2. Assessment of the Pacific Cod Stock in the Eastern Bering Sea

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EXECUTIVE SUMMARY

Summary of Changes in Assessment Inputs

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

Changes in the Input Data

- Catches for 1991-2019 were updated, and a preliminary catch estimate for 2020 was incorporated.
- Commercial fishery size compositions for 1991-2019 were updated, and a preliminary size composition from the 2020 commercial fishery was incorporated.
- Age compositions from the EBS, Northern Bering Sea (NBS) and combined EBS+NBS survey time series were updated through 2019, based on the VAST approach.
- Long-term average weight-length parameters, and the time series of annual deviations therefrom, were re-estimated.
- For a pair of new models, a catch-weighted, all-gear, relative CPUE time series for the commercial fishery was incorporated.

Changes in the Assessment Methodology

Many changes have been made or considered in the stock assessment model since the 2019 assessment (Thompson and Thorson 2019). Fourteen models (including the current base model) were presented in this year's preliminary assessment (Appendix 2.1). After reviewing the preliminary assessment, the Team requested that five of the models from the preliminary assessment be included in this final assessment, including the current base model (19.12) and a model featuring explicit movement back and forth between the EBS and NBS. The SSC agreed, for the most part, with the Team's requested list, but suggested that the model featuring explicit movement be omitted. The SSC's model set spans a 2×2 factorial design, where the factors are: A1) whether survey catchability should be allowed to vary, and A2) whether the EBS and NBS bottom trawl surveys should be combined into a single (EBS+NBS) survey. The SSC's requested model set is included here, along with three new models intended to explore features that were suggested during public comment at the September Team meeting. The base model and the three new models span a second 2×2 factorial design, where the factors are: B1) whether fishery catch per unit effort (CPUE) should be used as an index of abundance, and B2) whether dome-shaped survey selectivity should be allowed. The four models corresponding to the A1×A2 factorial design are labeled "Ensemble A," and the four models spanning the B1×B2 factorial design are labeled "Ensemble B," and the union of Ensembles A and B is labeled "Ensemble AB" (note that the base model is a member of both Ensembles A and B, so a total of seven models is included in Ensemble AB). Results are provided for each of the seven individual models, and also for weighted averages of the models in Ensembles A and AB.

Summary of Results

The principal results of the present assessment, **based on Ensemble AB**, are listed in the table below (biomass and catch figures are in units of t) and compared with the corresponding quantities as specified last year by the SSC (note that the values specified last year by the SSC are, for the most part, different than those listed in last year's assessment, due to a difference in recommended model):

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
	2020	2021	2021*	2022*
M (natural mortality rate)	0.35	0.35	0.32	0.32
Tier	3a	3b	3b	3b
Projected total (age 0+) biomass (t)	756,811	702,235	842,254	878,837
Projected female spawning biomass (t)	267,333	216,255	273,584	253,506
$B_{100\%}$	672,795	672,795	771,600	771,600
$B_{40\%}$	269,118	269,118	308,640	308,640
$B_{35\%}$	235,478	235,478	270,060	270,060
F_{OFL}	0.41	0.33	0.31	0.30
$maxF_{ABC}$	0.34	0.27	0.26	0.25
F_{ABC}	0.33	0.26	0.26	0.25
OFL (t)	191,386	125,734	139,984	130,076
maxABC (t)	160,789	105,046	118,013	109,266
ABC (t)	155,873	102,975	118,013	109,266
Status	As determined *last* year for:		As determined *this* year for:	
	2018	2019	2019	2020
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

*Projections are based on assumed catches of 155,873 t, and 118,013 t in 2020 and 2021, respectively.

Note that the recommended 2021 and 2022 F_{ABC} and ABC values listed above may be subject to modification following consideration by the SSC of the "risk table" (see subsection in the "Harvest Recommendations" section). The summarized results of the risk analysis are shown below:

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 1: Normal	Level 1: Normal	Level 2: Substantially increased concerns	Level 1: Normal

In the event that the 2021 F_{ABC} or ABC values are changed from those shown above, projected 2022 values of other non-constant quantities would need to change in response.

Responses to SSC and Plan Team Comments on Assessments in General

Since last year's assessment was completed, the Joint Plan Teams (JPT) and SSC have made 9 comments on assessments in general. Comments made during 2019 were listed in the preliminary assessment

(Appendix 2.1), but were not addressed there, and so are repeated here. Note that numbering of new comments (i.e., those received during 2020) is continuous with numbering of comments in Appendix 2.1.

Comments from the November 2019 Joint Groundfish Plan Team meeting
JPT1: "The Teams recommended that authors continue to fill out the risk tables for full assessments." *Response*: A risk table is included in the "Risk Table" subsection of the "Harvest Recommendations" section.

JPT2: "The Teams recommended that adjustment of ABC in response to levels of concern should be left to the discretion of the author, the Team(s), and/or the SSC, but should not be mandated by the inclusion of a >1 level in any particular category." *Response*: One category (environmental/ecosystem) is assigned a level of 2 in this assessment (the other categories are all level 1), but an ABC adjustment is not recommended. See "Risk Table and ABC Recommendation" subsection of "Harvest Recommendations" section for details.

Comments from the December 2019 SSC meeting
SSC1: "The SSC requests that the GPTs, as time allows, update the risk tables for the 2020 full assessments, as the SSC found this exercise to be very helpful." *Response*: See response to Comment JPT1.

SSC2: "The SSC recommends dropping the overall risk scores in the tables." *Response*: The overall risk column in the previous risk table has been omitted.

SSC3: "The SSC requests that the table explanations be included in all the assessments which include a risk table for completeness." *Response*: The table explanations are included here.

SSC4: "The SSC discussed whether increased risk or uncertainty was relative to previous assessments of the same stock, or relative to other stocks. Both are relevant and elaboration by the authors or GPTs as to what the elevated risk refers to is encouraged." *Response*: In the "Risk Table and ABC Recommendation" subsection, uncertainty is evaluated relative to both previous assessments of EBS Pacific cod and assessments of other stocks. The evaluation with respect to previous assessments of EBS Pacific cod is undertaken primarily monitor between-year consistency in risk determinations, but the risk determinations themselves are based primarily on the evaluation relative to assessments of other stocks.

Comments from the September 2020 Joint Groundfish Plan Team meeting
JPT3: Referring to the analyses described by Bryan et al. (https://meetings.npfmc.org/CommentReview/DownloadFile?p=f95ec800-30da-487b-a35a-506c71f5accb.pdf&fileName=Uncertainty_retrospective_Bryanetal.pdf), "The Teams recommend that, to the extent practicable, authors consider these analyses, or analyses like them, for incorporation in the risk table." *Response*: The analysis of Bryan et al. was considered in the "Risk Table" section.

Comments from the September/October 2020 SSC meeting
SSC13: "The SSC recommends that standardized documentation (both format and content) will be very helpful to the authors, Plan Teams and SSC for review and diagnosis of VAST model results for each species. However, the SSC cautions against standardized model fitting (e.g., a single error distribution, set of covariates), other than as a starting point. The species-specific biological distribution, and interaction of this distribution with covariates, may require differing error distributions to fit the data adequately. It is more important for each species to have a statistically rigorous model selection process resulting in good model fit and diagnostics than the simplicity of fitting the same approach to all species: unlike design based estimators, the SSC suggests that one size does not fit all for VAST models." *Response*: The standardized documentation introduced in the preliminary assessment (Appendix 2.1) is retained here.

Time since the October SSC meeting was insufficient to explore alternative VAST specifications, although this could be undertaken in the future.

SSC14: "The SSC received a summary of the work done by Meaghan Bryan (NOAA-AFSC) and Grant Thompson (NOAA-AFSC) to inform the Joint Plan Team regarding the effects of missing survey data on groundfish stock assessments. The SSC notes that missing data are expected due to the biennial nature of the GOA and AI surveys, and that the planned or unplanned nature of missing data does not inherently imply bias in the stock assessment. The SSC supports the JPT's recommendation for authors to explicitly consider the survey loss analyses (or analyses like them) in developing their risk tables for this year, but does not suggest a standardized approach for all species, noting important differences in the behavior of individual assessments." *Response*: See response to Comment JPT3.

Responses to SSC and Plan Team Comments Specific to this Assessment

Since last year's assessment was completed, the BSAI Plan Team (BPT) and the SSC have made many comments specific to this assessment. A total of 18 Team and SSC comments specific to this assessment were addressed in the preliminary assessment (Appendix 2.1). In addition, the Team made 2 new comments specific to this assessment at its September 2020 meeting and the SSC made 11 new comments specific to this assessment at its September/October 2020 meeting. Note that numbering of new comments here is continuous with numbering of comments in the preliminary assessment and above.

Comments from the September 2020 Team meeting

BPT10: "The Team recommends that the ESR and/or ESP provide an index of movement (e.g., using the standard EBS bottom trawl survey stations, evaluate the proportion of Pacific cod biomass over time in the northernmost survey stations that are located between 59°N and 60°N in years 1982-2019) to validate the movement indices in this model. This would be needed in November if these models move forward, or if not, should be included in the ESP for Pacific cod in 2021." *Response*: This assessment includes a draft Ecosystem and Socioeconomic Profile (ESP) for the first time (Appendix 2.2), which provides some information on potential movement covariates. In particular, sea ice indicators are shown to be highly correlated with the northings in the center of gravity output from VAST. See also Comment SSC22.

BPT11: "The Team recommends the author run the model ensemble averaging approach using models 19.12a., 20.4, 19.12e, 19.12, 19.15, and using last year's ensemble averaging methodology (without the exponential weighting as per the SSC recommendations from 2019)." *Response*: All of the Team's requested models except 19.12e are included here (see Comment SSC19). Last year's ensemble averaging methodology is retained, except that the arithmetic mean is used instead of exponential weighting. See also Comment SSC25.

Comments from the September/October 2020 SSC meeting

SSC15: "The SSC does think there is value in looking back at previously accepted models to consider what advice they would provide under current conditions." *Response*: Two of the models in Ensemble B feature potentially dome-shaped survey selectivity, which was a regular feature of EBS Pacific cod assessment models prior to 2016.

SSC16: "The use of the Dirichlet-multinomial distribution was discussed because the sample size parameter was quite large, potentially allowing the sample size to represent more samples than hauls. The author did not think this was causing any convergence issues, but the SSC recommends that the authors explore this and potentially constrain that parameter." *Response*: There may have been some miscommunication during the SSC meeting, because one of the features of the Dirichlet-multinomial is that it *does not* allow the effective sample size to exceed the input sample size (here, number of hauls). All of the models presented here passed a "jitter" test (see "Convergence Behavior" subsection in the "Analytic Approach" section), indicating that convergence was not an issue, even though the log of the

Dirichlet-multinomial parameter was invariably estimated to be near the upper bound (=10.0) in the case of size composition data (but not age composition data).

SSC17: "The SSC was very interested to see the exploration of spatial models with movement. New tagging analyses and the analysis of western Bering Sea data show there is likely considerable movement and support the existence of a single Pacific cod stock in the Bering Sea and perhaps beyond. However, the SSC notes that this is a fairly large modeling innovation that needs further review before it is used for management as either a single model or as part of an ensemble. Although Stock Synthesis is under frequent and ongoing development, it may not have the flexibility to model movement in this context without additional tagging data to inform movement rates among areas. The structure of the underlying linear model for age-dependent movement across a certain subset of ages needs further justification; a simplifying assumption would be to estimate a common movement probability across all ages and perhaps constrain movement rates to only vary among years for which strong evidence of ontogenetic movement is available. In some years, like 2018, the interpretation of model results is that there is almost a complete exchange between EBS and NBS and in other years almost zero exchange. These movement parameters are necessarily confounded with the recruitment allocation to each area as well as catchability when it is allowed to vary over time or when estimated separately for the EBS and NBS surveys. The SSC would like to have clear evidence of spawning occurring in the NBS that would result in large amounts of age-0 Pacific cod being apportioned there as some models suggest. Fully vetting all of the models for these ensembles may be better suited for the upcoming CIE review in 2021, but the SSC supports continued progress in this assessment cycle." *Response*: The suggestion for further investigation of movement models is consistent with the advice given by both the Team and the SSC following the presentation of movement models, with and without environmental covariates, in the preliminary 2018 assessment. Further investigation of movement models will be proposed as a topic for the 2021 CIE review. Regarding the desire for clear evidence of spawning in the NBS, the size composition data from the 2019 NBS survey show a very pronounced peak in the size range corresponding to 1-year-old fish (Figure 2.9b). Unless there was a very substantial migration of age 0 fish (in 2018) or early age 1 fish (in 2019) from the EBS to the NBS, the most likely explanation for this pronounced size mode is successful spawning in the NBS.

SSC18: "The SSC supports the BSAI-GPT recommendation of using the set of models that do not have a catchability prior." *Response*: None of the models included here feature a prior distribution (other than uniform) on the logarithm of catchability.

SSC19: "The SSC supports the models that the BSAI-GPT selected for inclusion in the ensemble, but not 19.12e because the SSC would like to see additional exploration of hypotheses about movement and spatial dynamics and how these are handled by the model. This reduces the model ensemble to four models. These models are 19.12a, 19.12, 20.4, and 19.15. Model 19.12a is the base model, 19.2, without time varying catchability. Model 20.4 considers the NBS and EBS survey separately with time-invariant catchability. Model 19.15 has time-varying catchability and separate surveys. This selection of models eliminates all four of the two-area models. If it were desired to have a fifth model in the ensemble or for consideration on its own, a simpler model that was previously used for management (e.g., 16.6i) might be a useful addition." *Response*: The four models requested by the SSC are included here, and Model 19.12e is not. Model 16.6i is also not included.

SSC20: "The SSC suggests that spatial models that apportion movement and recruitment to sub-areas be considered research models and be brought along in parallel as time allows, including explorations of the relationships of the environmental covariates used, and other hypotheses about movement such as natal homing. The SSC suggests that if environmental covariates are to be used in the future, they should be sufficiently constrained by informative priors penalizing estimates toward no effect, such that only when

there is strong evidence of their relationship will movement be substantially altered." *Response*: This comment will be forwarded for consideration during the 2021 CIE review.

SSC21: "The SSC notes that the use of time-varying catchability in the NBS may be diluting the information content from that small set of surveys. It may be possible to include movement in a simple way by mirroring the NBS with the EBS catchability inversely (e.g., NBS catchability = 1 - EBS catchability)." *Response*: Stock Synthesis currently lacks the capability to implement this suggestion, although it is under consideration for inclusion in a future release.

SSC22: "The BSAI-GPT recommended examining survey catches at the northern stations in the EBS survey over time as a potential index of movement. In addition to the BSAI-GPT request, there are some outputs of VAST that might be useful including the index of area occupied and the center of gravity estimates." *Response*: See Comment BPT10.

SSC23: "The SSC recommends trying to obtain some fishery size and age composition samples in the NBS to verify that selectivities for both areas are similar." *Response*: It is likely that size composition data from the fishery in the NBS will become available in time for use next year. The assumption that NBS fishery selectivity mirrors EBS fishery selectivity was used in this year's preliminary assessment only because NBS fishery size composition data were unavailable.

SSC24: "Finally, the cross-conditional decision analysis (CCDA) is interesting and the SSC really appreciates the work done to identify viable alternative methods for weighting ensemble models, and the comparison to machine learning. This is a novel effort to address model weighting which is one of the most controversial aspects of ensemble modeling. However, it was noted that CCDA is a new, computationally-intensive method that might be too difficult for use due to time limitations before the November Plan Team meeting in the current assessment cycle. The SSC recommends that this methodology be reviewed at the upcoming CIE review." *Response*: The CCDA approach will be proposed as a topic for the 2021 CIE review.

SSC25: "The SSC affirms that the authors should use last year's ensemble averaging methodology (without the exponential weighting as per the SSC recommendations from 2019)." *Response*: See Comment BPT11.

INTRODUCTION

Pacific cod (*Gadus macrocephalus*) is a transoceanic species, ranging from Santa Monica Bay, California, northward along the North American coast; across the Gulf of Alaska and Bering Sea north to Norton Sound; and southward along the Asian coast from the Gulf of Anadyr to the northern Yellow Sea; and occurring at depths from shoreline to 500 m (Ketchen 1961, Bakkala et al. 1984). The southern limit of the species' distribution is about 34° N latitude, with a northern limit of about 65° N latitude (Lauth 2011). Pacific cod is distributed widely over the eastern Bering Sea (EBS) as well as in the Aleutian Islands (AI) area. Tagging studies (e.g., Shimada and Kimura 1994) have demonstrated significant migration both within and between the EBS, AI, and Gulf of Alaska (GOA). However, recent research indicates the existence of discrete stocks in the EBS and AI (Canino et al. 2005, Cunningham et al. 2009, Canino et al. 2010, Spies 2012). Research conducted in 2018 indicates that the genetic samples from the NBS survey in 2017 are very similar to those from the EBS survey area, and quite distinct from samples collected in the Aleutian Islands and the Gulf of Alaska (Spies et al. 2019).

Although the resource in the combined EBS and AI (BSAI) region had been managed as a single unit from 1977 through 2013, separate harvest specifications have been set for the two areas since the 2014 season.

Pacific cod are 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 BSAI.

Additional information on the biology of Pacific cod, including early life history, can be found in the draft ESP (Appendix 2.2).

FISHERY

Description of the Directed Fishery

During the early 1960s, a Japanese longline fishery harvested EBS Pacific cod for the frozen fish market. Beginning in 1964, the Japanese trawl fishery for walleye pollock (*Gadus chalcogrammus*) expanded and cod became an important bycatch species and an occasional target species when high concentrations were detected during pollock operations. By the time that the Magnuson Fishery Conservation and Management Act went into effect in 1977, foreign catches of Pacific cod had consistently been in the 30,000-70,000 t range for a full decade. In 1981, a U.S. domestic trawl fishery and several joint venture fisheries began operations in the EBS. The foreign and joint venture sectors dominated catches through 1988, but by 1989 the domestic sector was dominant and by 1991 the foreign and joint venture sectors had been displaced entirely.

Presently, the Pacific cod stock is exploited by a multiple-gear fishery, including trawl, longline, pot, and jig components (although catches by jig gear are very small in comparison to the other three main gear types, with an average annual catch of less than 200 t since 1991). The breakdown of catch by gear during the most recent complete five-year period (2015-2019) is as follows: longline gear accounted for an average of 51.8% of the catch, trawl gear accounted for an average of 28.9%, and pot gear accounted for an average of 19.3%.

In the EBS, Pacific cod are caught throughout much of the continental shelf, with National Marine Fisheries Service (NMFS) statistical areas 509, 513, 517, 519, 521, and 524 each accounting for at least 5% of the total catch over the most recent 5-year period (2015-2019).

Catches of Pacific cod taken in the EBS for the periods 1964-1980, 1981-1990, and 1991-2020 are shown in Tables 2.1a, 2.1b, and 2.1c, respectively; and the time series for the overall fishery (1977-2020) and by gear type (1988-2020) are shown in Figure 2.1. The catches in Tables 2.1a and 2.1b are broken down by fleet sector (foreign, joint venture, domestic annual processing). The catches in Table 2.1b are also broken down by gear to the extent possible. The catches in Table 2.1c are broken down by gear.

Figures 2.2a and 2.2b compare the Northern Bering Sea Research Area (NBSRA) and the area covered by the NBS bottom trawl survey, showing them to be very similar. Figure 2.3 breaks down the total catch time series from 2003-2020 in terms of the NBSRA and the rest of the EBS.

The draft ESP (Appendix 2.2) incorporates the Economic Performance Report that was included in previous EBS Pacific cod assessments.

The extent to which catches of Pacific cod in Russian waters affect the EBS stock are unknown, and the available catch data from the Western Bering Sea (shown below) are likely not comprehensive:

Year:	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Catch (t):	11124	16252	16260	15397	18065	23068	19799	21420	31664	45793

(Source: S. Barbeaux, AFSC, *pers. commun*., March 8, 2019.)

Effort and CPUE

Catch-per-unit-effort (CPUE) data from the 1991-2020 fisheries are shown in Table 2.2, with trawl fishery data shown in Table 2.2a, longline fishery data shown in Table 2.2b, and pot fishery data shown in Table 2.2c. Data in each panel have been normalized to an overall mean of 1.0.

Beginning with the 2017 assessment (Thompson 2017), the time series of catch-per-unit-effort (CPUE) data from the longline fishery have been analyzed in each assessment using a model that estimates a time series of year and month effects. This enables the average (across months) CPUE for 2020 to be estimated even though data for the last few months of the year are not yet available. The estimated year and month effects are shown in the two upper panels of Figure 2.4 and the overall fit to the time series (inverse-variance-weighted $R^2 = 0.91$) is shown in the lower panel. The CPUE for 2020 is estimated to be 26% above the average for the time series.

The model shown in Figure 2.4 fits the time series of year-and-month mean CPUE data, weighted inversely by the squared standard errors. Thus, the data are weighted by sample size, but not by catch. New this year is an alternative CPUE index that provides a time series of catch-weighted annual relative indices that combines CPUE data from all gear types. The new index was developed as follows:

For each *gear* and *year*:

1. For each month, weight the CPUE mean by that *month's* proportion of the gear-specific and year-specific catch.
2. Sum the month-specific, catch-weighted CPUE mean obtained in step #1 across months, except for the terminal year, where the sum for the year to date is adjusted by the sum of the "month effects" estimated in the previous method (i.e., the model that estimated the non-catch-weighted year effects and month effects, as in Figure 2.4) so as to produce a year-end equivalent.
3. Divide the summed monthly catch-weighted CPUE means obtained in step #2 by the average of the sum computed in step #2.
4. Repeat the above 3 steps for the squared CPUE standard error, except that the weighting in step #1 is the proportion *squared*, and the divisor in step #3 will be the *square* of the average of the sum for the catch-weighted CPUE means

Then, for each *year*:

1. For each gear, weight the catch-weighted-and-scaled CPUE means obtained above by that *gear's* proportion of the year-specific catch.
2. Sum the gear-specific, catch-weighted-and-scaled CPUE means obtained in step #1 across gear.
3. Repeat the above 2 steps for the catch-weighted-and-scaled squared CPUE standard error, except that the weighting in step #1 is the proportion *squared*.

The resulting time series is shown in Table 2.3 and Figure 2.5. The estimate for 2020 is the all-time high for the time series, and is 67% above the time series average.

Discards

The catches shown in Tables 2.1b and 2.1c include estimated discards. Discards of Pacific cod in the EBS Pacific cod fisheries are shown for each year 1991-2020 in Table 2.4. Amendment 49, which mandated increased retention and utilization of Pacific cod, was implemented in 1998. From 1991-1997, discard rates in the Pacific cod fishery averaged about 4.9%. Since then, they have averaged about 1.3%, and have decreased continuously since 2013.

Management History

The history of acceptable biological catch (ABC), overfishing level (OFL), and total allowable catch (TAC) levels is summarized and compared with the time series of aggregate (i.e., all-gear, combined area) commercial catches in Table 2.5. Note that, prior to 2014, this time series pertains to the combined BSAI region, so the catch time series differs from that shown in Table 2.1, which pertains to the EBS only.

From 1980 through 2019 TAC averaged about 85% of ABC (ABC was not specified prior to 1980), and from 1980 through 2019, commercial catch averaged about 93% of TAC. In 10 of these 40 years, TAC equaled ABC exactly, and in 12 of these 40 years, catch exceeded TAC (by an average of 4.1%). However, seven of those overages occurred in 2007, 2008, 2010, and 2016-2019, when TAC was reduced by various proportions to account for a small, State-managed fishery inside State of Alaska waters (such reductions have been made in all years since 2006; see text table below for recent formulae); thus, while the combined Federal and State catch exceeded the Federal TAC in 2007, 2008, 2010, and 2016-2019 by up to 7.4%, the overall target catch (Federal TAC plus State GHL) was *not* exceeded.

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

Changes in ABC over time are typically attributable to three factors: 1) changes in resource abundance, 2) changes in management strategy, and 3) changes in the stock assessment model. Assessments conducted prior to 1985 consisted of simple projections of current survey numbers at age. In 1985, the assessment was expanded to consider all survey numbers at age from 1979-1985. From 1985-1991, the assessment was conducted using an *ad hoc* separable age-structured model. In 1992, the assessment was conducted using the Stock Synthesis modeling software (Methot 1986, 1990) with age-based data. All assessments from 1993 through 2003 continued to use the Stock Synthesis modeling software, but with length-based data. Age data based on a revised ageing protocol were added to the model in the 2004 assessment. At about that time, a major upgrade in the Stock Synthesis architecture resulted in a substantially new product, at that time labeled "SS2" (Methot 2005). The assessment was migrated to SS2 in 2005. Changes to model structure were made annually through 2011, then the base model remained constant through 2015, and new base models were adopted in both 2016, 2018, and 2019 (see Appendix 2.3). A note on software nomenclature: The label "SS2" was dropped in 2008. Since then, the program has been known simply as "Stock Synthesis" or "SS," with several versions typically produced each year, each given a numeric or alpha-numeric label.

A previous version of the time series shown in Table 2.5 was used in by Thompson (2018b) to estimate a statistical relationship between ABC and realized catch, yielding the following segmented linear model: For ABC≥198,000 t, catch = 89,000 t + 0.55×ABC; for ABC<198,000 t, catch = ABC. The root-mean-squared relative error from this model was 4%.

Beginning with the 2014 fishery, the Board of Fisheries for the State of Alaska has established guideline harvest levels (GHLs) in State waters between 164 and 167 degrees west longitude in the EBS subarea (these have supplemented GHLs that had been set aside for the Aleutian Islands subarea since 2006). The table below shows the formulas that have been used to set the State GHL for the EBS (including the formula anticipated for setting the 2021 GHL):

Year	Formula
2014	0.030 × (EBS ABC + AI ABC)
2015	0.030 × (EBS ABC + AI ABC)
2016	0.064 × EBS ABC
2017	0.064 × EBS ABC
2018	0.064 × EBS ABC

2019	0.080 × EBS ABC
2020	0.090 × EBS ABC
2021	0.100 × EBS ABC

For 2020 and 2021, the Board of Fisheries established an additional GHL of 45 t for vessels using jig gear within State waters.

Table 2.6 lists all implemented amendments to the BSAI Groundfish FMP that reference Pacific cod explicitly. In addition to those, the following regulations are currently at the proposed rule stage, with a final rule expected at some time in 2021:

"NMFS proposes regulatory amendments that would modify Federal permit conditions and impose participation requirements for certain Federally-permitted vessels when fishing for Pacific cod in state waters adjacent to the EEZ of the Bering Sea and Aleutian Islands (BSAI) during the State of Alaska's Pacific cod fishery that runs concurrent with the Federal Pacific cod fishery, commonly known as the Pacific cod parallel fishery. Specifically, this proposed rule would prohibit (1) a hook-and-line, pot, or trawl gear vessel named on an Federal Fisheries Permit (FFP) or License Limitation Program (LLP) license from being used to catch and retain BSAI Pacific cod in State of Alaska (State) waters adjacent to the BSAI during the State's parallel Pacific cod fishery unless the vessel is named on an FFP and LLP license that have the required endorsements; (2) a hook-and-line, pot, or trawl gear vessel named on an FFP or LLP license from catching and retaining BSAI Pacific cod in state waters adjacent to the BSAI EEZ during the State's parallel fishery when NMFS has closed the EEZ to directed fishing for Pacific cod by the sector to which the vessel belongs; (3) the holder of an FFP with certain endorsements from modifying those endorsements during the effective period of the FFP; and (4) the reissuance of a surrendered FFP with certain endorsements for the remainder of the three-year term, or cycle, of FFPs."

DATA

The first two subsections below describe fishery and survey data that are used in the current stock assessment models. The third subsection describes data that are not used in the current stock assessment models, but that may help to provide some context for the data that are used.

The following table summarizes the sources, types, and years of data included in the data file for at least one of the stock assessment models:

Source	Type	Years
Fishery	Catch biomass	1977-2020
Fishery	Catch size composition	1977-2020
Fishery	Catch per unit effort	1991-2020
EBS shelf trawl survey	Survey numerical abundance	1982-2019
EBS shelf trawl survey	Survey size composition	1982-2019
EBS shelf trawl survey	Survey age composition	1994-2019
NBS shelf trawl survey	Survey numerical abundance	1982, 1985, 1988, 1991, 2010, 2017-2019
NBS shelf trawl survey	Survey size composition	1982, 1985, 1988, 1991, 2010, 2017, 2019
NBS shelf trawl survey	Survey age composition	2010, 2017-2019
EBS+NBS trawl survey	Survey numerical abundance	1982-2019
EBS+NBS trawl survey	Survey size composition	1982-2019
EBS+NBS trawl survey	Survey age composition	1994-2019

Fishery Data Used in the Models

Catch Biomass
Catch estimates for the period 1977-2020 are shown Tables 2.1a, 2.1b, and 2.1c. However, the estimate for 2020 is complete only through October 21. Because the 2020 ABC (155,873 t) is lower than any year-end catch since 2010, the year-end catch for 2020 was set equal to the 2020 ABC.

The catches shown in Tables 2.1a, 2.1b, and 2.1c consist of "official" data from the NMFS Alaska Region. However, other removals of Pacific cod are known to have occurred over the years, including removals due to subsistence fishing, sport fishing, scientific research, and fisheries managed under other FMPs. Estimates of such other removals are shown in Appendix 2.4.

The catch estimates for the years 1977-1980 shown in Table 2.1a may or may not include discards.

Size Composition
Table 2.7 shows the fishery size compositions from 1977 through October 2020, which are parsed into 1-cm bins for use in the assessment models. The size composition data Table 2.7 were computed by using month/gear/area catch proportions to create a weighted average for each year's record, with a minimum sample size of 30 fish for any month/gear/area combination (this minimum sample size was determined in Attachment 2.1.2 of Appendix 2.1).

The sample sizes (number of sampled hauls) for the annual size compositions are shown in Table 2.8.

Survey Data Used in the Models

Overview of Survey Areas and Frequency
The areas covered by the EBS shelf and NBS bottom trawl surveys are shown in Figure 2.2b. Prior to this year, in the EBS, strata 10-62 had been surveyed annually since 1982 and strata 82 and 90 had been surveyed annually since 1987. However, this year, the EBS bottom trawl survey was cancelled due to the COVID-19 pandemic. In the NBS, strata 70, 71, and 81 in the NBS were surveyed fully in 2010, 2017, and 2019. Less extensive surveys of the NBS were conducted in 1982, 1985, 1988, 1991, and 2018. The NBS was also scheduled to be surveyed this year, but, like the EBS survey, the 2020 NBS survey was cancelled due to the COVID-19 pandemic.

Abundance

Design-based, area-swept estimates of abundance (in 1000s of fish) obtained from the EBS, NBS, and combined EBS and NBS are shown in Table 2.9, together with their respective log-scale standard deviations ("Sigma"). Abundance estimates and 95% confidence intervals for the same four time series are shown in Figure 2.6. The 2019 estimate for the EBS was up 112% from the 2018 estimate and up 44% from the 2017 estimate. The 2019 estimate for the NBS was up 47% from the 2017 estimate (the 2018 "rapid response" survey did not cover the entire NBS survey area, and is not included in the design-based estimates). The 2019 estimate for the combined EBS and NBS surveys was up 45% from 2017.

For the 2019 assessment (Thompson and Thorson 2019), alternative sets of survey abundance estimates based on the VAST approach of Thorson et al. (2015) became available, and were used in all models other than the base model. More specifically, four sets of estimates (each covering the EBS, NBS, and combined EBS and NBS) were developed, following a 2×2 factorial design, where the first factor was whether the location and extent of the "cold pool" was included as a covariate or not, and the second factor was whether the estimates were bias corrected or not. All four sets of estimates are shown in Table 2.10, and are illustrated for the EBS, NBS, and combined EBS and NBS in Figure 2.7. All settings used to generate the VAST estimates followed the recommendations given by Thorson (2019). As Figure 2.7 shows, the results for the EBS are extremely similar across the four datasets, although some differences are visually discernible for the NBS. The set of estimates with the cold pool covariate included and bias corrected was chosen for use in the 2019 assessment, because: 1) the SSC had previously expressed a preference for mechanistic models over mere correlation and use of the cold pool as a covariate for changes in the distribution of Pacific cod in particular (SSC minutes, October 2018), and 2) bias is generally something to be avoided (all else being equal). The estimates for the EBS, NBS, and combined EBS and NBS from this dataset are consolidated in Figure 2.8. Broadly speaking, this set of estimates is similar to the design-based estimates shown in Table 2.9. The 2019 EBS estimate was up 95% from 2018 and up 46% from 2017, the 2019 NBS estimate was down 13% from 2018 but up 58% from 2017, and the 2019 EBS+NBS estimate was up 44% from 2018 and up 49% from 2017.

In response to an SSC request, all specifications used in making the VAST estimates used in this assessment are described in the "VAST specifications" subsection of the "Data" section in Appendix 2.1. In the interest of brevity, they are not repeated here.

Size and Age Composition

Design-based estimates of the size compositions (in 1-cm bins) from the bottom trawl surveys for the years 1982-2019 are shown in Table 2.11 (VAST estimates of size composition are not yet available, so design-based estimates were used for all models). Each row sums to unity. Sample sizes for the survey size composition data, in units of sampled hauls, are shown in Table 2.12.

Recent size compositions, up to 80 cm, are compared in Figure 2.9. The size compositions from the nine most recent surveys of the EBS are shown in Figure 2.9a along with the 1987-2019 mean size composition. While the size compositions from 2011-2014 show clear indications of incoming year classes that are larger than the long-term mean, the 2015-2018 size compositions indicate a string of poor recruitments. The 2019 size composition shows that the 2018 year class may break that string. Figure 2.8b shows the size compositions from the 2010, 2017, and 2019 NBS surveys. As in the 2019 EBS survey, the 2019 NBS survey indicates that the 2018 year class may be large. However, it should be noted that bottom temperatures near shore in both the EBS and NBS were extremely high in 2019, and it is possible that the apparent large size of the 2018 year class may be due in part or entirely to a change in selectivity, if age 1 fish that might normally reside largely in waters close to shore and outside the survey areas were pushed into the survey areas by the high temperatures near shore.

Age compositions from the 1994-2019 EBS surveys are shown in Table 2.13, where the values in each row sum to unity. Table 2.13a shows the design-based estimates of age composition for the EBS. Table 2.13b shows the VAST estimates of age composition for the EBS, NBS, and EBS and NBS combined. Sample sizes for the survey age composition data, in units of read otoliths, are shown in Table 2.14 (but note that the sample sizes actually specified in the models are in units of sampled hauls (Table 2.12)).

Data Provided for Context Only

Fishery Age Composition
Fishery age composition data have not been included in assessment models of EBS Pacific cod for many years, as attempts to use those data have proven unsatisfactory for various reasons. Nevertheless, otoliths from commercial fishing operations continue to be collected and read in the hope that they can be included in assessment models at some point, and the data currently available (2010-2018) are shown in Table 2.15. The most recent attempt at including fishery age composition data in assessment models was the preliminary assessment of 2019 (Appendix 2.1 of Thompson and Thorson 2019). However, the models developed in that preliminary assessment exhibited unacceptable levels of retrospective bias, and, during the process of developing the final draft of the 2019 assessment, removal of the fishery age composition data proved to be key in restoring retrospective bias to acceptable levels.

Biomass Estimates from the EBS Shelf and NBS Bottom Trawl Surveys
Design-based, area-swept estimates of biomass for the EBS, NBS, and EBS and NBS combined are shown in Table 2.16, together with their respective standard errors. Biomass estimates and 95% confidence intervals are shown in Figure 2.10. The 2019 estimate for the EBS was up 2% from the 2018 estimate, but down 20% from the 2017 estimate. The 2019 estimate for the NBS was up 29% from the 2017 estimate (the 2018 "rapid response" survey did not cover the entire NBS survey area, and is not included in the design-based estimates). The 2019 estimate for the combined EBS and NBS surveys was down 5% from 2017.

IPHC Longline Survey
Figuer 2.10a shows the locations of BSAI stations sampled by the IPHC longline survey. The time series (1997-2019) of relative population numbers (RPN) is shown in Figure 2.10b. The 2019 estimate was up 32% from the 2018 estimate, and is almost identical to the mean value for the time series. No estimate for 2020 is available.

ANALYTIC APPROACH

General Model Structure

Although Pacific cod in the EBS and AI were managed on a BSAI-wide basis through 2013, the stock assessment model has always been configured for the EBS stock only. Since 1992, the assessment model has always been developed under some version of the SS modeling framework (technical details given in Methot and Wetzel 2013; see especially Appendix A to that paper). Beginning with the 2005 assessment, the EBS Pacific cod models have all used versions of SS based on the ADMB software package (Fournier et al. 2012). A history of previous model structures, including all SS-based models that have been fully vetted since 2005, is given in Appendix 2.3.

SS V3.30.16.02 was used to run all of the models in this final assessment. The user manual is available at https://vlab.ncep.noaa.gov/web/stock-synthesis/document-library/-/document_library/0LmuycloZeIt/view/1933976 .

Parameter Estimation

SS requires that prior distributions be associated with all internally estimated time-invariant parameters and the base values of all internally estimated time-varying parameters. For the models presented in this preliminary assessment, uniform prior distributions were used for estimation of all such parameters, with bounds set at values sufficiently extreme that:

- they were non-constraining (with two exceptions; see "Results" section below), or
- extending the bounds to even more extreme values would have no practical impact (because, when the parameter is back-transformed to the natural scale, the resulting quantity is indistinguishable from a logical constraint; e.g., selectivity cannot fall outside the (0,1) range).

To simplify terminology, such parameters will be referred to here as being "freely estimated."

On the other hand, for each parameter that varies randomly on an annual basis, SS estimates a vector of annual deviations that is constrained by a standard normal probability density function, and then multiplies that vector by a standard deviation (σ) specific to that parameter. For all models in this assessment, each σ was tuned iteratively as follows:

- For a vector associated with log catchability, σ was tuned to set the root-mean-squared-standardized-residual (RMSSR) equal to unity.
- For the vector of annual deviations associated with log-scale recruitment, σ was tuned to match the square root of the variance of the estimates plus the sum of the estimates' variances (Methot and Taylor 2011).
- For all other vectors, σ was tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.

Description of Alternative Models

List of Models

Beginning with the final 2015 assessment (Thompson 2015), model numbering has followed the protocol given by Option A in the SAFE chapter guidelines. Names of all final models adopted between the 2005 assessment (when an ADMB-based version of SS was first used) and the 2015 assessment were translated according to that protocol in Table 2.11 of the 2015 assessment. The goal of the protocol is to make it easy to distinguish between major and minor changes in models and to identify the years in which major model changes were introduced. Names of models constituting *major* changes get linked to the year that they are introduced (e.g., the current base model, Model 19.12, was one of several models introduced in 2019 that constituted a major change from the then-current base model), while names of models constituting *minor* changes from the original form of the current base model get linked to the name of that model (e.g., the name of the base model from 2018, Model 16.6i, referred to a model that constituted a minor change from Model 16.6, regardless of the year in which it was introduced).

This year's preliminary assessment (Appendix 2.1) included an 8-model "primary" ensemble based on a factorial design, where the factors were:

- Is catchability (Q) time-varying?
- Are the EBS and NBS modeled as separate areas?
- Are the EBS and NBS surveys included as separate surveys?
- Is movement between the EBS and NBS modeled explicitly?

The six models in the primary ensemble that included the EBS and NBS surveys as separate surveys included an informative prior distribution on NBS survey log catchability. An "alternative" ensemble was also included, in which that prior distribution was removed from the six models. Two models were common (19.12a and 19.12) were common to both ensembles. The factorial design and the corresponding models in the two ensembles are shown below:

Time-varying *Q*?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Primary ensemble	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
Alternative ensemble	19.12a	20.4	20.5	19.12e	19.12	19.15	20.6	20.7

Following review of the preliminary assessment, the SSC requested that Models 19.12a, 20.4, 19.12, and 19.15 be included in the final assessment. These comprise a 2×2 factorial design, where the factors are a subset of those used in the preliminary assessment:

- A1: Is catchability (*Q*) time-varying?
- A2: Are the EBS and NBS surveys combined into a single survey?

The SSC's requested models will be referred to here as "Ensemble A."

During the September Team meeting, public comment, including a review of last year's assessment commissioned by a fishing industry group, suggested that there was interest in pursuing alternative model structures. In response, a second 2×2 factorial design was used to develop some additional models, where the factors are:

- B1: Should fishery CPUE be included as an index of abundance?
- B2: Should dome-shaped survey selectivity be allowed?

Although fishery CPUE has never been used as an index of abundance in previous assessment models of EBS Pacific cod, allowing survey selectivity to be dome-shaped was a standard feature of assessment models of this stock for many years, up until it was discontinued in the 2016 assessment.

The four models corresponding to this second factorial design will be referred to here as "Ensemble B," and the union of Ensembles A and B will be referred to as "Ensemble AB" (note that the base model, 19.12, is a member of both Ensembles A and B). The factorial designs of Ensembles A (blue) and B (yellow) are shown below, where Model 19.12 (green) is common to both Ensembles A and B:

Factor A1: Allow *Q* to vary?	no		yes		(yes)			
Factor A2: Combine surveys?	no	yes	no	yes				
Factor B1: Use fishery CPUE?	(no)				no		yes	
Factor B2: Allow domed selex?					no	yes	no	yes
Model:	20.4	19.12a	19.15	19.12	TBD	TBD	TBD	

The names ("to be determined") of the three new models in Ensemble B will be assigned in the "Results" section, based on their performance relative to the base model.

Base Model

Model 19.12 was adopted by the SSC last year as the new base model. It contains the following features:

- Sexes combined
- One season per year
- Natural mortality (constant across age and time) freely estimated
- Mean length at age follows a Richards growth function, with parameters as follow:
    - Base value of length at age 1.5 freely estimated
        - With constrained annual deviations on the log scale, in order to begin addressing the significant amount of time-variability in size at age documented by Puerta et al. (2019) and Ciannelli et al. (2019)
    - Von Bertalanffy (Brody) growth coefficient freely estimated
    - Asymptotic length freely estimated
    - Richards growth coefficient freely estimated
- Standard deviation of length at age varies linearly with length at age, parameters freely estimated
- Weight at length varies annually ($W = \exp(\ln(\alpha_t)+\beta_t \ln(\mathrm{L}))$), estimated outside the model
- Maturity at length (constant across time) estimated outside the model
- Mean ageing error varies linearly with age, freely estimated within each of 2 time blocks in order to compensate for an apparent change in ageing criteria (Beth Matta, AFSC Age and Growth Program, *pers. commun*., 6/27/2019):
    - 1977-2007
    - 2008-present
- Recruitment is independent of stock size:
    - Mean freely estimated within each of 2 time blocks:
        - Pre-1977
        - 1977-present
    - With constrained annual deviations on the log scale
- One survey, covering the EBS and NBS combined
    - Base value of log catchability freely estimated
        - With constrained annual deviations
    - Size-based, double-normal selectivity, with parameters as follow:
        - Base value of first size with selectivity=1 freely estimated
            - With constrained annual deviations on the log scale
        - Logit of size range with selectivity=1 fixed at 10.0
        - Base value of log of standard deviation for 1st normal pdf freely estimated
            - With constrained annual deviations
        - Log of standard deviation for 2nd normal pdf fixed at 10.0
        - Logit of selectivity at minimum size fixed at -10.0
        - Logit of selectivity at maximum size fixed at 10.0
- One fishery, covering the EBS and NBS combined
    - Size-based, double-normal selectivity, with parameters as follow (however, see "Parameterization issues" section below):
        - First size with selectivity=1 freely estimated
        - Logit of size range with selectivity=1 freely estimated
        - Base value of log of standard deviation for 1st normal pdf freely estimated
            - With constrained annual deviations
        - Log of standard deviation for 2nd normal pdf freely estimated
        - Logit of selectivity at minimum size fixed at -10.0
        - Base value of logit of selectivity at maximum size freely estimated
            - With constrained annual deviations

- Following Thorson et al. (2017), input sample sizes (*Nsamp*) for compositional data range between zero and an initial number of (*Ninit*) according to the formula $Nsamp = (1 + \exp(ln\theta)\, Ninit)/(1 + \exp(ln\theta))$, where $ln\theta$ is a time-invariant parameter (the "Dirichlet-multinomial" parameter, estimated in natural log space, so that *Nsamp* approaches 0 as $ln\theta$ approaches $-\infty$, *Nsamp*=(1+*Ninit*)/2 when $ln\theta$=0, and *Nsamp* approaches *Ninit* as $ln\theta$ approaches $+\infty$), freely estimated for each of the compositional data types (fishery size composition data, survey size composition data, and survey age composition data), where:
    - For survey compositional data, *Ninit* is the number of sampled hauls
    - For fishery compositional data, *Ninit* is equal to the number of sampled hauls rescaled so that the average *Ninit* for the fishery is equal to the average *Ninit* for the survey (so that, on average, fishery data are emphasized equally with survey data)

Alternative Models
Differences in parameterization between the base model and the alternative models in Ensemble A:

- Models 20.4 and 19.15 include five additional true parameters (not annual devs):
    - Base log catchability in the NBS survey
    - Two parameters for the NBS survey selectivity (size-based double-normal):
        - First size with selectivity=1
        - Log standard deviation for 1st normal pdf
    - Two Dirichlet-multinomial parameters for the NBS survey:
        - One for size composition
        - One for age composition
- Models 20.4 and 19.12a lack annual devs for survey log catchability.
- Model 19.15 includes a set of annual devs for NBS survey log catchability.

Differences in parameterization between the base model and the alternative models in Ensemble B:

- The two models that use fishery CPUE data include a base value for fishery log catchability and, potentially, annual devs for fishery catchability
- The two models that allow survey selectivity to be dome-shaped include three additional survey selectivity parameters:
    - Logit of size range with selectivity=1
    - Log of standard deviation for 2nd normal pdf
    - Logit of selectivity at maximum size

Convergence Behavior
As in previous assessments, development of the final versions of all models included calculation of the Hessian matrix and a requirement that all models pass a "jitter" test of 50 runs, with the "jitter rate" in SS was set at a value of 0.1. Parameter bounds were set wide enough to allow a thorough exploration of the likely parameter space, without being so extreme that jitter runs were likely to fail.

In the event that a jitter run produced a non-negligibly better value for the objective function than the base run, then:

1. The model was re-run starting from the final parameter file from the best jitter run.
2. The resulting new control file, with the parameter estimates from the best jitter run incorporated as starting values, became the new base run.
3. The entire process (starting with a new set of jitter runs) was repeated until no jitter run produced a better value for the objective function than the most recent base run.

For models with several time-varying parameters and iteratively tuned sigma terms, previous experience with the above method has shown that a jitter run with a slightly better value for the objective function can sometimes be misleading, in that the iteratively tuned sigma terms are no longer in equilibrium with the results, and that starting from the "better" jitter run and retuning the sigma terms simply returns the model to the configuration of the base run. In cases where this occurred, the "better" jitter run was ignored.

Parameters Estimated Outside the Assessment Model

Variability in Estimated Age
Variability in estimated age in the assessment models is based on the standard deviation of estimated age between "reader" and "tester" age determinations (note that this is not the same as ageing *bias*, which is estimated internally). Weighted least squares regression, without an intercept, has been used in the past several assessments to estimate a proportional relationship between standard deviation and age. The regression has traditionally been computed over ages 1 through 13, yielding a slope parameter that is used to estimate standard deviation at age as the product of slope and age. To maintain consistency between models, only survey age data were used to estimate the slope parameter.

For the survey-only data, the estimated slope was 0.083, giving a weighted R^2 of 0.97. This regression corresponds to a standard deviation at age 1 of 0.083 and a standard deviation at age 20 of 1.669.

Weight at Length
Using the functional form weight = $\alpha \times \text{length}^{\beta}$, where weight is measured in kg and length is measured in cm, the long-term base values for the parameters were estimated this year (using fishery data from 1974 through 2020) as α = 5.51962E-06 (mean-unbiased) and β = 3.1915.

All of the models allow inter-annual, externally estimated, variability in weight-length parameters. Values of annual additive offsets from the base α and β values are shown in Table 2.17.

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 the length-based maturity schedule in the 2005 and 2006 assessments were set on the basis of a study by Stark (2007) at the following values: length at 50% maturity = 58 cm and slope of linearized logistic equation = –0.132. However, in 2007, changes in SS allowed for use of either a length-based or an age-based maturity schedule. Beginning with the 2007 assessment, the accepted model has used an age-based schedule with intercept = 4.88 years and slope = –0.965 (Stark 2007). The use of an age-based rather than a length-based schedule followed a recommendation from the maturity study's author (James Stark, AFSC, *pers. commun.*), and the age-based parameters were retained through the 2018 assessment. However, because all assessments since 2009 have estimated some amount of ageing bias, all of the models in the ensemble for the 2019 assessment went back to using the length-based schedule, and that assumption was retained for all the models in the present assessment.

Stock-Recruitment "Steepness"
Following the standard Tier 3 approach, all models assume that there is no relationship between stock and recruitment, so the "steepness" parameter is set at 1.0 in each.

Parameters Estimated Inside the Assessment Models

The parameters estimated inside the assessment models were enumerated above, in the "Description of Alternative Models" subsection.

For all parameters estimated within individual SS runs, the estimator used was the minimum negative log likelihood.

In addition to the above, the full set of fishing mortality rates were also estimated internally, but not in the same sense as the above parameters. The fishing mortality rates are determined (almost) exactly as functions of other model parameters, because SS assumes that the input total catch data are true values rather than estimates, so the fishing mortality rates can be computed algebraically given the other parameter values and the input catch data. An option does exist in SS for treating the fishing mortality rates as full parameters, but previous explorations have indicated that adding these parameters has almost no effect on other model output (Methot and Wetzel 2013).

Objective Function Components

All models in this assessment include likelihood components for catch, initial (equilibrium) catch, trawl survey relative abundance, fishery and survey size composition, survey age composition, recruitment, initial recruitment, "softbounds" (analogous to a very weak prior distribution designed to keep parameters from hitting bounds, and parameter deviations.

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

Use of Size Composition Data in Parameter Estimation
Size composition data are assumed to be drawn from a multinomial distribution specific to a particular year and fleet (fishery or survey). In the parameter estimation process, SS weights a given size composition observation according to the emphasis associated with the respective likelihood component and the sample size specified (and perhaps adjusted by a multiplier) 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. Over the years, assessments of EBS Pacific cod have used a variety of approaches to specify multinomial sample sizes that are roughly consistent with this recommendation (summarized most recently by Thompson and Thorson (2019)).

The models in the present assessment all set input sample sizes for size composition data as follows:

- Input sample size for a survey is equal to the number of sampled hauls from that survey.
- Input sample size for the fishery is equal to the number of sampled hauls from the fishery, rescaled so that the mean is equal to the mean number of sampled hauls from the combined EBS+NBS survey.

Input sample sizes for survey size composition data are shown in Table 2.12 and for fishery size composition data in Table 2.18.

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 year. Because only survey age composition data are used here, input sample size is set equal to the number of hauls in the respective survey (Table 2.12), just as with the survey size composition data.

Note that the age compositions are used in the marginal form, not in conditional-age-at-length form.

Use of Survey Relative Abundance Data in Parameter Estimation
For the survey, each year's survey abundance estimate is assumed to be drawn from a lognormal distribution specific to that year. The point estimates and lognormal "sigma" terms are shown in Table 2.10.

Use of Recruitment Deviation "Data" in Parameter Estimation
The likelihood component for recruitment is different from traditional likelihoods because it does not involve "data" in the same sense that traditional likelihoods do. Instead, the log-scale recruitment deviation plays the role of the datum in a normal distribution with mean zero and specified (or estimated) standard deviation; but, of course, the deviations are parameters, not data.

RESULTS

Note: Some tables referenced in this section employ red-to-green color scales. In all cases, the scale ranges from red=low to green=high, and can extend across a row, a column, or the entire table, depending on the context.

Naming the New Models

Per the model numbering protocol given by Option A in the SAFE chapter guidelines, the three new models in Ensemble B were run with a single retrospective peel, so that the data would be comparable to the data used when Model 19.12 was developed. The resulting spawning biomass time series for each of the new models was then compared to that from the original version of Model 19.12, which enabled computation of the "average difference in spawning biomass" (ADSB) for each of the new models. The ADSB for all three of the new models exceeded the cutoff value of 0.1, meaning that all three constitute "major" changes from the base model, and so were assigned names of the form "20.*j*," where *j* is an integer. The factorial designs of Ensembles A (blue) and B (yellow, now with final model names) are shown below, where Model 19.12 (green) is common to both Ensembles A and B:

Factor A1: Allow *Q* to vary?	no		yes		(yes)		
Factor A2: Combine surveys?	no	yes	no	yes			
Factor B1: Use fishery CPUE?	(no)			no		yes	
Factor B2: Allow domed selex?				no	yes	no	yes
Model:	20.4	19.12a	19.15	19.12	20.8	20.9	20.10

Model Evaluation

Individual Model Goodness of Fit
Table 2.19 shows the objective function value for each data component in each model, along with the number of parameters in each model, where the latter is broken down into "true" (unconstrained) parameters and constrained deviations. With few exceptions, objective function values are not truly comparable across models, and attempts to apply information-theoretic statistics such as the Akaike information criterion may be misleading, because:

- The total parameter counts overestimate the number of "effective" parameters, as these counts include parameters with prior distributions and constrained deviations.
- The models sometimes use different data files:
  - Models 20.4 and 19.15 share a data file.
  - Models 19.12a, 19.12, and 20.8 share a data file.
  - Models 20.9 and 20.10 share a data file.
- The data are weighted differently between models, due to tuning of the "sigma" terms for devs.

The root-mean-squared-standardized-residual for the survey abundance data (and fishery CPUE where applicable) is shown for all models below, where values within the range of 0.99-1.01 are shaded green:

Index:	EBS		NBS	
Model:	M20.4	M19.15	M20.4	M19.15
RMSSR:	2.448	1.001	6.516	1.000

Index:	EBS+NBS					Fishery	
Model:	M19.12a	M19.12	M20.8	M20.9	M20.10	M20.9	M20.10
RMSSR:	2.319	0.999	1.000	0.999	1.000	0.992	0.659

Ideally, RMSSR values should equal unity, and this was the standard that was used to tune the sigma terms for the log catchability devs. All models with (potentially) time-varying catchability were tuned successfully. Although the RMSSR for the fishery CPUE component was not within the target range of 0.99-1.01, this is because the log catchability devs for that component were "tuned out" of the model entirely, as the RMSSR was less than unity even without them (i.e., the amount of variability in fishery selectivity was more than adequate to account for the observed variability in the fishery CPUE data). The models without time-varying catchability (Models 20.4 and 19.12a) under-fit the index data, particularly in the case of the NBS survey index in Model 20.4.

Fits to the trawl survey abundance data are shown for all models in Figure 2.12.

Effective sample sizes implied by the models' fits to the size composition and age composition data are compared with the corresponding input sample sizes in Table 2.20. Input sample sizes are expressed as arithmetic means. Two formulations of effective sample size are shown:

- The formulation popularized by McAllister and Ianelli (1997), which has been used in many previous assessments, is expressed as a harmonic mean. Ideally, the harmonic mean of this formulation of effective sample size should equal the arithmetic mean of the input sample size, which typically requires iterative tuning.
- The formulation of Thorson et al. (2017), which uses the Dirichlet-multinomial distribution to model compositional data, is expressed a function of an internally estimated parameter ($\ln(\theta)$), so iterative tuning is not required. However, in the case of size composition data, the estimated parameter was constrained by the upper bound for both the fishery and survey (or surveys) in all models, in which case the effective sample size was equal to the average input sample size.

For the age composition data, the effective sample sizes for the Thorson et al. formulation were of the same magnitude as, but larger than, the effective sample sizes for the McAllister-Ianelli formulation.

Residual plots for the size and age composition data are shown in Figures 2.13 and 2.14, respectively.

Choice of Ensembles and Model Weights
The models used in this assessment are described under "Description of Alternative Models" above.

For the last few years, the Team and SSC have expressed interest in using a model averaging approach for the EBS Pacific cod assessment, and both the Team and SSC used such an approach for specifying the 2020 ABC (although the adopted Model 19.12 as the base model, it used a weighted average of the values in the authors' and Team's recommended ensemble to specify the ABC). For this year's assessment, the Team and SSC again recommended consideration of a model averaging approach.

Model averaging requires specification of at least one model ensemble. Three potential ensembles were identified in the "Description of Alternative Models" section: Ensemble A, Ensemble B, and Ensemble AB (the union of Ensembles A and B). Ensemble A has the benefit of having been developed through the standard process of review and recommendation by the Team and SSC, but the 2×2 factorial design omits other alternative models whose behavior could be important to consider. Ensemble B has the benefit of addressing some concerns that have been expressed through public comment during the Team/SSC process, but the three new models in that ensemble have not previously been subject to Team or SSC review, and, like Ensemble A, the 2×2 factorial design omits other alternative models whose behavior could be important to consider. Ensemble AB has the benefits of being responsive to both Team/SSC and public comment and of including a larger number of factors in the embedded factorial design than either Ensemble A or Ensemble B individually, but it does have the problem of including the three new models from Ensemble B that have not previously been subject to Team or SSC review. On balance, it does not seem prudent to consider Ensemble B as a viable candidate ensemble on its own at this time, so results will instead be presented for: 1) each individual model, 2) a weighted average of Ensemble A, and 3) a weighted average of Ensemble AB.

Once one or more ensembles have been identified, it is necessary to assign weights to the included models. This has proven to be a challenging task in previous assessments, as a large number of alternative model weightings were presented in every assessment from 2017-2019, but neither the Team nor SSC gave an unqualified endorsement of any of them. In contrast, the September 2020 Team and September/October SSC meetings did result in an endorsement of the model weighting approach recommended by the authors in last year's assessment, except that the arithmetic mean of the scores should be used instead of the "exponential average" technique advocated last year by the authors.

The criteria used in last year's assessment are as follow:

1. Is the associated "hypothesis" plausible?
2. Are the catchability estimates plausible?
3. Is the retrospective bias within the acceptable range?
4. Is the model complexity similar to that of other BSAI groundfish Tier 3 assessments?
5. Are input standard deviations of "dev" vectors estimated appropriately?
6. Are fits to the data consistent with the variances specified for those data?
7. Are changes from the base model, if any, suitably incremental?
8. Is an objective criterion used to specify input sample sizes for compositional data?
9. Is the apparent change in ageing criteria (pre-2008 and post-2007) addressed?

The decision rules used in the 2019 assessment to evaluate each model in the ensemble with respect to the above criteria follow.

1. "Hypothesis," in this context, refers to the three hypotheses that were used to structure the 2019 assessment. Hypothesis 1 was that Pacific cod in the NBS are insignificant to the managed stock, so the assessment should include data from the EBS only. Hypothesis 2 was that Pacific cod in the EBS and NBS comprise a single stock, and the EBS and NBS surveys can be modeled in combination. Hypothesis 3 was that Pacific cod in the EBS and NBS comprise a single stock, but the EBS and NBS surveys should be modeled separately. The SSC determined during its October 2019 meeting that Hypothesis 1 was implausible. All models in the present assessment are consistent with either Hypothesis 2 or 3.

2. Estimates of survey catchability for the years 2017-2019 are shown below:

	20.4			19.15			EBS+NBS				
Year	EBS	NBS	Sum	EBS	NBS	Sum	19.12a	19.12	20.8	20.9	20.10
2017	0.894	0.430	1.324	0.838	0.441	1.279	0.986	0.952	1.023	0.771	1.084
2018	0.894	0.430	1.324	0.894	0.928	1.822	0.986	1.193	1.298	0.972	1.401
2019	0.894	0.430	1.324	0.906	0.884	1.790	0.986	1.113	1.278	0.900	1.456
Mean	0.894	0.430	1.324	0.879	0.751	1.630	0.986	1.086	1.199	0.881	1.314

Note that, because all of the models lack explicit spatial structure, the estimates of catchability apply to the *entire stock*. In the case of Models 20.4 and 19.15, which feature separate EBS and NBS surveys, this means that the catchability for a given survey does not apply only the portion of the stock with the respective survey area. Thus, for example, the results of Model 20.4 suggest that the EBS survey observed 89.4% of the fully selected fish in the combined EBS and NBS stock, while, at the same time, the NBS survey observed 43.0% of the fully selected fish in the combined EBS and NBS stock. Given that field studies (e.g., Somerton 2004) have indicated that catchability of Pacific cod in the EBS survey is unlikely to be much greater than unity, average estimates of 2017-2019 catchability greater than 1.2 for the EBS and NBS combined (represented by the sum of EBS and NBS catchability for Models 20.4 and 19.15, or by the EBS+NBS catchability for all other models) were deemed implausible (cells shaded pink in the above table).

3. Retrospective behavior will be addressed in detail in the next subsection, but values of ρ (Mohn 1999, equation corrected in the 2013 Retrospective Working Group report) for spawning biomass are shown below, together with lower and upper bounds on acceptable levels defined as a function of *M*, based on results reported by Hurtado-Ferro et al. (2015):

Allow *Q* to vary?	no		yes		(yes)		
Combine surveys?	no	yes	no	yes			
Use fishery CPUE?	(no)			no		yes	
Allow domed selex?				no	yes	no	yes
Quantity	20.4	19.12a	19.15	19.12	20.8	20.9	20.10
M	0.3713	0.3543	0.3615	0.3422	0.2944	0.3410	0.2124
Mohn's ρ	0.0601	-0.0211	0.1046	-0.0028	0.0076	0.1533	0.0071
ρmin	-0.2099	-0.2040	-0.2065	-0.1998	-0.1831	-0.1993	-0.1543
ρmax	0.2856	0.2772	0.2808	0.2711	0.2472	0.2705	0.2062

All values of ρ within the model-specific range (above) were deemed acceptable.

4. All models with levels of complexity similar to Model 19.12 were deemed in the 2019 assessment to exhibit levels of complexity substantially greater than that of typical BSAI groundfish Tier 3 assessments. For this year's assessment, all models are at least as complex as Model 19.12, with the exception of Model 20.4 (which lacks time-varying catchability) and Model 19.12a (which lacks time-varying catchability, but adds a second survey, with its three new "true" (unconstrained) parameters (catchability and two selectivity parameters)). Although cases could be made for Models 20.4 and 19.12a being slightly less complex than Model 19.12, they still seem substantially more complex than typical BSAI groundfish tier 3 assessments, as they both involve, at a minimum, internally estimated natural mortality, growth, catchability, and selectivity parameters; a time-varying growth parameter; and four time-varying selectivity parameters. Therefore, all models presented here were determined to be substantially more complex than typical BSAI groundfish tier 3 assessments.

5. In last year's assessment, Model 19.12 was determined to exhibit appropriately estimated input standard deviations (sigmas) for their associated "dev" vectors. All models in the present assessment use the same approach for tuning sigmas as Model 19.12.

6. All models that exhibit RMSSR values within the range 0.99-1.01 for the index data (or that "tune out" log catchability devs, in the case of Model 20.10) were deemed to exhibit fits to the data that were consistent with the variances specified for those data.

7. All models other than the base model involve only 1 or 2 changes relative to the base model, and were deemed to exhibit suitably incremental changes from the base model.

8. In the 2019 assessment, all models that used the Dirichlet-multinomial approach to specifying input sample sizes were deemed to use an objective criterion to specify input sample sizes for compositional data. All models in the present assessment use the Dirichlet-multinomial approach.

9. In last year's assessment, all models that estimated ageing bias criteria separately for pre-2008 and post-2007 time blocks were deemed to have addressed the apparent change in ageing criteria. All models in the present assessment do so.

The above decision rules were used to assign a score (S) of either 0 or 1 to each model j=1,2,...,$nmod$ (where $nmod$ is the number of models in the ensemble) for each criterion i=1,2,...,9.

The next step in the development of model weights was to assign an emphasis (E) to each criterion. As in the 2019 assessment, criteria 1-3 were assigned an emphasis of 3, criteria 4-6 were assigned an emphasis of 2, and criteria 7-9 were assigned an emphasis of 1. These assignments were based on the subjective judgement of the senior author at the time.

The next step is to compute a weighted average emphasis for each model j=1,2,...,$nmod$, defined as:

$$WAE_j = \sum_{i=1}^{nmod} E_i \, S_{i,j} \Big/ \sum_{i=1}^{nmod} E_i$$

The final step is to scale the WAE values proportionally so that the resulting vector sums to unity.

The entire procedure, including the resulting model weights, is summarized in Table 2.21. For Ensemble A, Model 19.12 received the highest weight (0.2963), and Model 20.4 received the lowest weight (0.2037). For Ensemble AB, Models 19.12, 20.8, and 20.9 all received the highest weight (0.1616); and Model 20.4 again received the lowest weight (0.1111).

Retrospective Performance

Retrospective analyses of all models, along with retrospective analyses of the weighted averages for Ensembles A and AB, are shown in Figure 2.15. The text table of ρ values from the previous subsection is repeated below, but with values for the weighted ensemble averages included:

Allow Q to vary?	no		yes		(yes)				
Combine surveys?	no	yes	no	yes					
Use fishery CPUE?	(no)			no		yes			
Allow domed selex?				no	yes	no	yes	Ensemble	
Quantity	20.4	19.12a	19.15	19.12	20.8	20.9	20.10	A	AB
M	0.3713	0.3543	0.3615	0.3422	0.2944	0.3410	0.2124	0.3559	0.3247
Mohn's ρ	0.0601	-0.0211	0.1046	-0.0028	0.0076	0.1533	0.0071	0.0311	0.0439
ρmin	-0.2099	-0.2040	-0.2065	-0.1998	-0.1831	-0.1993	-0.1543	-0.2046	-0.1937
ρmax	0.2856	0.2772	0.2808	0.2711	0.2472	0.2705	0.2062	0.2780	0.2624

All models, including Ensembles A and AB, have values of ρ well within the acceptable range, and all but three models (including ensembles) have values within the range -0.05 to 0.05.

Parameter Estimates

Table 2.22 displays the values of all parameters (except fishing mortality rates, because these are functions of other parameters and are therefore shown separately) estimated internally in any of the models, along with their standard deviations (for completeness, a few selectivity parameters whose values were fixed *a priori* are also shown). Standard deviations are based on the inverse of the Hessian matrix, and assume a normal distribution. Means and standard deviations for each parameter are also shown for the Ensembles A and AB, based on weighted averages of the individual model pdfs. However, it should be noted that the distributions for the ensembles, being averages of normal distributions, are themselves *not* normal, meaning that, while the standard deviations are correct, the 95% confidence intervals may or may not be well approximated by +/– two standard deviations. In the case of any parameter that is not used in all models, the weights for the models that do use that were rescaled to sum to unity. A blank cell in Table 2.22 indicates that the respective parameter (row) is not used in the respective model (column), and a parameter with an estimate (Est.) but no standard deviation (SD) means that the respective parameter was fixed *a priori*.

Table 2.22a shows time-invariant parameters other than selectivity parameters (color scales are row-specific). Natural mortality ranges from 0.212 (Model 20.10) to 0.371 (Model 20.4). The sign of the ageing bias flips from almost all positive (pre-2008) to very near zero at age 1 but negative at older ages (post-2007). Initial fishing mortality ranges from 0.041 (Model 20.10) to 0.130 (Model 19.15). For the two models that treat the EBS and NBS surveys separately, the base value of log catchability for the EBS survey ranges from -0.112 (Model 20.4) to -0.058 (Model 19.15), while the base value of log catchability for the NBS survey ranges from -1.998 to -0.844. For the five models that combine the EBS and NBS surveys, the base value of log catchability ranges from -0.087 (Model 20.9) to 0.274 (Model 2.10). As noted previously, the log of the Dirichlet-multinomial parameter tends to be pinned near the upper bound (10.0) for the size composition component of all models (this is one of the two parameters for which bounds were constraining). Overall for this portion of Table 2.22, Model 20.10 tends to have more extreme values than any of the other models.

Table 2.22b shows time-invariant selectivity parameters, including parameters that are fixed *a priori* (color scales are row-specific). The upper bound of the size at which selectivity first reaches unity was set at 80 cm for all fleets and models. For the two models that treat the EBS and NBS surveys separately, this upper bound proved to be constraining in the case of the NBS survey (this is the second of the two parameters for which bounds were constraining). The upper bound of 80 cm was chosen during the process of developing the preliminary assessment (Appendix 2.1), because it seemed desirable to avoid confounding time-variation for this parameter with time-variation in log catchability, and if the base value of this parameter were much greater than about 80 cm, it was observed that annual deviations could cause selectivity to be noticeably less than unity even at very large sizes, which would then tend to be

confounded with catchability deviations. As in Table 2.22a, Model 20.10 tends to have the most extreme values of the parameters shown on this portion of Table 2.22.

Tables 2.22c-2.22g show time series of annual parameter deviations. Color scales are column-specific in all these portions of Table 2.22, and show that, in general, time trends between models (for comparable quantities) are very similar. Table 2.22c shows log deviations for the initial numbers-at-age vector, Table 2.22d shows log recruitment deviations for the time series, Table 2.22e shows deviations for mean length at age 1.5, Table 2.24f shows deviations for log catchability, and Table 2.22g shows deviations for the time-varying selectivity parameters.

Tuning of Annually Varying Parameters
As noted in the "Parameter Estimation" subsection of the "Analytic Approach" section, except for the sigmas associated with annual deviations of log catchability, tuning of the sigmas involved two quantities: 1) the variance of the estimated deviations, and 2) the sum of the variances of the individual estimated deviations. For parameters other than log-scale recruitment, devs are modeled in SS as being normal(0,1), and sigma was tuned so that the sum of those two quantities equaled unity, with a tolerance of +/- 0.01). For recruitment, devs are modeled in SS as being normal(0,σ^2), and sigma was tuned so that it matched the square root of the sum, again with a tolerance of +/- 0.01.

Table 2.23 shows the values of the iteratively tuned "sigma" quantities for parameters with annual deviations (other than log catchabilities), where the models in Ensemble A are shown in the upper portion of the table and the models for Ensemble B are shown in the lower portion (color scales are parameter-specific, and wrap around both portions of the table). Model 2.10 had the lowest sigma values for four of the six parameters common to the five combined-survey models, while Model 20.9 had the highest sigma values for three of those six parameters, and sigma values for Model 19.12 tended to be in the middle of the range for all parameters. Sigmas for log recruitment, the logit of fishery selectivity at maximum size, and the log of the standard deviation of the 1st normal pdf for the "main" survey selectivity schedule (EBS in the case of separate-survey models, EBS+NBS in the case of combined-survey models) tended to have larger sigmas than those associated with other parameters. Sigmas for length at 1.5 cm and for the log of the standard deviation of the 1st normal pdf for the fishery selectivity schedule tended to have smaller sigmas than those associated with other parameters.

For vectors of annual deviations associated with log catchability, sigma was tuned so as to set RMSSR=1.0 (tolerance = +/- 0.01), as noted above. This resulted in the following sigma values (color scales are row-specific):

Index	19.15	19.12	20.8	20.9	20.10
EBS survey	0.0797				
NBS survey	0.5993				
EBS+NBS survey		0.0807	0.0785	0.0910	0.0889
Fishery CPUE				0.0188	0.0000

The following points may be noted about the above table:

- The sigma for log catchability for the NBS survey was much larger than for any other log catchability term in any model.
- Allowing survey selectivity to be dome-shaped meant that *less* variability in log catchability for the EBS+NBS survey was required (comparing Model 20.8 to Model 19.12).
- Including fishery CPUE data in the model meant that *more* variability in log catchability for the EBS+NBS survey was required (comparing Models 20.9 and 20.10 to Model 19.12).

- The sigma values for log catchability for fishery CPUE were very small (zero, in fact, for Model 20.10) relative to any others estimated for any parameter in any model in this assessment.

Derived Quantities
Figure 2.16 shows selectivity for all models. Figure 2.16a shows selectivity for the fishery, Figure 2.16b shows selectivity for the "main" survey (EBS survey in the case of Models 20.4 and 19.15, combined EBS+NBS survey for all other models), and Figure 2.16c shows selectivity for the NBS survey (Models 20.4 and 19.15 only).

Table 2.24 shows back-transformed catchability for the EBS and NBS surveys (Models 20.4 and 19.15), EBS+NBS surveys (Models 19.12a, 19.12, 20.8, 20.9, and 20.10), and fishery CPUE (Models 20.9 and 20.10). Color scales are column-specific, and are omitted for cases in which catchability is constant.

Table 2.25 and Figure 2.17 show the time series of female spawning biomass for all models, including weighted averages for Ensembles A and AB.

Table 2.26 and Figure 2.18 show the time series of female spawning biomass relative to $B_{100\%}$ for all models, including weighted averages for Ensembles A and AB.

Table 2.27 and Figure 2.19 show the time series of age 0 recruitment for all models, including weighted averages for Ensembles A and AB.

Table 2.28 and Figure 2.20 show the time series of fishing mortality for all models, including weighted averages for Ensembles A and AB.

Table 2.29 contains selected management reference points. Static quantities include $B_{100\%}$, $B_{40\%}$, $B_{35\%}$, $F_{40\%}$, and $F_{35\%}$. Quantities shown for each of the first two projection years (2021 and 2022) consist of female spawning biomass, relative spawning biomass, the probability that the ratio of spawning biomass to $B_{100\%}$ will fall below 0.2, $maxF_{ABC}$, maxABC, catch, F_{OFL}, OFL, and the probability that maxABC exceeds the true-but-unknown OFL.

The values of 2021 female spawning biomass, relative spawning biomass, and maxABC projected by the current base model (19.12) in this assessment differ from last year's projections of those same quantities (using the same model) by -2.6%, -2.1%, and -5.5%, respectively. Those differences are accounted for by changes in data and also updated estimates of the sigma terms associated with time-varying parameters. Table 2.30 shows how the updating of various data components in various combinations (given that the catch data have to be updated first in order to enable SS to increment the ending year in the model), and then updating both the data and the sigmas simultaneously, interact to produce the observed changes.

Choice of Final Model
As noted in the "Choice of Ensembles and Model Weights" subsection above, Ensemble AB has the benefits of being responsive to both Team/SSC and public comment and of including a larger number of factors in the embedded factorial design than either Ensemble A or Ensemble B individually. At a time when ABC has been projected (based on the 2019 assessment) to decrease substantially between 2020 and 2021, it seems prudent to consider a wide range of alternative model structures, so long as they are appropriately weighted. Ensemble AB (weighted average) is therefore chosen as the final model.

As noted in the 2019 assessment, one downside to choosing an ensemble, particularly one the size of Ensemble AB, is that running all of the models in the ensemble and performing all of the calculations necessary to implement the ensemble approach fully is so time-consuming that it may not be possible to include any alternatives to that ensemble in next year's assessment unless the SAFE chapter guidelines are changed or unless the SSC changes the base model next October to something simpler.

Final Parameter Estimates and Associated Schedules
Because the Team or SSC may wish to retain the current base model (19.12) or choose Ensemble A as the final model instead of Ensemble AB, values corresponding to those two choices are presented along with values for Ensemble AB.

Final parameter estimates for individual models, Ensemble A, and Ensemble AB are shown in Table 2.22.

Table 2.31 shows length at age by year for Model 19.12, Ensemble A, and Ensemble AB.

Table 2.32 shows fishery weight at age by year for Model 19.12, Ensemble A, and Ensemble AB.

Table 2.33 shows survey weight at age by year, where applicable, for Model 19.12, Ensemble A, and Ensemble AB. Table 2.33a pertains to the EBS survey, Table 2.33b pertains to the NBS survey, and Table 2.33c pertains to the combined EBS and NBS surveys. In the case of Tables 2.33a and 2.33b, Model 19.12 is not applicable, and Ensembles A and AB are identical.

Table 2.34 shows fishery selectivity at age by year for Model 19.12, Ensemble A, and Ensemble AB.

Table 2.35 shows survey selectivity at age by year, and is structured similarly to Table 2.33.

Time Series Results

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 January of a given year. The recruitment estimates presented here will be defined as numbers of age 0 fish in a given year.

Table 2.36 shows the time series of age 0+ and female spawning biomass (t) since 1977 as estimated last year in the model accepted by the SSC and this year for Ensembles A and AB. The estimated spawning biomass time series are accompanied by their respective standard deviations.

Table 2.37 shows the time series of recruitment (1000s of fish) for the years since 1977 as estimated last year in the model accepted by the SSC and this year for Ensembles A and AB. The estimated time series are accompanied by their respective standard deviations. The correlations between last year's estimated recruitment time series and this year's are greater than 0.99, for both Ensembles A and AB.

For the time series as a whole, the largest year class appears to have been either the 2008 cohort or the 2013 cohort; and the 2006, 2010, 2011, 2013 are also estimated to have been well above average. In contrast, the 2014-2017 year classes are all estimated to be well below average, with the 2016 and 2017 year classes being two of the three smallest year classes of all time (1987 being the third member of that group). However, the 2018 year class may break that string. The estimates of the 2018 year class from Ensembles A and AB are 46% and 49% above average, respectively.

The coefficients of autocorrelation for this year's estimated recruitment time series are –0.14 (Ensemble A) and -0.16 (Ensemble AB).

Table 2.38 shows the time series of numbers at age for Model 19.12, Ensemble A, and Ensemble AB.

Figure 2.21 shows the time series of female spawning biomass for Ensembles A and AB, with error bars representing plus-or-minus two standard deviations.

Figure 2.22 shows the time series of female spawning biomass relative to $B_{100\%}$ for Ensembles A and AB, with error bars representing plus-or-minus two standard deviations.

Figure 2.23 shows the time series of recruitment for Ensembles A and AB, with error bars representing plus-or-minus two standard deviations.

Figure 2.24 shows the time series of full-selection fishing mortality for Ensembles A and AB, with error bars representing plus-or-minus two standard deviations.

Figure 2.25 plots the estimated/projected trajectory of relative fishing mortality ($F/F_{35\%}$) and relative female spawning biomass ($B/B_{35\%}$) from 1977 through 2022 based on full-selection fishing mortality, overlaid with the current harvest control rules (results for Ensemble A are shown in Figure 2.25a, and results for Ensemble AB in Figure 2.25b). Models prior to 2016 featured dome-shaped survey selectivity, while models since 2016 have forced survey selectivity to be asymptotic, which changed the appearance of the trajectory considerably, so that, in hindsight, the stock was being subjected to fishing mortality rates in excess of the retroactively calculated F_{OFL} values (but not the official F_{OFL} values that were calculated at the time) in all years from the early 1990s through 2017. Because of nonlinearities involved in computation, model-averaged $maxF_{ABC}$ projections for 2021 and 2022 do not fall exactly on the model-averaged $maxF_{ABC}$ control rule.

Harvest Recommendations

Some of the results presented in this section pertain primarily from Ensembles A and AB. However, a full set of parallel results for the items in this section, but pertaining to the current base model (19.12), is provided in Appendix 2.5. In addition, sufficient information is provided the tables of results presented so far (in particular Table 2.29) and the standard projection tables described below to enable the Team or SSC to choose any of the seven models for the purpose of recommending or setting harvest specifications.

Amendment 56 Reference Points

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

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

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

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

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

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

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

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

$F_{OFL} = 0$

$F_{ABC} = 0$

The weighted average estimates of $F_{35\%}$ from Ensembles A and AB are 0.43 and 0.39, respectively; and the weighted average estimates of $F_{40\%}$ from Ensembles A and AB are 0.35 and 0.32, respectively (Table 2.29).

The weighted average estimates of $B_{100\%}$ from Ensembles A and AB are 649,506 t and 771,600 t, respectively; the weighted average estimates of $B_{40\%}$ from Ensembles A and AB are 259,803 t and 308,640 t, respectively; and the weighted average estimates of $B_{35\%}$ from Ensembles A and AB are 227,328 t and 270,060 t, respectively (Table 2.29).

Means and standard deviations of the ABC and OFL distributions for 2021 and 2022 are shown for each model and for Ensembles A and AB in Table 2.39 (along with medians for Ensembles A and AB), and the distributions are shown in Figure 2.26.

Specification of OFL and Maximum Permissible ABC
Given the assumptions of Scenario 2 (below), female spawning biomass for 2021 is estimated to be 185,645 t and 273,584 t by Ensembles A and AB, respectively; and female spawning biomass for 2022 is estimated to be 181,032 t and 253,506 t by Ensembles A and AB, respectively. All of these projected values are below their respective $B_{40\%}$ values, thereby placing Pacific cod in Tier 3b for both 2021 and 2022. Given this, the estimates of OFL, maximum permissible ABC, and the associated fishing mortality rates for 2021 and 2022 as follows (Table 2.29):

	OFL (t)		maxABC (t)	
Year	Ensemble A	Ensemble AB	Ensemble A	Ensemble AB
2021	103,668	139,984	86,480	118,013
2022	103,208	130,076	85,758	109,266

	F_{OFL}		$maxF_{ABC}$	
Year	Ensemble A	Ensemble AB	Ensemble A	Ensemble AB
2021	0.30	0.31	0.24	0.26
2022	0.29	0.30	0.24	0.25

The age 0+ biomass projections for 2021 from Ensembles A and AB are 651,088 t and 842,254 t, respectively; and the projections for 2022 are 727,640 t and 878,837 t, respectively.

Standard Harvest Scenarios, Projection Methodology, and Projection Results
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). Prior to the 2018 assessment, the standard harvest scenarios were made using the AFSC's "Proj" program. Beginning with the 2018 assessment, however, the projections have been made within SS. Year-end catch for 2020 was estimated to be 155,873 t, equal to the 2020 ABC. In the event that catch is likely to be less than the recommended ABC in either of the first two projection years, Scenario 2 must be conducted, using the best estimates of catch in those two years (otherwise, Scenario 2 can be omitted if the author's recommended ABCs for the next two years are equal to the maximum permissible ABCs). The following relationship between ABC and catch was described under "Management History" in the "Fishery" section: For ABC≥198,000 t, catch = 89,000 t + 0.55×ABC; for ABC<198,000 t, catch = ABC. Because the recommended ABCs for both of the first two projection years are less than 198,000 t, no adjustment is necessary.

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.

Five of the seven standard scenarios are sometimes used in an Environmental Assessment prepared in conjunction with the final SAFE. These five scenarios, which are designed to provide a range of harvest alternatives that are likely to bracket the final TACs for 2021 and 2022, 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 ("author's F") of *max* F_{ABC}, where this fraction is equal to the ratio of the F_{ABC} value for 2021 recommended in the assessment to the *max* F_{ABC} for 2021, and where catches for 2021 and 2022 are estimated at their most likely values given the 2021 and 2022 recommended ABCs under this scenario. (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; also, catch tends not to equal ABC exactly.)
>
> *Scenario 3*: In all future years, F is set equal to the 2015-2019 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 2020 or 2) above 1/2 of its MSY level in 2020 and expected to be above its MSY level in 2030 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2021, F is set equal to *max* F_{ABC}, and in all subsequent years, F is set equal to F_{OFL}. (Rationale: This scenario determines whether a stock is approaching an overfished condition. If the stock is 1) above its MSY level in 2022 or 2) above 1/2 of its MSY level in 2022 and expected to be above its MSY level in 2032 under this scenario, then the stock is not approaching an overfished condition.)

Projections (means and standard deviations) of female spawning biomass (B), full selection fishing mortality (F), and catch (C) corresponding to the standard scenarios are shown for all models and both the weighted and unweighted ensemble averages in Table 2.40.

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 2021, it does not provide the best estimate of OFL for 2022,

because the mean 2022 catch under Scenario 6 is predicated on the 2021 catch being equal to the 2021 OFL, whereas the actual 2021 catch will likely be less than the 2021 OFL. Table 2.29 contains the appropriate one- and two-year ahead projections for both ABC and OFL.

Risk Table and ABC Recommendation

Overview

The following template is used to complete the risk table:

	Assessment-related considerations	*Population dynamics considerations*	*Environmental/ecosystem considerations*	*Fishery Performance*
Level 1: Normal	Typical to moderately increased uncertainty/minor unresolved issues in assessment.	Stock trends are typical for the stock; recent recruitment is within normal range.	No apparent environmental/ecosystem concerns	No apparent fishery/resource-use performance and/or behavior concerns
Level 2: Substantially increased concerns	Substantially increased assessment uncertainty/ unresolved issues.	Stock trends are unusual; abundance increasing or decreasing faster than has been seen recently, or recruitment pattern is atypical.	Some indicators showing adverse signals relevant to the stock but the pattern is not consistent across all indicators.	Some indicators showing adverse signals but the pattern is not consistent across all indicators
Level 3: Major Concern	Major problems with the stock assessment; very poor fits to data; high level of uncertainty; strong retrospective bias.	Stock trends are highly unusual; very rapid changes in stock abundance, or highly atypical recruitment patterns.	Multiple indicators showing consistent adverse signals a) across the same trophic level as the stock, and/or b) up or down trophic levels (i.e., predators and prey of the stock)	Multiple indicators showing consistent adverse signals a) across different sectors, and/or b) different gear types
Level 4: Extreme concern	Severe problems with the stock assessment; severe retrospective bias. Assessment considered unreliable.	Stock trends are unprecedented; More rapid changes in stock abundance than have ever been seen previously, or a very long stretch of poor recruitment compared to previous patterns.	Extreme anomalies in multiple ecosystem indicators that are highly likely to impact the stock; Potential for cascading effects on other ecosystem components	Extreme anomalies in multiple performance indicators that are highly likely to impact the stock

The table is applied by evaluating the severity of four types of considerations that could be used to support a scientific recommendation to reduce the ABC from the maximum permissible. These considerations are stock assessment considerations, population dynamics considerations, environmental/ecosystem considerations, and fishery performance. Examples of the types of concerns that might be relevant include the following:

1. Assessment considerations—data-inputs: biased ages, skipped surveys, lack of fishery-independent trend data; model fits: poor fits to fits to fishery or survey data, inability to

simultaneously fit multiple data inputs; model performance: poor model convergence, multiple minima in the likelihood surface, parameters hitting bounds; estimation uncertainty: poorly-estimated but influential year classes; retrospective bias in biomass estimates.

2. Population dynamics considerations—decreasing biomass trend, poor recent recruitment, inability of the stock to rebuild, abrupt increase or decrease in stock abundance.

3. Environmental/ecosystem considerations—adverse trends in environmental/ecosystem indicators, ecosystem model results, decreases in ecosystem productivity, decreases in prey abundance or availability, increases or increases in predator abundance or productivity.

4. Fishery performance—fishery CPUE is showing a contrasting pattern from the stock biomass trend, unusual spatial pattern of fishing, changes in the percent of TAC taken, changes in the duration of fishery openings.

Assessment Considerations

Recent range expansion of the stock into the NBS has made assessment modeling more difficult. On one hand, detailed investigation of multiple models gives some confidence that relevant uncertainties have been explored. Use of an ensemble approach likewise gives some confidence that alternative explanations of the data are considered. Moreover, an ensemble approach mitigates, at least to some extent, concerns that may exist regarding any individual model. On the other hand, wide ranges of key quantities such as 2021 ABC (42,029 t to 179,712 t) tend to temper such confidence. Retrospective behavior of all models is within the acceptable range. Ageing bias has long been suspected to exist, but this has been estimated within, and accounted for by, the assessment models for over a decade now, including (as of the present assessment) a change in the amount and direction of ageing bias during the time series. This is a fairly data-rich assessment, with annual surveys (until this year) covering a substantial portion of the stock's range, typically with very low standard errors compared to other species, and extensive observer coverage.

While the cancellation of this year's bottom trawl surveys likely makes the current status of the stock somewhat less certain than it would be otherwise, the analysis of Bryan et al. (2020) indicates that, under normal conditions, this assessment has the lowest uncertainty of any of the 10 assessments analyzed, and that cancellation of a survey simply makes the uncertainty associated with this assessment more like that of the other assessments *without* a survey cancellation. Specifically, with no survey cancellations, the "Ralston sigma" for this assessment was 0.062, compared to a mean of 0.226 across all 10 assessments; whereas cancellation of a survey increases the Ralston sigma for this assessment to 0.238 (the mean across all 10 assessments under this circumstance was 0.298). Moreover, particularly in the Aleutian Islands and Gulf of Alaska, bottom trawl surveys occur in alternating years only, and lack of a survey in any given year is typically not cited as a cause for extra concern. More specifically, the review by Thompson (2018a) of all ABC reductions from 2003-2017 found that there was only a single instance where absence of a survey was cited as a reason for reducing the ABC. The fact that the lack of a survey this year was *unanticipated* surely has no impact on model performance.

Finally, relative to other assessments, the assessment of this stock must be considered among the most intensively explored and reviewed, with full results for multiple models presented for Team and SSC review twice every year (Appendix 2.3), including responses to dozens of Team and SSC comments annually. Assessment considerations were rated as level 1 (normal), which was the same rating given last

year. More specifically, within level 1, the degree of concern is nearer the bottom end of the level than the upper end.

Population Dynamics Considerations

Looking at the EBS in isolation, survey biomass has been undergoing a pronounced decline since 2015. However, when examined from the perspective of the combined EBS and NBS, the decline is much less dramatic. Moreover, numerical abundance took a sharp upturn during 2019 in both the EBS and NBS, due apparently to a strong 2018 year class. On the other hand, nearshore temperatures were very high during the 2018 surveys, and it has been suggested that some of the 2018 cohort's apparent strength may actually represent a change in selectivity or catchability, as age 1 fish that would normally reside outside the survey areas in nearshore waters were forced to move into the survey areas. This possibility is corroborated to some extent by the fact that the two models that lack time-varying catchability (20.4 and 19.12a) gave higher estimates of 2018 age 0 recruitment than did the other models (on average). Nevertheless, every model ranked the strength of the 2018 cohort as being between 39-62% above average, with CVs ranging from 0.10-0.17. Also of note is the string of four very poor year classes spawned in 2014-2017, two of which are among the three worst of all time. However, these considerations are already incorporated into the assessment models and are also addressed by the harvest control rules. Population dynamics considerations were rated as level 1 (normal), which was the same rating given last year. More specifically, within level 1, the degree of concern is nearer the bottom end of the level than the upper end.

Environmental/Ecosystem Considerations

Appendix 2.2 provides a detailed look at environmental/ecosystem considerations. In response to a Team comment (BPT7, listed in Appendix 2.1), the discussion in the ESP distinguishes between direct and indirect effects on the stock. The concerns described in the ESP may be summarized as follows:

- Sea ice formation was delayed into late winter 2019.
- A rapid build-up of sea ice occurred after late winter, even exceeding median ice extent in parts of February and March 2020.
- Sea ice concentration (i.e., thickness) was low, and retreated at a faster rate than the previous 5 years after June.
- Late winter sea surface temperatures were closer to the long term means over the southeastern and northern shelves.
- Above-average temperatures returned in spring and summer, especially over the southeast shelf.
- Summer temperatures remained above average in the SEBS and NBS.
- Bottom water temperatures from ROMS show 2020 was an average year.
- Spatial extent of the cold pool in 2020 most closely resembles 1997.
- Pacific cod expanded their range into the northern Bering Sea in 2018 and 2019.
- Based on conditions metrics, both juvenile and adult Pacific cod were able to find sufficient prey resources in 2018 and 2019.
- Low abundances of euphausiids were observed in 2018 (MACE acoustic survey), while higher abundances were indicated in 2019 (RPA RZA).
- Effects of cannibalism might be mediated by spatial mismatch between juvenile and adult cod.
- The 2019/2020 gray whale UME reflects poor feeding conditions in the NBS during 2018/2019.
- The 2019 Shearwater die-off events could also reflect feeding conditions in the NBS in 2018.
- The decoupling of recruitment time series for Pacific cod and walleye pollock around 2008-2009 suggests a shift in drivers of survival in these two populations; mechanistic understanding of recruitment drivers is less well-known than for pollock.

Environmental/ecosystem considerations were rated as level 2 (substantially increased concern), which was the same rating given last year. More specifically, within level 2, the degree of concern is nearer the bottom end of the level than the upper end.

Fishery Performance Considerations

The estimated "year effect" for longline fishery mean CPUE in 2020 (not catch-weighted) is the highest since 1997 and is 26% above the average for the time series. The catch-weighted, all-gear mean CPUE estimate for 2020 is the all-time high for the time series, and is 67% above the time series average. The fact that the fishery CPUE data tend to paint a somewhat different picture than the survey data is concerning, but hardly a reason to reduce ABC, as including fishery CPUE data in the assessment model (20.9 and 20.10) results in higher, not lower, maxABC values. Recent expansion of the fishery into the NBS is noteworthy, but is not necessarily a concern in terms of fishery performance. Fishery performance considerations were rated as level 1 (normal), which was the same rating given last year. More specifically, within level 1, the degree of concern is nearer the bottom end of the level than the upper end.

Summary and ABC Recommendation

The ratings of the four categories are summarized below:

Assessment-related considerations	*Population dynamics considerations*	*Environmental/ ecosystem considerations*	*Fishery Performance considerations*
Level 1: Normal	Level 1: Normal	Level 2: Substantially increased concerns	Level 1: Normal

If all categories had been ranked as level 1 (normal), the expectation would be that no reduction is necessary, because "normally" ABC is set equal to maxABC. However, because one of the category ratings exceeds level 1, it is necessary to consider whether ABC may need to be reduced from the maximum permissible value. Last year the same set ratings was assigned, and the SSC chose to reduce ABC. Nevertheless, the SSC has also said that identification of a level greater than 1 does not mandate an ABC reduction.

Appendix 2.6 was developed in an attempt to provide a formulaic approach to answering the following pair of questions:

- How do the levels of concern identified in the risk table map into the need for an ABC reduction?
- If an ABC reduction is needed, how large should the reduction be?

Based on the method described in Appendix 2.6 and given the 2021 OFL distributions for Ensembles A and AB described in Table 2.39 and Figure 2.26b, a reduction in this particular case would be necessary only if the degree of concern for each of the four categories was, on average, much closer to the upper end of the assigned level than to the lower end. Specifically, for both Ensembles A and AB, the degree of concern would have to be about twice as far from the lower end of the respective level than the upper end, on average. However, as indicated above, this is not the case, as the degree of concern for each category was identified as being near the lower end of the designated level. Therefore, no ABC reduction is recommended here, and the authors' ABC recommendations for 2021 and 2022 are 118,013 t and 109,266 t, respectively, based on Ensemble AB.

Area Allocation of Harvests

No recommendations are made regarding area allocation of harvests.

Status Determination
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 (2019) is 178,816 t. This is less than the 2019 OFL of 216,000 t. Therefore, the EBS Pacific cod 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 2020:

a. If spawning biomass for 2020 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2020 is estimated to be above $B_{35\%}$, the stock is above its MSST.
c. If spawning biomass for 2020 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 2.40e). If the mean spawning biomass for 2030 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 2.40f):

a. If the mean spawning biomass for 2022 is below ½ $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2022 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2022 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2032. If the mean spawning biomass for 2032 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 2.40e and 2.40f, the stock is not overfished and is not approaching an overfished condition under Model 19.12, Ensemble A, or Ensemble AB.

To fulfill reporting requirements for the Species Information System, each model was used to reverse-engineer the fishing mortality rate corresponding to the specified OFL for the last complete year (2019). These reverse-engineered F_{OFL} values ($RE\ F_{OFL}$) are shown below:

Model:	20.4	19.12a	19.15	19.12	20.8	20.9	20.10	Ens. A	Ens. AB
$RE\ F_{OFL}$:	0.469	0.363	0.563	0.312	0.300	0.356	0.206	0.417	0.361

ECOSYSTEM CONSIDERATIONS

Ecosystem considerations are addressed in Appendix 2.2 and in the Ecosystem Status Report.

DATA GAPS AND RESEARCH PRIORITIES

Significant improvements in the quality of this assessment could be made if future research were directed toward closing certain data gaps. At this point, the most critical needs pertain to the effects of the large and potentially unprecedented movements of Pacific cod from the EBS and NBS that appear to have taken place in the last few years, including: 1) to understand the factors determining these movements, 2) to understand whether/how these movements change over time, 3) to obtain accurate estimates of these movements, 4) to understand the extent to which reciprocal movements occur, and 5) to understand the spawning contribution of NBS fish to the overall stock. Additional surveys of the NBS are strongly encouraged, as are genetic analyses and tagging studies. Ageing also continues to be an issue, as the assessment models consistently estimate a positive ageing bias, at least for otoliths read prior to 2008. Longer-term research needs include improved understanding of: 1) the ecology of Pacific cod in the EBS, including spatial dynamics, trophic and other interspecific relationships, and the relationship between climate and recruitment; 2) ecology of species taken as bycatch in the Pacific cod fisheries, including estimation of biomass, carrying capacity, and resilience; and 3) ecology of species that interact with Pacific cod, including estimation of interaction strengths, biomass, carrying capacity, and resilience.

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TABLES

Table 2.1a—Summary of 1964-1980 catches (t) of Pacific cod in the EBS by fleet sector. "For." = foreign, "JV" = joint venture processing, "Dom." = domestic annual processing. Catches by gear are not available for these years. Catches may not always include discards.

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

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

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

Table 2.1c—Summary of 1991-2020 catches (t) of Pacific cod in the EBS by gear type. The small catches taken by "other" gear types have been merged proportionally with the catches of the gear types shown. Pot catches for 2014-2020 include the State-managed fishery. Catches for 2020 are through October 21.

Year	Trawl	Longline	Pot	Total
1991	129,393	77,505	3,343	210,241
1992	77,276	79,420	7,514	164,210
1993	81,792	49,296	2,098	133,186
1994	85,294	78,898	8,071	172,263
1995	111,250	97,923	19,326	228,498
1996	92,029	88,996	28,042	209,067
1997	93,995	117,097	21,509	232,601
1998	60,855	84,426	13,249	158,529
1999	51,939	81,520	12,408	145,867
2000	53,841	81,678	15,856	151,376
2001	35,670	90,394	16,478	142,542
2002	51,118	100,371	15,067	166,555
2003	46,717	108,769	19,957	175,443
2004	57,866	108,618	17,264	183,748
2005	52,638	113,190	17,112	182,940
2006	53,236	96,613	18,969	168,818
2007	45,700	77,181	17,248	140,129
2008	33,497	88,936	17,368	139,802
2009	36,959	96,606	13,609	147,174
2010	41,304	81,815	19,725	142,845
2011	64,085	117,078	28,064	209,226
2012	75,536	128,507	28,738	232,781
2013	81,619	124,828	30,253	236,699
2014	72,262	127,271	39,195	238,728
2015	66,680	128,217	37,942	232,838
2016	72,591	127,942	47,086	247,619
2017	68,885	122,769	46,184	237,838
2018	59,967	100,213	39,686	199,866
2019	48,948	88,803	41,064	178,816
2020	49,399	61,584	32,751	143,734

Table 2.2a—Trawl fishery mean CPUE by year (row) and month (column), normalized to an overall mean of 1.0. Year-month combinations with fewer than 3 distinct vessels not shown. Color scale applies to the entire matrix, and extends from red=low to green=high.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1991	1.019	1.348	1.441	1.256	0.668	0.503	0.718					
1992	1.438	1.280	1.297	0.892	0.545	0.410		1.424				
1993	1.167	1.289	1.310	0.988	0.764	1.192		1.168	0.756	1.085	0.754	
1994	0.634	1.247	1.495	0.841	0.595	0.665		1.026	0.904	1.310		
1995	1.189	2.095	1.410	1.072			1.341	1.171		0.953		
1996	0.791	1.214	0.901	0.658	0.607	0.793		1.043		0.764	0.667	
1997	1.495	1.697	1.312	0.813	0.502		0.702	0.576	0.196		0.707	
1998	1.191	1.401	0.834	0.465	0.418	0.671	0.727	0.555	0.638	1.106	0.381	
1999	0.569	1.158	0.862	0.676	0.369		0.334	0.431	0.642	0.387	0.293	
2000	0.747	0.794	0.935	0.506	0.927	0.307	0.349	0.299	0.453			
2001	0.397	0.616	0.662	0.356	0.431	1.583	1.304	0.439	0.314	0.213		
2002	0.672	0.851	0.832	0.392	0.625	1.247	0.826	0.310	0.326	0.443		
2003	0.561	0.553	0.822	0.483	0.362	1.464	1.177	0.408	0.478			
2004	1.551	1.445	1.268	0.627	0.759	0.749	0.738	0.546	0.412	0.257		
2005	0.774	1.059	1.453	0.508	0.643	0.513	0.333					
2006	0.793	0.801	1.031	1.483	0.697		0.452	0.598				
2007	0.472	0.750	1.169	0.957	0.822	1.065	0.522	0.348				
2008	0.361	0.636	0.919	0.962	0.537	0.277	1.793	1.563	0.571	1.388		
2009	0.397	0.901	1.248	1.438	0.251	0.734	1.045	1.228	1.055	1.283	0.641	
2010	0.740	0.935	1.321	0.732	0.371	1.059	0.657	1.788	1.765	1.395	0.905	
2011	1.304	1.096	2.031	0.897	1.242	0.665	1.184	1.359	1.266	1.239	0.476	
2012	2.853	2.095	2.753	1.211	2.959	1.256	0.327	1.097	0.952	1.289		1.190
2013	1.860	1.404	0.980	1.991	1.001	0.592	1.245	1.482	2.186	1.310	0.388	
2014	1.284	1.289	1.360	1.462	1.494	0.553	0.545	1.171	1.407		0.548	
2015	0.422	1.313	1.741	1.322	1.358	1.221	0.854	2.208	0.520	1.062		
2016	1.097	1.543	2.345	1.031	0.562	0.720	0.800	0.611	0.606	0.731	1.266	
2017	0.918	2.064	1.917	1.355	0.659	0.783	0.525	0.338	0.217			
2018	1.233	1.748	5.913	3.990	0.466	0.573	0.314	0.348	0.420	0.575	0.313	
2019	1.484	1.739	4.923	4.627	0.527	0.208	0.385	0.464	0.478	0.247		
2020	0.726	4.234	1.790	0.731	0.564	0.416						

Table 2.2b—Longline fishery mean CPUE by year (row) and month (column), normalized to an overall mean of 1.0. Year-month combinations with fewer than 3 distinct vessels not shown. Color scale applies to the entire matrix, and extends from red=low to green=high.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1991	1.898	2.126	1.904	1.724	1.761	1.529	1.164	1.276	1.114	0.877	0.923	1.092
1992	1.374	1.722	1.540	1.562	1.135	0.888	0.877	0.953	0.886			
1993	1.148	1.222	1.300	1.129	1.001	0.624						
1994	1.306	1.327	1.418	1.257	1.289				1.056	1.019		
1995	1.509	1.720	1.586	1.456	1.374				1.120	0.971	1.157	1.190
1996	1.601	1.569	1.406	1.323	1.213				0.945	1.017	1.066	
1997	1.727	1.846	1.484	1.522	1.189				1.070	1.037	0.992	1.122
1998	1.544	1.679	1.249	0.990	0.900				0.685	0.739	0.896	0.927
1999	1.311	1.378	1.152	1.065	1.214	0.922		0.826	0.912	0.840	0.935	1.074
2000	1.525	1.095	1.186	0.961	1.091			0.854	0.744	0.669	0.712	0.825
2001	1.065	1.053	1.021	0.914	0.943	1.014	0.792	0.760	0.701	0.715	0.708	0.907
2002	1.232	1.226	1.218	1.238	0.986		0.695	0.707	0.674	0.639	0.689	0.763
2003	0.906	0.965	1.032	0.829	0.783	0.661	0.651	0.626	0.606	0.626	0.619	0.727
2004	0.938	1.109	1.076	1.001	0.697	0.603	0.659	0.588	0.548	0.560	0.710	0.958
2005	1.123	1.144	1.223	1.246		0.684	0.696	0.619	0.576	0.596	0.638	0.802
2006	1.298	1.445	1.481	1.164			0.659	0.803	0.702	0.609	0.774	0.802
2007	1.292	1.377	1.253				0.718	0.846	0.670	0.647		1.146
2008	1.415	1.486	1.359	1.501		0.437	0.633	0.657	0.542	0.485	0.632	1.237
2009	1.569	1.723	2.096			0.670	0.695	0.666	0.620	0.603	0.655	1.023
2010	1.341	1.573	1.652				0.726	0.695	0.616	0.600	0.746	0.934
2011	1.246	1.333	1.371	1.133	0.821	0.718	0.597	0.631	0.670	0.697	0.747	0.882
2012	1.413	1.390	1.072	1.087	0.904	0.916	0.662	0.598	0.551	0.592	0.697	1.036
2013	1.370	1.290	1.205	1.158	0.923	0.671	0.729	0.660	0.624	0.644	0.775	0.984
2014	1.006	1.174	0.940	0.952	0.777	0.657	0.577	0.623	0.644	0.691	0.767	0.827
2015	0.944	1.150	1.094	0.954	0.878	0.774	0.829	0.713	0.638	0.668	0.767	0.931
2016	1.126	1.290	1.040	0.975	0.919	0.751	0.758	0.749	0.734	0.687	0.784	0.923
2017	1.004	1.342	1.175	1.047	0.893	0.786	0.669	0.550	0.577	0.668	0.878	1.010
2018	1.495	1.540	1.289	1.269	0.841	0.687	0.542	0.583	0.804	0.767	0.683	0.991
2019	1.619	1.624	1.331	1.296	0.875	0.823	0.665	0.650	0.763	0.834	0.882	0.935
2020	1.468	1.722	1.514	1.247	1.425	1.007	0.756	0.681				

Table 2.2c—Pot fishery mean CPUE by year (row) and month (column), normalized to an overall mean of 1.0. Year-month combinations with fewer than 3 distinct vessels not shown. Color scale applies to the entire matrix, and extends from red=low to green=high.

Year	1	2	3	4	5	6	7	8	9	10	11	12
1991							0.851	0.941	1.670	1.271		0.983
1992					1.002	0.770	0.801	0.423	0.358			
1993				1.132	1.204							
1994			1.049	1.229	1.026				1.374	1.269		
1995			1.088	1.303	0.989	0.877	0.941	0.986	0.589	0.758	0.807	0.685
1996			0.948	0.997	0.746	0.781	0.696	0.655	0.664	0.666	0.716	
1997			1.001	1.257	0.624	0.637	0.579	0.674	0.446	0.707	0.512	0.568
1998				1.030	0.685	0.572	0.734	0.471	0.452	0.399	0.396	0.675
1999			0.649	0.906	0.638	0.533			0.457	0.531		
2000		0.754	0.602									
2001		0.959	0.862						0.598	0.673	0.510	
2002		1.088	0.819						0.570	0.556	0.665	
2003		0.981							0.767	0.832	0.815	
2004	0.827	1.064	0.904						0.646	0.678	0.882	
2005	1.294	1.093							0.631	0.572		
2006	1.108	1.088		1.697					0.651	0.894	0.503	
2007	0.840	1.073							0.828	1.235		
2008	1.084								0.820	0.582		
2009	1.220											
2010	1.144								1.127	1.003	1.395	
2011	1.750								1.103	1.022		
2012	1.904								0.762	1.131		
2013	1.731	1.656							1.269	1.086	1.194	
2014	1.301	1.691							1.200	0.870	0.759	1.374
2015	1.225	1.798	1.830	1.354					1.276	1.013	0.880	1.152
2016	1.178	1.466	1.539	1.603					1.337	0.975	0.956	1.055
2017	1.245	2.287							0.943	0.935	0.979	0.738
2018	1.201		2.417						1.206	1.267	1.025	1.139
2019	1.330		2.708						1.811		1.764	
2020	1.257											

Table 2.3—Catch-weighted relative CPUE (all gears combined). Although the mean for each gear type is 1.0, because of the way the index is constructed, the overall mean is slightly different from 1.0. Data for 2020 are through October 21.

Year	Mean	SE
1991	1.094	0.017
1992	1.021	0.012
1993	0.983	0.015
1994	1.028	0.010
1995	1.219	0.012
1996	0.946	0.006
1997	1.107	0.008
1998	0.917	0.008
1999	0.887	0.008
2000	0.782	0.004
2001	0.720	0.005
2002	0.780	0.005
2003	0.695	0.005
2004	0.809	0.009
2005	0.808	0.007
2006	0.910	0.007
2007	0.890	0.008
2008	0.896	0.005
2009	1.026	0.009
2010	0.983	0.008
2011	1.015	0.009
2012	1.161	0.013
2013	1.081	0.007
2014	0.916	0.005
2015	0.979	0.006
2016	1.035	0.008
2017	1.063	0.007
2018	1.240	0.018
2019	1.294	0.028
2020	1.667	0.022

Table 2.4—Discards (t) and discard rates (%) of Pacific cod in the Pacific cod fishery, by area, gear, and year for the period 1991-2020 (2019 data are current through October 21. The small amounts of discards taken by other gear types (never more than 0.1% of total discards in any year) are not included. Note that Amendment 49, which mandated increased retention and utilization, was implemented in 1998.

	Discard amount (t)				Discard rate (%)			
Year	Trawl	Longline	Pot	Total	Trawl	Longline	Pot	All
1991	1,278	1,493	4	2,774	4.11	2.62	0.26	3.10
1992	3,314	1,768	59	5,141	8.68	2.23	0.78	4.12
1993	5,449	2,234	25	7,708	12.89	4.54	1.21	8.24
1994	4,599	2,917	161	7,677	9.98	3.71	2.01	5.79
1995	7,987	3,669	222	11,877	12.24	3.77	1.15	6.54
1996	2,971	2,833	391	6,194	5.12	3.19	1.39	3.54
1997	3,327	3,183	79	6,590	5.42	2.72	0.37	3.30
1998	102	2,456	52	2,610	0.27	2.92	0.39	1.94
1999	353	1,285	52	1,691	0.95	1.58	0.42	1.29
2000	207	2,267	71	2,546	0.56	2.78	0.45	1.90
2001	142	1,531	52	1,726	0.76	1.70	0.32	1.38
2002	557	2,066	91	2,715	1.73	2.06	0.61	1.84
2003	240	1,771	159	2,170	0.79	1.63	0.80	1.36
2004	158	1,814	48	2,019	0.41	1.67	0.28	1.23
2005	86	2,599	61	2,747	0.26	2.30	0.36	1.68
2006	193	1,528	63	1,784	0.54	1.58	0.33	1.18
2007	238	1,373	45	1,656	0.74	1.78	0.26	1.31
2008	13	1,280	156	1,449	0.09	1.44	0.90	1.20
2009	126	1,503	16	1,645	1.02	1.56	0.12	1.34
2010	151	1,402	3	1,556	1.06	1.72	0.02	1.35
2011	86	1,853	8	1,947	0.30	1.59	0.03	1.12
2012	93	1,760	26	1,879	0.26	1.37	0.09	0.98
2013	97	3,060	23	3,180	0.26	2.46	0.07	1.65
2014	149	2,893	119	3,161	0.39	2.28	0.30	1.55
2015	119	2,374	29	2,522	0.36	1.85	0.08	1.27
2016	73	2,552	27	2,652	0.18	2.00	0.06	1.23
2017	47	1,937	32	2,016	0.12	1.58	0.07	0.97
2018	102	1,540	21	1,663	0.29	1.54	0.05	0.95
2019	111	1,286	50	1,447	0.48	1.45	0.12	0.95
2020	32	782	52	866	0.14	1.27	0.16	0.74

Table 2.5—History of BSAI (1977-2013) and EBS (2014-2020) Pacific cod catch, TAC, ABC, and OFL (t). Catch for 2020 is through October 21. Note that specifications through 2013 were for the combined BSAI region, so BSAI catch is shown rather than the EBS catches from Table 2.1 for the period 1977-2013. Source for historical specifications: NPFMC staff.

Year	Catch	TAC	ABC	OFL
1977	36,597	58,000	-	-
1978	45,838	70,500	-	-
1979	39,354	70,500	-	-
1980	51,649	70,700	148,000	-
1981	63,941	78,700	160,000	-
1982	69,501	78,700	168,000	-
1983	103,231	120,000	298,200	-
1984	133,084	210,000	291,300	-
1985	150,384	220,000	347,400	-
1986	142,511	229,000	249,300	-
1987	163,110	280,000	400,000	-
1988	208,236	200,000	385,300	-
1989	182,865	230,681	370,600	-
1990	179,608	227,000	417,000	-
1991	220,038	229,000	229,000	-
1992	207,278	182,000	182,000	188,000
1993	167,391	164,500	164,500	192,000
1994	193,802	191,000	191,000	228,000
1995	245,033	250,000	328,000	390,000
1996	240,676	270,000	305,000	420,000
1997	257,765	270,000	306,000	418,000
1998	193,256	210,000	210,000	336,000
1999	173,998	177,000	177,000	264,000
2000	191,060	193,000	193,000	240,000
2001	176,749	188,000	188,000	248,000
2002	197,356	200,000	223,000	294,000
2003	207,907	207,500	223,000	324,000
2004	212,618	215,500	223,000	350,000
2005	205,635	206,000	206,000	265,000
2006	193,025	194,000	194,000	230,000
2007	174,486	170,720	176,000	207,000
2008	171,277	170,720	176,000	207,000
2009	175,756	176,540	182,000	212,000
2010	171,875	168,780	174,000	205,000
2011	220,109	227,950	235,000	272,000
2012	250,899	261,000	314,000	369,000
2013	250,274	260,000	307,000	359,000
2014	238,728	246,897	255,000	299,000
2015	232,838	240,000	255,000	346,000
2016	247,619	238,680	255,000	390,000
2017	237,838	223,704	239,000	284,000
2018	199,866	188,136	201,000	238,000
2019	178,816	166,475	181,000	216,000
2020	143,734	141,799	155,873	191,386

Table 2.6 (page 1 of 2)—Amendments to the BSAI Fishery Management Plan (FMP) that reference Pacific cod explicitly (excerpted from Appendix A of the FMP, except that Amendment 113, which is listed in Appendix A of the FMP, is omitted here, due to the fact that the final rule implementing that amendment was vacated by the U.S. District Court for the District of Columbia on March 21, 2019).

Amendment 2, implemented January 12, 1982:

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

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

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

Amendment 10, implemented March 16, 1987:

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

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

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

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

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

Amendment 49, implemented January 3, 1998:

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

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

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

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

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

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

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

(Continued on next page.)

Table 2.6 (page 2 of 2)—Amendments to the BSAI Fishery Management Plan (FMP) that reference Pacific cod explicitly (excerpted from Appendix A of the FMP).

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

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

Amendment 99, implemented January 6, 2014 (effective February 6, 2014):

Allows holders of license limitation program (LLP) licenses endorsed to catch and process Pacific cod in the Bering Sea/Aleutian Islands hook-and-line fisheries to use their LLP license on larger newly built or existing vessels by:

1. Increasing the maximum vessel length limits of the LLP license, and
2. Waiving vessel length, weight, and horsepower limits of the American Fisheries Act.

Amendment 103, implemented November 14, 2014:

Revise the Pribilof Islands Habitat Conservation Zone to close to fishing for Pacific cod with pot gear (in addition to the closure to all trawling).

Amendment 109, implemented May 4, 2016:

Revised provisions regarding the Western Alaska CDQ Program to update information and to facilitate increased participation in the groundfish CDQ fisheries (primarily Pacific cod) by:

1. Exempting CDQ group-authorized catcher vessels greater than 32 ft LOA and less than or equal to 46 ft LOA using hook-and-line gear from License Limitation Program license requirements while groundfish CDQ fishing,
2. Modifying observer coverage category language to allow for the placement of catcher vessels less than or equal to 46 ft LOA using hook-and-line gear into the partial observer coverage category while groundfish CDQ fishing, and
3. Updating CDQ community population information, and making other miscellaneous editorial revisions to CDQ Program-related text in the FMP.

Amendment 120, implemented December 20, 2019:

1. Limits the number of catcher/processors (C/Ps) eligible to operate as motherships receiving and processing Pacific cod from catcher vessels (CVs) directed fishing in the BSAI non-Community Development Quota Program Pacific cod trawl fishery.
2. Prohibits replaced Amendment 80 C/Ps from receiving and processing Pacific cod harvested and delivered by CVs directed fishing for Pacific cod in the BSAI and GOA.

Table 2.6 (page 1 of 6)—Fishery size composition data (units = within-year proportion at age).

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1977	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1978	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1979	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1980	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1981	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0002	0.0002
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0006	0.0006	0.0007
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001	0.0001	0.0002
1987	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0001	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
1993	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0000	0.0000	0.0000
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
1996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
2001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
2006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
2007	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001
2008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000
2009	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000
2016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002
2020	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000

Table 2.6a (page 2 of 6)—Fishery size composition data (units = within-year proportion at age).

Year	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1977	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0010	0.0023	0.0043	0.0067	0.0043	0.0113	0.0120	0.0133	0.0097	0.0073	0.0130	0.0097
1978	0.0002	0.0005	0.0002	0.0005	0.0008	0.0034	0.0040	0.0034	0.0034	0.0022	0.0016	0.0014	0.0005	0.0006	0.0019	0.0016	0.0013	0.0008	0.0011	0.0018
1979	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0005	0.0014	0.0026	0.0019	0.0042	0.0062	0.0087	0.0104	0.0165	0.0227	0.0223	0.0290	0.0331	0.0328
1980	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0010	0.0009	0.0021	0.0024	0.0022	0.0036	0.0058	0.0074	0.0122	0.0143	0.0250	0.0301	0.0351	0.0389
1981	0.0002	0.0002	0.0003	0.0002	0.0008	0.0007	0.0020	0.0043	0.0052	0.0116	0.0214	0.0298	0.0332	0.0391	0.0339	0.0258	0.0248	0.0165	0.0155	0.0197
1982	0.0001	0.0001	0.0000	0.0000	0.0002	0.0001	0.0002	0.0002	0.0003	0.0007	0.0021	0.0042	0.0049	0.0042	0.0055	0.0049	0.0032	0.0022	0.0032	0.0060
1983	0.0001	0.0002	0.0002	0.0001	0.0003	0.0005	0.0004	0.0008	0.0015	0.0021	0.0023	0.0020	0.0015	0.0015	0.0013	0.0018	0.0018	0.0028	0.0044	0.0056
1984	0.0008	0.0006	0.0008	0.0013	0.0018	0.0027	0.0034	0.0037	0.0036	0.0036	0.0035	0.0036	0.0037	0.0038	0.0044	0.0040	0.0037	0.0037	0.0038	0.0046
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0002	0.0004	0.0007	0.0008	0.0008	0.0015	0.0017	0.0027	0.0040	0.0056	0.0076
1986	0.0003	0.0003	0.0003	0.0005	0.0007	0.0008	0.0010	0.0017	0.0024	0.0034	0.0040	0.0043	0.0048	0.0046	0.0043	0.0041	0.0046	0.0040	0.0043	0.0051
1987	0.0001	0.0001	0.0002	0.0002	0.0004	0.0007	0.0009	0.0011	0.0011	0.0013	0.0015	0.0015	0.0015	0.0016	0.0017	0.0021	0.0028	0.0037	0.0045	0.0058
1988	0.0001	0.0001	0.0001	0.0001	0.0003	0.0006	0.0011	0.0021	0.0029	0.0041	0.0050	0.0061	0.0069	0.0064	0.0071	0.0063	0.0076	0.0085	0.0111	0.0142
1989	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0008	0.0016	0.0014	0.0027	0.0029	0.0038	0.0048	0.0046	0.0059	0.0054	0.0044	0.0049	0.0049	0.0055
1990	0.0002	0.0001	0.0003	0.0005	0.0006	0.0013	0.0014	0.0023	0.0019	0.0022	0.0021	0.0021	0.0021	0.0020	0.0016	0.0018	0.0017	0.0015	0.0014	0.0015
1991	0.0000	0.0001	0.0001	0.0003	0.0004	0.0007	0.0008	0.0011	0.0014	0.0015	0.0016	0.0016	0.0018	0.0015	0.0018	0.0020	0.0024	0.0024	0.0035	0.0038
1992	0.0001	0.0001	0.0002	0.0002	0.0003	0.0004	0.0009	0.0008	0.0010	0.0017	0.0018	0.0022	0.0022	0.0024	0.0033	0.0038	0.0051	0.0068	0.0087	0.0108
1993	0.0001	0.0001	0.0003	0.0003	0.0004	0.0009	0.0023	0.0033	0.0042	0.0039	0.0033	0.0037	0.0036	0.0051	0.0049	0.0117	0.0139	0.0163	0.0192	0.0196
1994	0.0000	0.0001	0.0002	0.0004	0.0005	0.0011	0.0016	0.0023	0.0029	0.0036	0.0037	0.0037	0.0040	0.0031	0.0031	0.0026	0.0031	0.0038	0.0054	0.0075
1995	0.0001	0.0001	0.0002	0.0003	0.0004	0.0009	0.0006	0.0008	0.0010	0.0011	0.0012	0.0014	0.0016	0.0021	0.0034	0.0058	0.0091	0.0121	0.0153	0.0185
1996	0.0000	0.0000	0.0001	0.0001	0.0004	0.0004	0.0007	0.0009	0.0013	0.0012	0.0013	0.0014	0.0013	0.0015	0.0013	0.0014	0.0016	0.0025	0.0031	0.0042
1997	0.0000	0.0001	0.0001	0.0003	0.0004	0.0006	0.0009	0.0015	0.0018	0.0024	0.0027	0.0033	0.0028	0.0030	0.0029	0.0029	0.0031	0.0035	0.0038	0.0050
1998	0.0000	0.0001	0.0002	0.0004	0.0005	0.0009	0.0010	0.0011	0.0012	0.0014	0.0013	0.0015	0.0015	0.0018	0.0018	0.0021	0.0026	0.0035	0.0045	0.0054
1999	0.0001	0.0000	0.0000	0.0001	0.0003	0.0006	0.0007	0.0013	0.0011	0.0011	0.0011	0.0013	0.0010	0.0015	0.0020	0.0031	0.0053	0.0080	0.0118	0.0148
2000	0.0000	0.0001	0.0001	0.0001	0.0003	0.0004	0.0006	0.0006	0.0009	0.0007	0.0006	0.0007	0.0009	0.0012	0.0015	0.0024	0.0035	0.0047	0.0060	0.0076
2001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0002	0.0003	0.0003	0.0003	0.0008	0.0007	0.0011	0.0015	0.0020	0.0020	0.0024	0.0036	0.0049	0.0053
2002	0.0001	0.0001	0.0002	0.0002	0.0004	0.0008	0.0011	0.0017	0.0024	0.0023	0.0030	0.0027	0.0032	0.0034	0.0033	0.0046	0.0047	0.0067	0.0081	0.0102
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0003	0.0007	0.0008	0.0010	0.0021	0.0017	0.0018	0.0021	0.0026	0.0032	0.0044	0.0059	0.0079
2004	0.0000	0.0000	0.0000	0.0001	0.0001	0.0002	0.0004	0.0004	0.0005	0.0010	0.0013	0.0011	0.0018	0.0018	0.0020	0.0019	0.0024	0.0024	0.0033	0.0036
2005	0.0001	0.0000	0.0002	0.0002	0.0003	0.0004	0.0005	0.0009	0.0007	0.0009	0.0018	0.0021	0.0017	0.0020	0.0019	0.0020	0.0029	0.0039	0.0038	0.0049
2006	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0002	0.0004	0.0007	0.0008	0.0008	0.0011	0.0016	0.0018	0.0021	0.0022	0.0027	0.0037	0.0038
2007	0.0001	0.0001	0.0002	0.0001	0.0003	0.0003	0.0004	0.0008	0.0008	0.0009	0.0013	0.0015	0.0017	0.0017	0.0021	0.0025	0.0024	0.0025	0.0036	0.0036
2008	0.0002	0.0004	0.0008	0.0009	0.0011	0.0011	0.0011	0.0013	0.0012	0.0012	0.0018	0.0018	0.0026	0.0031	0.0035	0.0041	0.0055	0.0050	0.0056	0.0064
2009	0.0002	0.0000	0.0001	0.0001	0.0003	0.0002	0.0005	0.0004	0.0007	0.0003	0.0009	0.0009	0.0011	0.0013	0.0020	0.0028	0.0047	0.0062	0.0081	0.0098
2010	0.0000	0.0001	0.0001	0.0002	0.0004	0.0004	0.0003	0.0006	0.0004	0.0009	0.0012	0.0011	0.0018	0.0026	0.0033	0.0049	0.0061	0.0056	0.0064	0.0064
2011	0.0000	0.0000	0.0001	0.0001	0.0000	0.0002	0.0003	0.0002	0.0006	0.0004	0.0004	0.0003	0.0006	0.0010	0.0015	0.0030	0.0043	0.0063	0.0080	0.0094
2012	0.0000	0.0000	0.0001	0.0004	0.0004	0.0006	0.0005	0.0007	0.0008	0.0010	0.0012	0.0011	0.0010	0.0021	0.0016	0.0019	0.0021	0.0027	0.0035	0.0045
2013	0.0002	0.0001	0.0001	0.0004	0.0006	0.0008	0.0012	0.0009	0.0015	0.0015	0.0016	0.0020	0.0020	0.0027	0.0027	0.0034	0.0036	0.0051	0.0062	0.0075
2014	0.0000	0.0000	0.0000	0.0001	0.0001	0.0004	0.0004	0.0004	0.0007	0.0009	0.0009	0.0010	0.0007	0.0010	0.0017	0.0022	0.0037	0.0054	0.0074	0.0094
2015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0008	0.0011	0.0012	0.0012	0.0015	0.0012	0.0016	0.0014	0.0019	0.0019	0.0018	0.0024	0.0042
2016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0003	0.0004	0.0005	0.0005	0.0013	0.0008	0.0012	0.0020	0.0023	0.0037	0.0054
2017	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0003	0.0006	0.0006	0.0006	0.0008	0.0012	0.0013
2018	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001	0.0002	0.0002	0.0005	0.0010	0.0005	0.0017	0.0016	0.0023	0.0022
2019	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0004	0.0001	0.0004	0.0002	0.0001	0.0006	0.0005	0.0006	0.0008	0.0009	0.0012	0.0014
2020	0.0002	0.0000	0.0000	0.0000	0.0008	0.0009	0.0025	0.0018	0.0019	0.0020	0.0013	0.0024	0.0023	0.0026	0.0031	0.0023	0.0030	0.0024	0.0021	0.0022

Table 2.6 (page 3 of 6)—Fishery size composition data (units = within-year proportion at age).

Year	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
1977	0.0047	0.0067	0.0047	0.0030	0.0067	0.0100	0.0167	0.0260	0.0450	0.0384	0.0454	0.0437	0.0370	0.0350	0.0330	0.0297	0.0344	0.0354	0.0377	0.0377
1978	0.0026	0.0040	0.0059	0.0076	0.0108	0.0134	0.0171	0.0237	0.0278	0.0338	0.0437	0.0508	0.0579	0.0657	0.0613	0.0638	0.0626	0.0567	0.0523	0.0438
1979	0.0290	0.0287	0.0277	0.0240	0.0224	0.0166	0.0155	0.0151	0.0180	0.0189	0.0206	0.0218	0.0230	0.0253	0.0282	0.0283	0.0298	0.0316	0.0339	0.0333
1980	0.0364	0.0384	0.0351	0.0375	0.0314	0.0312	0.0257	0.0284	0.0268	0.0250	0.0252	0.0272	0.0270	0.0249	0.0238	0.0263	0.0237	0.0243	0.0192	0.0170
1981	0.0239	0.0284	0.0339	0.0425	0.0393	0.0382	0.0378	0.0366	0.0373	0.0369	0.0334	0.0278	0.0285	0.0245	0.0231	0.0224	0.0209	0.0197	0.0164	0.0166
1982	0.0078	0.0114	0.0091	0.0130	0.0116	0.0116	0.0148	0.0116	0.0191	0.0174	0.0255	0.0256	0.0245	0.0229	0.0252	0.0279	0.0261	0.0291	0.0328	0.0330
1983	0.0067	0.0068	0.0079	0.0077	0.0083	0.0081	0.0073	0.0090	0.0102	0.0119	0.0153	0.0207	0.0221	0.0259	0.0266	0.0310	0.0321	0.0357	0.0380	0.0341
1984	0.0053	0.0063	0.0062	0.0058	0.0061	0.0063	0.0067	0.0069	0.0075	0.0074	0.0097	0.0113	0.0134	0.0169	0.0177	0.0200	0.0228	0.0255	0.0282	0.0299
1985	0.0087	0.0089	0.0097	0.0110	0.0116	0.0138	0.0154	0.0167	0.0186	0.0195	0.0201	0.0192	0.0177	0.0170	0.0157	0.0146	0.0148	0.0145	0.0152	0.0177
1986	0.0061	0.0077	0.0077	0.0092	0.0104	0.0117	0.0131	0.0153	0.0169	0.0175	0.0214	0.0224	0.0242	0.0264	0.0276	0.0282	0.0296	0.0301	0.0318	0.0316
1987	0.0065	0.0072	0.0089	0.0096	0.0101	0.0113	0.0132	0.0143	0.0169	0.0191	0.0216	0.0238	0.0246	0.0258	0.0266	0.0267	0.0276	0.0263	0.0266	0.0274
1988	0.0187	0.0210	0.0230	0.0245	0.0240	0.0225	0.0227	0.0205	0.0221	0.0227	0.0231	0.0221	0.0222	0.0217	0.0215	0.0199	0.0207	0.0202	0.0183	0.0180
1989	0.0071	0.0078	0.0097	0.0111	0.0112	0.0135	0.0147	0.0139	0.0156	0.0161	0.0166	0.0166	0.0166	0.0169	0.0172	0.0175	0.0183	0.0198	0.0194	0.0214
1990	0.0015	0.0015	0.0019	0.0024	0.0025	0.0036	0.0042	0.0064	0.0068	0.0080	0.0088	0.0103	0.0120	0.0136	0.0154	0.0176	0.0194	0.0215	0.0254	0.0264
1991	0.0055	0.0067	0.0086	0.0100	0.0107	0.0119	0.0118	0.0120	0.0114	0.0118	0.0120	0.0115	0.0131	0.0132	0.0139	0.0150	0.0173	0.0176	0.0207	0.0233
1992	0.0134	0.0164	0.0162	0.0160	0.0171	0.0195	0.0194	0.0188	0.0200	0.0197	0.0191	0.0196	0.0183	0.0195	0.0179	0.0192	0.0212	0.0199	0.0227	0.0220
1993	0.0195	0.0196	0.0212	0.0205	0.0204	0.0225	0.0253	0.0257	0.0278	0.0299	0.0329	0.0337	0.0331	0.0323	0.0318	0.0308	0.0300	0.0274	0.0279	0.0262
1994	0.0109	0.0148	0.0161	0.0189	0.0193	0.0191	0.0207	0.0193	0.0223	0.0236	0.0255	0.0279	0.0288	0.0312	0.0312	0.0319	0.0362	0.0341	0.0342	0.0349
1995	0.0208	0.0205	0.0202	0.0191	0.0172	0.0165	0.0173	0.0173	0.0184	0.0199	0.0214	0.0234	0.0247	0.0262	0.0276	0.0296	0.0310	0.0316	0.0325	0.0337
1996	0.0062	0.0079	0.0096	0.0114	0.0141	0.0174	0.0201	0.0226	0.0262	0.0277	0.0290	0.0303	0.0307	0.0310	0.0312	0.0310	0.0313	0.0308	0.0306	0.0309
1997	0.0069	0.0093	0.0107	0.0127	0.0130	0.0151	0.0149	0.0161	0.0166	0.0182	0.0199	0.0234	0.0243	0.0276	0.0285	0.0320	0.0344	0.0354	0.0371	0.0374
1998	0.0068	0.0083	0.0094	0.0101	0.0111	0.0125	0.0139	0.0148	0.0161	0.0174	0.0185	0.0205	0.0205	0.0225	0.0240	0.0250	0.0286	0.0292	0.0319	0.0338
1999	0.0163	0.0187	0.0198	0.0199	0.0205	0.0207	0.0205	0.0204	0.0209	0.0217	0.0207	0.0231	0.0227	0.0223	0.0227	0.0231	0.0252	0.0247	0.0267	0.0286
2000	0.0085	0.0114	0.0132	0.0152	0.0183	0.0201	0.0229	0.0259	0.0283	0.0290	0.0309	0.0322	0.0330	0.0329	0.0327	0.0336	0.0338	0.0334	0.0335	0.0332
2001	0.0065	0.0078	0.0103	0.0122	0.0129	0.0149	0.0175	0.0188	0.0215	0.0236	0.0265	0.0290	0.0311	0.0331	0.0351	0.0366	0.0391	0.0404	0.0403	0.0421
2002	0.0114	0.0122	0.0139	0.0158	0.0169	0.0184	0.0194	0.0204	0.0225	0.0232	0.0246	0.0256	0.0272	0.0283	0.0301	0.0319	0.0340	0.0358	0.0366	0.0378
2003	0.0099	0.0117	0.0137	0.0164	0.0176	0.0200	0.0212	0.0231	0.0267	0.0271	0.0288	0.0296	0.0308	0.0311	0.0306	0.0304	0.0313	0.0311	0.0312	0.0324
2004	0.0048	0.0065	0.0085	0.0104	0.0123	0.0143	0.0175	0.0194	0.0216	0.0243	0.0263	0.0293	0.0316	0.0332	0.0341	0.0361	0.0388	0.0393	0.0391	0.0404
2005	0.0064	0.0076	0.0090	0.0104	0.0118	0.0135	0.0140	0.0153	0.0176	0.0184	0.0206	0.0223	0.0239	0.0258	0.0268	0.0276	0.0309	0.0313	0.0328	0.0347
2006	0.0040	0.0057	0.0088	0.0102	0.0122	0.0131	0.0155	0.0168	0.0189	0.0207	0.0235	0.0243	0.0256	0.0263	0.0270	0.0272	0.0288	0.0282	0.0295	0.0295
2007	0.0043	0.0060	0.0071	0.0088	0.0101	0.0119	0.0137	0.0145	0.0174	0.0192	0.0203	0.0230	0.0242	0.0260	0.0287	0.0293	0.0344	0.0339	0.0343	0.0342
2008	0.0060	0.0079	0.0091	0.0101	0.0104	0.0119	0.0144	0.0141	0.0181	0.0200	0.0212	0.0244	0.0251	0.0276	0.0287	0.0309	0.0337	0.0342	0.0337	0.0358
2009	0.0111	0.0138	0.0166	0.0178	0.0214	0.0229	0.0263	0.0279	0.0285	0.0307	0.0275	0.0266	0.0256	0.0244	0.0254	0.0237	0.0263	0.0277	0.0297	0.0309
2010	0.0071	0.0079	0.0086	0.0109	0.0132	0.0156	0.0196	0.0230	0.0258	0.0310	0.0316	0.0371	0.0360	0.0387	0.0406	0.0400	0.0407	0.0408	0.0407	0.0415
2011	0.0105	0.0138	0.0157	0.0185	0.0217	0.0234	0.0239	0.0251	0.0241	0.0243	0.0249	0.0253	0.0262	0.0275	0.0300	0.0332	0.0358	0.0385	0.0410	0.0450
2012	0.0050	0.0066	0.0079	0.0092	0.0113	0.0160	0.0214	0.0270	0.0311	0.0355	0.0375	0.0397	0.0399	0.0400	0.0389	0.0398	0.0419	0.0398	0.0386	0.0397
2013	0.0082	0.0097	0.0103	0.0119	0.0131	0.0131	0.0161	0.0182	0.0208	0.0220	0.0248	0.0271	0.0288	0.0328	0.0333	0.0361	0.0414	0.0415	0.0426	0.0440
2014	0.0107	0.0108	0.0123	0.0133	0.0137	0.0152	0.0190	0.0188	0.0200	0.0212	0.0238	0.0260	0.0265	0.0285	0.0303	0.0311	0.0350	0.0332	0.0337	0.0374
2015	0.0052	0.0063	0.0083	0.0112	0.0126	0.0132	0.0155	0.0193	0.0220	0.0259	0.0305	0.0333	0.0365	0.0377	0.0379	0.0379	0.0393	0.0372	0.0383	0.0382
2016	0.0078	0.0097	0.0131	0.0155	0.0163	0.0164	0.0170	0.0198	0.0198	0.0210	0.0219	0.0235	0.0253	0.0294	0.0292	0.0313	0.0348	0.0371	0.0388	0.0427
2017	0.0016	0.0026	0.0035	0.0040	0.0056	0.0088	0.0115	0.0152	0.0181	0.0222	0.0275	0.0315	0.0335	0.0357	0.0380	0.0379	0.0399	0.0391	0.0397	0.0402
2018	0.0033	0.0028	0.0040	0.0041	0.0051	0.0058	0.0074	0.0086	0.0108	0.0130	0.0149	0.0164	0.0203	0.0225	0.0258	0.0293	0.0338	0.0377	0.0411	0.0450
2019	0.0013	0.0024	0.0025	0.0031	0.0054	0.0065	0.0088	0.0101	0.0118	0.0141	0.0154	0.0177	0.0177	0.0215	0.0219	0.0239	0.0268	0.0278	0.0314	0.0347
2020	0.0030	0.0033	0.0034	0.0041	0.0060	0.0052	0.0064	0.0059	0.0095	0.0105	0.0118	0.0151	0.0180	0.0177	0.0219	0.0240	0.0252	0.0281	0.0294	0.0349

Table 2.6 (page 4 of 6)—Fishery size composition data (units = within-year proportion at age).

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
1977	0.0417	0.0410	0.0474	0.0344	0.0284	0.0264	0.0230	0.0220	0.0167	0.0120	0.0087	0.0133	0.0100	0.0097	0.0097	0.0053	0.0057	0.0037	0.0033	0.0010
1978	0.0391	0.0315	0.0230	0.0182	0.0183	0.0167	0.0155	0.0126	0.0103	0.0117	0.0106	0.0079	0.0079	0.0065	0.0060	0.0041	0.0034	0.0022	0.0040	0.0031
1979	0.0352	0.0347	0.0339	0.0303	0.0289	0.0218	0.0218	0.0203	0.0149	0.0135	0.0122	0.0090	0.0068	0.0071	0.0049	0.0033	0.0026	0.0028	0.0024	0.0013
1980	0.0163	0.0152	0.0119	0.0128	0.0144	0.0137	0.0168	0.0158	0.0150	0.0161	0.0144	0.0140	0.0131	0.0128	0.0101	0.0087	0.0072	0.0060	0.0050	0.0036
1981	0.0124	0.0133	0.0127	0.0100	0.0098	0.0086	0.0086	0.0071	0.0067	0.0059	0.0052	0.0046	0.0047	0.0032	0.0023	0.0022	0.0013	0.0016	0.0005	0.0011
1982	0.0347	0.0385	0.0375	0.0360	0.0375	0.0355	0.0387	0.0359	0.0381	0.0301	0.0279	0.0252	0.0212	0.0216	0.0148	0.0148	0.0112	0.0126	0.0065	0.0064
1983	0.0364	0.0379	0.0393	0.0357	0.0354	0.0363	0.0345	0.0316	0.0304	0.0282	0.0273	0.0254	0.0229	0.0228	0.0218	0.0204	0.0187	0.0161	0.0126	0.0111
1984	0.0337	0.0342	0.0345	0.0363	0.0379	0.0372	0.0369	0.0361	0.0355	0.0347	0.0326	0.0304	0.0296	0.0272	0.0250	0.0234	0.0207	0.0187	0.0171	0.0159
1985	0.0202	0.0238	0.0262	0.0301	0.0327	0.0355	0.0387	0.0379	0.0392	0.0380	0.0365	0.0347	0.0324	0.0303	0.0271	0.0240	0.0228	0.0191	0.0178	0.0154
1986	0.0327	0.0318	0.0301	0.0311	0.0279	0.0250	0.0230	0.0223	0.0220	0.0218	0.0225	0.0228	0.0211	0.0216	0.0210	0.0206	0.0197	0.0181	0.0162	0.0158
1987	0.0286	0.0283	0.0296	0.0301	0.0303	0.0292	0.0302	0.0291	0.0284	0.0285	0.0270	0.0265	0.0237	0.0231	0.0213	0.0186	0.0181	0.0153	0.0141	0.0137
1988	0.0191	0.0202	0.0201	0.0203	0.0232	0.0223	0.0249	0.0249	0.0251	0.0255	0.0245	0.0261	0.0220	0.0217	0.0198	0.0178	0.0164	0.0142	0.0113	0.0100
1989	0.0224	0.0232	0.0234	0.0235	0.0253	0.0267	0.0287	0.0280	0.0276	0.0295	0.0290	0.0308	0.0266	0.0272	0.0259	0.0249	0.0238	0.0220	0.0208	0.0184
1990	0.0281	0.0307	0.0322	0.0326	0.0329	0.0349	0.0342	0.0339	0.0349	0.0332	0.0336	0.0328	0.0316	0.0299	0.0280	0.0268	0.0241	0.0230	0.0209	0.0193
1991	0.0246	0.0266	0.0284	0.0302	0.0309	0.0329	0.0329	0.0315	0.0330	0.0323	0.0319	0.0319	0.0297	0.0275	0.0263	0.0252	0.0233	0.0209	0.0202	0.0188
1992	0.0260	0.0250	0.0247	0.0263	0.0274	0.0265	0.0269	0.0228	0.0240	0.0225	0.0229	0.0224	0.0208	0.0201	0.0198	0.0190	0.0184	0.0147	0.0146	0.0157
1993	0.0225	0.0209	0.0195	0.0188	0.0175	0.0171	0.0163	0.0147	0.0147	0.0140	0.0137	0.0137	0.0123	0.0116	0.0110	0.0102	0.0101	0.0087	0.0083	0.0081
1994	0.0354	0.0350	0.0329	0.0337	0.0318	0.0288	0.0288	0.0227	0.0206	0.0188	0.0167	0.0156	0.0127	0.0118	0.0105	0.0088	0.0092	0.0074	0.0068	0.0059
1995	0.0329	0.0346	0.0329	0.0336	0.0316	0.0299	0.0292	0.0248	0.0234	0.0208	0.0188	0.0171	0.0143	0.0127	0.0113	0.0102	0.0090	0.0074	0.0071	0.0062
1996	0.0309	0.0311	0.0299	0.0297	0.0286	0.0279	0.0287	0.0252	0.0244	0.0227	0.0219	0.0207	0.0183	0.0167	0.0155	0.0139	0.0133	0.0116	0.0106	0.0094
1997	0.0387	0.0391	0.0376	0.0366	0.0351	0.0340	0.0330	0.0279	0.0261	0.0233	0.0213	0.0199	0.0171	0.0152	0.0135	0.0122	0.0110	0.0087	0.0083	0.0078
1998	0.0355	0.0369	0.0374	0.0387	0.0384	0.0373	0.0380	0.0343	0.0325	0.0319	0.0279	0.0255	0.0230	0.0202	0.0175	0.0152	0.0134	0.0110	0.0098	0.0090
1999	0.0278	0.0290	0.0291	0.0300	0.0299	0.0288	0.0306	0.0278	0.0284	0.0246	0.0241	0.0214	0.0207	0.0171	0.0164	0.0147	0.0144	0.0119	0.0108	0.0095
2000	0.0324	0.0299	0.0295	0.0286	0.0269	0.0260	0.0251	0.0212	0.0217	0.0198	0.0185	0.0172	0.0152	0.0139	0.0131	0.0118	0.0110	0.0097	0.0087	0.0079
2001	0.0404	0.0412	0.0389	0.0367	0.0355	0.0335	0.0325	0.0271	0.0238	0.0210	0.0185	0.0161	0.0134	0.0112	0.0100	0.0091	0.0082	0.0072	0.0062	0.0053
2002	0.0374	0.0373	0.0363	0.0352	0.0348	0.0318	0.0310	0.0275	0.0254	0.0213	0.0198	0.0163	0.0141	0.0122	0.0109	0.0091	0.0078	0.0068	0.0058	0.0047
2003	0.0322	0.0316	0.0313	0.0316	0.0311	0.0291	0.0309	0.0271	0.0245	0.0222	0.0218	0.0190	0.0180	0.0155	0.0135	0.0125	0.0119	0.0095	0.0085	0.0077
2004	0.0387	0.0371	0.0359	0.0332	0.0329	0.0301	0.0299	0.0253	0.0224	0.0206	0.0180	0.0167	0.0154	0.0136	0.0128	0.0112	0.0111	0.0096	0.0089	0.0075
2005	0.0356	0.0361	0.0365	0.0369	0.0368	0.0348	0.0370	0.0307	0.0295	0.0272	0.0246	0.0223	0.0202	0.0176	0.0167	0.0140	0.0140	0.0123	0.0108	0.0093
2006	0.0302	0.0297	0.0299	0.0299	0.0307	0.0284	0.0314	0.0265	0.0268	0.0255	0.0252	0.0238	0.0220	0.0202	0.0195	0.0174	0.0177	0.0154	0.0147	0.0137
2007	0.0349	0.0342	0.0317	0.0317	0.0309	0.0279	0.0307	0.0254	0.0239	0.0228	0.0210	0.0208	0.0180	0.0176	0.0163	0.0145	0.0157	0.0138	0.0131	0.0130
2008	0.0358	0.0360	0.0369	0.0358	0.0352	0.0329	0.0326	0.0289	0.0254	0.0238	0.0212	0.0185	0.0156	0.0145	0.0129	0.0113	0.0108	0.0091	0.0090	0.0084
2009	0.0321	0.0324	0.0311	0.0334	0.0324	0.0302	0.0327	0.0282	0.0263	0.0241	0.0214	0.0188	0.0169	0.0136	0.0142	0.0111	0.0093	0.0087	0.0079	0.0059
2010	0.0398	0.0371	0.0345	0.0331	0.0297	0.0265	0.0268	0.0225	0.0201	0.0181	0.0162	0.0150	0.0130	0.0103	0.0094	0.0080	0.0078	0.0063	0.0049	0.0044
2011	0.0443	0.0449	0.0404	0.0394	0.0366	0.0325	0.0306	0.0241	0.0207	0.0171	0.0157	0.0128	0.0107	0.0088	0.0080	0.0068	0.0066	0.0053	0.0042	0.0035
2012	0.0370	0.0379	0.0348	0.0344	0.0328	0.0311	0.0324	0.0256	0.0220	0.0194	0.0171	0.0150	0.0113	0.0093	0.0081	0.0069	0.0059	0.0045	0.0038	0.0029
2013	0.0450	0.0453	0.0433	0.0401	0.0370	0.0348	0.0334	0.0278	0.0256	0.0212	0.0187	0.0165	0.0131	0.0103	0.0093	0.0075	0.0061	0.0048	0.0042	0.0029
2014	0.0363	0.0374	0.0348	0.0373	0.0368	0.0380	0.0370	0.0327	0.0305	0.0283	0.0251	0.0234	0.0188	0.0141	0.0127	0.0109	0.0095	0.0075	0.0063	0.0053
2015	0.0380	0.0380	0.0365	0.0368	0.0354	0.0324	0.0335	0.0267	0.0247	0.0232	0.0202	0.0177	0.0156	0.0131	0.0117	0.0104	0.0094	0.0075	0.0069	0.0057
2016	0.0438	0.0440	0.0422	0.0422	0.0395	0.0361	0.0355	0.0292	0.0267	0.0239	0.0229	0.0185	0.0161	0.0136	0.0120	0.0108	0.0090	0.0076	0.0060	0.0049
2017	0.0387	0.0392	0.0395	0.0375	0.0375	0.0364	0.0378	0.0316	0.0284	0.0286	0.0265	0.0234	0.0208	0.0183	0.0163	0.0124	0.0120	0.0084	0.0078	0.0065
2018	0.0468	0.0501	0.0462	0.0466	0.0445	0.0409	0.0392	0.0330	0.0308	0.0298	0.0251	0.0231	0.0206	0.0179	0.0159	0.0138	0.0137	0.0113	0.0091	0.0079
2019	0.0367	0.0357	0.0405	0.0439	0.0418	0.0449	0.0479	0.0442	0.0434	0.0424	0.0397	0.0373	0.0304	0.0264	0.0242	0.0200	0.0185	0.0154	0.0127	0.0100
2020	0.0313	0.0321	0.0316	0.0307	0.0307	0.0326	0.0338	0.0314	0.0311	0.0310	0.0308	0.0334	0.0292	0.0310	0.0302	0.0270	0.0259	0.0232	0.0192	0.0174

Table 2.6 (page 5 of 6)—Fishery size composition data (units = within-year proportion at age).

Year	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
1977	0.0033	0.0003	0.0023	0.0010	0.0000	0.0000	0.0003	0.0000	0.0013	0.0000	0.0000	0.0010	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1978	0.0023	0.0022	0.0014	0.0013	0.0012	0.0008	0.0004	0.0002	0.0004	0.0003	0.0004	0.0004	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000
1979	0.0013	0.0014	0.0006	0.0008	0.0005	0.0005	0.0003	0.0005	0.0005	0.0003	0.0005	0.0001	0.0001	0.0001	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000
1980	0.0026	0.0024	0.0025	0.0022	0.0023	0.0009	0.0019	0.0012	0.0012	0.0010	0.0003	0.0007	0.0005	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001
1981	0.0005	0.0007	0.0007	0.0005	0.0004	0.0002	0.0005	0.0002	0.0002	0.0000	0.0003	0.0000	0.0000	0.0001	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000
1982	0.0056	0.0032	0.0023	0.0032	0.0022	0.0023	0.0028	0.0013	0.0019	0.0009	0.0015	0.0019	0.0009	0.0009	0.0005	0.0007	0.0001	0.0004	0.0000	0.0004
1983	0.0097	0.0086	0.0077	0.0062	0.0052	0.0037	0.0036	0.0028	0.0024	0.0020	0.0011	0.0009	0.0008	0.0007	0.0006	0.0004	0.0004	0.0003	0.0003	0.0001
1984	0.0137	0.0120	0.0094	0.0089	0.0076	0.0057	0.0050	0.0036	0.0032	0.0023	0.0019	0.0014	0.0009	0.0009	0.0005	0.0004	0.0003	0.0003	0.0002	0.0002
1985	0.0137	0.0127	0.0106	0.0087	0.0079	0.0069	0.0060	0.0045	0.0039	0.0034	0.0029	0.0023	0.0016	0.0013	0.0010	0.0010	0.0006	0.0005	0.0003	0.0003
1986	0.0135	0.0123	0.0106	0.0088	0.0075	0.0061	0.0054	0.0042	0.0034	0.0031	0.0025	0.0022	0.0016	0.0013	0.0010	0.0008	0.0008	0.0006	0.0004	0.0003
1987	0.0118	0.0111	0.0100	0.0092	0.0081	0.0073	0.0069	0.0058	0.0050	0.0046	0.0035	0.0033	0.0022	0.0021	0.0016	0.0014	0.0012	0.0008	0.0008	0.0006
1988	0.0087	0.0084	0.0074	0.0059	0.0053	0.0045	0.0051	0.0038	0.0030	0.0031	0.0023	0.0029	0.0018	0.0013	0.0012	0.0011	0.0010	0.0009	0.0007	0.0005
1989	0.0175	0.0156	0.0135	0.0129	0.0115	0.0096	0.0085	0.0069	0.0054	0.0059	0.0046	0.0044	0.0028	0.0030	0.0027	0.0025	0.0019	0.0019	0.0010	0.0010
1990	0.0176	0.0166	0.0150	0.0132	0.0121	0.0119	0.0093	0.0090	0.0085	0.0080	0.0065	0.0064	0.0052	0.0047	0.0041	0.0034	0.0023	0.0021	0.0018	0.0018
1991	0.0181	0.0162	0.0144	0.0130	0.0119	0.0115	0.0096	0.0082	0.0075	0.0064	0.0057	0.0051	0.0045	0.0041	0.0036	0.0030	0.0022	0.0019	0.0017	0.0014
1992	0.0134	0.0123	0.0112	0.0106	0.0094	0.0087	0.0090	0.0066	0.0065	0.0054	0.0056	0.0052	0.0046	0.0036	0.0028	0.0030	0.0026	0.0021	0.0018	0.0014
1993	0.0071	0.0060	0.0057	0.0051	0.0045	0.0040	0.0040	0.0031	0.0028	0.0026	0.0023	0.0022	0.0018	0.0014	0.0013	0.0011	0.0010	0.0007	0.0009	0.0008
1994	0.0059	0.0053	0.0045	0.0041	0.0039	0.0036	0.0038	0.0026	0.0027	0.0022	0.0021	0.0018	0.0015	0.0015	0.0013	0.0009	0.0012	0.0007	0.0006	0.0005
1995	0.0055	0.0052	0.0043	0.0038	0.0035	0.0033	0.0034	0.0021	0.0022	0.0021	0.0017	0.0015	0.0014	0.0011	0.0011	0.0009	0.0009	0.0007	0.0006	0.0004
1996	0.0087	0.0078	0.0069	0.0063	0.0057	0.0051	0.0049	0.0037	0.0035	0.0031	0.0028	0.0026	0.0022	0.0018	0.0015	0.0014	0.0014	0.0009	0.0008	0.0007
1997	0.0069	0.0062	0.0056	0.0051	0.0046	0.0043	0.0038	0.0032	0.0028	0.0023	0.0020	0.0019	0.0016	0.0014	0.0011	0.0010	0.0009	0.0006	0.0006	0.0005
1998	0.0076	0.0065	0.0056	0.0048	0.0042	0.0037	0.0039	0.0030	0.0027	0.0024	0.0021	0.0020	0.0016	0.0015	0.0013	0.0012	0.0010	0.0007	0.0006	0.0005
1999	0.0081	0.0074	0.0059	0.0052	0.0044	0.0039	0.0039	0.0029	0.0026	0.0023	0.0018	0.0015	0.0014	0.0010	0.0009	0.0009	0.0009	0.0006	0.0006	0.0004
2000	0.0068	0.0064	0.0054	0.0050	0.0045	0.0039	0.0037	0.0028	0.0027	0.0022	0.0021	0.0017	0.0014	0.0012	0.0012	0.0010	0.0010	0.0006	0.0006	0.0004
2001	0.0051	0.0042	0.0039	0.0032	0.0027	0.0026	0.0027	0.0020	0.0017	0.0017	0.0015	0.0014	0.0011	0.0009	0.0007	0.0005	0.0006	0.0006	0.0004	0.0003
2002	0.0039	0.0032	0.0030	0.0026	0.0022	0.0017	0.0019	0.0015	0.0012	0.0010	0.0010	0.0010	0.0007	0.0007	0.0006	0.0004	0.0003	0.0003	0.0003	0.0002
2003	0.0063	0.0056	0.0046	0.0039	0.0035	0.0026	0.0025	0.0021	0.0018	0.0013	0.0010	0.0012	0.0008	0.0007	0.0005	0.0004	0.0004	0.0004	0.0003	0.0002
2004	0.0074	0.0060	0.0060	0.0049	0.0043	0.0040	0.0037	0.0031	0.0026	0.0024	0.0020	0.0019	0.0015	0.0014	0.0009	0.0010	0.0008	0.0008	0.0005	0.0005
2005	0.0087	0.0075	0.0065	0.0059	0.0055	0.0046	0.0046	0.0033	0.0032	0.0026	0.0023	0.0021	0.0018	0.0012	0.0012	0.0008	0.0009	0.0006	0.0005	0.0004
2006	0.0128	0.0105	0.0102	0.0095	0.0080	0.0074	0.0070	0.0053	0.0049	0.0045	0.0039	0.0032	0.0027	0.0022	0.0024	0.0018	0.0016	0.0010	0.0009	0.0007
2007	0.0118	0.0110	0.0097	0.0097	0.0092	0.0081	0.0079	0.0065	0.0055	0.0054	0.0045	0.0043	0.0036	0.0029	0.0027	0.0022	0.0019	0.0017	0.0011	0.0010
2008	0.0075	0.0067	0.0063	0.0060	0.0058	0.0050	0.0057	0.0047	0.0044	0.0037	0.0036	0.0031	0.0025	0.0026	0.0021	0.0018	0.0019	0.0011	0.0011	0.0009
2009	0.0060	0.0041	0.0039	0.0037	0.0035	0.0027	0.0026	0.0023	0.0022	0.0016	0.0018	0.0015	0.0014	0.0012	0.0010	0.0008	0.0008	0.0007	0.0005	0.0004
2010	0.0037	0.0032	0.0028	0.0021	0.0019	0.0014	0.0016	0.0010	0.0009	0.0007	0.0007	0.0005	0.0005	0.0004	0.0003	0.0003	0.0002	0.0003	0.0002	0.0001
2011	0.0034	0.0027	0.0021	0.0022	0.0016	0.0014	0.0013	0.0009	0.0009	0.0006	0.0006	0.0006	0.0004	0.0004	0.0004	0.0003	0.0003	0.0002	0.0002	0.0001
2012	0.0028	0.0020	0.0017	0.0011	0.0011	0.0012	0.0009	0.0006	0.0005	0.0004	0.0005	0.0003	0.0002	0.0004	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001
2013	0.0026	0.0022	0.0016	0.0014	0.0010	0.0009	0.0007	0.0005	0.0005	0.0004	0.0005	0.0003	0.0002	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001	0.0000
2014	0.0039	0.0033	0.0022	0.0020	0.0018	0.0012	0.0011	0.0008	0.0007	0.0006	0.0005	0.0004	0.0003	0.0002	0.0002	0.0003	0.0001	0.0001	0.0001	0.0001
2015	0.0051	0.0040	0.0034	0.0030	0.0023	0.0021	0.0017	0.0011	0.0008	0.0007	0.0007	0.0005	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001
2016	0.0046	0.0035	0.0034	0.0023	0.0022	0.0017	0.0016	0.0012	0.0010	0.0008	0.0007	0.0006	0.0004	0.0004	0.0006	0.0002	0.0002	0.0001	0.0001	0.0001
2017	0.0060	0.0047	0.0037	0.0027	0.0025	0.0022	0.0018	0.0014	0.0009	0.0009	0.0006	0.0006	0.0005	0.0004	0.0003	0.0003	0.0001	0.0001	0.0002	0.0001
2018	0.0066	0.0052	0.0052	0.0040	0.0029	0.0027	0.0024	0.0017	0.0011	0.0009	0.0010	0.0008	0.0011	0.0006	0.0004	0.0003	0.0002	0.0002	0.0001	0.0002
2019	0.0086	0.0067	0.0063	0.0053	0.0038	0.0039	0.0034	0.0022	0.0020	0.0018	0.0014	0.0009	0.0009	0.0008	0.0006	0.0006	0.0005	0.0003	0.0002	0.0001
2020	0.0162	0.0138	0.0128	0.0099	0.0095	0.0071	0.0084	0.0056	0.0048	0.0044	0.0034	0.0027	0.0024	0.0019	0.0020	0.0014	0.0013	0.0013	0.0016	0.0009

Table 2.6 (page 6 of 6)—Fishery size composition data (units = within-year proportion at age).

Year	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120+
1977	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1978	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1979	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1980	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1981	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1982	0.0000	0.0001	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1985	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0002	0.0002	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	0.0004	0.0004	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0004	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0009	0.0007	0.0005	0.0003	0.0002	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
1990	0.0012	0.0009	0.0006	0.0005	0.0004	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.0010	0.0009	0.0006	0.0005	0.0004	0.0002	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	0.0011	0.0010	0.0007	0.0006	0.0003	0.0003	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1993	0.0005	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0005	0.0004	0.0003	0.0002	0.0001	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	0.0004	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	0.0005	0.0004	0.0003	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	0.0004	0.0004	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	0.0005	0.0003	0.0002	0.0002	0.0002	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	0.0003	0.0004	0.0003	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
2000	0.0004	0.0003	0.0002	0.0001	0.0001	0.0002	0.0004	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
2001	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.0002	0.0003	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	0.0006	0.0005	0.0004	0.0003	0.0002	0.0001	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2007	0.0008	0.0006	0.0003	0.0003	0.0003	0.0002	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	0.0007	0.0004	0.0003	0.0003	0.0002	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	0.0004	0.0003	0.0003	0.0001	0.0002	0.0001	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2016	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2017	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2019	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2020	0.0003	0.0002	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003

Table 2.8—Size composition nominal sample sizes (fishery).

Year	Hauls
1977	30
1978	160
1979	235
1980	208
1981	148
1982	187
1983	782
1984	1913
1985	2825
1986	2496
1987	4726
1988	1458
1989	966
1990	3601
1991	5188
1992	5322
1993	2993
1994	4687
1995	5215
1996	6618
1997	7278
1998	6838
1999	9231
2000	9731
2001	10364
2002	11472
2003	14341
2004	12242
2005	11568
2006	8849
2007	6901
2008	8320
2009	7482
2010	6514
2011	8804
2012	9287
2013	11126
2014	12165
2015	11309
2016	9772
2017	8486
2018	6462
2019	4672
2020	2373

Table 2.9—Trawl survey abundance (design-based).

	EBS		NBS		EBS + NBS	
Year	Estimate	Sigma	Estimate	Sigma	Estimate	Sigma
1982	583,781	0.065			583,781	0.065
1983	752,456	0.107			752,456	0.107
1984	651,058	0.072			651,058	0.072
1985	841,108	0.134			841,108	0.134
1986	838,217	0.100			838,217	0.100
1987	697,075	0.064			697,075	0.064
1988	512,095	0.069			512,095	0.069
1989	301,748	0.066			301,748	0.066
1990	438,107	0.084			438,107	0.084
1991	496,765	0.103			496,765	0.103
1992	585,436	0.117			585,436	0.117
1993	814,187	0.121			814,187	0.121
1994	1,255,544	0.121			1,255,544	0.121
1995	761,681	0.099			761,681	0.099
1996	614,493	0.143			614,493	0.143
1997	493,660	0.143			493,660	0.143
1998	522,586	0.090			522,586	0.090
1999	542,229	0.100			542,229	0.100
2000	488,605	0.090			488,605	0.090
2001	974,016	0.094			974,016	0.094
2002	544,602	0.099			544,602	0.099
2003	516,468	0.120			516,468	0.120
2004	404,687	0.085			404,687	0.085
2005	464,647	0.136			464,647	0.136
2006	407,584	0.059			407,584	0.059
2007	753,821	0.256			753,821	0.256
2008	492,643	0.101			492,643	0.101
2009	721,812	0.087			721,812	0.087
2010	896,301	0.130	6,671	0.184	902,972	0.129
2011	844,482	0.094			844,482	0.094
2012	991,342	0.092			991,342	0.092
2013	760,225	0.163			760,225	0.163
2014	1,129,255	0.127			1,129,255	0.127
2015	985,698	0.115			985,698	0.115
2016	660,996	0.093			660,996	0.093
2017	364,129	0.088	137,182	0.123	501,311	0.073
2018	248,542	0.071			492,180	0.097
2019	525,688	0.120	202,148	0.113	727,836	0.092

Table 2.10a—VAST index alternatives (covariate = cold pool, bias correction = true).

	EBS				NBS				EBS+NBS			
Year	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%
1982	629277	0.055	565057	700796	20920	0.336	10824	40431	650197	0.055	583526	724485
1983	768218	0.059	684673	861958	44320	0.370	21475	91469	812539	0.060	722231	914139
1984	689763	0.054	620630	766598	17838	0.490	6825	46623	707602	0.055	635712	787621
1985	885941	0.052	800694	980265	23649	0.494	8972	62335	909591	0.052	820799	1007988
1986	852873	0.053	768456	946564	13787	0.494	5238	36292	866661	0.053	780744	962031
1987	718654	0.052	649131	795624	32866	0.518	11915	90661	751521	0.054	675438	836174
1988	520983	0.052	470083	577395	5886	0.492	2244	15442	526869	0.052	475422	583884
1989	315396	0.053	284319	349869	9715	0.529	3448	27372	325110	0.054	292502	361353
1990	454178	0.055	408127	505426	14554	0.511	5349	39603	468733	0.056	420388	522637
1991	507255	0.061	449842	571994	23851	0.464	9600	59256	531106	0.062	469975	600188
1992	573945	0.067	503759	653909	12968	0.515	4723	35608	586913	0.067	514928	668961
1993	796600	0.064	702602	903173	47914	0.455	19644	116871	844514	0.065	743015	959878
1994	1213283	0.057	1085907	1355600	23881	0.534	8379	68065	1237164	0.057	1107091	1382519
1995	760347	0.056	681955	847749	13743	0.553	4649	40625	774090	0.056	694118	863276
1996	630970	0.060	561168	709455	57785	0.549	19688	169601	688756	0.068	602894	786846
1997	494958	0.055	444745	550841	34300	0.480	13385	87893	529258	0.059	471576	593995
1998	538333	0.062	476886	607697	58687	0.489	22509	153016	597020	0.071	519918	685556
1999	539870	0.063	476940	611104	6563	0.566	2165	19895	546433	0.063	482876	618355
2000	483267	0.053	435531	536235	19424	0.471	7723	48854	502691	0.054	451826	559282
2001	983394	0.056	880600	1098187	30513	0.492	11625	80090	1013907	0.057	907324	1133010
2002	573232	0.061	508476	646234	39060	0.459	15874	96113	612292	0.064	540404	693743
2003	537707	0.066	472429	612005	56580	0.495	21457	149198	594287	0.073	514749	686115
2004	410458	0.056	367746	458132	26038	0.449	10791	62830	436497	0.059	389046	489735
2005	449774	0.055	404067	500651	33326	0.357	16561	67065	483100	0.056	432483	539641
2006	420395	0.054	378385	467069	7224	0.426	3132	16666	427619	0.054	384930	475042
2007	657651	0.066	578233	747977	14582	0.421	6384	33308	672233	0.065	591479	764012
2008	492652	0.060	438059	554049	7249	0.431	3116	16862	499900	0.060	444612	562064
2009	733335	0.053	660606	814072	13448	0.384	6337	28539	746783	0.053	672895	828785
2010	825808	0.058	736508	925935	4895	0.295	2746	8726	830703	0.058	741201	931011
2011	856192	0.057	765925	957098	24642	0.412	10982	55293	880834	0.057	787907	984722
2012	1039589	0.069	908979	1188966	9512	0.454	3911	23138	1049101	0.068	917811	1199172
2013	707204	0.061	627232	797372	22110	0.425	9613	50853	729314	0.061	646749	822420
2014	1134920	0.068	994039	1295767	103002	0.422	45070	235400	1237922	0.071	1077582	1422120
2015	973341	0.062	861814	1099300	98981	0.439	41849	234114	1072322	0.068	938049	1225816
2016	688581	0.058	614524	771562	204914	0.424	89292	470251	893494	0.098	737908	1081886
2017	379541	0.055	340797	422691	139791	0.098	115456	169255	519332	0.048	472454	570861
2018	284098	0.064	250779	321844	254397	0.139	193830	333890	538496	0.073	466983	620960
2019	553266	0.076	477004	641721	220212	0.096	182317	265983	773478	0.061	686109	871973

Table 2.10b—VAST index alternatives (covariate = cold pool, bias correction = false).

	EBS				NBS				EBS+NBS			
Year	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%
1982	575607	0.055	516864	641026	16658	0.336	8619	32195	592265	0.055	531534	659934
1983	700520	0.059	624337	785999	34475	0.370	16704	71150	734995	0.060	653305	826899
1984	631705	0.054	568390	702072	13124	0.490	5021	34301	644829	0.055	579316	717750
1985	813556	0.052	735273	900172	17197	0.494	6524	45327	830752	0.052	749656	920621
1986	783943	0.053	706348	870061	9972	0.494	3788	26249	793914	0.053	715210	881280
1987	658405	0.052	594711	728922	23715	0.518	8597	65417	682121	0.054	613064	758956
1988	480542	0.052	433593	532575	4332	0.492	1651	11366	484874	0.052	437527	537345
1989	290470	0.053	261850	322219	7005	0.529	2486	19737	297475	0.054	267639	330637
1990	418959	0.055	376479	466232	10559	0.511	3880	28731	429518	0.056	385217	478912
1991	467199	0.061	414320	526827	17645	0.464	7102	43836	484843	0.062	429037	547908
1992	525079	0.067	460868	598235	9195	0.515	3349	25246	534273	0.067	468745	608963
1993	733865	0.064	647270	832045	35354	0.455	14494	86235	769219	0.065	676770	874297
1994	1120257	0.057	1002647	1251661	16736	0.534	5872	47702	1136993	0.057	1017452	1270579
1995	699202	0.056	627114	779576	9526	0.553	3223	28159	708728	0.056	635509	790383
1996	581428	0.060	517107	653751	40515	0.549	13804	118911	621943	0.068	544410	710518
1997	454588	0.055	408470	505913	24777	0.480	9669	63490	479365	0.059	427121	538000
1998	494383	0.062	437952	558085	42341	0.489	16239	110396	536724	0.071	467409	616318
1999	496965	0.063	439036	562538	4386	0.566	1447	13296	501351	0.063	443038	567340
2000	447034	0.053	402877	496031	14129	0.471	5618	35536	461163	0.054	414500	513079
2001	909224	0.056	814183	1015359	22061	0.492	8405	57907	931286	0.057	833388	1040683
2002	528648	0.061	468928	595972	28468	0.459	11569	70051	557116	0.064	491706	631227
2003	492657	0.066	432848	560731	40213	0.495	15250	106038	532870	0.073	461552	615208
2004	378975	0.056	339539	422992	19074	0.449	7905	46026	398050	0.059	354778	446598
2005	415151	0.055	372962	462112	25602	0.357	12722	51520	440753	0.056	394573	492337
2006	390057	0.054	351079	433362	5340	0.426	2315	12318	395396	0.054	355924	439246
2007	606524	0.066	533279	689828	10795	0.421	4726	24659	617319	0.065	543162	701600
2008	456288	0.060	405725	513153	5310	0.431	2282	12352	461598	0.060	410545	518998
2009	676493	0.053	609401	750971	10197	0.384	4805	21640	686690	0.053	618748	762093
2010	767365	0.058	684385	860406	3944	0.295	2213	7031	771309	0.058	688207	864446
2011	791045	0.057	707646	884272	18847	0.412	8399	42291	809892	0.057	724449	905413
2012	948000	0.069	828897	1084217	6741	0.454	2771	16397	954741	0.068	835260	1091313
2013	648512	0.061	575178	731198	16306	0.425	7090	37504	664818	0.061	589555	749690
2014	1036673	0.068	907988	1183596	75720	0.422	33132	173049	1112393	0.071	968312	1277913
2015	895876	0.062	793226	1011811	72397	0.439	30609	171235	968273	0.068	847029	1106873
2016	631351	0.058	563449	707435	151365	0.424	65958	347363	782716	0.098	646419	947750
2017	347494	0.055	312021	386999	125515	0.098	103666	151970	473009	0.048	430312	519941
2018	258827	0.064	228472	293215	214565	0.139	163481	281612	473392	0.073	410526	545887
2019	501794	0.076	432626	582019	197095	0.096	163178	238061	698889	0.061	619945	787885

Table 2.10c—VAST index alternatives (covariate = none, bias correction = true).

	EBS				NBS				EBS+NBS			
Year	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%
1982	634948	0.056	569443	707989	23304	0.357	11567	46952	658253	0.056	589801	734649
1983	777887	0.060	691494	875074	41619	0.393	19276	89857	819506	0.061	726963	923830
1984	694380	0.054	624181	772474	19883	0.543	6861	57619	714263	0.056	640618	796375
1985	887202	0.052	801439	982142	28124	0.552	9541	82900	915326	0.053	824612	1016020
1986	851553	0.053	766896	945555	20966	0.554	7076	62120	872519	0.054	784857	969972
1987	717952	0.052	648728	794563	20482	0.510	7540	55644	738434	0.053	666162	818547
1988	522399	0.053	471052	579342	6526	0.527	2321	18348	528925	0.053	476939	586577
1989	318264	0.053	286651	353362	6030	0.532	2127	17099	324294	0.054	291944	360229
1990	456772	0.055	410065	508799	14826	0.552	5026	43738	471599	0.056	422442	526476
1991	511935	0.062	453481	577922	25302	0.500	9502	67374	537236	0.063	474498	608270
1992	585609	0.070	510729	671468	20057	0.566	6616	60802	605666	0.071	527325	695645
1993	800098	0.065	704869	908193	42765	0.477	16792	108911	842864	0.066	741197	958476
1994	1214787	0.057	1086135	1358677	40180	0.597	12476	129398	1254966	0.058	1119831	1406409
1995	759884	0.056	681399	847409	26359	0.608	8002	86823	786243	0.057	703140	879167
1996	627231	0.059	558810	704030	40238	0.557	13500	119934	667470	0.063	590011	755098
1997	497269	0.055	446272	554093	38822	0.525	13883	108560	536091	0.061	475318	604634
1998	529489	0.059	471881	594129	43264	0.502	16172	115744	572753	0.064	504981	649620
1999	521616	0.061	462906	587773	20455	0.599	6319	66218	542072	0.062	479648	612619
2000	485494	0.053	437206	539116	23670	0.532	8340	67178	509164	0.056	456179	568304
2001	992387	0.057	887239	1109997	32604	0.543	11252	94477	1024991	0.058	915336	1147783
2002	573851	0.061	509475	646360	31259	0.459	12706	76901	605109	0.062	535799	683385
2003	529994	0.063	468573	599466	35462	0.459	14426	87175	565457	0.065	497619	642542
2004	410878	0.056	368208	458493	20715	0.446	8637	49686	431593	0.057	385709	482935
2005	449349	0.054	404102	499663	27078	0.342	13862	52891	476427	0.055	427818	530558
2006	420263	0.054	378099	467129	8700	0.472	3450	21934	428963	0.054	385881	476854
2007	662775	0.067	581008	756049	22651	0.475	8936	57413	685425	0.067	600979	781738
2008	493190	0.061	437669	555754	12517	0.476	4923	31825	505707	0.061	448644	570028
2009	727717	0.053	655702	807642	20652	0.410	9247	46123	748369	0.053	674033	830902
2010	832482	0.059	741881	934149	5012	0.301	2779	9042	837495	0.059	746696	939335
2011	865608	0.058	772241	970262	17908	0.439	7569	42367	883515	0.058	788428	990071
2012	1028498	0.069	898513	1177287	19718	0.486	7613	51067	1048215	0.069	916385	1199011
2013	708041	0.062	626986	799574	29536	0.473	11695	74593	737577	0.063	652221	834104
2014	1147562	0.069	1002576	1313515	82113	0.444	34424	195867	1229676	0.070	1071044	1411802
2015	983422	0.063	869474	1112303	79148	0.465	31804	196969	1062570	0.067	932024	1211401
2016	683877	0.057	611633	764655	143736	0.446	59925	344766	827613	0.083	703106	974167
2017	379303	0.056	340156	422954	144023	0.099	118668	174796	523326	0.049	475513	575946
2018	278400	0.059	247861	312702	240266	0.136	183944	313834	518667	0.070	452331	594731
2019	556261	0.077	478703	646385	217015	0.096	179889	261804	773277	0.062	685195	872682

Table 2.10d—VAST index alternatives (covariate = none, bias correction = false).

	EBS				NBS				EBS+NBS			
Year	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%	Est.	σ	L95%	U95%
1982	578694	0.056	518993	645263	18366	0.357	9116	37002	597060	0.056	534972	666354
1983	706822	0.060	628322	795130	31836	0.393	14746	68736	738659	0.061	655246	832691
1984	633828	0.054	569750	705112	14171	0.543	4890	41065	647999	0.056	581185	722493
1985	812602	0.052	734051	899559	19763	0.552	6705	58252	832365	0.053	749873	923932
1986	781366	0.053	703687	867620	14756	0.554	4980	43720	796122	0.054	716136	885042
1987	657122	0.052	593763	727242	14685	0.510	5406	39894	671807	0.053	606056	744692
1988	480749	0.053	433496	533153	4688	0.527	1667	13180	485437	0.053	437726	538349
1989	292625	0.053	263559	324896	4290	0.532	1513	12165	296915	0.054	267296	329816
1990	420250	0.055	377278	468117	10405	0.552	3527	30696	430655	0.056	385766	480768
1991	470180	0.062	416494	530786	18206	0.500	6837	48480	488386	0.063	431353	552961
1992	533858	0.070	465595	612129	13847	0.566	4568	41977	547705	0.071	476861	629074
1993	735788	0.065	648213	835195	30981	0.477	12165	78899	766769	0.066	674280	871944
1994	1120402	0.057	1001746	1253113	27457	0.597	8526	88424	1147859	0.058	1024258	1286377
1995	698068	0.056	625968	778473	17904	0.608	5436	58974	715973	0.057	640297	800592
1996	577621	0.059	514612	648345	27842	0.557	9341	82987	605463	0.063	535200	684951
1997	455510	0.055	408796	507562	27025	0.525	9665	75573	482535	0.061	427834	544231
1998	486402	0.059	433482	545782	30756	0.502	11496	82280	517158	0.064	455964	586563
1999	482265	0.061	427984	543430	14135	0.599	4366	45758	496400	0.062	439236	561004
2000	448235	0.053	403653	497741	16559	0.532	5835	46996	464794	0.056	416426	518780
2001	915390	0.057	818400	1023875	22703	0.543	7835	65787	938093	0.058	837735	1050475
2002	528427	0.061	469148	595197	22550	0.459	9166	55476	550977	0.062	487867	622250
2003	485686	0.063	429400	549350	25642	0.459	10431	63035	511329	0.065	449985	581035
2004	378814	0.056	339474	422714	15052	0.446	6276	36103	393867	0.057	351994	440721
2005	414298	0.054	372580	460687	20911	0.342	10705	40846	435209	0.055	390806	484657
2006	389356	0.054	350293	432775	6272	0.472	2488	15815	395629	0.054	355895	439798
2007	610130	0.067	534858	695995	16537	0.475	6524	41917	626667	0.067	549460	714724
2008	456558	0.061	405161	514474	9200	0.476	3619	23392	465758	0.061	413202	524998
2009	671113	0.053	604700	744821	15746	0.410	7050	35166	686859	0.053	618633	762609
2010	772285	0.059	688234	866599	4086	0.301	2265	7372	776371	0.059	692199	870778
2011	798511	0.058	712382	895054	13470	0.439	5693	31868	811981	0.058	724592	909909
2012	939610	0.069	820859	1075540	14276	0.486	5512	36974	953886	0.069	833919	1091111
2013	648148	0.062	573950	731938	21226	0.473	8405	53606	669374	0.063	591911	756975
2014	1045784	0.069	913657	1197018	59069	0.444	24763	140898	1104852	0.070	962323	1268491
2015	902975	0.063	798349	1021314	56501	0.465	22704	140608	959476	0.067	841596	1093868
2016	626277	0.057	560117	700251	104771	0.446	43680	251304	731048	0.083	621068	860502
2017	346504	0.056	310743	386381	129047	0.099	106328	156620	475551	0.049	432103	523368
2018	254255	0.059	226364	285582	204927	0.136	156889	267674	459182	0.070	400454	526522
2019	504445	0.077	434111	586173	194839	0.096	161507	235051	699284	0.062	619630	789177

Table 2.11a (page 1 of 6)—Size composition data (EBS survey, units = proportions).

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0007	0.0009	0.0018	0.0025	0.0049	0.0056	0.0103	0.0063	0.0048	0.0049	0.0044	0.0018	0.0008	0.0008
1983	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0073	0.0221	0.0346	0.0348	0.0368	0.0351	0.0330	0.0300	0.0192	0.0190	0.0091	0.0056	0.0034	0.0022
1984	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0020	0.0030	0.0045	0.0036	0.0022	0.0021	0.0021	0.0025	0.0038	0.0026	0.0053	0.0059	0.0074	0.0103
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0033	0.0060	0.0106	0.0086	0.0128	0.0170	0.0180	0.0220	0.0298	0.0300	0.0312	0.0383	0.0331	0.0329
1986	0.0000	0.0000	0.0000	0.0000	0.0000	0.0015	0.0025	0.0061	0.0087	0.0085	0.0131	0.0114	0.0115	0.0097	0.0060	0.0022	0.0017	0.0013	0.0014	0.0047
1987	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012	0.0003	0.0007	0.0022	0.0035	0.0056	0.0074	0.0099	0.0111	0.0110	0.0141	0.0113	0.0074	0.0056
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0008	0.0007	0.0028	0.0013	0.0029	0.0026	0.0023	0.0042	0.0028	0.0019	0.0027	0.0034	0.0047
1989	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0003	0.0018	0.0046	0.0036	0.0067	0.0083	0.0105	0.0102	0.0098	0.0064	0.0038	0.0019	0.0021	0.0029
1990	0.0000	0.0000	0.0000	0.0000	0.0000	0.0044	0.0123	0.0179	0.0264	0.0258	0.0318	0.0405	0.0446	0.0355	0.0258	0.0203	0.0155	0.0098	0.0061	0.0072
1991	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0042	0.0128	0.0153	0.0191	0.0186	0.0223	0.0181	0.0186	0.0176	0.0147	0.0184	0.0118	0.0099	0.0099
1992	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0017	0.0083	0.0189	0.0196	0.0180	0.0155	0.0204	0.0229	0.0242	0.0256	0.0222	0.0234	0.0117
1993	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0028	0.0077	0.0182	0.0406	0.0281	0.0386	0.0339	0.0307	0.0305	0.0331	0.0298	0.0307	0.0206	0.0129
1994	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0007	0.0004	0.0019	0.0029	0.0054	0.0064	0.0070	0.0071	0.0083	0.0097	0.0079	0.0074	0.0068	0.0100
1995	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0013	0.0016	0.0014	0.0021	0.0045	0.0040	0.0045	0.0060	0.0064	0.0087	0.0074	0.0037	0.0026	0.0020
1996	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0012	0.0010	0.0024	0.0035	0.0051	0.0068	0.0057	0.0071	0.0073	0.0068	0.0057	0.0038	0.0022
1997	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009	0.0019	0.0070	0.0123	0.0179	0.0207	0.0206	0.0213	0.0228	0.0307	0.0243	0.0234	0.0242	0.0191	0.0113
1998	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004	0.0024	0.0055	0.0086	0.0120	0.0107	0.0140	0.0094	0.0047	0.0023	0.0007	0.0004	0.0020	0.0025
1999	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0012	0.0041	0.0077	0.0084	0.0094	0.0072	0.0087	0.0060	0.0032	0.0023	0.0034	0.0040	0.0034	0.0050
2000	0.0000	0.0000	0.0000	0.0003	0.0008	0.0018	0.0040	0.0078	0.0108	0.0235	0.0378	0.0459	0.0349	0.0219	0.0216	0.0113	0.0069	0.0026	0.0007	0.0010
2001	0.0000	0.0000	0.0000	0.0000	0.0002	0.0003	0.0013	0.0031	0.0064	0.0102	0.0156	0.0225	0.0330	0.0355	0.0383	0.0340	0.0332	0.0221	0.0177	0.0111
2002	0.0000	0.0000	0.0000	0.0000	0.0001	0.0002	0.0005	0.0018	0.0035	0.0051	0.0064	0.0084	0.0128	0.0090	0.0133	0.0089	0.0057	0.0041	0.0028	0.0014
2003	0.0000	0.0000	0.0001	0.0000	0.0001	0.0002	0.0004	0.0009	0.0044	0.0073	0.0108	0.0160	0.0182	0.0162	0.0196	0.0199	0.0222	0.0198	0.0188	0.0156
2004	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0003	0.0018	0.0042	0.0078	0.0139	0.0097	0.0178	0.0172	0.0196	0.0192	0.0123	0.0131	0.0101	0.0061
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0003	0.0019	0.0038	0.0075	0.0119	0.0173	0.0213	0.0261	0.0245	0.0260	0.0249	0.0313	0.0312
2006	0.0000	0.0001	0.0000	0.0003	0.0006	0.0032	0.0080	0.0268	0.0323	0.0341	0.0363	0.0321	0.0275	0.0263	0.0287	0.0225	0.0195	0.0117	0.0085	0.0052
2007	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006	0.0098	0.0365	0.0883	0.1086	0.1067	0.0872	0.0562	0.0551	0.0406	0.0265	0.0318	0.0182	0.0095	0.0095
2008	0.0000	0.0000	0.0001	0.0000	0.0000	0.0004	0.0040	0.0126	0.0261	0.0283	0.0291	0.0262	0.0232	0.0169	0.0112	0.0056	0.0030	0.0016	0.0030	0.0056
2009	0.0000	0.0000	0.0000	0.0004	0.0021	0.0063	0.0239	0.0578	0.0630	0.0648	0.0523	0.0444	0.0388	0.0290	0.0277	0.0193	0.0132	0.0069	0.0021	0.0017
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0006	0.0023	0.0031	0.0038	0.0066	0.0065	0.0074	0.0061	0.0040	0.0020	0.0022	0.0012	0.0018	0.0041
2011	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0009	0.0036	0.0068	0.0123	0.0147	0.0185	0.0198	0.0285	0.0301	0.0434	0.0425	0.0410	0.0257	0.0138
2012	0.0000	0.0000	0.0004	0.0000	0.0000	0.0056	0.0289	0.0523	0.0558	0.0429	0.0323	0.0318	0.0237	0.0312	0.0302	0.0159	0.0098	0.0036	0.0024	0.0008
2013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0026	0.0061	0.0077	0.0109	0.0117	0.0150	0.0129	0.0095	0.0067	0.0019	0.0011	0.0034	0.0045	0.0141
2014	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0005	0.0050	0.0065	0.0132	0.0189	0.0258	0.0288	0.0364	0.0276	0.0337	0.0272	0.0289	0.0171	0.0121
2015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006	0.0022	0.0022	0.0044	0.0040	0.0027	0.0024	0.0029	0.0030	0.0031	0.0038	0.0044	0.0036	0.0040
2016	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0009	0.0015	0.0031	0.0034	0.0023	0.0013	0.0029	0.0037	0.0056	0.0086	0.0129	0.0156	0.0147
2017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0011	0.0030	0.0039	0.0039	0.0052	0.0048	0.0059	0.0072	0.0082	0.0106	0.0113	0.0133
2018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003	0.0005	0.0006	0.0021	0.0022	0.0042	0.0038	0.0060	0.0051	0.0062	0.0107	0.0115
2019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010	0.0026	0.0056	0.0100	0.0245	0.0337	0.0490	0.0408	0.0466	0.0546	0.0627	0.0624	0.0595

Table 2.11a (page 2 of 6)—Size composition data (EBS survey, units = proportions).

Year	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
1982	0.0002	0.0008	0.0017	0.0024	0.0038	0.0064	0.0082	0.0117	0.0183	0.0209	0.0227	0.0289	0.0300	0.0225	0.0186	0.0137	0.0138	0.0119	0.0130	0.0171
1983	0.0007	0.0004	0.0014	0.0026	0.0035	0.0042	0.0076	0.0095	0.0111	0.0132	0.0126	0.0162	0.0111	0.0097	0.0082	0.0046	0.0047	0.0066	0.0072	0.0108
1984	0.0190	0.0257	0.0312	0.0379	0.0473	0.0494	0.0533	0.0469	0.0393	0.0324	0.0284	0.0243	0.0181	0.0127	0.0088	0.0084	0.0072	0.0048	0.0077	0.0062
1985	0.0190	0.0126	0.0077	0.0054	0.0059	0.0063	0.0094	0.0130	0.0128	0.0161	0.0178	0.0183	0.0185	0.0170	0.0203	0.0208	0.0230	0.0245	0.0305	0.0296
1986	0.0074	0.0142	0.0234	0.0292	0.0453	0.0409	0.0401	0.0415	0.0425	0.0377	0.0362	0.0291	0.0261	0.0227	0.0216	0.0143	0.0126	0.0090	0.0082	0.0089
1987	0.0043	0.0059	0.0071	0.0111	0.0114	0.0184	0.0254	0.0280	0.0301	0.0270	0.0263	0.0193	0.0217	0.0187	0.0164	0.0183	0.0217	0.0209	0.0279	0.0316
1988	0.0070	0.0078	0.0088	0.0086	0.0110	0.0083	0.0126	0.0121	0.0136	0.0178	0.0189	0.0267	0.0214	0.0194	0.0209	0.0140	0.0182	0.0166	0.0240	0.0222
1989	0.0003	0.0015	0.0015	0.0034	0.0013	0.0033	0.0029	0.0027	0.0032	0.0036	0.0070	0.0032	0.0105	0.0110	0.0145	0.0114	0.0125	0.0098	0.0115	0.0113
1990	0.0076	0.0060	0.0086	0.0135	0.0136	0.0171	0.0182	0.0172	0.0161	0.0205	0.0214	0.0138	0.0197	0.0165	0.0116	0.0099	0.0116	0.0089	0.0080	0.0070
1991	0.0110	0.0138	0.0140	0.0236	0.0270	0.0374	0.0399	0.0446	0.0397	0.0510	0.0422	0.0343	0.0357	0.0268	0.0237	0.0195	0.0163	0.0117	0.0095	0.0087
1992	0.0123	0.0140	0.0192	0.0277	0.0299	0.0315	0.0364	0.0385	0.0363	0.0323	0.0314	0.0254	0.0230	0.0187	0.0157	0.0132	0.0192	0.0151	0.0223	0.0195
1993	0.0094	0.0059	0.0054	0.0064	0.0084	0.0090	0.0166	0.0198	0.0225	0.0278	0.0303	0.0230	0.0235	0.0217	0.0188	0.0146	0.0154	0.0178	0.0176	0.0212
1994	0.0092	0.0136	0.0122	0.0160	0.0237	0.0315	0.0403	0.0462	0.0523	0.0545	0.0479	0.0455	0.0334	0.0257	0.0206	0.0140	0.0084	0.0094	0.0083	0.0157
1995	0.0040	0.0051	0.0096	0.0118	0.0171	0.0211	0.0248	0.0236	0.0266	0.0245	0.0216	0.0169	0.0235	0.0269	0.0260	0.0345	0.0409	0.0405	0.0451	0.0457
1996	0.0024	0.0025	0.0062	0.0068	0.0138	0.0173	0.0206	0.0243	0.0291	0.0251	0.0265	0.0203	0.0212	0.0178	0.0167	0.0177	0.0164	0.0188	0.0227	0.0253
1997	0.0062	0.0044	0.0044	0.0038	0.0076	0.0118	0.0111	0.0165	0.0241	0.0248	0.0238	0.0189	0.0170	0.0167	0.0148	0.0157	0.0147	0.0137	0.0137	0.0149
1998	0.0061	0.0075	0.0193	0.0288	0.0398	0.0511	0.0622	0.0647	0.0635	0.0529	0.0554	0.0358	0.0269	0.0235	0.0171	0.0151	0.0139	0.0105	0.0131	0.0123
1999	0.0092	0.0096	0.0165	0.0181	0.0177	0.0246	0.0217	0.0231	0.0242	0.0191	0.0185	0.0178	0.0187	0.0242	0.0315	0.0292	0.0373	0.0422	0.0474	0.0513
2000	0.0019	0.0031	0.0062	0.0094	0.0135	0.0156	0.0176	0.0206	0.0242	0.0178	0.0157	0.0148	0.0152	0.0139	0.0159	0.0178	0.0204	0.0211	0.0241	0.0246
2001	0.0071	0.0059	0.0083	0.0116	0.0161	0.0188	0.0258	0.0331	0.0419	0.0416	0.0462	0.0405	0.0351	0.0258	0.0209	0.0152	0.0111	0.0096	0.0089	0.0077
2002	0.0035	0.0053	0.0087	0.0131	0.0197	0.0219	0.0351	0.0384	0.0448	0.0446	0.0421	0.0309	0.0322	0.0252	0.0238	0.0202	0.0236	0.0211	0.0335	0.0294
2003	0.0171	0.0121	0.0094	0.0054	0.0046	0.0047	0.0063	0.0046	0.0093	0.0113	0.0247	0.0169	0.0251	0.0191	0.0216	0.0231	0.0254	0.0287	0.0278	0.0312
2004	0.0052	0.0068	0.0085	0.0099	0.0172	0.0182	0.0202	0.0219	0.0253	0.0275	0.0290	0.0283	0.0308	0.0286	0.0298	0.0232	0.0225	0.0195	0.0191	0.0172
2005	0.0336	0.0325	0.0249	0.0181	0.0121	0.0121	0.0126	0.0102	0.0139	0.0156	0.0173	0.0170	0.0180	0.0200	0.0250	0.0220	0.0183	0.0177	0.0184	0.0185
2006	0.0044	0.0048	0.0045	0.0051	0.0072	0.0094	0.0138	0.0156	0.0199	0.0202	0.0214	0.0207	0.0252	0.0217	0.0244	0.0214	0.0200	0.0175	0.0165	0.0136
2007	0.0033	0.0037	0.0053	0.0071	0.0097	0.0094	0.0121	0.0095	0.0107	0.0113	0.0095	0.0088	0.0072	0.0072	0.0058	0.0048	0.0058	0.0061	0.0063	0.0053
2008	0.0125	0.0233	0.0363	0.0416	0.0539	0.0570	0.0555	0.0522	0.0429	0.0360	0.0263	0.0218	0.0151	0.0129	0.0118	0.0106	0.0101	0.0092	0.0112	0.0101
2009	0.0021	0.0049	0.0056	0.0104	0.0152	0.0202	0.0237	0.0280	0.0261	0.0203	0.0183	0.0132	0.0128	0.0128	0.0135	0.0180	0.0183	0.0217	0.0227	0.0227
2010	0.0079	0.0166	0.0255	0.0317	0.0467	0.0565	0.0554	0.0518	0.0520	0.0427	0.0358	0.0245	0.0222	0.0142	0.0127	0.0088	0.0099	0.0103	0.0163	0.0174
2011	0.0053	0.0019	0.0018	0.0027	0.0023	0.0028	0.0036	0.0058	0.0066	0.0091	0.0079	0.0112	0.0109	0.0131	0.0138	0.0194	0.0219	0.0324	0.0383	0.0413
2012	0.0022	0.0029	0.0045	0.0065	0.0136	0.0197	0.0205	0.0273	0.0270	0.0297	0.0216	0.0236	0.0145	0.0120	0.0076	0.0062	0.0048	0.0035	0.0049	0.0045
2013	0.0211	0.0345	0.0415	0.0519	0.0569	0.0444	0.0481	0.0344	0.0348	0.0220	0.0164	0.0127	0.0095	0.0092	0.0077	0.0066	0.0098	0.0081	0.0124	0.0158
2014	0.0062	0.0057	0.0051	0.0040	0.0053	0.0123	0.0137	0.0233	0.0184	0.0268	0.0256	0.0277	0.0194	0.0173	0.0102	0.0106	0.0081	0.0113	0.0158	0.0247
2015	0.0039	0.0040	0.0042	0.0063	0.0093	0.0145	0.0199	0.0271	0.0373	0.0468	0.0545	0.0575	0.0509	0.0485	0.0395	0.0298	0.0257	0.0148	0.0138	0.0104
2016	0.0129	0.0087	0.0062	0.0033	0.0021	0.0023	0.0039	0.0050	0.0060	0.0076	0.0103	0.0094	0.0131	0.0143	0.0170	0.0164	0.0191	0.0223	0.0268	0.0339
2017	0.0149	0.0153	0.0140	0.0115	0.0082	0.0083	0.0077	0.0101	0.0077	0.0095	0.0097	0.0106	0.0109	0.0134	0.0124	0.0131	0.0141	0.0156	0.0139	0.0163
2018	0.0146	0.0114	0.0093	0.0047	0.0047	0.0050	0.0046	0.0050	0.0086	0.0103	0.0123	0.0168	0.0188	0.0209	0.0202	0.0259	0.0245	0.0246	0.0253	0.0263
2019	0.0630	0.0578	0.0470	0.0375	0.0239	0.0073	0.0039	0.0015	0.0010	0.0010	0.0010	0.0010	0.0018	0.0020	0.0031	0.0036	0.0051	0.0055	0.0057	0.0081

Table 2.11a (page 3 of 6)—Size composition data (EBS survey, units = proportions).

Year	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
1982	0.0192	0.0267	0.0287	0.0258	0.0311	0.0311	0.0266	0.0270	0.0256	0.0241	0.0226	0.0264	0.0245	0.0253	0.0213	0.0247	0.0250	0.0248	0.0213	0.0215
1983	0.0119	0.0161	0.0205	0.0229	0.0219	0.0227	0.0240	0.0193	0.0189	0.0187	0.0171	0.0227	0.0210	0.0196	0.0199	0.0187	0.0199	0.0187	0.0153	0.0170
1984	0.0075	0.0077	0.0079	0.0089	0.0110	0.0087	0.0090	0.0078	0.0090	0.0117	0.0106	0.0129	0.0137	0.0162	0.0163	0.0127	0.0177	0.0139	0.0164	0.0167
1985	0.0304	0.0286	0.0278	0.0213	0.0191	0.0144	0.0114	0.0099	0.0076	0.0057	0.0055	0.0061	0.0060	0.0062	0.0050	0.0051	0.0054	0.0050	0.0088	0.0065
1986	0.0106	0.0120	0.0140	0.0133	0.0160	0.0141	0.0161	0.0175	0.0168	0.0179	0.0187	0.0195	0.0147	0.0164	0.0163	0.0114	0.0111	0.0078	0.0095	0.0072
1987	0.0316	0.0314	0.0308	0.0302	0.0246	0.0247	0.0250	0.0149	0.0152	0.0126	0.0111	0.0140	0.0130	0.0091	0.0119	0.0085	0.0131	0.0127	0.0117	0.0120
1988	0.0196	0.0317	0.0275	0.0294	0.0275	0.0245	0.0307	0.0265	0.0228	0.0252	0.0253	0.0258	0.0223	0.0213	0.0228	0.0192	0.0198	0.0167	0.0206	0.0165
1989	0.0135	0.0179	0.0163	0.0174	0.0186	0.0170	0.0199	0.0251	0.0228	0.0256	0.0243	0.0232	0.0329	0.0290	0.0215	0.0234	0.0211	0.0292	0.0187	0.0221
1990	0.0066	0.0058	0.0064	0.0090	0.0069	0.0072	0.0053	0.0092	0.0060	0.0110	0.0100	0.0126	0.0107	0.0129	0.0130	0.0139	0.0149	0.0157	0.0160	0.0144
1991	0.0083	0.0071	0.0085	0.0072	0.0086	0.0103	0.0067	0.0084	0.0058	0.0101	0.0122	0.0080	0.0104	0.0057	0.0050	0.0058	0.0058	0.0048	0.0071	0.0067
1992	0.0228	0.0253	0.0193	0.0191	0.0167	0.0147	0.0158	0.0123	0.0110	0.0091	0.0081	0.0059	0.0065	0.0032	0.0044	0.0052	0.0053	0.0069	0.0046	0.0036
1993	0.0213	0.0224	0.0260	0.0198	0.0178	0.0185	0.0152	0.0145	0.0124	0.0110	0.0114	0.0104	0.0084	0.0061	0.0064	0.0076	0.0063	0.0054	0.0056	0.0051
1994	0.0134	0.0118	0.0165	0.0181	0.0188	0.0213	0.0123	0.0134	0.0163	0.0135	0.0128	0.0125	0.0155	0.0179	0.0178	0.0116	0.0155	0.0110	0.0144	0.0116
1995	0.0427	0.0370	0.0363	0.0319	0.0215	0.0205	0.0166	0.0154	0.0125	0.0107	0.0118	0.0103	0.0095	0.0100	0.0093	0.0079	0.0101	0.0107	0.0114	0.0109
1996	0.0306	0.0276	0.0311	0.0342	0.0321	0.0316	0.0345	0.0289	0.0301	0.0301	0.0263	0.0274	0.0220	0.0180	0.0166	0.0144	0.0153	0.0109	0.0101	0.0093
1997	0.0147	0.0183	0.0211	0.0249	0.0163	0.0185	0.0146	0.0165	0.0195	0.0202	0.0178	0.0183	0.0134	0.0232	0.0185	0.0189	0.0143	0.0142	0.0116	0.0122
1998	0.0142	0.0134	0.0184	0.0124	0.0120	0.0143	0.0118	0.0097	0.0094	0.0088	0.0086	0.0077	0.0067	0.0083	0.0096	0.0079	0.0070	0.0081	0.0092	0.0090
1999	0.0511	0.0429	0.0327	0.0335	0.0256	0.0191	0.0164	0.0144	0.0129	0.0115	0.0097	0.0101	0.0078	0.0083	0.0080	0.0074	0.0057	0.0095	0.0071	0.0081
2000	0.0277	0.0245	0.0290	0.0260	0.0315	0.0275	0.0282	0.0209	0.0251	0.0191	0.0205	0.0155	0.0161	0.0145	0.0129	0.0126	0.0117	0.0088	0.0080	0.0072
2001	0.0081	0.0095	0.0117	0.0143	0.0116	0.0135	0.0130	0.0119	0.0135	0.0139	0.0133	0.0120	0.0113	0.0118	0.0097	0.0108	0.0095	0.0077	0.0101	0.0067
2002	0.0369	0.0323	0.0321	0.0226	0.0269	0.0155	0.0189	0.0151	0.0137	0.0112	0.0134	0.0105	0.0130	0.0074	0.0095	0.0098	0.0105	0.0087	0.0094	0.0088
2003	0.0371	0.0346	0.0372	0.0342	0.0317	0.0233	0.0232	0.0195	0.0208	0.0219	0.0170	0.0157	0.0145	0.0123	0.0106	0.0120	0.0115	0.0094	0.0081	0.0060
2004	0.0167	0.0144	0.0139	0.0139	0.0161	0.0157	0.0189	0.0184	0.0148	0.0168	0.0161	0.0174	0.0157	0.0178	0.0135	0.0145	0.0158	0.0139	0.0132	0.0127
2005	0.0193	0.0150	0.0191	0.0154	0.0173	0.0119	0.0152	0.0112	0.0131	0.0117	0.0122	0.0101	0.0098	0.0090	0.0090	0.0090	0.0105	0.0076	0.0108	0.0077
2006	0.0141	0.0122	0.0126	0.0114	0.0137	0.0128	0.0167	0.0145	0.0148	0.0133	0.0153	0.0114	0.0149	0.0089	0.0105	0.0075	0.0082	0.0085	0.0080	0.0089
2007	0.0068	0.0063	0.0068	0.0066	0.0064	0.0048	0.0062	0.0058	0.0070	0.0055	0.0056	0.0048	0.0049	0.0043	0.0044	0.0043	0.0052	0.0043	0.0050	0.0041
2008	0.0110	0.0105	0.0106	0.0088	0.0104	0.0095	0.0096	0.0098	0.0112	0.0089	0.0085	0.0077	0.0088	0.0067	0.0092	0.0078	0.0090	0.0069	0.0066	0.0062
2009	0.0208	0.0201	0.0167	0.0174	0.0148	0.0108	0.0088	0.0088	0.0070	0.0062	0.0056	0.0051	0.0045	0.0047	0.0052	0.0054	0.0043	0.0051	0.0047	0.0032
2010	0.0305	0.0202	0.0220	0.0209	0.0208	0.0162	0.0179	0.0140	0.0195	0.0150	0.0204	0.0199	0.0184	0.0125	0.0185	0.0148	0.0133	0.0097	0.0119	0.0077
2011	0.0443	0.0420	0.0379	0.0305	0.0246	0.0169	0.0170	0.0135	0.0127	0.0091	0.0112	0.0108	0.0128	0.0089	0.0134	0.0116	0.0145	0.0111	0.0142	0.0091
2012	0.0065	0.0062	0.0101	0.0085	0.0150	0.0143	0.0183	0.0218	0.0290	0.0246	0.0312	0.0236	0.0242	0.0168	0.0152	0.0128	0.0126	0.0074	0.0093	0.0066
2013	0.0194	0.0232	0.0281	0.0219	0.0208	0.0195	0.0176	0.0143	0.0139	0.0107	0.0112	0.0074	0.0103	0.0078	0.0117	0.0105	0.0128	0.0106	0.0115	0.0114
2014	0.0255	0.0365	0.0376	0.0339	0.0311	0.0274	0.0236	0.0159	0.0121	0.0113	0.0116	0.0104	0.0093	0.0110	0.0140	0.0140	0.0112	0.0108	0.0114	0.0076
2015	0.0195	0.0193	0.0258	0.0245	0.0243	0.0221	0.0235	0.0166	0.0182	0.0180	0.0165	0.0175	0.0201	0.0175	0.0225	0.0172	0.0157	0.0114	0.0127	0.0082
2016	0.0354	0.0472	0.0517	0.0502	0.0511	0.0444	0.0400	0.0313	0.0242	0.0244	0.0173	0.0172	0.0166	0.0162	0.0148	0.0157	0.0151	0.0133	0.0138	0.0140
2017	0.0202	0.0166	0.0213	0.0198	0.0206	0.0239	0.0281	0.0256	0.0301	0.0304	0.0351	0.0375	0.0345	0.0336	0.0294	0.0231	0.0218	0.0208	0.0168	0.0197
2018	0.0220	0.0185	0.0168	0.0181	0.0166	0.0202	0.0180	0.0186	0.0212	0.0197	0.0216	0.0198	0.0199	0.0181	0.0200	0.0231	0.0209	0.0227	0.0207	0.0252
2019	0.0069	0.0067	0.0076	0.0081	0.0073	0.0058	0.0078	0.0064	0.0066	0.0061	0.0078	0.0073	0.0082	0.0075	0.0078	0.0061	0.0067	0.0070	0.0067	0.0078

Table 2.11a (page 4 of 6)—Size composition data (EBS survey, units = proportions).

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
1982	0.0192	0.0183	0.0180	0.0188	0.0116	0.0163	0.0118	0.0125	0.0069	0.0069	0.0068	0.0061	0.0042	0.0032	0.0035	0.0028	0.0019	0.0025	0.0023	0.0012
1983	0.0149	0.0152	0.0145	0.0126	0.0143	0.0134	0.0110	0.0137	0.0096	0.0093	0.0059	0.0061	0.0060	0.0051	0.0045	0.0030	0.0037	0.0025	0.0022	0.0018
1984	0.0155	0.0133	0.0162	0.0150	0.0149	0.0141	0.0126	0.0119	0.0068	0.0098	0.0080	0.0086	0.0062	0.0068	0.0046	0.0056	0.0038	0.0033	0.0026	0.0027
1985	0.0065	0.0067	0.0101	0.0073	0.0080	0.0087	0.0087	0.0080	0.0080	0.0071	0.0082	0.0063	0.0080	0.0059	0.0056	0.0035	0.0045	0.0035	0.0030	0.0029
1986	0.0052	0.0064	0.0049	0.0055	0.0046	0.0057	0.0068	0.0064	0.0058	0.0046	0.0059	0.0056	0.0045	0.0053	0.0046	0.0040	0.0054	0.0036	0.0035	0.0028
1987	0.0117	0.0124	0.0116	0.0122	0.0124	0.0103	0.0109	0.0086	0.0056	0.0084	0.0048	0.0053	0.0051	0.0022	0.0042	0.0033	0.0035	0.0040	0.0026	0.0027
1988	0.0115	0.0124	0.0099	0.0138	0.0105	0.0107	0.0081	0.0117	0.0084	0.0084	0.0057	0.0080	0.0072	0.0048	0.0043	0.0055	0.0072	0.0065	0.0053	0.0030
1989	0.0242	0.0180	0.0169	0.0248	0.0216	0.0136	0.0200	0.0106	0.0186	0.0204	0.0164	0.0161	0.0147	0.0116	0.0149	0.0109	0.0064	0.0054	0.0084	0.0062
1990	0.0143	0.0100	0.0147	0.0101	0.0114	0.0069	0.0118	0.0083	0.0100	0.0100	0.0096	0.0084	0.0059	0.0070	0.0071	0.0047	0.0067	0.0067	0.0021	0.0044
1991	0.0058	0.0036	0.0062	0.0057	0.0068	0.0064	0.0066	0.0047	0.0044	0.0035	0.0059	0.0045	0.0039	0.0019	0.0023	0.0027	0.0030	0.0046	0.0033	0.0032
1992	0.0027	0.0032	0.0032	0.0050	0.0038	0.0034	0.0026	0.0016	0.0023	0.0025	0.0022	0.0018	0.0026	0.0016	0.0018	0.0026	0.0030	0.0015	0.0018	0.0015
1993	0.0035	0.0063	0.0035	0.0035	0.0059	0.0027	0.0027	0.0014	0.0014	0.0015	0.0014	0.0016	0.0012	0.0011	0.0010	0.0012	0.0012	0.0011	0.0009	0.0005
1994	0.0128	0.0113	0.0091	0.0059	0.0094	0.0044	0.0073	0.0035	0.0047	0.0021	0.0029	0.0014	0.0021	0.0009	0.0015	0.0007	0.0006	0.0007	0.0009	0.0004
1995	0.0095	0.0077	0.0058	0.0066	0.0077	0.0076	0.0075	0.0055	0.0059	0.0048	0.0039	0.0031	0.0024	0.0040	0.0022	0.0026	0.0023	0.0021	0.0019	0.0013
1996	0.0086	0.0063	0.0066	0.0066	0.0062	0.0061	0.0051	0.0061	0.0068	0.0037	0.0050	0.0039	0.0029	0.0031	0.0037	0.0024	0.0023	0.0026	0.0027	0.0016
1997	0.0133	0.0112	0.0111	0.0102	0.0094	0.0076	0.0064	0.0067	0.0060	0.0033	0.0024	0.0033	0.0025	0.0031	0.0020	0.0013	0.0011	0.0010	0.0013	0.0020
1998	0.0077	0.0069	0.0102	0.0060	0.0067	0.0053	0.0049	0.0059	0.0059	0.0042	0.0055	0.0030	0.0038	0.0022	0.0022	0.0025	0.0013	0.0018	0.0010	0.0016
1999	0.0067	0.0078	0.0050	0.0055	0.0041	0.0049	0.0054	0.0039	0.0040	0.0040	0.0030	0.0023	0.0022	0.0019	0.0020	0.0021	0.0019	0.0015	0.0011	0.0014
2000	0.0067	0.0044	0.0051	0.0047	0.0041	0.0028	0.0040	0.0026	0.0031	0.0025	0.0027	0.0023	0.0018	0.0010	0.0011	0.0017	0.0018	0.0010	0.0014	0.0015
2001	0.0079	0.0076	0.0054	0.0041	0.0053	0.0034	0.0039	0.0029	0.0026	0.0017	0.0019	0.0013	0.0010	0.0013	0.0010	0.0016	0.0009	0.0009	0.0006	0.0006
2002	0.0083	0.0048	0.0088	0.0059	0.0054	0.0055	0.0048	0.0038	0.0030	0.0030	0.0027	0.0020	0.0025	0.0019	0.0011	0.0008	0.0016	0.0011	0.0005	0.0005
2003	0.0079	0.0057	0.0058	0.0058	0.0055	0.0056	0.0061	0.0040	0.0045	0.0034	0.0035	0.0030	0.0028	0.0022	0.0022	0.0014	0.0015	0.0017	0.0017	0.0009
2004	0.0113	0.0097	0.0092	0.0083	0.0101	0.0079	0.0060	0.0068	0.0057	0.0059	0.0032	0.0047	0.0043	0.0039	0.0042	0.0029	0.0025	0.0022	0.0021	0.0014
2005	0.0114	0.0097	0.0099	0.0095	0.0095	0.0074	0.0079	0.0068	0.0065	0.0053	0.0074	0.0046	0.0066	0.0050	0.0057	0.0044	0.0041	0.0038	0.0035	0.0028
2006	0.0076	0.0072	0.0083	0.0051	0.0081	0.0041	0.0057	0.0051	0.0049	0.0055	0.0057	0.0046	0.0050	0.0037	0.0047	0.0037	0.0047	0.0042	0.0042	0.0030
2007	0.0041	0.0037	0.0038	0.0025	0.0034	0.0033	0.0025	0.0018	0.0026	0.0018	0.0029	0.0017	0.0015	0.0011	0.0010	0.0014	0.0013	0.0015	0.0008	0.0009
2008	0.0079	0.0048	0.0060	0.0050	0.0064	0.0036	0.0044	0.0026	0.0036	0.0019	0.0034	0.0014	0.0021	0.0018	0.0019	0.0009	0.0012	0.0009	0.0014	0.0011
2009	0.0039	0.0043	0.0032	0.0024	0.0030	0.0019	0.0024	0.0019	0.0012	0.0015	0.0008	0.0011	0.0010	0.0010	0.0009	0.0003	0.0008	0.0004	0.0005	0.0003
2010	0.0088	0.0054	0.0056	0.0039	0.0029	0.0022	0.0026	0.0023	0.0012	0.0009	0.0009	0.0011	0.0013	0.0003	0.0010	0.0003	0.0002	0.0006	0.0003	0.0003
2011	0.0121	0.0083	0.0099	0.0073	0.0078	0.0056	0.0062	0.0030	0.0038	0.0025	0.0024	0.0014	0.0013	0.0012	0.0008	0.0007	0.0009	0.0003	0.0008	0.0005
2012	0.0079	0.0059	0.0061	0.0048	0.0051	0.0035	0.0056	0.0029	0.0037	0.0018	0.0022	0.0016	0.0015	0.0015	0.0013	0.0005	0.0008	0.0003	0.0005	0.0005
2013	0.0125	0.0116	0.0104	0.0088	0.0078	0.0073	0.0058	0.0058	0.0050	0.0027	0.0034	0.0024	0.0017	0.0023	0.0016	0.0017	0.0005	0.0016	0.0007	0.0013
2014	0.0079	0.0061	0.0060	0.0035	0.0035	0.0030	0.0038	0.0032	0.0030	0.0037	0.0028	0.0024	0.0023	0.0017	0.0016	0.0011	0.0009	0.0009	0.0005	0.0005
2015	0.0086	0.0059	0.0056	0.0059	0.0051	0.0042	0.0034	0.0032	0.0032	0.0030	0.0024	0.0028	0.0023	0.0019	0.0013	0.0013	0.0010	0.0013	0.0008	0.0004
2016	0.0125	0.0132	0.0146	0.0114	0.0105	0.0096	0.0100	0.0084	0.0055	0.0051	0.0040	0.0029	0.0027	0.0028	0.0021	0.0015	0.0014	0.0021	0.0010	0.0011
2017	0.0154	0.0137	0.0120	0.0120	0.0110	0.0129	0.0114	0.0083	0.0071	0.0096	0.0067	0.0076	0.0071	0.0064	0.0053	0.0055	0.0054	0.0016	0.0032	0.0027
2018	0.0243	0.0219	0.0193	0.0221	0.0169	0.0176	0.0164	0.0118	0.0118	0.0111	0.0081	0.0069	0.0066	0.0080	0.0053	0.0061	0.0065	0.0045	0.0040	0.0040
2019	0.0078	0.0067	0.0080	0.0064	0.0072	0.0062	0.0064	0.0065	0.0060	0.0072	0.0066	0.0049	0.0054	0.0048	0.0056	0.0033	0.0038	0.0031	0.0021	0.0018

Table 2.11a (page 5 of 6)—Size composition data (EBS survey, units = proportions).

Year	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
1982	0.0007	0.0006	0.0009	0.0003	0.0006	0.0004	0.0001	0.0002	0.0003	0.0000	0.0002	0.0000	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0013	0.0009	0.0001	0.0005	0.0006	0.0002	0.0009	0.0000	0.0000	0.0002	0.0003	0.0000	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0022	0.0018	0.0023	0.0010	0.0013	0.0015	0.0010	0.0008	0.0003	0.0006	0.0005	0.0000	0.0003	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000
1985	0.0013	0.0022	0.0013	0.0013	0.0010	0.0008	0.0006	0.0005	0.0004	0.0005	0.0003	0.0001	0.0002	0.0004	0.0001	0.0002	0.0001	0.0000	0.0002	0.0000
1986	0.0019	0.0017	0.0023	0.0012	0.0014	0.0012	0.0020	0.0006	0.0011	0.0009	0.0003	0.0003	0.0004	0.0002	0.0005	0.0001	0.0003	0.0002	0.0000	0.0003
1987	0.0029	0.0031	0.0008	0.0008	0.0014	0.0009	0.0009	0.0012	0.0005	0.0011	0.0009	0.0001	0.0005	0.0006	0.0003	0.0001	0.0001	0.0002	0.0003	0.0000
1988	0.0033	0.0014	0.0028	0.0015	0.0008	0.0015	0.0003	0.0018	0.0003	0.0006	0.0006	0.0006	0.0005	0.0001	0.0004	0.0008	0.0003	0.0001	0.0003	0.0000
1989	0.0078	0.0085	0.0041	0.0063	0.0043	0.0014	0.0041	0.0029	0.0018	0.0023	0.0028	0.0031	0.0019	0.0010	0.0020	0.0011	0.0010	0.0021	0.0001	0.0022
1990	0.0037	0.0040	0.0033	0.0024	0.0021	0.0032	0.0022	0.0009	0.0008	0.0008	0.0011	0.0021	0.0017	0.0004	0.0003	0.0002	0.0008	0.0000	0.0010	0.0001
1991	0.0019	0.0018	0.0012	0.0020	0.0010	0.0011	0.0008	0.0007	0.0008	0.0005	0.0002	0.0009	0.0010	0.0004	0.0003	0.0004	0.0000	0.0001	0.0000	0.0008
1992	0.0012	0.0013	0.0014	0.0007	0.0010	0.0008	0.0013	0.0006	0.0007	0.0007	0.0004	0.0007	0.0008	0.0003	0.0009	0.0002	0.0004	0.0003	0.0003	0.0003
1993	0.0012	0.0010	0.0004	0.0007	0.0008	0.0007	0.0004	0.0003	0.0004	0.0007	0.0002	0.0007	0.0005	0.0004	0.0003	0.0003	0.0001	0.0002	0.0002	0.0001
1994	0.0006	0.0006	0.0006	0.0005	0.0003	0.0004	0.0024	0.0009	0.0007	0.0002	0.0001	0.0003	0.0004	0.0003	0.0001	0.0001	0.0002	0.0007	0.0004	0.0002
1995	0.0014	0.0011	0.0008	0.0008	0.0008	0.0008	0.0005	0.0012	0.0004	0.0005	0.0004	0.0011	0.0001	0.0003	0.0002	0.0003	0.0005	0.0001	0.0003	0.0001
1996	0.0028	0.0010	0.0015	0.0023	0.0019	0.0010	0.0004	0.0003	0.0007	0.0010	0.0003	0.0005	0.0005	0.0003	0.0003	0.0002	0.0004	0.0001	0.0002	0.0000
1997	0.0013	0.0011	0.0009	0.0010	0.0010	0.0005	0.0003	0.0009	0.0008	0.0002	0.0006	0.0004	0.0003	0.0004	0.0000	0.0001	0.0002	0.0000	0.0000	0.0001
1998	0.0011	0.0009	0.0010	0.0008	0.0004	0.0004	0.0006	0.0005	0.0010	0.0004	0.0006	0.0003	0.0001	0.0002	0.0002	0.0001	0.0001	0.0001	0.0009	0.0000
1999	0.0011	0.0009	0.0009	0.0014	0.0012	0.0005	0.0012	0.0005	0.0004	0.0004	0.0004	0.0002	0.0004	0.0005	0.0005	0.0003	0.0002	0.0001	0.0000	0.0002
2000	0.0007	0.0007	0.0004	0.0007	0.0021	0.0005	0.0006	0.0006	0.0003	0.0003	0.0008	0.0002	0.0006	0.0004	0.0003	0.0001	0.0000	0.0002	0.0000	0.0000
2001	0.0007	0.0003	0.0005	0.0003	0.0003	0.0003	0.0003	0.0002	0.0002	0.0001	0.0002	0.0003	0.0000	0.0001	0.0000	0.0002	0.0000	0.0001	0.0000	0.0001
2002	0.0002	0.0006	0.0001	0.0003	0.0004	0.0001	0.0002	0.0003	0.0004	0.0004	0.0001	0.0003	0.0001	0.0003	0.0005	0.0001	0.0001	0.0000	0.0000	0.0001
2003	0.0011	0.0006	0.0008	0.0004	0.0005	0.0004	0.0003	0.0003	0.0002	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2004	0.0021	0.0010	0.0024	0.0011	0.0018	0.0014	0.0012	0.0005	0.0004	0.0007	0.0004	0.0004	0.0004	0.0004	0.0003	0.0002	0.0000	0.0001	0.0000	0.0005
2005	0.0022	0.0015	0.0024	0.0018	0.0021	0.0012	0.0009	0.0013	0.0009	0.0007	0.0004	0.0008	0.0004	0.0002	0.0003	0.0000	0.0003	0.0002	0.0000	0.0001
2006	0.0036	0.0031	0.0028	0.0016	0.0028	0.0012	0.0019	0.0013	0.0014	0.0008	0.0008	0.0005	0.0010	0.0007	0.0001	0.0006	0.0004	0.0002	0.0002	0.0002
2007	0.0007	0.0021	0.0009	0.0007	0.0007	0.0011	0.0008	0.0010	0.0007	0.0003	0.0006	0.0003	0.0004	0.0002	0.0002	0.0002	0.0002	0.0001	0.0006	0.0001
2008	0.0010	0.0007	0.0015	0.0008	0.0008	0.0006	0.0012	0.0004	0.0007	0.0008	0.0007	0.0007	0.0002	0.0006	0.0006	0.0002	0.0003	0.0002	0.0005	0.0001
2009	0.0002	0.0004	0.0003	0.0003	0.0002	0.0002	0.0003	0.0000	0.0001	0.0001	0.0001	0.0002	0.0003	0.0001	0.0002	0.0000	0.0001	0.0001	0.0001	0.0000
2010	0.0001	0.0004	0.0006	0.0000	0.0003	0.0001	0.0003	0.0001	0.0001	0.0003	0.0001	0.0000	0.0002	0.0001	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000
2011	0.0003	0.0001	0.0002	0.0002	0.0002	0.0002	0.0001	0.0003	0.0002	0.0002	0.0004	0.0001	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000
2012	0.0005	0.0003	0.0003	0.0003	0.0001	0.0001	0.0002	0.0002	0.0001	0.0002	0.0002	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
2013	0.0006	0.0006	0.0004	0.0004	0.0003	0.0002	0.0003	0.0002	0.0002	0.0003	0.0001	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000
2014	0.0005	0.0002	0.0003	0.0003	0.0002	0.0001	0.0004	0.0001	0.0002	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0001
2015	0.0006	0.0004	0.0009	0.0005	0.0003	0.0001	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
2016	0.0013	0.0010	0.0006	0.0005	0.0004	0.0005	0.0003	0.0003	0.0003	0.0002	0.0001	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001	0.0002	0.0001	0.0001
2017	0.0018	0.0010	0.0009	0.0012	0.0009	0.0013	0.0003	0.0006	0.0007	0.0003	0.0005	0.0004	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018	0.0033	0.0015	0.0021	0.0024	0.0016	0.0013	0.0012	0.0007	0.0005	0.0005	0.0005	0.0004	0.0003	0.0004	0.0006	0.0004	0.0001	0.0000	0.0003	0.0000
2019	0.0023	0.0017	0.0011	0.0016	0.0012	0.0012	0.0013	0.0006	0.0006	0.0005	0.0006	0.0004	0.0002	0.0003	0.0003	0.0002	0.0002	0.0001	0.0001	0.0000

Table 2.11a (page 6 of 6)—Size composition data (EBS survey, units = proportions).

Year	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
1982	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1983	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1984	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1986	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1987	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1988	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1989	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1990	0.0000	0.0002	0.0002	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1991	0.0001	0.0001	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1992	0.0003	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
1993	0.0008	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
1994	0.0001	0.0005	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1995	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1996	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1997	0.0002	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1998	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
1999	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2001	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2002	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2004	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2006	0.0001	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2007	0.0002	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2008	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2009	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2010	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2011	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2012	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2013	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2014	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2015	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2016	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2017	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2018	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2019	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2.11b—Size composition data (NBS survey, units = proportions).

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2010	0.0000	0.0037	0.0000	0.0000	0.0000	0.0000	0.0114	0.0144	0.0153	0.0496	0.0457	0.0426	0.0072	0.0178	0.0036	0.0000	0.0000	0.0215	0.0102	0.0075
2017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0027	0.0014	0.0032	0.0025	0.0012	0.0016	0.0017	0.0019	0.0019	0.0028
2019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005	0.0019	0.0051	0.0055	0.0138	0.0201	0.0292	0.0280	0.0363	0.0345	0.0320

Year	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
2010	0.0217	0.0209	0.0037	0.0273	0.0180	0.0220	0.0317	0.0080	0.0074	0.0073	0.0037	0.0036	0.0000	0.0036	0.0034	0.0000	0.0038	0.0032	0.0000	0.0000
2017	0.0064	0.0037	0.0069	0.0093	0.0133	0.0133	0.0189	0.0186	0.0216	0.0178	0.0186	0.0109	0.0099	0.0092	0.0078	0.0045	0.0060	0.0051	0.0075	0.0079
2019	0.0406	0.0341	0.0337	0.0260	0.0157	0.0129	0.0071	0.0076	0.0092	0.0074	0.0071	0.0074	0.0044	0.0038	0.0047	0.0033	0.0065	0.0059	0.0057	0.0071

Year	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
2010	0.0039	0.0000	0.0000	0.0033	0.0000	0.0000	0.0000	0.0035	0.0000	0.0000	0.0000	0.0039	0.0000	0.0000	0.0000	0.0000	0.0036	0.0035	0.0073	0.0143
2017	0.0104	0.0131	0.0133	0.0115	0.0127	0.0145	0.0206	0.0227	0.0253	0.0257	0.0269	0.0321	0.0461	0.0382	0.0373	0.0380	0.0353	0.0328	0.0330	0.0329
2019	0.0093	0.0089	0.0087	0.0112	0.0084	0.0117	0.0103	0.0135	0.0140	0.0127	0.0161	0.0205	0.0188	0.0148	0.0217	0.0191	0.0140	0.0153	0.0174	0.0105

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
2010	0.0133	0.0166	0.0140	0.0073	0.0176	0.0070	0.0111	0.0141	0.0140	0.0497	0.0289	0.0146	0.0354	0.0328	0.0253	0.0176	0.0322	0.0187	0.0346	0.0255
2017	0.0283	0.0251	0.0186	0.0228	0.0184	0.0139	0.0165	0.0117	0.0152	0.0099	0.0100	0.0087	0.0054	0.0061	0.0036	0.0050	0.0043	0.0036	0.0024	0.0024
2019	0.0190	0.0191	0.0202	0.0135	0.0161	0.0170	0.0188	0.0210	0.0140	0.0166	0.0142	0.0110	0.0114	0.0101	0.0077	0.0086	0.0055	0.0039	0.0036	0.0032

Year	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
2010	0.0108	0.0282	0.0111	0.0035	0.0074	0.0074	0.0000	0.0077	0.0106	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2017	0.0013	0.0008	0.0006	0.0005	0.0006	0.0011	0.0010	0.0000	0.0000	0.0007	0.0000	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000
2019	0.0013	0.0016	0.0024	0.0017	0.0008	0.0008	0.0004	0.0003	0.0002	0.0003	0.0005	0.0001	0.0003	0.0000	0.0000	0.0001	0.0002	0.0001	0.0003	0.0000

Year	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2.11c—Size composition data (EBS survey and NBS survey combined (full NBS survey years ony), units = proportions).

Year	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
2010	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0007	0.0024	0.0032	0.0042	0.0069	0.0069	0.0074	0.0062	0.0040	0.0020	0.0021	0.0014	0.0019	0.0042
2017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0008	0.0022	0.0036	0.0032	0.0047	0.0042	0.0047	0.0057	0.0064	0.0082	0.0088	0.0105
2019	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008	0.0019	0.0042	0.0078	0.0191	0.0259	0.0392	0.0351	0.0418	0.0472	0.0554	0.0547	0.0518

Year	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
2010	0.0080	0.0166	0.0252	0.0316	0.0465	0.0561	0.0551	0.0514	0.0515	0.0423	0.0354	0.0242	0.0220	0.0141	0.0126	0.0087	0.0099	0.0102	0.0162	0.0172
2017	0.0126	0.0122	0.0121	0.0109	0.0096	0.0097	0.0107	0.0124	0.0115	0.0117	0.0121	0.0106	0.0106	0.0123	0.0111	0.0108	0.0119	0.0128	0.0122	0.0140
2019	0.0568	0.0512	0.0433	0.0343	0.0216	0.0088	0.0048	0.0032	0.0033	0.0028	0.0027	0.0028	0.0026	0.0025	0.0035	0.0035	0.0055	0.0056	0.0057	0.0078

Year	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
2010	0.0302	0.0200	0.0218	0.0207	0.0206	0.0161	0.0177	0.0139	0.0193	0.0149	0.0202	0.0197	0.0182	0.0124	0.0183	0.0146	0.0132	0.0096	0.0118	0.0077
2017	0.0176	0.0157	0.0191	0.0176	0.0184	0.0214	0.0261	0.0249	0.0288	0.0291	0.0329	0.0360	0.0376	0.0348	0.0316	0.0271	0.0254	0.0240	0.0211	0.0233
2019	0.0075	0.0073	0.0079	0.0090	0.0076	0.0074	0.0085	0.0083	0.0086	0.0079	0.0101	0.0110	0.0111	0.0095	0.0117	0.0097	0.0087	0.0093	0.0097	0.0086

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83
2010	0.0089	0.0055	0.0057	0.0039	0.0031	0.0022	0.0027	0.0024	0.0014	0.0013	0.0012	0.0012	0.0017	0.0007	0.0012	0.0005	0.0005	0.0007	0.0006	0.0006
2017	0.0189	0.0167	0.0137	0.0149	0.0130	0.0131	0.0128	0.0093	0.0093	0.0097	0.0076	0.0079	0.0067	0.0063	0.0048	0.0053	0.0051	0.0021	0.0030	0.0026
2019	0.0109	0.0101	0.0114	0.0084	0.0096	0.0092	0.0098	0.0106	0.0082	0.0098	0.0087	0.0066	0.0071	0.0063	0.0062	0.0047	0.0043	0.0033	0.0025	0.0022

Year	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
2010	0.0002	0.0007	0.0007	0.0001	0.0004	0.0001	0.0003	0.0002	0.0002	0.0002	0.0001	0.0000	0.0002	0.0001	0.0001	0.0002	0.0001	0.0000	0.0000	0.0000
2017	0.0017	0.0009	0.0008	0.0010	0.0008	0.0013	0.0005	0.0005	0.0005	0.0004	0.0004	0.0005	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000
2019	0.0020	0.0017	0.0015	0.0016	0.0011	0.0011	0.0010	0.0005	0.0005	0.0005	0.0005	0.0004	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0000

Year	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
2010	0.0000	0.0001	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2017	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2019	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 2.12—Size composition nominal sample sizes (survey, units = hauls).

Year	EBS	NBS	EBS+NBS
1982	313		313
1983	255		255
1984	264		264
1985	345		345
1986	349		349
1987	339		339
1988	339		339
1989	293		293
1990	329		329
1991	313		313
1992	332		332
1993	363		363
1994	364		364
1995	347		347
1996	359		359
1997	369		369
1998	362		362
1999	336		336
2000	355		355
2001	366		366
2002	364		364
2003	363		363
2004	361		361
2005	360		360
2006	354		354
2007	368		368
2008	338		338
2009	360		360
2010	342	63	405
2011	368		368
2012	356		356
2013	354		354
2014	373		373
2015	354		354
2016	376		376
2017	369	112	481
2018	364	49	413
2019	365	114	479

Table 2.13a—Age composition data (survey, design-based, units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00000	0.08923	0.38221	0.17151	0.12389	0.11889	0.07942	0.02029	0.00686	0.00459	0.00134	0.00097	0.00080
1995	0.00001	0.05525	0.26318	0.41972	0.09973	0.07967	0.04915	0.01568	0.00836	0.00573	0.00151	0.00083	0.00116
1996	0.00001	0.05722	0.20726	0.20254	0.29303	0.13617	0.05801	0.02848	0.00961	0.00412	0.00168	0.00102	0.00086
1997	0.00000	0.25721	0.16889	0.18421	0.15688	0.12022	0.07632	0.02138	0.00965	0.00289	0.00121	0.00079	0.00034
1998	0.00000	0.07711	0.44065	0.20411	0.11219	0.05658	0.05984	0.02837	0.01574	0.00389	0.00074	0.00058	0.00020
1999	0.00000	0.07951	0.19946	0.30280	0.23192	0.08067	0.05824	0.02720	0.01181	0.00514	0.00122	0.00145	0.00056
2000	0.00002	0.23442	0.12700	0.14998	0.24188	0.14762	0.06202	0.01399	0.01343	0.00525	0.00277	0.00122	0.00042
2001	0.00001	0.28965	0.23541	0.19359	0.09077	0.08370	0.06850	0.02622	0.00755	0.00210	0.00145	0.00079	0.00027
2002	0.00006	0.08017	0.18789	0.31773	0.23342	0.07222	0.05909	0.03367	0.01005	0.00370	0.00104	0.00051	0.00045
2003	0.00001	0.17536	0.15619	0.25046	0.20932	0.11884	0.04109	0.03015	0.01352	0.00358	0.00050	0.00051	0.00045
2004	0.00002	0.14401	0.16555	0.27094	0.12811	0.12794	0.09090	0.04006	0.01872	0.00849	0.00212	0.00252	0.00062
2005	0.00000	0.18334	0.24441	0.20925	0.12112	0.06527	0.07947	0.05507	0.02378	0.01041	0.00361	0.00364	0.00063
2006	0.00000	0.32441	0.14277	0.16496	0.12141	0.09301	0.06343	0.04642	0.02845	0.00985	0.00301	0.00141	0.00085
2007	0.00000	0.70068	0.09548	0.06707	0.04134	0.04593	0.01758	0.01428	0.00838	0.00504	0.00174	0.00150	0.00097
2008	0.00014	0.21331	0.44525	0.14489	0.08267	0.04862	0.03300	0.01036	0.01021	0.00570	0.00271	0.00138	0.00174
2009	0.00068	0.45428	0.18941	0.23091	0.06415	0.02879	0.01468	0.00945	0.00392	0.00202	0.00082	0.00057	0.00033
2010	0.00000	0.04654	0.47937	0.17931	0.20324	0.06443	0.01460	0.00772	0.00254	0.00123	0.00037	0.00052	0.00012
2011	0.00003	0.29079	0.07294	0.38794	0.11107	0.09553	0.02788	0.00692	0.00333	0.00160	0.00096	0.00055	0.00044
2012	0.00005	0.36624	0.23416	0.05827	0.23714	0.06170	0.03065	0.00743	0.00205	0.00154	0.00046	0.00016	0.00016
2013	0.00000	0.10724	0.42698	0.17804	0.10837	0.11292	0.05042	0.01095	0.00359	0.00081	0.00019	0.00029	0.00022
2014	0.00005	0.27949	0.18757	0.23783	0.19702	0.04776	0.03583	0.01022	0.00224	0.00087	0.00071	0.00013	0.00028
2015	0.00000	0.06386	0.42549	0.20207	0.19335	0.08191	0.01861	0.01123	0.00241	0.00054	0.00025	0.00015	0.00014
2016	0.00000	0.11204	0.09416	0.36104	0.22136	0.14505	0.04879	0.01147	0.00401	0.00126	0.00042	0.00029	0.00012
2017	0.00000	0.13108	0.15980	0.18671	0.28786	0.13280	0.07306	0.02000	0.00448	0.00285	0.00049	0.00047	0.00040
2018	0.00000	0.09350	0.11912	0.28383	0.15805	0.22759	0.07772	0.03161	0.00409	0.00281	0.00087	0.00045	0.00035
2019	0.00000	0.69095	0.05804	0.06445	0.05670	0.04357	0.05332	0.02589	0.00656	0.00053	0.00000	0.00000	0.00000

Table 2.13b (page 1 of 3)—Age composition data (EBS survey, VAST, units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00014	0.09684	0.40311	0.17300	0.11275	0.10804	0.07232	0.01897	0.00719	0.00414	0.00129	0.00108	0.00113
1995	0.00009	0.05860	0.26025	0.42485	0.10270	0.07367	0.05077	0.01307	0.00661	0.00514	0.00138	0.00152	0.00135
1996	0.00003	0.06643	0.20436	0.19021	0.28924	0.13783	0.06436	0.03074	0.00850	0.00342	0.00176	0.00156	0.00157
1997	0.00022	0.26522	0.17145	0.16112	0.15064	0.11987	0.09105	0.02394	0.01052	0.00244	0.00184	0.00103	0.00067
1998	0.00005	0.07888	0.43670	0.20044	0.11305	0.05834	0.05955	0.03024	0.01708	0.00366	0.00073	0.00084	0.00043
1999	0.00006	0.08529	0.20985	0.31454	0.21877	0.07292	0.05299	0.02593	0.01172	0.00499	0.00101	0.00132	0.00061
2000	0.00000	0.21410	0.11894	0.16673	0.24420	0.15494	0.06089	0.01426	0.01520	0.00494	0.00361	0.00148	0.00070
2001	0.00003	0.29068	0.23977	0.18758	0.08829	0.08774	0.06897	0.02508	0.00727	0.00176	0.00138	0.00104	0.00042
2002	0.00036	0.08025	0.19821	0.30692	0.23740	0.06882	0.05733	0.03618	0.00960	0.00288	0.00094	0.00049	0.00063
2003	0.00001	0.17377	0.16059	0.23988	0.20837	0.12121	0.04410	0.03073	0.01582	0.00369	0.00049	0.00059	0.00075
2004	0.00003	0.14240	0.15150	0.27349	0.13248	0.13308	0.09570	0.03815	0.02038	0.00786	0.00214	0.00202	0.00078
2005	0.00000	0.16013	0.23107	0.20801	0.13159	0.07010	0.09111	0.06218	0.02601	0.01093	0.00385	0.00444	0.00056
2006	0.00000	0.32806	0.14671	0.17235	0.11664	0.08944	0.06069	0.04520	0.02658	0.00932	0.00302	0.00125	0.00073
2007	0.00000	0.66311	0.10761	0.07726	0.04920	0.05002	0.01965	0.01593	0.00827	0.00530	0.00170	0.00103	0.00092
2008	0.00000	0.19855	0.43874	0.15454	0.09176	0.05206	0.03103	0.01100	0.01019	0.00616	0.00254	0.00208	0.00135
2009	0.00000	0.45443	0.18749	0.23091	0.06592	0.02847	0.01486	0.00932	0.00472	0.00181	0.00093	0.00071	0.00041
2010	0.00000	0.04692	0.48121	0.18272	0.19837	0.06219	0.01504	0.00809	0.00275	0.00146	0.00052	0.00057	0.00016
2011	0.00006	0.32498	0.07408	0.36438	0.10757	0.08841	0.02708	0.00686	0.00286	0.00156	0.00107	0.00065	0.00045
2012	0.00000	0.34163	0.26161	0.06290	0.23038	0.06132	0.02978	0.00754	0.00230	0.00165	0.00054	0.00015	0.00020
2013	0.00000	0.09847	0.40619	0.19723	0.11492	0.11565	0.05056	0.01182	0.00341	0.00096	0.00021	0.00031	0.00026
2014	0.00002	0.28243	0.16618	0.24391	0.20251	0.05071	0.03919	0.01040	0.00221	0.00094	0.00085	0.00009	0.00057
2015	0.00002	0.06374	0.43478	0.20234	0.18884	0.07785	0.01824	0.01088	0.00231	0.00047	0.00024	0.00010	0.00019
2016	0.00000	0.10144	0.09232	0.35802	0.22556	0.15175	0.05284	0.01204	0.00366	0.00143	0.00051	0.00029	0.00015
2017	0.00007	0.12976	0.16122	0.16736	0.29484	0.13726	0.07960	0.02119	0.00337	0.00328	0.00063	0.00064	0.00078
2018	0.00004	0.10276	0.11189	0.26585	0.15604	0.23968	0.08155	0.03448	0.00354	0.00254	0.00074	0.00033	0.00056
2019	0.00001	0.66561	0.06759	0.07021	0.05968	0.04527	0.05539	0.02725	0.00712	0.00095	0.00036	0.00026	0.00028

Table 2.13b (page 2 of 3)—Age composition data (EBS survey, VAST, units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
2010	0.00000	0.18694	0.26714	0.06787	0.08220	0.09759	0.09435	0.10392	0.06700	0.01893	0.00847	0.00409	0.00151
2017	0.00006	0.05266	0.17610	0.12311	0.33230	0.19159	0.09654	0.02153	0.00268	0.00216	0.00051	0.00033	0.00044
2018	0.00003	0.04349	0.07083	0.21424	0.17901	0.36691	0.09908	0.02368	0.00141	0.00086	0.00024	0.00007	0.00015
2019	0.00001	0.38902	0.10970	0.12504	0.12149	0.09523	0.10995	0.04340	0.00509	0.00052	0.00026	0.00013	0.00016

Table 2.13b (page 3 of 3)—Age composition data (EBS survey and NBS survey combined, VAST, units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00023	0.10687	0.39168	0.16687	0.10993	0.11016	0.07786	0.02046	0.00796	0.00429	0.00139	0.00112	0.00119
1995	0.00016	0.06599	0.25367	0.41385	0.10283	0.07699	0.05531	0.01406	0.00726	0.00536	0.00148	0.00161	0.00143
1996	0.00004	0.07478	0.19252	0.17794	0.28109	0.14719	0.07388	0.03455	0.00933	0.00358	0.00187	0.00160	0.00164
1997	0.00031	0.28915	0.15884	0.14680	0.14020	0.12082	0.10017	0.02652	0.01125	0.00239	0.00188	0.00100	0.00067
1998	0.00007	0.08831	0.42616	0.19395	0.10967	0.05954	0.06564	0.03355	0.01766	0.00351	0.00072	0.00080	0.00041
1999	0.00008	0.09441	0.21006	0.30641	0.20857	0.07354	0.05765	0.02869	0.01245	0.00512	0.00105	0.00135	0.00061
2000	0.00000	0.22279	0.11438	0.16042	0.23466	0.15885	0.06632	0.01564	0.01604	0.00497	0.00374	0.00151	0.00069
2001	0.00004	0.28991	0.23252	0.17774	0.08559	0.09391	0.07875	0.02913	0.00770	0.00177	0.00147	0.00105	0.00042
2002	0.00050	0.08432	0.19115	0.29213	0.23738	0.07348	0.06519	0.04049	0.01034	0.00292	0.00098	0.00049	0.00063
2003	0.00001	0.17456	0.15247	0.22935	0.20875	0.12968	0.04891	0.03429	0.01655	0.00364	0.00049	0.00057	0.00074
2004	0.00004	0.14521	0.14882	0.26203	0.13041	0.13604	0.10272	0.04095	0.02108	0.00782	0.00217	0.00193	0.00077
2005	0.00000	0.15679	0.22932	0.20299	0.12815	0.07095	0.09807	0.06720	0.02693	0.01086	0.00394	0.00424	0.00054
2006	0.00000	0.34491	0.14058	0.16129	0.11001	0.08780	0.06361	0.04911	0.02785	0.00961	0.00323	0.00125	0.00075
2007	0.00000	0.67159	0.10266	0.07173	0.04667	0.05048	0.02103	0.01761	0.00888	0.00556	0.00181	0.00103	0.00094
2008	0.00000	0.20472	0.42747	0.14971	0.09131	0.05455	0.03441	0.01252	0.01181	0.00689	0.00297	0.00218	0.00145
2009	0.00000	0.48983	0.17335	0.21259	0.06109	0.02729	0.01547	0.01054	0.00560	0.00201	0.00108	0.00073	0.00044
2010	0.00000	0.04908	0.47791	0.18095	0.19658	0.06274	0.01627	0.00957	0.00374	0.00173	0.00064	0.00062	0.00018
2011	0.00009	0.34980	0.07052	0.34220	0.10221	0.08933	0.02982	0.00830	0.00356	0.00176	0.00126	0.00069	0.00047
2012	0.00000	0.34499	0.25226	0.06095	0.22794	0.06512	0.03376	0.00926	0.00280	0.00192	0.00063	0.00016	0.00022
2013	0.00000	0.10485	0.37958	0.19558	0.11622	0.12667	0.05742	0.01389	0.00393	0.00104	0.00023	0.00032	0.00027
2014	0.00003	0.27171	0.16183	0.23740	0.20986	0.05760	0.04468	0.01201	0.00238	0.00095	0.00089	0.00009	0.00056
2015	0.00002	0.06140	0.42535	0.20121	0.19400	0.08361	0.01916	0.01180	0.00242	0.00048	0.00025	0.00010	0.00019
2016	0.00000	0.08281	0.08811	0.34848	0.23712	0.16853	0.05691	0.01226	0.00356	0.00133	0.00049	0.00026	0.00013
2017	0.00007	0.10715	0.16558	0.15438	0.30582	0.15319	0.08457	0.02129	0.00317	0.00295	0.00060	0.00055	0.00068
2018	0.00004	0.07564	0.09310	0.24224	0.16655	0.29790	0.08957	0.02954	0.00256	0.00177	0.00051	0.00021	0.00037
2019	0.00001	0.58805	0.07940	0.08558	0.07702	0.05928	0.07069	0.03178	0.00655	0.00083	0.00033	0.00022	0.00024

Table 2.14—Age composition nominal sample sizes (survey, units = otoliths read).

Year	Ages
1994	715
1995	1426
1996	711
1997	718
1998	635
1999	860
2000	864
2001	480
2002	947
2003	2711
2004	1044
2005	1280
2006	1299
2007	1440
2008	1213
2009	1412
2010	1469
2011	1253
2012	1301
2013	1385
2014	1420
2015	1819
2016	1624
2017	1382
2018	1532
2019	1449

Table 2.15—Fishery age composition, 2010-2018 (units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12
2010	0.00000	0.00000	0.01451	0.12663	0.40272	0.19933	0.10861	0.06656	0.05559	0.02089	0.00236	0.00188	0.00092
2011	0.00000	0.00000	0.00896	0.17771	0.24526	0.36574	0.12472	0.04414	0.01514	0.01091	0.00538	0.00096	0.00108
2012	0.00000	0.00000	0.01222	0.03449	0.34814	0.27280	0.22332	0.07956	0.01908	0.00672	0.00368	0.00000	0.00000
2013	0.00000	0.00000	0.01186	0.14670	0.11057	0.48885	0.17873	0.04982	0.01175	0.00127	0.00000	0.00000	0.00044
2014	0.00000	0.00000	0.00848	0.11993	0.29149	0.18957	0.27767	0.08306	0.02777	0.00065	0.00085	0.00000	0.00053
2015	0.00000	0.00000	0.00642	0.06708	0.32891	0.34409	0.13146	0.08672	0.02311	0.00860	0.00000	0.00184	0.00176
2016	0.00000	0.00000	0.00228	0.08529	0.20348	0.40852	0.21609	0.05773	0.02615	0.00000	0.00046	0.00000	0.00000
2017	0.00000	0.00000	0.00000	0.04490	0.31790	0.33394	0.23197	0.05912	0.00375	0.00842	0.00000	0.00000	0.00000
2018	0.00000	0.00000	0.00578	0.07697	0.18667	0.42933	0.20918	0.06975	0.01444	0.00788	0.00000	0.00000	0.00000

Table 2.16—Trawl survey biomass time series (design-based).

	EBS		NBS		EBS+NBS	
Year	Biomass	Sigma	Biomass	Sigma	Biomass	Sigma
1987	1,064,600	0.060			1,064,600	0.060
1988	976,152	0.079			976,152	0.079
1989	868,804	0.072			868,804	0.072
1990	728,996	0.072			728,996	0.072
1991	530,488	0.072			530,488	0.072
1992	538,862	0.083			538,862	0.083
1993	669,305	0.079			669,305	0.079
1994	1,377,095	0.178			1,377,095	0.178
1995	1,008,293	0.091			1,008,293	0.091
1996	909,133	0.096			909,133	0.096
1997	627,151	0.109			627,151	0.109
1998	550,504	0.078			550,504	0.078
1999	618,679	0.091			618,679	0.091
2000	537,563	0.080			537,563	0.080
2001	827,176	0.088			827,176	0.088
2002	597,943	0.106			597,943	0.106
2003	625,659	0.099			625,659	0.099
2004	578,064	0.058			578,064	0.058
2005	638,764	0.068			638,764	0.068
2006	544,035	0.053			544,035	0.053
2007	450,337	0.078			450,337	0.078
2008	427,503	0.065			427,503	0.065
2009	430,084	0.081			430,084	0.081
2010	870,639	0.117	29,124	0.223	899,763	0.114
2011	911,082	0.073			911,082	0.073
2012	896,401	0.112			896,401	0.112
2013	811,667	0.091			811,667	0.091
2014	1,095,270	0.139			1,095,270	0.139
2015	1,109,115	0.136			1,109,115	0.136
2016	986,013	0.078			986,013	0.078
2017	643,953	0.077	283,615	0.126	927,568	0.066
2018	506,943	0.058			506,943	0.058
2019	516,910	0.044	364,982	0.146	881,892	0.066

Table 2.17—Annual weight length parameter offsets.

Year:	1977	1978	1979	1980	1981	1982	1983	1984	1985
α offset:	2.31E-06	-2.29E-06	1.56E-06	-6.56E-08	8.92E-07	2.91E-06	5.29E-07	1.18E-05	-8.35E-07
β offset:	-8.00E-02	1.32E-01	-5.64E-02	-9.26E-04	-4.10E-02	-9.39E-02	-1.21E-02	-2.86E-01	4.93E-02

Year:	1986	1987	1988	1989	1990	1991	1992	1993	1994
α offset:	-2.08E-06	-2.11E-08	-2.00E-06	-1.08E-06	1.39E-06	1.87E-06	4.18E-07	2.86E-06	6.79E-07
β offset:	1.22E-01	7.77E-03	1.25E-01	7.25E-02	-3.87E-02	-7.02E-02	-2.63E-02	-8.16E-02	-2.61E-02

Year:	1995	1996	1997	1998	1999	2000	2001	2002	2003
α offset:	-7.87E-07	7.81E-06	1.38E-06	1.97E-06	2.06E-06	2.30E-06	4.19E-06	1.58E-06	-1.43E-07
β offset:	3.99E-02	-2.08E-01	-6.37E-02	-8.53E-02	-7.76E-02	-7.30E-02	-1.31E-01	-5.76E-02	6.74E-03

Year:	2004	2005	2006	2007	2008	2009	2010	2011	2012
α offset:	2.25E-06	1.93E-07	1.14E-06	6.10E-07	1.31E-06	-5.26E-07	-1.28E-07	-2.65E-07	3.18E-06
β offset:	-8.11E-02	-4.24E-03	-4.23E-02	-1.89E-02	-4.98E-02	2.87E-02	5.26E-03	7.08E-03	-1.18E-01

Year:	2013	2014	2015	2016	2017	2018	2019	2020
α offset:	-4.54E-07	-1.75E-06	-1.98E-06	-1.72E-06	-2.03E-06	-6.51E-07	-1.20E-06	-1.46E-06
β offset:	1.61E-02	8.30E-02	9.29E-02	8.05E-02	1.04E-01	2.69E-02	6.04E-02	6.49E-02

Table 2.18—Input composition sample sizes (survey includes EBS and NBS; units = hauls).

		Fishery	
Year	Survey	Raw	Scaled
1977		30	2
1978		160	9
1979		235	14
1980		208	12
1981		148	9
1982	313	187	11
1983	255	782	46
1984	264	1913	113
1985	345	2825	167
1986	349	2496	147
1987	339	4726	279
1988	339	1458	86
1989	293	966	57
1990	329	3601	212
1991	313	5188	306
1992	332	5322	314
1993	363	2993	177
1994	364	4687	277
1995	347	5215	308
1996	359	6618	390
1997	369	7278	429
1998	362	6838	403
1999	336	9231	545
2000	355	9731	574
2001	366	10364	611
2002	364	11472	677
2003	363	14341	846
2004	361	12242	722
2005	360	11568	682
2006	354	8849	522
2007	368	6901	407
2008	338	8320	491
2009	360	7482	441
2010	405	6514	384
2011	368	8804	519
2012	356	9287	548
2013	354	11126	656
2014	373	12165	718
2015	354	11309	667
2016	376	9772	576
2017	481	8486	501
2018	413	6462	381
2019	479	4672	276
2020		2373	140
Mean:	356	6031	356

Table 2.19—Objective function values (negative log likelihood) and parameter counts.

Objective function values

A1: Allow Q to vary?	no		yes		(yes)		
A2: Combine surveys?	no	yes	no	yes			
B1: Use fishery CPUE?	(no)			no		yes	
B2: Allow domed selex?				no	yes	no	yes
Component	M20.4	M19.12a	M19.15	M19.12	M20.8	M20.9	M20.10
Equil. catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey indices	164.73	-4.47	-95.89	-87.67	-87.63	-215.58	-223.83
Sizecomps	965.33	846.19	937.08	818.40	802.55	938.13	880.62
Agecomps	291.20	268.75	282.70	262.56	266.34	282.45	309.92
Recruitment	-1.19	-0.18	-1.73	-1.21	-0.82	-1.77	-2.28
Initial recruitment	4.09	4.64	4.57	5.59	3.35	5.29	1.49
"Softbounds"	0.03	0.02	0.03	0.02	0.02	0.02	0.02
Parameter devs	67.27	66.38	123.59	99.72	103.32	144.02	123.50
Total	1491.45	1181.33	1250.37	1097.40	1087.12	1152.56	1089.44

Parameter counts

Parameter type	M20.4	M19.12a	M19.15	M19.12	M20.8	M20.9	M20.10
True parameters	30	25	30	25	28	26	29
Parameter devs	269	269	345	307	307	336	307
Total	299	294	375	332	335	362	336

Table 2.20—Fits to size composition and age composition data.

Size composition data

	Fleet:	Fishery						
	Model:	M20.4	M19.12a	M19.15	M19.12	M20.8	M20.9	M20.10
	Nave:	356	356	356	356	356	356	356
McAllister-Ianelli	Neff:	820	824	823	820	816	795	835
	Ratio:	2.305	2.316	2.313	2.306	2.295	2.236	2.346
Thorson et al.	ln(θ):	9.989	9.989	9.989	9.989	9.989	9.988	9.989
	Neff:	356	356	356	356	356	356	356
	Ratio:	1.000	1.000	1.000	1.000	1.000	1.000	1.000

	Fleet:	EBS survey		NBS survey		EBS+NBS survey				
	Model:	M20.4	M19.15	M20.4	M19.15	M19.12a	M19.12	M20.8	M20.9	M20.10
	Nave:	347	347	96	96	356	356	356	356	356
McAllister-Ianelli	Neff:	584	607	84	85	596	621	630	601	599
	Ratio:	1.683	1.750	0.873	0.880	1.676	1.746	1.772	1.690	1.683
Thorson et al.	ln(θ):	9.984	9.984	9.117	9.236	9.983	9.984	9.985	9.982	9.986
	Neff:	347	347	96	96	356	356	356	356	356
	Ratio:	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Age composition data

	Fleet:	EBS survey		NBS survey		EBS+NBS survey				
	Model:	M20.4	M19.15	M20.4	M19.15	M19.12a	M19.12	M20.8	M20.9	M20.10
	Nave:	360	360	85	85	373	373	373	373	373
McAllister-Ianelli	Neff:	119	125	23	24	106	113	109	91	85
	Ratio:	0.332	0.349	0.278	0.284	0.284	0.303	0.292	0.244	0.229
Thorson et al.	ln(θ):	0.253	0.363	-0.367	-0.314	-0.044	0.045	-0.211	-0.547	-0.922
	Neff:	203	212	35	36	183	191	167	137	107
	Ratio:	0.564	0.591	0.416	0.429	0.490	0.513	0.449	0.368	0.287

Table 2.20—Computation of model weights.

Factor A1: Allow Q to vary?		no		yes		(yes)		
Factor A2: Combine surveys?		no	yes	no	yes			
Factor B1: Use fishery CPUE?		(no)			no		yes	
Factor B2: Allow domed selex?					no	yes	no	yes
Criterion	Emph.	20.4	19.12a	19.15	19.12	20.8	20.9	20.10
Plausible hypothesis	3	1	1	1	1	1	1	1
Plausible catchability	3	0	1	0	1	1	1	0
Acceptable retrospective bias	3	1	1	1	1	1	1	1
Comparable complexity	2	0	0	0	0	0	0	0
Dev sigmas estimated appropriately	2	1	1	1	1	1	1	1
Fits consistent with variances	2	0	0	1	1	1	1	1
Incremental changes	1	1	1	1	1	1	1	1
Objective criterion for sample sizes	1	1	1	1	1	1	1	1
Change in ageing criteria addressed	1	1	1	1	1	1	1	1
Average emphasis:		0.6111	0.7778	0.7222	0.8889	0.8889	0.8889	0.7222
Model weight (Ensemble A):		0.2037	0.2593	0.2407	0.2963			
Model weight (Ensemble AB):		0.1111	0.1414	0.1313	0.1616	0.1616	0.1616	0.1313

Table 2.22a—Time-invariant parameters other than selectivity parameters.

A1: Allow Q to vary?	no				yes				(yes)									
A2: Combine surveys?	no		yes		no		yes											
B1: Use fishery CPUE?	(no)						no				yes							
B2: Allow domed selex?							no		yes		no		yes					
Model:	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ensemble A		Ensemble AB	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Natural mortality	0.371	0.012	0.354	0.011	0.362	0.013	0.342	0.013	0.294	0.017	0.341	0.013	0.212	0.016	0.356	0.016	0.325	0.051
Mean length at age 1.5	14.766	0.396	14.784	0.388	14.831	0.405	14.872	0.391	14.915	0.376	14.887	0.389	14.766	0.362	14.818	0.397	14.838	0.391
Asymptotic length	113.710	3.117	113.400	3.130	114.788	3.253	115.298	3.356	102.316	2.561	117.562	3.535	94.646	1.138	114.360	3.322	110.342	8.322
Brody growth coefficient	0.118	0.009	0.117	0.009	0.116	0.009	0.113	0.009	0.163	0.013	0.102	0.009	0.204	0.009	0.116	0.009	0.133	0.035
Richards growth coefficient	1.428	0.042	1.443	0.042	1.423	0.043	1.444	0.042	1.264	0.053	1.507	0.042	1.154	0.043	1.435	0.043	1.382	0.123
SD(length at age 1)	3.479	0.065	3.483	0.067	3.483	0.065	3.498	0.065	3.527	0.067	3.493	0.067	3.636	0.072	3.487	0.066	3.514	0.084
SD(length at age 20)	9.927	0.383	9.956	0.381	9.789	0.389	9.773	0.388	8.784	0.343	10.160	0.464	7.832	0.251	9.856	0.394	9.466	0.856
Mean ageing bias at age 1	0.349	0.015	0.338	0.017	0.347	0.015	0.336	0.017	0.331	0.018	0.339	0.019	0.333	0.022	0.342	0.017	0.338	0.019
Mean ageing bias at age 20	0.779	0.206	0.973	0.222	0.826	0.207	1.015	0.222	1.122	0.242	1.059	0.259	1.266	0.300	0.911	0.236	1.016	0.281
Mean bias at age 1 (2008+)	-0.010	0.024	0.011	0.024	-0.008	0.024	0.014	0.024	0.016	0.026	0.018	0.027	0.019	0.030	0.003	0.026	0.010	0.028
Mean bias at age 20 (2008+)	-1.635	0.324	-1.640	0.315	-1.831	0.346	-1.822	0.327	-1.929	0.355	-2.413	0.480	-2.231	0.467	-1.739	0.341	-1.943	0.468
ln(mean post-1976 recruits)	13.275	0.099	13.177	0.096	13.179	0.106	13.072	0.104	12.846	0.136	13.177	0.115	12.513	0.160	13.166	0.124	13.031	0.267
ln(pre-1977 recruits offset)	-0.890	0.205	-0.905	0.198	-0.899	0.199	-0.933	0.189	-0.607	0.187	-0.893	0.190	-0.272	0.136	-0.909	0.198	-0.774	0.292
Pre-1977 fishing mortality	0.125	0.039	0.122	0.037	0.130	0.041	0.128	0.039	0.071	0.019	0.115	0.040	0.041	0.012	0.126	0.039	0.104	0.047
ln(Fishery catchability)											-13.015	0.071	-13.618	0.107	n/a	n/a	-13.285	0.312
ln(EBS survey catchability)	-0.112	0.066			-0.058	0.070									-0.083	0.073	-0.083	0.073
ln(NBS survey catchability)	-0.844	0.107			-1.998	0.257									-1.469	0.610	-1.469	0.610
ln(XBS survey catchability)			-0.014	0.062			0.045	0.068	0.155	0.090	-0.087	0.077	0.274	0.120	0.017	0.071	0.069	0.151
ln(DM)_fishery_sizecomp	9.989	0.346	9.989	0.348	9.989	0.346	9.989	0.347	9.989	0.356	9.988	0.373	9.989	0.336	9.989	0.347	9.989	0.351
ln(DM)_EBS_surv_sizecomp	9.984	0.502			9.984	0.505									9.984	0.504	9.984	0.504
ln(DM)_NBS_surv_sizecomp	9.117	18.864			9.236	18.346									9.182	18.586	9.182	18.586
ln(DM)_XBS_surv_sizecomp			9.983	0.547			9.984	0.520	9.985	0.463	9.982	0.565	9.986	0.448	9.983	0.533	9.984	0.512
ln(DM)_EBS_surv_agecomp	0.253	0.242			0.363	0.260									0.313	0.258	0.313	0.258
ln(DM)_NBS_surv_agecomp	-0.367	0.362			-0.314	0.366									-0.338	0.365	-0.338	0.365
ln(DM)_XBS_surv_agecomp			-0.044	0.205			0.045	0.217	-0.211	0.200	-0.547	0.163	-0.922	0.143		0.216	-0.320	0.393

Table 2.22b—Base values of selectivity parameters.

A1: Allow Q to vary?	no				yes				(yes)									
A2: Combine surveys?	no		yes		no		yes											
B1: Use fishery CPUE?	(no)								no				yes					
B2: Allow domed selex?									no		yes		no		yes			
	20.4		19.12a		19.15		19.12		20.8				20.9		20.10		Ensemble A		Ensemble AB	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Fishery_Begin_top	75.012	0.038	74.983	0.044	75.012	0.039	75.013	0.045	71.840	0.760	75.956	0.033	67.473	0.490	75.005	0.044	73.658	2.744
Fishery_Logit(top)	-9.650	9.886	-9.745	7.227	-9.701	8.331	-9.742	7.450	-9.627	9.879	-9.939	1.889	-9.926	2.276	-9.714	8.161	-9.764	7.306
Fishery_Ln(SD1)	5.902	0.026	5.910	0.028	5.904	0.026	5.914	0.028	5.850	0.043	5.968	0.034	5.750	0.050	5.908	0.028	5.888	0.072
Fishery_Ln(SD2)	-9.952	1.488	-9.844	4.711	-9.932	2.094	-9.899	3.060	4.139	0.476	-8.651	12.381	4.669	0.120	-9.903	3.168	-5.518	8.430
Fishery_Logit(start)	-10	_	-10	_	-10	_	-10	_	-10	_	-10	_	-10	_	n/a	n/a	n/a	n/a
Fishery_Logit(end)	2.005	0.276	2.145	0.314	2.060	0.289	2.232	0.349	0.662	0.348	1.558	0.298	-0.544	0.247	2.122	0.324	1.445	0.985
EBSsrv_Begin_top	21.038	0.799			20.948	0.840									20.989	0.823	20.989	0.823
EBSsrv_Logit(top)	10	_			10	_									n/a	n/a	n/a	n/a
EBSsrv_Ln(SD1)	3.529	0.152			3.507	0.161									3.517	0.157	3.517	0.157
EBSsrv_Ln(SD2)	10	_			10	_									n/a	n/a	n/a	n/a
EBSsrv_Logit(start)	-10	_			-10	_									n/a	n/a	n/a	n/a
EBSsrv_Logit(end)	10	_			10	_									n/a	n/a	n/a	n/a
NBSsrv_Begin_top	79.998	0.073			79.997	0.099									79.997	0.088	79.997	0.088
NBSsrv_Logit(top)	10	_			10	_									n/a	n/a	n/a	n/a
NBSsrv_Ln(SD1)	7.923	0.167			7.908	0.163									7.915	0.165	7.915	0.165
NBSsrv_Ln(SD2)	10	_			10	_									n/a	n/a	n/a	n/a
NBSsrv_Logit(start)	-10	_			-10	_									n/a	n/a	n/a	n/a
NBSsrv_Logit(end)	10	_			10	_									n/a	n/a	n/a	n/a
XBSsrv_Begin_top			20.903	0.781			20.782	0.821	20.678	0.819	20.613	0.850	19.737	0.702	20.839	0.805	20.565	0.891
XBSsrv_Logit(top)			10	_			10	_	-1.346	0.221	10	_	-1.610	0.180	n/a	n/a	2.612	5.491
XBSsrv_Ln(SD1)			3.526	0.152			3.496	0.160	3.510	0.163	3.461	0.168	3.366	0.147	3.510	0.157	3.474	0.168
XBSsrv_Ln(SD2)			10	_			10	_	7.314	0.459	10	_	6.962	0.170	n/a	n/a	7.156	0.400
XBSsrv_Logit(start)			-10	_			-10	_	-10	_	-10	_	-10	_	n/a	n/a	n/a	n/a
XBSsrv_Logit(end)			10	_			10	_	-0.859	0.578	10	_	-2.664	0.364	n/a	n/a	-1.668	1.025

Table 2.22c—Age composition devs in the initial year (1977).

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ensemble A		Ensemble AB	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
ln(InitN)_offset_at_20	-0.010	0.679	-0.014	0.685	-0.011	0.670	-0.016	0.670	-0.069	0.657	-0.025	0.660	-0.248	0.599	-0.013	0.676	-0.055	0.666
ln(InitN)_offset_at_19	-0.006	0.681	-0.008	0.687	-0.006	0.671	-0.009	0.673	-0.029	0.669	-0.013	0.663	-0.074	0.640	-0.008	0.678	-0.021	0.670
ln(InitN)_offset_at_18	-0.009	0.680	-0.012	0.685	-0.010	0.670	-0.014	0.671	-0.040	0.666	-0.020	0.661	-0.091	0.635	-0.012	0.676	-0.028	0.668
ln(InitN)_offset_at_17	-0.014	0.678	-0.020	0.683	-0.016	0.668	-0.022	0.668	-0.054	0.661	-0.029	0.658	-0.110	0.630	-0.019	0.674	-0.038	0.665
ln(InitN)_offset_at_16	-0.023	0.675	-0.029	0.680	-0.025	0.665	-0.034	0.665	-0.074	0.656	-0.043	0.654	-0.134	0.624	-0.028	0.671	-0.052	0.661
ln(InitN)_offset_at_15	-0.036	0.671	-0.047	0.675	-0.038	0.661	-0.051	0.660	-0.099	0.648	-0.064	0.648	-0.162	0.617	-0.044	0.666	-0.072	0.656
ln(InitN)_offset_at_14	-0.055	0.665	-0.068	0.668	-0.059	0.655	-0.077	0.652	-0.132	0.639	-0.092	0.640	-0.194	0.609	-0.066	0.660	-0.098	0.649
ln(InitN)_offset_at_13	-0.083	0.657	-0.102	0.658	-0.089	0.647	-0.113	0.642	-0.174	0.628	-0.131	0.630	-0.230	0.600	-0.098	0.651	-0.133	0.639
ln(InitN)_offset_at_12	-0.124	0.646	-0.148	0.646	-0.131	0.635	-0.162	0.630	-0.225	0.616	-0.182	0.617	-0.272	0.590	-0.143	0.639	-0.180	0.627
ln(InitN)_offset_at_11	-0.180	0.632	-0.212	0.631	-0.189	0.621	-0.227	0.615	-0.287	0.602	-0.247	0.602	-0.317	0.581	-0.204	0.624	-0.240	0.613
ln(InitN)_offset_at_10	-0.252	0.615	-0.287	0.613	-0.263	0.604	-0.308	0.597	-0.358	0.587	-0.325	0.586	-0.368	0.570	-0.280	0.607	-0.312	0.597
ln(InitN)_offset_at_09	-0.340	0.596	-0.381	0.594	-0.353	0.586	-0.402	0.579	-0.437	0.572	-0.415	0.569	-0.421	0.560	-0.372	0.588	-0.396	0.580
ln(InitN)_offset_at_08	-0.437	0.576	-0.478	0.575	-0.451	0.567	-0.502	0.560	-0.518	0.557	-0.509	0.552	-0.476	0.549	-0.470	0.569	-0.485	0.562
ln(InitN)_offset_at_07	-0.530	0.558	-0.566	0.557	-0.545	0.548	-0.593	0.542	-0.590	0.543	-0.596	0.535	-0.523	0.539	-0.562	0.551	-0.566	0.547
ln(InitN)_offset_at_06	-0.589	0.544	-0.623	0.544	-0.602	0.534	-0.644	0.529	-0.624	0.533	-0.645	0.523	-0.540	0.532	-0.617	0.538	-0.611	0.535
ln(InitN)_offset_at_05	-0.546	0.541	-0.565	0.542	-0.557	0.531	-0.588	0.527	-0.554	0.534	-0.591	0.522	-0.467	0.534	-0.566	0.535	-0.553	0.534
ln(InitN)_offset_at_04	-0.257	0.556	-0.267	0.558	-0.262	0.546	-0.280	0.542	-0.239	0.549	-0.293	0.537	-0.167	0.545	-0.267	0.550	-0.251	0.549
ln(InitN)_offset_at_03	0.219	0.494	0.208	0.497	0.205	0.485	0.178	0.484	0.193	0.486	0.127	0.493	0.170	0.489	0.201	0.490	0.186	0.491
ln(InitN)_offset_at_02	-0.083	0.572	-0.086	0.576	-0.084	0.563	-0.097	0.562	-0.128	0.564	-0.092	0.559	-0.148	0.550	-0.088	0.568	-0.102	0.565
ln(InitN)_offset_at_01	0.760	0.563	0.783	0.557	0.776	0.559	0.797	0.541	0.811	0.514	0.844	0.534	0.859	0.461	0.781	0.554	0.811	0.534

Table 2.22d—Age 0 ln(recruitment) devs.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1.02	0.22	1.00	0.22	0.99	0.23	0.92	0.23	1.02	0.25	0.93	0.24	1.02	0.30	0.98	0.23	0.98	0.24
1978	0.62	0.24	0.57	0.25	0.64	0.23	0.56	0.23	0.59	0.25	0.50	0.25	0.57	0.26	0.59	0.24	0.57	0.25
1979	0.65	0.13	0.62	0.13	0.65	0.13	0.58	0.13	0.57	0.13	0.54	0.13	0.45	0.14	0.62	0.13	0.58	0.15
1980	-0.81	0.23	-0.80	0.23	-0.83	0.24	-0.85	0.24	-0.81	0.24	-0.91	0.25	-0.75	0.22	-0.83	0.24	-0.83	0.24
1981	-0.65	0.16	-0.68	0.17	-0.64	0.17	-0.68	0.17	-0.70	0.17	-0.72	0.17	-0.80	0.17	-0.67	0.17	-0.70	0.18
1982	0.90	0.05	0.88	0.05	0.93	0.06	0.88	0.06	0.86	0.06	0.87	0.06	0.79	0.06	0.90	0.06	0.87	0.07
1983	-0.39	0.15	-0.43	0.15	-0.46	0.16	-0.50	0.16	-0.49	0.15	-0.58	0.17	-0.54	0.15	-0.45	0.16	-0.49	0.17
1984	0.80	0.06	0.77	0.06	0.81	0.06	0.77	0.06	0.72	0.06	0.75	0.06	0.65	0.06	0.79	0.06	0.75	0.08
1985	0.00	0.09	-0.02	0.09	0.05	0.09	0.01	0.09	-0.03	0.09	-0.07	0.09	-0.07	0.09	0.01	0.09	-0.02	0.10
1986	-0.59	0.11	-0.62	0.11	-0.53	0.11	-0.56	0.11	-0.61	0.11	-0.60	0.11	-0.64	0.11	-0.57	0.11	-0.59	0.12
1987	-1.78	0.23	-1.79	0.23	-1.63	0.23	-1.64	0.23	-1.69	0.22	-1.65	0.23	-1.67	0.21	-1.70	0.24	-1.69	0.23
1988	-0.25	0.09	-0.25	0.09	-0.22	0.09	-0.23	0.09	-0.30	0.09	-0.21	0.09	-0.32	0.09	-0.24	0.09	-0.25	0.10
1989	0.44	0.06	0.44	0.06	0.46	0.06	0.45	0.06	0.42	0.06	0.43	0.06	0.44	0.06	0.45	0.06	0.44	0.06
1990	0.44	0.07	0.42	0.07	0.43	0.07	0.41	0.07	0.38	0.07	0.38	0.07	0.33	0.07	0.42	0.07	0.40	0.08
1991	-0.12	0.09	-0.11	0.09	-0.18	0.10	-0.19	0.10	-0.18	0.10	-0.26	0.12	-0.19	0.09	-0.15	0.10	-0.18	0.11
1992	0.89	0.04	0.88	0.04	0.82	0.04	0.80	0.05	0.79	0.05	0.78	0.05	0.76	0.05	0.84	0.06	0.81	0.06
1993	-0.07	0.07	-0.11	0.08	-0.06	0.07	-0.10	0.08	-0.08	0.08	-0.19	0.08	-0.10	0.08	-0.09	0.08	-0.10	0.09
1994	-0.26	0.07	-0.28	0.07	-0.26	0.07	-0.29	0.07	-0.30	0.08	-0.38	0.08	-0.32	0.08	-0.28	0.07	-0.30	0.08
1995	-0.43	0.08	-0.43	0.08	-0.39	0.08	-0.41	0.08	-0.40	0.08	-0.54	0.09	-0.51	0.09	-0.41	0.08	-0.44	0.10
1996	0.76	0.04	0.74	0.04	0.78	0.04	0.75	0.04	0.75	0.05	0.58	0.04	0.57	0.04	0.76	0.05	0.70	0.09
1997	-0.06	0.07	-0.08	0.07	-0.03	0.07	-0.05	0.07	-0.06	0.07	-0.23	0.08	-0.23	0.08	-0.06	0.08	-0.11	0.11
1998	-0.34	0.09	-0.36	0.09	-0.28	0.09	-0.31	0.09	-0.36	0.09	-0.50	0.10	-0.53	0.09	-0.32	0.09	-0.39	0.13
1999	0.57	0.05	0.54	0.05	0.56	0.05	0.52	0.05	0.48	0.05	0.45	0.05	0.35	0.05	0.54	0.05	0.49	0.08
2000	0.21	0.05	0.21	0.05	0.25	0.05	0.22	0.05	0.24	0.06	0.28	0.05	0.26	0.05	0.22	0.06	0.24	0.06
2001	-0.62	0.10	-0.69	0.10	-0.58	0.10	-0.67	0.10	-0.70	0.10	-0.58	0.11	-0.69	0.10	-0.64	0.11	-0.65	0.12
2002	-0.18	0.06	-0.19	0.06	-0.12	0.06	-0.16	0.06	-0.15	0.06	0.08	0.06	0.02	0.06	-0.16	0.07	-0.10	0.12
2003	-0.21	0.06	-0.25	0.07	-0.17	0.07	-0.23	0.07	-0.23	0.07	0.03	0.07	0.03	0.07	-0.22	0.07	-0.15	0.13
2004	-0.52	0.08	-0.57	0.08	-0.46	0.08	-0.52	0.08	-0.53	0.08	-0.25	0.09	-0.23	0.08	-0.52	0.09	-0.44	0.16
2005	-0.35	0.08	-0.37	0.08	-0.30	0.07	-0.31	0.07	-0.32	0.08	-0.16	0.08	-0.08	0.08	-0.33	0.08	-0.27	0.12
2006	0.68	0.04	0.71	0.04	0.75	0.04	0.77	0.04	0.78	0.05	0.84	0.04	0.93	0.04	0.73	0.05	0.78	0.08
2007	-0.24	0.09	-0.22	0.09	-0.18	0.09	-0.17	0.09	-0.14	0.09	-0.23	0.09	-0.11	0.09	-0.20	0.09	-0.18	0.10
2008	1.04	0.04	1.09	0.04	1.02	0.04	1.06	0.04	1.07	0.04	0.98	0.04	1.07	0.04	1.06	0.05	1.05	0.05
2009	-0.68	0.13	-0.90	0.16	-0.70	0.13	-0.90	0.16	-0.86	0.16	-1.01	0.17	-0.95	0.16	-0.81	0.18	-0.87	0.19
2010	0.56	0.05	0.62	0.05	0.55	0.05	0.63	0.05	0.62	0.06	0.59	0.05	0.53	0.05	0.59	0.06	0.59	0.06
2011	0.79	0.05	0.86	0.05	0.77	0.05	0.86	0.05	0.91	0.06	0.81	0.05	0.86	0.05	0.83	0.06	0.84	0.07
2012	0.03	0.08	0.12	0.09	-0.05	0.09	0.06	0.09	0.07	0.09	0.01	0.11	-0.11	0.12	0.04	0.11	0.02	0.12
2013	0.91	0.04	1.11	0.04	0.84	0.05	1.08	0.05	1.10	0.05	1.14	0.04	1.11	0.05	0.99	0.12	1.05	0.11
2014	-0.80	0.11	-0.63	0.11	-0.84	0.11	-0.63	0.11	-0.58	0.11	-0.54	0.12	-0.49	0.12	-0.72	0.15	-0.64	0.16
2015	-0.50	0.07	-0.35	0.07	-0.53	0.08	-0.34	0.08	-0.32	0.08	-0.15	0.08	-0.23	0.08	-0.42	0.11	-0.34	0.15
2016	-0.97	0.10	-0.83	0.11	-1.08	0.11	-0.91	0.11	-0.87	0.11	-0.69	0.11	-0.71	0.11	-0.94	0.14	-0.86	0.17
2017	-1.16	0.18	-1.19	0.20	-1.29	0.18	-1.24	0.21	-1.21	0.20	-1.21	0.22	-1.15	0.21	-1.22	0.20	-1.21	0.21
2018	0.65	0.07	0.59	0.07	0.54	0.09	0.56	0.09	0.56	0.09	0.68	0.09	0.64	0.09	0.58	0.09	0.60	0.10

Table 2.22e—Length at age 1.5 devs.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.30	0.96	0.40	0.96	0.27	0.96	0.34	0.96	0.04	0.97	0.68	0.97	-0.07	0.98	0.33	0.96	0.29	0.99
1978	-0.11	0.94	-0.11	0.95	-0.12	0.94	-0.12	0.94	-0.18	0.94	-0.10	0.95	-0.26	0.94	-0.11	0.94	-0.14	0.94
1979	0.47	1.01	0.45	1.01	0.50	1.00	0.47	1.01	0.37	1.00	0.47	1.03	0.25	0.99	0.47	1.01	0.43	1.01
1980	-0.05	0.93	-0.04	0.94	-0.07	0.91	-0.07	0.92	-0.10	0.92	-0.04	0.94	-0.14	0.93	-0.06	0.93	-0.07	0.93
1981	-1.08	0.46	-1.05	0.47	-1.10	0.46	-1.12	0.48	-1.13	0.49	-1.10	0.48	-1.06	0.53	-1.09	0.47	-1.09	0.48
1982	-0.89	0.30	-0.88	0.30	-0.92	0.31	-0.95	0.31	-0.89	0.32	-1.00	0.32	-0.77	0.33	-0.91	0.31	-0.91	0.32
1983	0.84	0.72	0.77	0.72	1.05	0.74	1.07	0.77	0.94	0.68	1.16	0.84	0.77	0.67	0.94	0.75	0.95	0.75
1984	0.42	0.23	0.45	0.23	0.36	0.23	0.39	0.23	0.32	0.24	0.48	0.24	0.30	0.25	0.41	0.23	0.39	0.24
1985	-1.45	0.42	-1.49	0.43	-1.53	0.42	-1.59	0.44	-1.68	0.44	-1.59	0.43	-1.71	0.46	-1.52	0.43	-1.58	0.44
1986	0.12	0.26	0.13	0.27	0.13	0.26	0.13	0.27	0.12	0.27	0.16	0.28	0.13	0.27	0.13	0.27	0.13	0.27
1987	-0.48	0.43	-0.53	0.44	-0.43	0.41	-0.49	0.44	-0.44	0.42	-0.56	0.46	-0.40	0.42	-0.49	0.43	-0.48	0.44
1988	-0.87	0.46	-0.93	0.43	-0.78	0.41	-0.86	0.43	-0.69	0.44	-0.93	0.45	-0.62	0.42	-0.86	0.43	-0.81	0.45
1989	-0.83	0.27	-0.86	0.28	-0.78	0.27	-0.82	0.28	-0.87	0.29	-0.81	0.28	-0.85	0.31	-0.82	0.28	-0.83	0.28
1990	-0.06	0.31	-0.06	0.31	-0.02	0.29	-0.04	0.31	-0.06	0.31	-0.01	0.31	-0.02	0.31	-0.04	0.30	-0.04	0.31
1991	0.45	0.24	0.48	0.25	0.51	0.25	0.55	0.26	0.55	0.26	0.67	0.30	0.72	0.27	0.50	0.25	0.57	0.28
1992	0.01	0.23	0.03	0.23	-0.01	0.23	-0.01	0.23	-0.01	0.24	-0.01	0.24	0.04	0.25	0.00	0.23	0.01	0.23
1993	0.48	0.34	0.51	0.35	0.34	0.36	0.33	0.37	0.53	0.37	0.26	0.39	0.50	0.36	0.41	0.37	0.42	0.38
1994	-0.20	0.27	-0.22	0.28	-0.11	0.27	-0.14	0.28	-0.14	0.27	-0.10	0.29	-0.20	0.27	-0.17	0.28	-0.16	0.28
1995	-0.24	0.34	-0.25	0.35	-0.13	0.35	-0.18	0.35	-0.13	0.36	-0.16	0.37	-0.10	0.35	-0.20	0.35	-0.17	0.36
1996	-0.09	0.25	-0.06	0.26	-0.05	0.25	-0.05	0.26	-0.06	0.26	0.00	0.26	-0.10	0.27	-0.06	0.26	-0.06	0.26
1997	-0.18	0.31	-0.20	0.32	-0.13	0.30	-0.16	0.31	-0.14	0.32	-0.28	0.33	-0.96	0.39	-0.17	0.31	-0.29	0.42
1998	-0.78	0.30	-0.74	0.31	-0.74	0.29	-0.72	0.30	-0.61	0.28	-0.69	0.31	-0.56	0.27	-0.74	0.30	-0.69	0.30
1999	-1.30	0.26	-1.32	0.26	-1.22	0.25	-1.26	0.26	-1.25	0.26	-1.39	0.27	-1.22	0.28	-1.27	0.26	-1.28	0.27
2000	0.89	0.23	0.91	0.24	0.73	0.23	0.76	0.24	0.75	0.24	0.56	0.24	0.74	0.25	0.82	0.25	0.76	0.26
2001	0.33	0.26	0.37	0.27	0.31	0.26	0.35	0.27	0.39	0.27	0.15	0.28	0.41	0.27	0.34	0.27	0.33	0.28
2002	0.66	0.23	0.72	0.23	0.64	0.23	0.69	0.23	0.66	0.24	0.55	0.24	0.57	0.24	0.68	0.23	0.64	0.24
2003	0.12	0.29	0.16	0.29	0.15	0.28	0.17	0.29	0.13	0.30	0.03	0.31	0.07	0.32	0.15	0.29	0.12	0.30
2004	1.28	0.23	1.40	0.24	1.23	0.23	1.34	0.24	1.36	0.25	1.41	0.24	1.36	0.25	1.32	0.25	1.34	0.25
2005	-0.18	0.27	-0.19	0.28	-0.16	0.27	-0.18	0.28	-0.22	0.29	-0.10	0.29	-0.24	0.30	-0.18	0.27	-0.18	0.29
2006	-0.22	0.21	-0.27	0.22	-0.22	0.21	-0.28	0.22	-0.31	0.22	-0.22	0.22	-0.20	0.23	-0.25	0.21	-0.25	0.22
2007	-1.08	0.29	-1.15	0.30	-0.98	0.29	-1.05	0.31	-1.08	0.31	-0.77	0.33	-0.70	0.34	-1.07	0.30	-0.97	0.35
2008	-1.28	0.23	-1.31	0.25	-1.19	0.23	-1.23	0.23	-1.19	0.24	-1.01	0.24	-0.87	0.24	-1.25	0.24	-1.15	0.28
2009	-0.57	0.34	-0.63	0.38	-0.62	0.33	-0.76	0.38	-0.61	0.38	-0.84	0.40	-0.47	0.39	-0.65	0.37	-0.65	0.39
2010	0.31	0.21	0.37	0.21	0.27	0.20	0.30	0.21	0.29	0.21	0.37	0.21	0.39	0.22	0.31	0.21	0.33	0.21
2011	-1.11	0.27	-1.22	0.27	-1.06	0.27	-1.20	0.28	-1.29	0.28	-1.14	0.29	-1.21	0.29	-1.15	0.28	-1.18	0.29
2012	0.09	0.30	0.18	0.31	0.15	0.31	0.26	0.31	0.38	0.31	0.10	0.33	0.26	0.32	0.18	0.31	0.21	0.33
2013	-0.19	0.22	-0.27	0.23	-0.23	0.22	-0.33	0.23	-0.33	0.23	-0.41	0.24	-0.42	0.24	-0.26	0.23	-0.32	0.24
2014	0.25	0.38	0.26	0.40	0.19	0.38	0.18	0.40	0.23	0.40	-0.18	0.44	-0.05	0.42	0.21	0.40	0.12	0.44
2015	1.68	0.21	1.75	0.22	1.65	0.21	1.74	0.22	1.76	0.22	1.67	0.22	1.70	0.22	1.71	0.22	1.71	0.22
2016	2.03	0.29	1.80	0.33	2.15	0.28	1.89	0.32	1.97	0.34	1.82	0.34	2.01	0.36	1.96	0.34	1.94	0.35
2017	1.70	0.27	1.31	0.33	1.73	0.27	1.32	0.33	1.34	0.34	1.47	0.34	1.46	0.36	1.49	0.36	1.46	0.36
2018	2.43	0.19	2.52	0.19	2.31	0.19	2.46	0.19	2.53	0.19	2.55	0.19	2.69	0.20	2.43	0.20	2.50	0.22
2019	-1.26	0.90	-1.00	0.94	-1.66	0.83	-0.98	0.94	-1.07	0.94	-0.72	0.98	-1.10	1.00	-1.21	0.95	-1.09	0.98

Table 2.22f—Log catchability devs. (Note that Model 20.10 lacks devs for the fishery because they were "tuned out" of the model during the tuning process—see main text.)

	EBS survey		NBS survey		Fishery		XBS survey									
	19.15		19.15		20.9		19.12		20.8		20.9		20.10		Ensemble B	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.06	0.71	-1.34	0.58			0.11	0.70	-0.46	0.73	0.38	0.66	-0.40	0.72	-0.08	0.78
1983	0.60	0.74	0.00	1.00			0.81	0.74	0.58	0.75	1.03	0.70	0.88	0.72	0.82	0.74
1984	-0.96	0.67	0.00	1.00			-0.87	0.67	-1.03	0.68	-0.62	0.62	-0.74	0.65	-0.82	0.67
1985	1.01	0.67	-0.96	0.68			1.01	0.66	1.03	0.67	1.16	0.61	1.37	0.63	1.13	0.66
1986	0.44	0.64	0.00	1.00			0.36	0.63	0.69	0.65	0.62	0.58	1.29	0.62	0.71	0.70
1987	0.10	0.61	0.00	1.00			0.22	0.62	0.48	0.63	0.55	0.56	0.89	0.60	0.52	0.65
1988	-0.16	0.61	-2.15	0.68			-0.40	0.60	-0.08	0.63	-0.05	0.54	0.33	0.61	-0.07	0.65
1989	-1.74	0.63	0.00	1.00			-1.87	0.63	-1.69	0.66	-1.55	0.57	-1.67	0.68	-1.70	0.65
1990	-0.87	0.70	0.00	1.00			-1.03	0.69	-0.39	0.71	-0.93	0.65	-0.01	0.66	-0.62	0.79
1991	-1.15	0.70	-0.60	0.66	-0.82	0.96	-1.16	0.69	-0.96	0.71	-1.03	0.64	-1.13	0.66	-1.07	0.68
1992	-1.19	0.71	0.00	1.00	0.82	0.93	-1.34	0.70	-1.10	0.71	-1.22	0.68	-0.96	0.65	-1.17	0.70
1993	0.61	0.71	0.00	1.00	-0.24	0.98	0.64	0.71	0.70	0.72	0.85	0.66	0.69	0.66	0.72	0.70
1994	4.24	0.64	0.00	1.00	0.00	0.96	4.00	0.63	4.05	0.65	4.09	0.58	3.80	0.60	3.99	0.63
1995	2.00	0.62	0.00	1.00	1.25	0.89	1.77	0.62	1.63	0.63	1.99	0.57	1.39	0.59	1.71	0.64
1996	1.92	0.65	0.00	1.00	-1.17	0.94	2.04	0.68	1.93	0.69	2.28	0.63	1.75	0.65	2.02	0.69
1997	-0.29	0.65	0.00	1.00	1.29	0.84	-0.15	0.67	-0.34	0.68	0.28	0.62	-0.26	0.63	-0.11	0.69
1998	-0.48	0.69	0.00	1.00	0.64	0.86	-0.03	0.71	-0.36	0.72	0.69	0.66	0.16	0.66	0.11	0.79
1999	-0.31	0.67	0.00	1.00	0.60	0.90	-0.51	0.66	-0.68	0.67	0.59	0.61	0.10	0.62	-0.14	0.82
2000	-1.59	0.63	0.00	1.00	-0.43	0.94	-1.58	0.63	-1.49	0.65	-0.26	0.59	-0.18	0.59	-0.91	0.90
2001	1.86	0.64	0.00	1.00	-0.83	0.92	1.90	0.64	2.19	0.65	2.73	0.60	3.24	0.60	2.48	0.80
2002	-0.57	0.65	0.00	1.00	-0.55	0.91	-0.31	0.66	-0.29	0.67	0.14	0.61	0.28	0.62	-0.06	0.69
2003	-0.03	0.68	0.00	1.00	-2.35	0.91	0.46	0.71	0.49	0.72	0.60	0.66	0.75	0.67	0.57	0.70
2004	-1.29	0.64	0.00	1.00	-1.22	0.92	-0.96	0.65	-0.90	0.66	-1.50	0.60	-1.21	0.62	-1.14	0.68
2005	-0.49	0.65	0.00	1.00	-2.13	0.91	-0.06	0.65	0.08	0.65	-1.37	0.60	-1.00	0.59	-0.57	0.88
2006	-1.05	0.65	0.00	1.00	0.87	0.82	-1.01	0.64	-0.64	0.65	-2.61	0.58	-1.88	0.60	-1.52	1.00
2007	-0.92	0.68	0.00	1.00	0.04	0.85	-1.01	0.67	-0.66	0.69	-1.95	0.62	-1.54	0.64	-1.28	0.83
2008	-2.22	0.66	0.00	1.00	0.52	0.85	-2.53	0.65	-2.46	0.67	-3.36	0.60	-3.65	0.61	-2.97	0.81
2009	-1.59	0.68	0.00	1.00	3.14	0.86	-2.13	0.69	-2.29	0.67	-2.65	0.59	-2.89	0.58	-2.47	0.70
2010	0.43	0.63	-3.25	0.55	1.19	0.94	-0.18	0.62	-0.31	0.64	-0.10	0.57	-0.87	0.59	-0.34	0.67
2011	1.04	0.65	0.00	1.00	0.44	0.95	0.65	0.65	0.51	0.66	0.70	0.59	0.18	0.59	0.53	0.65
2012	0.41	0.72	0.00	1.00	0.63	0.93	-0.16	0.72	0.11	0.74	-0.11	0.65	0.55	0.66	0.08	0.74
2013	-0.84	0.65	0.00	1.00	0.05	0.90	-1.60	0.65	-1.95	0.67	-1.33	0.60	-1.84	0.61	-1.67	0.68
2014	2.52	0.70	0.00	1.00	-0.68	0.92	2.00	0.71	1.78	0.73	2.14	0.67	2.05	0.67	1.99	0.71
2015	1.90	0.67	0.00	1.00	0.40	0.93	0.78	0.69	0.49	0.71	0.64	0.63	0.51	0.64	0.61	0.68
2016	1.46	0.66	0.00	1.00	-0.34	0.94	0.89	0.80	0.56	0.81	0.67	0.75	0.33	0.76	0.62	0.80
2017	-1.49	0.68	1.97	0.42	-1.71	0.94	-1.17	0.66	-1.69	0.67	-1.91	0.53	-2.17	0.57	-1.71	0.71
2018	-0.69	0.74	3.21	0.44	-1.92	0.94	1.63	0.76	1.35	0.77	0.64	0.66	0.71	0.70	1.10	0.84
2019	-0.52	0.84	3.13	0.43	-1.02	0.96	0.77	0.80	1.15	0.81	-0.21	0.69	1.15	0.75	0.69	0.95

Table 2.22g (page 1 of 6)—Devs for the log standard deviation of the first normal pdf in the double-normal fishery selectivity function.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.11	0.98	0.13	0.98	0.12	0.98	0.14	0.98	0.12	0.98	0.17	0.96	0.11	0.97	0.13	0.98	0.13	0.97
1978	0.10	0.92	0.11	0.90	0.10	0.92	0.11	0.91	0.10	0.91	0.10	0.86	0.01	0.88	0.11	0.91	0.09	0.90
1979	0.38	0.83	0.39	0.80	0.38	0.83	0.40	0.81	0.49	0.81	0.37	0.75	0.50	0.77	0.39	0.82	0.42	0.80
1980	0.31	0.87	0.33	0.85	0.31	0.88	0.33	0.86	0.49	0.85	0.36	0.80	0.63	0.82	0.32	0.86	0.40	0.85
1981	1.00	0.89	1.05	0.87	0.99	0.89	1.04	0.87	1.13	0.86	1.13	0.83	1.25	0.82	1.02	0.88	1.09	0.86
1982	-0.08	0.94	-0.08	0.93	-0.08	0.95	-0.08	0.94	0.01	0.94	-0.11	0.90	0.10	0.92	-0.08	0.94	-0.05	0.93
1983	0.12	0.85	0.14	0.83	0.12	0.85	0.11	0.83	0.29	0.84	0.11	0.76	0.44	0.80	0.12	0.84	0.19	0.83
1984	0.92	0.64	0.90	0.60	0.93	0.64	0.89	0.61	1.07	0.61	0.75	0.52	1.11	0.55	0.91	0.62	0.93	0.61
1985	-0.24	0.57	-0.18	0.54	-0.21	0.58	-0.20	0.54	-0.12	0.56	-0.17	0.47	-0.12	0.52	-0.20	0.56	-0.18	0.54
1986	0.60	0.59	0.62	0.55	0.63	0.60	0.62	0.56	0.70	0.56	0.51	0.48	0.61	0.51	0.62	0.57	0.61	0.55
1987	-0.19	0.50	-0.13	0.46	-0.15	0.50	-0.13	0.47	-0.11	0.48	-0.13	0.40	-0.17	0.43	-0.15	0.48	-0.14	0.46
1988	2.31	0.71	2.33	0.68	2.27	0.71	2.28	0.69	2.30	0.69	2.17	0.62	2.10	0.65	2.30	0.70	2.25	0.68
1989	1.01	0.82	1.06	0.79	0.98	0.82	1.03	0.79	1.12	0.80	1.05	0.73	1.20	0.75	1.02	0.80	1.07	0.79
1990	0.19	0.64	0.17	0.60	0.16	0.64	0.12	0.61	0.35	0.61	0.08	0.52	0.55	0.55	0.16	0.62	0.23	0.61
1991	-0.05	0.45	-0.06	0.42	-0.02	0.46	-0.04	0.43	-0.04	0.43	-0.35	0.33	-0.24	0.36	-0.04	0.44	-0.12	0.43
1992	-0.45	0.41	-0.40	0.39	-0.34	0.43	-0.30	0.40	-0.30	0.40	0.11	0.30	-0.01	0.34	-0.37	0.41	-0.23	0.43
1993	1.51	0.52	1.44	0.49	1.71	0.54	1.63	0.50	1.55	0.50	1.15	0.36	1.43	0.41	1.57	0.52	1.48	0.51
1994	0.49	0.45	0.46	0.42	0.68	0.46	0.64	0.43	0.51	0.42	0.50	0.31	0.62	0.35	0.57	0.45	0.56	0.42
1995	0.78	0.45	0.75	0.42	0.89	0.45	0.86	0.42	0.67	0.42	1.26	0.30	0.97	0.37	0.82	0.44	0.89	0.44
1996	-0.31	0.46	-0.28	0.42	-0.32	0.46	-0.28	0.43	-0.30	0.43	-0.68	0.28	-0.63	0.34	-0.29	0.44	-0.40	0.44
1997	1.07	0.45	0.98	0.42	0.92	0.45	0.86	0.42	0.85	0.42	1.31	0.30	1.19	0.36	0.95	0.44	1.02	0.44
1998	-0.01	0.41	-0.05	0.38	-0.20	0.41	-0.21	0.38	-0.25	0.38	0.26	0.29	0.14	0.33	-0.13	0.40	-0.05	0.41
1999	0.17	0.36	0.13	0.33	-0.05	0.36	-0.06	0.33	-0.08	0.34	0.51	0.26	0.39	0.29	0.04	0.36	0.14	0.39
2000	-0.15	0.39	-0.17	0.36	-0.36	0.39	-0.37	0.36	-0.24	0.37	-0.17	0.26	-0.21	0.29	-0.27	0.39	-0.24	0.36
2001	-0.28	0.37	-0.28	0.34	-0.36	0.38	-0.36	0.35	-0.34	0.35	-0.59	0.25	-0.61	0.27	-0.32	0.36	-0.41	0.36
2002	0.71	0.35	0.65	0.33	0.74	0.35	0.70	0.33	0.58	0.33	0.08	0.24	0.30	0.26	0.70	0.34	0.53	0.39
2003	0.53	0.36	0.48	0.34	0.51	0.36	0.49	0.34	0.38	0.34	-0.80	0.23	-0.62	0.25	0.50	0.35	0.12	0.63
2004	0.70	0.38	0.64	0.36	0.65	0.39	0.61	0.36	0.47	0.36	-0.59	0.25	-0.33	0.28	0.64	0.37	0.29	0.61
2005	0.63	0.38	0.59	0.35	0.57	0.38	0.55	0.36	0.40	0.36	-0.79	0.25	-0.50	0.28	0.58	0.37	0.19	0.65
2006	-0.03	0.41	0.00	0.38	-0.08	0.42	-0.06	0.39	-0.12	0.39	-0.42	0.26	-0.71	0.31	-0.04	0.40	-0.20	0.44
2007	-0.21	0.44	-0.20	0.41	-0.25	0.45	-0.27	0.41	-0.23	0.42	-0.49	0.28	-0.71	0.34	-0.24	0.43	-0.34	0.43
2008	-0.14	0.37	-0.24	0.34	-0.16	0.37	-0.29	0.34	-0.29	0.34	0.05	0.26	-0.21	0.28	-0.21	0.36	-0.18	0.35
2009	-0.97	0.37	-1.11	0.34	-0.96	0.38	-1.13	0.34	-1.21	0.34	0.56	0.26	-0.26	0.30	-1.05	0.36	-0.71	0.71
2010	-1.48	0.39	-1.58	0.35	-1.42	0.40	-1.52	0.36	-1.53	0.36	-0.08	0.27	-0.49	0.31	-1.50	0.38	-1.15	0.68
2011	-1.41	0.36	-1.43	0.33	-1.22	0.37	-1.25	0.34	-1.28	0.34	-0.21	0.26	-0.51	0.29	-1.32	0.36	-1.03	0.56
2012	-0.50	0.39	-0.50	0.37	-0.35	0.40	-0.39	0.37	-0.37	0.37	0.38	0.27	0.37	0.31	-0.43	0.39	-0.19	0.51
2013	-0.20	0.34	-0.21	0.32	-0.11	0.35	-0.16	0.32	-0.27	0.32	0.06	0.24	0.06	0.26	-0.17	0.33	-0.12	0.33
2014	-1.26	0.34	-1.23	0.31	-1.20	0.35	-1.19	0.32	-1.25	0.32	-0.93	0.23	-1.13	0.25	-1.22	0.33	-1.16	0.32
2015	-1.59	0.34	-1.63	0.31	-1.54	0.35	-1.60	0.32	-1.61	0.32	-1.13	0.23	-1.24	0.26	-1.59	0.33	-1.47	0.36
2016	-1.54	0.37	-1.69	0.34	-1.53	0.38	-1.66	0.35	-1.69	0.35	-1.56	0.24	-1.65	0.27	-1.61	0.37	-1.62	0.34
2017	-1.53	0.46	-1.64	0.42	-1.60	0.47	-1.68	0.43	-1.60	0.45	-2.48	0.26	-2.61	0.31	-1.62	0.45	-1.88	0.59
2018	-0.47	0.53	-0.40	0.50	-0.52	0.54	-0.40	0.51	-0.43	0.52	-1.80	0.32	-1.19	0.43	-0.44	0.52	-0.76	0.71
2019	-0.40	0.58	-0.15	0.56	-0.44	0.59	-0.11	0.57	-0.21	0.58	-1.08	0.42	-0.59	0.53	-0.26	0.59	-0.43	0.64
2020	-0.17	0.58	0.29	0.57	-0.23	0.59	0.33	0.57	0.30	0.57	1.53	0.47	0.70	0.52	0.08	0.63	0.43	0.78

Table 2.22g (page 2 of 6)—Devs for the logit of fishery selectivity at maximum length.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	-0.06	1.02	-0.06	1.02	-0.07	1.02	-0.07	1.02	-0.14	1.02	-0.28	1.18	-0.36	0.96	-0.06	1.02	-0.15	1.05
1978	-0.11	1.03	-0.10	1.03	-0.11	1.03	-0.10	1.03	-0.23	1.02	-0.49	1.20	-0.59	0.87	-0.10	1.03	-0.25	1.06
1979	-0.12	1.03	-0.11	1.03	-0.12	1.04	-0.10	1.03	-0.26	1.02	-0.48	1.17	-0.64	0.85	-0.11	1.03	-0.26	1.05
1980	0.01	1.00	0.00	1.00	0.01	1.00	0.00	1.00	-0.05	1.00	0.01	0.97	-0.19	0.90	0.00	1.00	-0.03	0.98
1981	-0.02	1.00	-0.01	1.00	-0.01	1.00	-0.01	1.00	-0.05	1.00	-0.02	1.00	-0.24	0.94	-0.01	1.00	-0.05	1.00
1982	0.06	0.98	0.06	0.98	0.06	0.98	0.05	0.98	0.05	0.98	0.15	0.91	0.11	0.91	0.06	0.98	0.08	0.96
1983	0.27	0.91	0.24	0.92	0.26	0.91	0.22	0.93	0.30	0.92	0.47	0.76	0.49	0.72	0.24	0.92	0.32	0.88
1984	0.43	0.86	0.39	0.87	0.42	0.86	0.37	0.88	0.54	0.85	0.66	0.70	0.66	0.56	0.40	0.87	0.50	0.81
1985	0.14	0.90	0.11	0.91	0.11	0.90	0.10	0.92	0.11	0.82	0.29	0.69	0.27	0.44	0.12	0.91	0.16	0.82
1986	-0.03	0.93	-0.07	0.95	-0.06	0.94	-0.06	0.96	-0.19	0.82	0.05	0.66	-0.04	0.42	-0.06	0.95	-0.06	0.84
1987	0.24	0.86	0.14	0.89	0.19	0.87	0.13	0.90	-0.18	0.73	0.17	0.61	0.03	0.35	0.17	0.88	0.09	0.78
1988	0.09	0.94	0.05	0.95	0.10	0.94	0.07	0.95	-0.23	0.90	0.24	0.77	-0.23	0.52	0.08	0.95	0.01	0.88
1989	0.34	0.89	0.29	0.90	0.33	0.89	0.27	0.91	0.40	0.87	0.54	0.73	0.62	0.60	0.30	0.90	0.40	0.84
1990	0.90	0.78	0.82	0.80	0.86	0.78	0.77	0.80	1.18	0.75	0.99	0.63	1.05	0.46	0.83	0.79	0.94	0.74
1991	0.49	0.82	0.44	0.83	0.47	0.82	0.42	0.84	0.58	0.71	-0.39	0.25	0.15	0.22	0.45	0.83	0.30	0.76
1992	-0.04	0.87	-0.08	0.90	-0.11	0.88	-0.12	0.92	-0.05	0.69	1.06	0.58	0.52	0.22	-0.09	0.89	0.18	0.87
1993	0.07	0.93	0.05	0.94	-0.01	0.94	-0.03	0.96	-0.34	0.83	-0.64	0.27	-0.31	0.22	0.02	0.95	-0.19	0.83
1994	0.12	0.91	0.08	0.92	0.04	0.92	-0.01	0.95	-0.44	0.79	-0.21	0.35	0.03	0.21	0.05	0.93	-0.07	0.79
1995	0.05	0.91	0.02	0.93	-0.01	0.92	-0.04	0.95	-0.28	0.80	0.99	0.61	0.74	0.24	0.00	0.93	0.21	0.92
1996	0.83	0.79	0.76	0.80	0.76	0.79	0.67	0.82	1.13	0.75	-0.11	0.35	-0.38	0.22	0.75	0.80	0.52	0.85
1997	0.51	0.83	0.46	0.84	0.48	0.83	0.40	0.86	0.67	0.76	1.13	0.59	0.72	0.23	0.46	0.84	0.63	0.78
1998	0.29	0.85	0.26	0.86	0.34	0.84	0.28	0.87	0.43	0.76	0.80	0.58	0.30	0.21	0.29	0.86	0.40	0.77
1999	0.04	0.84	0.04	0.86	0.22	0.83	0.18	0.87	0.40	0.72	0.60	0.52	0.21	0.20	0.13	0.86	0.26	0.75
2000	-0.03	0.85	-0.02	0.88	0.23	0.84	0.19	0.87	0.39	0.72	-0.58	0.25	-0.76	0.20	0.10	0.87	-0.08	0.82
2001	-0.80	0.83	-0.77	0.89	-0.36	0.88	-0.36	0.94	-0.59	0.68	-1.08	0.23	-1.33	0.23	-0.56	0.91	-0.75	0.80
2002	-1.26	0.71	-1.25	0.77	-0.92	0.79	-0.87	0.89	-1.13	0.64	-1.02	0.23	-0.71	0.20	-1.06	0.82	-1.02	0.68
2003	-0.27	0.79	-0.27	0.83	-0.13	0.81	-0.14	0.86	-0.29	0.64	-1.02	0.22	-1.22	0.22	-0.20	0.83	-0.48	0.79
2004	-0.04	0.82	-0.09	0.85	-0.02	0.82	-0.09	0.87	0.14	0.67	-0.47	0.26	-0.22	0.20	-0.07	0.84	-0.12	0.72
2005	0.25	0.81	0.20	0.83	0.26	0.81	0.19	0.85	0.36	0.68	-0.38	0.27	-0.04	0.20	0.22	0.83	0.11	0.72
2006	0.77	0.78	0.69	0.80	0.76	0.78	0.67	0.80	1.33	0.71	1.44	0.56	1.15	0.24	0.72	0.79	0.99	0.76
2007	0.61	0.80	0.53	0.82	0.61	0.80	0.53	0.83	1.21	0.73	1.14	0.58	0.99	0.23	0.56	0.82	0.82	0.77
2008	-0.31	0.85	-0.38	0.89	-0.30	0.86	-0.31	0.91	0.04	0.70	0.85	0.56	1.12	0.24	-0.33	0.88	0.11	0.94
2009	-0.89	0.86	-0.79	0.94	-0.95	0.85	-0.76	0.98	-0.98	0.68	1.45	0.56	1.84	0.37	-0.84	0.92	-0.14	1.38
2010	-1.11	0.93	-0.69	1.03	-1.23	0.91	-0.71	1.07	-1.17	0.77	0.30	0.51	0.49	0.24	-0.91	1.02	-0.57	1.05
2011	-0.14	0.93	-0.02	0.93	-0.20	0.95	-0.04	0.95	-0.45	0.83	-0.62	0.30	-0.45	0.26	-0.09	0.94	-0.28	0.82
2012	-0.07	0.92	0.04	0.92	-0.19	0.94	-0.06	0.95	-0.33	0.86	-0.61	0.32	-0.39	0.27	-0.07	0.94	-0.24	0.82
2013	-0.60	0.91	-0.47	0.96	-0.89	0.88	-0.71	0.99	-0.97	0.77	-1.16	0.24	-1.10	0.27	-0.67	0.95	-0.85	0.81
2014	-0.74	0.82	-0.72	0.87	-0.96	0.77	-0.93	0.87	-0.84	0.71	-1.19	0.23	-1.73	0.30	-0.84	0.84	-1.01	0.76
2015	-0.34	0.87	-0.36	0.90	-0.45	0.87	-0.46	0.93	-0.45	0.72	-0.70	0.25	-0.79	0.22	-0.41	0.90	-0.51	0.75
2016	-0.01	0.88	0.05	0.90	-0.02	0.89	0.02	0.91	-0.25	0.78	-0.80	0.26	-0.92	0.24	0.01	0.90	-0.28	0.84
2017	0.39	0.84	0.47	0.84	0.37	0.84	0.41	0.85	0.35	0.80	-1.01	0.24	-1.46	0.29	0.41	0.84	-0.08	1.03
2018	0.27	0.86	0.34	0.86	0.29	0.86	0.31	0.87	0.34	0.80	-0.98	0.25	-0.54	0.26	0.30	0.86	-0.01	0.89
2019	-0.37	0.91	-0.38	0.94	-0.29	0.91	-0.37	0.96	-0.36	0.78	-0.89	0.25	0.05	0.26	-0.35	0.94	-0.39	0.81
2020	0.20	0.89	0.09	0.92	0.26	0.88	0.07	0.93	0.31	0.82	1.78	0.54	3.15	0.47	0.15	0.91	0.83	1.34

Table 2.22g (page 3 of 6)—Devs for the first size at which EBS survey selectivity reaches 1.0.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.22	0.42			-0.22	0.43									-0.22	0.42	-0.22	0.42
1983	-0.22	0.48			-0.09	0.49									-0.15	0.49	-0.15	0.49
1984	1.19	0.39			1.14	0.38									1.16	0.39	1.16	0.39
1985	0.46	0.27			0.50	0.27									0.48	0.27	0.48	0.27
1986	-0.42	0.53			-0.39	0.51									-0.41	0.52	-0.41	0.52
1987	0.03	0.35			0.08	0.35									0.06	0.35	0.06	0.35
1988	0.04	0.53			0.16	0.52									0.11	0.53	0.11	0.53
1989	0.65	0.60			0.60	0.50									0.62	0.55	0.62	0.55
1990	-0.25	0.35			-0.27	0.35									-0.26	0.35	-0.26	0.35
1991	1.07	0.50			0.96	0.45									1.01	0.47	1.01	0.47
1992	-0.22	0.35			-0.47	0.44									-0.36	0.42	-0.36	0.42
1993	0.23	0.32			0.15	0.33									0.19	0.32	0.19	0.32
1994	0.46	0.43			0.69	0.47									0.59	0.47	0.59	0.47
1995	0.57	0.42			0.77	0.42									0.68	0.43	0.68	0.43
1996	0.29	0.38			0.50	0.42									0.40	0.42	0.40	0.42
1997	0.76	0.34			0.80	0.36									0.78	0.35	0.78	0.35
1998	2.14	0.33			2.06	0.31									2.09	0.32	2.09	0.32
1999	0.31	0.51			0.40	0.47									0.36	0.49	0.36	0.49
2000	-0.58	0.30			-0.62	0.29									-0.60	0.29	-0.60	0.29
2001	-0.89	0.35			-0.64	0.32									-0.75	0.36	-0.75	0.36
2002	0.25	0.48			0.25	0.47									0.25	0.47	0.25	0.47
2003	0.24	0.31			0.28	0.30									0.26	0.31	0.26	0.31
2004	0.30	0.35			0.27	0.34									0.28	0.35	0.28	0.35
2005	0.06	0.38			0.07	0.38									0.07	0.38	0.07	0.38
2006	-1.50	0.32			-1.49	0.32									-1.49	0.32	-1.49	0.32
2007	-2.44	0.24			-2.32	0.23									-2.38	0.25	-2.38	0.25
2008	-1.46	0.30			-1.47	0.29									-1.47	0.29	-1.47	0.29
2009	-1.06	0.44			-1.57	0.38									-1.34	0.48	-1.34	0.48
2010	-0.13	0.47			-0.17	0.47									-0.15	0.47	-0.15	0.47
2011	-0.21	0.25			-0.17	0.24									-0.19	0.25	-0.19	0.25
2012	-2.09	0.37			-2.14	0.41									-2.12	0.40	-2.12	0.40
2013	0.83	0.34			0.71	0.40									0.77	0.38	0.77	0.38
2014	-0.20	0.28			-0.16	0.27									-0.18	0.28	-0.18	0.28
2015	0.32	0.45			0.34	0.44									0.33	0.44	0.33	0.44
2016	1.03	0.31			1.06	0.31									1.04	0.31	1.04	0.31
2017	1.06	0.35			0.81	0.39									0.93	0.39	0.93	0.39
2018	0.91	0.29			0.82	0.28									0.86	0.29	0.86	0.29
2019	-1.30	0.29			-1.27	0.32									-1.28	0.31	-1.28	0.31

Table 2.22g (page 4 of 6)—Devs for the first size at which EBS+NBS survey selectivity reaches 1.0.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982			-0.19	0.43			-0.19	0.43	-0.15	0.42	-0.17	0.42	-0.08	0.42	-0.19	0.43	-0.16	0.43
1983			-0.26	0.47			-0.14	0.49	-0.12	0.50	-0.12	0.48	-0.12	0.47	-0.19	0.49	-0.15	0.49
1984			1.18	0.39			1.14	0.38	1.13	0.36	1.10	0.37	1.17	0.41	1.16	0.39	1.14	0.38
1985			0.49	0.27			0.53	0.27	0.41	0.29	0.57	0.27	0.43	0.30	0.51	0.27	0.49	0.29
1986			-0.42	0.53			-0.38	0.52	-0.45	0.45	-0.39	0.45	-0.35	0.44	-0.40	0.53	-0.40	0.48
1987			0.03	0.36			0.09	0.34	0.06	0.36	0.11	0.33	0.22	0.36	0.06	0.35	0.10	0.36
1988			0.06	0.54			0.17	0.53	0.08	0.50	0.15	0.52	0.26	0.45	0.12	0.54	0.14	0.51
1989			0.65	0.51			0.60	0.51	0.88	0.57	0.57	0.50	1.21	0.50	0.62	0.51	0.77	0.57
1990			-0.23	0.36			-0.27	0.35	-0.28	0.35	-0.27	0.34	-0.08	0.37	-0.26	0.36	-0.23	0.36
1991			1.05	0.47			0.94	0.45	0.79	0.43	0.91	0.44	0.59	0.41	0.99	0.46	0.86	0.47
1992			-0.20	0.36			-0.49	0.47	-0.58	0.53	-0.71	0.74	-0.87	0.44	-0.35	0.45	-0.57	0.57
1993			0.20	0.35			0.13	0.33	0.02	0.36	0.16	0.33	-0.27	0.42	0.17	0.34	0.06	0.39
1994			0.41	0.45			0.62	0.44	1.01	0.49	0.55	0.44	1.11	0.44	0.52	0.46	0.73	0.53
1995			0.55	0.43			0.73	0.44	0.65	0.41	0.73	0.44	0.59	0.36	0.64	0.44	0.65	0.43
1996			0.28	0.38			0.44	0.38	0.51	0.41	0.40	0.38	0.55	0.36	0.36	0.39	0.44	0.39
1997			0.75	0.35			0.77	0.34	0.74	0.33	0.68	0.33	0.57	0.31	0.76	0.34	0.71	0.34
1998			2.06	0.37			2.01	0.33	1.92	0.34	1.74	0.36	-0.09	0.46	2.04	0.35	1.58	0.86
1999			0.35	0.52			0.42	0.49	0.41	0.48	0.40	0.51	0.14	0.43	0.39	0.51	0.35	0.50
2000			-0.60	0.30			-0.65	0.29	-0.69	0.29	-0.61	0.28	-0.68	0.30	-0.62	0.30	-0.64	0.29
2001			-0.88	0.36			-0.64	0.33	-0.62	0.33	-0.35	0.31	-0.36	0.33	-0.75	0.37	-0.57	0.38
2002			0.10	0.46			0.10	0.45	-0.11	0.42	0.18	0.42	0.06	0.38	0.10	0.45	0.07	0.44
2003			0.22	0.34			0.28	0.31	0.12	0.31	0.52	0.30	0.42	0.31	0.25	0.32	0.31	0.35
2004			0.27	0.35			0.25	0.35	0.15	0.34	0.39	0.34	0.56	0.35	0.26	0.35	0.32	0.37
2005			-0.10	0.42			-0.03	0.40	-0.14	0.42	0.23	0.41	0.44	0.37	-0.07	0.41	0.07	0.46
2006			-1.54	0.32			-1.49	0.30	-1.50	0.31	-1.46	0.30	-1.22	0.35	-1.51	0.31	-1.45	0.33
2007			-2.44	0.25			-2.30	0.24	-2.34	0.24	-2.21	0.23	-2.42	0.27	-2.36	0.25	-2.33	0.26
2008			-1.46	0.30			-1.46	0.30	-1.41	0.31	-1.50	0.29	-1.43	0.34	-1.46	0.30	-1.45	0.31
2009			-0.90	0.57			-1.64	0.45	-1.84	0.37	-1.97	0.37	-2.29	0.35	-1.30	0.63	-1.73	0.62
2010			-0.48	0.41			-0.51	0.38	-0.23	0.46	-0.58	0.36	-0.36	0.41	-0.49	0.39	-0.43	0.42
2011			-0.15	0.26			-0.11	0.25	-0.14	0.25	-0.05	0.25	-0.21	0.30	-0.13	0.25	-0.13	0.26
2012			-2.01	0.34			-1.99	0.41	-1.66	0.70	-2.09	0.29	-1.72	0.62	-2.00	0.38	-1.90	0.52
2013			0.97	0.36			0.85	0.33	0.98	0.35	0.69	0.41	0.28	0.56	0.91	0.35	0.77	0.48
2014			-0.05	0.30			-0.01	0.29	0.02	0.29	0.06	0.29	0.10	0.29	-0.03	0.29	0.03	0.29
2015			0.46	0.47			0.45	0.45	0.58	0.44	0.39	0.44	0.69	0.42	0.46	0.46	0.51	0.46
2016			1.17	0.33			1.17	0.33	1.14	0.32	1.22	0.33	1.35	0.31	1.17	0.33	1.20	0.33
2017			1.15	0.36			0.98	0.37	0.99	0.36	1.11	0.35	1.33	0.34	1.06	0.37	1.10	0.38
2018			0.81	0.35			0.80	0.34	0.83	0.34	0.78	0.35	1.23	0.35	0.81	0.35	0.88	0.38
2019			-1.29	0.29			-1.20	0.30	-1.14	0.30	-1.17	0.30	-0.78	0.32	-1.24	0.30	-1.12	0.35

Table 2.22g (page 5 of 6)—Devs for the log standard deviation of the first normal pdf in the double-normal EBS survey selectivity function.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.54	0.58			-0.52	0.59									-0.53	0.58	-0.53	0.58
1983	0.41	0.63			0.48	0.61									0.45	0.62	0.45	0.62
1984	0.84	0.44			0.89	0.43									0.87	0.44	0.87	0.44
1985	0.67	0.37			0.65	0.35									0.66	0.36	0.66	0.36
1986	-0.05	0.68			-0.07	0.65									-0.06	0.66	-0.06	0.66
1987	-0.11	0.55			-0.06	0.54									-0.08	0.55	-0.08	0.55
1988	-0.13	0.67			-0.02	0.65									-0.07	0.66	-0.07	0.66
1989	0.26	0.69			0.29	0.57									0.28	0.63	0.28	0.63
1990	0.15	0.44			0.16	0.43									0.15	0.44	0.15	0.44
1991	1.36	0.54			1.32	0.50									1.34	0.52	1.34	0.52
1992	-0.13	0.45			-0.35	0.57									-0.25	0.53	-0.25	0.53
1993	0.74	0.41			0.66	0.42									0.70	0.42	0.70	0.42
1994	0.42	0.56			0.55	0.58									0.49	0.57	0.49	0.57
1995	0.34	0.54			0.52	0.52									0.44	0.54	0.44	0.54
1996	-0.23	0.51			0.00	0.53									-0.11	0.53	-0.11	0.53
1997	0.75	0.41			0.80	0.41									0.78	0.41	0.78	0.41
1998	2.10	0.35			2.00	0.33									2.05	0.34	2.05	0.34
1999	0.33	0.57			0.43	0.53									0.38	0.55	0.38	0.55
2000	-0.63	0.41			-0.64	0.40									-0.64	0.41	-0.64	0.41
2001	-0.55	0.54			-0.36	0.48									-0.45	0.52	-0.45	0.52
2002	0.21	0.60			0.22	0.58									0.22	0.59	0.22	0.59
2003	0.24	0.41			0.29	0.40									0.27	0.41	0.27	0.41
2004	0.15	0.47			0.16	0.45									0.16	0.46	0.16	0.46
2005	-0.02	0.53			0.00	0.52									-0.01	0.52	-0.01	0.52
2006	-1.35	0.46			-1.36	0.47									-1.36	0.47	-1.36	0.47
2007	-2.50	0.52			-2.42	0.49									-2.45	0.50	-2.45	0.50
2008	-1.55	0.47			-1.55	0.47									-1.55	0.47	-1.55	0.47
2009	-0.09	0.63			-0.78	0.58									-0.46	0.70	-0.46	0.70
2010	-0.29	0.61			-0.32	0.60									-0.31	0.60	-0.31	0.60
2011	-0.22	0.34			-0.18	0.33									-0.20	0.34	-0.20	0.34
2012	-1.52	0.63			-1.71	0.75									-1.62	0.70	-1.62	0.70
2013	0.90	0.37			0.85	0.43									0.87	0.40	0.87	0.40
2014	-0.14	0.41			-0.11	0.40									-0.13	0.40	-0.13	0.40
2015	0.30	0.55			0.31	0.53									0.31	0.54	0.31	0.54
2016	0.67	0.44			0.71	0.43									0.69	0.43	0.69	0.43
2017	0.90	0.45			0.80	0.47									0.85	0.46	0.85	0.46
2018	-0.18	0.41			-0.16	0.39									-0.17	0.40	-0.17	0.40
2019	-1.52	0.54			-1.48	0.58									-1.50	0.56	-1.50	0.56

Table 2.22g (page 6 of 6)—Devs for for the log standard deviation of the first normal pdf in the double-normal EBS+NBS survey selectivity function.

	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982			-0.51	0.58			-0.50	0.59	-0.44	0.58	-0.46	0.57	-0.45	0.65	-0.51	0.59	-0.47	0.59
1983			0.39	0.62			0.45	0.62	0.54	0.65	0.44	0.60	0.76	0.69	0.42	0.62	0.51	0.64
1984			0.80	0.44			0.88	0.43	0.86	0.42	0.88	0.42	0.95	0.51	0.84	0.44	0.87	0.44
1985			0.69	0.37			0.68	0.36	0.57	0.38	0.74	0.35	0.63	0.44	0.68	0.36	0.66	0.38
1986			-0.04	0.68			-0.06	0.66	-0.13	0.60	-0.06	0.58	0.01	0.64	-0.05	0.67	-0.06	0.63
1987			-0.11	0.57			-0.06	0.53	-0.09	0.57	-0.02	0.52	0.02	0.63	-0.08	0.55	-0.05	0.56
1988			-0.14	0.67			-0.04	0.65	-0.16	0.64	-0.04	0.64	-0.06	0.65	-0.09	0.66	-0.09	0.65
1989			0.23	0.58			0.26	0.58	0.55	0.63	0.26	0.57	0.90	0.62	0.25	0.58	0.43	0.65
1990			0.16	0.45			0.15	0.43	0.14	0.44	0.16	0.42	0.44	0.51	0.16	0.44	0.20	0.46
1991			1.33	0.51			1.29	0.50	1.16	0.49	1.28	0.49	1.11	0.53	1.31	0.50	1.24	0.51
1992			-0.12	0.46			-0.38	0.61	-0.53	0.71	-0.66	1.01	-1.02	0.71	-0.26	0.56	-0.53	0.78
1993			0.73	0.44			0.66	0.42	0.54	0.47	0.68	0.41	0.26	0.60	0.69	0.43	0.58	0.50
1994			0.37	0.59			0.49	0.55	0.92	0.59	0.45	0.54	1.04	0.60	0.43	0.57	0.64	0.63
1995			0.31	0.55			0.49	0.54	0.36	0.52	0.54	0.53	0.24	0.54	0.40	0.55	0.39	0.55
1996			-0.26	0.51			-0.07	0.49	-0.03	0.53	-0.04	0.49	-0.07	0.53	-0.16	0.51	-0.09	0.52
1997			0.75	0.41			0.79	0.40	0.75	0.40	0.78	0.39	0.73	0.44	0.77	0.41	0.76	0.41
1998			2.04	0.38			1.98	0.34	1.91	0.36	1.80	0.37	-0.19	0.69	2.01	0.36	1.56	0.92
1999			0.35	0.58			0.44	0.54	0.43	0.54	0.45	0.55	0.16	0.57	0.40	0.56	0.38	0.56
2000			-0.65	0.42			-0.66	0.40	-0.72	0.41	-0.64	0.39	-0.80	0.48	-0.66	0.41	-0.69	0.42
2001			-0.51	0.55			-0.35	0.49	-0.35	0.49	-0.14	0.45	-0.13	0.55	-0.42	0.52	-0.30	0.52
2002			0.06	0.58			0.08	0.57	-0.18	0.55	0.10	0.53	-0.08	0.55	0.07	0.58	0.00	0.57
2003			0.23	0.45			0.29	0.40	0.06	0.43	0.43	0.37	0.21	0.46	0.26	0.43	0.25	0.44
2004			0.13	0.47			0.14	0.46	-0.01	0.46	0.22	0.44	0.31	0.52	0.14	0.47	0.15	0.48
2005			-0.20	0.58			-0.13	0.54	-0.28	0.60	0.20	0.52	0.30	0.57	-0.16	0.56	-0.03	0.61
2006			-1.38	0.47			-1.37	0.43	-1.39	0.46	-1.31	0.43	-0.98	0.52	-1.38	0.45	-1.30	0.48
2007			-2.45	0.52			-2.38	0.49	-2.46	0.50	-2.25	0.47	-2.55	0.60	-2.41	0.51	-2.41	0.52
2008			-1.54	0.47			-1.54	0.48	-1.46	0.49	-1.57	0.49	-1.49	0.58	-1.54	0.48	-1.52	0.50
2009			0.16	0.80			-0.82	0.70	-1.08	0.60	-1.28	0.64	-1.49	0.67	-0.37	0.89	-0.91	0.88
2010			-0.68	0.55			-0.70	0.53	-0.34	0.59	-0.76	0.52	-0.51	0.62	-0.69	0.54	-0.60	0.58
2011			-0.17	0.35			-0.14	0.34	-0.18	0.34	-0.05	0.33	-0.27	0.45	-0.16	0.34	-0.16	0.37
2012			-1.40	0.55			-1.46	0.68	-0.91	1.07	-1.68	0.52	-0.74	1.06	-1.43	0.62	-1.25	0.88
2013			0.96	0.38			0.93	0.36	1.07	0.38	0.79	0.42	0.47	0.69	0.95	0.37	0.86	0.49
2014			-0.08	0.42			-0.04	0.40	-0.01	0.41	0.00	0.39	-0.03	0.45	-0.06	0.41	-0.03	0.41
2015			0.39	0.56			0.39	0.53	0.51	0.53	0.30	0.52	0.59	0.56	0.39	0.55	0.43	0.55
2016			0.76	0.46			0.80	0.44	0.79	0.45	0.80	0.43	0.92	0.49	0.78	0.45	0.81	0.45
2017			0.90	0.46			0.88	0.47	0.89	0.47	0.96	0.44	1.21	0.51	0.89	0.46	0.96	0.48
2018			0.11	0.42			0.16	0.40	0.17	0.41	0.20	0.40	0.53	0.45	0.13	0.41	0.23	0.44
2019			-1.59	0.53			-1.53	0.56	-1.45	0.54	-1.48	0.56	-0.96	0.59	-1.56	0.54	-1.41	0.59

Table 2.23—"Sigma" terms for vectors of annual random deviations other than those associated with catchability. Deviations are ~normal(0,σ^2) for ln(Recruits), ~normal(0,1) for others. "XBS_srv" represents the combined EBS and NBS surveys. Color scales wrap around both halves of the table for a given parameter.

A1: Allow *Q* to vary?	no						yes					
A2: Combine surveys?	no			yes			no			yes		
	Model 20.4			Model 19.12a			Model 19.15			Model 19.12		
Parameter	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma
ln(Recruits)	0.4498	0.0119	0.6827	0.4628	0.0126	0.6896	0.4408	0.0124	0.6733	0.4431	0.0130	0.6757
Length_at_1.5	0.8109	0.1911	0.1530	0.7986	0.1989	0.1478	0.8138	0.1865	0.1566	0.7911	0.1996	0.1486
Sel_fsh_lnSD1	0.6838	0.3150	0.1399	0.7041	0.2888	0.1558	0.6753	0.3211	0.1378	0.6971	0.2943	0.1533
Sel_fsh_logitEnd	0.2152	0.7815	0.7443	0.1763	0.8188	0.7539	0.2125	0.7846	0.7771	0.1517	0.8488	0.7641
Sel_EBS_srv_PeakStart	0.8499	0.1506	0.2090				0.8510	0.1483	0.2221			
Sel_EBS_srv_lnSD1	0.7320	0.2648	0.7744				0.7424	0.2576	0.8309			
Sel_XBS_srv_PeakStart				0.8423	0.1564	0.2041			0.2221	0.8471	0.1488	0.2191
Sel_XBS_srv_lnSD1				0.7285	0.2694	0.7711			0.8309	0.7366	0.2565	0.8300

B1: Use fishery CPUE?	no						yes					
B2: Allow domed selex?	no			yes			no			yes		
	Model 19.12			Model 20.8			Model 20.9			Model 20.10		
Parameter	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma
ln(Recruits)	(see above)			0.4470	0.0135	0.6787	0.4320	0.0142	0.6678	0.4252	0.0141	0.6630
Length_at_1.5				0.8017	0.1985	0.1424	0.7869	0.2133	0.1452	0.7928	0.2068	0.1360
Sel_fsh_lnSD1				0.7042	0.2957	0.1722	0.7844	0.2158	0.1932	0.7557	0.2442	0.2433
Sel_fsh_logitEnd				0.3473	0.6454	0.6106	0.6467	0.3561	1.5431	0.7956	0.2045	1.1177
Sel_XBS_srv_PeakStart				0.8419	0.1594	0.2129	0.8515	0.1497	0.2302	0.8438	0.1535	0.1826
Sel_XBS_srv_lnSD1				0.7147	0.2846	0.8049	0.7468	0.2551	0.8804	0.6548	0.3445	0.6427

Table 2.24—Catchability time series (point estimates only; note difference in scale of fishery values).

	EBS		NBS		EBS+NBS					Fishery ($\times 10^6$)	
Year	20.4	19.15	20.4	19.15	19.12a	19.12	20.8	20.9	20.10	20.9	20.10
1982	0.894	0.939	0.430	0.061	0.986	1.055	1.126	0.949	1.269		
1983	0.894	0.990			0.986	1.116	1.222	1.006	1.421		
1984	0.894	0.874			0.986	0.975	1.077	0.867	1.231		
1985	0.894	1.023	0.430	0.076	0.986	1.134	1.266	1.018	1.486		
1986	0.894	0.977			0.986	1.077	1.233	0.970	1.475		
1987	0.894	0.951			0.986	1.065	1.213	0.964	1.423		
1988	0.894	0.932	0.430	0.037	0.986	1.012	1.160	0.912	1.354		
1989	0.894	0.822			0.986	0.899	1.022	0.796	1.134		
1990	0.894	0.881			0.986	0.962	1.133	0.842	1.314		
1991	0.894	0.861	0.430	0.095	0.986	0.952	1.083	0.835	1.189	2.192	1.219
1992	0.894	0.859			0.986	0.938	1.071	0.820	1.207	2.261	1.219
1993	0.894	0.991			0.986	1.101	1.234	0.991	1.398	2.216	1.219
1994	0.894	1.324			0.986	1.444	1.605	1.330	1.843	2.226	1.219
1995	0.894	1.107			0.986	1.206	1.327	1.098	1.487	2.279	1.219
1996	0.894	1.100			0.986	1.233	1.359	1.129	1.536	2.177	1.219
1997	0.894	0.923			0.986	1.033	1.137	0.940	1.285	2.280	1.219
1998	0.894	0.908			0.986	1.043	1.135	0.976	1.333	2.253	1.219
1999	0.894	0.921			0.986	1.004	1.107	0.967	1.326	2.251	1.219
2000	0.894	0.831			0.986	0.921	1.039	0.896	1.293	2.208	1.219
2001	0.894	1.095			0.986	1.218	1.387	1.175	1.754	2.192	1.219
2002	0.894	0.902			0.986	1.020	1.142	0.929	1.348	2.203	1.219
2003	0.894	0.941			0.986	1.085	1.214	0.969	1.405	2.130	1.219
2004	0.894	0.852			0.986	0.968	1.088	0.800	1.181	2.175	1.219
2005	0.894	0.908			0.986	1.040	1.175	0.809	1.203	2.139	1.219
2006	0.894	0.868			0.986	0.964	1.111	0.723	1.112	2.263	1.219
2007	0.894	0.877			0.986	0.964	1.108	0.768	1.146	2.227	1.219
2008	0.894	0.791			0.986	0.853	0.963	0.675	0.951	2.248	1.219
2009	0.894	0.831			0.986	0.880	0.976	0.720	1.017	2.361	1.219
2010	0.894	0.977	0.430	0.019	0.986	1.031	1.140	0.908	1.217	2.276	1.219
2011	0.894	1.025			0.986	1.102	1.215	0.977	1.336	2.244	1.219
2012	0.894	0.976			0.986	1.032	1.178	0.908	1.381	2.253	1.219
2013	0.894	0.883			0.986	0.919	1.002	0.812	1.116	2.228	1.219
2014	0.894	1.154			0.986	1.229	1.343	1.114	1.578	2.198	1.219
2015	0.894	1.098			0.986	1.114	1.214	0.972	1.376	2.243	1.219
2016	0.894	1.060			0.986	1.123	1.220	0.975	1.353	2.212	1.219
2017	0.894	0.838	0.430	0.441	0.986	0.952	1.023	0.771	1.084	2.155	1.219
2018	0.894	0.894	0.430	0.928	0.986	1.193	1.298	0.972	1.401	2.147	1.219
2019	0.894	0.906	0.430	0.884	0.986	1.113	1.278	0.900	1.456	2.184	1.219
2020										2.226	1.219

Table 2.25—Female spawning biomass (in millions of t) time series (point estimates and standard errors).

	no				yes				(yes)						Factor A1: Allow Q to vary?			
	no		yes		no		yes								Factor A2: Combine surveys?			
	(no)						no				yes				Factor B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.096	0.027	0.095	0.026	0.092	0.026	0.089	0.024	0.178	0.049	0.110	0.029	0.467	0.100	0.093	0.026	0.158	0.132
1978	0.098	0.027	0.097	0.026	0.094	0.026	0.091	0.024	0.183	0.050	0.112	0.029	0.488	0.102	0.095	0.026	0.163	0.138
1979	0.101	0.026	0.099	0.025	0.095	0.025	0.091	0.023	0.183	0.048	0.112	0.027	0.476	0.097	0.096	0.025	0.163	0.134
1980	0.124	0.026	0.121	0.025	0.117	0.026	0.111	0.023	0.207	0.049	0.133	0.028	0.505	0.098	0.118	0.025	0.186	0.136
1981	0.185	0.028	0.178	0.027	0.174	0.028	0.162	0.026	0.269	0.054	0.189	0.031	0.579	0.104	0.174	0.029	0.245	0.143
1982	0.290	0.034	0.278	0.032	0.274	0.035	0.253	0.032	0.380	0.064	0.287	0.038	0.724	0.120	0.272	0.036	0.351	0.161
1983	0.386	0.037	0.371	0.035	0.368	0.040	0.340	0.036	0.484	0.071	0.378	0.043	0.857	0.131	0.364	0.041	0.450	0.176
1984	0.390	0.032	0.376	0.030	0.375	0.036	0.349	0.033	0.479	0.063	0.384	0.039	0.813	0.117	0.370	0.036	0.448	0.158
1985	0.435	0.033	0.421	0.032	0.421	0.038	0.394	0.035	0.545	0.069	0.435	0.042	0.947	0.132	0.416	0.038	0.509	0.187
1986	0.424	0.030	0.413	0.029	0.413	0.035	0.388	0.032	0.535	0.065	0.431	0.039	0.941	0.127	0.408	0.035	0.502	0.187
1987	0.415	0.027	0.404	0.026	0.405	0.031	0.383	0.029	0.516	0.058	0.425	0.036	0.899	0.115	0.400	0.031	0.488	0.174
1988	0.440	0.026	0.428	0.025	0.430	0.030	0.408	0.028	0.541	0.057	0.453	0.035	0.940	0.116	0.425	0.030	0.516	0.179
1989	0.428	0.024	0.416	0.023	0.419	0.028	0.399	0.026	0.522	0.052	0.444	0.032	0.908	0.109	0.414	0.028	0.501	0.170
1990	0.384	0.021	0.373	0.019	0.378	0.023	0.362	0.022	0.469	0.045	0.403	0.027	0.825	0.096	0.373	0.023	0.453	0.155
1991	0.305	0.016	0.297	0.015	0.304	0.018	0.293	0.017	0.383	0.037	0.330	0.021	0.703	0.081	0.299	0.018	0.370	0.138
1992	0.221	0.014	0.216	0.013	0.222	0.015	0.215	0.014	0.292	0.031	0.250	0.018	0.588	0.071	0.218	0.014	0.284	0.125
1993	0.210	0.014	0.205	0.013	0.212	0.015	0.205	0.014	0.278	0.031	0.243	0.018	0.585	0.071	0.208	0.015	0.274	0.128
1994	0.214	0.013	0.209	0.012	0.214	0.014	0.207	0.013	0.268	0.027	0.243	0.017	0.544	0.064	0.211	0.014	0.269	0.113
1995	0.230	0.014	0.223	0.013	0.225	0.014	0.218	0.013	0.274	0.026	0.254	0.017	0.542	0.062	0.224	0.014	0.278	0.108
1996	0.232	0.015	0.224	0.014	0.220	0.014	0.212	0.013	0.260	0.025	0.247	0.017	0.500	0.058	0.221	0.016	0.268	0.095
1997	0.230	0.015	0.221	0.014	0.211	0.014	0.203	0.013	0.250	0.024	0.235	0.016	0.479	0.056	0.215	0.017	0.258	0.091
1998	0.207	0.015	0.198	0.014	0.186	0.014	0.177	0.012	0.223	0.024	0.209	0.015	0.442	0.055	0.191	0.018	0.232	0.087
1999	0.202	0.016	0.192	0.015	0.180	0.014	0.171	0.013	0.219	0.025	0.202	0.015	0.441	0.056	0.185	0.018	0.227	0.089
2000	0.212	0.017	0.202	0.015	0.191	0.015	0.181	0.014	0.231	0.027	0.206	0.016	0.453	0.057	0.195	0.019	0.237	0.090
2001	0.221	0.016	0.210	0.015	0.203	0.015	0.192	0.014	0.242	0.026	0.205	0.016	0.437	0.054	0.206	0.018	0.242	0.082
2002	0.236	0.016	0.225	0.015	0.221	0.015	0.210	0.014	0.260	0.027	0.211	0.015	0.440	0.053	0.222	0.018	0.255	0.078
2003	0.241	0.016	0.230	0.014	0.229	0.015	0.216	0.014	0.266	0.026	0.211	0.015	0.431	0.052	0.228	0.017	0.258	0.074
2004	0.246	0.015	0.234	0.014	0.235	0.015	0.222	0.013	0.270	0.026	0.216	0.015	0.420	0.050	0.233	0.016	0.261	0.069
2005	0.240	0.014	0.228	0.013	0.231	0.014	0.217	0.013	0.267	0.026	0.220	0.015	0.418	0.051	0.228	0.016	0.258	0.069
2006	0.213	0.013	0.202	0.012	0.206	0.013	0.193	0.011	0.241	0.024	0.212	0.015	0.393	0.049	0.202	0.014	0.235	0.067
2007	0.187	0.012	0.175	0.011	0.183	0.012	0.169	0.011	0.217	0.024	0.208	0.015	0.384	0.049	0.178	0.013	0.216	0.071
2008	0.162	0.011	0.150	0.010	0.160	0.011	0.146	0.010	0.191	0.022	0.204	0.015	0.372	0.047	0.154	0.012	0.197	0.074
2009	0.146	0.010	0.135	0.009	0.147	0.011	0.133	0.009	0.177	0.021	0.208	0.015	0.384	0.048	0.139	0.012	0.189	0.083
2010	0.142	0.010	0.132	0.009	0.144	0.010	0.132	0.010	0.172	0.021	0.217	0.016	0.397	0.048	0.137	0.011	0.190	0.088
2011	0.167	0.011	0.159	0.010	0.170	0.011	0.161	0.010	0.201	0.021	0.248	0.018	0.444	0.052	0.164	0.012	0.220	0.095
2012	0.193	0.012	0.188	0.011	0.193	0.012	0.188	0.012	0.229	0.023	0.269	0.019	0.481	0.055	0.190	0.012	0.247	0.098
2013	0.215	0.013	0.213	0.013	0.211	0.013	0.210	0.013	0.257	0.026	0.285	0.021	0.530	0.061	0.212	0.013	0.273	0.107
2014	0.216	0.014	0.216	0.014	0.208	0.014	0.211	0.014	0.261	0.027	0.278	0.021	0.537	0.063	0.213	0.015	0.274	0.109
2015	0.218	0.015	0.222	0.016	0.205	0.015	0.214	0.016	0.267	0.029	0.272	0.021	0.530	0.063	0.215	0.017	0.274	0.107
2016	0.243	0.018	0.256	0.018	0.223	0.017	0.243	0.019	0.303	0.034	0.297	0.024	0.560	0.067	0.242	0.021	0.302	0.109
2017	0.269	0.020	0.297	0.021	0.239	0.019	0.278	0.023	0.347	0.039	0.335	0.027	0.602	0.072	0.272	0.029	0.337	0.114
2018	0.278	0.021	0.324	0.023	0.241	0.021	0.302	0.025	0.379	0.044	0.368	0.028	0.636	0.074	0.288	0.038	0.362	0.122
2019	0.262	0.021	0.322	0.023	0.222	0.021	0.300	0.027	0.386	0.046	0.381	0.028	0.660	0.075	0.280	0.045	0.363	0.133
2020	0.208	0.018	0.271	0.021	0.170	0.020	0.252	0.025	0.336	0.043	0.338	0.024	0.607	0.068	0.228	0.045	0.313	0.133
2021	0.165	0.017	0.228	0.019	0.127	0.019	0.211	0.024	0.293	0.040	0.305	0.021	0.577	0.063	0.186	0.044	0.274	0.136
2022	0.171	0.011	0.206	0.010	0.142	0.014	0.198	0.015	0.266	0.027	0.262	0.014	0.529	0.050	0.181	0.028	0.254	0.117

Table 2.26—Relative spawning biomass time series (point estimates and standard errors).

	no				yes				(yes)						Factor A1: Allow Q to vary?			
	no		yes		no		yes								Factor A2: Combine surveys?			
	(no)						no				yes				Factor B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.152	0.043	0.144	0.040	0.146	0.042	0.134	0.037	0.221	0.058	0.149	0.040	0.364	0.074	0.143	0.041	0.186	0.089
1978	0.156	0.043	0.147	0.040	0.149	0.042	0.136	0.037	0.228	0.059	0.152	0.040	0.380	0.075	0.146	0.041	0.191	0.093
1979	0.160	0.041	0.149	0.038	0.152	0.040	0.136	0.035	0.227	0.057	0.152	0.038	0.371	0.072	0.148	0.039	0.191	0.089
1980	0.196	0.043	0.183	0.039	0.186	0.042	0.166	0.037	0.257	0.059	0.182	0.039	0.394	0.073	0.181	0.042	0.222	0.088
1981	0.292	0.047	0.270	0.044	0.277	0.049	0.242	0.043	0.334	0.065	0.257	0.045	0.451	0.078	0.268	0.049	0.301	0.085
1982	0.459	0.059	0.421	0.054	0.436	0.062	0.379	0.055	0.472	0.078	0.390	0.056	0.564	0.090	0.420	0.065	0.443	0.087
1983	0.611	0.066	0.562	0.062	0.585	0.073	0.509	0.065	0.601	0.088	0.515	0.065	0.668	0.099	0.562	0.076	0.574	0.091
1984	0.617	0.060	0.570	0.056	0.596	0.067	0.521	0.060	0.595	0.079	0.523	0.060	0.633	0.088	0.571	0.071	0.575	0.079
1985	0.688	0.062	0.639	0.059	0.668	0.071	0.588	0.065	0.677	0.085	0.592	0.065	0.738	0.099	0.641	0.075	0.652	0.089
1986	0.671	0.057	0.626	0.054	0.656	0.067	0.580	0.061	0.665	0.080	0.587	0.062	0.733	0.094	0.629	0.070	0.641	0.085
1987	0.657	0.052	0.612	0.050	0.643	0.061	0.572	0.056	0.641	0.071	0.579	0.057	0.700	0.085	0.617	0.064	0.626	0.076
1988	0.696	0.052	0.648	0.049	0.683	0.061	0.610	0.056	0.672	0.070	0.617	0.057	0.733	0.085	0.655	0.065	0.662	0.075
1989	0.677	0.049	0.630	0.046	0.666	0.057	0.596	0.053	0.648	0.065	0.604	0.053	0.708	0.080	0.639	0.061	0.644	0.069
1990	0.607	0.042	0.565	0.040	0.601	0.049	0.541	0.046	0.582	0.055	0.549	0.046	0.643	0.070	0.575	0.052	0.581	0.060
1991	0.482	0.033	0.451	0.031	0.483	0.038	0.437	0.036	0.476	0.044	0.449	0.036	0.548	0.058	0.461	0.040	0.473	0.052
1992	0.349	0.026	0.327	0.024	0.353	0.030	0.321	0.028	0.362	0.036	0.340	0.029	0.458	0.050	0.336	0.030	0.357	0.053
1993	0.332	0.026	0.311	0.025	0.337	0.030	0.306	0.028	0.345	0.035	0.331	0.029	0.456	0.050	0.320	0.030	0.344	0.056
1994	0.339	0.026	0.316	0.024	0.340	0.028	0.310	0.026	0.333	0.032	0.331	0.028	0.424	0.044	0.325	0.029	0.340	0.046
1995	0.364	0.028	0.339	0.026	0.358	0.029	0.326	0.027	0.340	0.032	0.345	0.028	0.422	0.044	0.345	0.031	0.354	0.042
1996	0.368	0.030	0.340	0.027	0.349	0.029	0.317	0.027	0.323	0.031	0.336	0.028	0.389	0.041	0.341	0.034	0.344	0.039
1997	0.363	0.030	0.334	0.027	0.335	0.028	0.303	0.026	0.310	0.031	0.321	0.027	0.373	0.040	0.331	0.035	0.332	0.038
1998	0.328	0.029	0.300	0.026	0.295	0.027	0.265	0.024	0.277	0.030	0.285	0.025	0.345	0.039	0.294	0.034	0.297	0.039
1999	0.319	0.029	0.291	0.027	0.286	0.027	0.256	0.025	0.272	0.031	0.275	0.025	0.344	0.040	0.285	0.035	0.289	0.040
2000	0.335	0.031	0.306	0.028	0.303	0.029	0.270	0.027	0.287	0.033	0.280	0.026	0.353	0.041	0.301	0.037	0.302	0.041
2001	0.349	0.031	0.319	0.028	0.323	0.030	0.288	0.027	0.301	0.033	0.279	0.025	0.341	0.039	0.317	0.036	0.311	0.039
2002	0.373	0.031	0.341	0.028	0.351	0.031	0.313	0.028	0.323	0.034	0.287	0.025	0.343	0.038	0.342	0.036	0.330	0.040
2003	0.381	0.031	0.349	0.028	0.363	0.031	0.324	0.028	0.331	0.034	0.287	0.025	0.336	0.038	0.351	0.036	0.336	0.041
2004	0.389	0.030	0.355	0.027	0.373	0.031	0.331	0.028	0.335	0.033	0.294	0.025	0.327	0.037	0.359	0.036	0.341	0.042
2005	0.380	0.029	0.346	0.026	0.367	0.030	0.325	0.027	0.331	0.033	0.300	0.025	0.325	0.037	0.352	0.035	0.337	0.039
2006	0.337	0.026	0.306	0.023	0.328	0.027	0.288	0.024	0.299	0.030	0.288	0.024	0.307	0.036	0.312	0.031	0.305	0.032
2007	0.295	0.023	0.266	0.021	0.291	0.024	0.252	0.021	0.269	0.029	0.283	0.024	0.299	0.036	0.274	0.029	0.278	0.031
2008	0.256	0.020	0.228	0.018	0.254	0.022	0.219	0.019	0.238	0.026	0.277	0.024	0.290	0.035	0.237	0.026	0.251	0.034
2009	0.231	0.019	0.204	0.017	0.233	0.020	0.199	0.018	0.220	0.025	0.283	0.025	0.299	0.036	0.215	0.024	0.238	0.043
2010	0.225	0.019	0.199	0.017	0.230	0.020	0.197	0.018	0.214	0.024	0.296	0.026	0.309	0.036	0.211	0.023	0.238	0.049
2011	0.264	0.021	0.241	0.019	0.270	0.022	0.240	0.021	0.249	0.026	0.337	0.029	0.346	0.039	0.252	0.025	0.278	0.050
2012	0.305	0.023	0.285	0.022	0.307	0.025	0.281	0.024	0.284	0.029	0.366	0.031	0.375	0.042	0.293	0.026	0.314	0.047
2013	0.339	0.026	0.323	0.025	0.336	0.027	0.313	0.027	0.319	0.032	0.388	0.033	0.413	0.047	0.327	0.028	0.347	0.048
2014	0.341	0.027	0.328	0.027	0.331	0.028	0.315	0.028	0.324	0.034	0.379	0.033	0.418	0.048	0.328	0.029	0.347	0.047
2015	0.345	0.029	0.337	0.029	0.326	0.028	0.320	0.030	0.332	0.036	0.370	0.034	0.413	0.048	0.331	0.031	0.348	0.045
2016	0.385	0.033	0.388	0.034	0.354	0.032	0.363	0.035	0.376	0.042	0.404	0.037	0.436	0.051	0.372	0.036	0.386	0.046
2017	0.426	0.037	0.450	0.039	0.380	0.035	0.416	0.041	0.431	0.049	0.456	0.042	0.469	0.055	0.418	0.046	0.433	0.051
2018	0.440	0.039	0.491	0.042	0.384	0.037	0.451	0.045	0.471	0.054	0.501	0.045	0.496	0.058	0.443	0.056	0.464	0.060
2019	0.415	0.037	0.489	0.042	0.353	0.037	0.449	0.046	0.479	0.056	0.519	0.045	0.514	0.059	0.429	0.065	0.463	0.071
2020	0.328	0.032	0.411	0.036	0.270	0.033	0.377	0.041	0.417	0.050	0.461	0.039	0.473	0.053	0.350	0.064	0.395	0.077
2021	0.260	0.028	0.346	0.032	0.202	0.031	0.315	0.037	0.364	0.046	0.415	0.034	0.449	0.048	0.285	0.064	0.340	0.085
2022	0.270	0.019	0.312	0.018	0.226	0.023	0.295	0.023	0.330	0.028	0.356	0.023	0.412	0.037	0.278	0.039	0.317	0.059

Table 2.27—Age 0 recruits (in billions of fish) time series (point estimates and standard errors).

	no				yes				(yes)						Factor A1: Allow Q to vary?			
	no		yes		no		yes								Factor A2: Combine surveys?			
	(no)						no				yes				Factor B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1.277	0.329	1.132	0.291	1.137	0.305	0.951	0.254	0.837	0.256	1.069	0.298	0.606	0.219	1.109	0.315	0.993	0.342
1978	0.859	0.230	0.739	0.202	0.799	0.213	0.661	0.176	0.543	0.161	0.694	0.200	0.385	0.124	0.755	0.216	0.662	0.235
1979	0.881	0.148	0.771	0.129	0.808	0.145	0.678	0.121	0.533	0.112	0.726	0.137	0.344	0.081	0.775	0.153	0.671	0.206
1980	0.205	0.053	0.186	0.047	0.184	0.051	0.161	0.044	0.134	0.038	0.170	0.049	0.103	0.029	0.182	0.051	0.162	0.055
1981	0.241	0.048	0.210	0.042	0.223	0.046	0.191	0.040	0.149	0.034	0.206	0.045	0.098	0.024	0.214	0.047	0.187	0.059
1982	1.139	0.135	1.001	0.116	1.066	0.139	0.916	0.118	0.712	0.114	1.010	0.138	0.481	0.087	1.019	0.151	0.897	0.239
1983	0.311	0.058	0.270	0.051	0.267	0.053	0.229	0.045	0.184	0.039	0.237	0.050	0.127	0.029	0.265	0.059	0.229	0.071
1984	1.025	0.120	0.902	0.103	0.946	0.119	0.820	0.102	0.620	0.097	0.891	0.116	0.418	0.074	0.913	0.132	0.797	0.216
1985	0.464	0.063	0.407	0.054	0.442	0.062	0.381	0.053	0.292	0.049	0.396	0.059	0.203	0.038	0.419	0.066	0.366	0.098
1986	0.256	0.038	0.224	0.033	0.248	0.038	0.216	0.033	0.164	0.030	0.232	0.038	0.115	0.023	0.234	0.039	0.207	0.056
1987	0.078	0.020	0.069	0.017	0.083	0.021	0.074	0.018	0.056	0.015	0.081	0.021	0.041	0.011	0.076	0.020	0.069	0.023
1988	0.360	0.047	0.325	0.041	0.337	0.046	0.301	0.041	0.223	0.037	0.342	0.050	0.158	0.029	0.328	0.049	0.291	0.079
1989	0.714	0.082	0.646	0.072	0.667	0.080	0.593	0.070	0.457	0.066	0.650	0.082	0.340	0.056	0.649	0.087	0.578	0.140
1990	0.715	0.083	0.634	0.072	0.650	0.078	0.572	0.068	0.439	0.064	0.619	0.077	0.305	0.051	0.636	0.090	0.558	0.145
1991	0.411	0.056	0.373	0.050	0.351	0.051	0.313	0.045	0.252	0.043	0.326	0.056	0.181	0.031	0.357	0.061	0.312	0.083
1992	1.127	0.120	1.001	0.103	0.958	0.103	0.843	0.089	0.665	0.090	0.921	0.100	0.468	0.073	0.970	0.143	0.847	0.219
1993	0.430	0.053	0.374	0.046	0.399	0.050	0.343	0.043	0.278	0.042	0.351	0.047	0.198	0.034	0.382	0.057	0.336	0.082
1994	0.357	0.044	0.315	0.038	0.324	0.040	0.282	0.035	0.224	0.034	0.289	0.038	0.159	0.027	0.316	0.047	0.276	0.070
1995	0.302	0.038	0.270	0.034	0.287	0.038	0.251	0.033	0.202	0.032	0.246	0.034	0.131	0.023	0.275	0.040	0.240	0.061
1996	0.985	0.108	0.875	0.092	0.920	0.106	0.802	0.091	0.636	0.089	0.753	0.088	0.385	0.061	0.887	0.119	0.759	0.201
1997	0.434	0.053	0.385	0.046	0.409	0.052	0.360	0.045	0.285	0.043	0.335	0.044	0.174	0.029	0.393	0.056	0.337	0.090
1998	0.327	0.042	0.289	0.037	0.319	0.042	0.277	0.036	0.210	0.034	0.256	0.036	0.129	0.023	0.300	0.044	0.256	0.071
1999	0.814	0.084	0.717	0.071	0.736	0.080	0.635	0.067	0.488	0.067	0.665	0.075	0.309	0.047	0.717	0.098	0.618	0.168
2000	0.572	0.060	0.513	0.052	0.540	0.060	0.472	0.052	0.383	0.052	0.559	0.066	0.284	0.043	0.519	0.067	0.473	0.110
2001	0.249	0.032	0.209	0.027	0.237	0.031	0.194	0.026	0.149	0.024	0.238	0.036	0.110	0.020	0.219	0.036	0.196	0.055
2002	0.387	0.043	0.343	0.037	0.372	0.043	0.323	0.037	0.259	0.036	0.459	0.057	0.223	0.036	0.353	0.047	0.338	0.086
2003	0.373	0.041	0.324	0.034	0.354	0.040	0.301	0.034	0.240	0.034	0.438	0.055	0.224	0.037	0.335	0.046	0.321	0.081
2004	0.275	0.034	0.234	0.029	0.265	0.034	0.224	0.029	0.176	0.027	0.328	0.050	0.174	0.031	0.247	0.038	0.239	0.063
2005	0.324	0.038	0.288	0.033	0.313	0.038	0.277	0.033	0.219	0.032	0.359	0.049	0.202	0.035	0.298	0.040	0.282	0.065
2006	0.914	0.088	0.848	0.079	0.890	0.091	0.821	0.083	0.656	0.084	0.980	0.116	0.554	0.087	0.863	0.092	0.808	0.166
2007	0.364	0.046	0.335	0.042	0.351	0.045	0.320	0.042	0.262	0.040	0.336	0.049	0.196	0.035	0.340	0.047	0.308	0.068
2008	1.310	0.127	1.239	0.119	1.175	0.120	1.095	0.114	0.878	0.113	1.131	0.127	0.638	0.096	1.195	0.143	1.060	0.238
2009	0.233	0.037	0.168	0.032	0.210	0.034	0.154	0.028	0.127	0.026	0.154	0.031	0.084	0.019	0.188	0.045	0.159	0.053
2010	0.807	0.086	0.772	0.082	0.733	0.080	0.708	0.079	0.560	0.078	0.764	0.091	0.372	0.057	0.751	0.090	0.672	0.160
2011	1.021	0.109	0.987	0.105	0.908	0.101	0.898	0.104	0.745	0.110	0.953	0.113	0.518	0.080	0.948	0.116	0.860	0.188
2012	0.476	0.061	0.469	0.062	0.401	0.053	0.401	0.056	0.323	0.053	0.428	0.065	0.196	0.039	0.434	0.068	0.384	0.104
2013	1.146	0.125	1.259	0.137	0.975	0.114	1.112	0.134	0.908	0.133	1.320	0.164	0.664	0.104	1.124	0.164	1.060	0.246
2014	0.208	0.030	0.221	0.033	0.182	0.027	0.201	0.031	0.168	0.030	0.247	0.042	0.134	0.027	0.203	0.033	0.195	0.047
2015	0.281	0.033	0.293	0.034	0.247	0.032	0.269	0.035	0.218	0.034	0.364	0.048	0.173	0.030	0.272	0.038	0.265	0.067
2016	0.176	0.025	0.181	0.026	0.143	0.022	0.152	0.024	0.126	0.022	0.212	0.035	0.107	0.021	0.162	0.029	0.157	0.042
2017	0.145	0.029	0.127	0.028	0.116	0.024	0.110	0.025	0.090	0.021	0.126	0.031	0.069	0.018	0.123	0.029	0.111	0.034
2018	0.885	0.098	0.750	0.077	0.720	0.093	0.663	0.080	0.529	0.077	0.835	0.100	0.413	0.070	0.745	0.117	0.681	0.173
2019	0.583	0.058	0.528	0.051	0.529	0.056	0.476	0.050	0.379	0.052	0.528	0.061	0.272	0.043	0.524	0.065	0.468	0.110
2020	0.583	0.058	0.528	0.051	0.529	0.056	0.476	0.050	0.379	0.052	0.528	0.061	0.272	0.043	0.524	0.065	0.468	0.110
2021	0.583	0.058	0.528	0.051	0.529	0.056	0.476	0.050	0.379	0.052	0.528	0.061	0.272	0.043	0.524	0.065	0.468	0.110
2022	0.583	0.058	0.528	0.051	0.529	0.056	0.476	0.050	0.379	0.052	0.528	0.061	0.272	0.043	0.524	0.065	0.468	0.110

Table 2.28—Instantaneous apical fishing mortality rate time series (point estimates and standard errors).

	no				yes				(yes)						Factor A1: Allow Q to vary?			
	no		yes		no		yes								Factor A2: Combine surveys?			
	(no)						no				yes				Factor B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
	20.4		19.12a		19.15		19.12		20.8		20.9		20.10		Ens. A		Ens. AB	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.185	0.053	0.186	0.052	0.194	0.056	0.197	0.054	0.107	0.029	0.176	0.060	0.057	0.019	0.191	0.054	0.157	0.069
1978	0.226	0.063	0.228	0.062	0.237	0.067	0.244	0.066	0.129	0.034	0.225	0.075	0.071	0.021	0.235	0.065	0.194	0.085
1979	0.162	0.042	0.164	0.041	0.171	0.045	0.177	0.045	0.093	0.024	0.161	0.048	0.051	0.014	0.169	0.044	0.140	0.059
1980	0.167	0.036	0.170	0.036	0.176	0.039	0.185	0.040	0.099	0.023	0.161	0.037	0.052	0.013	0.175	0.038	0.144	0.056
1981	0.124	0.019	0.127	0.019	0.131	0.021	0.139	0.022	0.083	0.016	0.123	0.022	0.049	0.010	0.131	0.021	0.111	0.035
1982	0.093	0.011	0.096	0.012	0.098	0.013	0.105	0.014	0.067	0.011	0.098	0.015	0.042	0.008	0.099	0.013	0.086	0.024
1983	0.113	0.011	0.116	0.011	0.117	0.013	0.126	0.013	0.087	0.012	0.117	0.014	0.056	0.010	0.119	0.013	0.105	0.026
1984	0.155	0.013	0.159	0.013	0.161	0.015	0.171	0.016	0.124	0.016	0.157	0.016	0.082	0.013	0.162	0.016	0.145	0.032
1985	0.172	0.014	0.176	0.014	0.177	0.017	0.187	0.017	0.140	0.017	0.173	0.019	0.098	0.015	0.179	0.017	0.161	0.033
1986	0.164	0.013	0.167	0.013	0.168	0.016	0.176	0.016	0.137	0.016	0.165	0.020	0.101	0.015	0.169	0.015	0.155	0.029
1987	0.188	0.013	0.192	0.013	0.192	0.016	0.201	0.016	0.160	0.018	0.189	0.019	0.117	0.016	0.194	0.016	0.177	0.031
1988	0.223	0.015	0.227	0.015	0.229	0.018	0.237	0.018	0.195	0.021	0.216	0.021	0.153	0.024	0.230	0.017	0.212	0.032
1989	0.210	0.013	0.214	0.013	0.213	0.015	0.221	0.016	0.177	0.018	0.201	0.017	0.119	0.020	0.215	0.015	0.194	0.036
1990	0.236	0.014	0.242	0.013	0.238	0.015	0.248	0.016	0.193	0.018	0.223	0.016	0.122	0.016	0.242	0.015	0.215	0.043
1991	0.405	0.026	0.412	0.026	0.402	0.028	0.414	0.028	0.327	0.033	0.416	0.031	0.233	0.025	0.409	0.028	0.374	0.069
1992	0.450	0.036	0.456	0.036	0.442	0.039	0.451	0.038	0.351	0.039	0.366	0.027	0.197	0.021	0.450	0.037	0.387	0.091
1993	0.304	0.023	0.308	0.023	0.300	0.024	0.305	0.024	0.246	0.026	0.299	0.022	0.165	0.018	0.304	0.024	0.276	0.053
1994	0.398	0.027	0.406	0.027	0.398	0.028	0.407	0.027	0.329	0.032	0.373	0.027	0.205	0.022	0.403	0.028	0.360	0.071
1995	0.493	0.035	0.504	0.034	0.508	0.036	0.520	0.035	0.419	0.040	0.431	0.031	0.230	0.025	0.507	0.036	0.444	0.098
1996	0.458	0.034	0.473	0.033	0.491	0.035	0.507	0.035	0.384	0.040	0.480	0.035	0.269	0.029	0.484	0.039	0.439	0.084
1997	0.501	0.037	0.520	0.037	0.556	0.040	0.578	0.040	0.445	0.047	0.481	0.035	0.257	0.027	0.542	0.049	0.479	0.104
1998	0.397	0.032	0.415	0.032	0.448	0.035	0.468	0.035	0.356	0.040	0.390	0.029	0.211	0.023	0.435	0.044	0.386	0.084
1999	0.378	0.033	0.394	0.033	0.426	0.037	0.445	0.037	0.333	0.039	0.371	0.028	0.201	0.022	0.413	0.044	0.366	0.080
2000	0.367	0.031	0.383	0.032	0.406	0.035	0.427	0.035	0.313	0.037	0.427	0.031	0.236	0.025	0.398	0.040	0.368	0.072
2001	0.333	0.025	0.346	0.025	0.353	0.027	0.370	0.027	0.285	0.030	0.433	0.031	0.241	0.026	0.352	0.030	0.340	0.064
2002	0.363	0.027	0.375	0.027	0.376	0.028	0.390	0.028	0.316	0.030	0.470	0.034	0.261	0.028	0.377	0.029	0.367	0.068
2003	0.366	0.025	0.380	0.025	0.381	0.027	0.399	0.027	0.321	0.030	0.536	0.039	0.307	0.033	0.383	0.029	0.387	0.078
2004	0.375	0.024	0.391	0.024	0.391	0.026	0.412	0.026	0.329	0.031	0.491	0.035	0.277	0.030	0.394	0.028	0.384	0.069
2005	0.393	0.025	0.411	0.025	0.407	0.027	0.431	0.026	0.344	0.033	0.482	0.034	0.275	0.029	0.412	0.029	0.395	0.068
2006	0.427	0.029	0.450	0.029	0.438	0.030	0.470	0.031	0.357	0.038	0.421	0.030	0.226	0.024	0.448	0.034	0.400	0.082
2007	0.406	0.029	0.431	0.030	0.411	0.030	0.447	0.031	0.331	0.038	0.351	0.026	0.192	0.021	0.426	0.034	0.368	0.085
2008	0.488	0.037	0.527	0.039	0.488	0.037	0.536	0.040	0.400	0.045	0.351	0.025	0.190	0.020	0.512	0.044	0.426	0.118
2009	0.603	0.052	0.659	0.056	0.596	0.053	0.658	0.057	0.494	0.060	0.343	0.025	0.176	0.019	0.632	0.062	0.503	0.174
2010	0.581	0.049	0.622	0.051	0.566	0.049	0.608	0.050	0.446	0.053	0.332	0.024	0.178	0.019	0.596	0.055	0.474	0.159
2011	0.693	0.051	0.726	0.053	0.666	0.050	0.700	0.052	0.512	0.058	0.464	0.034	0.252	0.027	0.697	0.056	0.571	0.164
2012	0.614	0.043	0.620	0.043	0.609	0.043	0.618	0.043	0.459	0.049	0.454	0.033	0.247	0.026	0.616	0.043	0.516	0.133
2013	0.568	0.039	0.564	0.038	0.581	0.040	0.574	0.040	0.440	0.045	0.488	0.035	0.267	0.029	0.572	0.040	0.497	0.110
2014	0.627	0.050	0.618	0.048	0.655	0.053	0.636	0.052	0.473	0.053	0.572	0.043	0.317	0.034	0.634	0.053	0.556	0.120
2015	0.598	0.047	0.585	0.046	0.639	0.051	0.607	0.050	0.442	0.053	0.534	0.039	0.290	0.031	0.607	0.053	0.527	0.120
2016	0.554	0.044	0.525	0.041	0.610	0.051	0.553	0.047	0.404	0.049	0.529	0.039	0.291	0.031	0.560	0.055	0.494	0.108
2017	0.467	0.038	0.417	0.033	0.533	0.047	0.447	0.040	0.324	0.040	0.480	0.035	0.271	0.029	0.464	0.058	0.419	0.092
2018	0.368	0.030	0.305	0.023	0.429	0.040	0.327	0.029	0.247	0.029	0.335	0.025	0.194	0.021	0.354	0.056	0.313	0.075
2019	0.376	0.035	0.293	0.024	0.449	0.050	0.312	0.031	0.243	0.029	0.289	0.022	0.169	0.018	0.353	0.071	0.301	0.086
2020	0.434	0.045	0.315	0.028	0.543	0.076	0.339	0.038	0.257	0.034	0.228	0.016	0.121	0.013	0.401	0.103	0.313	0.129
2021	0.238	0.036	0.303	0.040	0.171	0.035	0.257	0.042	0.246	0.042	0.350	0.019	0.215	0.011	0.245	0.061	0.258	0.064
2022	0.248	0.026	0.272	0.024	0.195	0.028	0.240	0.028	0.222	0.027	0.316	0.033	0.215	0.011	0.239	0.038	0.246	0.046

Table 2.29—Management reference points.

Factor A1: Allow Q to vary?		no		yes		(yes)				
Factor A2: Combine surveys?		no	yes	no	yes					
Factor B1: Use fishery CPUE?		(no)			no		yes			
Factor B2: Allow domed selex?					no	yes	no	yes	Ensemble	
Year	Quantity	20.4	19.12a	19.15	19.12	20.8	20.9	20.10	A	AB
n/a	B100%	632,190	659,545	629,325	669,025	805,200	734,275	1,283,340	649,506	771,600
n/a	B40%	252,876	263,818	251,730	267,610	322,080	293,710	513,336	259,803	308,640
n/a	B35%	221,267	230,841	220,264	234,159	281,820	256,996	449,169	227,328	270,060
n/a	F40%	0.37	0.35	0.36	0.33	0.27	0.35	0.22	0.35	0.32
n/a	F35%	0.46	0.43	0.44	0.40	0.33	0.43	0.25	0.43	0.39
2021	Female spawning biomass	164,682	228,219	126,883	210,551	293,096	304,723	576,525	185,645	273,584
2021	Relative spawning biomass	0.26	0.35	0.20	0.31	0.36	0.41	0.45	0.28	0.34
2021	Pr(B/B100%<0.2)	0.02	0.00	0.48	0.00	0.00	0.00	0.00	0.12	0.06
2021	maxFABC	0.24	0.30	0.17	0.26	0.25	0.35	0.22	0.24	0.26
2021	maxABC	72,848	123,805	42,029	99,310	123,210	179,712	166,665	86,480	118,013
2021	Catch	72,848	123,805	42,029	99,310	123,210	179,712	166,665	86,480	118,013
2021	FOFL	0.29	0.37	0.21	0.31	0.30	0.43	0.25	0.30	0.31
2021	OFL	87,678	147,949	50,770	118,895	145,354	213,427	193,833	103,668	139,984
2021	Pr(maxABC>truOFL)	0.23	0.18	0.30	0.25	0.28	0.07	0.16	0.38	0.37
2022	Female spawning biomass	170,874	205,906	142,384	197,652	265,895	261,637	529,300	181,032	253,506
2022	Relative spawning biomass	0.27	0.31	0.23	0.30	0.33	0.36	0.41	0.28	0.32
2022	Pr(B/B100%<0.2)	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.03	0.02
2022	maxFABC	0.25	0.27	0.19	0.24	0.22	0.32	0.22	0.24	0.25
2022	maxABC	84,295	106,852	56,788	91,845	108,512	146,209	162,378	85,758	109,266
2022	Catch	84,295	106,852	56,788	91,845	108,512	146,209	162,378	85,758	109,266
2022	FOFL	0.30	0.33	0.24	0.29	0.27	0.39	0.25	0.29	0.30
2022	OFL	101,682	128,340	68,639	110,353	128,447	174,509	188,997	103,208	130,076
2022	Pr(maxABC>truOFL)	0.23	0.20	0.29	0.26	0.29	0.21	0.18	0.30	0.37

Legend:
B100% = equilibrium unfished female 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)
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
Relative spawning biomass = ratio of female spawning biomass to B100%
Pr(B/B100%<0.2) = probability that relative spawning biomass is less than 0.2
maxFABC = maximum permissible ABC fishing mortality rate under Tier 3
maxABC = maximum permissible ABC under Tier 3
Catch = estimated catch conditional on ABC=maxABC
FOFL = OFL fishing mortality rate under Tier 3
OFL = OFL under Tier 3
Pr(maxABC>truOFL) = probability that maxABC is greater than the "true" OFL

Table 2.30—Bridging analysis, showing effects of new data (and tuning of "sigma" terms) on projections for 2021 from the base model.

	Data updates				Sigma	Results for 2021			Change from 2019 projection		
Bridge	Catch	Sizecomp	Agecomp	Wt-Len	updates	Spn. Bio	Rel. Bio	maxABC	Spn. Bio	Rel. Bio	maxABC
1	X					431444	0.320852	105500	-0.002	-0.002	0.004
2	X	X				434883	0.324352	107857	0.005	0.009	0.027
3	X		X			414585	0.305286	95306	-0.041	-0.050	-0.093
4	X			X		440513	0.327915	110096	0.019	0.020	0.048
5	X	X	X			410329	0.302825	93825	-0.051	-0.058	-0.107
6	X	X		X		432010	0.322163	106421	-0.001	0.002	0.013
7	X		X	X		412287	0.303727	94271	-0.047	-0.055	-0.103
8	X	X	X	X		408190	0.301314	92824	-0.056	-0.063	-0.116
9	X	X	X	X	X	421102	0.314714	99310	-0.026	-0.021	-0.055

Table 2.31a—Length (cm) at age (Model 19.12).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.2	15.6	32.0	43.8	53.2	61.1	67.7	73.4	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	108.2
1978	4.9	15.6	31.3	43.8	53.2	61.1	67.7	73.4	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	108.2
1979	5.3	14.6	32.2	43.3	53.2	61.1	67.7	73.4	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	108.0
1980	4.9	16.0	31.4	43.9	52.8	61.1	67.7	73.4	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.9
1981	4.2	14.7	30.0	43.3	53.4	60.7	67.7	73.4	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.9
1982	4.3	12.6	30.2	42.3	52.8	61.2	67.4	73.4	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.8
1983	5.8	12.9	33.1	42.4	52.0	60.7	67.8	73.1	78.3	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.8
1984	5.3	17.4	32.0	44.7	52.1	60.1	67.4	73.5	78.1	82.6	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.8
1985	3.9	15.8	29.5	43.8	54.0	60.2	66.8	73.2	78.4	82.4	86.4	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.8
1986	5.1	11.7	31.6	41.9	53.3	61.7	66.9	72.7	78.1	82.7	86.2	89.6	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.9
1987	4.6	15.2	30.8	43.5	51.7	61.1	68.3	72.7	77.7	82.4	86.4	89.5	92.5	95.1	97.3	99.3	101.1	102.6	104.0	105.3	107.9
1988	4.4	13.8	30.3	42.9	53.0	59.8	67.7	73.9	77.8	82.1	86.2	89.7	92.4	95.1	97.3	99.3	101.1	102.6	104.0	105.3	108.0
1989	4.4	13.1	30.4	42.5	52.5	60.9	66.6	73.4	78.7	82.1	85.9	89.5	92.6	95.0	97.3	99.3	101.1	102.6	104.0	105.3	108.0
1990	4.9	13.2	31.4	42.6	52.2	60.5	67.6	72.5	78.4	83.0	85.9	89.2	92.4	95.1	97.2	99.3	101.1	102.6	104.0	105.3	108.0
1991	5.4	14.8	32.3	43.4	52.2	60.2	67.2	73.3	77.5	82.6	86.7	89.3	92.2	95.0	97.4	99.2	101.1	102.6	104.0	105.3	108.0
1992	5.0	16.1	31.5	44.0	52.9	60.2	67.0	73.0	78.2	81.9	86.4	89.9	92.2	94.7	97.2	99.3	101.0	102.6	104.0	105.3	107.9
1993	5.2	14.8	32.0	43.4	53.4	60.8	67.0	72.8	77.9	82.5	85.7	89.7	92.8	94.8	97.0	99.2	101.1	102.6	104.0	105.3	107.7
1994	4.9	15.6	31.3	43.8	52.9	61.2	67.5	72.8	77.8	82.3	86.3	89.1	92.6	95.3	97.1	99.1	101.0	102.7	104.0	105.3	107.3
1995	4.8	14.6	31.2	43.2	53.2	60.8	67.9	73.2	77.8	82.1	86.1	89.6	92.1	95.1	97.5	99.1	100.8	102.6	104.0	105.2	107.4
1996	4.9	14.5	31.4	43.2	52.8	61.1	67.5	73.5	78.1	82.2	85.9	89.4	92.5	94.7	97.3	99.5	100.9	102.4	104.0	105.3	107.1
1997	4.8	14.8	31.2	43.3	52.7	60.7	67.7	73.2	78.4	82.5	86.0	89.3	92.3	95.0	97.0	99.3	101.2	102.5	103.8	105.2	106.8
1998	4.5	14.5	30.5	43.2	52.9	60.7	67.4	73.4	78.2	82.7	86.2	89.3	92.2	94.9	97.3	99.0	101.1	102.8	103.9	105.1	107.1
1999	4.1	13.4	29.9	42.7	52.8	60.8	67.4	73.1	78.3	82.5	86.4	89.5	92.2	94.8	97.2	99.3	100.8	102.7	104.1	105.1	107.2
2000	5.6	12.3	32.6	42.2	52.3	60.7	67.5	73.1	78.1	82.6	86.2	89.7	92.4	94.8	97.1	99.2	101.0	102.4	104.0	105.4	107.8
2001	5.2	16.7	32.0	44.3	51.9	60.3	67.4	73.2	78.1	82.4	86.4	89.5	92.6	95.0	97.1	99.1	100.9	102.6	103.8	105.3	108.2
2002	5.5	15.7	32.5	43.8	53.6	60.0	67.1	73.1	78.1	82.4	86.2	89.6	92.4	95.1	97.2	99.1	100.9	102.5	104.0	105.1	107.3
2003	5.1	16.5	31.7	44.2	53.2	61.4	66.8	72.8	78.1	82.5	86.2	89.5	92.5	95.0	97.4	99.2	100.9	102.5	103.9	105.2	107.7
2004	6.1	15.2	33.6	43.6	53.6	61.1	68.0	72.6	77.8	82.4	86.2	89.5	92.4	95.1	97.3	99.4	101.0	102.5	103.9	105.2	107.3
2005	4.8	18.2	31.2	45.1	53.1	61.4	67.7	73.7	77.6	82.2	86.2	89.5	92.4	95.0	97.3	99.3	101.1	102.6	103.9	105.1	107.6
2006	4.8	14.5	31.1	43.2	54.3	60.9	68.0	73.4	78.6	82.0	86.0	89.5	92.4	95.0	97.2	99.3	101.0	102.7	104.0	105.1	107.8
2007	4.2	14.3	30.1	43.1	52.8	62.0	67.6	73.6	78.3	82.8	85.8	89.3	92.4	95.0	97.2	99.2	101.1	102.6	104.1	105.2	108.3
2008	4.1	12.7	29.9	42.4	52.7	60.7	68.5	73.3	78.5	82.6	86.5	89.2	92.2	95.0	97.2	99.2	101.0	102.6	104.0	105.3	107.6
2009	4.4	12.4	30.5	42.2	52.1	60.6	67.4	74.1	78.2	82.8	86.4	89.8	92.1	94.8	97.2	99.2	101.0	102.6	104.0	105.2	107.0
2010	5.2	13.3	31.9	42.6	51.9	60.1	67.3	73.1	78.9	82.5	86.5	89.7	92.7	94.7	97.1	99.2	101.0	102.6	104.0	105.3	107.0
2011	4.1	15.6	29.9	43.7	52.3	60.0	66.9	73.1	78.1	83.1	86.3	89.8	92.5	95.2	97.0	99.1	101.0	102.6	104.0	105.2	107.3
2012	5.2	12.4	31.8	42.2	53.2	60.3	66.8	72.7	78.0	82.4	86.8	89.6	92.6	95.1	97.4	99.0	100.9	102.6	104.0	105.2	106.8
2013	4.7	15.5	31.0	43.7	52.0	61.0	67.0	72.6	77.7	82.4	86.2	90.0	92.5	95.2	97.3	99.4	100.8	102.5	104.0	105.2	107.2
2014	5.1	14.2	31.7	43.0	53.2	60.0	67.7	72.8	77.6	82.1	86.1	89.5	92.9	95.0	97.4	99.3	101.2	102.4	103.9	105.2	107.3
2015	6.4	15.3	34.4	43.6	52.6	61.0	66.8	73.4	77.8	82.0	85.9	89.4	92.4	95.4	97.3	99.4	101.1	102.7	103.8	105.1	107.4
2016	6.6	19.3	34.7	45.7	53.1	60.6	67.7	72.6	78.3	82.2	85.8	89.2	92.4	95.0	97.6	99.3	101.2	102.6	104.1	105.1	106.8
2017	6.0	19.7	33.6	45.9	54.8	60.9	67.3	73.4	77.7	82.6	86.0	89.2	92.2	94.9	97.2	99.6	101.1	102.7	104.0	105.3	107.1
2018	7.1	18.1	35.9	45.0	55.0	62.4	67.6	73.0	78.3	82.0	86.3	89.3	92.1	94.8	97.2	99.2	101.3	102.6	104.1	105.3	107.4
2019	4.3	21.4	30.2	46.9	54.3	62.6	68.8	73.3	78.0	82.6	85.8	89.6	92.2	94.7	97.0	99.2	101.0	102.8	104.0	105.3	107.1
2020	5.2	15.6	31.5	42.4	55.8	61.9	69.0	74.4	78.3	82.3	86.3	89.2	92.5	94.8	97.0	99.1	101.0	102.6	104.2	105.2	107.2

Table 2.31b—Length (cm) at age (Ensemble A).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.2	15.6	32.0	43.8	53.3	61.1	67.8	73.5	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.7
1978	4.9	15.6	31.3	43.8	53.3	61.1	67.8	73.5	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.7
1979	5.3	14.6	32.2	43.3	53.3	61.1	67.8	73.5	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.5
1980	4.9	15.9	31.4	44.0	52.9	61.1	67.8	73.5	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.4
1981	4.2	14.7	30.1	43.4	53.4	60.8	67.8	73.5	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.3
1982	4.3	12.6	30.3	42.3	52.9	61.3	67.5	73.5	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.3
1983	5.7	12.9	33.0	42.5	52.1	60.8	67.9	73.2	78.4	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.3
1984	5.3	17.1	32.1	44.6	52.2	60.1	67.5	73.5	78.1	82.6	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.3
1985	3.9	15.8	29.6	43.9	53.9	60.2	66.9	73.2	78.4	82.4	86.3	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.3
1986	5.0	11.8	31.7	42.0	53.4	61.7	67.0	72.7	78.2	82.7	86.2	89.6	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.3
1987	4.6	15.1	30.8	43.6	51.8	61.2	68.2	72.8	77.7	82.4	86.4	89.4	92.4	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.4
1988	4.3	13.8	30.3	42.9	53.1	59.9	67.8	73.9	77.8	82.1	86.2	89.6	92.3	94.9	97.1	99.1	100.8	102.3	103.7	104.9	107.4
1989	4.4	13.0	30.4	42.6	52.6	61.0	66.7	73.5	78.7	82.1	85.8	89.4	92.5	94.8	97.1	99.1	100.8	102.3	103.7	104.9	107.4
1990	4.9	13.1	31.4	42.6	52.3	60.5	67.6	72.5	78.4	82.9	85.9	89.2	92.3	95.0	97.0	99.1	100.8	102.3	103.7	104.9	107.5
1991	5.3	14.7	32.2	43.4	52.3	60.3	67.3	73.3	77.6	82.7	86.6	89.2	92.1	94.8	97.2	99.0	100.8	102.3	103.7	104.9	107.5
1992	4.9	16.0	31.5	44.0	52.9	60.3	67.0	73.0	78.3	81.9	86.4	89.8	92.1	94.6	97.0	99.1	100.7	102.3	103.7	104.9	107.4
1993	5.3	14.8	32.1	43.4	53.5	60.8	67.1	72.8	78.0	82.5	85.7	89.6	92.6	94.6	96.8	99.0	100.8	102.3	103.7	104.9	107.2
1994	4.8	15.8	31.2	43.9	53.0	61.3	67.5	72.8	77.8	82.3	86.3	89.0	92.4	95.1	96.9	98.8	100.7	102.3	103.6	104.9	106.8
1995	4.8	14.5	31.2	43.3	53.4	60.9	67.9	73.2	77.8	82.1	86.0	89.5	92.0	94.9	97.3	98.9	100.6	102.3	103.7	104.8	107.0
1996	4.9	14.4	31.4	43.2	52.8	61.2	67.6	73.6	78.2	82.2	85.9	89.3	92.4	94.5	97.2	99.2	100.6	102.1	103.6	104.9	106.6
1997	4.8	14.7	31.2	43.4	52.8	60.8	67.8	73.3	78.5	82.5	85.9	89.2	92.2	94.9	96.8	99.1	100.9	102.1	103.5	104.8	106.3
1998	4.4	14.5	30.5	43.3	52.9	60.7	67.5	73.5	78.2	82.7	86.2	89.2	92.1	94.7	97.1	98.8	100.8	102.4	103.5	104.7	106.6
1999	4.1	13.2	29.8	42.7	52.8	60.8	67.4	73.2	78.4	82.5	86.4	89.5	92.1	94.6	97.0	99.0	100.5	102.3	103.8	104.7	106.7
2000	5.6	12.2	32.7	42.2	52.4	60.8	67.5	73.2	78.1	82.7	86.2	89.6	92.3	94.7	96.9	98.9	100.8	102.1	103.7	104.9	107.3
2001	5.2	16.8	32.0	44.4	52.0	60.4	67.5	73.2	78.1	82.4	86.4	89.5	92.5	94.8	96.9	98.9	100.7	102.3	103.5	104.9	107.7
2002	5.5	15.6	32.5	43.8	53.8	60.0	67.1	73.2	78.2	82.4	86.1	89.6	92.3	95.0	97.1	98.9	100.6	102.2	103.6	104.7	106.8
2003	5.1	16.4	31.7	44.2	53.3	61.6	66.8	72.9	78.1	82.4	86.1	89.4	92.4	94.8	97.2	99.0	100.6	102.2	103.6	104.8	107.2
2004	6.0	15.2	33.6	43.6	53.6	61.2	68.1	72.6	77.9	82.4	86.2	89.4	92.3	95.0	97.1	99.1	100.7	102.2	103.5	104.8	106.8
2005	4.8	18.1	31.2	45.1	53.1	61.4	67.8	73.8	77.7	82.2	86.1	89.4	92.3	94.8	97.2	99.0	100.8	102.3	103.5	104.7	107.1
2006	4.8	14.4	31.1	43.2	54.4	61.0	68.0	73.5	78.6	82.0	86.0	89.4	92.3	94.8	97.0	99.1	100.7	102.4	103.6	104.7	107.4
2007	4.2	14.3	30.1	43.2	52.8	62.0	67.7	73.7	78.4	82.8	85.8	89.2	92.3	94.8	97.0	99.0	100.8	102.3	103.7	104.8	107.8
2008	4.1	12.6	29.9	42.4	52.8	60.7	68.5	73.4	78.5	82.6	86.5	89.1	92.1	94.8	97.0	99.0	100.7	102.3	103.6	104.9	107.1
2009	4.5	12.3	30.6	42.2	52.1	60.7	67.4	74.1	78.3	82.8	86.3	89.8	92.0	94.7	97.0	99.0	100.7	102.2	103.7	104.8	106.6
2010	5.2	13.4	31.9	42.8	52.0	60.2	67.4	73.2	78.9	82.5	86.5	89.6	92.6	94.6	96.9	99.0	100.7	102.2	103.6	104.9	106.5
2011	4.2	15.5	30.0	43.8	52.4	60.0	66.9	73.1	78.1	83.1	86.3	89.7	92.4	95.1	96.8	98.9	100.7	102.3	103.6	104.8	106.8
2012	5.1	12.4	31.7	42.3	53.3	60.4	66.8	72.7	78.1	82.4	86.8	89.5	92.5	94.9	97.3	98.8	100.6	102.2	103.6	104.8	106.4
2013	4.7	15.2	31.1	43.6	52.0	61.1	67.2	72.7	77.7	82.4	86.1	90.0	92.4	95.0	97.1	99.2	100.6	102.2	103.6	104.8	106.7
2014	5.1	14.2	31.8	43.2	53.1	60.1	67.8	72.9	77.7	82.1	86.1	89.4	92.8	94.9	97.2	99.1	100.9	102.1	103.5	104.8	106.9
2015	6.4	15.3	34.4	43.7	52.7	61.0	66.9	73.4	77.9	82.0	85.9	89.4	92.3	95.2	97.1	99.2	100.8	102.4	103.5	104.7	106.9
2016	6.6	19.2	34.9	45.7	53.2	60.7	67.7	72.7	78.4	82.2	85.8	89.2	92.3	94.8	97.4	99.0	100.9	102.3	103.7	104.7	106.3
2017	6.2	19.9	34.0	46.1	54.8	61.0	67.4	73.4	77.7	82.6	86.0	89.1	92.1	94.8	97.0	99.3	100.8	102.4	103.7	104.9	106.6
2018	7.1	18.6	35.9	45.4	55.2	62.4	67.7	73.1	78.3	82.0	86.3	89.3	92.0	94.6	97.0	99.0	101.0	102.3	103.7	104.9	107.0
2019	4.1	21.4	29.9	46.9	54.6	62.7	68.9	73.4	78.1	82.5	85.8	89.6	92.2	94.6	96.9	99.0	100.7	102.5	103.6	104.9	106.6

Table 2.31c—Length (cm) at age (Ensemble AB).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.2	15.5	31.9	43.8	53.3	61.2	67.7	73.2	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.7
1978	4.8	15.5	31.2	43.8	53.3	61.2	67.7	73.2	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.7
1979	5.3	14.5	32.1	43.3	53.3	61.2	67.7	73.2	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.6
1980	4.9	15.8	31.3	44.0	52.9	61.2	67.7	73.2	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1981	4.2	14.7	30.0	43.4	53.5	60.8	67.7	73.2	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1982	4.3	12.6	30.2	42.4	53.0	61.3	67.4	73.2	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1983	5.7	13.0	32.9	42.6	52.2	60.9	67.8	73.0	78.0	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1984	5.2	17.1	32.0	44.7	52.3	60.2	67.5	73.3	77.8	82.0	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1985	3.9	15.7	29.5	43.9	54.0	60.3	66.9	73.0	78.0	81.9	85.5	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1986	5.0	11.8	31.6	42.0	53.4	61.7	67.0	72.6	77.8	82.1	85.4	88.6	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.5
1987	4.6	15.1	30.8	43.6	51.8	61.2	68.2	72.6	77.4	81.9	85.6	88.4	91.2	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.6
1988	4.4	13.8	30.4	43.0	53.2	59.9	67.8	73.7	77.5	81.5	85.4	88.6	91.1	93.5	95.5	97.2	98.8	100.1	101.3	102.3	104.6
1989	4.4	13.2	30.3	42.7	52.7	61.0	66.7	73.3	78.3	81.6	85.1	88.4	91.2	93.4	95.5	97.2	98.8	100.1	101.3	102.3	104.6
1990	4.9	13.1	31.4	42.6	52.4	60.6	67.6	72.4	78.0	82.3	85.1	88.2	91.1	93.5	95.4	97.2	98.8	100.1	101.3	102.3	104.7
1991	5.4	14.8	32.3	43.5	52.4	60.4	67.2	73.2	77.2	82.1	85.8	88.2	90.9	93.4	95.5	97.1	98.8	100.1	101.3	102.3	104.7
1992	5.0	16.1	31.4	44.2	53.0	60.4	67.0	72.8	77.9	81.4	85.6	88.8	90.9	93.2	95.4	97.2	98.7	100.1	101.3	102.3	104.6
1993	5.3	14.8	32.1	43.5	53.6	60.9	67.0	72.7	77.6	82.0	85.0	88.6	91.4	93.2	95.2	97.2	98.8	100.0	101.3	102.3	104.4
1994	4.8	15.8	31.2	44.0	53.1	61.4	67.5	72.7	77.5	81.7	85.5	88.1	91.2	93.6	95.3	97.0	98.7	100.1	101.2	102.3	104.1
1995	4.8	14.5	31.2	43.3	53.5	60.9	67.9	73.1	77.5	81.6	85.3	88.5	90.8	93.5	95.6	97.0	98.6	100.0	101.3	102.3	104.2
1996	4.9	14.5	31.4	43.3	52.9	61.3	67.5	73.4	77.8	81.6	85.2	88.3	91.1	93.1	95.5	97.4	98.6	99.9	101.2	102.3	103.9
1997	4.8	14.7	31.0	43.4	52.9	60.8	67.8	73.1	78.1	81.9	85.2	88.2	91.0	93.4	95.2	97.2	98.9	99.9	101.1	102.3	103.6
1998	4.5	14.3	30.5	43.2	53.0	60.8	67.4	73.3	77.8	82.1	85.4	88.2	90.9	93.3	95.4	96.9	98.8	100.2	101.1	102.2	103.9
1999	4.1	13.4	29.8	42.8	52.8	60.9	67.4	73.0	78.0	81.9	85.6	88.5	90.9	93.2	95.3	97.2	98.5	100.1	101.4	102.2	104.0
2000	5.5	12.3	32.6	42.2	52.5	60.7	67.5	73.0	77.8	82.1	85.4	88.6	91.1	93.2	95.3	97.1	98.7	99.9	101.3	102.4	104.5
2001	5.2	16.6	31.9	44.4	52.0	60.5	67.3	73.1	77.8	81.9	85.6	88.5	91.3	93.4	95.3	97.0	98.6	100.1	101.1	102.3	104.8
2002	5.4	15.6	32.4	43.9	53.8	60.1	67.1	72.9	77.8	81.8	85.4	88.6	91.1	93.5	95.4	97.0	98.6	100.0	101.3	102.1	104.1
2003	5.0	16.3	31.6	44.2	53.4	61.5	66.8	72.7	77.7	81.9	85.4	88.4	91.2	93.4	95.5	97.2	98.6	100.0	101.2	102.3	104.5
2004	6.0	15.1	33.6	43.6	53.7	61.2	68.0	72.5	77.5	81.8	85.4	88.4	91.1	93.5	95.4	97.3	98.7	100.0	101.1	102.2	104.1
2005	4.8	18.1	31.2	45.2	53.2	61.4	67.7	73.5	77.3	81.7	85.3	88.5	91.1	93.4	95.5	97.2	98.8	100.0	101.1	102.2	104.3
2006	4.8	14.5	31.1	43.3	54.4	61.0	67.9	73.3	78.2	81.5	85.2	88.4	91.1	93.4	95.4	97.2	98.7	100.1	101.2	102.2	104.6
2007	4.3	14.3	30.2	43.2	52.9	62.1	67.6	73.5	78.0	82.2	85.0	88.3	91.0	93.4	95.4	97.1	98.8	100.1	101.3	102.3	104.9
2008	4.2	12.9	30.0	42.5	52.8	60.8	68.5	73.1	78.1	82.0	85.7	88.1	90.9	93.4	95.4	97.1	98.7	100.1	101.2	102.3	104.4
2009	4.5	12.5	30.6	42.3	52.3	60.8	67.4	73.9	77.9	82.2	85.5	88.7	90.8	93.3	95.4	97.2	98.7	100.0	101.3	102.3	103.9
2010	5.2	13.5	31.9	42.8	52.1	60.3	67.4	73.0	78.5	82.0	85.7	88.6	91.3	93.2	95.3	97.1	98.7	100.0	101.2	102.3	103.9
2011	4.2	15.6	29.9	43.9	52.5	60.2	67.0	73.0	77.8	82.5	85.5	88.7	91.2	93.6	95.2	97.1	98.7	100.0	101.2	102.3	104.1
2012	5.1	12.5	31.7	42.3	53.4	60.5	66.9	72.6	77.7	81.8	86.0	88.5	91.3	93.5	95.6	97.0	98.6	100.0	101.2	102.3	103.7
2013	4.7	15.3	31.0	43.7	52.1	61.2	67.1	72.5	77.4	81.8	85.4	88.9	91.1	93.6	95.5	97.3	98.5	100.0	101.2	102.3	104.0
2014	5.0	14.2	31.6	43.2	53.3	60.1	67.7	72.8	77.4	81.6	85.3	88.4	91.5	93.4	95.5	97.2	98.8	99.9	101.2	102.3	104.2
2015	6.4	15.1	34.3	43.6	52.8	61.1	66.9	73.3	77.6	81.5	85.1	88.4	91.1	93.8	95.4	97.3	98.8	100.2	101.1	102.2	104.2
2016	6.6	19.1	34.8	45.7	53.2	60.7	67.6	72.5	78.0	81.7	85.1	88.2	91.0	93.4	95.7	97.2	98.8	100.1	101.3	102.2	103.7
2017	6.1	19.7	33.8	46.1	54.9	61.0	67.3	73.2	77.4	82.0	85.2	88.2	90.9	93.4	95.4	97.4	98.7	100.1	101.3	102.4	104.0
2018	7.1	18.4	36.0	45.4	55.2	62.5	67.6	72.9	77.9	81.5	85.5	88.3	90.8	93.2	95.4	97.1	98.9	100.1	101.3	102.3	104.2
2019	4.2	21.4	30.0	47.0	54.6	62.7	68.8	73.2	77.7	82.0	85.1	88.6	91.0	93.2	95.2	97.1	98.7	100.3	101.2	102.3	103.9

Table 2.32a—Weight (kg) at age (fishery, Model 19.12).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.01	0.08	0.58	1.36	2.29	3.27	4.25	5.25	6.32	7.41	8.50	9.55	10.54	11.47	12.33	13.12	13.83	14.49	15.07	15.59	16.83
1978	0.00	0.06	0.49	1.28	2.24	3.28	4.33	5.43	6.61	7.84	9.08	10.28	11.42	12.49	13.50	14.42	15.27	16.03	16.72	17.34	18.81
1979	0.01	0.06	0.57	1.30	2.27	3.25	4.24	5.25	6.33	7.44	8.54	9.60	10.61	11.55	12.42	13.22	13.95	14.62	15.21	15.74	16.91
1980	0.00	0.07	0.51	1.29	2.15	3.16	4.14	5.15	6.22	7.34	8.44	9.51	10.52	11.47	12.35	13.17	13.91	14.58	15.18	15.72	16.86
1981	0.00	0.06	0.45	1.23	2.17	3.07	4.08	5.08	6.13	7.22	8.29	9.33	10.31	11.23	12.08	12.86	13.58	14.22	14.80	15.32	16.40
1982	0.00	0.04	0.52	1.29	2.30	3.35	4.28	5.34	6.41	7.51	8.61	9.66	10.66	11.59	12.45	13.25	13.97	14.63	15.21	15.74	16.82
1983	0.01	0.04	0.63	1.27	2.20	3.31	4.41	5.41	6.58	7.75	8.91	10.03	11.09	12.09	13.01	13.86	14.64	15.34	15.98	16.54	17.70
1984	0.01	0.12	0.59	1.39	2.06	2.92	3.87	4.79	5.63	6.59	7.49	8.34	9.15	9.89	10.58	11.22	11.79	12.31	12.77	13.18	14.03
1985	0.00	0.07	0.46	1.37	2.42	3.25	4.29	5.47	6.69	7.82	9.08	10.25	11.36	12.40	13.37	14.26	15.07	15.81	16.48	17.07	18.30
1986	0.00	0.03	0.50	1.15	2.27	3.41	4.27	5.37	6.68	8.01	9.19	10.47	11.63	12.72	13.74	14.68	15.53	16.31	17.01	17.64	18.96
1987	0.00	0.06	0.52	1.34	2.15	3.33	4.44	5.28	6.37	7.64	8.87	9.92	11.04	12.04	12.96	13.82	14.60	15.30	15.94	16.50	17.71
1988	0.01	0.05	0.43	1.20	2.23	3.17	4.51	5.79	6.79	8.08	9.51	10.84	11.97	13.15	14.21	15.18	16.06	16.87	17.59	18.24	19.65
1989	0.00	0.04	0.48	1.26	2.28	3.44	4.40	5.76	7.11	8.12	9.38	10.74	11.98	13.02	14.10	15.04	15.91	16.69	17.40	18.03	19.42
1990	0.00	0.05	0.57	1.32	2.28	3.35	4.46	5.38	6.72	7.99	8.90	10.01	11.18	12.24	13.11	14.00	14.78	15.48	16.12	16.68	17.93
1991	0.01	0.06	0.58	1.31	2.16	3.12	4.12	5.17	6.06	7.33	8.49	9.30	10.28	11.28	12.19	12.92	13.67	14.31	14.89	15.41	16.55
1992	0.00	0.07	0.52	1.31	2.15	3.02	3.96	4.95	6.04	6.95	8.21	9.32	10.09	11.00	11.93	12.76	13.43	14.10	14.68	15.20	16.31
1993	0.01	0.07	0.58	1.35	2.38	3.37	4.35	5.43	6.60	7.84	8.83	10.15	11.29	12.06	12.97	13.90	14.71	15.36	16.01	16.56	17.63
1994	0.01	0.07	0.52	1.31	2.20	3.24	4.18	5.13	6.20	7.36	8.55	9.46	10.67	11.70	12.40	13.21	14.03	14.75	15.32	15.88	16.78
1995	0.00	0.06	0.49	1.24	2.22	3.19	4.28	5.28	6.32	7.49	8.70	9.90	10.81	12.01	13.01	13.69	14.48	15.27	15.95	16.48	17.52
1996	0.01	0.07	0.61	1.38	2.29	3.28	4.19	5.19	6.12	7.06	8.05	9.04	10.00	10.72	11.64	12.41	12.92	13.51	14.09	14.59	15.26
1997	0.01	0.06	0.49	1.22	2.08	3.01	4.00	4.94	6.02	6.99	7.96	8.95	9.93	10.87	11.57	12.47	13.21	13.70	14.26	14.81	15.44
1998	0.00	0.06	0.49	1.25	2.13	3.03	3.95	4.93	5.88	6.96	7.91	8.82	9.74	10.64	11.49	12.12	12.92	13.57	14.00	14.48	15.26
1999	0.00	0.05	0.49	1.26	2.20	3.17	4.12	5.10	6.19	7.22	8.35	9.31	10.21	11.12	12.00	12.82	13.43	14.19	14.80	15.20	16.06
2000	0.01	0.04	0.64	1.30	2.29	3.34	4.36	5.38	6.47	7.66	8.74	9.88	10.84	11.73	12.62	13.47	14.27	14.84	15.57	16.15	17.21
2001	0.01	0.09	0.61	1.44	2.20	3.20	4.20	5.18	6.19	7.26	8.37	9.35	10.37	11.21	11.99	12.75	13.47	14.14	14.63	15.22	16.38
2002	0.01	0.08	0.58	1.32	2.29	3.09	4.10	5.14	6.21	7.31	8.43	9.56	10.53	11.53	12.35	13.09	13.83	14.52	15.15	15.60	16.56
2003	0.00	0.08	0.52	1.33	2.22	3.26	4.07	5.13	6.28	7.43	8.55	9.65	10.74	11.68	12.64	13.41	14.12	14.81	15.46	16.05	17.16
2004	0.01	0.07	0.63	1.31	2.28	3.22	4.23	5.03	6.13	7.27	8.36	9.38	10.37	11.33	12.15	12.98	13.65	14.25	14.83	15.37	16.25
2005	0.00	0.11	0.51	1.42	2.23	3.30	4.28	5.37	6.26	7.46	8.66	9.77	10.80	11.79	12.74	13.55	14.36	15.01	15.59	16.15	17.23
2006	0.00	0.06	0.53	1.31	2.39	3.25	4.30	5.29	6.42	7.31	8.46	9.58	10.60	11.54	12.42	13.27	13.98	14.69	15.25	15.75	16.91
2007	0.00	0.05	0.50	1.32	2.27	3.45	4.33	5.43	6.50	7.69	8.60	9.75	10.85	11.84	12.74	13.58	14.38	15.05	15.71	16.23	17.59
2008	0.00	0.04	0.49	1.25	2.22	3.21	4.35	5.20	6.32	7.39	8.54	9.39	10.44	11.44	12.32	13.11	13.85	14.54	15.11	15.67	16.65
2009	0.00	0.03	0.52	1.27	2.22	3.29	4.29	5.48	6.44	7.68	8.81	9.99	10.86	11.92	12.91	13.79	14.57	15.28	15.96	16.51	17.35
2010	0.00	0.03	0.59	1.30	2.20	3.18	4.20	5.18	6.44	7.41	8.61	9.66	10.74	11.52	12.47	13.35	14.12	14.79	15.41	15.99	16.76
2011	0.00	0.05	0.49	1.35	2.17	3.09	4.06	5.11	6.17	7.47	8.41	9.54	10.52	11.51	12.22	13.08	13.87	14.55	15.15	15.70	16.59
2012	0.00	0.04	0.57	1.22	2.21	3.04	3.92	4.85	5.90	6.92	8.11	8.94	9.91	10.74	11.57	12.15	12.86	13.49	14.04	14.52	15.15
2013	0.00	0.06	0.50	1.29	2.08	3.17	4.04	4.98	6.05	7.24	8.38	9.66	10.53	11.55	12.41	13.27	13.87	14.59	15.24	15.79	16.65
2014	0.00	0.04	0.53	1.25	2.21	3.05	4.12	5.00	6.01	7.17	8.40	9.53	10.78	11.62	12.60	13.42	14.23	14.79	15.46	16.07	17.03
2015	0.00	0.04	0.64	1.28	2.13	3.12	3.94	5.03	5.98	7.05	8.19	9.36	10.41	11.55	12.33	13.21	13.94	14.67	15.17	15.76	16.76
2016	0.00	0.10	0.68	1.47	2.22	3.14	4.15	5.01	6.23	7.24	8.32	9.44	10.57	11.56	12.64	13.36	14.18	14.85	15.50	15.96	16.72
2017	0.00	0.11	0.63	1.50	2.42	3.22	4.16	5.24	6.19	7.50	8.53	9.62	10.71	11.80	12.75	13.77	14.45	15.21	15.83	16.44	17.27
2018	0.01	0.10	0.73	1.40	2.41	3.38	4.18	5.14	6.29	7.26	8.54	9.52	10.52	11.51	12.48	13.32	14.21	14.80	15.45	15.98	16.93
2019	0.00	0.15	0.47	1.56	2.36	3.46	4.45	5.29	6.36	7.61	8.63	9.93	10.90	11.89	12.86	13.79	14.60	15.45	16.00	16.61	17.43
2020	0.00	0.04	0.48	1.14	2.40	3.21	4.28	5.29	6.16	7.23	8.42	9.37	10.55	11.43	12.31	13.16	13.98	14.68	15.42	15.89	16.76

Table 2.32b—Weight (kg) at age (fishery, Ensemble A).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.01	0.08	0.58	1.37	2.31	3.29	4.27	5.27	6.32	7.41	8.49	9.53	10.51	11.42	12.26	13.03	13.73	14.36	14.92	15.43	16.60
1978	0.00	0.06	0.49	1.29	2.26	3.30	4.35	5.44	6.61	7.84	9.07	10.25	11.38	12.44	13.42	14.32	15.14	15.88	16.55	17.15	18.55
1979	0.01	0.06	0.58	1.31	2.28	3.27	4.26	5.26	6.33	7.44	8.53	9.58	10.57	11.50	12.35	13.13	13.84	14.48	15.06	15.57	16.69
1980	0.00	0.07	0.51	1.30	2.16	3.18	4.16	5.16	6.23	7.34	8.43	9.49	10.49	11.42	12.28	13.07	13.79	14.44	15.03	15.55	16.64
1981	0.00	0.06	0.45	1.24	2.19	3.09	4.10	5.09	6.14	7.22	8.28	9.31	10.27	11.18	12.01	12.77	13.47	14.10	14.66	15.16	16.18
1982	0.00	0.04	0.53	1.30	2.32	3.37	4.30	5.35	6.42	7.51	8.60	9.64	10.62	11.54	12.38	13.16	13.86	14.50	15.06	15.57	16.59
1983	0.01	0.04	0.62	1.28	2.22	3.34	4.43	5.42	6.59	7.75	8.90	10.01	11.06	12.03	12.94	13.77	14.52	15.21	15.82	16.36	17.46
1984	0.01	0.11	0.59	1.38	2.08	2.94	3.88	4.80	5.64	6.59	7.48	8.33	9.12	9.85	10.53	11.14	11.70	12.20	12.65	13.05	13.86
1985	0.00	0.07	0.47	1.38	2.42	3.28	4.31	5.48	6.70	7.83	9.08	10.23	11.32	12.34	13.29	14.16	14.95	15.67	16.31	16.88	18.05
1986	0.00	0.03	0.51	1.17	2.29	3.42	4.30	5.39	6.69	8.01	9.18	10.45	11.59	12.66	13.66	14.57	15.41	16.16	16.84	17.44	18.69
1987	0.00	0.06	0.52	1.35	2.17	3.36	4.45	5.29	6.39	7.65	8.87	9.90	11.00	11.98	12.89	13.72	14.48	15.16	15.78	16.32	17.46
1988	0.01	0.05	0.43	1.21	2.25	3.20	4.53	5.79	6.80	8.08	9.50	10.82	11.93	13.09	14.12	15.07	15.93	16.71	17.41	18.04	19.36
1989	0.00	0.04	0.48	1.27	2.30	3.46	4.42	5.78	7.10	8.13	9.38	10.72	11.94	12.96	14.01	14.94	15.78	16.54	17.22	17.83	19.14
1990	0.00	0.05	0.57	1.32	2.29	3.37	4.48	5.40	6.73	7.97	8.90	10.00	11.15	12.19	13.03	13.91	14.66	15.35	15.96	16.50	17.69
1991	0.01	0.06	0.58	1.32	2.17	3.14	4.14	5.19	6.08	7.34	8.47	9.29	10.25	11.24	12.12	12.83	13.56	14.18	14.74	15.24	16.33
1992	0.00	0.07	0.53	1.32	2.17	3.04	3.98	4.97	6.05	6.96	8.20	9.29	10.06	10.95	11.87	12.67	13.32	13.98	14.54	15.04	16.09
1993	0.01	0.07	0.59	1.37	2.40	3.39	4.37	5.44	6.61	7.85	8.83	10.13	11.24	12.01	12.90	13.81	14.59	15.22	15.85	16.39	17.41
1994	0.00	0.07	0.52	1.33	2.22	3.26	4.20	5.14	6.21	7.37	8.54	9.45	10.64	11.64	12.33	13.13	13.92	14.62	15.16	15.71	16.57
1995	0.00	0.06	0.49	1.25	2.24	3.22	4.30	5.29	6.33	7.49	8.69	9.88	10.78	11.95	12.93	13.60	14.36	15.13	15.78	16.30	17.29
1996	0.01	0.07	0.61	1.39	2.31	3.31	4.20	5.20	6.13	7.06	8.05	9.03	9.97	10.68	11.58	12.32	12.83	13.40	13.96	14.44	15.08
1997	0.01	0.06	0.50	1.22	2.09	3.03	4.03	4.95	6.02	7.00	7.95	8.94	9.90	10.83	11.51	12.39	13.10	13.58	14.12	14.65	15.26
1998	0.00	0.06	0.49	1.26	2.14	3.04	3.96	4.95	5.89	6.96	7.90	8.80	9.71	10.59	11.43	12.04	12.82	13.44	13.86	14.33	15.08
1999	0.00	0.05	0.48	1.26	2.21	3.18	4.13	5.11	6.21	7.22	8.34	9.29	10.18	11.07	11.93	12.74	13.33	14.06	14.65	15.05	15.87
2000	0.01	0.04	0.64	1.30	2.30	3.36	4.37	5.38	6.47	7.66	8.73	9.85	10.80	11.68	12.55	13.38	14.16	14.72	15.41	15.97	17.00
2001	0.01	0.10	0.61	1.46	2.21	3.22	4.21	5.17	6.18	7.24	8.36	9.33	10.33	11.16	11.92	12.67	13.37	14.02	14.49	15.06	16.18
2002	0.01	0.08	0.58	1.33	2.32	3.11	4.11	5.13	6.19	7.28	8.40	9.53	10.49	11.47	12.27	13.00	13.72	14.39	15.00	15.44	16.36
2003	0.00	0.08	0.53	1.34	2.24	3.29	4.08	5.14	6.28	7.42	8.54	9.62	10.71	11.63	12.56	13.32	14.01	14.68	15.31	15.87	16.94
2004	0.01	0.07	0.64	1.32	2.29	3.23	4.26	5.05	6.13	7.27	8.35	9.36	10.33	11.29	12.09	12.89	13.54	14.12	14.69	15.21	16.06
2005	0.00	0.10	0.52	1.43	2.25	3.32	4.29	5.40	6.27	7.46	8.65	9.75	10.77	11.73	12.68	13.46	14.24	14.87	15.43	15.97	17.02
2006	0.00	0.06	0.54	1.31	2.41	3.27	4.32	5.30	6.44	7.31	8.46	9.56	10.57	11.49	12.35	13.19	13.87	14.56	15.10	15.58	16.71
2007	0.00	0.05	0.50	1.33	2.29	3.47	4.34	5.45	6.51	7.71	8.60	9.73	10.82	11.79	12.67	13.49	14.28	14.91	15.55	16.05	17.37
2008	0.00	0.04	0.49	1.26	2.24	3.22	4.36	5.21	6.33	7.38	8.53	9.37	10.41	11.38	12.25	13.02	13.73	14.42	14.96	15.50	16.44
2009	0.00	0.03	0.52	1.27	2.23	3.30	4.29	5.48	6.43	7.66	8.79	9.97	10.82	11.86	12.84	13.69	14.45	15.14	15.80	16.33	17.13
2010	0.00	0.03	0.59	1.32	2.21	3.19	4.20	5.17	6.42	7.38	8.58	9.62	10.70	11.46	12.39	13.25	14.00	14.66	15.26	15.82	16.55
2011	0.00	0.05	0.49	1.36	2.20	3.11	4.08	5.12	6.18	7.47	8.40	9.52	10.48	11.46	12.15	12.99	13.76	14.42	15.00	15.52	16.39
2012	0.00	0.04	0.57	1.23	2.23	3.07	3.93	4.86	5.91	6.93	8.10	8.92	9.88	10.69	11.51	12.07	12.76	13.38	13.91	14.37	14.97
2013	0.00	0.06	0.51	1.29	2.10	3.19	4.06	4.99	6.05	7.25	8.37	9.63	10.50	11.50	12.34	13.18	13.76	14.45	15.08	15.62	16.45
2014	0.00	0.04	0.53	1.26	2.21	3.07	4.14	5.02	6.02	7.17	8.40	9.51	10.74	11.57	12.53	13.32	14.12	14.66	15.31	15.89	16.83
2015	0.00	0.04	0.64	1.29	2.15	3.13	3.95	5.05	6.00	7.05	8.18	9.34	10.37	11.50	12.25	13.12	13.83	14.54	15.01	15.58	16.57
2016	0.00	0.10	0.69	1.47	2.24	3.16	4.16	5.02	6.23	7.25	8.31	9.42	10.53	11.51	12.56	13.26	14.06	14.71	15.35	15.78	16.53
2017	0.00	0.11	0.64	1.51	2.43	3.24	4.18	5.24	6.20	7.50	8.54	9.60	10.68	11.75	12.68	13.67	14.33	15.07	15.67	16.26	17.06
2018	0.01	0.11	0.73	1.44	2.45	3.40	4.20	5.17	6.29	7.27	8.54	9.51	10.48	11.46	12.41	13.23	14.10	14.66	15.30	15.81	16.73
2019	0.00	0.15	0.46	1.58	2.41	3.50	4.47	5.31	6.37	7.60	8.62	9.91	10.88	11.83	12.78	13.70	14.48	15.30	15.83	16.43	17.21
2020	0.00	0.03	0.49	1.14	2.43	3.27	4.32	5.30	6.18	7.25	8.41	9.36	10.52	11.39	12.23	13.07	13.87	14.55	15.26	15.71	16.56

Table 2.32c—Weight (kg) at age (fishery, Ensemble AB).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.01	0.08	0.57	1.36	2.28	3.25	4.19	5.12	6.10	7.10	8.10	9.05	9.95	10.78	11.53	12.22	12.84	13.39	13.88	14.32	15.32
1978	0.00	0.06	0.49	1.28	2.23	3.25	4.26	5.27	6.34	7.46	8.59	9.68	10.72	11.67	12.56	13.36	14.08	14.73	15.31	15.83	17.01
1979	0.01	0.06	0.56	1.29	2.26	3.23	4.18	5.11	6.08	7.09	8.10	9.07	9.98	10.82	11.59	12.29	12.92	13.48	13.98	14.43	15.39
1980	0.01	0.07	0.50	1.29	2.14	3.14	4.09	5.03	6.02	7.04	8.05	9.03	9.94	10.78	11.56	12.26	12.90	13.46	13.97	14.42	15.37
1981	0.01	0.06	0.44	1.22	2.16	3.05	4.03	4.96	5.93	6.92	7.91	8.85	9.74	10.56	11.31	11.99	12.60	13.15	13.64	14.07	14.97
1982	0.00	0.04	0.52	1.29	2.30	3.33	4.23	5.23	6.22	7.24	8.24	9.20	10.10	10.93	11.69	12.38	13.00	13.55	14.05	14.48	15.39
1983	0.01	0.05	0.61	1.27	2.20	3.30	4.36	5.31	6.41	7.49	8.55	9.57	10.53	11.41	12.22	12.96	13.62	14.21	14.74	15.21	16.19
1984	0.01	0.11	0.59	1.37	2.06	2.91	3.83	4.71	5.51	6.40	7.22	8.00	8.73	9.39	10.00	10.54	11.03	11.47	11.86	12.20	12.92
1985	0.00	0.07	0.46	1.37	2.40	3.24	4.24	5.36	6.50	7.54	8.70	9.76	10.76	11.68	12.53	13.30	13.99	14.61	15.17	15.66	16.70
1986	0.00	0.03	0.50	1.15	2.27	3.38	4.23	5.26	6.47	7.68	8.76	9.93	10.97	11.94	12.83	13.65	14.38	15.04	15.62	16.14	17.26
1987	0.00	0.06	0.52	1.34	2.15	3.32	4.37	5.17	6.19	7.35	8.47	9.43	10.44	11.33	12.14	12.88	13.55	14.14	14.68	15.15	16.16
1988	0.01	0.05	0.43	1.20	2.23	3.16	4.45	5.64	6.57	7.75	9.05	10.26	11.28	12.33	13.26	14.10	14.85	15.54	16.14	16.68	17.87
1989	0.01	0.05	0.47	1.26	2.28	3.42	4.36	5.66	6.90	7.86	9.02	10.25	11.37	12.28	13.22	14.04	14.78	15.44	16.03	16.55	17.72
1990	0.01	0.05	0.56	1.31	2.28	3.33	4.42	5.31	6.57	7.74	8.60	9.61	10.66	11.59	12.34	13.11	13.78	14.37	14.90	15.36	16.42
1991	0.01	0.06	0.59	1.32	2.16	3.11	4.07	5.06	5.88	7.06	8.11	8.87	9.75	10.65	11.44	12.07	12.71	13.26	13.75	14.18	15.14
1992	0.00	0.07	0.52	1.31	2.14	3.01	3.92	4.87	5.89	6.73	7.89	8.88	9.59	10.39	11.21	11.92	12.49	13.06	13.55	13.98	14.92
1993	0.01	0.07	0.58	1.35	2.39	3.36	4.30	5.30	6.36	7.49	8.40	9.61	10.63	11.34	12.15	12.95	13.65	14.20	14.75	15.21	16.13
1994	0.01	0.08	0.51	1.32	2.20	3.23	4.13	5.02	6.01	7.07	8.16	8.99	10.09	11.00	11.62	12.33	13.03	13.63	14.11	14.59	15.37
1995	0.01	0.06	0.49	1.24	2.22	3.18	4.24	5.19	6.17	7.25	8.36	9.45	10.27	11.33	12.20	12.79	13.46	14.13	14.69	15.14	16.03
1996	0.01	0.07	0.61	1.39	2.30	3.28	4.14	5.08	5.94	6.80	7.71	8.62	9.48	10.12	10.94	11.59	12.04	12.54	13.03	13.44	14.02
1997	0.01	0.06	0.48	1.21	2.07	2.99	3.97	4.86	5.88	6.79	7.67	8.58	9.46	10.29	10.90	11.67	12.30	12.72	13.18	13.64	14.18
1998	0.00	0.06	0.49	1.23	2.12	3.01	3.90	4.85	5.73	6.73	7.60	8.42	9.26	10.05	10.80	11.34	12.03	12.57	12.94	13.34	14.00
1999	0.00	0.05	0.48	1.25	2.18	3.15	4.07	5.01	6.03	6.98	8.01	8.89	9.70	10.51	11.28	11.99	12.50	13.15	13.66	14.00	14.73
2000	0.01	0.04	0.63	1.29	2.28	3.31	4.29	5.23	6.22	7.31	8.29	9.34	10.20	11.00	11.79	12.53	13.21	13.70	14.31	14.79	15.70
2001	0.01	0.10	0.61	1.45	2.20	3.19	4.12	5.01	5.89	6.85	7.86	8.75	9.68	10.44	11.12	11.80	12.42	13.00	13.41	13.91	14.90
2002	0.01	0.08	0.58	1.33	2.30	3.08	4.05	4.97	5.93	6.91	7.93	8.98	9.86	10.77	11.49	12.15	12.79	13.38	13.91	14.29	15.12
2003	0.00	0.08	0.53	1.34	2.24	3.26	4.01	4.98	5.98	7.01	8.03	9.03	10.03	10.86	11.71	12.39	13.00	13.59	14.14	14.63	15.59
2004	0.01	0.07	0.64	1.32	2.29	3.21	4.19	4.93	5.93	6.96	7.97	8.91	9.80	10.67	11.39	12.11	12.68	13.19	13.68	14.13	14.90
2005	0.00	0.11	0.52	1.44	2.25	3.29	4.23	5.26	6.07	7.17	8.26	9.29	10.22	11.10	11.94	12.64	13.33	13.88	14.36	14.83	15.76
2006	0.00	0.06	0.54	1.31	2.40	3.24	4.27	5.22	6.29	7.12	8.18	9.19	10.11	10.94	11.70	12.44	13.04	13.63	14.10	14.51	15.51
2007	0.00	0.06	0.50	1.33	2.27	3.44	4.29	5.35	6.36	7.47	8.31	9.36	10.33	11.21	12.00	12.72	13.40	13.96	14.51	14.94	16.10
2008	0.00	0.04	0.49	1.25	2.22	3.19	4.30	5.12	6.18	7.17	8.22	9.00	9.95	10.82	11.59	12.28	12.90	13.49	13.97	14.43	15.29
2009	0.00	0.03	0.51	1.25	2.20	3.25	4.24	5.40	6.29	7.43	8.46	9.54	10.32	11.26	12.12	12.88	13.55	14.15	14.72	15.17	15.92
2010	0.00	0.04	0.58	1.29	2.18	3.15	4.13	5.07	6.23	7.11	8.21	9.17	10.15	10.85	11.69	12.44	13.10	13.68	14.20	14.69	15.36
2011	0.00	0.06	0.48	1.34	2.17	3.07	4.00	4.96	5.92	7.11	7.97	9.00	9.89	10.78	11.41	12.16	12.83	13.42	13.92	14.38	15.16
2012	0.01	0.04	0.56	1.21	2.20	3.02	3.86	4.73	5.68	6.62	7.71	8.47	9.35	10.09	10.82	11.33	11.94	12.48	12.95	13.34	13.90
2013	0.00	0.06	0.50	1.28	2.07	3.15	3.98	4.82	5.76	6.82	7.85	9.02	9.81	10.73	11.49	12.25	12.77	13.38	13.93	14.40	15.15
2014	0.00	0.04	0.53	1.25	2.20	3.03	4.05	4.84	5.72	6.73	7.83	8.85	9.97	10.72	11.58	12.29	12.99	13.47	14.04	14.54	15.41
2015	0.00	0.04	0.64	1.27	2.12	3.09	3.88	4.89	5.74	6.70	7.74	8.80	9.75	10.77	11.45	12.22	12.85	13.47	13.89	14.38	15.28
2016	0.00	0.10	0.68	1.47	2.22	3.12	4.07	4.86	5.95	6.86	7.85	8.87	9.89	10.78	11.73	12.35	13.05	13.62	14.18	14.56	15.25
2017	0.00	0.10	0.65	1.53	2.44	3.21	4.09	5.06	5.90	7.07	8.01	8.99	9.98	10.94	11.78	12.66	13.24	13.89	14.41	14.92	15.66
2018	0.01	0.10	0.75	1.45	2.44	3.37	4.12	5.00	6.02	6.91	8.09	8.99	9.90	10.79	11.65	12.38	13.14	13.64	14.19	14.63	15.46
2019	0.00	0.16	0.47	1.58	2.40	3.46	4.38	5.16	6.12	7.25	8.20	9.40	10.29	11.17	12.03	12.84	13.53	14.25	14.71	15.22	15.92
2020	0.00	0.04	0.48	1.12	2.39	3.21	4.25	5.22	6.05	7.05	8.14	9.00	10.06	10.83	11.59	12.33	13.02	13.61	14.22	14.60	15.34

Table 2.33a—Weight (kg) at age (EBS survey, weighted average of Models 20.4 and 19.15 (a subset of Ensemble A)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.02	0.07	0.40	1.05	1.92	2.94	4.05	5.20	6.35	7.48	8.57	9.60	10.58	11.49	12.32	13.09	13.79	14.42	14.98	15.48	16.64
1978	0.01	0.05	0.33	0.98	1.86	2.93	4.11	5.37	6.65	7.92	9.15	10.34	11.46	12.52	13.49	14.39	15.21	15.95	16.62	17.21	18.58
1979	0.02	0.06	0.40	1.01	1.91	2.93	4.05	5.20	6.37	7.51	8.61	9.66	10.65	11.57	12.42	13.20	13.91	14.55	15.12	15.62	16.72
1980	0.02	0.06	0.35	1.01	1.80	2.85	3.95	5.10	6.26	7.40	8.51	9.56	10.56	11.49	12.35	13.14	13.86	14.51	15.09	15.60	16.66
1981	0.02	0.06	0.31	0.97	1.86	2.79	3.92	5.04	6.17	7.28	8.36	9.38	10.35	11.25	12.08	12.84	13.53	14.15	14.71	15.21	16.21
1982	0.02	0.05	0.35	0.97	1.92	3.02	4.06	5.27	6.43	7.57	8.67	9.71	10.69	11.61	12.45	13.22	13.93	14.56	15.12	15.62	16.62
1983	0.01	0.04	0.43	0.96	1.82	2.97	4.20	5.33	6.61	7.81	8.97	10.08	11.13	12.11	13.01	13.84	14.59	15.27	15.88	16.42	17.49
1984	0.02	0.11	0.44	1.12	1.76	2.65	3.70	4.75	5.65	6.63	7.53	8.38	9.17	9.91	10.58	11.20	11.75	12.25	12.70	13.09	13.87
1985	0.01	0.06	0.30	1.04	2.02	2.88	4.03	5.39	6.73	7.89	9.15	10.31	11.40	12.42	13.36	14.23	15.02	15.73	16.37	16.94	18.08
1986	0.01	0.03	0.35	0.87	1.92	3.09	4.06	5.31	6.73	8.10	9.27	10.53	11.67	12.74	13.74	14.65	15.48	16.23	16.90	17.50	18.72
1987	0.02	0.06	0.34	1.02	1.76	2.99	4.23	5.19	6.39	7.71	8.95	9.98	11.08	12.05	12.96	13.79	14.55	15.23	15.84	16.38	17.49
1988	0.02	0.05	0.31	0.97	1.95	2.89	4.36	5.77	6.85	8.16	9.59	10.92	12.02	13.18	14.20	15.15	16.01	16.78	17.48	18.10	19.39
1989	0.02	0.05	0.33	0.98	1.93	3.12	4.18	5.72	7.14	8.19	9.46	10.80	12.03	13.04	14.09	15.01	15.85	16.61	17.29	17.89	19.17
1990	0.02	0.05	0.39	1.00	1.89	2.99	4.24	5.28	6.73	8.02	8.96	10.06	11.22	12.26	13.11	13.97	14.73	15.41	16.02	16.56	17.71
1991	0.01	0.06	0.40	1.00	1.79	2.78	3.90	5.10	6.07	7.39	8.54	9.36	10.31	11.31	12.19	12.90	13.62	14.24	14.80	15.29	16.35
1992	0.02	0.06	0.35	1.00	1.78	2.68	3.74	4.89	6.08	7.02	8.28	9.37	10.13	11.02	11.94	12.74	13.39	14.04	14.59	15.09	16.11
1993	0.02	0.06	0.43	1.09	2.07	3.09	4.17	5.39	6.65	7.93	8.91	10.21	11.32	12.09	12.98	13.88	14.66	15.29	15.91	16.44	17.44
1994	0.02	0.07	0.36	1.03	1.86	2.94	3.99	5.07	6.24	7.43	8.62	9.53	10.71	11.71	12.41	13.19	13.99	14.68	15.22	15.76	16.61
1995	0.02	0.06	0.34	0.97	1.89	2.89	4.10	5.24	6.36	7.57	8.78	9.96	10.87	12.03	13.01	13.68	14.43	15.20	15.85	16.36	17.33
1996	0.03	0.08	0.41	1.06	1.92	2.96	3.97	5.11	6.12	7.09	8.10	9.09	10.03	10.74	11.64	12.38	12.89	13.45	14.01	14.49	15.12
1997	0.01	0.06	0.35	0.96	1.77	2.73	3.84	4.88	6.04	7.05	8.01	9.00	9.97	10.89	11.58	12.45	13.16	13.64	14.17	14.70	15.30
1998	0.01	0.05	0.34	0.95	1.77	2.70	3.74	4.87	5.90	7.01	7.97	8.86	9.78	10.66	11.49	12.10	12.88	13.50	13.92	14.38	15.11
1999	0.01	0.05	0.32	0.95	1.84	2.84	3.91	5.03	6.23	7.28	8.41	9.36	10.25	11.15	12.00	12.80	13.39	14.12	14.71	15.10	15.91
2000	0.02	0.05	0.44	0.96	1.87	2.98	4.13	5.29	6.49	7.73	8.80	9.93	10.88	11.75	12.63	13.46	14.22	14.78	15.47	16.02	17.04
2001	0.02	0.07	0.41	1.12	1.80	2.84	3.99	5.12	6.23	7.34	8.46	9.42	10.41	11.24	11.99	12.74	13.44	14.08	14.54	15.12	16.22
2002	0.02	0.07	0.41	1.04	1.97	2.77	3.92	5.14	6.30	7.43	8.53	9.65	10.59	11.56	12.35	13.08	13.79	14.46	15.06	15.50	16.40
2003	0.02	0.07	0.36	1.04	1.87	2.96	3.85	5.07	6.32	7.50	8.62	9.71	10.79	11.70	12.63	13.39	14.08	14.75	15.37	15.93	16.98
2004	0.02	0.07	0.46	1.03	1.94	2.92	4.08	4.97	6.16	7.34	8.43	9.44	10.41	11.36	12.16	12.96	13.60	14.18	14.74	15.26	16.10
2005	0.02	0.08	0.36	1.12	1.89	2.99	4.08	5.34	6.28	7.52	8.73	9.83	10.84	11.81	12.75	13.53	14.31	14.94	15.49	16.03	17.06
2006	0.02	0.04	0.36	0.99	2.02	2.91	4.09	5.21	6.44	7.35	8.51	9.63	10.64	11.56	12.42	13.26	13.94	14.62	15.16	15.64	16.74
2007	0.01	0.04	0.32	1.00	1.88	3.11	4.09	5.35	6.51	7.75	8.66	9.80	10.89	11.86	12.74	13.56	14.34	14.98	15.61	16.11	17.41
2008	0.02	0.04	0.32	0.93	1.84	2.86	4.16	5.15	6.37	7.46	8.62	9.45	10.48	11.46	12.32	13.09	13.80	14.48	15.02	15.56	16.48
2009	0.01	0.03	0.33	0.91	1.77	2.89	4.04	5.46	6.51	7.78	8.90	10.08	10.91	11.95	12.92	13.77	14.52	15.21	15.87	16.39	17.18
2010	0.02	0.05	0.37	0.93	1.73	2.75	3.94	5.12	6.50	7.50	8.69	9.73	10.80	11.55	12.47	13.33	14.07	14.73	15.32	15.88	16.60
2011	0.02	0.06	0.30	0.98	1.75	2.68	3.79	5.02	6.19	7.53	8.48	9.60	10.55	11.54	12.22	13.06	13.82	14.48	15.06	15.58	16.43
2012	0.02	0.03	0.38	0.92	1.84	2.71	3.69	4.77	5.93	6.99	8.17	8.99	9.95	10.76	11.57	12.14	12.82	13.43	13.96	14.42	15.01
2013	0.01	0.06	0.34	0.97	1.71	2.84	3.84	4.93	6.11	7.35	8.48	9.72	10.58	11.58	12.41	13.25	13.83	14.52	15.14	15.67	16.49
2014	0.01	0.04	0.34	0.91	1.77	2.65	3.90	4.96	6.08	7.28	8.51	9.62	10.83	11.66	12.61	13.40	14.19	14.73	15.37	15.95	16.88
2015	0.02	0.05	0.42	0.91	1.69	2.71	3.67	4.96	6.02	7.12	8.27	9.43	10.46	11.57	12.33	13.19	13.90	14.60	15.08	15.64	16.61
2016	0.02	0.09	0.47	1.08	1.77	2.73	3.87	4.90	6.24	7.30	8.38	9.50	10.61	11.59	12.63	13.34	14.13	14.77	15.41	15.84	16.58
2017	0.01	0.10	0.43	1.14	1.97	2.80	3.88	5.11	6.18	7.54	8.60	9.67	10.75	11.83	12.75	13.74	14.40	15.14	15.73	16.32	17.11
2018	0.03	0.11	0.52	1.13	2.09	3.05	3.96	5.07	6.29	7.32	8.60	9.59	10.56	11.53	12.49	13.30	14.16	14.73	15.36	15.86	16.78
2019	0.02	0.10	0.28	1.24	2.06	3.20	4.28	5.26	6.42	7.68	8.72	10.00	10.97	11.91	12.86	13.78	14.56	15.37	15.90	16.48	17.26
2019	0.01	0.03	0.33	0.83	2.07	2.99	4.18	5.26	6.20	7.31	8.48	9.43	10.59	11.46	12.31	13.14	13.94	14.62	15.31	15.77	16.61

Table 2.33b—Weight (kg) at age (NBS survey, weighted average of Models 20.4 and 19.15 (a subset of Ensemble A)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.01	0.06	0.44	1.12	2.01	3.03	4.13	5.26	6.39	7.50	8.58	9.61	10.58	11.49	12.33	13.09	13.79	14.42	14.98	15.48	16.64
1978	0.01	0.04	0.36	1.04	1.95	3.02	4.20	5.43	6.69	7.94	9.17	10.35	11.47	12.52	13.50	14.39	15.21	15.95	16.62	17.21	18.58
1979	0.01	0.05	0.44	1.07	2.00	3.03	4.13	5.26	6.40	7.53	8.62	9.67	10.65	11.57	12.42	13.20	13.91	14.55	15.12	15.62	16.72
1980	0.01	0.05	0.38	1.07	1.88	2.94	4.03	5.16	6.30	7.42	8.52	9.57	10.56	11.49	12.35	13.14	13.86	14.51	15.09	15.60	16.66
1981	0.01	0.05	0.34	1.03	1.95	2.88	3.99	5.10	6.21	7.30	8.37	9.39	10.35	11.25	12.08	12.84	13.53	14.16	14.71	15.21	16.21
1982	0.01	0.04	0.39	1.04	2.01	3.11	4.15	5.33	6.47	7.60	8.68	9.72	10.70	11.61	12.45	13.23	13.93	14.56	15.12	15.62	16.62
1983	0.01	0.03	0.47	1.03	1.91	3.07	4.29	5.40	6.65	7.83	8.99	10.09	11.13	12.11	13.01	13.84	14.59	15.27	15.88	16.42	17.49
1984	0.01	0.09	0.47	1.18	1.84	2.73	3.78	4.80	5.68	6.65	7.54	8.39	9.18	9.91	10.58	11.20	11.75	12.25	12.70	13.09	13.87
1985	0.01	0.05	0.33	1.11	2.11	2.97	4.12	5.46	6.77	7.92	9.17	10.31	11.40	12.42	13.37	14.23	15.02	15.73	16.37	16.94	18.08
1986	0.01	0.02	0.38	0.94	2.01	3.19	4.15	5.38	6.78	8.13	9.29	10.54	11.68	12.75	13.74	14.65	15.48	16.23	16.90	17.50	18.72
1987	0.01	0.05	0.38	1.08	1.85	3.08	4.31	5.26	6.44	7.74	8.96	9.99	11.08	12.06	12.96	13.79	14.55	15.23	15.84	16.38	17.49
1988	0.01	0.03	0.35	1.04	2.04	3.00	4.45	5.84	6.90	8.19	9.61	10.93	12.02	13.18	14.21	15.15	16.01	16.79	17.48	18.10	19.39
1989	0.01	0.03	0.37	1.05	2.02	3.22	4.27	5.78	7.18	8.22	9.47	10.81	12.04	13.05	14.09	15.02	15.85	16.61	17.29	17.89	19.17
1990	0.01	0.04	0.43	1.07	1.98	3.09	4.32	5.35	6.77	8.05	8.97	10.07	11.23	12.26	13.11	13.98	14.73	15.41	16.02	16.56	17.71
1991	0.01	0.05	0.44	1.07	1.87	2.87	3.98	5.16	6.11	7.41	8.55	9.36	10.32	11.31	12.19	12.90	13.62	14.24	14.80	15.29	16.35
1992	0.01	0.05	0.38	1.06	1.86	2.77	3.82	4.95	6.11	7.04	8.29	9.37	10.14	11.02	11.94	12.74	13.39	14.04	14.59	15.09	16.11
1993	0.01	0.05	0.47	1.16	2.16	3.19	4.26	5.46	6.70	7.95	8.93	10.22	11.33	12.09	12.98	13.88	14.67	15.29	15.91	16.44	17.44
1994	0.01	0.06	0.39	1.10	1.95	3.03	4.07	5.13	6.28	7.46	8.63	9.54	10.72	11.72	12.41	13.20	13.99	14.68	15.22	15.76	16.61
1995	0.01	0.04	0.38	1.03	1.98	2.98	4.19	5.30	6.41	7.59	8.79	9.97	10.87	12.03	13.01	13.68	14.44	15.20	15.85	16.36	17.33
1996	0.01	0.06	0.45	1.12	2.00	3.05	4.05	5.16	6.16	7.12	8.11	9.09	10.04	10.74	11.64	12.38	12.89	13.45	14.01	14.49	15.12
1997	0.01	0.05	0.38	1.02	1.85	2.82	3.92	4.94	6.07	7.07	8.02	9.01	9.97	10.89	11.58	12.45	13.16	13.64	14.17	14.70	15.30
1998	0.01	0.05	0.36	1.01	1.85	2.79	3.81	4.93	5.94	7.03	7.98	8.87	9.78	10.66	11.49	12.11	12.88	13.50	13.92	14.38	15.11
1999	0.01	0.04	0.35	1.01	1.92	2.93	3.99	5.09	6.26	7.31	8.42	9.37	10.26	11.15	12.00	12.80	13.39	14.12	14.71	15.10	15.91
2000	0.01	0.03	0.48	1.03	1.96	3.07	4.21	5.36	6.53	7.75	8.81	9.94	10.88	11.76	12.63	13.46	14.22	14.78	15.47	16.02	17.04
2001	0.01	0.07	0.45	1.19	1.89	2.93	4.07	5.18	6.27	7.36	8.47	9.42	10.42	11.24	11.99	12.74	13.44	14.08	14.54	15.12	16.22
2002	0.01	0.06	0.45	1.11	2.05	2.86	4.00	5.20	6.34	7.45	8.55	9.65	10.59	11.56	12.36	13.08	13.79	14.46	15.06	15.50	16.40
2003	0.01	0.06	0.40	1.10	1.96	3.06	3.94	5.13	6.36	7.53	8.64	9.72	10.80	11.71	12.64	13.40	14.08	14.75	15.37	15.93	16.98
2004	0.01	0.05	0.50	1.09	2.03	3.01	4.15	5.03	6.20	7.36	8.44	9.45	10.41	11.37	12.16	12.96	13.61	14.18	14.74	15.26	16.10
2005	0.01	0.08	0.39	1.19	1.97	3.08	4.16	5.40	6.33	7.54	8.74	9.83	10.85	11.81	12.75	13.53	14.31	14.94	15.49	16.03	17.06
2006	0.01	0.05	0.40	1.06	2.11	3.00	4.17	5.27	6.48	7.37	8.52	9.64	10.64	11.56	12.42	13.26	13.94	14.62	15.16	15.64	16.74
2007	0.01	0.04	0.36	1.06	1.96	3.20	4.18	5.42	6.55	7.78	8.67	9.81	10.90	11.86	12.74	13.56	14.34	14.98	15.61	16.11	17.41
2008	0.01	0.03	0.35	1.00	1.93	2.95	4.24	5.21	6.41	7.49	8.63	9.46	10.49	11.46	12.32	13.09	13.80	14.48	15.02	15.56	16.48
2009	0.01	0.03	0.36	0.97	1.86	2.98	4.13	5.52	6.55	7.81	8.91	10.09	10.92	11.95	12.92	13.77	14.52	15.21	15.87	16.39	17.18
2010	0.01	0.04	0.41	1.00	1.81	2.84	4.03	5.18	6.54	7.52	8.71	9.73	10.80	11.55	12.48	13.33	14.07	14.73	15.32	15.88	16.60
2011	0.01	0.05	0.33	1.05	1.83	2.77	3.87	5.08	6.23	7.55	8.49	9.61	10.56	11.54	12.22	13.06	13.82	14.48	15.06	15.58	16.43
2012	0.01	0.03	0.42	0.98	1.92	2.80	3.77	4.83	5.97	7.01	8.18	9.00	9.95	10.76	11.58	12.14	12.82	13.43	13.96	14.42	15.01
2013	0.01	0.05	0.37	1.03	1.79	2.93	3.92	4.99	6.16	7.38	8.49	9.73	10.59	11.58	12.41	13.25	13.83	14.52	15.14	15.67	16.49
2014	0.01	0.04	0.37	0.97	1.85	2.74	3.98	5.03	6.13	7.31	8.53	9.62	10.83	11.66	12.61	13.40	14.19	14.73	15.37	15.95	16.88
2015	0.01	0.04	0.45	0.97	1.77	2.80	3.75	5.02	6.07	7.14	8.28	9.44	10.46	11.57	12.33	13.19	13.90	14.60	15.08	15.64	16.61
2016	0.01	0.08	0.51	1.15	1.85	2.82	3.95	4.96	6.28	7.33	8.40	9.51	10.62	11.59	12.63	13.34	14.13	14.77	15.41	15.84	16.58
2017	0.01	0.09	0.47	1.21	2.05	2.89	3.96	5.17	6.22	7.57	8.62	9.68	10.76	11.83	12.76	13.74	14.40	15.14	15.73	16.32	17.11
2018	0.01	0.09	0.56	1.20	2.17	3.14	4.04	5.13	6.33	7.35	8.62	9.59	10.56	11.54	12.49	13.30	14.16	14.73	15.36	15.86	16.78
2019	0.01	0.11	0.32	1.30	2.14	3.29	4.36	5.32	6.47	7.70	8.74	10.01	10.97	11.92	12.86	13.78	14.56	15.37	15.90	16.48	17.26
2020	0.01	0.02	0.36	0.89	2.15	3.07	4.25	5.31	6.24	7.33	8.49	9.44	10.60	11.47	12.31	13.14	13.94	14.62	15.31	15.77	16.61

Table 2.33c (page 1 of 3)—Weight (kg) at age (EBS+NBS survey, Model 19.12).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.02	0.07	0.40	1.05	1.91	2.92	4.02	5.15	6.30	7.43	8.52	9.56	10.55	11.47	12.33	13.12	13.84	14.49	15.07	15.59	16.83
1978	0.01	0.05	0.33	0.97	1.85	2.90	4.08	5.32	6.59	7.86	9.10	10.29	11.43	12.50	13.50	14.42	15.27	16.03	16.72	17.34	18.81
1979	0.02	0.06	0.40	1.00	1.90	2.91	4.01	5.16	6.32	7.46	8.56	9.62	10.62	11.56	12.43	13.23	13.96	14.62	15.21	15.74	16.91
1980	0.02	0.06	0.35	1.00	1.78	2.82	3.91	5.05	6.21	7.35	8.46	9.52	10.53	11.48	12.36	13.17	13.91	14.58	15.18	15.72	16.87
1981	0.02	0.06	0.31	0.96	1.84	2.76	3.88	5.00	6.12	7.23	8.31	9.34	10.32	11.23	12.08	12.86	13.58	14.22	14.81	15.32	16.40
1982	0.02	0.05	0.35	0.97	1.91	2.99	4.02	5.23	6.38	7.52	8.62	9.67	10.67	11.60	12.46	13.25	13.97	14.63	15.21	15.74	16.82
1983	0.01	0.04	0.44	0.95	1.81	2.94	4.16	5.28	6.55	7.76	8.92	10.04	11.10	12.09	13.02	13.87	14.64	15.35	15.98	16.54	17.70
1984	0.02	0.11	0.44	1.12	1.75	2.63	3.67	4.70	5.61	6.59	7.49	8.35	9.15	9.90	10.59	11.22	11.79	12.31	12.77	13.18	14.03
1985	0.01	0.06	0.30	1.03	2.01	2.85	3.99	5.34	6.66	7.83	9.10	10.26	11.37	12.40	13.37	14.26	15.07	15.81	16.48	17.07	18.30
1986	0.01	0.03	0.35	0.87	1.90	3.07	4.01	5.25	6.67	8.03	9.21	10.49	11.64	12.73	13.74	14.68	15.54	16.31	17.02	17.64	18.96
1987	0.02	0.06	0.34	1.01	1.74	2.96	4.20	5.14	6.34	7.65	8.89	9.93	11.05	12.04	12.97	13.82	14.60	15.30	15.94	16.50	17.71
1988	0.02	0.05	0.32	0.96	1.93	2.86	4.31	5.73	6.78	8.10	9.53	10.86	11.98	13.16	14.21	15.18	16.07	16.87	17.60	18.24	19.65
1989	0.02	0.05	0.33	0.97	1.91	3.09	4.13	5.66	7.09	8.13	9.40	10.75	11.99	13.02	14.10	15.05	15.91	16.70	17.40	18.03	19.42
1990	0.02	0.05	0.39	0.99	1.88	2.96	4.19	5.22	6.67	7.98	8.90	10.02	11.18	12.24	13.11	14.00	14.78	15.48	16.12	16.68	17.93
1991	0.01	0.06	0.41	1.00	1.77	2.75	3.86	5.05	6.01	7.33	8.50	9.31	10.28	11.29	12.19	12.92	13.67	14.31	14.89	15.41	16.55
1992	0.02	0.06	0.35	0.99	1.76	2.65	3.70	4.84	6.02	6.96	8.23	9.33	10.10	11.00	11.94	12.76	13.43	14.10	14.68	15.20	16.31
1993	0.02	0.06	0.43	1.09	2.06	3.06	4.13	5.34	6.59	7.87	8.86	10.17	11.30	12.07	12.98	13.90	14.71	15.36	16.01	16.56	17.63
1994	0.02	0.07	0.36	1.02	1.84	2.92	3.95	5.02	6.18	7.38	8.57	9.48	10.68	11.71	12.40	13.22	14.04	14.75	15.32	15.88	16.79
1995	0.02	0.06	0.35	0.96	1.87	2.86	4.07	5.18	6.31	7.51	8.72	9.92	10.83	12.01	13.02	13.70	14.48	15.27	15.95	16.48	17.52
1996	0.03	0.08	0.41	1.05	1.90	2.92	3.93	5.07	6.07	7.04	8.05	9.04	10.00	10.72	11.64	12.41	12.92	13.51	14.09	14.59	15.26
1997	0.01	0.06	0.35	0.95	1.75	2.70	3.79	4.83	5.99	7.00	7.96	8.96	9.94	10.88	11.58	12.47	13.21	13.70	14.26	14.81	15.44
1998	0.01	0.05	0.34	0.95	1.75	2.68	3.70	4.82	5.85	6.97	7.92	8.82	9.75	10.64	11.49	12.12	12.92	13.57	14.00	14.49	15.26
1999	0.01	0.05	0.32	0.95	1.82	2.81	3.87	4.99	6.16	7.23	8.36	9.32	10.22	11.13	12.00	12.82	13.43	14.19	14.80	15.20	16.07
2000	0.02	0.05	0.44	0.96	1.86	2.95	4.09	5.25	6.43	7.66	8.75	9.89	10.85	11.74	12.63	13.48	14.27	14.85	15.57	16.15	17.21
2001	0.02	0.07	0.42	1.11	1.79	2.82	3.95	5.08	6.18	7.29	8.40	9.37	10.39	11.22	11.99	12.76	13.48	14.15	14.63	15.22	16.38
2002	0.02	0.07	0.41	1.04	1.94	2.75	3.89	5.09	6.25	7.38	8.49	9.59	10.55	11.54	12.36	13.10	13.83	14.52	15.15	15.61	16.56
2003	0.02	0.07	0.36	1.03	1.86	2.93	3.82	5.03	6.27	7.45	8.57	9.67	10.75	11.68	12.64	13.42	14.12	14.82	15.46	16.05	17.16
2004	0.02	0.07	0.46	1.02	1.93	2.89	4.03	4.93	6.11	7.29	8.38	9.40	10.38	11.34	12.16	12.98	13.65	14.25	14.83	15.37	16.26
2005	0.02	0.08	0.36	1.12	1.87	2.96	4.04	5.28	6.23	7.46	8.67	9.78	10.81	11.79	12.75	13.55	14.36	15.01	15.59	16.15	17.23
2006	0.02	0.04	0.36	0.99	2.01	2.88	4.05	5.16	6.38	7.30	8.46	9.59	10.61	11.54	12.42	13.27	13.98	14.69	15.25	15.75	16.91
2007	0.02	0.04	0.33	0.99	1.86	3.08	4.05	5.30	6.45	7.69	8.61	9.76	10.86	11.85	12.74	13.58	14.38	15.05	15.71	16.23	17.59
2008	0.02	0.04	0.32	0.93	1.82	2.83	4.12	5.10	6.32	7.41	8.56	9.41	10.46	11.44	12.32	13.11	13.85	14.54	15.11	15.67	16.65
2009	0.01	0.03	0.32	0.90	1.76	2.85	4.00	5.41	6.45	7.73	8.85	10.02	10.88	11.94	12.92	13.79	14.57	15.29	15.96	16.51	17.35
2010	0.02	0.05	0.37	0.92	1.72	2.72	3.90	5.07	6.45	7.45	8.64	9.68	10.76	11.53	12.48	13.35	14.12	14.80	15.42	15.99	16.76
2011	0.02	0.06	0.30	0.98	1.72	2.66	3.75	4.97	6.13	7.48	8.43	9.56	10.53	11.52	12.23	13.08	13.87	14.55	15.15	15.70	16.59
2012	0.02	0.03	0.39	0.91	1.83	2.67	3.65	4.73	5.87	6.94	8.13	8.96	9.92	10.74	11.57	12.16	12.86	13.50	14.04	14.52	15.15
2013	0.01	0.06	0.33	0.97	1.69	2.81	3.79	4.88	6.06	7.29	8.42	9.69	10.55	11.56	12.42	13.27	13.87	14.59	15.24	15.79	16.65
2014	0.02	0.04	0.33	0.89	1.76	2.61	3.86	4.90	6.03	7.23	8.45	9.57	10.80	11.64	12.61	13.42	14.23	14.80	15.47	16.07	17.03
2015	0.02	0.05	0.42	0.90	1.67	2.69	3.62	4.92	5.96	7.07	8.22	9.38	10.42	11.56	12.33	13.21	13.95	14.67	15.17	15.76	16.76
2016	0.02	0.09	0.44	1.08	1.75	2.69	3.85	4.84	6.18	7.23	8.33	9.45	10.57	11.57	12.64	13.36	14.18	14.85	15.50	15.96	16.72
2017	0.01	0.09	0.40	1.10	1.95	2.77	3.83	5.08	6.12	7.48	8.53	9.62	10.72	11.80	12.75	13.78	14.45	15.21	15.83	16.44	17.27
2018	0.03	0.09	0.52	1.07	2.02	3.02	3.91	5.01	6.25	7.26	8.55	9.53	10.52	11.51	12.48	13.32	14.22	14.80	15.45	15.98	16.93
2019	0.02	0.10	0.30	1.23	1.97	3.11	4.24	5.20	6.35	7.64	8.66	9.95	10.92	11.90	12.86	13.80	14.60	15.45	16.00	16.61	17.43
2020	0.01	0.04	0.33	0.86	2.05	2.88	4.08	5.21	6.14	7.24	8.44	9.38	10.56	11.43	12.31	13.16	13.98	14.69	15.42	15.89	16.76

Table 2.33c (page 2 of 3)—Weight (kg) at age (EBS+NBS survey, weighted average of Models 19.12a and 19.12 (a subset of Ensemble A)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.02	0.07	0.40	1.05	1.92	2.92	4.02	5.15	6.28	7.40	8.48	9.50	10.47	11.37	12.21	12.98	13.68	14.31	14.88	15.39	16.58
1978	0.01	0.05	0.33	0.98	1.85	2.91	4.08	5.31	6.57	7.83	9.05	10.22	11.34	12.39	13.36	14.26	15.09	15.83	16.50	17.10	18.52
1979	0.02	0.06	0.40	1.00	1.90	2.91	4.01	5.15	6.30	7.43	8.52	9.56	10.54	11.46	12.31	13.09	13.80	14.44	15.02	15.53	16.67
1980	0.02	0.06	0.35	1.00	1.79	2.83	3.91	5.05	6.19	7.32	8.41	9.46	10.45	11.38	12.24	13.03	13.75	14.40	14.98	15.51	16.62
1981	0.02	0.06	0.32	0.97	1.85	2.76	3.88	4.99	6.11	7.20	8.27	9.28	10.24	11.14	11.97	12.73	13.42	14.05	14.62	15.12	16.16
1982	0.02	0.05	0.35	0.97	1.91	2.98	4.02	5.22	6.37	7.49	8.58	9.61	10.59	11.50	12.34	13.11	13.82	14.45	15.02	15.53	16.58
1983	0.01	0.04	0.43	0.96	1.81	2.94	4.15	5.27	6.54	7.72	8.87	9.97	11.01	11.99	12.89	13.72	14.47	15.16	15.77	16.32	17.44
1984	0.02	0.11	0.44	1.11	1.75	2.63	3.67	4.69	5.59	6.57	7.46	8.30	9.09	9.82	10.49	11.11	11.67	12.17	12.62	13.02	13.84
1985	0.01	0.06	0.30	1.04	1.99	2.85	3.99	5.33	6.64	7.79	9.05	10.19	11.28	12.29	13.24	14.11	14.90	15.62	16.26	16.84	18.03
1986	0.01	0.03	0.35	0.87	1.90	3.05	4.01	5.25	6.65	7.99	9.16	10.42	11.55	12.61	13.60	14.52	15.35	16.11	16.79	17.40	18.67
1987	0.02	0.06	0.34	1.01	1.75	2.96	4.17	5.13	6.32	7.62	8.83	9.87	10.96	11.94	12.84	13.67	14.43	15.11	15.73	16.28	17.45
1988	0.02	0.05	0.31	0.96	1.93	2.87	4.31	5.69	6.77	8.07	9.48	10.78	11.88	13.04	14.07	15.01	15.87	16.66	17.36	17.99	19.34
1989	0.02	0.05	0.33	0.97	1.91	3.09	4.13	5.65	7.04	8.09	9.35	10.68	11.89	12.90	13.96	14.88	15.72	16.49	17.17	17.78	19.12
1990	0.02	0.05	0.39	1.00	1.88	2.96	4.19	5.22	6.65	7.92	8.86	9.95	11.10	12.13	12.98	13.85	14.61	15.30	15.91	16.46	17.67
1991	0.01	0.06	0.40	1.00	1.77	2.75	3.85	5.04	6.00	7.30	8.43	9.25	10.21	11.19	12.07	12.78	13.51	14.14	14.70	15.20	16.31
1992	0.02	0.06	0.35	0.99	1.76	2.65	3.69	4.83	6.00	6.94	8.18	9.25	10.02	10.91	11.82	12.62	13.27	13.93	14.49	15.00	16.07
1993	0.02	0.06	0.43	1.09	2.06	3.06	4.13	5.32	6.57	7.83	8.81	10.10	11.19	11.97	12.86	13.75	14.54	15.17	15.81	16.34	17.38
1994	0.02	0.07	0.36	1.03	1.85	2.91	3.95	5.01	6.16	7.34	8.52	9.42	10.60	11.59	12.29	13.08	13.87	14.57	15.12	15.67	16.55
1995	0.02	0.06	0.34	0.96	1.88	2.86	4.06	5.17	6.29	7.47	8.67	9.85	10.74	11.91	12.87	13.55	14.31	15.08	15.73	16.26	17.26
1996	0.03	0.08	0.41	1.05	1.90	2.93	3.93	5.05	6.05	7.01	8.01	8.99	9.93	10.64	11.54	12.27	12.78	13.35	13.92	14.40	15.05
1997	0.01	0.06	0.35	0.96	1.75	2.70	3.80	4.83	5.97	6.96	7.92	8.90	9.86	10.78	11.47	12.34	13.05	13.54	14.08	14.61	15.23
1998	0.01	0.05	0.34	0.95	1.76	2.68	3.70	4.82	5.83	6.93	7.87	8.76	9.67	10.55	11.38	12.00	12.77	13.39	13.82	14.30	15.05
1999	0.01	0.05	0.32	0.95	1.82	2.81	3.86	4.97	6.15	7.20	8.31	9.26	10.14	11.03	11.88	12.69	13.28	14.02	14.60	15.01	15.84
2000	0.02	0.05	0.44	0.96	1.87	2.95	4.08	5.23	6.41	7.63	8.70	9.82	10.76	11.63	12.50	13.33	14.11	14.67	15.37	15.92	16.97
2001	0.02	0.07	0.42	1.12	1.79	2.82	3.95	5.07	6.16	7.25	8.36	9.31	10.30	11.12	11.88	12.62	13.33	13.98	14.45	15.03	16.15
2002	0.02	0.07	0.42	1.04	1.95	2.75	3.88	5.07	6.23	7.34	8.43	9.54	10.47	11.44	12.23	12.96	13.67	14.34	14.96	15.40	16.33
2003	0.02	0.07	0.37	1.04	1.86	2.93	3.81	5.02	6.25	7.42	8.52	9.60	10.67	11.58	12.51	13.27	13.96	14.63	15.26	15.83	16.91
2004	0.02	0.07	0.46	1.02	1.93	2.89	4.03	4.92	6.09	7.25	8.33	9.33	10.30	11.25	12.04	12.84	13.49	14.08	14.64	15.16	16.03
2005	0.02	0.08	0.36	1.12	1.87	2.96	4.04	5.27	6.21	7.43	8.62	9.72	10.72	11.68	12.63	13.41	14.19	14.82	15.39	15.93	16.99
2006	0.02	0.04	0.36	0.99	2.01	2.88	4.05	5.15	6.36	7.26	8.42	9.52	10.52	11.44	12.30	13.14	13.82	14.51	15.06	15.54	16.68
2007	0.02	0.04	0.32	0.99	1.86	3.08	4.05	5.29	6.43	7.66	8.56	9.69	10.77	11.74	12.61	13.43	14.22	14.86	15.50	16.01	17.34
2008	0.02	0.04	0.32	0.93	1.83	2.83	4.12	5.09	6.30	7.38	8.52	9.35	10.38	11.34	12.20	12.97	13.69	14.37	14.92	15.46	16.41
2009	0.01	0.03	0.33	0.90	1.76	2.85	4.00	5.40	6.43	7.69	8.80	9.96	10.79	11.83	12.79	13.64	14.40	15.09	15.75	16.29	17.10
2010	0.02	0.05	0.37	0.93	1.72	2.72	3.90	5.06	6.43	7.41	8.59	9.62	10.68	11.43	12.35	13.21	13.95	14.61	15.21	15.78	16.52
2011	0.02	0.06	0.30	0.98	1.73	2.66	3.75	4.96	6.11	7.45	8.38	9.49	10.44	11.42	12.10	12.94	13.71	14.37	14.95	15.48	16.35
2012	0.02	0.03	0.38	0.91	1.83	2.68	3.65	4.72	5.85	6.90	8.08	8.90	9.85	10.65	11.46	12.03	12.71	13.33	13.87	14.33	14.94
2013	0.01	0.06	0.34	0.97	1.69	2.81	3.79	4.87	6.04	7.26	8.37	9.62	10.47	11.46	12.29	13.13	13.71	14.41	15.04	15.57	16.42
2014	0.01	0.04	0.34	0.90	1.76	2.62	3.86	4.89	6.01	7.19	8.40	9.50	10.71	11.53	12.48	13.27	14.07	14.61	15.26	15.84	16.80
2015	0.02	0.05	0.42	0.91	1.67	2.69	3.62	4.91	5.94	7.03	8.16	9.31	10.34	11.45	12.21	13.07	13.78	14.49	14.97	15.54	16.53
2016	0.02	0.09	0.44	1.08	1.76	2.69	3.84	4.83	6.17	7.21	8.28	9.39	10.49	11.46	12.51	13.21	14.01	14.66	15.30	15.74	16.49
2017	0.01	0.09	0.40	1.09	1.95	2.77	3.83	5.06	6.10	7.45	8.49	9.55	10.63	11.69	12.62	13.62	14.28	15.02	15.62	16.21	17.02
2018	0.03	0.09	0.52	1.07	2.01	3.02	3.91	5.00	6.23	7.23	8.51	9.47	10.44	11.41	12.36	13.18	14.05	14.61	15.25	15.76	16.70
2019	0.02	0.10	0.30	1.23	1.97	3.10	4.23	5.19	6.34	7.60	8.61	9.89	10.84	11.79	12.73	13.65	14.43	15.25	15.79	16.38	17.18
2020	0.01	0.04	0.33	0.86	2.06	2.88	4.07	5.19	6.12	7.21	8.39	9.32	10.48	11.34	12.18	13.02	13.82	14.50	15.21	15.67	16.52

Table 2.33c (page 3 of 3)—Weight (kg) at age (EBS+NBS survey, weighted average of 19.12a, 19.12, and 20.8-10 (a subset of Ensemble AB)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.02	0.07	0.40	1.05	1.90	2.87	3.91	4.96	6.00	7.01	7.97	8.87	9.70	10.47	11.18	11.82	12.39	12.91	13.37	13.78	14.71
1978	0.01	0.05	0.32	0.97	1.83	2.85	3.96	5.11	6.26	7.39	8.47	9.50	10.46	11.35	12.17	12.91	13.59	14.19	14.74	15.22	16.32
1979	0.02	0.06	0.40	1.00	1.89	2.86	3.91	4.97	6.02	7.03	8.00	8.91	9.76	10.54	11.26	11.91	12.49	13.02	13.49	13.90	14.81
1980	0.02	0.06	0.35	1.00	1.77	2.78	3.81	4.86	5.91	6.93	7.90	8.81	9.67	10.45	11.18	11.83	12.43	12.96	13.43	13.86	14.76
1981	0.02	0.06	0.31	0.97	1.83	2.72	3.78	4.81	5.83	6.82	7.77	8.65	9.48	10.24	10.94	11.58	12.15	12.66	13.12	13.53	14.38
1982	0.02	0.05	0.35	0.97	1.90	2.93	3.92	5.03	6.09	7.10	8.07	8.97	9.81	10.59	11.30	11.94	12.53	13.05	13.51	13.92	14.78
1983	0.01	0.04	0.43	0.96	1.80	2.90	4.04	5.08	6.24	7.31	8.33	9.29	10.19	11.02	11.78	12.47	13.09	13.65	14.15	14.59	15.53
1984	0.02	0.10	0.44	1.11	1.75	2.60	3.59	4.54	5.37	6.25	7.03	7.77	8.45	9.07	9.63	10.15	10.61	11.02	11.38	11.71	12.39
1985	0.01	0.06	0.30	1.03	1.98	2.81	3.90	5.14	6.33	7.37	8.48	9.48	10.41	11.27	12.07	12.79	13.44	14.02	14.54	15.01	16.00
1986	0.01	0.03	0.35	0.87	1.88	3.00	3.91	5.06	6.34	7.55	8.59	9.68	10.66	11.56	12.40	13.16	13.84	14.46	15.01	15.50	16.56
1987	0.02	0.06	0.34	1.01	1.74	2.91	4.07	4.96	6.04	7.21	8.29	9.19	10.13	10.96	11.72	12.41	13.04	13.60	14.10	14.54	15.51
1988	0.02	0.05	0.32	0.97	1.92	2.82	4.19	5.49	6.46	7.63	8.88	10.01	10.96	11.94	12.80	13.59	14.30	14.93	15.50	16.01	17.14
1989	0.02	0.05	0.33	0.98	1.91	3.05	4.03	5.45	6.73	7.66	8.77	9.93	10.96	11.82	12.70	13.47	14.15	14.77	15.33	15.82	16.93
1990	0.02	0.05	0.39	0.99	1.87	2.92	4.09	5.04	6.35	7.50	8.33	9.29	10.28	11.16	11.87	12.60	13.23	13.79	14.29	14.73	15.74
1991	0.01	0.06	0.41	1.00	1.77	2.72	3.77	4.87	5.74	6.92	7.92	8.64	9.45	10.29	11.02	11.62	12.22	12.73	13.19	13.59	14.52
1992	0.02	0.06	0.35	1.00	1.75	2.61	3.61	4.66	5.74	6.57	7.69	8.63	9.30	10.05	10.82	11.49	12.03	12.57	13.03	13.43	14.34
1993	0.02	0.06	0.43	1.09	2.05	3.02	4.03	5.15	6.29	7.43	8.29	9.43	10.37	11.03	11.78	12.53	13.17	13.69	14.21	14.64	15.52
1994	0.02	0.07	0.36	1.03	1.84	2.88	3.86	4.85	5.91	6.96	8.00	8.78	9.80	10.64	11.22	11.87	12.53	13.09	13.53	13.98	14.72
1995	0.02	0.06	0.34	0.97	1.87	2.82	3.97	4.99	6.01	7.08	8.14	9.16	9.93	10.92	11.73	12.29	12.92	13.54	14.07	14.49	15.33
1996	0.03	0.08	0.41	1.06	1.89	2.90	3.84	4.90	5.80	6.67	7.56	8.41	9.22	9.82	10.58	11.20	11.62	12.09	12.54	12.93	13.48
1997	0.01	0.06	0.34	0.96	1.75	2.67	3.71	4.66	5.71	6.60	7.45	8.31	9.13	9.91	10.49	11.21	11.80	12.19	12.63	13.06	13.57
1998	0.01	0.05	0.34	0.94	1.75	2.65	3.62	4.66	5.58	6.58	7.41	8.18	8.96	9.70	10.40	10.91	11.55	12.06	12.40	12.78	13.40
1999	0.02	0.05	0.32	0.95	1.80	2.77	3.77	4.81	5.89	6.83	7.82	8.64	9.40	10.16	10.88	11.55	12.03	12.63	13.11	13.43	14.13
2000	0.02	0.05	0.43	0.96	1.86	2.89	3.98	5.06	6.13	7.24	8.19	9.18	9.98	10.73	11.47	12.16	12.80	13.26	13.83	14.28	15.14
2001	0.02	0.07	0.41	1.11	1.78	2.78	3.84	4.89	5.90	6.89	7.87	8.71	9.57	10.27	10.90	11.53	12.11	12.64	13.02	13.49	14.42
2002	0.02	0.07	0.41	1.04	1.93	2.71	3.79	4.89	5.96	6.96	7.93	8.89	9.70	10.53	11.20	11.80	12.39	12.94	13.43	13.79	14.58
2003	0.02	0.07	0.36	1.03	1.85	2.88	3.72	4.85	5.96	7.02	8.01	8.94	9.87	10.64	11.42	12.05	12.62	13.17	13.67	14.13	15.04
2004	0.02	0.07	0.46	1.02	1.91	2.85	3.92	4.76	5.84	6.87	7.84	8.71	9.54	10.35	11.02	11.69	12.22	12.69	13.15	13.57	14.31
2005	0.02	0.08	0.35	1.12	1.86	2.91	3.94	5.08	5.94	7.05	8.09	9.06	9.93	10.74	11.53	12.18	12.83	13.34	13.80	14.23	15.12
2006	0.02	0.05	0.36	0.99	1.99	2.83	3.93	4.96	6.07	6.89	7.93	8.89	9.77	10.55	11.28	11.98	12.55	13.11	13.55	13.95	14.90
2007	0.02	0.04	0.33	0.99	1.84	3.02	3.93	5.09	6.14	7.25	8.06	9.07	10.00	10.84	11.58	12.27	12.92	13.45	13.97	14.38	15.50
2008	0.02	0.04	0.32	0.93	1.81	2.78	4.01	4.90	6.01	6.99	8.01	8.74	9.64	10.46	11.19	11.84	12.43	12.99	13.44	13.88	14.70
2009	0.01	0.03	0.33	0.91	1.75	2.80	3.89	5.20	6.14	7.28	8.27	9.29	10.02	10.91	11.72	12.44	13.06	13.63	14.17	14.60	15.32
2010	0.02	0.05	0.37	0.93	1.72	2.69	3.80	4.88	6.14	7.01	8.06	8.96	9.87	10.52	11.30	12.00	12.62	13.16	13.65	14.10	14.75
2011	0.02	0.06	0.30	0.98	1.72	2.63	3.67	4.79	5.84	7.04	7.86	8.83	9.66	10.48	11.07	11.77	12.39	12.94	13.41	13.84	14.58
2012	0.02	0.03	0.38	0.91	1.81	2.64	3.57	4.57	5.61	6.56	7.61	8.32	9.15	9.84	10.53	11.01	11.58	12.08	12.52	12.89	13.42
2013	0.01	0.06	0.33	0.97	1.68	2.78	3.70	4.72	5.79	6.88	7.86	8.95	9.67	10.51	11.21	11.90	12.38	12.95	13.45	13.89	14.60
2014	0.02	0.04	0.33	0.89	1.75	2.58	3.76	4.72	5.75	6.82	7.88	8.84	9.88	10.57	11.37	12.03	12.68	13.12	13.65	14.12	14.94
2015	0.02	0.05	0.42	0.90	1.66	2.65	3.53	4.74	5.68	6.67	7.67	8.66	9.54	10.48	11.11	11.82	12.40	12.98	13.37	13.83	14.68
2016	0.02	0.09	0.44	1.08	1.74	2.65	3.75	4.67	5.89	6.82	7.78	8.74	9.68	10.50	11.37	11.95	12.59	13.12	13.64	13.99	14.65
2017	0.01	0.09	0.40	1.10	1.94	2.73	3.73	4.89	5.83	7.05	7.96	8.89	9.81	10.71	11.48	12.30	12.84	13.44	13.92	14.39	15.09
2018	0.03	0.09	0.53	1.08	2.01	2.97	3.81	4.83	5.95	6.85	7.98	8.82	9.66	10.48	11.27	11.94	12.66	13.11	13.62	14.04	14.82
2019	0.02	0.10	0.30	1.23	1.96	3.05	4.10	4.99	6.05	7.19	8.09	9.21	10.03	10.85	11.65	12.40	13.05	13.72	14.15	14.63	15.30
2020	0.01	0.04	0.33	0.86	2.04	2.84	3.96	4.99	5.83	6.82	7.87	8.68	9.68	10.41	11.13	11.82	12.47	13.03	13.60	13.97	14.66

Table 2.34a—Selectivity at age (fishery, Model 19.12).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.000	0.000	0.012	0.099	0.318	0.594	0.797	0.886	0.908	0.908	0.904	0.902	0.900	0.900	0.899	0.899	0.899	0.899	0.899	0.899	0.899
1978	0.000	0.000	0.010	0.098	0.317	0.592	0.796	0.885	0.907	0.906	0.902	0.900	0.898	0.897	0.897	0.897	0.897	0.897	0.896	0.896	0.896
1979	0.000	0.000	0.014	0.100	0.331	0.604	0.802	0.888	0.908	0.906	0.902	0.900	0.898	0.897	0.897	0.896	0.896	0.896	0.896	0.896	0.896
1980	0.000	0.000	0.011	0.107	0.315	0.601	0.801	0.890	0.912	0.912	0.909	0.906	0.905	0.904	0.904	0.904	0.904	0.904	0.903	0.903	0.903
1981	0.000	0.000	0.014	0.121	0.366	0.617	0.816	0.896	0.914	0.912	0.908	0.906	0.904	0.903	0.903	0.903	0.903	0.903	0.903	0.903	0.903
1982	0.000	0.000	0.007	0.073	0.296	0.589	0.785	0.887	0.912	0.914	0.912	0.909	0.908	0.907	0.907	0.907	0.907	0.907	0.907	0.907	0.907
1983	0.000	0.000	0.014	0.080	0.281	0.581	0.800	0.890	0.919	0.923	0.921	0.919	0.918	0.918	0.917	0.917	0.917	0.917	0.917	0.917	0.917
1984	0.000	0.001	0.018	0.139	0.321	0.588	0.809	0.904	0.927	0.930	0.929	0.927	0.927	0.926	0.926	0.926	0.925	0.925	0.925	0.925	0.925
1985	0.000	0.000	0.005	0.090	0.326	0.547	0.767	0.884	0.914	0.916	0.914	0.912	0.911	0.910	0.910	0.910	0.910	0.910	0.910	0.910	0.910
1986	0.000	0.000	0.014	0.088	0.343	0.635	0.788	0.884	0.910	0.909	0.905	0.902	0.901	0.900	0.899	0.899	0.899	0.899	0.899	0.899	0.899
1987	0.000	0.000	0.008	0.087	0.260	0.584	0.805	0.880	0.913	0.918	0.916	0.914	0.913	0.912	0.912	0.911	0.911	0.911	0.911	0.911	0.911
1988	0.000	0.001	0.028	0.161	0.417	0.635	0.842	0.911	0.921	0.919	0.914	0.911	0.910	0.909	0.908	0.908	0.908	0.908	0.908	0.908	0.908
1989	0.000	0.000	0.014	0.109	0.338	0.623	0.792	0.902	0.925	0.926	0.924	0.922	0.921	0.921	0.920	0.920	0.920	0.920	0.920	0.920	0.920
1990	0.000	0.000	0.010	0.082	0.287	0.571	0.798	0.890	0.936	0.944	0.945	0.945	0.944	0.944	0.944	0.944	0.944	0.944	0.944	0.944	0.944
1991	0.000	0.000	0.011	0.088	0.280	0.556	0.782	0.893	0.922	0.931	0.930	0.930	0.929	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928
1992	0.000	0.000	0.008	0.089	0.287	0.546	0.767	0.876	0.904	0.904	0.900	0.898	0.896	0.896	0.895	0.895	0.895	0.895	0.895	0.894	0.894
1993	0.000	0.001	0.026	0.144	0.397	0.641	0.813	0.896	0.915	0.912	0.908	0.905	0.903	0.902	0.902	0.902	0.901	0.901	0.901	0.901	0.901
1994	0.000	0.000	0.014	0.115	0.332	0.619	0.802	0.886	0.911	0.912	0.908	0.906	0.904	0.903	0.903	0.903	0.903	0.902	0.902	0.902	0.902
1995	0.000	0.000	0.015	0.114	0.353	0.613	0.816	0.892	0.911	0.911	0.907	0.904	0.902	0.901	0.901	0.901	0.901	0.901	0.901	0.900	0.900
1996	0.000	0.000	0.008	0.079	0.285	0.577	0.786	0.898	0.931	0.940	0.941	0.941	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940
1997	0.000	0.000	0.015	0.115	0.338	0.610	0.815	0.901	0.929	0.932	0.931	0.929	0.928	0.928	0.927	0.927	0.927	0.927	0.927	0.927	0.927
1998	0.000	0.000	0.007	0.081	0.291	0.565	0.783	0.891	0.920	0.925	0.924	0.923	0.922	0.921	0.921	0.921	0.920	0.920	0.920	0.920	0.920
1999	0.000	0.000	0.007	0.078	0.295	0.575	0.785	0.887	0.917	0.921	0.919	0.917	0.916	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915
2000	0.000	0.000	0.010	0.065	0.267	0.559	0.780	0.884	0.915	0.920	0.919	0.917	0.916	0.916	0.915	0.915	0.915	0.915	0.915	0.915	0.915
2001	0.000	0.000	0.008	0.091	0.256	0.545	0.775	0.871	0.892	0.890	0.884	0.881	0.879	0.878	0.877	0.877	0.877	0.877	0.877	0.877	0.877
2002	0.000	0.000	0.018	0.117	0.358	0.577	0.787	0.865	0.867	0.853	0.841	0.834	0.831	0.829	0.829	0.828	0.828	0.828	0.828	0.828	0.828
2003	0.000	0.000	0.013	0.116	0.335	0.620	0.781	0.883	0.906	0.905	0.900	0.897	0.895	0.895	0.894	0.894	0.894	0.894	0.894	0.894	0.894
2004	0.000	0.000	0.021	0.111	0.352	0.613	0.814	0.882	0.908	0.907	0.903	0.900	0.899	0.898	0.897	0.897	0.897	0.897	0.897	0.897	0.897
2005	0.000	0.001	0.013	0.133	0.333	0.620	0.808	0.899	0.918	0.922	0.920	0.918	0.916	0.916	0.915	0.915	0.915	0.915	0.915	0.915	0.915
2006	0.000	0.000	0.008	0.085	0.343	0.581	0.803	0.899	0.934	0.940	0.941	0.941	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940
2007	0.000	0.000	0.006	0.078	0.285	0.611	0.788	0.897	0.928	0.935	0.935	0.935	0.934	0.934	0.933	0.933	0.933	0.933	0.933	0.933	0.933
2008	0.000	0.000	0.006	0.069	0.281	0.562	0.803	0.875	0.895	0.893	0.887	0.885	0.883	0.882	0.881	0.881	0.881	0.880	0.880	0.880	0.880
2009	0.000	0.000	0.003	0.049	0.227	0.524	0.752	0.857	0.866	0.858	0.850	0.845	0.843	0.841	0.840	0.840	0.840	0.840	0.840	0.840	0.840
2010	0.000	0.000	0.004	0.045	0.207	0.488	0.740	0.847	0.868	0.862	0.855	0.850	0.847	0.846	0.846	0.845	0.845	0.845	0.845	0.845	0.845
2011	0.000	0.000	0.003	0.061	0.228	0.496	0.740	0.868	0.903	0.907	0.905	0.903	0.902	0.901	0.901	0.901	0.901	0.901	0.901	0.901	0.901
2012	0.000	0.000	0.008	0.065	0.292	0.543	0.760	0.873	0.906	0.908	0.904	0.902	0.901	0.900	0.900	0.899	0.899	0.899	0.899	0.899	0.899
2013	0.000	0.000	0.008	0.089	0.266	0.580	0.767	0.857	0.873	0.864	0.855	0.849	0.847	0.845	0.845	0.844	0.844	0.844	0.844	0.844	0.844
2014	0.000	0.000	0.004	0.056	0.255	0.498	0.757	0.840	0.855	0.845	0.834	0.828	0.824	0.823	0.822	0.822	0.822	0.822	0.821	0.821	0.821
2015	0.000	0.000	0.006	0.053	0.222	0.520	0.725	0.857	0.880	0.881	0.876	0.872	0.870	0.869	0.868	0.868	0.868	0.868	0.868	0.868	0.868
2016	0.000	0.000	0.007	0.074	0.232	0.500	0.753	0.858	0.904	0.909	0.909	0.907	0.906	0.905	0.905	0.904	0.904	0.904	0.904	0.904	0.904
2017	0.000	0.000	0.005	0.077	0.284	0.515	0.744	0.876	0.914	0.928	0.929	0.929	0.928	0.928	0.928	0.927	0.927	0.927	0.927	0.927	0.927
2018	0.000	0.000	0.019	0.101	0.350	0.621	0.784	0.885	0.920	0.926	0.925	0.924	0.923	0.923	0.922	0.922	0.922	0.922	0.922	0.922	0.922
2019	0.000	0.001	0.007	0.142	0.340	0.637	0.814	0.875	0.893	0.889	0.884	0.880	0.878	0.877	0.876	0.876	0.876	0.876	0.876	0.876	0.876
2020	0.000	0.000	0.012	0.086	0.412	0.632	0.830	0.900	0.914	0.915	0.913	0.911	0.909	0.908	0.908	0.908	0.908	0.908	0.907	0.907	0.907

Table 2.34b—Selectivity at age (fishery, Ensemble A).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.000	0.000	0.011	0.098	0.318	0.594	0.795	0.881	0.900	0.899	0.895	0.892	0.890	0.889	0.889	0.888	0.888	0.888	0.888	0.888	0.888
1978	0.000	0.000	0.010	0.097	0.317	0.593	0.794	0.880	0.899	0.897	0.892	0.889	0.887	0.886	0.886	0.885	0.885	0.885	0.885	0.885	0.885
1979	0.000	0.000	0.014	0.099	0.330	0.604	0.800	0.882	0.899	0.897	0.892	0.889	0.887	0.886	0.885	0.885	0.885	0.885	0.885	0.885	0.885
1980	0.000	0.000	0.011	0.106	0.314	0.601	0.799	0.885	0.904	0.903	0.900	0.897	0.895	0.894	0.894	0.893	0.893	0.893	0.893	0.893	0.893
1981	0.000	0.000	0.013	0.119	0.364	0.616	0.814	0.890	0.906	0.903	0.899	0.896	0.894	0.893	0.892	0.892	0.892	0.892	0.892	0.892	0.892
1982	0.000	0.000	0.007	0.074	0.298	0.591	0.784	0.882	0.905	0.906	0.903	0.900	0.899	0.898	0.898	0.897	0.897	0.897	0.897	0.897	0.897
1983	0.000	0.000	0.014	0.081	0.282	0.583	0.800	0.886	0.914	0.916	0.914	0.912	0.911	0.910	0.910	0.910	0.909	0.909	0.909	0.909	0.909
1984	0.000	0.001	0.018	0.135	0.322	0.589	0.808	0.900	0.922	0.925	0.923	0.921	0.920	0.920	0.919	0.919	0.919	0.919	0.919	0.919	0.919
1985	0.000	0.000	0.005	0.090	0.323	0.549	0.767	0.880	0.907	0.909	0.906	0.904	0.903	0.902	0.901	0.901	0.901	0.901	0.901	0.901	0.901
1986	0.000	0.000	0.014	0.087	0.343	0.631	0.787	0.879	0.902	0.900	0.896	0.892	0.891	0.890	0.889	0.889	0.889	0.889	0.889	0.889	0.889
1987	0.000	0.000	0.007	0.087	0.262	0.586	0.802	0.877	0.908	0.912	0.909	0.908	0.906	0.905	0.905	0.905	0.905	0.905	0.905	0.905	0.905
1988	0.000	0.001	0.027	0.158	0.414	0.634	0.839	0.906	0.914	0.911	0.905	0.902	0.900	0.899	0.899	0.899	0.899	0.898	0.898	0.898	0.898
1989	0.000	0.000	0.014	0.107	0.337	0.622	0.791	0.899	0.920	0.920	0.918	0.916	0.915	0.914	0.914	0.913	0.913	0.913	0.913	0.913	0.913
1990	0.000	0.000	0.010	0.083	0.289	0.574	0.798	0.888	0.933	0.941	0.942	0.941	0.941	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940
1991	0.000	0.000	0.011	0.087	0.281	0.557	0.781	0.890	0.918	0.926	0.925	0.924	0.923	0.922	0.922	0.922	0.922	0.922	0.921	0.921	0.921
1992	0.000	0.000	0.007	0.087	0.286	0.544	0.765	0.871	0.897	0.897	0.892	0.889	0.888	0.887	0.886	0.886	0.886	0.886	0.886	0.886	0.886
1993	0.000	0.001	0.025	0.139	0.391	0.638	0.809	0.891	0.909	0.906	0.902	0.898	0.896	0.895	0.895	0.894	0.894	0.894	0.894	0.894	0.894
1994	0.000	0.000	0.013	0.113	0.329	0.616	0.799	0.882	0.906	0.907	0.903	0.900	0.898	0.898	0.897	0.897	0.897	0.897	0.897	0.897	0.897
1995	0.000	0.000	0.014	0.111	0.353	0.611	0.812	0.887	0.905	0.904	0.900	0.897	0.895	0.894	0.893	0.893	0.893	0.893	0.893	0.893	0.893
1996	0.000	0.000	0.008	0.079	0.285	0.581	0.785	0.896	0.928	0.937	0.938	0.938	0.937	0.937	0.937	0.937	0.937	0.936	0.936	0.936	0.936
1997	0.000	0.000	0.016	0.117	0.341	0.612	0.817	0.899	0.925	0.927	0.926	0.924	0.923	0.923	0.922	0.922	0.922	0.922	0.922	0.922	0.922
1998	0.000	0.000	0.007	0.083	0.296	0.570	0.784	0.888	0.914	0.918	0.917	0.915	0.914	0.913	0.913	0.913	0.912	0.912	0.912	0.912	0.912
1999	0.000	0.000	0.007	0.080	0.300	0.580	0.786	0.882	0.909	0.910	0.907	0.905	0.903	0.902	0.902	0.902	0.902	0.902	0.901	0.901	0.901
2000	0.000	0.000	0.010	0.067	0.272	0.565	0.781	0.878	0.906	0.908	0.905	0.903	0.901	0.901	0.900	0.900	0.900	0.900	0.900	0.900	0.900
2001	0.000	0.000	0.008	0.094	0.259	0.548	0.772	0.859	0.871	0.864	0.855	0.850	0.847	0.846	0.845	0.844	0.844	0.844	0.844	0.844	0.844
2002	0.000	0.000	0.017	0.116	0.360	0.576	0.781	0.849	0.841	0.820	0.805	0.796	0.792	0.790	0.789	0.788	0.788	0.788	0.787	0.787	0.787
2003	0.000	0.000	0.013	0.116	0.336	0.623	0.779	0.876	0.895	0.891	0.886	0.882	0.880	0.879	0.878	0.878	0.878	0.878	0.877	0.877	0.877
2004	0.000	0.000	0.021	0.110	0.353	0.614	0.813	0.878	0.902	0.900	0.895	0.892	0.890	0.889	0.889	0.888	0.888	0.888	0.888	0.888	0.888
2005	0.000	0.001	0.013	0.133	0.334	0.622	0.807	0.895	0.913	0.916	0.913	0.911	0.910	0.909	0.908	0.908	0.908	0.908	0.908	0.908	0.908
2006	0.000	0.000	0.008	0.085	0.344	0.583	0.803	0.896	0.930	0.936	0.937	0.936	0.936	0.936	0.935	0.935	0.935	0.935	0.935	0.935	0.935
2007	0.000	0.000	0.006	0.079	0.288	0.613	0.788	0.894	0.924	0.930	0.930	0.929	0.929	0.928	0.928	0.928	0.928	0.928	0.928	0.928	0.928
2008	0.000	0.000	0.006	0.071	0.287	0.566	0.802	0.869	0.886	0.881	0.875	0.872	0.869	0.868	0.867	0.867	0.867	0.867	0.867	0.867	0.867
2009	0.000	0.000	0.004	0.051	0.232	0.531	0.751	0.847	0.850	0.838	0.828	0.821	0.818	0.816	0.815	0.815	0.815	0.814	0.814	0.814	0.814
2010	0.000	0.000	0.004	0.048	0.210	0.492	0.738	0.831	0.840	0.829	0.817	0.811	0.807	0.806	0.805	0.804	0.804	0.804	0.804	0.804	0.804
2011	0.000	0.000	0.003	0.061	0.230	0.496	0.738	0.861	0.892	0.894	0.892	0.889	0.887	0.887	0.886	0.886	0.886	0.886	0.886	0.886	0.886
2012	0.000	0.000	0.008	0.065	0.293	0.546	0.758	0.867	0.897	0.898	0.893	0.891	0.889	0.888	0.888	0.888	0.888	0.887	0.887	0.887	0.887
2013	0.000	0.000	0.008	0.087	0.268	0.582	0.767	0.852	0.865	0.855	0.845	0.838	0.836	0.834	0.833	0.833	0.833	0.833	0.833	0.832	0.832
2014	0.000	0.000	0.004	0.057	0.255	0.502	0.756	0.836	0.849	0.839	0.828	0.821	0.817	0.816	0.815	0.815	0.814	0.814	0.814	0.814	0.814
2015	0.000	0.000	0.007	0.054	0.228	0.522	0.727	0.853	0.875	0.874	0.868	0.864	0.862	0.861	0.860	0.860	0.860	0.859	0.859	0.859	0.859
2016	0.000	0.000	0.007	0.077	0.239	0.508	0.753	0.855	0.897	0.900	0.899	0.897	0.895	0.894	0.894	0.894	0.894	0.894	0.894	0.894	0.894
2017	0.000	0.000	0.006	0.083	0.290	0.522	0.747	0.873	0.909	0.921	0.922	0.921	0.920	0.920	0.919	0.919	0.919	0.919	0.919	0.919	0.919
2018	0.000	0.000	0.018	0.105	0.354	0.620	0.783	0.880	0.913	0.918	0.917	0.915	0.914	0.914	0.913	0.913	0.913	0.913	0.913	0.913	0.913
2019	0.000	0.001	0.006	0.137	0.343	0.637	0.809	0.868	0.884	0.880	0.874	0.869	0.867	0.866	0.865	0.865	0.865	0.865	0.864	0.864	0.864
2020	0.000	0.000	0.010	0.077	0.401	0.632	0.827	0.895	0.910	0.911	0.909	0.906	0.905	0.904	0.904	0.904	0.903	0.903	0.903	0.903	0.903

Table 2.34c—Selectivity at age (fishery, Ensemble AB).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.000	0.000	0.014	0.119	0.363	0.636	0.809	0.860	0.846	0.818	0.795	0.780	0.770	0.764	0.760	0.757	0.756	0.754	0.753	0.753	0.752
1978	0.000	0.000	0.012	0.117	0.361	0.635	0.807	0.854	0.835	0.804	0.779	0.762	0.752	0.745	0.741	0.738	0.736	0.734	0.733	0.733	0.732
1979	0.000	0.000	0.018	0.123	0.378	0.647	0.813	0.856	0.836	0.803	0.778	0.761	0.750	0.743	0.739	0.736	0.734	0.733	0.732	0.731	0.730
1980	0.000	0.000	0.016	0.134	0.365	0.646	0.816	0.868	0.858	0.834	0.814	0.800	0.791	0.785	0.781	0.779	0.777	0.776	0.775	0.774	0.773
1981	0.000	0.001	0.020	0.153	0.418	0.662	0.830	0.873	0.859	0.833	0.811	0.797	0.788	0.782	0.778	0.776	0.774	0.773	0.772	0.771	0.770
1982	0.000	0.000	0.009	0.093	0.344	0.633	0.803	0.870	0.866	0.846	0.828	0.816	0.808	0.803	0.799	0.797	0.795	0.794	0.793	0.793	0.792
1983	0.000	0.000	0.019	0.105	0.331	0.629	0.818	0.879	0.884	0.870	0.855	0.845	0.838	0.834	0.831	0.829	0.828	0.827	0.826	0.826	0.825
1984	0.000	0.001	0.025	0.169	0.373	0.636	0.828	0.894	0.897	0.884	0.872	0.863	0.857	0.853	0.850	0.848	0.847	0.846	0.846	0.845	0.845
1985	0.000	0.000	0.007	0.111	0.370	0.595	0.789	0.870	0.872	0.855	0.839	0.827	0.820	0.815	0.812	0.809	0.808	0.807	0.806	0.806	0.805
1986	0.000	0.000	0.019	0.109	0.391	0.673	0.806	0.867	0.860	0.834	0.815	0.800	0.791	0.786	0.782	0.779	0.778	0.777	0.776	0.775	0.774
1987	0.000	0.000	0.010	0.107	0.302	0.628	0.816	0.864	0.866	0.845	0.826	0.814	0.806	0.800	0.797	0.794	0.792	0.791	0.790	0.790	0.789
1988	0.000	0.002	0.039	0.197	0.469	0.678	0.852	0.885	0.869	0.844	0.820	0.805	0.796	0.790	0.786	0.784	0.782	0.781	0.780	0.779	0.778
1989	0.000	0.000	0.020	0.139	0.391	0.668	0.815	0.892	0.891	0.879	0.865	0.854	0.847	0.844	0.841	0.839	0.838	0.837	0.836	0.836	0.835
1990	0.000	0.000	0.015	0.107	0.340	0.621	0.820	0.890	0.915	0.910	0.904	0.898	0.894	0.891	0.889	0.888	0.887	0.886	0.886	0.885	0.885
1991	0.000	0.000	0.013	0.105	0.319	0.599	0.797	0.869	0.869	0.847	0.829	0.819	0.811	0.806	0.802	0.800	0.799	0.798	0.797	0.796	0.795
1992	0.000	0.000	0.011	0.114	0.337	0.595	0.792	0.871	0.876	0.864	0.846	0.835	0.829	0.824	0.821	0.819	0.818	0.817	0.816	0.815	0.814
1993	0.000	0.001	0.034	0.170	0.442	0.678	0.822	0.865	0.843	0.807	0.784	0.763	0.752	0.747	0.742	0.739	0.737	0.736	0.735	0.734	0.733
1994	0.000	0.000	0.017	0.140	0.377	0.659	0.815	0.866	0.857	0.830	0.807	0.794	0.783	0.776	0.773	0.771	0.769	0.767	0.767	0.766	0.765
1995	0.000	0.001	0.021	0.142	0.408	0.659	0.834	0.886	0.886	0.869	0.853	0.841	0.835	0.830	0.826	0.825	0.823	0.822	0.822	0.821	0.820
1996	0.000	0.000	0.009	0.093	0.322	0.618	0.797	0.871	0.874	0.860	0.844	0.832	0.824	0.820	0.816	0.814	0.813	0.812	0.811	0.810	0.810
1997	0.000	0.001	0.022	0.150	0.398	0.661	0.838	0.896	0.903	0.893	0.882	0.874	0.868	0.864	0.862	0.860	0.859	0.858	0.858	0.857	0.857
1998	0.000	0.000	0.010	0.104	0.345	0.618	0.806	0.880	0.885	0.871	0.859	0.849	0.842	0.838	0.835	0.833	0.831	0.830	0.830	0.829	0.829
1999	0.000	0.000	0.010	0.106	0.348	0.629	0.808	0.876	0.878	0.863	0.847	0.837	0.831	0.826	0.822	0.820	0.819	0.818	0.817	0.817	0.816
2000	0.000	0.000	0.013	0.084	0.318	0.607	0.795	0.852	0.840	0.811	0.789	0.772	0.763	0.757	0.753	0.750	0.748	0.747	0.746	0.745	0.744
2001	0.000	0.000	0.010	0.109	0.295	0.589	0.782	0.824	0.791	0.746	0.710	0.689	0.675	0.667	0.662	0.659	0.656	0.655	0.654	0.653	0.651
2002	0.000	0.000	0.020	0.135	0.398	0.614	0.794	0.825	0.778	0.726	0.688	0.662	0.648	0.639	0.634	0.631	0.628	0.626	0.625	0.624	0.623
2003	0.000	0.000	0.013	0.124	0.361	0.646	0.784	0.837	0.811	0.769	0.738	0.717	0.704	0.697	0.691	0.688	0.686	0.685	0.684	0.683	0.681
2004	0.000	0.000	0.021	0.120	0.380	0.641	0.816	0.857	0.847	0.819	0.795	0.780	0.771	0.764	0.761	0.758	0.756	0.755	0.754	0.754	0.753
2005	0.000	0.000	0.012	0.143	0.358	0.646	0.811	0.867	0.861	0.838	0.817	0.803	0.795	0.789	0.785	0.783	0.781	0.780	0.780	0.779	0.778
2006	0.000	0.000	0.009	0.097	0.382	0.619	0.820	0.896	0.916	0.914	0.908	0.903	0.899	0.896	0.895	0.893	0.893	0.892	0.892	0.891	0.891
2007	0.000	0.000	0.007	0.093	0.324	0.651	0.808	0.893	0.908	0.904	0.898	0.892	0.887	0.884	0.882	0.881	0.880	0.879	0.879	0.878	0.878
2008	0.000	0.000	0.008	0.090	0.332	0.613	0.825	0.876	0.880	0.865	0.851	0.843	0.836	0.832	0.829	0.828	0.826	0.826	0.825	0.825	0.824
2009	0.000	0.000	0.007	0.076	0.291	0.591	0.790	0.867	0.863	0.843	0.827	0.815	0.810	0.805	0.801	0.800	0.798	0.797	0.797	0.796	0.796
2010	0.000	0.000	0.007	0.070	0.267	0.554	0.772	0.839	0.824	0.799	0.774	0.758	0.748	0.743	0.739	0.736	0.734	0.733	0.732	0.731	0.730
2011	0.000	0.000	0.004	0.085	0.283	0.554	0.764	0.839	0.828	0.792	0.772	0.754	0.743	0.736	0.733	0.730	0.728	0.726	0.725	0.724	0.723
2012	0.000	0.000	0.013	0.090	0.351	0.600	0.782	0.847	0.834	0.803	0.773	0.760	0.749	0.742	0.738	0.736	0.733	0.732	0.731	0.730	0.729
2013	0.000	0.000	0.010	0.111	0.313	0.626	0.782	0.823	0.787	0.736	0.699	0.672	0.660	0.651	0.646	0.642	0.640	0.638	0.637	0.636	0.635
2014	0.000	0.000	0.005	0.069	0.297	0.546	0.768	0.806	0.773	0.723	0.683	0.659	0.642	0.635	0.629	0.625	0.623	0.621	0.620	0.619	0.617
2015	0.000	0.000	0.008	0.067	0.267	0.569	0.748	0.826	0.811	0.779	0.750	0.730	0.718	0.710	0.706	0.703	0.701	0.699	0.698	0.697	0.696
2016	0.000	0.000	0.008	0.090	0.271	0.548	0.764	0.826	0.817	0.789	0.763	0.744	0.732	0.725	0.720	0.717	0.715	0.714	0.712	0.712	0.711
2017	0.000	0.000	0.005	0.086	0.313	0.547	0.750	0.828	0.821	0.789	0.766	0.749	0.737	0.730	0.725	0.722	0.720	0.719	0.718	0.717	0.716
2018	0.000	0.000	0.019	0.112	0.379	0.643	0.784	0.843	0.830	0.805	0.777	0.762	0.751	0.745	0.740	0.737	0.735	0.734	0.733	0.732	0.731
2019	0.000	0.001	0.006	0.158	0.376	0.665	0.812	0.842	0.823	0.787	0.763	0.743	0.733	0.726	0.721	0.718	0.717	0.715	0.714	0.714	0.713
2020	0.000	0.000	0.018	0.113	0.472	0.686	0.856	0.910	0.918	0.915	0.907	0.903	0.898	0.896	0.895	0.894	0.893	0.892	0.892	0.892	0.892

Table 2.35a—Selectivity at age (EBS survey, weighted average of Models 20.4 and 19.15 (a subset of Ensemble A)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.010	0.456	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978	0.008	0.456	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.011	0.375	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1980	0.009	0.501	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	0.006	0.386	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1982	0.003	0.205	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1983	0.040	0.377	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1984	0.005	0.303	0.986	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1985	0.007	0.412	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.021	0.280	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1987	0.005	0.385	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1988	0.004	0.264	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1989	0.002	0.130	0.989	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1990	0.021	0.376	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1991	0.021	0.309	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1992	0.013	0.602	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1993	0.028	0.462	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	0.006	0.341	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.004	0.212	0.992	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1996	0.002	0.202	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.008	0.257	0.992	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.009	0.160	0.891	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.005	0.222	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.017	0.286	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.025	0.776	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2002	0.010	0.402	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.009	0.478	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2004	0.011	0.343	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2005	0.007	0.650	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2006	0.027	0.716	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2007	0.039	0.843	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.014	0.508	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2009	0.049	0.569	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	0.008	0.290	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2011	0.006	0.499	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2012	0.070	0.693	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2013	0.010	0.310	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2014	0.012	0.401	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2015	0.016	0.369	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2016	0.009	0.454	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2017	0.015	0.643	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2018	0.002	0.386	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2019	0.008	0.986	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2019	0.009	0.177	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 2.35b—Selectivity at age (NBS survey, weighted average of Models 20.4 and 19.15 (a subset of Ensemble A)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.017	0.113	0.353	0.567	0.734	0.851	0.925	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978	0.016	0.113	0.343	0.567	0.734	0.851	0.925	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.018	0.102	0.359	0.558	0.734	0.851	0.925	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1980	0.016	0.119	0.344	0.571	0.728	0.851	0.925	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	0.012	0.104	0.322	0.559	0.738	0.847	0.925	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1982	0.013	0.080	0.325	0.540	0.729	0.854	0.922	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1983	0.021	0.084	0.373	0.543	0.714	0.848	0.926	0.964	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1984	0.018	0.133	0.356	0.583	0.717	0.838	0.922	0.966	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1985	0.011	0.116	0.314	0.569	0.746	0.840	0.917	0.964	0.985	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.017	0.072	0.349	0.534	0.736	0.859	0.918	0.961	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1987	0.014	0.109	0.335	0.563	0.709	0.852	0.929	0.961	0.982	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1988	0.013	0.094	0.327	0.552	0.732	0.835	0.925	0.967	0.983	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1989	0.013	0.085	0.327	0.545	0.723	0.850	0.915	0.965	0.986	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1990	0.016	0.086	0.345	0.545	0.718	0.844	0.924	0.960	0.985	0.994	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1991	0.018	0.104	0.359	0.560	0.718	0.840	0.920	0.964	0.982	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1992	0.016	0.119	0.346	0.571	0.729	0.841	0.918	0.963	0.984	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1993	0.018	0.105	0.356	0.561	0.738	0.848	0.918	0.961	0.983	0.993	0.996	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	0.016	0.116	0.342	0.570	0.730	0.854	0.923	0.961	0.983	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.015	0.101	0.341	0.557	0.736	0.848	0.926	0.964	0.983	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1996	0.016	0.101	0.344	0.557	0.727	0.853	0.923	0.966	0.984	0.992	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.016	0.103	0.342	0.559	0.727	0.847	0.925	0.964	0.985	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.013	0.101	0.328	0.557	0.728	0.846	0.922	0.965	0.984	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.012	0.087	0.318	0.546	0.727	0.848	0.922	0.963	0.985	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.020	0.076	0.368	0.538	0.719	0.847	0.922	0.963	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.017	0.128	0.354	0.579	0.712	0.841	0.922	0.964	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2002	0.019	0.114	0.363	0.568	0.743	0.837	0.918	0.963	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.017	0.124	0.349	0.575	0.735	0.857	0.916	0.962	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2004	0.022	0.109	0.382	0.564	0.740	0.852	0.928	0.960	0.983	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2005	0.015	0.143	0.342	0.591	0.732	0.856	0.925	0.967	0.982	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2006	0.015	0.101	0.340	0.557	0.752	0.850	0.927	0.965	0.985	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2007	0.013	0.100	0.323	0.556	0.727	0.863	0.924	0.966	0.985	0.994	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.012	0.081	0.319	0.541	0.726	0.847	0.931	0.964	0.985	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2009	0.014	0.077	0.332	0.538	0.715	0.846	0.922	0.968	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	0.017	0.091	0.353	0.549	0.713	0.839	0.921	0.963	0.986	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2011	0.012	0.113	0.322	0.567	0.721	0.837	0.917	0.963	0.984	0.994	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2012	0.017	0.080	0.349	0.540	0.734	0.842	0.916	0.961	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2013	0.015	0.108	0.341	0.563	0.714	0.851	0.919	0.960	0.983	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2014	0.017	0.100	0.351	0.556	0.731	0.838	0.925	0.962	0.982	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2015	0.025	0.111	0.396	0.565	0.726	0.850	0.917	0.965	0.983	0.992	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2016	0.028	0.159	0.412	0.602	0.733	0.846	0.924	0.961	0.984	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2017	0.025	0.176	0.398	0.616	0.760	0.851	0.922	0.964	0.982	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2018	0.030	0.161	0.423	0.604	0.770	0.868	0.924	0.963	0.984	0.992	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2019	0.011	0.188	0.314	0.624	0.761	0.875	0.935	0.965	0.984	0.993	0.997	0.999	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2020	0.016	0.072	0.346	0.534	0.776	0.869	0.938	0.970	0.984	0.993	0.997	0.998	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 2.35c (page 1 of 3)—Selectivity at age (EBS+NBS survey, Model 19.12).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.011	0.485	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978	0.009	0.485	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.012	0.395	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1980	0.009	0.514	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	0.006	0.402	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1982	0.004	0.217	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1983	0.044	0.391	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1984	0.006	0.342	0.988	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1985	0.008	0.416	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.022	0.284	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1987	0.006	0.395	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1988	0.004	0.261	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1989	0.003	0.143	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1990	0.023	0.403	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1991	0.025	0.340	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1992	0.015	0.661	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1993	0.030	0.493	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	0.006	0.331	0.995	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.005	0.223	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1996	0.002	0.210	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.009	0.281	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.011	0.177	0.910	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.006	0.237	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.019	0.322	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.025	0.759	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2002	0.012	0.460	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.010	0.500	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2004	0.013	0.376	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2005	0.007	0.701	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2006	0.028	0.731	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2007	0.039	0.838	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.015	0.532	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2009	0.054	0.642	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	0.010	0.350	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2011	0.006	0.499	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2012	0.074	0.678	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2013	0.010	0.330	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2014	0.010	0.350	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2015	0.016	0.346	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2016	0.008	0.445	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2017	0.012	0.579	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2018	0.005	0.381	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2019	0.009	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2020	0.010	0.255	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 2.35c (page 2 of 3)—Selectivity at age (EBS+NBS survey, weighted average of Models 19.12a and 19.12 (a subset of Ensemble A)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.011	0.485	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1978	0.009	0.485	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1979	0.012	0.390	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1980	0.009	0.505	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1981	0.006	0.400	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1982	0.004	0.217	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1983	0.043	0.402	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1984	0.005	0.308	0.988	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1985	0.008	0.427	0.991	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1986	0.022	0.290	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1987	0.006	0.398	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1988	0.004	0.265	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1989	0.002	0.133	0.990	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1990	0.022	0.386	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1991	0.023	0.323	0.995	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1992	0.013	0.613	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1993	0.030	0.484	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1994	0.007	0.371	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1995	0.005	0.229	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1996	0.002	0.216	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1997	0.009	0.279	0.993	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1998	0.011	0.177	0.914	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1999	0.006	0.237	0.994	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2000	0.018	0.303	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.027	0.784	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2002	0.012	0.457	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2003	0.010	0.503	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2004	0.013	0.368	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2005	0.007	0.707	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2006	0.027	0.721	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2007	0.038	0.834	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2008	0.014	0.506	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2009	0.052	0.580	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2010	0.010	0.350	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2011	0.006	0.502	0.998	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2012	0.071	0.665	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2013	0.009	0.309	0.990	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2014	0.010	0.354	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2015	0.016	0.351	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2016	0.008	0.447	0.997	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2017	0.011	0.540	0.996	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2018	0.005	0.377	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2019	0.009	0.985	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2020	0.010	0.250	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Table 2.35c (page 3 of 3)—Selectivity at age (EBS+NBS survey, weighted average of 19.12a, 19.12, and 20.8-10 (a subset of Ensemble AB)).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.012	0.489	0.999	0.987	0.945	0.894	0.850	0.815	0.790	0.771	0.757	0.747	0.739	0.733	0.729	0.725	0.723	0.720	0.719	0.717	0.715
1978	0.010	0.489	0.999	0.987	0.945	0.894	0.850	0.815	0.790	0.771	0.757	0.747	0.739	0.733	0.729	0.725	0.723	0.720	0.719	0.717	0.715
1979	0.013	0.402	0.999	0.988	0.945	0.894	0.850	0.815	0.790	0.771	0.757	0.747	0.739	0.733	0.729	0.725	0.723	0.720	0.719	0.717	0.715
1980	0.010	0.511	0.999	0.986	0.946	0.894	0.850	0.815	0.790	0.771	0.757	0.747	0.739	0.733	0.729	0.725	0.723	0.720	0.719	0.717	0.714
1981	0.007	0.415	0.998	0.988	0.943	0.895	0.850	0.815	0.790	0.771	0.757	0.747	0.739	0.733	0.729	0.725	0.723	0.720	0.719	0.717	0.714
1982	0.004	0.232	0.998	0.989	0.944	0.890	0.848	0.813	0.788	0.769	0.756	0.746	0.738	0.732	0.728	0.724	0.722	0.719	0.718	0.716	0.714
1983	0.047	0.421	1.000	0.988	0.948	0.892	0.846	0.814	0.788	0.769	0.756	0.746	0.738	0.732	0.728	0.724	0.722	0.719	0.718	0.716	0.713
1984	0.006	0.337	0.990	0.993	0.969	0.926	0.878	0.841	0.814	0.793	0.777	0.764	0.755	0.748	0.742	0.738	0.734	0.732	0.729	0.727	0.724
1985	0.009	0.440	0.992	0.990	0.948	0.907	0.863	0.825	0.797	0.779	0.764	0.753	0.744	0.738	0.733	0.729	0.726	0.724	0.722	0.720	0.717
1986	0.023	0.300	1.000	0.989	0.936	0.881	0.845	0.811	0.783	0.765	0.752	0.742	0.735	0.730	0.725	0.722	0.719	0.717	0.716	0.714	0.712
1987	0.006	0.409	0.998	0.988	0.955	0.896	0.849	0.821	0.795	0.773	0.759	0.749	0.741	0.735	0.730	0.726	0.724	0.721	0.720	0.718	0.715
1988	0.005	0.280	0.997	0.990	0.948	0.905	0.852	0.816	0.795	0.775	0.760	0.749	0.741	0.735	0.730	0.727	0.724	0.722	0.720	0.718	0.715
1989	0.003	0.146	0.989	0.996	0.966	0.919	0.882	0.838	0.809	0.792	0.776	0.762	0.753	0.746	0.741	0.736	0.733	0.730	0.728	0.726	0.722
1990	0.024	0.405	0.999	0.988	0.945	0.892	0.845	0.816	0.786	0.767	0.756	0.746	0.737	0.731	0.727	0.724	0.721	0.719	0.717	0.716	0.713
1991	0.026	0.362	0.996	0.992	0.960	0.912	0.867	0.830	0.807	0.783	0.767	0.758	0.749	0.742	0.736	0.733	0.729	0.727	0.725	0.723	0.719
1992	0.016	0.681	0.999	0.978	0.932	0.883	0.838	0.804	0.778	0.764	0.748	0.738	0.733	0.728	0.723	0.720	0.718	0.716	0.714	0.713	0.710
1993	0.032	0.516	0.999	0.986	0.938	0.891	0.850	0.815	0.789	0.769	0.758	0.746	0.738	0.733	0.728	0.725	0.722	0.720	0.718	0.716	0.714
1994	0.007	0.353	0.994	0.994	0.964	0.916	0.876	0.842	0.813	0.791	0.775	0.764	0.753	0.746	0.741	0.737	0.733	0.730	0.728	0.726	0.723
1995	0.005	0.244	0.994	0.992	0.953	0.908	0.861	0.829	0.804	0.783	0.767	0.755	0.748	0.740	0.735	0.732	0.729	0.726	0.724	0.722	0.719
1996	0.003	0.230	0.996	0.991	0.955	0.903	0.862	0.825	0.800	0.782	0.766	0.755	0.746	0.740	0.734	0.730	0.728	0.725	0.723	0.721	0.719
1997	0.010	0.310	0.994	0.992	0.957	0.910	0.863	0.830	0.801	0.783	0.769	0.757	0.748	0.741	0.737	0.732	0.729	0.726	0.724	0.723	0.720
1998	0.011	0.211	0.938	0.990	0.956	0.914	0.873	0.838	0.813	0.792	0.778	0.767	0.757	0.750	0.744	0.740	0.736	0.733	0.731	0.729	0.726
1999	0.007	0.269	0.994	0.990	0.952	0.900	0.856	0.822	0.794	0.776	0.761	0.751	0.743	0.737	0.732	0.728	0.726	0.723	0.721	0.719	0.717
2000	0.019	0.327	0.999	0.985	0.936	0.883	0.836	0.803	0.779	0.761	0.749	0.739	0.732	0.728	0.723	0.720	0.718	0.716	0.714	0.713	0.710
2001	0.025	0.738	1.000	0.981	0.943	0.887	0.842	0.806	0.782	0.764	0.750	0.741	0.734	0.729	0.725	0.721	0.719	0.717	0.715	0.714	0.711
2002	0.012	0.468	0.999	0.986	0.941	0.899	0.852	0.816	0.790	0.771	0.757	0.746	0.739	0.733	0.729	0.725	0.722	0.720	0.718	0.717	0.714
2003	0.009	0.480	0.998	0.988	0.948	0.896	0.860	0.823	0.796	0.775	0.761	0.750	0.742	0.736	0.731	0.728	0.725	0.722	0.721	0.719	0.716
2004	0.012	0.359	0.999	0.990	0.949	0.900	0.855	0.826	0.798	0.778	0.762	0.751	0.743	0.737	0.732	0.728	0.725	0.723	0.721	0.720	0.717
2005	0.008	0.688	0.999	0.985	0.948	0.895	0.852	0.816	0.795	0.774	0.760	0.749	0.741	0.735	0.730	0.726	0.723	0.721	0.720	0.718	0.715
2006	0.030	0.726	0.999	0.977	0.913	0.867	0.822	0.791	0.768	0.755	0.742	0.734	0.727	0.722	0.719	0.716	0.714	0.712	0.710	0.709	0.707
2007	0.044	0.841	0.999	0.967	0.908	0.844	0.810	0.779	0.759	0.744	0.735	0.727	0.721	0.717	0.714	0.711	0.709	0.708	0.707	0.706	0.703
2008	0.017	0.556	0.999	0.978	0.922	0.868	0.818	0.792	0.768	0.753	0.741	0.734	0.727	0.722	0.718	0.716	0.713	0.712	0.710	0.709	0.707
2009	0.062	0.674	0.999	0.972	0.915	0.858	0.815	0.780	0.762	0.747	0.736	0.728	0.724	0.719	0.715	0.713	0.711	0.709	0.708	0.707	0.705
2010	0.011	0.369	0.999	0.986	0.944	0.892	0.845	0.811	0.782	0.767	0.753	0.743	0.736	0.731	0.727	0.723	0.720	0.718	0.717	0.715	0.713
2011	0.007	0.521	0.998	0.984	0.944	0.895	0.849	0.813	0.787	0.766	0.755	0.744	0.737	0.731	0.728	0.724	0.721	0.719	0.717	0.716	0.713
2012	0.077	0.673	0.999	0.977	0.914	0.865	0.823	0.791	0.767	0.751	0.738	0.731	0.725	0.720	0.717	0.715	0.712	0.711	0.709	0.708	0.707
2013	0.011	0.355	0.992	0.990	0.960	0.906	0.866	0.833	0.805	0.784	0.769	0.755	0.748	0.741	0.736	0.732	0.730	0.727	0.725	0.723	0.720
2014	0.010	0.352	0.999	0.989	0.944	0.901	0.850	0.818	0.793	0.773	0.758	0.748	0.739	0.734	0.729	0.726	0.723	0.721	0.719	0.718	0.715
2015	0.016	0.336	0.999	0.992	0.958	0.907	0.869	0.828	0.803	0.784	0.768	0.756	0.747	0.740	0.735	0.731	0.728	0.726	0.724	0.722	0.719
2016	0.008	0.443	0.997	0.992	0.968	0.926	0.879	0.848	0.815	0.796	0.780	0.767	0.757	0.749	0.743	0.739	0.735	0.733	0.730	0.729	0.726
2017	0.012	0.553	0.996	0.991	0.958	0.922	0.880	0.841	0.817	0.792	0.777	0.765	0.756	0.748	0.742	0.737	0.734	0.731	0.729	0.727	0.724
2018	0.006	0.394	0.999	0.992	0.954	0.909	0.875	0.840	0.810	0.792	0.774	0.763	0.754	0.746	0.741	0.736	0.732	0.730	0.728	0.726	0.723
2019	0.010	0.983	1.000	0.964	0.919	0.863	0.823	0.798	0.776	0.757	0.747	0.736	0.730	0.725	0.721	0.718	0.716	0.714	0.712	0.711	0.709
2020	0.011	0.273	0.999	0.990	0.927	0.886	0.840	0.809	0.790	0.772	0.757	0.748	0.739	0.734	0.729	0.726	0.723	0.720	0.718	0.717	0.715

Table 2.36—Biomass time series comparison (last year's assessment and this year's assessment).

	Last year's assessment			Ensemble A			Ensemble AB		
Year	Age 0+	Spawn.	SB SD	Age 0+	Spawn.	SB SD	Age 0+	Spawn.	SB SD
1977	288,365	87,291	24,382	313,046	92,733	25,880	467,740	158,357	132,341
1978	318,610	89,416	24,224	336,959	94,592	25,708	499,707	163,321	138,479
1979	432,338	90,235	22,958	461,106	96,116	24,660	619,219	162,512	133,651
1980	613,467	110,821	23,610	656,333	117,680	25,410	811,774	185,565	136,326
1981	827,720	162,689	26,158	886,998	173,669	28,544	1,043,231	244,621	143,115
1982	1,065,000	254,335	32,158	1,139,483	272,292	35,757	1,308,089	351,320	160,891
1983	1,171,540	342,024	36,391	1,243,736	364,145	40,504	1,427,263	450,431	176,141
1984	1,138,530	349,049	32,735	1,204,144	370,447	36,112	1,362,430	448,323	158,033
1985	1,233,550	395,706	35,123	1,293,591	415,694	37,700	1,482,036	509,477	187,350
1986	1,234,960	391,257	32,845	1,286,951	407,735	34,539	1,473,359	502,052	186,520
1987	1,258,100	384,797	29,469	1,310,281	400,152	30,847	1,480,113	488,363	173,559
1988	1,291,110	411,155	28,791	1,334,725	424,737	30,036	1,513,779	515,753	178,610
1989	1,185,070	401,468	26,282	1,220,844	414,190	27,541	1,397,095	501,178	170,496
1990	1,014,240	363,081	22,122	1,039,760	373,210	22,970	1,204,306	452,811	154,937
1991	851,633	293,189	17,393	867,775	298,905	17,625	1,013,371	370,470	137,527
1992	735,851	215,679	14,431	748,974	218,056	14,392	877,939	283,626	125,155
1993	822,939	205,408	14,520	844,590	207,622	14,633	971,681	274,246	127,552
1994	825,841	207,485	13,078	852,658	210,685	13,513	961,248	268,907	112,631
1995	865,520	218,140	13,067	900,931	223,518	14,142	1,001,824	278,309	107,877
1996	855,852	211,220	13,075	904,280	221,212	15,855	991,266	268,167	95,161
1997	740,506	202,194	12,658	785,352	214,839	17,108	870,179	258,443	90,702
1998	647,829	176,813	12,336	690,918	190,748	17,732	769,344	231,990	86,751
1999	686,569	170,681	12,803	730,853	184,885	18,349	803,709	226,783	88,586
2000	754,880	180,641	13,869	800,245	195,044	19,139	867,789	236,518	89,587
2001	783,736	191,824	13,897	827,256	205,523	18,275	880,872	241,692	81,667
2002	824,557	209,003	13,972	866,965	221,596	17,637	914,990	254,782	78,190
2003	818,582	216,146	13,752	858,306	227,879	17,044	907,490	257,992	73,895
2004	793,676	221,080	13,197	832,390	233,031	16,492	886,553	260,734	68,626
2005	728,716	216,737	12,554	763,342	228,140	15,755	831,784	257,956	68,533
2006	640,463	192,137	11,413	671,671	202,460	14,286	753,535	235,222	67,259
2007	571,218	168,215	10,675	598,543	177,538	13,341	696,863	215,915	71,163
2008	542,395	145,695	9,615	564,603	153,821	12,070	673,386	196,612	74,359
2009	585,230	132,582	9,425	602,368	139,488	11,732	724,814	188,621	82,936
2010	680,259	131,783	9,535	695,404	136,990	11,397	820,239	189,767	88,341
2011	802,283	160,175	10,380	817,429	163,763	11,526	944,118	220,183	95,238
2012	856,087	186,733	11,633	871,098	190,220	11,991	995,249	247,311	98,445
2013	884,317	208,802	13,203	892,647	211,899	13,265	1,021,432	272,735	107,497
2014	905,731	211,576	14,459	904,225	212,745	14,512	1,032,115	273,721	109,378
2015	976,222	216,461	16,110	957,823	214,802	16,596	1,084,121	273,936	106,940
2016	1,081,840	247,820	19,218	1,042,893	241,536	21,442	1,183,537	302,197	108,880
2017	1,079,230	286,039	23,069	1,020,591	271,827	29,480	1,182,954	337,486	114,250
2018	1,008,030	310,929	25,922	937,294	288,249	38,207	1,119,865	361,561	121,825
2019	892,809	305,678	26,934	821,976	279,538	44,772	1,022,475	363,103	133,473
2020	756,811	267,333	25,998	660,551	228,083	44,760	854,515	313,085	132,586
2021				651,088	185,645	44,487	842,254	273,584	135,750

Table 2.37—Recruitment (1000s of fish) time series comparison (last year's assessment and this year's).

	Last year's values		Ensemble A		Ensemble AB	
Year	Recruits	Std. dev.	Recruits	Std. dev.	Recruits	Std. dev.
1977	971,996	261,452	1,108,935	314,691	992,540	342,160
1978	682,964	181,852	754,796	216,278	662,276	235,343
1979	699,436	124,879	774,779	153,424	671,226	205,597
1980	165,169	45,773	182,028	51,006	162,040	54,527
1981	197,948	41,192	213,860	47,306	186,905	59,389
1982	942,409	121,491	1,019,296	150,578	897,465	238,829
1983	233,796	46,451	265,440	59,012	229,483	71,411
1984	841,211	104,088	913,382	132,496	797,374	216,189
1985	389,913	54,519	419,140	65,806	366,376	97,823
1986	222,849	33,976	234,144	38,900	206,873	56,310
1987	75,267	18,844	75,705	19,594	68,736	22,596
1988	307,895	41,961	327,984	48,512	291,004	79,137
1989	606,893	71,650	649,225	87,100	577,665	140,452
1990	579,634	68,641	635,804	90,060	557,746	144,945
1991	322,854	45,944	357,478	61,044	312,183	83,421
1992	864,234	90,757	969,536	143,406	846,624	219,379
1993	348,352	43,108	382,090	56,957	336,109	82,482
1994	289,186	35,824	315,813	47,064	276,060	69,647
1995	259,078	33,835	274,830	40,193	239,665	61,254
1996	818,767	92,302	886,640	118,953	758,579	201,206
1997	362,920	45,275	393,207	55,651	337,432	89,809
1998	285,573	37,245	300,355	44,146	256,120	71,222
1999	654,520	69,331	716,701	98,071	617,871	167,607
2000	480,310	52,268	519,252	66,736	472,795	110,089
2001	200,573	26,845	219,215	36,332	196,457	54,648
2002	329,632	37,381	352,897	46,826	337,772	85,715
2003	305,884	34,418	334,664	46,253	321,467	81,456
2004	231,823	29,852	247,037	37,633	239,087	62,607
2005	282,043	33,840	298,034	40,096	282,496	64,567
2006	837,599	84,621	863,482	92,209	808,091	166,371
2007	324,000	42,259	340,489	46,535	308,310	68,337
2008	1,125,310	116,384	1,195,403	143,192	1,060,321	238,103
2009	158,651	29,408	187,571	44,959	158,789	52,520
2010	734,348	82,828	750,833	89,795	672,337	160,324
2011	936,510	108,435	948,439	116,274	859,924	188,057
2012	413,656	57,434	434,052	68,043	383,895	103,883
2013	1,159,020	139,003	1,123,907	163,516	1,060,461	246,418
2014	205,284	31,880	203,060	33,415	195,386	47,010
2015	278,444	35,702	272,314	37,609	265,336	67,240
2016	150,854	24,643	162,266	28,734	157,253	41,975
2017	101,525	29,620	122,811	29,314	110,819	34,016
2018	655,284	84,502	744,721	116,610	680,814	172,716
Average	476,991		511,705		457,623	

Table 2.38a—Numbers at age (1000s of fish, Model 19.12).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	950539	234708	68151	63642	28236	14147	8808	5943	4128	2885	2004	1375	928	617	405	263	169	109	69	44	75
1978	660882	675072	166684	48291	44328	18833	8937	5346	3544	2451	1713	1191	817	552	367	241	156	101	65	41	71
1979	678328	469357	479416	118096	33489	29141	11576	5227	3059	2017	1395	976	679	466	315	209	138	89	58	37	64
1980	161449	481748	333327	339638	82406	22430	18595	7132	3172	1850	1220	845	591	411	282	191	127	83	54	35	61
1981	191429	114661	342123	236230	236491	55222	14256	11390	4297	1904	1110	733	507	355	247	170	115	76	50	33	58
1982	915760	135953	81428	242517	164965	159614	35989	9036	7140	2687	1191	695	459	318	222	155	106	72	48	31	57
1983	228516	650374	96554	57789	170910	113564	106544	23532	5845	4606	1733	768	448	296	205	144	100	69	46	31	57
1984	820163	162292	461892	68449	40628	117164	74958	68410	14941	3697	2912	1096	486	284	187	130	91	63	43	29	55
1985	380749	582478	115248	327025	47474	27314	75249	46355	41629	9056	2240	1765	664	295	172	114	79	55	38	26	51
1986	216142	270408	413667	81766	228395	31721	17512	46295	27901	24919	5418	1341	1057	398	176	103	68	47	33	23	47
1987	73766	153504	192041	293043	57180	152705	20146	10825	28140	16882	15080	3281	812	640	241	107	62	41	29	20	42
1988	301109	52389	109016	136181	204500	38539	96425	12168	6440	16633	9969	8909	1939	480	379	143	63	37	24	17	37
1989	592688	213844	37197	76903	93098	131573	23549	56094	6963	3677	9502	5701	5098	1110	275	217	82	36	21	14	31
1990	571861	420925	151864	26333	53316	61345	81405	14035	32623	4029	2127	5499	3301	2953	643	159	126	47	21	12	26
1991	313481	406135	298934	107583	18325	35270	37822	47455	7997	18376	2265	1196	3091	1856	1660	361	90	71	27	12	21
1992	843312	222632	288422	211337	73680	11588	19897	19426	23276	3876	8874	1094	578	1494	897	803	175	43	34	13	16
1993	342625	598914	158104	204120	144178	45977	6436	10001	9299	11001	1831	4200	519	274	709	426	381	83	21	16	14
1994	281881	243328	425258	111382	138743	90704	26845	3566	5403	4995	5914	986	2263	280	148	382	230	205	45	11	16
1995	251243	200190	172790	300357	75500	86077	50064	13755	1766	2648	2447	2902	484	1113	137	73	188	113	101	22	13
1996	801687	178430	142153	121747	201053	44635	44456	23263	6143	781	1171	1085	1288	215	494	61	32	84	50	45	16
1997	359639	569351	126715	100559	83068	123553	23656	21199	10477	2721	344	516	478	568	95	218	27	14	37	22	27
1998	276579	255410	404279	89197	66811	48522	61698	10489	8945	4351	1128	143	214	199	236	39	91	11	6	15	20
1999	634826	196424	181384	286215	60983	41406	26443	30365	4909	4130	2004	520	66	99	92	109	18	42	5	3	16
2000	472115	450850	139495	128447	196306	37982	22767	13241	14532	2318	1947	945	245	31	47	43	51	9	20	2	9
2001	193849	335293	320186	98664	88720	124388	21243	11588	6448	6981	1111	934	454	118	15	22	21	25	4	9	6
2002	322702	137671	238113	226691	67751	57305	72195	11324	5960	3291	3566	569	479	233	60	8	12	11	13	2	8
2003	301250	229180	97761	167940	153812	41833	32488	37711	5738	3018	1676	1824	292	246	120	31	4	6	5	7	5
2004	224230	213946	162743	69058	113866	95560	23203	16899	18838	2839	1494	831	906	145	122	59	15	2	3	3	6
2005	276515	159246	151927	114593	46862	69964	52738	11788	8346	9206	1388	732	407	444	71	60	29	8	1	1	4
2006	821168	196379	113070	107310	76854	28833	38026	26437	5682	3989	4393	663	350	195	213	34	29	14	4	0	3
2007	320457	583187	139461	79987	73233	46471	15587	18521	12310	2603	1822	2005	303	160	89	97	16	13	6	2	1
2008	1094950	227587	414163	98784	54863	45802	25126	7786	8812	5776	1218	852	938	142	75	42	45	7	6	3	1
2009	154415	777622	161626	293264	67609	33514	24071	11600	3460	3872	2542	537	377	415	63	33	18	20	3	3	2
2010	707953	109664	552251	114530	201669	41365	16864	10424	4685	1389	1563	1032	219	154	169	26	14	8	8	1	2
2011	897999	502780	77882	391337	79123	126293	21837	7636	4425	1963	584	660	437	93	65	72	11	6	3	3	1
2012	400770	637749	357060	55206	266217	47916	63391	9236	2953	1670	739	220	249	165	35	25	27	4	2	1	2
2013	1111770	284622	452912	252336	37661	157844	24332	28156	3825	1199	677	300	90	101	67	14	10	11	2	1	1
2014	201150	789568	202123	320230	170329	22954	80343	11122	12223	1645	518	294	131	39	44	29	6	4	5	1	1
2015	268579	142854	560734	143143	219520	102870	11875	35274	4631	5040	683	217	123	55	16	19	12	3	2	2	1
2016	152469	190742	101452	396683	98468	136222	53275	5429	14891	1927	2097	285	91	52	23	7	8	5	1	1	1
2017	109721	108282	135459	71788	270386	61509	73361	24951	2399	6416	828	901	123	39	22	10	3	3	2	0	1
2018	663252	77923	76899	95989	49257	169150	34708	37370	11977	1132	3010	388	422	57	18	10	5	1	2	1	1
2019	475535	471037	55338	54280	65964	31205	98068	19076	19874	6296	594	1579	204	222	30	10	5	2	1	1	1
2020	475535	337723	334465	39218	36882	42133	18165	54009	10309	10681	3387	320	852	110	120	16	5	3	1	0	1

Table 2.38b—Numbers at age (1000s of fish, Ensemble A).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1108935	256073	75255	70304	30424	15184	9378	6278	4311	2973	2038	1376	916	600	388	249	158	100	63	40	67
1978	754796	776040	179275	52572	48309	20048	9493	5643	3717	2542	1754	1203	813	541	355	230	147	94	59	37	63
1979	774779	528239	543118	125246	35979	31401	12218	5520	3216	2109	1443	997	684	463	308	202	131	84	53	34	57
1980	182028	542241	369717	379293	86256	23824	19853	7473	3330	1934	1269	869	601	413	279	186	122	79	51	32	55
1981	213860	127414	379525	258302	260639	57176	15018	12089	4484	1991	1157	759	520	360	247	167	111	73	47	30	52
1982	1019296	149690	89192	265227	178036	173992	36944	9455	7535	2789	1239	720	473	324	224	154	104	69	46	29	51
1983	265440	713479	104786	62403	184346	121053	114949	23954	6071	4827	1787	794	462	303	208	144	99	67	45	29	52
1984	913382	185752	499466	73243	43280	124833	79105	73221	15106	3816	3033	1123	499	290	191	131	90	62	42	28	51
1985	419140	639338	129991	348688	50171	28769	79456	48594	44320	9113	2301	1829	678	301	175	115	79	55	38	25	48
1986	234144	293403	447558	90900	240272	33160	18266	48520	29080	26394	5426	1370	1090	404	180	104	69	47	33	22	44
1987	75705	163917	205406	312609	62698	158763	20869	11198	29283	17481	15873	3266	825	657	243	108	63	41	28	20	40
1988	327984	53017	114764	143615	215239	41728	99260	12513	6618	17202	10261	9322	1919	485	386	143	64	37	24	17	35
1989	649225	229614	37125	79866	96995	137065	25265	57339	7120	3759	9776	5839	5309	1094	276	220	82	36	21	14	29
1990	635804	454501	160760	25928	54659	63178	83973	14926	33107	4092	2160	5621	3359	3055	629	159	127	47	21	12	25
1991	357478	445052	318212	112297	17805	35704	38524	48508	8435	18512	2284	1205	3137	1875	1705	351	89	71	26	12	21
1992	969536	250203	311549	221853	75884	11122	19917	19604	23613	4059	8882	1096	579	1507	901	819	169	43	34	13	16
1993	382090	678532	175132	217406	149410	46745	6101	9893	9284	11050	1899	4165	515	272	708	424	385	79	20	16	13
1994	315813	267440	474845	121677	145920	92906	26965	3342	5284	4932	5875	1011	2220	275	145	378	226	206	42	11	16
1995	274830	221051	187194	330736	81409	89510	50788	13694	1642	2571	2399	2862	493	1084	134	71	185	110	100	21	13
1996	886640	192395	154722	130110	218903	47668	45976	23558	6115	726	1138	1064	1272	219	482	60	32	82	49	45	15
1997	393207	620649	134697	107926	87705	133527	25210	22022	10696	2733	323	506	473	566	98	215	27	14	37	22	27
1998	300355	275260	434435	93530	70948	51063	67179	11356	9485	4542	1159	137	215	201	240	41	91	11	6	16	21
1999	716701	210269	192708	303264	63171	43698	27919	33501	5414	4468	2136	545	64	101	95	113	20	43	5	3	17
2000	519252	501628	147215	134562	205435	39085	24094	14140	16324	2610	2152	1030	263	31	49	46	55	9	21	3	10
2001	219215	363495	351129	102662	91744	129102	21864	12372	6986	7986	1276	1053	504	129	15	24	22	27	5	10	6
2002	352897	153416	254478	245085	69567	58659	74568	11671	6407	3602	4132	662	547	262	67	8	12	12	14	2	8
2003	334664	247043	107368	177036	164280	42533	33059	38898	5935	3269	1852	2138	344	285	137	35	4	6	6	7	6
2004	247037	234250	172942	74783	118605	101178	23477	17189	19490	2952	1628	925	1069	172	143	68	17	2	3	3	6
2005	298034	172916	163967	120121	50130	72288	55653	11938	8520	9572	1451	802	456	528	85	70	34	9	1	2	5
2006	863482	208655	121024	114206	79639	30591	39185	27953	5781	4096	4596	697	386	220	254	41	34	16	4	0	3
2007	340489	604658	146090	84415	76968	47802	16501	19155	13104	2669	1886	2116	321	178	101	117	19	16	8	2	2
2008	1195403	238411	423451	102046	57147	47691	25792	8265	9169	6196	1258	889	998	151	84	48	55	9	7	4	2
2009	187571	836941	166951	295729	68932	34562	24997	11980	3711	4081	2764	563	399	448	68	38	21	25	4	3	2
2010	750833	131182	586025	116650	200603	41704	17319	10896	4917	1521	1685	1148	235	167	187	28	16	9	10	2	2
2011	948439	525776	91754	409466	79428	123996	21799	7819	4654	2091	652	726	497	102	72	81	12	7	4	5	2
2012	434052	664178	368211	64067	274825	47408	61504	9132	3006	1752	786	246	274	188	39	27	31	5	3	1	2
2013	1123907	303930	465157	256718	43072	160775	23736	27029	3751	1212	706	318	99	111	76	16	11	12	2	1	2
2014	203060	787455	212829	324388	171104	25853	80781	10726	11638	1602	521	305	138	43	48	33	7	5	5	1	1
2015	272314	142263	551775	148640	219227	102009	13155	35064	4423	4759	659	216	127	58	18	20	14	3	2	2	1
2016	162266	190771	99679	385158	100743	133790	52091	5918	14654	1823	1962	273	89	53	24	7	8	6	1	1	1
2017	122811	113642	133657	69563	258657	61767	70606	23991	2566	6231	773	832	116	38	22	10	3	4	2	1	1
2018	744721	85959	79595	93400	46935	158717	34027	35091	11256	1179	2861	355	382	53	17	10	5	1	2	1	1
2019	523820	521204	60168	55403	63098	29071	89709	18154	18113	5747	598	1460	181	195	27	9	5	2	1	1	1
2020	523820	366697	364751	42041	37015	39263	16367	47719	9452	9390	2985	309	762	94	102	14	5	3	1	0	1

Table 2.38c—Numbers at age (1000s of fish, Ensemble AB).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	992540	272161	79222	76725	36057	18909	12364	8841	6553	4933	3735	2832	2150	1635	1246	953	732	565	437	340	1036
1978	662276	711298	197565	57408	55007	25153	12763	8205	5877	4407	3364	2583	1985	1527	1176	907	702	544	424	331	1060
1979	671226	474211	510721	143535	40972	37816	16655	8285	5346	3886	2964	2299	1792	1397	1089	849	663	519	407	319	1070
1980	162040	479875	340182	366675	103265	28566	25654	11218	5616	3676	2712	2096	1645	1297	1022	805	634	499	394	311	1080
1981	186905	116173	343655	244064	259939	72267	19299	17122	7568	3846	2556	1912	1495	1187	945	752	597	475	377	299	1077
1982	897465	133679	83450	246120	173156	179953	49776	13111	11717	5278	2723	1834	1387	1095	877	703	564	451	361	288	1070
1983	229483	642044	95778	60035	175675	121633	123905	34596	9104	8237	3777	1974	1344	1025	816	657	531	428	345	277	1058
1984	797374	164178	460126	68633	42890	122519	82665	83027	23701	6269	5756	2689	1423	979	753	603	489	398	322	261	1027
1985	366376	570206	117659	329335	48263	29475	80939	53471	53638	15853	4230	3949	1883	1010	702	545	440	359	293	239	971
1986	206873	262186	408463	84410	233061	32864	19491	51786	34094	34561	10659	2873	2731	1329	722	507	397	323	265	218	914
1987	68736	148070	187962	292387	59799	158554	21448	12564	33038	22052	22724	7327	1995	1928	956	526	373	294	240	198	861
1988	291004	49261	106173	134808	206568	40968	102770	13481	7923	20825	14180	14885	5035	1384	1360	687	382	273	217	178	799
1989	577665	208197	35359	75708	93274	135153	25712	62339	8164	4894	12951	9048	9700	3456	960	959	493	277	200	160	733
1990	557746	413724	149211	25350	53161	62562	86012	15974	38350	5063	3101	8239	5891	6432	2400	671	680	355	201	146	662
1991	312183	399055	296860	106855	17898	35798	39750	52467	9671	23286	3110	1952	5200	3809	4238	1656	466	478	253	144	590
1992	846624	223502	286015	212478	74138	11541	20835	21565	27886	5218	12862	1761	1148	3077	2336	2667	1105	314	327	176	523
1993	336109	605709	160305	204654	147079	47300	6711	11261	11432	14955	2874	7274	1021	694	1868	1469	1718	750	215	226	496
1994	276060	240731	434044	114259	140968	94496	28502	3920	6548	6790	9107	1797	4659	668	469	1265	1021	1215	550	158	542
1995	239665	197643	172725	310011	78529	89315	54389	15560	2136	3629	3887	5366	1092	2905	426	310	838	695	841	393	510
1996	758579	171556	141741	123169	210456	47699	48657	27744	7837	1107	1934	2149	3057	643	1751	263	197	535	455	558	622
1997	337432	542455	123022	101510	85431	132635	26553	25174	14208	4083	603	1092	1265	1856	404	1126	173	134	364	316	845
1998	256120	241356	388489	87559	68413	51479	70638	13139	12303	7182	2125	330	617	741	1116	249	709	110	88	238	784
1999	617871	183113	172933	277863	60736	43526	29636	38047	7016	6700	4096	1249	202	389	481	739	168	485	76	62	730
2000	472795	441618	131136	123751	192880	38813	25235	16228	20578	3902	3848	2472	775	131	257	325	507	117	341	54	574
2001	196457	338805	316176	93677	86496	124346	22600	13805	8834	11475	2284	2343	1587	511	89	179	232	366	86	251	473
2002	337772	140572	243239	226085	65050	56660	73905	12653	7719	5109	6900	1444	1537	1088	359	64	131	172	274	65	556
2003	321467	242328	100756	173805	155119	40717	32846	40192	6889	4360	3021	4243	931	1022	752	252	46	95	126	203	466
2004	239087	230737	174185	72034	119790	97714	23028	17671	21344	3775	2501	1819	2657	611	693	529	180	34	70	94	506
2005	282496	171704	165945	124542	49661	75233	55429	12244	9331	11473	2110	1459	1106	1671	400	466	365	126	24	50	436
2006	808091	202875	123555	119087	85288	31294	42498	29253	6374	4943	6262	1203	869	686	1069	265	315	253	88	17	350
2007	308310	580193	145997	88820	82975	53423	17818	22515	15026	3303	2618	3412	683	514	421	672	172	207	169	59	252
2008	1060321	221164	417413	105061	62243	53792	30948	9736	12119	8062	1813	1476	1983	414	323	273	445	116	142	118	220
2009	158789	759800	158960	300093	73397	39670	30756	16389	5056	6447	4331	1006	845	1174	256	207	180	299	79	98	237
2010	672337	113487	545481	114185	210060	46777	22205	15938	8390	2604	3468	2358	568	493	707	160	134	119	200	54	232
2011	859924	481484	81254	391435	80163	136099	26914	11892	8519	4641	1465	2043	1407	351	313	463	108	93	84	143	208
2012	383895	616602	345419	58170	270422	50042	73946	13364	5954	4483	2592	837	1229	857	221	204	310	75	66	60	259
2013	1060461	274684	442960	246952	40132	165076	27136	37400	6831	3245	2592	1576	518	793	559	148	139	216	53	48	236
2014	195386	761144	196867	317412	169136	24947	88787	13737	19250	3773	1946	1645	1044	349	550	391	106	101	159	40	216
2015	265336	140406	547352	140978	220974	104483	13431	43069	6740	10154	2183	1221	1086	716	242	393	281	77	75	119	197
2016	157253	190523	101102	392861	98192	140013	56748	6657	21276	3519	5735	1331	791	729	494	169	280	201	56	55	235
2017	110819	112931	137069	72686	272282	62394	78359	28697	3309	11240	1993	3500	866	539	510	352	122	204	147	41	218
2018	680814	79427	81264	98619	50841	174332	36196	42256	15190	1799	6607	1249	2331	605	389	375	262	91	154	112	200
2019	468100	487740	57036	58292	69021	33002	104600	20738	24225	8908	1090	4265	843	1635	437	286	279	197	68	116	237
2020	468100	335259	350038	40974	40363	45040	19921	60749	11926	14369	5452	689	2844	582	1163	317	210	206	146	51	265

Table 2.39—Some statistics of the ABC and OFL distributions for 2021 and 2022.

A1: Allow Q to vary?			no		yes		(yes)			
A2: Combine surveys?			no	yes	no	yes				
B1: Use fishery CPUE?			(no)			no		yes		
B2: Allow domed selex?						no	yes	no	yes	
Model weight (Ens. A):			0.2037	0.2593	0.2407	0.2963				
Model weight (Ens. AB):			0.1111	0.1414	0.1313	0.1616	0.1616	0.1616	0.1313	
Year	Quantity	Statistic	20.4	19.12a	19.15	19.12	20.8	20.9	20.10	Ens. A	Ens. AB
2021	ABC	mean	72848	123805	42029	99310	123210	179712	166665	86480	118013
2021	ABC	sdev	16432	22694	13506	24099	31763	18917	23334	36442	49895
2021	OFL	mean	87678	147949	50770	118895	145354	213427	193833	103668	139984
2021	OFL	sdev	19644	26858	16234	28608	37136	22528	27196	43294	58318
2022	ABC	mean	84295	106852	56788	91845	108512	146209	162378	85758	109266
2022	ABC	sdev	14110	13506	13963	16394	21007	21712	21903	23307	37408
2022	OFL	mean	101682	128340	68639	110353	128447	174509	188997	103208	130076
2022	OFL	sdev	23758	26060	21533	29374	36376	34645	28869	33546	47961

Year	Quantity	Statistic	Ens. A	Ens. AB
2021	ABC	median	86068	118386
2021	OFL	median	103312	140815
2022	ABC	median	87850	104975
2022	OFL	median	103421	126579

(Note that medians for the individual models are equal to their respective means.)

Table 2.40a—Standard harvest scenarios 1 and 2 (female spawning biomass and catch in 1000s of t).

	no				yes				(yes)						A1: Allow Q to vary?			
	no		yes		no		yes								A2: Combine surveys?			
	(no)						no				yes				B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
Model:	M20.4		M19.12a		M19.15		M19.12		M20.8		M20.9		M20.10		Ensemble A		Ensemble AB	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	164.7	17.0	227.9	14.1	126.9	28.4	210.6	18.8	293.1	24.9	304.7	11.5	576.5	30.3	185.6	44.5	273.5	133.5
B2022	170.9	11.2	205.8	8.2	142.4	22.3	197.7	12.6	265.9	16.6	261.6	8.1	529.3	23.0	181.0	28.8	253.5	116.1
B2023	203.9	9.5	219.7	6.7	180.2	19.7	214.8	10.4	274.2	13.1	261.7	7.3	513.3	18.8	205.5	19.7	266.1	101.7
B2024	235.1	7.8	241.7	5.9	218.6	16.4	239.7	8.8	294.0	10.9	275.8	7.0	512.1	14.4	234.2	13.8	287.1	91.4
B2025	249.4	6.3	255.1	4.8	241.0	12.0	256.2	6.9	309.0	8.7	284.1	5.8	513.0	11.4	250.9	10.0	300.1	86.1
B2026	252.4	5.9	260.1	4.1	249.3	9.3	263.3	5.6	317.1	7.2	286.3	4.7	513.6	9.5	256.9	8.6	305.1	84.4
B2027	252.2	5.8	261.0	3.9	250.8	8.5	265.3	5.2	320.7	6.5	286.1	4.2	514.1	8.4	258.0	8.6	306.3	84.3
B2028	251.3	5.7	260.8	3.9	250.6	8.2	265.5	5.0	322.0	6.2	285.6	4.0	514.7	8.0	257.8	8.7	306.4	84.6
B2029	250.5	5.7	260.4	3.9	249.9	8.2	265.1	5.0	322.4	6.2	285.1	4.0	515.2	7.8	257.3	8.8	306.2	84.9
B2030	249.9	5.6	260.1	3.8	249.4	8.1	264.8	5.0	322.4	6.1	284.9	3.9	515.6	7.7	256.8	8.8	306.0	85.2
B2031	249.7	5.6	260.0	3.8	249.1	8.1	264.6	4.9	322.3	6.1	284.8	3.9	515.9	7.7	256.6	8.9	305.9	85.4
B2032	249.6	5.6	259.9	3.8	249.0	8.1	264.5	4.9	322.2	6.1	284.8	3.9	516.1	7.6	256.6	8.9	305.8	85.5
F2021	0.238	0.036	0.303	0.025	0.171	0.022	0.257	0.026	0.246	0.025	0.350	0.010	0.215	0.005	0.245	0.055	0.258	0.059
F2022	0.248	0.026	0.272	0.015	0.195	0.017	0.240	0.017	0.222	0.016	0.316	0.017	0.215	0.005	0.239	0.033	0.246	0.042
F2023	0.300	0.024	0.291	0.012	0.251	0.016	0.263	0.014	0.229	0.012	0.316	0.013	0.214	0.013	0.275	0.025	0.266	0.038
F2024	0.349	0.022	0.322	0.011	0.309	0.014	0.295	0.012	0.247	0.010	0.334	0.012	0.213	0.010	0.316	0.024	0.294	0.046
F2025	0.371	0.019	0.341	0.010	0.343	0.011	0.316	0.010	0.260	0.009	0.345	0.010	0.214	0.008	0.340	0.023	0.311	0.051
F2026	0.373	0.018	0.348	0.009	0.355	0.010	0.326	0.009	0.267	0.008	0.348	0.009	0.214	0.007	0.348	0.021	0.317	0.052
F2027	0.373	0.017	0.349	0.009	0.356	0.009	0.328	0.009	0.270	0.007	0.347	0.009	0.214	0.006	0.350	0.020	0.319	0.052
F2028	0.373	0.017	0.349	0.009	0.356	0.009	0.329	0.009	0.272	0.007	0.347	0.009	0.214	0.006	0.350	0.020	0.319	0.052
F2029	0.373	0.018	0.349	0.009	0.356	0.009	0.328	0.009	0.272	0.007	0.346	0.009	0.215	0.005	0.349	0.020	0.319	0.051
F2030	0.372	0.018	0.348	0.009	0.355	0.009	0.328	0.009	0.272	0.007	0.346	0.009	0.215	0.005	0.349	0.020	0.318	0.051
F2031	0.372	0.018	0.348	0.009	0.355	0.009	0.327	0.009	0.272	0.007	0.346	0.009	0.215	0.005	0.348	0.020	0.318	0.051
F2032	0.372	0.018	0.348	0.009	0.355	0.009	0.327	0.009	0.272	0.007	0.346	0.009	0.215	0.005	0.348	0.020	0.318	0.051
C2021	72.8	16.4	123.5	15.6	42.0	9.4	99.3	17.1	123.2	20.6	179.7	9.8	166.7	11.8	86.4	33.8	118.0	46.9
C2022	84.3	14.1	106.6	9.5	56.8	9.9	91.8	12.1	108.5	14.1	146.2	12.0	162.4	11.3	85.7	21.4	109.2	34.9
C2023	125.8	14.6	128.5	8.4	95.6	11.1	114.4	10.7	125.4	11.7	154.9	10.3	171.8	17.0	115.8	16.9	131.0	26.0
C2024	165.6	13.0	156.9	7.6	139.4	10.5	143.9	9.4	148.6	9.9	175.5	9.4	179.3	13.8	150.6	14.2	158.1	17.8
C2025	182.3	9.7	172.9	5.7	165.1	7.3	162.4	6.6	163.8	7.4	185.6	6.9	182.7	10.9	169.8	10.5	173.1	12.2
C2026	183.3	8.0	178.0	4.5	173.6	5.0	169.7	4.7	170.8	5.7	187.2	5.2	183.8	9.0	175.6	7.5	177.8	9.0
C2027	182.4	7.5	178.5	4.1	174.0	4.2	171.4	3.9	173.3	5.0	186.4	4.8	184.2	7.9	176.1	6.5	178.4	7.8
C2028	181.6	7.6	178.0	4.1	173.4	4.1	171.2	3.8	174.0	4.8	185.5	4.8	184.6	7.4	175.6	6.3	178.1	7.5
C2029	180.9	7.7	177.4	4.1	172.9	4.1	170.7	3.8	174.0	4.7	185.0	4.8	184.8	7.1	175.0	6.3	177.8	7.6
C2030	180.2	7.8	177.1	4.1	172.2	4.2	170.3	3.8	173.9	4.7	184.7	4.9	185.0	7.1	174.5	6.3	177.4	7.7
C2031	179.9	7.9	176.9	4.2	171.8	4.2	170.1	3.8	173.7	4.7	184.6	4.9	185.2	7.1	174.3	6.4	177.3	7.8
C2032	179.9	7.9	176.8	4.2	171.7	4.3	170.0	3.9	173.6	4.8	184.6	4.9	185.3	7.1	174.2	6.4	177.2	7.8

Table 2.40b—Standard harvest scenario 3 (female spawning biomass and catch in 1000s of t).

	no				yes				(yes)						A1: Allow Q to vary?			
	no		yes		no		yes								A2: Combine surveys?			
	(no)						no				yes				B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
Model:	M20.4		M19.12a		M19.15		M19.12		M20.8		M20.9		M20.10		Ensemble A		Ensemble AB	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	164.7	17.0	227.9	14.1	126.9	14.2	210.6	18.8	293.1	24.9	304.7	11.5	576.5	30.3	185.6	42.8	273.5	133.2
B2022	149.4	12.4	189.3	9.8	116.1	10.0	173.8	13.4	250.9	19.1	248.2	8.4	521.6	24.0	158.9	29.9	235.8	121.0
B2023	169.1	11.0	190.7	7.9	137.0	8.4	175.6	10.8	245.5	15.7	236.8	8.1	499.6	20.4	168.9	21.8	235.7	109.3
B2024	191.8	9.6	204.6	6.7	161.0	7.1	190.0	8.8	254.4	13.1	242.4	7.8	492.4	18.3	187.2	17.8	247.0	100.6
B2025	204.3	8.2	214.8	5.4	175.5	5.5	200.6	6.7	262.8	10.6	246.2	6.6	487.7	16.4	199.0	15.7	254.8	95.1
B2026	209.7	7.4	220.2	4.4	182.6	4.3	206.5	5.1	268.4	8.4	247.0	5.4	483.7	14.6	205.0	14.6	258.6	91.8
B2027	212.0	7.0	223.0	3.8	186.0	3.6	209.6	4.1	272.1	6.9	246.8	4.6	480.5	13.1	207.9	14.2	260.4	89.8
B2028	213.0	6.9	224.5	3.5	187.6	3.4	211.2	3.7	274.5	6.0	246.5	4.3	478.3	11.9	209.3	14.0	261.2	88.6
B2029	213.4	6.9	225.2	3.4	188.4	3.3	212.0	3.4	276.2	5.4	246.2	4.1	476.7	11.0	210.0	14.0	261.6	87.9
B2030	213.6	6.9	225.6	3.4	188.7	3.2	212.5	3.3	277.3	5.1	246.1	4.1	475.6	10.3	210.4	13.9	261.8	87.5
B2031	213.7	6.9	225.7	3.4	188.9	3.2	212.7	3.3	277.9	4.9	246.0	4.1	474.8	9.8	210.6	13.9	261.9	87.2
B2032	213.7	6.9	225.8	3.4	189.0	3.2	212.8	3.2	278.4	4.7	245.9	4.1	474.3	9.5	210.6	13.9	261.9	87.0
F2021	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2022	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2023	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2024	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2025	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2026	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2027	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2028	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2029	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2030	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2031	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
F2032	0.470	0.000	0.430	0.000	0.530	0.000	0.450	0.000	0.330	0.000	0.430	0.000	0.240	0.000	0.468	0.037	0.410	0.087
C2021	133.1	12.5	167.7	9.8	115.5	12.1	162.4	13.9	160.6	12.9	215.0	7.7	184.4	9.3	146.5	24.7	164.8	32.0
C2022	134.4	11.0	149.7	8.0	119.4	11.0	144.3	11.6	148.8	11.4	183.6	7.6	177.4	9.3	137.7	15.6	152.1	23.1
C2023	161.7	10.1	162.1	6.9	149.9	9.8	157.1	9.7	160.5	9.8	187.7	7.6	187.1	9.0	157.6	10.4	166.8	16.5
C2024	181.7	8.7	176.3	5.9	173.8	7.8	172.3	7.9	172.6	8.1	197.1	7.0	193.7	8.2	175.6	8.3	181.0	12.5
C2025	189.6	7.2	183.4	4.6	185.0	5.7	180.3	5.8	178.8	6.3	200.0	5.5	195.4	7.4	184.2	6.7	187.3	9.7
C2026	192.4	6.5	186.6	3.8	189.9	4.5	184.0	4.4	181.7	5.2	199.8	4.5	195.2	6.8	187.8	5.8	189.7	8.0
C2027	193.6	6.3	188.1	3.5	192.2	4.1	185.8	3.8	183.2	4.6	199.2	4.1	194.8	6.5	189.5	5.4	190.8	7.2
C2028	194.1	6.1	188.9	3.3	193.3	3.9	186.8	3.5	184.2	4.3	198.9	3.9	194.4	6.3	190.4	5.2	191.3	6.7
C2029	194.3	6.1	189.3	3.3	193.8	3.9	187.3	3.4	184.8	4.1	198.7	3.9	194.2	6.1	190.8	5.1	191.6	6.4
C2030	194.4	6.1	189.5	3.3	194.0	3.8	187.5	3.3	185.2	4.0	198.6	3.9	194.0	6.0	191.0	5.1	191.7	6.3
C2031	194.5	6.1	189.6	3.3	194.1	3.8	187.6	3.3	185.4	3.9	198.5	3.9	193.9	6.0	191.1	5.1	191.8	6.2
C2032	194.5	6.1	189.7	3.3	194.2	3.8	187.7	3.3	185.6	3.9	198.5	3.9	193.8	5.9	191.2	5.1	191.8	6.1

Table 2.40c—Standard harvest scenario 4 (female spawning biomass and catch in 1000s of t).

	no				yes				(yes)						A1: Allow Q to vary?			
	no		yes		no		yes								A2: Combine surveys?			
	(no)						no				yes				B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
Model:	M20.4		M19.12a		M19.15		M19.12		M20.8		M20.9		M20.10		Ensemble A		Ensemble AB	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	164.7	17.0	227.9	14.1	126.9	14.2	210.6	18.8	293.1	24.9	304.7	11.5	576.5	30.3	185.6	42.8	273.5	133.2
B2022	184.6	13.9	229.5	10.7	150.4	12.9	217.2	15.7	290.2	20.2	296.1	9.5	563.3	25.2	197.7	33.6	276.6	122.7
B2023	228.5	12.8	255.8	9.2	196.4	12.5	246.0	14.1	313.1	17.6	313.0	9.8	575.9	22.4	233.0	25.7	303.9	113.9
B2024	274.2	11.1	289.3	8.3	247.4	11.5	282.7	12.6	346.4	15.5	341.2	10.5	602.4	20.9	274.2	19.4	339.8	108.3
B2025	308.1	10.1	318.7	7.8	286.5	9.4	314.3	11.6	378.0	14.3	366.3	10.1	630.4	19.5	307.5	15.8	370.8	106.2
B2026	331.5	9.1	341.0	7.0	314.9	8.2	339.0	10.3	404.2	12.8	384.8	9.0	655.7	17.9	332.2	13.5	394.8	106.3
B2027	346.9	8.5	356.9	6.4	334.7	7.2	357.0	9.2	424.8	11.6	397.8	7.9	677.7	16.3	349.5	12.2	412.6	107.7
B2028	356.8	8.2	367.9	5.9	348.0	6.6	369.8	8.4	440.5	10.6	406.7	7.0	696.3	14.7	361.4	11.5	425.5	110.0
B2029	363.2	8.2	375.3	5.7	356.9	6.3	378.6	7.9	452.3	9.9	412.7	6.4	711.8	13.5	369.4	11.4	434.7	112.5
B2030	367.2	8.2	380.2	5.6	362.7	6.1	384.5	7.6	460.9	9.5	416.8	6.1	724.6	12.5	374.6	11.4	441.4	115.0
B2031	369.8	8.3	383.5	5.6	366.4	6.1	388.6	7.5	467.3	9.2	419.5	6.0	734.9	11.8	378.1	11.6	446.0	117.4
B2032	371.3	8.4	385.5	5.6	368.8	6.0	391.2	7.4	471.8	9.1	421.3	5.9	743.3	11.3	380.3	11.8	449.4	119.4
F2021	0.110	0.016	0.141	0.011	0.080	0.010	0.120	0.012	0.121	0.012	0.165	0.004	0.111	0.003	0.114	0.025	0.123	0.027
F2022	0.125	0.014	0.142	0.009	0.096	0.009	0.124	0.010	0.119	0.010	0.165	0.004	0.111	0.003	0.122	0.019	0.127	0.023
F2023	0.157	0.014	0.159	0.008	0.128	0.009	0.141	0.009	0.129	0.008	0.165	0.004	0.111	0.003	0.146	0.016	0.142	0.020
F2024	0.173	0.008	0.162	0.004	0.164	0.009	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2025	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2026	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2027	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2028	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2029	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2030	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2031	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
F2032	0.173	0.008	0.162	0.004	0.165	0.004	0.153	0.004	0.134	0.003	0.165	0.004	0.111	0.003	0.162	0.009	0.151	0.020
C2021	35.2	8.1	60.7	7.9	20.1	4.6	48.7	8.6	63.2	10.8	90.1	4.9	89.1	6.3	42.2	16.9	59.5	24.8
C2022	46.9	8.9	63.8	6.7	30.2	5.7	53.4	8.1	65.0	9.6	89.1	4.7	91.6	6.4	49.2	14.3	63.8	21.4
C2023	75.2	10.5	82.8	6.6	54.2	7.4	71.7	8.2	81.2	9.2	98.1	4.9	101.8	6.5	71.1	13.2	81.1	16.6
C2024	98.7	6.7	96.7	3.8	85.8	8.3	89.9	4.4	95.1	4.8	109.0	4.9	110.8	6.5	92.5	7.7	98.0	10.2
C2025	108.5	6.4	105.4	3.5	98.1	3.9	99.0	3.9	103.2	4.4	116.5	4.5	116.2	6.2	102.4	6.1	106.6	8.5
C2026	114.5	6.0	111.3	3.3	105.5	3.5	105.3	3.5	108.5	4.0	121.0	4.1	119.6	5.9	108.8	5.6	112.1	7.5
C2027	118.3	5.8	115.3	3.1	110.4	3.3	109.6	3.2	112.2	3.8	123.9	3.8	121.9	5.7	113.0	5.2	115.8	6.8
C2028	120.7	5.6	118.0	3.0	113.6	3.2	112.6	3.0	114.8	3.7	125.9	3.6	123.6	5.6	115.9	4.9	118.4	6.3
C2029	122.3	5.5	119.8	3.0	115.7	3.1	114.7	2.9	116.7	3.6	127.3	3.5	125.0	5.5	117.8	4.7	120.1	6.0
C2030	123.3	5.4	120.9	2.9	117.1	3.0	116.0	2.8	118.1	3.5	128.2	3.4	126.1	5.4	119.0	4.6	121.3	5.8
C2031	123.9	5.4	121.7	2.9	118.0	3.0	117.0	2.7	119.0	3.4	128.8	3.4	126.9	5.3	119.9	4.5	122.1	5.7
C2032	124.3	5.3	122.2	2.8	118.6	2.9	117.6	2.7	119.7	3.4	129.2	3.3	127.6	5.2	120.4	4.4	122.6	5.7

Table 2.40d—Standard harvest scenario 5 (female spawning biomass and catch in 1000s of t).

	no				yes				(yes)						A1: Allow Q to vary?			
	no		yes		no		yes								A2: Combine surveys?			
	(no)						no				yes				B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
Model:	M20.4		M19.12a		M19.15		M19.12		M20.8		M20.9		M20.10		Ensemble A		Ensemble AB	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	164.7	17.0	227.9	14.1	126.9	14.2	210.6	18.8	293.1	24.9	304.7	11.5	576.5	30.3	185.6	42.8	273.5	133.2
B2022	197.6	16.7	252.9	13.5	157.9	14.6	236.1	18.9	316.1	24.4	331.3	11.1	602.5	27.8	213.8	40.1	300.4	131.8
B2023	256.3	17.4	299.7	13.5	213.6	15.7	282.8	19.4	362.1	24.5	377.9	12.1	652.6	26.8	265.1	36.6	349.9	130.6
B2024	325.1	17.9	357.8	13.6	281.8	16.6	341.7	19.8	422.8	24.6	434.8	13.6	720.4	27.1	328.1	33.1	412.2	131.4
B2025	389.8	17.4	415.3	13.3	349.2	16.4	401.0	19.3	486.0	24.0	490.3	14.2	793.4	27.4	390.0	29.8	474.7	134.2
B2026	444.9	16.2	466.0	12.4	408.8	15.5	454.5	18.1	544.9	22.6	538.8	13.9	864.1	27.0	444.5	26.6	531.1	138.9
B2027	489.3	15.0	508.4	11.4	458.6	14.2	500.0	16.6	596.5	20.9	579.0	13.0	929.2	25.9	490.0	23.8	579.3	144.8
B2028	524.0	13.9	542.5	10.5	498.6	12.9	537.2	15.2	640.0	19.2	611.4	12.0	987.2	24.5	526.6	21.6	619.1	151.5
B2029	550.6	13.1	569.3	9.8	530.0	11.8	566.9	14.1	675.9	17.7	637.0	11.2	1037.7	23.0	555.3	20.1	651.3	158.5
B2030	570.6	12.7	590.0	9.4	554.1	11.0	590.2	13.2	704.8	16.6	656.8	10.5	1081.0	21.5	577.5	19.1	677.0	165.4
B2031	585.5	12.6	605.7	9.1	572.4	10.5	608.2	12.6	727.8	15.8	672.1	10.1	1117.7	20.2	594.3	18.7	697.2	171.9
B2032	596.4	12.6	617.6	9.0	586.1	10.2	621.9	12.3	745.9	15.2	683.7	9.8	1148.5	19.2	607.0	18.6	712.9	177.9
F2021	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
F2022	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
F2023	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
F2024	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
F2025	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
F2026	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
F2027	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
F2028	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
F2029	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
F2030	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
F2031	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
F2032	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
C2021	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2022	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2023	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2024	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2025	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2026	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2027	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2028	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2029	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2030	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2031	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2.40e—Standard harvest scenario 6 (female spawning biomass and catch in 1000s of t).

	no				yes				(yes)						A1: Allow Q to vary?			
	no		yes		no		yes								A2: Combine surveys?			
	(no)						no				yes				B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
Model:	M20.4		M19.12a		M19.15		M19.12		M20.8		M20.9		M20.10		Ensemble A		Ensemble AB	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	164.7	17.0	227.9	14.1	126.9	14.2	210.6	18.8	293.1	24.9	304.7	11.5	576.5	30.3	185.6	42.8	273.5	133.2
B2022	165.5	10.2	196.8	7.3	139.2	10.5	190.2	11.6	257.0	15.3	248.8	7.6	517.4	22.2	174.6	24.9	244.9	113.7
B2023	195.4	8.6	207.9	6.1	174.4	9.0	204.3	9.4	261.4	11.9	245.8	6.8	492.3	14.9	196.2	15.5	253.7	97.4
B2024	222.7	7.0	227.5	5.4	209.0	7.3	226.6	7.9	278.2	9.8	258.1	6.5	485.9	11.6	221.8	10.2	271.5	86.7
B2025	233.2	5.8	238.4	4.3	227.0	5.2	240.1	6.1	290.4	7.8	264.7	5.2	483.0	9.7	235.1	7.5	281.4	81.4
B2026	234.0	5.5	241.5	3.8	232.1	4.2	245.0	5.1	296.2	6.5	265.6	4.2	481.2	8.5	238.8	7.1	284.2	79.7
B2027	232.6	5.4	241.6	3.6	232.2	3.9	245.9	4.7	298.5	6.0	264.9	3.8	480.3	7.9	238.8	7.4	284.4	79.5
B2028	231.6	5.3	241.1	3.6	231.4	3.8	245.6	4.6	299.2	5.8	264.3	3.7	480.1	7.5	238.1	7.6	284.0	79.6
B2029	231.0	5.3	240.7	3.6	230.8	3.8	245.1	4.6	299.3	5.7	263.9	3.7	480.2	7.3	237.7	7.6	283.7	79.8
B2030	230.9	5.2	240.5	3.6	230.5	3.8	244.9	4.6	299.2	5.7	263.7	3.6	480.4	7.2	237.4	7.6	283.6	80.0
B2031	230.9	5.2	240.4	3.6	230.3	3.8	244.8	4.6	299.1	5.7	263.7	3.6	480.7	7.2	237.3	7.6	283.5	80.1
B2032	230.9	5.2	240.4	3.6	230.3	3.8	244.7	4.6	299.0	5.7	263.7	3.6	480.9	7.1	237.3	7.6	283.5	80.2
F2021	0.292	0.044	0.371	0.031	0.210	0.027	0.314	0.032	0.295	0.030	0.426	0.012	0.253	0.006	0.299	0.067	0.313	0.073
F2022	0.294	0.030	0.317	0.016	0.232	0.020	0.282	0.019	0.257	0.018	0.365	0.019	0.253	0.018	0.281	0.037	0.287	0.047
F2023	0.351	0.027	0.336	0.013	0.297	0.018	0.304	0.015	0.261	0.013	0.360	0.015	0.241	0.013	0.320	0.028	0.307	0.045
F2024	0.404	0.025	0.370	0.012	0.360	0.015	0.339	0.013	0.279	0.011	0.380	0.013	0.237	0.010	0.366	0.028	0.337	0.055
F2025	0.424	0.022	0.389	0.011	0.393	0.013	0.361	0.011	0.292	0.009	0.390	0.011	0.236	0.008	0.389	0.026	0.353	0.061
F2026	0.425	0.020	0.394	0.011	0.403	0.011	0.369	0.011	0.298	0.008	0.391	0.011	0.235	0.007	0.395	0.024	0.358	0.062
F2027	0.423	0.020	0.394	0.010	0.403	0.011	0.370	0.010	0.301	0.008	0.390	0.011	0.235	0.006	0.395	0.023	0.358	0.061
F2028	0.421	0.020	0.393	0.010	0.402	0.011	0.370	0.010	0.302	0.008	0.389	0.011	0.234	0.006	0.394	0.022	0.357	0.061
F2029	0.420	0.020	0.393	0.010	0.400	0.011	0.369	0.010	0.302	0.008	0.389	0.011	0.234	0.006	0.393	0.022	0.357	0.060
F2030	0.419	0.020	0.392	0.010	0.400	0.011	0.369	0.010	0.302	0.008	0.388	0.011	0.235	0.006	0.393	0.022	0.356	0.060
F2031	0.419	0.020	0.392	0.010	0.400	0.011	0.368	0.010	0.301	0.008	0.388	0.011	0.235	0.006	0.392	0.022	0.356	0.060
F2032	0.419	0.020	0.392	0.010	0.400	0.011	0.368	0.010	0.301	0.008	0.388	0.011	0.235	0.006	0.392	0.022	0.356	0.060
C2021	87.7	19.6	147.5	18.4	50.8	11.3	118.9	20.3	145.4	24.1	213.4	11.6	193.8	13.7	103.6	40.2	139.9	54.8
C2022	95.9	15.2	118.0	9.8	65.8	11.0	102.8	12.8	120.7	15.0	159.3	12.9	185.2	21.1	96.4	22.6	122.2	38.8
C2023	140.2	15.2	139.8	8.6	108.6	11.9	125.5	10.9	136.5	12.0	165.6	10.7	185.3	15.7	128.1	17.2	143.0	26.1
C2024	180.1	13.1	168.8	7.7	154.2	10.7	155.7	9.4	159.5	9.9	186.3	9.5	190.0	12.4	163.7	14.3	170.1	17.3
C2025	193.4	9.5	183.2	5.7	177.4	7.0	172.9	6.4	173.4	7.2	195.1	6.8	191.3	9.9	180.8	10.3	183.3	11.7
C2026	192.9	8.1	186.6	4.6	182.7	4.9	178.3	4.6	179.0	5.6	195.4	5.3	191.2	8.3	184.5	7.6	186.3	8.8
C2027	190.2	7.9	186.2	4.3	182.0	4.3	178.8	4.0	180.7	5.1	194.0	5.0	191.1	7.6	183.8	6.7	185.9	7.8
C2028	188.5	8.1	185.2	4.3	180.5	4.3	178.1	4.0	180.9	4.9	192.9	5.1	191.2	7.4	182.6	6.6	185.1	7.7
C2029	187.8	8.2	184.7	4.4	179.5	4.4	177.5	4.0	180.7	5.0	192.4	5.1	191.4	7.3	181.9	6.7	184.7	7.9
C2030	187.6	8.3	184.4	4.4	179.1	4.5	177.1	4.0	180.5	5.0	192.2	5.2	191.6	7.4	181.6	6.7	184.5	8.0
C2031	187.6	8.3	184.3	4.4	179.0	4.5	177.0	4.1	180.4	5.0	192.2	5.2	191.8	7.4	181.5	6.8	184.4	8.0
C2032	187.6	8.3	184.3	4.4	178.9	4.5	176.9	4.1	180.3	5.0	192.2	5.2	191.9	7.4	181.5	6.8	184.4	8.1

Table 2.40f—Standard harvest scenario 7 (female spawning biomass and catch in 1000s of t).

	no				yes				(yes)						A1: Allow Q to vary?			
	no		yes		no		yes								A2: Combine surveys?			
	(no)						no				yes				B1: Use fishery CPUE?			
							no		yes		no		yes		B2: Allow domed selex?			
Model:	M20.4		M19.12a		M19.15		M19.12		M20.8		M20.9		M20.10		Ensemble A		Ensemble AB	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	164.7	17.0	227.9	14.1	126.9	14.2	210.6	18.8	293.1	24.9	304.7	11.5	576.5	30.3	185.6	42.8	273.5	133.2
B2022	170.9	16.7	205.6	13.4	142.4	14.5	197.7	18.7	265.9	24.3	261.6	11.2	529.3	28.0	181.0	29.6	253.5	116.6
B2023	198.2	11.0	212.3	8.1	176.4	11.1	208.3	12.5	266.7	16.3	251.7	7.5	502.4	22.2	199.6	17.7	258.6	100.1
B2024	223.9	7.5	229.3	5.8	210.0	8.0	228.3	8.9	281.0	11.6	260.5	6.6	492.8	15.5	223.3	10.9	274.0	88.6
B2025	233.4	5.8	238.8	4.4	227.3	5.4	240.6	6.3	291.6	8.3	265.3	5.2	487.4	11.3	235.5	7.6	282.4	82.7
B2026	234.0	5.5	241.5	3.8	232.1	4.2	245.0	5.1	296.6	6.6	265.6	4.3	483.7	8.9	238.7	7.1	284.6	80.5
B2027	232.6	5.5	241.5	3.6	232.2	3.9	245.8	4.7	298.5	6.0	264.8	3.9	481.7	7.8	238.7	7.4	284.5	79.9
B2028	231.5	5.4	241.0	3.6	231.4	3.8	245.5	4.6	299.1	5.8	264.2	3.7	480.7	7.4	238.1	7.6	284.0	79.9
B2029	231.0	5.3	240.7	3.6	230.7	3.8	245.1	4.6	299.2	5.7	263.8	3.7	480.4	7.3	237.6	7.6	283.7	79.9
B2030	230.9	5.2	240.5	3.6	230.4	3.8	244.9	4.6	299.1	5.7	263.7	3.6	480.5	7.2	237.4	7.6	283.6	80.0
B2031	230.9	5.2	240.4	3.6	230.3	3.8	244.7	4.6	299.0	5.7	263.7	3.6	480.6	7.2	237.3	7.6	283.5	80.1
B2032	230.9	5.2	240.4	3.6	230.3	3.8	244.7	4.6	299.0	5.7	263.7	3.6	480.8	7.1	237.3	7.6	283.5	80.1
F2021	0.238	0.025	0.304	0.020	0.171	0.019	0.257	0.025	0.246	0.022	0.350	0.015	0.215	0.012	0.245	0.052	0.258	0.058
F2022	0.304	0.043	0.332	0.028	0.238	0.028	0.294	0.031	0.266	0.028	0.385	0.027	0.253	0.006	0.292	0.047	0.298	0.056
F2023	0.357	0.033	0.344	0.018	0.301	0.022	0.310	0.020	0.267	0.019	0.370	0.017	0.246	0.017	0.326	0.032	0.313	0.047
F2024	0.406	0.027	0.373	0.014	0.362	0.017	0.342	0.015	0.282	0.013	0.383	0.014	0.241	0.013	0.368	0.029	0.340	0.056
F2025	0.424	0.022	0.389	0.011	0.394	0.013	0.362	0.012	0.293	0.010	0.391	0.012	0.238	0.010	0.389	0.026	0.354	0.061
F2026	0.425	0.020	0.394	0.010	0.403	0.011	0.369	0.011	0.299	0.009	0.391	0.011	0.236	0.008	0.395	0.024	0.358	0.062
F2027	0.423	0.020	0.394	0.010	0.403	0.011	0.370	0.010	0.301	0.008	0.390	0.010	0.235	0.007	0.395	0.023	0.358	0.061
F2028	0.421	0.020	0.393	0.010	0.401	0.011	0.370	0.010	0.301	0.008	0.389	0.011	0.235	0.006	0.394	0.022	0.357	0.061
F2029	0.420	0.020	0.393	0.010	0.400	0.011	0.369	0.010	0.302	0.008	0.389	0.011	0.235	0.006	0.393	0.022	0.357	0.060
F2030	0.419	0.020	0.392	0.010	0.400	0.011	0.369	0.010	0.301	0.008	0.388	0.011	0.235	0.006	0.393	0.022	0.356	0.060
F2031	0.419	0.020	0.392	0.010	0.400	0.011	0.368	0.010	0.301	0.008	0.388	0.011	0.235	0.006	0.392	0.022	0.356	0.060
F2032	0.419	0.020	0.392	0.010	0.400	0.011	0.368	0.010	0.301	0.008	0.388	0.011	0.235	0.006	0.392	0.022	0.356	0.060
C2021	72.8	0.0	123.8	0.0	42.0	0.0	99.3	0.0	123.2	0.0	179.7	0.0	166.7	0.0	86.5	30.4	118.0	44.5
C2022	101.7	23.8	127.9	18.0	68.6	15.1	110.4	21.4	128.4	24.2	174.5	18.7	189.0	14.8	103.1	29.2	130.0	42.6
C2023	143.8	19.3	144.9	11.8	110.7	14.4	129.8	14.9	141.2	16.7	172.5	12.5	191.9	21.6	132.0	20.3	147.9	29.2
C2024	181.6	14.3	170.9	8.6	155.3	11.6	157.7	10.8	161.9	11.9	189.1	9.9	194.1	16.0	165.4	15.2	172.5	18.7
C2025	193.6	9.5	183.7	5.7	177.6	7.1	173.5	6.6	174.3	7.8	195.7	6.8	193.6	11.8	181.2	10.3	184.1	12.1
C2026	192.8	7.9	186.4	4.4	182.7	4.8	178.3	4.4	179.2	5.6	195.3	5.2	192.4	9.3	184.4	7.5	186.4	8.9
C2027	190.1	7.8	186.0	4.2	181.9	4.3	178.7	3.9	180.6	5.0	193.7	4.9	191.6	8.0	183.7	6.6	185.8	7.9
C2028	188.4	8.0	185.1	4.3	180.4	4.3	178.0	3.9	180.8	4.8	192.8	5.0	191.4	7.5	182.6	6.5	185.1	7.7
C2029	187.8	8.2	184.6	4.3	179.5	4.4	177.4	4.0	180.6	4.9	192.3	5.1	191.4	7.3	181.9	6.6	184.6	7.8
C2030	187.6	8.3	184.4	4.4	179.1	4.4	177.1	4.0	180.5	4.9	192.2	5.2	191.6	7.3	181.6	6.7	184.4	8.0
C2031	187.6	8.3	184.3	4.4	179.0	4.5	177.0	4.1	180.4	5.0	192.2	5.2	191.7	7.4	181.5	6.8	184.4	8.0
C2032	187.6	8.3	184.3	4.4	178.9	4.5	176.9	4.1	180.3	5.0	192.2	5.2	191.9	7.4	181.5	6.8	184.4	8.1

FIGURES

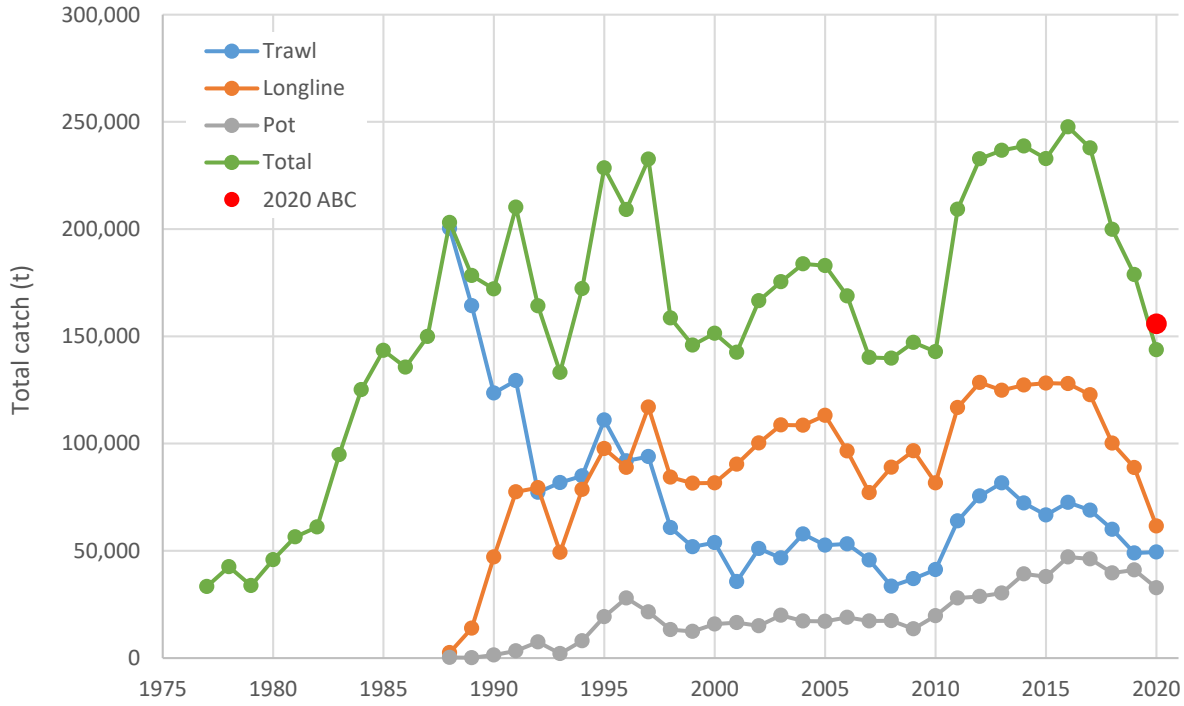


Figure 2.1. Total catch and catch by gear type.

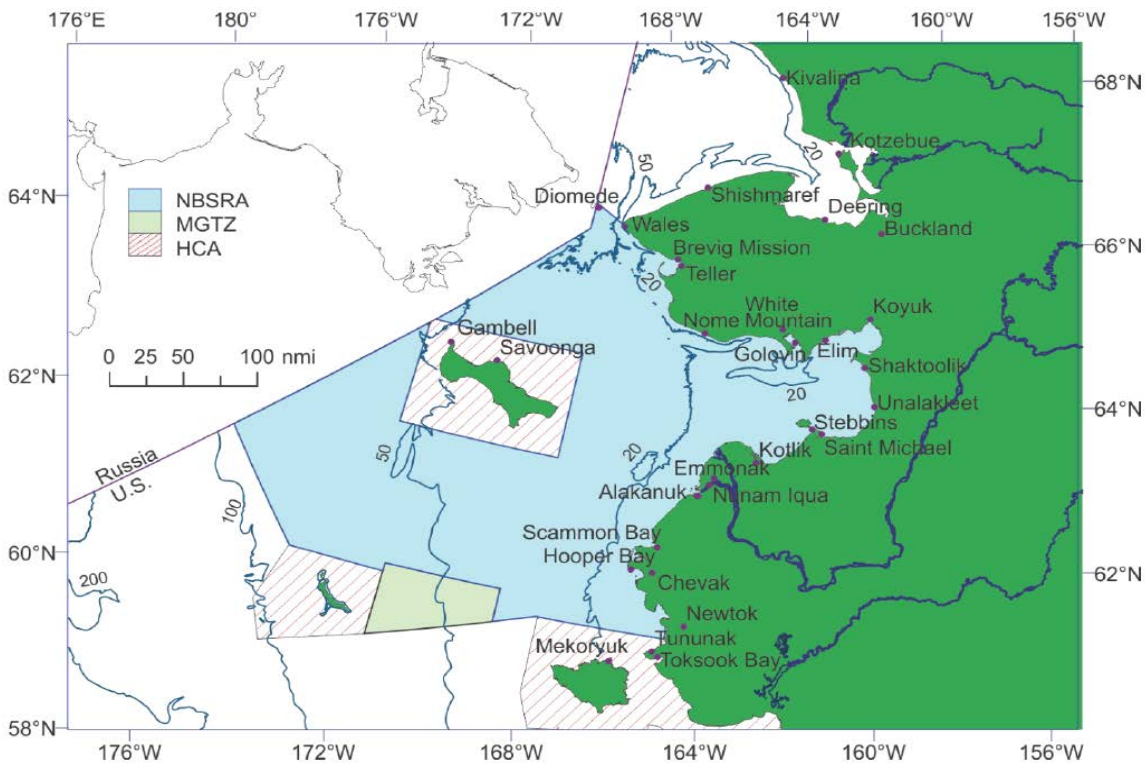


Figure 2.2a. The Northern Bering Sea Research Area (NBSRA) and bordering communities, Modified Gear Trawl Zone (MGTZ), and adjacent Habitat Conservation Areas (HCA).

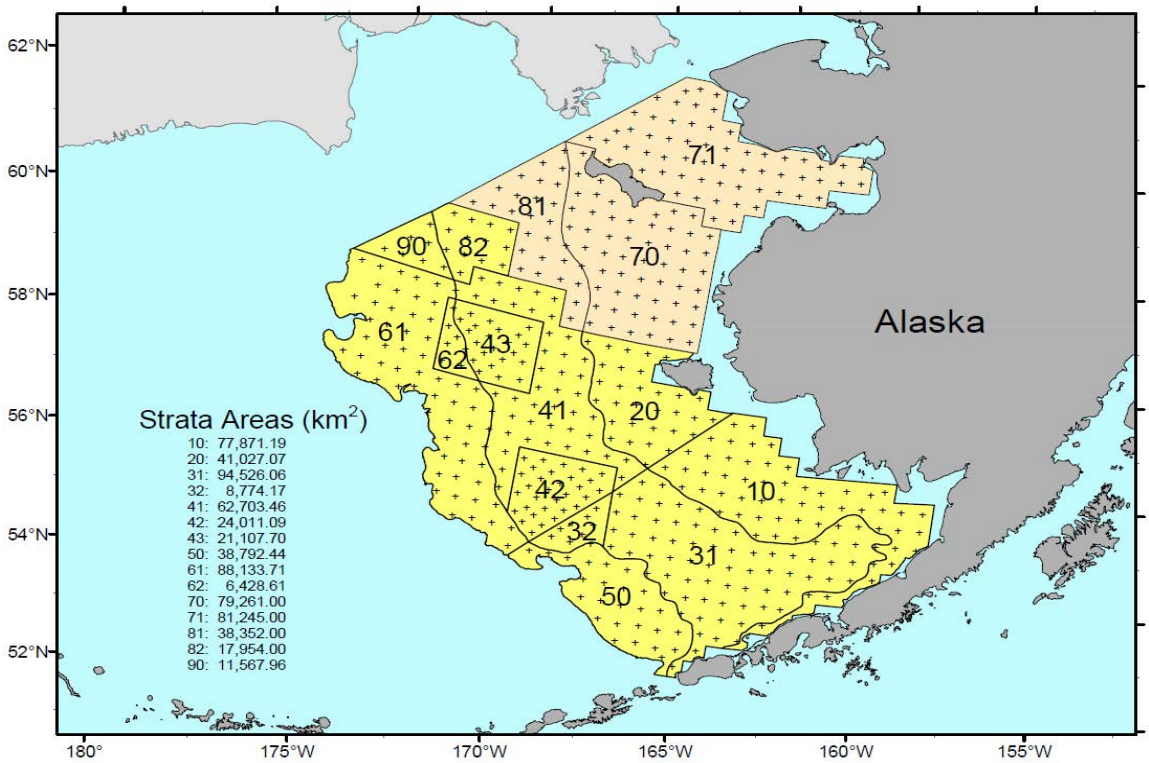


Figure 2.2b. AFSC bottom trawl survey areas (yellow=EBS, beige=NBS).

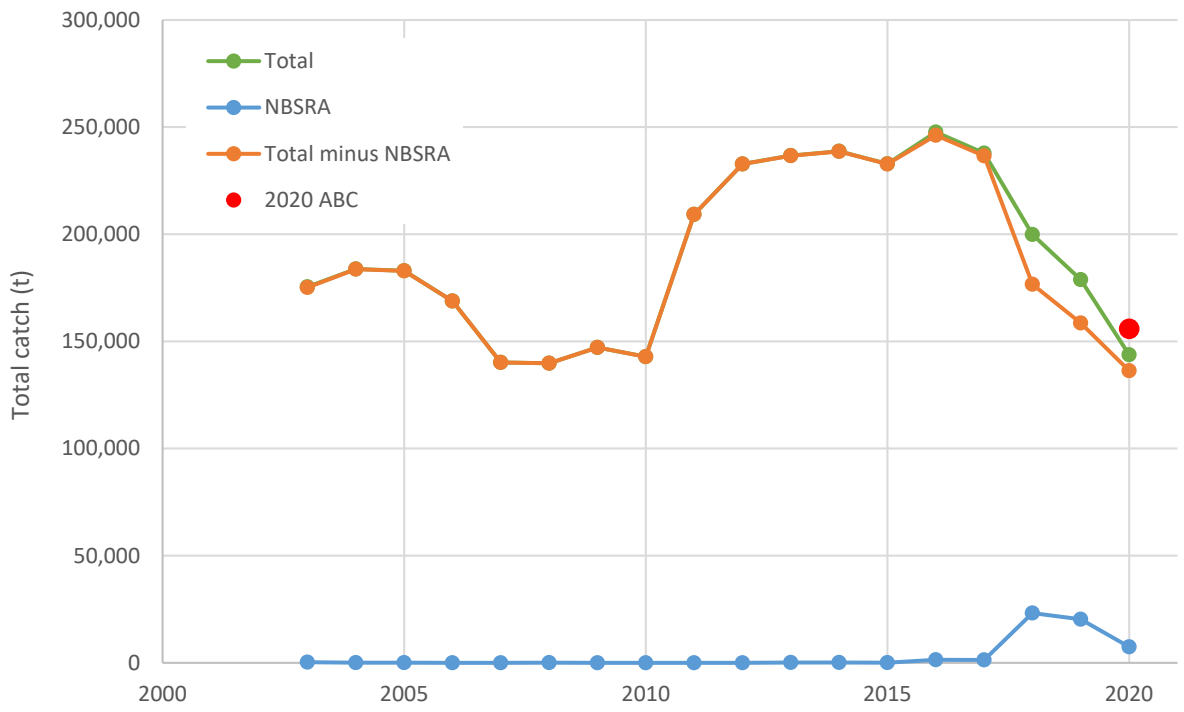


Figure 2.3. Catch time series by area, 2003-2020 (catch data for NBSRA not available prior to 2003).

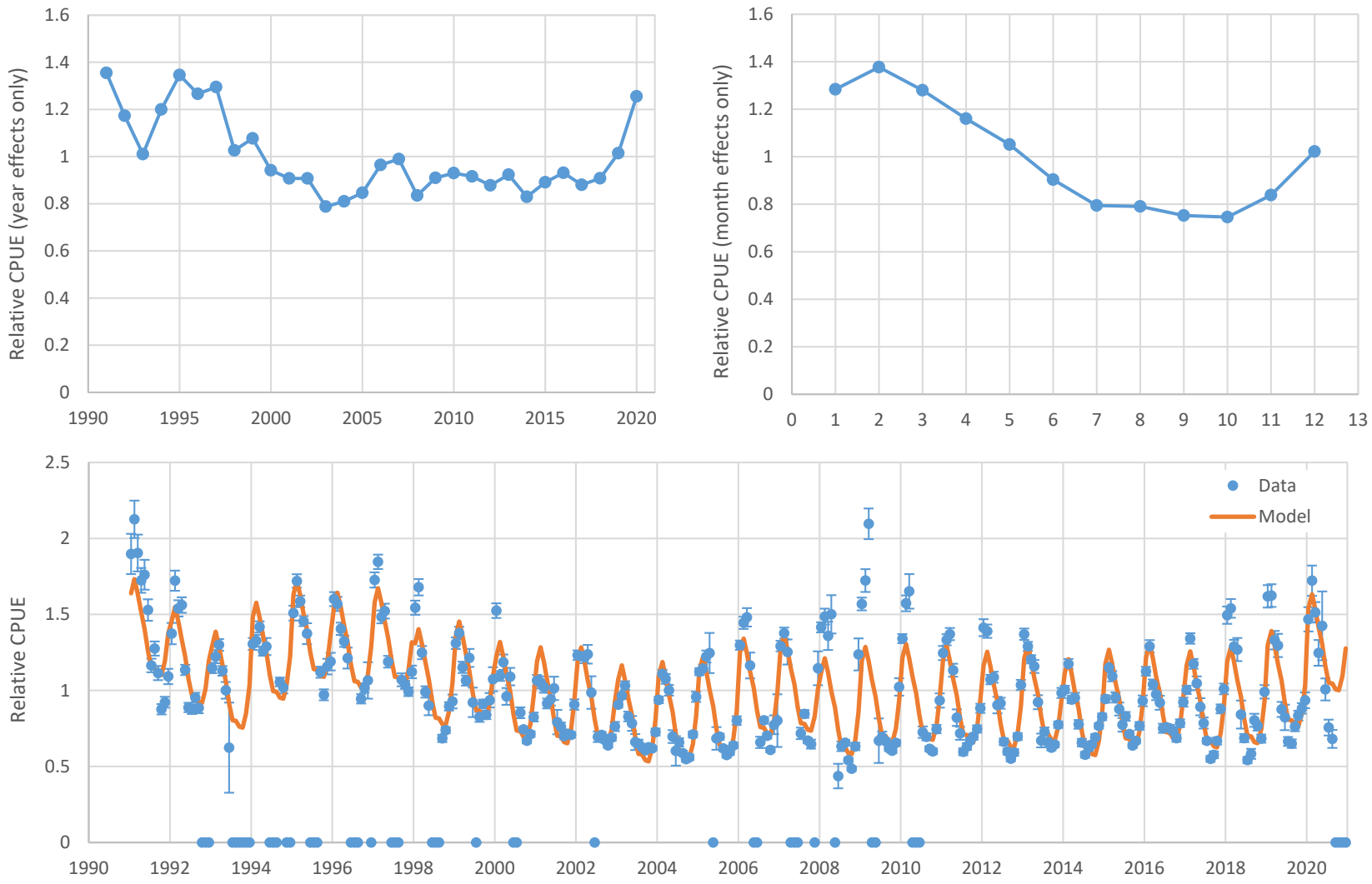


Figure 2.4. Longline fishery CPUE. Upper left panel: year effects, upper right panel: month effects, lower panel: monthly data and model fit.

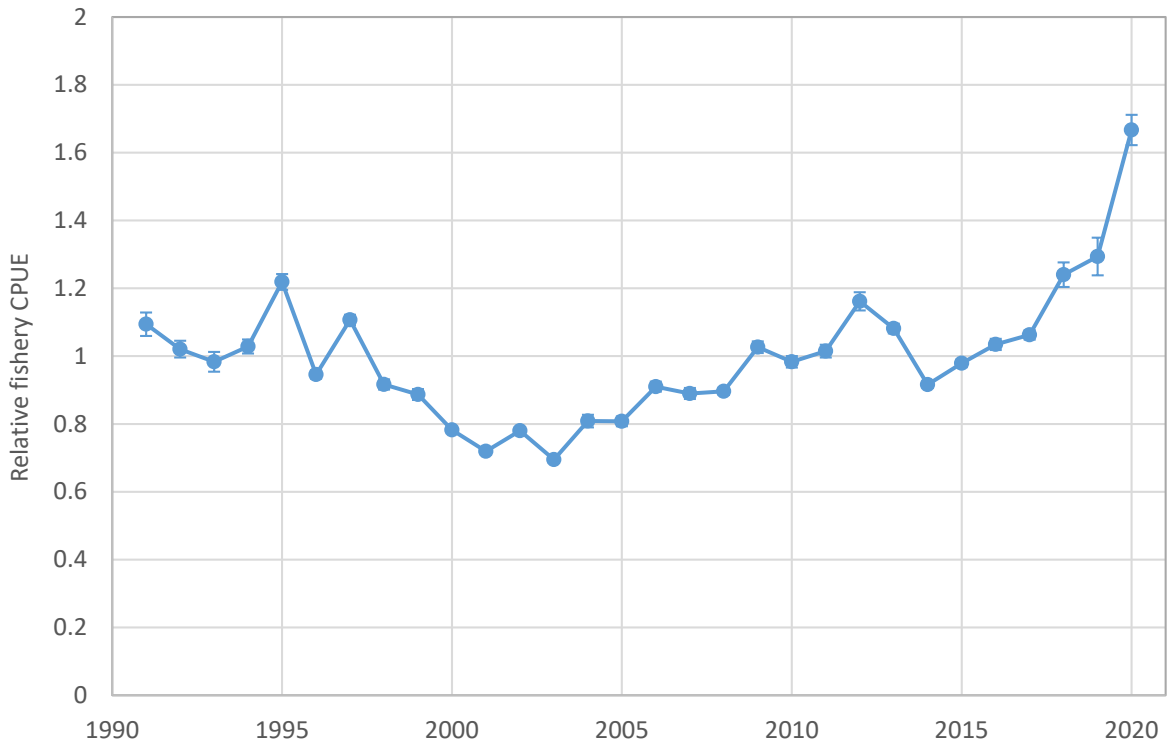


Figure 2.5. Catch-weighted relative CPUE (all gear types combined).

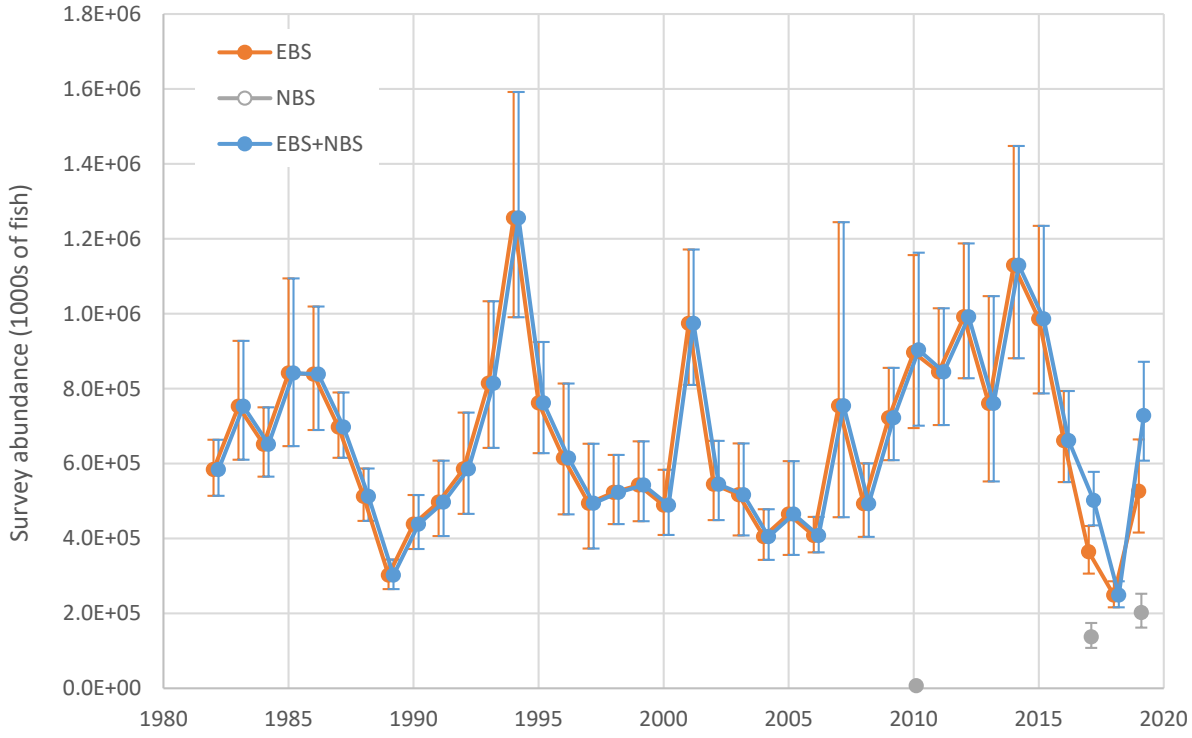


Figure 2.6. Trawl survey abundance time series (design-based).

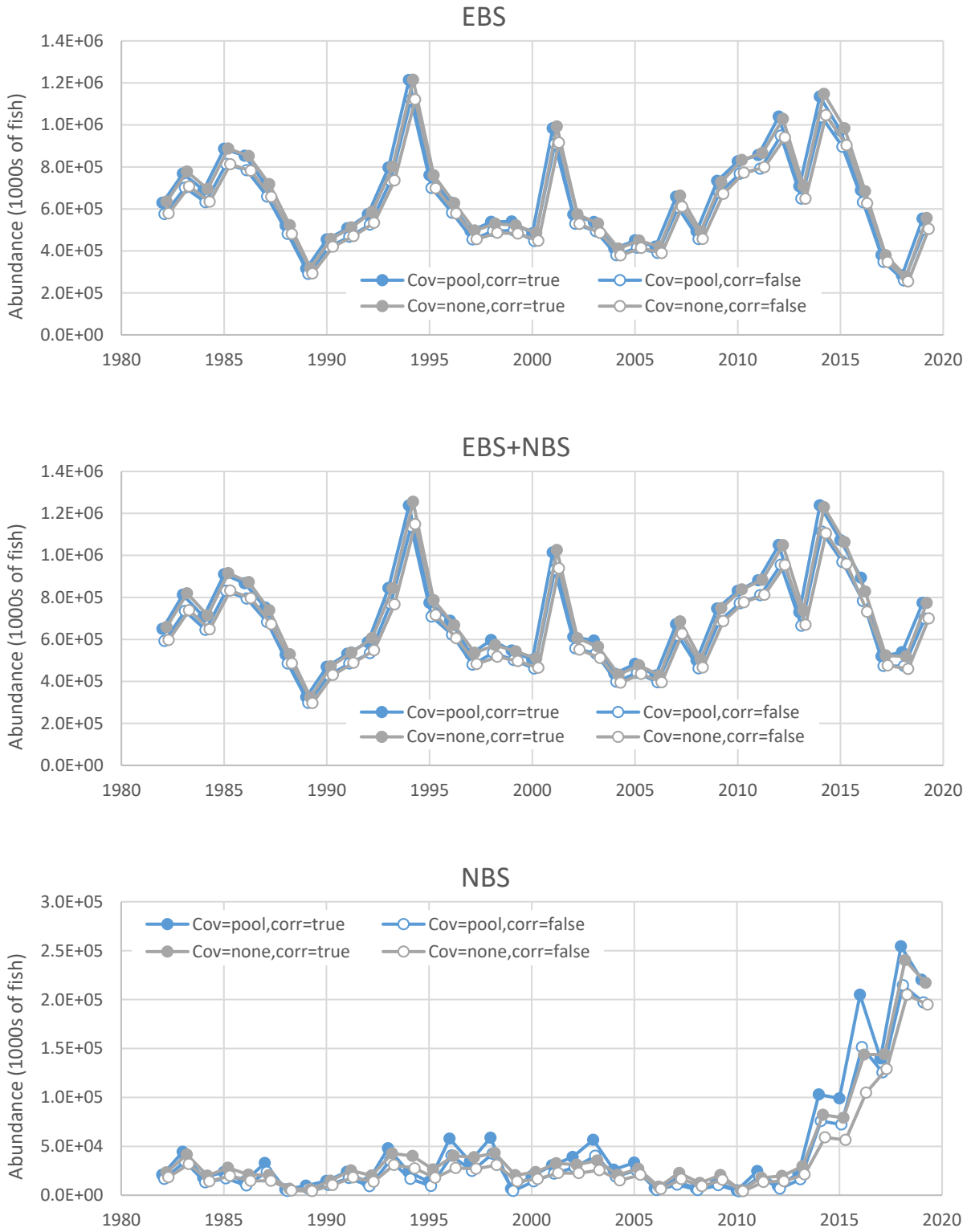


Figure 2.7. Trawl survey abundance alternatives (VAST).

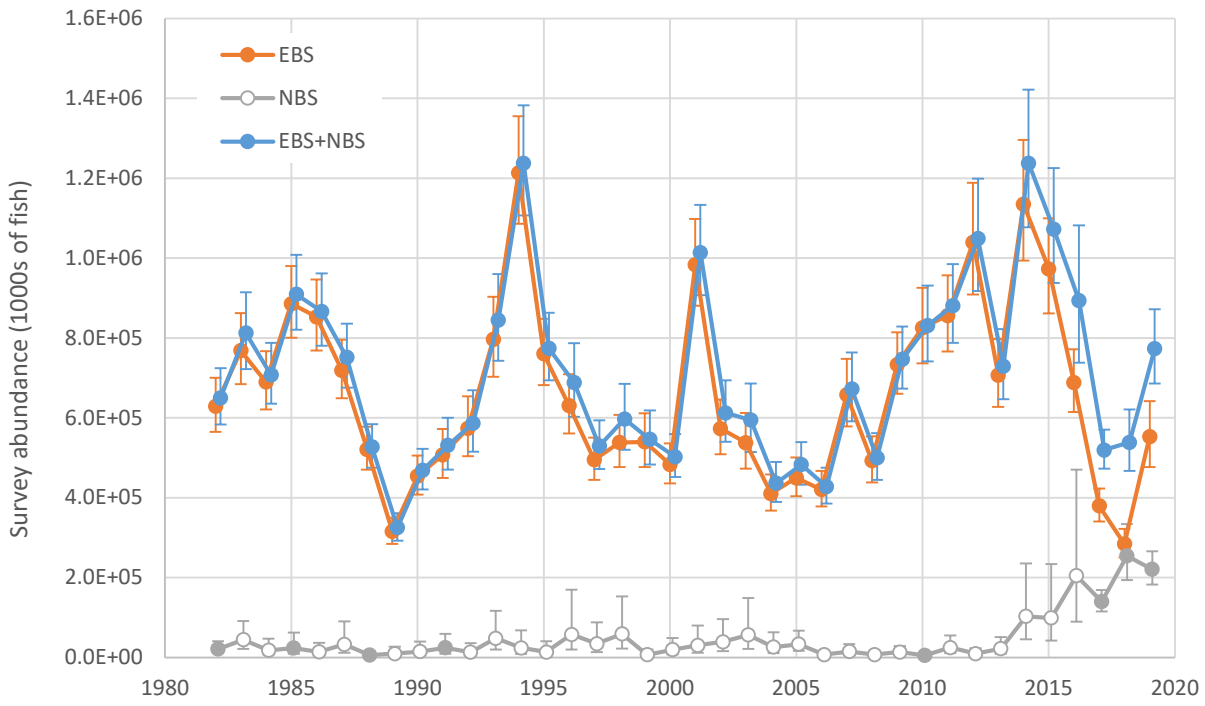


Figure 2.8. VAST survey indices (covariate = cold pool, bias correction = true).

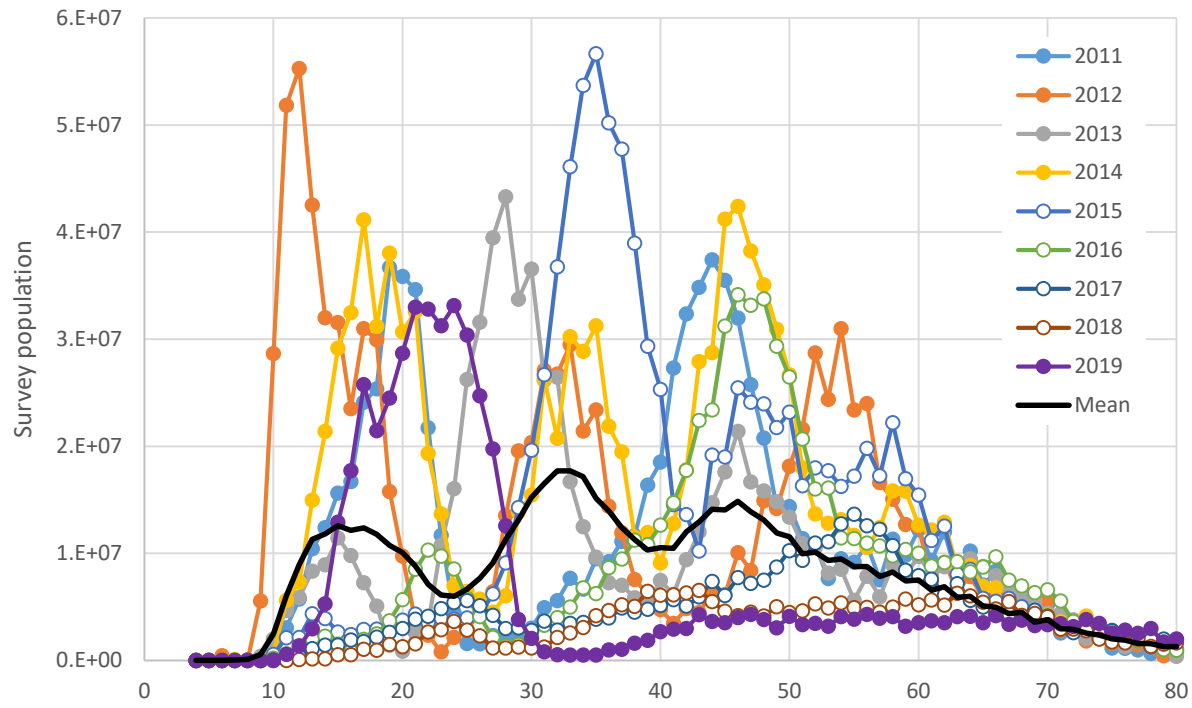


Figure 2.9a. Recent survey size compositions (EBS).

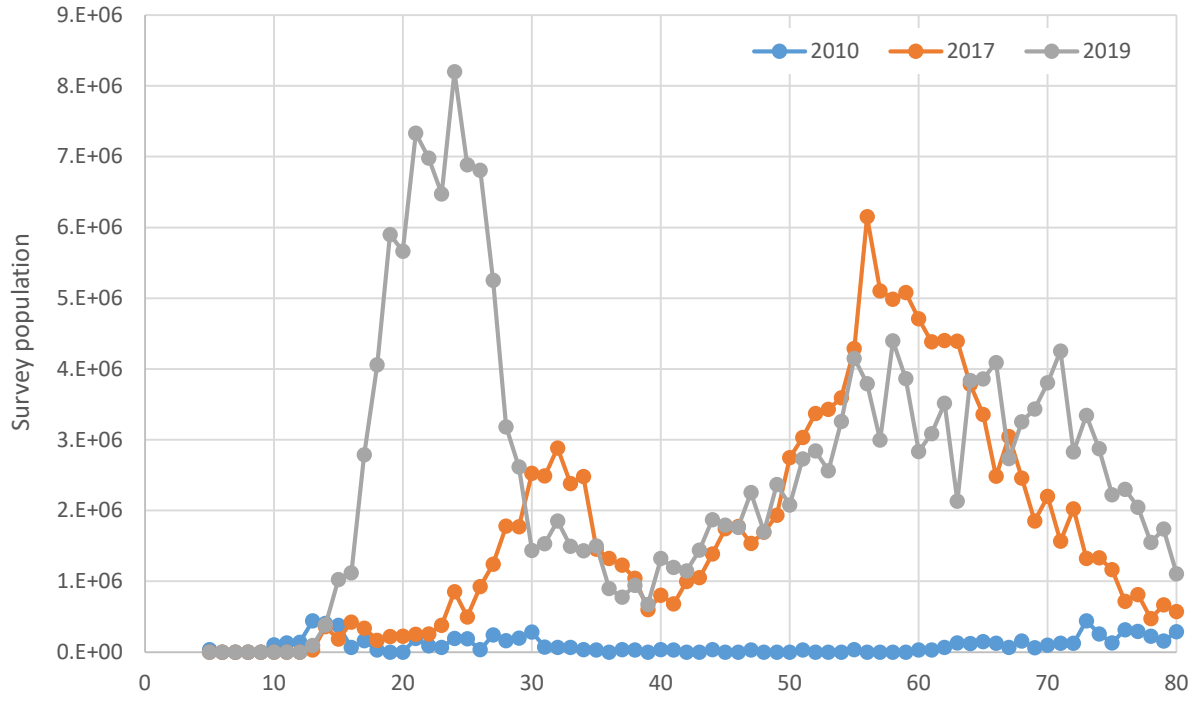


Figure 2.9b. Recent survey size compositions (NBS).

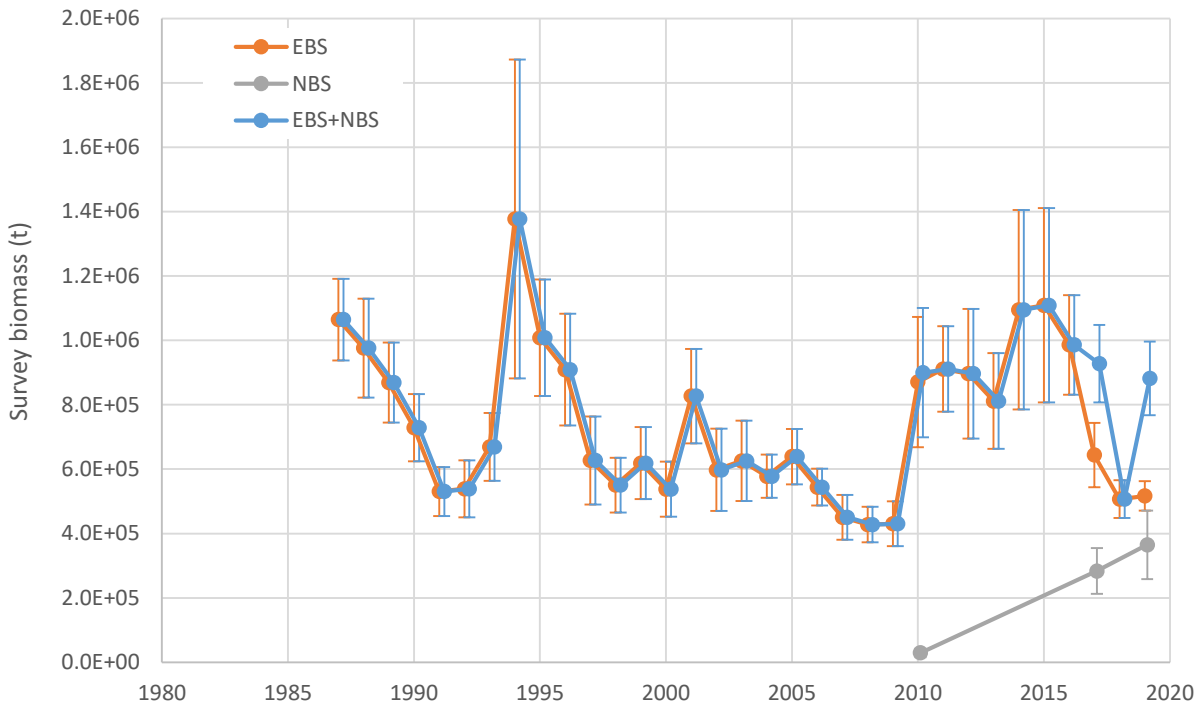


Figure 2.10. Survey biomass (design-based).

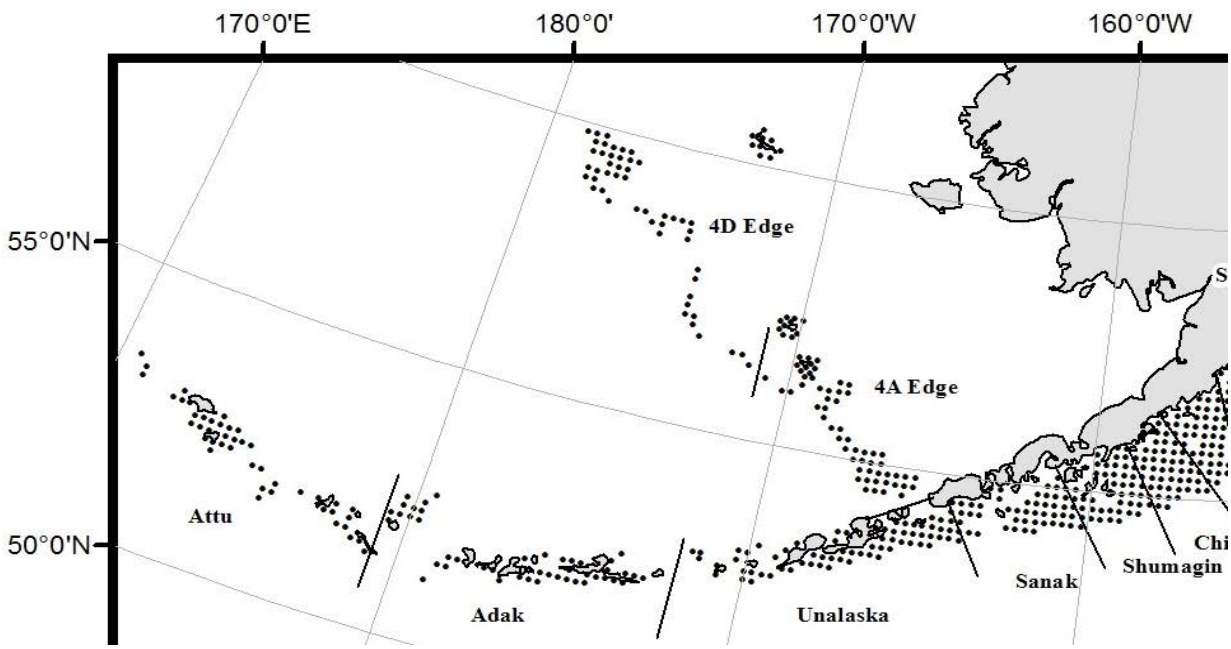


Figure 2.11a. Locations of IPHC survey stations in the BSAI region.

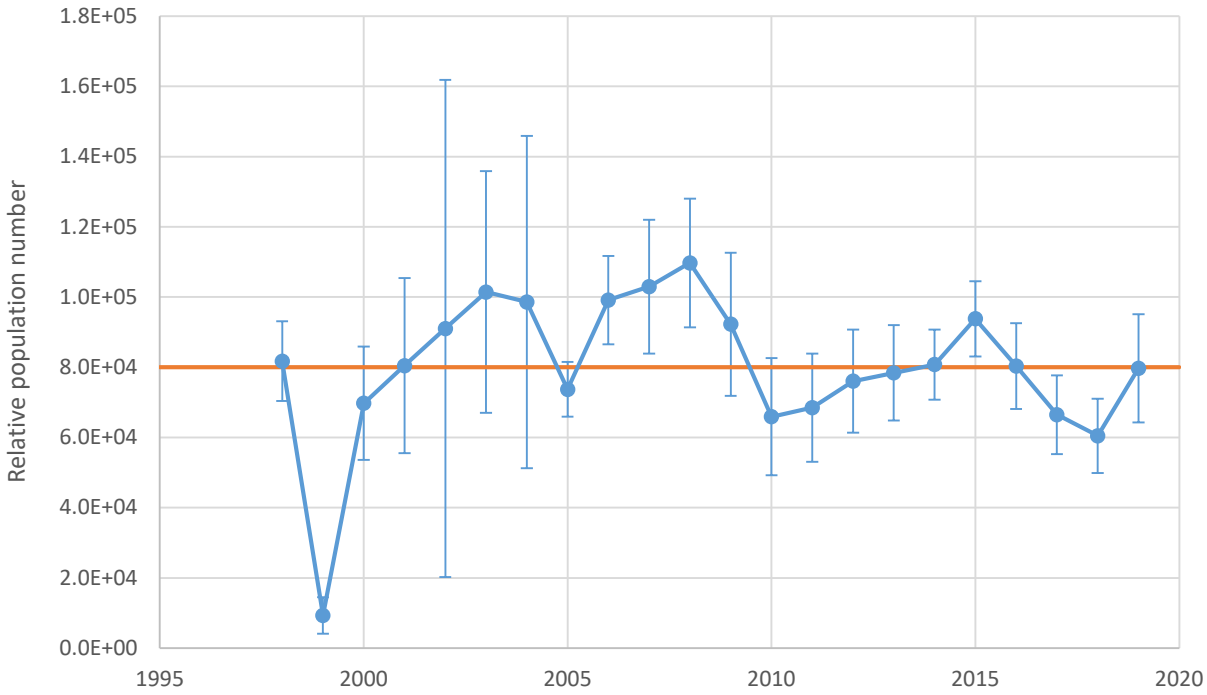


Figure 2.11b. IPHC survey relative population number (2020 data not available).

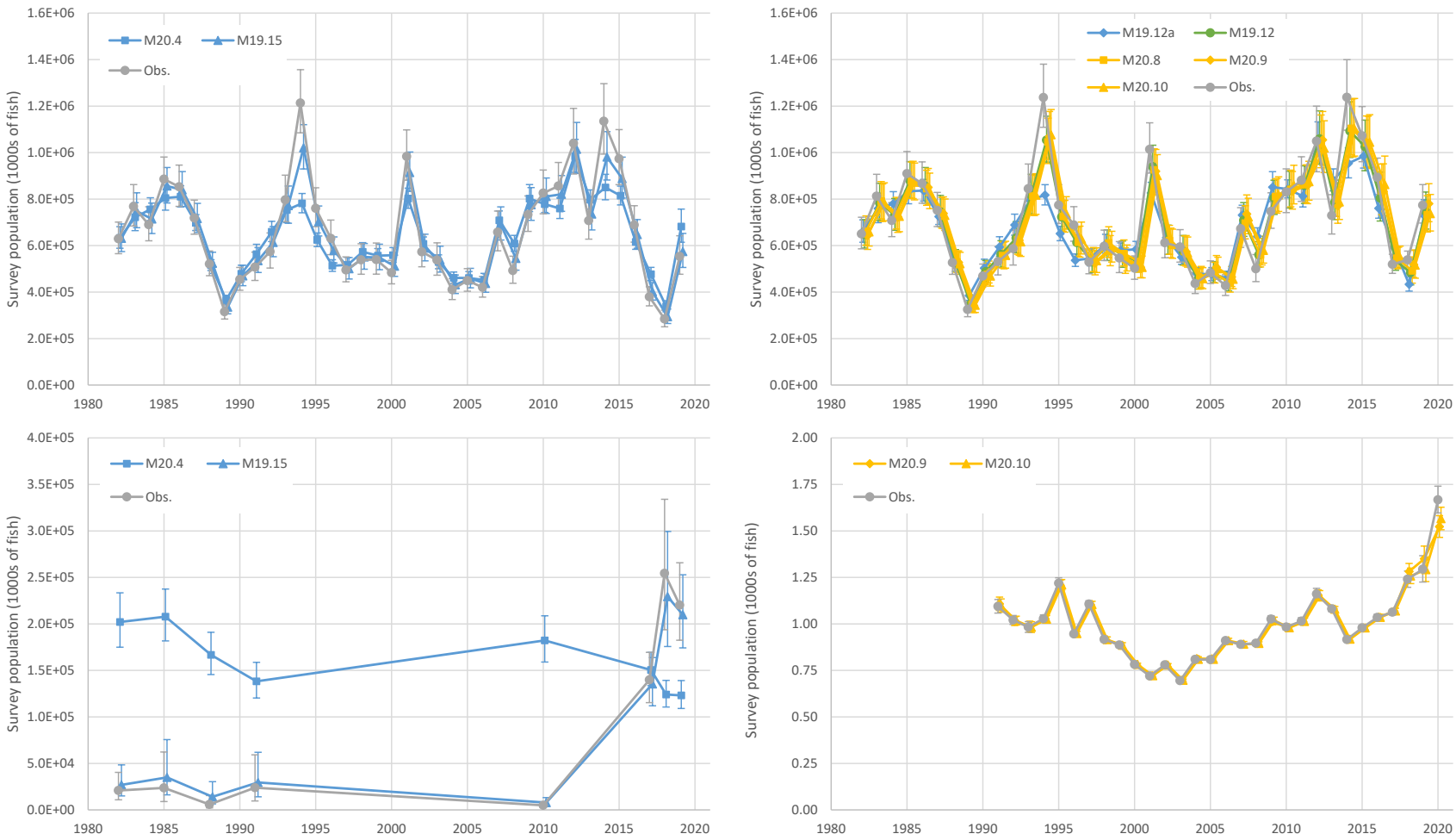
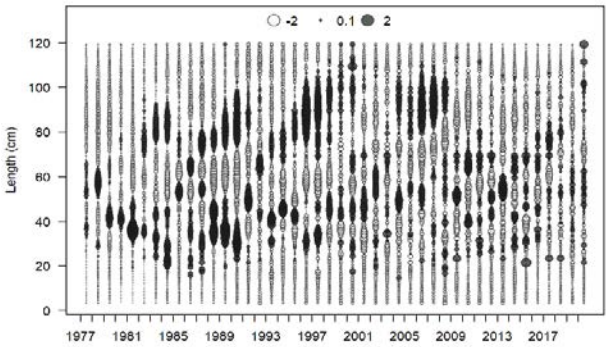
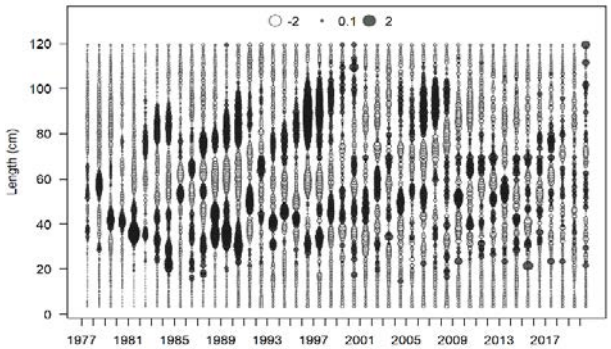


Figure 2.12. Fits to the survey index data. Upper left = EBS survey, lower left = NBS survey, upper right = combined EBS and NBS surveys, lower right = fishery CPUE.

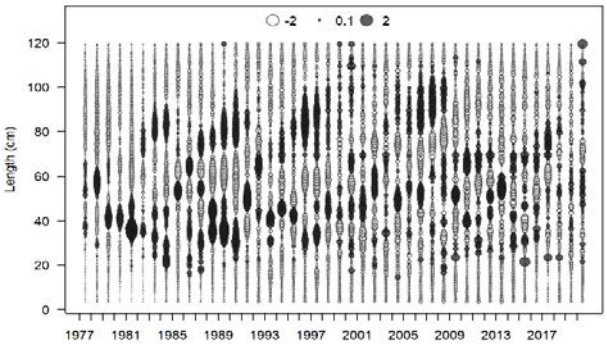
Model 19.12



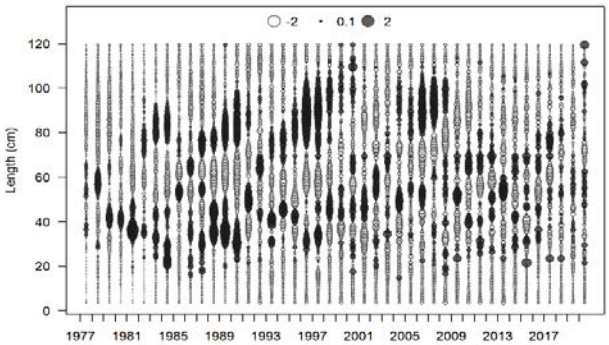
Model 20.4



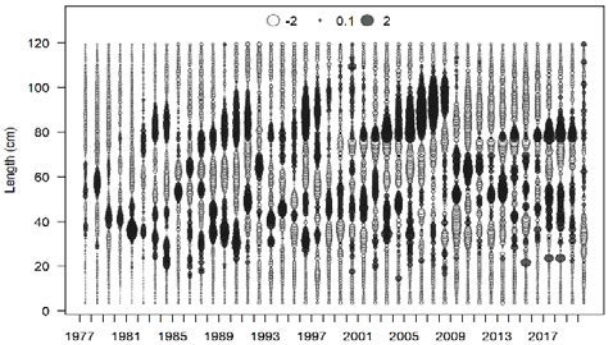
Model 20.8



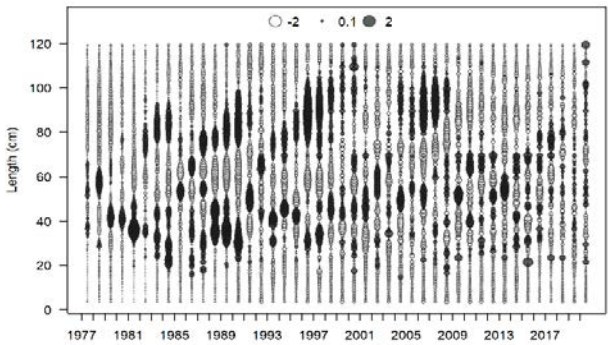
Model 19.12a



Model 20.9



Model 19.15



Model 20.10

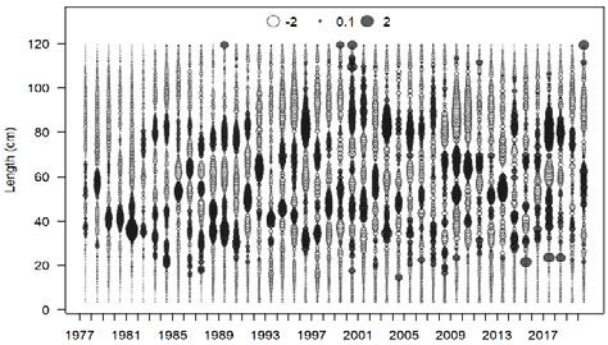
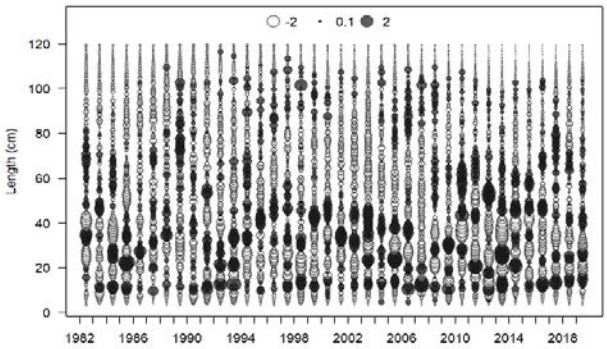
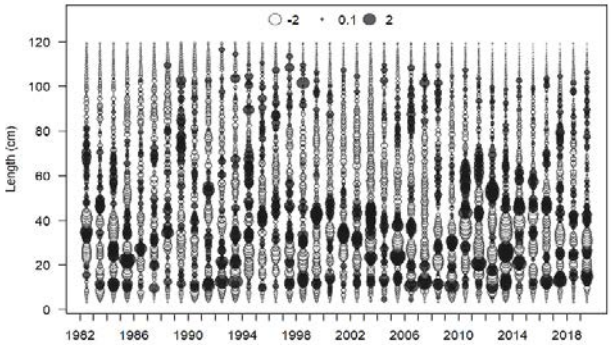


Figure 2.13a. Residual plots of model fits to the fishery size composition data.

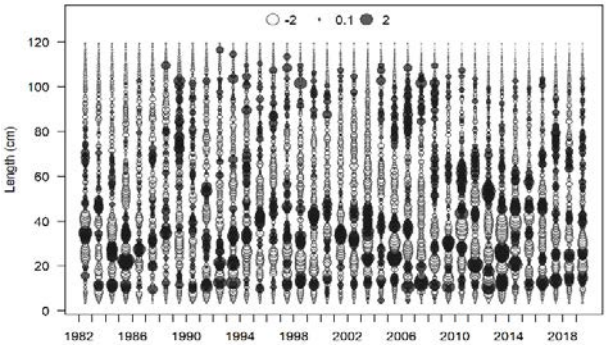
Model 19.12 (EBS+NBS)



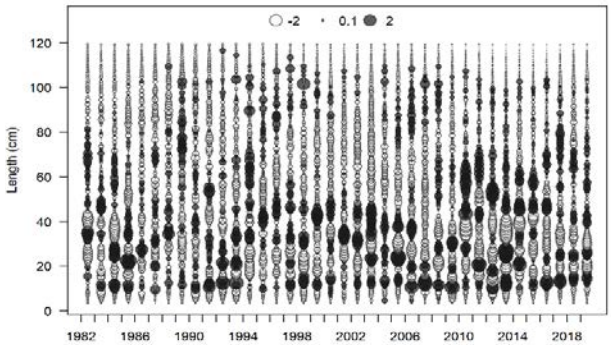
Model 20.4 (EBS only)



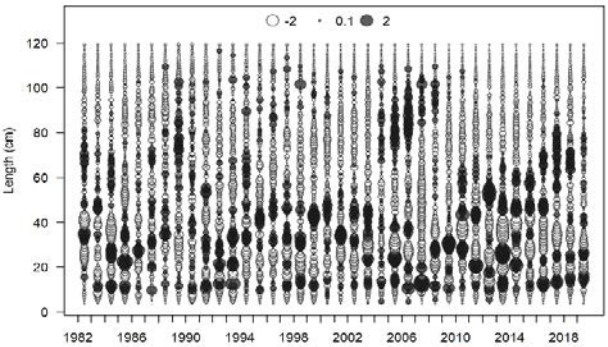
Model 20.8 (EBS+NBS)



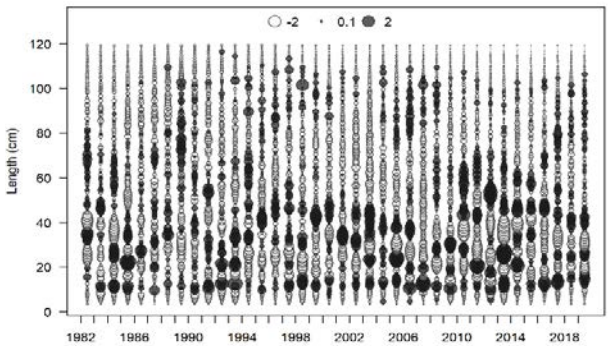
Model 19.12a (EBS+NBS)



Model 20.9 (EBS+NBS)



Model 19.15 (EBS only)



Model 20.10 (EBS+NBS)

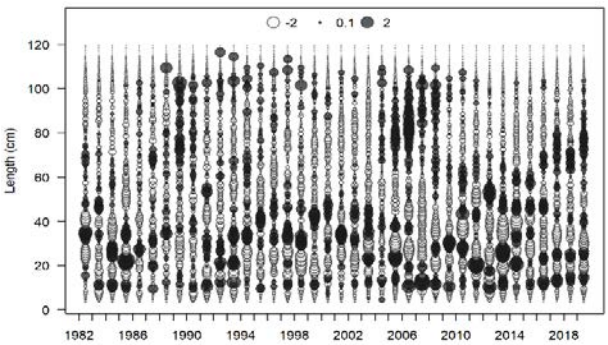


Figure 2.13b. Residual plots of model fits to the main survey (EBS or EBS+NBS) size composition data.

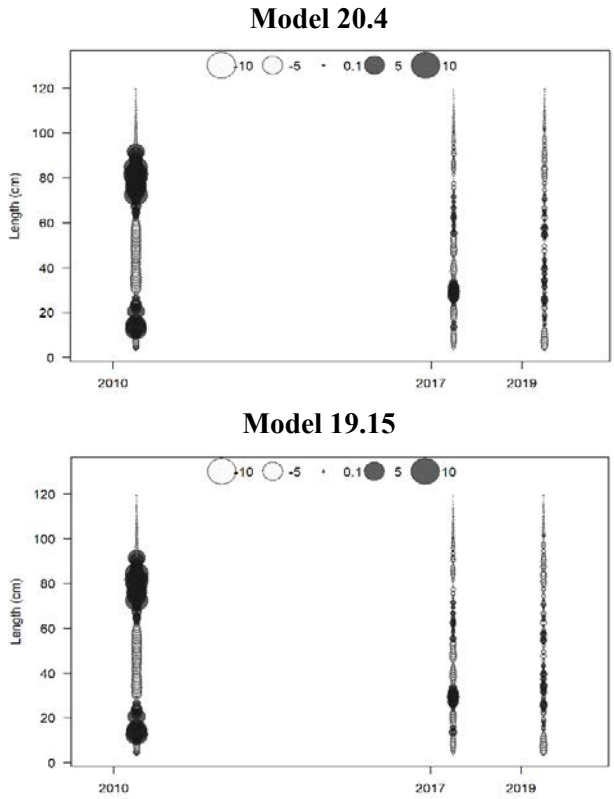
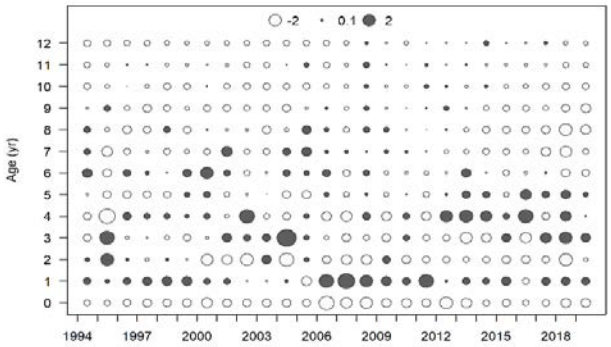
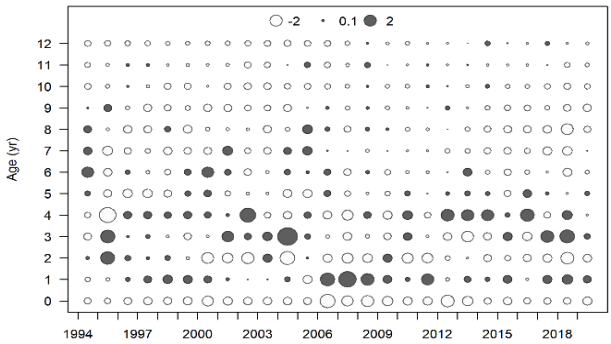


Figure 2.13c. Residual plots of model fits to the NBS survey size composition data.

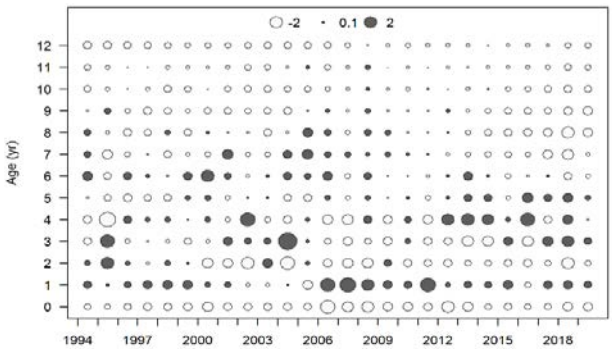
Model 19.12 (EBS+NBS)



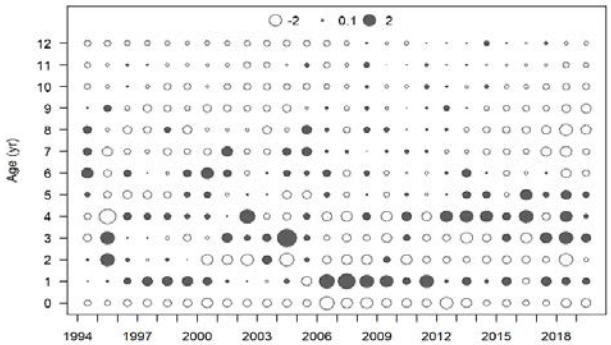
Model 20.4 (EBS only)



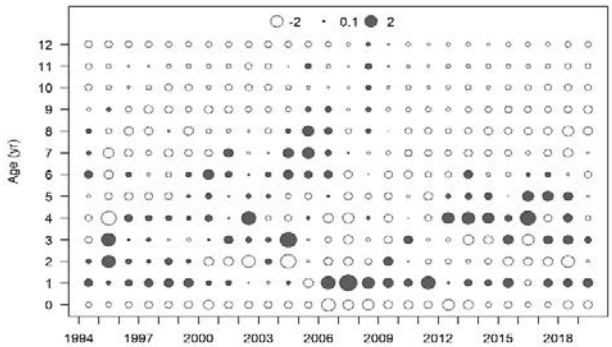
Model 20.8 (EBS+NBS)



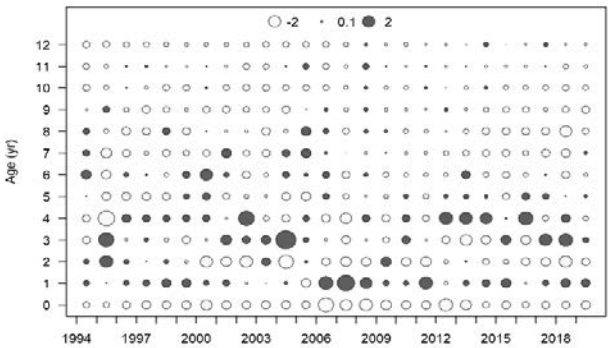
Model 19.12a (EBS+NBS)



Model 20.9 (EBS+NBS)



Model 19.15 (EBS only)



Model 20.10 (EBS+NBS)

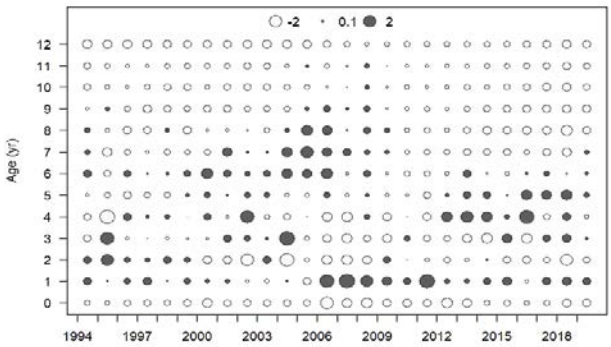
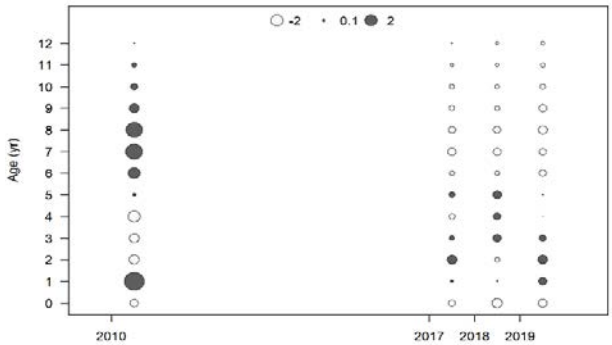


Figure 2.14a. Residual plots of model fits to the main survey (EBS or EBS+NBS) age composition data.

Model 20.4 (EBS only)



Model 19.15 (EBS only)

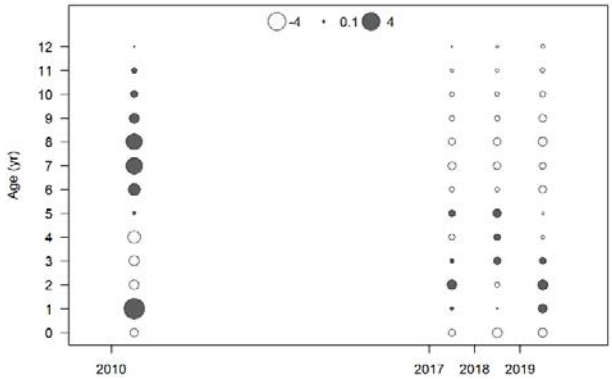


Figure 2.14b. Residual plots of model fits to the NBS survey age composition data.

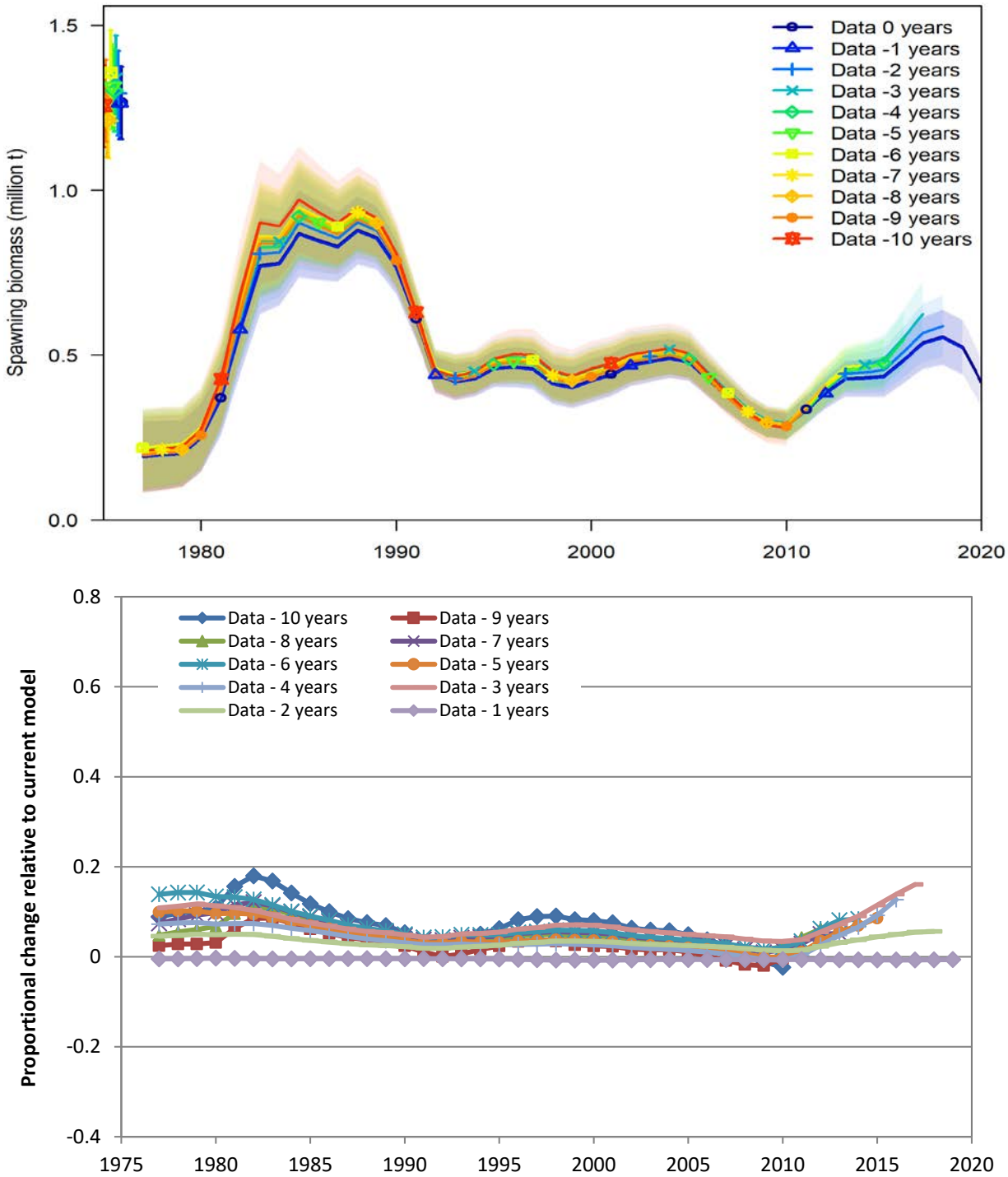


Figure 2.15a. Retrospective analysis of Model 20.4.

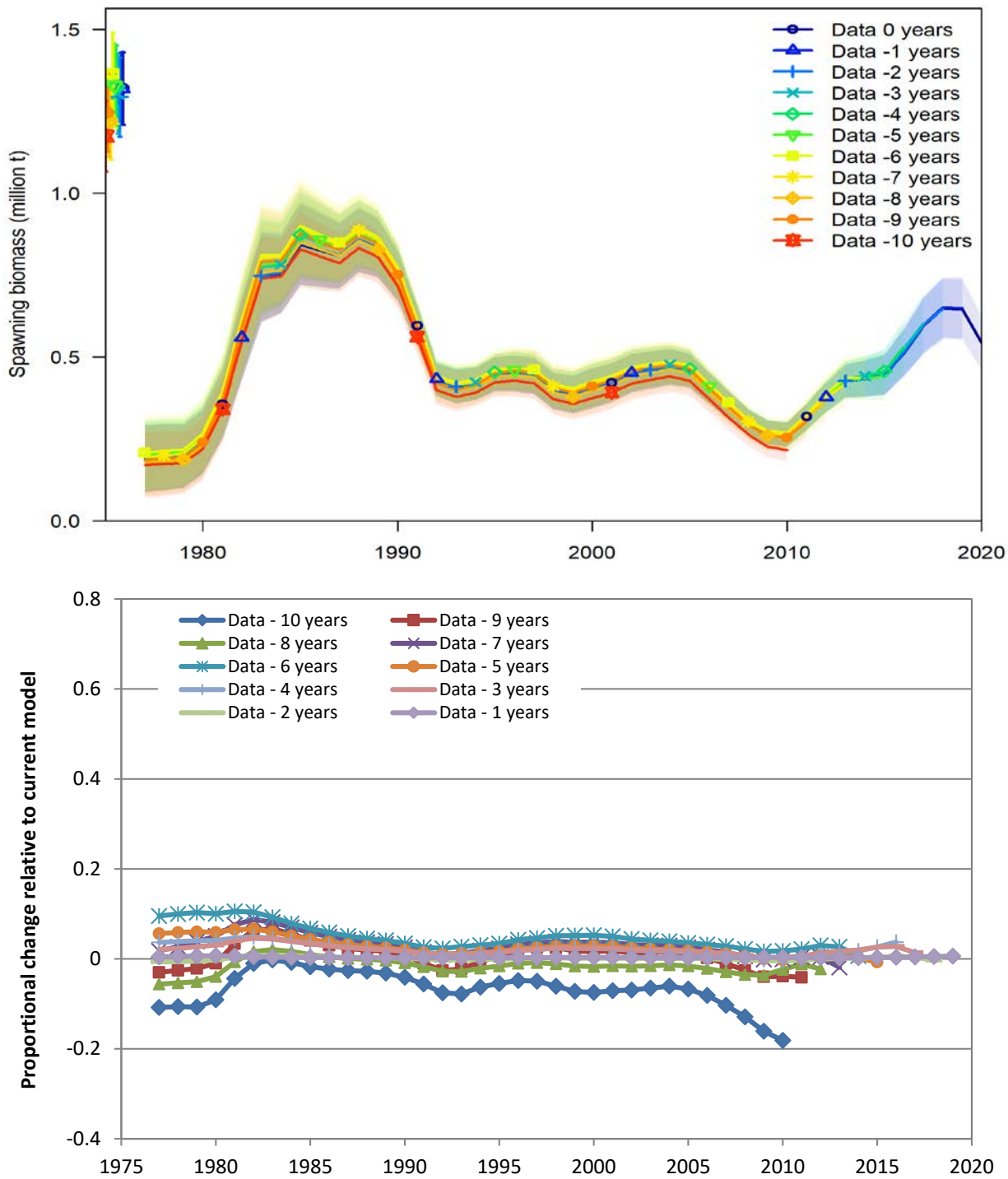


Figure 2.15b. Retrospective analysis of Model 19.12a.

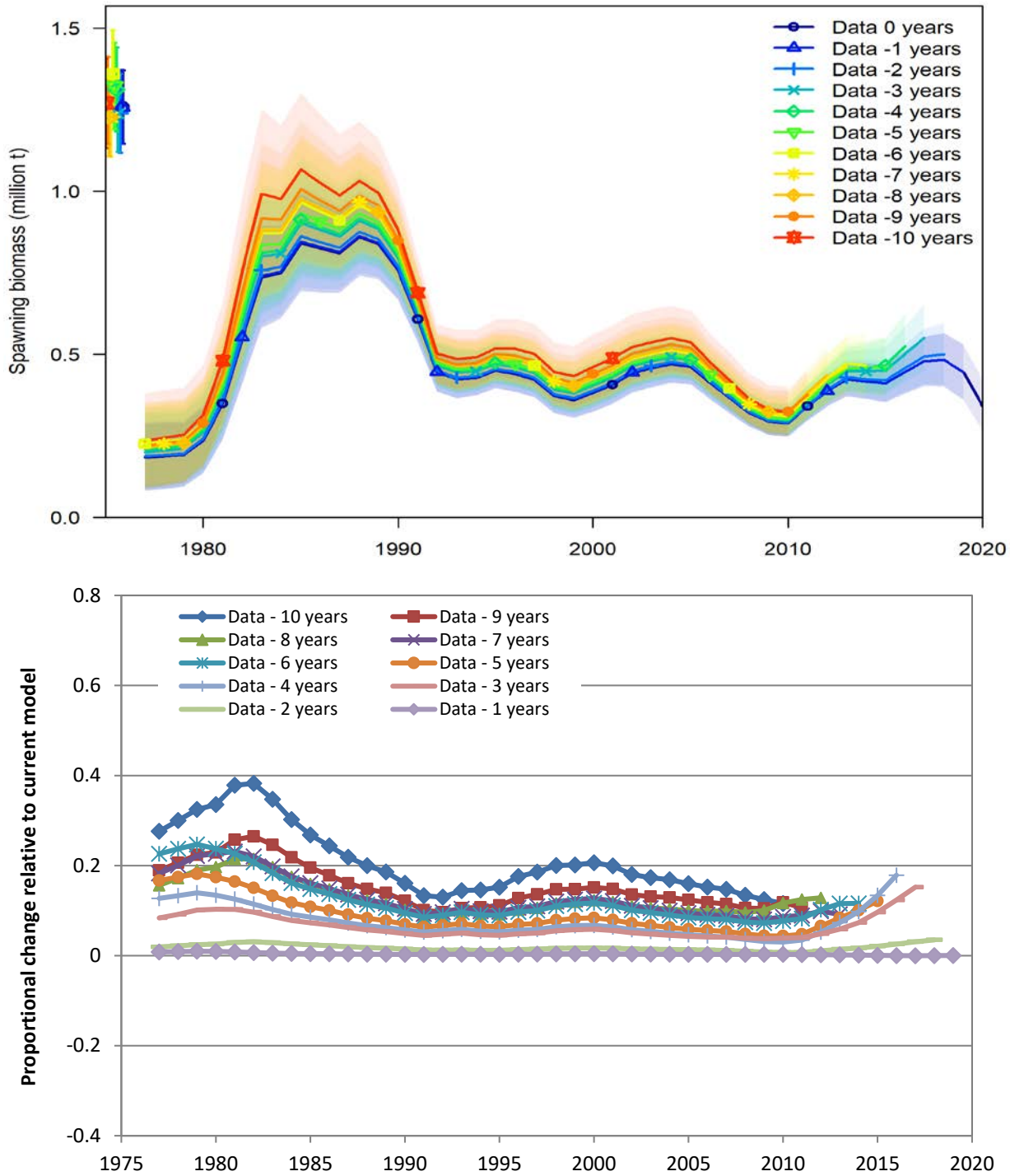


Figure 2.15c. Retrospective analysis of Model 19.15.

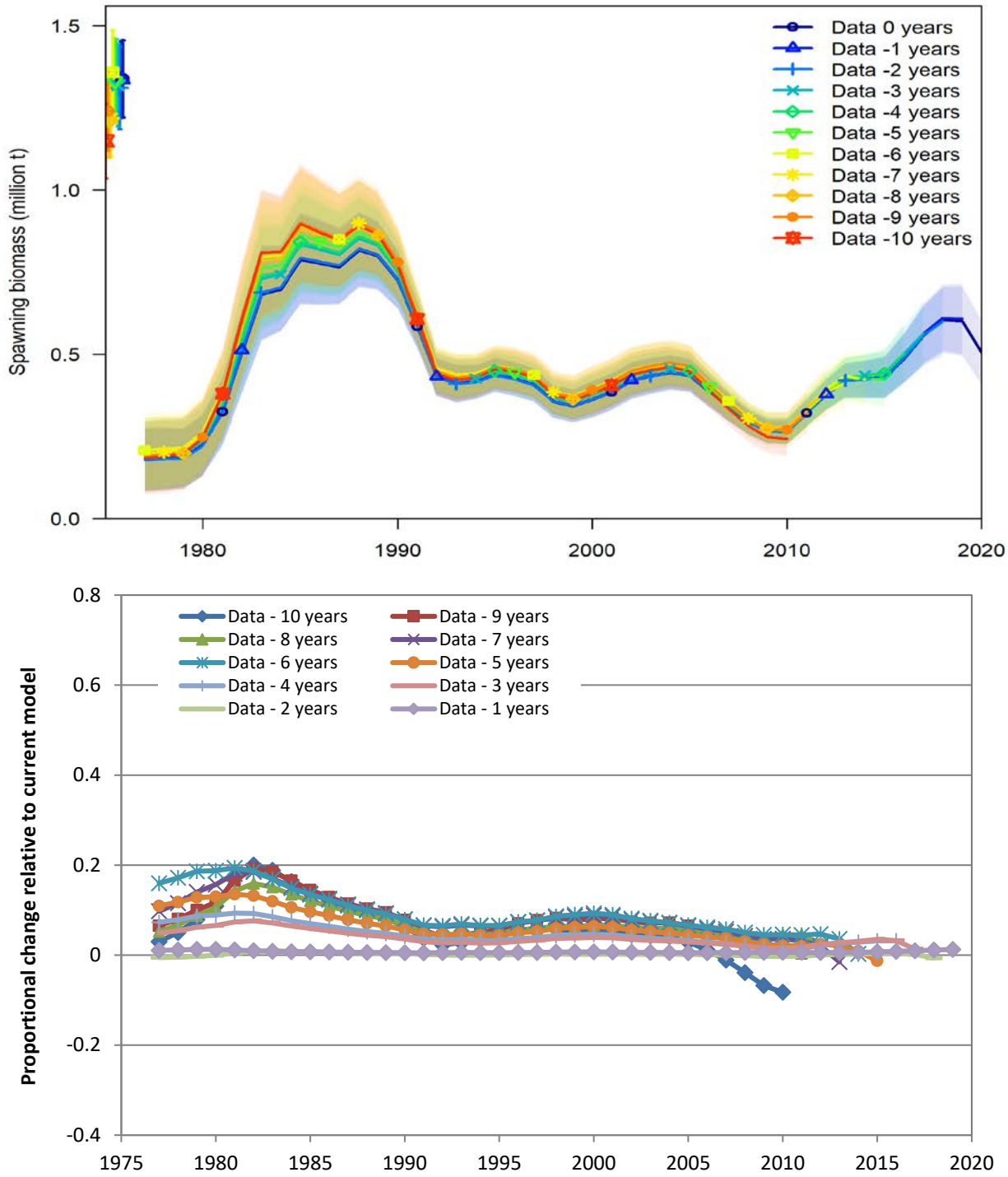


Figure 2.15d. Retrospective analysis of Model 19.12.

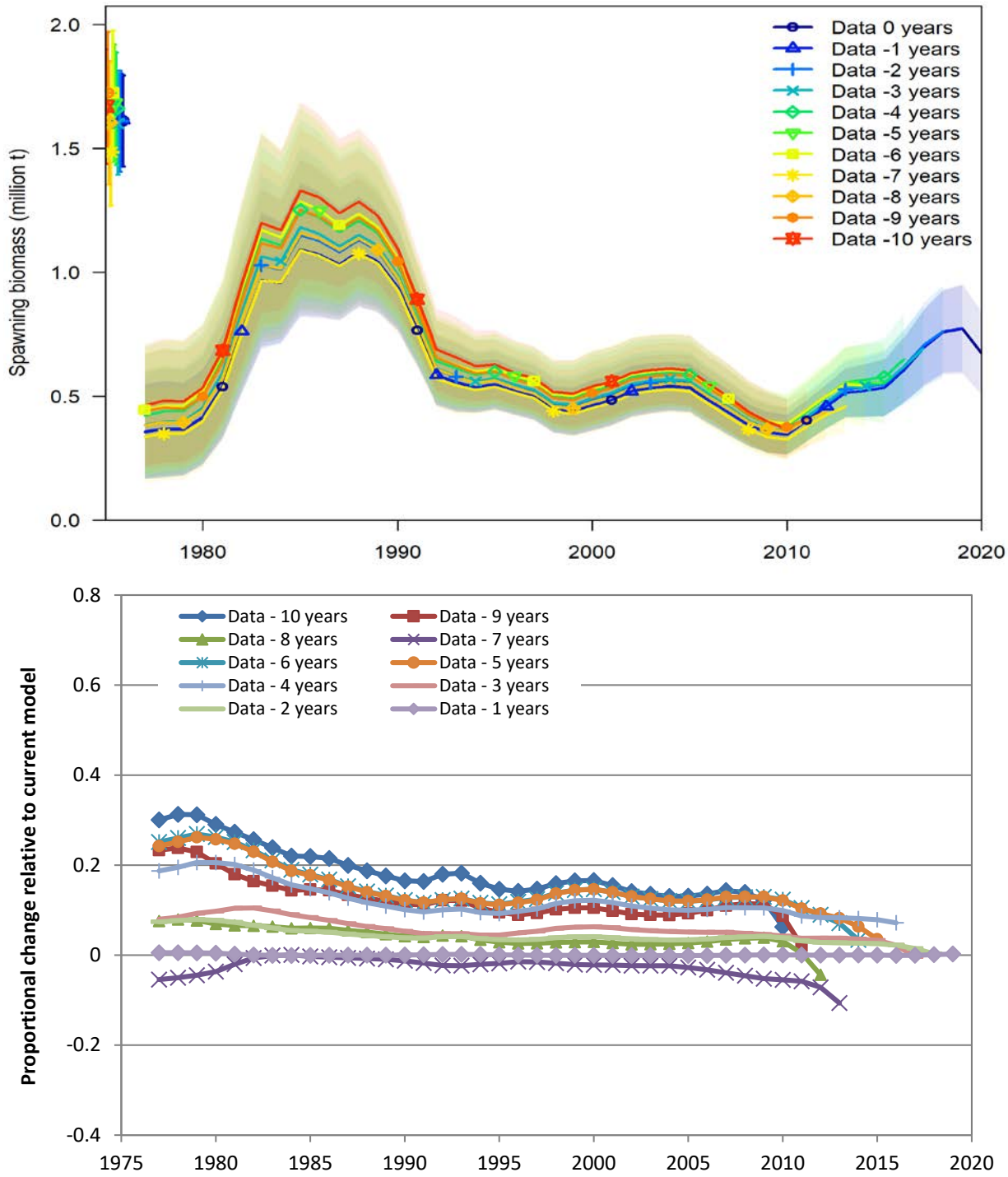


Figure 2.15e. Retrospective analysis of Model 20.8.

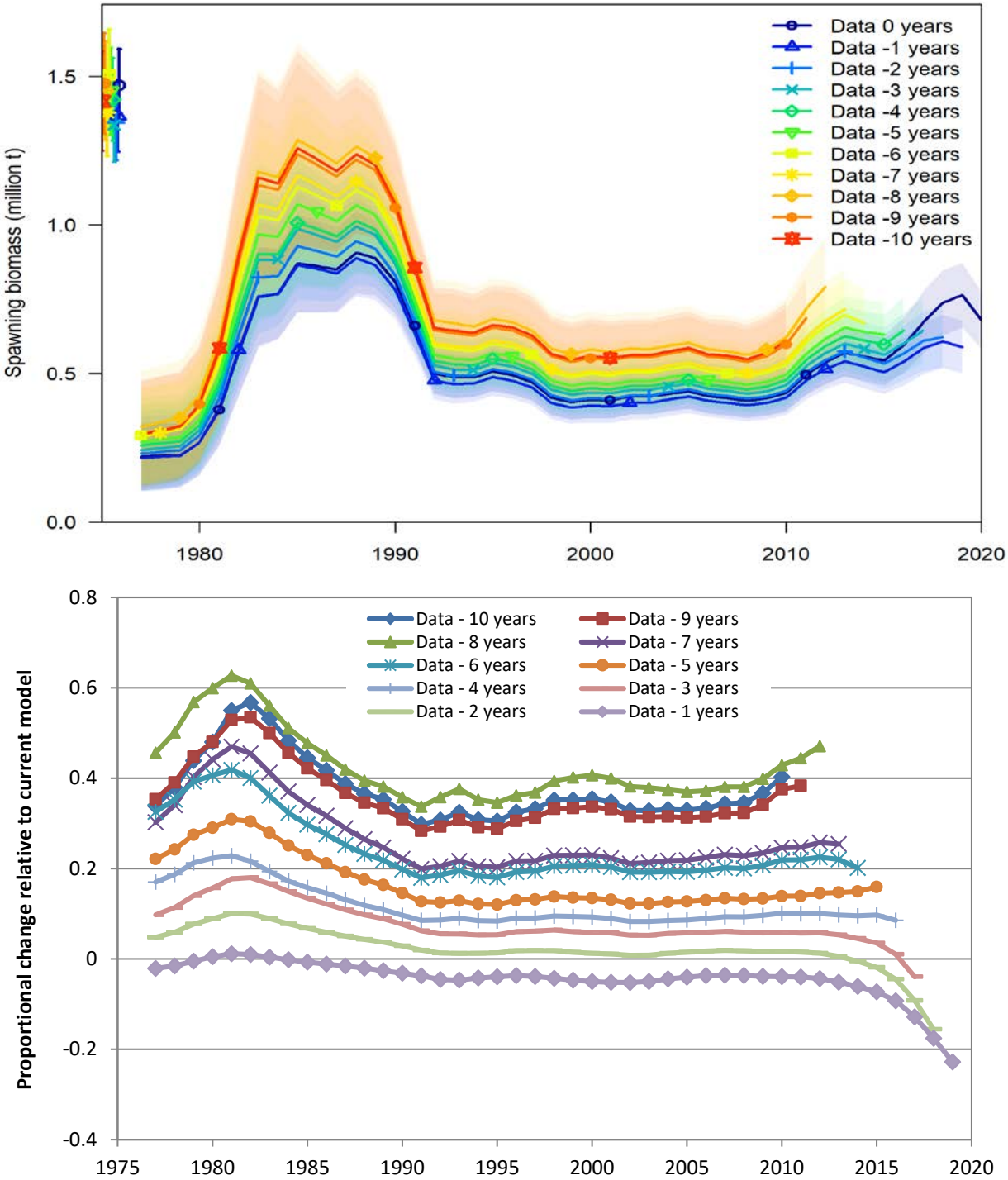


Figure 2.15f. Retrospective analysis of Model 20.9.

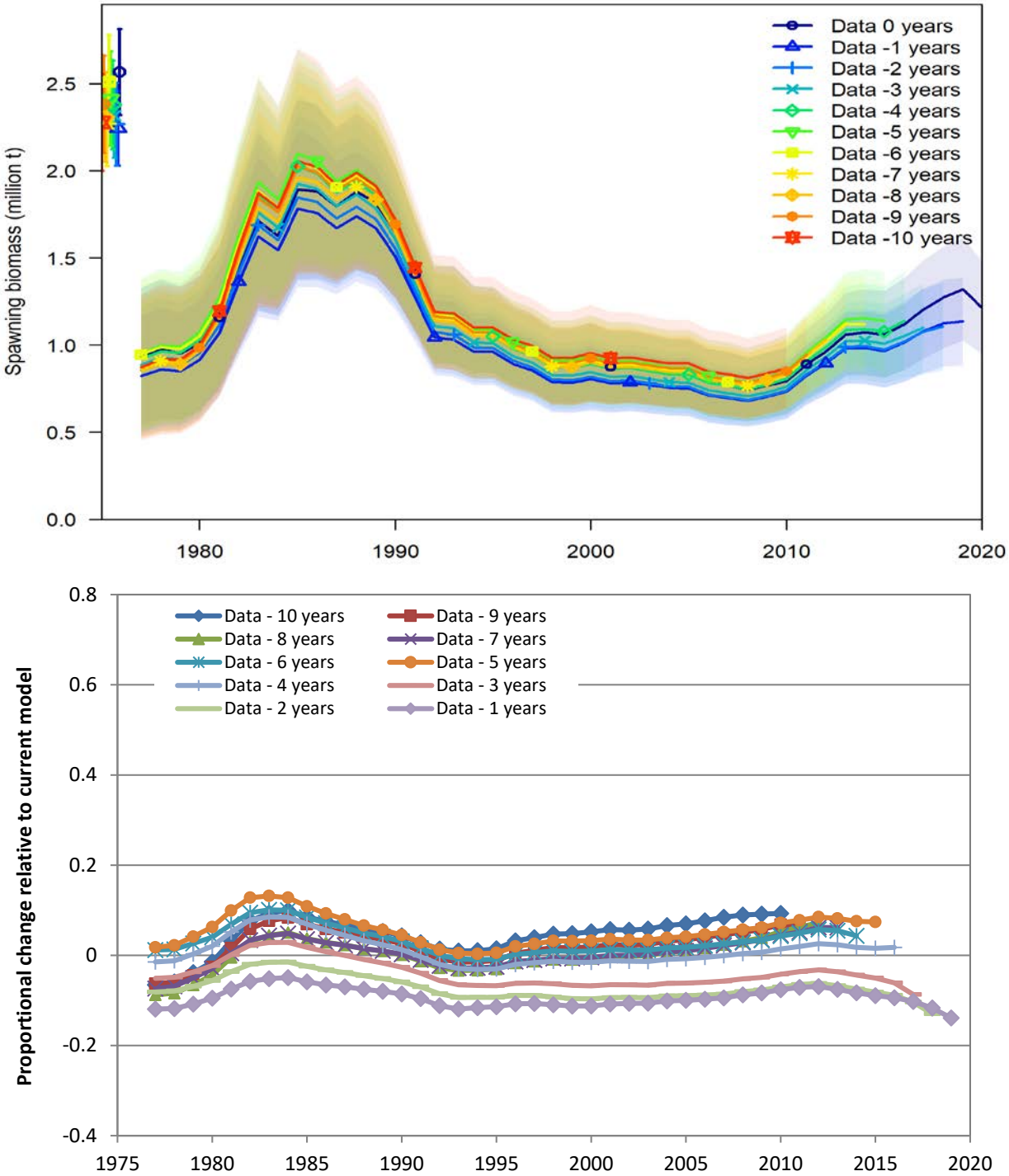


Figure 2.15g. Retrospective analysis of Model 20.10.

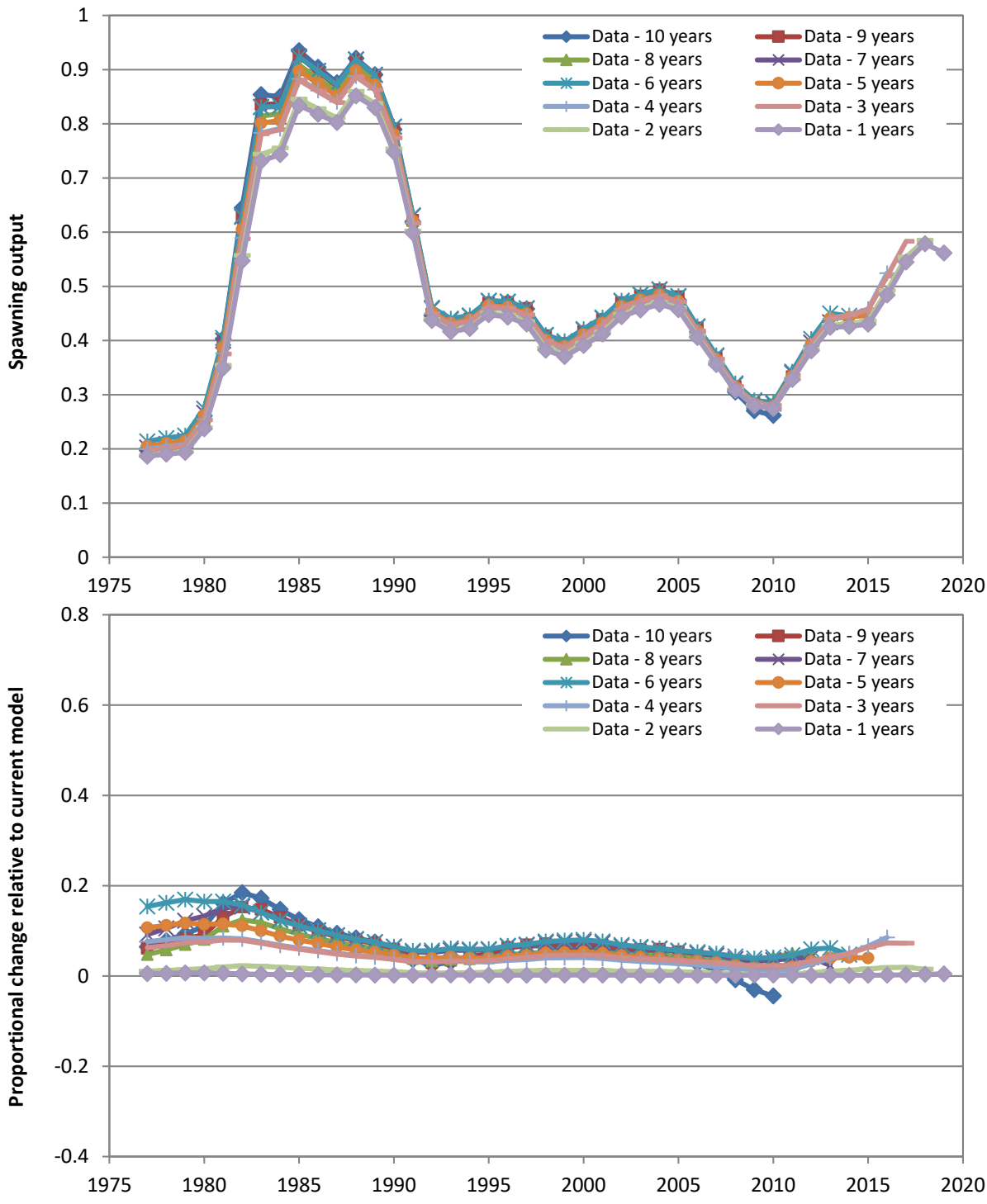


Figure 2.15h. Retrospective analysis of Ensemble A.

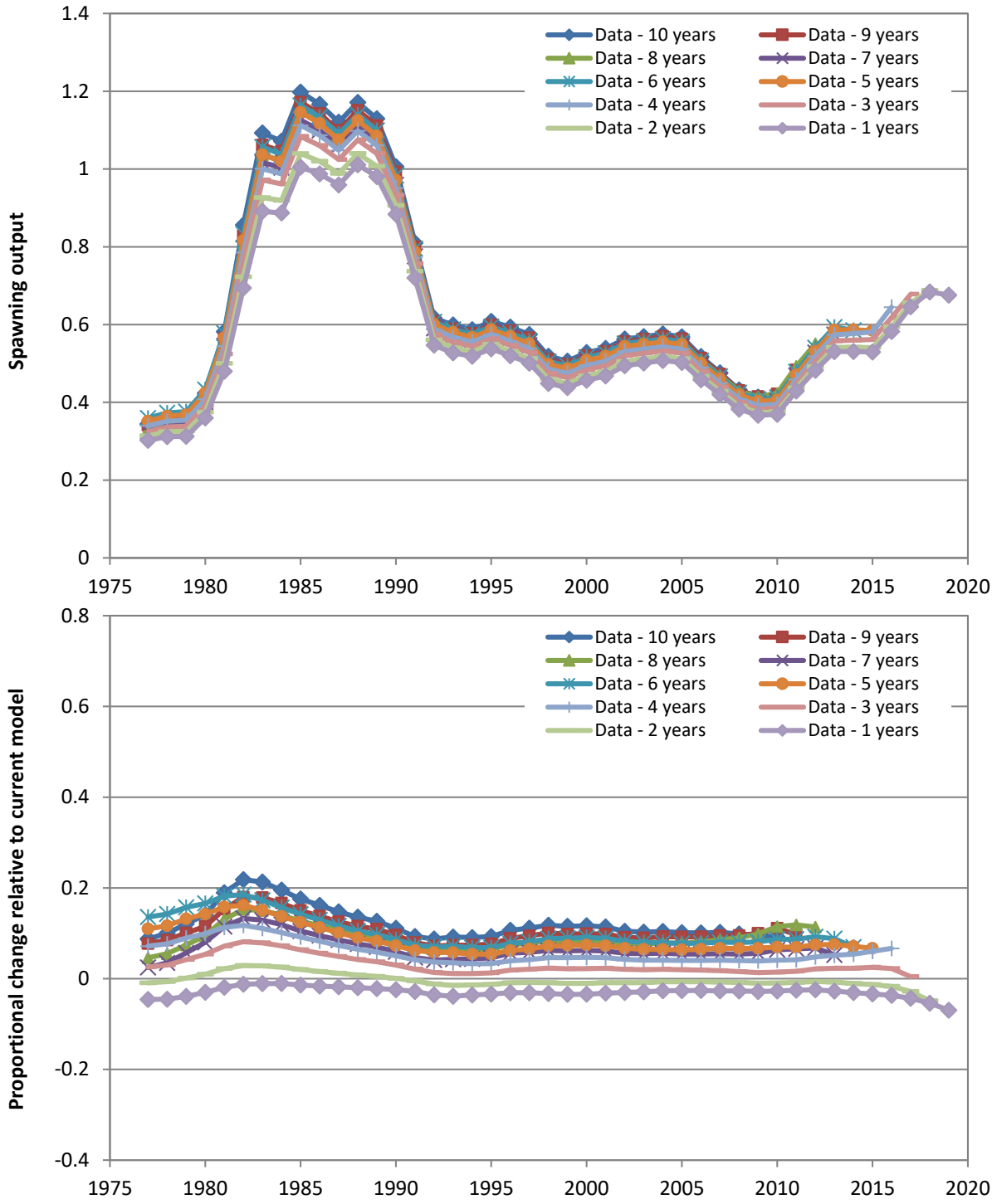


Figure 2.15i. Retrospective analysis of Ensemble AB.

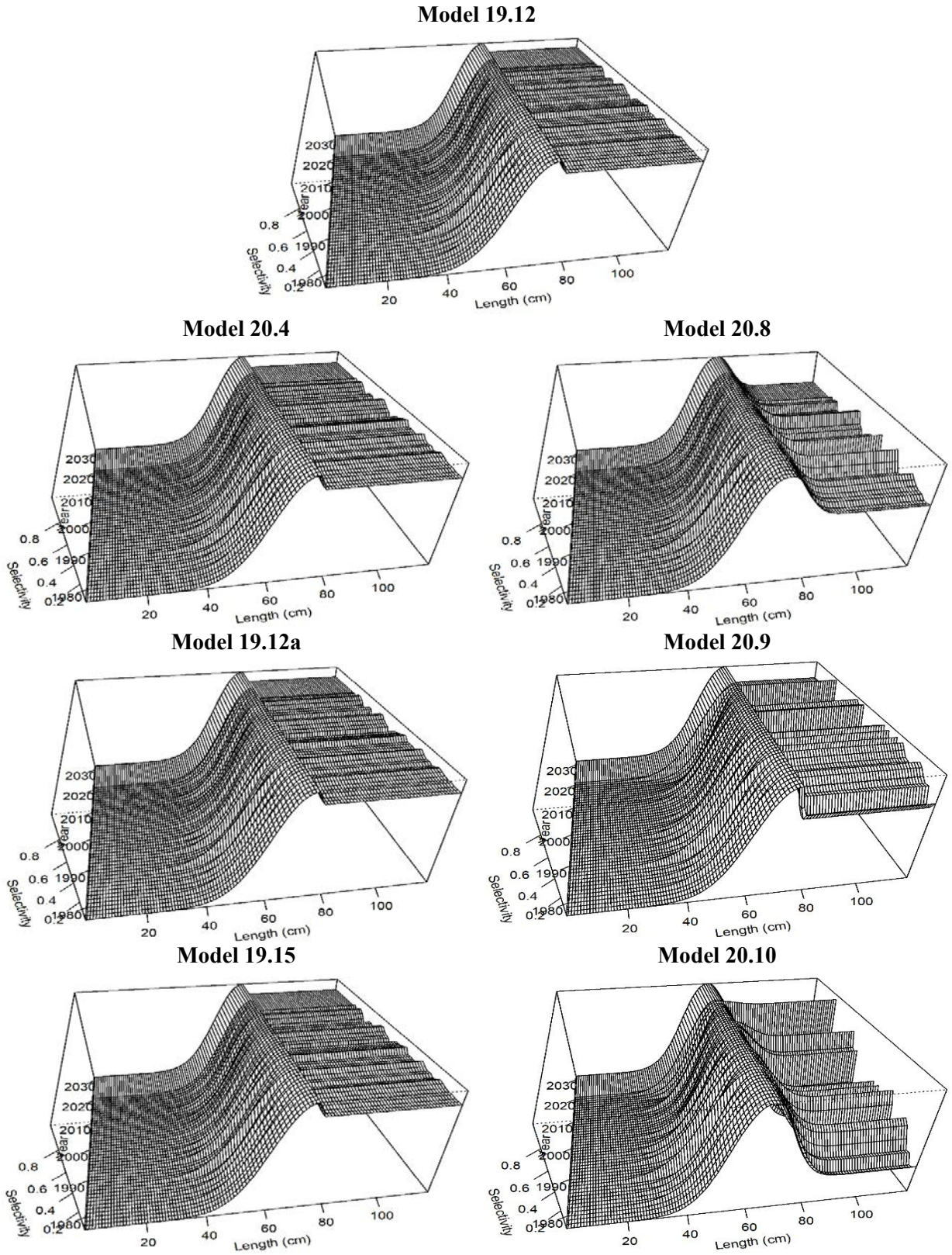
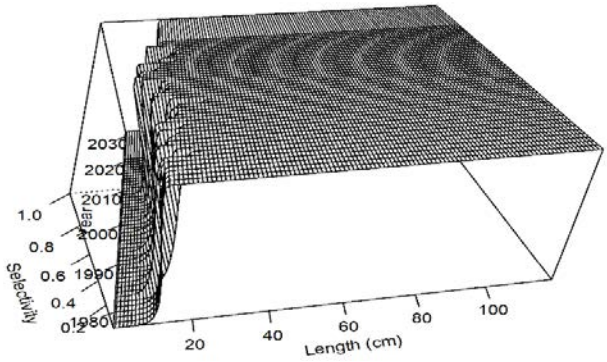
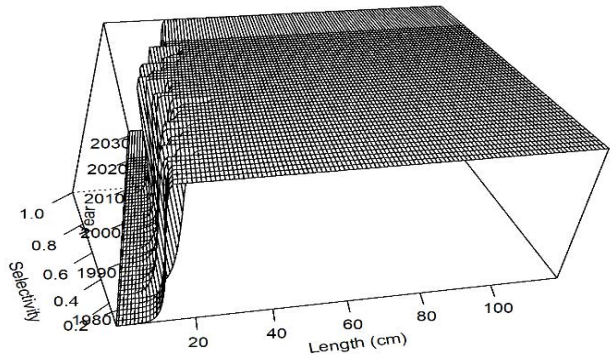


Figure 2.16a. Selectivity at age for the fishery.

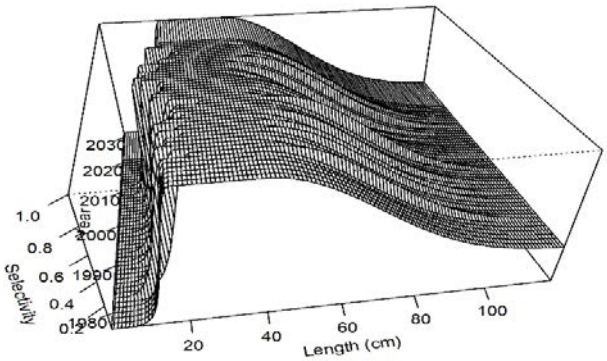
Model 19.12 (EBS+NBS)



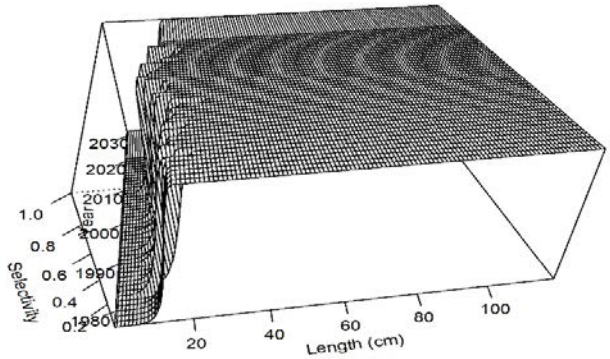
Model 20.4 (EBS only)



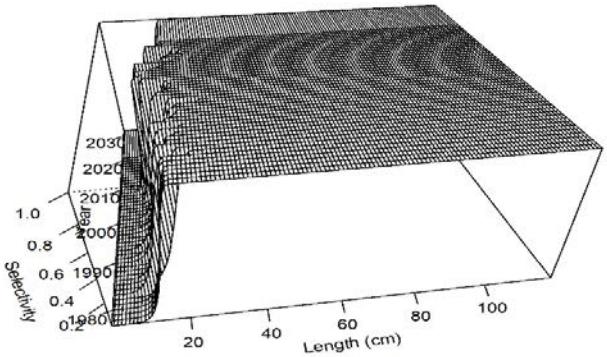
Model 20.8 (EBS+NBS)



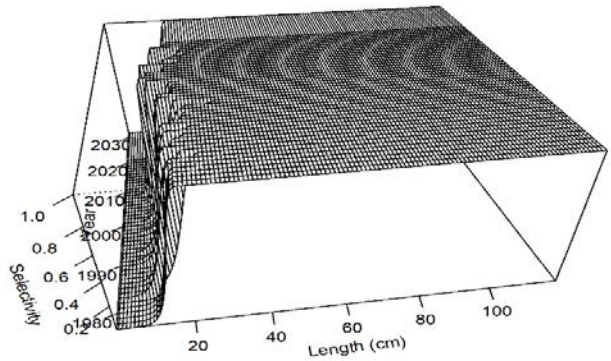
Model 19.12a (EBS+NBS)



Model 20.9 (EBS+NBS)



Model 19.15 (EBS only)



Model 20.10 (EBS+NBS)

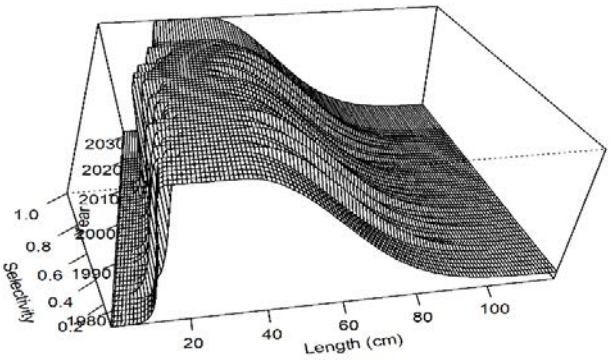


Figure 2.16b. Selectivity at age for the main survey (EBS or EBS+NBS).

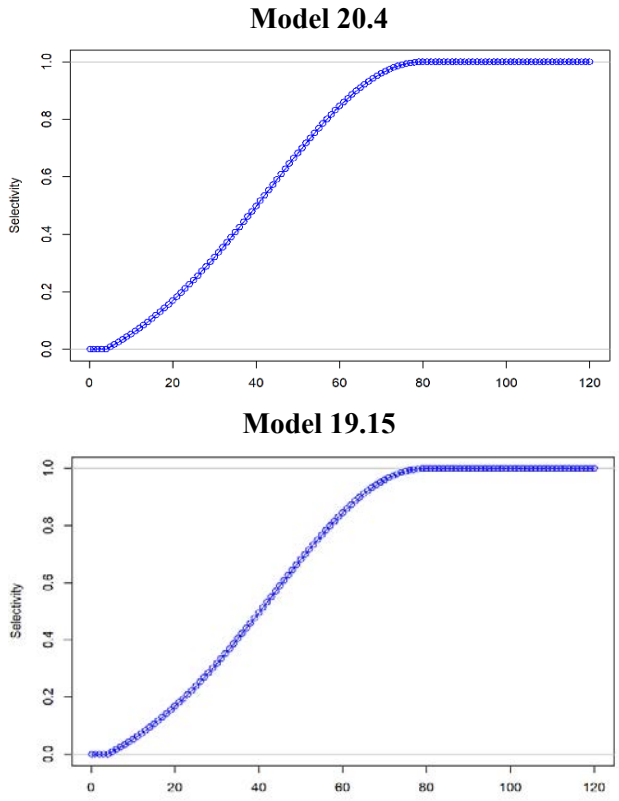


Figure 2.16c. Selectivity at age for the NBS survey.

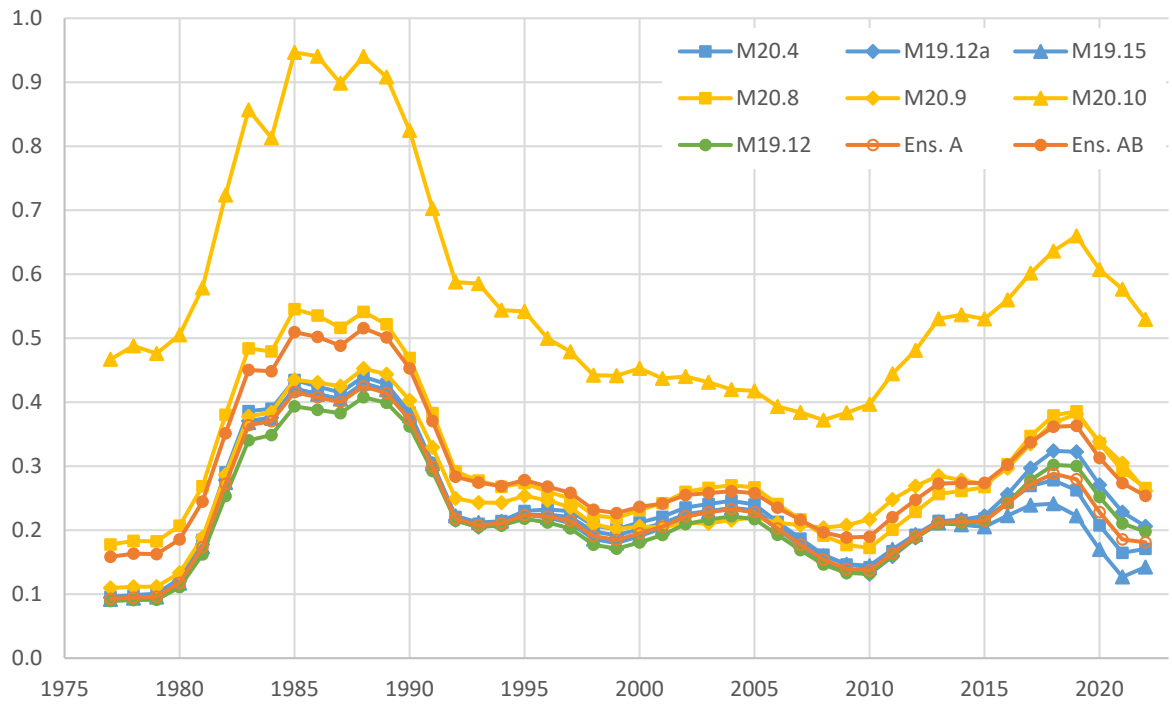


Figure 2.17. Female spawning biomass (millions of t) time series.

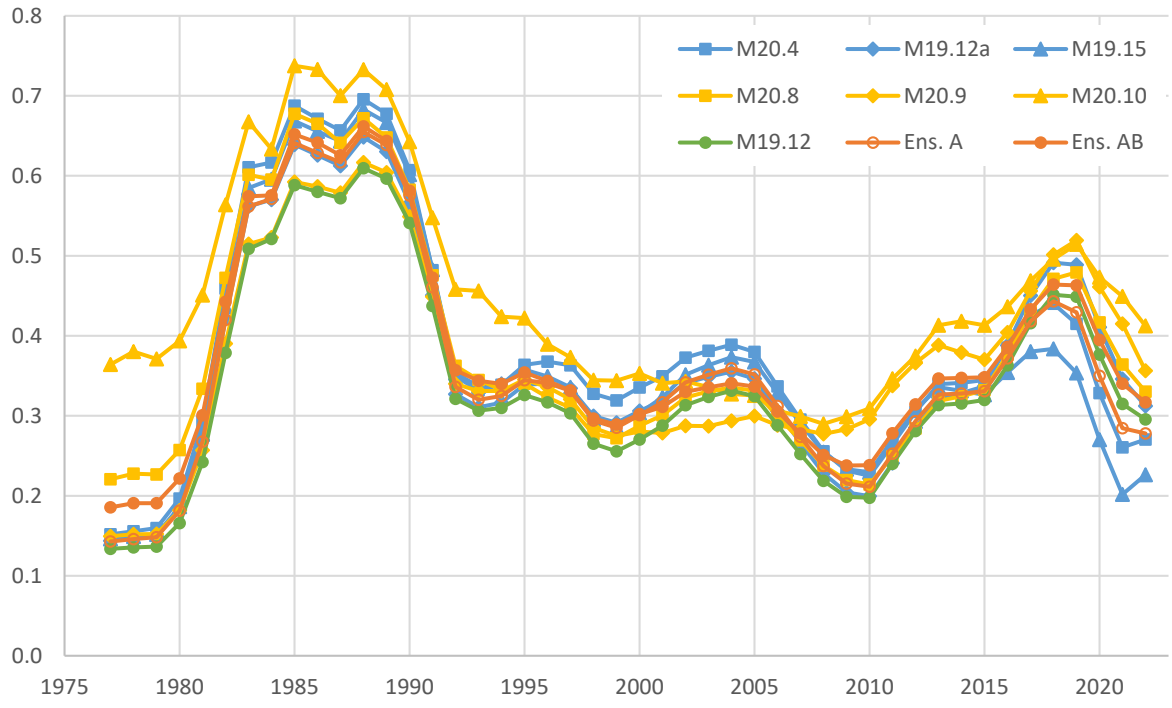


Figure 2.18. Relative spawning biomass time series.

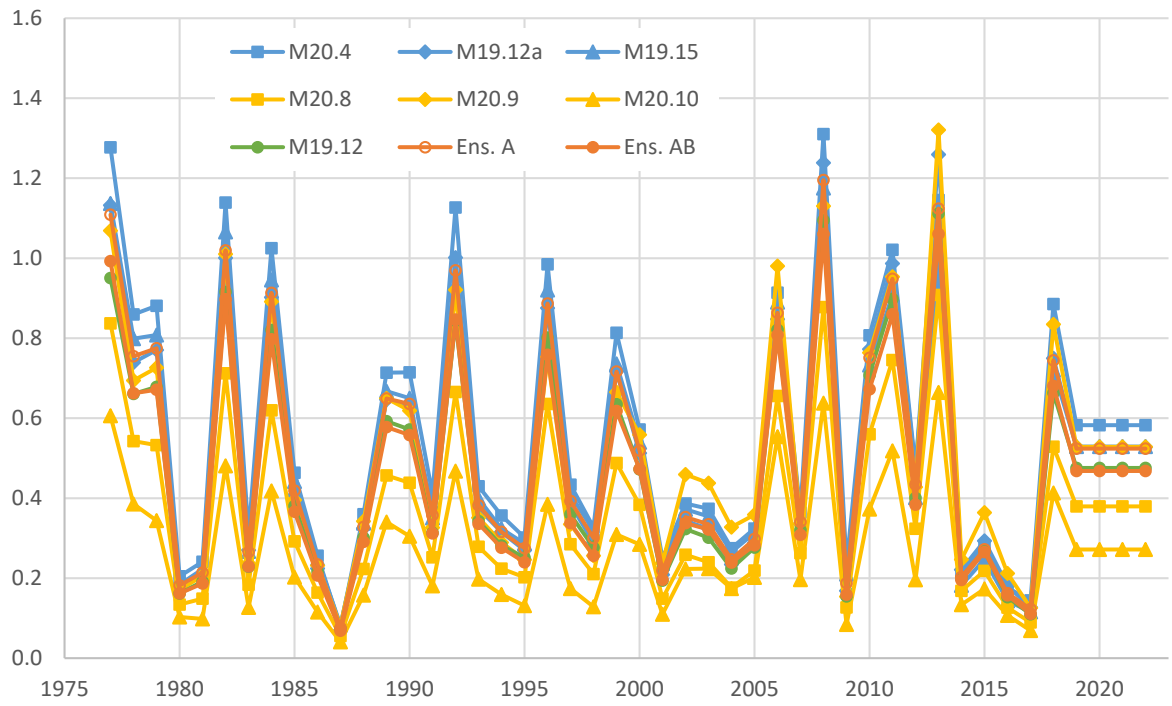


Figure 2.19. Recruitment (billions of fish) time series.

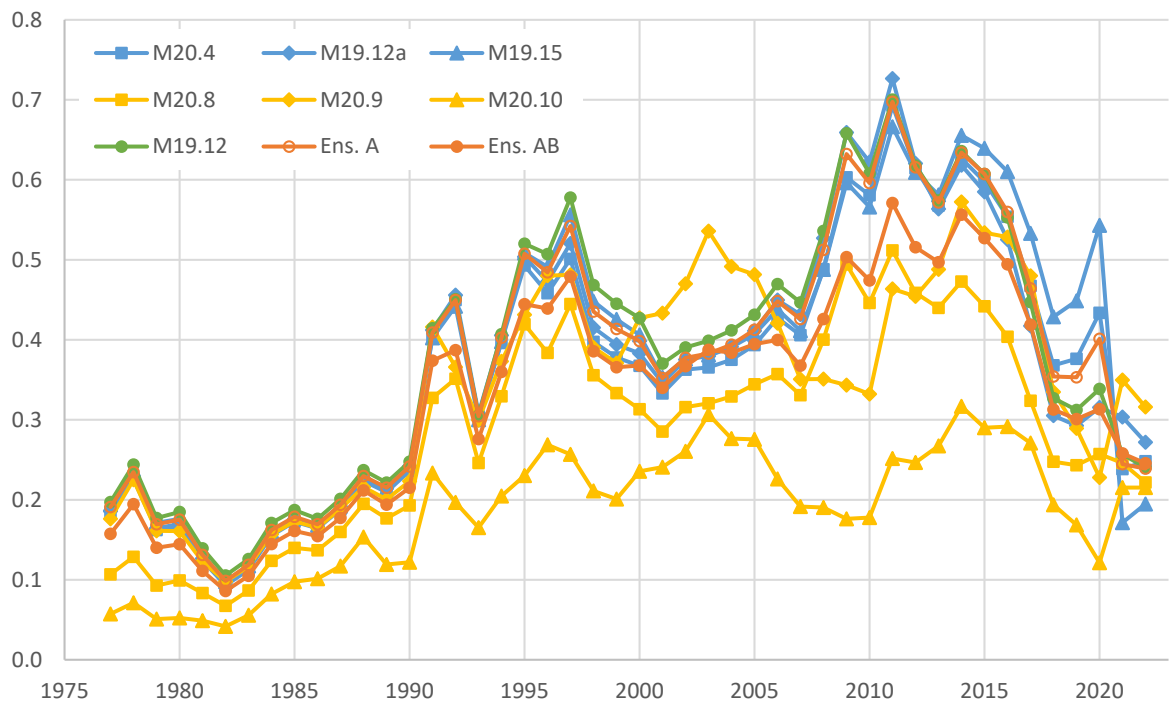


Figure 2.20. Full selection fishing mortality time series.

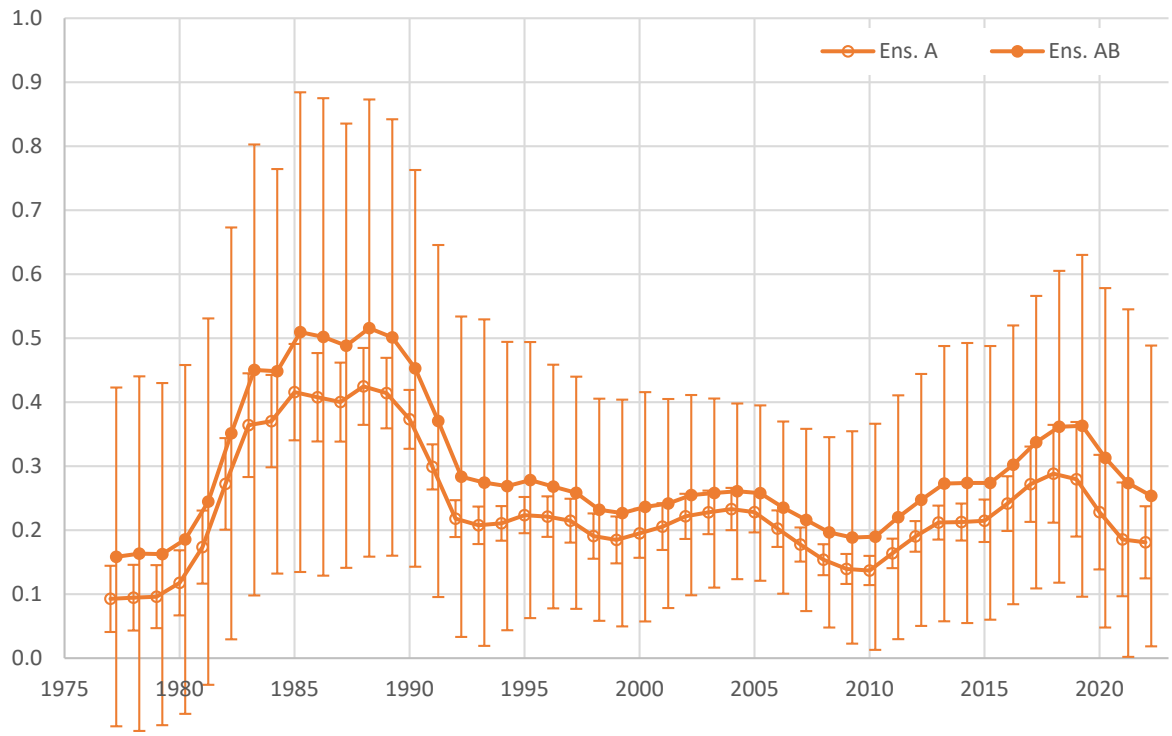


Figure 2.21. Ensemble estimates of female spawning biomass (millions of t), +/– 2 standard deviations.

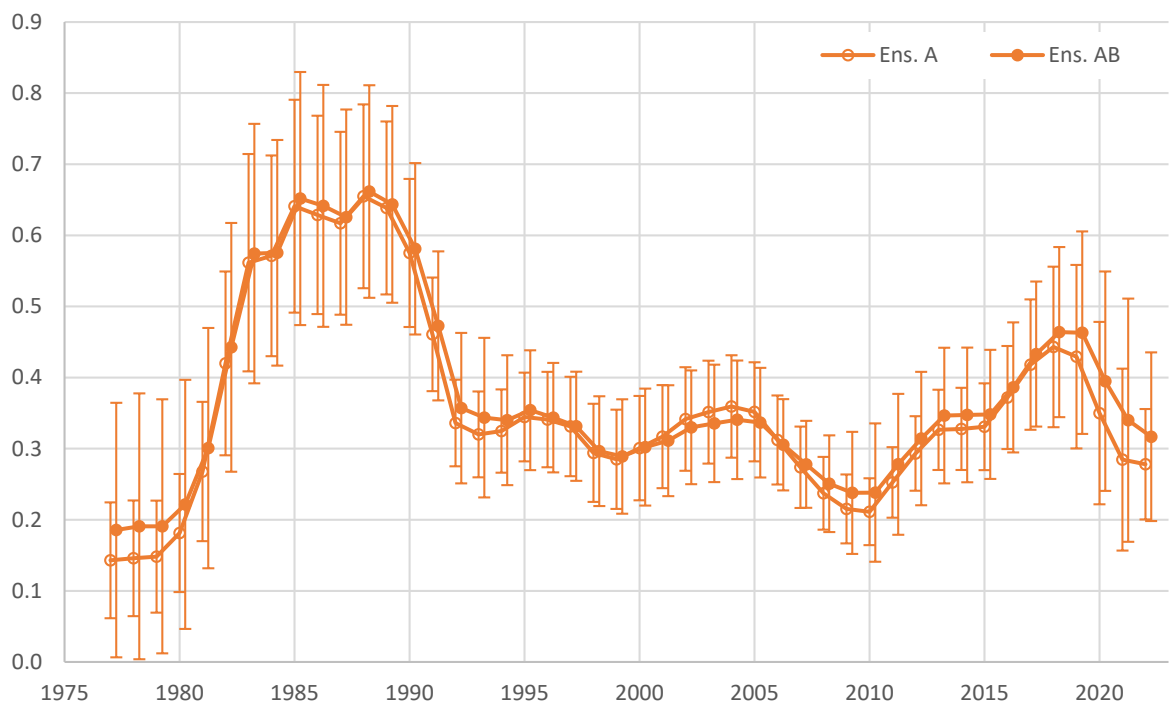


Figure 2.22. Ensemble estimates of relative spawning biomass, +/– 2 standard deviations.

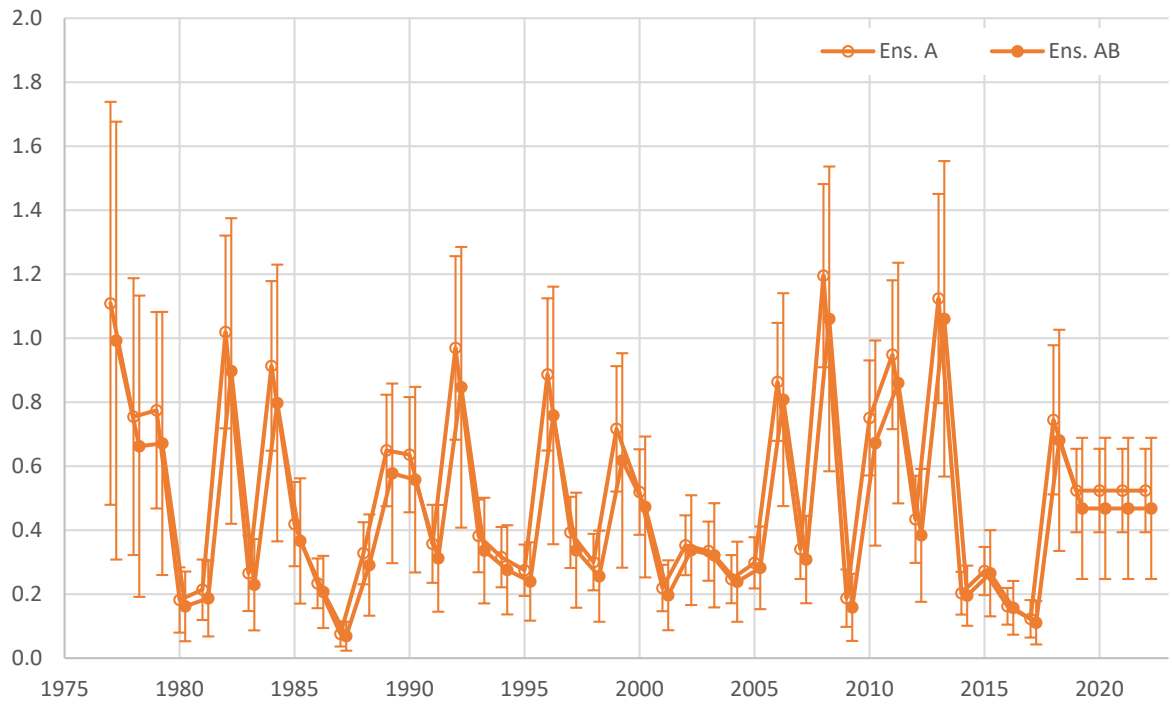


Figure 2.23. Ensemble estimates of recruitment (billions of fish), +/– 2 standard deviations.

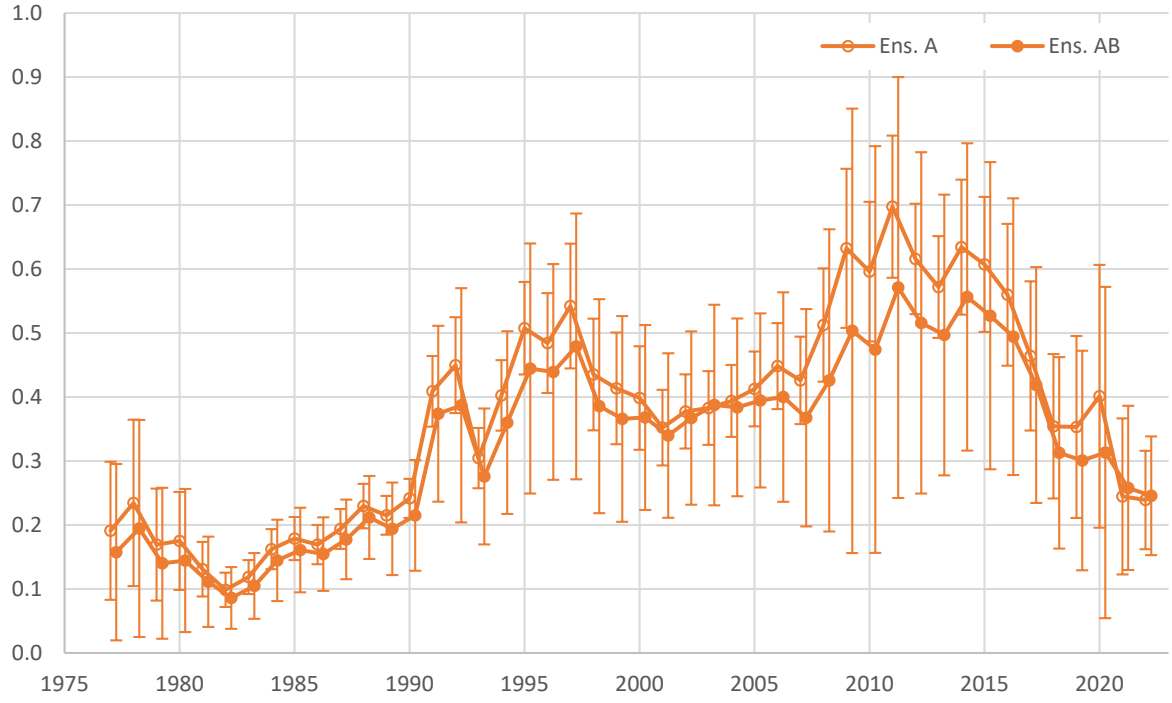


Figure 2.24. Ensemble estimates of full selection fishing mortality, +/– 2 standard deviations.

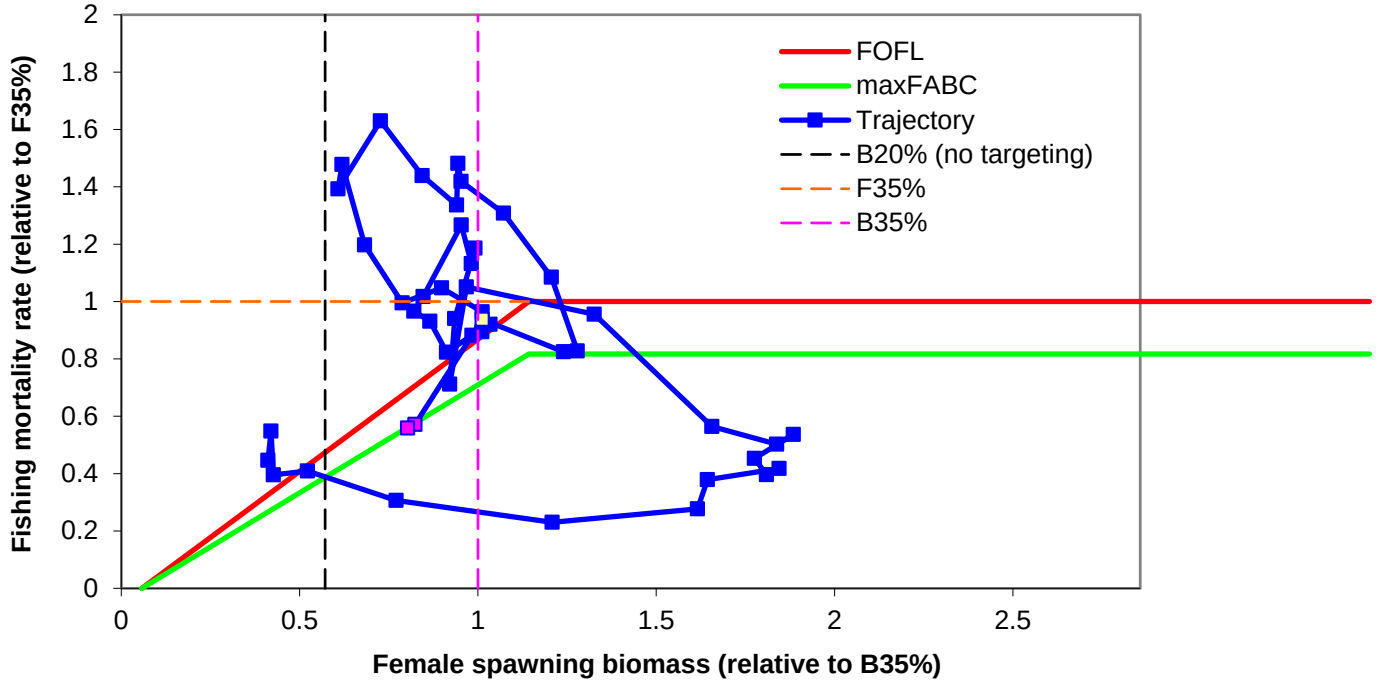


Figure 2.25a. Phase plane for Ensemble A.

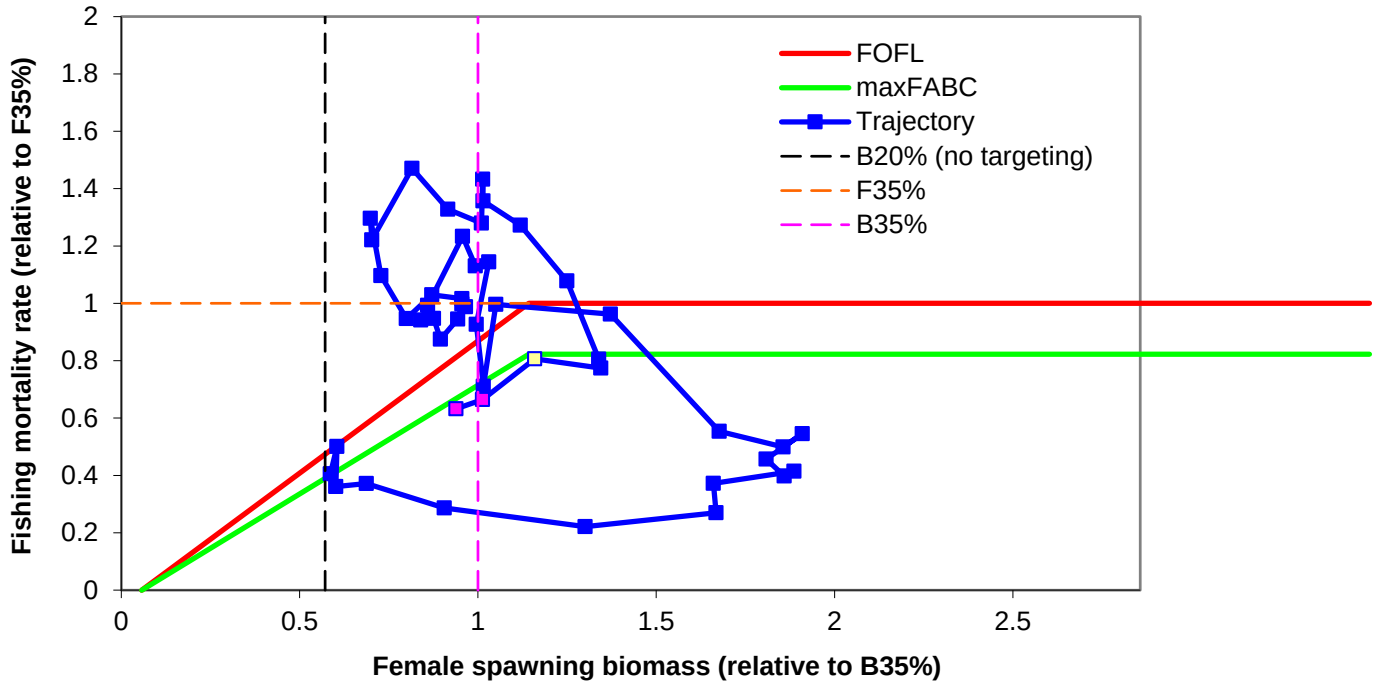


Figure 2.25b. Phase plane for the unweighted average ensemble.

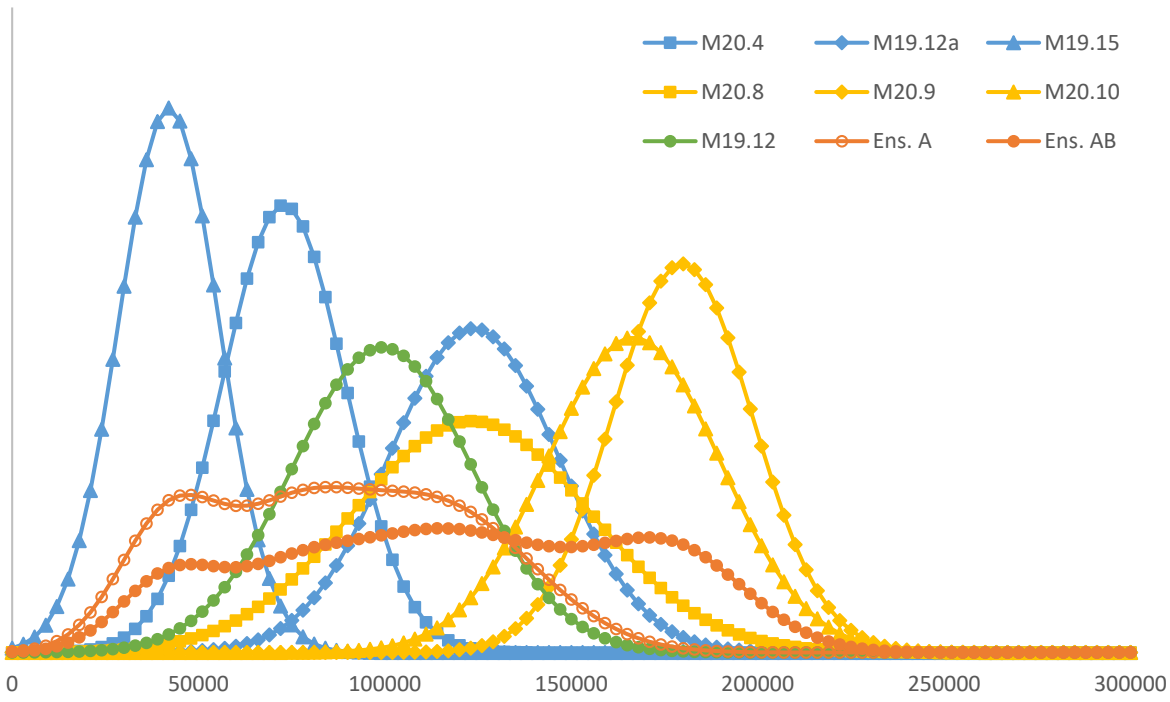


Figure 2.26a. Individual model and ensemble distributions of 2021 ABC.

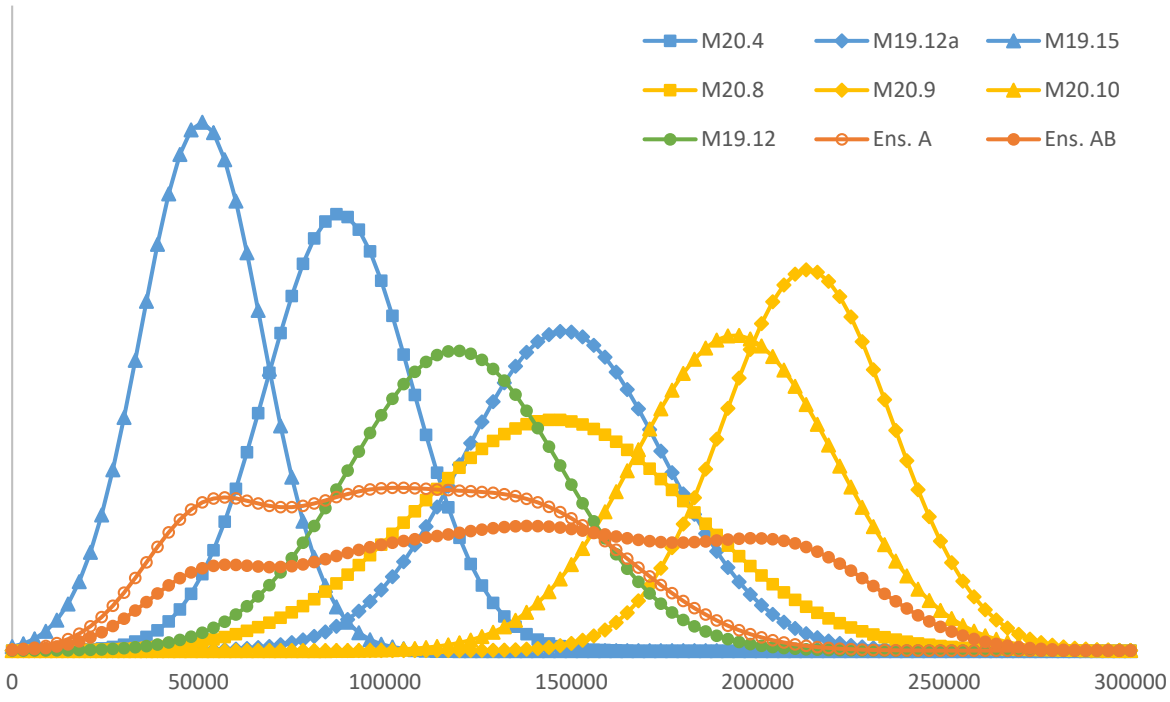


Figure 2.26b. Individual model and ensemble distributions of 2021 OFL.

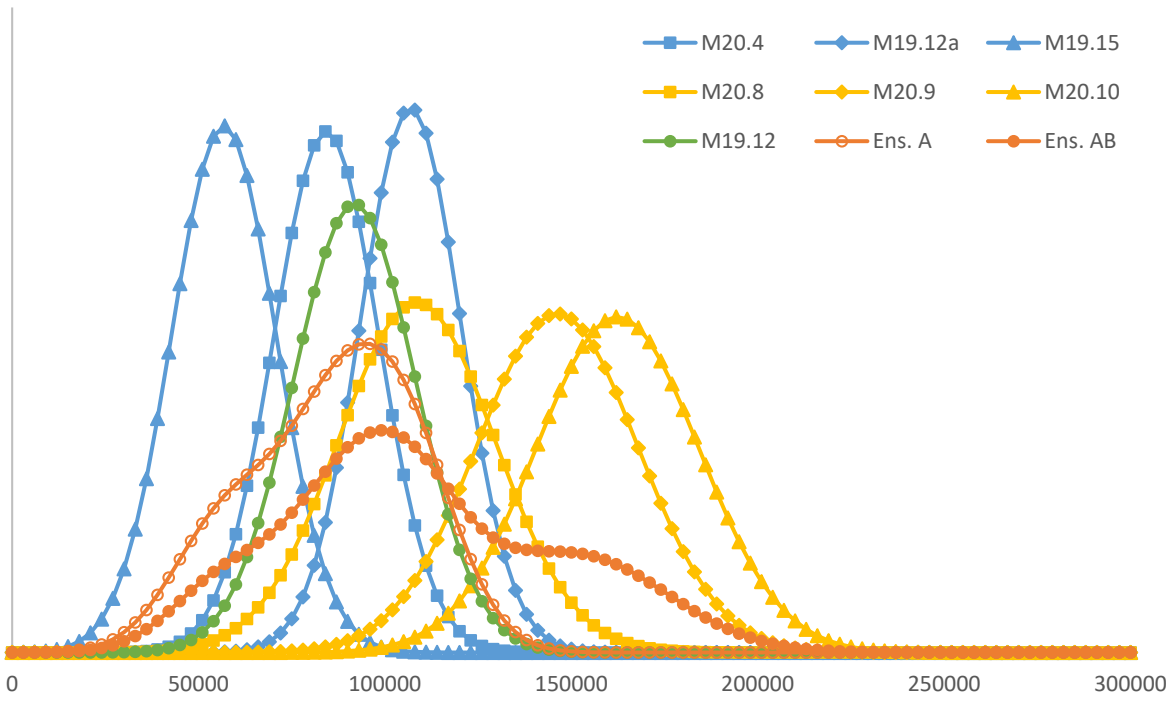


Figure 2.26c. Individual model and ensemble distributions of 2022 ABC.

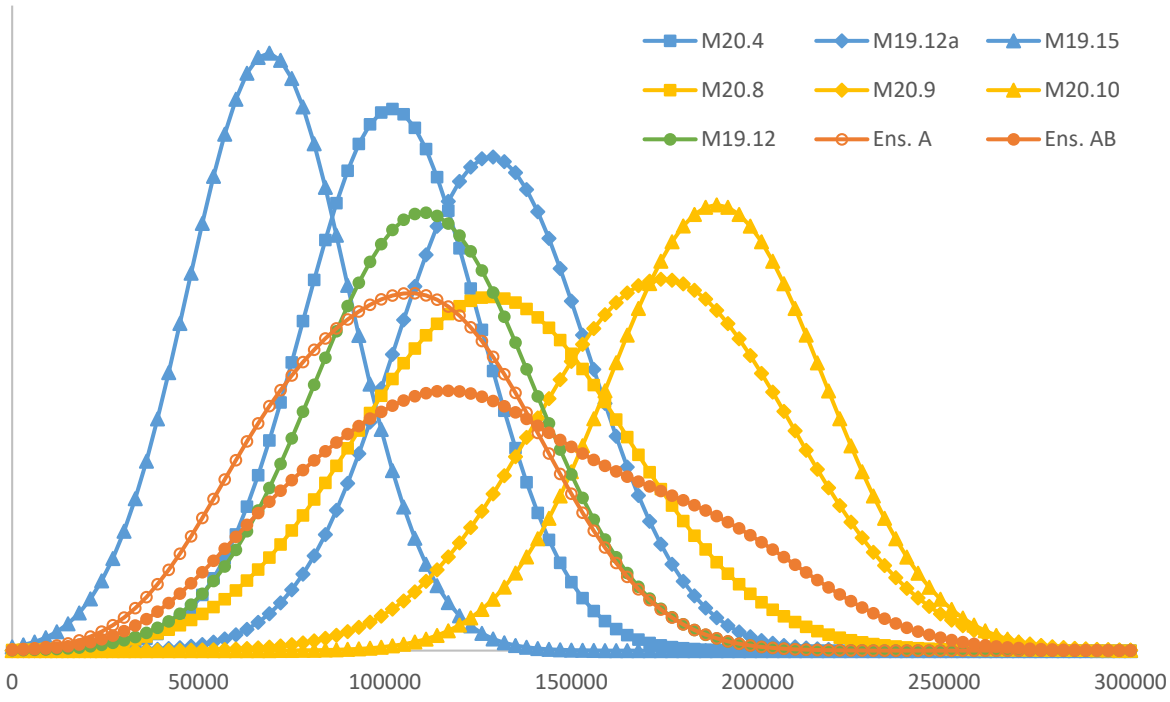


Figure 2.26d. Individual model and ensemble distributions of 2022 OFL.

APPENDIX 2.1: PRELIMINARY ASSESSMENT OF THE PACIFIC COD STOCK IN THE EASTERN BERING SEA

Grant G. Thompson

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Introduction

This document represents an effort to respond to comments made by the BSAI Plan Team ("Team") and the Scientific and Statistical Committee ("SSC") on last year's assessment of the Pacific cod stock in the Eastern Bering Sea ("EBS"), which also includes Pacific cod in the Northern Bering Sea ("NBS," Thompson and Thorson 2019).

Responses to Team and SSC comments on assessments in general

Comments from the November 2019 Joint Groundfish Plan Team meeting
JPT1: "The Teams recommended that authors continue to fill out the risk tables for full assessments." *Response*: This request will be addressed in the final assessment.

JPT2: "The Teams recommended that adjustment of ABC in response to levels of concern should be left to the discretion of the author, the Team(s), and/or the SSC, but should not be mandated by the inclusion of a >1 level in any particular category." *Response*: This request will be addressed in the final assessment.

Comments from the December 2019 SSC meeting
SSC1: "The SSC requests that the GPTs, as time allows, update the risk tables for the 2020 full assessments, as the SSC found this exercise to be very helpful." *Response*: This comment will be addressed in the final assessment.

SSC2: "The SSC recommends dropping the overall risk scores in the tables." *Response*: This comment will be addressed in the final assessment.

SSC3: "The SSC requests that the table explanations be included in all the assessments which include a risk table for completeness." *Response*: This comment will be addressed in the final assessment.

SSC4: "The SSC discussed whether increased risk or uncertainty was relative to previous assessments of the same stock, or relative to other stocks. Both are relevant and elaboration by the authors or GPTs as to what the elevated risk refers to is encouraged." *Response*: This comment will be addressed in the final assessment.

Responses to Team and SSC comments specific to this assessment
Note: Given the time constraints posed by this year's meeting schedule, the SSC co-chairs have suggested that authors not feel obligated to respond to all of last year's SSC and Team comments in this year's assessments.

Comments from the September 2019 BSAI Groundfish Team meeting
BPT1: "The Team recommends continuing investigation of the CCDA model averaging method, realizing it is unlikely to be implemented this year. The Team is very enthusiastic about this approach. The Team will discuss with the author whether additional input would be useful in further testing and developing the

method." *Response*: Investigation of the approach is continued in the "Cross-conditional decision analysis" (CCDA) section.

Comments from the October 2019 SSC meeting
SSC5: "The SSC thanks Dr. Thompson for his work on developing the CCDA and supports continued efforts to explore this method. An important feature of this work will be how this method interacts with existing FMP control rules, and specifically how the level of risk aversion chosen ("ra" term in the loss function) maps onto existing control rule policies." *Response*: The level of risk aversion used for calculating ABC in this preliminary assessment is derived from the current harvest control rules in Attachment 2.1.4.

Comments from the November 2019 BSAI Groundfish Team meeting
BPT2: "A major discussion point was whether all three hypotheses should be retained. Hypothesis #2, combining the EBS and NBS surveys, was deemed likely given the observations of Pacific cod in the NBS, no evidence of genetic difference, and the presence of age-1 fish throughout the EBS and NBS. Hypothesis #3 is useful because it admits that dynamics in the NBS may be different than in the EBS. However, the models presented did not capture this possibility and spatial models would be worth investigating. Hypothesis #1 is the most unlikely hypothesis but is worth retaining at this point because it: 1) is the legacy model, 2) is important to understand the dynamics operating at only the EBS level, 3) can help determine the synergy between the NBS and EBS regions, 4) had acceptable retrospective patterns, and 5) may be necessary if NBS surveys are discontinued. It was noted that models under hypothesis #2 may explain the dynamics similarly as models under hypothesis #1, but hypothesis #1 should be retained at least another year, even when given little weight in the ensemble. It was noted that hypothesis #2 carried most of the weight in the ensemble." *Response*: To recap, the hypotheses explored in last year's assessment were as follow: 1) Pacific cod in the NBS are insignificant to the managed stock, so the assessment should include data from the EBS only; 2) Pacific cod in the EBS and NBS comprise a single stock, and the EBS and NBS surveys can be modeled in combination; and 3) Pacific cod in the EBS and NBS comprise a single stock, but the EBS and NBS surveys should be modeled separately. Models consistent with Hypotheses #2 and #3 are included in this preliminary assessment (see this comment and comments BPT5 and SSC7), but models consistent with Hypothesis #1 have been dropped, in part because this hypothesis seems inconsistent with current knowledge regarding stock structure (see comment SSC7) and also in the interest of reducing the number of models (see comments BPT5 and SSC10). Instead, the ensemble included in this preliminary assessment includes models designed to address possible over-parameterization in Model 19.12 (see comment SSC9), use of spatial models (see this comment), and fish movement between areas (see comments BPT5 and SSC11).

BPT3: "The Team supported continued research into the abundance and mortality of Pacific cod outside of U.S. waters for inclusion in the stock assessment." *Response*: Some preliminary results on abundance of Pacific cod in the Western Bering Sea are summarized in the "Data provided for context only" section, courtesy of Cecilia O'Leary (AFSC).

BPT4: "The Team recommended using spatio-temporal models for survey data (i.e., VAST with a cold pool covariate and bias correction) and also recommended that the survey team investigate the efficacy of VAST estimates using methods such as cross-validation." *Response*: As in the ensemble of models included in last year's final assessments, all survey data used in the models presented here are based on the VAST approach, using a cold pool covariate with bias correction, with one exception: Technical issues precluded estimation of the 2019 survey age composition using VAST, so a design-based estimate is used here instead. No new results from cross-validation are available, although efforts are underway to use a "leave-one-out" approach in the next year or two (Jim Thorson, AFSC, *pers. commun*. 8/24/2020).

BPT5: "The Team recommended the 3×3 factorial design for defining models in the ensemble and feels that the current nine models should be used for management advice. Hypothesis #1 is the hypothesis under which the assessment has historically operated, and it is useful to carry forward that legacy and retain the historic EBS only assessment. Hypothesis #3 is useful because it allows for a single stock with different dynamics in the two areas. Although the three models for Hypothesis #3 did not perform particularly well, this hypothesis is useful and the Team supports further development of models under this hypothesis that may incorporate spatial processes such as migration and differences in growth, for example. All three hypotheses and levels of complexity incorporate features that are of interest and useful for explaining structural uncertainty, but it would be useful to investigate reducing the number of models, such as eliminating one of the hypotheses or one of the levels of complexity." *Response*: See comment BPT2.

BPT6: "The Team recommended retaining all models in the ensemble for this assessment, but to simplify and reduce workload, only report models that are above a cutoff of 1% weight to represent the base model in the next assessment. This would include five models for comparison next year." *Response*: In order to address several of the Team and SSC comments, it was necessary to rework the ensemble substantially for this preliminary assessment, and most of the five models referenced in this comment have been dropped. Model 19.12 is included in the new ensemble, as is a minor modification of Model 19.15, but the remaining members of last year's ensemble have been abandoned.

BPT7: "The Team recommended organizing the environmental/ecosystem considerations content of the risk table to those items that are associated with the stock and those that are not (working with ESP and ESR editors may help with this)." *Response*: This comment will be addressed in the final assessment.

BPT8: "The Team recommended a continued investigation into whether a change in growth contributed to the ageing bias fit for 2008 and onward in the complex models as ageing bias and growth may be confounded." *Response*: All models in this preliminary assessment include time-variability in length at age 1.5, but not in any of the other parameters describing size at age. This issue will likely be among the terms of reference for next year's review of the assessment by the Center of Independent Experts (CIE), and will be addressed in next year's assessment.

BPT9: "The Team recommended continued research into the inclusion of fishery age compositions in the models." *Response*: This will likely be among the terms of reference for next year's review of the assessment by the CIE, and will be addressed in next year's assessment (see comment SSC8).

<u>Comments from the December 2019 SSC meeting</u>
SSC6: "The weighted ensemble was determined using a set of nine criteria with different emphasis factors. These criteria were developed by extracting various comments from the PT and the SSC as to what are important features or hypotheses to include in the model. Factors that were given an emphasis of 3 were deemed to be ones that the PT or SSC has explicitly used for criteria to reject or express strong concern about a model (plausibility). Lower emphasis (factors 2 and 1) was given to criteria that generally were more related to technical model specifications. The SSC thought this part of the weighting scheme was transparent and a reasonable step forward. However, the choice of an exponential average instead of the arithmetic average is a much more influential choice than the ad hoc 3:2:1 choice. For example, Model 19.12 is given over 7 times more weight than the next candidate, despite emphasis-weighted scores of 15 and 13, respectively. The SSC suggested that it may be more transparent to use a more intuitive arithmetic mean, recognizing that all weighting systems will have subjective decisions and that assessment authors are likely best suited to identify relative model weightings." *Response*: This preliminary assessment explores the use of cross-conditional decision analysis, which involves two sets of model weights. The first set represents the probabilities that each of the models in the ensemble is the true model. The second set represents how well each of the models in the ensemble performs after considering the possibility that *any* of the models in the ensemble *could* be the true model, and is

computed conditionally on the first set. The first set of weights was computed as the (rescaled) arithmetic mean of a set of scores, in response to this comment.

SSC7: "A major discussion point was whether all three hypotheses should be retained going forward. Hypothesis #2, combining the EBS and NBS surveys, was considered the most likely given the observations of Pacific cod in the NBS and the lack of genetic differences between these areas. There was general support for removing the models related to Hypothesis #1 (19.7-19.9) altogether, given our understanding of stock structure." *Response*: Two models consistent with Hypothesis #2, including Model 19.12, are included in the new ensemble presented in this preliminary assessment. The new ensemble does not contain any models consistent with Hypothesis #1.

SSC8: "The SSC recommends that the authors focus on continuing to improve Model 19.12 and attempt to resolve problems with using fishery age compositions." *Response*: Although it does not change the structure of Model 19.12, this preliminary assessment presents an improved method for processing the size composition data that go into Model 19.12 (and all of the other models in the ensemble) by excluding sample sizes sufficiently small that they are unlikely to be positively correlated with the stratum-specific catches by which they are weighted. Problems associated with using fishery age compositions will likely be among the terms of reference for next year's review of the assessment by the CIE, and will be addressed in next year's assessment (see comment BPT9).

SSC9: "The authors should consider whether 19.12 could be 'overfitting' as the GPT suggested." *Response*: Half of the models in the new ensemble presented in this preliminary assessment have fewer time-varying parameters than Model 19.12. Also, the use of cross-conditional decision analysis should help to mitigate problems of over-parameterization to the extent that it causes a model to perform poorly.

SSC10: "The SSC recommends that if the authors bring an ensemble model forward in 2021, that it consists of a reduced set of models that still reflect adequate diversity in model structure and hypotheses about stock structure." *Response*: The new ensemble presented in this preliminary assessment is smaller, albeit only slightly, than the ensemble used in last year's assessment, consisting of 8 models rather than 9. Thorough investigation of even a few of the various factors that have been requested for consideration (over-parameterization (see comment SSC9), inter-area movement/migration (see comments BPT2, BPT5, and SSC11), and inclusion of both Hypotheses #2 and #3 (see comments BPT2, BPT5, and SSC7)) proved to be a difficult task with fewer than 8 models. Of course, after reviewing the new ensemble, it is possible that the Team/SSC will determine that one or more of the models in this ensemble can be dropped from the final assessment.

SSC11: "The SSC encourages further investigations into fish movement, both analytically and through tagging studies." *Response*: Two of the models in the new ensemble presented in this preliminary assessment include analytical treatment of fish movement between the EBS and NBS. Recent results from tagging studies are summarized in the "Data provided for context only" section.

SSC12: "The SSC requests that the use of VAST, including its assumptions, are clearly documented in next year's assessment." *Response*: Use of VAST, including its assumptions, are documented in the "Data used in the models" section.

SSC13: "The SSC notes that development of an ESP for EBS Pacific cod would be advantageous. Given the results of the stock assessments and the vital historic economic, social, and community importance of Pacific cod, the SSC recommends that within the recognized constraints of available time and resources, Ecosystem and Socioeconomic Profiles (ESPs) of EBS Pacific cod (as well as AI and GOA Pacific cod) be prioritized as new ESPs are developed." *Response*: Several people have been developing an ESP for GOA and EBS Pacific cod since spring of this year. Draft versions are anticipated to be available in time for review at this year's November Team and December SSC meetings.

Models

Software
As with all assessments of the EBS Pacific cod stock since 1992, the Stock Synthesis (SS) software package (Methot and Wetzel 2013) was used to develop and run the models. Since 2005, new versions of SS have been programmed in ADMB (Fournier et al. 2012). SS V3.30.15.09 was used to run all of the models in this preliminary assessment. For the current base model, using last year's data set, this version of SS gave the same value for the objective function as the version used in last year's assessment (Thompson and Thorson 2019).

Parameter estimation
SS requires that prior distributions be associated with all internally estimated time-invariant parameters and the base values of all internally estimated time-varying parameters. For the models presented in this preliminary assessment, uniform prior distributions were used for estimation of all such parameters (with one exception; see "Parameterization issues" section below), with bounds set at values sufficiently extreme that:

- they were non-constraining (with two exceptions; see "Results" section below), or
- extending the bounds to even more extreme values would have no practical impact (because, when the parameter is back-transformed to the natural scale, the resulting quantity is indistinguishable from a logical constraint; e.g., selectivity cannot fall outside the (0,1) range).

To simplify terminology, such parameters will be referred to here as being "freely estimated."

On the other hand, for each parameter that varies randomly on an annual basis, SS estimates a vector of annual deviations that is constrained by a standard normal probability density function, and then multiplies that vector by a standard deviation (σ) specific to that parameter. For all models in this preliminary assessment, each σ was tuned iteratively as follows:

- Except for the vector associated with log-scale recruitment, σ was tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.
- For the vector of annual deviations associated with log-scale recruitment, σ was tuned to match the square root of the variance of the estimates plus the sum of the estimates' variances (Methot and Taylor 2011).

Model naming
Beginning with the final 2015 assessment (Thompson 2015), model naming has followed the protocol given by Option A in the SAFE chapter guidelines. Names of all final models adopted between the 2005 assessment (when an ADMB-based version of SS was first used) and the 2015 assessment were translated according to that protocol in Table 2.11 of the 2015 assessment. The goal of the protocol is to make it easy to distinguish between major and minor changes in models and to identify the years in which major model changes were introduced. Names of models constituting *major* changes get linked to the year that they are introduced (e.g., the current base model, Model 19.12, was one of several models introduced in 2019 that constituted a major change from the then-current base model, Model 16.6i), while names of models constituting *minor* changes from the original form of the current base model get linked to the name of that model (e.g., the name of the base model going into 2019, Model 16.6i, referred to a model that constituted a minor change from Model 16.6, regardless of the year in which it was introduced).

The distinction between major and minor changes, in turn, is based on the average difference in spawning biomass ("ADSB"), defined as the root-mean-squared relative difference in spawning biomass between the new model and the original version of the current base model over the time series from 1977 through

the year in which the original version of the current base model was first adopted, using only data from that set of years. A value of ADSB<0.1 means that the new model constitutes only a minor change, while a value of ADSB≥0.1 means that the new model constitutes a major change.

Base model
Model 19.12 was adopted by the SSC last year as the new base model. It contains the following features:

- Sexes combined
- One season per year
- Natural mortality (constant across age and time) freely estimated
- Mean length at age follows a Richards growth function, with parameters as follow:
    - Base value of length at age 1.5 freely estimated
        - With constrained annual deviations on the log scale, in order to begin addressing the significant amount of time-variability in size at age documented by Puerta et al. (2019) and Ciannelli et al. (2019)
    - Von Bertalanffy (Brody) growth coefficient freely estimated
    - Asymptotic length freely estimated
    - Richards growth coefficient freely estimated
- Standard deviation of length at age varies linearly with length at age, parameters freely estimated
- Weight at length varies annually ($W = \exp(\ln(\alpha_t)+\beta_t \ln(\mathrm{L}))$), estimated outside the model
- Maturity at length (constant across time) estimated outside the model
- Mean ageing error varies linearly with age, freely estimated within each of 2 time blocks in order to compensate for an apparent change in ageing criteria (Beth Matta, AFSC Age and Growth Program, *pers. commun*., 6/27/2019):
    - 1977-2007
    - 2008-present
- Recruitment is independent of stock size:
    - Mean freely estimated within each of 2 time blocks:
        - Pre-1977
        - 1977-present
    - With constrained annual deviations on the log scale
- One survey, covering the EBS and NBS combined
    - Base value of log catchability freely estimated
        - With constrained annual deviations
    - Size-based, double-normal selectivity, with parameters as follow:
        - Base value of first size with selectivity=1 freely estimated
            - With constrained annual deviations on the log scale
        - Logit of size range with selectivity=1 fixed at 10.0
        - Base value of log of standard deviation for 1st normal pdf freely estimated
            - With constrained annual deviations
        - Log of standard deviation for 2nd normal pdf fixed at 10.0
        - Logit of selectivity at minimum size fixed at -10.0
        - Logit of selectivity at maximum size fixed at 10.0
- One fishery, covering the EBS and NBS combined
    - Size-based, double-normal selectivity, with parameters as follow (however, see "Parameterization issues" section below):
        - First size with selectivity=1 freely estimated
        - Logit of size range with selectivity=1 fixed at -10.0
        - Base value of log of standard deviation for 1st normal pdf freely estimated
            - With constrained annual deviations

        - Log of standard deviation for 2nd normal pdf freely estimated
        - Logit of selectivity at minimum size freely estimated
        - Base value of logit of selectivity at maximum size freely estimated
            - With constrained annual deviations
- Following Thorson et al. (2017), input sample sizes (*Nsamp*) for compositional data range between zero and an initial number of (*Ninit*) according to the formula $Nsamp = (1 + \exp(ln\theta)\, Ninit)/(1 + \exp(ln\theta))$, where $ln\theta$ is a time-invariant parameter (the "Dirichlet-multinomial" parameter, estimated in natural log space, so that *Nsamp* approaches 0 as $ln\theta$ approaches $-\infty$, *Nsamp*=(1+*Ninit*)/2 when $ln\theta$=0, and *Nsamp* approaches *Ninit* as $ln\theta$ approaches $+\infty$), freely estimated for each of the compositional data types (fishery size composition data, survey size composition data, and survey age composition data), where:
    - For survey compositional data, *Ninit* is the number of sampled hauls
    - For fishery compositional data, *Ninit* is equal to the number of sampled hauls rescaled so that the average *Ninit* for the fishery is equal to the average *Ninit* for the survey (so that, on average, fishery data are emphasized equally with survey data)

Primary ensemble

Factorial design

One way to guard against "stacking the deck" in development of a model ensemble is to employ a factorial design. In the "Responses to Team and SSC comments specific to this assessment" section, four topics were identified as being the highest priority for consideration in this preliminary assessment. Each of these is shown below, together with a "binary factor" that interprets the topic in terms of a no/yes question:

Topic	Comment(s)	Binary factor: Does the model...
M19.12 over-parameterization	SSC9	...allow time-varying survey catchability (Q)?
Spatial structure	BPT2	...treat the EBS and NBS as separate areas?
Hypotheses #2 and #3	BPT2, BPT5, SSC7	...use area-specific surveys?
Movement	BPT5, SSC11	...incorporate explicit inter-area movement?

Ordinarily, a factorial design spanning four factors would require 2^4=16 models. However, certain combinations of the above factors are internally inconsistent. Specifically, it would not make sense to entertain the four nominally possible models that *do not* treat the EBS and NBS as separate areas but that *do* incorporate explicit inter-area movement, nor the four nominally possible models that *do* treat the EBS and NBS as separate areas but that *do not* use area-specific surveys, which leaves only eight feasible models, as follows (shading indicates factor/column combinations where the factors are constrained to have the same value, in order to eliminate infeasible combinations):

Time-varying Q?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2

Temporary names have been assigned to all eight models in the above table, because "final" model names are dependent on the average difference in spawning biomass relative to the current base model ("final" model names are assigned near the beginning of the "Results" section below). However, it may be noted that Models A2 and B2 are very similar to Models 19.12 and 19.15, respectively. This is addressed further in the "Parameterization issues" and "Alternative ensemble" sections below.

Models A1 and A2 correspond to Hypothesis #2, Models B1 and B2 correspond to Hypothesis #3, and the remaining models correspond to new hypotheses.

Parameterization issues

As the models in the ensemble were being developed, five parameterization issues were encountered:

1) The various 2-area models require estimation of a parameter (potentially time-varying) describing the inter-area recruitment distribution, and the pair of 2-area models that incorporate explicit inter-area movement require estimation of four parameters (also potentially time-varying) describing the probabilities of staying or moving in or to each of the two areas. The recruitment distribution parameter is simply the logit transform of the proportion of the total number of age 0 recruits that is allocated to the NBS. The interpretation of the movement parameters, on the other hand, is complicated (see Attachment 2.1.1). In developing these models, considerable effort was expended in exploring versions in which the annual values of the parameters describing inter-area recruitment distribution and movement were treated as base parameters modified by constrained annual deviations. Ultimately, these efforts proved unsuccessful, in part because so many years are missing from the NBS survey time series, meaning that little information is available for estimating the deviations in most years. Instead, development of these models was redirected toward use of environmental covariates to provide mechanisms for the time-varying recruitment distribution and movement parameters, where each of these parameters was estimated as a linear function of a single covariate. The following seven potential environmental covariates of inter-area recruitment distribution and movement were explored: sea ice extent, the North Pacific Index (NPI), benthic epifauna, condition factor, and three versions of cold pool extent (temperatures less than 0° C, less than 1° C, and less than 2° C). Sea ice extent proved to have the greatest explanatory power for the proportion of recruitment occurring in the NBS and for the movement of fish from the EBS to the NBS, while the NPI had the greatest explanatory power for the movement of fish from the NBS to the EBS.

2) The pair of 2-area models that incorporate explicit inter-area movement also require specification of three constants governing the ages at which movement is allowed to occur and the range of ages over which movement probabilities are allowed to vary with age (see Attachment 2.1.1). Age 2 was specified as the first age at which movement is allowed to occur. This value was chosen subjectively, albeit informed by the life history of the species. Ages 2 and 7 were specified as the endpoints of the range of ages over which movement probabilities are allowed to vary with age, and were chosen by trial and error, after examining the log-likelihood values associated with alternative combinations of endpoints and also with a view toward keeping the signs of the covariate linkages constant across age.

3) Because no fishery size composition or age composition data are available for the NBS, all NBS fishery selectivity parameters were assumed to "mirror" their base EBS counterparts.

4) As noted in the "Base model" section above, Model 19.12 fixes the logit of the size range with selectivity=1 at -10.0, whereas the logit of selectivity at the minimum size is freely estimated. As other models in the ensemble were being developed, better fits were obtained by flipping the treatments of those two parameters, so that the logit of the size range with selectivity=1 was estimated freely and the logit of selectivity at the minimum size was fixed at -10.0. When these assumptions were applied to the Model 19.12 also (thus transforming Model 19.12 into Model A2), the results were only trivially different (negative log likelihood changed by only 0.01 and 2019 spawning biomass changed by only 0.001%). In the interest of consistency with the other models in the ensemble, the structure of Model 19.12 was changed accordingly without assigning it a new name.

5) At the time the models were being developed, no data on catches in the NBS were available. For the four models that treat the EBS and NBS as separate areas (C1, D1, C2, and D2), this made estimation of ln(Q) for the NBS survey difficult, if not impossible. Therefore, those models included an informative

prior distribution for that parameter (or for the base value, in the case of models with time-varying catchability). More specifically, for each such model, a normal prior distribution for the NBS survey ln(Q) was used, with unit variance and a mean equal to the point estimate of the EBS survey ln(Q). This involved tuning the prior mean iteratively for each such model. Although the two models that use area-specific surveys without treating the EBS and NBS as separate areas (Models B1 and B2) appeared to be capable of estimating ln(Q) without imposing an informative prior distribution, the same type of prior distribution was used for those models also, so as to employ a consistent set of assumptions for all six models that use area-specific surveys. The use of an informative prior distribution for NBS survey ln(Q) is the only feature that distinguishes Model B2 from Model 19.15, and the results from Model B2 were very similar to those from Model 19.15. Nevertheless, a new "final" name for Model B2 will be adopted (see "Results" section), for the reason given the "Alternative ensemble" section below.

Parameter counts

The numbers of parameters in the eight models, for data through 2019, are as follow (color gradients in the final three rows proceed from red=low to green=high):

Time-varying Q?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2
True parameters	25	30	37	46	25	30	37	46
Annual deviations	267	267	267	267	305	343	343	343
Total parameters	292	297	304	313	330	373	380	389

In terms of the number of true parameters (i.e., time-invariant parameters and base values of time-varying parameters), the above table proceeds in increasing order from left to right within a given value for the "Time-varying Q?" factor, and the four counts in the "No" column are identical to the four counts in the "Yes" column. So, Models A1 and A2 have the same number of true parameters, as do Models B1 and B2, Models C1 and C2, and Models D1 and D2; with the A1/A2 pair having the fewest and the D1/D2 pair having the most.

In terms of the number of annual deviations, Models A1, B1, C2, and D1 are identical. Model A2 has 38 more than Models A1-D1 because of annually varying catchability in the survey. Models B2, C2, and D2 have 38 more than Model A2 because they include annually varying catchability for two surveys rather than one.

In terms of the total number of parameters (true parameters and annual deviations combined), the above table proceeds in increasing order from left to right. So, Model A1 has the fewest total parameters and Model D2 has the most.

Table 2.1.1 shows the breakdown of parameter counts in further detail.

The five true parameters in Models B1 and B2 that are not included in Models A1 and A2 consist of:

- Base log catchability in the NBS survey
- Two parameters for the NBS survey selectivity (size-based double-normal):
    - Base value of first size with selectivity=1
    - Base value of log standard deviation for 1st normal pdf
- Two Dirichlet-multinomial parameters for the NBS survey:

- One for size composition
- One for age composition

The seven true parameters in Models C1 and C2 that are not included in Models B1 and B2 consist of:

- One parameter that governs the distribution of recruits between the EBS and NBS
- Initial fishing mortality rate for the NBS fishery
- Five selectivity parameters for the NBS fishery (size-based double-normal):
    - First size with selectivity=1
    - Logit of size range with selectivity=1
    - Base value of log of standard deviation for 1st normal pdf
    - Log of standard deviation for 2nd normal pdf
    - Base value of logit of selectivity at maximum size

The nine true parameters in Models D1 and D2 that are not included in Models C1 and C2 consist of:

- Four parameters that govern base age-specific movement rates:
    - Slope and intercept terms that govern base movement rates from the EBS to the NBS
    - Slope and intercept terms that govern base movement rates from the NBS to the EBS
- Linkage between an environmental covariate and the distribution of recruits between EBS, NBS
- Linkages between environmental covariates and the four movement parameters

Alternative ensemble
After the models in the primary ensemble had already been largely developed, a small amount of data on catches in the NBS became available (see "NBS catch data" section below), which suggested that it might be appropriate to revisit the question of whether the four models that treat the EBS and NBS as separate areas (C1, D1, C2, and D2) are able to estimate ln(Q) for the NBS survey after all. Moreover, if the prior distribution on NBS ln(Q) is removed from analogues of Models C1, D1, C2, and D2, it seems appropriate to develop prior-less analogues of Models B1 and B2 as well. Thus, in addition to the primary ensemble, a small subset of results will be presented for analogues of Models B1, B2 , C1, C2, D1, and D2 with the prior distribution on NBS ln(Q) removed; which, together with Models A1 and A2 (ie., Model 19.12) from the primary ensemble, can be considered to constitute an alternative ensemble.

Note that, when the prior distribution on NBS ln(Q) is removed from Model B2, it is identical to Model 19.15. Because results from both of these models will be reported (for Model B2 in the primary ensemble and Model 19.15 in the alternative ensemble), it is appropriate to assign a new "final" name to Model B2.

Data

Data used in the models
With the exceptions of a small change in the method used to compile the fishery size composition data (used in all models) and the addition of a time series of NBS catch data (used in the four models that include explicit EBS and NBS areas) and a pair of environmental covariate time series (used in the two models that incorporate explicit movement between areas), the data used in all models presented in this preliminary assessment were all described previously in last year's assessment (Thompson and Thorson 2019). As in last year's ensemble, the survey index and age composition data used for all models in this preliminary assessment are based on the Vector Autoregressive Spatio-Temporal (VAST) approach (Thorson 2019a).

VAST specifications

As noted in last year's assessment, the settings that were used to produce the VAST estimates follow the recommendations given by Thorson (2019a). However, a more detailed description was requested by the SSC (see comment SSC12). In response, the following text was provided by Jim Thorson and Jason Conner (AFSC):

The software versions of dependent programs used to generate VAST estimates were:

- Microsoft Open R (3.5.3)
- INLA (18.7.12)
- TMB (1.7.18)
- TMBhelper (1.2.0)
- VAST (3.2.0)
- FishStatsUtils (2.3.0)

We fitted records of numerical abundance per unit area from all grid cells and corner stations in the 83-112 bottom trawl survey of the EBS, 1982-2019, as well as 83-112 samples available in the NBS in 1982, 1985, 1988, 1991, 2010, and 2017-2019. NBS samples prior to 2010 did not follow the 30 nautical mile sampling grid that was used in 2010, 2017, and 2019; and the 2018 sampling followed a coarsened grid as well. Assimilating these data therefore required extrapolating into unsampled areas. This extrapolation was assisted by including a spatially varying response to cold-pool extent (Thorson 2019). This spatially varying response was estimated for both linear predictors of the delta-model, and detailed comparison of results for EBS pollock has showed that it has a small but notable effect (O'Leary et al. in press). For example, the NBS was not sampled between 2010 and 2017, and the cold-pool extent started to decrease substantially around 2014; therefore including this covariate results in estimates that depart somewhat from a "Brownian bridge" between 2010 and 2017, and instead suggests that densities in the NBS increased progressively after 2014 when cold-pool-extent declined prior to 2017.

Specifically, we used a Poisson-link delta-model (Thorson 2018) involving two linear predictors, and a gamma distribution for the distribution of positive catch rates. We extrapolated density to the entire EBS and NBS in each year, using extrapolation-grids that are available within FishStatsUtils are used when integrating densities. These extrapolation-grids are defined using 3705 m (2 nmi) × 3705 m (2 nmi) cells; this results in 36,690 extrapolation-grid cells for the eastern Bering Sea and 15,079 in the northern Bering Sea. We used bilinear interpolation to interpolate densities from 250 "knots" to these extrapolation-grid cells; knots were distributed spatially in proportion to the distribution of extrapolation-grid cells (i.e., having an approximately even distribution across space). We estimated "geometric anisotropy" (the tendency for correlations to decline faster in some cardinal directions than others), and including a spatial and spatio-temporal term for both linear predictors. To improve interpolation of density "hotspots" between unsampled years, we specified that the spatio-temporal term was autocorrelated across years (where the magnitude of autocorrelation was estimated as a fixed effect for each linear predictor). However, we did not include any temporal correlation for intercepts, which we treated as fixed effects for each linear predictor and year. Finally, we used epsilon bias-correction to correct for retransformation bias (Thorson and Kristensen 2016).

Fishery size composition

In last year's assessment, each year's fishery size composition consisted of a catch-weighted average of the respective month-, area-, and gear-specific size compositions, using 1-cm bins. A potential problem with this approach is that, conceivably, a particular month-, area-, and gear-specific size composition could be based on a very small number of measured fish, but be associated with a very large catch, meaning that a very imprecise month-, area-, and gear-specific size composition could have a large impact on that year's catch-weighted average size composition. To avoid this possibility, the number of

measured fish by month, area, and gear should be positively correlated with the associated catch. Visual examination of the data suggests that, for the most part, this is true; however, for very small sample sizes, the correlation actually appears to be slightly negative. This suggests that it may be possible to identify an optimal cutoff value for fishery size composition sample size.

Attachment 2.1.2 describes a statistical analysis suggesting that the optimal cutoff value is approximately 30 fish (for any combination of month, area, and gear). Omitting records with sample sizes less than 30 would eliminate 12.1% of all records, but only 0.1% of the total number of fish measured and only 1.8% of the total catch. After eliminating those records, re-running the current base model resulted in less than a 1% change in ending spawning biomass, suggesting that the problem of potential negative correlation between catch and sample size when the latter is small is likely not a major one. However, because a minimum sample size of 30 fish (for any combination of year, month, area, and gear) has a firmer statistical basis than simply accepting any sample size no matter how small, the models presented here all used the recompiled fishery size composition time series with a minimum sample size of 30 fish.

NBS catch data

The NMFS Alaska Region office was able to compile a time series of catches for the NBS, shown below:

Year:	2003	2004	2005	2006	2007	2008	2009	2010	2011
Catch (t):	305	54	57	1	3	19	7	2	2

Year:	2012	2013	2014	2015	2016	2017	2018	2019
Catch (t):	1	102	101	81	1425	1299	23217	20295

Environmental covariates

As noted above in the "Parameterization issues" section, of the seven potential environmental covariates that were explored, sea ice extent proved to have the greatest explanatory power for the proportion of recruitment occurring in the NBS and for the movement of fish from the EBS to the NBS, while the NPI had the greatest explanatory power for the movement of fish from the NBS to the EBS (data obtained from https://access.afsc.noaa.gov/REFM/REEM/ecoweb/Index.php?ID=9). More specifically, the sea ice extent for each year t is computed as the average of the monthly values from August of year t–1 through July of year t, while the NPI is computed as the average of the monthly values from November of year t–1 through March of year t. The time series for these two covariates that were used in the models presented here are shown below (as z-scores):

Year:	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Ice:	-0.113	0.254	0.669	-0.078	-0.217	0.010	0.173	-0.490	0.441	0.643
NPI:	0.812	-2.314	-1.079	0.554	-1.731	-1.215	-0.269	1.311	0.943	1.092

Year:	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Ice:	0.532	0.154	0.479	1.150	-1.075	-0.326	0.636	1.017	1.114	-0.861
NPI:	-1.005	0.002	0.707	-0.081	-0.427	-0.033	-1.429	0.308	-0.129	-0.729

Year:	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Ice:	0.284	-1.171	-0.841	-0.639	0.736	-0.190	0.679	1.037	1.054	-0.581
NPI:	0.199	-1.613	-0.081	-0.261	0.597	0.475	0.243	2.068	-0.987	1.044

Year:	2012	2013	2014	2015	2016	2017	2018
Ice:	2.179	1.227	-0.839	-1.419	-0.926	-1.642	-3.058
NPI:	0.694	0.685	0.466	-0.388	-0.944	0.663	1.854

Preview of data changes in final assessment

Size composition update

Although not included in the data set for any of the models presented here, the fishery size composition time series has been updated through late August of 2020. Broadly speaking, the size composition for 2020 does not appear to include any surprises. Each year in the 1991-2020 time series shows a peak falling somewhere within the 55-75 cm size range. The size associated with the peak has increased in each of the last three years, which might reflect the lack of strong recruitment from the 2014-2016 cohorts, with the peak for 2020 occurring at 75 cm.

The fishery catches very few age 2 fish, making it difficult to draw a strong conclusion from these data regarding the strength of the 2018 year class, which was estimated to be very large in last year's assessment on the basis of the 2019 EBS and NBS surveys. However, it may be noted that the relative frequency of fish within the 30-34 cm range, which may be representative of age 2 fish during the first half of the year, is several times larger in the 2020 size composition than in the size compositions from any of the preceding four years.

It should also be noted that, as with the data files used in last year's assessment, the data file used for the models in this preliminary assessment included a size composition record for 2018 in the NBS survey time series, which could be problematic, given that the sampling design in that year's "rapid response" survey was different from the other years in the time series. It is likely that this record will be dropped from the data used in the final draft of the assessment.

EBS survey age composition update

Last year's assessment used VAST estimates of survey age composition for the entire time series (1994-2018). The otoliths from the 2019 EBS shelf bottom trawl survey have now been processed. However, technical issues have precluded estimation of the 2019 survey age composition using VAST, so a design-based estimate for the 2019 survey age composition will be used in the data file for the final assessment instead. The entire time series, with VAST estimates for the years 1994-2018 and the design-based estimates for 2019, is shown in Table 2.1.2.

Environmental covariates update

The z-scores for sea ice extent in 2019 and 2020 are -2.114 and -0.763, respectively (Rick Thoman, University of Alaska International Arctic Research Center, pers. commun. 8/9/2020); and the z-scores for the NPI in 2019 and 2020 are 0.245 and 1.284, respectively (Adam Phillips, National Center for Atmospheric Research, pers. commun. 8/10/2020). Note that the addition of the new data will result in the z-scores for the rest of each time series changing slightly.

Data provided for context only

Fishery catch per unit effort (CPUE)

Year-to-date CPUE data from the longline fishery suggest that 2020 is on track to have the highest average in the 1991-2020 time series. Monthly averages from January-July of 2020 (except for June, where reporting of data is precluded due to confidentiality restrictions) are all 5-41% higher than their 1991-2019 averages. In particular, the monthly averages for February and May 2020 are the both the second largest in their respective time series and the largest in their respective time series since 1991. Results from a model estimating both "year" and "month" effects for the time series are shown in Figure 2.1.1. The year effect for 2020 is projected to be 46% above the average for the 1991-2020 time series.

The CPUE data from the bottom trawl fishery are harder to interpret than the CPUE data from the longline fishery, because the former tend to be much more variable than the latter. After normalizing each gear-specific year × month time series to a mean of unity, the overall standard deviation for the

bottom trawl fishery is 0.71, compared to only 0.34 for the longline fishery. As an example of this variability, the February 2020 average for the bottom trawl fishery was by far the largest in the time series, being 238% higher than the 1991-2019 average for February, whereas the March 2020 was only 12% higher than the 1991-2019 average for March, and the 2020 averages for January, April, May, and June were all 25-48% *lower* than their respective monthly 1991-2019 averages.

Tagging
The following information was provided by Susanne McDermott (AFSC):

Pop-up satellite archival tags were attached to 38 fish near St Lawrence Island during August and September of 2019. In addition, and three stationary tags were deployed in the same area.

To date, 33 fish tags and three stationary tags have popped up and transmitted data. Data from the remaining five fish are expected in August/September of this year.

The number of tags popping up by month is shown below:

Popup year	Popup month	Tags
2019	9	2
2019	10	2
2019	11	7
2019	12	3
2020	1	5
2020	2	3
2020	3	8
2020	6	2
2020	7	1
Total		33
Still in the water		5

The breakdown of recoveries by month is as follows:

- September 2019 to December 2019:
  - 9 fish stayed in the NBS
  - 3 fish moved to Russian waters
- January 2020 to March 2020:
  - 9 fish moved to the NBS slope
  - 1 fish moved to the Gulf of Alaska
  - 3 fish stayed in Russian waters
- June 2020 to July 2020:
  - 1 fish stayed in the EBS and went to Bristol bay
  - 2 fish moved back to the NBS

Western Bering Sea (WBS) abundance
The following was provided by Cecilia O'Leary (AFSC):

Basin-wide Bering Sea biomass indices were explored for Pacific cod. Biomass indices were estimated using a spatio-temporal index model with and without cold pool extent effects incorporated. Models were fit using multiple spatially unbalanced survey data products from western (WBS), northern (NBS), and

eastern (EBS) Bering Sea and the vector autoregressive spatio-temporal model (VAST; Thorson and Barnett 2017). Epsilon bias-corrected biomass indices were used to correct for retransformation bias (Thorson and Kristensen 2016), and a temporally-invariant catchability parameter between WBS and EBS/NBS surveys was estimated within the models. Data were analyzed from multiple surveys using a Poisson link delta-model, while using a gamma distribution for the observation error distribution of the positive catch rates (Thorson 2018). Model specification included spatial & spatiotemporal random effects for encounter probability & positive catch rate with no autocorrelation across time. Spatial smoothing at every location for models estimating biomass indices is interpolated using bilinear interpolation in a triangulated mesh (Lindgren 2012; Lindgren and Rue 2015).

AIC indicated that including the cold pool extent in the spatio-temporal model was more parsimonious than excluding this effect. Agreement was also found between the area-swept (i.e., design-based) index and model-based index of abundance for Pacific cod (Figure 2.1.2), and an overall increase in the proportion of cod in the WBS relative to the EBS + NBS (Figure 2.1.3).

Results

Please note: In tables with color scales, red and green correspond to the minimum and maximum values within the given row or column (whether the scale varies horizontally or vertically depends on the table).

Primary ensemble

Final model names

Based on the time series of spawning biomass estimates (see next section), ADSB values for the models in the primary and alternative ensembles were calculated and final model names were established as shown below:

Time-varying *Q*?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2
ADSB	0.0755	0.0981	1.2983	0.0732	n/a	0.0775	0.1692	0.3918
Final name	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3

Parameter estimates and derived time series

Table 2.1.3 lists the estimates and standard deviations of all internally estimated parameters except fishing mortality.

Table 2.1.3a shows the values of the main parameters (time-invariant parameters that are common to at least half of the ensemble). A blank cell indicates that the respective parameter (row) is not used in the respective model (column).

Nomenclature pertaining to parameter labels in Table 2.1.3a:

- The terms “fsh” and “srv” refer to the fishery and survey, respectively
- Except for 1-area models with separate EBS and NBS surveys, the term “main” in a parameter label refers to the combined EBS and NBS in a 1-area model and to the EBS in a 2-area model.
- In 1-area models with separate EBS and NBS surveys, the term “main” refers to the combined EBS and NBS in the case of fishery-related parameters, but to the EBS in the case of survey-related parameters.

- Except in the context of log catchability, the term "base" in a parameter label denotes that the parameter is subject to annual random deviations. In the context of log catchability, "base" denotes that the parameter is subject to annual random deviations in at least some of the models (specifically, Models 19.12, 19.12d, 20.2, and 20.3).
- The term "lnDM" refers to the log-scale Dirichlet-multinomial parameter that scales sample size relative to the specified (input) sample size.

The "Parameter estimation" section above noted that there were only two exceptions to the claim that bounds were either non-constraining or bound only by a logical constraint. These exceptions were the estimates of NBS_srv_sel_PeakStart_base in Models 19.12b and 19.12d, where the estimates were just below the upper bound of 80 cm that was specified for that parameter. Other values for the upper bound were explored, but the upper bound of 80 cm was retained because: 1) the corresponding parameter for fishery selectivity was less than 80 cm for all models, and it seems unlikely that the survey would have a lower selectivity for fish of that size than the fishery; 2) setting the upper bound substantially higher than 80 cm still resulted in the estimates being bound; and 3) if the upper bound is set high enough, the becomes confounded with the estimate of catchability.

For many of the parameters in Table 2.1.3a, the estimates do not vary much between models. For example, the estimates of natural mortality range from 0.332 to 0.372 the estimates of mean length at age 1.5 range from 14.594 14.903, and the estimates of the von Bertalanffy (Brody) growth coefficient range from 0.106 to 0.123. Within either of the two specified time blocks (1977-2007 and 2008-2019), the estimates of ageing bias at ages 1 and 20 likewise do not vary by much between models. However, the estimates differ considerably *between* the two time blocks. For the years prior to 2008, the estimates of ageing bias at age 1 range from 0.337 to 0.349, but they are essentially zero after 2007 in all models (range = -0.002 to 0.019). The estimates of ageing bias at age 20 for the years prior to 2008 range from 0.776 to 0.954, but they are strongly negative after 2007 in all models (range = -2.179 to -1.532). Initial fishing mortality ranges from 0.114 to 0.173. Log catchability for the main survey ranges from -0.116 to 0.261, and log catchability for the NBS survey ranges from -1.842 to 0.827. For the size composition components, estimates of the log-scale Dirichlet-multinomial parameter are all near the upper bound set at 10.0; but for the age composition components, values range from -0.006 to 0.541 (for the main survey) and -1.511 to 0.383 (for the NBS survey).

Table 2.1.3b shows the base values of the four movement parameters and the coefficients linking the recruitment distribution parameter and the four movement parameters to their respective environmental covariates (notes that these parameters appear only in Models 19.12c and 20.3). The signs of the parameters lining the proportion of recruitment allocated to the NBS and the base values of the four movement parameters are consistent between the two models that incorporate movement:

- The sign of RecrDist_NBS is negative (i.e., the proportion of recruitment allocated to the NBS varies inversely with sea ice extent).
- The signs of Move_EBS_to_NBS_A_link and Move_EBS_to_NBS_B_link are both negative (i.e., the proportion of fish moving from the EBS to the NBS varies inversely with sea ice extent).
- The signs of Move_NBS_to_EBS_A_link and Move_NBS_to_EBS_B_link are both positive (i.e., the proportion of fish moving from the NBS to the EBS varies directly with the NPI).

The remaining parts of Table 2.1.3 pertain to annual parameter deviations, and generally show very consistent trends across models (i.e., the color scales are similar), with the single exception noted below:

- Table 2.1.3c shows log recruitment deviations for the initial numbers-at-age vector.
- Table 2.1.3d shows log recruitment deviations.
- Table 2.1.3e shows length at age 1.5 deviations.

- Table 2.1.3f shows log catchability deviations (Models 19.12, 19.12d, 20.2, and 20.3 only).
- Table 2.1.3g shows deviations for the fishery selectivity lnSD1 parameter.
- Table 2.1.3h shows deviations for the fishery selectivity logitEnd parameter. This is the only case where the trends are not similar across models. However, for the three models with trends that are noticeably different from the others (Models 19.12c, 20.2, and 20.3), it should be noted that the deviations are all very close to zero.
- Table 2.1.3i shows deviations for the survey selectivity PeakStart parameter.
- Table 2.1.3j shows deviations for the survey selectivity lnSD1 parameter.

The only other internally estimated parameters, which SS treats somewhat differently from those shown in Table 2.1.3, is the time series of fishing mortality rates, which are shown in Table 2.1.4. Separate time series for the EBS and NBS are shown for the 2-area models (20.1, 19.12c, 20.2, and 20.3). The trends are highly similar across models.

Table 2.1.5 shows the iteratively tuned values of the sigma parameters for the various vectors of annual random deviations. For each parameter and model, the columns labeled "var_dev" and "ave_var" represent the variance of the vector of estimated deviations and the average of the variances of the individual estimates in the vector. For parameters other than log recruitment, the deviations pertaining to the other parameters, sigma is tuned so that the square root of the sum of var_dev and ave_var is unity. For the deviations pertaining to log recruitment, sigma is tuned to equal the square root of the sum of var_dev2 and ave_var2 (note that SS treats sigma for log recruitment deviations differently from sigma for other parameter deviations). Note that a few of the parameter/model combinations (shaded gray) have a var_dev value close to zero and an ave_var value close to unity, meaning that the respective vector of deviations had very little effect on model results. Finally, note that the iterative tuning of the sigma parameters was based on a data file that erroneously included the VAST NBS age composition record for 2016, and it was too late to retune them after the error was discovered. However, removal of the extra age composition record tended to have very little impact on estimates of other parameters, so it seems likely that removal of that record would have little effect on the estimates of the sigma parameters.

Schedules of quantities that function like parameters in the state transition and observation processes, but that are actually functions of parameters listed in Table 2.1.3, are shown in Figure 2.1.4 (selectivity, both fishery and survey), Figure 2.1.5 (survey catchability), and Table 2.1.6 (movement probabilities, Models 19.12c and 20.3 only).

- With only a couple of exceptions, fishery and survey selectivity schedules are fairly similar across models (Figure 2.1.4). The first exception is with respect to the "main" fishery (EBS and NBS combined in Models 19.12a and 19.12, EBS by itself in all other models), where the 1-area models (19.12a, 19.12, 19.12b, and 19.12d) all appear fairly similar to each other, but distinct from the 2-area models, which likewise all appear to be fairly similar to each other. Specifically, the 1-area models lack the large decrease in fishery selectivity at the largest sizes that is exhibited by the 2-area models. The second exception is with respect to the NBS survey, where the two models incorporating inter-area movement (19.12c and 20.3) reach maximum selectivity at a much smaller size than in the other models that treat the EBS and NBS surveys separately.
- The catchability time series are displayed on separate panels for the "main" (EBS or combined EBS and NBS) survey and for the NBS survey. For the "main" survey (Figure 2.1.5a), average catchability tended to fall within or very close to the 0.9-1.1 range for all models except those that incorporate inter-area movement, where Model 19.12c gave an average EBS catchability of 1.188 and Model 20.3 gave an average EBS catchability of 1.302. For the NBS survey (Figure 2.1.5b), on the other hand, average catchability fell well outside the 0.9-1.1 range, and, for the models with time-varying catchability, some of the annual values were quite extreme. For example,

Model 20.2 resulted in NBS catchability estimates >5 in the final three years of the time series, and Model 20.3 resulted in NBS catchability estimates less than <1/5 in the first 5 years of the time series.

- The movement parameters estimated by Models 19.12c and 20.3 are translated into movement probabilities in Table 2.1.6. For either of the model-specific columns, each row shows the probability of moving from the specified source ("Src.") area to the destination ("Dst.") area for ages 2 through 7+. The probability of staying in the source area is simply 1.0 minus the probability of moving, and is not shown in the table, in the interest of efficiency. Estimated movement probabilities vary substantially over time, and can occasionally be quite high. For example, estimates in excess of 0.5 occurred in 5.1% of the possible cases in Model 19.12c and in 2.6% of the cases in Model 20.3.

Time series of biomass and recruitment are shown for all models in Figure 2.1.6 (age 0+ biomass), and Table 2.1.7 (female spawning biomass), Table 2.1.8 (relative spawning biomass), and Table 2.1.9 (age 0 recruitment). Projected values for 2020 and 2021 are included in all of these except for Table 2.1.9.

- The time series of age 0+ biomass is shown for the combined EBS and NBS areas (all models) in Figure 2.1.6a. The 1-area models show very similar values through most years, although the magnitudes diverge a bit in the last few years. Qualitatively, the 2-area models show the same patterns of highs and lows, but the scales are somewhat different, with that of Model 20.1 being much higher than the others. The time series of age 0+ biomass is shown for the separate areas (2-area models only) in Figure 2.1.6b. For the EBS, the two models *without* inter-area movement (yellow) tend to cluster together, with values substantially higher than the two models *with* inter-area movement (green), which tend to form a separate cluster. For the NBS, all of the trajectories are distinct, with Model 20.1 estimating much higher values than the other three models and Model 20.2 tending to estimate the lowest values, particularly in the last few years of the series.
- The time series of female spawning biomass spawning is shown for the combined EBS and NBS areas (all models) in Table 2.1.7a. Qualitatively, the trends are very similar across models, although, in terms of magnitude, Model 20.1 tends to exhibit the highest values. For the last few years of the series, Models 19.12b, 19.12d, and 20.2 exhibit the lowest values. The time series of female spawning biomass is shown for the separate areas (2-area models only) in Table 2.1.7b. As with the time series of NBS age 0+ biomass, Model 20.1 estimates much higher values than the other models. For the last few years of the series, Model 20.2 estimates the lowest values.
- Even though some of the models are spatially structured, Pacific cod in the EBS and NBS are still considered to comprise the same stock, so relative biomass is reported only for the combined EBS and NBS areas in Table 2.1.8. As with female spawning biomass, the relative biomass trends area qualitatively similar across models. Model 19.12c tends to estimate the highest values across all years. For the last few years of the series, Model 19.12d estimates the lowest values.
- The time series of age 0 recruitment is shown for the combined EBS and NBS areas (all models) in Table 2.1.9a. Qualitatively, the time series are extremely similar across models. In absolute terms, Model 20.1 consistently estimates the highest values. For most of the last few years of the series, Model 19.12d estimates the lowest values. The time series of age 0 recruitment is shown for the separate areas (2-area models only) in Table 2.1.9b. Again, the series are qualitatively very similar. In absolute terms, Model 20.1 consistently estimates the highest values and Model 19.12c the lowest values.

<u>Performance measures</u>

Figure 2.1.7 shows the model fits to the surveys. Fits to the "main" survey are shown in Figure 2.1.7a (all models). Qualitatively, the estimated trajectories from all models match their respective observed trajectories, although models *with* time-varying catchability tend to fit the data better than those *without* it, as would be expected. Fits to the NBS survey are shown in Figure 2.1.7b (2-area models only), where

the models that lack *both* time-varying catchability and inter-area movement (Models 19.12b and 20.1) clearly fail to fit the data.

Retrospective analyses of all models are shown in Figure 2.1.8, where the value of Mohn's (1999) ρ is listed for each model. As measured by Mohn's ρ, Models 20.1 and 20.3 have the largest retrospective bias, exhibiting values of -0.539 and 0.467, respectively. However, the value for Model 20.3 is influenced heavily by the 10th peel, which will disappear when this year's final assessment is produced. To address the potential sensitivity of Mohn's ρ value to outliers, the 10 bias estimates (one for each peel) that are averaged in order to calculate Mohn's ρ were bootstrapped 100,000 times, enabling estimates of imprecision. The point estimates of Mohn's ρ are shown below, together with bootstrap estimates of the standard deviation and the endpoints of the 95% confidence interval (note that the standard deviation and the width of the 95% confidence interval for Model 20.3 are much larger than for the other models):

Statistic	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
mean	-0.070	-0.079	-0.539	0.100	-0.053	-0.025	-0.109	0.466
st. dev.	0.022	0.034	0.045	0.038	0.014	0.023	0.022	0.339
L95%	-0.116	-0.146	-0.615	0.027	-0.081	-0.074	-0.150	0.028
U95%	-0.031	-0.015	-0.443	0.174	-0.028	0.014	-0.065	1.212

Table 2.1.10 shows objective function values for all components and models. Table 2.1.10a shows aggregated components, and Table 2.1.10b breaks down the survey index, size composition, and age composition components by fleet type (fishery or survey) and area ("main" or NBS). Note the different models use different data sets, so values are difficult to compare across models. Note also that fishery size composition data for the NBS were unavailable at the time that this preliminary assessment was developed, so the objective function values for that sub-component are zero for the 2-area models.

Table 2.1.11 summarizes goodness of fit for the survey index (abundance), size composition, and age composition in terms of ratios, where a value of unity is the goal. For the two columns under the "Area" heading, "Actual" refers to the area associated with the survey data used in the model (EBS, NBS, or "XBS," where the latter refers to the EBS and NBS combined), and "Assumed" refers to the area that the model assumes the data represent (for most models, the Actual and Assumed areas are the same, but for the 1-area models that use separate EBS and NBS surveys, they are different).

- For the abundance data, goodness of fit is measured by the ratio of the log-scale root-mean-squared error to the average of the input log-scale standard errors. The four models exhibiting time-variable catchability do very well by this measure, at least for their respective "main" survey, with ratios ranging from 0.98 to 1.00. However, none of the models that include the NBS survey data as a separate index do a particularly good job of fitting those data, with ratios ranging from 0.70 to 0.78.
- For the compositional data, goodness of fit is measured by the ratio of *Nsamp* to *Ninit* (see "Base model" section). All models fit all of their respective size composition data extremely well, with ratio=1.00 in all cases. Fits to the age composition data were not nearly as good, with ratios for the "main" survey ranging from 0.50 to 0.63, and ratios for the NBS survey ranging from 0.18 to 0.60. The NBS survey age composition data were fit the best by the two models that used those data in a 1-area structure (Models 19.12b and 19.12d).

Table 2.1.12 shows goodness of fit for the size composition on a finer scale, where "N" is the input sample size (same as *Ninit*) and where "DM" and "MI" represent two measures of effective sample size: "DM" (same as *Nsamp*) uses the definition that is consistent with the Dirichlet-multinomial approach of Thorson et al. (2017), and "MI" is the harmonic mean of the quantity as defined by McAllister and Ianelli

(1997). Table 2.1.12a shows the results for the fishery data and Table 2.1.12b shows the results for the survey data. In general, DM and MI show similar trends, but MI tends to be larger.

Table 2.1.13 is the age composition analogue to Table 2.1.12 (note that color scales extend across rows in this table, rather than across columns for most tables that show results by year).

- For the "main" survey, the pair of 2-area models that treat the NBS and EBS surveys separately (Models 20.2 and 20.3) show the highest values of DM for all years except 2017, which was one of the years in which an NBS survey took place; while the pair of models that combined the EBS and NBS surveys (Models 19.12a and 19.12) show the lowest values of DM in all years except 2010, 2017, and 2018, which are the years in which an NBS survey took place.
- For the NBS survey, Models 19.12c and 19.12d show the highest values in all three years, and Models 20.1 and 20.2 show the lowest values in all three years.

Alternative ensemble
A small set of results is presented here for the alternative ensemble, so that the performance of the alternative ensemble can be compared easily with that of the primary ensemble, so that the Team and SSC have enough information to determine which (if either) ensemble they would like to see presented in the final draft of this year's assessment.

Final model names
After computing ADSB for the "prior-less" versions of the six models in the primary ensemble that included informative prior distributions for log catchabiltiy in the NBS survey, the models in the alternative ensemble were assigned the names shown below (note that Models 19.12a and 19.12, shaded gray, members of both ensembles; also, new ADSB values are not relevant to Models 19.12 and 19.15, as these models retain the names assigned to them in last year's assessment):

Time-varying *Q*?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
ADSB:	0.0755	0.1105	36.5771	0.0724	n/a	n/a	0.1874	0.3642
Model name:	19.12a	20.4	20.5	19.12e	19.12	19.15	20.6	20.7

Parameter estimates and derived time series
Table 2.1.14 compares estimates and standard deviations of the time-invariant parameters that are common to at least half the models in the primary ensemble (estimates for Models 19.12a and 19.12 are not shown, because they are the same in both ensembles).

- Table 2.1.14a compares the point estimates of the parameters between each pair of models. For parameters that are constrained to be positive (top 12 rows in the table), changes (D) are expressed as A/P-1 (where "A" and "B" represent the version of the particular model in the alternative and primary ensembles, respectively), while changes for parameters that are defined on the whole real line are expressed as A-P. To facilitate a focus on the largest changes, let a "substantial" change be defined as one outside the {-0.05, 0.05} range. In the table, changes below a value of -0.05 are highlighted in red, and changes above a value of 0.05 are highlighted in green. There were only 15 cases where changes in parameter estimates were in the "substantial" category (the {19.12c, 19.12e} pair exhibited no substantial changes at all). Not surprisingly, the parameter that most frequently exhibited substantial changes was log catchability for the NBS survey (highlighted by the bold box), which exhibited a substantial change in four

out of the six pairs of models. In particular, removing the informative prior distribution on NBS log catchability from Model 20.1 caused the estimate of that parameter to decrease by 3.375 in Model 20.5. Aside from changes in NBS ln(Q), the {20.2, 20.6} and {20.3, 20.7} pairs exhibited no substantial changes in parameter estimates. Note that Model 20.7 exhibited convergence issues unless the value of initial fishing mortality in the NBS fishery was fixed at a very small number rather than estimated, so the value of that parameter is not displayed for Model 20.7.

- Table 2.1.14b is analogous, except that it describes differences in the standard deviations of the parameter estimates rather than the point estimates themselves. Because standard deviations are always constrained to be positive, all changes are expressed as A/P-1. Substantial changes are more common in Table 2.1.14b than in Table 2.1.14a, with 38 occurrences out of a possible 187. For the model pairs {19.12b, 20.4}, {20.2, 20.6}, and {20.3, 20.7}, substantial changes in standard deviations were all negative (i.e., the parameters were more precisely estimated when the prior distribution on NBS ln(*Q*) was removed), while substantial changes in the {19.12d, 19.15} pair were all positive. Substantial changes in the {20.1, 20.5} and {20.2, 20.6} pairs were of mixed direction, while the {19.12c, 19.12e} pair exhibited no substantial changes in standard deviations.

Table 2.1.15 compares estimates of the catchability time series (*not* on the log scale), expressed as A/P-1.

- Table 2.1.15a compares estimates for the EBS survey for the two pairs of 1-area models. The changes are negative and small for all years in both model pairs, staying within the –0.011 to –0.008 range.
- Table 2.1.15b compares estimates for the NBS survey for the two pairs of 1-area models. Changes are slightly larger here than in Table 2.1.15b, still consistently negative, with a value of –0.016 for the {19.12b, 20.4} pair and ranging from -0.056 to -0.017 for the {19.12d, 19.15} pair.
- Table 2.1.15c compares estimates for the EBS survey for the four pairs of 2-area models. Changes are small and positive for the {20.1, 20.5} pair (0.017 in all years) and the {20.2, 20.6} pair (ranging from 0.002 to 0.003}, while changes are small and negative for the {19.12c 19.12e} pair (-0.001 in all years) and the {20.3, 20.7} pair (ranging from -0.012 to 0).
- Table 2.1.15d compares estimates for the NBS survey for the four pairs of 2-area models. Changes here are sometimes quite substantial. In particular, the constant value of NBS Q in Model 20.5 is lower than in its counterpart (Model 20.1) by a factor of 0.966. Changes are uniformly negative in the {19.12c, 19.12e} pair (-0.005 in all years) and the {20.3, 20.7} pair (ranging from -0.107 to -0.054), while changes in the {20.2, 20.6} pair are uniformly positive (ranging from 0.049 to 0.078).

Table 2.1.16 compares estimates of the age 0+ biomass time series, expressed as A/P-1.

- Table 2.1.16a compares combined-area age 0+ biomass. The changes in the {20.2, 20.6} pair are uniformly negative and small, ranging from -0.006 to -0.003. The changes for all other pairs are uniformly positive, with all of the changes in the {20.1, 20.5} pair being truly enormous. For the other pairs with positive changes, the values are all within the 0.001 to 0.047 range.
- Table 2.1.16b compares age 0+ biomass for the individual areas (2-area models only). For the EBS, changes are all small; uniformly negative for the {20.1, 20.5} and {20.2, 20.6} pairs and uniformly positive (with a single exception) for the {19.12c and 19.12e} and {20.3, 20.7} pairs, with values ranging from -0.037 to 0.002. For the NBS, changes are uniformly negative for the {20.2, 20.6} pair, ranging from -0.081 to -0.036, and uniformly positive for the other three model pairs. The changes for the {20.1, 20.5} pair, like their combined-area counterparts, are truly enormous. The changes for the {19.12c, 19.12e} pair range from 0.002 to 0.008, while changes in the {20.3, 20.7} pair range from 0.065 to 0.101.

Performance measures

Table 2.1.17 compares values of the objective function components, expressed as P-A. Cells with negative values (better fit) are shaded red, and cells with positive values (worse fit) are shaded green.

- Table 2.1.17a compares values for the major components. All totals are negative, indicating that removal of the informative prior distribution on log catchability in the NBS survey results in overall better fits to the data, as would be expected. However, a few individual components in each model pair show an improved fit when the prior distribution is removed, although the components associated with such improved fits are not consistent across models, although the survey index is fit better in all but one pair of models {20.2, 20.6}. The age composition component is fit better in half the model pairs.
- Table 2.1.17b compares values for fleet- and area-specific subcomponents. A few individual subcomponents in each model pair show an improved fit when the prior distribution is removed. For each subcomponent of the size composition and age composition components (except for the NBS fishery sizecomp subcomponent, where data do not exist), half the models fit the NBS data better when the prior distribution on log catchability in the NBS survey is removed, and half the models fit the "main" survey data better.

The point estimates of Mohn's ρ for the models in the alternative ensemble are shown below, together with bootstrap estimates of the standard deviation and the endpoints of the 95% confidence interval (values for Models 19.12a and 19.12, shaded gray, are the same as in the primary ensemble):

Statistic	19.12a	20.4	20.5	19.12e	19.12	19.15	20.6	20.7
mean	-0.070	-0.094	-0.012	0.790	-0.053	-0.034	-0.013	0.052
st. dev.	0.022	0.032	0.012	0.329	0.014	0.023	0.038	0.075
L95%	-0.116	-0.158	-0.036	0.231	-0.081	-0.082	-0.078	-0.091
U95%	-0.031	-0.034	0.010	1.509	-0.028	0.006	0.068	0.199

Cross-conditional decision analysis

Introduction

CCDA was introduced during the September 2019 Team meeting (see document posted at https://meetings.npfmc.org/Meeting/Details/843). Briefly, CCDA is a systematic method for answering a question that regularly plagues attempts to choose a single model from a set of alternatives, namely, *"But what if we're wrong?"* CCDA answers this question by considering not only the performance of a given model within the ensemble when the structure of that model is the "true" one, but also the performance of that model when any of the *other* models in the ensemble is the "true" one, repeating this process for each model in the ensemble. Performances are measured by generating a series of bootstrap data sets from each fitted model, then applying each model to each data set and comparing the respective estimates of the quantity of interest to the best estimate from the model that generated the bootstrap data (the "pivot" model). Those performances, together with a set of user-specified values representing the subjective probabilities that each of the models in the ensemble is the "true" one, are then used to estimate a set of model weights that optimize the performance of the overall ensemble. This results in a probability mass function, *pmf*, for the quantity being estimated. Finally, decision theory is then used to obtain an optimal point estimate, given the *pmf* and a specified level of risk aversion, *ra*, where $ra<0$ implies risk proclivity, $ra=0$ implies risk neutrality, and $ra>0$ represents true risk aversion. A full description of the steps involved in CCDA is given in Attachment 2.1.3.

It should be noted that one change has been made to the method since it was introduced in September 2019. This will be addressed in the "Discussion" section.

Application: Estimating OFL and ABC in the primary ensemble
CCDA was applied here to the primary ensemble for the purpose of developing preliminary estimates of the OFL and ABC for 2021. Due to time constraints, a fairly small sample of 10 bootstrap data sets was generated from each of the 8 models in the ensemble. When each of the 8 models was fit to each of the 8×10 bootstrap data sets, the estimates of 2021 OFL shown in Table 2.1.18 resulted. In the event that at least one model failed to converge for a given bootstrap data set, all estimates for that data set were dropped from the analysis (these are represented by blank lines in Table 2.1.18, where cell(s) corresponding to the model(s) that failed to converge are shaded gray).

The probability that any given model in the ensemble is the "true" one was based on scores that were derived from factor-specific formulas that considered the following:

- The extent to which the model structure seems consistent with observed inter-area trends.
- Goodness of fit.
- Retrospective performance (Mohn's ρ).
- The extent to which catchability (combined area or by separate areas) deviates from unity.

The details of the formulas are omitted here in the interest of brevity, given that the choice of functional forms was ultimately subjective, but the resulting scores are shown below:

Model	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
Structure	0.667	0.667	0.333	0.667	1.000	1.000	0.667	1.000
Fit	0.838	0.764	0.712	0.813	1.000	0.972	0.912	0.922
Mohn's ρ	0.956	0.947	0.598	0.927	0.972	1.000	0.920	0.643
Catchability	1.000	0.762	0.673	0.829	0.962	0.824	0.514	0.425
Mean	0.865	0.785	0.579	0.809	0.984	0.949	0.753	0.747
Probability	0.134	0.121	0.089	0.125	0.152	0.147	0.116	0.115

The arithmetic mean of the scores was used as the basis for assigning the probabilities (by rescaling so that the values sum to unity), following the recommendation of the SSC (see comment SSC6).

An important distinction in CCDA is that the probability of a given model being the "true" one is not necessarily equal to, or even related to, how well that model performs when either it or one of the other models in the ensemble is *actually* the true model. The latter concept is represented in CCDA by a vector of model *weights* (as distinguished from probabilities). The model weights are used to form a conditional mean squared error (CMSE) for each pivot model, where the weighted average is computed across models for each bootstrap data set, and then the bootstrap-specific weighted average squared errors are averaged across bootstrap data sets (without weighting, because the bootstrap data sets for a given pivot model are considered to be a random sample). Table 2.1.19 shows example calculations for the case where all of the model weights are equal.

Given the CMSE for each pivot model, an ensemble mean squared error is calculated as the sum of the product of the model CMSEs and the model probabilities. The results for the equal weighting example are shown below:

Model:	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
probability	0.1337	0.1213	0.0895	0.1250	0.1520	0.1467	0.1164	0.1155
CMSE:	0.0207	0.0015	0.0001	0.0005	0.0215	0.0018	0.0014	0.0002
probability×CMSE:	0.0028	0.0002	0.0000	0.0001	0.0033	0.0003	0.0002	0.0000

The sum of the values on the bottom row (=0.0067, or -5.0007 on the log scale) is the ensemble MSE when equal weights are used.

However, a central feature of CCDA is that the model weights are estimated statistically by minimizing the ensemble MSE. The model weights estimated in this application are shown below:

Model	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
Weight	0.000	0.012	0.000	0.244	0.000	0.060	0.000	0.684

Table 2.1.20 shows the results of calculations analogous to those in Table 2.1.19 when the optimized model weights are used instead of equal weighting. The CMSE values from Table 2.1.20 are then multiplied by the model probabilities as shown below:

Model:	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
probability	0.1337	0.1213	0.0895	0.1250	0.1520	0.1467	0.1164	0.1155
CMSE:	0.0004	0.0010	0.0005	0.0002	0.0006	0.0006	0.0003	0.0002
probability×CMSE:	0.0001	0.0001	0.0000	0.0000	0.0001	0.0001	0.0000	0.0000

The sum of the values on the bottom row (=0.0005, or -7.6132 on the log scale) is the ensemble MSE when the optimized weights are used.

The above results illustrate the point that a given model's performance across alternative (conditional) truths may be largely unrelated to its probability of being the "true" model. For example, Model 19.12 was subjectively judged to be the most likely to be "true," but its performance weight ended up being essentially zero, while Model 20.3 was subjectively judged to rank next to last in terms of the probability of being "true," but it ended up with the highest performance weight. The two models that incorporate explicit inter-area movement (19.12c and 20.3) ended up with 92.7% of the overall performance weight.

For a given pivot model, the estimates in each column of the corresponding section of Table 2.1.18 can be converted into a scaled histogram, which can then be weighted by the respective performance weight, and then the columns can be summed to generate a conditional weighted average *pmf* for that pivot model. These are shown in Table 2.1.21. Note that the range of OFL values in Table 2.1.9 is truncated at 200,000 t, even though some of the individual *pmf*s or weighted average *pmf*s include some amount of mass outside that range. This is simply for display purposes (i.e., larger values of OFL were not ignored in the analysis).

The model-specific, performance-weighted average *pmf*s are then weighted by the model probabilities, giving the final *pmf* for the overall ensemble shown in Figure 2.1.9 (approximately 2% of the total mass of the final *pmf* occurs at values of OFL larger than 300,000 t; these are not shown in the figure, but were not ignored in the analysis).

Given this *pmf*, the only other quantities that need to be specified in order to estimate OFL and ABC in the CCDA approach are the corresponding values of *ra*.

Because OFL is commonly understood as being a risk-neutral estimate of the fishing mortality rate corresponding to maximum sustainable yield (at least for stocks above the inflection point in the OFL harvest control rule), it seems reasonable to identify *ra*=0 for estimation of OFL. Because ABC is constrained to be less than OFL, it can be viewed as a risk-averse alternative, but this begs the question of *how much* risk aversion is appropriate for estimation of ABC (see comment SSC5). For the present application, *ra*=2 was identified as a reasonable value for estimation of ABC (see Attachment 2.1.4).

Given *ra*=0, the estimate of OFL from CCDA is simply the arithmetic mean of the *pmf*; and given *ra*=2, the estimate of ABC from CCDA is simply the harmonic mean of the *pmf*. The arithmetic and harmonic means of the *pmf* shown in Figure 2.1.9 are 127,084 t (OFL) and 114,288 t (ABC), respectively, representing a buffer of approximately 10%. Of course, the ABC harvest control rule identified in the BSAI Groundfish FMP still applies, so the CCDA estimate of ABC could be used only if it does not exceed the value resulting from application of that control rule.

Discussion

Looking ahead to developing the final draft of this year's assessment, two main issues are important to highlight with at this point: 1) how to structure the ensemble, and 2) whether to use CCDA.

Structure of the ensemble

Two ensembles have been presented here: 1) the primary ensemble, consisting of eight models, one of which is the current base model (19.12); and 2) an alternative ensemble, which is the same as the primary model except that the six models that use an informative prior distribution on NBS survey log catchability in the primary ensemble are replaced by six models that are the same as their primary ensemble counterparts in all respects except for use of that prior distribution.

Fitting and documenting eight models in the brief time available for development of the final draft of this year's assessment will likely prove to be a challenging undertaking, based on last year's experience with a 9-model ensemble. However, both of the 8-model ensembles presented here have the desirable attribute of being based on a factorial design, which helps to regard against "stacking the deck" in selecting models for inclusion in the ensemble, so eliminating models from either ensemble would remove this attribute unless done carefully.

The prior distribution on NBS survey log catchability in the two-survey models from the primary ensemble each have a mean equal to the corresponding point estimate of EBS survey log catchability, which seems reasonable, but it complicates the model fitting process by requiring an iterative process, and these models already involve a complicated iterative process for tuning the sigma terms of the various vectors of annual random deviations. Although the assumption of unit variance in the prior distribution was made with the expectation that it would be only mildly constraining, the effects were, in practice, sometimes substantial, particularly when comparing Models 20.1 (with the prior distribution) and 20.5 (the analogous model without the prior distribution).

Of course, once the Team and SSC have the opportunity to review the results of this preliminary assessment, they may prefer to replace some of the models with new models of their own.

If any of the two-area models presented here are to be included in the final draft, the experience of developing these models for the preliminary draft suggests that fixing the value of initial fishing mortality in the NBS fishery at some very small value would likely be of negligible consequence in terms of parameter estimation but would likely result in improved performance in terms of model convergence.

Use of CCDA

As noted in the "Cross-conditional decision analysis" section, the application of CCDA in this preliminary assessment included some changes relative to the method described in September 2019 (see document posted at https://meetings.npfmc.org/Meeting/Details/843). Here, a single set of model weights and a single ensemble *pmf* were generated, both of which were implicitly based on a risk-neutral loss function, with contrasting attitudes toward risk coming into play only when deriving point estimates from the single ensemble *pmf*. In contrast, the original description of CCDA envisioned estimation of a separate set of model weights and a separate ensemble *pmf* for each value of *ra*. There were two reasons for making this change: First, while risk aversion has a fairly intuitive meaning for something like setting

ABC, it is not at all clear that the meaning is similarly clear for many other quantities estimated in the assessment (for example, what does risk aversion mean in the context of estimating a selectivity parameter?). Second, when a separate set of model weights and a separate ensemble *pmf* are estimated for each value of *ra*, it is possible for the estimate of ABC to exceed the estimate of OFL, which might be theoretically valid, but would likely be difficult to explain, and moreover would be precluded by the MSFCMA National Standard Guidelines.

The main advantage of including CCDA in this year's final assessment is that it provides a statistically rigorous answer to the "*But what if we're wrong?*" question that so often plagues the process of selecting a single model.

However, there are several disadvantages as well:

- It is much harder to understand (or explain) than typical approaches to model averaging.
- It is currently very time-consuming, perhaps to such an extent that its use in this year's final assessment is precluded on logistical grounds alone. A major impediment is the fact that some of the models in the ensemble have spatial structures that are nested within those of other models in the ensemble. Even if an analysis similar to the one described here could be conducted in time for this year's final assessment, it would be limited to estimation of OFL and ABC (i.e., there would definitely not be enough time to produce a full set of model-averaged results for parameters or time series of derived quantities).
- As discussed in the document presented in September 2019, use of bootstrap distributions as an approximation of Bayesian posterior distributions is controversial. Even if the approximation is acceptable in principle, the precision of the distributions estimated here is questionable, given the small sample (10 bootstrap data sets per model). As a quick comparison, the averages from the bootstrap distributions presented here were sometimes noticeably (although not drastically) different from the point estimates derived from the actual data.

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Tables

Table 2.1.1. Parameter counts. Gray shading indicates that the parameter/model combination is not applicable. Color scales extend from red=low to green=high.

Time-varying *Q*?	No				Yes			
Separate areas?	No		Yes		No		Yes	
Separate surveys?	No	Yes	Yes		No	Yes	Yes	
Movement?	No		No	Yes	No		No	Yes
Temporary name	A1	B1	C1	D1	A2	B2	C2	D2
NatMort	1	1	1	1	1	1	1	1
Growth	6	6	6	6	6	6	6	6
Recr_dist			1	1			1	1
Movement				4				4
Recr_dist_cov				1				1
Movement_cov				4				4
Ageing_error	4	4	4	4	4	4	4	4
SR	2	2	2	2	2	2	2	2
InitF(main_srv)	1	1	1	1	1	1	1	1
InitF(NBS_srv)			1	1			1	1
LnQ(main_srv)	1	1	1	1	1	1	1	1
LnQ(NBS_srv)		1	1	1		1	1	1
Sel(main_fsh)	5	5	5	5	5	5	5	5
Sel(NBS_fsh)			5	5			5	5
Sel(main_srv)	2	2	2	2	2	2	2	2
Sel(NBS_srv)		2	2	2		2	2	2
DM(fish&main)	3	3	3	3	3	3	3	3
DM(NBS_srv)		2	2	2		2	2	2
True parameters	25	30	37	46	25	30	37	46
Early_devs	20	20	20	20	20	20	20	20
Rec_devs	42	42	42	42	42	42	42	42
L1_devs	43	43	43	43	43	43	43	43
Main_lnQ_devs					38	38	38	38
NBS_lnQ_devs						38	38	38
Sel(fish)_devs	86	86	86	86	86	86	86	86
Sel(main)_devs	76	76	76	76	76	76	76	76
Annual deviations	267	267	267	267	305	343	343	343
Total parameters	292	297	304	313	330	373	380	389

Table 2.1.2. Age composition time series. Data through 2018 are VAST estimates, and were used in the models presented here. The record for 2019 is a design-based estimate, and will likely be used for this year's final assessment.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00014	0.09613	0.40395	0.17319	0.11261	0.10797	0.07225	0.01885	0.00719	0.00419	0.00127	0.00109	0.00116
1995	0.00010	0.05819	0.26053	0.42510	0.10262	0.07361	0.05060	0.01300	0.00666	0.00523	0.00141	0.00155	0.00140
1996	0.00003	0.06610	0.20487	0.19054	0.28907	0.13770	0.06404	0.03050	0.00856	0.00355	0.00183	0.00161	0.00161
1997	0.00022	0.26517	0.17172	0.16133	0.15060	0.11976	0.09091	0.02379	0.01050	0.00246	0.00183	0.00103	0.00069
1998	0.00005	0.07845	0.43779	0.20042	0.11281	0.05824	0.05939	0.03005	0.01704	0.00369	0.00076	0.00085	0.00045
1999	0.00006	0.08528	0.20960	0.31480	0.21893	0.07289	0.05280	0.02580	0.01176	0.00507	0.00103	0.00135	0.00062
2000	0.00000	0.21363	0.11948	0.16697	0.24416	0.15478	0.06074	0.01415	0.01521	0.00502	0.00365	0.00150	0.00072
2001	0.00003	0.29245	0.23927	0.18907	0.08810	0.08647	0.06788	0.02470	0.00733	0.00181	0.00141	0.00105	0.00043
2002	0.00035	0.08038	0.19872	0.30697	0.23702	0.06869	0.05722	0.03609	0.00957	0.00291	0.00095	0.00050	0.00064
2003	0.00001	0.17330	0.16086	0.24003	0.20847	0.12118	0.04409	0.03070	0.01583	0.00370	0.00049	0.00060	0.00076
2004	0.00003	0.14206	0.15181	0.27385	0.13242	0.13298	0.09559	0.03803	0.02036	0.00788	0.00216	0.00203	0.00080
2005	0.00000	0.16085	0.23187	0.20703	0.13136	0.07043	0.09116	0.06183	0.02580	0.01090	0.00382	0.00439	0.00055
2006	0.00000	0.32732	0.14621	0.17330	0.11701	0.08947	0.06074	0.04509	0.02659	0.00932	0.00297	0.00125	0.00074
2007	0.00000	0.66271	0.10804	0.07737	0.04920	0.04994	0.01963	0.01592	0.00825	0.00530	0.00170	0.00102	0.00092
2008	0.00000	0.19811	0.43937	0.15456	0.09171	0.05198	0.03097	0.01097	0.01018	0.00616	0.00254	0.00209	0.00135
2009	0.00000	0.45311	0.18811	0.23141	0.06606	0.02852	0.01488	0.00933	0.00472	0.00181	0.00094	0.00071	0.00041
2010	0.00000	0.04654	0.48121	0.18329	0.19871	0.06219	0.01489	0.00793	0.00257	0.00140	0.00050	0.00060	0.00017
2011	0.00006	0.32372	0.07444	0.36511	0.10766	0.08847	0.02708	0.00687	0.00286	0.00157	0.00107	0.00064	0.00045
2012	0.00000	0.34130	0.26174	0.06302	0.23036	0.06137	0.02983	0.00755	0.00230	0.00165	0.00054	0.00015	0.00020
2013	0.00000	0.09807	0.40589	0.19757	0.11512	0.11578	0.05059	0.01181	0.00341	0.00096	0.00021	0.00031	0.00026
2014	0.00002	0.28151	0.16686	0.24402	0.20263	0.05073	0.03919	0.01039	0.00220	0.00095	0.00084	0.00010	0.00057
2015	0.00002	0.06356	0.43477	0.20238	0.18886	0.07797	0.01825	0.01087	0.00231	0.00047	0.00023	0.00011	0.00020
2016	0.00000	0.10111	0.09245	0.35833	0.22552	0.15171	0.05281	0.01203	0.00365	0.00143	0.00051	0.00030	0.00015
2017	0.00007	0.12941	0.16222	0.16720	0.29456	0.13708	0.07948	0.02114	0.00338	0.00333	0.00065	0.00066	0.00082
2018	0.00004	0.09856	0.11454	0.26881	0.15622	0.23896	0.08099	0.03415	0.00351	0.00254	0.00074	0.00035	0.00059
2019	0.00000	0.69868	0.06224	0.06420	0.05415	0.04050	0.04793	0.02339	0.00620	0.00163	0.00048	0.00043	0.00018

Table 2.1.3a. Estimates of time-invariant parameters common to at least half the models.

Time-varying *Q*?	No								Yes							
Separate areas?	No				Yes				No				Yes			
Separate surveys?	No		Yes		Yes				No		Yes		Yes			
Movement?	No				No		Yes		No				No		Yes	
Model	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Natural_mortality	0.358	0.011	0.372	0.012	0.372	0.011	0.332	0.011	0.348	0.013	0.358	0.012	0.374	0.011	0.344	0.013
L_at_1.5_base	14.815	0.398	14.799	0.400	14.794	0.404	14.805	0.400	14.894	0.401	14.903	0.418	14.807	0.416	14.594	0.400
L_infinity	113.4	3.123	114.2	3.340	112.9	3.189	118.2	4.594	115.1	3.315	114.6	3.265	116.5	4.188	111.2	3.467
VonBert_K	0.117	0.009	0.117	0.010	0.118	0.010	0.106	0.011	0.114	0.009	0.117	0.009	0.108	0.011	0.123	0.011
Richards_coef	1.444	0.042	1.435	0.045	1.444	0.043	1.480	0.047	1.445	0.042	1.419	0.043	1.479	0.047	1.438	0.046
SD_len_at_1	3.493	0.067	3.483	0.066	3.466	0.066	3.481	0.066	3.510	0.066	3.473	0.065	3.485	0.067	3.490	0.065
SD_len_at_20	9.905	0.383	9.945	0.397	10.136	0.387	10.153	0.446	9.705	0.388	9.882	0.391	10.014	0.430	9.397	0.392
RecrDist_NBS_base					-0.676	0.759	-3.037	0.245					-3.345	0.177	-1.690	0.213
AgeBias_at_1_1977_2007	0.339	0.017	0.349	0.015	0.349	0.015	0.347	0.015	0.337	0.017	0.347	0.015	0.348	0.014	0.346	0.015
AgeBias_at_1_2008_2019	0.014	0.025	-0.002	0.025	0.001	0.024	0.009	0.023	0.019	0.025	0.002	0.026	0.004	0.023	0.008	0.024
AgeBias_at_20_1977_2007	0.859	0.221	0.776	0.205	0.772	0.198	0.843	0.200	0.898	0.221	0.804	0.204	0.825	0.200	0.954	0.205
AgeBias_at_20_2008_2019	-1.532	0.316	-1.697	0.325	-1.646	0.313	-1.698	0.305	-1.708	0.326	-1.930	0.345	-1.790	0.324	-2.179	0.365
ln(Recr_ave_1977_2018)	13.208	0.097	13.271	0.099	13.678	0.271	12.991	0.089	13.121	0.105	13.144	0.103	13.313	0.097	13.185	0.123
ln(Recr_ave_pre1977_offset)	-0.903	0.202	-0.885	0.204	-0.862	0.206	-0.986	0.181	-0.925	0.195	-0.909	0.199	-0.839	0.208	-0.919	0.180
InitF_main_fsh	0.122	0.038	0.127	0.040	0.119	0.037	0.147	0.046	0.127	0.039	0.134	0.043	0.114	0.035	0.173	0.056
InitF_NBS_fsh					0.000	0.000	0.000	0.000					0.000	0.000	0.000	0.000
lnQ_main_srv_base	-0.029	0.063	-0.111	0.066	-0.102	0.057	0.172	0.059	0.019	0.069	-0.037	0.068	-0.116	0.064	0.261	0.065
lnQ_NBS_srv_base			-0.788	0.105	-0.747	0.767	-0.260	0.108			-1.842	0.254	0.827	0.325	-1.466	0.284
Main_fsh_sel_PeakStart	74.984	0.039	75.220	0.598	74.971	0.196	74.982	0.528	74.985	0.035	74.986	0.030	74.931	0.520	75.968	0.590
Main_fsh_sel_logitPeakWidth	-9.765	6.733	-5.712	18.562	-9.439	14.705	0.208	0.465	-9.782	6.361	-9.761	6.755	0.469	0.593	0.097	0.522
Main_fsh_sel_lnSD1_base	5.908	0.029	5.913	0.039	5.898	0.029	5.907	0.039	5.911	0.028	5.905	0.027	5.896	0.037	5.950	0.039
Main_fsh_sel_lnSD2	-9.867	4.111	-1.410	8.489	-9.091	18.173	4.707	1.251	-9.883	3.621	-9.886	3.556	4.345	1.767	4.827	1.357
Main_fsh_sel_logitEnd_base	2.135	0.313	1.987	0.301	3.114	0.786	-3.140	3.513	2.225	0.348	2.084	0.296	-2.647	3.443	-2.855	3.301
Main_srv_sel_PeakStart_base	20.923	0.779	21.036	0.801	20.986	0.794	21.110	0.811	20.817	0.807	20.699	0.831	20.970	0.819	21.827	0.905
Main_srv_sel_lnSD1_base	3.529	0.151	3.532	0.151	3.522	0.151	3.535	0.154	3.503	0.156	3.460	0.161	3.513	0.155	3.613	0.157
NBS_srv_sel_PeakStart			79.998	0.072	74.051	8.817	15.530	1.383			79.997	0.113	68.696	7.855	14.453	1.161
NBS_srv_sel_lnSD1			7.784	0.139	8.881	0.882	2.067	0.640			7.821	0.146	7.925	0.490	1.750	0.675
lnDM_size_main_fish	9.989	0.337	9.989	0.351	9.989	0.358	9.990	0.325	9.989	0.355	9.989	0.358	9.990	0.347	9.989	0.343
lnDM_size_main_sur	9.984	0.520	9.984	0.524	9.985	0.499	9.984	0.496	9.984	0.540	9.984	0.522	9.985	0.470	9.984	0.482
lnDM_size_NBS_sur			9.656	9.374	9.717	7.603	9.923	2.327			9.756	7.420	9.712	8.223	9.935	1.982
lnDM_age_main_srv	-0.006	0.213	0.281	0.252	0.444	0.278	0.478	0.280	0.075	0.225	0.432	0.274	0.522	0.297	0.541	0.282
lnDM_age_NBS_srv			0.213	0.568	-1.511	0.343	0.381	1.052			0.383	0.609	-1.342	0.362	-0.201	0.578

Table 2.1.3b. Estimates of movement parameters and environmental linkages (used by Models 19.12c and 20.3 only).

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Move_EBS_to_NBS_A_base							-3.365	0.227							-1.471	0.275
Move_EBS_to_NBS_B_base							-12.77	3.025							-13.82	0.000
Move_NBS_to_EBS_A_base							-6.627	1.796							-7.897	2.424
Move_NBS_to_EBS_B_base							-1.480	0.321							-2.166	0.335
RecrDist_NBS_link							-0.620	0.086							-0.035	0.084
Move_EBS_to_NBS_A_link							-1.740	0.140							-0.870	0.120
Move_EBS_to_NBS_B_link							-7.274	1.963							-3.979	0.280
Move_NBS_to_EBS_A_link							5.615	1.065							6.307	1.380
Move_NBS_to_EBS_B_link							1.209	0.265							0.006	0.184

Table 2.1.3c. Estimates of log-scale recruitment deviations that are used to represent offsets from equilibrium in the initial numbers-at-age vector.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
ln(InitN)_offset_at_01	0.786	0.562	0.751	0.563	0.768	0.577	0.690	0.544	0.803	0.548	0.756	0.570	0.826	0.570	0.748	0.556
ln(InitN)_offset_at_02	-0.081	0.582	-0.077	0.568	-0.059	0.581	-0.112	0.547	-0.089	0.569	-0.086	0.565	-0.048	0.576	-0.081	0.534
ln(InitN)_offset_at_03	0.225	0.499	0.217	0.492	0.246	0.503	0.137	0.479	0.200	0.488	0.204	0.487	0.250	0.497	0.196	0.485
ln(InitN)_offset_at_04	-0.262	0.564	-0.254	0.552	-0.241	0.566	-0.314	0.532	-0.271	0.549	-0.266	0.548	-0.230	0.558	-0.236	0.534
ln(InitN)_offset_at_05	-0.563	0.547	-0.543	0.536	-0.535	0.547	-0.615	0.519	-0.579	0.534	-0.560	0.533	-0.533	0.540	-0.546	0.519
ln(InitN)_offset_at_06	-0.614	0.550	-0.585	0.539	-0.585	0.548	-0.671	0.522	-0.634	0.537	-0.605	0.537	-0.589	0.541	-0.610	0.520
ln(InitN)_offset_at_07	-0.562	0.563	-0.527	0.554	-0.532	0.562	-0.619	0.535	-0.583	0.550	-0.548	0.551	-0.538	0.554	-0.562	0.533
ln(InitN)_offset_at_08	-0.471	0.581	-0.433	0.572	-0.441	0.580	-0.525	0.552	-0.491	0.568	-0.455	0.569	-0.446	0.572	-0.479	0.549
ln(InitN)_offset_at_09	-0.373	0.601	-0.336	0.591	-0.344	0.599	-0.420	0.571	-0.391	0.587	-0.356	0.588	-0.346	0.591	-0.385	0.566
ln(InitN)_offset_at_10	-0.282	0.620	-0.248	0.610	-0.255	0.619	-0.319	0.591	-0.298	0.606	-0.266	0.607	-0.254	0.611	-0.294	0.584
ln(InitN)_offset_at_11	-0.205	0.637	-0.177	0.627	-0.181	0.636	-0.231	0.609	-0.218	0.623	-0.191	0.624	-0.179	0.629	-0.216	0.600
ln(InitN)_offset_at_12	-0.144	0.653	-0.122	0.640	-0.125	0.650	-0.162	0.624	-0.155	0.638	-0.133	0.638	-0.121	0.643	-0.153	0.614
ln(InitN)_offset_at_13	-0.099	0.665	-0.081	0.651	-0.084	0.662	-0.110	0.637	-0.107	0.651	-0.090	0.649	-0.079	0.655	-0.106	0.626
ln(InitN)_offset_at_14	-0.066	0.674	-0.053	0.659	-0.055	0.670	-0.073	0.647	-0.072	0.661	-0.059	0.658	-0.051	0.663	-0.071	0.635
ln(InitN)_offset_at_15	-0.043	0.681	-0.034	0.665	-0.036	0.676	-0.047	0.654	-0.048	0.668	-0.039	0.664	-0.032	0.669	-0.047	0.641
ln(InitN)_offset_at_16	-0.028	0.686	-0.022	0.669	-0.023	0.680	-0.031	0.659	-0.031	0.673	-0.025	0.669	-0.020	0.673	-0.031	0.646
ln(InitN)_offset_at_17	-0.018	0.689	-0.014	0.672	-0.015	0.683	-0.020	0.663	-0.020	0.676	-0.016	0.671	-0.012	0.675	-0.021	0.649
ln(InitN)_offset_at_18	-0.012	0.691	-0.009	0.673	-0.009	0.685	-0.013	0.665	-0.013	0.679	-0.010	0.673	-0.008	0.676	-0.014	0.652
ln(InitN)_offset_at_19	-0.007	0.693	-0.006	0.674	-0.006	0.686	-0.008	0.666	-0.008	0.680	-0.006	0.674	-0.005	0.677	-0.009	0.653
ln(InitN)_offset_at_20	-0.013	0.691	-0.009	0.673	-0.010	0.684	-0.016	0.664	-0.014	0.678	-0.011	0.673	-0.008	0.676	-0.017	0.650

Table 2.1.3d. Estimates of log-scale age 0 recruitment deviations.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1.008	0.224	1.017	0.222	1.071	0.225	0.857	0.218	0.938	0.227	0.993	0.225	1.061	0.231	0.925	0.225
1978	0.591	0.243	0.622	0.237	0.624	0.252	0.494	0.234	0.578	0.230	0.642	0.231	0.662	0.242	0.566	0.231
1979	0.625	0.129	0.647	0.127	0.663	0.129	0.537	0.128	0.600	0.129	0.652	0.128	0.684	0.130	0.597	0.129
1980	-0.797	0.228	-0.808	0.231	-0.827	0.237	-0.810	0.220	-0.834	0.239	-0.843	0.248	-0.805	0.245	-0.782	0.226
1981	-0.675	0.166	-0.645	0.164	-0.650	0.168	-0.732	0.166	-0.672	0.169	-0.640	0.170	-0.617	0.172	-0.655	0.168
1982	0.881	0.055	0.904	0.054	0.925	0.054	0.825	0.054	0.890	0.059	0.932	0.058	0.959	0.058	0.877	0.061
1983	-0.424	0.152	-0.394	0.151	-0.402	0.155	-0.493	0.150	-0.494	0.159	-0.456	0.160	-0.467	0.163	-0.534	0.156
1984	0.777	0.058	0.798	0.057	0.813	0.058	0.727	0.057	0.778	0.061	0.814	0.062	0.824	0.061	0.800	0.065
1985	-0.015	0.088	0.004	0.088	0.007	0.089	-0.050	0.088	0.013	0.091	0.052	0.092	0.043	0.092	0.045	0.092
1986	-0.610	0.108	-0.585	0.108	-0.588	0.109	-0.632	0.107	-0.553	0.110	-0.529	0.111	-0.528	0.111	-0.597	0.110
1987	-1.790	0.228	-1.767	0.225	-1.793	0.230	-1.808	0.222	-1.636	0.225	-1.625	0.228	-1.639	0.228	-1.705	0.215
1988	-0.248	0.087	-0.244	0.086	-0.227	0.086	-0.263	0.086	-0.230	0.093	-0.213	0.092	-0.204	0.093	-0.273	0.114
1989	0.441	0.061	0.438	0.060	0.457	0.061	0.404	0.061	0.448	0.064	0.469	0.063	0.472	0.063	0.390	0.077
1990	0.420	0.068	0.438	0.067	0.449	0.067	0.386	0.067	0.409	0.070	0.444	0.070	0.431	0.069	0.364	0.076
1991	-0.110	0.091	-0.117	0.091	-0.122	0.093	-0.159	0.093	-0.186	0.097	-0.184	0.100	-0.193	0.098	-0.168	0.094
1992	0.882	0.042	0.893	0.041	0.899	0.041	0.860	0.041	0.804	0.045	0.831	0.044	0.817	0.044	0.845	0.046
1993	-0.105	0.076	-0.071	0.073	-0.069	0.073	-0.088	0.072	-0.101	0.076	-0.047	0.074	-0.068	0.074	-0.053	0.074
1994	-0.276	0.073	-0.256	0.071	-0.262	0.070	-0.270	0.070	-0.294	0.074	-0.257	0.072	-0.278	0.072	-0.312	0.075
1995	-0.428	0.081	-0.424	0.079	-0.426	0.079	-0.317	0.079	-0.406	0.082	-0.379	0.080	-0.393	0.080	-0.126	0.092
1996	0.744	0.043	0.758	0.043	0.771	0.043	0.755	0.043	0.751	0.044	0.788	0.044	0.781	0.044	0.830	0.050
1997	-0.082	0.073	-0.063	0.072	-0.059	0.072	-0.112	0.070	-0.056	0.073	-0.026	0.072	-0.041	0.072	-0.090	0.072
1998	-0.353	0.089	-0.339	0.087	-0.339	0.088	-0.407	0.086	-0.306	0.089	-0.271	0.088	-0.293	0.088	-0.395	0.090
1999	0.542	0.047	0.567	0.046	0.574	0.046	0.528	0.046	0.515	0.049	0.566	0.048	0.547	0.048	0.501	0.053
2000	0.204	0.052	0.213	0.052	0.199	0.051	0.246	0.052	0.214	0.054	0.252	0.054	0.207	0.054	0.410	0.066
2001	-0.680	0.100	-0.617	0.097	-0.623	0.097	-0.595	0.095	-0.662	0.101	-0.567	0.099	-0.612	0.097	-0.556	0.097
2002	-0.201	0.061	-0.181	0.060	-0.202	0.061	-0.096	0.061	-0.169	0.062	-0.122	0.062	-0.173	0.061	0.094	0.074
2003	-0.250	0.065	-0.214	0.064	-0.230	0.063	-0.199	0.062	-0.231	0.067	-0.167	0.066	-0.220	0.065	-0.090	0.070
2004	-0.577	0.082	-0.524	0.081	-0.546	0.081	-0.558	0.080	-0.529	0.084	-0.467	0.083	-0.513	0.083	-0.461	0.079
2005	-0.371	0.076	-0.358	0.075	-0.364	0.075	-0.442	0.074	-0.319	0.075	-0.295	0.073	-0.326	0.075	-0.498	0.081
2006	0.711	0.041	0.681	0.040	0.697	0.040	0.655	0.040	0.772	0.042	0.754	0.041	0.738	0.042	0.583	0.052
2007	-0.218	0.088	-0.245	0.086	-0.223	0.086	-0.240	0.084	-0.171	0.088	-0.183	0.086	-0.197	0.087	-0.374	0.096
2008	1.092	0.039	1.048	0.038	1.058	0.038	1.045	0.039	1.066	0.040	1.037	0.039	1.037	0.040	0.877	0.059
2009	-0.897	0.164	-0.681	0.130	-0.733	0.133	-0.856	0.146	-0.896	0.159	-0.693	0.131	-0.752	0.133	-0.812	0.134
2010	0.623	0.052	0.558	0.051	0.559	0.051	0.650	0.050	0.632	0.053	0.553	0.051	0.558	0.052	0.692	0.071
2011	0.876	0.048	0.794	0.046	0.798	0.046	0.859	0.048	0.883	0.050	0.769	0.045	0.789	0.048	0.682	0.060
2012	0.131	0.089	0.024	0.085	0.023	0.085	0.080	0.088	0.070	0.093	-0.056	0.087	-0.044	0.089	-0.087	0.094
2013	1.120	0.045	0.921	0.044	0.920	0.044	1.187	0.048	1.099	0.052	0.838	0.050	0.893	0.051	1.122	0.060
2014	-0.630	0.115	-0.795	0.108	-0.807	0.109	-0.480	0.109	-0.620	0.116	-0.818	0.110	-0.804	0.112	-0.546	0.120
2015	-0.343	0.076	-0.472	0.073	-0.483	0.074	-0.279	0.077	-0.325	0.083	-0.489	0.077	-0.457	0.080	-0.382	0.084
2016	-0.888	0.116	-1.011	0.105	-1.013	0.107	-0.791	0.110	-0.966	0.124	-1.241	0.093	-1.079	0.119	-0.911	0.118
2017	-1.268	0.267	-1.103	0.238	-1.103	0.240	-0.993	0.225	-1.329	0.274	-1.257	0.236	-1.232	0.229	-1.145	0.230
2018	0.569	0.080	0.590	0.086	0.583	0.085	0.577	0.084	0.525	0.099	0.439	0.104	0.432	0.103	0.350	0.102

Table 2.1.3e. Estimates of log-scale mean length at age 1.5 deviations.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.393	0.963	0.301	0.962	0.466	0.964	0.319	0.956	0.335	0.959	0.268	0.953	0.502	0.961	0.264	0.965
1978	-0.111	0.945	-0.110	0.942	-0.102	0.944	-0.132	0.943	-0.116	0.941	-0.114	0.934	-0.101	0.940	-0.136	0.942
1979	0.460	1.011	0.484	1.006	0.479	1.012	0.439	1.000	0.479	1.010	0.516	1.001	0.506	1.021	0.485	1.011
1980	-0.048	0.935	-0.048	0.928	-0.021	0.937	-0.055	0.933	-0.078	0.920	-0.063	0.909	-0.044	0.924	-0.061	0.930
1981	-1.063	0.468	-1.096	0.462	-1.069	0.457	-1.015	0.463	-1.128	0.474	-1.112	0.453	-1.049	0.449	-1.099	0.475
1982	-0.900	0.299	-0.913	0.300	-0.925	0.297	-0.860	0.295	-0.967	0.312	-0.933	0.300	-0.933	0.301	-0.899	0.324
1983	0.762	0.722	0.836	0.725	0.761	0.726	0.843	0.754	1.045	0.768	0.994	0.743	1.051	0.787	0.934	0.750
1984	0.423	0.231	0.410	0.228	0.419	0.226	0.452	0.229	0.360	0.235	0.325	0.226	0.385	0.226	0.364	0.235
1985	-1.501	0.427	-1.468	0.421	-1.458	0.415	-1.453	0.422	-1.598	0.434	-1.543	0.412	-1.492	0.413	-1.553	0.462
1986	0.097	0.271	0.107	0.266	0.118	0.264	0.064	0.270	0.099	0.270	0.111	0.256	0.117	0.260	0.121	0.269
1987	-0.546	0.438	-0.503	0.430	-0.495	0.430	-0.598	0.440	-0.507	0.433	-0.446	0.409	-0.463	0.421	-0.446	0.434
1988	-0.946	0.426	-0.891	0.459	-0.901	0.436	-0.952	0.428	-0.874	0.426	-0.799	0.406	-0.824	0.409	-0.783	0.452
1989	-0.878	0.279	-0.854	0.274	-0.852	0.270	-0.834	0.275	-0.832	0.281	-0.791	0.268	-0.781	0.269	-0.782	0.282
1990	-0.074	0.308	-0.074	0.312	-0.087	0.310	-0.082	0.313	-0.057	0.305	-0.050	0.291	-0.049	0.293	-0.049	0.314
1991	0.450	0.250	0.443	0.246	0.449	0.244	0.456	0.248	0.515	0.256	0.484	0.246	0.513	0.246	0.489	0.248
1992	0.004	0.232	-0.005	0.228	0.001	0.226	-0.004	0.230	-0.035	0.234	-0.040	0.225	-0.021	0.226	-0.014	0.233
1993	0.485	0.351	0.469	0.342	0.445	0.340	0.473	0.346	0.316	0.364	0.296	0.361	0.289	0.365	0.439	0.374
1994	-0.254	0.281	-0.220	0.274	-0.206	0.273	-0.214	0.279	-0.180	0.280	-0.125	0.265	-0.142	0.271	-0.099	0.280
1995	-0.279	0.347	-0.259	0.342	-0.246	0.339	-0.302	0.351	-0.212	0.350	-0.155	0.347	-0.169	0.352	-0.069	0.429
1996	-0.086	0.257	-0.107	0.255	-0.112	0.253	-0.092	0.256	-0.074	0.258	-0.079	0.249	-0.085	0.250	-0.045	0.289
1997	-0.219	0.319	-0.198	0.311	-0.211	0.308	-0.232	0.314	-0.179	0.314	-0.156	0.296	-0.163	0.301	-0.121	0.310
1998	-0.769	0.308	-0.798	0.304	-0.814	0.307	-0.880	0.302	-0.754	0.302	-0.738	0.288	-0.779	0.300	-0.861	0.310
1999	-1.332	0.262	-1.326	0.259	-1.299	0.256	-1.365	0.260	-1.266	0.260	-1.213	0.248	-1.209	0.250	-1.311	0.260
2000	0.899	0.238	0.880	0.234	0.884	0.231	0.812	0.236	0.753	0.241	0.695	0.230	0.736	0.230	0.558	0.236
2001	0.336	0.269	0.312	0.267	0.300	0.267	0.268	0.272	0.316	0.268	0.273	0.259	0.281	0.261	0.268	0.282
2002	0.687	0.235	0.651	0.231	0.665	0.229	0.612	0.235	0.660	0.234	0.609	0.224	0.638	0.226	0.565	0.237
2003	0.146	0.291	0.108	0.289	0.108	0.284	0.123	0.292	0.149	0.291	0.115	0.278	0.129	0.278	0.103	0.310
2004	1.367	0.242	1.277	0.235	1.266	0.234	1.324	0.235	1.311	0.242	1.183	0.230	1.212	0.230	1.246	0.236
2005	-0.196	0.276	-0.189	0.270	-0.183	0.266	-0.127	0.271	-0.194	0.280	-0.175	0.264	-0.176	0.265	-0.162	0.275
2006	-0.284	0.217	-0.232	0.212	-0.243	0.211	-0.276	0.215	-0.295	0.217	-0.242	0.207	-0.231	0.209	-0.202	0.217
2007	-1.164	0.303	-1.088	0.295	-1.097	0.290	-1.164	0.295	-1.056	0.306	-0.971	0.288	-0.978	0.288	-1.079	0.295
2008	-1.330	0.248	-1.304	0.232	-1.281	0.231	-1.358	0.248	-1.263	0.236	-1.184	0.224	-1.212	0.226	-1.299	0.236
2009	-0.657	0.384	-0.567	0.342	-0.576	0.342	-0.745	0.371	-0.774	0.377	-0.615	0.329	-0.614	0.330	-0.680	0.355
2010	0.330	0.211	0.300	0.208	0.324	0.207	0.278	0.209	0.262	0.211	0.256	0.204	0.276	0.205	0.260	0.211
2011	-1.251	0.270	-1.128	0.267	-1.117	0.262	-1.156	0.267	-1.246	0.277	-1.052	0.265	-1.106	0.263	-1.016	0.272
2012	0.145	0.314	0.072	0.324	0.059	0.319	0.151	0.311	0.232	0.307	0.105	0.301	0.113	0.308	0.222	0.318
2013	-0.310	0.229	-0.216	0.222	-0.201	0.220	-0.337	0.226	-0.369	0.230	-0.243	0.217	-0.247	0.219	-0.367	0.228
2014	0.222	0.402	0.236	0.387	0.210	0.384	0.196	0.397	0.141	0.402	0.156	0.374	0.150	0.379	0.096	0.401
2015	1.709	0.218	1.666	0.215	1.656	0.213	1.709	0.217	1.699	0.217	1.607	0.208	1.628	0.210	1.725	0.219
2016	1.831	0.325	2.036	0.292	2.017	0.290	1.884	0.298	1.939	0.320	2.470	0.268	2.127	0.288	1.987	0.294
2017	1.354	0.342	1.647	0.284	1.619	0.282	1.559	0.281	1.369	0.338	1.668	0.273	1.668	0.275	1.628	0.280
2018	2.502	0.190	2.413	0.189	2.383	0.189	2.497	0.188	2.451	0.190	2.215	0.187	2.261	0.188	2.535	0.192
2019	-0.405	1.275	-1.053	1.112	-1.135	1.077	-0.226	1.210	-0.379	1.309	-1.506	0.976	-1.711	0.935	-1.153	1.002

Table 2.1.3f. Estimates of log catchability deviations for each model's "main" survey and NBS survey.

	M19.12		Model 19.12d				Model 20.2				Model 20.3			
	Main		Main		NBS		Main		NBS		Main		NBS	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	0.015	0.703	-0.031	0.707	-1.448	0.564	-0.362	0.711	-1.162	0.582	0.235	0.743	-1.311	0.618
1983	0.758	0.742	0.619	0.741	0.000	1.000	0.425	0.745	0.000	1.000	0.607	0.783	0.000	1.000
1984	-0.931	0.672	-0.946	0.672	0.000	1.000	-1.238	0.678	0.000	1.000	-0.944	0.716	0.000	1.000
1985	0.976	0.664	1.009	0.668	-1.053	0.667	0.813	0.674	-0.860	0.685	0.959	0.720	-0.985	0.723
1986	0.329	0.632	0.432	0.636	0.000	1.000	0.292	0.642	0.000	1.000	0.402	0.690	0.000	1.000
1987	0.207	0.621	0.081	0.614	0.000	1.000	0.032	0.621	0.000	1.000	0.189	0.667	0.000	1.000
1988	-0.403	0.603	-0.189	0.607	-2.253	0.665	-0.188	0.613	-2.053	0.684	0.073	0.664	-2.168	0.719
1989	-1.857	0.634	-1.771	0.633	0.000	1.000	-1.718	0.639	0.000	1.000	-1.491	0.697	0.000	1.000
1990	-1.007	0.696	-0.903	0.697	0.000	1.000	-0.901	0.704	0.000	1.000	-1.163	0.743	0.000	1.000
1991	-1.149	0.697	-1.183	0.697	-0.695	0.649	-1.237	0.703	-0.619	0.667	-1.424	0.748	-0.657	0.705
1992	-1.317	0.705	-1.226	0.711	0.000	1.000	-1.225	0.713	0.000	1.000	-1.752	0.762	0.000	1.000
1993	0.669	0.713	0.588	0.712	0.000	1.000	0.623	0.718	0.000	1.000	0.009	0.764	0.000	1.000
1994	4.017	0.634	4.210	0.637	0.000	1.000	4.272	0.643	0.000	1.000	3.844	0.694	0.000	1.000
1995	1.794	0.623	1.958	0.625	0.000	1.000	2.063	0.631	0.000	1.000	1.465	0.689	0.000	1.000
1996	2.073	0.683	1.883	0.647	0.000	1.000	2.015	0.653	0.000	1.000	1.483	0.711	0.000	1.000
1997	-0.133	0.668	-0.314	0.651	0.000	1.000	-0.198	0.656	0.000	1.000	-0.310	0.710	0.000	1.000
1998	-0.027	0.714	-0.496	0.687	0.000	1.000	-0.489	0.693	0.000	1.000	-0.259	0.745	0.000	1.000
1999	-0.481	0.664	-0.326	0.666	0.000	1.000	-0.262	0.672	0.000	1.000	-0.181	0.721	0.000	1.000
2000	-1.556	0.635	-1.620	0.632	0.000	1.000	-1.491	0.638	0.000	1.000	-1.547	0.690	0.000	1.000
2001	1.900	0.642	1.826	0.641	0.000	1.000	1.961	0.646	0.000	1.000	1.591	0.711	0.000	1.000
2002	-0.260	0.663	-0.594	0.652	0.000	1.000	-0.387	0.656	0.000	1.000	-0.438	0.704	0.000	1.000
2003	0.511	0.712	-0.064	0.685	0.000	1.000	0.190	0.690	0.000	1.000	-0.018	0.737	0.000	1.000
2004	-0.891	0.651	-1.305	0.637	0.000	1.000	-0.962	0.643	0.000	1.000	-0.818	0.696	0.000	1.000
2005	-0.003	0.648	-0.508	0.647	0.000	1.000	-0.112	0.651	0.000	1.000	0.440	0.708	0.000	1.000
2006	-0.946	0.646	-1.041	0.641	0.000	1.000	-0.634	0.655	0.000	1.000	0.198	0.731	0.000	1.000
2007	-0.993	0.678	-0.906	0.682	0.000	1.000	-0.768	0.690	0.000	1.000	-0.499	0.750	0.000	1.000
2008	-2.496	0.656	-2.219	0.658	0.000	1.000	-2.051	0.665	0.000	1.000	-0.859	0.749	0.000	1.000
2009	-2.055	0.682	-1.614	0.684	0.000	1.000	-1.359	0.716	0.000	1.000	-0.137	0.795	0.000	1.000
2010	-0.171	0.627	0.403	0.632	-3.310	0.534	0.447	0.637	-3.282	0.549	-0.861	0.699	-2.148	0.604
2011	0.688	0.648	1.001	0.648	0.000	1.000	1.116	0.655	0.000	1.000	-0.172	0.718	0.000	1.000
2012	-0.157	0.714	0.418	0.704	0.000	1.000	0.494	0.724	0.000	1.000	-0.304	0.773	0.000	1.000
2013	-1.679	0.657	-0.821	0.655	0.000	1.000	-0.915	0.664	0.000	1.000	-1.709	0.712	0.000	1.000
2014	1.950	0.718	2.546	0.703	0.000	1.000	2.446	0.712	0.000	1.000	1.675	0.759	0.000	1.000
2015	0.662	0.699	1.943	0.668	0.000	1.000	1.630	0.678	0.000	1.000	1.141	0.723	0.000	1.000
2016	0.807	0.800	1.466	0.665	0.000	1.000	1.158	0.676	0.000	1.000	1.603	0.720	0.000	1.000
2017	-1.340	0.661	-1.746	0.680	1.722	0.408	-1.941	0.697	1.796	0.417	-0.919	0.759	1.213	0.435
2018	1.592	0.763	-0.519	0.744	2.965	0.430	-1.140	0.750	3.222	0.439	0.416	0.818	2.523	0.465
2019	0.905	0.813	-0.042	0.853	2.946	0.413	-0.397	0.847	3.516	0.455	-0.526	0.939	2.616	0.466

Table 2.1.3g. Estimates of fishery selectivity lnSD1 deviations.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.127	0.975	0.117	0.979	0.111	0.977	0.178	0.975	0.138	0.977	0.127	0.979	0.114	0.977	0.151	0.975
1978	0.106	0.904	0.105	0.916	0.110	0.911	0.133	0.901	0.105	0.907	0.103	0.917	0.106	0.911	0.108	0.906
1979	0.393	0.804	0.384	0.824	0.402	0.815	0.438	0.798	0.400	0.811	0.377	0.825	0.410	0.817	0.449	0.814
1980	0.332	0.854	0.314	0.869	0.322	0.862	0.339	0.845	0.337	0.857	0.302	0.870	0.350	0.862	0.383	0.854
1981	1.060	0.868	1.014	0.882	1.029	0.875	1.054	0.862	1.044	0.871	1.005	0.882	1.045	0.876	1.055	0.871
1982	-0.078	0.933	-0.083	0.942	-0.085	0.938	-0.093	0.929	-0.080	0.935	-0.080	0.942	-0.071	0.938	-0.064	0.934
1983	0.141	0.826	0.121	0.844	0.143	0.837	0.134	0.818	0.120	0.830	0.119	0.846	0.140	0.836	0.152	0.827
1984	0.906	0.601	0.899	0.627	0.916	0.614	0.909	0.592	0.893	0.608	0.921	0.630	0.921	0.616	0.938	0.606
1985	-0.182	0.536	-0.238	0.561	-0.195	0.547	-0.136	0.525	-0.191	0.544	-0.214	0.567	-0.146	0.551	-0.067	0.539
1986	0.624	0.550	0.592	0.575	0.639	0.560	0.731	0.541	0.625	0.558	0.620	0.581	0.699	0.564	0.772	0.556
1987	-0.134	0.462	-0.192	0.486	-0.150	0.472	0.013	0.455	-0.131	0.469	-0.154	0.490	-0.075	0.475	0.099	0.471
1988	2.329	0.683	2.306	0.702	2.318	0.692	2.449	0.677	2.282	0.685	2.268	0.702	2.299	0.690	2.483	0.689
1989	1.055	0.790	1.013	0.809	1.030	0.801	1.153	0.783	1.027	0.794	0.996	0.810	1.018	0.799	1.241	0.795
1990	0.177	0.598	0.175	0.625	0.156	0.613	0.232	0.591	0.133	0.606	0.160	0.629	0.134	0.614	0.145	0.605
1991	-0.055	0.418	-0.055	0.441	-0.064	0.429	0.066	0.413	-0.031	0.428	-0.025	0.448	-0.026	0.433	0.054	0.429
1992	-0.403	0.385	-0.440	0.406	-0.399	0.390	-0.268	0.376	-0.293	0.398	-0.341	0.417	-0.251	0.398	-0.276	0.396
1993	1.442	0.490	1.476	0.515	1.484	0.503	1.501	0.484	1.637	0.505	1.669	0.525	1.683	0.510	1.604	0.500
1994	0.466	0.418	0.473	0.441	0.482	0.429	0.546	0.412	0.643	0.429	0.663	0.448	0.653	0.434	0.650	0.428
1995	0.749	0.417	0.766	0.439	0.764	0.427	0.834	0.410	0.854	0.423	0.857	0.440	0.851	0.427	0.851	0.420
1996	-0.279	0.423	-0.310	0.446	-0.327	0.434	-0.305	0.412	-0.273	0.427	-0.320	0.446	-0.324	0.431	-0.371	0.422
1997	0.987	0.418	1.039	0.441	0.995	0.429	0.973	0.409	0.871	0.420	0.891	0.439	0.844	0.426	0.772	0.416
1998	-0.043	0.377	-0.024	0.398	-0.056	0.387	-0.093	0.368	-0.197	0.380	-0.209	0.398	-0.220	0.385	-0.306	0.378
1999	0.136	0.333	0.165	0.351	0.114	0.336	-0.055	0.319	-0.047	0.334	-0.065	0.348	-0.060	0.334	-0.240	0.329
2000	-0.157	0.362	-0.156	0.380	-0.209	0.364	-0.392	0.344	-0.349	0.363	-0.368	0.380	-0.375	0.363	-0.597	0.355
2001	-0.273	0.344	-0.284	0.362	-0.270	0.348	-0.437	0.330	-0.349	0.350	-0.364	0.365	-0.361	0.350	-0.567	0.340
2002	0.656	0.326	0.697	0.342	0.750	0.329	0.578	0.313	0.703	0.331	0.693	0.345	0.743	0.330	0.523	0.323
2003	0.489	0.336	0.512	0.352	0.537	0.339	0.394	0.321	0.503	0.340	0.481	0.354	0.522	0.340	0.321	0.332
2004	0.644	0.358	0.681	0.376	0.690	0.365	0.593	0.348	0.618	0.363	0.617	0.378	0.635	0.365	0.554	0.356
2005	0.594	0.354	0.611	0.372	0.609	0.362	0.527	0.345	0.552	0.359	0.549	0.375	0.555	0.362	0.505	0.354
2006	0.001	0.383	-0.027	0.403	-0.052	0.391	-0.214	0.373	-0.060	0.388	-0.080	0.406	-0.091	0.391	-0.168	0.388
2007	-0.196	0.410	-0.214	0.432	-0.266	0.418	-0.404	0.396	-0.269	0.414	-0.247	0.436	-0.301	0.417	-0.464	0.408
2008	-0.239	0.337	-0.145	0.358	-0.222	0.343	-0.352	0.328	-0.296	0.342	-0.166	0.362	-0.255	0.344	-0.332	0.346
2009	-1.121	0.337	-0.957	0.360	-1.075	0.341	-1.267	0.335	-1.147	0.343	-0.967	0.365	-1.059	0.344	-1.094	0.364
2010	-1.576	0.354	-1.481	0.377	-1.558	0.361	-1.361	0.347	-1.524	0.364	-1.414	0.386	-1.493	0.366	-1.735	0.373
2011	-1.427	0.334	-1.413	0.353	-1.460	0.342	-1.356	0.327	-1.257	0.345	-1.217	0.362	-1.323	0.347	-1.296	0.344
2012	-0.500	0.367	-0.525	0.386	-0.552	0.375	-0.499	0.360	-0.394	0.374	-0.362	0.393	-0.483	0.376	-0.387	0.375
2013	-0.219	0.315	-0.209	0.333	-0.215	0.323	-0.168	0.308	-0.174	0.321	-0.108	0.339	-0.176	0.324	-0.021	0.323
2014	-1.236	0.312	-1.236	0.330	-1.204	0.318	-1.175	0.302	-1.209	0.319	-1.179	0.337	-1.145	0.321	-1.031	0.318
2015	-1.631	0.313	-1.568	0.334	-1.541	0.324	-1.554	0.307	-1.609	0.320	-1.521	0.340	-1.512	0.326	-1.421	0.322
2016	-1.677	0.341	-1.539	0.366	-1.506	0.357	-1.434	0.342	-1.659	0.348	-1.539	0.369	-1.525	0.357	-1.249	0.363
2017	-1.612	0.425	-1.547	0.451	-1.501	0.440	-1.604	0.420	-1.644	0.433	-1.643	0.452	-1.613	0.437	-1.296	0.443
2018	-0.309	0.503	-0.447	0.520	-0.421	0.509	-0.478	0.494	-0.298	0.513	-0.493	0.527	-0.581	0.509	-0.165	0.513
2019	-0.069	0.563	-0.370	0.576	-0.272	0.563	-0.128	0.568	-0.002	0.575	-0.342	0.590	-0.255	0.576	-0.663	0.601

Table 2.1.3h. Estimates of fishery selectivity logitEnd deviations.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	-0.061	1.020	-0.065	1.021	-0.003	1.000	-0.001	1.000	-0.065	1.022	-0.074	1.025	0.000	1.000	0.000	1.000
1978	-0.098	1.031	-0.106	1.032	-0.005	1.000	0.000	1.000	-0.096	1.031	-0.111	1.036	0.000	1.000	0.000	1.000
1979	-0.105	1.032	-0.114	1.034	-0.006	1.000	0.000	1.000	-0.101	1.033	-0.118	1.038	0.000	1.000	0.000	1.000
1980	0.006	0.996	0.003	0.996	0.000	1.000	0.000	1.000	0.006	0.996	0.007	0.995	0.000	1.000	0.000	1.000
1981	-0.013	1.003	-0.015	1.004	-0.001	1.000	0.000	1.000	-0.011	1.003	-0.013	1.003	0.000	1.000	0.000	1.000
1982	0.058	0.979	0.060	0.979	0.003	1.000	0.000	1.000	0.055	0.980	0.065	0.976	0.000	1.000	0.000	1.000
1983	0.237	0.922	0.263	0.915	0.014	0.999	0.000	1.000	0.224	0.925	0.260	0.911	0.000	1.000	0.000	1.000
1984	0.398	0.874	0.428	0.865	0.026	0.999	0.000	1.000	0.378	0.878	0.421	0.860	0.000	1.000	0.000	1.000
1985	0.115	0.910	0.125	0.896	0.002	1.000	-0.001	1.000	0.104	0.917	0.113	0.898	-0.001	1.000	-0.001	1.000
1986	-0.065	0.951	-0.026	0.929	-0.007	1.000	0.000	1.000	-0.067	0.959	-0.061	0.936	0.000	1.000	0.000	1.000
1987	0.149	0.886	0.181	0.867	0.007	0.999	-0.001	1.000	0.137	0.895	0.200	0.865	-0.001	1.000	-0.001	1.000
1988	0.061	0.952	0.073	0.943	0.003	1.000	0.000	1.000	0.080	0.950	0.106	0.934	0.000	1.000	0.000	1.000
1989	0.297	0.901	0.332	0.891	0.020	0.999	0.001	1.000	0.279	0.905	0.331	0.886	0.001	1.000	0.001	1.000
1990	0.829	0.794	0.890	0.781	0.081	0.998	0.000	1.000	0.784	0.801	0.860	0.777	0.000	1.000	0.001	1.000
1991	0.446	0.831	0.508	0.813	0.031	0.998	-0.002	1.000	0.420	0.840	0.457	0.816	-0.003	1.000	-0.001	1.000
1992	-0.081	0.897	-0.014	0.866	-0.011	1.000	-0.001	1.000	-0.133	0.917	-0.121	0.877	-0.002	1.000	0.000	1.000
1993	0.053	0.941	0.058	0.930	0.002	1.000	0.000	1.000	-0.027	0.963	0.000	0.942	-0.001	1.000	0.000	1.000
1994	0.079	0.923	0.102	0.908	0.003	1.000	-0.001	1.000	-0.010	0.946	0.043	0.917	-0.001	1.000	0.000	1.000
1995	0.017	0.928	0.046	0.911	-0.003	1.000	-0.002	1.000	-0.040	0.945	-0.013	0.919	-0.002	1.000	-0.002	1.000
1996	0.764	0.802	0.825	0.790	0.071	0.998	-0.001	1.000	0.681	0.815	0.757	0.790	-0.001	1.000	0.000	1.000
1997	0.467	0.841	0.505	0.828	0.033	0.998	-0.001	1.000	0.411	0.852	0.485	0.826	-0.001	1.000	0.000	1.000
1998	0.264	0.861	0.286	0.847	0.013	0.999	0.000	1.000	0.285	0.866	0.338	0.839	0.000	1.000	0.000	1.000
1999	0.042	0.862	0.062	0.838	-0.006	1.000	0.005	1.000	0.180	0.863	0.221	0.833	0.005	1.000	0.005	1.000
2000	-0.020	0.876	-0.018	0.850	-0.006	1.000	0.008	1.000	0.181	0.870	0.245	0.838	0.009	1.000	0.009	1.000
2001	-0.789	0.879	-0.799	0.826	-0.046	1.002	0.000	1.000	-0.381	0.934	-0.349	0.878	0.000	1.000	0.000	1.000
2002	-1.259	0.761	-1.202	0.729	-0.073	1.004	0.000	1.000	-0.900	0.874	-0.929	0.774	0.000	1.000	0.000	1.000
2003	-0.271	0.830	-0.271	0.793	-0.025	1.001	-0.001	1.000	-0.139	0.855	-0.117	0.806	-0.001	1.000	-0.002	1.000
2004	-0.099	0.849	-0.003	0.820	-0.015	1.000	0.000	1.000	-0.107	0.867	-0.019	0.822	0.000	1.000	-0.001	1.000
2005	0.201	0.831	0.269	0.808	0.005	0.999	-0.001	1.000	0.184	0.844	0.258	0.809	-0.001	1.000	-0.002	1.000
2006	0.697	0.795	0.794	0.777	0.062	0.998	0.001	1.000	0.672	0.803	0.757	0.775	0.001	1.000	0.001	1.000
2007	0.535	0.821	0.641	0.800	0.042	0.998	0.000	1.000	0.525	0.827	0.604	0.800	0.001	1.000	0.001	1.000
2008	-0.379	0.888	-0.249	0.852	-0.028	1.001	0.000	1.000	-0.321	0.910	-0.316	0.853	0.000	1.000	0.000	1.000
2009	-0.785	0.932	-0.891	0.856	-0.041	1.002	0.001	1.000	-0.750	0.968	-0.961	0.834	0.001	1.000	0.001	1.000
2010	-0.673	1.030	-1.138	0.931	-0.032	1.002	-0.001	1.000	-0.680	1.060	-1.208	0.898	0.000	1.000	0.000	1.000
2011	-0.005	0.932	-0.151	0.937	-0.004	1.000	0.000	1.000	-0.020	0.942	-0.183	0.942	0.000	1.000	0.000	1.000
2012	0.046	0.922	-0.070	0.927	-0.002	1.000	-0.001	1.000	-0.046	0.944	-0.176	0.937	-0.001	1.000	-0.001	1.000
2013	-0.465	0.954	-0.570	0.921	-0.032	1.001	-0.001	1.000	-0.707	0.979	-0.877	0.872	0.000	1.000	-0.001	1.000
2014	-0.716	0.863	-0.713	0.823	-0.048	1.002	-0.001	1.000	-0.907	0.864	-0.962	0.759	0.000	1.000	-0.002	1.000
2015	-0.348	0.902	-0.347	0.869	-0.025	1.001	-0.001	1.000	-0.446	0.926	-0.426	0.865	0.000	1.000	-0.002	1.000
2016	0.065	0.894	-0.025	0.886	-0.005	1.000	0.000	1.000	0.033	0.908	0.010	0.882	0.000	1.000	-0.001	1.000
2017	0.472	0.839	0.361	0.844	0.023	0.999	0.000	1.000	0.420	0.850	0.409	0.835	0.000	1.000	-0.001	1.000
2018	0.288	0.867	0.258	0.861	0.008	0.999	0.000	1.000	0.261	0.876	0.291	0.855	0.001	1.000	-0.001	1.000
2019	-0.353	0.938	-0.283	0.908	-0.026	1.001	0.000	1.000	-0.348	0.958	-0.203	0.909	0.001	1.000	-0.001	1.000

Table 2.1.3i. Estimates of survey selectivity log-scale PeakStart deviations.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.185	0.431	-0.207	0.421	-0.204	0.421	-0.229	0.421	-0.191	0.428	-0.194	0.421	-0.202	0.413	-0.258	0.424
1983	-0.258	0.474	-0.217	0.481	-0.201	0.477	-0.273	0.467	-0.142	0.491	-0.067	0.478	-0.089	0.485	-0.063	0.511
1984	1.187	0.397	1.193	0.396	1.184	0.407	1.101	0.389	1.156	0.388	1.178	0.400	1.155	0.409	0.948	0.390
1985	0.489	0.275	0.463	0.273	0.496	0.277	0.436	0.272	0.532	0.274	0.554	0.270	0.544	0.279	0.399	0.274
1986	-0.409	0.534	-0.418	0.525	-0.422	0.524	-0.450	0.527	-0.381	0.518	-0.374	0.498	-0.400	0.513	-0.357	0.575
1987	0.026	0.353	0.031	0.348	0.043	0.350	-0.020	0.346	0.087	0.348	0.124	0.343	0.085	0.351	-0.034	0.346
1988	0.058	0.539	0.051	0.530	0.036	0.534	-0.015	0.521	0.171	0.530	0.187	0.525	0.144	0.528	0.082	0.505
1989	0.653	0.510	0.658	0.599	0.648	0.554	0.600	0.508	0.601	0.511	0.625	0.505	0.582	0.510	0.558	0.564
1990	-0.237	0.362	-0.251	0.354	-0.227	0.349	-0.286	0.355	-0.279	0.355	-0.225	0.347	-0.258	0.356	-0.332	0.351
1991	1.051	0.469	1.063	0.496	1.071	0.502	0.995	0.486	0.934	0.453	0.997	0.449	0.937	0.453	0.802	0.465
1992	-0.197	0.360	-0.224	0.352	-0.226	0.361	-0.271	0.389	-0.465	0.451	-0.455	0.465	-0.465	0.439	-0.353	0.342
1993	0.206	0.347	0.225	0.318	0.246	0.318	0.198	0.324	0.131	0.331	0.203	0.326	0.161	0.333	0.126	0.312
1994	0.427	0.454	0.467	0.426	0.464	0.424	0.448	0.422	0.642	0.440	0.722	0.472	0.652	0.484	0.650	0.459
1995	0.546	0.431	0.579	0.421	0.584	0.421	0.563	0.418	0.725	0.439	0.816	0.423	0.748	0.431	0.587	0.410
1996	0.285	0.385	0.295	0.380	0.300	0.381	0.373	0.388	0.451	0.384	0.538	0.420	0.484	0.427	0.760	0.560
1997	0.753	0.347	0.759	0.344	0.772	0.345	0.730	0.343	0.778	0.343	0.840	0.341	0.799	0.344	0.816	0.426
1998	2.054	0.361	2.133	0.330	2.172	0.334	2.019	0.322	2.027	0.325	2.098	0.314	2.105	0.336	1.913	0.310
1999	0.347	0.515	0.310	0.503	0.262	0.518	0.172	0.454	0.418	0.492	0.444	0.474	0.326	0.495	0.168	0.477
2000	-0.601	0.303	-0.575	0.299	-0.563	0.300	-0.606	0.294	-0.657	0.290	-0.574	0.285	-0.643	0.292	-0.726	0.285
2001	-0.908	0.361	-0.898	0.350	-0.924	0.351	-0.764	0.345	-0.669	0.333	-0.609	0.323	-0.691	0.327	-0.329	0.298
2002	0.123	0.453	0.253	0.475	0.243	0.481	0.216	0.468	0.131	0.445	0.292	0.477	0.227	0.450	0.303	0.478
2003	0.215	0.338	0.234	0.307	0.231	0.314	0.351	0.315	0.273	0.308	0.323	0.303	0.277	0.309	0.478	0.288
2004	0.279	0.355	0.296	0.352	0.288	0.350	0.320	0.356	0.259	0.347	0.316	0.339	0.261	0.343	0.366	0.372
2005	-0.111	0.415	0.053	0.379	0.037	0.387	0.058	0.380	-0.036	0.397	0.087	0.391	0.082	0.379	0.311	0.295
2006	-1.533	0.322	-1.505	0.314	-1.512	0.313	-1.584	0.316	-1.492	0.325	-1.451	0.291	-1.470	0.313	-1.478	0.298
2007	-2.442	0.253	-2.440	0.245	-2.430	0.247	-2.414	0.246	-2.327	0.240	-2.269	0.232	-2.374	0.242	-2.427	0.248
2008	-1.454	0.302	-1.468	0.297	-1.463	0.296	-1.478	0.293	-1.473	0.297	-1.435	0.289	-1.500	0.295	-1.525	0.289
2009	-0.910	0.565	-1.058	0.438	-1.024	0.451	-0.991	0.568	-1.609	0.411	-1.522	0.384	-1.437	0.524	-1.187	0.440
2010	-0.464	0.444	-0.111	0.471	-0.200	0.478	-0.454	0.427	-0.500	0.386	-0.133	0.472	-0.234	0.429	-0.453	0.411
2011	-0.144	0.258	-0.215	0.249	-0.202	0.250	-0.149	0.253	-0.110	0.251	-0.127	0.243	-0.158	0.251	-0.174	0.244
2012	-1.990	0.351	-2.095	0.372	-2.082	0.369	-2.070	0.363	-1.943	0.368	-2.112	0.286	-2.024	0.374	-2.180	0.376
2013	0.980	0.358	0.814	0.425	0.804	0.414	0.876	0.343	0.867	0.335	0.724	0.396	0.693	0.405	0.572	0.389
2014	-0.050	0.296	-0.192	0.283	-0.179	0.284	-0.028	0.280	-0.005	0.289	-0.115	0.273	-0.125	0.283	-0.116	0.259
2015	0.457	0.469	0.312	0.448	0.281	0.445	0.507	0.450	0.455	0.453	0.392	0.432	0.331	0.438	0.448	0.431
2016	1.169	0.333	1.056	0.316	1.068	0.317	1.231	0.331	1.186	0.328	1.156	0.311	1.159	0.320	1.190	0.335
2017	1.107	0.365	0.985	0.375	0.997	0.378	1.188	0.354	0.915	0.385	-0.638	0.490	0.762	0.466	1.077	0.345
2018	0.780	0.373	0.950	0.305	0.955	0.306	1.038	0.295	0.764	0.366	0.924	0.298	0.873	0.301	0.858	0.287
2019	-1.302	0.297	-1.308	0.314	-1.321	0.354	-1.341	0.343	-1.224	0.307	-1.241	0.328	-1.318	0.348	-1.419	0.331

Table 2.1.3j. Estimates of survey selectivity lnSD1 deviations.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.518	0.587	-0.536	0.586	-0.530	0.584	-0.508	0.581	-0.507	0.587	-0.495	0.585	-0.521	0.576	-0.546	0.585
1983	0.392	0.618	0.411	0.632	0.415	0.623	0.409	0.616	0.450	0.623	0.502	0.603	0.484	0.616	0.544	0.642
1984	0.810	0.443	0.847	0.448	0.836	0.455	0.803	0.440	0.891	0.440	0.938	0.448	0.908	0.466	0.729	0.450
1985	0.683	0.369	0.674	0.371	0.698	0.374	0.687	0.369	0.674	0.360	0.702	0.354	0.694	0.371	0.502	0.364
1986	-0.041	0.683	-0.044	0.686	-0.050	0.682	-0.042	0.684	-0.058	0.663	-0.059	0.643	-0.070	0.666	-0.017	0.727
1987	-0.116	0.561	-0.110	0.560	-0.096	0.561	-0.132	0.555	-0.072	0.543	-0.018	0.535	-0.077	0.555	-0.182	0.551
1988	-0.145	0.677	-0.129	0.678	-0.139	0.681	-0.168	0.669	-0.043	0.659	0.000	0.654	-0.058	0.667	-0.079	0.646
1989	0.224	0.582	0.265	0.687	0.245	0.637	0.222	0.584	0.257	0.588	0.313	0.581	0.240	0.596	0.266	0.648
1990	0.156	0.449	0.149	0.446	0.169	0.438	0.146	0.445	0.149	0.441	0.199	0.429	0.169	0.447	0.118	0.442
1991	1.334	0.514	1.367	0.548	1.364	0.552	1.313	0.535	1.301	0.504	1.359	0.497	1.316	0.511	1.187	0.526
1992	-0.125	0.458	-0.140	0.456	-0.136	0.466	-0.157	0.497	-0.363	0.585	-0.343	0.605	-0.352	0.576	-0.204	0.449
1993	0.729	0.447	0.742	0.415	0.763	0.413	0.728	0.419	0.657	0.426	0.714	0.416	0.683	0.432	0.615	0.405
1994	0.385	0.592	0.414	0.565	0.405	0.562	0.406	0.555	0.501	0.551	0.576	0.583	0.492	0.611	0.541	0.577
1995	0.300	0.553	0.341	0.548	0.343	0.548	0.328	0.537	0.471	0.544	0.569	0.520	0.483	0.542	0.355	0.521
1996	-0.264	0.513	-0.237	0.513	-0.235	0.513	-0.146	0.509	-0.081	0.496	0.038	0.531	-0.055	0.550	0.270	0.664
1997	0.751	0.413	0.753	0.413	0.755	0.412	0.746	0.409	0.795	0.405	0.848	0.399	0.794	0.409	0.809	0.497
1998	2.036	0.375	2.112	0.353	2.144	0.355	2.022	0.345	2.001	0.341	2.055	0.329	2.091	0.353	1.934	0.336
1999	0.350	0.578	0.325	0.578	0.273	0.598	0.200	0.529	0.436	0.549	0.469	0.531	0.342	0.567	0.226	0.558
2000	-0.658	0.420	-0.639	0.417	-0.624	0.417	-0.661	0.407	-0.681	0.408	-0.592	0.398	-0.681	0.413	-0.781	0.400
2001	-0.544	0.553	-0.567	0.545	-0.586	0.545	-0.417	0.526	-0.381	0.499	-0.339	0.481	-0.413	0.497	-0.104	0.443
2002	0.083	0.578	0.211	0.605	0.198	0.614	0.158	0.592	0.099	0.567	0.260	0.596	0.183	0.577	0.241	0.594
2003	0.221	0.452	0.235	0.417	0.241	0.426	0.334	0.420	0.279	0.408	0.334	0.400	0.281	0.416	0.382	0.376
2004	0.131	0.472	0.143	0.473	0.135	0.470	0.182	0.470	0.144	0.462	0.206	0.448	0.132	0.462	0.217	0.482
2005	-0.215	0.579	-0.040	0.537	-0.057	0.545	0.000	0.529	-0.140	0.548	0.006	0.537	-0.012	0.528	0.244	0.411
2006	-1.384	0.467	-1.369	0.462	-1.383	0.460	-1.462	0.470	-1.379	0.479	-1.337	0.427	-1.356	0.458	-1.316	0.427
2007	-2.469	0.528	-2.516	0.522	-2.500	0.522	-2.466	0.515	-2.417	0.502	-2.374	0.484	-2.483	0.511	-2.509	0.521
2008	-1.542	0.474	-1.576	0.476	-1.568	0.475	-1.566	0.468	-1.567	0.482	-1.530	0.474	-1.611	0.483	-1.600	0.463
2009	0.144	0.787	-0.087	0.630	-0.033	0.646	0.015	0.808	-0.773	0.639	-0.737	0.591	-0.563	0.800	-0.241	0.637
2010	-0.674	0.601	-0.281	0.610	-0.379	0.629	-0.648	0.591	-0.710	0.538	-0.289	0.615	-0.418	0.575	-0.615	0.570
2011	-0.183	0.355	-0.231	0.348	-0.212	0.348	-0.174	0.350	-0.157	0.341	-0.128	0.330	-0.191	0.347	-0.200	0.336
2012	-1.376	0.560	-1.537	0.630	-1.511	0.620	-1.495	0.602	-1.389	0.599	-1.696	0.501	-1.478	0.626	-1.646	0.654
2013	0.970	0.382	0.892	0.458	0.878	0.446	0.895	0.369	0.943	0.361	0.867	0.427	0.820	0.441	0.699	0.429
2014	-0.097	0.420	-0.149	0.419	-0.131	0.420	-0.078	0.394	-0.062	0.405	-0.068	0.393	-0.114	0.412	-0.195	0.363
2015	0.381	0.560	0.291	0.557	0.263	0.554	0.429	0.540	0.379	0.541	0.347	0.526	0.274	0.543	0.356	0.525
2016	0.756	0.458	0.687	0.448	0.698	0.447	0.795	0.451	0.810	0.447	0.798	0.428	0.774	0.445	0.771	0.458
2017	0.910	0.470	0.843	0.479	0.852	0.479	0.927	0.454	0.871	0.483	-0.762	0.730	0.757	0.544	0.882	0.451
2018	0.079	0.436	-0.151	0.424	-0.150	0.423	-0.075	0.406	0.116	0.427	-0.038	0.403	-0.136	0.417	-0.169	0.403
2019	-1.476	0.558	-1.364	0.581	-1.357	0.637	-1.551	0.632	-1.445	0.576	-1.296	0.602	-1.328	0.628	-1.489	0.608

Table 2.1.4. Estimates of instantaneous full-selection fishing mortality rates.

	19.12a	19.12b	20.1		19.12c		19.12	19.12d	20.2		20.3	
Year	XBS	XBS	EBS	NBS	EBS	NBS	XBS	XBS	EBS	NBS	EBS	NBS
1977	0.186	0.186	0.176	0.000	0.232	0.000	0.195	0.200	0.168	0.000	0.257	0.000
1978	0.225	0.225	0.212	0.000	0.290	0.000	0.237	0.244	0.202	0.000	0.315	0.000
1979	0.162	0.162	0.153	0.000	0.215	0.000	0.172	0.177	0.145	0.000	0.226	0.000
1980	0.167	0.167	0.158	0.000	0.226	0.000	0.178	0.182	0.150	0.000	0.236	0.000
1981	0.124	0.124	0.118	0.000	0.169	0.000	0.134	0.135	0.114	0.000	0.182	0.000
1982	0.095	0.094	0.090	0.000	0.127	0.000	0.102	0.100	0.088	0.000	0.140	0.000
1983	0.114	0.113	0.110	0.000	0.146	0.000	0.122	0.120	0.106	0.000	0.162	0.000
1984	0.157	0.157	0.153	0.000	0.198	0.000	0.166	0.164	0.146	0.000	0.220	0.000
1985	0.173	0.173	0.167	0.000	0.213	0.000	0.182	0.180	0.158	0.000	0.236	0.000
1986	0.164	0.164	0.158	0.000	0.194	0.000	0.171	0.170	0.149	0.000	0.217	0.000
1987	0.190	0.189	0.184	0.000	0.226	0.000	0.196	0.195	0.174	0.000	0.252	0.000
1988	0.224	0.223	0.218	0.000	0.269	0.000	0.231	0.230	0.208	0.000	0.303	0.000
1989	0.211	0.210	0.207	0.000	0.257	0.000	0.216	0.215	0.198	0.000	0.291	0.000
1990	0.240	0.238	0.239	0.000	0.279	0.000	0.243	0.241	0.227	0.000	0.320	0.000
1991	0.409	0.407	0.406	0.000	0.466	0.000	0.407	0.408	0.379	0.000	0.528	0.000
1992	0.452	0.451	0.442	0.000	0.507	0.000	0.442	0.449	0.404	0.000	0.567	0.000
1993	0.305	0.306	0.303	0.000	0.355	0.000	0.300	0.304	0.279	0.000	0.384	0.000
1994	0.402	0.401	0.400	0.000	0.474	0.000	0.400	0.402	0.377	0.000	0.516	0.000
1995	0.498	0.496	0.496	0.000	0.592	0.000	0.510	0.514	0.482	0.000	0.666	0.000
1996	0.469	0.464	0.472	0.000	0.580	0.000	0.498	0.500	0.476	0.000	0.682	0.000
1997	0.514	0.506	0.515	0.000	0.665	0.000	0.566	0.565	0.537	0.000	0.800	0.000
1998	0.410	0.402	0.410	0.000	0.552	0.000	0.458	0.456	0.431	0.000	0.682	0.000
1999	0.390	0.381	0.388	0.000	0.548	0.000	0.435	0.434	0.407	0.000	0.665	0.000
2000	0.379	0.372	0.377	0.000	0.523	0.000	0.418	0.414	0.391	0.000	0.637	0.000
2001	0.343	0.337	0.334	0.000	0.453	0.000	0.363	0.360	0.339	0.000	0.539	0.000
2002	0.372	0.365	0.354	0.000	0.479	0.000	0.384	0.383	0.353	0.000	0.554	0.000
2003	0.376	0.368	0.367	0.001	0.482	0.004	0.391	0.387	0.365	0.007	0.563	0.001
2004	0.388	0.379	0.382	0.000	0.532	0.001	0.406	0.397	0.380	0.001	0.587	0.000
2005	0.408	0.397	0.406	0.000	0.585	0.000	0.425	0.413	0.402	0.001	0.643	0.000
2006	0.447	0.432	0.451	0.000	0.695	0.000	0.464	0.446	0.443	0.000	0.755	0.000
2007	0.430	0.411	0.433	0.000	0.630	0.000	0.442	0.419	0.421	0.000	0.729	0.000
2008	0.526	0.494	0.517	0.000	0.724	0.000	0.532	0.500	0.497	0.001	0.861	0.000
2009	0.657	0.613	0.635	0.000	0.897	0.000	0.652	0.613	0.601	0.000	1.079	0.000
2010	0.619	0.593	0.609	0.000	0.643	0.000	0.600	0.582	0.569	0.000	0.800	0.000
2011	0.721	0.708	0.734	0.000	0.813	0.000	0.690	0.683	0.685	0.000	0.861	0.000
2012	0.616	0.627	0.640	0.000	0.712	0.000	0.608	0.623	0.612	0.000	0.752	0.000
2013	0.557	0.574	0.580	0.000	0.647	0.010	0.563	0.593	0.562	0.003	0.699	0.001
2014	0.608	0.631	0.634	0.000	0.711	0.007	0.618	0.670	0.615	0.002	0.801	0.001
2015	0.571	0.604	0.613	0.000	0.691	0.003	0.585	0.654	0.603	0.002	0.830	0.001
2016	0.510	0.560	0.570	0.002	0.741	0.013	0.528	0.627	0.571	0.031	0.838	0.006
2017	0.403	0.471	0.482	0.002	0.674	0.007	0.423	0.547	0.491	0.027	0.788	0.004
2018	0.295	0.368	0.330	0.031	0.597	0.065	0.309	0.437	0.336	0.582	0.567	0.057
2019	0.288	0.380	0.324	0.029	0.592	0.054	0.300	0.464	0.326	0.934	0.543	0.051

Table 2.1.5. "Sigma" terms for vectors of annual random deviations. Deviations are ~norma(0,σ^2) for ln(Recruits), ~normal(0,1) for others.

	Model 19.12a			Model 19.12b			Model 20.1			Model 19.12c		
Parameter	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma
ln(Recruits)	0.4701	0.0134	0.6954	0.4448	0.0124	0.6762	0.4602	0.0129	0.6877	0.4351	0.0124	0.6690
Length_at_1.5	0.7825	0.2159	0.1494	0.7955	0.2018	0.1524	0.8005	0.2011	0.1548	0.7889	0.2112	0.1508
Sel_fsh_lnSD1	0.7155	0.2879	0.1560	0.6940	0.3081	0.1434	0.7060	0.2961	0.1486	0.7234	0.2807	0.1601
Sel_fsh_logitEnd	0.1803	0.8161	0.7517	0.2183	0.7790	0.7504	0.0000	1.0000	0.1004	0.0000	1.0000	0.1000
Sel_srv_PeakStart	0.8399	0.1572	0.2034	0.8511	0.1502	0.2085	0.8471	0.1505	0.2072	0.8498	0.1490	0.2106
Sel_srv_lnSD1	0.7220	0.2729	0.7641	0.7297	0.2692	0.7640	0.7265	0.2705	0.7631	0.7307	0.2672	0.7824

	Model 19.12			Model 19.12d			Model 20.2			Model 20.3		
Parameter	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma
ln(Recruits)	0.4525	0.0139	0.6830	0.4451	0.0130	0.6766	0.4477	0.0133	0.6791	0.4172	0.0131	0.6559
Length_at_1.5	0.7791	0.2188	0.1502	0.8066	0.1900	0.1603	0.8085	0.1939	0.1601	0.8000	0.2060	0.1512
Sel_fsh_lnSD1	0.7107	0.2936	0.1532	0.6810	0.3104	0.1433	0.7031	0.2975	0.1482	0.7099	0.2921	0.1514
Sel_fsh_logitEnd	0.1557	0.8422	0.7670	0.2134	0.7812	0.7976	0.0000	1.0000	0.1004	0.0000	1.0000	0.1000
Sel_srv_PeakStart	0.8472	0.1485	0.2153	0.8530	0.1486	0.2227	0.8453	0.1557	0.2136	0.8453	0.1542	0.2203
Sel_srv_lnSD1	0.7345	0.2581	0.8064	0.7410	0.2602	0.8318	0.7250	0.2759	0.7829	0.7321	0.2713	0.7850

Table 2.1.6 (page 1 of 2). Movement probabilities (Models 19.12c and 20.3 only).

Year	Src.	Dst.	M19.12c						M20.3					
			2	3	4	5	6	7+	2	3	4	5	6	7+
1981	EBS	NBS	0.033	0.005	0.001	0.000	0.000	0.000	0.187	0.019	0.002	0.000	0.000	0.000
	NBS	EBS	0.001	0.004	0.010	0.028	0.075	0.185	0.000	0.001	0.004	0.011	0.035	0.103
1982	EBS	NBS	0.040	0.007	0.001	0.000	0.000	0.000	0.202	0.023	0.002	0.000	0.000	0.000
	NBS	EBS	0.112	0.148	0.192	0.245	0.307	0.378	0.059	0.066	0.074	0.083	0.092	0.103
1983	EBS	NBS	0.022	0.003	0.000	0.000	0.000	0.000	0.156	0.013	0.001	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.000	0.001	0.014	0.000	0.000	0.000	0.000	0.002	0.102
1984	EBS	NBS	0.011	0.001	0.000	0.000	0.000	0.000	0.114	0.007	0.000	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.001	0.008	0.058	0.000	0.000	0.000	0.001	0.009	0.102
1985	EBS	NBS	0.038	0.007	0.001	0.000	0.000	0.000	0.197	0.021	0.002	0.000	0.000	0.000
	NBS	EBS	0.029	0.048	0.081	0.131	0.206	0.308	0.012	0.019	0.029	0.045	0.068	0.103
1986	EBS	NBS	0.048	0.010	0.002	0.000	0.000	0.000	0.217	0.026	0.003	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.000	0.002	0.027	0.000	0.000	0.000	0.000	0.004	0.102
1987	EBS	NBS	0.033	0.005	0.001	0.000	0.000	0.000	0.186	0.019	0.002	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.001	0.006	0.050	0.000	0.000	0.000	0.001	0.008	0.102
1988	EBS	NBS	0.025	0.003	0.000	0.000	0.000	0.000	0.165	0.015	0.001	0.000	0.000	0.000
	NBS	EBS	0.000	0.001	0.004	0.013	0.044	0.141	0.000	0.000	0.001	0.006	0.025	0.103
1989	EBS	NBS	0.075	0.021	0.006	0.001	0.000	0.000	0.260	0.039	0.005	0.001	0.000	0.000
	NBS	EBS	0.676	0.648	0.618	0.588	0.557	0.526	0.592	0.466	0.345	0.241	0.161	0.104
1990	EBS	NBS	0.016	0.001	0.000	0.000	0.000	0.000	0.135	0.010	0.001	0.000	0.000	0.000
	NBS	EBS	0.209	0.244	0.282	0.324	0.369	0.416	0.125	0.120	0.116	0.111	0.107	0.103
1991	EBS	NBS	0.011	0.001	0.000	0.000	0.000	0.000	0.116	0.007	0.000	0.000	0.000	0.000
	NBS	EBS	0.379	0.395	0.411	0.427	0.444	0.460	0.267	0.224	0.187	0.155	0.127	0.103
1992	EBS	NBS	0.014	0.001	0.000	0.000	0.000	0.000	0.126	0.009	0.001	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.001	0.010	0.063	0.000	0.000	0.000	0.001	0.010	0.102
1993	EBS	NBS	0.026	0.003	0.000	0.000	0.000	0.000	0.167	0.015	0.001	0.000	0.000	0.000
	NBS	EBS	0.001	0.004	0.010	0.028	0.076	0.186	0.000	0.001	0.004	0.012	0.035	0.103
1994	EBS	NBS	0.015	0.001	0.000	0.000	0.000	0.000	0.132	0.009	0.001	0.000	0.000	0.000
	NBS	EBS	0.066	0.095	0.136	0.192	0.263	0.349	0.031	0.040	0.051	0.065	0.082	0.103
1995	EBS	NBS	0.005	0.000	0.000	0.000	0.000	0.000	0.078	0.003	0.000	0.000	0.000	0.000
	NBS	EBS	0.001	0.003	0.008	0.022	0.064	0.171	0.000	0.001	0.003	0.009	0.032	0.103
1996	EBS	NBS	0.183	0.101	0.053	0.027	0.014	0.007	0.369	0.088	0.016	0.003	0.000	0.000
	NBS	EBS	0.000	0.000	0.002	0.008	0.032	0.120	0.000	0.000	0.001	0.004	0.021	0.103
1997	EBS	NBS	0.057	0.013	0.003	0.001	0.000	0.000	0.234	0.031	0.003	0.000	0.000	0.000
	NBS	EBS	0.001	0.003	0.009	0.026	0.071	0.180	0.000	0.001	0.003	0.011	0.034	0.103
1998	EBS	NBS	0.011	0.001	0.000	0.000	0.000	0.000	0.117	0.007	0.000	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.000	0.004	0.039	0.000	0.000	0.000	0.000	0.006	0.102
1999	EBS	NBS	0.006	0.000	0.000	0.000	0.000	0.000	0.087	0.004	0.000	0.000	0.000	0.000
	NBS	EBS	0.007	0.016	0.033	0.068	0.134	0.248	0.003	0.006	0.012	0.025	0.051	0.103
2000	EBS	NBS	0.005	0.000	0.000	0.000	0.000	0.000	0.080	0.004	0.000	0.000	0.000	0.000
	NBS	EBS	0.001	0.002	0.006	0.019	0.058	0.163	0.000	0.001	0.002	0.008	0.030	0.103
2001	EBS	NBS	0.134	0.058	0.024	0.009	0.004	0.001	0.327	0.066	0.010	0.001	0.000	0.000
	NBS	EBS	0.000	0.000	0.001	0.003	0.017	0.086	0.000	0.000	0.000	0.002	0.014	0.102
2002	EBS	NBS	0.021	0.002	0.000	0.000	0.000	0.000	0.152	0.013	0.001	0.000	0.000	0.000
	NBS	EBS	0.004	0.009	0.022	0.050	0.110	0.225	0.001	0.003	0.008	0.019	0.045	0.103

Table 2.1.6 (page 1 of 2). Movement probabilities (Models 19.12c and 20.3 only).

			M19.12c						M20.3					
Year	Src.	Dst.	2	3	4	5	6	7+	2	3	4	5	6	7+
2003	EBS	NBS	0.209	0.129	0.076	0.044	0.025	0.014	0.389	0.100	0.019	0.003	0.001	0.000
	NBS	EBS	0.000	0.000	0.000	0.000	0.003	0.031	0.000	0.000	0.000	0.000	0.005	0.102
2004	EBS	NBS	0.130	0.055	0.022	0.009	0.003	0.001	0.323	0.064	0.010	0.001	0.000	0.000
	NBS	EBS	0.001	0.003	0.008	0.022	0.064	0.171	0.000	0.001	0.003	0.009	0.032	0.103
2005	EBS	NBS	0.095	0.031	0.010	0.003	0.001	0.000	0.286	0.048	0.006	0.001	0.000	0.000
	NBS	EBS	0.000	0.001	0.004	0.013	0.045	0.142	0.000	0.000	0.001	0.006	0.026	0.103
2006	EBS	NBS	0.010	0.001	0.000	0.000	0.000	0.000	0.108	0.006	0.000	0.000	0.000	0.000
	NBS	EBS	0.037	0.059	0.094	0.146	0.221	0.319	0.016	0.023	0.034	0.050	0.072	0.103
2007	EBS	NBS	0.046	0.009	0.002	0.000	0.000	0.000	0.213	0.025	0.002	0.000	0.000	0.000
	NBS	EBS	0.019	0.034	0.061	0.106	0.180	0.288	0.007	0.013	0.022	0.037	0.062	0.103
2008	EBS	NBS	0.010	0.001	0.000	0.000	0.000	0.000	0.113	0.007	0.000	0.000	0.000	0.000
	NBS	EBS	0.005	0.012	0.026	0.056	0.119	0.234	0.002	0.004	0.009	0.021	0.047	0.103
2009	EBS	NBS	0.006	0.000	0.000	0.000	0.000	0.000	0.085	0.004	0.000	0.000	0.000	0.000
	NBS	EBS	0.993	0.985	0.968	0.931	0.860	0.735	0.994	0.976	0.903	0.683	0.333	0.104
2010	EBS	NBS	0.005	0.000	0.000	0.000	0.000	0.000	0.084	0.004	0.000	0.000	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.002	0.010	0.065	0.000	0.000	0.000	0.001	0.010	0.102
2011	EBS	NBS	0.087	0.027	0.008	0.002	0.001	0.000	0.276	0.044	0.006	0.001	0.000	0.000
	NBS	EBS	0.318	0.342	0.367	0.393	0.419	0.446	0.212	0.185	0.161	0.139	0.120	0.103
2012	EBS	NBS	0.001	0.000	0.000	0.000	0.000	0.000	0.033	0.001	0.000	0.000	0.000	0.000
	NBS	EBS	0.061	0.090	0.131	0.186	0.257	0.345	0.029	0.037	0.048	0.063	0.081	0.103
2013	EBS	NBS	0.004	0.000	0.000	0.000	0.000	0.000	0.073	0.003	0.000	0.000	0.000	0.000
	NBS	EBS	0.058	0.087	0.127	0.182	0.254	0.343	0.027	0.036	0.047	0.061	0.080	0.103
2014	EBS	NBS	0.129	0.054	0.022	0.008	0.003	0.001	0.323	0.064	0.010	0.001	0.000	0.000
	NBS	EBS	0.018	0.033	0.059	0.104	0.177	0.286	0.007	0.012	0.021	0.036	0.062	0.103
2015	EBS	NBS	0.290	0.230	0.180	0.138	0.105	0.079	0.441	0.139	0.032	0.007	0.001	0.000
	NBS	EBS	0.000	0.001	0.002	0.009	0.035	0.125	0.000	0.000	0.001	0.004	0.022	0.103
2016	EBS	NBS	0.148	0.068	0.030	0.013	0.006	0.002	0.340	0.072	0.012	0.002	0.000	0.000
	NBS	EBS	0.000	0.000	0.000	0.002	0.011	0.068	0.000	0.000	0.000	0.001	0.011	0.102
2017	EBS	NBS	0.375	0.360	0.346	0.331	0.317	0.304	0.489	0.184	0.050	0.012	0.003	0.001
	NBS	EBS	0.052	0.079	0.118	0.172	0.245	0.337	0.024	0.032	0.043	0.058	0.078	0.103
2018	EBS	NBS	0.876	0.969	0.993	0.998	1.000	1.000	0.767	0.650	0.513	0.374	0.253	0.161
	NBS	EBS	0.978	0.960	0.929	0.878	0.797	0.682	0.978	0.931	0.804	0.556	0.276	0.104
2019	EBS	NBS	0.018	0.020	0.023	0.026	0.029	0.033	0.187	0.019	0.002	0.000	0.000	0.000
	NBS	EBS	0.001	0.004	0.010	0.028	0.075	0.185	0.000	0.001	0.004	0.011	0.035	0.103

Table 2.1.7a (page 1 of 2). Combined-area female spawning biomass (t) time series.

	Model 19.12a		Model 19.12b		Model 20.1		Model 19.12c	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	94746	26527	95697	27309	172363	70968	82214	21943
1978	97838	26384	99000	27195	180714	73440	83066	21527
1979	99646	25063	101067	25900	185245	73202	81785	19846
1980	122635	25509	124562	26402	222456	81577	98551	19695
1981	181260	27479	184845	28554	317690	105210	143606	20543
1982	283156	32653	289321	34085	482882	149770	226329	24207
1983	377388	35776	385013	37367	633260	191108	308192	26919
1984	381020	31085	387458	32414	637205	192295	317517	23827
1985	428286	32392	433815	33651	732850	230541	361716	25297
1986	419983	29514	424656	30617	735310	239610	359235	23438
1987	409327	26056	414239	27103	724275	239376	355079	20912
1988	434265	25341	440144	26480	780705	263394	380714	20434
1989	421399	23286	427929	24488	777195	270628	371474	18761
1990	376820	19748	382515	20831	711235	255168	335121	15943
1991	299868	15601	303580	16421	591000	223434	268668	12669
1992	217791	13055	220039	13686	478111	200478	193058	10644
1993	206812	13476	209029	14166	479881	209894	180701	10843
1994	210956	12695	213567	13457	468504	197480	184857	9950
1995	226093	13385	229476	14313	496414	206983	197319	10229
1996	226615	14216	231075	15326	499209	208182	195457	10635
1997	223121	14366	228396	15575	501300	212400	192222	10699
1998	200084	14336	205792	15518	479281	213397	171251	10750
1999	194495	14841	200343	15965	481264	219634	168179	11390
2000	204284	15752	210431	16876	501325	227580	180775	12462
2001	212671	15376	219033	16494	498632	218810	193037	12593
2002	227165	15138	233871	16284	515745	220713	209382	12799
2003	232430	14673	239634	15865	524300	222786	215331	12804
2004	236152	13975	244027	15214	527095	221676	219575	12645
2005	230334	13274	238612	14502	526605	226183	216878	12455
2006	202967	12013	211179	13125	484713	215616	195171	11655
2007	176443	11134	185018	12150	448344	208463	174913	11082
2008	151021	9877	159842	10752	397704	189263	153880	9936
2009	135434	9501	144649	10276	374266	183178	139434	9446
2010	132435	9434	140479	10109	358535	173411	132154	8867
2011	160157	10205	165318	10802	388740	176276	150089	8843
2012	189655	11557	190513	11983	427561	185309	169486	9356
2013	215368	13263	212904	13510	482726	210560	187918	10466
2014	219956	14547	214677	14540	501765	224392	189933	11462
2015	227123	16069	217215	15719	516640	234233	196343	12855
2016	262823	18876	242699	17924	567875	254709	230409	15438
2017	306482	22120	269155	20339	620065	275465	275175	18743
2018	334399	23967	278519	21505	637390	282649	311780	21221
2019	328197	23785	259843	21076	609165	276701	318790	22129
2020	286189	21240	213933	18807	535980	250900	290688	20706
2021	212502	12223	169717	8128	321877	226453	266319	16187

Table 2.1.7a (page 2 of 2). Combined-area female spawning biomass (t) time series.

	Model 19.12		Model 19.12d		Model 20.2		Model 20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	90527	25164	88610	25444	106112	29541	108510	27530
1978	92880	25056	91030	25347	110678	29488	112258	27481
1979	93774	23810	92069	24129	114115	28194	113548	26142
1980	114789	24485	113309	24820	140647	28838	136351	26948
1981	168189	27122	168755	27481	205819	31458	194655	30826
1982	262535	33334	266828	33867	317050	37920	299127	40315
1983	352222	37682	359513	38271	417791	42058	399463	48656
1984	358534	33837	365785	34268	419084	37149	407875	46667
1985	405674	36211	412711	36532	470753	39127	466778	53138
1986	400253	33782	406163	33967	462286	35996	466037	52722
1987	392821	30277	397999	30368	450255	31927	460329	50550
1988	419106	29581	424325	29617	476846	30918	495110	53650
1989	409065	27030	413977	27019	463038	28115	490217	53771
1990	369532	22762	373089	22718	415134	23641	449299	49636
1991	297917	17883	299362	17827	333069	18572	370089	42267
1992	219181	14819	219000	14762	247915	15372	284467	36324
1993	209018	14926	208289	14856	238681	15471	274846	35476
1994	211257	13489	210813	13442	238924	14021	268658	30730
1995	222343	13524	222118	13519	250560	14140	279244	30211
1996	215621	13581	215818	13649	244115	14273	273676	29668
1997	206781	13186	207670	13298	234777	13850	270080	30213
1998	181185	12866	182523	13010	208483	13407	249797	30881
1999	174833	13334	176321	13498	202502	13710	252335	33287
2000	184945	14427	186964	14624	214231	14711	275157	37353
2001	196378	14455	199209	14693	225331	14762	291274	38876
2002	213600	14520	216995	14828	242649	14867	311246	40611
2003	220637	14259	224805	14660	250007	14670	317862	41448
2004	225243	13668	230735	14168	254494	14154	322738	42046
2005	220518	12998	227236	13583	249004	13463	325660	44101
2006	195253	11805	202715	12429	221276	12185	305946	44000
2007	170820	11030	179213	11666	195008	11337	290363	44617
2008	147813	9919	156591	10480	169137	10190	266234	42150
2009	134535	9717	143324	10157	154803	9958	251065	40914
2010	133897	9867	140687	10072	152800	9995	233291	36588
2011	163132	10814	166168	10688	180806	10740	241448	32914
2012	190979	12184	188804	11555	207656	11818	242599	28306
2013	213967	13837	207036	12648	230154	13196	250251	26769
2014	216640	15099	204240	13326	230823	14144	244357	25236
2015	221443	16751	200719	14167	231548	15280	246305	25289
2016	253395	19936	217521	16075	254786	17544	277508	28639
2017	292477	23889	233992	18544	278192	20300	320184	35022
2018	318141	26780	236373	20393	285011	22244	353374	41788
2019	312750	27721	214846	21081	264360	22825	355783	45983
2020	272794	25887	169028	19870	217784	21241	321413	44663
2021	206964	16471	146840	11157	165623	9775	243557	26186

Table 2.1.7b. Area-specific female spawning biomass (t) time series.

	Model 20.1			Model 19.12c			Model 20.2			Model 20.3		
Year	EBS	NBS	Sum	EBS	NBS	Sum	EBS	NBS	Sum	EBS	NBS	Sum
1977	96638	75722	172360	75717	6494	82211	100681	5427	106108	69444	39063	108506
1978	100535	80179	180714	76375	6691	83065	104928	5750	110678	71511	40747	112257
1979	103417	81828	185245	74974	6810	81784	108241	5873	114114	72407	41141	113548
1980	127905	94551	222456	90547	8003	98550	133854	6793	140647	89157	47194	136351
1981	189870	127820	317690	131859	11747	143606	196691	9129	205819	128546	66109	194655
1982	295606	187277	482882	207553	18776	226329	303752	13298	317050	197238	101889	299127
1983	390466	242794	633260	288944	19248	308191	400576	17215	417791	270397	129067	399463
1984	390314	246890	637203	295456	22062	317517	401553	17531	419084	276096	131779	407875
1985	434654	298196	732850	333779	27937	361716	449529	21224	470753	311593	155186	466778
1986	423793	311519	735312	335766	23469	359234	440081	22206	462286	309932	156105	466037
1987	411964	312310	724274	328773	26306	355079	427997	22258	450255	305170	155160	460329
1988	436147	344558	780705	349121	31593	380714	452326	24520	476846	322342	172768	495110
1989	422530	354668	777198	338572	32902	371473	437837	25201	463037	309640	180577	490217
1990	376360	334873	711233	318829	16292	335120	391328	23806	415134	287652	161648	449299
1991	297445	293557	591002	259125	9543	268668	312144	20925	333069	235944	134145	370089
1992	214526	263586	478111	187504	5553	193057	229064	18851	247915	172720	111748	284468
1993	203842	276039	479881	173371	7330	180701	218925	19756	238681	165148	109698	274846
1994	208771	259733	468504	176590	8267	184857	220403	18522	238924	169835	98823	268657
1995	224187	272228	496415	188958	8361	197319	231307	19253	250560	178856	100388	279244
1996	225518	273691	499209	184814	10643	195457	225045	19070	244115	169176	104500	273676
1997	222017	279282	501299	175226	16996	192222	215534	19243	234777	158122	111958	270080
1998	198635	280646	479281	150013	21238	171251	189287	19195	208482	131354	118444	249797
1999	192361	288902	481263	139214	28965	168179	182778	19724	202502	123477	128858	252335
2000	201971	299353	501324	147763	33012	180775	193755	20476	214231	130775	144382	275157
2001	210852	287781	498632	156272	36764	193036	205563	19768	225330	140356	150919	291274
2002	225432	290314	515745	167624	41758	209382	222603	20046	242649	153850	157397	311246
2003	231208	293093	524300	177527	37803	215330	229699	20308	250007	161706	156156	317862
2004	235535	291559	527093	172010	47565	219575	234366	20129	254494	164559	158180	322738
2005	229025	297583	526607	163986	52892	216878	228428	20576	249004	156930	168730	325660
2006	200970	283743	484713	137769	57403	195171	201614	19662	221276	133232	172714	305946
2007	173944	274400	448344	124496	50417	174913	175921	19086	195007	114461	175903	290364
2008	148544	249161	397704	110910	42970	153880	151735	17402	169137	99848	166387	266234
2009	133108	241159	374267	100658	38776	139434	137883	16920	154803	90328	160737	251065
2010	130246	228289	358535	122961	9193	132153	136698	16102	152800	106572	126719	233291
2011	156706	232035	388741	142196	7893	150089	164383	16422	180805	139782	101667	241448
2012	183698	243863	427561	165015	4470	169485	190431	17225	207656	164454	78144	242598
2013	205621	277106	482726	183567	4351	187918	210650	19504	230154	179421	70830	250251
2014	206487	295278	501765	183772	6161	189933	210145	20679	230823	173172	71185	244357
2015	208458	308181	516639	184727	11616	196343	210084	21463	231547	165120	81185	246305
2016	232820	335057	567877	182732	47677	230409	231582	23204	254785	170376	107132	277508
2017	258289	361775	620064	190981	84194	275175	253754	24438	278192	172895	147290	320185
2018	266598	370790	637388	156526	155254	311780	260403	24608	285010	166739	186635	353374
2019	255012	354153	609165	146026	172763	318789	249058	15303	264360	162243	193540	355783
2020	216417	319562	535979	134119	156569	290688	210848	6936	217783	144463	176950	321413
2021	34979	286899	321877	124781	141538	266319	158671	6952	165622	83987	159570	243557

Table 2.1.8. Relative spawning biomass time series.

	M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.14	0.04	0.15	0.04	0.19	0.05	0.12	0.03	0.14	0.04	0.14	0.04	0.17	0.05	0.15	0.04
1978	0.15	0.04	0.16	0.04	0.19	0.05	0.12	0.03	0.14	0.04	0.14	0.04	0.17	0.05	0.15	0.04
1979	0.15	0.04	0.16	0.04	0.20	0.05	0.12	0.03	0.14	0.04	0.15	0.04	0.18	0.04	0.16	0.03
1980	0.19	0.04	0.20	0.04	0.24	0.05	0.14	0.03	0.17	0.04	0.18	0.04	0.22	0.05	0.19	0.04
1981	0.28	0.04	0.29	0.05	0.34	0.05	0.21	0.03	0.25	0.04	0.27	0.05	0.32	0.05	0.27	0.04
1982	0.43	0.06	0.46	0.06	0.52	0.06	0.33	0.04	0.39	0.06	0.42	0.06	0.50	0.07	0.41	0.05
1983	0.57	0.06	0.61	0.07	0.68	0.07	0.45	0.05	0.53	0.07	0.57	0.07	0.65	0.08	0.55	0.06
1984	0.58	0.06	0.62	0.06	0.69	0.06	0.46	0.05	0.54	0.06	0.58	0.07	0.65	0.07	0.56	0.06
1985	0.65	0.06	0.69	0.06	0.79	0.07	0.52	0.05	0.61	0.07	0.66	0.07	0.74	0.07	0.64	0.07
1986	0.64	0.06	0.68	0.06	0.79	0.08	0.52	0.05	0.60	0.06	0.65	0.07	0.72	0.07	0.64	0.06
1987	0.62	0.05	0.66	0.05	0.78	0.08	0.51	0.04	0.59	0.06	0.63	0.06	0.70	0.06	0.64	0.06
1988	0.66	0.05	0.70	0.05	0.84	0.08	0.55	0.04	0.63	0.06	0.68	0.06	0.75	0.06	0.68	0.06
1989	0.64	0.05	0.68	0.05	0.84	0.09	0.54	0.04	0.61	0.05	0.66	0.06	0.72	0.06	0.68	0.06
1990	0.57	0.04	0.61	0.04	0.76	0.09	0.49	0.04	0.56	0.05	0.59	0.05	0.65	0.05	0.62	0.06
1991	0.46	0.03	0.48	0.03	0.64	0.08	0.39	0.03	0.45	0.04	0.48	0.04	0.52	0.04	0.51	0.05
1992	0.33	0.02	0.35	0.03	0.51	0.09	0.28	0.02	0.33	0.03	0.35	0.03	0.39	0.03	0.39	0.04
1993	0.31	0.03	0.33	0.03	0.52	0.10	0.26	0.02	0.31	0.03	0.33	0.03	0.37	0.03	0.38	0.04
1994	0.32	0.02	0.34	0.03	0.50	0.09	0.27	0.02	0.32	0.03	0.34	0.03	0.37	0.03	0.37	0.03
1995	0.34	0.03	0.37	0.03	0.53	0.09	0.29	0.02	0.33	0.03	0.35	0.03	0.39	0.03	0.39	0.03
1996	0.34	0.03	0.37	0.03	0.54	0.09	0.28	0.02	0.32	0.03	0.34	0.03	0.38	0.03	0.38	0.03
1997	0.34	0.03	0.36	0.03	0.54	0.09	0.28	0.02	0.31	0.03	0.33	0.03	0.37	0.03	0.37	0.03
1998	0.30	0.03	0.33	0.03	0.52	0.10	0.25	0.02	0.27	0.03	0.29	0.03	0.33	0.03	0.34	0.03
1999	0.30	0.03	0.32	0.03	0.52	0.11	0.24	0.02	0.26	0.03	0.28	0.03	0.32	0.03	0.35	0.04
2000	0.31	0.03	0.34	0.03	0.54	0.11	0.26	0.02	0.28	0.03	0.30	0.03	0.33	0.03	0.38	0.04
2001	0.32	0.03	0.35	0.03	0.54	0.10	0.28	0.03	0.30	0.03	0.32	0.03	0.35	0.03	0.40	0.04
2002	0.35	0.03	0.37	0.03	0.55	0.10	0.30	0.03	0.32	0.03	0.35	0.03	0.38	0.03	0.43	0.05
2003	0.35	0.03	0.38	0.03	0.56	0.10	0.31	0.03	0.33	0.03	0.36	0.03	0.39	0.03	0.44	0.05
2004	0.36	0.03	0.39	0.03	0.57	0.10	0.32	0.03	0.34	0.03	0.37	0.03	0.40	0.03	0.45	0.05
2005	0.35	0.03	0.38	0.03	0.57	0.10	0.31	0.03	0.33	0.03	0.36	0.03	0.39	0.03	0.45	0.05
2006	0.31	0.02	0.34	0.03	0.52	0.10	0.28	0.02	0.29	0.02	0.32	0.03	0.35	0.03	0.42	0.05
2007	0.27	0.02	0.30	0.02	0.48	0.10	0.25	0.02	0.26	0.02	0.29	0.02	0.30	0.02	0.40	0.05
2008	0.23	0.02	0.25	0.02	0.43	0.10	0.22	0.02	0.22	0.02	0.25	0.02	0.26	0.02	0.37	0.05
2009	0.21	0.02	0.23	0.02	0.40	0.10	0.20	0.02	0.20	0.02	0.23	0.02	0.24	0.02	0.35	0.05
2010	0.20	0.02	0.22	0.02	0.39	0.09	0.19	0.02	0.20	0.02	0.22	0.02	0.24	0.02	0.32	0.04
2011	0.24	0.02	0.26	0.02	0.42	0.08	0.22	0.02	0.25	0.02	0.26	0.02	0.28	0.02	0.33	0.04
2012	0.29	0.02	0.30	0.02	0.46	0.08	0.25	0.02	0.29	0.02	0.30	0.02	0.32	0.02	0.33	0.03
2013	0.33	0.03	0.34	0.03	0.52	0.10	0.27	0.02	0.32	0.03	0.33	0.03	0.36	0.03	0.35	0.03
2014	0.33	0.03	0.34	0.03	0.54	0.11	0.27	0.02	0.33	0.03	0.33	0.03	0.36	0.03	0.34	0.03
2015	0.35	0.03	0.35	0.03	0.56	0.11	0.28	0.03	0.33	0.03	0.32	0.03	0.36	0.03	0.34	0.03
2016	0.40	0.03	0.39	0.03	0.61	0.12	0.33	0.03	0.38	0.04	0.35	0.03	0.40	0.03	0.38	0.03
2017	0.47	0.04	0.43	0.04	0.67	0.13	0.40	0.04	0.44	0.04	0.37	0.04	0.43	0.04	0.44	0.04
2018	0.51	0.04	0.44	0.04	0.69	0.13	0.45	0.04	0.48	0.05	0.38	0.04	0.45	0.04	0.49	0.05
2019	0.50	0.04	0.41	0.04	0.66	0.13	0.46	0.04	0.47	0.05	0.34	0.04	0.41	0.04	0.49	0.05
2020	0.44	0.04	0.34	0.03	0.58	0.13	0.42	0.04	0.41	0.04	0.27	0.03	0.34	0.04	0.44	0.05
2021	0.32	0.02	0.27	0.02	0.35	0.16	0.39	0.03	0.31	0.03	0.23	0.02	0.26	0.02	0.34	0.03

Table 2.1.9a (page 1 of 2). Combined-area age 0 recuitment (1000s of fish) time series.

	Model 19.12a		Model 19.12b		Model 20.1		Model 19.12c	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1171540	301539	1275640	328011	2007950	722214	825921	205286
1978	771777	209276	859653	229236	1284300	482769	574372	149297
1979	798850	134127	881015	148098	1336060	404698	599817	97729
1980	192765	48845	205698	52867	301136	109628	155945	37737
1981	217606	43571	241939	48410	359166	116080	168644	33044
1982	1031930	119767	1139800	135029	1735270	482197	800109	87663
1983	279869	52426	311233	58458	460543	145724	214032	38974
1984	930307	106622	1025050	120310	1551380	431017	725260	78376
1985	421194	56221	462971	62762	693345	198749	333349	42743
1986	232290	34034	257001	38112	382303	112123	186257	26132
1987	71396	17850	78790	19600	114543	41038	57495	13904
1988	333710	42570	361405	46873	548662	155570	269549	32214
1989	664484	74421	715204	81999	1086470	300947	524898	54269
1990	650495	74385	715005	83436	1078500	299928	515790	54449
1991	383116	51375	410407	56167	608998	175047	298967	38526
1992	1032920	106293	1126720	119500	1691010	461785	828624	76444
1993	384916	46870	429623	52631	642081	179905	321075	35854
1994	324551	39215	356994	43533	529838	148194	267625	30013
1995	278619	35141	301812	38342	449395	126811	255304	30056
1996	900055	95381	984338	107811	1487840	408678	745454	74258
1997	393715	46777	433331	52535	648809	181751	313472	35723
1998	300298	37921	328531	41841	490274	138805	233283	28104
1999	735255	73494	813543	83563	1222220	333073	594047	57057
2000	524544	53752	570706	60321	839804	229917	448076	44514
2001	216525	28191	248851	32028	369092	104796	193360	23932
2002	349751	37785	385068	42591	562216	155004	318373	33128
2003	332865	35379	372477	40355	547002	150482	287278	29336
2004	240025	29334	273286	33625	398671	112267	200622	23536
2005	294908	34108	322454	37746	478169	133231	225336	24901
2006	870408	81673	911184	87496	1382260	373382	674794	59647
2007	343974	43755	361074	45430	550623	155269	275709	32514
2008	1274290	122854	1315890	128183	1983320	537113	996204	89445
2009	174317	33011	233420	37246	330542	99576	148880	24874
2010	797284	84805	806159	86179	1204150	330048	671114	65100
2011	1026450	109494	1020920	109181	1528220	418625	827330	83561
2012	487197	64431	472440	61296	704234	199579	379778	47813
2013	1309710	142785	1158510	127242	1727170	474522	1148440	119784
2014	227792	34106	208313	30172	307108	89537	216841	30615
2015	303316	35725	287764	33955	424429	118284	265230	29558
2016	175850	26841	167819	24583	249885	72835	158939	22614
2017	120326	33959	153116	39006	228381	82322	129827	31160
2018	755194	83211	831852	99152	1233090	343785	624088	67349

Table 2.1.9a (page 2 of 2). Combined-area age 0 recuitment (1000s of fish) time series.

	Model 19.12		Model 19.12d		Model 20.2		Model 20.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1010390	270800	1097010	291879	1387920	368726	1083210	299314
1978	704913	187756	772350	205170	931863	254053	755881	209711
1979	720034	128941	780313	138383	952343	164775	779849	150871
1980	171641	47076	175025	49213	214766	58981	196421	52789
1981	201953	41920	214326	44457	259261	53213	223142	48553
1982	963079	124882	1032120	132516	1253530	151258	1032200	154258
1983	241238	47828	257597	51009	301117	59347	251676	51749
1984	861012	107262	917546	113503	1094990	128030	955206	144294
1985	400514	56118	428066	59400	501540	67938	448942	72594
1986	227327	34702	239576	36492	283433	41982	236472	38198
1987	76962	19177	80013	20056	93266	23274	78088	19175
1988	314109	42935	328370	44709	391977	51249	326923	45607
1989	618896	73572	649591	76757	770432	86939	634424	76662
1990	595065	70896	633428	74876	739119	83948	618107	75906
1991	328394	46824	338021	48935	395985	54898	363125	55652
1992	883265	93650	933354	98248	1088070	107941	999720	126839
1993	357532	44519	387625	47397	448724	52887	407313	57656
1994	294794	36769	314232	38520	363880	42680	314217	45023
1995	263437	34614	278176	36153	324286	40325	378670	65791
1996	837501	95180	894125	101522	1048940	111876	984248	141207
1997	373702	46856	396092	49403	461161	55287	392616	56254
1998	291211	38176	310084	40231	358509	44871	289358	42978
1999	661484	70614	716089	76401	830057	82382	708825	94232
2000	489803	53604	522868	57288	590979	61548	647059	99876
2001	203959	27358	230553	30310	260467	32566	246280	38922
2002	333755	38078	359744	41235	404247	43846	471560	74971
2003	313826	35486	343996	38562	385420	41253	392274	57874
2004	232928	30139	254781	32843	287726	35572	270852	39221
2005	287267	35008	302766	35619	346961	40039	261024	34292
2006	855756	87534	864124	86496	1004910	93672	769540	82383
2007	333216	43895	338470	42820	394680	48115	295345	36832
2008	1147680	119702	1146620	114878	1354690	130473	1031640	98723
2009	161462	30011	203171	32335	226506	36072	190554	32650
2010	743872	84584	706714	76817	839597	87403	857957	104575
2011	956412	111402	877189	94124	1057560	111464	849672	94950
2012	423840	59225	384390	50771	459923	58990	393499	60619
2013	1186520	143369	939778	108842	1174060	130053	1318470	202370
2014	212677	33131	179325	26805	215069	31531	248745	45170
2015	285657	36801	249342	31804	304177	36868	293038	43448
2016	150501	24687	117529	15869	163353	25511	172748	28993
2017	104641	30414	115607	29380	140203	34400	136658	35448
2018	668202	86356	630652	87428	739984	98406	609473	81087

Table 2.1.9b. Area-specific age 0 recruitment (1000s of fish) time series.

	Model 20.1			Model 19.12c			Model 20.2			Model 20.3		
Year	EBS	NBS	Sum	EBS	NBS	Sum	EBS	NBS	Sum	EBS	NBS	Sum
1977	1330950	676935	2007885	788078	37808	825886	1340600	47264	1387864	914447	168717	1083164
1978	851290	432975	1284265	548054	26293	574347	900089	31733	931822	638118	117734	755852
1979	885596	450423	1336019	572334	27457	599791	919871	32431	952302	658352	121467	779819
1980	199606	101522	301128	148800	7139	155939	207443	7314	214757	165820	30594	196414
1981	238070	121085	359155	160917	7720	168637	250421	8829	259250	188378	34756	223134
1982	1150210	585007	1735217	760908	39166	800074	1210790	42687	1253477	870860	161305	1032165
1983	305267	155262	460529	205600	8423	214023	290849	10254	301103	212756	38910	251666
1984	1028320	523013	1551333	702964	22264	725228	1057650	37288	1094938	809268	145901	955169
1985	459578	233746	693324	317353	15982	333335	484439	17079	501518	378839	70085	448924
1986	253407	128885	382292	176558	9691	186249	273769	9652	283421	199398	37066	236464
1987	75924	38616	114540	54876	2617	57493	90086	3176	93262	65925	12159	78085
1988	363676	184970	548646	258404	11133	269537	378612	13348	391960	276246	50664	326910
1989	720157	366279	1086436	492825	32051	524876	744162	26236	770398	534164	100236	634400
1990	714876	363593	1078469	497614	18154	515768	713917	25170	739087	523041	95043	618084
1991	403669	205310	608979	289630	9324	298954	382483	13485	395968	307603	55508	363111
1992	1120870	570088	1690958	800956	27631	828587	1050970	37053	1088023	846365	153317	999682
1993	425598	216464	642062	307644	13418	321062	433424	15281	448705	344139	63158	407297
1994	351199	178623	529822	258404	9210	267614	351472	12391	363863	265943	48262	314205
1995	297878	151504	449382	249430	5863	255293	313229	11043	324272	321624	57031	378655
1996	986200	501591	1487791	681722	63701	745423	1013170	35720	1048890	826046	158165	984211
1997	430058	218732	648790	296066	17393	313459	445437	15704	461141	330865	61737	392602
1998	324974	165285	490259	225967	7306	233273	346285	12209	358494	245107	44241	289348
1999	810141	412046	1222187	579232	14789	594021	801754	28266	830020	601625	107173	708798
2000	556657	283122	839779	437540	10516	448056	570828	20125	590953	549478	97556	647034
2001	244649	124431	369080	178721	14631	193352	251586	8870	260456	206938	39333	246271
2002	372660	189539	562199	306045	12313	318358	390463	13766	404229	398698	72844	471542
2003	362576	184410	546986	261342	25924	287266	372278	13125	385403	329046	63213	392259
2004	264256	134403	398659	185607	15006	200613	277916	9798	287714	227610	43232	270842
2005	316950	161204	478154	210327	15000	225327	335130	11815	346945	219595	41419	261014
2006	916222	466000	1382222	654859	19905	674764	970644	34221	1004865	652196	117314	769510
2007	364976	185630	550606	261582	14115	275697	381223	13440	394663	249077	46257	295334
2008	1314630	668633	1983263	965761	30399	996160	1308500	46132	1354632	874072	157531	1031603
2009	219097	111435	330532	145212	3661	148873	218782	7713	226495	161753	28795	190548
2010	798159	405952	1204111	654747	16337	671084	810969	28591	839560	728343	129581	857924
2011	1012970	515206	1528176	774029	53266	827295	1021500	36014	1057514	715039	134600	849639
2012	466796	237417	704213	375105	4656	379761	444241	15662	459903	335986	57498	393484
2013	1144840	582279	1727119	1123230	25167	1148397	1134020	39981	1174001	1120300	198125	1318425
2014	203564	103535	307099	200636	16195	216831	207736	7324	215060	209036	39700	248736
2015	281329	143087	424416	237714	27506	265220	293805	10358	304163	245465	47562	293027
2016	165634	84243	249877	146451	12481	158932	157783	5563	163346	145101	27641	172742
2017	151381	76994	228375	114596	15225	129821	135423	4774	140197	114329	22324	136653
2018	817347	415711	1233058	472842	151225	624067	714752	25199	739951	505752	103698	609450

Table 2.1.10a. Objective function values by major component.

Component	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.1	20.2
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Initial_eq_catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey index	-4.39	164.73	145.19	-17.62	-87.66	-95.81	-95.70	-96.60
Size composition	843.93	971.67	974.94	883.72	817.05	941.12	940.86	856.31
Age composition	256.47	270.90	278.82	262.00	251.01	260.10	271.40	250.23
Recruitment	0.24	-1.57	-0.61	-2.00	-0.67	-1.42	-1.29	-3.10
Initial_eq_recr	4.42	4.12	3.76	6.85	5.16	4.75	3.61	5.70
Priors	n/a	0.23	0.21	0.09	n/a	1.64	0.46	1.52
"Softbounds"	0.02	0.03	0.02	0.02	0.02	0.03	0.02	0.02
Deviations	65.76	66.61	62.12	62.55	99.16	122.28	118.52	100.10
Total	1166.45	1476.71	1464.47	1195.61	1084.06	1232.70	1237.87	1114.18

Table 2.1.10b. Objective function values by subcomponent.

Component	Type	Area	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.1	20.2
Index	Survey	Main	-4.39	4.97	3.84	-18.33	-87.66	-88.66	-88.53	-89.56
		NBS		159.77	141.36	0.71		-7.15	-7.16	-7.04
		Total	-4.39	164.73	145.19	-17.62	-87.66	-95.81	-95.70	-96.60
Sizecomp	Fishery	Main	181.89	182.60	186.97	185.96	176.94	175.85	177.63	181.13
		NBS			0.00	0.00			0.00	0.00
	Survey	Main	662.04	664.39	663.65	650.64	640.10	641.90	645.53	623.25
		NBS		124.69	124.33	47.13		123.37	117.70	51.94
	All	Total	843.93	971.67	974.94	883.72	817.05	941.12	940.86	856.31
Agecomp	Survey	Main	256.47	238.80	238.42	234.85	251.01	229.31	233.70	223.48
		NBS		32.10	40.40	27.15		30.79	37.71	26.75
		Total	256.47	270.90	278.82	262.00	251.01	260.10	271.40	250.23

Table 2.1.11. Goodness of fit summary. Ideal value of each ratio is unity.

			Area		Ratio of output to input							
Component	Stat.	Type	Actual	Assumed	M19.12a	M19.12b	M20.1	M19.12c	M19.12	M19.12d	M20.2	M20.3
Abundance	RMSE	Survey	EBS	EBS			0.41	0.47			0.99	1.00
Abundance	RMSE	Survey	EBS	XBS		0.41				0.99		
Abundance	RMSE	Survey	NBS	NBS			0.15	0.45			0.78	0.70
Abundance	RMSE	Survey	NBS	XBS		0.14				0.75		
Abundance	RMSE	Survey	XBS	XBS	0.43				0.98			
Sizecomp	N	Fishery	EBS	EBS			1.00	1.00			1.00	1.00
Sizecomp	N	Fishery	EBS	XBS	1.00	1.00			1.00	1.00		
Sizecomp	N	Survey	EBS	EBS			1.00	1.00			1.00	1.00
Sizecomp	N	Survey	EBS	XBS		1.00				1.00		
Sizecomp	N	Survey	NBS	NBS			1.00	1.00			1.00	1.00
Sizecomp	N	Survey	NBS	XBS		1.00				1.00		
Sizecomp	N	Survey	XBS	XBS	1.00				1.00			
Agecomp	N	Survey	EBS	EBS			0.63	0.59			0.63	0.61
Agecomp	N	Survey	EBS	XBS		0.57				0.62		
Agecomp	N	Survey	NBS	NBS			0.18	0.47			0.20	0.34
Agecomp	N	Survey	NBS	XBS		0.56				0.60		
Agecomp	N	Survey	XBS	XBS	0.50				0.52			

Table 2.1.12a. Two measures of effective sample size for individual fishery size composition records.

		M19.12a		M19.12b		M20.1		M19.12c		M19.12		M19.12d		M20.2		M20.3	
Year	N	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI
1977	2	2	159	2	161	2	159	2	138	2	153	2	158	2	155	2	137
1978	9	9	110	9	110	9	109	9	100	9	108	9	109	9	109	9	98
1979	14	14	344	14	337	14	330	14	312	14	346	14	342	14	339	14	303
1980	12	12	392	12	389	12	389	12	396	12	383	12	385	12	382	12	361
1981	9	9	90	9	88	9	88	9	93	9	90	9	88	9	89	9	90
1982	11	11	337	11	344	11	348	11	349	11	337	11	334	11	346	11	400
1983	46	46	1017	46	1035	46	1130	46	1209	46	1016	46	1013	46	1181	46	1299
1984	113	113	1700	113	1795	113	1953	113	2057	113	1679	113	1740	113	2090	113	2438
1985	168	168	2205	168	2334	168	2292	168	2159	168	2092	168	2162	168	2121	168	2232
1986	148	148	1744	148	1712	148	1773	148	1597	148	1547	148	1587	148	1502	148	1490
1987	280	280	1601	280	1536	280	1653	280	1569	280	1435	280	1421	280	1519	280	1709
1988	86	86	426	86	409	86	422	86	464	86	441	86	425	86	459	86	490
1989	57	57	274	57	269	57	277	57	308	57	277	57	274	57	297	57	337
1990	214	214	1026	214	1034	214	994	214	1245	214	989	214	1017	214	1079	214	1112
1991	308	308	3528	308	3442	308	3778	308	4648	308	3540	308	3679	308	4273	308	3660
1992	316	316	2991	316	2855	316	2823	316	2415	316	3087	316	3095	316	2663	316	2767
1993	177	177	2155	177	2131	177	2141	177	2156	177	2284	177	2180	177	2302	177	2370
1994	278	278	1807	278	1812	278	1766	278	1824	278	1932	278	1919	278	1902	278	2050
1995	309	309	3123	309	3199	309	3077	309	3294	309	3927	309	3836	309	3962	309	3900
1996	392	392	1785	392	1805	392	1689	392	1748	392	2412	392	2340	392	2512	392	2260
1997	432	432	2330	432	2421	432	2247	432	2073	432	2436	432	2492	432	2374	432	2120
1998	405	405	5848	405	6145	405	5954	405	6359	405	5793	405	5915	405	6051	405	5818
1999	547	547	9952	547	8684	547	10265	547	12927	547	12262	547	12305	547	12951	547	14078
2000	577	577	5358	577	5321	577	5332	577	4104	577	4229	577	4173	577	4260	577	3320
2001	615	615	8353	615	8149	615	7387	615	7463	615	7981	615	8472	615	7222	615	6742
2002	680	680	4805	680	4072	680	4011	680	4743	680	5820	680	5380	680	5007	680	4685
2003	850	850	11109	850	10447	850	10275	850	8182	850	13760	850	12067	850	11996	850	8777
2004	726	726	8689	726	7838	726	8903	726	9552	726	8792	726	8389	726	9363	726	9445
2005	686	686	10700	686	10430	686	13550	686	16280	686	10302	686	11005	686	14706	686	17369
2006	525	525	2541	525	2552	525	2570	525	3241	525	2589	525	2658	525	2816	525	3178
2007	409	409	3554	409	3463	409	3700	409	4445	409	3660	409	3719	409	3891	409	4053
2008	493	493	5061	493	4711	493	4647	493	4469	493	5443	493	5500	493	4302	493	4719
2009	444	444	3075	444	2814	444	2718	444	2595	444	3036	444	2879	444	2519	444	2332
2010	386	386	2487	386	2776	386	2586	386	1691	386	2110	386	2493	386	2148	386	1627
2011	522	522	3547	522	4113	522	3431	522	3400	522	3705	522	4203	522	3417	522	3428
2012	551	551	2284	551	2674	551	2403	551	2297	551	3138	551	3362	551	3077	551	2976
2013	660	660	3574	660	4160	660	4661	660	3911	660	3198	660	3672	660	4231	660	3501
2014	721	721	5635	721	5447	721	4413	721	3782	721	5312	721	5492	721	4006	721	3950
2015	671	671	6997	671	7110	671	6360	671	5734	671	6910	671	7002	671	5819	671	6234
2016	579	579	4514	579	4964	579	4086	579	5049	579	5302	579	5363	579	4710	579	5665
2017	503	503	3059	503	3886	503	3348	503	3430	503	3434	503	3694	503	3855	503	4632
2018	383	383	10855	383	9258	383	12895	383	10444	383	12436	383	12213	383	17577	383	13061
2019	277	277	9342	277	11078	277	8963	277	10674	277	9273	277	16462	277	8895	277	13186

Table 2.1.12b. Two measures of effective sample size for individual survey size composition records.

		1-area models					2-area models												
			M19.12a		M19.12			M19.12b		M20.1		M19.12c		M19.12d		M20.2		M20.3	
Area	Year	N	DM	MI	DM	MI	N	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI
Main	1982	313	313	543	313	523	313	313	522	313	536	313	531	313	510	313	517	313	523
Main	1983	255	255	892	255	990	255	255	902	255	944	255	907	255	1015	255	1054	255	1034
Main	1984	264	264	324	264	354	264	264	324	264	317	264	309	264	366	264	329	264	348
Main	1985	345	345	486	345	519	345	345	485	345	491	345	478	345	514	345	529	345	498
Main	1986	349	349	1485	349	1575	349	349	1579	349	1545	349	1411	349	1676	349	1618	349	1535
Main	1987	339	339	1495	339	1533	339	339	1545	339	1514	339	1449	339	1563	339	1546	339	1562
Main	1988	339	339	1454	339	1454	339	339	1463	339	1503	339	1432	339	1457	339	1512	339	1438
Main	1989	293	293	1092	293	1005	293	293	1040	293	1051	293	1091	293	995	293	961	293	1061
Main	1990	329	329	1825	329	1991	329	329	1779	329	1758	329	1834	329	1916	329	1894	329	2057
Main	1991	313	313	1007	313	899	313	313	1043	313	1054	313	935	313	940	313	956	313	952
Main	1992	332	332	936	332	919	332	332	991	332	958	332	882	332	962	332	928	332	936
Main	1993	363	363	535	363	515	363	363	541	363	535	363	541	363	511	363	517	363	531
Main	1994	364	364	549	364	675	364	364	548	364	556	364	613	364	678	364	696	364	733
Main	1995	347	347	953	347	903	347	347	970	347	950	347	966	347	899	347	909	347	895
Main	1996	359	359	1258	359	1299	359	359	1272	359	1304	359	1382	359	1299	359	1382	359	1458
Main	1997	369	369	892	369	888	369	369	933	369	928	369	944	369	908	369	918	369	967
Main	1998	362	362	655	362	707	362	362	702	362	710	362	684	362	736	362	781	362	815
Main	1999	336	336	599	336	625	336	336	589	336	586	336	613	336	617	336	618	336	625
Main	2000	355	355	983	355	1109	355	355	963	355	992	355	1038	355	1082	355	1113	355	1162
Main	2001	366	366	745	366	760	366	366	743	366	746	366	771	366	753	366	795	366	828
Main	2002	364	364	727	364	724	364	364	759	364	738	364	757	364	757	364	757	364	828
Main	2003	363	363	496	363	508	363	363	490	363	489	363	501	363	498	363	507	363	502
Main	2004	361	361	1915	361	1972	361	361	2140	361	2088	361	2024	361	2190	361	2286	361	2210
Main	2005	360	360	430	360	429	360	360	418	360	420	360	432	360	418	360	419	360	435
Main	2006	354	354	687	354	693	354	354	674	354	668	354	657	354	688	354	661	354	584
Main	2007	368	368	271	368	269	368	368	248	368	272	368	306	368	245	368	275	368	348
Main	2008	338	338	773	338	819	338	338	788	338	770	338	787	338	829	338	800	338	782
Main	2009	360	360	435	360	475	360	360	427	360	429	360	444	360	461	360	448	360	426
Main	2010	405	405	292	405	337	342	342	304	342	293	342	303	342	344	342	315	342	346
Main	2011	368	368	416	368	426	368	368	370	368	372	368	409	368	382	368	391	368	415
Main	2012	356	356	289	356	301	356	356	290	356	286	356	314	356	327	356	294	356	332
Main	2013	354	354	177	354	186	354	354	172	354	168	354	176	354	180	354	172	354	189
Main	2014	373	373	417	373	427	373	373	407	373	403	373	424	373	421	373	421	373	433
Main	2015	354	354	680	354	723	354	354	707	354	694	354	710	354	747	354	736	354	762
Main	2016	376	376	831	376	854	376	376	762	376	741	376	767	376	760	376	766	376	802
Main	2017	481	481	1755	481	1675	369	369	1055	369	1077	369	871	369	1000	369	999	369	950
Main	2018	413	413	1761	413	1979	364	364	1831	364	1837	364	1985	364	1573	364	1778	364	1275
Main	2019	479	479	665	479	728	365	365	491	365	490	365	407	365	489	365	519	365	489
NBS	2010						63	63	30	63	37	63	99	63	30	63	36	63	94
NBS	2017						112	112	595	112	369	112	313	112	605	112	389	112	294
NBS	2018						49	49	545	49	219	49	610	49	569	49	284	49	466
NBS	2019						114	114	1161	114	525	114	865	114	1103	114	878	114	809

Table 2.1.13. Two measures of effective sample size for individual survey age composition records.

		Combined-survey models					Separate survey models												
			M19.12a		M19.12			M19.12b		M20.1		M19.12c		M19.12d		M20.2		M20.3	
Area	Year	N	DM	MI	DM	MI	N	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI	DM	MI
Main	1994	364	182	448	189	414	364	208	474	222	505	225	480	221	521	229	527	230	377
Main	1995	347	173	33	181	34	347	198	33	212	33	215	31	211	34	218	33	220	30
Main	1996	359	179	511	187	465	359	205	403	219	405	222	363	218	400	226	372	227	327
Main	1997	369	184	337	192	442	369	211	410	225	415	228	398	224	603	232	612	234	694
Main	1998	362	181	575	188	690	362	207	530	221	561	224	530	220	678	228	700	229	615
Main	1999	336	168	348	175	385	336	192	349	205	335	208	403	204	374	211	377	213	390
Main	2000	355	177	187	185	194	355	203	187	217	193	219	197	216	191	223	186	225	181
Main	2001	366	183	177	190	180	366	209	165	223	160	226	165	222	173	230	171	232	172
Main	2002	364	182	71	189	69	364	208	74	222	78	225	87	221	72	229	76	230	89
Main	2003	363	181	384	189	408	363	207	366	222	340	224	353	220	392	228	363	230	425
Main	2004	361	180	37	188	37	361	206	36	220	37	223	37	219	37	227	37	229	39
Main	2005	360	180	277	187	287	360	206	374	220	364	223	250	219	367	226	371	228	285
Main	2006	354	177	68	184	72	354	202	88	216	94	219	109	215	97	223	99	224	116
Main	2007	368	184	33	191	35	368	210	34	225	38	228	47	224	35	231	40	233	61
Main	2008	338	169	95	176	117	338	193	123	206	113	209	107	205	149	213	132	214	179
Main	2009	360	180	92	187	170	360	206	225	220	222	223	204	219	348	226	333	228	523
Main	2010	405	202	166	211	360	342	195	123	209	135	211	195	208	224	215	200	217	250
Main	2011	368	184	105	191	88	368	210	151	225	166	228	133	224	124	231	135	233	133
Main	2012	356	178	164	185	158	356	203	167	217	172	220	219	216	181	224	167	225	262
Main	2013	354	177	111	184	114	354	202	149	216	143	219	124	215	152	223	144	224	137
Main	2014	373	186	172	194	164	373	213	211	228	218	231	214	227	183	234	192	236	190
Main	2015	354	177	280	184	280	354	202	410	216	446	219	304	215	408	223	359	224	357
Main	2016	376	188	75	196	69	376	215	120	229	128	232	127	228	110	236	112	238	138
Main	2017	481	240	276	250	295	369	211	173	225	178	228	160	224	207	232	191	234	174
Main	2018	413	206	72	215	90	364	208	82	222	79	225	68	221	146	229	101	230	83
NBS	2010						63	35	19	12	29	38	20	38	16	14	23	29	22
NBS	2017						49	28	87	10	37	30	55	30	102	11	39	23	50
NBS	2018						114	63	40	21	14	68	74	68	51	24	19	52	58

Table 2.1.14a. Comparison of primary and alternative ensembles: point estimates of main parameters.

Time-varying *Q*?	No									Yes								
Separate areas?	No			Yes						No			Yes					
Separate surveys?	Yes			Yes						Yes			Yes					
Movement?	No			No			Yes			No			No			Yes		
Parameter	19.12b	20.4	Δ	20.1	20.5	Δ	19.12c	19.12e	Δ	19.12d	19.15	Δ	20.2	20.6	Δ	20.3	20.7	Δ
Natural_mortality	0.372	0.373	0.004	0.372	0.369	-0.006	0.332	0.332	0.001	0.358	0.359	0.004	0.374	0.373	-0.001	0.344	0.346	0.006
L_at_1.5_base	14.799	14.798	0.000	14.794	14.796	0.000	14.805	14.804	0.000	14.903	14.900	0.000	14.807	14.808	0.000	14.594	14.577	-0.001
L_infinity	114.2	113.5	-0.006	112.9	115.9	0.027	118.2	118.1	0.000	114.6	114.5	-0.001	116.5	116.5	0.000	111.2	111.1	-0.001
VonBert_K	0.117	0.119	0.019	0.118	0.109	-0.074	0.106	0.106	0.000	0.117	0.117	0.000	0.108	0.108	0.000	0.123	0.123	0.002
Richards_coef	1.435	1.427	-0.006	1.444	1.477	0.023	1.480	1.480	0.000	1.419	1.420	0.001	1.479	1.478	0.000	1.438	1.439	0.001
SD_len_at_1	3.483	3.484	0.000	3.466	3.465	0.000	3.481	3.481	0.000	3.473	3.474	0.000	3.485	3.485	0.000	3.490	3.490	0.000
SD_len_at_20	9.945	9.892	-0.005	10.136	10.393	0.025	10.153	10.150	0.000	9.882	9.869	-0.001	10.014	10.017	0.000	9.397	9.384	-0.001
InitF_main_fsh	0.127	0.124	-0.018	0.119	0.119	0.003	0.147	0.147	-0.001	0.134	0.132	-0.011	0.114	0.115	0.004	0.173	0.172	-0.002
InitF_NBS_fsh				0.000	0.000	-0.965	0.000	0.000	-0.005				0.000	0.000	0.040	0.000		
Main_fsh_sel_PeakStart	75.220	75.012	-0.003	74.971	74.889	-0.001	74.982	74.980	0.000	74.986	74.986	0.000	74.931	74.937	0.000	75.968	75.976	0.000
Main_srv_sel_PeakStart_base	21.036	21.054	0.001	20.986	20.932	-0.003	21.110	21.112	0.000	20.699	20.704	0.000	20.970	20.968	0.000	21.827	21.893	0.003
NBS_srv_sel_PeakStart	79.998	79.998	0.000	74.051	73.453	-0.008	15.530	15.528	0.000	79.997	79.996	0.000	68.696	69.355	0.010	14.453	14.418	-0.002
RecrDist_NBS_base				-0.676	2.691	3.367	-3.037	-3.033	0.004				-3.345	-3.382	-0.037	-1.690	-1.640	0.050
AgeBias_at_1_1977_2007	0.349	0.349	0.000	0.349	0.348	-0.001	0.347	0.347	0.000	0.347	0.347	0.000	0.348	0.348	0.000	0.346	0.347	0.001
AgeBias_at_1_2008_2019	-0.002	-0.002	0.000	0.001	0.001	0.000	0.009	0.009	0.000	0.002	0.002	0.000	0.004	0.004	0.000	0.008	0.007	-0.001
AgeBias_at_20_1977_2007	0.776	0.771	-0.005	0.772	0.782	0.010	0.843	0.842	0.000	0.804	0.802	-0.002	0.825	0.825	0.000	0.954	0.954	0.000
AgeBias_at_20_2008_2019	-1.697	-1.700	-0.003	-1.646	-1.648	-0.002	-1.698	-1.698	0.000	-1.930	-1.932	-0.003	-1.790	-1.790	0.000	-2.179	-2.201	-0.022
ln(Recr_ave_1977_2018)	13.271	13.285	0.014	13.678	16.000	2.321	12.991	12.993	0.002	13.144	13.157	0.013	13.313	13.308	-0.005	13.185	13.220	0.034
ln(Recr_ave_pre1977_offset)	-0.885	-0.877	0.008	-0.862	-0.866	-0.004	-0.986	-0.986	0.001	-0.909	-0.903	0.006	-0.839	-0.841	-0.002	-0.919	-0.912	0.007
lnQ_main_srv_base	-0.111	-0.121	-0.010	-0.102	-0.085	0.017	0.172	0.171	-0.001	-0.037	-0.046	-0.009	-0.116	-0.114	0.002	0.261	0.254	-0.007
lnQ_NBS_srv_base	-0.788	-0.804	-0.016	-0.747	-4.122	-3.375	-0.260	-0.265	-0.005	-1.842	-1.967	-0.125	0.827	0.933	0.106	-1.466	-1.618	-0.151
Main_fsh_sel_logitPeakWidth	-5.712	-9.672	-3.960	-9.439	0.434	9.873	0.208	0.208	0.001	-9.761	-9.772	-0.011	0.469	0.470	0.001	0.097	0.093	-0.004
Main_fsh_sel_lnSD1_base	5.913	5.903	-0.010	5.898	5.892	-0.006	5.907	5.907	0.000	5.905	5.905	0.000	5.896	5.896	0.000	5.950	5.951	0.000
Main_fsh_sel_lnSD2	-1.410	-9.947	-8.537	-9.091	4.406	13.497	4.707	4.707	0.000	-9.886	-9.880	0.006	4.345	4.342	0.00	4.827	4.829	0.00
Main_fsh_sel_logitEnd_base	1.987	2.000	0.013	3.114	-2.759	-5.873	-3.140	-3.137	0.003	2.084	2.079	-0.006	-2.647	-2.643	0.005	-2.855	-2.860	-0.005
Main_srv_sel_lnSD1_base	3.532	3.535	0.003	3.522	3.512	-0.010	3.535	3.535	0.000	3.460	3.460	0.000	3.513	3.513	0.000	3.613	3.620	0.006
NBS_srv_sel_lnSD1	7.784	7.790	0.006	8.881	8.930	0.049	2.067	2.066	-0.001	7.821	7.834	0.014	7.925	7.922	-0.003	1.750	1.738	-0.012
lnDM_size_main_fish	9.989	9.989	0.000	9.989	9.990	0.001	9.990	9.990	0.000	9.989	9.989	0.000	9.990	9.990	0.000	9.989	9.989	0.000
lnDM_size_main_sur	9.984	9.984	0.000	9.985	9.984	-0.001	9.984	9.984	0.000	9.984	9.984	0.000	9.985	9.985	0.000	9.984	9.984	0.000
lnDM_size_NBS_sur	9.656	9.655	0.000	9.717	9.714	-0.003	9.923	9.924	0.002	9.756	9.687	-0.069	9.712	9.712	0.000	9.935	9.936	0.001
lnDM_age_main_srv	0.281	0.252	-0.029	0.444	0.520	0.076	0.478	0.475	-0.002	0.432	0.419	-0.013	0.522	0.527	0.005	0.541	0.540	0.000
lnDM_age_NBS_srv	0.213	0.196	-0.017	-1.511	-1.528	-0.016	0.381	0.377	-0.005	0.383	0.380	-0.003	-1.342	-1.346	-0.004	-0.201	-0.192	0.009

Table 2.1.14b. Comparison of primary and alternative ensembles: standard deviations of main parameters.

Time-varying *Q*?	No									Yes								
Separate areas?	No			Yes						No			Yes					
Separate surveys?	Yes			Yes						Yes			Yes					
Movement?	No			No			Yes			No			No			Yes		
Parameter	19.12b	20.4	Δ	20.1	20.5	Δ	19.12c	19.12e	Δ	19.12d	19.15	Δ	20.2	20.6	Δ	20.3	20.7	Δ
Natural_mortality	0.012	0.012	0.004	0.011	0.011	-0.001	0.011	0.011	0.001	0.012	0.012	0.005	0.011	0.011	0.002	0.013	0.012	-0.066
L_at_1.5_base	0.400	0.400	-0.001	0.404	0.404	-0.001	0.400	0.400	0.000	0.418	0.418	0.000	0.416	0.416	0.000	0.400	0.399	-0.003
L_infinity	3.340	3.088	-0.075	3.189	4.178	0.310	4.594	4.588	-0.001	3.265	3.251	-0.004	4.188	4.193	0.001	3.467	3.440	-0.008
VonBert_K	0.010	0.009	-0.058	0.010	0.011	0.148	0.011	0.011	0.000	0.009	0.009	-0.003	0.011	0.011	0.000	0.011	0.011	0.000
Richards_coef	0.045	0.042	-0.051	0.043	0.047	0.090	0.047	0.047	0.000	0.043	0.043	-0.001	0.047	0.047	0.000	0.046	0.046	0.004
SD_len_at_1	0.066	0.066	0.000	0.066	0.066	-0.004	0.066	0.066	0.000	0.065	0.065	0.001	0.067	0.067	0.000	0.065	0.065	-0.003
SD_len_at_20	0.397	0.382	-0.038	0.387	0.439	0.137	0.446	0.445	-0.001	0.391	0.390	-0.001	0.430	0.430	0.001	0.392	0.391	-0.003
InitF_main_fsh	0.040	0.039	-0.025	0.037	0.037	0.003	0.046	0.046	-0.001	0.043	0.042	-0.013	0.035	0.036	0.004	0.056	0.045	-0.197
InitF_NBS_fsh				0.000	0.000	-0.989	0.000	0.000	-0.003				0.000	0.000	-0.008	0.000		-1.000
Main_fsh_sel_PeakStart	0.598	0.037	-0.938	0.196	0.514	1.619	0.528	0.529	0.000	0.030	0.031	0.013	0.520	0.520	0.000	0.590	0.592	0.002
Main_srv_sel_PeakStart_base	0.801	0.800	-0.001	0.794	0.789	-0.006	0.811	0.811	0.000	0.831	0.831	0.000	0.819	0.819	0.000	0.905	0.903	-0.003
NBS_srv_sel_PeakStart	0.072	0.074	0.031	8.817	8.871	0.006	1.383	1.382	-0.001	0.113	0.124	0.097	7.855	7.947	0.012	1.161	1.144	-0.014
RecrDist_NBS_base				0.759	0.146	-0.807	0.245	0.245	0.001				0.177	0.158	-0.109	0.213	0.179	-0.159
AgeBias_at_1_1977_2007	0.015	0.015	0.002	0.015	0.014	-0.008	0.015	0.015	0.000	0.015	0.015	0.000	0.014	0.014	0.000	0.015	0.015	-0.007
AgeBias_at_1_2008_2019	0.025	0.025	0.001	0.024	0.024	-0.005	0.023	0.023	0.000	0.026	0.026	-0.001	0.023	0.023	0.000	0.024	0.024	0.000
AgeBias_at_20_1977_2007	0.205	0.206	0.005	0.198	0.196	-0.012	0.200	0.200	0.000	0.204	0.205	0.002	0.200	0.200	-0.001	0.205	0.205	
AgeBias_at_20_2008_2019	0.325	0.327	0.007	0.313	0.309	-0.013	0.305	0.305	0.000	0.345	0.347	0.004	0.324	0.324	-0.001	0.365	0.363	-0.003
ln(Recr_ave_1977_2018)	0.099	0.100	0.008	0.271	0.105	-0.612	0.089	0.090	0.002	0.103	0.104	0.010	0.097	0.097	0.000	0.123	0.099	-0.191
ln(Recr_ave_pre1977_offset)	0.204	0.205	0.003	0.206	0.206	-0.002	0.181	0.182	0.001	0.199	0.200	0.004	0.208	0.207	-0.001	0.180	0.136	-0.244
lnQ_main_srv_base	0.066	0.066	0.011	0.057	0.057	-0.012	0.059	0.059	0.002	0.068	0.069	0.013	0.064	0.064	0.000	0.065	0.063	-0.025
lnQ_NBS_srv_base	0.105	0.105	0.007	0.767	0.161	-0.790	0.108	0.109	0.007	0.254	0.263	0.035	0.325	0.325	0.001	0.284	0.250	-0.119
Main_fsh_sel_logitPeakWidth	18.562	9.043	-0.513	14.705	0.533	-0.964	0.465	0.465	0.000	6.755	6.552	-0.030	0.593	0.592	0.000	0.522	0.520	-0.004
Main_fsh_sel_lnSD1_base	0.039	0.027	-0.315	0.029	0.037	0.276	0.039	0.039	0.000	0.027	0.027	0.000	0.037	0.037	0.000	0.039	0.039	0.000
Main_fsh_sel_lnSD2	8.489	1.649	-0.806	18.173	1.598	-0.912	1.251	1.252	0.001	3.556	3.758	0.057	1.767	1.768	0.001	1.357	1.349	-0.006
Main_fsh_sel_logitEnd_base	0.301	0.277	-0.080	0.786	3.537	3.499	3.513	3.513	0.000	0.296	0.295	-0.004	3.443	3.438	-0.002	3.301	3.289	-0.003
Main_srv_sel_lnSD1_base	0.151	0.150	-0.003	0.151	0.150	-0.004	0.154	0.154	0.000	0.161	0.161	0.000	0.155	0.155	0.000	0.157	0.157	0.000
NBS_srv_sel_lnSD1	0.139	0.140	0.007	0.882	0.945	0.071	0.640	0.640	0.000	0.146	0.148	0.017	0.490	0.480	-0.019	0.675	0.673	-0.004
lnDM_size_main_fish	0.351	0.357	0.015	0.358	0.323	-0.099	0.325	0.332	0.022	0.358	0.372	0.041	0.347	0.333	-0.039	0.343	0.349	0.017
lnDM_size_main_sur	0.524	0.515	-0.018	0.499	0.484	-0.030	0.496	0.490	-0.012	0.522	0.510	-0.022	0.470	0.492	0.048	0.482	0.478	-0.010
lnDM_size_NBS_sur	9.374	8.502	-0.093	7.603	8.695	0.144	2.327	2.328	0.000	7.420	10.704	0.443	8.223	9.056	0.101	1.982	1.945	-0.019
lnDM_age_main_srv	0.252	0.246	-0.026	0.278	0.295	0.061	0.280	0.280	-0.001	0.274	0.273	-0.007	0.297	0.298	0.004	0.282	0.282	0.001
lnDM_age_NBS_srv	0.568	0.564	-0.007	0.343	0.342	-0.005	1.052	1.048	-0.004	0.609	0.609	0.001	0.362	0.362	0.000	0.578	0.578	0.000

Table 2.1.15a. Comparison of primary and alternative ensembles: EBS catchability (1-area models).

Q var?	No			Yes		
2 area?	No			No		
2 srv?	Yes			Yes		
Move?	No			No		
Year	19.12b	20.4	Δ	19.12d	19.15	Δ
1982	0.895	0.886	-0.010	0.961	0.951	-0.011
1983	0.895	0.886	-0.010	1.012	1.002	-0.010
1984	0.895	0.886	-0.010	0.893	0.884	-0.010
1985	0.895	0.886	-0.010	1.044	1.034	-0.010
1986	0.895	0.886	-0.010	0.997	0.988	-0.009
1987	0.895	0.886	-0.010	0.969	0.961	-0.009
1988	0.895	0.886	-0.010	0.949	0.941	-0.008
1989	0.895	0.886	-0.010	0.837	0.830	-0.008
1990	0.895	0.886	-0.010	0.896	0.889	-0.008
1991	0.895	0.886	-0.010	0.877	0.869	-0.008
1992	0.895	0.886	-0.010	0.874	0.867	-0.008
1993	0.895	0.886	-0.010	1.009	1.001	-0.008
1994	0.895	0.886	-0.010	1.347	1.336	-0.008
1995	0.895	0.886	-0.010	1.126	1.117	-0.008
1996	0.895	0.886	-0.010	1.119	1.110	-0.008
1997	0.895	0.886	-0.010	0.939	0.932	-0.008
1998	0.895	0.886	-0.010	0.926	0.918	-0.009
1999	0.895	0.886	-0.010	0.939	0.931	-0.009
2000	0.895	0.886	-0.010	0.847	0.840	-0.008
2001	0.895	0.886	-0.010	1.114	1.105	-0.008
2002	0.895	0.886	-0.010	0.919	0.911	-0.008
2003	0.895	0.886	-0.010	0.958	0.951	-0.008
2004	0.895	0.886	-0.010	0.868	0.861	-0.008
2005	0.895	0.886	-0.010	0.925	0.918	-0.008
2006	0.895	0.886	-0.010	0.887	0.880	-0.008
2007	0.895	0.886	-0.010	0.896	0.889	-0.009
2008	0.895	0.886	-0.010	0.807	0.801	-0.008
2009	0.895	0.886	-0.010	0.847	0.840	-0.008
2010	0.895	0.886	-0.010	0.995	0.987	-0.008
2011	0.895	0.886	-0.010	1.043	1.035	-0.008
2012	0.895	0.886	-0.010	0.996	0.987	-0.008
2013	0.895	0.886	-0.010	0.902	0.895	-0.009
2014	0.895	0.886	-0.010	1.180	1.169	-0.009
2015	0.895	0.886	-0.010	1.124	1.114	-0.010
2016	0.895	0.886	-0.010	1.083	1.072	-0.010
2017	0.895	0.886	-0.010	0.838	0.830	-0.010
2018	0.895	0.886	-0.010	0.924	0.915	-0.010
2019	0.895	0.886	-0.010	0.960	0.951	-0.009

Table 2.1.15b. Comparison of primary and alternative ensembles: NBS catchability (1-area models).

Q var?	No			Yes		
2 area?	No			No		
2 srv?	Yes			Yes		
Move?	No			No		
Year	19.12b	20.4	Δ	19.12d	19.15	Δ
1982	0.455	0.448	-0.016	0.065	0.062	-0.040
1985	0.455	0.448	-0.016	0.082	0.078	-0.056
1988	0.455	0.448	-0.016	0.039	0.037	-0.054
1991	0.455	0.448	-0.016	0.103	0.098	-0.053
2010	0.455	0.448	-0.016	0.020	0.020	-0.034
2017	0.455	0.448	-0.016	0.462	0.454	-0.017
2018	0.455	0.448	-0.016	1.000	0.979	-0.021
2019	0.455	0.448	-0.016	0.987	0.968	-0.020

Table 2.1.15c. Comparison of primary and alternative ensembles: EBS catchability (2-area models).

Q var?	No						Yes					
2 area?	Yes						Yes					
2 srv?	Yes						Yes					
Move?	No			Yes			No			Yes		
Year	20.1	20.5	Δ	19.12c	19.12e	Δ	20.2	20.6	Δ	20.3	20.7	Δ
1982	0.903	0.918	0.017	1.188	1.186	-0.001	0.865	0.868	0.003	1.319	1.308	-0.008
1983	0.903	0.918	0.017	1.188	1.186	-0.001	0.920	0.923	0.003	1.353	1.342	-0.009
1984	0.903	0.918	0.017	1.188	1.186	-0.001	0.808	0.810	0.003	1.217	1.207	-0.009
1985	0.903	0.918	0.017	1.188	1.186	-0.001	0.949	0.951	0.003	1.386	1.374	-0.008
1986	0.903	0.918	0.017	1.188	1.186	-0.001	0.911	0.913	0.003	1.334	1.323	-0.008
1987	0.903	0.918	0.017	1.188	1.186	-0.001	0.893	0.895	0.002	1.315	1.306	-0.007
1988	0.903	0.918	0.017	1.188	1.186	-0.001	0.877	0.879	0.002	1.305	1.297	-0.006
1989	0.903	0.918	0.017	1.188	1.186	-0.001	0.778	0.780	0.002	1.173	1.167	-0.005
1990	0.903	0.918	0.017	1.188	1.186	-0.001	0.830	0.832	0.002	1.199	1.192	-0.006
1991	0.903	0.918	0.017	1.188	1.186	-0.001	0.808	0.810	0.002	1.178	1.171	-0.006
1992	0.903	0.918	0.017	1.188	1.186	-0.001	0.809	0.811	0.002	1.152	1.143	-0.008
1993	0.903	0.918	0.017	1.188	1.186	-0.001	0.935	0.937	0.002	1.299	1.290	-0.007
1994	0.903	0.918	0.017	1.188	1.186	-0.001	1.244	1.247	0.002	1.687	1.677	-0.006
1995	0.903	0.918	0.017	1.188	1.186	-0.001	1.046	1.049	0.002	1.435	1.424	-0.007
1996	0.903	0.918	0.017	1.188	1.186	-0.001	1.042	1.045	0.002	1.436	1.426	-0.007
1997	0.903	0.918	0.017	1.188	1.186	-0.001	0.877	0.879	0.002	1.271	1.262	-0.007
1998	0.903	0.918	0.017	1.188	1.186	-0.001	0.857	0.859	0.002	1.275	1.266	-0.007
1999	0.903	0.918	0.017	1.188	1.186	-0.001	0.872	0.874	0.002	1.282	1.273	-0.007
2000	0.903	0.918	0.017	1.188	1.186	-0.001	0.792	0.794	0.002	1.168	1.160	-0.007
2001	0.903	0.918	0.017	1.188	1.186	-0.001	1.038	1.040	0.002	1.447	1.435	-0.008
2002	0.903	0.918	0.017	1.188	1.186	-0.001	0.864	0.866	0.002	1.260	1.251	-0.007
2003	0.903	0.918	0.017	1.188	1.186	-0.001	0.904	0.906	0.002	1.297	1.288	-0.007
2004	0.903	0.918	0.017	1.188	1.186	-0.001	0.826	0.828	0.002	1.228	1.220	-0.006
2005	0.903	0.918	0.017	1.188	1.186	-0.001	0.883	0.884	0.002	1.338	1.330	-0.006
2006	0.903	0.918	0.017	1.188	1.186	-0.001	0.847	0.849	0.002	1.316	1.309	-0.005
2007	0.903	0.918	0.017	1.188	1.186	-0.001	0.838	0.840	0.002	1.255	1.246	-0.007
2008	0.903	0.918	0.017	1.188	1.186	-0.001	0.758	0.760	0.002	1.224	1.222	-0.002
2009	0.903	0.918	0.017	1.188	1.186	-0.001	0.800	0.802	0.002	1.286	1.286	0.000
2010	0.903	0.918	0.017	1.188	1.186	-0.001	0.922	0.924	0.002	1.224	1.216	-0.007
2011	0.903	0.918	0.017	1.188	1.186	-0.001	0.972	0.974	0.002	1.283	1.275	-0.006
2012	0.903	0.918	0.017	1.188	1.186	-0.001	0.925	0.927	0.002	1.272	1.264	-0.006
2013	0.903	0.918	0.017	1.188	1.186	-0.001	0.829	0.831	0.002	1.155	1.148	-0.007
2014	0.903	0.918	0.017	1.188	1.186	-0.001	1.078	1.081	0.002	1.455	1.444	-0.008
2015	0.903	0.918	0.017	1.188	1.186	-0.001	1.011	1.014	0.002	1.403	1.392	-0.008
2016	0.903	0.918	0.017	1.188	1.186	-0.001	0.975	0.977	0.002	1.448	1.439	-0.006
2017	0.903	0.918	0.017	1.188	1.186	-0.001	0.765	0.766	0.002	1.219	1.213	-0.005
2018	0.903	0.918	0.017	1.188	1.186	-0.001	0.814	0.816	0.002	1.335	1.327	-0.006
2019	0.903	0.918	0.017	1.188	1.186	-0.001	0.863	0.866	0.003	1.252	1.237	-0.012

Table 2.1.15c. Comparison of primary and alternative ensembles: EBS catchability (2-area models).

Q var?	No						Yes					
2 area?	Yes						Yes					
2 srv?	Yes						Yes					
Move?	No			Yes			No			Yes		
Year	20.1	20.5	Δ	19.12c	19.12e	Δ	20.2	20.6	Δ	20.3	20.7	Δ
1982	0.474	0.016	-0.966	0.771	0.767	-0.005	1.158	1.235	0.066	0.116	0.105	-0.096
1985	0.474	0.016	-0.966	0.771	0.767	-0.005	1.382	1.489	0.077	0.138	0.123	-0.107
1988	0.474	0.016	-0.966	0.771	0.767	-0.005	0.688	0.739	0.074	0.074	0.066	-0.105
1991	0.474	0.016	-0.966	0.771	0.767	-0.005	1.592	1.711	0.075	0.163	0.147	-0.099
2010	0.474	0.016	-0.966	0.771	0.767	-0.005	0.335	0.357	0.065	0.075	0.067	-0.101
2017	0.474	0.016	-0.966	0.771	0.767	-0.005	6.540	6.858	0.049	0.437	0.408	-0.066
2018	0.474	0.016	-0.966	0.771	0.767	-0.005	15.068	15.949	0.058	0.869	0.813	-0.065
2019	0.474	0.016	-0.966	0.771	0.767	-0.005	17.897	19.296	0.078	0.913	0.864	-0.054

Table 2.1.16a. Comparison of primary and alternative ensembles: age 0+ biomass (combined areas).

Q vary?	No			Yes		
2 area?	No	Yes		No	Yes	
2 srv?	Yes	Yes		Yes	Yes	
Move?	No	No	Yes	No	No	Yes
Pri. model	M19.12b	M20.1	M19.12c	M19.12d	M20.2	M20.3
Alt. model	M20.4	M20.5	M19.12e	M19.5	M20.6	M20.7
1977	0.0184	11.2099	0.0018	0.0154	-0.0061	0.0389
1978	0.0181	11.1805	0.0019	0.0164	-0.0063	0.0399
1979	0.0171	10.6704	0.0021	0.0172	-0.0064	0.0407
1980	0.0161	10.2505	0.0020	0.0161	-0.0061	0.0397
1981	0.0153	10.0626	0.0018	0.0147	-0.0057	0.0383
1982	0.0144	10.0409	0.0017	0.0133	-0.0053	0.0367
1983	0.0134	10.1309	0.0015	0.0119	-0.0049	0.0351
1984	0.0121	10.2756	0.0013	0.0110	-0.0046	0.0340
1985	0.0115	10.7248	0.0013	0.0104	-0.0045	0.0342
1986	0.0109	11.0471	0.0012	0.0098	-0.0044	0.0342
1987	0.0104	11.1514	0.0011	0.0091	-0.0042	0.0338
1988	0.0101	11.4527	0.0010	0.0083	-0.0040	0.0337
1989	0.0099	11.9718	0.0010	0.0078	-0.0040	0.0345
1990	0.0095	12.4605	0.0009	0.0074	-0.0040	0.0346
1991	0.0092	12.9328	0.0009	0.0073	-0.0040	0.0343
1992	0.0097	13.6095	0.0010	0.0078	-0.0043	0.0349
1993	0.0102	13.5437	0.0010	0.0079	-0.0043	0.0330
1994	0.0103	13.1643	0.0010	0.0075	-0.0041	0.0307
1995	0.0108	13.0980	0.0010	0.0073	-0.0041	0.0305
1996	0.0116	13.1391	0.0010	0.0075	-0.0042	0.0315
1997	0.0123	13.7166	0.0011	0.0075	-0.0044	0.0337
1998	0.0135	14.4294	0.0012	0.0084	-0.0048	0.0383
1999	0.0135	14.3758	0.0013	0.0088	-0.0049	0.0402
2000	0.0132	14.1261	0.0013	0.0087	-0.0047	0.0404
2001	0.0124	13.7430	0.0013	0.0083	-0.0045	0.0395
2002	0.0116	13.5157	0.0012	0.0078	-0.0043	0.0388
2003	0.0111	13.5753	0.0012	0.0074	-0.0042	0.0393
2004	0.0108	13.6674	0.0012	0.0071	-0.0042	0.0402
2005	0.0108	14.1880	0.0012	0.0070	-0.0043	0.0425
2006	0.0109	14.6944	0.0013	0.0071	-0.0044	0.0448
2007	0.0111	15.2584	0.0014	0.0073	-0.0047	0.0468
2008	0.0108	15.2350	0.0014	0.0075	-0.0047	0.0458
2009	0.0107	14.9710	0.0013	0.0077	-0.0047	0.0430
2010	0.0104	14.1607	0.0012	0.0077	-0.0044	0.0371
2011	0.0102	13.4183	0.0011	0.0073	-0.0041	0.0310
2012	0.0103	13.2645	0.0010	0.0073	-0.0039	0.0275
2013	0.0106	13.6615	0.0011	0.0077	-0.0041	0.0271
2014	0.0109	13.9092	0.0012	0.0083	-0.0042	0.0270
2015	0.0113	13.8976	0.0014	0.0091	-0.0042	0.0292
2016	0.0118	13.8698	0.0016	0.0098	-0.0041	0.0322
2017	0.0124	14.2303	0.0018	0.0105	-0.0041	0.0354
2018	0.0130	14.7128	0.0019	0.0114	-0.0042	0.0385
2019	0.0136	15.3426	0.0020	0.0125	-0.0044	0.0414
2020	0.0141	15.9889	0.0022	0.0139	-0.0048	0.0443
2021	0.0075	20.7057	0.0018	0.0077	-0.0033	0.0241

Table 2.1.16b. Comparison of primary and alternative ensembles: age 0+ biomass (separate areas).

Area:	Eastern Bering Sea				Northern Bering sea			
Q vary?	No		Yes		No		Yes	
2 area?	Yes		Yes		Yes		Yes	
2 srv?	Yes		Yes		Yes		Yes	
Move?	No	Yes	No	Yes	No	Yes	No	Yes
Pri. mod.	M20.1	M19.12c	M20.2	M20.3	M20.1	M19.12c	M20.2	M20.3
Alt. mod.	M20.5	M19.12e	M20.6	M20.7	M20.5	M19.12e	M20.6	M20.7
1977	-0.0188	0.0015	-0.0046	0.0104	27.7443	0.0056	-0.0391	0.0941
1978	-0.0210	0.0016	-0.0048	0.0127	27.6981	0.0057	-0.0393	0.0944
1979	-0.0257	0.0018	-0.0050	0.0149	27.5130	0.0058	-0.0398	0.0933
1980	-0.0270	0.0017	-0.0047	0.0143	27.4182	0.0057	-0.0398	0.0916
1981	-0.0270	0.0015	-0.0043	0.0128	27.3785	0.0055	-0.0396	0.0893
1982	-0.0261	0.0013	-0.0039	0.0114	27.3885	0.0052	-0.0393	0.0865
1983	-0.0244	0.0012	-0.0035	0.0114	27.4387	0.0050	-0.0389	0.0857
1984	-0.0212	0.0011	-0.0032	0.0104	27.5233	0.0048	-0.0386	0.0843
1985	-0.0194	0.0010	-0.0031	0.0096	27.6095	0.0046	-0.0383	0.0854
1986	-0.0178	0.0009	-0.0029	0.0087	27.6769	0.0049	-0.0380	0.0874
1987	-0.0167	0.0008	-0.0026	0.0078	27.7158	0.0047	-0.0378	0.0864
1988	-0.0160	0.0007	-0.0024	0.0066	27.7671	0.0045	-0.0375	0.0853
1989	-0.0156	0.0007	-0.0023	0.0052	27.8156	0.0044	-0.0372	0.0855
1990	-0.0145	0.0007	-0.0021	0.0051	27.8743	0.0060	-0.0370	0.0913
1991	-0.0133	0.0007	-0.0021	0.0046	27.9366	0.0060	-0.0368	0.0928
1992	-0.0141	0.0009	-0.0022	0.0062	27.9752	0.0053	-0.0367	0.0923
1993	-0.0162	0.0009	-0.0023	0.0073	27.9559	0.0041	-0.0367	0.0867
1994	-0.0171	0.0008	-0.0021	0.0067	27.9396	0.0037	-0.0367	0.0826
1995	-0.0187	0.0008	-0.0021	0.0071	27.9143	0.0037	-0.0366	0.0803
1996	-0.0208	0.0009	-0.0022	0.0074	27.8519	0.0038	-0.0367	0.0779
1997	-0.0224	0.0008	-0.0022	0.0070	27.8745	0.0039	-0.0365	0.0771
1998	-0.0242	0.0008	-0.0024	0.0077	27.8888	0.0038	-0.0365	0.0771
1999	-0.0241	0.0008	-0.0025	0.0077	27.8977	0.0038	-0.0365	0.0784
2000	-0.0238	0.0009	-0.0025	0.0077	27.8993	0.0038	-0.0365	0.0794
2001	-0.0224	0.0009	-0.0024	0.0079	27.8972	0.0038	-0.0365	0.0797
2002	-0.0209	0.0008	-0.0022	0.0070	27.9177	0.0037	-0.0365	0.0799
2003	-0.0204	0.0007	-0.0021	0.0062	27.9339	0.0039	-0.0364	0.0821
2004	-0.0195	0.0005	-0.0020	0.0057	27.9527	0.0038	-0.0365	0.0811
2005	-0.0191	0.0005	-0.0020	0.0053	27.9966	0.0036	-0.0364	0.0801
2006	-0.0187	0.0005	-0.0020	0.0047	28.0302	0.0035	-0.0363	0.0788
2007	-0.0186	0.0006	-0.0021	0.0052	28.0700	0.0036	-0.0362	0.0791
2008	-0.0174	0.0007	-0.0022	0.0044	28.0942	0.0036	-0.0362	0.0788
2009	-0.0173	0.0008	-0.0022	0.0013	28.0950	0.0036	-0.0363	0.0788
2010	-0.0168	0.0010	-0.0022	0.0069	28.0470	0.0083	-0.0364	0.0957
2011	-0.0170	0.0009	-0.0020	0.0067	27.9864	0.0079	-0.0365	0.1008
2012	-0.0180	0.0009	-0.0019	0.0063	27.9258	0.0067	-0.0365	0.0990
2013	-0.0187	0.0010	-0.0019	0.0065	27.9272	0.0048	-0.0364	0.0905
2014	-0.0195	0.0011	-0.0020	0.0078	27.9233	0.0036	-0.0364	0.0808
2015	-0.0199	0.0012	-0.0020	0.0086	27.9117	0.0038	-0.0365	0.0746
2016	-0.0208	0.0010	-0.0019	0.0077	27.8969	0.0036	-0.0365	0.0695
2017	-0.0220	0.0009	-0.0018	0.0061	27.9423	0.0035	-0.0369	0.0684
2018	-0.0228	0.0009	-0.0017	0.0070	27.9927	0.0029	-0.0373	0.0664
2019	-0.0228	0.0017	-0.0016	0.0165	28.6826	0.0024	-0.0555	0.0653
2020	-0.0220	0.0020	-0.0018	0.0179	29.3332	0.0023	-0.0977	0.0687
2021	-0.0191	0.0013	-0.0002	-0.0367	29.1930	0.0023	-0.0810	0.0693

Table 2.1.17a. Comparison of primary and alternative ensembles: objective function components.

Time-varying *Q*?	No			Yes		
Separate areas?	No	Yes		No	Yes	
Separate surveys?	Yes	Yes		Yes	Yes	
Movement?	No	No	Yes	No	No	Yes
Primary model	M19.12b	M20.1	M19.12c	M19.12d	M20.2	M20.3
Alternative model	M20.4	M20.5	M19.12e	M19.15	M20.6	M20.7
Catch	0.00	0.00	0.00	0.00	0.00	0.00
Initial_eq_catch	0.00	0.00	0.00	0.00	0.00	0.00
Survey index	-0.31	-1.08	-0.02	-0.39	0.20	-0.39
Size composition	-0.74	-1.20	0.00	-0.22	-0.09	0.60
Age composition	0.39	-0.48	0.04	0.34	-0.11	-0.44
Recruitment	-0.01	0.06	0.00	0.02	-0.01	-0.01
Initial_eq_recr	-0.11	0.10	-0.02	-0.11	0.03	-0.17
Priors	-0.23	-0.21	-0.09	-1.64	-0.46	-1.52
"Softbounds"	0.01	0.00	0.00	0.00	0.00	0.00
Deviations	0.17	0.27	-0.01	0.24	-0.06	0.27
Total	-0.84	-2.55	-0.09	-1.76	-0.50	-1.65

Table 2.1.17 b. Comparison of primary and alternative ensembles: objective function subcomponents.

Time-varying *Q*?			No			Yes		
Separate areas?			No	Yes		No	Yes	
Separate surveys?			Yes	Yes		Yes	Yes	
Movement?			No	No	Yes	No	No	Yes
Primary model			M19.12b	M20.1	M19.12c	M19.12d	M20.2	M20.3
Alternative model			M20.4	M20.5	M19.12e	M19.15	M20.6	M20.7
Index	Survey	Main	-0.14	0.31	-0.06	-0.01	-0.01	-0.09
		NBS	-0.17	-1.39	0.04	-0.38	0.21	-0.30
		Total	-0.31	-1.08	-0.02	-0.39	0.20	-0.39
Sizecomp	Fishery	Main	-0.64	-3.04	0.04	0.01	-0.04	0.32
		NBS		0.00	0.00		0.00	0.00
	Survey	Main	0.19	0.28	-0.05	-0.17	0.07	-0.47
		NBS	-0.30	1.56	0.01	-0.06	-0.13	0.75
	All	Total	-0.74	-1.20	0.00	-0.22	-0.09	0.60
Agecomp	Survey	Main	0.41	-0.72	0.03	0.30	-0.08	-0.20
		NBS	-0.03	0.25	0.01	0.04	-0.03	-0.24
		Total	0.39	-0.48	0.04	0.34	-0.11	-0.44

Table 2.1.18 (page 1 of 2). 2021 OFL (millions of t) from each pivot model, bootstrap set, and model.

Pivot	Bootstrap	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
19.12a	1	0.173737	0.086842	0.205788	0.117112	0.182797	0.347790	0.155245	0.123295
19.12a	2	0.130955	0.612486	0.183632	0.159884	0.137460	0.460267	0.118251	0.084947
19.12a	3	0.144781	0.888500	0.174957	0.175976	0.139972	0.503465	0.128246	0.098897
19.12a	4								
19.12a	5	0.140907	0.813571	0.188078	0.169968	0.149442	0.720794	0.125180	0.091742
19.12a	6	0.123061	0.635104	0.184306	0.081843	0.123493	0.327995	0.114028	0.081357
19.12a	7								
19.12a	8	0.135166	0.696681	0.168117	0.088548	0.141402	0.449962	0.121584	0.098517
19.12a	9	0.156612	1.976270	0.199516	0.109585	0.161574	0.740566	0.142221	0.113775
19.12a	10	0.145384	0.645751	0.162544	0.137253	0.150044	0.330400	0.124064	0.095015
19.12a	Mean:	0.143825	0.794401	0.183367	0.130021	0.148273	0.485155	0.128602	0.098443
19.12b	1								
19.12b	2	0.152494	0.094537	0.155844	0.102819	0.148098	0.102465	0.173651	0.098581
19.12b	3	0.189535	0.129290	0.174717	0.151174	0.170709	0.126970	0.192962	0.160842
19.12b	4	0.170058	0.106575	0.177122	0.123438	0.159576	0.109069	0.175323	0.127174
19.12b	5	0.188338	0.119969	0.175631	0.120163	0.178696	0.125905	0.181572	0.208493
19.12b	6	0.174678	0.113795	0.163867	0.230344	0.158695	0.116166	0.188448	0.120425
19.12b	7	0.138569	0.092467	0.156156	0.096059	0.127208	0.091422	0.147605	0.113901
19.12b	8	0.178934	0.107990	0.149150	0.117374	0.154957	0.109561	0.177806	0.119380
19.12b	9	0.169921	0.110958	0.168141	0.117143	0.154050	0.110399	0.162895	0.118692
19.12b	10	0.214668	0.124157	0.200153	0.131974	0.190791	0.122530	0.203910	0.139028
19.12b	Mean:	0.175244	0.111082	0.168976	0.132276	0.160309	0.112721	0.178241	0.134057
20.1	1	0.171488	0.119874	0.143676	0.160999	0.166624	0.116842	0.149411	0.152360
20.1	2	0.163941	0.109704	0.154499	0.200808	0.148936	0.111515	0.144413	0.119665
20.1	3	0.178794	0.111091	0.136407	0.137927	0.158229	0.112784	0.163071	0.207692
20.1	4	0.147444	0.098269	0.141818	0.154253	0.135775	0.100660	0.135432	0.144199
20.1	5	0.203695	0.101116	0.154951	0.185721	0.167896	0.096316	0.152070	0.162534
20.1	6	0.149695	0.103975	0.147962	0.122669	0.143200	0.103780	0.143738	0.131927
20.1	7	0.172157	0.114134	0.156532	0.166863	0.170647	0.126731	0.159857	0.160075
20.1	8	0.184566	0.120655	0.138388	0.151073	0.175102	0.118568	0.165221	0.178269
20.1	9	0.157238	0.108942	0.114135	0.153186	0.145113	0.101524	0.128932	0.190844
20.1	10	0.174516	0.113434	0.140678	0.193775	0.157878	0.113458	0.160402	0.154601
20.1	Mean:	0.170353	0.110119	0.142905	0.162727	0.156940	0.110218	0.150255	0.160217
19.12c	1	0.154889	0.164829	0.213415	0.124113	0.144934	0.090785	0.108790	0.121162
19.12c	2	0.177546	0.147460	0.293632	0.106440	0.156568	0.096011	0.114062	0.111264
19.12c	3	0.163948	0.105986	0.177798	0.119639	0.169187	0.099943	0.123426	0.120686
19.12c	4	0.147312	0.131403	0.145325	0.107183	0.132959	0.079328	0.104620	0.102163
19.12c	5	0.121456	0.080609	0.121291	0.094740	0.120913	0.078202	0.097958	0.093502
19.12c	6	0.145744	0.097622	0.139275	0.114438	0.137042	0.082926	0.109461	0.108081
19.12c	7	0.119867	0.074426	0.237446	0.076568	0.116404	0.064699	0.086050	0.081446
19.12c	8	0.147224	0.090198	0.144347	0.123496	0.137003	0.077827	0.112138	0.119345
19.12c	9	0.150199	0.109888	0.196776	0.117881	0.153669	0.085152	0.116871	0.107808
19.12c	10	0.149988	0.091762	0.148068	0.092598	0.138250	0.081791	0.103969	0.098379
19.12c	Mean:	0.147817	0.109418	0.181737	0.107710	0.140693	0.083666	0.107734	0.106384

Table 2.1.18 (page 2 of 2). 2021 OFL (millions of t) from each pivot model, bootstrap set, and model.

Bootstrap	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3
1	0.130161	0.695315	0.189438	0.130728	0.131280	0.482620	0.115622	0.091581
2	0.113908	0.605577	0.163460	0.081156	0.117364	0.418270	0.108168	0.081145
3	0.114120	1.544130	0.162043	0.102335	0.127082	0.284478	0.107207	0.089666
4	0.116546	0.690755	0.182201	0.083978	0.115425	0.381620	0.103526	0.077039
5	0.165445	0.636654	0.188824	0.156525	0.170032	0.559963	0.147025	0.114110
6	0.158209	1.383390	0.187681	0.115999	0.166263	0.522446	0.146343	0.123167
7	0.117985	0.540450	0.129349	0.126402	0.129405	0.497735	0.109780	0.099661
8	0.141947	0.726739	0.190814	0.137894	0.152606	0.754240	0.126873	0.154281
9	0.134068	1.983360	0.172112	0.134077	0.139347	0.342950	0.118892	0.093320
10	0.141505	0.567170	0.188713	0.136289	0.152741	0.400268	0.136638	0.104825
Mean:	0.133389	0.937354	0.175464	0.120538	0.140155	0.464459	0.122007	0.102879
1	0.134360	0.099397	0.160378	0.085538	0.132194	0.087306	0.110108	0.100950
2	0.156229	0.111846	0.190383	0.102026	0.151006	0.095493	0.160975	0.113748
3	0.144575	0.105431	0.247162	0.161211	0.143636	0.087218	0.134318	0.129116
4	0.135142	0.089562	0.167667	0.206668	0.130972	0.076285	0.108904	0.080150
5	0.135669	0.096272	0.203018	0.146241	0.139299	0.086168	0.140776	0.104634
6	0.119321	0.089728	0.170994	0.107767	0.117051	0.077402	0.117078	0.107009
7	0.128997	0.087731	0.160857	0.113272	0.126928	0.077522	0.111917	0.088440
8	0.126540	0.123602	0.300317	0.108371	0.129016	0.085378	0.121560	0.103326
9	0.131794	0.095597	0.174743	0.091390	0.136382	0.079053	0.109373	0.093168
10	0.136453	0.102672	0.189532	0.103113	0.133495	0.089306	0.129501	0.108363
Mean:	0.134908	0.100184	0.196505	0.122560	0.133998	0.084113	0.124451	0.102890
1	0.180419	0.128213	0.184852	0.119080	0.187737	0.112551	0.148799	0.145497
2								
3	0.189190	0.175585	0.292001	0.108569	0.190152	0.115402	0.119677	0.111899
4	0.115743	0.091239	0.144020	0.099407	0.119432	0.080142	0.088351	0.095886
5	0.145680	0.152242	0.272229	0.089333	0.149135	0.105311	0.103229	0.090767
6	0.173953	0.176171	0.304587	0.147976	0.179385	0.101074	0.104237	0.111539
7	0.178346	0.120074	0.170311	0.106768	0.162765	0.106706	0.112913	0.131326
8	0.150871	0.191392	0.418798	0.080199	0.152017	0.091148	0.099444	0.129059
9	0.155972	0.109936	0.154057	0.095710	0.161048	0.101217	0.109947	0.110924
10	0.173460	0.163544	0.273513	0.149734	0.175735	0.100807	0.137176	0.145647
Mean:	0.162626	0.145377	0.246041	0.110753	0.164156	0.101595	0.113753	0.119172
1	0.137311	0.101591	0.219715	0.120053	0.146247	0.094338	0.127480	0.139565
2	0.160293	0.106903	0.159192	0.120748	0.155310	0.094677	0.119074	0.131841
3	0.154193	0.111519	0.176409	0.131527	0.161344	0.102117	0.124339	0.145360
4	0.179490	0.113337	0.227064	0.124316	0.163615	0.092677	0.122113	0.121110
5	0.172208	0.154254	0.304405	0.118841	0.169247	0.095994	0.118638	0.143999
6	0.170335	0.106354	0.154204	0.127129	0.161648	0.090107	0.104138	0.129489
7	0.140625	0.126107	0.269291	0.100685	0.143895	0.078117	0.099242	0.119518
8								
9	0.162532	0.131650	0.159611	0.110745	0.154016	0.096385	0.110008	0.127280
10	0.197704	0.131018	0.228517	0.150290	0.189955	0.105585	0.136750	0.172422
Mean:	0.163855	0.120304	0.210934	0.122704	0.160586	0.094444	0.117976	0.136732

Table 2.1.19 (page 1 of 2). Calculation of mean squared error for each pivot model (equal weights).

Pivot	Boot.	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	Sum	Best	SqErr
19.12a	1	0.0217	0.0109	0.0257	0.0146	0.0228	0.0435	0.0194	0.0154	0.1741	0.1438	0.0009
19.12a	2	0.0164	0.0766	0.0230	0.0200	0.0172	0.0575	0.0148	0.0106	0.2360	0.1438	0.0085
19.12a	3	0.0181	0.1111	0.0219	0.0220	0.0175	0.0629	0.0160	0.0124	0.2818	0.1438	0.0191
19.12a	4											
19.12a	5	0.0176	0.1017	0.0235	0.0212	0.0187	0.0901	0.0156	0.0115	0.3000	0.1438	0.0244
19.12a	6	0.0154	0.0794	0.0230	0.0102	0.0154	0.0410	0.0143	0.0102	0.2089	0.1438	0.0042
19.12a	7											
19.12a	8	0.0169	0.0871	0.0210	0.0111	0.0177	0.0562	0.0152	0.0123	0.2375	0.1438	0.0088
19.12a	9	0.0196	0.2470	0.0249	0.0137	0.0202	0.0926	0.0178	0.0142	0.4500	0.1438	0.0938
19.12a	10	0.0182	0.0807	0.0203	0.0172	0.0188	0.0413	0.0155	0.0119	0.2238	0.1438	0.0064
19.12a	Mean:											0.0207
19.12b	1											
19.12b	2	0.0191	0.0118	0.0195	0.0129	0.0185	0.0128	0.0217	0.0123	0.1286	0.1111	0.0003
19.12b	3	0.0237	0.0162	0.0218	0.0189	0.0213	0.0159	0.0241	0.0201	0.1620	0.1111	0.0026
19.12b	4	0.0213	0.0133	0.0221	0.0154	0.0199	0.0136	0.0219	0.0159	0.1435	0.1111	0.0011
19.12b	5	0.0235	0.0150	0.0220	0.0150	0.0223	0.0157	0.0227	0.0261	0.1623	0.1111	0.0026
19.12b	6	0.0218	0.0142	0.0205	0.0288	0.0198	0.0145	0.0236	0.0151	0.1583	0.1111	0.0022
19.12b	7	0.0173	0.0116	0.0195	0.0120	0.0159	0.0114	0.0185	0.0142	0.1204	0.1111	0.0001
19.12b	8	0.0224	0.0135	0.0186	0.0147	0.0194	0.0137	0.0222	0.0149	0.1394	0.1111	0.0008
19.12b	9	0.0212	0.0139	0.0210	0.0146	0.0193	0.0138	0.0204	0.0148	0.1390	0.1111	0.0008
19.12b	10	0.0268	0.0155	0.0250	0.0165	0.0238	0.0153	0.0255	0.0174	0.1659	0.1111	0.0030
19.12b	Mean:											0.0015
20.1	1	0.0214	0.0150	0.0180	0.0201	0.0208	0.0146	0.0187	0.0190	0.1477	0.1429	0.0000
20.1	2	0.0205	0.0137	0.0193	0.0251	0.0186	0.0139	0.0181	0.0150	0.1442	0.1429	0.0000
20.1	3	0.0223	0.0139	0.0171	0.0172	0.0198	0.0141	0.0204	0.0260	0.1507	0.1429	0.0001
20.1	4	0.0184	0.0123	0.0177	0.0193	0.0170	0.0126	0.0169	0.0180	0.1322	0.1429	0.0001
20.1	5	0.0255	0.0126	0.0194	0.0232	0.0210	0.0120	0.0190	0.0203	0.1530	0.1429	0.0001
20.1	6	0.0187	0.0130	0.0185	0.0153	0.0179	0.0130	0.0180	0.0165	0.1309	0.1429	0.0001
20.1	7	0.0215	0.0143	0.0196	0.0209	0.0213	0.0158	0.0200	0.0200	0.1534	0.1429	0.0001
20.1	8	0.0231	0.0151	0.0173	0.0189	0.0219	0.0148	0.0207	0.0223	0.1540	0.1429	0.0001
20.1	9	0.0197	0.0136	0.0143	0.0191	0.0181	0.0127	0.0161	0.0239	0.1375	0.1429	0.0000
20.1	10	0.0218	0.0142	0.0176	0.0242	0.0197	0.0142	0.0201	0.0193	0.1511	0.1429	0.0001
20.1	Mean:											0.0001
19.12c	1	0.0194	0.0206	0.0267	0.0155	0.0181	0.0113	0.0136	0.0151	0.1404	0.1077	0.0011
19.12c	2	0.0222	0.0184	0.0367	0.0133	0.0196	0.0120	0.0143	0.0139	0.1504	0.1077	0.0018
19.12c	3	0.0205	0.0132	0.0222	0.0150	0.0211	0.0125	0.0154	0.0151	0.1351	0.1077	0.0007
19.12c	4	0.0184	0.0164	0.0182	0.0134	0.0166	0.0099	0.0131	0.0128	0.1188	0.1077	0.0001
19.12c	5	0.0152	0.0101	0.0152	0.0118	0.0151	0.0098	0.0122	0.0117	0.1011	0.1077	0.0000
19.12c	6	0.0182	0.0122	0.0174	0.0143	0.0171	0.0104	0.0137	0.0135	0.1168	0.1077	0.0001
19.12c	7	0.0150	0.0093	0.0297	0.0096	0.0146	0.0081	0.0108	0.0102	0.1071	0.1077	0.0000
19.12c	8	0.0184	0.0113	0.0180	0.0154	0.0171	0.0097	0.0140	0.0149	0.1189	0.1077	0.0001
19.12c	9	0.0188	0.0137	0.0246	0.0147	0.0192	0.0106	0.0146	0.0135	0.1298	0.1077	0.0005
19.12c	10	0.0187	0.0115	0.0185	0.0116	0.0173	0.0102	0.0130	0.0123	0.1131	0.1077	0.0000
19.12c	Mean:											0.0005

Table 2.1.19 (page 2 of 2). Calculation of mean squared error for each pivot model (equal weights).

Pivot	Boot.	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	Sum	Best	SqErr
19.12	1	0.0163	0.0869	0.0237	0.0163	0.0164	0.0603	0.0145	0.0114	0.2458	0.1402	0.0112
19.12	2	0.0142	0.0757	0.0204	0.0101	0.0147	0.0523	0.0135	0.0101	0.2111	0.1402	0.0050
19.12	3	0.0143	0.1930	0.0203	0.0128	0.0159	0.0356	0.0134	0.0112	0.3164	0.1402	0.0311
19.12	4	0.0146	0.0863	0.0228	0.0105	0.0144	0.0477	0.0129	0.0096	0.2189	0.1402	0.0062
19.12	5	0.0207	0.0796	0.0236	0.0196	0.0213	0.0700	0.0184	0.0143	0.2673	0.1402	0.0162
19.12	6	0.0198	0.1729	0.0235	0.0145	0.0208	0.0653	0.0183	0.0154	0.3504	0.1402	0.0442
19.12	7	0.0147	0.0676	0.0162	0.0158	0.0162	0.0622	0.0137	0.0125	0.2188	0.1402	0.0062
19.12	8	0.0177	0.0908	0.0239	0.0172	0.0191	0.0943	0.0159	0.0193	0.2982	0.1402	0.0250
19.12	9	0.0168	0.2479	0.0215	0.0168	0.0174	0.0429	0.0149	0.0117	0.3898	0.1402	0.0623
19.12	10	0.0177	0.0709	0.0236	0.0170	0.0191	0.0500	0.0171	0.0131	0.2285	0.1402	0.0078
19.12	Mean:											0.0215
19.12d	1	0.0168	0.0124	0.0200	0.0107	0.0165	0.0109	0.0138	0.0126	0.1138	0.0841	0.0009
19.12d	2	0.0195	0.0140	0.0238	0.0128	0.0189	0.0119	0.0201	0.0142	0.1352	0.0841	0.0026
19.12d	3	0.0181	0.0132	0.0309	0.0202	0.0180	0.0109	0.0168	0.0161	0.1441	0.0841	0.0036
19.12d	4	0.0169	0.0112	0.0210	0.0258	0.0164	0.0095	0.0136	0.0100	0.1244	0.0841	0.0016
19.12d	5	0.0170	0.0120	0.0254	0.0183	0.0174	0.0108	0.0176	0.0131	0.1315	0.0841	0.0022
19.12d	6	0.0149	0.0112	0.0214	0.0135	0.0146	0.0097	0.0146	0.0134	0.1133	0.0841	0.0009
19.12d	7	0.0161	0.0110	0.0201	0.0142	0.0159	0.0097	0.0140	0.0111	0.1120	0.0841	0.0008
19.12d	8	0.0158	0.0155	0.0375	0.0135	0.0161	0.0107	0.0152	0.0129	0.1373	0.0841	0.0028
19.12d	9	0.0165	0.0119	0.0218	0.0114	0.0170	0.0099	0.0137	0.0116	0.1139	0.0841	0.0009
19.12d	10	0.0171	0.0128	0.0237	0.0129	0.0167	0.0112	0.0162	0.0135	0.1241	0.0841	0.0016
19.12d	Mean:											0.0018
20.2	1	0.0226	0.0160	0.0231	0.0149	0.0235	0.0141	0.0186	0.0182	0.1509	0.1138	0.0014
20.2	2											
20.2	3	0.0236	0.0219	0.0365	0.0136	0.0238	0.0144	0.0150	0.0140	0.1628	0.1138	0.0024
20.2	4	0.0145	0.0114	0.0180	0.0124	0.0149	0.0100	0.0110	0.0120	0.1043	0.1138	0.0001
20.2	5	0.0182	0.0190	0.0340	0.0112	0.0186	0.0132	0.0129	0.0113	0.1385	0.1138	0.0006
20.2	6	0.0217	0.0220	0.0381	0.0185	0.0224	0.0126	0.0130	0.0139	0.1624	0.1138	0.0024
20.2	7	0.0223	0.0150	0.0213	0.0133	0.0203	0.0133	0.0141	0.0164	0.1362	0.1138	0.0005
20.2	8	0.0189	0.0239	0.0523	0.0100	0.0190	0.0114	0.0124	0.0161	0.1641	0.1138	0.0025
20.2	9	0.0195	0.0137	0.0193	0.0120	0.0201	0.0127	0.0137	0.0139	0.1249	0.1138	0.0001
20.2	10	0.0217	0.0204	0.0342	0.0187	0.0220	0.0126	0.0171	0.0182	0.1650	0.1138	0.0026
20.2	Mean:											0.0014
20.3	1	0.0172	0.0127	0.0275	0.0150	0.0183	0.0118	0.0159	0.0174	0.1358	0.1367	0.0000
20.3	2	0.0200	0.0134	0.0199	0.0151	0.0194	0.0118	0.0149	0.0165	0.1310	0.1367	0.0000
20.3	3	0.0193	0.0139	0.0221	0.0164	0.0202	0.0128	0.0155	0.0182	0.1384	0.1367	0.0000
20.3	4	0.0224	0.0142	0.0284	0.0155	0.0205	0.0116	0.0153	0.0151	0.1430	0.1367	0.0000
20.3	5	0.0215	0.0193	0.0381	0.0149	0.0212	0.0120	0.0148	0.0180	0.1597	0.1367	0.0005
20.3	6	0.0213	0.0133	0.0193	0.0159	0.0202	0.0113	0.0130	0.0162	0.1304	0.1367	0.0000
20.3	7	0.0176	0.0158	0.0337	0.0126	0.0180	0.0098	0.0124	0.0149	0.1347	0.1367	0.0000
20.3	8											
20.3	9	0.0203	0.0165	0.0200	0.0138	0.0193	0.0120	0.0138	0.0159	0.1315	0.1367	0.0000
20.3	10	0.0247	0.0164	0.0286	0.0188	0.0237	0.0132	0.0171	0.0216	0.1640	0.1367	0.0007
20.3	Mean:											0.0002

Table 2.1.20 (page 1 of 2). Calculation of mean squared error for each pivot model (equal weights).

Pivot	Boot.	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	Sum	Best	SqErr
19.12a	1	0.0000	0.0010	0.0000	0.0280	0.0026	0.0209	0.0000	0.0832	0.1357	0.1438	0.0001
19.12a	2	0.0000	0.0072	0.0000	0.0383	0.0020	0.0276	0.0000	0.0573	0.1323	0.1438	0.0001
19.12a	3	0.0000	0.0104	0.0000	0.0421	0.0020	0.0302	0.0000	0.0667	0.1514	0.1438	0.0001
19.12a	4											
19.12a	5	0.0000	0.0095	0.0000	0.0407	0.0021	0.0432	0.0000	0.0619	0.1575	0.1438	0.0002
19.12a	6	0.0000	0.0074	0.0000	0.0196	0.0018	0.0197	0.0000	0.0549	0.1033	0.1438	0.0016
19.12a	7											
19.12a	8	0.0000	0.0081	0.0000	0.0212	0.0020	0.0270	0.0000	0.0665	0.1248	0.1438	0.0004
19.12a	9	0.0000	0.0231	0.0000	0.0262	0.0023	0.0444	0.0000	0.0768	0.1728	0.1438	0.0008
19.12a	10	0.0000	0.0075	0.0000	0.0329	0.0021	0.0198	0.0000	0.0641	0.1265	0.1438	0.0003
19.12a	Mean:											0.0004
19.12b	1											
19.12b	2	0.0000	0.0011	0.0000	0.0246	0.0021	0.0061	0.0000	0.0665	0.1005	0.1111	0.0001
19.12b	3	0.0000	0.0015	0.0000	0.0362	0.0024	0.0076	0.0000	0.1085	0.1563	0.1111	0.0020
19.12b	4	0.0000	0.0012	0.0000	0.0295	0.0023	0.0065	0.0000	0.0858	0.1254	0.1111	0.0002
19.12b	5	0.0000	0.0014	0.0000	0.0288	0.0026	0.0076	0.0000	0.1407	0.1809	0.1111	0.0049
19.12b	6	0.0000	0.0013	0.0000	0.0551	0.0023	0.0070	0.0000	0.0812	0.1470	0.1111	0.0013
19.12b	7	0.0000	0.0011	0.0000	0.0230	0.0018	0.0055	0.0000	0.0768	0.1082	0.1111	0.0000
19.12b	8	0.0000	0.0013	0.0000	0.0281	0.0022	0.0066	0.0000	0.0805	0.1187	0.1111	0.0001
19.12b	9	0.0000	0.0013	0.0000	0.0280	0.0022	0.0066	0.0000	0.0801	0.1182	0.1111	0.0001
19.12b	10	0.0000	0.0015	0.0000	0.0316	0.0027	0.0074	0.0000	0.0938	0.1369	0.1111	0.0007
19.12b	Mean:											0.0010
20.1	1	0.0000	0.0014	0.0000	0.0385	0.0024	0.0070	0.0000	0.1028	0.1521	0.1429	0.0001
20.1	2	0.0000	0.0013	0.0000	0.0481	0.0021	0.0067	0.0000	0.0807	0.1389	0.1429	0.0000
20.1	3	0.0000	0.0013	0.0000	0.0330	0.0023	0.0068	0.0000	0.1401	0.1835	0.1429	0.0016
20.1	4	0.0000	0.0011	0.0000	0.0369	0.0019	0.0060	0.0000	0.0973	0.1433	0.1429	0.0000
20.1	5	0.0000	0.0012	0.0000	0.0445	0.0024	0.0058	0.0000	0.1097	0.1635	0.1429	0.0004
20.1	6	0.0000	0.0012	0.0000	0.0294	0.0020	0.0062	0.0000	0.0890	0.1279	0.1429	0.0002
20.1	7	0.0000	0.0013	0.0000	0.0399	0.0024	0.0076	0.0000	0.1080	0.1593	0.1429	0.0003
20.1	8	0.0000	0.0014	0.0000	0.0362	0.0025	0.0071	0.0000	0.1203	0.1675	0.1429	0.0006
20.1	9	0.0000	0.0013	0.0000	0.0367	0.0021	0.0061	0.0000	0.1288	0.1749	0.1429	0.0010
20.1	10	0.0000	0.0013	0.0000	0.0464	0.0023	0.0068	0.0000	0.1043	0.1611	0.1429	0.0003
20.1	Mean:											0.0005
19.12c	1	0.0000	0.0019	0.0000	0.0297	0.0021	0.0054	0.0000	0.0817	0.1209	0.1077	0.0002
19.12c	2	0.0000	0.0017	0.0000	0.0255	0.0022	0.0058	0.0000	0.0751	0.1103	0.1077	0.0000
19.12c	3	0.0000	0.0012	0.0000	0.0286	0.0024	0.0060	0.0000	0.0814	0.1197	0.1077	0.0001
19.12c	4	0.0000	0.0015	0.0000	0.0257	0.0019	0.0048	0.0000	0.0689	0.1028	0.1077	0.0000
19.12c	5	0.0000	0.0009	0.0000	0.0227	0.0017	0.0047	0.0000	0.0631	0.0931	0.1077	0.0002
19.12c	6	0.0000	0.0011	0.0000	0.0274	0.0020	0.0050	0.0000	0.0729	0.1084	0.1077	0.0000
19.12c	7	0.0000	0.0009	0.0000	0.0183	0.0017	0.0039	0.0000	0.0549	0.0797	0.1077	0.0008
19.12c	8	0.0000	0.0011	0.0000	0.0296	0.0020	0.0047	0.0000	0.0805	0.1178	0.1077	0.0001
19.12c	9	0.0000	0.0013	0.0000	0.0282	0.0022	0.0051	0.0000	0.0727	0.1095	0.1077	0.0000
19.12c	10	0.0000	0.0011	0.0000	0.0222	0.0020	0.0049	0.0000	0.0664	0.0965	0.1077	0.0001
19.12c	Mean:											0.0002

Table 2.1.20 (page 2 of 2). Calculation of mean squared error for each pivot model (equal weights).

Pivot	Boot.	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	Sum	Best	SqErr
19.12	1	0.0000	0.0081	0.0000	0.0313	0.0019	0.0290	0.0000	0.0618	0.1320	0.1402	0.0001
19.12	2	0.0000	0.0071	0.0000	0.0194	0.0017	0.0251	0.0000	0.0547	0.1080	0.1402	0.0010
19.12	3	0.0000	0.0181	0.0000	0.0245	0.0018	0.0171	0.0000	0.0605	0.1219	0.1402	0.0003
19.12	4	0.0000	0.0081	0.0000	0.0201	0.0016	0.0229	0.0000	0.0520	0.1047	0.1402	0.0013
19.12	5	0.0000	0.0074	0.0000	0.0375	0.0024	0.0336	0.0000	0.0770	0.1579	0.1402	0.0003
19.12	6	0.0000	0.0162	0.0000	0.0278	0.0024	0.0313	0.0000	0.0831	0.1608	0.1402	0.0004
19.12	7	0.0000	0.0063	0.0000	0.0303	0.0018	0.0299	0.0000	0.0672	0.1355	0.1402	0.0000
19.12	8	0.0000	0.0085	0.0000	0.0330	0.0022	0.0453	0.0000	0.1041	0.1930	0.1402	0.0028
19.12	9	0.0000	0.0232	0.0000	0.0321	0.0020	0.0206	0.0000	0.0630	0.1408	0.1402	0.0000
19.12	10	0.0000	0.0066	0.0000	0.0326	0.0022	0.0240	0.0000	0.0707	0.1362	0.1402	0.0000
19.12	Mean:											0.0006
19.12d	1	0.0000	0.0012	0.0000	0.0205	0.0019	0.0052	0.0000	0.0681	0.0969	0.0841	0.0002
19.12d	2	0.0000	0.0013	0.0000	0.0244	0.0022	0.0057	0.0000	0.0767	0.1104	0.0841	0.0007
19.12d	3	0.0000	0.0012	0.0000	0.0386	0.0021	0.0052	0.0000	0.0871	0.1342	0.0841	0.0025
19.12d	4	0.0000	0.0010	0.0000	0.0495	0.0019	0.0046	0.0000	0.0541	0.1110	0.0841	0.0007
19.12d	5	0.0000	0.0011	0.0000	0.0350	0.0020	0.0052	0.0000	0.0706	0.1139	0.0841	0.0009
19.12d	6	0.0000	0.0010	0.0000	0.0258	0.0017	0.0046	0.0000	0.0722	0.1054	0.0841	0.0005
19.12d	7	0.0000	0.0010	0.0000	0.0271	0.0018	0.0047	0.0000	0.0597	0.0943	0.0841	0.0001
19.12d	8	0.0000	0.0014	0.0000	0.0259	0.0018	0.0051	0.0000	0.0697	0.1041	0.0841	0.0004
19.12d	9	0.0000	0.0011	0.0000	0.0219	0.0019	0.0047	0.0000	0.0629	0.0925	0.0841	0.0001
19.12d	10	0.0000	0.0012	0.0000	0.0247	0.0019	0.0054	0.0000	0.0731	0.1063	0.0841	0.0005
19.12d	Mean:											0.0006
20.2	1	0.0000	0.0015	0.0000	0.0285	0.0027	0.0068	0.0000	0.0982	0.1376	0.1138	0.0006
20.2	2											
20.2	3	0.0000	0.0021	0.0000	0.0260	0.0027	0.0069	0.0000	0.0755	0.1132	0.1138	0.0000
20.2	4	0.0000	0.0011	0.0000	0.0238	0.0017	0.0048	0.0000	0.0647	0.0961	0.1138	0.0003
20.2	5	0.0000	0.0018	0.0000	0.0214	0.0021	0.0063	0.0000	0.0612	0.0928	0.1138	0.0004
20.2	6	0.0000	0.0021	0.0000	0.0354	0.0026	0.0061	0.0000	0.0753	0.1214	0.1138	0.0001
20.2	7	0.0000	0.0014	0.0000	0.0256	0.0023	0.0064	0.0000	0.0886	0.1243	0.1138	0.0001
20.2	8	0.0000	0.0022	0.0000	0.0192	0.0022	0.0055	0.0000	0.0871	0.1161	0.1138	0.0000
20.2	9	0.0000	0.0013	0.0000	0.0229	0.0023	0.0061	0.0000	0.0748	0.1074	0.1138	0.0000
20.2	10	0.0000	0.0019	0.0000	0.0358	0.0025	0.0060	0.0000	0.0983	0.1446	0.1138	0.0009
20.2	Mean:											0.0003
20.3	1	0.0000	0.0012	0.0000	0.0287	0.0021	0.0057	0.0000	0.0942	0.1318	0.1367	0.0000
20.3	2	0.0000	0.0012	0.0000	0.0289	0.0022	0.0057	0.0000	0.0889	0.1270	0.1367	0.0001
20.3	3	0.0000	0.0013	0.0000	0.0315	0.0023	0.0061	0.0000	0.0981	0.1393	0.1367	0.0000
20.3	4	0.0000	0.0013	0.0000	0.0298	0.0023	0.0056	0.0000	0.0817	0.1207	0.1367	0.0003
20.3	5	0.0000	0.0018	0.0000	0.0284	0.0024	0.0058	0.0000	0.0971	0.1356	0.1367	0.0000
20.3	6	0.0000	0.0012	0.0000	0.0304	0.0023	0.0054	0.0000	0.0874	0.1268	0.1367	0.0001
20.3	7	0.0000	0.0015	0.0000	0.0241	0.0021	0.0047	0.0000	0.0806	0.1130	0.1367	0.0006
20.3	8											
20.3	9	0.0000	0.0015	0.0000	0.0265	0.0022	0.0058	0.0000	0.0859	0.1219	0.1367	0.0002
20.3	10	0.0000	0.0015	0.0000	0.0360	0.0027	0.0063	0.0000	0.1163	0.1629	0.1367	0.0007
20.3	Mean:											0.0002

Table 2.1.21 (page 1 of 4). Model-specific scaled histograms and performance-weighted average *pmf*s for each pivot model.

	Pivot model = 19.12a									Pivot model = 19.12b								
OFL	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve
0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.075	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.080	0	0	0	0.125	0	0	0	0.125	0.116	0	0	0	0	0	0	0	0	0
0.085	0	0.125	0	0	0	0	0	0.125	0.087	0	0	0	0	0	0	0	0	0
0.090	0	0	0	0.125	0	0	0	0.125	0.116	0	0.111	0	0	0	0.111	0	0	0.008
0.095	0	0	0	0	0	0	0	0.125	0.085	0	0.111	0	0.111	0	0	0	0	0.028
0.100	0	0	0	0	0	0	0	0.250	0.171	0	0	0	0	0	0.111	0	0.111	0.083
0.105	0	0	0	0	0	0	0	0	0	0	0.111	0	0.111	0	0	0	0	0.028
0.110	0	0	0	0.125	0	0	0	0	0.030	0	0.222	0	0	0	0.333	0	0	0.023
0.115	0	0	0	0.125	0	0	0.125	0.125	0.116	0	0.111	0	0.222	0	0.111	0	0.111	0.138
0.120	0	0	0	0	0	0	0.250	0	0.000	0	0.111	0	0.111	0	0	0	0.333	0.256
0.125	0.125	0	0	0	0.125	0	0.250	0.125	0.086	0	0.111	0	0.111	0.111	0.333	0	0.111	0.125
0.130	0.125	0	0	0	0	0	0.125	0	0.000	0	0.111	0	0.111	0	0	0	0	0.028
0.135	0.125	0	0	0.125	0.125	0	0	0	0.030	0	0	0	0	0	0	0	0	0
0.140	0.125	0	0	0	0.250	0	0.125	0	0.000	0.111	0	0	0	0	0	0	0.111	0.076
0.145	0.250	0	0	0	0	0	0	0	0.000	0	0	0	0	0	0	0	0	0
0.150	0	0	0	0	0.250	0	0	0	0.000	0.111	0	0.111	0.111	0.111	0	0.111	0	0.027
0.155	0.125	0	0	0	0	0	0.125	0	0.000	0	0	0.222	0	0.222	0	0	0	0.000
0.160	0	0	0	0.125	0.125	0	0	0	0.030	0	0	0	0	0.222	0	0	0.111	0.076
0.165	0	0	0.125	0	0	0	0	0	0.000	0	0	0.111	0	0	0	0.111	0	0.000
0.170	0	0	0.125	0.125	0	0	0	0	0.030	0.222	0	0.111	0	0.111	0	0	0	0.000
0.175	0.125	0	0.125	0.125	0	0	0	0	0.030	0.111	0	0.333	0	0	0	0.222	0	0.000
0.180	0	0	0	0	0	0	0	0	0	0.111	0	0	0	0.111	0	0.222	0	0.000
0.185	0	0	0.250	0	0.125	0	0	0	0.000	0	0	0	0	0	0	0	0	0
0.190	0	0	0.125	0	0	0	0	0	0.000	0.222	0	0	0	0.111	0	0.111	0	0.000
0.195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.111	0	0.000
0.200	0	0	0.125	0	0	0	0	0	0.000	0	0	0.111	0	0	0	0	0	0.000
> 0.2	0	0.875	0.125	0	0	1.000	0	0	0.071	0.111	0	0	0.111	0	0	0.111	0.111	0.103

Table 2.1.21 (page 2 of 4). Model-specific scaled histograms and performance-weighted average *pmf*s for each pivot model.

	Pivot model = 20.1									Pivot model = 19.12c								
OFL	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve
0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.100	0	0	0.006
0.070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.075	0	0	0	0	0	0	0	0	0	0	0.100	0	0.100	0	0	0	0	0.026
0.080	0	0	0	0	0	0	0	0	0	0	0.100	0	0	0	0.400	0	0.100	0.094
0.085	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.200	0.100	0	0.012
0.090	0	0	0	0	0	0	0	0	0	0	0.200	0	0	0	0.100	0	0	0.008
0.095	0	0	0	0	0	0.100	0	0	0.006	0	0	0	0.200	0	0.100	0	0.100	0.123
0.100	0	0.200	0	0	0	0.200	0	0	0.014	0	0.100	0	0	0	0.100	0.100	0.200	0.144
0.105	0	0.100	0	0	0	0.100	0	0	0.007	0	0.100	0	0.200	0	0	0.200	0	0.050
0.110	0	0.300	0	0	0	0.100	0	0	0.010	0	0.100	0	0	0	0	0.300	0.300	0.206
0.115	0	0.200	0.100	0	0	0.300	0	0	0.021	0	0	0	0.100	0.100	0	0.200	0	0.024
0.120	0	0.200	0	0	0	0.100	0	0.100	0.077	0.200	0	0.100	0.200	0.100	0	0	0.300	0.254
0.125	0	0	0	0.100	0	0.100	0	0	0.030	0	0	0	0.200	0	0	0.100	0	0.049
0.130	0	0	0	0	0	0	0.100	0.100	0.068	0	0.100	0	0	0	0	0	0	0.001
0.135	0	0	0.100	0	0.100	0	0.100	0	0.000	0	0	0	0	0.300	0	0	0	0.000
0.140	0	0	0.300	0.100	0	0	0	0	0.024	0	0	0.100	0	0.100	0	0	0	0.000
0.145	0.100	0	0.100	0	0.200	0	0.200	0.100	0.068	0.300	0.100	0.200	0	0.100	0	0	0	0.001
0.150	0.100	0	0.100	0.100	0.100	0	0.200	0.100	0.093	0.200	0	0.100	0	0	0	0	0	0.000
0.155	0.100	0	0.300	0.200	0	0	0	0.100	0.117	0.100	0	0	0	0.200	0	0	0	0.000
0.160	0	0	0	0.100	0.200	0	0.200	0.100	0.093	0	0	0	0	0	0	0	0	0
0.165	0.100	0	0	0.100	0.100	0	0.200	0.100	0.093	0.100	0.100	0	0	0	0	0	0	0.001
0.170	0.200	0	0	0	0.200	0	0	0	0.000	0	0	0	0	0.100	0	0	0	0.000
0.175	0.100	0	0	0	0.100	0	0	0	0.000	0	0	0	0	0	0	0	0	0
0.180	0.100	0	0	0	0	0	0	0.100	0.068	0.100	0	0.100	0	0	0	0	0	0.000
0.185	0.100	0	0	0.100	0	0	0	0	0.024	0	0	0	0	0	0	0	0	0
0.190	0	0	0	0	0	0	0	0.100	0.068	0	0	0	0	0	0	0	0	0
0.195	0	0	0	0.100	0	0	0	0	0.024	0	0	0.100	0	0	0	0	0	0.000
0.200	0	0	0	0.100	0	0	0	0	0.024	0	0	0	0	0	0	0	0	0
> 0.2	0.100	0	0	0	0	0	0	0.100	0.068	0	0	0.300	0	0	0	0	0	0

Table 2.1.21 (page 3 of 4). Model-specific scaled histograms and performance-weighted average *pmf*s for each pivot model.

	Pivot model = 19.12									Pivot model = 19.12d								
OFL	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve
0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.075	0	0	0	0	0	0	0	0.100	0.068	0	0	0	0	0	0.200	0	0	0.012
0.080	0	0	0	0.100	0	0	0	0.100	0.093	0	0	0	0	0	0.200	0	0.100	0.080
0.085	0	0	0	0.100	0	0	0	0	0.024	0	0	0	0.100	0	0.400	0	0	0.049
0.090	0	0	0	0	0	0	0	0.200	0.137	0	0.300	0	0.100	0	0.100	0	0.100	0.102
0.095	0	0	0	0	0	0	0	0.100	0.068	0	0.200	0	0	0	0.100	0	0.100	0.077
0.100	0	0	0	0.100	0	0	0	0.100	0.093	0	0.100	0	0.100	0	0	0	0.100	0.094
0.105	0	0	0	0	0	0	0.200	0.100	0.068	0	0.200	0	0.100	0	0	0	0.300	0.232
0.110	0	0	0	0	0	0	0.200	0	0.000	0	0.100	0	0.200	0	0	0.400	0.100	0.118
0.115	0.300	0	0	0.100	0.200	0	0.100	0.100	0.093	0	0	0	0.100	0.100	0	0.100	0.100	0.093
0.120	0.100	0	0	0	0	0	0.100	0	0.000	0.100	0	0	0	0	0	0.100	0	0.000
0.125	0	0	0	0.100	0.100	0	0.100	0.100	0.093	0.100	0.100	0	0	0.100	0	0	0	0.001
0.130	0.100	0	0.100	0.100	0.200	0	0	0	0.024	0.200	0	0	0	0.300	0	0.100	0.100	0.068
0.135	0.100	0	0	0.200	0	0	0.100	0	0.049	0.400	0	0	0	0.200	0	0.100	0	0.000
0.140	0.200	0	0	0.100	0.100	0	0	0	0.024	0	0	0	0	0.100	0	0.100	0	0.000
0.145	0	0	0	0	0	0	0.200	0	0.000	0.100	0	0	0.100	0.100	0	0	0	0.024
0.150	0	0	0	0	0	0	0	0	0	0	0	0	0	0.100	0	0	0	0.000
0.155	0	0	0	0.100	0.200	0	0	0.100	0.093	0.100	0	0	0	0	0	0	0	0.000
0.160	0.100	0	0.100	0	0	0	0	0	0.000	0	0	0.200	0.100	0	0	0.100	0	0.024
0.165	0.100	0	0.100	0	0.100	0	0	0	0.000	0	0	0	0	0	0	0	0	0
0.170	0	0	0.100	0	0.100	0	0	0	0.000	0	0	0.200	0	0	0	0	0	0.000
0.175	0	0	0	0	0	0	0	0	0	0	0	0.100	0	0	0	0	0	0.000
0.180	0	0	0.100	0	0	0	0	0	0.000	0	0	0	0	0	0	0	0	0
0.185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.190	0	0	0.500	0	0	0	0	0	0.000	0	0	0.200	0	0	0	0	0	0.000
0.195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.200	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
> 0.2	0	1.000	0	0	0	1.000	0	0	0.072	0	0	0.300	0.100	0	0	0	0	0.024

Table 2.1.21 (page 4 of 4). Model-specific scaled histograms and performance-weighted average *pmf*s for each pivot model.

	Pivot model = 20.2									Pivot model = 20.3								
OFL	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve	19.12a	19.12b	20.1	19.12c	19.12	19.12d	20.2	20.3	WtAve
0.005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.015	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.020	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.025	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.030	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.035	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.040	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.045	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.050	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.055	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.060	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.065	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.070	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.075	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.080	0	0	0	0.111	0	0.111	0	0	0.034	0	0	0	0	0	0.111	0	0	0.007
0.085	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.090	0	0.111	0	0.111	0	0.111	0.111	0.111	0.111	0	0	0	0	0	0.111	0	0	0.007
0.095	0	0	0	0.111	0	0	0	0.111	0.103	0	0	0	0	0	0.556	0	0	0.034
0.100	0	0	0	0.111	0	0.333	0.111	0	0.047	0	0.111	0	0.111	0	0.111	0.111	0	0.035
0.105	0	0	0	0.111	0	0.222	0.222	0	0.041	0	0.222	0	0	0	0.111	0.111	0	0.009
0.110	0	0.111	0	0.111	0	0	0.111	0.333	0.256	0	0.111	0	0.111	0	0	0.111	0	0.028
0.115	0.111	0	0	0	0	0.222	0.111	0	0.013	0	0.111	0	0	0	0	0	0	0.001
0.120	0	0.111	0	0.111	0.111	0	0.111	0	0.028	0	0	0	0.333	0	0	0.333	0.222	0.233
0.125	0	0	0	0	0	0	0	0	0	0	0.111	0	0.222	0	0	0.222	0.111	0.131
0.130	0	0.111	0	0	0	0	0	0.222	0.153	0	0.222	0	0.111	0	0	0	0.222	0.182
0.135	0	0	0	0	0	0	0.111	0	0.000	0.111	0	0	0	0	0	0.111	0	0.000
0.140	0	0	0	0	0	0	0	0	0	0.111	0	0	0	0	0	0	0.111	0.076
0.145	0.111	0	0.111	0	0	0	0	0.222	0.152	0	0	0	0	0.222	0	0	0.222	0.152
0.150	0.111	0.111	0	0.222	0.222	0	0.111	0	0.055	0	0	0	0.111	0	0	0	0	0.027
0.155	0.111	0	0.111	0	0	0	0	0	0.000	0.111	0.111	0.111	0	0.222	0	0	0	0.001
0.160	0	0	0	0	0.111	0	0	0	0.000	0.111	0	0.222	0	0.222	0	0	0	0.000
0.165	0	0.111	0	0	0.111	0	0	0	0.001	0.111	0	0	0	0.111	0	0	0	0.000
0.170	0	0	0.111	0	0	0	0	0	0.000	0.222	0	0	0	0.111	0	0	0.111	0.076
0.175	0.222	0.222	0	0	0.111	0	0	0	0.003	0	0	0.111	0	0	0	0	0	0.000
0.180	0.222	0	0	0	0.111	0	0	0	0.000	0.111	0	0	0	0	0	0	0	0.000
0.185	0	0	0.111	0	0	0	0	0	0.000	0	0	0	0	0	0	0	0	0
0.190	0.111	0.111	0	0	0.222	0	0	0	0.001	0	0	0	0	0.111	0	0	0	0.000
0.195	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.200	0	0	0	0	0	0	0	0	0	0.111	0	0	0	0	0	0	0	0.000
> 0.2	0	0	0.556	0	0	0	0	0	0	0	0	0.556	0	0	0	0	0	0

Figures

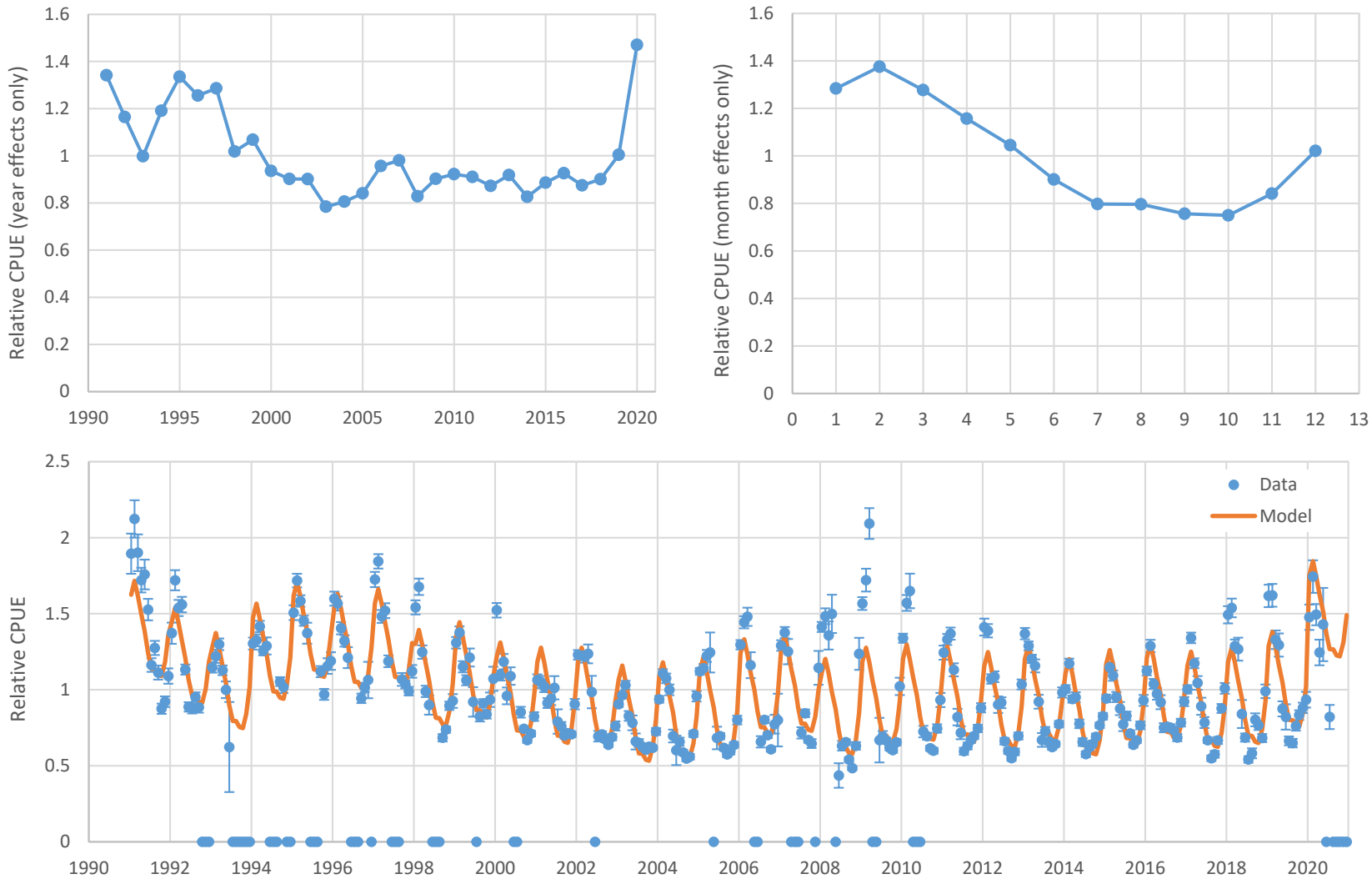


Figure 2.1.1. Estimates of longline fishery CPUE "year effects" and "month effects" (top), and overall model fit to data (bottom).

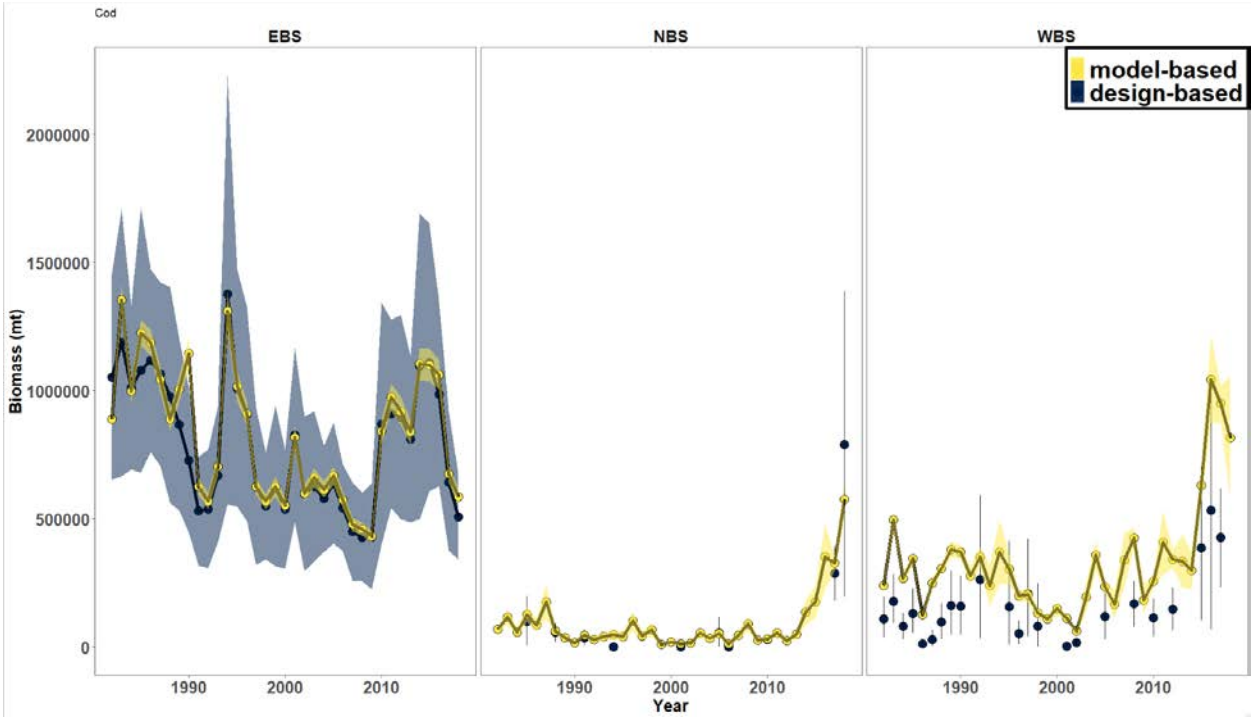


Figure 2.1.2. Comparison of model-based indices (yellow) to area-swept (design-based) biomass indices (blue) for Pacific cod in the EBS, NBS, and WBS.

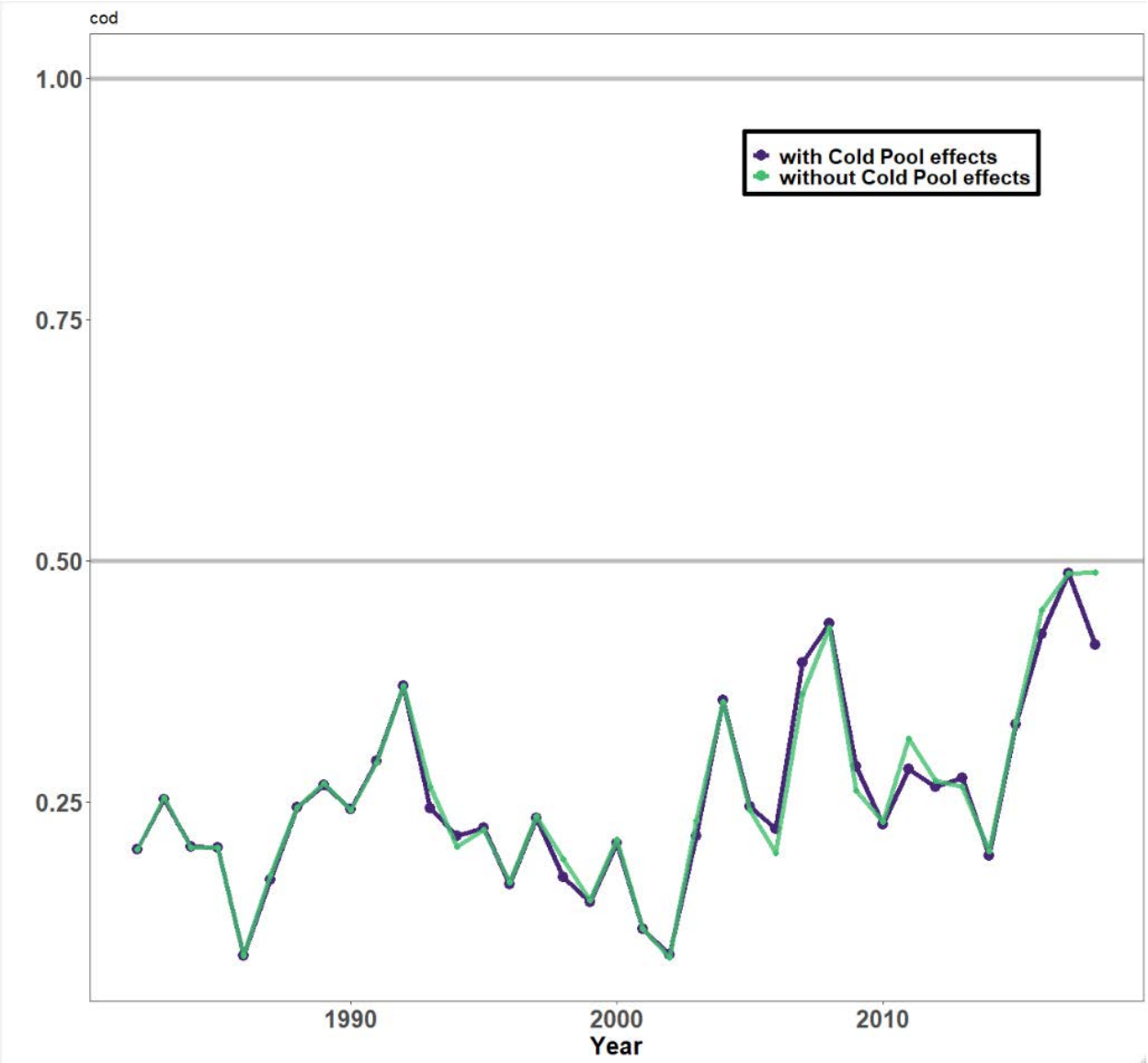
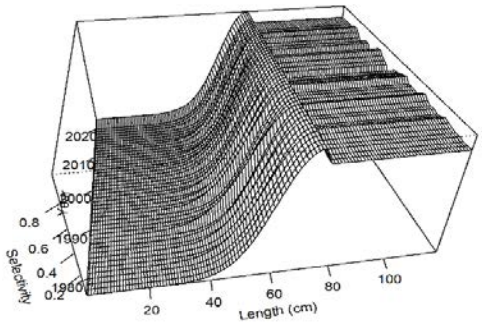
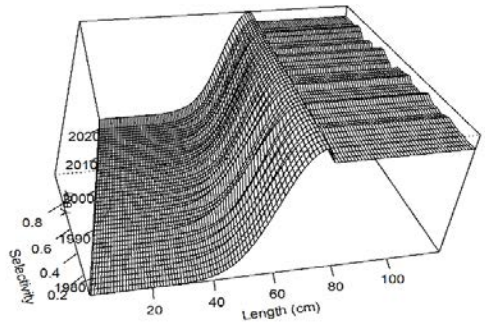


Figure 2.1.3. Proportion of Pacific cod stock in the western Bering Sea (WBS) relative to the entire Bering Sea region (EBS + NBS + WBS) based on explored model-based biomass indices.

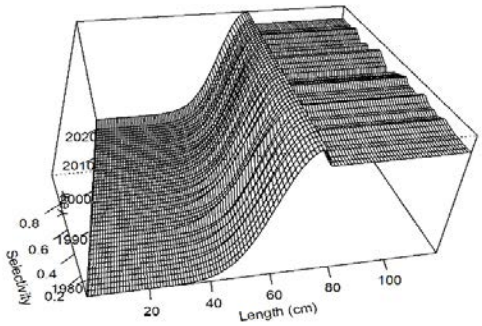
Model 19.12a



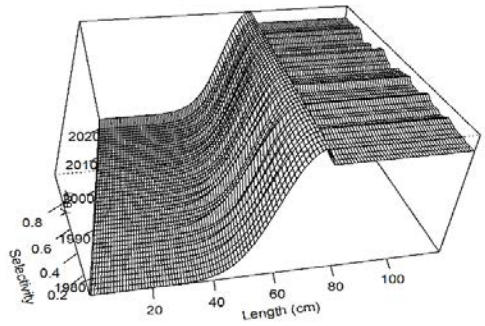
Model 19.12



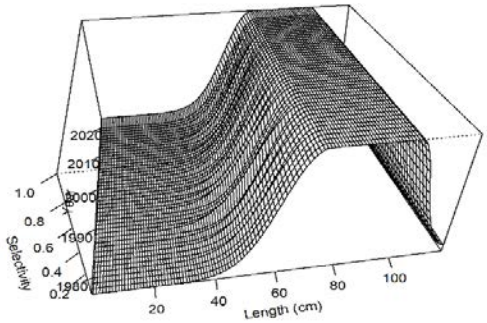
Model 19.12b



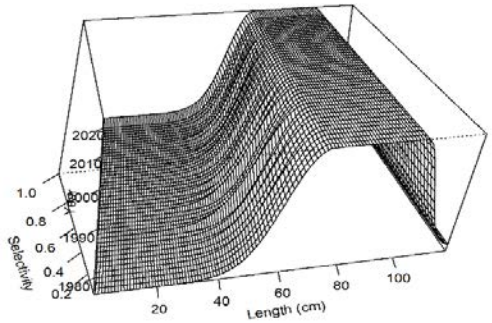
Model 19.12d



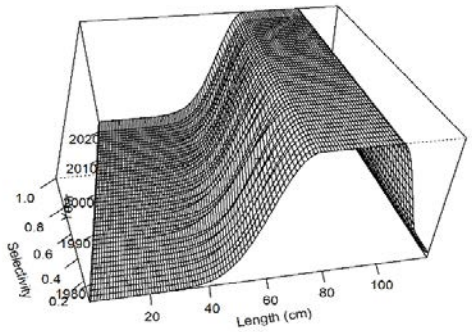
Model 20.1



Model 20.2



Model 19.12c



Model 20.3

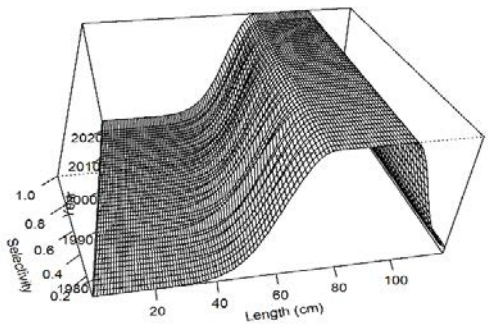


Figure 2.1.4a. Fishery selectivity in the "main" area (EBS or combined EBS and NBS).

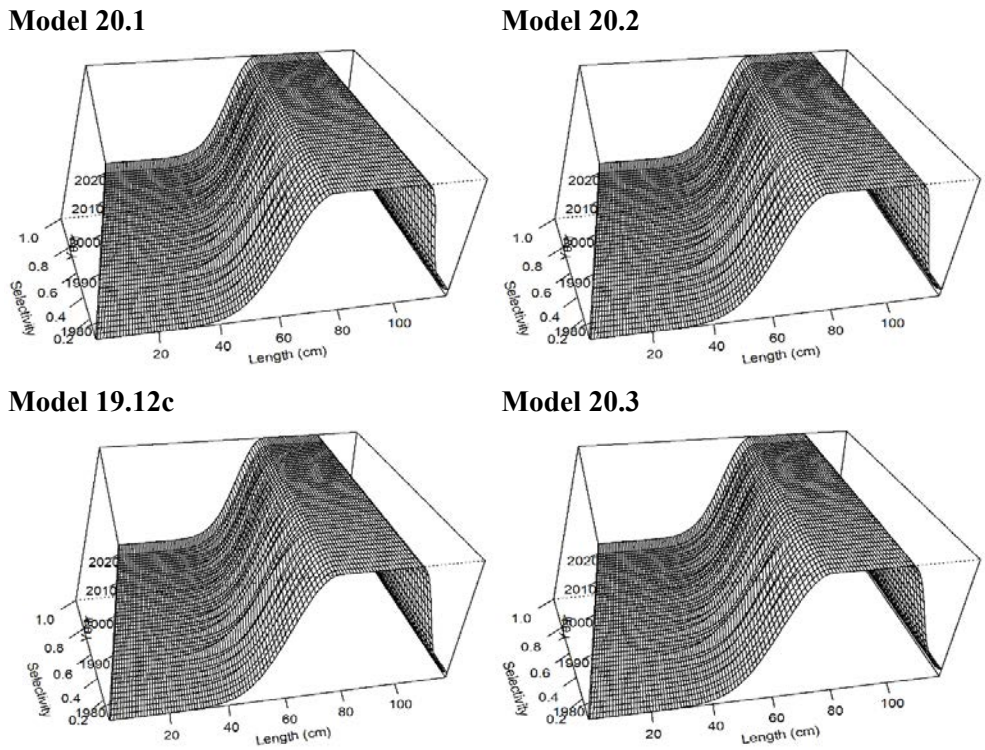
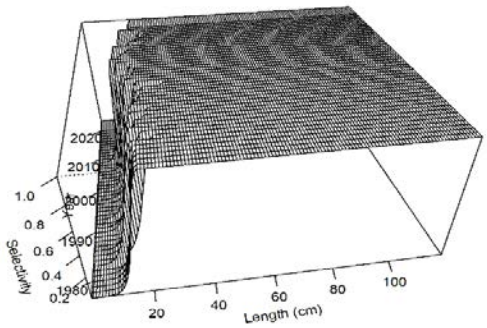
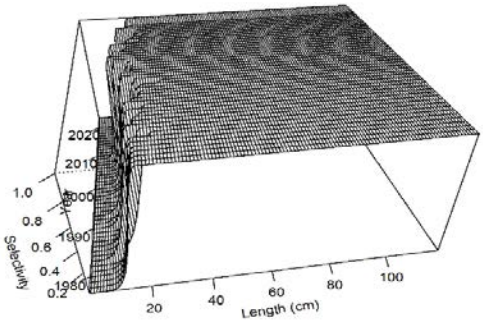


Figure 2.1.4b. Fishery selectivity in the NBS.

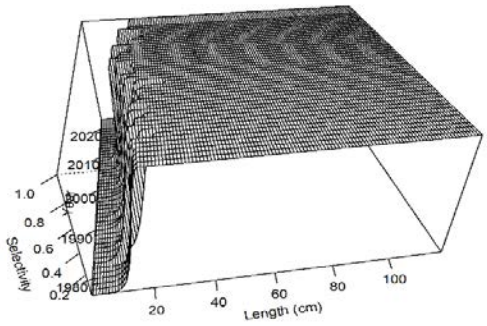
Model 19.12a



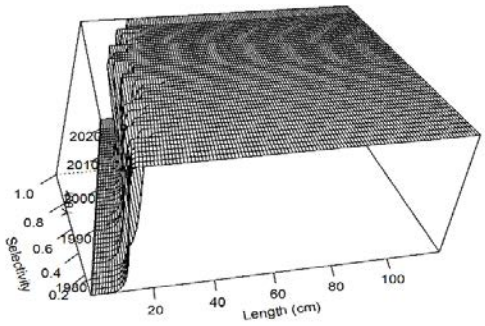
Model 19.12



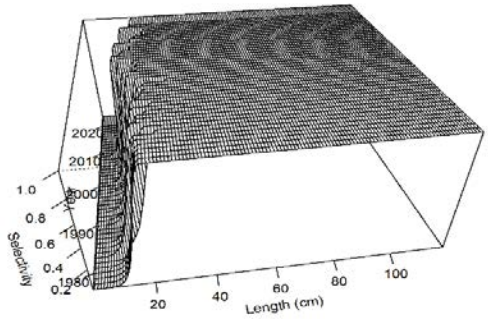
Model 19.12b



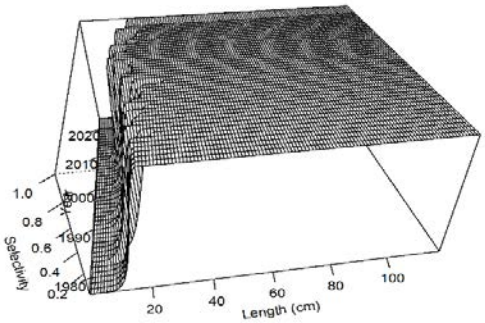
Model 19.12d



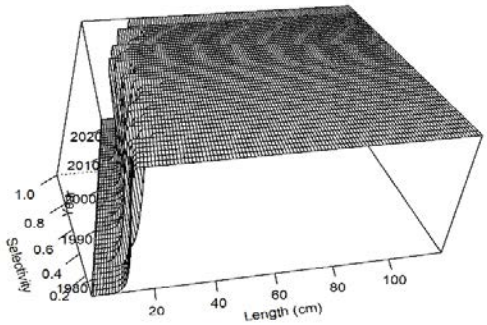
Model 20.1



Model 20.2



Model 19.12c



Model 20.3

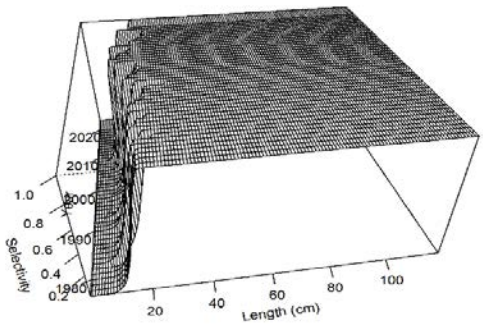


Figure 2.1.4c. Survey selectivity in the "main" area (EBS or combined EBS and NBS).

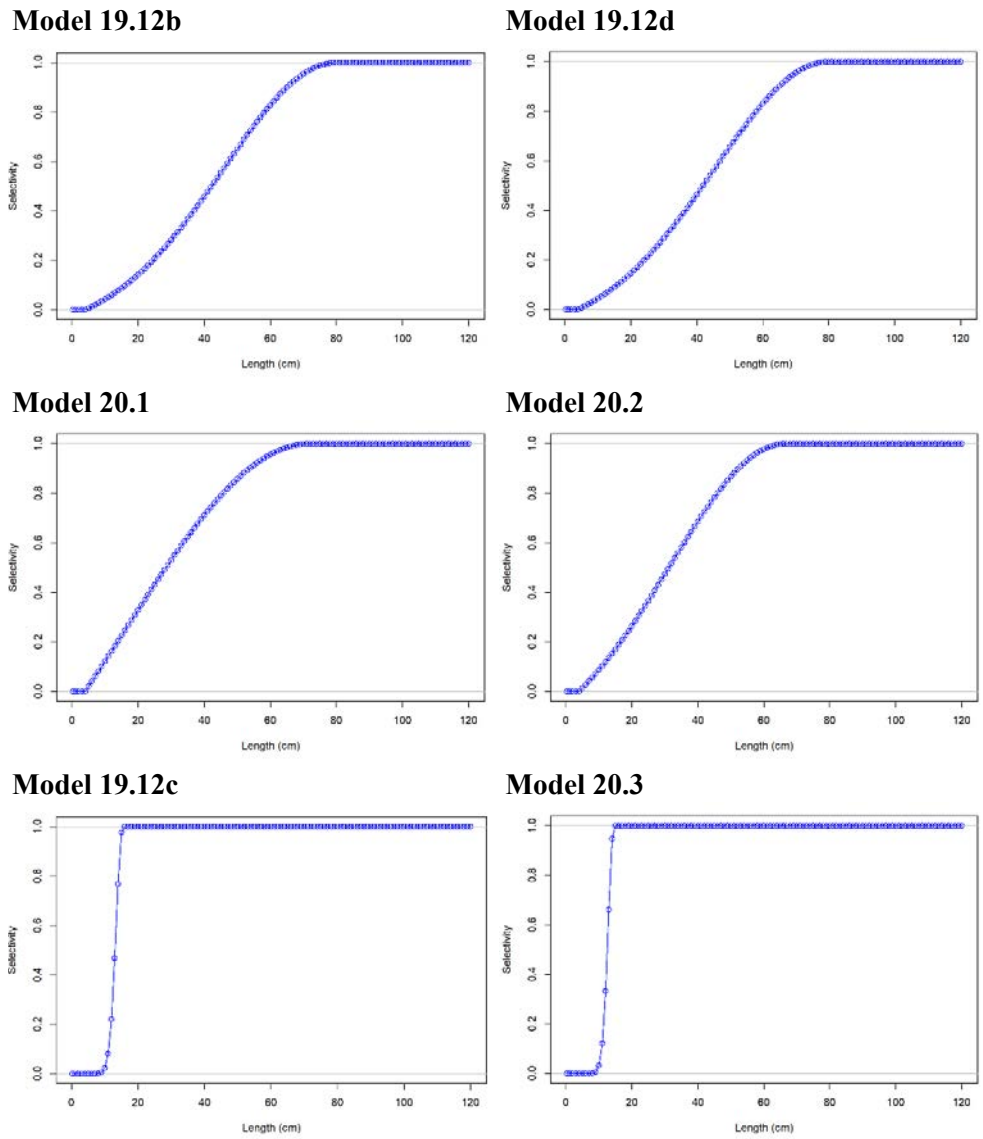


Figure 2.1.4d. Survey selectivity in the NBS.

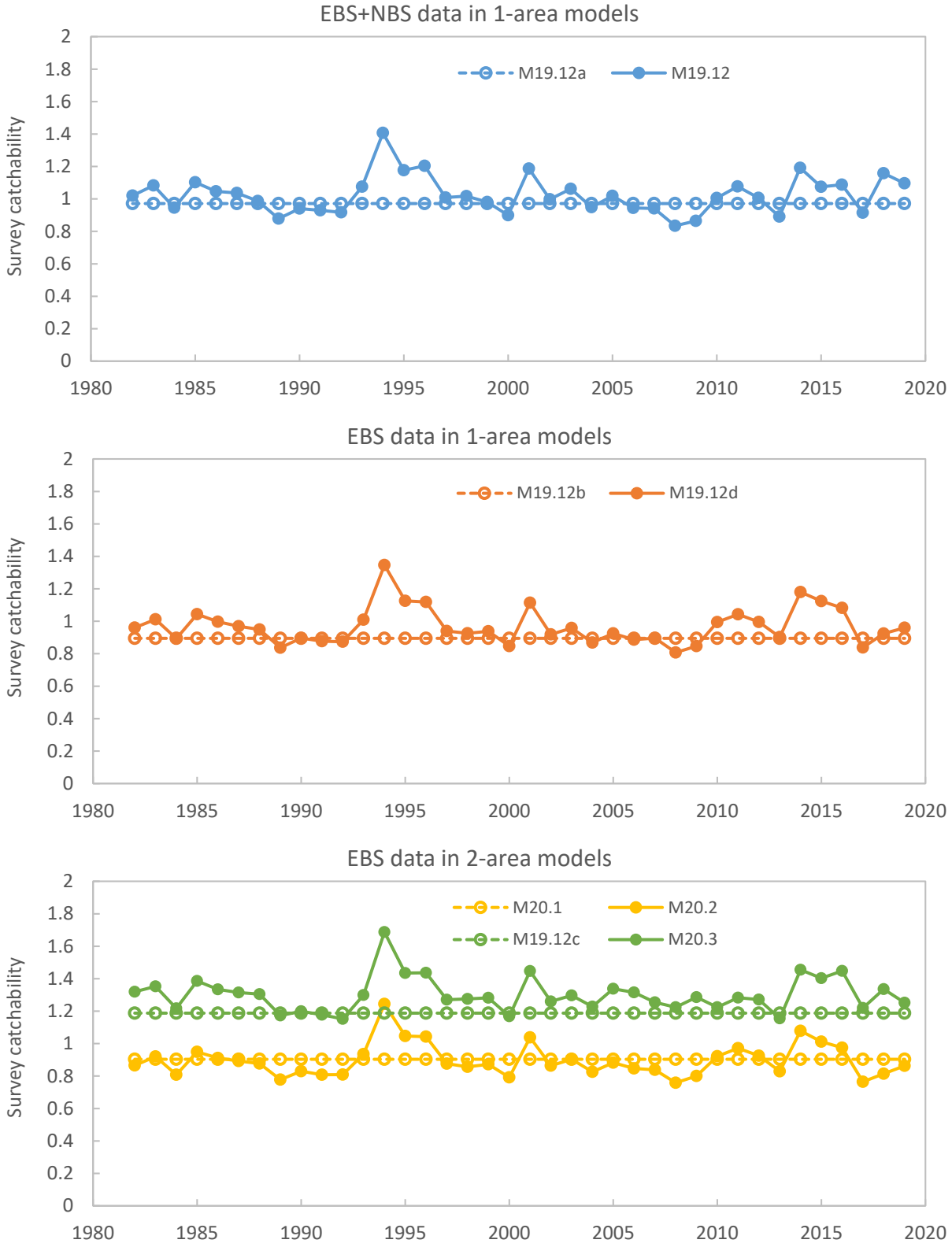


Figure 2.1.5a. Catchability in the "main" survey area (EBS or combined EBS and NBS).

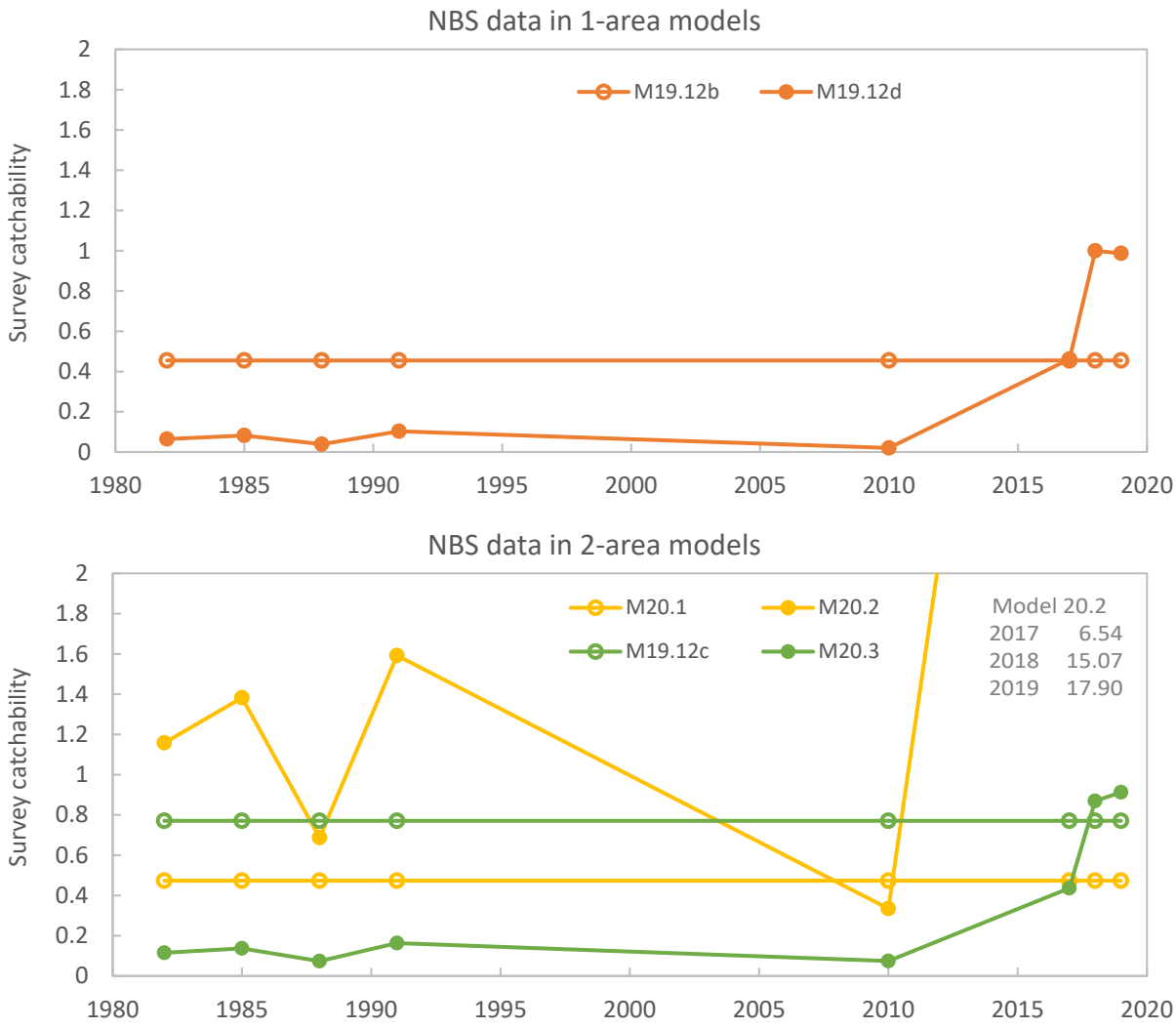


Figure 2.1.5b. Catchability in the NBS survey area.

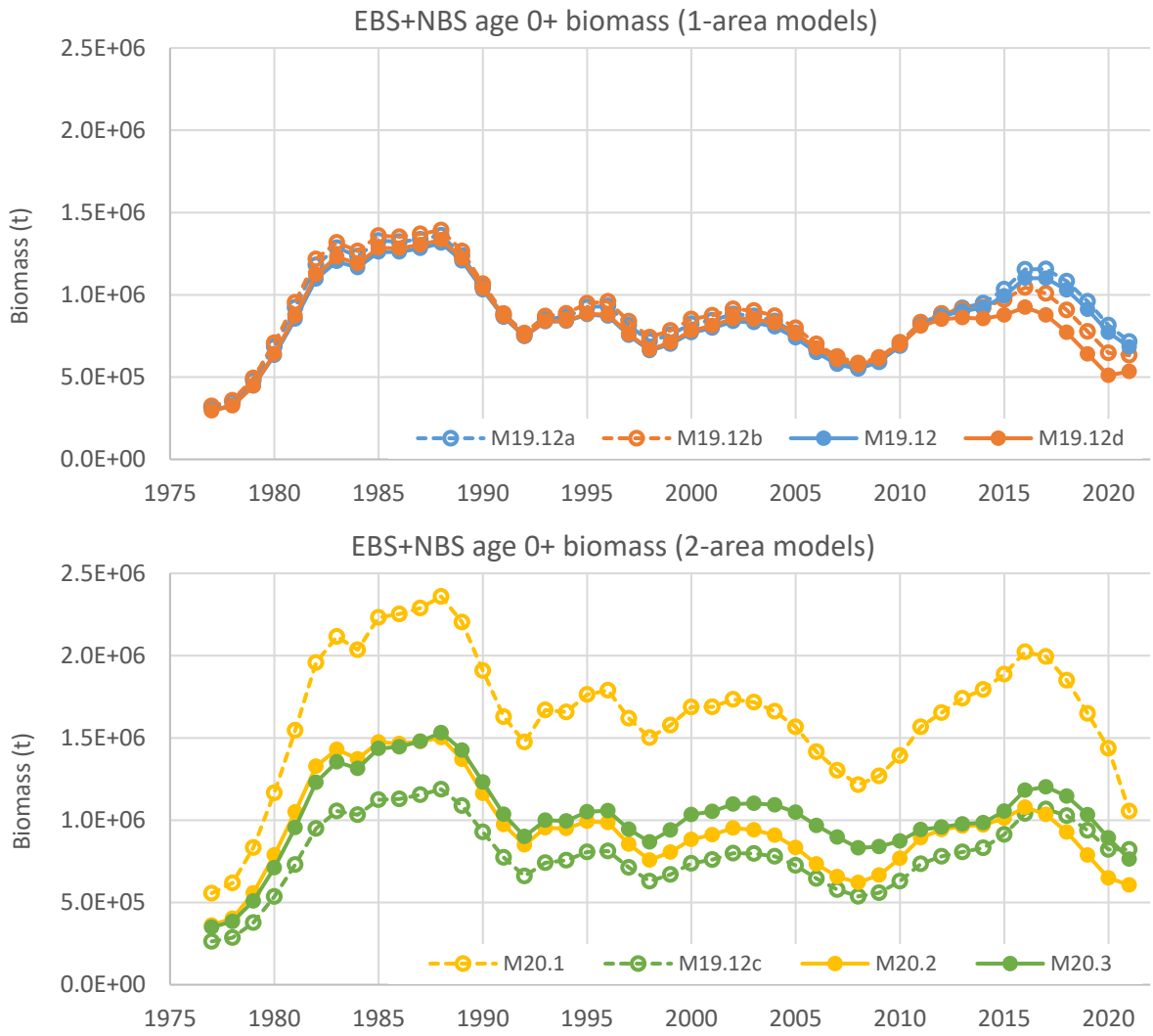


Figure 2.1.6a. Combined area age 0+ biomass (t).

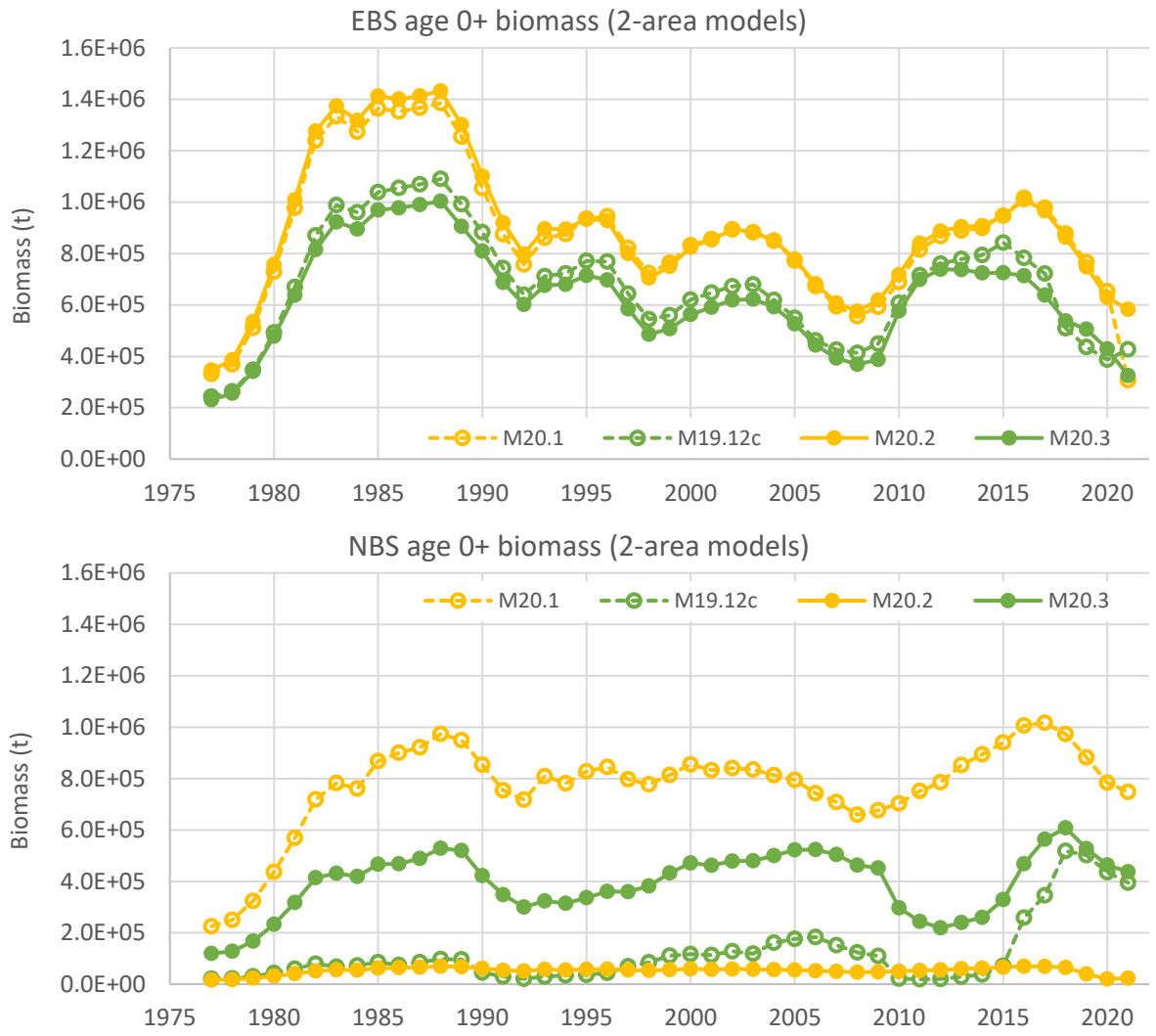


Figure 2.1.6b. Area-specific age 0+ biomass (t), 2-area models only.

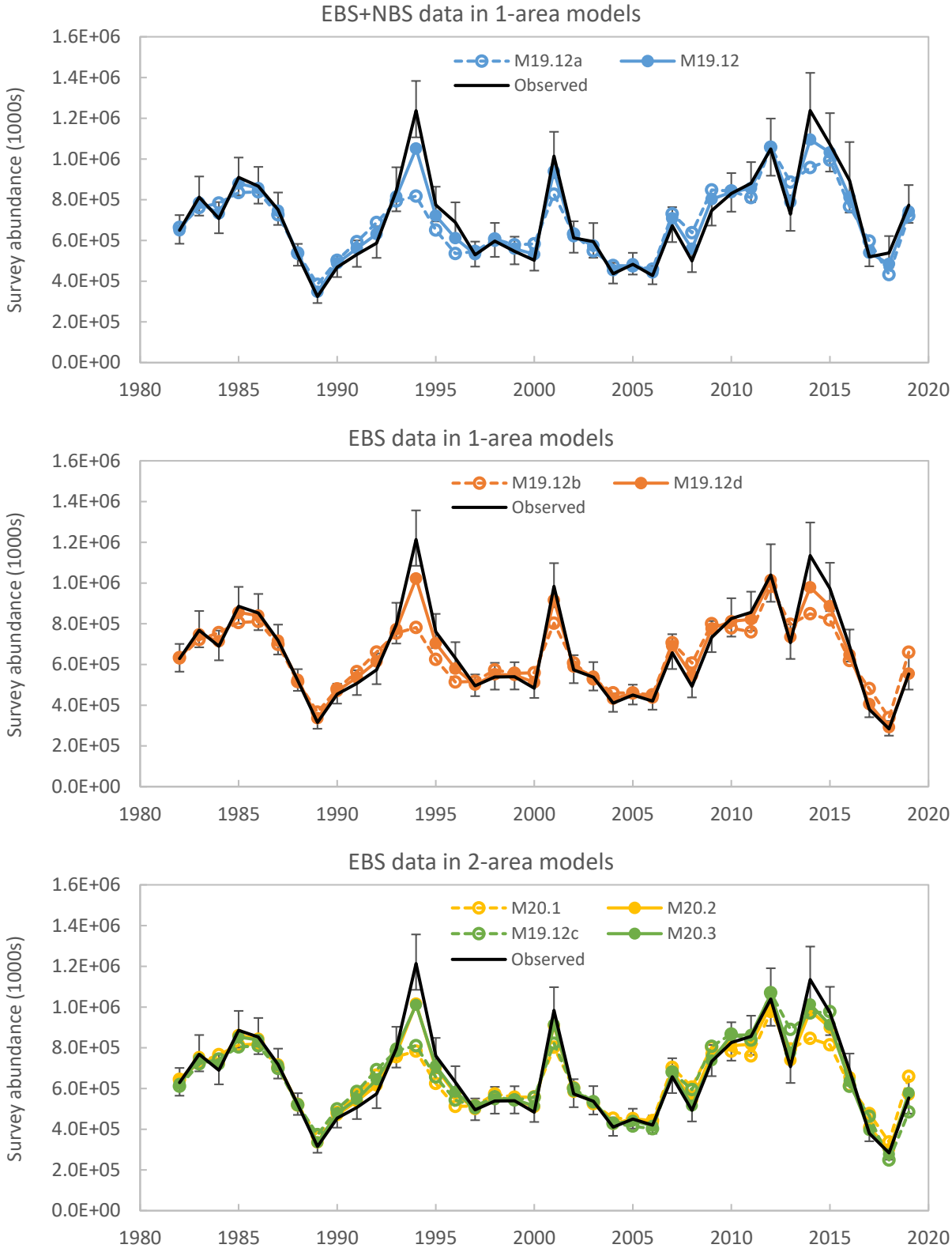


Figure 2.1.7a. Model fits to the "main" survey index time series (EBS or combined EBS and NBS).

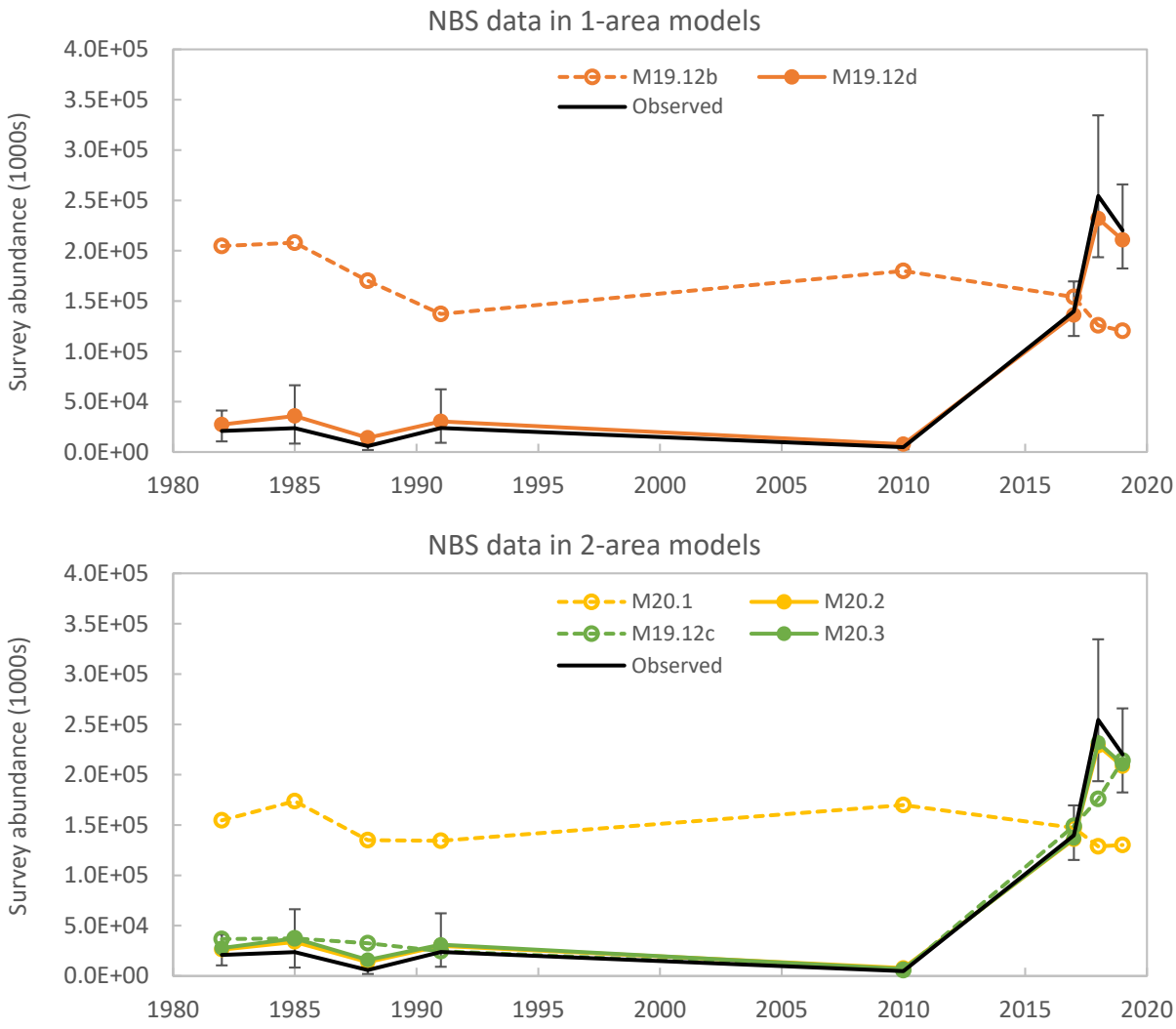
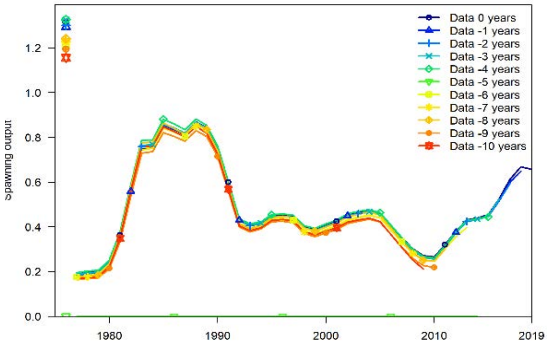
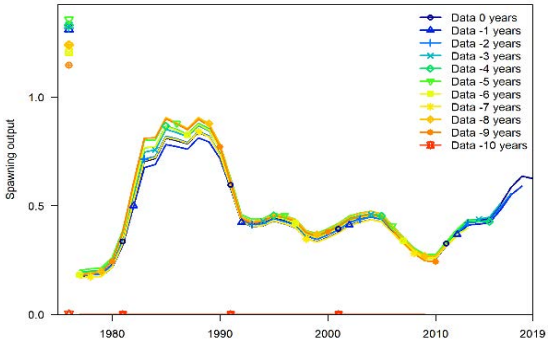


Figure 2.1.7b. Model fits to the NBS survey index time series.

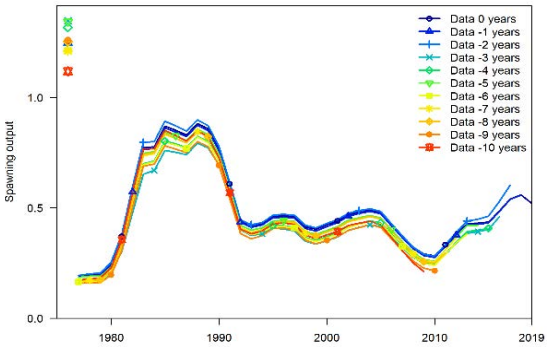
Model 19.12a (ρ = -0.070)



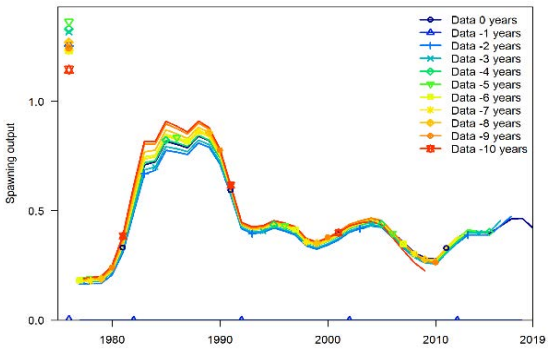
Model 19.12 (ρ = -0.053)



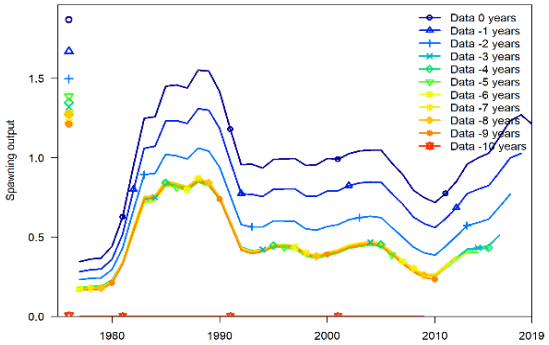
Model 19.12b (ρ = -0.080)



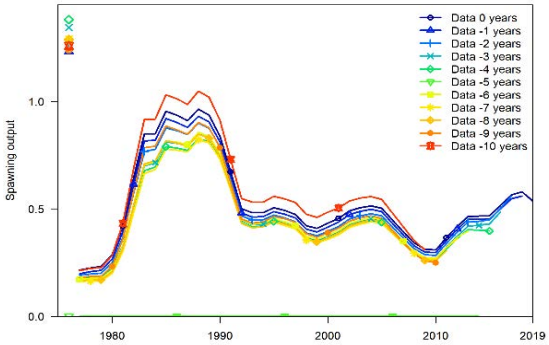
Model 19.12d (ρ = 0.025)



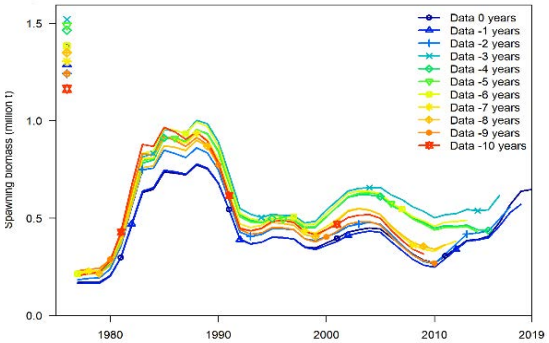
Model 20.1 (ρ = -0.539)



Model 20.2 (ρ = -0.108)



Model 19.12c (ρ = 0.100)



Model 20.3 (ρ = 0.467)

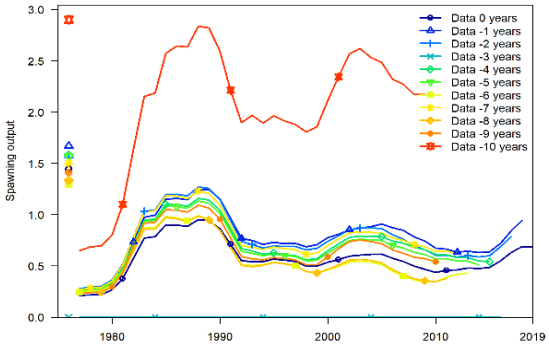


Figure 2.1.8. Retrospective analyses.

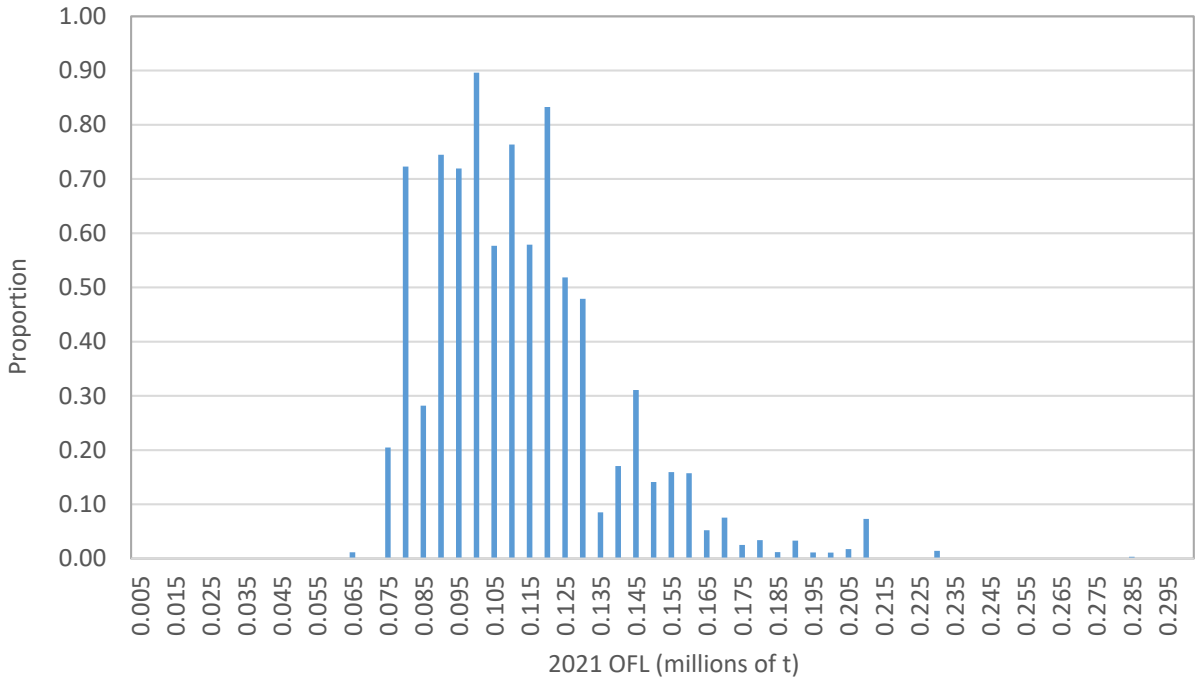


Figure 2.1.9. Probability mass function (pmf) of 2021 OFL (millions of t) from CCDA.

Attachment 2.1.1: Parameterization of two-area movement in Stock Synthesis

Parameterization of movement in SS is somewhat complicated, even for a model with only two areas.

First, three critical ages need to be identified:

- The first age at which movement is allowed, *first_move_age*.
- The ages associated with the endpoints *endp*={1,2} of a linear ramp.
  - Let the age for *endp*=1 be labeled *beg_ramp*, and
  - let the age for *endp*=2 be labeled *end_ramp*.

Second, it is necessary to specify or estimate a vector four parameters, two of which (*move_1to2_A* and *move_1to2_B*) relate to movement from area 1 to area 2 an two of which (*move_2to1_A* and *move_2to1_B*) relate to movement from area 2 to 1.

Third, define a matrix-valued vector **p**, where:

$$p_1 = \begin{bmatrix} 0 & 0 \\ move_1to2_A & move_1to2_B \end{bmatrix} \text{ and } p_2 = \begin{bmatrix} 0 & 0 \\ move_2to1_A & move_2to1_B \end{bmatrix}.$$

Fourth, define **Ramp** as a matrix-valued function of age, where, for each combination of source area *sorc*={1,2} and destination area *dest*={1,2}:

$$ramp_{dest,sorc} = q_{dest,1} + \left(\frac{age - beg_ramp}{end_ramp - beg_ramp}\right)\left(q_{dest,2} - q_{dest,1}\right), \text{where } \mathbf{Q} = p_{sorc}\,.$$

The functions $ramp(age)_{1,sorc}$ return a value of 0 for all values of *age* and each value of *sorc*={1,2}. The functions $ramp(age)_{2,sorc}$ return a line passing through the points {*beg_ramp*, $q_{2,1}$} and {*end_ramp*, $q_{2,2}$} for all values of *age* and each value of *sorc*={1,2}, where $\mathbf{Q} = p_{sorc}$ in all cases.

Fifth, define a matrix-valued vector **r**, where, for each *sorc*={1,2}, r_{sorc} is equal to a matrix **S**, where, for each combination of *dest*={1,2} and *endp*={1,2}:

$$s_{dest,endp} = exp\left(q_{dest,endp}\right)\left(\sum_{i=1}^{2} exp\left(q_{i,endp}\right)\right)^{-1}, \text{where } \mathbf{Q} = p_{sorc}\,.$$

Finally, define **Prop** as a matrix-valued function of age, where, for each combination of *sorc*={1,2} and *dest*={1,2}:

$$prop_{1,sorc} = 1 \text{ and } prop_{2,sorc} = 0 \text{ if } age < first_move_age\,,$$

$$prop_{dest,sorc} = s_{dest,1} \text{ if } first_move_age \le age < beg_ramp\,, \text{and}$$

$$prop_{dest,sorc} = s_{dest,2} \text{ if } age > end_ramp\,; \text{otherwise,}$$

$$prop_{dest,sorc} = exp\left(ramp(age)_{dest,sorc}\right)\left(\sum_{i=1}^{2} exp\left(ramp(age)_{i,sorc}\right)\right)^{-1}, \text{where } \mathbf{S} = r_{sorc}\,.$$

Each column of **Prop** pertains to a particular source area (1 or 2) and defines the proportions of fish:

- that stay in the source area (row 1), and

- that move to the other area (row 2).

Attachment 2.1.2: Estimation of an optimal cutoff sample size for fishery size composition data

The following model was developed for the purpose of estimating an optimal cutoff value for fishery size composition sample size (*lnC* and *lnN* represent the logs of catch and sample size, respectively; a_2, b_1, b_2, c_2, d_1, d_2, and m are parameters, where m represents cutoff sample size (for any combination of year, month, area, and gear); and a_1 and c_1 are functions of parameters):

$$lnC \sim normal(a_1(a_2, b_1, b_2) + b_1 lnN, exp(c_1(c_2, d_1, d_2) + d_1 lnN)^2)\ \forall\ lnN \leq ln(m)$$

$$lnC \sim normal(a_2 + b_2 lnN, exp(c_2 + d_2 lnN)^2)\ \forall\ lnN \geq ln(m),$$

where

$$a_1(a_2, b_1, b_2) = a_2 + (b_2 - b_1)ln(m) \text{ and } c_1(c_2, d_1, d_2) = c_2 + (d_2 - d_1)ln(m)\,.$$

The available data from 1991 onward include a total of 4,196 size composition records (with associated catch), with sample sizes ranging from 1 to 47,750 (median = 386, mean = 1,689) measured fish.

Conditional on c_2, d_1, d_2, and m, closed-form solutions for the maximum likelihood estimates of a_2, b_1, and b_2 are available. The maximum likelihood estimate of m was approximated by profiling over values from 5 to 100, in increments of 5. Maximum likelihood estimates of all parameters were as follow:

a_2	b_1	b_2	c_2	d_1	d_2	m
0.265	-0.427	0.893	1.616	0.054	-0.233	30

The increases in negative log likelihood relative to the minimum for the m profile were as follow:

5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
24.7	17.8	11.1	5.8	1.3	0.0	0.9	1.7	2.3	2.8	3.0	3.1	3.1	3.2	3.3	3.2	3.1	2.9	3.0	2.9

Data and results are shown in Figure 2.1.2.1.

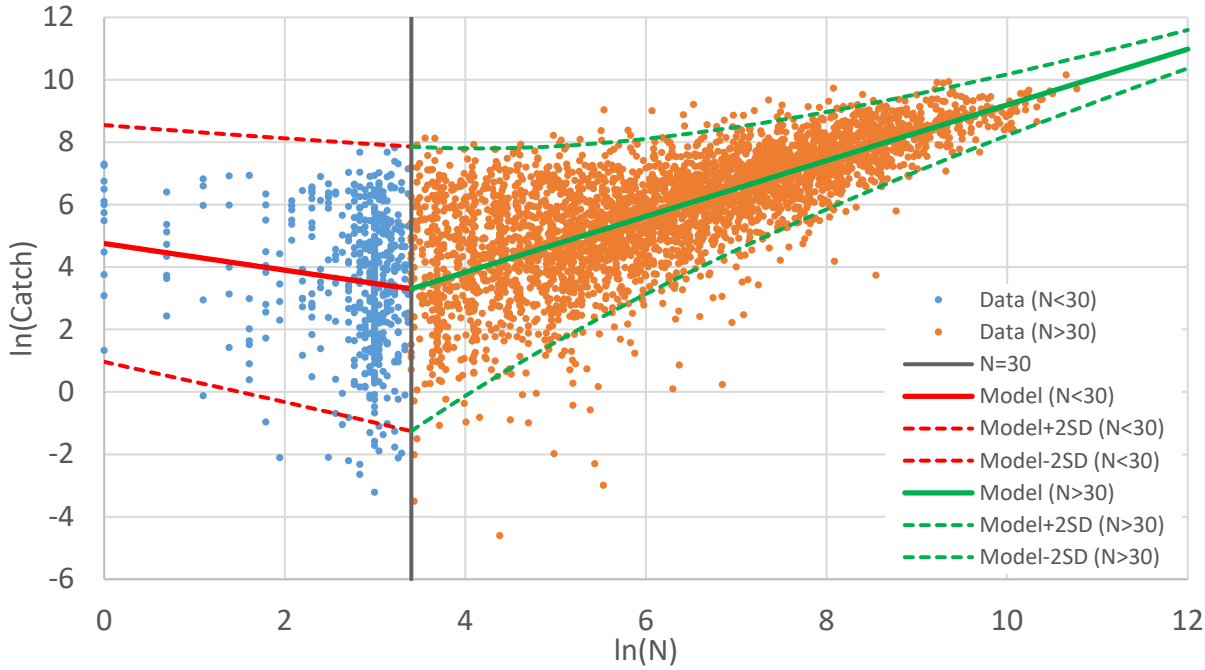


Figure 2.1.2.1. Catch and size composition sample size (*N*) for all available combinations of year, month, area, and gear; and best fit of the model used to estimate an optimal cutoff value of 30 fish.

Attachment 2.1.3: Steps used in cross-conditional decision analysis

The following notational conventions are used:

- Names of matrices consist of, or begin with, an upper-case letter.
- Names of vectors and scalars consist of, or begin with, a lower-case letter.
- Names of matrices and vectors appear in bold font.
- Names of scalars appear in italicized font.

Assume the following loss function:

$$loss(y|\hat{y}, ra) = \left(\frac{y^{1-ra} - \hat{y}^{1-ra}}{1 - ra}\right)^2,$$

where y is the quantity of interest, $\hat{y}$ is intended to approximate the true-but-unknown value of y, and ra is the level of risk aversion, where any value of $ra > 0$ implies true risk aversion, the special case of $ra = 0$ implies risk neutrality, and any value of $ra < 0$ implies "negative" risk aversion (i.e., risk proclivity). Here, risk aversion means that any underestimate is preferred to an overestimate of the same magnitude.

The following procedure is fairly general, and should be applicable to a wide range of choices as to the quantity of interest, with two constraints: 1) the quantity of interest cannot take negative values; and 2) if any value of ra other than 0 is chosen, the scaling of the quantity has to be consistent with the meaning of risk aversion given above.

The risk-minimizing value of $\hat{y}$ is the y mean of order $1-ra$, defined as the $(1-ra)$th root of the $(1-ra)$th noncentral moment of the probability mass function *pmf*:

$$m(1 - ra) = \left(\sum_{i=1}^{\infty} pmf_i {y_i}^{1-ra}\right)^{1/(1-ra)}.$$

For an ensemble containing *nmod* candidate models, compute *pmf* as follows:

1. For each model $i = 1,2,...,nmod$ (referred to below as the "pivot" model, indexed i):
    a. Fit pivot model i to the data; this is the "base" run of the pivot model.
    b. Using the parameters estimated from the base run, generate *nsim* sets of conditional parametric bootstrap data.
    c. Fit pivot model i to each bootstrap data set $k=1,2,...,nsim$, resulting in a set of *nsim* estimates of y ($\mathbf{yest}_i$), which will be taken to characterize the distribution of y, conditional on the structure of the pivot model being "true."
    d. Compute the risk-neutral point estimate of $\hat{y}$ ($yopt_i$) conditional on the structure of the pivot model being "true," which will be the $\mathbf{yest}_i$ mean of order 1.
    e. Fit each model $j \neq i$ in the ensemble to each of the *nsim* sets of bootstrap data generated by pivot model i, resulting in a vector $\mathbf{yest}_j$ for each such model, which, together with $\mathbf{yest}_i$, form the columns of the matrix $\mathbf{Yest}_i$ (note: after steps 1a-1e have been completed for all pivot models, a total of *nmod* **Yest** matrices will have been created, one for each pivot model, and each **Yest** matrix will consist of *nsim* rows and *nmod* columns).

   f. For each set of bootstrap data k=1,2,...,*nsim*, if *any* of the *nmod* fitted models fails to produce a positive definite Hessian matrix or if the maximum gradient exceeds a specified tolerance (e.g., 0.01), delete the corresponding row from $\mathbf{Yest}_i$, resulting in a matrix $\mathbf{Yest_use}_i$.
   g. Determine the probability (p_i) that the structure of pivot model i corresponds to the structure of the true model, using either quantitative or qualitative methods.
2. Create a vector of weights **w**, where each element $0 \le w_i \le 1$, i = 1,2,..,*nmod*, and the vector is constrained to sum to unity (see note at the end of this list on choice of initial values for **w**).
3. Define a conditional risk for each pivot model i=1,2,...,*nmod* as follows:

$$condrisk(\mathbf{w})_i = \left(\frac{1}{nuse_i}\right) \sum_{k=1}^{nuse_i} loss\left(\sum_{j=1}^{nmod} \left(w_j(\mathbf{Yest_use}_i)_{k,j}\right) \mid yopt_i, 0\right),$$

4. Define the overall risk (i.e., expected loss) associated with **w** as

$$risk(\mathbf{w}) = \sum_{i=1}^{nmod} \left(p_i condrisk(\mathbf{w})_i\right).$$

5. Minimize *risk*(**w**) w.r.t. **w** (the minimization will actually occur w.r.t. only *nmod*–1 elements of **w**, as the remaining element is determined by the constraint that the vector sums to unity; see note at the end of this list regarding a suggested parameterization).
6. For each combination of pivot model i=1,2,...,*nmod* and candidate model j=1,2,...,*nmod*, form a histogram from the jth column of $\mathbf{Yest_use}_i$, using *nbin* equal-sized bins spanning the range min(**Yest_use**) to max(**Yest_use**) (see note at the end of this list on choice of value for *nbin*).
7. Form an *nmod*×*nmod* matrix of probability mass functions (**Pmf**) by converting each histogram into a probability mass function by normalizing so that the sum of the bar heights equals unity.
8. Form a weighted average probability mass function across models by computing the probability in each *bin*=1,2,...,*nbin* as follows:

$$pmf_{bin} = \sum_{i=1}^{nmod} p_i \sum_{j=1}^{nmod} w_j \left(Pmf_{i,j}\right)_{bin}.$$

Once *pmf* has been calculated, values of $\hat{y}$ can be obtained for as many values of *ra* as desired by computing the corresponding values of $m(1-ra)$.

Notes:

1. Minimizing risk as a function of **w** can be sensitive to the choice of initial values. Some options to try include the following: A) set each $w_i = 1/nmod$, B) set **w** = **p**, and 3) draw *nmod* random values from a standard normal distribution and convert them via a multivariate logistic transform (this can be done many times as a check on convergence).

2. Problems associated with bounds and tradeoffs between the elements of **w** can be addressed by basing the minimization of *risk*(**w**) on a multivariate logit transform of **w**.
3. Statistics of the distribution can be sensitive to the value of *nbin*. Convergence can be tested by choosing a series of values for *nbin* and computing whatever statistic is of interest for each value. Regardless of the value of *nbin* that is used for computing statistics of the distribution, it may be helpful to use a different value of *nbin* to produce the estimate of *pmf* used for plotting.

Attachment 2.1.4: Deriving the level of risk aversion in the current harvest control rules

Background

Let x denote a positive random variable and let $f(x)$ denote its probability density function (pdf). Then, for real number k, define the "mean of order k" $m(k)$ as the kth root of the kth noncentral moment:

$$m(k) = \left(\int_0^\infty f(x) x^k \, dx \right)^{1/k} .$$

Common special cases include the arithmetic mean ($k = 1$), the geometric mean (in the limit as k approaches 0), and the harmonic mean ($k = -1$). For the loss function used in cross-conditional decision analysis, if the level of risk aversion is ra, the optimal estimator is $m(1-ra)$.

Deriving the level of risk aversion implied by the Tier 1 harvest control rules

In Tier 1 of the current harvest control rules:

- F_{OFL} is set at the arithmetic mean of the pdf of F_{MSY},
  - which implies that $m(1-ra_{OFL})=m(1)$,
  - which implies that $ra_{OFL}=0$.
- $maxF_{ABC}$ is set at the harmonic mean of the pdf of F_{MSY}
  - which implies that $m(1-ra_{ABC})=m(-1)$,
  - which implies that $ra_{ABC}=2$.

Deriving the level of risk aversion implied by the Tier 3 $maxF_{ABC}$ harvest control rule

By definition, reliable estimates of the F_{MSY} pdf are not available for Tier 3 stocks. However, proxies for the levels of uncertainty that would be implied by those pdfs, if they did exist, can be obtained by assuming that they are similar to those estimated in assessments of Tier 1 stocks.

Assume that the pdfs of F_{MSY} for all Tier 1 and Tier 3 stocks are lognormal. Then, $m(k)$ takes the form

$$m(k) = \exp\left(\mu + \frac{k\sigma^2}{2} \right),$$

where μ and σ are the mean and standard deviation of $\ln(F_{MSY})$.

Let *buffer* be defined as $1- maxF_{ABC}/F_{OFL}$. Then, given the results from the previous section, σ can be calculated from *buffer* for a Tier 1 stock as

$$\sigma = \sqrt{-\ln(1 - buffer)} .$$

Using the above equation, example values of σ were computed from the values of *buffer* implied by the stock assessment for EBS walleye pollock (a Tier 1 stock) in each year from 2014-2018:

Year:	2014	2015	2016	2017	2018
Sigma:	0.370	0.498	0.394	0.536	0.402

The above were assumed to constitute a random sample of σ values for a Tier 1 stock. Then, the values of *buffer* implied by all "full" stock assessments of Tier 3 BSAI groundfish species over the period 2014-2018 were calculated. Finally, an estimate of the implicit Tier 3 value of ra_{ABC} was computed for every possible combination of Tier 1 σ (n=5) and Tier 3 *buffer* (n=42), using the following equation:

$$ra_{ABC} = ra_{OFL} - \frac{2\ln(1 - buffer)}{\sigma^2},$$

where it was assumed that ra_{OFL}=0. The resulting set of 210 values had a mean of 1.88 (standard deviation = 0.55, histogram shown in Figure 2.1.3.1), suggesting that the *ra* value of 2 that is identified with the Tier 1 $maxF_{ABC}$ harvest control rule is also a reasonable estimate of the *ra* value that is implied by the Tier 3 $maxF_{ABC}$ harvest control rule.

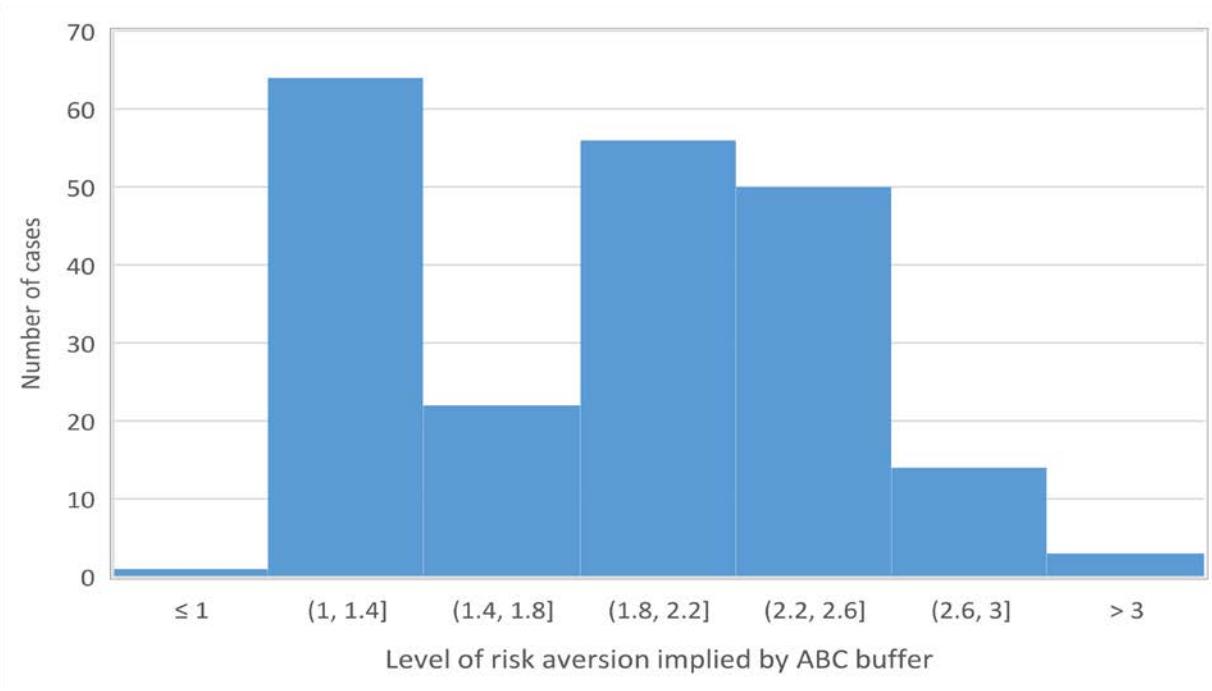


Figure 2.1.3.1. Histogram of risk aversion values implied by the Tier 3 $maxF_{ABC}$ harvest control rule.

Appendix 2.2. Ecosystem and Socioeconomic Profile of the Pacific cod stock in Eastern Bering Sea

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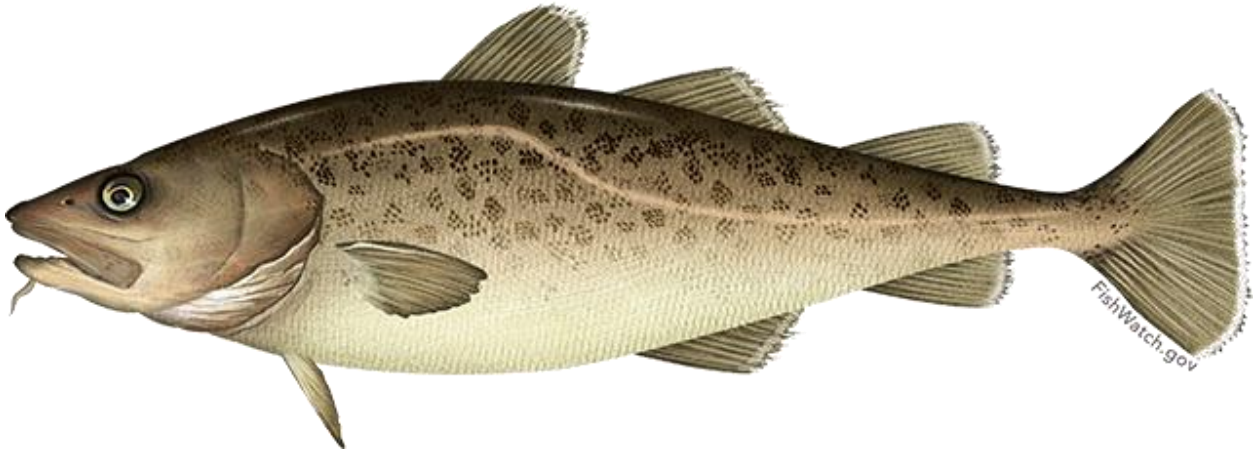
November 2020



With Contributions from:

Kerim Aydin, Steve Barbeaux, Curry Cunningham, Bridget Ferriss, Kirstin Holsman, Beth Matta, Sandi Neidetcher, Jens Nielsen, Patrick Ressler, Heather Renner, Sean Rohan, Ingrid Spies, Katie Sweeney, Muyin Wang, Jordan Watson, Sarah Wise, Stephani Zador

Executive Summary

National initiative scoring and AFSC research priorities suggest a high priority for conducting an ecosystem and socioeconomic profile (ESP) for Eastern Bering Sea (EBS) Pacific cod. Annual guidelines for the AFSC support research that improves our understanding of environmental and climate forcing of ecosystem processes with a focus on variables that can provide direct input into or improve stock assessment and management. The EBS Pacific cod ESP follows the new standardized framework for evaluating ecosystem and socioeconomic considerations for EBS Pacific cod and may be considered a proving ground for potential use in the main stock assessment.

We use information from a variety of data streams available for the EBS Pacific cod stock and present results of applying the ESP process through a metric and subsequent indicator assessment. Analysis of the ecosystem and socioeconomic processes for EBS Pacific cod by life history stage along with information from the literature identified a suite of indicators for testing and continued monitoring within the ESP. Results of the metric and indicator assessment are summarized below as ecosystem and socioeconomic considerations that can be used for evaluating concerns in the main stock assessment.

Ecosystem Considerations

- Pacific cod tagged in the northern Bering Sea (NBS) in summer and fall move to the NBS slope region as sea ice advanced in January to March and also to the Gulf of Alaska or Russian waters
- Hatch timing and success is highly temperature dependent with optimal hatch occurring in waters between 4-6°C and has implications for spawning habitat suitability and subsequent recruitment
- High temperatures combined with low energy content prey may lead to reduced summer growth potential (based on bioenergetics) during warm years in the southeastern Bering Sea (SEBS)
- Spatial mismatch of large Pacific cod in the NBS and smaller Pacific cod in the SEBS may mediate impacts of cannibalism on juvenile Pacific cod
- Sea ice extent during the ice advance and retreat season has steadily decreased since 2014 with moderate increase in extent in 2020 which has implications for movement and spawning
- A rapid build-up of sea ice occurred after late winter 2020, but sea ice concentration (i.e., thickness) was low, and retreated at a faster rate than the previous 5 years after June.
- Spring summer surface and bottom temperatures are closely linked in the SEBS and have been steadily increasing since 2012, but a decoupling seems to have occurred in 2020
- The euphausiid index has been steadily decreasing since 2009 and remained low in the most recent surveys, but condition of juvenile Pacific cod in 2018 and 2019 suggests sufficient prey
- Condition for adult Pacific cod in the SEBS has been moderate to low since 2008 but condition in the NBS has been above average for juveniles 2018 to 2019
- Center of gravity estimates suggest the Pacific cod population has moved north and west since 2012 with an east and south shift in 2019, with a fairly stable area occupied over this time
- Arrowtooth flounder biomass has steadily increased over the time series but has stabilized since 2009, but other predator populations appear steady
- 2019/2020 gray whale UME and 2019 shearwater seabird die-off event could reflects poor feeding conditions in the NBS during 2018/2019
- Overall, ecosystem indicators have been decreasing since 2009 and have shown some modest recovery since 2017 when the heat in the system was reduced, similar to the GOA Pacifc cod
- Highest ranked predictor for recruitment regression model was spring and summer sea surface temperature on the SEBS shelf (inclusion probability > 0.5)

Socioeconomic Considerations

- Unalaska/Dutch Harbor was selected as medium to highly engaged community when evaluating commercial processing and harvesting engagement relative to all other Alaska communities

- Ex-vessel value, price per pound and revenue per unit effort are highly correlated and show an increasing trend to 2008, drop in 2009, and steadily increasing to 2019
- Processing regional quotient (RQ) in Unalaska/Dutch Harbor has an overall decreasing trend with spike in 2018, while harvesting RQ has an increasing trend through 2017 and average in 2018/19

Responses to SSC and Plan Team Comments on ESPs in General

"Regarding ESPs in general, the SSC recommends development of a method to aggregate indices into a score that could be estimated over time and compared to stock history. One potential pathway forward may be to normalize and use an unweighted sum of all the indicators where all time series overlap, or just assign +1 or -1 to each indicator so that a neutral environment would be zero." (SSC, February 2020)

"The Teams discussed concerns of over-emphasizing the 1:1 weighting on the first stage. In the absence of information to indicate an appropriate weighting strategy, it is recommended to not rely too heavily on the uninformed 1:1 weighting to select appropriate indicators. The Teams also requested that the ESP team/authors consider appropriately caveating the indicators to ensure they are interpreted species-specific and not over generalized. The Teams support continuing with the current 3-stage indicator analyses for now, and re-evaluate as the ESP process develops, recognizing that the actual value of the integrated index is yet to be clearly demonstrated although it is one high-level summary statistic that may be valuable to examine." (Joint Groundfish Plan Team, September 2020)

We provide a simple score following the SSC recommendation and compare the 1:1 weighting of indicators in this first stage score with the results of the second stage Bayesian Adaptive Sampling (BAS) method that produces inclusion probabilities for a subset of indicators with the most potential for informing a stock assessment parameter of interest (e.g., recruitment of EBS Pacific cod). This second stage may provide insight on how to weight the indicators in the first stage for a more informed score.

Responses to SSC and Plan Team Comments Specific to this ESP

"The SSC requests that the use of VAST, including its assumptions, are clearly documented in next year's assessment. The SSC notes that development of an ESP for EBS Pacific cod would be advantageous.

Given the results of the stock assessments and the vital historic economic, social, and community importance of Pacific cod, the SSC recommends that within the recognized constraints of available time and resources, Ecosystem and Socioeconomic Profiles (ESPs) of EBS Pacific cod (as well as AI and GOA Pacific cod) be prioritized as new ESPs are developed." (SSC, December 2019, pg. 24)

We have developed a first draft of the ESP for EBS Pacific cod, but some delays in production occurred due to the limitations under COVID-19. This is a near complete full ESP but certain element such as the life history tables and references therein may need more updating. Additionally, more information may become available for developing and evaluating indicators following the next ESP workshop. We recommend re-submitting this ESP with updates following those efforts for next year.

"The Team recommends that the ESR and/or ESP provide an index of movement (e.g., using the standard EBS bottom trawl survey stations, evaluate the proportion of Pacific cod biomass over time in the northernmost survey stations that are located between 59o N and 60o N in years 1982- 2019) to validate the movement indices in this model. This would be needed in November if these models move forward, or if not, should be included in the ESP for Pacific cod in 2021." (BSAI GPT, September 2020)

"The BSAI-GPT recommended examining survey catches at the northern stations in the EBS survey over time as a potential index of movement. In addition to the BSAI-GPT request, there are some outputs of

VAST that might be useful including the index of area occupied and the center of gravity estimates." (SSC, October 2020)

We include indicators of center of gravity and area occupied from the model-based estimates (VAST) for EBS Pacific cod. The northings center of gravity indicator is highly correlated to sea ice extent during the ice retreat season (March-May) and may relate to movement of the population into the NBS in recent years. Area occupied has remained relatively steady during this time suggesting the population is not expanding much but actually moving north. This may also be in response to the decreased ice extent during ice-retreat season and impact movement during spawning.

Introduction

Ecosystem-based science is becoming a component of effective marine conservation and resource management; however, the gap remains between conducting ecosystem research and integrating it with the stock assessment. A consistent approach has been lacking for deciding when and how to incorporate ecosystem and socioeconomic information into a stock assessment and how to test the reliability of this information for identifying future change. This new standardized framework termed the ecosystem and socioeconomic profile (ESP) has recently been developed to serve as a proving ground for testing ecosystem and socioeconomic linkages within the stock assessment process (Shotwell et al., *In Review*). The ESP uses data collected from a variety of national initiatives, literature, process studies, and laboratory analyses in a four-step process to generate a set of standardized products that culminate in a focused, succinct, and meaningful communication of potential drivers on a given stock. The ESP process and products are supported in several strategic documents (Sigler et al., 2017; Dorn et al., 2018; Lynch et al., 2018) and recommended by the North Pacific Fishery Management Council's (NPFMC) groundfish and crab Plan Teams and the Scientific and Statistical Committee (SSC).

This ESP for Eastern Bering Sea (EBS) Pacific cod (*Gadus macrocephalus*) follows the template for ESPs (Shotwell et al., *In Review*) and replaces the previous ecosystem considerations section in the main EBS Pacific cod stock assessment and fishery evaluation (SAFE) report. Information from the original ecosystem considerations section may be found in Barbeaux et al. (2019).

The ESP process consists of the following four steps:

1) Evaluate national initiative and stock assessment classification scores (Lynch et al., 2018) along with regional research priorities to assess the priority and goals for conducting an ESP.
2) Perform a metric assessment to identify potential vulnerabilities and bottlenecks throughout the life history of the stock and provide mechanisms to refine indicator selection.
3) Select a suite of indicators that represent the critical processes identified in the metric assessment and monitor the indicators using statistical tests appropriate for the data availability of the stock.
4) Generate the standardized ESP report following the guideline template and report ecosystem and socioeconomic considerations, data gaps, caveats, and future research priorities.

Justification

The national initiative prioritization scores for EBS Pacific cod are overall high due to the high commercial importance of this stock and early life history habitat requirements (Hollowed et al., 2016; McConnaughey et al., 2017). The vulnerability scores were in the low to moderate of all groundfish scores based on productivity, susceptibility (Ormseth and Spencer, 2011), and sensitivity to future climate exposure (Spencer et al., 2019). The new data classification scores for Pacific cod suggest a data-rich stock with high quality data for catch, size/age composition, abundance, and life history categories with a high ecosystem linkage target (Lynch et al., 2018). These initiative scores and data classification levels suggest a high priority for conducting an ecosystem and socioeconomic profile (ESP) for EBS Pacific cod particularly given the high level of life history information and current application of ecosystem linkages in the stock assessment model for recruitment and movement. Additionally, AFSC research priorities support studies that improve our understanding of environmental and climate forcing of ecosystem processes with focus on variables that provide direct input into stock assessment and management. Specifically, research that that improves our understanding of Pacific cod dynamics in the Gulf of Alaska and the Bering Sea.

Data

Initial information on EBS Pacific cod was gathered through a variety of national initiatives that were conducted by AFSC personnel in 2015 and 2016. These include (but were not limited to) stock assessment prioritization, habitat assessment prioritization, climate vulnerability analysis, and stock

assessment classification. Data from an earlier productivity susceptibility analysis conducted for all groundfish stocks in Alaska were also included (Ormseth and Spencer, 2011). Data derived from this effort served as the initial starting point for developing the ESP metrics for stocks in the Bering Sea Aleutian Islands (BSAI) and Gulf of Alaska (GOA) groundfish fishery management plans (FMP). Please see Shotwell et al., *In Review*, for more details.

Supplementary data were also collected from the literature and a variety of process studies, surveys, laboratory analyses, accounting systems, and regional reports (Appendix Table 2.2.1). Information for the first year of life was derived from ecosystem surveys and laboratory analyses run by multiple programs and divisions at the AFSC (e.g., Ecosystems and Fisheries Oceanography Coordinated Investigations (EcoFOCI), Recruitment Processes Alliance (RPA), Resource Assessment and Conservation Engineering (RACE) Division, Resource Ecology and Fisheries Management (REFM) Division, Auke Bay Laboratory (ABL) Division, Marine Mammal Laboratory (MML) Division). Data for juveniles (less or equal to than 46 cm) through adult were consistently available from the AFSC bottom trawl surveys, and the North Pacific Observer Program administered by the Fisheries Monitoring and Analysis (FMA) division.

Data from Ecosystem Status Report (ESR) contributions were provided through personal communication with the contact author of the contribution (e.g., Ressler et al., 2019). Essential fish habitat (EFH) model output and maps were provided by personal communication with the editors of the EFH update (e.g., Rooney et al., 2018). Remote sensing data were collected through coordination with CoastWatch personnel at the Southwest Fisheries Science Center and initial development of an AFSC-specific ERDDAP (Simons, 2019). High resolution regional ocean modeling system (ROMS) and nutrient-phytoplankton-zooplankton (NPZ) data were provided through personal communication with authors of various publications (e.g., Kearney et al., 2020) that develop these models.

The majority of EBS Pacific cod economic value data were compiled and provided by the Alaska Fisheries Information Network (AKFIN). EBS Pacific cod ex-vessel pricing data were derived from the NMFS Alaska Region Blend and Catch Accounting System, the NMFS Alaska Region At-sea Production Reports, and the ADFG Commercial Operators Annual Reports (COAR). EBS Pacific cod first-wholesale data were from NMFS Alaska Region At-sea and Shoreside Production Reports and ADFG Commercial Operators Annual Reports (COAR). Global catch statistics were found online at FAO Fisheries & Aquaculture Department of Statistics (http://www.fao.org/fishery/statistics/en), NOAA Fisheries, Fisheries Statistics Division, Foreign Trade Division of the U.S. Census Bureau (http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/index), and the U.S. Department of Agriculture (http://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set.aspx). Information regarding the community involvement and percent value was derived from reports of the Community Development Quota (CDQ) Program.

Metrics Assessment

We first provide the analysis of the national initiative data used to generate the baseline metrics for this second step of the ESP process and then provide more specific analyses on relevant ecosystem and/or socioeconomic processes. Metrics are quantitative stock-specific measures that identify vulnerability or resilience of the stock with respect to biological or socioeconomic processes. Over a century of process studies on cod stocks around the world, including research conducted by the FOCI program, revealed that evaluating ecosystem linkages by life history stage can highlight potential bottlenecks and improve mechanistic understanding of ecosystem or socioeconomic pressures on the stock (Pepin, 1991; Bailey et al., 1996; Megrey et al., 1996; Bailey, 2000; Bailey, 2005; Ciannelli et al., 2005; Sundby and Nakken, 2008; Reum et al., 2020).

National Metrics

The national initiative data were summarized into a metric panel (Appendix Figure 2.2.1) that acts as a first pass ecosystem and socioeconomic synthesis. Metrics range from estimated values to qualitative scores of population dynamics, life history, or economic data for a given stock (see Shotwell et al., *In Review* for more details). To simplify interpretation, the metrics are rescaled by using a percentile rank for EBS Pacific cod relative to all other stocks in the groundfish FMP. Additionally, some metrics are inverted so that all metrics can be compared on a low to high scale between all stocks in the FMP. These adjustments allow for initial identification of vulnerable (percentile rank value is high) and resilient (percentile rank value is low) traits for EBS Pacific cod. Data quality estimates are also provided from the lead stock assessment author (0 or green shaded means no data to support answer, 4 or purple shaded means complete data), and if there are no data available for a particular metric then an "NA" will appear in the panel. EBS Pacific cod did not have any data gaps for the metric panel and the data quality was rated as moderate to complete for nearly all metrics. The metric panel gives context for how EBS Pacific cod relate to other groundfish stocks in the FMP and highlights the potential vulnerabilities for the EBS Pacific cod stock.

The 80th and 90th percentile rank areas are provided to highlight metrics indicating a high level of vulnerability for EBS Pacific cod (Appendix Figure 2.2.1). For ecosystem metrics, maximum length for EBS Pacific cod fell within the 90th percentile rank of vulnerability. Spawning duration, top-down ecosystem value, natural mortality, and length at 50% maturity fell within the 80th percentile rank when compared to other stocks in the groundfish FMP. For socioeconomic metrics, commercial importance and non-catch value fell within the 90th percentile rank and constituent demand fell within the 80th percentile rank. Additionally, EBS Pacific cod maximum length and commercial importance exceeded a threshold of highly vulnerable established in the national initiatives (e.g., Methot, 2015; Patrick et al., 2010). EBS Pacific cod were relatively resilient for growth rate, mean age, prey specificity, reproductive strategy, age at 50% maturity, latitude range, other stressors, fecundity, population growth rate, geographic concentration, breeding strategy index and habitat dependence.

Ecosystem Processes

Pacific cod release all their eggs near the bottom in a single event during the late winter/ early spring period in the Gulf of Alaska (Stark, 2007). Unlike most cod species, Pacific cod eggs are negatively buoyant and are semi-adhesive to the ocean bottom substrate during development (Alderdice and Forrester, 1971). Known areas of EBS Pacific cod spawning occur north of Unimak Island, near the Pribilof Islands, and on the shelf break in the vicinity of Zhemchug Canyon with spawning occurring in late-March and early April (Shimada and Kimura, 1994; Neidtcher et al., 2014). Analysis of otolith elemental composition indicated that age-0 recruits on the southeastern Bering Sea (SEBS) shelf originated from three chemically distinct spawning areas, but these could not be associated with identified spawning areas (Miller et al., 2016). It is unknown whether recent warming events have allowed a northward expansion of the spawning distribution or a shift in the timing of spawning. Preliminary results from a recent tagging study in the northern Bering Sea (NBS) suggest that EBS Pacific cod tagged in the NBS in late summer and fall generally moved to the NBS slope region as sea ice advanced in January to March, but also moved south to the Gulf of Alaska or west to Russian waters (S. McDermott, *pers. commun.*).

Hatch timing/success is highly temperature-dependent (Laurel et al., 2008), with optimal hatch occurring in waters ranging between 4-6°C (Bian et al., 2016; Laurel and Rogers, 2020) over a broad range of salinities (Alderdice and Forrester, 1971). Eggs hatch into 4 mm larvae in ~2 wks at 5°C (Laurel et al., 2008) and become surface oriented and available to pelagic ichthyoplankton nets during the spring (Doyle and Mier, 2016). During this period, Pacific cod larvae are feeding principally on eggs, nauplii and early copepodite stages of copepod prey <300 um (Strasburger et al., 2014). Warm surface waters can accelerate larval growth when prey are abundant (Hurst et al., 2010). Laboratory studies suggest warm

temperatures can also indirectly impact Pacific cod larvae by way of two mechanisms: 1) increased susceptibility to starvation when the timing and biomass of prey is 'mis-matched' under warm spring conditions (Laurel et al., 2011), and 2) reduced growth by way of changes in the lipid/fatty acid composition of the zooplankton assemblage (Copeman and Laurel, 2010). Recent work has shown a stage-dependent sensitivity to cod larvae to elevated CO_2 associated with ongoing ocean acidification (Hurst et al., 2019). Growth rates immediately after hatch were reduced at high CO_2 levels, but the opposite was observed at 2-5 weeks of age. In addition, exposure to elevated CO_2 levels altered the behavior of cod larvae which may be related to the observed changes in growth rates. Finally, OA-induced changes in the species composition and biochemical characteristics (fatty acid composition) of lower trophic levels may also impact the early growth and survival of cod larvae in the future.

Pacific cod larvae are known to occur in the SEBS along the Alaska Peninsula, but the full distribution of larvae is not well known due to spatial and temporal limitations of historical ichthyoplankton sampling. Newly hatched larvae are surface oriented and make extended diel vertical migrations with increased size and development (Hurst et al., 2009). Larvae reach a developmental milestone ('flexion') between 10-15 mm and gradually become more competent swimmers with increasing size (Voesenek et al., 2018). The dominant current regimes suggest a dispersal from south to north over the shelf and to the east along the Alaska Peninsula, and there is evidence of coherent patterns of dispersal which may link juvenile distributions to specific spawning areas (Miller et al., 2016).

Age-0 Pacific cod are found in coastal areas along the Alaska Peninsula and in surface and sub-surface waters over the middle shelf (Hurst et al., 2012, 2015; Parker-Stetter et al., 2013). Analysis of the 2012 year-class indicated maximum abundances were found along the Alaska Peninsula at depths < 50 m (Hurst et al., 2015). Other analyses of cohort distributions based on trawl and acoustic sampling over the shelf indicated that the majority of age-0 cod were found south of St. Lawrence Island (Hurst et al., 2012; Parker-Stetter et al., 2013). These patterns were supported by an absence of age-0 Pacific cod further north in the Bering Sea and in the Chukchi Sea (Norcross et al., 2010; Rand and Logerwell, 2011). However, it is important to recognize that all of those analyses were conducted prior to the warming events. Meso-scale distributions have been linked to conditions with higher abundances at sites with higher local temperatures and growth potential (Hurst et al., 2012, 2018), suggesting a behavioral mechanism contributing to shifting juvenile distributions.

Juvenile cod feed predominantly on copepods and euphausiids, with additional contributions of pteropods, shrimp, crab zoea, and fishes (Strasburger et al., 2014; Farley et al., 2016). Growth conditions in summer-fall are related to temperature and foraging conditions with warm years resulting in larger body sizes but lower energy content (i.e., lower lipid content) (Farley et al., 2016). Bioenergetic model estimates of growth potential suggest that temperatures above the thermal optimal for growth combined with lower energetic content of the diet may lead to reduced late-summer growth during warm years in the SEBS (Hurst et al., 2018). These differences may have implications determining patterns of overwinter survival of age-0 Pacific cod, as observed in SEBS walleye pollock (Heintz et al., 2013; Farley et al., 2016). The overwintering dynamics are currently unknown for Pacific cod, although laboratory held age-0 juveniles are capable of growth and survival at very low temperatures (0°C) for extended periods (Laurel et al., 2016a).

Adult Pacific cod are opportunistic predators, eating a variety of zooplankton (including euphausiids), crab, and fish species (Aydin and Mueter, 2007) and are able to switch between benthic and demersal foraging based on prey availability (Aydin, 2020). In the eastern Bering Sea, Pacific cod feed on zooplankton until reaching approximately 20cm fork length, then feed primarily on benthic epifauna between 20-60cm fork length, and at larger sizes (60cm+) switch to feeding on fish, crustaceans, and other large invertebrates, in particular walleye pollock (*Gadus chalcogrammus*) and *Chionoecetes* spp. of crab (snow crab and tanner crab). Diet proportions by weight have been examined for three key EBS strata, the southeast middle domain, the northwest outer domain, and the NBS (Appendix Figure 2.2.3, reproduced from Aydin, 2020). In the southeast middle domain, pollock were the dominant prey in most

years, but were extremely low from 2008-2012, when other prey became more dominant in the mix (e.g., *Chionoecetes* spp. and flatfish in particular). In the northwest outer domain, pollock were the dominant prey except for the periods 1996-97, 2008-09, and 2016-19. In particular, in that most recent period both *Chionoecetes* spp. and octopus were seen at increased levels. During 2009-12 in the northwest outer domain, Pandalid shrimp were also higher in the cod diets. There have been limited surveys in the NBS but of the years surveyed, for most years *Chionoecetes* spp. (primarily identified as snow crab) were the largest portion of cod diet, except for 2010 in which both flatfish and forage fish were the main prey items. The trends in particular show the influence of the Bering Sea cold pool. Years with a large cold pool extent show a decrease of pollock in Pacific cod prey and an increase in a range of other prey items. In recent years however (2015-2019), pollock have remained relatively low in diets in spite of a decreased cold pool, particularly on the northwest outer shelf, with octopus increasing. This may represent a trend of increasing octopus in the region.

Competitors for prey resources may also provide indirect evidence of conditions experienced by Pacific cod. While historical recruitment trends between Pacific cod and walleye pollock have mirrored each other, suggesting the species respond similarly to environmental conditions, the time series appear to decouple after approximately 2010 and may indicate broad-scale transitions in the southeastern Bering Sea ecosystem. The mechanisms driving early life history survival versus recruitment success of Pacific cod and walleye pollock may differ based on pelagic versus benthic habitat associations (e.g., prey availability). The decoupling of abundance timeseries after 2010 suggests a shift (or greater disparity) between drivers of survival in these two populations. Other competitors of EBS Pacific cod may include gray whales (feeding on benthic amphipods, zooplankton) and seabirds (e.g., short-tailed shearwaters are planktivorous birds and feed on euphausiids).

Pacific cod are cannibalistic and rates of cannibalism might be expected to increase as the abundance of older, larger fish increases concurrent with increases in juvenile abundance. However, a spatial mismatch may mediate that stressor; based on bottom trawl survey results, large increases of small fish occurred over the SEBS while larger fish occurred over the NBS (L. Britt, *pers commun.*). Other predators of Pacific cod include northern fur seals, Steller sea lions, various whale species, and tufted puffin.

Socioeconomic Processes

Catches of Pacific cod are the second largest in the Bering Sea & Aleutian Island (BSAI) region. Pacific cod accounted for 10% of the BSAI's FMP groundfish harvest and 93% of the total Pacific cod harvest in Alaska. The Pacific cod total allowable catch (TAC) is allocated to multiple sectors (fleets). CDQ entities receive 10% of the total BSAI quota. The largest sectoral allocation goes to the freezer longline CPs, which receive roughly 44% of the total BSAI cod quota (48.7% non-CDQ quota). While not an official catch share program, the Freezer longline CPs have formed a voluntary cooperative that allows them to form private contracts among members to distribute the sectoral allocation. The remaining large sectors are the trawl CPs, trawl CVs, the pot gear CVs and some smaller sideboard limits to cover the catch of Pacific cod while targeting other species. The CVs (collectively referred to as the inshore sector) make deliveries to shore-based processors, and catcher/processors process catch at-sea before going directly to the wholesale markets. Among the at-sea CPs, catch is distributed approximately three-quarters to the hook-and-line and one quarter to trawl. Prior to 2016 the inshore sector accounted for 25-30% of the total BSAI Pacific cod retained catch. Since 2016 this share has increased to 33-40%. In 2019, 46% of the retained catch was harvested by the hook and line sector 24% by the pot gear sector, and 30% by the trawl sector.

Retained catch of Pacific cod across all sectors decreased 10% to 196 thousand t in 2019 and was below the 2010-2014 average (Appendix Table 2.2.3a). The retained catch of the inshore sectors decreased 6% to 77.5 thousand t. The value of these deliveries (shoreside ex-vessel value) totaled $62.3 million in 2019, which was down 4% from 2018. Ex-vessel prices increased 5% to $0.42 per pound. Changes in ex-vessel prices over time generally reflect changes in the corresponding wholesale prices. Catch from the fixed

gear vessels (which includes hook-and-line and pot gear) typically receive a slightly higher price from processors because they incur less damage when caught. The fixed gear price premium has varied over time recently varying in the range of $0.03-$0.06 per pound. In 2019 the fixed gear price premium increased to $0.11 per pound.

The products made from BSAI Pacific cod had a first-wholesale value of $346.5 million in 2019, which was down from $458.8 million in 2018 and above the 2010-2014 average of $330 million (Appendix Table 2.2.3b). Revenues in recent years have remained high as prices increases offset decreases in as catch and production. The lower revenue in 2019 was the result of decreased first-wholesale prices for fillet and headed-and-gutted (H&G) Pacific cod products as well as decreases in volume. The average price of Pacific cod products in 2019 decreased 15% to $1.65. Head and gut (H&G) production is the focus of the BSAI processors but a significant amount of fillets are produced as well. H&G typically constitutes approximately 70%-80% of value and fillets approximately 10%-20% of value. Shoreside processors produce the majority of the fillets. Almost all of the at-sea sector's catch is processed into H&G. Other product types are not produced in significant quantities. At-sea head and gut prices tend to be about 20%-30% higher, in part because of the shorter period of time between catch and freezing, and in part because the at-sea sector is disproportionately caught by hook-and-line which yields a better price. The H&G price was down 14% to $1.60 per pound in 2019. Fillet prices decreased 5% in 2019 to $3.92 from 2018.

U.S. exports of cod are roughly proportional to U.S. cod production. More than 90% of the exports are H&G, much of which goes to China for secondary processing and re-export (Appendix Table 2.2.3c). China's rise as a re-processor is fairly recent. Between 2001 and 2011 exports to China have increased nearly 10 fold and continued to increase up to 2016. Since 2017 China's share of exports has declined slightly going from 55% in 2016 to 41% in 2019. The cod industry has largely avoided U.S. tariffs that would have a significant negative impact on them in the U.S.-China trade war. However, Chinese tariffs on U.S. products could inhibit growth in that market. Japan and Europe (mostly Germany and the Netherlands) are also important export destinations. Japan and Europe accounted for 12% and 22% of the export volume respectively. Approximately 35% of Alaska's cod production is estimated to remain in the U.S.. Because U.S. cod production is approximately 15% of global production and the BSAI is over 90% of U.S. production, the BSAI Pacific cod is a significant component of the broader global cod market. Strong demand and tight supply in 2017-2018 from the U.S. and globally contributed to increasing prices over this period. The Barents Sea quota was reduced by 13% 2018 and the global cod supply will remain constrained. Groundfish forum estimates for 2019 indicate global catches of Atlantic and Pacific cod will be reduced by approximately 100 thousand t. Markets may have incorporated these supply adjustments as export prices in 2019 have leveled off, decreasing slightly by 2% (Appendix Table 2.2.3c). A portion of the Russian catch of Pacific cod became MSC certified in Oct. 2019 which could put further downward pressure on prices going forward.

In order to examine participation trends for those communities substantially engaged in the commercial EBS Pacific cod fishery, commercial processing and harvesting data were analyzed. This community engagement analysis has been conducted for several groundfish stocks in Alaska as part of the Annual Community Engagement and Participation Overview (ACEPO). This is a new summary document that focuses on providing an overview of harvesting and processing sectors of identified highly engaged communities for groundfish and crab fisheries in Alaska. The analysis presented here is similar to that conducted for the ACEPO report but on the stock level rather than the community level. The analysis separates variables into two categories of fisheries involvement: commercial processing and commercial harvesting. Processing engagement is represented by the amount of landings and associated revenues from landings in the community, the number of vessels delivering in the community, and the number of processors in the community. Harvesting engagement is represented by: the landings, revenues associated with vessels owned by community residents, the number of vessel landings owned by residents in the

community, and the number of distinct resident vessel owners whose vessels made landings in any community. By separating commercial processing from commercial harvesting, the engagement indices highlight the importance of fisheries in communities that may not have a large amount of landings or processing in their community, but have a large number of fishers and/or vessel owners that participate in commercial fisheries who are based in the community. To examine the relative harvesting and processing engagement of each community, a separate principal components factor analysis (PCFA) was conducted each year for each category to determine a community's engagement relative to all other Alaska communities. Top communities were then selected for each sector based on the value and volume of EBS Pacific cod landed (for processing engagement) and value and volume harvested for harvesting engagement. To examine sustained participation in the commercial EBS Pacific cod fishery, engagement indices were calculated from 2000-2019. During that time period, four communities were identified as being substantially engaged in processing BSAI for at least one year. Only the At Sea processing sector emerged at Highly Engaged in processing BSAI Pcod, while Unalaska/Dutch Harbor appeared as Medium-High engagement. Harvesting engagement to some degree involved a number of communities; however Seattle MSA alone emerged as Highly Engaged (Table below of harvesting and processing engagement indices for BSAI Pacific cod from 2000-2019).

	Harvesting Engagement				Processing Engagement			
Community	Low	Medium	Med./High	High	Low	Medium	Med./High	High
Akutan	10	0	0	0	14	6	0	0
Anchorage	18	1	0	0	0	0	0	0
At Sea	0	0	0	0	0	0	0	20
Homer	19	1	0	0	0	0	0	0
Kodiak	6	14	0	0	10	0	0	0
Newport	12	8	0	0	0	0	0	0
Other WA	7	13	0	0	0	0	0	0
Petersburg	19	1	0	0	0	0	0	0
Seattle MSA	0	0	0	20	0	0	0	0
Unalaska/D.H.	20	0	0	0	5	14	1	0

Closer examination of At Sea and Unalaska/Dutch harbor processing engagement illustrates participation trends. In 2019, the total volume of BSAI Pcod processed in all communities was 419 million pounds with $102.4 million in landed value. One indication of community engagement in processing activities for the BSAI Pcod fishery is calculating volume landed as well as the associated value. In 2019, 73% of landed volume occurred At Sea. Several other communities accounted for smaller, but notable percentages of landed volume including Akutan, Adak, and Unalaska/Dutch Harbor. The number of processors landing BSAI Pcod has decreased since 2000 (down 34% or 38 plants); however the number of communities engaging in processing has increased to include False Pass, St. Paul, and Nome. Since 2000, At Sea processors decreased by 30 facilities (down 32%); while the number of processors in Unalaska/Dutch Harbor declined by 8 (down 67%).

Among the two most highly engaged regions: At Sea and Unalaska/Dutch Harbor, the volume processed At Sea increased in 2009 and continued to rise, reaching a peak in 2016 of 432 million pounds, and then beginning a steep decline, dropping by 26% (from 412 to 305 million pounds) by 2019. The associated value landed at At Sea remained relatively steady with the notable exceptions of jumps in 2008 (up 42%) and 2013 (up 87%) when the value landed bumped upward, only to fall back down the following year. In 2015, the value increased steadily until falling sharply by 67% in 2019 (down $108.2 million). Overall, Unalaska/Dutch Harbor processing engagement saw greater fluctuation since 2000, reaching a peak in volume in 2012 of 61.2 million pounds with an associated valued of $21.2 million, before starting a

steady decline. Between 2015 and 2019, Unalaska/Dutch Harbor's volume processed decreased by 43%, but the associated value only fell 9% (Appendix Figure 2.2.4a).

Within the BSAI Pacific cod harvesting sector, eight communities were identified as being substantially engaged and only the Seattle MSA (metropolitan statistical area) emerged as Highly Engaged (see Table above of harvesting and processing engagement indices for BSAI Pacific cod from 2000-2019). When comparing the past five year average value of BSAI Pcod harvested by vessels owned by community residents, Seattle MSA accounted for 63% of the harvest value and 65% of volume. In order to explore community participation in BSAI Pcod harvesting, the average value of harvest per vessel owned by residents from 2000 to 2019 was examined (Appendix Figure 2.2.4b). The average value Seattle MSA decreased by 23% (down $13 million) since 2000. Within the past five years, Seattle MSA's vessel's harvest average dropped by 28% (down $17 million). During the same time period, Unalaska/Dutch Harbor decreased 24% (down $404,500); however when comparing over the past 20 years, the community saw an overall increase in harvest value, from just under an average of $250,000 per vessel (2000) to $1.3 million per vessel (2019), an increase of 423%. Harvest value began to turn upward in 2005 in Unalaska/Dutch Harbor, climbing to a peak of $2.5 million in 2014 before slipping downward to $1.3 million (2019) (Appendix Figure 2.2.4b).

Indicators Assessment

We first provide information on how we selected the indicators for the third step of the ESP process and then provide results on the indicators analysis. In this indicator assessment a time-series suite is first created that represent the critical processes identified by the metric assessment. These indicators must be useful for the stock assessment process in that they are regularly updated, reliable, consistent, and long-term. The indicator suite is then monitored in a series of stages that are statistical tests that gradually increase in complexity depending on the data availability of the stock (Shotwell et al., *In Review*).

Indicator Suite

Previous research on mechanistic drivers of Pacific cod growth and survival can be divided by life stage: (i) eggs and larvae, (ii) juvenile, and (iii) adult. Eggs and larval stages are particularly vulnerable to abiotic forces such as temperature and salinity. Laboratory studies focused on temperature effects have demonstrated impacts to egg hatch success and larval size at hatching (Alderdice and Forrester, 1971; Laurel et al., 2008; Bian et al., 2014). Differential survival of eggs and early life stages has been linked to temperature effects on the lipid/fatty acid composition of eggs and unfed larvae (Laurel et al., 2012). The interactive effects of temperature and salinity can affect hatching characteristics and larval developmental rates (Bian et al., 2016). Post-hatch effects of temperature and light have been investigated with respect to the vertical movements of larvae (Hurst et al., 2009). Temperature-dependent growth rates have been observed in embryos, preflexion and postflexion larvae, and postsettlement juveniles (Hurst et al., 2010) while temperature-mediated growth and survival vary under varying prey regimes (match-mismatch hypothesis) (Laurel et al., 2011).

Assessment of cohort strength is first assessed at age-1 based on catch rates in the AFSC groundfish survey. As discussed above, age-0 fish are captured in annual surface trawl sampling (BASIS survey), however catch rates in this survey have not consistently reflected the recruitment estimated in the stock assessment (Hurst et al. 2012). This is likely due in part to the BASIS survey samples only a portion of the occupied habitat distribution, and may be exacerbated by shifting distributions under extended warm periods. Juvenile Pacific cod are also sensitive to temperature; range expansion/contraction of age-0 fish distributions has been linked to thermal regimes in the eastern Bering Sea (Hurst et al., 2012). Several factors, including temperature, light, and prey availability are thought to control the vertical distribution of juvenile Pacific cod (Davis and Ottmar, 2009). Temperature has also been shown to affect behavioral characteristics like swimming activity and habitat choice (Ottmar and Hurst, 2012). Age-0 prey quality

and quantity, and therefore energetic condition, impacts survival and recruitment success of Pacific cod (Farley et al., 2015). Fish condition (length-weight residuals of Pacific cod) is another proxy for prey availability (Brodeur et al., 2004).

Adult Pacific cod are susceptible to direct and indirect impacts of temperature. Direct impacts include effects on metabolic rate, swimming performance, and condition (Hanna et al., 2008a) as well as recovery time of adult Pacific cod (Hanna et al., 2008b). Marine heatwaves have shown to have both direct and indirect impacts on adult Pacific cod biomass (Cheung and Frölicher, 2020). In addition to demonstrated temperature effects, Pacific cod seem to benefit from decreased along-shelf and on-shelf flow (Vestfals et al., 2014). The strength of the Bering Slope Current is correlated with the North Pacific Index (NPI), such that weaker flows correlate with higher recruitment success of Pacific cod (Thompson, 2018a)

Environmental covariates were explored during the development of the 2018 eastern Bering Sea Pacific cod assessment. The following 14 indicators were initially evaluated; the top 6 listed below were then used in exploratory models.

1) North Pacific Index (Nov-Mar average)*
2) Benthic forager biomass*
3) Seabird breeding index*
4) Fish condition**
5) Bottom temperature**
6) Nutrition deficit**
7) Fur seal pups*
8) Ice retreat index (at mooring M2)*
9) Pelagic forager biomass*
10) Habitat impacted by trawls*
11) Euphausiid biomass*
12) Apex predator biomass*
13) Motile epifauna biomass*
14) Pollock**

*These indicators are (or were recently) presented in the eastern Bering Sea Ecosystem Status Report EBS Report Card and the timeseries are available online (https://access.afsc.noaa.gov/REFM/REEM/ecoweb/Index.php?ID=9).

**(1) The Fish condition index was derived from Boldt et al. 2018. (2) The Bottom temperature index was derived from bottom temperatures collected during the eastern Bering Sea bottom trawl survey. (3) The Nutrition deficit indicator was derived by the assessment author. Mean bottom temperature was chosen to represent an index of metabolic demand, and average of euphausiid biomass and age-1 pollock abundance was chosen to represent an index of prey supply (where all variables are represented as z-scores). The specific steps involved in constructing the nutrition deficit index are shown in Table 2.1.8 in (Thompson, 2018b). (4) The Pollock index for age-1 fish was derived from Table 28 of the 2017 EBS Pollock assessment (Ianelli et al., 2017)

The current EBS Pacific cod stock assessment includes the cold pool as a covariate in the estimation of the model-based survey estimates (VAST estimates) for the SEBS and NBS. Additionally, the suite of models explored for the EBS Pacific cod ensemble in September 2020 included development of models that used environmental covariates to provide mechanisms for the time-varying recruitment distribution and movement parameters of the various 2-area models. Seven potential environmental covariates of inter-area recruitment distribution and movement were explored, three versions of the cold pool, the NPI, sea ice extent (Thoman, 2020), benthic epifauna, and condition factor. Ultimately, the movement models using these covariates were not selected for the 2020 ensemble but the Plan Team and SSC suggested that the ESR and/or ESP provide further exploration into an index of movement for EBS Pacific cod to the NBS (e.g., evaluation of northernmost survey stations or of VAST model outputs such as the center of gravity).

We generated a suite of ecosystem and socioeconomic indicators using the mechanisms and tested relationships listed above from previous studies and the relevant ecosystem processes identified in the metric assessment (Appendix Table 2.2.2b, Appendix Figure 2.2.2). The following list of indicators for EBS Pacific cod is organized by categories, three for ecosystem indicators (physical, lower trophic, and upper trophic) and three for socioeconomic indicators (fishery performance, economic, and community) and provides information on whether the indicator was updated or new this year with references where possible. Time series of the ecosystem and socioeconomic indicators are provided in Appendix Figure 2.2.5a and Appendix Figure 2.2.5b, respectively.

Ecosystem Indicators:

1. Physical Indicators (Appendix Figure 2.2.5a.a-f)
    - North Pacific Index (NPI), November to March average: index is the area-weighted sea level pressure over the region 30°N-65°N, 160°E-140°W (Hurrell et al., 2020). The NPI is defined to measure interannual to decadal variations in the atmospheric circulation and depicts changes in the intensity of the Aleutian Low. The NPI is relevant to the Bering Sea because the strength of the Aleutian Low relates to wintertime temperatures, with a deeper low (negative SLP anomalies) associated with a greater preponderance of maritime air masses and hence warmer conditions. data available from 1899 to present (contact: E. Siddon, ESR).
    - Sea ice extent and advance: Daily sea ice extent for the Bering Sea was obtained from NSIDC (G02135_v3.0, https://nsidc.org/arcticseaicenews/sea-ice-tools/). The climatology of the daily sea-ice extent was computed for the period of 1981-2010 (following 30-year protocol for a climatology definition), and then daily anomalies relative to this mean were calculated for each day on the entire data period (1978-2020). The Bering Sea is ice free during the summer (June to October, with little sea ice cover in November), and has maximum sea ice cover in March. We then computed the seasonal mean of the sea-ice extent for two seasons: ice-advance season (December through February or DJF), and ice-retreat season (March through May or MAM) (contact: M. Wang).
    - Spring to summer (April-June) daily sea surface temperatures (SST) for the southeastern Bering Sea (10 m to shelf break (200 m) south of 60 degN) (Watson, 2020) from the NOAA Coral Reef Watch Program which provides the Global 5km Satellite Coral Bleaching Heat Stress Monitoring Product Suite Version 3.1, derived from CoralTemp v1.0. product (NOAA Coral Reef Watch, 2018), 1985 to present (contact: J. Watson).
    - Summer bottom temperature from the Bering Ecosystem Study Nutrient-Phytoplankton-Zooplankton (BESTNPZ) model for July through September (Kearney et al., 2020), averaged over the Bering Sea shelf region, data available from 1970 to present (contact: K. Kearney).
    - Peak timing of the spring bloom was calculated for the southeast Bering Sea (SEBS) region obtained from MODIS satellite sensor at a 4x4 km resolution and aggregated 8-day composites. Peak timing of the spring bloom was calculated for individual ADF&G statistical areas in the southeastern Bering Sea (SEBS) and for the eastern GOA (EGOA) region. For the EBS the peak timing was then averaged across all statistical areas in order to weight each stat area equally. This is to avoid giving inner shelf areas more weight since the chlorophyll a biomass is higher in those areas during the peak (Nielsen et al., 2020). The data are served through the ERDDAP maintained by NOAA CoastWatch West Coast Regional Node and Southwest Fisheries Science Center's Environment Research Division. Data available from 2003 to present (contact: J. Nielsen).
2. Lower Trophic Indicators (Appendix Figure 2.2.5a.g)
    - Summer euphausiid abundance is represented as the acoustic backscatter per unit area (sA at 120 kHz, m2 nmi-2) classified as euphausiids and integrated over the water column and then across the surveyed area to produce an annual estimate of acoustic abundance (sA * area, proportional to the total abundance of euphausiids). The index is for the eastern Bering Sea shelf survey area (Ressler et al., 2019), data available for variable years historically and biennially since 2012 (contact: P. Ressler)
3. Upper Trophic Indicators (Appendix Figure 2.2.5a.h-m)
    - Summer condition for juvenile (<460 mm) and adult (>=460mm) Pacific cod. Body condition was estimated using a length-weight relationship (Rohan and Laman, 2020)

from data collected randomly for otoliths in the eastern Bering Sea shelf bottom trawl survey, 1998 to present (contact: S. Rohan).

- Spatio-temporal delta-generalized linear mixed model using standard settings for an "index standardization" model (Thorson 2019), implemented using the package VAST (Thorson and Barnett 2017) in the R statistical environment (R Core Team 2017). This configuration includes spatial and spatio-temporal variation in two linear predictors of a Poisson-link delta model (Thorson 2018), using a gamma distribution for residual variation in positive catch rates. We specified a model with 500 "knots" while using the "fine_scale=TRUE" feature to conduct bilinear interpolation from the location of knots to the location of extrapolation-grid cells. For the extrapolation-grid, we used the Bering Sea grid that covers the spatial domain from which the bottom trawl survey randomizes sampling stations. Knots were distributed proportional to the spatial distribution of extrapolation-grid cells within this spatial domain. We calculated center of gravity as the biomass-weighted average of the location of extrapolation-grid cells (Thorson et al. 2016a) available as northings and eastings. We also calculated effective area occupied as the area required to contain the population at its average biomass (Thorson et al. 2016b). We used epsilon bias-correction to correct for retransformation bias (Thorson and Kristensen, 2016) (contact: J. Thorson).
- Arrowtooth flounder total biomass (metric tons) from the most recent stock assessment model (contact: K. Shotwell).

Socioeconomic Indicators:

1. Economic Indicators (Appendix Figure 2.2.5b.a-c)
    - Annual estimated real ex-vessel value measured in millions of dollars and inflation adjusted to 2019 USD (contact: B. Fissel).
    - Average real ex-vessel price per pound of EBS Pacific cod measured in millions of dollars and inflation adjusted to 2019 USD (contact: B. Fissel).
    - Annual estimated real revenue per unit effort measured in weeks fished and inflation adjusted to 2019 USD (contact: B. Fissel).
2. Community Indicators (Appendix Figure 2.2.5b.d-e)
    - The suite of community indicators are expressed as regional quotient (RQ) which is a measure of the importance of the community relative to all Alaska fisheries as calculated in pounds landed or revenue generated from specific fisheries. The RQ is calculated as the landings or revenue attributable to a community divided by the total landings or revenue from all communities and community groupings. Indicators of the annual RQ (expressed as percentage) for processing and harvesting revenue are evaluated for the highly engaged community of Unalaska, Dutch Harbor. Data were available from 2000-2019 for processing engagement and 2008 to 2019 for harvesting engagement (contact: S. Wise).

Indicator Monitoring Analysis

We provide the list and time-series of indicators (Appendix Figure 2.2.5) and then monitor the indicators using three stages of statistical tests that gradually increase in complexity depending on the stability of the indicator for monitoring the ecosystem or socioeconomic process and the data availability for the stock (Shotwell et al., *In Review*). At this time, we report the initial results of the first and second stage statistical tests of the indicator monitoring analysis for EBS Pacific cod. The third stage will require more indicator development and review of the ESP modeling applications.

Stage 1, Traffic Light Test:

The first stage of the indicator analysis is a simple traffic-light style assessment of the time series values (log-transformed where applicable) relative to one standard deviation from the long-term mean of the time series. Following recommendations from the SSC in Febuary 2020, we include a scoring calculation to this test. The indicator values are evaluated if they are greater than (+), less than (-), or within (•) one standard deviation of the long-term mean for the time series. A value is then provided for the traffic-light based on whether the indicator creates conditions that are good (1) or poor (-1) for EBS Pacific cod (Caddy et al., 2015). This is based on the conceptual model and associated processes tables. We then assign a simple score based on the value compared to the long term mean and the traffic light code. If a high value of an indicator generates good conditions for EBS Pacific cod and is also greater than one standard deviation from the mean, then that value receives a +1 score. If a high value generates poor conditions for EBS Pacific cod and is greater than one standard deviation from the mean, then that value receives a -1 score. All values less than or equal to one standard deviation from the long-term mean are average and receive a 0 score. The scores are summed by the three organizational categories within the ecosystem (physical, lower trophic, and upper trophic) or socioeconomic (fishery performance, economic, and community) indicators and divided by the total number of indicators available in that category for a given year. We also calculate the overall ecosystem and socioeconomic score and provide these aggregated scores for the past twenty years as the majority of indicators were available throughout this time period. The scores over time allow for comparison of the indicator performance and the history of stock productivity. Future iterations of this first stage test should recognize that these qualitative indicators represent sequential events through the life history and therefore stopping rules should be considered where a mortality event in the early life history could govern a year class (e.g., see the "switch model proposed for GOA pollock in 1996 in Megrey et al., 1996).

We evaluate the list of ecosystem indicators to understand the pressures on the EBS Pacific cod stock regarding recruitment, movement, and stock productivity. We start with the physical indicators and proceed through the increasing trophic levels as the indicators are listed above. The winter to spring NPI steadily decreased from 2011 to 2016 and then increased to very near the time series peak in 2018, was near average in 2019 and then peaked during the winter of 2019–2020 (Appendix Figure 2.2.5a.a). The NPI effectively represents the state of the Aleutian Low with higher values signifying high sea level pressure, warming sea surface tempeartures, higher precipitation, and increased downwelling (Weingartner, 2005). This can lead to earlier onset of stratification, which decreases the depth of the mixed layer and potentially a more intense and early spring bloom (Henson, 2007). In the Bering Sea, however, the intensity and timing of the spring bloom also depend on the timing of sea ice retreat. Early spring blooms have been observed in cold and average temperature years and also have varied considerably in the recent warm years of 2018-2020 (Eisner et al., 2020), implying several factors contribute to the timing of the spring bloom (e.g., springtime winds, L. Eisner, *pers. commun*.).

The extent of the sea ice during the ice advance season (Dec-Feb) decreased dramtically in 2014 and continued to decline to a time-series low in 2018, but increased somewhat in 2019 and 2020 (Appendix Figure 2.2.5a.b). Similarly the extent of sea ice during the ice retreat season (Mar-May) steadily decreased from a time-series high in 2012 to the time-series low in 2018, but did increase somewhat in 2020 to just below the time-series average (Appendix Figure 2.2.4a.c). The winter of 2018/2019 began with near-average accumulation of sea ice in the Bering Sea during December and January, but warm, moist winds from the southwest persisted throughout February and eroded sea ice to extremely low levels (only 2018 was lower). Trends in sea ice and resulting extent of the cold pool were similar between 2018 and 2019. Residual warmth in the fall of 2019 delayed sea ice formation into late winter 2019. Considerable cooling through winter (Dec-Feb) resulted in a rapid build-up of sea ice and the spatial extent reached near-normal limits, even exceeding median ice extent over the Bering Sea shelf in parts of February and March 2020. However, the sea ice concentration (i.e., thickness) was low, and retreated quickly when southerly spring winds brought warm air over the shelf. The low and high of ice extent in

either the advance or retreat season seem to mark the last two large recruitments of EBS Pacific cod, suggesting that sea ice extent likely does not relate directly to recruitment for this stock, but rather to movement during spawning and potentially influence subsequent match/mismatch with the spring bloom.

Spring to summer surface temperatures have increased steadily since 2012 to 2020, with a time series high in 2019, somewhat mirroring the sea ice extent (Appendix Figure 2.2.5a.d). The Bering Sea shelf appears to be highly mixed as surface shelf temperatures are highly correlated with summer bottom temperatures (Appendix Figure 2.2.5a.e). However, the bottom temperature appeared to cool faster in 2020 than the surface temperature. Bottom water temperatures also indicate that the cold pool extent was average for 2020 with slightly more <2°C water and slightly less <0°C water. In terms of summer spatial patterns for the cold pool, 2020 is similar to 1995, 1997, 2000, and 2011. Considering the evolution of bottom temperatures between November through August, 2020 most closely resembles 1997. Both years were preceded by a warm year, with almost no water <2°C at the start of the preceding winter. Throughout the winter, <2°C water increased and remained above average into late summer. The <0°C water followed a similar pattern through May, but then dropped rapidly through summer (Siddon, 2020). The cold pool is currently used as a covariate in the model-based (VAST) survey estimates for EBS Pacific cod and clearly has a large impact on the distribution of the stock.

Spring bloom timing over the shelf appears to be highly variable throughout the majority of the time series but anomalously stable from 2013 to 2016 during the marine heatwave years (Appendix Figure 2.2.5a.f). The timing was average or very high (i.e., late bloom) during the two most recent high recruitment events for EBS Pacific cod. The bloom timing also varies spatially with blooms occurring earlier in the inner domain to later in the outer domain (J. Nielsen, *pers. commun.*). A match or mismatch with larvae of the EBS Pacific cod stock would likely depend on where the primary spawning was occurring from year to year and thus seems dependent on movement. In 2018, warm water temperatures and salinity north of St. Lawrence Island may have contributed to northward movement of EBS Pacific cod into the NBS (Eisner et al., 2019). With warm conditions persisting through winter 2018/2019, it is possible that EBS Pacific cod remained in the NBS or were able to move northward early in the spring/summer of 2019, thereby continuing their expanded range and habitat use into the NBS.

For the lower trophic level, the euphausiid abundance index (Appendix Figure 2.2.5a.g) has steadily dropped from a high in 2009 to a low in 2016 and only moderate increase in 2018 but still low for the time-series, similar to the Gulf of Alaska euphausiid index (Ressler, 2018, 2019; Kimmel et al., 2020). The 2019 year class may have encountered higher abundances of euphausiids in spring and late summer (Kimmel at al., 2020). It is possible that the survival of planktivorous seabirds in the Bering Sea may serve as a proxy for zooplankton productivity in the region. Short-tailed shearwaters are planktivorous birds that feed on euphausiids. A widespread die-off event of these shearwaters began in the southeastern Bering Sea in June 2019 and extended into the NBS and Chukchi Sea in August 2019. These events may also reflect 2018 conditions as shearwaters feed in the Bering Sea in summer before migrating to the southern hemisphere for breeding during the winter. Most sampled birds showed signs of emaciation. The 2018 year class was sampled using surface trawls in the southern and NBS as age-0 in late summer 2018. These fish represent pre-settlement fish and their correlation with year class strength is unknown. However, age-0 fish in the SEBS were large (based on length) (Siddon et al., 2019) and age-0 fish in the NBS had higher total energy in 2018 compared to 2017 (Sewall et al., 2019). No direct observations of prey dynamics were available for the 2020 year class of EBS Pacific cod due to survey cancellations in response to COVID-19.

For the upper trophic level, condition of juvenile (<=46 cm) and adult (>46 cm) EBS Pacific cod (based on length-weight residuals) decreased steadily from 2003 and 2004 through 2009 and has been mostly variable since that time with moderate condition for the 2013 year class and moderate condition from 2018 to 2019. Additionally, juvenile Pacific cod condition in the NBS was above average from 2018 to 2019 and adult condition was above average in 2019 (Rohan and Laman, 2020). This suggests that both juvenile and adult Pacific cod were able to find sufficient prey resources potentially more so in the NBS

in recent years. Again, no direct observations were available for prey of junvenile or adult EBS Pacific cod for 2020 due to survey cancellations in response to COVID-19. However, an indirect measure of benthic productivity can be taken from gray whales that feed primarily on benthic amphipods in the Bering, Chukchi, and Beaufort seas. An Unusual Mortality Event was declared for gray whales in 2019 (see Savage, 2019) and preliminary findings in several of the whales in 2019 and 2020 show evidence of emaciation. The 2020 (2019) strandings may reflect 2019 (2018) conditions (prior to their migration) of poor feeding or competition for limited prey resources and/or indicate thresholds in the carrying capacity of the NBS ecosystem coincident with northward movement of Pacific cod into the region.

The area occupied and center of gravity (COG) estimates provide information on the spread and the location of the EBS Pacific cod population (Appendix Figure 2.2.5a.j-l). COG eastings and northings suggest that the population has move steadily more west and north from 2012 to 2018 with an east and south shift in 2019. The northings COG is highly correlated with the extent of sea ice during the ice retreat season (Mar-May) and may relate to movement of the population into the NBS in recent years. Area occupied seems to be contracting from the beginning of the time series to about 2005 where the population begins to expand again with somewhat average area occupied during the two most recent high recruitment years. The area occupied being somewhat stable combined with the northwest movement of the population in recent years suggests that EBS Pacific cod are moving northwest rather than expanding. Arrowtooth flounder biomass has steadily increased over the time series but has stabilized since 2009 (Appendix Figure 2.2.5a.m). At this time there are no indicators that suggest populations of other predators of EBS Pacific cod are increasing in the eastern Bering Sea (although note that the Bogoslof Island population of northern fur seals is increasing while the Pribilof Islands populations are decreasing, see Kuhn et al., 2019).

For the socioeconomic indicators (Appendix Figure 2.2.5b.a-c), exvessel value, price, and revenue per unit effort are all highly correlated. There was an increasing trend from the start of the time series until 2008 with a large drop in 2009 and then a steadily increasing trend to 2019, with a large projected decrease in value and price in 2020. The increases from 2009 seem to be concurrent with the overall northward movement of the stock from the COG northings indicator (Appendix Figure 2.2.5a.k). Processing regional quotient (RQ) in Unalaska/Dutch Harbor appears to be on a decreasing trend overall, with an increase in 2018 and return to low RQ in 2019. Harvesting RQ seems to be somewhat opposite the processing RQ with an increasing trend through 2017 and return to average RQ in 2018 and 2019.

Traffic light scores by category and overall are provided in Appendix Table 2.2.4. Overall, ecosystem indicators have been decreasing since 2009 and have shown some modest recovery since 2017 when the heat in the system was reduced, similar to the GOA Pacifc cod stock (Figure 2.2.6). For the indicators available in the current year, the traffic light analysis shows improved condition in the physical indicators, and stable in the upper trophic indicators. This is a change from 2019 where physical indiators were largely negative. It should be noted that only 7 of the potential 13 indicators were available this year for the ecosystem indicators (Appendix Table 2.2.5a). Overall, socioeconomic indicators have been largely stable since 2012. Also note only 2 of the potential 6 were available this year for the socioeconomic indicators (Appendix Table 2.2.4b). No community indicators were available this year as that information data lags the current year by at least one year. We also provide the direction of the current year score from the previous year score for these categories with arrows on the conceptual model graphic for quick reference (Figure 2.2.2).

Stage 2, Regression Test:

Bayesian adaptive sampling (BAS) was used for the second stage statistical test to quantify the association between hypothesized predictors and EBS Pacific cod recruitment and to assess the strength of support for each hypothesis. BAS explores model space, or the full range of candidate combinations of predictor variables, to calculate marginal inclusion probabilities for each predictor, model weights for each combination of predictors, and generate Bayesian model averaged predictions for outcomes (Clyde

et al., 2011). In this second test, the full set of indicators is first winnowed to the predictors that could directly relate to recruitment and highly correlated covariates are removed (Appendix Figure 2.2.7a). We further restrict potential covariates to those that can provide the longest model run and through the most recent estimate of recruitment that is well estimated in the current operational stock assessment model. This results in a model run from 1985 through the 2018 estimate of age 0 or the 2018 year-class. We then provide the mean relationship between each predictor variable and log EBS Pacific cod recruitment over time (Appendix Figure 2.2.7b, left side), with error bars describing the uncertainty (95% confidence intervals) in each estimated effect and the marginal inclusion probabilities for each predictor variable (Appendix Figure 2.2.7b, right side). A higher probability indicates that the variable is a better candidate predictor of EBS Pacific cod recruitment. The highest ranked predictor variable (inclusion probability > 0.5) based on this process was the spring summer sea surface temperature index on the shelf (Appendix Figure 2.2.7).

The BAS method requires observations of all predictor variables in order to fit a given data point. This method estimates the inclusion probability for each predictor, generally by looking at the relative likelihood of all model combinations (subsets of predictors). If the value of one predictor is missing in a given year, all likelihood comparisons cannot be computed. When the model is run, only the subset of observations with complete predictor and response time series are fit. It is possible to effectively "trick" the model into fitting all years by specifying a 0 (the long-term average in z-score space) for missing predictor values. However, this may bias inclusion probabilities for time series that have more zeros and result in those time series exhibiting low inclusion probability, independent of the strength of the true relationship. Due to this consideration of bias, we only fit years with complete observations for each covariate at the longest possible time frame. This resulted in a smaller final subset of covariates. We plan to explore alternate model runs (e.g., biennial) to potentially include more covariates in the future. Also, as noted above, Megrey et al. (1996) found that a critical step in multi-variate statistical searches of processes governing recruitment required that the analysts considered the temporal sequence of mortality events. Temporal sequencing of mortality events will be considered in future versions of this statististical approach. Additionally, efforts to include mortality switches could be informed by the planned Individual Based Models (IBM)s for Gulf of Alaska Pacific Cod.

Stage 3, Modeling Test:

In the future, highly ranked predictor variables could be evaluated in the third stage statistical test, which is a modeling application that analyzes predictor performance and estimates risk probabilities within the operational stock assessment model. A multi-species statistical catch-at-age assessment model (known as CEATTLE; Climate- Enhanced, Age-based model with Temperature-specific Trophic Linkages and Energetics; Holsman et al., 2016) has recently been developed for understanding trends in age 1 total mortality for walleye pollock, Pacific cod, and arrowtooth flounder from the EBS (Holsman et al., 2020). Total mortality rates are based on residual mortality inputs (M1), model estimates of annual predation mortality (M2), and fishing mortality (F). CEATTLE for the southeastern Bering Sea has recently been implemented in Template Model Builder (Kristensen et al., 2015) to allow for the fitting of multiple sources of data, time-varying selectivity, time-varying catchability, and random effects. The model is based, in part, on the parameterization and data used for the most recent stock assessment model of each species (Ianelli et al., 2019, Thompson et al., 2019, and Spies et al., 2019). The model is fit to data from five fisheries and seven surveys, including both age and length composition assumed to come from a multinomial distribution. Model estimates of M2 are empirically driven by bioenergetics-based consumption information and diet data from the EBS to inform predator-prey suitability. The most recent model was fit to data from 1979 to 2020 and showed evidence of continued decline in predation mortality on age-1 EBS Pacific cod, pollock, and arrowtooth flounder. The warm temperatures in this system continue to lead to high metabolic (and energetic) demand of predators; however, declines in total predator biomass may be contributing to an overall decline in total consumption and therefore reduced

predation rates and mortality. This pattern may also explain recent increases in recruitment of EBS Pacific cod in 2020 (Holsman et al., 2020).

The EBS CEATTLE model can provide gap free estimates of predation mortality that could be tested in the operational stock assessment model. Additionally, the time series of bioenergetics-based consumption input to the model could be used to compare to condition indicators from the surveys for context on recent condition trends. The spring and summer sea surface temperature index could be used directly to help explain the variability in recruitment deviations and predict pending recruitment events for EBS Pacific cod. Also, the sea ice extent during the ice retreat period or simply the center of gravity northings from the VAST model could be used as covariates in future versions of the movement model.

Recommendations

The EBS Pacific cod ESP follows the standardized framework for evaluating the various ecosystem and socioeconomic considerations for this stock (Shotwell et al., *In Review*). Given the metric and indicator assessment we provide the following set of considerations:

Ecosystem Considerations

- Pacific cod tagged in the northern Bering Sea (NBS) in summer and fall move to the NBS slope region as sea ice advanced in January to March and also to the Gulf of Alaska or Russian waters
- Hatch timing and success is highly temperature dependent with optimal hatch occurring in waters between 4-6°C and has implications for spawning habitat suitability and subsequent recruitment
- High temperatures combined with low energy content prey may lead to reduced summer growth potential (based on bioenergetics) during warm years in the southeastern Bering Sea (SEBS)
- Spatial mismatch of large Pacific cod in the NBS and smaller Pacific cod in the SEBS may mediate impacts of cannibalism on juvenile Pacific cod
- Sea ice extent during the ice advance and retreat season has steadily decreased since 2014 with moderate increase in extent in 2020 which has implications for movement and spawning
- A rapid build-up of sea ice occurred after late winter 2020, but sea ice concentration (i.e., thickness) was low, and retreated at a faster rate than the previous 5 years after June.
- Spring summer surface and bottom temperatures are closely linked in the SEBS and have been steadily increasing since 2012, but a decoupling seems to have occurred in 2020
- The euphausiid index has been steadily decreasing since 2009 and remained low in the most recent surveys, but condition of juvenile Pacific cod in 2018 and 2019 suggests sufficient prey
- Condition for adult Pacific cod in the SEBS has been moderate to low since 2008 but condition in the NBS has been above average from 2017 to 2019
- Center of gravity estimates suggest the Pacific cod population has moved north and west since 2012 with an east and south shift in 2019, with a fairly stable area occupied over this time
- Arrowtooth flounder biomass has steadily increased over the time series but has stabilized since 2009, but other predator populations appear steady
- 2019/2020 gray whale UME and 2019 shearwater seabird die-off event could reflects poor feeding conditions in the NBS during 2018/2019
- Overall, ecosystem indicators have been decreasing since 2009 and have shown some modest recovery since 2017 when the heat in the system was reduced, similar to the GOA Pacifc cod
- Highest ranked predictor for recruitment regression model was spring and summer sea surface temperature on the SEBS shelf (inclusion probability > 0.5)

Socioeconomic Considerations

- Unalaska/Dutch Harbor was selected as medium to highly engaged community when evaluating commercial processing and harvesting engagement relative to all other Alaska communities

- Ex-vessel value, price per pound and revenue per unit effort are highly correlated and show an increasing trend to 2008, drop in 2009, and steadily increasing to 2019
- Processing regional quotient (RQ) in Unalaska/Dutch Harbor has an overall decreasing trend with spike in 2018, while harvesting RQ has an increasing trend through 2017 and average in 2018/19

Data Gaps and Future Research Priorities

While the metric and indicator assessments provide a relevant set of proxy indicators for evaluation at this time, there are certainly areas for improvement. The majority of indicators collected for EBS Pacific cod have a fair number of gaps due to the biennial nature of survey sampling in the GOA. This causes issues with updating the ESP and the ecosystem considerations during off-cycle years and can lead to difficulty in identifying impending shifts in the ecosystem that may impact the EBS Pacific cod population. Development of high-resolution remote sensing (e.g., regional surface temperature, transport estimates, primary production estimates) or climate model indicators (e.g., bottom temperature, NPZ variables) would assist with the current multi-year data gap for several indicators if they sufficiently capture the main trends of the survey data and are consistently and reliably available.

The EBS CEATTLE model might also allow for a gap-free index of predation mortality and bioenergetics indices for EBS Pacific cod. An updated set of indicators may then be used in the second and third stage modeling applications that provide direction of relationships, inclusion probabilities, and evaluation of performance and risk within the operational stock assessment model.

The AFSC continues investigating environmental regulation of 1st year of life processes in Pacific cod to better understand the interrelationship between processes occurring during pre-settlement (spawning/larvae), settlement (summer growth) and post-settlement (1st overwintering) phases. Work is underway to develop a spawning habitat index for Pacific cod, analogous to that for the GOA, based on refined bottom temperature measurements and ROMS model output. This research will characterize spatial and temporal changes in spawning habitat in the EBS and its importance for larval phenology, advection, and survival. Transport processes and connectivity between larval and juvenile nursery areas will continue to be an important area of research as the Regional Oceanographic Model (ROMS) for the Bering Sea is updated.

We currently lack an indicator of predation on YOY Pacific cod during their first autumn and winter, during a period when predation mortality is thought to be significant. Sampling of predator diets in fall and winter would help to fill this gap. Additionally, evaluating condition and energy density of juvenile and adult Pacific cod samples at the outer edge of the population may be useful for understanding the impacts of shifting spatial statistics such as center of gravity and area occupied. Information is available from the GulfWatch Alaska program that could be helpful for evaluating the eastern edge of the EBS Pacific cod population.

As indicators are improved or updated, they may replace those in the current set of indicators to allow for refinement of the BAS model and potential evaluation of performance and risk within the operational stock assessment model. This could be accomplished in the next full ESP assessment and the timing of that will depend on how the ESP process matures.

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Tables

Appendix Table 2.2.1: List of data sources used in the ESP evaluation. Please see the main EBS Pacific cod SAFE document, the Ecosystem Considerations Report (Siddon et al., 2019, Zador et al., 2019) and the Economic Status Report (Fissel et al., 2019) for more details.

Title	Description	Years	Extent
EcoFOCI Spring Survey	Shelf larval survey in spring on the eastern Bering Sea shelf using oblique 60 cm bongo tows, fixed-station grid, catch per unit effort in numbers per 10 m^2	1978 – present	Eastern Bering Sea annual, biennial
AFSC Summer Survey	Midwater trawl survey of groundfish and forage fish from August-September using Stauffer trawl and bongo tows in the eastern Bering Sea shelf, fixed-station grid	2000 – present	Eastern Bering Sea biennial
AFSC Bottom Trawl Survey	Bottom trawl survey of groundfish in June through August, eastern Bering Sea using Poly Nor'Eastern trawl on stratified random sample grid, catch per unit of effort in metric tons	1982 – present	Eastern Bering Sea annual
AFSC Acoustic Survey	Mid-water acoustic survey in March in Eastern Bering Sea for pre-spawning pollock and again in summer for age 1 pollock	1981 – present	Eastern Bering Sea annual, biennial
Seabird Surveys	Ecological monitoring for status and trend of suite of seabird species conducted by Institute for Seabird Research and Conservation	1978 – present	Bering Sea, Aleutian Islands
REEM Diet Database	Food habits data and associated analyses collected by the Resource Ecology and Ecosystem Modeling (REEM) Program, AFSC on multiple platforms	1990 – present	Eastern Bering Sea annual
Coral Reef Watch Program	NOAA Coral Reef Watch Program, Global 5km Satellite Coral Bleaching Heat Stress Monitoring Product Suite Version 3.1, derived from CoralTemp v1.0. product (NOAA Coral Reef Watch, 2018)	1985 – present	Global
MODIS	4 km MODIS ocean color data aggregated 8-day composites.	2003-present	Global
ROMS/NPZ Model Output	Coupled hydrographic Regional Ocean Modeling System and lower tropic Nutrient-Phytoplankton-Zooplankton dynamics model	1996 – 2013	Alaska variable

Appendix Table 2.2.1 (cont.): List of data sources used in the ESP evaluation. Please see the main EBS Pacific cod SAFE document, the Ecosystem Considerations Report (Siddon et al., 2019, Zador et al., 2019) and the Economic Status Report (Fissel et al., 2019) for more details.

Title	Description	Years	Extent
Essential Fish Habitat Models	Habitat suitability MaxEnt models for describing essential fish habitat of groundfish and crab in Alaska, EFH 2016 Update	1970 – 2016	Alaska
FMA Observer Database	Observer sample database maintained by Fisheries Monitoring and Analysis Division	1988 – present	Alaska annual
NMFS Alaska Regional Office	Catch, economics, and social values for fishing industry, data processed and provided by Alaska Fisheries Information Network	1992 – 2018	Alaska annual
Reports & Online	ADFG Commercial Operators Annual Reports, AKRO At-sea Production Reports, Shoreside Production Reports, FAO Fisheries & Aquaculture Department of Statistics	2011 – 2018	Alaska, U.S., Global annual

Appendix Table 2.2.2a: Ecological information by life history stage for EBS Pacific cod

Stage	Habitat & Distribution	Phenology	Age, Length, Growth	Energetics	Diet	Predators/Competitors
Recruit	Shore to Shelf (0-500 m), depth varies by age then size(24), sublittoral-bathyal zone, move w/in, between LMEs(24)	Recruit to survey and fishery age-1, length 20-27 cm(24)	Max: 25 yrs, 147♀/134♂ cm L_inf=94 cm, K= 0.2 (24,AFSC)		Opportunistic, small on inverts, large on fish(20, 21, 24, AFSC)	Halibut, Steller sea lions, whales, tufted puffins, fisheries(24); shelf groundfish(24)
Spawning	Shelf (40-290 m)(13-16,24), semi-demersal in shelf areas(13,15,16), seasonal migrations variable duration(26)	Winter-spring, peak mid-March, 13 wks (1,20,25)	1st mature: 2 yr, 26♀/36♂cm, 50%: 4-5yr, 46-65cm (24,AFSC)	Oviparous, high fecundity (250-2220·10^3) eggs (13,15), range 4-6 °C(14,16)	Opportunistic (20,21)	Halibut, Steller sea lions, whales, tufted puffins, fisheries(24); shelf groundfish(24)
Egg	Shelf (20-200 m), demersal, adhesive eggs(13,15-17,24)	Incubation is ~20 days, 6 wks(14,22)	Egg size: 0.98-1.08 mm (28)	Optimal incubation 3-6°C, 13-23 ppt, 2-3ppm dO_2 (27)	Yolk is dense and homogenous (AFSC)	
Yolk-sac Larvae	Epipelagic, nearshore shelf, coastal, upper 45 m, semi-demersal at hatching(13-15,18,24)	Spring, peak mid May, 14 wks(22,29)	3-4.5 mm NL at hatch (13-15,24,28)	Hatch temperature 4.5-5.8°C(2)	Endogenous	Share larval period with pollock(13)
Feeding Larvae	Epipelagic, nearshore shelf(13-15,24), 0-45 m (24)	Late spring, April – June, (22	25-35 mm SL at transformation (3,13-15,24)	1-2 weeks before onset of feeding(28,29)	Copepod eggs, nauplii, and early copepodite stages (Strasburger et al. 2014)	Share larval period with pollock(13)
Juvenile	Nearshore (2-110 m), 15-30 m peak density, inside bays, coastal, mixed, structural complexity (1-6,10,11,21)	Nearshore settlement in June, deeper water migrations in October(3,10,13-15)	YOY: 35-110 mm FL(2), age 1+: 130-480 mm FL(1,3,4,6,10); growth sensitive to temp	Energy density ↑ with length, lower in pelagic stage,	Copepods, mysids, amphipods(2), small fish(10), crabs(19-21)	Pollock, halibut, arrowtooth flounder(19,20); macroalgae, eelgrass, structural inverts, king crab, skate egg case, juvenile pollock (1-5,7-9,11)
Pre-Recruit	Nearshore, shelf (10-216 m)(4), inside bays, coastal, mixed, mud, sand, gravel, rock pebble(1,2,4,6)	Age-2 may congregate more than age-1(25)	Begin to mature age 2-3, 480-490 mm FL (15)	Energy density and condition lower than in pelagic stage	Opportunistic, benthic invert, pollock, small fish, crabs(19-21)	Pacific cod, halibut, salmon, fur seal, sea lion, porpoise, whales, puffin(24); macroalgae, macroinvertebrate, king crab, skate egg case(4-5,7-9)

Appendix Table 2.2.2b. Key processes affecting survival by life history stage for EBS Pacific cod.

Stage	Processes Affecting Survival	Relationship to EBS Pacific cod
Recruit	1. Competition 2. Predation 3. Temperature	Increases in main predator of Pacific cod would be negative but minor predators may indicate Pacific cod biomass increase. Increases in overall prey biomass would be positive for Pacific cod but generalists.
Spawning	1. Ice Dynamics 2. Spawning Habitat Suitability 3. Distribution	Temperatures outside the 3-6 C range contribute to poor hatching success and may impact physiological and behavioral aspects of spawning. Spring bottom temperatures outside this range are linked to observed pre-recruits and recruitment estimates(27)
Egg	1. Temperature(14,18,29,30)	Eggs are highly stenothermic(27)
Yolk-sac Larvae	1. Temperature(14,18,29,30) 2. Timing of spring bloom(13) 3. Onshore shelf transport(13,31,32)	Increases in temperature would increase metabolic rate and may result in rapid yolk-sac absorption that may lead to mismatch with prey. Current direction to preferred habitat would be positive for Pacific cod.
Feeding Larvae	1. Temperature(14,18,29,30) 2. Prey availability 3. Onshore shelf transport(13,31,32)	Increases in temperature would increase metabolic rate and may result in poor condition if feeding conditions are not optimal. Onshore transport to nursery habitat would be positive for Pacific cod while predation increases would be negative.
Juvenile	1. Competition(33) 2. Predation(33) 3. Temperature(34)	Evidence of density-dependent growth in coastal nurseries(33) would suggest that increases in competitors or predators would be negative for Pacific cod condition and therefore survival. Temperature increases may amplify risk of food availability and energy allocation(34)
Pre-Recruit	1. Competition(33) 2. Predation(33) 3. Temperature(34)	Evidence of density-dependent growth in coastal nurseries(33) would suggest that increases in competitors or predators would be negative for Pacific cod condition and therefore survival. Temperature increases may amplify risk of food availability and energy allocation(34)

Appendix Table 2.2.3a. Bering Sea & Aleutian Islands Pacific cod catch and ex-vessel data. Total and retained catch (thousand metric tons), number of vessel, catcher/processor (CP) hook-and-line (H&L) share of catch, CP trawl share of catch, Shoreside retained catch (thousand metric tons), shoreside number of vessel, shoreside pot gear share of catch, shoreside trawl share of catch, shoreside ex-vessel value and price (million US$), and fixed gear to trawl price premium (US$ per pound); 2010-2014 average and 2015-2019.

	Avg 10-14	2015	2016	2017	2018	2019
Total catch K mt	228.52	242.1	260.9	253	220.3	197.9
Retained catch K mt	224.1	239.0	257.7	250.1	218.0	195.8
Vessels #	168.4	150	162	173	193	196
CP H&L share of BSAI catch	51%	54%	49%	50%	46%	45%
CP trawl share of BSAI catch	16%	15%	14%	13%	14%	13%
Shoreside retained catch K mt	67.7	68.4	86.0	88.0	82.5	77.5
Shoreside catcher vessels #	116.4	101	110	128	144	149
CV pot gear share of BSAI catch	12%	13%	15%	17%	19%	22%
CV trawl share of BSAI catch	18%	16%	18%	18%	18%	17%
Shoreside ex-vessel value M $	$38.2	$34.1	$44.6	$54.1	$65.1	$62.3
Shoreside ex-vessel price lb $	$0.278	$0.248	$0.264	$0.316	$0.399	$0.418
Shoreside fixed gear ex-vessel price premium	$0.03	$0.06	$0.04	$0.05	$0.06	$0.11

Appendix Table 2.2.3b. Bering Sea & Aleutian Islands Pacific cod first-wholesale market data. First-wholesale production (thousand metric tons), value (million US$), price (US$ per pound); fillet and head and gut volume (thousand metric tons), value share, and price (US$ per pound); At-sea share of value and at-sea shoreside price difference (US$ per pound); 2010-2014 average and 2015-2019.

		Avg 10-14	2015	2016	2017	2018	2019
All products	volume K mt	111.82	120.47	126.40	119.54	107.41	94.97
All products	Value M $	$ 330.7	$ 365.0	$ 388.3	$ 434.7	$ 458.8	$ 346.5
All products	price lb $	$ 1.34	$ 1.37	$ 1.39	$ 1.65	$ 1.94	$ 1.65
Fillets	volume K mt	7.23	6.28	10.03	10.01	10.36	8.02
Fillets	value share	14%	10%	19%	19%	21%	20%
Fillets	price lb $	$ 2.86	$ 2.67	$ 3.37	$ 3.70	$ 4.12	$ 3.92
Head & Gut	volume K mt	91.55	100.82	98.68	92.38	79.04	70.25
Head & Gut	value share	79%	83%	72%	74%	71%	72%
Head & Gut	price lb $	$ 1.30	$ 1.36	$ 1.29	$ 1.57	$ 1.86	$ 1.60
At-sea	value share	72%	76%	69%	70%	64%	67%
At-sea	price premium ($/lb)	-$0.07	$0.07	-$0.32	-$0.33	-$0.51	-$0.36

Appendix Table 2.2.3c. Cod U.S. trade and global market data. Global production (thousand metric tons), U.S. share of global production, and Europe's share of global production; U.S. export volume (thousand metric tons), value (million US$), and price (US$ per pound); U.S. cod consumption (estimated), and share of domestic production remaining in the U.S. (estimated); and the share of U.S. export volume and value for head and gut (H&G), fillets, China, Japan, and Europe; 2010-2014 average and 2015-2019.

		Avg 10-14	2015	2016	2017	2018	2019
Global cod catch K mt		1,631	1,762	1,789	1,761	1,633	-
U.S. P. cod share of global catch		18.5%	18.0%	18.0%	16.9%	14.2%	-
Europe share of global catch		74.7%	74.8%	74.9%	75.9%	78.3%	-
Pacific cod share of U.S. catch		97.8%	99.3%	99.5%	99.5%	99.7%	-
U.S. cod consumption K mt (est.)		97	108	114	118	114	106
Share of U.S. cod not exported		29%	26%	29%	32%	36%	37%
Export volume K mt		103.8	113.2	105.3	92.8	73.1	65.1
Export value M US$		$325.2	$335.0	$312.0	$295.5	$253.4	$218.1
Export price lb US$		$1.421	$1.342	$1.344	$1.445	$1.571	$1.519
Frozen (H&G)	volume Share	81%	91%	94%	94%	91%	92%
	value share	81%	90%	92%	92%	90%	91%
Fillets	volume Share	7%	3%	3%	4%	5%	5%
	value share	9%	4%	4%	5%	6%	6%
China	volume Share	44%	53%	55%	52%	48%	41%
	value share	41%	51%	52%	50%	46%	40%
Japan	volume Share	17%	13%	14%	16%	15%	12%
	value share	17%	14%	15%	18%	17%	13%
Europe*	volume Share	27%	19%	17%	17%	16%	22%
	value share	29%	19%	18%	18%	18%	23%

Note: Pacific cod in this table is for all U.S. unless noted, `cod' in this table refers to Atlantic and Pacific cod. Russia, Norway, and Iceland account for the majority of Europe's cod catch which is largely focused in the Barents sea.

*Europe export statistics refers to: Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom.

Source: NMFS Alaska Region Blend and Catch-accounting System estimates; NMFS Alaska Region At-sea and Shoreside Production Reports; and ADF&G Commercial Operators Annual Reports (COAR). Data compiled and provided by the Alaska Fisheries Information Network (AKFIN). FAO Fisheries & Aquaculture Dept. Statistics http://www.fao.org/fishery/statistics/en. NMFS Alaska Region Blend and Catch-accounting System estimates. NOAA Fisheries, Fisheries Statistics Division, Foreign Trade Division of the U.S. Census Bureau, http://www.st.nmfs.noaa.gov/commercial-fisheries/foreign-trade/index. U.S. Department of Agriculture http://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set.aspx.

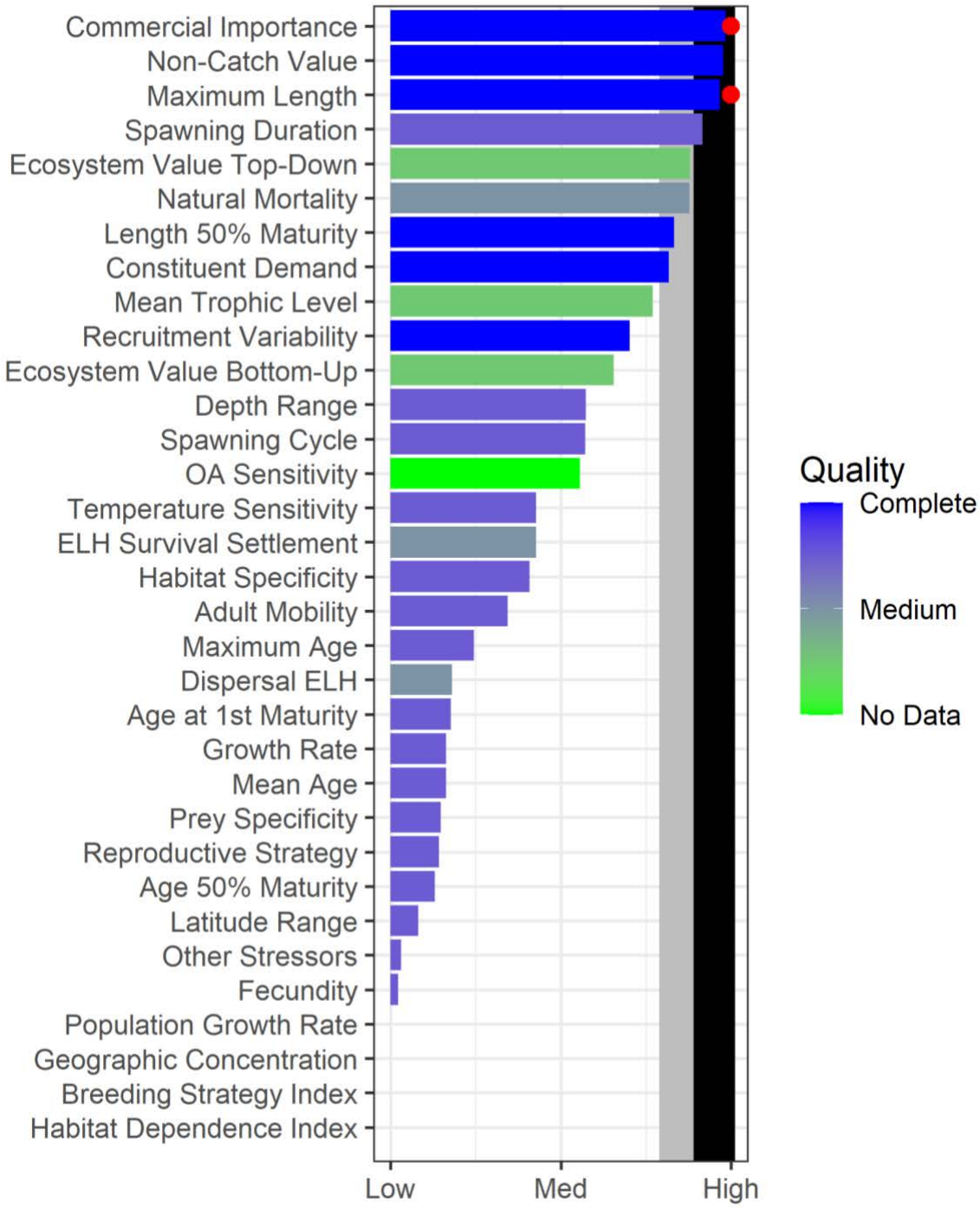
Appendix Table 2.2.4a. First stage ecosystem indicator score analysis for EBS Pacific cod by four main categories (physical, lower trophic, upper trophic, and overall ecosystem). Each indicator is scored based on the traffic light evaluation for that indicator (1 if a positive value increase creates good conditions for EBS Pacific cod, -1 if positive increase create poor conditions for EBS Pacific cod), multiplied by the value relative to the long-term mean of the time series (greater than, less than, or within 1 standard deviation). Those scores are summed by category and then divided by the total number of indicators for that category. Number of indicators for each category are also provided. NA = no indicators available. Color coding based on column, blue = 1 shading through white = 0 shading through red = -1.

	Physical		Lower Trophic		Upper Trophic		Total Ecosystem	
Year	Score	# Indicators	Score	# Indicators	Score	# Indicators	Score	# Indicators
2000	0.20	5	0.00	0	-0.17	6	0.00	11
2001	-0.20	5	0.00	0	0.00	6	-0.09	11
2002	0.20	5	0.00	0	-0.17	6	0.00	11
2003	-0.67	6	0.00	0	0.00	6	-0.33	12
2004	0.00	6	0.00	1	-0.17	6	-0.08	13
2005	-0.17	6	0.00	0	-0.33	6	-0.25	12
2006	0.17	6	0.00	1	-0.17	6	0.00	13
2007	0.17	6	0.00	1	0.00	6	0.08	13
2008	0.67	6	1.00	1	-0.17	6	0.31	13
2009	0.83	6	1.00	1	-0.17	6	0.38	13
2010	0.50	6	0.00	1	0.00	6	0.23	13
2011	0.17	6	0.00	0	0.00	6	0.08	12
2012	0.83	6	0.00	1	-0.17	6	0.31	13
2013	0.50	6	0.00	0	0.17	6	0.33	12
2014	0.00	6	0.00	1	0.17	6	0.08	13
2015	-0.17	6	0.00	0	0.00	6	-0.08	12
2016	-0.33	6	-1.00	1	0.00	6	-0.23	13
2017	-0.50	6	0.00	0	-0.50	6	-0.50	12
2018	-0.33	6	0.00	1	-0.33	6	-0.31	13
2019	-0.83	6	0.00	0	0.00	6	-0.42	12
2020	0.00	6	0.00	0	0.00	1	0.00	7

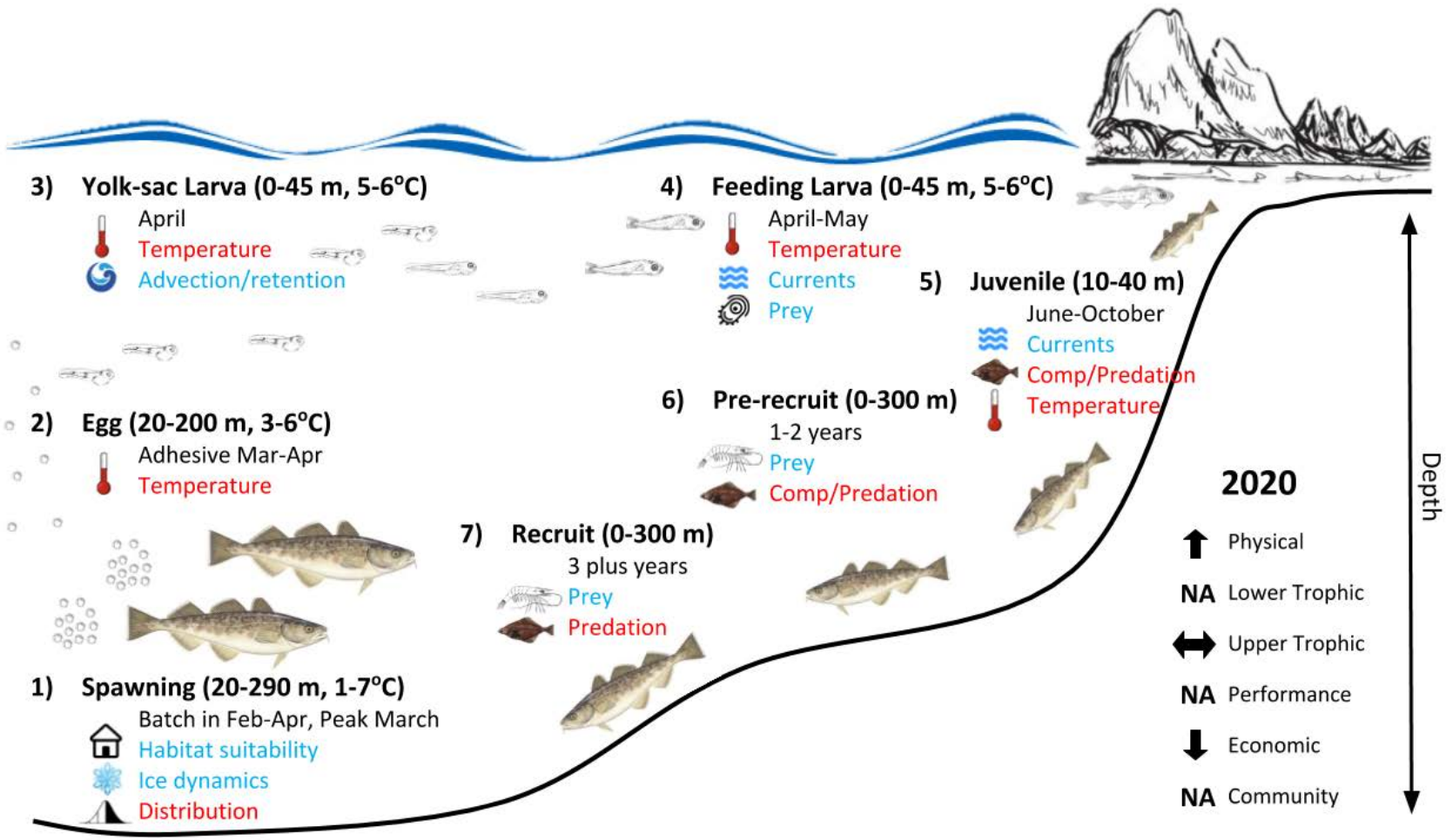
Appendix Table 2.2.4b. First stage socioeconomic indicator score analysis for EBS Pacific cod by four main categories (performance, economic, community, and overall socioeconomic). Each indicator is scored based on the traffic light evaluation for that indicator (1 if a positive value increase creates good socioeconomic environment for EBS Pacific cod, -1 if positive increase create poor conditions for EBS Pacific cod), multiplied by the value relative to the long-term mean of the time series (greater than, less than, or within 1 standard deviation). Those scores are summed by category and then divided by the total number of indicators for that category. Number of indicators for each category are also provided. NA = no indicators available. Color coding based on column, blue = 1 shading through white = 0 shading through red = -1.

	Fishery Performance		Economic		Community		Total Socioeconomic	
Year	Score	# Indicators	Score	# Indicators	Score	# Indicators	Score	# Indicators
2000	NA	NA	0.00	0	1.00	1	1	1
2001	NA	NA	0.00	0	0.00	1	0	1
2002	NA	NA	0.00	0	0.00	1	0	1
2003	NA	NA	0.00	3	0.00	1	0	4
2004	NA	NA	-0.33	3	0.00	1	-0.25	4
2005	NA	NA	0.00	3	0.00	1	0	4
2006	NA	NA	1.00	3	1.00	1	1	4
2007	NA	NA	0.67	3	1.00	1	0.75	4
2008	NA	NA	1.00	3	0.50	2	0.8	5
2009	NA	NA	-1.00	3	-1.00	2	-1	5
2010	NA	NA	-0.33	3	0.00	2	-0.2	5
2011	NA	NA	-0.33	3	0.00	2	-0.2	5
2012	NA	NA	0.00	3	0.00	2	0	5
2013	NA	NA	0.00	3	0.00	2	0	5
2014	NA	NA	0.00	3	0.50	2	0.2	5
2015	NA	NA	0.00	3	-0.50	2	-0.2	5
2016	NA	NA	0.00	3	0.00	2	0	5
2017	NA	NA	0.00	3	0.00	2	0	5
2018	NA	NA	0.67	3	0.00	2	0.4	5
2019	NA	NA	0.33	3	-0.50	2	0	5
2020	NA	NA	0.00	2	0.00	0	0	2

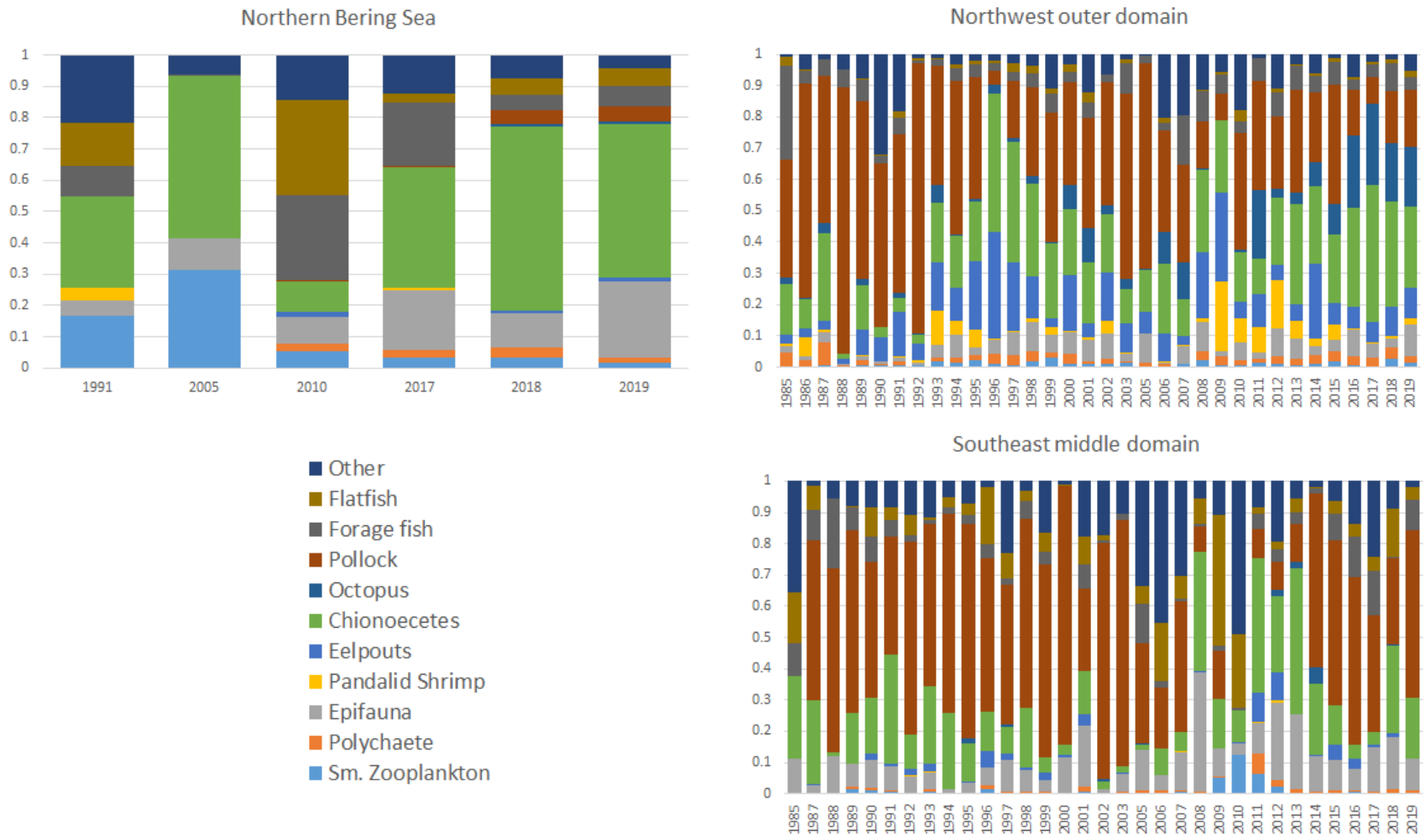
Figures



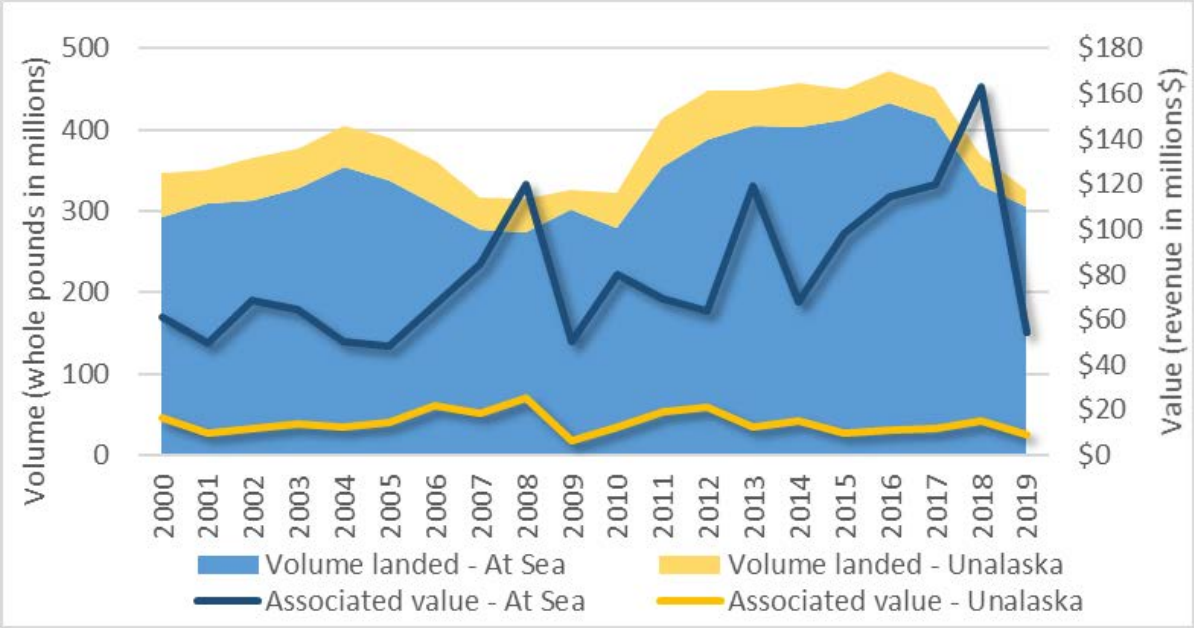
Appendix Figure 2.2.1. Baseline metrics for EBS Pacific cod graded as percentile rank over all groundfish in the FMP. Black bar indicates 90th percentile, gray bar indicates 80th percentile for all groundfish in Alaska. Red dots indicates value passes a national threshold for vulnerability. Higher rank values indicate a vulnerability and color of the horizontal bar describes data quality of the metric (see Shotwell et al., *In Review*, for more details on the metric definitions and thresholds).



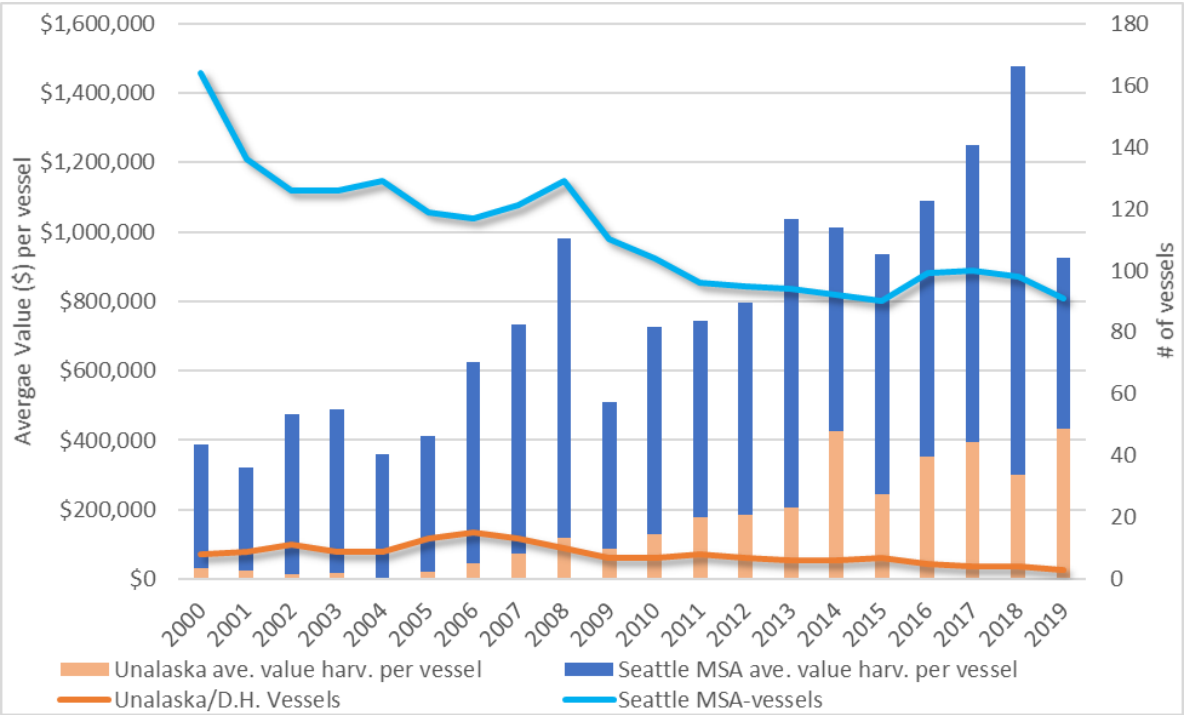
Appendix Figure 2.2.2: Life history conceptual model for EBS Pacific cod summarizing ecological information and key ecosystem processes affecting survival by life history stage. Red text means increases in process negatively affect survival, while blue text means increases in process positively affect survival. Trend of current year value compared to last year's value depicted with arrows on the right. NA means no indicators for that category.



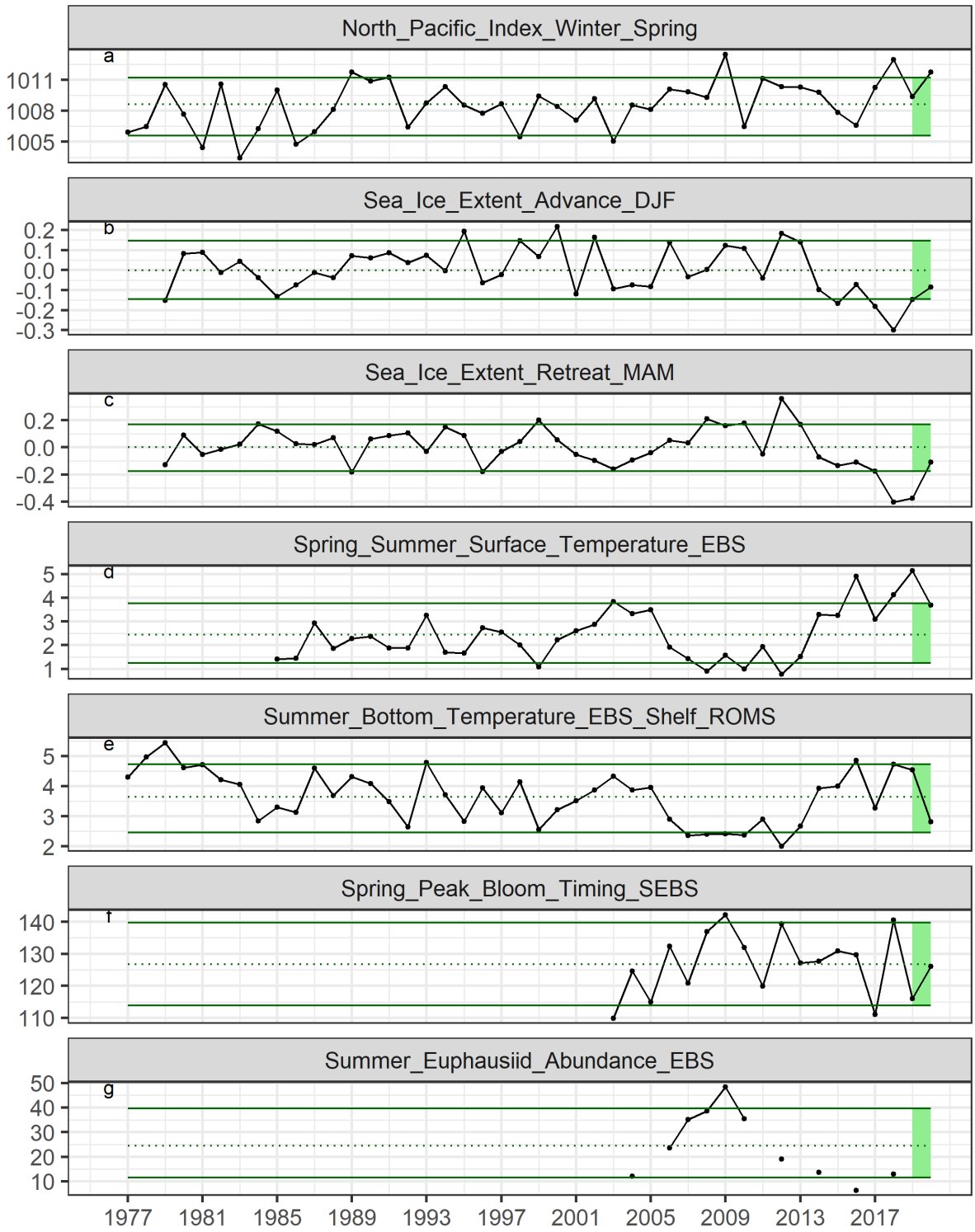
Appendix Figure 2.2.3: Diet proportions (proportion by weight) of eastern Bering Sea Pacific cod with fork lengths of 60+cm, by survey stratum, as sampled from Alaska Fisheries Science Center summer bottom-trawl surveys (reproduced from Aydin, 2020).



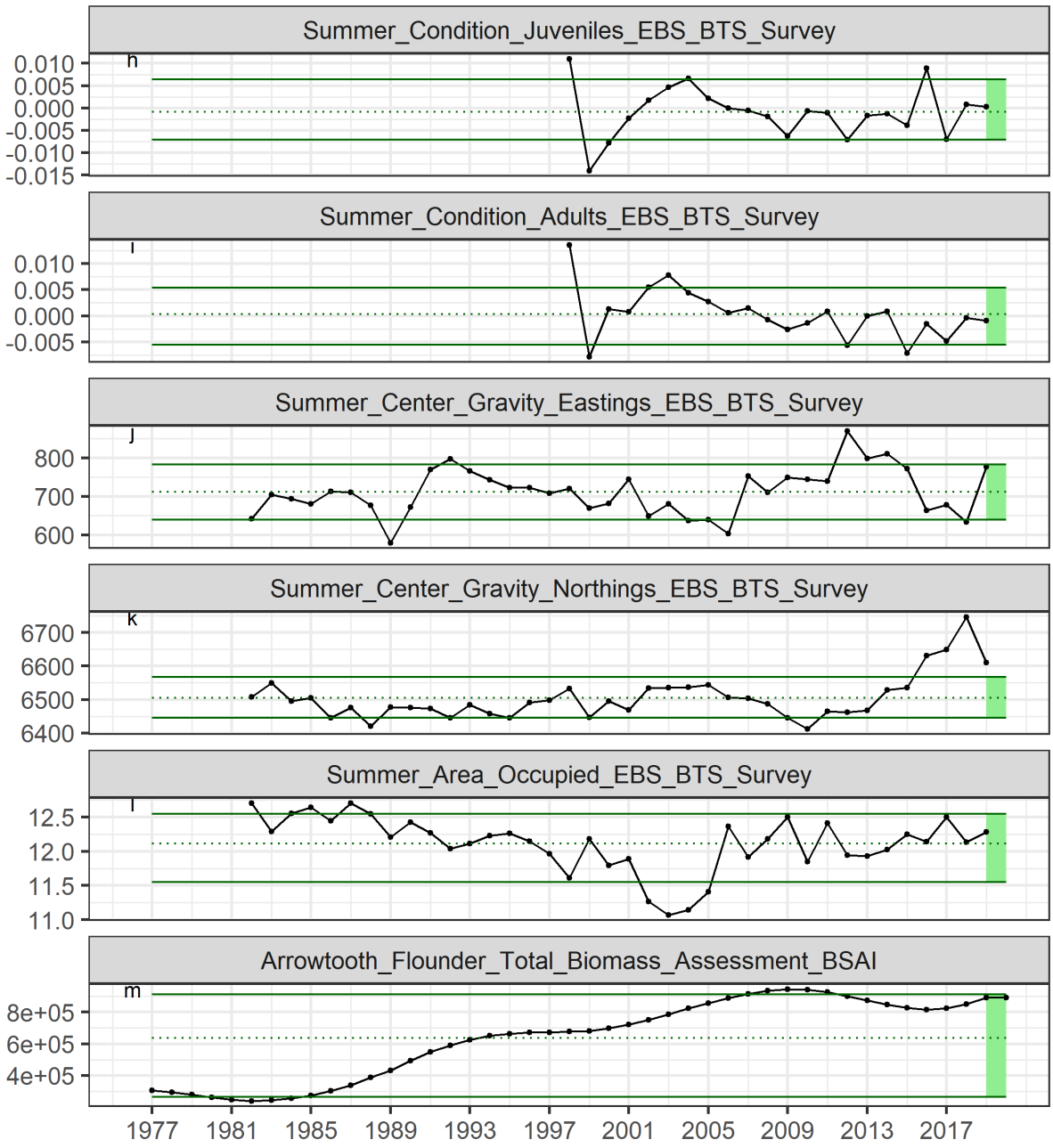
Appendix Figure 2.2.4a: Processing engagement: volume BSAI Pcod and value landed At Sea and in Unalaska/Dutch Harbor (2000-2019).



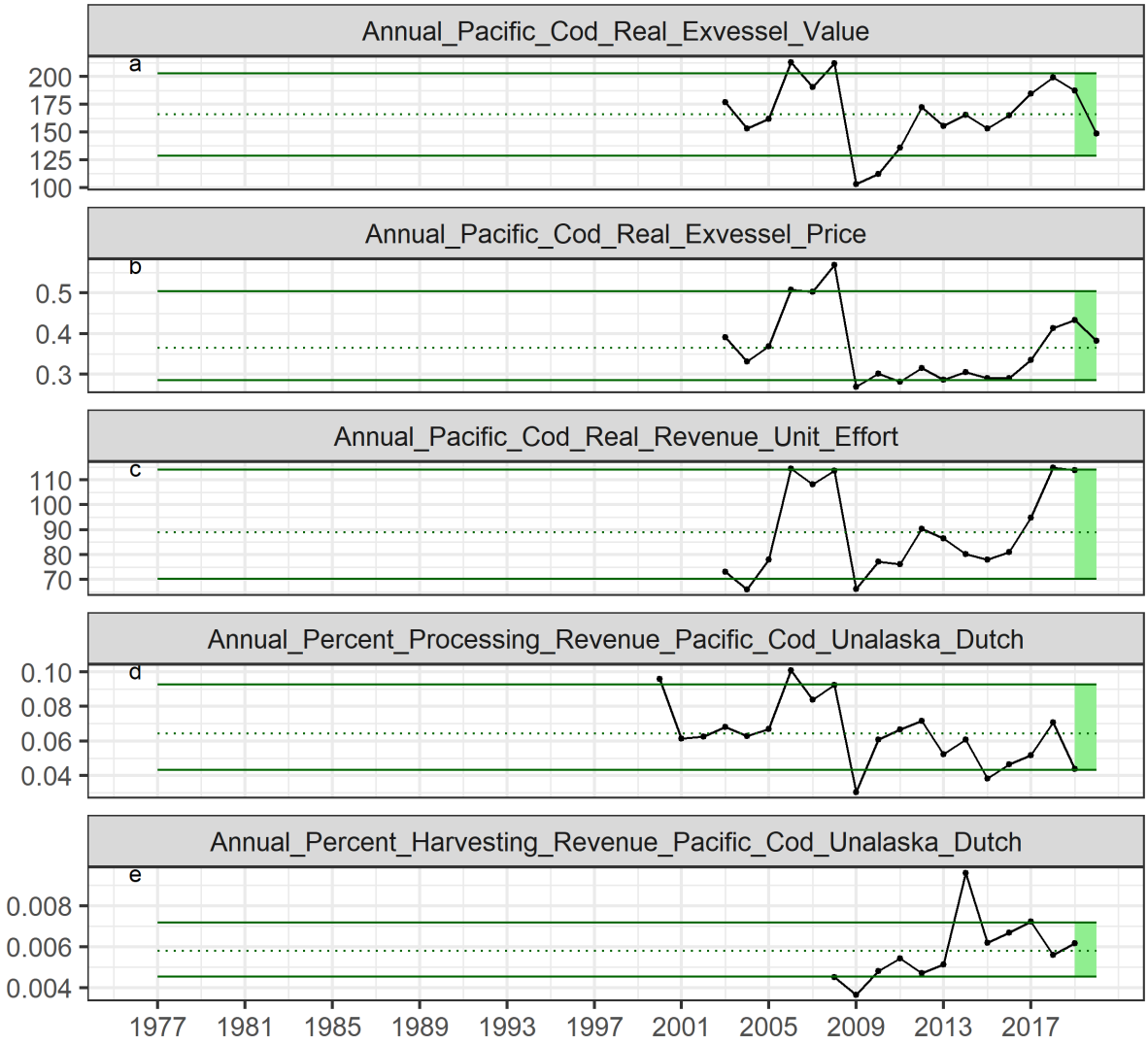
Appendix Figure 2.2.4b: Harvesting engagement: Average value of BSAI Pcod harvested by vessels owned by residents (2000-2019).



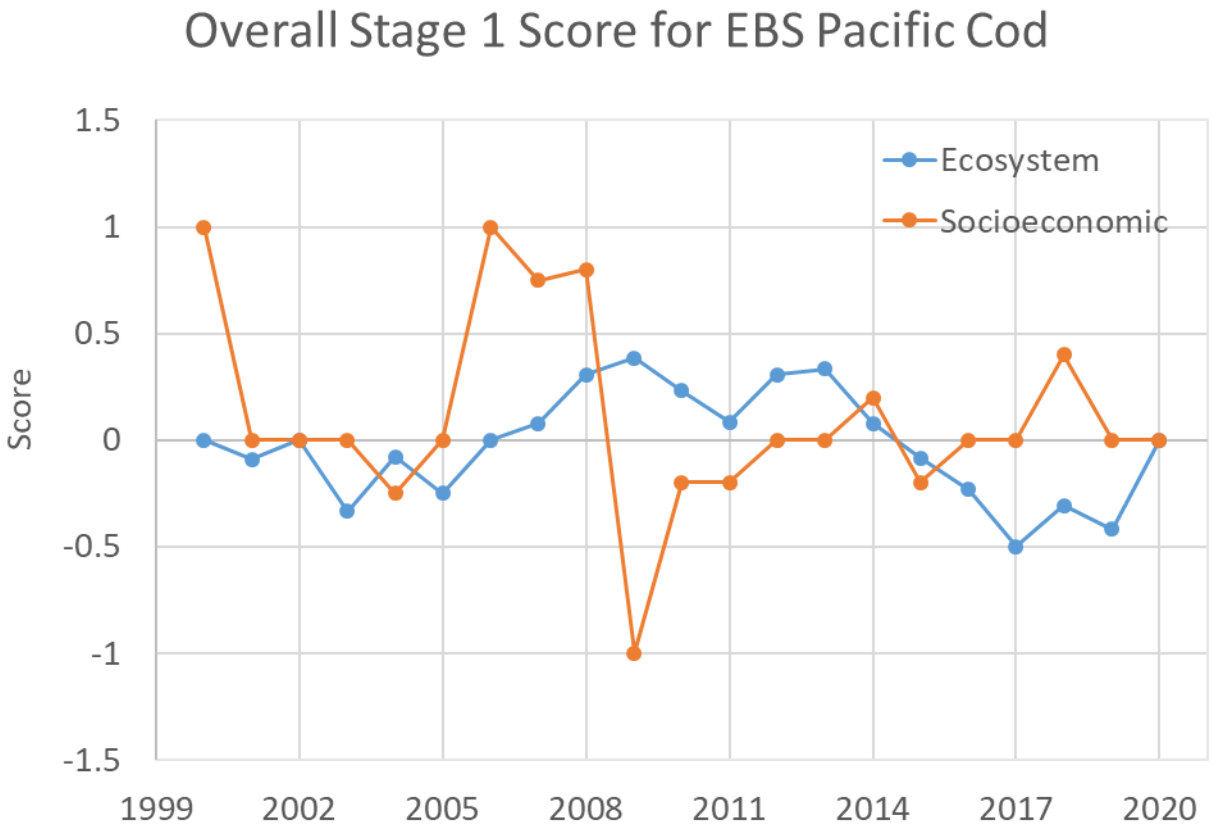
Appendix Figure 2.2.5a. Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is mean of time series. Light green shaded area represents most recent year for traffic light analysis.



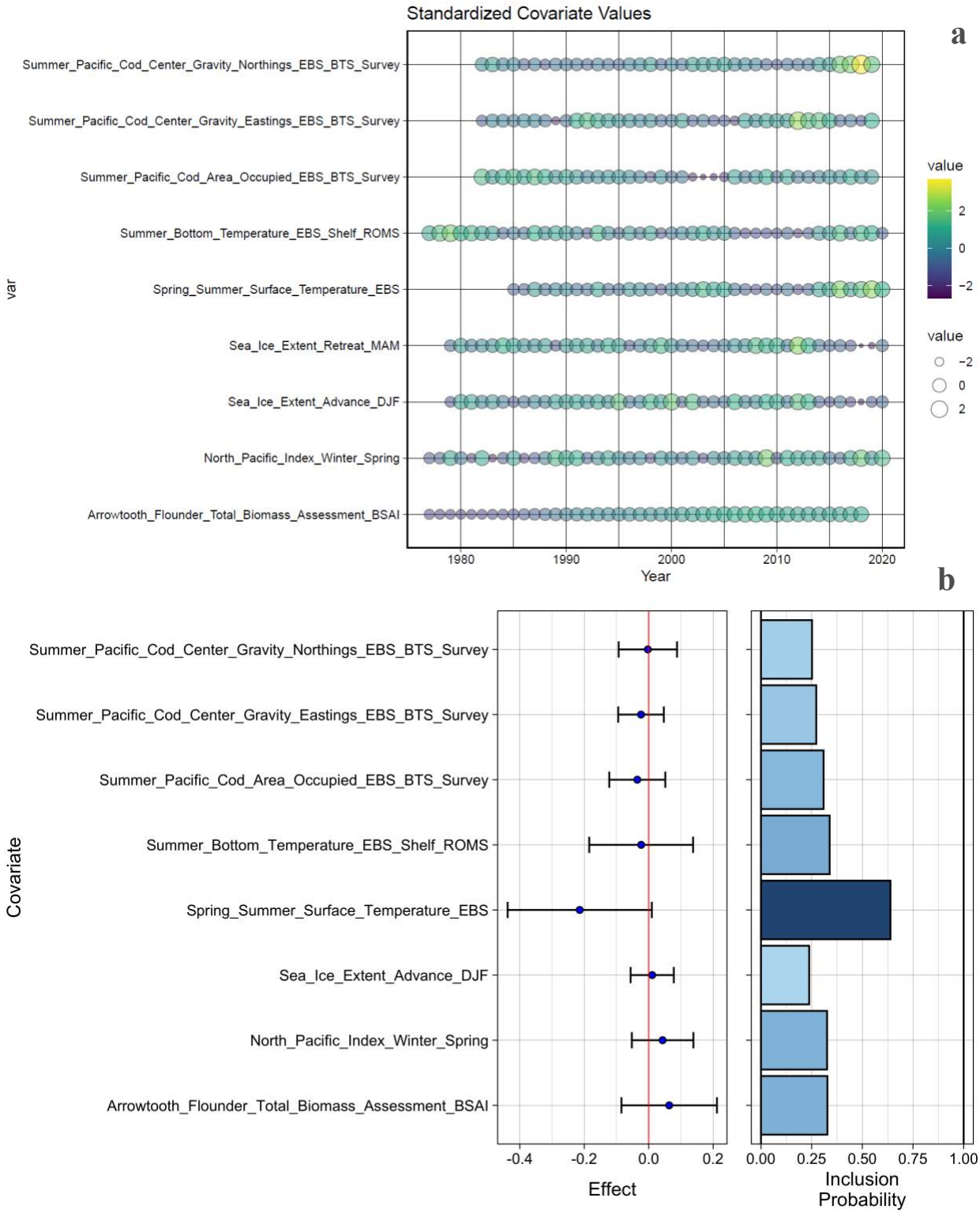
Appendix Figure 2.2.5a (cont.). Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is mean of time series. Light green shaded area represents most recent year for traffic light analysis.



Appendix Figure 2.2.5b. Selected socioeconomic indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is mean of time series. Light green shaded area represents most recent year for traffic light analysis.



Appendix Figure 2.2.6: Simple traffic light score for overall ecosystem and socioeconomic categories from 2000 to present.



Appendix Figure 2.2.7: Bayesian adaptive sampling output showing (a) standardized covariates prior to subsetting and (b) the mean relationship and uncertainty (95% confidence intervals) with log EBS Pacific cod recruitment, in each estimated effect (left bottom graph), and marginal inclusion probabilities (right bottom graph) for each predictor variable of the subsetted covariate set.

APPENDIX 2.3: HISTORY OF PREVIOUS EBS PACIFIC COD MODEL STRUCTURES DEVELOPED UNDER STOCK SYNTHESIS

For 2005 and beyond, the SSC's accepted model from the final assessment is shown in **bold red**.

Pre-2005

Timeline

- Pre-1985: Simple projections of current survey numbers at age
- 1985: Projections based on 1979-1985 survey numbers at age
- 1986-1991: *ad hoc* separable age-structured FORTRAN model
- 1992: FORTRAN-based Stock Synthesis (SS), with age-based data
    - Strong 1989 cohort "disappears;" production ageing ceased
- 1993-2003: Models continued to be developed using SS, with length-based data only
- 2001: CIE review of code for proposed "ALASKA" (Age-, Length-, and Area-Structured Kalman Assessment) model and methodology for decision-theoretic estimation of OFL and ABC
    - Although review was favorable, use of ALASKA was postponed "temporarily"
- 2004: Models continued to be developed using SS, with length- *and* age-based data
    - New age data, based on revised ageing protocol
    - Agecomp data used in "marginal" form

Main features of the early Stock Synthesis EBS Pacific cod models

- Start year = 1977
- Three seasons (Jan-May, Jun-Aug, Sep-Dec)
- Four fisheries (Jan-May trawl, Jun-Dec trawl, longline, pot)
- *M* constant at 0.37
- *Q* constant at 1.00
- Efforts at internal estimation of *M*, *Q* unsuccessful
- Double-logistic selectivity for all fleets (fisheries and survey)
- No fleets constrained to exhibit asymptotic selectivity
- Sizecomp input sample size = square root of true sample size
- Survey index standard deviations set to values reported by RACE Division

2005

This assessment marked the first application of ADMB-based Stock Synthesis to EBS Pacific cod

Three models were included:

- Model 1 was identical to the 2004 final model (configured under FORTRAN-based SS), except for use of new maturity schedule developed by Stark
- **Model 2** was configured under ADMB-based SS, and was designed to be as close as possible to Model 1 given the limitations of the respective software packages, except:
    - Nonuniform priors used throughout
    - *M* fixed at 0.37, *Q* fixed at 1.00
- Model 3 was identical to Model 2 except that *M* and *Q* were estimated internally

Weight-length and length-age data examined for evidence of sexual dimorphism; none found.

2006

Nine models were included, consisting of 2005 final model and a 3-way factorial design of alternative models (the factorial models all differed from the 2005 final model in that they estimated trawl survey *Q*

internally—in the 2005 final model, it was fixed at 1.0; and they estimated all selectivity parameters except for selectivity at the minimum size bin internally—in the 2005 final model, a few selectivity parameters were fixed externally):

- Model 0 was identical to 2005 final model
- Model A1 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double logistic selectivity
    - Prior emphasis = 1.0
- Model A2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double logistic selectivity
    - Prior emphasis = 0.5
- **Model B1** was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double normal (four parameter) selectivity
    - Prior emphasis = 1.0
- Model B2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double normal (four parameter) selectivity
    - Prior emphasis = 0.5
- Model C1 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double logistic selectivity
    - Prior emphasis = 1.0
- Model C2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double logistic selectivity
    - Prior emphasis = 0.5
- Model D1 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double normal (four parameter) selectivity
    - Prior emphasis = 1.0
- Model D2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double normal (four parameter) selectivity
    - Prior emphasis = 0.5

2007

Technical workshop
SS introduced a six-parameter form of the double normal selectivity curve (the previous version used only four parameters). This functional form is constructed from two underlying and linearly rescaled normal distributions, with a horizontal line segment joining the two peaks. As configured in SS, the equation uses the following six parameters:

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

6. *final_selectivity* (at maximum length/age)

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

Model 0 was prepared ahead of workshop:

- *M* estimated internally
- Length-at-age parameters estimated internally
- Disequilibrium initial age structure
- Regime shift recruitment offset estimated internally
- Start year changed from 1964 to 1976
- New six-parameter double normal selectivity function used
- Prior distributions reflect 50% CV for most parameters

Twenty-one other models were prepared ahead of workshop, each of which was based on Model 0:

- Two models to examine inside/outside growth estimation:
    - Model 1 was identical to Model 0 except length-at-age parameters estimated outside the model
    - Model 2 was identical to Model 0 except standard deviation of length at age 12 estimated internally
- Two models to examine *M* conditional on *Q,* vice-versa:
    - Model 3 was identical to Model 0 except *M* fixed at 0.37 and *Q* free
    - Model 4 was identical to Model 0 except *Q* fixed at 0.75 and *M* free
- Six models to examine effects of prior distributions:
    - Model 5 was identical to Model 0 except 30% CV instead of 50%
    - Model 6 was identical to Model 0 except 40% CV instead of 50%
    - Model 7 was identical to Model 0 except emphasis = 0.2 instead of 1.0
    - Model 8 was identical to Model 0 except emphasis = 0.4 instead of 1.0
    - Model 9 was identical to Model 0 except emphasis = 0.6 instead of 1.0
    - Model 10 was identical to Model 0 except emphasis = 0.8 instead of 1.0
- Four models to examine effects of asymptotic selectivity:
    - Model 11 was identical to Model 0 except Jan-May trawl fishery selectivity forced asymptotic
    - Model 12 was identical to Model 0 except longline fishery selectivity forced asymptotic
    - Model 13 was identical to Model 0 except pot fishery selectivity forced asymptotic
    - Model 14 was identical to Model 0 except shelf trawl survey selectivity forced asymptotic
- One model to examine estimation of stock-recruit relationship:
    - Model 15 was identical to Model 0 except parameters of a Ricker stock-recruitment relationship estimated internally
- Six models to address EBS-specific comments from the public:
    - Model 16 was identical to Model 0 except input *N* determined by iterative re-weighting
    - Model 17 was identical to Model 0 except input *N* for mean-size-at-age data decreased by an order of magnitude
    - Model 18 was identical to Model 0 except standard error from the shelf trawl survey doubled
    - Model 19 was identical to Model 0 except all age data removed
    - Model 20 was identical to Model 0 except slope survey data removed
    - Model 21 was identical to Model 0 except start year changed to 1982

An immense factorial grid of fixed *M*×*Q* models also prepared ahead of workshop, for which only partial results were presented

Eight models were developed during the workshop itself:

- Model 22 was identical to Model 0 except "old" (pre-Stark) maturity schedule used
- Model 23 was identical to Model 0 except priors turned off and separate *M* estimated for ages 1-2
- Model 24 was identical to Model 0 except priors turned off and longline fishery CPUE included as an index of abundance
- Model 25 was identical to Model 0 except priors turned off and Pcod bycatch from IPHC survey included as an index of abundance
- Model 26 was identical to Model 0 except priors turned off and either *Q* (=0.75) or *M* (=0.37) fixed
- Model 27 was identical to Model 0 except all priors turned off other than that for Jan-May trawl selectivity in largest size bin
- Model 28 was identical to Model 0 except survey selectivity forced asymptotic and *Q* fixed at 0.5
- Model 29 was identical to Model 0 except separate *M* estimated for ages 9+

Preliminary assessment
In general:

- Agecomp data presented as "age conditioned on length" (i.e., not marginals)
- Length-at-age SD a linear function of age
- Annual *dev*s for length at age 1, sigma=0.11
- Annual *dev*s for recruitment, sigma=0.6, 1973-2005
- Annual *dev*s for ascending selectivity, sigma=0.4
- All parameters estimated internally
- Except selectivity parameters pinned against bounds
- Uniform priors used exclusively
- Monotone selectivity for Jan-May trawl fishery
- All other selectivities new "double normal"

Four models were included, all of which were identical to the 2006 final model except as specified above and below:

- Model 1:
    - Estimated effect of 1976 regime shift on median recruitment
    - Added a large constant to fishery CPUE sigmas
- Model 2 was identical to Model 1 except age-dependent *M* estimated for ages 8+
- Model 3 was identical to Model 1 except that it did not add the large constant to longline CPUE sigmas
- Model 4 was identical to Model 1 except:
    - Effect of regime shift assumed to be zero
    - Did not add large constant to longline CPUE sigmas
    - Zero emphasis placed on initial catch and age composition
    - Iteratively re-weighted input sigmas and input *N*

Also attempted but not included:

- Simplified model with only a single fishery and no seasons

Final assessment
Four models were included:

- **Model 1** (comparisons to 2006 final model in parentheses):
  - *M* fixed at 0.34 (*M* fixed at 0.37 in 2006)
  - Length-at-age parameters estimated internally (fixed at point estimates from data in 2006)
  - Start year set at 1977 (start year set at 1964 in 2006)
  - Three age groups in initial state vector estimated (initial state vector assumed to be in equilibrium in 2006)
  - 6-parameter double normal selectivity (4-parameter version used in 2006)
  - Uniform priors used exclusively (informative normal priors used for many parameters in 2006)
  - Fishery selectivities constant across all years (approximately decadal "time blocks" used in 2006)
  - Ascending limb of survey selectivity varies annually with σ=0.2 (survey selectivity assumed to be constant in 2006)
  - Survey selectivity based on age (length-based selectivity used in 2006)
  - Some fishery selectivities forced asymptotic (all selectivities free in 2006)
  - Fishery CPUE data included for comparison (not included in 2006)
  - Age-based maturity schedule (length-based schedule used in 2006)
  - All fisheries seasonally structured (trawl partially seasonal, other gears non-seasonal in 2006)
  - Trawl survey abundance measured in numbers (abundance measured in biomass in 2006)
  - Multinomial *N* based on rescaled bootstrap (sample size set equal to square root of actual *N* in 2006)
- Model 2 was identical to Model 1 except *M* fixed at 0.37
- Model 3 was identical to Model 1 except *M* estimated internally
- Model 4 was identical to Model 1 except:
  - *M* estimated internally
  - Survey selectivities forced to be asymptotic
  - Age data ignored
  - Start year set at 1982; 1977 regime shift ignored
  - Length-based maturity used
  - Length-based survey selectivity used
  - Sigma=0.4 for annual deviations in selectivity parameters
  - Initial catch ignored in estimating initial fishing mortality

2008

Preliminary assessment
Five models were included:

- Model 1 was identical to the 2007 final model
- Model 2 was identical to Model 1 except growth parameter *L2* estimated externally
- Model 3 was identical to Model 1 except exponential-logistic selectivity used instead of double normal
- Model 4 was identical to 2007 Model 4
- Model 5 was identical to Model 1 except:
  - Fishery selectivity blocks (5 yr, 10 yr, 20 yr, or no blocks) chosen by AIC
  - Lower bound of descending "width" = 5.0
  - Regime-specific recruitment "dev" vectors
  - "SigmaR" set equal (iteratively) to stdev(dev) from current regime

  - Seasonal weight-length, based on fishery data
  - Number of free initial ages chosen by AIC
  - Size-at-age data used if modes ambiguous

Final assessment
Eight models were included:

- Model A1 was identical to Model 5 from September except lower bound on selectivity descending "width" parameter relaxed so as not to be constraining
- Model A2 was identical to Model A1, except without age data
- **Model B1** was identical to Model A1, except:
  - "Asymptotic algorithm" used to determine which fisheries will be forced to exhibit asymptotic selectivity
  - "Constant-parameters-across-blocks algorithm" used to determine which selectivity parameters can be held constant across blocks
- Model B2 was identical to Model B1, except without age data
- Model C1 was identical to Model B1, except with M estimated internally
- Model D2 was identical to Model B1, except:
  - No age data
  - Maturity modeled as function of length rather than age
  - M estimated iteratively, based on mat. at len and len. at age
- Model E2 was identical to Model B1, except:
  - No age data
  - Post-1981 trawl survey selectivity forced to be asymptotic
  - *M* estimated internally
- Model F2 was identical to Model 4 from the final assessment for 2007, except start year = 1977

2009

Preliminary assessment
Eight models were included, based on factorial design of the following:

- Selectivity functional form: double normal or exponential-logistic?
- Catchability: free or fixed at 1.0?
- Survey selectivity estimation: free or forced asymptotic?

Partial results were presented for a model with a prior distribution for *Q* based on archival tags (the prior had virtually no impact, which was why only partial results were presented)

Other features explored but not included in the above models:

- Fixing trawl survey catchability at the mean of the above normal prior distribution
- Allowing trawl survey catchability to vary as a random walk
- Fixing trawl survey catchability at a value of 1.00 for the pre-1982 portion of the time series, but allowing it to be estimated freely for the post-1981 portion of the time series
- Reducing the number of survey selectivity parameters subject to annual deviations
- Use of additive, rather than multiplicative, deviations for certain survey selectivity parameters
- Decreasing the value of the σ parameter used to constrain annual survey selectivity deviations
- Turning off annual deviations in survey selectivity parameters for the three most recent years
- Turning off all annual deviations in survey selectivity parameters

- Forcing trawl survey selectivity to peak at age 6.5, the approximate mid-point of the size range of 60-81 cm spanned by the results of Nichol et al. (2007)
- Imposing a beta prior distribution on the shape parameter of the exponential-logistic selectivity function in the trawl survey.

Final assessment
Fourteen models were included (all new since the preliminary assessment except for Model A1):

- Models without mean-size-at-age data:
    - Model A1 was identical to the 2008 final model, with the addition of new data, including the first available fishery agecomp data (from the 2008 Jan-May longline fishery)
    - Model A2 was identical to Model A1, except all agecomp data omitted
    - Model A3 was identical to Model A1, except 2008 Jan-May longline fishery agecomp data omitted
    - Model F2 was identical to Model F2 from the final assessment for 2008
- Models with mean-size-at-age data and agecomp data:
    - **Model B1** was identical to Model A1 except:
        - Survey selectivity held constant for most recent two years
        - Cohort-specific growth included
        - Input standard deviations of all "dev" vectors were set iteratively by matching the standard deviations of the set of estimated *dev*s
        - Standard deviation of length at age was estimated outside the model as a linear function of mean length at age
        - Selectivity at maximum size or age was treated as a controllable parameter
        - *Q* for the post-1981 trawl survey was fixed at the value that sets the average (weighted by numbers at length) of the product of *Q* and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007)
        - 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 (age-specific bias values were also examined, but did not improve the fit significantly).
    - Model C1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - *Catchability itself* (rather than the average product of catchability and selectivity for the 60-81 cm size range) set equal to 0.47
    - Model D1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - Selectivity at maximum size or age was removed from the set of controllable parameters (instead, selectivity at maximum size or age becomes a function of other selectivity parameters)
    - Model E1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - Selectivity at maximum size or age for all non-asymptotic fleets was set equal to a single value that was constant across fleets
    - Model G1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - Survey selectivity was held constant across all years (i.e., no selectivity *dev*s are estimated for any years)

- Models with mean-size-at-age data and without agecomp data:
    - Models B2, C2, D2, E2, and G2 were identical to their B1, C1, D1, E1, and G1 counterparts except that agecomp data were ignored and the corresponding sizecomp data were active.

2010

Preliminary assessment
Six models were included:

- Model 1 was identical to the 2009 final model
- Model 2 was identical to Model 1 except:
    - Input standard deviations for all "dev" vectors fixed at the values obtained iteratively in Model 1
    - IPHC survey data omitted
    - Fishery age data omitted
    - Traditional 3-or-5 cm size bins replaced with 1 cm size bins
    - Traditional 3-season structure replaced with new, 5-season structure
    - Spawn time changed from beginning of season 1 to beginning of season 2
- Model 3 was identical to Model 2 except:
    - Non-uniform prior distributions used for selectivity parameters and Q
- Model 4 was identical to Model 2 except:
    - All age data omitted
    - Maturity schedule was length-based rather than age-based
- Model 5 was identical to Model 4 except:
    - Parameters governing spread of lengths at age around mean length at age estimated internally
- Model 6 was identical to Model 5 except:
    - Cohort-specific growth replaced by annual variability in each of the three von Bertalanffy parameters

Final assessment
Three models were included:

- Model A was identical to Model 1 from the preliminary assessment
- **Model B** was identical Model 2 from the preliminary assessment, except cohort-specific growth replaced by constant growth
- Model C: same as Model 4 from the preliminary assessment, except cohort-specific growth replaced by constant growth

2011

CIE review
Exploratory model developed prior to review, which was the same as the 2010 final model, except:

- All sizecomp data turned on
- Nine season × gear fisheries consolidated into five seasonal fisheries
- Pre-1982 trawl survey data omitted
- Mean-size-at-age data omitted
- Fishery CPUE data omitted
- Average input N set to 100 for all fisheries and the survey
- First reference age for length-at-age relationship set at 0.833333
- Richards growth implemented
- Ageing bias estimated internally

    - Selectivities modeled as random walks with age (constant for ages 8+)

Twelve new models were developed during the review itself:

- Model 1 was identical to the 2010 final model except:
    - Length at age 0 constrained to be positive
    - Richards growth implemented
- Model 2 was identical to the 2010 final model except length at age 0 constrained to be positive
- Model 3 was identical to the 2010 final model except:
    - All time blocks removed
    - All selectivity parameters freed except fishery selectivity at initial age
    - All selectivity parameters initialized at mid-point of bounds
- Model 4 was identical to the 2010 final model except:
    - All time blocks removed
    - Emphasis on fishery sizecomps set to 0.001
- Model 5 was identical to the 2010 final model except:
    - Richards growth implemented
    - Ageing bias estimated internally
- Model 6 was identical to Model 4 except time blocks included
- Model 7 was identical to the 2010 final model except *Q* estimated internally
- Model 8 was identical to the 2010 final model except *M* estimated internally with an informative prior
- Model 9 was identical to the 2010 final model except tail compression increased
- Model 10 was identical to the 2010 final model except mean-size-at-age data turned off
- Model 11 was the same the "exploratory" model except:
    - Pre-1982 trawl survey data included
    - All time blocks removed
    - Fishery CPUE data included (but not used for estimation)
    - Input *N* set as in the 2010 final model
    - First reference age for length-at-age relationship set at as in the 2010 final model
- Model 12 was identical to Model 11 except two iterations of survey variance and input *N* re-weighting added

Preliminary assessment
Seven models were included:

- Model 1 was identical to the 2010 final model
- Model 2a was identical to Model 1 except for use of spline-based selectivity
- Model 2b was identical to Model 1 except for omission of pre-1982 survey data
- Model 3 was identical to Model 2b except:
    - Ageing bias estimated internally rather than by trial and error
    - First reference age for length-at-age relationship (*amin*) set at 1.0
    - Standard deviation of length at age *amin* tuned iteratively to match the value predicted externally by regression
- Model 4 was identical to Model 2b except:
    - All agecomp data turned off
    - All sizecomp data turned on
    - First reference age for length-at-age relationship (*amin*) set at 1.0
    - Parameters governing standard deviation of length at age estimated internally
- Model A was identical to Model 2b except:

- First reference age in the mean length-at-age relationship was set at 1.41667, to coincide with age 1 at the time of year when the survey takes place (in Models 1-2b, first reference age was set at 0; in Models 3-4, it was set at 1)
- Richards growth equation was used (in Models 1-4, von Bertalanffy was used)
- Ageing bias was estimated internally (as in Model 3; in Models 1-2 and 4, ageing bias was left at the values specified in the 2009 and 2010 assessments—although this was irrelevant for Model 4, which did not attempt to fit the age data)
- σ_R was estimated internally (in Models 1-4, this parameter was left at the value used in the 2009 and 2010 assessments)
- Fishery selectivity curves were defined for each of the five seasons, but were not stratified by gear type (in Models 1-4, seasons 1-2 and 4-5 were lumped into a pair of "super" seasons, and fisheries were also *gear*-specific)
- Selectivity curve for the fishery that came closest to being asymptotic on its own (in this case, the season 4 fishery) was forced to be asymptotic by fixing both *width_of_peak_region* and *final_selectivity* at a value of 10.0 and *descending_width* at a value of 0.0 (in Models 1-4, the Jan-Apr trawl fishery was forced to exhibit asymptotic selectivity)
- Survey selectivity was modeled as a function of length (in Models 1-4, survey selectivity was modeled as a function of age)
- Number of estimated year class strengths in the initial numbers-at-age vector was set at 10 (in Models 1-4, only 3 elements were estimated)
- The following parameters were tuned iteratively:
    - Standard deviation of length at the first reference age was tuned iteratively to match the value from the regression of standard deviation against length at age presented in the final assessment for 2010 (as in Model 3; in Models 1-2, this parameter was set at 0.01 because the first reference age was 0; in Model 4, it was estimated internally)
    - Base value for *Q* was tuned iteratively to set the average of the product of *Q* and survey selectivity across the 60-81 cm range equal to 0.47, corresponding to the Nichol et al. (2007) estimate (in Models 1-4, the base value was left at the value used in the 2009 and 2010 assessments)
    - *Q* was given annual (but not random walk) *dev*s, with σdev tuned iteratively to set the root-mean-squared-standardized-residual of the survey abundance estimates equal to 1.0 (in Models 1-4, *Q* was constant)
    - All estimated selectivity parameters were given annual random walk *dev*s with *σdev* tuned iteratively to match the standard deviation of the estimated *dev*s, except that the *dev*s for any selectivity parameter with a tuned σdev less than 0.005 were removed (in Models 1-4, certain fishery selectivity parameters were estimated independently in pre-specified blocks of years; the only time-varying selectivity parameter for the survey was *ascending_width*, which had annual—but not random walk—*dev*s with *σdev* set at the value used in the 2009 and 2010 assessments)
    - Age composition "variance adjustment" multiplier was tuned iteratively to set the mean effective sample size equal to the mean input sample size (in Models 1-4, this multiplier was fixed at 1.0)

- Model 5 was identical to Model A except that it used the time series of selectivity parameters estimated (using random walk *dev*s) in Model A to identify appropriate breakpoints for defining block-specific selectivity parameters

Other model features explored but not included in any of the above:

- Annually varying Brody growth parameter
- Annually varying length at the first reference age
- Internal estimation of standard deviation of length at age

- Ordinary (not random walk) *dev*s for annually varying selectivity parameters
- One selectivity parameter for each age (up to some age-plus group) and fleet, either with ordinary or random walk *dev*s or constant
- Not forcing any fleet to exhibit asymptotic selectivity
- Internal estimation of survey catchability
- Iterative re-weighting of size composition likelihood components
- Internal estimation of the natural mortality rate
- Changing the SS parameter *comp_tail_compression* (the tails of each age or size composition record are compressed until the specified amount was reached; sometimes referred to as "dynamic binning")
- Changing the SS parameter *add_to_comp* (this amount was added to each element of each age or size composition vector—both observed and expected, which avoids taking the logarithm of zero and may also have robustness-related attributes)
- Internal estimation of ageing error variances

Final assessment
Five models were included:

- Model 1 was identical to the 2010 final model (and Model 1 from the preliminary assessment)
- Model 2b was identical to Model 2b from the preliminary assessment
- Model 3 was identical to Model 3 from the preliminary assessment
- Model 4 was identical to Model 4 from the preliminary assessment
- **Model 3b** was identical to Model 3 from the preliminary assessment except:
    - Parameters governing variability in length at age estimated internally
    - All sizecomp data turned on
    - Mean-size-at-age data turned off

2012

Preliminary assessment
Five primary and nine secondary models were included (names of secondary models have decimal points; full results presented for primary models only):

- Model 1 was identical to the 2011 final model
    - Model 1.1: Same as Model 1, except survey catchability estimated internally
    - Model 1.2: Same as Model 1, except ageing bias parameters fixed at GOA values
    - Model 1.3 Same as Model 1, except with revised weight-length representation
- Model 2 was identical to Model 1, except survey catchability re-tuned to match archival tag data
- Model 3 was identical to Model 1, except new fishery selectivity period beginning in 2008
- Model 4 was identical to Model 4 from the final assessment for 2011
    - Model Pre5.1: Same as Model 1.3, except for three minor changes to the data file
    - Model Pre5.2: Same as Model Pre5.1, except ages 1-10 in the initial vector estimated individually
    - Model Pre5.3: Same as Model Pre5.2, except Richards growth curve used
    - Model Pre5.4: Same as Model Pre5.3, except σ for recruitment *dev*s estimated internally as a free parameter
    - Model Pre5.5: Same as Model Pre5.4, except survey selectivity modeled as a function of length
    - Model Pre5.6: Same as Model Pre5.5, except fisheries defined by season only (not season-and-gear)
- Model 5: Same as Model Pre5.6, except four quantities estimated iteratively:
    - Survey catchability tuned to match archival tag data

  - Agecomp *N* tuned to set the mean ratio of effective *N* to input *N* equal to 1
  - Selectivity *dev* sigmas tuned according to the new method described in Annex 2.1.1 of the SAFE chapter

Final assessment
Four models were included:

- **Model 1** was identical to the 2011 final model
- Model 2 was identical to Model 1 except *Q* was estimated freely
- Model 3 was identical to Model 1 except:
  - Ageing bias was not estimated
  - All agecomp data are ignored
- Model 4 was identical to Model 5 from the the preliminary assessment

2013

Preliminary assessment
Four models were included:

- Model 1 was identical to the 2012 final model
- Model 2 was identical to Model 4 from the final 2012 assessment except *Q* estimated internally using a non-constraining uniform prior distribution
- Model 3 was identical to Model 4 from the final 2012 assessment except:
  - *Q* estimated internally using a prior distribution based on archival tagging data
  - Survey selectivity forced asymptotic
- Model 4 was identical to Model 4 from the final 2012 assessment

Final assessment
Due to a protracted government shutdown during the peak of the final assessment season, only one model was presented:

- The **unnumbered model** was identical to the 2012 final model

2014

Preliminary assessment
Six models were included:

- Model 1 was identical to the 2011-2013 final models
- Model 2 was the identical to Model 5 from the 2012 preliminary assessment (also identical to Model 4 in the 2012 final assessment and the 2013 preliminary assessment)
- Model 3 was identical to Model 2, except that survey catchability *Q* was fixed at 1.0
- Model 4 was identical to Model 2, except that *Q* was estimated with a uniform prior and with an internally estimated constant added to each year's log-scale survey abundance standard deviation
- Model 5 was identical to Model 2, except that Q was fixed at 1.0, survey selectivity was forced to be asymptotic, and the natural mortality rate *M* was estimated freely
- Model 6 was a substantially new model, with the following differences from Model 1:
  - Each year consisted of a single season instead of five
  - A single fishery was defined instead of nine season-and-gear-specific fisheries
  - The survey was assumed to sample age 1 fish at true age 1.5 instead of 1.41667
  - Initial abundances were estimated for the first ten age groups instead of the first three
  - The natural mortality rate was estimated internally

- The base value of survey catchability was estimated internally
- Length at age 1.5 was allowed to vary annually
- Survey catchability was allowed to vary annually
- Selectivity for both the fishery and the survey were allowed to vary annually
- Selectivity for both the fishery and survey was modeled using a random walk with respect to age (SS selectivity-at-age pattern #17) instead of the usual double normal
- Several quantities were tuned iteratively: prior distributions for selectivity parameters, catchability, and time-varying parameters other than catchability

Final assessment
Two models were included:

- **Model 1** was identical to the 2011-2013 final models
- Model 2 was identical to Model 2 from the preliminary assessment, except that the *L1* growth parameter was not allowed to vary with time

2015

Preliminary assessment
Eight models were included.

Group A:

- Model 0 was the same as Model 1 from the 2014 final assessment.
- Model 7 was the same as Model 0, but with composition data weighted by Equation TA1.8 of Francis (2011).
- Model 8 was the same as Model 0, but with Richards growth (Model 0 used von Bertalanffy growth, which is a special case of Richards growth).

Subgroup B1:

- Model 2 was the same as Model 2 from the 2014 final assessment.
- Model 3 was the same as Model 2, but with composition data weighted by tuning the mean input sample size to the harmonic mean of the effective sample size, and with time-varying survey catchability (*Q*) turned off.
- Model 4 was the same as Model 2, but with 20 age groups estimated in the initial numbers-at-age vector (Model 2 estimated 10 age groups in the initial numbers-at-age vector).

For all models in Subgroup B1, selectivity prior distributions and the parameters governing time-variability in recruitment, selectivity, and survey catchability were *not* re-tuned. That is, they were left at the values estimated for Model 2 during the 2014 assessment, except that time variability in survey catchability was turned off in Model 3. Note that the tuning for Model 2 was performed during the 2014 *preliminary* assessment (where it was labeled Model 6), and was not updated during the final 2014 assessment.

Subgroup B2:

- Model 5 was based on Model 2, but had a number of differences (described below), one of which was that SS runs were accepted even if the gradient was large, so long as the estimated covariance matrix of the parameters appeared reasonable.

- Model 6 was the same as Model 5, except that SS runs were accepted only if the gradient was small. In the event that a large gradient was obtained, age-specific selectivity *dev* vectors were removed, one at a time, until the large gradient disappeared.

Except for some procedures related to iterative tuning (see next set paragraph), the differences between Model 5 and Model 2 were as follow:

- Composition data were given a weight of unity if the harmonic mean of the effective sample size was greater than the mean input sample size of 300; otherwise, composition data were weighted by tuning the mean input sample size to the harmonic mean of the effective sample size.
- 20 age groups were estimated in the initial numbers-at-age vector.
- Selectivity at ages 9+ was constrained to equal selectivity at age 8 for both the fishery and the survey.
- A superfluous selectivity parameter was fixed at the mean of the prior (in Model 2, the estimate of this parameter automatically went to the mean of the prior).
- The SS feature known as "Fballpark" was turned off (this feature, which functions something like a very weak prior distribution on the fishing mortality rate in some specified year, did not appear to be providing any benefit in terms of model performance, and what little impact it had on resulting estimates was not easily justified).
- SS runs were accepted even if the gradient was large, so long as the estimated covariance matrix of the parameters appeared reasonable (i.e., all values were numeric, no values were unbelievably large).

Iterative tuning of prior distributions for selectivity parameters and time-varying catchability in Model 5 proceeded as in Model 2, except that all iterative tuning procedures were undertaken simultaneously, rather than in the phased approach used for Model 2. For time-varying recruitment and selectivity, the approach used in Model 2, which was based on the method of Thompson and Lauth (2012), was not retained in Model 5. For a univariate model, *if* the method of Thompson and Lauth (2012) returns a non-zero estimate of σ, there is reason to believe that this estimate will be unbiased. However, the method carries a fairly high probability of returning a "false negative;" that is, returning a zero estimate for σ when the true value is non-zero (Thompson in prep.). To reduce this bias toward under-parameterization, the following algorithm was used in Model 5 (Thompson in prep.; note that this is a multivariate generalization of one of the methods mentioned by Methot and Taylor (2011, *viz*., the third method listed on p. 1749)):

1. Set initial guesses for the σs.
2. Run SS.
3. Compute the covariance matrix (**V1**) of the set of *dev* vectors (e.g., element $\{i,j\}$ is equal to the covariance between the subsets of the *i*th *dev* vector and the *j*th *dev* vector consisting of years that those two vectors have in common).
4. Compute the covariance matrix of the parameters (the negative inverse of the Hessian matrix).
5. Extract the part of the covariance matrix of the parameters corresponding to the *dev* vectors, using only those years common to all *dev* vectors.
6. Average the values in the matrix obtained in step 5 across years to obtain an "average" covariance matrix (**V2**).
7. Compute the vector of σs corresponding to **V1**+**V2**.
8. Return to step 2 and repeat until the σs converge.

To speed the above algorithm, the σs obtained in step 7 were sometimes substituted with values obtained by extrapolation or interpolation based on previous runs.

As noted above, the procedure used in Model 5 for iterative tuning of time-varying *Q* was the same as that used in Model 2. However, unlike Model 2, this procedure resulted in time-varying *Q* being "tuned out" in Model 5. Model 6, which also used this procedure, ended up retaining time-varying *Q*.

Final assessment
The final assessment included the same two models that were featured in the 2014 final assessment:

- **Model 11.5** was identical to the 2011-2014 final models
- Model 14.2 was identical to Model 2 from the 2014 final assessment

2016

Preliminary assessment
Six models were presented in this preliminary assessment, including Model 11.5 and five variants of Model 15.6, which was introduced in the 2015 preliminary assessment (where it was labeled "Model 6"). As described by the Joint Team Subcommittee (with subsequent re-numbering to adhere to the established model numbering convention), the full set of models consisted of the following:

- Model 11.5: BS Model 11.5, the final model from 2015
- Model 16.1: Like BS Model 15.6, but simplified as follows:
    - Weight abundance indices more heavily than sizecomps.
    - Use the simplest selectivity form that gives a reasonable fit.
    - Do not allow survey selectivity to vary with time.
    - Do not allow survey catchability to vary with time.
    - Force trawl survey selectivity to be asymptotic.
    - Do not allow strange selectivity patterns.
    - Use empirical weight at age.
- Model 16.2: Like Model 15.6, but including the IPHC longline survey data and other features, specifically:
    - Do not allow strange selectivity patterns.
    - Estimate catchability of new surveys internally with non-restrictive priors.
    - Include additional data sets to increase confidence in model results.
    - Include IPHC longline survey, with 'extra SD.'
- Model 16.3: Like Model 16.2 above, but including the NMFS longline survey instead of the IPHC longline survey.
- Model 16.4: Like Models 16.2 and 16.3 above, but including both the IPHC and NMFS longline survey data and two features not included in either Model 16.2 or 16.3, specifically:
    - Start including fishery agecomp data.
    - Use empirical weight at age.
- Model 16.5: Like Model 16.4 above, but including two features not included in Model 16.4, specifically:
    - Use either Francis or harmonic mean weighting.
    - Explore age-specific M (e.g., using Lorenzen function)."

Note that some points in the above lists of features may be somewhat duplicative, but were included by the JTS in order to address specific comments made by CIE reviewers. For Model 6, harmonic mean weighting (Punt in press) and the age-specific natural mortality function proposed by Lorenzen (1996, 2011) were used.

In the minutes of its May 2016 meeting, the JTS recognized that some of the terms used in the descriptions of its requested models were somewhat subjective and that, in making those requests, the assessment author would need to determine:

1. How to measure the "weight" assigned to abundance indices and size composition data in the same units (Model 16.1).
2. What constitutes a "reasonable fit" to the size/age composition data (Model 16.1).
3. What constitutes a "strange" selectivity pattern (Models 16.1-16.5).

These issues were addressed as follows:

1. The relative "weight" assigned to abundance indices and size composition data was determined by comparing the average spawning biomasses from three models:
   A. a model with a specified set of likelihood "emphasis" (λ) values, with each $\lambda \geq 1.0$;
   B. a model in which λ for the abundance data was set equal to 0.01 while each λ for the size composition data (fishery and survey) was left at the value specified in model A; and
   C. a model in which each λ for the size composition data (fishery and survey) was set equal to 0.01 while each λ for the abundance data was left at the value specified in model B.

   Model B was taken to represent model A with the *abundance* data "turned off," while model C was taken to represent model A with the *size composition* data "turned off" (a λ value of 0.01 rather than 0 was used for to represent "turning off" a data component because some parameters might prove inestimable if that data component were removed entirely). The abundance data in model A were determined to receive greater weight than the size composition data in that model if the absolute value of the proportional change in spawning biomass between models B and A exceeded the analogous value between models C and A. The JTS requested that this criterion (giving greater weight to abundance data than size composition data) be included in Model 16.1 only. As it turned out, the default λ value of 1.0 for all data components was sufficient to satisfy this criterion, so no adjustments to any of the λ values were necessary.
2. To focus on the ability of a particular functional form to fit the data, independent of the absolute values of the sample sizes specified for the associated multinomial distribution or λ values, weighted coefficients of determination (R^2), computed on both the raw and logit scales, were used to measure goodness of fit (the equations below are written in terms of age composition; the equations for size compositions are analogous):

$$R^2 = \sum_{y=ymin}^{ymax} \left(w_y \cdot \left(1 - \frac{\sum_{a=0}^{amax} \left(Pobs_{a,y} - Pest_{a,y} \right)^2}{\sum_{a=0}^{amax} \left(Pobs_{a,y} - Pobs_{ave,y} \right)^2} \right) \right) ,$$

and

$$R^2 = \sum_{y=ymin}^{ymax} \left(w_y \cdot \left(1 - \frac{\sum_{a=0}^{amax} \left(logit\left(Pobs_{a,y} \right) - logit\left(Pest_{a,y} \right) \right)^2}{\sum_{a=0}^{amax} \left(logit\left(Pobs_{a,y} \right) - logit\left(Pobs_{ave,y} \right) \right)^2} \right) \right) ,$$

where

$$w_y = \frac{n_y}{\sum_{i=ymin}^{ymax} n_i} \quad ,$$

$Pobs_{a,y}$ represents the observed proportion at age a in year y, $Pobs_{ave,y}$ represents the average (across ages) observed proportion in year y, $Pest_{a,y}$ represents the estimated proportion at age a in year y, and n_y represents the specified multinomial sample size in year y. To guard against the possibility of achieving misleadingly high R^2 values by extending the size or age range beyond the sizes or ages actually observed, the data were filtered by removing all records with $Pobs_{a,y} < 0.001$ prior to computing the R^2 values. A fit was determined to be "reasonable" if it yielded *both* an R^2 value of at least 0.99 on the raw scale *and* an R^2 value of at least 0.70 on the logit scale. As with #1 above, the JTS requested that this criterion (simplest selectivity function that gives a reasonable fit) be included in Model 16.1 only. Because the "random walk with respect to age" selectivity function gave a reasonable fit, the function was simplified in successive steps first by removing all time-variability, then by switching to a double-normal function, and finally by switching to a logistic function. The logistic function (for both the fishery and the survey) gave a reasonable fit to the fishery size composition data, the survey size composition data, and the survey age composition data, so it was retained as the final functional form.

3. In general, a "strange" selectivity pattern was defined here as one which was non-monotonic (i.e., where the signs of adjacent first differences changed), particularly if the first differences associated with sign changes were large (in absolute value), and particularly if sign changes in first differences occurred at relatively early ages. Specifically, an index of "strangeness" was defined as follows:
   A. Age-specific weighting factors P_a were calculated as the equilibrium unfished numbers at age expressed as a proportion of equilibrium unfished numbers.
   B. For each year, age-specific first differences in selectivity $\Delta_{a,y}$ were calculated.
   C. "Strangeness" was then calculated as:

$$\left(\frac{1}{ymax - ymin + 1}\right) \cdot \sum_{y=ymin}^{ymax} \sqrt{\sum_{a=2}^{amax} \left(P_a \cdot \left(\left(sign\left(\Delta_{a,y}\right) \neq sign\left(\Delta_{a-1,y}\right)\right) \cdot \left(\Delta_a\right)^2\right)\right)} \quad ,$$

   where the expression $sign\left(\Delta_{a,y}\right) \neq sign\left(\Delta_{a-1,y}\right)$ returned a value of 1 if the sign of $\Delta_{a,y}$ differed from the sign of $\Delta_{a-1,y}$ and a value of 0 otherwise. This index attains a minimum of 0 when selectivity is constant across age (or varies monotonically) and a maximum of 1 if selectivity alternates between values of 0 and 1 at all pairs of adjacent ages.

A time series of selectivity at age (for a given fleet) was determined to be "strange" if the index described above exceeded a value of 0.05. If a model produced a "strange" selectivity pattern, the standard deviations of the prior distributions for the selectivity parameters and the standard deviations of any selectivity *dev* vectors were decreased proportionally relative to the values estimated for Model 15.6 in last year's assessment until the threshold value of 0.05 was satisfied.

Final assessment

The final assessment included Models 11.5 and Model 16.1 from the preliminary assessment, and four variants of Model 16.1:

- **Model 16.6**: Model 16.1 without empirical weight at age
- Model 16.7: Model 16.1 without empirical weight at age and including the NMFS LL survey
- Model 16.8: Model 16.1 with time-varying survey selectivity

- Model 16.9: Model 16.1 with time-varying fishery selectivity

Empirical weight at age was first explored for the EBS Pacific cod stock in this year's preliminary assessment. Some key similarities and differences between the models *without* empirical weight at age (Models 11.5, 16.6, and 16.7) and those *with* empirical weight at age (Models 16.1, 16.8, and 16.9) are as follow: All six models estimate (internally) a time-invariant relationship between mean length and age, which is used for fitting the size composition data, among other things. Models *without* empirical weight at age use externally estimated parameters describing a weight-at-length relationship (seasonally varying but constant across years in the case of Model 11.5, annually varying in the cases of Models 16.6 and 16.7) in combination with the internally estimated length-at-age relationship to compute weight at age. Models *with* empirical weight at age bypass the link between weight at age and length at age, and instead use externally estimated, time-varying schedules of weight at age directly.

In Model 16.7, logistic selectivity was assumed for the NMFS longline survey, just as for fishery and trawl survey selectivity.

Time-varying selectivity in Models 16.8 and 16.9 was implemented in the form of annual deviations from a base selectivity function. The "sigma" parameters governing the extent to which selectivity *dev*s can vary from zero (specified as inputs to the model, not estimated internally) in Models 16.8 and 16.9 were set at large values to maximize those models' ability to fit the data, essentially treating each *dev* as an unconstrained parameter. Values of the sigma parameters were increased across several trial runs of each model until the resulting estimate of 2016 spawning biomass did not change (to 3 significant digits) with further increases.

2017

Preliminary assessment
The Joint Team Subcommittee (with subsequent re-numbering to adhere to the established model numbering convention) requested the following six models, all of which were included:

- Model 16.6 (last year's final model), after translating from SS V3.24u to V3.30.
- Model 17.1: Same as Model 16.6, but with the following features added:
    1. Adjust timing of the fishery and survey in SS.
    2. Do not use currently available fishery agecomp data, but do add new fishery agecomps.
    3. Switch to haul-based input sample size and catch-weighted sizecomp data.
    4. Develop a prior distribution for natural mortality based on previous estimates.
    5. Switch to age-based, flat-topped, double normal selectivity.
    6. Allow random time variability in selectivity, with σs fixed at the restricted MLEs.
- Model 17.2: Same as Model 17.1, but with the following features added:
    1. Use harmonic mean weighting of composition data.
    2. Allow time-varying selectivity for the fishery but not the survey.
- Model 17.3: Same as Model 17.1, but with the following features added:
    1. Use harmonic mean weighting of composition data.
    2. Estimate survey index standard error internally ('extra SD' option in SS).
- Model 17.4: Same as Model 17.1, but with the following feature added:
    1. Use Francis weighting.
- Model 17.5: Same as Model 17.1, but with the following feature added:
    1. Give less weight to fishery comps than survey comps, less to sizecomps than agecomps."

In addition to the above six models, a seventh model, designated Model 17.6, was also included in the preliminary assessment. It was similar to Model 17.2, except that it includes annually time-varying length at age 1.5, trawl survey catchability, and survey selectivity.

Final assessment
The SSC requested the following six models, of which the first five were included in the preliminary assessment:

- **Model 16.6**
- Model 17.1
- Model 17.2
- Model 17.3
- Model 17.6
- Model 17.7, which was the same as Model 17.6, but with all sizecomp and agecomp multipliers capped at a value of 1.0.

2018

Preliminary assessment
A total of 15 alternative models were presented in addition to the base model. These differed either in terms of model structure, data used, or both. Two of the alternative models were presented in the 2016 assessment, and the other 13 were new (8 of which constituted minor changes from the base model and 5 of which constituted major changes). The list of alternative models was as follows (the distinction between "minor" and "major" changes, along with the model numbering convention, conform to Option A in the SAFE chapter guidelines; the symbols *Q*, *K*, *Lmin*, and *M* represent catchability, the Brody growth coefficient, length at age 1.5, and the instantaneous natural mortality rate, respectively).

<u>Models constituting minor changes from the base model</u>
Models dealing with the use of data from the "expanded" EBS survey area:

- Model 16.6a:
  - Structure differences: None.
  - Data differences:
    - Exclude 1982-1986 EBS survey data.
    - Switch to expanded EBS survey data for 1987-2017.
- Model 16.6b
  - Structure difference: Estimate a separate *Q* for the 1982-1986 EBS survey.
  - Data difference: Switch to expanded EBS survey data for 1987-2017.

Models incorporating an environmental covariate of growth:

- Model 16.6c
  - Structure difference: Estimate a parameter linking *K* to fish condition.
  - Data difference: Include the fish condition time series (as z-scores).
- Model 16.6d
  - Structure difference: Estimate a parameter linking *Lmin* to bottom temperature.
  - Data difference: Include the bottom temperature time series (as z-scores).

Models incorporating time-varying catchability, without NBS survey data:

- Model 16.6e

    - Structure difference: Allow randomly time-varying EBS survey *Q*.
    - Data differences: None.
- Model 16.6f
    - Structure difference: Estimate a parameter linking EBS *Q* to the North Pacific Index.
    - Data difference: Include the North Pacific Index time series (as z-scores).

Models incorporating time-varying catchability, with NBS survey data:

- Model 16.6g
    - Structure differences:
        - Allow randomly time-varying EBS survey *Q*.
        - Estimate NBS survey selectivity and *Q*.
        - Allow randomly time-varying NBS survey *Q*.
    - Data differences: Include NBS survey data.
- Model 16.6h
    - Structure differences same as Model 16.6g, plus:
        - Estimate a parameter linking NBS *Q* to the North Pacific Index.
    - Data differences same as Model 16.6g, plus:
        - Include the North Pacific Index time series (as z-scores).

<u>Models constituting major changes from the base model</u>
Previously reviewed models:

- Model 17.2
    - Structure differences:
        - Adjust timing of fishery and survey per SS V3.30 conventions
        - Include a prior distribution for the natural mortality rate
        - Switch to flat-topped double normal selectivity for the fishery and survey
        - Allow randomly time-varying fishery selectivity
        - Use harmonic mean weighting of composition data
    - Data differences:
        - Set multinomial input sample size equal to number of sampled hauls
        - Include fishery age composition data (data for 2011 and 2012 new this year)
- Model 17.6
    - Structure differences same as Model 17.2, plus:
        - Allow randomly time-varying survey selectivity
        - Allow randomly time-varying *Lmin*
        - Allow randomly time-varying EBS survey catchability
    - Data differences same as Model 17.2

Models incorporating migration:

- Model 18.1
    - Structure differences:
        - Estimate base values of three migration parameters.
        - Allow random variation in migration parameters.
    - Data differences:
        - Include NBS survey data.
        - Treat EBS and NBS as separate areas.
- Model 18.2
    - Structure differences:

        - Estimate base values of three migration parameters.
        - Estimate three parameters linking migration to covariates.
    - Data differences same as Model 18.1, plus:
        - Include North Pacific Index (as z-scores).
        - Include benthic forager biomass index (as z-scores).
        - Include seabird breeding success index (as z-scores).

Models incorporating an environmental covariate of the instantaneous natural mortality rate:

- Model 18.3
    - Structure difference: Estimate a parameter linking *M* to fish condition
    - Data difference: Include fish condition time series (as z-scores)
- Model 18.4
    - Structure differences:
        - Estimate two additional parameters linking *M* to age
        - Estimate a parameter linking *M* at ages 2-4 to nutrition deficit
    - Data differences: Include nutrition deficit time series (as z-scores)

Model incorporating many new features:

- Model 18.5
    - Structure differences:
        - Estimate a parameter linking EBS *Q* to the North Pacific Index
        - Estimate NBS selectivity and *Q*.
        - Estimate base values of three migration parameters.
        - Allow random variation in migration parameters.
        - Estimate two additional parameters linking *M* to age.
        - Estimate a parameter linking *M* to a nutrition deficit index.
        - Estimate block-specific Ricker steepness internally.
    - Data differences:
        - Include NBS survey data.
        - Treat EBS and NBS as separate areas.
        - Include the North Pacific Index time series (as z-scores).
        - Include the nutrition deficit time series (as z-scores).

Models 17.2 and 17.6 were requested by the Team and SSC, Model 16.6a was requested by the Team, Model 16.6b was requested by the SSC, and several of the other models were requested by various AFSC scientists.

Final assessment
The following eight models were included in the final assessment (the first six were requested by the SSC, and the last two were added by the author in an attempt to address some behaviors of Models 16.6k and 18.6 that might not have been anticipated by the SSC):

- Model 16.6: The current base model, exhibiting the following features:
    - One fishery, one gear type, one season per year.
    - Input sample sizes average 300, with season×gear catch-weighted sizecomps.
    - Logistic age-based selectivity for both the fishery and survey.
    - External estimation of time-varying weight-at-length parameters and the standard deviations of ageing error at ages 1 and 20.
    - All parameters constant over time except for recruitment and fishing mortality.

    - Internal estimation of all natural mortality, fishing mortality, length-at-age (including ageing bias), recruitment (conditional on Beverton-Holt recruitment steepness fixed at 1.0), catchability, and selectivity parameters.
- **Model 16.6i**: Same as Model 16.6, but with the following features added:
    - Include EBS survey strata 82 and 90 (i.e., use the 1987-2018 expanded EBS survey area).
    - Sum the EBS survey and NBS survey data sets into a single survey.
- Model 16.6j: Same as Model 16.6i, but with the following feature added:
    - Allow randomly time-varying catchability for the combined EBS+NBS survey.
- Model 16.6k: Same as Model 16.6, but with the following feature added:
    - Include EBS survey strata 82 and 90 (i.e., use the 1987-2018 expanded EBS survey area).
    - Include the NBS survey as a separate data set.
    - Allow randomly time-varying catchability for the EBS survey.
    - Estimate NBS survey catchability internally.
    - Allow randomly time-varying catchability for the NBS survey.
- Model 17.2: Same as Model 16.6, but with the following features added:
    - Include fishery agecomps.
    - Include a prior distribution for natural mortality based on previous estimates.
    - Switch to age-based, flat-topped, double normal selectivity.
    - Allow randomly time-varying fishery selectivity, with σs fixed at the restricted MLEs.
    - Switch to haul-based input sample size and week×gear×area catch-weighted sizecomps.
    - Use harmonic mean weighting of composition data.
- Model 18.6: Same as Model 17.2, but with the following features added:
    - Include EBS survey strata 82 and 90 (i.e., use the 1987-2018 expanded EBS survey area).
    - Include the NBS survey as a separate data set.
    - Allow randomly time-varying catchability for the EBS survey.
    - Estimate NBS survey catchability internally.
    - Allow randomly time-varying catchability for the NBS survey.
- Model 18.7: Same as Model 16.6k, but with the following changes:
    - Instead of estimating EBS survey catchability internally, set it equal to the average EBS proportion of combined EBS+NBS survey abundance.
    - Instead of estimating NBS survey catchability internally, set it equal to the average NBS proportion of combined EBS+NBS survey abundance.
- Model 18.8: Same as Model 18.6, but with the following changes:
    - Instead of estimating EBS survey catchability internally, set it equal to the average EBS proportion of combined EBS+NBS survey abundance.
    - Instead of estimating NBS survey catchability internally, set it equal to the average NBS proportion of combined EBS+NBS survey abundance.

2019

Preliminary assessment

- Model 16.6i: The current base model, exhibiting the following features:
    - One fishery, one gear type, one season per year.
    - Input sample sizes average 300, with season×gear catch-weighted sizecomps.
    - Logistic age-based selectivity for both the fishery and survey.
    - External estimation of time-varying weight-at-length parameters and the standard deviations of ageing error at ages 1 and 20.
    - All parameters constant over time except for recruitment and fishing mortality.
    - Internal estimation of all natural mortality, fishing mortality, length-at-age (including ageing bias), recruitment (conditional on Beverton-Holt recruitment steepness fixed at 1.0), catchability, and selectivity parameters.

- Includes EBS survey strata 82 and 90 (i.e., the 1987-2018 expanded EBS survey area).
- EBS survey and NBS survey data sets summed into a single survey.

A total of six alternative models were presented in addition to the base model. These constituted a factorial design involving the Team's three hypotheses regarding treatment of the NBS (Comments BPT7 and SSC8) and the SSC's desire to explore multiple ranges of possible enhancements to the structure of the base model (Comment SSC3).

The Team's three hypotheses were:

1. Pacific cod in the NBS are insignificant to the managed stock, so the assessment should include data from the EBS only.
2. Pacific cod in the EBS and NBS comprise a single stock, and the EBS and NBS surveys can be modeled in combination.
3. Pacific cod in the EBS and NBS comprise a single stock, but the EBS and NBS surveys should be modeled separately.

Relative to the base model, two ranges of structural modifications were featured among the alternative models. More specifically, two models were presented for each hypothesis, one of which contained a certain set of structural modifications, and the other of which contained a second, larger, set of structural modifications. The two sets of structural modifications were the same across hypotheses, except that an additional set of survey parameters was required for Hypothesis 3. In addition to structural differences, the models for the various hypotheses also involve different data.

The first (smaller) set of structural modifications was as follows:

- Set input sample size for compositional data equal to the number of hauls, rescaled to an average of 300 for each component (Model 16.6i sets input sample size equal to the number of *observations*, rescaled to an average of 300 for each component).
- Include the available fishery age composition data (Model 16.6i ignores those data).
- Use age-based, double-normal selectivity, potentially dome-shaped for the fishery but forced asymptotic for the survey (Model 16.6i uses age-based, logistic survey for both fleets).
- Tune the input standard deviation of log-scale recruitment deviations (σ_R) to match the square root of the variance of the estimates plus the sum of the estimates' variances (Methot and Taylor 2011; Model 16.6i estimates σ_R internally).
- Use size-based maturity (Model 16.6i uses age-based maturity).

The second (larger) set of structural modifications was as follows:

- Set input sample size for compositional data equal to raw number of hauls rather (than rescaled to an average of 300 for each component).
- Reweight compositional data internally using the Dirichlet-multinomial distribution (Thorson et al. 2017; see also Discussion section here).
- Use size-based double-normal selectivity rather than age-based (but keeping the assumption of asymptotic survey selectivity).
- Allow mean ageing bias at ages 1 and 20 to differ between the pre-2008 and post-2007 periods in order to compensate for an apparent change in ageing criteria (Beth Matta, AFSC Age and Growth Program, pers. commun., 6/27/2019) .

- Allow yearly random variation in survey selectivity (two parameters), with the input standard deviation of the deviations tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.
- Allow yearly random variation in survey catchability, with the input standard deviation of the deviations tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.
- Allow yearly random variation in mean length at age 1.5, with the input standard deviation of the deviations tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity, in order to address the significant amount of time-variability in growth documented by Puerta et al. (2019).
- Allow yearly random variation in fishery selectivity (three parameters), with the input standard deviation of the deviations tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.

(Note that the method for tuning the input standard deviations of log-scale recruitment deviations was slightly different than the method for tuning the input standard deviations of all other deviation vectors. This was because SS treats log-scale recruitment deviations differently from all other deviation vectors.)

Referring to models conforming to the first set of structural modifications as "simple" and models conforming to the second (larger) set of structural modifications as "complex," the set of alternative models can be summarized as follows:

Hypothesis:	1: EBS only		2: Combine EBS and NBS		3: Separate EBS and NBS	
Structure:	Simple	Complex	Simple	Complex	Simple	Complex
Name:	M19.1	M19.2	M19.3	M19.4	M19.5	M19.6

Final assessment
Both the Team and SSC requested that Models 16.6i and 19.1-19.6 be included in this year's final assessment. Additionally, the SSC requested three other new models (see comment SSC15), bringing the total of requested models to ten. However, this set of models was rendered problematic by some of the Team and SSC comments from the September 2019 and October 2019 meetings, respectively:

- Although the SSC asked that the authors "bring forward" all six of the new models (including the two models corresponding to Hypothesis 1), it also requested that the Team "strongly consider not carrying forward Hypothesis 1," implying that Models 19.1 and 19.2 would have very little chance of being adopted by the SSC (see comment SSC13).
- In contrast to the Team's perspective, the SSC reaffirmed its view that retrospective bias should be among the model evaluation criteria (comments SSC14 and SSC17), but Models 19.2-19.6 all exhibited very high levels of retrospective bias. Taken together with the preceding item, this implies that none of the new models would likely be adopted by the SSC.
- Overall, there seemed to be considerable interest by both the Team and the SSC in seeing VAST estimates of survey abundance and age composition used in the new models (see comments BPT3, BPT11, BPT13, SSC3, SSC6, and SSC15), but only two of the new models (19.3 and 19.4) actually used those data. If VAST-based analogues of Models 19.1, 19.2, 19.5, and 19.6 were to be developed, it would bring the total number of models to 14, which would likely prove impractical, and it seems likely that at least three of those analogues would suffer the same problem with retrospective bias as their respective original versions.

Rather than produce a large number of models that would seem to have very little chance of being either adopted or given substantial weight in an ensemble, attention was turned instead to investigating the issue

of the large retrospective biases exhibited by Models 19.2-19.6. Although the time available for this investigation was extremely limited, the results suggested that the retrospective biases of at least some of the new models might be reduced to acceptable levels by making the following changes to the simple and complex models, both of which result in model structures closer to that of all recent base models:

- For both the simple and complex models, eliminate the fishery age composition data that were added as part of the first set of structural modifications (note that no base model since 1992 has included fishery age composition data).
- For the complex models, reduce the average input sample size of the fishery size composition data so that it equals the average input sample size of the survey size composition data (note that this has been the practice for all base models since 2007).

The above modifications resulted in six new models, following the original 3×2 factorial design. The three new models requested by the SSC (see comment SSC15) had the same structure as the base model and were therefore be referred to as having a "basic" structure, which results in a 3×3 factorial design. Together with the base model, this brought the total number of models to ten, where the nine new models were labeled 19.7-19.15. The relationships of Models 19.7-19.15 to each other and to those presented in the preliminary assessment (Models 19.1-19.6) are shown below (note that Model 16.6i used design-based versions of the survey index and age composition data, while Models 19.7-19.15 used VAST versions of those data):

Hypothesis	Structure	Preliminary	Final	Changes (from preliminary to final)
2: EBS+NBS	Basic	M16.6i	M16.6i	none
1: EBS only	Basic	n/a	M19.7	n/a
	Simple	M19.1	M19.8	fishery: no agecomps
	Complex	M19.2	M19.9	fishery: no agecomps, downweighted sizecomps
2: EBS and NBS combined	Basic	n/a	M19.10	n/a
	Simple	M19.3	M19.11	fishery: no agecomps
	Complex	M19.4	M19.12	fishery: no agecomps, downweighted sizecomps
3: EBS and NBS separated	Basic	n/a	M19.13	n/a
	Simple	M19.5	M19.14	fishery: no agecomps
	Complex	M19.6	M19.15	fishery: no agecomps, downweighted sizecomps

APPENDIX 2.4: SUPPLEMENTAL CATCH DATA

NMFS Alaska Region has made substantial progress in developing a database documenting many of the removals of FMP species that have resulted from activities outside of fisheries prosecuted under the BSAI Groundfish FMP, including removals resulting from scientific research, subsistence fishing, personal use, recreational fishing, exempted fishing permit activities, and commercial fisheries other than those managed under the BSAI groundfish FMP. Estimates for EBS Pacific cod from this dataset are shown in Table 2.4.1.

It should be noted that this year's version of Table 2.4.1 is substantially different from previous years' versions, mostly due to a revision in the AKFIN database for the "Bait for Crab Fishery" activity. The following notice were posted on the AKFIN dashboard on October 12, 2020:

> "2019 data currently include ADF&G survey data, IPHC surveys, groundfish caught and retained for bait in rationalized crab fisheries; and AFSC longline, bottom trawl, and acoustic surveys. The data do not include ADF&G 2019 sport fish harvest data, which will be added once they become available. Prior year data have also been updated as follows:
>
> - Addition of 1998 and 1989 AFSC Annual Longline Survey data
> - Revisions to the 1990-2018 AFSC Annual Longline Survey data: In 2020 there was a change in how catch in weight was calculated at a station/depth strata level for the AFSC longline survey research catch table. This change affects the whole time series. In some instances catch was recorded, but no lengths. Because weight is estimated from length and catch for some species, this catch was not included. This has been adapted so that catch is now included and an average length from the same depths is used for deriving catch in weight. This affects sablefish, Pacific cod, giant grenadier, pacific grenadier, Pacific halibut, arrowtooth flounder, kamchatka flounder, rougheye and shortraker rockfish, and shortspine thornyhead. Overall changes are not considerable.
> - Revisions to the 2010-2018 Bait for Crab Fishery data: A mistake was identified and corrected in the query used to summarize groundfish catch used for bait in the crab fisheries. The overall changes for BSAI Pacific cod are considerable, with corrected values lower than previously reported. Overall changes to non-Pacific cod species are small."

As a result of the above, the time series average for the "Bait for Crab Fishery" category went from 6,496 t in last year's assessment to 1,217 t in this year's assessment a reduction of 81%.

Although many sources of removal are documented in Table 2.4.1, the time series is highly incomplete for many of these. Cells shaded gray represent data contained in the NMFS database. Other entries represent extrapolations for years in which the respective activity was known or presumed to have taken place, where each extrapolated value consists of the time series average of the official data for the corresponding activity. In the case of surveys, years with missing values were identified from the literature or by contacting individuals knowledgeable about the survey (the NMFS database contains names of contact persons for most activities); in the case of fisheries, it was assumed that the activity occurred every year.

In the 2012 analysis (Attachment 2.4 of Thompson and Lauth 2012), the supplemental catch data were used to provide estimates of potential impacts of these data in the event that they were included in the catch time series used in the assessment model. The results of that analysis indicated that $F_{40\%}$ increased by about 0.01 and that the one-year-ahead catch corresponding to harvesting at $F_{40\%}$ decreased by about 4,000 t. Note that this is a separate issue from the effects of taking other removals "off the top" when

specifying an ABC for the groundfish fishery; the former accounts for the impact on reference points, while the latter accounts for the fact that "other" removals will continue to occur.

The average of the total removals in Table 2.4.1 for the last three complete years (2017-2019) is 970 t.

It should be emphasized that these calculations are provided purely for purposes of comparison and discussion, as NMFS and the Council continue to refine policy pertaining to treatment of removals from sources other than the directed groundfish fishery.

Reference

Thompson, G. G., and R. R. Lauth. 2012. Assessment of the Pacific cod stock in the Eastern Bering Sea and Aleutian Islands Area. *In* Plan Team for the 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. 245-544. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

Table 2.4.1—Total removals of Pacific cod (t) from activities not related to directed fishing. Cells shaded gray represent data contained in the NMFS database. Other entries represent extrapolations for years in which the respective activity was known or presumed to have taken place.

Activity	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
AFSC Annual Longline Survey			28	28	28	28	28	28	28	28	28	28	28	28	28
AI Bottom Trawl Survey				2			2			2					2
Bait for Crab Fishery	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217
Bering Sea Slope Survey			1		1	1			1			1			1
EBS Bottom Trawl Survey	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
EBS Acoustic Trawl Survey			0			0			0			0			0
GOA Bottom Trawl Survey								0			0			0	
IPHC Annual Longline Survey															
Large-Mesh Trawl Survey														1	1
NBS Bottom Trawl Survey			7		7	7			7			7			7
Pollock EFP 11-01															
Pribilof Island Tanner Tagging															
Pribilof Islands Crab Survey															
Sport fishery	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
St. Mathews Crab Survey															
Subsistence Fishery	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2
Summer EBS Survey w/ Russia															

Activity	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
AFSC Annual Longline Survey	28	28	28			38		30		36		30		23	
AI Bottom Trawl Survey			2			2			2		2		2		2
Bait for Crab Fishery	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217	1217
Bering Sea Slope Survey									1		1		1		
EBS Bottom Trawl Survey	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
EBS Acoustic Trawl Survey			0		0	0		0	0		0		0		0
GOA Bottom Trawl Survey		0			0			0		0		0		0	
IPHC Annual Longline Survey							37	37	37	37	37	37	37	37	37
Large-Mesh Trawl Survey			1	1				1	1			1	1	1	1
NBS Bottom Trawl Survey															
Pollock EFP 11-01															
Pribilof Island Tanner Tagging															
Pribilof Islands Crab Survey												5		5	
Sport fishery	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
St. Mathews Crab Survey				6			6			6			6		
Subsistence Fishery	0	2	5	2	2	2	1	0	2	2	2	2	2	2	2
Summer EBS Survey w/ Russia			0								0		0		

Activity	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
AFSC Annual Longline Survey	25		20		24		27		33		26		29
AI Bottom Trawl Survey				2		1		2		2		3	
Bait for Crab Fishery	1217	1217	1217	413	1021	1551	1383	1751	2013	1424	864	886	864
Bering Sea Slope Survey		1		2		1	1	1		1			
EBS Bottom Trawl Survey	34	34	34	38	42	52	33	39	39	36	24	19	19
EBS Acoustic Trawl Survey	0	0	0	0		0		0		0		0	
GOA Bottom Trawl Survey	0		0		0		0		0		0	0	0
IPHC Annual Longline Survey	37	37	37	32	20	17	29	52	59	47	37	34	46
Large-Mesh Trawl Survey	1	1	1	1	1	2	1	1	1	1	1	0	0
NBS Bottom Trawl Survey				1							9	6	12
Pollock EFP 11-01					11	307							
Pribilof Island Tanner Tagging													0
Pribilof Islands Crab Survey		5			5					5		5	
Sport fishery	2	2	2	2	2	2	2	2	2	2	2	4	2
St. Mathews Crab Survey	6			9			6		6	6	5	3	6
Subsistence Fishery	2	2	2	2	2	2	2	2	2		2	2	2
Summer EBS Survey w/ Russia	0	0	0	0		0							

APPENDIX 2.5: PARALLEL RESULTS FOR THE "HARVEST RECOMMENDATIONS" SECTION, BASED ON MODEL 19.12

The results presented in the "Harvest Recommendations" section of the main text are based primarily on Ensembles A and AB. Because the structure of these ensembles differs substantively from Model 19.12 (the current base model), a set of parallel results for the items in that section, based on Model 16.6i, is provided here.

Amendment 56 Reference Points
Model 19.12's estimates of $B_{100\%}$, $B_{40\%}$, and $B_{35\%}$ are 669,025 t, 267,610 t, and 234,159 t, respectively.

Specification of OFL and Maximum Permissible ABC
Given the assumptions of Scenario 1 (below), female spawning biomass for 2021 and 2021 is estimated by Model 19.12 to be below the $B_{40\%}$ value of 267,610 t, thereby placing Pacific cod in sub-tier "b" of Tier 3 for both 2021 and 2022. Given this, Model 19.12 estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2021 and 2022 as follows:

Year	Overfishing Level	Maximum Permissible ABC
2021	OFL = 118,895 t	maxABC = 99,310 t
2022	OFL = 110,353 t	maxABC = 91,845 t
2021	*FOFL* = 0.31	*maxFABC* = 0.26
2022	*FOFL* = 0.29	*maxFABC* = 0.24

The age 0+ biomass projections for 2021 and 2022 from Model 19.12 are 693,203 t and 744,854 t.

Standard Harvest Scenarios, Projection Methodology, and Projection Results
The standard harvest scenarios and projection methodology were the same as described in the main text. Projections corresponding to the standard harvest scenarios are shown for Model 19.12 in Table 2.5.1.

Risk Table and ABC Recommendation
The risk table levels are the same as described in the main text. No reduction from maxABC is recommended. The recommended ABCs for 2021 and 2022 are the maxABC values shown above.

Status Determination
Methodology for status determination is as described in the main text. The status with respect to overfishing is independent of model choice for next year's specifications, as it depends entirely on the previous year's catch and OFL.

Based on the criteria described in the main text and the results shown in Table 2.5.1, the stock is not overfished and is not approaching an overfished condition.

Table 2.5.1. Results of the 7 standard harvest scenarios for Model 19.12, the current base model.

	Scenario 1-2		Scenario 3		Scenario 4		Scenario 5		Scenario 6		Scenario 7	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2021	210.6	18.8	210.6	18.8	210.6	18.8	210.6	18.8	210.6	18.8	210.6	18.8
B2022	197.7	12.6	173.8	13.4	217.2	15.7	236.1	18.9	190.2	11.6	197.7	18.7
B2023	214.8	10.4	175.6	10.8	246.0	14.1	282.8	19.4	204.3	9.4	208.3	12.5
B2024	239.7	8.8	190.0	8.8	282.7	12.6	341.7	19.8	226.6	7.9	228.3	8.9
B2025	256.2	6.9	200.6	6.7	314.3	11.6	401.0	19.3	240.1	6.1	240.6	6.3
B2026	263.3	5.6	206.5	5.1	339.0	10.3	454.5	18.1	245.0	5.1	245.0	5.1
B2027	265.3	5.2	209.6	4.1	357.0	9.2	500.0	16.6	245.9	4.7	245.8	4.7
B2028	265.5	5.0	211.2	3.7	369.8	8.4	537.2	15.2	245.6	4.6	245.5	4.6
B2029	265.1	5.0	212.0	3.4	378.6	7.9	566.9	14.1	245.1	4.6	245.1	4.6
B2030	264.8	5.0	212.5	3.3	384.5	7.6	590.2	13.2	244.9	4.6	244.9	4.6
B2031	264.6	4.9	212.7	3.3	388.6	7.5	608.2	12.6	244.8	4.6	244.7	4.6
B2032	264.5	4.9	212.8	3.2	391.2	7.4	621.9	12.3	244.7	4.6	244.7	4.6
F2021	0.257	0.026	0.450	0.000	0.120	0.012	0.000	0.000	0.314	0.032	0.257	0.025
F2022	0.240	0.017	0.450	0.000	0.124	0.010	0.000	0.000	0.282	0.019	0.294	0.031
F2023	0.263	0.014	0.450	0.000	0.141	0.009	0.000	0.000	0.304	0.015	0.310	0.020
F2024	0.295	0.012	0.450	0.000	0.153	0.004	0.000	0.000	0.339	0.013	0.342	0.015
F2025	0.316	0.010	0.450	0.000	0.153	0.004	0.000	0.000	0.361	0.011	0.362	0.012
F2026	0.326	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.369	0.011	0.369	0.011
F2027	0.328	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.370	0.010	0.370	0.010
F2028	0.329	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.370	0.010	0.370	0.010
F2029	0.328	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.369	0.010	0.369	0.010
F2030	0.328	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.369	0.010	0.369	0.010
F2031	0.327	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.368	0.010	0.368	0.010
F2032	0.327	0.009	0.450	0.000	0.153	0.004	0.000	0.000	0.368	0.010	0.368	0.010
C2021	99.3	17.1	162.4	13.9	48.7	8.6	0.0	0.0	118.9	20.3	99.3	0.0
C2022	91.8	12.1	144.3	11.6	53.4	8.1	0.0	0.0	102.8	12.8	110.4	21.4
C2023	114.4	10.7	157.1	9.7	71.7	8.2	0.0	0.0	125.5	10.9	129.8	14.9
C2024	143.9	9.4	172.3	7.9	89.9	4.4	0.0	0.0	155.7	9.4	157.7	10.8
C2025	162.4	6.6	180.3	5.8	99.0	3.9	0.0	0.0	172.9	6.4	173.5	6.6
C2026	169.7	4.7	184.0	4.4	105.3	3.5	0.0	0.0	178.3	4.6	178.3	4.4
C2027	171.4	3.9	185.8	3.8	109.6	3.2	0.0	0.0	178.8	4.0	178.7	3.9
C2028	171.2	3.8	186.8	3.5	112.6	3.0	0.0	0.0	178.1	4.0	178.0	3.9
C2029	170.7	3.8	187.3	3.4	114.7	2.9	0.0	0.0	177.5	4.0	177.4	4.0
C2030	170.3	3.8	187.5	3.3	116.0	2.8	0.0	0.0	177.1	4.0	177.1	4.0
C2031	170.1	3.8	187.6	3.3	117.0	2.7	0.0	0.0	177.0	4.1	177.0	4.1
C2032	170.0	3.9	187.7	3.3	117.6	2.7	0.0	0.0	176.9	4.1	176.9	4.1

APPENDIX 2.6: LINKING THE "RISK TABLE" TO ABC REDUCTIONS

The "risk table" consists of a set of rows representing *levels* of "risk" (defined loosely as levels of "concern") and columns representing *categories* of risk (Dorn and Zador 2020). An approach for implementing the risk table is described here, in which the standard implementation is augmented in a way that ties the risk table directly to the need for a reduction from the maximum permissible value of acceptable biological catch, *maxABC*, and the appropriate amount of reduction (if any). The approach is completely consistent with current requirements for implementing the risk table. As with existing implementations, subjective judgments are required. In contrast to existing implementations, however, once those judgments are made, the approach automatically determines whether a reduction from *maxABC* is warranted, and, if a reduction is warranted, the magnitude of such reduction is quantified in an objective and statistically meaningful manner.

The currency of the proposed approach is the probability that *maxABC* exceeds the true-but-unknown overfishing level (*truOFL*, as distinguished from the overfishing level estimated from the assessment model point estimate, *OFL*). Under the conventional "*P**" interpretation (e.g., Prager et al. 2003), an ABC reduction is necessary if the probability of *maxABC* being greater than *truOFL* exceeds 50%.

Let the probability density function and cumulative distribution function of *truOFL* be denoted *pdf*(*truOFL*) and *cdf*(*truOFL*), respectively, and let $cdf^{-1}(P)$ return the value of *truOFL* that sets *cdf*(*truOFL*)=*P*.

Considering only the statistical uncertainty estimated by the assessment model for the moment, let the probability of *maxABC* being less than *truOFL* be designated P_0, which is given by evaluating *cdf*(*truOFL*) at *truOFL*=*maxABC*, that is, P_0=*cdf*(*maxABC*).

The proposed approach for implementing the risk table involves adjusting the probability of *maxABC* exceeding *truOFL* so as to account for the uncertainties that are *not* included in P_0. Two basic principles of the proposed approach are as follow:

1. The probability of *maxABC* exceeding *truOFL* should depend on *all* risk categories.
2. A higher probability in any single category should map into a higher probability of *maxABC* exceeding *truOFL* overall.

The proposed approach incorporates these principles by expressing the probability of *maxABC* exceeding *truOFL* as a *joint* probability, while the corresponding quantities for the various categories are expressed as *marginal* probabilities. Thus, letting *P* represent the joint probability, p_j represent the marginal probability for category *j*, and *ncat* represent the number of categories, the joint probability is given as:

$$P = 1 - (1 - P_0)\prod_{j=1}^{ncat}\left(1 - p_j\right) \quad (1)$$

It is natural to assume that cases in which *all* categories exhibit the lowest level of risk (indexed as 1 and described as "normal" in the current risk table) should always result in an overall *P* value (i.e., P_0 plus any probability not accounted for in the assessment model) between P_0 and 0.5 (meaning that a reduction is not warranted), which then suggests that cases in which at least 1 category exhibits a higher risk level *might* map into an overall *P* value somewhere between 0.5 and 1.0.

If the risk table describes *nlev* levels of risk, a straightforward way to partition the 0.5-1.0 range is by setting the upper bounds of *nlev* intervals as

$$P_upper_i = \frac{i + nlev - 2}{2(nlev - 1)}\ , \forall\ i = 1,2, \dots, nlev\ ,$$

and the lower bounds as

$$P_lower_1 = P_0 \ \text{ and } \ P_lower_i = P_upper_{i-1}\ , \forall\ i = 2,3, \dots, nlev\ .$$

For example, the current version of the risk table sets *nlev*=4, in which case the following intervals of *P* can be identified:

Bound	*level*=1	*level*=2	*level*=3	*level*=4
P_lower	P_0	1/2	2/3	5/6
P_upper	1/2	2/3	5/6	1

Assessment authors are currently required to make a subjective determination as to the risk *level* for each risk category. This requirement is retained in the proposed approach, but the proposed approach also requires users to make a *second* subjective determination for each risk category, namely, an *intra-level* risk estimate, expressed as a fraction (Δ) of the distance between the upper and lower bounds of the identified *level*. Given the determinations of *level* and Δ for a given category, a *conditional* joint probability can be defined by interpolation as

$$P_cond_j = P_lower_{level_j} + \Delta_j \left(P_upper_{level_j} - P_lower_{level_j}\right)\ , \forall\ j = 1,2, \dots, ncat\ .$$

The above probability is "conditional" in the sense that it is the joint probability that would result if *every* category were assigned the same values of *level* and Δ. Given P_cond_j, the *marginal* probability is

$$p_j = 1 - \left(\frac{1 - P_cond_j}{1 - P_0}\right)^{1/ncat}\ , \forall\ j = 1,2, \dots, nlev\ .$$

Finally, given a value of *p* for every category, the joint probability is obtained by Equation 1.

The next step is to determine the appropriate reduction, if any, from *maxABC*. The procedure for this begins by computing a "probability-equivalent" *maxABC* as:

$$maxABC_{PE} = cdf^{-1}(P)\ ,$$

which becomes the denominator of the following quotient:

$$ratio = \frac{OFL}{maxABC_{PE}}\ .$$

The above pair of equations results in the following relationships:

- For $P < 0.5$: $maxABC_{PE} < OFL$, $ratio > 1$.
- For $P = 0.5$: $maxABC_{PE} = OFL$, $ratio = 1$.
- For $P > 0.5$: $maxABC_{PE} > OFL$, $ratio < 1$.

Finally, *ABC* is computed as

$$ABC = \min(1, ratio) maxABC\ .$$

The assumptions underlying the above equation are:

1. There is a "probability-equivalent" ABC, ABC_{PE}, that is analogous to $maxABC_{PE}$.
2. $ABC_{PE}/ABC = maxABC_{PE}/maxABC$.
3. ABC_{PE} should not exceed OFL.

The above results in the following relationships:

- For $P \leq 0.5$: $ABC = maxABC$.
- For $P \geq 0.5$: $ABC = OFL\left(\frac{maxABC}{maxABC_{PE}}\right)$.

References

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