18	27.42	29.71	16.8	17.94	16.9	8.71	91.65
2008	0	0	12.28	46.14	60.05	42.37	23.47	33.67	32.77	24.79	10.82	13.96	25.29	113.03
2009	0	0.55	9.92	14.33	89.06	61.3	24.44	36.06	26.58	17.58	15.89	12.03	18.55	120.89
2010	0	0	4.59	10.4	16.1	85.19	55.96	28.89	29.6	26.81	13.44	13.31	17.39	117.21
2011	0	0.03	0.61	21.03	34.45	31.66	73.68	60.28	24.6	16.22	26.19	8.6	9.66	116.23
2012	0	0	1.35	9.97	19.64	37.37	39.03	63.35	57.44	40.12	22.53	29.85	10.64	162.65
2013	0	0	3.47	8.83	12.58	37.11	33.53	22.53	48.73	38.42	42.84	28.05	14.08	91.81

Table 10.7 (continued).

	males													
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16+**
1982	0.58	0	22.23	73.69	58.78	95.64	113.81	126.18	144.63	170.99	93.5	155.86	99.64	103.54
1988	0	0.14	3.66	6.49	37.64	36.15	47.49	32.31	102.5	17.23	6.35	28.89	15.16	139.34
1992	0	5.31	16.81	1.29	22.86	29.62	19.29	22.23	46.34	25.41	21.31	19.97	10.93	110.33
1993	0	0	2.94	36.76	14.75	25.43	43.65	15.2	17.67	34.2	42.85	6.14	12.04	124.69
1994	0.18	2	13.65	13.11	57.64	61.53	15.17	30.2	21.32	14.81	57.29	47.05	31.05	128.2
1995	0	0	0	28.54	20.44	84.71	20.96	17.54	38.87	17.38	20.09	17.17	27.44	112.23
1998	0	0.3	5.05	22.12	37.94	34.11	51.34	31.63	26.46	27.3	11.56	18.07	15.01	54.87
2000	0	0	9.04	0.98	20.94	20.93	75.64	44.57	27.81	30.16	21.56	16.45	3.35	134.13
2001	0	0	1.68	17.13	6.41	70.21	46.7	64.95	26.29	52.48	23.07	69.35	5.37	132.58
2002	0	1.01	2.18	13.73	15.76	21.47	30.88	45.28	37.32	20.83	32.13	13.55	32.91	62.78
2005	0.64	4.19	10.18	32.27	23.25	50.37	14.58	43.1	18.7	32.76	41.25	21.95	10.57	56.32
2006	0.09	9.84	46.73	29.28	60.61	61.64	46.65	29.81	24.25	25.34	23.38	55.71	31.55	82.37
2007	1.64	3.98	39.18	63.35	46.71	18.93	21.23	41.58	36.97	6.87	12.81	20.21	20.92	72.91
2008	0	0	6.71	87.18	60.27	14.47	29.59	52.29	13.51	32.08	15.63	18.74	23.65	144.92
2009	0	2.88	6.06	12.58	93.08	83.7	71.81	39.87	23.12	25.57	11.52	39.2	19.17	142.87
2010	0	0.48	6.62	17.02	31.68	61.44	65	40.38	48.41	35.67	30.19	24.47	10.99	154.91
2011	0	1.08	1.4	17.47	47.71	26.43	56.99	63.27	22.49	33.17	31.88	11.36	13.32	149.74
2012	0	0	7.33	3.57	39.68	66.94	25.25	85.81	49.72	33.23	20.86	12.86	9.19	121.85
2013	0	0	1.3	7.11	21.61	46.81	35.16	26.77	51.47	72.59	31.89	16.53	19.41	89.16

Table 10.8. Alaska plaice sample sizes from the BSAI trawl survey. The hauls columns refer to the number (Num.) of hauls from which either lengths or aged otoliths were obtained.

Year	Total Hauls	Hauls w/Lengths	Num. lengths	Hauls w/otoliths	Hauls w/ages	Num. otoliths	Num. ages
1982	334	152	14274	27	27	298	298
1983	353	118	11624				
1984	355	151	14026	32		457	
1985	357	168	10914	24		430	
1986	354	236	12349				
1987	357	172	8533				
1988	373	170	7079	10	10	284	284
1989	374	207	7741				
1990	371	215	7739	10		228	
1991	372	235	8163				
1992	356	219	7584	10	10	311	311
1993	375	241	8365	4	4	183	183
1994	375	248	9299	6	6	228	228
1995	376	252	9919	11	11	287	285
1996	375	254	10186	5		250	
1997	376	248	10143	3		82	
1998	375	281	10101	14	14	420	416
1999	373	268	13024	13		297	
2000	372	250	9803	16	16	368	359
2001	375	261	10990	16	16	339	335
2002	375	251	8409	24	24	359	355
2003	376	252	8343	15		320	
2004	375	262	8578	17		325	
2005	373	262	9284	20	20	341	337
2006	376	255	12097	18	18	362	362
2007	376	261	11729	43	42	343	335
2008	375	252	12804	35	35	342	338
2009	376	233	13547	68	68	620	590
2010	376	225	11366	60	51	627	448
2011	376	236	11514	59	59	571	560
2012	376	240	10399	62	62	484	475
2013	376	221	9705	69	69	544	537
2014	376	215	7296	51		502	

Table 10.9 Estimated maturity at age for female Alaska plaice. Anatomical estimates were estimated by Zhang (1987). Histological estimates (TenBrink and Wilderbuer in review) are used in the assessment.

	proportion mature	
age	Anatomical estimate	Histological estimate
3	0	0.00
4	0	0.02
5	0	0.03
6	0.08	0.08
7	0.2	0.16
8	0.43	0.30
9	0.58	0.50
10	0.79	0.70
11	0.88	0.84
12	0.95	0.92
13	0.97	0.97
14	0.98	0.98
15	0.99	1.00
16	1	1
17	1	1
18	1	1
19	1	1
20	1	1
21	1	1
22	1	1
23	1	1
24	1	1
25	1	1

Table 10.10. Estimated total biomass (ages 3+), female spawner biomass, and recruitment (age 3), with comparison to the 2012 SAFE estimates.

	Female spawning biomass		Total biomass (t)		Age 3 recruitment (millions)	
	2012	2014	2012	2014	2012	2014
1975	93,922	124875	376,087	461354	309	301
1976	115,398	144225	427,654	510624	310	297
1977	143,739	170930	484,362	563145	587	563
1978	173,741	201324	540,118	613486	352	341
1979	199,372	227398	584,939	652100	316	309
1980	222,092	249242	622,927	683520	326	322
1981	245,546	270179	660,681	714743	225	223
1982	269,498	288980	689,595	737346	242	240
1983	291,152	307430	713,892	755708	262	259
1984	309,464	321465	729,366	765685	302	299
1985	317,777	327741	727,772	759120	134	134
1986	315,476	323920	713,605	740553	148	147
1987	304,866	311424	675,243	698174	256	254
1988	296,660	301705	661,991	681595	156	155
1989	276,180	279520	604,079	620520	208	206
1990	274,630	277299	598,868	612766	321	319
1991	272,600	274164	595,635	607320	185	185
1992	266,657	267284	590,641	600509	281	284
1993	259,584	259368	583,070	591526	224	229
1994	256,247	254385	583,736	590827	329	323
1995	254,174	250716	587,994	593997	238	239
1996	249,714	245661	584,441	589519	235	236
1997	248,443	242787	581,303	585652	130	132
1998	245,696	239978	570,552	574341	152	154
1999	248,450	241149	564,212	567282	154	146
2000	249,626	242696	555,980	558167	175	167
2001	251,274	244231	546,637	547727	210	201
2002	251,559	245832	543,417	543054	218	205
2003	248,943	243638	537,335	535629	222	223
2004	245,293	240524	541,091	536820	434	390
2005	242,062	236770	557,301	547828	534	438
2006	236,992	230949	570,451	555093	194	162
2007	231,404	223749	580,344	557979	276	232
2008	229,524	218793	588,615	558513	263	216
2009	234,376	218891	594,890	557008	139	104
2010	244,008	223622	600,677	554461	171	111
2011	251,901	228099	598,432	544393		100
2012	257,418	229250	588,499	522533		
2013		229062		505340		
2014		222922		484582		

Table 10.11 Estimated numbers at age (millions) from the stock assessment model for ages 3-25.

	number of females at age (millions)											
	3	4	5	6	7	8	9	10	11	12	13	14
1975	151	125	137	187	163	106	27	25	15	12	11	9
1976	148	132	110	120	164	143	93	23	22	13	10	9
1977	281	130	116	96	106	144	125	81	20	19	11	9
1978	170	247	114	102	84	93	126	109	70	18	16	10
1979	155	149	217	100	89	74	81	109	94	60	15	14
1980	161	136	131	190	88	78	64	69	93	80	51	13
1981	111	141	119	115	167	77	68	56	60	81	69	44
1982	120	98	124	105	101	146	67	59	48	52	69	59
1983	130	105	86	109	92	89	128	59	52	42	45	60
1984	150	114	92	75	95	80	77	111	51	44	36	39
1985	67	131	100	81	66	83	70	67	95	43	38	30
1986	74	59	115	88	71	58	72	60	57	80	36	31
1987	127	65	51	101	77	62	49	61	49	46	64	29
1988	78	111	57	45	88	67	53	43	52	42	39	54
1989	103	68	98	50	39	76	57	44	34	41	32	30
1990	160	91	60	86	43	34	66	49	38	29	35	28
1991	93	140	80	52	75	38	30	58	42	33	25	30
1992	142	81	123	70	46	66	33	26	49	36	28	21
1993	115	125	71	108	61	40	57	28	22	42	30	23
1994	161	101	109	63	95	53	35	49	24	19	36	26
1995	120	142	88	96	55	83	47	30	42	21	16	30
1996	118	105	124	78	84	48	72	40	26	36	18	13
1997	66	104	92	109	68	73	42	62	34	22	30	15
1998	77	58	91	81	95	59	63	36	52	29	18	25
1999	73	68	51	80	71	83	51	55	30	44	24	15
2000	83	64	59	45	70	62	73	44	47	26	38	20
2001	101	73	56	52	39	61	54	63	38	40	22	32
2002	102	88	64	49	46	34	53	47	54	33	34	19
2003	111	90	77	56	43	40	30	46	40	46	28	29
2004	195	98	79	68	49	38	35	26	40	34	40	24
2005	219	171	86	69	60	43	33	30	22	34	30	34
2006	81	192	150	75	61	52	38	29	26	19	29	25
2007	116	71	169	132	66	53	45	32	24	22	16	24
2008	108	102	63	148	115	57	46	39	27	20	18	13
2009	52	95	89	55	130	101	50	39	33	23	17	15
2010	55	46	83	78	48	113	87	43	34	28	19	14
2011	50	49	40	73	69	42	98	75	36	28	23	16
2012	57	44	43	35	64	60	36	83	63	30	23	19
2013	68	50	38	37	31	56	52	31	71	53	25	20
2014	153	59	44	34	33	27	48	44	26	59	44	21

Table 10.11 (continued) Females

	15	16	17	18	19	20	21	22	23	24	25
1975	8	7	7	6	5	5	4	4	4	3	9
1976	8	7	6	6	5	4	4	4	3	3	11
1977	8	7	6	6	5	4	4	3	3	3	12
1978	8	7	6	5	5	4	4	3	3	3	13
1979	8	7	6	5	5	4	4	3	3	3	13
1980	12	7	6	5	4	4	3	3	3	2	13
1981	11	10	6	5	4	4	3	3	3	2	13
1982	38	9	9	5	4	4	3	3	3	2	13
1983	51	33	8	8	5	4	3	3	2	2	14
1984	52	44	28	7	6	4	3	3	2	2	13
1985	33	44	37	24	6	5	3	3	2	2	13
1986	25	27	36	31	20	5	5	3	2	2	13
1987	25	20	22	29	25	16	4	4	2	2	12
1988	24	21	17	18	24	21	13	3	3	2	11
1989	42	19	16	13	14	19	16	10	3	2	10
1990	25	35	16	14	11	12	16	14	9	2	11
1991	24	22	30	14	12	10	10	14	12	7	11
1992	25	20	18	26	12	10	8	9	12	10	15
1993	18	21	17	15	22	10	8	7	7	10	21
1994	20	15	18	14	13	18	8	7	6	6	26
1995	22	17	13	15	12	11	16	7	6	5	28
1996	25	18	14	11	13	10	9	13	6	5	27
1997	11	21	15	12	9	11	9	8	11	5	27
1998	12	9	18	13	10	7	9	7	6	9	26
1999	21	10	8	15	11	8	6	8	6	5	30
2000	13	18	9	7	13	9	7	5	6	5	30
2001	17	11	15	7	6	11	8	6	5	5	30
2002	27	15	9	13	6	5	9	7	5	4	30
2003	16	23	13	8	11	5	4	8	6	4	29
2004	25	14	20	11	7	9	5	4	7	5	28
2005	20	21	12	17	9	6	8	4	3	6	28
2006	29	17	18	10	14	8	5	7	3	3	29
2007	21	24	15	15	8	12	7	4	6	3	26
2008	20	18	20	12	13	7	10	5	3	5	24
2009	11	17	15	17	10	11	6	8	5	3	24
2010	13	9	14	12	14	8	9	5	7	4	23
2011	12	11	8	12	10	12	7	7	4	6	22
2012	13	10	9	6	10	8	10	6	6	3	23
2013	16	11	8	7	5	8	7	8	5	5	22
2014	16	13	9	7	6	4	7	6	7	4	22

Table 10.11 (continued) Male numbers at age (millions)

	3	4	5	6	7	8	9	10	11	12	13	14
1975	151	125	137	187	163	106	27	25	15	12	11	9
1976	148	132	110	120	164	143	93	23	22	13	10	9
1977	281	130	116	96	106	144	125	81	20	19	11	9
1978	170	247	114	102	84	93	126	110	71	18	16	10
1979	155	149	217	100	89	74	81	109	94	61	15	14
1980	161	136	131	190	88	78	64	70	94	81	51	13
1981	111	141	119	115	167	77	68	56	61	81	70	44
1982	120	98	124	105	101	146	67	59	48	52	70	60
1983	130	105	86	109	92	88	128	59	52	42	45	61
1984	150	114	92	75	95	80	77	111	51	45	36	39
1985	67	131	100	81	66	83	70	67	95	43	38	31
1986	74	59	115	88	71	57	72	60	57	81	37	32
1987	127	65	51	101	76	61	49	61	50	47	66	29
1988	78	111	57	45	88	67	53	43	52	43	40	56
1989	103	68	98	49	39	76	56	44	35	42	34	31
1990	160	91	60	85	43	34	66	49	38	30	36	29
1991	93	140	80	52	75	38	30	57	42	33	26	31
1992	142	81	123	70	46	65	33	26	49	36	28	22
1993	115	125	71	108	61	40	57	28	22	42	31	24
1994	161	101	109	63	94	53	35	49	24	19	36	26
1995	120	142	88	96	55	82	46	30	43	21	16	31
1996	118	105	124	77	84	48	72	40	26	36	18	14
1997	66	104	92	109	68	73	41	62	34	22	31	15
1998	77	58	91	81	95	59	63	36	53	29	18	25
1999	73	68	51	80	71	83	51	55	31	45	25	16
2000	83	64	59	45	70	62	72	44	47	26	38	21
2001	101	73	56	52	39	61	54	62	38	40	22	32
2002	102	88	64	49	45	34	53	47	54	33	35	19
2003	111	90	77	56	43	40	30	46	40	46	28	30
2004	195	98	79	68	49	38	35	26	40	35	40	24
2005	219	171	86	69	59	43	33	30	22	34	30	34
2006	81	192	150	75	61	52	38	29	26	19	29	26
2007	116	71	169	132	66	53	45	32	24	22	16	25
2008	108	102	62	148	115	57	46	39	28	21	19	14
2009	52	95	89	55	129	100	50	39	33	23	17	16
2010	55	46	83	78	48	113	87	43	34	28	20	15
2011	50	49	40	73	68	42	98	75	37	29	24	17
2012	57	44	43	35	64	59	36	84	63	31	24	20
2013	68	50	38	37	31	55	52	31	71	54	26	20
2014	153	59	44	34	33	27	48	44	26	60	45	21

Table 10.11 (continued) Males (continued)

	15	16	17	18	19	20	21	22	23	24	25
1975	8	7	7	6	5	5	4	4	4	3	9
1976	8	7	6	6	5	4	4	4	3	3	11
1977	8	7	6	6	5	4	4	3	3	3	12
1978	8	7	6	5	5	4	4	3	3	3	13
1979	8	7	6	5	5	4	4	3	3	3	13
1980	12	7	6	5	4	4	3	3	3	2	13
1981	11	10	6	5	4	4	3	3	3	2	13
1982	38	10	9	5	4	4	3	3	3	2	13
1983	52	33	8	8	5	4	3	3	2	2	14
1984	52	45	28	7	7	4	3	3	2	2	13
1985	33	44	38	24	6	5	3	3	2	2	13
1986	26	28	37	31	20	5	5	3	2	2	13
1987	26	21	22	29	25	16	4	4	2	2	12
1988	25	22	17	19	25	21	13	3	3	2	11
1989	43	19	17	13	14	19	16	10	3	2	10
1990	26	36	16	14	11	12	16	14	9	2	11
1991	25	23	31	14	12	10	10	14	12	7	11
1992	26	21	19	26	12	10	8	9	12	10	16
1993	18	22	17	16	22	10	9	7	7	10	21
1994	20	16	19	15	14	19	8	7	6	6	27
1995	22	17	13	16	13	12	16	7	6	5	28
1996	26	19	14	11	13	11	10	13	6	5	28
1997	12	22	16	12	9	11	9	8	11	5	27
1998	12	10	18	13	10	8	9	7	7	9	27
1999	22	11	8	15	11	8	7	8	6	6	31
2000	13	18	9	7	13	9	7	6	7	5	31
2001	18	11	15	8	6	11	8	6	5	6	30
2002	28	15	10	13	6	5	9	7	5	4	31
2003	16	24	13	8	11	5	4	8	6	4	30
2004	25	14	20	11	7	10	5	4	7	5	29
2005	21	22	12	17	9	6	8	4	3	6	29
2006	29	18	18	10	15	8	5	7	3	3	30
2007	21	25	15	15	9	12	7	4	6	3	27
2008	21	18	20	12	13	7	10	6	4	5	25
2009	11	17	15	17	10	11	6	9	5	3	25
2010	13	10	14	12	14	9	9	5	7	4	23
2011	12	11	8	12	10	12	7	8	4	6	23
2012	14	10	9	7	10	9	10	6	6	3	24
2013	16	11	8	8	5	8	7	8	5	5	23
2014	16	14	9	7	6	4	7	6	7	4	23

Table 10.12 Estimate of the number of female spawners (millions), at age, from the stock assessment model.

	6	7	8	9	10	11	12	13	14
1975	0	2	5	14	26	32	13	17	13
1976	0	2	4	9	26	43	46	16	18
1977	0	2	4	7	17	44	63	56	17
1978	0	4	4	8	13	28	63	76	59
1979	0	2	7	8	14	22	40	76	79
1980	0	2	5	14	14	24	32	48	78
1981	0	2	4	9	27	23	34	39	51
1982	0	1	4	8	16	44	34	41	41
1983	0	2	3	8	15	27	64	41	43
1984	0	2	3	6	15	24	39	77	43
1985	0	2	3	6	10	25	35	47	80
1986	0	1	4	7	11	17	36	42	48
1987	0	1	2	8	12	19	25	42	42
1988	0	2	2	3	14	20	27	30	44
1989	0	1	3	4	6	23	28	31	29
1990	0	1	2	7	7	10	33	34	32
1991	0	2	3	4	12	12	15	40	36
1992	0	1	4	5	7	20	17	18	42
1993	0	2	2	8	10	12	29	20	19
1994	0	2	4	5	15	16	17	34	21
1995	0	2	3	7	9	25	23	21	36
1996	0	2	4	6	13	15	36	28	22
1997	0	2	3	8	11	22	21	43	29
1998	0	1	3	6	15	18	32	25	44
1999	0	1	2	6	11	25	26	38	26
2000	0	1	2	3	11	19	36	31	39
2001	0	1	2	4	6	19	27	44	32
2002	0	1	2	4	7	10	27	33	46
2003	0	1	3	4	7	12	15	32	34
2004	0	1	3	5	8	11	17	18	33
2005	0	3	3	5	9	13	17	21	19
2006	0	3	5	6	10	16	19	20	22
2007	0	1	6	10	10	16	23	23	20
2008	0	2	2	11	18	17	23	27	23
2009	0	1	3	4	21	30	25	27	28
2010	0	1	3	6	8	34	44	30	28
2011	0	1	1	6	11	13	49	52	31
2012	0	1	1	3	10	18	18	58	53
2013	0	1	1	3	5	17	26	22	60
2014	0	1	2	3	5	8	24	31	22

Table 10.12 continued.

	15	16	17	18	19	20	21	22	23	24	25+
1975	8	7	7	6	5	5	4	4	4	3	9
1976	8	7	6	6	5	4	4	4	3	3	11
1977	8	7	6	6	5	4	4	3	3	3	12
1978	8	7	6	5	5	4	4	3	3	3	13
1979	8	7	6	5	5	4	4	3	3	3	13
1980	12	7	6	5	4	4	3	3	3	2	13
1981	11	10	6	5	4	4	3	3	3	2	13
1982	37	9	9	5	4	4	3	3	3	2	13
1983	51	33	8	8	5	4	3	3	2	2	14
1984	51	44	28	7	6	4	3	3	2	2	13
1985	32	43	37	24	6	5	3	3	2	2	13
1986	25	27	36	31	20	5	5	3	2	2	13
1987	25	20	22	29	25	16	4	4	2	2	12
1988	24	21	17	18	24	21	13	3	3	2	11
1989	41	19	16	13	14	19	16	10	3	2	10
1990	25	35	16	14	11	12	16	14	9	2	11
1991	23	22	30	14	12	10	10	14	12	7	11
1992	25	20	18	26	12	10	8	9	12	10	15
1993	18	21	17	15	22	10	8	7	7	10	21
1994	20	15	18	14	13	18	8	7	6	6	26
1995	22	17	13	15	12	11	16	7	6	5	28
1996	25	18	14	11	13	10	9	13	6	5	27
1997	11	21	15	12	9	11	9	8	11	5	27
1998	12	9	18	13	10	7	9	7	6	9	26
1999	21	10	8	15	11	8	6	8	6	5	30
2000	13	18	9	7	13	9	7	5	6	5	30
2001	17	11	15	7	6	11	8	6	5	5	30
2002	27	15	9	13	6	5	9	7	5	4	30
2003	16	23	13	8	11	5	4	8	6	4	29
2004	25	14	20	11	7	9	5	4	7	5	28
2005	20	21	12	17	9	6	8	4	3	6	28
2006	29	17	18	10	14	8	5	7	3	3	29
2007	21	24	15	15	8	12	7	4	6	3	26
2008	20	17	20	12	13	7	10	5	3	5	24
2009	11	17	15	17	10	11	6	8	5	3	24
2010	13	9	14	12	14	8	9	5	7	4	23
2011	12	11	8	12	10	12	7	7	4	6	22
2012	13	10	9	6	10	8	10	6	6	3	23
2013	16	11	8	7	5	8	7	8	5	5	22
2014	16	13	9	7	6	4	7	6	7	4	22

Table 10.13. Projections of spawning biomass (1,000s t), catch (1,000s t), and fishing mortality rate for each of the several scenarios. The values of $B_{40\%}$ and $B_{35\%}$ are 142,100 t and 124,300 t, respectively.

Scenarios 1 and 2

Maximum ABC harvest permissible

Year	Female spwn bio	catch	F
2014	222.92	19.00	0.057
2015	211.18	44.89	0.143
2016	186.74	39.83	0.143
2017	164.94	35.25	0.143
2018	147.51	31.54	0.143
2019	135.87	27.69	0.137
2020	130.64	25.49	0.131
2021	130.15	25.24	0.131
2022	131.93	25.91	0.132
2023	134.37	26.82	0.134
2024	136.77	27.68	0.136
2025	138.89	28.41	0.137
2026	140.62	28.98	0.138
2027	141.96	29.41	0.138

Scenario 3

1/2 Maximum ABC harvest permissible

Year	Female spwn bio	catch	F
2014	222.92	19.00	0.057
2015	214.80	22.44	0.069
2016	202.92	20.43	0.067
2017	191.11	19.26	0.067
2018	180.95	18.22	0.067
2019	174.17	17.49	0.067
2020	171.66	17.17	0.067
2021	172.82	17.25	0.067
2022	176.11	17.57	0.067
2023	180.27	18.00	0.067
2024	184.60	18.46	0.067
2025	188.79	18.91	0.067
2026	192.64	19.31	0.067
2027	196.04	19.67	0.067

Scenario 4

Harvest at average F over the past 5 years

Year	Female spwn bio	catch	F
2014	222.92	19.00	0.057
2015	215.51	17.90	0.055
2016	205.94	18.04	0.058
2017	195.35	17.13	0.058
2018	186.14	16.30	0.058
2019	180.09	15.73	0.058
2020	178.15	15.50	0.058
2021	179.78	15.60	0.058
2022	183.50	15.92	0.058
2023	188.07	16.33	0.058
2024	192.81	16.76	0.058
2025	197.39	17.18	0.058
2026	201.62	17.57	0.058
2027	205.38	17.92	0.058

Scenario 5

No fishing

Year	Female spwn bio	catch	F
2014	222.923	19.00	0.0567
2015	218.261	0	0
2016	219.182	0	0
2017	218.458	0	0
2018	217.838	0	0
2019	219.118	0	0
2020	223.498	0	0
2021	230.808	0	0
2022	239.903	0	0
2023	249.692	0	0
2024	259.533	0	0
2025	269.08	0	0
2026	278.11	0	0
2027	286.455	0	0

Table 10.13- continued.

Scenario 6
Determination of overfishing

B_{35}=124,300

Year	Female spwn bio	catch	F
2014	222.92	19.00	0.057
2015	209.65	**54.04**	0.175
2016	180.29	46.66	0.175
2017	155.16	40.26	0.175
2018	135.92	33.74	0.167
2019	124.14	28.03	0.152
2020	119.59	25.89	0.146
2021	119.68	25.89	0.146
2022	121.85	26.89	0.149
2023	124.44	28.12	0.152
2024	126.77	29.25	0.155
2025	128.65	30.16	0.157
2026	130.04	30.82	0.159
2027	131.00	31.28	0.160

Scenario 7
Determination of whether Alaska plaice are approaching an overfished condition

B_{35}=124,300

Year	Female spwn bio	catch	F
2014	222.92	19.00	0.057
2015	211.18	44.89	0.143
2016	186.74	39.83	0.143
2017	163.75	42.44	0.175
2018	142.53	36.97	0.175
2019	128.62	30.10	0.158
2020	122.62	27.23	0.150
2021	121.71	26.78	0.149
2022	123.16	27.47	0.151
2023	125.25	28.49	0.153
2024	127.26	29.47	0.155
2025	128.92	30.28	0.157
2026	130.18	30.88	0.159
2027	131.06	31.30	0.160

Figures

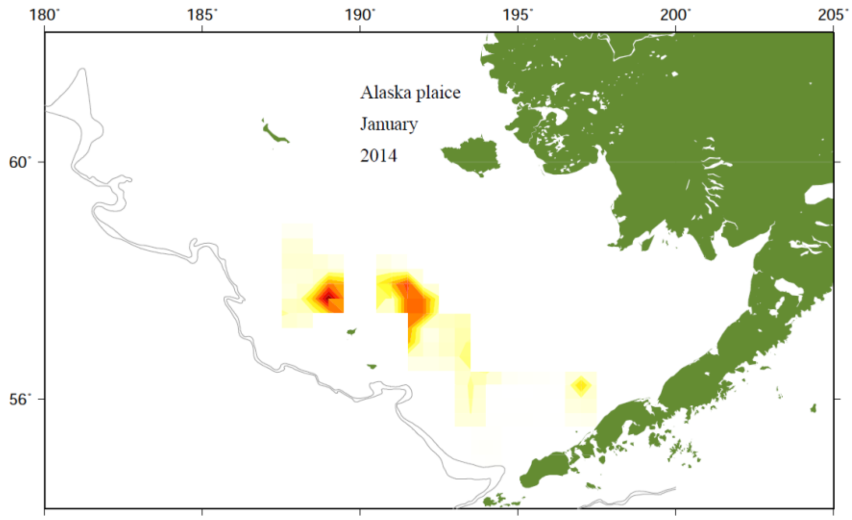


Figure 10.1--Locations of Alaska plaice catch in 2012, by month. The harvest primarily occurred in the yellowfin sole fishery and rock sole fisheries.

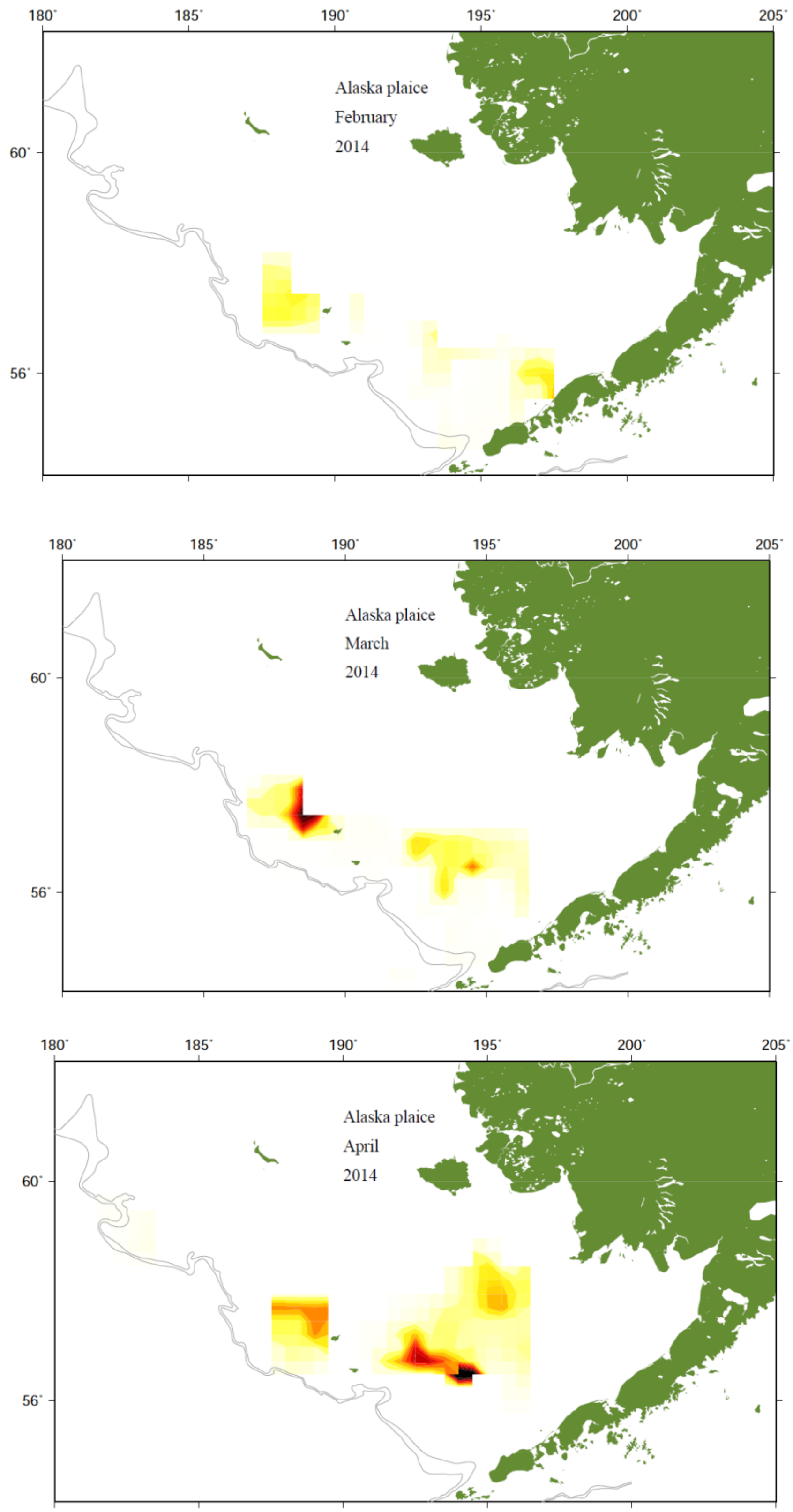


Figure 10.1 (continued).

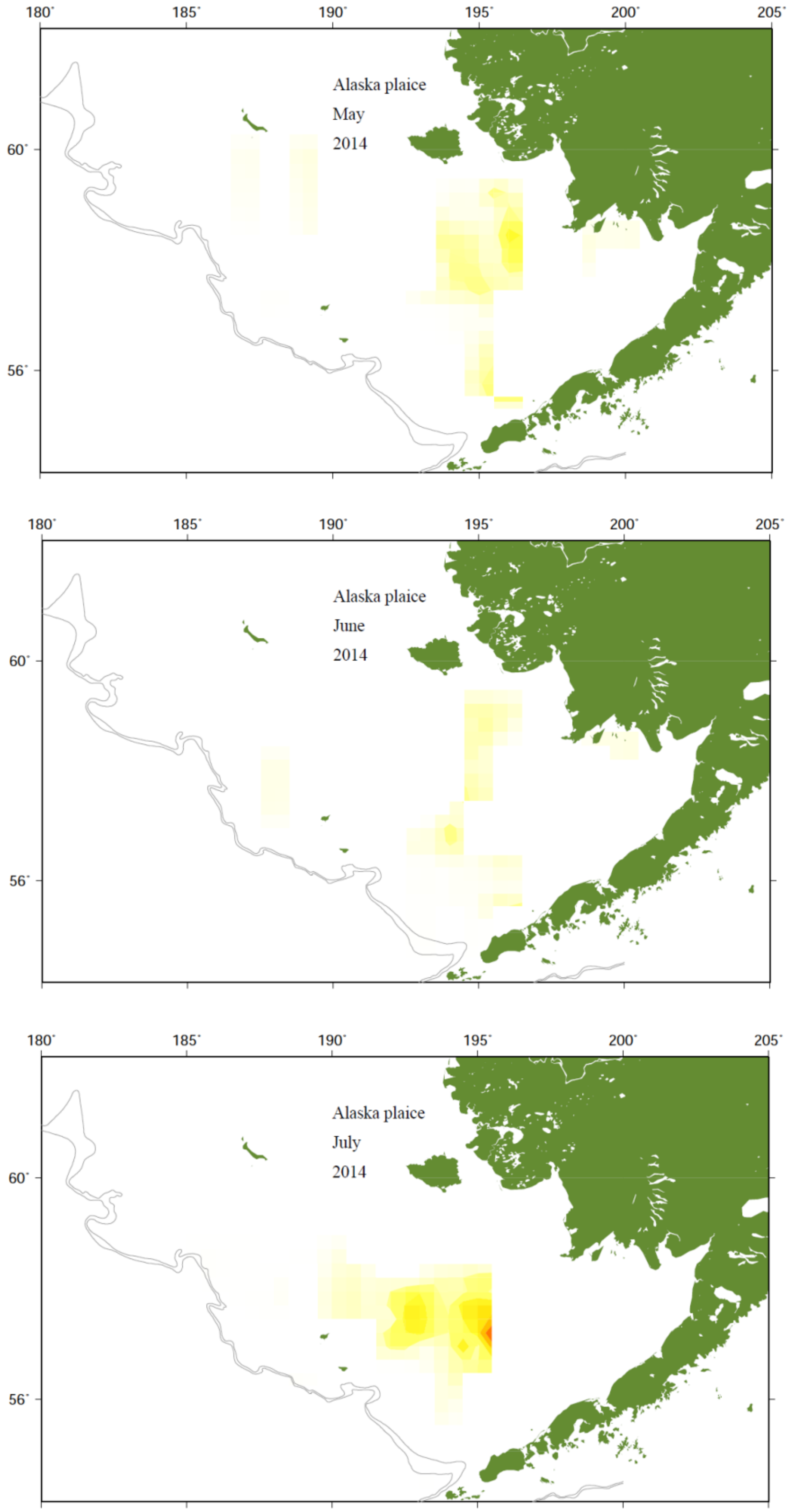


Figure 10.1--(Continued).

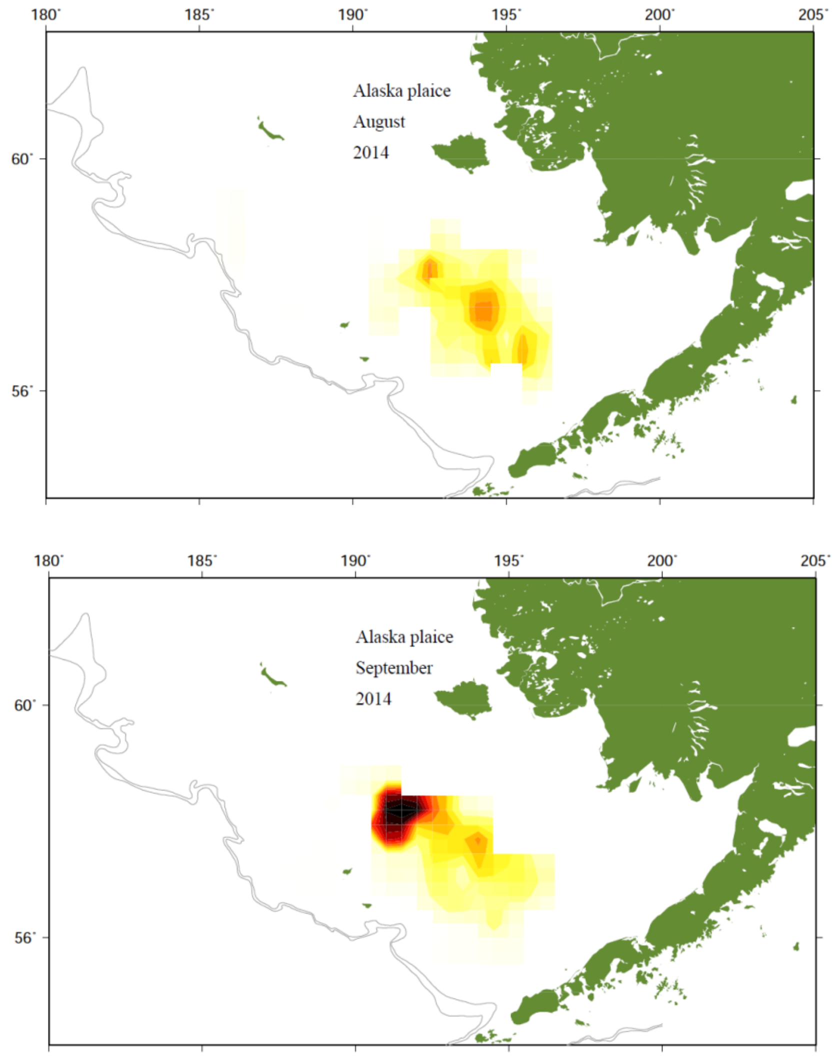


Figure 10.1--(Continued).

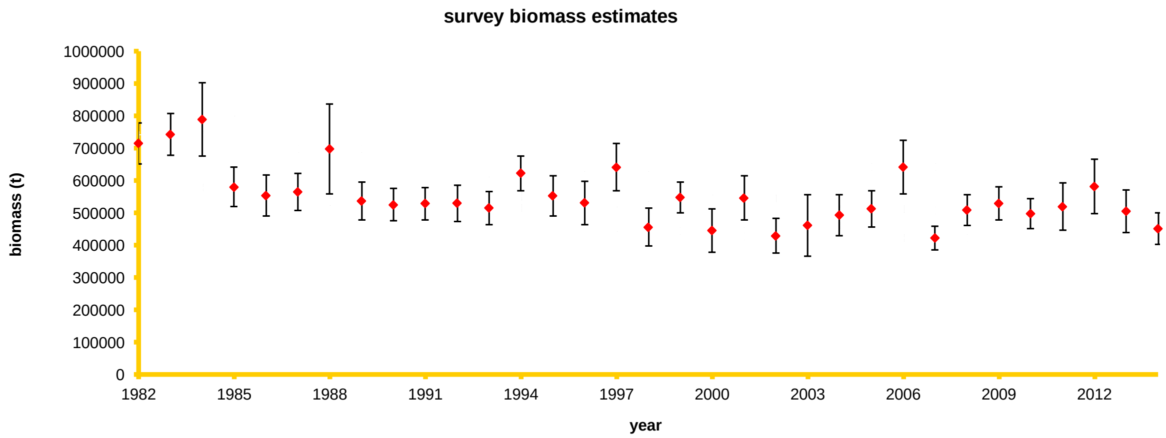


Figure 10.2--Estimated survey biomass and 95% confidence intervals from NMFS eastern Bering Sea bottom trawl surveys.

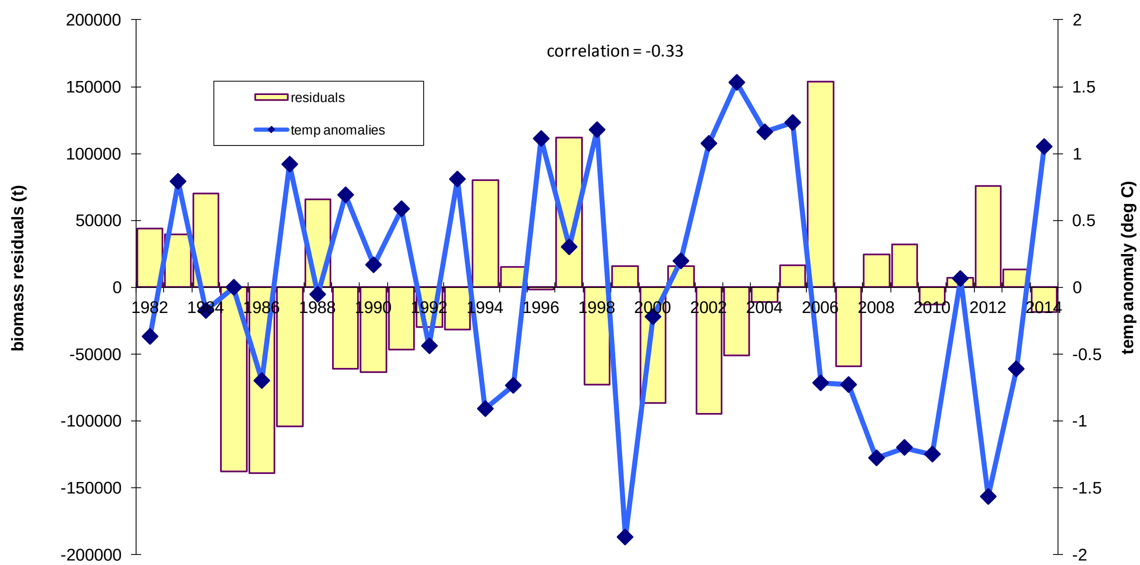


Figure 10.3--Residuals from fitting the trawl survey biomass (bars) compared to the average annual bottom temperature anomalies (degrees Celcius) obtained during the trawl survey.

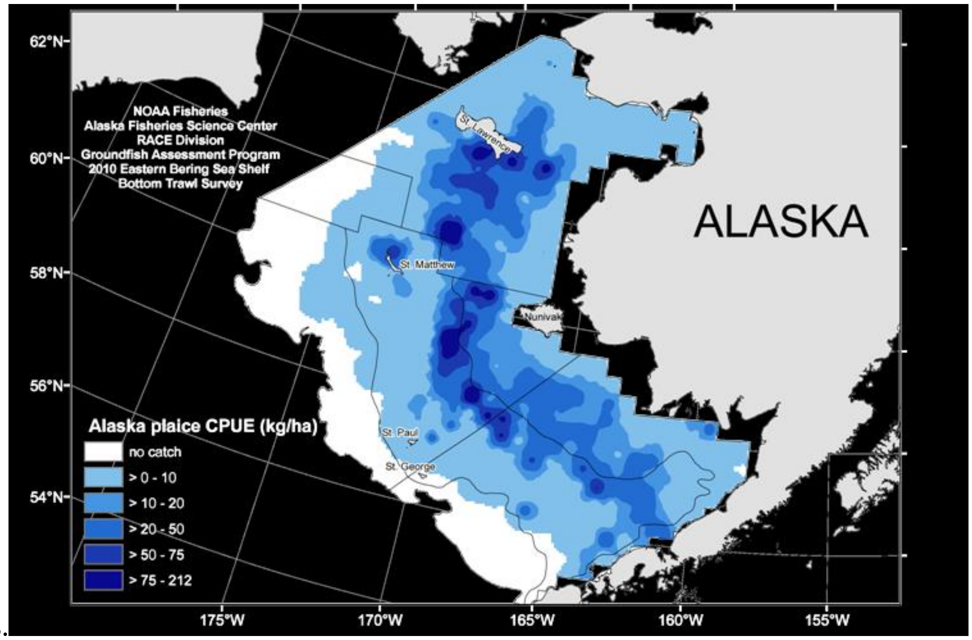
surveys.

Figure 10.4.--Eastern and northern Bering Sea survey CPUE (kg/ha) of Alaska plaice from 2010.

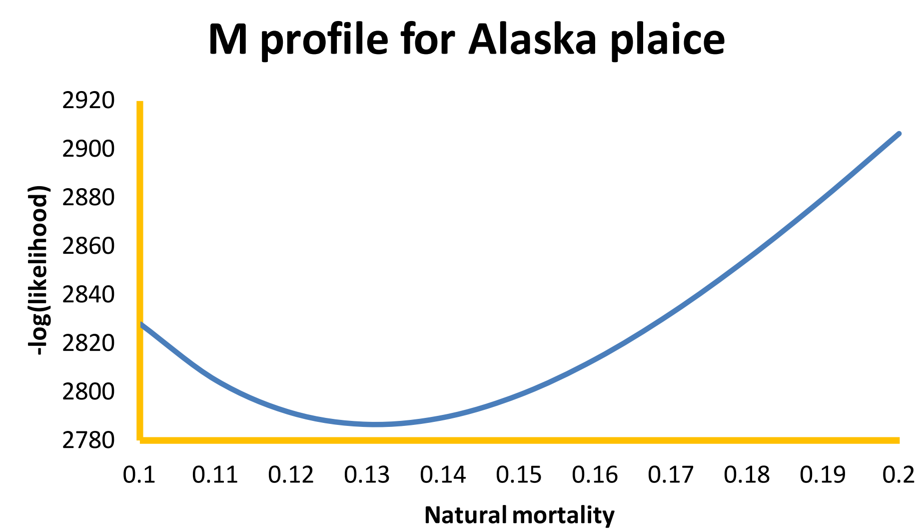
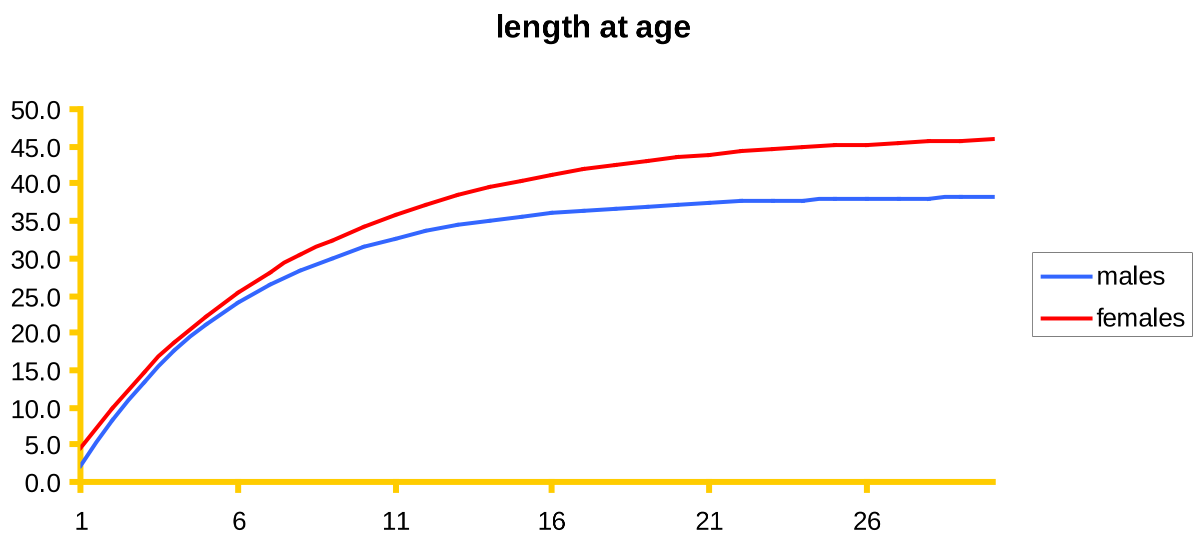


Figure 10.5 -- Stock assessment model fit (in terms of –log(likelihood)) to a range of male and female natural mortality values.



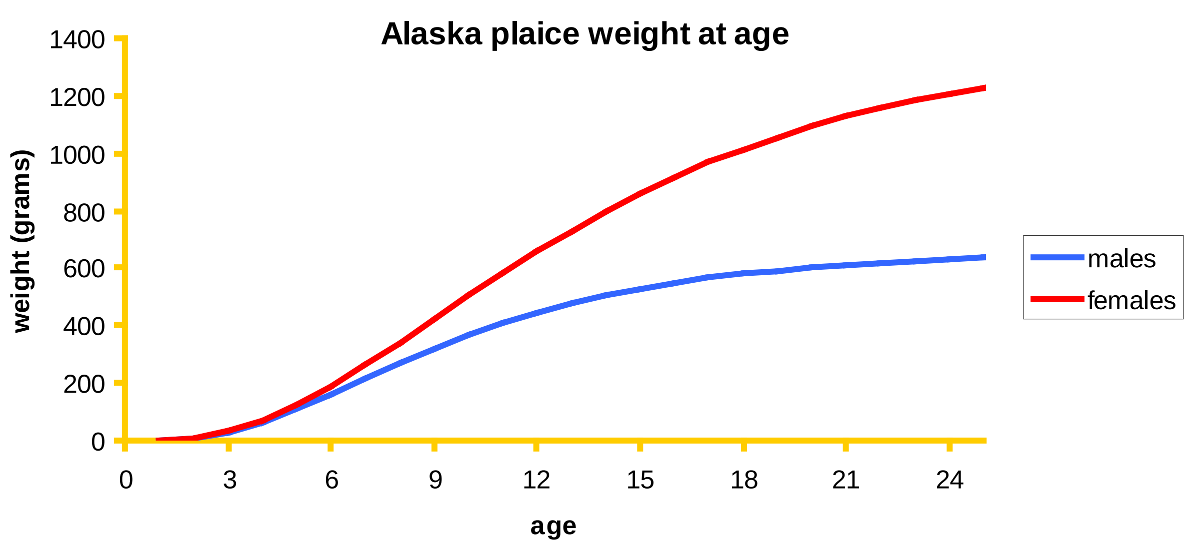


Figure 10.6-- Estimated length and weight-at-age relationships for Alaska plaice used in the 2014 assessment.

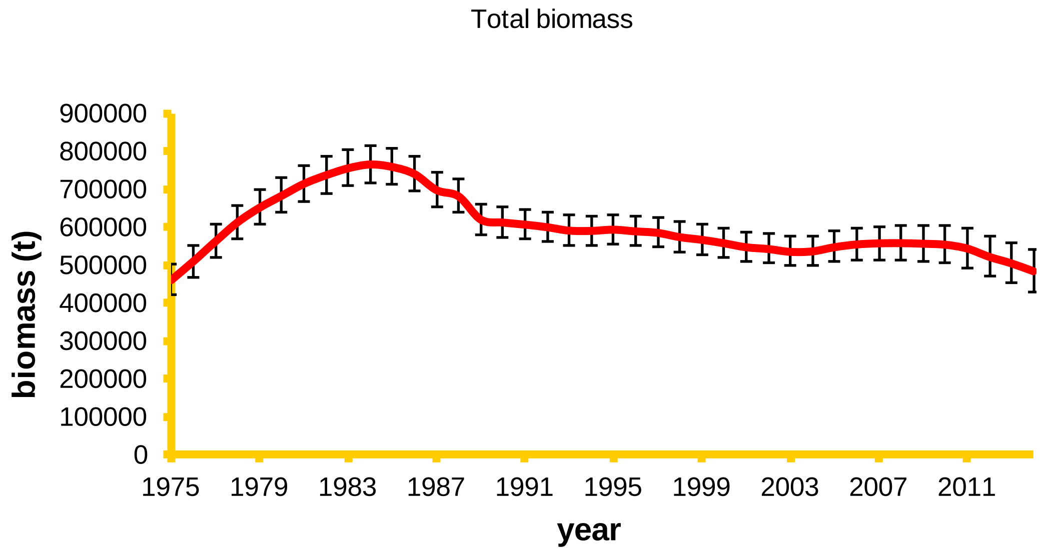


Figure 10.7--Estimated beginning year total biomass of Alaska plaice from the assessment model. 95% percent confidence intervals are from mcmc integration.

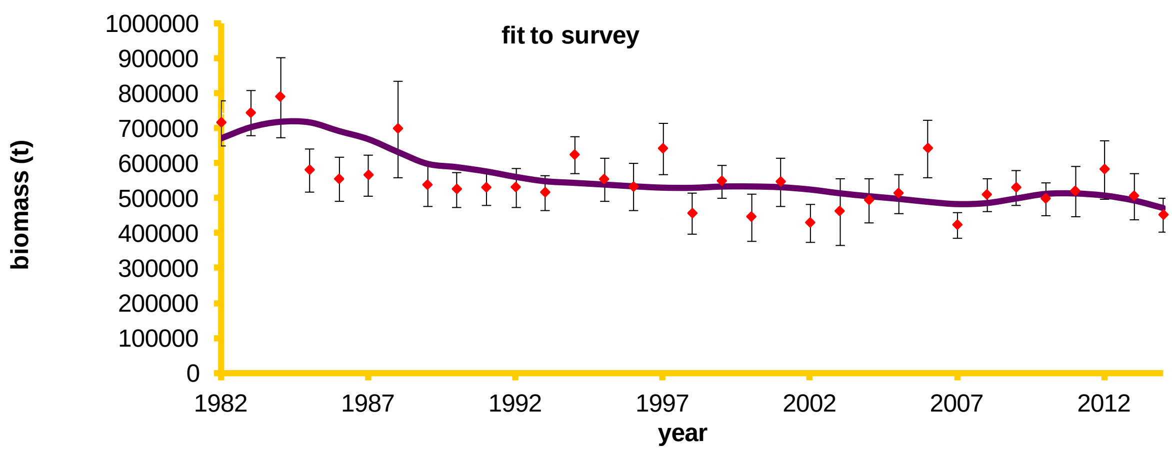


Figure 10.8--Observed (data points) and predicted (solid line) survey biomass of Alaska plaice.

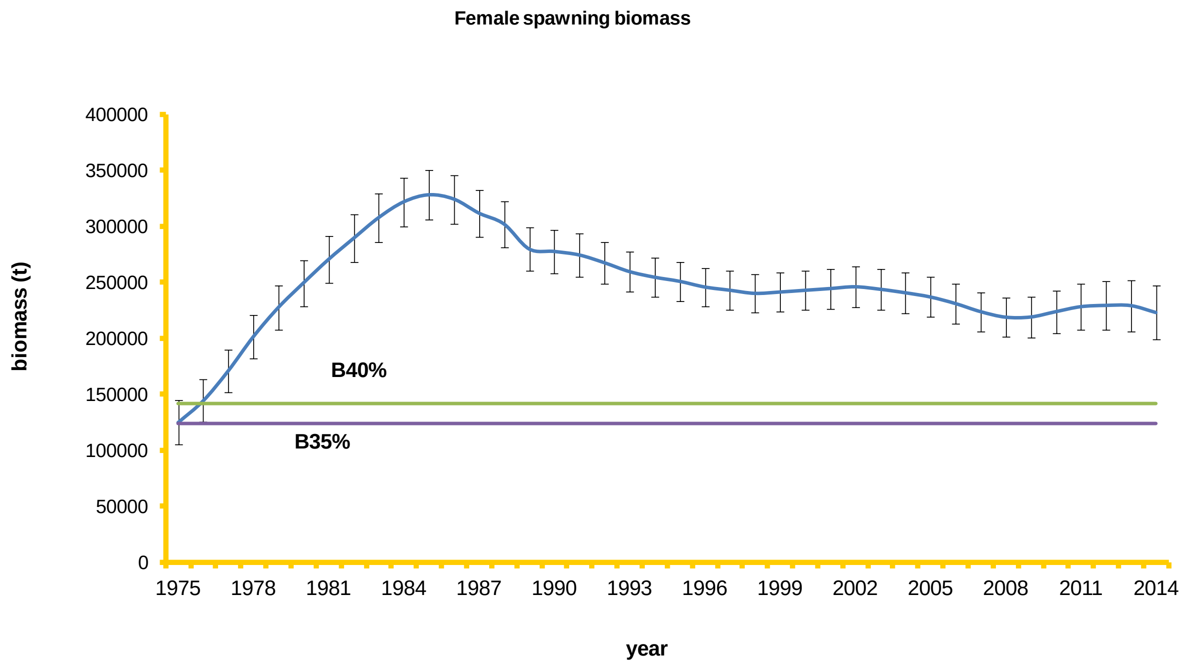


Figure 10.9--Model estimates of Alaska plaice female spawning biomass with estimates of B_{35} and B_{40}. Ninety-five percent credible intervals are from MCMC integration.

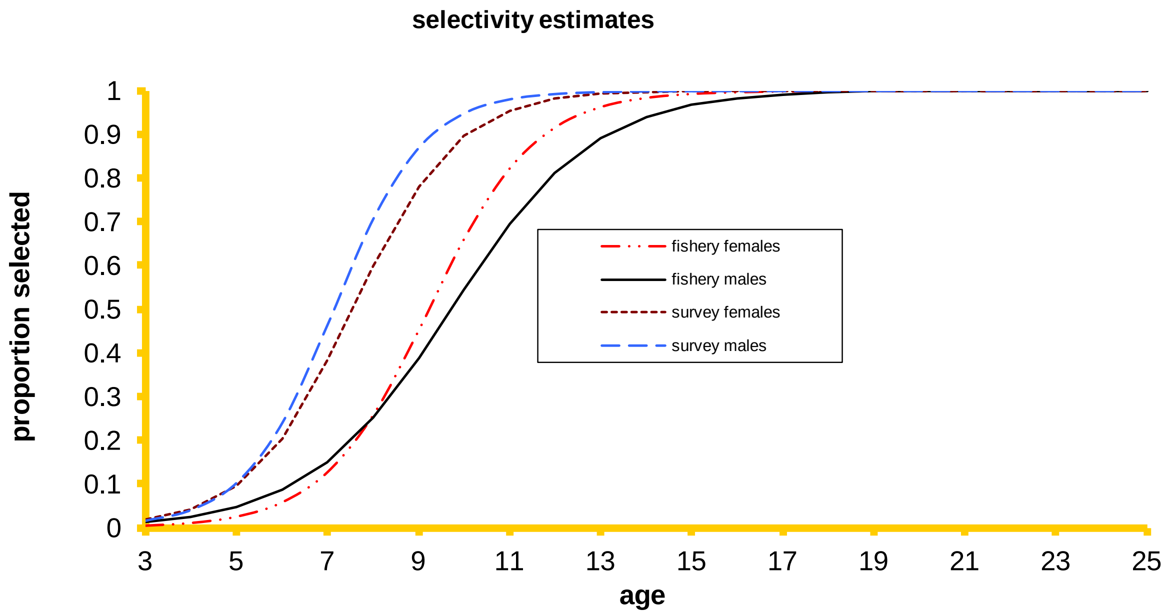


Figure 10.10--Model estimates of survey and fishery selectivity.

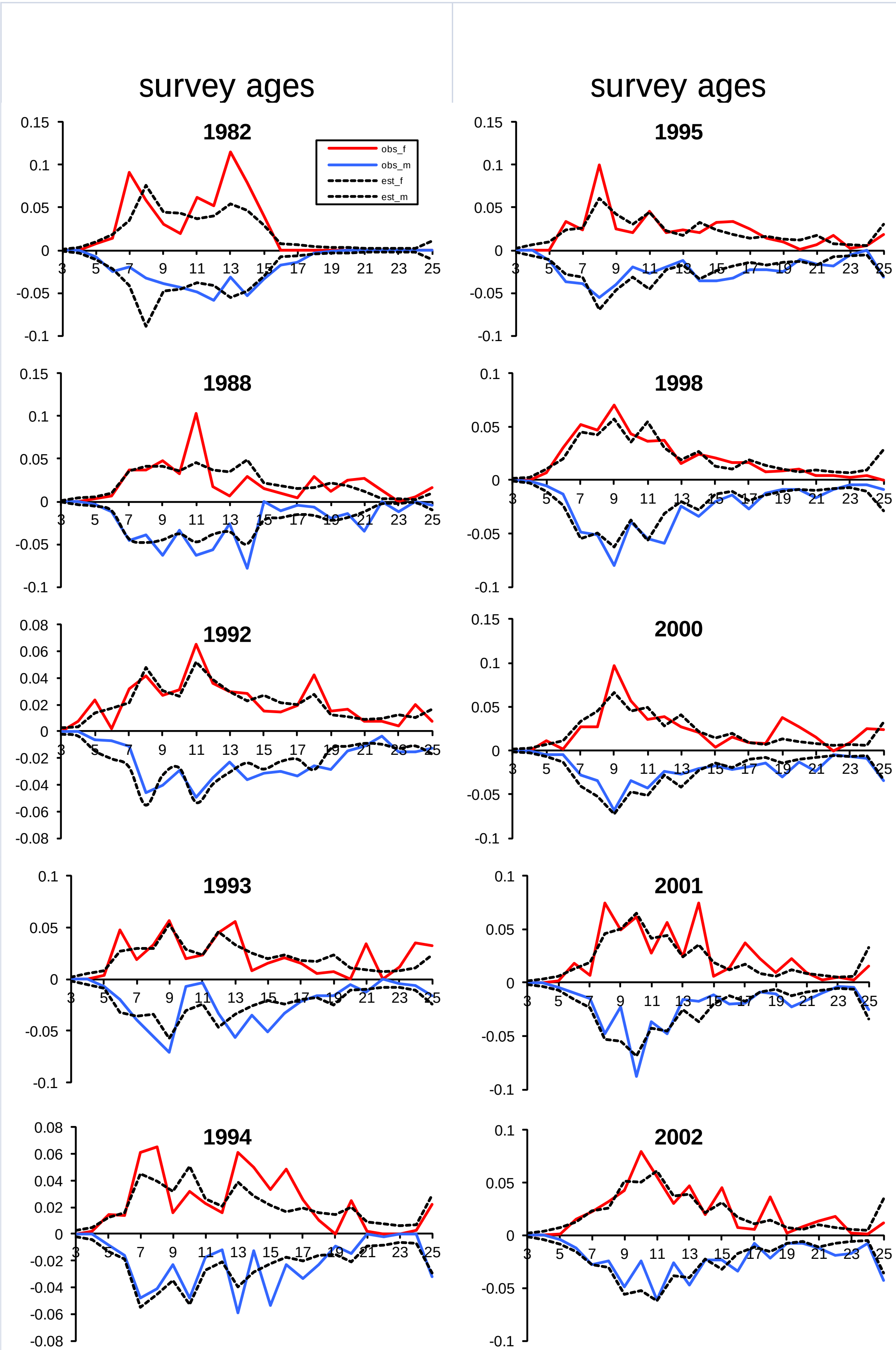


Figure 10.11--Survey age composition (solid line = observed, dotted line = predicted, females above x axis, males below x axis).

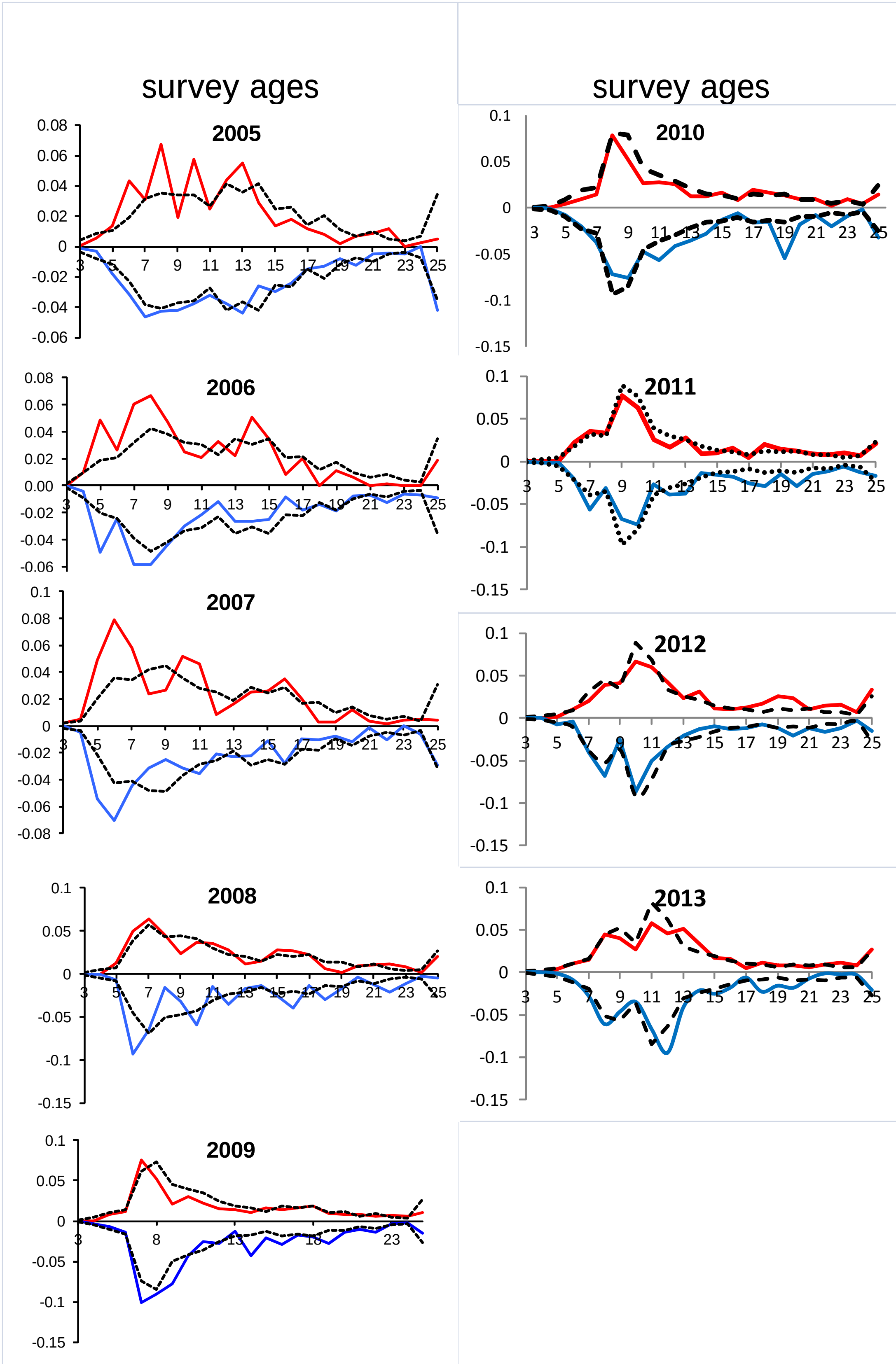


Figure 10.11—(continued).

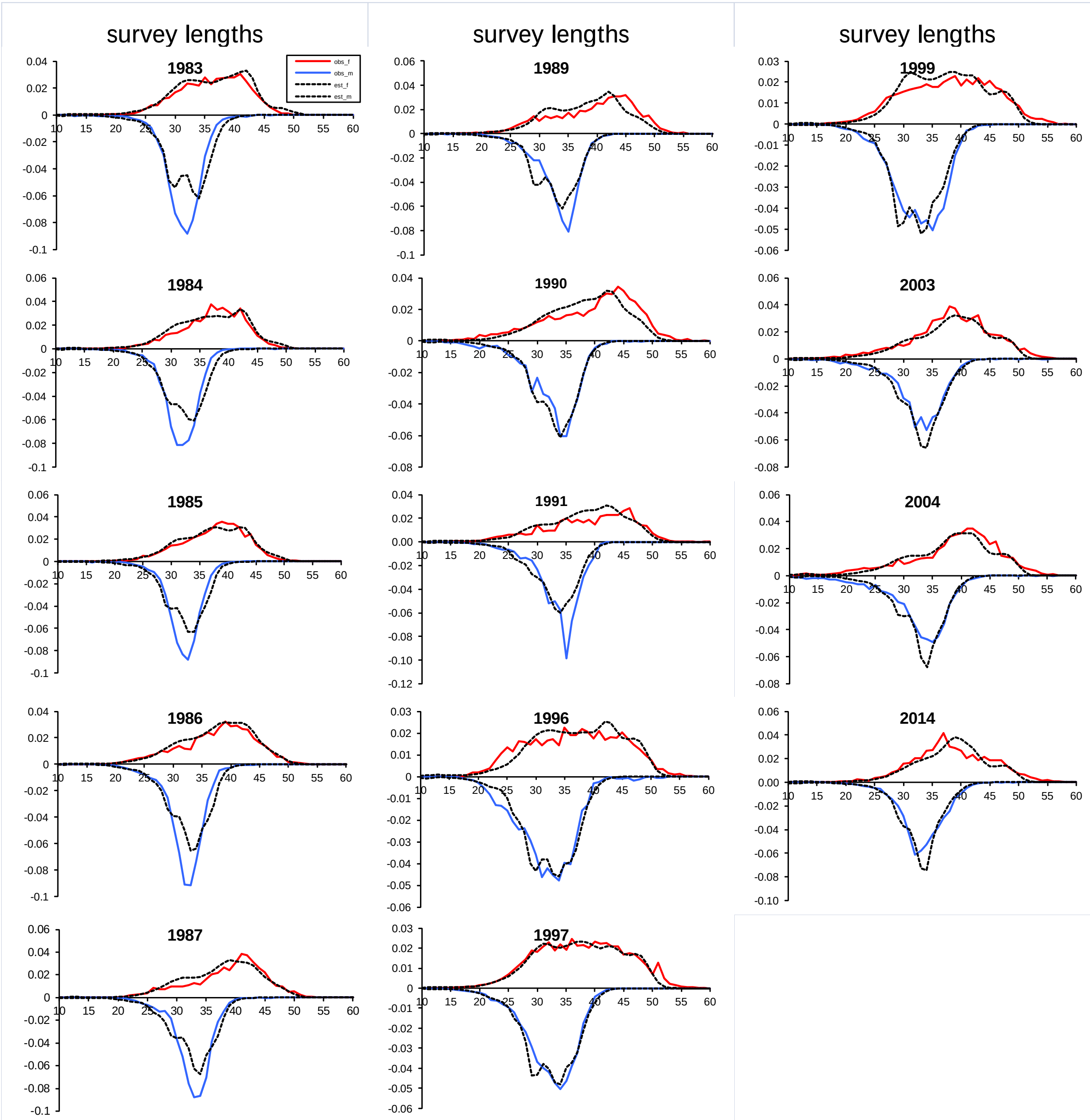


Figure 10.12--Survey length composition by year (solid line = observed, dotted line = predicted, females above x axis, males below x axis).)

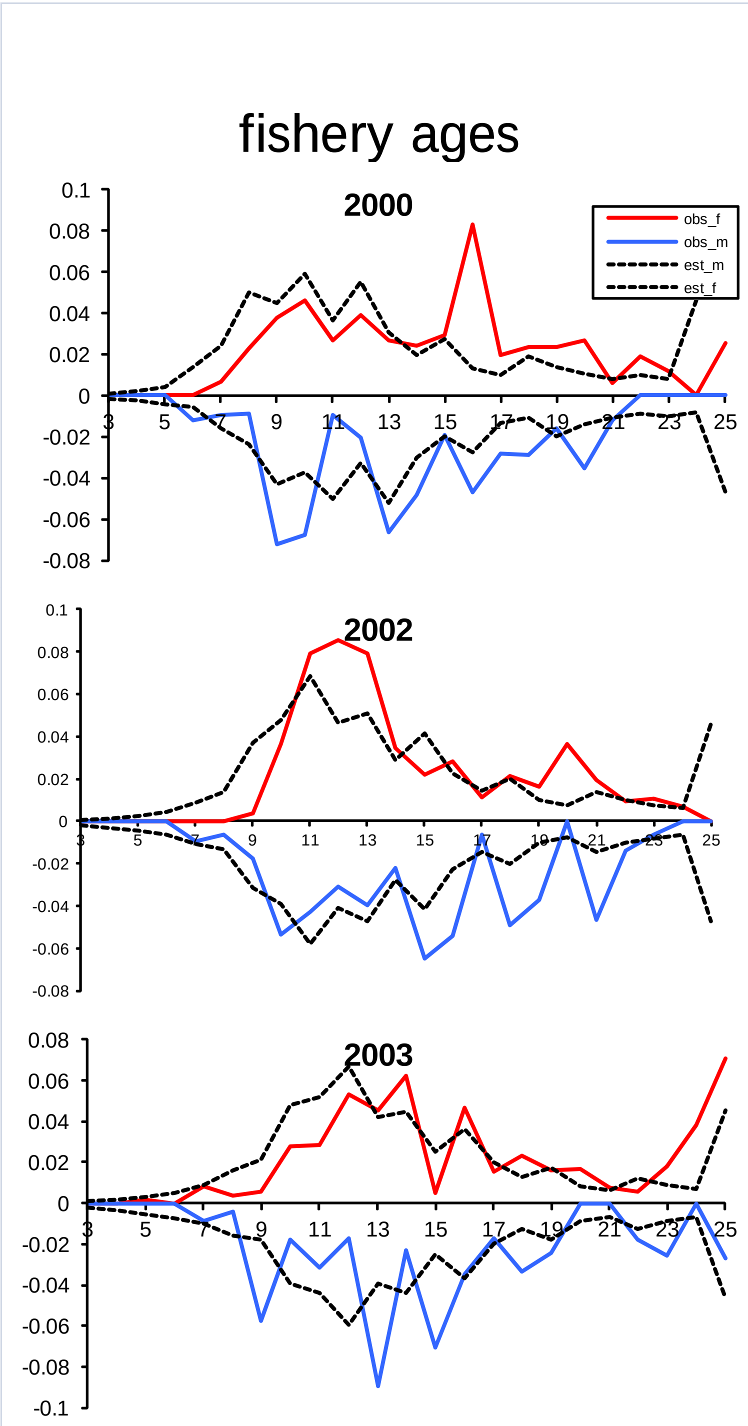


Figure 10.13--Fishery age composition by year (solid line = observed, dotted line = predicted, females above x axis, males below x axis).

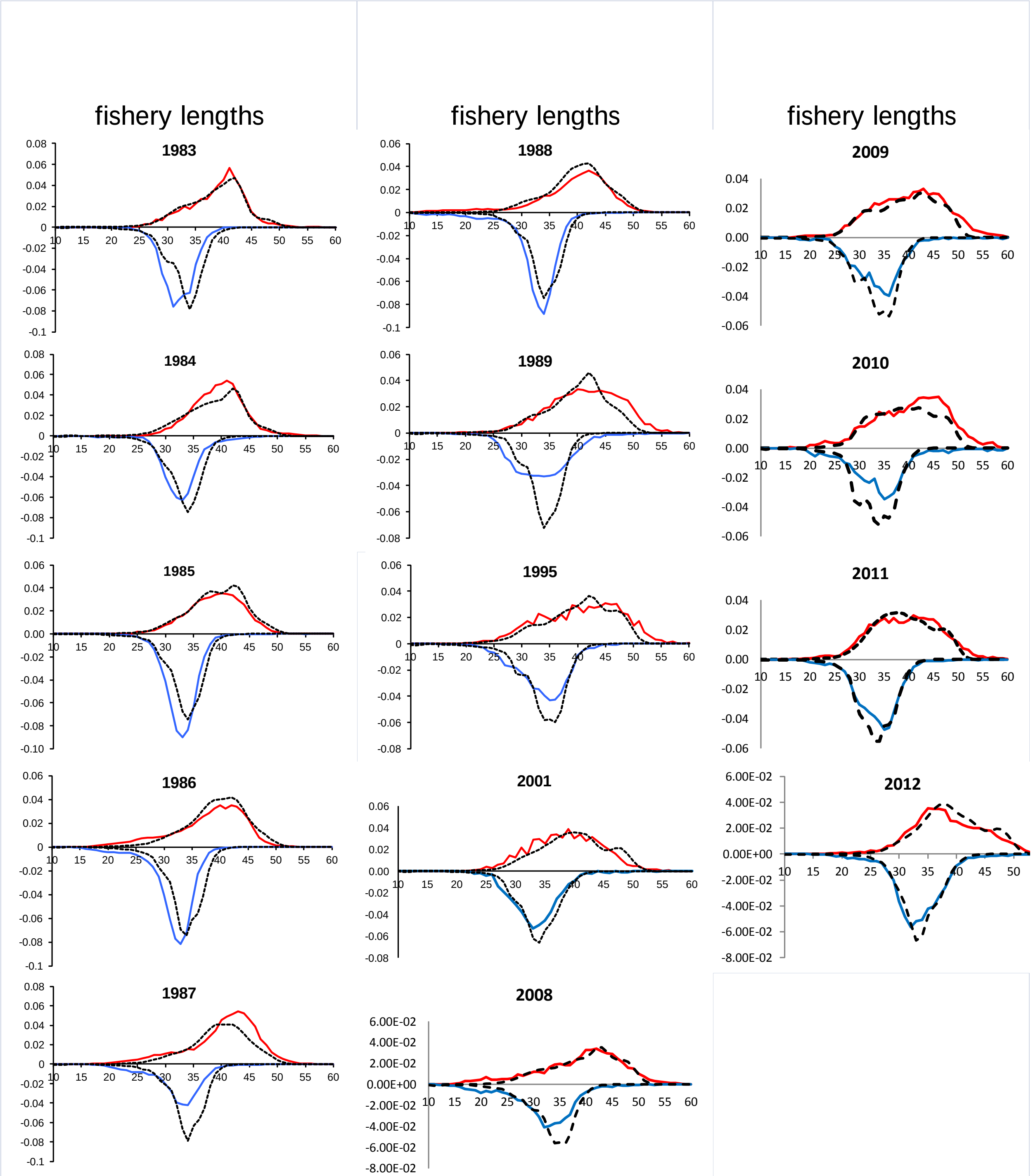


Figure 10.14--Fishery length composition by year (solid line = observed, dotted line = predicted, females above x axis, males below x axis).

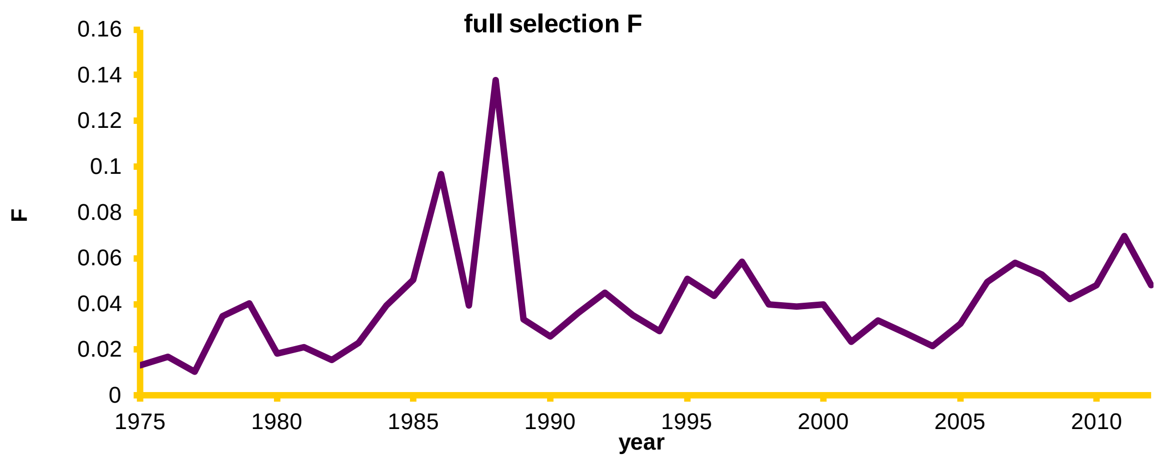


Figure 10.15--Estimated fully selected fishing mortality.

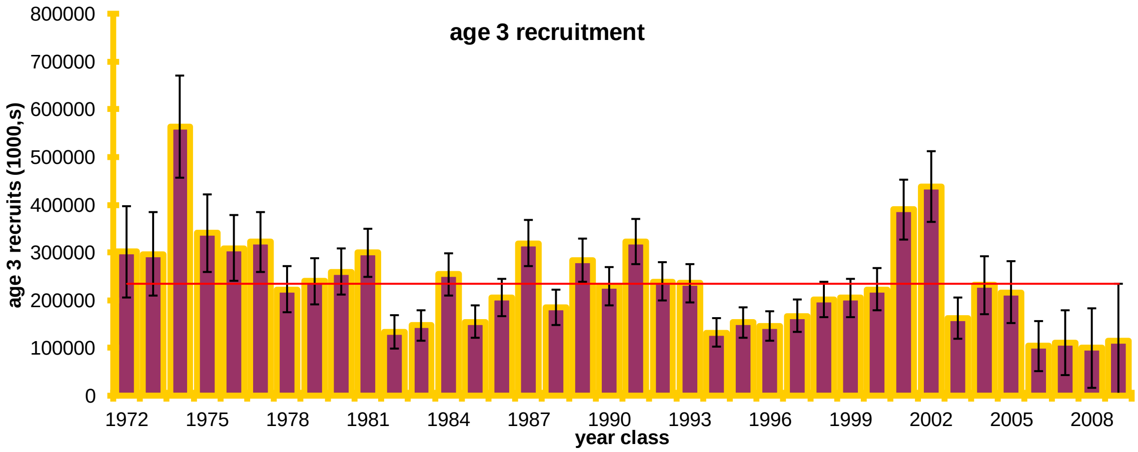


Figure 10.16--Estimated recruitment (age 3) for Alaska plaice. 95% credible intervals are from mcmc integration.

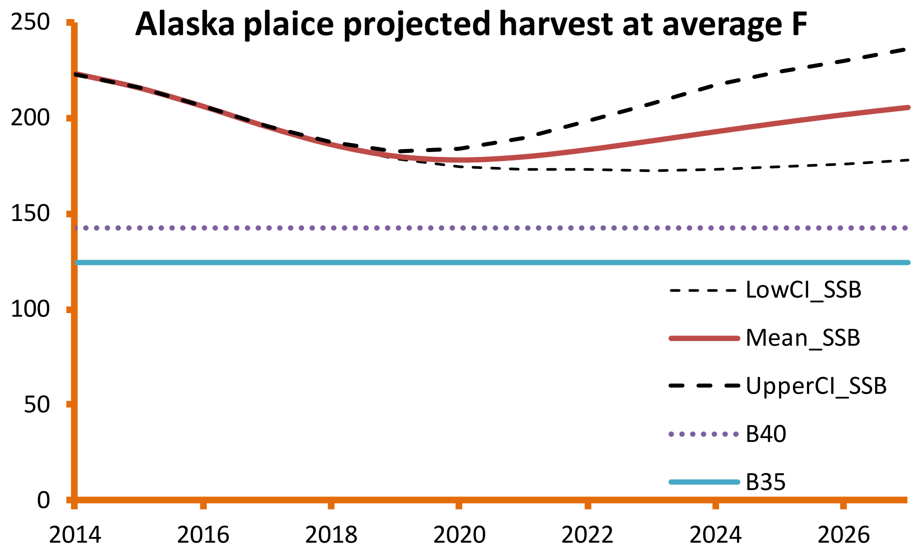


Figure 10.17 Model projection of Alaska plaice at the harvest rate of the average of the past five years assuming the estimated 2011 numbers-at-age from the stock assessment model.

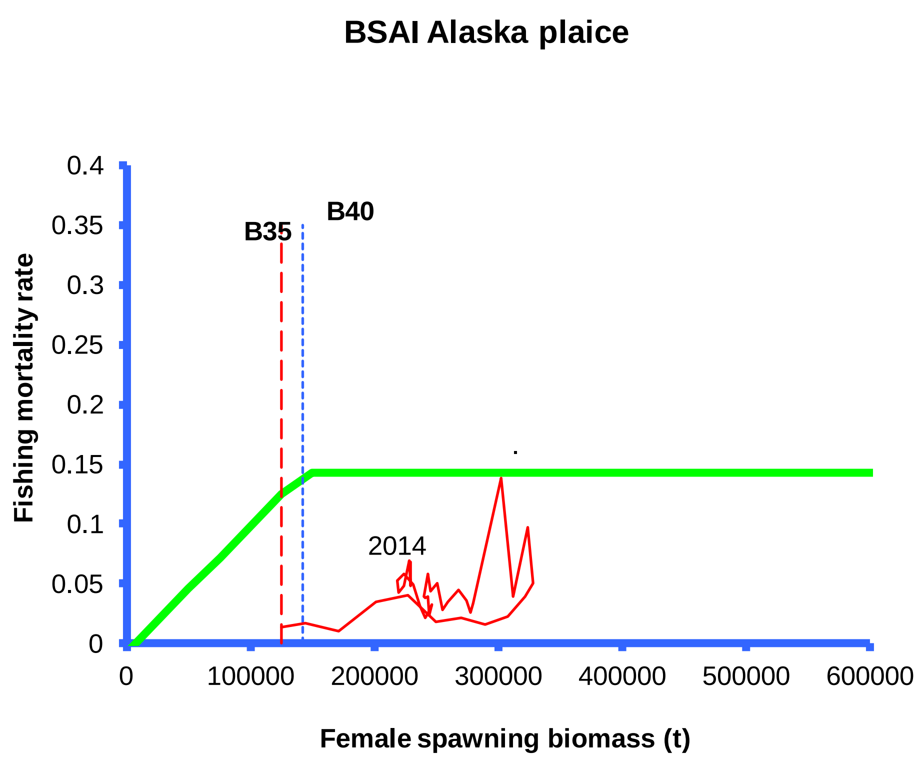


Figure 10.18 Phase-plane diagram of the estimated time-series of Alaska plaice female spawning biomass and fishing mortality relative to the tier 3 control rule.

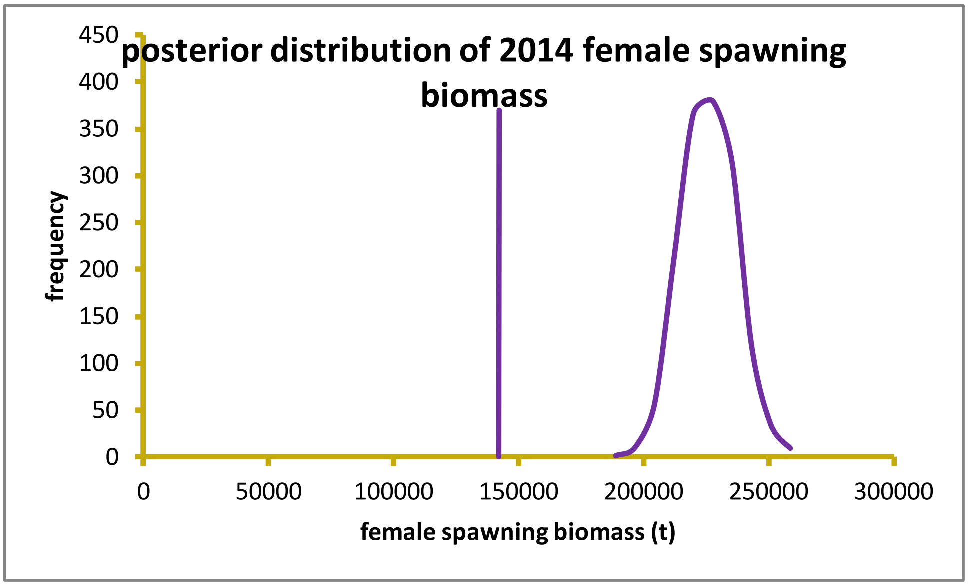


Figure 10.19. Posterior distribution of the 2014 estimate of female spawning biomass (t) from mcmc integration with $B_{40\%}$ =142,100 indicated as a vertical line.

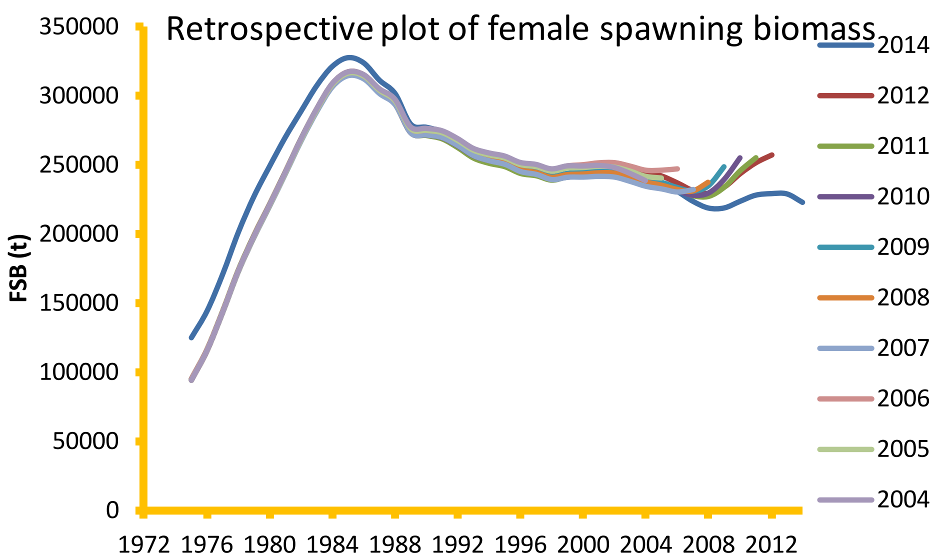


Figure 10.20. Retrospective plot of female spawning biomass (t) from 2004 to 2014.