Chapter 2: Assessment of the Pacific Cod Stock in the Eastern Bering Sea and Aleutian Islands Area

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EXECUTIVE SUMMARY

Summary of Changes in Assessment Inputs

Relative to the November edition of last year's BSAI SAFE report, the following substantive changes have been made in the Pacific cod stock assessment.

Changes in the Input Data

1) Catch data for 2004-2009 were updated, and preliminary catch data for 2010 were incorporated.
2) Commercial fishery size composition data for 2009 were updated, and preliminary size composition data from the 2010 commercial fisheries were incorporated.
3) Size composition data from the 2010 EBS shelf bottom trawl survey were incorporated.
4) The numeric abundance estimate from the 2010 EBS shelf bottom trawl survey was incorporated (the 2010 estimate of 887 million fish was up about 24% from the 2009 estimate).
5) Age composition data from the 2009 EBS shelf bottom trawl survey were incorporated.
6) Age composition data from the 2008 January-May longline fishery were removed from two of the models.
7) Mean length at age data from the 2009 EBS shelf bottom trawl survey were incorporated.
8) Mean length at age data from the 2008 January-May longline fishery were removed from two of the models.
9) Seasonal catch per unit effort (CPUE) data for the trawl, longline, and pot fisheries from 2009 were updated, and preliminary catch rates for the trawl, longline, and pot fisheries from 2010 were incorporated.
10) The Pacific cod catch rate from the 2009 International Pacific Halibut Commission (IPHC) longline survey was incorporated into one of the models (the 2009 estimate was down 35% from 2008, and was the second lowest point in the ten-year time series).
11) Size composition data from the 2008-2009 IPHC longline surveys were removed from two of the models.
12) The biomass estimate from the 2010 AI bottom trawl survey was added to the time series used to compute the current ratio of BSAI biomass to EBS biomass. The 2010 AI biomass estimate of 68,161 t was down 26% from the 2006 estimate, and is the low point in the survey time series.

Changes in the Assessment Methodology

Many changes have been made or considered in the stock assessment model since the 2009 assessment (Thompson et al. 2009). Six models were presented in this year's preliminary assessment (Attachment 2.1). The relationships between the six models presented in the preliminary assessment are summarized in Table 2.1.1 of Attachment 2.1. The set of six models in the preliminary assessment was requested by the Plan Teams in May of this year, with subsequent concurrence (given two minor modifications) by the SSC in June. Following review in September and October, three of these models, or modifications thereof, were requested by the Plan Teams or SSC to be included in the final assessment.

Model 1 in the preliminary assessment was identical to the model accepted for use by the BSAI Plan Team and SSC last year, and was the only model from the preliminary assessment recommended by either the Plan Team or SSC to be carried forward without modification for inclusion in the final assessment, where it is labeled Model A.

Model 2 in the preliminary assessment included four changes in data or data structure: 1) exclude relative abundance data and the two records of size composition data from the IPHC longline survey, 2) exclude the single record (each) of fishery age composition and mean length-at-age data, 3) use a finer length bin structure than previous models, and 4) re-evaluate the existing seasonal structure used in the model and revise it as appropriate. The length bin structure adopted in Model 2 consisted of 1-cm bins, replacing the combination of 3-cm and 5-cm bins used in previous assessments. The seasonal structure adopted in Model 2 consisted of five catch seasons defined as January-February, March-April, May-July, August-October, and November-December; and three selectivity seasons defined as January-April, May-July, and August-December; with spawning identified as occurring at the beginning of the second catch season (March).

Model 4 in the preliminary assessment included all of the changes in Model 2, plus disuse of all mean length-at-age data and all age composition data, and a change from age-based to length-based maturity.

The Plan Teams and SSC requested that modified forms of preliminary Models 2 and 4 be included in the final assessment. The requested modification in each case was removal of cohort-specific growth rates (use of cohort-specific growth rates was new in last year's assessment). The modified Models 2 and 4 from the preliminary assessment are labeled here as Models B and C, respectively.

Version 3.11b of Stock Synthesis (SS) was used to run all the models in the preliminary assessment and in the final assessment up until the very last stages of the analysis, at which point version 3.11c was used.

Model B is the authors' recommended model.

Summary of Results

The principal results of the present assessment, based on the authors' preferred model, are listed in the table below (biomass and catch figures are in units of t) and compared with the corresponding quantities from last year's assessment as specified by the SSC.

Quantity/Status	Last year 2010	2011	This year **2011**	2012
M (natural mortality)	0.34	0.34	**0.34**	0.34
Specified/recommended Tier	3b	3b	**3b**	3a
Projected biomass (ages 3+)	1,144,000	1,358,000	**1,560,000**	1,751,000
Female spawning biomass (t)				
Projected	345,000	370,000	**358,000**	389,000
$B_{100\%}$	1,027,000	1,027,000	**961,000**	961,000
$B_{40\%}$	411,000	411,000	**384,000**	384,000
$B_{35\%}$	360,000	360,000	**336,000**	336,000
F_{OFL}	0.29	0.31	**0.29**	0.31
$maxF_{ABC}$	0.24	0.26	**0.25**	0.26
Specified/recommended F_{ABC}	0.24	0.26	**0.25**	0.26
Specified/recommended OFL (t)	205,000	251,000	**272,000**	329,000
Specified/recommended ABC (t)	174,000	214,000	**235,000**	281,000
Is the stock being subjected to overfishing?	No	n/a	**No**	n/a
Is the stock currently overfished?	No	No	**No**	No
Is the stock approaching a condition of being overfished?	No	n/a	**No**	n/a

Responses to Comments from the Plan Teams and SSC

A total of 23 comments from the November, 2009 meetings of the BSAI Plan Team (1 comment) and the GOA Plan Team (2 comments); the December, 2009 meeting of the SSC (7 comments); the May, 2010 meeting of the Joint Plan Teams (11 comments); and the June, 2010 meeting of the SSC (2 comments) were previously addressed in the preliminary assessment (included here as Attachment 2.1). In the interest of efficiency, these comments and responses are not repeated in this section. Joint Plan Team and SSC comments from the September, 2010 and October, 2010 meetings, respectively, are addressed below.

Joint Plan Team Comments

JPT1 (09/10 minutes): *"Do not iterate to obtain estimates for penalties associated with dev vectors (see also next paragraph* [Comment JPT5] *below)."* See response to Comment JPT5.

JPT2 (09/10 minutes): *"Use finer (1-cm vs. 3 to 5-cm) length bins and seasons (5 rather than 3) as done for Models 2-6."* Models B and C exhibit the requested characteristics. However, Model A, which was requested by the SSC (see Comment SSC1), does not.

JPT3 (09/10 minutes): *"Continue to apply the catchability values (Q) derived by Dan Nichol (based on archival tag data on Pacific cod depth distribution)."* The trawl survey catchability coefficient (for the post-1981 portion of the time series) in last year's preferred model was tuned iteratively so that the weighted average product of selectivity and catchability across the 60-81 cm size range matched the results of the study by Nichol et al. (2007). The value obtained in last year's preferred model was retained for all three models in this final assessment (see also response to Comment JPT5).
JPT4 (09/10 minutes): *"Use constant growth rather than annually-varying or cohort-specific growth."* Models B and C exhibit the requested characteristic. However, Model A, which was requested by the SSC (see Comment SSC1), does not.

JPT5 (09/10 minutes): *"Several quantities have traditionally been estimated iteratively in the Pacific cod assessments, for example, the catchability coefficient and the input standard deviations for all deviation ("dev") vectors. To make the process of tuning the models less cumbersome, the Teams encouraged the* *authors to consider external weighting (i.e., setting such quantities on the basis of common sense) or one-time reweighting of likelihood components."* A total of eight quantities were estimated iteratively in last year's preferred model:

1. ageing error bias (assumed constant across ages 2-20; units = years)
2. input standard deviation of length at length-at-age-0 (units = cm)
3. input standard deviation of length at length-at-age-20 (units = cm)
4. input standard deviation for cohort-specific growth devs (lognormal, multiplicative)
5. input standard deviation for log recruitment devs (normal, additive)
6. number of pre-1977 recruitment devs to estimate (1977 = model start year)
7. catchability for trawl survey (assumed constant since 1982)
8. input standard deviation for ascending post-1981 survey "width" devs (normal, additive)

To make sure that comment JPT5 was not misinterpreted by the assessment authors, ten Plan Team members with experience in developing age-structured models were invited to provide advice on how this comment should be applied. Four responses were received. None of the responses contained any suggestions as to how any of the quantities listed above could be estimated by one-time reweighting of likelihood components. However, several suggestions, sometimes with multiple options, were offered regarding "common sense" methods of setting one or more of the quantities listed above. Of these, the only option mentioned in a majority of the responses was to keep all of the quantities fixed at last year's values, the rationale being that this would facilitate comparison of models across years. Based on majority opinion, this approach was adopted for all models in the final assessment. See also Comment SSC3.

JPT6 (09/10 minutes): *"Prior to the 2009 assessment, constant growth was assumed in the model. Cohort-specific growth was estimated in the 2009 model and Models 1-5 and annually varying growth was tested in Model 6. The Plan Team recommends returning to a constant growth assumption for this year's assessment until there is evidence for either time-varying or cohort-specific growth in the Pacific cod age or length data."* See response to Comment JPT4.

JPT7 (09/10 minutes): *"The Team recommended that the author prepare two models for November, with these features: one with, and one without, age data, along the lines of Model 2 and Model 4."* Models B and C correspond to this request.

SSC Comments

SSC1 (10/10 minutes): *"The SSC agrees with the GPTs recommendations to bring forward models 2 and 4 in November, but to modify the models to include constant growth over time. However, the SSC requests that the authors include results from the previously approved Model 1 (last year's model) for comparison. Models 5 and 6 appear to either overfit the data and/or resulted in unreasonable estimates of the standard deviation of length-at-age."* Models B and C correspond to the request in the first sentence of this comment, and Model A corresponds to the request in the second sentence.

SSC2 (10/10 minutes): *"The SSC agreed with the use of the 1 cm bin structure, but had concerns about possible artifacts arising from the large number of length bin / year / season combinations and the likely presence of a large number of zero entries. Therefore, we recommend that the authors explore an intermediate bin size in next year's assessment that results in fewer zeros and faster run times."* As requested, this suggestion will be considered next year. For now, however, it may be noted that the extremely long run times experienced during the preliminary assessment (several hours) did not arise during the final assessment, presumably due to the omission of cohort-specific growth rates from the two models using the more complicated bin and seasonal structures (Models B and C).

SSC3 (10/10 minutes): *"With respect to iterative estimation of input standard deviations (for 'deviation vectors') and other quantities, the SSC recommends that the author use his judgment in determining a reasonable approach for setting these quantities."* The authors' judgment is that keeping the quantities listed in the response to Comment JPT5 fixed at last year's values is a prudent course of action given Comment JPT5 and subsequent clarification thereof by Plan Team members.

SSC4 (10/10 minutes): *"The SSCs recommends that an examination of maturity-at-length (instead of maturity-at-age) in the 'age-free' models, as suggested in public comments, would be appropriate but should be deferred to next year."* This comment may reflect poor communication on the part of the authors in presenting the preliminary assessment. Models 4-6 in the preliminary assessment already included use of length rather than age as the basis of the maturity schedule. The issue raised in the preliminary assessment was whether the estimate of the natural mortality rate, which is presently based on Jensen's (1996) Equation 7, should be revised in models which do not use age data and which describe maturity as a function of length (by using the age corresponding to the length at the inflection of the length-based maturity schedule, rather than the age at the inflection of the age-based maturity schedule). Model C in the final assessment, which is based on Model 4 in the preliminary assessment, continues to use length as the basis of the maturity schedule.

INTRODUCTION

General

Pacific cod (*Gadus macrocephalus*) is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34° N latitude, with a northern limit of about 63° N latitude. Pacific cod is distributed widely over the eastern Bering Sea (EBS) as well as in the Aleutian Islands (AI) area. The resource in these two areas (BSAI) is managed as a single unit. Tagging studies (e.g., Shimada and Kimura 1994) have demonstrated significant migration both within and between the EBS, AI, and Gulf of Alaska (GOA). Although at least one previous genetic study (Grant et al. 1987) failed to show significant evidence of stock structure within these areas, current genetic research underway at the Alaska Fisheries Science Center is shedding additional light on the issue of stock structure of Pacific cod within the BSAI (M. Canino, AFSC, pers. commun.). Pacific cod is not known to exhibit any special life history characteristics that would require it to be assessed or managed differently from other groundfish stocks in the EBS or AI areas.

Review of Life History

Pacific cod eggs are demersal and adhesive. Eggs hatch in about 15 to 20 days. Spawning takes place in the sublittoral-bathyal zone (40 to 290 m) near bottom. Eggs sink to the bottom after fertilization and are somewhat adhesive. Optimal temperature for incubation is 3° to 6°C, optimal salinity is 13 to 23 parts per thousand (ppt), and optimal oxygen concentration is from 2 to 3 ppm to saturation. Little is known about the optimal substrate type for egg incubation.

Little is known about the distribution of Pacific cod larvae, which undergo metamorphosis at about 25 to 35 mm. Larvae are epipelagic, occurring primarily in the upper 45 m of the water column shortly after hatching, moving downward in the water column as they grow.

Juveniles occur mostly over the inner continental shelf at depths of 60 to 150 m. Adults occur in depths from the shoreline to 500 m, although occurrence in depths greater than 300 m is fairly rare. Preferred substrate is soft sediment, from mud and clay to sand. Average depth of occurrence tends to vary directly with age for at least the first few years of life.

It is conceivable that mortality rates, both fishing and natural, may vary with age in Pacific cod. In particular, very young fish likely have higher natural mortality rates than older fish (note that this may not be particularly important from the perspective of single-species stock assessment, so long as these higher natural mortality rates do not occur at ages or sizes that are present in substantial numbers in the data). For example, Leslie matrix analysis of a Pacific cod stock occurring off Korea estimated the instantaneous natural mortality rate of 0-year-olds at 910% per year (Jung et al. 2009). This may be compared to a mean estimate for age 0 Atlantic cod (*Gadus morhua*) in Newfoundland of 4.42% per day, with a 95% confidence interval ranging from about 3.32% to 5.52% (Gregory et al. in review); and age 0 Greenland cod (*Gadus ogac*) of 2.12% per day, with a 95% confidence interval ranging from about 1.56% to 2.68% (Robert Gregory and Corey Morris, *pers. commun.*).

Although little is known about the likelihood of age-dependent natural mortality in adult Pacific cod, it has been suggested that Atlantic cod may exhibit increasing natural mortality with age (Greer-Walker 1970).

At least one study (Ueda et al. 2006) indicates that age 2 Pacific cod may congregate more, relative to age 1 Pacific cod, in areas where trawling efficiency is reduced (e.g., areas of rough substrate), causing their selectivity to decrease. Also, Atlantic cod have been shown to dive in response to a passing vessel (Ona and Godø 1990), which may complicate attempts to estimate catchability or selectivity. It is not known whether Pacific cod undertake a similar response.

As noted above, Pacific cod are known to undertake seasonal migrations, the timing and duration of which may be variable (Savin 2008).

FISHERY

Catches of Pacific cod taken in the EBS for the periods 1964-1980 and 1981-2010 are shown in Tables 2.1a and 2.1b respectively. Catches of Pacific cod in the AI for the periods 1964-1980, 1981-1990, and 1991-2010 are shown in Tables 2.2a, 2.2b, and 2.2c respectively. Catches of Pacific cod in the EBS and AI regions combined for the periods 1964-1980, 1981-1990, and 1991-2010 are shown in Tables 2.3a, 2.3b, and 2.3c respectively.

The catches in Tables 2.1a, 2.2a, and 2.3a are broken down by year and fleet sector (foreign, joint venture, domestic annual processing), while the catches in Tables 2.1b, 2.1c, 2.2b, 2.2c, 2.3b, and 2.3c are broken down by gear type as well. During the early 1960s, a Japanese longline fishery harvested BSAI Pacific cod for the frozen fish market. Beginning in 1964, the Japanese trawl fishery for walleye pollock (*Theragra chalcogramma*) expanded and cod became an important bycatch species and an occasional target species when high concentrations were detected during pollock operations. By the time that the Magnuson Fishery Conservation and Management Act went into effect in 1977, foreign catches of Pacific cod had consistently been in the 30,000-70,000 t range for a full decade. In 1981, a U.S. domestic trawl fishery and several joint venture fisheries began operations in the BSAI. The foreign and joint venture sectors dominated catches through 1988, but by 1989 the domestic sector was dominant and by 1991 the foreign and joint venture sectors had been displaced entirely. A State-managed fishery for Pacific cod in the Aleutian Islands began in 2006.

Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including trawl, longline, pot, and jig components. Figures 2.1a-2.1c show areas in which sampled hauls or sets for each of the three main gear types (trawl, longline, and pot) were concentrated during January-May, June-August, and September-December, 2009. Figures 2.1d-2.1e show the corresponding information for January-May and

June-August, 2010 (preliminary data). To create these figures, the EEZ off Alaska was divided into 20 km × 20 km squares. For each gear type, a square is shaded if hauls/sets containing Pacific cod from more than two distinct vessels were sampled in it during the respective gear/season/year.

The chapters entitled "Profile for Pacific cod Fleet" and "Pacific Cod Market Analysis" in the economic section of the SAFE Report (Hiatt et al., 2007) provide additional information on the Pacific cod fishery.

The history of acceptable biological catch (ABC), overfishing level (OFL), and total allowable catch (TAC) levels is summarized and compared with the time series of aggregate (i.e., all-gear, combined area) commercial catches in Table 2.4. From 1980 through 2010 TAC averaged about 80% of ABC (ABC was not specified prior to 1980), and from 1980 through 2009 aggregate commercial catch averaged about 90% of TAC (remembering that 2010 catch data are not yet final). In 10 of these 31 years (32%), TAC equaled ABC exactly, and in 6 of these 31 years (20%), catch exceeded TAC (by an average of 4%). However, one of those overages occurred in 2007, when TAC was reduced by 3% to account for a small, State-managed fishery inside State of Alaska waters (similar reductions were made in 2008-2009); thus, while the combined Federal and State catch exceeded the Federal TAC in 2007 by about 2%, the overall target catch (Federal TAC plus State GHL) was not exceeded. Total catch has been less than OFL in every year since 1994.

Changes in ABC over time are typically attributable to three factors: 1) changes in resource abundance, 2) changes in management strategy, and 3) changes in the stock assessment model. Assessments conducted prior to 1985 consisted of simple projections of survey numbers at age. In 1985, the assessment was expanded to consider all survey numbers at age from 1979-1985. From 1985-1991, the assessment was conducted using an *ad hoc* separable age-structured model. In 1992, the assessment was conducted using the Stock Synthesis 1 modeling software (Methot 1986, 1990) with age-based data. All assessments from 1992 through 2003 continued to use the Stock Synthesis 1 modeling software, but with length-based data. Age data based on a revised ageing protocol were added to the model in the 2004 assessment. The assessment was migrated to Stock Synthesis 2 in 2005 (Methot 2005), and several changes have been made to the model within the SS2 framework (renamed "Stock Synthesis," without a numeric modifier, in 2008) each year since then.

Historically, the great majority of the BSAI catch has come from the EBS area. During the most recent complete five-year period (2005-2009), the EBS accounted for an average of about 85% of the BSAI catch.

The catches shown in Tables 2.1b, 2.2b, 2.2c, 2.3b, 2.3c, and 2.4 include estimated discards. Discard rates of Pacific cod in the various EBS and AI target fisheries are shown for each year 1991-2002 in Table 2.5a, for each year 2003-2004 in Table 2.5b, and for each year 2005-2010 in Table 2.5c.

Seasons for the Pacific cod fisheries are defined in 50 CFR §679.23(5) as follows:

> (i) Hook-and-line gear. Subject to other provisions of this part, directed fishing for CDQ and non-CDQ Pacific cod with vessels equal to or greater than 60 ft (18.3 m) LOA using hook-and-line gear is authorized only during the following two seasons:
>
> > (A) A season. From 0001 hours, A.l.t., Jan. 1 through 1200 hours, A.l.t., June 10; and
> > (B) B season. From 1200 hours, A.l.t., June 10 through 2400 hours, A.l.t., Dec. 31.
>
> (ii) Trawl gear. Subject to other provisions of this part, directed fishing for CDQ and non-CDQ Pacific cod with trawl gear in the BSAI is authorized only during the following three seasons:
>
> > (A) A season. From 1200 hours, A.l.t., Jan. 20 through 1200 hours, A.l.t., Apr. 1;
> > (B) B season. From 1200 hours, A.l.t., Apr. 1 through 1200 hours, A.l.t., June 10; and
> > (C) C season. From 1200 hours, A.l.t., June 10 through 1200 hours, A.l.t., Nov. 1.

(iii) Pot gear. Subject to other provisions of this part, non-CDQ directed fishing for Pacific cod with vessels equal to or greater than 60 ft (18.3 m) LOA using pot gear in the BSAI is authorized only during the following two seasons:

(A) A season. From 0001 hours, A.l.t., January 1 through 1200 hours, A.l.t., June 10; and

(B) B season. From 1200 hours, A.l.t., September 1 through 2400 hours, A.l.t., Dec. 31.

(iv) Jig gear. Subject to other provisions of this part, directed fishing for CDQ and non-CDQ Pacific cod with jig gear is authorized only during the following three seasons:

(A) A season. From 0001 hours, A.l.t., Jan. 1 through 1200 hours, A.l.t., Apr. 30;

(B) B season. From 1200 hours, A.l.t., Apr. 30 through 1200 hours, A.l.t., Aug. 31; and

(C) C season. From 1200 hours, A.l.t., Aug. 31 through 2400 hours, A.l.t., Dec. 31.

Under Amendment 85, 10.7% of the TAC is allocated to the CDQ fisheries. The remaining 89.3% is allocated as follows:

	Percentage	
Sector	non-CDQ TAC	overall TAC
Jig vessels	1.4	1.250
Hook-and-line/pot catcher vessels < 60 ft. LOA	2.0	1.786
Hook-and-line/pot catcher vessels ≥ 60 ft. LOA	0.2	0.179
Hook-and-line catcher-processors	48.7	43.489
Pot catcher vessels > 60 ft. LOA	8.4	7.501
Pot catcher-processors	1.5	1.340
AFA trawl catcher-processors	2.3	2.054
Non-AFA trawl cathcer-processors	13.4	11.966
Trawl catcher vessels	22.1	19.735
Total	100.0	89.300

Amendment 85 further apportions the above allocations (in percent) by season as follows:

Gear Type	A Season	B Season	C Season
CDQ trawl	60	20	20
CDQ trawl catcher vessels	70	10	20
CDQ trawl catcher-processors	50	30	20
Non-CDQ trawl catcher vessels	74	11	15
Non-CDQ trawl catcher-processors	75	25	0
CDQ hook-and-line catcher-processors, and hook-and-line catcher vessels ≥ 60 ft. LOA	60	40	n/a
Non-CDQ hook-and-line catcher-processors, hook-and-line catcher vessels ≥ 60 ft. LOA, pot catcher-processors, and pot catcher vessels ≥ 60 ft. LOA	51	49	n/a
CDQ jig vessels	40	20	40
Non-CDQ jig vessels	60	20	20
All other nontrawl vessels	---------- no seasonal allowance ----------		

An incidental catch allowance will be deducted from the aggregate portion of Pacific cod TAC annually allocated to the hook-and-line and pot gear sectors before the allocations above are made to these sectors. Since 2001 this amount has been 500 t and included in the harvest specifications.

It is likely that some changes will be made to the regulations governing the Pacific cod fisheries in response to the Biological Opinion released earlier this year, but the exact nature of these changes was not known at the time this assessment was completed.

DATA

This section describes data used in the current stock assessment models. It does not attempt to summarize all available data pertaining to Pacific cod in the BSAI.

Commercial Catch Data

Catch Biomass

Catches taken in the EBS for the period 1977-2010 are shown for the three main gear types and two different seasonal configurations in Tables 2.6a and 2.6b. The seasons used in Table 2.6a are January-May, June-August, and September-December. This particular division, which was suggested in the early 1990s by fishery participants, was intended to reflect actual intra-annual differences in fleet operation (e.g., fishing operations during the spawning period may be different than at other times of year), and is used by Model A in the present assessment.

Table 2.6b makes use of two different types of season: catch seasons and selectivity seasons. The catch seasons are defined as January-February, March-April, May-July, August-October, and November-December. Three selectivity seasons are defined by combining catch seasons 1 and 2 into selectivity season 1, equating catch season 3 with selectivity season 2, and combining catch seasons 4 and 5 into selectivity season 3. The catch seasons used in Table 2.6b were the result of a statistical analysis described in this year's preliminary assessment (see Attachment 2.1), and the selectivity seasons were chosen to correspond as closely as possible to the traditional seasons used in Table 2.6a given the revised catch seasons. This seasonal structure is used by Models B and C in the present assessment.

In years for which estimates of the distribution by gear or period were not available, proxies based on other years' distributions were used to create Tables 2.6a and 2.6b. Catches for the years 1977-1980 may or may not include discards.

Catch Per Unit Effort

Fishery catch per unit effort data are available by gear and season for the years 1991-2010 and are shown in Table 2.6c for the seasonal structure used by Model A and Table 2.6d for the seasonal structure used by Models B and C. Units are kg/minute for trawl gear, kg/hook for longline gear, and kg/pot for pot gear; data for 2010 are partial. The "sigma" values shown in the tables are intended only to give an idea of the relative variability of the respective point estimates, and are not actually used in any of the analyses presented here.

Catch Size Composition

Fishery size compositions are presently available, by gear, for at least one gear type in every year from 1977 through the first part of 2010. For ease of representation and analysis, length frequency data for Pacific cod have traditionally been grouped according to the following set of 25 intervals or "bins," with the upper and lower boundaries shown in cm:

BinNumber:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
LowerBound:	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
UpperBound:	11	14	17	20	23	26	29	32	35	38	41	44	49	54	59	64	69	74	79	84	89	94	99	104	110

The collections of relative length frequencies are shown by year and size bin for the trawl fishery in Tables 2.7a, 2.7b, and 2.7c; the longline fishery in Tables 2.8a, 2.8b, and 2.8c; and the pot fishery in Tables 2.9a, 2.9b, and 2.9c. These are the size composition data used by Model A. Models B and C use a finer scale consisting of 1-cm bins ranging from 4 to 120 cm. Because displaying these data would add approximately 40 pages to the present document, they are not shown here but are available on request by contacting the senior author.

Fishery Age Composition Data

The 2008 assessment marked the first time that fishery age composition data were used since production ageing of Pacific cod resumed several years ago (Roberson 2001, Roberson et al. 2005). Specifically, the estimate of age composition from the 2008 January-May longline fishery shown in Table 2.11a was used. These data continue to be used in Model A in the present assessment, but not in Models B or C.

Survey Data

EBS Shelf Bottom Trawl Survey

The relative size compositions from bottom trawl surveys of the EBS shelf conducted by the Alaska Fisheries Science Center since 1979 are shown in Table 2.10a for the years 1979-1981 and Table 2.10b for the years 1982-2010, using the same length bins defined above for the commercial catch size compositions. The survey is shown as two separate time series because of a gear change that was instituted in 1982.

Age compositions from the 1994-2009 surveys are available. The age compositions and actual sample sizes are shown in Table 2.11b.

Estimates of total abundance (both in biomass and numbers of fish) obtained from the trawl surveys are shown in Table 2.12a (1979-1981) and 2.12b (1982-2010), together with their respective standard errors. Upper and lower 95% confidence intervals are also shown for the biomass estimates. Survey results indicate that biomass increased steadily from 1979 through 1983, and then remained relatively constant from 1983 through 1988. The highest biomass ever observed by the survey was the 1994 estimate of 1,368,120 t. Following the high observation in 1994, the survey biomass estimate declined steadily through 1998. The survey biomass estimates remained in the 596,000-619,000 t range from 2002 through 2005. However, the survey biomass estimates dropped after 2005, producing all-time lows in 2007 and again in 2008. The 2009 biomass estimate was slightly higher than the 2008 estimate, and the 2010 biomass estimate was more than double the 2009 estimate.

Numerical abundance has shown more variability than biomass. The 2007 estimate was the highest since 2001 the time series, but the 2008 estimate was down considerably. The 2009 estimate was up again, nearly as high as the 2007 value, and the 2010 estimate is the highest since 2001.

Mean size-at-age data are available for all of the years in which age compositions are available. These are shown, along with sample sizes, in Table 2.13. This table also includes mean size at age for the single record of fishery age composition data currently available (2008 Jan-May longline fishery). Note that the fishery mean sizes at ages 3-5 are much larger than any of the survey mean sizes at those ages.

Aleutian Bottom Trawl Survey

Biomass estimates for the Aleutian Islands region were derived from U.S.-Japan cooperative bottom trawl surveys conducted during the summers of 1980, 1983, and 1986, and by U.S. bottom trawl surveys of the same area in 1991, 1994, 1997, 2000, 2002, 2004, 2006, and 2010. These surveys covered both the Aleutian management area (170 degrees east to 170 degrees west) and a portion of the Bering Sea management area ("Southern Bering Sea") not covered by the EBS shelf bottom trawl surveys. The time series of biomass estimates from the overall Aleutian survey area are shown below (all estimates are in t):

Year	Survey Type	Aleutian Survey Area
1980	U.S.-Japan	148,272
1983	U.S.-Japan	215,755
1986	U.S.-Japan	255,072
1991	U.S.	191,049
1994	U.S.	184,068
1997	U.S.	83,416
2000	U.S.	136,028
2002	U.S.	82,970
2004	U.S.	114,161
2006	U.S.	92,526
2010	U.S.	68,161

The 2010 estimate is the lowest in the time series.

For many years, the assessments of Pacific cod in the BSAI have used a weighted average formed from EBS and AI survey biomass estimates to provide a conversion factor which is used to translate model projections of EBS catch and biomass into BSAI equivalents. Prior to the 2004 assessment, the weighted average was based on the sums of the biomass estimates from the EBS shelf and AI survey biomass time series. However, in December of 2003 the SSC requested that alternative methods of estimating relative biomass between the EBS and AI be explored. Following a presentation of some possible alternatives (Thompson and Dorn 2004), the SSC recommended that an approach based on a simple Kalman filter be used. Applying this approach to the updated (through 2010) time series indicates that the best estimate of the current biomass distribution is 91% EBS and 9% AI, replacing the previous proportions of 84% and 16% respectively.

IPHC Longline Survey

The International Pacific Halibut Commission (IPHC) conducts an annual longline survey designed to estimate the relative abundance of Pacific halibut (*Hippoglossus stenolepis*). The survey also takes Pacific cod incidentally. The CPUE time series (number of Pacific cod per hook) from stations in the BS since 2000 is as follows (the 2010 value is not available yet):

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
0.077	0.083	0.083	0.098	0.069	0.109	0.154	0.119	0.117	0.077

Pacific cod length composition data were taken in the IPHC survey during the years 2007-2009. The sampling protocol was improved substantially after the 2007 season, so only the data since 2008 were used in the 2009 assessment. The 2008 and 2009 size compositions are shown in Table 2.10c. These data are used in Model A in the present assessment, but not in Models B or C.

ANALYTIC APPROACH

Model Structure

History of Previous Model Structures Developed Under Stock Synthesis

Stock Synthesis 1 (SS1, Methot 1986, 1990, 1998, 2000) was first applied to the EBS Pacific cod stock in the 1992 assessment (Thompson 1992). This first application used age-structured data. Beginning with the 1993 SAFE report (Thompson and Methot 1993) and continuing through the 2004 SAFE report (Thompson and Dorn 2004), SS1 continued to be used, but based largely on length-structured data. It should be emphasized that the model has always been intended to assess only the EBS portion of the BSAI stock. Conversion of model estimates of EBS biomass and catch to BSAI equivalents has traditionally been accomplished by application of an expansion factor based on the relative survey biomasses between the EBS and AI.

SS1 was a program that used the parameters of a set of equations governing the assumed dynamics of the stock (the "model parameters") as surrogates for the parameters of statistical distributions from which the data were assumed to be drawn (the "distribution parameters"), and varies the model parameters systematically in the direction of increasing likelihood until a maximum is reached. The overall likelihood was the product of the likelihoods for each of the model components. In part because the overall likelihood could be a very small number, SS1 used the logarithm of the likelihood as the objective function. Each likelihood component was associated with a set of data assumed to be drawn from statistical distributions of the same general form (e.g., multinomial, lognormal, etc.). Typically, likelihood components were associated with data sets such as catch size (or age) composition, survey size (or age) composition, and survey abundance (either biomass or numbers, either relative or absolute).

SS1 permitted each data time series to be divided into multiple segments, resulting in a separate set of parameter estimates for each segment. The EBS Pacific cod assessments, for example, usually divided the shelf bottom trawl survey size composition time series into pre-1982 and post-1981 segments to account for the effects of a change in the trawl survey gear instituted in 1982. Also, to account for possible differences in selectivity between the mostly foreign (also joint venture) and mostly domestic fisheries, the fishery size composition time series was split into pre-1989 and post-1988 segments during the era of SS1-based assessments.

In the EBS Pacific cod model, each year has traditionally been partitioned into three seasons: January-May, June-August, and September-December (these seasonal boundaries were suggested by industry participants). Four fisheries were defined during the era of SS1-based assessments: The January-May trawl fishery, the June-December trawl fishery, the longline fishery, and the pot fishery.

Following a series of modifications from 1993 through 1997, the base model for EBS Pacific cod remained completely unchanged from 1997 through 2001. During the late 1990s, a number of attempts were made to estimate the natural mortality rate M and the shelf bottom trawl survey catchability coefficient Q, but these were not particularly successful and the Plan Team and SSC always opted to retain the base model in which M and Q were fixed at their traditional values of 0.37 and 1.0, respectively.

A minor modification of the base model was suggested by the SSC in 2001, namely, that consideration be given to dividing the domestic era into pre-2000 and post-1999 segments. This modification was tested in the 2002 assessment (Thompson and Dorn 2002), where it was found to result in a statistically significant improvement in the model's ability to fit the data. In the 2004 assessment (Thompson and Dorn 2004), further modifications were made to the base model. The 2004 model included a set of selectivity parameters for the EBS slope bottom trawl survey and added new likelihood components for the age compositions and length-at-age data from the 1998-2003 EBS shelf bottom trawl surveys and the size composition and biomass data from the 2002 and 2004 EBS slope bottom trawl surveys. Incorporation of age data and slope survey data had been suggested by the SSC (SSC minutes, December 2003).

A major change took place in the 2005 assessment (Thompson and Dorn 2005), as the model was migrated to the newly developed Stock Synthesis 2 (SS2) program, which made use of the ADMB modeling architecture (Fournier 2005) currently used in most age-structured assessments of BSAI and GOA groundfish. The move to SS2 facilitated improved estimation of model parameters as well as statistical characterization of the uncertainty associated with parameter estimates and derived quantities such as spawning biomass. Technical details of SS2 were described by Methot (2005, 2007).

The 2006 assessment (Thompson et al. 2006) explored alternative functional forms for selectivity, use of Pacific cod incidental catch data from the NMFS sablefish longline survey, and the influence of prior distributions.

A technical workshop was held in April of 2007 to address possible improvements to the assessment model (Thompson and Conners 2007). Based on suggestions received at the workshop, several alternative models were considered in a preliminary 2007 assessment (Thompson et al. 2007a), and four models were advanced during the final 2007 assessment (Thompson et al. 2007b). The recommended model from the final 2007 assessment (Model 1) included a number of features that distinguished it from the model used in the 2006 assessment, including: a fixed value for the natural mortality rate (0.34) based on life history theory, maturity schedule modeled as a function of age rather than length, trawl survey selectivity modeled as a function of age rather than length, constant fishery selectivity across all years, annual variability in the ascending "width" parameter of the trawl survey selectivity schedule (with a standard deviation of 0.2), standard deviation of length at age modeled as a linear function of length at age, survey abundance measured in numbers of fish (rather than biomass), and setting the input sample size for multinomial distributions on the basis of a scaled bootstrap harmonic mean.

Relative to the 2007 assessment, the model accepted by the Plan Team and SSC from the 2008 assessment featured two main changes: 1) an explicit algorithm was used to determine which fleets (including surveys as well as fisheries) would be forced to exhibit asymptotic selectivity; and 2) an explicit algorithm was used to determine which selectivity parameters would be allowed to vary periodically in "blocks" of years, and to determine the appropriate block length for each such time-varying parameter (Thompson et al. 2008).

The 2009 assessment (Thompson et al. 2009) featured a total of 14 models reflecting a great many alternative assumptions and use or non-use of certain data, particularly age composition data. Relative to the 2008 assessment, the main changes in the model accepted by the Plan Team and SSC were as follow: 1) input standard deviations of all "dev" vectors were set iteratively by matching the standard deviations of the set of estimated "devs;" 2) the standard deviation of length at age was estimated outside the model as a linear function of mean length at age; 3) catchability for the post-1981 trawl survey was fixed at the value that sets the average (weighted by numbers at length) of the product of catchability and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007); 4) potential ageing bias was accounted for in the ageing error matrix by examining alternative bias values in increments of 0.1 for ages 2 and above, resulting in a positive bias of 0.4 years for these ages (age-specific bias values were also examined, but did not improve the fit significantly); and 5) cohort-specific growth devs were estimated for all years through 2008.

Model Structures Considered in This Year's Assessment

Many changes have been made or considered in the stock assessment model since the 2009 assessment (Thompson et al. 2009). Six models were presented in this year's preliminary assessment (Attachment 2.1). The relationships between the six models presented in the preliminary assessment are summarized in Table 2.1.1 of Attachment 2.1. The set of six models in the preliminary assessment was requested by the Plan Teams in May of this year, with subsequent concurrence (given two minor modifications) by the SSC in June. Following review in September and October, three of these models, or modifications thereof, were requested by the Plan Teams or SSC to be included in the final assessment.

Model 1 in the preliminary assessment was identical to the model accepted for use by the BSAI Plan Team and SSC last year, and was the only model from the preliminary assessment recommended by either the Plan Team or SSC to be carried forward without modification for inclusion in the final assessment, where it is labeled Model A.

Model 2 in the preliminary assessment included four changes in data or data structure: 1) exclude relative abundance data and the two records of size composition data from the IPHC longline survey, 2) exclude the single record (each) of fishery age composition and mean length-at-age data, 3) use a finer length bin structure than previous models, and 4) re-evaluate the existing seasonal structure used in the model and revise it as appropriate. The length bin structure adopted in Model 2 consisted of 1-cm bins, replacing the combination of 3-cm and 5-cm bins used in previous assessments. The seasonal structure adopted in Model 2 consisted of five catch seasons defined as January-February, March-April, May-July, August-October, and November-December; and three selectivity seasons defined as January-April, May-July, and August-December; with spawning identified as occurring at the beginning of the second catch season (March).

Model 4 in the preliminary assessment included all of the changes in Model 2, plus disuse of all mean length-at-age data and all age composition data, and a change from age-based to length-based maturity.

The Plan Teams and SSC requested that modified forms of preliminary Models 2 and 4 be included in the final assessment. The requested modification in each case was removal of cohort-specific growth rates (this feature was new in last year's assessment). The modified Models 2 and 4 from the preliminary assessment are labeled here as Models B and C, respectively.

Version 3.11b of Stock Synthesis (SS) was used to run all the models in the preliminary assessment and in the final assessment up until the very last stages of the analysis, at which point version 3.11c was used. The most recent user manual is for version 3.11a (Methot 2010).

Parameters Estimated Independently

Natural Mortality

In the 1993 BSAI Pacific cod assessment (Thompson and Methot 1993), the natural mortality rate *M* was estimated using SS1 at a value of 0.37. Although attempts have been made to obtain internal estimates of *M* in some years, all models of the BSAI Pacific cod stock accepted by the Plan Team and SSC from 1993 through 2006 ultimately retained a value of 0.37 for *M*. The 2007 assessment marked the first time since 1993 that a different value of *M*, 0.34, was accepted by the SSC. This value was based on Equation 7 of Jensen (1996) and an age at maturity of 4.9 years (Stark 2007). In response to a request from the SSC, the 2008 assessment included a discussion of alternative values and a justification for the value chosen (Thompson et al. 2008). However, it should be emphasized that, even if Jensen's Equation 7 is exactly right, variability in the estimate of the age at maturity implies that the point of estimate of 0.34 is accompanied by a level of uncertainty. Using the variance for the age at 50% maturity published by Stark (0.0663), the 95% confidence interval for *M* extends from about 0.30 to 0.38.

For historical completeness, some other published estimates of *M* for Pacific cod are shown below:

Area	Author	Year	Value
Eastern Bering Sea	Low	1974	0.30-0.45
	Wespestad et al.	1982	0.70
	Bakkala and Wespestad	1985	0.45
	Thompson and Shimada	1990	0.29
	Thompson and Methot	1993	0.37
Gulf of Alaska	Thompson and Zenger	1993	0.27
	Thompson and Zenger	1995	0.50
British Columbia	Ketchen	1964	0.83-0.99
	Fournier	1983	0.65

All of the models in this assessment set *M* independently at the SSC-approved value of 0.34.

Catchability

In the 2009 assessment (Thompson et al. 2009), catchability for the post-1981 trawl survey was estimated iteratively by matching the average (weighted by numbers at length) of the product of catchability and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007). The resulting value of 0.77 was retained for all models in the present assessment. Catchability for the pre-1982 trawl survey is fixed at 1.00, following last year's assessment.

Variability in Estimated Age

Variability in estimated age in SS is based on the standard deviation of estimated age. Weighted least squares regression has been used in the past several assessments to estimate a proportional relationship between standard deviation and age. The regression was last recomputed in the 2009 assessment (Thompson et al. 2009), yielding an estimated coefficient of 0.088 (i.e, the standard deviation of estimated age was modeled as 0.088 × age). This regression was retained for all models in the present assessment.

Variability in Length at Age

As described in the SS user manual (Methot 2010), problems can arise when estimating cohort-specific growth unless the first reference age in the length-at-age equation is set at true age 0. Because no data are available to describe the standard deviation of length at true age 0 (which is mostly a theoretical extrapolation anyway), the 2009 assessment used a regression approach to extrapolate the parameters of the schedule of variability in length at age, based on the outside-the-model estimates of standard deviation of length at age from the survey age data (Thompson et al. 2009). The best fit was obtained by assuming that the standard deviation is a linear function of length at age, with an intercept of 1.15 and a slope of 0.079.

Use of this regression required an iterative, "quasi-conditional" procedure for specifying the standard deviations of length at ages 0 and 20, because the regression is a function of length at age, and length at age is estimated conditionally (i.e., inside the model). The resulting standard deviations were 0.01 (for length at age 0) and 8.68 (for length at age 20). These values were retained for all models in the present assessment.

Weight at Length

Weight-at-length parameters specific to each of the three seasons used in Model A were estimated in the 2008 assessment (Thompson et al. 2008). These were determined from all weight-length records present in the observer database (both shore-based and at-sea samples) as of the 2008 assessment, giving the following values:

Season:	Jan-May	Jun-Aug	Sep-Dec	Annual
α:	5.705×10^{-6}	9.055×10^{-6}	5.774×10^{-6}	6.161×10^{-6}
β:	3.184	3.065	3.183	3.165
Samples:	54,798	13,370	22,710	90,878

In the 2008 assessment, the seasonal model gave a statistically significant improvement (AIC = 84,762 for the annual model; AIC = 83,989 for the seasonal model).

For Models B and C, new season-specific parameters were computed from the same data set in order to comply with the new seasonal structure of those models, giving the following values:

Season:	Jan-Feb	Mar-Apr	May-Jul	Aug-Oct	Nov-Dec
α:	3.741×10^{-6}	7.221×10^{-6}	9.406×10^{-6}	6.987×10^{-6}	4.356×10^{-6}
β:	3.296	3.122	3.054	3.134	3.253
Samples:	21,616	25,818	20,734	12,754	9,956

The weight-length parameters for the new seasonal structure give a better (lower) AIC than the weight-length parameters for the old seasonal structure.

Maturity

A detailed history and evaluation of parameter values used to describe the maturity schedule for BSAI Pacific cod was presented in the 2005 assessment (Thompson and Dorn 2005). A length-based maturity schedule was used for many years. The parameter values used for this schedule in the 2005 and 2006 assessments (Thompson and Dorn 2005, Thompson et al. 2006) were set on the basis of a study by Stark (2007) at the following values: length at 50% maturity = 58 cm and slope of linearized logistic equation = -0.132. However, in 2007, changes in SS allowed for use of either a length-based or an age-based maturity schedule. Since 2007, the accepted model has used an age-based schedule with intercept = 4.9 years and slope = -0.965 (Stark 2007). The use of an age-based rather than a length-based schedule follows a recommendation from the author of the maturity study from which the parameter values were taken (James Stark, Alaska Fisheries Science Center, personal communication). In the present assessment, Models A and B use the age-based schedule and Model C uses the length-based schedule.

Parameters Estimated Conditionally

Parameters estimated conditionally (i.e., within individual SS runs, based on the data and the parameters estimated independently) in all models include the von Bertalanffy growth parameters, log mean recruitment, annual recruitment deviations, initial fishing mortality, gear-season-and-block-specific fishery selectivity parameters, survey selectivity parameters, and annual deviations in the ascending limb of the trawl survey selectivity schedule. In addition, Model A estimates cohort-specific deviations in growth rates.

The same functional form (pattern 24 for length-based selectivity, pattern 20 for age-based selectivity) used to define the selectivity schedules in all assessments since 2007 was used again this year. This functional form is constructed from two underlying and rescaled normal distributions, with a horizontal line segment joining the two peaks. This form uses the following six parameters (selectivity parameters are referenced by these numbers in several of the tables in this assessment):

1. Beginning of peak region (where the curve first reaches a value of 1.0)
2. Width of peak region (where the curve first departs from a value of 1.0)
3. Ascending "width" (equal to twice the variance of the underlying normal distribution)
4. Descending width
5. Initial selectivity (at minimum length/age)
6. Final selectivity (at maximum length/age)

All but the "beginning of peak region" parameter are transformed: The widths are log-transformed and the other parameters are logit-transformed.

Fishery selectivities are length-based and trawl survey selectivities are age-based in all models considered in this assessment. In addition, Model A assumes length-based selectivity for the IPHC longline survey.

Uniform prior distributions are used for all parameters, except that *dev* vectors are constrained by input standard deviations ("sigma"), which imply a type of joint prior distribution. These input standard deviations were determined iteratively in the 2009 assessment (Thompson et al. 2009) by matching the standard deviations of the estimated *dev*s. The same input standard deviations were used in all models in the present assessment.

For all parameters estimated within individual SS runs, the estimator used is the mode of the logarithm of the joint posterior distribution, which is in turn calculated as the sum of the logarithms of the parameter-specific prior distributions and the logarithm of the likelihood function.

In addition to the above, the full set of year-, season-, and gear-specific fishing mortality rates are also estimated conditionally, but not in the same sense as the above parameters. The fishing mortality rates are determined exactly rather than estimated statistically because SS assumes that the input total catch data are true values rather than estimates, so the fishing mortality rates can be computed algebraically given the other parameter values and the input catch data.

Likelihood Components

All three models included likelihood components for trawl survey relative abundance, fishery and survey size composition, recruitment, parameter deviations, and "softbounds" (equivalent to an extremely weak prior distribution used to keep parameters from hitting bounds), and initial (equilibrium) catch. In addition, Models A and B included likelihood components for age composition and mean size at age.

In SS, emphasis factors are specified to determine which likelihood components receive the greatest attention during the parameter estimation process. As in previous assessments, likelihood components were given an emphasis of 1.0 in the present assessment.

Use of Size Composition Data in Parameter Estimation

Size composition data are assumed to be drawn from a multinomial distribution specific to a particular year, gear, and season within the year. In the parameter estimation process, SS weights a given size composition observation (i.e., the size frequency distribution observed in a given year, gear, and season) according to the emphasis associated with the respective likelihood component and the sample size specified for the multinomial distribution from which the data are assumed to be drawn. In developing the model upon which SS was originally based, Fournier and Archibald (1982) suggested truncating the multinomial sample size at a value of 400 in order to compensate for contingencies which cause the sampling process to depart from the process that gives rise to the multinomial distribution. For many years, the Pacific cod assessments assumed a multinomial sample size equal to the square root of the true length sample size, rather than the true length sample size itself. Given the true length sample sizes observed in the EBS Pacific cod data, this procedure tended to give values somewhat below 400 while still providing SS with usable information regarding the appropriate effort to devote to fitting individual length samples.

Although the "square root rule" for specifying multinomial sample sizes gave reasonable values, the rule itself was largely *ad hoc*. In an attempt to move toward a more statistically based specification, the 2007 assessment used the harmonic means from a bootstrap analysis of the available fishery length data from 1990-2006 (Thompson et al. 2007b). The harmonic means were smaller than the actual sample sizes, but still ranged well into the thousands. A multinomial sample size in the thousands would likely overemphasize the size composition data. As a compromise, the harmonic means were rescaled proportionally in the 2007 assessment so that the average value (across all samples) was 300. However, the question then remained of what to do about years not covered by the bootstrap analysis (2007 and pre-1990) and what to do about the survey samples. The solution adopted in the 2007 assessment was based on the consistency of the ratios between the harmonic means (the raw harmonic means, not the rescaled harmonic means) and the actual sample sizes. For the years prior to 1999, the ratio was very consistently close to 0.16, and for the years after 1998, the ratio was very consistently close to 0.34. This consistency was used to specify the missing values as follows: For fishery data, the sample sizes for length compositions from years prior to 1999 were tentatively set at 16% of the actual sample size, and the sample sizes for length compositions from 2007 were tentatively set at 34% of the actual sample size. For the pre-1982 trawl survey, length compositions were tentatively set at 16% of an assumed sample size of 10,000. For the post-1981 trawl survey and IPHC survey length compositions, sample sizes were tentatively set at 34% of the actual sample size. Then, with sample sizes for fishery length compositions from 1990-2007 tentatively set at their bootstrap harmonic means (not rescaled), all sample sizes were adjusted proportionally so that the average was 300.

The same procedure was used in the 2008 and 2009 assessments (Thompson et al. 2008, Thompson et al. 2009) and Model A in the present assessment as well. The resulting set of multinomial sample sizes for Model A is shown in Table 2.14a. For Models B and C, however, this procedure had to be modified somewhat, because the bootstrap values for the 1990-2006 size composition data did not match the bin and seasonal structures used by these two models. To be as consistent as possible with the approach used to set sample sizes for Model A, sample sizes for Models B and C were set using the 16/34% rule for *all* size composition records (not just those lying outside the set of 1990-2006 fishery data), then rescaling proportionally to achieve an average sample size of 300. The resulting set of multinomial sample sizes for Models B and C is shown in Tale 2.14b.

Use of Age Composition Data in Parameter Estimation

Like the size composition data, the age composition data are assumed to be drawn from a multinomial distribution specific to a particular gear, year, and season within the year. Input sample sizes for the multinomial distributions were computed by scaling the actual number of otoliths read in each year proportionally such that the average of the input sample sizes was equal to 300.

To avoid double counting of the same data, Models A and B ignore size composition data from each gear/year/season combination in which age composition data are available. Model C, which ignores the age composition data, uses all the available size composition data.

Use of Fishery CPUE and Survey Relative Abundance Data in Parameter Estimation

Fishery CPUE data are included in the models for comparative purposes only. Their respective catchabilities are estimated analytically, not statistically. The same is true for the relative abundance data from the IPHC longline survey (which are used in Model A only).

For the trawl surveys, each year's survey abundance datum is assumed to be drawn from a lognormal distribution specific to that year. The model's estimate of survey abundance in a given year serves as the geometric mean for that year's lognormal distribution, and the ratio of the survey abundance datum's standard error to the survey abundance datum itself serves as the distribution's coefficient of variation, which is then transformed into the "sigma" parameter for the lognormal distribution.

Use of Recruitment Deviation "Data" in Parameter Estimation

The recruitment deviations likelihood component is different from traditional likelihoods because it does not involve "data" in the same sense that traditional likelihoods do. Instead, the log-scale recruitment deviation plays the role of the datum and the log-scale recruitment mean and input standard deviation are related to the parameters of a normal distribution, but, of course, all of these are treated as parameters by SS (although the input standard deviation is estimated iteratively rather than internally).

RESULTS

Model Evaluation

As described above, three models are evaluated in the present assessment. All models appeared to converge successfully and the Hessian matrices from all models were positive definite. At several points during the model development process, sets of (typically about 50) additional runs were made for most models with initial parameter values displaced randomly from their converged values to provide additional assurance that another (better) solution did not exist. If a better solution was found, the process was repeated.

Comparing and Contrasting the Models

Tables 2.15-2.21 and Figures 2.2-2.10 present summaries of some key results from the three models.

Tables 2.15-2.17 pertain to statistical goodness of fit.

Table 2.15 shows negative log-likelihoods and numbers of parameters for each of the three models. It should be emphasized that, although the negative log-likelihood values for the three models are displayed next to one another, they are not strictly comparable, because the data sets are different for every model. The first part of Table 2.15 shows negative log-likelihoods for the aggregate data components. The second part shows the number of parameters. Model A has 218 parameters, while Models B and C (which do not estimate cohort-specific growth *devs*) have 183. The third part breaks down the CPUE and size composition components into fleet-specific values. For the CPUE component, the fishery and IPHC survey values are shown for completeness, but only the trawl survey values count toward the total negative log-likelihood. For the size composition component, the IPHC data are not included in the data files for Models B and C, so no value is reported for those two models. The final part of Table 2.15 breaks down the age composition and mean size at age components into fleet-specific values. The season 1 longline fishery age composition data and mean size at age components are not included in the data for Models B and C, so no values are reported for those two models.

Table 2.16 provides two alternative measures of how well the models are fitting the fishery CPUE and survey relative abundance data: root mean squared errors (lower values are better) and correlations between observed and estimated values (higher values are better). Note that none of the models actually attempts to fit the fishery CPUE or the IPHC longline survey; these results are shown for information only. As with the 2009 assessment, Model A shows a negative correlation with the IPHC survey. Most important is the row for the post-1981 trawl survey, where all three models give an RMSE of 0.20 or 0.21 and a correlation between 0.68 and 0.73. Figure 2.2 shows the fits of the three models to the trawl survey abundance data. For the post-1981 portion of the time series, all three models tend to fall within the 95% confidence intervals of the surveys except for 1993-1996 and 2001, where the survey is higher than the models; and 2008, where the models are higher than the survey.

Table 2.17a shows the average of the ratio and the ratio of the average between output "effective" sample size (McAllister and Ianelli 1997) and input sample size for the size composition data, thus providing an alternative measure of how well the models are these data (higher values are better). Rows in this table correspond to different fisheries or surveys. Models B and C tend to do better by this measure than Model A, but it should be remembered that, because of the finer seasonal structure used by Models B and C, they have many more records of size composition data than Model A and, because the average input sample size is constrained to equal 300 for both data sets, the overall emphasis (number of records × average input sample size) on size composition data is much greater for Models B and C than Model A.

Table 2.17b provides a similar analysis for the age composition, except that the rows in the main part of this table correspond to individual records rather than fisheries or surveys. The bottom two rows show the overall average of ratios and ratio of averages for the post-1981 trawl survey age compositions. In general, Model A tends to do a bit better here than Model B, and both Models A and B do much better than Model C, which does not attempt to fit these data at all. The three models' fits to the age composition data are shown in Figures 2.3a, 2.3b, and 2.3c. If the age data are approximately correct, Model C appears to be off by about one year in Figure 2.3c. Figure 2.4 shows Model A's fit to the single record of fishery age composition data (Models B and C do not include this record).

Table 2.18 displays all of the quantities listed in the "parameters" section of the SS report file, including quantities whose values are set externally. Each quantity that is estimated internally is given a parameter number ("par. no."); and the phase in which it is estimated, its value, and its standard deviation are reported. For quantities estimated externally, values are reported, but the other columns are not applicable. A blank row for a given quantity/model combination indicates that the given quantity is not used by that model. Most labels are either fairly straightforward to interpret or probably correspond to quantities that are not essential to understanding the analysis. It should be noted that the post-1976 recruitment mean *R0* and all catchability coefficients are reported on natural log scales and that the *R1 offset* parameter describes the log ratio of the recruitment means before and after the 1976-1977 regime shift. Labels for selectivity parameters include the fleet number (e.g., in the order given in Table 2.15) followed by a "P," then the parameter number (see "Parameters Estimated Conditionally"). Note that many selectivity parameters get overwritten by other selectivity parameters specific to blocks of years (the labels for these end in "*block* YEAR," where YEAR is the first year in the block).

Tables 2.19a, 2.19b, and 2.19c show estimates of full-selection fishing mortality rates for Models A, B, and C, respectively (note that these are not counted as parameters in SS).

Figure 2.5 shows the time series of recruitment devs as estimated by the three models. Models A and B show a high degree of synchrony. As with the fits to the age composition data, Model C seems to differ from Models A and B by one year.

Figure 2.6 shows the time series of spawning biomass relative to $B_{35\%}$ as estimated by the three models (the year coordinates of the three time series have been offset from one another slightly in order to reduce overplotting). Model C tends to have the highest ratio throughout the time series and Model A the lowest, although the qualitative shapes of the trajectories are very similar and the absolute values are not very part from about 1993 onward.

Figure 2.7 shows the time series of total (age 0+) biomass as estimated by the three models, with the trawl survey biomass estimates included for comparison. Model B estimates the highest biomass throughout almost all of the time series, while Models A and C are very close from about 1992 onward. All three of the models tend to produce much higher biomass estimates than the survey, which would be expected given a post-1981 catchability coefficient of 0.77.

Figure 2.8 shows post-1981 trawl survey selectivity as estimated by the three models. The red line in each figure corresponds to 2010, which is fixed at the baseline level to avoid confounding the ascending slope with incoming recruitment. Models A and B produce similar curves, while the curves produced by Model C have an extra kink at age 1 and do not reach unity until age 3.

Figures 2.9a, 2.9b, and 2.9c show fishery selectivity as estimated by all three models. Visually, there does not appear to be a great deal of difference between the curves estimated by the various models. In general, selectivities that are not forced to be asymptotic tend to show decreasing selectivity at large size.

Figures 2.10a, 2.10b, and 2.10c show how the mean lengths at ages 1-4 from the age data and the respective models compare to the modes from the long-term trawl survey size composition for lengths up to 60 cm. As in the 2009 assessment, Model A tends to do a better job of matching the first three modes than the age data (Figure 2.10a). However, Model B does not (Figure 2.10b). The mean length at age 1 estimated by Model B is almost at the bottom of the trough between what might be assumed to be the age 1 and age 2 modes, and the model's estimates of mean length at ages 2 and three tend to overshoot the modes. This may be a result of the ageing bias that was estimated in the preferred model from the 2009 assessment and carried over into all three of the models in the present assessment. Meanwhile, Model C does a superb job of matching the modes Figure 2.10c), but the ages cannot possibly be right, as the first mode is identified with age 2, the second mode with age 3, and the third mode with age 4, while age 1 is assigned a mean length of -8.26. This is consistent with Model C tending to be one year off from Models A and B with respect to the age composition data (Figures 2.3a, 2.3b, and 2.3c) and cohort strengths (Figure 2.5).

Table 2.20 shows how estimated size (cm) at age 1 under each of the models compares with the observed values from the trawl survey for the years in which data are available (1994-2009). Model A is the only model that does not assume constant growth, and it succeeds in producing a fairly small RMSE and a positive correlation between observed and expected values. Model B estimates an age 1 size that appears to be 4-5 cm high (assuming that the age data are correct), which, again, may be the result of the assumed ageing bias. Model C estimates an age 1 size that is not biologically possible.

Because the catchability coefficient for the post-1981 trawl survey was held constant for all models at the value estimated in the 2009 assessment (0.77), it may be wondered how well this value continues to achieve the intended result of matching the value of 0.47 obtained by Nichol et al. (2007) for the weighted average of the product of trawl survey catchability and selectivity across the 60-81 cm size range. This weighted average product was computed for each year of the post-1981 survey (i.e., 1982-2010), which resulted in the following statistics:

Statistic	Model A	Model B	Model C
Average:	0.52	0.49	0.39
Minimum:	0.44	0.41	0.32
Maximum:	0.60	0.55	0.47
Standard deviation:	0.03	0.03	0.03
Coefficient of variation:	0.07	0.07	0.09

Model B comes closest to achieving the desired average of 0.47, while Model A is a bit high and Model C is noticeably low (in only one year did the weighted average for Model C reach the desired value).

Table 2.21 contains selected output from the standard projection model, based on SS parameter estimates from the three models, along with the probability that the stock will fall below $B_{20\%}$ in each of the next five years (these probabilities are given by SS rather than the standard projection model). Recruitments, numbers at age, and biomasses have been divided by the conversion factor of 0.91 described in the "Aleutian Bottom Trawl Survey" subsection, so as to represent quantities relevant to the entire BSAI management region, rather than the BS area on the basis of which the models are configured. Model B tends to produce the highest *reference* levels of spawning biomass and Model C the lowest, while Model C tends to produce the highest *current* levels of spawning biomass. Model C tends to produce the highest estimates of OFL and maximum permissible ABC, while Model A tends to produce the lowest. All three models agree that the probability of spawning biomass falling below $B_{20\%}$ within the next five years is negligible.

Evaluation Criteria

The following criteria were used to select the final model:

1. Does the model make full use of the information in the size composition data?
2. Has the seasonal structure of the model been justified statistically?
3. Is the model sufficiently parsimonious?
4. Does the model estimate plausible lengths at age for the time of year when the data are collected?

Selection of Final Model

The three models can be evaluated by the three criteria as follows:

1. The raw size composition data are expressed in 1-cm intervals. It is possible that some amount of binning would not diminish the information content of the raw data, but the acceptable amount of binning has yet to be determined. All else being equal, the 1-cm intervals used in Models B and C guard against loss of information content.
2. The seasonal structure used in Model A has been a consistent feature of the Pacific cod assessment for over 15 years. However, its original rationale was never made explicit, and the statistical analysis conducted in this year's preliminary assessment indicated that the seasonal structure used in Models B and C is superior in terms of defining seasons within which the fishing mortality is relatively constant. On the other hand, it should be acknowledged that the optimality of combining some of the five new catch seasons to yield three selectivity seasons has not been evaluated.
3. Model A, with cohort-specific growth *dev*s, has 35 more parameters than Models B or C. At their September meeting, the Plan Teams expressed a preference for models with constant growth.
4. Models A estimates the most plausible lengths at age, followed by Model B. Model C does not estimate plausible lengths for the youngest ages. This may be because, in a sense, Model C does not "care" about *absolute* ages, so long as the *relative* ages are correct. By placing suitable

constraints on length-at-age parameters, it may be possible for a future version of Model C to give plausible estimates of length at age.

On the basis of the above, Model B is selected as the final model.

Final Parameter Estimates and Associated Schedules

As noted previously, estimates of all statistically estimated parameters in Model B are shown in Table 2.18. Estimates of year-, gear-, and season-specific fishing mortality rates from Model B are shown in Table 2.19b.

Schedules of selectivity at length for the commercial fisheries from Model B are shown in Table 2.22a, and schedules of selectivity at age for the trawl surveys from Model B are shown in Table 2.22b. Post-1981 trawl survey and all fishery selectivity schedules for Model B are plotted in Figures 2.8 and 2.9b, respectively.

Schedules of length at age and weight at age for the population, length at age for each gear-and-season-specific fishery and each survey, and weight at age for each gear-and-season-specific fishery and each survey from Model B are shown in Tables 2.23, and 2.24a, and 2.24b, respectively.

Time Series Results

Note: Because the preferred model differs substantively from last year's model (Model A), the tables and figures referenced in this section are reproduced using Model A in Attachment 2.2.

Definitions

The biomass estimates presented here will be defined in two ways: 1) age 0+ biomass, consisting of the biomass of all fish aged 0 years or greater in January of a given year; and 2) spawning biomass, consisting of the biomass of all spawning females in a given year. The recruitment estimates presented here will be defined as numbers of age 0 fish in a given year. To supplement the full-selection fishing mortality rates already shown in Table 2.19b, an alternative "effective" fishing mortality rate will be provided here, defined for each age and time by $-\ln(N_{a+1,t+1}/N_{a,t})-M$, where N = number of fish, a = age measured in years, t = time measured in years, and M = instantaneous natural mortality rate. In addition, the ratio of full-selection fishing mortality to $F_{35\%}$ will be provided.

Biomass

Table 2.25a shows the time series of EBS (not expanded to BSAI) Pacific cod age 0+ and female spawning biomass for the years 1977-2011 as estimated last year and this year under Model B. The estimated spawning biomass time series are accompanied by their respective standard deviations. The estimated time series of EBS age 0+ biomass and female spawning biomass from Model B are shown, together with the observed time series of trawl survey biomass (assuming a catchability of 1.0), in Figure 2.11. Confidence intervals are shown for the model estimates of female spawning biomass and for the trawl survey biomass estimates.

Recruitment and Numbers at Age

Table 2.25b shows the time series of EBS (not expanded to BSAI) Pacific cod age 0 recruitment (1000s of fish) for the years 1977-2009 as estimated last year and this year under Model B. Both estimated time series are accompanied by their respective standard deviations. For the time series as a whole, the largest year class appears to have been the 1977 cohort. Other large cohorts include the 1982, 1984, 1992, 1996, 2006, and 2008 year classes. However, note that the 2006 year class followed a string of five consecutive sub-par year classes spawned from 2001-2005.

Model B's recruitment estimates for the entire time series (1977-2009) are shown in Figure 2.12, along with their respective 95% confidence intervals.

To date, it has not been possible to estimate a reliable stock-recruitment relationship for this stock.

The time series of numbers at age as estimated by Model B is shown in Table 2.25c.

Fishing Mortality

Table 2.26 shows "effective" fishing mortality by age and year for ages 1-19 and years 1977-2010.

Figure 2.13 plots the trajectory of relative fishing mortality and relative female spawning biomass from 1977 through 2010 based on Model B, overlaid with the current harvest control rules (fishing mortality rates in the figure are standardized relative to $F_{35\%}$ and biomasses are standardized relative to $B_{35\%}$, per SSC request). The entire trajectory lies underneath the $maxF_{ABC}$ control rule. While the ratio of $F_{40\%}$ to $F_{35\%}$ shown in Figure 2.13 is based on output from the standard projection model, the trajectory itself is based on SS output, which may not match the estimates obtained by the standard projection program exactly.

Projections and Harvest Alternatives

Note: Because the preferred model differs substantively from last year's model (Model A), the tables referenced in this section are reproduced using Model A in Attachment 2.2.

Amendment 56 Reference Points

Amendment 56 to the BSAI Groundfish Fishery Management Plan (FMP) defines the "overfishing level" (OFL), the fishing mortality rate used to set OFL (F_{OFL}), the maximum permissible ABC, and the fishing mortality rate used to set the maximum permissible ABC. The fishing mortality rate used to set ABC (F_{ABC}) may be less than this maximum permissible level, but not greater. Because reliable estimates of reference points related to maximum sustainable yield (MSY) are currently not available but reliable estimates of reference points related to spawning per recruit are available, Pacific cod in the BSAI have generally been managed under Tier 3 of Amendment 56. Tier 3 uses the following reference points: $B_{40\%}$, equal to 40% of the equilibrium spawning biomass that would be obtained in the absence of fishing; $F_{35\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the level that would be obtained in the absence of fishing; and $F_{40\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing. The following formulae apply under Tier 3:

3a) Stock status: $B/B_{40\%} > 1$

$F_{OFL} = F_{35\%}$

$F_{ABC} \leq F_{40\%}$

3b) Stock status: $0.05 < B/B_{40\%} \leq 1$

$F_{OFL} = F_{35\%} \times (B/B_{40\%} - 0.05) \times 1/0.95$

$F_{ABC} \leq F_{40\%} \times (B/B_{40\%} - 0.05) \times 1/0.95$

3c) Stock status: $B/B_{40\%} \leq 0.05$

$F_{OFL} = 0$

$F_{ABC} = 0$

Other useful biomass reference points which can be calculated using this assumption are $B_{100\%}$ and $B_{35\%}$, defined analogously to $B_{40\%}$. These reference points are estimated as follows, based on Model B1:

Reference point:	$B_{35\%}$	$B_{40\%}$	$B_{100\%}$
BSAI:	336,000 t	384,000 t	961,000 t
EBS:	306,000 t	350,000 t	874,000 t

For a stock exploited by multiple gear types, estimation of $F_{35\%}$ and $F_{40\%}$ requires an assumption regarding the apportionment of fishing mortality among those gear types. For this assessment, the apportionment was based on Model B's estimates of fishing mortality by gear for the five most recent complete years of data (2005-2009). The average fishing mortality rates for those years implied that total fishing mortality was divided among the three main gear types according to the following percentages: trawl 22%, longline 66%, and pot 12%. This apportionment results in estimates of $F_{35\%}$ and $F_{40\%}$ equal to 0.31 and 0.26, respectively.

Specification of OFL and Maximum Permissible ABC

BSAI spawning biomass for 2011 is estimated by Model B at a value of 358,000 t. This is about 7% below the BSAI $B_{40\%}$ value of 384,000 t, thereby placing Pacific cod in sub-tier "b" of Tier 3. Given this, Model B estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2011 and 2012 as follows (2012 values are predicated on the assumption that 2011 catch will equal 2011 maximum permissible ABC; catches are for the entire BSAI):

Year	Overfishing Level	Maximum Permissible ABC
2011	272,000 t	235,000 t
2012	329,000 t	281,000 t
2011	0.29	0.25
2012	0.31	0.26

The age 0+ biomass BSAI projections for 2011 and 2012 from Model B (using SS) are 1,668,000 t and 1,834,000 t.

For comparison, the age 3+ BSAI projections for 2011 and 2012 from Model B (using SS) are 1,560,000 t and 1,751,000 t.

ABC Recommendation

In 2005, the Plan Team and SSC selected a model that resulted in a maximum permissible ABC of 194,000 t, which was adopted as the 2006 ABC.

Similarly, the maximum permissible ABC was selected in 2006, giving a 2007 ABC of 176,000 t.

In 2007, the SSC adopted the following rationale in recommending the 2008-2009 ABCs and OFLs: *"While the recent trawl survey trend has been downward and present biomass is low relative to the mid 1980s, the model indicates that the spawning biomass will be on an upward trend from 2008. This suggests keeping ABC where it is for the time being and the SSC therefore recommends that ABC remain at 176,000 t in 2008/09 and OFLs for 2008/09 also rollover the 2007 OFL value of 207,000 t."*

In 2008, the SSC returned to the practice of setting ABC at the maximum permissible level, which resulted in specifications of 182,000 t for 2009 and 199,000 t for 2010.

In 2009, the SSC again recommended the maximum permissible ABC, which resulted in specifications of 174,000 t for 2010 and 214,000 t for 2011.

Based on Model B, the maximum permissible ABC (Tier 3b) for 2011 is 235,000 t. The maximum permissible ABC for 2012 is 281,000 t, when the stock is projected to be above $B_{40\%}$. These increases are fueled largely by the 2006 and 2008 year classes, whose strengths have now been confirmed by multiple surveys. The maximum permissible values are the recommended ABCs for 2011 and 2012.

Area Allocation of Harvests

At present, ABC of BSAI Pacific cod is not allocated by area. However, the Council is presently considering the possibility of specifying separate harvests in the EBS and AI.

Standard Harvest and Recruitment Scenarios and Projection Methodology

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

For each scenario, the projections begin with an estimated vector of 2011 numbers at age. 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 TACs for 2011 and 2012, are as follow ("*max* F_{ABC}" refers to the maximum permissible value of F_{ABC} under Amendment 56):

> *Scenario 1*: In all future years, F is set equal to *max* F_{ABC}. (Rationale: Historically, TAC has been constrained by ABC, so this scenario provides a likely upper limit on future TACs.)
>
> *Scenario 2*: In all future years, F is set equal to a constant fraction of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2011 recommended in the assessment to the *max* F_{ABC} for 2011. (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 the 2005-2009 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 4*: In all future years, the upper bound on F_{ABC} is set at $F_{60\%}$. (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 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.)

Two other scenarios are needed to satisfy the MSFCMA's requirement to determine whether a stock is currently in an overfished condition or is approaching an overfished condition. These two scenarios are as follow (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 1) above its MSY level in 2010 or 2) above 1/2 of its MSY level in 2010 and expected to be above its MSY level in 2020 under this scenario, then the stock is not overfished.)

Scenario 7: In 2011 and 2012, 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 2023 under this scenario, then the stock is not approaching an overfished condition.)

Projections and Status Determination

Projections corresponding to the standard scenarios are shown for Model B in Tables 2.27-2.32 (note that Scenarios 1 and 2 are identical in this case, because the recommended ABC is equal to the maximum permissible ABC).

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 2011, it does not provide the best estimate of OFL for 2012, because the mean 2012 catch under Scenario 6 is predicated on the 2011 catch being equal to the 2011 OFL, whereas the actual 2011 catch will likely be less than the 2011 OFL. Table 2.21 contains the appropriate one- and two-year ahead projections for both ABC and OFL under any of the three models considered in the present assessment.

Under the MSFCMA, the Secretary of Commerce is required to report on the status of each U.S. fishery with respect to overfishing. This report involves the answers to three questions: 1) Is the stock being subjected to overfishing? 2) Is the stock currently overfished? 3) Is the stock approaching an overfished condition?

Is the stock being subjected to overfishing? The official catch estimate for the most recent complete year (2009) is 175,746 t. This is less than the 2009 OFL of 212,000 t. Therefore, the stock is not being subjected to overfishing.

Harvest Scenarios #6 and #7 are intended to permit determination of the status of a stock with respect to its minimum stock size threshold (MSST). Any stock that is below its MSST is defined to be *overfished*. Any stock that is expected to fall below its MSST in the next two years is defined to be *approaching* an overfished condition. Harvest Scenarios #6 and #7 are used in these determinations as follows:

Is the stock currently overfished? This depends on the stock's estimated spawning biomass in 2011:

a. If spawning biomass for 2010 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.

b. If spawning biomass for 2010 is estimated to be above $B_{35\%}$ the stock is above its MSST.

c. If spawning biomass for 2010 is estimated to be above ½ $B_{35\%}$ but below $B_{35\%}$, the stock's status relative to MSST is determined by referring to harvest Scenario #6 (Table 2.31). If the mean spawning biomass for 2020 is below $B_{35\%}$, the stock is below its MSST. Otherwise, the stock is above its MSST.

Is the stock approaching an overfished condition? This is determined by referring to harvest Scenario #7 (Table 2.32):

a. If the mean spawning biomass for 2013 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.

b. If the mean spawning biomass for 2013 is above $B_{35\%}$, the stock is not approaching an overfished condition.

c. If the mean spawning biomass for 2013 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2023. If the mean spawning biomass for 2023 is below $B_{35\%}$, the stock is approaching an overfished condition. Otherwise, the stock is not approaching an overfished condition.

Based on the above criteria and Tables 2.31 and 2.32, the stock is not overfished and is not approaching an overfished condition.

ECOSYSTEM CONSIDERATIONS

This section is largely unchanged from recent assessments, except for the subsection on "Bycatch of Target and Nontarget Species."

Ecosystem Effects on the Stock

A primary ecosystem phenomenon affecting the Pacific cod stock seems to be the occurrence of periodic "regime shifts," in which central tendencies of key variables in the physical environment change on a scale spanning several years to a few decades (Boldt (ed.), 2005). One well-documented example of such a regime shift occurred in 1977, and shifts occurring in 1989 and 1999 have also been suggested (e.g., Hare and Mantua 2000). In the present assessment, an attempt was made to estimate the change in median recruitment of EBS Pacific cod associated with the 1977 regime shift. According to Model 1, pre-1977 median recruitment was only about 20% of post-1976 median recruitment. Establishing a link between environment and recruitment within a particular regime is more difficult. In the 2004 assessment (Thompson and Dorn 2004), for example, the correlations between age 1 recruits spawned since 1977 and monthly values of the Pacific Decadal Oscillation (Mantua et al. 1997) were computed and found to be very weak.

The prey and predators of Pacific cod have been described or reviewed by Albers and Anderson (1985), Livingston (1989, 1991), Lang et al. (2003), Westrheim (1996), and Yang (2004). The composition of Pacific cod prey varies to some extent by time and area. In terms of percent occurrence, some of the most important items in the diet of Pacific cod in the BSAI and GOA have been polychaetes, amphipods, and crangonid shrimp. In terms of numbers of individual organisms consumed, some of the most important dietary items have been euphausids, miscellaneous fishes, and amphipods. In terms of weight of organisms consumed, some of the most important dietary items have been walleye pollock, fishery offal, yellowfin sole, and crustaceans. Small Pacific cod feed mostly on invertebrates, while large Pacific cod are mainly piscivorous. Predators of Pacific cod include Pacific cod, halibut, salmon shark, northern fur seals, Steller sea lions, harbor porpoises, various whale species, and tufted puffin. Major trends in the most important prey or predator species could be expected to affect the dynamics of Pacific cod to some extent.

Fishery Effects on the Ecosystem

Potentially, fisheries for Pacific cod can have effects on other species in the ecosystem through a variety of mechanisms, for example by relieving predation pressure on shared prey species (i.e., species which serve as prey for both Pacific cod and other species), by reducing prey availability for predators of Pacific cod, by altering habitat, by imposing bycatch mortality, or by "ghost fishing" caused by lost fishing gear.

Bycatch of Target and Nontarget Species

Bycatch (discards) of target and nontarget species in each year 2003-2010 are shown for the EBS in Table 2.33a and the AI in Table 2.33b.

It is not clear how much bycatch of a particular species constitutes "too much" in the context of ecosystem concerns. In the EBS, only two species groups account for an average of more than 1,000 t of discards on average over the 2003-2010 period: "skate (other)"—13,865 t, and "large sculpins"—1,646 t. In the AI, these same two species groups are the only ones that account for an average of more than 100 t of discards on average over the same species (493 t and 303 t, respectively).

Steller Sea Lions

Sinclair and Zeppelin (2002) showed that Pacific cod was one of the four most important prey items of Steller sea lions in terms of frequency of occurrence averaged over years, seasons, and sites, and was especially important in winter. Pitcher (1981) and Calkins (1998) also showed Pacific cod to be an important winter prey item in the GOA and BSAI, respectively. Furthermore, the size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery operates to some extent in the same geographic areas used by Steller sea lion as foraging grounds (Livingston (ed.), 2002).

The Fisheries Interaction Team of the Alaska Fisheries Science Center has been engaged in research to determine the effectiveness of recent management measures designed to mitigate the impacts of the Pacific cod fisheries (among others) on Steller sea lions. Results from studies conducted in 2002-2003 were summarized by Conners et al. (2004). These studies included a tagging feasibility study, which may evolve into an ongoing research effort capable of providing information on the extent and rate to which Pacific cod move in and out of various portions of Steller sea lion critical habitat. Nearly 6,000 cod with spaghetti tags were released, of which approximately 1,000 had been returned as of September, 2003.

Seabirds

The following is a summary of information provided by Livingston (ed., 2002): In both the BSAI and GOA, the northern fulmar (*Fulmarus glacialis*) comprises the majority of seabird bycatch, which occurs primarily in the longline fisheries, including the hook and line fishery for Pacific cod (Tables 2.33b and 2.36b). Shearwater (*Puffinus* spp.) distribution overlaps with the Pacific cod longline fishery in the Bering Sea, and with trawl fisheries in general in both the Bering Sea and GOA. Black-footed albatross (*Phoebastria nigripes*) is taken in much greater numbers in the GOA longline fisheries than the Bering Sea longline fisheries, but is not taken in the trawl fisheries. The distribution of Laysan albatross (*Phoebastria immutabilis*) appears to overlap with the longline fisheries in the central and western Aleutians. The distribution of short-tailed albatross (*Phoebastria albatrus*) also overlaps with the Pacific cod longline fishery along the Aleutian chain, although the majority of the bycatch has taken place along the northern portion of the Bering Sea shelf edge (in contrast, only two takes have been recorded in the GOA). Some success has been obtained in devising measures to mitigate fishery-seabird interactions. For example, on vessels larger than 60 ft. LOA, paired streamer lines of specified performance and material standards have been found to reduce seabird incidental take significantly.

Fishery Usage of Habitat

The following is a summary of information provided by Livingston (ed., 2002): The longline and trawl fisheries for Pacific cod each comprise an important component of the combined fisheries associated with the respective gear type in each of the three major management regions (BS, AI, and GOA). Looking at each gear type in each region as a whole (i.e., aggregating across all target species) during the period 1998-2001, the total number of observed sets was as follows:

Gear	BS	AI	GOA
Trawl	240,347	43,585	68,436
Longline	65,286	13,462	7,139

In the BS, both longline and trawl effort was concentrated north of False Pass (Unimak Island) and along the shelf edge represented by the boundary of areas 513, 517 (in addition, longline effort was concentrated along the shelf edge represented by the boundary of areas 521-533). In the AI, both longline and trawl effort were dispersed over a wide area along the shelf edge. The catcher vessel longline fishery in the AI occurred primarily over mud bottoms. Longline catcher-processors in the AI tended to fish more over rocky bottoms. In the GOA, fishing effort was also dispersed over a wide area along the shelf, though pockets of trawl effort were located near Chirikof, Cape Barnabus, Cape Chiniak and Marmot Flats. The GOA longline fishery for Pacific cod generally took place over gravel, cobble, mud, sand, and rocky bottoms, in depths of 25 fathoms to 140 fathoms.

Impacts of the Pacific cod fisheries on essential fish habitat were further analyzed in an environmental impact statement by NMFS (2005).

DATA GAPS AND RESEARCH PRIORITIES

Significant improvements in the quality of this assessment could be made if future research were directed toward closing certain data gaps. Such research would have several foci, including the following: 1) ecology of the Pacific cod stock, including spatial dynamics, trophic and other interspecific relationships, and the relationship between climate and recruitment; 2) behavior of the Pacific cod fishery, including spatial dynamics; 3) determinants of trawl survey catchability and selectivity; 4) age determination; 5) ecology of species taken as bycatch in the Pacific cod fisheries, including estimation of biomass, carrying capacity, and resilience; and 6) ecology of species that interact with Pacific cod, including estimation of biomass, carrying capacity, and resilience.

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Table 2.1a—Summary of 1964-1980 catches (t) of Pacific cod in the Eastern Bering Sea by fleet sector. Catches by gear are not available for these years. Catches may not always include discards.

Eastern Bering Sea only:

Year	Foreign	Joint Venture	Domestic	Total
1964	13408	0	0	13408
1965	14719	0	0	14719
1966	18200	0	0	18200
1967	32064	0	0	32064
1968	57902	0	0	57902
1969	50351	0	0	50351
1970	70094	0	0	70094
1971	43054	0	0	43054
1972	42905	0	0	42905
1973	53386	0	0	53386
1974	62462	0	0	62462
1975	51551	0	0	51551
1976	50481	0	0	50481
1977	33335	0	0	33335
1978	42512	0	31	42543
1979	32981	0	780	33761
1980	35058	8370	2433	45861

Table 2.1b—Summary of 1981-2010 catches (t) of Pacific cod in the Eastern Bering Sea by fleet sector and gear type. All catches include discards. LLine = longline, Subt. = sector subtotal. Catches for 2010 are through October 13.

Eastern Bering Sea only:

	Foreign			Joint Venture		Domestic Annual Processing					
Year	Trawl	LLine	Subt.	Trawl	Subt.	Trawl	LLine	Pot	Other	Subt.	Total
1981	30347	5851	36198	7410	7410	12884	1	0	14	12899	56507
1982	23037	3142	26179	9312	9312	23893	5	0	1715	25613	61104
1983	32790	6445	39235	9662	9662	45310	4	21	569	45904	94801
1984	30592	26642	57234	24382	24382	43274	8	0	205	43487	125103
1985	19596	36742	56338	35634	35634	51425	50	0	0	51475	143447
1986	13292	26563	39855	57827	57827	37646	48	62	167	37923	135605
1987	7718	47028	54746	47722	47722	46039	1395	1	0	47435	149903
1988	0	0	0	106592	106592	93706	2474	299	0	96479	203071
1989	0	0	0	44612	44612	119631	13935	145	0	133711	178323
1990	0	0	0	8078	8078	115493	47114	1382	0	163989	172067
1991	0	0	0	0	0	129393	77505	3343	0	210241	210241
1992	0	0	0	0	0	77261	79398	7512	33	164204	164204
1993	0	0	0	0	0	81763	49294	2098	2	133157	133157
1994	0	0	0	0	0	84932	78564	8037	730	172263	172263
1995	0	0	0	0	0	110958	97666	19275	599	228498	228498
1996	0	0	0	0	0	91912	88883	28006	267	209067	209067
1997	0	0	0	0	0	93925	117010	21493	173	232601	232601
1998	0	0	0	0	0	60781	84324	13233	192	158529	158529
1999	0	0	0	0	0	51903	81464	12400	100	145867	145867
2000	0	0	0	0	0	53817	81642	15849	68	151376	151376
2001	0	0	0	0	0	35657	90361	16472	52	142542	142542
2002	0	0	0	0	0	51067	100271	15052	166	166555	166555
2003	0	0	0	0	0	108677	6350	21959	41615	178600	178600
2004	0	0	0	0	0	108021	6640	17242	51385	183288	183288
2005	0	0	0	0	0	113120	7474	17104	45239	182936	182936
2006	0	0	0	0	0	96559	7425	18957	45865	168806	168806
2007	0	0	0	0	0	77102	5649	17222	40106	140079	140079
2008	0	0	0	0	0	88726	6749	17366	26763	139604	139604
2009	0	0	0	0	0	96611	7537	13586	29432	147166	147166
2010	0	0	0	0	0	63852	6857.3	16311	31598	118618	118618

Table 2.2a—Summary of 1964-1980 catches (t) of Pacific cod in the Aleutian Islands region by fleet sector. Catches by gear are not available for these years. Catches may not always include discards.

Aleutian Islands region only:

Year	Foreign	Joint Venture	Domestic	Total
1964	241	0	0	241
1965	451	0	0	451
1966	154	0	0	154
1967	293	0	0	293
1968	289	0	0	289
1969	220	0	0	220
1970	283	0	0	283
1971	2078	0	0	2078
1972	435	0	0	435
1973	977	0	0	977
1974	1379	0	0	1379
1975	2838	0	0	2838
1976	4190	0	0	4190
1977	3262	0	0	3262
1978	3295	0	0	3295
1979	5593	0	0	5593
1980	5788	0	0	5788

Table 2.2b—Summary of 1981-1990 catches (t) of Pacific cod in the Aleutian Islands region by fleet sector and gear type. All catches include discards. LLine = longline, Subt. = sector subtotal.

Aleutian Islands region only:

	Foreign			Joint Venture		Domestic Annual Processing					
Year	Trawl	LLine	Subt.	Trawl	Subt.	Trawl	LLine	Pot	Other	Subt.	Total
1981	2680	235	2915	1749	1749	2744	26	0	0	2770	7434
1982	1520	476	1996	4280	4280	2121	0	0	0	2121	8397
1983	1869	402	2271	4700	4700	1459	0	0	0	1459	8430
1984	473	804	1277	6390	6390	314	0	0	0	314	7981
1985	10	829	839	5638	5638	460	0	0	0	460	6937
1986	5	0	5	6115	6115	784	1	1	0	786	6906
1987	0	0	0	10435	10435	2662	22	88	0	2772	13207
1988	0	0	0	3300	3300	1698	137	30	0	1865	5165
1989	0	0	0	6	6	4233	284	19	0	4536	4542
1990	0	0	0	0	0	6932	602	7	0	7541	7541

Table 2.2c—Summary of 1991-2010 catches (t) of Pacific cod in the Aleutian Islands by fleet sector and gear type. All catches include discards. LLine = longline, Subt. = sector subtotal. Catches since 2006 include those from a State-managed fishery. Catches for 2010 are through October 13.

Aleutian Islands only:											
	Federal					State					
Year	Trawl	LLine	Pot	Other	Subt.	Trawl	LLine	Pot	Other	Subt.	Total
1991	3414	3203	3180	0	9798						9798
1992	14559	22108	6317	84	43068						43068
1993	17312	16860	0	33	34205						34205
1994	14383	7009	147	0	21539						21539
1995	10574	4935	1025	0	16534						16534
1996	21179	5819	4611	0	31609						31609
1997	17349	7151	575	89	25164						25164
1998	20531	13771	424	0	34726						34726
1999	16437	7874	3750	69	28130						28130
2000	20362	16183	3107	33	39685						39685
2001	15827	17817	544	19	34207						34207
2002	27929	2865	7	0	30801						30801
2003	978	0	2	31478	32459						32459
2004	3103		0	25770	28873						28873
2005	3073	13	0	19613	22699						22699
2006	3128	8	401	16956	20493	455		156	3106	3717	24210
2007	4182	2	313	25724	30221	529	6	383	2907	3824	34045
2008	5468	157	1679	19291	26595	234	53	1634	2540	4462	31056
2009	5469	0	754	20284	26507	279	20	1237	537	2074	28580
2010	5331	0	481	16713	22525	32		1635	2113	3780	26306

Table 2.3a—Summary of 1964-1980 catches (t) of Pacific cod in the combined Eastern Bering Sea and Aleutian Islands region by fleet sector. Catches by gear are not available for these years. Catches may not always include discards.

Eastern Bering Sea and Aleutian Islands region combined:

Year	Foreign	Joint Venture	Domestic	Total
1964	13649	0	0	13649
1965	15170	0	0	15170
1966	18354	0	0	18354
1967	32357	0	0	32357
1968	58191	0	0	58191
1969	50571	0	0	50571
1970	70377	0	0	70377
1971	45132	0	0	45132
1972	43340	0	0	43340
1973	54363	0	0	54363
1974	63841	0	0	63841
1975	54389	0	0	54389
1976	54671	0	0	54671
1977	36597	0	0	36597
1978	45807	0	31	45838
1979	38574	0	780	39354
1980	40846	8370	2433	51649

Table 2.3b—Summary of 1981-1990 catches (t) of Pacific cod in the combined Eastern Bering Sea and Aleutian Islands region by fleet sector and gear type. All catches include discards. LLine = longline, Subt. = sector subtotal.

Eastern Bering Sea and Aleutian Islands region combined:

	Foreign			Joint Venture		Domestic Annual Processing					
Year	Trawl	LLine	Subt.	Trawl	Subt.	Trawl	LLine	Pot	Other	Subt.	Total
1981	33027	6086	39113	9159	9159	15628	27	0	14	15669	63941
1982	24557	3618	28175	13592	13592	26014	5	0	1715	27734	69501
1983	34659	6847	41506	14362	14362	46769	4	21	569	47363	103231
1984	31065	27446	58511	30772	30772	43588	8	0	205	43801	133084
1985	19606	37571	57177	41272	41272	51885	50	0	0	51935	150384
1986	13297	26563	39860	63942	63942	38430	49	63	167	38709	142511
1987	7718	47028	54746	58157	58157	48701	1417	89	0	50207	163110
1988	0	0	0	109892	109892	95404	2611	329	0	98344	208236
1989	0	0	0	44618	44618	123864	14219	164	0	138247	182865
1990	0	0	0	8078	8078	122425	47716	1389	0	171530	179608

Table 2.3c—Summary of 1991-2010 catches (t) of Pacific cod in the Eastern Bering Sea and Aleutian Islands by fleet sector and gear type. All catches include discards. LLine = longline, Subt. = sector subtotal. Catches since 2006 include those from a State-managed fishery in the Aleutian Islands. Catches for 2010 are through October 13.

Bering Sea and Aleutian Islands region combined:

	Federal					State					
Year	Trawl	LLine	Pot	Other	Subt.	Trawl	LLine	Pot	Other	Subt.	Total
1991	132808	80708	6523	0	220038						220038
1992	91820	101507	13829	117	207272						207272
1993	99075	66154	2098	35	167362						167362
1994	99315	85573	8184	730	193802						193802
1995	121532	102601	20300	599	245033						245033
1996	113091	94702	32617	267	240676						240676
1997	111275	124161	22068	262	257765						257765
1998	81312	98095	13657	192	193256						193256
1999	68341	89338	16150	169	173998						173998
2000	74179	97825	18956	101	191060						191060
2001	51484	108178	17016	71	176749						176749
2002	78996	103136	15058	166	197356						197356
2003	109655	6350	21961	73093	211059						211059
2004	111124	6640	17242	77155	212161						212161
2005	116193	7486	17104	64852	205635						205635
2006	99688	7433	19358	62822	189300	455	0	156	3106	3717	193017
2007	81285	5650	17535	65830	170300	529	6	383	2907	3824	174124
2008	94194	6905	19045	46054	166199	234	53	1634	2540	4462	170661
2009	102080	7537	14339	49716	173672	279	20	1237	537	2074	175746
2010	69183	6857	16792	48311	141143	32	0	1635	2113	3780	144924

Table 2.4—History of BSAI Pacific cod catch, TAC, ABC, OFL, and age 3+ biomass projections (from the previous year's assessment). Catch for 2010 is through October 13. Source: NPFMC staff.

Year	Catch	TAC	ABC	OFL	Biomass
1977	36,597	58,000	-	-	-
1978	45,838	70,500	-	-	-
1979	39,354	70,500	-	-	-
1980	51,649	70,700	148,000	-	-
1981	63,941	78,700	160,000	-	-
1982	69,501	78,700	168,000	-	-
1983	103,231	120,000	298,200	-	-
1984	133,084	210,000	291,300	-	-
1985	150,384	220,000	347,400	-	-
1986	142,511	229,000	249,300	-	-
1987	163,110	280,000	400,000	-	-
1988	208,236	200,000	385,300	-	1,481,000
1989	182,865	230,681	370,600	-	1,190,000
1990	179,608	227,000	417,000	-	1,389,500
1991	172,158	229,000	229,000	-	1,030,000
1992	206,129	182,000	182,000	188,000	910,000
1993	167,390	164,500	164,500	142,000	655,000
1994	196,572	191,000	191,000	228,000	925,000
1995	245,030	250,000	328,000	390,000	1,620,000
1996	240,590	270,000	305,000	420,000	1,640,000
1997	234,641	270,000	306,000	418,000	1,590,000
1998	195,645	210,000	210,000	336,000	1,340,000
1999	162,361	177,000	177,000	264,000	1,210,000
2000	191,056	193,000	193,000	240,000	1,300,000
2001	176,659	188,000	188,000	248,000	1,320,000
2002	197,353	200,000	223,000	294,000	1,540,000
2003	211,059	207,500	223,000	324,000	1,680,000
2004	212,161	215,500	223,000	350,000	1,660,000
2005	205,635	206,000	206,000	265,000	1,290,000
2006	193,017	194,000	194,000	230,000	922,000
2007	174,124	170,720	176,000	207,000	960,000
2008	170,661	170,720	176,000	154,000	1,080,000
2009	175,746	176,540	182,000	212,000	1,260,000
2010	144,924	168,780	174,000	205,000	1,140,000

Table 2.5a—Pacific cod discard rates by area, target species/group, and year for the period 1991-2002 (see Table 2.5b for the period 2003-2004 and Table 2.5c for the period 2005-2009). The discard rate is the ratio of discarded Pacific cod catch to total Pacific cod catch for a given area/target/year combination. An empty cell indicates that no Pacific cod were caught in that area/target/year combination. Note that the absolute amount of discards may be small even if the discard rate is large.

Eastern Bering Sea

Target species/group	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Arrowtooth flounder	0.61	0.00	0.94		0.66	0.08	0.07	1.00	1.00	0.99	1.00	0.22
Atka mackerel	1.00		0.70	1.00		0.23		0.51	0.00	0.00	1.00	
Flathead sole					0.39	0.58	0.10	0.75	0.87	0.75	0.00	1.00
Greenland turbot	0.01	0.00	0.12	0.04	0.35	0.09	0.03	0.04	0.13	0.10	0.01	0.18
Other flatfish	0.63	0.31	0.47	0.88	0.22	0.28	0.91	0.28	0.33	0.32	0.00	0.00
Other species	0.04	0.99	0.38		1.00	1.00	0.01	0.95	0.07	0.92	0.08	0.00
Pacific cod	0.03	0.04	0.08	0.06	0.07	0.04	0.03	0.02	0.01	0.02	0.01	0.02
Pollock	0.70	0.85	0.73	0.68	0.21	0.41	0.24	0.42	0.49	0.68	0.84	0.52
Rock sole	1.00	0.00	0.08	0.87	0.25	0.90		1.00	0.02	0.16	1.00	1.00
Rockfish	1.00	0.00	0.89	0.01	0.84	0.69	0.16		0.00	0.03	0.00	0.00
Sablefish	0.00	0.12	0.42	0.40	0.96	0.94	0.78	0.93	0.61	0.98	0.12	0.48
Unknown	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.49	0.04	0.02		
Yellowfin sole		0.74	0.72	0.50	0.08	1.00	0.24	0.77	0.50	0.60	0.39	0.77
All targets	0.03	0.04	0.08	0.06	0.07	0.04	0.03	0.02	0.01	0.02	0.01	0.02

Aleutian Islands

Target species/group	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Arrowtooth flounder	1.00										0.00	0.00
Atka mackerel								1.00		1.00	1.00	1.00
Flathead sole		0.35										
Greenland turbot	0.11	0.00	0.73	0.58	0.40	0.89	0.04	0.01	0.18	0.40	0.00	0.00
Other species		1.00			0.00				0.14	0.08	0.00	0.06
Pacific cod	0.02	0.03	0.12	0.09	0.04	0.04	0.05	0.02	0.02	0.02	0.01	0.02
Pollock	0.76	0.00	0.29	0.00	0.47	0.74	0.75	0.61	0.00			
Rock sole			0.00									
Rockfish	0.83		0.75	0.28	0.18	0.80	0.91	1.00	0.64	0.12	0.22	0.03
Sablefish	1.00	0.04	0.49	0.52	0.97	0.53	0.70	0.88	0.51	0.31	0.06	0.76
Unknown	0.09				1.00	1.00		0.03		1.00	1.00	
All targets	0.04	0.03	0.12	0.09	0.12	0.04	0.06	0.02	0.02	0.02	0.01	0.02

Table 2.5b—Pacific cod discard rates by area, target species/group, and year for the period 2003-2004 (see Table 2.5a for the period 1991-2002 and Table 2.5c for the period 2005-2009). The discard rate is the ratio of discarded Pacific cod catch to total Pacific cod catch for a given area/target/year combination. An empty cell indicates that no Pacific cod were caught in that area/target/year combination. Note that the absolute amount of discards may be small even if the discard rate is large.

	Eastern Bering Sea		**Aleutian Islands**	
Target species/group	2003	2004	2003	2004
Arrowtooth flounder	0.01	0.00		
Atka mackerel	0.02	0.00	0.03	0.02
Flathead sole	0.00	0.02		
Greenland turbot	0.07	0.05	0.00	
IFQ halibut	0.28	0.28	0.58	0.38
Other flatfish	0.02	0.00		
Other species	0.02	0.04	0.00	
Pacific cod	0.01	0.01	0.01	0.01
Pollock	0.00	0.02		
Rock sole	0.08	0.03	0.11	
Rockfish	0.00	0.00	0.00	0.02
Sablefish	0.44	0.03	0.37	0.06
Unknown				
Yellowfin sole	0.06	0.02		
All targets	0.02	0.01	0.01	0.01

Table 2.5c—Eastern Bering Sea (EBS) and Aleutian Islands (AI) Pacific cod discard rates by area, target species/group, and year for the period 2005-2010 (see Table 2.5a for the period 1991-2002 and Table 2.5b for the period 2003-2004). The discard rate is the ratio of discarded Pacific cod catch to total Pacific cod catch for a given area/target/year combination. An empty cell indicates that no Pacific cod were caught in that area/target/year combination. Note that the absolute amount of discards may be small even if the discard rate is large.

EBS target fishery	2005	2006	2007	2008	2009	2010	Ave.
Alaska Plaice		0.405	0.000	0.000	0.004	0.010	0.084
Arrowtooth	0.050	0.006	0.034	0.001	0.024	0.021	0.023
Atka Mackerel	0.007	0.054	0.002	0.015	0.019		0.019
Flathead Sole	0.019	0.085	0.004	0.028	0.029	0.010	0.029
Greenland Turbot	0.010	0.157	0.026	0.026	0.013	0.331	0.094
Halibut	0.700	0.018	0.109	0.517	0.011	0.000	0.226
Other Flatfish	0.072	0.015	0.018	0.027	0.000	0.000	0.022
Other Species	0.062	0.125	0.002		0.000	0.000	0.038
Pacific Cod	0.017	0.012	0.013	0.012	0.013	0.014	0.013
Pollock - bottom	0.000	0.008	0.000	0.001	0.002	0.002	0.002
Pollock - midwater	0.005	0.008	0.010	0.002	0.007	0.002	0.006
Rock Sole	0.019	0.027	0.045	0.015	0.024	0.021	0.025
Rockfish	0.000	0.010	0.000	0.000	0.000	0.001	0.004
Sablefish	0.696	0.022	0.729	0.587	0.000	1.000	0.506
Unknown	1.000	1.000	1.000	1.000		0.055	0.056
Yellowfin Sole	0.045	0.096	0.057	0.061	0.020	0.040	0.047
Total	0.017	0.014	0.014	0.014	0.027	0.017	0.017

AI target fishery	2005	2006	2007	2008	2009	2010	Ave.
Arrowtooth		0.078	0.138		1.000	0.032	0.312
Atka Mackerel	0.063	0.028	0.028	0.002	0.019	0.005	0.024
Flathead sole			0.000				0.000
Greenland Turbot		0.000	0.017			1.000	0.339
Halibut	0.905	0.390	0.341	0.627	0.001	0.004	0.378
Other Species	0.000	0.414	0.190	0.000	0.002		0.125
Pacific Cod	0.007	0.010	0.015	0.005	0.006	0.009	0.009
Pollock - bottom		1.000	1.000	0.451		0.017	0.617
Pollock - midwater		0.086	0.057	0.000	0.523	0.586	0.250
Rockfish	0.000	0.107	0.090	0.002	0.201	0.000	0.066
Sablefish	0.029	0.565	0.314	0.076	0.021	0.816	0.303
Unknown				1.000			1.000
Total	0.022	0.013	0.016	0.007	0.008	0.009	0.012

Table 2.6a—EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2010 as configured in Model A. Because direct estimates of gear- and period-specific catches are not available for the years 1977-1980, the figures shown here are estimates derived by distributing each year's total catch according to the average proportion observed for each gear/period combination during the years 1981-1988. The small amounts of catch from "other" gear types have been merged into the gear types listed below proportionally. Sea. 1 = Jan-May, Sea. 2 = Jun-Aug, Sea. 3 = Sep-Dec. Sea. 3 catches for 2010 are extrapolated.

	Trawl fishery			Longline fishery			Pot fishery		
Year	Sea. 1	Sea. 2	Sea. 3	Sea. 1	Sea. 2	Sea. 3	Sea. 1	Sea. 2	Sea. 3
1977	14935	6139	6858	1851	260	3292	0	0	0
1978	19710	8101	9051	2443	343	4344	0	0	0
1979	16131	6630	7407	1999	281	3555	0	0	0
1980	18387	7558	8444	2279	320	4053	0	0	0
1981	15067	14087	21486	1286	624	3942	0	0	0
1982	21742	18151	16348	363	475	2308	0	0	0
1983	40757	24300	22705	2941	748	2756	0	0	0
1984	48237	24964	25045	5012	2128	19508	0	0	0
1985	55673	28673	22310	13703	1710	21379	0	0	0
1986	59786	26598	22382	8895	438	17278	0	0	0
1987	64413	15604	21462	20947	723	26752	0	0	0
1988	127470	25662	47166	534	697	1545	0	0	0
1989	127459	16986	19798	3810	4968	5157	33	63	49
1990	101645	11402	10524	13171	16643	17299	0	986	395
1991	107980	15550	5864	26240	21472	29792	12	1042	2289
1992	59478	11841	5959	48941	24196	6276	2622	4632	258
1993	67122	5362	9281	49244	27	23	2073	24	0
1994	61117	5974	18265	58071	13	20752	4932	0	3139
1995	90472	8707	12094	68539	27	29292	12498	3536	3335
1996	78249	3159	10605	62055	26	26882	18155	6469	3467
1997	81354	3971	8685	70711	43	46296	14591	3616	3333
1998	45048	5656	10174	54283	18	30082	9030	2805	1433
1999	44921	3329	3690	55201	1933	24384	9349	1006	2054
2000	44538	4579	4731	40206	1375	40088	15752	0	107
2001	22850	7052	5782	38369	6725	45292	11732	444	4298
2002	37026	9606	4504	50049	12197	38114	10857	403	3799
2003	31570	9445	2537	55618	12362	44325	16081	1	6661
2004	39319	11855	2600	57275	11085	43278	13003	429	4443
2005	41663	5824	181	56307	13727	47433	12772	0	5028
2006	43228	4671	209	53475	16385	31144	14891	0	4802
2007	34068	7374	197	45911	13868	20871	12575	20	5197
2008	20920	3671	3659	47804	14510	31033	11544	1	6461
2009	18608	6287	6391	51864	13522	36107	12007	0	2381
2010	22178	6118	5365	45948	9999	29337	13489	0	4679

Table 2.6b (p. 1 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2010 as configured in Models B and C. Because direct estimates of gear- and period-specific catches are not available for the years 1977-1980, the figures shown here are estimates derived by distributing each year's total catch according to the average proportion observed for each gear/period combination during the years 1981-1988. The small amounts of catch from "other" gear types have been merged into the gear types listed below proportionally. Aug-Oct and Nov-Dec catches for 2010 are extrapolated.

		Trawl fishery			Longline fishery			Pot fishery		
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec
1977	Jan-Feb	5974	0	0	740	0	0	0	0	0
1977	Mar-Apr	5974	0	0	740	0	0	0	0	0
1977	May-Jul	0	7080	0	0	544	0	0	0	0
1977	Aug-Oct	0	0	5475	0	0	1733	0	0	0
1977	Nov-Dec	0	0	3429	0	0	1646	0	0	0
1978	Jan-Feb	7884	0	0	977	0	0	0	0	0
1978	Mar-Apr	7884	0	0	977	0	0	0	0	0
1978	May-Jul	0	9343	0	0	717	0	0	0	0
1978	Aug-Oct	0	0	7226	0	0	2286	0	0	0
1978	Nov-Dec	0	0	4526	0	0	2172	0	0	0
1979	Jan-Feb	6452	0	0	800	0	0	0	0	0
1979	Mar-Apr	6452	0	0	800	0	0	0	0	0
1979	May-Jul	0	7646	0	0	587	0	0	0	0
1979	Aug-Oct	0	0	5914	0	0	1871	0	0	0
1979	Nov-Dec	0	0	3704	0	0	1778	0	0	0
1980	Jan-Feb	7355	0	0	912	0	0	0	0	0
1980	Mar-Apr	7355	0	0	912	0	0	0	0	0
1980	May-Jul	0	8716	0	0	669	0	0	0	0
1980	Aug-Oct	0	0	6741	0	0	2133	0	0	0
1980	Nov-Dec	0	0	4222	0	0	2027	0	0	0
1981	Jan-Feb	6027	0	0	514	0	0	0	0	0
1981	Mar-Apr	6027	0	0	514	0	0	0	0	0
1981	May-Jul	0	12405	0	0	673	0	0	0	0
1981	Aug-Oct	0	0	15439	0	0	2179	0	0	0
1981	Nov-Dec	0	0	10743	0	0	1971	0	0	0
1982	Jan-Feb	8697	0	0	145	0	0	0	0	0
1982	Mar-Apr	8697	0	0	145	0	0	0	0	0
1982	May-Jul	0	16449	0	0	389	0	0	0	0
1982	Aug-Oct	0	0	14224	0	0	1312	0	0	0
1982	Nov-Dec	0	0	8174	0	0	1154	0	0	0
1983	Jan-Feb	16303	0	0	1176	0	0	0	0	0
1983	Mar-Apr	16303	0	0	1176	0	0	0	0	0
1983	May-Jul	0	24351	0	0	1087	0	0	0	0
1983	Aug-Oct	0	0	19453	0	0	1627	0	0	0
1983	Nov-Dec	0	0	11353	0	0	1378	0	0	0
1984	Jan-Feb	19295	0	0	2005	0	0	0	0	0
1984	Mar-Apr	19295	0	0	2005	0	0	0	0	0
1984	May-Jul	0	26290	0	0	2421	0	0	0	0
1984	Aug-Oct	0	0	20844	0	0	10463	0	0	0
1984	Nov-Dec	0	0	12523	0	0	9754	0	0	0
1985	Jan-Feb	22269	0	0	5481	0	0	0	0	0
1985	Mar-Apr	22269	0	0	5481	0	0	0	0	0
1985	May-Jul	0	30250	0	0	3881	0	0	0	0
1985	Aug-Oct	0	0	20713	0	0	11260	0	0	0
1985	Nov-Dec	0	0	11155	0	0	10690	0	0	0

Table 2.6b (p. 2 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2010 as configured in Models B and C.

		Trawl fishery			Longline fishery			Pot fishery		
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec
1986	Jan-Feb	23914	0	0	3558	0	0	0	0	0
1986	Mar-Apr	23914	0	0	3558	0	0	0	0	0
1986	May-Jul	0	29689	0	0	2071	0	0	0	0
1986	Aug-Oct	0	0	20057	0	0	8785	0	0	0
1986	Nov-Dec	0	0	11191	0	0	8639	0	0	0
1987	Jan-Feb	25765	0	0	8379	0	0	0	0	0
1987	Mar-Apr	25765	0	0	8379	0	0	0	0	0
1987	May-Jul	0	23285	0	0	4671	0	0	0	0
1987	Aug-Oct	0	0	15932	0	0	13617	0	0	0
1987	Nov-Dec	0	0	10731	0	0	13376	0	0	0
1988	Jan-Feb	50988	0	0	214	0	0	0	0	0
1988	Mar-Apr	50988	0	0	214	0	0	0	0	0
1988	May-Jul	0	42602	0	0	571	0	0	0	0
1988	Aug-Oct	0	0	32137	0	0	1005	0	0	0
1988	Nov-Dec	0	0	23583	0	0	773	0	0	0
1989	Jan-Feb	50984	0	0	1524	0	0	13	0	0
1989	Mar-Apr	50984	0	0	1524	0	0	13	0	0
1989	May-Jul	0	36816	0	0	4074	0	0	49	0
1989	Aug-Oct	0	0	15561	0	0	4235	0	0	46
1989	Nov-Dec	0	0	9899	0	0	2579	0	0	25
1990	Jan-Feb	40658	0	0	5268	0	0	0	0	0
1990	Mar-Apr	40658	0	0	5268	0	0	0	0	0
1990	May-Jul	0	27930	0	0	13730	0	0	657	0
1990	Aug-Oct	0	0	9063	0	0	14197	0	0	526
1990	Nov-Dec	0	0	5262	0	0	8650	0	0	198
1991	Jan-Feb	35012	0	0	8232	0	0	1	0	0
1991	Mar-Apr	65705	0	0	12398	0	0	12	0	0
1991	May-Jul	0	16403	0	0	20115	0	0	410	0
1991	Aug-Oct	0	0	12271	0	0	21276	0	0	2306
1991	Nov-Dec	0	0	2	0	0	15484	0	0	614
1992	Jan-Feb	23287	0	0	13646	0	0	50	0	0
1992	Mar-Apr	32239	0	0	22401	0	0	149	0	0
1992	May-Jul	0	11784	0	0	27045	0	0	5321	0
1992	Aug-Oct	0	0	8182	0	0	16319	0	0	1992
1992	Nov-Dec	0	0	1788	0	0	0	0	0	0
1993	Jan-Feb	28010	0	0	22406	0	0	1	0	0
1993	Mar-Apr	35631	0	0	21654	0	0	1010	0	0
1993	May-Jul	0	6095	0	0	5208	0	0	1086	0
1993	Aug-Oct	0	0	9943	0	0	3	0	0	0
1993	Nov-Dec	0	0	2084	0	0	23	0	0	0
1994	Jan-Feb	13856	0	0	22458	0	0	0	0	0
1994	Mar-Apr	44222	0	0	29481	0	0	3179	0	0
1994	May-Jul	0	4453	0	0	6210	0	0	1792	0
1994	Aug-Oct	0	0	20070	0	0	20718	0	0	3133
1994	Nov-Dec	0	0	2691	0	0	0	0	0	0
1995	Jan-Feb	31919	0	0	29918	0	0	62	0	0
1995	Mar-Apr	58159	0	0	34516	0	0	7715	0	0
1995	May-Jul	0	1145	0	0	4161	0	0	7342	0
1995	Aug-Oct	0	0	19770	0	0	21305	0	0	2927
1995	Nov-Dec	0	0	108	0	0	8039	0	0	1413

Table 2.6b (p. 3 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2010 as configured in Models B and C.

		Trawl fishery			Longline fishery			Pot fishery		
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec
1996	Jan-Feb	21160	0	0	28848	0	0	4	0	0
1996	Mar-Apr	50436	0	0	29471	0	0	12571	0	0
1996	May-Jul	0	8398	0	0	3755	0	0	10423	0
1996	Aug-Oct	0	0	10543	0	0	23629	0	0	4347
1996	Nov-Dec	0	0	1475	0	0	3278	0	0	728
1997	Jan-Feb	25706	0	0	31962	0	0	46	0	0
1997	Mar-Apr	52321	0	0	30578	0	0	9639	0	0
1997	May-Jul	0	5049	0	0	8211	0	0	7411	0
1997	Aug-Oct	0	0	9321	0	0	21323	0	0	3780
1997	Nov-Dec	0	0	1585	0	0	25011	0	0	658
1998	Jan-Feb	16120	0	0	30359	0	0	31	0	0
1998	Mar-Apr	26963	0	0	19925	0	0	5550	0	0
1998	May-Jul	0	4180	0	0	4022	0	0	5770	0
1998	Aug-Oct	0	0	12586	0	0	16155	0	0	1890
1998	Nov-Dec	0	0	999	0	0	13928	0	0	53
1999	Jan-Feb	18354	0	0	31749	0	0	5	0	0
1999	Mar-Apr	24661	0	0	20876	0	0	4937	0	0
1999	May-Jul	0	3028	0	0	3283	0	0	5420	0
1999	Aug-Oct	0	0	5658	0	0	20571	0	0	2054
1999	Nov-Dec	0	0	231	0	0	5040	0	0	0
2000	Jan-Feb	18935	0	0	30652	0	0	11647	0	0
2000	Mar-Apr	23194	0	0	8195	0	0	4105	0	0
2000	May-Jul	0	4588	0	0	1683	0	0	0	0
2000	Aug-Oct	0	0	6540	0	0	23325	0	0	107
2000	Nov-Dec	0	0	590	0	0	17816	0	0	0
2001	Jan-Feb	8588	0	0	19639	0	0	150	0	0
2001	Mar-Apr	13895	0	0	16568	0	0	11279	0	0
2001	May-Jul	0	3687	0	0	4089	0	0	611	0
2001	Aug-Oct	0	0	8701	0	0	30261	0	0	3878
2001	Nov-Dec	0	0	807	0	0	19831	0	0	558
2002	Jan-Feb	13410	0	0	35198	0	0	1845	0	0
2002	Mar-Apr	21130	0	0	14486	0	0	8407	0	0
2002	May-Jul	0	7772	0	0	1811	0	0	1013	0
2002	Aug-Oct	0	0	8594	0	0	34463	0	0	2997
2002	Nov-Dec	0	0	263	0	0	14360	0	0	804
2003	Jan-Feb	13578	0	0	37470	0	0	14499	0	0
2003	Mar-Apr	15985	0	0	17357	0	0	1706	0	0
2003	May-Jul	0	6947	0	0	2524	0	0	0	0
2003	Aug-Oct	0	0	6734	0	0	36740	0	0	5278
2003	Nov-Dec	0	0	156	0	0	18183	0	0	1444
2004	Jan-Feb	19091	0	0	39688	0	0	9566	0	0
2004	Mar-Apr	17077	0	0	16930	0	0	2906	0	0
2004	May-Jul	0	9534	0	0	3094	0	0	1005	0
2004	Aug-Oct	0	0	7876	0	0	31730	0	0	3939
2004	Nov-Dec	0	0	75	0	0	20182	0	0	596
2005	Jan-Feb	24189	0	0	49594	0	0	9546	0	0
2005	Mar-Apr	14745	0	0	6867	0	0	3234	0	0
2005	May-Jul	0	6968	0	0	3731	0	0	0	0
2005	Aug-Oct	0	0	1593	0	0	36495	0	0	4698
2005	Nov-Dec	0	0	113	0	0	20756	0	0	407

Table 2.6b (p. 4 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2010 as configured in Models B and C.

		Trawl fishery			Longline fishery			Pot fishery		
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec
2006	Jan-Feb	25833	0	0	47385	0	0	11134	0	0
2006	Mar-Apr	13647	0	0	6191	0	0	3393	0	0
2006	May-Jul	0	6057	0	0	2144	0	0	410	0
2006	Aug-Oct	0	0	2702	0	0	44005	0	0	4024
2006	Nov-Dec	0	0	48	0	0	1025	0	0	808
2007	Jan-Feb	14546	0	0	43955	0	0	10946	0	0
2007	Mar-Apr	16320	0	0	1966	0	0	1168	0	0
2007	May-Jul	0	10050	0	0	1337	0	0	528	0
2007	Aug-Oct	0	0	921	0	0	32257	0	0	5240
2007	Nov-Dec	0	0	62	0	0	783	0	0	0
2008	Jan-Feb	12952	0	0	43741	0	0	9299	0	0
2008	Mar-Apr	6972	0	0	3779	0	0	2016	0	0
2008	May-Jul	0	3132	0	0	3295	0	0	283	0
2008	Aug-Oct	0	0	4737	0	0	34187	0	0	6467
2008	Nov-Dec	0	0	654	0	0	7967	0	0	124
2009	Jan-Feb	8885	0	0	47453	0	0	9959	0	0
2009	Mar-Apr	8958	0	0	4174	0	0	1929	0	0
2009	May-Jul	0	3724	0	0	2812	0	0	133	0
2009	Aug-Oct	0	0	9807	0	0	36042	0	0	1312
2009	Nov-Dec	0	0	403	0	0	10494	0	0	1081
2010	Jan-Feb	14404	0	0	42536	0	0	11094	0	0
2010	Mar-Apr	7305	0	0	2508	0	0	2112	0	0
2010	May-Jul	0	3734	0	0	3047	0	0	368	0
2010	Aug-Oct	0	0	8943	0	0	34162	0	0	4340
2010	Nov-Dec	0	0	373	0	0	6415	0	0	402

Table 2.6c—Fishery catch per unit effort as configured in Model A. Effort units are kg/minute (trawl), kg/hook (longline), and kg/pot (pot). "Sigma" is a proxy for the log-scale standard error. It was computed by first calculating the reciprocal of the number of hauls associated with each CPUE value, then rescaling such that the average across all records was 0.2. Records with fewer than three distinct vessels are excluded.

	Trawl fishery						Longline fishery						Pot fishery					
	Jan-May		Jun-Aug		Sep-Dec		Jan-May		Jun-Aug		Sep-Dec		Jan-May		Jun-Aug		Sep-Dec	
Year	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma	CPUE	Sigma
1991	58.85	0.048	49.23	0.330	24.40	1.649	1.022	0.078	0.713	0.067	0.550	0.057			68.53	0.144	103.16	0.155
1992	49.11	0.062	104.89	0.596	30.40	1.428	0.804	0.047	0.501	0.051	0.490	0.107	76.14	0.108	49.20	0.082	26.94	0.197
1993	51.00	0.065	50.84	0.596	106.54	0.490	0.655	0.043	0.345	1.428			85.53	0.115				
1994	51.41	0.050	45.97	0.609	51.01	0.404	0.730	0.042			0.576	0.067	86.03	0.090			97.17	0.150
1995	62.04	0.054	57.44	0.446	62.76	0.441	0.858	0.044			0.605	0.058	85.19	0.074	69.59	0.138	52.18	0.129
1996	35.70	0.047	36.59	0.522	32.98	0.251	0.805	0.046			0.544	0.058	67.67	0.062	53.19	0.122	49.54	0.162
1997	51.20	0.054	32.77	0.382	75.73	0.714	0.873	0.048			0.579	0.048	76.71	0.095	47.20	0.150	46.56	0.163
1998	36.26	0.064	27.95	0.277	43.34	0.366	0.736	0.050			0.443	0.047	63.17	0.121	46.65	0.197	32.70	0.280
1999	37.54	0.068	16.67	0.463	20.80	0.436	0.679	0.045	0.464	0.127	0.499	0.058	53.98	0.106	40.13	0.452	37.50	0.209
2000	32.73	0.068	14.17	0.385	22.40	1.166	0.684	0.053	0.486	0.133	0.403	0.043	51.31	0.110				
2001	22.42	0.088	45.65	0.236	14.42	0.326	0.555	0.049	0.444	0.092	0.409	0.043	70.30	0.128			46.11	0.161
2002	29.70	0.079	31.72	0.199	16.28	0.270	0.677	0.049	0.392	0.071	0.375	0.043	67.55	0.144			44.93	0.170
2003	26.91	0.080	33.46	0.144	21.86	0.287	0.519	0.040	0.351	0.067	0.352	0.039	73.86	0.137			58.16	0.153
2004	50.06	0.085	29.76	0.130	16.12	0.260	0.563	0.046	0.337	0.070	0.365	0.042	76.48	0.153			51.93	0.188
2005	45.06	0.077	21.12	0.215			0.636	0.049	0.357	0.063	0.350	0.042	86.93	0.160			46.12	0.188
2006	41.58	0.077	25.74	0.344			0.759	0.054	0.429	0.072	0.370	0.055	87.16	0.143			52.40	0.168
2007	37.90	0.059	42.90	0.184	15.94	1.010	0.731	0.043	0.457	0.059	0.369	0.047	64.67	0.107			65.36	0.149
2008	29.91	0.115	55.52	0.243	39.38	0.513	0.780	0.060	0.359	0.075	0.333	0.047	81.64	0.206			57.25	0.162
2009	44.64	0.121	44.76	0.260	54.07	0.257	0.930	0.063	0.371	0.072	0.366	0.050	93.46	0.173			67.06	0.227
2010	44.63	0.120	55.67	0.295	77.42	0.792	0.781	0.062	0.428	0.143	0.314	0.366	88.54	0.165				

Table 2.6d (page 1 of 3)— Fishery CPUE as configured in Models B and C. See Table 2.6c for details.

Jan-Apr trawl fishery				May-Jul trawl fishery				Aug-Dec trawl fishery			
Year	Season	CPUE	Sigma	Year	Season	CPUE	Sigma	Year	Season	CPUE	Sigma
1991	Jan-Feb	55.864	0.092	1991	May-Jul	36.761	0.205	1991	Aug-Oct	71.702	0.607
1992	Jan-Feb	60.427	0.163	1992	May-Jul	38.568	0.293	1992	Aug-Oct	57.517	0.778
1993	Jan-Feb	62.047	0.158	1993	May-Jul	39.902	0.472	1993	Aug-Oct	113.970	0.507
1994	Jan-Feb	51.965	0.224	1994	May-Jul	26.767	0.250	1994	Aug-Oct	56.308	0.393
1995	Jan-Feb	88.482	0.123	1995	May-Jul	59.393	1.682	1995	Aug-Oct	60.164	0.326
1996	Jan-Feb	48.331	0.133	1996	May-Jul	29.174	0.316	1996	Aug-Oct	34.896	0.293
1997	Jan-Feb	75.605	0.123	1997	May-Jul	24.880	0.261	1997	Aug-Oct	62.619	0.571
1998	Jan-Feb	59.920	0.160	1998	May-Jul	26.245	0.305	1998	Aug-Oct	38.995	0.307
1999	Jan-Feb	42.399	0.120	1999	May-Jul	15.672	0.429	1999	Aug-Oct	20.611	0.370
2000	Jan-Feb	34.522	0.124	2000	May-Jul	32.694	0.296	2000	Aug-Oct	15.070	0.532
2001	Jan-Feb	25.452	0.167	2001	May-Jul	60.120	0.300	2001	Aug-Oct	16.662	0.251
2002	Jan-Feb	35.892	0.142	2002	May-Jul	39.985	0.211	2002	Aug-Oct	15.141	0.197
2003	Jan-Feb	24.642	0.170	2003	May-Jul	49.493	0.212	2003	Aug-Oct	19.171	0.157
2004	Jan-Feb	62.609	0.139	2004	May-Jul	34.588	0.165	2004	Aug-Oct	21.519	0.155
2005	Jan-Feb	43.993	0.117	2005	May-Jul	24.100	0.173	2005	Aug-Oct	15.932	0.841
2006	Jan-Feb	36.397	0.108	2006	May-Jul	30.653	0.188	2006	Aug-Oct	26.772	0.379
2007	Jan-Feb	30.849	0.096	2007	May-Jul	39.485	0.115	2007	Aug-Oct	18.147	0.687
2008	Jan-Feb	24.385	0.153	2008	May-Jul	40.650	0.253	2008	Aug-Oct	60.047	0.339
2009	Jan-Feb	37.853	0.172	2009	May-Jul	33.932	0.294	2009	Aug-Oct	54.154	0.227
2010	Jan-Feb	41.949	0.138	2010	May-Jul	32.398	0.356	2010	Aug-Oct	93.972	0.439
1991	Mar-Apr	61.454	0.059					1993	Nov-Dec	32.678	0.921
1992	Mar-Apr	48.269	0.070					1996	Nov-Dec	29.543	0.485
1993	Mar-Apr	48.840	0.074					1997	Nov-Dec	31.309	1.101
1994	Mar-Apr	52.428	0.053					1998	Nov-Dec	16.891	0.651
1995	Mar-Apr	55.463	0.062					1999	Nov-Dec	12.994	0.971
1996	Mar-Apr	33.954	0.052					2009	Nov-Dec	28.369	1.189
1997	Mar-Apr	45.985	0.063								
1998	Mar-Apr	31.809	0.072								
1999	Mar-Apr	35.675	0.087								
2000	Mar-Apr	31.397	0.086								
2001	Mar-Apr	21.213	0.107								
2002	Mar-Apr	26.640	0.104								
2003	Mar-Apr	28.131	0.096								
2004	Mar-Apr	42.816	0.117								
2005	Mar-Apr	48.932	0.114								
2006	Mar-Apr	56.188	0.142								
2007	Mar-Apr	45.097	0.093								
2008	Mar-Apr	40.343	0.198								
2009	Mar-Apr	55.557	0.185								
2010	Mar-Apr	55.766	0.268								

Table 2.6d (page 2 of 3)— Fishery CPUE as configured in Models B and C. See Table 2.6c for details.

Jan-Apr longline fishery				May-Jul longline fishery				Aug-Dec longline fishery			
Year	Season	CPUE	Sigma	Year	Season	CPUE	Sigma	Year	Season	CPUE	Sigma
1991	Jan-Feb	1.124	0.157	1991	May-Jul	0.771	0.076	1991	Aug-Oct	0.595	0.063
1992	Jan-Feb	0.873	0.089	1992	May-Jul	0.530	0.053	1992	Aug-Oct	0.512	0.070
1993	Jan-Feb	0.654	0.066	1993	May-Jul	0.551	0.177	1994	Aug-Oct	0.576	0.068
1994	Jan-Feb	0.728	0.068	1994	May-Jul	0.713	0.134	1995	Aug-Oct	0.587	0.070
1995	Jan-Feb	0.895	0.069	1995	May-Jul	0.760	0.180	1996	Aug-Oct	0.542	0.061
1996	Jan-Feb	0.878	0.069	1996	May-Jul	0.669	0.179	1997	Aug-Oct	0.580	0.065
1997	Jan-Feb	0.989	0.073	1997	May-Jul	0.657	0.121	1998	Aug-Oct	0.398	0.064
1998	Jan-Feb	0.888	0.074	1998	May-Jul	0.496	0.185	1999	Aug-Oct	0.481	0.061
1999	Jan-Feb	0.743	0.068	1999	May-Jul	0.637	0.144	2000	Aug-Oct	0.404	0.053
2000	Jan-Feb	0.730	0.070	2000	May-Jul	0.610	0.170	2001	Aug-Oct	0.398	0.052
2001	Jan-Feb	0.586	0.080	2001	May-Jul	0.514	0.108	2002	Aug-Oct	0.372	0.046
2002	Jan-Feb	0.680	0.062	2002	May-Jul	0.405	0.138	2003	Aug-Oct	0.342	0.045
2003	Jan-Feb	0.517	0.053	2003	May-Jul	0.376	0.110	2004	Aug-Oct	0.312	0.048
2004	Jan-Feb	0.562	0.061	2004	May-Jul	0.367	0.116	2005	Aug-Oct	0.330	0.046
2005	Jan-Feb	0.626	0.055	2005	May-Jul	0.385	0.107	2006	Aug-Oct	0.391	0.047
2006	Jan-Feb	0.747	0.063	2006	May-Jul	0.366	0.163	2007	Aug-Oct	0.402	0.039
2007	Jan-Feb	0.734	0.046	2007	May-Jul	0.406	0.143	2008	Aug-Oct	0.307	0.048
2008	Jan-Feb	0.794	0.068	2008	May-Jul	0.366	0.141	2009	Aug-Oct	0.348	0.049
2009	Jan-Feb	0.893	0.069	2009	May-Jul	0.384	0.152	2010	Aug-Oct	0.411	0.174
2010	Jan-Feb	0.781	0.067	2010	May-Jul	0.443	0.195	1991	Nov-Dec	0.551	0.094
1991	Mar-Apr	0.993	0.111					1995	Nov-Dec	0.648	0.111
1992	Mar-Apr	0.858	0.071					1996	Nov-Dec	0.590	0.279
1993	Mar-Apr	0.669	0.062					1997	Nov-Dec	0.577	0.073
1994	Mar-Apr	0.735	0.061					1998	Nov-Dec	0.501	0.073
1995	Mar-Apr	0.841	0.062					1999	Nov-Dec	0.541	0.121
1996	Mar-Apr	0.756	0.067					2000	Nov-Dec	0.416	0.067
1997	Mar-Apr	0.829	0.078					2001	Nov-Dec	0.432	0.066
1998	Mar-Apr	0.619	0.076					2002	Nov-Dec	0.394	0.073
1999	Mar-Apr	0.617	0.068					2003	Nov-Dec	0.365	0.060
2000	Mar-Apr	0.617	0.097					2004	Nov-Dec	0.441	0.066
2001	Mar-Apr	0.539	0.073					2005	Nov-Dec	0.385	0.065
2002	Mar-Apr	0.676	0.083					2006	Nov-Dec	0.433	0.215
2003	Mar-Apr	0.530	0.068					2007	Nov-Dec	0.449	0.334
2004	Mar-Apr	0.579	0.076					2008	Nov-Dec	0.449	0.088
2005	Mar-Apr	0.678	0.113					2009	Nov-Dec	0.428	0.091
2006	Mar-Apr	0.796	0.113								
2007	Mar-Apr	0.693	0.156								
2008	Mar-Apr	0.774	0.147								
2009	Mar-Apr	1.159	0.173								
2010	Mar-Apr	0.829	0.197								

Table 2.6d (page 3 of 3)— Fishery CPUE as configured in Models B and C. See Table 2.6c for details.

Jan-Apr pot fishery			
Year	Season	CPUE	Sigma
2000	Jan-Feb	56.553	0.153
2001	Jan-Feb	72.207	0.507
2002	Jan-Feb	81.893	0.266
2003	Jan-Feb	73.858	0.140
2004	Jan-Feb	78.980	0.171
2005	Jan-Feb	85.328	0.169
2006	Jan-Feb	83.292	0.155
2007	Jan-Feb	64.671	0.109
2008	Jan-Feb	81.642	0.210
2009	Jan-Feb	92.345	0.190
2010	Jan-Feb	88.535	0.169
1992	Mar-Apr	86.412	0.425
1993	Mar-Apr	84.191	0.137
1994	Mar-Apr	89.313	0.108
1995	Mar-Apr	91.679	0.095
1996	Mar-Apr	73.485	0.077
1997	Mar-Apr	93.226	0.121
1998	Mar-Apr	77.558	0.185
1999	Mar-Apr	67.604	0.196
2000	Mar-Apr	45.310	0.164
2001	Mar-Apr	69.247	0.138
2002	Mar-Apr	61.628	0.177
2004	Mar-Apr	65.936	0.393
2006	Mar-Apr	116.202	0.425

May-Jul pot fishery			
Year	Season	CPUE	Sigma
1991	May-Jul	64.037	0.253
1992	May-Jul	66.730	0.077
1993	May-Jul	90.669	0.230
1994	May-Jul	75.421	0.174
1995	May-Jul	72.065	0.099
1996	May-Jul	55.819	0.090
1997	May-Jul	46.843	0.115
1998	May-Jul	49.999	0.130
1999	May-Jul	47.466	0.125

Aug-Dec pot fishery			
Year	Season	CPUE	Sigma
1991	Aug-Oct	88.556	0.133
1992	Aug-Oct	30.252	0.114
1994	Aug-Oct	97.172	0.152
1995	Aug-Oct	57.783	0.154
1996	Aug-Oct	49.758	0.137
1997	Aug-Oct	47.938	0.168
1998	Aug-Oct	32.057	0.283
1999	Aug-Oct	37.675	0.214
2001	Aug-Oct	46.493	0.170
2002	Aug-Oct	42.331	0.190
2003	Aug-Oct	57.632	0.176
2004	Aug-Oct	48.802	0.212
2005	Aug-Oct	45.872	0.194
2006	Aug-Oct	55.342	0.187
2007	Aug-Oct	65.356	0.152
2008	Aug-Oct	57.252	0.165
2009	Aug-Oct	72.836	0.268
1991	Nov-Dec	91.633	0.264
1995	Nov-Dec	53.251	0.189
1996	Nov-Dec	46.456	0.425
1997	Nov-Dec	41.829	0.416
1998	Nov-Dec	41.138	0.808
2001	Nov-Dec	40.740	0.636
2002	Nov-Dec	55.955	0.420
2003	Nov-Dec	60.093	0.336
2004	Nov-Dec	66.375	0.455
2006	Nov-Dec	37.187	0.425

Table 2.7a—Length frequencies for the January-May trawl fishery by length bin as configured in Model A.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
1	1	1978	4	0	0	0	1	1	0	1	0	3	16	19	73	220	103	29	19	13	4	5	4	0	1	2	0	0
1	1	1979	12	0	0	0	0	0	0	1	21	45	94	204	315	329	77	122	147	144	37	5	4	3	1	1	0	0
1	1	1980	62	0	0	0	0	0	0	2	36	75	235	635	1014	1560	1038	971	714	497	632	485	197	86	49	17	5	2
1	1	1982	30	0	0	0	0	0	2	1	6	58	113	64	73	294	386	518	729	731	534	241	104	51	41	21	3	3
1	1	1983	76	0	0	0	0	0	1	1	50	154	93	95	176	492	758	1626	2344	2071	1307	644	211	77	36	21	12	6
1	1	1984	122	0	1	2	1	0	15	194	401	367	220	105	223	709	779	1264	2262	3195	2930	2027	1039	434	144	24	13	2
1	1	1985	223	0	0	2	0	4	0	2	39	116	257	720	1752	2234	1079	1388	2440	4999	5563	4288	2630	1385	594	221	67	23
1	1	1986	213	0	4	16	8	34	60	118	249	635	761	683	783	2228	3560	3287	2095	2631	3469	3357	2442	1346	454	168	58	17
1	1	1987	306	0	0	3	13	15	58	192	440	477	592	1161	2054	3898	2890	3326	5470	5461	4306	3650	3106	1953	1076	440	198	63
1	1	1988	718	1	0	1	1	6	29	92	580	1448	1956	2185	4311	11135	10599	10194	9103	10096	12012	10395	5807	3010	1686	814	346	92
1	1	1989	436	0	0	3	3	1	0	28	217	494	795	720	954	3110	4341	4654	5664	7033	8561	8246	6265	3826	1867	919	388	144
1	1	1990	498	0	0	0	0	0	11	93	214	284	269	232	203	416	853	1482	2458	3274	3396	3059	2109	1365	738	424	161	52
1	1	1991	599	0	0	0	0	0	14	128	335	393	367	389	604	2129	2128	1770	2416	3307	3528	3007	2104	1371	761	403	192	66
1	1	1992	368	0	0	0	0	0	9	52	156	323	382	568	1077	2241	1742	1545	1531	1753	1532	1385	1024	682	409	230	102	44
1	1	1993	409	0	0	0	0	0	10	93	428	617	658	1718	2987	4493	3792	3576	2542	1640	1288	1041	759	505	316	182	78	35
1	1	1994	730	0	0	0	0	0	13	136	457	789	664	398	626	2039	2917	2912	2322	2297	1901	1170	699	424	240	140	69	34
1	1	1995	411	0	0	0	0	0	20	71	127	163	303	1181	2663	4198	2714	3176	3669	3894	3045	1763	1022	624	345	175	92	32
1	1	1996	794	0	0	0	0	0	7	76	224	277	232	232	507	1862	3157	2940	2095	2323	2488	1957	1292	733	441	227	116	59
1	1	1997	831	0	0	0	0	0	8	76	296	564	574	439	503	1842	2099	2798	3872	3840	2762	1613	1010	641	342	169	75	31
1	1	1998	675	0	0	0	0	0	11	106	204	191	144	125	191	697	831	920	1389	1982	2110	1283	646	312	183	102	45	20
1	1	1999	534	1	0	0	0	0	1	36	143	134	119	347	847	1669	1011	1038	1292	1673	1697	1218	781	384	190	77	36	17
1	1	2000	541	0	0	0	0	0	1	21	61	54	83	180	336	950	1383	1491	1376	1361	1405	1104	761	466	259	135	63	28
1	1	2001	278	0	0	0	0	0	1	3	10	29	54	37	59	306	487	646	918	972	783	497	358	215	137	61	30	13
1	1	2002	381	0	0	0	0	0	4	34	148	255	253	221	261	749	860	906	1494	1912	1672	959	440	211	97	45	19	10
1	1	2003	387	0	0	0	0	0	0	3	31	95	128	139	246	670	703	760	989	1290	1466	1049	622	308	130	58	27	10
1	1	2004	334	0	0	0	0	0	2	3	32	122	196	194	186	799	1329	1487	1739	1760	1393	946	590	315	190	111	62	26
1	1	2005	372	0	0	0	0	0	2	7	52	120	162	147	140	461	756	1118	1584	1958	1796	1139	728	404	232	108	44	16
1	1	2006	377	0	0	0	0	0	1	5	28	91	147	161	176	582	882	992	1186	1473	1570	1299	952	578	290	133	39	25
1	1	2007	346	0	1	2	8	13	28	55	149	230	276	380	443	1225	1865	2284	3131	3028	2593	2096	1637	1078	657	352	131	55
1	1	2008	163	0	0	2	4	5	32	66	79	82	75	117	179	631	799	1019	1591	1726	1480	869	554	373	291	145	69	25
1	1	2009	102	0	0	1	3	0	3	9	17	30	49	200	408	610	411	573	1054	1085	879	412	287	154	112	66	25	11
1	1	2010	141	0	0	0	0	5	12	45	44	43	29	130	302	586	916	1786	1633	1458	1057	440	217	99	36	28	12	8

Table 2.7b—Length frequencies for the June-August trawl fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
2	2	1977	13	0	0	0	0	0	0	0	0	6	12	22	39	40	273	331	367	355	188	104	38	12	3	2	0	0
2	2	1981	35	0	0	0	1	2	3	10	71	398	675	423	365	1109	1006	448	152	34	13	1	0	0	0	0	0	0
2	2	1983	10	0	0	0	0	0	1	0	1	4	15	42	71	77	81	200	284	248	186	83	28	6	3	4	0	0
2	2	1984	71	0	1	4	51	201	206	313	556	455	357	339	305	679	695	891	1109	959	817	597	453	312	120	41	8	1
2	2	1985	9	0	0	0	0	0	0	0	3	24	74	68	119	404	256	66	35	39	58	46	23	9	5	7	2	1
2	2	1986	5	0	0	0	0	0	0	7	2	2	3	5	7	15	62	92	72	67	95	98	84	46	30	8	4	0
2	2	1987	41	0	0	0	0	0	1	2	5	9	4	8	22	116	204	333	592	974	1093	720	525	385	248	133	68	25
2	2	1991	8	2	0	0	0	0	2	11	15	24	43	37	54	237	258	411	444	435	467	409	362	252	142	30	6	9
2	2	1997	4	0	0	0	0	0	0	2	0	0	2	5	5	45	167	229	219	283	167	67	27	12	2	0	0	0
2	2	1998	14	0	0	0	0	0	0	0	1	36	70	82	54	127	282	351	324	252	165	110	46	15	12	6	12	8
2	2	2001	28	0	0	0	0	0	0	0	2	11	27	53	65	151	337	356	301	313	226	115	58	61	31	33	15	2
2	2	2002	53	0	0	0	0	0	0	2	2	8	40	155	227	306	505	667	480	356	210	171	128	59	37	18	9	2
2	2	2003	96	0	0	0	0	0	0	1	2	4	19	34	51	141	324	345	361	401	336	267	192	110	45	16	8	3
2	2	2004	55	0	0	0	0	0	1	2	5	5	12	9	27	92	193	291	355	333	289	289	283	215	130	69	25	5
2	2	2005	18	0	0	0	0	0	0	1	0	4	12	38	72	97	124	154	167	173	165	175	150	97	66	37	12	4
2	2	2006	12	0	0	0	0	0	0	4	9	20	44	48	64	129	156	128	126	112	90	89	128	133	101	32	12	2
2	2	2007	42	0	0	0	0	1	5	9	25	89	185	172	150	331	363	416	340	227	119	72	43	27	21	14	3	1
2	2	2008	25	0	0	0	0	0	0	2	46	137	171	98	64	87	203	272	148	117	68	42	38	28	24	22	8	2
2	2	2009	32	0	0	0	0	0	0	10	36	59	63	120	273	587	333	202	142	122	47	23	8	5	4	1	2	1
2	2	2010	17	0	0	0	0	0	2	3	6	21	34	35	41	161	202	233	182	85	22	9	3	5	2	0	0	0

Table 2.7c—Length frequencies for the September-December trawl fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
3	3	1978	24	0	0	0	0	0	6	35	79	37	21	19	5	62	387	999	882	337	159	81	37	13	2	0	0	0
3	3	1979	6	0	0	0	0	0	0	0	3	5	24	74	150	220	78	38	47	58	31	14	4	0	0	0	1	1
3	3	1981	11	0	0	0	0	0	0	0	2	1	0	2	7	21	111	315	353	284	179	103	27	13	7	2	0	0
3	3	1982	12	0	0	0	0	0	0	1	0	0	1	4	27	70	143	215	196	302	346	215	90	18	9	5	1	0
3	3	1983	109	0	0	0	0	1	15	24	26	15	8	35	205	421	508	1450	1996	2482	2430	2220	1546	742	272	64	21	5
3	3	1984	31	0	0	0	0	0	7	21	15	114	434	372	190	140	126	235	375	502	506	437	363	210	92	29	11	0
3	3	1985	13	0	0	0	0	0	0	0	1	0	5	43	104	389	168	98	63	144	212	187	148	76	39	2	0	0
3	3	1986	11	0	0	0	0	0	0	2	1	13	15	25	24	69	111	153	184	209	156	179	133	92	59	22	4	5
3	3	1987	149	0	0	0	0	0	0	0	0	6	10	56	60	198	929	1639	1957	2591	3113	2678	2055	1930	1548	802	306	53
3	3	1988	22	0	0	0	0	0	0	0	0	5	0	13	52	257	326	284	348	348	373	332	305	166	56	20	6	6
3	3	1990	41	0	0	0	0	0	0	4	8	13	10	32	115	211	102	69	137	228	284	234	199	170	107	50	25	12
3	3	1992	1	0	0	0	0	0	0	0	68	205	2359	4667	479	120	171	17	51	0	0	0	0	0	0	0	0	0
3	3	1994	1	0	0	0	0	0	0	0	0	0	228	330	1650	9415	1700	482	51	25	0	0	0	0	0	0	0	0
3	3	1995	8	0	0	0	0	0	0	0	0	0	0	83	76	206	251	127	54	114	200	213	289	181	162	130	25	6
3	3	1996	23	0	0	0	0	0	0	0	0	1	0	7	27	94	120	150	153	135	132	136	197	197	170	98	43	15
3	3	1998	16	0	0	0	0	0	0	2	4	6	25	74	123	269	366	485	308	300	199	148	127	74	53	55	39	16
3	3	1999	11	0	0	0	0	0	0	1	1	2	3	4	18	49	97	127	100	107	84	65	56	43	26	21	9	3
3	3	2001	18	0	0	0	0	0	0	3	10	15	10	27	43	103	143	263	253	243	203	116	67	34	15	8	5	3
3	3	2002	40	0	0	0	0	0	0	0	1	7	7	30	69	116	121	161	125	107	112	95	85	55	25	12	5	1
3	3	2003	35	0	0	0	0	0	0	0	0	0	0	2	9	29	58	61	67	69	75	72	71	48	28	11	2	0
3	3	2004	26	0	0	0	0	0	0	0	0	0	1	6	5	20	37	71	64	50	49	59	79	60	33	23	5	1
3	3	2008	7	1	0	0	0	0	2	0	7	28	74	106	43	27	33	33	20	12	11	5	1	1	3	0	0	1
3	3	2009	32	0	0	0	0	0	1	1	5	12	56	73	117	528	758	321	88	36	22	2	4	2	2	2	1	0

Table 2.8a—Length frequencies for the January-May longline fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
4	1	1978	22	0	0	0	0	0	0	0	0	1	4	23	124	623	812	435	269	216	160	110	58	36	7	7	0	0
4	1	1979	74	0	0	0	0	0	0	0	8	83	377	683	434	337	1135	2126	2432	1356	465	233	128	56	27	3	6	0
4	1	1980	19	0	0	0	0	0	0	0	0	5	15	66	212	591	604	320	182	199	244	111	36	11	4	0	0	0
4	1	1981	17	0	0	0	0	5	18	7	7	10	0	18	48	285	496	448	335	197	153	89	70	36	9	4	0	0
4	1	1982	13	0	0	0	0	0	0	0	1	0	9	13	18	131	184	266	334	314	211	101	61	44	31	10	1	1
4	1	1983	130	0	0	0	0	0	0	0	0	3	16	48	170	1116	1525	2035	2732	3421	3065	1838	792	334	163	88	36	7
4	1	1984	112	0	0	0	0	0	1	0	6	19	40	41	46	416	800	1323	2414	3163	3015	2012	1015	437	155	70	24	6
4	1	1985	266	0	0	0	0	0	0	0	1	12	34	186	550	1367	958	1828	3877	7018	8009	5977	3362	1591	537	175	44	7
4	1	1986	248	0	0	0	0	0	0	0	8	30	81	121	385	1765	3055	3578	3014	3739	5900	5622	3348	1554	654	237	63	13
4	1	1987	692	0	0	0	0	0	2	0	5	18	88	425	1362	4950	5219	8337	14661	16709	12862	11421	9132	4689	1828	519	180	31
4	1	1990	170	0	0	0	0	0	0	0	0	0	0	1	2	20	100	221	377	480	420	342	230	174	107	67	31	11
4	1	1991	375	0	0	0	0	0	0	0	0	1	3	12	32	109	249	502	912	1150	978	700	406	248	137	84	33	14
4	1	1992	1024	0	0	0	0	0	0	0	4	7	24	96	256	869	1282	1329	1601	1886	1639	1158	837	528	307	165	75	25
4	1	1993	743	0	0	0	0	0	0	2	9	21	49	167	369	1080	2056	2763	2413	1688	1280	946	692	425	229	98	49	12
4	1	1994	969	0	0	0	0	0	0	2	3	9	20	54	144	733	1845	3065	3958	3309	1817	850	485	294	186	91	46	15
4	1	1995	1081	0	0	0	0	0	0	2	3	8	27	159	456	1231	2085	3529	4520	4244	2616	1121	443	214	111	54	28	13
4	1	1996	970	0	0	0	0	0	0	0	2	6	18	62	181	996	2224	2991	3323	3131	2280	1335	655	297	146	82	36	16
4	1	1997	1133	0	0	0	0	0	0	1	2	10	24	62	190	970	2005	3472	4601	4086	2399	1243	658	376	172	71	25	10
4	1	1998	1047	0	0	0	0	0	0	0	4	16	34	88	253	843	1395	2048	2946	3141	2307	1196	518	233	125	52	18	8
4	1	1999	1246	0	0	0	0	0	0	1	5	12	45	261	775	1824	1807	2111	2533	2483	2089	1308	679	291	139	59	29	18
4	1	2000	809	1	0	0	0	0	0	1	4	12	45	154	364	1510	2476	2555	2115	1736	1219	708	361	176	72	36	14	4
4	1	2001	998	0	0	0	0	0	1	2	6	23	67	98	203	909	1761	2404	2672	2095	1110	545	274	136	73	33	16	7
4	1	2002	1079	0	0	0	0	0	2	5	25	57	89	255	641	1465	1704	2443	3386	3031	1836	722	300	133	77	55	12	6
4	1	2003	1490	0	0	0	0	0	0	2	8	46	107	290	704	2109	3046	3153	2909	2552	1841	937	414	150	61	24	10	3
4	1	2004	1293	0	0	0	0	0	0	7	15	23	45	84	233	1128	2541	3874	4240	2951	1562	801	422	183	76	34	13	4
4	1	2005	1175	0	0	0	0	0	0	1	7	21	49	128	274	931	1516	2204	3184	3467	2395	947	380	182	73	28	9	2
4	1	2006	939	0	0	0	0	0	0	0	3	10	31	70	146	750	1880	2391	2453	2317	1988	1335	650	248	101	38	11	4
4	1	2007	674	0	0	0	0	0	1	2	6	16	32	138	369	1824	3707	6392	8815	7310	5432	3714	2456	1322	520	200	81	37
4	1	2008	698	0	0	0	0	0	1	6	13	44	91	276	619	1862	3350	5706	8177	9462	7003	3388	1896	1009	554	258	101	33
4	1	2009	590	0	0	0	0	0	0	1	4	8	61	360	787	1514	2266	3812	6094	7710	7045	4232	1799	701	388	183	82	32
4	1	2010	611	0	0	0	0	0	0	0	5	9	49	247	650	2478	5872	6730	5173	5304	5241	3642	1861	711	281	82	50	11

Table 2.8b—Length frequencies for the June-August longline fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
5	2	1978	26	0	0	0	0	0	0	0	0	0	0	3	2	78	444	1093	783	436	328	170	64	30	6	1	1	0
5	2	1979	18	0	0	0	0	0	0	0	0	2	14	49	90	155	93	302	604	628	274	74	33	14	3	3	0	0
5	2	1980	10	0	0	0	0	0	0	0	0	0	0	1	29	169	334	293	185	148	140	67	17	4	2	0	0	0
5	2	1981	10	0	0	0	0	0	0	0	0	2	1	8	29	88	160	265	292	228	108	35	32	24	3	1	0	0
5	2	1982	8	0	0	0	0	0	0	0	0	0	9	42	17	98	190	128	161	130	117	74	38	11	5	3	2	0
5	2	1983	28	0	0	0	0	0	0	0	0	1	2	14	13	91	319	383	504	623	675	505	355	150	50	18	10	0
5	2	1984	75	0	0	0	0	0	2	0	0	2	7	14	17	102	376	750	1602	2167	1873	1405	891	567	203	59	16	3
5	2	1985	39	0	0	0	0	0	0	0	0	0	1	3	28	246	368	206	418	775	1000	823	590	429	245	105	23	2
5	2	1986	11	0	0	0	0	0	0	0	0	0	0	0	1	15	94	247	306	175	162	205	104	60	24	13	0	0
5	2	1990	476	0	0	0	0	0	0	0	0	1	3	6	11	35	106	263	439	574	560	462	332	227	149	97	39	14
5	2	1991	472	0	0	0	0	0	0	0	0	0	1	2	8	43	124	266	466	614	690	629	513	357	191	109	49	18
5	2	1992	575	0	0	0	0	0	0	0	1	5	12	32	63	320	643	671	729	793	685	515	411	317	219	136	74	25
5	2	1999	123	0	0	0	0	0	0	0	0	0	0	2	6	44	88	75	74	76	66	45	32	19	10	4	2	1
5	2	2000	102	0	0	0	0	0	0	0	0	0	0	0	1	9	26	54	85	65	45	31	22	11	7	3	1	0
5	2	2001	262	0	0	0	0	0	0	0	1	2	6	13	27	106	260	374	417	410	285	116	50	23	12	7	2	1
5	2	2002	508	0	0	0	0	0	0	0	4	10	24	42	81	328	578	653	664	646	447	260	115	49	26	13	7	1
5	2	2003	571	0	0	0	0	0	0	0	1	3	9	25	60	248	541	674	636	538	403	219	116	51	21	9	3	1
5	2	2004	543	0	0	0	0	0	0	0	0	1	2	4	17	91	247	457	564	531	399	236	156	80	36	13	5	1
5	2	2005	618	0	0	0	0	0	0	0	0	1	2	9	20	100	208	320	415	507	496	390	257	142	78	29	8	2
5	2	2006	525	0	0	0	0	0	0	0	0	0	1	9	27	106	257	403	419	422	363	329	317	243	150	72	27	7
5	2	2007	355	0	0	0	0	0	0	0	1	0	5	19	75	580	1805	2889	3506	3490	2709	1836	1780	1563	1122	600	248	52
5	2	2008	433	0	0	0	0	1	1	1	3	7	18	75	205	1191	2686	4106	5194	4452	3100	1961	1302	1055	881	573	293	70
5	2	2009	495	0	0	0	0	0	0	0	1	5	17	127	490	3414	6023	4759	5270	4684	2831	1343	831	546	373	245	108	43
5	2	2010	124	0	0	0	0	0	0	0	1	0	4	13	15	205	650	1471	2265	1502	827	400	192	113	53	37	21	23

Table 2.8c—Length frequencies for the September-December longline fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
6	3	1978	18	0	0	0	0	0	0	0	0	0	0	2	0	54	344	719	770	275	94	49	32	16	7	2	0	0
6	3	1979	21	0	0	0	0	0	0	0	0	0	4	11	51	252	263	195	401	705	605	220	44	11	9	2	0	0
6	3	1980	22	0	0	0	0	0	0	0	0	0	0	1	18	235	558	679	652	350	194	138	76	25	5	0	1	0
6	3	1981	10	0	0	0	0	0	0	0	0	0	0	0	2	8	86	230	318	300	220	89	29	15	2	0	1	0
6	3	1982	36	0	0	0	0	0	0	0	1	0	1	14	33	92	235	460	773	1149	1066	614	235	77	27	6	2	2
6	3	1983	72	0	0	0	0	0	0	1	0	0	0	4	28	129	459	1162	1260	1544	1776	1561	991	476	148	37	9	6
6	3	1984	624	0	0	0	0	0	0	1	3	14	55	293	764	1721	2467	6595	12255	15779	15982	12816	8397	4192	1528	407	91	24
6	3	1985	982	0	0	0	0	0	1	0	0	4	23	116	605	5449	16095	14240	10594	17780	24998	19637	11586	6071	2786	920	215	51
6	3	1986	793	0	0	0	0	0	0	0	0	0	18	158	616	2233	5154	14368	23612	20725	10897	10483	9006	4991	2308	881	326	85
6	3	1987	1319	0	0	0	3	0	0	0	3	9	30	147	593	4503	18418	29582	24338	25914	28336	20972	10694	6630	3800	1532	414	134
6	3	1990	464	0	0	0	0	0	0	0	0	0	1	1	3	19	87	270	489	604	569	456	306	182	108	67	31	14
6	3	1991	719	0	0	0	0	0	1	2	2	4	7	11	24	94	231	406	623	759	807	766	615	421	239	138	62	25
6	3	1992	176	0	0	0	0	0	0	0	0	0	1	3	10	49	147	160	152	173	152	120	98	78	55	35	18	6
6	3	1994	362	0	0	0	0	0	0	0	1	1	6	16	27	84	295	603	870	1016	766	446	238	140	87	53	31	15
6	3	1995	443	0	0	0	0	0	0	0	2	2	5	21	51	280	678	784	907	1101	1008	739	443	246	136	79	38	12
6	3	1996	496	0	0	0	0	0	0	0	0	1	7	14	32	123	423	909	1132	871	640	560	453	321	178	82	33	10
6	3	1997	984	0	0	0	0	0	0	1	6	11	20	42	114	329	639	1037	1424	1841	1709	1182	614	415	251	135	58	23
6	3	1998	1364	0	0	0	0	0	0	2	2	3	13	69	146	339	539	812	988	1140	1031	767	474	242	127	76	32	13
6	3	1999	761	0	0	0	0	0	0	1	4	8	15	47	87	463	990	859	780	837	761	523	362	208	109	48	24	12
6	3	2000	1317	0	0	0	0	0	0	0	1	1	5	44	145	485	1156	1903	2459	1908	1086	665	411	240	131	62	23	9
6	3	2001	1397	0	0	0	0	0	0	1	2	6	26	126	268	767	1331	2128	2431	2309	1726	794	352	164	92	54	22	9
6	3	2002	1388	0	0	0	0	0	0	2	9	29	67	144	300	982	1601	1807	1785	1676	1314	763	375	163	71	29	13	6
6	3	2003	1533	0	0	0	0	0	0	0	0	3	10	31	136	734	1577	2155	2151	1869	1381	889	489	217	85	33	13	4
6	3	2004	1430	0	0	0	0	0	0	3	6	10	22	49	119	491	1008	1604	2136	2099	1574	883	500	268	118	45	14	4
6	3	2005	1383	0	0	0	0	0	0	1	3	8	19	49	125	556	976	1408	1504	1500	1457	1227	831	447	244	95	31	7
6	3	2006	862	0	0	0	0	0	0	0	0	2	7	28	84	388	783	1259	1326	1171	1095	906	874	639	408	213	91	31
6	3	2007	580	1	0	1	0	0	0	0	1	2	14	71	236	1145	3412	4914	5159	5115	3921	2716	2672	2708	2286	1316	572	166
6	3	2008	1056	0	0	0	0	1	2	3	16	24	195	958	1791	4503	8073	11092	10994	9622	6888	4116	2732	2092	1685	1021	425	111
6	3	2009	968	0	0	0	0	2	0	0	4	14	95	546	1155	6677	15049	11216	8409	7474	5001	2430	1246	678	410	256	130	45
6	3	2010	18	0	0	0	0	0	0	0	0	0	1	4	3	16	80	121	222	219	283	135	49	17	1	3	1	0

Table 2.9a—Length frequencies for the January-May pot fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
7	1	1992	87	0	0	0	0	0	0	0	0	0	0	1	2	12	33	42	75	121	108	69	42	27	16	9	4	1
7	1	1993	64	0	0	0	0	0	0	0	0	0	0	0	2	14	33	59	86	87	76	53	32	20	12	5	2	1
7	1	1994	167	0	0	0	0	0	0	0	0	0	0	1	7	38	136	216	225	223	175	118	60	34	20	12	5	1
7	1	1995	236	0	0	0	0	0	0	0	0	0	0	4	19	96	224	493	713	642	452	261	150	88	50	19	10	4
7	1	1996	363	0	0	0	0	0	0	0	1	1	4	8	20	145	430	717	818	838	679	408	237	132	81	44	19	7
7	1	1997	216	0	0	0	0	0	0	0	0	1	2	5	10	70	204	450	805	882	551	298	159	88	60	32	14	7
7	1	1998	153	0	0	0	0	0	0	0	0	0	0	1	7	60	126	186	391	506	440	261	114	44	25	11	5	4
7	1	1999	204	0	0	0	0	0	0	0	0	0	1	2	15	126	198	294	442	456	385	240	123	59	33	11	7	3
7	1	2000	176	0	0	0	0	0	0	0	0	0	0	3	27	226	526	774	766	654	613	362	209	94	42	21	8	3
7	1	2001	142	0	0	0	0	0	0	0	0	1	1	4	6	69	218	514	896	840	428	171	72	38	22	9	5	2
7	1	2002	108	0	0	0	0	0	0	0	0	0	0	2	5	45	179	421	785	768	458	187	65	31	17	9	3	3
7	1	2003	141	0	0	0	0	0	0	0	1	1	3	4	23	115	292	498	735	880	732	394	189	78	29	9	4	2
7	1	2004	103	0	0	0	0	0	2	2	5	6	4	5	9	113	368	613	745	684	461	250	142	52	31	14	6	2
7	1	2005	85	0	0	0	0	0	0	0	0	1	0	4	8	51	194	473	725	698	488	238	121	63	47	22	7	1
7	1	2006	100	0	0	0	0	0	0	0	0	0	1	1	2	66	274	577	799	794	562	282	173	85	46	24	10	4
7	1	2007	167	0	0	0	0	0	0	0	0	0	0	10	24	255	727	1222	1650	1834	1643	1115	802	581	311	195	100	26
7	1	2008	106	0	0	0	0	0	0	0	0	3	3	7	28	153	472	906	1146	1155	987	609	500	286	244	129	41	22
7	1	2009	101	0	0	0	0	0	0	0	0	0	4	8	41	183	358	588	1023	1157	1109	751	474	316	174	93	56	20
7	1	2010	106	0	0	0	0	0	0	0	0	0	1	4	15	123	681	1423	1242	1261	996	479	210	99	58	30	12	4

Table 2.9b—Length frequencies for the June-August pot fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
8	2	1990	13	0	0	0	0	0	0	0	0	0	0	0	0	1	5	9	17	28	36	27	28	17	10	5	0	0
8	2	1991	71	0	0	0	0	0	0	0	0	0	0	0	0	1	8	18	32	44	45	34	23	11	7	2	1	0
8	2	1992	146	0	0	0	0	0	0	0	0	0	1	5	20	113	201	194	215	211	147	90	62	38	21	11	8	3
8	2	1995	46	0	0	0	0	0	0	0	0	0	0	0	3	31	55	73	125	140	113	89	59	33	27	20	8	5
8	2	1996	64	0	0	0	0	0	0	0	0	0	0	1	4	28	98	202	283	252	179	126	107	75	53	30	16	11
8	2	1997	43	0	0	0	0	0	0	0	0	0	1	1	2	15	51	110	171	235	152	74	37	23	13	9	7	3
8	2	1998	37	0	0	0	0	0	0	0	0	0	0	0	0	8	23	55	99	136	141	84	42	23	16	5	2	1

Table 2.9c—Length frequencies for the September-December pot fishery by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
9	3	1990	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	13	13	16	8	5	3	1	0	0
9	3	1991	64	0	0	0	0	0	0	0	0	0	0	0	0	1	8	21	39	66	81	77	50	27	14	7	2	1
9	3	1992	27	0	0	0	0	0	0	0	0	0	1	2	3	13	21	17	13	10	5	2	2	1	1	0	0	0
9	3	1994	20	0	0	0	0	0	0	0	0	1	0	1	3	19	63	117	141	118	92	66	39	27	16	8	5	2
9	3	1995	33	0	0	0	0	0	0	0	0	0	0	0	0	10	40	73	128	148	111	73	50	32	19	9	4	0
9	3	1996	52	0	0	0	0	0	0	0	0	0	0	0	1	9	25	54	102	111	88	58	53	49	34	20	10	4
9	3	1997	70	0	0	0	0	0	0	0	0	0	0	1	2	11	30	63	107	154	153	79	32	24	17	11	5	2
9	3	1998	26	0	0	0	0	0	0	0	0	0	0	1	1	7	24	35	51	59	59	38	17	9	4	4	2	1
9	3	1999	39	0	0	0	0	0	0	0	0	0	0	0	2	11	57	83	65	71	70	37	26	18	11	5	4	4
9	3	2001	69	0	0	0	0	0	0	0	0	0	1	0	2	26	104	212	229	237	158	63	37	22	13	5	2	1
9	3	2002	73	0	0	0	0	0	0	0	0	0	0	1	4	27	93	190	201	154	112	72	48	21	17	6	3	2
9	3	2003	86	0	0	0	0	0	0	0	0	0	0	0	3	45	206	324	305	258	197	122	85	54	27	10	6	1
9	3	2004	66	0	0	0	0	0	0	0	0	0	0	1	3	18	85	169	193	155	115	71	56	54	27	17	7	2
9	3	2005	73	0	0	0	0	0	0	0	0	0	1	2	3	23	78	176	225	190	125	73	60	45	31	22	15	7
9	3	2006	87	0	0	0	0	0	0	0	0	0	0	0	3	19	78	156	169	142	106	88	70	58	43	27	16	8
9	3	2007	70	0	0	0	0	0	0	0	0	0	1	0	19	150	395	791	1009	726	505	331	193	136	81	49	19	14
9	3	2008	83	1	0	0	0	0	0	0	1	3	5	12	46	174	435	982	1021	752	523	364	240	215	193	132	97	40
9	3	2009	47	0	0	0	0	0	0	0	0	0	0	3	7	74	242	349	583	592	519	298	164	70	34	16	6	2

Table 2.10a—Length frequencies for the pre-1982 EBS shelf bottom trawl survey by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
10	2	1979	159	0	5	44	186	374	457	694	1764	2393	1884	1171	618	202	70	44	51	29	8	0	3	1	1	0	0	0
10	2	1980	75	0	6	85	241	82	42	224	687	929	1320	1542	2062	1364	893	333	100	33	31	19	6	2	0	0	0	0
10	2	1981	75	0	20	156	330	278	32	100	330	653	724	511	1063	1396	1746	1215	812	398	156	39	27	13	1	0	0	0

Table 2.10b—Length frequencies for the post-1981 EBS shelf bottom trawl survey by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
11	2	1982	79	17	97	234	148	37	28	132	403	766	750	416	520	1512	1327	1288	1179	875	474	210	90	29	9	4	0	0
11	2	1983	209	393	1396	1289	622	147	32	135	370	551	380	209	394	1367	1289	1341	1128	921	650	325	151	31	19	4	1	0
11	2	1984	193	70	129	82	142	282	920	1653	1712	1041	485	249	261	536	579	864	961	880	590	381	173	94	38	9	1	0
11	2	1985	269	162	540	964	1537	1761	664	298	595	880	942	1154	1528	1879	678	480	543	687	674	496	253	111	38	17	5	0
11	2	1986	245	154	465	501	154	114	693	1775	1908	1585	1083	553	425	1069	1338	1203	628	416	453	370	264	119	74	21	13	0
11	2	1987	169	18	69	250	398	267	185	440	899	779	606	617	956	1478	827	598	654	632	413	211	166	71	49	16	7	0
11	2	1988	159	8	49	76	88	109	233	280	383	639	623	490	658	1415	1305	1115	851	572	422	294	246	74	32	25	7	4
11	2	1989	159	24	154	299	206	70	34	82	87	140	350	341	368	875	1196	1294	1143	941	854	662	336	246	144	89	62	0
11	2	1990	90	201	488	699	355	133	122	249	292	322	276	175	123	194	223	347	419	283	266	182	128	82	33	26	11	3
11	2	1991	115	131	389	432	370	230	275	623	899	931	630	345	192	300	312	249	214	206	177	109	112	49	20	22	7	2
11	2	1992	153	18	456	517	698	556	435	854	1075	856	542	451	622	915	546	242	222	176	103	97	86	51	37	28	15	4
11	2	1993	166	114	923	1087	981	677	213	247	614	847	666	489	615	1072	665	399	266	230	86	62	49	37	21	24	14	6
11	2	1994	222	19	145	291	364	326	445	956	1922	2081	1121	444	523	1216	961	1059	920	565	288	92	46	34	60	16	22	9
11	2	1995	147	30	74	135	208	77	173	460	691	579	705	1064	1233	1359	616	434	483	326	254	132	84	40	27	19	9	3
11	2	1996	149	14	65	164	198	110	103	356	698	677	526	499	744	1478	1405	907	499	288	238	148	109	71	25	16	7	3
11	2	1997	146	91	474	601	728	508	139	214	479	627	451	405	397	916	810	841	584	439	217	106	60	41	26	10	4	1
11	2	1998	153	30	262	334	74	46	311	1151	1837	1396	655	379	367	659	458	378	391	333	244	132	64	33	29	9	10	1
11	2	1999	186	71	334	286	113	141	415	760	874	667	719	1170	1649	1855	768	493	447	337	252	132	89	62	37	24	7	2
11	2	2000	200	174	913	1303	503	54	141	487	784	604	562	747	957	1720	1424	898	538	266	186	98	79	56	32	19	3	0
11	2	2001	314	95	646	1828	2113	1010	408	903	1990	2543	1614	705	486	1192	1277	1077	818	513	257	123	71	34	22	14	4	5
11	2	2002	195	31	190	374	352	105	209	664	1459	1449	1005	792	1216	1578	878	609	545	367	208	103	49	19	16	15	3	2
11	2	2003	197	19	287	640	779	684	490	183	251	680	837	972	1189	1971	1216	768	515	338	260	142	86	35	14	2	1	0
11	2	2004	172	24	278	486	566	320	218	483	728	929	979	711	577	804	923	843	713	474	283	210	111	82	34	15	5	4
11	2	2005	180	5	153	587	889	1013	1052	481	415	572	727	650	627	866	705	521	529	495	358	291	182	103	46	21	7	0
11	2	2006	193	478	1286	1075	883	317	165	266	604	753	866	706	532	728	855	643	494	395	320	259	238	144	76	35	14	3
11	2	2007	204	618	3990	2589	1239	473	151	327	417	386	262	211	225	381	370	260	270	206	148	83	64	67	43	17	16	5
11	2	2008	206	228	1118	890	266	131	948	2000	1958	1083	512	380	409	645	607	519	454	311	192	98	70	58	47	32	17	1
11	2	2009	265	1481	3030	1885	1000	177	209	764	1304	867	655	969	1108	1334	605	410	351	239	127	63	35	26	9	14	5	3
11	2	2010	121	23	103	153	62	54	380	1028	1206	776	366	218	488	758	658	638	389	150	60	31	11	11	6	5	1	1

Table 2.10c—Length frequencies for the IPHC longline survey by length bin.

Fleet	Sea.	Year	N	9	12	15	18	21	24	27	30	33	36	39	42	45	50	55	60	65	70	75	80	85	90	95	100	105
12	2	2008	81	0	0	0	0	0	0	0	0	0	0	0	2	19	71	284	673	835	807	550	467	438	449	318	139	41
12	2	2009	91	0	0	0	0	0	0	0	0	0	0	1	8	90	247	458	856	994	805	603	424	378	310	294	184	72

Table 2.11a—Age compositions observed in the 2008 January-May longline fishery. Nact = actual sample size (these get rescaled in Model A so that the average across all age composition records, including those from Table 2.11b, equals 300).

Year	Nact	1	2	3	4	5	6	7	8	9	10	11	12+
2008	701	0.0000	0.0000	0.0643	0.1323	0.2108	0.3339	0.1308	0.0741	0.0439	0.0078	0.0021	0.0000

Table 2.11b—Age compositions observed by the EBS shelf bottom trawl survey, 1994-2009. Nact = actual sample size (in Model A, these get rescaled so that the average across the age compositions from Tables 2.11a and 2.11b combined equals 300; in Models B and C, these get rescaled so that the average across all age compositions in Table 2.11b equals 300).

Year	Nact	1	2	3	4	5	6	7	8	9	10	11	12+
1994	715	0.0885	0.3828	0.1712	0.1204	0.1174	0.0823	0.0216	0.0077	0.0050	0.0013	0.0010	0.0007
1995	599	0.0507	0.2648	0.4213	0.0978	0.0763	0.0503	0.0182	0.0104	0.0066	0.0017	0.0010	0.0008
1996	711	0.0538	0.2079	0.2042	0.2937	0.1337	0.0568	0.0289	0.0119	0.0049	0.0021	0.0015	0.0008
1997	719	0.2500	0.1680	0.1822	0.1548	0.1218	0.0811	0.0246	0.0113	0.0035	0.0014	0.0009	0.0004
1998	635	0.0775	0.4405	0.2020	0.1119	0.0572	0.0594	0.0287	0.0166	0.0043	0.0008	0.0008	0.0003
1999	860	0.0791	0.2001	0.3018	0.2314	0.0803	0.0570	0.0281	0.0130	0.0058	0.0014	0.0014	0.0006
2000	864	0.2335	0.1267	0.1516	0.2417	0.1464	0.0609	0.0137	0.0145	0.0063	0.0028	0.0014	0.0005
2001	950	0.2874	0.2358	0.1935	0.0915	0.0833	0.0677	0.0269	0.0086	0.0025	0.0015	0.0008	0.0003
2002	947	0.0810	0.1872	0.3168	0.2330	0.0717	0.0586	0.0345	0.0110	0.0040	0.0011	0.0006	0.0006
2003	1360	0.1732	0.1564	0.2514	0.2099	0.1190	0.0410	0.0299	0.0139	0.0038	0.0006	0.0006	0.0005
2004	1040	0.1431	0.1655	0.2717	0.1292	0.1279	0.0899	0.0392	0.0195	0.0086	0.0022	0.0025	0.0005
2005	1280	0.1830	0.2444	0.2094	0.1212	0.0659	0.0792	0.0546	0.0236	0.0108	0.0037	0.0036	0.0006
2006	1300	0.3243	0.1428	0.1650	0.1214	0.0927	0.0632	0.0463	0.0286	0.0101	0.0032	0.0013	0.0011
2007	1441	0.6993	0.0959	0.0674	0.0415	0.0462	0.0177	0.0143	0.0084	0.0051	0.0017	0.0016	0.0010
2008	1213	0.2139	0.4448	0.1449	0.0829	0.0484	0.0328	0.0100	0.0104	0.0059	0.0030	0.0013	0.0017
2009	1412	0.4548	0.1895	0.2309	0.0641	0.0287	0.0146	0.0094	0.0040	0.0021	0.0009	0.0006	0.0003

Table 2.12a—Abundance measured in units of biomass and numbers, with standard deviations, as estimated by EBS shelf bottom trawl surveys, 1979-1981. For biomass, 95% confidence intervals (CI) are also shown. All biomass figures are expressed in metric tons. Population numbers are expressed in terms of individual fish. The actual standard deviations for abundance measured in numbers during these years are unknown; the standard deviations shown here are estimates obtained by assuming that the coefficient of variation was the same as for the biomass estimate.

	Abundance (biomass)				Abundance (numbers)	
Year	Estimate	Std. deviation	Lower 95% CI	Upper 95% CI	Estimate	Std. deviation
1979	754,314	97,844	562,539	946,089	1,530,429,650	198,515,948
1980	905,344	87,898	733,063	1,077,624	1,084,147,540	105,257,671
1981	1,034,629	123,849	791,855	1,277,373	794,619,624	95,118,971

Table 2.12b— Abundance measured in units of biomass and numbers, with standard deviations, as estimated by EBS shelf bottom trawl surveys, 1982-2010. For biomass, 95% confidence intervals (CI) are also shown. All biomass figures are expressed in metric tons. Population numbers are expressed in terms of individual fish.

	Abundance (biomass)				Abundance (numbers)	
Year	Estimate	Std. deviation	Lower 95% CI	Upper 95% CI	Estimate	Std. deviation
1982	1,012,856	73,588	867,151	1,158,562	583,715,842	38,078,866
1983	1,185,419	120,830	941,146	1,429,692	751,066,723	80,436,310
1984	1,048,595	63,643	922,583	1,174,608	680,914,697	49,899,900
1985	1,001,108	55,845	890,536	1,111,681	841,108,075	112,249,722
1986	1,117,774	69,604	979,957	1,255,590	838,123,105	83,845,095
1987	1,106,621	68,682	970,630	1,242,612	728,956,963	48,476,799
1988	959,401	76,118	808,688	1,110,114	507,103,872	35,496,479
1989	833,850	62,714	709,677	958,024	292,383,206	20,000,000
1990	691,255	51,455	589,375	793,136	423,835,267	36,469,165
1991	516,314	38,160	440,757	591,871	489,470,390	51,088,159
1992	551,369	45,780	460,725	642,013	601,795,262	70,569,115
1993	691,311	54,581	583,240	799,383	852,288,385	106,770,783
1994	1,368,120	250,000	868,032	1,868,209	1,237,758,281	152,970,585
1995	1,002,850	91,622	821,437	1,184,262	757,826,810	75,498,344
1996	892,377	87,532	719,064	1,065,690	609,986,848	88,317,609
1997	604,439	68,120	468,199	740,678	485,642,845	70,781,353
1998	558,419	45,182	468,960	647,879	537,278,347	48,270,074
1999	584,762	50,591	484,592	684,932	501,496,289	46,583,259
2000	531,171	43,160	445,714	616,627	483,808,002	44,158,804
2001	833,626	76,247	681,133	986,119	985,568,802	94,973,681
2002	618,680	69,082	480,516	756,845	566,471,072	57,706,152
2003	593,258	62,153	468,951	717,564	499,365,769	62,369,865
2004	596,279	35,216	526,552	666,007	424,662,313	36,193,922
2005	606,394	43,047	521,160	691,628	450,917,953	63,324,561
2006	517,698	28,341	461,583	573,813	394,051,399	23,790,755
2007	423,703	34,811	354,080	493,326	733,374,144	195,959,179
2008	403,125	26,822	350,018	456,232	476,696,976	49,396,356
2009	421,290	34,969	352,051	490,528	716,590,485	62,689,712
2010	859,642	102,470	657,157	1,062,127	887,456,665	117,046,999

Table 2.13—Mean size (cm) at age from age-length key applied to respective size compositions, and sample sizes. Mean lengths for samples of size zero result from application of area-specific long-term average age-length keys. Green = column minimum, pink = column maximum.

Average length (cm) at age:

Year	Fleet	1	2	3	4	5	6	7	8	9	10	11	12
2008	Season 1 longline fishery	n/a	n/a	47.06	54.75	62.69	67.33	73.01	78.98	80.43	84.37	89.73	n/a
1994	Post-81 trawl survey	19.01	31.76	39.91	49.30	58.04	64.05	70.72	80.88	87.31	93.59	91.46	95.51
1995	Post-81 trawl survey	17.33	32.35	43.21	53.00	61.83	69.46	74.12	81.20	85.00	92.64	92.26	94.19
1996	Post-81 trawl survey	17.64	31.63	41.43	50.28	57.59	66.97	75.24	81.90	88.10	90.37	90.97	94.39
1997	Post-81 trawl survey	17.19	31.76	41.76	51.42	59.39	64.68	71.86	78.78	85.59	91.58	92.59	95.19
1998	Post-81 trawl survey	15.47	30.77	37.82	49.33	58.92	66.28	70.26	77.56	88.93	88.64	91.69	91.99
1999	Post-81 trawl survey	15.79	29.66	40.33	46.23	56.60	65.25	71.42	79.75	82.62	91.48	90.32	97.28
2000	Post-81 trawl survey	15.25	30.30	39.01	47.71	53.70	59.71	72.91	74.70	79.70	82.38	82.49	95.20
2001	Post-81 trawl survey	17.88	31.36	36.70	48.31	55.24	61.86	65.96	77.07	82.69	79.05	88.36	95.19
2002	Post-81 trawl survey	16.53	30.08	36.95	46.92	55.68	62.58	68.78	72.23	80.04	92.03	89.15	95.35
2003	Post-81 trawl survey	18.00	29.82	40.87	48.29	56.51	65.30	70.28	75.44	81.77	85.82	84.01	93.85
2004	Post-81 trawl survey	17.26	30.23	37.99	48.98	56.99	64.01	70.95	75.84	83.31	88.13	86.15	95.65
2005	Post-81 trawl survey	18.59	26.70	39.16	48.56	57.04	64.07	72.45	78.46	82.05	88.47	87.30	92.31
2006	Post-81 trawl survey	15.33	30.89	38.55	47.57	55.90	64.98	73.78	82.35	85.63	88.82	93.83	96.98
2007	Post-81 trawl survey	15.04	31.03	41.18	50.60	59.34	66.64	74.68	81.58	84.30	94.00	88.32	91.33
2008	Post-81 trawl survey	15.39	29.78	41.31	53.39	60.87	66.06	72.39	79.10	84.16	90.23	95.66	96.14
2009	Post-81 trawl survey	14.14	31.10	42.51	51.63	59.78	65.89	71.77	75.68	83.52	90.11	89.45	91.35

Number of samples at age (0 indicates mean length inferred from long-term average age-length key):

Year	Fleet	1	2	3	4	5	6	7	8	9	10	11	12
2008	Season 1 longline fishery	0	0	39	83	147	253	92	52	27	6	2	0
1994	Post-81 trawl survey	40	213	143	109	89	73	26	12	7	1	2	0
1995	Post-81 trawl survey	25	153	202	90	57	38	14	9	6	1	1	2
1996	Post-81 trawl survey	34	143	138	183	101	65	37	5	2	0	1	2
1997	Post-81 trawl survey	94	92	109	125	120	110	38	21	5	3	2	0
1998	Post-81 trawl survey	56	145	97	94	73	88	47	28	6	0	1	0
1999	Post-81 trawl survey	84	167	195	162	105	77	44	17	8	0	1	0
2000	Post-81 trawl survey	112	102	131	204	177	83	21	20	7	6	1	0
2001	Post-81 trawl survey	173	161	159	135	127	119	43	15	7	4	5	1
2002	Post-81 trawl survey	114	165	206	189	85	91	70	16	6	2	0	2
2003	Post-81 trawl survey	193	222	205	198	206	129	114	68	17	1	4	0
2004	Post-81 trawl survey	150	134	205	133	160	136	62	35	17	4	4	0
2005	Post-81 trawl survey	141	218	238	171	112	146	121	73	30	18	10	0
2006	Post-81 trawl survey	205	176	179	168	155	140	133	93	36	10	4	1
2007	Post-81 trawl survey	114	87	88	56	105	31	40	21	17	7	3	2
2008	Post-81 trawl survey	141	262	244	188	134	97	45	45	28	13	8	6
2009	Post-81 trawl survey	222	259	325	187	133	100	82	47	23	13	12	4

Table 2.14a—Multinomial sample sizes for length compositions (Model A). Sea1=Jan-May, Sea2=Jun-Aug, Sea3=Sep-Dec.

	Trawl fishery			Longline fishery			Pot fishery			Trawl survey		
Year	Sea1	Sea2	Sea3	Sea1	Sea2	Sea3	Sea1	Sea2	Sea3	pre82	post81	IPHC
1977		13										
1978	4		24	22	26	18						
1979	12		6	74	18	21				159		
1980	62			19	10	22				75		
1981		35	11	17	10	10				75		
1982	30		12	13	8	36					79	
1983	76	10	109	130	28	72					209	
1984	122	71	31	112	75	624					193	
1985	223	9	13	266	39	982					269	
1986	213	5	11	248	11	793					245	
1987	306	41	149	692		1319					169	
1988	718		22								159	
1989	436										159	
1990	498		41	170	476	464		13	16		90	
1991	599	8		375	472	719		71	64		115	
1992	368		1	1024	575	176	87	146	27		153	
1993	409			743			64				166	
1994	730		1	969		362	167		20		222	
1995	411		8	1081		443	236	46	33		147	
1996	794		23	970		496	363	64	52		149	
1997	831	4		1133		984	216	43	70		146	
1998	675	14	16	1047		1364	153	37	26		153	
1999	534		11	1246	123	761	204		39		186	
2000	541			809	102	1317	176				200	
2001	278	28	18	998	262	1397	142		69		314	
2002	381	53	40	1079	508	1388	108		73		195	
2003	387	96	35	1490	571	1533	141		86		197	
2004	334	55	26	1293	543	1430	103		66		172	
2005	372	18		1175	618	1383	85		73		180	
2006	377	12		939	525	862	100		87		193	
2007	346	42		674	355	580	167		70		204	
2008	163	25	7	698	433	1056	106		83		206	81
2009	102	32	32	590	495	968	101		47		265	91
2010	141	17		611	124	18	106				121	

Table 2.14b (page 1 of 3)—Multinomial sample sizes for length compositions (Models B and C).

		Trawl fishery			Longline fishery			Pot fishery			Survey
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Post-81
1977	May-Jul		10								
1977	Aug-Oct			14							
1978	Jan-Feb				9						
1978	Mar-Apr				24						
1978	Aug-Oct			36			44				
1978	Nov-Dec						18				
1979	Jan-Feb				78						
1979	Mar-Apr				26						
1979	May-Jul		18			33					
1979	Aug-Oct						12				
1979	Nov-Dec			6			21				
1980	Jan-Feb	24			8						
1980	Mar-Apr	67			6						
1980	May-Jul					31					
1980	Aug-Oct						14				
1980	Nov-Dec						20				
1981	Jan-Feb				7						
1981	Mar-Apr				5						
1981	May-Jul		54			28					
1981	Nov-Dec			16			12				
1982	Mar-Apr	27			13						
1982	May-Jul		21			17					
1982	Aug-Oct			5			36				120
1982	Nov-Dec			14			20				
1983	Jan-Feb	20			88						
1983	Mar-Apr	75			92						
1983	May-Jul		29			51					
1983	Aug-Oct			11			57				149
1983	Nov-Dec			160			62				
1984	Jan-Feb	83			71						
1984	Mar-Apr	103			96						
1984	May-Jul		96			87					
1984	Aug-Oct			23			202				138
1984	Nov-Dec			36			777				
1985	Jan-Feb	78			332						
1985	Mar-Apr	260			72						
1985	May-Jul		11			8					
1985	Aug-Oct			17			398				192
1985	Nov-Dec			6			1145				
1986	Jan-Feb	90			243						
1986	Mar-Apr	212			30						
1986	May-Jul		84			104			12		
1986	Aug-Oct			48			214			14	175
1986	Nov-Dec						1005				
1987	Jan-Feb	271			734						
1987	Mar-Apr	188			213						
1987	May-Jul		109			106			5		
1987	Aug-Oct			162			656			16	120
1987	Nov-Dec			85			1345				
1988	Jan-Feb	770			13						
1988	Mar-Apr	339									
1988	May-Jul		36								
1988	Aug-Oct			6							114
1988	Nov-Dec			37							

Table 2.14b (page 2 of 3)—Multinomial sample sizes for length compositions (Models B and C).

		Trawl fishery			Longline fishery			Pot fishery			Survey
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Post-81
1989	Jan-Feb	662									
1989	May-Jul		72								
1989	Aug-Oct						40			9	114
1989	Nov-Dec			13							
1990	Jan-Feb	235			15						
1990	Mar-Apr	601			87						
1990	May-Jul		292			659			7		
1990	Aug-Oct			6			663			76	64
1990	Nov-Dec						325				
1991	Jan-Feb	456			176						
1991	Mar-Apr	1089			262						
1991	May-Jul		57			594			18		
1991	Aug-Oct						976			127	82
1991	Nov-Dec						305			14	
1992	Jan-Feb	113			419			6			
1992	Mar-Apr	780			773			11			
1992	May-Jul		59			1100			261		
1992	Aug-Oct						573			123	109
1993	Jan-Feb	177			521						
1993	Mar-Apr	965			768			97			
1993	May-Jul					89			38		
1993	Aug-Oct										118
1994	Jan-Feb	117			632						
1994	Mar-Apr	1436			912			218			
1994	May-Jul		88			192			113		
1994	Aug-Oct						469			73	158
1995	Jan-Feb	94			642			7			
1995	Mar-Apr	952			824			287			
1995	May-Jul					107			361		
1995	Aug-Oct			8			527			102	105
1995	Nov-Dec						231			65	
1996	Jan-Feb	70			790						
1996	Mar-Apr	1376			789			464			
1996	May-Jul		102			110			488		
1996	Aug-Oct			43			794			189	106
1996	Nov-Dec			15			40			21	
1997	Jan-Feb	135			803						
1997	Mar-Apr	1175			851			287			
1997	May-Jul		31			284			367		
1997	Aug-Oct						887			135	104
1997	Nov-Dec						757			24	
1998	Jan-Feb	80			689						
1998	Mar-Apr	1004			614			225			
1998	May-Jul		34			119			257		
1998	Aug-Oct			40			1056			54	109
1998	Nov-Dec			5			917				
1999	Jan-Feb	254			792						
1999	Mar-Apr	605			844			126			
1999	May-Jul		13			255			313		
1999	Aug-Oct			16			1044			89	283
1999	Nov-Dec						263				

Table 2.14b (page 3 of 3)—Multinomial sample sizes for length compositions (Models B and C).

		Trawl fishery			Longline fishery			Pot fishery			Survey
Year	Season	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Jan-Apr	May-Jul	Aug-Dec	Post-81
2000	Jan-Feb	212			732			325			
2000	Mar-Apr	563			422			179			
2000	May-Jul		39			139					
2000	Aug-Oct						1353				303
2000	Nov-Dec						887				
2001	Jan-Feb	79			596			29			
2001	Mar-Apr	326			717			311			
2001	May-Jul		44			350			21		
2001	Aug-Oct			56			1519			148	477
2001	Nov-Dec						914			10	
2002	Jan-Feb	173			1049			86			
2002	Mar-Apr	338			587			173			
2002	May-Jul		96			224			17		
2002	Aug-Oct			130			1833			134	296
2002	Nov-Dec						748			18	
2003	Jan-Feb	130			1366			282			
2003	Mar-Apr	443			858			14			
2003	May-Jul		107			345					
2003	Aug-Oct			159			2028			145	298
2003	Nov-Dec						1076			42	
2004	Jan-Feb	156			1116			169			
2004	Mar-Apr	273			714			37			
2004	May-Jul		143			297			15		
2004	Aug-Oct			90			1778			125	261
2004	Nov-Dec						890			19	
2005	Jan-Feb	219			1300			153			
2005	Mar-Apr	291			320			24			
2005	May-Jul		120			337					
2005	Aug-Oct						1775			145	273
2005	Nov-Dec						875				
2006	Jan-Feb	298			1027			214			
2006	Mar-Apr	168			315			52			
2006	May-Jul		88			161			12		
2006	Aug-Oct			14			1775			147	293
2006	Nov-Dec						87			31	
2007	Jan-Feb	201			943			225			
2007	Mar-Apr	225			80			24			
2007	May-Jul		155			95					
2007	Aug-Oct						1302			107	309
2007	Nov-Dec						60				
2008	Jan-Feb	176			861			129			
2008	Mar-Apr	98			203			28			
2008	May-Jul		34			221					
2008	Aug-Oct			23			1659			131	313
2008	Nov-Dec						494				
2009	Jan-Feb	91			771			130			
2009	Mar-Apr	61			124			22			
2009	May-Jul		29			174					
2009	Aug-Oct			71			1586			56	403
2009	Nov-Dec						461			16	
2010	Jan-Feb	174			829			152			
2010	Mar-Apr	39			81						
2010	May-Jul		18			99					
2010	Aug-Oct			11			135				183

Table 2.15—Negative log-likelihoods and parameter numbers for Models A, B, and C. Note that the data sets for each model are different, so log-likelihoods are not comparable. Note that selectivity seasons are defined differently between Model A (Jan-May, Jun-Aug, Sep-Dec) and Models B and C (Jan-Apr, May-Jul, Aug-Dec). Shaded cells indicate values that are not used in computing the total.

	Aggregate -lnL		
Component	Model A	Model B	Model C
Equilibrium catch	0.01	0.01	0.01
Survey CPUE (numbers)	-16.05	-8.99	-2.84
Size composition	1,560.62	4,292.48	3,942.88
Age composition	161.40	170.19	n/a
Mean size at age	848.42	1,346.29	n/a
Recruitment	16.29	7.90	8.19
"Softbounds"	0.03	0.03	0.03
Deviations	58.59	16.30	13.23
Total	2,629.31	5,824.21	3,961.49

	Model A	Model B	Model C
Number of parameters	218	183	183

	Fleet CPUE -lnL			**Size composition -lnL**		
Fleet	Model A	Model B	Model C	Model A	Model B	Model C
Season 1 trawl fishery	55.63	59.63	44.26	419.16	827.07	884.30
Season 2 trawl fishery	-2.83	-12.39	-12.00	70.74	190.35	183.95
Season 3 trawl fishery	23.77	49.02	49.67	77.61	216.90	219.73
Season 1 longline fishery	200.66	138.94	133.79	259.04	591.59	603.86
Season 2 longline fishery	48.65	7.38	2.25	172.69	218.47	224.65
Season 3 longline fishery	32.59	64.69	57.22	306.19	834.99	834.28
Season 1 pot fishery	-8.68	-21.80	-24.36	40.85	99.97	100.13
Season 2 pot fishery	-9.75	-5.57	-8.25	21.98	75.96	80.42
Season 3 pot fishery	4.52	0.60	-0.79	46.34	169.67	173.99
Pre-1982 trawl survey	2.05	-0.75	6.66	21.48	65.43	57.84
Post-1981 trawl survey	-18.10	-8.24	-9.50	113.23	1,002.10	579.73
IPHC longline survey	-0.79	n/a	n/a	11.32	n/a	n/a
Total	-16.05	-8.99	-2.84	1,560.62	4,292.48	3,942.88

	Age composition -lnL			**Mean size at age -lnL**		
Fleet	Model A	Model B	Model C	Model A	Model B	Model C
Season 1 longline fishery	18.51	n/a	n/a	63.28	n/a	n/a
Post-1981 trawl survey	142.89	170.19	n/a	785.14	1,346.29	n/a
Total	161.40	170.19	n/a	848.42	1,346.29	n/a

Table 2.16—Root mean squared errors (RMSE) and observed:predicted correlations for fishery CPUE and survey relative abundance time series. Green = within-section row minimum, pink = within-section row maximum. Note that selectivity seasons are defined differently between Model A (Jan-May, Jun-Aug, Sep-Dec) and Models B and C (Jan-Apr, May-Jul, Aug-Dec). Only the trawl survey data are used in fitting the models (shown in bold box); other results are displayed for comparison only.

	No. records		RMSE			Correlation		
Fleet	A	B/C	A	B	C	A	B	C
Sea. 1 trawl fishery	20	40	0.26	0.33	0.32	0.47	0.33	0.41
Sea. 2 trawl fishery	20	20	0.47	0.30	0.30	-0.02	0.35	0.36
Sea. 3 trawl fishery	18	26	0.78	0.77	0.79	-0.11	0.13	0.00
Sea. 1 longline fishery	20	40	0.27	0.29	0.29	-0.17	-0.13	-0.09
Sea. 2 longline fishery	15	20	0.24	0.26	0.25	0.20	0.30	0.36
Sea. 3 longline fishery	19	35	0.17	0.19	0.19	0.65	0.42	0.49
Sea. 1 pot fishery	19	24	0.24	0.23	0.21	-0.21	-0.12	0.01
Sea. 2 pot fishery	7	9	0.13	0.24	0.22	0.76	-0.20	0.12
Sea. 3 pot fishery	17	27	0.36	0.32	0.31	0.07	0.04	0.16
Pre-82 trawl survey	3	3	0.30	0.25	0.38	0.75	0.50	-0.82
Post-81 trawl survey	29	29	0.20	0.21	0.21	0.73	0.68	0.69
IPHC longline survey	10	n/a	0.36	n/a	n/a	-0.43	n/a	n/a

Table 2.17a—Number of records, average input sample size (N), average ratio of effective multinomial sample size (Neff) to input sample size, and ratio of average Neff to average N for each fishery and survey size composition time series. Note that size composition records from gear/year/season combinations are turned off if age composition records are available and used. Green = within-section row minimum, pink = within-section row maximum. Note that selectivity seasons are defined differently between Model A (Jan-May, Jun-Aug, Sep-Dec) and Models B and C (Jan-Apr, May-Jul, Aug-Dec).

	No. records			Ave. input N			Ave(Neff/N)			Ave(Neff)/Ave(N)		
Fleet	A	B	C	A	B	C	A	B	C	A	B	C
Sea. 1 trawl fishery	32	58	58	359	340	340	1.36	5.73	5.60	0.96	3.26	3.22
Sea. 2 trawl fishery	20	30	30	29	70	70	7.85	8.53	9.06	3.43	6.73	7.20
Sea. 3 trawl fishery	23	33	33	28	42	42	3.85	14.93	15.46	3.34	7.08	7.20
Sea. 1 longline fishery	30	62	62	667	474	474	1.93	9.41	9.02	1.02	4.06	4.16
Sea. 2 longline fishery	24	30	30	267	214	214	2.86	9.59	9.14	1.10	5.32	5.11
Sea. 3 longline fishery	30	57	57	720	687	687	1.54	7.99	8.40	1.03	3.77	3.76
Sea. 1 pot fishery	19	31	31	149	145	145	3.02	13.51	13.48	3.20	10.12	10.35
Sea. 2 pot fishery	7	16	16	60	144	144	4.64	17.02	17.05	3.67	5.95	7.41
Sea. 3 pot fishery	18	31	31	56	78	78	5.06	12.19	12.00	4.68	9.83	9.54
Pre-82 trawl survey	3	3	3	103	100	100	1.31	0.44	0.90	1.33	0.44	0.90
Post-81 trawl survey	13	13	29	164	129	199	1.85	1.70	3.71	1.60	1.56	2.58
IPHC longline survey	2	n/a	n/a	86	n/a	n/a	1.56	n/a	n/a	1.57	n/a	n/a

Table 2.17b—Input sample size (input N), effective multinomial sample size (effective N), and ratio of effective N to input N for each record of age composition data. Average of ratios and ratio of averages are shown for the post-1981 trawl survey in the bottom two rows. Green = within-section row minimum, pink = within-section row maximum. Note that selectivity seasons are defined differently between Model A (Jan-May, Jun-Aug, Sep-Dec) and Models B and C (Jan-Apr, May-Jul, Aug-Dec).

		Input N		Effective N			Effective N / Input N		
Fleet	Year	A	B/C	A	B	C	A	B	C
Sea. 1 longline fishery	2008	213	n/a	51	n/a	n/a	0.24	n/a	n/a
Post-81 trawl survey	1994	218	214	69	71	5	0.32	0.32	0.02
Post-81 trawl survey	1995	182	179	29	28	5	0.16	0.15	0.03
Post-81 trawl survey	1996	217	213	196	109	18	0.90	0.50	0.08
Post-81 trawl survey	1997	219	215	322	419	20	1.47	1.91	0.09
Post-81 trawl survey	1998	193	190	89	96	4	0.46	0.50	0.02
Post-81 trawl survey	1999	262	257	302	169	13	1.15	0.65	0.05
Post-81 trawl survey	2000	263	258	180	107	17	0.69	0.41	0.07
Post-81 trawl survey	2001	289	284	525	148	9	1.82	0.51	0.03
Post-81 trawl survey	2002	288	283	115	82	19	0.40	0.29	0.07
Post-81 trawl survey	2003	414	407	622	577	20	1.50	1.39	0.05
Post-81 trawl survey	2004	317	311	67	65	47	0.21	0.20	0.15
Post-81 trawl survey	2005	390	383	170	176	32	0.44	0.45	0.08
Post-81 trawl survey	2006	396	389	218	183	16	0.55	0.46	0.04
Post-81 trawl survey	2007	439	431	29	23	2	0.07	0.05	0.00
Post-81 trawl survey	2008	369	363	48	43	4	0.13	0.12	0.01
Post-81 trawl survey	2009	430	422	66	61	3	0.15	0.14	0.01
Ave(effective N / input N)--post-81 trawl survey:							0.65	0.50	0.05
Ave(effective N)/ave(input N)--post-81 trawl survey:							0.62	0.49	0.05

Table 2.18 (page 1 of 8)—All of the quantities listed in the "parameters" section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
M			0.34				0.34				0.34	
L-at-age-0	1	3	-15.5426	0.282713	1	3	-6.53854	0.172178	1	3	-51.2811	0.716726
Linf	2	3	96.4037	0.420321	2	3	94.0624	0.295709	2	3	92.4723	0.413761
K	3	3	0.232031	0.002721	3	3	0.226161	0.001523	3	3	0.251011	0.002371
SD_of_len_at_L-at-age-0			0.01				0.01				0.01	
SD_of_len_at_L-at-age-20			8.68				8.68				8.68	
Wtlen_1			6.2E-06				6.2E-06				6.2E-06	
Wtlen_2			3.16503				3.16503				3.16503	
Maturity_inflection			4.8832				4.8832				58	
Maturity_slope			-0.9654				-0.9654				-0.132	
Eggs/kg_intercept			1				1				1	
Eggs/kg_slope			0				0				0	
RecrDist_growpattern_1			0				0				0	
RecrDist_Area_1			0				0				0	
RecrDist_Seas_1			0				0				0	
RecrDist_Seas_2			0				0				0	
RecrDist_Seas_3			0				0				0	
RecrDist_Seas_4							0				0	
RecrDist_Seas_5							0				0	
CohortGrowDev			1				1				1	
WL1_offsetseas_1			-0.076907				-0.498995				-0.498995	
WL1_offsetseas_2			0.385047				0.158725				0.158725	
WL1_offsetseas_3			-0.064895				0.458791				0.458791	
WL1_offsetseas_4			0.006045				0.179321				0.179321	
WL1_offsetseas_5			-0.032055				-0.346794				-0.346794	
WL2_offsetseas_1			0.005582				0.040581				0.040581	
WL2_offsetseas_2							-0.013719				-0.013719	
WL2_offsetseas_3							-0.038867				-0.038867	
WL2_offsetseas_4							-0.014281				-0.014281	
WL2_offsetseas_5							0.027567				0.027567	
CohortGrow_dev_1977	4	4	-0.00079	0.01122								
CohortGrow_dev_1978	5	4	0.002647	0.020796								
CohortGrow_dev_1979	6	4	0.022828	0.017722								
CohortGrow_dev_1980	7	4	0.050565	0.015473								
CohortGrow_dev_1981	8	4	-0.002705	0.018793								
CohortGrow_dev_1982	9	4	-0.043567	0.008773								
CohortGrow_dev_1983	10	4	-0.10036	0.027361								
CohortGrow_dev_1984	11	4	-0.018674	0.010153								
CohortGrow_dev_1985	12	4	-0.063217	0.013727								
CohortGrow_dev_1986	13	4	-0.030632	0.018937								

Table 2.18 (page 2 of 8)—All of the quantities listed in the "parameters" section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
CohortGrow_dev_1987	14	4	0.026649	0.021851								
CohortGrow_dev_1988	15	4	0.032711	0.012762								
CohortGrow_dev_1989	16	4	-0.014002	0.009636								
CohortGrow_dev_1990	17	4	-0.040221	0.010617								
CohortGrow_dev_1991	18	4	-0.037178	0.012396								
CohortGrow_dev_1992	19	4	-0.043307	0.008401								
CohortGrow_dev_1993	20	4	-0.050584	0.009566								
CohortGrow_dev_1994	21	4	-0.074241	0.009663								
CohortGrow_dev_1995	22	4	-0.090501	0.010015								
CohortGrow_dev_1996	23	4	-0.071421	0.008272								
CohortGrow_dev_1997	24	4	-0.124141	0.009209								
CohortGrow_dev_1998	25	4	-0.083073	0.009789								
CohortGrow_dev_1999	26	4	-0.071873	0.008403								
CohortGrow_dev_2000	27	4	-0.062559	0.008349								
CohortGrow_dev_2001	28	4	-0.109114	0.009036								
CohortGrow_dev_2002	29	4	-0.05984	0.008369								
CohortGrow_dev_2003	30	4	-0.112628	0.008695								
CohortGrow_dev_2004	31	4	-0.026874	0.008813								
CohortGrow_dev_2005	32	4	-0.043811	0.009871								
CohortGrow_dev_2006	33	4	-0.0695	0.008224								
CohortGrow_dev_2007	34	4	-0.085042	0.009264								
CohortGrow_dev_2008	35	4	-0.128434	0.010081								
CohortGrow_dev_2009	36	4	-0.031345	0.032791								
SR_R0	37	1	13.291	0.021794	4	1	13.3176	0.018647	4	1	13.514	0.034253
SR_steepness			1				1				1	
SR_sigmaR			0.57				0.57				0.57	
SR_envlink			0				0				0	
SR_R1_offset	38	3	-1.33615	0.126438	5	3	-0.988564	0.105617	5	3	-0.565063	0.104139
SR_autocorr			0				0				0	
InitialAge_dev_3	39		1.14334	0.215718	6		1.41846	0.192693	6		-0.237675	0.32714
InitialAge_dev_2	40		-0.171114	0.366587	7		-0.118766	0.341005	7		1.31631	0.148601
InitialAge_dev_1	41		0.341061	0.302606	8		1.11653	0.174814	8		2.07074	0.117021
Recr_dev_1977	42		1.31903	0.078283	9		1.43805	0.064112	9		0.377352	0.163845
Recr_dev_1978	43		0.327289	0.150556	10		0.307332	0.123441	10		0.791308	0.094655
Recr_dev_1979	44		0.228528	0.143958	11		0.517512	0.084773	11		-0.230512	0.130779
Recr_dev_1980	45		0.157755	0.104775	12		-0.067586	0.091114	12		-0.929725	0.16148
Recr_dev_1981	46		-0.584362	0.123559	13		-1.01249	0.133648	13		0.976705	0.044831
Recr_dev_1982	47		0.886773	0.046053	14		0.755647	0.038082	14		-0.544874	0.116014
Recr_dev_1983	48		-0.575684	0.181256	15		-0.401724	0.075755	15		0.767574	0.050103
Recr_dev_1984	49		0.5909	0.063474	16		0.515079	0.042808	16		0.067861	0.070581

Table 2.18 (page 3 of 8)—All of the quantities listed in the “parameters” section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
Recr_dev_1985	50		0.059141	0.084712	17		0.010526	0.055181	17		-0.707635	0.09552
Recr_dev_1986	51		-0.92608	0.143076	18		-0.634718	0.070639	18		-0.923285	0.092843
Recr_dev_1987	52		-1.49889	0.176018	19		-0.98207	0.075331	19		-0.273212	0.060076
Recr_dev_1988	53		-0.4192	0.067332	20		-0.427641	0.048722	20		0.530718	0.04236
Recr_dev_1989	54		0.502621	0.050513	21		0.376259	0.03317	21		0.400714	0.047256
Recr_dev_1990	55		0.332857	0.059084	22		0.297857	0.035779	22		-0.246435	0.063954
Recr_dev_1991	56		-0.110955	0.067679	23		-0.14993	0.040698	23		0.670175	0.037433
Recr_dev_1992	57		0.529663	0.042039	24		0.479437	0.027857	24		-0.35364	0.065509
Recr_dev_1993	58		-0.116671	0.055463	25		-0.197299	0.038668	25		-0.221141	0.053748
Recr_dev_1994	59		-0.200701	0.056819	26		-0.357191	0.039346	26		-0.212859	0.057571
Recr_dev_1995	60		-0.07696	0.063835	27		-0.250462	0.039081	27		0.720215	0.03611
Recr_dev_1996	61		0.667988	0.037361	28		0.561177	0.026523	28		-0.014202	0.051005
Recr_dev_1997	62		0.068418	0.052696	29		-0.006416	0.033636	29		-0.143578	0.051076
Recr_dev_1998	63		-0.265919	0.066131	30		-0.215166	0.036123	30		0.493397	0.036087
Recr_dev_1999	64		0.380281	0.04041	31		0.268137	0.027675	31		0.196663	0.044084
Recr_dev_2000	65		0.096224	0.041003	32		0.100126	0.030065	32		-0.774937	0.067953
Recr_dev_2001	66		-0.557709	0.057666	33		-0.644156	0.040138	33		-0.102518	0.044773
Recr_dev_2002	67		-0.214122	0.044201	34		-0.331086	0.03377	34		-0.368113	0.05732
Recr_dev_2003	68		-0.38488	0.053366	35		-0.374516	0.03812	35		-0.357754	0.059489
Recr_dev_2004	69		-0.653592	0.061145	36		-0.505414	0.043131	36		-0.411184	0.066791
Recr_dev_2005	70		-0.263101	0.0573	37		-0.445679	0.045842	37		0.764639	0.056338
Recr_dev_2006	71		0.629419	0.053091	38		0.447882	0.044157	38		-0.06321	0.101535
Recr_dev_2007	72		-0.097524	0.092233	39		-0.194722	0.078016	39		1.09185	0.090872
Recr_dev_2008	73		1.0371	0.090983	40		0.699548	0.085117	40		-0.832755	0.28282
Recr_dev_2009	74		-0.867638	0.328263	41		0.42369	0.170626	41		-0.137601	0.546851
Late_RecrDev_2010			0				0				0	
ForeRecr_2011			0				0				0	
ForeRecr_2012			0				0				0	
ForeRecr_2013			0				0				0	
ForeRecr_2014			0				0				0	
ForeRecr_2015			0				0				0	
InitF_1	75	1	0.101576	0.020826	42	1	0.061761	0.010619	42	1	0.048157	0.008274
InitF_2			0				0				0	
InitF_3			0				0				0	
InitF_4			0				0				0	
InitF_5			0				0				0	
InitF_6			0				0				0	
InitF_7			0				0				0	
InitF_8			0				0				0	
InitF_9			0				0				0	

Table 2.18 (page 4 of 8)—All of the quantities listed in the "parameters" section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
Q_base_10			0				0				0	
Q_base_11			-0.261365				-0.261365				-0.261365	
SizeSel_1P_1_			0				0				0	
SizeSel_1P_2_			0				0				0	
SizeSel_1P_3_			0				0				0	
SizeSel_1P_4_			0				0				0	
SizeSel_1P_5_			-999				-999				-999	
SizeSel_1P_6_			10				10				10	
SizeSel_2P_1_			0				0				0	
SizeSel_2P_2_			0				0				0	
SizeSel_2P_3_	76	4	5.62571	0.185686	43	4	5.70723	0.103731	43	4	5.60581	0.108153
SizeSel_2P_4_			0				0				0	
SizeSel_2P_5_			-999				-999				-999	
SizeSel_2P_6_			10				10				10	
SizeSel_3P_1_			0				0				0	
SizeSel_3P_2_			0				0				0	
SizeSel_3P_3_			0				0				0	
SizeSel_3P_4_			0				0				0	
SizeSel_3P_5_			-999				-999				-999	
SizeSel_3P_6_			10				10				10	
SizeSel_4P_1_			0				0				0	
SizeSel_4P_2_	77	4	-9.53996	12.0468	44	4	-4.322	1.1431	44	4	-4.1014	0.871164
SizeSel_4P_3_			0				0				0	
SizeSel_4P_4_	78	4	4.98243	0.113447	45	4	4.93392	0.135379	45	4	4.89982	0.128057
SizeSel_4P_5_			-999				-999				-999	
SizeSel_4P_6_			0				0				0	
SizeSel_5P_1_			0				0				0	
SizeSel_5P_2_			0				0				0	
SizeSel_5P_3_	79	4	5.00412	0.057431	46	4	4.96989	0.055646	46	4	4.90413	0.059859
SizeSel_5P_4_			0				0				0	
SizeSel_5P_5_			-999				-999				-999	
SizeSel_5P_6_			10				10				10	
SizeSel_6P_1_			0				0				0	
SizeSel_6P_2_	80	4	-2.20728	0.371992	47	4	-2.06707	0.218972	47	4	-2.07692	0.18082
SizeSel_6P_3_			0				0				0	
SizeSel_6P_4_	81	4	4.88914	0.316206	48	4	4.70607	0.291724	48	4	4.76248	0.239041
SizeSel_6P_5_			-999				-999				-999	
SizeSel_6P_6_			0				0				0	
SizeSel_7P_1_			0				0				0	
SizeSel_7P_2_	82	4	-8.89101	24.4423	49	4	-7.91606	36.6752	49	4	-5.35293	7.83633

Table 2.18 (page 5 of 8)—All of the quantities listed in the "parameters" section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
SizeSel_7P_3_	83	4	5.0616	0.065967	50	4	5.02279	0.055391	50	4	4.99828	0.065519
SizeSel_7P_4_	84	4	4.3161	0.392949	51	4	4.49125	0.293892	51	4	4.47983	0.399507
SizeSel_7P_5_			-999				-999				-999	
SizeSel_7P_6_			0				0				0	
SizeSel_8P_1_			0				0				0	
SizeSel_8P_2_			0				0				0	
SizeSel_8P_3_	85	4	4.86591	0.188613	52	4	4.91771	0.082226	52	4	4.87219	0.084344
SizeSel_8P_4_			0				0				0	
SizeSel_8P_5_			-999				-999				-999	
SizeSel_8P_6_			10				10				10	
SizeSel_9P_1_			0				0				0	
SizeSel_9P_2_			0				0				0	
SizeSel_9P_3_			0				0				0	
SizeSel_9P_4_			0				0				0	
SizeSel_9P_5_			-999				-999				-999	
SizeSel_9P_6_			10				10				10	
SizeSel_12P_1	86	4	74.8286	3.26911								
SizeSel_12P_2			0									
SizeSel_12P_3	87	4	5.15249	0.30014								
SizeSel_12P_4			0									
SizeSel_12P_5			-999									
SizeSel_12P_6			10									
AgeSel_10P_1	88	4	1.12903	1.97861	53	4	1.96635	0.598128	53	4	3.10259	0.062297
AgeSel_10P_2	89	4	-2.17497	2.09593	54	4	-4.15347	4.65976	54	4	-9.43072	14.447
AgeSel_10P_3	90	4	-5.12444	46.4587	55	4	-7.70145	2.95197	55	4	-10.0001	447.21
AgeSel_10P_4	91	4	-4.41751	98.3109	56	4	0.5568	2.30068	56	4	0.916987	0.593339
AgeSel_10P_5	92	4	-13.7289	83.333	57	4	-2.24567	0.345398	57	4	-1.62084	0.404957
AgeSel_10P_6	93	4	-2.15927	0.999423	58	4	-1.87232	1.05093	58	4	-2.71728	1.37605
AgeSel_11P_1	94	4	1.28032	0.06972	59	4	1.27839	0.066427	59	4	2.3829	0.121651
AgeSel_11P_2	95	4	-2.87727	0.491994	60	4	-3.05529	0.465992	60	4	-4.10124	1.56256
AgeSel_11P_3	96	4	-2.20025	0.533113	61	4	-2.16998	0.512009	61	4	-1.64424	0.654652
AgeSel_11P_4	97	4	1.91628	0.49514	62	4	1.78186	0.399396	62	4	1.73995	0.442449
AgeSel_11P_5	98	4	-5.52133	0.519677	63	4	-3.88073	0.087672	63	4	-3.05897	0.436204
AgeSel_11P_6	99	4	-0.458616	0.196071	64	4	-0.47339	0.151949	64	4	-0.825181	0.185035
SizeSel_1P_1_block_1977	100	4	41.9087	3.24054	65	4	14.941	42.6322	65	4	6.1445	34.1724
SizeSel_1P_1_block_1980	101	4	69.7272	3.32128	66	4	67.8519	3.01569	66	4	67.0664	3.04904
SizeSel_1P_1_block_1985	102	4	74.9105	1.97183	67	4	74.1572	1.60204	67	4	72.6153	1.80995
SizeSel_1P_1_block_1990	103	4	61.4352	1.39643	68	4	69.9731	0.980157	68	4	66.8413	1.16401
SizeSel_1P_1_block_1995	104	4	72.7344	1.13536	69	4	74.123	0.916113	69	4	72.2184	0.928897
SizeSel_1P_1_block_2000	105	4	77.2465	1.37248	70	4	77.1613	1.14582	70	4	76.9594	1.16086

Table 2.18 (page 6 of 8)—All of the quantities listed in the "parameters" section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
SizeSel_1P_1_block_2005	106	4	73.3567	1.27929	71	4	72.9674	1.05866	71	4	72.584	1.07278
SizeSel_1P_3_block_1977	107	4	3.05487	0.930762	72	4	9.22755	21.0099	72	4	9.52642	13.1886
SizeSel_1P_3_block_1980	108	4	6.1362	0.198043	73	4	6.16294	0.181667	73	4	6.17302	0.182543
SizeSel_1P_3_block_1985	109	4	6.58006	0.098862	74	4	6.56757	0.079968	74	4	6.52994	0.091889
SizeSel_1P_3_block_1990	110	4	5.76488	0.097318	75	4	6.12796	0.053129	75	4	6.02759	0.066157
SizeSel_1P_3_block_1995	111	4	6.26104	0.058913	76	4	6.31534	0.046	76	4	6.26479	0.04846
SizeSel_1P_3_block_2000	112	4	6.30701	0.071669	77	4	6.28819	0.061074	77	4	6.29077	0.061754
SizeSel_1P_3_block_2005	113	4	6.06757	0.077953	78	4	6.05286	0.065932	78	4	6.06523	0.066976
SizeSel_2P_1_block_1977	114	4	49.2566	2.5392	79	4	50.2512	1.74333	79	4	48.7522	1.65556
SizeSel_2P_1_block_1985	115	4	68.8319	3.50946	80	4	51.9031	1.74048	80	4	50.3647	1.72562
SizeSel_2P_1_block_1990	116	4	64.2381	3.72571	81	4	63.4804	1.56075	81	4	60.9099	1.50044
SizeSel_2P_1_block_2000	117	4	66.2653	2.51927	82	4	53.4801	1.51234	82	4	52.092	1.51204
SizeSel_2P_1_block_2005	118	4	56.6301	2.52959	83	4	59.6351	1.53693	83	4	57.8824	1.51537
SizeSel_3P_1_block_1977	119	4	58.7526	4.54977	84	4	63.1182	3.89579	84	4	59.5924	3.51759
SizeSel_3P_1_block_1980	120	4	84.4469	7.4099	85	4	76.1421	6.70955	85	4	73.7223	5.72965
SizeSel_3P_1_block_1985	121	4	81.2472	4.43854	86	4	82.8172	4.51808	86	4	80.746	4.06978
SizeSel_3P_1_block_1990	122	4	49.2444	3.82061	87	4	46.9152	15.3177	87	4	75.9645	28.4475
SizeSel_3P_1_block_1995			102.5				102.5				102.5	
SizeSel_3P_1_block_2000	123	4	61.4715	4.13402	88	4	61.7362	2.48017	88	4	61.545	2.51879
SizeSel_3P_3_block_1977	124	4	5.23614	0.410886	89	4	5.54276	0.309204	89	4	5.31412	0.334226
SizeSel_3P_3_block_1980	125	4	6.67821	0.291993	90	4	6.45729	0.321527	90	4	6.41058	0.286771
SizeSel_3P_3_block_1985	126	4	6.14391	0.265765	91	4	6.49983	0.221177	91	4	6.42997	0.212057
SizeSel_3P_3_block_1990	127	4	4.43124	0.704572	92	4	3.18205	4.78063	92	4	6.33268	1.62813
SizeSel_3P_3_block_1995	128	4	7.04675	0.128467	93	4	7.02438	0.088388	93	4	7.05821	0.0893
SizeSel_3P_3_block_2000	129	4	5.50382	0.366975	94	4	5.56899	0.212083	94	4	5.55901	0.217495
SizeSel_4P_1_block_1977	130	4	56.0229	2.50867	95	4	58.6408	2.23844	95	4	59.0534	1.50206
SizeSel_4P_1_block_1980	131	4	69.2839	3.03288	96	4	68.8369	2.8199	96	4	69.4746	2.35382
SizeSel_4P_1_block_1985	132	4	72.9206	0.919846	97	4	73.5853	0.868266	97	4	73.2182	0.873176
SizeSel_4P_1_block_1990	133	4	65.9317	0.54808	98	4	66.3575	0.459541	98	4	65.6979	0.46831
SizeSel_4P_1_block_1995	134	4	65.638	0.446667	99	4	65.7281	0.415228	99	4	65.115	0.41743
SizeSel_4P_1_block_2000	135	4	63.4925	0.431199	100	4	63.162	0.439358	100	4	63.0746	0.436354
SizeSel_4P_1_block_2005	136	4	68.0993	0.47231	101	4	67.122	0.416075	101	4	66.7073	0.420877
SizeSel_4P_3_block_1977	137	4	4.75297	0.279027	102	4	5.06455	0.217048	102	4	4.98247	0.176502
SizeSel_4P_3_block_1980	138	4	5.6947	0.238681	103	4	5.73441	0.221907	103	4	5.81204	0.192012
SizeSel_4P_3_block_1985	139	4	5.67922	0.07927	104	4	5.77975	0.069459	104	4	5.7917	0.069454
SizeSel_4P_3_block_1990	140	4	5.16283	0.056171	105	4	5.23803	0.044878	105	4	5.22062	0.046319
SizeSel_4P_3_block_1995	141	4	5.25133	0.043974	106	4	5.30464	0.039403	106	4	5.27762	0.040149
SizeSel_4P_3_block_2000	142	4	5.32456	0.044333	107	4	5.35288	0.042109	107	4	5.35046	0.041857
SizeSel_4P_3_block_2005	143	4	5.37763	0.045446	108	4	5.3346	0.038569	108	4	5.3178	0.039472
SizeSel_4P_6_block_1977	144	4	-1.29235	0.831759	109	4	-0.955998	0.783116	109	4	-2.35897	0.718473

Table 2.18 (page 7 of 8)—All of the quantities listed in the "parameters" section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
SizeSel_4P_6_block_1980	145	4	0.992672	1.45196	110	4	0.958977	1.15424	110	4	0.323489	0.799286
SizeSel_4P_6_block_1985	146	4	-1.07277	0.392361	111	4	-0.849377	0.34263	111	4	-0.934648	0.328948
SizeSel_4P_6_block_1990	147	4	-0.346824	0.153239	112	4	-0.470758	0.129433	112	4	-0.576968	0.121644
SizeSel_4P_6_block_1995	148	4	-0.830736	0.15766	113	4	-0.60913	0.131412	113	4	-0.7186	0.123723
SizeSel_4P_6_block_2000	149	4	-1.20149	0.162168	114	4	-1.17389	0.130816	114	4	-1.18696	0.127714
SizeSel_4P_6_block_2005	150	4	-1.06618	0.199096	115	4	-1.14046	0.139935	115	4	-1.09566	0.133556
SizeSel_5P_1_block_1977	151	4	62.7292	1.91757	116	4	63.3544	2.09499	116	4	63.3372	1.9523
SizeSel_5P_1_block_1980	152	4	64.8056	1.64681	117	4	61.3386	1.34542	117	4	60.1498	1.40953
SizeSel_5P_1_block_1985	153	4	66.3405	2.09476	118	4	62.4871	1.11786	118	4	61.6496	1.12799
SizeSel_5P_1_block_1990	154	4	65.7892	0.630035	119	4	63.446	0.531263	119	4	62.225	0.552875
SizeSel_5P_1_block_2000	155	4	61.9872	0.574493	120	4	59.2123	0.556104	120	4	58.643	0.574226
SizeSel_5P_1_block_2005	156	4	64.776	0.585639	121	4	63.716	0.625785	121	4	62.9574	0.639705
SizeSel_6P_1_block_1977	157	4	59.8587	3.45168	122	4	60.903	2.31087	122	4	59.3785	1.66081
SizeSel_6P_1_block_1980	158	4	67.6433	1.90323	123	4	66.4439	1.47403	123	4	66.3409	1.48264
SizeSel_6P_1_block_1985	159	4	65.4602	0.765825	124	4	64.3849	0.6545	124	4	63.5122	0.651569
SizeSel_6P_1_block_1990	160	4	67.649	0.844926	125	4	67.1075	0.686528	125	4	66.2143	0.693227
SizeSel_6P_1_block_1995	161	4	69.0658	0.826217	126	4	69.1213	0.671651	126	4	67.8663	0.680824
SizeSel_6P_1_block_2000	162	4	64.6983	0.564364	127	4	63.0035	0.410147	127	4	62.8082	0.422071
SizeSel_6P_1_block_2005	163	4	61.8152	0.559708	128	4	61.4683	0.450316	128	4	60.8491	0.437729
SizeSel_6P_3_block_1977	164	4	4.27688	0.519387	129	4	4.53303	0.325148	129	4	4.26757	0.281387
SizeSel_6P_3_block_1980	165	4	5.21868	0.177722	130	4	5.13083	0.145322	130	4	5.19105	0.143475
SizeSel_6P_3_block_1985	166	4	4.92675	0.088751	131	4	4.8929	0.077599	131	4	4.80237	0.080911
SizeSel_6P_3_block_1990	167	4	5.0367	0.091805	132	4	4.9967	0.074296	132	4	4.96948	0.077595
SizeSel_6P_3_block_1995	168	4	5.44557	0.065703	133	4	5.48417	0.052983	133	4	5.41938	0.055518
SizeSel_6P_3_block_2000	169	4	5.24736	0.053128	134	4	5.14014	0.041573	134	4	5.1367	0.042179
SizeSel_6P_3_block_2005	170	4	4.89126	0.063661	135	4	4.8642	0.050066	135	4	4.80676	0.050019
SizeSel_6P_6_block_1977	171	4	-2.29616	2.33323	136	4	-1.7409	1.42124	136	4	-3.08066	1.5509
SizeSel_6P_6_block_1980	172	4	1.26382	1.02812	137	4	1.30352	0.748324	137	4	0.738928	0.536518
SizeSel_6P_6_block_1985	173	4	-0.287569	0.229093	138	4	0.114109	0.184625	138	4	0.012892	0.176345
SizeSel_6P_6_block_1990	174	4	1.31862	0.459497	139	4	2.49954	0.852703	139	4	1.80065	0.451211
SizeSel_6P_6_block_1995	175	4	2.93975	1.74704	140	4	9.62759	10.0791	140	4	9.31039	16.8857
SizeSel_6P_6_block_2000	176	4	-0.443008	0.201753	141	4	-0.266859	0.141059	141	4	-0.284751	0.135494
SizeSel_6P_6_block_2005	177	4	9.72383	7.74724	142	4	9.75228	7.02386	142	4	9.64193	9.73896
SizeSel_7P_1_block_1977	178	4	69.2364	0.93568	143	4	69.0607	0.928564	143	4	68.3953	1.01376
SizeSel_7P_1_block_1995	179	4	67.9032	0.686845	144	4	68.4879	0.589215	144	4	67.9968	0.701268
SizeSel_7P_1_block_2000	180	4	68.0123	0.717409	145	4	67.9509	0.55908	145	4	67.6962	0.692366
SizeSel_7P_1_block_2005	181	4	68.3182	0.756173	146	4	67.5892	0.610556	146	4	67.1978	0.706976
SizeSel_7P_6_block_1977	182	4	-0.308646	0.416284	147	4	0.000371	0.499093	147	4	-0.013473	0.488291
SizeSel_7P_6_block_1995	183	4	0.228776	0.297355	148	4	-0.235495	0.251633	148	4	-0.372741	0.244688
SizeSel_7P_6_block_2000	184	4	-0.825777	0.355696	149	4	-0.667209	0.228696	149	4	-0.693091	0.239504

Table 2.18 (page 8 of 8)—All of the quantities listed in the “parameters” section of the SS report file. Quantities with a value listed but no standard deviation were fixed externally. A blank value means that the quantity was not used in the respective model. See text for other details.

	Model A				Model B				Model C			
Label	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.	Par. no.	Phase	Value	St. Dev.
SizeSel_7P_6_block_2005	185	4	0.55399	0.382802	150	4	0.377672	0.25925	150	4	0.366838	0.261775
SizeSel_8P_1_block_1977	186	4	63.0933	1.5572	151	4	67.3704	0.842415	151	4	66.4407	0.856924
SizeSel_8P_1_block_1995	187	4	67.3768	1.73994	152	4	65.8492	0.709273	152	4	65.1019	0.701872
SizeSel_9P_1_block_1977	188	4	69.6595	2.04875	153	4	68.4796	1.15465	153	4	67.4309	1.14299
SizeSel_9P_1_block_2000	189	4	61.8712	1.13248	154	4	60.7551	0.789418	154	4	60.4201	0.79845
SizeSel_9P_3_block_1977	190	4	5.21996	0.202872	155	4	5.1914	0.117235	155	4	5.13724	0.121498
SizeSel_9P_3_block_2000	191	4	4.47022	0.180117	156	4	4.36762	0.134445	156	4	4.33311	0.139399
AgeSel_11P_3_dev_1982	192	4	-0.074863	0.035833	157	4	-0.056411	0.039865	157	4	-0.047725	0.039397
AgeSel_11P_3_dev_1983	193	4	-0.037048	0.019604	158	4	-0.046928	0.022555	158	4	-0.044085	0.020453
AgeSel_11P_3_dev_1984	194	4	-0.088315	0.032778	159	4	0.064167	0.044012	159	4	-0.06871	0.036225
AgeSel_11P_3_dev_1985	195	4	0.007712	0.025434	160	4	0.044238	0.033142	160	4	0.003517	0.025476
AgeSel_11P_3_dev_1986	196	4	-0.064399	0.023344	161	4	0.033764	0.038073	161	4	-0.050607	0.027512
AgeSel_11P_3_dev_1987	197	4	0.040068	0.046536	162	4	0.058023	0.045956	162	4	0.040987	0.048672
AgeSel_11P_3_dev_1988	198	4	-0.025627	0.046472	163	4	-0.022325	0.041147	163	4	-0.070708	0.039395
AgeSel_11P_3_dev_1989	199	4	-0.107293	0.021322	164	4	-0.126445	0.024303	164	4	-0.125498	0.02512
AgeSel_11P_3_dev_1990	200	4	-0.032913	0.022308	165	4	-0.035349	0.024953	165	4	-0.035376	0.02361
AgeSel_11P_3_dev_1991	201	4	-0.048558	0.024004	166	4	-0.027394	0.028943	166	4	-0.053121	0.025824
AgeSel_11P_3_dev_1992	202	4	0.042159	0.037617	167	4	0.09754	0.043752	167	4	0.061569	0.04111
AgeSel_11P_3_dev_1993	203	4	0.060157	0.034791	168	4	0.070069	0.039667	168	4	0.048162	0.035029
AgeSel_11P_3_dev_1994	204	4	-0.041622	0.026517	169	4	-0.083159	0.02202	169	4	-0.022328	0.037136
AgeSel_11P_3_dev_1995	205	4	-0.087168	0.024648	170	4	-0.089326	0.025093	170	4	-0.06278	0.034642
AgeSel_11P_3_dev_1996	206	4	-0.109513	0.020499	171	4	-0.102031	0.019976	171	4	-0.101026	0.029914
AgeSel_11P_3_dev_1997	207	4	-0.059198	0.018114	172	4	-0.079387	0.017511	172	4	-0.067173	0.021625
AgeSel_11P_3_dev_1998	208	4	-0.090611	0.021126	173	4	-0.096226	0.021063	173	4	-0.088182	0.027402
AgeSel_11P_3_dev_1999	209	4	-0.068322	0.021706	174	4	-0.074993	0.020032	174	4	-0.084282	0.021104
AgeSel_11P_3_dev_2000	210	4	-0.037355	0.019297	175	4	-0.038456	0.019693	175	4	-0.045286	0.017609
AgeSel_11P_3_dev_2001	211	4	0.119498	0.038741	176	4	0.00375	0.025469	176	4	0.099582	0.03782
AgeSel_11P_3_dev_2002	212	4	-0.035967	0.024827	177	4	-0.035669	0.024245	177	4	-0.014869	0.029432
AgeSel_11P_3_dev_2003	213	4	-0.011106	0.021178	178	4	-0.051464	0.017683	178	4	-0.006549	0.023376
AgeSel_11P_3_dev_2004	214	4	-0.027851	0.021773	179	4	-0.058988	0.018753	179	4	-0.027729	0.023393
AgeSel_11P_3_dev_2005	215	4	0.038007	0.029597	180	4	-0.052318	0.018026	180	4	0.04283	0.032199
AgeSel_11P_3_dev_2006	216	4	0.055724	0.028653	181	4	0.096648	0.034258	181	4	0.083942	0.032229
AgeSel_11P_3_dev_2007	217	4	0.205221	0.03759	182	4	0.207423	0.037469	182	4	0.170763	0.037984
AgeSel_11P_3_dev_2008	218	4	0.026462	0.029128	183	4	0.018486	0.02792	183	4	0.021588	0.029562

Table 2.19a—Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model A). Sea1=Jan-May, Sea2=Jun-Aug, Sea3=Sep-Dec. Rates must be multiplied by relative season length before summing to get total.

	Trawl fishery			Longline fishery			Pot fishery			
Year	Sea1	Sea2	Sea3	Sea1	Sea2	Sea3	Sea1	Sea2	Sea3	Total
1977	0.074	0.050	0.044	0.018	0.003	0.036	0	0	0	0.079
1978	0.090	0.063	0.054	0.019	0.003	0.040	0	0	0	0.093
1979	0.069	0.037	0.037	0.016	0.002	0.033	0	0	0	0.069
1980	0.068	0.025	0.041	0.010	0.002	0.018	0	0	0	0.059
1981	0.034	0.035	0.068	0.003	0.002	0.010	0	0	0	0.051
1982	0.035	0.038	0.038	0.001	0.001	0.005	0	0	0	0.039
1983	0.055	0.049	0.046	0.004	0.002	0.005	0	0	0	0.054
1984	0.062	0.050	0.048	0.007	0.005	0.035	0	0	0	0.070
1985	0.075	0.070	0.046	0.024	0.004	0.048	0	0	0	0.091
1986	0.083	0.067	0.047	0.017	0.001	0.039	0	0	0	0.087
1987	0.091	0.040	0.047	0.041	0.002	0.062	0	0	0	0.102
1988	0.186	0.068	0.108	0.001	0.002	0.004	0	0	0	0.133
1989	0.200	0.049	0.049	0.008	0.014	0.013	0.000	0.000	0.000	0.123
1990	0.166	0.036	0.023	0.031	0.055	0.045	0.000	0.003	0.001	0.129
1991	0.211	0.060	0.015	0.076	0.087	0.099	0.000	0.004	0.007	0.197
1992	0.132	0.050	0.015	0.175	0.115	0.024	0.010	0.021	0.001	0.192
1993	0.147	0.022	0.022	0.171	0.000	0.000	0.008	0.000	0.000	0.149
1994	0.126	0.023	0.043	0.176	0.000	0.068	0.017	0.000	0.010	0.179
1995	0.212	0.034	0.069	0.208	0.000	0.091	0.038	0.016	0.011	0.261
1996	0.185	0.012	0.061	0.187	0.000	0.083	0.055	0.030	0.011	0.240
1997	0.197	0.016	0.052	0.216	0.000	0.152	0.044	0.017	0.011	0.271
1998	0.117	0.025	0.063	0.184	0.000	0.105	0.030	0.014	0.005	0.206
1999	0.121	0.015	0.023	0.201	0.010	0.086	0.033	0.005	0.008	0.194
2000	0.126	0.019	0.013	0.132	0.006	0.139	0.060	0.000	0.000	0.190
2001	0.061	0.028	0.015	0.116	0.026	0.153	0.040	0.002	0.012	0.164
2002	0.097	0.039	0.012	0.155	0.049	0.132	0.037	0.002	0.011	0.194
2003	0.083	0.038	0.007	0.173	0.049	0.152	0.056	0.000	0.019	0.211
2004	0.105	0.049	0.007	0.180	0.045	0.156	0.045	0.002	0.014	0.220
2005	0.113	0.024	0.001	0.192	0.066	0.158	0.041	0.000	0.017	0.225
2006	0.132	0.022	0.001	0.210	0.089	0.117	0.055	0.000	0.019	0.239
2007	0.117	0.038	0.001	0.206	0.084	0.086	0.052	0.000	0.022	0.223
2008	0.078	0.019	0.015	0.232	0.094	0.136	0.052	0.000	0.029	0.239
2009	0.072	0.030	0.024	0.260	0.089	0.152	0.057	0.000	0.011	0.254
2010	0.080	0.027	0.018	0.204	0.058	0.107	0.060	0.000	0.018	0.212

Table 2.19b—Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model B). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov-Dec. Rates must be multiplied by relative season length before summing to get total.

	Trawl fishery					Longline fishery					Pot fishery					
Year	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Total
1977	0.042	0.044	0.037	0.034	0.029	0.011	0.011	0.004	0.017	0.021	0	0	0	0	0	0.050
1978	0.048	0.048	0.044	0.038	0.033	0.011	0.011	0.004	0.017	0.023	0	0	0	0	0	0.055
1979	0.029	0.029	0.027	0.026	0.022	0.008	0.008	0.003	0.012	0.016	0	0	0	0	0	0.036
1980	0.039	0.039	0.020	0.024	0.020	0.006	0.006	0.002	0.008	0.010	0	0	0	0	0	0.034
1981	0.022	0.022	0.023	0.039	0.038	0.002	0.002	0.002	0.006	0.007	0	0	0	0	0	0.033
1982	0.025	0.026	0.028	0.030	0.024	0.000	0.000	0.001	0.003	0.003	0	0	0	0	0	0.028
1983	0.041	0.044	0.041	0.038	0.032	0.003	0.004	0.002	0.003	0.004	0	0	0	0	0	0.042
1984	0.048	0.053	0.045	0.041	0.036	0.006	0.006	0.005	0.021	0.029	0	0	0	0	0	0.058
1985	0.060	0.067	0.054	0.049	0.038	0.019	0.021	0.008	0.028	0.039	0	0	0	0	0	0.076
1986	0.068	0.075	0.055	0.050	0.040	0.014	0.015	0.004	0.023	0.033	0	0	0	0	0	0.074
1987	0.076	0.084	0.045	0.042	0.040	0.034	0.038	0.011	0.037	0.052	0	0	0	0	0	0.088
1988	0.157	0.175	0.088	0.090	0.094	0.001	0.001	0.001	0.003	0.003	0	0	0	0	0	0.117
1989	0.170	0.191	0.086	0.047	0.043	0.007	0.008	0.010	0.013	0.012	0.000	0.000	0.000	0.000	0.000	0.111
1990	0.148	0.169	0.080	0.025	0.021	0.027	0.030	0.041	0.045	0.040	0.000	0.000	0.002	0.002	0.001	0.121
1991	0.150	0.326	0.057	0.040	0.000	0.051	0.090	0.074	0.083	0.089	0.000	0.000	0.002	0.009	0.003	0.184
1992	0.119	0.186	0.046	0.027	0.008	0.106	0.197	0.115	0.074	0.000	0.000	0.001	0.025	0.009	0.000	0.177
1993	0.150	0.212	0.023	0.031	0.009	0.178	0.187	0.022	0.000	0.000	0.000	0.010	0.005	0.000	0.000	0.144
1994	0.070	0.245	0.016	0.061	0.012	0.153	0.218	0.024	0.084	0.000	0.000	0.026	0.008	0.013	0.000	0.172
1995	0.166	0.340	0.004	0.153	0.001	0.191	0.246	0.016	0.084	0.045	0.000	0.061	0.031	0.012	0.008	0.251
1996	0.110	0.292	0.029	0.082	0.016	0.181	0.204	0.014	0.092	0.018	0.000	0.098	0.043	0.017	0.004	0.223
1997	0.135	0.311	0.019	0.074	0.018	0.202	0.218	0.033	0.086	0.146	0.000	0.075	0.031	0.016	0.004	0.250
1998	0.091	0.171	0.017	0.103	0.012	0.215	0.158	0.017	0.070	0.086	0.000	0.047	0.026	0.008	0.000	0.190
1999	0.107	0.159	0.012	0.046	0.003	0.240	0.174	0.014	0.088	0.030	0.000	0.045	0.025	0.009	0.000	0.175
2000	0.115	0.155	0.014	0.021	0.003	0.217	0.062	0.006	0.095	0.103	0.096	0.036	0.000	0.000	0.000	0.165
2001	0.048	0.085	0.011	0.027	0.004	0.126	0.114	0.014	0.119	0.113	0.001	0.087	0.002	0.013	0.003	0.143
2002	0.073	0.127	0.023	0.027	0.001	0.230	0.104	0.006	0.138	0.083	0.013	0.065	0.004	0.010	0.004	0.169
2003	0.074	0.096	0.021	0.021	0.001	0.250	0.126	0.008	0.147	0.105	0.105	0.014	0.000	0.018	0.007	0.183
2004	0.105	0.105	0.031	0.026	0.000	0.268	0.126	0.011	0.135	0.126	0.070	0.023	0.004	0.014	0.003	0.193
2005	0.134	0.093	0.026	0.006	0.001	0.364	0.057	0.015	0.142	0.118	0.065	0.025	0.000	0.019	0.002	0.195
2006	0.160	0.096	0.025	0.011	0.000	0.402	0.060	0.010	0.193	0.007	0.086	0.030	0.002	0.018	0.005	0.206
2007	0.099	0.127	0.045	0.004	0.000	0.418	0.021	0.007	0.154	0.005	0.094	0.011	0.003	0.026	0.000	0.189
2008	0.096	0.058	0.015	0.022	0.004	0.449	0.043	0.018	0.173	0.058	0.087	0.021	0.002	0.034	0.001	0.202
2009	0.069	0.078	0.017	0.043	0.003	0.510	0.049	0.016	0.176	0.072	0.099	0.022	0.001	0.007	0.008	0.216
2010	0.108	0.059	0.015	0.036	0.002	0.411	0.026	0.015	0.149	0.039	0.104	0.021	0.002	0.020	0.003	0.188

Table 2.19c—Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model C). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov-Dec. Rates must be multiplied by relative season length before summing to get total.

	Trawl fishery					Longline fishery					Pot fishery					
Year	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Total
1977	0.041	0.044	0.038	0.030	0.027	0.012	0.013	0.003	0.018	0.025	0	0	0	0	0	0.050
1978	0.052	0.055	0.049	0.040	0.036	0.016	0.018	0.005	0.024	0.034	0	0	0	0	0	0.065
1979	0.034	0.034	0.031	0.028	0.023	0.013	0.014	0.004	0.017	0.022	0	0	0	0	0	0.043
1980	0.043	0.044	0.023	0.025	0.021	0.007	0.007	0.003	0.009	0.012	0	0	0	0	0	0.037
1981	0.024	0.024	0.026	0.041	0.039	0.003	0.003	0.002	0.006	0.008	0	0	0	0	0	0.035
1982	0.026	0.028	0.030	0.030	0.025	0.001	0.001	0.001	0.003	0.004	0	0	0	0	0	0.030
1983	0.043	0.046	0.043	0.039	0.032	0.004	0.004	0.002	0.003	0.004	0	0	0	0	0	0.044
1984	0.050	0.055	0.049	0.043	0.037	0.006	0.007	0.005	0.023	0.032	0	0	0	0	0	0.061
1985	0.063	0.070	0.058	0.050	0.039	0.020	0.023	0.009	0.031	0.043	0	0	0	0	0	0.080
1986	0.072	0.079	0.060	0.052	0.041	0.015	0.016	0.005	0.025	0.035	0	0	0	0	0	0.078
1987	0.080	0.089	0.048	0.043	0.041	0.037	0.041	0.011	0.040	0.057	0	0	0	0	0	0.093
1988	0.164	0.183	0.093	0.091	0.096	0.001	0.001	0.001	0.003	0.003	0	0	0	0	0	0.122
1989	0.176	0.198	0.091	0.048	0.044	0.007	0.008	0.011	0.014	0.012	0.000	0.000	0.000	0.000	0.000	0.115
1990	0.153	0.174	0.084	0.030	0.025	0.029	0.033	0.043	0.048	0.043	0.000	0.000	0.002	0.002	0.001	0.128
1991	0.156	0.342	0.061	0.050	0.000	0.057	0.100	0.078	0.091	0.097	0.000	0.000	0.002	0.009	0.004	0.199
1992	0.126	0.199	0.049	0.039	0.012	0.121	0.225	0.125	0.083	0.000	0.000	0.001	0.027	0.010	0.000	0.197
1993	0.160	0.226	0.025	0.046	0.013	0.202	0.212	0.024	0.000	0.000	0.000	0.011	0.006	0.000	0.000	0.163
1994	0.074	0.261	0.017	0.089	0.017	0.171	0.244	0.026	0.093	0.000	0.000	0.028	0.008	0.014	0.000	0.194
1995	0.180	0.372	0.004	0.167	0.001	0.219	0.285	0.018	0.093	0.049	0.000	0.070	0.034	0.013	0.009	0.280
1996	0.121	0.322	0.033	0.090	0.018	0.211	0.239	0.016	0.102	0.020	0.000	0.113	0.048	0.019	0.005	0.252
1997	0.150	0.347	0.021	0.083	0.020	0.236	0.257	0.037	0.098	0.166	0.000	0.087	0.035	0.018	0.004	0.284
1998	0.104	0.195	0.019	0.116	0.013	0.257	0.191	0.020	0.080	0.099	0.000	0.056	0.030	0.010	0.000	0.222
1999	0.123	0.185	0.014	0.053	0.003	0.293	0.214	0.017	0.103	0.035	0.000	0.055	0.030	0.011	0.000	0.208
2000	0.136	0.183	0.017	0.025	0.003	0.261	0.074	0.007	0.111	0.121	0.115	0.043	0.000	0.000	0.000	0.196
2001	0.056	0.099	0.013	0.032	0.004	0.147	0.134	0.016	0.138	0.132	0.001	0.101	0.003	0.015	0.003	0.167
2002	0.084	0.147	0.027	0.031	0.001	0.271	0.123	0.007	0.161	0.096	0.015	0.076	0.005	0.012	0.005	0.197
2003	0.085	0.111	0.023	0.024	0.001	0.290	0.146	0.010	0.167	0.119	0.122	0.016	0.000	0.020	0.008	0.211
2004	0.118	0.118	0.035	0.030	0.000	0.302	0.142	0.012	0.151	0.141	0.079	0.026	0.004	0.016	0.003	0.217
2005	0.150	0.104	0.029	0.007	0.001	0.409	0.064	0.017	0.161	0.133	0.072	0.028	0.000	0.021	0.003	0.220
2006	0.180	0.109	0.028	0.013	0.000	0.458	0.068	0.011	0.219	0.007	0.098	0.034	0.002	0.020	0.006	0.234
2007	0.113	0.144	0.052	0.005	0.000	0.479	0.024	0.008	0.176	0.006	0.108	0.013	0.003	0.029	0.000	0.216
2008	0.109	0.067	0.017	0.026	0.005	0.517	0.050	0.021	0.199	0.067	0.099	0.024	0.002	0.039	0.001	0.233
2009	0.079	0.089	0.019	0.049	0.003	0.594	0.057	0.018	0.201	0.081	0.115	0.025	0.001	0.008	0.009	0.249
2010	0.120	0.065	0.016	0.038	0.002	0.458	0.028	0.016	0.159	0.042	0.117	0.024	0.002	0.021	0.003	0.206

Table 2.20—Time series of mean length (cm) at age 1 as estimated by Models A, B, and C. Years 1994-2009 are shown, to correspond with the range for which observations are available. Mean = average, RMSE = root mean squared error, Corr. = correlation between estimates and data.

Year	Data	Model A	Model B	Model C
1994	19.01	16.70	21.04	-8.26
1995	17.33	16.06	21.04	-8.26
1996	17.64	15.62	21.04	-8.26
1997	17.19	16.13	21.04	-8.26
1998	15.47	14.72	21.04	-8.26
1999	15.79	15.82	21.04	-8.26
2000	15.25	16.12	21.04	-8.26
2001	17.88	16.37	21.04	-8.26
2002	16.53	15.12	21.04	-8.26
2003	18.00	16.45	21.04	-8.26
2004	17.26	15.03	21.04	-8.26
2005	18.59	17.36	21.04	-8.26
2006	15.33	16.89	21.04	-8.26
2007	15.04	16.18	21.04	-8.26
2008	15.39	15.76	21.04	-8.26
2009	14.14	14.61	21.04	-8.26
Mean:	16.62	15.93	21.04	-8.26
RMSE:	n/a	1.39	4.64	24.92
Corr:	n/a	0.50	0	0

Table 2.21—Summary of key management reference points from the standard projection algorithm (last five rows are from SS). All biomass figures are in t. Green = row minimum, pink = row maximum.

Quantity	Model A	Model B	Model C
B100%	892,731	960,858	839,474
B40%	357,093	384,343	335,789
B35%	312,456	336,300	293,816
B2011	340,659	358,188	361,081
B2012	389,699	389,064	403,376
B2011/B100%	0.38	0.37	0.43
B2012/B100%	0.44	0.40	0.48
F40%	0.28	0.26	0.29
F35%	0.34	0.31	0.35
maxFABC2011	0.27	0.25	0.29
maxFABC2012	0.28	0.26	0.29
maxABC2011	227,440	234,825	264,584
maxABC2012	278,524	280,904	286,728
FOFL2011	0.32	0.29	0.35
OFL2011	265,783	272,414	310,451
OFL2012	327,031	328,514	336,110
Pr(B2011<B20%)	~0	~0	~0
Pr(B2012<B20%)	~0	~0	~0
Pr(B2013<B20%)	~0	~0	~0
Pr(B2014<B20%)	~0	~0	~0
Pr(B2015<B20%)	~0	~0	~0

Legend:
B100% = equilibrium unfished spawning biomass
B40% = 40% of B100% (the inflection point of the harvest control rules in Tier 3)
B35% = 35% of B100% (the BMSY proxy for Tier 3)
B2011 = projected spawning biomass for 2011 (assuming 2011 catch = maxABC)
B2012 = projected spawning biomass for 2012 (assuming 2011-2012 catch = maxABC)
B2011/B100% = ratio of 2011 spawning biomass to B100%
B2012/B100% = ratio of 2012 spawning biomass to B100%
F40% = fishing mortality that reduces equilibrium spawning per recruit to 40% of unfished
F35% = fishing mortality that reduces equilibrium spawning per recruit to 35% of unfished
maxFABC2011 = maximum permissible ABC fishing mortality rate for 2011 under Tier 3
maxFABC2012 = maximum permissible ABC fishing mortality rate for 2012 under Tier 3
maxABC2011 = maximum permissible ABC for 2011 under Tier 3
maxABC2012 = maximum permissible ABC for 2012 under Tier 3
FOFL2011 = OFL fishing mortality rate for 2011 under Tier 3
OFL2011 = OFL for 2011 under Tier 3
OFL2012 = OFL for 2012 under Tier 3 assuming 2011 catch = maxABC2011
Pr(B2011<B20%) = probability that spawning biomass will fall below 20% of B100% in 2011
Pr(B2012<B20%) = probability that spawning biomass will fall below 20% of B100% in 2012
Pr(B2013<B20%) = probability that spawning biomass will fall below 20% of B100% in 2013
Pr(B2014<B20%) = probability that spawning biomass will fall below 20% of B100% in 2014
Pr(B2015<B20%) = probability that spawning biomass will fall below 20% of B100% in 2015

Table 2.22a (page 1 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	January-April trawl fishery							May-July trawl fishery				
Len.	1977	1980	1985	1990	1995	2000	2005	1977	1985	1990	2000	2005
4	0.988	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
5	0.990	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
6	0.992	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000
7	0.994	0.000	0.002	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.001	0.000
8	0.995	0.001	0.002	0.000	0.000	0.000	0.000	0.003	0.002	0.000	0.001	0.000
9	0.996	0.001	0.003	0.000	0.000	0.000	0.000	0.004	0.002	0.000	0.001	0.000
10	0.998	0.001	0.003	0.000	0.001	0.000	0.000	0.005	0.003	0.000	0.002	0.000
11	0.998	0.001	0.004	0.001	0.001	0.000	0.000	0.006	0.004	0.000	0.002	0.000
12	0.999	0.001	0.004	0.001	0.001	0.000	0.000	0.008	0.005	0.000	0.003	0.001
13	1.000	0.002	0.005	0.001	0.001	0.000	0.000	0.010	0.007	0.000	0.004	0.001
14	1.000	0.002	0.006	0.001	0.001	0.001	0.000	0.013	0.008	0.000	0.006	0.001
15	1.000	0.003	0.007	0.001	0.002	0.001	0.000	0.016	0.011	0.000	0.007	0.001
16	1.000	0.003	0.009	0.002	0.002	0.001	0.000	0.020	0.014	0.001	0.009	0.002
17	1.000	0.004	0.010	0.002	0.003	0.001	0.001	0.025	0.017	0.001	0.012	0.002
18	1.000	0.005	0.012	0.003	0.003	0.001	0.001	0.032	0.022	0.001	0.015	0.003
19	1.000	0.007	0.014	0.003	0.004	0.002	0.001	0.039	0.027	0.001	0.019	0.004
20	1.000	0.008	0.016	0.004	0.005	0.002	0.001	0.048	0.034	0.002	0.024	0.005
21	1.000	0.010	0.019	0.005	0.006	0.003	0.002	0.058	0.042	0.002	0.030	0.007
22	1.000	0.012	0.022	0.007	0.007	0.003	0.002	0.071	0.051	0.003	0.037	0.009
23	1.000	0.014	0.025	0.008	0.009	0.004	0.003	0.085	0.062	0.004	0.046	0.012
24	1.000	0.017	0.029	0.010	0.011	0.005	0.004	0.101	0.075	0.006	0.056	0.015
25	1.000	0.021	0.034	0.012	0.013	0.006	0.004	0.120	0.090	0.007	0.067	0.019
26	1.000	0.025	0.038	0.015	0.015	0.008	0.006	0.142	0.108	0.009	0.081	0.023
27	1.000	0.030	0.044	0.018	0.018	0.009	0.007	0.166	0.127	0.012	0.097	0.029
28	1.000	0.035	0.050	0.021	0.021	0.011	0.009	0.193	0.150	0.015	0.116	0.036
29	1.000	0.042	0.057	0.026	0.025	0.013	0.011	0.223	0.175	0.019	0.136	0.044
30	1.000	0.049	0.065	0.031	0.030	0.016	0.013	0.256	0.203	0.024	0.160	0.054
31	1.000	0.057	0.073	0.036	0.035	0.019	0.016	0.292	0.234	0.030	0.186	0.066
32	1.000	0.067	0.082	0.043	0.040	0.023	0.019	0.331	0.268	0.037	0.216	0.079
33	1.000	0.077	0.092	0.051	0.047	0.027	0.023	0.372	0.305	0.046	0.248	0.095
34	1.000	0.089	0.104	0.059	0.054	0.031	0.028	0.416	0.345	0.056	0.283	0.113
35	1.000	0.103	0.116	0.069	0.063	0.037	0.034	0.462	0.387	0.067	0.321	0.133
36	1.000	0.118	0.129	0.081	0.072	0.043	0.040	0.509	0.431	0.081	0.362	0.156
37	1.000	0.135	0.144	0.093	0.083	0.050	0.048	0.558	0.478	0.097	0.405	0.182
38	1.000	0.153	0.159	0.107	0.094	0.058	0.056	0.607	0.526	0.116	0.451	0.211
39	1.000	0.173	0.176	0.123	0.107	0.067	0.066	0.657	0.575	0.136	0.498	0.243
40	1.000	0.195	0.194	0.141	0.122	0.077	0.078	0.705	0.624	0.160	0.546	0.278
41	1.000	0.219	0.213	0.160	0.137	0.088	0.090	0.752	0.674	0.186	0.596	0.315
42	1.000	0.245	0.234	0.181	0.154	0.100	0.105	0.797	0.722	0.216	0.645	0.356
43	1.000	0.272	0.256	0.204	0.173	0.114	0.121	0.840	0.768	0.248	0.694	0.398
44	1.000	0.302	0.278	0.229	0.193	0.130	0.139	0.878	0.812	0.283	0.742	0.444
45	1.000	0.333	0.303	0.256	0.215	0.146	0.159	0.912	0.853	0.321	0.787	0.491
46	1.000	0.366	0.328	0.285	0.239	0.165	0.181	0.942	0.891	0.362	0.830	0.539
47	1.000	0.400	0.355	0.316	0.264	0.184	0.205	0.965	0.923	0.405	0.869	0.588
48	1.000	0.436	0.382	0.349	0.291	0.206	0.231	0.983	0.951	0.451	0.905	0.637
49	1.000	0.473	0.411	0.383	0.319	0.229	0.259	0.995	0.972	0.498	0.935	0.686
50	1.000	0.511	0.440	0.419	0.349	0.254	0.289	1.000	0.988	0.546	0.960	0.734
51	1.000	0.550	0.471	0.456	0.380	0.280	0.321	1.000	0.997	0.596	0.980	0.780
52	1.000	0.589	0.501	0.494	0.412	0.308	0.356	1.000	1.000	0.645	0.993	0.824
53	1.000	0.628	0.533	0.533	0.446	0.338	0.391	1.000	1.000	0.694	0.999	0.864
54	1.000	0.667	0.565	0.573	0.480	0.369	0.429	1.000	1.000	0.742	1.000	0.900
55	1.000	0.706	0.597	0.613	0.516	0.401	0.468	1.000	1.000	0.787	1.000	0.931
56	1.000	0.744	0.629	0.653	0.552	0.435	0.508	1.000	1.000	0.830	1.000	0.957
57	1.000	0.780	0.661	0.693	0.588	0.470	0.549	1.000	1.000	0.869	1.000	0.977
58	1.000	0.815	0.693	0.731	0.624	0.505	0.590	1.000	1.000	0.905	1.000	0.991
59	1.000	0.848	0.724	0.769	0.661	0.542	0.632	1.000	1.000	0.935	1.000	0.999
60	1.000	0.878	0.754	0.805	0.697	0.578	0.673	1.000	1.000	0.960	1.000	1.000
61	1.000	0.906	0.784	0.839	0.732	0.615	0.714	1.000	1.000	0.980	1.000	1.000
62	1.000	0.930	0.812	0.870	0.766	0.652	0.754	1.000	1.000	0.993	1.000	1.000

Table 2.22a (page 2 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	January-April trawl fishery							May-July trawl fishery				
Len.	1977	1980	1985	1990	1995	2000	2005	1977	1985	1990	2000	2005
63	1.000	0.952	0.839	0.899	0.799	0.689	0.792	1.000	1.000	0.999	1.000	1.000
64	1.000	0.969	0.865	0.925	0.830	0.725	0.828	1.000	1.000	1.000	1.000	1.000
65	1.000	0.983	0.889	0.947	0.860	0.760	0.861	1.000	1.000	1.000	1.000	1.000
66	1.000	0.993	0.911	0.966	0.887	0.793	0.892	1.000	1.000	1.000	1.000	1.000
67	1.000	0.998	0.930	0.981	0.912	0.825	0.920	1.000	1.000	1.000	1.000	1.000
68	1.000	1.000	0.948	0.992	0.934	0.856	0.944	1.000	1.000	1.000	1.000	1.000
69	1.000	1.000	0.963	0.998	0.953	0.884	0.964	1.000	1.000	1.000	1.000	1.000
70	1.000	1.000	0.976	1.000	0.970	0.909	0.979	1.000	1.000	1.000	1.000	1.000
71	1.000	1.000	0.986	1.000	0.982	0.932	0.991	1.000	1.000	1.000	1.000	1.000
72	1.000	1.000	0.993	1.000	0.992	0.952	0.998	1.000	1.000	1.000	1.000	1.000
73	1.000	1.000	0.998	1.000	0.998	0.968	1.000	1.000	1.000	1.000	1.000	1.000
74	1.000	1.000	1.000	1.000	1.000	0.982	1.000	1.000	1.000	1.000	1.000	1.000
75	1.000	1.000	1.000	1.000	1.000	0.991	1.000	1.000	1.000	1.000	1.000	1.000
76	1.000	1.000	1.000	1.000	1.000	0.997	1.000	1.000	1.000	1.000	1.000	1.000
77	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
78	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
79	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
80	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
81	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
82	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
83	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
84	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
85	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
86	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
87	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
88	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
89	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
90	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
91	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
92	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
93	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
94	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
95	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
96	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
97	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
98	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
99	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
100	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
101	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
102	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
103	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
104	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
105	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
106	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
107	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
108	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
109	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
110	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
111	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
112	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
113	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
114	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
115	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
116	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
117	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
118	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
119	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
120	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 2.22a (page 3 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	August-December trawl fishery						January-April longline fishery						
Len.	1977	1980	1985	1990	1995	2000	1977	1980	1985	1990	1995	2000	2005
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.002	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.002	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.002	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.003	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.003	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.004	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.005	0.002	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.006	0.002	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.001	0.007	0.003	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.001	0.008	0.003	0.000	0.003	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000
22	0.001	0.010	0.004	0.000	0.003	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000
23	0.002	0.012	0.005	0.000	0.004	0.003	0.000	0.001	0.000	0.000	0.000	0.000	0.000
24	0.002	0.014	0.006	0.000	0.004	0.004	0.001	0.002	0.001	0.000	0.000	0.001	0.000
25	0.003	0.017	0.007	0.000	0.005	0.006	0.001	0.002	0.001	0.000	0.000	0.001	0.000
26	0.005	0.019	0.008	0.000	0.005	0.008	0.001	0.003	0.001	0.000	0.000	0.001	0.000
27	0.006	0.023	0.009	0.000	0.006	0.010	0.002	0.003	0.001	0.000	0.001	0.002	0.000
28	0.008	0.026	0.011	0.000	0.007	0.013	0.003	0.005	0.002	0.000	0.001	0.003	0.001
29	0.010	0.031	0.013	0.000	0.008	0.017	0.004	0.006	0.002	0.001	0.001	0.004	0.001
30	0.014	0.035	0.015	0.000	0.009	0.021	0.006	0.008	0.003	0.001	0.002	0.005	0.001
31	0.018	0.041	0.018	0.000	0.011	0.027	0.008	0.010	0.004	0.001	0.002	0.007	0.002
32	0.023	0.047	0.021	0.000	0.012	0.034	0.011	0.012	0.005	0.002	0.004	0.010	0.003
33	0.029	0.054	0.024	0.000	0.014	0.043	0.016	0.016	0.006	0.003	0.005	0.013	0.004
34	0.036	0.062	0.028	0.001	0.015	0.053	0.022	0.020	0.008	0.004	0.007	0.018	0.005
35	0.045	0.070	0.032	0.003	0.017	0.065	0.029	0.025	0.010	0.005	0.009	0.023	0.007
36	0.056	0.080	0.037	0.007	0.019	0.080	0.039	0.031	0.013	0.007	0.012	0.030	0.009
37	0.069	0.090	0.043	0.017	0.022	0.097	0.052	0.038	0.016	0.010	0.017	0.039	0.013
38	0.085	0.102	0.049	0.037	0.025	0.116	0.068	0.046	0.020	0.014	0.022	0.050	0.017
39	0.102	0.115	0.056	0.074	0.028	0.139	0.087	0.056	0.025	0.019	0.029	0.063	0.022
40	0.123	0.129	0.063	0.137	0.031	0.165	0.111	0.068	0.031	0.025	0.037	0.079	0.029
41	0.147	0.144	0.072	0.232	0.034	0.194	0.140	0.082	0.038	0.033	0.048	0.098	0.037
42	0.174	0.161	0.082	0.363	0.038	0.226	0.174	0.097	0.046	0.043	0.061	0.120	0.048
43	0.205	0.178	0.092	0.524	0.043	0.262	0.213	0.116	0.056	0.055	0.077	0.146	0.060
44	0.239	0.198	0.104	0.697	0.047	0.301	0.258	0.136	0.067	0.070	0.096	0.176	0.076
45	0.276	0.218	0.116	0.853	0.053	0.343	0.309	0.159	0.080	0.089	0.118	0.210	0.094
46	0.317	0.240	0.130	0.962	0.058	0.389	0.364	0.185	0.095	0.111	0.144	0.248	0.116
47	0.362	0.264	0.145	1.000	0.064	0.437	0.425	0.214	0.113	0.137	0.175	0.290	0.142
48	0.409	0.289	0.162	1.000	0.071	0.487	0.489	0.246	0.132	0.167	0.210	0.337	0.171
49	0.458	0.315	0.179	1.000	0.078	0.538	0.556	0.280	0.154	0.202	0.249	0.387	0.205
50	0.510	0.342	0.198	1.000	0.086	0.591	0.624	0.317	0.179	0.241	0.292	0.440	0.243
51	0.563	0.371	0.218	1.000	0.094	0.644	0.691	0.357	0.207	0.286	0.340	0.496	0.285
52	0.616	0.401	0.240	1.000	0.103	0.696	0.757	0.400	0.237	0.334	0.392	0.554	0.332
53	0.670	0.431	0.263	1.000	0.113	0.747	0.818	0.444	0.270	0.387	0.447	0.613	0.382
54	0.722	0.463	0.287	1.000	0.123	0.796	0.873	0.491	0.306	0.444	0.504	0.672	0.436
55	0.773	0.496	0.312	1.000	0.134	0.841	0.920	0.538	0.344	0.504	0.564	0.729	0.492
56	0.820	0.529	0.339	1.000	0.146	0.882	0.957	0.587	0.385	0.565	0.624	0.784	0.551
57	0.864	0.563	0.367	1.000	0.158	0.918	0.983	0.636	0.427	0.628	0.684	0.835	0.610
58	0.902	0.597	0.396	1.000	0.171	0.948	0.997	0.684	0.472	0.690	0.743	0.881	0.669
59	0.936	0.630	0.426	1.000	0.185	0.972	1.000	0.731	0.518	0.750	0.798	0.921	0.727
60	0.963	0.664	0.457	1.000	0.200	0.988	1.000	0.777	0.565	0.807	0.849	0.954	0.783
61	0.983	0.698	0.489	1.000	0.216	0.998	0.998	0.820	0.613	0.858	0.895	0.978	0.835
62	0.995	0.731	0.521	1.000	0.232	1.000	0.987	0.860	0.660	0.904	0.933	0.994	0.881

Table 2.22a (page 4 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	August-December trawl fishery						January-April longline fishery						
Len.	1977	1980	1985	1990	1995	2000	1977	1980	1985	1990	1995	2000	2005
63	1.000	0.763	0.554	1.000	0.249	1.000	0.966	0.896	0.707	0.942	0.964	1.000	0.921
64	1.000	0.793	0.587	1.000	0.267	1.000	0.936	0.927	0.753	0.971	0.985	1.000	0.954
65	1.000	0.823	0.620	1.000	0.286	1.000	0.899	0.953	0.796	0.990	0.997	1.000	0.979
66	1.000	0.851	0.654	1.000	0.305	1.000	0.855	0.974	0.837	0.999	1.000	0.993	0.994
67	1.000	0.877	0.686	1.000	0.326	1.000	0.806	0.989	0.874	1.000	1.000	0.976	1.000
68	1.000	0.901	0.719	1.000	0.346	1.000	0.755	0.998	0.908	1.000	0.998	0.948	1.000
69	1.000	0.923	0.750	1.000	0.368	1.000	0.703	1.000	0.937	0.996	0.988	0.912	1.000
70	1.000	0.942	0.781	1.000	0.390	1.000	0.650	1.000	0.961	0.983	0.969	0.868	0.992
71	1.000	0.959	0.811	1.000	0.413	1.000	0.600	0.999	0.980	0.962	0.943	0.819	0.974
72	1.000	0.973	0.839	1.000	0.437	1.000	0.552	0.995	0.992	0.934	0.909	0.766	0.946
73	1.000	0.985	0.865	1.000	0.461	1.000	0.509	0.988	0.999	0.900	0.870	0.711	0.909
74	1.000	0.993	0.890	1.000	0.485	1.000	0.469	0.976	1.000	0.861	0.826	0.656	0.865
75	1.000	0.998	0.912	1.000	0.510	1.000	0.434	0.962	1.000	0.818	0.780	0.601	0.816
76	1.000	1.000	0.932	1.000	0.535	1.000	0.403	0.945	0.996	0.774	0.733	0.550	0.763
77	1.000	1.000	0.950	1.000	0.560	1.000	0.377	0.927	0.983	0.729	0.686	0.501	0.708
78	1.000	1.000	0.966	1.000	0.586	1.000	0.356	0.907	0.961	0.685	0.641	0.457	0.653
79	1.000	1.000	0.978	1.000	0.612	1.000	0.338	0.887	0.930	0.643	0.599	0.418	0.600
80	1.000	1.000	0.988	1.000	0.637	1.000	0.323	0.867	0.891	0.604	0.559	0.383	0.548
81	1.000	1.000	0.995	1.000	0.663	1.000	0.312	0.848	0.848	0.568	0.524	0.354	0.501
82	1.000	1.000	0.999	1.000	0.688	1.000	0.303	0.830	0.800	0.535	0.492	0.329	0.458
83	1.000	1.000	1.000	1.000	0.713	1.000	0.296	0.813	0.750	0.507	0.465	0.308	0.419
84	1.000	1.000	1.000	1.000	0.737	1.000	0.291	0.797	0.699	0.482	0.442	0.291	0.385
85	1.000	1.000	1.000	1.000	0.761	1.000	0.287	0.784	0.649	0.462	0.422	0.278	0.356
86	1.000	1.000	1.000	1.000	0.785	1.000	0.284	0.772	0.600	0.444	0.406	0.267	0.332
87	1.000	1.000	1.000	1.000	0.807	1.000	0.282	0.762	0.555	0.430	0.393	0.259	0.312
88	1.000	1.000	1.000	1.000	0.829	1.000	0.281	0.753	0.513	0.419	0.383	0.253	0.295
89	1.000	1.000	1.000	1.000	0.850	1.000	0.280	0.747	0.476	0.410	0.375	0.248	0.282
90	1.000	1.000	1.000	1.000	0.870	1.000	0.279	0.741	0.443	0.403	0.369	0.244	0.272
91	1.000	1.000	1.000	1.000	0.889	1.000	0.279	0.736	0.415	0.398	0.364	0.242	0.264
92	1.000	1.000	1.000	1.000	0.906	1.000	0.278	0.733	0.391	0.394	0.361	0.240	0.258
93	1.000	1.000	1.000	1.000	0.923	1.000	0.278	0.730	0.371	0.391	0.358	0.239	0.254
94	1.000	1.000	1.000	1.000	0.938	1.000	0.278	0.728	0.354	0.389	0.356	0.238	0.250
95	1.000	1.000	1.000	1.000	0.951	1.000	0.278	0.727	0.341	0.388	0.355	0.237	0.248
96	1.000	1.000	1.000	1.000	0.963	1.000	0.278	0.726	0.330	0.386	0.354	0.237	0.246
97	1.000	1.000	1.000	1.000	0.973	1.000	0.278	0.725	0.322	0.386	0.353	0.237	0.245
98	1.000	1.000	1.000	1.000	0.982	1.000	0.278	0.724	0.316	0.385	0.353	0.237	0.244
99	1.000	1.000	1.000	1.000	0.989	1.000	0.278	0.724	0.311	0.385	0.353	0.236	0.244
100	1.000	1.000	1.000	1.000	0.994	1.000	0.278	0.724	0.308	0.385	0.353	0.236	0.243
101	1.000	1.000	1.000	1.000	0.998	1.000	0.278	0.723	0.305	0.385	0.352	0.236	0.243
102	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.304	0.384	0.352	0.236	0.243
103	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.302	0.384	0.352	0.236	0.243
104	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.301	0.384	0.352	0.236	0.243
105	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.301	0.384	0.352	0.236	0.243
106	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
107	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
108	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
109	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
110	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
111	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
112	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
113	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
114	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
115	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
116	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
117	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
118	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
119	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243
120	1.000	1.000	1.000	1.000	1.000	1.000	0.278	0.723	0.300	0.384	0.352	0.236	0.243

Table 2.22a (page 5 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	May-July longline fishery						August-December longline fishery						
Len.	1977	1980	1985	1990	2000	2005	1977	1980	1985	1990	1995	2000	2005
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
28	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
29	0.000	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000
30	0.000	0.001	0.001	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.002	0.002	0.000
31	0.001	0.002	0.001	0.001	0.004	0.001	0.000	0.001	0.000	0.000	0.002	0.002	0.001
32	0.001	0.003	0.002	0.001	0.006	0.001	0.000	0.001	0.000	0.000	0.003	0.004	0.001
33	0.002	0.004	0.002	0.002	0.008	0.001	0.000	0.001	0.001	0.000	0.004	0.005	0.002
34	0.003	0.006	0.004	0.002	0.012	0.002	0.000	0.002	0.001	0.001	0.006	0.007	0.003
35	0.004	0.008	0.005	0.004	0.017	0.003	0.001	0.003	0.002	0.001	0.008	0.010	0.004
36	0.006	0.012	0.008	0.005	0.024	0.005	0.001	0.004	0.002	0.001	0.010	0.014	0.007
37	0.008	0.016	0.011	0.008	0.032	0.007	0.002	0.006	0.004	0.002	0.014	0.019	0.010
38	0.012	0.023	0.016	0.011	0.044	0.010	0.004	0.008	0.005	0.003	0.018	0.026	0.014
39	0.016	0.031	0.022	0.016	0.059	0.014	0.006	0.012	0.008	0.005	0.023	0.034	0.020
40	0.023	0.042	0.030	0.022	0.077	0.020	0.009	0.016	0.012	0.007	0.030	0.045	0.028
41	0.031	0.057	0.040	0.030	0.100	0.028	0.014	0.022	0.017	0.010	0.037	0.059	0.039
42	0.042	0.074	0.054	0.041	0.128	0.038	0.021	0.029	0.023	0.014	0.047	0.075	0.054
43	0.056	0.097	0.072	0.055	0.161	0.051	0.032	0.039	0.032	0.020	0.059	0.096	0.072
44	0.074	0.124	0.093	0.072	0.200	0.067	0.046	0.051	0.044	0.027	0.073	0.121	0.095
45	0.096	0.157	0.120	0.094	0.246	0.088	0.066	0.066	0.060	0.037	0.089	0.150	0.123
46	0.123	0.195	0.151	0.121	0.297	0.113	0.092	0.085	0.079	0.049	0.109	0.184	0.158
47	0.156	0.240	0.189	0.153	0.355	0.144	0.125	0.107	0.104	0.065	0.131	0.223	0.199
48	0.195	0.291	0.233	0.191	0.418	0.180	0.167	0.134	0.134	0.085	0.157	0.267	0.246
49	0.239	0.347	0.283	0.235	0.485	0.222	0.218	0.165	0.169	0.109	0.186	0.317	0.301
50	0.290	0.410	0.339	0.285	0.555	0.271	0.279	0.202	0.212	0.138	0.219	0.371	0.362
51	0.346	0.476	0.400	0.341	0.626	0.325	0.348	0.244	0.261	0.173	0.256	0.430	0.429
52	0.408	0.546	0.466	0.403	0.697	0.385	0.426	0.291	0.316	0.214	0.296	0.492	0.500
53	0.475	0.617	0.535	0.469	0.765	0.450	0.511	0.343	0.378	0.260	0.340	0.556	0.575
54	0.545	0.688	0.606	0.538	0.828	0.519	0.599	0.400	0.445	0.313	0.387	0.622	0.650
55	0.616	0.757	0.678	0.609	0.884	0.590	0.687	0.461	0.516	0.371	0.437	0.687	0.724
56	0.687	0.820	0.747	0.680	0.931	0.661	0.772	0.525	0.590	0.434	0.489	0.750	0.794
57	0.756	0.878	0.811	0.749	0.967	0.731	0.849	0.590	0.664	0.501	0.543	0.810	0.857
58	0.820	0.926	0.870	0.814	0.990	0.797	0.913	0.656	0.736	0.571	0.598	0.864	0.911
59	0.877	0.963	0.919	0.872	1.000	0.857	0.962	0.721	0.804	0.641	0.653	0.910	0.954
60	0.925	0.988	0.958	0.921	1.000	0.909	0.991	0.782	0.866	0.711	0.708	0.949	0.983
61	0.962	0.999	0.985	0.959	1.000	0.950	1.000	0.839	0.918	0.777	0.760	0.977	0.998
62	0.987	1.000	0.998	0.986	1.000	0.980	1.000	0.890	0.958	0.838	0.810	0.994	1.000

Table 2.22a (page 6 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	May-July longline fishery						August-December longline fishery						
Len.	1977	1980	1985	1990	2000	2005	1977	1980	1985	1990	1995	2000	2005
63	0.999	1.000	1.000	0.999	1.000	0.996	1.000	0.932	0.986	0.892	0.856	1.000	1.000
64	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.965	0.999	0.937	0.897	1.000	1.000
65	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.988	1.000	0.970	0.932	1.000	1.000
66	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.999	1.000	0.992	0.960	1.000	1.000
67	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.981	1.000	1.000
68	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.995	1.000	1.000
69	1.000	1.000	1.000	1.000	1.000	1.000	0.996	1.000	1.000	1.000	1.000	1.000	1.000
70	1.000	1.000	1.000	1.000	1.000	1.000	0.978	1.000	1.000	1.000	1.000	1.000	1.000
71	1.000	1.000	1.000	1.000	1.000	1.000	0.946	1.000	1.000	1.000	1.000	0.996	1.000
72	1.000	1.000	1.000	1.000	1.000	1.000	0.901	1.000	0.998	1.000	1.000	0.983	1.000
73	1.000	1.000	1.000	1.000	1.000	1.000	0.846	1.000	0.989	1.000	1.000	0.960	1.000
74	1.000	1.000	1.000	1.000	1.000	1.000	0.783	0.999	0.972	1.000	1.000	0.929	1.000
75	1.000	1.000	1.000	1.000	1.000	1.000	0.716	0.994	0.947	0.999	1.000	0.892	1.000
76	1.000	1.000	1.000	1.000	1.000	1.000	0.647	0.986	0.917	0.997	1.000	0.850	1.000
77	1.000	1.000	1.000	1.000	1.000	1.000	0.578	0.974	0.883	0.993	1.000	0.805	1.000
78	1.000	1.000	1.000	1.000	1.000	1.000	0.512	0.960	0.846	0.989	1.000	0.758	1.000
79	1.000	1.000	1.000	1.000	1.000	1.000	0.451	0.944	0.808	0.983	1.000	0.713	1.000
80	1.000	1.000	1.000	1.000	1.000	1.000	0.396	0.927	0.770	0.978	1.000	0.670	1.000
81	1.000	1.000	1.000	1.000	1.000	1.000	0.347	0.910	0.733	0.972	1.000	0.629	1.000
82	1.000	1.000	1.000	1.000	1.000	1.000	0.305	0.893	0.699	0.965	1.000	0.593	1.000
83	1.000	1.000	1.000	1.000	1.000	1.000	0.270	0.876	0.668	0.959	1.000	0.561	1.000
84	1.000	1.000	1.000	1.000	1.000	1.000	0.241	0.861	0.640	0.954	1.000	0.534	1.000
85	1.000	1.000	1.000	1.000	1.000	1.000	0.217	0.847	0.617	0.948	1.000	0.511	1.000
86	1.000	1.000	1.000	1.000	1.000	1.000	0.199	0.835	0.597	0.944	1.000	0.492	1.000
87	1.000	1.000	1.000	1.000	1.000	1.000	0.185	0.825	0.581	0.940	1.000	0.477	1.000
88	1.000	1.000	1.000	1.000	1.000	1.000	0.175	0.816	0.567	0.936	1.000	0.466	1.000
89	1.000	1.000	1.000	1.000	1.000	1.000	0.167	0.809	0.557	0.933	1.000	0.457	1.000
90	1.000	1.000	1.000	1.000	1.000	1.000	0.161	0.803	0.549	0.931	1.000	0.450	1.000
91	1.000	1.000	1.000	1.000	1.000	1.000	0.157	0.799	0.543	0.929	1.000	0.445	1.000
92	1.000	1.000	1.000	1.000	1.000	1.000	0.155	0.795	0.539	0.928	1.000	0.442	1.000
93	1.000	1.000	1.000	1.000	1.000	1.000	0.153	0.793	0.536	0.927	1.000	0.439	1.000
94	1.000	1.000	1.000	1.000	1.000	1.000	0.151	0.791	0.533	0.926	1.000	0.437	1.000
95	1.000	1.000	1.000	1.000	1.000	1.000	0.151	0.790	0.532	0.925	1.000	0.436	1.000
96	1.000	1.000	1.000	1.000	1.000	1.000	0.150	0.789	0.531	0.925	1.000	0.435	1.000
97	1.000	1.000	1.000	1.000	1.000	1.000	0.150	0.788	0.530	0.925	1.000	0.435	1.000
98	1.000	1.000	1.000	1.000	1.000	1.000	0.150	0.787	0.529	0.924	1.000	0.434	1.000
99	1.000	1.000	1.000	1.000	1.000	1.000	0.150	0.787	0.529	0.924	1.000	0.434	1.000
100	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
101	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
102	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
103	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
104	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
105	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
106	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
107	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
108	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
109	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
110	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
111	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
112	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
113	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
114	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
115	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
116	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
117	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
118	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
119	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000
120	1.000	1.000	1.000	1.000	1.000	1.000	0.149	0.787	0.529	0.924	1.000	0.434	1.000

Table 2.22a (page 7 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	January-April pot fishery				May-July pot		Sep-Dec pot	
Len.	1977	1995	2000	2005	1977	1995	1977	2000
4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
33	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
34	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000
35	0.000	0.001	0.001	0.001	0.000	0.001	0.002	0.000
36	0.001	0.001	0.001	0.001	0.001	0.001	0.003	0.000
37	0.001	0.001	0.002	0.002	0.001	0.002	0.004	0.001
38	0.002	0.002	0.003	0.003	0.002	0.003	0.006	0.001
39	0.003	0.003	0.004	0.005	0.003	0.005	0.008	0.002
40	0.004	0.005	0.006	0.007	0.004	0.008	0.011	0.004
41	0.006	0.007	0.008	0.010	0.006	0.011	0.015	0.007
42	0.008	0.010	0.012	0.013	0.009	0.016	0.020	0.012
43	0.011	0.014	0.017	0.019	0.013	0.022	0.027	0.018
44	0.016	0.019	0.023	0.026	0.018	0.030	0.036	0.028
45	0.022	0.026	0.031	0.035	0.026	0.042	0.046	0.043
46	0.030	0.036	0.042	0.046	0.035	0.056	0.060	0.063
47	0.041	0.048	0.056	0.061	0.048	0.074	0.077	0.091
48	0.054	0.063	0.073	0.080	0.064	0.097	0.097	0.127
49	0.071	0.082	0.094	0.103	0.085	0.125	0.121	0.173
50	0.091	0.105	0.120	0.130	0.110	0.159	0.149	0.231
51	0.117	0.133	0.151	0.163	0.141	0.199	0.183	0.299
52	0.147	0.167	0.187	0.202	0.178	0.246	0.221	0.378
53	0.183	0.206	0.229	0.246	0.221	0.299	0.264	0.466
54	0.224	0.251	0.278	0.296	0.270	0.358	0.311	0.561
55	0.272	0.302	0.331	0.352	0.326	0.423	0.364	0.657
56	0.325	0.358	0.390	0.413	0.388	0.492	0.420	0.751
57	0.384	0.419	0.454	0.478	0.455	0.564	0.480	0.836
58	0.447	0.485	0.521	0.546	0.526	0.637	0.543	0.908
59	0.513	0.553	0.590	0.615	0.599	0.709	0.607	0.962
60	0.582	0.622	0.660	0.685	0.672	0.779	0.670	0.993
61	0.652	0.691	0.728	0.752	0.743	0.842	0.733	1.000
62	0.720	0.758	0.792	0.814	0.810	0.897	0.792	1.000

Table 2.22a (page 8 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries survey as defined by parameter estimates under Model B. Years correspond to beginnings of blocks.

	January-April pot fishery				May-July pot		Sep-Dec pot	
Len.	1977	1995	2000	2005	1977	1995	1977	2000
63	0.785	0.820	0.851	0.871	0.870	0.942	0.846	1.000
64	0.845	0.876	0.902	0.919	0.920	0.975	0.894	1.000
65	0.897	0.923	0.944	0.957	0.960	0.995	0.935	1.000
66	0.940	0.960	0.975	0.984	0.986	1.000	0.966	1.000
67	0.972	0.986	0.994	0.998	0.999	1.000	0.988	1.000
68	0.993	0.998	1.000	1.000	1.000	1.000	0.999	1.000
69	1.000	1.000	1.000	0.999	1.000	1.000	1.000	1.000
70	1.000	0.998	0.992	0.991	1.000	1.000	1.000	1.000
71	0.995	0.986	0.970	0.975	1.000	1.000	1.000	1.000
72	0.980	0.962	0.935	0.951	1.000	1.000	1.000	1.000
73	0.954	0.929	0.890	0.921	1.000	1.000	1.000	1.000
74	0.921	0.887	0.837	0.887	1.000	1.000	1.000	1.000
75	0.881	0.840	0.779	0.850	1.000	1.000	1.000	1.000
76	0.837	0.790	0.719	0.814	1.000	1.000	1.000	1.000
77	0.792	0.739	0.660	0.778	1.000	1.000	1.000	1.000
78	0.747	0.690	0.604	0.745	1.000	1.000	1.000	1.000
79	0.705	0.645	0.553	0.715	1.000	1.000	1.000	1.000
80	0.666	0.604	0.508	0.688	1.000	1.000	1.000	1.000
81	0.631	0.568	0.470	0.666	1.000	1.000	1.000	1.000
82	0.602	0.539	0.438	0.648	1.000	1.000	1.000	1.000
83	0.577	0.514	0.412	0.633	1.000	1.000	1.000	1.000
84	0.557	0.495	0.392	0.622	1.000	1.000	1.000	1.000
85	0.541	0.479	0.376	0.614	1.000	1.000	1.000	1.000
86	0.529	0.468	0.365	0.607	1.000	1.000	1.000	1.000
87	0.520	0.460	0.357	0.603	1.000	1.000	1.000	1.000
88	0.514	0.454	0.351	0.600	1.000	1.000	1.000	1.000
89	0.509	0.449	0.347	0.598	1.000	1.000	1.000	1.000
90	0.506	0.447	0.344	0.596	1.000	1.000	1.000	1.000
91	0.504	0.445	0.342	0.595	1.000	1.000	1.000	1.000
92	0.502	0.444	0.341	0.595	1.000	1.000	1.000	1.000
93	0.501	0.443	0.340	0.594	1.000	1.000	1.000	1.000
94	0.501	0.442	0.340	0.594	1.000	1.000	1.000	1.000
95	0.501	0.442	0.340	0.594	1.000	1.000	1.000	1.000
96	0.500	0.442	0.340	0.594	1.000	1.000	1.000	1.000
97	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
98	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
99	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
100	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
101	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
102	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
103	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
104	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
105	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
106	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
107	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
108	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
109	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
110	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
111	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
112	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
113	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
114	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
115	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
116	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
117	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
118	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
119	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000
120	0.500	0.442	0.339	0.594	1.000	1.000	1.000	1.000

Table 2.22b—Schedules of Pacific cod selectivities at age in the pre-1982 and post-1981 bottom trawl surveys as defined by final parameter estimates under Model B (pre-1982 surveys do not vary).

Age	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
0	0.096	0.096	0.096	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1	0.096	0.096	0.096	0.338	0.369	0.704	0.654	0.625	0.689	0.451	0.142	0.408	0.434	0.775	0.717	0.254
2	0.716	0.716	0.716	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	0.999	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	0.750	0.750	0.750	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917
5	0.277	0.277	0.277	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
6	0.144	0.144	0.144	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529
7	0.134	0.134	0.134	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430
8	0.134	0.134	0.134	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395
9	0.134	0.134	0.134	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
10	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
11	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
12	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
13	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
14	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
15	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
16	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
17	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
18	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
19	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
20	0.134	0.134	0.134	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385

Age	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
0	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
1	0.236	0.200	0.265	0.216	0.279	0.397	0.535	0.406	0.354	0.329	0.351	0.773	0.903	0.580	0.523	0.523
2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917	0.917
5	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713	0.713
6	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529	0.529
7	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430	0.430
8	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395	0.395
9	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
10	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
11	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
12	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
13	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
14	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
15	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
16	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
17	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
18	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
19	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385
20	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385	0.385

Table 2.23—Schedules of population length (cm) and weight (kg) by season and age as estimated by Model B. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov=Dec. Lengths and weights correspond to season mid-points.

	Population length (cm)					Population weight (kg)				
Age	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5
1	12.30	15.32	18.95	23.08	26.34	0.02	0.04	0.08	0.14	0.19
2	28.85	31.26	34.15	37.44	40.05	0.25	0.35	0.47	0.62	0.74
3	42.05	43.97	46.28	48.90	50.98	0.87	1.01	1.18	1.42	1.62
4	52.58	54.11	55.95	58.04	59.70	1.82	1.92	2.10	2.42	2.70
5	60.97	62.20	63.66	65.33	66.66	2.96	2.96	3.11	3.50	3.86
6	67.67	68.65	69.82	71.15	72.20	4.17	4.03	4.12	4.56	5.01
7	73.01	73.79	74.72	75.79	76.63	5.36	5.04	5.06	5.55	6.08
8	77.27	77.89	78.64	79.49	80.16	6.46	5.97	5.91	6.44	7.03
9	80.67	81.17	81.76	82.44	82.97	7.44	6.79	6.65	7.22	7.87
10	83.38	83.78	84.25	84.79	85.22	8.30	7.49	7.29	7.88	8.58
11	85.54	85.86	86.24	86.67	87.01	9.03	8.09	7.82	8.43	9.18
12	87.27	87.52	87.82	88.16	88.44	9.64	8.59	8.27	8.90	9.68
13	88.64	88.84	89.08	89.36	89.57	10.15	9.00	8.63	9.28	10.09
14	89.74	89.90	90.09	90.31	90.48	10.57	9.34	8.93	9.59	10.43
15	90.62	90.74	90.90	91.07	91.21	10.91	9.61	9.18	9.84	10.70
16	91.31	91.41	91.54	91.68	91.79	11.19	9.83	9.38	10.05	10.92
17	91.87	91.95	92.05	92.16	92.25	11.42	10.02	9.54	10.21	11.10
18	92.31	92.38	92.46	92.54	92.61	11.60	10.16	9.67	10.35	11.24
19	92.67	92.72	92.78	92.85	92.91	11.75	10.28	9.77	10.45	11.36
20	93.18	93.22	93.26	93.30	93.33	11.96	10.46	9.93	10.62	11.53

Table 2.24a—Schedules of 2010 fleet-specific length (cm) by season and age as estimated by Model B. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov=Dec. Survey lengths correspond to beginning of Sea4.

	Trawl fishery					Longline fishery					Pot fishery					Trawl survey	
Age	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Pre82	Post81
1	13.07	16.30	20.24	24.94	28.42	13.71	17.09	21.82	26.65	30.28	13.37	17.54	22.08	28.42	32.24	23.08	23.08
2	30.72	33.27	36.10	39.87	42.45	32.04	34.63	38.51	41.85	44.35	33.13	35.77	39.04	43.72	46.10	37.44	37.44
3	44.42	46.36	47.91	50.82	52.70	45.70	47.58	50.20	52.20	53.90	46.88	48.72	50.86	53.29	54.80	48.90	48.90
4	54.81	56.27	56.69	58.94	60.42	55.51	56.84	58.27	59.53	60.89	56.42	57.70	58.95	59.89	61.16	58.04	58.04
5	62.64	63.75	63.86	65.61	66.86	62.55	63.52	64.58	65.78	67.00	63.11	64.05	65.04	65.87	67.06	65.33	65.33
6	68.67	69.54	69.86	71.22	72.26	67.74	68.47	70.11	71.27	72.30	68.20	68.95	70.33	71.29	72.31	71.15	71.15
7	73.53	74.25	74.74	75.81	76.65	71.68	72.25	74.82	75.82	76.66	72.45	73.11	74.91	75.83	76.66	75.79	75.79
8	77.54	78.13	78.64	79.49	80.16	74.86	75.34	78.67	79.50	80.17	76.19	76.77	78.71	79.50	80.17	79.49	79.49
9	80.81	81.30	81.76	82.44	82.97	77.57	77.99	81.78	82.44	82.98	79.46	79.96	81.80	82.44	82.98	82.44	82.44
10	83.46	83.85	84.25	84.79	85.22	79.94	80.31	84.26	84.79	85.22	82.23	82.65	84.27	84.79	85.22	84.79	84.79
11	85.60	85.91	86.24	86.67	87.01	82.01	82.32	86.24	86.67	87.01	84.51	84.85	86.25	86.67	87.01	86.67	86.67
12	87.30	87.55	87.82	88.16	88.44	83.77	84.04	87.82	88.16	88.44	86.36	86.63	87.83	88.16	88.44	88.16	88.16
13	88.67	88.87	89.08	89.36	89.57	85.25	85.47	89.09	89.36	89.57	87.83	88.05	89.09	89.36	89.57	89.36	89.36
14	89.76	89.92	90.09	90.31	90.48	86.47	86.65	90.09	90.31	90.48	89.01	89.18	90.10	90.31	90.48	90.31	90.31
15	90.63	90.76	90.89	91.07	91.21	87.47	87.61	90.90	91.07	91.21	89.95	90.09	90.90	91.07	91.21	91.07	91.07
16	91.33	91.43	91.54	91.67	91.78	88.27	88.39	91.54	91.67	91.78	90.70	90.81	91.54	91.67	91.78	91.67	91.67
17	91.88	91.96	92.05	92.16	92.25	88.92	89.02	92.05	92.16	92.25	91.29	91.38	92.05	92.16	92.25	92.16	92.16
18	92.32	92.39	92.45	92.54	92.61	89.44	89.52	92.45	92.54	92.61	91.77	91.84	92.46	92.54	92.61	92.54	92.54
19	92.68	92.73	92.78	92.85	92.91	89.86	89.92	92.78	92.85	92.91	92.14	92.20	92.78	92.85	92.91	92.85	92.85
20	93.19	93.22	93.25	93.30	93.33	90.47	90.46	93.25	93.30	93.33	92.69	92.71	93.25	93.30	93.33	93.30	93.30

Table 2.24b—Schedules of 2010 fleet-specific weight (kg) by season and age as estimated by Model B. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov=Dec. Survey lengths correspond to beginning of Sea4.

	Trawl fishery					Longline fishery					Pot fishery					Trawl survey	
Age	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Pre82	Post81
1	0.02	0.05	0.10	0.17	0.24	0.02	0.05	0.12	0.21	0.30	0.02	0.06	0.12	0.26	0.36	0.14	0.14
2	0.31	0.42	0.55	0.75	0.89	0.35	0.47	0.67	0.86	1.02	0.39	0.52	0.70	0.99	1.15	0.62	0.62
3	1.04	1.18	1.30	1.59	1.79	1.14	1.27	1.50	1.72	1.92	1.23	1.37	1.56	1.83	2.02	1.42	1.42
4	2.07	2.16	2.18	2.53	2.79	2.15	2.22	2.36	2.60	2.86	2.27	2.32	2.44	2.64	2.89	2.42	2.42
5	3.22	3.18	3.13	3.54	3.90	3.19	3.14	3.23	3.56	3.92	3.28	3.21	3.30	3.57	3.93	3.50	3.50
6	4.36	4.18	4.12	4.57	5.02	4.15	3.97	4.16	4.58	5.02	4.25	4.05	4.19	4.58	5.03	4.56	4.56
7	5.47	5.13	5.06	5.56	6.08	5.01	4.70	5.08	5.56	6.08	5.20	4.88	5.09	5.56	6.08	5.55	5.55
8	6.52	6.02	5.91	6.44	7.03	5.79	5.36	5.92	6.44	7.03	6.16	5.70	5.92	6.44	7.03	6.44	6.44
9	7.48	6.82	6.65	7.22	7.87	6.53	5.99	6.65	7.22	7.87	7.09	6.49	6.66	7.22	7.87	7.22	7.22
10	8.32	7.51	7.29	7.88	8.58	7.24	6.58	7.29	7.88	8.58	7.95	7.20	7.29	7.88	8.58	7.88	7.88
11	9.04	8.10	7.82	8.43	9.18	7.89	7.13	7.82	8.43	9.18	8.70	7.82	7.82	8.43	9.18	8.43	8.43
12	9.65	8.59	8.27	8.90	9.68	8.48	7.61	8.27	8.90	9.68	9.35	8.34	8.27	8.90	9.68	8.90	8.90
13	10.16	9.00	8.63	9.28	10.09	9.00	8.03	8.63	9.28	10.09	9.88	8.78	8.63	9.28	10.09	9.28	9.28
14	10.57	9.34	8.93	9.59	10.43	9.44	8.39	8.93	9.59	10.43	10.32	9.13	8.93	9.59	10.43	9.59	9.59
15	10.92	9.61	9.18	9.84	10.70	9.80	8.69	9.18	9.84	10.70	10.69	9.42	9.18	9.84	10.70	9.84	9.84
16	11.19	9.84	9.38	10.05	10.92	10.11	8.93	9.38	10.05	10.92	10.98	9.66	9.38	10.05	10.92	10.05	10.05
17	11.42	10.02	9.54	10.21	11.10	10.36	9.13	9.54	10.21	11.10	11.22	9.85	9.54	10.21	11.10	10.21	10.21
18	11.60	10.16	9.67	10.35	11.24	10.56	9.29	9.67	10.35	11.24	11.41	10.00	9.67	10.35	11.24	10.35	10.35
19	11.75	10.28	9.77	10.45	11.36	10.72	9.43	9.77	10.45	11.36	11.56	10.13	9.77	10.45	11.36	10.45	10.45
20	11.96	10.46	9.93	10.62	11.53	10.97	9.61	9.93	10.62	11.53	11.79	10.31	9.93	10.62	11.53	10.62	10.62

Table 2.25a—Time series of EBS (not expanded to BSAI) Pacific cod age 0+ biomass, female spawning biomass (t), and standard deviation of spawning biomass as estimated last year under the Plan Team's and SSC's preferred model and this year under Model B. Values for 2011 listed under this year's assessment represent Stock Synthesis projections, and may not correspond exactly to values generated by the standard projection model (even after correcting for the BSAI expansion).

	Last year's assessment			This year's assessment		
Year	Age 0+ bio.	Spawn. bio.	Std. dev.	Age 0+ bio.	Spawn. bio.	Std. dev.
1977	795,891	263,530	44,567	834,627	216,589	37,927
1978	826,579	276,465	44,488	968,676	243,639	37,560
1979	1,003,650	292,366	44,769	1,282,910	290,302	37,886
1980	1,387,200	332,876	45,113	1,767,440	369,757	38,756
1981	1,806,980	427,033	45,062	2,249,760	500,315	39,867
1982	2,142,350	581,305	45,242	2,593,560	670,040	41,598
1983	2,328,540	739,845	44,871	2,738,400	817,145	42,222
1984	2,390,860	830,570	42,362	2,740,820	882,575	39,969
1985	2,376,230	848,075	38,382	2,668,450	867,150	35,638
1986	2,325,540	824,990	34,315	2,574,910	816,915	30,812
1987	2,283,750	805,020	30,928	2,499,160	773,980	26,600
1988	2,182,830	782,115	28,228	2,373,550	733,295	23,292
1989	1,958,450	732,800	25,890	2,130,630	679,105	20,717
1990	1,719,200	675,220	23,712	1,878,370	622,710	18,566
1991	1,538,620	592,160	21,326	1,680,260	545,890	16,396
1992	1,431,110	487,744	18,863	1,547,260	454,646	14,291
1993	1,437,960	438,239	17,092	1,536,830	406,254	12,776
1994	1,513,920	449,454	16,596	1,610,980	419,403	12,255
1995	1,559,310	470,584	17,056	1,651,460	426,772	12,508
1996	1,518,370	470,617	17,698	1,599,380	427,849	13,040
1997	1,453,940	472,657	17,946	1,524,880	423,471	13,384
1998	1,383,630	451,367	17,772	1,451,680	401,978	13,429
1999	1,422,590	446,887	17,428	1,498,780	393,734	13,300
2000	1,466,010	455,622	17,196	1,558,300	400,034	13,278
2001	1,489,450	478,210	17,227	1,602,420	434,215	13,528
2002	1,519,000	499,153	17,285	1,645,100	449,783	13,715
2003	1,497,830	497,816	17,193	1,627,360	448,342	13,756
2004	1,436,530	492,587	17,187	1,547,710	440,618	13,872
2005	1,320,810	469,524	17,327	1,428,430	412,921	14,088
2006	1,186,120	428,010	17,363	1,299,170	373,573	14,168
2007	1,063,630	381,627	17,154	1,189,470	338,856	14,089
2008	998,912	344,463	16,904	1,166,660	313,534	14,152
2009	981,017	313,218	16,895	1,208,150	298,073	14,718
2010	1,044,580	300,485	17,587	1,323,180	303,883	16,280
2011				1,517,480	331,545	16,707

Table 2.25b—Time series of EBS (not expanded to BSAI) Pacific cod age 0 recruitment (1000s of fish), with standard deviations, as estimated last year under the Plan Team's and SSC's preferred model and this year under Model B.

	Last year's values		This year's values	
Year	Recruits	Std. dev.	Recruits	Std. dev.
1977	1,985,750	156,335	2,173,820	141,849
1978	760,057	112,013	701,641	88,122
1979	692,919	97,612	865,775	73,124
1980	598,415	65,526	482,379	43,633
1981	317,281	39,612	187,485	25,641
1982	1,252,250	57,638	1,098,730	40,442
1983	324,619	49,762	345,339	26,643
1984	927,481	55,460	863,779	35,918
1985	546,818	42,182	521,494	28,749
1986	216,123	27,882	273,598	19,196
1987	123,829	22,007	193,316	14,522
1988	356,052	24,312	336,546	16,504
1989	857,757	41,640	751,861	25,314
1990	753,031	40,586	695,184	25,148
1991	493,823	30,713	444,630	18,422
1992	897,198	36,060	834,553	24,219
1993	489,914	25,413	424,298	16,888
1994	451,380	24,431	361,508	14,711
1995	508,799	31,241	402,104	16,543
1996	1,031,330	38,805	905,191	26,483
1997	582,869	28,516	513,004	18,026
1998	420,094	27,064	416,374	15,675
1999	772,362	31,955	675,222	20,531
2000	582,584	24,702	570,900	18,896
2001	311,973	17,820	271,300	11,762
2002	425,951	20,512	371,140	14,271
2003	343,915	19,790	355,402	15,505
2004	269,951	17,660	311,781	15,238
2005	380,035	25,899	331,043	17,298
2006	727,875	50,440	809,072	41,200
2007	479,143	52,453	425,480	35,511
2008	1,446,850	202,881	1,040,250	94,823
2009			789,492	140,368
Average	635,263		598,294	

Table 2.25c—Numbers (1000s) at age at time of spawning (March) as estimated by Model B.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1977	2176510	415018	80586	250237	47545	31742	21204	14165	9461	6319	4220	2818	1882	1257	839	561	374	250	167	112	224
1978	702577	1536860	290780	56145	171964	32323	21525	14395	9633	6443	4307	2878	1923	1285	858	573	383	256	171	114	229
1979	866910	497640	1079260	202907	38594	116847	21901	14600	9780	6554	4388	2935	1962	1311	876	585	391	261	174	116	234
1980	482913	617035	352301	759991	141171	26590	80271	15051	10045	6735	4516	3025	2024	1353	904	604	404	270	180	120	242
1981	187717	343721	438944	249557	533675	98290	18419	55495	10400	6940	4654	3121	2090	1399	935	625	418	279	186	124	250
1982	1100010	133611	244478	310626	174925	370870	67947	12704	38244	7165	4781	3206	2150	1440	964	644	431	288	192	128	258
1983	345744	782943	95024	172891	217525	121553	256589	46923	8767	26388	4944	3299	2212	1483	994	665	445	297	199	133	267
1984	864803	246087	556690	67043	120338	149779	83184	175146	32002	5978	17991	3371	2249	1508	1011	677	453	303	203	135	272
1985	522147	615512	174918	392196	46412	81895	100894	55813	117404	21453	4009	12069	2262	1510	1012	679	455	304	204	136	274
1986	273884	371629	437540	123259	271028	31425	54737	67043	37024	77888	14241	2663	8021	1504	1004	674	452	303	203	135	273
1987	193515	194931	264144	308089	85043	183180	20958	36282	44357	24497	51566	9435	1765	5319	998	666	447	300	201	134	271
1988	336899	137721	138456	185599	211375	56824	120360	13671	23620	28885	15967	33640	6159	1153	3476	652	436	292	196	131	265
1989	752711	239762	97752	96653	125604	139170	36691	76849	8681	14961	18275	10096	21265	3893	729	2197	412	275	185	124	251
1990	695952	535748	170364	68428	65565	82810	90174	23583	49246	5558	9578	11701	6465	13620	2494	467	1407	264	176	118	240
1991	444741	495348	381031	120050	46535	42730	52663	56929	14877	31092	3512	6057	7403	4092	8623	1579	296	891	167	112	227
1992	834523	316549	352334	268503	80745	29274	25783	31388	33920	8886	18614	2107	3637	4449	2461	5188	950	178	537	101	204
1993	424166	593978	225131	248167	180718	50666	17578	15319	18706	20324	5348	11241	1275	2205	2700	1494	3152	578	108	326	185
1994	361489	301906	422600	159077	169831	118502	32317	11143	9745	11960	13049	3444	7252	824	1426	1747	967	2041	374	70	332
1995	402205	257290	214701	297218	106470	106636	71347	19252	6662	5864	7234	7922	2096	4422	503	871	1068	592	1249	229	246
1996	905602	286272	182981	151318	201043	67001	63559	41697	11234	3899	3442	4255	4666	1236	2608	297	514	630	349	737	280
1997	513375	644566	203581	128886	102159	126213	39885	37174	24396	6603	2302	2038	2524	2771	734	1551	176	306	375	208	606
1998	416655	365400	458461	143428	86693	63482	74155	23012	21457	14149	3846	1345	1193	1479	1625	431	910	104	180	220	478
1999	675572	296557	259888	323200	97233	55269	38860	44851	13933	13039	8625	2349	822	730	906	996	264	558	64	110	428
2000	571091	480848	210954	183079	218559	61876	33895	23665	27456	8586	8076	5360	1463	513	456	566	622	165	349	40	337
2001	271311	406484	342124	148867	124737	142933	39719	21743	15276	17842	5608	5293	3521	963	338	301	373	411	109	230	249
2002	371050	193110	289173	240635	99671	78795	88167	24587	13631	9691	11416	3609	3419	2280	625	219	195	243	267	71	312
2003	355280	264101	137368	203070	159939	62080	47799	53695	15181	8524	6116	7249	2301	2186	1461	401	141	125	156	172	246
2004	311690	252876	187853	96390	134496	99206	37620	29140	33203	9507	5386	3888	4627	1473	1402	938	257	91	81	100	269
2005	330876	221851	179886	131923	63616	82068	58535	22259	17505	20242	5860	3345	2427	2898	925	881	590	162	57	51	233
2006	808601	235507	157834	126604	87408	38936	48487	34499	13230	10499	12224	3556	2037	1481	1771	566	540	362	99	35	174
2007	425260	575536	167568	111247	84377	53939	23213	28860	20724	8024	6414	7506	2191	1258	916	1097	351	335	225	62	130
2008	1040000	302687	409499	118046	74148	52265	32371	13919	17459	12649	4931	3960	4649	1360	782	570	683	219	209	140	120
2009	789274	740236	215375	288396	78143	45198	30802	19099	8307	10536	7697	3018	2433	2864	839	483	353	423	135	129	161
2010	607817	561780	526671	151602	190948	47774	26709	18180	11376	4994	6379	4683	1842	1489	1755	515	297	217	260	83	179

Table 2.26—Estimates of "effective" fishing mortality (= $-\ln(N_{a+1,t+1}/N_{a,t})-M$) at age and year for Model B.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1977	0.015	0.020	0.033	0.045	0.048	0.047	0.045	0.043	0.043	0.042	0.042	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041
1978	0.017	0.023	0.037	0.050	0.053	0.052	0.050	0.049	0.048	0.047	0.047	0.046	0.046	0.046	0.046	0.046	0.046	0.046	0.046
1979	0.010	0.014	0.024	0.032	0.034	0.034	0.032	0.031	0.030	0.030	0.030	0.030	0.029	0.029	0.029	0.029	0.029	0.029	0.029
1980	0.000	0.004	0.013	0.023	0.030	0.032	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
1981	0.001	0.005	0.014	0.023	0.029	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032
1982	0.000	0.005	0.013	0.020	0.025	0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
1983	0.001	0.007	0.019	0.030	0.037	0.040	0.041	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
1984	0.001	0.008	0.024	0.041	0.051	0.055	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.055	0.055	0.055
1985	0.001	0.008	0.026	0.046	0.060	0.068	0.070	0.070	0.069	0.069	0.068	0.067	0.067	0.067	0.067	0.066	0.066	0.066	0.066
1986	0.001	0.008	0.026	0.045	0.059	0.066	0.069	0.069	0.069	0.068	0.068	0.068	0.067	0.067	0.067	0.067	0.067	0.067	0.067
1987	0.001	0.007	0.027	0.052	0.069	0.078	0.081	0.080	0.079	0.078	0.077	0.076	0.075	0.075	0.074	0.074	0.074	0.074	0.073
1988	0.001	0.014	0.042	0.070	0.091	0.104	0.111	0.114	0.115	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.116
1989	0.001	0.013	0.041	0.069	0.089	0.101	0.106	0.107	0.108	0.108	0.108	0.108	0.108	0.108	0.107	0.107	0.107	0.107	0.107
1990	0.000	0.005	0.035	0.077	0.105	0.116	0.118	0.118	0.117	0.116	0.116	0.115	0.115	0.115	0.115	0.115	0.115	0.115	0.115
1991	0.000	0.006	0.045	0.111	0.158	0.174	0.177	0.175	0.173	0.172	0.171	0.170	0.170	0.169	0.169	0.169	0.169	0.169	0.168
1992	0.000	0.004	0.037	0.101	0.150	0.166	0.165	0.161	0.157	0.154	0.152	0.150	0.149	0.149	0.148	0.148	0.147	0.147	0.147
1993	0.000	0.004	0.030	0.078	0.119	0.133	0.131	0.126	0.121	0.117	0.115	0.113	0.112	0.111	0.110	0.110	0.110	0.109	0.109
1994	0.000	0.005	0.040	0.097	0.144	0.159	0.157	0.151	0.146	0.142	0.139	0.137	0.136	0.135	0.135	0.134	0.134	0.134	0.133
1995	0.000	0.005	0.037	0.113	0.180	0.207	0.211	0.208	0.204	0.202	0.200	0.199	0.199	0.198	0.198	0.198	0.198	0.197	0.197
1996	0.000	0.005	0.034	0.105	0.166	0.190	0.192	0.187	0.183	0.180	0.177	0.176	0.175	0.174	0.174	0.174	0.174	0.173	0.173
1997	0.000	0.005	0.041	0.122	0.190	0.216	0.218	0.213	0.209	0.205	0.203	0.201	0.200	0.200	0.199	0.199	0.199	0.199	0.198
1998	0.000	0.004	0.029	0.089	0.140	0.159	0.160	0.156	0.153	0.150	0.148	0.147	0.147	0.146	0.146	0.146	0.145	0.145	0.145
1999	0.000	0.003	0.026	0.084	0.134	0.152	0.151	0.145	0.140	0.136	0.133	0.132	0.131	0.130	0.129	0.129	0.129	0.128	0.128
2000	0.000	0.005	0.037	0.094	0.133	0.141	0.133	0.122	0.114	0.108	0.104	0.102	0.100	0.099	0.098	0.097	0.097	0.097	0.096
2001	0.000	0.005	0.038	0.092	0.122	0.125	0.115	0.104	0.096	0.091	0.087	0.085	0.083	0.082	0.082	0.081	0.081	0.080	0.080
2002	0.000	0.006	0.043	0.105	0.142	0.146	0.135	0.123	0.114	0.108	0.104	0.101	0.099	0.098	0.097	0.096	0.096	0.095	0.095
2003	0.000	0.006	0.045	0.114	0.155	0.159	0.145	0.131	0.120	0.112	0.107	0.104	0.102	0.101	0.100	0.099	0.098	0.098	0.097
2004	0.000	0.007	0.050	0.120	0.162	0.167	0.154	0.140	0.129	0.122	0.117	0.114	0.112	0.110	0.109	0.108	0.108	0.107	0.107
2005	0.000	0.004	0.039	0.108	0.161	0.179	0.177	0.168	0.160	0.154	0.150	0.147	0.145	0.144	0.143	0.142	0.142	0.142	0.141
2006	0.000	0.003	0.036	0.109	0.167	0.187	0.185	0.175	0.166	0.160	0.155	0.152	0.150	0.149	0.148	0.147	0.146	0.146	0.145
2007	0.000	0.003	0.034	0.100	0.153	0.172	0.170	0.160	0.152	0.146	0.142	0.139	0.137	0.135	0.134	0.133	0.133	0.132	0.132
2008	0.000	0.003	0.038	0.111	0.167	0.186	0.181	0.171	0.161	0.154	0.150	0.146	0.144	0.142	0.141	0.140	0.140	0.139	0.139
2009	0.000	0.004	0.042	0.118	0.178	0.198	0.193	0.181	0.170	0.162	0.157	0.153	0.150	0.149	0.147	0.146	0.146	0.145	0.144
2010	0.000	0.003	0.035	0.101	0.154	0.172	0.168	0.159	0.150	0.144	0.139	0.136	0.134	0.133	0.132	0.131	0.131	0.130	0.130

Table 2.27—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in 2011-2023 (Scenarios 1 and 2), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	235,000	235,000	235,000	235,000	0
2012	281,000	281,000	281,000	281,000	0
2013	296,000	296,000	296,000	296,000	6
2014	291,000	292,000	292,000	294,000	1,121
2015	264,000	276,000	279,000	302,000	12,559
2016	232,000	262,000	267,000	321,000	28,830
2017	190,000	254,000	257,000	343,000	46,624
2018	163,000	251,000	250,000	348,000	57,842
2019	151,000	248,000	249,000	356,000	62,760
2020	152,000	247,000	249,000	360,000	64,223
2021	150,000	248,000	248,000	352,000	63,697
2022	150,000	247,000	247,000	354,000	62,031
2023	153,000	248,000	247,000	348,000	61,053

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	358,000	358,000	358,000	358,000	0
2012	389,000	389,000	389,000	389,000	0
2013	418,000	419,000	419,000	419,000	81
2014	432,000	434,000	434,000	437,000	1,619
2015	420,000	428,000	430,000	445,000	8,291
2016	387,000	411,000	416,000	460,000	23,345
2017	350,000	394,000	403,000	488,000	42,531
2018	323,000	386,000	395,000	509,000	56,907
2019	306,000	382,000	393,000	512,000	64,795
2020	305,000	381,000	394,000	526,000	68,665
2021	303,000	380,000	394,000	530,000	69,871
2022	302,000	381,000	393,000	519,000	68,602
2023	305,000	381,000	392,000	519,000	66,240

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.25	0.25	0.25	0.25	0.00
2012	0.26	0.26	0.26	0.26	0.00
2013	0.26	0.26	0.26	0.26	0.00
2014	0.26	0.26	0.26	0.26	0.00
2015	0.26	0.26	0.26	0.26	0.00
2016	0.26	0.26	0.26	0.26	0.00
2017	0.24	0.26	0.26	0.26	0.01
2018	0.22	0.26	0.25	0.26	0.02
2019	0.21	0.26	0.25	0.26	0.02
2020	0.21	0.26	0.25	0.26	0.02
2021	0.21	0.26	0.25	0.26	0.02
2022	0.21	0.26	0.25	0.26	0.02
2023	0.21	0.26	0.25	0.26	0.02

Table 2.28—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that the upper bound on F_{ABC} is set the most recent five-year average fishing mortality rate in 2011-2023 (Scenario 3), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	194,000	194,000	194,000	194,000	0
2012	222,000	222,000	222,000	222,000	0
2013	242,000	242,000	242,000	242,000	4
2014	244,000	245,000	245,000	247,000	848
2015	228,000	237,000	239,000	257,000	9,593
2016	204,000	228,000	232,000	274,000	22,479
2017	185,000	222,000	228,000	294,000	33,723
2018	170,000	222,000	226,000	301,000	40,726
2019	162,000	220,000	225,000	306,000	44,642
2020	161,000	218,000	225,000	311,000	46,529
2021	159,000	218,000	224,000	305,000	46,682
2022	156,000	217,000	222,000	307,000	45,408
2023	156,000	218,000	222,000	301,000	44,463

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	362,000	362,000	362,000	362,000	0
2012	407,000	407,000	407,000	407,000	0
2013	455,000	455,000	455,000	456,000	81
2014	487,000	488,000	488,000	491,000	1,620
2015	488,000	495,000	497,000	513,000	8,359
2016	461,000	486,000	491,000	536,000	24,066
2017	423,000	472,000	481,000	570,000	45,828
2018	387,000	464,000	473,000	599,000	65,074
2019	359,000	459,000	468,000	610,000	78,109
2020	345,000	456,000	466,000	626,000	85,945
2021	337,000	453,000	464,000	633,000	89,713
2022	332,000	453,000	462,000	626,000	89,894
2023	332,000	452,000	460,000	621,000	87,987

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.20	0.20	0.20	0.20	0.00
2012	0.20	0.20	0.20	0.20	0.00
2013	0.20	0.20	0.20	0.20	0.00
2014	0.20	0.20	0.20	0.20	0.00
2015	0.20	0.20	0.20	0.20	0.00
2016	0.20	0.20	0.20	0.20	0.00
2017	0.20	0.20	0.20	0.20	0.00
2018	0.20	0.20	0.20	0.20	0.00
2019	0.20	0.20	0.20	0.20	0.00
2020	0.20	0.20	0.20	0.20	0.00
2021	0.20	0.20	0.20	0.20	0.00
2022	0.20	0.20	0.20	0.20	0.00
2023	0.20	0.20	0.20	0.20	0.00

Table 2.29—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that the upper bound on F_{ABC} is set at $F_{60\%}$ in 2011-2023 (Scenario 4), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	132,000	132,000	132,000	132,000	0
2012	157,000	157,000	157,000	157,000	0
2013	176,000	176,000	176,000	176,000	3
2014	183,000	184,000	184,000	185,000	564
2015	176,000	182,000	183,000	195,000	6,450
2016	161,000	177,000	180,000	209,000	15,480
2017	148,000	174,000	178,000	225,000	23,899
2018	137,000	174,000	177,000	232,000	29,542
2019	130,000	173,000	177,000	235,000	32,892
2020	129,000	172,000	177,000	242,000	34,664
2021	128,000	172,000	177,000	239,000	35,115
2022	126,000	172,000	176,000	239,000	34,388
2023	126,000	172,000	175,000	234,000	33,656

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	367,000	367,000	367,000	367,000	0
2012	433,000	433,000	433,000	433,000	0
2013	503,000	503,000	503,000	503,000	81
2014	556,000	557,000	558,000	561,000	1,622
2015	575,000	583,000	585,000	601,000	8,430
2016	560,000	585,000	590,000	637,000	24,831
2017	524,000	576,000	586,000	681,000	48,937
2018	488,000	571,000	581,000	723,000	71,928
2019	456,000	568,000	579,000	741,000	88,692
2020	433,000	565,000	577,000	763,000	99,493
2021	427,000	562,000	576,000	774,000	105,394
2022	419,000	563,000	574,000	770,000	106,908
2023	418,000	562,000	572,000	760,000	105,425

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.13	0.13	0.13	0.13	0.00
2012	0.13	0.13	0.13	0.13	0.00
2013	0.13	0.13	0.13	0.13	0.00
2014	0.13	0.13	0.13	0.13	0.00
2015	0.13	0.13	0.13	0.13	0.00
2016	0.13	0.13	0.13	0.13	0.00
2017	0.13	0.13	0.13	0.13	0.00
2018	0.13	0.13	0.13	0.13	0.00
2019	0.13	0.13	0.13	0.13	0.00
2020	0.13	0.13	0.13	0.13	0.00
2021	0.13	0.13	0.13	0.13	0.00
2022	0.13	0.13	0.13	0.13	0.00
2023	0.13	0.13	0.13	0.13	0.00

Table 2.30—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that *F* = 0 in 2011-2023 (Scenario 5), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	0	0	0	0	0
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	0	0	0
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	379,000	379,000	379,000	379,000	0
2012	488,000	488,000	488,000	488,000	0
2013	614,000	614,000	614,000	614,000	81
2014	730,000	731,000	731,000	734,000	1,625
2015	807,000	815,000	817,000	833,000	8,571
2016	836,000	863,000	868,000	918,000	26,428
2017	827,000	886,000	897,000	1,000,000	55,869
2018	801,000	900,000	914,000	1,090,000	88,420
2019	766,000	910,000	926,000	1,150,000	115,953
2020	740,000	916,000	935,000	1,180,000	136,345
2021	727,000	924,000	941,000	1,220,000	149,917
2022	719,000	928,000	944,000	1,240,000	156,994
2023	710,000	930,000	945,000	1,230,000	158,601

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00
2016	0.00	0.00	0.00	0.00	0.00
2017	0.00	0.00	0.00	0.00	0.00
2018	0.00	0.00	0.00	0.00	0.00
2019	0.00	0.00	0.00	0.00	0.00
2020	0.00	0.00	0.00	0.00	0.00
2021	0.00	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00

Table 2.31—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = F_{OFL}$ in 2011-2023 (Scenario 6), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	272,000	272,000	272,000	272,000	0
2012	313,000	313,000	313,000	313,000	0
2013	332,000	332,000	332,000	332,000	7
2014	319,000	320,000	321,000	323,000	1,332
2015	280,000	298,000	300,000	329,000	16,144
2016	223,000	267,000	275,000	349,000	40,849
2017	185,000	253,000	262,000	371,000	58,788
2018	161,000	251,000	259,000	374,000	68,204
2019	154,000	252,000	260,000	388,000	72,564
2020	157,000	252,000	261,000	391,000	73,653
2021	156,000	254,000	261,000	383,000	72,779
2022	157,000	254,000	260,000	385,000	70,848
2023	158,000	253,000	260,000	379,000	70,309

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	355,000	355,000	355,000	355,000	0
2012	374,000	374,000	374,000	374,000	0
2013	393,000	393,000	393,000	393,000	81
2014	396,000	397,000	398,000	401,000	1,618
2015	377,000	384,000	386,000	401,000	8,094
2016	345,000	365,000	370,000	412,000	21,529
2017	315,000	352,000	360,000	434,000	36,921
2018	293,000	349,000	356,000	451,000	47,893
2019	281,000	348,000	356,000	452,000	53,921
2020	283,000	349,000	358,000	466,000	56,980
2021	282,000	350,000	359,000	471,000	57,830
2022	282,000	350,000	358,000	462,000	56,481
2023	284,000	350,000	357,000	459,000	54,514

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.29	0.29	0.29	0.29	0.00
2012	0.31	0.31	0.31	0.31	0.00
2013	0.31	0.31	0.31	0.31	0.00
2014	0.31	0.31	0.31	0.31	0.00
2015	0.31	0.31	0.31	0.31	0.00
2016	0.28	0.30	0.30	0.31	0.01
2017	0.25	0.29	0.29	0.31	0.02
2018	0.24	0.28	0.28	0.31	0.03
2019	0.23	0.28	0.28	0.31	0.03
2020	0.23	0.28	0.28	0.31	0.03
2021	0.23	0.28	0.28	0.31	0.03
2022	0.23	0.29	0.28	0.31	0.03
2023	0.23	0.29	0.28	0.31	0.03

Table 2.32—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in each year 2011-2012 and $F = F_{OFL}$ thereafter (Scenario 7), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	235,000	235,000	235,000	235,000	0
2012	281,000	281,000	281,000	281,000	0
2013	346,000	346,000	346,000	346,000	7
2014	329,000	330,000	331,000	333,000	1,332
2015	291,000	305,000	308,000	335,000	14,796
2016	229,000	276,000	282,000	353,000	39,994
2017	188,000	256,000	265,000	373,000	58,832
2018	162,000	252,000	260,000	375,000	68,330
2019	154,000	252,000	261,000	388,000	72,656
2020	156,000	252,000	261,000	391,000	73,714
2021	155,000	253,000	261,000	383,000	72,816
2022	157,000	254,000	260,000	385,000	70,867
2023	158,000	253,000	260,000	379,000	70,317

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	358,000	358,000	358,000	358,000	0
2012	389,000	389,000	389,000	389,000	0
2013	414,000	414,000	414,000	414,000	81
2014	412,000	414,000	414,000	417,000	1,618
2015	388,000	396,000	397,000	413,000	8,240
2016	350,000	372,000	376,000	419,000	22,078
2017	317,000	355,000	363,000	439,000	37,634
2018	294,000	350,000	357,000	454,000	48,449
2019	281,000	349,000	357,000	454,000	54,258
2020	283,000	349,000	358,000	466,000	57,153
2021	282,000	350,000	359,000	471,000	57,910
2022	281,000	350,000	358,000	462,000	56,514
2023	284,000	350,000	357,000	459,000	54,524

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.25	0.25	0.25	0.25	0.00
2012	0.26	0.26	0.26	0.26	0.00
2013	0.31	0.31	0.31	0.31	0.00
2014	0.31	0.31	0.31	0.31	0.00
2015	0.31	0.31	0.31	0.31	0.00
2016	0.29	0.30	0.30	0.31	0.01
2017	0.26	0.29	0.29	0.31	0.02
2018	0.24	0.29	0.28	0.31	0.03
2019	0.23	0.28	0.28	0.31	0.03
2020	0.23	0.28	0.28	0.31	0.03
2021	0.23	0.28	0.28	0.31	0.03
2022	0.23	0.29	0.28	0.31	0.03
2023	0.23	0.29	0.28	0.31	0.03

Table 2.33a—Discarded catch (t) of species groups by EBS Pacific cod fisheries, 2003-2010.

Species group	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Benthic urochordata	14	4	10	5	1	2	0	3
Birds	6	7	8	6	6	5	9	1
Bivalves	5	16	6	5	2	11	9	2
Brittle star unidentified	1	1	0	1	0	0	0	0
Capelin		0			0	0		
Corals Bryozoans	1	1	1	1	2	2	4	1
Dark Rockfish						1	0	0
Eelpouts	48	35	42	17	18	7	2	2
Eulachon		0	0	0	0			0
Giant Grenadier	2	15	143	101	95	133	203	141
Greenlings	6	3	2	2	0	1	0	0
Grenadier	239	224	192	25	84	15	0	1
Gunnels		0	0		0			
Hermit crab unidentified	5	3	2	2	2	1	1	0
Invertebrate unidentified	19	5	3	17	20	2	12	28
Lanternfishes (myctophidae)		0						
Large Sculpins	837	2829	2248	1920	2110	1390	1071	760
Misc crabs	8	4	4	16	28	5	1	5
Misc crustaceans	0	0	0	1	1	0	0	0
Misc fish	231	226	205	93	88	37	46	30
Misc inverts (worms etc)	0	0	0	0	0	0	0	0
Octopus	202	264	299	268	140	175	36	83
Other osmerids	0	0	0	0	0		0	0
Other Sculpins	1903	348	339	382	338	273	210	54
Pacific Sand lance	0	0	0	0	0	0		
Pandalid shrimp	0	0	0	0	0	0	0	0
Polychaete unidentified	0	0	0	0	0	0	0	0
Scypho jellies	669	709	399	66	112	41	86	26
Sea anemone unidentified	92	114	113	87	37	49	118	61
Sea pens whips	6	12	30	16	7	9	34	18
Sea star	442	420	439	316	235	177	144	100
Shark, Other	20	20	10	4	2	1	0	0
Shark, pacific sleeper	121	228	189	123	44	12	11	4
Shark, salmon	1	0	2	1				
Shark, spiny dogfish	11	8	11	6	2	7	17	6
Skate, Alaska								1172
Skate, Big		158	174	243	74	49	62	111
Skate, Longnose	0	12	21	20	1	1	1	9
Skate, Other	14749	17679	18850	14430	12736	13666	11890	6921
Snails	26	20	12	16	16	18	25	12
Sponge unidentified	6	8	6	11	2	2	11	4
Squid	5	4	1	0	1	0	0	0
Stichaeidae	0	0	0	0	0	0		
Urchins, dollars, cucumbers	11	11	13	4	13	3	1	1
Grand total	19687	23392	23776	18202	16217	16094	14004	9561

Table 2.33b—Discarded catch (t) of species groups by AI Pacific cod fisheries, 2003-2010.

Species group	2003	2004	2005	2006	2007	2008	2009	2010
Benthic urochordata	0	0	0	0	1	0	0	0
Birds	1	0	1	0	0	0	0	0
Bivalves	15	1	1	3	2	1	0	0
Brittle star unidentified	0	0	0	0	1	0	0	0
Capelin						0		
Corals Bryozoans	25	13	12	12	16	11	10	5
Dark Rockfish						2	4	3
Eelpouts	0	1	0	0	0	0	0	0
Eulachon			0	0		0		
Giant Grenadier	0	0	1	94	31	26	11	61
Greenlings	1	0	0	4	1	1	0	0
Grenadier	46	13	1	26	10	0	2	36
Gunnels			0					
Hermit crab unidentified	0	0	0	0	0	0	0	0
Invertebrate unidentified	0	1	0	14	2	4	0	3
Large Sculpins	107	294	207	307	374	370	403	360
Misc crabs	1	1	0	1	1	1	1	1
Misc crustaceans	0	0	0	0	0	0	0	0
Misc fish	29	18	20	17	26	17	18	14
Misc inverts (worms etc)		0	0	0	0			
Octopus	14	14	12	64	26	19	20	27
Other osmerids			0					
Other Sculpins	153	64	7	69	29	26	76	124
Pacific Sand lance	0		0			0		
Pandalid shrimp	0	0	0	0	0	0	0	0
Polychaete unidentified	0	0	0		0	0	0	
Scypho jellies	0	0	1	2	0	0	0	0
Sea anemone unidentified	0	0	1	1	1	0	1	0
Sea pens whips	0	0	0	0	0	0	1	0
Sea star	6	9	6	7	9	11	20	10
Shark, Other		0						
Shark, pacific sleeper	0	2	2	0	0	0	0	0
Shark, salmon							0	
Shark, spiny dogfish	0	0	0	1	0	3	1	1
Skate, Alaska								130
Skate, Big		0	0	5	0	0	0	0
Skate, Longnose		0	0	0		0	0	0
Skate, Other	200	486	405	411	647	576	748	473
Snails	1	1	0	1	1	1	3	1
Sponge unidentified	25	23	26	28	19	4	14	6
Squid	3	2	1	1	0	0	0	0
Stichaeidae			0	0			0	
Urchins, dollars, cucumbers	1	1	0	1	1	0	1	0
Grand total	631	946	706	1067	1200	1073	1336	1257

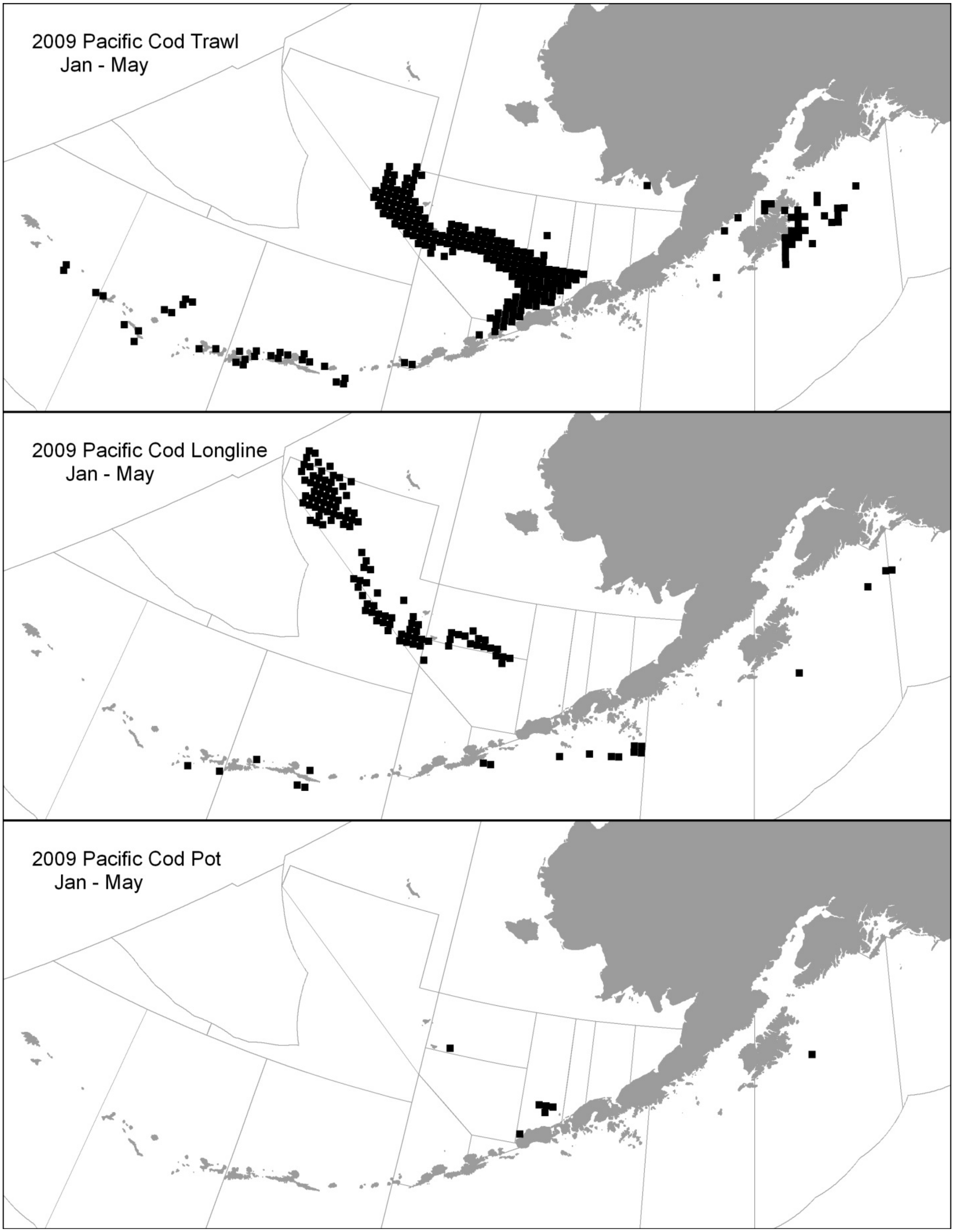

Figure 2.1a—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, January-May 2000, by gear type, overlaid against NMFS 3-digit statistical areas.

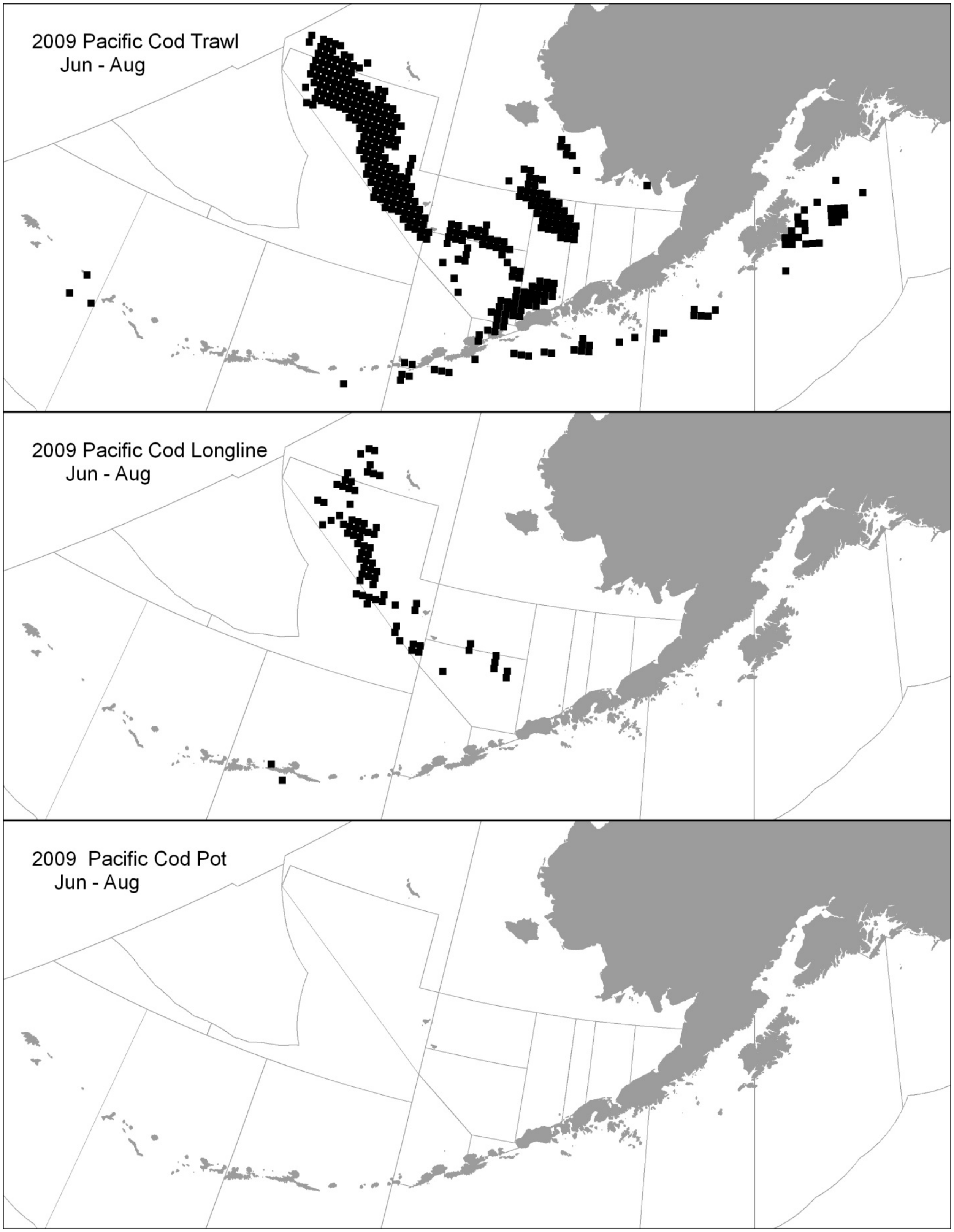

Figure 2.1b—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, June-August 2009, by gear type, overlaid against NMFS 3-digit statistical areas.

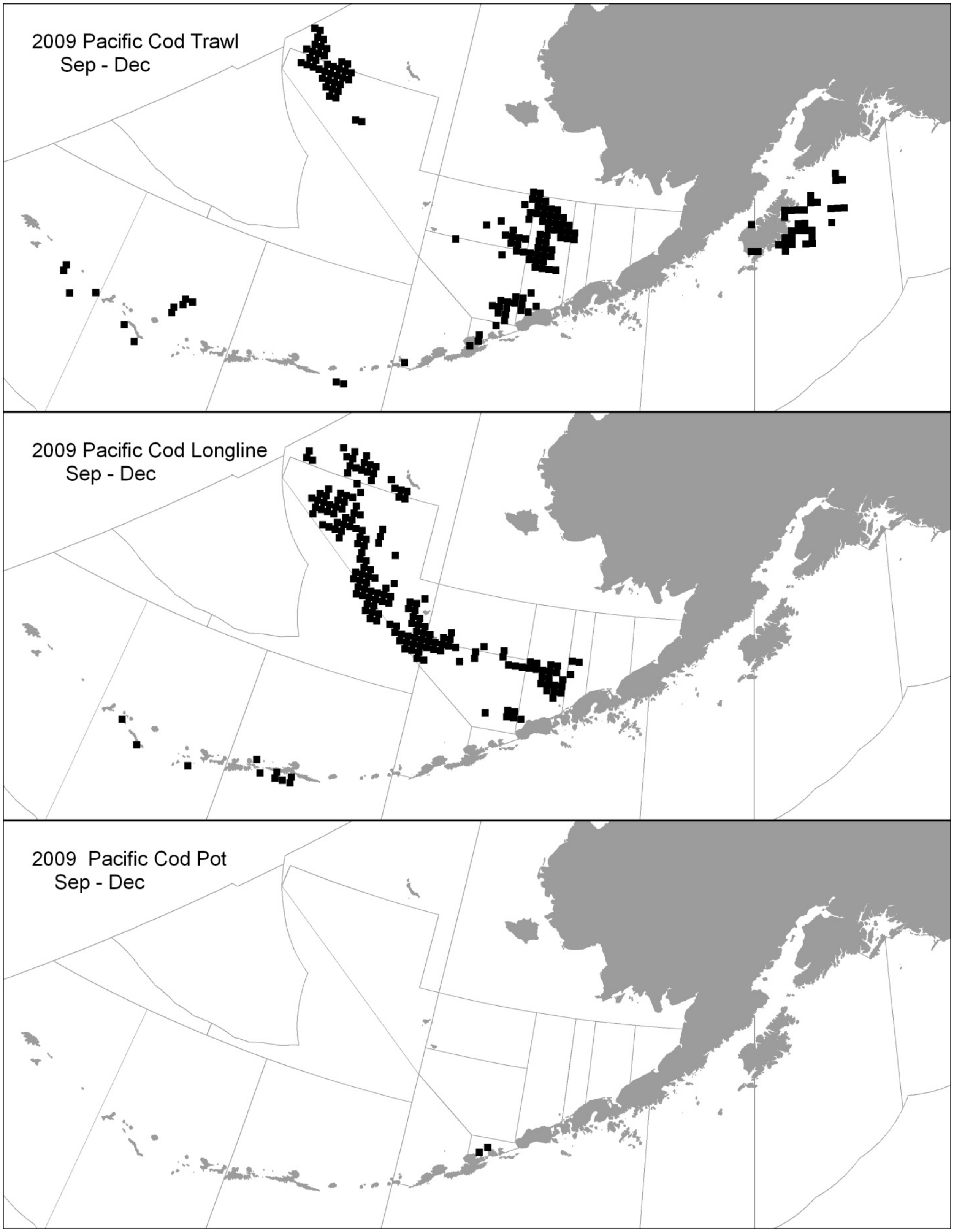

Figure 2.1c—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, Sept.-Dec. 2009, by gear type, overlaid against NMFS 3-digit statistical areas.

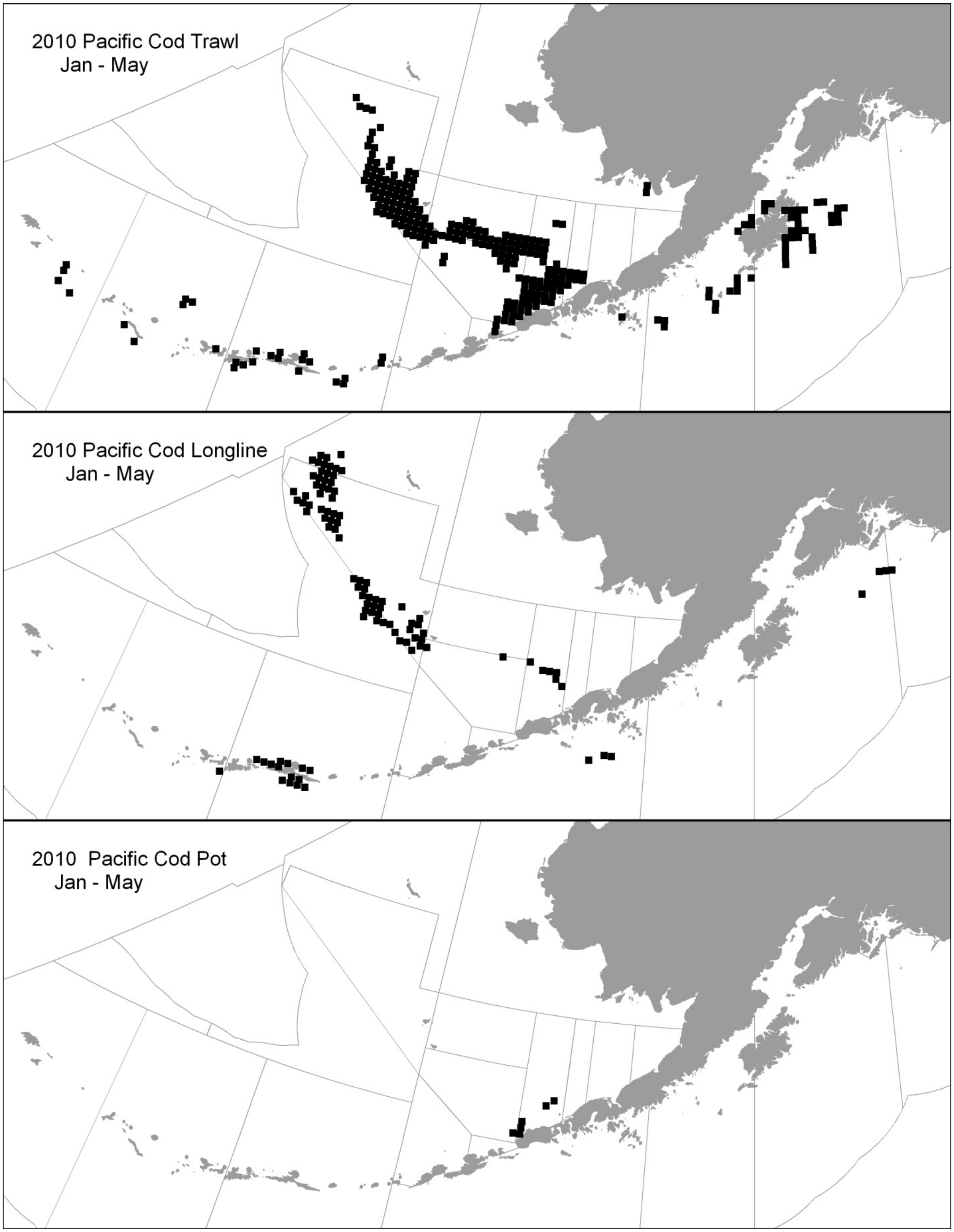

Figure 2.1d—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, January-May 2010, by gear type, overlaid against NMFS 3-digit statistical areas.

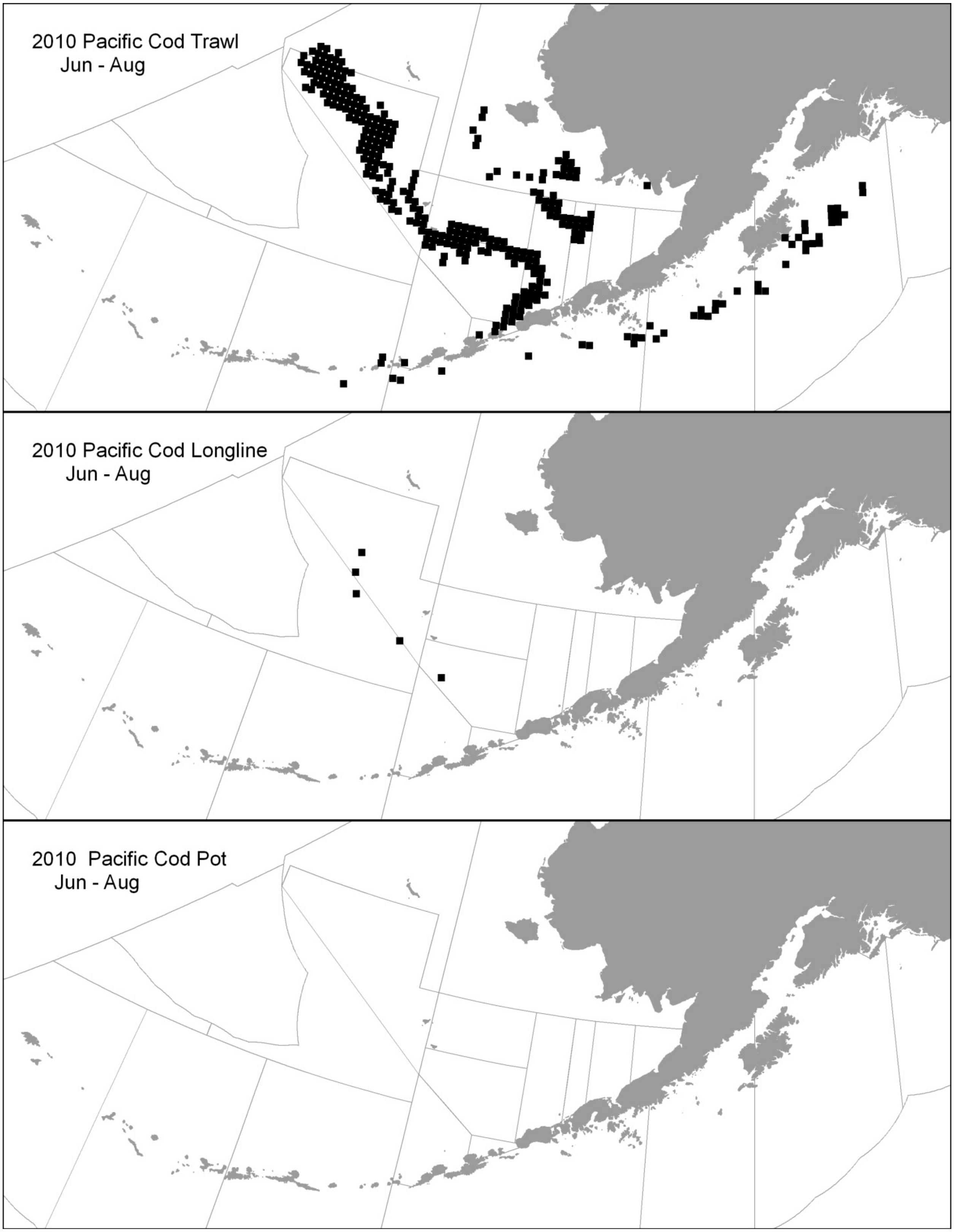

Figure 2.1e—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, June-August 2010, by gear type, overlaid against NMFS 3-digit statistical areas.

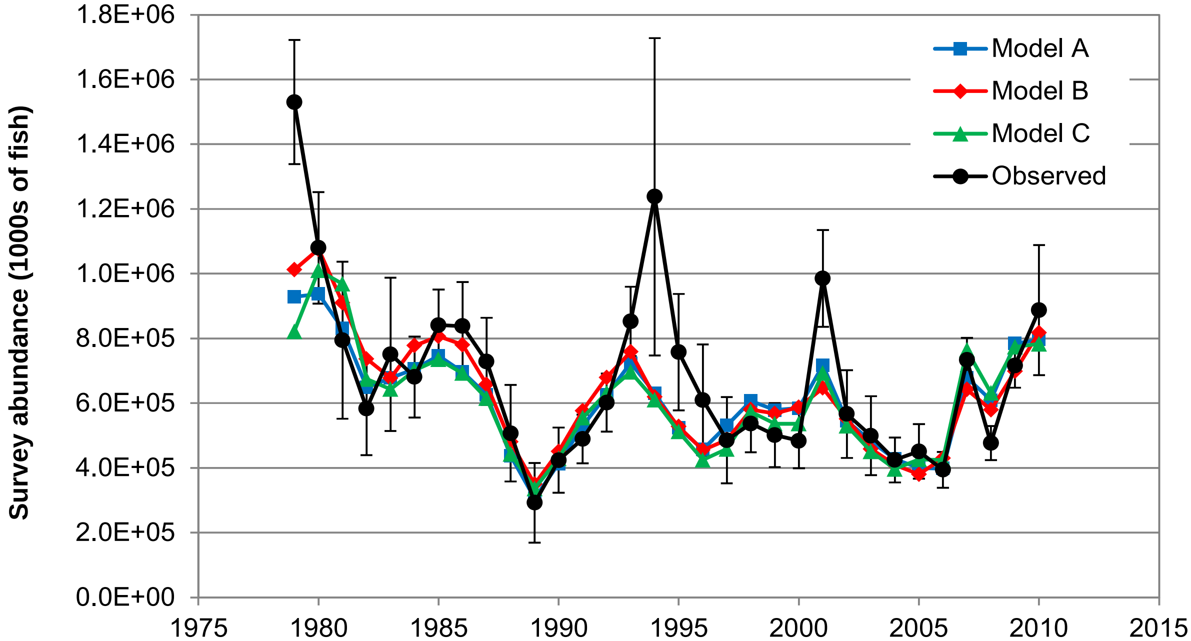

Figure 2.2—Fits of the three models to the trawl survey abundance time series.

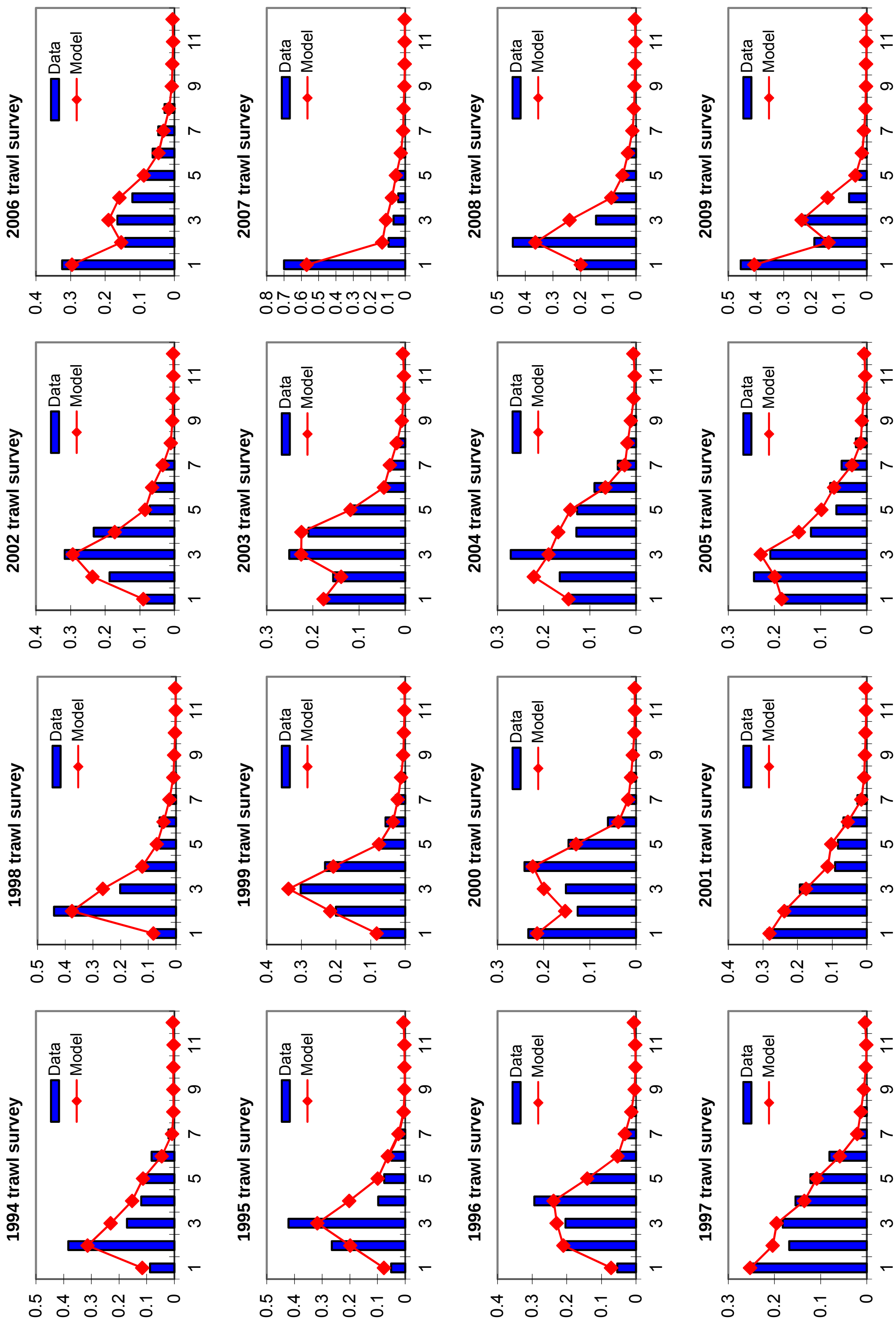

Figure 2.3a—Fit to trawl survey age composition data obtained by Model A.

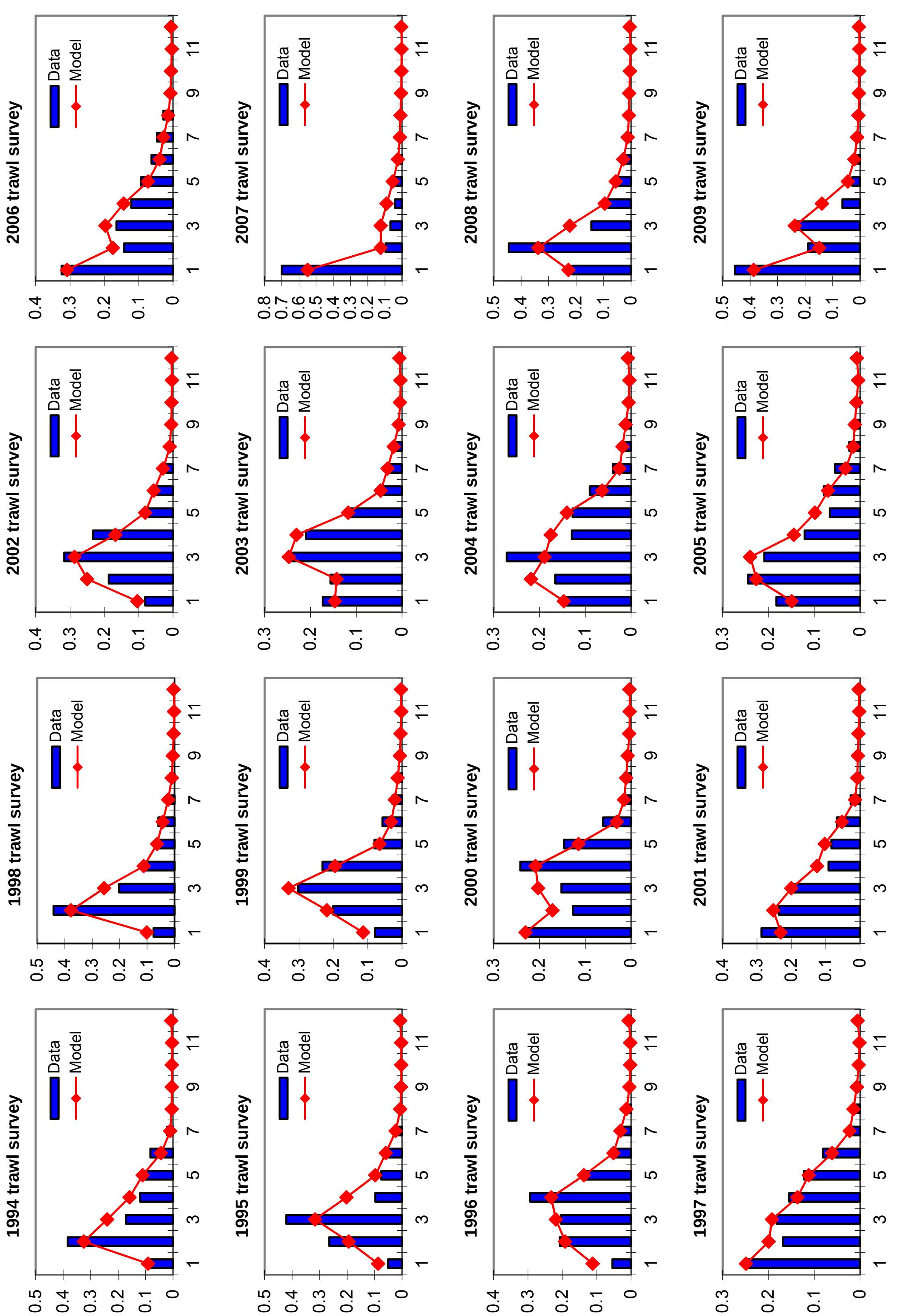

Figure 2.3b—Fit to trawl survey age composition data obtained by Model B.

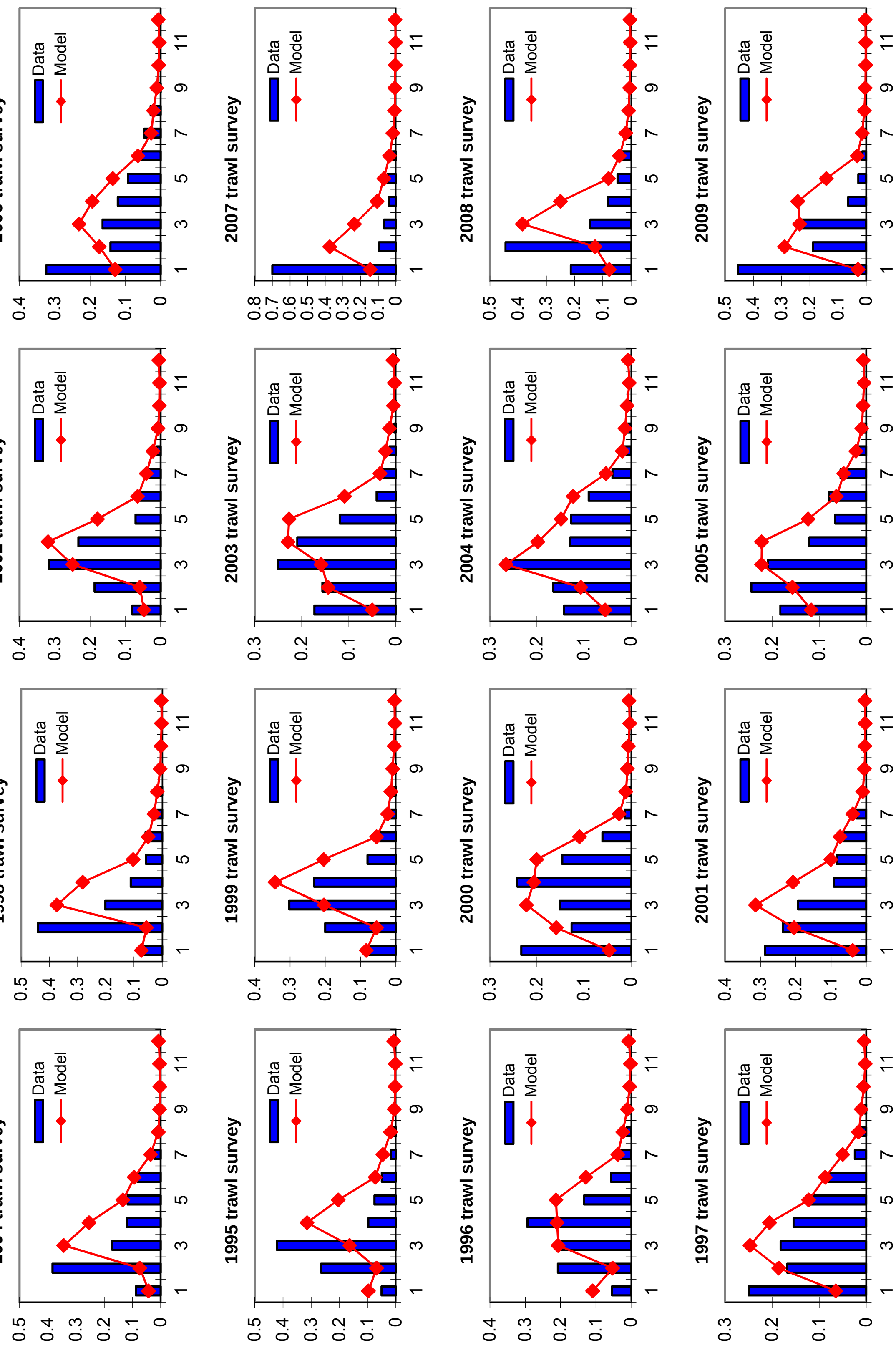

Figure 2.3c—Fit to trawl survey age composition data obtained by Model C.

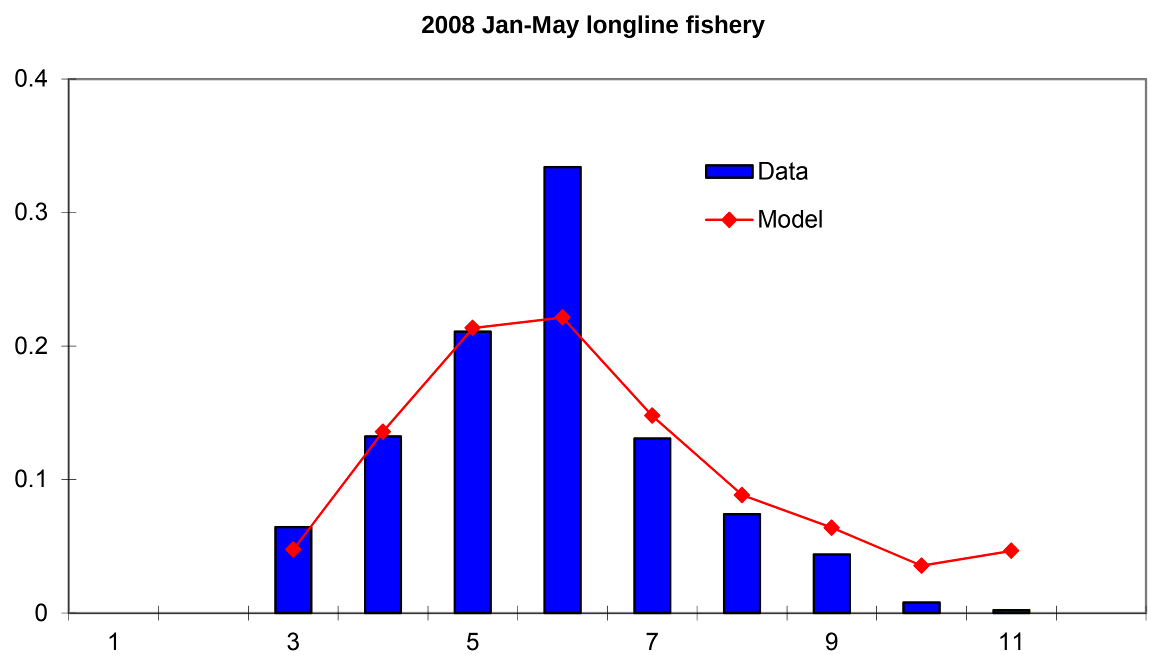

Figure 2.4—Fit to 2008 January-May longline fishery age composition data obtained by Model A.

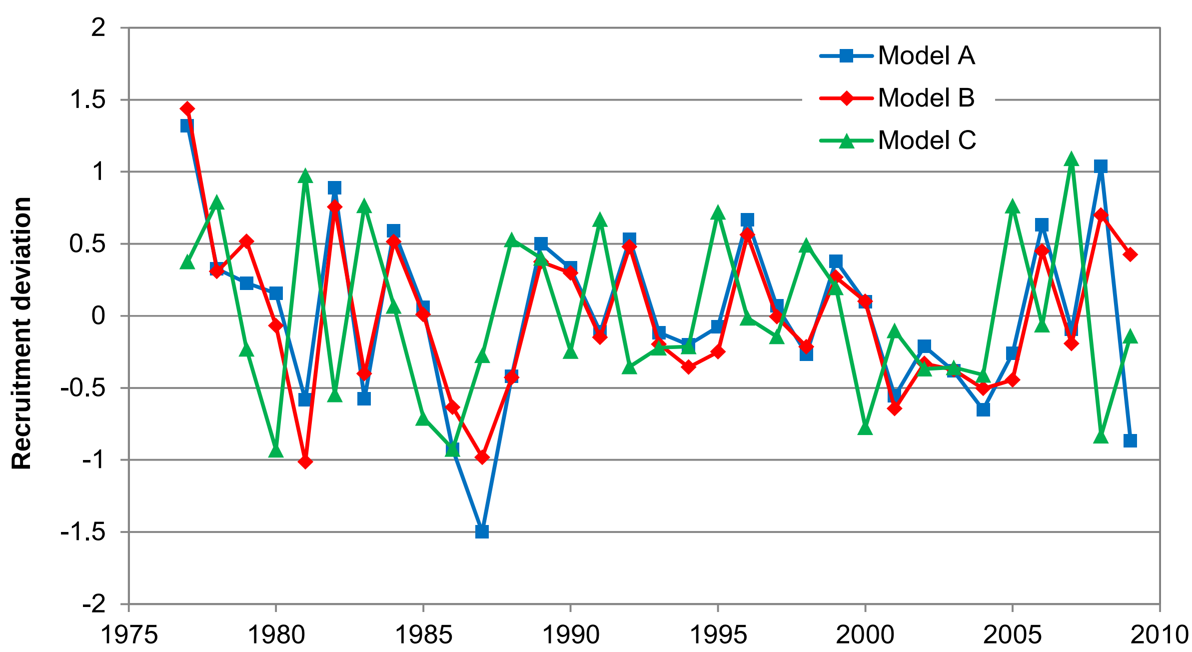

Figure 2.5—Time series of estimated recruitment deviations from the three models. Note that the pre-1977 deviations are with respect to the pre-1977 log median.

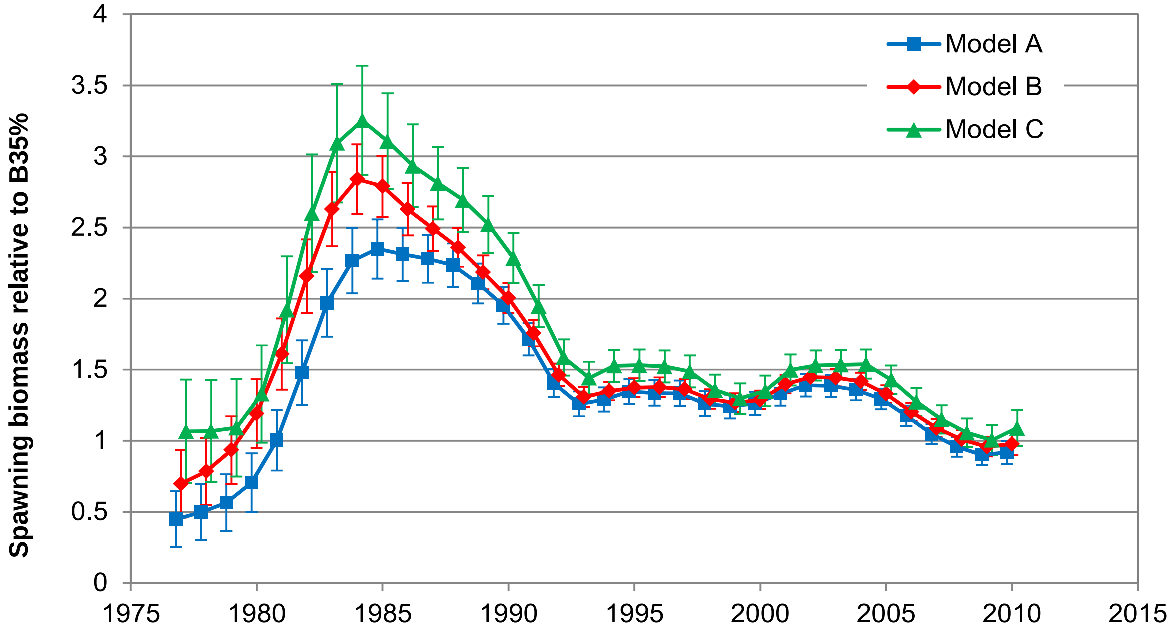

Figure 2.6—Time series of spawning biomass relative to $B_{35\%}$ as estimated by the three models.

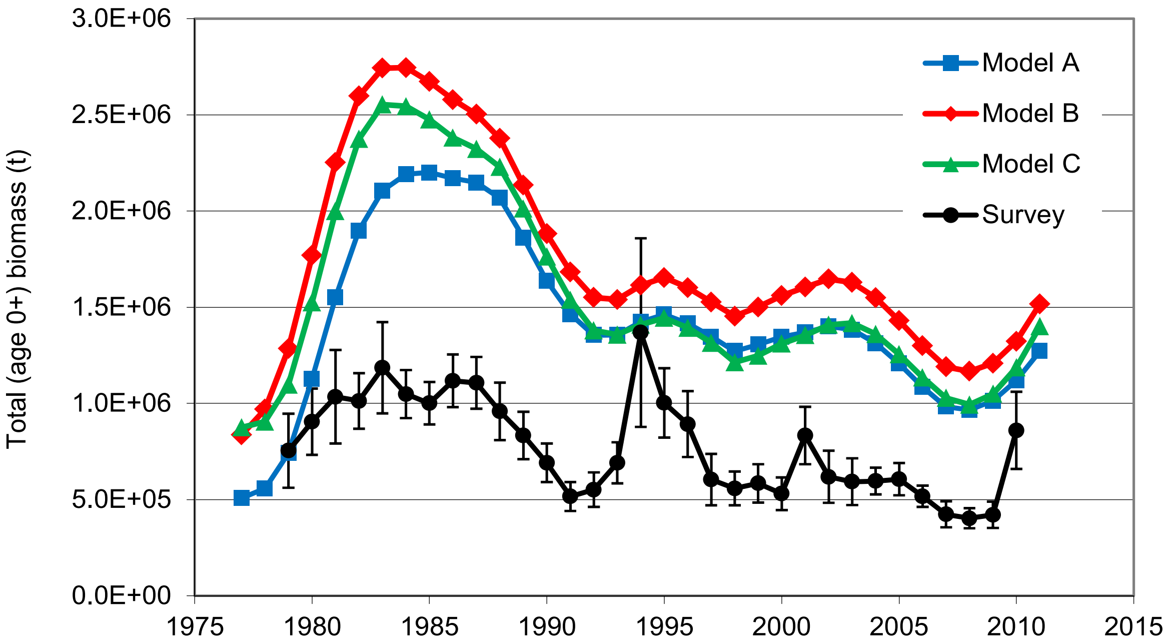

Figure 2.7—Time series of total (age 0+) biomass as estimated by the three models. Survey biomass is shown for comparison.

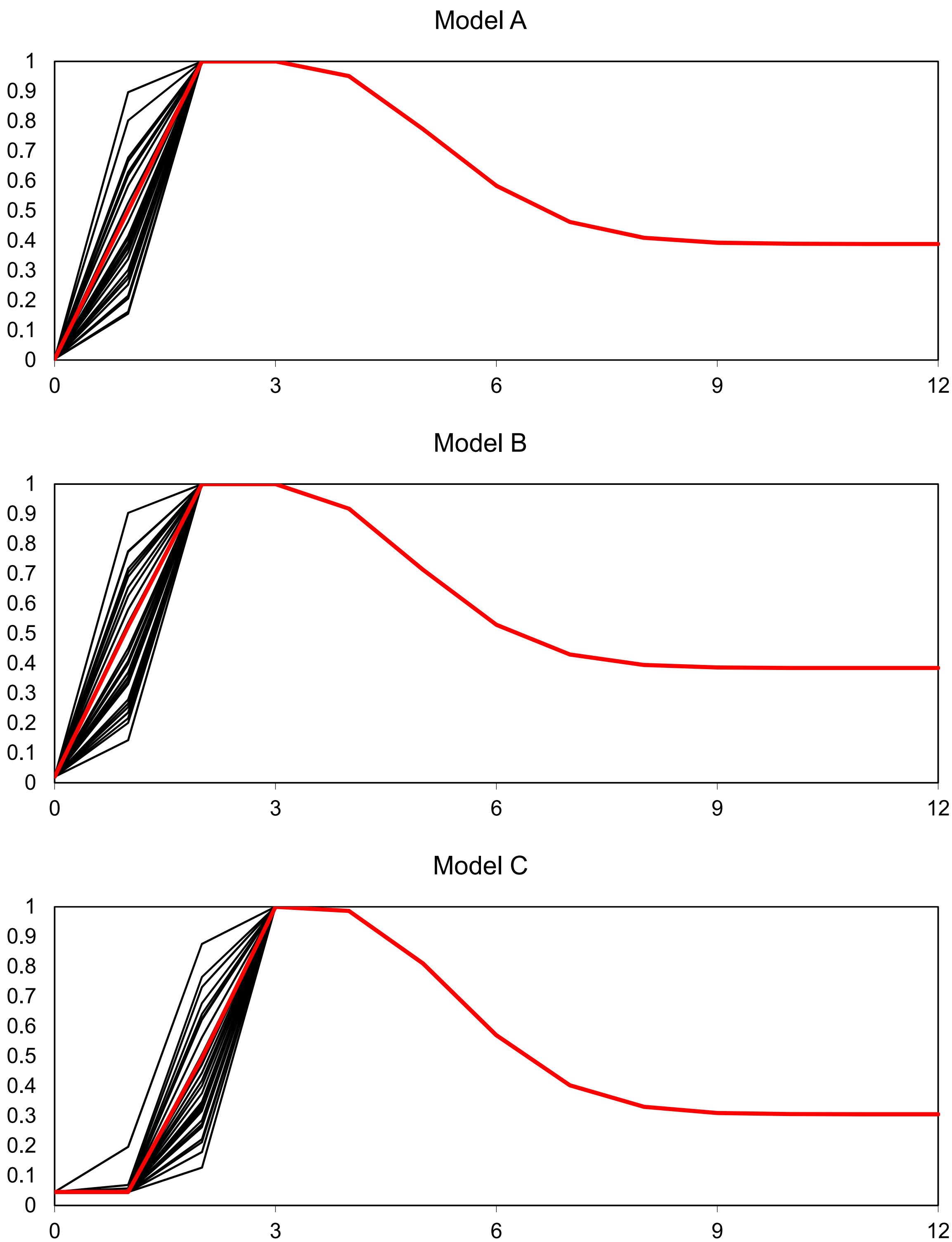

Figure 2.8—Post-1981 trawl survey selectivity at age as estimated by the three models. "*Dev*" parameters affect the ascending limb annually in all models. Selectivity for 2010 is shown in red.

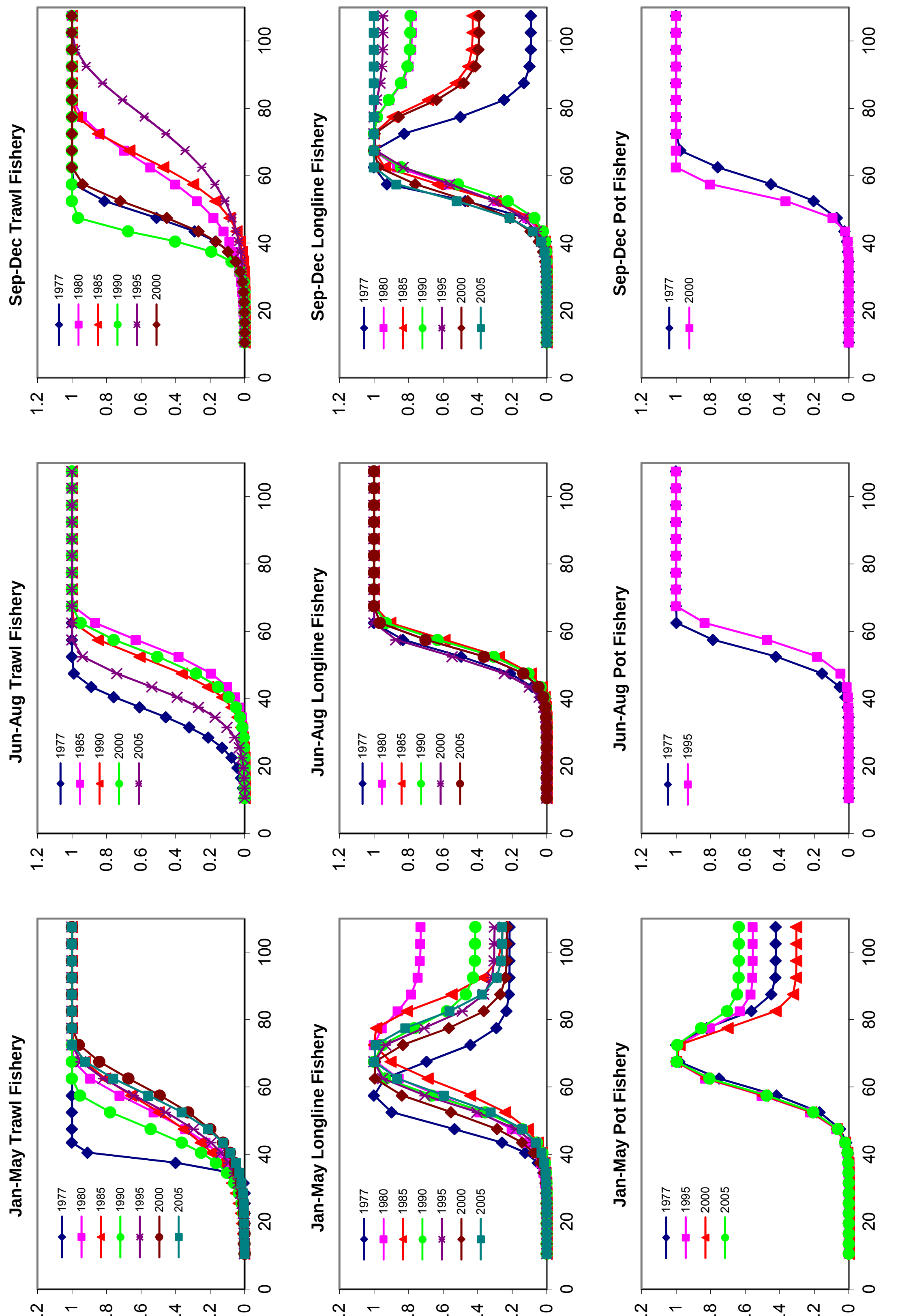

Figure 2.9a—Fishery selectivity at length (cm) as estimated by Model A.

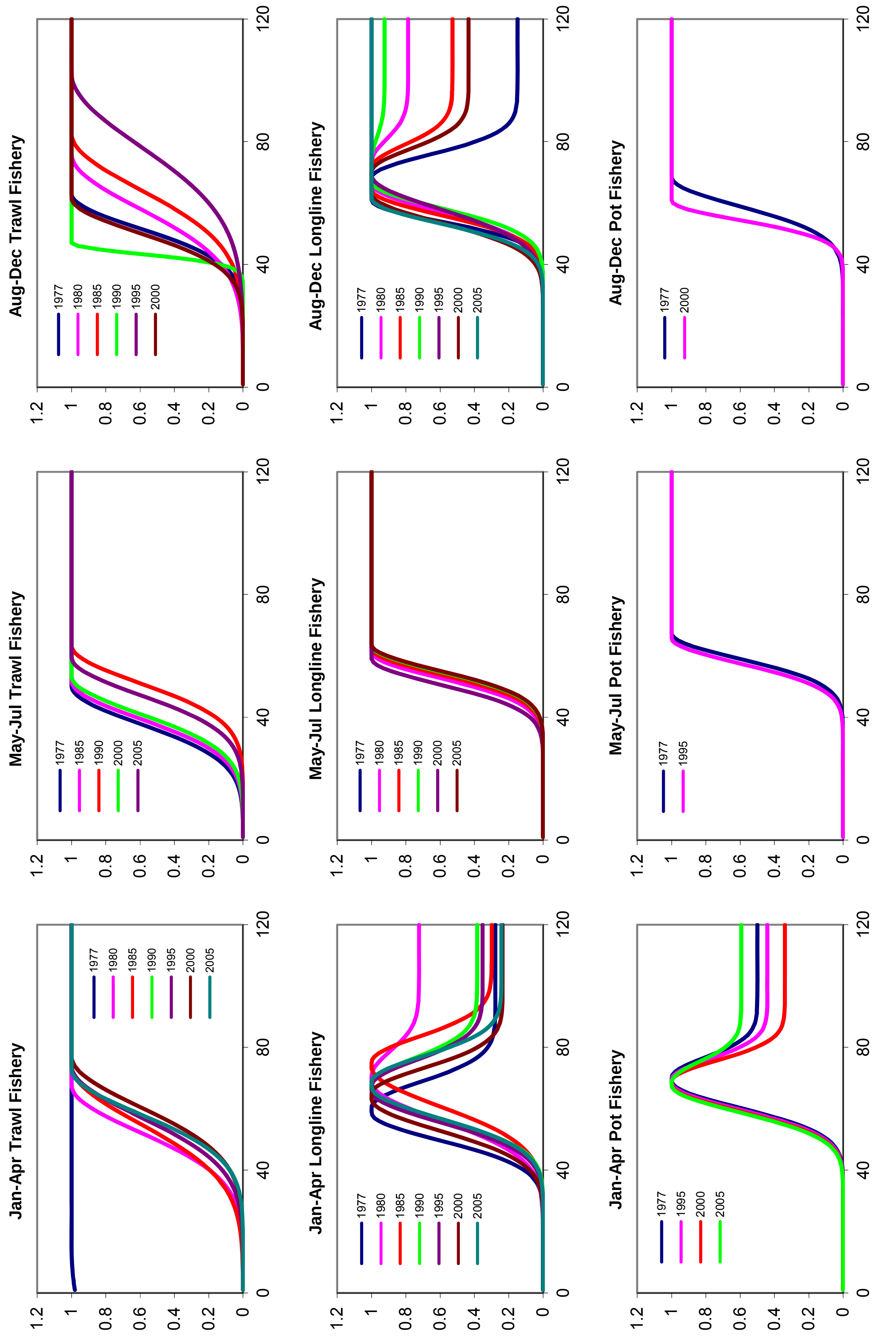

Figure 2.9b—Fishery selectivity at length (cm) as estimated by Model B.

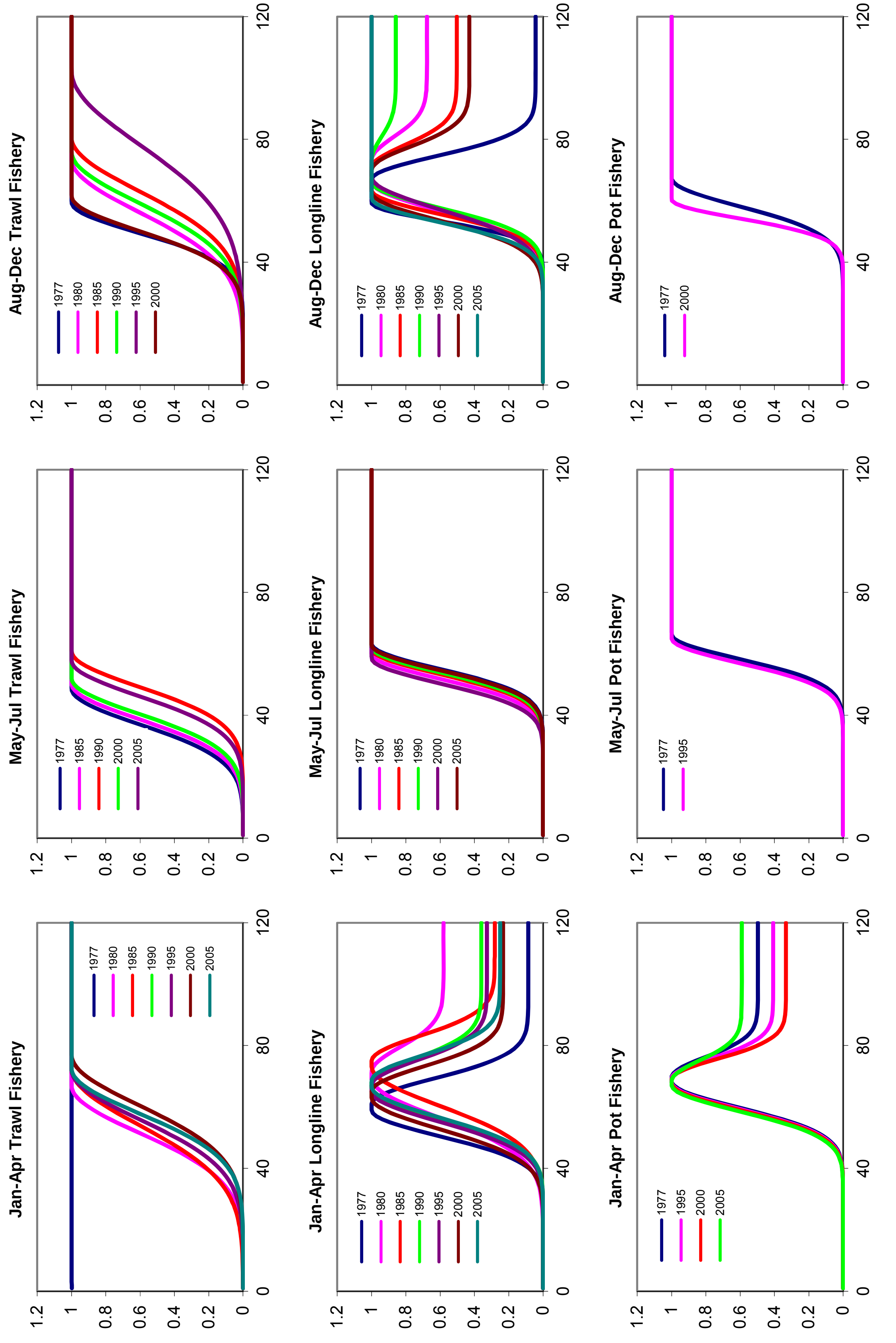

Figure 2.9c—Fishery selectivity at length (cm) as estimated by Model C.

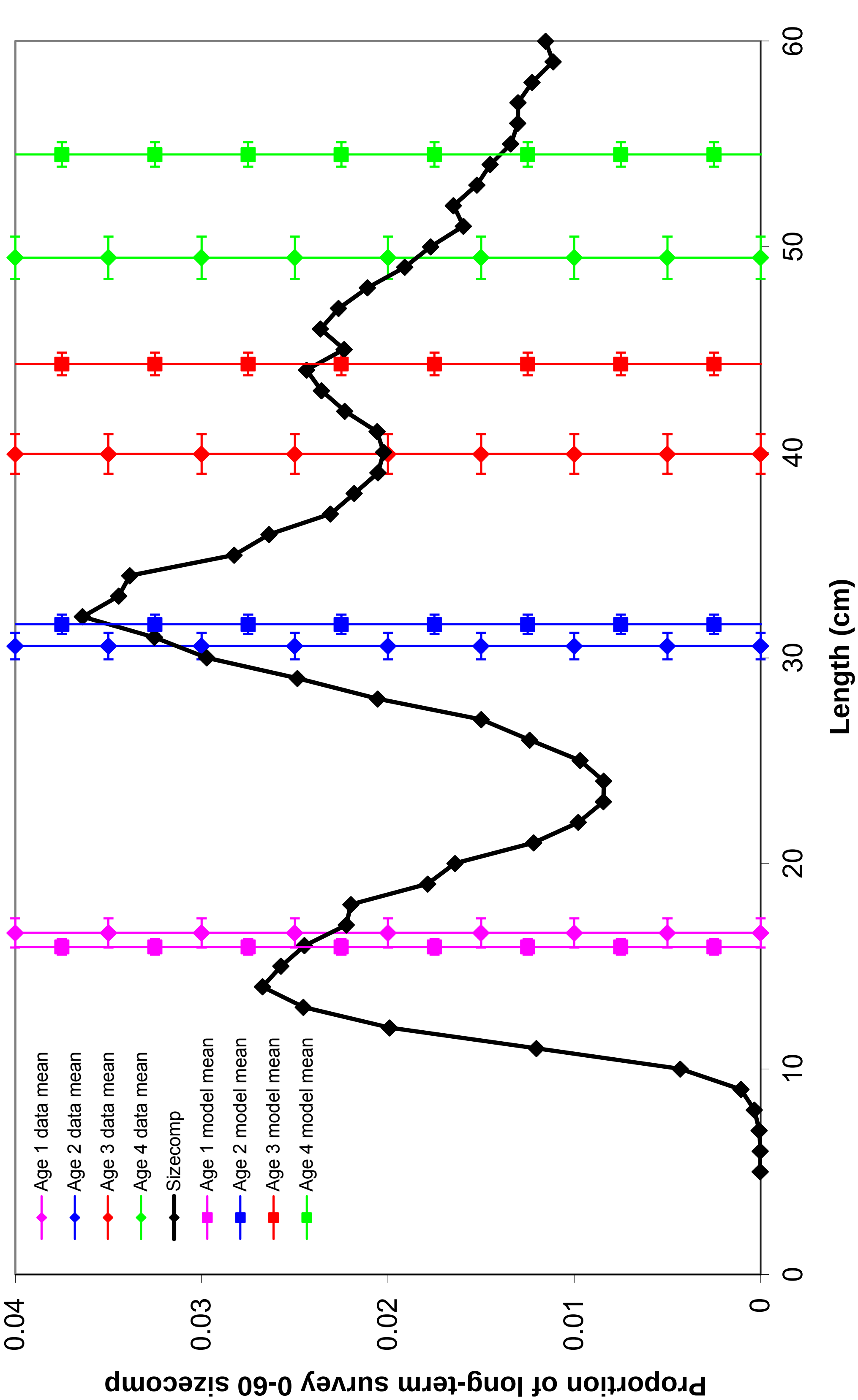

Figure 2.10a—Long-term trawl survey size composition, mean lengths for ages 1-4 from age data, and mean lengths for ages 1-4 from Model A.

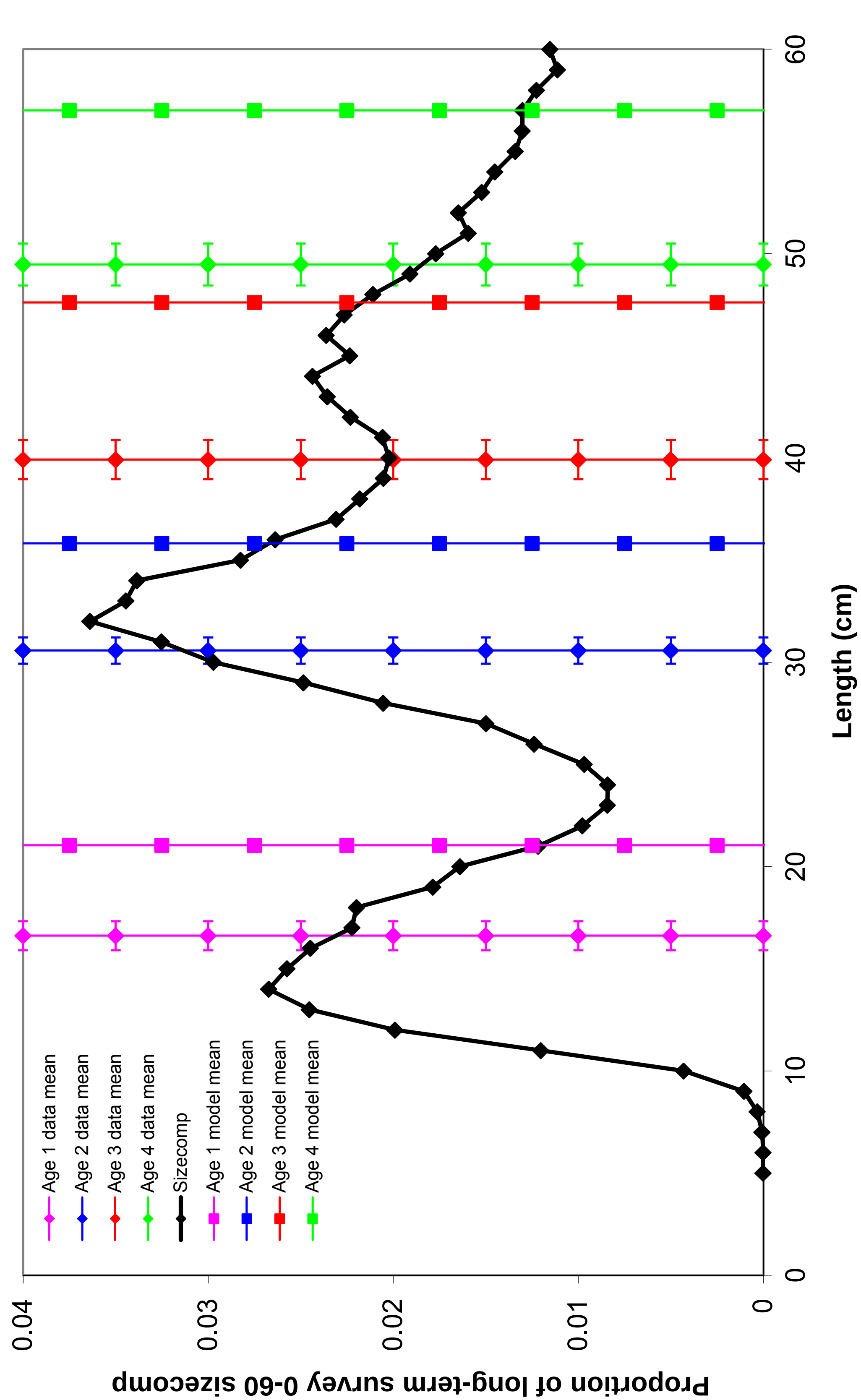

Figure 2.10b—Long-term trawl survey size composition, mean lengths for ages 1-4 from age data, and mean lengths for ages 1-4 from Model B.

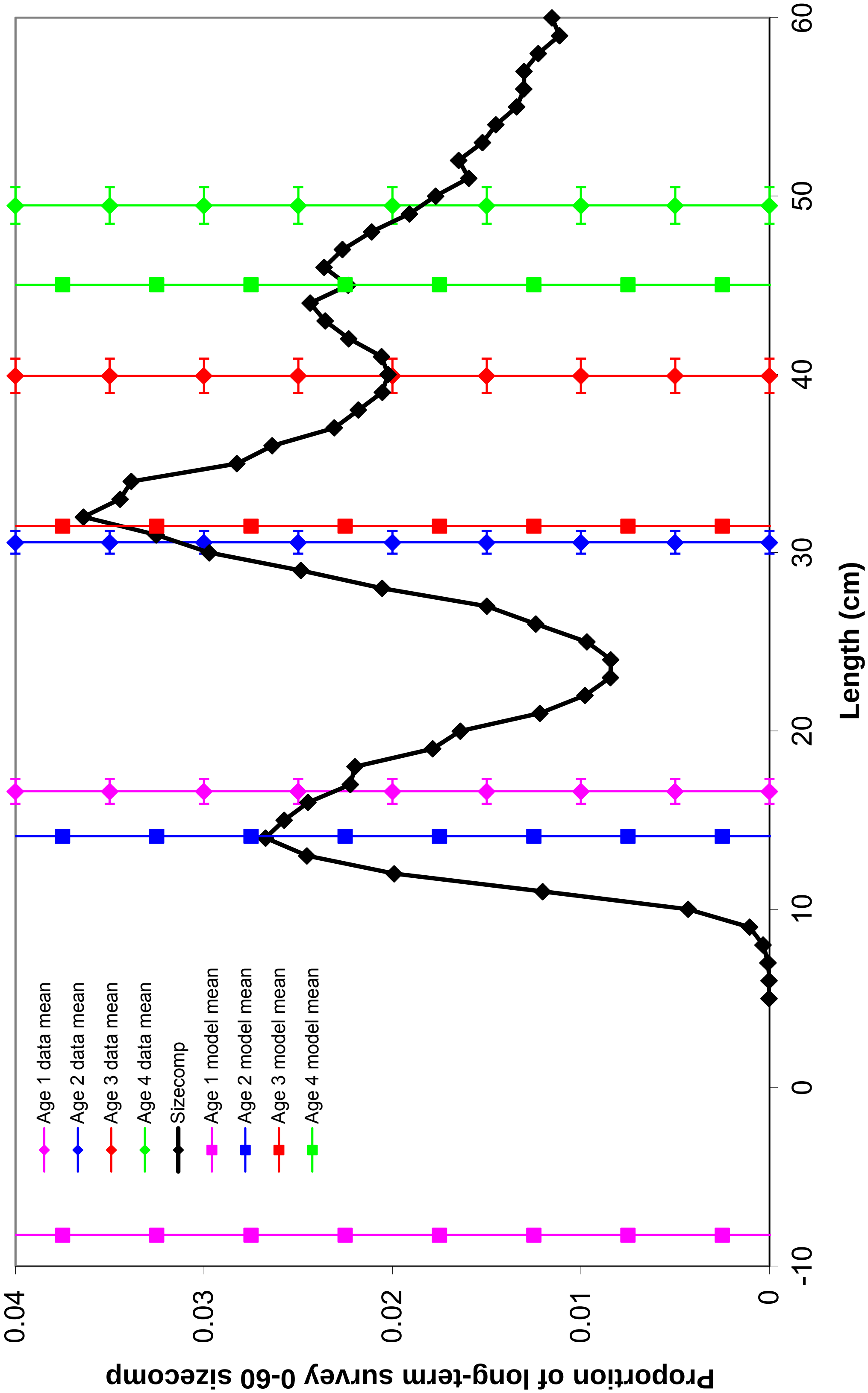

Figure 2.10c—Long-term trawl survey size composition, mean lengths for ages 1-4 from age data, and mean lengths for ages 1-4 from Model C.

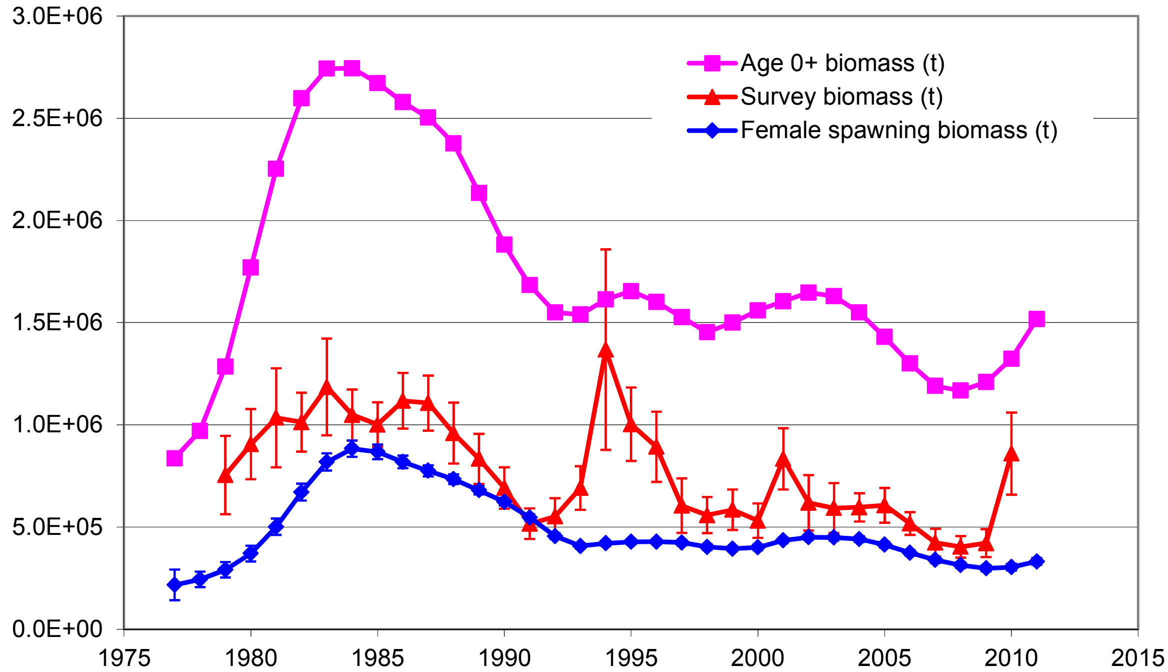

Figure 2.11—Biomass time trends (age 0+ biomass, female spawning biomass, survey biomass) of EBS Pacific cod as estimated by Model B. Spawning biomass and survey biomass show 95% CI.

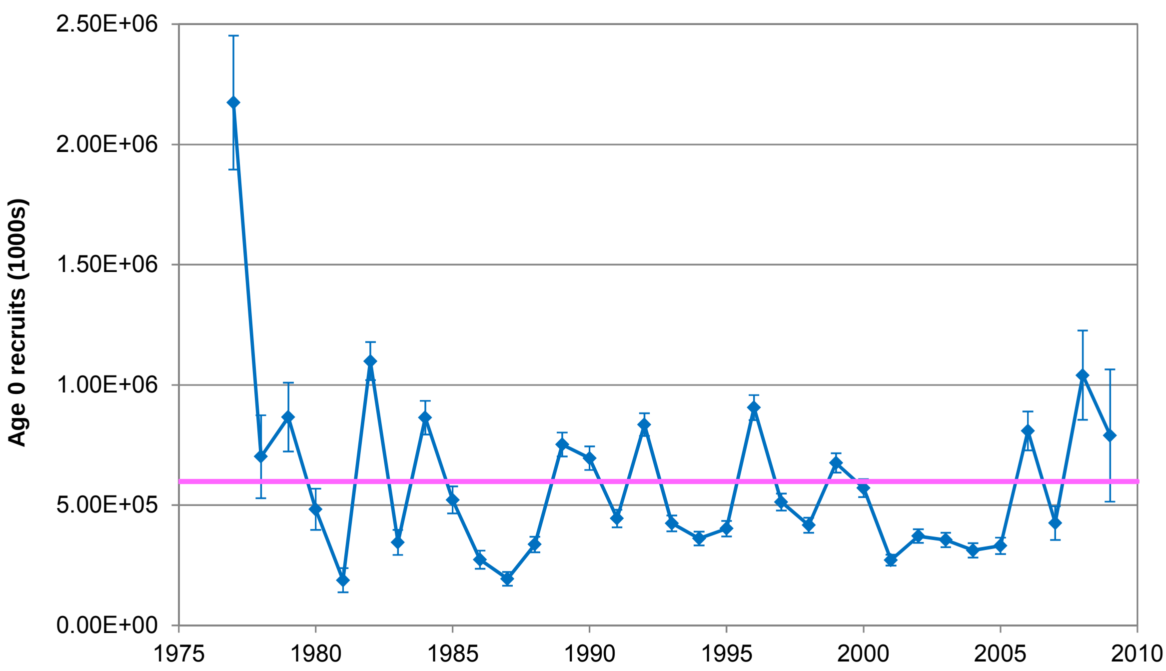

Figure 2.12—Time series of EBS Pacific cod recruitment at age 0, with 95% confidence intervals, as estimated by Model B. Magenta line = 1977-2009 average.

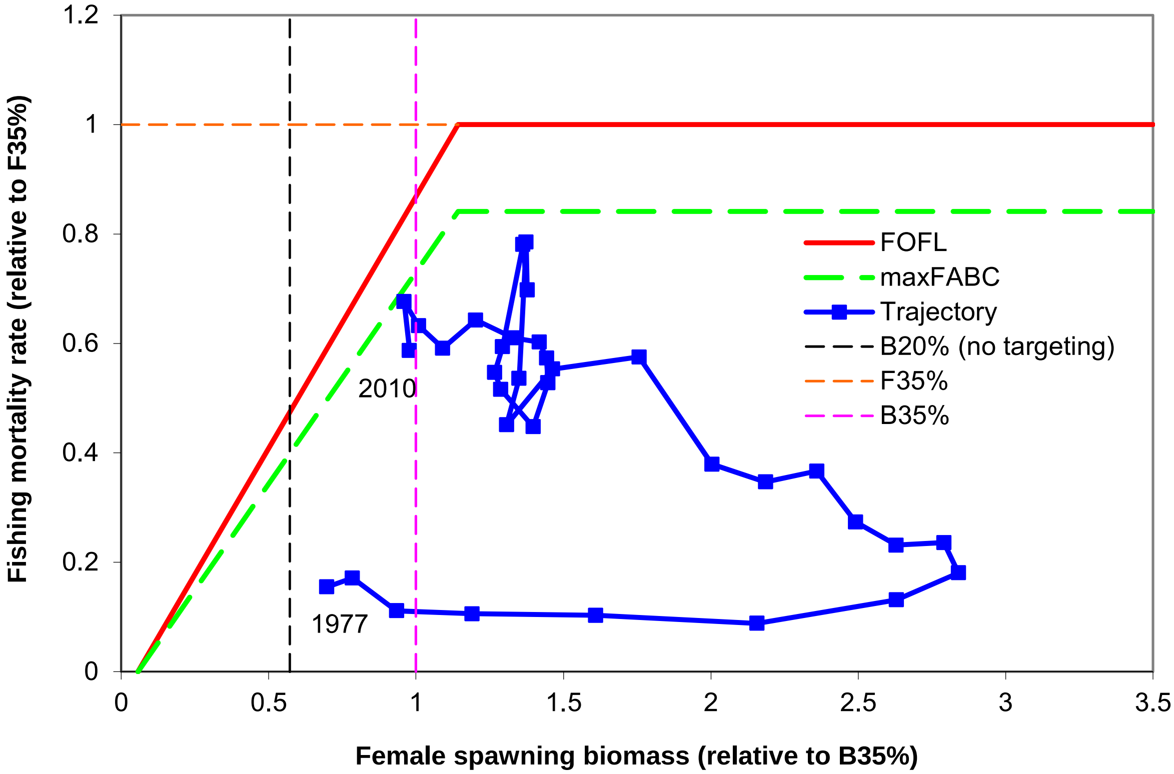

Figure 2.13—Trajectory of Pacific cod fishing mortality and female spawning biomass as estimated by Model B, 1977-present. Because Pacific cod is a key prey of Steller sea lions, harvests would be restricted to incidental catch in the event that spawning biomass fell below $B_{20\%}$.

Attachment 2.1
An exploration of alternative models of the Bering Sea Pacific cod stock

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Introduction

This document represents an effort to respond to comments made by the BSAI Plan Team, the GOA Plan Team, the joint BSAI and GOA Plan Teams, and the SSC on the 2009 assessment of the Pacific cod (*Gadus macrocephalus*) stock in the eastern Bering Sea and Aleutian Islands area (Thompson et al. 2009).

Six models are presented here. These include the model that was recommended in the 2009 assessment and adopted by the BSAI Plan Team and the SSC ("Model 1"), plus five alternative models.

BSAI Plan Team Comments from the November, 2009 Minutes

BPT1: *"The Team requested that the lead author analyze three alternative models for the September 2009 meeting: 1) current Model B1, 2) Model B1 with data-based estimates of aging bias from the radiocarbon study if available, and 3) Model B2 without mean length at age data and with maturity a function of length rather than age."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comments JPT1 and JPT6), and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

GOA Plan Team Comments from the November, 2009 Minutes

GPT1: *"Include a model run without age data. It was noted that developing a totally age-free model may be difficult and that some things may require constraining (e.g., variability in length-at-age)."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comment JPT1 and JPT2) and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."
GPT2: *"As a low priority, it may be useful to evaluate a model run from the preferred configuration but only advanced by one year for comparison with projections. For example, for the preferred 2010 assessment model, re-run with (expected) catch for 2010 and 2011 as new data inputs as if the assessment was being conducted in 2011. The idea being to compare projected numbers at age (for the same catch assumptions) with modeled numbers at age in 2011."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comment JPT10) and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC Comments Specific to the Pacific Cod Assessments from the December, 2009 Minutes

SSC1: *"The SSC encourages studies to evaluate the causes for the mismatch between survey length modes and estimated mean length at age of younger fish in the Bering Sea and difficulty of fitting age* *compositions in the Gulf of Alaska."* A progress report on this topic by the AFSC Age and Growth Unit is scheduled for the September, 2010 Plan Team meeting.

SSC2: *"The SSC recommends that proposals for model configurations be submitted to the assessment author in April. These proposals will be reviewed the Plan Team(s) and recommendations for future model runs will be vetted by the SSC in June. During the summer months, the stock assessment authors will run the selected models and will present preliminary results to the Plan Team(s) in September. The Plan Teams will then select their preferred suite of models for October SSC review and selection based on model performance. The authors can reserve the right to bring forward additional models for the final SAFE as needed."* The steps described in the first three sentences of the above have been completed, and the remaining steps are scheduled to be completed as described. A total of 20 proposals for model configurations were submitted to the senior assessment author by the April, 2010 deadline. These proposals were reviewed by the Plan Teams in May, 2010 (see comments JPT1-JPT11) and by the SSC in June, 2010 (see comment SSC8). A set of six model requests resulted. These were analyzed over the course of the summer and are presented in this preliminary assessment. See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC3: *"Evaluate incorporating age conditioned on length rather than age composition and mean size-at-age."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comment JPT4) and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC4: *"Evaluate the use of informative priors on selectivities to alleviate convergence problems and constrain selectivity parameters to preserve a reasonable shape."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comment JPT7) and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC5: *"Exclude fishery age composition data unless a reasonable spatial distribution of samples becomes available."* This request was inadvertently overlooked by the joint Plan Teams at their May, 2010 meeting. However, it was reviewed by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC6: *"The IPHC survey does not appear to inform the model and should be removed."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comment JPT8) and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC7: *"Evaluate spatial temporal variation in fishery CPUE trends for next year (time permitting)."* This request was addressed by the joint Plan Teams at their May, 2010 meeting (see comment JPT9) and by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

Joint Plan Team Comments from the May, 2010 Minutes

JPT1: *"Exclude mean length-at-age data and exclude age composition data: The teams recommended adding this component to models 4, 5, and 6."* This refers to proposals made in comments BPT1 and GPT1 and by members of the public. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT2: *"Estimate the two parameters describing variation in length-at-age: The Teams recommended adding this component to models 5 and 6."* This refers to a proposal made by members of the public and, perhaps, to the proposal made in comment GPT1 (depending on whether these parameters are among those, if any, that "require constraining"). This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT3: *"Eliminate cohort-specific growth and add time-varying growth: The teams recommended adding this component to Model 6 (BSAI only)."* This refers to a proposal made by members of the public. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT4: *"Age conditioned on length: The Teams did not recommend adding this component to any of the models until age determination issues are resolved."* This refers to a proposal made in comment SSC3. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT5: *"Finer length bins: After some discussion the teams felt this was a routine housekeeping change to the model. The teams agreed that the author was free to test and implement minor changes to the model as he felt appropriate. The Teams recorded this as a change to models 2 through 6."* This refers to a proposal made by the senior assessment author. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT6: *"Maturity as a function of length rather than age and ageing bias from radiocarbon study: The Teams recommended adding maturity as a function of length rather than age to models 4, 5, and 6. The teams recommended no change related to the radiocarbon study."* This refers to a pair of proposals made in comment BPT1. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT7: *"Priors on selectivity, estimate catchability: The Teams recommended adding these components as the main new features of Model 3."* This refers to proposals made in comment SSC4, by the senior assessment author, and by another AFSC assessment scientist. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT8: *"Exclude IPHC data: The Teams rejected the proposal and recommended that the IPHC data be considered for use in both the BSAI and GOA model as well."* This refers to the proposal made in comment SSC6. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT9: *"Evaluate spatial-temporal variation in fishery CPUE: The Teams recommended that the SSC proposal to evaluate spatial-temporal variation in fishery CPUE be included in the next set of research priorities."* This refers to the proposal made in comment SSC7. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT10: *"Advance model one year, compare with projections: No action was taken."* This refers to the proposal made in comment GPT2. This recommendation was further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

JPT11: *"Other GOA proposals: The Team recommended to treat the seasonal proposal under models 2 through 6, but not to address the plus group proposal. The catchability and selectivity-at-age proposals are treated under Model 3 (see 'prior' proposals). No recommendations were made on the remaining two proposals (weight, lower bound)."* The "seasonal proposal" and the "catchability and selectivity-at-age proposals" refer to proposals made by the senior assessment author and another AFSC assessment scientist. The "remaining two proposals" refer to proposals made by an AFSC assessment scientist. These recommendations were further considered by the SSC at its June, 2010 meeting (see comment SSC8). See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC Comments from the June, 2010 Minutes

SSC8: *"The SSC supports* ... the Plan Teams' *suite of models, with two modifications.* One *SSC proposal ... is to exclude fishery age composition data because of concerns about the spatial distribution and having only one year of data.* Another *SSC proposal ... is to exclude IPHC survey data in the BSAI because of its conflict with other data series. The SSC requests that these two proposals be included in the housekeeping category, because achieving stability in the data sources used in a stock assessment is desirable. The conclusion may be that excluding these data sources is not a good idea, but at least an evaluation will have been done." (Terms in* non-italicized font *added.)* For the Plan Teams' suite of models, see comments JPT1-JPT11. The SSC proposals referenced here with respect to exclusion of fishery age composition data and IPHC survey data are given in comments SSC5 and SSC6. See Table 2.1.1 and "Model Structures" under "Data and Analytic Approach."

SSC9: *"The SSC encourages continued ageing of the Pacific cod winter fishery age samples and acquisition of length composition from the IPHC survey. The assessment author is encouraged to evaluate these data for inclusion in the model after a sufficient time series has been acquired."* The requests for continued ageing of winter fishery age samples and acquisition of length composition data from the IPHC survey will be communicated to the responsible parties.

Data and Analytic Approach

Model Structures

Six models were requested by the Plan Teams. The SSC adopted the Plan Team requests, with three revisions, as shown in Table 2.1.1. The models are described in more detail below. The software used to run these models was SS V3.10b (Methot 2010); V3.03c was used in the 2009 assessment.

The Plan Teams and SSC developed their list of models by considering all 20 proposals that had been submitted, accepting some and rejecting others, grouping the accepted proposals into categories, then subdividing the categories into separate models if appropriate. In addition to last year's model (Model 1), the categories were "data and data structure" (Model 2), "selectivity and catchability" (Model 3) and "age and growth" (Models 4-6). To simplify the analysis and make models more comparable for this preliminary assessment, input standard deviations of all *dev* vectors appearing in Model 1 were held constant in all other models using those same vectors. Similarly, catchabilities in all models were held constant at the values used in Model 1, except for Model 3, where estimation of catchability was an explicit feature of the model.

Model 1 is the basis for Model 2, and Model 2 is the basis for Models 3-6.

Data for all models were the same as those used in last year's assessment, with the following exceptions:
1) Size composition data were re-assembled for Models 2-6 (see description under Model 2 below).
2) IPHC survey data (both CPUE and size composition) and *fishery* age data (both age composition and mean size at age) were not used in Models 2-6.
3) *Survey* age data (both age composition and mean size at age) were not used in Models 3-6.

Model 1 (last year's model)

Model 1 is the model recommended by the authors and adopted by the BSAI Plan Team and SSC in 2009 (Thompson et al. 2009). Briefly, some features that characterized last year's model were as follow:
1) Growth rates were cohort-specific.
2) The standard deviation of length at age was estimated outside the model as a linear function of mean length at age.
3) Potential ageing bias was accounted for in the ageing error matrix by examining alternative bias values in increments of 0.1 for ages 2 and above and choosing the value (0.4) that gave the highest log-likelihood (age-specific bias values were also examined, but did not improve the fit significantly).
4) Mean size-at-age data were included (because trawl survey size composition data were not used for any year in which trawl survey age composition data were used, and because fishery size composition data give almost no information about ages 1 or 2, inclusion of mean size-at-age data was necessary for meaningful estimation of cohort-specific growth).
5) Pre-1982 trawl survey catchability was fixed at 1.0.
6) Catchability for the post-1981 trawl survey was fixed at the value that set the average (weighted by numbers at length) of the product of catchability and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007).
7) Fishery selectivity was modeled as a function of length and was defined separately for various combinations of gear, season, and block of years (blocks of years come in 5, 10, or 20-year increments).
8) Trawl survey selectivity was modeled as a function of age and was defined separately for the pre-1982 and post-1981 portions of the time series.
9) Pre-1982 trawl survey selectivity was constant across years.
10) Ascending "width" of the post-1981 trawl survey selectivity varied yearly, except that survey selectivity was held constant at base values for the two most recent years (i.e., no selectivity *devs* were estimated for those years).
11) Input standard deviations of all *dev* vectors were set iteratively by matching the standard deviations of the set of estimated *dev*s.

Model 2 (data and data structure)

Model 2 deals with changes in data and data structure (except for changes in use of trawl survey age data, which are dealt with in Models 4-6). These changes were: to exclude the IPHC survey data (this was an SSC request), to exclude the fishery age data (also an SSC request), to use a finer length bin structure, and to re-evaluate the seasonal structure. The SSC's reason for wishing to exclude the IPHC survey data is that the CPUE observations were inversely correlated with the estimated values for all 14 models considered in last year's assessment. The SSC's reason for wishing to exclude the fishery age data (which consist of a single record of age composition data and a single record of mean size-at-age data, both from the 2008 January-May longline fishery) was that these data seemed to be at odds with the rest of the data in last year's assessment. For example, the mean lengths at ages 3-5 from the 2008 January-May longline fishery are higher than the mean lengths at those ages in any of the 15 years of survey age data, exceeding the survey averages by 2.5-4.0 standard deviations, despite the fact that the fishery data were collected earlier in the year than the survey data.

In Plan Team discussions, the features of Model 2 were described as "incremental," the idea being that individual features would be explored separately, then combined as appropriate. Therefore, the development of Model 2 described below goes beyond a description of model structure and ventures into the realm of model results, so that the effects of individual features and combinations of features can be evaluated.

Model 2 was developed as follows: The first step was to remove the IPHC survey data (both CPUE and size composition) from Model 1, resulting in Model 2.1. The second step was to remove the fishery age data (both age composition and mean size at age) from Model 2.1, resulting in Model 2.2.

Values of the objective function, spawning biomass (t) in 2009, spawning biomass in 2009 relative to $B_{35\%}$, and age 0 recruits in 2006 are shown below, along with the proportional change in each estimate relative to Model 1:

		Spawning biomass 2009		SB2009 per $B_{35\%}$		Recruits 2006 (1000s)	
Model	Obj. func.	Estimate	Change	Estimate	Change	Estimate	Change
1	2600.04	312,618	0.000	0.985	0.000	727,095	0.000
2.1	2587.83	312,182	-0.001	0.985	0.000	728,470	0.002
2.2	2461.33	317,105	0.014	0.994	0.009	689,081	-0.052

Time series of spawning biomass, spawning biomass relative to $B_{35\%}$, and age 0 recruits for Models 1, 2.1, and 2.2 are plotted in Figure 2.1.1. Throughout the time series, the spawning biomass estimates from Model 2.1 are within 1.2% of those from Model 1; and from 1983 onward, the spawning biomass estimates from Model 2.2 are within 5.7% of those from Model 1.

Model 2.2 then formed the baseline for a factorial design involving various aspects of season structure and bin structure. Factors and options within factors are shown in italics in the following paragraphs.

Season structure in the BSAI Pacific cod model has traditionally consisted of three seasons defined as January-May, June-August, and September-December. This structure dates from the 1993 assessment, and was suggested by industry representatives. It did not have an explicit statistical basis. In an attempt to develop a statistically derived seasonal structure, the catch data from 2003-2008 were averaged by month across years. For a given putative season (e.g., January-May), monthly average catches were assumed to be drawn from a lognormal distribution with season-specific μ and σ. All possible numbers of seasons and all possible combinations of monthly starting and ending dates for each season were considered (note that no more than six seasons per year are possible, because at least two observations (months) are required to compute the maximum likelihood estimate of a season-specific σ). The optimal season structure, as determined by minimum AIC, was five seasons defined as January-February, March-April, May-July, August-October, and November-December (Figure 2.1.2). *The factorial design includes two options with respect to seasonal structure per se: 1) the old, three-season structure; and 2) the new, five-season structure.*

Changing from three to five seasons requires two additional decisions. First is whether the catch data alone will be partitioned accordingly, or whether survey selectivity schedules will also follow the new partition. To simplify matters, this preliminary assessment retains the old pattern of three selectivity seasons, but the beginning and ending dates were changed slightly in some cases so that the catch seasons would be subsets of the selectivity seasons. This was done by combining catch seasons 1 and 2 into the first selectivity season (January-April), equating the second selectivity season with catch season 3 (May-July), and combining catch seasons 4 and 5 into the third selectivity season (August-December). The resulting set of selectivity seasons is close to the old set, with starting or ending points (or both) differing by one month in each selectivity season. *All models using the new, five-season structure for catch in the factorial design retain the use of three selectivity seasons, but with starting and ending dates adjusted as described here.*

The second decision related to the change from three to five seasons is the timing of each year's spawning event. Prior to the 2005 assessment, spawning was specified to occur in March, which was estimated to be the month of peak spawning based on maturity data. However, with the move to SS2 in the 2006 assessment, the month of peak spawning was constrained to coincide with the start of one of the specified seasons. Given that seasons 1 and 2 were specified to begin in January and June and that January seemed to be a more biologically realistic choice than June, the 2006-2009 assessments specified the beginning of season 1 (January) as the time when spawning would occur in the model. However, under the new season structure, season 2 begins in March, which would allow the model to compute spawning biomass in the month where spawning is estimated to peak in the real population. *The factorial design includes two options with respect to timing of annual spawning for all models using the new, five-season structure: 1) beginning of season 1 (January), and 2) beginning of season 2 (March).*

Beginning with the 1993 assessment, the length bin structure in the BSAI Pacific cod model has consisted of a length range spanning 9 cm to 105 cm (where the 105 cm bin constitutes a "plus" group), with 3 cm bins used for fish smaller than 45 cm and 5 cm bins used for fish 45 cm and larger, for a total of 25 bins. This structure was adopted in part due to computational limits associated with the desktop computers used in the 1993 assessment. To take advantage of the greater computational power afforded by today's computers, an alternative bin structure was devised. The first step in doing so was to reconsider the bounds of the length range. The new lower bound of the overall range was set at 4 cm, corresponding to the smallest fish observed in the trawl survey; and the new lower bound of the "plus" group was set at 120 cm, corresponding approximately to the upper 99.9th percentile of observations in the fishery observer database. The second step was to reconsider the bin size. Lengths in both the post-1981 survey and observer databases are recorded to the nearest cm, so bins smaller than 1 cm would not be expected to improve parameter estimates. To provide the maximum amount of contrast with the current bin structure, the new bin size was set at 1 cm throughout the length range. *The factorial design includes two options with respect to bin structure: 1) the old structure, with a combination of 3 cm and 5 cm bins spanning the 9-105+ cm range; and 2) the new structure, with 1 cm bins spanning the 4-120+ cm range (except for the pre-1982 trawl survey, where the old structure has been retained due to unavailability of the raw data).*

Use of the new bin structure required re-assembling the fishery size composition data from the observer database, because the existing size composition data were not stored in 1 cm bins. Re-assembling the data involved the following changes: 1) various small changes resulting from routine corrections to the observer database, 2) substitution of raw data from the years 1990-2006 for bootstrapped data from those years (which had been used in the 2007-2009 assessments), and 3) incorporation of a large number of 2009 data that were not available in time for use in the 2009 assessment. *The factorial design includes two options with respect to use of re-assembled ("new") fishery size composition data: 1) new data in all years except 2009, and 2) new data in all years.*

The full factorial design is shown below (shaded cells highlight differences within each 4-model group):

Model	Season structure	Sizecomp data	Bin structure	Spawning season
2.2	old	old	old	1
2.3.1	old	new except 2009	old	1
2.3.2	old	new except 2009	new	1
2.3.2	old	new	old	1
2.3.4	old	new	new	1
2.4.1	new	new except 2009	old	1
2.4.2	new	new except 2009	old	2
2.4.3	new	new except 2009	new	1
2.4.4	new	new except 2009	new	2
2.5.1	new	new	old	1
2.5.2	new	new	old	2
2.5.3	new	new	new	1
2.5.4	new	new	new	2

Note that use of season 2 to define the time of peak spawning in the "old" season structure is not biologically reasonable, which is why the factorial design includes only 12 models rather than 16.

Values of the objective function, spawning biomass (t) in 2009, spawning biomass in 2009 relative to $B_{35\%}$, and age 0 recruits in 2006 (the most recent year class observed in at least two survey years) are shown below, along with the proportional change in each estimate relative to Model 2.2 (rows shaded yellow correspond to models with spawning at the start of new season 2 (March) to emphasize that spawning biomass values for these models are not strictly comparable to values for models with spawning at the start of season 1; pink cells indicate relative changes with absolute value greater than 10%):

		Spawning biomass 2009		SB2009 per $B_{35\%}$		Recruits 2006 (1000s)	
Model	Obj. func.	Estimate	Change	Estimate	Change	Estimate	Change
2.2	2461.33	317,105	0.000	0.994	0.000	689,081	0.000
2.3.1	2538.07	316,671	-0.001	0.987	-0.007	687,258	-0.003
2.3.2	2769.32	311,296	-0.018	0.986	-0.008	716,873	0.040
2.3.2	2631.57	273,245	-0.138	0.873	-0.121	809,159	0.174
2.3.4	2863.39	269,962	-0.149	0.876	-0.119	848,919	0.232
2.4.1	3995.80	326,688	0.030	0.968	-0.026	714,378	0.037
2.4.2	4131.94	270,999	-0.145	0.894	-0.100	665,017	-0.035
2.4.3	4371.81	314,650	-0.008	1.029	0.035	720,416	0.045
2.4.4	4497.33	261,624	-0.175	0.949	-0.046	672,934	-0.023
2.5.1	4138.12	271,813	-0.143	0.829	-0.165	831,844	0.207
2.5.2	4274.91	224,472	-0.292	0.763	-0.232	769,145	0.116
2.5.3	4522.12	262,549	-0.172	0.882	-0.112	839,977	0.219
2.5.4	4650.23	216,704	-0.317	0.807	-0.188	779,741	0.132

Some patterns pertaining to the estimates of spawning biomass in 2009 are evident from the above table:

1) All but one (2.4.1) of the models using the new seasonal structure show a decrease relative to Model 2.2 (average relative change = –0.153).
2) Only half of the runs using new sizecomp data in all years except 2009 show a decrease relative to Model 2.2 (average relative change = –0.046), but *all* of the runs using new size composition data in *all* years show a decrease relative to Model 2.2 (average relative change = –0.202).

3) All but one (2.3.2) of the models using the new bin structure show a decrease relative to Model 2.2 (average relative change = –0.133).
4) All of the models with spawning in season 2 show a decrease relative to Model 2.2 (average relative change = –0.232).

Time series of spawning biomass, spawning biomass relative to $B_{35\%}$, and age 0 recruits for Models 2.2-2.5.4 are plotted in Figure 2.1.3.

It should be noted that Hessian matrices were not computed for any of the models in the 2.x series except for Model 2.5.4.

Model 2.5.4 is the final version of Model 2 in this preliminary assessment. This should not be taken to imply that all of the changes leading from Model 1 to Model 2.5.4 are insignificant (in fact, some of them are substantial). Rather, justification for their use is as follows:
1) Omission of the IPHC data and the fishery age data was requested by the SSC, and the impacts on ending spawning biomass appear to be small.
2) The new catch seasons are a better representation of catch patterns than the old catch seasons, statistically speaking.
3) Although some of the changes resulting from new size composition data are due to disuse of bootstrapped data from the years 1990-2006, most of the changes appear to be due to the incorporation of data from 2009 that were not available for use in last year's assessment, and these new 2009 data will almost certainly be used in the final assessment.
4) The new (1 cm) bin structure corresponds to the actual resolution of the observations, and therefore provides maximum ability to infer selectivity and growth patterns from size composition data.
5) March appears to be the peak spawning time for Pacific cod, so it is biologically more reasonable to specify spawning as taking place at the start of new season 2 (March) than the start of season 1 (January).

Except for the features related to use of the new season structure and new bin structure, Model 2 is identical to Model 1.

Model 3 (selectivity and catchability)

Model 3 deals with use of informative prior distributions to the estimation of selectivity parameters and catchability. In last year's assessment, all selectivity parameters had uniform prior distributions, catchability for the pre-1982 portion of the trawl survey time series was fixed at 1.0, and catchability for the post-1981 portion of the trawl survey time series was estimated iteratively by setting the average (weighted by numbers at length) of the product of catchability and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007).

Inclusion of Model 3 in this preliminary assessment was prompted by the following considerations:
1) As in previous assessments, some of the selectivity curves estimated in last year's assessment featured fairly abrupt and difficult-to-rationalize changes, and surprisingly low values for large fish. Moreover, minor changes in starting values of parameters often led to large changes in ending values of the objective function. These features suggest that incorporation of prior knowledge regarding likely values of selectivity parameters might improve model behavior.
2) The point estimate obtained by Nichol et al. was based on only 11 fish, and the distribution of this quantity was shown in last year's assessment to be extremely diffuse (Thompson et al. 2009, p. 428). This makes it desirable to examine how the estimate of catchability might change if catchability were not assumed to be known with certainty.

Before discussing suitable prior distributions for selectivity parameters, it will prove worthwhile to review the functional form of the selectivity curve and its parameterization. The functional form (SS pattern 24 for length-based selectivity, SS pattern 20 for age-based selectivity) is constructed from two underlying and linearly rescaled normal distributions, with a horizontal line segment joining the two peaks. This form uses the following six parameters:

1) *beginning_of_peak_region* (where the curve first reaches a value of 1.0)
2) *width_of_peak_region* (where the curve first departs from a value of 1.0)
3) *ascending_width* (equal to twice the variance of the underlying normal distribution)
4) *descending_width* (equal to twice the variance of the underlying normal distribution)
5) *initial_selectivity* (at minimum length/age)
6) *final_selectivity* (at maximum length/age)

All but *beginning_of_peak_region* are transformed: The *ascending_width* and *descending_width* are log-transformed and the other three parameters are logit-transformed.

The candidate prior distributions were all assumed to be normal except for the *beginning_of_peak_region*. This parameter was assumed to have a symmetric beta prior distribution instead, because the bounds placed on the *beginning_of_peak_region* would cause a normal prior distribution to behave awkwardly unless the standard deviation were set at a very small value.

Development of candidate prior means for the selectivity parameters proceeded as follows:

1) The (logit-transformed) *width_of_peak_region* was set at 0.0. This results in the selectivity curve being flat between *beginning_of_peak_region* and the midpoint between *beginning_of_peak_region* and the maximum size/age.
2) The (logit-transformed) *initial_selectivity* was set at -5.0. This results in selectivity equaling approximately 0.0 at the minimum size/age.
3) Provisionally, the (log-transformed) *descending_width* was set at 10.0 and the (logit-transformed) *final_selectivity* was set at 5.0 (these provisional values get changed in steps 5 and 6 below). This results in a provisional selectivity curve equaling approximately 1.0 for all sizes/ages above the *beginning_of_peak_region*.
4) The *beginning_of_peak_region* and *ascending_width* were then set by forcing the provisional selectivity curve to match the maturity curve (in units of size or age, as appropriate) as closely as possible, using least squares as the criterion.
5) Given the values of *width_of_peak_region* and *beginning_of_peak_region* obtained in steps 1 and 4 respectively, the (log-transformed) *descending_width* was then re-set (from the provisional value used in step 3) so as to locate the descending inflection point midway between the end of the peak region and the maximum size/age.
6) The (logit-transformed) *final_selectivity* was then re-set (from the provisional value used in step 3) to a value of 0.0. This results in selectivity equaling 0.5 at the maximum size/age.

If all parameters are set at their respective means as defined above, it is worth noting that the portion of the selectivity curve to the right of the *beginning_of_peak_region* is dependent on the specified maximum size/age (actually the lower bound of the "plus" group). For this preliminary assessment, the lower bound of the age+ group was kept at the value of 20 years that has been used since the 2005 assessment (note that the Plan Teams and SSC rejected a proposal to reduce this to 15 years—Table 2.1.1). As discussed under Model 2 above, the lower bound of the length+ group was set at 120 cm, based on the approximate 99.9^{th} percentile of the lengths in the observer database. These values are thus not arbitrary, but it should be emphasized that other values could have been chosen.

Candidate prior standard deviations were specified so as to satisfy a desired coefficient of variation for each of the following "natural scale" quantities:

1) the *beginning_of_peak_region*

2) the logistic transform of the *width_of_peak_region* (i.e., the actual width of the peak region)
3) the square root of the *ascending_width*/2 (i.e., the standard deviation of the ascending normal)
4) the square root of the *descending_width*/2 (i.e., the standard deviation of the descending normal)
5) the logistic transform of the *initial_selectivity* (i.e., the actual initial selectivity)
6) the logistic transform of the *final_selectivity* (i.e., the actual final selectivity)

For this preliminary assessment, the desired coefficient of variation was set at 50%.

One difficulty with the double-normal selectivity curve is that it is sometimes difficult to infer how prior distributions of the parameters translate into prior distributions on selectivity itself. To make this inference easier, the prior distributions specified above were used to simulate a large number of selectivity curves by drawing parameter values randomly from the prior distributions. Figures 2.1.4 and 2.1.5 show some results of this exercise, for length-based and age-based selectivity, respectively. In each of these figures, the red curve shows the selectivity corresponding to the means of the prior distributions, the blue diamonds show the median selectivity resulting from the simulations, and the blue error bars show the inter-quartile range resulting from the simulations.

A possible shortcoming of Figures 2.1.4 and 2.1.5 is that the inter-quartile range is based on the distribution of selectivities at each size/age taken one at a time, and thus may not provide sufficient information about how selectivities tend to change *across* size/age. To mitigate this possible shortcoming, Figures 2.1.6 and 2.1.7 show the distributions of the multiplicative inverse (reciprocal) of the slope at the ascending inflection point, a quantity which indicates how many units of size/age would be needed to move from a selectivity of 0.0 to a selectivity of 1.0 if the slope of the ascending limb were held constant at the inflection slope. The inter-quartile range for length-based selectivity (Figure 2.1.6) extends from 17.5 to 34.9 cm, and the inter-quartile range for age-based selectivity (Figure 2.1.7) extends from 2.7 to 5.3 years.

For survey catchability (which is log-transformed in SS), a normal prior distribution was specified, with mean 0.0 and standard deviation 0.472. When back-transformed, this corresponds to a lognormal prior with mean 1.0 and a 50% coefficient of variation. A mean of 1.0 (on the natural scale) was viewed as appropriate because the relative magnitudes of typical off-bottom distribution and possible dive response to an oncoming vessel are not precisely quantified, and the effects of these two behaviors would tend to move catchability in opposite directions. The 50% coefficient of variation was chosen to match the value used for the selectivity prior distributions.

Except for the selectivity and catchability prior distributions (and treating catchability as a free parameter), Model 3 is identical to Model 2.

Model 4 (age and growth)

Model 4 is the first of the three models in the “age and growth” group, all of which exclude all age data (both age composition and mean size at age) and all of which describe maturity as a function of length rather than age.

Except for excluding all age data and describing maturity as a function of length rather than age, Model 4 is identical to Model 2.

Model 5 (age and growth)

Model 5 is the second of the three models in the "age and growth" group. It is distinguished from Models 1-4 by internal estimation of the two parameters governing conditional variability in length at age. The term "conditional variability" is used here to distinguish "between-individuals" variability in length at age *given a set of von Bertalanffy growth parameters* from "between-cohorts" or "between-years" variability *in the von Bertalanffy growth parameters themselves*. In all models in this preliminary assessment, the conditional standard deviation of length at age is modeled as a linear function of length at age.

Except for internal estimation of the two parameters governing conditional variability in length at age, Model 5 is identical to Model 4.

Model 6 (age and growth)

Model 6 is the third of the three models in the "age and growth" group. It is distinguished from Models 1-5 by use of year-specific *devs* for each of the three von Bertalanffy growth parameters, rather than the use of single growth *devs* for each cohort in Models 1-5. In Models 1-5, *devs* were estimated for each cohort from 1977 through 2008. In Model 6, *devs* were estimated for each year from 1982 through 2009. Attempts were made to estimate year-specific devs prior to 1982, but these tended to be extremely unrealistic, likely due to the fact that size composition information for small fish at 1-cm resolution is not available prior to the 1982 trawl survey. As with other *dev* vectors, the input standard deviations for the von Bertalanffy *devs* were set iteratively, by matching the input and output standard deviations.

Except for use of year-specific *devs* for each of the three von Bertalanffy growth parameters and disuse of single growth *devs* for each cohort, Model 6 is identical to Model 5.

Parameters Estimated Independently

Natural mortality

The natural mortality rate is fixed at a value of 0.34 in all models.

Variability in estimated age

The slope of the proportional relationship between the standard deviation of estimated age and age was set at 0.088 in all models.

Variability in length at age

Models 1-4 set the standard deviation of length corresponding to length-at-age-0 at a value of 0.01 and the standard deviation of length corresponding to length-at-age-20 at a value of 8.68. Models 5 and 6 estimated these parameters internally.

Weight at Length

For Model 1, the season-specific weight-at-length parameters estimated in the 2008 assessment are used. These were determined from all weight-length records present in the observer database (both shore-based and at-sea samples) as of the 2008 assessment, giving the following values:

Season:	Jan-May	Jun-Aug	Sep-Dec	Annual
α:	5.705×10^{-6}	9.055×10^{-6}	5.774×10^{-6}	6.161×10^{-6}
β:	3.184	3.065	3.183	3.165
Samples:	54,798	13,370	22,710	90,878

For Models 2-6, new season-specific parameters were computed from the same data set in order to comply with the new seasonal structure of the models, giving the following values:

Season:	Jan-Feb	Mar-Apr	May-Jul	Aug-Oct	Nov-Dec
α:	3.741×10^{-6}	7.221×10^{-6}	9.406×10^{-6}	6.987×10^{-6}	4.356×10^{-6}
β:	3.296	3.122	3.054	3.134	3.253
Samples:	21,616	25,818	20,734	12,754	9,956

The weight-length parameters for the new seasonal structure give a better (lower) AIC than the weight-length parameters for the old seasonal structure.

Maturity

Models 1-3 use an age-based logistic maturity schedule with intercept = 4.9 years and slope = -0.965. Models 4-6 use a length-based logistic maturity schedule with intercept = 58 cm and slope = -0.132. Both schedules are taken from Stark (2007).

Parameters Estimated Conditionally

Parameters estimated conditionally (i.e., within individual SS runs, based on the data and the parameters estimated independently) in all models include mean length at age 0, the Brody growth coefficient *K*, asymptotic length, log mean recruitment before and after the 1977 regime shift, initial fishing mortality, fishery selectivity parameters for various combinations of gear, season, and block of years; pre-1982 and post-1981 trawl survey selectivity parameters; annual recruitment deviations, annual deviations in the ascending limb of the post-1981 trawl survey selectivity curve, and cohort-specific deviations in growth (except Model 6).

Additional parameters estimated conditionally in Model 1 consist of two parameters used to describe the IPHC survey selectivity schedule.

Additional parameters estimated conditionally in Model 3 consist of the pre-1982 and post-1981 trawl survey catchabilities.

Additional parameters estimated conditionally in Model 5 consist of the standard deviation of length at length-at-age-0 and the standard deviation of length at length-at-age-20.

Additional parameters estimated conditionally in Model 6 consist of the standard deviation of length at length-at-age-0, the standard deviation of length at length-at-age-20, and annual deviations for each of the three von Bertalanffy growth parameters in the years 1982-2009.

No additional parameters were estimated conditionally in Models 2 or 4.

Results

Goodness of Fit

Table 2.1.2 shows the number of parameters along with values of the objective function (both in aggregate and broken down by category) for Models 1-6.

Using Model 2 as a reference point, differences in number of parameters can be explained as follows: Model 1 has two more parameters than Model 2 because Model 1 includes parameters that describe the selectivity schedule of the IPHC survey. Model 3 has two more parameters than Model 2 because the pre-1982 and post-1981 trawl survey selectivity schedules are estimated internally in Model 3. Model 4 has the same number of parameters as Model 2. Model 5 has two more parameters than Model 4 because it estimates conditional variability in length at age internally. Model 6 has 54 more parameters than Model 2 because it estimates conditional variability in length at age internally (+2 parameters), it does not estimate cohort-specific growth *devs* for 1977-2008 (–32 parameters), but it does estimate annual *devs* for each of the three von Bertalanffy growth parameters for 1982-2009 (3×28 = +84 parameters).

It is important to emphasize that the log likelihood values shown in Table 2.1.2 are comparable across Models 4-6 only. Model 1 uses a different data file; and Models 2-3, while they use the same data file as Models 4-6, do not assign zero weight to the age data like Models 4-6 do. Also, Model 3 uses informative prior distributions for selectivity parameters and survey catchabilities. Because the log likelihoods for Models 4-6 are comparable, AIC could be used to compare these models if all parameters were unconstrained. However, because the growth *dev* vectors in Model 6 are constrained, AIC is not an ideal measure for comparing Model 6 with Models 4 and 5. Model 5 is superior to Model 4 on the basis of AIC. If AIC is at least approximately valid, Model 6 is superior to Model 4 or Model 5.

Table 2.1.3 shows the ratio of mean effective sample size to mean input sample size for the size composition data. Here, the results from Model 1 are not comparable to the others, because Model 1 uses a different set of input sample sizes. Even Models 2-6 are not perfectly comparable, however, because Models 2 and 3 do not attempt to fit the size composition data from the trawl survey in years where age composition data are available. It is also probably important to remember that Models 4-6 are able to focus more attention on fitting the size composition data because they ignore the age composition data and the mean size-at-age data. With these caveats in mind, Model 6 tends to produce the highest values in Table 2.1.3.

Table 2.1.4 shows the ratio of effective sample size to means input sample size for each record of age composition data, and overall for the post-1981 trawl survey age composition data. Here, Model 1 tends to do the best, but is probably important to remember that the simpler seasonal structure used in Model 1 results in many fewer records of size composition data, which, because the *average* input sample size is fixed at 300 for all models, means that Model 1 can focus more attention on fitting the age composition data than Models 2 or 3 (Models 4-6 ignore the age composition data entirely).

Figure 2.1.8 shows how well Models 1-8 fit the trawl survey time series of population numbers. The upper panel shows the observed and estimated abundances, and the lower panel shows the time series of standardized residuals. The means and standard deviations of the standardized residual time series are shown below:

Quantity	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Mean:	0.32	0.28	0.08	0.40	0.35	0.29
Standard deviation:	1.76	1.78	1.83	1.94	1.55	1.43

Model 3 comes closest to achieving a mean of 0.0, and Model 6 comes closest to having a standard deviation of 1.0. Models 4-6 do a noticeably better job than the others in fitting the observations from 1997-1999, but a noticeably worse job than the others in fitting the observations from 2008-2009.

Estimates of Length at Age, Catchability, and Selectivity at Length or Age

Figure 2.1.9 shows three ways of comparing the length at age estimates produced by the six models. Each model produces a mean length at each age in each year, meaning that each model produces a distribution of mean lengths at each age. The upper panel compares the medians of these distributions across models. Given the thickness of the lines in the graph and the height of the vertical axis, the six curves might appear to be almost identical. The middle panel shows a different way of comparing these data, by expressing the medians for each model in terms of their differences from the medians for Model 1. Here, the medians may not appear so similar as in the upper panel. For example, the medians for Models 4 and 6 at age 0 are 6-9 cm lower than the median for Model 1 at age 0. The medians for Models 2, 3, and 5 are pretty consistently 1-4 cm lower than the medians for Model 1. The lower panel shows the range of mean lengths at age for the six models. The ranges for Models 1-3 all peak between about 6 and 7 cm, with each peak each occurring at age 4. The range for Model 4 is about 8 cm, occurring at age 3; and the range for Model 5 is about 9 cm, occurring at age 4. The pattern for Model 6 is very different from the pattern for the other five models, with the range peaking at about 27 cm at age 0, then decreasing to a value of about 10 cm at age 12, then increasing again to between 11 and 12 cm at age 20. The main reason for the different pattern exhibited by Model 6 is likely the input standard deviations for the annual *devs* in the von Bertalanffy growth parameters, which were 0.29 for length at age 0, 0.10 for asymptotic length, and 0.29 for the Brody growth coefficient *K* (these are all multiplicative *dev* vectors, so the standard deviation is approximately equal to the coefficient of variation). In contrast, the input standard deviation for the cohort-specific growth *dev* vector in Models 1-5 was only 0.04. This may indicate that matching the output standard deviations is not an appropriate way to set the input standard deviations for annual *dev*s in the von Bertalanffy parameters, or it may indicate that these *dev* vectors are tracking something other than actual changes in the von Bertalanffy parameters.

Figure 2.1.10 plots standard deviation of length at age versus mean length at age in the data and as estimated by Models 1-6. The black dots ("data") represent 15 years' worth of mean lengths and standard deviations of length at ages 1-9, and the solid black line represents the least-squares regression through those data. Models 1-3 approximate the regression very closely. Models 4-6 tend to exceed the regression by averages of about 0.4 cm, 1.7 cm, and 1.3 cm, respectively.

Another way to measure model performance in terms of matching size at age is to compare the models' average sizes at ages 1-3 (as estimated over the period 1982-2009) against the first three size modes from the long-term average trawl survey size composition, as shown in the table below (all sizes are in cm):

Mode	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
14	16.617	14.073	14.080	13.953	13.805	13.173
32	32.317	30.313	30.304	31.771	29.975	31.512
45	44.931	43.198	43.198	45.449	42.809	45.178

The root-mean-squared-errors (RMSEs), measured on both linear and log scales, are as follow:

Scale	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Linear	1.522	1.426	1.430	0.292	1.726	0.564
Log	0.099	0.039	0.039	0.007	0.048	0.036

On either a linear or log scale, Model 4 comes closest to matching the survey modes in terms of RMSE, followed by Model 6. Model 5 does the worst when RMSE is measured on a linear scale, while Model 1 does the worst when RMSE is measured on a log scale.

Finally, model performance in terms of matching size at age can be measured by comparing annual estimates of size at age 1 against annual mean size at age 1 against observed size at age 1, as shown in Table 2.1.5. In terms of RMSE, Model 1 does the best job of matching observed size at age 1 (RMSE=1.22), while Model 6 does the worst (RMSE=6.93). Annual sizes at age 1 estimated by Models 1-4 all have positive correlations with observed mean sizes at age 1, Model 5 produces a negative correlation, and the correlation for Model 6 is virtually zero. Model 4 has the highest correlation (0.63), which is somewhat surprising, given that Model 4 does not attempt to fit the size-at-age data.

Catchability in all models except Model 3 was fixed at 1.00 (log = 0.00) for the pre-1982 portion of the trawl survey time series and 0.77 (log = -0.26) for the post-1981 portion. For Model 3, the estimated values were 1.18 (log = 0.16) and 0.84 (log = -0.17), respectively.

Selectivity at age for the post-1981 portion of the trawl survey time series is shown for each model in Figure 2.1.11. Visually, there does not appear to be much difference between Models 1-3. Models 4-5 have more pronounced kinks in the selectivity schedules, and Model 6 looks fairly similar to Models 1-3.

Fishery selectivities at length for Models 1-6 are shown in Figures 2.1.12.1-2.1.12.6, respectively. Visually, the curves appear very similar across the six models. The informative prior distributions used in Model 3 may have helped to smooth out the kinks in the 1990-1994 curve for the Aug-Dec trawl fishery (analogous to the Sep-Dec trawl fishery for Model 1), but other impacts of these prior distributions are not particularly obvious.

Estimates of Time Series

Time series of estimated spawning biomass, spawning biomass relative to $B_{35\%}$, and age 0 recruits are shown for each of the six models in Figures 2.1.13, 2.1.14, and 2.1.15, respectively. The upper panel in each figure shows the point estimates, and the lower panel shows the coefficients of variation associated with those estimates.

In Figure 2.1.13, Model 1 results in the highest 2009 spawning biomass, although Model 6 is only about 12% lower. Model 5 gives the lowest 2009 spawning biomass, about 43% below Model 1. Model 3 is nearly as low, about 40% below Model 1. It is important to remember that Model 1 measures spawning biomass in January, while Models 2-6 measure it in March, so the estimates from Models 2-6 would be expected to be lower so long as mortality exceeds growth, all else being equal. The trajectory estimated by Model 6 has more abrupt changes than the trajectories estimated by the other models, which is probably due to the large interannual changes in growth parameters estimated by Model 6. Model 6 also has the largest coefficients of variation throughout most of the time series.

In Figure 2.1.14, the 2009 ratios of spawning biomass to $B_{35\%}$ for Models 1-5 are much closer to one another than the 2009 spawning biomasses themselves. The time series for Model 6 is much higher than the time series for any of the other models, with more abrupt changes. Model 6 also has the largest coefficients of variation throughout most of the time series.

In Figure 2.1.15, the age 0 recruitment trajectories are fairly similar across models, with the possible exception of Model 6. The correlations between the time series estimated by Models 1 and 6, 2 and 6, 3 and 6, 4 and 6, and 5 and 6 are 0.70, 0.82, 0.79, 0.73, and 0.89, respectively. No other pairwise comparison between models has a correlation smaller than 0.91. Model 6 also estimates a below-average recruitment in 1977, in contrast to all the other models. The estimate of 2006 age 0 recruitment is highest in Models 4-6, ranging from 40-43% higher than in Model 1. Model 2's estimate is about 7% higher than in Model 1, and Model 3's estimate is about 5% lower than in Model 1. Unlike Figures 2.1.13 and 2.1.14, Model 6 does not have the highest coefficient of variation for the majority of the time series in Figure 2.1.15. Model 6 has the highest coefficient of variation in 16 of the 32 years, Model 5 has the highest coefficient of variation in 15 years, and Model 3 has the highest coefficient of variation in one year.

Discussion

The six models requested by the Plan Teams and SSC are broadly similar in many respects. The estimated time series of spawning biomass, spawning biomass relative to $B_{35\%}$, and age 0 recruitment for the most part show at least qualitatively similar shapes. A possible exception is Model 6, which has many more parameters than the other models and fairly large input standard deviations for the annual *devs* in the three von Bertalanffy parameters.

Each of the features associated with Models 2-6 presents a decision point for the Plan Teams and the SSC in developing model requests for the final assessment. Some (all?) of them can also be subdivided into multiple decision points. For example, Model 6 is distinguished by removal of the cohort-specific growth *devs* found in Models 1-5 and incorporation of year-specific *devs* for each of the three von Bertalanffy growth parameters instead. Because the input standard deviations of all other *dev* vectors was set iteratively by matching the output standard deviations, the same procedure was used here for the three von Bertalanffy *dev* vectors in Model 6. However, this resulted in very large values for the input standard deviations, which resulted in some model behavior that is difficult to rationalize. One option would be to retain the three von Beralanffy *dev* vectors, but use some other method to specify the input standard deviations (of course, it would be important for the Plan Teams or SSC to specify what other method they would like to use).

One obvious decision point is whether to use the age data for none, some, or all of the models in the final assessment. If one or more totally "age-free" models is desired, a related decision is whether to keep the current natural mortality rate, which is based on the age at 50% maturity, or use a natural mortality rate derived from a length-based maturity schedule.

Another decision point that is worth discussing in some detail is whether the new season structure and bin structure used in Models 2-6 should be retained or modified for the final assessment. Although the new season structure has a more explicit statistical justification than the old season structure, and although the new bin structure makes the fullest possible use of the information contained in the size composition data, one cost of adopting these two new data structures is that models take much longer to run. For example, when starting from a converged parameter file, computing the Hessian matrix for Model 1 took about 14 minutes. In contrast, when starting from converged parameter files, computing the Hessian matrices for Models 2-6 took an average of about 3 hours and 50 minutes, more than 16 times as long as Model 1. When starting from something other than a converged parameter file, run times under the new data structures can be much longer still.

Another decision point is whether to keep fixing survey catchability at the level that sets the average (weighted by numbers at length) of the product of catchability and selectivity for the 60-81 cm size range equal to the point estimate obtained by Nichol et al. (2007). When catchability is estimated (rather than fixed) in Model 3, resulting biomass estimates are lower than in the other models, but still much higher than survey biomass estimates.

Because of the much longer run times associated with Models 2-6, little testing for global minimization of the objective function was done in this preliminary assessment. This is in sharp contrast to previous assessments in recent years (both preliminary and final), when many hundreds of "jitter" runs were conducted to test whether SS had found the global minimum of the objective function.

The simplicity of the old data structures and the resulting short run times, contrasted with the complexity of the new data structures and the resulting long run times, imply a dilemma: On the one hand, finding the global minimum of the objective function is more likely under the old data structures, but it is also more likely that the global minimum will give inaccurate parameter estimates (because the coarseness of the old data structures can mask the true behavior of the system). On the other hand, finding the global minimum of the objective function is less likely under the new data structures, but it is more likely that the global minimum (if found) would give accurate parameter estimates.

As with the other new features of Models 2-6, the issue of data structures is not necessarily a binomial one, as many possible data structures of intermediate complexity can be imagined. In the case of bin structure, for example, bins could be 2 cm wide throughout the length range rather than 1 cm, or bins could be 1 cm wide up to lengths of 40 cm and 2 cm wide for all larger lengths. Many other intermediate structures are also possible.

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Table 2.1.1. Proposed model features and final model requests. “Group” is a designation intended to combine related proposals. Column colors are intended to help match models or sets of models with groups of proposals.

		Model(s) where proposal is used					
Group	Proposal	1	2	3	4	5	6[1]
Last year's model	Keep all features of last year's model	x					
Data and data structure[2]	Exclude IPHC data[3]		x	x	x	x	x
	Exclude fishery (but not survey) age data[4]		x	x	x	x	x
	Use finer length bin structure		x	x	x	x	x
	Re-evaluate seasonal structure		x	x	x	x	x
Selectivity and Q	Use informative priors or other constraints on selectivity			x			
	Estimate catchability internally			x			
Age and growth	Exclude all mean length-at-age data				x	x	x
	Exclude all age composition data				x	x	x
	Describe maturity as a function of length, not age				x	x	x
	Estimate variation in length-at-age internally					x	x
	Omit cohort-specific growth, add time-varying growth						x
Considered but rejected	Use age conditioned on length						
	Estimate ageing bias from radiocarbon study						
	Decrease emphasis on season 1 fishery sizecomps						
	Reduce "plus" age from 20 to 15						
	Put a cap on catchability for sub-27 survey in the GOA						
	Decrease lower bound for selectivity parameters						
	Examine spatial-temporal variation in fishery CPUE						
	Advance model one year, compare with projections						

Footnotes:

1. Model 6 is to be used only in the BSAI assessment.
2. This group does not include proposals relating to exclusion of survey age data (see "Age and growth" group).
3. Plan Teams recommended rejecting this proposal.
4. Plan Teams inadvertently omitted this proposal from their discussion.

Table 2.1.2. Objective function values and components thereof for Models 1-6. Shaded cells represent values that have zero weight in the objective function and are shown for comparison only. Likelihoods for Models 4-6 are directly comparable; likelihoods for other models are not. Only one set of initial parameter values was considered for most models, so the potential for reaching a solution other than the global minimum is greater than in recent assessments.

Parameters	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Unbound	215	209	215	212	214	265
Bound	0	4	0	1	1	2
ALL	215	213	215	213	215	267

Negative log likelihoods and priors	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Survey	-22.65	-22.39	-20.56	-11.69	-32.99	-38.92
Age comp	160.86	141.17	145.92	n/a	n/a	n/a
Size at age	896.36	938.83	928.15	n/a	n/a	n/a
Length comp	1524.26	3538.87	3536.65	3729.62	3438.91	3072.11
Recruitment	9.80	12.00	13.48	14.82	21.96	9.55
Parameter priors	n/a	n/a	76.59	n/a	n/a	n/a
Parameter softbounds	0.03	0.04	0.02	0.04	0.04	0.03
Parameter devs	31.37	41.71	41.35	43.67	58.62	61.42
ALL	2600.04	4650.23	4721.60	3776.46	3486.55	3104.19

Akaike Information Criterion	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ALL (including priors for Model 3)	5630.08	9726.46	9873.20	7978.92	7403.10	6742.38

CPUE negative log likelihoods	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Jan-Apr Trawl Fishery	53.11	76.41	80.52	58.20	40.01	34.93
May-Jul Trawl Fishery	-1.22	9.81	12.23	4.92	7.11	-1.33
Aug-Dec Trawl Fishery	9.89	22.51	24.77	21.39	22.36	14.39
Jan-Apr Longline Fishery	205.28	290.26	325.80	230.03	266.58	169.47
May-Jul Longline Fishery	59.52	90.42	104.65	62.84	76.53	18.48
Aug-Dec Longline Fishery	43.36	41.68	61.98	19.03	63.59	30.84
Jan-Apr Pot Fishery	-9.46	-6.26	-1.11	-14.98	-15.34	-12.69
May-Jul Pot Fishery	-9.67	-9.83	-9.91	-10.65	-10.52	-11.31
Aug-Dec Pot Fishery	6.03	14.46	17.29	8.47	8.27	-3.73
Pre82 Shelf Survey	-2.22	-3.66	-1.10	-4.33	-4.49	-4.23
Post81 Shelf Survey	-20.42	-18.73	-19.47	-7.35	-28.50	-34.68
IPHC Survey	1.46	n/a	n/a	n/a	n/a	n/a
ALL	-22.65	-22.39	-20.56	-11.69	-32.99	-38.92

Agecomp negative log likelihoods	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Jan-Apr Longline Fishery	24.06	n/a	n/a	n/a	n/a	n/a
Post81 Shelf Survey	136.80	141.17	145.92	n/a	n/a	n/a
ALL	160.86	141.17	145.92	n/a	n/a	n/a

Size-at-age negative log likelihoods	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Jan-Apr Longline Fishery	97.68	n/a	n/a	n/a	n/a	n/a
Post81 Shelf Survey	798.68	938.83	928.15	n/a	n/a	n/a
ALL	896.36	938.83	928.15	n/a	n/a	n/a

Sizecomp negative log likelihoods	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Jan-Apr Trawl Fishery	452.07	923.43	927.27	872.28	783.59	654.11
May-Jul Trawl Fishery	73.47	201.40	201.40	195.22	179.90	161.78
Aug-Dec Trawl Fishery	65.14	207.81	207.33	203.12	205.64	213.28
Jan-Apr Longline Fishery	220.68	579.46	583.50	535.38	529.52	470.53
May-Jul Longline Fishery	146.24	204.81	200.22	212.13	174.13	148.34
Aug-Dec Longline Fishery	277.09	824.90	825.99	793.24	760.78	635.45
Jan-Apr Pot Fishery	36.37	88.06	89.13	95.68	89.66	88.52
May-Jul Pot Fishery	21.39	73.13	72.31	75.61	67.52	62.93
Aug-Dec Pot Fishery	42.26	165.79	164.96	178.12	160.30	164.46
Pre82 Shelf Survey	25.67	45.64	36.18	59.03	37.03	23.49
Post81 Shelf Survey	151.84	224.44	228.37	509.81	450.85	449.20
IPHC Survey	12.03	n/a	n/a	n/a	n/a	n/a
ALL	1524.26	3538.87	3536.65	3729.62	3438.91	3072.11

Table 2.1.3. Ratios of mean effective sample size to input sample size for size composition data. Cells under Model 1 are shaded yellow to indicate that different input sample sizes were used for that model. Pink = row maximum for Models 2-6, green = row minimum for Models 2-6.

	Mean effective sample size / mean input sample size					
Fleet	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Jan-Apr Trawl Fishery	0.89	3.23	3.24	3.28	3.54	4.00
May-Jul Trawl Fishery	3.62	7.01	6.98	6.97	7.30	10.37
Aug-Dec Trawl Fishery	3.41	7.13	7.30	7.13	7.35	7.45
Jan-Apr Longline Fishery	0.98	4.16	4.10	3.98	4.18	4.66
May-Jul Longline Fishery	1.17	5.06	5.18	5.38	5.96	6.93
Aug-Dec Longline Fishery	1.15	3.54	3.38	3.75	3.72	4.02
Jan-Apr Pot Fishery	3.60	11.41	10.15	10.74	10.55	11.68
May-Jul Pot Fishery	3.53	7.74	7.46	8.27	7.69	11.05
Aug-Dec Pot Fishery	5.24	9.94	9.91	9.13	10.14	9.45
Pre82 Shelf Survey	0.92	0.50	0.78	0.44	0.60	1.06
Post81 Shelf Survey	1.20	3.28	3.21	2.34	2.50	2.77
IPHC Survey	1.60	n/a	n/a	n/a	n/a	n/a

Table 2.1.4. Ratios of effective sample size to input sample size for age composition data. Cells shaded yellow indicate that the 2008 Jan-Apr longline fishery age composition were given zero weight in Models 2-6. Pink = row maximum, green = row minimum.

		Effective sample size / input sample size					
Fleet	Year	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Jan-Apr Longline Fishery	2008	0.20	0.17	0.18	0.16	0.13	0.14
Post81 Shelf Survey	1994	0.28	0.21	0.20	0.25	0.13	0.24
Post81 Shelf Survey	1995	0.15	0.13	0.13	0.10	0.08	0.13
Post81 Shelf Survey	1996	0.63	0.49	0.49	1.14	0.63	0.32
Post81 Shelf Survey	1997	0.98	0.63	0.57	0.57	0.97	0.11
Post81 Shelf Survey	1998	0.39	0.23	0.22	0.54	1.07	0.92
Post81 Shelf Survey	1999	0.97	1.45	1.39	0.31	0.60	0.59
Post81 Shelf Survey	2000	0.44	0.37	0.34	0.40	0.83	0.45
Post81 Shelf Survey	2001	1.87	0.91	0.71	0.88	1.41	0.70
Post81 Shelf Survey	2002	0.36	0.59	0.64	0.33	0.36	0.29
Post81 Shelf Survey	2003	1.95	1.00	1.05	1.13	0.79	0.28
Post81 Shelf Survey	2004	0.21	0.26	0.26	0.16	0.17	0.13
Post81 Shelf Survey	2005	0.38	0.32	0.30	0.10	0.10	0.10
Post81 Shelf Survey	2006	0.57	1.15	1.07	0.38	1.11	0.16
Post81 Shelf Survey	2007	0.08	0.12	0.10	0.29	0.35	0.27
Post81 Shelf Survey	2008	0.08	0.10	0.10	0.12	0.11	0.14
Post81 Shelf Survey	All	0.67	0.57	0.55	0.45	0.58	0.30

Table 2.1.5. Comparison of annual lengths at age 1 as in the age data and as estimated by Models 1-6 ("SE" = squared error). Pink = row maximum, green = row minimum.

		Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
Year	Data	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE	Est.	SE
1994	19.0	16.9	4.5	14.2	22.8	14.2	23.0	14.6	19.2	11.7	52.7	12.2	46.0
1995	17.3	16.2	1.2	13.6	13.6	13.6	13.7	15.2	4.5	11.4	34.9	6.2	122.4
1996	17.6	15.9	3.1	13.1	20.5	13.1	20.8	15.9	2.9	12.0	31.6	-4.7	496.5
1997	17.2	16.5	0.5	14.4	7.5	14.4	7.8	14.9	5.3	15.2	3.9	15.0	4.6
1998	15.4	15.1	0.1	12.9	6.6	12.9	6.5	13.7	3.0	14.2	1.7	13.8	2.7
1999	15.8	15.9	0.0	13.3	6.2	13.3	6.4	14.0	3.1	15.6	0.0	13.8	4.0
2000	15.2	16.4	1.3	14.0	1.5	14.0	1.6	13.9	1.8	14.9	0.1	12.3	8.4
2001	17.9	16.6	1.6	14.2	13.8	14.1	14.0	14.5	11.4	15.3	6.7	15.9	4.1
2002	16.5	15.4	1.4	12.8	13.9	12.8	13.9	12.6	15.5	12.1	19.4	15.1	1.9
2003	18.0	16.7	1.8	13.9	16.7	13.9	16.8	13.6	19.7	13.8	17.5	16.2	3.3
2004	17.3	15.3	3.8	12.8	20.0	12.8	20.0	13.9	11.0	13.8	12.1	16.0	1.5
2005	18.6	17.4	1.4	14.7	15.4	14.6	15.6	15.5	9.5	15.9	7.2	18.1	0.2
2006	15.3	16.4	1.1	13.7	2.8	13.6	2.8	13.7	2.7	13.9	2.1	13.5	3.4
2007	14.9	15.3	0.2	13.9	1.0	13.9	1.1	13.0	3.6	13.6	1.7	12.3	6.9
2008	15.4	16.0	0.4	13.9	2.2	13.9	2.3	12.2	10.0	12.6	7.8	11.7	13.8
RMSE:			1.22		3.31		3.33		2.86		3.65		6.93
Correl:			0.60		0.33		0.33		0.63		-0.11		0.00

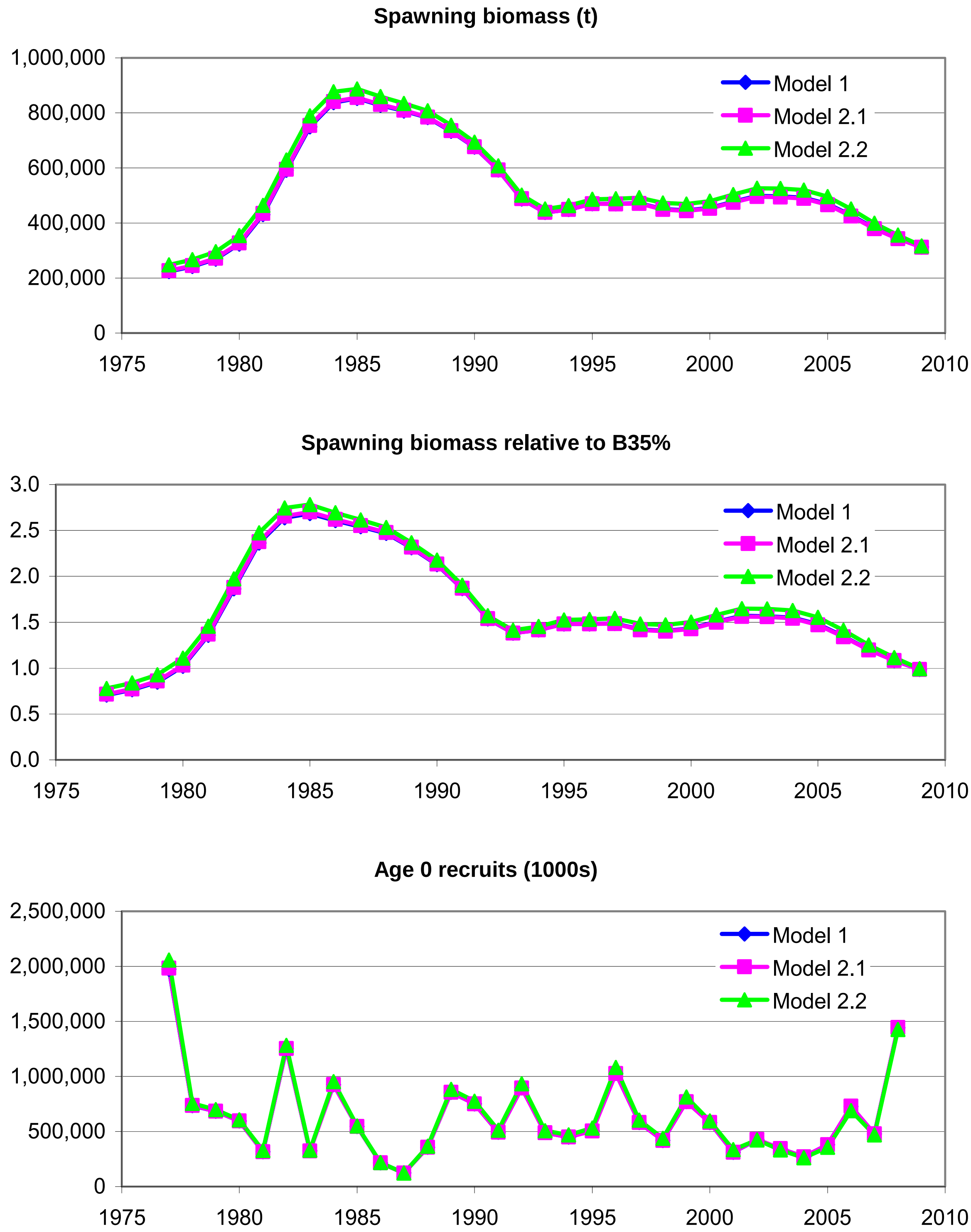


Figure 2.1.1. Time series of spawning biomass (t), spawning biomass relative to $B_{35\%}$, and age 0 recruits (1000s of fish) for Models 1, 2.1, and 2.2. The time series for Model 1 are difficult to see because they are almost identical to the time series for Model 2.1.

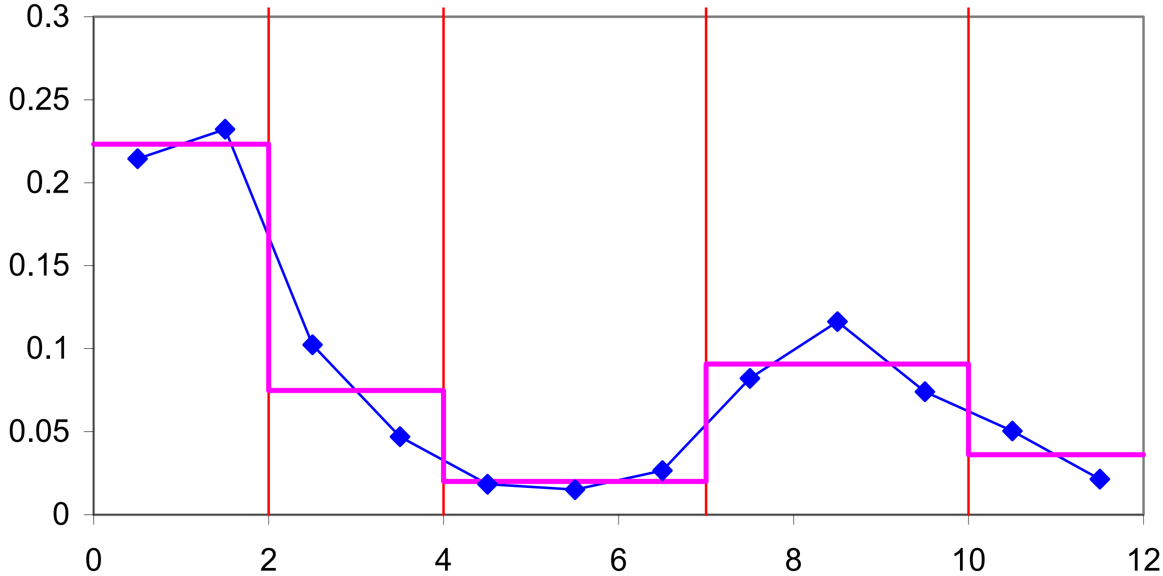


Figure 2.1.2. New season structure. Average monthly catch proportions are shown by the blue diamonds, average seasonal catch proportions are shown by the magenta stair-step, and season ending boundaries are shown by the red vertical lines

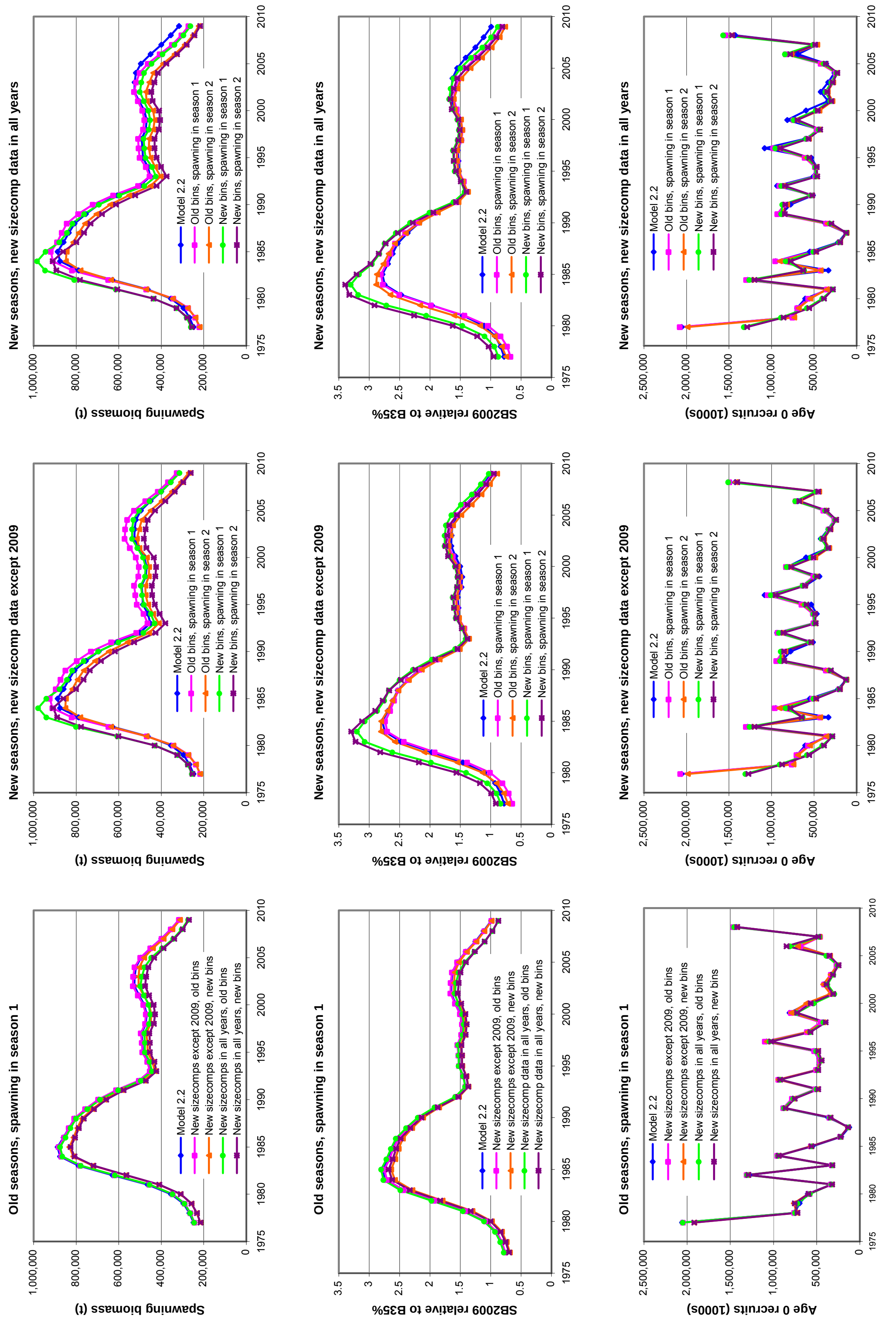


Figure 2.1.3. Time series of spawning biomass (t), spawning biomass relative to $B_{35\%}$, and age 0 recruits (1000s of fish) for Models 2.2-2.5.4.

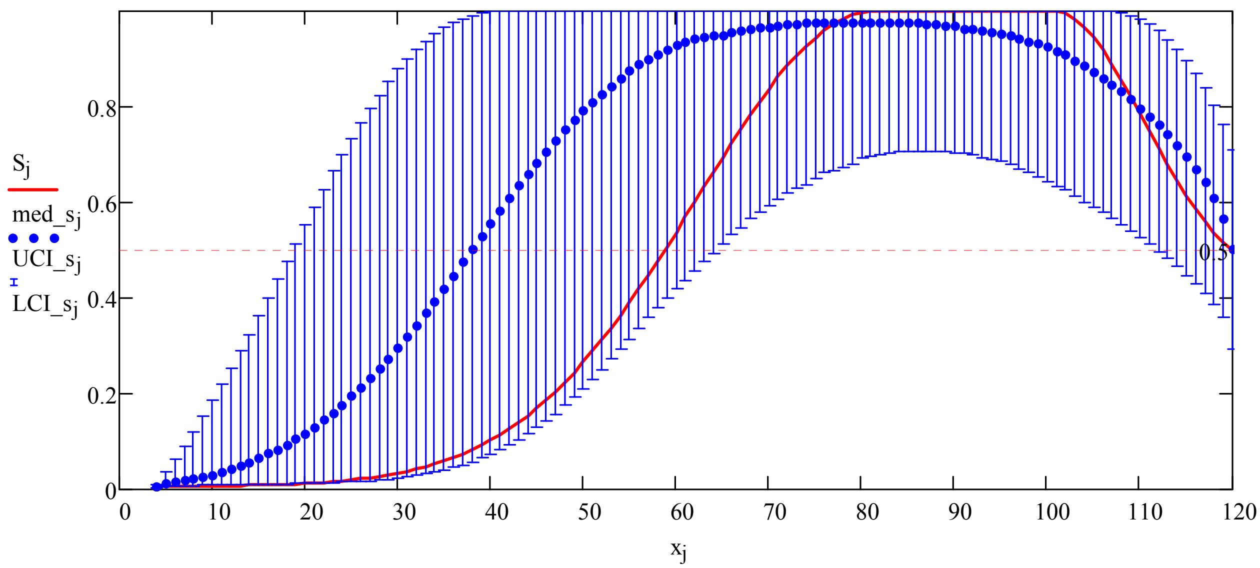


Figure 2.1.4. Selectivity at length implied by prior distributions. Red = curve corresponding to means of prior distributions, blue dots = median of simulations, blue error bars = inter-quartile range.

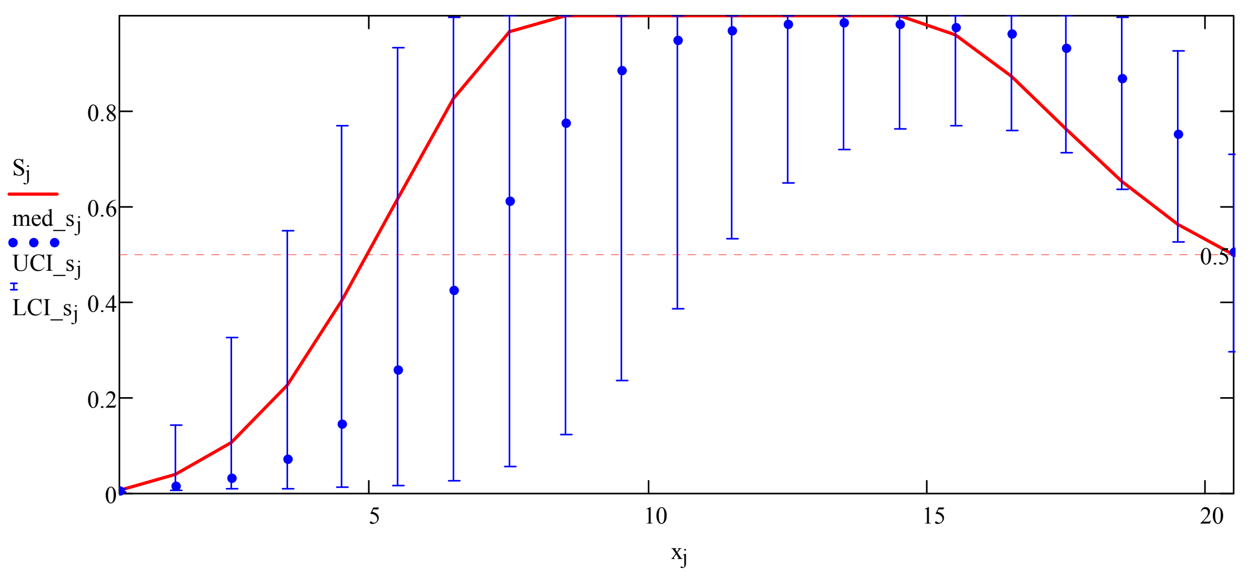


Figure 2.1.5. Selectivity at age implied by prior distributions. Red = curve corresponding to means of prior distributions, blue dots = median of simulations, blue error bars = inter-quartile range.

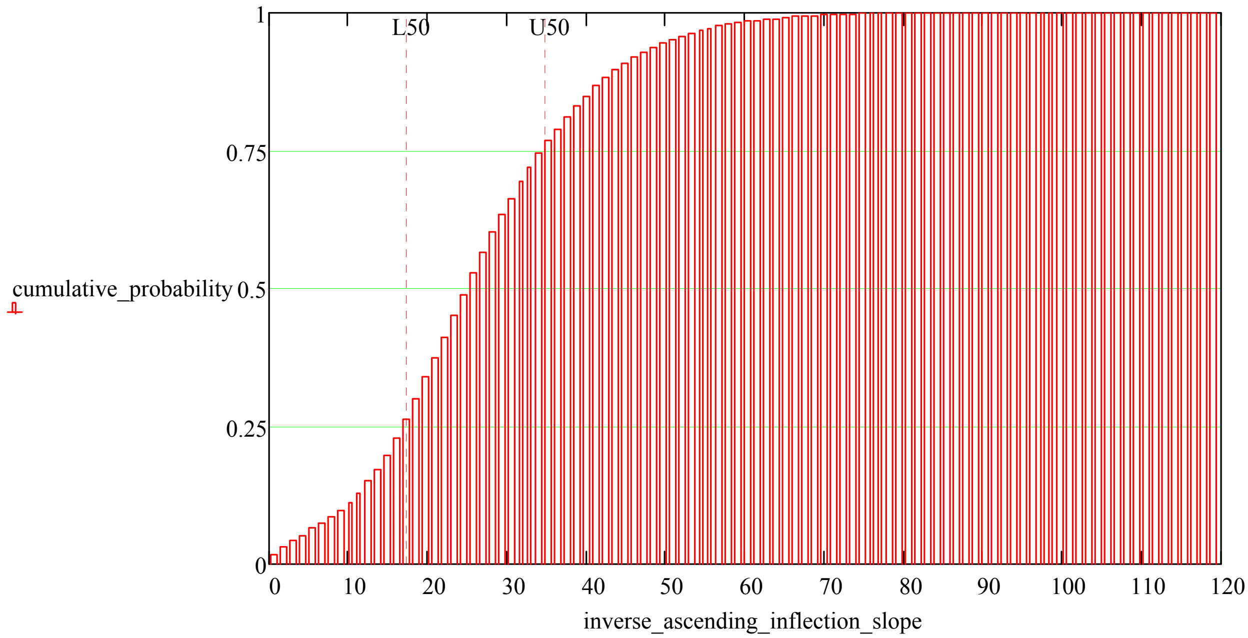


Figure 2.1.6. Distribution of the reciprocal of the slope at the length-based ascending inflection point. L50 and U50 represent limits of inter-quartile range.

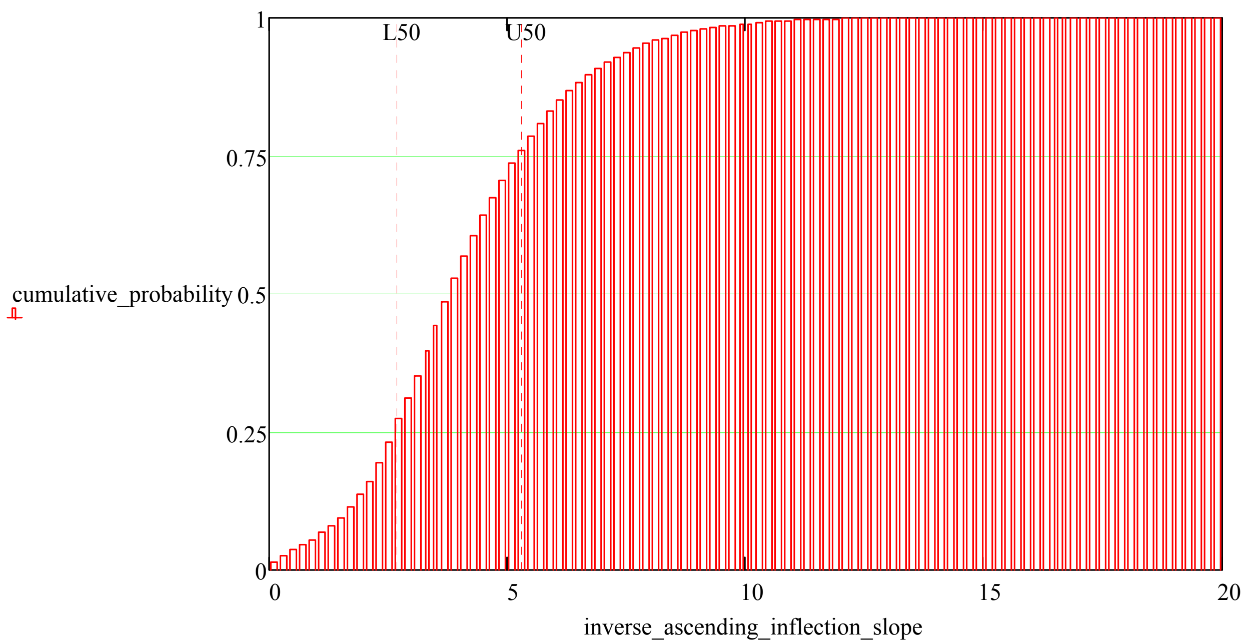


Figure 2.1.7. Distribution of the reciprocal of the slope at the age-based ascending inflection point. L50 and U50 represent limits of inter-quartile range.

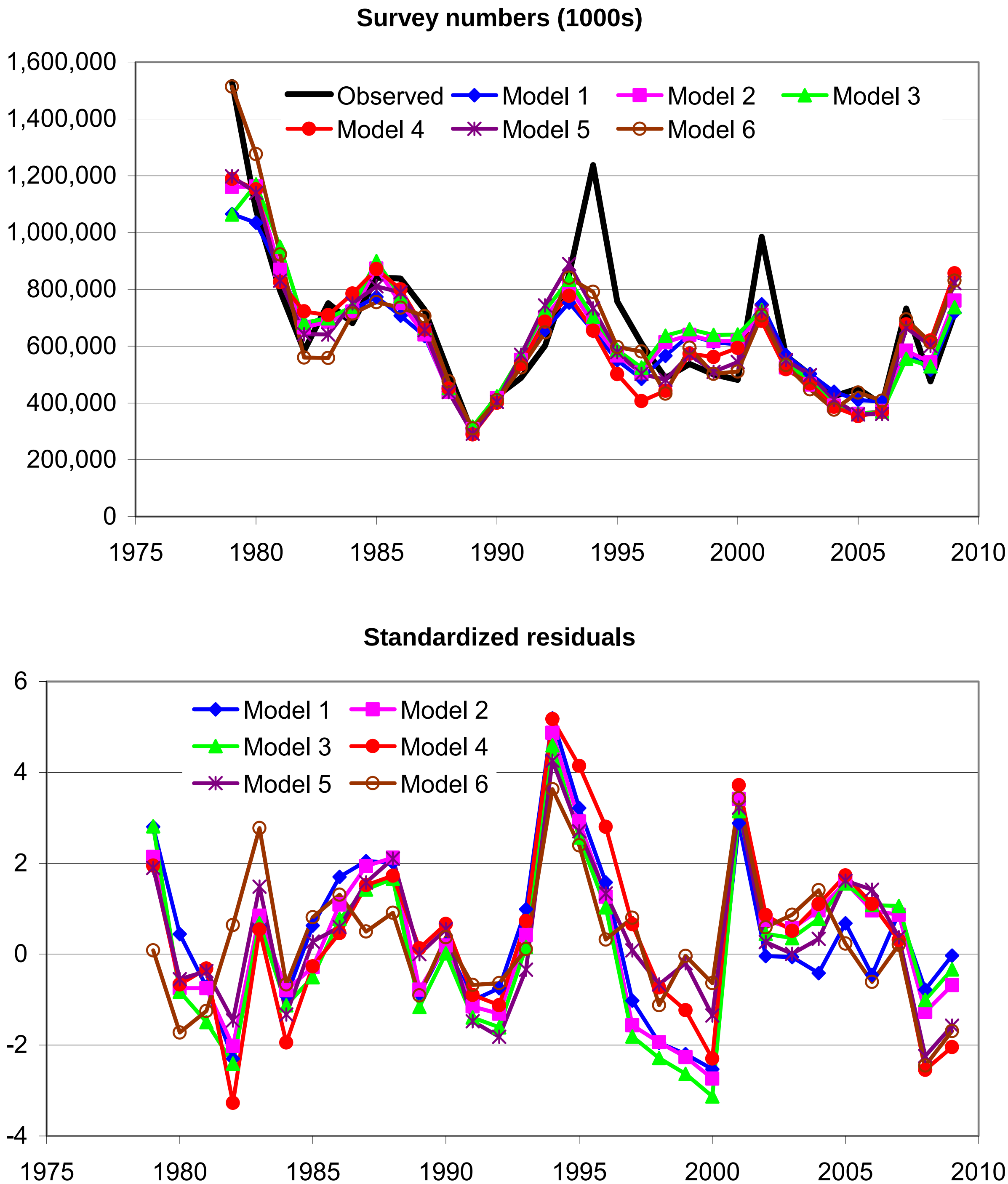


Figure 2.1.8. Model fits to the time series of trawl survey population numbers. The upper panel shows the observed and estimated abundances, and the lower panel shows the time series of standardized residuals.

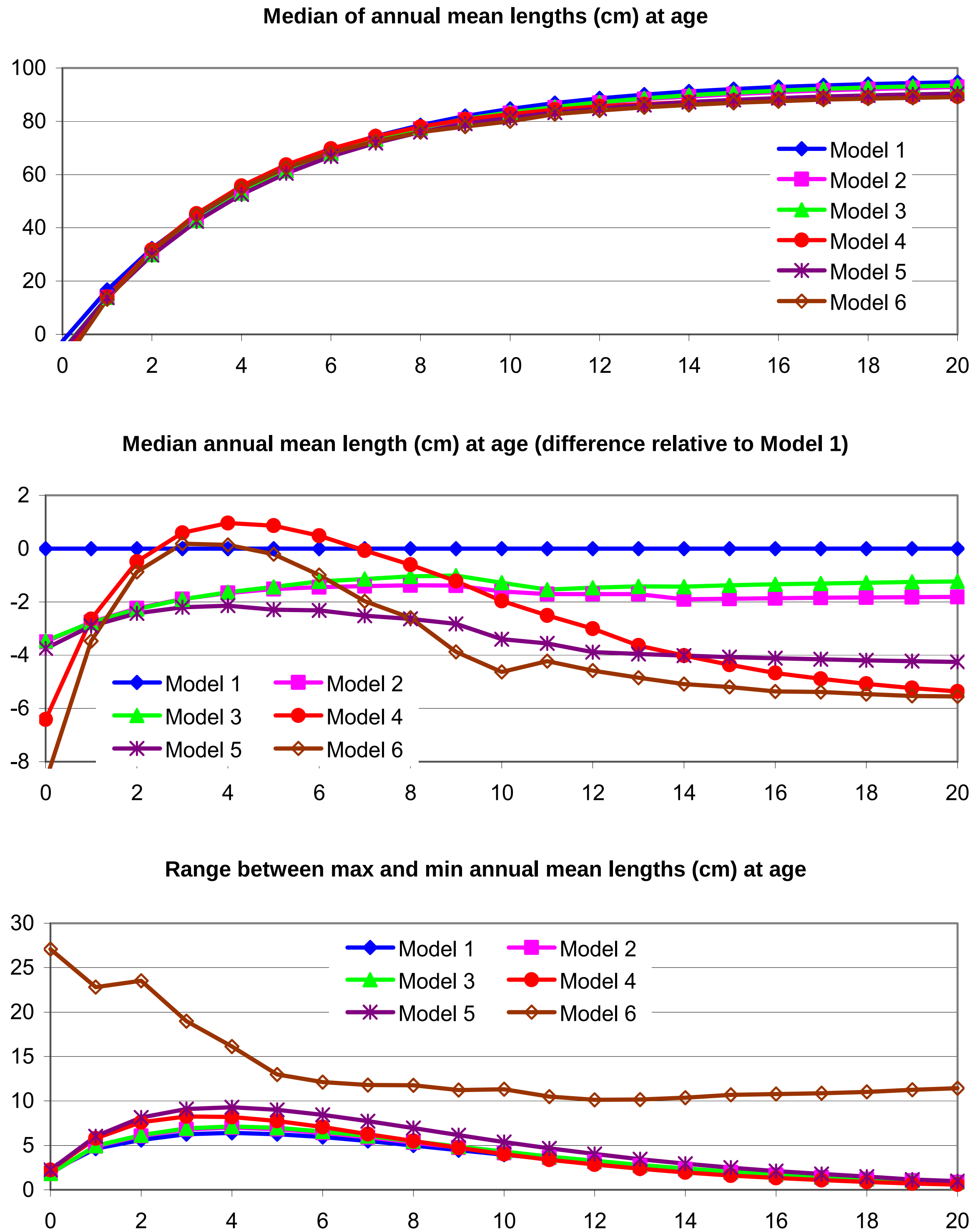


Figure 2.1.9. Three ways of looking at the pattern of mean lengths at age. The upper panel shows the median of each distribution, the middle panel shows the difference between the median for a given model and the corresponding median for Model 1, and the bottom panel shows the range of each distribution.

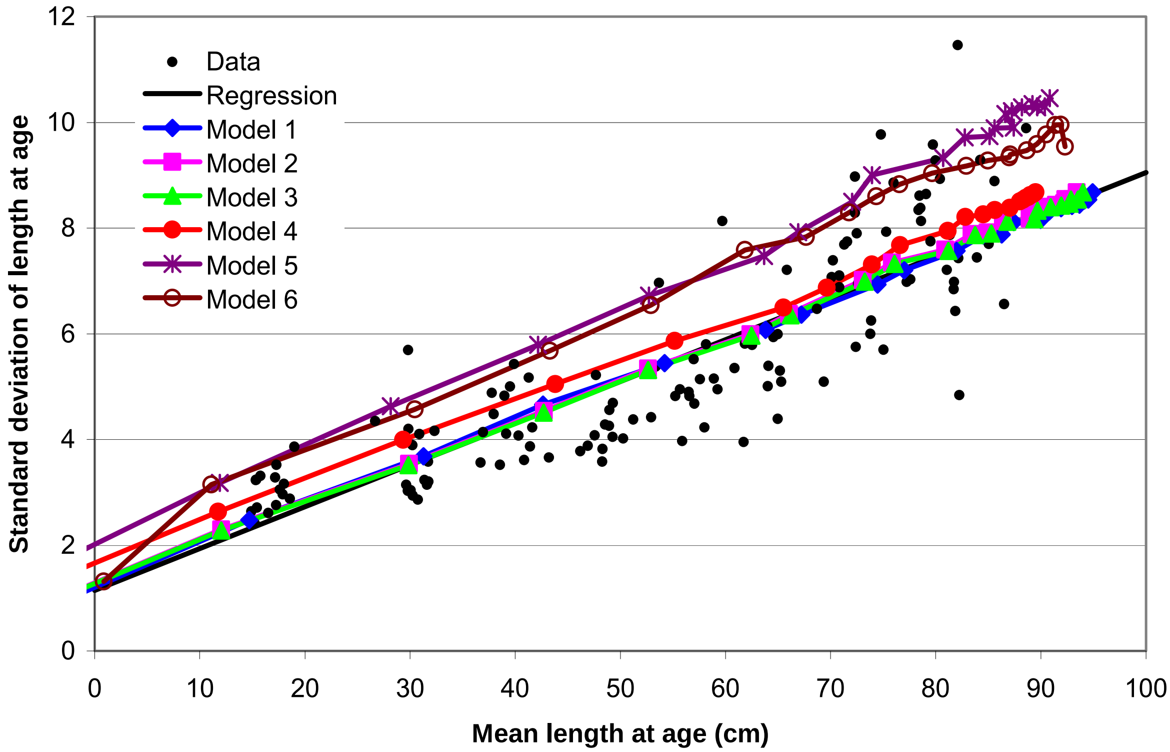


Figure 2.1.10. Standard deviation of length at age versus mean length at age in the data and as estimated by Models 1-6. The black dots (“data”) represent 15 years’ worth of mean lengths and standard deviations of length at ages 1-9, and the solid black line represents the least-squares regression through those data. Colored lines with symbols represent model estimates.

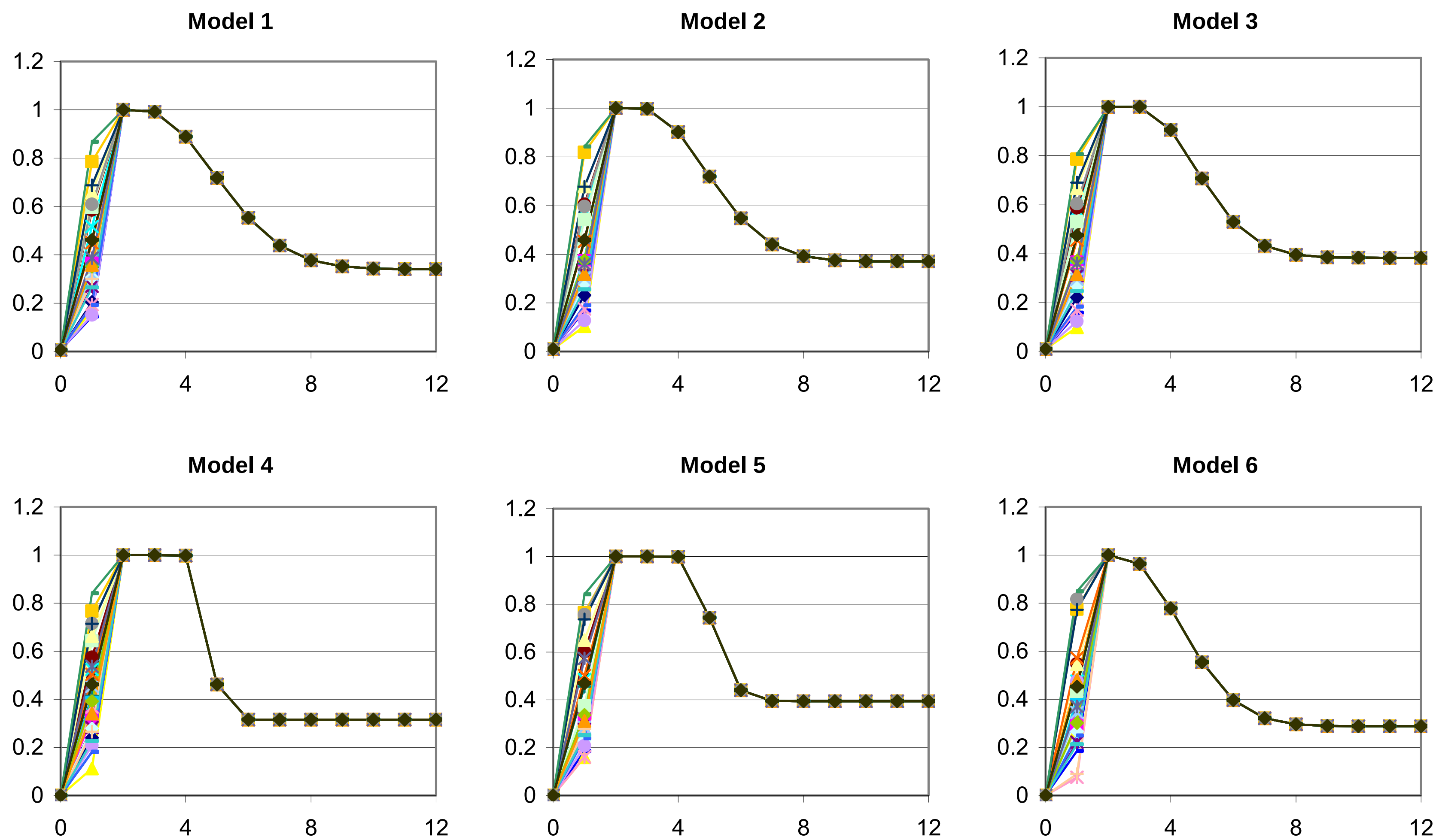


Figure 2.1.11. Estimated post-1981 trawl survey selectivity at age in each model. The actual age range extends to age 20+, but the graphs here have been truncated at age 12 to make differences easier to identify.

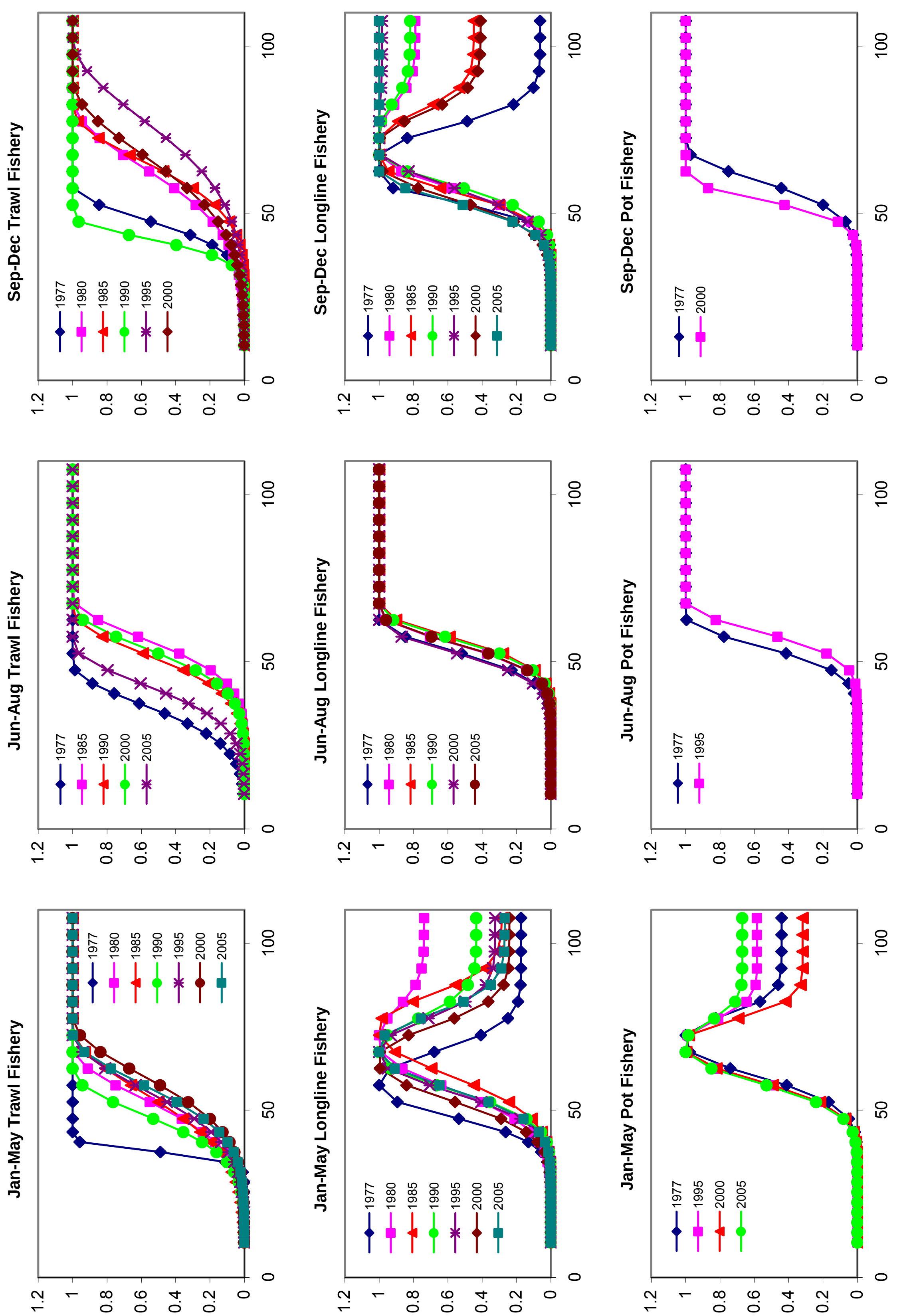
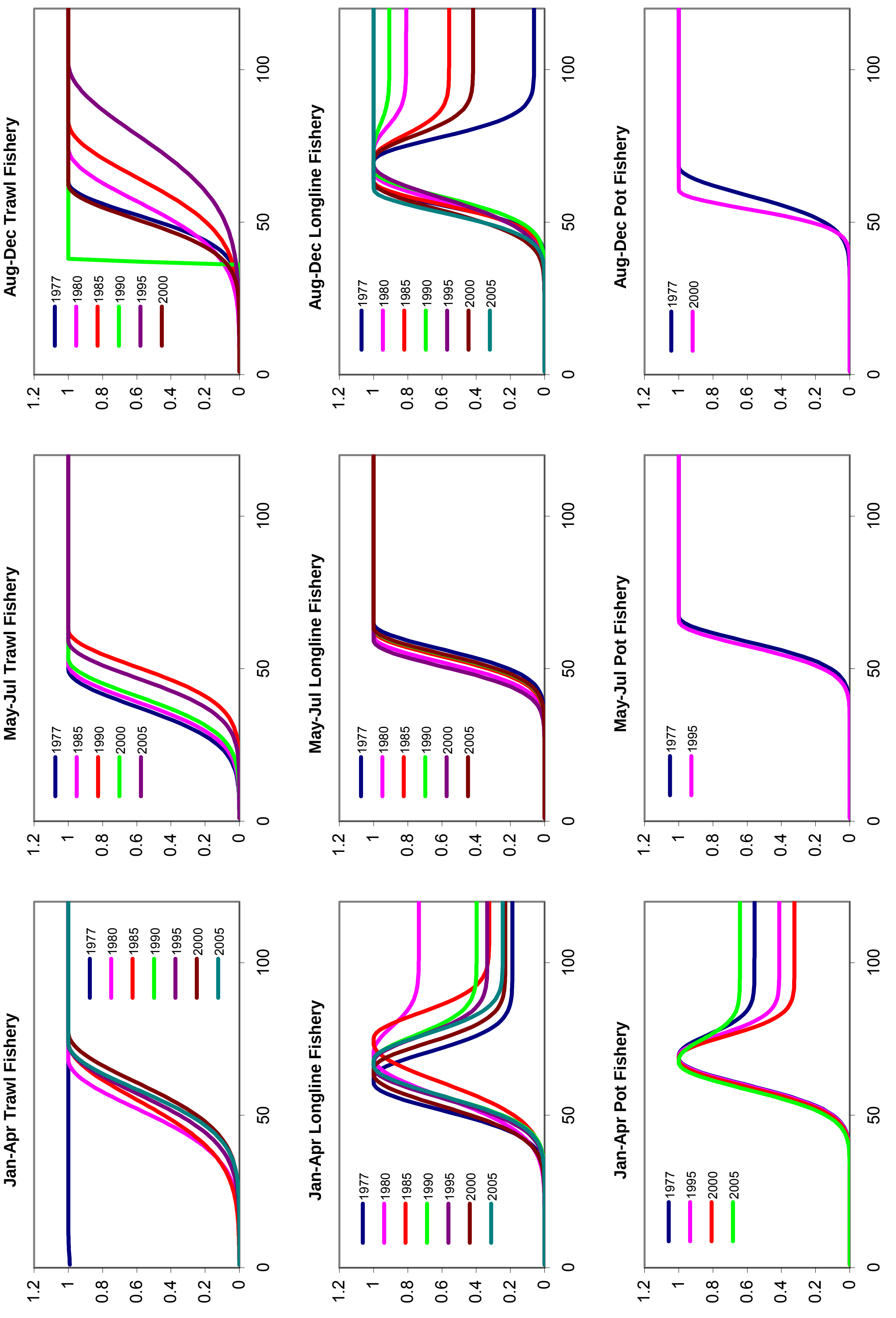
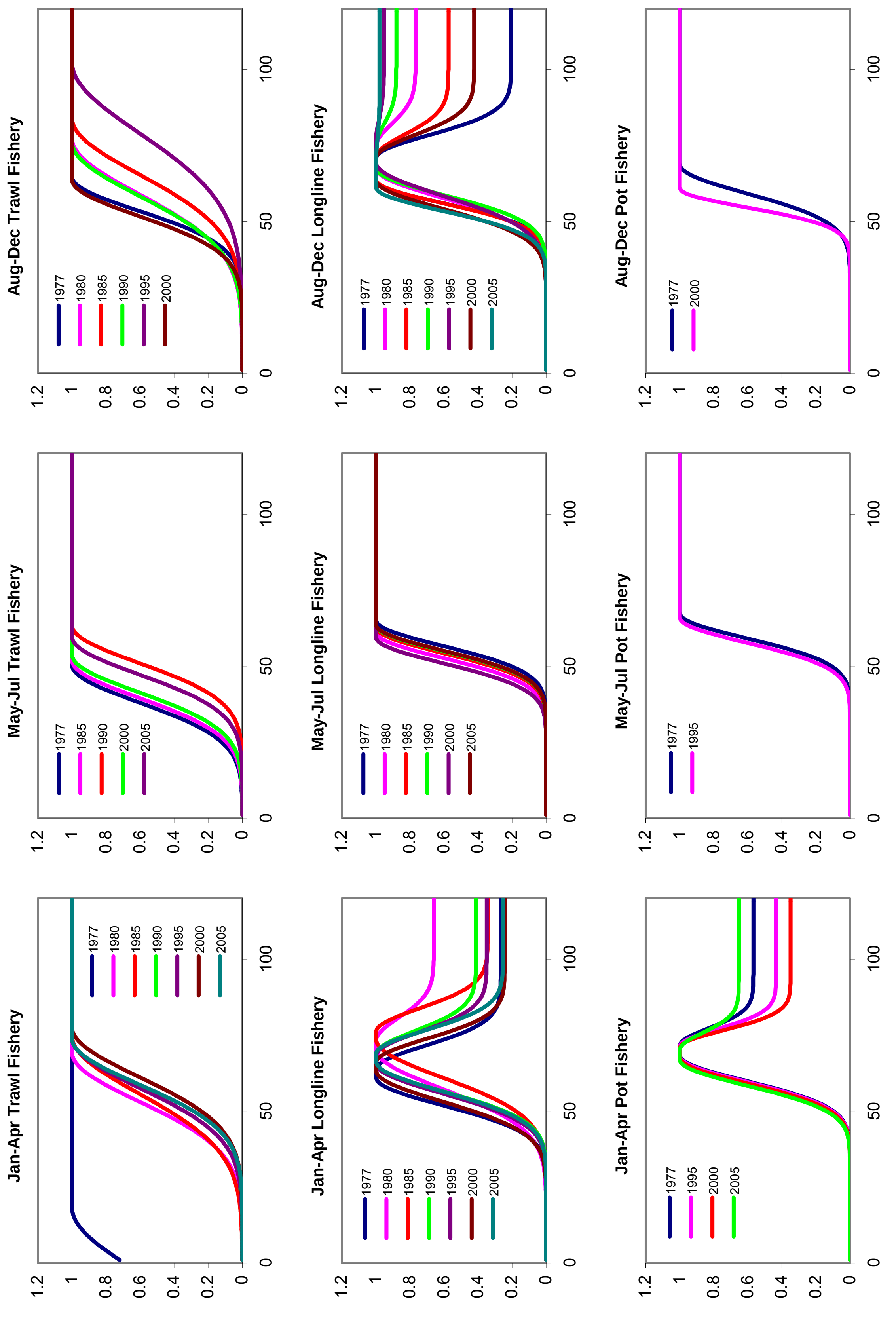


Figure 2.1.12.1. Fishery selectivity at length as estimated by Model 1.



Fishery 2.1.12.2. Fishery selectivity at length as estimated by Model 2.



Fishery 2.1.12.3. Fishery selectivity at length as estimated by Model 3.

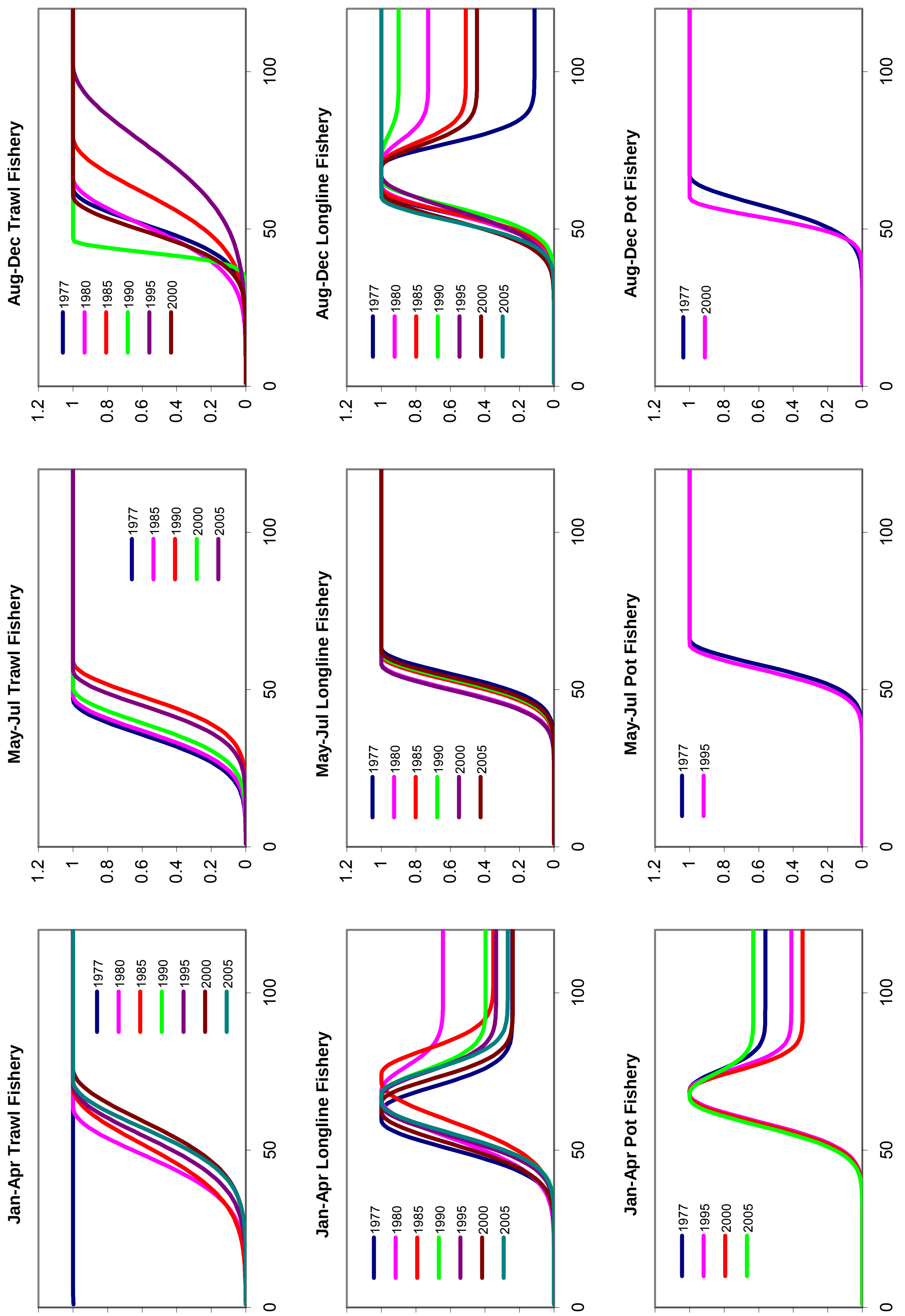


Figure 2.1.12.4. Fishery selectivity at length as estimated by Model 4.

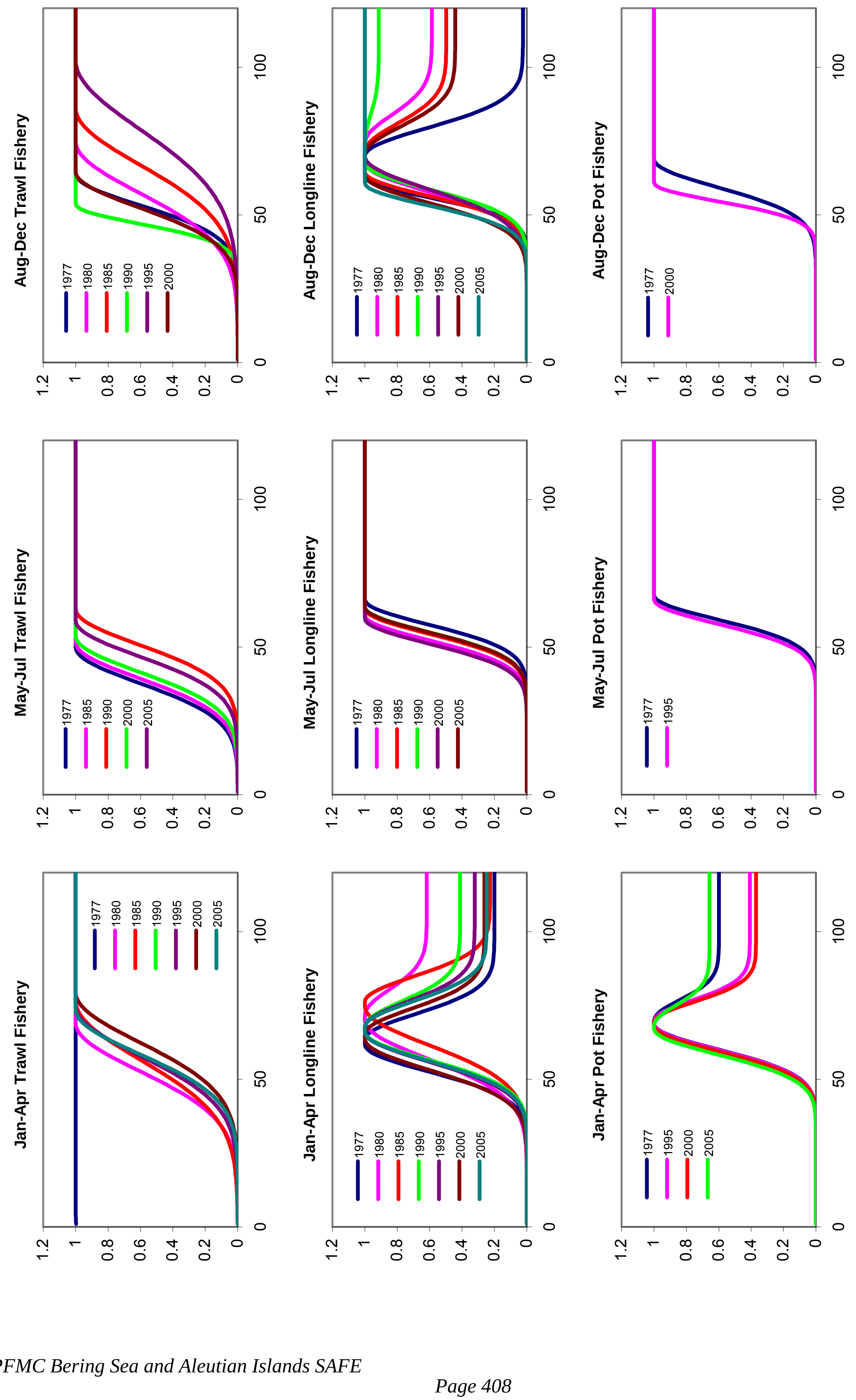


Figure 2.1.12.5. Fishery selectivity at length as estimated by Model 5.

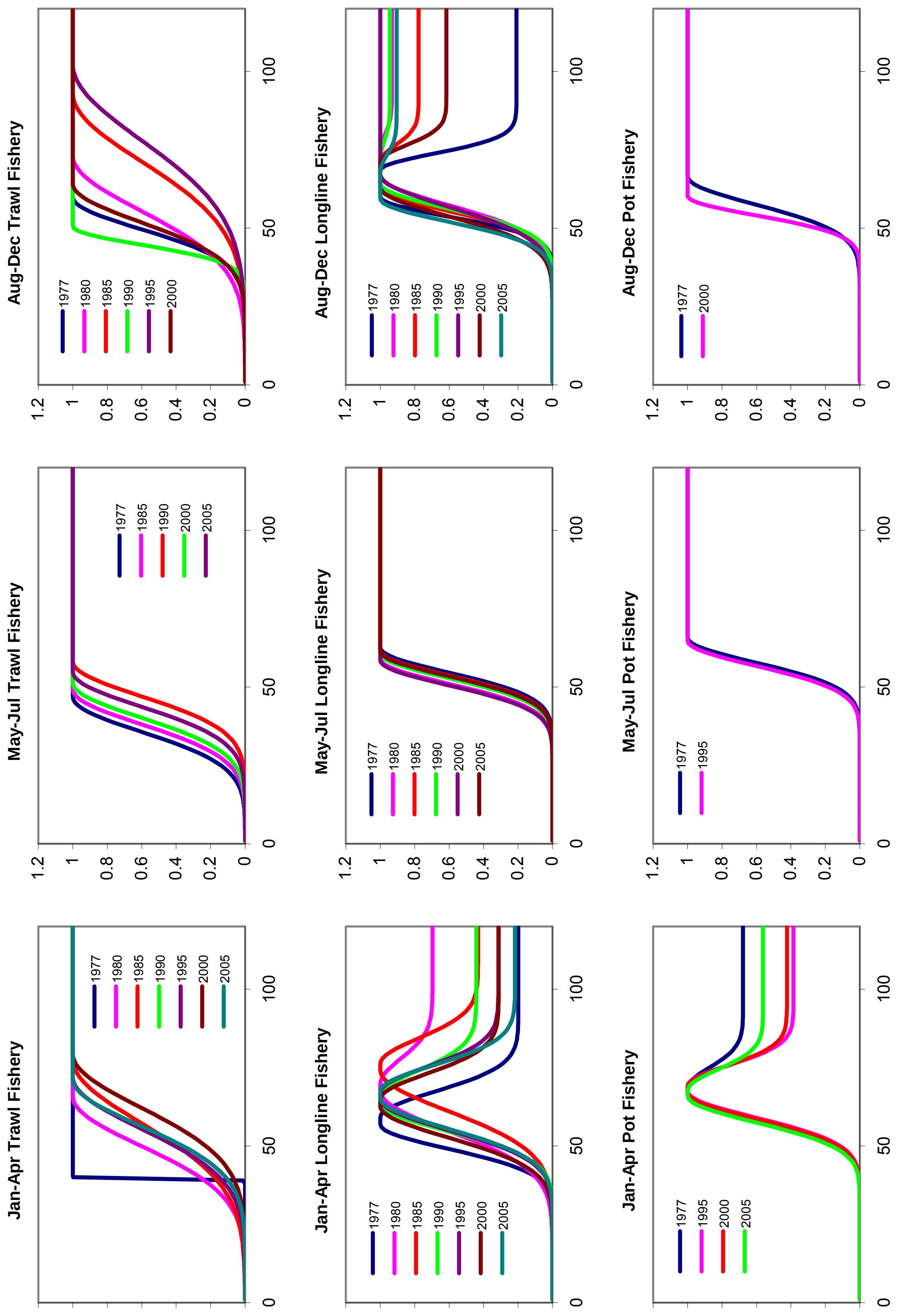
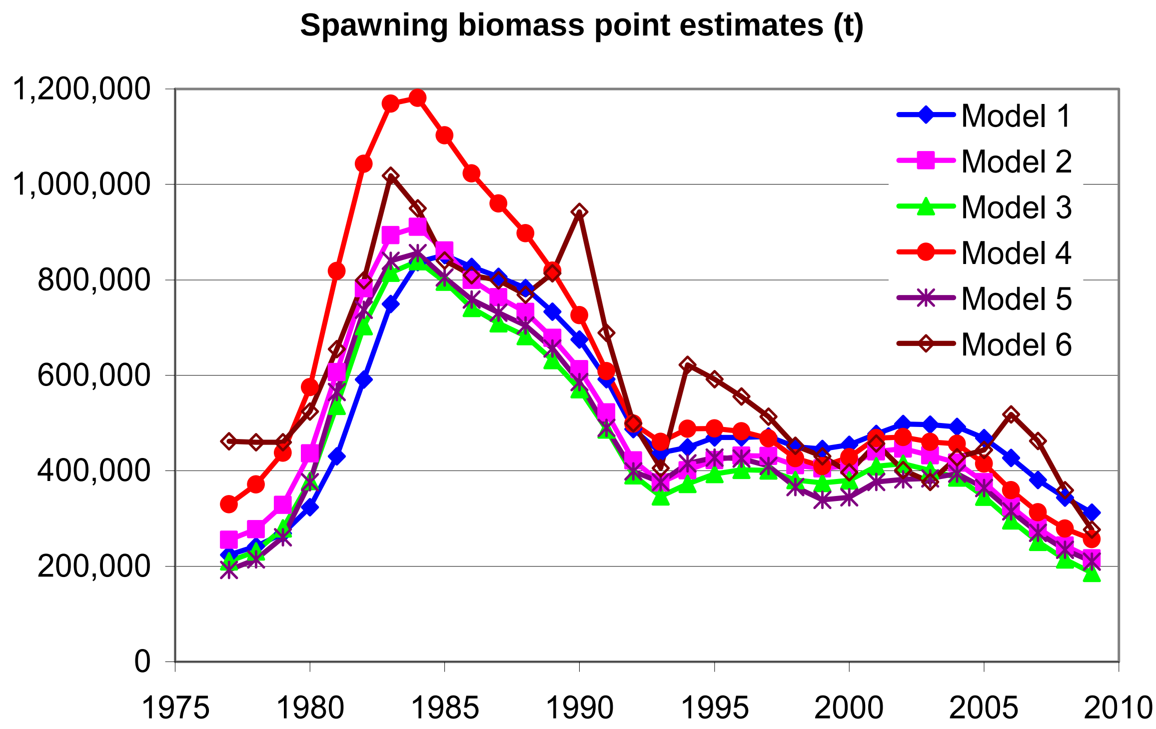


Figure 2.1.12.6. Fishery selectivity at length as estimated by Model 6.



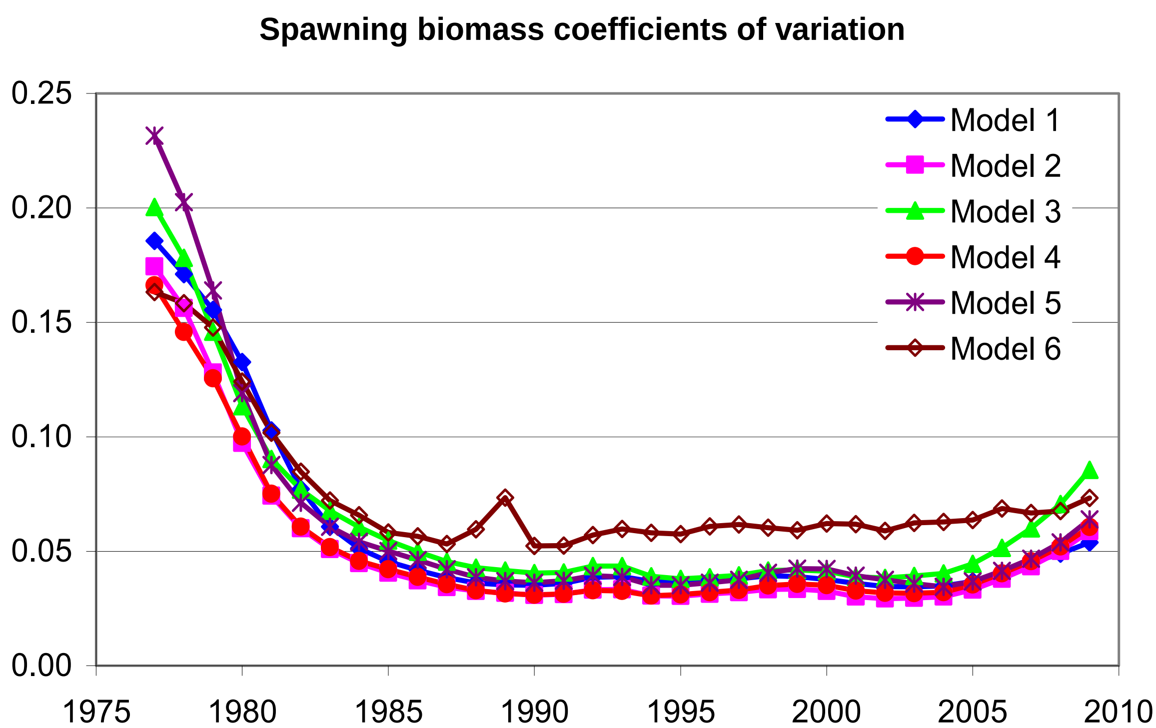
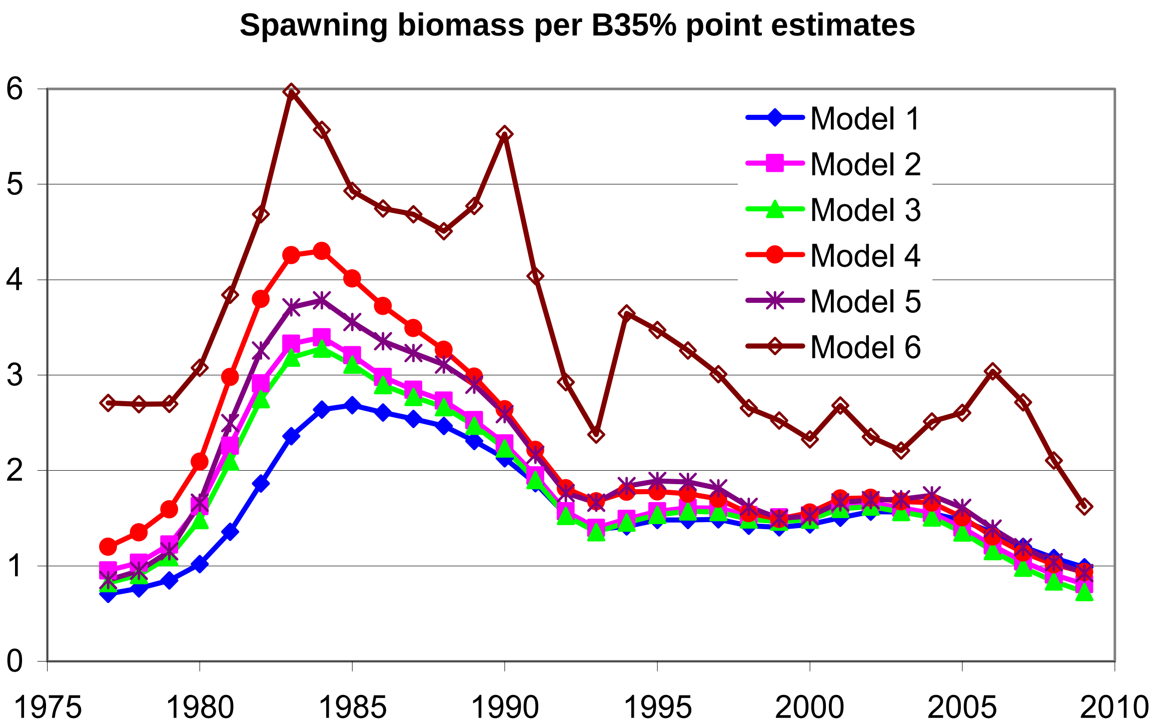


Figure 2.1.13. Time series of spawning biomass estimates for Models 1-6. The upper panel shows the estimates, and the lower panel shows the coefficients of variation corresponding to the estimates.



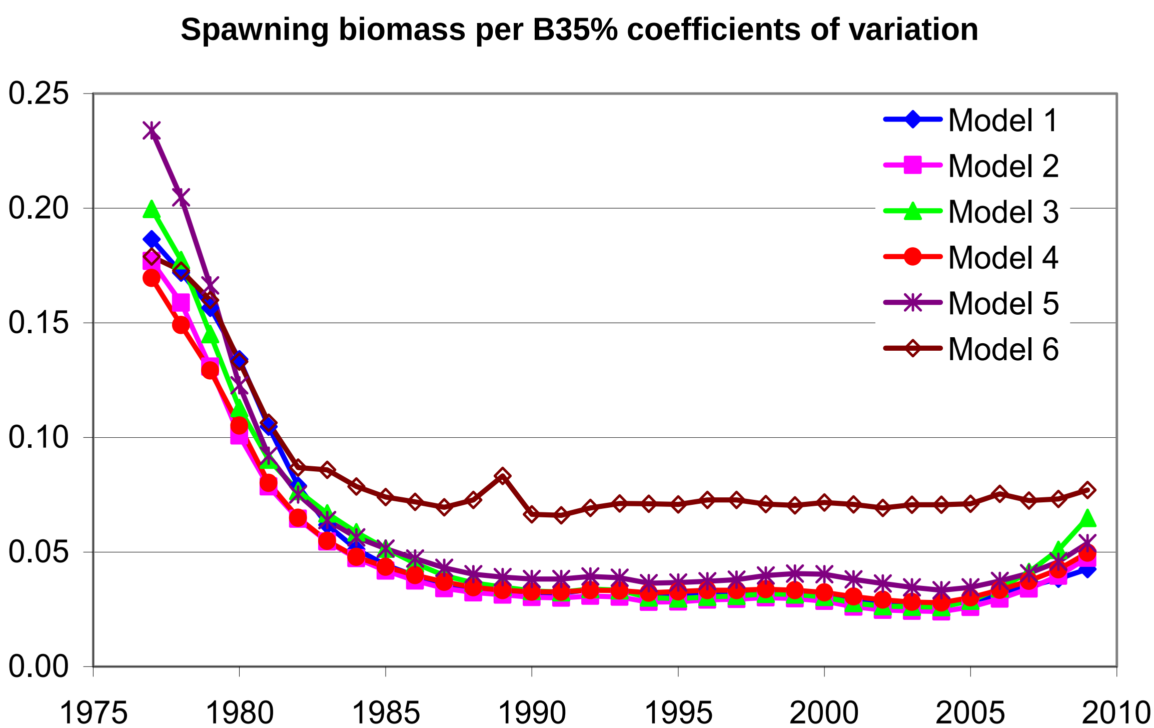


Figure 2.1.14. Time series of spawning biomass relative to $B_{35\%}$ for Models 1-6. The upper panel shows the estimates, and the lower panel shows the coefficients of variation corresponding to the estimates.

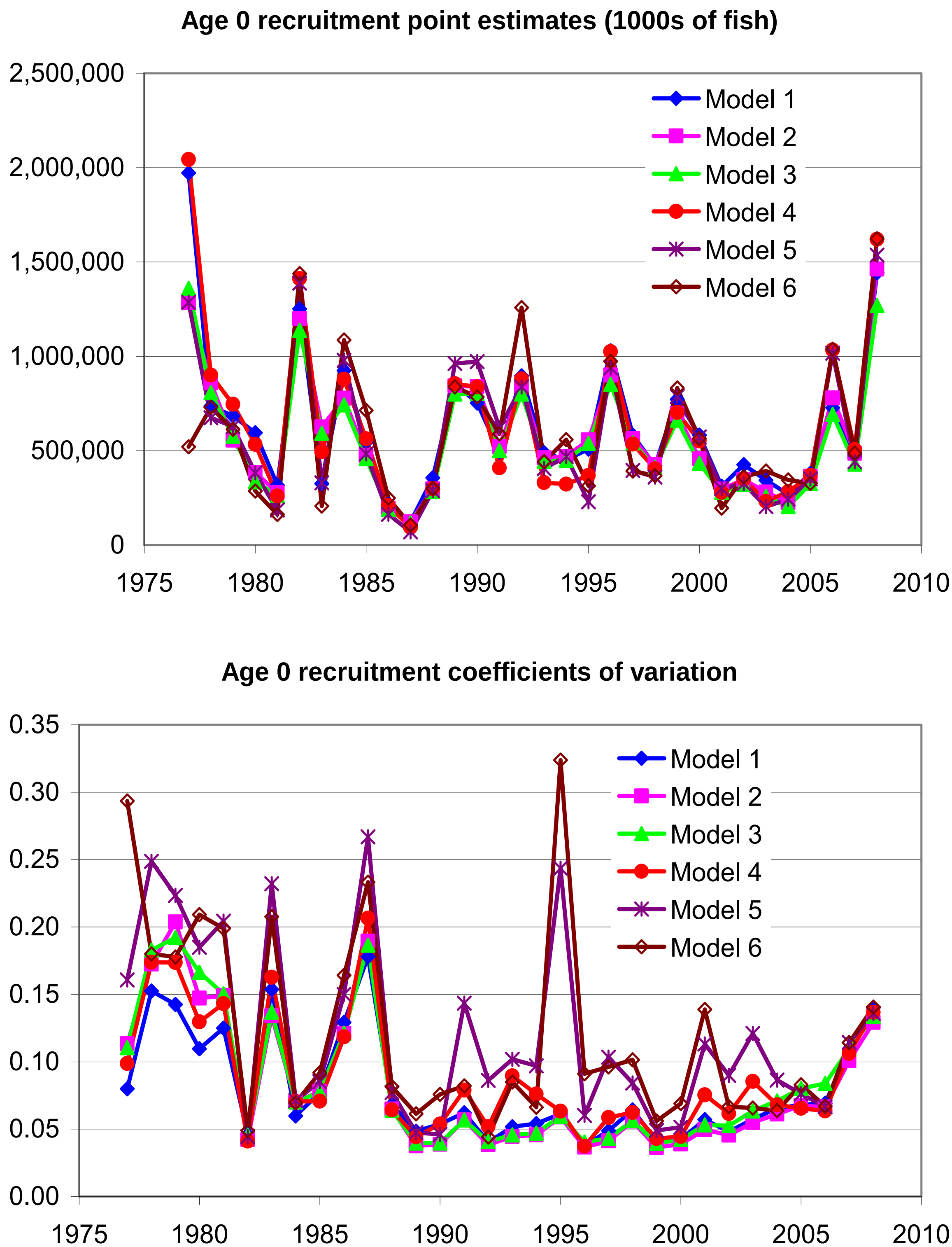


Figure 2.1.15. Time series of age 0 recruitment estimates for Models 1-6. The upper panel shows the estimates, and the lower panel shows the coefficients of variation corresponding to the estimates.

Attachment 2.2: Tables and figures for the "Time Series Results" and "Projections and Harvest Alternatives" sections based on the SSC's reference model (Model A)

The tables and figures contained in the "Time Series Results" and "Projections and Harvest Alternatives" sections in the main text are based on Model B. This attachment reproduces those tables and figures, but based on the SSC's reference model (A).

Table 2.2.25a—Time series of EBS (not expanded to BSAI) Pacific cod age 0+ biomass, female spawning biomass (t), and standard deviation of spawning biomass as estimated last year under the Plan Team's and SSC's preferred model and this year under Model A. Values for 2011 listed under this year's assessment represent Stock Synthesis projections, and may not correspond exactly to values generated by the standard projection model (even after correcting for the BSAI expansion).

	Last year's assessment			This year's assessment		
Year	Age 0+ bio.	Spawn. bio.	Std. dev.	Age 0+ bio.	Spawn. bio.	Std. dev.
1977	795,891	263,530	44,567	506,015	145,939	32,563
1978	826,579	276,465	44,488	557,535	162,232	32,605
1979	1,003,650	292,366	44,769	741,716	183,754	33,156
1980	1,387,200	332,876	45,113	1,126,460	229,785	34,077
1981	1,806,980	427,033	45,062	1,548,270	326,793	35,096
1982	2,142,350	581,305	45,242	1,894,470	481,299	37,169
1983	2,328,540	739,845	44,871	2,101,330	641,290	38,832
1984	2,390,860	830,570	42,362	2,186,820	737,910	37,854
1985	2,376,230	848,075	38,382	2,195,560	765,075	34,939
1986	2,325,540	824,990	34,315	2,165,060	752,635	31,643
1987	2,283,750	805,020	30,928	2,143,250	742,200	28,846
1988	2,182,830	782,115	28,228	2,062,330	727,525	26,565
1989	1,958,450	732,800	25,890	1,856,510	685,985	24,460
1990	1,719,200	675,220	23,712	1,632,230	635,480	22,443
1991	1,538,620	592,160	21,326	1,458,800	558,215	20,205
1992	1,431,110	487,744	18,863	1,350,480	457,883	17,851
1993	1,437,960	438,239	17,092	1,352,080	409,928	16,123
1994	1,513,920	449,454	16,596	1,419,850	420,051	15,566
1995	1,559,310	470,584	17,056	1,457,470	438,193	15,860
1996	1,518,370	470,617	17,698	1,411,240	434,982	16,294
1997	1,453,940	472,657	17,946	1,343,420	434,176	16,368
1998	1,383,630	451,367	17,772	1,268,120	410,688	16,053
1999	1,422,590	446,887	17,428	1,301,790	404,104	15,607
2000	1,466,010	455,622	17,196	1,342,520	411,285	15,260
2001	1,489,450	478,210	17,227	1,365,400	432,705	15,137
2002	1,519,000	499,153	17,285	1,395,970	452,620	15,004
2003	1,497,830	497,816	17,193	1,378,780	451,517	14,691
2004	1,436,530	492,587	17,187	1,309,330	442,065	14,441
2005	1,320,810	469,524	17,327	1,203,240	421,033	14,396
2006	1,186,120	428,010	17,363	1,083,160	382,779	14,357
2007	1,063,630	381,627	17,154	981,216	341,278	14,199
2008	998,912	344,463	16,904	964,688	311,803	14,149
2009	981,017	313,218	16,895	1,012,460	293,552	14,622
2010	1,044,580	300,485	17,587	1,120,150	298,812	16,302
2011				1,273,770	339,533	19,677

Table 2.2.25b—Time series of EBS (not expanded to BSAI) Pacific cod age 0 recruitment (1000s of fish), with standard deviations, as estimated last year under the Plan Team's and SSC's preferred model and this year under Model A.

	Last year's values		This year's values	
Year	Recruits	Std. dev.	Recruits	Std. dev.
1977	2,577,100	312,291	1,985,750	156,335
1978	651,724	136,257	760,057	112,013
1979	855,987	115,728	692,919	97,612
1980	398,064	65,379	598,415	65,526
1981	175,500	36,606	317,281	39,612
1982	1,312,260	101,877	1,252,250	57,638
1983	296,381	43,943	324,619	49,762
1984	1,062,620	82,816	927,481	55,460
1985	509,878	51,303	546,818	42,182
1986	241,701	29,914	216,123	27,882
1987	145,513	22,956	123,829	22,007
1988	406,441	37,804	356,052	24,312
1989	884,194	69,872	857,757	41,640
1990	754,655	55,679	753,031	40,586
1991	444,549	39,206	493,823	30,713
1992	1,014,130	72,658	897,198	36,060
1993	414,229	34,677	489,914	25,413
1994	409,616	34,346	451,380	24,431
1995	506,237	45,551	508,799	31,241
1996	1,110,340	85,107	1,031,330	38,805
1997	454,069	35,349	582,869	28,516
1998	533,278	40,779	420,094	27,064
1999	901,297	65,843	772,362	31,955
2000	586,787	42,102	582,584	24,702
2001	312,067	26,662	311,973	17,820
2002	361,796	30,906	425,951	20,512
2003	325,788	31,611	343,915	19,790
2004	197,043	21,591	269,951	17,660
2005	288,607	31,737	380,035	25,899
2006	1,029,020	116,919	727,875	50,440
2007	475,798	192,125	479,143	52,453
2008			1,446,850	202,881
Average	633,441		635,263	

Table 2.2.25c—Numbers (1000s) at age as estimated by Model A.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1977	1881550	132388	56462	149251	36374	23267	14879	9514	6084	3891	2488	1591	1017	651	416	266	170	109	70	44	79
1978	697922	1339230	94185	39835	100574	24036	15358	9858	6327	4056	2597	1662	1063	680	435	278	178	114	73	47	83
1979	632289	496760	952645	66270	26561	65523	15636	10031	6464	4159	2670	1712	1096	701	449	287	184	117	75	48	85
1980	589087	450045	353446	673074	44994	17716	43657	10453	6727	4344	2799	1798	1153	739	473	303	194	124	79	51	90
1981	280467	419295	320186	250279	470429	30893	12006	29416	7030	4522	2920	1881	1209	775	497	318	203	130	83	53	94
1982	1221200	199628	298222	226320	174893	324572	21108	8162	19952	4764	3063	1978	1274	819	525	336	215	138	88	56	100
1983	282912	869216	142020	210737	158390	121325	223639	14494	5596	13672	3263	2098	1354	873	561	360	230	147	94	60	107
1984	908430	201368	618384	100324	146453	108698	82522	151389	9792	3778	9227	2202	1416	914	589	378	243	155	99	64	113
1985	533767	646594	143276	437159	69628	99194	72822	55015	100737	6513	2513	6138	1465	942	608	392	252	161	103	66	118
1986	199286	379920	460163	101809	306300	47190	65432	47728	36005	65977	4272	1650	4035	964	620	401	258	166	106	68	121
1987	112385	141846	270383	326621	71613	209047	31355	42978	31313	23630	43341	2809	1086	2657	635	409	264	170	109	70	125
1988	330835	79992	100946	192005	227997	48989	138032	20373	27871	20342	15382	28272	1835	710	1740	416	268	173	112	72	128
1989	831673	235478	56912	71480	133540	152010	32006	87539	12773	17405	12695	9597	17635	1145	443	1085	259	167	108	70	125
1990	701819	591960	167534	40243	49599	89894	98493	20539	55451	8065	10986	8014	6059	11136	723	280	685	164	106	68	123
1991	450277	499534	421317	118263	27303	32323	57093	61858	12898	34871	5082	6932	5059	3826	7034	457	177	433	104	67	121
1992	854470	320494	355535	297923	78851	16808	19282	33646	36437	7608	20677	3024	4136	3020	2285	4203	273	106	259	62	112
1993	447711	608187	228110	252047	203540	49240	10046	11450	20023	21901	4582	12556	1845	2531	1850	1400	2577	168	65	159	107
1994	411627	318667	432873	161638	173710	132149	30569	6215	7112	12508	13805	2891	7968	1174	1614	1180	894	1646	107	41	170
1995	465848	292984	226810	306373	110521	111659	80422	18402	3771	4337	7669	8532	1787	4951	732	1007	737	558	1028	67	132
1996	981230	331576	208509	160846	210793	70049	65502	45554	10469	2165	2500	4439	4969	1041	2893	428	590	432	327	603	117
1997	538742	698410	235980	148016	111305	135464	41723	37858	26326	6123	1275	1475	2626	2951	618	1722	255	352	258	195	430
1998	385638	383461	497050	167505	102273	70460	78661	23395	21221	14927	3514	736	852	1520	1714	359	1002	149	205	150	364
1999	735904	274486	272913	352963	116862	67175	43168	46937	13963	12758	9051	2145	450	522	931	1052	220	616	91	126	316
2000	553933	523795	195360	193993	246142	77377	41544	25887	28200	8474	7809	5584	1331	280	324	580	656	137	384	57	276
2001	288043	394273	372810	138757	135374	160353	47919	25111	15750	17402	5292	4915	3538	847	178	207	370	419	88	246	214
2002	406140	205020	280624	264764	96270	89697	100021	29513	15569	9911	11074	3394	3167	2289	550	116	134	240	273	57	299
2003	342386	289078	145924	199241	182925	62391	55457	60044	17810	9532	6154	6936	2138	2001	1451	349	74	85	153	173	227
2004	261707	243700	205752	103696	137159	117140	37668	32870	35830	10775	5863	3832	4349	1346	1264	919	222	47	54	97	254
2005	386727	186276	173455	146046	71894	87164	70082	22104	19358	21536	6553	3609	2379	2712	842	792	577	139	29	34	221
2006	944106	275261	132580	123272	100652	46851	52230	40710	12772	11229	12650	3874	2148	1424	1628	506	477	348	84	18	154
2007	456366	671986	195915	94091	85884	64512	28339	29977	23250	7346	6500	7423	2285	1274	848	972	303	285	208	50	103
2008	1419300	324828	478279	139052	64678	56427	38836	16608	17381	13586	4332	3854	4447	1374	769	513	589	184	173	127	94
2009	211279	1010210	231196	339648	95439	40666	33968	22217	9472	10024	7919	2547	2275	2649	821	461	308	355	111	104	133
2010	591859	150382	719017	164129	233501	59913	23524	19304	12510	5371	5786	4616	1495	1340	1571	488	275	184	212	66	142

Table 2.26—Estimates of “effective” fishing mortality (= $-\ln(N_{a+1,t+1}/N_{a,t})-M$) at age and year for Model A.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1977	0.000	0.009	0.055	0.074	0.075	0.072	0.068	0.066	0.064	0.063	0.063	0.063	0.062	0.062	0.062	0.062	0.062	0.062	0.062
1978	0.001	0.012	0.066	0.089	0.090	0.086	0.082	0.080	0.078	0.077	0.077	0.076	0.076	0.076	0.076	0.076	0.076	0.076	0.076
1979	0.000	0.007	0.047	0.065	0.066	0.063	0.060	0.057	0.056	0.055	0.055	0.055	0.055	0.054	0.054	0.054	0.054	0.054	0.054
1980	0.000	0.005	0.018	0.036	0.049	0.055	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057	0.057
1981	0.001	0.007	0.018	0.031	0.041	0.046	0.048	0.049	0.049	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
1982	0.000	0.007	0.017	0.026	0.033	0.036	0.037	0.038	0.038	0.038	0.038	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
1983	0.000	0.008	0.024	0.037	0.045	0.050	0.052	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
1984	0.000	0.007	0.025	0.050	0.061	0.066	0.067	0.068	0.068	0.068	0.068	0.068	0.067	0.067	0.067	0.067	0.067	0.067	0.067
1985	0.000	0.002	0.016	0.049	0.076	0.083	0.084	0.083	0.082	0.081	0.079	0.079	0.078	0.078	0.077	0.077	0.077	0.077	0.077
1986	0.000	0.003	0.012	0.042	0.069	0.080	0.081	0.081	0.080	0.079	0.079	0.078	0.078	0.077	0.077	0.077	0.077	0.077	0.076
1987	0.000	0.002	0.020	0.040	0.075	0.091	0.093	0.091	0.089	0.087	0.086	0.084	0.083	0.083	0.082	0.082	0.082	0.081	0.081
1988	0.000	0.005	0.024	0.066	0.086	0.115	0.127	0.130	0.131	0.131	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132	0.132
1989	0.000	0.007	0.026	0.057	0.094	0.104	0.116	0.119	0.120	0.120	0.120	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119
1990	0.000	0.008	0.049	0.089	0.114	0.125	0.125	0.124	0.122	0.121	0.120	0.120	0.120	0.119	0.119	0.119	0.119	0.119	0.119
1991	0.000	0.007	0.067	0.146	0.177	0.189	0.189	0.188	0.183	0.179	0.177	0.176	0.176	0.175	0.175	0.175	0.174	0.174	0.174
1992	0.000	0.004	0.042	0.132	0.174	0.180	0.178	0.169	0.167	0.159	0.154	0.151	0.151	0.150	0.150	0.149	0.149	0.149	0.148
1993	0.000	0.005	0.033	0.093	0.135	0.139	0.135	0.130	0.121	0.120	0.115	0.112	0.110	0.110	0.109	0.109	0.109	0.108	0.108
1994	0.000	0.006	0.041	0.103	0.156	0.166	0.159	0.154	0.149	0.141	0.141	0.136	0.134	0.132	0.132	0.132	0.131	0.131	0.131
1995	0.000	0.004	0.035	0.119	0.193	0.226	0.222	0.214	0.210	0.207	0.201	0.201	0.198	0.196	0.195	0.195	0.194	0.194	0.194
1996	0.000	0.003	0.029	0.104	0.178	0.206	0.207	0.196	0.189	0.187	0.185	0.181	0.181	0.179	0.178	0.177	0.177	0.177	0.177
1997	0.000	0.003	0.031	0.120	0.204	0.236	0.237	0.226	0.215	0.210	0.209	0.207	0.204	0.205	0.203	0.201	0.201	0.201	0.200
1998	0.000	0.002	0.021	0.082	0.150	0.176	0.175	0.169	0.161	0.154	0.152	0.151	0.151	0.149	0.149	0.148	0.147	0.147	0.147
1999	0.000	0.001	0.021	0.074	0.141	0.170	0.168	0.159	0.151	0.143	0.138	0.136	0.136	0.135	0.134	0.134	0.133	0.132	0.132
2000	0.000	0.002	0.020	0.090	0.139	0.162	0.156	0.142	0.131	0.123	0.117	0.112	0.111	0.110	0.110	0.108	0.109	0.108	0.107
2001	0.000	0.002	0.026	0.072	0.132	0.144	0.138	0.123	0.112	0.105	0.100	0.096	0.093	0.092	0.092	0.092	0.091	0.091	0.090
2002	0.000	0.003	0.030	0.095	0.141	0.170	0.165	0.151	0.137	0.129	0.123	0.120	0.117	0.115	0.114	0.114	0.114	0.113	0.112
2003	0.000	0.002	0.034	0.107	0.164	0.182	0.176	0.162	0.147	0.134	0.128	0.123	0.121	0.118	0.116	0.116	0.116	0.115	0.114
2004	0.000	0.003	0.027	0.115	0.174	0.192	0.189	0.169	0.158	0.146	0.138	0.133	0.130	0.129	0.127	0.125	0.125	0.125	0.124
2005	0.000	0.002	0.033	0.090	0.173	0.202	0.207	0.204	0.192	0.186	0.179	0.174	0.172	0.170	0.168	0.167	0.166	0.166	0.165
2006	0.000	0.003	0.022	0.107	0.164	0.214	0.219	0.212	0.206	0.193	0.188	0.183	0.179	0.177	0.175	0.174	0.173	0.172	0.172
2007	0.000	0.003	0.036	0.082	0.168	0.193	0.203	0.196	0.188	0.183	0.173	0.169	0.166	0.163	0.161	0.160	0.159	0.159	0.158
2008	0.000	0.002	0.037	0.126	0.168	0.217	0.220	0.209	0.199	0.191	0.187	0.179	0.176	0.173	0.171	0.169	0.168	0.168	0.167
2009	0.000	0.003	0.035	0.127	0.206	0.223	0.232	0.225	0.209	0.199	0.193	0.190	0.183	0.181	0.178	0.176	0.175	0.174	0.173
2010	0.000	0.002	0.026	0.094	0.166	0.193	0.194	0.184	0.179	0.167	0.161	0.157	0.156	0.152	0.150	0.149	0.148	0.147	0.146

Table 2.2.27—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in 2011-2023 (Scenarios 1 and 2), with random variability in future recruitment under Model A.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	227,000	227,000	227,000	227,000	0
2012	279,000	279,000	279,000	279,000	0
2013	280,000	280,000	280,000	280,000	9
2014	261,000	262,000	262,000	265,000	1,275
2015	238,000	244,000	245,000	259,000	6,881
2016	201,000	229,000	234,000	282,000	25,742
2017	167,000	225,000	229,000	318,000	45,835
2018	136,000	220,000	222,000	329,000	60,474
2019	124,000	220,000	223,000	333,000	66,429
2020	123,000	220,000	223,000	344,000	67,878
2021	124,000	221,000	223,000	338,000	66,689
2022	122,000	220,000	222,000	335,000	64,993
2023	125,000	221,000	222,000	333,000	63,951

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	341,000	341,000	341,000	341,000	0
2012	390,000	390,000	390,000	390,000	0
2013	420,000	420,000	420,000	420,000	15
2014	416,000	416,000	417,000	419,000	1,016
2015	393,000	397,000	399,000	409,000	5,258
2016	347,000	365,000	370,000	408,000	20,226
2017	322,000	359,000	370,000	451,000	42,193
2018	290,000	350,000	362,000	485,000	61,316
2019	273,000	350,000	365,000	502,000	72,376
2020	270,000	350,000	366,000	504,000	76,674
2021	268,000	352,000	367,000	518,000	77,878
2022	266,000	351,000	366,000	508,000	75,728
2023	271,000	353,000	365,000	507,000	73,267

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.27	0.27	0.27	0.27	0.00
2012	0.28	0.28	0.28	0.28	0.00
2013	0.28	0.28	0.28	0.28	0.00
2014	0.28	0.28	0.28	0.28	0.00
2015	0.28	0.28	0.28	0.28	0.00
2016	0.27	0.28	0.28	0.28	0.00
2017	0.25	0.28	0.28	0.28	0.01
2018	0.23	0.28	0.27	0.28	0.02
2019	0.21	0.28	0.26	0.28	0.02
2020	0.21	0.28	0.26	0.28	0.03
2021	0.21	0.28	0.26	0.28	0.03
2022	0.21	0.28	0.26	0.28	0.03
2023	0.21	0.28	0.26	0.28	0.03

Table 2.2.28—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that the upper bound on F_{ABC} is set the most recent five-year average fishing mortality rate in 2011-2023 (Scenario 3), with random variability in future recruitment under Model A.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	205,000	205,000	205,000	205,000	0
2012	243,000	243,000	243,000	243,000	0
2013	251,000	251,000	251,000	251,000	8
2014	238,000	239,000	240,000	241,000	1,082
2015	220,000	225,000	226,000	238,000	5,865
2016	193,000	213,000	218,000	259,000	21,321
2017	174,000	210,000	218,000	292,000	36,137
2018	155,000	209,000	215,000	304,000	46,135
2019	145,000	208,000	216,000	306,000	51,606
2020	143,000	207,000	215,000	319,000	53,569
2021	142,000	207,000	214,000	313,000	53,094
2022	141,000	206,000	213,000	309,000	51,489
2023	141,000	206,000	212,000	307,000	50,516

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	342,000	342,000	342,000	342,000	0
2012	399,000	399,000	399,000	399,000	0
2013	442,000	442,000	442,000	442,000	15
2014	447,000	448,000	448,000	450,000	1,016
2015	431,000	436,000	437,000	447,000	5,273
2016	386,000	405,000	409,000	448,000	20,527
2017	359,000	401,000	411,000	494,000	44,163
2018	319,000	389,000	401,000	534,000	67,064
2019	292,000	389,000	401,000	555,000	82,708
2020	276,000	384,000	399,000	559,000	90,074
2021	272,000	384,000	398,000	574,000	93,307
2022	266,000	384,000	396,000	562,000	92,053
2023	266,000	380,000	394,000	560,000	89,796

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.24	0.24	0.24	0.24	0.00
2012	0.24	0.24	0.24	0.24	0.00
2013	0.24	0.24	0.24	0.24	0.00
2014	0.24	0.24	0.24	0.24	0.00
2015	0.24	0.24	0.24	0.24	0.00
2016	0.24	0.24	0.24	0.24	0.00
2017	0.24	0.24	0.24	0.24	0.00
2018	0.24	0.24	0.24	0.24	0.00
2019	0.24	0.24	0.24	0.24	0.00
2020	0.24	0.24	0.24	0.24	0.00
2021	0.24	0.24	0.24	0.24	0.00
2022	0.24	0.24	0.24	0.24	0.00
2023	0.24	0.24	0.24	0.24	0.00

Table 2.2.29—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that the upper bound on F_{ABC} is set at $F_{60\%}$ in 2011-2023 (Scenario 4), with random variability in future recruitment under Model A.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	123,000	123,000	123,000	123,000	0
2012	155,000	155,000	155,000	155,000	0
2013	168,000	168,000	168,000	168,000	4
2014	167,000	168,000	168,000	169,000	631
2015	160,000	163,000	164,000	170,000	3,452
2016	144,000	156,000	159,000	184,000	12,914
2017	133,000	156,000	161,000	207,000	22,816
2018	121,000	155,000	159,000	218,000	30,282
2019	113,000	155,000	160,000	221,000	34,769
2020	110,000	155,000	160,000	231,000	36,743
2021	109,000	154,000	160,000	228,000	37,002
2022	107,000	153,000	159,000	226,000	36,173
2023	108,000	154,000	158,000	225,000	35,449

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	346,000	346,000	346,000	346,000	0
2012	432,000	432,000	432,000	432,000	0
2013	506,000	506,000	506,000	506,000	15
2014	540,000	541,000	541,000	543,000	1,017
2015	546,000	551,000	552,000	562,000	5,307
2016	506,000	525,000	530,000	570,000	21,077
2017	486,000	531,000	541,000	632,000	47,319
2018	439,000	518,000	532,000	683,000	75,616
2019	407,000	521,000	535,000	718,000	97,259
2020	383,000	516,000	533,000	721,000	108,612
2021	375,000	516,000	533,000	751,000	115,331
2022	368,000	515,000	531,000	743,000	115,772
2023	365,000	513,000	529,000	740,000	113,911

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.14	0.14	0.14	0.14	0.00
2012	0.14	0.14	0.14	0.14	0.00
2013	0.14	0.14	0.14	0.14	0.00
2014	0.14	0.14	0.14	0.14	0.00
2015	0.14	0.14	0.14	0.14	0.00
2016	0.14	0.14	0.14	0.14	0.00
2017	0.14	0.14	0.14	0.14	0.00
2018	0.14	0.14	0.14	0.14	0.00
2019	0.14	0.14	0.14	0.14	0.00
2020	0.14	0.14	0.14	0.14	0.00
2021	0.14	0.14	0.14	0.14	0.00
2022	0.14	0.14	0.14	0.14	0.00
2023	0.14	0.14	0.14	0.14	0.00

Table 2.2.30—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that *F* = 0 in 2011-2023 (Scenario 5), with random variability in future recruitment under Model A.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0	0	0	0	0
2012	0	0	0	0	0
2013	0	0	0	0	0
2014	0	0	0	0	0
2015	0	0	0	0	0
2016	0	0	0	0	0
2017	0	0	0	0	0
2018	0	0	0	0	0
2019	0	0	0	0	0
2020	0	0	0	0	0
2021	0	0	0	0	0
2022	0	0	0	0	0
2023	0	0	0	0	0

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	353,000	353,000	353,000	353,000	0
2012	482,000	482,000	482,000	482,000	0
2013	614,000	614,000	614,000	614,000	15
2014	710,000	710,000	711,000	712,000	1,018
2015	773,000	777,000	779,000	789,000	5,355
2016	760,000	779,000	785,000	826,000	21,870
2017	771,000	820,000	832,000	933,000	52,177
2018	726,000	818,000	836,000	1,020,000	90,008
2019	697,000	837,000	856,000	1,100,000	123,956
2020	665,000	839,000	863,000	1,120,000	144,650
2021	650,000	848,000	870,000	1,160,000	160,752
2022	639,000	852,000	872,000	1,190,000	167,139
2023	633,000	856,000	875,000	1,190,000	168,746

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.00	0.00	0.00	0.00	0.00
2012	0.00	0.00	0.00	0.00	0.00
2013	0.00	0.00	0.00	0.00	0.00
2014	0.00	0.00	0.00	0.00	0.00
2015	0.00	0.00	0.00	0.00	0.00
2016	0.00	0.00	0.00	0.00	0.00
2017	0.00	0.00	0.00	0.00	0.00
2018	0.00	0.00	0.00	0.00	0.00
2019	0.00	0.00	0.00	0.00	0.00
2020	0.00	0.00	0.00	0.00	0.00
2021	0.00	0.00	0.00	0.00	0.00
2022	0.00	0.00	0.00	0.00	0.00
2023	0.00	0.00	0.00	0.00	0.00

Table 2.2.31—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = F_{OFL}$ in 2011-2023 (Scenario 6), with random variability in future recruitment under Model A.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	266,000	266,000	266,000	266,000	0
2012	318,000	318,000	318,000	318,000	0
2013	311,000	311,000	311,000	311,000	11
2014	283,000	285,000	285,000	288,000	1,522
2015	248,000	258,000	260,000	279,000	9,986
2016	191,000	223,000	232,000	307,000	36,773
2017	163,000	224,000	236,000	346,000	57,219
2018	136,000	222,000	232,000	357,000	70,476
2019	126,000	223,000	235,000	361,000	76,240
2020	128,000	226,000	236,000	373,000	77,231
2021	127,000	226,000	236,000	369,000	75,681
2022	127,000	226,000	235,000	365,000	73,881
2023	130,000	224,000	234,000	361,000	72,964

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	338,000	338,000	338,000	338,000	0
2012	375,000	375,000	375,000	375,000	0
2013	392,000	392,000	392,000	392,000	15
2014	377,000	377,000	378,000	380,000	1,015
2015	348,000	353,000	354,000	364,000	5,116
2016	307,000	323,000	327,000	363,000	18,830
2017	289,000	323,000	332,000	403,000	37,147
2018	264,000	319,000	328,000	433,000	52,833
2019	251,000	320,000	332,000	445,000	61,736
2020	250,000	321,000	333,000	452,000	65,301
2021	249,000	323,000	334,000	462,000	65,940
2022	248,000	321,000	333,000	454,000	63,745
2023	251,000	322,000	332,000	454,000	61,712

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.32	0.32	0.32	0.32	0.00
2012	0.34	0.34	0.34	0.34	0.00
2013	0.34	0.34	0.34	0.34	0.00
2014	0.34	0.34	0.34	0.34	0.00
2015	0.33	0.33	0.33	0.34	0.00
2016	0.29	0.30	0.31	0.34	0.01
2017	0.27	0.30	0.31	0.34	0.02
2018	0.25	0.30	0.30	0.34	0.03
2019	0.23	0.30	0.30	0.34	0.04
2020	0.23	0.30	0.30	0.34	0.04
2021	0.23	0.30	0.30	0.34	0.04
2022	0.23	0.30	0.30	0.34	0.04
2023	0.23	0.30	0.30	0.34	0.04

Table 2.2.32—Projections for BSAI Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in each year 2011-2012 and $F = F_{OFL}$ thereafter (Scenario 7), with random variability in future recruitment under Model A.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	227,000	227,000	227,000	227,000	0
2012	279,000	279,000	279,000	279,000	0
2013	329,000	329,000	329,000	329,000	11
2014	295,000	296,000	297,000	299,000	1,522
2015	261,000	269,000	271,000	286,000	8,175
2016	197,000	231,000	240,000	311,000	36,771
2017	165,000	227,000	238,000	349,000	57,158
2018	137,000	223,000	232,000	358,000	70,555
2019	126,000	223,000	235,000	361,000	76,307
2020	128,000	225,000	236,000	373,000	77,279
2021	127,000	226,000	236,000	369,000	75,709
2022	127,000	226,000	234,000	364,000	73,897
2023	130,000	224,000	234,000	361,000	72,971

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	341,000	341,000	341,000	341,000	0
2012	390,000	390,000	390,000	390,000	0
2013	417,000	417,000	417,000	417,000	15
2014	396,000	397,000	397,000	399,000	1,015
2015	361,000	366,000	367,000	377,000	5,240
2016	313,000	330,000	335,000	372,000	19,448
2017	291,000	326,000	335,000	407,000	37,772
2018	265,000	320,000	329,000	436,000	53,311
2019	251,000	321,000	332,000	446,000	62,012
2020	250,000	321,000	333,000	453,000	65,424
2021	249,000	323,000	334,000	462,000	65,993
2022	248,000	321,000	333,000	454,000	63,765
2023	251,000	322,000	332,000	454,000	61,718

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2011	0.27	0.27	0.27	0.27	0.00
2012	0.28	0.28	0.28	0.28	0.00
2013	0.34	0.34	0.34	0.34	0.00
2014	0.34	0.34	0.34	0.34	0.00
2015	0.34	0.34	0.34	0.34	0.00
2016	0.29	0.31	0.31	0.34	0.01
2017	0.27	0.31	0.31	0.34	0.02
2018	0.25	0.30	0.30	0.34	0.03
2019	0.23	0.30	0.30	0.34	0.04
2020	0.23	0.30	0.30	0.34	0.04
2021	0.23	0.30	0.30	0.34	0.04
2022	0.23	0.30	0.30	0.34	0.04
2023	0.23	0.30	0.30	0.34	0.04

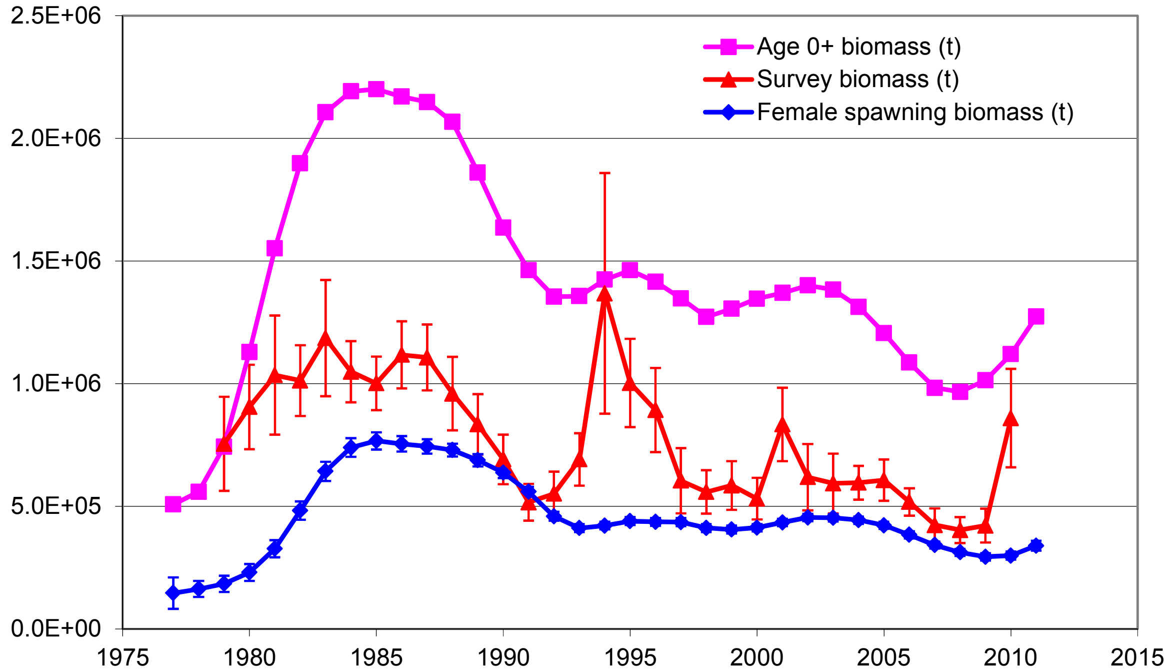


Figure 2.2.11—Biomass time trends (age 0+ biomass, female spawning biomass, survey biomass) of EBS Pacific cod as estimated by Model A. Spawning survey and survey biomass show 95% CI.

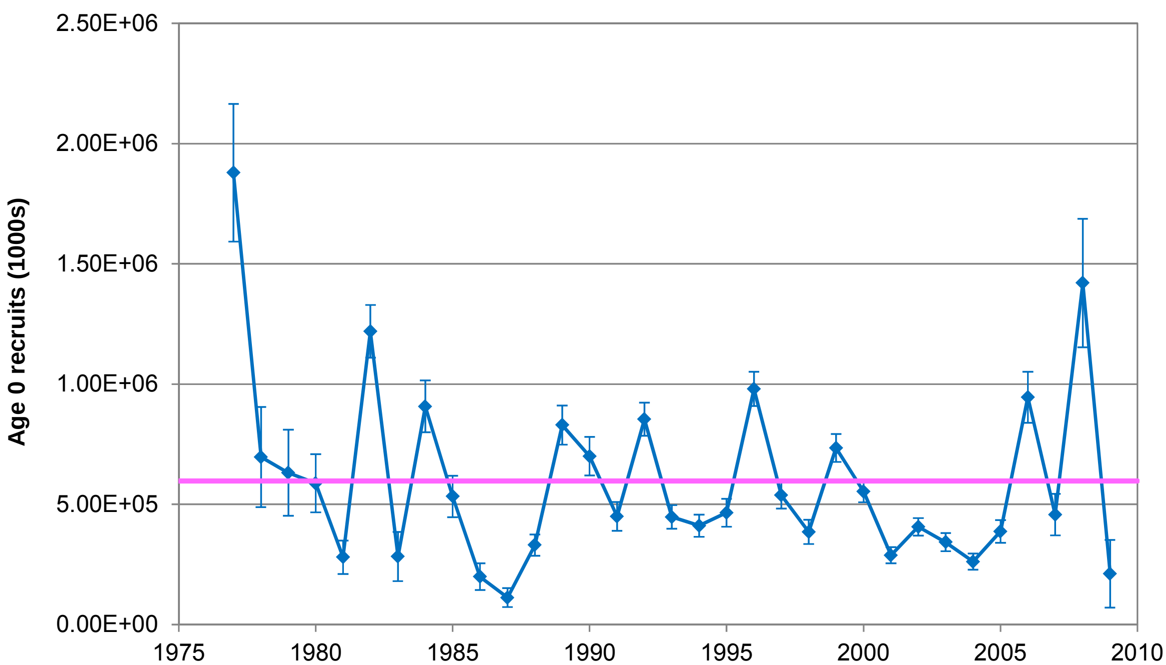


Figure 2.2.12—Time series of EBS Pacific cod recruitment at age 0, with 95% confidence intervals, as estimated by Model A. Magenta line = 1977-2009 average.

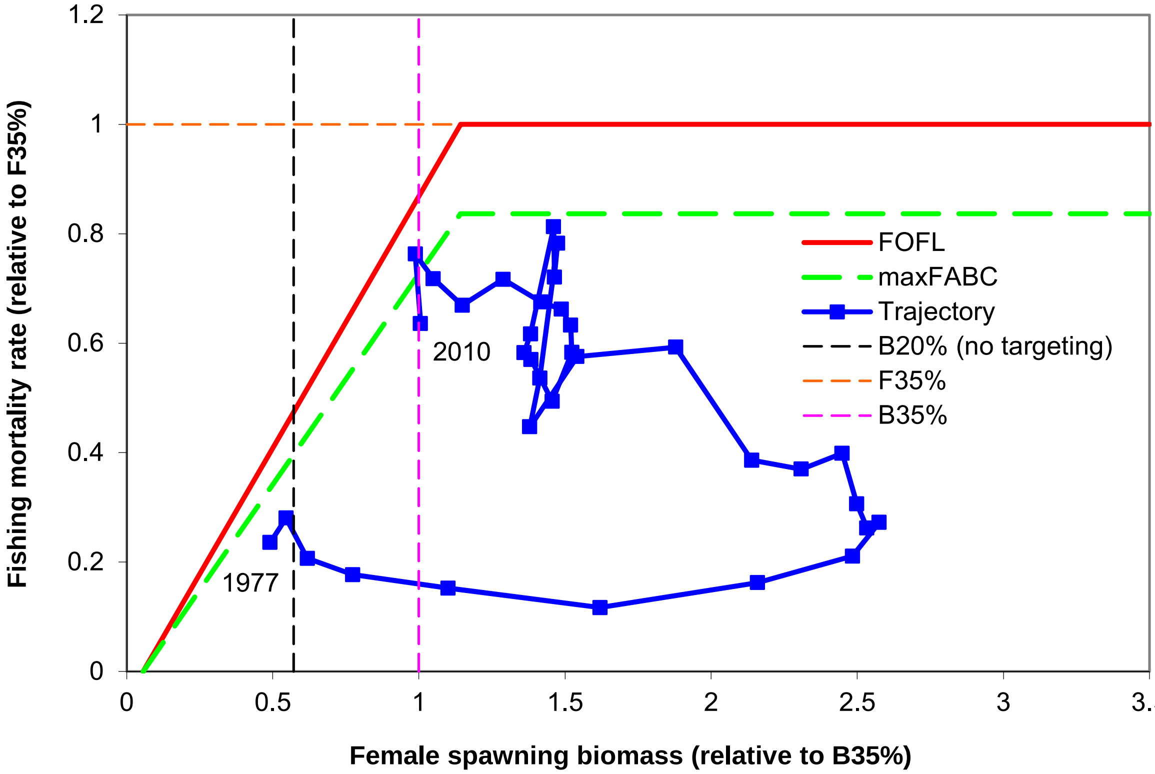


Figure 2.2.13—Trajectory of Pacific cod fishing mortality and female spawning biomass as estimated by Model A, 1977-present. Because Pacific cod is a key prey of Steller sea lions, harvests would be restricted to incidental catch in the event that spawning biomass fell below $B_{20\%}$. Note that $B_{35\%}$ is defined by 2010 parameter values for purposes of this graph (with cohort-specific growth rates, the value of $B_{35\%}$ changes every year).