# Chapter 2: Assessment of the Pacific Cod Stock in the Gulf of Alaska

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## EXECUTIVE SUMMARY

### Summary of Changes in Assessment Inputs

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

*Changes in the Input Data*

1) Catch data for 2003-2010 were updated, and preliminary catch data for 2011 were incorporated.

2) Commercial fishery size composition data for 2010 were updated, and preliminary size composition data from the 2011 commercial fisheries were incorporated.

3) Size composition data from the 2011 GOA bottom trawl survey were incorporated.

4) The numeric abundance estimate from the 2011 GOA bottom trawl survey was incorporated (the 2011 estimate of 348 million fish was down about 33% from the 2009 estimate, which had been up about 199% from the 2007 estimate).

5) Seasonal catch per unit effort (CPUE) data for the trawl, longline, and pot fisheries from 2010 were updated, and preliminary catch rates for the trawl, longline, and pot fisheries from 2011 were incorporated.

6) Size composition data from the State-managed Pacific cod fishery for 1997-2010 were updated, and preliminary size composition data from the 2011 State-managed fishery were incorporated.

*Changes in the Assessment Methodology*

Many changes have been made or considered in the stock assessment model since the 2010 assessment (Thompson et al. 2010). Seven models were presented in this year's preliminary assessment of the eastern Bering Sea (EBS) stock (see Attachment 2.1 to the Pacific cod chapter in this year's BSAI SAFE report). The set of seven models in the preliminary EBS assessment was requested by the Plan Teams in May of this year, with subsequent concurrence by the SSC in June. Although the original intent was to develop GOA versions of all but one of those models in addition to the EBS versions, the available time proved insufficient to do so. Following review of the preliminary EBS assessment in August and September, four of those models (Models 1, 3, and 4) were requested by the Plan Teams or SSC to be included in the final GOA assessment. In addition, the SSC requested one new model, which is labeled here as Model 3b.

Model 1 is identical to the model accepted for use by the GOA Plan Team and SSC last year, except for inclusion of new data and corrections to old data.

Model 3 is identical to Model 1, except that the age corresponding to the *L1* parameter in the length-at-age equation was increased from 0 to 1.3333 (to correspond to the age of a 1-year-old fish at the time of the survey, when the age data are collected), the parameters governing variability in length at age were re-tuned, a column for age 0 fish was added to the age composition and mean-size-at-age portions of the data file, and ageing bias was estimated internally (ageing bias was constrained to be positive at ages 1 and above, but this constraint proved to be binding only at the maximum age).

Model 3b is identical to Model 3, except that the parameters governing variability in length were estimated internally, all size composition records were included in the log likelihood function, the fit to the mean-size-at-age data was not included in the log likelihood function, selectivity and catchability in the 27-plus trawl survey were both forced to be constant over time, and catchability deviations in the sub-27 survey were given normal priors with mean = 0 and standard deviation = 0.46. The (positive) constraint on ageing bias proved to be binding only at age 1.

Model 4 is identical to Model 3b, except that variability in survey catchability and selectivity was configured as in Models 1 and 3, ageing bias was not estimated internally, the fit to the age composition data was not included in the log-likelihood function, and mean recruitment in the pre-1977 environmental regime was constrained to be less than mean recruitment in the post-1976 environmental regime.

Version 3.22b (as compiled on 8/3/11) of Stock Synthesis (SS) was used to run all the models in this assessment.

Model 3 is the authors' recommended model.

**Summary of Results**

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

| Quantity | As estimated or *specified last* year for: 2011 | 2012 | As estimated or *recommended this* year for: 2012 | 2013 |
|---|---|---|---|---|
| *M* (natural mortality rate) | 0.38 | 0.38 | 0.38 | 0.38 |
| Tier | 3a | 3a | 3a | 3a |
| Projected total (age 0+) biomass (t) | 428,000 | 401,300 | 521,000 | 530,000 |
| Female spawning biomass (t) | | | | |
| Projected | 124,100 | 111,900 | 121,000 | 127,000 |
| $B_{100\%}$ | 256,300 | 256,300 | 261,000 | 261,000 |
| $B_{40\%}$ | 102,500 | 102,500 | 104,000 | 104,000 |
| $B_{35\%}$ | 89,700 | 89,700 | 91,400 | 91,400 |
| $F_{OFL}$ | 0.51 | 0.51 | 0.53 | 0.53 |
| $maxF_{ABC}$ | 0.42 | 0.42 | 0.44 | 0.44 |
| $F_{ABC}$ | 0.42 | 0.42 | 0.44 | 0.44 |
| OFL (t) | 102,600 | 92,300 | 104,000 | 108,000 |
| maxABC (t) | 86,800 | 78,200 | 87,600 | 91,000 |
| ABC (t) | 86,800 | 78,200 | 87,600 | 91,000 |
| **Status** | As determined *last* year for: 2009 | 2010 | As determined *this* year for: 2010 | 2011 |
| Overfishing | No | n/a | No | n/a |
| Overfished | n/a | No | n/a | No |
| Approaching overfished | n/a | No | n/a | No |

**Responses to Comments from the Plan Teams and SSC**

The Pacific cod stock assessment models were reviewed in March of this year by three scientists contracted by the Center for Independent Experts (CIE). A total of 128 unique recommendations from the CIE reviewers and 5 model proposals from a member of the public were included among information considered by the Joint Plan Teams and SSC in developing the recommendations from their respective May and June meetings. The CIE recommendations and public proposals were summarized in Appendix A of the minutes from the May Joint Plan Team meeting. In the interest of efficiency, they are not repeated here.

A total of 21 comments from the November, 2010 meetings of the Joint Plan Teams (1 comment) and the GOA Plan Team (1 comment); the December, 2010 meeting of the SSC (12 comments); the February, 2011 meeting of the SSC (1 comment); the May, 2011 meeting of the Joint Plan Teams (5 comments); and the June, 2011 meeting of the SSC (1 comment) were addressed in the preliminary EBS and AI assessments (included as Attachments 2.1 and 2.2 to the Pacific cod chapter in this year's BSAI SAFE report, respectively). In the interest of efficiency, they are not repeated in this section, except for the following two comments that were directed specifically at the GOA Pacific cod assessment:

GPT0 (10/10): *"The Team noted that it would be useful to have a presentation of the estimates relative to the data, particularly for the most recent survey (and sub-27 cm abundance index)."* Estimates of the most recent sub-27 cm index are presented relative to the data in the subsection entitled "Model Evaluation."

SSC0 (12/10): *"For the GOA, apply a simple Kalman filter approach, as adopted by the SSC in 2004 for BSAI for estimation of current biomass distribution."* This approach is applied in the subsection entitled "Area Allocation of Harvests."

Plan Team and SSC comments from the August, 2011 and September, 2011 meetings, respectively, are addressed below.

*Joint Plan Team Comments*

JPT1 (8/11 minutes): *"Performance of a model was measured by: (i) how often the fits with random starting points reached the MLE (match rate), (ii) the root mean squared deviation of the negative log likelihood from the minimum (likelihood variation), and (iii) the CV of the estimate of present biomass. … Model 3 had a zero match rate and astronomical variability. … The extent that the variability shown by some models was due to a few extreme values rather than a lot of moderate deviations was raised and should be examined in future presentations of this sort."* The possibility that SS might be able to find the true MLE most of the time but occasionally miss it by a lot was the reason for reporting the match rate along with the other two measures. To provide an even more complete description of the jitter tests, the present assessment includes a graph (Figure 2.12) profiling the cumulative likelihood variation (with individual runs sorted in order of increasing deviation) for each model. Also, just to be clear, the "CV" of present biomass is measured as the ratio between: A) the square root of the average squared deviation from the biomass estimated by the best run and B) the biomass estimated by the best run. It is *not* the CV of the biomass estimated by the best run.

JPT2 (8/11 minutes): *"A number of concerns about the models and the convergence tests were raised during the Teams' discussion:*

- *i. "The jitter tests, at least with a jitter rate of 0.1, are not necessarily meaningful because they can produce wild and perhaps even impermissible starting values. In particular, it seems possible that the the hugely variable performance of Model 3 in jitter tests is the result of some quirk.*
- *ii. "In Model A (and Model 5), the catchability and selectivity deviations are treated as random effects but they are not properly integrated out. The MLEs are therefore suspect, and the iterative tuning may produce pathological results.*
- *iii. "Allowing survey catchability to vary from year to year, perhaps substantially, achieves a better fit to the data but at the expense of discounting the relative abundance data. Some members felt strongly that this was a mistake. The survey catchability estimates produced by Model A seemed to be missing in the presentation.*
- *iv. "The great variability of survey selectivity estimates from Model A is a clear indication that the model is overfitting the data.*

*"In view of the many new features in Model A and several concerns about it, the Teams do not favor including it (or Model 5) as one of the candidates in November. The Teams requested Models 2b and 4 in November, and requested a brief investigation into the reasons for the wild performance of Model 3. If it turns out that the uneven performance of Model 3 was the result of some quirk in the jitter tests, the Teams … would like Model 3 included as well. (If a short investigation is unproductive, the Teams recommend dropping Model 3 rather than taking time this year for a long investigation.)"* Some of the theoretical issues involved with the Teams' concerns will be explored next year. In practical terms relating to the present assessment, these concerns have been addressed as follows:

- i. Following the Plan Team meeting, further explorations involving tighter bounds on the ageing bias parameters improved the robustness of Model 3 considerably, resulting in a lower likelihood variation than all other models except Model 4.

ii. Models A and 5 are not included in the present assessment. Moreover, in keeping with a Plan Team request from September, 2010, input standard deviations for all *dev* vectors in the present assessment were held at the values estimated in the 2009 assessment.

iii. For the GOA Pacific cod assessment, Models 1, 3, and 4 all allow survey catchability (*Q*) to vary widely. For the 27-plus survey, two time blocks (pre-1996 and post-1993) are defined for *Q*, and for the sub-27 survey, *Q* varies with every survey year. In both cases, variation in *Q* is completely unconstrained. In contrast, Model A constrained variability in *Q* fairly tightly ($\sigma$= 0.15). Thus, it is not clear that eliminating Model A from consideration results in a set of models with lower overall variability in *Q* than Model A. To provide an alternative with lower overall variability in *Q*, Model 3b in the present assessment eliminates the two catchability time blocks for the 27-plus survey and constrains the *Q* deviations for the sub-27 survey by imposing a normal prior with $\mu = 0$ and $\sigma = 0.46$.

iv. Model A is not included in the present assessment. However, in the context of the GOA Pacfic cod assessment, again it is unclear that eliminating Model A from consideration results in a set of models with overall variability in survey selectivity than Model A. Model A allowed only two survey selectivity parameters to vary, and both were constrained ($\sigma$ = 1.05 and 0.61). In contrast, five of the six survey selectivity parameters in Models 1, 3, and 4 vary with every survey year, and these variations are completely unconstrained. To provide an alternative with lower overall variability in *Q*, Model 3b in the present assessment forces selectivity for both the sub-27 and 27-plus surveys to be constant over time. The degree of variability in survey selectivity exhibited by Model A in the preliminary EBS assessment is used as a reference point against which the other models are evaluated.

Models 3 (given the improved robustness that was estimated following the Plan Team meeting) and 4 are included in the present assessment (Model 2b is not included here, because it is specific to the EBS Pacific cod assessment). Per SSC request, Model 1 is also included and a new model based on Model 3 (Model 3b, see above) has been added. See also comments SSC2 and SSC3.

JPT3 (8/11 minutes): *"The Teams recommend that the IPHC continue to collect cod length frequencies on its survey."* The IPHC continues to collect cod length frequencies on its survey, as requested by the SSC during its June, 2010 meeting.

*SSC Comments*

SSC1 (9/11 minutes) is specific to the BSAI Pacific cod assessment (see Pacific cod chapter in this year's BSAI SAFE report), so is not repeated here.

SSC2 (9/11 minutes): [The author] *"resolved the issue with Model 3 and presented the results to the SSC and the SSC agrees that this model should be brought forward for consideration."* Model 3 is included in the present assessment. See also comment JPT2.

SSC3 (9/11 minutes): *"The SSC supports the Team's suite of models and two additional model runs. First, the SSC would like last year's base model (Model 1) brought forward for consideration. Second, the SSC also requests an additional run using Model 3, but excluding the mean-size-at-age composition data, because of concerns with incorporation of this dataset. The conclusion may be that excluding these data sources is not a good idea, but at least an evaluation will have been done. The SSC notes that the author has discretion for modest changes to the above models to improve performance."* Model 1 and the SSC's new requested model (labeled here as Model 3b) are included in the present assessment, along with Models 3 and 4. The following modest changes have been made to these models, to improve performance: A) the age corresponding to the *L1* parameter in the length-at-age equation was increased from 0 to 1.3333, B) a column for age 0 fish has been added to the age composition and mean-size-at-age portions of the data file in all models except Model 1, and C) the parameters governing variability in length at age have been re-tuned in Model 3 and estimated internally in Model 3b (these parameters were already being estimated internally in Model 4). In addition, some additional (not particularly modest) changes have been included in Model 3b (see comment JPT2), in order to provide the Plan Teams with an alternative that responds to their concerns regarding excessive variability in survey catchability and selectivity.

## INTRODUCTION

### General

Pacific cod (*Gadus macrocephalus*) is a transoceanic species, occurring at depths from shoreline to 500 m. The southern limit of the species' distribution is about 34° N latitude, with a northern limit of about 63° N latitude. Pacific cod is distributed widely over Gulf of Alaska (GOA), as well as the eastern Bering Sea (EBS) and 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 GOA. 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 in review). 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 GOA.

### 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. In a study focusing on waters near Kodiak Island, Abookire et al. (2007) found that age 0 cod typically occurred in nearshore waters adjacent to commercial fishing grounds, with highest densities at depths of 15-20 m and positive associations with sea cucumber mounds and salinity.

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. However, in the GOA trawl survey, the percentage of fish residing in waters less than 100 m tends to increase with length beyond about 90 cm. The GOA trawl survey also indicates that fish occupying depths of 200-300 m are typically in the 40-90 cm size range.

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 4.42% per day, with a 95% confidence interval ranging from about 3.32% to 5.52% (Gregory et al. in review); and age 0

Greenland cod (*Gadus ogac*) of 2.12% per day, with a 95% confidence interval ranging from about 1.56% to 2.68% (Robert Gregory and Corey Morris, *pers. commun.*).

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

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

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

## FISHERY

During the two decades prior to passage of the Magnuson Fishery Conservation and Management Act (MFCMA) in 1976, the fishery for Pacific cod in the GOA was small, averaging around 3,000 t per year. Most of the catch during this period was taken by the foreign fleet, whose catches of Pacific cod were usually incidental to directed fisheries for other species. By 1976, catches had increased to 6,800 t. Catches of Pacific cod since 1978 are shown in Tables 2.1a and 2.1b. In Table 2.1a, catches for 1978-1990 are broken down by year, fleet sector, and gear type. In Table 2.1b, catches for 1991-2011 are broken down by year, jurisdiction, and gear type. The foreign fishery peaked in 1981 at a catch of nearly 35,000 t. A small joint venture fishery existed through 1988, averaging a catch of about 1,400 t per year. The domestic fishery increased steadily through 1986, then increased more than three-fold in 1987 to a catch of nearly 31,000 t as the foreign fishery was eliminated. Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including trawl, longline, pot, and jig components. Trawl gear took the largest share of the catch in every year but one from 1991-2002, although pot gear has taken the largest single-gear share of the catch in each year since 2003. Figures 2.1a-2.1c show areas in which sampled hauls or sets for each of the three main gear types (trawl, longline, and pot) were concentrated during January-April, May-July, and August-December, 2010 (note that season boundaries correspond to those used in the EBS Pacific cod assessment, to facilitate plotting all areas on a single map). Figures 2.1d-2.1e show the corresponding information for January-April and May-July, 2011 (preliminary data). To create these figures, the EEZ off Alaska was divided into 20 km × 20 km squares. For each gear type, a square is shaded if hauls/sets containing Pacific cod from more than two distinct vessels were sampled in it during the respective gear/season/year.

The chapter entitled “Pacific Cod Market Profile” in the economic section of the SAFE Report (Hiatt et al., 2010) provides additional information on the Pacific cod fishery.

The history of acceptable biological catch (ABC), overfishing level (OFL), and total allowable catch (TAC) levels is summarized and compared with the time series of aggregate commercial catches in Table 2.2. For the first year of management under the MFCMA (1977), the catch limit for GOA Pacific cod was established at slightly less than the 1976 total reported landings. During the period 1978-1981, catch limits varied between 34,800 and 70,000 t, settling at 60,000 t in 1982. Prior to 1981 these limits were assigned for “fishing years” rather than calendar years. In 1981 the catch limit was raised temporarily to 70,000 t and the fishing year was extended until December 31 to allow for a smooth transition to management based on calendar years, after which the catch limit returned to 60,000 t until 1986, when ABC began to be set on an annual basis. From 1986 (the first year in which an ABC was set) through

1996, TAC averaged about 83% of ABC and catch averaged about 81% of TAC. In 8 of those 11 years, TAC equaled ABC exactly. In 2 of those 11 years (1992 and 1996), catch exceeded TAC.

To understand the relationships between ABC, TAC, and catch for the period since 1997, it is important to understand that a substantial fishery for Pacific cod has been conducted during these years inside State of Alaska waters, mostly in the Western and Central Regulatory Areas. To accommodate the State-managed fishery, the Federal TAC was set well below (between 15% and 25%) ABC in each of those years. Thus, while the combined Federal and State catch has exceeded the Federal TAC in all but three years since 1997, the overall target catch (Federal TAC plus State GHL) was not exceeded. At no time since the separate State waters fishery began in 1997 has total catch exceeded ABC, and total catch has never exceeded OFL.

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 1988 were based on survey biomass alone. From 1988-1993, the assessment was based on stock reduction analysis (Kimura et al. 1984). From 1994-2004, the assessment was conducted using the Stock Synthesis 1 modeling software (Methot 1986, 1990) with length-based data. The assessment was migrated to Stock Synthesis 2 in 2005 (Methot 2005), at which time age-based data began to enter the assessment. Several changes have been made to the model within the SS2 framework (renamed “Stock Synthesis,” without a numeric modifier, in 2008) each year since then.

Historically, the majority of the GOA catch has come from the Central regulatory area. To some extent the distribution of effort within the GOA is driven by regulation, as catch limits within this region have been apportioned by area throughout the history of management under the MFCMA. Changes in area-specific allocation between years have usually been traceable to changes in biomass distributions estimated by Alaska Fisheries Science Center trawl surveys or management responses to local concerns. Currently, both the ABC and TAC allocation follows the average biomass distribution estimated by the three most recent trawl surveys. The complete history of allocation (in percentage terms) by regulatory area within the GOA is shown in Table 2.3.

The catches shown in Tables 2.1a-b and 2.2 include estimated discards for all years since 1980. Discard rates of Pacific cod in the various GOA target fisheries are shown for each year 1991-2002 in Table 2.4a, and for each year 2003-2011 in Table 2.4b (2011 data are partial). Although the catches shown in Tables 2.1-2.3 do include discards, they do not account for all removals. For example, they do not include removals taken in fisheries managed under other FMPs or international agreements, or removals taken in the process of conducting scientific research. Attachment 2.1 summarizes current efforts toward accounting for such “other” removals.

In addition to area allocations, GOA Pacific cod is allocated on the basis of processor component (inshore/offshore) and season. The inshore component is allocated 90% of the TAC and the remainder is allocated to the offshore component. Within the Central and Western Regulatory Areas, 60% of each component’s portion of the TAC is allocated to the A season (January 1 through June 10) and the remainder is allocated to the B season (June 10 through December 31, although the B season directed fishery does not open until September 1).

NMFS has also published the following proposed rule to implement Amendment 83 to the GOA Groundfish FMP (publication of the final rule is anticipated for November of this year, with an effective date of January 1, 2012):

> “Amendment 83 allocates the Pacific cod TAC in the Western and Central regulatory areas of the GOA among various gear and operational sectors, and eliminates inshore and offshore allocations in

> these two regulatory areas. These allocations apply to both annual and seasonal limits of Pacific cod for the applicable sectors. These apportionments are discussed in detail in a subsequent section of this rule. Amendment 83 is intended to reduce competition among sectors and to support stability in the Pacific cod fishery. The final rule implementing Amendment 83 limits access to the Federal Pacific cod TAC fisheries prosecuted in State of Alaska (State) waters adjacent to the Western and Central regulatory areas in the GOA, otherwise known as parallel fisheries. Amendment 83 does not change the existing annual Pacific cod TAC allocation between the inshore and offshore processing components in the Eastern regulatory area of the GOA.
>
> "In the Central GOA, NMFS must allocate the Pacific cod TAC between vessels using jig gear, catcher vessels (CVs) less than 50 feet (15.24 meters) length overall using hook-and-line gear, CVs equal to or greater than 50 feet (15.24 meters) length overall using hook-and-line gear, catcher/processors (C/Ps) using hook-and-line gear, CVs using trawl gear, C/Ps using trawl gear, and vessels using pot gear. In the Western GOA, NMFS must allocate the Pacific cod TAC between vessels using jig gear, CVs using hook-and-line gear, C/Ps using hook-and-line gear, CVs using trawl gear, and vessels using pot gear. Table 3 lists the proposed amounts of these seasonal allowances. For the Pacific cod sector splits and associated management measures to become effective in the GOA at the beginning of the 2012 fishing year, NMFS published a final rule (76 FR 74670, December 1, 2011) to revise the final 2012 harvest specifications (76 FR 11111, March 1, 2011).
>
> "NMFS proposes to calculate of the 2012 and 2013 Pacific cod TAC allocations in the following manner. First, the jig sector would receive 1.5 percent of the annual Pacific cod TAC in the Western GOA and 1.0 percent of the annual Pacific cod TAC in the Central GOA, as required by proposed § 679.20(c)(7). The jig sector annual allocation would further be apportioned between the A (60 percent) and B (40 percent) seasons as required by § 679.20(a)(12)(i). Should the jig sector harvest 90 percent or more of its allocation in a given area during the fishing year, then this allocation would increase by one percent in the subsequent fishing year, up to six percent of the annual TAC. NMFS proposes to allocate the remainder of the annual Pacific cod TAC based on gear type, operation type, and vessel length overall in the Western and Central GOA seasonally as required by proposed § 679.20(a)(12)(A) and (B)."

The longline and trawl fisheries are also associated with a Pacific halibut mortality limit which sometimes constrains the magnitude and timing of harvests taken by these two gear types.

## DATA

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

### Commercial Catch Data

*Catch Biomass*

Catches for the period 1977-2010 are shown for the three main gear 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-August, September-October, and November-December. Three selectivity seasons are defined by combining catch seasons 1 and 2 into selectivity season 1, equating catch season 3 with selectivity season 2, and combining catch seasons 4 and 5 into selectivity season 3. The catch seasons used in Table 2.5 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 previous assessments (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.

*Catch Per Unit Effort*

Fishery catch per unit effort data are available by gear and season for the years 1991-2011 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 2011 are partial. The "sigma" values shown in the tables are intended only to give an idea of the relative variability of the respective point estimates, and are not actually used in any of the analyses presented here.

*Catch Size Composition*

Fishery size compositions are presently available, by gear, for at least one gear type in every year from 1977 through the first part of 2011. 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/2011/GOA_Pcod_fishery_sizecomp_data.xlsx.

**Survey Data**

*Survey Size Composition*

For the last few assessments, the size composition data from the trawl surveys of the GOA conducted by the Alaska Fisheries Science Center have been partitioned into two length categories: fish smaller than 27 cm (the "sub-27" survey) and fish 27 cm and larger (the "27-plus" survey). The relative size compositions from 1984-2011 are shown for the sub-27 survey in Tables 2.7 and for the 27-plus survey in Table 2.8, using the same 1-cm length bins defined above for the fishery catch size compositions. Rows in Tables 2.7 and 2.8 sum to the actual number of fish measured in each year.

*Survey Age Composition*

Age compositions from each survey except 1984 and 2011 are available (note that the sample size for the 1987 was very small, however). The age compositions and actual sample sizes are shown in Table 2.9a for the 27-plus survey and Table 2.9b for the sub-27 survey.

*Abundance Estimates*

Estimates of total abundance (both in biomass and numbers of fish) obtained from the trawl surveys are shown in Table 2.10, together with their respective coefficients of variation.

The highest biomass ever observed by the survey was the 2009 estimate of 752,651 t, and the low point was the preceding (2007) estimate of 233,310 t. The 2009 biomass estimate represented a 223% increase over the 2007 estimate. The 2011 biomass estimate was down 33% from 2009, but still 115% above the 2007 estimate.

In terms of population numbers, the record high was observed in 2009, when the population was estimated to include over 573 million fish. The 2005 estimate of 140 million fish was the low point in the time series. The 2009 abundance estimate represented a 199% increase over the 2007 estimate. The 2011 abundance estimate was down 39% from 2009, but still 81% above the 2007 estimate.

*Mean Size at Age*

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 2.11. Figure 2.2 shows the time series of age 1 size distributions, as computed from the age data and also by fitting normal distributions to the lengths surrounding the apparent age 1 mode in each year's survey size composition.

## ANALYTIC APPROACH

### Model Structure

*History of Previous Model Structures Developed Under Stock Synthesis*

Beginning with the 1994 SAFE report (Thompson and Zenger 1994), a model using the Stock Synthesis 1 (SS1) assessment program (Methot 1986, 1990, 1998, 2000) and based largely on length-structured data formed the primary analytical tool used to assess the GOA Pacific cod stock.

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. In the base model for the GOA Pacific cod assessment, for example, possible differences in selectivity between the mostly foreign (also joint venture) and mostly domestic fisheries were accommodated by splitting the fishery size composition time series into pre-1987 and post-1986 segments during the era of SS1-based assessments.

Until 2010, each year was been partitioned into three seasons defined as January-May, June-August, and September-December (these seasonal boundaries were suggested by industry participants in the EBS fishery). 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 GOA 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 et al. 2002), where it was found to result in a statistically significant improvement in the model's ability to fit the data.

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

The 2006 assessment model (Thompson et al. 2006) was structured similarly to the 2005 assessment model; the primary change being external estimation of growth parameters.

A technical workshop was convened in April, 2007 to consider a wide range of issues pertaining to both the BSAI and GOA Pacific cod assessments (Thompson and Conners 2007).

The 2007 assessment model (Thompson et al. 2007b) for Pacific cod in the GOA was patterned after the model used in that year's assessment of the BSAI Pacific cod stock (Thompson et al. 2007a), with several changes as described in the assessment document. However, the 2007 assessment model was not accepted by the Plan Team or the SSC.

For the 2008 assessment, the recommended model for the GOA was based largely on the recommended model from the 2008 BSAI Pacific cod assessment. Among other things, this model used an explicit algorithm to determine which fleets (including surveys as well as fisheries) would be forced to exhibit asymptotic selectivity, and another explicit algorithm 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. One other significant change in the recommended model from the 2008 GOA assessment, which was not shared by the BSAI assessment, was a substantial downweighting of the age composition data. This downweighting was instituted as a means of keeping the root mean squared error of the fit to the survey abundance data close to the sampling variability of those data.

The 2009 assessment (Thompson et al. 2009) featured a total of ten models reflecting a great many alternative assumptions and use or non-use of certain data, particularly age composition data. Relative to the 2008 assessment, the main changes in the model accepted by the Plan Team and SSC were as follow: 1) input standard deviations of all "dev" vectors were set iteratively by matching the standard deviations of the set of estimated "devs;" 2) the standard deviation of length at age was estimated outside the model as a linear function of mean length at age; 3) catchability for the pre-1996 trawl survey was estimated freely while catchability for the post-1993 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 0.92 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) weighting of the age composition data was returned to its traditional level; 6) except for the parameter governing selectivity at age 0, all parameters of the selectivity function for the post-1993 years of the 27-plus trawl survey were allowed to vary in each survey year except for the most recent; and 7) cohort-specific growth devs were estimated for all years through 2008.

Many changes were made or considered in the 2010 stock assessment model (Thompson et al. 2010). Five models were presented 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) exclude the single record (each) of fishery age composition and mean length-at-age data, 2) use a finer length bin structure than previous models, and 3) re-evaluate the existing seasonal structure used in the model and revise it as appropriate, and 4) remove cohort-specific growth rates (these were introduced for the first time in the 2009 assessment). The new length bin structure consisted of 1-cm bins, replacing the combination of 3-cm and 5-cm bins used in previous assessments. The new seasonal structure consisted of five catch seasons defined as January-February, March-April, May-August, September-October, and November-December; and three selectivity seasons defined as January-April, May-August, and September-December; with spawning identified as occurring at the beginning of the second catch season (March).

*Model Structures Considered in This Year's Assessment*

The Pacific cod stock assessment models were reviewed in March of this year by three scientists contracted by the CIE. A total of 128 unique recommendations were received from the CIE reviewers. Following the review in March, a set of seven models was requested for inclusion in the preliminary assessments (of which only the EBS version was actually completed; see Attachment 2.1 to the Pacific cod chapter in this year's BSAI SAFE report) by the Plan Teams in May, with subsequent concurrence by the SSC in June. Following review in August and September, GOA versions of three of these models (Models 1, 3, and 4) were requested by the Plan Teams or SSC to be included in the final GOA assessment. In addition, the SSC requested one new model, which is labeled here as Model 3b.

Model 1 is identical to the model accepted for use by the GOA Plan Team and SSC last year, except for inclusion of new data and corrections to old data.

Model 3 in the present assessment differs from Model 1 in the following respects:

- The age corresponding to the *L1* parameter in the length-at-age equation was increased from 0 to 1.3333, 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 in previous EBS Pacific cod models), and to facilitate comparison of estimated and observed length at age and variability in length at age.
- The parameters governing variability in length at age were re-tuned. This was necessitated by the change in the age corresponding to the *L1* parameter (above).
- 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.
- Ageing bias was estimated internally. To preserve a large value for the strength of the 1977 year class and to keep the mean recruitment from the pre-1977 environmental regime lower than the mean recruitment from the post-1976 environmental regime, ageing bias was constrained to be positive (this constraint was not included in the EBS version of Model 3; here, it ultimately proved to be binding only at the maximum age).

Model 3b is identical to Model 3, except that the parameters governing variability in length were estimated internally, all size composition records were included in the log likelihood function, the fit to the mean-size-at-age data was not included in the log likelihood function, selectivity and catchability in the 27-plus trawl survey were both forced to be constant over time, and catchability deviations in the sub-

27 survey were given normal priors with mean = 0 and standard deviation = 0.46. The sigma value of 0.46 for the annual deviations in catchability for the sub-27 survey was chosen on the basis of the variability in age 1 survey selectivity from Model 3b in this year's EBS Pacific cod model. This variability had a CV of 0.49, which corresponds to a sigma of 0.46, assuming a lognormal distribution. As with Model 3, ageing bias was constrained to be positive (this constraint was not included in the EBS version of Model 3b; here, it ultimately proved to be binding only at age 1).

Model 4 is identical to Model 3b, except that variability in survey catchability and selectivity was configured as in Models 1 and 3, ageing bias was not estimated internally, the fit to the age composition data was not included in the log-likelihood function, and mean recruitment in the pre-1977 environmental regime was constrained to be less than mean recruitment in the post-1976 environmental regime (this constraint was not included in the EBS version of Model 4; here, it ultimately proved to be binding).

It should also be noted that, consistent with Plan Team policy adopted in 2010, quantities that were estimated iteratively in the 2009 assessment were not re-estimated in the present assessment (with the exception of the parameters governing variability in length at age, for the reason listed above).

Version 3.22b (as compiled on 8/3/11) of Stock Synthesis was used to run all the models in this assessment. The most recent user manual is for version 3.21d (Methot 2011). Although slightly outdated, the best source for documentation of equations is Methot (2005).

**Parameters Estimated Independently**

*Natural Mortality*

In the 1993 BSAI Pacific cod assessment (Thompson and Methot 1993), the natural mortality rate *M* was estimated using SS1 at a value of 0.37. All subsequent assessments of the BSAI and GOA Pacific cod stocks (except the 1995 GOA assessment) have used this value for *M*, until the 2007 assessments, at which time the BSAI assessment adopted a value of 0.34 and the GOA assessment adopted a value of 0.38. Both of these were accepted by the respective Plan Teams and the SSC. The new values were based on Equation 7 of Jensen (1996) and ages at 50% maturity reported by (Stark 2007; see “Maturity” subsection below). In response to a request from the SSC, the 2008 BSAI assessment included further discussion and justification for these values.

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

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

All of the models in this assessment set *M* independently at the SSC-approved value of 0.38.

*Catchability*

In the 2009 assessment (Thompson et al. 2009), catchability for the post-1993 27-plus trawl survey was estimated iteratively by matching the average (weighted by numbers at length) of the product of catchability and selectivity for the 60-81 cm size range equal to the point estimate of 0.92 obtained by Nichol et al. (2007). The resulting value of 1.04 was retained for all models in the present assessment.

*Variability in Estimated Age*

Variability in estimated age in SS is based on the standard deviation of estimated age. Weighted least squares regression has been used in the past several assessments to estimate a linear relationship between standard deviation and age. The regression was recomputed this year, yielding an estimated intercept of 0.023 and an estimated slope of 0.072 (i.e, the standard deviation of estimated age was modeled as 0.023 + 0.072 × age), which gives a weighted $R^2$ of 0.88. This regression was used for all models in the present assessment.

*Variability in Length at Age*

The last few assessments have used a regression approach to estimate the parameters of the schedule of variability in length at age, based on the outside-the-model estimates of standard deviation of length at age and mean length at age from the survey age data (Thompson et al. 2009). The best fit was obtained by assuming that the standard deviation is a linear function of length at age. The regression was re-estimated this year after updating with the most recent data, giving an intercept of 2.248 and a slope of 0.044.

Use of this regression requires an iterative, “quasi-conditional” procedure for specifying the standard deviations of length at ages 0 and 20, because the regression is a function of length at age, and length at age is estimated conditionally (i.e., inside the model).

For Model 1, the standard deviations of length at ages 0 and 20 were set at 1.87 and 6.53, corresponding to the values estimated in the 2009 assessment and retained in the 2010 assessment.

In Model 3, the age corresponding to the *L1* parameter in the length-at-age equation was increased from 0 to 1.3333 (to correspond to the age of a 1-year-old fish at the time of the survey, when the age data are collected). This made it necessary to re-do the iterative tuning process for Model 3 (it should also be noted that two more years’ worth of age data have been collected since the values used in Model 1 were initially estimated).

In Models 3b and 4, the parameters governing variability in length at age were estimated conditionally.

*Weight at Length*

Season-specific parameters governing the weight-at-length schedule were estimated in the 2010 assessment (based on data through 2008), giving the following values:

| Season: | Jan-Feb | Mar-Apr | May-Aug | Sep-Oct | Nov-Dec |
|---|---|---|---|---|---|
| $\alpha$: | $8.799\times10^{-6}$ | $8.013\times10^{-6}$ | $1.147\times10^{-5}$ | $1.791\times10^{-5}$ | $7.196\times10^{-6}$ |
| $\beta$: | 3.084 | 3.088 | 2.990 | 2.893 | 3.120 |
| Samples: | 36,566 | 29,753 | 6,950 | 9,352 | 2,957 |

The above parameters were retained for all models 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 = 50 cm and slope of linearized logistic equation = –0.222. 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 = 4.3 years and slope = –1.963 (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 all models in the present assessment.

**Parameters Estimated Conditionally**

Parameters estimated conditionally (i.e., within individual SS runs, based on the data and the parameters estimated independently) in all models include the von Bertalanffy growth parameters, log mean recruitment before and since the 1976-1977 regime shift, annual recruitment deviations, initial fishing mortality, gear-season-and-block-specific fishery selectivity parameters, survey selectivity parameters, and annual deviations values for catchability in the sub-27 survey. In addition, all models except Model 3b estimate pre-1996 catchability for the 27-plus survey, Models 3 and 3b estimate two parameters describing ageing bias as a linear function of age (in Models 1 and 4, these parameters are fixed at the levels estimated by trial and error in the 2008 assessment), and Models 3b and 4 estimate two parameters describing the standard deviation of length at age as a linear function of length at age (in Model 1, these parameters are fixed at the values estimated iteratively in the 2008 assessment, and in Model 3 they are estimated iteratively).

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

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

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

Fishery selectivities are length-based and trawl survey selectivities are age-based in all models considered in this assessment.

Uniform prior distributions are used for all parameters, except that *dev* vectors are constrained by input standard deviations ("sigma"), which imply a type of joint prior distribution. These input standard deviations were determined iteratively in the 2009 assessment (Thompson et al. 2009) by matching the standard deviations of the estimated *dev*s. The same input standard deviations were used in all models in the present assessment. (Note that the annual deviations for catchability in the sub-27 survey are treated as unconstrained parameters in all models except Model 3b. Because no sigma was specified for these deviations in the 2009 assessment, specification of a sigma value (0.46) in Model 3b is consistent with the Plan Team's policy of not re-tuning sigmas that were tuned iteratively in the 2009 assessment. Furthermore, the sigma value of 0.49 was not determined iteratively.)

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

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

**Likelihood Components**

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

In SS, emphasis factors are specified to determine which likelihood components receive the greatest attention during the parameter estimation process. As in previous assessments, likelihood components were given an emphasis of 1.0 in the present assessment, except that the mean size at age component is given zero emphasis in Models 3b and 4 and the age composition component is given zero emphasis in Model 4.

*Use of Size Composition Data in Parameter Estimation*

Size composition data are assumed to be drawn from a multinomial distribution specific to a particular year, gear, and season within the year. In the parameter estimation process, SS weights a given size composition observation (i.e., the size frequency distribution observed in a given year, gear, and season) according to the emphasis associated with the respective likelihood component and the sample size specified for the multinomial distribution from which the data are assumed to be drawn. In developing the model upon which SS was originally based, Fournier and Archibald (1982) suggested truncating the multinomial sample size at a value of 400 in order to compensate for contingencies which cause the sampling process to depart from the process that gives rise to the multinomial distribution. For many years, the Pacific cod assessments assumed a multinomial sample size equal to the square root of the true length sample size, rather than the true length sample size itself. Given the true length sample sizes observed in the GOA 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 BSAI assessment (Thompson et al. 2007a) used the harmonic means from a bootstrap analysis of the available fishery length data from 1990-2006. 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 BSAI 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 BSAI assessment was based on the consistency of the ratios between the harmonic means (the raw harmonic means, not the rescaled harmonic means) and the actual sample sizes. For the years prior to 1999, the ratio was very consistently close to 0.16, and for the years after 1998, the ratio was very consistently close to 0.34.

This consistency was used to specify input sample sizes for size composition data in all GOA assessments since 2007 as follows: For fishery data, the sample sizes for length compositions from years prior to 1999 were tentatively set at 16% of the actual sample size, and the sample sizes for length compositions from 2007 were tentatively set at 34% of the actual sample size. For the trawl survey, sample sizes were tentatively set at 34% of the actual sample size. Then, all sample sizes were adjusted proportionally so that the average was 300. Input sample sizes for all size composition records are shown in Table 2.12.

*Use of Age Composition Data in Parameter Estimation*

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

To avoid double counting of the same data, Models 1 and 3 ignore size composition data from each year in which survey age composition data are available. Model 3b keeps all size composition data active in the estimation, even though this amounts (strictly speaking) to double counting, in order to enable a realistic estimation of size at age (recall that Model 3b turns off the mean-size-at-age data). Model 4, which ignores both the mean-size-at-age data and the age composition data, uses all the available size composition data.

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

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

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

*Use of Recruitment Deviation "Data" in Parameter Estimation*

The recruitment deviations likelihood component is different from traditional likelihoods because it does not involve "data" in the same sense that traditional likelihoods do. Instead, the log-scale recruitment deviation plays the role of the datum and the log-scale recruitment mean and input standard deviation are related to the parameters of a normal distribution, but, of course, all of these are treated as parameters by SS (except for the input standard deviation, which is fixed at the value estimated in the 2009 assessment).

# RESULTS

## Model Evaluation

As described above, four models are evaluated in the present assessment.

*Comparing and Contrasting the Models*

Table 2.13 shows numbers of parameters and negative log-likelihoods for each of the models. It should be emphasized that, although the negative log-likelihood values for the models are displayed next to one another, they are not strictly comparable, because the data sets are different for every model. The first part of Table 2.13 shows the number of parameters for each model, which range from a low of 215 for Model 3b to a high of 260 for Model 4. The second part shows negative log-likelihoods for the aggregate data components. The value for the age composition component is shaded under Model 4, and the values for the mean-size-at-age component are shaded under Models 3b and 4, because these values do not count toward the respective models' total. The third and fourth 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.

Tables 2.14 and 2.15 provide alternative measures of how well the models are fitting the fishery CPUE and survey relative abundance data. Table 2.14 shows root mean squared errors (lower values are better) and correlations between observed and estimated values (higher values are better). The most important parts of this table are the two rows for the trawl survey. Model 3b gives a much better fit to the 27-plus survey than the other models, while Model 4 gives a much better fit to the sub-27 survey than the other models. Table 2.15 shows the means and standard deviations of the normalized residuals. For the 27-plus survey, all models have a positive value for mean normalized residual (ranging from 0.42 to 1.17), and, with the exception of Model 3b, the standard deviations tend to be quite a bit larger than unity.

Figure 2.3 shows the fits of the four models to the trawl survey abundance data. For the 27-plus survey, the four models tended to fall within the 95% confidence intervals of the surveys except for 1984, 1996, 2003, and 2009, where the survey was higher than at least two of the models. Model 3b did the best job of staying within the 95% confidence interval for the 27-plus survey, missing only in 1984 (where it missed the confidence interval by only about 200 t).

At the November, 2010 GOA Plan Team meeting, the Team requested an analysis of why the model did not do a better job of fitting the sub-27 abundance index in the most recent year of the time series (comment GPT0). For example, Model 1 estimates the 2010 recruitment *dev* at a value of 0.092373 and a 2011 sub-27 abundance index of 21,494, compared to an observed value of 8,650. If the 2010 recruitment dev is fixed at a value of -1.5 and SS is run without re-estimating parameters (i.e., forcing the program to exit before entering phase 1), Model 1 estimates a 2011 sub-27 abundance index of 8,738, which is very close to the observed value. This results in a gain of 3.64 log-likelihood points in the survey abundance component, which, all else being equal, implies a better fit overall. However, all else is *not* equal. For example, -1.5 is a very extreme value for a recruitment dev, given that $\sigma_R$ is only 0.41, so this change causes a loss of 6.67 log-likelihood points in the recruitment component, more than offsetting the gain in the gain in the survey abundance component. Another result is that the proportions at length in the 2011 sub-27 size composition vector become distorted. The proportions at length from 4-26 cm must sum to unity, and if the number of age 1 fish in 2011 is held at a very low level, the proportions of age 0 and age 2 fish must increase, resulting in a U-shaped size composition in the model. However, the 2011 observed sub-27 size composition is not at all U-shaped, implying a large degradation in the fit to this component; in fact, the log-likelihood for the sub-27 size composition goes down by 20.82 points; more than 5 times the gain realized in the sub-27 abundance component.

Table 2.16 shows the mean of the ratios and the ratio of the means between output "effective" sample size (McAllister and Ianelli 1997) and input sample size for the size composition data, thus providing an alternative measure of how well the models are fitting these data (higher values are better, all else being equal). Model 4 tends to perform the best by either measure. However, as with the likelihood table, such comparisons are problematic, because different data sets are used for the different models. For example, Models 3b and 4 attempt to fit all the available size composition data, whereas Models 1 and 3 ignore all size composition records for which a corresponding age composition record exists. Also, Model 4 does not attempt to fit the age composition data, so it can focus more on fitting the size composition data.

Table 2.17 provides a similar analysis for the age composition, except that the rows in the main part of this table correspond to individual records rather than fisheries or surveys (all age composition data come from the survey). The bottom two rows show the overall mean of the ratios and ratio of the means for the post-1981 trawl survey age compositions. By either measure, Model 1 does better than the other models with respect to the 27-plus survey and worse than the other models with respect to the sub-27 survey. Model 4 does worse than all other models with respect to every age composition record in the 27-plus survey (but, of course, it is not attempting to fit those data). Model 3b also does much worse than Models 1 or 3 with respect to the 27-plus survey. Model 3 does better than the other models with respect to the sub-27 survey.

The four models' fits to the age composition data are shown in Figure 2.4 (four pages, one for each model). Estimates of mean sizes at age 1 (at the time of the survey) from each model are compared to the long-term average survey size composition (through 50 cm) in Figure 2.5. Models 3, 3b, and 4 seem to match the apparent age 1 mode well, although the mode is somewhat indistinct. A mode for age 2 seems to be missing entirely, which is why the assessment splits the surveys into two parts, as the double-normal selectivity function cannot fit a bimodal selection pattern. Models 1, 3, and 3b seem to match the apparent age 3 mode well , although, as with the age 1 mode, the age 3 mode is rather indistinct.

Table 2.18 displays all of the quantities listed in the "parameters" section of the SS report file, including quantities whose values are set externally. Quantities for which values ("Est.") and standard deviations ("SD") are listed represent parameters that are estimated internally, quantities for which only values are listed represent coefficients that are fixed externally, and quantities for which values are not listed represent items that are not used in the respective model.

Most labels are either fairly straightforward to interpret or probably correspond to quantities that are not essential to understanding the analysis. It should be noted that the post-1976 recruitment mean *R0* and all catchability coefficients are reported on natural log scales and that the *R1 offset* parameter describes the log ratio of the recruitment means before and after the 1976-1977 regime shift. Log-scale recruitment deviations are labeled "Main_RecrDev" followed by the year. Labels for selectivity ("Sel") parameters include the parameter number (see "Parameters Estimated Conditionally") and fleet name. Note that many selectivity parameters get overwritten by other selectivity parameters specific to blocks of years. The labels for block-specific parameters end in a four-digit year, representing the starting point for the respective block. Labels for survey selectivity deviations end in a four-digit year followed by "d."

Table 2.19 (four pages, one for each model) show estimates of full-selection fishing mortality rates (note that these are not counted as parameters in SS).

Figure 2.7 shows the time series of log recruitment *dev*s as estimated by the four models. Models 1 and 3 show a high degree of synchrony except for the last two years. Models 3b and 4 tend to be more extreme than the other two models, and they are often out of phase with one another, although they both estimate a strong 2008 year class.

Figure 2.8 shows the time series of spawning biomass relative to $B_{35\%}$ as estimated by the four models. Qualitatively, all models exhibit approximately the same trend, but Models 3b and 4 tend to be much higher than Models 1 and 3 throughout the time series. Relative to the other models, Models 1 and 3 are almost identical.

Figure 2.9 shows the time series of total (age 0+) biomass as estimated by the four models, with the trawl survey biomass estimates included for comparison. The average ratio of model biomass to survey biomass is 1.24 for Model 1, 1.23 for Model 3, 2.07 for Model 3b, and 1.92 for Model 4.

Figure 2.10a shows 27-plus trawl survey selectivity as estimated by the four models. Model 3b, where selectivity is forced to remain constant over time, obviously shows far less variability than any of the other models. It also exhibits the greatest degree of "domed-ness," followed by Model 4, which explains why those two models estimate total biomasses so much greater than the survey (Figure 2.9). Figure 2.10b shows sub-27 trawl survey selectivity as estimated by the four models. Model 3 estimates a surprisingly large selectivity for age 0, perhaps influenced by the spike at 8-11 cm observed in the 1984-1990 survey size compositions (Table 2.7). Figure 2.10c shows the time series of sub-27 survey catchabilities estimated by the four models. Model 3b, which is the only model that places a constraint on variability, obviously exhibits much less variability than any of the other models.

As shown in Figure 2.10a, all models except Model 3b exhibit variation in survey selectivity over time. An index of temporal variability for survey selectivity and catchability can be computed as follows: 1) For each age, compute the mean and variance (over time) of the product of selectivity and catchability (where the product has been summed across the sub-27 and 27-plus surveys). 2) Weight each age-specific mean and variance by the long-term average proportion of population numbers at age. 3) Compute the average of the means and variances over all ages. 4) Compute a weighted average coefficient of variation (CV) as the square root of the average variance over the average mean. This results in the following CVs:

| Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|
| 0.595 | 0.632 | 0.060 | 0.614 |

For comparison, Model A from the preliminary EBS assessment (Attachment 2.1 in the Pacific cod chapter of this year's BSAI SAFE report), which the Plan Teams viewed as exhibiting an impermissibly high estimate of survey variability, produced a CV of 0.330. All models except Model 3b are much more variable than Model A, which is not surprising, given that Model A allowed annual *constrained* variability in *three* survey selectivity/catchability parameters, but Models 1, 3, and 4 (in the GOA) allow annual *unconstrained* variability in *six* survey selectivity/catchability parameters and unconstrained two-block variability in a seventh.

Figure 2.11 (four pages, one for each model) shows fishery selectivity as estimated by all four models. Visually, there does not appear to be a great deal of difference between the curves estimated by the various models, except that Model 3b exhibits asymptotic selectivity in the 1990-1994 time block of the September-December trawl fishery, whereas the other models exhibit a dome. In general, selectivities that are not forced to be asymptotic tend to show decreasing selectivity at large size.

Because the catchability coefficient for the 27-plus trawl survey was held constant for all models at the value estimated in the 2009 assessment (1.04), it may be wondered how well this value continues to achieve the intended result of matching the value of 0.92 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, which resulted in the following statistics:

| Statistic | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| Average: | 0.94 | 0.94 | 0.67 | 0.87 |
| Minimum: | 0.84 | 0.87 | 0.57 | 0.79 |
| Maximum: | 1.04 | 1.04 | 0.79 | 0.97 |
| Standard deviation: | 0.07 | 0.07 | 0.07 | 0.07 |
| Coefficient of variation: | 0.08 | 0.07 | 0.10 | 0.08 |

All models except Model 3b come within 0.05 of the target value, and the range of values spanned by each model except Model 3b includes the target value.

Table 2.20 contains selected output from the standard projection model, based on SS parameter estimates from the four models, 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). Model 1 tends to produce the lowest ratios of all quantities, Model 3b tends to produce the highest values of biomass and catch values, and Model 4 tends to produce the highest values of fishing mortality reference points. The probability of exceeding the true-but-unknown OFL in either of the next two years is between 8% and 17% under all models, and the probability of falling below $B_{20\%}$ in any of the next five years is very small under all models.

All models converged successfully and the Hessian matrices from all models were positive definite. Once each model appeared to have converged, a set of (typically 50) "jitter" runs were made with initial parameter values displaced randomly from their converged values to provide additional assurance that another (better) solution did not exist. If a better solution was found, the process was repeated until such time as no further improvement was obtained. No model was considered final until a set of 50 jitter runs failed to find a better value of the objective function.

In the table below, the row labeled "Success" shows the proportion of jitters that ran successfully (i.e., that returned a numeric value for the objective function). The row labeled "Match" shows the proportion of successful jitters that matched the final version. The row labeled "-lnL 'RMSE'" shows a statistic for the objective function that is similar to a root-mean-squared-error, but in which the squared difference is taken with respect to the *minimum* value (across jitters) rather than the *mean*; this statistic is reported in units of log-likelihood. Finally, the row labeled "SB2011 'CV'" shows a statistic for 2011 spawning biomass that is similar to a coefficient of variation, but in which (as with the preceding column) the mean is replaced by the value corresponding to the final (i.e., best case) version of the model. Green shading denotes the cell with the minimum value in the row, and pink shading denotes the cell with the maximum.

| Quantity | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| Success | 0.980 | 1.000 | 0.940 | 1.000 |
| Match | 0.000 | 0.000 | 0.064 | 0.000 |
| -lnL "RMSE" | 567.996 | 199.123 | 67.451 | 205.442 |
| SB2011 "CV" | 0.774 | 0.772 | 0.065 | 0.203 |

Model 3 did the best of the four models in terms of match rate (although all four models did very poorly by this measure), -lnL "RMSE," and SB2011 "CV." Models 1 and 3 had very high SB2011 "CV" values.

Figure 2.12 sorts the jitter runs for each model in order of decreasing log likelihood, and shows how the running (cumulative) value of –lnL "RMSE" changes with each additional (sorted) jitter run. This figure is included to address the Plan Teams' concern that the reported value of –lnL "RMSE" may be due to a small number of outliers.

In response to requests from individual Plan Team and SSC members, five retrospective runs were conducted for each of the four models. For each model, results of the retrospective runs were compared in a 2×2 factorial design. The first factor involved a choice of which model output to analyze. Spawning biomass and age 0 recruitment (as assessed at age 1) were chosen for this purpose. The second factor involved a choice of baseline to use in computing bias. Bias relative to the subsequent run (e.g., treating the 4-year retrospective as an estimator of the 3-year retrospective) and bias relative to the current run (e.g., treating the 4-year retrospective as an estimator of the 0-year retrospective) were chosen for this purpose. Bias was calculated for each model, each retrospective run, each choice of model output, each choice of baseline, and each year from 1977 through the end of the respective retrospective run. The results are shown in Figure 2.13 (four pages, one for each model; note that colors in this figure correspond to different retrospective runs, not different models).

To distill the information contained in Figure 2.13 into more manageable form, the following set of summary statistics was computed for each model, each retrospective run, each choice of model output, and each choice of baseline: the average bias (across all years), the end-year bias, and the root-mean-squared-error (across all years). These statistics are reported in Tables 2.21 and 2.22 for spawning biomass and age 0 recruitment, respectively; and in Figures 2.14 and 2.15 for spawning biomass and age 0 recruitment, respectively.

With respect to spawning biomass, all four models have biases or RMSEs close to zero under a 1-year retrospective. As the number of retrospective years increase, biases and RMSEs vary, but the patterns are difficult to characterize. Model 3b tends to behave a bit differently from the other three models in terms of average bias, as Model 3b's bias tends to go from positive to negative with increasing retrospective year, whereas the other three models tend to stay mostly positive. On average (across retrospective years), Model 4 tends to do best in terms of average bias, while Model 3b tends to do best in terms of end-year bias and RMSE.

With respect to age 0 recruitment, in terms of average bias, all four models again have biases close to zero under a 1-year retrospective, but again the patterns are difficult to characterize as a function of retrospective year. End-year biases are not always close to zero, even for a 1-year retrospective (Model 3's end-year bias for a 1-year retrospective exceeds 50%). On average (across retrospective years), Model 3b tends to do best in terms of average bias and RMSE, while Models 3 and 4 tend to do best in terms of end-year bias.

*Evaluation Criteria*

The following criteria were considered in selecting the final model:

1. The model should continue to use the age composition data and, if possible, achieve a good fit to those data. Of the 128 unique recommendations received from the three CIE reviews, only 4 were common to all three, and continued use of the age composition data was among those.
2. The model should estimate ageing bias internally. Assuming that this new feature of SS is working properly, internal estimation of ageing bias is vastly more efficient than estimation by trial and error, and it also provides estimates of variance around the estimated parameters.
3. The mean sizes at age estimated by the model should give a reasonably good fit to the first few modes in the long-term average survey size composition data and the mean-size-at-age data, regardless of whether the latter are actually used in the estimation.

4. The model should exhibit an average (across the 61-80 cm size range) value for the product of survey catchability and selectivity that comes reasonably close to the value estimated by Nichol et al. (2007).
5. The parameters governing variability in length at age in the model should account for between-cohort (or between-year) variability as well as between-individual variability. Regardless of whether the age data or the normal distributions fitted to the survey size composition are used, Figure 2.2 gives strong evidence that the distribution of size at age 1 is not constant over time. However, the regression approach used in the last few assessments to estimate variability in length at age assumes that this distribution *is* constant over time, which should tend to underestimate the true amount of variability.
6. The time series of survey selectivity and catchability should exhibit a level of temporal variability lower than that estimated by Model A in the preliminary assessment. The Plan Teams felt that the level of temporal variability estimated by Model A constituted "a clear indication that the model is overfitting the data" (see comment JPT2).
7. The model should exhibit reasonable retrospective behavior.

*Selection of Final Model*

The four models can be evaluated by the six criteria as follows:

1. All models except Model 4 continue to use the age composition data. Although Model 3b attempts to fit the age composition data, it does so much more poorly than Models 1 or 3.
2. Models 3 and 3b estimate ageing bias internally. The other models do not. However, the bias estimates in both of these models had to be constrained in order to keep the models from estimating unrealistic values for other parameters.
3. Models 3 and 3b (and possibly 1) do the best job of matching the apparent age 1 and age 3 modes in the long-term average survey size composition (Figure 2.5). Models 3b and 4 seem to be undershooting the mean size data at older ages (Figure 2.6). Model 4's log likelihood value for the mean-size-at-age data is more than 1300 points worse than any other model.
4. All models except Model 3b come within 0.05 of Nichol et al.'s (2007) estimate of the average (across the 61-80 cm size range) value for the product of survey catchability and selectivity, and the range for each model except Model 3b includes the target value.
5. Models 3b and 4 estimate the parameters governing variability in length at age internally. The other models do not; instead, they estimate those parameters based on an outside-the-model regression. Given the extent of between-individual and between-cohort variability depicted in Figure 2.2, the standard deviation of length at age 1 at the time of the survey could be as high as 3.58 (based on the age data) or 4.24 (based on the normal fits to the size compositions). For comparison, the five models imply, assume, or estimate the following values:

   | Model 1 | Model 3 | Model 3b | Model 4 |
   |---|---|---|---|
   | 2.83 | 3.13 | 4.14 | 4.26 |

   From the above, it appears that Models 3b and 4 are doing a reasonable job of incorporating both between-individual and between-cohort variability in the parameters governing variability in length at age, whereas the other models appear to be underestimating variability in length at age.
6. As noted previously, all models except Model 3b estimate levels of inter-temporal variability in survey and catchability that are substantially higher (0.595-0.632) than that exhibited by Model A in the preliminary assessment (0.330).
7. While none of the models exhibits perfect retrospective behavior, avoiding the type of bias exhibited by Model 3 in estimation of the most recent recruitment is something that would be desirable. On the other hand, when results were averaged across all retrospective years, Model 3 did the best of all models in terms of end-year bias in recruitment relative to the current run. In terms of most other measures of retrospective behavior, Models 3b and 4 did the best.

Given the above, the best model overall is not obvious, because no model exhibits all of the desired characteristics. It is therefore necessary to prioritize the criteria. Based on the last few years of Plan Team and SSC discussions, it seems reasonable to assign highest priority to criteria #1, 2, 3, and 4. When consideration is limited to those four criteria, Model 3 emerges as the preferred model.

*Final Parameter Estimates and Associated Schedules*

As noted previously, estimates of all statistically estimated parameters in Model 3 are shown in Table 2.18. Estimates of year-, gear-, and season-specific fishing mortality rates from Model 3 are shown in Table 2.19b.

Schedules of selectivity at length for the commercial fisheries from Model 3 are shown in Table 2.23, and schedules of selectivity at age for the trawl surveys from Model 3 are shown in Table 2.24. Trawl survey and all fishery selectivity schedules for Model 3 are plotted in Figures 2.10 and 2.11b, respectively.

Schedules of length at age and weight at age for the population, length at age for each gear-and-season-specific fishery and each survey, and weight at age for each gear-and-season-specific fishery and each survey from Model 3 are shown in Tables 2.25, and 2.26, and 2.27, respectively.

**Time Series Results**

Note: Because the preferred model differs substantively from last year's model (Model 1), the tables and figures referenced in this section are reproduced using Model 1 in Attachment 2.2.

*Definitions*

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

*Biomass*

Table 2.28 shows the time series of GOA Pacific cod age 0+ and female spawning biomass for the years 1977-2012 as estimated last year and this year under Model 3. The estimated spawning biomass time series are accompanied by their respective standard deviations.

The estimated time series of GOA age 0+ biomass and female spawning biomass from Model 3 are shown, together with the observed time series of trawl survey biomass (assuming a catchability of 1.0), in Figure 2.16. Confidence intervals are shown for the model estimates of female spawning biomass and for the trawl survey biomass estimates.

*Recruitment and Numbers at Age*

Table 2.29 shows the time series of GOA Pacific cod age 0 recruitment (1000s of fish) for the years 1977-2010 as estimated last year and this year under Model 3. Both estimated time series are accompanied by their respective standard deviations. For the time series as a whole, the largest year class appears to have been the 1977 cohort. Other cohorts that are estimated to be at least 20% larger than the average include the 1982, 1985, 1989, 2006, 2007, 2008, and 2010 year classes. Based on current estimates, the five most recent year classes include four of the top five year classes of all time. However, it should be emphasized that the estimate of the 2010 year class is based entirely on the 2011 survey.

Model 3's recruitment estimates for the entire time series (1977-2010) are shown in Figure 2.17, along with their respective 95% confidence intervals.

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

The time series of numbers at age as estimated by Model 3 is shown in Table 2.30.

*Fishing Mortality*

Table 2.31 shows "effective" fishing mortality by age and year for ages 1-19 and years 1977-2010.

Figure 2.18 plots the trajectory of relative fishing mortality and relative female spawning biomass from 1977 through 2011 based on Model 3, 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). Except for the last few points, the entire trajectory lies underneath the $maxF_{ABC}$ control rule. While the ratio of $F_{40\%}$ to $F_{35\%}$ shown in Figure 2.18 is based on output from the standard projection model, the trajectory itself is based on SS output, which may not match the estimates obtained by the standard projection program exactly.

**Projections and Harvest Alternatives**

Note: Because the preferred model differs substantively from last year's model (Model 1), the tables referenced in this section are reproduced using Model 1 in Attachment 2.2.

*Amendment 56 Reference Points*

Amendment 56 to the GOA 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 GOA have generally been managed under Tier 3 of Amendment 56 (with the exception of the current year, when the stock is being managed under Tier 5). Tier 3 uses the following reference points: $B_{40\%}$, equal to 40% of the equilibrium spawning biomass that would be obtained in the absence of fishing; $F_{35\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 35% of the level that would be obtained in the absence of fishing; and $F_{40\%}$, equal to the fishing mortality rate that reduces the equilibrium level of spawning per recruit to 40% of the level that would be obtained in the absence of fishing. The following formulae apply under Tier 3:

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

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

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

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

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

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

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

$F_{OFL} = 0$

$F_{ABC} = 0$

Other useful biomass reference points which can be calculated using this assumption are $B_{100\%}$ and $B_{35\%}$, defined analogously to $B_{40\%}$. These reference points are estimated as follows, based on Model 3:

| Reference point: | $B_{35\%}$ | $B_{40\%}$ | $B_{100\%}$ |
|---|---|---|---|
| Spawning biomass: | 91,400 t | 104,000 t | 261,000 t |

For a stock exploited by multiple gear types, estimation of $F_{35\%}$ and $F_{40\%}$ requires an assumption regarding the apportionment of fishing mortality among those gear types. For this assessment, the apportionment was based on Model 3's estimates of fishing mortality by gear for the five most recent complete years of data (2006-2010). 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 27%, longline 25%, and pot 48%. This apportionment results in estimates of $F_{35\%}$ and $F_{40\%}$ equal to 0.53 and 0.44, respectively.

*Specification of OFL and Maximum Permissible ABC*

Spawning biomass for 2012 is estimated by Model 3 at a value of 121,000 t. This is well above the $B_{40\%}$ value of 104,000 t, thereby placing Pacific cod in sub-tier "a" of Tier 3. Given this, Model 3 estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2012 and 2013 as follows (2013 values are predicated on the assumption that 2012 catch will equal 2012 maximum permissible ABC):

| Units | Year | Overfishing Level | Maximum Permissible ABC |
|---|---|---|---|
| Harvest amount | 2012 | 104,000 t | 87,600 t |
| Harvest amount | 2013 | 108,000 t | 91,000 t |
| Fishing mortality rate | 2012 | 0.53 | 0.44 |
| Fishing mortality rate | 2013 | 0.53 | 0.44 |

The age 0+ biomass projections for 2012 and 2013 from Model 3 (using SS) are 521,000 t and 530,000 t.

For comparison, the age 3+ projections for 2012 and 2013 from Model 3 (using SS) are 472,000 t and 494,000 t.

*ABC Recommendation*

In 2005, the SSC used a two-year stair-step approach to recommend the 2006 ABC.

In 2006, the GOA Plan Team and SSC recommended keeping ABC at the 2006 level for 2007.

In 2007, the GOA Plan Team and SSC adopted a Tier 5 approach for setting the 2008 ABC.

In 2008-2010, the GOA Plan Team and SSC recommended setting 2009 ABC at the maximum permissible level under Tier 3.

Following recent practice, this year's ABC recommendations for 2012 and 2013 are at their respective maximum permissible levels of 87,600 t and 91,000 t.

*Area Allocation of Harvests*

For the past several years, ABC has been allocated among regulatory areas on the basis of the three most recent surveys. The current proportions of 35% Western, 62% Central, and 3% Eastern are based on the average (across years) of the area-specific biomass estimates from the 2005-2009 surveys. If the same methodology were applied to the 2007-2011 surveys, the proportions would be 32% Western, 65% Central, and 3% Eastern. The SSC and GOA Plan Team have requested that the simple Kalman filter approach that has been used to estimate the proportions of Pacific cod biomass in the EBS and AI since 2004 be applied to the GOA as well. Using this approach, the proportions would be 35% Western, 61% Central, and 4% Eastern.

*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 2012 numbers at age. In each subsequent year, the fishing mortality rate is prescribed on the basis of the spawning biomass in that year and the respective harvest scenario. In each year, recruitment is drawn from an inverse Gaussian distribution whose parameters consist of maximum likelihood estimates determined from recruitments estimated in the assessment. Spawning biomass is computed in each year based on the time of peak spawning and the maturity and weight schedules described in the assessment. Total catch is assumed to equal the catch associated with the respective harvest scenario in all years. This projection scheme is run 1000 times to obtain distributions of possible future stock sizes, fishing mortality rates, and catches.

Five of the seven standard scenarios will be used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TACs for 2012 and 2013, 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 2012 recommended in the assessment to the *max* $F_{ABC}$ for 2012. (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 2006-2010 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 2011 or 2) above 1/2 of its MSY level in 2011 and expected to be above its MSY level in 2021 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2012 and 2013, $F$ is set equal to *max* $F_{ABC}$, and in all subsequent years, $F$ is set equal to $F_{OFL}$. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is expected to be above its MSY level in 2024 under this scenario, then the stock is not approaching an overfished condition.)

*Projections and Status Determination*

Projections corresponding to the standard scenarios are shown for Model 3b in Tables 2.32-2.37 (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 2012, it does not provide the best estimate of OFL for 2013, because the mean 2013 catch under Scenario 6 is predicated on the 2012 catch being equal to the 2012 OFL, whereas the actual 2012 catch will likely be less than the 2012 OFL. Table 2.20 contains the appropriate one- and two-year ahead projections for both ABC and OFL under any of the five models considered in the present assessment.

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

*Is the stock being subjected to overfishing?* The official catch estimate for the most recent complete year (2010) is 78,071 t. This is less than the 2010 OFL of 94,100 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 2012:

a. If spawning biomass for 2011 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2011 is estimated to be above $B_{35\%}$ the stock is above its MSST.
c. If spawning biomass for 2011 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 2.36). If the mean spawning biomass for 2021 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 2.37):

a. If the mean spawning biomass for 2014 is below 1/2 $B_{35\%}$, the stock is approaching an overfished condition.

b. If the mean spawning biomass for 2014 is above $B_{35\%}$, the stock is not approaching an overfished condition.

c. If the mean spawning biomass for 2014 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2024. If the mean spawning biomass for 2024 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 2.36 and 2.37, the stock is not overfished and is not approaching an overfished condition.

## ECOSYSTEM CONSIDERATIONS

This section is largely unchanged from last year's assessment, except for the subsection on "Incidental Catch of Nontarget Species."

### Ecosystem Effects on the Stock

A primary ecosystem phenomenon affecting the Pacific cod stock seems to be the occurrence of periodic "regime shifts," in which central tendencies of key variables in the physical environment change on a scale spanning several years to a few decades (Boldt (ed.), 2005). One well-documented example of such a regime shift occurred in 1977, and shifts occurring in 1989 and 1999 have also been suggested (e.g., Hare and Mantua 2000). In the present assessment, an attempt was made to estimate the change in median recruitment of GOA Pacific cod associated with the 1977 regime shift. According to this year's model, pre-1977 median recruitment was only about 32% of post-1976 median recruitment. Establishing a link between environment and recruitment within a particular regime is more difficult. In the 2004 assessment (Thompson et al. 2004), for example, the correlations between age 1 recruits spawned since 1977 and monthly values of the Pacific Decadal Oscillation (Mantua et al. 1997) were computed and found to be very weak.

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

### Fishery Effects on the Ecosystem

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

*Incidental Catch of Nontarget Species*

Incidental catches of nontarget species in each year 2003-2011 are shown Table 2.38. In terms of average catch over the time series, only sea stars account for more than 200 t per year.

Incidental catches of prohibited species in each year 2003-2011 are shown in Table 2.39a, and the halibut portion of Table 2.39a is translated into units of halibut mortality in Table 2.39b.

*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 2.30b and 2.30b). 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

Understanding of the above ecosystem considerations would be improved 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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## REFERENCES

Abookire, A. A., J. T. Duffy-Anderson, and C. M. Jump. 2007. Habitat associations and diet of young-of-the-year Pacific cod (*Gadus macrocephalus*) near Kodiak, Alaska. Marine Biology 150:713-726.

Albers, W. D., and P. J. Anderson. 1985. Diet of Pacific cod, *Gadus macrocephalus*, and predation on the northern pink shrimp, *Pandalus borealis*, in Pavlof Bay, Alaska. Fish. Bull., U.S. 83:601-610.

Bakkala, R. G., and V. G. Wespestad. 1985. Pacific cod. *In* R. G. Bakkala and L. L. Low (editors), Condition of groundfish resources of the eastern Bering Sea and Aleutian Islands region in 1984, p. 37-49. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-83.

Boldt, J. (editor). 2005. Ecosystem Considerations for 2006. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Calkins, D. G. 1998. Prey of Steller sea lions in the Bering Sea. Biosphere Conservation 1:33-44.

Canino, M. F., I. B. Spies, and L. Hauser. 2005. Development and characterization of novel di- and tetranucleotide microsatellite markers in Pacific cod (*Gadus macrocephalus*). Molecular Ecology Notes 5:908-910.

Canino, M. F., I. B. Spies, K. M. Cunningham, L. Hauser, and W. S. Grant. 2010. Multiple ice-age refugia in Pacific cod, *Gadus macrocephalus*. Molecular Ecology 19:4339-4351.

Cunningham, K. M., M. F. Canino, I. B. Spies, and L. Hauser. 2009. Genetic isolation by distance and localized fjord population structure in Pacific cod (*Gadus macrocephalus*): limited effective dispersal in the northeastern Pacific Ocean. Can. J. Fish. Aquat. Sci. 66:153-166.

Fournier, D. 1983. An analysis of the Hecate Strait Pacific cod fishery using an age-structured model incorporating density-dependent effects. Can. J. Fish. Aquat. Sci. 40:1233-1243.

Fournier, D. 2005. An introduction to AD Model Builder Version 6.0.2 for use in nonlinear modeling and statistics. Otter Research Ltd. P.O. Box 2040, Sidney BC V8L3S3.

Fournier, D., and C. P. Archibald. 1982. A general theory for analyzing catch at age data. Can. J. Fish. Aquat. Sci. 38:1195-1207.

Grant, W. S., C. I. Zhang, and T. Kobayashi. 1987. Lack of genetic stock discretion in Pacific cod (*Gadus macrocephalus*). Can. J. Fish. Aquat. Sci. 44:490-498.

Greer-Walker, M. 1970. Growth and development of the skeletal muscle fibres of the cod (*Gadus morhua L.*). Journal du Conseil 33:228-244.

Gregory, R. S., C. Morris, and B. Newton. In review. Relative strength of the 2007 and 2008 year-classes, from nearshore surveys of demersal age 0 Atlantic cod in Newman Sound, Bonavista Bay. Can. Sci. Advis. Sec. Res. Doc. 2009/xxx.

Hare, S. R., and N. J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1977 and 1989. Progress in Oceanography 47:103-146.

Hiatt, T., M. Dalton, R. Felthoven, B. Fissel, B. Garber-Yonts, A. Haynie, S. Kasperski, D. Lew, C. Package, J. Sepez, and C. Seung. 2010. Stock Assessment and Fishery Evaluation Report for the Groundfish Fisheries of the Gulf of Alaska and Bering Sea/Aleutian Islands Area: Economic Status of the Groundfish Fisheries off Alaska, 2009. Economic and Social Sciences Research Program, Resource Ecology and Fisheries Management Division, Alaska Fisheries Science Center, NMFS, NOAA, 7600 Sand Point Way N.E., Seattle, Washington 98115-6349. 253 p.

Jensen, A. L. 1996. Beverton and Holt life history invariants result from optimal trade-off of reproduction and survival. Can. J. Fish. Aquat. Sci. 53:820-822.

Jung, S., I. Choi, H. Jin, D.-w. Lee, H.-k. Cha, Y. Kim, and J.-y. Lee. 2009. Size-dependent mortality formulation for isochronal fish species based on their fecundity: an example of Pacific cod (*Gadus macrocephalus*) in the eastern coastal areas of Korea. Fisheries Research 97:77-85.

Ketchen, K.S. 1964. Preliminary results of studies on a growth and mortality of Pacific cod (*Gadus macrocephalus*) in Hecate Strait, British Columbia. J. Fish. Res. Bd. Canada 21:1051-1067.

Kimura, D. K., J. W. Balsiger, and D. H. Ito. 1984. Generalized stock reduction analysis. Can. J. Fish. Aquat. Sci. 41:1325-1333.

Lang, G. M., C. W. Derrah, and P. A. Livingston. 2003. Groundfish food habits and predation on commercially important prey species in the Eastern Bering Sea from 1993 through 1996. Alaska Fisheries Science Center Processed Report 2003-04. Alaska Fisheries Science Center, 7600 Sand Point Way NE., Seattle, WA 98115-6349. 351 p.

Livingston, P. A. 1989. Interannual trends in Pacific cod, Gadus macrocephalus, predation on three commercially important crab species in the eastern Bering Sea. Fish. Bull., U.S. 87:807-827.

Livingston, P. A. 1991. Pacific cod. *In* P. A. Livingston (editor), Groundfish food habits and predation on commercially important prey species in the eastern Bering Sea from 1984 to 1986, p. 31-88. U.S. Dept. Commer., NOAA Tech. Memo. NMFS F/NWC-207.

Livingston, P. A. (editor). 2002. Ecosystem Considerations for 2003. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Low, L. L. 1974. A study of four major groundfish fisheries of the Bering Sea. Ph.D. Thesis, Univ. Washington, Seattle, WA 240 p.

Mantua, N. J., Hare, S. R., Zhang, Y., Wallace, J. M., & Francis, R. C.. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society 78, 1069-1079.

McAllister, M. K., and J. N. Ianelli. 1997. Bayesian stock assessment using catch-age data and the sampling-importance resampling algorithm. Can. J. Fish. Aquat. Sci. 54:284-300.

Methot, R. D. 1986. Synthetic estimates of historical abundance and mortality for northern anchovy, *Engraulis mordax*. NMFS, Southwest Fish. Cent., Admin. Rep. LJ 86-29, La Jolla, CA.

Methot, R. D. 1990. Synthesis model: An adaptable framework for analysis of diverse stock assessment data. Int. N. Pac. Fish. Comm. Bull. 50:259-277.

Methot, R. D. 1998. Application of stock synthesis to NRC test data sets. *In* V. R. Restrepo (editor), Analyses of simulated data sets in support of the NRC study on stock assessment methods, p. 59-80. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-30.

Methot, R. D. 2000. Technical description of the stock synthesis assessment program. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NWFSC-43, 46 p.

Methot, R. D. 2005. Technical description of the Stock Synthesis II Assessment Program. Unpubl. manuscr. National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Blvd. East, Seattle, WA 98112-2097. 54 p.

Methot, R. D. 2007. User manual for the integrated analysis program Stock Synthesis 2 (SS2), Model Version 2.00c. National Marine Fisheries Service, Northwest Fisheries Science Center, 2725 Montlake Blvd. East, Seattle, WA 98112-2097. 47 p.

Methot, R. D. 2009. User Manual for Stock Synthesis, Model Version 3.03a. Unpublished manuscript, available from NOAA Fisheries Stock Assessment Toolbox website: http://nft.nefsc.noaa.gov/. 143 p.

National Marine Fisheries Service (NMFS). 2005. Final environmental impact statement for essential fish habitat identification and conservation in Alaska. National Marine Fisheries Service, Alaska Region. P.O. Box 21668, Juneau, AK 99802-1668.

Nichol, D. G., T. Honkalehto, and G. G. Thompson. 2007. Proximity of Pacific cod to the sea floor: Using archival tags to estimate fish availability to research bottom trawls. *Fisheries Research* 86:129-135.

Ona, E., and O. R. Godø. 1990. Fish reaction to trawling noise: the significance for trawl sampling. Rapports et Procès-Verbaux des Réunions du Conseil International pour l'Exploration de la Mer 189: 159–166.

Pitcher, K. W. 1981. Prey of Steller sea lion, *Eumetopias jubatus*, in the Gulf of Alaska. Fishery Bulletin 79:467-472.

Roberson, N. E. 2001. Age determination of Pacific cod (*Gadus macrocephalus*). MS thesis, University of Washington, Seattle, WA. 44 p.

Roberson, N. E., D. K. Kimura, D. R. Gunderson, and A. M. Shimada. 2005. Indirect validation of the age-reading method for Pacific cod (Gadus macrocephalus) using otoliths from marked and recaptured fish. U.S. Natl. Mar. Fish. Serv., Fish. Bull. 103:153-160.

Savin, A. B. 2008. Seasonal distribution and Migrations of Pacific cod *Gadus macrocephalus* (Gadidae) in Anadyr Bay and adjacent waters. Journal of Ichythyology 48:610-621.

Shimada, A. M., and D. K. Kimura. 1994. Seasonal movements of Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea and adjacent waters based on tag-recapture data. U.S. Natl. Mar. Fish. Serv., Fish. Bull. 92:800-816.

Sinclair, E.S. and T. K. Zeppelin. 2002. Seasonal and spatial differences in diet in the western stock of Steller sea lions (*Eumetopias jubatus*). Journal of Mammalogy 83(4).

Spies I. B. In review. A landscape genetics approach to Pacific cod (*Gadus macrocephalus*) population structure in the Bering Sea and Aleutian Islands reveals isolation-by-distance and distinct populations. Submitted to Canadian Journal of Fisheries and Aquatic Sciences.

Stark, J. W. 2007. Geographic and seasonal variations in maturation and growth of female Pacific cod (*Gadus macrocephalus*) in the Gulf of Alaska and Bering Sea. Fish. Bull. 105:396-407.

Thompson, G. G., and M. E. Conners. 2007. Report of the Pacific cod technical workshop held at the Alaska Fisheries Science Center, April 24-25, 2007. Unpubl. manuscr., Alaska Fisheries Science Center, Resource Ecology and Fisheries Management Division, 7600 Sand Point Way NE., Seattle, WA 98115-6349. 56 p.

Thompson, G. G., and M. W. Dorn. 2004. Assessment of the Pacific cod stock in the Eastern Bering Sea and Aleutian Islands Area. In Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 185-302. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., and M. W. Dorn. 2005. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 155-244. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G., M. Dorn, and D. Nichol. 2006. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 147-220. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G., J. Ianelli, M. Dorn, D. Nichol, S. Gaichas, and K. Aydin. 2007a. Assessment of the Pacific cod stock in the Eastern Bering Sea and Aleutian Islands Area. *In* Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 209-327. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G., J. Ianelli, M. Dorn, and M. Wilkins. 2007b. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 169-194. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., J. N. Ianelli, and M. E. Wilkins. 2009. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 165-351. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., J. N. Ianelli, and M. E. Wilkins. 2010. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska, p. 157-327. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., and R. D. Methot. 1993. Pacific cod. *In* Plan Team for Groundfish Fisheries of the Bering Sea/Aleutian Islands (editor), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands region as projected for 1994, chapter 2. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., and A. M. Shimada. 1990. Pacific cod. *In* L. L. Low and R. E. Narita (editors), Condition of groundfish resources of the eastern Bering Sea-Aleutian Islands region as assessed in 1988, p. 44-66. U.S. Dep. Commer., NOAA Tech. Memo. NMFS F/NWC-178.

Thompson, G. G, and H. H. Zenger. 1993. Pacific cod. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (editor), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 1994, chapter 2. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G, and H. H. Zenger. 1994. Pacific cod. *In* Plan Team for Groundfish Fisheries of the Gulf of Alaska (editor), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 1995, chapter 2. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., and H. H. Zenger. 1995. Pacific cod. *In* Plan Team for the Groundfish Fisheries of the Gulf of Alaska (editor), Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska as projected for 1996, chapter 2. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Thompson, G. G., H. H. Zenger, and M. K. Dorn. 2002. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for the Groundfish Fisheries of the Gulf of Alaska (compiler), Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska p. 89-167. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Thompson, G. G., H. H. Zenger, and M. K. Dorn. 2004. Assessment of the Pacific cod stock in the Gulf of Alaska. *In* Plan Team for the Groundfish Fisheries of the Gulf of Alaska (compiler), Stock Assessment and Fishery Evaluation Report for the Groundfish Resources of the Gulf of Alaska p. 131-232. North Pacific Fishery Management Council, 605 West 4th Ave., Suite 306, Anchorage, AK 99501.

Ueda, Y., Y. Narimatsu, T. Hattori, M. Ito, D. Kitagawa, N. Tomikawa, and T. Matsuishi. 2006. Fishing efficiency estimated based on the abundance from virtual population analysis and bottom-trawl surveys of Pacific cod (Gadus macrocephalus) in the waters off the Pacific coast of northern Honshu, Japan. Nippon Suisan Gakkaishi 72:201-209.

Wespestad, V., R. Bakkala, and J. June. 1982. Current abundance of Pacific cod (*Gadus macrocephalus*) in the eastern Bering Sea and expected abundance in 1982-1986. NOAA Tech. Memo. NMFS F/NWC-25, 26 p.

Westrheim, S. J. 1996. On the Pacific cod (*Gadus macrocephalus*) in British Columbia waters, and a comparison with Pacific cod elsewhere, and Atlantic cod (*G. morhua*). Can. Tech. Rep. Fish. Aquat. Sci. 2092. 390 p.

Yang, M-S. 2004. Diet changes of Pacific cod (Gadus macrocephalus) in Pavlof Bay associated with climate changes in the Gulf of Alaska between 1980 and 1995. U.S. Natl. Mar. Fish. Serv., Fish. Bull. 102:400-405.

Table 2.1a—Summary of catches (t) of Pacific cod by fleet sector and gear type, 1964-1990. All catches since 1980 include discards. Jt. Vent. = joint venture.

| | Fleet Sector | | | Gear Type | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Foreign | Jt. Vent. | Domestic | Trawl | Longline | Pot | Other | Total |
| 1964 | 196 | 0 | 0 | 56 | 140 | 0 | 0 | 196 |
| 1965 | 599 | 0 | 0 | 172 | 427 | 0 | 0 | 599 |
| 1966 | 1,376 | 0 | 0 | 396 | 980 | 0 | 0 | 1,376 |
| 1967 | 2,225 | 0 | 0 | 640 | 1,585 | 0 | 0 | 2,225 |
| 1968 | 1,046 | 0 | 0 | 301 | 745 | 0 | 0 | 1,046 |
| 1969 | 1,335 | 0 | 0 | 384 | 951 | 0 | 0 | 1,335 |
| 1970 | 1,805 | 0 | 0 | 519 | 1,286 | 0 | 0 | 1,805 |
| 1971 | 523 | 0 | 0 | 150 | 373 | 0 | 0 | 523 |
| 1972 | 3,513 | 0 | 0 | 1,010 | 2,503 | 0 | 0 | 3,513 |
| 1973 | 5,963 | 0 | 0 | 1,715 | 4,248 | 0 | 0 | 5,963 |
| 1974 | 5,182 | 0 | 0 | 1,491 | 3,691 | 0 | 0 | 5,182 |
| 1975 | 6,745 | 0 | 0 | 1,940 | 4,805 | 0 | 0 | 6,745 |
| 1976 | 6,764 | 0 | 0 | 1,946 | 4,818 | 0 | 0 | 6,764 |
| 1977 | 2,267 | 0 | 0 | 652 | 1,615 | 0 | 0 | 2,267 |
| 1978 | 11,370 | 7 | 813 | 4,547 | 6,800 | 0 | 843 | 12,190 |
| 1979 | 13,173 | 711 | 1,020 | 3,629 | 9,545 | 0 | 1,730 | 14,904 |
| 1980 | 34,245 | 466 | 634 | 6,464 | 27,780 | 0 | 1,101 | 35,345 |
| 1981 | 34,969 | 58 | 1,104 | 10,484 | 25,472 | 0 | 175 | 36,131 |
| 1982 | 26,937 | 193 | 2,335 | 6,679 | 22,667 | 0 | 119 | 29,465 |
| 1983 | 29,777 | 2,426 | 4,337 | 9,512 | 26,756 | 0 | 272 | 36,540 |
| 1984 | 15,896 | 4,649 | 3,353 | 8,805 | 14,844 | 0 | 249 | 23,898 |
| 1985 | 9,086 | 2,266 | 3,076 | 4,876 | 9,411 | 2 | 139 | 14,428 |
| 1986 | 15,211 | 1,357 | 8,444 | 6,850 | 17,619 | 141 | 402 | 25,012 |
| 1987 | 0 | 1,978 | 30,961 | 22,486 | 8,261 | 642 | 1,550 | 32,939 |
| 1988 | 0 | 1,661 | 32,141 | 27,145 | 3,933 | 1,422 | 1,302 | 33,802 |
| 1989 | 0 | 0 | 43,293 | 37,637 | 3,662 | 376 | 1,618 | 43,293 |
| 1990 | 0 | 0 | 72,517 | 59,188 | 5,919 | 5,661 | 1,749 | 72,517 |

Table 2.1b—Summary of catches (t) of Pacific cod since 1991 by management jurisdiction and gear type. Longl. = longline, Subt. = subtotal. All entries include discards. Catches for 2011 are complete through October 22.

| | Federal | | | | | State | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Trawl | Longl. | Pot | Other | Subt. | Longl. | Pot | Other | Subt. | Total |
| 1991 | 58,093 | 7,656 | 10,464 | 115 | 76,328 | 0 | 0 | 0 | 0 | 76,328 |
| 1992 | 54,593 | 15,675 | 10,154 | 325 | 80,747 | 0 | 0 | 0 | 0 | 80,747 |
| 1993 | 37,806 | 8,963 | 9,708 | 11 | 56,488 | 0 | 0 | 0 | 0 | 56,488 |
| 1994 | 31,447 | 6,778 | 9,161 | 100 | 47,485 | 0 | 0 | 0 | 0 | 47,485 |
| 1995 | 41,875 | 10,978 | 16,055 | 77 | 68,985 | 0 | 0 | 0 | 0 | 68,985 |
| 1996 | 45,991 | 10,196 | 12,040 | 53 | 68,280 | 0 | 0 | 0 | 0 | 68,280 |
| 1997 | 48,406 | 10,978 | 9,065 | 26 | 68,476 | 0 | 7,224 | 1,319 | 8,542 | 77,018 |
| 1998 | 41,570 | 10,012 | 10,510 | 29 | 62,121 | 0 | 9,088 | 1,316 | 10,404 | 72,525 |
| 1999 | 37,167 | 12,363 | 19,015 | 70 | 68,614 | 0 | 12,075 | 1,096 | 13,171 | 81,785 |
| 2000 | 25,458 | 11,667 | 17,351 | 54 | 54,529 | 0 | 10,388 | 1,643 | 12,031 | 66,560 |
| 2001 | 24,383 | 9,914 | 7,171 | 155 | 41,622 | 0 | 7,836 | 2,084 | 9,920 | 51,542 |
| 2002 | 19,810 | 14,666 | 7,694 | 176 | 42,346 | 0 | 10,423 | 1,714 | 12,137 | 54,483 |
| 2003 | 18,885 | 9,585 | 12,740 | 161 | 41,371 | 0 | 7,966 | 3,242 | 11,207 | 52,579 |
| 2004 | 17,513 | 10,380 | 14,965 | 400 | 43,258 | 0 | 10,602 | 2,765 | 13,367 | 56,625 |
| 2005 | 14,549 | 5,758 | 14,749 | 203 | 35,260 | 0 | 9,653 | 2,673 | 12,326 | 47,585 |
| 2006 | 13,131 | 10,274 | 14,795 | 118 | 38,319 | 0 | 8,890 | 646 | 9,536 | 47,854 |
| 2007 | 14,774 | 11,677 | 13,515 | 39 | 40,004 | 0 | 10,885 | 573 | 11,458 | 51,462 |
| 2008 | 20,309 | 12,367 | 11,220 | 62 | 43,959 | 0 | 13,438 | 1,568 | 15,005 | 58,964 |
| 2009 | 13,981 | 14,069 | 11,576 | 194 | 39,820 | 310 | 10,293 | 2,497 | 13,100 | 52,920 |
| 2010 | 21,791 | 16,673 | 20,114 | 426 | 59,004 | 373 | 14,604 | 4,090 | 19,067 | 78,071 |
| 2011 | 16,007 | 14,436 | 28,067 | 703 | 59,212 | 720 | 16,146 | 4,613 | 21,480 | 80,692 |

Table 2.2—History of Pacific cod catch (includes catch from State waters), Federal TAC (does *not* include State guideline harvest level), ABC, and OFL. ABC was not used in management of GOA groundfish prior to 1986. Catch for 2011 is current through October 22. The values in the column labeled "TAC" correspond to "optimum yield" for the years 1980-1986, "target quota" for the year 1987, and true TAC for the years 1988-2009. The ABC value listed for 1987 is the upper bound of the range. Source: NPFMC staff.

| Year | Catch | TAC | ABC | OFL |
|---|---|---|---|---|
| 1980 | 35,345 | 60,000 | - | - |
| 1981 | 36,131 | 70,000 | - | - |
| 1982 | 29,465 | 60,000 | - | - |
| 1983 | 36,540 | 60,000 | - | - |
| 1984 | 23,898 | 60,000 | - | - |
| 1985 | 14,428 | 60,000 | 136,000 | - |
| 1986 | 25,012 | 75,000 | 125,000 | - |
| 1987 | 32,939 | 50,000 | 185,000* | - |
| 1988 | 33,802 | 80,000 | 99,000 | - |
| 1989 | 43,293 | 71,200 | 71,200 | - |
| 1990 | 72,517 | 90,000 | 90,000 | - |
| 1991 | 76,328 | 77,900 | 77,900 | - |
| 1992 | 80,747 | 63,500 | 63,500 | 87,600 |
| 1993 | 56,488 | 56,700 | 56,700 | 78,100 |
| 1994 | 47,485 | 50,400 | 50,400 | 71,100 |
| 1995 | 68,985 | 69,200 | 69,200 | 126,000 |
| 1996 | 68,280 | 65,000 | 65,000 | 88,000 |
| 1997 | 77,018 | 69,115 | 81,500 | 180,000 |
| 1998 | 72,525 | 66,060 | 77,900 | 141,000 |
| 1999 | 81,785 | 67,835 | 84,400 | 134,000 |
| 2000 | 66,560 | 59,800 | 76,400 | 102,000 |
| 2001 | 51,542 | 52,110 | 67,800 | 91,200 |
| 2002 | 54,483 | 44,230 | 57,600 | 77,100 |
| 2003 | 52,579 | 40,540 | 52,800 | 70,100 |
| 2004 | 56,625 | 48,033 | 62,810 | 102,000 |
| 2005 | 47,585 | 44,433 | 58,100 | 86,200 |
| 2006 | 47,854 | 52,264 | 68,859 | 95,500 |
| 2007 | 51,462 | 52,264 | 68,859 | 97,600 |
| 2008 | 58,964 | 50,269 | 64,493 | 88,660 |
| 2009 | 52,920 | 41,807 | 55,300 | 66,000 |
| 2010 | 78,071 | 59,563 | 79,100 | 94,100 |
| 2011 | 80,692 | 65,100 | 86,800 | 102,600 |

Table 2.3—History of GOA Pacific cod allocations by regulatory area (in percent).

| | Regulatory Area | | |
|---|---|---|---|
| Year(s) | Western | Central | Eastern |
| 1977-1985 | 28 | 56 | 16 |
| 1986 | 40 | 44 | 16 |
| 1987 | 27 | 56 | 17 |
| 1988-1989 | 19 | 73 | 8 |
| 1990 | 33 | 66 | 1 |
| 1991 | 33 | 62 | 5 |
| 1992 | 37 | 61 | 2 |
| 1993-1994 | 33 | 62 | 5 |
| 1995-1996 | 29 | 66 | 5 |
| 1997-1999 | 35 | 63 | 2 |
| 2000-2001 | 36 | 57 | 7 |
| 2002 (ABC) | 39 | 55 | 6 |
| 2002 (TAC) | 38 | 56 | 6 |
| 2003 (ABC) | 39 | 55 | 6 |
| 2003 (TAC) | 38 | 56 | 6 |
| 2004 (ABC) | 36 | 57 | 7 |
| 2004 (TAC) | 35.3 | 56.5 | 8.2 |
| 2005 (ABC) | 36 | 57 | 7 |
| 2005 (TAC) | 35.3 | 56.5 | 8.2 |
| 2006 (ABC) | 39 | 55 | 6 |
| 2006 (TAC) | 38.54 | 54.35 | 7.11 |
| 2007 (ABC) | 39 | 55 | 6 |
| 2007 (TAC) | 38.54 | 54.35 | 7.11 |
| 2008 (ABC) | 39 | 57 | 4 |
| 2008 (TAC) | 38.69 | 56.55 | 4.76 |
| 2009 (ABC) | 39 | 57 | 4 |
| 2009 (TAC) | 38.69 | 56.55 | 4.76 |
| 2010 (ABC) | 35 | 62 | 3 |
| 2010 (TAC) | 34.86 | 61.75 | 3.39 |
| 2011 (ABC) | 35 | 62 | 3 |
| 2011 (TAC) | 35 | 62 | 3 |

Table 2.4a—Pacific cod discard rates by area, target species/group, and year for the period 1991-2002 (see Table 2.4b for the period 2003--2011). The discard rate is the ratio of discarded Pacific cod catch to total Pacific cod catch for a given area/target/year combination. An empty cell indicates that no Pacific cod were caught in that area/target/year combination. Note that the absolute amount of discards may be small even if the discard rate is large.

| Target species/group | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arrowtooth flounder | | 0.98 | 0.59 | 0.00 | 0.10 | 0.09 | 0.00 | 1.00 | 0.63 | 0.06 | | 0.00 |
| Atka mackerel | | | | 0.81 | 1.00 | 0.00 | | | | | | |
| Deepwater Flat | 1.00 | | | 0.43 | 0.00 | 0.68 | 0.53 | 0.00 | 0.36 | 0.00 | 0.75 | |
| Flathead sole | | | | 1.00 | | 0.07 | 0.99 | 0.00 | | 0.29 | 0.75 | 0.00 |
| Other species | 1.00 | 0.15 | 0.63 | | 0.10 | 0.91 | 0.00 | 0.00 | 0.96 | 0.01 | 0.00 | 0.00 |
| Pacific cod | 0.05 | 0.03 | 0.03 | 0.02 | 0.03 | 0.02 | 0.02 | 0.01 | 0.01 | 0.00 | 0.02 | 0.02 |
| Pollock | 0.82 | 0.59 | 0.15 | 0.15 | 0.95 | 0.17 | 0.98 | 0.75 | 0.89 | 0.44 | 0.00 | 1.00 |
| Rex sole | | | | | 0.16 | 0.25 | 0.61 | 0.57 | | | | 1.00 |
| Rockfish | 0.15 | 0.11 | 0.13 | 0.16 | 0.11 | 0.13 | 0.14 | 0.17 | 0.17 | 0.17 | 0.00 | 0.04 |
| Sablefish | 0.84 | 0.72 | 0.72 | 0.77 | 0.55 | 0.78 | 0.54 | 0.66 | 0.52 | 0.25 | 0.27 | 0.22 |
| Shallow-water flatfish | 0.43 | 0.00 | 0.00 | 0.87 | 0.00 | 0.97 | 0.00 | 1.00 | 0.74 | 0.28 | | 1.00 |
| Unknown | 0.01 | | | | | 1.00 | 1.00 | 1.00 | | 1.00 | | |
| All targets | 0.03 | 0.03 | 0.04 | 0.02 | 0.03 | 0.02 | 0.03 | 0.01 | 0.02 | 0.00 | 0.02 | 0.02 |

Table 2.4b—Pacific cod discard rates by area, target species/group, and year for the period 2003-2011 (see Table 2.4a for the period 1991-2002). The discard rate is the ratio of discarded Pacific cod catch to total Pacific cod catch for a given area/target/year combination. An empty cell indicates that no Pacific cod were caught in that area/target/year combination. Note that the absolute amount of discards may be small even if the discard rate is large.

| | Discard rate | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Target fishery | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | Ave. |
| Arrowtooth Flounder | 0.417 | 0.299 | 0.267 | 0.168 | 0.066 | 0.480 | 0.147 | 0.278 | 0.087 | 0.250 |
| Deep Water Flatfish | 0.014 | 0.252 | | | | | | | | 0.188 |
| Flathead Sole | 0.258 | 0.327 | 0.123 | 0.085 | 0.104 | 0.162 | 0.033 | 0.191 | 0.109 | 0.167 |
| Halibut | 0.542 | 0.635 | 0.302 | 0.252 | 0.234 | 0.161 | 0.565 | 0.238 | 0.713 | 0.453 |
| Other Species | 0.170 | 0.070 | 0.000 | 0.050 | | | | | | 0.137 |
| Pacific Cod | 0.008 | 0.005 | 0.004 | 0.025 | 0.006 | 0.006 | 0.008 | 0.004 | 0.004 | 0.007 |
| Pollock - bottom | 0.005 | 0.013 | 0.001 | 0.007 | 0.039 | 0.041 | 0.058 | 0.026 | 0.000 | 0.019 |
| Pollock - midwater | 0.072 | 0.116 | 0.003 | 0.004 | 0.003 | 0.000 | 0.009 | 0.009 | 0.000 | 0.029 |
| Rex Sole | 0.244 | 0.155 | 0.121 | 0.054 | 0.116 | 0.036 | 0.145 | 0.131 | 0.132 | 0.141 |
| Rockfish | 0.147 | 0.045 | 0.040 | 0.139 | 0.023 | 0.081 | 0.049 | 0.043 | 0.023 | 0.075 |
| Sablefish | 0.641 | 0.229 | 0.518 | 0.278 | 0.204 | 0.155 | 0.291 | 0.084 | 0.613 | 0.344 |
| Shallow Water Flatfish | 0.599 | 0.533 | 0.394 | 0.306 | 0.384 | 0.604 | 0.641 | 0.742 | 0.538 | 0.563 |
| All | 0.046 | 0.022 | 0.021 | 0.038 | 0.028 | 0.057 | 0.073 | 0.036 | 0.022 | 0.038 |

Table 2.5 (p. 1 of 4)— Catch (t) of Pacific cod by year, gear, and season for the years 1977-2011 as configured in the stock assessment models. 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. Sep-Oct and Nov-Dec catches for 2011 are extrapolated.

| | | Trawl fishery | | | Longline fishery | | | Pot fishery | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec |
| 1977 | Jan-Feb | 73 | 0 | 0 | 377 | 0 | 0 | 0 | 0 | 0 |
| 1977 | Mar-Apr | 73 | 0 | 0 | 377 | 0 | 0 | 0 | 0 | 0 |
| 1977 | May-Aug | 0 | 195 | 0 | 0 | 379 | 0 | 0 | 0 | 0 |
| 1977 | Sep-Oct | 0 | 0 | 156 | 0 | 0 | 241 | 0 | 0 | 0 |
| 1977 | Nov-Dec | 0 | 0 | 156 | 0 | 0 | 241 | 0 | 0 | 0 |
| 1978 | Jan-Feb | 366 | 0 | 0 | 1888 | 0 | 0 | 0 | 0 | 0 |
| 1978 | Mar-Apr | 366 | 0 | 0 | 1888 | 0 | 0 | 0 | 0 | 0 |
| 1978 | May-Aug | 0 | 973 | 0 | 0 | 1894 | 0 | 0 | 0 | 0 |
| 1978 | Sep-Oct | 0 | 0 | 779 | 0 | 0 | 1207 | 0 | 0 | 0 |
| 1978 | Nov-Dec | 0 | 0 | 779 | 0 | 0 | 1207 | 0 | 0 | 0 |
| 1979 | Jan-Feb | 425 | 0 | 0 | 2192 | 0 | 0 | 0 | 0 | 0 |
| 1979 | Mar-Apr | 425 | 0 | 0 | 2192 | 0 | 0 | 0 | 0 | 0 |
| 1979 | May-Aug | 0 | 1130 | 0 | 0 | 2199 | 0 | 0 | 0 | 0 |
| 1979 | Sep-Oct | 0 | 0 | 905 | 0 | 0 | 1401 | 0 | 0 | 0 |
| 1979 | Nov-Dec | 0 | 0 | 905 | 0 | 0 | 1401 | 0 | 0 | 0 |
| 1980 | Jan-Feb | 1106 | 0 | 0 | 5698 | 0 | 0 | 0 | 0 | 0 |
| 1980 | Mar-Apr | 1106 | 0 | 0 | 5698 | 0 | 0 | 0 | 0 | 0 |
| 1980 | May-Aug | 0 | 2937 | 0 | 0 | 5717 | 0 | 0 | 0 | 0 |
| 1980 | Sep-Oct | 0 | 0 | 2351 | 0 | 0 | 3641 | 0 | 0 | 0 |
| 1980 | Nov-Dec | 0 | 0 | 2351 | 0 | 0 | 3641 | 0 | 0 | 0 |
| 1981 | Jan-Feb | 155 | 0 | 0 | 4202 | 0 | 0 | 0 | 0 | 0 |
| 1981 | Mar-Apr | 155 | 0 | 0 | 4202 | 0 | 0 | 0 | 0 | 0 |
| 1981 | May-Aug | 0 | 3609 | 0 | 0 | 7413 | 0 | 0 | 0 | 0 |
| 1981 | Sep-Oct | 0 | 0 | 3283 | 0 | 0 | 4828 | 0 | 0 | 0 |
| 1981 | Nov-Dec | 0 | 0 | 3283 | 0 | 0 | 4828 | 0 | 0 | 0 |
| 1982 | Jan-Feb | 457 | 0 | 0 | 3965 | 0 | 0 | 0 | 0 | 0 |
| 1982 | Mar-Apr | 457 | 0 | 0 | 3965 | 0 | 0 | 0 | 0 | 0 |
| 1982 | May-Aug | 0 | 2270 | 0 | 0 | 4872 | 0 | 0 | 0 | 0 |
| 1982 | Sep-Oct | 0 | 0 | 1748 | 0 | 0 | 4933 | 0 | 0 | 0 |
| 1982 | Nov-Dec | 0 | 0 | 1748 | 0 | 0 | 4933 | 0 | 0 | 0 |
| 1983 | Jan-Feb | 1144 | 0 | 0 | 4384 | 0 | 0 | 0 | 0 | 0 |
| 1983 | Mar-Apr | 1144 | 0 | 0 | 4384 | 0 | 0 | 0 | 0 | 0 |
| 1983 | May-Aug | 0 | 3416 | 0 | 0 | 6843 | 0 | 0 | 0 | 0 |
| 1983 | Sep-Oct | 0 | 0 | 1904 | 0 | 0 | 5573 | 0 | 0 | 0 |
| 1983 | Nov-Dec | 0 | 0 | 1904 | 0 | 0 | 5573 | 0 | 0 | 0 |
| 1984 | Jan-Feb | 1372 | 0 | 0 | 4736 | 0 | 0 | 0 | 0 | 0 |
| 1984 | Mar-Apr | 1372 | 0 | 0 | 4736 | 0 | 0 | 0 | 0 | 0 |
| 1984 | May-Aug | 0 | 2694 | 0 | 0 | 2793 | 0 | 0 | 0 | 0 |
| 1984 | Sep-Oct | 0 | 0 | 1684 | 0 | 0 | 1290 | 0 | 0 | 0 |
| 1984 | Nov-Dec | 0 | 0 | 1684 | 0 | 0 | 1290 | 0 | 0 | 0 |
| 1985 | Jan-Feb | 971 | 0 | 0 | 3651 | 0 | 0 | 0 | 0 | 0 |
| 1985 | Mar-Apr | 971 | 0 | 0 | 3651 | 0 | 0 | 0 | 0 | 0 |
| 1985 | May-Aug | 0 | 1056 | 0 | 0 | 1831 | 0 | 0 | 0 | 0 |
| 1985 | Sep-Oct | 0 | 0 | 939 | 0 | 0 | 140 | 0 | 0 | 0 |
| 1985 | Nov-Dec | 0 | 0 | 939 | 0 | 0 | 140 | 0 | 0 | 0 |

Table 2.5 (p. 2 of 4)—Catch (t) of Pacific cod by year, gear, and season for the years 1977-2011 as configured in the stock assessment models.

| | | Trawl fishery | | | Longline fishery | | | Pot fishery | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec |
| 1986 | Jan-Feb | 1200 | 0 | 0 | 6371 | 0 | 0 | 0 | 0 | 0 |
| 1986 | Mar-Apr | 1200 | 0 | 0 | 6371 | 0 | 0 | 0 | 0 | 0 |
| 1986 | May-Aug | 0 | 1031 | 0 | 0 | 3645 | 0 | 0 | 0 | 0 |
| 1986 | Sep-Oct | 0 | 0 | 1710 | 0 | 0 | 687 | 0 | 0 | 0 |
| 1986 | Nov-Dec | 0 | 0 | 1710 | 0 | 0 | 687 | 0 | 0 | 0 |
| 1987 | Jan-Feb | 2151 | 0 | 0 | 2137 | 0 | 0 | 88 | 0 | 0 |
| 1987 | Mar-Apr | 2151 | 0 | 0 | 2137 | 0 | 0 | 88 | 0 | 0 |
| 1987 | May-Aug | 0 | 9003 | 0 | 0 | 2052 | 0 | 0 | 185 | 0 |
| 1987 | Sep-Oct | 0 | 0 | 4591 | 0 | 0 | 968 | 0 | 0 | 141 |
| 1987 | Nov-Dec | 0 | 0 | 4591 | 0 | 0 | 968 | 0 | 0 | 141 |
| 1988 | Jan-Feb | 6408 | 0 | 0 | 1192 | 0 | 0 | 432 | 0 | 0 |
| 1988 | Mar-Apr | 6408 | 0 | 0 | 1192 | 0 | 0 | 432 | 0 | 0 |
| 1988 | May-Aug | 0 | 9773 | 0 | 0 | 1103 | 0 | 0 | 239 | 0 |
| 1988 | Sep-Oct | 0 | 0 | 2278 | 0 | 0 | 224 | 0 | 0 | 159 |
| 1988 | Nov-Dec | 0 | 0 | 2278 | 0 | 0 | 224 | 0 | 0 | 159 |
| 1989 | Jan-Feb | 9846 | 0 | 0 | 951 | 0 | 0 | 96 | 0 | 0 |
| 1989 | Mar-Apr | 9846 | 0 | 0 | 951 | 0 | 0 | 96 | 0 | 0 |
| 1989 | May-Aug | 0 | 17780 | 0 | 0 | 832 | 0 | 0 | 151 | 0 |
| 1989 | Sep-Oct | 0 | 0 | 83 | 0 | 0 | 464 | 0 | 0 | 16 |
| 1989 | Nov-Dec | 0 | 0 | 83 | 0 | 0 | 464 | 0 | 0 | 16 |
| 1990 | Jan-Feb | 17312 | 0 | 0 | 2223 | 0 | 0 | 1031 | 0 | 0 |
| 1990 | Mar-Apr | 17312 | 0 | 0 | 2223 | 0 | 0 | 1031 | 0 | 0 |
| 1990 | May-Aug | 0 | 16170 | 0 | 0 | 1220 | 0 | 0 | 1523 | 0 |
| 1990 | Sep-Oct | 0 | 0 | 4198 | 0 | 0 | 127 | 0 | 0 | 1038 |
| 1990 | Nov-Dec | 0 | 0 | 4198 | 0 | 0 | 127 | 0 | 0 | 1038 |
| 1991 | Jan-Feb | 12061 | 0 | 0 | 1289 | 0 | 0 | 2503 | 0 | 0 |
| 1991 | Mar-Apr | 43801 | 0 | 0 | 5763 | 0 | 0 | 6910 | 0 | 0 |
| 1991 | May-Aug | 0 | 778 | 0 | 0 | 540 | 0 | 0 | 183 | 0 |
| 1991 | Sep-Oct | 0 | 0 | 1492 | 0 | 0 | 44 | 0 | 0 | 28 |
| 1991 | Nov-Dec | 0 | 0 | 1 | 0 | 0 | 28 | 0 | 0 | 906 |
| 1992 | Jan-Feb | 17072 | 0 | 0 | 6058 | 0 | 0 | 2586 | 0 | 0 |
| 1992 | Mar-Apr | 34407 | 0 | 0 | 6487 | 0 | 0 | 7112 | 0 | 0 |
| 1992 | May-Aug | 0 | 1828 | 0 | 0 | 966 | 0 | 0 | 19 | 0 |
| 1992 | Sep-Oct | 0 | 0 | 1386 | 0 | 0 | 2168 | 0 | 0 | 470 |
| 1992 | Nov-Dec | 0 | 0 | 114 | 0 | 0 | 75 | 0 | 0 | 0 |
| 1993 | Jan-Feb | 9116 | 0 | 0 | 3937 | 0 | 0 | 2936 | 0 | 0 |
| 1993 | Mar-Apr | 24521 | 0 | 0 | 4062 | 0 | 0 | 6448 | 0 | 0 |
| 1993 | May-Aug | 0 | 2625 | 0 | 0 | 784 | 0 | 0 | 326 | 0 |
| 1993 | Sep-Oct | 0 | 0 | 734 | 0 | 0 | 134 | 0 | 0 | 0 |
| 1993 | Nov-Dec | 0 | 0 | 817 | 0 | 0 | 47 | 0 | 0 | 0 |
| 1994 | Jan-Feb | 10235 | 0 | 0 | 3958 | 0 | 0 | 5213 | 0 | 0 |
| 1994 | Mar-Apr | 18915 | 0 | 0 | 2473 | 0 | 0 | 3501 | 0 | 0 |
| 1994 | May-Aug | 0 | 1433 | 0 | 0 | 299 | 0 | 0 | 33 | 0 |
| 1994 | Sep-Oct | 0 | 0 | 852 | 0 | 0 | 50 | 0 | 0 | 5 |
| 1994 | Nov-Dec | 0 | 0 | 25 | 0 | 0 | 2 | 0 | 0 | 491 |
| 1995 | Jan-Feb | 5994 | 0 | 0 | 5458 | 0 | 0 | 9033 | 0 | 0 |
| 1995 | Mar-Apr | 32204 | 0 | 0 | 5095 | 0 | 0 | 6377 | 0 | 0 |
| 1995 | May-Aug | 0 | 1117 | 0 | 0 | 214 | 0 | 0 | 76 | 0 |
| 1995 | Sep-Oct | 0 | 0 | 2597 | 0 | 0 | 180 | 0 | 0 | 416 |
| 1995 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 47 | 0 | 0 | 176 |

Table 2.5 (p. 3 of 4)—Catch (t) of Pacific cod by year, gear, and season for the years 1977-2011 as configured in the stock assessment models.

| | | Trawl fishery | | | Longline fishery | | | Pot fishery | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec |
| 1996 | Jan-Feb | 10154 | 0 | 0 | 5880 | 0 | 0 | 7481 | 0 | 0 |
| 1996 | Mar-Apr | 30352 | 0 | 0 | 4005 | 0 | 0 | 4544 | 0 | 0 |
| 1996 | May-Aug | 0 | 4023 | 0 | 0 | 215 | 0 | 0 | 27 | 0 |
| 1996 | Sep-Oct | 0 | 0 | 932 | 0 | 0 | 59 | 0 | 0 | 0 |
| 1996 | Nov-Dec | 0 | 0 | 562 | 0 | 0 | 47 | 0 | 0 | 0 |
| 1997 | Jan-Feb | 12168 | 0 | 0 | 6707 | 0 | 0 | 8331 | 0 | 0 |
| 1997 | Mar-Apr | 28239 | 0 | 0 | 3506 | 0 | 0 | 5080 | 0 | 0 |
| 1997 | May-Aug | 0 | 1970 | 0 | 0 | 390 | 0 | 0 | 2356 | 0 |
| 1997 | Sep-Oct | 0 | 0 | 4862 | 0 | 0 | 261 | 0 | 0 | 917 |
| 1997 | Nov-Dec | 0 | 0 | 1182 | 0 | 0 | 118 | 0 | 0 | 931 |
| 1998 | Jan-Feb | 17009 | 0 | 0 | 7786 | 0 | 0 | 11899 | 0 | 0 |
| 1998 | Mar-Apr | 17363 | 0 | 0 | 1521 | 0 | 0 | 5753 | 0 | 0 |
| 1998 | May-Aug | 0 | 4014 | 0 | 0 | 444 | 0 | 0 | 2137 | 0 |
| 1998 | Sep-Oct | 0 | 0 | 3200 | 0 | 0 | 183 | 0 | 0 | 568 |
| 1998 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 81 | 0 | 0 | 568 |
| 1999 | Jan-Feb | 14236 | 0 | 0 | 7773 | 0 | 0 | 13883 | 0 | 0 |
| 1999 | Mar-Apr | 15886 | 0 | 0 | 4035 | 0 | 0 | 8910 | 0 | 0 |
| 1999 | May-Aug | 0 | 1520 | 0 | 0 | 403 | 0 | 0 | 6859 | 0 |
| 1999 | Sep-Oct | 0 | 0 | 5550 | 0 | 0 | 96 | 0 | 0 | 1940 |
| 1999 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 62 | 0 | 0 | 632 |
| 2000 | Jan-Feb | 13420 | 0 | 0 | 9432 | 0 | 0 | 19229 | 0 | 0 |
| 2000 | Mar-Apr | 8159 | 0 | 0 | 1969 | 0 | 0 | 6539 | 0 | 0 |
| 2000 | May-Aug | 0 | 3148 | 0 | 0 | 170 | 0 | 0 | 2938 | 0 |
| 2000 | Sep-Oct | 0 | 0 | 551 | 0 | 0 | 90 | 0 | 0 | 307 |
| 2000 | Nov-Dec | 0 | 0 | 199 | 0 | 0 | 17 | 0 | 0 | 392 |
| 2001 | Jan-Feb | 8621 | 0 | 0 | 9234 | 0 | 0 | 6971 | 0 | 0 |
| 2001 | Mar-Apr | 5901 | 0 | 0 | 410 | 0 | 0 | 5304 | 0 | 0 |
| 2001 | May-Aug | 0 | 2753 | 0 | 0 | 135 | 0 | 0 | 2885 | 0 |
| 2001 | Sep-Oct | 0 | 0 | 7220 | 0 | 0 | 127 | 0 | 0 | 1106 |
| 2001 | Nov-Dec | 0 | 0 | 8 | 0 | 0 | 15 | 0 | 0 | 852 |
| 2002 | Jan-Feb | 7264 | 0 | 0 | 7978 | 0 | 0 | 7490 | 0 | 0 |
| 2002 | Mar-Apr | 7202 | 0 | 0 | 3432 | 0 | 0 | 5559 | 0 | 0 |
| 2002 | May-Aug | 0 | 4069 | 0 | 0 | 161 | 0 | 0 | 2288 | 0 |
| 2002 | Sep-Oct | 0 | 0 | 1106 | 0 | 0 | 2070 | 0 | 0 | 2569 |
| 2002 | Nov-Dec | 0 | 0 | 203 | 0 | 0 | 1089 | 0 | 0 | 2004 |
| 2003 | Jan-Feb | 9003 | 0 | 0 | 6598 | 0 | 0 | 12786 | 0 | 0 |
| 2003 | Mar-Apr | 1793 | 0 | 0 | 2334 | 0 | 0 | 6613 | 0 | 0 |
| 2003 | May-Aug | 0 | 3238 | 0 | 0 | 460 | 0 | 0 | 0 | 0 |
| 2003 | Sep-Oct | 0 | 0 | 5819 | 0 | 0 | 867 | 0 | 0 | 3029 |
| 2003 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 13 | 0 | 0 | 27 |
| 2004 | Jan-Feb | 7982 | 0 | 0 | 8037 | 0 | 0 | 13895 | 0 | 0 |
| 2004 | Mar-Apr | 1239 | 0 | 0 | 222 | 0 | 0 | 9439 | 0 | 0 |
| 2004 | May-Aug | 0 | 2286 | 0 | 0 | 240 | 0 | 0 | 277 | 0 |
| 2004 | Sep-Oct | 0 | 0 | 6543 | 0 | 0 | 2064 | 0 | 0 | 3549 |
| 2004 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 10 | 0 | 0 | 843 |
| 2005 | Jan-Feb | 8820 | 0 | 0 | 3617 | 0 | 0 | 11969 | 0 | 0 |
| 2005 | Mar-Apr | 838 | 0 | 0 | 221 | 0 | 0 | 9392 | 0 | 0 |
| 2005 | May-Aug | 0 | 1883 | 0 | 0 | 165 | 0 | 0 | 251 | 0 |
| 2005 | Sep-Oct | 0 | 0 | 3407 | 0 | 0 | 1401 | 0 | 0 | 3946 |
| 2005 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 484 | 0 | 0 | 1192 |

Table 2.5 (p. 4 of 4)—Catch (t) of Pacific cod by year, gear, and season for the years 1977-2011 as configured in the stock assessment models.

| | | Trawl fishery | | | Longline fishery | | | Pot fishery | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec | Jan-Apr | May-Aug | Sep-Dec |
| 2006 | Jan-Feb | 8790 | 0 | 0 | 5385 | 0 | 0 | 11969 | 0 | 0 |
| 2006 | Mar-Apr | 1238 | 0 | 0 | 771 | 0 | 0 | 9448 | 0 | 0 |
| 2006 | May-Aug | 0 | 1429 | 0 | 0 | 175 | 0 | 0 | 274 | 0 |
| 2006 | Sep-Oct | 0 | 0 | 1972 | 0 | 0 | 2264 | 0 | 0 | 1131 |
| 2006 | Nov-Dec | 0 | 0 | 0 | 0 | 0 | 1759 | 0 | 0 | 1250 |
| 2007 | Jan-Feb | 7804 | 0 | 0 | 5580 | 0 | 0 | 8986 | 0 | 0 |
| 2007 | Mar-Apr | 1809 | 0 | 0 | 1514 | 0 | 0 | 11080 | 0 | 0 |
| 2007 | May-Aug | 0 | 1764 | 0 | 0 | 357 | 0 | 0 | 564 | 0 |
| 2007 | Sep-Oct | 0 | 0 | 3408 | 0 | 0 | 3226 | 0 | 0 | 2151 |
| 2007 | Nov-Dec | 0 | 0 | 288 | 0 | 0 | 1085 | 0 | 0 | 1847 |
| 2008 | Jan-Feb | 9897 | 0 | 0 | 7886 | 0 | 0 | 8564 | 0 | 0 |
| 2008 | Mar-Apr | 1259 | 0 | 0 | 1435 | 0 | 0 | 11821 | 0 | 0 |
| 2008 | May-Aug | 0 | 2514 | 0 | 0 | 606 | 0 | 0 | 0 | 0 |
| 2008 | Sep-Oct | 0 | 0 | 7027 | 0 | 0 | 2655 | 0 | 0 | 3348 |
| 2008 | Nov-Dec | 0 | 0 | 623 | 0 | 0 | 67 | 0 | 0 | 1261 |
| 2009 | Jan-Feb | 5798 | 0 | 0 | 8709 | 0 | 0 | 10630 | 0 | 0 |
| 2009 | Mar-Apr | 1078 | 0 | 0 | 889 | 0 | 0 | 8396 | 0 | 0 |
| 2009 | May-Aug | 0 | 3868 | 0 | 0 | 1063 | 0 | 0 | 0 | 0 |
| 2009 | Sep-Oct | 0 | 0 | 4359 | 0 | 0 | 3356 | 0 | 0 | 3095 |
| 2009 | Nov-Dec | 0 | 0 | 273 | 0 | 0 | 896 | 0 | 0 | 511 |
| 2010 | Jan-Feb | 9820 | 0 | 0 | 10856 | 0 | 0 | 18773 | 0 | 0 |
| 2010 | Mar-Apr | 1189 | 0 | 0 | 816 | 0 | 0 | 12236 | 0 | 0 |
| 2010 | May-Aug | 0 | 4609 | 0 | 0 | 676 | 0 | 0 | 1 | 0 |
| 2010 | Sep-Oct | 0 | 0 | 7993 | 0 | 0 | 5071 | 0 | 0 | 5554 |
| 2010 | Nov-Dec | 0 | 0 | 247 | 0 | 0 | 147 | 0 | 0 | 83 |
| 2011 | Jan-Feb | 7413 | 0 | 0 | 9556 | 0 | 0 | 23700 | 0 | 0 |
| 2011 | Mar-Apr | 2051 | 0 | 0 | 808 | 0 | 0 | 13240 | 0 | 0 |
| 2011 | May-Aug | 0 | 1137 | 0 | 0 | 1103 | 0 | 0 | 0 | 0 |
| 2011 | Sep-Oct | 0 | 0 | 6460 | 0 | 0 | 4247 | 0 | 0 | 11174 |
| 2011 | Nov-Dec | 0 | 0 | 381 | 0 | 0 | 370 | 0 | 0 | 618 |

Table 2.6 (page 1 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 trawl fishery | | | | May-Aug trawl fishery | | | | Sep-Dec trawl fishery | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | CPUE | Sigma | Year | Season | CPUE | Sigma | Year | Season | CPUE | Sigma |
| 1991 | Jan-Feb | 74.23 | 0.066 | 1991 | May-Aug | 19.20 | 0.353 | 1991 | Sep-Oct | 63.12 | 0.333 |
| 1992 | Jan-Feb | 60.41 | 0.051 | 1992 | May-Aug | 22.19 | 0.365 | 1992 | Sep-Oct | 27.81 | 0.192 |
| 1993 | Jan-Feb | 43.00 | 0.100 | 1993 | May-Aug | 25.95 | 0.272 | 1993 | Sep-Oct | 15.02 | 0.272 |
| 1994 | Jan-Feb | 56.35 | 0.129 | 1994 | May-Aug | 29.49 | 0.308 | 1994 | Sep-Oct | 37.70 | 0.272 |
| 1995 | Jan-Feb | 67.22 | 0.094 | 1995 | May-Aug | 18.59 | 0.220 | 1995 | Sep-Oct | 53.43 | 0.138 |
| 1996 | Jan-Feb | 52.59 | 0.088 | 1996 | May-Aug | 25.73 | 0.153 | 1996 | Sep-Oct | 23.55 | 0.262 |
| 1997 | Jan-Feb | 44.17 | 0.080 | 1997 | May-Aug | 30.92 | 0.189 | 1997 | Sep-Oct | 70.38 | 0.121 |
| 1998 | Jan-Feb | 38.18 | 0.077 | 1998 | May-Aug | 223.12 | 0.132 | 1998 | Sep-Oct | 204.47 | 0.157 |
| 1999 | Jan-Feb | 45.75 | 0.083 | 1999 | May-Aug | 237.30 | 0.342 | 1999 | Sep-Oct | 209.30 | 0.218 |
| 2000 | Jan-Feb | 42.16 | 0.091 | 2000 | May-Aug | 147.62 | 0.200 | 2001 | Sep-Oct | 51.21 | 0.104 |
| 2001 | Jan-Feb | 31.72 | 0.095 | 2001 | May-Aug | 169.12 | 0.190 | 2002 | Sep-Oct | 39.87 | 0.324 |
| 2002 | Jan-Feb | 37.39 | 0.101 | 2002 | May-Aug | 115.75 | 0.149 | 2003 | Sep-Oct | 185.81 | 0.150 |
| 2003 | Jan-Feb | 65.48 | 0.103 | 2003 | May-Aug | 147.54 | 0.166 | 2004 | Sep-Oct | 88.72 | 0.127 |
| 2004 | Jan-Feb | 72.40 | 0.131 | 2004 | May-Aug | 264.53 | 0.198 | 2005 | Sep-Oct | 145.48 | 0.185 |
| 2005 | Jan-Feb | 71.38 | 0.139 | 2005 | May-Aug | 85.58 | 0.262 | 2006 | Sep-Oct | 66.73 | 0.342 |
| 2006 | Jan-Feb | 49.07 | 0.144 | 2006 | May-Aug | 176.86 | 0.471 | 2007 | Sep-Oct | 62.05 | 0.141 |
| 2007 | Jan-Feb | 38.63 | 0.077 | 2007 | May-Aug | 139.79 | 0.127 | 2008 | Sep-Oct | 90.74 | 0.123 |
| 2008 | Jan-Feb | 32.93 | 0.126 | 2008 | May-Aug | 184.70 | 0.170 | 2009 | Sep-Oct | 96.88 | 0.159 |
| 2009 | Jan-Feb | 77.79 | 0.152 | 2009 | May-Aug | 95.43 | 0.184 | 2010 | Sep-Oct | 97.78 | 0.110 |
| 2010 | Jan-Feb | 67.62 | 0.111 | 2010 | May-Aug | 164.73 | 0.169 | 1993 | Nov-Dec | 14.65 | 0.288 |
| 2011 | Jan-Feb | 91.12 | 0.134 | 2011 | May-Aug | 238.09 | 0.262 | 1996 | Nov-Dec | 27.31 | 0.426 |
| 1991 | Mar-Apr | 122.97 | 0.046 | | | | | 1997 | Nov-Dec | 21.33 | 0.631 |
| 1992 | Mar-Apr | 77.74 | 0.058 | | | | | 2007 | Nov-Dec | 25.48 | 0.353 |
| 1993 | Mar-Apr | 89.45 | 0.057 | | | | | 2008 | Nov-Dec | 11.60 | 0.333 |
| 1994 | Mar-Apr | 119.65 | 0.096 | | | | | 2009 | Nov-Dec | 30.49 | 0.576 |
| 1995 | Mar-Apr | 157.65 | 0.058 | | | | | 2010 | Nov-Dec | 16.32 | 0.446 |
| 1996 | Mar-Apr | 136.51 | 0.064 | | | | | | | | |
| 1997 | Mar-Apr | 86.48 | 0.068 | | | | | | | | |
| 1998 | Mar-Apr | 82.78 | 0.077 | | | | | | | | |
| 1999 | Mar-Apr | 43.69 | 0.083 | | | | | | | | |
| 2000 | Mar-Apr | 54.66 | 0.159 | | | | | | | | |
| 2001 | Mar-Apr | 61.07 | 0.122 | | | | | | | | |
| 2002 | Mar-Apr | 50.05 | 0.109 | | | | | | | | |
| 2003 | Mar-Apr | 30.44 | 0.232 | | | | | | | | |
| 2004 | Mar-Apr | 19.92 | 0.308 | | | | | | | | |
| 2005 | Mar-Apr | 23.24 | 0.324 | | | | | | | | |
| 2006 | Mar-Apr | 19.03 | 0.426 | | | | | | | | |
| 2007 | Mar-Apr | 66.48 | 0.258 | | | | | | | | |
| 2008 | Mar-Apr | 48.35 | 0.365 | | | | | | | | |
| 2009 | Mar-Apr | 37.39 | 0.282 | | | | | | | | |
| 2010 | Mar-Apr | 42.94 | 0.282 | | | | | | | | |
| 2011 | Mar-Apr | 56.13 | 0.277 | | | | | | | | |

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-Aug longline fishery | | | | Sep-Dec longline fishery | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | CPUE | Sigma | Year | Season | CPUE | Sigma | Year | Season | CPUE | Sigma |
| 1991 | Jan-Feb | 0.803 | 0.182 | 1991 | May-Aug | 0.472 | 0.301 | 1992 | Sep-Oct | 0.543 | 0.160 |
| 1992 | Jan-Feb | 1.099 | 0.071 | 1992 | May-Aug | 0.347 | 0.288 | 1995 | Sep-Oct | 0.620 | 0.499 |
| 1993 | Jan-Feb | 0.909 | 0.119 | 1993 | May-Aug | 0.453 | 0.282 | 2002 | Sep-Oct | 0.664 | 0.202 |
| 1994 | Jan-Feb | 0.769 | 0.161 | 1994 | May-Aug | 0.451 | 0.534 | 2004 | Sep-Oct | 0.392 | 0.155 |
| 1995 | Jan-Feb | 0.871 | 0.121 | 1995 | May-Aug | 0.231 | 0.408 | 2005 | Sep-Oct | 0.389 | 0.208 |
| 1996 | Jan-Feb | 0.879 | 0.126 | 1996 | May-Aug | 0.406 | 0.426 | 2006 | Sep-Oct | 0.505 | 0.102 |
| 1997 | Jan-Feb | 0.958 | 0.132 | 1997 | May-Aug | 0.656 | 0.534 | 2007 | Sep-Oct | 0.582 | 0.063 |
| 1998 | Jan-Feb | 0.639 | 0.206 | 1998 | May-Aug | 0.913 | 0.408 | 2008 | Sep-Oct | 0.424 | 0.181 |
| 1999 | Jan-Feb | 0.620 | 0.272 | 1999 | May-Aug | 0.362 | 0.426 | 2009 | Sep-Oct | 0.491 | 0.114 |
| 2000 | Jan-Feb | 0.727 | 0.133 | 2002 | May-Aug | 0.625 | 0.471 | 2010 | Sep-Oct | 0.605 | 0.066 |
| 2001 | Jan-Feb | 0.647 | 0.093 | 2003 | May-Aug | 0.787 | 0.324 | 2002 | Nov-Dec | 0.743 | 0.181 |
| 2002 | Jan-Feb | 0.863 | 0.103 | 2004 | May-Aug | 0.726 | 0.426 | 2006 | Nov-Dec | 0.553 | 0.102 |
| 2003 | Jan-Feb | 0.745 | 0.116 | 2009 | May-Aug | 0.306 | 0.471 | | | | |
| 2004 | Jan-Feb | 0.648 | 0.114 | 2011 | May-Aug | 0.539 | 0.576 | | | | |
| 2005 | Jan-Feb | 0.723 | 0.190 | | | | | | | | |
| 2006 | Jan-Feb | 0.680 | 0.121 | | | | | | | | |
| 2007 | Jan-Feb | 0.724 | 0.100 | | | | | | | | |
| 2008 | Jan-Feb | 0.534 | 0.083 | | | | | | | | |
| 2009 | Jan-Feb | 0.670 | 0.075 | | | | | | | | |
| 2010 | Jan-Feb | 0.748 | 0.086 | | | | | | | | |
| 2011 | Jan-Feb | 0.806 | 0.070 | | | | | | | | |
| 1991 | Mar-Apr | 0.989 | 0.112 | | | | | | | | |
| 1992 | Mar-Apr | 0.697 | 0.104 | | | | | | | | |
| 1993 | Mar-Apr | 0.750 | 0.131 | | | | | | | | |
| 1994 | Mar-Apr | 0.727 | 0.124 | | | | | | | | |
| 1995 | Mar-Apr | 0.935 | 0.079 | | | | | | | | |
| 1996 | Mar-Apr | 0.667 | 0.135 | | | | | | | | |
| 1998 | Mar-Apr | 0.551 | 0.365 | | | | | | | | |
| 1999 | Mar-Apr | 0.826 | 0.113 | | | | | | | | |
| 2000 | Mar-Apr | 1.112 | 0.408 | | | | | | | | |
| 2002 | Mar-Apr | 0.693 | 0.148 | | | | | | | | |
| 2003 | Mar-Apr | 0.861 | 0.125 | | | | | | | | |
| 2004 | Mar-Apr | 0.415 | 0.576 | | | | | | | | |
| 2005 | Mar-Apr | 0.358 | 0.353 | | | | | | | | |
| 2006 | Mar-Apr | 0.635 | 0.392 | | | | | | | | |
| 2007 | Mar-Apr | 0.592 | 0.154 | | | | | | | | |
| 2008 | Mar-Apr | 0.496 | 0.213 | | | | | | | | |
| 2009 | Mar-Apr | 0.695 | 0.534 | | | | | | | | |

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-Aug pot fishery | | | | Sep-Dec pot fishery | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Season | CPUE | Sigma | Year | Season | CPUE | Sigma | Year | Season | CPUE | Sigma |
| 1991 | Jan-Feb | 45.16 | 0.081 | 1992 | May-Aug | 95.04 | 0.174 | 1992 | Sep-Oct | 33.14 | 0.097 |
| 1992 | Jan-Feb | 80.38 | 0.116 | 1995 | May-Aug | 62.95 | 0.427 | 1994 | Sep-Oct | 48.26 | 0.576 |
| 1993 | Jan-Feb | 62.13 | 0.171 | 1996 | May-Aug | 63.05 | 0.295 | 1995 | Sep-Oct | 56.15 | 0.246 |
| 1994 | Jan-Feb | 83.45 | 0.120 | 1997 | May-Aug | 58.00 | 0.354 | 1998 | Sep-Oct | 35.07 | 0.365 |
| 1995 | Jan-Feb | 58.24 | 0.060 | 1998 | May-Aug | 34.68 | 0.707 | 1999 | Sep-Oct | 30.51 | 0.142 |
| 1996 | Jan-Feb | 57.23 | 0.098 | 1999 | May-Aug | 53.21 | 0.084 | 2001 | Sep-Oct | 36.77 | 0.146 |
| 1997 | Jan-Feb | 46.27 | 0.125 | 2000 | May-Aug | 45.80 | 0.141 | 2002 | Sep-Oct | 62.09 | 0.110 |
| 1998 | Jan-Feb | 66.84 | 0.088 | 2001 | May-Aug | 35.33 | 0.272 | 2003 | Sep-Oct | 63.04 | 0.106 |
| 1999 | Jan-Feb | 69.83 | 0.097 | | | | | 2004 | Sep-Oct | 49.46 | 0.107 |
| 2000 | Jan-Feb | 42.27 | 0.066 | | | | | 2005 | Sep-Oct | 43.64 | 0.110 |
| 2001 | Jan-Feb | 38.81 | 0.141 | | | | | 2006 | Sep-Oct | 35.57 | 0.150 |
| 2002 | Jan-Feb | 57.97 | 0.166 | | | | | 2007 | Sep-Oct | 42.76 | 0.118 |
| 2003 | Jan-Feb | 78.75 | 0.143 | | | | | 2008 | Sep-Oct | 57.87 | 0.198 |
| 2004 | Jan-Feb | 68.20 | 0.116 | | | | | 2010 | Sep-Oct | 66.82 | 0.204 |
| 2005 | Jan-Feb | 69.63 | 0.107 | | | | | 1997 | Nov-Dec | 76.60 | 0.378 |
| 2006 | Jan-Feb | 62.31 | 0.099 | | | | | 1998 | Nov-Dec | 64.68 | 0.194 |
| 2007 | Jan-Feb | 53.14 | 0.061 | | | | | 1999 | Nov-Dec | 21.59 | 0.302 |
| 2008 | Jan-Feb | 51.87 | 0.099 | | | | | 2002 | Nov-Dec | 67.94 | 0.184 |
| 2009 | Jan-Feb | 55.50 | 0.129 | | | | | 2004 | Nov-Dec | 66.30 | 0.325 |
| 2010 | Jan-Feb | 75.44 | 0.145 | | | | | 2005 | Nov-Dec | 54.56 | 0.267 |
| 2011 | Jan-Feb | 90.69 | 0.118 | | | | | 2006 | Nov-Dec | 57.45 | 0.191 |
| 1991 | Mar-Apr | 58.98 | 0.068 | | | | | 2007 | Nov-Dec | 30.09 | 0.174 |
| 1992 | Mar-Apr | 49.33 | 0.054 | | | | | | | | |
| 1993 | Mar-Apr | 73.68 | 0.075 | | | | | | | | |
| 1994 | Mar-Apr | 51.06 | 0.087 | | | | | | | | |
| 1995 | Mar-Apr | 61.20 | 0.071 | | | | | | | | |
| 1996 | Mar-Apr | 52.26 | 0.095 | | | | | | | | |
| 1997 | Mar-Apr | 68.99 | 0.159 | | | | | | | | |
| 1998 | Mar-Apr | 59.33 | 0.168 | | | | | | | | |
| 1999 | Mar-Apr | 73.53 | 0.208 | | | | | | | | |
| 2000 | Mar-Apr | 40.31 | 0.147 | | | | | | | | |
| 2001 | Mar-Apr | 78.03 | 0.164 | | | | | | | | |
| 2002 | Mar-Apr | 41.92 | 0.169 | | | | | | | | |
| 2006 | Mar-Apr | 43.72 | 0.229 | | | | | | | | |

Table 2.7—Relative size composition from the 1984-2011 sub-27 trawl surveys.

| Year | N | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 53 | 0 | 0 | 7 | 65 | 144 | 168 | 94 | 39 | 6 | 3 | 1 | 0 | 7 | 2 | 6 | 10 | 12 | 15 | 24 | 20 | 45 | 42 | 66 |
| 1987 | 39 | 0 | 0 | 0 | 0 | 14 | 30 | 56 | 30 | 20 | 2 | 1 | 4 | 11 | 22 | 36 | 39 | 59 | 38 | 51 | 48 | 58 | 37 | 15 |
| 1990 | 22 | 0 | 0 | 9 | 27 | 27 | 61 | 28 | 0 | 1 | 0 | 0 | 0 | 2 | 4 | 4 | 12 | 21 | 25 | 21 | 34 | 28 | 19 | 7 |
| 1993 | 78 | 0 | 0 | 26 | 14 | 3 | 0 | 0 | 0 | 1 | 7 | 11 | 28 | 95 | 159 | 149 | 121 | 71 | 60 | 74 | 79 | 103 | 95 | 62 |
| 1996 | 89 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 4 | 10 | 17 | 31 | 49 | 86 | 98 | 176 | 135 | 161 | 184 | 173 | 113 | 77 |
| 1999 | 58 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 3 | 21 | 22 | 37 | 58 | 72 | 86 | 104 | 89 | 106 | 89 | 60 | 51 | 55 |
| 2001 | 68 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 5 | 9 | 15 | 39 | 42 | 35 | 39 | 67 | 78 | 68 | 87 | 69 | 103 | 122 | 112 | 120 |
| 2003 | 22 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | 14 | 11 | 12 | 32 | 32 | 51 | 46 | 39 | 25 | 33 | 28 |
| 2005 | 37 | 0 | 8 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 6 | 24 | 30 | 40 | 47 | 62 | 53 | 67 | 65 | 41 | 43 | 27 | 31 |
| 2007 | 125 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 4 | 23 | 80 | 159 | 228 | 282 | 292 | 219 | 173 | 115 | 83 | 70 | 57 | 65 |
| 2009 | 103 | 0 | 0 | 0 | 0 | 4 | 0 | 0 | 12 | 46 | 179 | 420 | 391 | 221 | 70 | 30 | 22 | 22 | 20 | 22 | 23 | 14 | 12 | 7 |
| 2011 | 34 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 1 | 6 | 4 | 7 | 29 | 38 | 42 | 38 | 50 | 57 | 34 | 47 | 61 | 55 | 24 |

Table 2.8—Relative size composition from the 1984-2011 27-plus trawl surveys.

| Year | N | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 1126 | 100 | 138 | 186 | 141 | 149 | 172 | 199 | 171 | 229 | 164 | 176 | 219 | 212 | 375 | 403 | 339 | 413 | 393 | 423 | 475 |
| 1987 | 1287 | 28 | 37 | 64 | 130 | 184 | 222 | 230 | 373 | 524 | 507 | 543 | 600 | 601 | 637 | 582 | 409 | 388 | 455 | 249 | 272 |
| 1990 | 752 | 45 | 19 | 14 | 23 | 52 | 45 | 64 | 78 | 91 | 71 | 84 | 133 | 137 | 138 | 157 | 207 | 142 | 224 | 224 | 232 |
| 1993 | 1083 | 74 | 65 | 53 | 60 | 88 | 115 | 135 | 143 | 170 | 155 | 169 | 192 | 219 | 259 | 328 | 393 | 396 | 495 | 435 | 410 |
| 1996 | 736 | 138 | 106 | 48 | 11 | 39 | 60 | 87 | 78 | 69 | 106 | 137 | 138 | 174 | 180 | 204 | 208 | 178 | 170 | 191 | 168 |
| 1999 | 528 | 26 | 23 | 21 | 38 | 36 | 61 | 87 | 105 | 103 | 110 | 113 | 110 | 123 | 112 | 146 | 159 | 201 | 191 | 203 | 211 |
| 2001 | 390 | 73 | 85 | 68 | 72 | 63 | 48 | 63 | 52 | 65 | 80 | 98 | 128 | 165 | 119 | 163 | 149 | 141 | 139 | 152 | 125 |
| 2003 | 596 | 27 | 19 | 20 | 16 | 21 | 28 | 38 | 53 | 69 | 84 | 83 | 129 | 147 | 185 | 164 | 216 | 243 | 294 | 281 | 258 |
| 2005 | 426 | 36 | 23 | 11 | 25 | 28 | 50 | 52 | 70 | 68 | 88 | 72 | 84 | 61 | 64 | 80 | 79 | 76 | 64 | 78 | 86 |
| 2007 | 490 | 110 | 83 | 89 | 87 | 66 | 82 | 83 | 93 | 107 | 135 | 166 | 197 | 210 | 265 | 257 | 295 | 315 | 245 | 252 | 235 |
| 2009 | 1090 | 37 | 48 | 82 | 101 | 126 | 124 | 173 | 215 | 324 | 357 | 429 | 359 | 403 | 386 | 358 | 349 | 362 | 364 | 370 | 375 |
| 2011 | 771 | 22 | 19 | 17 | 21 | 35 | 95 | 78 | 139 | 233 | 240 | 276 | 183 | 281 | 206 | 391 | 429 | 539 | 512 | 562 | 487 |

| Year | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 448 | 491 | 629 | 719 | 829 | 704 | 689 | 702 | 691 | 550 | 609 | 556 | 473 | 454 | 376 | 270 | 339 | 222 | 213 | 167 | 141 |
| 1987 | 301 | 442 | 453 | 547 | 694 | 694 | 709 | 661 | 706 | 611 | 521 | 588 | 517 | 536 | 426 | 413 | 391 | 428 | 343 | 274 | 275 |
| 1990 | 325 | 442 | 495 | 396 | 366 | 370 | 345 | 417 | 324 | 505 | 390 | 391 | 405 | 390 | 433 | 312 | 281 | 289 | 275 | 240 | 181 |
| 1993 | 474 | 335 | 357 | 434 | 411 | 447 | 590 | 672 | 696 | 587 | 631 | 663 | 523 | 563 | 484 | 396 | 351 | 325 | 319 | 362 | 312 |
| 1996 | 172 | 150 | 207 | 222 | 201 | 279 | 297 | 258 | 339 | 301 | 349 | 369 | 314 | 386 | 443 | 458 | 383 | 340 | 439 | 387 | 327 |
| 1999 | 197 | 230 | 196 | 233 | 176 | 217 | 217 | 238 | 245 | 244 | 296 | 297 | 288 | 261 | 260 | 232 | 197 | 191 | 183 | 163 | 142 |
| 2001 | 138 | 143 | 178 | 128 | 170 | 140 | 129 | 173 | 145 | 144 | 135 | 150 | 141 | 148 | 143 | 130 | 185 | 146 | 153 | 106 | 112 |
| 2003 | 236 | 262 | 244 | 261 | 226 | 273 | 265 | 294 | 336 | 282 | 328 | 314 | 365 | 301 | 300 | 271 | 236 | 201 | 161 | 181 | 134 |
| 2005 | 74 | 98 | 90 | 118 | 116 | 162 | 185 | 275 | 248 | 311 | 308 | 357 | 318 | 359 | 252 | 252 | 214 | 195 | 120 | 120 | 87 |
| 2007 | 163 | 203 | 169 | 174 | 131 | 130 | 104 | 136 | 144 | 133 | 179 | 189 | 190 | 164 | 178 | 160 | 163 | 143 | 116 | 127 | 109 |
| 2009 | 343 | 413 | 384 | 417 | 491 | 523 | 503 | 637 | 529 | 734 | 587 | 671 | 605 | 556 | 438 | 406 | 372 | 410 | 238 | 272 | 231 |
| 2011 | 436 | 395 | 384 | 358 | 308 | 283 | 327 | 369 | 373 | 349 | 368 | 328 | 320 | 273 | 250 | 254 | 216 | 217 | 143 | 129 | 110 |

| Year | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 134 | 133 | 82 | 55 | 74 | 81 | 42 | 64 | 66 | 60 | 31 | 84 | 95 | 41 | 46 | 25 | 30 | 27 | 20 | 22 | 17 |
| 1987 | 207 | 198 | 142 | 140 | 126 | 85 | 102 | 73 | 65 | 34 | 53 | 47 | 26 | 20 | 14 | 22 | 14 | 23 | 13 | 7 | 6 |
| 1990 | 147 | 133 | 173 | 119 | 122 | 91 | 79 | 51 | 50 | 42 | 37 | 36 | 32 | 29 | 29 | 23 | 30 | 15 | 14 | 10 | 14 |
| 1993 | 278 | 216 | 193 | 137 | 150 | 123 | 96 | 64 | 72 | 59 | 56 | 46 | 28 | 27 | 25 | 14 | 16 | 15 | 12 | 10 | 8 |
| 1996 | 262 | 271 | 236 | 160 | 112 | 93 | 131 | 59 | 65 | 47 | 50 | 52 | 25 | 27 | 23 | 15 | 14 | 12 | 15 | 9 | 7 |
| 1999 | 130 | 130 | 107 | 81 | 82 | 69 | 54 | 36 | 35 | 34 | 32 | 22 | 10 | 10 | 18 | 12 | 5 | 11 | 3 | 3 | 2 |
| 2001 | 88 | 66 | 94 | 59 | 61 | 35 | 49 | 36 | 35 | 30 | 17 | 13 | 20 | 12 | 5 | 4 | 10 | 2 | 5 | 4 | 3 |
| 2003 | 121 | 103 | 96 | 74 | 83 | 69 | 51 | 46 | 32 | 36 | 36 | 39 | 30 | 28 | 25 | 14 | 16 | 12 | 9 | 8 | 4 |
| 2005 | 94 | 69 | 62 | 52 | 40 | 34 | 29 | 27 | 33 | 20 | 16 | 9 | 17 | 12 | 10 | 11 | 23 | 11 | 4 | 11 | 11 |
| 2007 | 83 | 93 | 79 | 59 | 60 | 42 | 44 | 51 | 21 | 31 | 20 | 10 | 11 | 10 | 6 | 7 | 3 | 2 | 2 | 4 | 1 |
| 2009 | 161 | 123 | 131 | 98 | 75 | 72 | 44 | 65 | 45 | 36 | 23 | 18 | 15 | 11 | 18 | 6 | 5 | 5 | 4 | 4 | 2 |
| 2011 | 91 | 59 | 54 | 44 | 45 | 27 | 14 | 17 | 17 | 11 | 9 | 6 | 13 | 4 | 4 | 2 | 5 | 1 | 2 | 2 | 2 |

| Year | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 | 101 | 102 | 103 | 104 | 105 | 106 | 107 | 108 | 109+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 11 | 14 | 6 | 9 | 3 | 2 | 7 | 1 | 1 | 2 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 1987 | 8 | 2 | 2 | 4 | 2 | 4 | 2 | 4 | 0 | 1 | 2 | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1990 | 21 | 11 | 10 | 4 | 3 | 8 | 2 | 5 | 3 | 3 | 1 | 1 | 3 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| 1993 | 15 | 4 | 4 | 4 | 6 | 4 | 5 | 4 | 3 | 3 | 2 | 4 | 3 | 2 | 1 | 1 | 1 | 0 | 1 | 0 | 0 |
| 1996 | 7 | 8 | 13 | 8 | 6 | 1 | 7 | 3 | 5 | 2 | 1 | 4 | 1 | 7 | 2 | 1 | 2 | 0 | 1 | 0 | 0 |
| 1999 | 8 | 1 | 2 | 0 | 4 | 0 | 1 | 0 | 2 | 2 | 4 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2001 | 4 | 2 | 2 | 2 | 7 | 2 | 2 | 2 | 2 | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2003 | 3 | 4 | 6 | 4 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2005 | 9 | 26 | 17 | 17 | 19 | 10 | 22 | 20 | 19 | 20 | 18 | 10 | 13 | 4 | 8 | 11 | 5 | 2 | 0 | 0 | 0 |
| 2007 | 3 | 2 | 1 | 1 | 3 | 1 | 3 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 0 | 2 |
| 2009 | 2 | 1 | 0 | 2 | 1 | 24 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 2011 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

Table 2.9a—Age compositions observed by the 27-plus GOA bottom trawl survey, 1994-2009. Nact = actual sample size (these get rescaled so that the average across all age compositions in Tables 2.9a and 2.9b equals 300). The record for 1987 is shaded to indicate that these data are ignored in the fitting process due to very low sample size.

| Year | Nact | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 98 | 0.0000 | 0.0032 | 0.2064 | 0.2409 | 0.2488 | 0.1776 | 0.0781 | 0.0273 | 0.0134 | 0.0030 | 0.0008 | 0.0003 | 0.0003 |
| 1990 | 441 | 0.0000 | 0.0035 | 0.0721 | 0.2533 | 0.2496 | 0.2040 | 0.1289 | 0.0516 | 0.0256 | 0.0085 | 0.0026 | 0.0002 | 0.0001 |
| 1993 | 769 | 0.0000 | 0.0045 | 0.0906 | 0.2237 | 0.2819 | 0.2129 | 0.1271 | 0.0346 | 0.0195 | 0.0038 | 0.0012 | 0.0001 | 0.0000 |
| 1996 | 690 | 0.0000 | 0.0026 | 0.0588 | 0.1754 | 0.1978 | 0.2202 | 0.2100 | 0.1058 | 0.0207 | 0.0062 | 0.0019 | 0.0002 | 0.0005 |
| 1999 | 610 | 0.0000 | 0.0010 | 0.0582 | 0.1645 | 0.2412 | 0.2808 | 0.1594 | 0.0562 | 0.0255 | 0.0097 | 0.0023 | 0.0010 | 0.0001 |
| 2001 | 672 | 0.0000 | 0.0126 | 0.1144 | 0.2509 | 0.2246 | 0.1683 | 0.1313 | 0.0632 | 0.0238 | 0.0069 | 0.0028 | 0.0001 | 0.0011 |
| 2003 | 636 | 0.0000 | 0.0013 | 0.0325 | 0.1868 | 0.2763 | 0.2824 | 0.1372 | 0.0514 | 0.0250 | 0.0041 | 0.0010 | 0.0009 | 0.0011 |
| 2005 | 479 | 0.0000 | 0.0000 | 0.0661 | 0.1221 | 0.1953 | 0.2950 | 0.1912 | 0.0560 | 0.0353 | 0.0232 | 0.0097 | 0.0029 | 0.0031 |
| 2007 | 421 | 0.0000 | 0.0183 | 0.2369 | 0.3205 | 0.1561 | 0.1234 | 0.0551 | 0.0295 | 0.0207 | 0.0209 | 0.0148 | 0.0024 | 0.0014 |
| 2009 | 490 | 0.0000 | 0.0003 | 0.0972 | 0.3485 | 0.3070 | 0.1755 | 0.0507 | 0.0106 | 0.0069 | 0.0013 | 0.0020 | 0.0000 | 0.0000 |

Table 2.9b—Age compositions observed by the sub-27 GOA bottom trawl survey, 1993-2009. Nact = actual sample size (these get rescaled so that the average across all age compositions in Table 2.9a and 2.9b equals 300). The record for 1987 is shaded to indicate that these data are ignored in the fitting process due to very low sample size.

| Year | Nact | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12+ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1987 | 25 | 0.0000 | 0.9276 | 0.0701 | 0.0023 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1990 | 18 | 0.0000 | 0.9778 | 0.0222 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1993 | 92 | 0.0000 | 0.9812 | 0.0188 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1996 | 89 | 0.0000 | 0.9354 | 0.0646 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1999 | 88 | 0.0000 | 0.9691 | 0.0309 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2001 | 112 | 0.0000 | 0.9224 | 0.0776 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2003 | 51 | 0.0000 | 0.9070 | 0.0930 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2005 | 58 | 0.0000 | 0.8336 | 0.1664 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2007 | 83 | 0.0000 | 0.9961 | 0.0039 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2009 | 76 | 0.0000 | 0.9903 | 0.0084 | 0.0014 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

Table 2.10—Pacific cod abundance measured in biomass (t) and numbers of fish (1000s), as assessed by the GOA bottom trawl survey. Point estimates are shown along with coefficients of variation. The two right-hand sections show the total abundance divided into fish 27 cm or larger and fish smaller than 27 cm (totals are very slightly different in the first four years due to exclusion of tows with no length data from the strata extrapolations).

| | All lengths | | | | 27-plus | | Sub-27 | |
|---|---|---|---|---|---|---|---|---|
| Year | Biomass | CV | Abundance | CV | Abundance | CV | Abundance | CV |
| 1984 | 550,971 | 0.146 | 320,525 | 0.156 | 296,057 | 0.175 | 19,526 | 0.596 |
| 1987 | 394,987 | 0.130 | 247,020 | 0.185 | 238,165 | 0.234 | 6,772 | 0.374 |
| 1990 | 416,788 | 0.153 | 212,132 | 0.208 | 193,577 | 0.243 | 14,739 | 0.412 |
| 1993 | 409,848 | 0.179 | 231,963 | 0.190 | 214,244 | 0.210 | 17,021 | 0.372 |
| 1996 | 538,154 | 0.200 | 319,068 | 0.215 | 234,528 | 0.172 | 84,540 | 0.615 |
| 1999 | 306,413 | 0.126 | 166,584 | 0.112 | 157,019 | 0.118 | 9,565 | 0.272 |
| 2001 | 257,614 | 0.204 | 158,424 | 0.180 | 137,041 | 0.203 | 21,384 | 0.270 |
| 2003 | 297,402 | 0.150 | 159,749 | 0.129 | 153,895 | 0.134 | 5,854 | 0.231 |
| 2005 | 308,091 | 0.262 | 139,852 | 0.208 | 127,282 | 0.221 | 12,570 | 0.388 |
| 2007 | 233,310 | 0.139 | 192,025 | 0.175 | 134,261 | 0.163 | 57,764 | 0.425 |
| 2009 | 752,651 | 0.303 | 573,509 | 0.286 | 422,370 | 0.239 | 151,139 | 0.867 |
| 2011 | 500,975 | 0.136 | 348,060 | 0.177 | 339,410 | 0.178 | 8,650 | 0.347 |

Table 2.11—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 long-term average age-length keys. Green = column minimum, pink = column maximum (not shown for age 0).

**Average length (cm) at age:**

| Fleet | Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27plus | 1987 | n/a | n/a | 34.26 | 43.17 | 52.68 | 58.92 | 64.66 | n/a | n/a | n/a | n/a | n/a | n/a |
| 27plus | 1990 | n/a | 27.27 | 35.07 | 45.92 | 53.46 | 59.92 | 65.13 | 70.78 | 77.15 | 83.98 | 89.18 | 98.32 | 102.3 |
| 27plus | 1993 | n/a | 27.55 | 34.31 | 44.04 | 52.12 | 58.89 | 65.61 | 70.36 | 74.71 | 87.64 | 94.81 | 97.41 | n/a |
| 27plus | 1996 | n/a | 27.12 | 32.32 | 41.56 | 52.39 | 59.24 | 64.13 | 68.51 | 75.55 | 82.94 | 93.91 | 97.31 | 85.00 |
| 27plus | 1999 | n/a | 27.42 | 32.94 | 41.03 | 48.71 | 58.17 | 64.39 | 71.13 | 71.91 | 77.90 | 80.16 | 83.68 | n/a |
| 27plus | 2001 | n/a | 27.44 | 32.84 | 42.65 | 52.15 | 58.81 | 65.61 | 70.62 | 74.94 | 84.30 | 86.75 | 85.00 | 78.72 |
| 27plus | 2003 | n/a | 29.29 | 32.65 | 43.83 | 48.97 | 57.85 | 64.94 | 71.73 | 75.50 | 84.10 | 83.41 | 75.69 | 75.96 |
| 27plus | 2005 | n/a | n/a | 33.35 | 41.20 | 51.27 | 57.14 | 62.27 | 67.95 | 78.36 | 90.90 | 95.88 | 95.08 | 90.54 |
| 27plus | 2007 | n/a | 27.47 | 35.21 | 43.36 | 55.49 | 59.64 | 63.47 | 70.06 | 69.86 | 99.57 | 103.7 | 94.10 | n/a |
| 27plus | 2009 | n/a | 27.00 | 33.71 | 44.70 | 55.50 | 61.95 | 65.66 | 74.05 | 74.25 | 84.82 | 92.46 | n/a | n/a |
| Sub27 | 1987 | n/a | 20.00 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 1990 | n/a | 21.83 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 1993 | n/a | 20.38 | 25.65 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 1996 | n/a | 20.44 | 25.37 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 1999 | n/a | 20.57 | 26.00 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 2001 | n/a | 21.14 | 25.01 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 2003 | n/a | 21.13 | 25.04 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 2005 | n/a | 18.94 | 24.49 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 2007 | n/a | 17.38 | 26.00 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |
| Sub27 | 2009 | n/a | 15.20 | 24.65 | 25.00 | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a | n/a |

**Number of samples:**

| Fleet | Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 27plus | 1987 | 0 | 0 | 20 | 56 | 22 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 27plus | 1990 | 0 | 3 | 50 | 95 | 81 | 78 | 59 | 41 | 36 | 20 | 7 | 2 | 1 |
| 27plus | 1993 | 0 | 9 | 103 | 127 | 124 | 116 | 117 | 66 | 53 | 23 | 10 | 2 | 0 |
| 27plus | 1996 | 0 | 2 | 45 | 146 | 123 | 100 | 107 | 92 | 34 | 17 | 3 | 1 | 1 |
| 27plus | 1999 | 0 | 1 | 26 | 83 | 124 | 141 | 103 | 58 | 30 | 11 | 5 | 2 | 0 |
| 27plus | 2001 | 0 | 9 | 88 | 121 | 106 | 83 | 85 | 70 | 35 | 16 | 8 | 3 | 2 |
| 27plus | 2003 | 0 | 2 | 40 | 119 | 141 | 140 | 91 | 62 | 41 | 12 | 2 | 2 | 2 |
| 27plus | 2005 | 0 | 0 | 64 | 87 | 83 | 78 | 85 | 40 | 21 | 6 | 4 | 1 | 1 |
| 27plus | 2007 | 0 | 5 | 47 | 86 | 73 | 65 | 34 | 36 | 25 | 4 | 1 | 2 | 0 |
| 27plus | 2009 | 0 | 1 | 60 | 120 | 105 | 86 | 47 | 19 | 16 | 5 | 4 | 0 | 0 |
| Sub27 | 1987 | 0 | 28 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 1990 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 1993 | 0 | 101 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 1996 | 0 | 92 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 1999 | 0 | 95 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 2001 | 0 | 117 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 2003 | 0 | 52 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 2005 | 0 | 50 | 15 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 2007 | 0 | 92 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sub27 | 2009 | 0 | 79 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2.12—Multinomial sample sizes for length compositions. Trawl survey is divided into fish 27 cm and larger ("≥27") and fish smaller than 27 cm ("<27"). S1=Jan-Feb, S2=Mar-Apr, S3=May-Aug, S4=Sep-Oct, S5=Nov-Dec.

| | Trawl fishery | | | | | Longline fishery | | | | | Pot fishery | | | | | Survey | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | S1 | S2 | S3 | S4 | S5 | S1 | S2 | S3 | S4 | S5 | S1 | S2 | S3 | S4 | S5 | ≥27 | <27 |
| 1977 | | | | 13 | | | | | | | | | | | | | |
| 1978 | | | | | 18 | | | 166 | 292 | 136 | | | | | | | |
| 1979 | | | | | | 46 | 109 | 57 | 109 | 140 | | | | | | | |
| 1980 | | | 23 | | | 233 | 103 | 154 | 110 | | | | | | | | |
| 1981 | | | | | | 61 | 184 | 173 | 101 | 94 | | | | | | | |
| 1982 | | | 22 | 27 | | 92 | 220 | 169 | 127 | 119 | | | | | | | |
| 1983 | | | 43 | 48 | | 473 | 914 | 490 | 612 | 1593 | | | | | | | |
| 1984 | 26 | 33 | 325 | 82 | 17 | 1474 | 507 | 145 | 716 | 219 | | | | | | 1126 | 53 |
| 1985 | | 14 | 195 | 114 | | 787 | 806 | | | | | | | | | | |
| 1986 | | | | | | 1406 | 1452 | | | | | | | | | | |
| 1987 | | | | 19 | | | | | | | | | | | | 1287 | 39 |
| 1988 | 47 | 71 | 68 | | | | | | | | | | | | | | |
| 1989 | | 21 | | | | | | | | | | | | | | | |
| 1990 | 64 | 718 | 378 | 363 | 18 | 78 | 213 | 55 | | | | 85 | 110 | 313 | 68 | 752 | 22 |
| 1991 | 358 | 846 | | | | 61 | 409 | | | | 476 | 1074 | | | | | |
| 1992 | 572 | 704 | | 72 | | 428 | 438 | | 120 | | 396 | 684 | 23 | 173 | | | |
| 1993 | 160 | 700 | | | | 151 | 211 | 16 | | | 116 | 582 | 27 | | | 1083 | 78 |
| 1994 | 131 | 276 | | | | 85 | 179 | | | | 271 | 212 | | | 18 | | |
| 1995 | 302 | 525 | | 78 | | 369 | 512 | | | | 970 | 670 | | 39 | | | |
| 1996 | 199 | 366 | | | | 266 | 209 | | | | 716 | 429 | 35 | | | 736 | 89 |
| 1997 | 367 | 348 | | 121 | | 196 | 50 | 15 | | | 433 | 399 | 209 | 60 | 37 | | |
| 1998 | 927 | 711 | 120 | 183 | | 286 | 55 | 17 | | | 533 | 736 | | 36 | 63 | | |
| 1999 | 424 | 374 | | 74 | | 300 | 303 | | | | 608 | 1506 | 432 | 172 | 75 | 528 | 58 |
| 2000 | 375 | 92 | 35 | | | 662 | 100 | | | | 1298 | 1270 | 220 | | | | |
| 2001 | 280 | 125 | 62 | 309 | | 836 | | | | | 409 | 1087 | 87 | 171 | 95 | 390 | 68 |
| 2002 | 243 | 163 | 70 | | | 453 | 190 | | 113 | 91 | 341 | 764 | 62 | 253 | 63 | | |
| 2003 | 252 | | 90 | 119 | | 334 | 169 | 60 | 154 | | 412 | 403 | | 397 | | 596 | 22 |
| 2004 | 156 | | 44 | 172 | | 390 | 42 | 41 | 197 | | 701 | 437 | | 298 | 28 | | |
| 2005 | 111 | | 39 | 119 | | 315 | 82 | 38 | 195 | 30 | 728 | 501 | | 400 | 65 | 426 | 37 |
| 2006 | 138 | | | | | 459 | 38 | 32 | 360 | 307 | 678 | 725 | | 276 | 71 | | |
| 2007 | 212 | | 52 | 53 | | 381 | 61 | 55 | 474 | 35 | 652 | 705 | | 160 | 65 | 490 | 125 |
| 2008 | 142 | | 80 | 167 | 27 | 600 | 68 | 85 | 308 | | 564 | 514 | | 264 | 34 | | |
| 2009 | 92 | | 58 | 86 | | 683 | | 56 | 344 | | 580 | 258 | | 134 | | 1090 | 103 |
| 2010 | 138 | | 70 | 169 | | 524 | | 51 | 667 | | 585 | 286 | | 198 | | | |
| 2011 | 124 | 30 | 31 | | | 701 | | | | | 525 | 121 | | | | 771 | 34 |

Table 2.13— Number of parameters and negative log-likelihoods. Note that the data sets for each model are different, so log-likelihoods are not comparable. Shaded cells indicate values that are not used in computing the total.

| | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| Number of parameters | 258 | 252 | 215 | 260 |

| Obj. func. component | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| Equilibrium catch | 0.00 | 0.00 | 0.00 | 0.00 |
| Catch per unit effort | 4.03 | 5.28 | -19.47 | -15.49 |
| Size composition | 3123.28 | 3113.53 | 3709.26 | 3454.72 |
| Age composition | 98.23 | 97.30 | 183.45 | 1128.63 |
| Mean size at age | 742.97 | 651.19 | 846.09 | 2192.70 |
| Recruitment | -22.43 | -22.51 | -1.56 | 13.26 |
| Priors | 0.00 | 0.00 | 2.78 | 0.00 |
| "Softbounds" | 0.05 | 0.05 | 0.05 | 0.07 |
| Deviations | 0.06 | 0.08 | 0.01 | 0.02 |
| Total | 3946.19 | 3844.93 | 3874.52 | 3452.58 |

| CPUE component | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| Jan-Apr trawl fishery | 394.46 | 398.29 | 373.81 | 369.10 |
| May-Aug trawl fishery | 199.43 | 191.43 | 181.57 | 204.69 |
| Sep-Dec trawl fishery | 216.91 | 209.02 | 207.91 | 221.71 |
| Jan-Apr longline fishery | -21.92 | -29.39 | -26.83 | -13.98 |
| May-Aug longline fishery | -3.01 | -3.45 | -4.05 | -2.41 |
| Sep-Dec longline fishery | -10.48 | -10.74 | -2.49 | -8.42 |
| Jan-Apr pot fishery | 50.96 | 40.38 | 22.39 | 53.01 |
| May-Aug pot fishery | -6.47 | -6.23 | -6.51 | -7.52 |
| Sep-Dec pot fishery | 14.95 | 12.58 | 12.39 | 17.90 |
| 27-plus trawl survey | 11.35 | 11.22 | -12.25 | -4.95 |
| Sub-27 trawl survey | -7.31 | -5.94 | -7.22 | -10.54 |

| Sizecomp component | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| Jan-Apr trawl fishery | 711.91 | 696.32 | 728.62 | 679.50 |
| May-Aug trawl fishery | 186.38 | 180.54 | 169.99 | 171.46 |
| Sep-Dec trawl fishery | 289.72 | 281.36 | 268.37 | 290.16 |
| Jan-Apr longline fishery | 611.63 | 611.94 | 580.61 | 613.49 |
| May-Aug longline fishery | 113.85 | 115.73 | 107.99 | 116.64 |
| Sep-Dec longline fishery | 281.74 | 283.74 | 275.42 | 273.17 |
| Jan-Apr pot fishery | 462.06 | 459.59 | 493.03 | 459.39 |
| May-Aug pot fishery | 70.66 | 72.21 | 69.09 | 69.46 |
| Sep-Dec pot fishery | 179.47 | 179.26 | 191.51 | 178.80 |
| 27-plus trawl survey | 131.04 | 137.27 | 498.26 | 301.64 |
| Sub-27 trawl survey | 84.81 | 95.58 | 326.39 | 301.01 |

| Agecomp component | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| 27-plus trawl survey | 83.21 | 80.19 | 165.18 | 1052.35 |
| Sub-27 trawl survey | 15.02 | 17.12 | 18.27 | 76.28 |

| Size-at-age component | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| 27-plus trawl survey | 518.75 | 493.55 | 695.09 | 2081.38 |
| Sub-27 trawl survey | 224.21 | 157.64 | 151.00 | 111.31 |

Table 2.14— Root mean squared errors (RMSE) and observed:predicted correlations for fishery CPUE and survey relative abundance time series. Green = within-section row minimum, pink = within-section row maximum. Fishery CPUE data are not used in fitting the models; fishery CPUE data results are shown for comparison only.

| | Root mean squared error | | | |
|---|---|---|---|---|
| Fleet | Model 1 | Model 3 | Model 3b | Model 4 |
| Jan-Apr trawl fishery | 0.45 | 0.45 | 0.46 | 0.44 |
| May-Jul trawl fishery | 1.05 | 1.03 | 1.00 | 1.06 |
| Aug-Dec trawl fishery | 1.09 | 1.08 | 1.09 | 1.09 |
| Jan-Apr longline fishery | 0.25 | 0.24 | 0.24 | 0.26 |
| May-Jul longline fishery | 0.45 | 0.44 | 0.43 | 0.46 |
| Aug-Dec longline fishery | 0.24 | 0.23 | 0.23 | 0.25 |
| Jan-Apr pot fishery | 0.29 | 0.28 | 0.25 | 0.29 |
| May-Jul pot fishery | 0.27 | 0.27 | 0.26 | 0.25 |
| Aug-Dec pot fishery | 0.37 | 0.36 | 0.35 | 0.37 |
| 27-plus survey | 0.43 | 0.42 | 0.23 | 0.31 |
| Sub-27 survey | 0.31 | 0.36 | 0.44 | 0.15 |
| | Correlation (observed versus expected) | | | |
| Fleet | Model 1 | Model 3 | Model 3b | Model 4 |
| Jan-Apr trawl fishery | 0.34 | 0.34 | 0.39 | 0.39 |
| May-Aug trawl fishery | -0.44 | -0.35 | -0.06 | -0.48 |
| Sep-Dec trawl fishery | -0.29 | -0.30 | -0.32 | -0.30 |
| Jan-Apr longline fishery | 0.55 | 0.56 | 0.55 | 0.55 |
| May-Aug longline fishery | -0.27 | -0.29 | -0.35 | -0.33 |
| Sep-Dec longline fishery | 0.37 | 0.37 | 0.31 | 0.33 |
| Jan-Apr pot fishery | -0.05 | -0.02 | 0.15 | -0.02 |
| May-Aug pot fishery | 0.70 | 0.68 | 0.68 | 0.82 |
| Sep-Dec pot fishery | 0.07 | 0.09 | 0.16 | 0.06 |
| 27-plus survey | 0.36 | 0.43 | 0.76 | 0.55 |
| Sub-27 survey | 1.00 | 1.00 | 0.96 | 1.00 |

Table 2.15—Average and standard deviation of normalized residuals for fishery CPUE and survey relative abundance time series. In the upper (“average”) portion of the table, blue = row value closest to 0, yellow = row value furthest from 0; in the lower (“standard deviation”) portion of the table, blue = row value closest to 1, yellow = row value furthest from 1. Fishery CPUE data are not used in fitting the models; fishery CPUE results are shown for comparison only.

| | Average of normalized residuals | | | |
|---|---|---|---|---|
| Fleet | Model 1 | Model 3 | Model 3b | Model 4 |
| Jan-Apr trawl fishery | -0.54 | -0.60 | -0.71 | -0.49 |
| May-Aug trawl fishery | -0.46 | -0.46 | -0.48 | -0.48 |
| Sep-Dec trawl fishery | -0.90 | -0.89 | -0.89 | -0.90 |
| Jan-Apr longline fishery | -0.16 | -0.15 | -0.12 | -0.16 |
| May-Aug longline fishery | 0.04 | 0.04 | 0.03 | 0.05 |
| Sep-Dec longline fishery | -0.38 | -0.33 | -0.28 | -0.38 |
| Jan-Apr pot fishery | 0.30 | 0.28 | 0.26 | 0.34 |
| May-Aug pot fishery | -0.11 | -0.11 | -0.08 | -0.13 |
| Sep-Dec pot fishery | -0.02 | -0.02 | 0.02 | 0.00 |
| 27-plus survey | 1.14 | 1.17 | 0.42 | 0.47 |
| Sub-27 survey | 0.05 | 0.06 | 0.15 | 0.02 |
| | Standard deviation of normalized residuals | | | |
| Fleet | Model 1 | Model 3 | Model 3b | Model 4 |
| Jan-Apr trawl fishery | 4.83 | 4.84 | 4.70 | 4.71 |
| May-Aug trawl fishery | 4.79 | 4.70 | 4.60 | 4.84 |
| Sep-Dec trawl fishery | 4.43 | 4.36 | 4.35 | 4.47 |
| Jan-Apr longline fishery | 1.64 | 1.52 | 1.57 | 1.77 |
| May-Aug longline fishery | 1.21 | 1.18 | 1.14 | 1.24 |
| Sep-Dec longline fishery | 1.47 | 1.46 | 1.92 | 1.59 |
| Jan-Apr pot fishery | 2.74 | 2.63 | 2.41 | 2.76 |
| May-Aug pot fishery | 1.13 | 1.16 | 1.12 | 0.98 |
| Sep-Dec pot fishery | 2.22 | 2.17 | 2.16 | 2.28 |
| 27-plus survey | 2.08 | 2.06 | 1.12 | 1.59 |
| Sub-27 survey | 0.87 | 1.00 | 0.87 | 0.42 |

Table 2.16—Number of records, average input sample size ("Ave. N"), average ratio of effective multinomial sample size to input sample size ("Mean of ratios"), and ratio of average effective multinomial sample size to average input sample size ("Ratio of means") for each fishery and survey size composition time series. Note that size composition records from gear/year/season combinations are turned off if age composition records are available and used in Models 1 and 3, but not in Models 3b or 4. Green = row minimum, pink = row maximum.

| | | | Mean of ratios | | | |
|---|---|---|---|---|---|---|
| Fleet | Records | Ave. N | Model 1 | Model 3 | Model 3b | Model 4 |
| Jan-Apr trawl fishery | 42 | 285 | 2.71 | 2.75 | 2.71 | 2.77 |
| May-Aug trawl fishery | 19 | 95 | 5.79 | 5.93 | 6.05 | 6.16 |
| Sep-Dec trawl fishery | 24 | 103 | 4.39 | 4.47 | 4.85 | 4.32 |
| Jan-Apr longline fishery | 56 | 371 | 5.76 | 5.75 | 5.58 | 5.38 |
| May-Aug longline fishery | 19 | 99 | 6.72 | 6.67 | 6.61 | 6.83 |
| Sep-Dec longline fishery | 27 | 288 | 4.60 | 4.64 | 4.68 | 4.56 |
| Jan-Apr pot fishery | 43 | 592 | 4.03 | 4.10 | 3.72 | 4.05 |
| May-Aug pot fishery | 9 | 134 | 7.33 | 7.31 | 7.67 | 7.34 |
| Sep-Dec pot fishery | 28 | 144 | 6.08 | 6.03 | 5.77 | 6.13 |
| 27-plus trawl survey | 12 | 1061 | 0.83 | 0.92 | 0.94 | 1.46 |
| Sub-27 trawl survey | 12 | 42 | 0.42 | 0.21 | 0.86 | 0.93 |

| | | | Ratio of means | | | |
|---|---|---|---|---|---|---|
| Fleet | Records | Ave. N | Model 1 | Model 3 | Model 3b | Model 4 |
| Jan-Apr trawl fishery | 42 | 285 | 2.40 | 2.42 | 2.26 | 2.40 |
| May-Aug trawl fishery | 19 | 95 | 6.03 | 6.29 | 6.21 | 6.89 |
| Sep-Dec trawl fishery | 24 | 103 | 2.95 | 3.01 | 3.07 | 2.88 |
| Jan-Apr longline fishery | 56 | 371 | 3.60 | 3.61 | 3.42 | 3.46 |
| May-Aug longline fishery | 19 | 99 | 4.17 | 4.05 | 4.21 | 4.30 |
| Sep-Dec longline fishery | 27 | 288 | 3.42 | 3.39 | 3.34 | 3.49 |
| Jan-Apr pot fishery | 43 | 592 | 3.58 | 3.67 | 3.12 | 3.46 |
| May-Aug pot fishery | 9 | 134 | 3.99 | 3.91 | 4.08 | 4.08 |
| Sep-Dec pot fishery | 28 | 144 | 5.75 | 5.73 | 5.33 | 6.09 |
| 27-plus trawl survey | 12 | 1061 | 0.75 | 0.83 | 0.80 | 1.24 |
| Sub-27 trawl survey | 12 | 42 | 0.37 | 0.19 | 0.65 | 0.70 |

Table 2.17—Input sample size ("Input N") and ratio of effective multinomial sample size ("effective N") to input N for each record of age composition data. The mean of the ratios and ratio of the means are shown in the bottom two rows. Green = row minimum, pink = row maximum. The record for 1987 in each half of the table is shaded to indicate that these data are ignored in the fitting process due to very low sample size.

**27-plus survey**

| | | Ratio of effective N to input N | | | |
|---|---|---|---|---|---|
| Year | Input N | Model 1 | Model 3 | Model 3b | Model 4 |
| 1987 | 98 | 1.43 | 0.95 | 0.14 | 0.10 |
| 1990 | 441 | 1.61 | 1.46 | 0.27 | 0.03 |
| 1993 | 769 | 0.54 | 0.43 | 0.76 | 0.02 |
| 1996 | 690 | 0.33 | 0.35 | 0.48 | 0.05 |
| 1999 | 610 | 0.20 | 0.23 | 0.56 | 0.09 |
| 2001 | 672 | 3.22 | 2.97 | 0.24 | 0.07 |
| 2003 | 636 | 0.16 | 0.16 | 0.18 | 0.08 |
| 2005 | 479 | 0.53 | 0.69 | 0.41 | 0.06 |
| 2007 | 421 | 0.36 | 0.45 | 0.08 | 0.03 |
| 2009 | 490 | 1.40 | 0.57 | 0.23 | 0.02 |
| | Mean of ratios: | 0.93 | 0.81 | 0.36 | 0.05 |
| | Ratio of means: | 0.93 | 0.82 | 0.38 | 0.05 |

**Sub-27 survey**

| | | Ratio of effective N to input N | | | |
|---|---|---|---|---|---|
| Year | Input N | Model 1 | Model 3 | Model 3b | Model 4 |
| 1987 | 25 | 8.30 | 289.14 | 2.12 | 0.03 |
| 1990 | 18 | 15.70 | 1.67 | 117.22 | 0.35 |
| 1993 | 92 | 0.49 | 0.26 | 0.52 | 0.32 |
| 1996 | 89 | 2.11 | 6.74 | 0.30 | 0.02 |
| 1999 | 88 | 3.03 | 0.58 | 48.80 | 0.04 |
| 2001 | 112 | 0.29 | 754.55 | 0.17 | 0.01 |
| 2003 | 51 | 0.38 | 2.26 | 0.48 | 0.00 |
| 2005 | 58 | 0.04 | 0.08 | 0.02 | 0.00 |
| 2007 | 83 | 0.36 | 0.18 | 0.57 | 50.47 |
| 2009 | 76 | 0.66 | 0.21 | 2.97 | 0.52 |
| | Mean of ratios: | 2.56 | 85.17 | 19.00 | 5.75 |
| | Ratio of means: | 1.37 | 127.98 | 10.19 | 6.40 |

Table 2.18 (page 1 of 8)—All of the quantities listed in the “parameters” section of the SS report file.

| | Model 1 | | Model 3 | | Model 3b | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Label | Est. | SD | Est. | SD | Est. | SD | Est. | SD |
| NatM | 0.38 | _ | 0.38 | _ | 0.38 | _ | 0.38 | _ |
| L_at_Amin | 1.2992 | 0.2665 | 20.204 | 0.1035 | 19.803 | 0.1747 | 19.373 | 0.1752 |
| L_at_Amax | 101.59 | 0.6556 | 100.54 | 0.6694 | 89.165 | 0.9557 | 98.1 | 0.9349 |
| VonBert_K | 0.1735 | 0.0023 | 0.1797 | 0.0026 | 0.2237 | 0.0052 | 0.1551 | 0.0031 |
| CV_young | 1.87 | _ | 3.13 | _ | 4.1421 | 0.1249 | 4.2647 | 0.1306 |
| CV_old | 6.53 | _ | 6.55 | _ | 9.2148 | 0.2295 | 7.9353 | 0.2501 |
| Wtlen_1 | 9E-06 | _ | 9E-06 | _ | 9E-06 | _ | 9E-06 | _ |
| Wtlen_2 | 3.0718 | _ | 3.0718 | _ | 3.0718 | _ | 3.0718 | _ |
| Mat50%_Fem | 4.35 | _ | 4.35 | _ | 4.35 | _ | 4.35 | _ |
| Mat_slope_Fem | -1.963 | _ | -1.963 | _ | -1.963 | _ | -1.963 | _ |
| Eggs/kg_inter | 1 | _ | 1 | _ | 1 | _ | 1 | _ |
| Eggs/kg_slope | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_GP_1 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_Area_1 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_Seas_1 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_Seas_2 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_Seas_3 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_Seas_4 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| RecrDist_Seas_5 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| CohortGrowDev | 1 | _ | 1 | _ | 1 | _ | 1 | _ |
| AgeKeyParm1 | | | 1 | _ | 1 | _ | | |
| AgeKeyParm2 | | | 0.3625 | 0.0091 | 3E-08 | 3E-05 | | |
| AgeKeyParm3 | | | 1E-08 | _ | 2.7958 | 0.153 | | |
| AgeKeyParm4 | | | 0 | _ | 0 | _ | | |
| AgeKeyParm5 | | | 0.096 | _ | 0.096 | _ | | |
| AgeKeyParm6 | | | 1.471 | _ | 1.471 | _ | | |
| AgeKeyParm7 | | | 0 | _ | 0 | _ | | |
| F-WL1_seas_1 | -0.004 | _ | -0.004 | _ | -0.004 | _ | -0.004 | _ |
| F-WL1_seas_2 | -0.098 | _ | -0.098 | _ | -0.098 | _ | -0.098 | _ |
| F-WL1_seas_3 | 0.2608 | _ | 0.2608 | _ | 0.2608 | _ | 0.2608 | _ |
| F-WL1_seas_4 | 0.7063 | _ | 0.7063 | _ | 0.7063 | _ | 0.7063 | _ |
| F-WL1_seas_5 | -0.205 | _ | -0.205 | _ | -0.205 | _ | -0.205 | _ |
| F-WL2_seas_1 | 0.0041 | _ | 0.0041 | _ | 0.0041 | _ | 0.0041 | _ |
| F-WL2_seas_2 | 0.0053 | _ | 0.0053 | _ | 0.0053 | _ | 0.0053 | _ |
| F-WL2_seas_3 | -0.027 | _ | -0.027 | _ | -0.027 | _ | -0.027 | _ |
| F-WL2_seas_4 | -0.06 | _ | -0.06 | _ | -0.06 | _ | -0.06 | _ |
| F-WL2_seas_5 | 0.0156 | _ | 0.0156 | _ | 0.0156 | _ | 0.0156 | _ |
| SR_LN(R0) | 12.433 | 0.0323 | 12.459 | 0.035 | 12.779 | 0.0466 | 12.824 | 0.0501 |
| SR_BH_steep | 1 | _ | 1 | _ | 1 | _ | 1 | _ |
| SR_sigmaR | 0.41 | _ | 0.41 | _ | 0.41 | _ | 0.41 | _ |
| SR_envlink | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| SR_R1_offset | -0.398 | 0.1257 | -0.373 | 0.1273 | -0.113 | 0.1512 | -1E-08 | 2E-05 |
| SR_autocorr | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Early_InitAge_13 | -0.276 | 0.3644 | -0.267 | 0.3656 | -0.121 | 0.3877 | -0.164 | 0.3804 |
| Early_InitAge_12 | -0.348 | 0.3551 | -0.337 | 0.3566 | -0.155 | 0.3823 | -0.179 | 0.3778 |
| Early_InitAge_11 | -0.417 | 0.3469 | -0.402 | 0.3486 | -0.189 | 0.3771 | -0.169 | 0.3785 |
| Early_InitAge_10 | -0.469 | 0.3405 | -0.452 | 0.3424 | -0.217 | 0.3727 | -0.122 | 0.3838 |
| Early_InitAge_9 | -0.478 | 0.3373 | -0.459 | 0.3395 | -0.229 | 0.3705 | -0.013 | 0.3981 |

Table 2.18 (page 2 of 8)—All of the quantities listed in the "parameters" section of the SS report file.

| | Model 1 | | Model 3 | | Model 3b | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Label | Est. | SD | Est. | SD | Est. | SD | Est. | SD |
| Early_InitAge_8 | -0.404 | 0.3386 | -0.387 | 0.3409 | -0.204 | 0.373 | 0.1789 | 0.432 |
| Early_InitAge_7 | -0.205 | 0.3437 | -0.2 | 0.3455 | -0.111 | 0.3853 | 0.4543 | 0.5274 |
| Early_InitAge_6 | 0.0903 | 0.3515 | 0.0714 | 0.3592 | 0.1146 | 0.4247 | 0.9649 | 0.6237 |
| Early_InitAge_5 | 0.4643 | 0.2852 | 0.5696 | 0.2772 | 0.8139 | 0.5164 | 1.6386 | 0.277 |
| Early_InitAge_4 | 0.9107 | 0.2159 | 0.8623 | 0.2147 | 1.3614 | 0.335 | 0.0852 | 0.4064 |
| Early_InitAge_3 | 0.1289 | 0.1886 | 0.0982 | 0.1937 | -0.278 | 0.3348 | 0.3023 | 0.2221 |
| Early_InitAge_2 | -0.049 | 0.1658 | -0.191 | 0.1771 | -0.422 | 0.2537 | -0.582 | 0.2967 |
| Early_InitAge_1 | 0.4962 | 0.1434 | 0.6014 | 0.1445 | -0.433 | 0.2601 | 1.8295 | 0.0955 |
| Main_RecrDev_1977 | 1.0497 | 0.068 | 1.0428 | 0.0716 | 1.6675 | 0.1021 | 0.2176 | 0.2471 |
| Main_RecrDev_1978 | -0.312 | 0.0966 | -0.399 | 0.1067 | -1.13 | 0.2601 | -0.725 | 0.2506 |
| Main_RecrDev_1979 | -0.212 | 0.0675 | -0.194 | 0.07 | -0.646 | 0.1663 | 0.4027 | 0.0902 |
| Main_RecrDev_1980 | -0.095 | 0.0562 | -0.096 | 0.0588 | 0.2859 | 0.0875 | 0.0369 | 0.1017 |
| Main_RecrDev_1981 | -0.068 | 0.0604 | -0.071 | 0.0655 | -0.161 | 0.0933 | 0.2578 | 0.1175 |
| Main_RecrDev_1982 | 0.2581 | 0.0593 | 0.2535 | 0.0629 | 0.4939 | 0.0843 | 0.3448 | 0.0993 |
| Main_RecrDev_1983 | -0.112 | 0.0768 | -0.112 | 0.0768 | -1.226 | 0.2306 | -1.783 | 0.2623 |
| Main_RecrDev_1984 | -0.101 | 0.0689 | -0.115 | 0.0703 | 0.5493 | 0.0783 | 0.9564 | 0.071 |
| Main_RecrDev_1985 | 0.3073 | 0.0549 | 0.3002 | 0.0568 | 0.1802 | 0.093 | -0.539 | 0.2025 |
| Main_RecrDev_1986 | -0.296 | 0.0628 | -0.32 | 0.066 | -0.179 | 0.0915 | -0.03 | 0.1235 |
| Main_RecrDev_1987 | 0.1884 | 0.0451 | 0.1986 | 0.0483 | 0.0753 | 0.0668 | 0.5728 | 0.0815 |
| Main_RecrDev_1988 | -0.074 | 0.0527 | -0.101 | 0.0563 | 0.0985 | 0.0697 | -0.194 | 0.1472 |
| Main_RecrDev_1989 | 0.2767 | 0.0471 | 0.2746 | 0.0494 | 0.307 | 0.0604 | 0.6392 | 0.0799 |
| Main_RecrDev_1990 | 0.1378 | 0.0498 | 0.1534 | 0.0547 | 0.2111 | 0.059 | 0.1908 | 0.1049 |
| Main_RecrDev_1991 | 0.1049 | 0.0473 | 0.0878 | 0.0504 | 0.2591 | 0.0562 | -0.003 | 0.1257 |
| Main_RecrDev_1992 | -0.067 | 0.0517 | -0.107 | 0.057 | -0.249 | 0.0751 | 0.0369 | 0.1167 |
| Main_RecrDev_1993 | 0.03 | 0.0462 | 0.0665 | 0.0483 | -0.129 | 0.0661 | 0.2141 | 0.0959 |
| Main_RecrDev_1994 | 0.0697 | 0.0434 | 0.0621 | 0.0465 | 0.1256 | 0.0621 | 0.1187 | 0.0932 |
| Main_RecrDev_1995 | 0.0027 | 0.0419 | -0.003 | 0.0438 | 0.1425 | 0.0563 | 0.052 | 0.0866 |
| Main_RecrDev_1996 | -0.131 | 0.0427 | -0.106 | 0.0436 | -0.195 | 0.0581 | -0.192 | 0.0941 |
| Main_RecrDev_1997 | -0.412 | 0.0463 | -0.443 | 0.0496 | -0.399 | 0.063 | -0.724 | 0.132 |
| Main_RecrDev_1998 | -0.427 | 0.045 | -0.4 | 0.0486 | -0.32 | 0.0576 | -0.076 | 0.0824 |
| Main_RecrDev_1999 | -0.19 | 0.0416 | -0.164 | 0.0428 | 0.0641 | 0.051 | 0.0352 | 0.0795 |
| Main_RecrDev_2000 | -0.064 | 0.0394 | -0.034 | 0.0404 | -0.046 | 0.0563 | -0.003 | 0.0787 |
| Main_RecrDev_2001 | -0.45 | 0.0462 | -0.485 | 0.0505 | -0.351 | 0.0686 | -1.075 | 0.1706 |
| Main_RecrDev_2002 | -0.487 | 0.0461 | -0.448 | 0.0495 | -0.845 | 0.091 | -0.047 | 0.0792 |
| Main_RecrDev_2003 | -0.371 | 0.0455 | -0.369 | 0.0502 | -0.421 | 0.0712 | -0.662 | 0.1347 |
| Main_RecrDev_2004 | -0.339 | 0.0506 | -0.288 | 0.0547 | -0.194 | 0.0718 | 0.3133 | 0.0914 |
| Main_RecrDev_2005 | 0.1459 | 0.0603 | 0.2074 | 0.066 | 0.3793 | 0.0694 | 0.1384 | 0.1122 |
| Main_RecrDev_2006 | 0.2636 | 0.0774 | 0.3162 | 0.0829 | 0.4961 | 0.0844 | 0.6617 | 0.1126 |
| Main_RecrDev_2007 | 0.3309 | 0.1034 | 0.3387 | 0.1118 | 0.4953 | 0.1039 | 0.2707 | 0.1566 |
| Main_RecrDev_2008 | 0.3475 | 0.1174 | 0.4531 | 0.1221 | 1.0815 | 0.1162 | 1.2626 | 0.1705 |
| Main_RecrDev_2009 | 0.6029 | 0.1696 | 0.0769 | 0.2232 | -0.104 | 0.2757 | -0.403 | 0.3204 |
| Main_RecrDev_2010 | 0.0924 | 0.2355 | 0.4234 | 0.254 | -0.319 | 0.244 | -0.267 | 0.2558 |
| Late_RecrDev_2011 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| ForeRecr_2012 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| ForeRecr_2013 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| ForeRecr_2014 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| ForeRecr_2015 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| ForeRecr_2016 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |

Table 2.18 (page 3 of 8)—All of the quantities listed in the "parameters" section of the SS report file.

| | Model 1 | | Model 3 | | Model 3b | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Label | Est. | SD | Est. | SD | Est. | SD | Est. | SD |
| Impl_err_2012 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Impl_err_2013 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Impl_err_2014 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Impl_err_2015 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Impl_err_2016 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_Jan-Apr_Trawl | 0.081 | 0.0113 | 0.0787 | 0.0112 | 0.0448 | 0.0077 | 0.0502 | 0.0027 |
| InitF_May-Aug_Trawl | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_Sep-Dec_Trawl | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_Jan-Apr_Longline | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_May-Aug_Longline | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_Sep-Dec_Longline | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_Jan-Apr_Pot | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_May-Aug_Pot | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| InitF_Sep-Dec_Pot | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Q_envlink_27plus_Survey | 0.4964 | 0.1113 | 0.5153 | 0.1135 | 0 | _ | 0.4068 | 0.1233 |
| Q_base_27plus_Survey | 0.0392 | _ | 0.0392 | _ | 0.0392 | _ | 0.0392 | _ |
| Q_base_sub27_Survey | -2.253 | 0.1393 | -2.562 | 0.1701 | -2.431 | 0.1327 | -2.499 | 0.1509 |
| Q_sub27_dev_1984 | -0.106 | 0.5206 | -0.082 | 0.5202 | 0.3538 | 0.3417 | 1.3001 | 0.5514 |
| Q_sub27_dev_1987 | -0.978 | 0.3584 | -1.022 | 0.3587 | -0.546 | 0.2805 | -0.98 | 0.372 |
| Q_sub27_dev_1990 | -0.61 | 0.3865 | -0.569 | 0.3867 | -0.323 | 0.2914 | -0.829 | 0.3934 |
| Q_sub27_dev_1993 | -0.168 | 0.3557 | -0.144 | 0.3555 | 0.0685 | 0.2781 | -0.1 | 0.3689 |
| Q_sub27_dev_1996 | 1.2743 | 0.5316 | 1.3037 | 0.5316 | 0.5164 | 0.3403 | 1.4375 | 0.5375 |
| Q_sub27_dev_1999 | -0.365 | 0.2792 | -0.401 | 0.2788 | -0.277 | 0.2356 | -0.537 | 0.2873 |
| Q_sub27_dev_2001 | 0.196 | 0.2777 | 0.2839 | 0.2789 | 0.1435 | 0.2347 | 0.2246 | 0.2858 |
| Q_sub27_dev_2003 | -0.756 | 0.2483 | -0.762 | 0.2478 | -0.284 | 0.2196 | -1.025 | 0.2559 |
| Q_sub27_dev_2005 | -0.29 | 0.3674 | -0.418 | 0.3683 | -0.155 | 0.2829 | -0.665 | 0.3731 |
| Q_sub27_dev_2007 | 0.7161 | 0.3995 | 0.6906 | 0.4006 | 0.339 | 0.2961 | 0.5083 | 0.4051 |
| Q_sub27_dev_2009 | 1.2625 | 0.696 | 1.3206 | 0.6964 | 0.246 | 0.3731 | 0.754 | 0.7053 |
| Q_sub27_dev_2011 | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_Jan-Apr_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_Jan-Apr_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel3_Jan-Apr_TWL | 5.8681 | 0.0279 | 5.8626 | 0.0279 | 5.8006 | 0.0287 | 5.8349 | 0.0275 |
| Sel4_Jan-Apr_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel5_Jan-Apr_TWL | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Jan-Apr_TWL | 10 | _ | 10 | _ | 10 | _ | 10 | _ |
| Sel1_May-Aug_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_May-Aug_TWL | -9.686 | 8.678 | -9.694 | 8.4956 | -9.747 | 7.1698 | -9.72 | 7.8368 |
| Sel3_May-Aug_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_May-Aug_TWL | 4.4352 | 0.4416 | 4.4224 | 0.4325 | 4.0075 | 0.4217 | 4.2418 | 0.4858 |
| Sel5_May-Aug_TWL | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_May-Aug_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_Sep-Dec_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_Sep-Dec_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel3_Sep-Dec_TWL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_Sep-Dec_TWL | 3.864 | 0.5361 | 3.8632 | 0.55 | 4.1156 | 0.4779 | 3.9096 | 0.528 |
| Sel5_Sep-Dec_TWL | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Sep-Dec_TWL | -1.084 | 0.2776 | -1.039 | 0.2628 | -1.178 | 0.2544 | -1.039 | 0.259 |
| Sel1_Jan-Apr_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |

Table 2.18 (page 4 of 8)—All of the quantities listed in the “parameters” section of the SS report file.

| Label | Model 1 Est. | Model 1 SD | Model 3 Est. | Model 3 SD | Model 3b Est. | Model 3b SD | Model 4 Est. | Model 4 SD |
|---|---|---|---|---|---|---|---|---|
| Sel2_Jan-Apr_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel3_Jan-Apr_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_Jan-Apr_LGL | 4.0593 | 0.37 | 4.0157 | 0.3637 | 3.82 | 0.2684 | 3.7347 | 0.458 |
| Sel5_Jan-Apr_LGL | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Jan-Apr_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_May-Aug_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_May-Aug_LGL | -9.041 | 21.914 | -9.099 | 20.873 | -8.664 | 28.086 | -8.54 | 29.908 |
| Sel3_May-Aug_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_May-Aug_LGL | 4.6646 | 0.5547 | 4.7968 | 0.5537 | 4.6483 | 0.3894 | 4.6717 | 0.4724 |
| Sel5_May-Aug_LGL | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_May-Aug_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_Sep-Dec_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_Sep-Dec_LGL | -13.6 | 84.474 | -13.68 | _ | -13.98 | 80.667 | -13.83 | 82.136 |
| Sel3_Sep-Dec_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_Sep-Dec_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel5_Sep-Dec_LGL | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Sep-Dec_LGL | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_Jan-Apr_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_Jan-Apr_POT | -14.33 | 77.184 | -14.31 | _ | -14.35 | 76.94 | -14.26 | 77.864 |
| Sel3_Jan-Apr_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_Jan-Apr_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel5_Jan-Apr_POT | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Jan-Apr_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_May-Aug_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_May-Aug_POT | -9.067 | 21.458 | -9.061 | 21.569 | -9.224 | 18.569 | -9.067 | 21.461 |
| Sel3_May-Aug_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_May-Aug_POT | 5.1066 | 0.4821 | 5.0706 | 0.4764 | 4.7881 | 0.4036 | 5.1002 | 0.5016 |
| Sel5_May-Aug_POT | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_May-Aug_POT | -1.191 | 0.6027 | -1.153 | 0.5714 | -1.014 | 0.3827 | -1.059 | 0.5862 |
| Sel1_Sep-Dec_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel2_Sep-Dec_POT | -7.886 | 37.403 | -5.829 | 14.432 | -4.179 | 2.5794 | -5.407 | 9.9838 |
| Sel3_Sep-Dec_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel4_Sep-Dec_POT | 4.725 | 0.36 | 4.6646 | 0.5218 | 4.3704 | 0.4799 | 4.5891 | 0.5885 |
| Sel5_Sep-Dec_POT | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Sep-Dec_POT | 0 | _ | 0 | _ | 0 | _ | 0 | _ |
| Sel1_27plus_SRV | 0 | _ | 0 | _ | 3.975 | 0.0558 | 0 | _ |
| Sel2_27plus_SRV | 0 | _ | 0 | _ | -13.09 | 89.695 | 0 | _ |
| Sel3_27plus_SRV | 0 | _ | 0 | _ | 0.4842 | 0.0521 | 0 | _ |
| Sel4_27plus_SRV | 0 | _ | 0 | _ | 0.6624 | 0.1411 | 0 | _ |
| Sel5_27plus_SRV | -10 | _ | -10 | _ | -9.999 | 0.0467 | -10 | _ |
| Sel6_27plus_SRV | 0 | _ | 0 | _ | -2.147 | 0.14 | 0 | _ |
| Sel1_Sub27_SRV | -0.59 | 0.1273 | 0.7145 | 0.4076 | -2.221 | 0.1984 | -2.459 | 0.2414 |
| Sel2_Sub27_SRV | 10 | _ | 10 | _ | 10 | _ | 10 | _ |
| Sel3_Sub27_SRV | -1.38 | 0.1909 | -2.049 | 0.2918 | -1.968 | 0.1807 | -3.766 | 1.4194 |
| Sel4_Sub27_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel5_Sub27_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel6_Sub27_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel7_Sub27_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |

Table 2.18 (page 5 of 8)—All of the quantities listed in the “parameters” section of the SS report file.

| | Model 1 | | Model 3 | | Model 3b | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Label | Est. | SD | Est. | SD | Est. | SD | Est. | SD |
| Sel8_Sub27_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel9_Sub27_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel2__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel2__Sub2_SRV | -10 | _ | -10 | _ | -10 | _ | -10 | _ |
| Sel1_Jan-Apr_TWL1977 | 62.937 | 1.2696 | 62.594 | 1.2705 | 60.803 | 1.3376 | 62.686 | 1.2774 |
| Sel1_Jan-Apr_TWL1990 | 74.493 | 0.5974 | 74.177 | 0.5917 | 71.813 | 0.5732 | 74.686 | 0.6101 |
| Sel1_Jan-Apr_TWL1995 | 75.954 | 0.5908 | 75.702 | 0.5872 | 72.833 | 0.5485 | 75.702 | 0.5895 |
| Sel1_Jan-Apr_TWL2000 | 70.528 | 0.6453 | 70.236 | 0.642 | 67.935 | 0.6364 | 70.567 | 0.6336 |
| Sel1_Jan-Apr_TWL2005 | 71.751 | 0.7753 | 71.213 | 0.7711 | 68.451 | 0.7253 | 72.214 | 0.7675 |
| Sel1_May-Aug_TWL1977 | 55.167 | 1.4268 | 55.064 | 1.4214 | 53.55 | 1.2262 | 54.366 | 1.3154 |
| Sel1_May-Aug_TWL1985 | 62.675 | 1.2842 | 62.435 | 1.2788 | 62.462 | 1.2615 | 62.356 | 1.2634 |
| Sel1_May-Aug_TWL1990 | 67.218 | 1.1159 | 67.145 | 1.1077 | 66.783 | 1.0518 | 67.611 | 1.1583 |
| Sel1_May-Aug_TWL2000 | 69.146 | 1.7353 | 68.92 | 1.6345 | 67.992 | 1.5477 | 69.109 | 1.7288 |
| Sel1_May-Aug_TWL2005 | 73.21 | 1.8398 | 72.756 | 1.7816 | 70.391 | 1.4044 | 72.724 | 1.681 |
| Sel3_May-Aug_TWL1977 | 4.5251 | 0.2103 | 4.5266 | 0.2115 | 4.362 | 0.2075 | 4.4654 | 0.209 |
| Sel3_May-Aug_TWL1985 | 5.1378 | 0.1556 | 5.1215 | 0.1562 | 5.2554 | 0.1608 | 5.1595 | 0.1557 |
| Sel3_May-Aug_TWL1990 | 5.1624 | 0.1172 | 5.1638 | 0.1169 | 5.2006 | 0.1178 | 5.1692 | 0.117 |
| Sel3_May-Aug_TWL2000 | 5.8142 | 0.1335 | 5.8118 | 0.1293 | 5.8409 | 0.1308 | 5.7769 | 0.1326 |
| Sel3_May-Aug_TWL2005 | 5.9385 | 0.1112 | 5.9367 | 0.1108 | 5.8484 | 0.102 | 5.8439 | 0.1052 |
| Sel6_May-Aug_TWL1977 | 0.1738 | 0.4022 | 0.1154 | 0.3878 | 0.1814 | 0.3346 | 0.1834 | 0.3587 |
| Sel6_May-Aug_TWL1985 | -0.963 | 0.3742 | -0.996 | 0.3657 | -0.897 | 0.3282 | -1.011 | 0.3422 |
| Sel6_May-Aug_TWL1990 | -2.467 | 0.7348 | -2.474 | 0.7127 | -1.882 | 0.442 | -2.2 | 0.6255 |
| Sel6_May-Aug_TWL2000 | -1.121 | 0.7829 | -1.11 | 0.752 | -0.833 | 0.5461 | -0.843 | 0.7079 |
| Sel6_May-Aug_TWL2005 | -1.327 | 1.0231 | -1.351 | 0.9752 | -1.376 | 0.6482 | -1.14 | 0.884 |
| Sel1_Sep-Dec_TWL1977 | 45.208 | 3.5873 | 48.294 | 5.5123 | 44.2 | 4.1669 | 50.108 | 3.1713 |
| Sel1_Sep-Dec_TWL1980 | 57.038 | 3.6563 | 56.453 | 3.4428 | 56.066 | 2.3882 | 56.53 | 3.7872 |
| Sel1_Sep-Dec_TWL1985 | 61.978 | 1.6832 | 61.762 | 1.6969 | 60.065 | 1.7195 | 60.76 | 1.6111 |
| Sel1_Sep-Dec_TWL1990 | 64.419 | 2.8959 | 63.749 | 2.8534 | 55.607 | 2.6627 | 65.035 | 2.905 |
| Sel1_Sep-Dec_TWL1995 | 75.458 | 1.6537 | 75.188 | 1.628 | 72.732 | 1.4995 | 75.211 | 1.621 |
| Sel1_Sep-Dec_TWL2000 | 71.77 | 1.3687 | 71.423 | 2.3447 | 69.069 | 2.3425 | 71.546 | 2.2928 |
| Sel1_Sep-Dec_TWL2005 | 75.306 | 1.4728 | 74.816 | 1.525 | 71.514 | 1.2611 | 74.46 | 1.4065 |
| Sel2_Sep-Dec_TWL1977 | -0.227 | 0.5555 | -2.768 | 2.604 | -3.009 | 2.8523 | -8.094 | 36.556 |
| Sel2_Sep-Dec_TWL1980 | -3.973 | 5.6946 | -3.548 | 3.486 | -6.824 | 47.036 | -4.492 | 9.4098 |
| Sel2_Sep-Dec_TWL1985 | -9.223 | 18.583 | -9.188 | 19.253 | -9.035 | 22.021 | -9.057 | 21.63 |
| Sel2_Sep-Dec_TWL1990 | -0.622 | 0.2932 | -0.599 | 0.262 | 6.4202 | 55.72 | -0.632 | 0.2994 |
| Sel2_Sep-Dec_TWL1995 | -9.274 | 17.599 | -9.278 | 17.536 | -9.381 | 15.467 | -9.307 | 16.963 |
| Sel2_Sep-Dec_TWL2000 | -7.552 | 42.133 | -5.444 | 17.896 | -3.504 | 2.7001 | -5.341 | 16.262 |
| Sel2_Sep-Dec_TWL2005 | -8.946 | 23.578 | -8.987 | 22.871 | -9.11 | 20.674 | -8.997 | 22.693 |

Table 2.18 (page 6 of 8)—All of the quantities listed in the “parameters” section of the SS report file.

| | Model 1 | | Model 3 | | Model 3b | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Label | Est. | SD | Est. | SD | Est. | SD | Est. | SD |
| Sel3_Sep-Dec_TWL1977 | 3.9789 | 0.7352 | 4.2729 | 0.8366 | 3.6168 | 0.8646 | 4.298 | 0.5932 |
| Sel3_Sep-Dec_TWL1980 | 5.0551 | 0.3512 | 5.0195 | 0.3452 | 5.0288 | 0.2817 | 5.0534 | 0.3734 |
| Sel3_Sep-Dec_TWL1985 | 5.6473 | 0.1836 | 5.6371 | 0.1854 | 5.6621 | 0.1845 | 5.5889 | 0.1723 |
| Sel3_Sep-Dec_TWL1990 | 5.5547 | 0.2251 | 5.5156 | 0.2295 | 4.8417 | 0.3258 | 5.5339 | 0.2224 |
| Sel3_Sep-Dec_TWL1995 | 6.2567 | 0.1009 | 6.2495 | 0.1 | 6.2115 | 0.1031 | 6.2153 | 0.0993 |
| Sel3_Sep-Dec_TWL2000 | 5.9495 | 0.0921 | 5.9441 | 0.1342 | 5.8928 | 0.1461 | 5.8952 | 0.1307 |
| Sel3_Sep-Dec_TWL2005 | 6.023 | 0.0836 | 6.0187 | 0.0875 | 5.8942 | 0.0843 | 5.9114 | 0.0821 |
| Sel1_Jan-Apr_LGL1977 | 57.878 | 0.8985 | 57.473 | 0.9438 | 55.316 | 0.9381 | 56.966 | 0.9034 |
| Sel1_Jan-Apr_LGL1985 | 73.139 | 1.2596 | 72.519 | 1.3761 | 70.446 | 2.2124 | 69.167 | 1.8783 |
| Sel1_Jan-Apr_LGL1990 | 70.816 | 1.0848 | 70.665 | 0.8018 | 68.486 | 0.7581 | 70.756 | 0.8389 |
| Sel1_Jan-Apr_LGL1995 | 74.323 | 0.7941 | 74.194 | 0.7926 | 72.448 | 0.6926 | 74.329 | 0.7815 |
| Sel1_Jan-Apr_LGL2000 | 69.426 | 0.7508 | 69.324 | 0.7817 | 68.247 | 0.7478 | 69.265 | 0.755 |
| Sel1_Jan-Apr_LGL2005 | 69.43 | 0.4923 | 69.183 | 0.4921 | 67.771 | 0.4378 | 69.288 | 0.4963 |
| Sel2_Jan-Apr_LGL1977 | -0.456 | 0.1097 | -0.455 | 0.1046 | -0.315 | 0.1373 | -0.404 | 0.127 |
| Sel2_Jan-Apr_LGL1985 | -3.911 | 2.5697 | -3.207 | 1.3324 | -1.742 | 0.6107 | -1.654 | 0.4002 |
| Sel2_Jan-Apr_LGL1990 | -5.16 | 25.242 | -7.898 | 39.053 | -9.316 | 16.785 | -7.134 | 49.31 |
| Sel2_Jan-Apr_LGL1995 | -9.05 | 21.768 | -9.108 | 20.72 | -9.418 | 14.701 | -9.129 | 20.347 |
| Sel2_Jan-Apr_LGL2000 | -4.285 | 3.4594 | -4.448 | 4.4744 | -3.653 | 1.4814 | -3.457 | 1.8948 |
| Sel2_Jan-Apr_LGL2005 | -9.767 | 6.6545 | -9.771 | 6.5375 | -9.773 | 6.4894 | -9.75 | 7.078 |
| Sel3_Jan-Apr_LGL1977 | 4.7054 | 0.1036 | 4.673 | 0.1107 | 4.4686 | 0.1187 | 4.6389 | 0.1052 |
| Sel3_Jan-Apr_LGL1985 | 5.7269 | 0.0736 | 5.7009 | 0.0815 | 5.7072 | 0.128 | 5.5534 | 0.1175 |
| Sel3_Jan-Apr_LGL1990d | 5.3105 | 0.0816 | 5.3081 | 0.0676 | 5.21 | 0.0712 | 5.2772 | 0.0689 |
| Sel3_Jan-Apr_LGL1995d | 5.4564 | 0.0607 | 5.456 | 0.0609 | 5.4069 | 0.0599 | 5.4398 | 0.0594 |
| Sel3_Jan-Apr_LGL2000d | 5.128 | 0.0659 | 5.1265 | 0.068 | 5.098 | 0.0695 | 5.0979 | 0.0661 |
| Sel3_Jan-Apr_LGL2005d | 5.0692 | 0.0448 | 5.0621 | 0.0452 | 4.9841 | 0.0444 | 5.0181 | 0.0447 |
| Sel6_Jan-Apr_LGL1977d | -0.99 | 0.4465 | -0.937 | 0.4204 | -0.354 | 0.4504 | -0.38 | 0.408 |
| Sel6_Jan-Apr_LGL1985d | 0.7308 | 0.2704 | 0.7401 | 0.2699 | 2.2004 | 0.8217 | 1.366 | 0.4192 |
| Sel6_Jan-Apr_LGL1990d | 1.2107 | 0.43 | 1.1883 | 0.3973 | 1.7555 | 0.5053 | 1.6999 | 0.57 |
| Sel6_Jan-Apr_LGL1995d | 1.1402 | 0.4738 | 1.1394 | 0.4606 | 0.8042 | 0.2996 | 1.2898 | 0.4805 |
| Sel6_Jan-Apr_LGL2000d | -0.147 | 0.2328 | -0.132 | 0.2243 | -0.238 | 0.1856 | 0.0414 | 0.2337 |
| Sel6_Jan-Apr_LGL2005d | 0.1883 | 0.2297 | 0.1149 | 0.2175 | -0.276 | 0.1517 | 0.3112 | 0.2181 |
| Sel1_May-Aug_LGL1977d | 57.047 | 3.0174 | 56.812 | 2.4635 | 53.555 | 3.1102 | 55.702 | 2.3686 |
| Sel1_May-Aug_LGL1980d | 56.296 | 0.8897 | 56.039 | 0.9036 | 55.685 | 0.8065 | 55.744 | 0.8809 |
| Sel1_May-Aug_LGL1990d | 70.791 | 2.2255 | 70.433 | 2.2033 | 69.315 | 2.2949 | 70.972 | 2.2459 |
| Sel1_May-Aug_LGL2000d | 72.63 | 1.5061 | 72.242 | 1.4866 | 70.488 | 1.3576 | 72.134 | 1.5361 |
| Sel3_May-Aug_LGL1977d | 4.5469 | 0.3903 | 4.5404 | 0.331 | 4.2108 | 0.4937 | 4.3232 | 0.3406 |
| Sel3_May-Aug_LGL1980d | 4.3102 | 0.1412 | 4.2814 | 0.1458 | 4.2767 | 0.1371 | 4.3058 | 0.1451 |
| Sel3_May-Aug_LGL1990d | 5.0488 | 0.2555 | 5.0237 | 0.2576 | 4.9991 | 0.2834 | 5.0537 | 0.2521 |
| Sel3_May-Aug_LGL2000d | 5.0097 | 0.1447 | 4.9913 | 0.1462 | 4.9178 | 0.1486 | 4.9542 | 0.1496 |
| Sel6_May-Aug_LGL1977d | 0.4312 | 0.8111 | 0.2416 | 0.7354 | 0.4608 | 0.8139 | 0.9966 | 0.9557 |
| Sel6_May-Aug_LGL1980d | -0.511 | 0.2295 | -0.588 | 0.2461 | -0.62 | 0.1962 | -0.499 | 0.2113 |
| Sel6_May-Aug_LGL1990d | -1.667 | 1.2851 | -1.788 | 1.385 | -1.15 | 1.0594 | -1.594 | 1.2847 |
| Sel6_May-Aug_LGL2000d | 1.1875 | 1.1342 | 1.1103 | 1.0897 | 0.8033 | 0.7634 | 1.8731 | 1.8949 |
| Sel1_Sep-Dec_LGL1977d | 60.522 | 2.6011 | 59.83 | 2.2516 | 55.308 | 1.7093 | 60.356 | 1.7719 |
| Sel1_Sep-Dec_LGL1980d | 57.018 | 0.3772 | 56.902 | 0.3787 | 56.191 | 0.3933 | 56.423 | 0.3976 |
| Sel1_Sep-Dec_LGL1990d | 69.042 | 0.5278 | 68.833 | 0.5159 | 67.342 | 0.4705 | 68.797 | 0.5009 |
| Sel3_Sep-Dec_LGL1977d | 4.808 | 0.271 | 4.7532 | 0.2437 | 4.2793 | 0.249 | 4.7551 | 0.1988 |
| Sel3_Sep-Dec_LGL1980d | 4.3362 | 0.0588 | 4.3318 | 0.0592 | 4.286 | 0.0628 | 4.2912 | 0.0617 |

Table 2.18 (page 7 of 8)—All of the quantities listed in the "parameters" section of the SS report file.

| | Model 1 | | Model 3 | | Model 3b | | Model 4 | |
|---|---|---|---|---|---|---|---|---|
| Label | Est. | SD | Est. | SD | Est. | SD | Est. | SD |
| Sel3_Sep-Dec_LGL1990d | 4.9723 | 0.052 | 4.967 | 0.0516 | 4.8841 | 0.052 | 4.9166 | 0.0501 |
| Sel4_Sep-Dec_LGL1977d | 7.2712 | 0.8137 | 7.2524 | 0.7017 | 8.7896 | 2.9351 | 9.9706 | 0.918 |
| Sel4_Sep-Dec_LGL1980d | 4.1515 | 0.1483 | 4.1775 | 0.1462 | 4.2304 | 0.1386 | 4.1837 | 0.1473 |
| Sel4_Sep-Dec_LGL1990d | 3.8688 | 0.4439 | 3.8727 | 0.414 | 3.9735 | 0.292 | 3.7051 | 0.4537 |
| Sel6_Sep-Dec_LGL1977d | -8.606 | 29.097 | -8.625 | 28.804 | -7.978 | 38.165 | -6.895 | 51.994 |
| Sel6_Sep-Dec_LGL1980d | -1.36 | 0.1027 | -1.395 | 0.1035 | -1.389 | 0.106 | -1.348 | 0.102 |
| Sel6_Sep-Dec_LGL1990d | -0.104 | 0.2213 | -0.162 | 0.2108 | -0.482 | 0.1618 | 0.0368 | 0.2095 |
| Sel1_Jan-Apr_POT1977d | 69.119 | 0.3766 | 69.035 | 0.3744 | 68.186 | 0.3726 | 68.965 | 0.3811 |
| Sel1_Jan-Apr_POT1995d | 71.769 | 0.3563 | 71.718 | 0.358 | 70.612 | 0.3324 | 71.698 | 0.3533 |
| Sel1_Jan-Apr_POT2000d | 68.058 | 0.3691 | 67.945 | 0.3716 | 66.944 | 0.3661 | 68.01 | 0.3712 |
| Sel1_Jan-Apr_POT2005d | 68.606 | 0.3832 | 68.366 | 0.3799 | 66.69 | 0.3386 | 68.318 | 0.3695 |
| Sel3_Jan-Apr_POT1977d | 4.7889 | 0.0442 | 4.7879 | 0.0443 | 4.779 | 0.0461 | 4.7591 | 0.0445 |
| Sel3_Jan-Apr_POT1995d | 4.9396 | 0.0362 | 4.9423 | 0.0364 | 4.9052 | 0.0369 | 4.9254 | 0.0358 |
| Sel3_Jan-Apr_POT2000d | 4.8703 | 0.0395 | 4.8655 | 0.04 | 4.8395 | 0.0418 | 4.8566 | 0.0396 |
| Sel3_Jan-Apr_POT2005d | 4.745 | 0.0398 | 4.7349 | 0.04 | 4.6264 | 0.0408 | 4.6993 | 0.039 |
| Sel4_Jan-Apr_POT1977d | 4.5695 | 0.1652 | 4.5517 | 0.1631 | 4.3863 | 0.1742 | 4.6531 | 0.1724 |
| Sel4_Jan-Apr_POT1995d | 4.2138 | 0.2547 | 4.1797 | 0.2516 | 4.1204 | 0.2023 | 4.1456 | 0.2624 |
| Sel4_Jan-Apr_POT2000d | 4.3396 | 0.222 | 4.3188 | 0.2189 | 4.4123 | 0.1842 | 4.2654 | 0.2332 |
| Sel4_Jan-Apr_POT2005d | 4.031 | 0.3096 | 4.0427 | 0.2876 | 4.1129 | 0.195 | 3.8776 | 0.323 |
| Sel6_Jan-Apr_POT1977d | -2.136 | 0.2537 | -2.12 | 0.2455 | -1.666 | 0.1941 | -2.061 | 0.2694 |
| Sel6_Jan-Apr_POT1995d | -0.612 | 0.1887 | -0.603 | 0.1834 | -0.758 | 0.1443 | -0.536 | 0.1831 |
| Sel6_Jan-Apr_POT2000d | -0.492 | 0.1583 | -0.494 | 0.1543 | -0.671 | 0.1356 | -0.363 | 0.1559 |
| Sel6_Jan-Apr_POT2005d | 0.4754 | 0.2156 | 0.3881 | 0.2008 | -0.067 | 0.1282 | 0.6579 | 0.2117 |
| Sel1_May-Aug_POT1977d | 64.746 | 1.5434 | 64.703 | 1.5313 | 64.353 | 1.4435 | 64.948 | 1.56 |
| Sel1_May-Aug_POT1995d | 71.137 | 1.0911 | 70.953 | 1.0944 | 69.459 | 1.0043 | 70.646 | 1.0786 |
| Sel1_May-Aug_POT2000d | 65.548 | 0.8901 | 65.491 | 0.8857 | 64.94 | 0.8896 | 65.502 | 0.8935 |
| Sel3_May-Aug_POT1977d | 4.425 | 0.2514 | 4.4289 | 0.2507 | 4.4324 | 0.2538 | 4.4409 | 0.249 |
| Sel3_May-Aug_POT1995d | 4.8881 | 0.1275 | 4.8747 | 0.1292 | 4.787 | 0.1323 | 4.8291 | 0.1293 |
| Sel3_May-Aug_POT2000d | 4.2746 | 0.1603 | 4.2706 | 0.1606 | 4.2534 | 0.1676 | 4.2651 | 0.1605 |
| Sel1_Sep-Dec_POT1977d | 72.033 | 1.0582 | 71.882 | 1.0959 | 70.752 | 1.1085 | 72.532 | 1.1307 |
| Sel1_Sep-Dec_POT1995d | 70.965 | 1.1953 | 70.828 | 1.2 | 69.574 | 1.1164 | 70.737 | 1.1782 |
| Sel1_Sep-Dec_POT2000d | 66.154 | 0.8168 | 65.991 | 0.8896 | 64.988 | 0.848 | 65.956 | 0.8714 |
| Sel1_Sep-Dec_POT2005d | 66.53 | 0.6452 | 66.287 | 0.7065 | 64.911 | 0.688 | 66.404 | 0.6886 |
| Sel3_Sep-Dec_POT1977d | 5.2851 | 0.1022 | 5.2834 | 0.1043 | 5.2805 | 0.1115 | 5.301 | 0.1024 |
| Sel3_Sep-Dec_POT1995d | 4.9735 | 0.1351 | 4.9661 | 0.1361 | 4.9112 | 0.1386 | 4.937 | 0.1345 |
| Sel3_Sep-Dec_POT2000d | 4.8109 | 0.0971 | 4.8025 | 0.1034 | 4.7678 | 0.1061 | 4.7683 | 0.1015 |
| Sel3_Sep-Dec_POT2005d | 4.729 | 0.077 | 4.7152 | 0.0824 | 4.6205 | 0.0857 | 4.6876 | 0.0793 |
| Sel6_Sep-Dec_POT1977d | -1.667 | 0.6595 | -1.588 | 0.66 | -0.789 | 0.4532 | -1.469 | 0.6845 |
| Sel6_Sep-Dec_POT1995d | 0.2119 | 0.6073 | 0.2189 | 0.5994 | -0.118 | 0.4481 | 0.2705 | 0.5958 |
| Sel6_Sep-Dec_POT2000d | -0.45 | 0.315 | -0.438 | 0.3221 | -0.36 | 0.2723 | -0.201 | 0.3325 |
| Sel6_Sep-Dec_POT2005d | -0.035 | 0.3212 | -0.101 | 0.3151 | -0.519 | 0.2346 | 0.087 | 0.3243 |
| Sel1_27plus_SRV1977d | 4.0578 | 0.0385 | 4.0801 | 0.0522 | | | 5.0168 | 0.0384 |
| Sel1_27plus_SRV1987d | 2.0466 | 0.0083 | 2.0682 | 0.0085 | | | 3.0498 | 0.011 |
| Sel1_27plus_SRV1990d | 3.8858 | 0.1825 | 4.0294 | 0.166 | | | 5.014 | 0.0272 |
| Sel1_27plus_SRV1993d | 3.8244 | 0.1816 | 4.2254 | 0.3537 | | | 5.97 | 0.1125 |
| Sel1_27plus_SRV1996d | 5.2241 | 0.2567 | 5.2539 | 0.2463 | | | 6.3468 | 0.3129 |
| Sel1_27plus_SRV1999d | 3.9817 | 0.2314 | 4.4844 | 0.3163 | | | 4.9047 | 0.3039 |
| Sel1_27plus_SRV2001d | 3.2454 | 0.203 | 3.5264 | 0.1716 | | | 4.2839 | 0.3167 |

Table 2.18 (page 8 of 8)—All of the quantities listed in the "parameters" section of the SS report file.

| Label | Model 1 Est. | Model 1 SD | Model 3 Est. | Model 3 SD | Model 3b Est. | Model 3b SD | Model 4 Est. | Model 4 SD |
|---|---|---|---|---|---|---|---|---|
| Sel1_27plus_SRV2003d | 4.0088 | 0.1779 | 4.4335 | 0.2403 | | | 5.1709 | 0.2496 |
| Sel1_27plus_SRV2005d | 5.077 | 0.2129 | 5.1354 | 0.2171 | | | 5.5795 | 0.353 |
| Sel1_27plus_SRV2007d | 2.7478 | 0.1153 | 2.9376 | 0.1361 | | | 4.0752 | 0.2897 |
| Sel1_27plus_SRV2009d | 2.0905 | 0.0102 | 2.7893 | 0.2978 | | | 4.6633 | 0.1679 |
| Sel2_27plus_SRV1977d | -13.62 | 84.275 | -13.66 | _ | | | -13.34 | 87.187 |
| Sel2_27plus_SRV1987d | -2.096 | 0.2247 | -2.101 | 0.2188 | | | -1.885 | 0.7805 |
| Sel2_27plus_SRV1990d | -9.025 | 22.237 | -1.863 | 0.0842 | | | -9.573 | 11.328 |
| Sel2_27plus_SRV1993d | -1.871 | 1.0325 | -2.063 | 0.9893 | | | -8.438 | 30.961 |
| Sel2_27plus_SRV1996d | -2.908 | 3.062 | -2.823 | 0.3252 | | | -3.896 | 5.7538 |
| Sel2_27plus_SRV1999d | -1.008 | 0.0632 | -1.117 | 0.0897 | | | -1.244 | 0.1022 |
| Sel2_27plus_SRV2001d | -2.735 | 1.1652 | -3.035 | 1.5295 | | | -1.588 | 4.1676 |
| Sel2_27plus_SRV2003d | -3.023 | 1.0173 | -4.434 | 4.3806 | | | -1.854 | 0.1598 |
| Sel2_27plus_SRV2005d | -0.574 | 0.3702 | -0.578 | 0.1134 | | | -7.908 | 38.487 |
| Sel2_27plus_SRV2007d | 0.0073 | 2.2536 | 0.2909 | 0.0183 | | | -1.008 | 0.0738 |
| Sel2_27plus_SRV2009d | -2.076 | 0.1445 | -2.529 | 0.3455 | | | -1.873 | 0.9784 |
| Sel3_27plus_SRV1977d | 0.615 | 0.0676 | 0.5573 | 0.0773 | | | 1.0522 | 0.0699 |
| Sel3_27plus_SRV1987d | -10 | _ | -10 | _ | | | -10 | _ |
| Sel3_27plus_SRV1990d | 0.4729 | 0.1933 | 0.5924 | 0.1677 | | | 0.513 | 0.087 |
| Sel3_27plus_SRV1993d | 0.5747 | 0.1883 | 0.8957 | 0.2875 | | | 1.5088 | 0.0837 |
| Sel3_27plus_SRV1996d | 1.4596 | 0.1555 | 1.4188 | 0.1546 | | | 1.7329 | 0.1542 |
| Sel3_27plus_SRV1999d | 0.7666 | 0.227 | 1.1032 | 0.252 | | | 1.0858 | 0.2441 |
| Sel3_27plus_SRV2001d | 0.1617 | 0.2448 | 0.418 | 0.1821 | | | 0.6695 | 0.2979 |
| Sel3_27plus_SRV2003d | 0.4081 | 0.2066 | 0.7582 | 0.2127 | | | 0.9726 | 0.2088 |
| Sel3_27plus_SRV2005d | 1.4273 | 0.1468 | 1.3914 | 0.149 | | | 1.227 | 0.2191 |
| Sel3_27plus_SRV2007d | -0.329 | 0.1944 | -0.1 | 0.202 | | | 0.4118 | 0.31 |
| Sel3_27plus_SRV2009d | -7.096 | 19.455 | -1.06 | 0.7465 | | | 0.6403 | 0.1512 |
| Sel4_27plus_SRV1977d | -7.924 | 16.354 | -7.309 | 18.82 | | | -9.908 | 2.798 |
| Sel4_27plus_SRV1987d | 1.0806 | 0.6013 | 1.037 | 0.589 | | | -4.924 | 48.237 |
| Sel4_27plus_SRV1990d | 1.8102 | 0.6222 | -9.977 | _ | | | -9.949 | 1.5294 |
| Sel4_27plus_SRV1993d | -2.306 | 21.305 | -2.408 | 23.392 | | | -8.802 | 19.725 |
| Sel4_27plus_SRV1996d | -5.832 | 75.616 | -9.967 | _ | | | -4.242 | 30.709 |
| Sel4_27plus_SRV1999d | -10 | _ | -10 | _ | | | -10 | _ |
| Sel4_27plus_SRV2001d | 2.7765 | 0.5992 | 2.8229 | 0.5919 | | | -3.809 | 78.438 |
| Sel4_27plus_SRV2003d | 1.9374 | 0.5185 | 2.0109 | 0.4888 | | | -9.572 | 9.8608 |
| Sel4_27plus_SRV2005d | -8.736 | 23.447 | -18.07 | _ | | | -5.008 | 335.17 |
| Sel4_27plus_SRV2007d | -2.927 | 98.587 | -9.886 | _ | | | -9.979 | 0.6503 |
| Sel4_27plus_SRV2009d | 1.1456 | 0.7255 | 1.2944 | 0.6233 | | | -4.045 | 31.277 |
| Sel6_27plus_SRV1977d | -1.989 | 0.1748 | -2.025 | 0.1768 | | | -2.247 | 0.185 |
| Sel6_27plus_SRV1987d | -2.601 | 0.5202 | -2.647 | 0.5134 | | | -2.512 | 0.285 |
| Sel6_27plus_SRV1990d | -2.002 | 0.8768 | -1.44 | 0.3808 | | | -1.708 | 0.2753 |
| Sel6_27plus_SRV1993d | -1.436 | 0.4086 | -1.519 | 0.424 | | | -1.505 | 0.3581 |
| Sel6_27plus_SRV1996d | -1.418 | 0.4385 | -1.44 | 0.4323 | | | -1.159 | 0.4419 |
| Sel6_27plus_SRV1999d | -10 | _ | -10 | _ | | | -10 | _ |
| Sel6_27plus_SRV2001d | -8.644 | 28.505 | -8.616 | 28.945 | | | -0.891 | 0.8655 |
| Sel6_27plus_SRV2003d | -9.318 | 16.437 | -9.516 | 12.546 | | | -1.444 | 0.7109 |
| Sel6_27plus_SRV2005d | -3.002 | 8.7706 | -2.239 | 4.617 | | | 0.2435 | 0.5167 |
| Sel6_27plus_SRV2007d | -7.218 | 48.025 | -7.375 | 46.051 | | | -1.509 | 1.1217 |
| Sel6_27plus_SRV2009d | -1.073 | 0.7519 | -1.228 | 0.7424 | | | -1.454 | 0.5349 |

Table 2.19a— Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model 1). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-Oct, Sea5=Nov-Dec. Rates are 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 | 0.001 | 0.001 | 0.002 | 0.002 | 0.002 | 0.006 | 0.006 | 0.003 | 0.004 | 0.004 | 0 | 0 | 0 | 0 | 0 | 0.006 |
| 1978 | 0.005 | 0.005 | 0.009 | 0.011 | 0.010 | 0.026 | 0.028 | 0.017 | 0.020 | 0.019 | 0 | 0 | 0 | 0 | 0 | 0.030 |
| 1979 | 0.005 | 0.006 | 0.011 | 0.011 | 0.010 | 0.030 | 0.032 | 0.021 | 0.024 | 0.022 | 0 | 0 | 0 | 0 | 0 | 0.034 |
| 1980 | 0.013 | 0.014 | 0.024 | 0.043 | 0.041 | 0.074 | 0.079 | 0.058 | 0.082 | 0.076 | 0 | 0 | 0 | 0 | 0 | 0.098 |
| 1981 | 0.002 | 0.002 | 0.026 | 0.054 | 0.054 | 0.047 | 0.049 | 0.060 | 0.090 | 0.089 | 0 | 0 | 0 | 0 | 0 | 0.093 |
| 1982 | 0.005 | 0.005 | 0.018 | 0.034 | 0.035 | 0.042 | 0.046 | 0.043 | 0.112 | 0.113 | 0 | 0 | 0 | 0 | 0 | 0.085 |
| 1983 | 0.012 | 0.013 | 0.030 | 0.045 | 0.044 | 0.049 | 0.054 | 0.071 | 0.155 | 0.153 | 0 | 0 | 0 | 0 | 0 | 0.121 |
| 1984 | 0.015 | 0.016 | 0.025 | 0.041 | 0.040 | 0.058 | 0.063 | 0.032 | 0.038 | 0.037 | 0 | 0 | 0 | 0 | 0 | 0.070 |
| 1985 | 0.011 | 0.012 | 0.012 | 0.020 | 0.020 | 0.057 | 0.062 | 0.020 | 0.004 | 0.004 | 0 | 0 | 0 | 0 | 0 | 0.042 |
| 1986 | 0.013 | 0.015 | 0.012 | 0.036 | 0.035 | 0.101 | 0.111 | 0.039 | 0.018 | 0.017 | 0 | 0 | 0 | 0 | 0 | 0.075 |
| 1987 | 0.024 | 0.027 | 0.100 | 0.099 | 0.097 | 0.034 | 0.037 | 0.022 | 0.027 | 0.026 | 0.0021 | 0.0023 | 0.0022 | 0.0033 | 0.0032 | 0.105 |
| 1988 | 0.075 | 0.082 | 0.114 | 0.050 | 0.049 | 0.020 | 0.021 | 0.013 | 0.006 | 0.006 | 0.0106 | 0.0116 | 0.003 | 0.0039 | 0.0037 | 0.100 |
| 1989 | 0.118 | 0.129 | 0.212 | 0.002 | 0.002 | 0.016 | 0.018 | 0.009 | 0.013 | 0.013 | 0.002 | 0.003 | 0.002 | 0.000 | 0.000 | 0.127 |
| 1990 | 0.278 | 0.313 | 0.242 | 0.073 | 0.070 | 0.039 | 0.044 | 0.018 | 0.003 | 0.003 | 0.027 | 0.030 | 0.021 | 0.029 | 0.027 | 0.250 |
| 1991 | 0.215 | 0.920 | 0.013 | 0.029 | 0.000 | 0.025 | 0.133 | 0.009 | 0.001 | 0.001 | 0.072 | 0.234 | 0.003 | 0.001 | 0.026 | 0.285 |
| 1992 | 0.344 | 0.818 | 0.032 | 0.028 | 0.002 | 0.134 | 0.169 | 0.018 | 0.068 | 0.002 | 0.082 | 0.263 | 0.000 | 0.016 | 0.000 | 0.338 |
| 1993 | 0.197 | 0.601 | 0.044 | 0.014 | 0.015 | 0.093 | 0.108 | 0.014 | 0.004 | 0.001 | 0.095 | 0.236 | 0.005 | 0.000 | 0.000 | 0.249 |
| 1994 | 0.217 | 0.448 | 0.022 | 0.016 | 0.000 | 0.090 | 0.063 | 0.005 | 0.001 | 0.000 | 0.159 | 0.118 | 0.000 | 0.000 | 0.013 | 0.197 |
| 1995 | 0.128 | 0.790 | 0.017 | 0.063 | 0.000 | 0.130 | 0.139 | 0.003 | 0.005 | 0.001 | 0.249 | 0.202 | 0.001 | 0.012 | 0.005 | 0.294 |
| 1996 | 0.222 | 0.766 | 0.064 | 0.023 | 0.013 | 0.142 | 0.112 | 0.004 | 0.002 | 0.001 | 0.209 | 0.147 | 0.000 | 0.000 | 0.000 | 0.296 |
| 1997 | 0.278 | 0.751 | 0.033 | 0.128 | 0.030 | 0.170 | 0.104 | 0.007 | 0.008 | 0.003 | 0.245 | 0.175 | 0.042 | 0.029 | 0.027 | 0.352 |
| 1998 | 0.424 | 0.502 | 0.071 | 0.089 | 0.000 | 0.216 | 0.049 | 0.008 | 0.006 | 0.002 | 0.387 | 0.218 | 0.041 | 0.019 | 0.017 | 0.362 |
| 1999 | 0.371 | 0.485 | 0.028 | 0.166 | 0.000 | 0.226 | 0.138 | 0.008 | 0.003 | 0.002 | 0.472 | 0.354 | 0.140 | 0.069 | 0.021 | 0.443 |
| 2000 | 0.316 | 0.223 | 0.052 | 0.018 | 0.006 | 0.293 | 0.071 | 0.003 | 0.003 | 0.001 | 0.625 | 0.247 | 0.061 | 0.011 | 0.013 | 0.343 |
| 2001 | 0.213 | 0.164 | 0.048 | 0.250 | 0.000 | 0.298 | 0.015 | 0.003 | 0.005 | 0.001 | 0.236 | 0.203 | 0.061 | 0.041 | 0.030 | 0.280 |
| 2002 | 0.190 | 0.215 | 0.078 | 0.042 | 0.007 | 0.278 | 0.138 | 0.004 | 0.090 | 0.045 | 0.275 | 0.235 | 0.055 | 0.106 | 0.078 | 0.329 |
| 2003 | 0.256 | 0.058 | 0.065 | 0.229 | 0.000 | 0.259 | 0.105 | 0.011 | 0.040 | 0.001 | 0.532 | 0.315 | 0.000 | 0.130 | 0.001 | 0.346 |
| 2004 | 0.233 | 0.041 | 0.046 | 0.260 | 0.000 | 0.325 | 0.010 | 0.006 | 0.095 | 0.000 | 0.594 | 0.457 | 0.007 | 0.151 | 0.034 | 0.387 |
| 2005 | 0.277 | 0.030 | 0.041 | 0.148 | 0.000 | 0.146 | 0.010 | 0.004 | 0.065 | 0.021 | 0.494 | 0.437 | 0.006 | 0.169 | 0.048 | 0.325 |
| 2006 | 0.287 | 0.046 | 0.033 | 0.089 | 0.000 | 0.222 | 0.037 | 0.005 | 0.111 | 0.082 | 0.506 | 0.461 | 0.007 | 0.052 | 0.054 | 0.339 |
| 2007 | 0.265 | 0.070 | 0.042 | 0.161 | 0.013 | 0.244 | 0.076 | 0.010 | 0.170 | 0.054 | 0.403 | 0.575 | 0.016 | 0.104 | 0.085 | 0.393 |
| 2008 | 0.352 | 0.051 | 0.061 | 0.336 | 0.028 | 0.370 | 0.078 | 0.019 | 0.145 | 0.003 | 0.416 | 0.666 | 0.000 | 0.168 | 0.060 | 0.472 |
| 2009 | 0.202 | 0.041 | 0.085 | 0.183 | 0.011 | 0.410 | 0.046 | 0.032 | 0.162 | 0.040 | 0.527 | 0.464 | 0.000 | 0.136 | 0.021 | 0.413 |
| 2010 | 0.302 | 0.041 | 0.088 | 0.296 | 0.009 | 0.444 | 0.037 | 0.018 | 0.212 | 0.006 | 0.815 | 0.598 | 0.000 | 0.211 | 0.003 | 0.531 |
| 2011 | 0.204 | 0.063 | 0.019 | 0.209 | 0.012 | 0.341 | 0.032 | 0.026 | 0.154 | 0.013 | 0.896 | 0.561 | 0.000 | 0.370 | 0.019 | 0.494 |

Table 2.19b— Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model 3). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-Oct, Sea5=Nov-Dec. Rates are 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 | 0.001 | 0.001 | 0.002 | 0.004 | 0.004 | 0.006 | 0.006 | 0.003 | 0.004 | 0.004 | 0 | 0 | 0 | 0 | 0 | 0.007 |
| 1978 | 0.005 | 0.005 | 0.009 | 0.021 | 0.021 | 0.025 | 0.027 | 0.017 | 0.020 | 0.019 | 0 | 0 | 0 | 0 | 0 | 0.033 |
| 1979 | 0.005 | 0.006 | 0.011 | 0.021 | 0.019 | 0.029 | 0.032 | 0.021 | 0.023 | 0.022 | 0 | 0 | 0 | 0 | 0 | 0.037 |
| 1980 | 0.012 | 0.013 | 0.025 | 0.042 | 0.040 | 0.073 | 0.078 | 0.058 | 0.082 | 0.076 | 0 | 0 | 0 | 0 | 0 | 0.097 |
| 1981 | 0.002 | 0.002 | 0.026 | 0.053 | 0.053 | 0.046 | 0.049 | 0.060 | 0.090 | 0.089 | 0 | 0 | 0 | 0 | 0 | 0.092 |
| 1982 | 0.004 | 0.005 | 0.018 | 0.034 | 0.034 | 0.042 | 0.045 | 0.043 | 0.112 | 0.114 | 0 | 0 | 0 | 0 | 0 | 0.085 |
| 1983 | 0.012 | 0.013 | 0.030 | 0.044 | 0.043 | 0.049 | 0.054 | 0.070 | 0.156 | 0.154 | 0 | 0 | 0 | 0 | 0 | 0.121 |
| 1984 | 0.015 | 0.016 | 0.026 | 0.041 | 0.039 | 0.057 | 0.063 | 0.032 | 0.038 | 0.037 | 0 | 0 | 0 | 0 | 0 | 0.070 |
| 1985 | 0.011 | 0.012 | 0.013 | 0.020 | 0.020 | 0.055 | 0.061 | 0.021 | 0.004 | 0.004 | 0 | 0 | 0 | 0 | 0 | 0.042 |
| 1986 | 0.013 | 0.015 | 0.012 | 0.036 | 0.035 | 0.100 | 0.109 | 0.039 | 0.018 | 0.018 | 0 | 0 | 0 | 0 | 0 | 0.074 |
| 1987 | 0.024 | 0.026 | 0.102 | 0.099 | 0.097 | 0.034 | 0.037 | 0.023 | 0.027 | 0.027 | 0.0021 | 0.0023 | 0.0022 | 0.0033 | 0.0031 | 0.106 |
| 1988 | 0.075 | 0.082 | 0.116 | 0.051 | 0.049 | 0.019 | 0.021 | 0.013 | 0.006 | 0.006 | 0.0106 | 0.0116 | 0.003 | 0.0039 | 0.0037 | 0.101 |
| 1989 | 0.118 | 0.129 | 0.216 | 0.002 | 0.002 | 0.016 | 0.017 | 0.010 | 0.013 | 0.013 | 0.002 | 0.003 | 0.002 | 0.000 | 0.000 | 0.128 |
| 1990 | 0.277 | 0.311 | 0.245 | 0.073 | 0.070 | 0.040 | 0.044 | 0.018 | 0.003 | 0.003 | 0.027 | 0.031 | 0.021 | 0.029 | 0.027 | 0.251 |
| 1991 | 0.214 | 0.917 | 0.013 | 0.029 | 0.000 | 0.025 | 0.134 | 0.009 | 0.001 | 0.001 | 0.073 | 0.236 | 0.003 | 0.001 | 0.026 | 0.285 |
| 1992 | 0.343 | 0.816 | 0.033 | 0.028 | 0.002 | 0.135 | 0.170 | 0.018 | 0.069 | 0.002 | 0.082 | 0.264 | 0.000 | 0.016 | 0.000 | 0.338 |
| 1993 | 0.197 | 0.600 | 0.044 | 0.014 | 0.015 | 0.093 | 0.109 | 0.014 | 0.004 | 0.001 | 0.096 | 0.238 | 0.005 | 0.000 | 0.000 | 0.249 |
| 1994 | 0.217 | 0.446 | 0.022 | 0.016 | 0.000 | 0.091 | 0.063 | 0.005 | 0.001 | 0.000 | 0.160 | 0.119 | 0.000 | 0.000 | 0.013 | 0.197 |
| 1995 | 0.127 | 0.786 | 0.017 | 0.063 | 0.000 | 0.129 | 0.139 | 0.003 | 0.005 | 0.001 | 0.250 | 0.202 | 0.001 | 0.012 | 0.005 | 0.294 |
| 1996 | 0.221 | 0.762 | 0.064 | 0.023 | 0.013 | 0.142 | 0.112 | 0.004 | 0.002 | 0.001 | 0.209 | 0.147 | 0.000 | 0.000 | 0.000 | 0.295 |
| 1997 | 0.277 | 0.747 | 0.034 | 0.128 | 0.030 | 0.170 | 0.103 | 0.007 | 0.008 | 0.003 | 0.246 | 0.175 | 0.042 | 0.029 | 0.027 | 0.351 |
| 1998 | 0.421 | 0.498 | 0.071 | 0.089 | 0.000 | 0.216 | 0.049 | 0.008 | 0.006 | 0.002 | 0.387 | 0.218 | 0.041 | 0.019 | 0.017 | 0.360 |
| 1999 | 0.367 | 0.479 | 0.028 | 0.165 | 0.000 | 0.225 | 0.136 | 0.008 | 0.003 | 0.002 | 0.469 | 0.352 | 0.139 | 0.069 | 0.021 | 0.439 |
| 2000 | 0.312 | 0.220 | 0.052 | 0.018 | 0.006 | 0.291 | 0.071 | 0.003 | 0.003 | 0.001 | 0.621 | 0.245 | 0.060 | 0.011 | 0.013 | 0.340 |
| 2001 | 0.209 | 0.161 | 0.047 | 0.245 | 0.000 | 0.295 | 0.015 | 0.003 | 0.005 | 0.001 | 0.233 | 0.200 | 0.060 | 0.040 | 0.030 | 0.275 |
| 2002 | 0.186 | 0.210 | 0.077 | 0.041 | 0.007 | 0.274 | 0.135 | 0.003 | 0.089 | 0.044 | 0.271 | 0.232 | 0.054 | 0.104 | 0.077 | 0.323 |
| 2003 | 0.250 | 0.056 | 0.063 | 0.222 | 0.000 | 0.254 | 0.103 | 0.011 | 0.039 | 0.001 | 0.523 | 0.309 | 0.000 | 0.128 | 0.001 | 0.339 |
| 2004 | 0.226 | 0.040 | 0.045 | 0.251 | 0.000 | 0.318 | 0.010 | 0.006 | 0.093 | 0.000 | 0.580 | 0.445 | 0.007 | 0.146 | 0.033 | 0.376 |
| 2005 | 0.264 | 0.028 | 0.040 | 0.141 | 0.000 | 0.141 | 0.010 | 0.004 | 0.063 | 0.021 | 0.479 | 0.422 | 0.006 | 0.164 | 0.047 | 0.313 |
| 2006 | 0.273 | 0.044 | 0.032 | 0.085 | 0.000 | 0.215 | 0.035 | 0.004 | 0.108 | 0.079 | 0.489 | 0.444 | 0.007 | 0.050 | 0.053 | 0.327 |
| 2007 | 0.252 | 0.067 | 0.041 | 0.154 | 0.012 | 0.236 | 0.074 | 0.010 | 0.164 | 0.052 | 0.390 | 0.554 | 0.016 | 0.101 | 0.083 | 0.379 |
| 2008 | 0.333 | 0.048 | 0.059 | 0.318 | 0.027 | 0.357 | 0.075 | 0.018 | 0.139 | 0.003 | 0.400 | 0.638 | 0.000 | 0.162 | 0.057 | 0.452 |
| 2009 | 0.189 | 0.039 | 0.080 | 0.171 | 0.010 | 0.392 | 0.044 | 0.030 | 0.153 | 0.038 | 0.502 | 0.439 | 0.000 | 0.129 | 0.020 | 0.391 |
| 2010 | 0.279 | 0.038 | 0.082 | 0.273 | 0.008 | 0.417 | 0.035 | 0.017 | 0.197 | 0.005 | 0.763 | 0.556 | 0.000 | 0.197 | 0.003 | 0.495 |
| 2011 | 0.187 | 0.058 | 0.018 | 0.193 | 0.011 | 0.316 | 0.030 | 0.024 | 0.143 | 0.012 | 0.829 | 0.516 | 0.000 | 0.345 | 0.018 | 0.457 |

Table 2.19c— Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model 3b). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-Oct, Sea5=Nov-Dec. Rates are 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 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.002 | 0.002 | 0 | 0 | 0 | 0 | 0 | 0.003 |
| 1978 | 0.002 | 0.002 | 0.005 | 0.013 | 0.013 | 0.011 | 0.012 | 0.008 | 0.008 | 0.008 | 0 | 0 | 0 | 0 | 0 | 0.016 |
| 1979 | 0.002 | 0.003 | 0.006 | 0.011 | 0.010 | 0.013 | 0.015 | 0.010 | 0.011 | 0.010 | 0 | 0 | 0 | 0 | 0 | 0.018 |
| 1980 | 0.006 | 0.006 | 0.012 | 0.021 | 0.020 | 0.035 | 0.037 | 0.029 | 0.040 | 0.037 | 0 | 0 | 0 | 0 | 0 | 0.048 |
| 1981 | 0.001 | 0.001 | 0.013 | 0.029 | 0.030 | 0.022 | 0.023 | 0.031 | 0.046 | 0.047 | 0 | 0 | 0 | 0 | 0 | 0.048 |
| 1982 | 0.002 | 0.002 | 0.010 | 0.020 | 0.020 | 0.020 | 0.022 | 0.023 | 0.061 | 0.062 | 0 | 0 | 0 | 0 | 0 | 0.046 |
| 1983 | 0.006 | 0.007 | 0.017 | 0.026 | 0.025 | 0.025 | 0.027 | 0.039 | 0.084 | 0.083 | 0 | 0 | 0 | 0 | 0 | 0.066 |
| 1984 | 0.008 | 0.009 | 0.014 | 0.024 | 0.023 | 0.030 | 0.032 | 0.018 | 0.021 | 0.021 | 0 | 0 | 0 | 0 | 0 | 0.039 |
| 1985 | 0.006 | 0.007 | 0.007 | 0.012 | 0.012 | 0.027 | 0.030 | 0.012 | 0.002 | 0.002 | 0 | 0 | 0 | 0 | 0 | 0.022 |
| 1986 | 0.008 | 0.009 | 0.007 | 0.023 | 0.022 | 0.050 | 0.054 | 0.025 | 0.012 | 0.012 | 0 | 0 | 0 | 0 | 0 | 0.042 |
| 1987 | 0.015 | 0.016 | 0.064 | 0.061 | 0.060 | 0.018 | 0.019 | 0.015 | 0.017 | 0.016 | 0.0012 | 0.0013 | 0.0014 | 0.0019 | 0.0018 | 0.065 |
| 1988 | 0.045 | 0.049 | 0.069 | 0.030 | 0.029 | 0.010 | 0.011 | 0.008 | 0.004 | 0.004 | 0.0064 | 0.007 | 0.0018 | 0.0022 | 0.002 | 0.060 |
| 1989 | 0.071 | 0.078 | 0.128 | 0.001 | 0.001 | 0.008 | 0.009 | 0.006 | 0.008 | 0.008 | 0.001 | 0.002 | 0.001 | 0.000 | 0.000 | 0.076 |
| 1990 | 0.161 | 0.179 | 0.142 | 0.037 | 0.036 | 0.022 | 0.025 | 0.010 | 0.002 | 0.002 | 0.015 | 0.017 | 0.013 | 0.016 | 0.015 | 0.143 |
| 1991 | 0.122 | 0.505 | 0.008 | 0.014 | 0.000 | 0.014 | 0.072 | 0.005 | 0.001 | 0.000 | 0.041 | 0.128 | 0.002 | 0.000 | 0.014 | 0.157 |
| 1992 | 0.188 | 0.429 | 0.018 | 0.014 | 0.001 | 0.072 | 0.087 | 0.009 | 0.039 | 0.001 | 0.046 | 0.142 | 0.000 | 0.008 | 0.000 | 0.181 |
| 1993 | 0.104 | 0.309 | 0.025 | 0.007 | 0.007 | 0.048 | 0.055 | 0.007 | 0.002 | 0.001 | 0.053 | 0.127 | 0.003 | 0.000 | 0.000 | 0.131 |
| 1994 | 0.114 | 0.232 | 0.013 | 0.008 | 0.000 | 0.047 | 0.032 | 0.003 | 0.001 | 0.000 | 0.089 | 0.065 | 0.000 | 0.000 | 0.007 | 0.105 |
| 1995 | 0.067 | 0.401 | 0.010 | 0.035 | 0.000 | 0.072 | 0.075 | 0.002 | 0.003 | 0.001 | 0.142 | 0.112 | 0.001 | 0.007 | 0.003 | 0.157 |
| 1996 | 0.116 | 0.390 | 0.039 | 0.013 | 0.008 | 0.079 | 0.060 | 0.002 | 0.001 | 0.001 | 0.119 | 0.081 | 0.000 | 0.000 | 0.000 | 0.158 |
| 1997 | 0.147 | 0.386 | 0.021 | 0.075 | 0.017 | 0.095 | 0.056 | 0.004 | 0.005 | 0.002 | 0.142 | 0.098 | 0.024 | 0.017 | 0.016 | 0.192 |
| 1998 | 0.222 | 0.254 | 0.044 | 0.051 | 0.000 | 0.120 | 0.026 | 0.005 | 0.004 | 0.001 | 0.224 | 0.122 | 0.023 | 0.011 | 0.010 | 0.198 |
| 1999 | 0.192 | 0.241 | 0.017 | 0.092 | 0.000 | 0.124 | 0.073 | 0.004 | 0.002 | 0.001 | 0.270 | 0.195 | 0.076 | 0.038 | 0.012 | 0.239 |
| 2000 | 0.167 | 0.115 | 0.030 | 0.010 | 0.003 | 0.163 | 0.038 | 0.002 | 0.002 | 0.000 | 0.351 | 0.134 | 0.034 | 0.006 | 0.007 | 0.188 |
| 2001 | 0.113 | 0.086 | 0.027 | 0.136 | 0.000 | 0.167 | 0.008 | 0.001 | 0.003 | 0.000 | 0.134 | 0.114 | 0.035 | 0.023 | 0.017 | 0.155 |
| 2002 | 0.100 | 0.110 | 0.043 | 0.022 | 0.004 | 0.155 | 0.075 | 0.002 | 0.050 | 0.025 | 0.155 | 0.129 | 0.030 | 0.057 | 0.042 | 0.179 |
| 2003 | 0.127 | 0.028 | 0.034 | 0.112 | 0.000 | 0.134 | 0.052 | 0.005 | 0.021 | 0.000 | 0.278 | 0.158 | 0.000 | 0.066 | 0.001 | 0.176 |
| 2004 | 0.113 | 0.019 | 0.024 | 0.128 | 0.000 | 0.161 | 0.005 | 0.003 | 0.048 | 0.000 | 0.294 | 0.220 | 0.004 | 0.076 | 0.017 | 0.190 |
| 2005 | 0.130 | 0.014 | 0.022 | 0.074 | 0.000 | 0.076 | 0.005 | 0.002 | 0.034 | 0.011 | 0.251 | 0.218 | 0.003 | 0.093 | 0.027 | 0.164 |
| 2006 | 0.138 | 0.022 | 0.018 | 0.047 | 0.000 | 0.121 | 0.020 | 0.002 | 0.062 | 0.046 | 0.268 | 0.239 | 0.004 | 0.030 | 0.032 | 0.179 |
| 2007 | 0.132 | 0.034 | 0.024 | 0.086 | 0.007 | 0.139 | 0.043 | 0.005 | 0.096 | 0.031 | 0.224 | 0.311 | 0.009 | 0.061 | 0.050 | 0.215 |
| 2008 | 0.171 | 0.024 | 0.032 | 0.165 | 0.014 | 0.208 | 0.042 | 0.009 | 0.076 | 0.002 | 0.228 | 0.349 | 0.000 | 0.090 | 0.032 | 0.247 |
| 2009 | 0.091 | 0.018 | 0.041 | 0.083 | 0.005 | 0.208 | 0.023 | 0.014 | 0.077 | 0.019 | 0.261 | 0.220 | 0.000 | 0.067 | 0.010 | 0.198 |
| 2010 | 0.128 | 0.017 | 0.039 | 0.124 | 0.004 | 0.208 | 0.017 | 0.007 | 0.095 | 0.003 | 0.371 | 0.259 | 0.000 | 0.097 | 0.001 | 0.236 |
| 2011 | 0.081 | 0.024 | 0.008 | 0.082 | 0.005 | 0.150 | 0.014 | 0.010 | 0.064 | 0.005 | 0.384 | 0.230 | 0.000 | 0.159 | 0.008 | 0.207 |

Table 2.19d— Estimates of seasonal full-selection fishing mortality rates, expressed on an annual time scale (Model 4). Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-Oct, Sea5=Nov-Dec. Rates are 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 | 0.000 | 0.000 | 0.001 | 0.002 | 0.002 | 0.002 | 0.002 | 0.001 | 0.001 | 0.001 | 0 | 0 | 0 | 0 | 0 | 0.002 |
| 1978 | 0.002 | 0.002 | 0.004 | 0.009 | 0.009 | 0.010 | 0.011 | 0.006 | 0.007 | 0.007 | 0 | 0 | 0 | 0 | 0 | 0.013 |
| 1979 | 0.002 | 0.002 | 0.004 | 0.008 | 0.008 | 0.012 | 0.013 | 0.008 | 0.009 | 0.008 | 0 | 0 | 0 | 0 | 0 | 0.014 |
| 1980 | 0.005 | 0.006 | 0.010 | 0.018 | 0.017 | 0.028 | 0.030 | 0.022 | 0.032 | 0.031 | 0 | 0 | 0 | 0 | 0 | 0.039 |
| 1981 | 0.001 | 0.001 | 0.012 | 0.026 | 0.026 | 0.019 | 0.021 | 0.027 | 0.043 | 0.043 | 0 | 0 | 0 | 0 | 0 | 0.043 |
| 1982 | 0.002 | 0.002 | 0.009 | 0.017 | 0.018 | 0.019 | 0.021 | 0.021 | 0.056 | 0.057 | 0 | 0 | 0 | 0 | 0 | 0.042 |
| 1983 | 0.006 | 0.006 | 0.015 | 0.023 | 0.023 | 0.024 | 0.026 | 0.035 | 0.078 | 0.078 | 0 | 0 | 0 | 0 | 0 | 0.061 |
| 1984 | 0.008 | 0.008 | 0.013 | 0.022 | 0.022 | 0.029 | 0.032 | 0.016 | 0.020 | 0.020 | 0 | 0 | 0 | 0 | 0 | 0.037 |
| 1985 | 0.006 | 0.007 | 0.007 | 0.012 | 0.012 | 0.027 | 0.029 | 0.011 | 0.002 | 0.002 | 0 | 0 | 0 | 0 | 0 | 0.022 |
| 1986 | 0.008 | 0.009 | 0.007 | 0.023 | 0.023 | 0.051 | 0.056 | 0.024 | 0.012 | 0.012 | 0 | 0 | 0 | 0 | 0 | 0.043 |
| 1987 | 0.015 | 0.017 | 0.069 | 0.065 | 0.064 | 0.019 | 0.021 | 0.015 | 0.018 | 0.018 | 0.0013 | 0.0015 | 0.0014 | 0.0022 | 0.0021 | 0.069 |
| 1988 | 0.049 | 0.053 | 0.077 | 0.032 | 0.032 | 0.011 | 0.013 | 0.008 | 0.004 | 0.004 | 0.0072 | 0.0079 | 0.002 | 0.0027 | 0.0025 | 0.065 |
| 1989 | 0.078 | 0.086 | 0.142 | 0.001 | 0.001 | 0.010 | 0.011 | 0.006 | 0.009 | 0.008 | 0.002 | 0.002 | 0.001 | 0.000 | 0.000 | 0.085 |
| 1990 | 0.195 | 0.218 | 0.163 | 0.050 | 0.048 | 0.027 | 0.030 | 0.012 | 0.002 | 0.002 | 0.018 | 0.020 | 0.014 | 0.020 | 0.019 | 0.171 |
| 1991 | 0.151 | 0.629 | 0.009 | 0.019 | 0.000 | 0.017 | 0.088 | 0.006 | 0.001 | 0.001 | 0.048 | 0.152 | 0.002 | 0.001 | 0.018 | 0.193 |
| 1992 | 0.237 | 0.546 | 0.021 | 0.019 | 0.001 | 0.089 | 0.109 | 0.012 | 0.044 | 0.001 | 0.054 | 0.168 | 0.000 | 0.010 | 0.000 | 0.224 |
| 1993 | 0.134 | 0.401 | 0.029 | 0.010 | 0.010 | 0.061 | 0.070 | 0.009 | 0.003 | 0.001 | 0.062 | 0.152 | 0.003 | 0.000 | 0.000 | 0.164 |
| 1994 | 0.149 | 0.305 | 0.015 | 0.011 | 0.000 | 0.061 | 0.042 | 0.003 | 0.001 | 0.000 | 0.106 | 0.078 | 0.000 | 0.000 | 0.009 | 0.133 |
| 1995 | 0.089 | 0.538 | 0.011 | 0.043 | 0.000 | 0.091 | 0.095 | 0.002 | 0.003 | 0.001 | 0.174 | 0.138 | 0.001 | 0.008 | 0.003 | 0.202 |
| 1996 | 0.155 | 0.526 | 0.044 | 0.016 | 0.009 | 0.100 | 0.077 | 0.002 | 0.001 | 0.001 | 0.146 | 0.100 | 0.000 | 0.000 | 0.000 | 0.204 |
| 1997 | 0.196 | 0.519 | 0.023 | 0.090 | 0.021 | 0.120 | 0.072 | 0.005 | 0.006 | 0.002 | 0.173 | 0.120 | 0.029 | 0.020 | 0.019 | 0.245 |
| 1998 | 0.297 | 0.345 | 0.050 | 0.062 | 0.000 | 0.152 | 0.034 | 0.006 | 0.004 | 0.002 | 0.271 | 0.149 | 0.028 | 0.013 | 0.012 | 0.252 |
| 1999 | 0.262 | 0.334 | 0.020 | 0.116 | 0.000 | 0.160 | 0.095 | 0.006 | 0.002 | 0.001 | 0.333 | 0.244 | 0.096 | 0.048 | 0.015 | 0.309 |
| 2000 | 0.222 | 0.154 | 0.036 | 0.013 | 0.004 | 0.203 | 0.048 | 0.002 | 0.002 | 0.000 | 0.435 | 0.168 | 0.041 | 0.007 | 0.009 | 0.238 |
| 2001 | 0.151 | 0.116 | 0.034 | 0.177 | 0.000 | 0.209 | 0.010 | 0.002 | 0.004 | 0.000 | 0.166 | 0.141 | 0.042 | 0.029 | 0.021 | 0.197 |
| 2002 | 0.137 | 0.153 | 0.054 | 0.029 | 0.005 | 0.196 | 0.096 | 0.002 | 0.064 | 0.032 | 0.195 | 0.165 | 0.038 | 0.074 | 0.055 | 0.232 |
| 2003 | 0.182 | 0.041 | 0.045 | 0.160 | 0.000 | 0.180 | 0.072 | 0.008 | 0.028 | 0.000 | 0.373 | 0.217 | 0.000 | 0.090 | 0.001 | 0.242 |
| 2004 | 0.166 | 0.029 | 0.032 | 0.183 | 0.000 | 0.226 | 0.007 | 0.004 | 0.067 | 0.000 | 0.414 | 0.314 | 0.005 | 0.105 | 0.024 | 0.270 |
| 2005 | 0.201 | 0.021 | 0.029 | 0.106 | 0.000 | 0.104 | 0.007 | 0.003 | 0.046 | 0.015 | 0.347 | 0.303 | 0.004 | 0.120 | 0.035 | 0.230 |
| 2006 | 0.209 | 0.033 | 0.024 | 0.064 | 0.000 | 0.160 | 0.026 | 0.003 | 0.080 | 0.059 | 0.358 | 0.320 | 0.005 | 0.037 | 0.039 | 0.241 |
| 2007 | 0.194 | 0.051 | 0.030 | 0.115 | 0.009 | 0.176 | 0.054 | 0.007 | 0.121 | 0.039 | 0.286 | 0.400 | 0.011 | 0.074 | 0.061 | 0.279 |
| 2008 | 0.253 | 0.036 | 0.043 | 0.233 | 0.020 | 0.264 | 0.054 | 0.013 | 0.101 | 0.002 | 0.291 | 0.454 | 0.000 | 0.116 | 0.041 | 0.329 |
| 2009 | 0.143 | 0.029 | 0.059 | 0.127 | 0.007 | 0.284 | 0.032 | 0.021 | 0.112 | 0.028 | 0.357 | 0.309 | 0.000 | 0.094 | 0.014 | 0.283 |
| 2010 | 0.214 | 0.028 | 0.060 | 0.202 | 0.006 | 0.310 | 0.026 | 0.012 | 0.147 | 0.004 | 0.557 | 0.400 | 0.000 | 0.146 | 0.002 | 0.364 |
| 2011 | 0.140 | 0.042 | 0.013 | 0.137 | 0.008 | 0.235 | 0.022 | 0.017 | 0.103 | 0.008 | 0.608 | 0.370 | 0.000 | 0.247 | 0.013 | 0.332 |

Table 2.20—Summary of key management reference points from the standard projection algorithm (last seven rows are from SS). All biomass figures are in t. Green = row minimum, pink = row maximum.

| Quantity | Model 1 | Model 3 | Model 3b | Model 4 |
|---|---|---|---|---|
| B100% | 259,000 | 261,000 | 370,000 | 322,000 |
| B40% | 104,000 | 104,000 | 148,000 | 129,000 |
| B35% | 90,600 | 91,400 | 129,000 | 113,000 |
| B(2012) | 112,000 | 121,000 | 254,000 | 216,000 |
| B(2013) | 125,000 | 127,000 | 253,000 | 226,000 |
| B(2012)/B100% | 0.43 | 0.46 | 0.69 | 0.67 |
| B(2013)/B100% | 0.48 | 0.49 | 0.68 | 0.70 |
| F40% | 0.43 | 0.44 | 0.46 | 0.60 |
| F35% | 0.53 | 0.53 | 0.56 | 0.76 |
| maxFABC(2012) | 0.43 | 0.44 | 0.46 | 0.60 |
| maxFABC(2013) | 0.43 | 0.44 | 0.46 | 0.60 |
| maxABC(2012) | 81,200 | 87,600 | 206,000 | 163,000 |
| maxABC(2013) | 89,400 | 91,000 | 192,000 | 165,000 |
| FOFL(2012) | 0.53 | 0.53 | 0.56 | 0.76 |
| FOFL(2013) | 0.53 | 0.53 | 0.56 | 0.76 |
| OFL(2012) | 96,300 | 104,000 | 243,000 | 198,000 |
| OFL(2013) | 106,000 | 108,000 | 223,000 | 200,000 |
| Pr(maxABC(2012)>truOFL(2012)) | 0.140 | 0.151 | 0.084 | 0.115 |
| Pr(maxABC(2013)>truOFL(2013)) | 0.151 | 0.171 | 0.111 | 0.140 |
| Pr(B(2012)<B20%) | ~0 | ~0 | ~0 | ~0 |
| Pr(B(2013)<B20%) | ~0 | ~0 | ~0 | ~0 |
| Pr(B(2014)<B20%) | ~0 | ~0 | ~0 | ~0 |
| Pr(B(2015)<B20%) | ~0 | ~0 | ~0 | ~0 |
| Pr(B(2016)<B20%) | ~0 | ~0 | ~0 | ~0 |

Legend:
B100% = equilibrium unfished spawning biomass
B40% = 40% of B100% (the inflection point of the harvest control rules in Tier 3)
B35% = 35% of B100% (the BMSY proxy for Tier 3)
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 2.21—Spawning biomass retrospective statistics for each of the four models. For average (across five retrospective years) and end-year bias, blue = row value closes to zero, yellow = row value furthest from zero. For root mean squared error, green = row minimum, pink = row maximum.

| | Average bias | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Relative to subsequent run | | | | Relative to current run | | | |
| Retro | M1 | M3 | M3b | M4 | M1 | M3 | M3b | M4 |
| 1 | 0.012 | 0.009 | 0.034 | 0.005 | 0.012 | 0.009 | 0.034 | 0.005 |
| 2 | 0.054 | 0.053 | -0.017 | 0.048 | 0.067 | 0.064 | 0.015 | 0.049 |
| 3 | -0.011 | -0.024 | -0.051 | -0.027 | 0.042 | 0.022 | -0.042 | 0.006 |
| 4 | 0.006 | 0.012 | -0.030 | 0.004 | 0.045 | 0.030 | -0.073 | 0.009 |
| 5 | 0.026 | 0.050 | -0.034 | 0.044 | 0.076 | 0.084 | -0.104 | 0.054 |
| Mean: | 0.017 | 0.020 | -0.020 | 0.015 | 0.048 | 0.042 | -0.034 | 0.024 |

| | End-year bias | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Relative to subsequent run | | | | Relative to current run | | | |
| Retro | M1 | M3 | M3b | M4 | M1 | M3 | M3b | M4 |
| 1 | 0.090 | 0.044 | 0.121 | 0.243 | 0.090 | 0.044 | 0.121 | 0.243 |
| 2 | 0.270 | 0.388 | 0.039 | 0.113 | 0.393 | 0.481 | 0.168 | 0.349 |
| 3 | -0.174 | -0.184 | -0.128 | -0.223 | 0.124 | 0.155 | 0.014 | 0.035 |
| 4 | 0.008 | 0.012 | -0.083 | 0.000 | 0.180 | 0.188 | -0.048 | 0.084 |
| 5 | 0.512 | 0.567 | 0.038 | 0.327 | 0.834 | 0.886 | 0.015 | 0.485 |
| Mean: | 0.141 | 0.165 | -0.002 | 0.092 | 0.324 | 0.351 | 0.054 | 0.239 |

| | Root mean squared error | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Relative to subsequent run | | | | Relative to current run | | | |
| Retro | M1 | M3 | M3b | M4 | M1 | M3 | M3b | M4 |
| 1 | 0.033 | 0.024 | 0.052 | 0.080 | 0.033 | 0.024 | 0.052 | 0.080 |
| 2 | 0.099 | 0.121 | 0.039 | 0.067 | 0.135 | 0.150 | 0.070 | 0.130 |
| 3 | 0.039 | 0.046 | 0.056 | 0.058 | 0.078 | 0.072 | 0.070 | 0.057 |
| 4 | 0.009 | 0.014 | 0.033 | 0.005 | 0.083 | 0.074 | 0.090 | 0.057 |
| 5 | 0.131 | 0.148 | 0.041 | 0.088 | 0.228 | 0.241 | 0.125 | 0.145 |
| Mean: | 0.062 | 0.070 | 0.044 | 0.060 | 0.111 | 0.112 | 0.081 | 0.094 |

Table 2.22—Age 0 recruitment (as assessed at age 1) retrospective statistics for each of the four models. For average (across five retrospective years) and end-year bias, blue = row value closes to zero, yellow = row value furthest from zero. For root mean squared error, green = row minimum, pink = row maximum.

| | Average bias | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Relative to subsequent run | | | | Relative to current run | | | |
| Retro | M1 | M3 | M3b | M4 | M1 | M3 | M3b | M4 |
| 1 | 0.011 | 0.006 | 0.009 | 0.028 | 0.011 | 0.006 | 0.009 | 0.028 |
| 2 | 0.040 | 0.052 | -0.005 | 0.030 | 0.042 | 0.042 | 0.011 | 0.053 |
| 3 | 0.014 | 0.003 | -0.043 | -0.024 | 0.057 | 0.040 | -0.017 | 0.040 |
| 4 | -0.009 | -0.013 | -0.018 | 0.010 | 0.024 | 0.006 | -0.015 | 0.044 |
| 5 | 0.129 | 0.143 | -0.037 | 0.105 | 0.140 | 0.154 | -0.072 | 0.137 |
| Mean: | 0.037 | 0.038 | -0.019 | 0.030 | 0.055 | 0.050 | -0.017 | 0.061 |

| | End-year bias | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Relative to subsequent run | | | | Relative to current run | | | |
| Retro | M1 | M3 | M3b | M4 | M1 | M3 | M3b | M4 |
| 1 | 0.304 | 0.522 | -0.163 | 0.231 | 0.304 | 0.522 | -0.163 | 0.231 |
| 2 | 0.093 | 0.103 | -0.062 | 0.114 | -0.268 | -0.310 | -0.493 | -0.533 |
| 3 | 0.858 | 1.042 | -0.571 | -0.095 | 0.729 | 0.490 | -0.597 | -0.413 |
| 4 | 0.160 | -0.013 | 0.039 | 0.521 | 0.325 | -0.032 | 0.408 | 0.514 |
| 5 | 0.463 | 0.299 | -0.695 | -0.205 | -0.204 | -0.305 | -0.656 | -0.229 |
| Mean: | 0.376 | 0.391 | -0.290 | 0.113 | 0.177 | 0.073 | -0.300 | -0.086 |

| | Root mean squared error | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Relative to subsequent run | | | | Relative to current run | | | |
| Retro | M1 | M3 | M3b | M4 | M1 | M3 | M3b | M4 |
| 1 | 0.083 | 0.115 | 0.097 | 0.150 | 0.083 | 0.115 | 0.097 | 0.150 |
| 2 | 0.078 | 0.117 | 0.032 | 0.080 | 0.111 | 0.144 | 0.106 | 0.182 |
| 3 | 0.178 | 0.201 | 0.140 | 0.176 | 0.148 | 0.112 | 0.140 | 0.218 |
| 4 | 0.101 | 0.110 | 0.054 | 0.147 | 0.118 | 0.100 | 0.114 | 0.125 |
| 5 | 0.311 | 0.324 | 0.178 | 0.312 | 0.325 | 0.366 | 0.176 | 0.342 |
| Mean: | 0.150 | 0.174 | 0.100 | 0.173 | 0.157 | 0.168 | 0.126 | 0.203 |

Table 2.23 (page 1 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | Jan-Apr trawl fishery | | | | | May-Aug trawl fishery | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Len. | 1977 | 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 |
| 2 | 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 |
| 4 | 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 |
| 6 | 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 |
| 8 | 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 |
| 10 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 11 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 12 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 13 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 14 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 15 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 16 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 17 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 18 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 19 | 0.004 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| 20 | 0.006 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| 21 | 0.007 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| 22 | 0.009 | 0.000 | 0.000 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.001 |
| 23 | 0.012 | 0.001 | 0.000 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.002 | 0.001 |
| 24 | 0.014 | 0.001 | 0.001 | 0.002 | 0.002 | 0.000 | 0.000 | 0.000 | 0.002 | 0.002 |
| 25 | 0.018 | 0.001 | 0.001 | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.003 | 0.002 |
| 26 | 0.022 | 0.001 | 0.001 | 0.004 | 0.003 | 0.000 | 0.000 | 0.000 | 0.004 | 0.003 |
| 27 | 0.027 | 0.002 | 0.001 | 0.005 | 0.004 | 0.000 | 0.001 | 0.000 | 0.005 | 0.004 |
| 28 | 0.033 | 0.002 | 0.002 | 0.006 | 0.005 | 0.000 | 0.001 | 0.000 | 0.007 | 0.005 |
| 29 | 0.040 | 0.003 | 0.002 | 0.008 | 0.006 | 0.001 | 0.001 | 0.000 | 0.009 | 0.006 |
| 30 | 0.049 | 0.004 | 0.003 | 0.010 | 0.008 | 0.001 | 0.002 | 0.000 | 0.011 | 0.008 |
| 31 | 0.058 | 0.005 | 0.003 | 0.013 | 0.010 | 0.002 | 0.003 | 0.001 | 0.014 | 0.010 |
| 32 | 0.070 | 0.006 | 0.004 | 0.016 | 0.013 | 0.003 | 0.004 | 0.001 | 0.017 | 0.012 |
| 33 | 0.083 | 0.008 | 0.006 | 0.019 | 0.016 | 0.005 | 0.006 | 0.001 | 0.021 | 0.015 |
| 34 | 0.098 | 0.010 | 0.007 | 0.024 | 0.020 | 0.008 | 0.008 | 0.002 | 0.026 | 0.019 |
| 35 | 0.115 | 0.013 | 0.009 | 0.029 | 0.024 | 0.013 | 0.011 | 0.003 | 0.032 | 0.023 |
| 36 | 0.134 | 0.016 | 0.011 | 0.036 | 0.029 | 0.020 | 0.016 | 0.004 | 0.039 | 0.028 |
| 37 | 0.155 | 0.020 | 0.014 | 0.043 | 0.036 | 0.029 | 0.021 | 0.006 | 0.047 | 0.034 |
| 38 | 0.179 | 0.024 | 0.018 | 0.052 | 0.043 | 0.043 | 0.028 | 0.008 | 0.057 | 0.041 |
| 39 | 0.205 | 0.030 | 0.022 | 0.062 | 0.052 | 0.061 | 0.038 | 0.011 | 0.069 | 0.049 |
| 40 | 0.234 | 0.036 | 0.027 | 0.074 | 0.063 | 0.086 | 0.050 | 0.015 | 0.082 | 0.059 |
| 41 | 0.266 | 0.044 | 0.033 | 0.088 | 0.075 | 0.118 | 0.065 | 0.020 | 0.097 | 0.070 |
| 42 | 0.299 | 0.053 | 0.040 | 0.104 | 0.088 | 0.158 | 0.083 | 0.027 | 0.114 | 0.082 |
| 43 | 0.336 | 0.063 | 0.048 | 0.121 | 0.104 | 0.207 | 0.105 | 0.036 | 0.134 | 0.097 |
| 44 | 0.374 | 0.075 | 0.057 | 0.141 | 0.122 | 0.266 | 0.132 | 0.047 | 0.156 | 0.113 |
| 45 | 0.415 | 0.089 | 0.069 | 0.164 | 0.142 | 0.334 | 0.163 | 0.061 | 0.181 | 0.131 |
| 46 | 0.457 | 0.105 | 0.081 | 0.188 | 0.164 | 0.411 | 0.200 | 0.078 | 0.208 | 0.151 |
| 47 | 0.501 | 0.122 | 0.096 | 0.215 | 0.189 | 0.495 | 0.241 | 0.098 | 0.238 | 0.173 |
| 48 | 0.546 | 0.143 | 0.113 | 0.245 | 0.216 | 0.583 | 0.288 | 0.123 | 0.270 | 0.198 |
| 49 | 0.591 | 0.165 | 0.132 | 0.277 | 0.246 | 0.672 | 0.341 | 0.152 | 0.305 | 0.225 |
| 50 | 0.637 | 0.190 | 0.153 | 0.312 | 0.278 | 0.758 | 0.397 | 0.186 | 0.343 | 0.255 |
| 51 | 0.682 | 0.217 | 0.176 | 0.349 | 0.313 | 0.836 | 0.458 | 0.225 | 0.383 | 0.287 |
| 52 | 0.727 | 0.247 | 0.202 | 0.388 | 0.350 | 0.903 | 0.522 | 0.269 | 0.425 | 0.321 |
| 53 | 0.770 | 0.279 | 0.231 | 0.430 | 0.389 | 0.955 | 0.588 | 0.318 | 0.468 | 0.357 |
| 54 | 0.811 | 0.314 | 0.262 | 0.473 | 0.431 | 0.988 | 0.654 | 0.372 | 0.514 | 0.395 |
| 55 | 0.849 | 0.351 | 0.296 | 0.517 | 0.474 | 1.000 | 0.719 | 0.430 | 0.560 | 0.435 |
| 56 | 0.884 | 0.391 | 0.332 | 0.562 | 0.518 | 1.000 | 0.781 | 0.491 | 0.607 | 0.476 |
| 57 | 0.915 | 0.432 | 0.370 | 0.608 | 0.563 | 0.995 | 0.838 | 0.555 | 0.654 | 0.519 |
| 58 | 0.942 | 0.475 | 0.410 | 0.653 | 0.609 | 0.979 | 0.889 | 0.620 | 0.700 | 0.563 |
| 59 | 0.964 | 0.519 | 0.452 | 0.698 | 0.654 | 0.954 | 0.932 | 0.684 | 0.745 | 0.607 |
| 60 | 0.981 | 0.565 | 0.496 | 0.742 | 0.699 | 0.920 | 0.965 | 0.747 | 0.788 | 0.651 |

Table 2.23 (page 2 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | Jan-Apr trawl fishery | | | | | May-Aug trawl fishery | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Len. | 1977 | 1990 | 1995 | 2000 | 2005 | 1977 | 1985 | 1990 | 2000 | 2005 |
| 61 | 0.993 | 0.610 | 0.541 | 0.785 | 0.743 | 0.881 | 0.988 | 0.806 | 0.829 | 0.694 |
| 62 | 0.999 | 0.656 | 0.586 | 0.825 | 0.786 | 0.838 | 0.999 | 0.860 | 0.867 | 0.737 |
| 63 | 1.000 | 0.701 | 0.632 | 0.862 | 0.825 | 0.793 | 1.000 | 0.906 | 0.900 | 0.778 |
| 64 | 1.000 | 0.745 | 0.677 | 0.895 | 0.862 | 0.750 | 0.997 | 0.945 | 0.930 | 0.817 |
| 65 | 1.000 | 0.787 | 0.722 | 0.925 | 0.896 | 0.710 | 0.979 | 0.974 | 0.955 | 0.853 |
| 66 | 1.000 | 0.827 | 0.765 | 0.950 | 0.926 | 0.673 | 0.945 | 0.993 | 0.975 | 0.886 |
| 67 | 1.000 | 0.864 | 0.806 | 0.971 | 0.951 | 0.641 | 0.897 | 1.000 | 0.989 | 0.916 |
| 68 | 1.000 | 0.897 | 0.845 | 0.986 | 0.971 | 0.614 | 0.839 | 1.000 | 0.997 | 0.942 |
| 69 | 1.000 | 0.927 | 0.880 | 0.996 | 0.986 | 0.592 | 0.773 | 0.992 | 1.000 | 0.963 |
| 70 | 1.000 | 0.952 | 0.912 | 1.000 | 0.996 | 0.575 | 0.705 | 0.963 | 1.000 | 0.980 |
| 71 | 1.000 | 0.972 | 0.939 | 1.000 | 1.000 | 0.561 | 0.637 | 0.914 | 0.990 | 0.992 |
| 72 | 1.000 | 0.987 | 0.962 | 1.000 | 1.000 | 0.551 | 0.573 | 0.850 | 0.962 | 0.998 |
| 73 | 1.000 | 0.996 | 0.979 | 1.000 | 1.000 | 0.544 | 0.513 | 0.773 | 0.919 | 1.000 |
| 74 | 1.000 | 1.000 | 0.992 | 1.000 | 1.000 | 0.539 | 0.461 | 0.689 | 0.864 | 0.999 |
| 75 | 1.000 | 1.000 | 0.999 | 1.000 | 1.000 | 0.535 | 0.416 | 0.603 | 0.800 | 0.985 |
| 76 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.533 | 0.380 | 0.518 | 0.731 | 0.954 |
| 77 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.531 | 0.350 | 0.438 | 0.660 | 0.906 |
| 78 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.530 | 0.327 | 0.365 | 0.592 | 0.846 |
| 79 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.530 | 0.310 | 0.302 | 0.528 | 0.777 |
| 80 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.297 | 0.248 | 0.470 | 0.703 |
| 81 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.288 | 0.205 | 0.420 | 0.629 |
| 82 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.281 | 0.170 | 0.378 | 0.557 |
| 83 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.277 | 0.143 | 0.344 | 0.491 |
| 84 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.274 | 0.123 | 0.318 | 0.431 |
| 85 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.272 | 0.108 | 0.297 | 0.380 |
| 86 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.271 | 0.098 | 0.282 | 0.337 |
| 87 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.271 | 0.091 | 0.271 | 0.303 |
| 88 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.086 | 0.263 | 0.275 |
| 89 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.083 | 0.257 | 0.255 |
| 90 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.081 | 0.254 | 0.239 |
| 91 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.079 | 0.252 | 0.228 |
| 92 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.079 | 0.250 | 0.220 |
| 93 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.249 | 0.215 |
| 94 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.249 | 0.212 |
| 95 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.209 |
| 96 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.208 |
| 97 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.207 |
| 98 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 99 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 100 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 101 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 102 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 103 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 104 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 105 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 106 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 107 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 108 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 109 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 110 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 111 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 112 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 113 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 114 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 115 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 116 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 117 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 118 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 119 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |
| 120 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.529 | 0.270 | 0.078 | 0.248 | 0.206 |

Table 2.23 (page 3 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| Len. | 1977 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 1977 | 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 | 0.001 | 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 | 0.001 | 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 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 16 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 17 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 18 | 0.000 | 0.000 | 0.001 | 0.000 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 19 | 0.000 | 0.000 | 0.002 | 0.000 | 0.002 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 20 | 0.000 | 0.000 | 0.002 | 0.000 | 0.003 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 21 | 0.000 | 0.000 | 0.003 | 0.001 | 0.003 | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 22 | 0.000 | 0.000 | 0.004 | 0.001 | 0.004 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 23 | 0.000 | 0.001 | 0.005 | 0.001 | 0.005 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 24 | 0.000 | 0.001 | 0.006 | 0.002 | 0.006 | 0.003 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 25 | 0.001 | 0.001 | 0.008 | 0.002 | 0.008 | 0.004 | 0.002 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 26 | 0.001 | 0.002 | 0.011 | 0.003 | 0.009 | 0.005 | 0.003 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27 | 0.002 | 0.003 | 0.014 | 0.004 | 0.011 | 0.006 | 0.004 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 28 | 0.003 | 0.005 | 0.017 | 0.006 | 0.014 | 0.007 | 0.005 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 29 | 0.006 | 0.007 | 0.022 | 0.008 | 0.016 | 0.009 | 0.006 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| 30 | 0.009 | 0.010 | 0.028 | 0.010 | 0.019 | 0.011 | 0.008 | 0.001 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 |
| 31 | 0.016 | 0.014 | 0.034 | 0.013 | 0.023 | 0.014 | 0.009 | 0.001 | 0.003 | 0.000 | 0.000 | 0.000 | 0.000 |
| 32 | 0.025 | 0.019 | 0.043 | 0.017 | 0.027 | 0.017 | 0.012 | 0.002 | 0.004 | 0.001 | 0.001 | 0.000 | 0.000 |
| 33 | 0.038 | 0.026 | 0.052 | 0.022 | 0.032 | 0.021 | 0.014 | 0.004 | 0.005 | 0.001 | 0.001 | 0.000 | 0.000 |
| 34 | 0.058 | 0.036 | 0.064 | 0.028 | 0.038 | 0.025 | 0.017 | 0.006 | 0.007 | 0.001 | 0.001 | 0.001 | 0.000 |
| 35 | 0.085 | 0.048 | 0.078 | 0.036 | 0.044 | 0.031 | 0.021 | 0.009 | 0.009 | 0.002 | 0.001 | 0.001 | 0.001 |
| 36 | 0.122 | 0.063 | 0.094 | 0.045 | 0.051 | 0.037 | 0.026 | 0.014 | 0.012 | 0.003 | 0.002 | 0.001 | 0.001 |
| 37 | 0.169 | 0.082 | 0.113 | 0.056 | 0.060 | 0.045 | 0.031 | 0.020 | 0.015 | 0.004 | 0.003 | 0.002 | 0.001 |
| 38 | 0.228 | 0.105 | 0.134 | 0.069 | 0.069 | 0.054 | 0.037 | 0.029 | 0.019 | 0.005 | 0.004 | 0.003 | 0.002 |
| 39 | 0.300 | 0.134 | 0.158 | 0.085 | 0.080 | 0.064 | 0.044 | 0.041 | 0.023 | 0.007 | 0.005 | 0.004 | 0.003 |
| 40 | 0.383 | 0.167 | 0.185 | 0.103 | 0.091 | 0.075 | 0.052 | 0.058 | 0.029 | 0.010 | 0.007 | 0.006 | 0.005 |
| 41 | 0.476 | 0.206 | 0.215 | 0.125 | 0.105 | 0.088 | 0.062 | 0.079 | 0.036 | 0.013 | 0.009 | 0.009 | 0.007 |
| 42 | 0.576 | 0.252 | 0.249 | 0.149 | 0.119 | 0.103 | 0.073 | 0.107 | 0.044 | 0.017 | 0.012 | 0.012 | 0.009 |
| 43 | 0.677 | 0.302 | 0.285 | 0.177 | 0.135 | 0.120 | 0.085 | 0.141 | 0.054 | 0.023 | 0.016 | 0.016 | 0.013 |
| 44 | 0.773 | 0.359 | 0.325 | 0.208 | 0.153 | 0.139 | 0.099 | 0.183 | 0.066 | 0.030 | 0.020 | 0.022 | 0.018 |
| 45 | 0.860 | 0.420 | 0.367 | 0.243 | 0.172 | 0.160 | 0.115 | 0.234 | 0.080 | 0.038 | 0.026 | 0.030 | 0.025 |
| 46 | 0.929 | 0.486 | 0.413 | 0.282 | 0.193 | 0.184 | 0.133 | 0.292 | 0.095 | 0.049 | 0.034 | 0.040 | 0.033 |
| 47 | 0.977 | 0.554 | 0.460 | 0.323 | 0.216 | 0.209 | 0.152 | 0.359 | 0.113 | 0.063 | 0.043 | 0.052 | 0.044 |
| 48 | 0.999 | 0.624 | 0.509 | 0.369 | 0.240 | 0.237 | 0.174 | 0.432 | 0.134 | 0.079 | 0.053 | 0.067 | 0.058 |
| 49 | 1.000 | 0.693 | 0.560 | 0.417 | 0.266 | 0.268 | 0.198 | 0.511 | 0.157 | 0.098 | 0.067 | 0.086 | 0.076 |
| 50 | 1.000 | 0.759 | 0.611 | 0.467 | 0.294 | 0.300 | 0.224 | 0.593 | 0.184 | 0.121 | 0.082 | 0.109 | 0.097 |
| 51 | 1.000 | 0.822 | 0.662 | 0.520 | 0.323 | 0.335 | 0.252 | 0.676 | 0.213 | 0.147 | 0.101 | 0.136 | 0.123 |
| 52 | 1.000 | 0.877 | 0.712 | 0.574 | 0.354 | 0.372 | 0.282 | 0.756 | 0.245 | 0.178 | 0.122 | 0.168 | 0.154 |
| 53 | 1.000 | 0.924 | 0.761 | 0.628 | 0.386 | 0.411 | 0.314 | 0.829 | 0.280 | 0.213 | 0.147 | 0.206 | 0.190 |
| 54 | 0.994 | 0.961 | 0.807 | 0.682 | 0.420 | 0.451 | 0.349 | 0.893 | 0.318 | 0.253 | 0.175 | 0.248 | 0.232 |
| 55 | 0.961 | 0.986 | 0.850 | 0.735 | 0.455 | 0.493 | 0.385 | 0.944 | 0.358 | 0.297 | 0.207 | 0.296 | 0.280 |
| 56 | 0.902 | 0.999 | 0.888 | 0.785 | 0.491 | 0.536 | 0.423 | 0.980 | 0.402 | 0.345 | 0.243 | 0.349 | 0.333 |
| 57 | 0.824 | 1.000 | 0.922 | 0.833 | 0.528 | 0.580 | 0.462 | 0.998 | 0.447 | 0.397 | 0.283 | 0.406 | 0.391 |
| 58 | 0.735 | 1.000 | 0.951 | 0.875 | 0.565 | 0.624 | 0.503 | 1.000 | 0.494 | 0.452 | 0.326 | 0.467 | 0.453 |
| 59 | 0.644 | 1.000 | 0.973 | 0.913 | 0.603 | 0.667 | 0.544 | 1.000 | 0.543 | 0.510 | 0.373 | 0.531 | 0.519 |
| 60 | 0.557 | 0.989 | 0.989 | 0.945 | 0.641 | 0.710 | 0.586 | 1.000 | 0.592 | 0.569 | 0.423 | 0.597 | 0.586 |

Table 2.23 (page 4 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | Sep-Dec trawl fishery | | | | | | | Jan-Apr longline fishery | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Len. | 1977 | 1980 | 1985 | 1990 | 1995 | 2000 | 2005 | 1977 | 1985 | 1990 | 1995 | 2000 | 2005 |
| 61 | 0.481 | 0.950 | 0.998 | 0.970 | 0.678 | 0.752 | 0.629 | 1.000 | 0.642 | 0.630 | 0.476 | 0.663 | 0.654 |
| 62 | 0.418 | 0.886 | 1.000 | 0.988 | 0.715 | 0.792 | 0.671 | 1.000 | 0.691 | 0.690 | 0.530 | 0.727 | 0.721 |
| 63 | 0.368 | 0.804 | 0.999 | 0.998 | 0.751 | 0.830 | 0.712 | 1.000 | 0.739 | 0.748 | 0.586 | 0.789 | 0.785 |
| 64 | 0.331 | 0.714 | 0.977 | 1.000 | 0.785 | 0.865 | 0.752 | 1.000 | 0.785 | 0.803 | 0.642 | 0.845 | 0.844 |
| 65 | 0.305 | 0.623 | 0.927 | 1.000 | 0.818 | 0.897 | 0.791 | 1.000 | 0.828 | 0.853 | 0.697 | 0.895 | 0.895 |
| 66 | 0.288 | 0.539 | 0.854 | 1.000 | 0.850 | 0.926 | 0.828 | 1.000 | 0.868 | 0.898 | 0.751 | 0.937 | 0.938 |
| 67 | 0.277 | 0.465 | 0.768 | 1.000 | 0.879 | 0.950 | 0.862 | 1.000 | 0.903 | 0.936 | 0.802 | 0.968 | 0.970 |
| 68 | 0.270 | 0.405 | 0.677 | 1.000 | 0.905 | 0.970 | 0.893 | 1.000 | 0.934 | 0.965 | 0.849 | 0.990 | 0.991 |
| 69 | 0.266 | 0.358 | 0.588 | 1.000 | 0.929 | 0.985 | 0.921 | 1.000 | 0.959 | 0.986 | 0.891 | 0.999 | 1.000 |
| 70 | 0.264 | 0.324 | 0.508 | 1.000 | 0.949 | 0.995 | 0.945 | 1.000 | 0.979 | 0.998 | 0.928 | 1.000 | 1.000 |
| 71 | 0.262 | 0.300 | 0.439 | 1.000 | 0.967 | 1.000 | 0.965 | 1.000 | 0.992 | 1.000 | 0.957 | 1.000 | 0.994 |
| 72 | 0.262 | 0.285 | 0.385 | 1.000 | 0.981 | 1.000 | 0.981 | 1.000 | 0.999 | 1.000 | 0.980 | 0.988 | 0.973 |
| 73 | 0.262 | 0.275 | 0.343 | 1.000 | 0.991 | 0.998 | 0.992 | 1.000 | 1.000 | 0.993 | 0.994 | 0.959 | 0.937 |
| 74 | 0.261 | 0.269 | 0.314 | 1.000 | 0.997 | 0.971 | 0.998 | 1.000 | 1.000 | 0.978 | 1.000 | 0.914 | 0.891 |
| 75 | 0.261 | 0.265 | 0.293 | 1.000 | 1.000 | 0.917 | 1.000 | 1.000 | 1.000 | 0.958 | 1.000 | 0.860 | 0.839 |
| 76 | 0.261 | 0.263 | 0.280 | 1.000 | 1.000 | 0.843 | 1.000 | 1.000 | 0.997 | 0.933 | 0.997 | 0.800 | 0.785 |
| 77 | 0.261 | 0.262 | 0.272 | 1.000 | 0.990 | 0.755 | 0.979 | 1.000 | 0.983 | 0.907 | 0.986 | 0.739 | 0.733 |
| 78 | 0.261 | 0.262 | 0.267 | 1.000 | 0.951 | 0.664 | 0.930 | 1.000 | 0.960 | 0.880 | 0.968 | 0.681 | 0.685 |
| 79 | 0.261 | 0.262 | 0.264 | 1.000 | 0.887 | 0.576 | 0.859 | 1.000 | 0.929 | 0.855 | 0.944 | 0.630 | 0.645 |
| 80 | 0.261 | 0.261 | 0.263 | 1.000 | 0.806 | 0.497 | 0.773 | 1.000 | 0.893 | 0.834 | 0.918 | 0.586 | 0.612 |
| 81 | 0.261 | 0.261 | 0.262 | 1.000 | 0.716 | 0.431 | 0.682 | 1.000 | 0.856 | 0.815 | 0.890 | 0.551 | 0.586 |
| 82 | 0.261 | 0.261 | 0.262 | 1.000 | 0.625 | 0.378 | 0.593 | 1.000 | 0.820 | 0.801 | 0.863 | 0.524 | 0.567 |
| 83 | 0.261 | 0.261 | 0.261 | 1.000 | 0.540 | 0.338 | 0.512 | 0.984 | 0.787 | 0.790 | 0.838 | 0.505 | 0.553 |
| 84 | 0.261 | 0.261 | 0.261 | 1.000 | 0.467 | 0.310 | 0.443 | 0.945 | 0.759 | 0.782 | 0.818 | 0.491 | 0.544 |
| 85 | 0.261 | 0.261 | 0.261 | 0.982 | 0.406 | 0.291 | 0.387 | 0.885 | 0.736 | 0.776 | 0.800 | 0.482 | 0.538 |
| 86 | 0.261 | 0.261 | 0.261 | 0.936 | 0.359 | 0.279 | 0.345 | 0.812 | 0.718 | 0.772 | 0.787 | 0.476 | 0.534 |
| 87 | 0.261 | 0.261 | 0.261 | 0.867 | 0.325 | 0.271 | 0.315 | 0.731 | 0.704 | 0.770 | 0.777 | 0.472 | 0.532 |
| 88 | 0.261 | 0.261 | 0.261 | 0.782 | 0.301 | 0.266 | 0.294 | 0.649 | 0.694 | 0.768 | 0.770 | 0.470 | 0.530 |
| 89 | 0.261 | 0.261 | 0.261 | 0.691 | 0.285 | 0.264 | 0.281 | 0.571 | 0.688 | 0.767 | 0.765 | 0.468 | 0.529 |
| 90 | 0.261 | 0.261 | 0.261 | 0.601 | 0.275 | 0.263 | 0.272 | 0.501 | 0.684 | 0.767 | 0.762 | 0.468 | 0.529 |
| 91 | 0.261 | 0.261 | 0.261 | 0.519 | 0.269 | 0.262 | 0.267 | 0.443 | 0.681 | 0.767 | 0.760 | 0.467 | 0.529 |
| 92 | 0.261 | 0.261 | 0.261 | 0.449 | 0.265 | 0.262 | 0.264 | 0.395 | 0.679 | 0.767 | 0.759 | 0.467 | 0.529 |
| 93 | 0.261 | 0.261 | 0.261 | 0.392 | 0.263 | 0.261 | 0.263 | 0.359 | 0.678 | 0.767 | 0.758 | 0.467 | 0.529 |
| 94 | 0.261 | 0.261 | 0.261 | 0.349 | 0.262 | 0.261 | 0.262 | 0.333 | 0.678 | 0.766 | 0.758 | 0.467 | 0.529 |
| 95 | 0.261 | 0.261 | 0.261 | 0.317 | 0.262 | 0.261 | 0.262 | 0.314 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 96 | 0.261 | 0.261 | 0.261 | 0.296 | 0.262 | 0.261 | 0.261 | 0.301 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 97 | 0.261 | 0.261 | 0.261 | 0.282 | 0.261 | 0.261 | 0.261 | 0.293 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 98 | 0.261 | 0.261 | 0.261 | 0.273 | 0.261 | 0.261 | 0.261 | 0.288 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 99 | 0.261 | 0.261 | 0.261 | 0.268 | 0.261 | 0.261 | 0.261 | 0.285 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 100 | 0.261 | 0.261 | 0.261 | 0.265 | 0.261 | 0.261 | 0.261 | 0.283 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 101 | 0.261 | 0.261 | 0.261 | 0.263 | 0.261 | 0.261 | 0.261 | 0.282 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 102 | 0.261 | 0.261 | 0.261 | 0.262 | 0.261 | 0.261 | 0.261 | 0.282 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 103 | 0.261 | 0.261 | 0.261 | 0.262 | 0.261 | 0.261 | 0.261 | 0.282 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 104 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.282 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 105 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.282 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 106 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 107 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 108 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 109 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 110 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 111 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 112 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 113 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 114 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 115 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 116 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 117 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 118 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 119 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |
| 120 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.261 | 0.281 | 0.677 | 0.766 | 0.758 | 0.467 | 0.529 |

Table 2.23 (page 5 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | May-Aug longline | | | | Sep-Dec longline | | | Jan-Apr pot fishery | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Len. | 1977 | 1980 | 1990 | 2000 | 1977 | 1980 | 1990 | 1977 | 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 |
| 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 | 0.000 | 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 |
| 5 | 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 |
| 7 | 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 |
| 9 | 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 |
| 11 | 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 |
| 13 | 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 |
| 15 | 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 |
| 17 | 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 |
| 19 | 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 |
| 21 | 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 |
| 23 | 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 |
| 25 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 26 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27 | 0.000 | 0.000 | 0.000 | 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 | 0.000 | 0.000 | 0.000 |
| 29 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 30 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 31 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 32 | 0.001 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 33 | 0.002 | 0.001 | 0.000 | 0.000 | 0.002 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 34 | 0.004 | 0.001 | 0.000 | 0.000 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 35 | 0.006 | 0.002 | 0.000 | 0.000 | 0.005 | 0.002 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 36 | 0.010 | 0.004 | 0.000 | 0.000 | 0.008 | 0.003 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 37 | 0.015 | 0.007 | 0.001 | 0.000 | 0.011 | 0.006 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 |
| 38 | 0.023 | 0.011 | 0.001 | 0.000 | 0.016 | 0.009 | 0.001 | 0.000 | 0.000 | 0.001 | 0.000 |
| 39 | 0.034 | 0.018 | 0.002 | 0.001 | 0.024 | 0.015 | 0.002 | 0.001 | 0.001 | 0.002 | 0.001 |
| 40 | 0.049 | 0.029 | 0.002 | 0.001 | 0.034 | 0.023 | 0.003 | 0.001 | 0.001 | 0.002 | 0.001 |
| 41 | 0.069 | 0.044 | 0.003 | 0.001 | 0.047 | 0.036 | 0.005 | 0.001 | 0.001 | 0.004 | 0.001 |
| 42 | 0.096 | 0.066 | 0.005 | 0.002 | 0.064 | 0.054 | 0.007 | 0.002 | 0.002 | 0.006 | 0.002 |
| 43 | 0.131 | 0.095 | 0.007 | 0.003 | 0.087 | 0.079 | 0.010 | 0.004 | 0.003 | 0.008 | 0.004 |
| 44 | 0.174 | 0.135 | 0.010 | 0.004 | 0.115 | 0.112 | 0.014 | 0.005 | 0.004 | 0.012 | 0.005 |
| 45 | 0.226 | 0.186 | 0.014 | 0.006 | 0.150 | 0.155 | 0.019 | 0.008 | 0.006 | 0.017 | 0.008 |
| 46 | 0.287 | 0.248 | 0.020 | 0.009 | 0.192 | 0.210 | 0.027 | 0.012 | 0.009 | 0.024 | 0.012 |
| 47 | 0.358 | 0.323 | 0.027 | 0.013 | 0.242 | 0.276 | 0.036 | 0.018 | 0.013 | 0.034 | 0.018 |
| 48 | 0.437 | 0.409 | 0.037 | 0.018 | 0.299 | 0.353 | 0.049 | 0.025 | 0.018 | 0.047 | 0.026 |
| 49 | 0.521 | 0.504 | 0.049 | 0.025 | 0.364 | 0.440 | 0.065 | 0.035 | 0.025 | 0.063 | 0.037 |
| 50 | 0.610 | 0.604 | 0.064 | 0.035 | 0.435 | 0.535 | 0.085 | 0.049 | 0.035 | 0.084 | 0.052 |
| 51 | 0.697 | 0.704 | 0.083 | 0.047 | 0.510 | 0.633 | 0.109 | 0.067 | 0.047 | 0.109 | 0.071 |
| 52 | 0.781 | 0.798 | 0.107 | 0.062 | 0.589 | 0.729 | 0.139 | 0.089 | 0.062 | 0.141 | 0.095 |
| 53 | 0.856 | 0.880 | 0.135 | 0.081 | 0.669 | 0.819 | 0.175 | 0.117 | 0.082 | 0.179 | 0.126 |
| 54 | 0.919 | 0.944 | 0.169 | 0.104 | 0.746 | 0.895 | 0.216 | 0.152 | 0.106 | 0.223 | 0.163 |
| 55 | 0.966 | 0.985 | 0.209 | 0.133 | 0.818 | 0.954 | 0.264 | 0.194 | 0.136 | 0.275 | 0.208 |
| 56 | 0.993 | 1.000 | 0.254 | 0.167 | 0.881 | 0.989 | 0.318 | 0.243 | 0.171 | 0.333 | 0.261 |
| 57 | 1.000 | 1.000 | 0.305 | 0.206 | 0.933 | 1.000 | 0.377 | 0.299 | 0.213 | 0.397 | 0.322 |
| 58 | 1.000 | 0.995 | 0.362 | 0.252 | 0.972 | 1.000 | 0.442 | 0.363 | 0.261 | 0.467 | 0.389 |
| 59 | 0.995 | 0.980 | 0.423 | 0.304 | 0.994 | 0.985 | 0.510 | 0.432 | 0.315 | 0.540 | 0.463 |
| 60 | 0.983 | 0.955 | 0.489 | 0.361 | 1.000 | 0.948 | 0.581 | 0.507 | 0.375 | 0.615 | 0.541 |

Table 2.23 (page 6 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | May-Aug longline | | | | Sep-Dec longline | | | Jan-Apr pot fishery | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Len. | 1977 | 1980 | 1990 | 2000 | 1977 | 1980 | 1990 | 1977 | 1995 | 2000 | 2005 |
| 61 | 0.965 | 0.922 | 0.557 | 0.424 | 1.000 | 0.890 | 0.652 | 0.584 | 0.440 | 0.690 | 0.621 |
| 62 | 0.941 | 0.882 | 0.626 | 0.490 | 0.999 | 0.818 | 0.722 | 0.662 | 0.510 | 0.762 | 0.701 |
| 63 | 0.913 | 0.837 | 0.695 | 0.560 | 0.996 | 0.737 | 0.789 | 0.738 | 0.581 | 0.828 | 0.777 |
| 64 | 0.881 | 0.788 | 0.762 | 0.630 | 0.992 | 0.652 | 0.850 | 0.810 | 0.654 | 0.887 | 0.846 |
| 65 | 0.847 | 0.738 | 0.823 | 0.700 | 0.987 | 0.569 | 0.903 | 0.873 | 0.725 | 0.935 | 0.905 |
| 66 | 0.813 | 0.689 | 0.879 | 0.767 | 0.980 | 0.492 | 0.946 | 0.926 | 0.792 | 0.971 | 0.952 |
| 67 | 0.779 | 0.641 | 0.925 | 0.830 | 0.971 | 0.424 | 0.977 | 0.966 | 0.853 | 0.993 | 0.984 |
| 68 | 0.747 | 0.596 | 0.962 | 0.885 | 0.961 | 0.366 | 0.995 | 0.991 | 0.906 | 1.000 | 0.999 |
| 69 | 0.717 | 0.555 | 0.987 | 0.931 | 0.950 | 0.320 | 1.000 | 1.000 | 0.949 | 1.000 | 1.000 |
| 70 | 0.689 | 0.518 | 0.999 | 0.966 | 0.937 | 0.284 | 1.000 | 1.000 | 0.979 | 0.991 | 0.997 |
| 71 | 0.665 | 0.486 | 1.000 | 0.990 | 0.923 | 0.256 | 0.985 | 0.991 | 0.996 | 0.966 | 0.981 |
| 72 | 0.644 | 0.459 | 0.998 | 1.000 | 0.908 | 0.237 | 0.950 | 0.964 | 1.000 | 0.927 | 0.954 |
| 73 | 0.626 | 0.436 | 0.983 | 1.000 | 0.891 | 0.223 | 0.898 | 0.921 | 0.999 | 0.878 | 0.916 |
| 74 | 0.611 | 0.417 | 0.955 | 0.999 | 0.874 | 0.214 | 0.836 | 0.864 | 0.984 | 0.821 | 0.873 |
| 75 | 0.599 | 0.402 | 0.915 | 0.994 | 0.855 | 0.208 | 0.770 | 0.796 | 0.951 | 0.760 | 0.827 |
| 76 | 0.589 | 0.390 | 0.865 | 0.985 | 0.836 | 0.204 | 0.705 | 0.721 | 0.902 | 0.699 | 0.783 |
| 77 | 0.581 | 0.381 | 0.807 | 0.973 | 0.815 | 0.202 | 0.645 | 0.642 | 0.842 | 0.641 | 0.741 |
| 78 | 0.575 | 0.374 | 0.744 | 0.958 | 0.794 | 0.200 | 0.595 | 0.564 | 0.775 | 0.587 | 0.705 |
| 79 | 0.571 | 0.369 | 0.678 | 0.941 | 0.772 | 0.199 | 0.554 | 0.490 | 0.707 | 0.541 | 0.675 |
| 80 | 0.568 | 0.365 | 0.611 | 0.922 | 0.750 | 0.199 | 0.523 | 0.420 | 0.641 | 0.501 | 0.651 |
| 81 | 0.565 | 0.363 | 0.546 | 0.903 | 0.727 | 0.199 | 0.500 | 0.358 | 0.580 | 0.469 | 0.633 |
| 82 | 0.564 | 0.361 | 0.484 | 0.884 | 0.703 | 0.199 | 0.484 | 0.304 | 0.527 | 0.443 | 0.620 |
| 83 | 0.562 | 0.360 | 0.427 | 0.865 | 0.679 | 0.199 | 0.474 | 0.259 | 0.482 | 0.424 | 0.611 |
| 84 | 0.562 | 0.359 | 0.376 | 0.848 | 0.655 | 0.199 | 0.468 | 0.221 | 0.446 | 0.409 | 0.605 |
| 85 | 0.561 | 0.358 | 0.331 | 0.831 | 0.630 | 0.199 | 0.464 | 0.191 | 0.418 | 0.399 | 0.601 |
| 86 | 0.561 | 0.358 | 0.292 | 0.817 | 0.605 | 0.199 | 0.462 | 0.168 | 0.397 | 0.392 | 0.599 |
| 87 | 0.560 | 0.357 | 0.259 | 0.804 | 0.581 | 0.199 | 0.461 | 0.150 | 0.382 | 0.387 | 0.598 |
| 88 | 0.560 | 0.357 | 0.232 | 0.793 | 0.556 | 0.199 | 0.460 | 0.137 | 0.372 | 0.384 | 0.597 |
| 89 | 0.560 | 0.357 | 0.210 | 0.784 | 0.531 | 0.199 | 0.460 | 0.127 | 0.365 | 0.382 | 0.596 |
| 90 | 0.560 | 0.357 | 0.193 | 0.777 | 0.506 | 0.199 | 0.460 | 0.121 | 0.360 | 0.381 | 0.596 |
| 91 | 0.560 | 0.357 | 0.180 | 0.771 | 0.481 | 0.199 | 0.460 | 0.116 | 0.358 | 0.380 | 0.596 |
| 92 | 0.560 | 0.357 | 0.169 | 0.766 | 0.457 | 0.199 | 0.460 | 0.113 | 0.356 | 0.380 | 0.596 |
| 93 | 0.560 | 0.357 | 0.162 | 0.762 | 0.433 | 0.199 | 0.460 | 0.111 | 0.355 | 0.379 | 0.596 |
| 94 | 0.560 | 0.357 | 0.156 | 0.759 | 0.409 | 0.199 | 0.460 | 0.109 | 0.354 | 0.379 | 0.596 |
| 95 | 0.560 | 0.357 | 0.152 | 0.757 | 0.386 | 0.199 | 0.460 | 0.108 | 0.354 | 0.379 | 0.596 |
| 96 | 0.560 | 0.357 | 0.149 | 0.756 | 0.363 | 0.199 | 0.460 | 0.108 | 0.354 | 0.379 | 0.596 |
| 97 | 0.560 | 0.357 | 0.147 | 0.755 | 0.341 | 0.199 | 0.460 | 0.108 | 0.354 | 0.379 | 0.596 |
| 98 | 0.560 | 0.357 | 0.146 | 0.754 | 0.319 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 99 | 0.560 | 0.357 | 0.145 | 0.753 | 0.298 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 100 | 0.560 | 0.357 | 0.144 | 0.753 | 0.277 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 101 | 0.560 | 0.357 | 0.144 | 0.753 | 0.257 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 102 | 0.560 | 0.357 | 0.144 | 0.752 | 0.237 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 103 | 0.560 | 0.357 | 0.144 | 0.752 | 0.218 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 104 | 0.560 | 0.357 | 0.143 | 0.752 | 0.200 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 105 | 0.560 | 0.357 | 0.143 | 0.752 | 0.183 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 106 | 0.560 | 0.357 | 0.143 | 0.752 | 0.166 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 107 | 0.560 | 0.357 | 0.143 | 0.752 | 0.150 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 108 | 0.560 | 0.357 | 0.143 | 0.752 | 0.134 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 109 | 0.560 | 0.357 | 0.143 | 0.752 | 0.120 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 110 | 0.560 | 0.357 | 0.143 | 0.752 | 0.106 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 111 | 0.560 | 0.357 | 0.143 | 0.752 | 0.092 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 112 | 0.560 | 0.357 | 0.143 | 0.752 | 0.080 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 113 | 0.560 | 0.357 | 0.143 | 0.752 | 0.067 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 114 | 0.560 | 0.357 | 0.143 | 0.752 | 0.056 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 115 | 0.560 | 0.357 | 0.143 | 0.752 | 0.045 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 116 | 0.560 | 0.357 | 0.143 | 0.752 | 0.035 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 117 | 0.560 | 0.357 | 0.143 | 0.752 | 0.026 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 118 | 0.560 | 0.357 | 0.143 | 0.752 | 0.017 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 119 | 0.560 | 0.357 | 0.143 | 0.752 | 0.008 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |
| 120 | 0.560 | 0.357 | 0.143 | 0.752 | 0.000 | 0.199 | 0.460 | 0.107 | 0.354 | 0.379 | 0.596 |

Table 2.23 (page 7 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | May-Aug pot | | | Sep-Dec pot fishery | | | |
|---|---|---|---|---|---|---|---|
| Len. | 1977 | 1995 | 2000 | 1977 | 1995 | 2000 | 2005 |
| 1 | 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 |
| 3 | 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 |
| 5 | 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 |
| 7 | 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 |
| 9 | 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 |
| 11 | 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 |
| 13 | 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 |
| 15 | 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 |
| 17 | 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 |
| 19 | 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 |
| 21 | 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 |
| 23 | 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 |
| 25 | 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 |
| 27 | 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 |
| 29 | 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 |
| 31 | 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 | 0.000 |
| 33 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| 34 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| 35 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 |
| 36 | 0.000 | 0.000 | 0.000 | 0.001 | 0.000 | 0.001 | 0.000 |
| 37 | 0.000 | 0.000 | 0.000 | 0.002 | 0.000 | 0.001 | 0.001 |
| 38 | 0.000 | 0.000 | 0.000 | 0.003 | 0.001 | 0.002 | 0.001 |
| 39 | 0.000 | 0.000 | 0.000 | 0.004 | 0.001 | 0.003 | 0.001 |
| 40 | 0.001 | 0.001 | 0.000 | 0.006 | 0.001 | 0.004 | 0.002 |
| 41 | 0.001 | 0.001 | 0.000 | 0.008 | 0.002 | 0.006 | 0.003 |
| 42 | 0.002 | 0.002 | 0.000 | 0.011 | 0.003 | 0.009 | 0.005 |
| 43 | 0.004 | 0.003 | 0.001 | 0.015 | 0.005 | 0.013 | 0.008 |
| 44 | 0.006 | 0.004 | 0.002 | 0.019 | 0.007 | 0.019 | 0.012 |
| 45 | 0.010 | 0.006 | 0.003 | 0.026 | 0.010 | 0.027 | 0.017 |
| 46 | 0.015 | 0.009 | 0.005 | 0.033 | 0.014 | 0.038 | 0.025 |
| 47 | 0.024 | 0.013 | 0.008 | 0.043 | 0.019 | 0.052 | 0.036 |
| 48 | 0.036 | 0.018 | 0.014 | 0.055 | 0.026 | 0.070 | 0.050 |
| 49 | 0.053 | 0.025 | 0.022 | 0.070 | 0.036 | 0.094 | 0.069 |
| 50 | 0.076 | 0.035 | 0.035 | 0.088 | 0.049 | 0.123 | 0.093 |
| 51 | 0.107 | 0.048 | 0.053 | 0.109 | 0.065 | 0.158 | 0.123 |
| 52 | 0.146 | 0.064 | 0.079 | 0.135 | 0.085 | 0.201 | 0.161 |
| 53 | 0.195 | 0.085 | 0.113 | 0.164 | 0.109 | 0.250 | 0.206 |
| 54 | 0.255 | 0.111 | 0.158 | 0.197 | 0.139 | 0.307 | 0.259 |
| 55 | 0.325 | 0.143 | 0.215 | 0.235 | 0.174 | 0.371 | 0.320 |
| 56 | 0.405 | 0.181 | 0.284 | 0.278 | 0.216 | 0.441 | 0.388 |
| 57 | 0.493 | 0.226 | 0.365 | 0.325 | 0.264 | 0.515 | 0.462 |
| 58 | 0.585 | 0.278 | 0.457 | 0.376 | 0.318 | 0.592 | 0.541 |
| 59 | 0.678 | 0.336 | 0.555 | 0.431 | 0.377 | 0.670 | 0.622 |
| 60 | 0.768 | 0.400 | 0.656 | 0.488 | 0.442 | 0.745 | 0.702 |

Table 2.23 (page 8 of 8)—Schedules of Pacific cod selectivity at length (cm) in the commercial fisheries as defined by parameter estimates under Model 3. Years correspond to beginnings of blocks.

| | May-Aug pot | | | Sep-Dec pot fishery | | | |
|---|---|---|---|---|---|---|---|
| Len. | 1977 | 1995 | 2000 | 1977 | 1995 | 2000 | 2005 |
| 61 | 0.849 | 0.469 | 0.754 | 0.548 | 0.510 | 0.815 | 0.779 |
| 62 | 0.917 | 0.542 | 0.843 | 0.609 | 0.581 | 0.877 | 0.848 |
| 63 | 0.966 | 0.617 | 0.917 | 0.670 | 0.652 | 0.929 | 0.908 |
| 64 | 0.994 | 0.691 | 0.969 | 0.730 | 0.723 | 0.968 | 0.954 |
| 65 | 1.000 | 0.763 | 0.997 | 0.786 | 0.789 | 0.992 | 0.985 |
| 66 | 1.000 | 0.829 | 1.000 | 0.839 | 0.850 | 1.000 | 0.999 |
| 67 | 0.992 | 0.888 | 0.999 | 0.886 | 0.903 | 1.000 | 1.000 |
| 68 | 0.975 | 0.936 | 0.989 | 0.926 | 0.946 | 0.996 | 0.998 |
| 69 | 0.950 | 0.971 | 0.971 | 0.959 | 0.977 | 0.981 | 0.988 |
| 70 | 0.917 | 0.993 | 0.944 | 0.982 | 0.995 | 0.955 | 0.968 |
| 71 | 0.878 | 1.000 | 0.909 | 0.996 | 1.000 | 0.920 | 0.941 |
| 72 | 0.833 | 1.000 | 0.868 | 1.000 | 1.000 | 0.879 | 0.906 |
| 73 | 0.784 | 0.995 | 0.823 | 1.000 | 0.996 | 0.832 | 0.867 |
| 74 | 0.734 | 0.980 | 0.774 | 0.992 | 0.983 | 0.782 | 0.825 |
| 75 | 0.682 | 0.957 | 0.723 | 0.970 | 0.963 | 0.732 | 0.781 |
| 76 | 0.631 | 0.926 | 0.671 | 0.933 | 0.937 | 0.682 | 0.738 |
| 77 | 0.581 | 0.888 | 0.620 | 0.885 | 0.905 | 0.635 | 0.697 |
| 78 | 0.534 | 0.844 | 0.571 | 0.827 | 0.871 | 0.592 | 0.658 |
| 79 | 0.491 | 0.797 | 0.525 | 0.762 | 0.834 | 0.554 | 0.624 |
| 80 | 0.451 | 0.746 | 0.482 | 0.694 | 0.797 | 0.520 | 0.593 |
| 81 | 0.415 | 0.695 | 0.443 | 0.625 | 0.761 | 0.492 | 0.567 |
| 82 | 0.384 | 0.643 | 0.408 | 0.558 | 0.727 | 0.468 | 0.546 |
| 83 | 0.356 | 0.593 | 0.377 | 0.494 | 0.696 | 0.449 | 0.528 |
| 84 | 0.333 | 0.546 | 0.351 | 0.436 | 0.668 | 0.434 | 0.514 |
| 85 | 0.313 | 0.501 | 0.329 | 0.384 | 0.644 | 0.422 | 0.503 |
| 86 | 0.297 | 0.460 | 0.310 | 0.339 | 0.624 | 0.413 | 0.495 |
| 87 | 0.284 | 0.424 | 0.294 | 0.301 | 0.607 | 0.407 | 0.489 |
| 88 | 0.274 | 0.391 | 0.282 | 0.270 | 0.594 | 0.402 | 0.484 |
| 89 | 0.265 | 0.363 | 0.272 | 0.244 | 0.583 | 0.399 | 0.481 |
| 90 | 0.259 | 0.338 | 0.264 | 0.224 | 0.575 | 0.397 | 0.479 |
| 91 | 0.254 | 0.318 | 0.257 | 0.209 | 0.569 | 0.395 | 0.477 |
| 92 | 0.250 | 0.301 | 0.253 | 0.197 | 0.565 | 0.394 | 0.476 |
| 93 | 0.247 | 0.287 | 0.249 | 0.189 | 0.561 | 0.393 | 0.476 |
| 94 | 0.245 | 0.276 | 0.247 | 0.183 | 0.559 | 0.393 | 0.475 |
| 95 | 0.243 | 0.267 | 0.245 | 0.178 | 0.558 | 0.393 | 0.475 |
| 96 | 0.242 | 0.260 | 0.243 | 0.175 | 0.556 | 0.392 | 0.475 |
| 97 | 0.242 | 0.255 | 0.242 | 0.173 | 0.556 | 0.392 | 0.475 |
| 98 | 0.241 | 0.251 | 0.241 | 0.172 | 0.555 | 0.392 | 0.475 |
| 99 | 0.241 | 0.248 | 0.241 | 0.171 | 0.555 | 0.392 | 0.475 |
| 100 | 0.240 | 0.245 | 0.241 | 0.170 | 0.555 | 0.392 | 0.475 |
| 101 | 0.240 | 0.244 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 102 | 0.240 | 0.243 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 103 | 0.240 | 0.242 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 104 | 0.240 | 0.241 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 105 | 0.240 | 0.241 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 106 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 107 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 108 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 109 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 110 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 111 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 112 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 113 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 114 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 115 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 116 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 117 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 118 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 119 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |
| 120 | 0.240 | 0.240 | 0.240 | 0.170 | 0.555 | 0.392 | 0.475 |

Table 2.24—Schedules of Pacific cod selectivities at age in the sub-27 and 27-plus bottom trawl surveys as defined by final parameter estimates under Model 3.

| Survey | Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sub-27 | All | 0.429 | 1.000 | 0.045 | 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 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27-plus | 1984 | 0.000 | 0.004 | 0.084 | 0.513 | 0.997 | 0.837 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 | 0.117 |
| 27-plus | 1987 | 0.000 | 0.000 | 0.218 | 1.000 | 1.000 | 0.997 | 0.671 | 0.260 | 0.097 | 0.069 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 | 0.066 |
| 27-plus | 1990 | 0.000 | 0.006 | 0.102 | 0.557 | 1.000 | 1.000 | 1.000 | 0.656 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 | 0.192 |
| 27-plus | 1993 | 0.000 | 0.014 | 0.132 | 0.541 | 0.980 | 1.000 | 1.000 | 0.871 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 | 0.180 |
| 27-plus | 1996 | 0.000 | 0.011 | 0.076 | 0.292 | 0.683 | 0.985 | 1.000 | 0.656 | 0.192 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 | 0.191 |
| 27-plus | 1999 | 0.000 | 0.017 | 0.128 | 0.481 | 0.925 | 1.000 | 1.000 | 1.000 | 1.000 | 0.574 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27-plus | 2001 | 0.000 | 0.015 | 0.216 | 0.833 | 1.000 | 1.000 | 0.965 | 0.830 | 0.633 | 0.429 | 0.258 | 0.138 | 0.066 | 0.028 | 0.010 | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27-plus | 2003 | 0.000 | 0.004 | 0.062 | 0.382 | 0.916 | 1.000 | 0.979 | 0.770 | 0.463 | 0.213 | 0.075 | 0.020 | 0.004 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| 27-plus | 2005 | 0.000 | 0.013 | 0.085 | 0.321 | 0.725 | 0.996 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.733 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 | 0.096 |
| 27-plus | 2007 | 0.000 | 0.016 | 0.378 | 0.999 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 0.578 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| 27-plus | 2009 | 0.000 | 0.000 | 0.166 | 0.996 | 1.000 | 1.000 | 0.805 | 0.477 | 0.289 | 0.236 | 0.227 | 0.227 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 |
| 27-plus | 2011 | 0.000 | 0.000 | 0.166 | 0.996 | 1.000 | 1.000 | 0.805 | 0.477 | 0.289 | 0.236 | 0.227 | 0.227 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 | 0.226 |

Table 2.25—Schedules of population length (cm) and weight (kg) by season and age as estimated by Model 3. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-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 | 14.05 | 16.51 | 20.20 | 23.73 | 26.00 | 0.04 | 0.05 | 0.10 | 0.18 | 0.20 |
| 2 | 28.20 | 30.33 | 33.41 | 36.36 | 38.26 | 0.27 | 0.32 | 0.43 | 0.60 | 0.65 |
| 3 | 40.09 | 41.88 | 44.45 | 46.92 | 48.50 | 0.80 | 0.84 | 1.00 | 1.25 | 1.34 |
| 4 | 50.03 | 51.52 | 53.68 | 55.73 | 57.06 | 1.57 | 1.59 | 1.75 | 2.06 | 2.22 |
| 5 | 58.34 | 59.58 | 61.38 | 63.10 | 64.21 | 2.52 | 2.48 | 2.60 | 2.94 | 3.21 |
| 6 | 65.28 | 66.32 | 67.82 | 69.26 | 70.18 | 3.55 | 3.45 | 3.50 | 3.84 | 4.22 |
| 7 | 71.08 | 71.95 | 73.20 | 74.40 | 75.17 | 4.61 | 4.43 | 4.39 | 4.72 | 5.23 |
| 8 | 75.92 | 76.65 | 77.70 | 78.70 | 79.34 | 5.64 | 5.38 | 5.24 | 5.55 | 6.18 |
| 9 | 79.97 | 80.58 | 81.45 | 82.29 | 82.83 | 6.62 | 6.27 | 6.03 | 6.31 | 7.07 |
| 10 | 83.35 | 83.86 | 84.59 | 85.29 | 85.74 | 7.52 | 7.09 | 6.75 | 7.00 | 7.87 |
| 11 | 86.18 | 86.60 | 87.21 | 87.80 | 88.18 | 8.33 | 7.83 | 7.40 | 7.61 | 8.58 |
| 12 | 88.54 | 88.89 | 89.41 | 89.90 | 90.21 | 9.05 | 8.48 | 7.96 | 8.14 | 9.22 |
| 13 | 90.51 | 90.81 | 91.24 | 91.65 | 91.91 | 9.68 | 9.06 | 8.46 | 8.61 | 9.77 |
| 14 | 92.16 | 92.41 | 92.77 | 93.11 | 93.33 | 10.24 | 9.56 | 8.89 | 9.01 | 10.24 |
| 15 | 93.54 | 93.75 | 94.05 | 94.33 | 94.51 | 10.71 | 9.99 | 9.26 | 9.36 | 10.65 |
| 16 | 94.69 | 94.86 | 95.11 | 95.35 | 95.50 | 11.12 | 10.36 | 9.58 | 9.65 | 11.00 |
| 17 | 95.65 | 95.80 | 96.01 | 96.21 | 96.33 | 11.48 | 10.68 | 9.85 | 9.90 | 11.30 |
| 18 | 96.46 | 96.58 | 96.75 | 96.92 | 97.02 | 11.77 | 10.95 | 10.08 | 10.12 | 11.56 |
| 19 | 97.13 | 97.23 | 97.37 | 97.51 | 97.60 | 12.03 | 11.18 | 10.27 | 10.30 | 11.77 |
| 20 | 98.29 | 98.35 | 98.45 | 98.54 | 98.60 | 12.48 | 11.59 | 10.62 | 10.62 | 12.16 |

Table 2.26—Schedules of fleet-specific length (cm) by season and age as estimated by Model 3. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-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 | 27plus | Sub27 |
| 1 | 16.40 | 19.07 | 22.70 | 26.25 | 28.56 | 14.05 | 16.53 | 20.22 | 24.23 | 27.48 | 14.05 | 16.51 | 20.20 | 23.90 | 26.71 | 20.20 | 20.20 |
| 2 | 30.96 | 33.09 | 36.07 | 38.92 | 40.78 | 31.85 | 34.90 | 38.19 | 41.75 | 43.56 | 29.21 | 32.99 | 36.65 | 42.41 | 44.20 | 33.41 | 33.41 |
| 3 | 42.67 | 44.39 | 46.83 | 49.20 | 50.71 | 44.95 | 46.59 | 49.75 | 51.36 | 52.73 | 46.19 | 47.79 | 51.31 | 51.69 | 52.99 | 44.45 | 44.45 |
| 4 | 52.14 | 53.53 | 55.57 | 57.55 | 58.78 | 53.82 | 55.09 | 57.77 | 58.77 | 59.83 | 54.70 | 55.90 | 58.03 | 58.69 | 59.70 | 53.68 | 53.68 |
| 5 | 59.81 | 60.94 | 62.66 | 64.35 | 65.35 | 60.76 | 61.77 | 64.06 | 64.58 | 65.42 | 61.21 | 62.15 | 63.26 | 64.26 | 65.10 | 61.38 | 61.38 |
| 6 | 66.08 | 67.02 | 68.36 | 69.80 | 70.58 | 66.28 | 67.09 | 69.15 | 69.24 | 69.94 | 66.40 | 67.18 | 67.85 | 69.07 | 69.82 | 67.82 | 67.82 |
| 7 | 71.39 | 72.21 | 72.78 | 73.95 | 74.53 | 70.83 | 71.53 | 73.56 | 73.30 | 73.96 | 70.89 | 71.60 | 72.02 | 73.42 | 74.12 | 73.20 | 73.20 |
| 8 | 76.02 | 76.72 | 76.21 | 77.14 | 77.62 | 74.92 | 75.58 | 77.51 | 77.26 | 77.92 | 75.09 | 75.78 | 75.80 | 77.47 | 78.11 | 77.70 | 77.70 |
| 9 | 80.00 | 80.60 | 79.09 | 79.91 | 80.36 | 78.82 | 79.45 | 81.03 | 81.08 | 81.68 | 79.09 | 79.72 | 79.28 | 81.17 | 81.75 | 81.45 | 81.45 |
| 10 | 83.36 | 83.87 | 81.74 | 82.59 | 83.03 | 82.42 | 82.97 | 84.12 | 84.46 | 84.97 | 82.69 | 83.23 | 82.48 | 84.42 | 84.91 | 84.59 | 84.59 |
| 11 | 86.18 | 86.60 | 84.27 | 85.20 | 85.62 | 85.53 | 86.00 | 86.77 | 87.28 | 87.69 | 85.74 | 86.19 | 85.34 | 87.16 | 87.57 | 87.21 | 87.21 |
| 12 | 88.54 | 88.90 | 86.65 | 87.64 | 88.02 | 88.11 | 88.50 | 89.02 | 89.57 | 89.90 | 88.26 | 88.64 | 87.83 | 89.44 | 89.78 | 89.41 | 89.41 |
| 13 | 90.51 | 90.81 | 88.81 | 89.79 | 90.11 | 90.23 | 90.55 | 90.91 | 91.44 | 91.71 | 90.33 | 90.64 | 89.94 | 91.31 | 91.59 | 91.24 | 91.24 |
| 14 | 92.16 | 92.41 | 90.68 | 91.61 | 91.88 | 91.97 | 92.23 | 92.49 | 92.97 | 93.20 | 92.04 | 92.30 | 91.71 | 92.86 | 93.09 | 92.77 | 92.77 |
| 15 | 93.54 | 93.75 | 92.27 | 93.12 | 93.34 | 93.41 | 93.62 | 93.81 | 94.23 | 94.42 | 93.46 | 93.67 | 93.16 | 94.14 | 94.33 | 94.05 | 94.05 |
| 16 | 94.69 | 94.86 | 93.60 | 94.36 | 94.55 | 94.60 | 94.77 | 94.91 | 95.28 | 95.44 | 94.63 | 94.81 | 94.37 | 95.20 | 95.36 | 95.11 | 95.11 |
| 17 | 95.65 | 95.80 | 94.70 | 95.38 | 95.53 | 95.58 | 95.73 | 95.83 | 96.15 | 96.28 | 95.61 | 95.76 | 95.37 | 96.08 | 96.21 | 96.01 | 96.01 |
| 18 | 96.46 | 96.58 | 95.61 | 96.22 | 96.34 | 96.40 | 96.52 | 96.60 | 96.87 | 96.98 | 96.42 | 96.54 | 96.19 | 96.81 | 96.92 | 96.75 | 96.75 |
| 19 | 97.13 | 97.23 | 96.36 | 96.90 | 97.01 | 97.08 | 97.18 | 97.23 | 97.48 | 97.57 | 97.10 | 97.20 | 96.87 | 97.42 | 97.51 | 97.37 | 97.37 |
| 20 | 98.29 | 98.35 | 97.59 | 98.04 | 98.11 | 98.26 | 98.32 | 98.33 | 98.51 | 98.57 | 98.27 | 98.33 | 98.02 | 98.47 | 98.53 | 98.45 | 98.45 |

Table 2.27—Schedules of fleet-specific weight (kg) by season and age as estimated by Model 3. Sea1=Jan-Feb, Sea2=Mar-Apr, Sea3=May-Aug, Sea4=Sep-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 | 27plus | Sub27 |
| 1 | 0.06 | 0.08 | 0.14 | 0.24 | 0.26 | 0.04 | 0.05 | 0.10 | 0.19 | 0.24 | 0.04 | 0.05 | 0.10 | 0.18 | 0.22 | 0.10 | 0.10 |
| 2 | 0.36 | 0.41 | 0.54 | 0.73 | 0.78 | 0.40 | 0.48 | 0.64 | 0.89 | 0.96 | 0.31 | 0.42 | 0.58 | 0.93 | 1.00 | 0.43 | 0.43 |
| 3 | 0.96 | 1.00 | 1.16 | 1.43 | 1.54 | 1.13 | 1.16 | 1.38 | 1.62 | 1.73 | 1.22 | 1.25 | 1.51 | 1.65 | 1.75 | 1.00 | 1.00 |
| 4 | 1.78 | 1.78 | 1.93 | 2.25 | 2.43 | 1.95 | 1.94 | 2.16 | 2.38 | 2.56 | 2.05 | 2.03 | 2.18 | 2.37 | 2.54 | 1.75 | 1.75 |
| 5 | 2.71 | 2.65 | 2.76 | 3.10 | 3.38 | 2.83 | 2.76 | 2.94 | 3.13 | 3.38 | 2.90 | 2.81 | 2.82 | 3.08 | 3.33 | 2.60 | 2.60 |
| 6 | 3.68 | 3.55 | 3.57 | 3.92 | 4.29 | 3.70 | 3.56 | 3.69 | 3.82 | 4.16 | 3.72 | 3.57 | 3.49 | 3.80 | 4.14 | 3.50 | 3.50 |
| 7 | 4.67 | 4.47 | 4.30 | 4.62 | 5.07 | 4.54 | 4.34 | 4.44 | 4.51 | 4.96 | 4.56 | 4.35 | 4.17 | 4.54 | 5.00 | 4.39 | 4.39 |
| 8 | 5.66 | 5.39 | 4.93 | 5.22 | 5.76 | 5.41 | 5.15 | 5.20 | 5.27 | 5.85 | 5.45 | 5.19 | 4.87 | 5.31 | 5.90 | 5.24 | 5.24 |
| 9 | 6.62 | 6.28 | 5.52 | 5.79 | 6.42 | 6.34 | 6.01 | 5.94 | 6.06 | 6.79 | 6.40 | 6.08 | 5.57 | 6.08 | 6.80 | 6.03 | 6.03 |
| 10 | 7.52 | 7.09 | 6.10 | 6.38 | 7.13 | 7.28 | 6.88 | 6.64 | 6.82 | 7.67 | 7.35 | 6.94 | 6.27 | 6.81 | 7.65 | 6.75 | 6.75 |
| 11 | 8.33 | 7.83 | 6.69 | 6.99 | 7.86 | 8.15 | 7.68 | 7.29 | 7.49 | 8.45 | 8.21 | 7.73 | 6.95 | 7.46 | 8.42 | 7.40 | 7.40 |
| 12 | 9.05 | 8.48 | 7.28 | 7.59 | 8.57 | 8.93 | 8.38 | 7.87 | 8.07 | 9.13 | 8.97 | 8.42 | 7.58 | 8.03 | 9.09 | 7.96 | 7.96 |
| 13 | 9.68 | 9.06 | 7.84 | 8.15 | 9.23 | 9.60 | 8.99 | 8.37 | 8.56 | 9.71 | 9.63 | 9.01 | 8.13 | 8.53 | 9.67 | 8.46 | 8.46 |
| 14 | 10.24 | 9.56 | 8.34 | 8.63 | 9.80 | 10.18 | 9.51 | 8.82 | 8.98 | 10.20 | 10.20 | 9.53 | 8.61 | 8.95 | 10.17 | 8.89 | 8.89 |
| 15 | 10.71 | 9.99 | 8.79 | 9.05 | 10.29 | 10.67 | 9.96 | 9.20 | 9.33 | 10.62 | 10.69 | 9.97 | 9.02 | 9.31 | 10.60 | 9.26 | 9.26 |
| 16 | 11.12 | 10.36 | 9.17 | 9.39 | 10.70 | 11.09 | 10.34 | 9.52 | 9.63 | 10.98 | 11.11 | 10.35 | 9.37 | 9.61 | 10.96 | 9.58 | 9.58 |
| 17 | 11.48 | 10.68 | 9.49 | 9.69 | 11.05 | 11.45 | 10.66 | 9.80 | 9.89 | 11.29 | 11.46 | 10.67 | 9.67 | 9.87 | 11.26 | 9.85 | 9.85 |
| 18 | 11.77 | 10.95 | 9.76 | 9.93 | 11.34 | 11.76 | 10.93 | 10.03 | 10.11 | 11.54 | 11.76 | 10.94 | 9.92 | 10.09 | 11.52 | 10.08 | 10.08 |
| 19 | 12.03 | 11.18 | 9.99 | 10.13 | 11.58 | 12.01 | 11.17 | 10.23 | 10.29 | 11.76 | 12.02 | 11.17 | 10.13 | 10.27 | 11.74 | 10.27 | 10.27 |
| 20 | 12.48 | 11.59 | 10.37 | 10.48 | 11.99 | 12.46 | 11.58 | 10.58 | 10.61 | 12.15 | 12.47 | 11.58 | 10.49 | 10.60 | 12.13 | 10.62 | 10.62 |

Table 2.28—Time series of GOA Pacific cod age 0+ biomass, female spawning biomass (t), and standard deviation of spawning biomass as estimated last year under the Plan Team's and SSC's preferred model and this year under Model 3. Values for 2012 listed under this year's assessment represent Stock Synthesis projections, and may not correspond exactly to values generated by the standard projection model.

| | Last year's assessment | | | This year's assessment | | |
|---|---|---|---|---|---|---|
| Year | Age 0+ bio. | Spawn. bio. | Std. dev. | Age 0+ bio. | Spawn. bio. | Std. dev. |
| 1977 | 537,214 | 158,247 | 18,298 | 548,713 | 167,351 | 19,894 |
| 1978 | 584,201 | 186,593 | 19,999 | 591,549 | 195,614 | 21,366 |
| 1979 | 650,385 | 194,541 | 19,925 | 653,818 | 202,005 | 21,089 |
| 1980 | 713,082 | 196,358 | 18,802 | 716,863 | 202,656 | 19,838 |
| 1981 | 728,761 | 215,009 | 18,752 | 732,964 | 221,969 | 19,786 |
| 1982 | 715,356 | 242,461 | 19,612 | 718,672 | 248,968 | 20,576 |
| 1983 | 695,164 | 240,658 | 18,671 | 695,843 | 245,648 | 19,490 |
| 1984 | 668,973 | 223,085 | 16,781 | 666,676 | 227,027 | 17,444 |
| 1985 | 658,371 | 213,126 | 14,785 | 654,501 | 216,277 | 15,268 |
| 1986 | 658,605 | 211,306 | 12,913 | 652,885 | 213,715 | 13,230 |
| 1987 | 653,493 | 212,431 | 11,268 | 646,067 | 214,332 | 11,480 |
| 1988 | 639,902 | 203,905 | 9,846 | 631,371 | 205,381 | 9,968 |
| 1989 | 628,407 | 197,412 | 8,816 | 618,747 | 198,367 | 8,835 |
| 1990 | 611,117 | 187,446 | 7,967 | 600,034 | 187,980 | 7,930 |
| 1991 | 577,245 | 169,320 | 7,203 | 564,328 | 169,558 | 7,152 |
| 1992 | 554,076 | 150,715 | 6,696 | 540,285 | 150,833 | 6,655 |
| 1993 | 535,341 | 144,140 | 6,462 | 521,126 | 143,790 | 6,413 |
| 1994 | 539,574 | 148,816 | 6,470 | 524,264 | 148,362 | 6,339 |
| 1995 | 549,595 | 156,929 | 6,387 | 532,685 | 156,445 | 6,121 |
| 1996 | 537,665 | 151,639 | 6,182 | 518,761 | 150,276 | 5,816 |
| 1997 | 527,015 | 144,069 | 5,986 | 505,819 | 141,684 | 5,508 |
| 1998 | 504,428 | 132,668 | 5,999 | 481,450 | 129,846 | 5,389 |
| 1999 | 479,797 | 129,351 | 6,256 | 455,140 | 125,501 | 5,464 |
| 2000 | 439,671 | 117,910 | 6,489 | 412,571 | 112,891 | 5,501 |
| 2001 | 417,246 | 117,221 | 6,558 | 386,067 | 111,225 | 5,410 |
| 2002 | 413,776 | 111,480 | 6,520 | 377,446 | 104,223 | 5,211 |
| 2003 | 407,624 | 102,852 | 6,629 | 365,788 | 94,330 | 5,128 |
| 2004 | 401,492 | 103,224 | 7,142 | 353,550 | 92,875 | 5,338 |
| 2005 | 390,737 | 105,580 | 7,863 | 335,282 | 92,640 | 5,657 |
| 2006 | 395,661 | 103,394 | 8,370 | 329,766 | 87,802 | 5,788 |
| 2007 | 418,804 | 102,792 | 8,964 | 339,631 | 84,669 | 5,987 |
| 2008 | 451,683 | 101,898 | 10,109 | 367,134 | 80,278 | 6,552 |
| 2009 | 475,665 | 109,328 | 12,474 | 407,113 | 83,448 | 8,031 |
| 2010 | 490,165 | 122,871 | 16,437 | 465,276 | 95,784 | 11,105 |
| 2011 | 470,608 | 123,640 | 17,729 | 497,366 | 108,953 | 15,548 |
| 2012 | | | | 520,918 | 121,180 | 18,284 |

Table 2.29—Time series of GOA Pacific cod age 0 recruitment (1000s of fish), with standard deviations, as estimated by the model presented in last year's assessment and this year under Model 3.

| | Last year's assessment | | This year's assessment | |
|---|---|---|---|---|
| Year | Recruits | Std. dev. | Recruits | Std. dev. |
| 1977 | 658,920 | 48,397 | 671,545 | 51,305 |
| 1978 | 170,043 | 16,672 | 158,776 | 17,249 |
| 1979 | 187,438 | 13,303 | 194,972 | 14,217 |
| 1980 | 211,016 | 12,578 | 215,021 | 13,158 |
| 1981 | 216,926 | 13,576 | 220,450 | 14,577 |
| 1982 | 300,084 | 18,063 | 304,994 | 18,701 |
| 1983 | 206,808 | 15,683 | 211,702 | 15,936 |
| 1984 | 208,685 | 14,453 | 211,084 | 14,512 |
| 1985 | 314,747 | 16,047 | 319,579 | 16,570 |
| 1986 | 172,579 | 10,498 | 171,859 | 11,039 |
| 1987 | 279,948 | 11,851 | 288,696 | 12,634 |
| 1988 | 216,671 | 11,154 | 213,873 | 11,618 |
| 1989 | 307,094 | 14,263 | 311,488 | 14,659 |
| 1990 | 269,066 | 12,780 | 275,951 | 13,772 |
| 1991 | 260,819 | 11,848 | 258,427 | 12,177 |
| 1992 | 221,870 | 11,224 | 212,641 | 11,492 |
| 1993 | 245,288 | 11,515 | 252,984 | 11,668 |
| 1994 | 258,490 | 12,092 | 251,854 | 11,581 |
| 1995 | 243,707 | 11,608 | 236,085 | 10,438 |
| 1996 | 216,053 | 11,415 | 212,948 | 9,303 |
| 1997 | 164,429 | 8,726 | 152,037 | 7,726 |
| 1998 | 165,149 | 9,035 | 158,598 | 8,120 |
| 1999 | 212,406 | 11,888 | 200,927 | 9,842 |
| 2000 | 248,005 | 15,008 | 228,817 | 11,275 |
| 2001 | 171,103 | 11,481 | 145,779 | 8,515 |
| 2002 | 168,121 | 12,162 | 151,163 | 9,182 |
| 2003 | 196,272 | 15,826 | 163,610 | 10,797 |
| 2004 | 208,035 | 18,859 | 177,435 | 12,943 |
| 2005 | 354,908 | 38,594 | 291,254 | 25,963 |
| 2006 | 297,679 | 38,266 | 324,737 | 34,283 |
| 2007 | 244,508 | 41,571 | 332,116 | 44,918 |
| 2008 | 136,909 | 28,520 | 372,360 | 53,770 |
| 2009 | | | 255,623 | 61,794 |
| 2010 | | | 361,467 | 95,517 |
| Average | 241,681 | | 250,319 | |

Table 2.30—Numbers (1000s) at age at time of spawning (March) as estimated by Model 3.

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 671545 | 203378 | 62963 | 57464 | 84047 | 42521 | 17459 | 8982 | 5032 | 3159 | 2148 | 1524 | 1098 | 794 | 762 | 514 | 347 | 234 | 158 | 107 | 222 |
| 1978 | 158776 | 459243 | 139077 | 43015 | 39093 | 56968 | 28806 | 11833 | 6090 | 3413 | 2144 | 1459 | 1035 | 746 | 540 | 518 | 350 | 236 | 159 | 108 | 224 |
| 1979 | 194972 | 108581 | 314037 | 94836 | 28971 | 26024 | 37887 | 19201 | 7900 | 4072 | 2285 | 1438 | 979 | 696 | 502 | 364 | 349 | 236 | 159 | 108 | 223 |
| 1980 | 215021 | 133333 | 74245 | 213929 | 63505 | 19081 | 17104 | 24962 | 12677 | 5226 | 2699 | 1519 | 958 | 653 | 465 | 336 | 244 | 234 | 158 | 107 | 222 |
| 1981 | 220450 | 147045 | 91175 | 50593 | 141523 | 40330 | 12138 | 11051 | 16270 | 8295 | 3429 | 1775 | 1001 | 632 | 432 | 308 | 223 | 161 | 155 | 105 | 218 |
| 1982 | 304994 | 150757 | 100548 | 62097 | 33382 | 89667 | 25678 | 7869 | 7235 | 10695 | 5466 | 2263 | 1174 | 663 | 419 | 287 | 204 | 148 | 107 | 103 | 215 |
| 1983 | 211702 | 208573 | 103083 | 68496 | 41035 | 21234 | 57324 | 16693 | 5161 | 4763 | 7057 | 3614 | 1499 | 779 | 440 | 279 | 191 | 136 | 98 | 71 | 212 |
| 1984 | 211084 | 144774 | 142610 | 70138 | 44687 | 25356 | 13211 | 36527 | 10775 | 3349 | 3100 | 4605 | 2363 | 982 | 511 | 289 | 183 | 125 | 89 | 65 | 186 |
| 1985 | 319579 | 144352 | 98991 | 97217 | 46834 | 28973 | 16408 | 8625 | 23979 | 7093 | 2209 | 2048 | 3046 | 1565 | 651 | 339 | 192 | 121 | 83 | 59 | 167 |
| 1986 | 171859 | 218547 | 98696 | 67531 | 65667 | 31102 | 19057 | 10782 | 5681 | 15838 | 4696 | 1465 | 1360 | 2024 | 1040 | 433 | 225 | 127 | 81 | 55 | 150 |
| 1987 | 288696 | 117527 | 149407 | 67266 | 45375 | 43116 | 20240 | 12428 | 7060 | 3732 | 10433 | 3099 | 968 | 899 | 1338 | 688 | 286 | 149 | 84 | 53 | 136 |
| 1988 | 213873 | 197424 | 80299 | 101272 | 44259 | 28616 | 26819 | 12754 | 7956 | 4563 | 2424 | 6794 | 2021 | 631 | 587 | 874 | 449 | 187 | 97 | 55 | 124 |
| 1989 | 311488 | 146255 | 134868 | 54429 | 66875 | 28113 | 17847 | 16836 | 8106 | 5099 | 2939 | 1565 | 4391 | 1307 | 409 | 380 | 565 | 291 | 121 | 63 | 116 |
| 1990 | 275951 | 213013 | 99993 | 91799 | 35969 | 41568 | 16778 | 10644 | 10189 | 4964 | 3144 | 1817 | 969 | 2722 | 810 | 253 | 236 | 351 | 180 | 75 | 111 |
| 1991 | 258427 | 188712 | 145637 | 68090 | 60955 | 22311 | 23826 | 9275 | 5931 | 5811 | 2890 | 1857 | 1084 | 582 | 1640 | 489 | 153 | 143 | 213 | 109 | 113 |
| 1992 | 212641 | 176727 | 129020 | 99162 | 45185 | 37642 | 12461 | 12388 | 4717 | 3033 | 3005 | 1508 | 975 | 571 | 307 | 867 | 259 | 81 | 76 | 113 | 118 |
| 1993 | 252984 | 145417 | 120837 | 87960 | 66186 | 28207 | 21298 | 6583 | 6436 | 2477 | 1617 | 1620 | 819 | 532 | 312 | 168 | 475 | 142 | 45 | 42 | 127 |
| 1994 | 251854 | 173005 | 99427 | 82382 | 58795 | 41679 | 16339 | 11681 | 3576 | 3540 | 1383 | 913 | 921 | 467 | 304 | 179 | 96 | 273 | 82 | 26 | 97 |
| 1995 | 236085 | 172232 | 118302 | 67874 | 55463 | 37832 | 25125 | 9424 | 6673 | 2059 | 2061 | 812 | 538 | 545 | 277 | 180 | 106 | 57 | 162 | 49 | 73 |
| 1996 | 212948 | 161448 | 117760 | 80668 | 45437 | 35030 | 21845 | 13491 | 4915 | 3484 | 1086 | 1097 | 435 | 290 | 294 | 150 | 98 | 57 | 31 | 88 | 66 |
| 1997 | 152037 | 145626 | 110387 | 80282 | 53872 | 28449 | 19962 | 11600 | 6991 | 2558 | 1834 | 577 | 587 | 233 | 156 | 158 | 81 | 53 | 31 | 17 | 83 |
| 1998 | 158598 | 103971 | 99547 | 75084 | 53023 | 32649 | 15252 | 9788 | 5531 | 3367 | 1255 | 915 | 291 | 298 | 119 | 80 | 81 | 41 | 27 | 16 | 51 |
| 1999 | 200927 | 108458 | 71081 | 67793 | 49825 | 32473 | 17841 | 7710 | 4863 | 2794 | 1739 | 660 | 486 | 156 | 160 | 64 | 43 | 44 | 22 | 15 | 36 |
| 2000 | 228817 | 137404 | 74119 | 48215 | 44049 | 28857 | 16354 | 8293 | 3560 | 2312 | 1373 | 876 | 338 | 251 | 81 | 84 | 34 | 23 | 23 | 12 | 27 |
| 2001 | 145779 | 156477 | 93930 | 50419 | 31866 | 27007 | 16247 | 8896 | 4567 | 2011 | 1332 | 801 | 515 | 199 | 148 | 48 | 49 | 20 | 13 | 14 | 23 |
| 2002 | 151163 | 99691 | 106959 | 63814 | 33109 | 19256 | 14946 | 8715 | 4859 | 2573 | 1161 | 780 | 473 | 305 | 118 | 88 | 29 | 29 | 12 | 8 | 22 |
| 2003 | 163610 | 103373 | 68143 | 72651 | 41573 | 19242 | 9902 | 7371 | 4405 | 2556 | 1395 | 641 | 435 | 265 | 172 | 67 | 50 | 16 | 17 | 7 | 17 |
| 2004 | 177435 | 111885 | 70657 | 46257 | 47256 | 24228 | 10011 | 4962 | 3794 | 2366 | 1418 | 789 | 366 | 250 | 153 | 99 | 39 | 29 | 9 | 10 | 14 |
| 2005 | 291254 | 121339 | 76476 | 48001 | 30328 | 28069 | 12863 | 5089 | 2571 | 2039 | 1308 | 797 | 448 | 209 | 143 | 88 | 57 | 22 | 17 | 5 | 13 |
| 2006 | 324737 | 199175 | 82945 | 52017 | 31634 | 18205 | 15090 | 6595 | 2637 | 1369 | 1110 | 722 | 444 | 250 | 117 | 80 | 49 | 32 | 12 | 9 | 11 |
| 2007 | 332116 | 222072 | 136159 | 56451 | 34403 | 19204 | 9952 | 7868 | 3471 | 1424 | 755 | 620 | 406 | 251 | 142 | 66 | 46 | 28 | 18 | 7 | 11 |
| 2008 | 372360 | 227118 | 151791 | 92493 | 36898 | 20076 | 9751 | 4740 | 3792 | 1732 | 731 | 395 | 327 | 216 | 133 | 76 | 35 | 24 | 15 | 10 | 10 |
| 2009 | 255623 | 254640 | 155253 | 103177 | 60448 | 21360 | 9983 | 4511 | 2220 | 1849 | 875 | 378 | 207 | 173 | 114 | 71 | 40 | 19 | 13 | 8 | 10 |
| 2010 | 361467 | 174808 | 174059 | 105475 | 67113 | 34492 | 10474 | 4595 | 2110 | 1079 | 928 | 448 | 196 | 108 | 91 | 60 | 37 | 21 | 10 | 7 | 10 |
| 2011 | 257455 | 247190 | 119498 | 118339 | 68781 | 38303 | 16760 | 4746 | 2117 | 1015 | 538 | 474 | 232 | 102 | 56 | 47 | 32 | 20 | 11 | 5 | 9 |

Table 2.31—Estimates of "effective" fishing mortality (= $-\ln(N_{a+1,t+1}/N_{a,t})-M$) at age and year for Model 3.

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 0.000 | 0.000 | 0.002 | 0.005 | 0.005 | 0.005 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| 1978 | 0.000 | 0.002 | 0.012 | 0.025 | 0.027 | 0.025 | 0.023 | 0.022 | 0.021 | 0.020 | 0.018 | 0.017 | 0.016 | 0.015 | 0.015 | 0.014 | 0.014 | 0.014 | 0.013 |
| 1979 | 0.000 | 0.002 | 0.013 | 0.028 | 0.031 | 0.029 | 0.027 | 0.026 | 0.024 | 0.023 | 0.021 | 0.020 | 0.019 | 0.018 | 0.017 | 0.017 | 0.016 | 0.016 | 0.016 |
| 1980 | 0.000 | 0.003 | 0.030 | 0.075 | 0.078 | 0.063 | 0.054 | 0.051 | 0.048 | 0.045 | 0.043 | 0.040 | 0.038 | 0.037 | 0.036 | 0.035 | 0.034 | 0.034 | 0.033 |
| 1981 | 0.000 | 0.003 | 0.032 | 0.074 | 0.071 | 0.054 | 0.044 | 0.040 | 0.038 | 0.036 | 0.034 | 0.033 | 0.031 | 0.031 | 0.030 | 0.029 | 0.029 | 0.029 | 0.028 |
| 1982 | 0.000 | 0.003 | 0.029 | 0.068 | 0.065 | 0.048 | 0.039 | 0.036 | 0.034 | 0.032 | 0.031 | 0.029 | 0.028 | 0.027 | 0.027 | 0.026 | 0.026 | 0.026 | 0.025 |
| 1983 | 0.000 | 0.004 | 0.041 | 0.096 | 0.092 | 0.069 | 0.056 | 0.051 | 0.048 | 0.046 | 0.044 | 0.043 | 0.041 | 0.040 | 0.039 | 0.039 | 0.039 | 0.038 | 0.038 |
| 1984 | 0.000 | 0.002 | 0.022 | 0.054 | 0.057 | 0.048 | 0.043 | 0.040 | 0.038 | 0.036 | 0.034 | 0.032 | 0.031 | 0.029 | 0.028 | 0.028 | 0.027 | 0.027 | 0.027 |
| 1985 | 0.000 | 0.001 | 0.008 | 0.022 | 0.030 | 0.031 | 0.030 | 0.028 | 0.027 | 0.025 | 0.024 | 0.024 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 |
| 1986 | 0.000 | 0.002 | 0.015 | 0.039 | 0.052 | 0.053 | 0.052 | 0.049 | 0.045 | 0.043 | 0.041 | 0.040 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.038 | 0.038 |
| 1987 | 0.000 | 0.006 | 0.031 | 0.071 | 0.085 | 0.074 | 0.059 | 0.050 | 0.045 | 0.042 | 0.041 | 0.040 | 0.040 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 |
| 1988 | 0.000 | 0.004 | 0.025 | 0.063 | 0.084 | 0.080 | 0.068 | 0.059 | 0.054 | 0.052 | 0.050 | 0.050 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.048 | 0.048 |
| 1989 | 0.000 | 0.003 | 0.028 | 0.080 | 0.111 | 0.106 | 0.090 | 0.079 | 0.073 | 0.070 | 0.068 | 0.068 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 |
| 1990 | 0.000 | 0.003 | 0.022 | 0.084 | 0.165 | 0.210 | 0.210 | 0.191 | 0.171 | 0.157 | 0.148 | 0.142 | 0.138 | 0.136 | 0.134 | 0.133 | 0.132 | 0.131 | 0.130 |
| 1991 | 0.000 | 0.001 | 0.015 | 0.066 | 0.155 | 0.230 | 0.258 | 0.255 | 0.244 | 0.235 | 0.229 | 0.225 | 0.223 | 0.221 | 0.221 | 0.220 | 0.219 | 0.219 | 0.219 |
| 1992 | 0.000 | 0.001 | 0.016 | 0.077 | 0.185 | 0.273 | 0.303 | 0.296 | 0.281 | 0.269 | 0.261 | 0.256 | 0.253 | 0.252 | 0.251 | 0.250 | 0.249 | 0.249 | 0.249 |
| 1993 | 0.000 | 0.001 | 0.012 | 0.056 | 0.136 | 0.201 | 0.221 | 0.213 | 0.199 | 0.188 | 0.181 | 0.177 | 0.174 | 0.173 | 0.172 | 0.171 | 0.170 | 0.170 | 0.170 |
| 1994 | 0.000 | 0.001 | 0.009 | 0.042 | 0.104 | 0.158 | 0.176 | 0.171 | 0.160 | 0.152 | 0.147 | 0.143 | 0.141 | 0.140 | 0.139 | 0.139 | 0.139 | 0.138 | 0.138 |
| 1995 | 0.000 | 0.001 | 0.011 | 0.052 | 0.134 | 0.217 | 0.259 | 0.263 | 0.252 | 0.240 | 0.232 | 0.227 | 0.224 | 0.222 | 0.221 | 0.220 | 0.220 | 0.219 | 0.219 |
| 1996 | 0.000 | 0.001 | 0.012 | 0.055 | 0.138 | 0.219 | 0.257 | 0.260 | 0.250 | 0.239 | 0.232 | 0.228 | 0.225 | 0.224 | 0.223 | 0.222 | 0.222 | 0.221 | 0.221 |
| 1997 | 0.000 | 0.002 | 0.017 | 0.069 | 0.168 | 0.264 | 0.309 | 0.310 | 0.294 | 0.278 | 0.267 | 0.260 | 0.256 | 0.254 | 0.252 | 0.251 | 0.250 | 0.250 | 0.249 |
| 1998 | 0.000 | 0.002 | 0.013 | 0.064 | 0.167 | 0.268 | 0.313 | 0.309 | 0.289 | 0.270 | 0.258 | 0.250 | 0.245 | 0.242 | 0.240 | 0.239 | 0.238 | 0.238 | 0.237 |
| 1999 | 0.000 | 0.002 | 0.016 | 0.075 | 0.202 | 0.329 | 0.385 | 0.377 | 0.347 | 0.319 | 0.299 | 0.287 | 0.280 | 0.275 | 0.272 | 0.270 | 0.269 | 0.268 | 0.266 |
| 2000 | 0.000 | 0.002 | 0.016 | 0.080 | 0.203 | 0.290 | 0.297 | 0.264 | 0.232 | 0.211 | 0.200 | 0.193 | 0.190 | 0.188 | 0.187 | 0.186 | 0.186 | 0.185 | 0.185 |
| 2001 | 0.000 | 0.003 | 0.021 | 0.081 | 0.177 | 0.238 | 0.236 | 0.207 | 0.180 | 0.162 | 0.152 | 0.146 | 0.143 | 0.141 | 0.140 | 0.140 | 0.139 | 0.139 | 0.139 |
| 2002 | 0.000 | 0.002 | 0.021 | 0.093 | 0.208 | 0.278 | 0.275 | 0.241 | 0.211 | 0.191 | 0.180 | 0.174 | 0.171 | 0.169 | 0.168 | 0.167 | 0.167 | 0.167 | 0.166 |
| 2003 | 0.000 | 0.003 | 0.022 | 0.091 | 0.210 | 0.290 | 0.289 | 0.250 | 0.213 | 0.190 | 0.177 | 0.170 | 0.166 | 0.164 | 0.163 | 0.162 | 0.162 | 0.162 | 0.161 |
| 2004 | 0.000 | 0.003 | 0.023 | 0.099 | 0.233 | 0.321 | 0.317 | 0.271 | 0.230 | 0.203 | 0.189 | 0.181 | 0.177 | 0.174 | 0.173 | 0.172 | 0.172 | 0.171 | 0.171 |
| 2005 | 0.000 | 0.002 | 0.014 | 0.072 | 0.182 | 0.263 | 0.272 | 0.248 | 0.223 | 0.207 | 0.198 | 0.193 | 0.190 | 0.188 | 0.187 | 0.187 | 0.186 | 0.186 | 0.186 |
| 2006 | 0.000 | 0.001 | 0.013 | 0.071 | 0.187 | 0.273 | 0.284 | 0.259 | 0.234 | 0.218 | 0.209 | 0.205 | 0.202 | 0.200 | 0.200 | 0.199 | 0.199 | 0.199 | 0.198 |
| 2007 | 0.000 | 0.002 | 0.018 | 0.089 | 0.223 | 0.318 | 0.327 | 0.296 | 0.266 | 0.246 | 0.235 | 0.228 | 0.225 | 0.223 | 0.222 | 0.221 | 0.221 | 0.220 | 0.220 |
| 2008 | 0.000 | 0.003 | 0.024 | 0.109 | 0.265 | 0.380 | 0.394 | 0.358 | 0.319 | 0.293 | 0.278 | 0.270 | 0.265 | 0.262 | 0.260 | 0.259 | 0.259 | 0.258 | 0.258 |
| 2009 | 0.000 | 0.002 | 0.018 | 0.087 | 0.224 | 0.326 | 0.339 | 0.306 | 0.272 | 0.249 | 0.236 | 0.228 | 0.224 | 0.222 | 0.221 | 0.220 | 0.219 | 0.219 | 0.218 |
| 2010 | 0.000 | 0.003 | 0.022 | 0.109 | 0.282 | 0.413 | 0.430 | 0.389 | 0.346 | 0.317 | 0.300 | 0.291 | 0.286 | 0.283 | 0.281 | 0.280 | 0.279 | 0.279 | 0.278 |
| 2011 | 0.000 | 0.002 | 0.018 | 0.098 | 0.261 | 0.381 | 0.394 | 0.356 | 0.318 | 0.293 | 0.280 | 0.272 | 0.268 | 0.266 | 0.264 | 0.264 | 0.263 | 0.263 | 0.262 |

Table 2.32—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in 2012-2024 (Scenarios 1 and 2), with random variability in future recruitment.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 87,600 | 87,600 | 87,600 | 87,600 | 0 |
| 2013 | 91,000 | 91,000 | 91,000 | 91,000 | 0 |
| 2014 | 90,200 | 90,200 | 90,200 | 90,200 | 2 |
| 2015 | 88,000 | 88,100 | 88,100 | 88,200 | 79 |
| 2016 | 82,900 | 84,100 | 84,200 | 86,000 | 993 |
| 2017 | 74,900 | 79,400 | 79,900 | 86,600 | 3,694 |
| 2018 | 61,900 | 76,300 | 76,100 | 90,400 | 8,570 |
| 2019 | 55,400 | 74,800 | 74,000 | 92,900 | 11,546 |
| 2020 | 53,800 | 74,700 | 73,500 | 93,400 | 12,346 |
| 2021 | 53,000 | 74,200 | 73,500 | 95,000 | 12,339 |
| 2022 | 53,100 | 73,600 | 73,200 | 92,600 | 12,281 |
| 2023 | 52,800 | 73,800 | 72,900 | 92,000 | 12,156 |
| 2024 | 53,200 | 73,500 | 72,600 | 91,400 | 12,117 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 121,000 | 121,000 | 121,000 | 121,000 | 0 |
| 2013 | 127,000 | 127,000 | 127,000 | 127,000 | 0 |
| 2014 | 126,000 | 126,000 | 126,000 | 126,000 | 2 |
| 2015 | 125,000 | 125,000 | 125,000 | 125,000 | 53 |
| 2016 | 118,000 | 119,000 | 119,000 | 120,000 | 666 |
| 2017 | 107,000 | 112,000 | 113,000 | 121,000 | 4,242 |
| 2018 | 96,000 | 108,000 | 109,000 | 128,000 | 9,816 |
| 2019 | 91,000 | 106,000 | 108,000 | 131,000 | 12,360 |
| 2020 | 89,300 | 105,000 | 107,000 | 131,000 | 13,189 |
| 2021 | 88,900 | 105,000 | 107,000 | 134,000 | 13,300 |
| 2022 | 88,600 | 104,000 | 107,000 | 131,000 | 13,108 |
| 2023 | 88,700 | 104,000 | 106,000 | 130,000 | 12,862 |
| 2024 | 88,700 | 104,000 | 106,000 | 128,000 | 12,683 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2013 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2014 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2015 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2016 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2017 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2018 | 0.40 | 0.44 | 0.43 | 0.44 | 0.01 |
| 2019 | 0.38 | 0.44 | 0.42 | 0.44 | 0.02 |
| 2020 | 0.37 | 0.44 | 0.42 | 0.44 | 0.02 |
| 2021 | 0.37 | 0.44 | 0.42 | 0.44 | 0.02 |
| 2022 | 0.37 | 0.44 | 0.42 | 0.44 | 0.02 |
| 2023 | 0.37 | 0.44 | 0.42 | 0.44 | 0.03 |
| 2024 | 0.37 | 0.44 | 0.42 | 0.44 | 0.03 |

Table 2.33—Projections for GOA 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 2012-2024 (Scenario 3), with random variability in future recruitment.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 82,600 | 82,600 | 82,600 | 82,600 | 0 |
| 2013 | 87,000 | 87,000 | 87,000 | 87,000 | 0 |
| 2014 | 87,000 | 87,000 | 87,000 | 87,000 | 2 |
| 2015 | 85,300 | 85,400 | 85,400 | 85,500 | 74 |
| 2016 | 80,700 | 81,900 | 82,000 | 83,700 | 930 |
| 2017 | 73,200 | 77,500 | 78,000 | 84,300 | 3,476 |
| 2018 | 65,500 | 74,500 | 75,300 | 87,900 | 6,888 |
| 2019 | 60,800 | 73,000 | 73,900 | 90,500 | 9,074 |
| 2020 | 59,000 | 72,600 | 73,300 | 90,700 | 9,956 |
| 2021 | 58,200 | 71,900 | 73,000 | 92,100 | 10,147 |
| 2022 | 57,600 | 71,500 | 72,600 | 90,300 | 10,070 |
| 2023 | 57,300 | 71,400 | 72,200 | 89,600 | 9,929 |
| 2024 | 57,400 | 71,300 | 72,000 | 88,700 | 9,840 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 122,000 | 122,000 | 122,000 | 122,000 | 0 |
| 2013 | 129,000 | 129,000 | 129,000 | 129,000 | 0 |
| 2014 | 129,000 | 129,000 | 129,000 | 129,000 | 2 |
| 2015 | 129,000 | 129,000 | 129,000 | 129,000 | 53 |
| 2016 | 123,000 | 124,000 | 124,000 | 125,000 | 667 |
| 2017 | 112,000 | 117,000 | 118,000 | 126,000 | 4,260 |
| 2018 | 100,000 | 113,000 | 114,000 | 133,000 | 10,113 |
| 2019 | 92,800 | 110,000 | 112,000 | 136,000 | 13,310 |
| 2020 | 89,300 | 110,000 | 111,000 | 136,000 | 14,726 |
| 2021 | 88,000 | 108,000 | 110,000 | 139,000 | 15,144 |
| 2022 | 86,300 | 107,000 | 109,000 | 136,000 | 15,078 |
| 2023 | 86,200 | 107,000 | 109,000 | 135,000 | 14,895 |
| 2024 | 86,300 | 107,000 | 108,000 | 133,000 | 14,748 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2013 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2014 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2015 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2016 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2017 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2018 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2019 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2020 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2021 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2022 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2023 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |
| 2024 | 0.41 | 0.41 | 0.41 | 0.41 | 0.00 |

Table 2.34—Projections for GOA 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 2012-2024 (Scenario 4), with random variability in future recruitment.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 44,100 | 44,100 | 44,100 | 44,100 | 0 |
| 2013 | 51,200 | 51,200 | 51,200 | 51,200 | 0 |
| 2014 | 55,100 | 55,100 | 55,100 | 55,100 | 1 |
| 2015 | 56,700 | 56,800 | 56,800 | 56,800 | 37 |
| 2016 | 55,900 | 56,400 | 56,500 | 57,300 | 472 |
| 2017 | 52,500 | 54,700 | 55,000 | 58,300 | 1,820 |
| 2018 | 48,200 | 53,200 | 53,600 | 60,600 | 3,843 |
| 2019 | 44,900 | 52,300 | 52,800 | 62,700 | 5,415 |
| 2020 | 43,400 | 52,000 | 52,300 | 63,000 | 6,209 |
| 2021 | 42,500 | 51,500 | 52,100 | 63,800 | 6,497 |
| 2022 | 42,200 | 51,100 | 51,800 | 63,700 | 6,534 |
| 2023 | 41,600 | 50,900 | 51,500 | 63,000 | 6,478 |
| 2024 | 41,600 | 50,900 | 51,300 | 62,500 | 6,416 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 126,000 | 126,000 | 126,000 | 126,000 | 0 |
| 2013 | 149,000 | 149,000 | 149,000 | 149,000 | 0 |
| 2014 | 161,000 | 161,000 | 161,000 | 161,000 | 2 |
| 2015 | 170,000 | 170,000 | 170,000 | 170,000 | 53 |
| 2016 | 169,000 | 170,000 | 170,000 | 171,000 | 671 |
| 2017 | 161,000 | 166,000 | 167,000 | 175,000 | 4,397 |
| 2018 | 148,000 | 162,000 | 164,000 | 184,000 | 11,087 |
| 2019 | 139,000 | 160,000 | 161,000 | 190,000 | 15,491 |
| 2020 | 134,000 | 159,000 | 160,000 | 190,000 | 17,921 |
| 2021 | 131,000 | 157,000 | 159,000 | 193,000 | 19,008 |
| 2022 | 130,000 | 156,000 | 158,000 | 192,000 | 19,286 |
| 2023 | 128,000 | 155,000 | 157,000 | 191,000 | 19,226 |
| 2024 | 128,000 | 155,000 | 156,000 | 190,000 | 19,084 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2013 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2014 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2015 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2016 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2017 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2018 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2019 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2020 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2021 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2022 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2023 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |
| 2024 | 0.21 | 0.21 | 0.21 | 0.21 | 0.00 |

Table 2.35—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F$ = 0 in 2012-2024 (Scenario 5), with random variability in future recruitment.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0 | 0 | 0 | 0 | 0 |
| 2013 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 0 | 0 | 0 | 0 | 0 |
| 2019 | 0 | 0 | 0 | 0 | 0 |
| 2020 | 0 | 0 | 0 | 0 | 0 |
| 2021 | 0 | 0 | 0 | 0 | 0 |
| 2022 | 0 | 0 | 0 | 0 | 0 |
| 2023 | 0 | 0 | 0 | 0 | 0 |
| 2024 | 0 | 0 | 0 | 0 | 0 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 131,000 | 131,000 | 131,000 | 131,000 | 0 |
| 2013 | 172,000 | 172,000 | 172,000 | 172,000 | 0 |
| 2014 | 205,000 | 205,000 | 205,000 | 205,000 | 2 |
| 2015 | 231,000 | 231,000 | 231,000 | 231,000 | 53 |
| 2016 | 246,000 | 247,000 | 247,000 | 248,000 | 675 |
| 2017 | 248,000 | 254,000 | 254,000 | 262,000 | 4,540 |
| 2018 | 241,000 | 257,000 | 258,000 | 281,000 | 12,188 |
| 2019 | 234,000 | 258,000 | 260,000 | 294,000 | 18,280 |
| 2020 | 229,000 | 260,000 | 261,000 | 301,000 | 22,505 |
| 2021 | 226,000 | 260,000 | 262,000 | 306,000 | 25,124 |
| 2022 | 223,000 | 259,000 | 262,000 | 309,000 | 26,499 |
| 2023 | 219,000 | 258,000 | 261,000 | 310,000 | 27,102 |
| 2024 | 220,000 | 258,000 | 261,000 | 309,000 | 27,308 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2024 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 2.36—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = F_{OFL}$ in 2012-2024 (Scenario 6), with random variability in future recruitment.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 104,000 | 104,000 | 104,000 | 104,000 | 0 |
| 2013 | 103,000 | 103,000 | 103,000 | 103,000 | 0 |
| 2014 | 99,400 | 99,400 | 99,400 | 99,400 | 3 |
| 2015 | 95,300 | 95,400 | 95,500 | 95,600 | 96 |
| 2016 | 88,000 | 90,000 | 90,100 | 92,400 | 1,363 |
| 2017 | 72,100 | 80,200 | 81,200 | 93,200 | 6,472 |
| 2018 | 60,300 | 76,300 | 77,600 | 97,700 | 11,704 |
| 2019 | 56,000 | 75,800 | 76,800 | 100,000 | 14,025 |
| 2020 | 55,300 | 76,100 | 77,100 | 102,000 | 14,656 |
| 2021 | 54,600 | 75,800 | 77,300 | 103,000 | 14,616 |
| 2022 | 54,800 | 75,600 | 77,100 | 101,000 | 14,531 |
| 2023 | 54,900 | 75,700 | 76,600 | 100,000 | 14,333 |
| 2024 | 55,200 | 75,100 | 76,400 | 100,000 | 14,402 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 119,000 | 119,000 | 119,000 | 119,000 | 0 |
| 2013 | 119,000 | 119,000 | 119,000 | 119,000 | 0 |
| 2014 | 114,000 | 114,000 | 114,000 | 114,000 | 2 |
| 2015 | 111,000 | 111,000 | 111,000 | 111,000 | 53 |
| 2016 | 104,000 | 104,000 | 105,000 | 106,000 | 643 |
| 2017 | 94,100 | 98,600 | 99,200 | 106,000 | 3,827 |
| 2018 | 85,900 | 96,100 | 97,200 | 113,000 | 8,321 |
| 2019 | 82,800 | 95,700 | 96,700 | 116,000 | 10,170 |
| 2020 | 82,000 | 96,000 | 97,000 | 117,000 | 10,837 |
| 2021 | 81,800 | 95,400 | 97,200 | 119,000 | 10,924 |
| 2022 | 81,800 | 95,500 | 97,000 | 116,000 | 10,737 |
| 2023 | 81,700 | 95,500 | 96,700 | 115,000 | 10,569 |
| 2024 | 82,000 | 95,200 | 96,500 | 115,000 | 10,457 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2013 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2014 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2015 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2016 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2017 | 0.48 | 0.50 | 0.50 | 0.53 | 0.02 |
| 2018 | 0.43 | 0.49 | 0.49 | 0.53 | 0.03 |
| 2019 | 0.42 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2020 | 0.41 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2021 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2022 | 0.41 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2023 | 0.41 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2024 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |

Table 2.37—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in each year 2012-2013 and $F = F_{OFL}$ thereafter (Scenario 7), with random variability in future recruitment.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 87,600 | 87,600 | 87,600 | 87,600 | 0 |
| 2013 | 91,000 | 91,000 | 91,000 | 91,000 | 0 |
| 2014 | 107,000 | 107,000 | 107,000 | 107,000 | 3 |
| 2015 | 99,600 | 99,700 | 99,700 | 99,900 | 96 |
| 2016 | 90,800 | 92,300 | 92,500 | 94,600 | 1,204 |
| 2017 | 73,900 | 82,300 | 83,200 | 94,300 | 6,365 |
| 2018 | 60,800 | 76,900 | 78,100 | 98,200 | 11,707 |
| 2019 | 56,100 | 75,900 | 76,900 | 101,000 | 14,046 |
| 2020 | 55,300 | 76,100 | 77,100 | 102,000 | 14,668 |
| 2021 | 54,700 | 75,800 | 77,300 | 103,000 | 14,621 |
| 2022 | 54,800 | 75,600 | 77,100 | 101,000 | 14,533 |
| 2023 | 54,900 | 75,700 | 76,600 | 100,000 | 14,334 |
| 2024 | 55,200 | 75,100 | 76,400 | 100,000 | 14,403 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 121,000 | 121,000 | 121,000 | 121,000 | 0 |
| 2013 | 127,000 | 127,000 | 127,000 | 127,000 | 0 |
| 2014 | 123,000 | 123,000 | 123,000 | 123,000 | 2 |
| 2015 | 117,000 | 117,000 | 117,000 | 117,000 | 53 |
| 2016 | 107,000 | 108,000 | 108,000 | 109,000 | 664 |
| 2017 | 95,400 | 100,000 | 101,000 | 108,000 | 3,904 |
| 2018 | 86,300 | 96,500 | 97,700 | 114,000 | 8,415 |
| 2019 | 82,900 | 95,800 | 96,900 | 116,000 | 10,222 |
| 2020 | 82,000 | 96,000 | 97,000 | 117,000 | 10,857 |
| 2021 | 81,800 | 95,400 | 97,200 | 119,000 | 10,932 |
| 2022 | 81,800 | 95,500 | 97,000 | 116,000 | 10,740 |
| 2023 | 81,700 | 95,500 | 96,700 | 115,000 | 10,570 |
| 2024 | 82,000 | 95,200 | 96,500 | 115,000 | 10,458 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2013 | 0.44 | 0.44 | 0.44 | 0.44 | 0.00 |
| 2014 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2015 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2016 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2017 | 0.48 | 0.51 | 0.51 | 0.53 | 0.02 |
| 2018 | 0.44 | 0.49 | 0.49 | 0.53 | 0.03 |
| 2019 | 0.42 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2020 | 0.41 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2021 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2022 | 0.41 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2023 | 0.41 | 0.49 | 0.48 | 0.53 | 0.04 |
| 2024 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |

Table 2.38—Incidental catch (t) of non-target species groups by GOA Pacific cod fisheries, 2003-2011.

| Species/group | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| Benthic urochordata | | 0 | | 0 | 0 | 1 | 3 | 0 | 0 |
| Birds | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| Bivalves | 1 | 0 | 1 | 2 | 1 | 2 | 4 | 3 | 6 |
| Brittle star unidentified | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Capelin | | | | | | 0 | | | |
| Corals bryozoans | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 |
| Dark rockfish | | | | | | 0 | 3 | 12 | 1 |
| Eelpouts | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 |
| Eulachon | 0 | | 0 | 2 | 0 | 0 | | 1 | |
| Giant grenadier | | | | 22 | 79 | 31 | 51 | 138 | 76 |
| Greenlings | 3 | 6 | 1 | 4 | 1 | 7 | 1 | 1 | 1 |
| Grenadier | 5 | 0 | | 1 | | 66 | 7 | 0 | 4 |
| Gunnels | | | | | | 0 | | | |
| Hermit crab unidentified | 1 | 0 | 0 | 1 | 2 | 3 | 4 | 2 | 1 |
| Invertebrate unidentified | 1 | 4 | 0 | 13 | 2 | 1 | 0 | 1 | 8 |
| Misc crabs | 1 | 0 | 2 | 1 | 7 | 2 | 2 | 3 | 2 |
| Misc crustaceans | | 0 | | | | | 0 | | 0 |
| Misc fish | 86 | 136 | 152 | 176 | 539 | 210 | 99 | 87 | 127 |
| Misc inverts (worms etc) | | | | 0 | 0 | | 0 | | |
| Other osmerids | | 0 | | | 0 | 0 | | | |
| Pacific sand lance | | 0 | | 0 | | | 0 | | 0 |
| Pandalid shrimp | | | 0 | | 0 | 0 | 0 | 0 | |
| Scypho jellies | 9 | 2 | 1 | 5 | 0 | 0 | 0 | 11 | 1 |
| Sea anemone unidentified | 1 | 2 | 1 | 0 | 5 | 6 | 6 | 7 | 9 |
| Sea pens whips | 0 | 0 | 0 | 3 | 1 | | 3 | 3 | 1 |
| Sea star | 468 | 1009 | 937 | 703 | 301 | 314 | 470 | 868 | 675 |
| Snails | 5 | 1 | 5 | 3 | 1 | 1 | 2 | 1 | 1 |
| Sponge unidentified | 0 | 1 | 1 | 1 | 0 | 1 | 2 | 0 | 0 |
| Stichaeidae | 0 | | 0 | | | | 2 | | 0 |
| Surf smelt | | | 0 | | | | | | |
| Urchins dollars cucumbers | 1 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 2 |

Table 2.39a—Catches of prohibited species by GOA Pacific cod fisheries, 2003-2011. Halibut and herring are in kg, salmon and crab are in number of individuals.

| Species/group | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| Halibut | 2,145,501 | 3,884,980 | 2,842,541 | 3,170,012 | 2,938,422 | 4,671,974 | 2,487,203 | 2,456,282 | 2,615,115 |
| Herring | 0 | 22 | 0 | 0 | 0 | 0 | 8 | 0 | 0 |
| Chinook Salmon | 3,167 | 920 | 41 | 888 | 624 | 436 | 111 | 435 | 1,247 |
| Non-Chinook Salmon | 0 | 56 | 144 | 0 | 150 | 34 | 0 | 114 | 0 |
| Bairdi Tanner Crab | 15,263 | 18,192 | 118,876 | 104,761 | 308,021 | 261,055 | 37,040 | 173,873 | 18,116 |
| Blue King Crab | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Golden (Brown) King Crab | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Opilio Tanner (Snow) Crab | 850 | 0 | 0 | 401 | 4,960 | 262 | 20 | 18 | 0 |
| Red King Crab | 0 | 31 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |

Table 2.39b—Halibut mortality (t) resulting from GOA Pacific cod fisheries, 2003-2011.

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| Halibut mortality (t) | 656 | 1247 | 900 | 689 | 779 | 1116 | 573 | 502 | 685 |

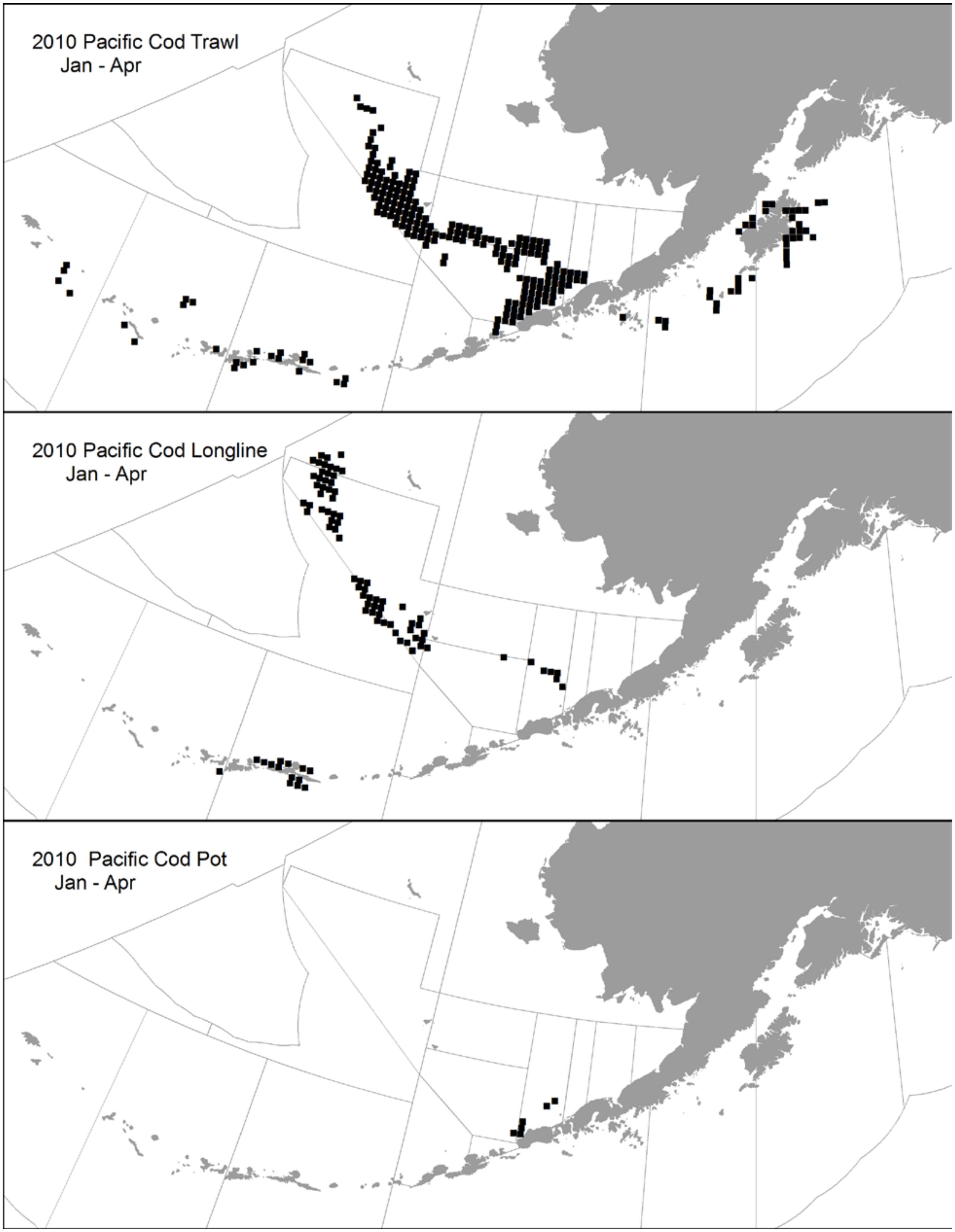



Figure 2.1a—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, January-April 2010, by gear type, overlaid against NMFS 3-digit statistical areas.

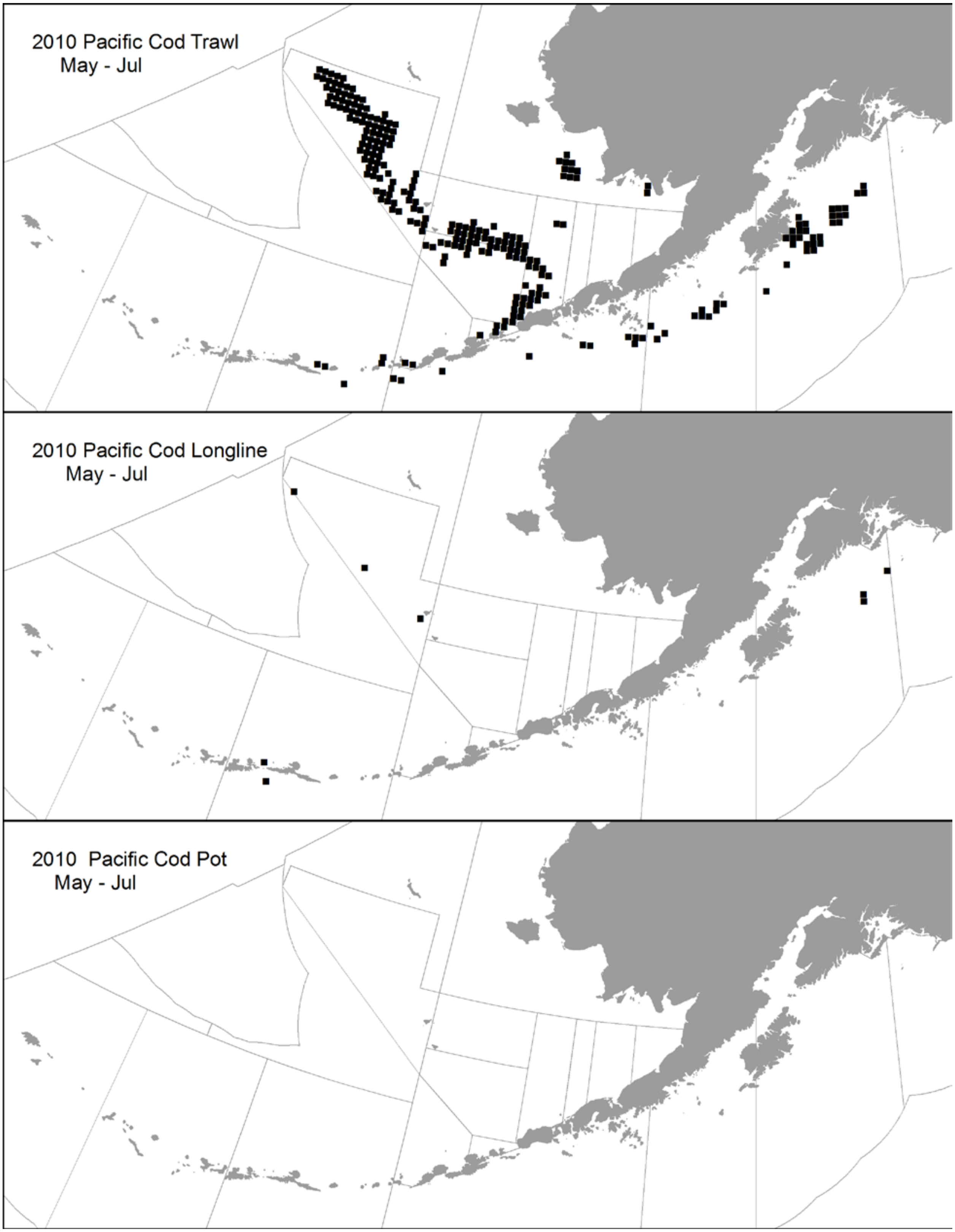



Figure 2.1b—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, May-July 2010, by gear type, overlaid against NMFS 3-digit statistical areas.

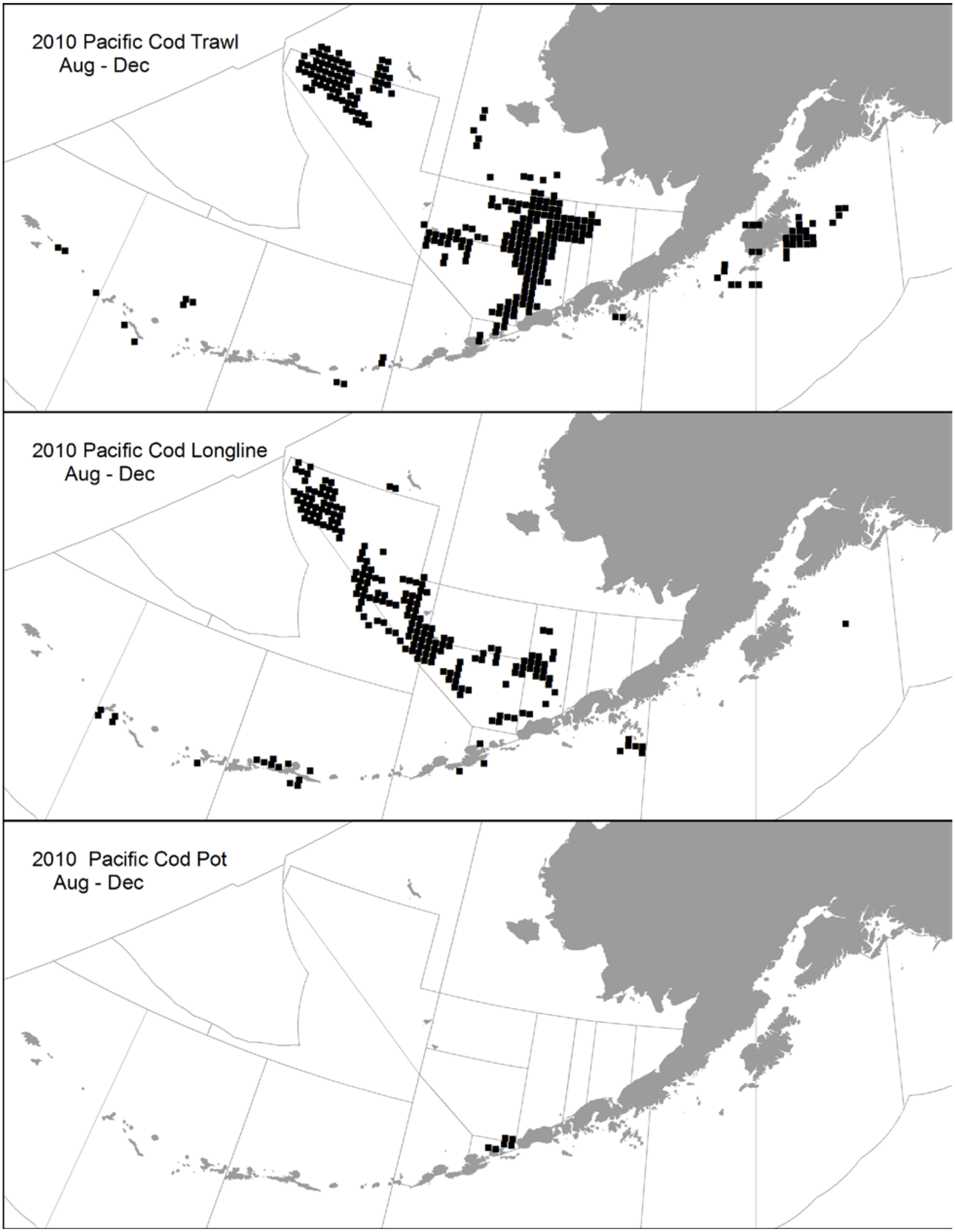



Figure 2.1c—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, August-Dec. 2010, by gear type, overlaid against NMFS 3-digit statistical areas.

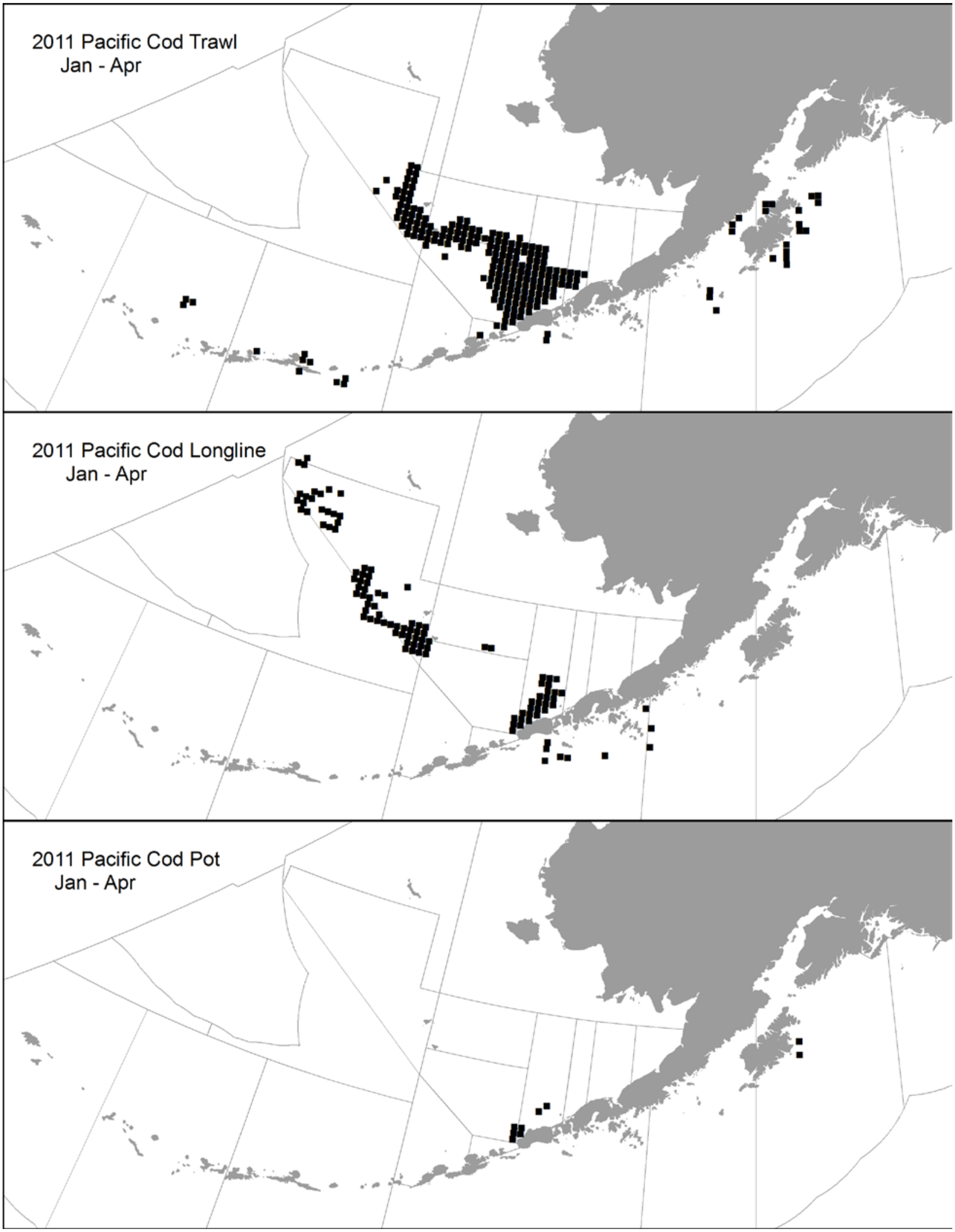



Figure 2.1d—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, January-April 2011, by gear type, overlaid against NMFS 3-digit statistical areas.

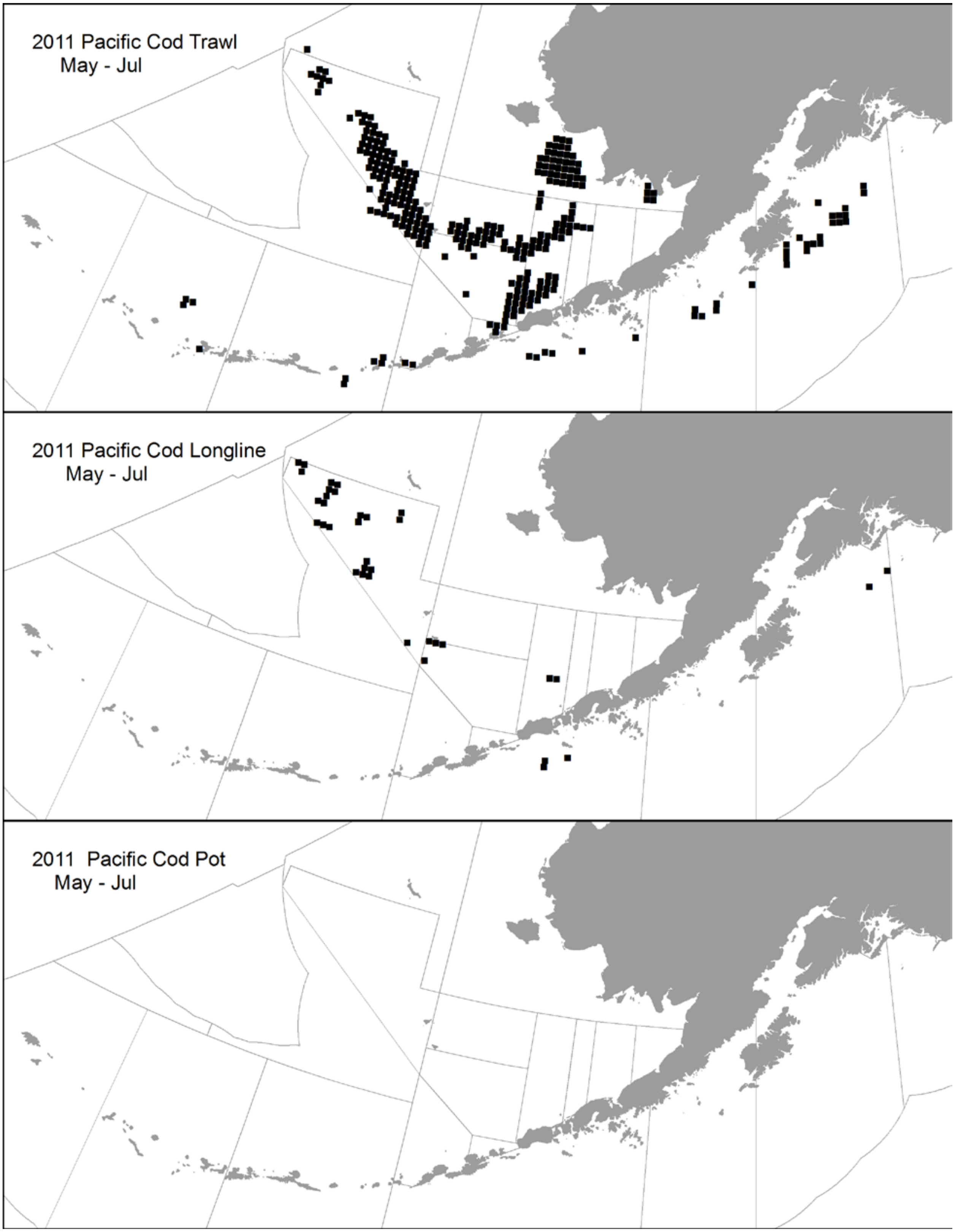



Figure 2.1e—Maps showing each 400 square kilometer cell with hauls/sets containing Pacific cod from at least 3 distinct vessels, May-July 2011, by gear type, overlaid against NMFS 3-digit statistical areas.

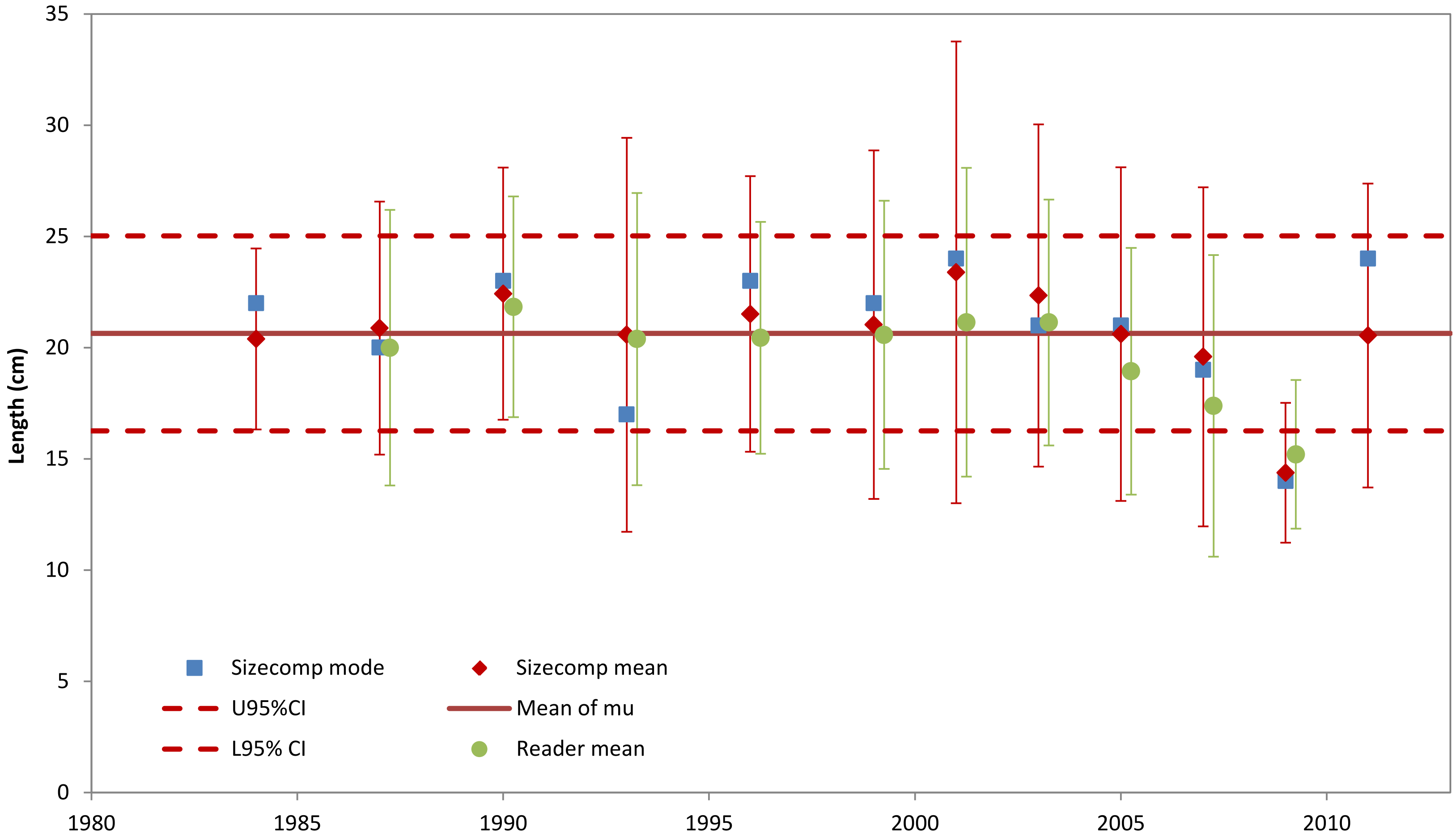
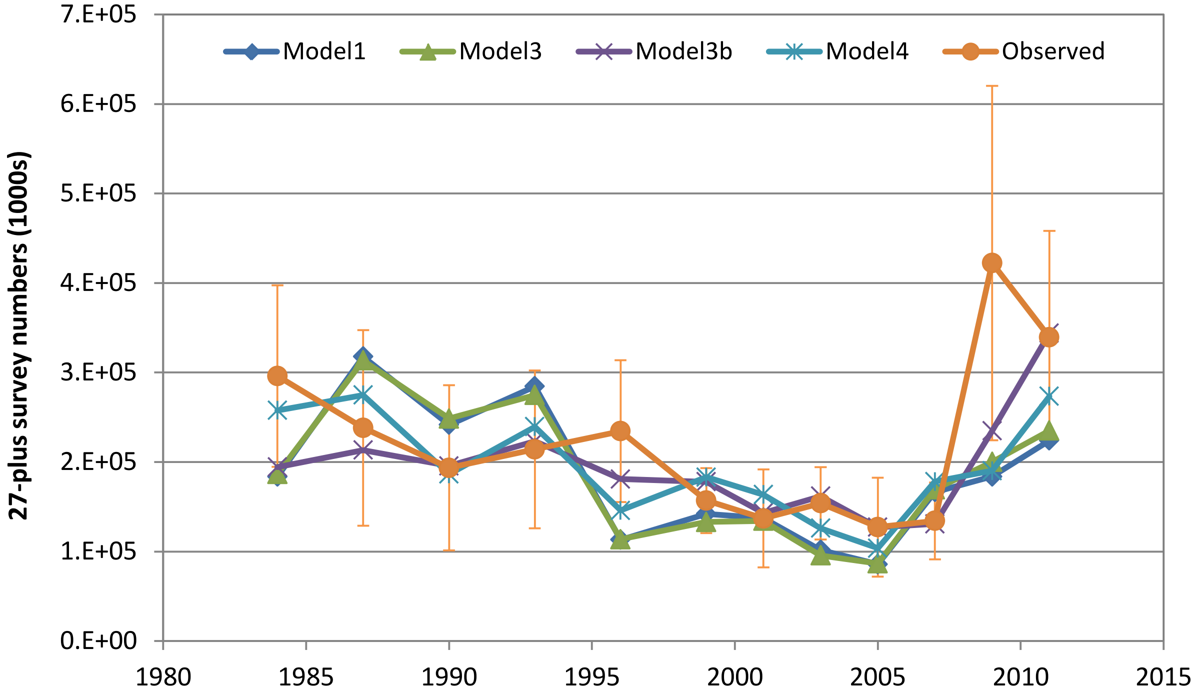



Figure 2.2—Time series of age 1 size distributions as estimated from survey size composition data and age readings.

**27-plus**




**Sub-27**

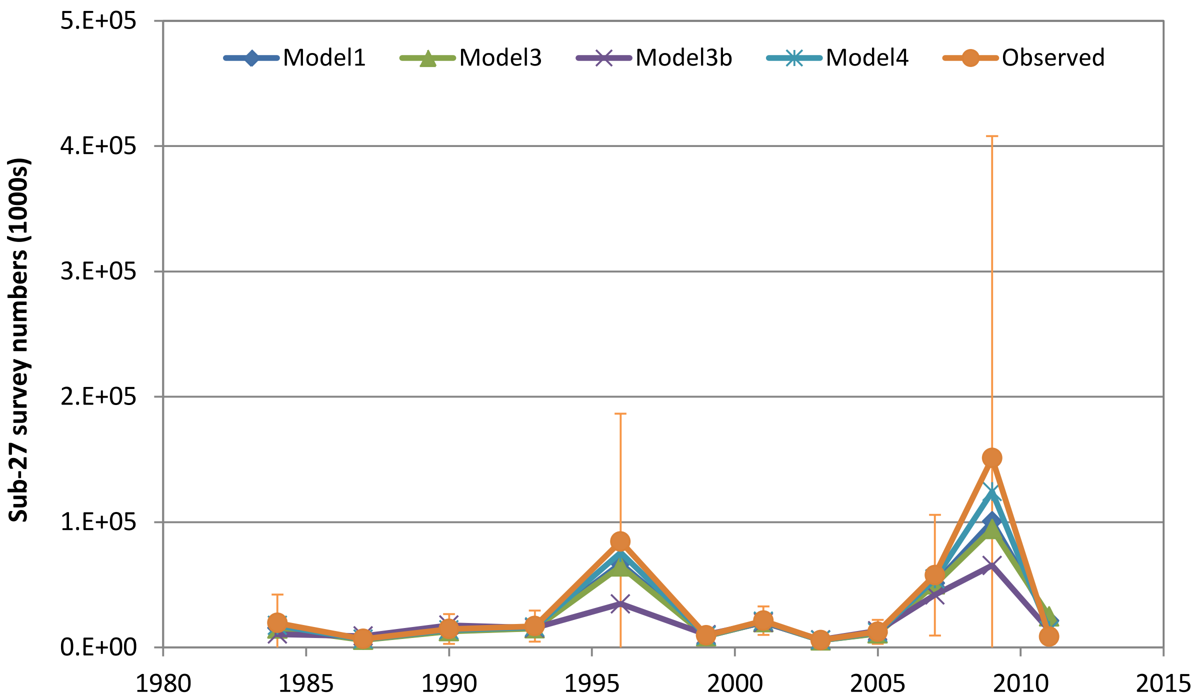



Figure 2.3—Fits of the four models to the 27-plus and sub-27 trawl survey abundance time series.

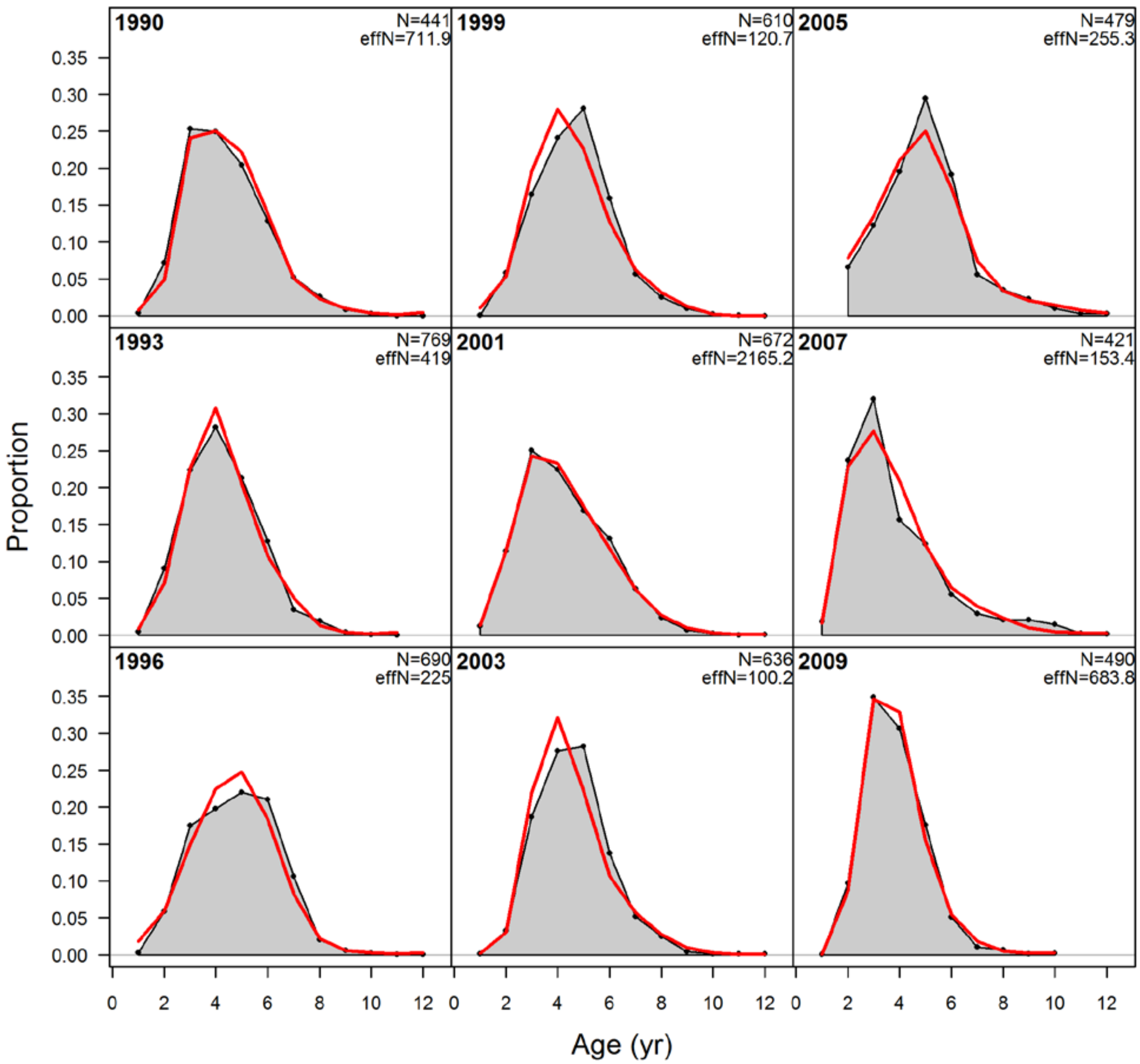



Figure 2.4a—Fit to 27-plus trawl survey age composition data obtained by Model 1.

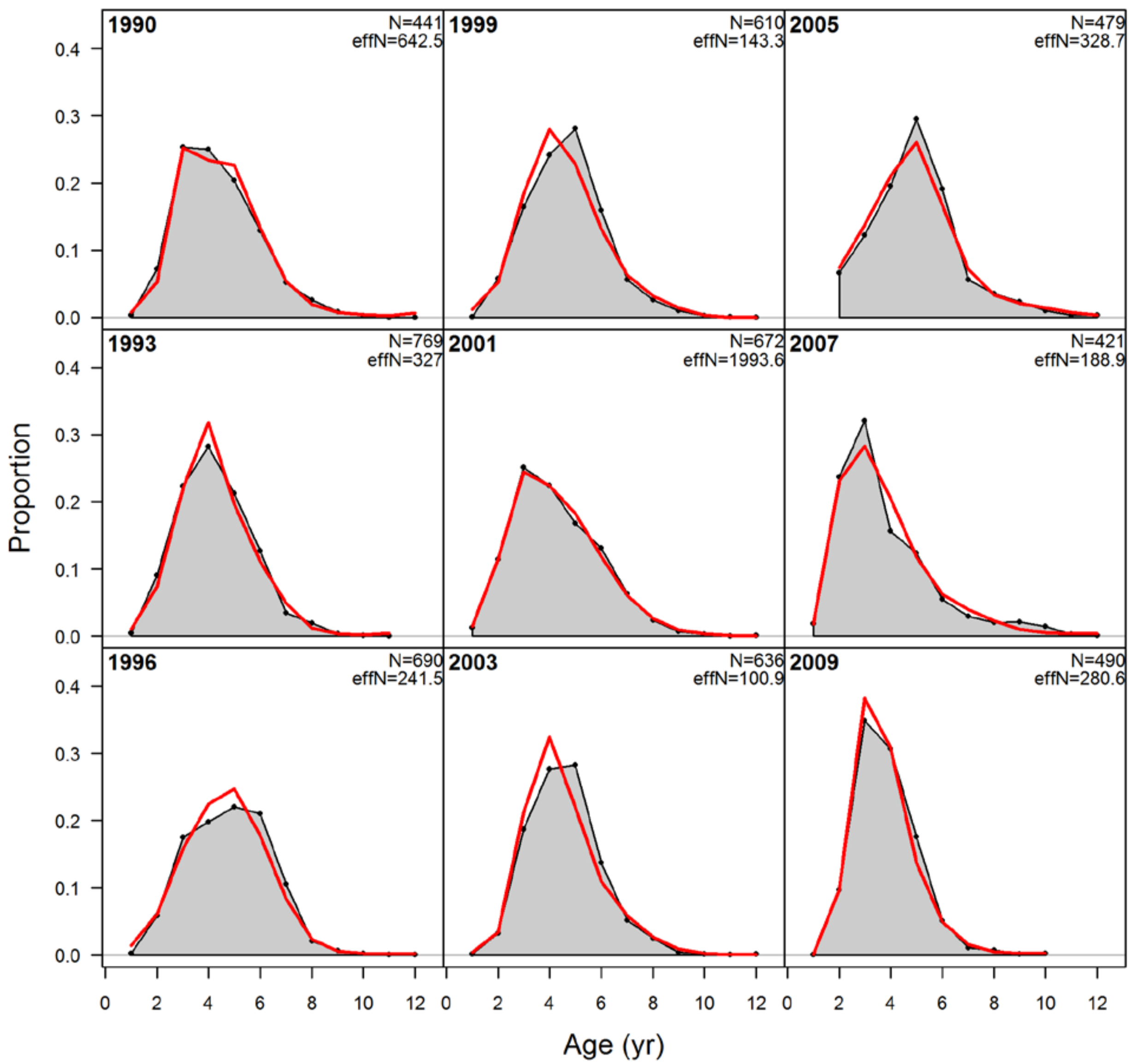



Figure 2.4b—Fit to 27-plus trawl survey age composition data obtained by Model 3.

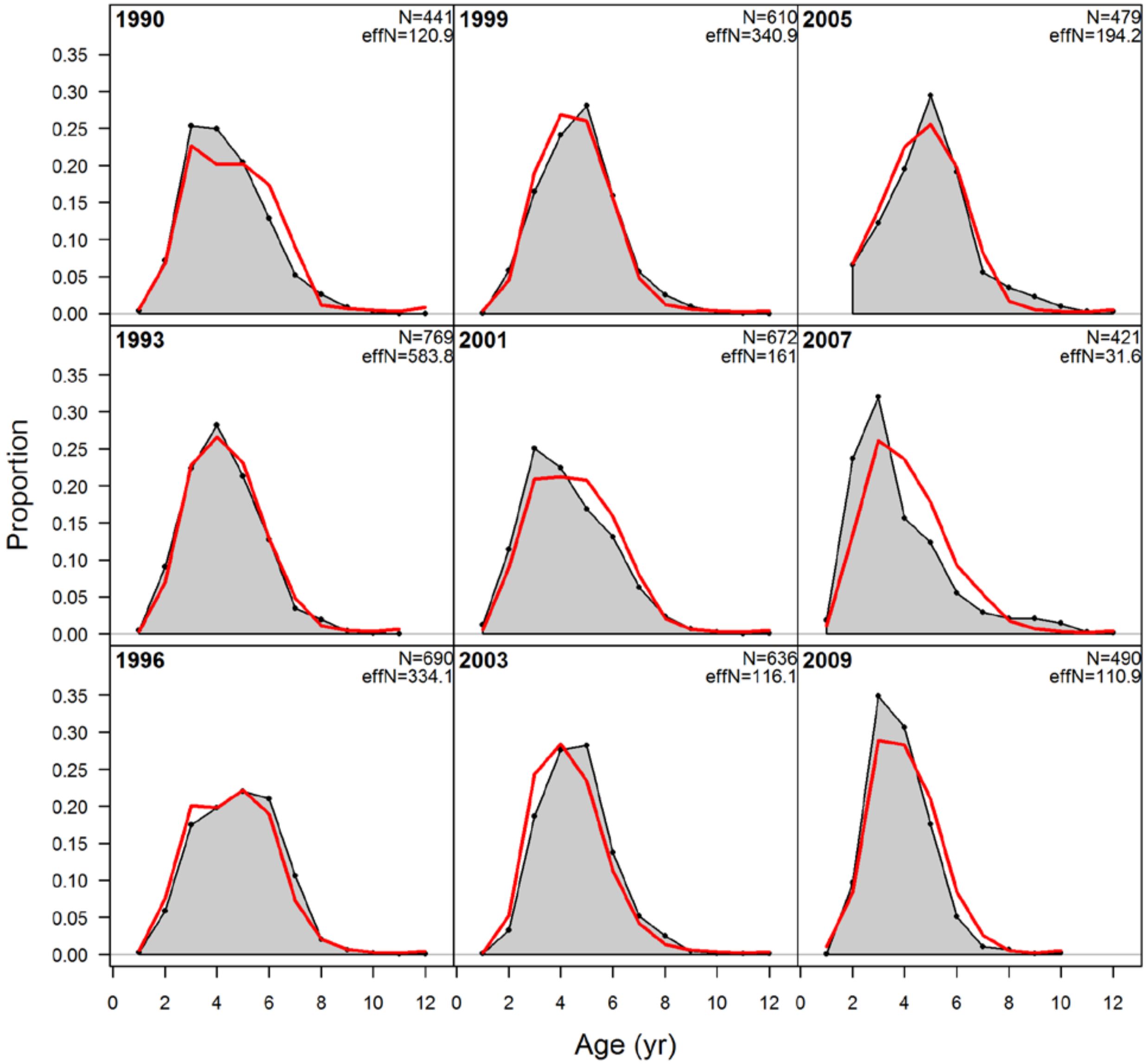



Figure 2.4c—Fit to 27-plus trawl survey age composition data obtained by Model 3b.

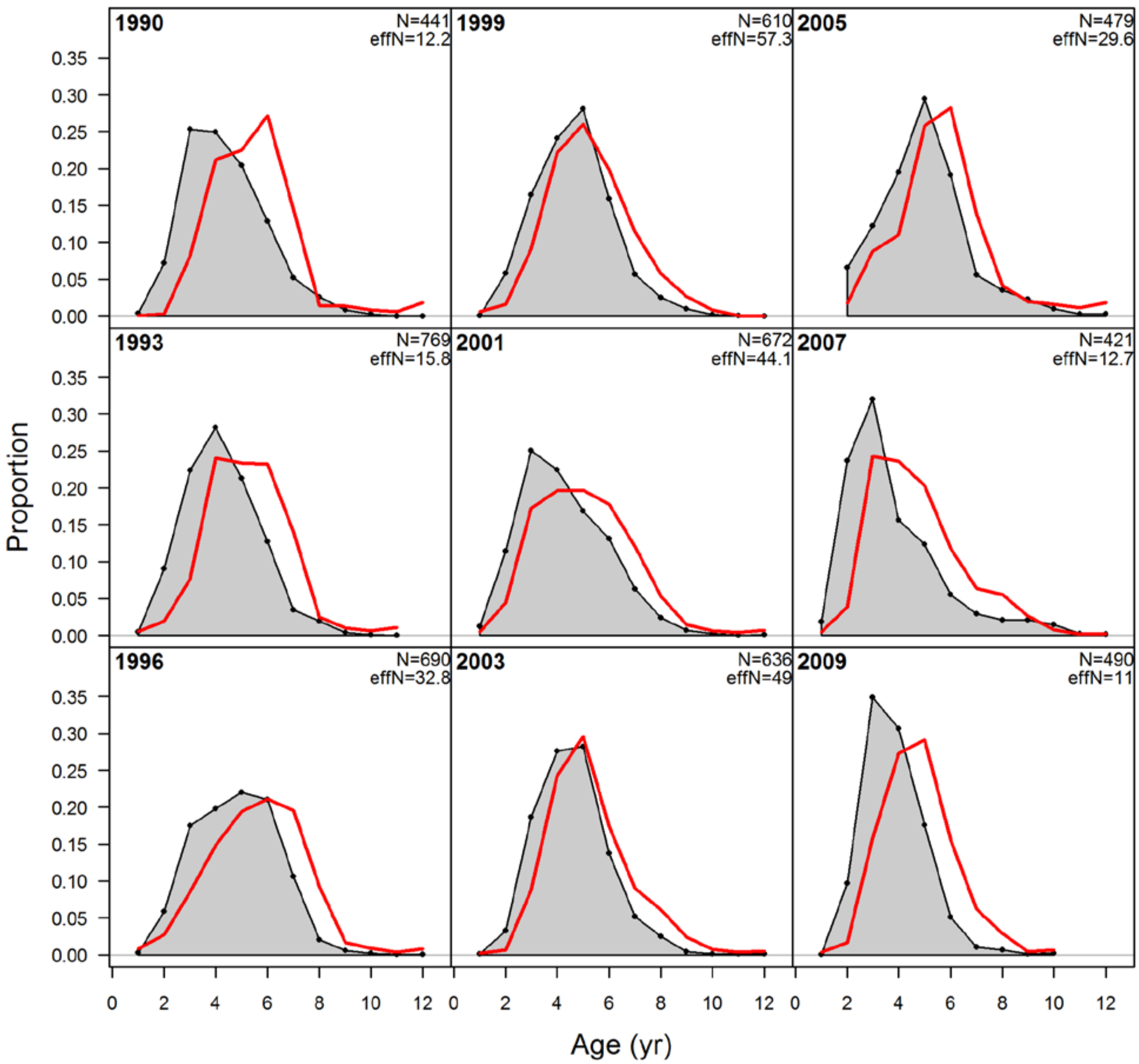



Figure 2.4d—Fit to 27-plus trawl survey age composition data obtained by Model 4.

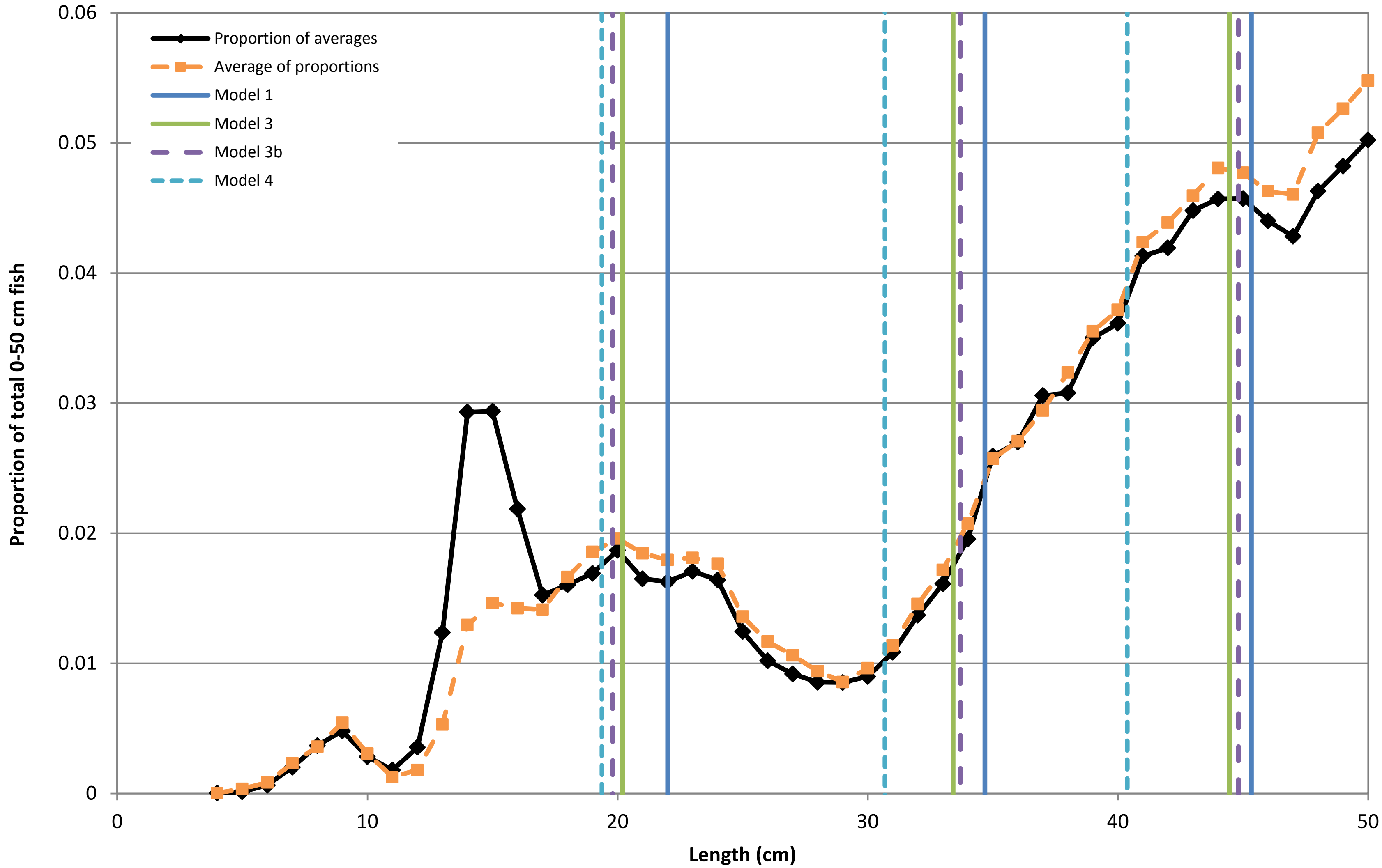



Figure 2.5—Estimates of mean size at ages 1-3 from each of the models, compared to long-term average survey size (0-50 cm) composition.

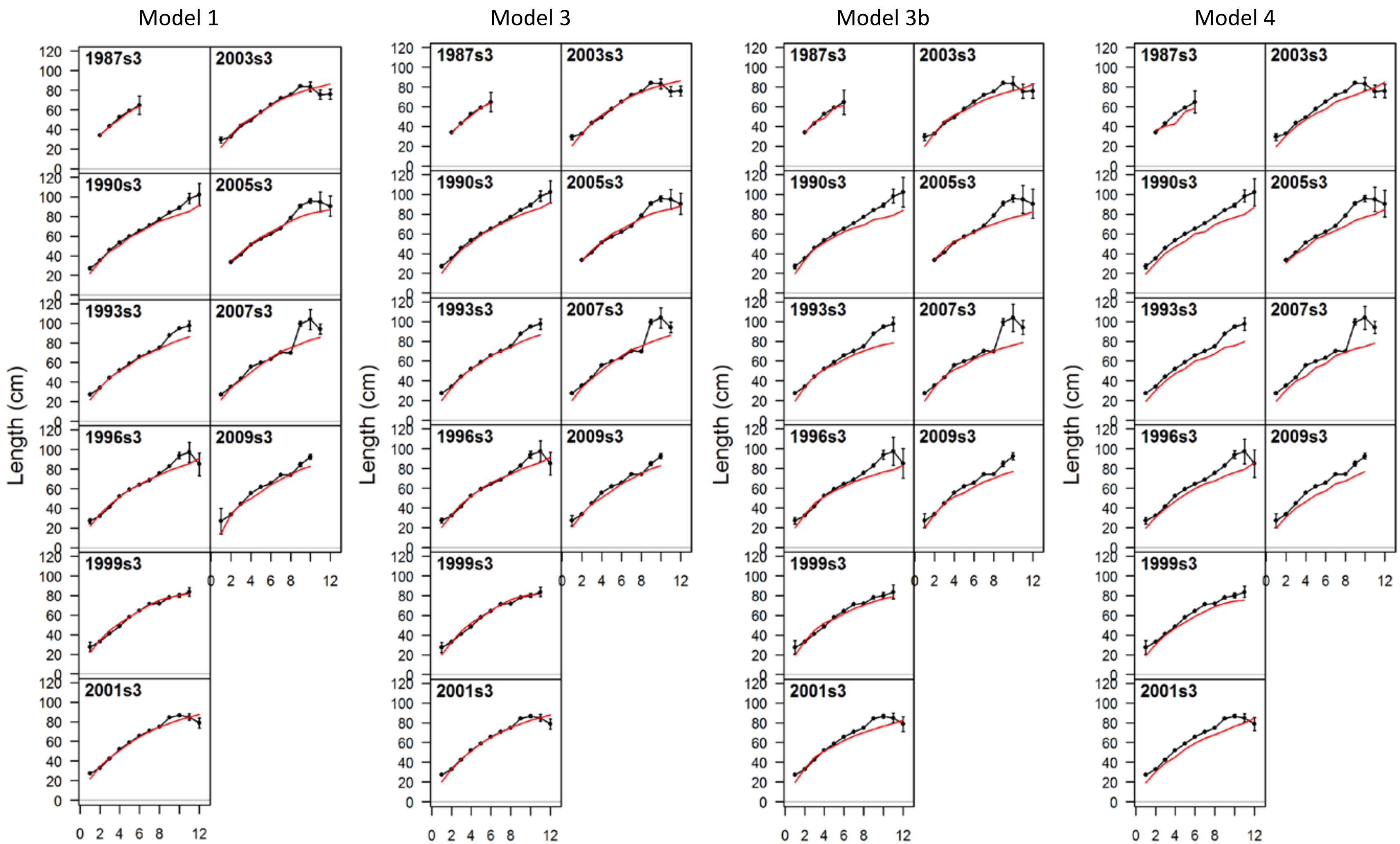



Figure 2.6—Fit to size-at-age data from all four models.

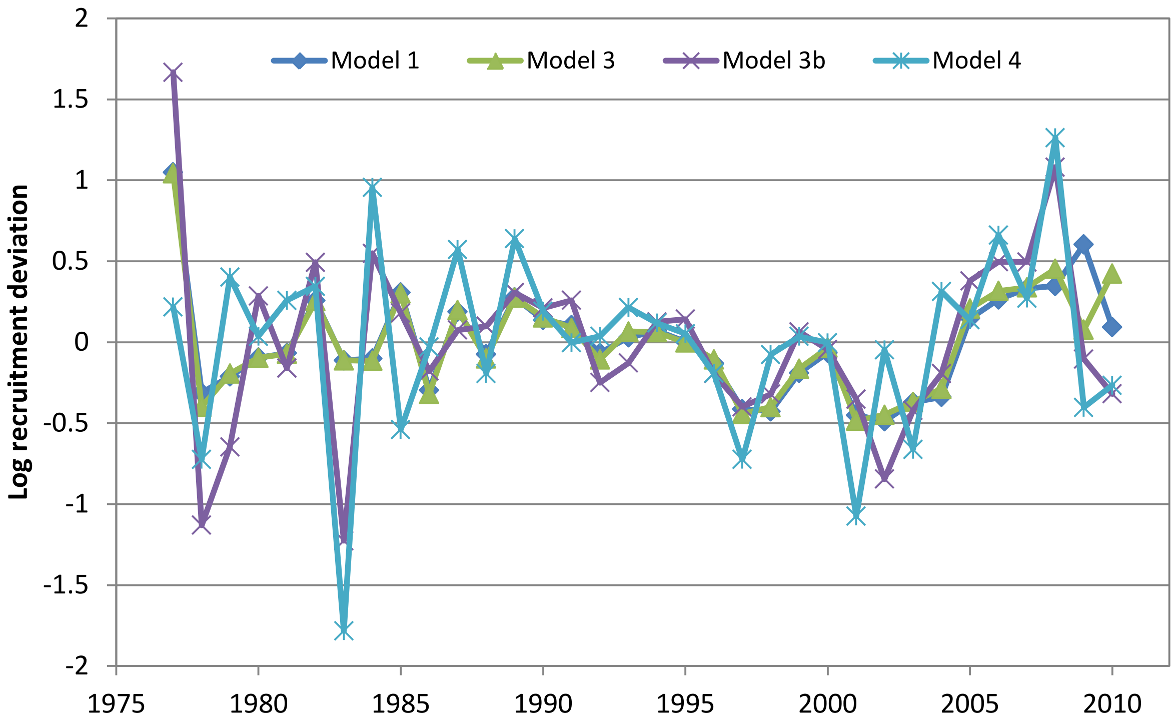



Figure 2.7—Time series of estimated log recruitment deviations from the four models.

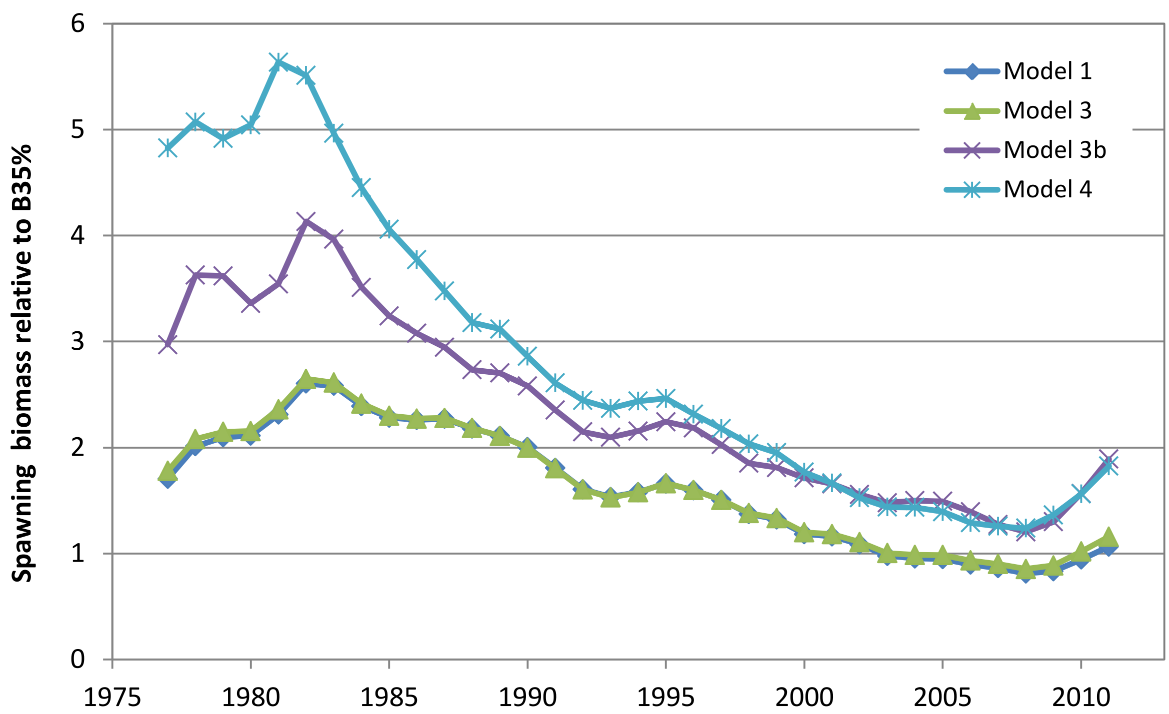



Figure 2.8—Time series of spawning biomass relative to $B_{35\%}$ as estimated by the four models.

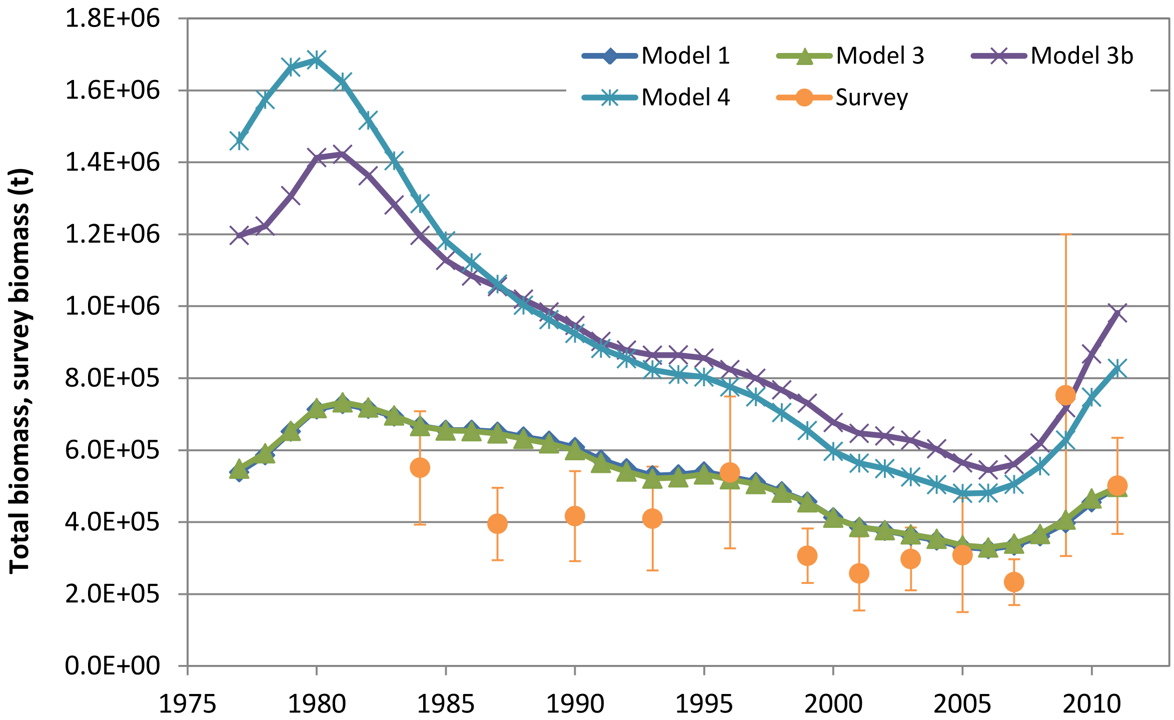



Figure 2.9—Time series of total (age 0+) biomass as estimated by the four models. Survey biomass (all lengths) is shown for comparison.

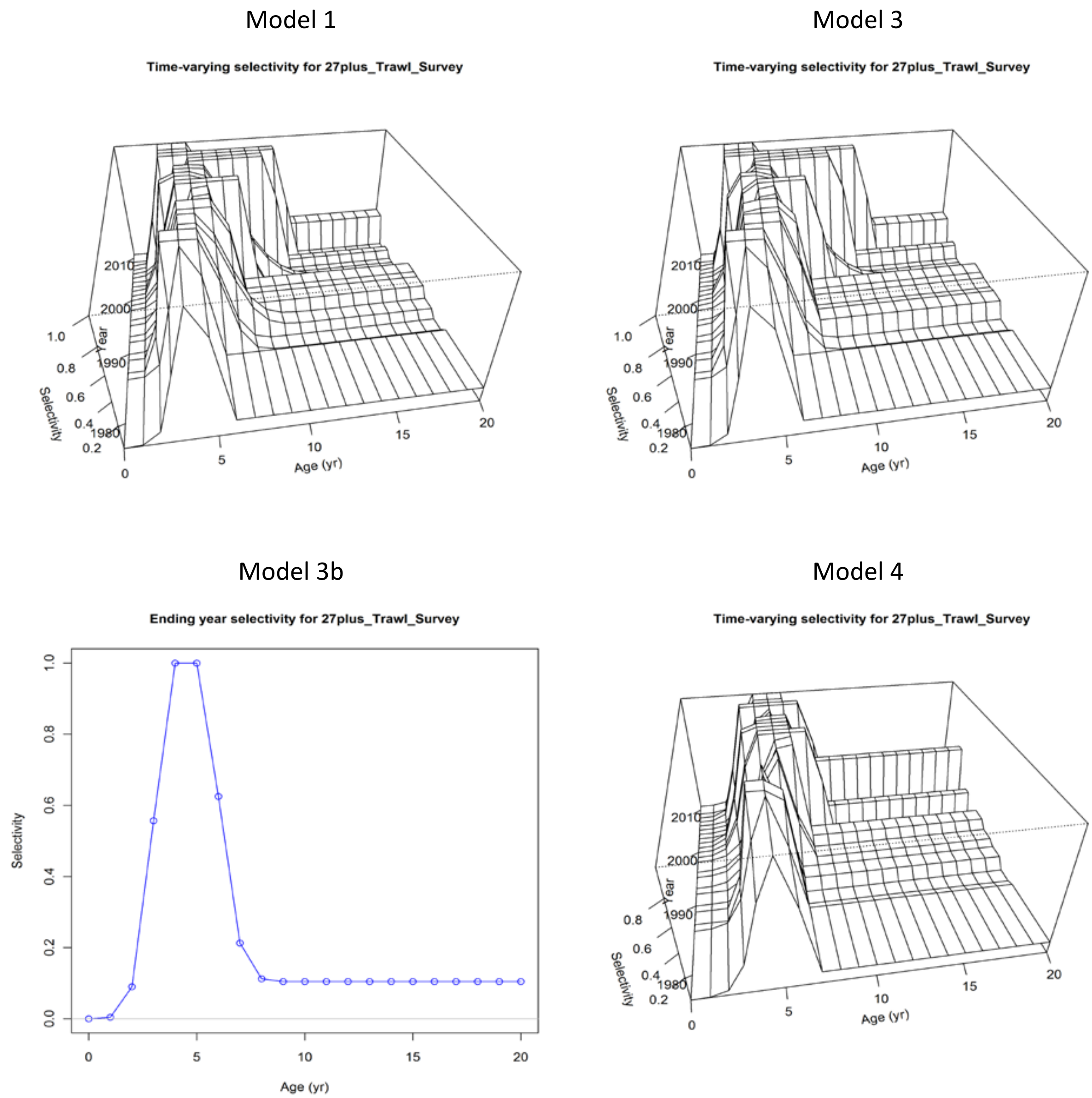



Figure 2.10a—27-plus trawl survey selectivity at age as estimated by the four models.

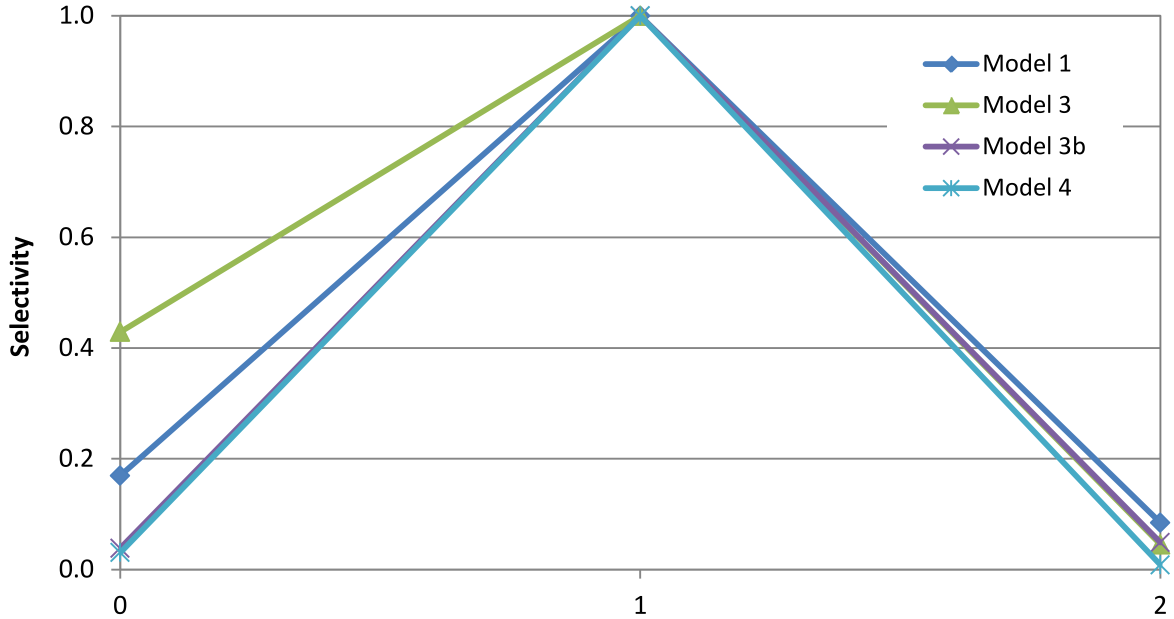



Figure 2.10b—Sub-27 trawl survey selectivity at ages 0-2 as estimated by the four models.

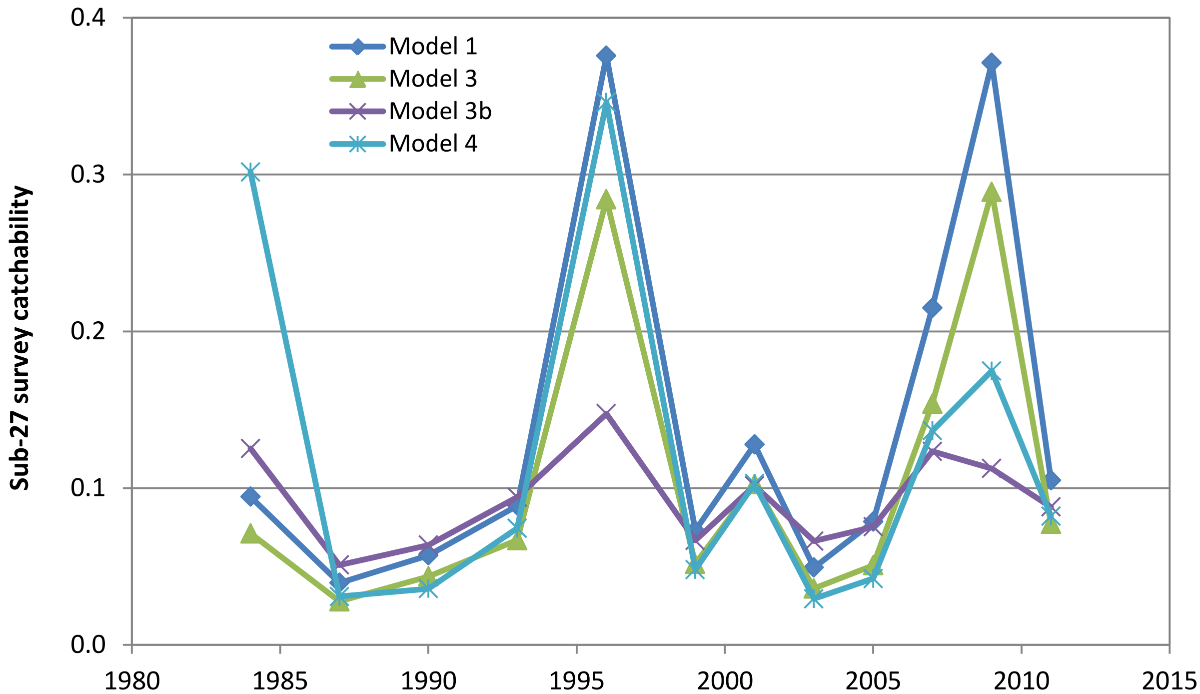



Figure 2.10c—Sub-27 trawl survey catchability as estimated by the four models.

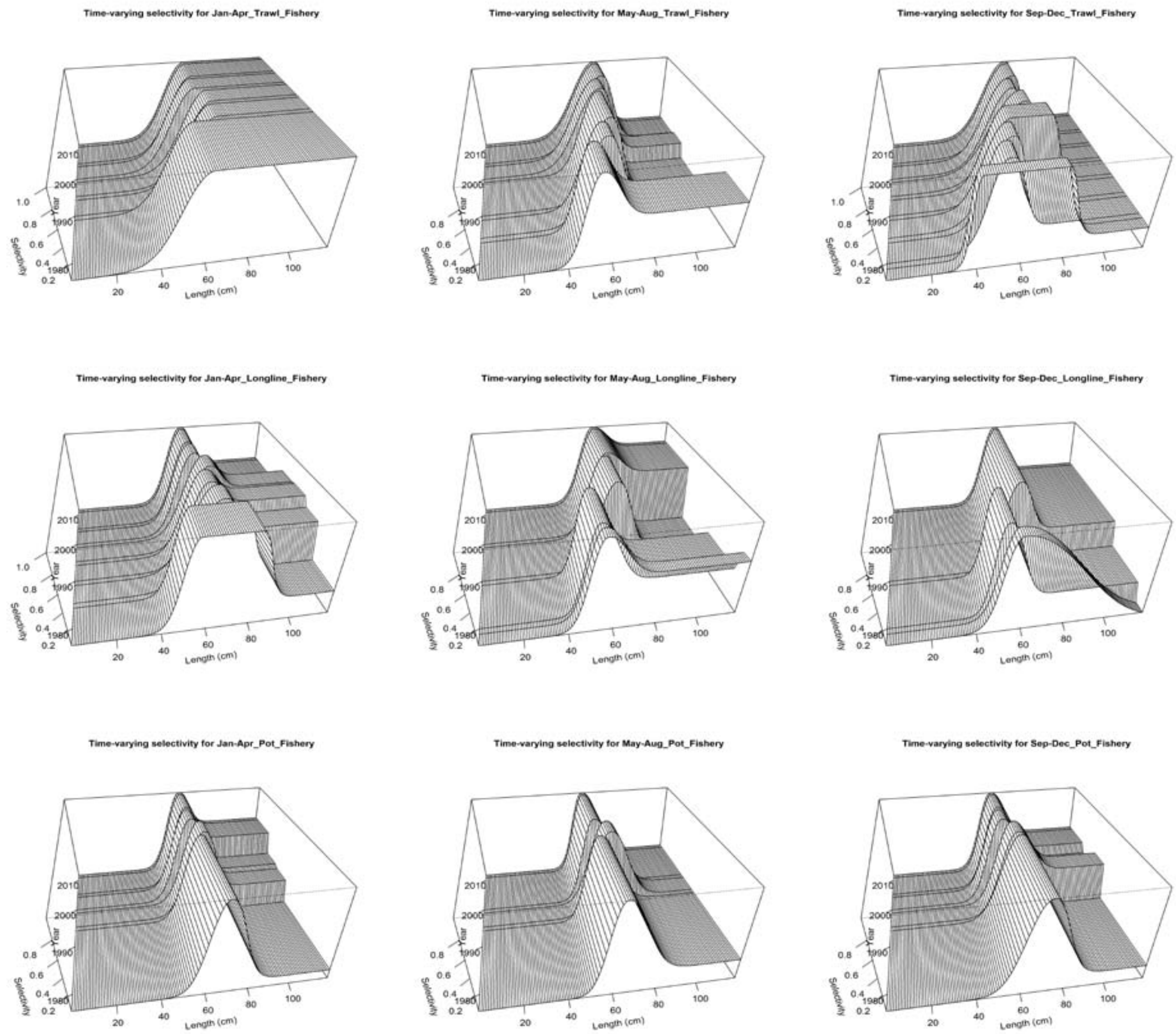



Figure 2.11a—Fishery selectivity at length (cm) as estimated by Model 1.

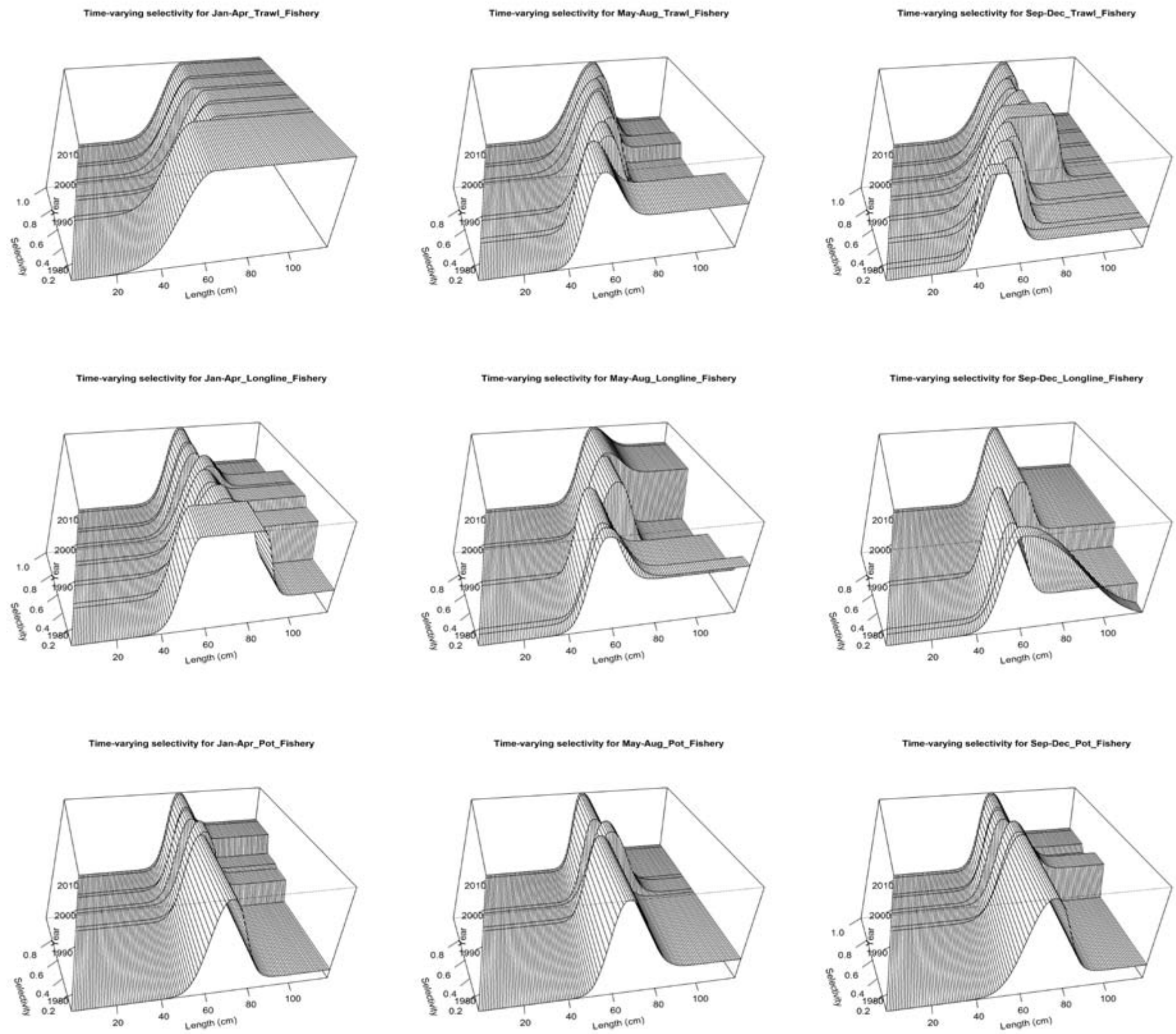



Figure 2.11b—Fishery selectivity at length (cm) as estimated by Model 3.

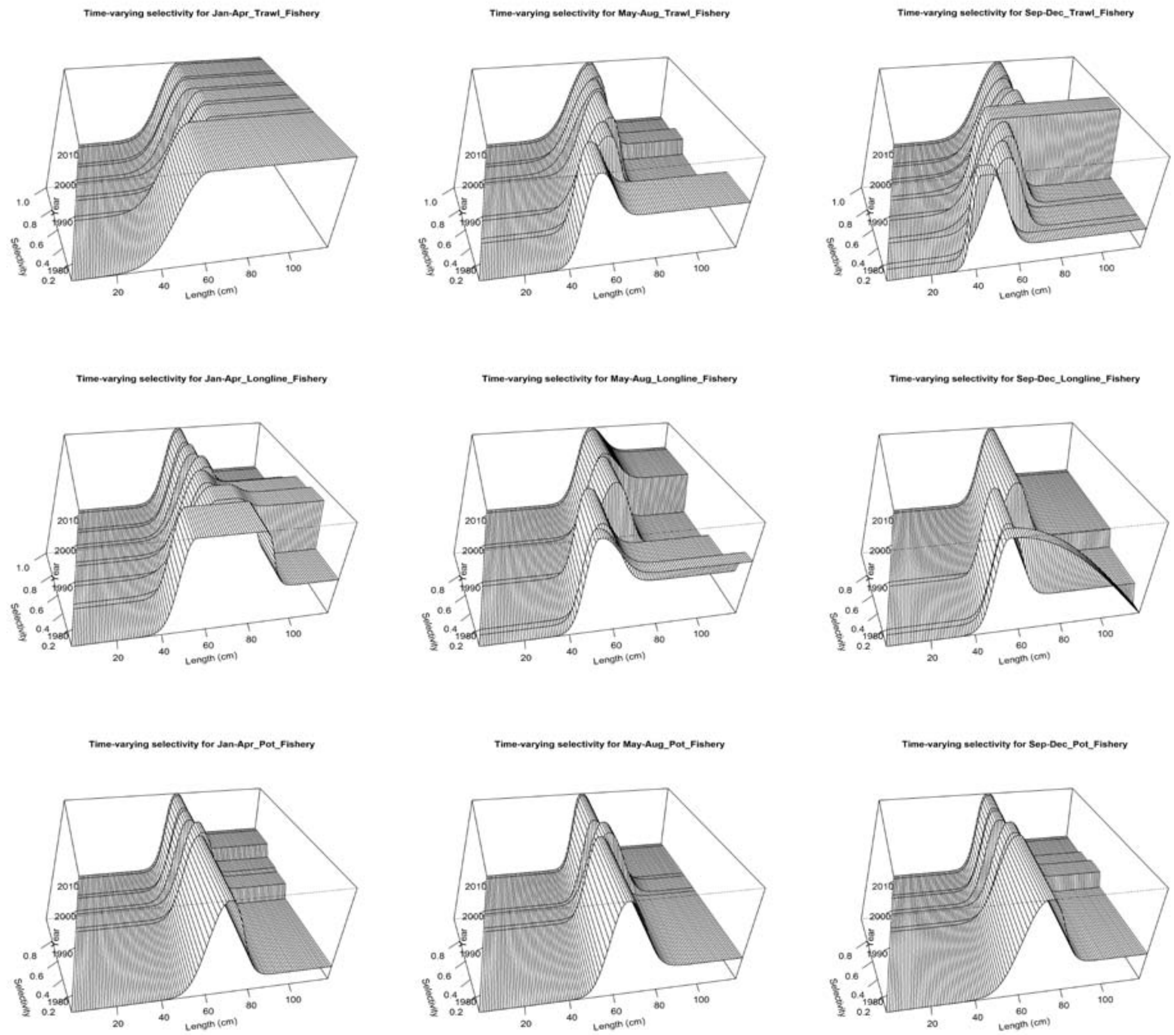



Figure 2.11c—Fishery selectivity at length (cm) as estimated by Model 3b.

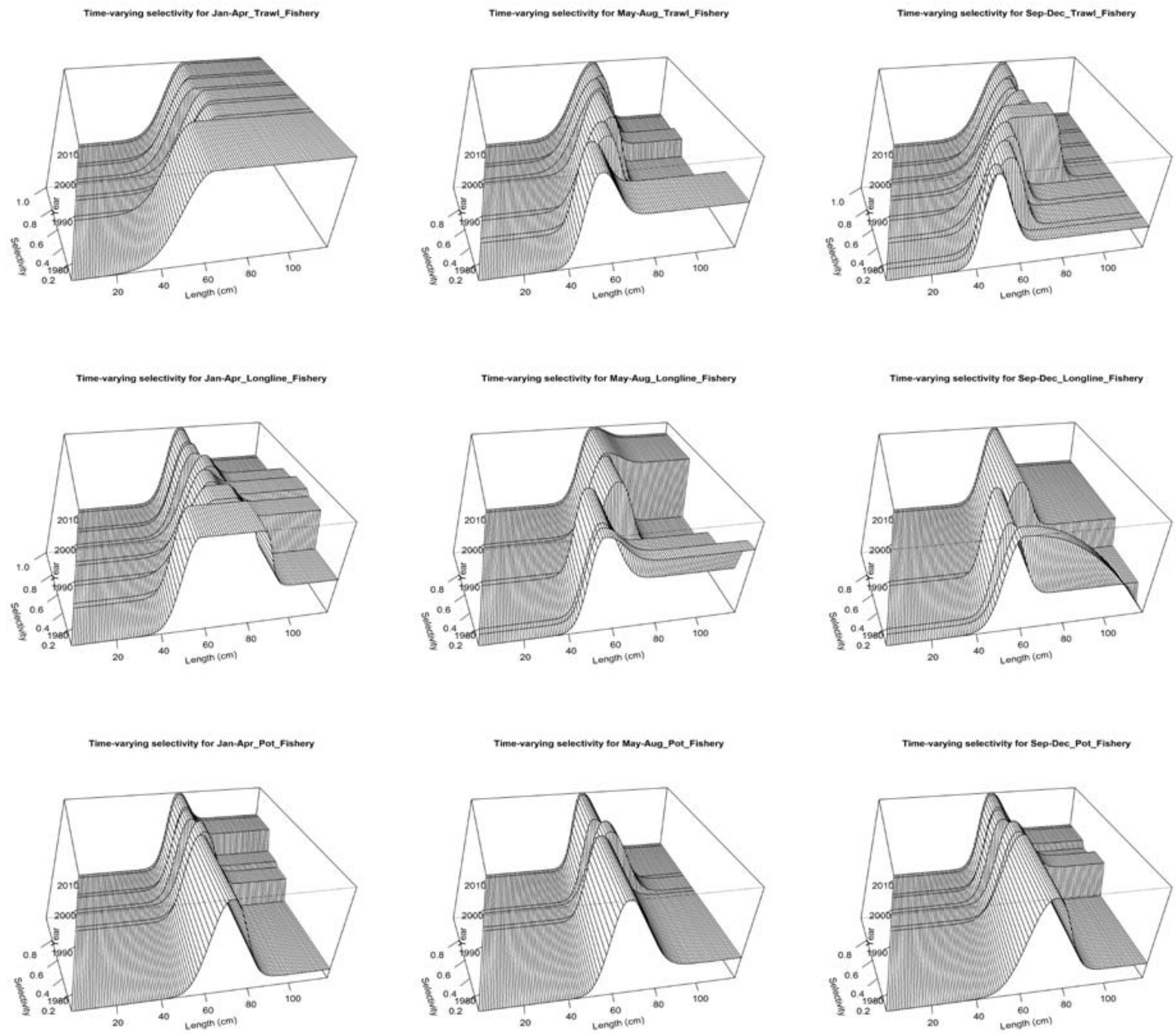



Figure 2.11d—Fishery selectivity at length (cm) as estimated by Model 4.

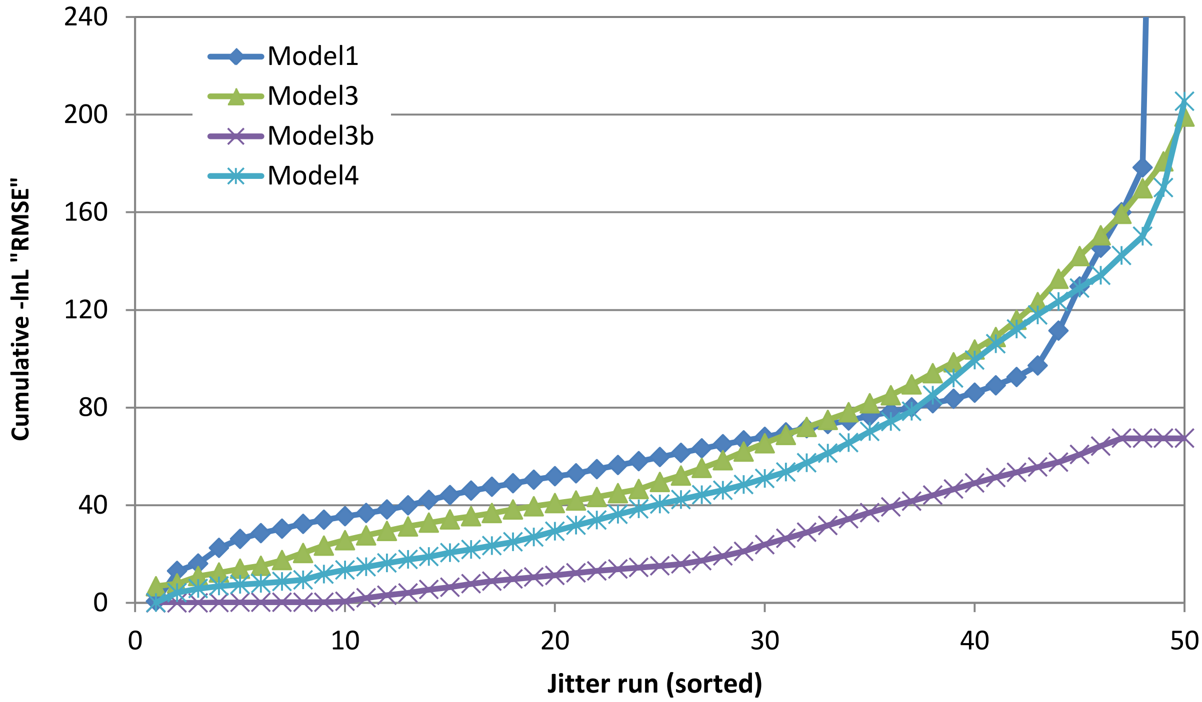



Figure 2.12—Variability in objective function value for each of the four models. See text for details.

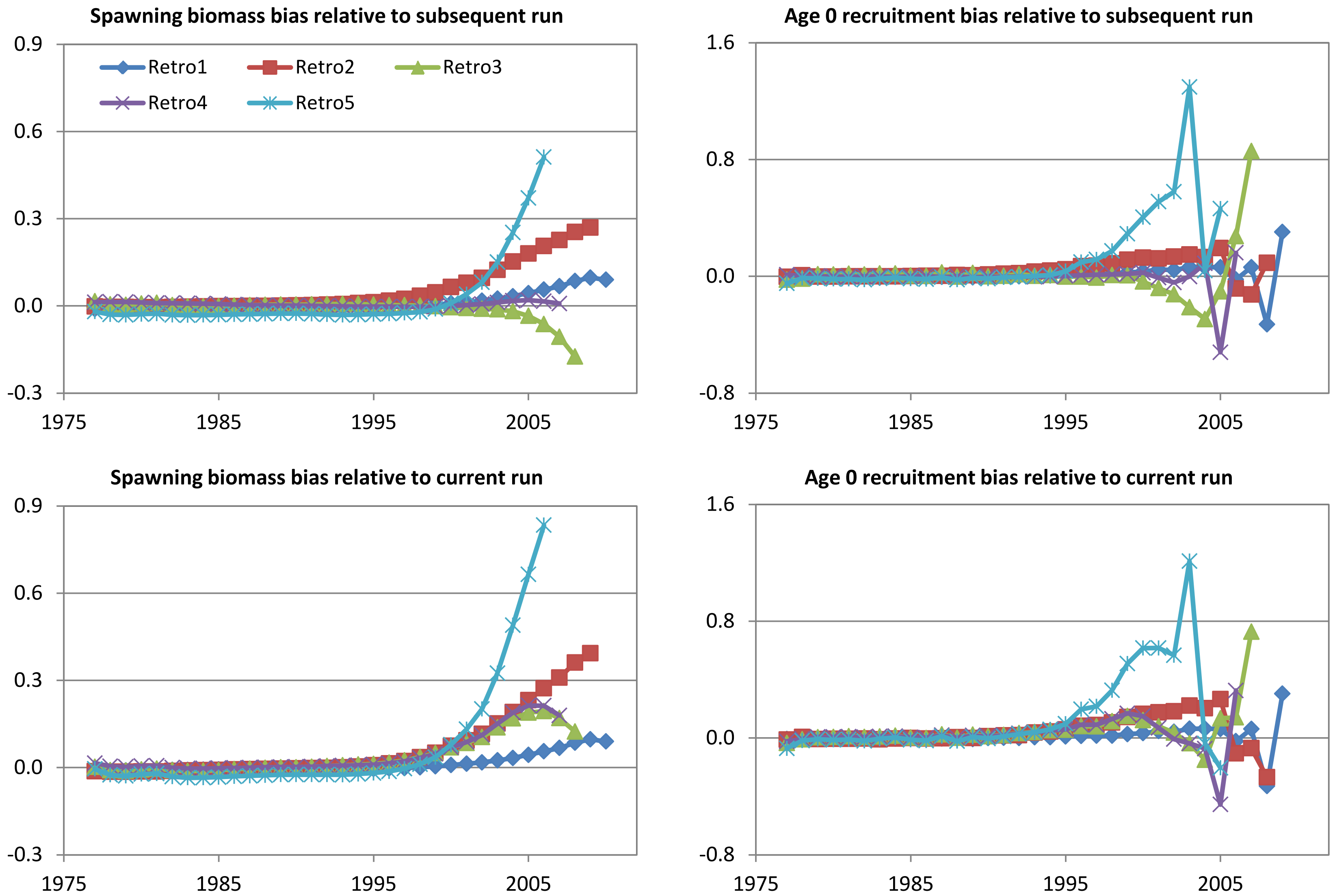



Figure 2.13a—Retrospective bias in spawning biomass and age 0 recruitment (assessed at age 1) in Model 1.

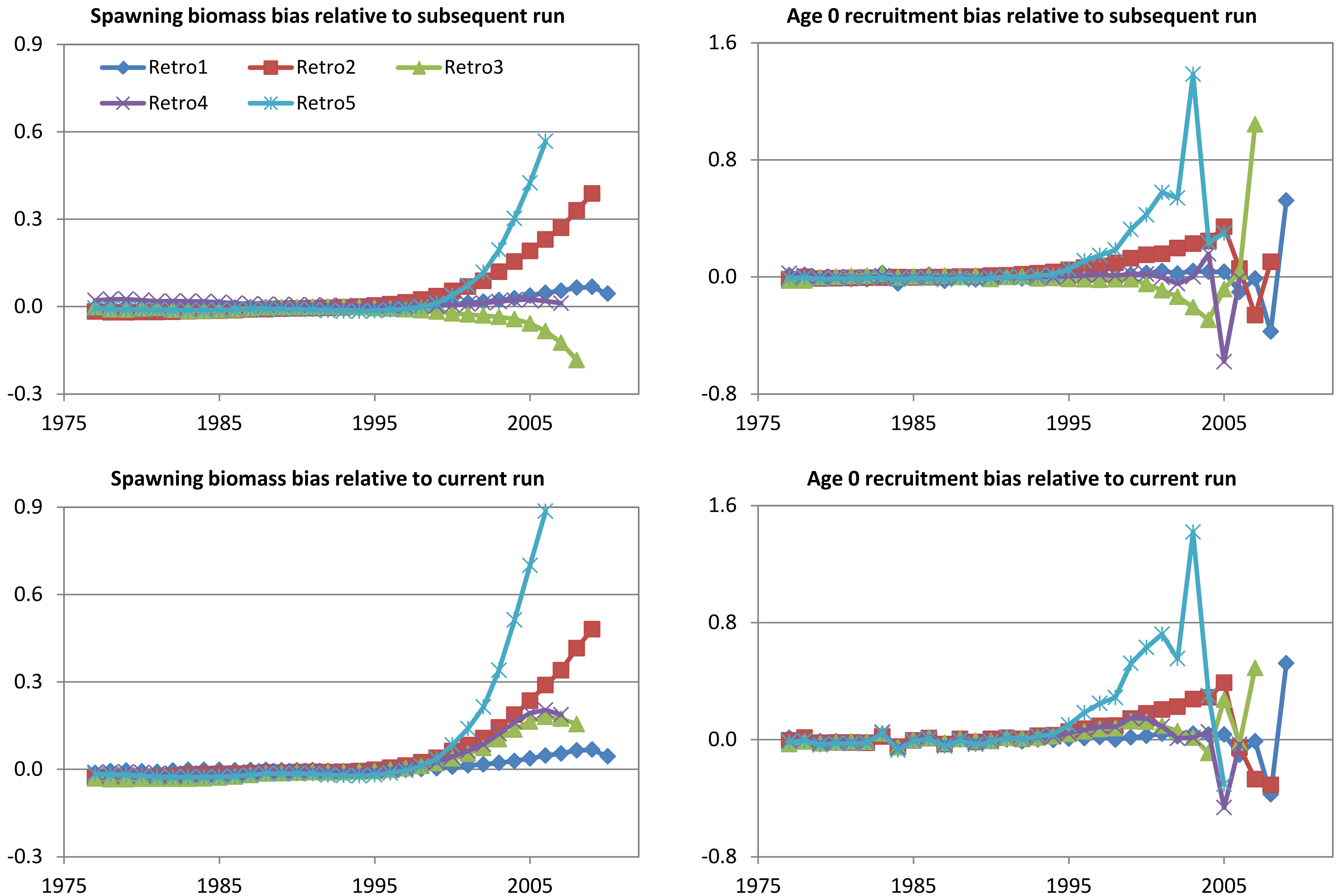



Figure 2.13b—Retrospective bias in spawning biomass and age 0 recruitment (assessed at age 1) in Model 3.

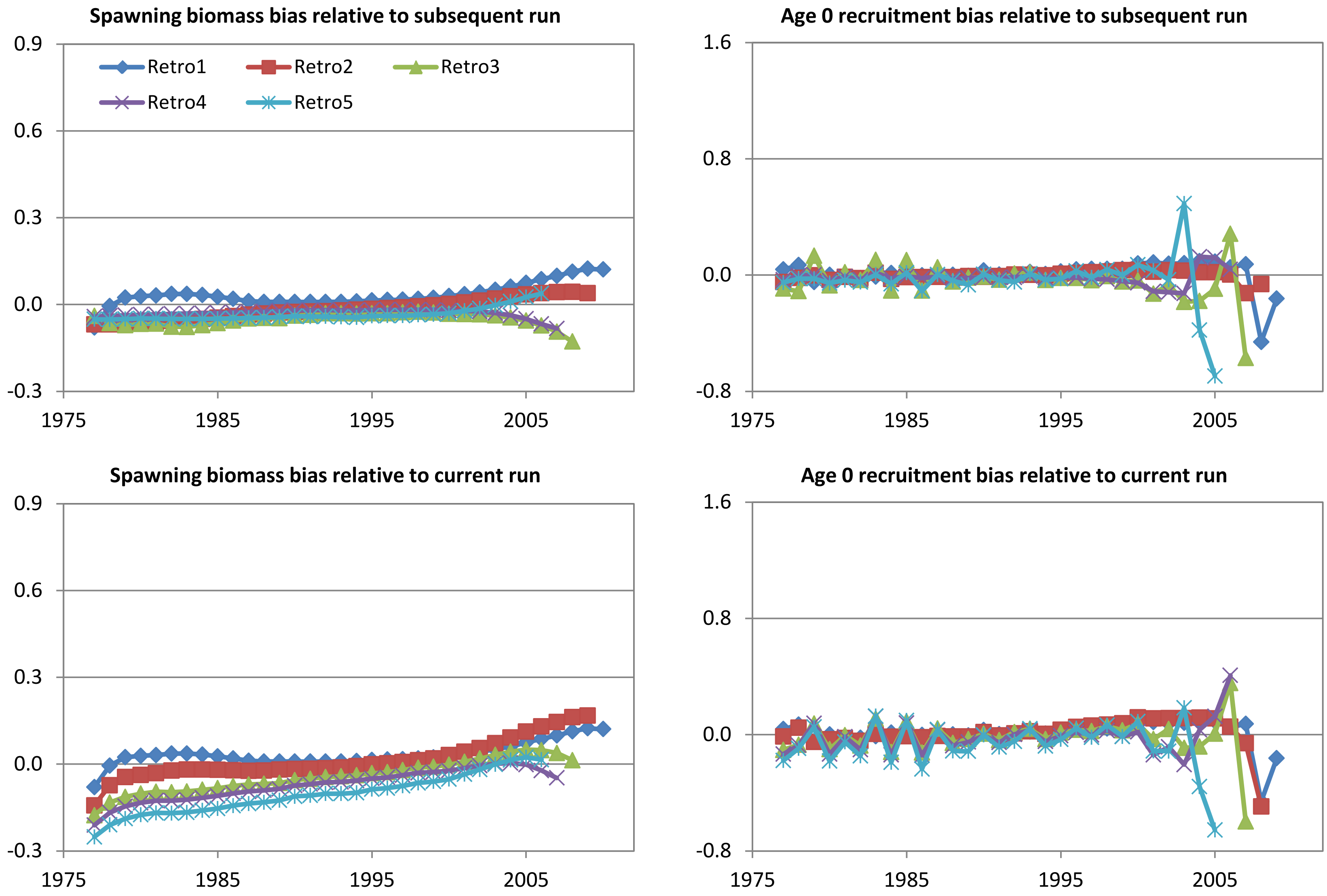



Figure 2.13c—Retrospective bias in spawning biomass and age 0 recruitment (assessed at age 1) in Model 3b.

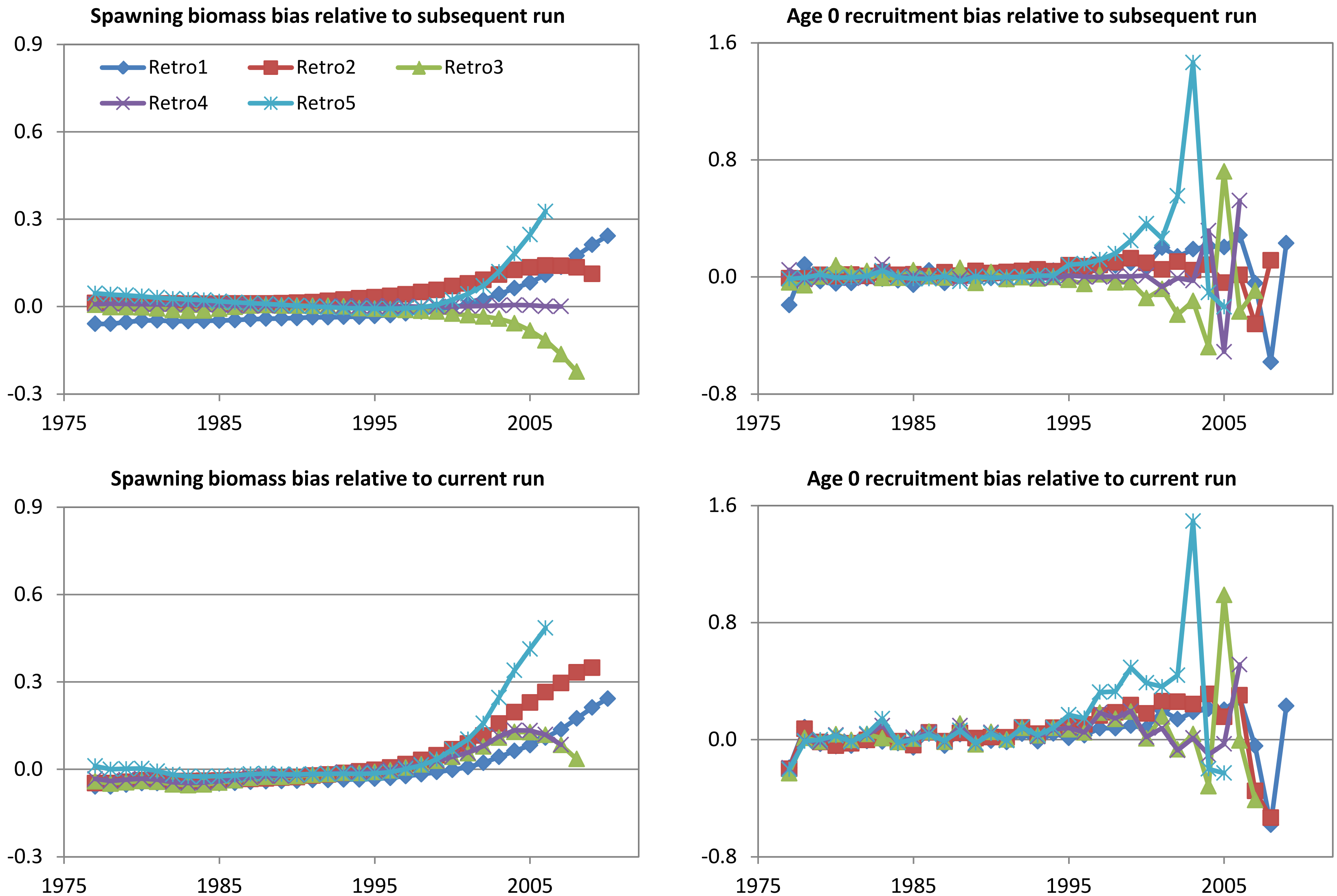



Figure 2.13d—Retrospective bias in spawning biomass and age 0 recruitment (assessed at age 1) in Model 4.

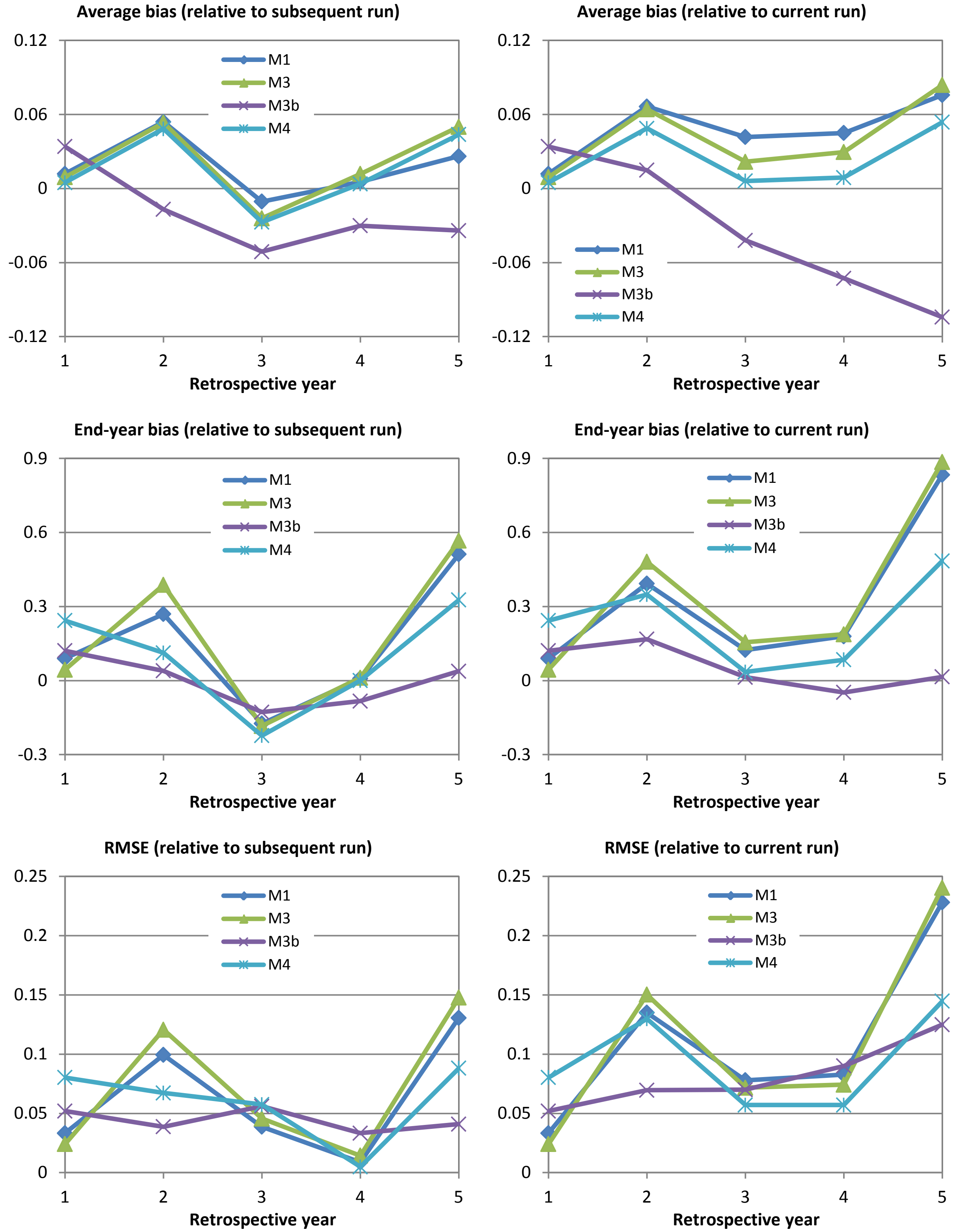



Figure 2.14—Retrospective bias and variability in spawning biomass. See text for details.

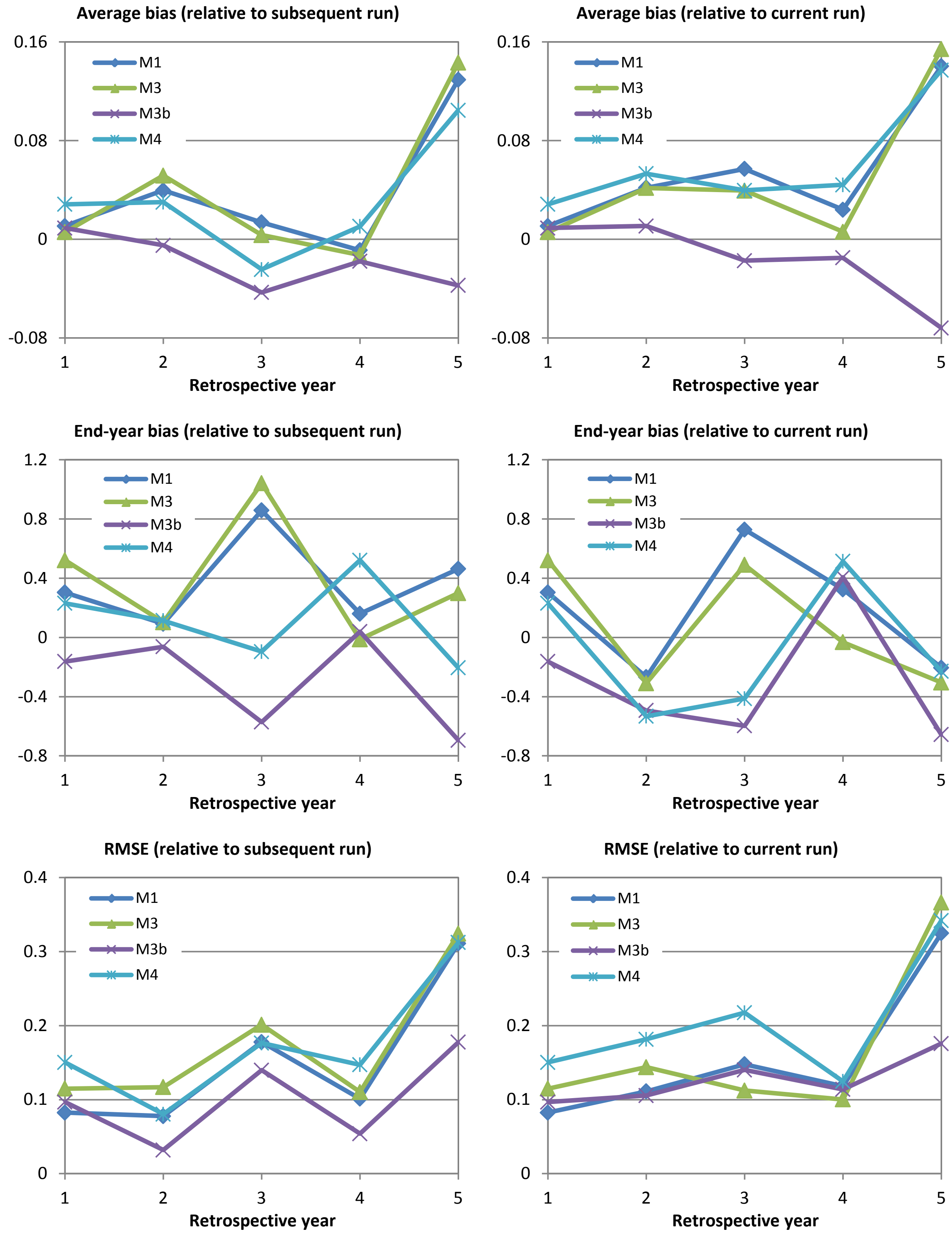



Figure 2.15—Retrospective bias and variability in age 0 recruitment. See text for details.

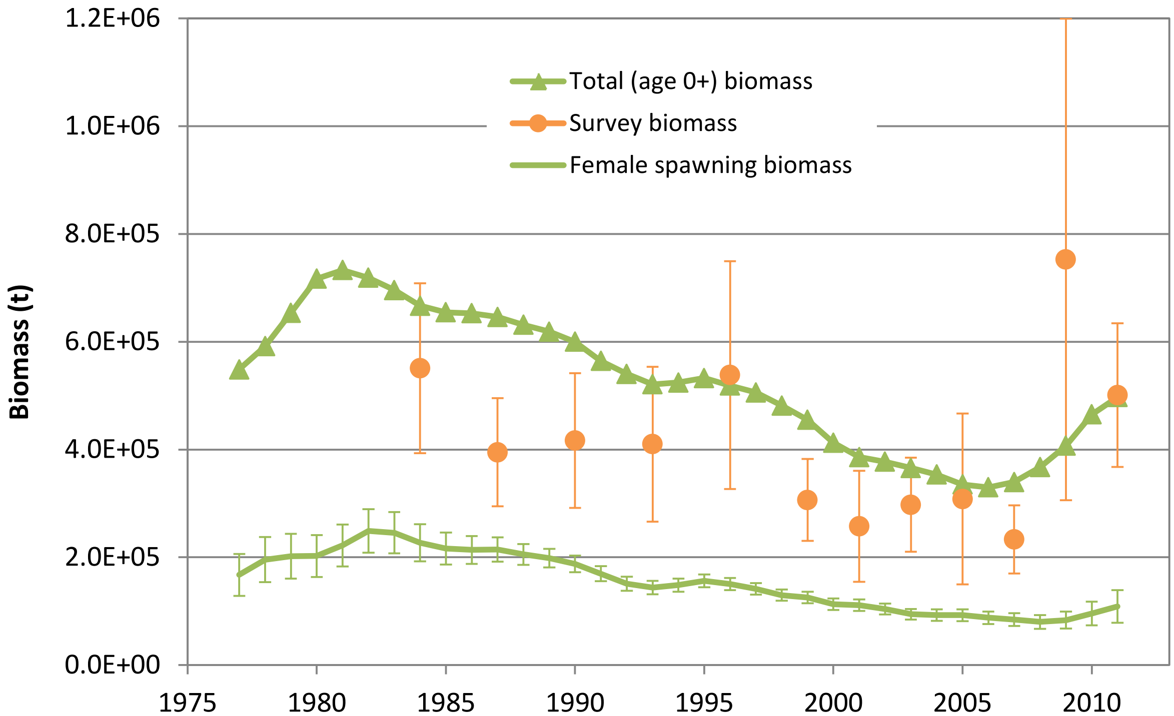



Figure 2.16—Biomass time trends (age 0+ biomass, female spawning biomass, survey biomass) of GOA Pacific cod as estimated by Model 3. Spawning biomass and survey biomass show 95% CI.

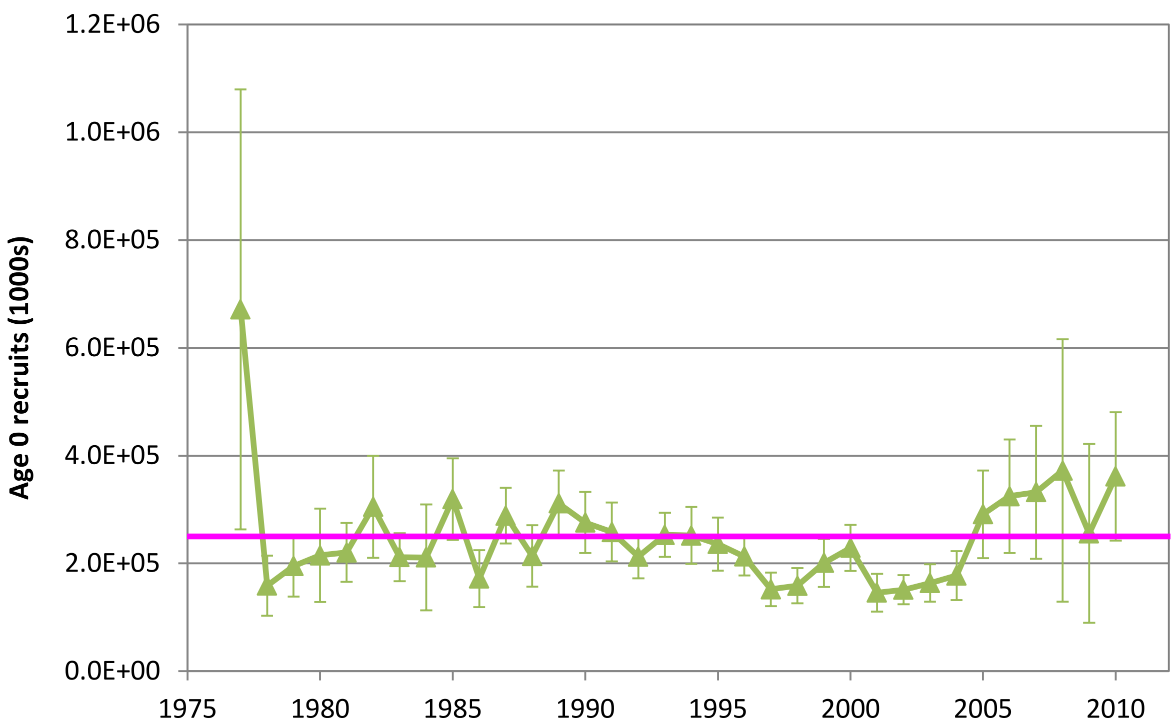



Figure 2.17—Time series of GOA Pacific cod recruitment at age 0 as estimated by Model 3.

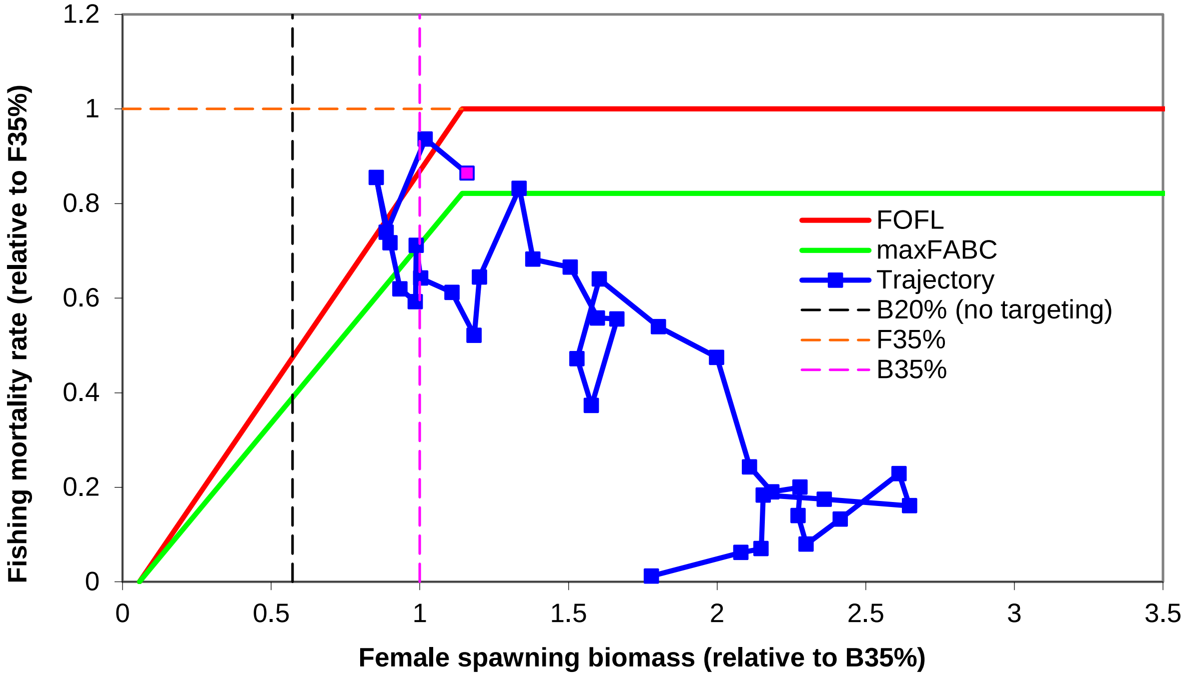



Figure 2.18—Trajectory of Pacific cod fishing mortality and female spawning biomass as estimated by Model 3, 1977-present (magenta square = 2011).

## Attachment 2.1:

## Supplemental catch data

In order to comply with the Annual Catch Limit (ACL) requirements, two new datasets have been generated to help estimate total catch and removals from NMFS stocks in Alaska.

The first dataset, non-commercial removals, estimates total 2010 removals that do not occur during directed groundfish fishing activities. These include removals incurred during research, subsistence, personal use, recreational, and exempted fishing permit activities, but do not include removals taken in fisheries other than those managed under the groundfish FMP. These estimates represent additional sources of removals to the existing Catch Accounting System estimates. Estimates for Pacific cod from this dataset are shown along with trawl survey removals from 1977-2009 in Table 2.1.1. Removals from activities other than directed fishing totaled 292 t in 2010. This is approximately 0.37% of the 2010 ABC of 79,100 and represents a very low risk to the stock. If these removals were accounted for in the stock assessment model, the recommended ABCs for 2012 and 2013 would likely change very little.

The second dataset, Halibut Fishery Incidental Catch Estimation (HFICE), is an estimate of the incidental catch of groundfish in the halibut IFQ fishery in Alaska, which is currently unobserved. To estimate removals in the halibut fishery, methods were developed by the HFICE working group and approved by the Gulf of Alaska and Bering Sea/Aleutian Islands Groundfish Plan Teams and the Scientific and Statistical Committee of the North Pacific Fishery Management Council. A detailed description of the methods is available in Tribuzio et al. (2011).

These estimates are for total catch of groundfish species in the halibut IFQ fishery and do not distinguish between "retained" and "discarded" catch. These estimates should be considered a separate time series from the current CAS estimates of total catch. Because of potential overlaps, HFICE removals should not be added to the CAS catch estimates. An overlap will exist whenever groundfish are retained or discarded during an IFQ halibut trip. IFQ halibut landings that also include landed groundfish are recorded as retained in eLandings and a discard amount for all groundfish is estimated for such landings in CAS. Discard amounts for groundfish are not currently estimated for IFQ halibut landings that do not also include landed groundfish. For example, catch information for a trip that includes both landed IFQ halibut and Pacific cod would contain the total amount of Pacific cod landed (reported in eLandings) and an estimate of discard based on at-sea observer information. Further, because a groundfish species was landed during the trip, catch accounting would also estimate discard for all groundfish species based on available observer information and following methods described in Cahalan et al. (2010). The HFICE method estimates all groundfish caught during a halibut IFQ trip and thus is an estimate of groundfish caught, whether landed or discarded. This precludes simply adding the HFICE estimate to the CAS total, which would be analogous to counting both retained and discarded groundfish species twice. Further, there are situations where the HFICE estimate includes groundfish caught in State waters, and this would need to be considered with respect to ACLs. Therefore, the HFICE estimates should be considered as preliminary estimates of what is caught in the IFQ halibut fishery. Improved estimates of groundfish catch in the halibut fishery may become available following restructuring of the Observer Program in 2013.

The HFICE estimates of Pacific cod catch by the halibut fishery are fairly small, averaging approximately 3.98% of the annual ABC over the period 2001-2010 (Table 2.1.2). Pacific cod and halibut are often caught and landed in association with each other by the IFQ fishery. It is unknown what level of Pacific cod catch reported here is already accounted for as IFQ harvest in the CAS system because the HFICE estimates do not separate retained and discarded catch. However, even if these were strictly additive removals, 3.98% would represent only a small amount of additional mortality, with little potential risk to the stock. The HFICE estimates may contain useful information on the level of Pacific cod discards in the IFQ fishery, but that level will remain unknown until these estimates are separated from the IFQ landings and CAS system.

## References

Cahalan J., J. Mondragon., and J. Gasper. 2010. Catch Sampling and Estimation in the Federal Groundfish Fisheries off Alaska. NOAA Technical Memorandum NMFS-AFSC-205. 42 p.

Tribuzio, CA, S Gaichas, J Gasper, H Gilroy, T Kong, O Ormseth, J Cahalan, J DiCosimo, M Furuness, H Shen, K Green. 2011. Methods for the estimation of non-target species catch in the unobserved halibut IFQ fleet. August Plan Team document. Presented to the Joint Plan Teams of the North Pacific Fishery Management Council.

Table 2.1.1 Total removals of GOA Pacific cod (t) from activities not related to directed fishing, since 1977. "Trawl" refers to a combination of the NMFS echo-integration; small-mesh; large-mesh; and GOA bottom trawl surveys; and occasional short-term research projects involving trawl gear. "Longline" refers to either the NMFS or IPHC longline survey. "Other" refers to recreational, personal use, and subsistence harvest.

| | | | Longline | | | |
|---|---|---|---|---|---|---|
| Year | Source | Trawl | NMFS | IPHC | Other | Total |
| 1977 | AFSC | 10 | | | | 10 |
| 1978 | AFSC | 26 | | | | 26 |
| 1979 | AFSC | 61 | | | | 61 |
| 1980 | AFSC | 37 | | | | 37 |
| 1981 | AFSC | 94 | | | | 94 |
| 1982 | AFSC | 116 | | | | 116 |
| 1983 | AFSC | 95 | | | | 95 |
| 1984 | AFSC | 52 | | | | 52 |
| 1985 | AFSC | 100 | | | | 100 |
| 1986 | AFSC | 41 | | | | 41 |
| 1987 | AFSC | 41 | | | | 41 |
| 1988 | AFSC | 71 | | | | 71 |
| 1989 | AFSC | 56 | | | | 56 |
| 1990 | AFSC | 51 | | | | 51 |
| 1991 | AFSC | 76 | | | | 76 |
| 1992 | AFSC | 17 | | | | 17 |
| 1993 | AFSC | 25 | | | | 25 |
| 1994 | AFSC | 51 | | | | 51 |
| 1995 | AFSC | 54 | | | | 54 |
| 1996 | AFSC | 33 | | | | 33 |
| 1997 | AFSC | 26 | | | | 26 |
| 1998 | AFSC | 21 | | | | 21 |
| 1999 | AFSC | 28 | | | | 28 |
| 2000 | AFSC | 22 | | | | 22 |
| 2001 | AFSC | 35 | | | | 35 |
| 2002 | AFSC | 24 | | | | 24 |
| 2003 | AFSC | 26 | | | | 26 |
| 2004 | AFSC | 26 | | | | 26 |
| 2005 | AFSC | 23 | | | | 23 |
| 2006 | AFSC | 23 | | | | 23 |
| 2007 | AFSC | 19 | | | | 19 |
| 2008 | AFSC | 18 | | | | 18 |
| 2009 | AFSC | 21 | | | | 21 |
| 2010 | AKRO | 15 | 21 | 142 | 114 | 292 |

Table 2.1.2. Estimates of GOA Pacific cod catch (t) by 3-digit statistical area from the Halibut Fishery Incidental Catch Estimation (HFICE) working group. Areas 640 and 649 have been combined due to confidentiality restrictions.

| Year | 610 | 620 | 630 | 640/649 | 650 | 659 | Total |
|---|---|---|---|---|---|---|---|
| 2001 | 502 | 405 | 271 | 8 | 4 | 111 | 1301 |
| 2002 | 627 | 600 | 453 | 15 | 7 | 55 | 1757 |
| 2003 | 778 | 775 | 323 | 41 | 16 | 133 | 2066 |
| 2004 | 837 | 703 | 255 | 9 | 10 | 97 | 1911 |
| 2005 | 610 | 931 | 369 | 13 | 22 | 171 | 2115 |
| 2006 | 871 | 484 | 606 | 28 | 31 | 183 | 2203 |
| 2007 | 644 | 812 | 792 | 37 | 39 | 156 | 2480 |
| 2008 | 1329 | 1088 | 949 | 53 | 22 | 85 | 3526 |
| 2009 | 1078 | 1704 | 1125 | 103 | 22 | 73 | 4105 |
| 2010 | 1249 | 1411 | 849 | 61 | 13 | 35 | 3618 |

## Attachment 2.2:

## Tables and figures for the "Time Series Results" and "Projections and Harvest Alternatives" sections based on the SSC's most recent preferred model (Model 1)

The tables and figures contained in the "Time Series Results" and "Projections and Harvest Alternatives" sections in the main text are based on Model 3b. This attachment reproduces those tables and figures, but based on the SSC's most recent preferred model (Model 1).

Table 2.2.28—Time series GOA Pacific cod age 0+ biomass, female spawning biomass (t), and standard deviation of spawning biomass as estimated last year under the Plan Team's and SSC's preferred model and this year under Model 1. Values for 2012 listed under this year's assessment represent Stock Synthesis projections, and may not correspond exactly to values generated by the standard projection model.

| | Last year's assessment | | | This year's assessment | | |
|---|---|---|---|---|---|---|
| Year | Age 0+ bio. | Spawn. bio. | Std. dev. | Age 0+ bio. | Spawn. bio. | Std. dev. |
| 1977 | 537,214 | 158,247 | 18,298 | 539,029 | 158,782 | 18,276 |
| 1978 | 584,201 | 186,593 | 19,999 | 585,618 | 187,267 | 19,964 |
| 1979 | 650,385 | 194,541 | 19,925 | 651,331 | 195,141 | 19,877 |
| 1980 | 713,082 | 196,358 | 18,802 | 713,504 | 196,718 | 18,724 |
| 1981 | 728,761 | 215,009 | 18,752 | 728,598 | 215,095 | 18,628 |
| 1982 | 715,356 | 242,461 | 19,612 | 714,566 | 242,355 | 19,445 |
| 1983 | 695,164 | 240,658 | 18,671 | 693,750 | 240,334 | 18,481 |
| 1984 | 668,973 | 223,085 | 16,781 | 667,009 | 222,556 | 16,587 |
| 1985 | 658,371 | 213,126 | 14,785 | 656,030 | 212,400 | 14,597 |
| 1986 | 658,605 | 211,306 | 12,913 | 656,083 | 210,406 | 12,737 |
| 1987 | 653,493 | 212,431 | 11,268 | 650,910 | 211,426 | 11,095 |
| 1988 | 639,902 | 203,905 | 9,846 | 637,257 | 202,910 | 9,658 |
| 1989 | 628,407 | 197,412 | 8,816 | 625,613 | 196,464 | 8,609 |
| 1990 | 611,117 | 187,446 | 7,967 | 607,981 | 186,483 | 7,745 |
| 1991 | 577,245 | 169,320 | 7,203 | 573,527 | 168,293 | 6,968 |
| 1992 | 554,076 | 150,715 | 6,696 | 549,466 | 149,545 | 6,438 |
| 1993 | 535,341 | 144,140 | 6,462 | 529,514 | 142,705 | 6,163 |
| 1994 | 539,574 | 148,816 | 6,470 | 532,160 | 146,990 | 6,108 |
| 1995 | 549,595 | 156,929 | 6,387 | 540,123 | 154,573 | 5,945 |
| 1996 | 537,665 | 151,639 | 6,182 | 525,468 | 148,648 | 5,643 |
| 1997 | 527,015 | 144,069 | 5,986 | 511,438 | 140,268 | 5,324 |
| 1998 | 504,428 | 132,668 | 5,999 | 485,066 | 127,800 | 5,160 |
| 1999 | 479,797 | 129,351 | 6,256 | 456,654 | 123,112 | 5,193 |
| 2000 | 439,671 | 117,910 | 6,489 | 412,665 | 110,197 | 5,201 |
| 2001 | 417,246 | 117,221 | 6,558 | 385,533 | 108,149 | 5,069 |
| 2002 | 413,776 | 111,480 | 6,520 | 375,850 | 101,195 | 4,840 |
| 2003 | 407,624 | 102,852 | 6,629 | 362,732 | 90,985 | 4,698 |
| 2004 | 401,492 | 103,224 | 7,142 | 349,356 | 88,867 | 4,801 |
| 2005 | 390,737 | 105,580 | 7,863 | 330,526 | 88,171 | 5,011 |
| 2006 | 395,661 | 103,394 | 8,370 | 325,000 | 83,482 | 5,083 |
| 2007 | 418,804 | 102,792 | 8,964 | 334,466 | 80,289 | 5,206 |
| 2008 | 451,683 | 101,898 | 10,109 | 360,151 | 75,638 | 5,650 |
| 2009 | 475,665 | 109,328 | 12,474 | 397,262 | 77,579 | 6,876 |
| 2010 | 490,165 | 122,871 | 16,437 | 454,765 | 87,809 | 9,519 |
| 2011 | 470,608 | 123,640 | 17,729 | 498,180 | 99,249 | 13,504 |
| 2012 | | | | 530,829 | 112,228 | 16,226 |

Table 2.2.29—Time series of GOA Pacific cod age 0 recruitment (1000s of fish), with standard deviations, as estimated last year under the Plan Team's and SSC's preferred model and this year under Model 1.

| | Last year's assessment | | This year's assessment | |
|---|---|---|---|---|
| Year | Recruits | Std. dev. | Recruits | Std. dev. |
| 1977 | 658,920 | 48,397 | 658,983 | 48,109 |
| 1978 | 170,043 | 16,672 | 168,925 | 16,604 |
| 1979 | 187,438 | 13,303 | 186,559 | 13,200 |
| 1980 | 211,016 | 12,578 | 209,748 | 12,451 |
| 1981 | 216,926 | 13,576 | 215,529 | 13,425 |
| 1982 | 300,084 | 18,063 | 298,610 | 17,748 |
| 1983 | 206,808 | 15,683 | 206,173 | 15,514 |
| 1984 | 208,685 | 14,453 | 208,512 | 14,348 |
| 1985 | 314,747 | 16,047 | 313,662 | 15,992 |
| 1986 | 172,579 | 10,498 | 171,502 | 10,434 |
| 1987 | 279,948 | 11,851 | 278,507 | 11,645 |
| 1988 | 216,671 | 11,154 | 214,231 | 10,909 |
| 1989 | 307,094 | 14,263 | 304,196 | 13,846 |
| 1990 | 269,066 | 12,780 | 264,760 | 12,346 |
| 1991 | 260,819 | 11,848 | 256,189 | 11,305 |
| 1992 | 221,870 | 11,224 | 215,763 | 10,614 |
| 1993 | 245,288 | 11,515 | 237,694 | 10,501 |
| 1994 | 258,490 | 12,092 | 247,316 | 10,655 |
| 1995 | 243,707 | 11,608 | 231,291 | 9,727 |
| 1996 | 216,053 | 11,415 | 202,448 | 8,549 |
| 1997 | 164,429 | 8,726 | 152,716 | 7,164 |
| 1998 | 165,149 | 9,035 | 150,518 | 7,064 |
| 1999 | 212,406 | 11,888 | 190,841 | 8,770 |
| 2000 | 248,005 | 15,008 | 216,339 | 9,933 |
| 2001 | 171,103 | 11,481 | 147,064 | 7,748 |
| 2002 | 168,121 | 12,162 | 141,673 | 7,808 |
| 2003 | 196,272 | 15,826 | 159,177 | 9,404 |
| 2004 | 208,035 | 18,859 | 164,388 | 10,926 |
| 2005 | 354,908 | 38,594 | 266,917 | 21,626 |
| 2006 | 297,679 | 38,266 | 300,236 | 29,532 |
| 2007 | 244,508 | 41,571 | 321,150 | 40,085 |
| 2008 | 136,909 | 28,520 | 326,531 | 45,190 |
| 2009 | | | 421,538 | 79,303 |
| 2010 | | | 252,999 | 62,143 |
| Average | 241,681 | | 244,197 | |

Table 2.2.30—Numbers (1000s) at age as estimated by Model 1.

| Year | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 658983 | 173950 | 68958 | 56296 | 83770 | 36327 | 16881 | 8483 | 4689 | 2938 | 2001 | 1422 | 1027 | 745 | 721 | 486 | 328 | 221 | 149 | 101 | 209 |
| 1978 | 168925 | 450652 | 118951 | 47103 | 38300 | 56776 | 24600 | 11434 | 5748 | 3179 | 1993 | 1358 | 966 | 698 | 507 | 490 | 331 | 223 | 151 | 102 | 211 |
| 1979 | 186559 | 115521 | 308156 | 81111 | 31785 | 25527 | 37727 | 16367 | 7619 | 3836 | 2126 | 1335 | 912 | 649 | 470 | 341 | 330 | 223 | 151 | 102 | 211 |
| 1980 | 209748 | 127580 | 78987 | 209856 | 54380 | 20952 | 16761 | 24807 | 10782 | 5030 | 2539 | 1411 | 889 | 608 | 434 | 314 | 229 | 221 | 150 | 101 | 210 |
| 1981 | 215529 | 143439 | 87237 | 53784 | 138396 | 34470 | 13333 | 10835 | 16168 | 7052 | 3298 | 1669 | 930 | 587 | 402 | 287 | 208 | 151 | 147 | 99 | 206 |
| 1982 | 298610 | 147392 | 98078 | 59365 | 35369 | 87511 | 21956 | 8648 | 7093 | 10624 | 4644 | 2176 | 1103 | 615 | 389 | 267 | 191 | 138 | 101 | 98 | 203 |
| 1983 | 206173 | 204207 | 100777 | 66759 | 39104 | 22457 | 55969 | 14281 | 5672 | 4668 | 7006 | 3068 | 1440 | 731 | 408 | 258 | 177 | 127 | 92 | 67 | 200 |
| 1984 | 208512 | 140993 | 139616 | 68496 | 43364 | 24107 | 13984 | 35697 | 9219 | 3679 | 3036 | 4567 | 2004 | 942 | 479 | 268 | 169 | 116 | 83 | 60 | 175 |
| 1985 | 313662 | 142593 | 96400 | 95120 | 45645 | 28082 | 15604 | 9132 | 23433 | 6067 | 2426 | 2005 | 3021 | 1327 | 625 | 318 | 178 | 113 | 77 | 55 | 157 |
| 1986 | 171502 | 214500 | 97486 | 65740 | 64194 | 30292 | 18466 | 10252 | 6013 | 15474 | 4016 | 1608 | 1331 | 2006 | 882 | 415 | 211 | 118 | 75 | 51 | 141 |
| 1987 | 278507 | 117282 | 146626 | 66408 | 44112 | 42112 | 19713 | 12045 | 6712 | 3950 | 10191 | 2650 | 1062 | 879 | 1326 | 583 | 275 | 140 | 78 | 49 | 127 |
| 1988 | 214231 | 190454 | 80111 | 99266 | 43586 | 27777 | 26199 | 12431 | 7715 | 4340 | 2567 | 6637 | 1728 | 693 | 574 | 866 | 381 | 179 | 91 | 51 | 115 |
| 1989 | 304196 | 146497 | 130073 | 54244 | 65419 | 27651 | 17327 | 16457 | 7904 | 4947 | 2796 | 1657 | 4290 | 1117 | 448 | 371 | 560 | 246 | 116 | 59 | 108 |
| 1990 | 264760 | 208026 | 100150 | 88459 | 35750 | 40580 | 16501 | 10340 | 9963 | 4841 | 3049 | 1729 | 1026 | 2659 | 693 | 278 | 230 | 348 | 153 | 72 | 103 |
| 1991 | 256189 | 181058 | 142216 | 68149 | 58601 | 22097 | 23203 | 9116 | 5764 | 5687 | 2821 | 1802 | 1031 | 616 | 1602 | 419 | 168 | 140 | 211 | 93 | 107 |
| 1992 | 215763 | 175196 | 123777 | 96763 | 45115 | 36047 | 12298 | 12039 | 4632 | 2947 | 2941 | 1472 | 946 | 543 | 325 | 847 | 222 | 89 | 74 | 112 | 106 |
| 1993 | 237694 | 147551 | 119784 | 84340 | 64448 | 28058 | 20326 | 6485 | 6250 | 2432 | 1571 | 1585 | 799 | 516 | 297 | 178 | 464 | 122 | 49 | 41 | 119 |
| 1994 | 247316 | 162548 | 100881 | 81622 | 56268 | 40452 | 16207 | 11135 | 3522 | 3439 | 1359 | 887 | 901 | 456 | 295 | 170 | 102 | 267 | 70 | 28 | 92 |
| 1995 | 231291 | 169129 | 111148 | 68843 | 54871 | 36107 | 24322 | 9334 | 6357 | 2028 | 2003 | 797 | 523 | 533 | 271 | 175 | 101 | 61 | 158 | 41 | 71 |
| 1996 | 202448 | 158170 | 115631 | 75750 | 45991 | 34520 | 20760 | 13017 | 4858 | 3315 | 1069 | 1066 | 427 | 281 | 288 | 146 | 95 | 55 | 33 | 86 | 61 |
| 1997 | 152716 | 138445 | 108139 | 78787 | 50474 | 28676 | 19588 | 10990 | 6733 | 2526 | 1744 | 568 | 570 | 229 | 151 | 155 | 79 | 51 | 29 | 18 | 79 |
| 1998 | 150518 | 104436 | 94626 | 73490 | 51876 | 30422 | 15288 | 9565 | 5228 | 3238 | 1239 | 870 | 286 | 289 | 117 | 77 | 79 | 40 | 26 | 15 | 50 |
| 1999 | 190841 | 102933 | 71393 | 64395 | 48626 | 31589 | 16519 | 7690 | 4738 | 2636 | 1671 | 651 | 462 | 153 | 155 | 63 | 42 | 43 | 22 | 14 | 35 |
| 2000 | 216339 | 130505 | 70328 | 48362 | 41642 | 27921 | 15766 | 7623 | 3533 | 2245 | 1292 | 840 | 333 | 238 | 80 | 81 | 33 | 22 | 22 | 11 | 26 |
| 2001 | 147064 | 147944 | 89203 | 47796 | 31857 | 25375 | 15620 | 8536 | 4185 | 1991 | 1291 | 753 | 493 | 196 | 141 | 47 | 48 | 19 | 13 | 13 | 22 |
| 2002 | 141673 | 100570 | 101111 | 60533 | 31265 | 19118 | 13942 | 8332 | 4644 | 2352 | 1147 | 755 | 444 | 292 | 116 | 84 | 28 | 28 | 12 | 8 | 21 |
| 2003 | 159177 | 96883 | 68733 | 68592 | 39232 | 17989 | 9727 | 6819 | 4186 | 2432 | 1271 | 631 | 420 | 248 | 164 | 65 | 47 | 16 | 16 | 7 | 16 |
| 2004 | 164388 | 108853 | 66209 | 46592 | 44371 | 22623 | 9250 | 4826 | 3483 | 2236 | 1344 | 716 | 360 | 241 | 143 | 94 | 38 | 27 | 9 | 9 | 13 |
| 2005 | 266917 | 112417 | 74392 | 44930 | 30414 | 26096 | 11857 | 4643 | 2474 | 1855 | 1226 | 749 | 403 | 203 | 136 | 81 | 54 | 21 | 15 | 5 | 13 |
| 2006 | 300236 | 182531 | 76837 | 50557 | 29498 | 18094 | 13855 | 5998 | 2374 | 1300 | 997 | 669 | 412 | 223 | 113 | 76 | 45 | 30 | 12 | 9 | 10 |
| 2007 | 321150 | 205317 | 124768 | 52254 | 33322 | 17759 | 9774 | 7132 | 3117 | 1266 | 708 | 550 | 372 | 230 | 125 | 63 | 42 | 25 | 17 | 7 | 10 |
| 2008 | 326531 | 219617 | 140318 | 84662 | 33991 | 19221 | 8868 | 4572 | 3376 | 1529 | 639 | 364 | 286 | 194 | 121 | 65 | 33 | 22 | 13 | 9 | 9 |
| 2009 | 421538 | 223299 | 150106 | 95271 | 55028 | 19405 | 9361 | 4008 | 2092 | 1611 | 757 | 324 | 187 | 148 | 101 | 63 | 34 | 17 | 12 | 7 | 9 |
| 2010 | 252999 | 288267 | 152613 | 101844 | 61547 | 30842 | 9263 | 4183 | 1821 | 990 | 788 | 378 | 164 | 95 | 76 | 52 | 32 | 18 | 9 | 6 | 8 |
| 2011 | 250902 | 173013 | 197032 | 103627 | 65931 | 34409 | 14506 | 4046 | 1859 | 847 | 478 | 390 | 190 | 83 | 49 | 39 | 26 | 17 | 9 | 5 | 7 |

Table 2.2.31—Estimates of “effective” fishing mortality (= $-\ln(N_{a+1,t+1}/N_{a,t})-M$) at age and year for Model 1.

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1977 | 0.000 | 0.000 | 0.002 | 0.005 | 0.006 | 0.006 | 0.005 | 0.005 | 0.005 | 0.004 | 0.004 | 0.004 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| 1978 | 0.000 | 0.002 | 0.010 | 0.023 | 0.028 | 0.027 | 0.025 | 0.024 | 0.022 | 0.020 | 0.019 | 0.017 | 0.016 | 0.015 | 0.015 | 0.014 | 0.014 | 0.013 | 0.013 |
| 1979 | 0.000 | 0.002 | 0.012 | 0.027 | 0.032 | 0.031 | 0.029 | 0.027 | 0.026 | 0.024 | 0.022 | 0.020 | 0.019 | 0.018 | 0.017 | 0.016 | 0.016 | 0.016 | 0.015 |
| 1980 | 0.000 | 0.003 | 0.033 | 0.077 | 0.078 | 0.063 | 0.055 | 0.051 | 0.049 | 0.046 | 0.043 | 0.041 | 0.039 | 0.037 | 0.036 | 0.035 | 0.035 | 0.034 | 0.034 |
| 1981 | 0.000 | 0.004 | 0.035 | 0.076 | 0.071 | 0.053 | 0.044 | 0.041 | 0.039 | 0.037 | 0.035 | 0.033 | 0.032 | 0.031 | 0.030 | 0.030 | 0.029 | 0.029 | 0.029 |
| 1982 | 0.000 | 0.003 | 0.032 | 0.069 | 0.064 | 0.048 | 0.039 | 0.036 | 0.035 | 0.033 | 0.031 | 0.030 | 0.029 | 0.028 | 0.027 | 0.027 | 0.026 | 0.026 | 0.026 |
| 1983 | 0.000 | 0.004 | 0.045 | 0.099 | 0.091 | 0.068 | 0.056 | 0.051 | 0.049 | 0.047 | 0.045 | 0.043 | 0.042 | 0.041 | 0.040 | 0.040 | 0.039 | 0.039 | 0.038 |
| 1984 | 0.000 | 0.003 | 0.024 | 0.056 | 0.057 | 0.048 | 0.043 | 0.040 | 0.039 | 0.037 | 0.034 | 0.032 | 0.031 | 0.029 | 0.029 | 0.028 | 0.027 | 0.027 | 0.027 |
| 1985 | 0.000 | 0.002 | 0.009 | 0.022 | 0.030 | 0.032 | 0.030 | 0.029 | 0.027 | 0.025 | 0.024 | 0.024 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 | 0.023 |
| 1986 | 0.000 | 0.003 | 0.016 | 0.040 | 0.052 | 0.053 | 0.052 | 0.049 | 0.046 | 0.043 | 0.041 | 0.040 | 0.040 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 |
| 1987 | 0.001 | 0.007 | 0.033 | 0.073 | 0.085 | 0.073 | 0.058 | 0.049 | 0.045 | 0.042 | 0.041 | 0.040 | 0.040 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 | 0.039 |
| 1988 | 0.000 | 0.005 | 0.027 | 0.065 | 0.084 | 0.079 | 0.067 | 0.059 | 0.054 | 0.052 | 0.050 | 0.049 | 0.049 | 0.049 | 0.049 | 0.049 | 0.048 | 0.048 | 0.048 |
| 1989 | 0.000 | 0.004 | 0.031 | 0.082 | 0.111 | 0.105 | 0.090 | 0.079 | 0.073 | 0.070 | 0.068 | 0.068 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 | 0.067 |
| 1990 | 0.000 | 0.003 | 0.024 | 0.087 | 0.167 | 0.211 | 0.210 | 0.190 | 0.171 | 0.157 | 0.148 | 0.142 | 0.138 | 0.135 | 0.133 | 0.132 | 0.131 | 0.131 | 0.130 |
| 1991 | 0.000 | 0.002 | 0.017 | 0.069 | 0.158 | 0.232 | 0.259 | 0.255 | 0.244 | 0.235 | 0.229 | 0.225 | 0.223 | 0.222 | 0.221 | 0.220 | 0.220 | 0.219 | 0.219 |
| 1992 | 0.000 | 0.002 | 0.018 | 0.081 | 0.189 | 0.275 | 0.304 | 0.296 | 0.281 | 0.269 | 0.261 | 0.256 | 0.254 | 0.252 | 0.251 | 0.250 | 0.250 | 0.249 | 0.249 |
| 1993 | 0.000 | 0.001 | 0.014 | 0.059 | 0.139 | 0.203 | 0.222 | 0.213 | 0.199 | 0.188 | 0.181 | 0.176 | 0.174 | 0.172 | 0.171 | 0.171 | 0.170 | 0.170 | 0.170 |
| 1994 | 0.000 | 0.001 | 0.010 | 0.044 | 0.107 | 0.159 | 0.176 | 0.171 | 0.160 | 0.152 | 0.146 | 0.143 | 0.141 | 0.140 | 0.139 | 0.139 | 0.139 | 0.138 | 0.138 |
| 1995 | 0.000 | 0.002 | 0.013 | 0.055 | 0.138 | 0.221 | 0.262 | 0.264 | 0.252 | 0.240 | 0.232 | 0.227 | 0.224 | 0.222 | 0.221 | 0.220 | 0.220 | 0.220 | 0.219 |
| 1996 | 0.000 | 0.001 | 0.013 | 0.058 | 0.143 | 0.222 | 0.260 | 0.261 | 0.250 | 0.240 | 0.233 | 0.228 | 0.226 | 0.224 | 0.223 | 0.223 | 0.222 | 0.222 | 0.222 |
| 1997 | 0.000 | 0.003 | 0.018 | 0.073 | 0.173 | 0.268 | 0.312 | 0.311 | 0.294 | 0.278 | 0.267 | 0.260 | 0.256 | 0.254 | 0.252 | 0.251 | 0.250 | 0.250 | 0.249 |
| 1998 | 0.000 | 0.002 | 0.015 | 0.068 | 0.172 | 0.272 | 0.316 | 0.311 | 0.290 | 0.271 | 0.258 | 0.250 | 0.245 | 0.243 | 0.241 | 0.240 | 0.239 | 0.238 | 0.238 |
| 1999 | 0.000 | 0.003 | 0.018 | 0.080 | 0.210 | 0.337 | 0.391 | 0.381 | 0.349 | 0.321 | 0.301 | 0.288 | 0.281 | 0.276 | 0.273 | 0.271 | 0.270 | 0.269 | 0.268 |
| 2000 | 0.000 | 0.002 | 0.018 | 0.086 | 0.211 | 0.297 | 0.301 | 0.267 | 0.234 | 0.213 | 0.201 | 0.195 | 0.191 | 0.189 | 0.188 | 0.188 | 0.187 | 0.187 | 0.187 |
| 2001 | 0.000 | 0.004 | 0.024 | 0.087 | 0.184 | 0.244 | 0.241 | 0.210 | 0.181 | 0.163 | 0.153 | 0.147 | 0.144 | 0.143 | 0.142 | 0.141 | 0.141 | 0.141 | 0.140 |
| 2002 | 0.000 | 0.003 | 0.023 | 0.100 | 0.217 | 0.286 | 0.281 | 0.246 | 0.214 | 0.194 | 0.182 | 0.177 | 0.173 | 0.171 | 0.170 | 0.170 | 0.169 | 0.169 | 0.169 |
| 2003 | 0.000 | 0.004 | 0.025 | 0.098 | 0.221 | 0.300 | 0.296 | 0.255 | 0.217 | 0.193 | 0.180 | 0.173 | 0.169 | 0.167 | 0.166 | 0.165 | 0.165 | 0.164 | 0.164 |
| 2004 | 0.000 | 0.004 | 0.026 | 0.108 | 0.247 | 0.334 | 0.327 | 0.279 | 0.235 | 0.208 | 0.193 | 0.185 | 0.181 | 0.178 | 0.177 | 0.176 | 0.176 | 0.176 | 0.175 |
| 2005 | 0.000 | 0.002 | 0.016 | 0.078 | 0.192 | 0.275 | 0.285 | 0.260 | 0.235 | 0.219 | 0.209 | 0.204 | 0.201 | 0.199 | 0.198 | 0.198 | 0.197 | 0.197 | 0.197 |
| 2006 | 0.000 | 0.002 | 0.015 | 0.077 | 0.198 | 0.287 | 0.298 | 0.272 | 0.247 | 0.231 | 0.222 | 0.217 | 0.214 | 0.213 | 0.212 | 0.212 | 0.211 | 0.211 | 0.211 |
| 2007 | 0.000 | 0.002 | 0.020 | 0.097 | 0.236 | 0.334 | 0.343 | 0.312 | 0.280 | 0.260 | 0.249 | 0.242 | 0.239 | 0.237 | 0.236 | 0.235 | 0.234 | 0.234 | 0.234 |
| 2008 | 0.000 | 0.004 | 0.027 | 0.118 | 0.283 | 0.401 | 0.416 | 0.378 | 0.339 | 0.312 | 0.296 | 0.288 | 0.283 | 0.280 | 0.278 | 0.277 | 0.276 | 0.276 | 0.275 |
| 2009 | 0.000 | 0.003 | 0.020 | 0.096 | 0.242 | 0.349 | 0.362 | 0.328 | 0.292 | 0.268 | 0.255 | 0.247 | 0.243 | 0.240 | 0.239 | 0.238 | 0.237 | 0.237 | 0.236 |
| 2010 | 0.000 | 0.003 | 0.026 | 0.122 | 0.309 | 0.448 | 0.466 | 0.423 | 0.377 | 0.347 | 0.329 | 0.319 | 0.314 | 0.311 | 0.309 | 0.308 | 0.307 | 0.306 | 0.306 |
| 2011 | 0.000 | 0.002 | 0.021 | 0.112 | 0.288 | 0.417 | 0.431 | 0.390 | 0.350 | 0.324 | 0.309 | 0.302 | 0.297 | 0.295 | 0.294 | 0.293 | 0.292 | 0.292 | 0.292 |

Table 2.2.32—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in 2012-2024 (Scenarios 1-2), with random variability in future recruitment under Model 1.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 81,200 | 81,200 | 81,200 | 81,200 | 0 |
| 2013 | 89,400 | 89,400 | 89,400 | 89,400 | 0 |
| 2014 | 92,600 | 92,600 | 92,600 | 92,600 | 3 |
| 2015 | 88,000 | 88,100 | 88,100 | 88,300 | 85 |
| 2016 | 80,000 | 81,200 | 81,300 | 83,100 | 1,011 |
| 2017 | 72,000 | 76,400 | 77,000 | 83,700 | 3,699 |
| 2018 | 59,200 | 74,000 | 73,700 | 88,000 | 8,638 |
| 2019 | 53,800 | 72,900 | 72,000 | 90,500 | 11,390 |
| 2020 | 52,400 | 73,000 | 71,700 | 91,300 | 12,121 |
| 2021 | 51,700 | 72,500 | 71,800 | 92,900 | 12,090 |
| 2022 | 51,900 | 72,000 | 71,600 | 90,800 | 12,036 |
| 2023 | 51,700 | 72,200 | 71,300 | 90,100 | 11,928 |
| 2024 | 52,100 | 71,800 | 71,000 | 89,800 | 11,896 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 112,000 | 112,000 | 112,000 | 112,000 | 0 |
| 2013 | 125,000 | 125,000 | 125,000 | 125,000 | 0 |
| 2014 | 132,000 | 132,000 | 132,000 | 132,000 | 2 |
| 2015 | 125,000 | 125,000 | 125,000 | 125,000 | 59 |
| 2016 | 116,000 | 116,000 | 117,000 | 118,000 | 700 |
| 2017 | 105,000 | 110,000 | 111,000 | 118,000 | 4,314 |
| 2018 | 94,200 | 106,000 | 108,000 | 126,000 | 9,816 |
| 2019 | 89,700 | 104,000 | 106,000 | 129,000 | 12,278 |
| 2020 | 88,500 | 104,000 | 106,000 | 130,000 | 13,092 |
| 2021 | 88,100 | 104,000 | 106,000 | 132,000 | 13,187 |
| 2022 | 87,800 | 103,000 | 106,000 | 130,000 | 12,994 |
| 2023 | 87,800 | 103,000 | 105,000 | 129,000 | 12,781 |
| 2024 | 88,000 | 103,000 | 105,000 | 127,000 | 12,622 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2013 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2014 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2015 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2016 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2017 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2018 | 0.39 | 0.43 | 0.42 | 0.43 | 0.01 |
| 2019 | 0.37 | 0.43 | 0.42 | 0.43 | 0.02 |
| 2020 | 0.37 | 0.43 | 0.42 | 0.43 | 0.02 |
| 2021 | 0.36 | 0.43 | 0.42 | 0.43 | 0.02 |
| 2022 | 0.36 | 0.43 | 0.42 | 0.43 | 0.02 |
| 2023 | 0.36 | 0.43 | 0.42 | 0.43 | 0.02 |
| 2024 | 0.36 | 0.43 | 0.41 | 0.43 | 0.02 |

Table 2.2.33—Projections for GOA 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 2012-2024 (Scenario 3), with random variability in future recruitment under Model 1.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 80,700 | 80,700 | 80,700 | 80,700 | 0 |
| 2013 | 89,100 | 89,100 | 89,100 | 89,100 | 0 |
| 2014 | 92,200 | 92,200 | 92,200 | 92,200 | 3 |
| 2015 | 87,800 | 87,900 | 87,900 | 88,000 | 84 |
| 2016 | 79,800 | 81,000 | 81,200 | 82,900 | 1,004 |
| 2017 | 71,800 | 76,300 | 76,800 | 83,500 | 3,672 |
| 2018 | 64,500 | 73,800 | 74,700 | 87,800 | 7,144 |
| 2019 | 60,200 | 72,700 | 73,600 | 90,300 | 9,295 |
| 2020 | 58,700 | 72,500 | 73,200 | 91,000 | 10,129 |
| 2021 | 57,900 | 72,000 | 72,900 | 92,100 | 10,274 |
| 2022 | 57,400 | 71,500 | 72,600 | 90,500 | 10,185 |
| 2023 | 57,100 | 71,500 | 72,300 | 89,700 | 10,058 |
| 2024 | 57,200 | 71,100 | 72,000 | 88,900 | 9,980 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 112,000 | 112,000 | 112,000 | 112,000 | 0 |
| 2013 | 125,000 | 125,000 | 125,000 | 125,000 | 0 |
| 2014 | 132,000 | 132,000 | 132,000 | 132,000 | 2 |
| 2015 | 126,000 | 126,000 | 126,000 | 126,000 | 59 |
| 2016 | 116,000 | 117,000 | 117,000 | 118,000 | 700 |
| 2017 | 105,000 | 111,000 | 111,000 | 119,000 | 4,317 |
| 2018 | 93,900 | 107,000 | 108,000 | 127,000 | 10,022 |
| 2019 | 87,600 | 105,000 | 106,000 | 130,000 | 13,044 |
| 2020 | 84,500 | 104,000 | 105,000 | 130,000 | 14,336 |
| 2021 | 83,300 | 103,000 | 105,000 | 133,000 | 14,666 |
| 2022 | 81,900 | 102,000 | 104,000 | 130,000 | 14,566 |
| 2023 | 81,800 | 102,000 | 104,000 | 129,000 | 14,409 |
| 2024 | 81,900 | 102,000 | 103,000 | 127,000 | 14,284 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2013 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2014 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2015 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2016 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2017 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2018 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2019 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2020 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2021 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2022 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2023 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2024 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |

Table 2.2.34—Projections for GOA 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 2012-2024 (Scenario 4), with random variability in future recruitment under Model 1.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 40,700 | 40,700 | 40,700 | 40,700 | 0 |
| 2013 | 49,800 | 49,800 | 49,800 | 49,800 | 0 |
| 2014 | 55,900 | 55,900 | 55,900 | 55,900 | 1 |
| 2015 | 57,000 | 57,000 | 57,100 | 57,100 | 40 |
| 2016 | 54,500 | 55,100 | 55,100 | 56,000 | 481 |
| 2017 | 50,700 | 52,900 | 53,200 | 56,500 | 1,822 |
| 2018 | 46,700 | 51,600 | 52,100 | 58,900 | 3,807 |
| 2019 | 43,700 | 50,900 | 51,400 | 61,100 | 5,334 |
| 2020 | 42,300 | 50,700 | 51,000 | 61,500 | 6,101 |
| 2021 | 41,500 | 50,200 | 50,800 | 62,400 | 6,368 |
| 2022 | 41,100 | 49,900 | 50,600 | 62,100 | 6,398 |
| 2023 | 40,600 | 49,700 | 50,400 | 61,700 | 6,352 |
| 2024 | 40,600 | 49,700 | 50,100 | 61,000 | 6,299 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 117,000 | 117,000 | 117,000 | 117,000 | 0 |
| 2013 | 145,000 | 145,000 | 145,000 | 145,000 | 0 |
| 2014 | 167,000 | 167,000 | 167,000 | 167,000 | 2 |
| 2015 | 171,000 | 171,000 | 171,000 | 171,000 | 59 |
| 2016 | 167,000 | 168,000 | 168,000 | 169,000 | 705 |
| 2017 | 158,000 | 164,000 | 164,000 | 172,000 | 4,479 |
| 2018 | 146,000 | 160,000 | 162,000 | 182,000 | 11,135 |
| 2019 | 137,000 | 158,000 | 159,000 | 188,000 | 15,482 |
| 2020 | 132,000 | 157,000 | 158,000 | 188,000 | 17,865 |
| 2021 | 130,000 | 156,000 | 157,000 | 192,000 | 18,900 |
| 2022 | 128,000 | 154,000 | 156,000 | 191,000 | 19,143 |
| 2023 | 126,000 | 154,000 | 155,000 | 190,000 | 19,107 |
| 2024 | 126,000 | 154,000 | 155,000 | 188,000 | 18,994 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2013 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2014 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2015 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2016 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2017 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2018 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2019 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2020 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2021 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2022 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2023 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |
| 2024 | 0.20 | 0.20 | 0.20 | 0.20 | 0.00 |

Table 2.2.35—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = 0$ in 2012-2024 (Scenario 5), with random variability in future recruitment under Model 1.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0 | 0 | 0 | 0 | 0 |
| 2013 | 0 | 0 | 0 | 0 | 0 |
| 2014 | 0 | 0 | 0 | 0 | 0 |
| 2015 | 0 | 0 | 0 | 0 | 0 |
| 2016 | 0 | 0 | 0 | 0 | 0 |
| 2017 | 0 | 0 | 0 | 0 | 0 |
| 2018 | 0 | 0 | 0 | 0 | 0 |
| 2019 | 0 | 0 | 0 | 0 | 0 |
| 2020 | 0 | 0 | 0 | 0 | 0 |
| 2021 | 0 | 0 | 0 | 0 | 0 |
| 2022 | 0 | 0 | 0 | 0 | 0 |
| 2023 | 0 | 0 | 0 | 0 | 0 |
| 2024 | 0 | 0 | 0 | 0 | 0 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 121,000 | 121,000 | 121,000 | 121,000 | 0 |
| 2013 | 167,000 | 167,000 | 167,000 | 167,000 | 0 |
| 2014 | 209,000 | 209,000 | 209,000 | 209,000 | 2 |
| 2015 | 233,000 | 233,000 | 233,000 | 233,000 | 59 |
| 2016 | 244,000 | 245,000 | 245,000 | 246,000 | 709 |
| 2017 | 245,000 | 251,000 | 252,000 | 260,000 | 4,630 |
| 2018 | 238,000 | 254,000 | 255,000 | 278,000 | 12,262 |
| 2019 | 231,000 | 255,000 | 257,000 | 291,000 | 18,292 |
| 2020 | 226,000 | 257,000 | 258,000 | 298,000 | 22,452 |
| 2021 | 223,000 | 257,000 | 259,000 | 304,000 | 24,996 |
| 2022 | 220,000 | 256,000 | 259,000 | 306,000 | 26,304 |
| 2023 | 217,000 | 256,000 | 259,000 | 306,000 | 26,911 |
| 2024 | 217,000 | 256,000 | 258,000 | 306,000 | 27,149 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2013 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2014 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2015 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2016 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2017 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2018 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2019 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2020 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2021 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2022 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2023 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2024 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Table 2.2.36—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = F_{OFL}$ in 2012-2024 (Scenario 6), with random variability in future recruitment under Model 1.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 96,300 | 96,300 | 96,300 | 96,300 | 0 |
| 2013 | 102,000 | 102,000 | 102,000 | 102,000 | 0 |
| 2014 | 102,000 | 102,000 | 102,000 | 102,000 | 3 |
| 2015 | 95,100 | 95,200 | 95,200 | 95,400 | 103 |
| 2016 | 83,400 | 85,400 | 85,700 | 88,700 | 1,650 |
| 2017 | 68,800 | 76,800 | 77,800 | 90,100 | 6,427 |
| 2018 | 58,300 | 74,200 | 75,400 | 95,300 | 11,535 |
| 2019 | 54,700 | 74,000 | 75,000 | 98,000 | 13,774 |
| 2020 | 54,000 | 74,300 | 75,400 | 99,800 | 14,373 |
| 2021 | 53,200 | 74,200 | 75,600 | 101,000 | 14,323 |
| 2022 | 53,500 | 74,000 | 75,400 | 98,600 | 14,245 |
| 2023 | 53,600 | 73,900 | 75,000 | 98,100 | 14,067 |
| 2024 | 53,900 | 73,300 | 74,700 | 97,700 | 14,133 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 110,000 | 110,000 | 110,000 | 110,000 | 0 |
| 2013 | 117,000 | 117,000 | 117,000 | 117,000 | 0 |
| 2014 | 120,000 | 120,000 | 120,000 | 120,000 | 2 |
| 2015 | 111,000 | 111,000 | 111,000 | 112,000 | 59 |
| 2016 | 101,000 | 102,000 | 102,000 | 103,000 | 636 |
| 2017 | 92,200 | 96,800 | 97,400 | 104,000 | 3,792 |
| 2018 | 84,700 | 94,900 | 96,000 | 111,000 | 8,263 |
| 2019 | 81,800 | 94,700 | 95,800 | 115,000 | 10,117 |
| 2020 | 81,200 | 95,100 | 96,100 | 116,000 | 10,782 |
| 2021 | 80,800 | 94,600 | 96,300 | 117,000 | 10,850 |
| 2022 | 81,000 | 94,600 | 96,100 | 115,000 | 10,661 |
| 2023 | 81,000 | 94,700 | 95,800 | 115,000 | 10,516 |
| 2024 | 81,200 | 94,300 | 95,600 | 114,000 | 10,414 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2013 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2014 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2015 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2016 | 0.51 | 0.52 | 0.52 | 0.53 | 0.00 |
| 2017 | 0.47 | 0.49 | 0.49 | 0.53 | 0.02 |
| 2018 | 0.43 | 0.48 | 0.48 | 0.53 | 0.03 |
| 2019 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2020 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2021 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2022 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2023 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2024 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |

Table 2.2.37—Projections for GOA Pacific cod catch (t), spawning biomass (t), and fishing mortality under the assumption that $F = max\ F_{ABC}$ in each year 2012-2013 and $F = F_{OFL}$ thereafter (Scenario 7), with random variability in future recruitment under Model 1.

**Catch projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 81,200 | 81,200 | 81,200 | 81,200 | 0 |
| 2013 | 89,400 | 89,400 | 89,400 | 89,400 | 0 |
| 2014 | 110,000 | 110,000 | 110,000 | 110,000 | 3 |
| 2015 | 99,300 | 99,500 | 99,500 | 99,700 | 103 |
| 2016 | 87,300 | 88,800 | 89,000 | 91,200 | 1,225 |
| 2017 | 70,000 | 78,300 | 79,300 | 91,100 | 6,497 |
| 2018 | 58,600 | 74,500 | 75,700 | 95,700 | 11,572 |
| 2019 | 54,700 | 74,000 | 75,000 | 98,200 | 13,800 |
| 2020 | 53,900 | 74,400 | 75,400 | 99,800 | 14,385 |
| 2021 | 53,200 | 74,200 | 75,600 | 101,000 | 14,327 |
| 2022 | 53,500 | 74,000 | 75,400 | 98,600 | 14,247 |
| 2023 | 53,600 | 73,900 | 74,900 | 98,200 | 14,068 |
| 2024 | 53,900 | 73,300 | 74,700 | 97,700 | 14,134 |

**Biomass projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 112,000 | 112,000 | 112,000 | 112,000 | 0 |
| 2013 | 125,000 | 125,000 | 125,000 | 125,000 | 0 |
| 2014 | 129,000 | 129,000 | 129,000 | 129,000 | 2 |
| 2015 | 117,000 | 117,000 | 117,000 | 117,000 | 59 |
| 2016 | 104,000 | 105,000 | 105,000 | 106,000 | 697 |
| 2017 | 93,200 | 97,900 | 98,500 | 106,000 | 3,950 |
| 2018 | 84,900 | 95,200 | 96,400 | 112,000 | 8,372 |
| 2019 | 81,900 | 94,700 | 95,900 | 115,000 | 10,166 |
| 2020 | 81,200 | 95,200 | 96,100 | 116,000 | 10,799 |
| 2021 | 80,800 | 94,600 | 96,300 | 117,000 | 10,856 |
| 2022 | 81,000 | 94,600 | 96,100 | 115,000 | 10,663 |
| 2023 | 81,000 | 94,700 | 95,800 | 115,000 | 10,517 |
| 2024 | 81,200 | 94,300 | 95,600 | 114,000 | 10,414 |

**Fishing mortality projections:**

| Year | L90%CI | Median | Mean | U90%CI | Std. Dev. |
|---|---|---|---|---|---|
| 2012 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2013 | 0.43 | 0.43 | 0.43 | 0.43 | 0.00 |
| 2014 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2015 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2016 | 0.53 | 0.53 | 0.53 | 0.53 | 0.00 |
| 2017 | 0.47 | 0.50 | 0.50 | 0.53 | 0.02 |
| 2018 | 0.43 | 0.48 | 0.48 | 0.53 | 0.03 |
| 2019 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2020 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2021 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2022 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2023 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |
| 2024 | 0.41 | 0.48 | 0.48 | 0.53 | 0.04 |

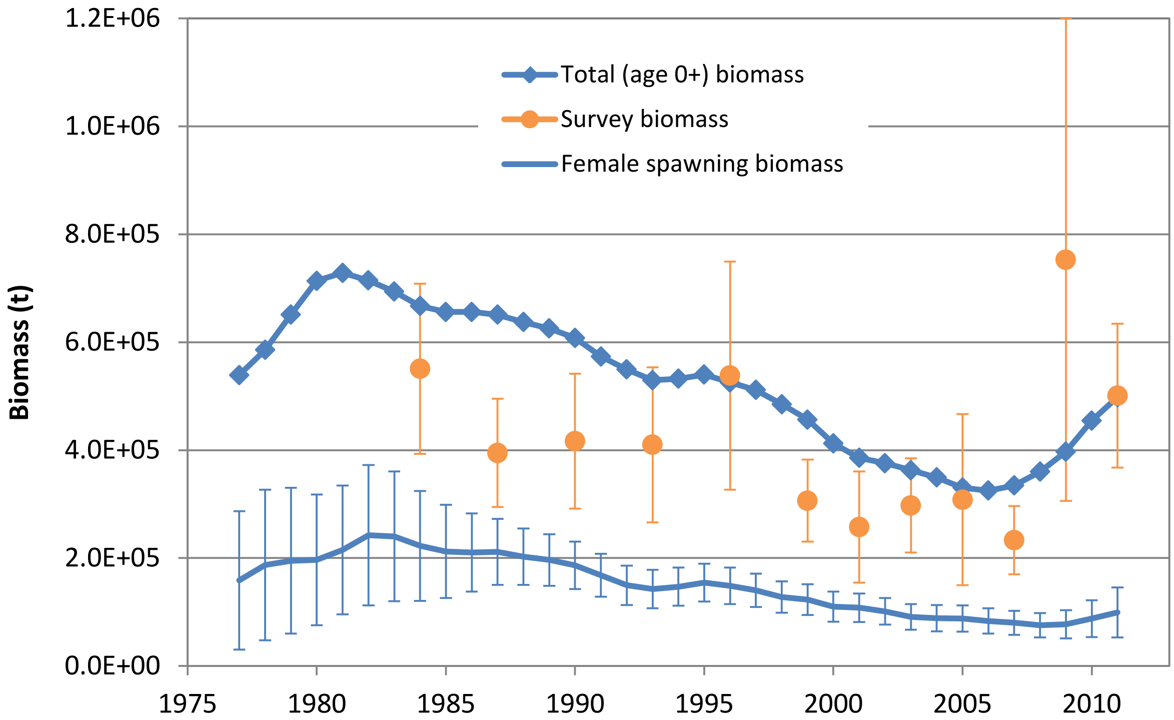



Figure 2.2.16—Biomass time trends (age 0+ biomass, female spawning biomass, survey biomass) of GOA Pacific cod as estimated by Model 1. Spawning survey and survey biomass show 95% CI.

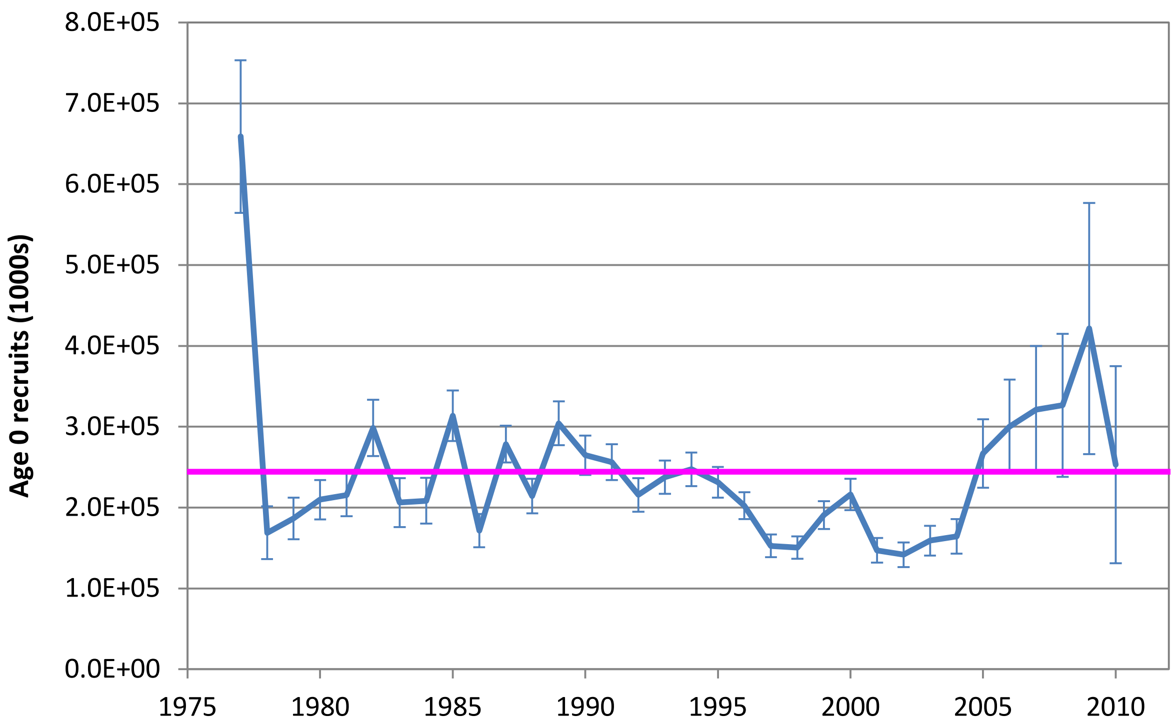



Figure 2.2.17—Time series of GOA Pacific cod recruitment at age 0, with 95% confidence intervals, as estimated by Model 1. Magenta line = 1977-2010 average.

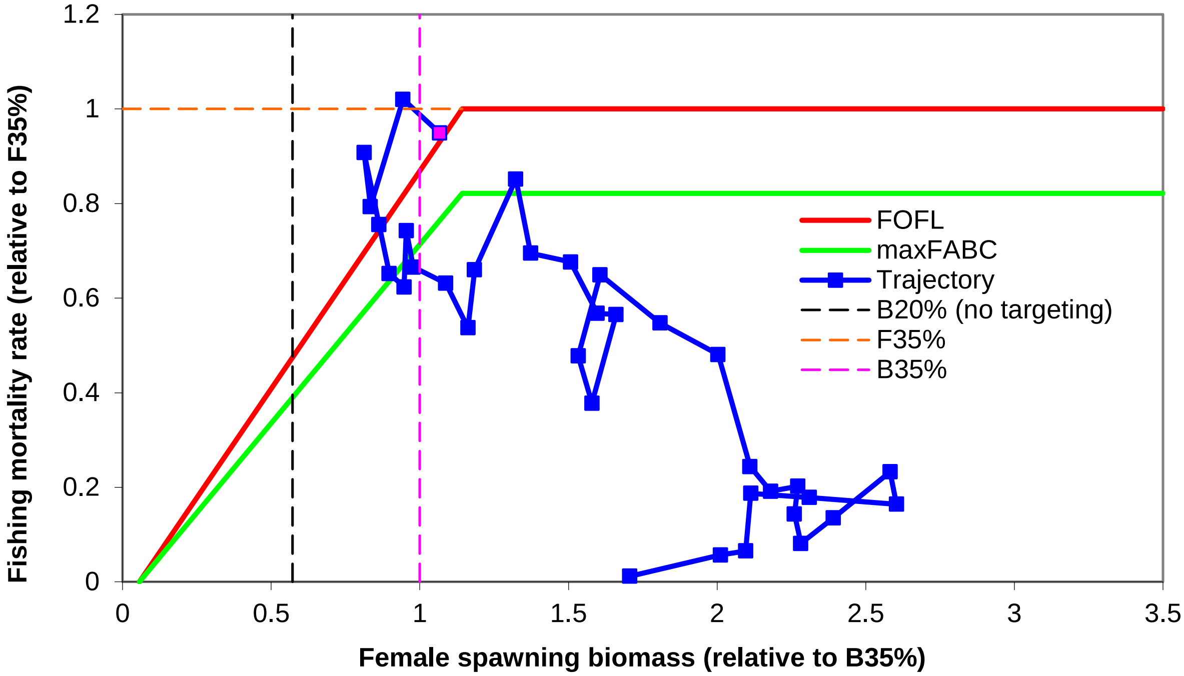



Figure 2.2.18—Trajectory of Pacific cod fishing mortality and female spawning biomass as estimated by Model 1, 1977-present (magenta square = 2011).

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