Chapter 2: Assessment of the Pacific Cod Stock in the Eastern Bering Sea

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EXECUTIVE SUMMARY

Note: Due to a shutdown of the Federal government during the dates October 1-16, 2013, some customary features are missing from this stock assessment, including:

1. Responses to SSC and Plan Team comments (other than those already addressed in the preliminary assessment, Appendix 2.1)
2. Alternatives to the model structure used for setting harvest specifications last year
3. Retrospective analyses

For the same reason, certain tables have not been updated, including:

1. Discards of Pacific cod in the Pacific cod fishery
2. Incidental catch of FMP species in the Pacific cod fishery
3. Incidental catch of non-target species in the Pacific cod fishery
4. Incidental catch of prohibited species in the Pacific cod fishery

Unrelated to the government shutdown, the former BSAI Pacific cod SAFE chapter has been split into two chapters this year: Chapter 2 pertains to the eastern Bering Sea (EBS) stock, and Chapter 2A pertains to the Aleutian Islands (AI) stock. This change has been anticipated for several years, but was precipitated this year by the likelihood that separate harvest specifications will be set for the EBS and AI Pacific cod stocks beginning with the 2014 fishery.

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 EBS Pacific cod stock assessment.

Changes in the Input Data

1) Catch data for 1991-2012 were updated, and preliminary catch data for 2013 were incorporated.
2) Commercial fishery size composition data for 2012 were updated, and preliminary size composition data from the 2013 commercial fisheries were incorporated.
3) Size composition data from the 2013 EBS shelf bottom trawl survey were incorporated.
4) The numeric abundance estimate from the 2013 EBS shelf bottom trawl survey was incorporated (the 2013 estimate of 751 million fish was down about 24% from the 2012 estimate).
5) Age composition data from the 2012 EBS shelf bottom trawl survey were incorporated.

6) Mean length at age data from the 2012 EBS shelf bottom trawl survey were incorporated.
7) Seasonal catch per unit effort (CPUE) data for the trawl, longline, and pot fisheries from 2012 were updated, and preliminary CPUE data for the trawl, longline, and pot fisheries from 2013 were incorporated.

Changes in the Assessment Methodology

Many changes have been made or considered in the stock assessment model since the 2012 assessment (Thompson and Lauth 2012). Four models were presented in this year's preliminary assessment (Appendix 2.1), as requested in May and June by the Plan Team and SSC. After reviewing the preliminary assessment, the Plan Team requested six models for inclusion in the final assessment. The SSC agreed with this suggestion, and asked for an additional two models, bringing the total number of models requested for inclusion in the final assessment to eight.

However, due to the government shutdown, the only model presented here is the model that was used last year to set harvest specifications for 2013-2014 (updated with new data, as described above). This is also model that was used in 2011 to set harvest specifications for 2012-2013 (Thompson and Lauth 2011).

Summary of Results

The principal results of the present assessment, based on the current 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 (**note that last year's assessment was for the combined EBS and AI (BSAI) region, but this year's assessment is for the EBS only; also note that the projected total (age 0+) biomass listed for 2013 and 2014 in last year's summary table was incorrect, but has been corrected below**):

Quantity	As estimated or *specified last* year for: 2013	2014	As estimated or *recommended this* year for: 2014	2015
M (natural mortality rate)	0.34	0.34	0.34	0.34
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	1,720,000	1,840,000	1,570,000	1,640,000
Female spawning biomass (t)				
Projected				
Upper 95% confidence interval	470,000	495,000	407,000	437,000
Point estimate	422,000	447,000	361,000	389,000
Lower 95% confidence interval	373,000	399,000	315,000	341,000
$B_{100\%}$	896,000	896,000	796,000	796,000
$B_{40\%}$	358,000	358,000	318,000	318,000
$B_{35\%}$	314,000	314,000	279,000	279,000
F_{OFL}	0.34	0.34	0.34	0.34
$maxF_{ABC}$	0.29	0.29	0.28	0.28
F_{ABC}	0.29	0.29	0.28	0.28
OFL (t)	359,000	379,000	299,000	319,000
maxABC (t)	307,000	323,000	255,000	272,000
ABC (t)	307,000	323,000	255,000	272,000
Status	As determined *last* year for: 2011	2012	As determined *this* year for: 2012	2013
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Below is a table similar to the one on the proceeding page, except with the catch and biomass numbers for last year's assessment multiplied by 0.93 (the reciprocal of last year's BSAI/EBS expansion factor), to show what those values might have been *if* the 2013-2014 specifications that were made last year had pertained to the EBS stock only:

Quantity	As estimated or *specified last* year for: 2013	2014	As estimated or *recommended this* year for: 2014	2015
M (natural mortality rate)	0.34	0.34	0.34	0.34
Tier	3a	3a	3a	3a
Projected total (age 0+) biomass (t)	1,600,000	1,710,000	1,570,000	1,640,000
Female spawning biomass (t)				
Projected				
Upper 95% confidence interval	437,000	461,000	407,000	437,000
Point estimate	392,000	416,000	361,000	389,000
Lower 95% confidence interval	347,000	371,000	315,000	341,000
$B_{100\%}$	833,000	833,000	796,000	796,000
$B_{40\%}$	333,000	333,000	318,000	318,000
$B_{35\%}$	292,000	292,000	279,000	279,000
F_{OFL}	0.34	0.34	0.34	0.34
$maxF_{ABC}$	0.29	0.29	0.28	0.28
F_{ABC}	0.29	0.29	0.28	0.28
OFL (t)	334,000	352,000	299,000	319,000
maxABC (t)	285,000	300,000	255,000	272,000
ABC (t)	285,000	300,000	255,000	272,000
Status	As determined *last* year for: 2011	2012	As determined *this* year for: 2012	2013
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Responses to SSC and Plan Team Comments on Assessments in General

Three comments on assessments in general were addressed in the preliminary assessment (Appendix 2.1). In the interest of efficiency, they are not repeated in this section. Joint Plan Team (JPT) and SSC comments that were developed following completion of the preliminary assessment are shown below. Due to the October government shutdown, responses to these comments will be deferred to a future assessment.

JPT1 (9/13 minutes): *"The Teams recommended that SAFE chapter authors continue to include 'other' removals as an appendix. Optionally, authors could also calculate the impact of these removals on reference points and specifications, but are not required to include such calculations in final recommendations for OFL and ABC."*

JPT2 (9/13 minutes): *"In conformity with the main recommendations of the working group, the Teams recommended the following:*

1. *Assessment authors should routinely do retrospective analyses extending back 10 years, plot spawning biomass estimates and error bars, plot relative differences, and report Mohn's rho (revised).*
2. *If a model exhibits a retrospective pattern, try to investigate possible causes.*
3. *Communicate the uncertainty implied by retrospective variability in biomass estimates.*
4. *For the time being, do not disqualify a model on the grounds of poor retrospective performance alone.*
5. *Do consider retrospective performance as one factor in model selection."*

JPT3 (9/13 minutes): *"The Teams recommended that each stock assessment model incorporate the best possible estimate of the current year's removals. The Teams plan to inventory how their respective authors address and calculate total current year removals. Following analysis of this inventory, the Teams will provide advice to authors on the appropriate methodology for calculating current year removals to ensure consistency across assessments and FMPs."*

SSC1 (10/13 minutes): *"We agree with the recommendations of the Plan Team that retrospective analyses extending back 10 years and including Mohn's revised ρ, should routinely be presented in the assessments, and that retrospective patterns should be taken into consideration when selecting a model and when communicating uncertainties associated with biomass estimates. The SSC also notes that a strong retrospective bias should be one of the criteria considered when setting ABCs and could provide justification for recommending a higher or lower ABC."*

Responses to SSC and Plan Team Comments Specific to this Assessment

Nine comments specific to this assessment were addressed in the preliminary assessment. In the interest of efficiency, they are not repeated in this section. BSAI Plan Team (BPT) and SSC comments that were developed following completion of the preliminary assessment are shown below. Due to the October government shutdown, responses to these comments will be deferred to a future assessment.

BPT1 (9/13 minutes): *"The Plan Team recommended that studies of the vertical distribution of Pacific cod continue in order to test the previous finding that the average product of survey catchability and selectivity across the 60-81 cm size range is 0.47 (based on vertical distribution from archival tags). These studies should include: 1) analysis of existing fish acoustic data (as recommended by Bob Lauth); and 2) depending on the results of that analysis, repeat the 2012 experiment in an area where Pacific cod are distributed farther off bottom and using an acoustic buoy to measure vertical response to the passing vessel."*

BPT2 (9/13 minutes): *"The Team recommended the following candidate models for the November meeting, intended to provide a number of alternatives to the present standard Model 1:*

- i. *Model 1: the standard for the last two years.*
- ii. *Model 2a: Model 2 from the September meeting, with fixed M and freely estimated survey Q.*
- iii. *Model 2b: Model 2 from the September meeting, with fixed M but annually varying survey Q (mean value and dev vector estimated freely).*
- iv. *Model 3a: Model 3 from the September meeting, with asymptotic survey selectivity and a prior on survey Q.*
- v. *Model 3b: Like Model 3a but with M estimated.*
- vi. *Model 4: Same as last year's Model 4.*

The Team recommended that the author feel free to apply the iterative tuning procedures to Model 4 only, and use the values of the iteratively tuned quantities from Model 4 for the remaining models (other than

Model 1) because all of the models other than Model 1 involve labor-intensive iterative tuning, and given that all of these iteratively tuned models are based to some extent on Model 4."

SSC2 (10/13 minutes): *"The SSC notes that all of the Pacific cod models are characterized by a large number of parameters and dome-shaped selectivities, features that were found to be associated with retrospective patterns and a higher risk of overfishing in the meta-analysis by Hanselman et al. (see separate section). The SSC has previously encouraged the authors to simplify the models when possible and appreciates the suggestion by Grant Thompson (AFSC) to consider omitting seasonal structure in one or more of these models in the future."*

SSC3 (10/13 minutes): *"The SSC agrees with Plan Team recommendations regarding models to bring forward in December. In addition to the recommended model configurations, the SSC would like to see a model or models that fix survey catchability at Q=1. We suggest presenting variants of model 2a (or 2b with mean Q=1) and model 3a with Q=1. Our rationale for this request is based on the increasing evidence that catchability is higher and quite possibly much higher than the current standard assumption that selectivity in the 60-81 cm size range is 0.47, which is based on a limited study by Nichol (2007). Evidence from an unpublished study conducted in 2012 (Lauth) suggests that there is no difference in catchability between the low-opening (2.5 m) trawl used in the Bering Sea survey and the high opening (7 m) trawl used in the Gulf of Alaska survey. Moreover, observations of acoustic backscatter showed that Pacific cod tended to be near the bottom in the study area, consistent with a dive response to passing vessels commonly observed in other gadids. We note that the default assumption in most assessments is that survey catchability is 1, unless there is strong evidence to the contrary. The evidence to date consists of the vertical distribution of 11 tagged fish under undisturbed conditions over a period of one month (Nichol et al 2007)."*

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 65° N latitude (Lauth 2011). Pacific cod is distributed widely over the eastern Bering Sea (EBS) as well as in the Aleutian Islands (AI) area. Tagging studies (e.g., Shimada and Kimura 1994) have demonstrated significant migration both within and between the EBS, AI, and Gulf of Alaska (GOA). However, recent research indicates the existence of discrete stocks in the EBS and AI (Canino et al. 2005, Cunningham et al. 2009, Canino et al. 2010, Spies 2012). Although the resource in the combined EBS and AI (BSAI) region has traditionally been managed as a single unit, the SSC has indicated that it intends to set separate 2014-2015 harvest specifications for the two areas.

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 2.49% per day (Jung et al. 2009). This may be compared to a mean estimate for age 0 Atlantic cod (*Gadus morhua*) in Newfoundland of 4.17% per day, with a 95% confidence interval ranging from about 3.31% to 5.03% (Gregory et al. in prep.); 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 exhibit 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

Description of the Directed Fishery

During the early 1960s, a Japanese longline fishery harvested EBS 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 EBS. 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.

Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including trawl, longline, pot, and jig components (although catches by jig gear are very small in comparison to the other three main gear types, with an average annual catch of less than 200 t since 1992). The breakdown of catch by gear during the most recent complete five-year period (2008-2012) is as follows: longline gear accounted for an average of 59% of the catch, trawl gear accounted for an average of 29%, and pot gear accounted for an average of 12%.

In the EBS, Pacific cod are caught throughout much of the continental shelf, with NMFS statistical areas 509, 513, 517, 519, and 521 each accounting for at least 5% of the average catch over the most recent 5-year period (2008-2012).

Catches of Pacific cod taken in the EBS for the periods 1964-1980, 1981-1990, and 1991-2013 are shown in Tables 2.1a, 2.1b, and 2.1c, respectively. The catches in Tables 2.1a and 2.1b are broken down by fleet sector (foreign, joint venture, domestic annual processing). The catches in Table 2.1b are also broken down by gear to the extent possible. The catches in Table 2.1c are broken down by gear.

Excerpts from then-current regulations governing the BSAI Pacific cod fisheries, including license limitation permits, prohibitions, allocations, closures, and seasons, were given in Attachment 2.3 of last year's assessment (Thompson and Lauth 2012). The major change for 2014 is that the Board of Fisheries for the State of Alaska established a guideline harvest level (GHL) in State waters between 164 and 167 degrees west longitude in the EBS subarea equal to 3 percent of the Pacific cod ABC in the BSAI (this supplements the corresponding 3% GHL that has been set aside for the Aleutian Islands area since 2006). In the event that separate subarea (EBS and AI) ABCs replace the BSAI-wide ABC in 2014, the State will sum the two subarea ABCs, then set a GHL in each subarea equal to 3% of the total.

Effort and CPUE

Figures 2.1 and 2.2 show, subject to confidentiality restrictions, the approximate locations in which hauls or sets sampled during 2011 and 2012 contained Pacific cod. To create these figures, the areas managed under the FMP were 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. Figure 2.1 shows locations of sampled EBS hauls/sets containing Pacific cod for trawl, longline, and pot gear, for the January-April, May-July, and August-December seasons. Figure 2.2 shows locations of sampled EBS hauls/sets for the same gear types, but aggregated across seasons. More squares are shaded in Figure 2.2 than in Figure 2.1 because aggregating across seasons increases the number of squares that satisfy the confidentiality constraint.

Various gear-specific time series of fishery catch per unit effort (CPUE) are plotted in Figure 2.3. Most CPUE time series are either flat or increasing since about the middle of the last decade.

Discards

The catches shown in Tables 2.1b and 2.1c include estimated discards. Discard rates of Pacific cod in the EBS Pacific cod fisheries are shown for each year 1991-2012 in Table 2.2. Implementation of Amendment 49, which mandated increased retention and utilization, resulted in an average reduction of 90% in discards of Pacific cod between 1991-1997 and 1998-2012.

Management History

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 2.3. Note that this time series pertains to the combined BSAI region, so the catch time series differs from that shown in Table 2.1, which pertains to the EBS only.

From 1980 through 2013, TAC averaged about 83% of ABC (ABC was not specified prior to 1980), and from 1980 through 2013 aggregate commercial catch averaged about 91% of TAC (remembering that 2013 catch data are not yet final). In 10 of these 33 years (29%), TAC equaled ABC exactly, and in 8 of these 34 years (24%), catch exceeded TAC (by an average of 3%). However, three of those overages occurred in 2007, 2008, and 2010, when TAC was reduced by 3% to account for a small, State-managed fishery inside State of Alaska waters (similar reductions have been made in all years since 2006); thus, while the combined Federal and State catch exceeded the Federal TAC in 2007, 2008, and 2010 by 2% or less, the overall target catch (Federal TAC plus State GHL) was *not* exceeded.

Total (BSAI) catch has been less than OFL in every year since 1993.

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 modeling software (Methot 1986, 1990) with age-based data. All assessments from 1993 through 2003 continued to use the Stock Synthesis modeling software, but with length-based data. Age data based on a revised ageing protocol were added to the model in the 2004 assessment. At about that time, a major upgrade in the Stock Synthesis architecture resulted in a substantially new product, labeled "SS2" (Methot 2005). The assessment was migrated to SS2 in 2005, and several changes have been made to the model in most years since then (see Appendix 2.2). A note on nomenclature: The label "SS2" was dropped in 2008. Since then, the program has been known simply as "Stock Synthesis" or "SS," with several versions produced each year, each given an alpha-numeric label.

Table 2.4 lists all amendments to the BSAI Groundfish FMP that reference Pacific cod explicitly.

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 EBS.

The following table summarizes the sources, types, and years of data included in the data file for the stock assessment model:

Source	Type	Years
Fishery	Catch biomass	1977-2013
Fishery	Catch size composition	1977-2013
Fishery	Catch per unit effort	1991-2013
EBS shelf bottom trawl survey	Numerical abundance	1982-2013
EBS shelf bottom trawl survey	Size composition	1982-2013
EBS shelf bottom trawl survey	Age composition	1994-2012
EBS shelf bottom trawl survey	Mean size at age	1994-2012

Fishery

Catch Biomass

Catches taken in the EBS for the period 1977-2013 are shown for the three main gear types in Table 2.5. Table 2.5 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 were the result of a statistical analysis described in the 2010 preliminary assessment (Thompson et al. 2010), and the selectivity seasons were chosen to correspond as closely as possible to the traditional seasons used in assessments prior to 2010 (given the revised catch seasons).

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 Table 2.5. Catches for the years 1977-1980 may or may not include discards.

The catches shown in Table 2.5 consist of "official" data from the NMFS Alaska Region. However, other removals of Pacific cod are known to have occurred over the years, including removals due to subsistence fishing, scientific research, and fisheries managed under other FMPs. Estimates of such other removals are available at: http://www.afsc.noaa.gov/REFM/Docs/2013/EBS_Pcod_other_removals.xlsx.

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 2013. Beginning with the 2010 assessment (Thompson et al. 2010), size composition data are based on 1-cm bins ranging from 4 to 120 cm. Because displaying these data would add a large number of pages to the present document, they are not shown here but are available at: http://www.afsc.noaa.gov/REFM/Docs/2013/EBS_Pcod_fishery_sizecomp_data.xlsx.

Catch Per Unit Effort

Fishery catch per unit effort data are available by gear and season for the years 1991-2013 and are shown in Table 2.6. Units are kg/minute for trawl gear, kg/hook for longline gear, and kg/pot for pot gear; data for 2013 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.

Survey

EBS Shelf Bottom Trawl Survey

Estimates of total abundance (both in biomass and numbers of fish) obtained from the trawl surveys are shown in Table 2.7, together with their respective standard errors. Upper and lower 95% confidence intervals are also shown for the biomass estimates. Survey results indicate that biomass remained relatively constant from 1982 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 an all-time low in 2007 and again in 2008. Estimated biomass more than doubled between 2009 and 2010, and has remained within 10% of the 2010 value for the last three years.

Numerical abundance has shown more variability than biomass, with the estimates since 2007 generally well above average pre-2007 levels (with the exception of 2008, estimates since 2007 have all been at least 15% above the pre-2007 average). While still well above average, the 2013 estimate is down 24% from the 2012 estimate (which was the second highest in the time series).

The relative size compositions from the EBS shelf bottom trawl survey for the years 1982-2013 are shown in Table 2.8 (actual numbers of fish measured are shown in column 2 in the upper portion of the first page). The 1982-2013 time series is shown according to the 1-cm bins described above for fishery size composition data. Rows in Table 2.8 sum to the actual number of fish measured in each year.

Age compositions from the 1994-2012 surveys are available. The age compositions and actual sample sizes are shown in Table 2.9.

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 2.10.

ANALYTIC APPROACH

Model Structure

Although Pacific cod in the EBS and AI were managed on a BSAI-wide basis through 2013, the stock assessment model has always been configured for the EBS stock only. Since 1992, the assessment model has always been developed under some version of the SS modeling framework (technical details given in Methot and Wetzel 2013; see especially Appendix A to that paper). A history of previous model structures, including details of the present model, is given in Appendix 2.2.

Briefly, some of the main features characterizing this year's model (the same model used to recommend harvest specifications for the last two years) are as follow:

1. Age- and time-invariant natural mortality, estimated outside the model
2. Parameters governing time-invariant mean length at age estimated internally
3. Parameters governing width of length-at-age distribution (for a given mean) estimated internally
4. Ageing bias parameters estimated internally
5. Standard deviations of *dev* vectors fixed at the values estimated in 2009
6. Survey catchability fixed at the value estimated in 2009 (based on Nichol et al. 2007)
7. Gear-and-season-specific catch and selectivity for the fisheries
8. Double normal selectivity for the fisheries and survey (see Appendix 2.2 for parameterization)
9. Length-based selectivity for the fisheries
10. Age-based selectivity for the survey
11. Fishery selectivity estimated for "blocks" of years
12. Survey selectivity constant over time, except with annual *dev*s for the *ascending_width* parameter
13. Survey size composition data used in all years, including those years with age composition data (at the request of Plan Team members, inclusion of survey size composition data in all years was instituted in the 2011 assessment and has been retained ever since, based on the view that the costs of double-counting are outweighed by the benefits of including this information for estimation of growth parameters)
14. Fishery CPUE data included but not used for estimation
15. Mean size at age included but not used for estimation

Version 3.24q (compiled on 05/20/13) of SS was used to run the model in this assessment. SS is programmed using the ADMB software package (Fournier et al. 2012). The current SS user manual is available at:
https://drive.google.com/a/noaa.gov/?tab=mo#folders/0Bz1UsDoLaOMLN2FiOTI3MWQtZDQwOS00YWZkLThmNmEtMTk2NTA2M2FjYWVh.

Parameters Estimated Outside the Assessment Model

Natural Mortality

A value of 0.34 has been used for the natural mortality rate *M* in all BSAI Pacific cod stock assessments since 2007 (Thompson et al. 2007b). 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 some 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.

The value of 0.34 adopted in 2007 replaced the value of 0.37 that had been used in all BSAI Pacific cod stock assessments from 1993 through 2006.

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

The model in this assessment fixes *M* at the value of 0.34 used since 2007.

Variability in Estimated Age

Variability in estimated age in SS is based on the standard deviation of estimated age between "reader" and "tester" age determinations. 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 recomputed this year, yielding an estimated slope of 0.08550 (i.e, the standard deviation of estimated age was modeled as 0.08550 × age) and a weighted R^2 of 0.93. This regression corresponds to a standard deviation at age 1 of 0.085 and a standard deviation at age 20 of 1.71. These parameters were used for the model in the present assessment.

Weight at Length

Parameters governing the weight-at-length schedule were re-estimated in the 2012 assessment (Thompson and Lauth 2012, Attachment 2.1, Annex 2.1.2), based on fishery data collected from 1974 through 2011.

Using the functional form weight = $\alpha \times \text{length}^{\beta}$, where weight is measured in kg and length is measured in cm, long-term base values for the parameters were estimated as $\alpha = 6.358\times10^{-6}$ and $\beta = 3.157$.

Seasonal additive offsets from the base parameter values were also re-estimated in the 2012 assessment, resulting in the following values:

Season:	Jan-Feb	Mar-Apr	May-Jul	Aug-Oct	Nov-Dec
α:	-2.312×10^{-2}	2.769×10^{-3}	1.946×10^{-2}	2.343×10^{-3}	-1.433×10^{-2}
β:	5.344×10^{-2}	-6.503×10^{-2}	-4.617×10^{-2}	-5.500×10^{-2}	3.329×10^{-2}

The above values for the base parameters and seasonal offsets were used for the model in the present assessment.

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 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. Beginning with the 2007 assessment, the accepted model has used an age-based schedule with intercept = 4.88 years and slope = –0.965 (Stark 2007). The use of an age-based rather than a length-based schedule follows a recommendation from the maturity study's author (James Stark, Alaska Fisheries Science Center, personal communication). The age-based parameters were retained for the model in the present assessment.

Standard Deviation of Log Recruitment

The standard deviation specified for log-scale age 0 recruitment was estimated iteratively in the 2009 assessment (Thompson et al. 2009), by matching the input value to the standard deviation of the estimated *dev*s. The resulting value of 0.57 was retained for the model in the present assessment.

Catchability

In the 2009 assessment (Thompson et al. 2009), catchability for the post-1981 trawl survey 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). The resulting value of 0.77 was retained for the model in the present assessment.

Parameters Estimated Inside the Assessment Model

A total of 186 parameters are estimated inside SS for the model used in this assessment. These include:

1. all three von Bertalanffy growth parameters
2. standard deviation of length at ages 1 and 20
3. mean ageing bias at ages 1 and 20
4. log mean recruitment since the 1976-1977 regime shift
5. offset for log-scale mean recruitment prior to the 1976-1977 regime shift
6. *dev*s for log-scale initial (i.e., 1977) abundance at ages 1 through 3
7. annual log-scale recruitment *dev*s for 1977-2012
8. initial (equilibrium) fishing mortality for the Jan-Apr trawl fishery
9. gear-, season-, and-block-specific selectivity parameters for nine fisheries
10. base values for all survey selectivity parameters
11. annual *dev*s for the *ascending_width* parameter of the survey selectivity function

Uniform prior distributions are used for all parameters, except that *dev* vectors are constrained by input standard deviations ("sigma"), which are somewhat analogous to a joint prior distribution.

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 internally, but not in the same sense as the above parameters. The fishing mortality rates are determined (almost) 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. An option does exist in SS for treating the fishing mortality rates as full parameters, but previous explorations have indicated that adding these parameters has almost no effect on other model output (Methot and Wetzell 2013).

Likelihood Components

The model in this assessment includes likelihood components for initial (equilibrium) catch, trawl survey relative abundance, fishery and survey size composition, survey age composition, recruitment, "softbounds" (equivalent to an extremely weak prior distribution used to keep parameters from hitting bounds), and parameter deviations.

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

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 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 an observed consistency in the ratios between the harmonic means (the raw harmonic means, not the rescaled harmonic means) and the actual sample sizes: Whenever the actual sample size exceeded about 400 fish, 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, records with actual sample sizes less than 400 were omitted. Then, the sample sizes for fishery length compositions from years prior to 1999 were tentatively set at 16% of the actual sample size, and the sample sizes for fishery 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 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. For the 2010 assessment, however, this procedure had to be modified somewhat, because the bootstrap values for the 1990-2006 size composition data did not match the new bin and seasonal structures. To be as consistent as possible with the approach used to set sample sizes in the 2008 and 2009 assessments, the 2010 and 2011 assessments set sample sizes by applying the 16/34% rule for *all* size composition records with actual sample sizes greater than 400 (not just those lying outside the set of 1990-2006 fishery data), then rescaling proportionally to achieve an average sample size of 300. The same procedure was used for the 2012 assessment, except the pre-1982 trawl survey data were no longer used. This year's assessment uses the same procedure as the 2012 assessment. Input sample sizes for all size composition records are shown in Tables 2.11.

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 (Table 2.9, column 2) proportionally such that the average of the input sample sizes was equal to 300, giving the following:

Year:	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
N:	205	172	204	206	182	246	248	272	271	390	298	367	372

Year:	2007	2008	2009	2010	2011	2012
N:	413	347	404	370	359	374

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

Fishery CPUE data are included in the model for comparative purposes only. Their respective catchabilities are estimated analytically, not statistically.

For the trawl surveys, each year's survey abundance estimate 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 estimate's standard error to the survey abundance estimate 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 likelihood component for recruitment is different from traditional likelihoods because it does not involve "data" in the same sense that traditional likelihoods do. Instead, the log-scale recruitment *dev* plays the role of the datum in a normal distribution with mean zero and specified (or estimated) standard deviation; but, of course, the *dev*s are parameters, not data.

RESULTS

Model Evaluation

The model used in this assessment is described under "Model Structure" above.

Goodness of Fit, Parameter Estimates, and Derived Quantities

Table 2.12 shows the negative log-likelihood for each data component and sub-component in the model. The first part of the table shows negative log-likelihoods for the aggregate data components. The second and third parts of the table break down the CPUE and size composition components into fleet-specific values. For the CPUE component, the fishery values are shown for completeness, but they are shaded to indicate that they do not count toward the total.

Table 2.13 provides alternative measures of how well the model fits the fishery CPUE and survey relative abundance data. The first column shows root mean squared errors (RMSE; lower values are better) and correlations between observed and estimated values (higher values are better). The most important parts of this column are the entries for the shelf trawl survey, where the model is shown to give an RMSE of 0.22 and a correlation of 0.72. Although the model does not actually attempt to fit the fishery CPUE data (only the survey CPUE are used), of the 9 correlations with fishery CPUE, all are positive, with no correlation less than 0.21. The second column shows the mean normalized residual (values closer to zero are better) and standard deviation of the normalized residuals (values closer to unity are better) for each fleet. For the shelf trawl survey, the model gave a mean normalized residual of 0.92, and a standard deviation of 1.86.

Figure 2.4 shows the model's fit to the trawl survey abundance data. The model's estimates fall within the 95% confidence intervals 75% of the time.

Table 2.14 shows how output "effective" sample sizes (McAllister and Ianelli 1997) compare to input sample sizes for the size composition data. Two sets of ratios are provided, with the arithmetic mean input sample size used as the denominator for both sets. The *arithmetic* mean effective sample size is used as the numerator for the first set, and the *harmonic* mean effective sample size is used for the second (values greater than unity are preferred in both measures, all else being equal). The model gives ratios greater (usually *much* greater) than unity for all cases in both measures, except for the Aug-Dec longline fishery in the measure based on the harmonic mean (ratio=0.88).

Table 2.15 provides a similar analysis for the age composition data, except that the rows in the main part of this table correspond to individual records rather than fisheries or surveys (all age composition data come from the survey). The bottom two rows in the table show the ratios of the means (using the arithmetic mean as the numerator in the next-to-last row and the harmonic mean in the last row). Both ratios are less than unity.

The model's fits to the age composition data are shown in Figure 2.5. Estimates of mean size at ages 1 through 3 (at the time of the survey) from the model are compared to the long-term average survey size composition (through 50 cm) in Figure 2.6. The model tends to undershoot the modes, but only by about 1 cm. The model's fits to the mean-size-at-age data are shown in Figure 2.7 (recall that the model does not actually attempt to fit these data). Because of the large number of size composition records (n=416), figures showing the model's fits to these data are not included in this document, but are available at: http://www.afsc.noaa.gov/REFM/Docs/2013/EBS_Pcod_sizecomp fits.xlsx.

Table 2.16 displays all of the parameters (except fishing mortality rates) estimated internally in the model, along with the standard deviations of those estimates. Table 2.16a shows growth, ageing bias, recruitment (except annual *dev*s), initial fishing mortality, and initial age composition parameters; Table 2.16b shows annual log-scale recruitment *dev*s (these are plotted in Figure 2.8), Table 2.16c shows fishery selectivity parameters, and Table 2.16d shows survey selectivity parameters.

Table 2.17 shows estimates of full-selection seasonal fishing mortality rates for each gear type and year (note that these are not counted as parameters in SS, and so do not have estimated standard deviations). The three right-hand columns show different measures of the "total" (i.e., across season and gear) fishing mortality rate. The first ("Peak") simply multiplies the season-and-gear-specific rates in each row (year) by the respective relative season lengths, then sums across seasons and gears. The other two columns make use of a new feature in SS that allows an average fishing mortality rate to be computed across a user-specified range of ages. Values of this statistic are shown for two age ranges in Table 2.17: ages 7-9, corresponding to the range with at least 85% selection based on a catch-weighted average over the last three years; and ages 6-20, corresponding to ≥80% selection based on the same measure.

Figure 2.9 shows the time series of spawning biomass relative to $B_{100\%}$ as estimated by the model.

Figure 2.10 shows trawl survey selectivity as estimated by the model. The variability across years for age 1 fish is due to the fact that annual *dev*s are estimated for the *ascending_width* parameter. All ages greater than 10 have selectivity estimates less than 0.26, meaning that the survey is estimated to miss more than 80% (=1–0.26×0.77) of all fish greater than 10 years of age.

Figure 2.11 shows gear-, season-, and block-specific fishery selectivity as estimated by the model. In general, selectivities that are not forced to be asymptotic tend to show decreasing selectivity at large size.

Because the catchability coefficient for the trawl survey was held constant 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 survey (i.e., 1982-2013), which resulted in the following statistics:

Statistic	Value
Average:	0.56
Minimum:	0.47
Maximum:	0.64
Standard deviation:	0.04
Coefficient of variation:	0.08

The average value implied by the model exceeds the target value by 0.09. The range bracketed by the includes the target value, but just barely.

Table 2.18 contains selected output from the standard projection model, based on SS parameter estimates from the assessment model, along with the probability that the maximum permissible ABC in each of the next two years will exceed the corresponding true-but-unknown OFL and the probability that the stock will fall below $B_{20\%}$ in each of the next five years (probabilities are given by SS rather than the standard projection model).

Evaluation Criteria

The following criteria were considered in evaluating the model:

1. Has the model previously been accepted by the SSC? Yes. The model presented here is the same one accepted by the Plan Team and SSC in each of the last two years.
2. Does the model appear to have converged successfully? Yes. A Hessian matrix was returned by ADMB, with no warning that it may not be positive definite.
3. Has the converged solution been tested for sensitivity to alternative starting values? Yes. The model passed a “jitter” test, in which 50 runs were made with initial parameter values displaced randomly from their converged values. No “jitter” run produced a better objective function value than the base run.

On the basis of the above, the model is recommended for use in setting final harvest specifications for 2014 and preliminary harvest specifications for 2015.

Final Parameter Estimates and Associated Schedules

As noted previously, estimates of all statistically estimated parameters in the model are shown in Table 2.16. Estimates of year-, gear-, and season-specific fishing mortality rates from the model are shown in Table 2.17.

Schedules of selectivity at length for the commercial fisheries from the model are shown in Table 2.19, and schedules of selectivity at age for the trawl surveys from the model are shown in Table 2.20. The trawl survey selectivity schedule and all fishery selectivity schedules for the model are plotted in Figures 2.11 and 2.12, 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 the model are shown in Tables 2.21, and 2.22, and 2.23, respectively.

Time Series Results

Definitions

The biomass estimates presented here will be defined in three ways: 1) age 0+ biomass, consisting of the biomass of all fish aged 0 years or greater in January of a given year; 2) age 3+ biomass, consisting of the biomass of all fish aged 3 years or greater in January of a given year; and 3) 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 2.17, an alternative “effective” fishing mortality rate will be provided here, defined for each age and time as $-\ln(N_{a+1,t+1}/N_{a,t})-M$, 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 2.24 shows the time series of age 0+, age 3+, and female spawning biomass for the years 1977-2013 as estimated last year and this year by the model (projections through 2014 are also shown for this year's assessment). The estimated spawning biomass time series are accompanied by their respective standard deviations.

The estimated time series of EBS age 0+, age 3+, and female spawning biomass from the model are shown, together with the observed time series of trawl survey biomass, in Figure 2.12. Confidence intervals are shown for the model estimates of female spawning biomass and for the trawl survey biomass estimates. The average ratio of estimated age 0+ biomass to survey biomass over the time series is 1.82. Given that the catchability coefficient is fixed at 0.77, estimation of biomasses at least 30% (on average) higher than observed by the survey is to be expected.

Recruitment and Numbers at Age

Table 2.25 shows the time series of age 0 recruitment (1000s of fish) for the years 1977-2012 as estimated last year and this year. 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, followed by the 2008 cohort. The year classes since 2006 include four of the top ten year classes of all time (2006, 2008, 2010, and 2011). The set of year classes comprising the top ten is the same this year as last year.

Recruitment estimates for the entire time series (1977-2012) are shown in Figure 2.13, along with their respective 95% confidence intervals.

The coefficient of autocorrelation for the recruitment time series is –0.15.

To date, it has not been possible to estimate a reliable stock-recruitment relationship for this stock. A possible (and very preliminary) relationship between recruitment and an environmental index is discussed under "Ecosystem Considerations," "Ecosystem Effects on the Stock."

The estimated time series of numbers at age is shown in Table 2.26.

Fishing Mortality

Table 2.27 shows "effective" fishing mortality by age and year for ages 1-19 and years 1977-2013 as estimated by the model.

Figure 2.14 plots the estimated trajectory of relative fishing mortality and relative female spawning biomass from 1977 through 2013 based on full-selection fishing mortality, 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). Nearly the entire trajectory lies underneath the $maxF_{ABC}$ control rule. It should be noted that this trajectory is based on SS output, which may not match the estimates obtained by the standard projection program exactly.

Harvest Recommendations

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: $B/B_{40\%} \leq 0.05$

$F_{OFL} = 0$

$F_{ABC} = 0$

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 the model's estimates of fishing mortality by gear for the five most recent complete years of data (2008-2012). 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 26%, longline 60%, and pot 14%. This apportionment results in estimates of $F_{35\%}$ and $F_{40\%}$ equal to 0.34 and 0.28, respectively.

The model's estimates of $B_{100\%}$, $B_{40\%}$, and $B_{35\%}$ are 796,000 t, 318,000 t, and 279,000 t, respectively.

Specification of OFL and Maximum Permissible ABC

Female spawning biomass for 2014 and 2015 is estimated by the model at values of 361,000 t and 389,000 t, respectively. These values are about 14% and 22% above the $B_{40\%}$ value of 318,000 t, respectively, thereby placing Pacific cod in sub-tier "a" of Tier 3 for both 2014 and 2015. Given this, the model estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2014 and 2015 as follows (2015 values are predicated on the assumption that 2014 catch will equal 2014 maximum permissible ABC; catches are for the entire BSAI):

Year	Overfishing Level	Maximum Permissible ABC
2014	Catch = 299,000 t	Catch = 255,000 t
2015	Catch = 319,000 t	Catch = 272,000 t
2014	$F = 0.34$	$F = 0.28$
2015	$F = 0.34$	$F = 0.28$

The age 0+ biomass projections for 2014 and 2015 from the model (using SS rather than the standard projection model) are 1,570,000 t and 1,710,000 t.

For comparison, the age 3+ projections for 2014 and 2015 from the model (again using SS) are 1,550,000 t and 1,600,000 t.

ABC Recommendation

Since 2005, the SSC has set ABC at the maximum permissible level every year with the exception of the 2007 assessment cycle, when the SSC held the 2008-2009 ABCs constant at the 2007 level. Specifications for 2006-2011 were set under Tier 3b, and specifications for 2012-2013 were set under Tier 3a.

In the present assessment, spawning biomass is estimated to be well above $B_{40\%}$, and is projected to increase further. These increases are fueled largely by the 2006, 2008, and 2010, and 2011 year classes, whose strengths have now been confirmed by multiple surveys.

Based on the precedents of the last several years and the evidence of multiple strong year classes in the population, the maximum permissible values of 255,000 t and 272,000 t are the recommended ABCs for 2014 and 2015, respectively.

At the same time, the continuing concerns regarding estimation of survey catchability should be kept in mind: The present estimate, upon which the above projections depend, is based on an extremely small sample size (Nichol et al. 2007), implying that there is considerable uncertainty surrounding the point estimate. When catchability was estimated freely in in this year's preliminary assessment (Appendix 2.1), the estimate went up substantially, and 2012 spawning biomass dropped by 56%. See also comment SSC3, referencing *"the increasing evidence that catchability is higher and quite possibly much higher than the current standard assumption."*

Area Allocation of Harvests

Through 2013, ABC of BSAI Pacific cod has not been allocated by area. However, the SSC has indicated its intent to specify separate harvest specifications for the EBS and AI for the 2014 and 2015 seasons. For this reason, the present assessment deals with the EBS stock only, and a separate assessment is provided for the AI stock in Chapter 2A.

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 2014 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 are sometimes 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 2014 and 2015, 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 2014 recommended in the assessment to the *max* F_{ABC} for 2014. (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 2008-2012 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 2013 or 2) above 1/2 of its MSY level in 2013 and expected to be above its MSY level in 2023 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2014 and 2015, *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 1) above its MSY level in 2015 or 2) above 1/2 of its MSY level in 2015 and expected to be above its MSY level in 2025 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 the model in Tables 2.28-2.33 (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 2014, it does not provide the best estimate of OFL for 2015, because the mean 2015 catch under Scenario 6 is predicated on the 2014 catch being equal to the 2014 OFL, whereas the actual 2014 catch will likely be less than the 2014 OFL. Table 2.18 contains the appropriate one- and two-year ahead projections for both ABC and OFL under the model 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 BSAI catch estimate for the most recent complete year (2012) is 251,055 t. This is less than the 2012 BSAI OFL of 369,000 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 2013:

a. If spawning biomass for 2013 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.

b. If spawning biomass for 2013 is estimated to be above $B_{35\%}$, the stock is above its MSST.

c. If spawning biomass for 2013 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 2.32). If the mean spawning biomass for 2023 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 2.33):

a. If the mean spawning biomass for 2015 is below ½ $B_{35\%}$, the stock is approaching an overfished condition.

b. If the mean spawning biomass for 2015 is above $B_{35\%}$, the stock is not approaching an overfished condition.

c. If the mean spawning biomass for 2015 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2025. If the mean spawning biomass for 2025 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 2.32 and 2.33, the stock is not overfished and is not approaching an overfished condition.

ECOSYSTEM CONSIDERATIONS

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 (Zador, 2011). 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 mean recruitment of EBS Pacific cod associated with the 1977 regime shift. According to the assessment model, pre-1977 mean recruitment was only about 31% of post-1976 mean 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.

In the 2012 assessment, annual log-scale recruitment *dev*s estimated by the assessment model were regressed against each of several environmental indices summarized by Zador (2011). The highest univariate correlation was obtained for the spring-summer North Pacific Index (NPI), which was developed by Trenberth and Hurrell (1994). The NPI is the area-weighted sea level pressure over the region 30°N-65°N, 160°E-140°W. Further investigations were conducted with monthly NPI data from the Climate Analysis Section of the National Center for Atmospheric Research. The best univariate model obtained in the 2012 analysis was a linear regression of recruitment *dev*s from 1977-2011 against the October-December average NPI (from the same year), giving a correlation of 0.52 (R^2=0.27).

The above analysis was updated and expanded for this year's assessment. The NPI time series was updated through 2012, and this year's estimated time series (1977-2012) of recruitment *dev*s was used, giving a correlation of 0.51 (R^2=0.26). The time series, regression line, and 95% confidence interval are shown in the upper panel of Figure 2.15. In addition to updating the regression, this year's analysis included an attempt at cross-validation. Although many other forms of cross-validation are available, the one used here involved creation of 100,000 "training" data sets, each one obtained by randomly sub-sampling 50% of the data without replacement. A regression was performed on each of the training sets, and then the performance of each regression was computed against the corresponding "test" (i.e., non-training) data set. When the NPI *was not* included as an explanatory variable (i.e., only the intercept of the regression was estimated), the RMSE (computed across all 100,000 test data sets) was 0.69, but when the NPI *was* included as an explanatory variable, the RMSE was reduced to 0.62. The distribution of slope parameter estimates from the cross-validation is shown in the middle panel of Figure 2.15. Two years, 1990 and 2002, turned out to be far more influential than any other year in determining the magnitude of the estimated slope, and both of these influences were negative (lower panel of Figure 2.15). In other words, the positive slope is not due to the influence of outliers; if anything, the outliers are making the relationship appear less strong than would be the case without them.

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

Note: This section has not been updated since last year's assessment.

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.

Incidental Catch Taken in the Pacific Cod Fisheries

Incidental catches taken in the Pacific cod fisheries for the period 2003-2012 are summarized in Tables 2.36-2.40. Table 2.36a shows incidental catch of FMP species, other than squid and members of the former "other species" complex, taken in the EBS. Table 2.37a shows incidental catch of squid and members of the former "other species" complex taken in the EBS. Table 2.38a shows incidental catch of non-target species groups taken in the EBS. Table 2.38b shows analogous data for the AI. Table 2.39a shows incidental catches of prohibited species taken in the EBS. Tables 2.36b, 2.37b, 2.38b, and 2.39b show analogous data for the AI. Table 2.40 shows halibut mortality (as distinguished from catch).

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

Note: This section has not been updated since last year's assessment.

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 EBS by fleet sector. "For." = foreign, "JV" = joint venture processing, "Dom." = domestic annual processing. Catches by gear are not available for these years. Catches may not always include discards.

Year	For.	JV	Dom.	Total
1964	13,408	0	0	13,408
1965	14,719	0	0	14,719
1966	18,200	0	0	18,200
1967	32,064	0	0	32,064
1968	57,902	0	0	57,902
1969	50,351	0	0	50,351
1970	70,094	0	0	70,094
1971	43,054	0	0	43,054
1972	42,905	0	0	42,905
1973	53,386	0	0	53,386
1974	62,462	0	0	62,462
1975	51,551	0	0	51,551
1976	50,481	0	0	50,481
1977	33,335	0	0	33,335
1978	42,512	0	31	42,543
1979	32,981	0	780	33,761
1980	35,058	8,370	2,433	45,861

Table 2.1b—Summary of 1981-1990 catches (t) of Pacific cod in the EBS by area, fleet sector, and gear type. All catches include discards. "LLine" = longline, "Subt." = sector subtotal. Breakdown of domestic annual processing by gear is not available prior to 1988.

	Foreign			Joint Venture		Domestic Annual Processing				
Year	Trawl	LLine	Subt.	Trawl	Subt.	Trawl	LLine	Pot	Subt.	Total
1981	30,347	5,851	36,198	7,410	7,410	n/a	n/a	n/a	12,899	56,507
1982	23,037	3,142	26,179	9,312	9,312	n/a	n/a	n/a	25,613	61,104
1983	32,790	6,445	39,235	9,662	9,662	n/a	n/a	n/a	45,904	94,801
1984	30,592	26,642	57,234	24,382	24,382	n/a	n/a	n/a	43,487	125,103
1985	19,596	36,742	56,338	35,634	35,634	n/a	n/a	n/a	51,475	143,447
1986	13,292	26,563	39,855	57,827	57,827	n/a	n/a	n/a	37,923	135,605
1987	7,718	47,028	54,746	47,722	47,722	n/a	n/a	n/a	47,435	149,903
1988	0	0	0	106,592	106,592	93,706	2,474	299	96,479	203,071
1989	0	0	0	44,612	44,612	119,631	13,935	145	133,711	178,323
1990	0	0	0	8,078	8,078	115,493	47,114	1,382	163,989	172,067

Table 2.1c—Summary of 1991-2013 catches (t) of Pacific cod in the EBS. The small catches taken by "other" gear types have been merged proportionally with the catches of the gear types shown. Catches for 2013 are through October 12.

Year	Trawl	Longline	Pot	Total
1991	129,393	77,505	3,343	210,241
1992	77,276	79,420	7,514	164,210
1993	81,792	49,296	2,098	133,186
1994	85,294	78,898	8,071	172,263
1995	111,250	97,923	19,326	228,498
1996	92,029	88,996	28,042	209,067
1997	93,995	117,097	21,509	232,601
1998	60,855	84,426	13,249	158,529
1999	51,939	81,520	12,408	145,867
2000	53,841	81,678	15,856	151,376
2001	35,670	90,394	16,478	142,542
2002	51,118	100,371	15,067	166,555
2003	47,758	108,774	21,978	178,511
2004	57,867	108,157	17,264	183,288
2005	52,638	113,184	17,114	182,936
2006	53,234	96,606	18,966	168,806
2007	45,700	77,148	17,232	140,079
2008	33,497	88,928	17,368	139,794
2009	36,959	96,606	13,587	147,152
2010	41,297	81,855	19,702	142,854
2011	64,085	117,101	28,058	209,244
2012	75,583	128,520	28,729	232,832
2013	77,838	96,100	24,497	198,434

Table 2.2—Discards (t) of Pacific cod in the Pacific cod fishery, by area, gear, and year for the period 1991-2012. The small amounts of discards taken by other gear types have been merged proportionally into the gear types shown. Note that Amendment 49, which mandated increased retention and utilization, was implemented in 1998. **This table has not been updated since the 2012 assessment.**

Year	Trawl	Longline	Pot	Total
1991	15,216	1,543	10	16,770
1992	21,405	1,970	59	23,435
1993	28,898	2,258	25	31,182
1994	26,282	2,923	168	29,373
1995	35,689	4,100	222	40,011
1996	22,376	2,899	394	25,669
1997	16,556	3,218	79	19,853
1998	962	2,487	52	3,501
1999	1,677	1,322	52	3,051
2000	883	2,310	72	3,265
2001	861	1,539	52	2,452
2002	1,317	2,159	97	3,573
2003	827	1,789	176	2,791
2004	545	1,823	49	2,417
2005	455	2,663	64	3,182
2006	813	1,544	63	2,420
2007	588	1,385	31	2,004
2008	493	1,362	157	2,011
2009	534	1,503	16	2,053
2010	1,305	1,413	19	2,737
2011	487	1,853	34	2,374
2012	954	1,276	52	2,282

Table 2.3—History of **BSAI** Pacific cod catch, TAC, ABC, and OFL (t). Catch for 2013 is through October 12. Note that specifications through 2013 were for the combined BSAI region, so BSAI catch is shown rather than the EBS catches from Table 1. Source for historical specifications: NPFMC staff.

Year	Catch	TAC	ABC	OFL
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	-
1989	182,865	230,681	370,600	-
1990	179,608	227,000	417,000	-
1991	220,038	229,000	229,000	-
1992	207,278	182,000	182,000	188,000
1993	167,391	164,500	164,500	192,000
1994	193,802	191,000	191,000	228,000
1995	245,033	250,000	328,000	390,000
1996	240,676	270,000	305,000	420,000
1997	257,765	270,000	306,000	418,000
1998	193,256	210,000	210,000	336,000
1999	173,998	177,000	177,000	264,000
2000	191,060	193,000	193,000	240,000
2001	176,749	188,000	188,000	248,000
2002	197,356	200,000	223,000	294,000
2003	210,969	207,500	223,000	324,000
2004	212,161	215,500	223,000	350,000
2005	205,635	206,000	206,000	265,000
2006	193,016	194,000	194,000	230,000
2007	174,125	170,720	176,000	207,000
2008	170,853	170,720	176,000	207,000
2009	175,732	176,540	182,000	212,000
2010	171,854	168,780	174,000	205,000
2011	220,102	227,950	235,000	272,000
2012	251,055	261,000	314,000	369,000
2013	211,867	260,000	307,000	359,000

Table 2.4—Amendments to the BSAI Fishery Management Plan (FMP) that reference Pacific cod explicitly (excerpted from Appendix A of the FMP).

Amendment 2, implemented January 12, 1982:

For Pacific cod, decreased maximum sustainable yield to 55,000 t from 58,700 t, increased equilibrium yield to 160,000 t from 58,700 t, increased acceptable biological catch to 160,000 t from 58,700 t, increased optimum yield to 78,700 t from 58,700 t, increased reserves to 3,935 t from 2,935 t, increased domestic annual processing (DAP) to 26,000 t from 7,000 t, and increased DAH to 43,265 t from 24,265 t.

Amendment 4, implemented May 9, 1983, supersedes Amendment 2:

For Pacific Cod, increased equilibrium yield and acceptable biological catch to 168,000 t from 160,000 t, increased optimum yield to 120,000 t from 78,700 t, increased reserves to 6,000 t from 3,935 t, and increased TALFF to 70,735 t from 31,500 t.

Amendment 10, implemented March 16, 1987:

Established Bycatch Limitation Zones for domestic and foreign fisheries for yellowfin sole and other flatfish (including rock sole); an area closed to all trawling within Zone 1; red king crab, C. bairdi Tanner crab, and Pacific halibut PSC limits for DAH yellowfin sole and other flatfish fisheries; a C. bairdi PSC limit for foreign fisheries; and a red king crab PSC limit and scientific data collection requirement for U.S. vessels fishing for Pacific cod in Zone 1 waters shallower than 25 fathoms.

Amendment 24, implemented February 28, 1994, and effective through December 31, 1996:

1. Established the following gear allocations of BSAI Pacific cod TAC as follows: 2 percent to vessels using jig gear; 44.1 percent to vessels using hook-and-line or pot gear, and 53.9 percent to vessels using trawl gear.
2. Authorized the seasonal apportionment of the amount of Pacific cod allocated to gear groups. Criteria for seasonal apportionments and the seasons authorized to receive separate apportionments will be set forth in regulations.

Amendment 46, implemented January 1, 1997, superseded Amendment 24:

Replaced the three year Pacific cod allocation established with Amendment 24, with the following gear allocations in BSAI Pacific cod: 2 percent to vessels using jig gear; 51 percent to vessels using hook-and-line or pot gear; and 47 percent to vessels using trawl gear. The trawl apportionment will be divided 50 percent to catcher vessels and 50 percent to catcher processors. These allocations as well as the seasonal apportionment authority established in Amendment 24 will remain in effect until amended.

Amendment 49, implemented January 3, 1998:

Implemented an Increased Retention/Increased Utilization Program for pollock and Pacific cod beginning January 1, 1998 and rock sole and yellowfin sole beginning January 1, 2003.

Amendment 64, implemented September 1, 2000, revised Amendment 46:

Allocated the Pacific cod Total Allowable Catch to the jig gear (2 percent), fixed gear (51 percent), and trawl gear (47 percent) sectors.

Amendment 67, implemented May 15, 2002, revised Amendment 39:

Established participation and harvest requirements to qualify for a BSAI Pacific cod fishery endorsement for fixed gear vessels.

Amendment 77, implemented January 1, 2004, revised Amendment 64:

Implemented a Pacific cod fixed gear allocation between hook and line catcher processors (80 percent), hook and line catcher vessels (0.3 percent), pot catcher processors (3.3 percent), pot catcher vessels (15 percent), and catcher vessels (pot or hook and line) less than 60 feet (1.4 percent).

Amendment 85, partially implemented on March 5, 2007, superseded Amendments 46 and 77:

Implemented a gear allocation among all non-CDQ fishery sectors participating in the directed fishery for Pacific cod. After deduction of the CDQ allocation, the Pacific cod TAC is apportioned to vessels using jig gear (1.4 percent); catcher processors using trawl gear listed in Section 208(e)(1)-(20) of the AFA (2.3 percent); catcher processors using trawl gear as defined in Section 219(a)(7) of the Consolidated Appropriations Act, 2005 (Public Law 108-447) (13.4 percent); catcher vessels using trawl gear (22.1 percent); catcher processors using hook-and-line gear (48.7 percent); catcher vessels ≥60’ LOA using hook-and-line gear (0.2 percent); catcher processors using pot gear (1.5 percent); catcher vessels ≥60’ LOA using pot gear (8.4 percent); and catcher vessels <60’ LOA that use either hook-and-line gear or pot gear (2.0 percent).

Table 2.5 (p. 1 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2013 as configured in the stock assessment model. 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.

		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 2.5 (p. 2 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2013 as configured in the stock assessment model.

		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	34996	0	0	8229	0	0	20	0	0
1991	Mar-Apr	65276	0	0	12317	0	0	522	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	6420	0	0	9312	0	0	369
1992	Jan-Feb	23310	0	0	13660	0	0	13	0	0
1992	Mar-Apr	31836	0	0	22121	0	0	833	0	0
1992	May-Jul	0	11784	0	0	27051	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	27998	0	0	22396	0	0	24	0	0
1993	Mar-Apr	35294	0	0	21434	0	0	1597	0	0
1993	May-Jul	0	5552	0	0	4744	0	0	2093	0
1993	Aug-Oct	0	0	6944	0	0	3002	0	0	0
1993	Nov-Dec	0	0	1544	0	0	564	0	0	0
1994	Jan-Feb	13856	0	0	22458	0	0	0	0	0
1994	Mar-Apr	43634	0	0	29089	0	0	4159	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	31939	0	0	29936	0	0	23	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	119	0	0	8802	0	0	640

Table 2.5 (p. 3 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2013 as configured in the stock assessment model.

		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	21151	0	0	28835	0	0	25	0	0
1996	Mar-Apr	50436	0	0	29471	0	0	12571	0	0
1996	May-Jul	0	6797	0	0	4179	0	0	11600	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	25713	0	0	31971	0	0	30	0	0
1997	Mar-Apr	52321	0	0	30578	0	0	9639	0	0
1997	May-Jul	0	5174	0	0	8145	0	0	7352	0
1997	Aug-Oct	0	0	9321	0	0	21323	0	0	3780
1997	Nov-Dec	0	0	2366	0	0	24250	0	0	637
1998	Jan-Feb	15535	0	0	29256	0	0	1719	0	0
1998	Mar-Apr	27765	0	0	19060	0	0	5613	0	0
1998	May-Jul	0	4940	0	0	3709	0	0	5321	0
1998	Aug-Oct	0	0	12586	0	0	16155	0	0	1890
1998	Nov-Dec	0	0	1330	0	0	13196	0	0	454
1999	Jan-Feb	17660	0	0	30548	0	0	1900	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	229	0	0	4986	0	0	56
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	3800	0	0	1394	0	0	1077	0
2000	Aug-Oct	0	0	6199	0	0	22107	0	0	1667
2000	Nov-Dec	0	0	590	0	0	17816	0	0	0
2001	Jan-Feb	7930	0	0	18134	0	0	2312	0	0
2001	Mar-Apr	13895	0	0	16568	0	0	11279	0	0
2001	May-Jul	0	3500	0	0	3882	0	0	1005	0
2001	Aug-Oct	0	0	8904	0	0	30966	0	0	2970
2001	Nov-Dec	0	0	803	0	0	19751	0	0	641
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	8163	0	0	1903	0	0	531	0
2002	Aug-Oct	0	0	8594	0	0	34463	0	0	2997
2002	Nov-Dec	0	0	291	0	0	14335	0	0	803
2003	Jan-Feb	16424	0	0	35435	0	0	13711	0	0
2003	Mar-Apr	16459	0	0	17106	0	0	1661	0	0
2003	May-Jul	0	6752	0	0	2748	0	0	454	0
2003	Aug-Oct	0	0	7794	0	0	35121	0	0	5143
2003	Nov-Dec	0	0	264	0	0	18004	0	0	1430
2004	Jan-Feb	21886	0	0	37436	0	0	9023	0	0
2004	Mar-Apr	17432	0	0	16627	0	0	2854	0	0
2004	May-Jul	0	9773	0	0	2914	0	0	946	0
2004	Aug-Oct	0	0	8766	0	0	30938	0	0	3841
2004	Nov-Dec	0	0	75	0	0	20181	0	0	596
2005	Jan-Feb	27360	0	0	46935	0	0	9034	0	0
2005	Mar-Apr	15119	0	0	6612	0	0	3114	0	0
2005	May-Jul	0	7410	0	0	3289	0	0	0	0
2005	Aug-Oct	0	0	2892	0	0	35344	0	0	4549
2005	Nov-Dec	0	0	113	0	0	20756	0	0	407

Table 2.5 (p. 4 of 4)— EBS catch (t) of Pacific cod by year, gear, and season for the years 1977-2013 as configured in the stock assessment model. Aug-Oct and Nov-Dec catches for 2013 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
2006	Jan-Feb	28595	0	0	45149	0	0	10608	0	0
2006	Mar-Apr	13917	0	0	6017	0	0	3297	0	0
2006	May-Jul	0	6345	0	0	1903	0	0	363	0
2006	Aug-Oct	0	0	4357	0	0	42489	0	0	3885
2006	Nov-Dec	0	0	71	0	0	1013	0	0	798
2007	Jan-Feb	15938	0	0	42910	0	0	10686	0	0
2007	Mar-Apr	16311	0	0	1917	0	0	1139	0	0
2007	May-Jul	0	10225	0	0	1213	0	0	479	0
2007	Aug-Oct	0	0	3190	0	0	30304	0	0	4922
2007	Nov-Dec	0	0	68	0	0	777	0	0	0
2008	Jan-Feb	15579	0	0	41629	0	0	8850	0	0
2008	Mar-Apr	7093	0	0	3657	0	0	1951	0	0
2008	May-Jul	0	3868	0	0	2633	0	0	225	0
2008	Aug-Oct	0	0	6306	0	0	33040	0	0	6218
2008	Nov-Dec	0	0	655	0	0	7966	0	0	124
2009	Jan-Feb	12194	0	0	44713	0	0	9387	0	0
2009	Mar-Apr	9602	0	0	3726	0	0	1722	0	0
2009	May-Jul	0	4174	0	0	2239	0	0	258	0
2009	Aug-Oct	0	0	10491	0	0	35381	0	0	1288
2009	Nov-Dec	0	0	403	0	0	10494	0	0	1081
2010	Jan-Feb	16326	0	0	40595	0	0	10692	0	0
2010	Mar-Apr	8172	0	0	2050	0	0	1726	0	0
2010	May-Jul	0	3985	0	0	2898	0	0	267	0
2010	Aug-Oct	0	0	9604	0	0	25032	0	0	5481
2010	Nov-Dec	0	0	1601	0	0	12702	0	0	1722
2011	Jan-Feb	21217	0	0	28946	0	0	15345	0	0
2011	Mar-Apr	20796	0	0	26321	0	0	2297	0	0
2011	May-Jul	0	7276	0	0	14064	0	0	595	0
2011	Aug-Oct	0	0	13351	0	0	30921	0	0	8949
2011	Nov-Dec	0	0	1728	0	0	17438	0	0	0
2012	Jan-Feb	39025	0	0	33164	0	0	19238	0	0
2012	Mar-Apr	14807	0	0	24916	0	0	2295	0	0
2012	May-Jul	0	8808	0	0	21053	0	0	843	0
2012	Aug-Oct	0	0	11672	0	0	27636	0	0	6169
2012	Nov-Dec	0	0	1058	0	0	21260	0	0	887
2013	Jan-Feb	35429	0	0	38743	0	0	19223	0	0
2013	Mar-Apr	17547	0	0	22734	0	0	1930	0	0
2013	May-Jul	0	5975	0	0	13851	0	0	0	0
2013	Aug-Oct	0	0	11542	0	0	27863	0	0	6867
2013	Nov-Dec	0	0	1462	0	0	17133	0	0	870

Table 2.6 (page 1 of 3)— Fishery CPUE as configured in the stock assessment model. Units are kg/minute for trawl gear, kg/hook for longline gear, and kg/pot for pot gear.

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	0.204	1991	Aug-Oct	71.702	0.603
1992	Jan-Feb	60.427	0.161	1992	May-Jul	38.568	0.291	1992	Aug-Oct	57.517	0.773
1993	Jan-Feb	62.047	0.157	1993	May-Jul	39.902	0.469	1993	Aug-Oct	113.970	0.504
1994	Jan-Feb	51.965	0.223	1994	May-Jul	26.767	0.248	1994	Aug-Oct	56.308	0.390
1995	Jan-Feb	88.482	0.123	1995	May-Jul	59.393	1.670	1995	Aug-Oct	60.164	0.323
1996	Jan-Feb	48.331	0.132	1996	May-Jul	29.174	0.314	1996	Aug-Oct	34.896	0.291
1997	Jan-Feb	75.605	0.122	1997	May-Jul	24.880	0.259	1997	Aug-Oct	62.619	0.567
1998	Jan-Feb	59.920	0.159	1998	May-Jul	26.245	0.303	1998	Aug-Oct	38.995	0.305
1999	Jan-Feb	42.399	0.119	1999	May-Jul	15.672	0.427	1999	Aug-Oct	20.611	0.367
2000	Jan-Feb	34.522	0.123	2000	May-Jul	32.694	0.294	2000	Aug-Oct	15.070	0.528
2001	Jan-Feb	25.452	0.166	2001	May-Jul	60.120	0.298	2001	Aug-Oct	16.662	0.249
2002	Jan-Feb	35.892	0.141	2002	May-Jul	39.985	0.209	2002	Aug-Oct	15.141	0.196
2003	Jan-Feb	24.642	0.169	2003	May-Jul	49.493	0.210	2003	Aug-Oct	19.171	0.156
2004	Jan-Feb	62.609	0.138	2004	May-Jul	34.588	0.164	2004	Aug-Oct	21.519	0.154
2005	Jan-Feb	43.993	0.116	2005	May-Jul	24.100	0.172	2005	Aug-Oct	15.932	0.835
2006	Jan-Feb	36.397	0.108	2006	May-Jul	30.653	0.186	2006	Aug-Oct	26.772	0.377
2007	Jan-Feb	30.849	0.095	2007	May-Jul	39.485	0.115	2007	Aug-Oct	18.147	0.682
2008	Jan-Feb	24.385	0.152	2008	May-Jul	40.650	0.251	2008	Aug-Oct	60.047	0.336
2009	Jan-Feb	37.853	0.171	2009	May-Jul	33.932	0.292	2009	Aug-Oct	54.154	0.226
2010	Jan-Feb	41.949	0.137	2010	May-Jul	32.031	0.336	2010	Aug-Oct	73.484	0.198
2011	Jan-Feb	50.737	0.110	2011	May-Jul	49.228	0.259	2011	Aug-Oct	56.918	0.202
2012	Jan-Feb	97.338	0.099	2012	May-Jul	117.192	0.247	2012	Aug-Oct	52.247	0.255
2013	Jan-Feb	67.061	0.081	2013	May-Jul	39.438	0.302	2013	Aug-Oct	63.355	0.397
1991	Mar-Apr	61.454	0.059					1993	Nov-Dec	32.678	0.915
1992	Mar-Apr	48.269	0.069					1996	Nov-Dec	29.543	0.482
1993	Mar-Apr	48.840	0.073					1997	Nov-Dec	31.309	1.093
1994	Mar-Apr	52.428	0.053					1998	Nov-Dec	16.891	0.647
1995	Mar-Apr	55.463	0.061					1999	Nov-Dec	12.994	0.964
1996	Mar-Apr	33.954	0.051					2009	Nov-Dec	28.369	1.181
1997	Mar-Apr	45.985	0.062					2010	Nov-Dec	40.079	0.682
1998	Mar-Apr	31.809	0.072					2011	Nov-Dec	20.796	1.181
1999	Mar-Apr	35.675	0.086					2012	Nov-Dec	52.570	1.294
2000	Mar-Apr	31.397	0.085								
2001	Mar-Apr	21.213	0.106								
2002	Mar-Apr	26.640	0.103								
2003	Mar-Apr	28.131	0.095								
2004	Mar-Apr	42.816	0.116								
2005	Mar-Apr	48.932	0.114								
2006	Mar-Apr	56.188	0.141								
2007	Mar-Apr	45.097	0.092								
2008	Mar-Apr	40.343	0.196								
2009	Mar-Apr	55.557	0.183								
2010	Mar-Apr	55.766	0.266								
2011	Mar-Apr	76.788	0.149								
2012	Mar-Apr	76.796	0.154								
2013	Mar-Apr	64.049	0.138								

Table 2.6 (page 2 of 3)— Fishery CPUE as configured in the stock assessment models. Units are kg/minute for trawl gear, kg/hook for longline gear, and kg/pot for pot gear.

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	0.156	1991	May-Jul	0.771	0.075	1991	Aug-Oct	0.595	0.062
1992	Jan-Feb	0.873	0.088	1992	May-Jul	0.530	0.052	1992	Aug-Oct	0.512	0.069
1993	Jan-Feb	0.654	0.066	1993	May-Jul	0.551	0.176	1994	Aug-Oct	0.576	0.068
1994	Jan-Feb	0.728	0.068	1994	May-Jul	0.713	0.133	1995	Aug-Oct	0.587	0.070
1995	Jan-Feb	0.895	0.069	1995	May-Jul	0.760	0.179	1996	Aug-Oct	0.542	0.061
1996	Jan-Feb	0.878	0.069	1996	May-Jul	0.669	0.178	1997	Aug-Oct	0.580	0.064
1997	Jan-Feb	0.989	0.072	1997	May-Jul	0.657	0.120	1998	Aug-Oct	0.398	0.064
1998	Jan-Feb	0.888	0.074	1998	May-Jul	0.496	0.184	1999	Aug-Oct	0.481	0.061
1999	Jan-Feb	0.743	0.067	1999	May-Jul	0.637	0.143	2000	Aug-Oct	0.404	0.053
2000	Jan-Feb	0.730	0.069	2000	May-Jul	0.610	0.169	2001	Aug-Oct	0.398	0.052
2001	Jan-Feb	0.586	0.079	2001	May-Jul	0.514	0.107	2002	Aug-Oct	0.372	0.046
2002	Jan-Feb	0.680	0.062	2002	May-Jul	0.405	0.137	2003	Aug-Oct	0.342	0.044
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	0.060	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	0.106	2006	Aug-Oct	0.391	0.047
2006	Jan-Feb	0.747	0.062	2006	May-Jul	0.366	0.162	2007	Aug-Oct	0.402	0.038
2007	Jan-Feb	0.734	0.045	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	0.140	2009	Aug-Oct	0.348	0.049
2009	Jan-Feb	0.893	0.069	2009	May-Jul	0.384	0.151	2010	Aug-Oct	0.352	0.060
2010	Jan-Feb	0.781	0.067	2010	May-Jul	0.419	0.156	2011	Aug-Oct	0.369	0.059
2011	Jan-Feb	0.716	0.083	2011	May-Jul	0.374	0.088	2012	Aug-Oct	0.321	0.060
2012	Jan-Feb	0.774	0.082	2012	May-Jul	0.429	0.080	2013	Aug-Oct	0.399	0.179
2013	Jan-Feb	0.736	0.063	2013	May-Jul	0.425	0.097	1991	Nov-Dec	0.551	0.093
1991	Mar-Apr	0.993	0.110					1995	Nov-Dec	0.648	0.110
1992	Mar-Apr	0.858	0.071					1996	Nov-Dec	0.590	0.277
1993	Mar-Apr	0.669	0.061					1997	Nov-Dec	0.577	0.073
1994	Mar-Apr	0.735	0.060					1998	Nov-Dec	0.501	0.072
1995	Mar-Apr	0.841	0.062					1999	Nov-Dec	0.541	0.120
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	0.065
1998	Mar-Apr	0.619	0.075					2002	Nov-Dec	0.394	0.072
1999	Mar-Apr	0.617	0.067					2003	Nov-Dec	0.365	0.060
2000	Mar-Apr	0.617	0.097					2004	Nov-Dec	0.441	0.065
2001	Mar-Apr	0.539	0.073					2005	Nov-Dec	0.385	0.064
2002	Mar-Apr	0.676	0.082					2006	Nov-Dec	0.433	0.214
2003	Mar-Apr	0.530	0.068					2007	Nov-Dec	0.449	0.332
2004	Mar-Apr	0.579	0.076					2008	Nov-Dec	0.449	0.087
2005	Mar-Apr	0.678	0.113					2009	Nov-Dec	0.428	0.090
2006	Mar-Apr	0.796	0.112					2010	Nov-Dec	0.447	0.087
2007	Mar-Apr	0.693	0.155					2011	Nov-Dec	0.447	0.086
2008	Mar-Apr	0.774	0.146					2012	Nov-Dec	0.476	0.077
2009	Mar-Apr	1.159	0.172								
2010	Mar-Apr	0.829	0.195								
2011	Mar-Apr	0.703	0.072								
2012	Mar-Apr	0.597	0.082								
2013	Mar-Apr	0.665	0.085								

Table 2.6 (page 3 of 3)— Fishery CPUE as configured in the stock assessment models. Units are kg/minute for trawl gear, kg/hook for longline gear, and kg/pot for pot gear.

Jan-Apr pot fishery				May-Jul pot fishery				Aug-Dec pot fishery			
Year	Season	CPUE	Sigma	Year	Season	CPUE	Sigma	Year	Season	CPUE	Sigma
2000	Jan-Feb	56.553	0.152	1991	May-Jul	64.037	0.251	1991	Aug-Oct	88.556	0.132
2001	Jan-Feb	72.207	0.504	1992	May-Jul	66.730	0.077	1992	Aug-Oct	30.252	0.113
2002	Jan-Feb	81.893	0.264	1993	May-Jul	90.669	0.228	1994	Aug-Oct	97.172	0.151
2003	Jan-Feb	73.858	0.139	1994	May-Jul	75.421	0.173	1995	Aug-Oct	57.783	0.153
2004	Jan-Feb	78.980	0.170	1995	May-Jul	72.065	0.098	1996	Aug-Oct	49.758	0.136
2005	Jan-Feb	85.328	0.168	1996	May-Jul	55.819	0.089	1997	Aug-Oct	47.938	0.167
2006	Jan-Feb	83.292	0.154	1997	May-Jul	46.843	0.114	1998	Aug-Oct	32.057	0.281
2007	Jan-Feb	64.671	0.109	1998	May-Jul	49.999	0.129	1999	Aug-Oct	37.675	0.213
2008	Jan-Feb	81.642	0.208	1999	May-Jul	47.466	0.124	2001	Aug-Oct	46.493	0.169
2009	Jan-Feb	92.345	0.189					2002	Aug-Oct	42.331	0.189
2010	Jan-Feb	88.535	0.168					2003	Aug-Oct	57.632	0.174
2011	Jan-Feb	130.718	0.153					2004	Aug-Oct	48.802	0.210
2012	Jan-Feb	138.710	0.148					2005	Aug-Oct	45.872	0.192
2013	Jan-Feb	128.942	0.143					2006	Aug-Oct	55.342	0.186
1992	Mar-Apr	86.412	0.422					2007	Aug-Oct	65.356	0.151
1993	Mar-Apr	84.191	0.136					2008	Aug-Oct	57.252	0.164
1994	Mar-Apr	89.313	0.107					2009	Aug-Oct	72.836	0.266
1995	Mar-Apr	91.679	0.094					2010	Aug-Oct	82.936	0.210
1996	Mar-Apr	73.485	0.077					2011	Aug-Oct	81.445	0.148
1997	Mar-Apr	93.226	0.120					2012	Aug-Oct	64.934	0.130
1998	Mar-Apr	77.558	0.184					1991	Nov-Dec	91.633	0.262
1999	Mar-Apr	67.604	0.195					1995	Nov-Dec	53.251	0.188
2000	Mar-Apr	45.310	0.163					1996	Nov-Dec	46.456	0.422
2001	Mar-Apr	69.247	0.137					1997	Nov-Dec	41.829	0.413
2002	Mar-Apr	61.628	0.176					1998	Nov-Dec	41.138	0.802
2004	Mar-Apr	65.936	0.390					2001	Nov-Dec	40.740	0.631
2006	Mar-Apr	116.202	0.422					2002	Nov-Dec	55.955	0.418
								2003	Nov-Dec	60.093	0.334
								2004	Nov-Dec	66.375	0.452
								2006	Nov-Dec	37.187	0.422
								2010	Nov-Dec	104.985	0.373

Table 2.7— Total biomass and abundance, with standard deviations, as estimated by EBS shelf bottom trawl surveys, 1982-2013. For biomass, lower and upper 95% confidence intervals are also shown.

	Biomass (t)				Abundance (1000s of fish)	
Year	Estimate	Std. deviation	L95% CI	U95% CI	Estimate	Std. deviation
1982	1,013,061	73,621	867,292	1,158,831	583,781	38,064
1983	1,187,096	120,958	942,640	1,431,553	752,456	80,566
1984	1,048,493	63,632	922,501	1,174,484	680,883	49,913
1985	1,001,112	55,845	890,540	1,111,684	841,108	113,438
1986	1,118,006	69,626	980,146	1,255,866	838,217	83,855
1987	1,104,868	68,304	969,627	1,240,109	728,974	48,488
1988	960,962	76,961	808,579	1,113,344	507,560	35,581
1989	833,473	62,713	709,300	957,645	292,247	19,986
1990	691,256	51,455	589,376	793,136	423,835	36,466
1991	514,407	38,039	439,090	589,725	488,892	51,108
1992	551,369	45,780	460,725	642,013	601,795	70,551
1993	691,494	54,580	583,425	799,562	852,837	106,923
1994	1,368,109	250,045	868,019	1,868,200	1,237,291	153,084
1995	1,002,961	91,622	821,550	1,184,372	757,910	75,473
1996	889,366	87,521	716,076	1,062,657	607,198	88,384
1997	604,439	68,120	468,199	740,678	485,643	70,802
1998	558,510	45,182	469,050	647,970	537,342	48,429
1999	584,884	50,616	484,664	685,104	501,554	46,620
2000	531,171	43,160	445,714	616,627	483,808	44,188
2001	833,626	76,247	681,133	986,119	985,569	94,981
2002	618,680	69,082	480,516	756,845	566,471	57,676
2003	593,760	62,155	469,451	718,069	500,878	62,367
2004	596,279	35,216	526,552	666,007	424,662	36,140
2005	606,415	43,047	521,182	691,648	450,918	63,358
2006	517,698	28,341	461,583	573,813	394,051	23,784
2007	423,703	34,811	354,080	493,326	733,374	195,955
2008	403,125	26,822	350,018	456,232	476,697	49,413
2009	421,291	34,969	352,053	490,530	716,637	62,705
2010	860,210	102,307	657,642	1,062,778	887,836	117,022
2011	896,039	66,843	763,690	1,028,388	836,822	79,207
2012	890,665	100,473	689,718	1,091,612	987,973	91,589
2013	791,958	73,952	644,054	939,862	750,889	124,917

Table 2.8 (page 1 of 3)—Trawl survey size composition, by year and cm (sample size in column 2).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	10546	0	0	0	0	0	1	8	9	19	26	52	59	109	66	51	52	46
1983	13149	0	0	0	0	0	7	96	290	455	458	484	461	433	394	252	250	120
1984	12135	0	0	0	0	0	7	26	37	56	45	28	26	26	31	47	31	63
1985	16881	0	0	0	0	0	4	56	102	179	145	216	287	304	372	503	507	526
1986	15378	0	0	0	0	1	23	38	93	133	130	202	175	177	150	93	34	27
1987	10601	0	0	0	0	0	0	14	3	7	24	38	60	80	110	122	122	154
1988	9995	0	0	0	0	0	0	1	8	7	28	13	27	26	23	42	27	18
1989	9999	0	0	0	0	0	3	3	19	47	37	70	86	108	105	101	66	39
1990	5631	0	0	0	0	0	26	71	104	154	150	185	236	259	205	149	117	89
1991	7225	0	0	0	0	0	6	31	94	112	140	137	163	133	136	128	107	135
1992	9602	0	0	0	0	0	0	1	17	82	184	190	173	148	196	218	232	248
1993	10403	0	0	0	0	1	3	29	82	194	433	296	408	356	322	321	346	314
1994	13923	0	0	0	0	0	3	10	5	27	42	76	91	99	100	115	136	111
1995	9212	0	0	0	0	0	3	12	15	13	19	41	37	42	56	59	81	68
1996	9349	0	0	0	0	0	1	2	11	9	23	33	48	64	53	66	69	64
1997	9173	0	0	0	0	0	8	17	65	114	167	193	192	196	212	284	226	218
1998	9578	0	0	0	0	0	1	4	24	56	87	119	106	137	91	45	23	6
1999	11699	0	0	0	0	0	1	15	54	101	110	122	94	113	79	42	30	41
2000	12548	0	0	0	4	10	23	51	99	137	298	478	582	442	278	274	141	87
2001	19746	0	0	0	0	5	6	27	62	127	205	314	452	661	714	768	681	663
2002	12239	0	0	0	0	1	3	6	22	45	65	81	102	160	112	168	111	72
2003	12358	0	0	1	0	1	3	5	11	56	92	138	206	233	206	250	254	282
2004	10803	0	2	0	0	0	1	4	19	44	84	149	106	193	186	218	212	136
2005	11292	0	0	0	0	0	0	1	4	22	43	87	138	201	248	304	284	301
2006	12133	0	1	0	4	7	40	101	336	405	427	453	401	343	330	359	280	243
2007	12816	0	0	0	0	7	7	129	481	1163	1425	1398	1141	731	715	511	326	400
2008	12975	0	0	1	0	0	6	54	168	350	379	390	350	313	227	151	75	40
2009	16675	1	0	0	7	36	106	401	971	1058	1087	878	744	650	485	460	318	219
2010	7570	0	0	0	0	0	1	5	18	24	29	50	50	56	46	31	15	17
2011	20744	0	0	0	0	0	8	20	76	142	257	306	385	413	597	627	905	886
2012	13075	0	0	6	0	0	74	379	686	732	563	424	417	310	410	396	208	129
2013	18699	0	0	0	0	1	9	50	116	147	207	222	283	239	177	127	35	22

Year	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1982	19	8	9	2	8	18	25	40	67	87	123	193	221	240	305	317	237	197
1983	74	44	29	9	5	18	34	46	56	100	125	146	173	165	213	145	127	107
1984	71	89	123	229	310	381	465	580	608	656	577	480	395	349	297	222	156	107
1985	647	559	555	321	212	130	91	100	106	159	220	216	272	300	309	311	288	343
1986	20	22	72	114	218	360	449	697	629	616	638	653	580	557	448	402	349	332
1987	125	81	61	46	63	76	118	123	200	273	302	324	292	281	205	232	202	173
1988	26	35	48	68	77	88	86	109	83	124	122	137	179	190	269	216	195	211
1989	19	21	30	4	15	16	35	13	34	30	24	33	37	70	33	107	109	134
1990	57	35	41	42	33	47	76	77	96	103	97	92	118	124	80	113	96	67
1991	86	72	72	78	100	97	166	192	265	285	325	289	372	308	251	261	196	173
1992	216	228	113	119	134	182	262	288	303	349	375	351	310	304	242	217	177	149
1993	324	217	136	97	62	55	67	86	95	175	207	232	291	316	239	245	226	195
1994	103	91	131	120	171	154	205	320	430	552	639	732	766	672	643	471	362	288
1995	34	24	19	37	47	89	108	158	194	228	218	245	225	198	155	217	249	239
1996	54	36	20	22	23	58	65	129	163	194	229	275	237	251	191	200	168	157
1997	226	177	105	58	41	41	34	70	109	103	154	223	231	222	174	159	155	138
1998	4	17	24	57	72	181	275	382	494	598	626	612	514	538	343	261	229	165
1999	49	39	53	109	110	196	227	222	311	269	296	309	241	228	198	191	239	289
2000	33	9	12	25	39	77	119	170	197	220	258	305	222	197	184	188	174	199
2001	441	350	219	136	112	160	225	313	364	506	655	828	825	916	802	697	509	407
2002	52	35	17	42	62	105	159	240	266	433	473	553	552	519	379	400	313	293
2003	252	237	199	219	155	120	66	58	59	79	58	115	145	317	216	320	240	274
2004	143	113	64	55	73	90	102	186	195	219	236	273	301	318	311	341	313	326
2005	290	362	362	387	376	289	210	136	135	141	115	158	178	197	197	207	231	288
2006	146	105	65	54	56	55	64	86	115	168	189	246	243	264	245	303	263	298
2007	230	121	122	42	44	65	86	124	117	154	122	140	147	124	114	93	93	76
2008	21	40	70	162	307	479	550	707	745	719	681	559	461	341	281	200	161	151
2009	114	35	28	33	82	93	173	253	336	396	467	436	339	306	221	214	215	225
2010	9	13	31	60	126	193	241	355	431	417	394	394	323	269	183	165	106	95
2011	851	536	286	110	34	37	55	48	56	72	121	136	188	164	232	229	272	287
2012	48	31	10	28	37	59	84	178	259	269	358	352	390	279	309	190	158	98
2013	63	86	268	398	653	786	982	1078	840	908	652	658	415	310	241	180	174	145

Table 2.8 (page 2 of 3)—Trawl survey size composition, by year and cm.

Year	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
1982	144	146	126	137	180	203	282	302	272	328	328	280	284	270	254	239	278	258	267	225	260
1983	61	62	86	94	143	157	212	269	301	288	298	316	254	248	246	225	298	277	258	262	245
1984	102	89	58	94	76	92	93	95	108	135	105	108	95	108	140	128	155	164	194	198	153
1985	351	389	413	514	500	514	482	470	359	323	244	192	168	128	96	93	103	101	104	85	87
1986	220	194	138	126	136	163	185	216	205	246	218	248	269	258	275	288	299	226	252	251	175
1987	186	222	209	297	328	334	332	319	323	251	250	262	157	156	134	120	146	140	98	122	92
1988	141	184	165	239	222	197	319	277	294	277	247	308	266	229	250	250	260	220	214	227	194
1989	115	125	101	115	115	139	176	165	176	183	176	200	253	236	260	247	234	326	293	219	222
1990	57	67	51	47	38	38	31	35	48	39	41	25	51	31	62	53	66	58	74	72	75
1991	143	118	84	68	64	61	51	61	53	61	74	49	61	42	71	89	58	75	40	34	42
1992	125	179	147	216	187	219	240	186	185	160	143	153	119	108	88	78	57	63	29	42	51
1993	150	159	179	180	217	218	229	266	203	183	190	157	150	128	112	117	107	87	63	64	78
1994	196	115	132	114	221	188	164	233	256	265	299	173	189	230	189	181	175	219	251	252	162
1995	314	378	371	417	422	394	343	335	293	199	189	153	142	115	98	108	95	88	93	86	72
1996	168	154	176	214	238	288	261	292	320	301	297	323	272	282	282	244	254	206	167	152	132
1997	145	136	125	127	135	135	171	194	228	152	172	134	150	180	187	160	167	124	213	164	173
1998	146	134	100	117	116	133	125	168	118	114	134	111	94	88	82	82	72	61	78	90	76
1999	307	379	484	508	585	557	505	395	409	312	234	199	165	142	145	117	117	93	104	93	86
2000	223	256	267	303	306	347	308	355	321	391	342	351	262	315	239	256	194	202	183	159	159
2001	299	217	189	176	152	157	187	229	281	229	266	251	230	264	274	257	236	219	225	189	208
2002	249	287	256	405	357	453	393	387	278	330	189	228	184	167	137	162	130	157	90	109	123
2003	290	319	360	342	389	455	425	460	414	390	277	275	234	245	259	198	185	166	148	124	144
2004	254	244	213	208	188	181	156	149	152	176	172	207	201	162	182	172	186	167	192	142	157
2005	252	204	194	203	207	216	167	205	168	193	132	170	127	144	129	134	111	111	101	99	100
2006	253	244	209	200	161	171	145	151	127	157	147	191	169	175	145	174	137	182	105	128	90
2007	61	73	77	74	68	82	76	85	79	80	60	75	74	82	68	72	59	54	48	52	47
2008	133	130	117	143	129	138	138	139	113	135	121	124	127	134	114	108	101	111	90	113	103
2009	302	303	362	380	379	347	334	280	289	247	181	147	144	117	103	93	82	75	78	85	88
2010	64	75	78	124	132	232	154	166	160	157	124	135	106	147	114	156	151	140	95	140	112
2011	403	457	673	801	860	925	872	790	634	511	347	349	278	265	185	230	225	265	185	276	241
2012	81	61	46	63	59	85	81	130	111	196	188	239	285	379	323	408	309	316	218	198	168
2013	126	184	153	230	292	361	431	519	407	386	349	325	258	259	195	210	136	192	142	214	193

Year	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1982	264	261	225	227	202	193	190	198	122	172	124	132	73	73	72	64	45	34	37	30	20
1983	262	245	201	224	196	200	191	166	188	176	145	181	126	122	78	81	79	68	59	39	48
1984	212	167	196	199	187	159	195	181	177	168	151	143	82	118	96	104	74	81	56	66	45
1985	90	85	148	110	110	113	171	123	134	146	147	135	134	120	138	107	135	99	95	59	75
1986	171	120	146	111	81	99	76	84	70	87	105	99	89	70	90	86	69	81	71	62	84
1987	141	136	124	132	121	133	123	132	134	111	115	94	59	90	53	55	54	24	43	34	34
1988	199	166	207	165	116	124	99	138	106	106	81	116	84	84	56	79	71	48	41	55	71
1989	197	290	186	228	242	184	167	241	213	136	201	105	184	198	167	154	143	107	151	107	63
1990	85	89	89	78	78	54	80	55	60	34	64	43	53	52	53	49	33	38	38	25	37
1991	41	34	52	44	43	26	45	41	47	46	48	32	31	25	40	32	27	14	16	19	22
1992	50	66	45	36	25	32	31	47	35	32	24	14	21	23	21	15	24	15	18	25	29
1993	66	56	57	52	36	67	36	37	62	28	28	14	15	15	14	16	12	12	11	12	12
1994	220	153	204	164	180	160	127	84	133	62	102	49	67	30	41	20	29	13	21	9	9
1995	93	99	104	100	87	70	54	60	72	71	69	50	54	45	36	28	22	37	20	25	21
1996	141	99	94	86	79	57	60	60	56	56	45	56	62	32	44	36	28	29	35	22	21
1997	122	130	107	111	115	101	99	92	80	69	56	61	53	29	18	31	20	28	16	11	10
1998	66	77	88	86	75	65	98	59	64	48	46	52	55	38	52	29	37	21	21	25	13
1999	72	116	86	93	80	95	63	69	48	61	70	49	45	51	37	28	28	23	26	27	25
2000	149	112	101	90	85	54	65	58	52	36	50	33	38	31	34	29	22	12	14	22	22
2001	185	149	198	132	155	151	106	82	106	68	78	57	51	33	38	26	19	27	20	31	17
2002	125	101	113	107	99	57	107	72	64	66	57	48	35	36	31	25	31	24	13	10	20
2003	138	116	96	70	94	64	72	69	66	67	76	47	56	40	40	36	35	26	28	16	18
2004	166	148	141	138	121	102	100	86	104	81	63	72	58	57	33	49	44	42	44	31	27
2005	117	84	118	83	127	104	112	101	101	77	83	74	70	59	72	51	72	54	65	49	44
2006	97	105	95	106	90	88	98	61	96	51	71	60	58	64	67	57	59	42	57	44	58
2007	61	50	60	49	49	45	46	32	43	40	31	24	32	23	38	21	19	14	12	17	17
2008	113	91	81	81	88	62	71	64	71	44	53	35	39	23	43	19	23	21	23	13	16
2009	72	85	77	53	65	71	52	38	48	30	40	29	21	24	13	17	14	15	14	4	13
2010	101	71	90	58	67	40	42	29	22	16	19	17	9	6	7	8	10	3	7	2	2
2011	301	228	294	184	249	172	205	152	159	115	126	61	78	51	50	27	25	21	15	14	18
2012	164	97	120	86	104	78	79	63	66	46	72	37	47	24	29	21	20	19	18	6	10
2013	234	192	212	203	234	213	194	163	141	136	109	104	92	51	63	44	31	44	29	31	8

Table 2.8 (page 3 of 3)—Trawl survey size composition, by year and cm.

Year	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99
1982	27	24	12	8	7	9	3	6	4	1	2	3	0	2	0	1	2	1	0
1983	32	29	24	18	12	1	7	8	3	11	1	1	2	4	0	3	0	1	0
1984	39	31	32	26	21	27	12	16	18	12	9	4	7	6	0	4	3	2	1
1985	59	50	48	21	37	22	22	16	14	10	8	7	8	4	1	3	7	2	4
1986	56	53	43	29	26	35	18	21	18	30	10	16	13	5	4	6	2	7	2
1987	45	28	29	29	29	9	7	15	9	10	13	6	10	10	2	4	6	3	1
1988	63	53	31	30	11	27	15	6	15	2	15	2	6	6	6	5	1	4	8
1989	53	85	61	74	88	43	60	41	14	43	30	19	24	28	32	14	10	21	11
1990	39	10	24	19	23	19	10	11	18	11	6	5	5	7	11	10	3	1	1
1991	33	24	21	12	13	8	13	7	8	6	3	5	4	1	6	8	3	2	3
1992	14	16	15	11	13	14	6	10	8	13	6	7	7	4	7	8	3	9	1
1993	11	9	4	12	10	4	7	7	8	4	3	4	7	3	7	5	5	4	3
1994	10	12	5	9	8	9	7	4	6	34	13	9	3	1	3	6	4	2	1
1995	20	18	12	13	10	7	8	7	7	4	11	3	4	4	10	1	3	2	3
1996	24	25	15	25	10	13	22	17	9	3	3	7	10	3	5	5	3	2	2
1997	9	12	17	12	10	8	9	9	4	3	8	7	2	6	3	2	4	0	1
1998	16	9	15	11	8	10	7	4	3	5	5	10	3	6	3	1	2	2	1
1999	19	13	17	15	12	11	17	16	6	16	6	5	5	5	2	5	6	6	3
2000	12	18	19	8	9	5	9	26	7	7	7	4	4	10	2	8	5	3	1
2001	17	12	11	13	5	10	6	6	5	7	5	4	2	4	6	1	2	1	5
2002	14	6	6	3	7	2	4	5	2	2	4	5	5	1	3	2	3	6	1
2003	21	22	11	14	7	9	6	7	5	4	4	3	2	1	0	1	1	0	0
2004	23	23	16	22	10	25	13	19	14	13	6	4	8	4	3	4	4	2	2
2005	40	40	32	25	17	28	20	23	14	10	14	10	8	4	9	5	3	4	0
2006	50	51	37	42	39	34	20	35	16	23	15	18	10	10	6	11	9	1	7
2007	18	10	10	9	25	11	8	9	15	10	13	8	3	8	4	6	2	3	2
2008	12	16	14	12	8	20	11	10	8	12	5	10	10	10	9	3	8	9	2
2009	6	8	4	4	7	6	6	3	4	5	1	1	1	2	3	5	2	3	1
2010	4	2	2	1	3	4	0	2	1	2	1	1	2	0	0	2	1	0	1
2011	7	14	10	7	3	4	4	4	4	1	5	3	4	7	2	1	0	1	0
2012	4	7	6	6	4	4	4	1	1	2	2	1	3	3	2	0	0	1	2
2013	29	12	24	12	10	7	7	4	3	5	4	4	5	1	2	0	1	0	1

Year	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118+
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1984	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1985	2	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	4	3	0	4	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1987	1	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	3	1	3	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0
1989	10	22	1	22	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	5	0	6	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	6	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
1992	4	3	3	3	2	1	1	1	0	0	0	0	0	0	0	0	0	1	0
1993	1	2	2	1	8	3	0	1	0	0	0	0	0	0	0	2	0	0	0
1994	2	9	6	3	1	7	0	0	1	0	1	0	0	0	0	0	0	0	0
1995	5	1	3	0	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0
1996	4	1	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
1997	2	0	0	1	2	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1998	1	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	2	1	0	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
2000	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	1	1	0	2	1	3	1	0	1	0	0	0	0	0	0	0	0	0	0
2002	1	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0
2003	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	1	0	5	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0
2005	4	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	5	3	2	3	2	0	1	0	0	2	0	0	0	0	0	0	0	0	0
2007	3	2	8	1	2	1	2	0	1	0	0	0	1	0	0	0	0	0	0
2008	4	3	7	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
2009	2	1	1	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0
2010	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	2	2	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.9—Age compositions observed by the EBS shelf bottom trawl survey, 1994-2012. "Nact" = actual sample size (these get rescaled so that the average across all age compositions equals 300).

Year	Nact	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	715	0.0000	0.0886	0.3852	0.1657	0.1258	0.1189	0.0788	0.0213	0.0074	0.0049	0.0015	0.0010	0.0009
1995	599	0.0000	0.0523	0.2620	0.4223	0.0990	0.0789	0.0488	0.0167	0.0100	0.0063	0.0016	0.0009	0.0012
1996	711	0.0000	0.0558	0.2081	0.2033	0.2966	0.1352	0.0549	0.0266	0.0105	0.0050	0.0020	0.0012	0.0009
1997	719	0.0000	0.2544	0.1693	0.1824	0.1563	0.1210	0.0778	0.0215	0.0114	0.0034	0.0012	0.0009	0.0003
1998	635	0.0000	0.0776	0.4416	0.2012	0.1101	0.0622	0.0561	0.0286	0.0164	0.0043	0.0008	0.0007	0.0002
1999	860	0.0000	0.0797	0.1999	0.2997	0.2341	0.0798	0.0573	0.0277	0.0126	0.0058	0.0013	0.0015	0.0005
2000	864	0.0000	0.2340	0.1257	0.1524	0.2437	0.1454	0.0604	0.0137	0.0147	0.0062	0.0025	0.0008	0.0005
2001	950	0.0000	0.2917	0.2322	0.1948	0.0893	0.0840	0.0678	0.0268	0.0083	0.0024	0.0015	0.0008	0.0003
2002	947	0.0001	0.0809	0.1884	0.3114	0.2380	0.0715	0.0587	0.0342	0.0108	0.0040	0.0011	0.0005	0.0005
2003	1360	0.0000	0.1753	0.1566	0.2477	0.2067	0.1247	0.0426	0.0277	0.0132	0.0041	0.0005	0.0006	0.0002
2004	1040	0.0000	0.1438	0.1648	0.2726	0.1304	0.1258	0.0895	0.0401	0.0190	0.0090	0.0019	0.0026	0.0004
2005	1280	0.0000	0.1832	0.2443	0.2085	0.1214	0.0658	0.0798	0.0566	0.0224	0.0098	0.0039	0.0037	0.0007
2006	1300	0.0000	0.3244	0.1428	0.1650	0.1214	0.0929	0.0633	0.0462	0.0285	0.0101	0.0031	0.0015	0.0010
2007	1441	0.0000	0.7008	0.0953	0.0664	0.0419	0.0460	0.0176	0.0143	0.0084	0.0049	0.0017	0.0015	0.0013
2008	1213	0.0001	0.2132	0.4455	0.1447	0.0838	0.0489	0.0314	0.0101	0.0105	0.0057	0.0027	0.0014	0.0018
2009	1412	0.0006	0.4544	0.1910	0.2293	0.0641	0.0289	0.0146	0.0092	0.0040	0.0021	0.0008	0.0006	0.0003
2010	1292	0.0000	0.0466	0.4798	0.1791	0.2031	0.0646	0.0142	0.0077	0.0026	0.0013	0.0004	0.0004	0.0001
2011	1253	0.0000	0.2898	0.0729	0.3894	0.1098	0.0959	0.0287	0.0071	0.0030	0.0016	0.0010	0.0005	0.0004
2012	1307	0.0000	0.3658	0.2340	0.0560	0.2396	0.0630	0.0300	0.0071	0.0021	0.0015	0.0005	0.0002	0.0001

Table 2.10—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.

Average length (cm) at age:

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
1994	11.00	18.49	27.77	40.71	54.50	60.75	65.06	72.42	80.93	87.08	92.56	89.39	95.92
1995	11.00	17.46	28.74	42.03	56.81	62.84	69.55	74.56	82.05	85.52	90.90	89.93	82.34
1996	11.00	18.01	29.29	39.16	54.96	61.66	69.28	76.05	83.87	88.26	89.52	90.82	82.59
1997	n/a	16.74	30.55	39.92	51.72	60.18	70.84	74.67	80.60	86.41	91.41	91.77	94.80
1998	11.00	15.66	27.67	39.73	49.38	59.75	68.97	72.92	78.17	88.13	89.42	91.75	91.86
1999	11.00	15.99	27.69	43.49	49.58	59.76	67.23	73.08	80.08	83.67	91.23	91.25	91.60
2000	11.00	15.27	28.52	38.59	49.18	61.87	66.59	74.36	76.12	80.93	70.01	91.27	78.85
2001	11.00	15.91	30.78	37.99	47.92	62.14	66.77	69.16	78.35	82.57	84.05	86.50	95.15
2002	11.00	14.90	28.45	39.15	47.59	61.55	66.52	71.10	74.56	81.22	91.34	91.44	95.09
2003	11.00	15.70	29.83	39.50	48.14	61.78	69.86	74.10	80.40	83.33	86.23	72.22	95.19
2004	11.00	16.03	27.27	37.66	48.49	60.85	70.12	75.48	78.55	84.15	90.58	89.75	95.54
2005	n/a	15.90	27.02	38.40	48.58	57.07	68.91	79.60	81.93	86.43	88.86	90.63	93.04
2006	n/a	14.52	30.90	38.55	47.56	56.94	69.65	76.23	84.67	86.89	91.14	94.05	97.03
2007	n/a	15.51	31.03	42.21	51.69	59.48	65.83	73.75	67.55	65.83	93.50	90.98	89.85
2008	11.00	15.97	26.89	41.33	53.41	65.70	71.25	75.32	83.09	86.40	86.56	94.37	96.11
2009	11.00	13.07	29.02	42.57	51.65	65.95	69.93	76.50	79.53	85.21	90.09	91.29	94.54
2010	n/a	15.50	28.56	43.52	53.84	64.82	72.36	76.17	83.41	85.94	91.09	92.49	77.55
2011	11.00	13.81	31.94	43.96	53.67	67.29	66.56	76.37	79.69	86.38	85.35	85.43	94.53
2012	11.00	14.52	30.37	44.23	53.47	61.50	73.52	79.05	78.85	86.57	92.20	93.66	75.50

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

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
1994	0	40	213	143	109	89	73	26	12	7	1	2	0
1995	0	25	153	202	90	57	38	14	9	6	1	1	2
1996	0	34	143	138	183	101	65	37	5	2	0	1	2
1997	0	94	92	109	125	120	110	38	21	5	3	2	0
1998	0	56	145	97	94	73	88	47	28	6	0	1	0
1999	0	84	167	195	162	105	77	44	17	8	0	1	0
2000	0	112	102	131	204	177	83	21	20	7	6	1	0
2001	0	173	161	159	135	127	119	43	15	7	4	5	1
2002	1	114	165	206	189	85	91	70	16	6	2	0	2
2003	0	193	222	205	198	206	129	114	68	17	1	4	0
2004	0	150	134	205	133	160	136	62	35	17	4	4	0
2005	0	141	218	238	171	112	146	121	73	30	18	10	0
2006	0	205	176	179	168	155	140	133	93	36	10	4	1
2007	0	268	206	191	155	211	108	119	75	62	21	12	7
2008	0	141	262	244	188	134	97	45	45	28	13	8	6
2009	0	222	259	325	187	133	100	82	47	23	13	12	4
2010	0	105	344	229	296	144	71	48	30	13	5	7	0
2011	0	186	148	315	178	218	107	40	20	12	11	8	1
2012	0	163	289	130	284	161	151	55	30	20	11	3	4

Table 2.11—Input multinomial sample sizes for length composition data as specified in the stock assessment model (S1…S5 = seasons 1-5, Srv. = shelf trawl survey).

	Trawl fishery					Longline fishery					Pot fishery					Srv.
Year	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	S1	S2	S3	S4	S5	
1977			10	13												
1978				35		8	23		43	18						
1979			17		6	75	25	32	12	20						
1980	23	64				8	6	30	13	19						
1981			52		16	7	5	27		12						
1982		26	20	5	13		12	16	34	20						245
1983	20	72	28	11	153	84	88	49	55	59						305
1984	79	99	92	22	35	68	92	83	194	746						282
1985	75	250	10	16	6	319	69	8	382	1100						392
1986	86	204	81	46		233	29	100	206	966			12	13		357
1987	260	181	105	156	82	706	205	102	630	1292			5	15		246
1988	739	325	35	6	35	12										232
1989	636		69		12				38					9		232
1990	226	578	280	5		14	84	633	637	312			7	73		131
1991	438	1047	54			169	252	570	938	293			17	122	13	168
1992	109	749	57			403	743	1057	550		6	10	250	118		223
1993	170	927				500	738	86				93	37			241
1994	112	1380	84			608	876	185	450			209	108	70		323
1995	91	915		8		616	791	103	506	222	7	276	347	98	63	214
1996	68	1322	98	41	14	759	758	106	763	38		445	469	181	21	217
1997	129	1129	30			772	818	273	852	728		276	353	130	23	213
1998	77	965	32	39	5	662	590	114	1014	881		217	247	52		222
1999	244	581	13	16		761	811	245	1003	252		121	300	86		271
2000	204	541	37			703	406	134	1300	852	312	172				291
2001	76	314	43	54		573	689	336	1459	878	28	299	20	142	10	458
2002	166	325	92	125		1007	564	216	1761	719	82	166	17	129	17	284
2003	124	425	103	153		1313	824	331	1948	1033	271	13		139	41	287
2004	150	262	138	87		1072	686	285	1708	855	162	35	14	120	19	251
2005	210	280	115			1249	308	324	1705	841	147	23		140		262
2006	286	162	84	13		987	302	155	1705	84	205	50	12	141	30	282
2007	193	217	149			906	77	91	1251	58	216	23		103		297
2008	169	94	32	22		827	195	213	1594	475	124	27		126		301
2009	87	59	28	68		741	119	167	1524	443	125	21		53	15	387
2010	168	38	17	60		797	77	152	986	446	146			117	38	176
2011	249	142	37	86		505	685	431	1047	453	168			173		481
2012	337	128	46	28		589	557	571	1049	596	209	29		245		303
2013	478	172	29	12		914	502	386	115		131	9				434

Table 2.12—Negative log-likelihoods. Shaded cells indicate values not used in computing the total.

Obj. func. component	Value
Equilibrium catch	0.01
Survey abundance index	-5.96
Size composition	4680.93
Age composition	138.69
Recruitment	21.36
"Softbounds"	0.04
Deviations	20.64
Total	4855.71

CPUE component	Value
Jan-Apr trawl fishery	184.79
May-Jul trawl fishery	-1.22
Aug-Dec trawl fishery	58.84
Jan-Apr longline fishery	211.09
May-Jul longline fishery	-5.05
Aug-Dec longline fishery	98.69
Jan-Apr pot fishery	-3.85
May-Jul pot fishery	-8.96
Aug-Dec pot fishery	13.27
Shelf trawl survey	-5.96

Sizecomp component	Value
Jan-Apr trawl fishery	1027.73
May-Jul trawl fishery	187.92
Aug-Dec trawl fishery	236.72
Jan-Apr longline fishery	729.28
May-Jul longline fishery	232.17
Aug-Dec longline fishery	977.09
Jan-Apr pot fishery	127.43
May-Jul pot fishery	68.83
Aug-Dec pot fishery	226.59
Shelf trawl survey	867.19

Table 2.13—Root mean squared errors, observed:expected correlations, average normalized residuals, and standard deviation of normalized residuals for fishery CPUE and survey relative abundance time series. Fishery CPUE data are not used in fitting the model; fishery CPUE results are shown for comparison only.

Root mean squared error

Fleet	Value
Jan-Apr trawl fishery	0.43
May-Jul trawl fishery	0.39
Aug-Dec trawl fishery	0.69
Jan-Apr longline fishery	0.32
May-Jul longline fishery	0.24
Aug-Dec longline fishery	0.21
Jan-Apr pot fishery	0.31
May-Jul pot fishery	0.21
Aug-Dec pot fishery	0.38
Shelf trawl survey	0.22

Average of normalized residuals

Fleet	Value
Jan-Apr trawl fishery	0.48
May-Jul trawl fishery	-0.14
Aug-Dec trawl fishery	0.33
Jan-Apr longline fishery	0.24
May-Jul longline fishery	0.12
Aug-Dec longline fishery	0.20
Jan-Apr pot fishery	0.12
May-Jul pot fishery	0.03
Aug-Dec pot fishery	0.01
Shelf trawl survey	0.92

Correlation (observed vs. expected)

Fleet	Value
Jan-Apr trawl fishery	0.18
May-Jul trawl fishery	0.29
Aug-Dec trawl fishery	0.09
Jan-Apr longline fishery	-0.05
May-Jul longline fishery	0.54
Aug-Dec longline fishery	0.43
Jan-Apr pot fishery	0.04
May-Jul pot fishery	0.18
Aug-Dec pot fishery	-0.01
Shelf trawl survey	0.72

St. dev. of normalized residuals

Fleet	Value
Jan-Apr trawl fishery	3.52
May-Jul trawl fishery	1.60
Aug-Dec trawl fishery	2.31
Jan-Apr longline fishery	3.81
May-Jul longline fishery	1.97
Aug-Dec longline fishery	3.20
Jan-Apr pot fishery	1.82
May-Jul pot fishery	1.52
Aug-Dec pot fishery	1.97
Shelf trawl survey	1.86

Table 2.14—Number of records ("Nrec"), average input sample size ("Input N"), ratio of arithmetic mean effective sample size to average input sample size, and ratio of harmonic mean effective sample size to average input sample size for each fishery and survey size composition time series.

Fleet	Nrec	Input N	Mean(Neff)/Mean(Ninp)	Harm(Neff)/Mean(Ninp)
Jan-Apr trawl fishery	64	320	3.21	1.69
May-Jul trawl fishery	33	64	7.47	3.50
Aug-Dec trawl fishery	36	42	6.32	3.42
Jan-Apr longline fishery	68	470	4.06	1.15
May-Jul longline fishery	33	231	5.48	3.13
Aug-Dec longline fishery	63	670	3.21	0.88
Jan-Apr pot fishery	36	135	9.64	3.91
May-Jul pot fishery	16	138	7.64	1.81
Aug-Dec pot fishery	35	82	8.25	2.91
Trawl survey	32	282	1.72	1.06

Table 2.15—Number of records, effective sample size, and ratio thereof for each year of age composition data from the bottom trawl survey. Last two rows show arithmetic and harmonic means.

Year	Input N	Effective N	Ratio
1994	205	469	2.29
1995	172	38	0.22
1996	204	316	1.55
1997	206	150	0.73
1998	182	1032	5.67
1999	246	104	0.42
2000	248	111	0.45
2001	272	87	0.32
2002	271	87	0.32
2003	390	275	0.71
2004	298	31	0.10
2005	367	448	1.22
2006	372	148	0.40
2007	413	63	0.15
2008	347	211	0.61
2009	404	88	0.22
2010	370	147	0.40
2011	359	162	0.45
2012	374	82	0.22
Mean	300	213	0.87
Harm.	277	104	0.35

Table 2.16a—Growth, ageing bias, recruitment (except annual *devs*), catchability, initial fishing mortality, and initial age composition parameters as estimated internally the assessment model.

Parameter	Estimate	St. dev.
Length at age 1 (cm)	1.408E+01	1.076E-01
Asymptotic length (cm)	9.220E+01	5.228E-01
Brody growth coefficient	2.409E-01	2.649E-03
SD of length at age 1 (cm)	3.538E+00	7.034E-02
SD of length at age 20 (cm)	1.011E+01	1.657E-01
Ageing bias at age 1 (years)	3.398E-01	1.285E-02
Ageing bias at age 20 (years)	2.786E-01	1.516E-01
ln(mean post-1976 recruitment)	1.319E+01	1.938E-02
ln(pre-1977 recruitment offset)	-1.170E+00	1.313E-01
Initial F (Jan-Apr trawl fishery)	6.853E-01	1.493E-01
Initial age 1 ln(abundance) dev	1.381E+00	2.139E-01
Initial age 2 ln(abundance) dev	-7.314E-01	4.182E-01
Initial age 3 ln(abundance) dev	1.289E+00	1.889E-01

Table 2.16b—Annual log-scale recruitment *dev*s estimated by the stock assessment model. Color scale extends from red (low) to green (high) in each column.

Year	Estimate	St. dev.
1977	1.361E+00	1.095E-01
1978	4.955E-01	2.112E-01
1979	6.862E-01	1.119E-01
1980	-3.840E-01	1.369E-01
1981	-9.198E-01	1.467E-01
1982	9.945E-01	4.159E-02
1983	-5.359E-01	1.154E-01
1984	7.855E-01	4.629E-02
1985	-8.156E-02	7.297E-02
1986	-8.267E-01	9.684E-02
1987	-1.164E+00	1.112E-01
1988	-2.155E-01	5.724E-02
1989	5.382E-01	4.045E-02
1990	3.314E-01	4.615E-02
1991	-3.064E-01	6.267E-02
1992	6.285E-01	3.253E-02
1993	-4.242E-01	5.887E-02
1994	-3.323E-01	5.141E-02
1995	-2.498E-01	5.446E-02
1996	6.780E-01	3.228E-02
1997	-2.411E-01	5.208E-02
1998	-2.467E-01	4.984E-02
1999	4.363E-01	3.176E-02
2000	-6.559E-02	3.737E-02
2001	-8.467E-01	5.789E-02
2002	-3.054E-01	3.878E-02
2003	-5.218E-01	4.658E-02
2004	-6.540E-01	5.166E-02
2005	-5.174E-01	4.875E-02
2006	7.646E-01	3.059E-02
2007	-4.560E-01	6.369E-02
2008	1.147E+00	4.286E-02
2009	-9.351E-01	1.319E-01
2010	6.375E-01	7.267E-02
2011	1.027E+00	8.020E-02
2013	-2.814E-01	1.807E-01

Table 2.16c—Fishery selectivity parameters estimated by the stock assessment model.

Parameter	Estimate	St. dev.
P3_May-Jul_Trawl	5.642E+00	1.043E-01
P2_Jan-Apr_Longline	-4.853E+00	1.985E+00
P4_Jan-Apr_Longline	5.084E+00	1.440E-01
P3_May-Jul_Longline	5.020E+00	4.984E-02
P2_Aug-Dec_Longline	-2.148E+00	2.781E-01
P4_Aug-Dec_Longline	5.128E+00	3.378E-01
P2_Jan-Apr_Pot	-9.240E+00	1.825E+01
P3_Jan-Apr_Pot	5.003E+00	4.918E-02
P4_Jan-Apr_Pot	4.452E+00	2.875E-01
P3_May-Jul_Pot	4.928E+00	8.128E-02
P1_Jan-Apr_Trawl_1977	6.922E+01	3.061E+00
P1_Jan-Apr_Trawl_1985	7.661E+01	1.689E+00
P1_Jan-Apr_Trawl_1990	6.888E+01	1.111E+00
P1_Jan-Apr_Trawl_1995	7.406E+01	9.255E-01
P1_Jan-Apr_Trawl_2000	7.836E+01	1.196E+00
P1_Jan-Apr_Trawl_2005	7.588E+01	7.551E-01
P3_Jan-Apr_Trawl_1977	6.179E+00	1.713E-01
P3_Jan-Apr_Trawl_1985	6.630E+00	7.663E-02
P3_Jan-Apr_Trawl_1990	6.089E+00	5.877E-02
P3_Jan-Apr_Trawl_1995	6.297E+00	4.542E-02
P3_Jan-Apr_Trawl_2000	6.304E+00	6.066E-02
P3_Jan-Apr_Trawl_2005	5.968E+00	4.525E-02
P1_May-Jul_Trawl_1977	5.040E+01	1.716E+00
P1_May-Jul_Trawl_1985	5.144E+01	1.756E+00
P1_May-Jul_Trawl_1990	6.207E+01	1.573E+00
P1_May-Jul_Trawl_2000	5.318E+01	1.527E+00
P1_May-Jul_Trawl_2005	5.911E+01	1.458E+00
P1_Aug-Dec_Trawl_1977	6.268E+01	4.010E+00
P1_Aug-Dec_Trawl_1980	8.216E+01	5.632E+00
P1_Aug-Dec_Trawl_1985	8.695E+01	5.370E+00
P1_Aug-Dec_Trawl_1990	7.729E+01	3.949E+01
P1_Aug-Dec_Trawl_1995	1.025E+02	1.026E+00
P1_Aug-Dec_Trawl_2000	5.738E+01	1.909E+00
P3_Aug-Dec_Trawl_1977	5.552E+00	3.266E-01
P3_Aug-Dec_Trawl_1980	6.665E+00	2.272E-01
P3_Aug-Dec_Trawl_1985	6.623E+00	2.285E-01
P3_Aug-Dec_Trawl_1990	6.379E+00	2.117E+00
P3_Aug-Dec_Trawl_1995	7.014E+00	9.174E-02
P3_Aug-Dec_Trawl_2000	5.253E+00	1.932E-01
P1_Jan-Apr_Longline_1977	5.910E+01	2.068E+00
P1_Jan-Apr_Longline_1980	7.252E+01	2.498E+00
P1_Jan-Apr_Longline_1985	7.521E+01	9.132E-01
P1_Jan-Apr_Longline_1990	6.608E+01	4.783E-01
P1_Jan-Apr_Longline_1995	6.575E+01	4.274E-01
P1_Jan-Apr_Longline_2000	6.354E+01	4.436E-01
P1_Jan-Apr_Longline_2005	6.714E+01	3.669E-01
P3_Jan-Apr_Longline_1977	5.155E+00	2.091E-01
P3_Jan-Apr_Longline_1980	5.913E+00	1.794E-01
P3_Jan-Apr_Longline_1985	5.857E+00	6.710E-02
P3_Jan-Apr_Longline_1990	5.225E+00	4.644E-02
P3_Jan-Apr_Longline_1995	5.303E+00	3.975E-02

Parameter	Estimate	St. Dev.
P3_Jan-Apr_Longline_2000	5.362E+00	4.172E-02
P3_Jan-Apr_Longline_2005	5.316E+00	3.200E-02
P6_Jan-Apr_Longline_1977	-1.322E+00	8.170E-01
P6_Jan-Apr_Longline_1980	3.959E-01	1.079E+00
P6_Jan-Apr_Longline_1985	-1.278E+00	4.662E-01
P6_Jan-Apr_Longline_1990	-4.779E-01	1.390E-01
P6_Jan-Apr_Longline_1995	-6.904E-01	1.421E-01
P6_Jan-Apr_Longline_2000	-1.184E+00	1.476E-01
P6_Jan-Apr_Longline_2005	-8.826E-01	1.451E-01
P1_May-Jul_Longline_1977	6.354E+01	2.221E+00
P1_May-Jul_Longline_1980	6.257E+01	1.361E+00
P1_May-Jul_Longline_1985	6.346E+01	1.122E+00
P1_May-Jul_Longline_1990	6.366E+01	5.157E-01
P1_May-Jul_Longline_2000	5.992E+01	5.586E-01
P1_May-Jul_Longline_2005	6.456E+01	5.263E-01
P1_Aug-Dec_Longline_1977	6.073E+01	2.178E+00
P1_Aug-Dec_Longline_1980	6.982E+01	1.606E+00
P1_Aug-Dec_Longline_1985	6.446E+01	7.593E-01
P1_Aug-Dec_Longline_1990	6.713E+01	7.233E-01
P1_Aug-Dec_Longline_1995	6.958E+01	7.001E-01
P1_Aug-Dec_Longline_2000	6.365E+01	4.294E-01
P1_Aug-Dec_Longline_2005	6.339E+01	3.622E-01
P3_Aug-Dec_Longline_1977	4.536E+00	3.190E-01
P3_Aug-Dec_Longline_1980	5.418E+00	1.340E-01
P3_Aug-Dec_Longline_1985	4.875E+00	8.708E-02
P3_Aug-Dec_Longline_1990	5.039E+00	7.616E-02
P3_Aug-Dec_Longline_1995	5.509E+00	5.301E-02
P3_Aug-Dec_Longline_2000	5.184E+00	4.121E-02
P3_Aug-Dec_Longline_2005	4.970E+00	3.644E-02
P6_Aug-Dec_Longline_1977	-2.651E+00	2.277E+00
P6_Aug-Dec_Longline_1980	4.431E-01	7.850E-01
P6_Aug-Dec_Longline_1985	2.278E-01	2.555E-01
P6_Aug-Dec_Longline_1990	2.590E+00	1.049E+00
P6_Aug-Dec_Longline_1995	9.501E+00	1.294E+01
P6_Aug-Dec_Longline_2000	-3.698E-01	1.959E-01
P6_Aug-Dec_Longline_2005	9.730E+00	7.596E+00
P1_Jan-Apr_Pot_1977	6.874E+01	9.224E-01
P1_Jan-Apr_Pot_1995	6.847E+01	5.485E-01
P1_Jan-Apr_Pot_2000	6.812E+01	5.185E-01
P1_Jan-Apr_Pot_2005	6.885E+01	5.118E-01
P6_Jan-Apr_Pot_1977	2.465E-01	5.670E-01
P6_Jan-Apr_Pot_1995	-2.281E-01	2.538E-01
P6_Jan-Apr_Pot_2000	-5.604E-01	2.377E-01
P6_Jan-Apr_Pot_2005	2.088E-01	2.331E-01
P1_May-Jul_Pot_1977	6.733E+01	8.593E-01
P1_May-Jul_Pot_1995	6.604E+01	7.155E-01
P1_Aug-Dec_Pot_1977	6.856E+01	1.186E+00
P1_Aug-Dec_Pot_2000	6.199E+01	6.848E-01
P3_Aug-Dec_Pot_1977	5.194E+00	1.193E-01
P3_Aug-Dec_Pot_2000	4.450E+00	1.068E-01

Table 2.16d—Survey selectivity parameters as estimated by the stock assessment model.

Parameter	Estimate	St. dev.
P1	1.277E+00	5.578E-02
P2	-3.086E+00	5.911E-01
P3	-2.112E+00	4.330E-01
P4	2.922E+00	4.008E-01
P5	-9.985E+00	4.537E-01
P6	-1.303E+00	4.483E-01
P3_dev_1982	-5.215E-02	3.356E-02
P3_dev_1983	-5.408E-02	1.689E-02
P3_dev_1984	-9.095E-02	2.794E-02
P3_dev_1985	-1.049E-02	2.070E-02
P3_dev_1986	-5.626E-02	2.294E-02
P3_dev_1987	2.702E-02	4.221E-02
P3_dev_1988	-8.451E-02	3.275E-02
P3_dev_1989	-1.294E-01	1.828E-02
P3_dev_1990	-4.320E-02	2.046E-02
P3_dev_1991	-5.263E-02	2.219E-02
P3_dev_1992	7.785E-02	4.162E-02
P3_dev_1993	3.811E-02	2.959E-02
P3_dev_1994	-5.130E-02	2.166E-02
P3_dev_1995	-1.028E-01	1.946E-02
P3_dev_1996	-1.249E-01	1.746E-02
P3_dev_1997	-7.706E-02	1.477E-02
P3_dev_1998	-8.423E-02	1.889E-02
P3_dev_1999	-9.012E-02	1.708E-02
P3_dev_2000	-5.057E-02	1.535E-02
P3_dev_2001	1.519E-01	3.747E-02
P3_dev_2002	-2.696E-02	2.360E-02
P3_dev_2003	-1.031E-02	1.926E-02
P3_dev_2004	-3.073E-02	1.936E-02
P3_dev_2005	3.265E-02	2.648E-02
P3_dev_2006	1.454E-01	3.760E-02
P3_dev_2007	1.897E-01	3.702E-02
P3_dev_2008	1.088E-01	3.815E-02
P3_dev_2009	-5.297E-03	1.598E-02
P3_dev_2010	-2.739E-02	3.132E-02
P3_dev_2011	1.101E-02	2.058E-02

Table 2.17— Model estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov-Dec. Under "Total," the "Peak" rates have been multiplied by relative season length before summing; the "7-9" and "6-20" totals are an average across those respective age ranges. Color scale extends from red (low) to green (high) in each column.

	Trawl fishery					Longline fishery					Pot fishery					Total		
Year	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Peak	7-9	6-20
1977	0.088	0.092	0.057	0.050	0.044	0.017	0.017	0.006	0.025	0.032	0	0	0	0	0	0.083	0.074	0.074
1978	0.101	0.105	0.068	0.058	0.051	0.017	0.018	0.007	0.026	0.035	0	0	0	0	0	0.094	0.085	0.085
1979	0.073	0.075	0.044	0.040	0.034	0.013	0.013	0.005	0.019	0.025	0	0	0	0	0	0.066	0.060	0.060
1980	0.065	0.064	0.032	0.042	0.035	0.010	0.010	0.004	0.014	0.018	0	0	0	0	0	0.057	0.054	0.051
1981	0.034	0.034	0.033	0.066	0.062	0.004	0.004	0.002	0.009	0.011	0	0	0	0	0	0.052	0.048	0.048
1982	0.035	0.036	0.036	0.046	0.036	0.001	0.001	0.001	0.004	0.005	0	0	0	0	0	0.041	0.039	0.037
1983	0.055	0.057	0.051	0.054	0.045	0.005	0.005	0.003	0.004	0.005	0	0	0	0	0	0.057	0.054	0.051
1984	0.063	0.066	0.057	0.057	0.050	0.008	0.008	0.006	0.028	0.038	0	0	0	0	0	0.076	0.071	0.070
1985	0.079	0.085	0.067	0.066	0.052	0.024	0.026	0.010	0.034	0.048	0	0	0	0	0	0.097	0.087	0.084
1986	0.089	0.095	0.067	0.067	0.054	0.018	0.019	0.006	0.027	0.039	0	0	0	0	0	0.094	0.084	0.083
1987	0.098	0.104	0.053	0.054	0.053	0.043	0.046	0.013	0.043	0.061	0	0	0	0	0	0.108	0.096	0.095
1988	0.197	0.212	0.102	0.115	0.122	0.001	0.001	0.002	0.003	0.004	0	0	0	0	0	0.145	0.134	0.125
1989	0.209	0.227	0.100	0.060	0.055	0.008	0.009	0.012	0.015	0.013	0.000	0.000	0.000	0.000	0.000	0.134	0.121	0.122
1990	0.176	0.193	0.093	0.034	0.029	0.031	0.035	0.047	0.052	0.047	0.000	0.000	0.002	0.002	0.001	0.143	0.137	0.134
1991	0.181	0.380	0.068	0.057	0.044	0.062	0.105	0.088	0.100	0.066	0.000	0.004	0.002	0.011	0.003	0.222	0.209	0.207
1992	0.149	0.224	0.056	0.045	0.014	0.133	0.238	0.143	0.093	0.000	0.000	0.009	0.030	0.011	0.000	0.222	0.202	0.199
1993	0.190	0.258	0.026	0.037	0.012	0.225	0.229	0.025	0.016	0.004	0.000	0.018	0.012	0.000	0.000	0.185	0.161	0.158
1994	0.087	0.295	0.019	0.103	0.020	0.190	0.262	0.030	0.105	0.000	0.000	0.041	0.010	0.016	0.000	0.220	0.193	0.189
1995	0.214	0.431	0.005	0.197	0.002	0.244	0.312	0.021	0.109	0.064	0.000	0.077	0.039	0.015	0.005	0.322	0.264	0.254
1996	0.144	0.376	0.030	0.108	0.021	0.238	0.264	0.021	0.121	0.024	0.000	0.128	0.062	0.023	0.005	0.291	0.244	0.238
1997	0.180	0.406	0.025	0.099	0.036	0.267	0.284	0.043	0.116	0.192	0.000	0.099	0.041	0.021	0.005	0.331	0.281	0.276
1998	0.121	0.237	0.026	0.141	0.021	0.281	0.203	0.021	0.096	0.114	0.018	0.064	0.032	0.011	0.004	0.259	0.212	0.206
1999	0.145	0.221	0.016	0.065	0.004	0.323	0.241	0.020	0.125	0.043	0.022	0.063	0.035	0.013	0.000	0.246	0.205	0.202
2000	0.170	0.222	0.016	0.026	0.004	0.299	0.084	0.007	0.123	0.140	0.136	0.051	0.006	0.008	0.000	0.231	0.180	0.179
2001	0.065	0.120	0.014	0.038	0.005	0.157	0.153	0.018	0.166	0.154	0.023	0.118	0.005	0.014	0.004	0.197	0.152	0.154
2002	0.107	0.182	0.033	0.036	0.002	0.318	0.142	0.009	0.192	0.115	0.018	0.091	0.003	0.015	0.006	0.236	0.185	0.189
2003	0.133	0.144	0.028	0.033	0.002	0.326	0.169	0.013	0.193	0.144	0.143	0.019	0.002	0.025	0.010	0.255	0.202	0.201
2004	0.180	0.156	0.044	0.041	0.001	0.346	0.168	0.014	0.182	0.176	0.093	0.032	0.005	0.020	0.005	0.269	0.210	0.211
2005	0.245	0.150	0.040	0.015	0.001	0.486	0.076	0.020	0.208	0.182	0.094	0.036	0.000	0.027	0.004	0.290	0.252	0.247
2006	0.297	0.163	0.040	0.027	0.001	0.564	0.085	0.014	0.296	0.010	0.132	0.046	0.003	0.028	0.008	0.320	0.278	0.271
2007	0.193	0.221	0.074	0.023	0.001	0.624	0.031	0.010	0.240	0.009	0.156	0.018	0.004	0.040	0.000	0.306	0.265	0.259
2008	0.214	0.108	0.030	0.048	0.007	0.680	0.066	0.024	0.291	0.103	0.145	0.036	0.002	0.056	0.002	0.340	0.292	0.288
2009	0.187	0.162	0.030	0.069	0.004	0.798	0.072	0.022	0.302	0.123	0.174	0.035	0.003	0.012	0.013	0.370	0.319	0.312
2010	0.233	0.122	0.023	0.052	0.012	0.596	0.031	0.022	0.166	0.117	0.179	0.030	0.002	0.037	0.016	0.298	0.258	0.252
2011	0.240	0.248	0.035	0.110	0.020	0.318	0.305	0.091	0.337	0.278	0.190	0.030	0.004	0.095	0.007	0.441	0.396	0.387
2012	0.393	0.156	0.038	0.047	0.006	0.316	0.246	0.115	0.133	0.144	0.213	0.026	0.005	0.030	0.006	0.344	0.301	0.289
2013	0.300	0.158	0.024	0.000	0.000	0.314	0.198	0.069	0.000	0.000	0.172	0.018	0.000	0.000	0.000	0.217	0.181	0.177

Table 2.18—Summary of key management reference points from the standard projection algorithm (last seven rows are from SS). All biomass figures are in t.

Quantity	Value
B100%	796,000
B40%	318,000
B35%	279,000
B(2014)	361,000
B(2015)	389,000
B(2014)/B100%	0.45
B(2015)/B100%	0.49
F40%	0.28
F35%	0.34
maxFABC(2014)	0.28
maxFABC(2015)	0.28
maxABC(2014)	255,000
maxABC(2015)	272,000
FOFL(2014)	0.34
FOFL(2015)	0.34
OFL(2014)	299,000
OFL(2015)	319,000
Pr(maxABC(2014)>truOFL(2014))	0.01
Pr(maxABC(2015)>truOFL(2015))	0.02
Pr(B(2014)<B20%)	0.00
Pr(B(2015)<B20%)	0.00
Pr(B(2016)<B20%)	0.00
Pr(B(2017)<B20%)	0.00
Pr(B(2018)<B20%)	0.00

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)
B(year) = projected spawning biomass for year (assuming catch = maxABC)
B(year)/B100% = ratio of 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
maxFABC(year) = maximum permissible ABC fishing mortality rate under Tier 3
maxABC(year) = maximum permissible ABC under Tier 3
FOFL(year) = OFL fishing mortality rate under Tier 3
OFL(year) = OFL under Tier 3 (second year assumes catch = maxABC in first year)
Pr(maxABC(year)>truOFL(year)) = probability that maxABC is greater than the "true" OFL
Pr(B(year)<B20%) = probability that spawning biomass is less than 20% of unfished

Table 2.19 (page 1 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. Years correspond to beginnings of blocks.

	January-April trawl fishery						May-July trawl fishery				
Len.	1977	1985	1990	1995	2000	2005	1977	1985	1990	2000	2005
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
6	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	0.000
7	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.000
8	0.000	0.002	0.000	0.000	0.000	0.000	0.002	0.001	0.000	0.001	0.000
9	0.001	0.002	0.000	0.000	0.000	0.000	0.002	0.002	0.000	0.001	0.000
10	0.001	0.003	0.000	0.001	0.000	0.000	0.003	0.002	0.000	0.001	0.000
11	0.001	0.003	0.001	0.001	0.000	0.000	0.004	0.003	0.000	0.002	0.000
12	0.001	0.004	0.001	0.001	0.000	0.000	0.005	0.004	0.000	0.002	0.000
13	0.001	0.005	0.001	0.001	0.000	0.000	0.007	0.005	0.000	0.003	0.001
14	0.002	0.006	0.001	0.001	0.001	0.000	0.009	0.007	0.000	0.004	0.001
15	0.002	0.007	0.001	0.002	0.001	0.000	0.012	0.009	0.000	0.006	0.001
16	0.003	0.008	0.002	0.002	0.001	0.000	0.015	0.012	0.001	0.007	0.001
17	0.004	0.009	0.002	0.002	0.001	0.000	0.019	0.015	0.001	0.010	0.002
18	0.004	0.011	0.003	0.003	0.001	0.000	0.024	0.019	0.001	0.012	0.002
19	0.005	0.013	0.004	0.004	0.002	0.000	0.030	0.024	0.001	0.016	0.003
20	0.007	0.015	0.004	0.005	0.002	0.000	0.038	0.030	0.002	0.020	0.004
21	0.008	0.017	0.006	0.006	0.002	0.000	0.047	0.037	0.003	0.025	0.006
22	0.010	0.020	0.007	0.007	0.003	0.001	0.057	0.046	0.003	0.032	0.008
23	0.012	0.023	0.008	0.008	0.004	0.001	0.070	0.057	0.004	0.040	0.010
24	0.014	0.026	0.010	0.010	0.004	0.001	0.084	0.069	0.006	0.049	0.013
25	0.017	0.030	0.013	0.012	0.005	0.001	0.101	0.084	0.008	0.060	0.016
26	0.021	0.034	0.015	0.014	0.007	0.002	0.121	0.101	0.010	0.073	0.021
27	0.025	0.039	0.019	0.017	0.008	0.002	0.143	0.120	0.013	0.088	0.026
28	0.030	0.044	0.023	0.020	0.010	0.003	0.169	0.142	0.016	0.106	0.032
29	0.035	0.050	0.027	0.024	0.012	0.004	0.197	0.168	0.021	0.126	0.040
30	0.041	0.057	0.032	0.028	0.014	0.005	0.228	0.196	0.026	0.149	0.050
31	0.048	0.064	0.039	0.033	0.017	0.006	0.263	0.227	0.033	0.175	0.061
32	0.057	0.072	0.046	0.038	0.020	0.007	0.301	0.262	0.041	0.204	0.074
33	0.066	0.081	0.054	0.045	0.023	0.009	0.342	0.299	0.050	0.236	0.089
34	0.076	0.091	0.063	0.052	0.027	0.011	0.385	0.340	0.061	0.271	0.107
35	0.088	0.102	0.074	0.060	0.032	0.014	0.431	0.383	0.074	0.310	0.127
36	0.102	0.114	0.086	0.069	0.038	0.017	0.479	0.429	0.090	0.351	0.150
37	0.116	0.126	0.100	0.080	0.044	0.021	0.529	0.477	0.108	0.395	0.177
38	0.133	0.140	0.115	0.091	0.051	0.025	0.580	0.527	0.128	0.442	0.206
39	0.151	0.155	0.132	0.104	0.059	0.031	0.631	0.577	0.152	0.490	0.238
40	0.170	0.171	0.151	0.118	0.068	0.037	0.681	0.629	0.178	0.540	0.274
41	0.192	0.188	0.171	0.134	0.078	0.044	0.731	0.679	0.207	0.591	0.313
42	0.215	0.206	0.194	0.151	0.089	0.053	0.778	0.729	0.240	0.642	0.354
43	0.241	0.225	0.219	0.169	0.102	0.063	0.823	0.777	0.275	0.693	0.398
44	0.268	0.246	0.246	0.189	0.115	0.074	0.865	0.822	0.314	0.742	0.445
45	0.297	0.268	0.274	0.211	0.131	0.087	0.902	0.863	0.356	0.789	0.494
46	0.327	0.291	0.305	0.235	0.147	0.102	0.934	0.900	0.400	0.833	0.544
47	0.359	0.315	0.338	0.260	0.165	0.118	0.960	0.932	0.447	0.873	0.594
48	0.393	0.340	0.372	0.286	0.185	0.137	0.980	0.959	0.496	0.909	0.646
49	0.429	0.366	0.408	0.315	0.207	0.157	0.993	0.979	0.546	0.940	0.696
50	0.465	0.393	0.445	0.344	0.230	0.180	0.999	0.993	0.597	0.965	0.745
51	0.503	0.421	0.484	0.376	0.254	0.205	1.000	0.999	0.648	0.983	0.792
52	0.541	0.450	0.524	0.408	0.280	0.232	1.000	1.000	0.698	0.995	0.836
53	0.580	0.479	0.564	0.442	0.308	0.262	1.000	1.000	0.747	1.000	0.876
54	0.619	0.509	0.605	0.477	0.338	0.294	1.000	1.000	0.794	1.000	0.912
55	0.658	0.540	0.646	0.512	0.368	0.328	1.000	1.000	0.838	1.000	0.942
56	0.696	0.571	0.686	0.549	0.401	0.364	1.000	1.000	0.878	1.000	0.966
57	0.734	0.602	0.726	0.585	0.434	0.402	1.000	1.000	0.913	1.000	0.984
58	0.770	0.633	0.764	0.622	0.468	0.441	1.000	1.000	0.943	1.000	0.996
59	0.805	0.664	0.801	0.659	0.504	0.482	1.000	1.000	0.967	1.000	1.000
60	0.839	0.695	0.836	0.695	0.540	0.524	1.000	1.000	0.985	1.000	1.000

Table 2.19 (page 2 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. Years correspond to beginnings of blocks.

	January-April trawl fishery						May-July trawl fishery				
Len.	1977	1985	1990	1995	2000	2005	1977	1985	1990	2000	2005
61	0.869	0.725	0.869	0.730	0.576	0.567	1.000	1.000	0.996	1.000	1.000
62	0.898	0.755	0.898	0.765	0.613	0.611	1.000	1.000	1.000	1.000	1.000
63	0.923	0.783	0.925	0.798	0.649	0.654	1.000	1.000	1.000	1.000	1.000
64	0.945	0.811	0.947	0.830	0.686	0.697	1.000	1.000	1.000	1.000	1.000
65	0.964	0.837	0.966	0.860	0.721	0.739	1.000	1.000	1.000	1.000	1.000
66	0.979	0.862	0.981	0.887	0.756	0.779	1.000	1.000	1.000	1.000	1.000
67	0.990	0.885	0.992	0.912	0.790	0.817	1.000	1.000	1.000	1.000	1.000
68	0.997	0.907	0.998	0.935	0.822	0.853	1.000	1.000	1.000	1.000	1.000
69	1.000	0.926	1.000	0.954	0.852	0.886	1.000	1.000	1.000	1.000	1.000
70	1.000	0.944	1.000	0.970	0.880	0.915	1.000	1.000	1.000	1.000	1.000
71	1.000	0.959	1.000	0.983	0.906	0.941	1.000	1.000	1.000	1.000	1.000
72	1.000	0.972	1.000	0.992	0.929	0.962	1.000	1.000	1.000	1.000	1.000
73	1.000	0.983	1.000	0.998	0.949	0.979	1.000	1.000	1.000	1.000	1.000
74	1.000	0.991	1.000	1.000	0.966	0.991	1.000	1.000	1.000	1.000	1.000
75	1.000	0.997	1.000	1.000	0.980	0.998	1.000	1.000	1.000	1.000	1.000
76	1.000	1.000	1.000	1.000	0.990	1.000	1.000	1.000	1.000	1.000	1.000
77	1.000	1.000	1.000	1.000	0.997	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
79	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
81	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
83	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
85	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
87	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
89	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
91	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
93	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
95	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
97	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
99	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
101	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
103	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
105	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
107	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
109	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
111	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
113	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
115	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
117	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
119	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

Table 2.19 (page 3 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. 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
1	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
2	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
3	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
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	0.001	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	0.001	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	0.002	0.000	0.001	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	0.001	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	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	0.000	0.003	0.001	0.001	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	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	0.000	0.004	0.001	0.002	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	0.002	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	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	0.001	0.006	0.002	0.003	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	0.001	0.007	0.003	0.004	0.002	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
21	0.001	0.008	0.003	0.005	0.003	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
22	0.002	0.010	0.004	0.006	0.003	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000
23	0.002	0.012	0.004	0.007	0.003	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.000
24	0.003	0.013	0.005	0.008	0.004	0.003	0.001	0.002	0.001	0.000	0.000	0.001	0.000
25	0.004	0.016	0.006	0.010	0.005	0.004	0.001	0.002	0.001	0.000	0.000	0.001	0.000
26	0.005	0.018	0.007	0.012	0.005	0.006	0.002	0.003	0.001	0.000	0.000	0.001	0.000
27	0.007	0.021	0.008	0.014	0.006	0.008	0.003	0.004	0.001	0.000	0.001	0.002	0.000
28	0.009	0.024	0.010	0.016	0.007	0.011	0.004	0.005	0.002	0.000	0.001	0.003	0.001
29	0.012	0.027	0.012	0.019	0.008	0.015	0.005	0.006	0.002	0.001	0.001	0.004	0.001
30	0.016	0.031	0.013	0.023	0.009	0.020	0.008	0.008	0.003	0.001	0.002	0.005	0.001
31	0.020	0.036	0.016	0.026	0.010	0.026	0.010	0.009	0.004	0.001	0.002	0.007	0.002
32	0.026	0.040	0.018	0.031	0.012	0.034	0.014	0.012	0.005	0.002	0.003	0.009	0.002
33	0.033	0.046	0.021	0.036	0.013	0.045	0.020	0.015	0.006	0.003	0.005	0.013	0.003
34	0.041	0.052	0.024	0.042	0.015	0.057	0.026	0.018	0.008	0.004	0.007	0.017	0.005
35	0.051	0.059	0.028	0.048	0.017	0.073	0.035	0.022	0.010	0.006	0.009	0.022	0.006
36	0.063	0.066	0.032	0.055	0.019	0.092	0.046	0.027	0.012	0.008	0.012	0.028	0.009
37	0.077	0.074	0.036	0.064	0.021	0.114	0.060	0.033	0.015	0.011	0.016	0.037	0.012
38	0.094	0.083	0.041	0.073	0.024	0.140	0.077	0.040	0.019	0.014	0.022	0.047	0.015
39	0.113	0.093	0.047	0.083	0.027	0.171	0.097	0.048	0.024	0.019	0.028	0.059	0.021
40	0.136	0.104	0.053	0.095	0.030	0.206	0.122	0.057	0.029	0.026	0.037	0.074	0.027
41	0.161	0.115	0.060	0.107	0.033	0.246	0.151	0.068	0.035	0.034	0.047	0.092	0.035
42	0.190	0.128	0.068	0.121	0.037	0.290	0.185	0.081	0.043	0.044	0.060	0.113	0.045
43	0.222	0.142	0.077	0.136	0.042	0.339	0.224	0.095	0.051	0.057	0.076	0.138	0.057
44	0.258	0.156	0.086	0.153	0.046	0.392	0.268	0.111	0.062	0.073	0.095	0.167	0.072
45	0.297	0.172	0.096	0.171	0.051	0.449	0.317	0.129	0.074	0.092	0.117	0.199	0.090
46	0.340	0.189	0.108	0.190	0.057	0.508	0.371	0.149	0.087	0.114	0.144	0.236	0.112
47	0.385	0.207	0.120	0.211	0.063	0.569	0.429	0.172	0.103	0.141	0.174	0.277	0.137
48	0.433	0.226	0.133	0.233	0.069	0.631	0.491	0.197	0.120	0.172	0.209	0.322	0.166
49	0.484	0.246	0.147	0.257	0.077	0.693	0.555	0.224	0.140	0.208	0.248	0.371	0.199
50	0.536	0.268	0.163	0.283	0.084	0.752	0.620	0.254	0.162	0.249	0.291	0.423	0.237
51	0.589	0.290	0.179	0.310	0.092	0.808	0.685	0.286	0.187	0.294	0.339	0.478	0.278
52	0.642	0.314	0.197	0.338	0.101	0.860	0.747	0.320	0.214	0.344	0.390	0.535	0.325
53	0.695	0.338	0.216	0.368	0.111	0.905	0.807	0.357	0.244	0.399	0.445	0.594	0.375
54	0.746	0.364	0.236	0.399	0.121	0.942	0.861	0.396	0.276	0.456	0.503	0.652	0.429
55	0.795	0.391	0.257	0.431	0.132	0.971	0.907	0.436	0.311	0.517	0.563	0.710	0.485
56	0.841	0.418	0.280	0.464	0.144	0.990	0.946	0.478	0.348	0.579	0.623	0.766	0.544
57	0.882	0.446	0.303	0.497	0.156	0.999	0.975	0.521	0.387	0.642	0.683	0.818	0.604
58	0.918	0.475	0.328	0.532	0.169	1.000	0.993	0.565	0.429	0.704	0.742	0.866	0.664
59	0.949	0.505	0.354	0.567	0.183	1.000	1.000	0.610	0.472	0.764	0.797	0.908	0.723
60	0.973	0.535	0.381	0.602	0.198	1.000	1.000	0.655	0.516	0.820	0.848	0.943	0.779

Table 2.19 (page 4 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. 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
61	0.989	0.565	0.408	0.638	0.213	1.000	0.999	0.698	0.561	0.870	0.894	0.970	0.831
62	0.998	0.596	0.437	0.673	0.229	1.000	0.990	0.741	0.607	0.914	0.932	0.989	0.879
63	1.000	0.626	0.466	0.707	0.247	1.000	0.971	0.783	0.653	0.950	0.963	0.999	0.919
64	1.000	0.657	0.496	0.741	0.264	1.000	0.944	0.822	0.698	0.977	0.985	1.000	0.953
65	1.000	0.687	0.527	0.774	0.283	1.000	0.909	0.858	0.742	0.994	0.997	1.000	0.978
66	1.000	0.717	0.558	0.806	0.303	1.000	0.867	0.891	0.785	1.000	1.000	0.995	0.994
67	1.000	0.746	0.589	0.836	0.323	1.000	0.821	0.921	0.825	1.000	1.000	0.981	1.000
68	1.000	0.775	0.620	0.864	0.344	1.000	0.770	0.946	0.862	0.999	0.997	0.957	1.000
69	1.000	0.802	0.651	0.890	0.365	1.000	0.718	0.967	0.896	0.991	0.986	0.926	0.999
70	1.000	0.828	0.682	0.914	0.388	1.000	0.665	0.983	0.925	0.976	0.967	0.889	0.991
71	1.000	0.853	0.713	0.935	0.411	1.000	0.612	0.994	0.951	0.954	0.942	0.845	0.974
72	1.000	0.877	0.743	0.954	0.434	1.000	0.561	0.999	0.971	0.927	0.910	0.798	0.949
73	1.000	0.899	0.772	0.969	0.458	1.000	0.513	1.000	0.986	0.894	0.873	0.747	0.918
74	1.000	0.919	0.800	0.982	0.483	1.000	0.468	1.000	0.996	0.857	0.832	0.696	0.880
75	1.000	0.937	0.827	0.991	0.508	1.000	0.427	0.997	1.000	0.817	0.789	0.644	0.838
76	1.000	0.953	0.853	0.997	0.533	1.000	0.390	0.989	1.000	0.776	0.744	0.594	0.793
77	1.000	0.967	0.877	1.000	0.558	1.000	0.358	0.976	0.999	0.735	0.699	0.546	0.746
78	1.000	0.978	0.899	1.000	0.584	1.000	0.330	0.960	0.990	0.694	0.655	0.501	0.698
79	1.000	0.987	0.919	1.000	0.610	1.000	0.306	0.939	0.971	0.654	0.613	0.460	0.651
80	1.000	0.994	0.938	1.000	0.635	1.000	0.286	0.916	0.944	0.616	0.573	0.423	0.606
81	1.000	0.998	0.954	1.000	0.661	1.000	0.270	0.891	0.909	0.582	0.537	0.390	0.562
82	1.000	1.000	0.968	1.000	0.686	1.000	0.256	0.865	0.868	0.550	0.504	0.361	0.522
83	1.000	1.000	0.979	1.000	0.711	1.000	0.245	0.838	0.822	0.521	0.474	0.336	0.486
84	1.000	1.000	0.988	1.000	0.736	1.000	0.237	0.811	0.772	0.496	0.449	0.315	0.453
85	1.000	1.000	0.995	1.000	0.760	1.000	0.230	0.784	0.720	0.475	0.426	0.298	0.424
86	1.000	1.000	0.999	1.000	0.784	1.000	0.225	0.759	0.667	0.456	0.408	0.284	0.399
87	1.000	1.000	1.000	1.000	0.806	1.000	0.221	0.736	0.615	0.441	0.392	0.272	0.378
88	1.000	1.000	1.000	1.000	0.828	1.000	0.218	0.714	0.565	0.428	0.379	0.263	0.360
89	1.000	1.000	1.000	1.000	0.850	1.000	0.216	0.695	0.517	0.418	0.369	0.256	0.345
90	1.000	1.000	1.000	1.000	0.870	1.000	0.214	0.678	0.472	0.409	0.360	0.250	0.333
91	1.000	1.000	1.000	1.000	0.889	1.000	0.213	0.663	0.432	0.403	0.354	0.246	0.324
92	1.000	1.000	1.000	1.000	0.906	1.000	0.212	0.650	0.396	0.398	0.348	0.243	0.316
93	1.000	1.000	1.000	1.000	0.923	1.000	0.212	0.639	0.364	0.394	0.345	0.240	0.310
94	1.000	1.000	1.000	1.000	0.938	1.000	0.211	0.630	0.336	0.391	0.342	0.238	0.305
95	1.000	1.000	1.000	1.000	0.951	1.000	0.211	0.623	0.313	0.388	0.339	0.237	0.302
96	1.000	1.000	1.000	1.000	0.963	1.000	0.211	0.617	0.293	0.387	0.338	0.236	0.299
97	1.000	1.000	1.000	1.000	0.973	1.000	0.211	0.612	0.276	0.386	0.337	0.236	0.297
98	1.000	1.000	1.000	1.000	0.982	1.000	0.211	0.609	0.263	0.385	0.336	0.235	0.296
99	1.000	1.000	1.000	1.000	0.989	1.000	0.211	0.606	0.252	0.384	0.335	0.235	0.295
100	1.000	1.000	1.000	1.000	0.995	1.000	0.210	0.604	0.244	0.384	0.335	0.235	0.294
101	1.000	1.000	1.000	1.000	0.998	1.000	0.210	0.602	0.237	0.383	0.334	0.235	0.294
102	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.601	0.232	0.383	0.334	0.235	0.293
103	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.600	0.228	0.383	0.334	0.234	0.293
104	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.599	0.225	0.383	0.334	0.234	0.293
105	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.599	0.223	0.383	0.334	0.234	0.293
106	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.221	0.383	0.334	0.234	0.293
107	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.220	0.383	0.334	0.234	0.293
108	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.220	0.383	0.334	0.234	0.293
109	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.219	0.383	0.334	0.234	0.293
110	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.219	0.383	0.334	0.234	0.293
111	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
112	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
113	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
114	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
115	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
116	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
117	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
118	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
119	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293
120	1.000	1.000	1.000	1.000	1.000	1.000	0.210	0.598	0.218	0.383	0.334	0.234	0.293

Table 2.19 (page 5 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. 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
1	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
2	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
3	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
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	0.001	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	0.001	0.000	0.000	0.001	0.001	0.000
30	0.001	0.001	0.001	0.001	0.003	0.000	0.000	0.001	0.000	0.000	0.002	0.002	0.000
31	0.001	0.001	0.001	0.001	0.004	0.001	0.000	0.001	0.000	0.000	0.002	0.003	0.001
32	0.001	0.002	0.001	0.001	0.006	0.001	0.000	0.002	0.000	0.000	0.003	0.004	0.001
33	0.002	0.003	0.002	0.002	0.008	0.001	0.000	0.002	0.001	0.001	0.004	0.005	0.002
34	0.003	0.005	0.003	0.003	0.012	0.002	0.000	0.003	0.001	0.001	0.006	0.007	0.002
35	0.005	0.007	0.005	0.004	0.017	0.003	0.001	0.005	0.001	0.001	0.008	0.010	0.004
36	0.007	0.009	0.007	0.006	0.023	0.005	0.001	0.006	0.002	0.002	0.010	0.014	0.005
37	0.010	0.013	0.010	0.009	0.031	0.007	0.002	0.008	0.003	0.003	0.014	0.019	0.008
38	0.013	0.019	0.014	0.013	0.042	0.009	0.004	0.011	0.005	0.004	0.018	0.025	0.011
39	0.019	0.025	0.019	0.018	0.056	0.013	0.006	0.015	0.007	0.006	0.023	0.033	0.016
40	0.026	0.035	0.026	0.025	0.073	0.019	0.010	0.019	0.010	0.008	0.029	0.043	0.022
41	0.035	0.046	0.036	0.034	0.094	0.026	0.015	0.025	0.015	0.012	0.037	0.056	0.031
42	0.047	0.061	0.048	0.045	0.120	0.035	0.023	0.032	0.021	0.017	0.046	0.072	0.042
43	0.062	0.080	0.063	0.060	0.151	0.046	0.034	0.041	0.030	0.023	0.057	0.092	0.056
44	0.080	0.103	0.082	0.078	0.187	0.061	0.050	0.052	0.041	0.031	0.071	0.115	0.074
45	0.103	0.130	0.105	0.100	0.230	0.080	0.070	0.065	0.056	0.042	0.087	0.142	0.096
46	0.131	0.163	0.134	0.127	0.278	0.103	0.098	0.081	0.074	0.055	0.105	0.174	0.123
47	0.164	0.202	0.167	0.160	0.332	0.131	0.132	0.099	0.098	0.072	0.127	0.211	0.155
48	0.203	0.246	0.206	0.198	0.391	0.163	0.176	0.121	0.126	0.093	0.152	0.253	0.193
49	0.247	0.296	0.251	0.242	0.455	0.202	0.229	0.146	0.161	0.119	0.180	0.300	0.238
50	0.298	0.352	0.302	0.292	0.522	0.247	0.291	0.175	0.203	0.149	0.212	0.352	0.288
51	0.354	0.413	0.359	0.347	0.591	0.297	0.362	0.208	0.251	0.185	0.247	0.408	0.345
52	0.415	0.478	0.420	0.407	0.661	0.353	0.441	0.244	0.306	0.227	0.286	0.467	0.407
53	0.480	0.546	0.486	0.472	0.729	0.414	0.527	0.285	0.367	0.274	0.329	0.530	0.473
54	0.548	0.616	0.554	0.540	0.793	0.479	0.615	0.329	0.434	0.327	0.375	0.593	0.542
55	0.618	0.685	0.624	0.609	0.852	0.547	0.703	0.377	0.505	0.385	0.423	0.658	0.614
56	0.687	0.752	0.693	0.679	0.903	0.616	0.786	0.429	0.579	0.448	0.474	0.720	0.685
57	0.754	0.815	0.759	0.746	0.945	0.686	0.861	0.482	0.654	0.514	0.527	0.781	0.753
58	0.817	0.871	0.821	0.809	0.976	0.753	0.923	0.538	0.727	0.582	0.581	0.836	0.818
59	0.873	0.919	0.877	0.866	0.994	0.815	0.968	0.595	0.796	0.651	0.636	0.886	0.875
60	0.921	0.957	0.924	0.915	1.000	0.872	0.994	0.652	0.859	0.719	0.690	0.928	0.923

Table 2.19 (page 6 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. 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
61	0.958	0.984	0.961	0.954	1.000	0.920	1.000	0.708	0.913	0.784	0.743	0.961	0.961
62	0.984	0.998	0.986	0.982	1.000	0.958	1.000	0.762	0.955	0.843	0.793	0.985	0.987
63	0.998	1.000	0.999	0.997	1.000	0.984	1.000	0.814	0.984	0.895	0.839	0.998	0.999
64	1.000	1.000	1.000	1.000	1.000	0.998	1.000	0.860	0.998	0.938	0.882	1.000	1.000
65	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.902	1.000	0.971	0.919	1.000	1.000
66	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.937	1.000	0.992	0.950	1.000	1.000
67	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.965	1.000	1.000	0.974	1.000	1.000
68	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.985	1.000	1.000	0.990	1.000	1.000
69	1.000	1.000	1.000	1.000	1.000	1.000	0.991	0.997	1.000	1.000	0.999	1.000	1.000
70	1.000	1.000	1.000	1.000	1.000	1.000	0.971	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	0.942	1.000	1.000	1.000	1.000	0.998	1.000
72	1.000	1.000	1.000	1.000	1.000	1.000	0.903	1.000	0.998	1.000	1.000	0.990	1.000
73	1.000	1.000	1.000	1.000	1.000	1.000	0.857	1.000	0.990	1.000	1.000	0.975	1.000
74	1.000	1.000	1.000	1.000	1.000	1.000	0.804	1.000	0.978	1.000	1.000	0.954	1.000
75	1.000	1.000	1.000	1.000	1.000	1.000	0.747	1.000	0.961	0.999	1.000	0.928	1.000
76	1.000	1.000	1.000	1.000	1.000	1.000	0.687	1.000	0.940	0.997	1.000	0.897	1.000
77	1.000	1.000	1.000	1.000	1.000	1.000	0.625	0.997	0.916	0.995	1.000	0.862	1.000
78	1.000	1.000	1.000	1.000	1.000	1.000	0.564	0.989	0.889	0.992	1.000	0.825	1.000
79	1.000	1.000	1.000	1.000	1.000	1.000	0.504	0.977	0.861	0.988	1.000	0.786	1.000
80	1.000	1.000	1.000	1.000	1.000	1.000	0.447	0.962	0.832	0.984	1.000	0.747	1.000
81	1.000	1.000	1.000	1.000	1.000	1.000	0.393	0.943	0.803	0.980	1.000	0.709	1.000
82	1.000	1.000	1.000	1.000	1.000	1.000	0.344	0.921	0.774	0.975	1.000	0.671	1.000
83	1.000	1.000	1.000	1.000	1.000	1.000	0.299	0.897	0.746	0.971	1.000	0.636	1.000
84	1.000	1.000	1.000	1.000	1.000	1.000	0.259	0.872	0.720	0.966	1.000	0.603	1.000
85	1.000	1.000	1.000	1.000	1.000	1.000	0.224	0.847	0.696	0.962	1.000	0.573	1.000
86	1.000	1.000	1.000	1.000	1.000	1.000	0.194	0.821	0.674	0.958	1.000	0.546	1.000
87	1.000	1.000	1.000	1.000	1.000	1.000	0.168	0.796	0.655	0.954	1.000	0.522	1.000
88	1.000	1.000	1.000	1.000	1.000	1.000	0.147	0.772	0.637	0.950	1.000	0.501	1.000
89	1.000	1.000	1.000	1.000	1.000	1.000	0.129	0.749	0.622	0.947	1.000	0.483	1.000
90	1.000	1.000	1.000	1.000	1.000	1.000	0.115	0.728	0.609	0.944	1.000	0.468	1.000
91	1.000	1.000	1.000	1.000	1.000	1.000	0.103	0.709	0.598	0.941	1.000	0.455	1.000
92	1.000	1.000	1.000	1.000	1.000	1.000	0.094	0.692	0.589	0.939	1.000	0.445	1.000
93	1.000	1.000	1.000	1.000	1.000	1.000	0.087	0.677	0.582	0.937	1.000	0.437	1.000
94	1.000	1.000	1.000	1.000	1.000	1.000	0.081	0.664	0.576	0.936	1.000	0.430	1.000
95	1.000	1.000	1.000	1.000	1.000	1.000	0.077	0.653	0.571	0.935	1.000	0.425	1.000
96	1.000	1.000	1.000	1.000	1.000	1.000	0.074	0.644	0.568	0.934	1.000	0.420	1.000
97	1.000	1.000	1.000	1.000	1.000	1.000	0.072	0.636	0.565	0.933	1.000	0.417	1.000
98	1.000	1.000	1.000	1.000	1.000	1.000	0.070	0.630	0.563	0.932	1.000	0.415	1.000
99	1.000	1.000	1.000	1.000	1.000	1.000	0.069	0.625	0.561	0.932	1.000	0.413	1.000
100	1.000	1.000	1.000	1.000	1.000	1.000	0.068	0.621	0.560	0.931	1.000	0.412	1.000
101	1.000	1.000	1.000	1.000	1.000	1.000	0.067	0.618	0.559	0.931	1.000	0.411	1.000
102	1.000	1.000	1.000	1.000	1.000	1.000	0.067	0.616	0.558	0.931	1.000	0.410	1.000
103	1.000	1.000	1.000	1.000	1.000	1.000	0.067	0.614	0.558	0.931	1.000	0.410	1.000
104	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.613	0.557	0.930	1.000	0.409	1.000
105	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.612	0.557	0.930	1.000	0.409	1.000
106	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.611	0.557	0.930	1.000	0.409	1.000
107	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.610	0.557	0.930	1.000	0.409	1.000
108	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.610	0.557	0.930	1.000	0.409	1.000
109	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.610	0.557	0.930	1.000	0.409	1.000
110	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
111	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
112	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
113	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
114	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
115	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
116	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
117	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
118	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
119	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000
120	1.000	1.000	1.000	1.000	1.000	1.000	0.066	0.609	0.557	0.930	1.000	0.409	1.000

Table 2.19 (page 7 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. 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
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
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	0.000	0.000	0.000	0.001	0.001	0.000
35	0.000	0.001	0.001	0.000	0.001	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	0.001	0.001	0.001	0.002	0.004	0.001
38	0.002	0.002	0.002	0.002	0.002	0.003	0.006	0.001
39	0.003	0.003	0.003	0.003	0.003	0.005	0.008	0.002
40	0.004	0.004	0.005	0.004	0.004	0.007	0.011	0.004
41	0.006	0.006	0.007	0.005	0.007	0.011	0.015	0.006
42	0.008	0.009	0.010	0.008	0.010	0.015	0.020	0.009
43	0.012	0.013	0.014	0.011	0.014	0.021	0.027	0.015
44	0.016	0.018	0.020	0.016	0.019	0.030	0.035	0.023
45	0.023	0.025	0.028	0.022	0.027	0.041	0.046	0.034
46	0.031	0.034	0.037	0.030	0.037	0.055	0.059	0.051
47	0.042	0.045	0.050	0.041	0.050	0.072	0.076	0.073
48	0.056	0.060	0.066	0.054	0.067	0.095	0.096	0.102
49	0.073	0.078	0.086	0.071	0.088	0.122	0.120	0.140
50	0.095	0.101	0.110	0.092	0.114	0.155	0.148	0.187
51	0.121	0.129	0.140	0.118	0.145	0.194	0.181	0.244
52	0.153	0.162	0.175	0.149	0.182	0.240	0.218	0.312
53	0.190	0.200	0.215	0.185	0.226	0.292	0.261	0.389
54	0.233	0.245	0.262	0.227	0.276	0.350	0.308	0.475
55	0.282	0.296	0.315	0.276	0.333	0.414	0.360	0.565
56	0.337	0.352	0.373	0.330	0.395	0.482	0.416	0.658
57	0.397	0.413	0.436	0.390	0.462	0.554	0.476	0.748
58	0.461	0.479	0.503	0.454	0.533	0.626	0.538	0.831
59	0.529	0.547	0.572	0.521	0.605	0.699	0.602	0.901
60	0.599	0.617	0.642	0.591	0.678	0.768	0.666	0.955

Table 2.19 (page 8 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates. 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
61	0.669	0.687	0.711	0.661	0.748	0.832	0.728	0.989
62	0.737	0.755	0.778	0.730	0.814	0.889	0.787	1.000
63	0.802	0.818	0.839	0.795	0.873	0.935	0.842	1.000
64	0.860	0.874	0.892	0.854	0.923	0.970	0.891	1.000
65	0.911	0.922	0.937	0.905	0.962	0.992	0.932	1.000
66	0.951	0.960	0.970	0.947	0.987	1.000	0.964	1.000
67	0.980	0.986	0.992	0.977	0.999	1.000	0.987	1.000
68	0.996	0.998	1.000	0.995	1.000	1.000	0.998	1.000
69	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
70	1.000	0.998	0.994	1.000	1.000	1.000	1.000	1.000
71	0.992	0.985	0.974	0.993	1.000	1.000	1.000	1.000
72	0.975	0.960	0.942	0.977	1.000	1.000	1.000	1.000
73	0.949	0.925	0.898	0.951	1.000	1.000	1.000	1.000
74	0.916	0.882	0.846	0.919	1.000	1.000	1.000	1.000
75	0.879	0.834	0.789	0.881	1.000	1.000	1.000	1.000
76	0.839	0.782	0.731	0.841	1.000	1.000	1.000	1.000
77	0.799	0.731	0.673	0.799	1.000	1.000	1.000	1.000
78	0.759	0.682	0.618	0.759	1.000	1.000	1.000	1.000
79	0.723	0.637	0.568	0.721	1.000	1.000	1.000	1.000
80	0.690	0.597	0.524	0.687	1.000	1.000	1.000	1.000
81	0.661	0.562	0.487	0.657	1.000	1.000	1.000	1.000
82	0.637	0.533	0.456	0.632	1.000	1.000	1.000	1.000
83	0.618	0.509	0.431	0.612	1.000	1.000	1.000	1.000
84	0.602	0.491	0.412	0.596	1.000	1.000	1.000	1.000
85	0.590	0.477	0.397	0.583	1.000	1.000	1.000	1.000
86	0.581	0.466	0.387	0.574	1.000	1.000	1.000	1.000
87	0.575	0.459	0.379	0.567	1.000	1.000	1.000	1.000
88	0.570	0.453	0.373	0.562	1.000	1.000	1.000	1.000
89	0.567	0.450	0.370	0.558	1.000	1.000	1.000	1.000
90	0.565	0.447	0.367	0.556	1.000	1.000	1.000	1.000
91	0.564	0.446	0.366	0.554	1.000	1.000	1.000	1.000
92	0.563	0.445	0.365	0.553	1.000	1.000	1.000	1.000
93	0.562	0.444	0.364	0.553	1.000	1.000	1.000	1.000
94	0.562	0.444	0.364	0.553	1.000	1.000	1.000	1.000
95	0.562	0.443	0.364	0.552	1.000	1.000	1.000	1.000
96	0.561	0.443	0.364	0.552	1.000	1.000	1.000	1.000
97	0.561	0.443	0.364	0.552	1.000	1.000	1.000	1.000
98	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
99	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
100	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
101	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
102	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
103	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
104	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
105	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
106	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
107	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
108	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
109	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
110	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
111	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
112	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
113	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
114	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
115	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
116	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
117	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
118	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
119	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000
120	0.561	0.443	0.363	0.552	1.000	1.000	1.000	1.000

Table 2.20—Schedules of Pacific cod selectivity at age in the bottom trawl survey as defined by final parameter estimates.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	0.000	0.362	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1983	0.000	0.355	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1984	0.000	0.236	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1985	0.000	0.502	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1986	0.000	0.348	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1987	0.000	0.617	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1988	0.000	0.256	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1989	0.000	0.133	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1990	0.000	0.392	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1991	0.000	0.360	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1992	0.000	0.745	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1993	0.000	0.648	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1994	0.000	0.365	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1995	0.000	0.201	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1996	0.000	0.144	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1997	0.000	0.279	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1998	0.000	0.257	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
1999	0.000	0.238	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2000	0.000	0.367	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2001	0.000	0.861	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2002	0.000	0.447	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2003	0.000	0.502	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2004	0.000	0.434	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2005	0.000	0.633	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2006	0.000	0.854	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2007	0.000	0.894	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2008	0.000	0.803	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2009	0.000	0.519	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2010	0.000	0.446	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2011	0.000	0.570	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2012	0.000	0.536	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214
2013	0.000	0.536	1.000	1.000	0.962	0.853	0.705	0.552	0.423	0.330	0.272	0.240	0.224	0.218	0.215	0.214	0.214	0.214	0.214	0.214	0.214

Table 2.21—Schedules of population length (cm) and weight (kg) by season and age as estimated by the stock assessment model. 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	9.29	10.88	12.88	16.40	20.11	0.01	0.02	0.03	0.05	0.10
2	22.94	25.67	28.92	32.62	35.54	0.15	0.20	0.28	0.41	0.55
3	37.77	39.91	42.47	45.38	47.67	0.68	0.77	0.90	1.14	1.38
4	49.42	51.10	53.11	55.40	57.20	1.57	1.66	1.81	2.13	2.43
5	58.58	59.90	61.48	63.28	64.69	2.67	2.72	2.85	3.23	3.58
6	65.77	66.81	68.06	69.47	70.58	3.84	3.82	3.90	4.32	4.71
7	71.43	72.25	73.22	74.33	75.21	4.98	4.88	4.91	5.34	5.75
8	75.87	76.52	77.28	78.16	78.84	6.03	5.84	5.81	6.25	6.67
9	79.37	79.87	80.48	81.16	81.70	6.94	6.69	6.59	7.04	7.46
10	82.11	82.51	82.99	83.52	83.95	7.73	7.40	7.25	7.70	8.12
11	84.27	84.58	84.96	85.38	85.71	8.39	8.00	7.80	8.25	8.67
12	85.97	86.21	86.51	86.84	87.10	8.93	8.49	8.25	8.70	9.12
13	87.30	87.49	87.72	87.99	88.19	9.38	8.90	8.62	9.06	9.49
14	88.35	88.50	88.68	88.89	89.05	9.73	9.22	8.92	9.36	9.78
15	89.17	89.29	89.43	89.60	89.72	10.02	9.48	9.16	9.59	10.02
16	89.82	89.91	90.03	90.15	90.25	10.25	9.69	9.35	9.78	10.20
17	90.33	90.40	90.49	90.59	90.67	10.44	9.85	9.50	9.93	10.35
18	90.73	90.79	90.86	90.93	91.00	10.58	9.99	9.62	10.05	10.47
19	91.04	91.09	91.14	91.20	91.25	10.70	10.09	9.71	10.14	10.56
20	91.48	91.51	91.54	91.58	91.61	10.86	10.24	9.85	10.27	10.70

Table 2.22—Schedules of fleet-specific length (cm) by season and age as estimated by the stock assessment model. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov=Dec.

	Trawl fishery					Longline fishery					Pot fishery					Survey
Age	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	
1	13.33	14.82	16.67	21.64	25.58	15.62	17.06	20.17	24.04	28.15	12.27	15.77	20.31	24.95	31.61	12.88
2	27.51	30.43	33.16	37.93	40.57	29.72	32.60	37.23	40.80	43.46	32.05	34.97	38.20	43.74	46.14	28.92
3	42.94	45.07	45.80	48.84	50.65	44.57	46.53	49.48	51.62	53.35	46.84	48.74	50.43	53.23	54.70	42.47
4	54.14	55.69	54.83	56.83	58.34	54.64	55.97	57.58	58.94	60.25	56.48	57.73	58.41	59.54	60.71	53.11
5	62.28	63.41	62.11	63.73	65.04	61.60	62.56	63.72	64.89	66.04	62.96	63.84	64.31	65.06	66.17	61.48
6	68.34	69.21	68.26	69.61	70.69	66.68	67.39	69.06	70.15	71.15	67.71	68.40	69.41	70.19	71.18	68.06
7	73.09	73.79	73.30	74.38	75.25	70.57	71.14	73.68	74.63	75.46	71.58	72.18	73.87	74.64	75.47	73.22
8	76.94	77.51	77.32	78.18	78.86	73.72	74.19	77.51	78.30	78.97	74.96	75.49	77.62	78.30	78.97	77.28
9	80.07	80.53	80.49	81.17	81.71	76.37	76.78	80.60	81.24	81.77	77.94	78.39	80.66	81.24	81.77	80.48
10	82.60	82.97	82.99	83.53	83.95	78.64	78.98	83.06	83.57	83.99	80.49	80.88	83.10	83.57	83.99	82.99
11	84.63	84.93	84.96	85.38	85.72	80.56	80.85	85.01	85.41	85.74	82.62	82.94	85.04	85.41	85.74	84.96
12	86.25	86.48	86.51	86.84	87.10	82.17	82.41	86.54	86.86	87.12	84.37	84.62	86.56	86.86	87.12	86.51
13	87.53	87.71	87.73	87.99	88.19	83.49	83.69	87.75	88.00	88.21	85.77	85.97	87.77	88.00	88.21	87.72
14	88.54	88.69	88.68	88.89	89.05	84.57	84.73	88.70	88.90	89.06	86.88	87.04	88.72	88.90	89.06	88.68
15	89.34	89.45	89.43	89.59	89.72	85.44	85.57	89.45	89.61	89.73	87.77	87.89	89.46	89.61	89.73	89.43
16	89.97	90.06	90.02	90.15	90.25	86.13	86.23	90.04	90.16	90.26	88.46	88.57	90.05	90.16	90.26	90.02
17	90.46	90.53	90.49	90.59	90.66	86.69	86.77	90.50	90.60	90.67	89.01	89.09	90.51	90.60	90.67	90.49
18	90.85	90.91	90.85	90.93	90.99	87.13	87.19	90.86	90.94	91.00	89.45	89.51	90.87	90.94	91.00	90.85
19	91.16	91.20	91.14	91.20	91.25	87.47	87.52	91.15	91.21	91.26	89.79	89.84	91.16	91.21	91.26	91.14
20	91.59	91.62	91.54	91.57	91.60	87.96	87.96	91.55	91.58	91.61	90.26	90.28	91.56	91.58	91.61	91.53

Table 2.23—Schedules of fleet-specific weight (kg) by season and age as estimated by the stock assessment model. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov=Dec.

	Trawl fishery					Longline fishery					Pot fishery					Survey
Age	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	Sea1	Sea2	Sea3	Sea4	Sea5	
1	0.03	0.04	0.05	0.11	0.19	0.04	0.06	0.09	0.16	0.26	0.03	0.05	0.09	0.19	0.37	0.03
2	0.25	0.33	0.41	0.64	0.81	0.31	0.40	0.58	0.80	1.00	0.39	0.49	0.63	0.99	1.20	0.28
3	0.99	1.10	1.12	1.41	1.63	1.11	1.21	1.41	1.67	1.91	1.29	1.39	1.50	1.83	2.05	0.90
4	2.06	2.13	1.97	2.28	2.56	2.10	2.16	2.27	2.54	2.81	2.32	2.37	2.37	2.61	2.87	1.81
5	3.19	3.21	2.92	3.29	3.63	3.07	3.06	3.13	3.45	3.78	3.28	3.25	3.22	3.47	3.80	2.85
6	4.28	4.22	3.93	4.34	4.73	3.95	3.87	4.05	4.43	4.80	4.13	4.04	4.11	4.43	4.81	3.90
7	5.31	5.17	4.92	5.35	5.76	4.73	4.59	4.98	5.39	5.80	4.95	4.81	5.01	5.40	5.80	4.91
8	6.25	6.05	5.81	6.26	6.67	5.45	5.26	5.84	6.28	6.69	5.76	5.56	5.86	6.28	6.69	5.81
9	7.10	6.83	6.59	7.04	7.46	6.12	5.88	6.61	7.05	7.47	6.54	6.29	6.62	7.05	7.47	6.59
10	7.85	7.51	7.25	7.70	8.13	6.73	6.45	7.26	7.71	8.13	7.26	6.96	7.27	7.71	8.13	7.25
11	8.48	8.08	7.80	8.25	8.68	7.29	6.96	7.81	8.25	8.68	7.90	7.55	7.82	8.25	8.68	7.80
12	9.00	8.56	8.25	8.70	9.12	7.78	7.41	8.26	8.70	9.13	8.45	8.04	8.26	8.70	9.13	8.25
13	9.43	8.95	8.62	9.06	9.49	8.20	7.79	8.63	9.07	9.49	8.91	8.46	8.63	9.07	9.49	8.62
14	9.79	9.27	8.92	9.36	9.78	8.54	8.10	8.92	9.36	9.78	9.28	8.80	8.93	9.36	9.78	8.92
15	10.07	9.52	9.16	9.59	10.02	8.83	8.36	9.16	9.59	10.02	9.58	9.07	9.16	9.59	10.02	9.16
16	10.29	9.73	9.35	9.78	10.20	9.07	8.58	9.35	9.78	10.20	9.83	9.29	9.35	9.78	10.20	9.35
17	10.48	9.89	9.50	9.93	10.35	9.26	8.75	9.50	9.93	10.35	10.02	9.46	9.50	9.93	10.35	9.50
18	10.62	10.02	9.62	10.05	10.47	9.41	8.88	9.62	10.05	10.47	10.18	9.60	9.62	10.05	10.47	9.62
19	10.73	10.12	9.71	10.14	10.56	9.53	8.99	9.71	10.14	10.56	10.30	9.71	9.72	10.14	10.56	9.71
20	10.89	10.27	9.85	10.28	10.70	9.70	9.14	9.85	10.28	10.70	10.47	9.87	9.85	10.28	10.70	9.85

Table 2.24—Time series of EBS Pacific cod age 0+ biomass, age 3+ biomass, female spawning biomass (t), and standard deviation of spawning biomass (“SB SD”) as estimated last year and this year under the Plan Team’s and SSC’s preferred model. Spawning biomass for 2014 listed under this year’s assessment represents output from the standard projection model.

	Last year's assessment				This year's assessment			
Year	Age 0+	Age 3+	Spawn.	SB SD	Age 0+	Age 3+	Spawn.	SB SD
1977	569,478	561,480	159,465	31,807	561,621	553,541	157,153	31,383
1978	646,691	600,575	176,360	31,849	640,257	592,564	174,035	31,397
1979	814,516	693,807	203,132	32,830	810,988	692,685	201,152	32,341
1980	1,189,870	1,134,690	256,656	35,146	1,183,740	1,130,020	255,387	34,626
1981	1,621,340	1,560,720	360,543	38,792	1,608,760	1,548,960	359,542	38,170
1982	1,974,690	1,952,970	510,580	43,367	1,955,710	1,934,700	508,370	42,465
1983	2,157,450	2,138,000	654,455	46,003	2,134,940	2,115,170	650,040	44,805
1984	2,170,450	2,089,410	729,415	44,486	2,148,120	2,067,770	723,255	43,170
1985	2,151,230	2,127,280	726,290	39,989	2,129,910	2,106,260	719,565	38,729
1986	2,103,880	2,036,710	690,300	34,714	2,083,990	2,017,450	683,920	33,575
1987	2,088,340	2,059,250	666,580	30,110	2,069,030	2,040,920	660,835	29,068
1988	2,021,390	2,007,490	646,360	26,462	2,001,880	1,988,210	641,025	25,488
1989	1,822,510	1,811,030	609,270	23,442	1,803,710	1,792,190	603,990	22,529
1990	1,590,520	1,561,920	561,860	20,670	1,573,900	1,545,290	556,575	19,836
1991	1,387,960	1,333,140	485,065	17,764	1,374,340	1,320,330	480,137	17,063
1992	1,252,640	1,208,390	390,787	15,065	1,239,610	1,196,890	386,565	14,486
1993	1,246,770	1,219,300	342,683	13,228	1,231,310	1,204,240	338,645	12,666
1994	1,297,640	1,240,110	357,309	12,552	1,280,210	1,223,720	352,954	11,953
1995	1,328,740	1,306,730	361,860	12,592	1,310,130	1,288,940	356,898	11,957
1996	1,274,300	1,250,640	356,939	12,836	1,253,840	1,230,630	351,617	12,139
1997	1,196,590	1,167,730	347,429	12,868	1,174,940	1,146,330	341,393	12,116
1998	1,097,170	1,035,460	320,396	12,639	1,074,320	1,014,680	313,668	11,846
1999	1,129,590	1,102,940	306,593	12,330	1,102,280	1,077,070	299,245	11,502
2000	1,180,400	1,152,230	309,081	12,188	1,146,980	1,119,580	300,649	11,288
2001	1,209,090	1,158,890	340,418	12,249	1,169,800	1,121,990	330,058	11,228
2002	1,248,060	1,217,200	351,400	12,013	1,200,930	1,172,400	338,679	10,851
2003	1,241,430	1,225,920	347,580	11,464	1,185,320	1,170,620	332,244	10,158
2004	1,171,460	1,146,570	341,634	10,939	1,108,780	1,085,570	323,303	9,468
2005	1,061,770	1,041,140	314,994	10,525	994,247	975,421	293,807	8,905
2006	943,742	924,993	275,854	10,078	872,160	855,239	252,761	8,370
2007	845,398	819,008	242,782	9,602	769,195	745,362	218,450	7,846
2008	825,138	752,091	219,414	9,332	738,561	674,191	193,596	7,508
2009	918,703	887,286	208,925	9,615	808,198	780,237	180,024	7,605
2010	1,079,660	980,157	230,371	11,065	940,591	847,845	195,078	8,612
2011	1,330,430	1,313,520	291,406	14,373	1,163,810	1,146,670	246,167	11,188
2012	1,474,330	1,408,210	344,516	19,306	1,232,570	1,169,120	344,516	19,306
2013	1,600,230	1,508,140	391,961	22,806	1,347,910	1,264,450	316,266	20,736
2014					1,570,580	1,545,070	360,956	23,324

Table 2.25—Time series of EBS Pacific cod age 0 recruitment (1000s of fish), with standard deviations, as estimated last year and this year under the Plan Team's and SSC's preferred model.

	Last year's values		This year's values	
Year	Recruits	Std. dev.	Recruits	Std. dev.
1977	1,783,510	197,998	1,767,430	196,764
1978	758,050	160,459	743,958	159,596
1979	902,112	98,971	900,256	98,659
1980	317,104	42,618	308,752	42,735
1981	173,945	26,280	180,686	27,113
1982	1,222,410	49,941	1,225,390	49,555
1983	267,130	31,242	265,226	31,477
1984	991,872	44,000	994,261	43,759
1985	428,088	30,838	417,784	30,607
1986	199,925	19,059	198,317	19,072
1987	139,907	15,654	141,601	15,750
1988	360,918	20,832	365,429	21,053
1989	778,663	31,833	776,481	31,931
1990	647,798	28,864	631,381	28,870
1991	335,431	21,360	333,648	21,232
1992	855,563	28,123	849,853	27,220
1993	305,627	18,064	296,575	17,591
1994	328,665	16,966	325,136	16,665
1995	350,896	19,802	353,081	19,679
1996	913,070	30,856	892,906	29,009
1997	373,892	19,092	356,171	18,279
1998	359,370	17,798	354,175	17,206
1999	727,158	23,208	701,237	21,312
2000	455,028	16,863	424,510	15,137
2001	202,745	12,067	194,385	11,269
2002	353,813	14,410	333,977	13,088
2003	291,552	14,625	268,995	13,026
2004	258,775	14,376	235,688	12,624
2005	294,313	16,355	270,182	14,125
2006	1,092,540	44,523	973,726	35,471
2007	328,097	23,944	287,293	19,704
2008	1,516,810	80,964	1,427,530	70,863
2009	170,090	26,420	177,938	24,410
2010	878,979	74,498	857,525	66,895
2011	1,362,850	179,946	1,265,700	110,346
2012			342,104	64,450
Average	592,191		567,758	

Table 2.26—Numbers (1000s) at age at time of spawning (March) as estimated by the stock assessment model.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1977	1767430	398331	34289	183371	41316	27758	18099	11618	7410	4715	2997	1904	1209	768	488	310	197	125	79	50	88
1978	743958	1257980	283394	24214	126134	27635	18323	11913	7653	4888	3114	1981	1260	800	509	323	205	130	83	53	91
1979	900256	529522	895033	200102	16631	84122	18175	12013	7817	5029	3216	2051	1306	831	528	336	213	135	86	55	95
1980	308752	640770	376781	633464	138906	11299	56545	12184	8056	5247	3379	2163	1380	879	559	356	226	144	91	58	101
1981	180686	219760	455952	267101	443902	96023	7732	38485	8273	5465	3558	2291	1467	936	596	379	241	153	97	62	108
1982	1225390	128606	156364	323057	187008	306784	65724	5263	26117	5606	3701	2409	1551	993	633	403	257	163	104	66	115
1983	265226	872192	91506	110772	226182	129452	210751	44960	3593	17811	3821	2522	1641	1057	676	431	275	175	111	71	123
1984	994261	188778	620532	64736	77161	155214	87945	142388	30295	2418	11980	2570	1696	1104	710	455	290	185	118	75	130
1985	417784	707658	134280	438525	44895	52379	103711	58267	93996	19974	1594	7898	1694	1118	728	469	300	191	122	78	135
1986	198317	297353	503374	94906	303632	30313	34716	68031	38039	61252	13010	1038	5145	1104	729	475	306	196	125	80	139
1987	141601	141149	211504	355626	65644	204799	20068	22740	44342	24746	39825	8459	675	3347	718	474	309	199	127	81	142
1988	365429	100777	100358	149178	244934	43835	133613	12927	14565	28343	15810	25448	5407	432	2141	460	304	198	127	82	143
1989	776481	260074	71633	70496	101457	161083	28093	84182	8064	9036	17529	9761	15695	3332	266	1318	283	187	122	78	138
1990	631381	552668	184977	50415	48017	66774	103595	17839	53125	5074	5679	11010	6129	9854	2092	167	828	178	117	76	136
1991	333648	449392	393204	130788	34597	31334	42059	64323	11030	32826	3136	3511	6811	3793	6099	1295	103	513	110	73	132
1992	849853	237478	319731	277847	88816	21756	18585	24356	37022	6348	18917	1810	2029	3938	2195	3531	750	60	297	64	118
1993	296575	604891	168954	225855	188459	55480	12753	10640	13901	21197	3649	10910	1046	1175	2284	1274	2051	436	35	173	106
1994	325136	211092	430440	119694	155782	123293	34806	7879	6568	8613	13184	2277	6822	655	737	1434	800	1289	274	22	175
1995	353081	231417	150171	303870	81121	97556	72448	19941	4498	3763	4955	7613	1318	3959	381	429	835	466	751	160	115
1996	892906	251309	164648	106148	206422	50659	56549	40556	11056	2493	2089	2757	4242	735	2209	213	239	466	261	420	154
1997	356171	635533	178794	116320	71938	128343	29225	31551	22459	6133	1387	1166	1542	2377	413	1241	120	135	262	147	323
1998	354175	253509	452193	126350	78512	44117	72578	15949	17081	12178	3337	757	638	845	1304	227	682	66	74	144	258
1999	701237	252088	180371	319549	85702	49269	26026	41723	9120	9781	6992	1920	437	368	488	754	131	394	38	43	233
2000	424510	499116	179381	127427	216274	53608	29024	15006	24040	5282	5696	4089	1126	257	217	288	445	77	233	22	163
2001	194385	302153	355211	126984	87074	139798	33467	17942	9300	14988	3312	3587	2584	713	163	138	183	283	49	148	118
2002	333977	138357	215022	250744	85165	54022	82921	19698	10657	5592	9105	2028	2209	1597	442	101	86	114	176	31	166
2003	268995	237714	98455	151604	166913	51949	31327	47630	11417	6254	3317	5445	1220	1334	967	268	61	52	69	108	120
2004	235688	191461	169152	69381	100660	101433	30091	18014	27651	6710	3714	1985	3277	737	808	588	163	37	32	42	139
2005	270182	167756	136256	119355	45920	59966	56694	16570	9997	15546	3817	2132	1147	1903	429	472	344	96	22	19	107
2006	973726	192307	119391	96297	79375	27349	33235	30684	8961	5438	8510	2100	1178	636	1057	239	263	192	53	12	70
2007	287293	693069	136867	84414	64170	47380	15191	18049	16680	4907	3001	4724	1171	659	356	594	134	148	108	30	46
2008	1427530	204486	493256	96698	56067	38196	26300	8250	9806	9122	2702	1662	2627	653	368	200	333	75	83	61	43
2009	177938	1016070	145534	348197	63486	32351	20363	13724	4322	5189	4873	1454	899	1427	356	201	109	182	41	46	57
2010	857525	126651	723139	102782	229715	37098	17499	10748	7242	2296	2776	2621	786	487	775	194	110	60	99	23	56
2011	1265700	610360	90138	511728	69238	141618	21584	9977	6113	4131	1315	1594	1509	453	281	448	112	63	34	58	46
2012	342104	900889	434379	63579	332229	38208	69667	10157	4657	2864	1947	623	759	721	217	135	215	54	31	17	50
2013	533241	243499	641162	307257	42601	199800	21225	37560	5456	2513	1555	1063	341	417	397	120	74	119	30	17	37

Table 2.27—Estimates of "effective" fishing mortality (= $-\ln(N_{a+1,t+1}/N_{a,t})-M$) at age and year.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1977	0.000	0.005	0.027	0.056	0.071	0.076	0.075	0.074	0.073	0.072	0.071	0.071	0.070	0.070	0.070	0.070	0.069	0.069	0.069
1978	0.000	0.006	0.032	0.064	0.081	0.087	0.086	0.085	0.084	0.083	0.082	0.081	0.081	0.081	0.080	0.080	0.080	0.080	0.080
1979	0.000	0.004	0.022	0.044	0.057	0.061	0.060	0.059	0.058	0.058	0.057	0.057	0.056	0.056	0.056	0.056	0.056	0.056	0.056
1980	0.000	0.003	0.015	0.030	0.043	0.050	0.053	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
1981	0.000	0.004	0.015	0.028	0.038	0.045	0.048	0.049	0.050	0.050	0.050	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
1982	0.000	0.003	0.013	0.023	0.031	0.036	0.038	0.039	0.039	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040
1983	0.000	0.005	0.018	0.032	0.044	0.050	0.053	0.054	0.055	0.055	0.055	0.055	0.056	0.056	0.056	0.056	0.056	0.056	0.056
1984	0.000	0.005	0.022	0.042	0.058	0.067	0.070	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.071	0.071	0.071	0.071
1985	0.000	0.005	0.023	0.048	0.068	0.079	0.085	0.087	0.088	0.088	0.088	0.088	0.087	0.087	0.087	0.087	0.087	0.086	0.086
1986	0.000	0.005	0.023	0.046	0.065	0.077	0.082	0.085	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.086	0.085	0.085
1987	0.000	0.005	0.023	0.050	0.074	0.088	0.095	0.097	0.097	0.097	0.096	0.095	0.095	0.094	0.094	0.094	0.093	0.093	0.093
1988	0.001	0.009	0.037	0.069	0.097	0.116	0.128	0.134	0.137	0.139	0.140	0.141	0.142	0.142	0.142	0.142	0.142	0.143	0.143
1989	0.000	0.008	0.035	0.067	0.094	0.111	0.120	0.125	0.127	0.128	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
1990	0.000	0.003	0.024	0.072	0.112	0.130	0.136	0.137	0.137	0.137	0.137	0.137	0.136	0.136	0.136	0.136	0.136	0.136	0.136
1991	0.000	0.003	0.034	0.107	0.171	0.200	0.209	0.210	0.210	0.209	0.208	0.207	0.207	0.206	0.206	0.206	0.205	0.205	0.205
1992	0.000	0.002	0.027	0.100	0.168	0.198	0.204	0.202	0.199	0.196	0.194	0.192	0.191	0.190	0.189	0.189	0.188	0.188	0.188
1993	0.000	0.002	0.021	0.078	0.136	0.162	0.166	0.162	0.158	0.154	0.151	0.149	0.147	0.146	0.145	0.145	0.144	0.144	0.144
1994	0.000	0.003	0.026	0.093	0.161	0.191	0.197	0.194	0.190	0.186	0.183	0.181	0.179	0.178	0.177	0.177	0.176	0.176	0.175
1995	0.000	0.003	0.031	0.114	0.203	0.250	0.264	0.265	0.262	0.260	0.258	0.257	0.256	0.255	0.255	0.254	0.254	0.254	0.254
1996	0.000	0.003	0.028	0.107	0.191	0.233	0.244	0.243	0.240	0.236	0.234	0.232	0.230	0.229	0.229	0.228	0.228	0.228	0.227
1997	0.000	0.003	0.035	0.127	0.222	0.269	0.282	0.281	0.278	0.274	0.271	0.269	0.268	0.267	0.266	0.266	0.265	0.265	0.265
1998	0.000	0.002	0.025	0.095	0.167	0.203	0.213	0.212	0.209	0.206	0.204	0.203	0.202	0.201	0.201	0.200	0.200	0.200	0.200
1999	0.000	0.002	0.023	0.092	0.166	0.201	0.207	0.204	0.198	0.194	0.190	0.188	0.186	0.185	0.184	0.183	0.183	0.182	0.182
2000	0.000	0.003	0.032	0.101	0.164	0.188	0.187	0.178	0.169	0.162	0.156	0.153	0.150	0.148	0.147	0.145	0.145	0.144	0.143
2001	0.000	0.003	0.034	0.101	0.151	0.166	0.161	0.151	0.142	0.134	0.129	0.126	0.123	0.121	0.120	0.118	0.118	0.117	0.116
2002	0.000	0.004	0.039	0.117	0.178	0.197	0.192	0.180	0.169	0.161	0.155	0.151	0.148	0.146	0.144	0.143	0.142	0.141	0.140
2003	0.000	0.004	0.040	0.124	0.191	0.213	0.207	0.193	0.181	0.172	0.165	0.160	0.157	0.154	0.152	0.151	0.150	0.149	0.148
2004	0.000	0.005	0.045	0.133	0.202	0.225	0.220	0.207	0.195	0.186	0.179	0.174	0.171	0.168	0.167	0.165	0.164	0.163	0.162
2005	0.000	0.002	0.032	0.116	0.202	0.245	0.256	0.253	0.247	0.242	0.237	0.234	0.231	0.230	0.228	0.227	0.227	0.226	0.225
2006	0.000	0.002	0.031	0.121	0.217	0.268	0.280	0.276	0.269	0.262	0.257	0.253	0.250	0.248	0.247	0.246	0.245	0.244	0.243
2007	0.000	0.002	0.031	0.116	0.209	0.257	0.268	0.264	0.256	0.249	0.244	0.240	0.237	0.235	0.233	0.232	0.231	0.230	0.229
2008	0.000	0.002	0.037	0.138	0.239	0.290	0.300	0.294	0.284	0.276	0.270	0.265	0.262	0.260	0.258	0.256	0.255	0.255	0.254
2009	0.000	0.003	0.041	0.148	0.259	0.315	0.325	0.317	0.306	0.297	0.289	0.284	0.280	0.277	0.275	0.273	0.272	0.271	0.270
2010	0.000	0.002	0.032	0.115	0.204	0.251	0.261	0.257	0.249	0.242	0.236	0.232	0.230	0.227	0.226	0.225	0.224	0.223	0.222
2011	0.000	0.005	0.061	0.199	0.323	0.383	0.398	0.396	0.389	0.383	0.377	0.374	0.371	0.369	0.367	0.366	0.365	0.365	0.364
2012	0.000	0.002	0.035	0.130	0.232	0.287	0.302	0.301	0.295	0.289	0.284	0.281	0.278	0.276	0.275	0.274	0.273	0.272	0.272
2013	0.000	0.001	0.011	0.061	0.131	0.171	0.182	0.180	0.174	0.169	0.164	0.161	0.159	0.157	0.156	0.155	0.154	0.154	0.153

Table 2.28—Projections for EBS Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in 2014-2026 (Scenarios 1 and 2), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	255,000	255,000	255,000	255,000	0
2015	272,000	272,000	272,000	272,000	0
2016	269,000	269,000	269,000	269,000	1
2017	246,000	247,000	247,000	248,000	592
2018	219,000	227,000	230,000	249,000	10,535
2019	190,000	214,000	220,000	271,000	27,247
2020	146,000	206,000	210,000	304,000	48,028
2021	120,000	202,000	204,000	311,000	60,166
2022	107,000	200,000	203,000	312,000	65,607
2023	104,000	201,000	204,000	322,000	67,376
2024	103,000	202,000	204,000	320,000	66,803
2025	106,000	199,000	203,000	317,000	65,356
2026	106,000	202,000	202,000	314,000	64,541

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	361,000	361,000	361,000	361,000	0
2015	389,000	389,000	389,000	389,000	0
2016	404,000	404,000	404,000	404,000	44
2017	392,000	393,000	393,000	395,000	1,003
2018	360,000	365,000	367,000	380,000	7,111
2019	320,000	340,000	345,000	390,000	23,040
2020	282,000	322,000	333,000	417,000	45,076
2021	255,000	314,000	328,000	454,000	62,144
2022	239,000	313,000	327,000	460,000	71,267
2023	233,000	311,000	328,000	462,000	75,621
2024	233,000	314,000	329,000	470,000	76,878
2025	233,000	312,000	328,000	473,000	75,558
2026	234,000	311,000	328,000	472,000	73,593

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	0.28	0.28	0.28	0.28	0.00
2015	0.28	0.28	0.28	0.28	0.00
2016	0.28	0.28	0.28	0.28	0.00
2017	0.28	0.28	0.28	0.28	0.00
2018	0.28	0.28	0.28	0.28	0.00
2019	0.28	0.28	0.28	0.28	0.00
2020	0.25	0.28	0.27	0.28	0.01
2021	0.22	0.28	0.27	0.28	0.02
2022	0.21	0.28	0.26	0.28	0.03
2023	0.20	0.28	0.26	0.28	0.03
2024	0.20	0.28	0.26	0.28	0.03
2025	0.20	0.28	0.26	0.28	0.03
2026	0.20	0.28	0.26	0.28	0.03

Table 2.29—Projections for EBS 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 2014-2026 (Scenario 3), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	317,000	317,000	317,000	317,000	0
2015	324,000	324,000	324,000	324,000	0
2016	309,000	309,000	309,000	309,000	1
2017	274,000	275,000	275,000	276,000	752
2018	238,000	248,000	252,000	276,000	13,271
2019	203,000	232,000	240,000	304,000	33,535
2020	173,000	225,000	235,000	341,000	51,856
2021	154,000	224,000	232,000	345,000	61,159
2022	143,000	221,000	232,000	346,000	65,763
2023	140,000	221,000	232,000	356,000	67,595
2024	138,000	221,000	230,000	353,000	66,737
2025	141,000	219,000	229,000	352,000	64,939
2026	138,000	219,000	228,000	349,000	64,154

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	354,000	354,000	354,000	354,000	0
2015	363,000	363,000	363,000	363,000	0
2016	362,000	362,000	362,000	362,000	44
2017	338,000	339,000	339,000	341,000	1,002
2018	301,000	306,000	308,000	321,000	7,059
2019	262,000	281,000	286,000	330,000	22,392
2020	225,000	265,000	275,000	357,000	42,959
2021	196,000	258,000	269,000	386,000	58,810
2022	177,000	255,000	266,000	386,000	67,549
2023	169,000	253,000	265,000	390,000	71,906
2024	167,000	254,000	264,000	395,000	73,071
2025	164,000	252,000	263,000	398,000	71,853
2026	165,000	250,000	261,000	396,000	70,304

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	0.36	0.36	0.36	0.36	0.00
2015	0.36	0.36	0.36	0.36	0.00
2016	0.36	0.36	0.36	0.36	0.00
2017	0.36	0.36	0.36	0.36	0.00
2018	0.36	0.36	0.36	0.36	0.00
2019	0.36	0.36	0.36	0.36	0.00
2020	0.36	0.36	0.36	0.36	0.00
2021	0.36	0.36	0.36	0.36	0.00
2022	0.36	0.36	0.36	0.36	0.00
2023	0.36	0.36	0.36	0.36	0.00
2024	0.36	0.36	0.36	0.36	0.00
2025	0.36	0.36	0.36	0.36	0.00
2026	0.36	0.36	0.36	0.36	0.00

Table 2.30—Projections for EBS 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 2014-2026 (Scenario 4), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	133,000	133,000	133,000	133,000	0
2015	153,000	153,000	153,000	153,000	0
2016	163,000	163,000	163,000	163,000	0
2017	159,000	159,000	159,000	160,000	294
2018	148,000	152,000	154,000	164,000	5,329
2019	134,000	147,000	150,000	177,000	14,340
2020	120,000	143,000	148,000	198,000	24,143
2021	108,000	142,000	147,000	206,000	30,580
2022	100,000	141,000	147,000	207,000	34,448
2023	97,200	141,000	146,000	212,000	36,530
2024	94,600	141,000	146,000	212,000	37,027
2025	94,600	140,000	145,000	213,000	36,501
2026	93,300	140,000	144,000	212,000	36,001

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	374,000	374,000	374,000	374,000	0
2015	442,000	442,000	442,000	442,000	0
2016	498,000	498,000	498,000	498,000	44
2017	520,000	521,000	521,000	523,000	1,004
2018	509,000	514,000	516,000	529,000	7,210
2019	477,000	497,000	503,000	550,000	24,307
2020	435,000	480,000	493,000	591,000	51,314
2021	392,000	471,000	486,000	644,000	77,739
2022	358,000	466,000	482,000	663,000	96,603
2023	334,000	463,000	480,000	669,000	108,302
2024	325,000	463,000	479,000	688,000	114,400
2025	318,000	460,000	477,000	685,000	115,774
2026	311,000	460,000	474,000	686,000	114,592

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
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
2024	0.14	0.14	0.14	0.14	0.00
2025	0.14	0.14	0.14	0.14	0.00
2026	0.14	0.14	0.14	0.14	0.00

Table 2.31—Projections for EBS Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that F = 0 in 2014-2026 (Scenario 5), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
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
2024	0	0	0	0	0
2025	0	0	0	0	0
2026	0	0	0	0	0

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	387,000	387,000	387,000	387,000	0
2015	502,000	502,000	502,000	502,000	0
2016	615,000	615,000	615,000	615,000	44
2017	696,000	696,000	697,000	698,000	1,005
2018	731,000	737,000	739,000	752,000	7,309
2019	730,000	751,000	757,000	806,000	25,628
2020	703,000	753,000	768,000	878,000	57,676
2021	663,000	756,000	774,000	964,000	94,004
2022	623,000	759,000	779,000	1,020,000	124,555
2023	587,000	761,000	784,000	1,050,000	146,711
2024	569,000	762,000	787,000	1,070,000	161,141
2025	555,000	764,000	787,000	1,090,000	168,451
2026	548,000	769,000	787,000	1,090,000	170,539

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
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
2024	0.00	0.00	0.00	0.00	0.00
2025	0.00	0.00	0.00	0.00	0.00
2026	0.00	0.00	0.00	0.00	0.00

Table 2.32—Projections for EBS Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = F_{OFL}$ in 2014-2026 (Scenario 6), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	299,000	299,000	299,000	299,000	0
2015	310,000	310,000	310,000	310,000	0
2016	298,000	298,000	298,000	298,000	1
2017	267,000	268,000	268,000	269,000	705
2018	233,000	243,000	246,000	269,000	12,605
2019	178,000	214,000	224,000	295,000	38,745
2020	141,000	202,000	214,000	332,000	59,616
2021	119,000	202,000	212,000	337,000	70,193
2022	109,000	203,000	214,000	339,000	75,106
2023	107,000	205,000	215,000	348,000	76,466
2024	109,000	206,000	215,000	347,000	75,570
2025	107,000	206,000	214,000	351,000	74,013
2026	111,000	208,000	214,000	345,000	73,279

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	356,000	356,000	356,000	356,000	0
2015	370,000	370,000	370,000	370,000	0
2016	374,000	374,000	374,000	374,000	44
2017	353,000	353,000	354,000	356,000	1,002
2018	317,000	322,000	324,000	337,000	7,057
2019	281,000	298,000	304,000	346,000	21,625
2020	252,000	287,000	296,000	373,000	40,018
2021	232,000	285,000	295,000	405,000	53,656
2022	219,000	285,000	296,000	406,000	60,761
2023	216,000	286,000	298,000	414,000	64,269
2024	217,000	287,000	299,000	417,000	65,172
2025	217,000	286,000	299,000	423,000	63,763
2026	218,000	287,000	298,000	424,000	62,063

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	0.34	0.34	0.34	0.34	0.00
2015	0.34	0.34	0.34	0.34	0.00
2016	0.34	0.34	0.34	0.34	0.00
2017	0.34	0.34	0.34	0.34	0.00
2018	0.34	0.34	0.34	0.34	0.00
2019	0.30	0.32	0.32	0.34	0.01
2020	0.26	0.30	0.30	0.34	0.03
2021	0.24	0.30	0.30	0.34	0.03
2022	0.23	0.30	0.30	0.34	0.04
2023	0.22	0.30	0.30	0.34	0.04
2024	0.22	0.30	0.30	0.34	0.04
2025	0.22	0.30	0.30	0.34	0.04
2026	0.23	0.30	0.30	0.34	0.04

Table 2.33—Projections for EBS Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in each year 2014-2015 and $F = F_{OFL}$ thereafter (Scenario 7), with random variability in future recruitment.

Catch projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	255,000	255,000	255,000	255,000	0
2015	272,000	272,000	272,000	272,000	0
2016	315,000	315,000	315,000	315,000	1
2017	279,000	279,000	279,000	281,000	705
2018	241,000	250,000	254,000	276,000	12,474
2019	186,000	223,000	232,000	299,000	37,378
2020	144,000	205,000	217,000	334,000	59,421
2021	120,000	203,000	213,000	338,000	70,247
2022	109,000	203,000	214,000	340,000	75,176
2023	107,000	205,000	215,000	348,000	76,519
2024	109,000	206,000	215,000	347,000	75,603
2025	107,000	206,000	214,000	351,000	74,031
2026	111,000	208,000	214,000	345,000	73,287

Biomass projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	361,000	361,000	361,000	361,000	0
2015	389,000	389,000	389,000	389,000	0
2016	399,000	399,000	399,000	399,000	44
2017	372,000	372,000	373,000	374,000	1,002
2018	330,000	335,000	337,000	350,000	7,074
2019	288,000	306,000	311,000	354,000	21,850
2020	255,000	290,000	300,000	378,000	40,555
2021	233,000	286,000	296,000	408,000	54,132
2022	219,000	285,000	297,000	408,000	61,064
2023	216,000	286,000	298,000	415,000	64,421
2024	217,000	287,000	299,000	417,000	65,238
2025	217,000	286,000	299,000	423,000	63,789
2026	218,000	287,000	298,000	424,000	62,071

Fishing mortality projections:

Year	L90%CI	Median	Mean	U90%CI	Std. Dev.
2014	0.28	0.28	0.28	0.28	0.00
2015	0.28	0.28	0.28	0.28	0.00
2016	0.34	0.34	0.34	0.34	0.00
2017	0.34	0.34	0.34	0.34	0.00
2018	0.34	0.34	0.34	0.34	0.00
2019	0.30	0.32	0.32	0.34	0.01
2020	0.27	0.31	0.31	0.34	0.02
2021	0.24	0.30	0.30	0.34	0.03
2022	0.23	0.30	0.30	0.34	0.04
2023	0.22	0.30	0.30	0.34	0.04
2024	0.22	0.30	0.30	0.34	0.04
2025	0.22	0.30	0.30	0.34	0.04
2026	0.23	0.30	0.30	0.34	0.04

Table 2.34 (page 1 of 2)—Incidental catch (t) of FMP species, other than squid and members of the former "other species" complex, taken in the Bering Sea fisheries for Pacific cod, 2003-2012. **This table has not been updated since the 2012 assessment.**

Trawl fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alaska Plaice	265	372	389	342	404	54	55	73	502	159
Arrowtooth Flounder	4151	7859	3788	4297	1923	585	448	417	218	201
Atka Mackerel	3470	4442	652	367	123	10	28	46	69	51
Flathead Sole	1467	2817	1350	2899	3941	358	479	167	222	232
Greenland Turbot	71	76	10	20	82	8	1	5	0	1
Kamchatka Flounder									6	6
Northern Rockfish	12	51	22	48	4	1	1	3	6	5
Other Flatfish	897	2069	1331	600	463	76	28	63	73	71
Other Rockfish	34	63	18	12	5	5	2	8	2	16
Pacific Ocean Perch	31	64	80	50	25	2	1	0	4	30
Pollock	8840	13301	9926	12081	16913	4275	3332	2241	3481	3605
Rex Sole										
Rock Sole	5185	8650	7461	4528	3864	974	750	848	1329	1118
Rougheye Rockfish		1	1			0		0		
Sablefish	56	73	28	2	1	1	0	1	0	
Shortraker Rockfish		1		1	0		0			
Shortraker/Rougheye	3									
Yellowfin Sole	1007	1840	1266	1438	645	321	306	469	1141	635
Total	25488	41677	26322	26685	28393	6669	5432	4341	7054	6131

Longline fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alaska Plaice	0	0	0	4	0	0	0	0	0	0
Arrowtooth Flounder	1295	1333	1670	1322	1265	1622	1646	1510	1333	893
Atka Mackerel	6	25	5	0	4	1	0	1	6	1
Flathead Sole	372	586	618	539	352	334	248	265	334	236
Greenland Turbot	182	218	169	65	115	72	79	122	173	91
Kamchatka Flounder									25	70
Northern Rockfish	6	5	6	6	5	4	4	11	13	6
Other Flatfish	80	187	253	145	59	28	56	91	50	35
Other Rockfish	10	28	19	10	22	18	6	47	34	18
Pacific Ocean Perch	1	3	1	0	0	0	1	1	2	1
Pollock	7162	5300	4172	3040	3372	5230	4530	4168	5478	3977
Rex Sole	0									
Rock Sole	45	37	48	21	14	20	25	5	20	22
Rougheye Rockfish	0	2	4	2	2	6	2	7	7	7
Sablefish	66	18	22	22	14	4	2	3	16	3
Shortraker Rockfish	0	26	19	10	22	15	29	56	16	10
Shortraker/Rougheye	18									
Yellowfin Sole	631	615	717	485	264	507	653	198	674	669
Total	9875	8382	7723	5671	5509	7861	7282	6487	8180	6040

Table 2.34 (page 2 of 2)—Incidental catch (t) of FMP species, other than squid and members of the former "other species" complex, taken in the Bering Sea fisheries for Pacific cod, 2003-2012. **This table has not been updated since the 2012 assessment.**

Pot fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Alaska Plaice	0	0	0	0	0					0
Arrowtooth Flounder	5	4	5	12	2	7	0	1	1	1
Atka Mackerel	205	141	236	341	58	60	2	27	29	9
Flathead Sole	0	1	1	0	2	1	0	0	0	0
Greenland Turbot	0		0	1	0	0	0		0	
Kamchatka Flounder										0
Northern Rockfish	1	1	1	1	1	2	0	0	1	1
Other Flatfish	1	1	1	1	1	0	0	0	0	0
Other Rockfish	5	3	3	4	1	1	0	2	2	1
Pacific Ocean Perch	1	0	0	1	0	0	0	0	0	0
Pollock	20	9	8	26	12	11	17	8	7	6
Rex Sole										
Rock Sole	3	2	1	2	3	1	0	1	0	1
Rougheye Rockfish		0	0							
Sablefish	0	1	0	4					0	
Shortraker Rockfish								0		
Shortraker/Rougheye	0									
Yellowfin Sole	90	78	76	47	209	131	35	2	29	25
Total	332	241	332	439	289	214	56	41	69	44

Table 2.35—Incidental catch (t) of squid and members of the former "other species" complex taken in the Bering Sea fisheries for Pacific cod, 2003-2012. **This table has not been updated since the 2012 assessment.**

Trawl fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Octopus	21	64	17	22	10	11	1	4	18	1
Sculpins, large	520	1448	920	892	1102	286	221	214	330	327
Sculpins, other	775	96	59	109	194	27	17	1	3	6
Shark, Pacific sleeper	11	30	14	8	5	0	0	0		
Shark, salmon			1	0						
Shark, spiny dogfish	0	1	0	0	0	1	0			
Shark, other	0	1		0						
Skate, Alaska								222	188	162
Skate, Aleutian									2	3
Skate, big		33	68	120	31	20	16	16	49	26
Skate, longnose	0	9	20	18	1			3	1	1
Skate, whiteblotched									1	0
Skate, other	1228	1485	625	1435	2392	420	309	56	7	4
Squid	5	4	1	0	1	0		0	0	0
Total	2561	3170	1724	2605	3736	764	563	517	598	531

Longline fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Octopus	41	49	25	13	8	10	4	8	30	11
Sculpins, large	195	1189	1214	760	765	811	745	647	1133	874
Sculpins, other	996	239	278	267	138	240	192	62	141	214
Shark, Pacific sleeper	110	198	175	115	39	12	11	8	19	8
Shark, salmon	1	0	1	1						
Shark, spiny dogfish	10	8	11	6	2	6	17	13	7	3
Shark, other	20	20	10	4	2	1	3	1	1	0
Skate, Alaska								1272	1968	1903
Skate, Aleutian									101	174
Skate, big		125	107	123	43	30	47	101	84	159
Skate, longnose		3	1	2	0	1	1	2	3	1
Skate, whiteblotched									12	21
Skate, other	13521	16194	18224	12995	10343	13267	11578	8961	14128	12223
Squid	0	0	0			0	0		0	
Total	14894	18025	20046	14284	11339	14377	12597	11074	17629	15589

Pot fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Octopus	139	151	257	233	122	153	32	101	506	106
Sculpins, large	122	191	114	268	243	292	105	181	168	298
Sculpins, other	133	13	2	6	7	9	1	3	2	0
Shark, Pacific sleeper				0						
Shark, spiny dogfish								0	0	0
Skate, other	0	0	0	0					0	0
Squid			1		0			0		
Total	394	356	374	508	372	454	138	285	676	403

Table 2.36—Incidental catch (t) of non-target species groups by Bering Sea Pacific cod fisheries, 2003-2012, sorted in order of descending average. **This table has not been updated since the 2012 assessment.**

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Ave.
Sea star	442	420	439	316	235	180	144	134	191	303	280
Giant Grenadier	2	15	143	101	95	133	203	335	1083	268	238
Scypho jellies	669	709	399	66	112	41	87	42	185	53	237
Misc fish	231	226	205	93	88	37	46	43	92	83	114
Sea anemone unidentified	92	114	113	87	37	53	114	84	144	133	97
Grenadier	239	224	192	25	84	15	0	80	12	29	90
Invertebrate unidentified	19	5	3	17	20	2	13	35	55	30	20
Snails	26	20	12	16	16	18	25	17	23	14	19
Sea pens whips	6	12	30	16	7	9	34	22	25	24	18
Eelpouts	48	35	42	17	18	7	2	2	4	4	18
Benthic urochordata	14	4	10	5	1	2	0	10	35	32	11
Misc crabs	8	4	4	16	28	5	1	5	3	3	8
Sponge unidentified	6	8	6	11	2	2	11	5	12	12	7
Bivalves	5	16	6	5	2	11	9	2	11	8	7
Urchins dollars cucumbers	11	11	13	4	13	3	1	1	4	2	6
Corals Bryozoans	1	1	1	1	2	2	4	1	3	21	4
Hermit crab unidentified	5	3	2	2	2	1	1	1	1	0	2
Greenlings	6	3	2	2	0	1	0	0	0	0	2
Brittle star unidentified	1	1	0	1	0	0	0	0	1	0	1
Dark Rockfish						1	0	0	0	0	0
Misc crustaceans	0	0	0	1	1	0	0	0	0	0	0
Other osmerids	0	0	0	0	0		0	0	0	0	0
Pandalid shrimp	0	0	0	0	0	0	0	0	0	0	0
Eulachon		0	0	0	0	0		0	0	0	0
Pacific Sand lance	0	0	0	0	0	0		0	0	0	0
Misc inverts (worms etc)	0	0	0	0	0	0	0	0	0	0	0
Polychaete unidentified	0	0	0	0	0	0	0	0	0	0	0
Capelin		0			0	0		0	0	0	0
Stichaeidae	0	0	0	0	0	0	0	0			0
Lanternfishes (myctophidae)		0									0
Gunnels		0	0		0						0
Birds	0	0	0	0	0	0	0	0	0	0	0
Grand Total	1832	1834	1624	800	763	523	696	820	1885	1021	1180

Table 2.37—Catches of prohibited species by Bering Sea fisheries for Pacific cod, 2003-2012. Halibut and herring are in t, salmon and crab are in number of individuals. **This table has not been updated since the 2012 assessment.**

Trawl fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Halibut	1989	2328	2023	2048	1432	463	328	390	346	630
Herring	14	9	18	8	1	0	0	0	0	6
Chinook salmon	2131	4888	3091	2888	4970	571	180	472	54	597
Non-chinook salmon	992	6672	596	7288	618	138	0	0	61	24
Bairdi tanner crab	159969	214318	153997	185871	140988	36264	14210	26705	14648	9699
Blue king crab	1266	2134	0	1488	2537	0	148	0	8	0
Golden king crab	66	0	22	98	69	0	0	0	1	127
Opilio tanner crab	79065	94964	59816	101285	298407	22169	15112	5433	9877	6610
Red king crab	1147	756	1705	5968	1585	1281	1298	366	2125	313

Longline fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Halibut	4707	4337	5871	4229	4592	6713	6560	6170	5968	4147
Herring	0	0	0	0	0	0	0	0	0	0
Chinook salmon	0	49	48	23	43	10	11	13	40	46
Non-chinook salmon	13	118	81	449	250	60	51	26	119	137
Bairdi tanner crab	11559	11831	13409	14958	16290	32416	34241	25782	20452	13154
Blue king crab	1641	1001	831	2101	296	8776	12620	425	986	811
Golden king crab	247	45	273	167	165	305	495	405	222	223
Opilio tanner crab	63887	49722	56584	44979	46991	96688	66865	61018	60036	25036
Red king crab	13404	15199	16093	7995	7584	8146	6972	1989	5174	3338

Pot fishery:

Species/group	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Halibut	27	33	35	52	11	65	4	27	63	47
Herring	0	0	0	0	0	0	0	0	0	0
Chinook salmon	0	0	0	0	19	0	0	0	0	0
Non-chinook salmon	0	0	0	0	0	0	0	0	0	0
Bairdi tanner crab	100738	31749	123551	387420	465273	1340375	396107	369175	285448	65019
Blue king crab	147	16	492	135	211286	54	1762	35580	0	0
Golden king crab	0	0	0	29	29	0	188	5	147	0
Opilio tanner crab	21803	75208	77669	190198	568301	530634	481870	270878	131946	13559
Red king crab	59	320	3169	5238	23281	36087	2927	2435	16519	4680

Table 2.38—Halibut mortality (t) resulting from EBS Pacific cod fisheries, 2003-2012. **This table has not been updated since the 2012 assessment.**

Year	Trawl	Longline	Pot	Total
2003	1333	558	2	1893
2004	1583	477	3	2063
2005	1376	588	3	1967
2006	1393	414	4	1811
2007	1002	449	1	1451
2008	321	647	5	972
2009	229	645	0	874
2010	277	553	2	832
2011	244	529	5	777
2012	442	373	4	819

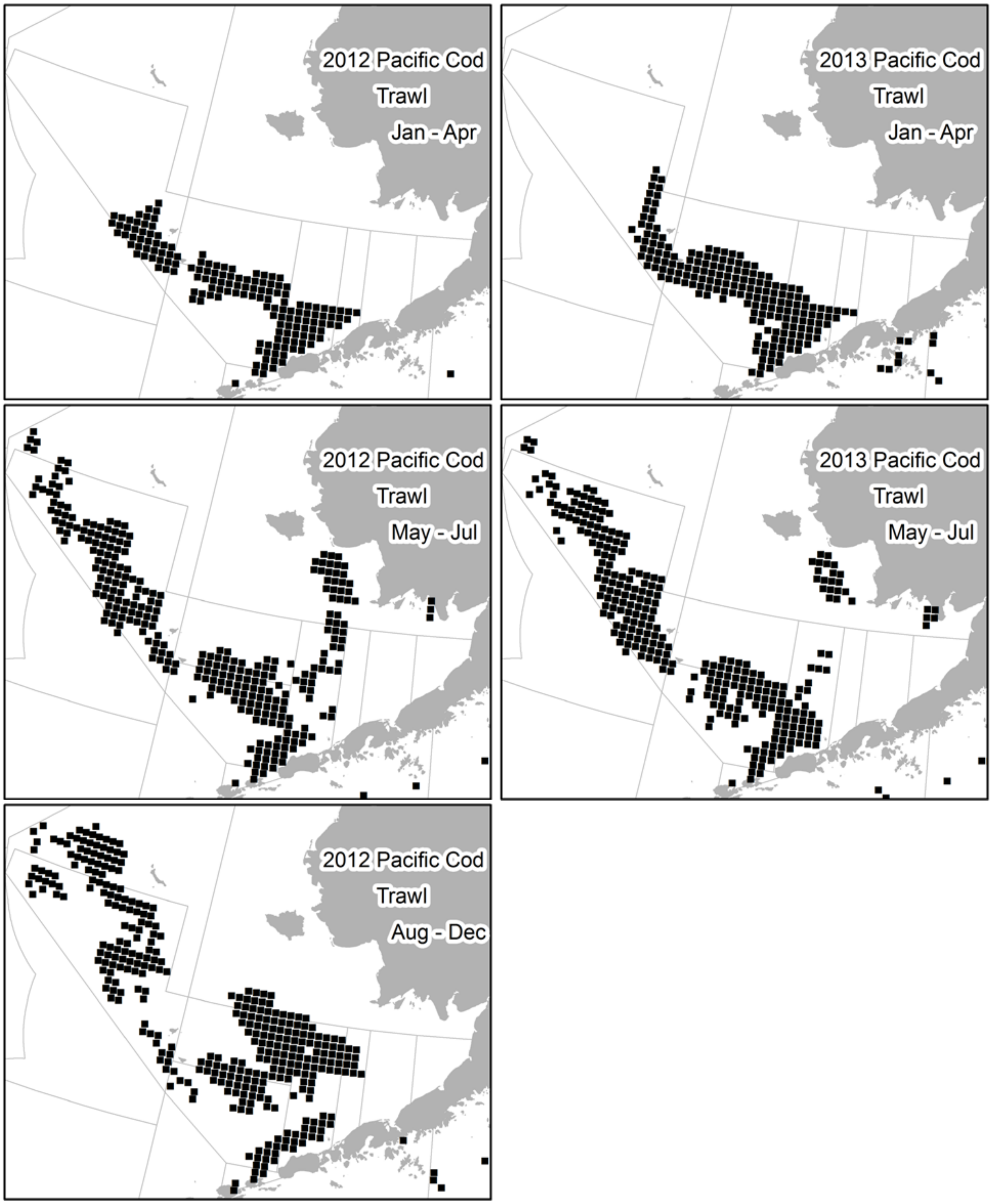

Figure 2.1a—EBS maps showing each 400 square km cell with **trawl hauls** containing Pacific cod from at least 3 distinct vessels **by season** in 2012-2013, overlaid against NMFS 3-digit statistical areas.

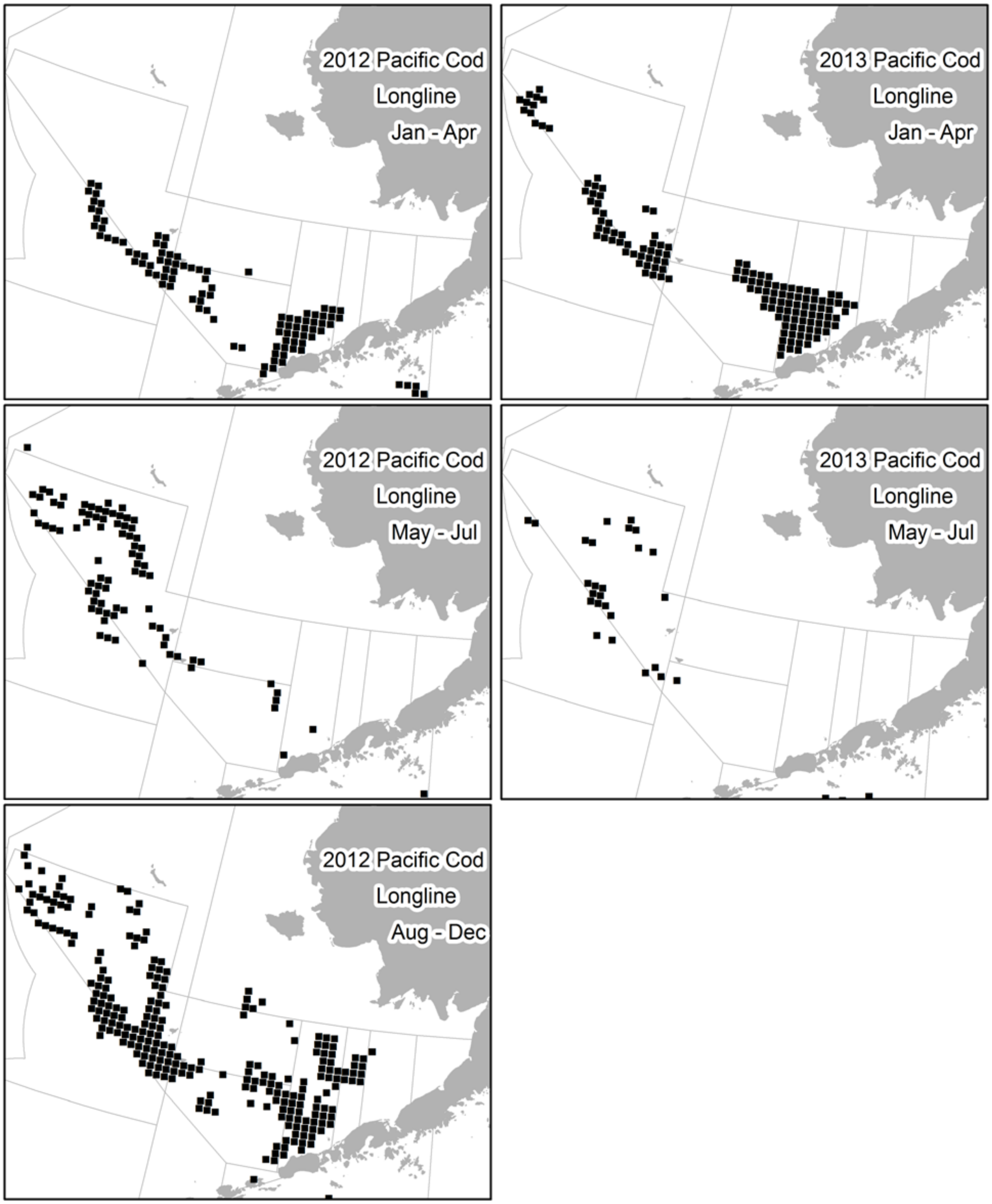

Figure 2.1b—EBS maps showing each 400 square km cell with **longline sets** containing Pacific cod from at least 3 distinct vessels **by season** in 2012-2013, overlaid against NMFS 3-digit statistical areas.

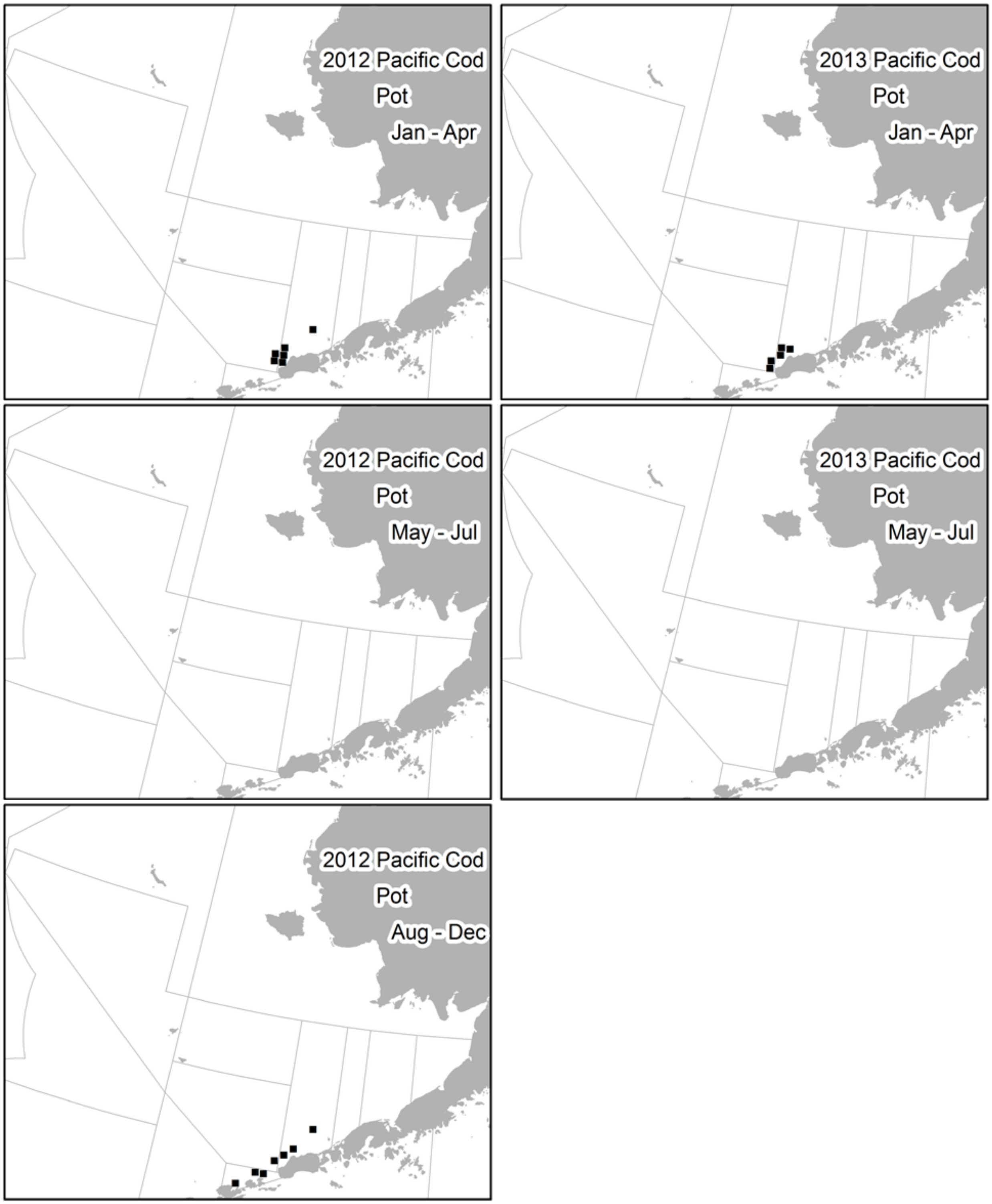

Figure 2.1c—EBS maps showing each 400 square km cell with **pot sets** containing Pacific cod from at least 3 distinct vessels **by season** in 2012-2013, overlaid against NMFS 3-digit statistical areas.

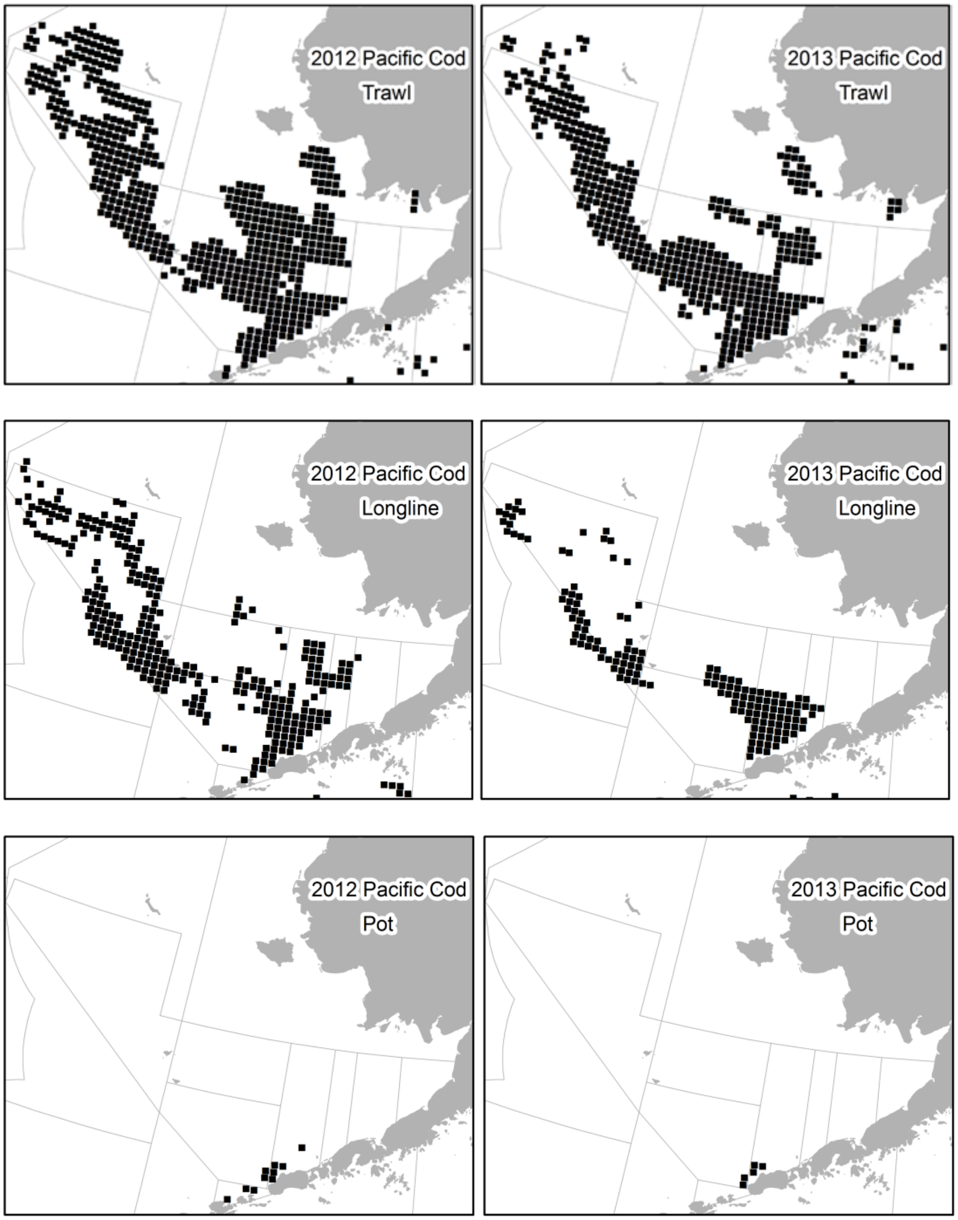

Figure 2.2—EBS maps showing each 400 square km cell with hauls/sets containing Pacific cod from at least 3 distinct vessels **by gear** in 2011-2012, overlaid against NMFS 3-digit statistical areas.

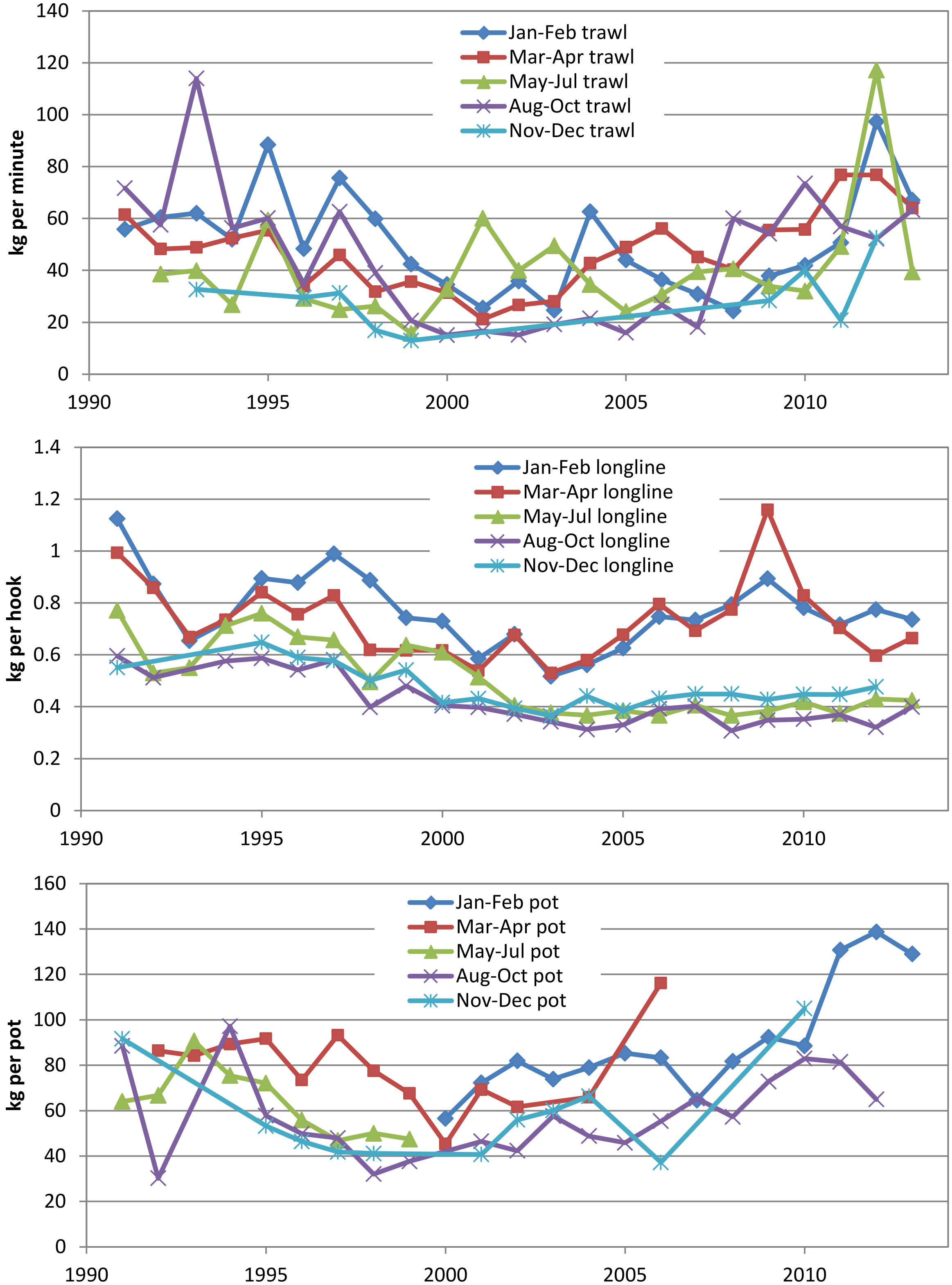

Figure 2.3—Time series of fishery catch per unit effort, by gear and season, in the EBS.

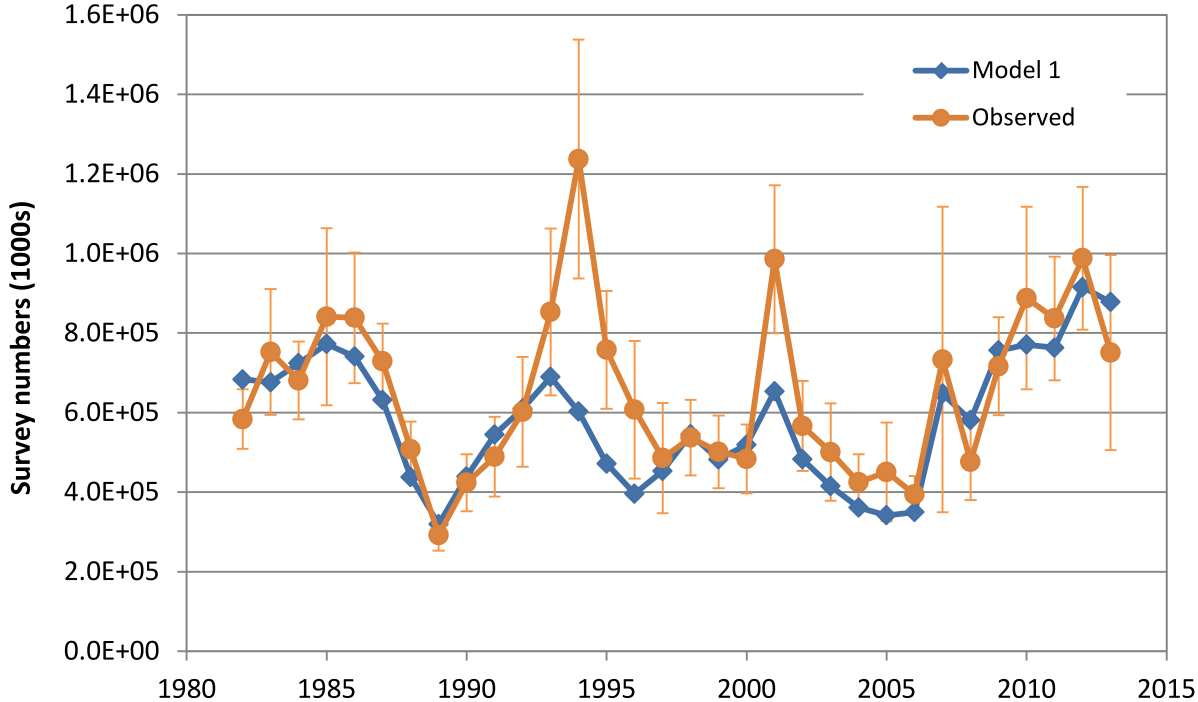

Figure 2.4—Model fit to the trawl survey abundance time series, with 95% confidence intervals.

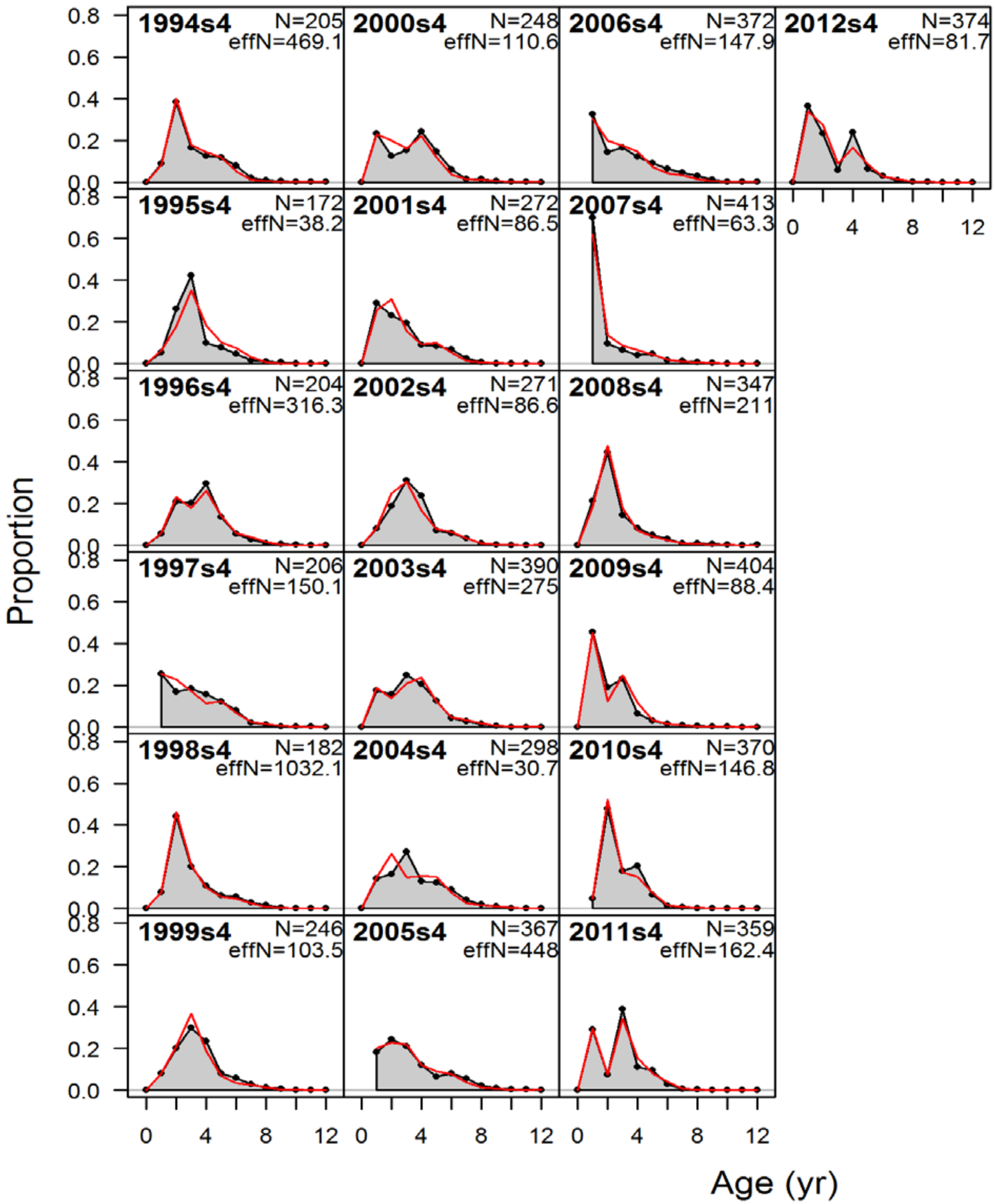

Figure 2.5—Fit to trawl survey age composition data obtained by the model (grey = observed, red = estimated).

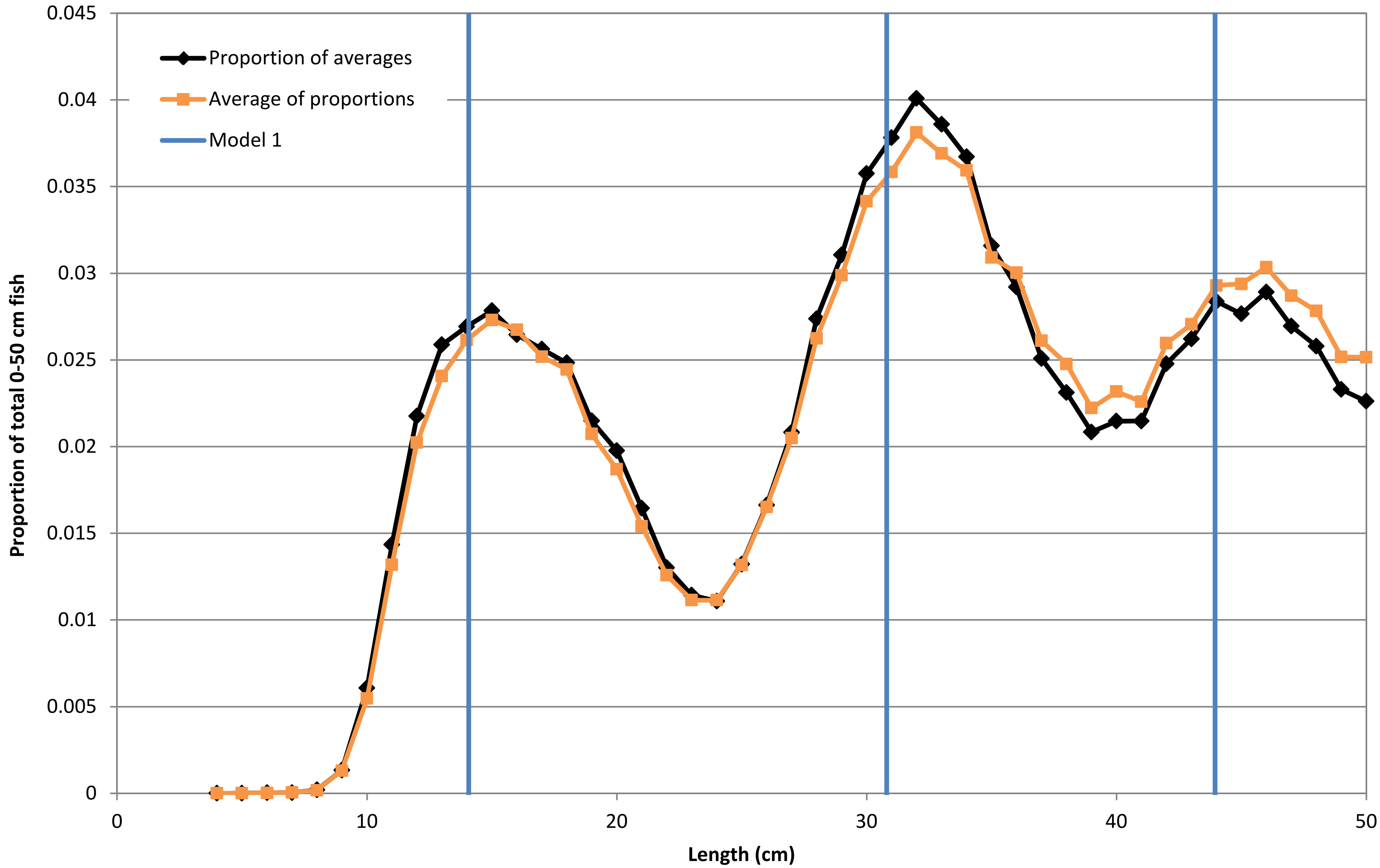

Figure 2.6—Estimates of mean size at ages 1-3 from the model, compared to long-term average survey size (0-50 cm) composition.

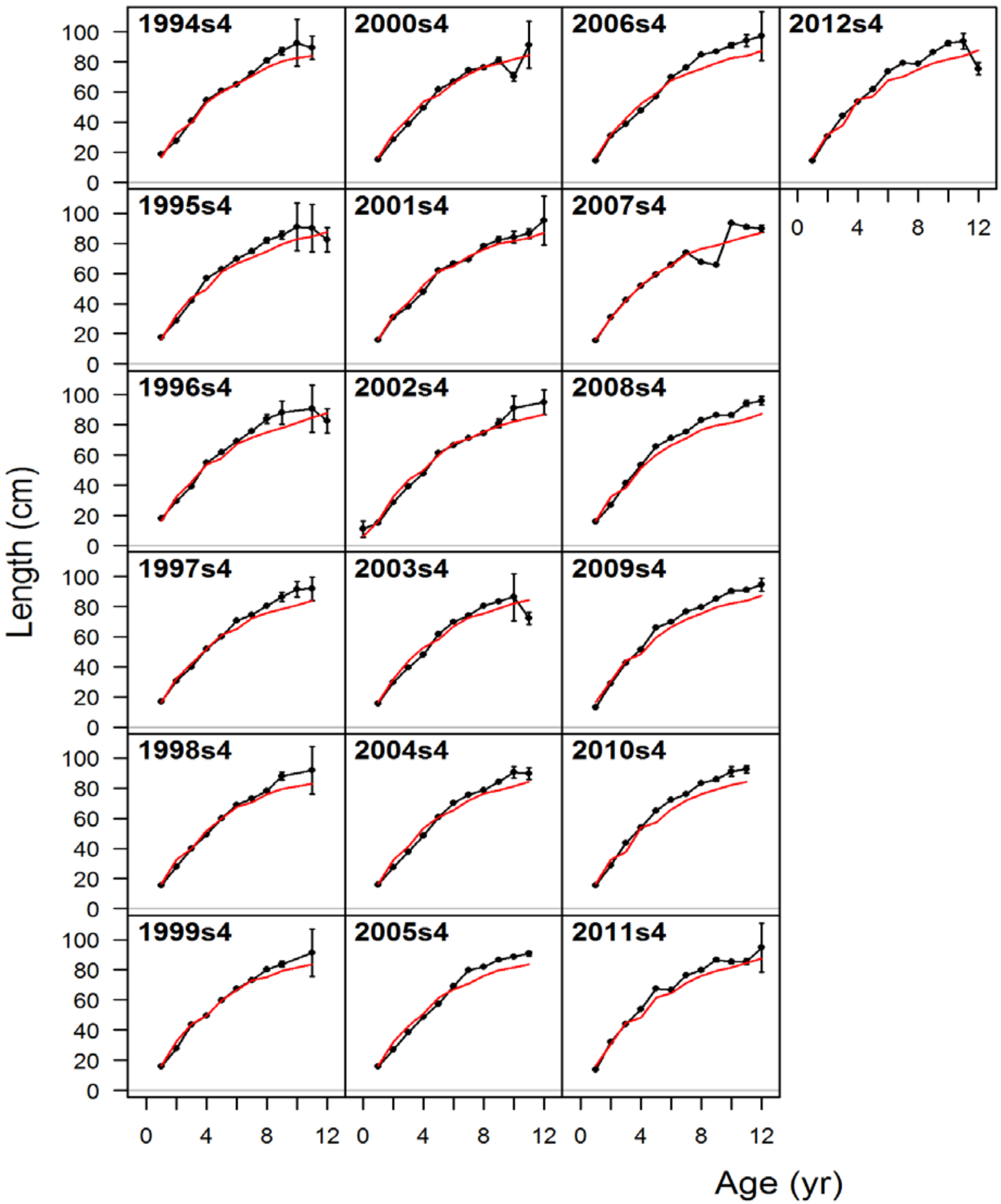

Figure 2.7—Fit to mean-size-at-age data from the stock assessment model (black = observed, red = estimated).

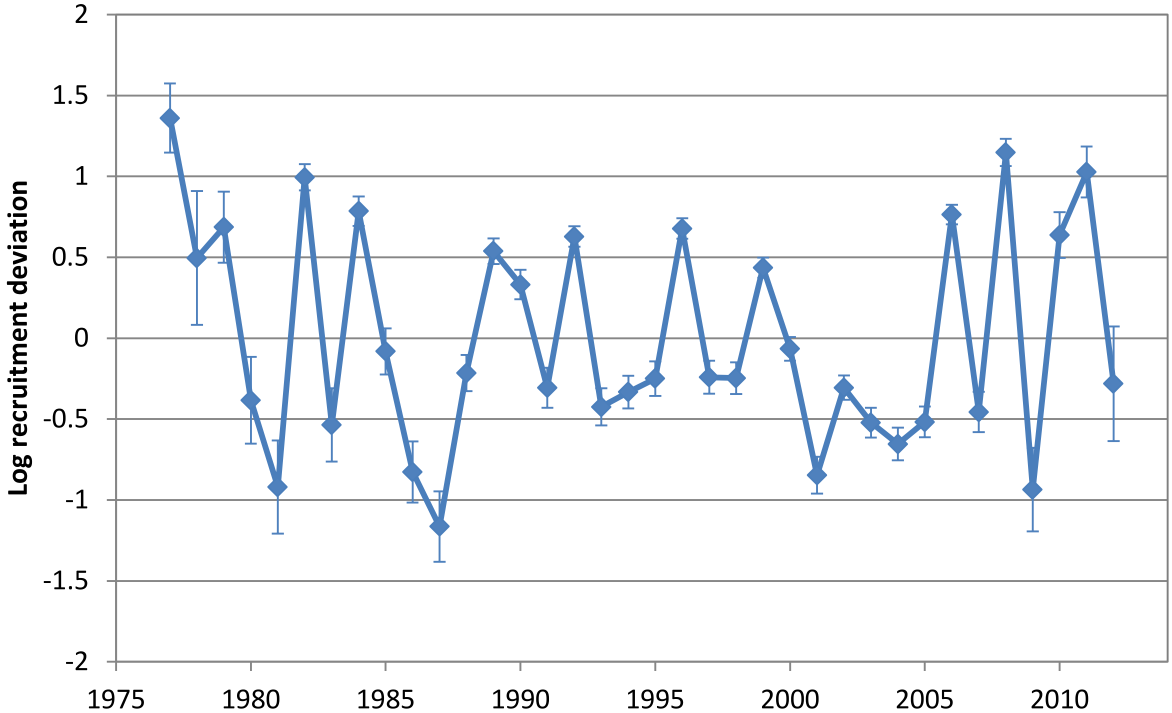

Figure 2.8—Time series of estimated log recruitment deviations from the stock assessment model, with 95% confidence intervals.

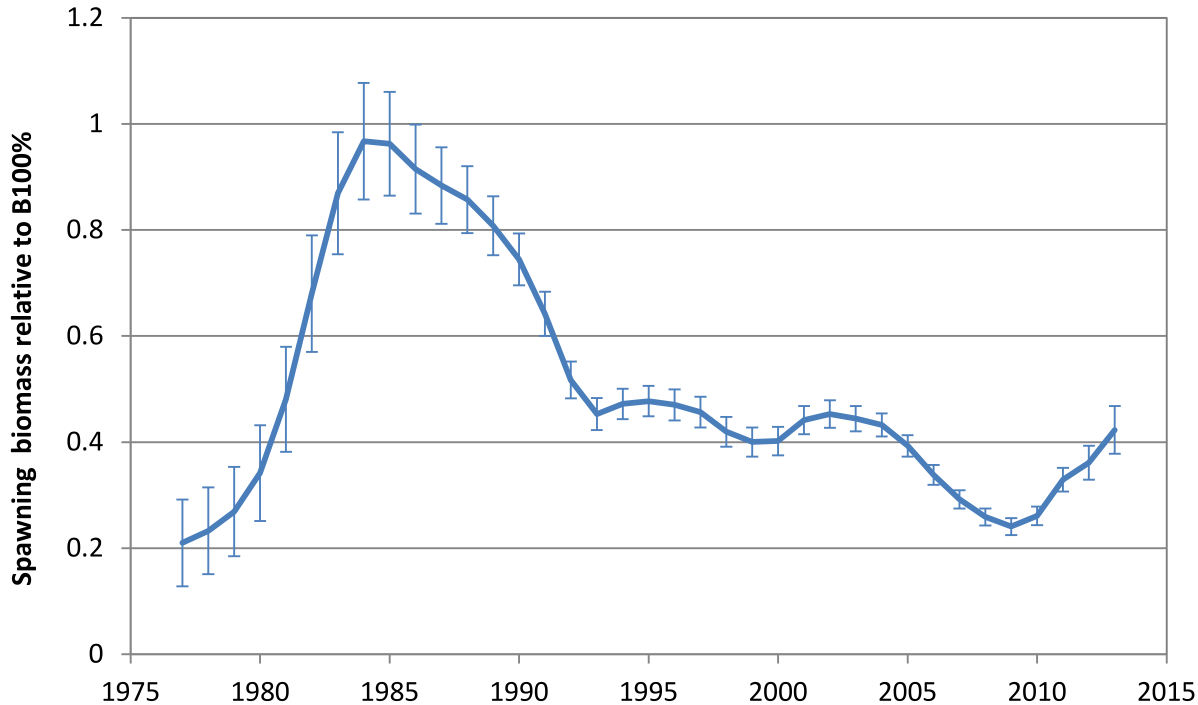

Figure 2.9—Time series of spawning biomass relative to $B_{100\%}$ as estimated by the assessment model.

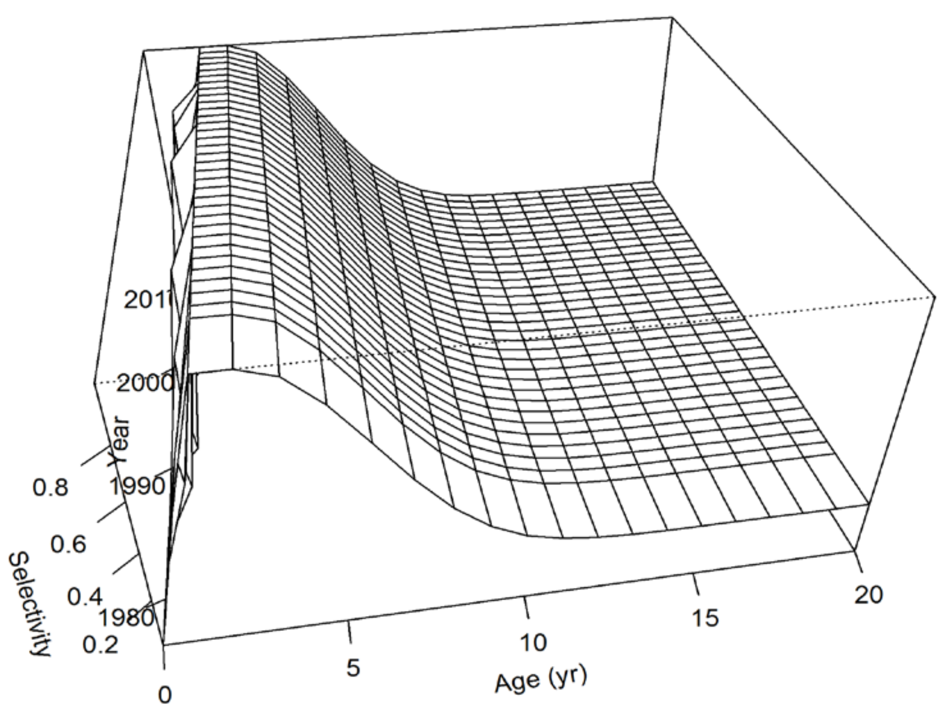

Figure 2.10—Trawl survey selectivity at age as estimated by the assessment model. "*Dev*" parameters affect the ascending limb.

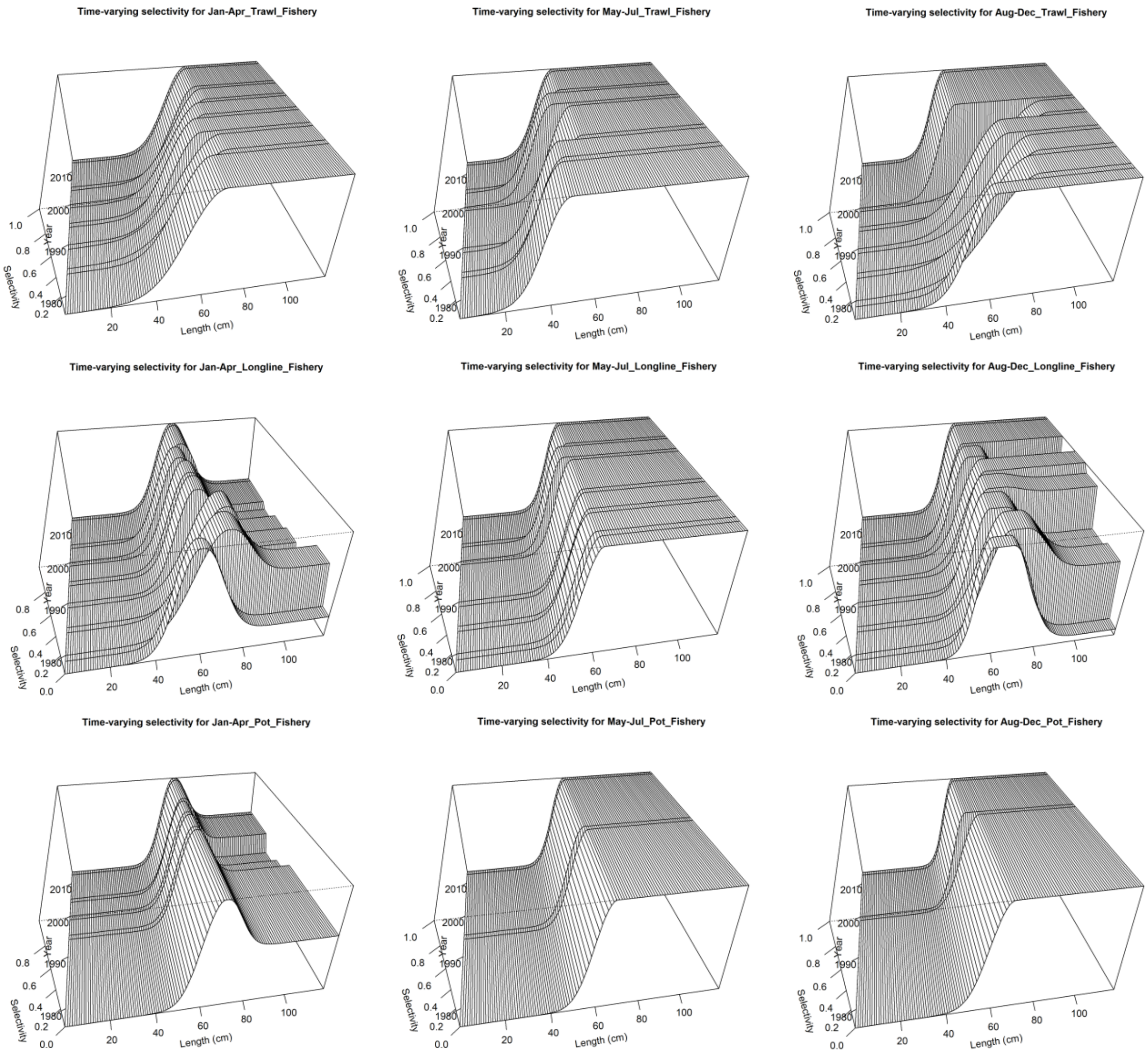

Figure 2.11—Fishery selectivity at length (cm) as estimated by the assessment model. Rows represent gear types (trawl, longline, and pot, respectively), and columns represent seasons (Jan-Apr, May-Jul, and Aug-Dec, respectively).

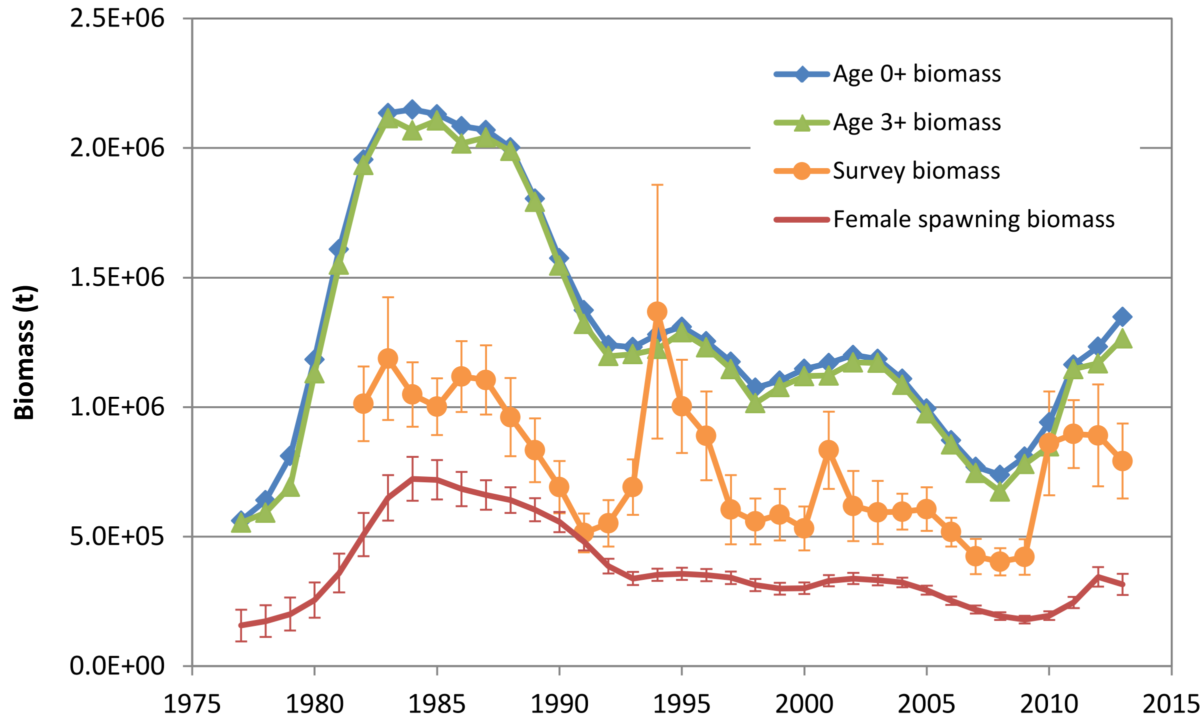

Figure 2.12—Time series of age 0+, age 3+, and female spawning biomass as estimated by the assessment model. Survey biomass is shown for comparison.

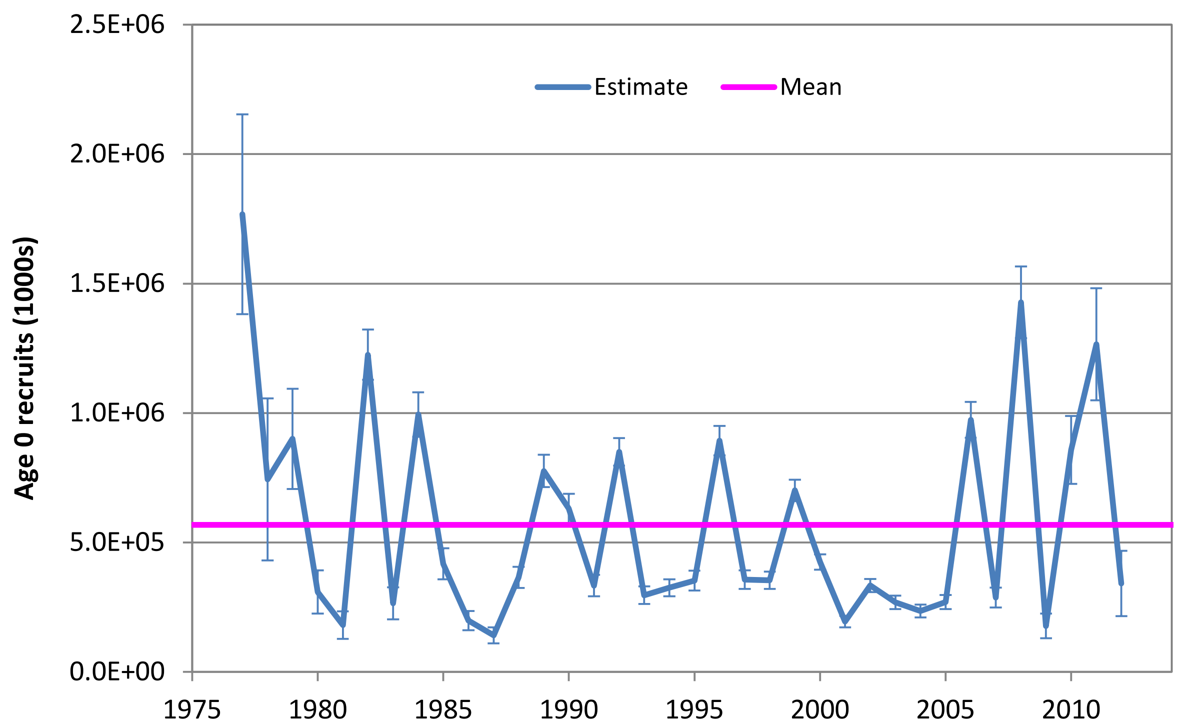

Figure 2.13—Time series of recruitment at age 0 as estimated by the stock assessment model.

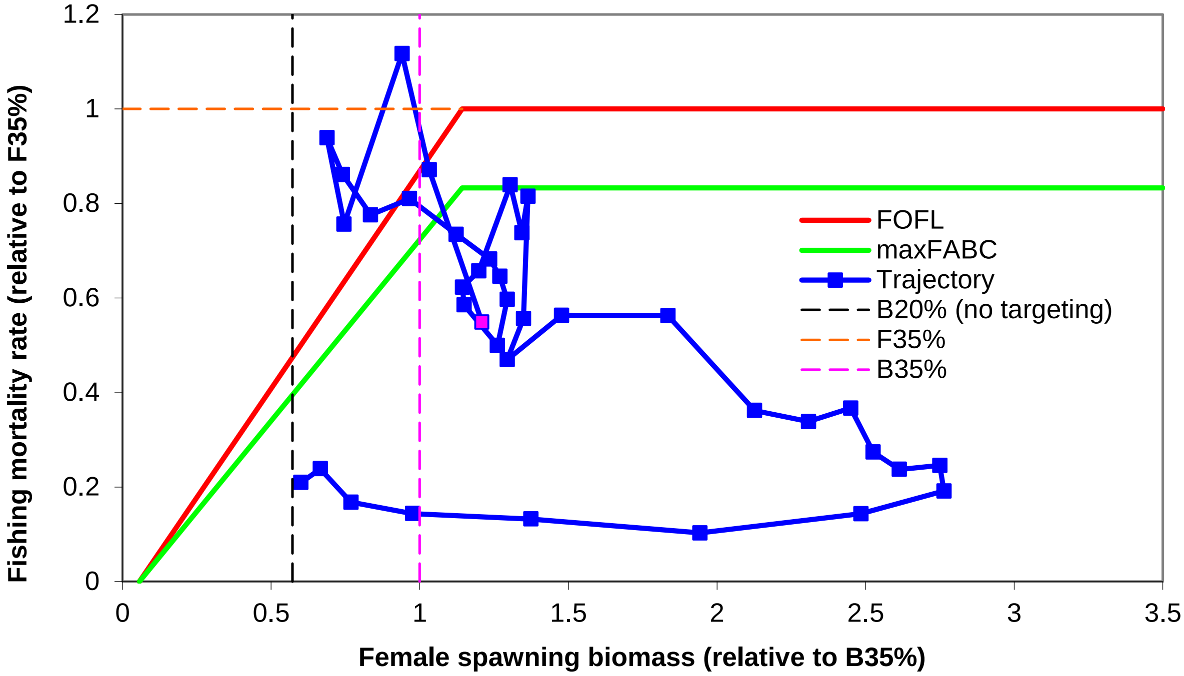

Figure 2.14—Trajectory of Pacific cod fishing mortality and female spawning biomass as estimated by the stock assessment model, 1977-present (magenta square = 2013).

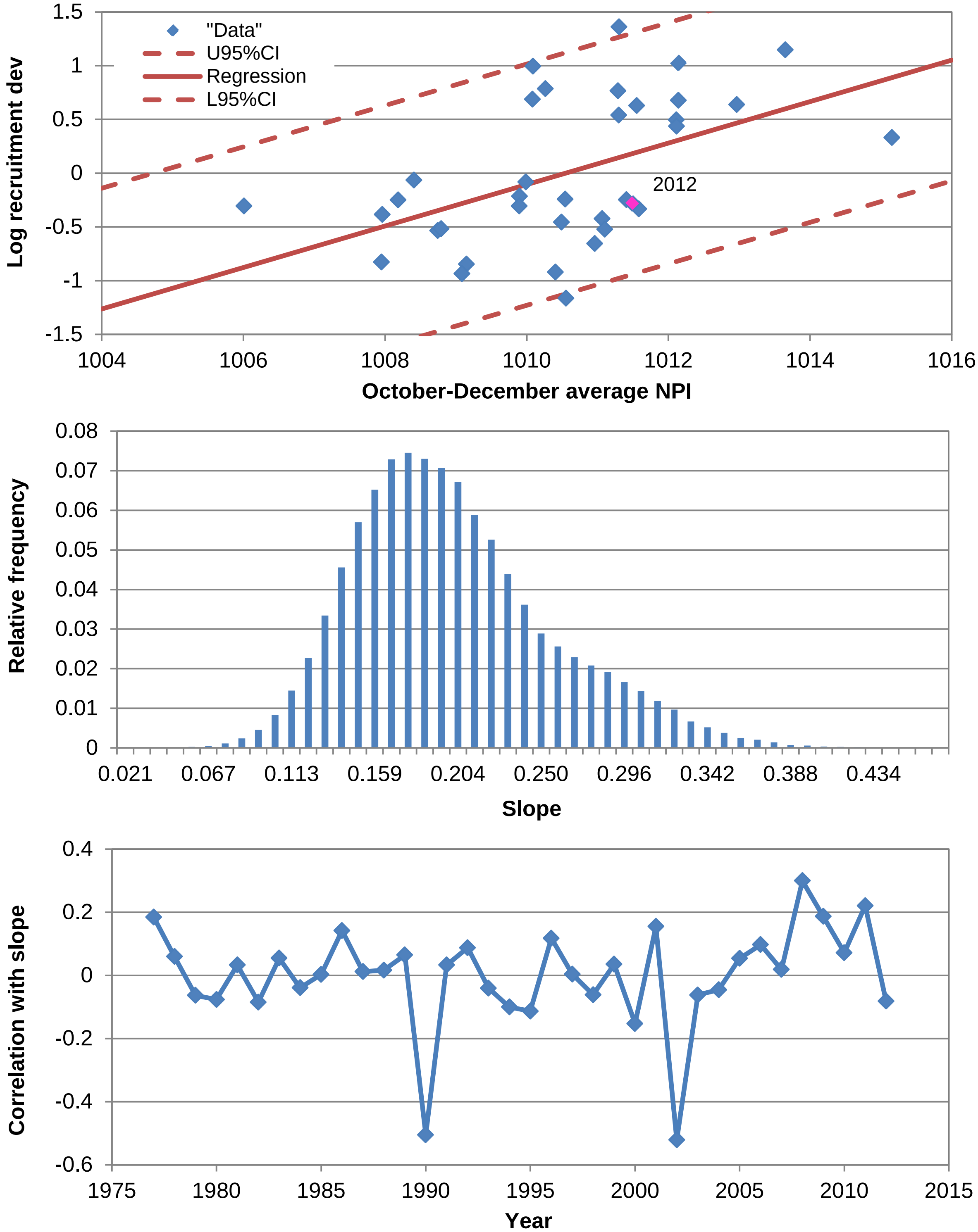

Figure 2.15—Environmental effects on recruitment. Upper panel: Estimated log recruitment *devs* (age 0) versus same-year October-December average of the NPI, with regression line and 95% confidence interval. Middle panel: Distribution of the regression slope, as generated by a cross-validation analysis. Lower panel: Correlation between individual data points and regression slope. See text for details.

Appendix 2.1:

Preliminary assessment of the Pacific Cod Stock in the eastern Bering Sea

Introduction

This document represents an effort to respond to comments made by the BSAI Plan Team, the joint BSAI Plan Team, and the SSC on the 2012 assessment of the Pacific cod (*Gadus macrocephalus*) stock in the eastern Bering Sea (EBS, Thompson and Lauth 2012). Data are the same as in last year's assessment.

Comments from the Plan Teams and SSC

Responses to SSC and Plan Team Comments on Assessments in General

SSC minutes (June, 2012)

SSC1: "We note that stock assessment authors are free to develop and bring forward an alternative model or models in both the preliminary and final assessment." The authors spent considerable time developing their own alternative model for EBS Pacific cod this summer, but were unable to complete it in time for inclusion in this preliminary assessment. However, they have included Model 4 from last year's assessment, which was not one of the Teams' or SSC's requested models (see also comments JPT1 and SSC6).

SSC minutes (December, 2012)

SSC2: "The SSC recommends that the authors consider whether it is possible to estimate *M* with at least two significant digits in all future stock assessments to increase validity of the estimated OFL." The natural mortality rate *M* is reported to two significant digits in this preliminary assessment.

Joint Plan Team minutes (May, 2013)

JPT1: "For the last two years, the Teams have reserved the right to request that the author's preferred model be excluded from the final assessment. Upon further reflection and consideration of the SSC's June, 2012 minute stating that authors are free to include their own models in both the preliminary and final assessments, the Teams decided to abandon their previous policy. The Teams recommend that authors feel free to include their own models in both the preliminary and final assessments." See comment SSC1.

Responses to SSC and Plan Team Comments Specific to Eastern Bering Sea Pacific Cod

BSAI Plan Team minutes (September, 2012)

BPT1: "There was also a lot of interest in a model intermediate between Model 1 and Model 5, such as a version of Model 5 in which the commercial fishery data are still broken out by gear and season, with selectivity parameters estimated by time block. The Team recommends that the author investigate a model like that and bring it forward on his own if it looks worthwhile." (Note: Model 5 from last year's preliminary assessment was relabeled Model 4 in the final assessment.) This comment was considered by the Joint Plan Teams at their May 2013 meeting, at which time the Teams decided not to recommend such a model for inclusion in this preliminary assessment, a decision with which the SSC concurred (see also comments JPT2 and SSC6).

BPT2: "While they are not candidates for the specifications, we think that Models 1.1 and 4 provide a useful check on the candidate models and recommend that they be reported in November (and next September)." (Note: Models 1.1 and 4 from last year's preliminary assessment were relabeled Models 2 and 3 in the final assessment, respectively.) This comment was considered by the Joint Plan Teams at their May 2013 meeting, at which time the Teams decided not to recommend these models for inclusion in this preliminary assessment, a decision with which the SSC concurred (see also comments JPT2 and SSC6).

SSC minutes (October, 2012)

SSC2: "The Plan Team recommended the author bring forward a version of Model 5 that incorporates time varying selectivity for the fishery, if time permits and is worthwhile. The SSC supports Plan Team recommendations and encourages the author - if time permits - to bring forward a model that considers time varying survey *Q* to see if that produces better fit to the survey data." (Note: Model 5 from last year's preliminary assessment was relabeled Model 4 in the final assessment.) Time did not permit such a model to be included in last year's final assessment. This comment was considered by the Joint Plan Teams at their May 2013 meeting, at which time the Teams decided not to recommend such a model for inclusion in this preliminary assessment, a decision with which the SSC concurred (see also comments JPT2 and SSC6).

BSAI Plan Team minutes (November, 2012)

BPT3: "The Team recommends that jitter tests continue to be conducted, but statistics related to jitter tests do not need to be reported in future assessments." Jitter tests were conducted on all models presented here, but statistics relating to these tests are not reported.

SSC minutes (December, 2012)

SSC3: "The SSC re-iterates continuing concerns over the best value for the catchability coefficient, which by long-standing practice is either tuned to experimental results or fixed at a previously tuned value to keep it close to the experimental results (currently fixed at 0.77 in Model 1). Based on exploratory models estimating *Q*, catchability may be much higher. The SSC expects to receive a report prior to next year's assessment about a comparison of the standard EBS trawl with a high-opening trawl conducted during the 2012 field season." The requested report was attached to the minutes of the May 2013 Joint Plan Team meeting, and the SSC received a presentation on the results at its June 2013 meeting. Briefly, the results from this study failed to reject the null hypothesis that the nets used in the EBS and GOA surveys have the same catchability for Pacific cod in the 60-81 cm size range. However, as this was just a small pilot study, these results were not viewed as conclusive.

SSC4: "The results for Model 4 suggest that several of the new features represent an improvement over the current base model and the SSC recommends bringing forward a similar model next year that retains at least some of these promising features such as the Richards growth curve, newly parameterized seasonal changes in weight-at-length, selectivity modeled as a function of length, and estimating log-scale standard deviations for recruitment internally rather than fixing them." All of the listed features are included in all but one of the models presented here.

SSC5: "The SSC would like to see [an] … analysis of retrospective patterns for a model with an alternative estimate for *Q* (internally estimated or updated value from field experiment) in next year's assessment." Retrospective analyses were not conducted during this preliminary assessment. If at least one of the models requested for inclusion in the final assessment includes an alternative estimate of *Q*, the requested analysis will be conducted at that time.

Joint Plan Team minutes (May, 2013)

JPT2: "For the preliminary EBS assessment, the Teams recommend that the following models be included: 1. Last year's final model (Model 1), which is the same as the 2011 final model. 2. Last year's "exploratory" model (Model 4), but with the logarithm of survey catchability estimated internally, using a non-constraining uniform prior. 3. Last year's 'exploratory' model (Model 4), but with the logarithm of survey catchability estimated internally, using a normal prior derived from the archival tagging data used by Nichol et al. (2007), and with asymptotic trawl survey selectivity." The Teams' requested models are included in this preliminary assessment (see also comment SSC6).

SSC minutes (June, 2013)

SSC6: "The SSC concurs with author and Team's EBS model development for this coming year. The SSC recommends that model changes be kept to a minimum to ensure that we can track model sensitivities to specific changes in model structure. In addition to the recommended models, the assessment author reported that he will likely bring forward an EBS model similar to last year's Model 4, which the SSC supports. The SSC encourages the author to investigate annually changing fishery selectivity, for example modeled as a random walk process. The SSC concurs with the Team recommendation to discontinue models with no age data." The three models requested by the Teams and SSC are included in this preliminary assessment, along with Model 4 from last year's final assessment. One of the requested models is last year's accepted model (Model 1, also the same as the accepted model in 2011), which, by definition, keeps the number of model changes to a minimum. As noted in the response to comment SSC1, the authors spent considerable time developing their own alternative model for EBS Pacific cod this summer, but were unable to complete it in time for inclusion in this preliminary assessment. All models presented in this preliminary assessment include time-varying selectivity. In Model 1, selectivity changes between blocks of years. In Models 2-4, selectivity changes annually. All of the models include age data.

Model Structures

All of the models in this preliminary assessment were developed using Stock Synthesis (SS, Methot and Wetzel 2013). SS is programmed using the ADMB software package (Fournier et al. 2012).

All of the models in this preliminary assessment used a double-normal curve to model selectivity (SS selectivity-at-length pattern #24 for the fisheries in all models and for the survey in Models 2-4, and SS selectivity-at-age pattern #20 for the survey in Model 1). This functional form is constructed from two underlying and linearly rescaled normal distributions, with a horizontal line segment joining the two peaks. As configured in SS, the equation 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.

As requested by the Teams and SSC, Model 1 in this preliminary assessment is the same as last year's final model (coincidentally labeled Model 1 in the 2012 assessment), while Models 2 and 3 are based on last year's Model 4. Although not requested by the Teams or SSC, last year's Model 4 is also included here (again labeled Model 4). It will thus prove helpful to list the ways in which Model 4 differs from Model 1, which are as follow:

1. A new, inter- and intra-annually varying weight-length representation based on an explicit phenological process (Attachment 2.1, Annex 2.1.2 in Thompson and Lauth 2012) was used. Model 1 also used an intra-annually varying weight-length representation, but each set of seasonal parameters was estimated independently of the other seasons, without being constrained by any phenological process.
2. "Tail compression" was turned off. This feature aggregates size composition bins with few or zero data on a record-by-record basis, which improves computational speed, but which also makes some of the graphs in the R4SS package difficult to interpret. In Model 1, tail compression is turned on.
3. Fishery CPUE data were omitted. In Model 1, fishery CPUE data were included for purposes of comparison, but are not used in estimation.
4. A new population length bin was added for fish in the 0-0.5 cm range, which was used for extrapolating the length-at age curve below the first reference age. In Model 1, the lower bound of the first population length bin was 0.5 cm.
5. Mean-size-at-age data were eliminated. In Model 1, mean-size-at-age data were included, but not used in estimation.
6. The number of estimated year class strengths in the initial numbers-at-age vector was set at 10. In Model 1, only 3 elements of the initial numbers-at-age vector were estimated, which causes an automatic warning in SS.
7. The Richards growth equation (Richards 1959, Schnute 1981, Schnute and Richards 1990) was used, which adds one more parameter. In Model 1, the von Bertalanffy equation—a special case of the Richards equation—was used.
8. The log-scale standard deviation of recruitment was estimated internally (i.e., as a free parameter estimated by ADMB). In Model 1, this parameter was held constant at the value of 0.57 that was estimated in the final 2009 assessment by matching the standard deviation of the recruitment *dev*s, per Plan Team request.
9. Survey selectivity was modeled as a function of length. In Model 1, survey selectivity was modeled as a function of age.
10. Fisheries were defined with respect to each of the five seasons, but not with respect to gear. In Model 1, fisheries were defined with respect to both season and gear.
11. Fishery selectivity curves were defined for each of the five seasons, but were not stratified by gear type. In Model 1, seasons 1-2 and 4-5 were lumped into a pair of "super" seasons for the purpose of defining fishery selectivity curves, and fishery selectivities were also *gear*-specific (3 super-seasons × 3 gears = 9 selectivity curves).
12. The selectivity curve for the fishery that came closest to being asymptotic on its own (in this case, the season 3 fishery) was forced to be asymptotic by fixing both *width_of_peak_region* and *final_selectivity* at a value of 10.0 and *descending_width* at a value of 0.0. In Model 1, six of the nine super-season × gear fisheries were forced to exhibit asymptotic selectivity.
13. The age composition sample size multiplier was tuned iteratively to set the mean of the ratio of effective sample size to input sample size equal to 1.0. In Model 1, the variance adjustment was fixed at 1.0.
14. The two parameters governing the ascending limb of the survey selectivity schedule were given annual additive *dev*s with each σ_{dev} tuned to match the estimate that would be appropriate for a univariate linear-normal model with random effects integrated out (see Attachment 2.1, Annex

2.1.1 in Thompson and Lauth 2012). In Model 1, no *dev* vector corresponding to the *initial_selectivity* parameter was used, because it was “tuned out” in the 2009 final assessment; and σ_{dev} for the *ascending_width* parameter was left at the value of 0.07 estimated iteratively in the final 2009 assessment, per Plan Team request.

15. The logarithm of survey catchability (ln(*Q*)) was re-tuned iteratively to set the average of the product of *Q* and survey selectivity across the 60-81 cm range equal to 0.47, corresponding to the Nichol et al. (2007) estimate. In Model 1, *Q* was left at the value of 0.77 estimated by a similar procedure in the final 2009 assessment, per Plan Team request.

Last year’s preliminary assessment also contained a set of nine “secondary” models that consisted of incremental transitional steps between last year’s Model 1 and Model 4, so that the effects of the items in the above list could be examined almost one at a time.

The only differences between Models 2 and 3 in this preliminary assessment and Model 4 are with respect to point #15 in the above list:

- Model 2 estimates ln(*Q*) internally, using a non-constraining uniform prior distribution.
- Model 3 estimates ln(*Q*) internally, using a normal prior distribution derived from the archival tagging data used by Nichol et al. (2007), and with asymptotic trawl survey selectivity.

Because this preliminary assessment is only an exploration of alternative models, and in the interest of time, the iterative tuning procedures described in points #13 and 14 above were not redone for Models 2 and 3 (i.e., Models 2 and 3 used the tuned quantities from Model 4, rather than retuning those quantities individually for Models 2 and 3).

Discussion with Plan Team members indicated a preference for the normal prior distribution in Model 3 to be based on an analysis that used the 11 individual tags in the Nichol et al. (2007) study as fixed effects and that resulted in a prior mean close to ln(0.47) = -0.755. Evaluating the empirical cdf of each tag at 2.5 m (the height of the headrope used in the EBS shelf bottom trawl survey) and log transforming the resulting values gave a data set with a mean of -0.773 and a standard deviation of 0.461. The implied assumption of lognormality for *Q* was tested by comparing the likelihoods for lognormal, normal, logit-normal, and beta distributions (all evaluated at the maximum likelihood estimates of their respective parameters). Lognormal had the highest likelihood. The values μ_{lnQ} = -0.773 and σ_{lnQ} = 0.461 were therefore used as the mean and standard deviation of the normal prior distribution for ln(*Q*) in Model 3.

Development of the final versions of all models included calculation of the Hessian matrix. All models also passed a “jitter” test of 50 runs with a jitter parameter (equal to half the standard deviation of the logit-scale distribution from which initial values are drawn) of 0.01. In the event that a jitter run produced a better value for the objective function than the base run, then: 1) the model was re-run starting from the final parameter file from the best jitter run, 2) the resulting new control file became the new base run, and 3) the entire process (starting with a new set of jitter runs) was repeated until no jitter run produced a better value for the objective function than the most recent base run.

Except for *dev* parameters and the ln(*Q*) parameter in Model 3, all parameters were estimated with uniform prior distributions. Bounds were non-constraining in all cases, except for two selectivity parameters in Model 1 (*beginning_of_peak_region* was bound high for the August-December trawl fishery in the 1995-1999 time block, and *initial_selectivity* was bound low for the trawl survey; these results mean simply that the August-December trawl fishery in the 1995-1999 time block does not reach peak selectivity until the maximum age, and the trawl survey has a selectivity of zero for age zero fish).

Model 1 uses the same data file as last year's Model 1, while Models 2-4 use the same data file as last year's Model 4.

The software used to run Model 1 was SS V3.23b, as compiled on 11/5/2011, and the software used to run Models 2-4 was SS V3.24q, as compiled on 5/20/2013 (the most recent user manual is for SS V3.24f, Methot 2012).

Results

Overview

The following table summarizes the status of the stock as estimated by the four models ("Estimate" is the point estimate, "CV" is the ratio of the standard deviation to the point estimate, "SB(2012)" is female spawning biomass in 2012 (t), and "Bratio(2012)" is the ratio of SB(2012) to $B_{100\%}$):

	Model 1		Model 2		Model 3		Model 4	
	Estimate	CV	Estimate	CV	Estimate	CV	Estimate	CV
SB(2012)	689,032	0.056	300,957	0.086	269,901	0.081	824,483	0.061
Bratio(2012)	0.442	0.046	0.211	0.097	0.191	0.094	0.422	0.087

The estimates of both absolute and relative spawning biomass in 2012 are markedly higher in Models 1 and 4 (where *Q* is tuned to the results of Nichol et al. (2007)) than in Models 2 and 3 (where *Q* is estimated internally). The CVs associated with these estimates are all fairly small (<10%).

Here are the values of ln(*Q*) and *Q* resulting from each of the four models:

Parameter	Model 1	Model 2	Model 3	Model 4
ln(*Q*)	-0.26	0.32	0.24	-0.29
Q	0.77	1.37	1.27	0.75

Note that the *Q* values for Models 2 and 3 are 65-83% greater than the *Q* values for Models 1 and 4.

Goodness of Fit

Objective function values are shown for each model below (lower values are better, all else being equal; objective function components with a value less than 0.005 for all models are omitted for brevity; color scale extends from red (minimum) to green (maximum)):

Obj. func. component	Model 1	Model 2	Model 3	Model 4
Equilibrium catch	0.00	0.02	0.02	0.00
Survey abundance	-6.27	-23.35	-16.73	13.93
Length composition	4442.11	2506.14	2545.16	2565.36
Age composition	127.75	121.69	117.16	125.62
Recruitment	22.49	16.31	16.06	16.25
Priors	0.00	0.00	2.41	0.00
"Softbounds"	0.04	0.01	0.01	0.01
Parameter *devs*	19.54	20.43	21.41	19.90
Total	4605.66	2641.24	2685.51	2741.07

Note that the four models have different numbers of parameters: Model 1 has 184, Model 2 has 144, Model 3 has 141 (three fewer than Model 2 because of force asymptotic selectivity for the survey), and Model 4 has 143 (one fewer than Model 2 because *Q* is not estimated internally). Also, note that Models 2-4 use a different data file than Model 1 (different seasonal/gear structure, etc.).

The table below shows four statistics related to goodness of fit with respect to the survey abundance data (color scale extends from red (minimum) to green (maximum)). Relative values of the four statistics can be interpreted as follows: correlation—higher values indicate a better fit, root mean squared error—lower values indicate a better fit, average of standardized residuals—values closer to zero indicate a better fit, root mean squared standardized residual—values closer to unity indicate a fit more consistent with the sampling variability in the data.

Statistic	Model 1	Model 2	Model 3	Model 4
Correlation (observed:expected)	0.719	0.753	0.767	0.655
Root mean squared error	0.221	0.189	0.193	0.259
Average of standardized residuals	0.799	0.157	0.197	0.974
Root mean squared standardized residual	2.045	1.755	1.873	2.342

Model 3 fits the survey abundance data best by the first criterion, but Model 2 fits these data best by the other three criteria.

Figure 2.1.1 shows the fits of the four models to the trawl survey abundance data. The time trends are all qualitatively similar, especially Models 2 and 3. Model 2's estimates fall within the 95% confidence intervals of the survey estimates in 25 of the 31 years in the time series, compared to 23 years for Models 1, 3, and 4. All four models estimate a 2012 survey biomass lower than the observed value, although Model 1's estimate is very close to the observed value.

Table 2.1.1 shows the mean of the ratios between effective sample size and input sample size for the length composition data. All four models have average ratios much greater than unity for all fleets. Table 2.1.2 shows similar information for the age composition data, except that values are shown for each year rather than averaged across years. Model 1 has an average ratio of less than unity (0.86). Models 2-4 have average ratios just above unity, but this is because Model 4 (upon which Models 2 and 3 are based) downweights the age composition data by a factor of 0.85 precisely to achieve this result.

Figure 2.1.2 shows the four models' fits to the survey age composition data. Visually, it is difficult to discern much difference between these fits.

Parameter Estimates

Table 2.1.3 displays all of the parameters (except fishing mortality rates) estimated internally in any of the models (plus some parameters that are specified externally). Table 2.1.3a shows growth, recruitment (except annual *dev*s), initial fishing mortality, catchability, and initial age composition parameters as estimated internally by at least one of the models. Table 2.1.3b shows annual log-scale recruitment *dev*s as estimated by all of the models. These are plotted in Figure 2.1.3, where it is apparent that all models show a high degree of synchrony, particularly during the years covered by the survey. Table 2.1.3c shows main selectivity parameters as estimated by, or specified for, Model 1 (many of these parameter values get over-written by block-specific values). Table 2.1.3d shows block-specific selectivity parameters as estimated by Model 1. Table 2.1.3e shows selectivity parameter *dev*s as estimated by Model 1. Table 2.1.3f shows main selectivity parameters as estimated by, or specified for, Models 2-4.

Table 2.1.3g shows selectivity *dev*s for survey selectivity parameter #3 as estimated by Models 2-4, and Table 2.1.3h shows selectivity *dev*s for survey selectivity parameter #5 as estimated by Models 2-4.

Values of externally estimated parameters (e.g., M = 0.34) are described by Thompson and Lauth (2012), and are not repeated here in the interest of brevity.

The parameter estimates in Table 2.1.3 imply the following values for the average of the product of catchability and survey selectivity across the 60-81 cm size range (these can be compared to the value of 0.47 obtained by Nichol et al. (2007)):

Model 1	Model 2	Model 3	Model 4
0.54	0.99	1.27	0.47

Table 2.1.4 shows estimates of full-selection fishing mortality for the four models (note that these are not counted as parameters in SS, and so do not have estimated standard deviations).

Estimates of Time Series

Figure 2.1.4 shows the time series of spawning biomass relative to $B_{100\%}$ as estimated by the four models (note that SS measures spawning biomass at the start of the year and uses a different estimator of mean recruitment than the standard projection model). Major qualitative features are similar, but the scales are different, particularly when comparing Models 1 and 4 to Models 2 and 3. Model 1 peaks at a value of 0.94 in 1984, Model 2 peaks at a value of 0.55 in 1988, Model 3 peaks at a value of 0.44 in 1989, and Model 4 peaks at a value of 0.94 in 1985.

Figure 2.1.5 shows the time series of total (age 0+) biomass as estimated by the four models, with the trawl survey biomass estimates included for comparison. Models 1 and 4 estimate total biomasses much higher than observed by the survey, whereas the total biomass estimates from Models 2 and 3 are much closer to the survey observations.

Figure 2.1.6 shows fishery selectivity as estimated by the four models. Model 1's block-varying selectivity by season and gear clearly exhibits a more complicated pattern than the seasonal but year-invariant selectivity curves of Models 2-4. Except for the curve corresponding to season 3, which is constrained to be asymptotic in both Models 2-4, the selectivity curves for Model 3 all drop off more sharply at large sizes than those of Models 2 or 4.

Figure 2.1.7 shows time-varying trawl survey selectivity as estimated by the four models. The surfaces for the four models all show significant variability at the youngest/smallest ages/sizes, although these are hard to compare visually because age and length are not proportional. Models 1, 2, and 4, where selectivity at the oldest/largest ages/sizes is unconstrained, show significant declines past the age/size of peak selectivity. Model 3, in contrast, is constrained to exhibit asymptotic selectivity. The selectivities at the oldest/largest ages/sizes are 0.20, 0.33, 1.00, and 0.23 in Models 1, 2, 3, and 4 respectively.

Discussion

This exploration of alternative models confirms some of the findings of previous such explorations. One of these is that it is difficult to fit some of the data sets at levels consistent with the best estimates of their associated measurement errors. One data set that stands out in this regard is survey abundance.

As noted in last year's preliminary assessment (Attachment 2.1 in Thompson and Lauth 2012), it is difficult to imagine how the survey abundance data could be fit in a manner consistent with the reported sampling variability without allowing *Q* to vary, because the *inter*-annual variability in survey estimates relative to the *intra*-annual variability (standard errors) is so great. For example, the following tables show the relative year-to-year changes in survey estimates of numbers and biomass, together with the coefficients of variation, for every year in which the estimates of numbers or biomass increased by at least 85% over the previous year or decreased by at least 25% from the previous year (tables are sorted in order of increasing relative change):

Numbers				Biomass			
Change	Year	CV(current)	CV(previous)	Change	Year	CV(current)	CV(previous)
-0.43	2002	0.10	0.10	-0.32	1997	0.11	0.10
-0.42	1989	0.07	0.07	-0.27	1995	0.09	0.18
-0.39	1995	0.10	0.12	-0.26	2002	0.11	0.09
-0.35	2008	0.10	0.27	-0.26	1991	0.07	0.07
-0.30	1988	0.07	0.07	0.98	1994	0.18	0.08
0.86	2007	0.27	0.06	1.04	2010	0.12	0.08
1.04	2001	0.10	0.09				

On the other hand, unless the base value of *Q* is estimated internally, it seems likely that the primary effect of allowing time variability in catchability will be compensation for an overall lack of fit resulting from a constrained (or fixed) base value for ln(*Q*), rather than estimating true time variability.

Unfortunately, estimating the base value of *Q* internally continues to be a challenging proposition, as shown in several previous assessments and again here in Models 2 and 3. To date, none of the field experiments aimed at direct estimation of Pacific cod catchability in the EBS shelf bottom trawl survey have suggested that *Q* should exceed unity, yet both Models 2 and 3 estimate *Q* (with high precision) at values far in excess of unity (1.37 and 1.27, respectively, both with CVs of about 3 %).

Use of a prior distribution based on the data of Nichol et al. (2007) in Model 3 did little to constrain *Q* to a value more in line with what might be expected from the field experiments, although the influence of this prior distribution was confounded by Model 3's assumption of asymptotic selectivity for the survey. This confirms the result obtained in the 2009 assessment (Annex 2.1.1 in Thompson et al. 2009), where a random effects analysis was used to estimate the parameters of the prior distribution, as opposed to the fixed effects analysis used here in Model 3.

As noted in the response to Plan Team and SSC comments, the authors spent considerable time developing their own alternative model for EBS Pacific cod this summer, but were unable to complete it in time for inclusion in this preliminary assessment. The main features distinguishing this model from Model 4 was use of SS selectivity-at-age pattern #17 (random walk with age) for both the fisheries and the survey, rather than the usual double-normal selectivity function. As with Model 4, *dev*s were allowed (potentially) for all selectivity parameters. A similar approach to selectivity was taken in this year's preliminary assessment of Pacific cod in the Aleutian Islands. In the interest of brevity, readers are referred to that document for further details. The major difference between the AI model and the EBS model was that the former was able to produce a positive definite Hessian matrix whereas the latter was not. Investigations to date have suggested a possible means to resolve this problem, so the EBS version of the model may be pursued in the future.

Another option that might be considered in the future is to omit seasonal structure from one or more models. The EBS Pacific cod models have been seasonally structured since the 1980s. Although this seasonal structure is helpful for reflecting intra-annual changes in fishing mortality and for capturing growth dynamics in this fast-growing species, it also makes examination of some other potential model features (such as time-varying parameters) difficult or impossible.

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Table 2.1.1a—Average input sample size and average ratio of effective sample size to input sample size for length composition data, Model 1.

Fleet	Mean input N	Mean Neff/Ninp
Jan-Apr Trawl Fishery	322.73	5.57
May-Jul Trawl Fishery	65.91	9.14
Aug-Dec Trawl Fishery	42.54	12.77
Jan-Apr Longline Fishery	467.76	8.88
May-Jul Longline Fishery	223.78	9.55
Aug-Dec Longline Fishery	671.07	6.70
Jan-Apr Pot Fishery	140.12	13.26
May-Jul Pot Fishery	139.81	18.03
Aug-Dec Pot Fishery	78.38	10.33
Post81 Shelf Survey	279.29	2.09

Table 2.1.1b—Average input sample size and average ratio of effective sample size to input sample size for length composition data, Models 2-4.

		Mean Neff/Ninp		
Fleet	Mean input N	Model 2	Model 3	Model 4
Season1 Fishery	326.41	7.37	7.19	7.83
Season2 Fishery	324.68	6.64	6.34	6.94
Season3 Fishery	122.91	8.06	8.06	8.09
Season4 Fishery	477.24	10.99	9.64	9.91
Season5 Fishery	324.39	8.36	8.20	8.78
Trawl Survey	225.16	3.38	3.02	3.26

Table 2.1.2—Input sample size and ratio of effective sample size to input sample size for each year of age composition data, all models. Note that Models 2-4 multiply the input sample size by 0.85, so the ratios between Model 1 and Models 2-4 are not directly comparable.

		Ratio of effective N to input N			
Year	Input N	Model 1	Model 2	Model 3	Model 4
1994	208	2.07	1.76	1.83	2.22
1995	174	0.20	0.18	0.19	0.23
1996	207	1.48	1.45	1.68	1.71
1997	209	0.81	2.08	2.22	1.15
1998	184	4.73	6.06	5.45	4.76
1999	250	0.51	0.40	0.32	0.39
2000	251	0.46	0.27	0.21	0.27
2001	276	0.40	0.18	0.21	0.24
2002	275	0.33	0.32	0.27	0.36
2003	395	0.74	2.29	1.42	1.32
2004	302	0.11	0.12	0.12	0.14
2005	372	1.39	1.19	0.66	2.37
2006	378	0.38	0.37	0.41	0.40
2007	419	0.18	0.24	0.20	0.33
2008	352	0.56	1.56	1.74	0.77
2009	410	0.21	0.29	0.32	0.32
2010	375	0.55	0.58	0.85	0.88
2011	364	0.31	0.16	0.20	0.25
Average:	300	0.86	1.08	1.02	1.01

Table 2.1.3a—Growth, recruitment (except devs), catchability, initial fishing mortality, and initial age composition devs as estimated by the four models ("Est." = point estimate, "SD" = standard deviation). Blanks indicate that the parameter in that row was not used by the model in that column, and "n/a" indicates that the parameter was used but not estimated (i.e., the parameter had a fixed value).

	Model 1		Model 2		Model 3		Model 4	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD
L_at_age01	1.41E+01	1.07E-01	1.39E+01	1.43E-01	1.38E+01	1.54E-01	1.38E+01	1.59E-01
L_at_age20	9.20E+01	5.33E-01	9.49E+01	1.24E+00	1.05E+02	2.43E+00	9.00E+01	8.78E-01
VonBert_K	2.43E-01	2.76E-03	2.95E-01	1.49E-02	2.07E-01	1.62E-02	2.85E-01	1.29E-02
Richards_growth			6.29E-01	5.94E-02	9.30E-01	6.63E-02	8.12E-01	5.81E-02
SD_of_length_at_age01	3.51E+00	6.94E-02	3.58E+00	8.50E-02	3.46E+00	8.61E-02	3.41E+00	8.47E-02
SD_of_length_at_age20	1.01E+01	1.66E-01	1.01E+01	2.65E-01	1.17E+01	4.38E-01	1.02E+01	2.12E-01
Ageing_bias_at_age01	3.41E-01	1.32E-02	2.75E-01	2.13E-02	2.99E-01	1.93E-02	3.33E-01	1.50E-02
Ageing_bias_at_age20	4.57E-01	1.60E-01	1.28E+00	2.14E-01	8.48E-01	2.01E-01	5.81E-01	1.83E-01
Log_mean_post76_recruits	1.32E+01	1.93E-02	1.30E+01	6.96E-02	1.29E+01	6.73E-02	1.34E+01	7.69E-02
SD_of_log_recruitment	5.70E-01	n/a	7.78E-01	8.26E-02	7.68E-01	8.23E-02	8.14E-01	9.14E-02
Pre1977_log_mean_offset	-1.20E+00	1.32E-01	-1.72E+00	1.16E-01	-1.73E+00	7.09E-02	-1.29E+00	2.16E-01
log_Q	-2.61E-01	n/a	3.16E-01	3.34E-02	2.40E-01	2.84E-02	-2.88E-01	n/a
Initial_F_Jan-Apr_trawl	6.71E-01	1.46E-01						
Initial_F_season1_fishery			3.82E+00	2.14E+00	6.80E+00	5.23E+00	7.06E-01	1.93E-01
Init_age10_dev			-6.85E-02	7.65E-01	-5.65E-03	7.67E-01	-4.68E-01	6.80E-01
Init_age09_dev			-1.26E-01	7.65E-01	-1.49E-02	7.66E-01	-5.76E-01	6.58E-01
Init_age08_dev			-2.15E-01	7.68E-01	-3.83E-02	7.73E-01	-6.76E-01	6.38E-01
Init_age07_dev			-3.25E-01	7.63E-01	-8.27E-02	8.07E-01	-7.35E-01	6.22E-01
Init_age06_dev			-3.78E-01	7.35E-01	-9.94E-02	8.63E-01	-6.97E-01	6.11E-01
Init_age05_dev			-2.85E-01	6.13E-01	-8.37E-02	7.15E-01	-5.35E-01	5.76E-01
Init_age04_dev			-7.00E-01	5.15E-01	-7.20E-01	5.14E-01	-5.79E-01	5.71E-01
Init_age03_dev	1.28E+00	1.89E-01	1.07E+00	2.04E-01	9.97E-01	1.67E-01	1.38E+00	2.54E-01
Init_age02_dev	-7.18E-01	4.18E-01	-2.79E-01	4.26E-01	-4.11E-01	4.25E-01	-3.89E-01	5.76E-01
Init_age01_dev	1.32E+00	2.17E-01	1.25E+00	2.18E-01	1.03E+00	2.00E-01	1.62E+00	2.69E-01

Table 2.1.3b—Recruitment *dev*s as estimated by the four models.

	Model 1		Model 2		Model 3		Model 4	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Rec_dev1977	1.33E+00	1.08E-01	5.36E-01	1.45E-01	3.17E-01	1.40E-01	1.29E+00	1.44E-01
Rec_dev1978	4.77E-01	2.08E-01	9.24E-01	1.24E-01	7.26E-01	1.27E-01	1.06E+00	1.79E-01
Rec_dev1979	6.51E-01	1.11E-01	3.20E-01	1.41E-01	3.87E-01	1.27E-01	4.21E-01	1.83E-01
Rec_dev1980	-3.94E-01	1.33E-01	-4.80E-02	1.20E-01	-1.97E-01	1.30E-01	-2.66E-01	1.54E-01
Rec_dev1981	-9.95E-01	1.47E-01	-8.16E-01	1.52E-01	-8.88E-01	1.57E-01	-7.69E-01	1.61E-01
Rec_dev1982	9.55E-01	4.10E-02	8.32E-01	4.45E-02	8.21E-01	4.50E-02	9.15E-01	4.83E-02
Rec_dev1983	-5.66E-01	1.13E-01	-6.46E-01	1.23E-01	-7.44E-01	1.40E-01	-7.68E-01	1.50E-01
Rec_dev1984	7.46E-01	4.58E-02	7.35E-01	4.68E-02	7.54E-01	4.80E-02	7.25E-01	5.11E-02
Rec_dev1985	-9.43E-02	7.14E-02	1.65E-01	6.62E-02	1.65E-01	6.91E-02	8.59E-02	7.47E-02
Rec_dev1986	-8.56E-01	9.59E-02	-7.23E-01	1.05E-01	-6.57E-01	1.07E-01	-8.54E-01	1.18E-01
Rec_dev1987	-1.21E+00	1.12E-01	-7.82E-01	9.49E-02	-9.06E-01	1.13E-01	-1.30E+00	1.46E-01
Rec_dev1988	-2.65E-01	5.69E-02	-3.25E-01	6.67E-02	-2.68E-01	6.84E-02	-2.73E-01	7.08E-02
Rec_dev1989	5.04E-01	3.93E-02	4.08E-01	4.54E-02	4.10E-01	4.68E-02	3.73E-01	5.10E-02
Rec_dev1990	3.20E-01	4.44E-02	4.32E-01	4.69E-02	4.52E-01	4.81E-02	3.12E-01	5.42E-02
Rec_dev1991	-3.38E-01	6.23E-02	-2.28E-01	6.98E-02	-2.36E-01	7.45E-02	-4.10E-01	8.14E-02
Rec_dev1992	5.98E-01	3.20E-02	5.64E-01	3.55E-02	6.06E-01	3.60E-02	4.77E-01	3.94E-02
Rec_dev1993	-4.31E-01	5.80E-02	-3.00E-01	6.01E-02	-3.05E-01	6.32E-02	-5.24E-01	7.01E-02
Rec_dev1994	-3.59E-01	5.10E-02	-4.61E-01	5.46E-02	-4.27E-01	5.60E-02	-5.81E-01	6.34E-02
Rec_dev1995	-2.93E-01	5.44E-02	-5.23E-01	5.68E-02	-5.30E-01	5.98E-02	-5.60E-01	6.73E-02
Rec_dev1996	6.63E-01	3.18E-02	3.92E-01	3.51E-02	3.90E-01	3.57E-02	4.83E-01	3.76E-02
Rec_dev1997	-2.30E-01	5.10E-02	-9.14E-02	4.78E-02	-9.35E-02	4.89E-02	-1.91E-01	5.72E-02
Rec_dev1998	-2.69E-01	5.00E-02	-6.24E-02	4.99E-02	-8.71E-02	5.09E-02	-2.05E-01	5.95E-02
Rec_dev1999	4.36E-01	3.15E-02	5.51E-01	3.29E-02	5.98E-01	3.36E-02	5.56E-01	3.58E-02
Rec_dev2000	-3.33E-02	3.73E-02	2.52E-01	4.02E-02	2.56E-01	4.11E-02	9.08E-02	4.44E-02
Rec_dev2001	-8.42E-01	5.87E-02	-5.81E-01	5.76E-02	-5.48E-01	5.95E-02	-7.21E-01	6.82E-02
Rec_dev2002	-2.85E-01	3.92E-02	-3.03E-01	4.33E-02	-2.66E-01	4.47E-02	-3.04E-01	4.99E-02
Rec_dev2003	-4.78E-01	4.73E-02	-4.77E-01	4.88E-02	-4.50E-01	5.03E-02	-4.51E-01	5.77E-02
Rec_dev2004	-5.98E-01	5.31E-02	-5.38E-01	5.29E-02	-5.29E-01	5.39E-02	-4.90E-01	6.27E-02
Rec_dev2005	-4.69E-01	5.15E-02	-4.81E-01	5.33E-02	-4.86E-01	5.64E-02	-4.01E-01	6.75E-02
Rec_dev2006	8.43E-01	3.52E-02	6.84E-01	3.63E-02	7.28E-01	3.54E-02	8.79E-01	4.05E-02
Rec_dev2007	-3.60E-01	6.87E-02	-1.45E-01	7.00E-02	-1.48E-01	7.20E-02	-1.14E-01	8.04E-02
Rec_dev2008	1.17E+00	4.90E-02	8.75E-01	5.74E-02	9.71E-01	5.64E-02	1.09E+00	5.39E-02
Rec_dev2009	-1.02E+00	1.50E-01	-1.40E+00	1.58E-01	-1.35E+00	1.63E-01	-1.26E+00	1.70E-01
Rec_dev2010	6.25E-01	7.97E-02	3.70E-01	1.04E-01	5.01E-01	1.05E-01	5.89E-01	9.53E-02
Rec_dev2011	1.06E+00	1.27E-01	8.93E-01	1.61E-01	1.03E+00	1.65E-01	1.10E+00	1.53E-01

Table 2.1.3c—Main selectivity parameters as estimated by, or specified for, Model 1. Many of these parameter values get over-written by block-specific values (see Table 2.1.3d). Parameter codes:
Par1 = *beginning_of_peak_region* (where the curve first reaches a value of 1.0)
Par2 = *width_of_peak_region* (where the curve first departs from a value of 1.0)
Par3 = *ascending_width* (equal to twice the variance of the underlying normal distribution)
Par4 = *descending_width* (equal to twice the variance of the underlying normal distribution)
Par5 = *initial_selectivity* (at minimum length/age)
Par6 = *final_selectivity* (at maximum length/age)

Parameter	Est.	SD	Parameter	Est.	SD
Par1_Jan-Apr_Trawl	0	n/a	Par1_Aug-Dec_Longline	0	n/a
Par2_Jan-Apr_Trawl	0	n/a	Par2_Aug-Dec_Longline	-2.16E+00	2.74E-01
Par3_Jan-Apr_Trawl	0	n/a	Par3_Aug-Dec_Longline	0	n/a
Par4_Jan-Apr_Trawl	0	n/a	Par4_Aug-Dec_Longline	5.14E+00	3.28E-01
Par5_Jan-Apr_Trawl	-999	n/a	Par5_Aug-Dec_Longline	-999	n/a
Par6_Jan-Apr_Trawl	10	n/a	Par6_Aug-Dec_Longline	0	n/a
Par1_May-Jul_Trawl	0	n/a	Par1_Jan-Apr_Pot	0	n/a
Par2_May-Jul_Trawl	0	n/a	Par2_Jan-Apr_Pot	-9.29E+00	1.72E+01
Par3_May-Jul_Trawl	5.63E+00	1.03E-01	Par3_Jan-Apr_Pot	5.01E+00	4.97E-02
Par4_May-Jul_Trawl	0	n/a	Par4_Jan-Apr_Pot	4.44E+00	2.86E-01
Par5_May-Jul_Trawl	-999	n/a	Par5_Jan-Apr_Pot	-999	n/a
Par6_May-Jul_Trawl	10	n/a	Par6_Jan-Apr_Pot	0	n/a
Par1_Aug-Dec_Trawl	0	n/a	Par1_May-Jul_Pot	0	n/a
Par2_Aug-Dec_Trawl	0	n/a	Par2_May-Jul_Pot	0	n/a
Par3_Aug-Dec_Trawl	0	n/a	Par3_May-Jul_Pot	4.92E+00	8.21E-02
Par4_Aug-Dec_Trawl	0	n/a	Par4_May-Jul_Pot	0	n/a
Par5_Aug-Dec_Trawl	-999	n/a	Par5_May-Jul_Pot	-999	n/a
Par6_Aug-Dec_Trawl	10	n/a	Par6_May-Jul_Pot	10	n/a
Par1_Jan-Apr_Longline	0	n/a	Par1_Aug-Dec_Pot	0	n/a
Par2_Jan-Apr_Longline	-4.92E+00	2.12E+00	Par2_Aug-Dec_Pot	0	n/a
Par3_Jan-Apr_Longline	0	n/a	Par3_Aug-Dec_Pot	0	n/a
Par4_Jan-Apr_Longline	5.08E+00	1.41E-01	Par4_Aug-Dec_Pot	0	n/a
Par5_Jan-Apr_Longline	-999	n/a	Par5_Aug-Dec_Pot	-999	n/a
Par6_Jan-Apr_Longline	0	n/a	Par6_Aug-Dec_Pot	10	n/a
Par1_May-Jul_Longline	0	n/a	AgeSel_1_Survey	1.29E+00	6.18E-02
Par2_May-Jul_Longline	0	n/a	AgeSel_2_Survey	-3.75E+00	8.53E-01
Par3_May-Jul_Longline	5.01E+00	5.16E-02	AgeSel_3_Survey	-1.99E+00	4.55E-01
Par4_May-Jul_Longline	0	n/a	AgeSel_4_Survey	3.03E+00	3.07E-01
Par5_May-Jul_Longline	-999	n/a	AgeSel_5_Survey	-9.99E+00	4.25E-01
Par6_May-Jul_Longline	10	n/a	AgeSel_6_Survey	-1.38E+00	4.20E-01

Table 2.1.3d—Block-specific selectivity parameters as estimated by Model 1. Years indicate beginning of selectivity blocks.

Parameter	Est.	SD	Parameter	Est.	SD
Par1_Jan-Apr_Trawl_1977	6.89E+01	3.11E+00	Par6_Jan-Apr_Longline_1990	-4.99E-01	1.37E-01
Par1_Jan-Apr_Trawl_1985	7.64E+01	1.68E+00	Par6_Jan-Apr_Longline_1995	-7.17E-01	1.40E-01
Par1_Jan-Apr_Trawl_1990	6.86E+01	1.08E+00	Par6_Jan-Apr_Longline_2000	-1.19E+00	1.46E-01
Par1_Jan-Apr_Trawl_1995	7.38E+01	9.33E-01	Par6_Jan-Apr_Longline_2005	-9.46E-01	1.50E-01
Par1_Jan-Apr_Trawl_2000	7.82E+01	1.18E+00	Par1_May-Jul_Longline_1977	6.33E+01	2.22E+00
Par1_Jan-Apr_Trawl_2005	7.54E+01	8.42E-01	Par1_May-Jul_Longline_1980	6.24E+01	1.36E+00
Par3_Jan-Apr_Trawl_1977	6.17E+00	1.74E-01	Par1_May-Jul_Longline_1985	6.33E+01	1.12E+00
Par3_Jan-Apr_Trawl_1985	6.63E+00	7.64E-02	Par1_May-Jul_Longline_1990	6.35E+01	5.22E-01
Par3_Jan-Apr_Trawl_1990	6.07E+00	5.83E-02	Par1_May-Jul_Longline_2000	5.98E+01	5.62E-01
Par3_Jan-Apr_Trawl_1995	6.29E+00	4.60E-02	Par1_May-Jul_Longline_2005	6.44E+01	5.48E-01
Par3_Jan-Apr_Trawl_2000	6.30E+00	6.03E-02	Par1_Aug-Dec_Longline_1977	6.05E+01	2.17E+00
Par3_Jan-Apr_Trawl_2005	6.02E+00	5.07E-02	Par1_Aug-Dec_Longline_1980	6.97E+01	1.60E+00
Par1_May-Jul_Trawl_1977	5.03E+01	1.69E+00	Par1_Aug-Dec_Longline_1985	6.44E+01	7.53E-01
Par1_May-Jul_Trawl_1985	5.13E+01	1.74E+00	Par1_Aug-Dec_Longline_1990	6.70E+01	7.15E-01
Par1_May-Jul_Trawl_1990	6.19E+01	1.52E+00	Par1_Aug-Dec_Longline_1995	6.94E+01	6.92E-01
Par1_May-Jul_Trawl_2000	5.31E+01	1.50E+00	Par1_Aug-Dec_Longline_2000	6.36E+01	4.27E-01
Par1_May-Jul_Trawl_2005	5.87E+01	1.44E+00	Par1_Aug-Dec_Longline_2005	6.28E+01	3.94E-01
Par1_Aug-Dec_Trawl_1977	6.25E+01	3.99E+00	Par3_Aug-Dec_Longline_1977	4.52E+00	3.21E-01
Par1_Aug-Dec_Trawl_1980	8.19E+01	5.60E+00	Par3_Aug-Dec_Longline_1980	5.41E+00	1.34E-01
Par1_Aug-Dec_Trawl_1985	8.67E+01	5.33E+00	Par3_Aug-Dec_Longline_1985	4.88E+00	8.64E-02
Par1_Aug-Dec_Trawl_1990	4.56E+01	1.49E+01	Par3_Aug-Dec_Longline_1990	5.03E+00	7.57E-02
Par1_Aug-Dec_Trawl_1995	1.02E+02	9.41E-01	Par3_Aug-Dec_Longline_1995	5.50E+00	5.28E-02
Par1_Aug-Dec_Trawl_2000	5.74E+01	2.02E+00	Par3_Aug-Dec_Longline_2000	5.18E+00	4.10E-02
Par3_Aug-Dec_Trawl_1977	5.55E+00	3.27E-01	Par3_Aug-Dec_Longline_2005	4.94E+00	4.04E-02
Par3_Aug-Dec_Trawl_1980	6.66E+00	2.27E-01	Par6_Aug-Dec_Longline_1977	-2.65E+00	2.25E+00
Par3_Aug-Dec_Trawl_1985	6.61E+00	2.29E-01	Par6_Aug-Dec_Longline_1980	4.17E-01	7.67E-01
Par3_Aug-Dec_Trawl_1990	3.22E+00	4.26E+00	Par6_Aug-Dec_Longline_1985	2.06E-01	2.53E-01
Par3_Aug-Dec_Trawl_1995	7.02E+00	9.09E-02	Par6_Aug-Dec_Longline_1990	2.42E+00	8.88E-01
Par3_Aug-Dec_Trawl_2000	5.27E+00	2.04E-01	Par6_Aug-Dec_Longline_1995	9.45E+00	1.40E+01
Par1_Jan-Apr_Longline_1977	5.88E+01	2.07E+00	Par6_Aug-Dec_Longline_2000	-3.86E-01	1.93E-01
Par1_Jan-Apr_Longline_1980	7.24E+01	2.48E+00	Par6_Aug-Dec_Longline_2005	9.75E+00	7.03E+00
Par1_Jan-Apr_Longline_1985	7.52E+01	9.11E-01	Par1_Jan-Apr_Pot_1977	6.88E+01	9.18E-01
Par1_Jan-Apr_Longline_1990	6.60E+01	4.74E-01	Par1_Jan-Apr_Pot_1995	6.85E+01	5.50E-01
Par1_Jan-Apr_Longline_1995	6.57E+01	4.26E-01	Par1_Jan-Apr_Pot_2000	6.81E+01	5.21E-01
Par1_Jan-Apr_Longline_2000	6.35E+01	4.45E-01	Par1_Jan-Apr_Pot_2005	6.87E+01	5.20E-01
Par1_Jan-Apr_Longline_2005	6.74E+01	3.91E-01	Par6_Jan-Apr_Pot_1977	2.10E-01	5.52E-01
Par3_Jan-Apr_Longline_1977	5.14E+00	2.10E-01	Par6_Jan-Apr_Pot_1995	-2.60E-01	2.49E-01
Par3_Jan-Apr_Longline_1980	5.91E+00	1.79E-01	Par6_Jan-Apr_Pot_2000	-5.73E-01	2.35E-01
Par3_Jan-Apr_Longline_1985	5.86E+00	6.70E-02	Par6_Jan-Apr_Pot_2005	1.98E-01	2.31E-01
Par3_Jan-Apr_Longline_1990	5.22E+00	4.63E-02	Par1_May-Jul_Pot_1977	6.72E+01	8.57E-01
Par3_Jan-Apr_Longline_1995	5.30E+00	3.97E-02	Par1_May-Jul_Pot_1995	6.59E+01	7.21E-01
Par3_Jan-Apr_Longline_2000	5.36E+00	4.17E-02	Par1_Aug-Dec_Pot_1977	6.84E+01	1.17E+00
Par3_Jan-Apr_Longline_2005	5.34E+00	3.40E-02	Par1_Aug-Dec_Pot_2000	6.31E+01	7.08E-01
Par6_Jan-Apr_Longline_1977	-1.33E+00	7.98E-01	Par3_Aug-Dec_Pot_1977	5.19E+00	1.19E-01
Par6_Jan-Apr_Longline_1980	3.74E-01	1.06E+00	Par3_Aug-Dec_Pot_2000	4.54E+00	1.05E-01
Par6_Jan-Apr_Longline_1985	-1.28E+00	4.62E-01			

Table 2.1.3e—Selectivity parameter *dev*s as estimated by Model 1.

Parameter	Est.	SD
Par3_Survey_dev1982	-4.93E-02	3.42E-02
Par3_Survey_dev1983	-5.64E-02	1.68E-02
Par3_Survey_dev1984	-9.14E-02	2.76E-02
Par3_Survey_dev1985	-1.25E-02	2.06E-02
Par3_Survey_dev1986	-6.03E-02	2.24E-02
Par3_Survey_dev1987	2.54E-02	4.20E-02
Par3_Survey_dev1988	-8.39E-02	3.27E-02
Par3_Survey_dev1989	-1.29E-01	1.81E-02
Par3_Survey_dev1990	-4.44E-02	2.04E-02
Par3_Survey_dev1991	-5.61E-02	2.17E-02
Par3_Survey_dev1992	7.72E-02	4.17E-02
Par3_Survey_dev1993	3.53E-02	2.93E-02
Par3_Survey_dev1994	-5.53E-02	2.12E-02
Par3_Survey_dev1995	-1.05E-01	1.92E-02
Par3_Survey_dev1996	-1.26E-01	1.73E-02
Par3_Survey_dev1997	-8.12E-02	1.47E-02
Par3_Survey_dev1998	-8.84E-02	1.85E-02
Par3_Survey_dev1999	-9.13E-02	1.70E-02
Par3_Survey_dev2000	-5.48E-02	1.53E-02
Par3_Survey_dev2001	1.37E-01	3.70E-02
Par3_Survey_dev2002	-2.99E-02	2.33E-02
Par3_Survey_dev2003	-1.72E-02	1.88E-02
Par3_Survey_dev2004	-3.85E-02	1.87E-02
Par3_Survey_dev2005	2.31E-02	2.52E-02
Par3_Survey_dev2006	1.30E-01	3.73E-02
Par3_Survey_dev2007	1.81E-01	3.73E-02
Par3_Survey_dev2008	9.77E-02	3.76E-02
Par3_Survey_dev2009	-3.02E-03	1.68E-02
Par3_Survey_dev2010	-1.48E-02	3.55E-02

Table 2.1.3f—Main selectivity parameters as estimated by Models 2-4.

	Model 2		Model 3		Model 4	
Parameter	Est.	SD	Est.	SD	Est.	SD
Par1_Season1	7.10E+01	4.84E-01	7.26E+01	4.83E-01	6.89E+01	4.94E-01
Par2_Season1	-9.49E+00	1.32E+01	-9.61E+00	1.06E+01	-9.43E+00	1.44E+01
Par3_Season1	5.76E+00	3.07E-02	5.80E+00	2.92E-02	5.71E+00	3.30E-02
Par4_Season1	5.06E+00	3.13E-01	6.05E+00	4.24E-01	5.02E+00	2.23E-01
Par5_Season1	-999	n/a	-999	n/a	-999	n/a
Par6_Season1	-4.23E-02	2.14E-01	-1.04E+00	7.21E-01	-2.24E-01	1.59E-01
Par1_Season2	7.15E+01	5.57E-01	7.35E+01	5.74E-01	6.91E+01	5.75E-01
Par2_Season2	-9.51E+00	1.28E+01	-9.57E+00	1.14E+01	-9.36E+00	1.59E+01
Par3_Season2	5.96E+00	3.10E-02	6.00E+00	2.96E-02	5.91E+00	3.40E-02
Par4_Season2	4.77E+00	4.42E-01	6.84E+00	4.38E-01	4.77E+00	2.82E-01
Par5_Season2	-999	n/a	-999	n/a	-999	n/a
Par6_Season2	4.05E-01	2.25E-01	-2.20E+00	1.54E+00	1.65E-01	1.58E-01
Par1_Season3	6.91E+01	7.43E-01	7.16E+01	7.75E-01	6.61E+01	7.49E-01
Par2_Season3	10	n/a	10	n/a	10	n/a
Par3_Season3	5.77E+00	4.93E-02	5.85E+00	4.75E-02	5.70E+00	5.37E-02
Par4_Season3	0	n/a	0	n/a	0	n/a
Par5_Season3	-999	n/a	-999	n/a	-999	n/a
Par6_Season3	10	n/a	10	n/a	10	n/a
Par1_Season4	6.67E+01	4.56E-01	6.92E+01	4.65E-01	6.45E+01	4.25E-01
Par2_Season4	8.31E-01	5.04E-01	4.24E-01	2.45E-01	-1.78E+00	3.28E-01
Par3_Season4	5.21E+00	3.69E-02	5.35E+00	3.36E-02	5.10E+00	3.86E-02
Par4_Season4	3.66E+00	3.32E+00	4.47E+00	9.95E-01	1.53E+00	2.21E+00
Par5_Season4	-999	n/a	-999	n/a	-999	n/a
Par6_Season4	-1.17E-01	1.78E+00	-1.95E+00	1.44E+00	2.07E+00	3.25E-01
Par1_Season5	6.61E+01	5.36E-01	6.84E+01	5.51E-01	6.36E+01	5.42E-01
Par2_Season5	-1.85E+00	5.64E-01	-1.79E+00	5.31E-01	-1.97E+00	4.52E-01
Par3_Season5	5.30E+00	4.38E-02	5.42E+00	4.06E-02	5.17E+00	4.91E-02
Par4_Season5	5.42E+00	1.08E+00	7.17E+00	7.49E-01	5.10E+00	6.41E-01
Par5_Season5	-999	n/a	-999	n/a	-999	n/a
Par6_Season5	3.40E-01	5.75E-01	-3.67E+00	4.95E+00	2.68E-01	2.71E-01
Par1_Survey	3.46E+01	7.74E-01	2.98E+01	5.87E-01	2.74E+01	1.17E+00
Par2_Survey	-8.93E+00	2.38E+01	10	n/a	-1.52572	0.184293
Par3_Survey	5.68E+00	3.83E-01	4.63E+00	4.64E-01	4.04E+00	4.77E-01
Par4_Survey	7.64E+00	4.00E-01	10	n/a	6.7493	0.271094
Par5_Survey	-9.91E-01	3.03E-01	-5.48E-01	2.54E-01	-3.96E-01	2.16E-01
Par6_Survey	-7.21E-01	5.61E-01	10	n/a	-1.1843	0.328352

Table 2.1.3g—Selectivity *dev*s for survey selectivity parameter #3 as estimated by Models 2-4.

	Model 2		Model 3		Model 4	
Parameter	Est.	SD	Est.	SD	Est.	SD
Par3_Survey_dev1982	-3.15E+00	6.85E-01	-3.75E+00	1.24E+00	-3.08E+00	1.42E+00
Par3_Survey_dev1983	-2.38E+00	6.63E-01	-2.75E+00	1.05E+00	-2.99E+00	1.18E+00
Par3_Survey_dev1984	-4.51E-01	4.75E-01	-2.94E-01	5.82E-01	-3.78E-01	5.97E-01
Par3_Survey_dev1985	1.48E-01	4.09E-01	4.55E-01	4.72E-01	5.98E-01	4.18E-01
Par3_Survey_dev1986	-1.02E+00	4.51E-01	-1.23E+00	5.41E-01	-1.59E+00	6.41E-01
Par3_Survey_dev1987	-1.31E-02	5.96E-01	4.38E-01	6.39E-01	9.24E-01	7.17E-01
Par3_Survey_dev1988	-9.14E-01	4.79E-01	-6.15E-01	6.22E-01	-3.01E-01	7.57E-01
Par3_Survey_dev1989	-5.33E+00	1.02E+00	-4.30E+00	1.53E+00	-2.70E+00	1.32E+00
Par3_Survey_dev1990	-1.93E+00	7.58E-01	-1.85E+00	9.96E-01	-1.78E+00	1.11E+00
Par3_Survey_dev1991	-1.18E+00	5.56E-01	-1.07E+00	7.34E-01	-9.43E-01	8.29E-01
Par3_Survey_dev1992	1.15E+00	1.03E+00	1.38E+00	9.55E-01	1.68E+00	1.01E+00
Par3_Survey_dev1993	1.04E+00	9.50E-01	1.23E+00	8.78E-01	1.47E+00	8.98E-01
Par3_Survey_dev1994	-3.92E-01	4.64E-01	-1.48E-02	5.82E-01	2.40E-01	5.78E-01
Par3_Survey_dev1995	-6.36E-01	4.48E-01	-4.60E-01	5.95E-01	-3.61E-01	6.29E-01
Par3_Survey_dev1996	-1.04E+00	5.15E-01	-8.76E-01	8.89E-01	-8.55E-01	8.57E-01
Par3_Survey_dev1997	-6.29E-01	5.15E-01	-1.52E-01	5.56E-01	-3.02E-01	4.91E-01
Par3_Survey_dev1998	-1.15E+00	4.46E-01	-1.49E+00	5.68E-01	-2.08E+00	8.10E-01
Par3_Survey_dev1999	-1.39E+00	4.43E-01	-1.30E+00	5.55E-01	-1.37E+00	6.10E-01
Par3_Survey_dev2000	-2.86E+00	6.25E-01	-3.11E+00	8.97E-01	-3.29E+00	1.05E+00
Par3_Survey_dev2001	1.42E+00	8.39E-01	1.81E+00	7.85E-01	2.26E+00	8.81E-01
Par3_Survey_dev2002	-2.04E+00	5.37E-01	-2.69E+00	8.78E-01	-2.68E+00	1.19E+00
Par3_Survey_dev2003	4.72E-01	5.03E-01	8.35E-01	5.41E-01	8.32E-01	4.65E-01
Par3_Survey_dev2004	-2.32E-01	5.87E-01	3.43E-01	5.86E-01	4.44E-01	5.41E-01
Par3_Survey_dev2005	7.59E-01	5.40E-01	1.09E+00	5.60E-01	9.38E-01	4.41E-01
Par3_Survey_dev2006	-3.85E+00	1.06E+00	-2.81E+00	1.74E+00	-1.75E+00	2.17E+00
Par3_Survey_dev2007	1.52E+00	1.50E+00	2.01E+00	1.40E+00	2.22E+00	1.39E+00
Par3_Survey_dev2008	-1.17E+00	5.58E-01	-1.26E+00	6.62E-01	-1.68E+00	8.53E-01
Par3_Survey_dev2009	-1.64E+00	5.11E-01	-1.94E+00	7.33E-01	-2.37E+00	9.52E-01
Par3_Survey_dev2010	-1.02E-01	1.29E+00	-1.01E+00	1.07E+00	-1.35E+00	1.26E+00

Table 2.1.3h—Selectivity *dev*s for survey selectivity parameter #5 as estimated by Models 2-4.

	Model 2		Model 3		Model 4	
Parameter	Est.	SD	Est.	SD	Est.	SD
Par5_Survey_dev1982	-4.46E-01	4.54E-01	-5.54E-01	4.59E-01	-6.49E-01	4.75E-01
Par5_Survey_dev1983	2.17E-01	3.55E-01	-6.26E-02	3.24E-01	-1.58E-01	3.00E-01
Par5_Survey_dev1984	-8.63E-01	7.43E-01	-7.97E-01	6.20E-01	-7.67E-01	5.77E-01
Par5_Survey_dev1985	-1.76E+00	7.71E-01	-1.82E+00	7.04E-01	-1.67E+00	6.61E-01
Par5_Survey_dev1986	-3.79E-01	4.29E-01	-6.02E-01	3.72E-01	-6.25E-01	3.56E-01
Par5_Survey_dev1987	-7.37E-01	9.73E-01	-9.24E-01	9.20E-01	-6.90E-01	9.99E-01
Par5_Survey_dev1988	-1.36E+00	7.26E-01	-1.38E+00	6.64E-01	-9.96E-01	7.27E-01
Par5_Survey_dev1989	-1.10E+00	3.89E-01	-1.40E+00	3.72E-01	-1.48E+00	3.60E-01
Par5_Survey_dev1990	2.55E-01	3.82E-01	1.03E-02	3.60E-01	6.74E-02	3.50E-01
Par5_Survey_dev1991	-2.63E-01	4.36E-01	-4.69E-01	3.87E-01	-3.91E-01	3.83E-01
Par5_Survey_dev1992	-4.69E-01	1.02E+00	-4.72E-01	1.04E+00	-2.81E-01	1.10E+00
Par5_Survey_dev1993	-4.79E-01	9.87E-01	-5.04E-01	9.96E-01	-4.22E-01	1.02E+00
Par5_Survey_dev1994	-1.04E+00	8.11E-01	-1.07E+00	7.61E-01	-1.06E+00	7.56E-01
Par5_Survey_dev1995	-1.27E+00	7.32E-01	-1.28E+00	6.23E-01	-1.26E+00	5.97E-01
Par5_Survey_dev1996	-1.23E+00	6.43E-01	-1.26E+00	6.09E-01	-1.52E+00	5.42E-01
Par5_Survey_dev1997	-7.39E-01	6.65E-01	-9.36E-01	5.65E-01	-1.13E+00	4.00E-01
Par5_Survey_dev1998	-9.42E-01	4.36E-01	-1.07E+00	3.52E-01	-1.03E+00	3.31E-01
Par5_Survey_dev1999	-9.24E-01	3.90E-01	-1.15E+00	3.44E-01	-1.11E+00	3.24E-01
Par5_Survey_dev2000	-1.80E-01	3.31E-01	-4.93E-01	2.91E-01	-5.60E-01	2.63E-01
Par5_Survey_dev2001	-9.38E-01	9.07E-01	-1.06E+00	8.95E-01	-8.11E-01	9.42E-01
Par5_Survey_dev2002	9.06E-02	3.77E-01	-1.78E-01	3.48E-01	-9.36E-02	3.47E-01
Par5_Survey_dev2003	-1.10E+00	8.89E-01	-1.22E+00	8.56E-01	-1.35E+00	8.11E-01
Par5_Survey_dev2004	-6.38E-01	9.71E-01	-9.54E-01	8.61E-01	-1.11E+00	7.92E-01
Par5_Survey_dev2005	-1.34E+00	8.63E-01	-1.37E+00	8.55E-01	-1.61E+00	8.05E-01
Par5_Survey_dev2006	1.68E+00	3.92E-01	2.01E+00	5.22E-01	1.85E+00	5.32E-01
Par5_Survey_dev2007	3.18E+00	6.93E-01	2.95E+00	7.21E-01	2.59E+00	7.65E-01
Par5_Survey_dev2008	1.03E+00	4.01E-01	8.72E-01	3.86E-01	9.12E-01	3.95E-01
Par5_Survey_dev2009	1.30E+00	3.66E-01	8.73E-01	3.23E-01	7.28E-01	2.94E-01
Par5_Survey_dev2010	2.93E-01	1.19E+00	5.77E-01	5.73E-01	5.38E-01	5.74E-01

Table 2.1.4a— Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model 1). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov-Dec. Rates have been 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	0.087	0.090	0.056	0.049	0.043	0.017	0.017	0.006	0.024	0.032	0	0	0	0	0	0.081
1978	0.099	0.103	0.067	0.057	0.050	0.017	0.017	0.006	0.026	0.035	0	0	0	0	0	0.093
1979	0.072	0.074	0.044	0.040	0.034	0.013	0.013	0.005	0.019	0.025	0	0	0	0	0	0.066
1980	0.064	0.063	0.031	0.042	0.035	0.010	0.010	0.004	0.014	0.017	0	0	0	0	0	0.056
1981	0.034	0.033	0.032	0.064	0.061	0.004	0.004	0.002	0.009	0.011	0	0	0	0	0	0.051
1982	0.035	0.035	0.036	0.045	0.036	0.001	0.001	0.001	0.004	0.005	0	0	0	0	0	0.040
1983	0.054	0.057	0.051	0.053	0.044	0.005	0.005	0.003	0.004	0.005	0	0	0	0	0	0.056
1984	0.062	0.066	0.057	0.056	0.049	0.007	0.008	0.006	0.028	0.038	0	0	0	0	0	0.075
1985	0.078	0.084	0.066	0.065	0.051	0.024	0.026	0.010	0.034	0.047	0	0	0	0	0	0.096
1986	0.088	0.093	0.066	0.065	0.053	0.017	0.019	0.005	0.027	0.038	0	0	0	0	0	0.092
1987	0.096	0.103	0.052	0.053	0.052	0.042	0.045	0.013	0.042	0.060	0	0	0	0	0	0.107
1988	0.194	0.209	0.101	0.113	0.120	0.001	0.001	0.002	0.003	0.004	0	0	0	0	0	0.143
1989	0.206	0.224	0.098	0.059	0.054	0.008	0.009	0.012	0.015	0.013	0.000	0.000	0.000	0.000	0.000	0.132
1990	0.174	0.191	0.092	0.029	0.025	0.031	0.034	0.047	0.051	0.047	0.000	0.000	0.002	0.002	0.001	0.139
1991	0.179	0.378	0.067	0.048	0.000	0.061	0.105	0.087	0.099	0.108	0.000	0.000	0.002	0.010	0.004	0.217
1992	0.147	0.223	0.055	0.033	0.010	0.133	0.240	0.141	0.091	0.000	0.000	0.002	0.030	0.011	0.000	0.216
1993	0.187	0.256	0.028	0.037	0.011	0.223	0.229	0.027	0.000	0.000	0.000	0.011	0.006	0.000	0.000	0.177
1994	0.085	0.293	0.019	0.075	0.014	0.188	0.263	0.029	0.103	0.000	0.000	0.031	0.009	0.016	0.000	0.208
1995	0.210	0.422	0.005	0.193	0.002	0.241	0.308	0.020	0.106	0.057	0.001	0.076	0.039	0.015	0.010	0.316
1996	0.141	0.367	0.037	0.105	0.021	0.235	0.260	0.018	0.118	0.023	0.000	0.126	0.054	0.022	0.005	0.285
1997	0.175	0.396	0.024	0.097	0.024	0.262	0.279	0.042	0.113	0.193	0.000	0.097	0.040	0.020	0.005	0.323
1998	0.122	0.224	0.022	0.136	0.016	0.287	0.208	0.023	0.093	0.116	0.000	0.062	0.034	0.011	0.000	0.252
1999	0.147	0.214	0.016	0.063	0.004	0.329	0.236	0.019	0.121	0.042	0.000	0.062	0.034	0.013	0.000	0.239
2000	0.164	0.215	0.019	0.027	0.003	0.291	0.081	0.008	0.126	0.136	0.132	0.049	0.000	0.001	0.000	0.223
2001	0.068	0.116	0.015	0.035	0.005	0.165	0.148	0.018	0.156	0.149	0.001	0.114	0.003	0.018	0.004	0.190
2002	0.103	0.174	0.031	0.035	0.002	0.307	0.137	0.008	0.184	0.110	0.018	0.087	0.005	0.015	0.006	0.226
2003	0.126	0.136	0.028	0.031	0.000	0.312	0.161	0.013	0.183	0.137	0.136	0.018	0.000	0.024	0.010	0.243
2004	0.169	0.146	0.041	0.038	0.000	0.328	0.159	0.013	0.171	0.165	0.088	0.030	0.005	0.019	0.004	0.254
2005	0.223	0.136	0.036	0.014	0.001	0.455	0.071	0.020	0.191	0.167	0.087	0.033	0.000	0.025	0.003	0.268
2006	0.267	0.146	0.036	0.025	0.000	0.521	0.078	0.013	0.267	0.009	0.121	0.042	0.002	0.025	0.008	0.291
2007	0.169	0.194	0.066	0.020	0.001	0.568	0.028	0.009	0.213	0.008	0.140	0.017	0.004	0.036	0.000	0.274
2008	0.184	0.094	0.027	0.042	0.006	0.608	0.059	0.021	0.253	0.089	0.129	0.031	0.002	0.050	0.001	0.299
2009	0.157	0.134	0.026	0.059	0.003	0.698	0.062	0.019	0.254	0.103	0.151	0.030	0.001	0.010	0.012	0.317
2010	0.189	0.098	0.021	0.050	0.010	0.512	0.026	0.016	0.133	0.098	0.150	0.025	0.002	0.031	0.015	0.251
2011	0.194	0.199	0.028	0.049	0.009	0.272	0.258	0.073	0.143	0.110	0.158	0.025	0.008	0.045	0.000	0.291
2012	0.294	0.117	0.032	0.038	0.006	0.253	0.197	0.093	0.115	0.073	0.164	0.021	0.001	0.021	0.005	0.263

Table 2.1.4b—Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Models 2-3). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Jul, Sea4=Aug-Oct, Sea5=Nov-Dec. Rates have been multiplied by relative season length before summing to get total.

	Model 2						Model 3						Model 4					
Year	Sea1	Sea2	Sea3	Sea4	Sea5	Total	Sea1	Sea2	Sea3	Sea4	Sea5	Total	Sea1	Sea2	Sea3	Sea4	Sea5	Total
1977	0.946	0.957	0.665	0.628	0.572	0.735	1.287	1.313	0.977	0.936	0.824	1.049	0.229	0.218	0.131	0.128	0.123	0.159
1978	1.037	0.991	0.669	0.598	0.568	0.749	1.479	1.438	1.031	0.937	0.864	1.122	0.222	0.207	0.127	0.118	0.116	0.152
1979	0.653	0.632	0.433	0.392	0.350	0.479	0.989	0.971	0.700	0.645	0.568	0.758	0.132	0.125	0.080	0.075	0.069	0.093
1980	0.535	0.473	0.295	0.249	0.200	0.337	0.861	0.769	0.504	0.429	0.334	0.561	0.107	0.095	0.058	0.052	0.045	0.069
1981	0.198	0.168	0.182	0.214	0.185	0.191	0.323	0.272	0.303	0.359	0.300	0.315	0.046	0.041	0.045	0.057	0.053	0.049
1982	0.120	0.109	0.119	0.098	0.077	0.105	0.190	0.170	0.189	0.155	0.116	0.166	0.036	0.034	0.038	0.034	0.028	0.034
1983	0.147	0.144	0.128	0.099	0.085	0.119	0.217	0.210	0.190	0.145	0.120	0.175	0.055	0.055	0.048	0.040	0.036	0.047
1984	0.172	0.176	0.147	0.157	0.174	0.163	0.236	0.238	0.207	0.221	0.234	0.225	0.074	0.076	0.061	0.071	0.079	0.071
1985	0.210	0.217	0.161	0.149	0.158	0.175	0.277	0.284	0.224	0.208	0.211	0.237	0.095	0.099	0.069	0.069	0.074	0.079
1986	0.219	0.221	0.147	0.129	0.138	0.165	0.287	0.286	0.202	0.178	0.181	0.220	0.103	0.105	0.066	0.063	0.069	0.078
1987	0.273	0.276	0.132	0.136	0.172	0.187	0.352	0.353	0.175	0.182	0.221	0.244	0.136	0.138	0.062	0.070	0.089	0.094
1988	0.381	0.390	0.193	0.144	0.162	0.240	0.481	0.490	0.252	0.190	0.205	0.306	0.199	0.202	0.094	0.076	0.087	0.124
1989	0.387	0.399	0.185	0.088	0.086	0.214	0.479	0.492	0.236	0.112	0.105	0.267	0.210	0.216	0.095	0.048	0.048	0.115
1990	0.369	0.390	0.219	0.124	0.119	0.232	0.443	0.465	0.271	0.155	0.143	0.281	0.209	0.219	0.115	0.070	0.068	0.129
1991	0.451	0.896	0.264	0.265	0.200	0.390	0.530	1.057	0.327	0.338	0.245	0.471	0.257	0.499	0.134	0.144	0.108	0.214
1992	0.546	0.860	0.418	0.258	0.027	0.408	0.659	1.046	0.535	0.341	0.034	0.509	0.293	0.450	0.199	0.131	0.014	0.209
1993	0.754	0.884	0.108	0.081	0.024	0.324	0.941	1.113	0.140	0.107	0.031	0.409	0.389	0.448	0.051	0.042	0.013	0.165
1994	0.478	1.035	0.101	0.340	0.030	0.367	0.588	1.279	0.127	0.434	0.037	0.458	0.266	0.569	0.052	0.190	0.018	0.203
1995	0.755	1.335	0.106	0.356	0.113	0.482	0.909	1.622	0.133	0.450	0.137	0.591	0.438	0.747	0.055	0.199	0.064	0.272
1996	0.654	1.283	0.196	0.323	0.067	0.464	0.782	1.546	0.246	0.409	0.081	0.565	0.373	0.714	0.103	0.181	0.039	0.259
1997	0.817	1.459	0.211	0.348	0.425	0.590	0.973	1.751	0.265	0.436	0.516	0.715	0.470	0.809	0.109	0.191	0.234	0.327
1998	0.841	1.047	0.176	0.385	0.292	0.504	1.006	1.260	0.222	0.489	0.358	0.615	0.456	0.548	0.086	0.200	0.152	0.264
1999	1.077	1.187	0.169	0.399	0.107	0.537	1.303	1.458	0.219	0.523	0.135	0.668	0.545	0.571	0.075	0.190	0.051	0.261
2000	1.299	0.771	0.079	0.351	0.304	0.503	1.625	0.975	0.104	0.464	0.387	0.640	0.617	0.356	0.035	0.168	0.149	0.238
2001	0.520	0.772	0.093	0.460	0.332	0.409	0.650	0.967	0.121	0.594	0.416	0.518	0.257	0.378	0.044	0.230	0.168	0.202
2002	0.872	0.791	0.115	0.482	0.228	0.464	1.079	0.985	0.149	0.626	0.287	0.585	0.438	0.389	0.054	0.241	0.116	0.231
2003	1.065	0.582	0.096	0.437	0.253	0.450	1.318	0.721	0.124	0.561	0.313	0.563	0.538	0.290	0.046	0.227	0.134	0.229
2004	0.972	0.544	0.121	0.371	0.264	0.420	1.183	0.662	0.152	0.464	0.318	0.515	0.515	0.284	0.061	0.201	0.145	0.223
2005	1.184	0.383	0.101	0.396	0.304	0.436	1.409	0.455	0.124	0.487	0.361	0.524	0.638	0.201	0.051	0.212	0.163	0.233
2006	1.443	0.439	0.098	0.580	0.034	0.489	1.696	0.519	0.121	0.721	0.040	0.586	0.745	0.218	0.046	0.289	0.017	0.247
2007	1.413	0.430	0.157	0.506	0.017	0.476	1.672	0.512	0.195	0.634	0.021	0.575	0.683	0.201	0.069	0.237	0.008	0.225
2008	1.608	0.335	0.103	0.709	0.211	0.562	1.921	0.404	0.129	0.898	0.259	0.687	0.731	0.146	0.043	0.310	0.091	0.250
2009	1.807	0.429	0.108	0.743	0.260	0.629	2.207	0.530	0.138	0.963	0.327	0.786	0.748	0.169	0.041	0.295	0.104	0.254
2010	1.633	0.279	0.093	0.479	0.261	0.505	2.024	0.347	0.118	0.609	0.319	0.630	0.647	0.109	0.036	0.197	0.110	0.203
2011	1.170	0.906	0.244	0.570	0.279	0.596	1.406	1.088	0.301	0.701	0.332	0.722	0.487	0.362	0.093	0.225	0.112	0.240
2012	1.411	0.670	0.297	0.428	0.204	0.562	1.648	0.780	0.356	0.510	0.232	0.660	0.552	0.253	0.108	0.164	0.079	0.215

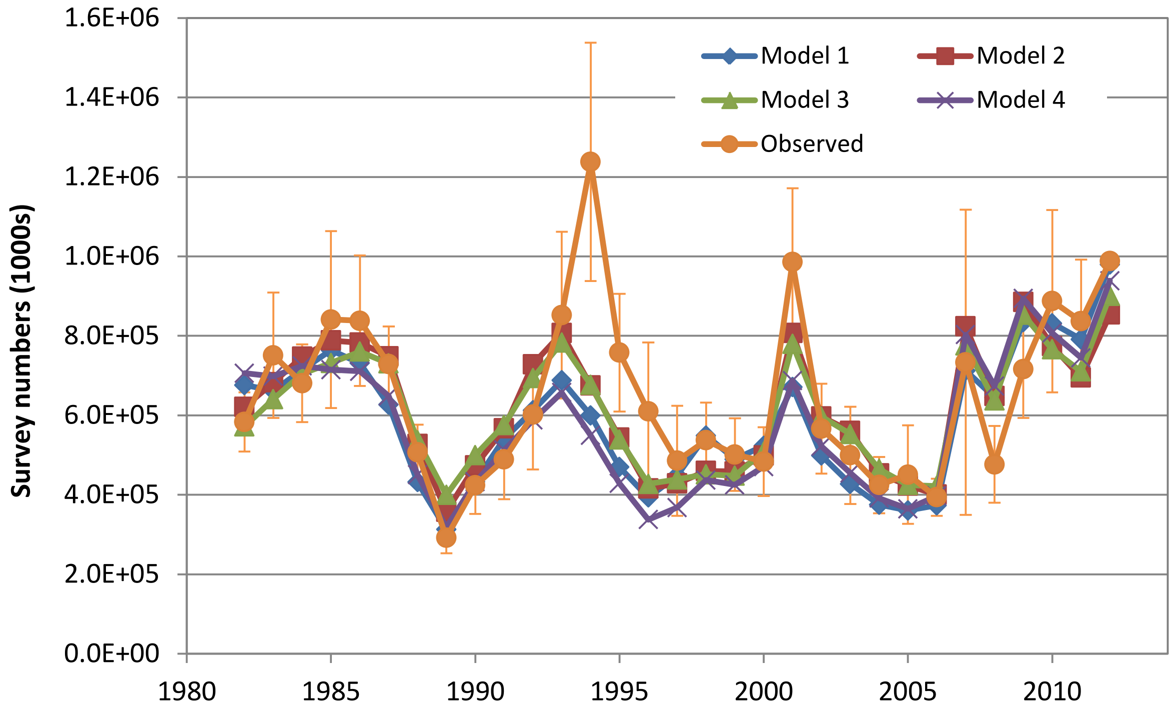

Figure 2.1.1—Fit of the four models to the trawl survey abundance time series.

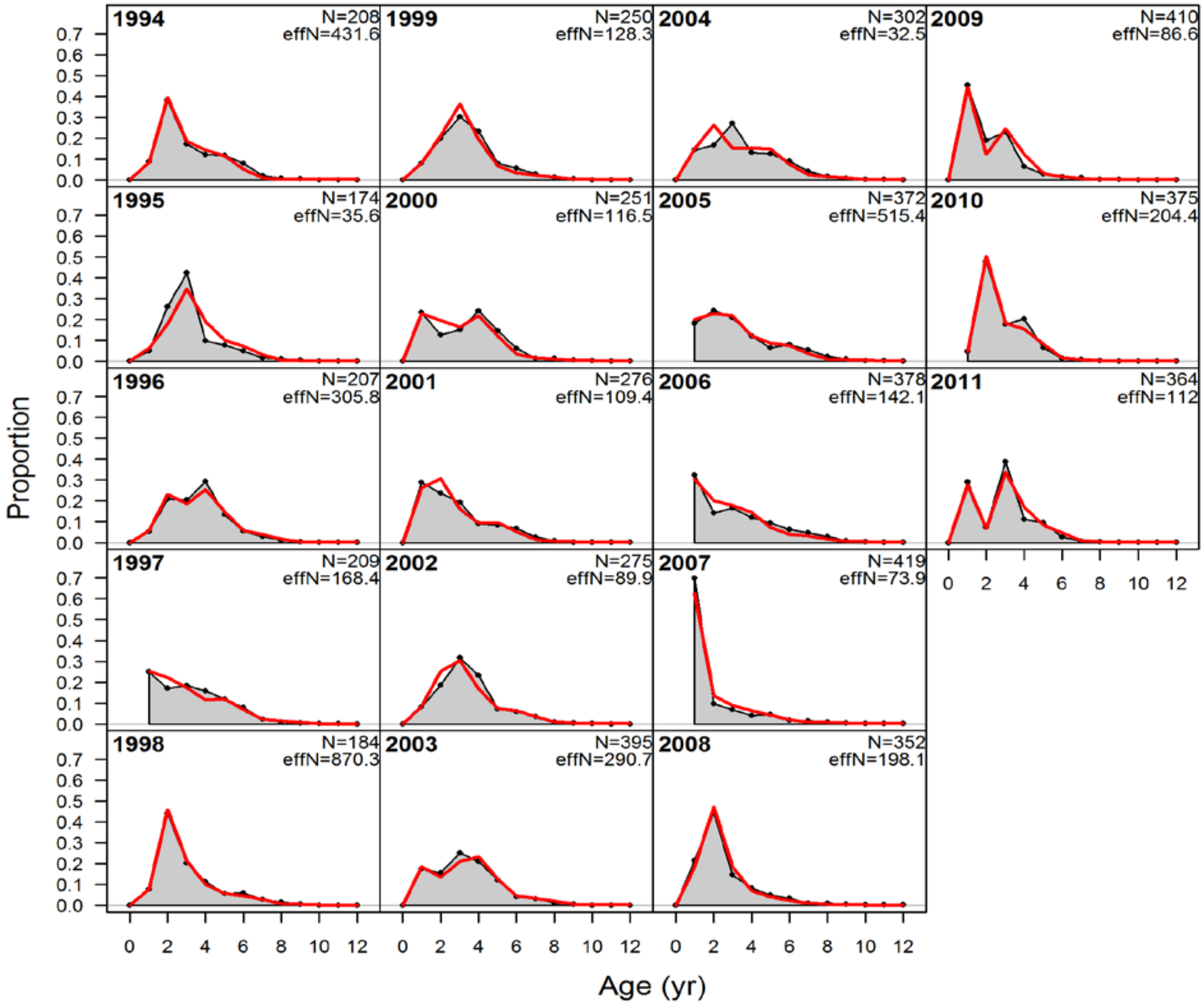

Figure 2.1.2a—Model 1's fit to the survey age composition data (grey = observed, red = estimated).

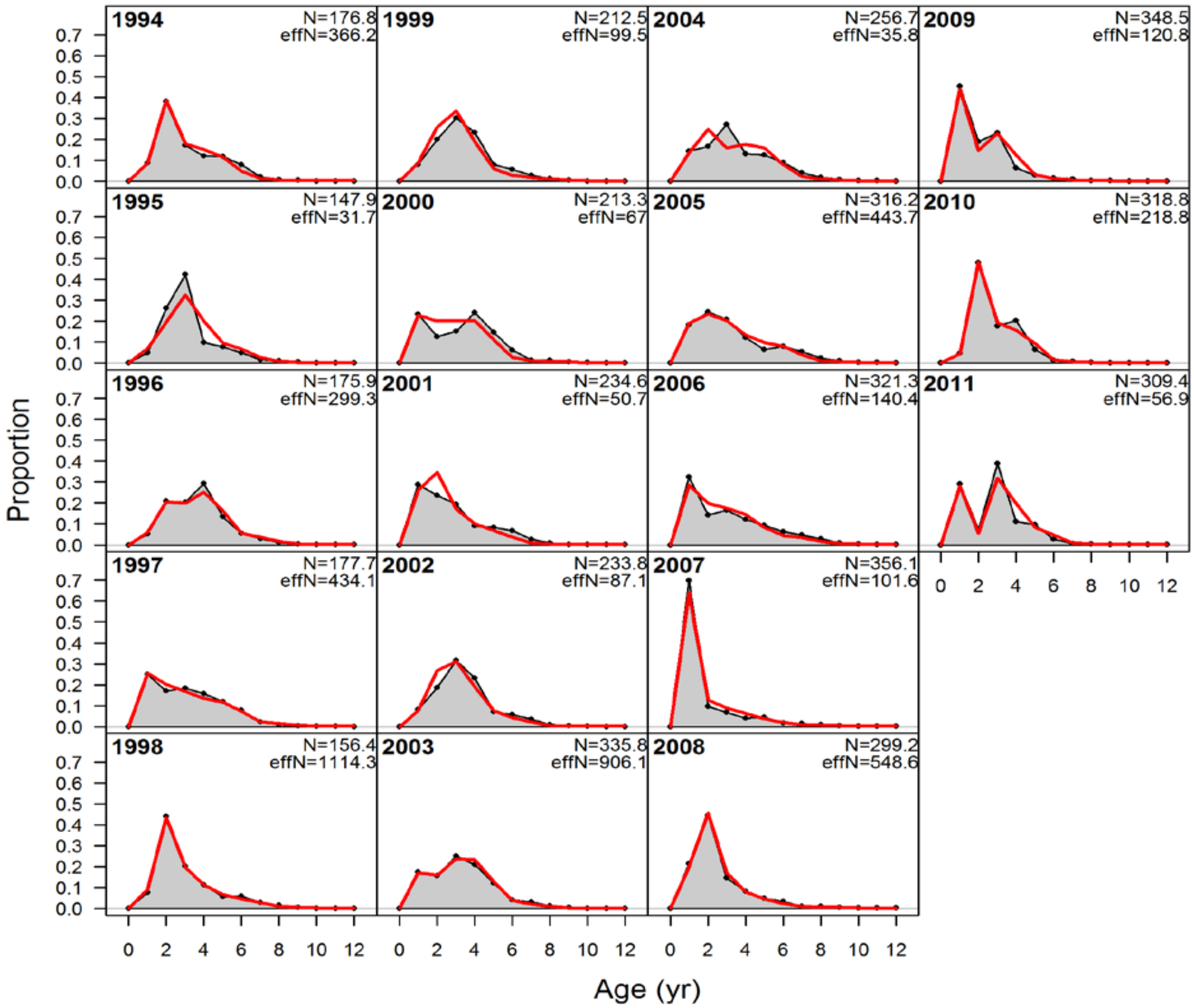

Figure 2.1.2b—Model 2's fit to the survey age composition data (grey = observed, red = estimated).

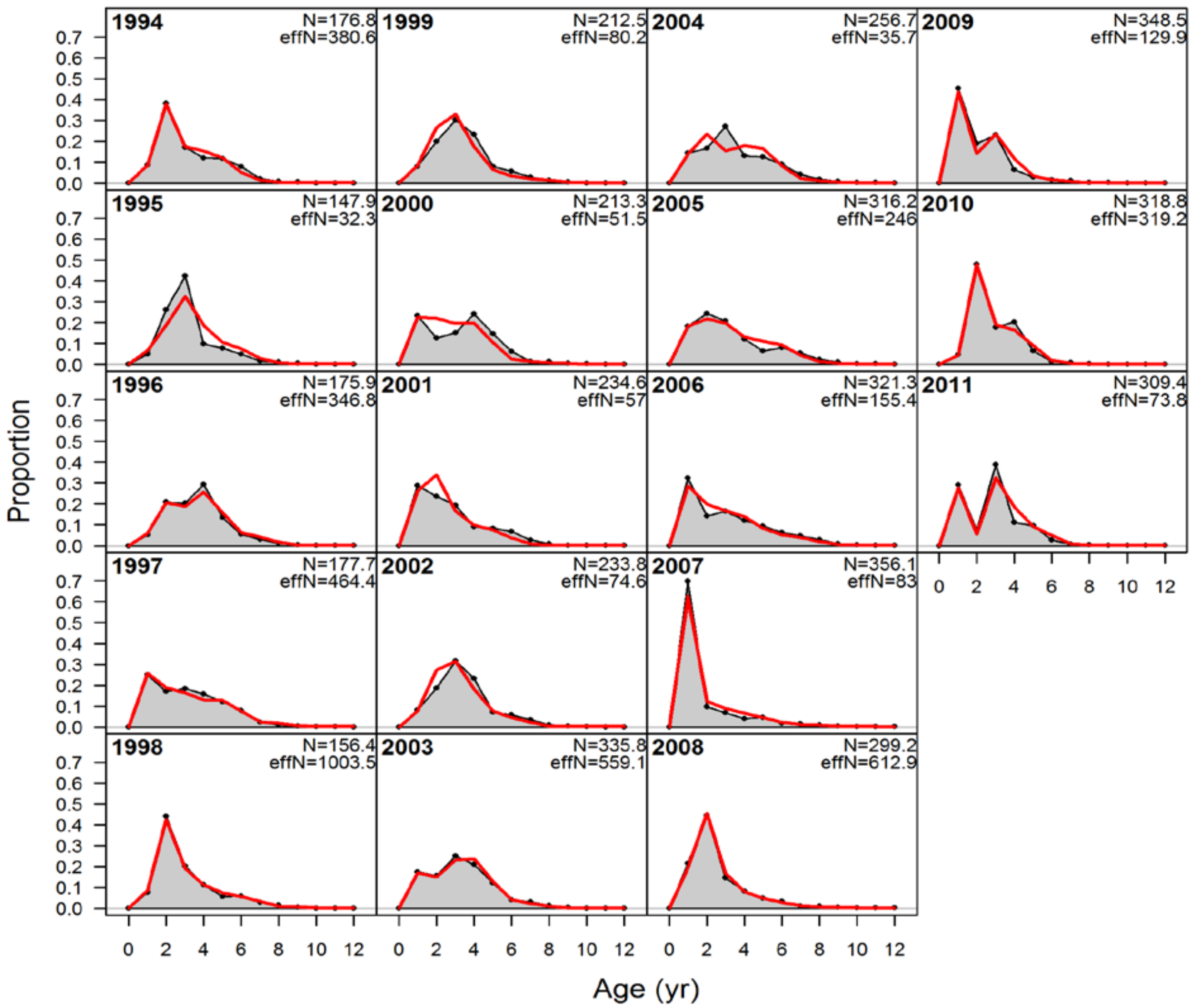

Figure 2.1.2c—Model 3's fit to the survey age composition data (grey = observed, red = estimated).

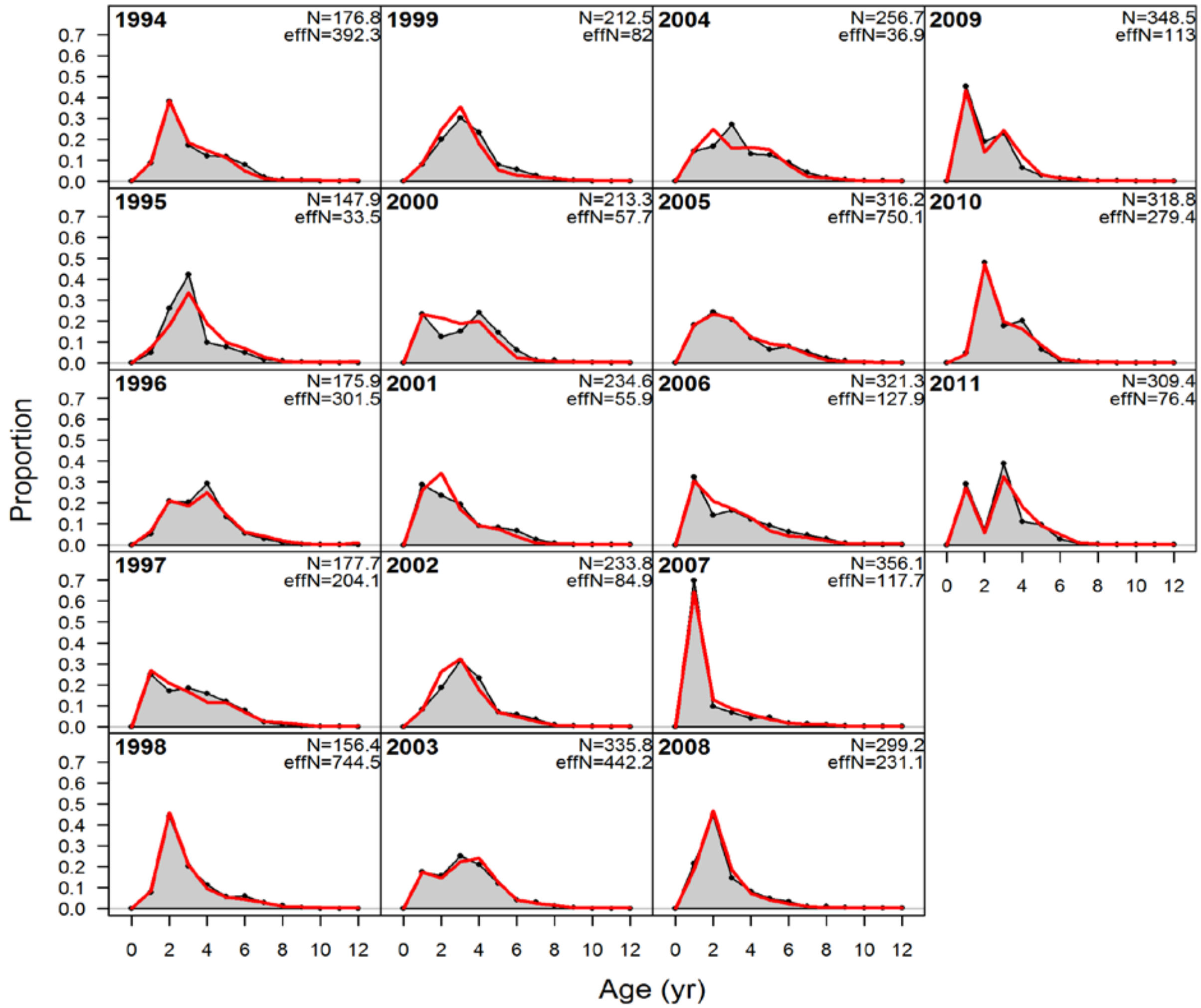

Figure 2.1.2d—Model 4's fit to the survey age composition data (grey = observed, red = estimated).

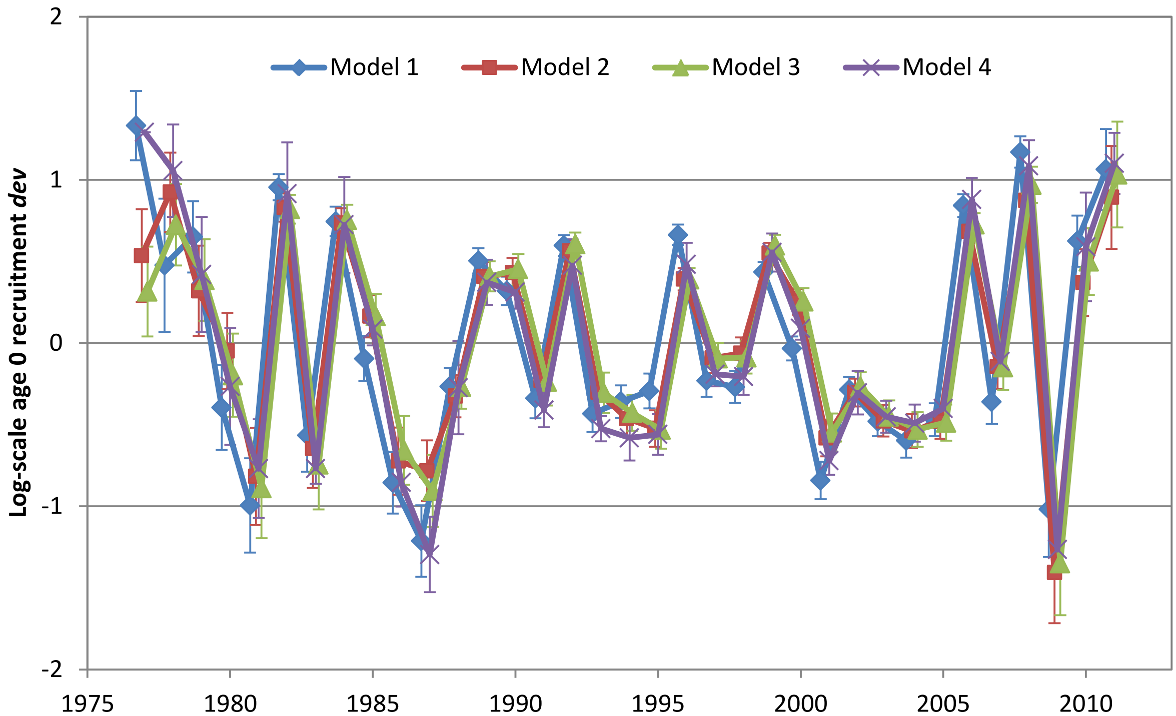

Figure 2.1.3—Time series of log recruitment deviations estimated by the four models. Horizontal axis values have been offset slightly between models to improve visibility.

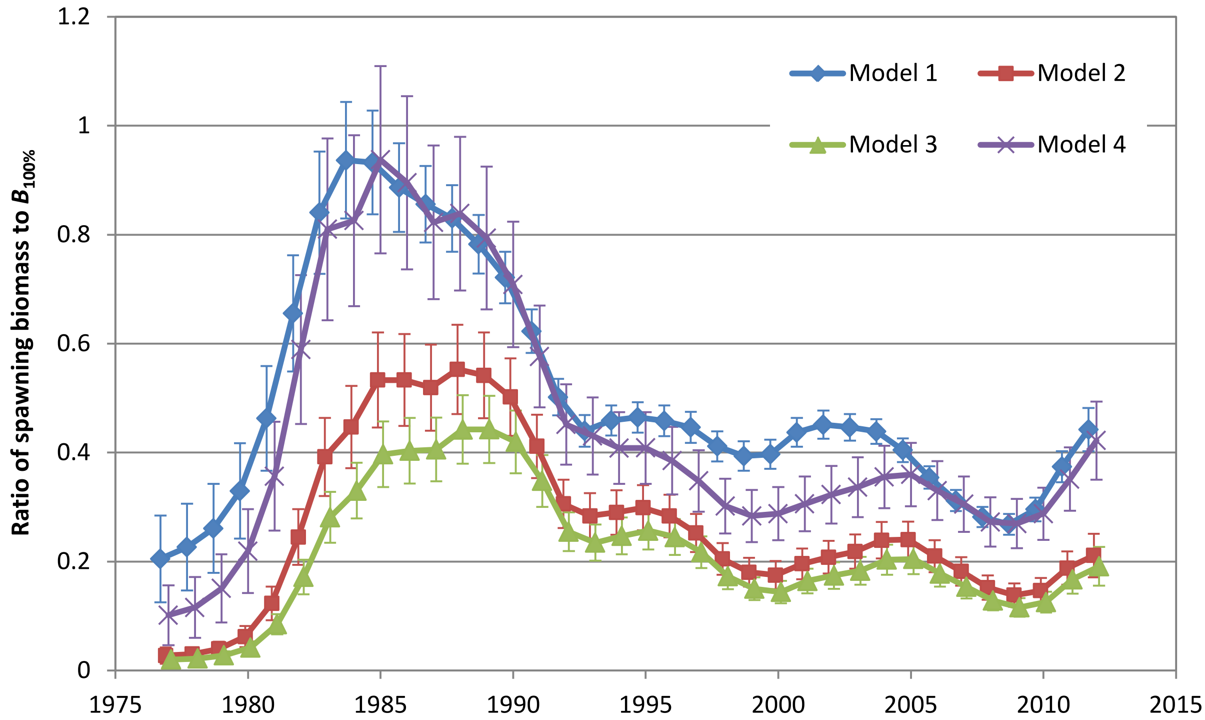

Figure 2.1.4—Time series of spawning biomass relative to $B_{100\%}$ as estimated by the four models.

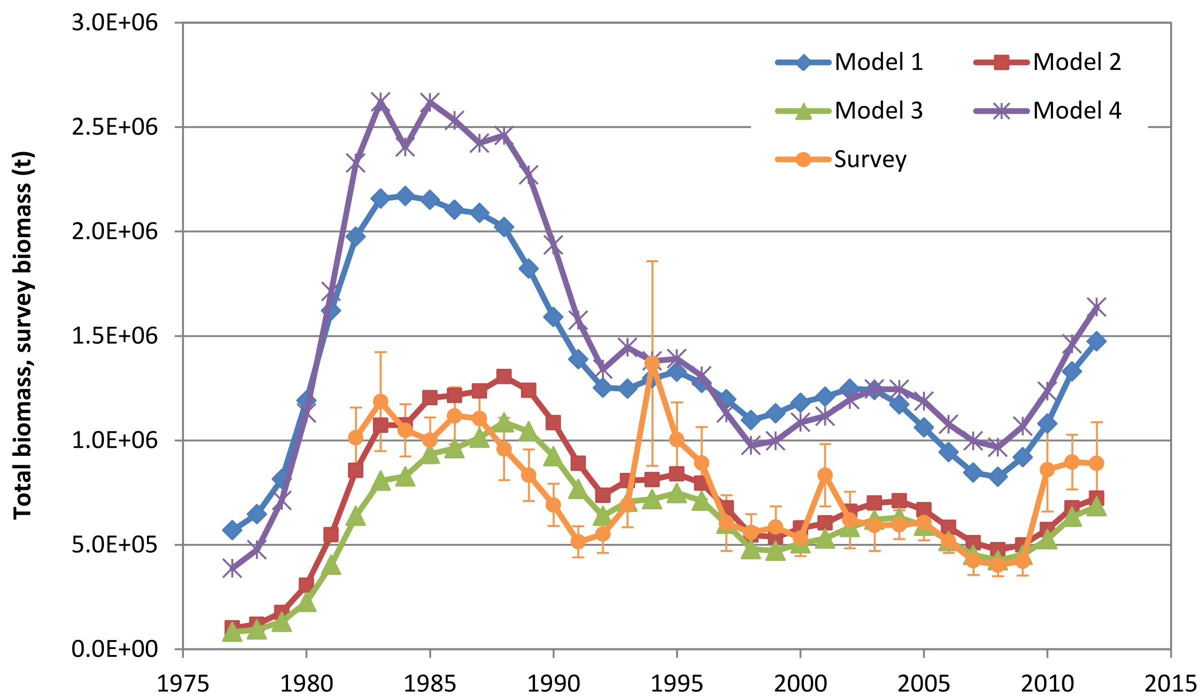

Figure 2.1.5— Time series of total (age 0+) biomass as estimated by the four models. Survey biomass is shown for comparison.

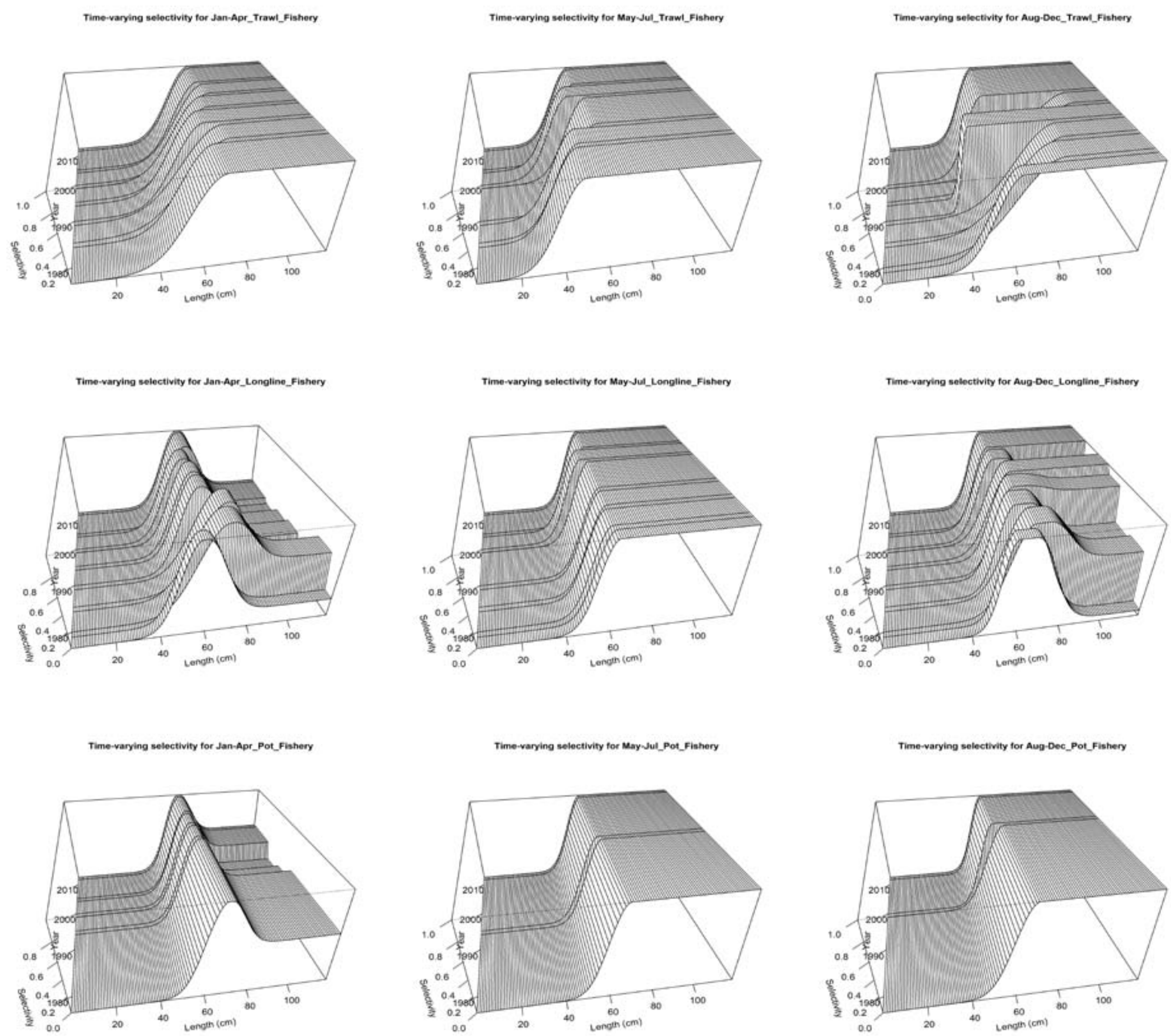

Figure 2.1.6a—Fishery selectivity at length (cm) as estimated by Model 1. Rows represent gear types (trawl, longline, and pot, respectively), and columns represent seasons (Jan-Apr, May-Jul, and Aug-Dec, respectively).

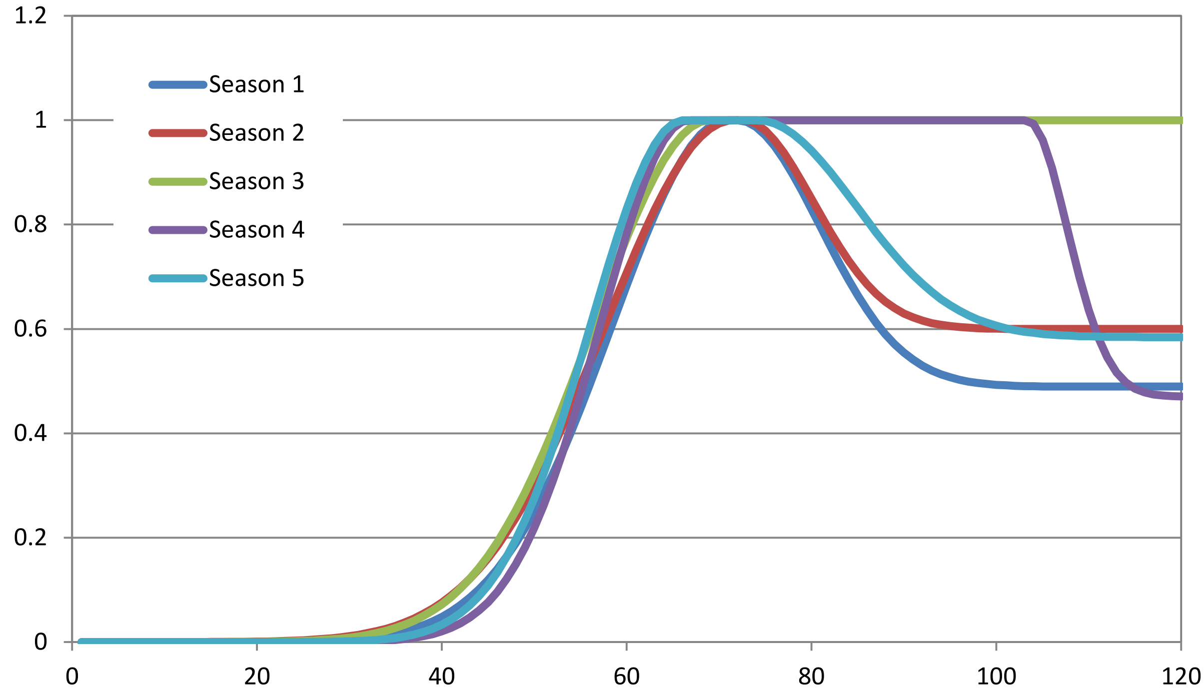

Figure 2.1.6b—Fishery selectivity at length (cm) as estimated by Model 2.

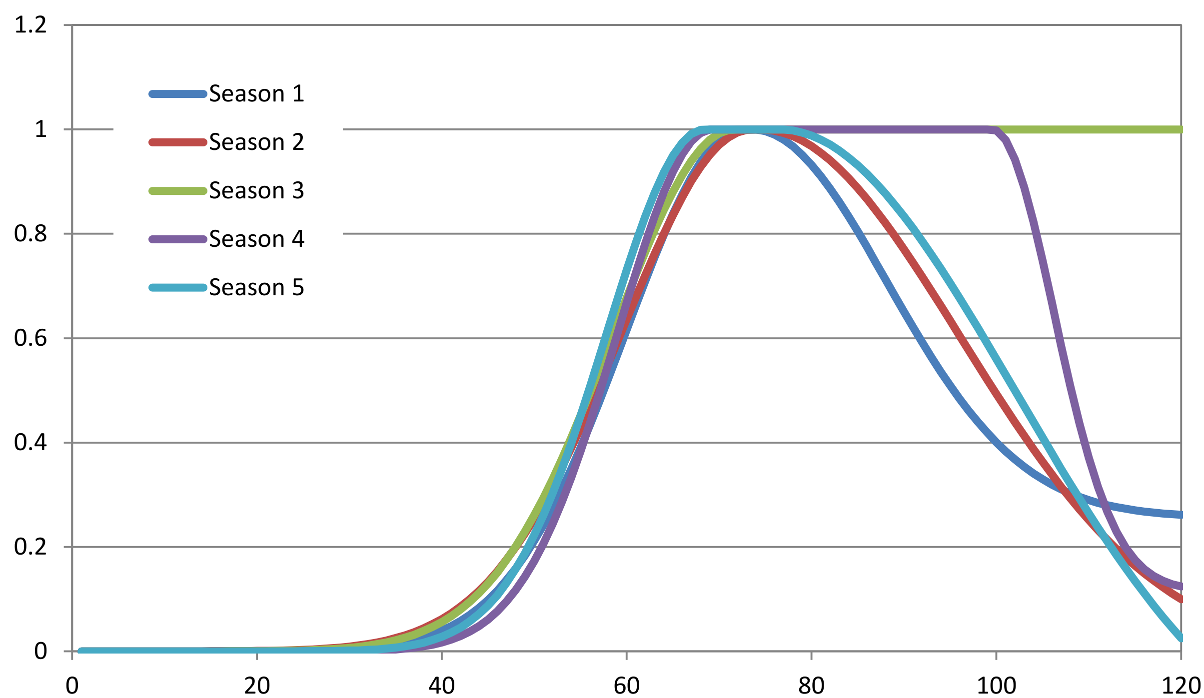

Figure 2.1.6c—Fishery selectivity at length (cm) as estimated by Model 3.

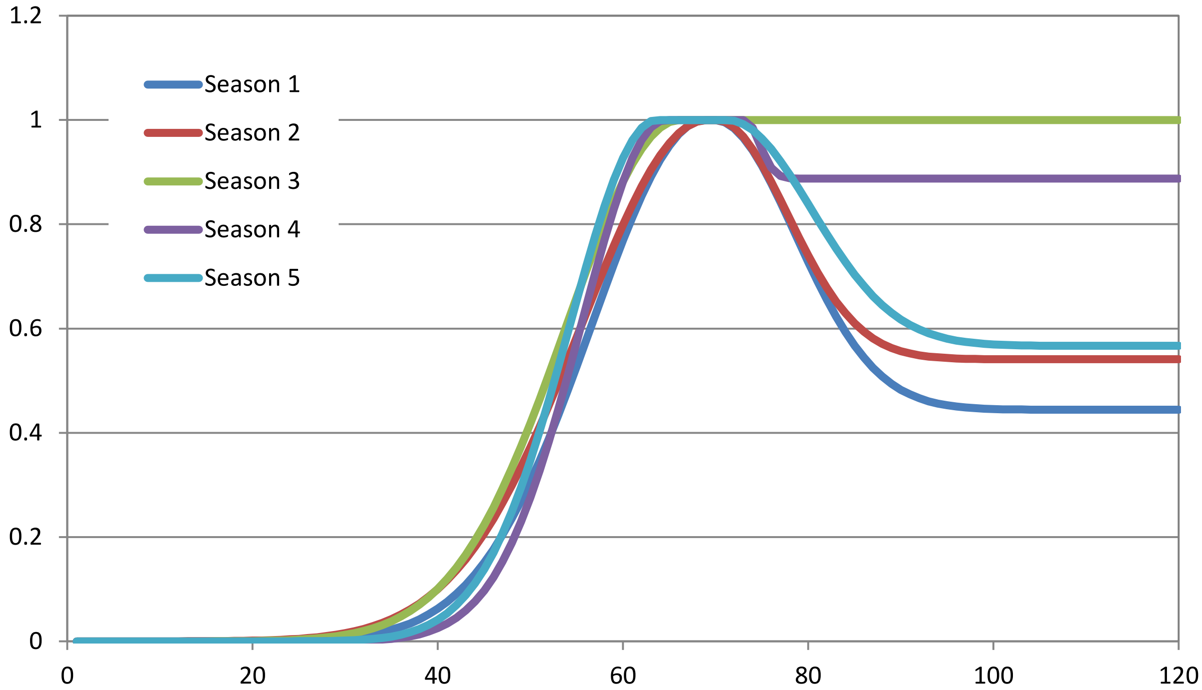

Figure 2.1.6d—Fishery selectivity at length (cm) as estimated by Model 4.

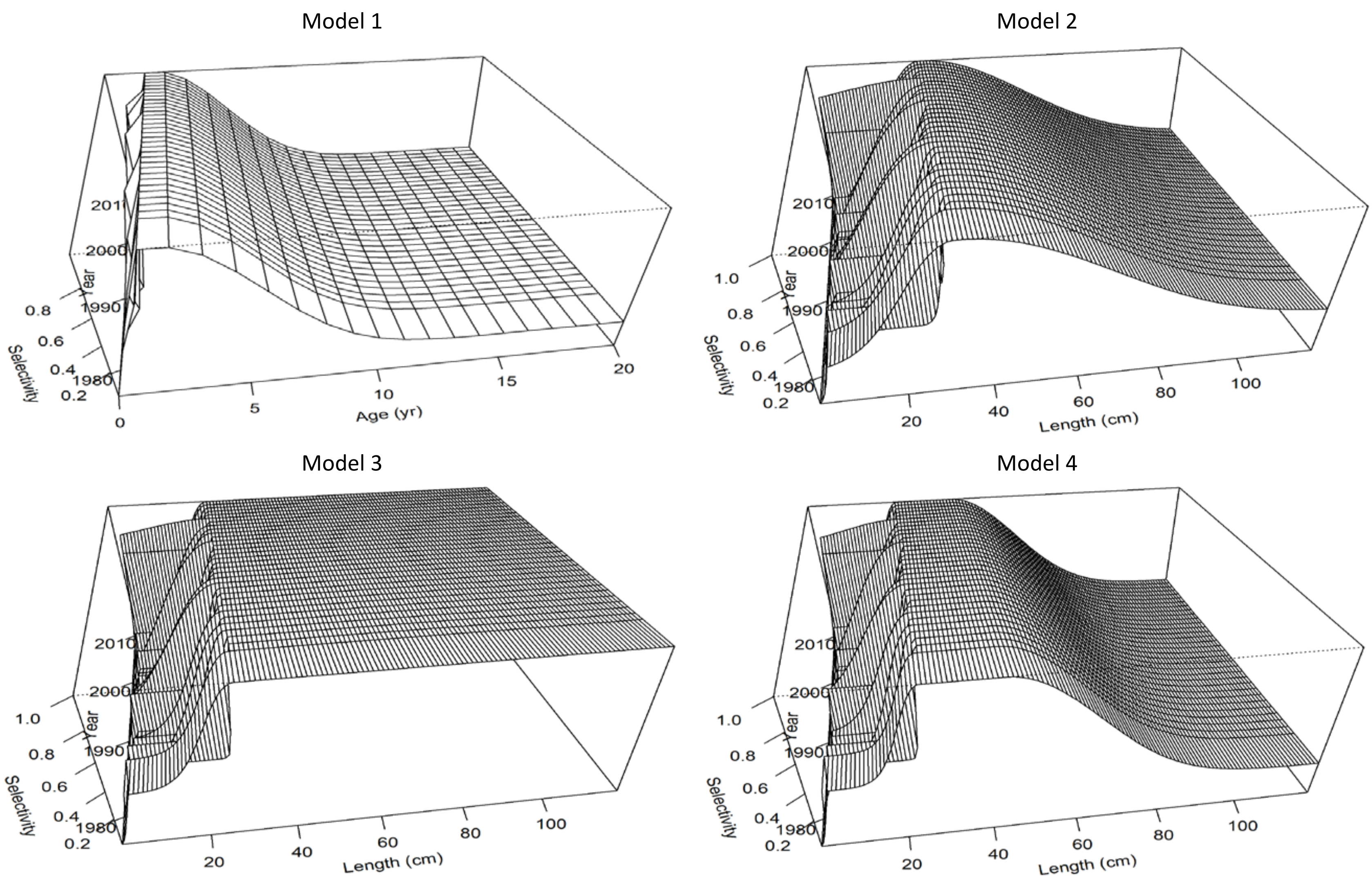

Figure 2.1.7—Survey selectivity at age (Model 1) and length (Models 2-4).

Appendix 2.2:

History of Previous EBS Pacific cod 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.

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.

Until 2010, each year was partitioned into three seasons defined as 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 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 program, which made use of the ADMB modeling architecture (Fournier et al. 2012) currently used in most age-structured assessments of BSAI and GOA groundfish. The move to Stock Synthesis 2 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 Stock Synthesis 2 were described by Methot (2005).

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.

In 2007, SS introduced a six-parameter double-normal selectivity curve. This functional form is constructed from two underlying and linearly rescaled normal distributions, with a horizontal line segment joining the two peaks. As configured in SS, the equation 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.

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:

1. A fixed value of 0.34 was adopted for the natural mortality rate, based on life history theory.
2. The six parameter double-normal function was used for all selectivities.
3. The maturity schedule modeled as a function of age rather than length.
4. Trawl survey selectivity modeled as a function of age rather than length.
5. Fishery selectivity was assumed to be constant across all years.
6. Annual *dev*s were estimated in the *ascending_width* parameter of the trawl survey selectivity schedule, with an assumed standard deviation of 0.2.
7. The standard deviation of length at age modeled as a linear function of length at age.
8. Survey abundance was measured in numbers of fish (rather than biomass).
9. The input sample sizes for multinomial distributions were set 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 (Thompson et al. 2008) 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.

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.

The 2009 assessment (Thompson et al. 2009) featured a total of 14 models reflecting 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 *dev*s.
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).
5. Cohort-specific growth *dev*s were estimated for all years through 2008.

Many changes were made or considered in the 2010 stock assessment (Thompson et al. 2010). Six models were presented in the preliminary assessment, as requested by the Plan Teams in May, 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. Relative to the 2009 assessment, the main changes in the model that was ultimately accepted by the Plan Team and SSC in 2010 were as follow:

1. Relative abundance data and the two records of size composition data from the IPHC longline survey were excluded.
2. The single available record (each) of fishery age composition and mean length-at-age data was excluded.
3. A new length structure consisting of 1-cm bins was adopted, replacing the combination of 3-cm and 5-cm bins used in previous assessments.
4. A new seasonal structure was adopted, consisting 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).
5. Cohort-specific growth rates were removed (these were introduced for the first time in the 2009 assessment).

Per request from the Plan Teams, quantities that were estimated iteratively in the 2009 assessment were not re-estimated in the 2010 assessment.

Following a review by the Center for Independent Experts earlier in the year that resulted in a total of 128 unique recommendations from the three reviewers, the 2011 stock assessment (Thompson and Lauth 2011) again considered several possible model changes. A set of seven models was requested for inclusion in the preliminary by the Plan Teams in May, with subsequent concurrence by the SSC in June. Following review in August and September, four of these models were requested by the Plan Teams or SSC to be included in the final assessment. In addition, the SSC requested one new model, which was ultimately accepted by both the BSAI Plan Team and the SSC. Relative to the 2010 assessment, the main changes in the accepted model were as follow:

1. The pre-1982 portion of the bottom trawl time series was omitted.
2. The 1977-1979 and 1980-1984 time blocks for the January-April trawl fishery selectivity parameters were combined. This change was made because the selectivity curve for the 1977-1979 time block tended to have a very difficult-to-rationalize shape (almost constant across length, even at very small sizes), which led to very high and also difficult-to-rationalize initial fishing mortality rates.
3. The age corresponding to the *L1* parameter in the length-at-age equation was increased from 0 to 1.4167, to correspond to the age of a 1-year-old fish at the time of the survey, which is when the age data are collected. This change was adopted to prevent mean size at age from going negative (as sometimes happened for age 0 fish in previous assessments, and as happened even for age 1 fish in one of the models from the 2010 assessment), and to facilitate comparison of estimated and observed length at age and variability in length at age.
4. A column for age 0 fish was added to the age composition and mean-size-at-age portions of the data file. Even though there are virtually no age 0 fish represented in these two portions of the data file, unless a column for age 0 is included, SS will interpret age 1 fish as being ages 0 and 1 combined, which can bias the estimates of year class strength.
5. Ageing bias was estimated internally.
6. The parameters governing variability in length were estimated internally.
7. All size composition records were included in the log-likelihood function.
8. The fit to the mean-size-at-age data was not included in the log-likelihood function.

It should also be noted that, consistent with the Plan Team request made in 2010, quantities that were estimated iteratively in the 2009 assessment were not re-estimated in the 2011 assessment.

Many model changes in the 2012 stock assessment (Thompson and Lauth 2012). Five primary models and nine secondary models were presented in the preliminary assessment. Of these, four of the primary models and three of the secondary models were requested by the Plan Teams, with subsequent concurrence by the SSC. Following review in September and October, four of the models from the preliminary assessment were requested by the Plan Teams or SSC to be included in the final assessment:

Model 1 was identical to the model accepted for use by the BSAI Plan Team and SSC last year, except for inclusion of new data.

Model 2 was identical to Model 1, except that the survey catchability coefficient was estimated as a free parameter.

Model 3 was also identical to Model 1, except that ageing bias was not estimated internally and the fit to the age composition data was not included in the log-likelihood function.

Model 4 was an exploratory model that differed from Model 1 in several respects:

1. A new, inter- and intra-annually varying weight-length representation developed in the preliminary assessment was used.
2. “Tail compression” was turned off. This feature aggregates size composition bins with few or zero data on a record-by-record basis, which improves computational speed, but which also makes some of the graphs in the R4SS package difficult to interpret. In Models 1-3, tail compression was turned on.

3. Fishery CPUE data were omitted. In Models 1-3, fishery CPUE data were included for purposes of comparison, but were not used in estimation.
4. A new population length bin was added for fish in the 0-0.5 cm range, which was used for extrapolating the length-at age curve below the first reference age. In Models 1-3, the lower bound of the first population length bin was 0.5 cm.
5. Mean-size-at-age data were eliminated. In Models 1-3, mean-size-at-age data were included, but not used in estimation.
6. The number of estimated year class strengths in the initial numbers-at-age vector was set at 10. In Models 1-3, only 3 elements of the initial numbers-at-age vector were estimated, which causes an automatic warning in SS.
7. The Richards growth equation (Richards 1959, Schnute 1981, Schnute and Richards 1990) was used, which adds one more parameter. In Models 1-3, the von Bertalanffy equation—a special case of the Richards equation—was used.
8. The log-scale standard deviation of recruitment was estimated internally (i.e., as a free parameter estimated by ADMB). In Models 1-3, this parameter was held constant at the value of 0.57 that was estimated in the final 2009 assessment by matching the standard deviation of the recruitment *dev*s, per Plan Team request.
9. Survey selectivity was modeled as a function of length. In Models 1-3, survey selectivity was modeled as a function of age.
10. Fisheries were defined with respect to each of the five seasons, but not with respect to gear. In Models 1-3, fisheries were defined with respect to both season and gear.
11. Fishery selectivity curves were defined for each of the five seasons, but were not stratified by gear type. In Models 1-3, seasons 1-2 and 4-5 were lumped into a pair of "super" seasons for the purpose of defining fishery selectivity curves, and fishery selectivities were also *gear*-specific (3 super-seasons × 3 gears = 9 selectivity curves).
12. The selectivity curve for the fishery that came closest to being asymptotic on its own (in this case, the season 3 fishery) was forced to be asymptotic by fixing both *width_of_peak_region* and *final_selectivity* at a value of 10.0 and *descending_width* at a value of 0.0. In Models 1-3, six of the nine super-season × gear fisheries were forced to exhibit asymptotic selectivity.
13. Survey catchability was tuned iteratively to set the average of the product of catchability and survey selectivity across the 60-81 cm range equal to 0.47, corresponding to the Nichol et al. (2007) estimate. In Models 1-3, Q was left at the value of 0.77 estimated by a similar procedure in the final 2009 assessment, per Plan Team request.
14. The age composition sample size multiplier was tuned iteratively to set the mean of the ratio of effective sample size to input sample size equal to 1.0. In Models 1-3, the variance adjustment was fixed at 1.0.
15. The two parameters governing the ascending limb of the survey selectivity schedule were given annual additive *dev*s with each σ_{dev} tuned to match the estimate that would be appropriate for a univariate linear-normal model with random effects integrated out. In Models 1-3, no *dev* vector corresponding to the *initial_selectivity* parameter was used, because it was "tuned out" in the 2009 final assessment; and σ_{dev} for the *ascending_width* parameter was left at the value of 0.07 estimated iteratively in the final 2009 assessment, per Plan Team request.

Following review of the 2012 final assessment, Model 1 (the same model used in 2011) was accepted by both the BSAI Plan Team and the SSC.

An updated description of the SS framework has been published by Methot and Wetzel (2013).

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