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 1991-2020 were updated, and a preliminary catch estimate for 2021 was incorporated.
- Using the VAST approach as before, but with some adjustments to the set of hauls included in the data and an increase in the number of knots, the EBS+NBS survey abundance time series was re-estimated through 2021.
- Commercial fishery size compositions for 1991-2020 were updated, and a preliminary size composition from the 2021 commercial fishery was incorporated.
- The size composition data from the 2018 NBS survey were removed from the EBS+NBS survey size composition for 2018 due to the nonstandard survey design used in the NBS that year, and the size composition from the 2021 EBS+NBS survey was incorporated
- Using the VAST approach as before, but including otolith samples from the 2010, 2017, and 2019 NBS surveys, age compositions from the combined EBS+NBS survey time series were re-estimated through 2019.
- Long-term average weight-length parameters, and the time series of annual deviations therefrom, were re-estimated through 2020, and preliminary estimates for 2021 were incorporated.
- For one new model, a fishery CPUE time series, based on the VAST approach, was incorporated.

Changes in the Assessment Methodology

Many changes have been made or considered in the stock assessment model since the 2020 assessment (Thompson et al. 2020). Following the recommendation from a review by the Center for Independent Experts (Attachment 2.1.1), an ensemble consisting of five models and a corresponding set of model weights was presented in this year's preliminary assessment (Appendix 2.1): Model 19.12a is the current base model, and the other four models each differed from the base model with respect to a single, model-specific, feature. Model 19.12 included time-varying survey catchability, Model 21.1 allowed for the possibility that survey selectivity declines at larger sizes ("dome-shaped" selectivity), Model 21.2 incorporated a fishery catch per unit effort (CPUE) index as a relative measure of stock biomass, and Model 21.3 estimated a constant that is added to the standard deviation of each year's log-scale abundance index. After reviewing the preliminary assessment, the Team requested that the five-model ensemble be included in this final assessment. The SSC agreed, for the most part, with the Team's requested list, but suggested that Model 21.3 be omitted.

Summary of Results

The principal results of the present assessment, **based on the SSC ensemble**, 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:	
	2021	2022	2022*	2023*
M (natural mortality rate)	0.35	0.35	0.34	0.34
Tier	3b	3b	3b	3b
Projected total (age 0+) biomass (t)	754,000	786,566	879,978	848,615
Projected female spawning biomass (t)	228,219	205,906	259,789	254,585
$B_{100\%}$	659,545	659,545	686,761	686,761
$B_{40\%}$	263,818	263,818	274,704	274,704
$B_{35\%}$	230,841	230,841	240,366	240,366
F_{OFL}	0.37	0.33	0.38	0.37
$maxF_{ABC}$	0.30	0.27	0.31	0.31
F_{ABC}	0.30	0.27	0.31	0.31
OFL (t)	147,949	128,340	183,012	180,909
maxABC (t)	123,805	106,852	153,383	151,709
ABC (t)	123,805	106,852	153,383	151,709
Status	As determined *last* year for:		As determined *this* year for:	
	2019	2020	2020	2021
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 123,805 t, and 153,383 t in 2021 and 2022, respectively.

Note that the recommended 2022 and 2023 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 2022 F_{ABC} or ABC values are changed from those shown above, projected 2023 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 SSC has made 16 comments on assessments in general. The two such comments made during 2020 were addressed in the preliminary assessment (Appendix 2.1), and are not repeated here.

SSC guidance on risk tables

The SSC held a workshop on use of the "risk table" in February 2021, and followed up with a draft report of that workshop in June 2021, which included preliminary recommendations from a subcommittee of the SSC. The full SSC suggested some revisions to those preliminary recommendations in June 2021. Then, after considering suggestions made by the Council in June 2021 and the Joint Groundfish Plan Teams in September 2021, the SSC suggested further revisions in October 2021. The SSC then consolidated the various recommendations and revisions as follows (Anne Hollowed, AFSC, pers. commun., 10/25/21):

SSC1: "The SSC concluded that the risk table framework is working well. The tables have expanded communication among assessment authors and between assessment authors and ecosystem/process researchers. The framework is intended to provide a clear and transparent basis for communicating assessment-related and stock condition concerns that are not directly captured in model-based uncertainty, the tier system, or harvest control rules." *Response:* The approach described by Thompson (2021), which was used to complete the risk table in this assessment, addresses the SSC's recommendation explicitly.

SSC2: "The SSC recommended no changes to the language in the Risk Table template." *Response:* No changes were made to the language in the risk table template.

SSC3: "The SSC recognizes that within the context of the risk tables, 'risk' is the risk of the ABC exceeding the true (but unknown) OFL. The risk tables are intended to inform the process of adjusting the ABC from the maximum permissible when needed. Recommendations of an ABC reduction from the maximum permissible requires justification. The risk tables provide an avenue for articulating that justification." *Response:* The approach described by Thompson (2021), which was used to complete the risk table in this assessment, addresses the SSC's recommendation explicitly.

SSC4: "The SSC recommends that consideration for reductions from maxABC be based on current year information unless relevant risk factors for a stock continue to be present from previous years." *Response:* All information used to consider a reduction from maxABC in this assessment is consistent with the SSC's recommendation.

SSC5: "The SSC recommends that for stocks managed in Tiers 1-3, that risk tables are produced for all full assessments of groundfish (and perhaps crab) stocks and stock complexes in the fishery. Risk tables can be produced in other years at the discretion of the lead author if there have been notable changes to previous conditions." *Response:* The EBS Pacific cod stock is subject to a full assessment annually, and risk tables are produced accordingly.

SSC6: "The SSC recommends that Risk Tables should not be mandatory for other Tiers; however, stock assessments must include compelling rationale for why a Risk Table would not be informative." *Response:* This comment is not relevant to the EBS Pacific cod assessment.

SSC7: "For stock complexes, the SSC recommends that the decision concerning which species (or multiple species) to focus on be up to the author." *Response:* This comment is not relevant to the EBS Pacific cod assessment.

SSC8: "The SSC recommended maintaining the status quo, where authors are encouraged (but not required) to provide a recommendation on a reduction from maxABC, if warranted, and the Plan Teams and SSC would then evaluate and modify the reductions (if needed) based on the information available for the stock." *Response:* No reduction from maxABC is recommended in this assessment.

SSC9: "Risk scores should be specific to a given stock or stock complex. While comparison across species (e.g., within a tier, with similar life histories) or stocks is useful for consistency, the SSC does not support trying to prescribe a common reduction from the maximum permissible ABC for a given risk score across species or stocks because the processes underlying the score may differ among species and stocks. The SSC recommends that considerations of reductions in ABCs below the maximum permissible continue to be made on a case-by-case basis with justification based on risk scoring. The risk table rankings include qualitative information that requires a certain amount of subjective but well-informed interpretation of the available data by the author(s), the Plan Teams and the SSC, and as such, the SSC feels that blanket comparisons across species or stocks for the purpose of explicitly defining reductions in ABC below the maximum permissible are not prudent." *Response:* The approach described by Thompson (2021), which was used to complete the risk table in this assessment, is completely consistent with the SSC's recommendation. Specifically: 1) it does not prescribe a common reduction from the maximum permissible ABC for a given risk score across species or stocks, 2) considerations of reductions in ABCs below the maximum permissible continue to be made on a case-by-case basis with justification based on risk scoring, 3) the risk table rankings include qualitative information that requires a certain amount of subjective but well-informed interpretation of the available data, and 4) it does not make blanket comparisons across species or stocks for the purpose of explicitly defining reductions in ABC below the maximum permissible. One of the main advantages of the approach, in fact, is that it shows *how* and *why* it can be perfectly reasonable for two assessments to have the same risk scores but different amounts of reduction, including the case in which no reduction is appropriate for one of the assessments but some amount of reduction is appropriate for the other.

SSC10: "The SSC encourages the inclusion of LK/TK/S as a source of knowledge about the condition of the stock, a shift in the spatial or temporal distribution of the resource, or changes in the size or condition of species in the fishery." *Response:* Local knowledge is mentioned in the "fishery performance" category of this year's risk table. However, comment SSC4 makes other aspects of LK/TK/S difficult to include. By definition, "traditional" knowledge is unlikely to be based on current year information; and, although current year information on subsistence harvests could be obtained in principle, in practice the "Noncommercial Fishery Catch" database in AKFIN always lags at least a year behind the current year (moreover, no subsistence catches of Pacific cod have been reported since 1999).

SSC11: "The SSC recommends that the fishery/community performance column should focus on information that would inform the biological status of the resource (e.g., an unexplained drop in CPUE that could indicate un-modelled stock decline, or a spatial shift indicating changes in species' range), and not the effects of proposed ABCs on the fishery or communities or bycatch-related considerations. The SSC recognizes that the community impact information is critical for Council decision making and supports efforts to effectively communicate where this information can be accessed." *Response:* All of the information used in the fishery/performance column in the risk table for this assessment is consistent with the SSC's recommendation.

SSC12: "The SSC appreciates the discussion of avoiding double-counting information, in the assessment/Tier system and risk table, or among columns of the risk table. The SSC agrees that authors should avoid inclusion of stock trends/processes that are incorporated in the assessment or reflected in the Tier when scoring the risk tables. For cases where a process external to the assessment is relevant to two or more risk categories, the SSC recommends that the narrative reflect the interconnected relationships that exist between rankings among risk categories." *Response:* The approach described by Thompson

(2021), which was used to complete the risk table in this assessment, is explicitly designed to avoid double-counting information, by partitioning the various uncertainties according to whether they or internal or external to the assessment model. The approach does assume, however, that the risk levels for the various categories (i.e., columns) are independent. In the event that the risk levels are positively correlated, the method will tend to be precautionary, in the sense of prescribing a larger reduction than is strictly warranted.

SSC13: “The SSC suggests a revision to the category levels: from the existing four to three categories (normal, increased, extreme). The SSC recommends postponing this change until 2022 as many authors have already begun working on risk tables for 2021.” *Response:* The existing four levels are retained in this assessment.

SSC14: “The SSC reiterates that reductions in ABC below the maximum permissible should be applied sparingly and that the tier system should be regarded as the primary basis for establishing the ABC. If they begin to become commonplace, that should warrant further review of the assessment and/or the Tier system.” *Response:* The tier system is regarded as the primary basis for establishing the ABC in this assessment.

Responses to SSC and Plan Team Comments Specific to this Assessment

Since last year’s assessment was completed, the BSAI Groundfish Plan Team (GPT) and the SSC have made 25 comments specific to this assessment. The nine such comments made during 2020 (3 from the GPT and 6 from the SSC) were addressed in the preliminary assessment (Appendix 2.1), and are not repeated here.

Comments from the September 2021 Team meeting
GPT1: “The Team recommended advancing the current assessment and ensemble and associated ranking and weights for November.” *Response:* See comments SSC24 and SSC26.

GPT2: “While the Team recommended the current ensemble weighting, the Team welcomes alternative weighting approaches as the authors see fit to present or explore in November. If alternative weighting scenarios are presented, the Team recommended the authors also provide explanations of alternative weighting schemes.” *Response:* No changes were made to the model weights developed by the CIE reviewers, except as necessitated by comment SSC25.

Comments from the September/October 2021 SSC meeting
SSC15: “The SSC highlights the tremendous value of these CIE reviews, which provide independent examinations that often bring new ideas and valuable outside perspectives to the table.” *Response:* Peer review is to science as democracy is to government, viz.: “Democracy is the worst form of government except for all those other forms that have been tried…”—Winston Churchill.

SSC16: “The SSC supports continued use of the current VAST estimates of survey biomass in the assessment.” *Response:* This assessment uses the VAST specifications recommended in the preliminary assessment, but the VAST estimates themselves have changed (see “Data” section).

SSC17: “The preliminary assessment includes a new fishery CPUE index based on a VAST model to address the public and the SSC’s desire to utilize fisheries data better…. The VAST index was fit to winter (January-February) longline CPUE data only and was extrapolated to the entire EBS survey area. The SSC notes that there is no basis for the extrapolation into shallower areas of the shelf that, although sampled by the survey, have never had fishery effort. Although this is reflected in large uncertainty in the estimates, the SSC is concerned that this could introduce biases in the estimates as the estimated proportion of CPUE in the shallow areas changes. Moreover, the index does not utilize CPUE data from any of the other gear types or seasons and has not been fully reviewed and considered by the BSAI GPT or the SSC. Although the CIE reviewers supported the index, the SSC has concerns about the index as currently constructed, and requests that a more thorough exploration of a VAST-based fishery CPUE index be conducted that should make use of more of the available CPUE data, or that a stronger justification for the selected component of the fishery be provided. Despite these concerns and due to limited time before the November plan team meetings, the SSC leaves it to the author to bring forward a model with the best currently available fishery CPUE index as part of the ensemble." *Response:* Model 21.1 uses a revised fishery CPUE index that is responsive to the SSC's concerns about extrapolation into shallower areas of the shelf.

SSC18: "In the longer term, the SSC strongly supports continued development of the VAST modeling approach to fishery-dependent CPUE standardization for this and potentially other assessments." *Response:* An AFSC "fishery CPUE discussion group" has recently been formed, with plans to meet every 2-3 months to discuss using fishery CPUE for standardizing an abundance index, measuring fishery performance, understanding seasonal distribution and availability, identifying technical interactions and bycatch associations, and mapping spring/fall distribution for habitat studies.

SSC19: "The SSC reiterates comments from December 2020 regarding the importance of including fishery age compositions in future models and highlights the need for fishery age and size composition data from the NBS." *Response:* The data files used in this assessment include approximately 20,000 length records from the NBS fishery, spanning the years 2003-2021.

SSC20: "The SSC appreciates the input from the CIE reviewers and agrees that using the accepted base model to explore the impact of changing one aspect of the model at a time provides a good basis for an ensemble approach for this year's assessment." *Response:* The ensemble used in this assessment follows the CIE reviewers' approach of beginning with the current base model and changing one feature at a time in each of the alternative models.

SSC21: "The author discussed some of the advantages and disadvantages of allowing for time-varying catchability (19.12) and notes that this approach has good support in the literature. It provides a sensible approach to address the potential for variations in catchability associated with a variable portion of the stock being available to the survey and other processes. Therefore, the SSC supports bringing this model forward for consideration in an ensemble." *Response:* Model 19.12 is included in the ensemble presented in this assessment.

SSC22: "With respect to model 21.1, the SSC notes that the model to some extent addresses one of the concerns about a proportion of the population, in particular larger fish, not being available to the survey. The model estimates a considerably higher biomass due to the dome-shaped survey selectivity, which implies that the survey still misses many of the larger Pacific cod. This can no longer be attributed to larger fish moving into the NBS, as NBS biomass is now included in the model, but could result from large fish moving deeper or into Russian waters. The SSC noted one additional concern with the model, specifically that the asymptotic length for Pacific cod in this model is considerably lower than in the other models. The SSC supports bringing this model forward as an ensemble member, but recommends that the author explore whether the low asymptotic length in the model is consistent with the data and, if warranted, consider a different weight for the model." *Response:* Model 21.1 is included in the ensemble presented in this assessment. After comparing this model's estimated distributions of length at ages 8-17 with the corresponding distributions of length in the data, the weight for this model in the ensemble was left at the value recommended by the CIE reviewers, the GPT, and the SSC (see "Parameter Estimates" in the "Results" section).

SSC23: “Model 21.2 suggests that the impact of including the new fishery CPUE index is fairly small, but the model is responsive to previous requests for including fishery information in the model to the extent possible. The SSC supports inclusion of the model in the ensemble, using the best available fishery CPUE index as noted above.” *Response:* Model 21.2 is included in the ensemble presented in this assessment, using a version of the fishery CPUE index that is responsive to the SSC’s concerns about extrapolation into shallower areas of the shelf (see comment SSC17).

SSC24: “Model 21.3 allows for additional survey CV that is estimated within the model and results in substantially lower biomass estimates in recent years and a different recent stock trajectory that appears inconsistent with either the survey CPUE or recent fishery CPUEs. The SSC was concerned about the resulting residual pattern and, more importantly, about the model estimate of ‘extra SD’, which implies that the true (log-scale) standard deviations for the survey biomass index are on average more than 3 times larger than the log-scale standard deviations estimated by the VAST model. The SSC discussed imposing an upper bound on the ‘extra SD’ in the model, noting that authors routinely impose bounds on the implied uncertainty for other quantities such as age composition estimates. However, while such approaches have been vetted through the review process, there is currently no accepted standard for imposing a bound on ‘extra SD.’ Because of these concerns, the SSC recommends excluding model 21.3 from consideration as part of the ensemble in November.” *Response*: This recommendation conflicts with comment GPT1. Ideally, both the GPT ensemble (including Model 21.3) and the SSC ensemble (excluding Model 21.3) would be presented in this assessment. However, COVID-related complications resulted in delay of this year’s VAST estimates of the survey index and survey age composition, and the remaining time proved insufficient to include both ensembles. Because the SSC is the Council’s primary scientific review body, this assessment includes the SSC ensemble only.

SSC25: “In addition to supporting the ensemble modeling approach, the CIE reviewers suggested some revisions to the model weights that the authors adopted in this assessment. Specifically, weights were expanded from two [0,1] to three levels [0,1,2], some old criteria were dropped and new ones were added. The CIE reviewers judged all models to be less plausible than the base model based on model performance and model structure. The SSC concurs with the proposed weights and accepts the revised criteria, but encourages the assessment authors to consider modifications to the weights if warranted (see discussion of Model 21.1 above) and to consider bringing forward a set of alternative weights based on the approach and the criteria used in the proposed 2020 ensemble.” *Response*: Because the SSC recommended deleting Model 21.3 from the ensemble (see comments SSC24 and SSC26), the weights for the remaining models in the ensemble were rescaled so that they sum to unity. No other changes were made to the model weights (see also comment SSC22). Per this SSC comment, consideration was given to bringing forward a set of alternative weights based on the approach and criteria used in the proposed 2020 ensemble. However, such a set of alternative weights is not included in this assessment, because: 1) at least one of the criteria seems obsolete (i.e., reference to the GPT’s three “hypotheses” from November 2018 regarding disuse of the NBS survey data, separate treatment of the EBS and NBS survey data, or combining the EBS and NBS survey data); 2) the phrase, “the approach and criteria used in the proposed 2020 ensemble,” is ambiguous, as multiple approaches, sets of criteria, and ensembles were presented in the 2020 assessment, with conflicting proposals from the authors, GPT, and SSC; and 3) given the GPT’s and SSC’s stated preference for the revised approach and results that were developed during the CIE review, the very short amount of time available for producing this assessment would likely be better spent on other priorities.

SSC26: “In summary, the SSC requests that the author bring forward model 19.12a as the base model and models 19.12, 21.1 and 21.2 (in addition to 19.12a) as part of a multi-model ensemble for consideration in December. For the ensemble, the SSC requests the CIE proposed weighting scheme (without model 21.3) with possible adjustment to the weights by the author and Plan Teams. At the authors’ discretion, the SSC also welcomes an alternative weighting scheme based on last year's assessment." *Response*: See comments SSC24 and SSC25.

SSC27: "The CIE reviewers addressed the question as to "whether to apply the sloping harvest control rule before or after ensemble averaging of SSB and other reference points" (December 2020 SSC minutes), but did not come to a definitive conclusion. The assessment authors explored the question through a simplified simulation approach and concluded, based on those explorations and literature, that the "before" approach is better because in the authors' view it accounts for both within-model and between model variability more appropriately. The SSC supports the rationale provided for this assessment cycle but encourages further consideration of this issue by the authors and BSAI GPT in the future." *Response:* Such further consideration will likely be expedited by giving due consideration to the large amount of work that has already been done on this subject, of which Attachment 2.1.3 (Appendix 2.1) is the most recent example.

SSC28: "Unresolved spatial movements of Pacific cod were raised in public testimony as a major concern and the SSC shares these concerns. The SSC notes that some previous research on estimating movement rates between the EBS and NBS has been presented in previous assessments. However, with the recent transition to using VAST model estimates for a combined EBS and NBS biomass index, the need for resolving movements into and out of the NBS has diminished. Nevertheless, the new tagging study clearly shows that some component of the Pacific cod stock moves between US and Russian waters and the GOA, and is potentially vulnerable to exploitation in Russian fisheries and GOA fisheries and are potentially unavailable to the EBS and NBS surveys. The SSC notes that several Pacific cod tagged in the NBS were located in Russian waters during the spawning season, suggesting the possibility that Pacific cod spawning in Russian waters may move into the NBS during summer. The SSC was encouraged to see a combined analysis of Russian and US survey data using the VAST modeling framework (Figure 2.1.6 in the report) and a time series of Russian catches, which increased substantially in the last two years of the time series (2017/18). The SSC would like to see more details on the VAST analyses at a future meeting to evaluate their possible use in the assessment model as a means to addressing transboundary concerns. The SSC also highlights the need to further develop a spatial model for Pacific cod as a research priority, reiterating comments from their October 2020 minutes." *Response:* Further development of a spatially structured research model for Pacific cod in the Bering Sea might begin with the model already presented in Attachment 2.1.2 (Appendix 2.1).

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 Ecosystem and Socioeconomic Profile (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 50.2% of the catch, trawl gear accounted for an average of 29.5%, and pot gear accounted for an average of 20.3%.

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 (2016-2020).

Catches of Pacific cod taken in the EBS for the periods 1964-1980, 1981-1990, and 1991-2021 are shown in Tables 2.1a, 2.1b, and 2.1c, respectively; and the time series for the overall fishery (1977-2021) and by gear type (1988-2021) 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 Ecosystem and Socioeconomic Profile (Appendix 2.2) incorporates the Economic Performance Report that was included in EBS Pacific cod assessments prior to 2020.

Catches of Pacific cod taken from the portion of the Bering Sea under Russian jurisdiction during 2001-2018 are summarized in Table 2.1.3 (Appendix 2.1).

Effort and CPUE

Appendix 2.1 describes the results of the conventional catch per unit effort (CPUE) model that has been used, with minor modifications, in the last several assessments to estimate gear-specific fishery CPUE by year and month. No new CPUE data have become available since Appendix 2.1 was distributed in

September, so Table 2.1.2 and Figure 2.1.4 (both in Appendix 2.1) remain the current best estimates from the conventional CPUE model. The estimates from the conventional CPUE model are provided for context only, and are not used in any of the assessment models. However, a new index of fishery CPUE, based on the VAST approach (Thorson and Barnett 2017) is used in one of the assessment models, and is described separately in the “Data” section below.

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 2.2. 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 been lower in *every* year from 2017-2021 than in *any* year from 1991-2016.

Management History

The history of acceptable biological catch (ABC), overfishing level (OFL), and total allowable catch (TAC) levels is summarized and compared with the time series of aggregate (i.e., all-gear, combined area) commercial catches in Table 2.3. Note that, 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 2020 TAC averaged about 85% of ABC (ABC was not specified prior to 1980), and from 1980 through 2020, commercial catch averaged about 93% of TAC. In 10 of these 41 years, TAC equaled ABC exactly, and in 13 of these 41 years, catch exceeded TAC (by an average of 3.9%). However, eight of those overages occurred in 2007, 2008, 2010, and 2016-2020, 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 2016-2020 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 a bespoke 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 2016, 2018, 2019, and 2020 (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 2.3 was used in by Thompson (2018) 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 2022 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
2022	0.110 × EBS ABC

For 2020, 2021, 2022, and 2023, the Board of Fisheries established an additional GHL of 45 t for vessels using jig gear within State waters.

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

In addition to those, the following rulemaking became effective for 2021 on permit requirements: https://www.federalregister.gov/documents/2020/12/03/2020-26593/fisheries-of-the-exclusive-economic-zone-off-alaska-pacific-cod-in-the-bering-sea-and-aleutian. In this rule, NMFS modified Federal permit conditions and imposed participation requirements for certain federally permitted vessels when fishing for Pacific cod in State of Alaska waters (state waters) adjacent to the Exclusive Economic Zone (EEZ) of the Bering Sea and Aleutian Islands (BSAI). The state waters portion of the Pacific cod fishery that runs concurrent with the Federal Pacific cod fishery is commonly known as the State's parallel fishery. The "parallel fisheries" in this preamble refer to the State waters Pacific cod parallel fisheries in the State of Alaska Bering Sea-Aleutian Islands Area, which presently is in the Dutch Harbor Subdistrict of the Bering Sea and within the Aleutian Islands Subdistrict of the Aleutian Islands, respectively. This rule prohibits (1) a hook-and-line, pot, or trawl gear vessel named on a 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 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.

For the second consecutive year, Bering Sea non-CDQ Pacific cod directed fishing closed for all non-CDQ sectors. The non-CDQ sectors have BSAI allocations and there was less fishing in the Aleutian Islands until after the Bering Sea non-CDQ sectors closed. In 2020, the closure was November 18, 2020. Directed fishing closed for the Pacific cod non-CDQ sectors on September 17, 2021, to prevent exceeding the non-CDQ allocation of the 2021 total allowable catch of Pacific cod in the Bering Sea subarea of the

BSAI. After the closure there was still fishing by the CDQ groups and incidental catch of Pacific cod in other targets.
https://www.fisheries.noaa.gov/bulletin/ib-21-42-nmfs-prohibits-directed-fishing-non-community-development-quota-pacific-cod

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	1977-2021
Fishery	Catch size composition	1977-2021
Fishery	Catch per unit effort (VAST)	1996-2021
EBS+NBS trawl survey	Survey numerical abundance (VAST)	1982-2021
EBS+NBS trawl survey	Survey size composition (design-based)	1982-2021
EBS+NBS trawl survey	Survey age composition (VAST)	1994-2019

Fishery Data Used in the Models

Catch Biomass
Catch estimates for the period 1977-2021 are shown Tables 2.1a, 2.1b, and 2.1c. However, the estimate for 2021 is complete only through September 26. Because the 2021 ABC (123,805 t) is lower than any year-end catch since 1983, the year-end catch for 2021 was set equal to the 2021 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 2.5.

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

Size Composition
Table 2.5 shows the fishery size compositions from 1977 through September 2021, which are parsed into 1-cm bins for use in the assessment models. The size composition data Table 2.5 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 in last year's assessment (Thompson et al. 2020)).

The nominal sample sizes (number of sampled hauls) for the size compositions are shown in Table 2.6.

Catch Per Unit Effort

SSC17: "The SSC notes that there is no basis for the extrapolation into shallower areas of the shelf that, although sampled by the survey, have never had fishery effort. Although this is reflected in large uncertainty in the estimates, the SSC is concerned that this could introduce biases in the estimates as the estimated proportion of CPUE in the shallow areas changes…. The SSC leaves it to the author to bring forward a model with the best currently available fishery CPUE index…."

A new index of fishery CPUE, based on the VAST approach (Thorson and Barnett 2017), was described and used in Model 21.2 of the preliminary assessment (Appendix 2.1). The SSC expressed some concerns with the index (comment SSC17), including a concern that the index involved extrapolation into shallower areas of the shelf that had experienced little fishing effort. The SSC requested that the version of Model 21.2 presented in the final assessment use "the best currently available fishery CPUE index."

The choices for a fishery CPUE index that were feasible in the time frame between the conclusion of the September/October SSC meeting and the due date for completion of the final assessment were as follow:

1. A simple average of observer data, extrapolated through the end of 2021 using the conventional CPUE model. Methods for this approach were described in the "Data" section of Appendix 2.1 and, in the interest of brevity, are not repeated here.
2. An update of the VAST fishery CPUE index through 2021, following the methods used to produce the original index. Those methods were described in the "Data" section of Appendix 2.1 and, in the interest of brevity, are not repeated here.
3. A revision and update of the VAST fishery CPUE index through 2021, following alternative methods designed to address the SSC's concern about extrapolating into poorly sampled areas. The differences in methods relative to those used to compute the original VAST index were:
    - Instead of predicting densities across the entire eastern Bering Sea bottom trawl survey area (such that the index would reflect uncertainty about abundance in both fished and unfished areas), density was predicted over a reduced area formed by overlaying an extrapolation grid across the maximal extent of the fishery, using 10 km × 10 km square cells and excluding any cell that is further than 14.14 km from the nearest sample. (The maximum distance was chosen so as to produce a grid that contained no holes other than land areas, and then further reduced to 2000 extrapolation locations. A possible alternative for consideration in a future assessment could be to include all cells that contain a sample.)
    - The number of knots was increased from 100 to 250.

As with the original VAST fishery CPUE index (option #2), the model used in option #3 converged successfully, with no evidence of poor fit based on standard Dunn-Smyth PIT residuals (Dunn and Smyth 1996), and epsilon bias correction was again used to account for retransformation bias (Thorson and Kristensen 2016) when calculating the index of relative biomass.

Figure 2.4 shows the time series for all three options (including two suboptions for option #1: one for January and one for February) on normalized scales, where "Conv" is the conventional CPUE model (option #1), "VAST(old)" is option #2, and "VAST(new)" is option #3. The correlation matrix for the four indices is shown below (the color scale extends from red=low to green=high):

Correlation	VAST(new)	VAST(old)	Conv(Jan)	Conv(Feb)
VAST(new)	1.000	0.708	0.734	0.516
VAST(old)	0.708	1.000	0.879	0.887
Conv(Jan)	0.734	0.879	1.000	0.812
Conv(Feb)	0.516	0.887	0.812	1.000

The highest correlations are between option #2 and the two suboptions of option #1.

A central difficulty with traditional methods such as option #1 above is that spatial targeting can cause sampled CPUE to be unrepresentative of population density (Walters 2003). In contrast, more recent methods such as VAST address this issue explicitly through use of high-resolution spatial and timing information. Recent methods such as VAST implicitly impute or predict the CPUE that would have arisen in unsampled locations, interpreting that CPUE as proportional to density after controlling for variables affecting catchability, weighting densities based on area, and integrating area-weighted uncertainty across poor- and well-sampled areas. This imputation occurs either structurally (Carruthers et al. 2011), via post-stratification and area-weighting of CPUE in different strata (Campbell 2016), or using area-weighting within spatio-temporal statistical models (Thorson, 2019a). Relative to explicit imputation approaches (e.g., Carruthers et al. 2011), spatio-temporal methods extrapolate densities based on spatial correlations in predicted density as well as correlations across time either via a spatial component (which affects estimates of leverage for observations based on location) or an autocorrelated spatio-temporal component. Spatio-temporal models for fishery CPUE data have been tested using operating models mimicking fishery-dependent CPUE data that were developed independently and do not match the estimation model (Grüss et al. 2019; Thorson et al. 2017a). In particular, testing using SEAPODYM as the operating model and VAST as the estimation model suggests that trends in abundance can be accurately reconstructed even when the spatial footprint of fishing has expanded or contracted over time (Ducharme-Barthe et al. *In press*).

The choice, then, becomes whether to use option #2 or option #3. Given the SSC's concerns regarding option #2 and the fact that option #3 addresses the SSC's primary concern explicitly, the clear pragmatic choice is to use option #3. The resulting fishery CPUE time series is listed in Table 2.7. Maps of log density and quantile residuals are shown in Figures 2.5a and 2.5b, respectively.

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 2020, in the EBS, strata 10-62 had been surveyed annually since 1982 and strata 82 and 90 had been surveyed annually since 1987. However, the EBS bottom trawl survey was cancelled in 2020 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 in 2020, but, like the EBS survey, the 2020 NBS survey was cancelled due to the COVID-19 pandemic. Both the EBS and NBS were once again surveyed with a full, standard sampling design in 2021.

VAST Estimates of Abundance From the EBS Shelf and NBS Bottom Trawl Surveys
A detailed description of VAST modeling procedures as well as a detailed comparison of alternative configurations of the VAST model used to produce the time series of abundance from the combined EBS shelf and NBS bottom trawl surveys for this stock were given in the "Data" section of Appendix 2.1 and, in the interest of brevity, are not repeated here. The configuration recommended by the authors in that appendix was used to estimate the time series for this assessment. The resulting set of estimates (in 1000s of fish) is shown in Table 2.8, together with their respective log-scale standard deviations ("Sigma"), and

compared with those used in the 2020 assessment in Figure 2.6a (correlation = 0.982). Differences in estimates for years prior to 2021 are due to: 1) an increase in the number of knots from 100 to 750, 2) changes in estimated values of parameters that are shared across the time series, and 3) changes to the sets of hauls used in the historical datasets. The new estimate for 2021 is down 20% from the new estimate for 2020, which in turn was up 43% from the new estimate for 2019. Maps of log density and quantile residuals are shown in Figures 2.6b and 2.6c, respectively.

Size and Age Composition
Design-based estimates of the size compositions (in 1-cm bins) from the combined EBS and NBS bottom trawl surveys for the years 1982-2021 are shown in Table 2.9 (VAST estimates of size composition are not available, so design-based estimates were used for all models). Each row sums to unity. In addition to including a row for 2021, this file differs from the one used in last year's assessment in that it does not include NBS data from the 2018 survey, because the NBS survey in that year did not follow the standard sampling design. Sample sizes for the survey size composition data, in units of sampled hauls, are shown in Table 2.10.

Recent size compositions, up to 80 cm, are compared in Figure 2.7. The size compositions from the nine most recent surveys of the EBS are shown in Figure 2.7a along with the 1987-2021 mean size composition. While the size compositions from 2012-2014 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 suggested that the 2018 year class might break that string, but the mode in the 40-50 cm range from the 2021 EBS survey did not provide particularly strong corroboration of that. Figure 2.7b shows the size compositions from the 2010, 2017, 2019, and 2021 NBS surveys. As in the 2019 EBS survey, the 2019 NBS survey suggested that the 2018 year class might be large, but, unlike the 2019 EBS survey, the large mode in the 40-50 cm range from the 2021 NBS survey would seem to corroborate that.

Updated VAST age compositions from the combined EBS and NBS surveys for 1994-2019 are shown in Table 2.11a, where the values in each row sum to unity (the color scale extends from red=low to green=high). The age-length keys used to produce these estimates include newly read samples of 178, 368, and 390 otoliths from the 2010, 2017, and 2019 NBS surveys, respectively. Although NBS size frequencies were included in the data used to generate the age compostions in last year's assessment, this year marks the first time that data from NBS *otoliths* have been included. Table 2.11b shows the differences in the proportions at age between last year's estimates and this year's. Sample sizes for the survey age composition data, in units of read otoliths, are shown in Table 2.12 (but note that the sample sizes actually specified in the models are in units of sampled hauls (Table 2.10)).

Data Provided for Context Only

Design-Based Index Estimates from the EBS Shelf and NBS Bottom Trawl Surveys
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 2.13a, together with their respective log-scale standard deviations ("Sigma"), and plotted in Figure 2.8a. The 2021 estimate for the EBS was down 20% from the 2019 estimate, which was up 112% from the 2018 estimate and up 44% from the 2017 estimate. The 2021 estimate for the NBS was down 36% from the 2019 estimate, which was up 49% 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 2021 estimate for the combined EBS and NBS surveys was down 24% from the 2019 estimate, which was up 46% from the 2017 estimate.

Design-based, area-swept estimates of biomass (t) for the EBS, NBS, and EBS and NBS combined are shown in Table 2.13b, together with their respective log-scale standard deviations ("Sigma"), and plotted in Figure 2.8b. The 2021 estimate for the EBS was up 19% from the 2019 estimate, which was up 2% from the 2018 estimate and down 20% from the 2017 estimate. The 2021 estimate for the NBS was down 38% from the 2019 estimate, which was up 27% 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 2021 estimate for the combined EBS and NBS surveys was down 4% from the 2019 estimate, which was down 5% from the 2017 estimate.

IPHC Longline Survey
Figure 2.9a shows the locations of BSAI stations sampled by the IPHC longline survey. The time series (1997-2021) of relative population numbers (RPN) is shown in Figure 2.9b (there are no data for EBS Pacific cod from the 2020 IPHC survey). The 2021 estimate was up 9% from the 2018 estimate, which was up 26% from the 2018 estimate. The 2021 estimate is 2% above the mean value for the time series.

AFSC Longline Survey
Figure 2.10a shows the locations of BSAI stations sampled by the AFSC longline survey. The biennial time series (1997-2021) of RPN and relative population weight (RPW) are shown in Figure 2.10b. The 2021 estimates are both up slightly from 2019, but still below their respective long-term averages. The RPW has been within +/– 10% of the long-term average every year since 2011.

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 V3.30.18.00 was used to run all of the models in this final assessment. The user manual is available at https://github.com/nmfs-stock-synthesis/ss-documentation/releases/tag/v3.30.18 .

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." With two exceptions (discussed in the "Results" section below), in the rare instances where parameter estimates are pinned against either bound, those parameters are fixed in the final run of that model at the values estimated in the penultimate model run.

On the other hand, for each parameter that varies randomly on an annual basis, SS estimates a vector of annual deviations that are either added to, or multiplied by, the base value of the parameter. In the case of log recruitment, the deviations are constrained by a $N(0,\sigma^2)$ distribution. The deviations in every other vector are constrained by a $N(0,1)$ distribution, and then the vector is multiplied by a σ term specific to that vector. For all models in this assessment, each σ was tuned iteratively as follows:

- For a vector of deviations associated with log catchability, σ was tuned to set the root-mean-squared-standardized-residual (RMSSR) equal to unity.
- For the vector of 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 of deviations, σ was tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.

All models were run using the "-hess_step" option in ADMB, with 2 steps specified. This resulted in all model gradients equaling 0 in the final pass. As an additional check on convergence, the final versions of all models successfully passed a "jitter" test of 50 runs with the jitter rate set at 0.1.

Description of Alternative Models

Names 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 *minor* changes from the original form of the current base model get linked to the name of that model (e.g., the current base model, Model 19.12a, is a minor modification of Model 19.12, which was the base model adopted at the conclusion of the 2019 assessment cycle), while names of models constituting *major* changes get linked to the year that they are introduced (e.g., when Model 19.12 was adopted at the conclusion of the 2019 assessment cycle, it constituted a major change from the previous base model (Model 16.6i).

The SSC Ensemble

The models presented in this assessment correspond to those in the SSC's recommended ensemble (comment SSC26). This ensemble consists of Models 19.12a (the current base model), 19.12, 21.1, and 21.2. The structures of these models were described in the "Models" section of Appendix 2.1 and, in the interest of brevity, those descriptions are not repeated here.

Following the procedure developed during this year's CIE review (Attachment 2.1.1), the SSC ensemble is "anchored" by the current base model, and then alternative models are constructed by adding features, one per alternative, to the base model as follows:

Feature	M19.12a	M19.12	M20.1	M20.2
Feature 1: Allow catchability to vary?	no	yes	no	no
Feature 2: Allow domed survey selectivity?	no	no	yes	no
Feature 3: Use fishery CPUE?	no	no	no	yes

Incorporating the above features into the alternative models involves adding the following parameters:

- Model 19.12: 39 constrained deviations
- Model 21.1: 3 survey selectivity parameters
- Model 21.2: 1 fishery catchability parameter

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 was modeled as 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 in the assessment models). 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 EBS survey age data have been used to estimate the slope parameter.

For the current data set, the estimated slope is 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 2021) as α = 5.40706E-06 (mean-unbiased) and β = 3.19601.

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 2.14.

Prior to the 2016 assessment, the EBS Pacific cod assessment models were seasonally structured, and seasonal adjustments to α and β were applied. Beginning with the 2012 assessment (Thompson and Lauth 2012, Annex 2.1.2), an explicit phenological model of intra-annually varying weight at length was used to estimate the α and β parameters, wherein α and β were modeled as trigonometric functions of time (within the calendar year), with time rescaled linearly so as to permit asymmetry in intra-annual rates of change. The simple functional forms enabled closed-form integration over any period within the year, so that seasonal averages could be computed straightforwardly. In October 2012, the SSC determined that the phenological model "provides a significant improvement" that "could also serve as a model for other assessments."

Although not documented in the 2020 assessment, the phenological model (specifically, the "unconstrained" version of the model described by Thompson and Lauth) was brought back into use in that assessment, not to provide seasonally varying estimates of α and β per se, but to use the estimated intra-annual patterns to extrapolate year-end values of α and β for the current year, for which only partial data are available (prior to the 2020 assessment, α and β for the current year were set equal to their respective base values). The same approach is used in the current assessment.

Maturity
A detailed history and evaluation of parameter values used to describe the maturity schedule for BSAI Pacific cod was presented in the 2005 assessment (Thompson and Dorn 2005). A length-based maturity schedule was used for many years. The parameter values used for 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 models beginning with the 2019 assessment have returned to using the length-based schedule.

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

Except for the addition of some annual deviations necessitated by extending the terminal year through 2021, the parameters estimated by the assessment models are enumerated in Table 2.1.8 (Appendix 2.1).

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 was 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 for the time series is equal to the mean number of sampled hauls from the combined EBS+NBS survey time series.

Input sample sizes for size composition data (survey and fishery) are shown in Table 2.15.

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 2.15), 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 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 2.8.

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 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.

Also, while the results for all of the models in this final assessment differ from their counterparts in the preliminary assessment (Appendix 2.1), for the special case of Model 21.2, it should be noted that such differences are due in part to an error in the data file that was used for Model 21.2 in the preliminary assessment, wherein the units for the fishery CPUE index were inadvertently specified as being in relative numbers of fish rather than relative biomass (the data file for Model 21.2 during the CIE review was correct in this regard; it was only the data file for the preliminary assessment that included the error).

Model Evaluation

Individual Model Goodness of Fit
Table 2.16 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 (e.g., Model 21.2 uses a different data file than the other models, as it includes the fishery CPUE time series).
- The data are weighted differently between models, due to tuning of the "sigma" terms for devs.

The RMSSRs for the index data and the correlations between model estimates and the index data are shown for all models below, where RMSSR values within the range of 0.99-1.01 are shaded green:

Index:	Survey				Fishery
Model:	M19.12a	M19.12	M21.1	M21.2	M21.2
RMSSR:	2.313	0.996	2.306	2.892	1.926
Correlation:	0.887	0.982	0.889	0.803	0.879

Ideally, RMSSR values should equal unity, and this was the standard that was used to tune the sigma terms for the log catchability devs in Model 19.12. Models 19.12a and 21.1 underfit the survey index data to similar extents. Model 21.2 fit the survey index data a bit worse than Models 19.12a or 21.1, because it had the added task of having to fit the fishery CPUE index, which it fit more successfully than it fit the survey index.

Fits to the trawl survey abundance data are shown for all models in Figure 2.11a, where the 95% confidence intervals for the data are based on the lognormal sigmas estimated by VAST. Figure 2.11b shows Model 21.2's fit to the fishery CPUE index.

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 2.17. 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. (2017b), which uses the Dirichlet-multinomial distribution to model compositional data, is expressed as a function of an internally estimated parameter (ln(θ)), so iterative tuning is not required.

Size composition: By the McAllister-Ianelli measure, both the fishery and survey size composition data were *over*fit by all of the models. The Dirichlet-multinomial parameter was constrained by the upper bound for both the fishery and survey size composition data in all models, meaning that, by the Thorson et al. measure, the effective sample size was equal to the average input sample size.

Age composition: By the McAllister-Ianelli measure, the age composition data were *under*fit by all of the models. The effective sample sizes for the Thorson et al. formulation were of the same magnitude and rank order as, but larger than, the effective sample sizes for the McAllister-Ianelli formulation. By both measures, Model 19.12 exhibited slightly better fits than the other models.

Residual plots for the size and age composition data are shown in Figures 2.12 and 2.13, respectively.

Model Weights
This year's CIE review resulted in a set of model weights for the five models in the reviewers' recommended ensemble (Table 2.1.14 of Appendix 2.1). These weights were developed from a procedure that was based on the procedures used in the 2019 and 2020 assessments, with some modifications (see "Model weights" section in Appendix 2.1). In brief, model weights were computed by normalizing the emphasis-weighted averages of reviewer-averaged scores (0, 1, or 2) for a set of criteria. Because the SSC's ensemble omits one model from the CIE reviewers' ensemble (Model 21.3), the weights in Table 2.1.14 of Appendix 2.1 were renormalized, giving the weights shown in Table 2.18.

The model weights in Table 2.18 will be used to augment nearly all of the model-specific results in the remainder of this section with "ensemble" values (i.e., weighted average values across all models).

Retrospective Performance
Retrospective analyses of all individual models, along with a retrospective analysis of the weighted averages for the ensemble, are shown in Figure 2.14. As in previous assessments, the results of Hurtado-Ferro et al. (2015) are interpolated to produce a range of "acceptable" values of Mohn's (1999) ρ as a function of the instantaneous natural mortality rate *M*, giving the results shown below (the acceptable range is bounded by ρmin and ρmax):

Model:	M19.12a	M19.12	M21.1	M21.2	Ensemble
M	0.3609	0.3381	0.3249	0.3514	0.3445
Mohn's ρ	-0.0474	-0.0552	0.0030	0.1387	0.0004
ρmin	-0.2063	-0.1983	-0.1937	-0.2030	-0.2006
ρmax	0.2804	0.2690	0.2624	0.2757	0.2722

All models, including the ensemble, have values of ρ well within their respective acceptable ranges, and all but Model 21.2 have values within the range -0.06 to 0.01.

Parameter Estimates
Table 2.19 displays the values of all estimated 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. Standard deviations are based on the inverse of the Hessian matrix, and assume a normal distribution.

Table 2.19a shows all time-invariant estimated parameters (color scales are row-specific). A blank cell in Table 2.19a indicates that the respective parameter (row) is not used in the respective model (column). As noted under "Goodness of fit" above, the Dirichlet-multinomial parameters for size composition ended up being pinned near the upper bound (=10.0) for all models, so those parameters (with two exceptions; see next sentence) were fixed in the final run of each model at the values estimated in the penultimate run of that model. The two exceptions were the Dirichlet-multinomial parameters for size composition in Model 21.2. In that model, fixing those two parameters at the values estimated in the penultimate run caused the model to converge to a slightly different point in parameter space, which made tuning the "sigma" terms for the time-varying parameters extremely difficult. As a compromise, the Dirichlet-multinomial parameters for size composition were left active in Model 21.2, with values estimated (on the log scale) at 9.98905 for the fishery and 9.98176 for the survey. The two other cases where a parameter was pinned near a bound are indicated in Table 2.19a by the presence of a "_" symbol in the SD column. Those were: 1) the log-scale standard deviation of thedescending limb of the fishery selectivity curve in Model 19.12a, and 2) the log-scale standard deviation of the ascending limb of the fishery selectivity curve in Model 21.2 (estimated close to the lower bound of -10.0). Some highlights for the other parameters in Table 2.19a include the following: Natural mortality ranges from 0.325 (Model 21.1) to 0.361 (Model 19.12a). Asymptotic length (L_∞) ranges from 102.963 cm (Model 21.1) to 120.757 cm (Model 19.12). The Brody growth coefficient (K) ranges from 0.098 (Model 19.12) to 0.158 (Model 21.1). Similar to last year's assessment, the sign of the ageing bias flips from all positive (pre-2008) to very near zero at age 1 but negative at older ages (post-2007) in all models. Initial fishing mortality ranges from 0.068 (Model 21.1) to 0.124 (Model 19.12). Log survey catchability (base value in the case of Model 19.12) ranges from -0.094 (Model 21.2) to 0.0.038 (Model 19.12).

The SSC has raised a possible concern that the asymptotic length estimated by Model 21.1 (102.963 cm) may be too low, and that the weight assigned to that model in the ensemble may need to be adjusted. It has long been known (e.g., Knight 1968) that estimates of L_∞ and K are inversely correlated, such that nearly equivalent fits can be obtained by a wide range of parameter combinations, and this appears to be borne out in Table 2.19a, where the model with the *lowest* estimate of L_∞ (Model 21.1) is also the model with the *highest* estimate of K, and the model with the *highest* estimate of L_∞ (Model 19.12) is also the model with the *lowest* estimate of K. It is also important to note that, in SS, L_∞ does not function as an absolute ceiling on length, but as the mean of the distribution of length for very old fish (with concomitant effects on the means of the distributions of length at other ages). With this in mind, the proportion of fish in the data that were of length greater than 103 cm (the approximate value of L_∞ estimated by Model 21.1) were tabulated for each age, and compared with the proportion of fish in the age-length key estimated by SS that were of length greater 103 cm, resulting in the table below (there were no fish in the data of length greather 103 cm at ages less than 8 years):

Age:	8	9	10	11	12	13	14	15	16	17	18	19	20
Data:	0.003	0.020	0.055	0.082	0.061	0.050	0.083	n/a	n/a	0.000	n/a	n/a	n/a
M21.1:	0.000	0.002	0.010	0.025	0.050	0.083	0.139	0.168	0.192	0.243	0.272	0.300	0.343

While the proportions estimated by Model 21.1 do seem slightly low for some ages, the differences are unlikely to be statistically significant, as the data contain no more than 8 fish of length greater than 103 cm at any age (and only 29 such fish across all ages, out of a total sample size of 30,048). Therefore, no change was made to the weight assigned to Model 21.1 in the ensemble.

Tables 2.19b-2.19f show time series of annual parameter deviations. Color scales are column-specific in all these portions of Table 2.19, and show that, in general, time trends between models are very similar. Table 2.19b shows log deviations for the initial numbers-at-age vector, Table 2.19c shows log recruitment (at age 0) deviations, Table 2.19d shows deviations for mean length at age 1.5, Table 2.19e shows deviations for the time-varying selectivity parameters, and Table 2.19f shows deviations for log survey catchability (Model 19.12 only).

Tuning of Constraints on Annually Varying Parameters
As noted in the "Parameter estimation" subsection of the "Models" section, except for the sigmas associated with annual deviations of log catchability, tuning of the sigmas for annually varying parameters 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, deviations 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, deviations are modeled in SS as being normal($0,\sigma^2$), and sigma was tuned so that it matched the square root of the sum, again with a tolerance of +/- 0.01.

Table 2.20 shows the values of the iteratively tuned sigmas for parameters with annual deviations (other than log catchabilities). Sigmas for log recruitment, the logit of fishery selectivity at maximum size, and the log of the standard deviation of the 1st (ascending) normal pdf for survey selectivity tended to have larger values than those associated with other parameters. The sigma for the logit of fishery selectivity at maximum size was especially large for Model 21.2 (nearly double the value for the other models), as this extra variability was evidently needed to help that model achieve the additional task of fitting the fishery CPUE data.

For Model 19.12 (the only model that includes annual deviations for log survey catchability), sigma was tuned so as to set RMSSR=1.0 (tolerance = +/- 0.01), resulting in a value of 0.0765.

Derived Quantities
Figure 2.15 shows selectivity for all models. Figure 2.15a shows selectivity for the fishery, and Figure 2.15b shows selectivity for the survey. For the fishery, Model 19.12a shows the least amount of "dome-shape," while Model 19.12 shows the most. For the survey, Models 19.12a, 19.12, and 21.2 appear broadly similar, while Model 21.1 shows steeply declining selectivity at lengths greater than about 60 cm.

Table 2.21 shows back-transformed survey catchability for Model 19.12. Estimates tended to be lower than average during the period 2006-2013 (except for 2011), and higher than average for the period 2014-2021 (except for 2017 and 2019).

For comparability with previous assessments, back-transformed estimates of catchability for the years 2017 through the present are shown for all models below (only Model 19.12 is time-varying):

Year	M19.12a	M19.12	M21.1	M21.2
2017	0.920	0.901	0.980	0.910
2018	0.920	1.121	0.980	0.910
2019	0.920	1.040	0.980	0.910
2021	0.920	1.144	0.980	0.910
Mean	0.920	1.052	0.980	0.910

In the following tables and figures, results are shown for all models and the ensemble (point estimates and standard deviations in the case of tables, point estimates in the case of figures).

Table	Figure	Quantity
2.22	2.16	female spawning biomass (millions of t)
2.23	2.17	female spawning biomass relative to $B_{100\%}$
2.24	2.18	age 0 recruitment (billions of fish)
2.25	2.19	full-selection instantaneous fishing mortality

For the above sets of tables and figures, the Hessian approximation to the distribution was used in the case of individual models, implying that each distribution is normal, while the distribution for the ensemble was computed as the weighted average of the individual model distributions.

In the following tables, point estimates for each age and year are shown for all models and the ensemble.

Table	Quantity
2.26	mid-year population length (cm)
2.27a	mid-year fishery weight (kg)
2.27b	mid-year survey weight (kg)
2.28a	fishery selectivity
2.28b	survey selectivity

The following figures show point estimates and error bars corresponding to +/– two standard deviations, for the ensemble only:

Figure	Quantity
2.20	female spawning biomass (millions of t)
2.21	female spawning biomass relative to $B_{100\%}$
2.22	age 0 recruitment (billions of fish)
2.23	full-selection instantaneous fishing mortality

For the above set of figures, it should be noted that, because the distributions for the ensemble are averages of normal distributions, the ensemble distributions are themselves *not* normal, meaning that, while the standard deviations are correct (given the Hessian approximations of the distributions for the individual models), the ensemble error bars shown in the figures may or may not approximate the 95% confidence intervals.

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 (2022 and 2023) 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 2022 female spawning biomass, relative spawning biomass, $maxF_{ABC}$, and maxABC projected by the current base model (19.12a) shown in Table 2.29 differ markedly from last year's projections of those same quantities (using the same model), as shown below:

Year	Quantity	Last year	This year	Change
2022	Female spawning biomass	205,906	259,007	26%
2022	Relative spawning biomass	0.31	0.40	28%
2022	$maxF_{ABC}$	0.27	0.36	34%
2022	maxABC	106,852	174,668	63%

Changes of the above magnitudes, particularly the change in projected maxABC, are not typical of previous assessments for this stock. Appendix 2.4 therefore provides a detailed bridging analysis, showing in step-by-step fashion how changes in the data led to the above change in maxABC.

Choice of Final Model
There is nearly a complete consenus among the CIE reviewers, the GPT, and the SSC regarding the preferred model for this year's assessment; the only disagreement being whether Model 21.3 should be included in the ensemble (as recommended by the CIE reviewers and the GPT) or excluded (as recommended by the SSC). Given that time was insufficient to present both the CIE/GPT ensemble and the SSC ensemble in this final assessment, the pragmatic choice is to adopt the SSC ensemble as the final model.

Final Parameter Estimates and Associated Schedules
Final parameter estimates are shown in Table 2.11.

Tables 2.19, 2.20, 2.21, 2.22, and 2.23 show the schedules of length at age by year, fishery weight at age by year, survey weight at age by year, fishery selectivity at age by year, and survey selectivity at age by year, respectively.

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 2.30 shows the time series of age 0+ biomass since 1977 for all models and the ensemble (point estimates only).

Table 2.31 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 the SSC ensemble. The estimated spawning biomass time series are accompanied by their respective standard deviations.

Table 2.32 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 the SSC ensemble. The estimated time series are accompanied by their respective standard deviations. The correlation between last year's estimated recruitment time series and this year's is 0.999.

For the time series as a whole, the 2013 cohort is currently estimated to be the largest. Other recent year classes that exceed the time series average by at least 50% are the 2006, 2008, 2010, 2011, and 2018 cohorts. In last year's assessment, the 2018 year class ranked 12th in the time series, with an estimated size of 749,855,000 fish. In this year's assessment, the 2018 year class is again ranked 12th in the time series, and the estimated size increases slightly, to 752,933,000 fish. Although the confirmed strength of the 2018 year class is a positive sign, it should also be noted that six of the last seven year classes have been below average, including three of the bottom ten in the overall time series, and seven of the last nine year classes have also been below average. By way of context, there has been one previous seven-year string in which six year classes have been below average, and three previous nine-year strings in which seven year classes have been below average.

The coefficient of autocorrelation for this year's estimated recruitment time series is -0.132.

Table 2.33 shows the time series of numbers at age for all models and the ensemble.

Figure 2.20 shows the time series of female spawning biomass for the ensemble, with error bars representing plus-or-minus two standard deviations.

Figure 2.21 shows the time series of female spawning biomass relative to $B_{100\%}$ for the ensemble, with error bars representing plus-or-minus two standard deviations.

Figure 2.22 shows the time series of recruitment for the ensemble, with error bars representing plus-or-minus two standard deviations.

Figure 2.23 shows the time series of full-selection fishing mortality for the ensemble, with error bars representing plus-or-minus two standard deviations.

Figure 2.24 plots the estimated/projected trajectory of relative fishing mortality ($F/F_{35\%}$) and relative female spawning biomass ($B/B_{35\%}$) from 1977 through 2023 based on full-selection fishing mortality, overlaid with the current harvest control rules. 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 2022 and 2023 do not fall exactly on the model-averaged $maxF_{ABC}$ control rule, although they are extremely close (within 1.7% in 2022 and within 0.3% in 2023).

Harvest Recommendations

Some of the results presented in this section pertain primarily to the SSC ensemble. However, a full set of parallel results for the items in this section, but pertaining to the current base model (19.12a), is provided in Appendix 2.6. 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 four 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 estimate of $F_{35\%}$ from the ensemble is 0.41; and the weighted average estimate of $F_{40\%}$ from the ensemble is 0.33 (Table 2.29).

The weighted average estimate of $B_{100\%}$ from the ensemble is 686,761 t; the weighted average estimate of $B_{40\%}$ from the ensemble is 274,704 t; and the weighted average estimates of $B_{35\%}$ from the ensemble is 240,366 t (Table 2.29).

Means and standard deviations of the ABC and OFL distributions for 2022 and 2023 are shown for each model and for the ensemble in Table 2.34, and the distributions are shown in Figure 2.25, where the vertical dashed black lines in the first two panels represent the current specifications and the vertical dashed gray lines in all four panels represent the ensemble means.

Specification of OFL and Maximum Permissible ABC

Given the assumptions of Scenario 2 (below), female spawning biomass for 2022 is estimated by the ensemble to be 259,789 t; and female spawning biomass for 2023 is estimated to be 253,585 t. Both of these projected values are below $B_{40\%}$, thereby placing Pacific cod in Tier 3b for both 2022 and 2023. Given this, the estimates of OFL, maximum permissible ABC, and the associated fishing mortality rates for 2022 and 2023 as follows (from Table 2.29):

Year	F_{OFL}	$maxF_{ABC}$	OFL (t)	maxABC (t)
2022	0.38	0.31	183,012	153,383
2023	0.37	0.31	180,909	151,709

The age 0+ biomass projections for 2022 and 2023 from the ensemble are 879,978 t and 848,615 t, respectively (Table 2.30).

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. Point estimates of all time-varying parameters used in the projections are set at their respective time series means, except for annual deviations governing length at age of year classes currently in the population, as these propagate into the future. Year-end catch for 2021 was estimated to be 123,805 t, equal to the 2021 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 2022 and 2023, 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 2022 recommended in the assessment to the *max* F_{ABC} for 2022, and where catches for 2022 and 2023 are estimated at their most likely values given the 2022 and 2023 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 2016-2020 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 2021 or 2) above 1/2 of its MSY level in 2021 and expected to be above its MSY level in 2031 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2022, 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 2023 or 2) above 1/2 of its MSY level in 2023 and expected to be above its MSY level in 2033 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 2.35.

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 2022, it does not provide the best estimate of OFL for 2023, because the mean 2023 catch under Scenario 6 is predicated on the 2022 catch being equal to the 2022 OFL, whereas the actual 2022 catch will likely be less than the 2022 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.

Development of the risk table in this assessment follows the approach described by Thompson (2021), which is an explicit attempt to view the risk table in the context of the probability that ABC exceeds the true-but-unknown OFL (comment SSC3). The approach partitions this probability into *internal* and *external* components. The *internal* probability is that which is routinely computed from the stock assessment model; for example, Table 2.29 indicates that, if the 2022 catch were to equal the 2022 maxABC, the internal probability for the ensemble is approximately 0.28 (see the line in the table labeled "Pr(maxABC>truOFL)"). The *external* probability is that which cannot be computed from the stock assessment model, because it involves factors that are external to the stock assessment model, and hence is evaluated using the risk table. The approach also includes an option whereby the integer levels in the risk table template can be supplemented by specifying an *intralevel* fraction between 0 and 1. The intralevel fraction describes where the stock falls within the assigned level. For example, does the stock barely qualify for the assigned level, does it lie squarely in the middle of the assigned level, or does it nearly qualify for the next higher level? The intralevel fractions, like the integer risk levels, are based on "subjective but well-informed interpretation of the available data" (comment SSC9).

<u>Assessment Considerations</u>

Recognizing the SSC's recommendation that, "Risk scores should be specific to a given stock or stock complex" (comment SSC9), the assessment considerations will be limited to a comparison of the present assessment with previous assessments of the same stock. As a point of departure, the assessment considerations category was assigned a risk level of 1 in each of the two previous assessments, and last year's assessment included the additional suggestion that "within level 1, the degree of concern is nearer the bottom end of the level than the upper end" (Thompson et al. 2020).

Recent range expansion of the stock into the NBS made assessment modeling more difficult for a few years. However, with the development of the VAST method (Thorson and Barnett 2017), it has become possible to treat the combined EBS and NBS surveys in a coherent fashion, eliminating the need to treat those surveys separately, either with or without explicit movment between areas. Spatial distribution concerns have now shifted to some extent toward movement between American and Russian jurisdictions (see Figure 2.1.5, Figure 2.1.6, and Table 2.1.3 in Appendix 2.1, and multiple comments by the CIE reviewers in Attachment 2.1.1 of Appendix 2.1). Although harvests in Russian waters have the potential to impact harvests in American waters if there is significant mixing between the two areas, the available data suggest that recent harvest rates in Russian waters do not appear to be particularly high (Attachment 2.1.2 of Appendix 2.1).

Ensemble models have been proposed in previous assessments, but none have been adopted as the base model by the SSC. This year, an ensemble model is proposed once again, but this time it appears to have the support of the CIE reviewers, the GPT, and the SSC (albeit with a disagreement about whether to add a model to the SSC ensemble). This is in stark contrast to previous years, when there was no agreement among the GPT and SSC as to which models to include in an ensemble or how they should be weighted, which suggests that there is now a higher degree of confidence in the set of models and model weights presented. As suggested in previous assessments, use of an ensemble approach gives some confidence that alternative explanations of the data are considered, and mitigates, at least to some extent, concerns that may exist regarding any individual model.

In addition to the usual pattern of presenting full results for multiple models to the GPT and SSC twice every year (Appendix 2.3) and responding to dozens of GPT and SSC comments annually, this year's assessment was subject to a CIE review (Attachment 2.1.1 in Appendix 2.1), which resulted in endorsements of both the base model and the present ensemble (with the addition of Model 21.3) as being suitable for providing management advice.

Assessment considerations were once again rated as level 1 (normal). More precisely, within level 1, the degree of concern is very near the bottom end of the level (intralevel fraction = 0.0).

<u>Population Dynamics Considerations</u>
Population dynamics considerations were assigned a risk level of 1 in each of the two previous assessments, and last year's assessment included the additional suggestion that "within level 1, the degree of concern is nearer the bottom end of the level than the upper end" (Thompson et al. 2020).

As noted above under "Time Series Results," six out of the seven most recent cohorts are estimated to have been below average, as have seven out of the last nine. Although neither of these occurrences is unprecedented (there was one previous six-out-of-seven string and three previous seven-out-of-nine strings in the time series), they are at least somewhat concerning, as they may be harbingers of a long-term change in mean recruitment. While the time series of recruitment estimates are already part of the stock assessment model, and therefore should not be considered as a reason for a risk table adjustment, the possibility of a long-term change in mean recruitment is not part of the stock assessment model.

The ensemble estimate of age 0+ biomass for 2022 is only 0.29 standard deviations removed from the pre-2022 time series mean, and the ensemble estimate of female spawning biomass for 2022 is only 0.12 standard deviations removed from the pre-2022 time series mean. The estimated rate of change in age 0+ biomass from 2021 to 2022 is 4.9%, which is within 0.19 standard deviations of the time series mean for annual rate of change in that quantity. The estimated rate of change in female spawning biomass from 2021 to 2022 is 2.0%, which is within 0.04 standard deviations of the time series mean for annual rate of change in that quantity. None of this suggests that abundance is "increasing or decreasing faster than has been seen recently" (see level 2 criteria for this category in the risk table template).

Population dynamics considerations were once again rated as level 1 (normal). More precisely, within level 1, the degree of concern is somewhat near the bottom end of the level (intralevel fraction = 0.2).

Environmental/Ecosystem Considerations

Environmental/Ecosysstem considerations were assigned a risk level of 2 in each of the two previous assessments, and last year's assessment included the additional suggestion that "within level 2, the degree of concern is nearer the bottom end of the level than the upper end" (Thompson et al. 2020).

Appendix 2.2 provides a detailed look at environmental/ecosystem considerations specific to this stock within the ecosystem and socioeconomic profile or ESP. Broad-scale information on environmental and ecosystem considerations are provided by the Eastern Bering Sea Ecosystem Status Report or EBS ESR (Siddon 2021). The text below summarizes ecosystem information related to EBS Pacific cod provided from both the ESP and EBS ESR.

Environmental processes: Beginning in approximately 2014, the EBS entered a warm phase of unprecedented duration. The EBS remains in this warm phase, though to a lesser degree compared to the extreme years of 2018 and 2019. Sea ice formation in fall of 2020 was delayed due to residual warmth in the system. While the areal extent of sea ice was closer to the pre-2014 levels than at any point in the last 7 years, ice thickness differed between the northern (thicker ice) and southern (thinner/no ice) shelves due to opposing prevailing winds (see Physical Environment Synthesis in Siddon, 2021). In early winter, sea ice extent in the Bering Sea was the lowest on record, but as the season progressed the ice advance was close to the climatological mean. Maximum sea-ice extent occurred in early March which was earlier than 2020 but later than 2017-2019. Even though the winter maximum ice cover is lower than the mean, ice retreat speed is following the mean (M. Wang, pers. commun., referencing UAF ACCAP at https://uaf-accap.org). The summer 2021 cold pool remained significantly reduced in area, and its southern boundary was shifted northwestward. The areal extent of the cold pool has increased since 2018, yet the 2021 extent was the 4th lowest on record and remains more than one standard deviation below the mean (Rohan and Barnett, 2021a). While the cold pool is included as a covariate of the spatiotemporal estimates of biomass used in the main stock assessment model, the dynamics are an important consideration and relevant to understanding the overall health of the EBS ecosystem. Spring to summer surface temperature was slightly lower than last year but remains very high. Summer bottom temperatures varied spatially over the shelf. Near-average conditions were present over the south EBS, while the northern Bering Sea (NBS) had a very warm inner domain (i.e., Norton Sound) and a small cold pool over the middle domain to the southwest of St. Lawrence Island (Rohan and Barnett, 2021b). Center of gravity estimates for EBS Pacific cod have shifted from 2019 with the population center moving more west than average and slightly less north. Area occupied has decreased to near average, although smaller than in the 2019 survey.

Multiple ecosystem "red flags" occurred in the NBS this year: crab population declines (Richar, 2021), salmon run failures in the Arctic-Yukon-Kuskokwim region (Liller, 2021), and seabird die-offs combined with low colony attendance and poor reproductive success (see Integrated Seabird Information in Siddon, 2021). In addition, results from the bottom trawl survey demonstrate a substantial drop in total CPUE in the NBS between 2019 and 2021 that reflected large decreases in all of the dominant species, including pollock (Mueter and Britt, 2021). Whether a single or suite of mechanisms can be identified to explain these coincident events, the common thread in these collapses is the marine environment in the NBS. Concerns about the food web dynamics and carrying capacity in the NBS have existed since 2018, highlighted by the gray whale Unusual Mortality Event and short-tailed shearwater mass mortality event (Siddon and Zador, 2019).

Prey: Peak timing of the spring bloom was later than average. This may have implications for match or mismatch between larval Pacific cod and the available plankton abundance. During warm years this may be particularly important for Pacific cod due to their increased metabolic requirements. Over the southern shelf, the springtime abundance of small copepods was within historical ranges and large copepods appeared on-track to be available for age-0 fish later in the year. In addition, higher abundances of adult euphausiids were observed which, if persistent through summer, would also provide a significant food source to forage fish (Kimmel et al., 2021). The biomass of motile epifauna within the standard bottom trawl survey area peaked in 2017 and remains above their long term mean in 2021 (Whitehouse, 2021). Trends in motile epifauna biomass indicate benthic productivity, although individual species and/or taxa may reflect varying time scales of productivity. The current mean biomass for all crab functional groups, including hermit crabs, king crabs, tanner crab, and snow crab are all below their long term means. Over the northern shelf in late summer, similar zooplankton patterns were observed to the springtime trends of the southern shelf with low abundances of small copepods, but slight increases in the abundance of large copepods and euphausiids (Kimmel et al., 2021). The annual ration of EBS Pacific cod has been well above average for the last several years due to warming ocean temperatures (Holsman et al., 2021) and the percentage of snow crab in the diets of EBS Pacific cod increased markedly during recent warm years from 2014-2016 and 2018 (Fedewa et al., 2021). Fish condition, as measured by length-weight residuals, trended downward from 2019 for multiple groundfish species, including benthic, pelagic, and apex predators, across both the southern and northern portions of the survey area (Rohan and Prohaska, 2021), indicating poor feeding conditions across trophic niches. Condition for juvenile Pacific cod in the EBS survey was average and similar to 2019, while adult condition was slightly lower than 2019, and slightly below average.

Predators: Pacific cod are cannibalistic and rates of cannibalism might be expected to increase as the abundance of older, larger fish increases concurrently with increases in juvenile abundance. Trends in apex predator biomass reflect relative predation pressure on zooplankton and juvenile fishes. The biomass of apex predators in 2021 is below their long term mean and is largely driven by Pacific cod, whose recent (2016-2021) mean biomass is below their long term mean (Whitehouse, 2021). Other predators of Pacific cod include northern fur seals, Steller sea lions, various whale species, and tufted puffin. Total predation of EBS Pacific cod by all other predators in the multispecies model remains low due to the declines in total predator biomass and subsequent net decrease in consumption (Holsman et al., 2021).

Competitors: Competitors of Pacific cod prey resources may include gray whales (e.g., benthic amphipods) and arrowtooth flounder. Gray whale life history includes annual migrations of up to 20,000 km from summer feeding grounds in the northern Bering and Chukchi seas to southern Baja California to mate and calve. Following several years of high numbers of stranded gray whales (an Unusual Mortality Event was declared in 2019), fewer gray whales were reported in 2021 (as of October 2, 23 had been reported in 2021 while 44 had been reported as of September 29, 2020) (Keogh and Savage, 2021). Arrowtooth flounder biomass has been increasing steadily since 2000 and remains at a high level in recent years.

Summary: Environmental/ecosystem considerations were once again rated as level 2 (substantially increased concerns), due to the overall warm conditions, reduced prey availability, population declines, and die-offs in the NBS. These considerations are somewhat tempered by the slightly less warm conditions in the EBS, near average sea ice extent, south-westward movement of the population, average condition of adults and juveniles and less predation pressure in the system. More precisely, within level 2, the degree of concern is near the middle of the level (intralevel fraction = 0.5).

Fishery Performance Considerations

Fishery performance considerations were assigned a risk level of 1 in each of the two previous assessments, and last year's assessment included the additional suggestion that "within level 1, the degree of concern is nearer the bottom end of the level than the upper end" (Thompson et al. 2020).

Table 2.1.2 in Appendix 2.1 shows simple year-and-month averages of catch (in weight) per unit effort for four gear types: longline, bottom trawl, pot, and pelagic trawl. The values have been normalized so that the average across all non-empty cells is unity (empty cells indicate either that there are no data, or that presentation of the data is precluded due to confidentiality restrictions). For all three of the gear types that target Pacific cod (i.e., all gears except pelagic trawl), Table 2.1.2 indicates that 2021 is an above-average year with respect to fishery CPUE. Relative to the 1996-2020 monthly averages, the 2021 monthly averages for the various gear types may be summarized as follows (reporting only those months where data are available and can be presented):

- Longline CPUE was above average for every month from January-August except for May.
- Bottom trawl CPUE was above average for every month from February-April; in particular, CPUE for February was extremely high (more than triple the 1996-2020 average), repeating the performance observed in 2020.
- Pot CPUE was above average for January.
- Pelagic trawl CPUE (including incidental catches) was mixed from January-March, with January being below average and February-March being above average; in particular, CPUE for March was more than double the 1996-2020 average.

Figure 2.1.4 in Appendix 2.1 shows the results of the conventional CPUE model that estimates "year" and "month" effects for each gear. The estimated year effects for 2021 (shown in the top left panel of each page of Figure 2.1.4) for all four gear types confirm that 2021 is an above-average year with respect to fishery CPUE.

An alternative perspective, at least for one locality, was provided by Dawn Wehde of the Norton Sound Economic Development Corporation (pers. commun., 11/1/2021), who reported that both she and the processing plant in Savoonga had "received numerous reports from Savoonga fishermen describing lower catch rates of Pacific cod this year compared to the past few years." The SSC has requested that such information be included as a source of knowledge about the condition of the stock (comment SSC10).

Fishery performance considerations were once again rated as level 1 (normal). More precisely, within level 1, the degree of concern is fairly near the bottom end of the level (intralevel fraction = 0.1).

Summary and ABC Recommendation

The risk levels and intralevel fractions assigned to 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
Intralevel: 0.0	Intralevel: 0.2	Intralevel: 0.5	Intralevel: 0.1

Given the above data, the category-specific external probabilities depend on the value of the α parameter that converts risk levels and intralevel fractions into probabilities. Using as data the risk levels specified in all risk tables through 2020 and the associated reductions (including reductions of zero), Thompson (2021) used a least-squares model to estimate an α value of 0.2, where the objective function considered the ability of the model to predict reductions on both a qualitative basis (i.e., did the model correctly predict whether a reduction was made?) and a quantitative basis (i.e., how closely did the model predict the ratio of ABC to maxABC?). The primary reasons for using data from all assessments were as follow:

- To maximize the precision of the estimate by using the largest possible sample size (n=48).
- To comply with the SSC guidance stating that reductions "should be applied sparingly" and not "become commonplace" (comment SSC14), by ensuring that the resulting frequency of reductions is consistent with the historic frequency of reductions.
- To comply with the SSC guidance stating that "comparison across species … or stocks is useful for consistency" (comment SSC9).

As noted in the Executive Summary, the approach of Thompson (2021) is highly consistent with the remainder of comment SSC9 as well:

- The approach does not prescribe a common reduction from the maximum permissible ABC for a given risk score across species or stocks.
- Considerations of reductions in ABCs below the maximum permissible continue to be made on a case-by-case basis with justification based on risk scoring.
- The approach does not make blanket comparisons across species or stocks for the purpose of explicitly defining reductions in ABC below the maximum permissible.

As interpreted here, the final bullet above, which references the concluding sentence of comment SSC9, is simply a summary restatement of the first two. However, depending on the meaning of the term, "blanket comparisons," an alternative interpretation of that bullet is also possible, viz., that a reduction for a particular stock can have *absolutely nothing* to do with the previous frequency or extent of reductions for stocks in general. This seems like an extreme interpretation, because:

- It would violate the SSC's advice in the same comment stating that "comparison across species … or stocks is useful for consistency."
- It would imply that the definitions of "applied sparingly" and "commonplace" in comment SSC14 would have to be entirely stock-specific as well, which is difficult to reconcile with the fact that the same comment suggests review of the Tier system (which applies to *all* stocks) as a remedy in the event that reductions become "commonplace."

Nevertheless, in the interest of exhausting all possibilities, the analysis that was used by Thompson (2021) to estimate α was re-done using previous risk tables and reductions (including reductions of zero) for EBS Pacific cod *only*. This reduced the sample size from n=48 to n=2, and resulted in an increase in the estimate of α from α=0.2 to α=0.4. The results that follow will consider both of these cases.

Given the data in the summary table above, the following category-specific external probabilities are obtained for the two cases:

α	Assessment	Population dynamics	Environmental/ ecosystem	Fishery performance
0.2	0.00	0.09	0.13	0.08
0.4	0.00	0.05	0.11	0.04

The above results imply a joint external probability of 0.27 in the α=0.2 case and 0.18 in the α=0.4 case. Given this value and the internal probability of 0.28 (Table 2.29), the overall joint probability that a catch equal to maxABC will exceed the true-but-unknown OFL is 0.47 in the α=0.2 case and 0.41 in the α=0.4 case. Because both of these values are less than 0.50, no reduction from maxABC is warranted in either case, and the authors' ABC recommendations for 2022 and 2023 are 153,383 t and 151,709 t, respectively, based on the ensemble.

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 (2020) is 155,639 t. This is less than the 2020 OFL of 191,386 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 2021:

a. If spawning biomass for 2021 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2021 is estimated to be above $B_{35\%}$, the stock is above its MSST.
c. If spawning biomass for 2021 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 2.35e). If the mean spawning biomass for 2031 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 2.35f):

a. If the mean spawning biomass for 2023 is below ½ $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2023 is above $B_{35\%}$, the stock is not approaching an overfished condition.

c. If the mean spawning biomass for 2023 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2033. If the mean spawning biomass for 2033 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 2.29, 2.35e, and 2.35f, the stock is not overfished and is not approaching an overfished condition.

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 (2020). These reverse-engineered F_{OFL} values (*RE* F_{OFL}) are shown below:

Model:	M19.12a	M19.12	M21.1	M21.2	Ensemble
RE F_{OFL} *:*	0.338	0.355	0.269	0.453	0.346

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 between the major subregions of the Bering Sea (eastern, northern, and western) 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 contributions fish in each subregion 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. Another need is development of methods to quantify input sample sizes based on the among-sample variance in compositional measurements, using bootstrapping or model-based methods. Longer-term biological 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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Ongoing contributions: Numerous AFSC personnel and countless fishery observers collected nearly all of the raw data that were used in this assessment.

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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 1991-2021 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 2014-2021 include the State-managed fishery. Catches for 2021 are through September 26.

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	64,084	117,077	28,063	209,224
2012	75,536	128,507	28,738	232,781
2013	81,619	124,863	30,253	236,735
2014	72,262	127,241	39,195	238,698
2015	66,680	128,186	37,942	232,808
2016	72,591	127,923	47,086	247,599
2017	68,885	122,769	46,184	237,837
2018	59,967	100,244	39,686	199,897
2019	49,037	88,751	41,064	178,853
2020	50,579	72,081	32,979	155,639
2021	36,478	52,331	25,468	114,277

Table 2.2—Discards (t) and discard rates (%) of Pacific cod in the Pacific cod fishery, by area, gear, and year for the period 1991-2021 (2021 data are current through September 26). 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	1,539	21	1,663	0.29	1.54	0.05	0.95
2019	111	1,286	50	1,447	0.47	1.45	0.12	0.95
2020	32	952	69	1,053	0.14	1.32	0.21	0.82
2021	79	763	26	868	0.45	1.46	0.10	0.91

Table 2.3—History of BSAI (1977-2013) and EBS (2014-2021) Pacific cod catch, TAC, ABC, and OFL (t). Catch for 2021 is through September 26. 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	238,698	246,897	255,000	299,000
2015	232,808	240,000	255,000	346,000
2016	247,599	238,680	255,000	390,000
2017	237,837	223,704	239,000	284,000
2018	199,897	188,136	201,000	238,000
2019	178,853	166,475	181,000	216,000
2020	155,639	141,799	155,873	191,386
2021	114,277	111,380	123,805	147,949

Table 2.4 (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 2.4 (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 2.5 (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	0.0001	0.0000
2021	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	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 2.5 (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	0.0005	0.0005	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	0.0002	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000	0.0001	0.0004	0.0001	0.0004	0.0002	0.0001	0.0006	0.0006	0.0006	0.0008	0.0009	0.0012	0.0014
2020	0.0002	0.0000	0.0000	0.0000	0.0007	0.0008	0.0021	0.0015	0.0016	0.0017	0.0011	0.0021	0.0020	0.0023	0.0028	0.0020	0.0033	0.0026	0.0022	0.0026
2021	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0007	0.0001	0.0002	0.0028	0.0018	0.0019	0.0016	0.0017	0.0036	0.0045

Table 2.5 (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	0.0270	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	0.0015	0.0026	0.0035	0.0040	0.0054	0.0086	0.0112	0.0148	0.0177	0.0217	0.0267	0.0307	0.0326	0.0343	0.0366	0.0362	0.0382	0.0374	0.0376	0.0383
2018	0.0034	0.0028	0.0041	0.0042	0.0053	0.0061	0.0077	0.0090	0.0113	0.0136	0.0157	0.0173	0.0212	0.0238	0.0272	0.0310	0.0354	0.0394	0.0431	0.0469
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	0.0034	0.0037	0.0040	0.0045	0.0063	0.0058	0.0053	0.0051	0.0085	0.0094	0.0110	0.0132	0.0155	0.0159	0.0210	0.0220	0.0250	0.0254	0.0281	0.0310
2021	0.0046	0.0058	0.0063	0.0144	0.0093	0.0140	0.0131	0.0114	0.0123	0.0125	0.0091	0.0125	0.0123	0.0127	0.0120	0.0137	0.0234	0.0214	0.0280	0.0185

Table 2.5 (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	0.0333	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	0.0368	0.0375	0.0381	0.0359	0.0364	0.0357	0.0371	0.0311	0.0279	0.0281	0.0261	0.0230	0.0206	0.0181	0.0161	0.0123	0.0119	0.0083	0.0077	0.0065
2018	0.0486	0.0517	0.0476	0.0481	0.0456	0.0416	0.0399	0.0335	0.0312	0.0302	0.0255	0.0234	0.0208	0.0180	0.0161	0.0139	0.0138	0.0114	0.0092	0.0079
2019	0.0367	0.0357	0.0405	0.0439	0.0419	0.0450	0.0479	0.0442	0.0434	0.0425	0.0397	0.0373	0.0304	0.0264	0.0241	0.0200	0.0185	0.0154	0.0127	0.0100
2020	0.0317	0.0308	0.0378	0.0363	0.0353	0.0342	0.0379	0.0371	0.0331	0.0294	0.0285	0.0307	0.0277	0.0286	0.0278	0.0244	0.0246	0.0236	0.0204	0.0187
2021	0.0186	0.0205	0.0250	0.0262	0.0276	0.0289	0.0320	0.0282	0.0233	0.0250	0.0261	0.0253	0.0340	0.0270	0.0190	0.0203	0.0306	0.0436	0.0492	0.0439

Table 2.5 (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	0.0021	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	0.0036	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	0.0010	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	0.0186	0.0147	0.0140	0.0114	0.0104	0.0082	0.0085	0.0056	0.0048	0.0041	0.0033	0.0026	0.0023	0.0017	0.0019	0.0014	0.0013	0.0011	0.0015	0.0008
2021	0.0346	0.0090	0.0102	0.0087	0.0060	0.0052	0.0063	0.0077	0.0057	0.0042	0.0054	0.0047	0.0025	0.0037	0.0041	0.0040	0.0040	0.0024	0.0040	0.0020

Table 2.5 (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	0.0000	0.0001	0.0001	0.0000	0.0001	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003
2021	0.0020	0.0015	0.0003	0.0001	0.0001	0.0001	0.0002	0.0000	0.0000	0.0002	0.0002	0.0000	0.0002	0.0000	0.0002	0.0002	0.0002

Table 2.6—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	5202
1992	5339
1993	3003
1994	4700
1995	5225
1996	6632
1997	7294
1998	6847
1999	9242
2000	9742
2001	10382
2002	11488
2003	14355
2004	12253
2005	11583
2006	8860
2007	6917
2008	8314
2009	7487
2010	6526
2011	8809
2012	9281
2013	11125
2014	12164
2015	11309
2016	9773
2017	8483
2018	6462
2019	4672
2020	3555
2021	1729

Table 2.7—VAST fishery CPUE index.

Year	Index	Sigma
1996	54.799	0.036
1997	57.798	0.043
1998	47.351	0.036
1999	42.047	0.033
2000	50.961	0.037
2001	37.635	0.037
2002	50.366	0.044
2003	39.350	0.023
2004	39.587	0.020
2005	37.140	0.020
2006	42.809	0.034
2007	43.094	0.026
2008	43.500	0.028
2009	45.815	0.031
2010	50.542	0.030
2011	49.651	0.035
2012	51.126	0.034
2013	48.394	0.031
2014	38.582	0.031
2015	37.356	0.034
2016	45.220	0.027
2017	40.084	0.024
2018	49.430	0.032
2019	42.604	0.047
2020	40.923	0.047
2021	37.065	0.045

Table 2.8—Survey abundance (1000s of fish) index (VAST).

Year	Abundance	Sigma
1982	705488	0.057
1983	867657	0.068
1984	698140	0.052
1985	872638	0.047
1986	871052	0.048
1987	820416	0.060
1988	536914	0.044
1989	355461	0.057
1990	473504	0.052
1991	513657	0.052
1992	546927	0.058
1993	809235	0.056
1994	1128385	0.049
1995	700131	0.048
1996	620931	0.059
1997	527396	0.056
1998	614477	0.071
1999	519047	0.053
2000	505236	0.054
2001	997129	0.053
2002	625059	0.068
2003	619202	0.078
2004	484673	0.077
2005	507615	0.070
2006	440336	0.047
2007	582740	0.052
2008	478838	0.052
2009	701063	0.046
2010	723828	0.048
2011	849677	0.049
2012	1026236	0.060
2013	735245	0.056
2014	1231311	0.069
2015	1082765	0.068
2016	944302	0.095
2017	515808	0.043
2018	529915	0.063
2019	756748	0.051
2021	606584	0.052

Table 2.9 (page 1 of 6)—Size composition data (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	0.0007	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
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	0.0001	0.0001	0.0008	0.0022	0.0036	0.0032	0.0046	0.0042	0.0047	0.0057	0.0064	0.0082	0.0087	0.0105
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	0.0008	0.0019	0.0042	0.0078	0.0191	0.0259	0.0392	0.0351	0.0418	0.0472	0.0554	0.0547	0.0518
2021	0.0000	0.0000	0.0007	0.0019	0.0031	0.0029	0.0011	0.0008	0.0014	0.0015	0.0040	0.0051	0.0053	0.0076	0.0129	0.0184	0.0220	0.0217	0.0252	0.0258

Table 2.9 (page 2 of 6)—Size composition data (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	0.0080	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
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	0.0126	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	0.0107	0.0119	0.0127	0.0122	0.0140
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	0.0568	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
2021	0.0199	0.0177	0.0142	0.0086	0.0064	0.0043	0.0052	0.0050	0.0057	0.0061	0.0065	0.0107	0.0133	0.0188	0.0208	0.0286	0.0300	0.0357	0.0350	0.0375

Table 2.9 (page 3 of 6)—Size composition data (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	0.0302	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
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	0.0176	0.0157	0.0192	0.0176	0.0185	0.0214	0.0261	0.0249	0.0288	0.0292	0.0329	0.0361	0.0377	0.0349	0.0316	0.0272	0.0254	0.0240	0.0212	0.0232
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	0.0075	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
2021	0.0331	0.0357	0.0385	0.0338	0.0312	0.0283	0.0241	0.0188	0.0173	0.0132	0.0114	0.0101	0.0090	0.0086	0.0076	0.0071	0.0061	0.0061	0.0071	0.0065

Table 2.9 (page 4 of 6)—Size composition data (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	0.0089	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
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	0.0189	0.0168	0.0137	0.0149	0.0130	0.0131	0.0128	0.0092	0.0093	0.0097	0.0076	0.0079	0.0067	0.0064	0.0048	0.0053	0.0051	0.0022	0.0030	0.0026
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	0.0109	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
2021	0.0065	0.0069	0.0070	0.0067	0.0071	0.0071	0.0064	0.0076	0.0058	0.0070	0.0069	0.0067	0.0054	0.0058	0.0061	0.0049	0.0050	0.0049	0.0054	0.0040

Table 2.9 (page 5 of 6)—Size composition data (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	0.0002	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
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	0.0017	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
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	0.0020	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
2021	0.0041	0.0038	0.0027	0.0034	0.0030	0.0024	0.0019	0.0018	0.0012	0.0011	0.0010	0.0008	0.0010	0.0008	0.0002	0.0006	0.0004	0.0008	0.0002	0.0002

Table 2.9 (page 6 of 6)—Size composition data (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	0.0000	0.0000	0.0000	0.0000	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	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2021	0.0002	0.0002	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

Table 2.10—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		364
2019	365	114	479
2021	367	109	476

Table 2.11a—Age composition data (survey, VAST, units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00023	0.10331	0.37221	0.16976	0.11463	0.11661	0.08407	0.02156	0.00908	0.00457	0.00149	0.00115	0.00134
1995	0.00014	0.05874	0.24791	0.42320	0.10589	0.07762	0.05519	0.01380	0.00751	0.00578	0.00143	0.00143	0.00136
1996	0.00003	0.06546	0.18632	0.17398	0.28677	0.15429	0.07868	0.03558	0.00992	0.00379	0.00189	0.00162	0.00166
1997	0.00029	0.26969	0.16732	0.14959	0.14387	0.12356	0.10223	0.02635	0.01158	0.00234	0.00175	0.00083	0.00061
1998	0.00007	0.07296	0.43473	0.19578	0.11266	0.05966	0.06538	0.03370	0.01918	0.00386	0.00077	0.00081	0.00044
1999	0.00008	0.09583	0.19394	0.30112	0.21781	0.07553	0.06146	0.03068	0.01407	0.00619	0.00117	0.00143	0.00069
2000	0.00000	0.19828	0.11423	0.16058	0.24534	0.16741	0.06897	0.01564	0.01786	0.00530	0.00399	0.00168	0.00072
2001	0.00004	0.28720	0.23328	0.18364	0.08708	0.09127	0.07600	0.02820	0.00814	0.00196	0.00162	0.00110	0.00047
2002	0.00022	0.07296	0.18279	0.29995	0.24837	0.07571	0.06397	0.04011	0.01066	0.00317	0.00100	0.00048	0.00061
2003	0.00001	0.16305	0.14540	0.23401	0.21525	0.13501	0.04948	0.03431	0.01768	0.00388	0.00050	0.00062	0.00081
2004	0.00005	0.13057	0.15215	0.26774	0.12965	0.13801	0.10492	0.04081	0.02240	0.00860	0.00226	0.00200	0.00084
2005	0.00000	0.14843	0.23140	0.20040	0.12733	0.07293	0.10040	0.06954	0.02897	0.01147	0.00408	0.00447	0.00058
2006	0.00000	0.33686	0.13459	0.15950	0.11167	0.09239	0.06694	0.05056	0.03065	0.01094	0.00357	0.00140	0.00093
2007	0.00000	0.66460	0.10007	0.07121	0.04885	0.05319	0.02284	0.01868	0.01003	0.00623	0.00205	0.00118	0.00107
2008	0.00000	0.21269	0.41950	0.15025	0.09035	0.05301	0.03368	0.01233	0.01333	0.00773	0.00319	0.00235	0.00160
2009	0.00000	0.47576	0.18249	0.21817	0.06073	0.02697	0.01485	0.00994	0.00614	0.00237	0.00126	0.00082	0.00050
2010	0.00000	0.04735	0.49961	0.17363	0.18849	0.05912	0.01549	0.00857	0.00397	0.00211	0.00081	0.00072	0.00015
2011	0.00008	0.29691	0.07115	0.37175	0.11312	0.09772	0.03185	0.00839	0.00417	0.00215	0.00138	0.00077	0.00056
2012	0.00000	0.36674	0.24202	0.05955	0.21961	0.06343	0.03346	0.00876	0.00307	0.00219	0.00071	0.00017	0.00027
2013	0.00000	0.10118	0.35807	0.19535	0.12305	0.13822	0.06232	0.01486	0.00464	0.00130	0.00028	0.00037	0.00036
2014	0.00004	0.27978	0.17081	0.22422	0.20306	0.05854	0.04612	0.01215	0.00260	0.00104	0.00092	0.00010	0.00063
2015	0.00002	0.05862	0.42019	0.20701	0.19466	0.08478	0.01907	0.01188	0.00269	0.00051	0.00026	0.00011	0.00021
2016	0.00000	0.08580	0.09320	0.34780	0.22669	0.17162	0.05616	0.01264	0.00380	0.00140	0.00047	0.00026	0.00014
2017	0.00007	0.10766	0.16989	0.15990	0.28618	0.16179	0.08175	0.02400	0.00394	0.00305	0.00059	0.00052	0.00066
2018	0.00003	0.07270	0.09867	0.25429	0.16670	0.28668	0.08598	0.02938	0.00264	0.00179	0.00051	0.00021	0.00041
2019	0.00001	0.57344	0.08559	0.07998	0.07930	0.06388	0.07840	0.02988	0.00699	0.00121	0.00039	0.00021	0.00072

Table 2.11b—Changes in age composition data relative to last year's assessment (survey, VAST, units = proportions).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00000	-0.00356	-0.01947	0.00289	0.00470	0.00645	0.00621	0.00110	0.00112	0.00028	0.00010	0.00003	0.00015
1995	-0.00002	-0.00725	-0.00576	0.00935	0.00306	0.00063	-0.00012	-0.00026	0.00025	0.00042	-0.00005	-0.00018	-0.00007
1996	-0.00001	-0.00932	-0.00620	-0.00396	0.00568	0.00710	0.00480	0.00103	0.00059	0.00021	0.00002	0.00002	0.00002
1997	-0.00002	-0.01946	0.00848	0.00279	0.00367	0.00274	0.00206	-0.00017	0.00033	-0.00005	-0.00013	-0.00017	-0.00006
1998	0.00000	-0.01535	0.00857	0.00183	0.00299	0.00012	-0.00026	0.00015	0.00152	0.00035	0.00005	0.00001	0.00003
1999	0.00000	0.00142	-0.01612	-0.00529	0.00924	0.00199	0.00381	0.00199	0.00162	0.00107	0.00012	0.00008	0.00008
2000	0.00000	-0.02451	-0.00015	0.00016	0.01068	0.00856	0.00265	0.00000	0.00182	0.00033	0.00025	0.00017	0.00003
2001	0.00000	-0.00271	0.00076	0.00590	0.00149	-0.00264	-0.00275	-0.00093	0.00044	0.00019	0.00015	0.00005	0.00005
2002	-0.00028	-0.01136	-0.00836	0.00782	0.01099	0.00223	-0.00122	-0.00038	0.00032	0.00025	0.00002	-0.00001	-0.00002
2003	0.00000	-0.01151	-0.00707	0.00466	0.00650	0.00533	0.00057	0.00002	0.00113	0.00024	0.00001	0.00005	0.00007
2004	0.00001	-0.01464	0.00333	0.00571	-0.00076	0.00197	0.00220	-0.00014	0.00132	0.00078	0.00009	0.00007	0.00007
2005	0.00000	-0.00836	0.00208	-0.00259	-0.00082	0.00198	0.00233	0.00234	0.00204	0.00061	0.00014	0.00023	0.00004
2006	0.00000	-0.00805	-0.00599	-0.00179	0.00166	0.00459	0.00333	0.00145	0.00280	0.00133	0.00034	0.00015	0.00018
2007	0.00000	-0.00699	-0.00259	-0.00052	0.00218	0.00271	0.00181	0.00107	0.00115	0.00067	0.00024	0.00015	0.00013
2008	0.00000	0.00797	-0.00797	0.00054	-0.00096	-0.00154	-0.00073	-0.00019	0.00152	0.00084	0.00022	0.00017	0.00015
2009	0.00000	-0.01407	0.00914	0.00558	-0.00036	-0.00032	-0.00062	-0.00060	0.00054	0.00036	0.00018	0.00009	0.00006
2010	0.00000	-0.00173	0.02170	-0.00732	-0.00809	-0.00362	-0.00078	-0.00100	0.00023	0.00038	0.00017	0.00010	-0.00003
2011	-0.00001	-0.05289	0.00063	0.02955	0.01091	0.00839	0.00203	0.00009	0.00061	0.00039	0.00012	0.00008	0.00009
2012	0.00000	0.02175	-0.01024	-0.00140	-0.00833	-0.00169	-0.00030	-0.00050	0.00027	0.00027	0.00008	0.00001	0.00005
2013	0.00000	-0.00367	-0.02151	-0.00023	0.00683	0.01155	0.00490	0.00097	0.00071	0.00026	0.00005	0.00005	0.00009
2014	0.00001	0.00807	0.00898	-0.01318	-0.00680	0.00094	0.00144	0.00014	0.00022	0.00009	0.00003	0.00001	0.00007
2015	0.00000	-0.00278	-0.00516	0.00580	0.00066	0.00117	-0.00009	0.00008	0.00027	0.00003	0.00001	0.00001	0.00002
2016	0.00000	0.00299	0.00509	-0.00068	-0.01043	0.00309	-0.00075	0.00038	0.00024	0.00007	-0.00002	0.00000	0.00001
2017	0.00000	0.00051	0.00431	0.00552	-0.01964	0.00860	-0.00282	0.00271	0.00077	0.00010	-0.00001	-0.00003	-0.00002
2018	-0.00001	-0.00294	0.00557	0.01205	0.00015	-0.01122	-0.00359	-0.00016	0.00008	0.00002	0.00000	0.00000	0.00004
2019	0.00000	-0.01461	0.00619	-0.00560	0.00228	0.00460	0.00771	-0.00190	0.00044	0.00038	0.00006	-0.00001	0.00048

Table 2.12—Number of otoliths read (survey).

Year	EBS	NBS	EBS+NBS
1994	715		715
1995	1426		1426
1996	711		711
1997	718		718
1998	635		635
1999	860		860
2000	864		864
2001	480		480
2002	947		947
2003	2711		2711
2004	1044		1044
2005	1280		1280
2006	1299		1299
2007	1440		1440
2008	1213		1213
2009	1412		1412
2010	1469	178	1647
2011	1253		1253
2012	1301		1301
2013	1385		1385
2014	1420		1420
2015	1819		1819
2016	1624		1624
2017	1382	368	1750
2018	1532		1532
2019	1449	390	1839

Table 2.13a—Survey abundance (1000s of fish) time series (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	8,903	0.192	905,204	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	135,450	0.123	499,579	0.073
2018	248,542	0.071			248,542	0.071
2019	525,688	0.120	202,148	0.113	727,836	0.092
2021	420,638	0.066	129,700	0.217	550,337	0.072

Table 2.13b—Survey biomass (t) time series (design-based).

	EBS		NBS		EBS + NBS	
Year	Estimate	Sigma	Estimate	Sigma	Estimate	Sigma
1982	1,013,061	0.073			1,013,061	0.073
1983	1,187,096	0.102			1,187,096	0.102
1984	1,013,558	0.062			1,013,558	0.062
1985	1,001,112	0.056			1,001,112	0.056
1986	1,118,006	0.062			1,118,006	0.062
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	287,535	0.146	931,488	0.066
2018	506,943	0.058			506,943	0.058
2019	516,910	0.044	364,982	0.113	881,892	0.066
2021	616,267	0.049	227,577	0.217	843,843	0.060

Table 2.14—Annual weight length parameter offsets.

Year:	1977	1978	1979	1980	1981	1982	1983	1984	1985
α offset:	2.42E-06	-2.17E-06	1.67E-06	4.56E-08	1.00E-06	3.02E-06	6.40E-07	1.19E-05	-7.24E-07
β offset:	-8.45E-02	1.27E-01	-6.09E-02	-5.44E-03	-4.55E-02	-9.84E-02	-1.66E-02	-2.90E-01	4.48E-02

Year:	1986	1987	1988	1989	1990	1991	1992	1993	1994
α offset:	-1.96E-06	9.02E-08	-1.89E-06	-9.69E-07	1.51E-06	2.01E-06	5.39E-07	2.97E-06	7.39E-07
β offset:	1.18E-01	3.26E-03	1.20E-01	6.80E-02	-4.37E-02	-7.56E-02	-3.12E-02	-8.61E-02	-2.85E-02

Year:	1995	1996	1997	1998	1999	2000	2001	2002	2003
α offset:	-6.52E-07	7.97E-06	1.89E-06	1.91E-06	2.17E-06	2.41E-06	4.30E-06	1.69E-06	-2.52E-08
β offset:	3.44E-02	-2.14E-01	-8.16E-02	-8.41E-02	-8.21E-02	-7.75E-02	-1.36E-01	-6.24E-02	1.96E-03

Year:	2004	2005	2006	2007	2008	2009	2010	2011	2012
α offset:	2.38E-06	2.43E-07	1.25E-06	7.78E-07	-3.85E-07	1.16E-07	1.10E-06	1.39E-07	-9.64E-08
β offset:	-8.59E-02	-6.29E-03	-4.69E-02	-2.57E-02	1.88E-02	-3.93E-03	-4.80E-02	-1.37E-02	-4.99E-03

Year:	2013	2014	2015	2016	2017	2018	2019	2020	2021
α offset:	-3.36E-07	-1.63E-06	-1.87E-06	-1.61E-06	-1.92E-06	-5.39E-07	-1.09E-06	-9.16E-07	-8.39E-07
β offset:	1.13E-02	7.84E-02	8.85E-02	7.62E-02	9.96E-02	2.24E-02	5.59E-02	4.47E-02	2.24E-02

Table 2.15—Input composition sample sizes (survey includes EBS and NBS; units = hauls).

		Fishery	
Year	Survey	Raw	Scaled
1977		30	2
1978		160	10
1979		235	14
1980		208	12
1981		148	9
1982	313	187	11
1983	255	782	47
1984	264	1913	115
1985	345	2825	169
1986	349	2496	150
1987	339	4726	283
1988	339	1458	87
1989	293	966	58
1990	329	3601	216
1991	313	5202	312
1992	332	5339	320
1993	363	3003	180
1994	364	4700	282
1995	347	5225	313
1996	359	6632	397
1997	369	7294	437
1998	362	6847	410
1999	336	9242	554
2000	355	9742	584
2001	366	10382	622
2002	364	11488	689
2003	363	14355	860
2004	361	12253	734
2005	360	11583	694
2006	354	8860	531
2007	368	6917	415
2008	338	8314	498
2009	360	7487	449
2010	405	6526	391
2011	368	8809	528
2012	356	9281	556
2013	354	11125	667
2014	373	12164	729
2015	354	11309	678
2016	376	9773	586
2017	481	8483	508
2018	364	6462	387
2019	479	4672	280
2020		3555	213
2021	476	1729	104
Mean:	358	5966	358

Table 2.16—Objective function values (negative log likelihood) and parameter counts (note that the parameter count for Model 21.2 includes two parameters that are bound near the upper end of their respective ranges; see main text for details).

Objective function values

Feature	M19.12a	M19.12	M21.1	M21.2
Allow catchability to vary?	no	yes	no	no
Allow domed survey selectivty?	no	no	yes	no
Use fishery CPUE?	no	no	no	yes
Catch	0.00	0.00	0.00	0.00
Equilibrium catch	0.00	0.00	0.00	0.00
Survey indices	-7.62	-92.70	-8.08	10.03
Sizecomps (survey)	4326.18	4321.49	4316.91	4400.47
Sizecomps (fishery)	5276.67	5247.28	5272.13	5313.03
Agecomps	780.39	771.43	779.93	790.73
Recruitment	-2.56	-2.16	-2.40	-4.34
Initial recruitment	4.44	6.02	2.56	4.71
"Softbounds"	0.01	0.00	0.01	0.02
Parameter deviations	70.76	104.33	74.73	79.33
Total	10448.26	10355.69	10435.79	10593.97

Parameter counts

Parameter type	M19.12a	M19.12	M21.1	M21.2
True parameters	22	23	26	25
Constrained deviations	279	319	279	279
Total	301	342	305	304

Table 2.17—Fits to size composition and age composition data. Note that the "Nave" values for the size composition data do not equal those for the age composition data due to the fact that the time series are of different length.

Size composition data

	Fleet:	Fishery			
	Model:	M19.12a	M19.12	M21.1	M21.2
	Nave:	358	358	358	358
McAllister-Ianelli	Neff:	797	798	797	757
	Ratio:	2.228	2.231	2.230	2.116
Thorson et al.	ln(θ):	9.990	9.991	9.989	9.989
	Neff:	358	358	358	358
	Ratio:	1.000	1.000	1.000	1.000

	Fleet:	Survey			
	Model:	M19.12a	M19.12	M21.1	M21.2
	Nave:	358	358	358	358
McAllister-Ianelli	Neff:	608	632	617	575
	Ratio:	1.701	1.767	1.726	1.609
Thorson et al.	ln(θ):	9.984	9.984	9.985	9.982
	Neff:	358	358	358	358
	Ratio:	1.000	1.000	1.000	1.000

Age composition data

	Fleet:	Survey			
	Model:	M19.12a	M19.12	M21.1	M21.2
	Nave:	373	373	373	373
McAllister-Ianelli	Neff:	101	112	100	85
	Ratio:	0.271	0.302	0.268	0.227
Thorson et al.	ln(θ):	-0.137	0.137	-0.296	-0.574
	Neff:	174	199	159	135
	Ratio:	0.467	0.535	0.428	0.362

Table 2.18—Computation of model weights.

Feature	M19.12a	M19.12	M21.1	M21.2
Feature 1: Allow catchability to vary?	no	yes	no	no
Feature 2: Allow domed survey selectivity?	no	no	yes	no
Feature 3: Use fishery CPUE?	no	no	no	yes

Criterion	Emph.	M19.12a	M19.12	M21.1	M21.2
General plausibility of the model	3	2	1	0.6667	1
Acceptable retrospective bias	3	2	2	1.3333	1
Uses properly vetted data	3	2	2	2	0
Acceptable residual patterns	3	2	2	2	2
Comparable complexity	2	2	1	1	2
Fits consistent with variances	2	1	2	1	0
Dev sigmas estimated appropriately	0				
Incremental changes	0				
Objective criterion for sample sizes	0				
Change in ageing criteria addressed	0				
Density dependence (other than R) addressed	0				
Regime shifts addressed	0				

Quantity	M19.12a	M19.12	M21.1	M21.2
Average emphasis:	1.8750	1.6875	1.3750	1.0000
Model weight:	0.3158	0.2842	0.2316	0.1684

Table 2.19a—Time-invariant parameters other than selectivity parameters.

Feature	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Allow catchability to vary?	no		yes		no		no		n/a	
Allow domed survey selectivty?	no		no		yes		no		n/a	
Use fishery CPUE?	no		no		no		yes		n/a	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Natural mortality	0.361	0.011	0.338	0.012	0.325	0.015	0.351	0.011	0.344	0.019
Mean length at age 1.5	15.140	0.459	15.227	0.450	15.181	0.441	15.048	0.447	15.159	0.454
Asymptotic length	112.053	2.884	120.757	5.038	102.963	2.534	113.152	2.874	112.607	7.299
Brody growth coefficient	0.119	0.009	0.098	0.011	0.158	0.012	0.114	0.008	0.121	0.024
Richards growth coefficient	1.443	0.042	1.509	0.047	1.287	0.052	1.473	0.041	1.431	0.094
SD(length at age 1)	3.487	0.066	3.501	0.065	3.497	0.068	3.534	0.069	3.501	0.068
SD(length at age 20)	9.978	0.377	10.208	0.474	9.138	0.357	9.814	0.403	9.822	0.569
Mean ageing bias at age 1 (pre-2008)	0.348	0.017	0.342	0.016	0.342	0.018	0.346	0.018	0.345	0.017
Mean ageing bias at age 20 (pre 2008)	0.990	0.223	1.065	0.216	1.093	0.238	1.030	0.249	1.042	0.233
Mean bias at age 1 (2008+)	0.004	0.024	0.012	0.023	0.006	0.026	0.010	0.026	0.008	0.025
Mean bias at age 20 (2008+)	-1.552	0.311	-1.777	0.307	-1.675	0.332	-1.925	0.377	-1.707	0.352
ln(mean post-1976 recruits)	13.236	0.097	13.034	0.101	13.094	0.122	13.194	0.100	13.139	0.135
ln(pre-1977 recruits offset)	-0.872	0.199	-0.938	0.187	-0.587	0.199	-0.844	0.190	-0.820	0.235
Pre-1977 fishing mortality	0.114	0.034	0.124	0.037	0.068	0.019	0.109	0.034	0.105	0.038
ln(Dirichlet-multinomial coef. for agecomps)	-0.137	0.192	0.137	0.226	-0.296	0.187	-0.574	0.155	-0.170	0.311
ln(survey catchability)	-0.083	0.063	0.038	0.064	-0.020	0.083	-0.094	0.066	-0.036	0.087
Fishery selectivity: begin flattop	75.013	0.034	74.836	0.507	71.990	0.708	74.972	0.034	74.256	1.319
Fishery selectivity: logit(flatop width)	-9.673	8.997	0.284	0.482	-9.708	8.144	-9.925	_	-6.893	8.352
Fishery selectivity: ln(ascending SD)	5.905	0.029	5.896	0.038	5.831	0.043	5.913	0.033	5.887	0.047
Fishery selectivity: ln(descending SD)	-9.795	_	4.504	1.403	4.087	0.465	-9.419	8.497	-2.453	8.217
Fishery selectivity: logit(ending value)	2.032	0.276	-2.473	2.629	0.696	0.325	1.805	0.286	0.404	2.359
Survey selectivity: begin flattop	21.242	0.799	21.026	0.845	21.343	0.814	21.010	0.773	21.165	0.823
Survey selectivity: ln(ascending SD)	3.582	0.150	3.540	0.161	3.631	0.153	3.552	0.147	3.576	0.157
Survey selectivity: logit(flattop width)					-1.223	0.217			-1.223	0.217
Survey selectivity: ln(descending SD)					7.315	0.513			7.315	0.513
Survey selectivity: logit(ending value)					-0.717	0.602			-0.717	0.602
ln(fishery catchability)							-9.205	0.064	-9.205	0.064

Table 2.19b—Additive devs for log population size in the initial year (1977).

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
ln(InitN)_offset_at_20	-0.013	0.661	-0.016	0.659	-0.037	0.656	-0.018	0.640	-0.020	0.656
ln(InitN)_offset_at_19	-0.008	0.663	-0.008	0.662	-0.017	0.663	-0.010	0.642	-0.010	0.659
ln(InitN)_offset_at_18	-0.012	0.661	-0.013	0.660	-0.024	0.660	-0.015	0.641	-0.015	0.657
ln(InitN)_offset_at_17	-0.018	0.659	-0.020	0.658	-0.034	0.657	-0.022	0.638	-0.023	0.655
ln(InitN)_offset_at_16	-0.028	0.656	-0.031	0.654	-0.048	0.653	-0.033	0.635	-0.034	0.651
ln(InitN)_offset_at_15	-0.043	0.652	-0.047	0.649	-0.067	0.647	-0.050	0.630	-0.051	0.647
ln(InitN)_offset_at_14	-0.064	0.645	-0.073	0.642	-0.092	0.640	-0.074	0.624	-0.075	0.640
ln(InitN)_offset_at_13	-0.095	0.637	-0.110	0.632	-0.126	0.631	-0.107	0.615	-0.109	0.630
ln(InitN)_offset_at_12	-0.139	0.625	-0.162	0.619	-0.170	0.619	-0.152	0.603	-0.155	0.619
ln(InitN)_offset_at_11	-0.197	0.611	-0.231	0.603	-0.224	0.606	-0.211	0.590	-0.215	0.604
ln(InitN)_offset_at_10	-0.271	0.595	-0.318	0.585	-0.289	0.592	-0.284	0.574	-0.291	0.588
ln(InitN)_offset_at_09	-0.358	0.577	-0.419	0.566	-0.365	0.576	-0.370	0.557	-0.379	0.571
ln(InitN)_offset_at_08	-0.454	0.558	-0.525	0.547	-0.446	0.560	-0.461	0.540	-0.474	0.554
ln(InitN)_offset_at_07	-0.544	0.541	-0.619	0.530	-0.521	0.545	-0.547	0.525	-0.560	0.538
ln(InitN)_offset_at_06	-0.598	0.529	-0.669	0.518	-0.563	0.535	-0.598	0.513	-0.610	0.526
ln(InitN)_offset_at_05	-0.555	0.527	-0.609	0.517	-0.509	0.535	-0.553	0.511	-0.560	0.524
ln(InitN)_offset_at_04	-0.274	0.547	-0.299	0.535	-0.214	0.555	-0.272	0.529	-0.267	0.544
ln(InitN)_offset_at_03	0.227	0.485	0.186	0.474	0.261	0.486	0.180	0.478	0.215	0.482
ln(InitN)_offset_at_02	-0.059	0.557	-0.085	0.550	-0.090	0.562	-0.072	0.541	-0.076	0.554
ln(InitN)_offset_at_01	0.666	0.615	0.737	0.588	0.722	0.581	0.672	0.591	0.700	0.596

Table 2.19c—Additive devs for age 0 ln(recruitment).

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1.040	0.226	0.909	0.228	1.129	0.245	1.007	0.227	1.018	0.244
1978	0.652	0.249	0.588	0.232	0.675	0.255	0.616	0.248	0.633	0.248
1979	0.652	0.134	0.584	0.133	0.637	0.135	0.622	0.135	0.624	0.137
1980	-0.722	0.224	-0.839	0.242	-0.717	0.223	-0.696	0.217	-0.750	0.235
1981	-0.679	0.168	-0.646	0.168	-0.682	0.166	-0.690	0.168	-0.672	0.169
1982	0.876	0.055	0.889	0.058	0.860	0.056	0.865	0.055	0.874	0.057
1983	-0.430	0.153	-0.532	0.161	-0.423	0.150	-0.441	0.153	-0.459	0.162
1984	0.800	0.057	0.785	0.061	0.777	0.059	0.795	0.057	0.789	0.059
1985	0.016	0.088	0.011	0.092	0.003	0.088	0.002	0.088	0.009	0.089
1986	-0.613	0.110	-0.555	0.111	-0.634	0.109	-0.611	0.109	-0.601	0.114
1987	-1.704	0.220	-1.591	0.222	-1.725	0.216	-1.684	0.217	-1.673	0.225
1988	-0.275	0.087	-0.216	0.093	-0.321	0.088	-0.262	0.088	-0.267	0.097
1989	0.394	0.061	0.441	0.064	0.359	0.061	0.412	0.061	0.402	0.069
1990	0.378	0.068	0.398	0.070	0.341	0.070	0.396	0.069	0.378	0.073
1991	-0.099	0.091	-0.189	0.098	-0.089	0.089	-0.054	0.090	-0.115	0.105
1992	0.874	0.043	0.795	0.046	0.863	0.044	0.903	0.042	0.854	0.059
1993	-0.137	0.079	-0.115	0.077	-0.105	0.076	-0.161	0.083	-0.128	0.081
1994	-0.289	0.074	-0.309	0.075	-0.296	0.075	-0.280	0.075	-0.295	0.075
1995	-0.427	0.082	-0.397	0.082	-0.419	0.082	-0.433	0.083	-0.418	0.083
1996	0.747	0.044	0.758	0.044	0.736	0.045	0.700	0.042	0.740	0.048
1997	-0.125	0.076	-0.078	0.075	-0.130	0.076	-0.186	0.077	-0.123	0.084
1998	-0.339	0.088	-0.293	0.089	-0.372	0.091	-0.426	0.089	-0.348	0.100
1999	0.548	0.048	0.539	0.050	0.520	0.050	0.469	0.048	0.526	0.056
2000	0.214	0.054	0.217	0.055	0.239	0.054	0.248	0.052	0.227	0.055
2001	-0.713	0.105	-0.675	0.104	-0.734	0.105	-0.567	0.104	-0.682	0.119
2002	-0.174	0.062	-0.145	0.062	-0.166	0.062	0.098	0.058	-0.118	0.115
2003	-0.268	0.068	-0.218	0.067	-0.272	0.067	0.037	0.065	-0.203	0.129
2004	-0.603	0.084	-0.530	0.085	-0.608	0.079	-0.354	0.089	-0.542	0.123
2005	-0.433	0.075	-0.317	0.074	-0.446	0.074	-0.190	0.080	-0.362	0.120
2006	0.647	0.042	0.764	0.043	0.626	0.044	0.737	0.041	0.690	0.073
2007	-0.235	0.088	-0.170	0.088	-0.237	0.088	-0.299	0.093	-0.228	0.098
2008	1.079	0.039	1.087	0.040	1.064	0.041	0.995	0.038	1.064	0.051
2009	-0.877	0.165	-0.881	0.160	-0.853	0.164	-0.984	0.170	-0.891	0.170
2010	0.616	0.054	0.658	0.054	0.592	0.056	0.499	0.051	0.603	0.075
2011	0.870	0.049	0.889	0.052	0.882	0.053	0.735	0.046	0.855	0.074
2012	0.147	0.090	0.105	0.092	0.129	0.091	-0.021	0.093	0.102	0.108
2013	1.115	0.044	1.110	0.048	1.105	0.046	0.963	0.042	1.086	0.072
2014	-0.597	0.116	-0.563	0.112	-0.585	0.115	-0.723	0.120	-0.606	0.128
2015	-0.294	0.075	-0.221	0.077	-0.304	0.075	-0.344	0.074	-0.284	0.087
2016	-0.600	0.096	-0.673	0.102	-0.619	0.096	-0.624	0.095	-0.629	0.102
2017	-1.085	0.188	-1.110	0.186	-1.068	0.185	-1.100	0.192	-1.091	0.188
2018	0.598	0.068	0.644	0.081	0.584	0.069	0.608	0.069	0.609	0.076
2019	-0.496	0.203	-0.872	0.313	-0.499	0.198	-0.503	0.207	-0.605	0.292
2020	-0.047	0.276	-0.039	0.274	0.184	0.291	-0.072	0.262	0.005	0.294

Table 2.19d—Multiplicative devs for length at age 1.5.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.541	0.939	0.563	0.934	0.158	0.961	0.502	0.943	0.452	0.958
1978	-0.108	0.926	-0.111	0.926	-0.174	0.920	-0.113	0.930	-0.125	0.926
1979	0.604	0.992	0.598	1.010	0.493	0.989	0.590	1.004	0.574	0.999
1980	-0.032	0.911	-0.079	0.896	-0.081	0.906	-0.046	0.918	-0.059	0.907
1981	-0.947	0.407	-1.066	0.422	-0.988	0.425	-0.925	0.421	-0.986	0.422
1982	-0.824	0.261	-0.918	0.275	-0.781	0.271	-0.816	0.266	-0.839	0.273
1983	0.481	0.637	1.082	0.741	0.411	0.575	0.532	0.659	0.644	0.715
1984	0.209	0.208	0.257	0.217	0.159	0.213	0.261	0.211	0.220	0.216
1985	-1.401	0.373	-1.489	0.389	-1.413	0.383	-1.402	0.379	-1.429	0.383
1986	-0.006	0.239	-0.008	0.245	0.016	0.238	-0.003	0.247	-0.001	0.242
1987	-0.589	0.383	-0.596	0.398	-0.527	0.370	-0.643	0.400	-0.586	0.389
1988	-0.900	0.370	-0.907	0.385	-0.782	0.383	-0.957	0.379	-0.884	0.384
1989	-0.814	0.243	-0.811	0.251	-0.825	0.247	-0.827	0.249	-0.818	0.248
1990	-0.236	0.273	-0.183	0.276	-0.279	0.271	-0.252	0.282	-0.234	0.277
1991	0.205	0.221	0.336	0.234	0.193	0.223	0.233	0.227	0.244	0.234
1992	-0.103	0.207	-0.129	0.213	-0.094	0.209	-0.088	0.212	-0.106	0.211
1993	0.356	0.301	0.167	0.327	0.566	0.294	0.425	0.310	0.362	0.341
1994	-0.347	0.249	-0.253	0.256	-0.289	0.244	-0.308	0.256	-0.300	0.254
1995	-0.386	0.308	-0.341	0.335	-0.320	0.306	-0.385	0.318	-0.358	0.318
1996	-0.189	0.230	-0.197	0.236	-0.209	0.231	-0.166	0.233	-0.192	0.233
1997	-0.309	0.279	-0.313	0.284	-0.291	0.284	-0.329	0.293	-0.309	0.284
1998	-0.774	0.269	-0.799	0.279	-0.717	0.259	-0.711	0.273	-0.757	0.273
1999	-1.260	0.234	-1.269	0.237	-1.281	0.236	-1.251	0.237	-1.266	0.236
2000	0.638	0.213	0.549	0.220	0.638	0.215	0.636	0.217	0.612	0.220
2001	0.154	0.239	0.158	0.245	0.195	0.237	0.000	0.251	0.139	0.251
2002	0.448	0.210	0.451	0.215	0.430	0.213	0.264	0.220	0.414	0.224
2003	0.046	0.255	-0.004	0.262	0.038	0.264	-0.115	0.270	0.003	0.268
2004	1.063	0.220	1.037	0.222	1.083	0.221	1.031	0.219	1.055	0.222
2005	-0.233	0.241	-0.276	0.249	-0.234	0.246	-0.420	0.250	-0.277	0.255
2006	-0.425	0.198	-0.398	0.200	-0.424	0.200	-0.409	0.202	-0.414	0.200
2007	-1.169	0.264	-1.026	0.274	-1.207	0.270	-0.949	0.280	-1.100	0.288
2008	-1.233	0.219	-1.247	0.215	-1.246	0.219	-1.090	0.221	-1.216	0.226
2009	-0.661	0.337	-0.823	0.342	-0.546	0.342	-0.617	0.352	-0.673	0.358
2010	0.155	0.191	0.107	0.195	0.148	0.193	0.256	0.194	0.157	0.199
2011	-1.138	0.237	-1.127	0.257	-1.162	0.237	-0.963	0.245	-1.111	0.253
2012	0.003	0.278	0.089	0.283	0.110	0.271	-0.072	0.293	0.040	0.288
2013	-0.332	0.206	-0.372	0.210	-0.326	0.208	-0.338	0.208	-0.343	0.209
2014	0.152	0.347	0.060	0.360	0.214	0.345	-0.157	0.372	0.088	0.376
2015	1.321	0.198	1.387	0.201	1.335	0.199	1.202	0.202	1.323	0.209
2016	1.474	0.271	1.614	0.268	1.474	0.279	1.446	0.283	1.509	0.282
2017	1.404	0.251	1.440	0.254	1.422	0.257	1.432	0.260	1.423	0.255
2018	1.939	0.177	1.971	0.179	1.995	0.179	2.035	0.179	1.977	0.182
2019	-1.208	0.931	-1.072	0.955	-1.304	0.925	-1.107	0.968	-1.174	0.947
2020	1.612	0.218	1.546	0.227	1.583	0.217	1.704	0.225	1.602	0.228
2021	2.818	0.355	2.403	0.605	2.836	0.357	2.909	0.378	2.719	0.488

Table 2.19e (page 1 of 4)—Additive devs for the log standard deviation of the first normal pdf in the double-normal fishery selectivity function.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.130	0.973	0.156	0.975	0.110	0.973	0.156	0.965	0.137	0.972
1978	0.152	0.887	0.145	0.892	0.127	0.889	0.153	0.859	0.144	0.884
1979	0.424	0.789	0.438	0.799	0.493	0.788	0.430	0.749	0.445	0.786
1980	0.353	0.841	0.361	0.846	0.488	0.839	0.385	0.806	0.392	0.838
1981	1.096	0.858	1.072	0.863	1.178	0.851	1.155	0.830	1.118	0.854
1982	-0.066	0.927	-0.078	0.930	0.018	0.927	-0.078	0.906	-0.052	0.925
1983	0.179	0.811	0.127	0.816	0.320	0.816	0.170	0.770	0.195	0.810
1984	0.958	0.583	0.904	0.592	1.092	0.580	0.879	0.533	0.960	0.582
1985	-0.077	0.520	-0.093	0.528	-0.080	0.528	-0.079	0.475	-0.083	0.517
1986	0.677	0.529	0.739	0.540	0.669	0.530	0.597	0.488	0.679	0.528
1987	-0.098	0.443	-0.002	0.453	-0.165	0.448	-0.097	0.405	-0.086	0.445
1988	2.349	0.668	2.367	0.672	2.330	0.670	2.289	0.631	2.339	0.664
1989	1.126	0.776	1.103	0.781	1.196	0.778	1.156	0.738	1.141	0.772
1990	0.245	0.581	0.165	0.589	0.441	0.584	0.239	0.529	0.267	0.585
1991	0.099	0.406	0.071	0.414	0.106	0.407	0.104	0.367	0.093	0.402
1992	-0.183	0.372	-0.099	0.379	-0.168	0.374	-0.171	0.345	-0.154	0.372
1993	1.475	0.469	1.705	0.487	1.414	0.465	1.319	0.431	1.500	0.487
1994	0.463	0.399	0.693	0.414	0.371	0.394	0.369	0.364	0.491	0.418
1995	0.725	0.400	0.906	0.408	0.587	0.397	0.664	0.366	0.734	0.414
1996	-0.243	0.405	-0.243	0.410	-0.217	0.408	0.099	0.320	-0.179	0.414
1997	0.980	0.400	0.847	0.405	1.004	0.400	1.236	0.338	0.991	0.412
1998	-0.008	0.361	-0.198	0.365	-0.013	0.359	0.221	0.309	-0.025	0.379
1999	0.181	0.320	-0.046	0.317	0.172	0.321	0.286	0.268	0.132	0.333
2000	-0.076	0.346	-0.377	0.344	0.000	0.349	0.425	0.287	-0.060	0.427
2001	-0.228	0.329	-0.362	0.333	-0.241	0.325	-0.400	0.270	-0.298	0.328
2002	0.632	0.312	0.724	0.314	0.527	0.306	0.738	0.263	0.652	0.314
2003	0.488	0.322	0.514	0.323	0.363	0.321	-0.206	0.242	0.350	0.402
2004	0.645	0.343	0.635	0.347	0.525	0.342	-0.451	0.253	0.430	0.519
2005	0.623	0.341	0.580	0.345	0.517	0.342	-0.827	0.255	0.342	0.622
2006	0.131	0.372	-0.019	0.373	0.119	0.376	-0.535	0.293	-0.026	0.432
2007	0.019	0.398	-0.207	0.397	0.091	0.402	-0.292	0.306	-0.081	0.413
2008	-0.038	0.326	-0.166	0.327	0.020	0.322	0.267	0.274	-0.010	0.348
2009	-0.921	0.326	-0.946	0.325	-0.923	0.321	0.358	0.279	-0.713	0.577
2010	-1.481	0.338	-1.416	0.345	-1.459	0.333	0.472	0.279	-1.129	0.793
2011	-1.434	0.316	-1.274	0.327	-1.444	0.315	-0.038	0.273	-1.156	0.596
2012	-0.566	0.349	-0.510	0.356	-0.515	0.349	0.334	0.286	-0.387	0.471
2013	-0.262	0.300	-0.195	0.307	-0.327	0.297	0.162	0.254	-0.187	0.337
2014	-1.200	0.297	-1.111	0.302	-1.238	0.296	-0.933	0.243	-1.139	0.308
2015	-1.554	0.299	-1.513	0.306	-1.540	0.298	-1.337	0.245	-1.503	0.302
2016	-1.571	0.326	-1.561	0.333	-1.582	0.329	-1.309	0.254	-1.527	0.332
2017	-1.561	0.402	-1.678	0.408	-1.510	0.412	-2.590	0.269	-1.756	0.543
2018	-0.447	0.468	-0.499	0.480	-0.516	0.475	-1.351	0.349	-0.630	0.560
2019	-0.254	0.534	-0.141	0.545	-0.364	0.545	-1.336	0.430	-0.430	0.669
2020	-0.259	0.471	-0.110	0.484	-0.304	0.467	-0.885	0.396	-0.333	0.530
2021	-1.624	0.571	-1.405	0.598	-1.671	0.576	-1.747	0.459	-1.593	0.577

Table 2.19e (page 2 of 4)—Additive devs for the logit of fishery selectivity at maximum length.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	-0.065	1.021	-0.007	0.998	-0.118	1.018	-0.174	1.104	-0.079	1.030
1978	-0.128	1.040	-0.005	0.998	-0.251	1.026	-0.386	1.206	-0.165	1.064
1979	-0.124	1.038	-0.004	0.999	-0.250	1.025	-0.357	1.182	-0.158	1.058
1980	0.002	0.996	-0.001	1.000	-0.044	0.997	0.008	0.980	-0.008	0.995
1981	-0.016	1.004	0.001	1.000	-0.049	1.004	-0.028	1.009	-0.021	1.004
1982	0.061	0.978	0.000	1.000	0.058	0.982	0.125	0.924	0.054	0.977
1983	0.258	0.913	-0.001	1.000	0.338	0.908	0.408	0.799	0.228	0.932
1984	0.434	0.860	-0.005	0.998	0.590	0.829	0.607	0.729	0.374	0.909
1985	0.132	0.893	-0.009	0.997	0.142	0.792	0.272	0.743	0.118	0.884
1986	-0.089	0.937	-0.005	0.998	-0.161	0.793	-0.045	0.734	-0.075	0.895
1987	0.075	0.874	-0.014	0.996	-0.138	0.695	0.143	0.685	0.012	0.851
1988	0.044	0.948	-0.004	0.999	-0.233	0.887	0.127	0.827	-0.020	0.938
1989	0.309	0.893	0.010	0.999	0.423	0.858	0.461	0.771	0.276	0.915
1990	0.866	0.779	-0.004	0.997	1.240	0.726	0.967	0.656	0.722	0.947
1991	0.458	0.814	-0.038	0.990	0.613	0.691	0.570	0.681	0.372	0.864
1992	-0.173	0.869	-0.029	0.992	-0.060	0.652	-0.151	0.569	-0.102	0.821
1993	-0.020	0.941	-0.010	0.997	-0.302	0.800	-0.041	0.771	-0.086	0.908
1994	-0.024	0.924	-0.016	0.995	-0.410	0.748	-0.059	0.718	-0.117	0.891
1995	-0.014	0.917	-0.030	0.992	-0.256	0.769	0.055	0.728	-0.063	0.885
1996	0.824	0.784	-0.018	0.994	1.209	0.731	1.092	0.631	0.719	0.950
1997	0.524	0.821	-0.012	0.995	0.737	0.743	0.932	0.648	0.490	0.901
1998	0.288	0.842	-0.002	0.998	0.381	0.732	0.562	0.631	0.273	0.858
1999	0.059	0.835	0.049	1.003	0.196	0.676	-0.357	0.339	0.018	0.814
2000	-0.021	0.847	0.094	1.024	0.078	0.667	0.433	0.587	0.111	0.842
2001	-0.889	0.793	0.000	0.999	-0.947	0.588	-1.319	0.253	-0.722	0.896
2002	-1.305	0.679	0.000	0.999	-1.409	0.557	-0.751	0.313	-0.865	0.929
2003	-0.280	0.785	-0.018	0.995	-0.498	0.574	-1.171	0.236	-0.406	0.843
2004	-0.068	0.814	-0.004	0.998	0.071	0.628	-1.116	0.239	-0.194	0.876
2005	0.232	0.805	-0.012	0.996	0.315	0.642	-1.092	0.236	-0.041	0.911
2006	0.749	0.775	0.019	1.005	1.255	0.688	1.052	0.611	0.710	0.935
2007	0.545	0.804	0.013	1.003	1.062	0.704	1.132	0.606	0.612	0.929
2008	-0.610	0.813	0.005	1.001	-0.279	0.631	1.043	0.611	-0.080	0.980
2009	-1.158	0.788	0.016	1.003	-1.298	0.593	1.250	0.606	-0.451	1.224
2010	-1.062	0.934	-0.004	0.998	-1.472	0.681	1.323	0.604	-0.455	1.294
2011	-0.119	0.931	-0.002	0.999	-0.675	0.770	0.473	0.665	-0.115	0.950
2012	0.078	0.903	-0.008	0.998	-0.279	0.833	-0.365	0.470	-0.104	0.877
2013	-0.332	0.915	-0.007	0.998	-0.721	0.759	-0.988	0.302	-0.440	0.907
2014	-0.522	0.835	-0.006	0.998	-0.535	0.695	-1.176	0.256	-0.489	0.879
2015	-0.241	0.864	-0.005	0.998	-0.206	0.707	-0.996	0.277	-0.293	0.870
2016	0.078	0.872	-0.004	0.999	-0.106	0.751	-0.300	0.430	-0.051	0.838
2017	0.517	0.820	-0.001	0.999	0.476	0.776	-1.116	0.269	0.085	0.994
2018	0.281	0.853	-0.003	0.999	0.305	0.773	-0.694	0.334	0.042	0.893
2019	-0.296	0.901	-0.003	0.999	-0.279	0.746	-1.004	0.289	-0.328	0.889
2020	0.255	0.857	0.036	1.006	0.634	0.751	-0.294	0.387	0.188	0.877
2021	0.486	0.847	0.046	1.008	0.850	0.791	0.946	0.637	0.523	0.921

Table 2.19e (page 3 of 4)—Multiplicative devs for the first size at which survey selectivity reaches 1.0.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.273	0.424	-0.227	0.421	-0.228	0.441	-0.244	0.440	-0.244	0.430
1983	-0.370	0.475	-0.227	0.465	-0.272	0.522	-0.429	0.477	-0.316	0.490
1984	1.101	0.400	1.129	0.348	1.007	0.376	1.138	0.396	1.094	0.383
1985	0.435	0.274	0.504	0.275	0.335	0.297	0.469	0.274	0.437	0.286
1986	-0.469	0.526	-0.432	0.511	-0.436	0.533	-0.484	0.525	-0.453	0.524
1987	-0.075	0.380	0.022	0.337	-0.047	0.357	-0.068	0.375	-0.040	0.364
1988	0.054	0.530	0.127	0.520	-0.015	0.500	0.055	0.530	0.059	0.523
1989	0.460	0.512	0.465	0.503	0.639	0.581	0.453	0.511	0.502	0.532
1990	-0.351	0.354	-0.346	0.345	-0.441	0.354	-0.349	0.357	-0.370	0.354
1991	0.930	0.468	0.841	0.444	0.680	0.434	0.923	0.472	0.846	0.465
1992	-0.121	0.348	-0.472	0.438	-0.229	0.346	-0.068	0.353	-0.237	0.408
1993	0.172	0.324	0.080	0.325	0.085	0.337	0.202	0.350	0.131	0.336
1994	0.346	0.452	0.568	0.433	0.899	0.487	0.330	0.464	0.535	0.508
1995	0.531	0.429	0.711	0.432	0.569	0.437	0.593	0.440	0.601	0.439
1996	0.253	0.385	0.408	0.424	0.336	0.385	0.278	0.391	0.321	0.402
1997	0.715	0.349	0.721	0.338	0.616	0.334	0.701	0.349	0.691	0.345
1998	1.918	0.347	1.888	0.312	1.805	0.371	1.812	0.388	1.865	0.354
1999	0.369	0.493	0.336	0.490	0.277	0.484	0.372	0.515	0.339	0.495
2000	-0.639	0.298	-0.658	0.281	-0.722	0.295	-0.701	0.297	-0.674	0.295
2001	-0.936	0.360	-0.712	0.345	-0.878	0.366	-0.878	0.356	-0.849	0.368
2002	0.037	0.450	0.095	0.436	-0.142	0.407	0.120	0.436	0.026	0.445
2003	0.198	0.313	0.245	0.304	0.046	0.321	0.388	0.316	0.208	0.331
2004	0.191	0.352	0.202	0.339	0.085	0.352	0.336	0.365	0.194	0.359
2005	-0.260	0.481	-0.120	0.414	-0.325	0.394	0.027	0.428	-0.187	0.451
2006	-1.697	0.290	-1.531	0.279	-1.773	0.299	-1.349	0.328	-1.609	0.331
2007	-2.372	0.259	-2.263	0.234	-2.481	0.252	-2.356	0.231	-2.363	0.258
2008	-1.449	0.293	-1.484	0.285	-1.482	0.299	-1.466	0.309	-1.469	0.295
2009	-0.686	0.474	-1.501	0.420	-0.797	0.488	-0.791	0.565	-0.961	0.590
2010	-0.348	0.443	-0.526	0.374	-0.078	0.561	-0.417	0.456	-0.348	0.486
2011	-0.131	0.257	-0.073	0.249	-0.169	0.263	-0.205	0.257	-0.136	0.261
2012	-2.027	0.326	-2.062	0.484	-1.710	0.598	-2.391	0.305	-2.025	0.494
2013	0.936	0.358	0.810	0.331	1.017	0.323	0.735	0.424	0.885	0.369
2014	-0.112	0.293	-0.051	0.283	-0.096	0.308	-0.226	0.281	-0.110	0.298
2015	0.500	0.462	0.471	0.435	0.615	0.463	0.273	0.460	0.480	0.467
2016	1.094	0.326	1.170	0.329	1.055	0.326	1.056	0.314	1.100	0.328
2017	1.409	0.363	1.177	0.340	1.219	0.344	1.389	0.358	1.296	0.367
2018	0.750	0.316	0.715	0.299	0.730	0.310	0.803	0.317	0.745	0.312
2019	-1.357	0.335	-1.272	0.347	-1.297	0.335	-1.312	0.316	-1.311	0.337
2020	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000
2021	1.273	0.473	1.268	0.430	1.601	0.484	1.279	0.469	1.349	0.484

Table 2.19e (page 4 of 4)—Additive devs for the log standard deviation of the first normal pdf in the double-normal survey selectivity function.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.564	0.588	-0.517	0.581	-0.519	0.603	-0.551	0.616	-0.538	0.595
1983	0.322	0.637	0.378	0.602	0.491	0.698	0.282	0.655	0.370	0.650
1984	0.747	0.448	0.914	0.411	0.628	0.432	0.783	0.451	0.773	0.447
1985	0.606	0.370	0.675	0.363	0.489	0.404	0.665	0.376	0.609	0.384
1986	-0.107	0.686	-0.108	0.663	-0.056	0.691	-0.108	0.698	-0.096	0.683
1987	-0.149	0.607	-0.088	0.532	-0.086	0.581	-0.158	0.610	-0.119	0.582
1988	-0.138	0.673	-0.066	0.650	-0.231	0.645	-0.158	0.685	-0.142	0.665
1989	0.102	0.605	0.161	0.588	0.293	0.665	0.070	0.617	0.158	0.622
1990	0.071	0.451	0.090	0.434	-0.009	0.458	0.073	0.461	0.058	0.451
1991	1.215	0.522	1.214	0.498	0.959	0.498	1.212	0.533	1.155	0.523
1992	-0.075	0.445	-0.369	0.569	-0.230	0.450	-0.041	0.457	-0.189	0.504
1993	0.703	0.425	0.616	0.422	0.603	0.447	0.739	0.464	0.661	0.439
1994	0.366	0.599	0.458	0.544	1.036	0.613	0.366	0.623	0.547	0.651
1995	0.290	0.551	0.477	0.530	0.308	0.560	0.350	0.568	0.358	0.556
1996	-0.287	0.515	-0.101	0.542	-0.208	0.510	-0.273	0.532	-0.214	0.530
1997	0.727	0.419	0.743	0.400	0.606	0.410	0.754	0.429	0.708	0.417
1998	1.947	0.369	1.883	0.331	1.837	0.393	1.930	0.411	1.900	0.374
1999	0.372	0.556	0.363	0.550	0.251	0.555	0.404	0.588	0.347	0.562
2000	-0.708	0.417	-0.693	0.395	-0.832	0.419	-0.783	0.427	-0.745	0.417
2001	-0.554	0.559	-0.419	0.517	-0.463	0.574	-0.527	0.561	-0.490	0.554
2002	0.001	0.581	0.065	0.556	-0.221	0.544	-0.007	0.570	-0.034	0.574
2003	0.217	0.424	0.263	0.404	0.007	0.445	0.248	0.427	0.187	0.435
2004	0.093	0.475	0.105	0.453	-0.051	0.489	0.126	0.489	0.069	0.479
2005	-0.334	0.672	-0.205	0.570	-0.422	0.573	-0.061	0.598	-0.272	0.622
2006	-1.584	0.439	-1.441	0.414	-1.679	0.457	-1.125	0.465	-1.488	0.478
2007	-2.440	0.542	-2.393	0.487	-2.622	0.528	-2.402	0.463	-2.462	0.519
2008	-1.564	0.463	-1.604	0.468	-1.615	0.471	-1.548	0.496	-1.584	0.473
2009	0.354	0.648	-0.701	0.649	0.234	0.677	0.392	0.806	0.033	0.827
2010	-0.556	0.584	-0.738	0.525	-0.227	0.688	-0.613	0.621	-0.541	0.629
2011	-0.180	0.357	-0.131	0.337	-0.217	0.367	-0.197	0.365	-0.177	0.357
2012	-1.458	0.530	-1.635	0.858	-0.916	0.920	-1.914	0.557	-1.460	0.811
2013	0.934	0.385	0.886	0.357	1.012	0.356	0.826	0.462	0.920	0.390
2014	-0.129	0.423	-0.068	0.399	-0.090	0.448	-0.211	0.421	-0.117	0.425
2015	0.422	0.551	0.383	0.518	0.544	0.554	0.222	0.571	0.406	0.555
2016	0.685	0.447	0.796	0.440	0.668	0.457	0.572	0.446	0.694	0.453
2017	1.050	0.463	1.001	0.434	0.816	0.453	1.002	0.468	0.974	0.462
2018	-0.235	0.447	-0.201	0.417	-0.283	0.445	-0.242	0.455	-0.237	0.441
2019	-1.327	0.614	-1.167	0.645	-1.217	0.613	-1.291	0.595	-1.250	0.623
2020	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000
2021	1.165	0.436	1.173	0.392	1.410	0.439	1.194	0.440	1.229	0.437

Table 2.19f—Additive devs for log survey catchability.

	Model 19.12	
Year	Est.	SD
1982	0.918	0.727
1983	1.210	0.777
1984	-0.984	0.684
1985	0.803	0.661
1986	0.564	0.624
1987	1.005	0.665
1988	-0.167	0.572
1989	-1.080	0.661
1990	-0.975	0.696
1991	-1.432	0.670
1992	-1.862	0.684
1993	0.566	0.694
1994	3.879	0.606
1995	1.336	0.592
1996	1.743	0.654
1997	0.089	0.668
1998	0.343	0.726
1999	-0.782	0.629
2000	-1.297	0.649
2001	1.976	0.638
2002	-0.003	0.695
2003	0.814	0.744
2004	0.005	0.739
2005	0.378	0.722
2006	-0.683	0.617
2007	-2.152	0.630
2008	-2.960	0.631
2009	-2.547	0.678
2010	-1.377	0.584
2011	0.604	0.624
2012	-0.418	0.720
2013	-1.666	0.646
2014	1.904	0.722
2015	0.775	0.702
2016	1.065	0.798
2017	-1.858	0.612
2018	0.990	0.714
2019	0.011	0.732
2020	0.000	1.000
2021	1.264	0.829

Table 2.20—"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.

	Model 19.12a			Model 19.12			Model 21.1			Model 21.2		
Parameter	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma
ln(Recruits)	0.4275	0.0146	0.6651	0.4243	0.0161	0.6642	0.4290	0.0150	0.6681	0.4019	0.0145	0.6452
Length_at_1.5	0.8345	0.1693	0.1804	0.8240	0.1828	0.1746	0.8367	0.1686	0.1725	0.8231	0.1769	0.1749
Sel_fsh_lnSD1	0.7237	0.2729	0.1639	0.7227	0.2794	0.1593	0.7282	0.2736	0.1817	0.7739	0.2262	0.1903
Sel_fsh_logitEnd	0.2219	0.7708	0.7726	0.0005	0.9981	0.7615	0.4028	0.5990	0.6754	0.5684	0.4340	1.3903
Sel_srv_PeakStart	0.8244	0.1751	0.2092	0.8298	0.1674	0.2258	0.8212	0.1844	0.2065	0.8252	0.1798	0.2028
Sel_srv_lnSD1	0.7111	0.2878	0.7710	0.7164	0.2788	0.8414	0.7016	0.3080	0.7573	0.7051	0.3030	0.7398

Table 2.21—Catchability time series (Model 19.12 only; other models assume constant catchability).

Year	M19.12
1982	1.115
1983	1.140
1984	0.964
1985	1.105
1986	1.085
1987	1.122
1988	1.026
1989	0.957
1990	0.964
1991	0.931
1992	0.901
1993	1.085
1994	1.398
1995	1.151
1996	1.187
1997	1.046
1998	1.067
1999	0.979
2000	0.941
2001	1.209
2002	1.039
2003	1.106
2004	1.039
2005	1.069
2006	0.986
2007	0.881
2008	0.828
2009	0.855
2010	0.935
2011	1.088
2012	1.006
2013	0.915
2014	1.202
2015	1.102
2016	1.127
2017	0.901
2018	1.121
2019	1.040
2021	1.144
Ave.	1.045

Table 2.22—Female spawning biomass (in millions of t) time series (point estimates and standard errors).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.106	0.029	0.090	0.024	0.191	0.054	0.114	0.030	0.122	0.052
1978	0.109	0.029	0.091	0.024	0.199	0.054	0.118	0.030	0.126	0.054
1979	0.111	0.027	0.091	0.022	0.202	0.053	0.119	0.028	0.128	0.054
1980	0.136	0.028	0.110	0.023	0.232	0.054	0.143	0.028	0.152	0.057
1981	0.199	0.030	0.160	0.025	0.308	0.059	0.204	0.030	0.214	0.066
1982	0.309	0.035	0.248	0.030	0.441	0.069	0.311	0.036	0.323	0.083
1983	0.409	0.039	0.334	0.034	0.559	0.075	0.409	0.040	0.422	0.095
1984	0.413	0.034	0.343	0.031	0.549	0.066	0.414	0.035	0.425	0.086
1985	0.462	0.035	0.390	0.033	0.619	0.071	0.467	0.037	0.479	0.095
1986	0.452	0.032	0.387	0.031	0.603	0.066	0.459	0.034	0.469	0.089
1987	0.439	0.028	0.382	0.028	0.576	0.058	0.448	0.030	0.456	0.080
1988	0.463	0.027	0.407	0.027	0.601	0.058	0.474	0.029	0.481	0.080
1989	0.450	0.025	0.398	0.025	0.580	0.054	0.463	0.027	0.468	0.075
1990	0.404	0.022	0.362	0.021	0.520	0.047	0.418	0.023	0.421	0.065
1991	0.324	0.017	0.294	0.017	0.422	0.039	0.338	0.019	0.340	0.053
1992	0.238	0.014	0.217	0.014	0.321	0.033	0.253	0.016	0.254	0.044
1993	0.225	0.015	0.206	0.014	0.304	0.033	0.242	0.016	0.241	0.042
1994	0.224	0.014	0.206	0.012	0.291	0.029	0.240	0.015	0.237	0.037
1995	0.236	0.014	0.215	0.012	0.299	0.029	0.255	0.015	0.248	0.036
1996	0.237	0.015	0.207	0.012	0.293	0.029	0.257	0.016	0.245	0.037
1997	0.232	0.015	0.196	0.011	0.289	0.030	0.255	0.016	0.239	0.039
1998	0.210	0.015	0.170	0.011	0.266	0.030	0.232	0.016	0.215	0.040
1999	0.204	0.016	0.163	0.011	0.263	0.031	0.227	0.016	0.210	0.041
2000	0.215	0.017	0.173	0.012	0.276	0.032	0.236	0.017	0.221	0.043
2001	0.224	0.016	0.184	0.013	0.283	0.032	0.239	0.017	0.229	0.041
2002	0.239	0.016	0.201	0.013	0.298	0.031	0.247	0.016	0.243	0.040
2003	0.244	0.016	0.209	0.013	0.303	0.031	0.246	0.016	0.248	0.039
2004	0.250	0.015	0.216	0.012	0.308	0.031	0.245	0.016	0.253	0.039
2005	0.245	0.015	0.212	0.012	0.305	0.031	0.242	0.015	0.249	0.039
2006	0.218	0.013	0.189	0.010	0.277	0.029	0.226	0.014	0.225	0.036
2007	0.191	0.012	0.166	0.010	0.249	0.028	0.216	0.014	0.202	0.035
2008	0.165	0.011	0.145	0.009	0.220	0.026	0.207	0.013	0.179	0.034
2009	0.144	0.010	0.129	0.008	0.194	0.024	0.200	0.013	0.161	0.033
2010	0.137	0.010	0.126	0.008	0.181	0.022	0.201	0.013	0.155	0.032
2011	0.160	0.010	0.152	0.009	0.202	0.022	0.225	0.014	0.178	0.032
2012	0.189	0.012	0.178	0.010	0.230	0.024	0.243	0.015	0.204	0.030
2013	0.217	0.013	0.202	0.012	0.262	0.026	0.257	0.016	0.230	0.031
2014	0.223	0.015	0.206	0.013	0.271	0.028	0.247	0.017	0.233	0.031
2015	0.233	0.016	0.212	0.015	0.283	0.030	0.238	0.017	0.239	0.033
2016	0.272	0.019	0.244	0.018	0.329	0.034	0.254	0.018	0.274	0.039
2017	0.320	0.022	0.283	0.021	0.384	0.039	0.278	0.020	0.317	0.048
2018	0.352	0.024	0.311	0.023	0.423	0.043	0.294	0.020	0.347	0.055
2019	0.355	0.024	0.317	0.024	0.432	0.043	0.291	0.020	0.351	0.057
2020	0.316	0.022	0.285	0.023	0.392	0.040	0.256	0.018	0.315	0.054
2021	0.254	0.018	0.230	0.020	0.320	0.034	0.207	0.015	0.255	0.046
2022	0.259	0.018	0.231	0.021	0.326	0.034	0.218	0.016	0.260	0.046
2023	0.247	0.010	0.232	0.014	0.309	0.027	0.234	0.011	0.255	0.035

Table 2.23—Relative spawning biomass time series (point estimates and standard errors).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.163	0.045	0.134	0.037	0.246	0.065	0.171	0.045	0.175	0.064
1978	0.168	0.044	0.136	0.037	0.257	0.066	0.175	0.044	0.181	0.066
1979	0.172	0.043	0.137	0.035	0.260	0.064	0.177	0.042	0.183	0.065
1980	0.209	0.044	0.165	0.036	0.299	0.065	0.212	0.043	0.218	0.068
1981	0.307	0.047	0.239	0.041	0.398	0.069	0.303	0.047	0.308	0.077
1982	0.476	0.058	0.372	0.053	0.570	0.079	0.463	0.057	0.466	0.094
1983	0.630	0.064	0.500	0.062	0.722	0.085	0.610	0.063	0.611	0.106
1984	0.637	0.056	0.515	0.058	0.710	0.072	0.617	0.056	0.616	0.094
1985	0.713	0.059	0.585	0.062	0.800	0.076	0.696	0.059	0.694	0.101
1986	0.697	0.053	0.580	0.059	0.778	0.069	0.684	0.054	0.680	0.093
1987	0.677	0.047	0.573	0.054	0.743	0.059	0.667	0.048	0.661	0.081
1988	0.714	0.046	0.610	0.054	0.776	0.057	0.706	0.047	0.697	0.079
1989	0.694	0.043	0.597	0.050	0.749	0.053	0.689	0.044	0.678	0.073
1990	0.624	0.036	0.543	0.043	0.671	0.045	0.623	0.038	0.611	0.062
1991	0.499	0.028	0.441	0.033	0.545	0.036	0.503	0.030	0.494	0.049
1992	0.367	0.023	0.326	0.026	0.415	0.031	0.376	0.024	0.368	0.041
1993	0.347	0.023	0.309	0.026	0.393	0.032	0.360	0.025	0.349	0.040
1994	0.345	0.022	0.309	0.024	0.376	0.028	0.358	0.023	0.344	0.035
1995	0.364	0.023	0.322	0.024	0.387	0.029	0.380	0.024	0.360	0.036
1996	0.365	0.025	0.310	0.024	0.379	0.030	0.383	0.026	0.356	0.040
1997	0.359	0.025	0.294	0.023	0.373	0.031	0.379	0.026	0.347	0.043
1998	0.323	0.025	0.255	0.022	0.344	0.032	0.346	0.025	0.312	0.045
1999	0.315	0.025	0.245	0.022	0.339	0.033	0.339	0.026	0.305	0.047
2000	0.332	0.027	0.259	0.024	0.357	0.035	0.352	0.027	0.320	0.049
2001	0.345	0.027	0.276	0.025	0.366	0.034	0.356	0.026	0.332	0.046
2002	0.368	0.026	0.302	0.025	0.385	0.033	0.369	0.026	0.353	0.043
2003	0.377	0.026	0.314	0.026	0.392	0.033	0.366	0.025	0.360	0.041
2004	0.385	0.025	0.323	0.025	0.398	0.032	0.365	0.025	0.367	0.040
2005	0.378	0.024	0.318	0.024	0.394	0.032	0.361	0.024	0.362	0.040
2006	0.336	0.022	0.283	0.022	0.357	0.030	0.336	0.023	0.326	0.037
2007	0.295	0.020	0.249	0.019	0.322	0.029	0.322	0.022	0.293	0.038
2008	0.255	0.018	0.217	0.017	0.284	0.026	0.308	0.021	0.260	0.038
2009	0.222	0.016	0.193	0.016	0.250	0.024	0.298	0.020	0.233	0.040
2010	0.211	0.016	0.189	0.016	0.234	0.023	0.300	0.021	0.225	0.042
2011	0.247	0.017	0.228	0.018	0.261	0.023	0.335	0.022	0.260	0.041
2012	0.291	0.019	0.267	0.021	0.297	0.025	0.363	0.025	0.298	0.038
2013	0.334	0.022	0.303	0.024	0.338	0.028	0.383	0.026	0.334	0.036
2014	0.344	0.024	0.309	0.026	0.350	0.030	0.369	0.026	0.339	0.034
2015	0.359	0.027	0.318	0.028	0.366	0.033	0.354	0.026	0.348	0.035
2016	0.420	0.031	0.366	0.033	0.425	0.038	0.379	0.029	0.399	0.042
2017	0.493	0.037	0.424	0.039	0.496	0.044	0.414	0.031	0.461	0.053
2018	0.543	0.040	0.467	0.043	0.546	0.047	0.438	0.032	0.504	0.061
2019	0.547	0.039	0.475	0.043	0.557	0.047	0.434	0.031	0.510	0.063
2020	0.487	0.035	0.428	0.039	0.506	0.043	0.382	0.028	0.457	0.058
2021	0.392	0.029	0.345	0.033	0.414	0.035	0.308	0.023	0.370	0.049
2022	0.399	0.029	0.347	0.034	0.421	0.035	0.325	0.024	0.377	0.048
2023	0.380	0.014	0.347	0.020	0.399	0.025	0.349	0.015	0.370	0.028

Table 2.24—Age 0 recruits (in billions of fish) time series (point estimates and standard errors).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1.271	0.329	0.912	0.243	1.202	0.344	1.194	0.312	1.140	0.341
1978	0.862	0.238	0.661	0.175	0.763	0.224	0.807	0.223	0.773	0.230
1979	0.862	0.148	0.658	0.118	0.735	0.141	0.812	0.142	0.766	0.160
1980	0.218	0.055	0.159	0.044	0.190	0.049	0.217	0.053	0.195	0.056
1981	0.228	0.046	0.193	0.039	0.197	0.042	0.219	0.045	0.209	0.046
1982	1.078	0.123	0.893	0.111	0.919	0.127	1.036	0.122	0.982	0.145
1983	0.292	0.055	0.216	0.043	0.255	0.051	0.281	0.053	0.260	0.059
1984	0.999	0.114	0.805	0.096	0.845	0.116	0.966	0.112	0.903	0.138
1985	0.457	0.061	0.371	0.051	0.390	0.060	0.437	0.060	0.414	0.068
1986	0.243	0.036	0.211	0.032	0.206	0.035	0.237	0.036	0.224	0.038
1987	0.082	0.020	0.075	0.018	0.069	0.017	0.081	0.020	0.077	0.019
1988	0.341	0.043	0.296	0.039	0.282	0.042	0.336	0.044	0.314	0.049
1989	0.666	0.074	0.571	0.065	0.556	0.075	0.658	0.074	0.612	0.087
1990	0.656	0.074	0.547	0.062	0.546	0.075	0.648	0.075	0.598	0.089
1991	0.407	0.054	0.304	0.042	0.356	0.054	0.413	0.056	0.367	0.068
1992	1.076	0.110	0.813	0.081	0.922	0.117	1.076	0.112	0.966	0.155
1993	0.391	0.048	0.327	0.040	0.350	0.049	0.372	0.047	0.360	0.053
1994	0.336	0.041	0.269	0.032	0.289	0.042	0.330	0.040	0.305	0.048
1995	0.293	0.037	0.247	0.031	0.256	0.037	0.283	0.037	0.270	0.041
1996	0.948	0.100	0.784	0.085	0.811	0.105	0.879	0.094	0.858	0.118
1997	0.396	0.048	0.340	0.042	0.341	0.048	0.362	0.045	0.362	0.052
1998	0.320	0.040	0.274	0.035	0.268	0.040	0.285	0.037	0.289	0.044
1999	0.777	0.078	0.629	0.064	0.654	0.082	0.698	0.072	0.693	0.096
2000	0.557	0.057	0.456	0.049	0.493	0.061	0.559	0.059	0.514	0.072
2001	0.220	0.030	0.187	0.025	0.187	0.029	0.248	0.034	0.208	0.037
2002	0.378	0.041	0.318	0.035	0.329	0.042	0.481	0.053	0.367	0.071
2003	0.344	0.037	0.295	0.032	0.296	0.038	0.453	0.052	0.337	0.068
2004	0.246	0.031	0.216	0.028	0.212	0.029	0.306	0.041	0.240	0.046
2005	0.291	0.032	0.267	0.030	0.249	0.033	0.361	0.046	0.286	0.051
2006	0.858	0.079	0.789	0.076	0.727	0.084	0.911	0.091	0.817	0.104
2007	0.355	0.045	0.310	0.039	0.307	0.044	0.324	0.044	0.326	0.048
2008	1.321	0.123	1.089	0.108	1.127	0.131	1.179	0.115	1.186	0.154
2009	0.187	0.036	0.152	0.028	0.166	0.033	0.163	0.032	0.168	0.035
2010	0.832	0.088	0.709	0.077	0.703	0.090	0.719	0.075	0.748	0.101
2011	1.072	0.113	0.894	0.102	0.939	0.122	0.910	0.091	0.963	0.133
2012	0.520	0.068	0.408	0.055	0.442	0.066	0.427	0.057	0.454	0.078
2013	1.370	0.147	1.114	0.128	1.173	0.151	1.142	0.119	1.213	0.176
2014	0.247	0.037	0.209	0.031	0.217	0.036	0.212	0.033	0.223	0.038
2015	0.335	0.039	0.294	0.036	0.287	0.039	0.309	0.036	0.308	0.042
2016	0.247	0.034	0.187	0.027	0.209	0.033	0.234	0.032	0.219	0.040
2017	0.152	0.032	0.121	0.025	0.134	0.029	0.145	0.031	0.138	0.032
2018	0.817	0.083	0.699	0.077	0.697	0.087	0.801	0.083	0.753	0.100
2019	0.274	0.064	0.154	0.053	0.236	0.058	0.264	0.064	0.229	0.078
2020	0.429	0.127	0.353	0.104	0.467	0.149	0.406	0.115	0.412	0.132

Table 2.25—Instantaneous apical fishing mortality rate time series (point estimates and standard errors).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.167	0.046	0.193	0.052	0.097	0.028	0.159	0.046	0.157	0.057
1978	0.203	0.055	0.240	0.064	0.116	0.032	0.198	0.057	0.192	0.070
1979	0.146	0.037	0.175	0.044	0.083	0.022	0.142	0.037	0.139	0.049
1980	0.152	0.032	0.184	0.039	0.087	0.020	0.145	0.031	0.145	0.047
1981	0.113	0.017	0.140	0.022	0.072	0.013	0.110	0.017	0.111	0.030
1982	0.087	0.011	0.106	0.014	0.058	0.009	0.087	0.011	0.086	0.021
1983	0.106	0.010	0.126	0.014	0.075	0.010	0.105	0.011	0.104	0.022
1984	0.145	0.012	0.169	0.016	0.108	0.013	0.143	0.012	0.143	0.026
1985	0.161	0.013	0.181	0.016	0.123	0.014	0.158	0.015	0.157	0.025
1986	0.154	0.013	0.168	0.014	0.122	0.014	0.153	0.016	0.150	0.022
1987	0.179	0.013	0.193	0.015	0.144	0.015	0.175	0.015	0.174	0.023
1988	0.210	0.015	0.229	0.016	0.174	0.018	0.203	0.018	0.206	0.026
1989	0.198	0.013	0.216	0.015	0.157	0.016	0.189	0.014	0.192	0.026
1990	0.223	0.013	0.244	0.015	0.172	0.016	0.212	0.013	0.215	0.030
1991	0.376	0.024	0.401	0.026	0.294	0.030	0.353	0.025	0.360	0.047
1992	0.413	0.034	0.425	0.032	0.319	0.036	0.394	0.039	0.391	0.054
1993	0.285	0.022	0.296	0.022	0.227	0.025	0.269	0.025	0.272	0.035
1994	0.385	0.026	0.403	0.028	0.307	0.032	0.363	0.029	0.368	0.046
1995	0.481	0.033	0.520	0.035	0.380	0.040	0.443	0.034	0.462	0.063
1996	0.450	0.032	0.518	0.037	0.334	0.037	0.397	0.026	0.433	0.076
1997	0.494	0.035	0.593	0.042	0.375	0.042	0.434	0.029	0.484	0.089
1998	0.392	0.031	0.480	0.036	0.296	0.035	0.344	0.024	0.387	0.076
1999	0.371	0.031	0.455	0.036	0.280	0.034	0.343	0.025	0.369	0.072
2000	0.360	0.030	0.438	0.037	0.269	0.032	0.315	0.023	0.353	0.070
2001	0.329	0.024	0.376	0.029	0.256	0.027	0.355	0.024	0.330	0.052
2002	0.358	0.026	0.387	0.027	0.288	0.028	0.357	0.025	0.350	0.045
2003	0.359	0.025	0.399	0.027	0.288	0.029	0.429	0.029	0.366	0.056
2004	0.367	0.023	0.410	0.026	0.290	0.028	0.451	0.029	0.376	0.061
2005	0.383	0.024	0.429	0.026	0.301	0.031	0.468	0.031	0.391	0.064
2006	0.413	0.028	0.468	0.030	0.310	0.035	0.395	0.027	0.402	0.064
2007	0.392	0.028	0.443	0.030	0.288	0.034	0.330	0.022	0.372	0.066
2008	0.484	0.037	0.516	0.037	0.359	0.041	0.338	0.022	0.439	0.083
2009	0.635	0.056	0.643	0.052	0.476	0.058	0.363	0.024	0.555	0.121
2010	0.622	0.053	0.618	0.052	0.461	0.055	0.331	0.022	0.535	0.123
2011	0.741	0.055	0.741	0.058	0.545	0.062	0.463	0.031	0.649	0.128
2012	0.625	0.044	0.647	0.049	0.465	0.051	0.477	0.032	0.569	0.093
2013	0.556	0.037	0.578	0.041	0.430	0.044	0.503	0.034	0.524	0.070
2014	0.599	0.047	0.618	0.049	0.453	0.051	0.610	0.043	0.572	0.081
2015	0.557	0.044	0.589	0.050	0.414	0.048	0.614	0.043	0.542	0.087
2016	0.492	0.038	0.535	0.046	0.370	0.043	0.554	0.038	0.486	0.080
2017	0.388	0.030	0.432	0.038	0.293	0.033	0.560	0.038	0.407	0.092
2018	0.282	0.021	0.310	0.026	0.223	0.023	0.383	0.026	0.293	0.056
2019	0.266	0.021	0.279	0.023	0.217	0.023	0.380	0.028	0.277	0.056
2020	0.268	0.021	0.280	0.024	0.214	0.023	0.357	0.027	0.274	0.051
2021	0.280	0.023	0.292	0.029	0.219	0.026	0.344	0.026	0.280	0.048
2022	0.363	0.042	0.267	0.039	0.306	0.016	0.284	0.035	0.309	0.053
2023	0.345	0.026	0.267	0.027	0.304	0.031	0.307	0.027	0.307	0.041

Table 2.26 (page 1 of 5)—Length (cm) at age (Model 19.12a).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.6	16.7	32.8	44.4	53.7	61.4	67.9	73.4	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	106.0
1978	4.9	16.7	31.6	44.4	53.7	61.4	67.9	73.4	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	106.0
1979	5.6	14.8	32.9	43.5	53.7	61.4	67.9	73.4	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.9
1980	5.0	16.9	31.7	44.5	53.0	61.4	67.9	73.4	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.8
1981	4.3	15.1	30.3	43.6	53.8	60.8	67.9	73.4	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.7
1982	4.4	12.8	30.4	42.5	53.0	61.5	67.3	73.4	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.7
1983	5.5	13.0	32.6	42.6	52.2	60.8	67.9	72.9	78.2	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.7
1984	5.2	16.5	32.1	44.3	52.3	60.1	67.4	73.4	77.8	82.3	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.7
1985	3.9	15.7	29.7	43.9	53.6	60.2	66.8	73.0	78.2	81.9	85.8	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.7
1986	5.0	11.8	31.7	42.0	53.3	61.3	66.8	72.5	77.8	82.3	85.5	89.0	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.8
1987	4.5	15.1	30.8	43.6	51.8	61.1	67.8	72.5	77.3	82.0	85.9	88.7	91.7	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.8
1988	4.3	13.6	30.3	42.9	53.1	59.8	67.6	73.4	77.4	81.6	85.6	89.0	91.5	94.1	96.2	98.0	99.6	101.1	102.3	103.4	105.8
1989	4.4	12.9	30.5	42.6	52.5	60.9	66.5	73.2	78.1	81.6	85.2	88.7	91.7	93.9	96.2	98.0	99.6	101.1	102.3	103.4	105.9
1990	4.8	13.1	31.3	42.6	52.2	60.4	67.4	72.2	77.9	82.2	85.3	88.4	91.5	94.1	96.0	98.0	99.6	101.1	102.3	103.4	105.9
1991	5.2	14.5	32.1	43.3	52.3	60.1	67.0	73.0	77.1	82.1	85.8	88.5	91.2	93.9	96.2	97.9	99.6	101.1	102.3	103.4	105.9
1992	5.0	15.7	31.6	43.9	52.8	60.2	66.8	72.7	77.8	81.4	85.7	88.9	91.2	93.7	96.0	98.0	99.5	101.1	102.3	103.4	105.8
1993	5.4	14.9	32.4	43.5	53.3	60.7	66.9	72.5	77.5	82.0	85.1	88.8	91.7	93.7	95.8	97.9	99.7	101.0	102.3	103.4	105.6
1994	4.7	16.1	31.2	44.1	53.0	61.1	67.2	72.5	77.4	81.7	85.6	88.3	91.6	94.1	95.8	97.7	99.5	101.1	102.2	103.4	105.3
1995	4.7	14.2	31.1	43.2	53.5	60.8	67.6	72.9	77.4	81.6	85.4	88.7	91.1	94.0	96.2	97.7	99.4	101.0	102.3	103.4	105.4
1996	4.9	14.1	31.4	43.1	52.7	61.2	67.3	73.2	77.7	81.6	85.2	88.5	91.5	93.6	96.1	98.0	99.4	100.8	102.2	103.5	105.1
1997	4.8	14.6	31.2	43.4	52.7	60.6	67.7	72.9	77.9	81.9	85.3	88.4	91.3	93.9	95.7	97.9	99.6	100.8	102.1	103.4	104.8
1998	4.4	14.3	30.5	43.2	52.9	60.5	67.2	73.3	77.8	82.1	85.5	88.5	91.2	93.7	96.0	97.6	99.6	101.1	102.1	103.3	105.1
1999	4.0	13.2	29.8	42.7	52.8	60.7	67.1	72.8	78.0	81.9	85.7	88.7	91.2	93.7	95.9	97.9	99.3	101.0	102.3	103.3	105.2
2000	5.7	12.1	32.9	42.2	52.3	60.6	67.3	72.8	77.6	82.2	85.5	88.8	91.4	93.7	95.8	97.8	99.5	100.8	102.3	103.4	105.7
2001	5.2	17.0	32.0	44.6	51.9	60.2	67.2	72.9	77.6	81.8	85.7	88.7	91.6	93.8	95.8	97.7	99.4	101.0	102.1	103.4	106.0
2002	5.5	15.6	32.6	43.8	53.8	59.9	66.9	72.8	77.7	81.8	85.4	88.9	91.5	94.0	96.0	97.7	99.4	100.9	102.2	103.2	105.3
2003	5.1	16.4	31.8	44.3	53.3	61.5	66.6	72.5	77.6	81.9	85.4	88.6	91.6	93.9	96.1	97.8	99.4	100.8	102.2	103.4	105.7
2004	6.1	15.3	33.9	43.7	53.6	61.0	68.0	72.3	77.4	81.8	85.5	88.6	91.4	94.0	96.0	97.9	99.5	100.8	102.1	103.3	105.3
2005	4.8	18.3	31.4	45.3	53.1	61.3	67.5	73.5	77.2	81.6	85.5	88.7	91.4	93.8	96.1	97.9	99.6	100.9	102.1	103.3	105.5
2006	4.7	14.5	31.0	43.3	54.4	60.9	67.8	73.1	78.2	81.4	85.3	88.6	91.4	93.8	95.9	98.0	99.5	101.0	102.2	103.3	105.8
2007	4.1	14.0	30.0	43.1	52.8	62.0	67.5	73.3	77.9	82.3	85.1	88.5	91.4	93.8	95.9	97.8	99.6	101.0	102.3	103.3	106.2
2008	4.0	12.3	29.9	42.3	52.6	60.7	68.4	73.0	78.1	82.1	85.9	88.3	91.3	93.8	96.0	97.8	99.5	101.0	102.2	103.4	105.6
2009	4.5	12.1	30.7	42.2	52.0	60.5	67.2	73.8	77.8	82.2	85.7	89.0	91.1	93.7	95.9	97.8	99.5	100.9	102.3	103.4	105.0
2010	5.2	13.4	32.0	42.8	51.9	59.9	67.1	72.9	78.5	82.0	85.8	88.8	91.7	93.6	95.8	97.8	99.5	100.9	102.2	103.4	105.0
2011	4.1	15.6	30.0	43.8	52.4	59.9	66.6	72.7	77.7	82.6	85.6	88.9	91.5	94.1	95.7	97.7	99.5	100.9	102.2	103.3	105.2
2012	5.0	12.3	31.8	42.3	53.3	60.3	66.6	72.3	77.6	81.9	86.1	88.8	91.6	93.9	96.2	97.6	99.4	100.9	102.2	103.3	104.8
2013	4.8	15.1	31.2	43.6	52.0	61.0	67.0	72.3	77.2	81.8	85.5	89.2	91.5	94.0	96.1	98.0	99.3	100.8	102.2	103.3	105.2
2014	5.2	14.3	32.0	43.2	53.1	60.0	67.5	72.6	77.2	81.5	85.4	88.7	91.9	93.9	96.1	97.9	99.7	100.8	102.1	103.3	105.3
2015	6.4	15.6	34.5	43.8	52.7	60.9	66.7	73.1	77.5	81.5	85.2	88.6	91.4	94.3	96.0	98.0	99.6	101.1	102.1	103.3	105.4
2016	6.6	19.2	34.8	45.7	53.2	60.6	67.4	72.4	77.9	81.7	85.1	88.4	91.4	93.8	96.3	97.9	99.6	101.0	102.4	103.2	104.8
2017	6.5	19.8	34.6	46.0	54.8	61.0	67.2	73.0	77.3	82.1	85.3	88.3	91.2	93.8	96.0	98.2	99.5	101.1	102.3	103.5	105.1
2018	7.2	19.5	36.0	45.9	55.0	62.3	67.5	72.8	77.8	81.5	85.7	88.5	91.1	93.6	95.9	97.8	99.8	101.0	102.3	103.4	105.4
2019	4.1	21.5	29.9	47.0	54.9	62.5	68.6	73.1	77.6	82.0	85.2	88.8	91.3	93.6	95.8	97.8	99.5	101.2	102.3	103.4	105.0
2020	6.8	12.2	35.2	42.2	55.8	62.4	68.8	74.1	77.9	81.8	85.6	88.4	91.5	93.7	95.8	97.7	99.4	100.9	102.4	103.4	105.2
2021	5.6	16.7	31.7	46.3	51.9	63.2	68.7	74.2	78.7	82.1	85.5	88.7	91.2	93.9	95.9	97.6	99.3	100.9	102.2	103.5	105.5

Table 2.26 (page 2 of 5)—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	5.6	16.8	32.7	44.2	53.5	61.2	67.8	73.5	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	111.2
1978	5.0	16.8	31.6	44.2	53.5	61.2	67.8	73.5	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	111.2
1979	5.6	14.9	32.8	43.3	53.5	61.2	67.8	73.5	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.9
1980	5.0	16.9	31.6	44.3	52.7	61.2	67.8	73.5	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1981	4.2	15.0	30.2	43.4	53.5	60.6	67.8	73.5	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1982	4.3	12.6	30.4	42.3	52.8	61.2	67.2	73.5	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1983	6.1	13.0	33.8	42.4	51.9	60.6	67.8	73.0	78.5	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1984	5.3	18.4	32.2	45.1	52.0	59.8	67.3	73.5	78.1	82.9	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1985	3.9	15.9	29.7	43.8	54.1	59.9	66.6	73.0	78.5	82.5	86.7	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1986	5.1	11.7	31.7	41.9	53.1	61.8	66.7	72.5	78.1	82.9	86.4	90.2	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.8
1987	4.6	15.2	30.8	43.5	51.5	60.9	68.3	72.5	77.6	82.5	86.7	89.9	93.2	96.0	98.4	100.6	102.6	104.3	105.9	107.3	110.9
1988	4.3	13.7	30.4	42.8	52.8	59.5	67.5	73.9	77.6	82.1	86.4	90.2	93.0	96.0	98.4	100.6	102.6	104.3	105.9	107.3	111.0
1989	4.4	13.0	30.5	42.4	52.3	60.6	66.4	73.3	78.8	82.1	86.0	89.9	93.2	95.7	98.4	100.6	102.6	104.3	105.9	107.3	111.0
1990	4.9	13.2	31.4	42.5	52.0	60.2	67.3	72.3	78.3	83.2	86.1	89.5	93.0	96.0	98.2	100.6	102.6	104.3	105.9	107.3	111.1
1991	5.4	14.7	32.3	43.2	52.1	59.9	66.9	73.1	77.4	82.7	87.0	89.6	92.7	95.7	98.4	100.4	102.6	104.3	105.9	107.3	111.1
1992	5.0	16.1	31.5	43.9	52.6	60.0	66.7	72.7	78.1	81.9	86.6	90.4	92.7	95.5	98.2	100.6	102.4	104.3	105.9	107.3	111.0
1993	5.2	14.9	32.0	43.3	53.2	60.5	66.8	72.5	77.8	82.5	85.9	90.0	93.5	95.5	98.0	100.4	102.6	104.2	105.9	107.3	110.7
1994	4.9	15.7	31.3	43.7	52.7	61.0	67.2	72.6	77.6	82.3	86.4	89.4	93.1	96.2	98.0	100.2	102.4	104.3	105.8	107.3	110.3
1995	4.8	14.6	31.2	43.1	53.0	60.5	67.6	73.0	77.7	82.1	86.2	89.9	92.6	95.9	98.6	100.2	102.2	104.2	105.9	107.2	110.3
1996	4.9	14.3	31.4	43.0	52.6	60.8	67.2	73.3	78.0	82.2	86.1	89.7	93.0	95.4	98.3	100.8	102.2	104.0	105.8	107.3	109.9
1997	4.8	14.7	31.2	43.2	52.5	60.4	67.4	73.0	78.3	82.4	86.1	89.6	92.8	95.8	97.9	100.5	102.7	104.0	105.6	107.2	109.3
1998	4.4	14.4	30.5	43.1	52.6	60.4	67.1	73.2	78.0	82.7	86.4	89.6	92.7	95.6	98.2	100.1	102.5	104.5	105.6	107.1	109.7
1999	4.1	13.2	29.9	42.5	52.5	60.5	67.1	72.9	78.2	82.5	86.6	89.8	92.7	95.5	98.1	100.4	102.1	104.3	106.0	107.1	109.9
2000	5.6	12.2	32.7	42.1	52.1	60.4	67.2	72.9	78.0	82.6	86.4	90.1	92.9	95.5	98.0	100.3	102.4	103.9	105.8	107.4	110.7
2001	5.2	16.8	32.0	44.2	51.7	60.0	67.1	73.0	77.9	82.4	86.5	89.9	93.1	95.7	98.0	100.2	102.3	104.2	105.6	107.3	111.2
2002	5.5	15.7	32.5	43.7	53.5	59.7	66.8	72.9	78.0	82.4	86.3	90.0	93.0	95.9	98.2	100.2	102.2	104.1	105.8	107.0	110.5
2003	5.1	16.5	31.7	44.1	53.0	61.2	66.5	72.6	77.9	82.4	86.3	89.8	93.1	95.7	98.3	100.4	102.2	104.0	105.7	107.2	111.1
2004	6.1	15.2	33.7	43.5	53.3	60.8	67.8	72.4	77.7	82.4	86.4	89.8	92.9	95.8	98.2	100.5	102.4	104.0	105.6	107.1	110.6
2005	4.8	18.2	31.3	45.0	52.8	61.1	67.4	73.5	77.5	82.2	86.3	89.8	92.9	95.7	98.3	100.4	102.5	104.2	105.7	107.1	110.9
2006	4.7	14.5	31.1	43.1	54.1	60.6	67.7	73.2	78.5	82.0	86.1	89.8	92.9	95.7	98.2	100.5	102.4	104.3	105.8	107.1	111.3
2007	4.2	14.2	30.2	43.0	52.6	61.7	67.3	73.4	78.2	82.8	86.0	89.6	92.9	95.7	98.1	100.4	102.5	104.2	105.9	107.2	111.8
2008	4.1	12.7	29.9	42.3	52.4	60.4	68.2	73.1	78.4	82.6	86.7	89.5	92.7	95.7	98.2	100.4	102.4	104.2	105.8	107.3	111.2
2009	4.4	12.2	30.5	42.1	51.9	60.3	67.1	73.9	78.1	82.8	86.5	90.2	92.6	95.5	98.1	100.4	102.3	104.1	105.8	107.2	110.3
2010	5.2	13.2	31.9	42.5	51.7	59.8	67.0	72.9	78.8	82.5	86.7	90.0	93.2	95.4	98.0	100.4	102.4	104.1	105.7	107.3	110.0
2011	4.2	15.5	30.1	43.6	52.1	59.7	66.6	72.8	78.0	83.2	86.4	90.1	93.1	96.0	97.9	100.2	102.3	104.2	105.7	107.2	110.2
2012	5.2	12.5	31.9	42.2	52.9	60.0	66.5	72.5	77.9	82.4	87.0	89.9	93.2	95.8	98.4	100.2	102.2	104.1	105.8	107.2	109.5
2013	4.8	15.5	31.1	43.6	51.8	60.7	66.7	72.4	77.6	82.3	86.3	90.4	93.0	95.9	98.3	100.6	102.2	104.0	105.7	107.2	109.9
2014	5.1	14.3	31.8	43.0	52.9	59.8	67.4	72.6	77.5	82.1	86.3	89.8	93.4	95.8	98.4	100.5	102.6	104.0	105.7	107.2	110.2
2015	6.5	15.4	34.5	43.5	52.5	60.7	66.6	73.2	77.7	82.0	86.0	89.8	92.9	96.1	98.2	100.6	102.5	104.3	105.6	107.1	110.3
2016	6.7	19.4	35.0	45.6	52.9	60.3	67.4	72.4	78.2	82.2	86.0	89.6	92.9	95.7	98.6	100.4	102.5	104.2	105.9	107.1	109.5
2017	6.5	20.2	34.6	46.0	54.6	60.7	67.0	73.1	77.5	82.6	86.1	89.5	92.7	95.6	98.2	100.7	102.4	104.3	105.8	107.3	109.9
2018	7.2	19.6	35.9	45.7	54.9	62.1	67.4	72.8	78.2	82.0	86.5	89.6	92.6	95.5	98.1	100.4	102.7	104.2	105.9	107.3	110.3
2019	4.2	21.5	30.2	46.7	54.7	62.4	68.6	73.1	77.9	82.6	86.0	90.0	92.7	95.4	98.0	100.3	102.4	104.4	105.8	107.3	110.0
2020	6.6	12.6	34.8	42.3	55.5	62.2	68.8	74.2	78.2	82.4	86.5	89.5	93.0	95.5	97.9	100.2	102.3	104.1	106.0	107.2	110.1
2021	5.6	16.8	31.7	45.9	51.8	62.9	68.6	74.4	79.1	82.6	86.3	90.0	92.7	95.8	98.0	100.2	102.2	104.1	105.7	107.4	110.5

Table 2.26 (page 3 of 5)—Length (cm) at age (Model 21.1).

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	31.9	44.1	53.7	61.6	68.0	73.4	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.1
1978	4.9	15.6	31.3	44.1	53.7	61.6	68.0	73.4	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.1
1979	5.5	14.7	32.6	43.6	53.7	61.6	68.0	73.4	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.2
1980	5.0	16.5	31.5	44.6	53.3	61.6	68.0	73.4	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.2
1981	4.3	15.0	30.0	43.7	54.1	61.3	68.0	73.4	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.2
1982	4.4	12.8	30.3	42.6	53.4	61.9	67.8	73.4	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.2
1983	5.4	13.3	32.4	42.8	52.5	61.3	68.3	73.2	77.9	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.2
1984	5.2	16.3	31.9	44.5	52.7	60.6	67.9	73.7	77.8	81.7	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.3
1985	4.0	15.6	29.4	44.1	54.0	60.8	67.2	73.3	78.1	81.6	84.9	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.3
1986	5.1	11.9	31.7	42.1	53.7	61.8	67.4	72.8	77.8	81.9	84.8	87.6	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.3
1987	4.6	15.2	30.7	43.9	52.2	61.6	68.3	72.9	77.4	81.6	85.1	87.5	89.9	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.3
1988	4.4	13.9	30.3	43.2	53.6	60.3	68.0	73.6	77.5	81.3	84.8	87.8	89.8	91.9	93.5	94.9	96.1	97.1	98.0	98.7	100.3
1989	4.4	13.3	30.3	42.8	53.0	61.4	67.0	73.4	78.1	81.3	84.5	87.6	90.0	91.8	93.5	94.9	96.1	97.1	98.0	98.7	100.4
1990	4.8	13.2	31.2	42.8	52.7	61.0	67.9	72.5	77.9	81.9	84.6	87.3	89.9	92.0	93.5	94.9	96.1	97.1	98.0	98.7	100.4
1991	5.2	14.5	32.0	43.5	52.7	60.7	67.5	73.3	77.2	81.7	85.0	87.4	89.6	91.8	93.6	94.9	96.1	97.1	98.0	98.7	100.4
1992	5.0	15.7	31.5	44.1	53.2	60.7	67.4	73.0	77.9	81.1	84.9	87.7	89.7	91.6	93.5	95.0	96.1	97.1	98.0	98.7	100.3
1993	5.6	14.9	32.7	43.7	53.8	61.2	67.3	72.9	77.6	81.7	84.4	87.6	90.0	91.7	93.3	94.9	96.2	97.1	98.0	98.7	100.2
1994	4.8	16.7	31.1	44.7	53.4	61.6	67.7	72.8	77.5	81.4	84.9	87.2	89.9	91.9	93.3	94.7	96.1	97.2	97.9	98.7	100.0
1995	4.8	14.4	31.1	43.5	54.2	61.3	68.1	73.2	77.5	81.3	84.7	87.6	89.6	91.9	93.6	94.8	96.0	97.1	98.0	98.7	100.1
1996	4.9	14.4	31.3	43.4	53.2	62.0	67.8	73.5	77.7	81.3	84.6	87.4	89.9	91.5	93.5	95.0	96.0	97.0	98.0	98.7	99.9
1997	4.8	14.6	31.1	43.6	53.2	61.2	68.4	73.3	78.0	81.5	84.6	87.4	89.7	91.8	93.2	94.9	96.1	97.0	97.9	98.7	99.7
1998	4.5	14.4	30.4	43.5	53.3	61.1	67.7	73.7	77.8	81.8	84.8	87.3	89.7	91.7	93.5	94.7	96.1	97.2	97.9	98.6	99.9
1999	4.1	13.4	29.6	42.9	53.2	61.2	67.7	73.2	78.2	81.6	85.0	87.5	89.7	91.7	93.4	94.9	95.9	97.1	98.0	98.6	99.9
2000	5.6	12.2	32.9	42.3	52.8	61.2	67.8	73.1	77.7	81.9	84.8	87.7	89.8	91.7	93.3	94.8	96.1	97.0	98.0	98.7	100.3
2001	5.2	16.9	32.0	44.8	52.3	60.8	67.7	73.2	77.7	81.5	85.1	87.6	89.9	91.8	93.3	94.8	96.0	97.1	97.8	98.7	100.5
2002	5.5	15.7	32.5	44.1	54.3	60.4	67.4	73.1	77.7	81.5	84.8	87.8	89.9	91.9	93.4	94.8	96.0	97.0	98.0	98.6	100.1
2003	5.1	16.3	31.7	44.5	53.8	62.1	67.1	72.9	77.7	81.6	84.8	87.5	90.1	91.8	93.5	94.8	96.0	97.0	97.9	98.7	100.3
2004	6.1	15.3	33.8	43.9	54.1	61.6	68.4	72.6	77.5	81.5	84.8	87.5	89.8	92.0	93.5	94.9	96.0	97.0	97.9	98.7	100.1
2005	4.9	18.3	31.2	45.6	53.6	61.8	68.1	73.8	77.3	81.4	84.8	87.5	89.8	91.8	93.6	94.9	96.1	97.1	97.9	98.6	100.2
2006	4.7	14.6	30.9	43.5	54.9	61.5	68.3	73.5	78.2	81.2	84.6	87.5	89.8	91.8	93.4	95.0	96.1	97.1	97.9	98.6	100.4
2007	4.1	14.1	29.7	43.3	53.3	62.6	67.9	73.6	78.0	82.0	84.4	87.4	89.8	91.8	93.4	94.8	96.2	97.1	98.0	98.7	100.6
2008	4.1	12.3	29.7	42.4	53.1	61.2	68.9	73.4	78.1	81.8	85.1	87.2	89.7	91.8	93.4	94.8	96.0	97.2	98.0	98.7	100.4
2009	4.6	12.2	30.7	42.3	52.3	61.0	67.7	74.1	77.9	81.9	85.0	87.8	89.6	91.7	93.4	94.9	96.0	97.1	98.0	98.7	100.0
2010	5.2	13.8	31.9	43.1	52.3	60.4	67.6	73.2	78.5	81.7	85.0	87.7	90.1	91.6	93.4	94.8	96.1	97.1	97.9	98.8	99.9
2011	4.1	15.6	29.8	44.1	53.0	60.4	67.1	73.1	77.7	82.2	84.9	87.7	89.9	92.0	93.3	94.8	96.0	97.1	97.9	98.7	100.0
2012	5.2	12.4	31.8	42.4	53.7	60.9	67.1	72.6	77.6	81.6	85.3	87.6	90.0	91.9	93.6	94.7	96.0	97.1	97.9	98.7	99.7
2013	4.8	15.5	31.1	44.0	52.4	61.6	67.5	72.6	77.3	81.5	84.8	88.0	89.9	91.9	93.5	95.0	95.9	97.0	97.9	98.7	99.9
2014	5.3	14.3	32.0	43.4	53.7	60.5	68.0	73.0	77.3	81.2	84.7	87.5	90.2	91.8	93.6	94.9	96.2	97.0	97.9	98.7	100.1
2015	6.4	15.8	34.4	44.2	53.2	61.5	67.1	73.4	77.6	81.2	84.5	87.5	89.8	92.1	93.5	95.0	96.1	97.2	97.8	98.6	100.1
2016	6.5	19.1	34.8	46.0	53.8	61.1	68.0	72.7	77.9	81.4	84.5	87.2	89.8	91.8	93.7	94.9	96.1	97.1	98.0	98.6	99.8
2017	6.5	19.6	34.6	46.3	55.3	61.6	67.7	73.4	77.3	81.7	84.7	87.2	89.6	91.7	93.4	95.1	96.1	97.2	98.0	98.8	99.9
2018	7.1	19.4	36.1	46.2	55.5	62.9	68.1	73.1	77.9	81.2	84.9	87.4	89.6	91.6	93.4	94.9	96.3	97.1	98.0	98.7	100.1
2019	4.0	21.4	29.6	47.3	55.4	63.0	69.1	73.5	77.7	81.7	84.5	87.6	89.7	91.6	93.3	94.8	96.1	97.2	98.0	98.7	99.9
2020	6.6	12.1	35.0	42.3	56.4	63.0	69.3	74.3	78.0	81.5	84.9	87.3	89.9	91.7	93.3	94.7	96.0	97.1	98.1	98.7	100.0
2021	5.2	15.6	31.6	46.5	52.3	63.7	69.2	74.5	78.7	81.8	84.8	87.6	89.6	91.9	93.4	94.7	95.9	97.0	97.9	98.8	100.2

Table 2.26 (page 4 of 5)—Length (cm) at age (Model 21.2).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.5	16.4	32.6	44.3	53.5	61.2	67.6	73.2	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.5
1978	4.9	16.4	31.6	44.3	53.5	61.2	67.6	73.2	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.5
1979	5.6	14.8	32.8	43.4	53.5	61.2	67.6	73.2	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.4
1980	5.0	16.7	31.7	44.4	52.9	61.2	67.6	73.2	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.3
1981	4.3	14.9	30.4	43.5	53.6	60.6	67.6	73.2	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.2
1982	4.3	12.8	30.5	42.5	52.9	61.3	67.2	73.2	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.2
1983	5.5	13.0	32.7	42.6	52.1	60.7	67.7	72.8	77.9	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.2
1984	5.3	16.5	32.2	44.3	52.2	60.0	67.2	73.2	77.6	82.1	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.2
1985	3.9	15.8	29.8	43.9	53.6	60.1	66.6	72.8	78.0	81.8	85.7	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.2
1986	5.0	11.8	31.7	42.1	53.2	61.2	66.7	72.3	77.6	82.1	85.4	88.8	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.3
1987	4.5	15.0	30.8	43.6	51.7	60.9	67.7	72.4	77.2	81.8	85.7	88.6	91.6	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.3
1988	4.2	13.4	30.3	42.8	53.0	59.7	67.4	73.2	77.2	81.4	85.4	88.9	91.4	94.0	96.2	98.1	99.8	101.3	102.6	103.7	106.3
1989	4.3	12.7	30.5	42.5	52.4	60.7	66.4	73.0	77.9	81.5	85.1	88.6	91.6	93.9	96.2	98.1	99.8	101.3	102.6	103.7	106.4
1990	4.8	13.0	31.3	42.6	52.1	60.2	67.2	72.1	77.8	82.1	85.1	88.3	91.4	94.1	96.0	98.1	99.8	101.3	102.6	103.7	106.4
1991	5.2	14.4	32.1	43.3	52.2	60.0	66.8	72.8	77.0	81.9	85.7	88.4	91.2	93.9	96.2	97.9	99.8	101.3	102.6	103.7	106.4
1992	4.9	15.7	31.6	43.9	52.7	60.1	66.6	72.4	77.6	81.3	85.6	88.8	91.2	93.7	96.0	98.1	99.6	101.3	102.6	103.7	106.3
1993	5.4	14.8	32.5	43.5	53.2	60.5	66.7	72.3	77.3	81.8	85.0	88.7	91.6	93.7	95.9	98.0	99.8	101.1	102.6	103.7	106.1
1994	4.8	16.2	31.3	44.2	52.9	60.9	67.1	72.4	77.2	81.5	85.4	88.2	91.5	94.0	95.9	97.8	99.7	101.3	102.5	103.7	105.8
1995	4.7	14.3	31.1	43.2	53.4	60.6	67.4	72.7	77.2	81.4	85.2	88.6	91.1	94.0	96.2	97.8	99.5	101.2	102.6	103.7	105.9
1996	4.9	14.1	31.5	43.1	52.7	61.1	67.2	73.0	77.5	81.5	85.1	88.4	91.4	93.6	96.1	98.1	99.5	101.0	102.5	103.8	105.5
1997	4.7	14.6	31.2	43.4	52.6	60.5	67.6	72.8	77.8	81.7	85.1	88.3	91.2	93.9	95.8	98.0	99.8	101.0	102.4	103.7	105.2
1998	4.4	14.2	30.7	43.2	52.8	60.4	67.0	73.1	77.6	81.9	85.3	88.4	91.2	93.7	96.1	97.7	99.7	101.3	102.4	103.6	105.5
1999	4.0	13.3	30.0	42.8	52.6	60.6	67.0	72.6	77.9	81.8	85.5	88.5	91.2	93.7	95.9	98.0	99.4	101.2	102.6	103.6	105.6
2000	5.6	12.1	32.9	42.2	52.3	60.4	67.1	72.6	77.5	82.0	85.4	88.7	91.4	93.7	95.8	97.8	99.7	101.0	102.5	103.7	106.2
2001	5.0	16.8	31.7	44.5	51.9	60.2	67.0	72.7	77.4	81.7	85.6	88.6	91.5	93.8	95.9	97.8	99.6	101.2	102.3	103.7	106.5
2002	5.3	15.0	32.2	43.6	53.7	59.8	66.8	72.6	77.5	81.6	85.3	88.8	91.4	94.0	96.0	97.8	99.5	101.1	102.5	103.5	105.7
2003	4.9	15.8	31.6	43.9	53.0	61.3	66.5	72.4	77.5	81.7	85.3	88.5	91.6	93.9	96.1	97.9	99.5	101.0	102.4	103.7	106.1
2004	6.0	14.7	33.7	43.4	53.2	60.7	67.7	72.1	77.3	81.7	85.4	88.5	91.3	94.0	96.0	98.0	99.6	101.0	102.4	103.6	105.7
2005	4.7	18.0	31.1	45.1	52.9	60.9	67.2	73.3	77.1	81.5	85.3	88.6	91.3	93.8	96.2	98.0	99.7	101.1	102.4	103.6	105.9
2006	4.7	14.0	31.1	43.1	54.2	60.6	67.4	72.8	78.0	81.3	85.2	88.5	91.4	93.8	96.0	98.1	99.6	101.2	102.5	103.6	106.2
2007	4.2	14.0	30.3	43.1	52.6	61.7	67.2	73.0	77.6	82.1	85.0	88.4	91.3	93.8	96.0	97.9	99.8	101.1	102.5	103.6	106.7
2008	4.1	12.7	30.2	42.5	52.6	60.4	68.1	72.8	77.8	81.8	85.7	88.2	91.2	93.8	96.0	97.9	99.6	101.2	102.5	103.7	106.1
2009	4.5	12.4	30.8	42.4	52.1	60.4	67.0	73.6	77.6	81.9	85.4	88.9	91.1	93.7	96.0	97.9	99.6	101.1	102.6	103.7	105.5
2010	5.2	13.5	32.2	42.9	52.0	60.0	67.0	72.6	78.3	81.8	85.6	88.6	91.6	93.6	95.9	97.9	99.6	101.1	102.4	103.7	105.4
2011	4.2	15.7	30.3	43.9	52.4	59.9	66.6	72.6	77.4	82.4	85.4	88.7	91.4	94.1	95.8	97.8	99.6	101.1	102.4	103.6	105.6
2012	5.0	12.7	31.6	42.5	53.2	60.2	66.5	72.3	77.4	81.6	85.9	88.6	91.5	93.9	96.2	97.7	99.5	101.1	102.5	103.6	105.2
2013	4.7	14.9	31.2	43.5	52.1	60.9	66.8	72.2	77.2	81.6	85.3	89.1	91.4	94.0	96.1	98.1	99.5	101.1	102.4	103.6	105.7
2014	4.9	14.2	31.5	43.2	52.9	60.0	67.4	72.5	77.1	81.4	85.3	88.5	91.8	93.9	96.1	98.0	99.8	101.0	102.4	103.6	105.9
2015	6.2	14.6	34.0	43.4	52.6	60.7	66.6	73.0	77.3	81.4	85.1	88.5	91.3	94.2	96.0	98.0	99.7	101.3	102.3	103.6	106.0
2016	6.5	18.6	34.6	45.4	52.8	60.4	67.2	72.3	77.8	81.5	85.1	88.3	91.3	93.8	96.3	97.9	99.7	101.2	102.6	103.5	105.4
2017	6.4	19.4	34.5	45.8	54.4	60.6	67.0	72.8	77.2	81.9	85.2	88.3	91.2	93.8	96.0	98.2	99.6	101.2	102.5	103.8	105.7
2018	7.2	19.3	36.0	45.8	54.8	61.9	67.1	72.6	77.6	81.4	85.6	88.4	91.1	93.7	96.0	97.9	99.9	101.1	102.5	103.7	106.0
2019	4.1	21.5	30.1	46.9	54.7	62.2	68.3	72.7	77.5	81.8	85.1	88.7	91.2	93.6	95.8	97.9	99.6	101.4	102.5	103.7	105.5
2020	6.8	12.4	35.2	42.4	55.7	62.2	68.5	73.7	77.5	81.7	85.4	88.3	91.5	93.7	95.8	97.8	99.6	101.1	102.7	103.7	105.5
2021	5.5	16.4	31.7	46.3	52.0	63.0	68.5	73.9	78.4	81.7	85.3	88.6	91.2	94.0	95.9	97.8	99.5	101.1	102.4	103.8	105.8

Table 2.26 (page 5 of 5)—Length (cm) at age (ensemble).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.5	16.4	32.5	44.3	53.6	61.3	67.8	73.4	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.2
1978	4.9	16.4	31.5	44.3	53.6	61.3	67.8	73.4	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.2
1979	5.6	14.8	32.8	43.5	53.6	61.3	67.8	73.4	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.1
1980	5.0	16.8	31.6	44.4	53.0	61.3	67.8	73.4	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1981	4.2	15.0	30.2	43.6	53.8	60.8	67.8	73.4	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1982	4.4	12.7	30.4	42.5	53.0	61.5	67.4	73.4	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1983	5.7	13.1	32.9	42.6	52.2	60.9	67.9	73.0	78.2	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1984	5.3	17.0	32.1	44.6	52.3	60.1	67.4	73.5	77.8	82.3	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1985	3.9	15.8	29.6	43.9	53.9	60.2	66.8	73.0	78.2	82.0	85.9	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1986	5.1	11.8	31.7	42.0	53.3	61.5	66.9	72.5	77.8	82.3	85.6	89.0	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.0
1987	4.6	15.2	30.8	43.6	51.8	61.1	68.0	72.6	77.4	82.0	85.9	88.7	91.7	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.1
1988	4.3	13.7	30.3	42.9	53.1	59.8	67.7	73.5	77.5	81.6	85.6	89.0	91.5	94.1	96.2	98.0	99.7	101.1	102.4	103.5	106.1
1989	4.4	13.0	30.4	42.6	52.5	60.9	66.6	73.2	78.3	81.7	85.3	88.8	91.7	93.9	96.2	98.0	99.7	101.1	102.4	103.5	106.1
1990	4.9	13.1	31.3	42.6	52.2	60.4	67.5	72.3	78.0	82.4	85.3	88.5	91.5	94.1	96.0	98.0	99.7	101.1	102.4	103.5	106.2
1991	5.3	14.5	32.2	43.3	52.3	60.2	67.1	73.1	77.2	82.1	86.0	88.5	91.3	93.9	96.2	97.9	99.7	101.1	102.4	103.5	106.2
1992	5.0	15.8	31.5	44.0	52.9	60.2	66.9	72.7	77.9	81.4	85.7	89.1	91.3	93.7	96.1	98.1	99.5	101.1	102.4	103.5	106.1
1993	5.4	14.9	32.4	43.5	53.4	60.7	66.9	72.6	77.6	82.0	85.1	88.9	91.8	93.7	95.8	97.9	99.7	101.0	102.4	103.5	105.9
1994	4.8	16.2	31.2	44.1	53.0	61.1	67.3	72.6	77.4	81.8	85.6	88.3	91.6	94.2	95.9	97.7	99.6	101.1	102.3	103.5	105.6
1995	4.7	14.4	31.1	43.2	53.5	60.8	67.7	72.9	77.5	81.6	85.4	88.8	91.2	94.0	96.3	97.8	99.4	101.0	102.4	103.4	105.7
1996	4.9	14.2	31.4	43.2	52.8	61.3	67.4	73.2	77.8	81.7	85.3	88.6	91.5	93.6	96.1	98.1	99.4	100.9	102.3	103.5	105.3
1997	4.8	14.7	31.2	43.4	52.7	60.6	67.8	73.0	78.0	81.9	85.3	88.5	91.4	93.9	95.8	98.0	99.7	100.9	102.2	103.4	105.0
1998	4.4	14.4	30.5	43.2	52.9	60.6	67.3	73.3	77.8	82.2	85.5	88.5	91.3	93.8	96.1	97.7	99.6	101.2	102.2	103.3	105.2
1999	4.0	13.3	29.8	42.7	52.8	60.7	67.2	72.9	78.1	82.0	85.8	88.7	91.3	93.7	95.9	97.9	99.3	101.1	102.4	103.3	105.4
2000	5.6	12.1	32.9	42.2	52.4	60.6	67.3	72.9	77.7	82.2	85.6	88.9	91.5	93.7	95.9	97.8	99.6	100.8	102.3	103.5	105.9
2001	5.2	16.9	32.0	44.5	51.9	60.3	67.3	73.0	77.7	81.9	85.8	88.8	91.6	93.9	95.9	97.8	99.5	101.0	102.1	103.5	106.3
2002	5.4	15.5	32.5	43.8	53.8	59.9	67.0	72.9	77.8	81.9	85.5	88.9	91.5	94.0	96.0	97.8	99.4	100.9	102.3	103.3	105.6
2003	5.1	16.3	31.7	44.2	53.3	61.5	66.6	72.6	77.7	81.9	85.5	88.7	91.7	93.9	96.1	97.9	99.4	100.9	102.2	103.4	106.0
2004	6.1	15.2	33.8	43.6	53.6	61.0	68.0	72.4	77.5	81.9	85.6	88.7	91.4	94.1	96.0	98.0	99.5	100.9	102.2	103.4	105.6
2005	4.8	18.3	31.3	45.2	53.1	61.3	67.6	73.5	77.3	81.7	85.5	88.7	91.4	93.9	96.2	97.9	99.6	101.0	102.2	103.3	105.9
2006	4.7	14.4	31.0	43.3	54.4	60.9	67.8	73.2	78.3	81.5	85.4	88.7	91.5	93.9	96.0	98.0	99.6	101.1	102.3	103.3	106.2
2007	4.2	14.1	30.0	43.1	52.8	62.0	67.5	73.4	78.0	82.4	85.2	88.5	91.4	93.9	96.0	97.9	99.6	101.0	102.3	103.4	106.6
2008	4.1	12.5	29.9	42.3	52.7	60.7	68.4	73.1	78.1	82.1	85.9	88.4	91.3	93.9	96.0	97.9	99.5	101.1	102.3	103.5	106.1
2009	4.5	12.2	30.7	42.2	52.1	60.6	67.3	73.9	77.9	82.3	85.7	89.0	91.2	93.8	96.0	97.9	99.5	101.0	102.4	103.4	105.4
2010	5.2	13.5	32.0	42.8	52.0	60.0	67.2	72.9	78.6	82.0	85.8	88.8	91.8	93.6	95.9	97.9	99.5	101.0	102.3	103.5	105.3
2011	4.2	15.6	30.0	43.8	52.4	60.0	66.7	72.8	77.7	82.6	85.6	89.0	91.6	94.1	95.8	97.8	99.5	101.0	102.3	103.4	105.5
2012	5.1	12.5	31.8	42.3	53.3	60.4	66.7	72.4	77.7	81.9	86.2	88.8	91.7	94.0	96.2	97.7	99.4	101.0	102.3	103.4	105.0
2013	4.8	15.3	31.2	43.7	52.0	61.1	67.0	72.4	77.3	81.8	85.5	89.2	91.5	94.1	96.1	98.1	99.4	100.9	102.3	103.4	105.4
2014	5.1	14.3	31.9	43.2	53.1	60.0	67.6	72.7	77.3	81.6	85.5	88.7	91.9	94.0	96.2	98.0	99.7	100.8	102.2	103.4	105.6
2015	6.4	15.4	34.4	43.8	52.7	60.9	66.7	73.2	77.5	81.5	85.2	88.6	91.5	94.3	96.1	98.0	99.6	101.1	102.1	103.3	105.7
2016	6.6	19.1	34.8	45.7	53.2	60.6	67.5	72.4	78.0	81.7	85.2	88.4	91.4	93.9	96.4	97.9	99.7	101.0	102.4	103.3	105.1
2017	6.5	19.8	34.6	46.0	54.8	61.0	67.2	73.1	77.3	82.1	85.4	88.4	91.2	93.8	96.0	98.2	99.6	101.1	102.3	103.5	105.4
2018	7.2	19.5	36.0	45.9	55.1	62.3	67.5	72.9	77.9	81.6	85.7	88.6	91.2	93.7	96.0	97.9	99.8	101.0	102.4	103.5	105.7
2019	4.1	21.5	29.9	47.0	54.9	62.6	68.7	73.1	77.7	82.1	85.2	88.8	91.3	93.7	95.8	97.8	99.5	101.2	102.3	103.5	105.3
2020	6.7	12.3	35.0	42.3	55.8	62.4	68.9	74.1	77.9	81.9	85.7	88.4	91.6	93.8	95.8	97.7	99.5	101.0	102.5	103.4	105.4
2021	5.5	16.4	31.7	46.2	52.0	63.2	68.8	74.3	78.8	82.1	85.5	88.8	91.2	94.0	95.9	97.7	99.4	101.0	102.3	103.6	105.8

Table 2.27a (page 1 of 5)—Weight (kg) at age (fishery, Model 19.12a).

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	0.09	0.62	1.43	2.36	3.34	4.29	5.26	6.28	7.32	8.35	9.33	10.25	11.11	11.89	12.61	13.26	13.84	14.37	14.83	15.91
1978	0.00	0.07	0.50	1.35	2.31	3.34	4.37	5.43	6.56	7.73	8.90	10.03	11.09	12.08	12.99	13.83	14.59	15.28	15.89	16.44	17.73
1979	0.01	0.07	0.61	1.33	2.34	3.31	4.28	5.25	6.28	7.34	8.38	9.38	10.32	11.18	11.98	12.71	13.37	13.96	14.49	14.97	16.00
1980	0.00	0.08	0.53	1.35	2.18	3.22	4.18	5.16	6.18	7.24	8.29	9.29	10.23	11.10	11.91	12.65	13.31	13.92	14.45	14.93	15.95
1981	0.01	0.06	0.46	1.26	2.23	3.09	4.12	5.08	6.09	7.12	8.14	9.11	10.02	10.87	11.65	12.36	13.01	13.59	14.10	14.57	15.53
1982	0.00	0.04	0.54	1.32	2.35	3.41	4.29	5.34	6.37	7.42	8.45	9.44	10.37	11.23	12.02	12.74	13.39	13.98	14.51	14.97	15.93
1983	0.01	0.04	0.61	1.30	2.24	3.35	4.44	5.37	6.55	7.66	8.75	9.80	10.79	11.70	12.55	13.32	14.02	14.65	15.22	15.72	16.75
1984	0.01	0.10	0.60	1.37	2.09	2.94	3.87	4.79	5.57	6.52	7.36	8.16	8.91	9.60	10.24	10.81	11.33	11.79	12.21	12.58	13.33
1985	0.00	0.07	0.47	1.39	2.40	3.28	4.29	5.44	6.64	7.68	8.92	10.01	11.04	12.00	12.88	13.69	14.42	15.08	15.68	16.21	17.30
1986	0.00	0.03	0.51	1.18	2.29	3.38	4.27	5.34	6.60	7.90	8.97	10.22	11.29	12.30	13.23	14.08	14.85	15.55	16.17	16.73	17.90
1987	0.00	0.06	0.52	1.36	2.18	3.35	4.38	5.24	6.29	7.51	8.70	9.65	10.73	11.65	12.50	13.27	13.97	14.61	15.17	15.68	16.75
1988	0.01	0.04	0.43	1.21	2.25	3.18	4.48	5.67	6.69	7.92	9.28	10.57	11.58	12.72	13.68	14.56	15.36	16.08	16.72	17.30	18.54
1989	0.00	0.04	0.48	1.27	2.29	3.45	4.39	5.71	6.94	7.97	9.17	10.45	11.64	12.56	13.58	14.44	15.22	15.92	16.55	17.11	18.34
1990	0.00	0.05	0.57	1.33	2.30	3.36	4.45	5.35	6.63	7.78	8.71	9.75	10.85	11.85	12.61	13.46	14.16	14.79	15.35	15.86	16.97
1991	0.01	0.06	0.58	1.32	2.18	3.13	4.10	5.13	5.99	7.19	8.24	9.06	9.97	10.90	11.75	12.39	13.09	13.67	14.19	14.65	15.66
1992	0.00	0.07	0.53	1.31	2.16	3.04	3.95	4.90	5.95	6.82	8.00	9.01	9.77	10.62	11.48	12.25	12.84	13.47	13.98	14.45	15.43
1993	0.01	0.07	0.60	1.38	2.39	3.38	4.35	5.38	6.50	7.69	8.63	9.86	10.88	11.65	12.49	13.34	14.09	14.65	15.26	15.75	16.72
1994	0.00	0.08	0.52	1.36	2.23	3.25	4.17	5.09	6.11	7.22	8.35	9.22	10.34	11.26	11.95	12.69	13.44	14.10	14.59	15.12	15.93
1995	0.00	0.05	0.50	1.26	2.27	3.22	4.26	5.23	6.23	7.34	8.48	9.62	10.47	11.57	12.46	13.12	13.84	14.55	15.17	15.64	16.59
1996	0.01	0.06	0.61	1.39	2.31	3.32	4.18	5.14	6.04	6.94	7.87	8.80	9.70	10.37	11.21	11.89	12.38	12.91	13.44	13.90	14.53
1997	0.01	0.06	0.50	1.23	2.08	3.01	4.01	4.89	5.90	6.83	7.75	8.67	9.58	10.45	11.09	11.89	12.53	13.00	13.50	13.99	14.56
1998	0.00	0.06	0.49	1.26	2.14	3.03	3.93	4.92	5.82	6.83	7.74	8.60	9.47	10.30	11.10	11.68	12.40	12.97	13.39	13.83	14.53
1999	0.00	0.05	0.48	1.26	2.21	3.17	4.09	5.04	6.12	7.08	8.13	9.04	9.89	10.73	11.54	12.29	12.84	13.53	14.06	14.45	15.24
2000	0.01	0.04	0.65	1.30	2.29	3.34	4.34	5.30	6.35	7.52	8.52	9.58	10.48	11.32	12.14	12.91	13.64	14.16	14.81	15.31	16.30
2001	0.01	0.10	0.62	1.48	2.22	3.21	4.17	5.09	6.03	7.06	8.16	9.07	10.01	10.80	11.53	12.23	12.89	13.49	13.93	14.47	15.53
2002	0.01	0.07	0.59	1.34	2.33	3.10	4.07	5.03	6.04	7.08	8.15	9.27	10.17	11.08	11.85	12.54	13.21	13.83	14.41	14.82	15.71
2003	0.00	0.08	0.53	1.35	2.24	3.29	4.05	5.07	6.17	7.26	8.31	9.35	10.41	11.26	12.12	12.84	13.49	14.11	14.69	15.22	16.24
2004	0.01	0.07	0.65	1.33	2.30	3.22	4.24	4.99	6.03	7.12	8.15	9.11	10.03	10.95	11.69	12.43	13.04	13.59	14.11	14.59	15.41
2005	0.00	0.11	0.52	1.44	2.26	3.30	4.26	5.34	6.17	7.31	8.44	9.50	10.45	11.36	12.27	12.99	13.71	14.30	14.83	15.33	16.33
2006	0.00	0.06	0.53	1.32	2.42	3.26	4.29	5.24	6.35	7.17	8.26	9.31	10.27	11.12	11.94	12.74	13.37	13.99	14.50	14.95	16.03
2007	0.00	0.05	0.49	1.32	2.29	3.46	4.31	5.38	6.40	7.55	8.39	9.47	10.49	11.41	12.22	12.99	13.74	14.32	14.90	15.37	16.63
2008	0.00	0.03	0.47	1.22	2.21	3.21	4.34	5.18	6.28	7.33	8.49	9.31	10.35	11.32	12.18	12.93	13.64	14.32	14.85	15.38	16.35
2009	0.00	0.03	0.53	1.27	2.20	3.24	4.18	5.28	6.15	7.28	8.33	9.44	10.20	11.16	12.04	12.82	13.49	14.12	14.73	15.19	15.94
2010	0.00	0.03	0.61	1.34	2.21	3.14	4.09	5.00	6.15	7.02	8.11	9.06	10.05	10.73	11.56	12.33	12.99	13.57	14.10	14.61	15.27
2011	0.00	0.05	0.50	1.38	2.20	3.09	4.00	4.98	5.99	7.20	8.06	9.09	9.98	10.89	11.51	12.27	12.97	13.57	14.09	14.57	15.37
2012	0.00	0.03	0.54	1.21	2.21	3.06	3.93	4.87	5.93	6.97	8.18	9.00	9.97	10.79	11.64	12.20	12.89	13.52	14.06	14.52	15.15
2013	0.00	0.06	0.52	1.31	2.11	3.20	4.05	4.95	5.97	7.11	8.19	9.39	10.20	11.13	11.92	12.71	13.24	13.89	14.47	14.97	15.77
2014	0.00	0.03	0.55	1.28	2.23	3.07	4.13	4.99	5.95	7.03	8.19	9.26	10.43	11.20	12.09	12.83	13.58	14.08	14.68	15.22	16.13
2015	0.00	0.04	0.66	1.32	2.17	3.14	3.94	5.01	5.92	6.91	7.98	9.08	10.07	11.13	11.83	12.64	13.30	13.96	14.40	14.93	15.88
2016	0.00	0.10	0.69	1.49	2.27	3.17	4.14	4.98	6.14	7.11	8.12	9.16	10.21	11.15	12.14	12.79	13.52	14.12	14.73	15.12	15.84
2017	0.00	0.10	0.68	1.52	2.45	3.26	4.16	5.19	6.11	7.36	8.34	9.34	10.35	11.36	12.25	13.18	13.78	14.47	15.02	15.58	16.35
2018	0.01	0.12	0.74	1.49	2.45	3.39	4.19	5.11	6.19	7.12	8.34	9.26	10.18	11.09	11.98	12.76	13.57	14.09	14.68	15.15	16.04
2019	0.00	0.16	0.47	1.59	2.47	3.48	4.44	5.27	6.28	7.44	8.41	9.64	10.56	11.45	12.33	13.20	13.94	14.70	15.19	15.74	16.49
2020	0.01	0.03	0.70	1.22	2.55	3.44	4.44	5.43	6.31	7.34	8.48	9.40	10.53	11.37	12.18	12.97	13.74	14.40	15.07	15.50	16.33
2021	0.01	0.12	0.88	1.50	2.07	3.35	4.15	5.09	6.03	6.85	7.78	8.77	9.56	10.53	11.23	11.91	12.57	13.20	13.73	14.28	15.11

Table 2.27a (page 2 of 5)—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	0.09	0.61	1.40	2.32	3.29	4.29	5.33	6.41	7.52	8.60	9.60	10.49	11.25	11.91	12.47	12.96	13.39	13.76	14.10	14.82
1978	0.00	0.07	0.50	1.32	2.27	3.30	4.37	5.51	6.72	7.97	9.19	10.33	11.35	12.24	13.00	13.66	14.23	14.73	15.17	15.56	16.42
1979	0.01	0.07	0.60	1.30	2.29	3.27	4.28	5.33	6.43	7.55	8.64	9.66	10.55	11.33	12.00	12.57	13.07	13.50	13.88	14.22	14.90
1980	0.00	0.08	0.52	1.32	2.14	3.18	4.18	5.22	6.32	7.44	8.54	9.56	10.47	11.25	11.93	12.50	13.00	13.44	13.83	14.17	14.83
1981	0.00	0.07	0.45	1.23	2.18	3.05	4.12	5.15	6.23	7.32	8.39	9.38	10.26	11.02	11.67	12.23	12.71	13.13	13.50	13.84	14.45
1982	0.00	0.04	0.53	1.29	2.30	3.36	4.28	5.41	6.50	7.62	8.70	9.71	10.60	11.38	12.04	12.60	13.09	13.52	13.90	14.24	14.85
1983	0.01	0.04	0.66	1.27	2.19	3.30	4.43	5.43	6.68	7.86	9.01	10.08	11.03	11.86	12.56	13.17	13.69	14.15	14.56	14.92	15.59
1984	0.01	0.14	0.60	1.41	2.05	2.90	3.86	4.83	5.66	6.67	7.56	8.38	9.10	9.72	10.26	10.71	11.10	11.44	11.74	12.01	12.49
1985	0.00	0.07	0.47	1.36	2.44	3.22	4.27	5.49	6.78	7.89	9.19	10.30	11.29	12.15	12.89	13.53	14.08	14.56	14.98	15.36	16.07
1986	0.00	0.03	0.51	1.15	2.25	3.42	4.25	5.39	6.74	8.12	9.26	10.53	11.56	12.47	13.24	13.91	14.48	14.99	15.44	15.84	16.60
1987	0.00	0.06	0.52	1.33	2.13	3.30	4.47	5.29	6.41	7.70	8.96	9.93	10.98	11.80	12.51	13.12	13.64	14.10	14.51	14.88	15.58
1988	0.01	0.04	0.43	1.19	2.21	3.13	4.49	5.86	6.83	8.13	9.57	10.89	11.86	12.89	13.69	14.38	14.97	15.50	15.96	16.38	17.21
1989	0.00	0.04	0.48	1.25	2.25	3.40	4.37	5.78	7.20	8.17	9.43	10.75	11.90	12.73	13.59	14.27	14.85	15.36	15.82	16.22	17.06
1990	0.00	0.05	0.57	1.31	2.26	3.31	4.43	5.37	6.73	8.07	8.93	10.01	11.08	11.99	12.64	13.31	13.83	14.29	14.70	15.06	15.82
1991	0.01	0.06	0.59	1.30	2.14	3.08	4.09	5.17	6.08	7.37	8.57	9.30	10.19	11.05	11.76	12.26	12.79	13.21	13.58	13.92	14.61
1992	0.00	0.07	0.52	1.30	2.12	2.99	3.94	4.96	6.08	7.00	8.26	9.36	10.01	10.77	11.50	12.11	12.55	13.01	13.38	13.71	14.39
1993	0.01	0.07	0.58	1.34	2.35	3.33	4.33	5.44	6.63	7.90	8.88	10.16	11.21	11.82	12.53	13.20	13.77	14.18	14.62	14.98	15.62
1994	0.01	0.07	0.52	1.30	2.18	3.21	4.16	5.15	6.24	7.41	8.60	9.49	10.59	11.48	11.98	12.57	13.14	13.62	13.97	14.35	14.86
1995	0.00	0.06	0.49	1.24	2.19	3.16	4.27	5.29	6.37	7.54	8.74	9.90	10.73	11.74	12.54	12.99	13.52	14.05	14.50	14.83	15.42
1996	0.01	0.07	0.61	1.37	2.28	3.25	4.16	5.18	6.13	7.08	8.07	9.03	9.91	10.51	11.24	11.81	12.14	12.52	12.91	13.24	13.58
1997	0.01	0.06	0.50	1.22	2.06	2.98	3.98	4.93	6.02	7.00	7.96	8.91	9.80	10.59	11.12	11.77	12.29	12.58	12.94	13.30	13.57
1998	0.00	0.06	0.50	1.24	2.11	3.00	3.94	4.95	5.92	7.02	7.97	8.85	9.69	10.45	11.12	11.57	12.13	12.58	12.84	13.15	13.53
1999	0.00	0.05	0.49	1.25	2.18	3.14	4.09	5.11	6.22	7.26	8.39	9.31	10.13	10.89	11.57	12.18	12.59	13.10	13.51	13.76	14.21
2000	0.01	0.03	0.65	1.30	2.27	3.31	4.34	5.38	6.50	7.70	8.77	9.87	10.74	11.49	12.18	12.80	13.35	13.73	14.21	14.61	15.22
2001	0.01	0.10	0.62	1.44	2.18	3.17	4.19	5.21	6.24	7.32	8.42	9.36	10.28	10.98	11.58	12.13	12.63	13.07	13.38	13.77	14.50
2002	0.01	0.08	0.58	1.31	2.27	3.06	4.10	5.19	6.30	7.40	8.51	9.58	10.45	11.28	11.90	12.44	12.94	13.40	13.81	14.10	14.74
2003	0.00	0.08	0.53	1.32	2.20	3.23	4.05	5.15	6.32	7.48	8.59	9.65	10.64	11.42	12.15	12.71	13.19	13.65	14.06	14.45	15.21
2004	0.01	0.07	0.64	1.30	2.25	3.18	4.22	5.05	6.16	7.31	8.40	9.38	10.28	11.08	11.71	12.31	12.76	13.16	13.53	13.88	14.50
2005	0.00	0.11	0.52	1.41	2.21	3.26	4.25	5.39	6.29	7.50	8.69	9.77	10.70	11.53	12.27	12.85	13.40	13.83	14.20	14.56	15.31
2006	0.00	0.06	0.53	1.30	2.37	3.21	4.27	5.28	6.43	7.33	8.49	9.57	10.50	11.28	11.97	12.59	13.07	13.54	13.90	14.22	15.05
2007	0.00	0.05	0.51	1.31	2.25	3.42	4.29	5.42	6.51	7.72	8.62	9.73	10.73	11.56	12.25	12.86	13.41	13.85	14.27	14.61	15.60
2008	0.00	0.03	0.47	1.22	2.17	3.17	4.36	5.27	6.46	7.58	8.77	9.62	10.62	11.49	12.21	12.81	13.34	13.83	14.21	14.60	15.41
2009	0.00	0.03	0.52	1.25	2.17	3.20	4.20	5.43	6.38	7.58	8.66	9.75	10.49	11.35	12.09	12.70	13.21	13.67	14.09	14.43	14.99
2010	0.00	0.03	0.60	1.30	2.16	3.11	4.12	5.12	6.36	7.29	8.42	9.37	10.30	10.91	11.61	12.21	12.71	13.13	13.52	13.87	14.31
2011	0.00	0.05	0.50	1.33	2.13	3.03	3.99	5.04	6.11	7.39	8.30	9.36	10.21	11.02	11.55	12.16	12.68	13.12	13.50	13.84	14.36
2012	0.00	0.03	0.54	1.18	2.16	3.00	3.92	4.93	6.05	7.15	8.41	9.26	10.20	10.94	11.64	12.09	12.61	13.07	13.46	13.79	14.14
2013	0.00	0.06	0.51	1.28	2.07	3.14	4.03	5.02	6.13	7.33	8.45	9.66	10.44	11.28	11.94	12.56	12.96	13.43	13.85	14.21	14.67
2014	0.00	0.04	0.54	1.25	2.18	3.02	4.13	5.06	6.11	7.27	8.48	9.56	10.67	11.36	12.11	12.69	13.24	13.61	14.04	14.43	14.98
2015	0.00	0.04	0.65	1.28	2.11	3.09	3.93	5.07	6.04	7.11	8.25	9.36	10.31	11.27	11.85	12.49	12.98	13.46	13.77	14.15	14.75
2016	0.00	0.10	0.69	1.46	2.21	3.11	4.14	5.03	6.26	7.28	8.36	9.45	10.46	11.30	12.13	12.64	13.19	13.63	14.06	14.34	14.75
2017	0.00	0.11	0.68	1.51	2.41	3.20	4.14	5.24	6.21	7.53	8.56	9.61	10.61	11.52	12.26	13.00	13.45	13.95	14.35	14.74	15.19
2018	0.01	0.12	0.73	1.46	2.42	3.36	4.17	5.16	6.32	7.31	8.57	9.51	10.42	11.26	12.01	12.62	13.23	13.61	14.04	14.38	14.93
2019	0.00	0.16	0.47	1.55	2.41	3.45	4.45	5.33	6.43	7.67	8.69	9.93	10.81	11.63	12.39	13.06	13.61	14.17	14.52	14.92	15.38
2020	0.01	0.03	0.67	1.20	2.49	3.39	4.46	5.50	6.42	7.53	8.74	9.68	10.77	11.52	12.22	12.86	13.44	13.91	14.40	14.71	15.23
2021	0.01	0.11	0.78	1.43	2.02	3.29	4.13	5.15	6.14	7.00	7.99	9.03	9.79	10.66	11.25	11.80	12.30	12.76	13.15	13.55	14.09

Table 2.27a (page 3 of 5)—Weight (kg) at age (fishery, Model 21.1).

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	1.38	2.32	3.29	4.21	5.10	5.99	6.90	7.80	8.65	9.43	10.12	10.74	11.28	11.74	12.15	12.50	12.80	13.37
1978	0.00	0.06	0.49	1.30	2.27	3.29	4.28	5.25	6.23	7.24	8.26	9.22	10.12	10.92	11.64	12.26	12.81	13.28	13.69	14.04	14.72
1979	0.01	0.07	0.59	1.31	2.29	3.26	4.19	5.09	5.99	6.90	7.81	8.67	9.46	10.17	10.79	11.34	11.82	12.23	12.59	12.89	13.50
1980	0.01	0.08	0.51	1.33	2.17	3.17	4.10	5.00	5.91	6.83	7.74	8.61	9.40	10.11	10.73	11.28	11.76	12.18	12.53	12.84	13.48
1981	0.01	0.06	0.44	1.24	2.22	3.08	4.04	4.93	5.82	6.72	7.61	8.45	9.22	9.91	10.51	11.04	11.51	11.91	12.25	12.55	13.17
1982	0.00	0.05	0.53	1.30	2.34	3.39	4.24	5.19	6.10	7.02	7.93	8.78	9.56	10.26	10.87	11.41	11.88	12.29	12.64	12.94	13.57
1983	0.01	0.05	0.59	1.29	2.22	3.33	4.39	5.27	6.29	7.27	8.23	9.14	9.96	10.70	11.35	11.92	12.42	12.85	13.22	13.54	14.23
1984	0.01	0.10	0.58	1.35	2.09	2.93	3.85	4.71	5.43	6.24	6.99	7.68	8.31	8.86	9.35	9.78	10.15	10.47	10.75	10.98	11.49
1985	0.00	0.07	0.46	1.38	2.39	3.27	4.25	5.33	6.40	7.31	8.35	9.29	10.15	10.93	11.61	12.21	12.73	13.18	13.58	13.91	14.65
1986	0.00	0.03	0.50	1.16	2.29	3.37	4.25	5.22	6.33	7.45	8.39	9.42	10.32	11.14	11.86	12.49	13.05	13.53	13.94	14.30	15.08
1987	0.00	0.07	0.52	1.37	2.18	3.34	4.34	5.13	6.05	7.11	8.14	8.97	9.84	10.59	11.25	11.83	12.33	12.77	13.15	13.47	14.19
1988	0.01	0.05	0.43	1.20	2.26	3.19	4.46	5.54	6.43	7.48	8.66	9.76	10.62	11.50	12.25	12.91	13.48	13.98	14.41	14.78	15.61
1989	0.01	0.05	0.47	1.27	2.30	3.45	4.37	5.61	6.72	7.65	8.68	9.79	10.77	11.51	12.26	12.89	13.44	13.92	14.33	14.69	15.51
1990	0.01	0.05	0.55	1.31	2.30	3.35	4.43	5.29	6.48	7.53	8.35	9.24	10.15	10.93	11.51	12.10	12.60	13.02	13.39	13.71	14.45
1991	0.01	0.06	0.57	1.31	2.18	3.13	4.09	5.06	5.83	6.91	7.83	8.54	9.29	10.04	10.69	11.16	11.64	12.03	12.37	12.67	13.35
1992	0.00	0.07	0.53	1.31	2.16	3.03	3.93	4.81	5.74	6.49	7.53	8.39	9.04	9.72	10.39	10.96	11.38	11.80	12.14	12.44	13.11
1993	0.01	0.07	0.61	1.37	2.40	3.38	4.32	5.28	6.25	7.28	8.08	9.15	10.01	10.65	11.30	11.94	12.48	12.87	13.26	13.58	14.25
1994	0.00	0.09	0.52	1.38	2.24	3.25	4.13	4.97	5.87	6.81	7.79	8.53	9.49	10.23	10.78	11.34	11.88	12.33	12.67	12.99	13.56
1995	0.00	0.06	0.49	1.26	2.31	3.23	4.23	5.11	5.99	6.95	7.94	8.92	9.63	10.53	11.22	11.72	12.23	12.72	13.13	13.43	14.08
1996	0.01	0.07	0.60	1.40	2.32	3.34	4.16	5.08	5.91	6.73	7.57	8.37	9.11	9.64	10.28	10.77	11.13	11.48	11.83	12.11	12.55
1997	0.01	0.06	0.49	1.23	2.09	3.02	4.02	4.83	5.75	6.59	7.39	8.20	8.95	9.64	10.12	10.72	11.16	11.49	11.81	12.12	12.52
1998	0.00	0.06	0.49	1.26	2.14	3.03	3.91	4.86	5.65	6.55	7.34	8.09	8.82	9.49	10.10	10.52	11.04	11.42	11.70	11.98	12.46
1999	0.00	0.05	0.47	1.26	2.22	3.17	4.07	4.96	5.96	6.78	7.69	8.47	9.18	9.87	10.49	11.05	11.44	11.91	12.26	12.51	13.05
2000	0.01	0.04	0.64	1.29	2.30	3.33	4.30	5.22	6.15	7.21	8.05	8.96	9.71	10.39	11.03	11.61	12.13	12.48	12.91	13.23	13.89
2001	0.01	0.10	0.61	1.48	2.21	3.21	4.14	4.97	5.77	6.62	7.57	8.33	9.13	9.78	10.36	10.91	11.39	11.82	12.12	12.47	13.19
2002	0.01	0.08	0.58	1.35	2.34	3.10	4.06	4.92	5.74	6.57	7.44	8.40	9.14	9.91	10.53	11.07	11.58	12.03	12.42	12.69	13.34
2003	0.01	0.08	0.53	1.35	2.26	3.29	4.02	4.96	5.90	6.83	7.75	8.64	9.56	10.23	10.90	11.44	11.91	12.35	12.74	13.08	13.78
2004	0.01	0.07	0.65	1.33	2.31	3.24	4.22	4.91	5.85	6.80	7.70	8.53	9.30	10.07	10.61	11.16	11.59	11.97	12.32	12.63	13.21
2005	0.01	0.11	0.51	1.45	2.27	3.31	4.24	5.25	5.99	7.01	8.00	8.90	9.70	10.44	11.15	11.66	12.17	12.57	12.92	13.24	13.93
2006	0.00	0.06	0.52	1.32	2.43	3.26	4.27	5.19	6.22	6.96	7.93	8.83	9.61	10.29	10.91	11.50	11.93	12.35	12.68	12.96	13.70
2007	0.00	0.06	0.48	1.31	2.29	3.46	4.29	5.31	6.27	7.30	8.03	8.97	9.81	10.53	11.16	11.71	12.25	12.63	13.00	13.30	14.15
2008	0.00	0.04	0.45	1.21	2.21	3.20	4.32	5.09	6.05	6.97	7.96	8.65	9.54	10.32	10.99	11.56	12.06	12.54	12.88	13.22	13.96
2009	0.00	0.03	0.53	1.27	2.20	3.23	4.14	5.12	5.82	6.73	7.60	8.54	9.18	9.99	10.71	11.31	11.81	12.26	12.69	12.98	13.57
2010	0.00	0.04	0.61	1.35	2.20	3.12	4.04	4.84	5.76	6.44	7.34	8.16	9.00	9.56	10.26	10.86	11.36	11.78	12.15	12.49	12.98
2011	0.00	0.05	0.50	1.38	2.21	3.07	3.94	4.83	5.68	6.71	7.46	8.35	9.11	9.86	10.34	10.93	11.44	11.86	12.21	12.52	13.08
2012	0.00	0.03	0.54	1.19	2.21	3.06	3.89	4.74	5.68	6.58	7.64	8.35	9.16	9.84	10.49	10.91	11.41	11.84	12.20	12.50	12.95
2013	0.00	0.06	0.51	1.32	2.11	3.19	4.02	4.82	5.68	6.64	7.57	8.61	9.29	10.06	10.69	11.29	11.67	12.13	12.52	12.84	13.39
2014	0.00	0.04	0.55	1.28	2.25	3.06	4.09	4.88	5.69	6.61	7.62	8.54	9.52	10.15	10.84	11.40	11.94	12.28	12.69	13.03	13.67
2015	0.00	0.05	0.65	1.32	2.17	3.13	3.89	4.88	5.69	6.54	7.47	8.42	9.26	10.12	10.66	11.25	11.73	12.18	12.46	12.81	13.47
2016	0.00	0.10	0.69	1.50	2.28	3.15	4.10	4.85	5.89	6.74	7.61	8.51	9.40	10.16	10.93	11.40	11.93	12.34	12.74	12.99	13.51
2017	0.00	0.11	0.68	1.52	2.45	3.25	4.12	5.10	5.91	7.03	7.91	8.76	9.60	10.41	11.09	11.78	12.20	12.66	13.02	13.37	13.91
2018	0.01	0.12	0.75	1.50	2.45	3.39	4.16	5.02	6.00	6.81	7.88	8.69	9.44	10.17	10.87	11.44	12.02	12.37	12.75	13.05	13.67
2019	0.00	0.16	0.46	1.60	2.48	3.48	4.40	5.16	6.03	7.05	7.87	8.94	9.71	10.43	11.12	11.77	12.30	12.83	13.15	13.50	14.04
2020	0.01	0.03	0.69	1.20	2.56	3.44	4.41	5.35	6.15	7.07	8.07	8.84	9.79	10.46	11.07	11.66	12.20	12.64	13.09	13.35	13.93
2021	0.01	0.11	0.87	1.50	2.06	3.34	4.12	5.00	5.87	6.61	7.42	8.28	8.92	9.69	10.23	10.72	11.18	11.61	11.96	12.31	12.88

Table 2.27a (page 4 of 5)—Weight (kg) at age (fishery, Model 21.2).

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	0.09	0.61	1.40	2.33	3.29	4.22	5.16	6.17	7.22	8.26	9.26	10.20	11.08	11.88	12.63	13.30	13.91	14.46	14.95	16.12
1978	0.00	0.07	0.50	1.33	2.28	3.29	4.28	5.30	6.40	7.59	8.78	9.93	11.02	12.04	12.98	13.84	14.63	15.35	16.00	16.58	17.97
1979	0.01	0.07	0.60	1.31	2.30	3.26	4.20	5.14	6.15	7.21	8.28	9.30	10.26	11.15	11.97	12.72	13.41	14.03	14.59	15.08	16.21
1980	0.00	0.08	0.52	1.33	2.15	3.18	4.12	5.08	6.10	7.16	8.21	9.23	10.18	11.08	11.90	12.66	13.36	13.98	14.55	15.05	16.16
1981	0.01	0.06	0.46	1.23	2.19	3.05	4.05	5.00	6.00	7.04	8.07	9.05	9.98	10.84	11.64	12.38	13.05	13.65	14.20	14.68	15.73
1982	0.00	0.04	0.54	1.32	2.32	3.37	4.24	5.28	6.30	7.35	8.39	9.39	10.33	11.21	12.02	12.76	13.43	14.05	14.60	15.09	16.14
1983	0.01	0.05	0.61	1.29	2.22	3.31	4.39	5.33	6.49	7.60	8.69	9.75	10.75	11.68	12.54	13.34	14.07	14.72	15.32	15.85	16.97
1984	0.01	0.11	0.60	1.36	2.07	2.92	3.84	4.75	5.54	6.47	7.32	8.13	8.89	9.59	10.23	10.83	11.36	11.85	12.28	12.67	13.50
1985	0.00	0.07	0.47	1.38	2.38	3.25	4.25	5.39	6.58	7.62	8.85	9.95	11.00	11.97	12.88	13.71	14.47	15.16	15.78	16.34	17.54
1986	0.00	0.03	0.51	1.17	2.27	3.34	4.22	5.27	6.51	7.81	8.90	10.15	11.24	12.27	13.22	14.10	14.90	15.63	16.28	16.87	18.15
1987	0.00	0.06	0.52	1.35	2.17	3.32	4.34	5.19	6.24	7.44	8.64	9.60	10.69	11.62	12.49	13.29	14.02	14.68	15.27	15.81	16.97
1988	0.01	0.04	0.43	1.18	2.21	3.14	4.43	5.61	6.62	7.86	9.21	10.51	11.54	12.69	13.67	14.58	15.41	16.16	16.84	17.45	18.80
1989	0.01	0.04	0.48	1.25	2.25	3.40	4.35	5.66	6.89	7.92	9.12	10.40	11.60	12.54	13.58	14.46	15.27	16.00	16.66	17.26	18.59
1990	0.01	0.05	0.57	1.32	2.27	3.32	4.41	5.32	6.59	7.74	8.67	9.72	10.82	11.83	12.62	13.48	14.20	14.86	15.45	15.99	17.20
1991	0.01	0.06	0.58	1.31	2.16	3.09	4.06	5.09	5.95	7.15	8.20	9.02	9.94	10.89	11.75	12.42	13.14	13.74	14.28	14.77	15.88
1992	0.00	0.07	0.53	1.30	2.14	3.01	3.90	4.83	5.86	6.74	7.94	8.96	9.74	10.60	11.48	12.27	12.88	13.53	14.07	14.56	15.64
1993	0.01	0.07	0.61	1.37	2.37	3.34	4.29	5.30	6.41	7.61	8.56	9.81	10.85	11.63	12.49	13.36	14.14	14.73	15.36	15.88	16.94
1994	0.00	0.08	0.52	1.35	2.22	3.22	4.12	5.02	6.03	7.13	8.28	9.17	10.31	11.24	11.95	12.72	13.49	14.17	14.69	15.24	16.14
1995	0.00	0.05	0.49	1.25	2.25	3.18	4.21	5.16	6.17	7.27	8.41	9.56	10.44	11.56	12.47	13.15	13.89	14.62	15.28	15.77	16.80
1996	0.01	0.07	0.60	1.37	2.27	3.28	4.14	5.10	6.00	6.90	7.83	8.77	9.68	10.36	11.22	11.91	12.43	12.98	13.53	14.00	14.68
1997	0.01	0.06	0.49	1.21	2.04	2.97	3.97	4.86	5.87	6.80	7.71	8.64	9.55	10.43	11.09	11.92	12.58	13.07	13.59	14.10	14.72
1998	0.00	0.06	0.49	1.24	2.11	2.99	3.90	4.89	5.78	6.79	7.70	8.57	9.44	10.29	11.10	11.70	12.45	13.04	13.48	13.94	14.70
1999	0.00	0.05	0.48	1.25	2.18	3.13	4.02	4.93	5.99	6.96	8.03	8.96	9.84	10.70	11.53	12.31	12.89	13.60	14.16	14.56	15.41
2000	0.01	0.04	0.63	1.27	2.25	3.27	4.28	5.26	6.32	7.49	8.49	9.55	10.46	11.31	12.14	12.94	13.69	14.24	14.91	15.44	16.49
2001	0.01	0.10	0.61	1.47	2.21	3.19	4.05	4.83	5.67	6.69	7.87	8.86	9.87	10.71	11.48	12.21	12.90	13.55	14.01	14.58	15.71
2002	0.01	0.07	0.56	1.31	2.29	3.06	4.02	4.94	5.94	6.98	8.08	9.21	10.12	11.06	11.85	12.56	13.25	13.90	14.50	14.94	15.89
2003	0.00	0.07	0.54	1.35	2.24	3.27	3.96	4.83	5.80	6.90	8.02	9.14	10.28	11.17	12.08	12.83	13.51	14.16	14.77	15.34	16.43
2004	0.01	0.06	0.68	1.36	2.32	3.22	4.13	4.77	5.71	6.78	7.89	8.91	9.90	10.88	11.65	12.43	13.06	13.64	14.19	14.70	15.58
2005	0.00	0.10	0.56	1.50	2.31	3.31	4.16	5.08	5.83	6.97	8.16	9.29	10.31	11.28	12.24	12.99	13.74	14.36	14.92	15.45	16.52
2006	0.00	0.05	0.56	1.34	2.43	3.25	4.26	5.21	6.32	7.15	8.24	9.28	10.24	11.11	11.95	12.77	13.42	14.07	14.60	15.08	16.23
2007	0.00	0.05	0.52	1.33	2.27	3.43	4.27	5.33	6.36	7.52	8.36	9.45	10.47	11.40	12.23	13.02	13.80	14.40	15.01	15.50	16.86
2008	0.00	0.04	0.47	1.21	2.17	3.14	4.32	5.18	6.29	7.34	8.50	9.32	10.36	11.32	12.20	12.97	13.70	14.41	14.96	15.51	16.57
2009	0.00	0.04	0.50	1.21	2.12	3.14	4.13	5.33	6.22	7.34	8.36	9.46	10.23	11.19	12.07	12.86	13.56	14.21	14.84	15.32	16.14
2010	0.01	0.05	0.55	1.23	2.07	3.03	4.03	5.00	6.20	7.07	8.13	9.07	10.06	10.75	11.59	12.36	13.05	13.65	14.20	14.74	15.45
2011	0.00	0.07	0.48	1.30	2.10	2.99	3.93	4.93	5.92	7.15	8.01	9.03	9.93	10.88	11.52	12.30	13.02	13.64	14.19	14.69	15.55
2012	0.00	0.04	0.51	1.17	2.14	2.98	3.84	4.76	5.78	6.82	8.06	8.90	9.89	10.75	11.63	12.22	12.94	13.58	14.15	14.64	15.33
2013	0.00	0.06	0.50	1.27	2.08	3.14	3.93	4.74	5.70	6.82	7.94	9.22	10.07	11.04	11.87	12.71	13.27	13.96	14.56	15.09	15.98
2014	0.00	0.04	0.53	1.27	2.19	3.04	4.00	4.73	5.61	6.70	7.91	9.03	10.28	11.10	12.03	12.81	13.61	14.14	14.77	15.34	16.37
2015	0.00	0.04	0.64	1.28	2.14	3.08	3.85	4.78	5.62	6.63	7.76	8.91	9.93	11.06	11.79	12.62	13.32	14.02	14.49	15.05	16.14
2016	0.00	0.09	0.68	1.45	2.21	3.12	4.06	4.89	6.02	6.99	8.03	9.10	10.16	11.10	12.12	12.79	13.55	14.18	14.83	15.25	16.10
2017	0.00	0.08	0.74	1.59	2.50	3.26	4.08	4.92	5.77	7.00	8.04	9.13	10.22	11.27	12.18	13.17	13.80	14.51	15.11	15.70	16.61
2018	0.01	0.11	0.79	1.54	2.47	3.38	4.10	4.96	5.96	6.94	8.18	9.14	10.10	11.05	11.96	12.75	13.61	14.15	14.76	15.27	16.30
2019	0.00	0.15	0.51	1.65	2.52	3.48	4.32	5.03	5.99	7.14	8.19	9.48	10.44	11.39	12.32	13.20	13.95	14.76	15.28	15.85	16.70
2020	0.01	0.03	0.72	1.26	2.57	3.43	4.37	5.30	6.14	7.22	8.36	9.33	10.49	11.34	12.18	13.01	13.79	14.46	15.17	15.62	16.49
2021	0.01	0.11	0.89	1.51	2.09	3.34	4.13	5.05	5.98	6.78	7.75	8.73	9.56	10.53	11.24	11.94	12.63	13.27	13.82	14.40	15.24

Table 2.27a (page 5 of 5)—Weight (kg) at age (fishery, ensemble).

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	0.09	0.61	1.40	2.34	3.30	4.26	5.23	6.23	7.26	8.28	9.24	10.12	10.92	11.63	12.26	12.83	13.33	13.78	14.17	15.05
1978	0.00	0.07	0.50	1.33	2.28	3.31	4.33	5.39	6.50	7.66	8.81	9.91	10.93	11.85	12.68	13.42	14.08	14.67	15.19	15.66	16.70
1979	0.01	0.07	0.60	1.32	2.31	3.28	4.24	5.22	6.23	7.28	8.31	9.28	10.18	10.99	11.71	12.36	12.93	13.44	13.89	14.29	15.14
1980	0.00	0.08	0.52	1.33	2.16	3.19	4.15	5.13	6.14	7.19	8.22	9.20	10.10	10.91	11.64	12.29	12.87	13.39	13.85	14.25	15.09
1981	0.01	0.06	0.45	1.24	2.21	3.07	4.09	5.05	6.05	7.07	8.08	9.02	9.90	10.68	11.39	12.02	12.58	13.08	13.52	13.91	14.71
1982	0.00	0.04	0.54	1.31	2.33	3.38	4.27	5.32	6.33	7.37	8.39	9.36	10.24	11.04	11.76	12.40	12.96	13.47	13.92	14.31	15.11
1983	0.01	0.04	0.62	1.29	2.22	3.32	4.42	5.36	6.51	7.61	8.69	9.72	10.66	11.51	12.27	12.96	13.56	14.10	14.58	15.01	15.87
1984	0.01	0.11	0.59	1.37	2.07	2.92	3.85	4.77	5.56	6.49	7.32	8.11	8.82	9.46	10.04	10.54	11.00	11.40	11.75	12.06	12.70
1985	0.00	0.07	0.47	1.38	2.40	3.25	4.27	5.42	6.61	7.65	8.85	9.92	10.90	11.79	12.59	13.30	13.94	14.51	15.01	15.46	16.38
1986	0.00	0.03	0.51	1.16	2.27	3.38	4.25	5.31	6.56	7.84	8.91	10.11	11.14	12.07	12.91	13.67	14.34	14.93	15.46	15.94	16.92
1987	0.00	0.06	0.52	1.35	2.17	3.33	4.39	5.22	6.26	7.46	8.63	9.57	10.59	11.44	12.21	12.90	13.51	14.05	14.53	14.96	15.86
1988	0.01	0.04	0.43	1.20	2.23	3.16	4.47	5.69	6.66	7.87	9.21	10.46	11.43	12.48	13.35	14.13	14.82	15.44	15.99	16.48	17.53
1989	0.01	0.04	0.48	1.26	2.28	3.43	4.37	5.70	6.96	7.94	9.12	10.37	11.50	12.36	13.28	14.04	14.71	15.31	15.85	16.32	17.36
1990	0.01	0.05	0.56	1.32	2.28	3.33	4.44	5.34	6.62	7.80	8.68	9.70	10.75	11.67	12.37	13.10	13.71	14.25	14.73	15.16	16.10
1991	0.01	0.06	0.58	1.31	2.16	3.11	4.09	5.12	5.97	7.17	8.23	9.00	9.87	10.74	11.51	12.08	12.68	13.17	13.61	14.00	14.86
1992	0.00	0.07	0.53	1.31	2.14	3.02	3.93	4.89	5.92	6.78	7.95	8.95	9.66	10.45	11.23	11.92	12.42	12.96	13.40	13.79	14.63
1993	0.01	0.07	0.60	1.36	2.38	3.36	4.33	5.36	6.46	7.64	8.56	9.77	10.77	11.46	12.23	12.98	13.63	14.12	14.63	15.05	15.87
1994	0.00	0.08	0.52	1.35	2.22	3.23	4.15	5.07	6.08	7.16	8.28	9.12	10.21	11.08	11.69	12.35	13.00	13.57	13.99	14.43	15.11
1995	0.00	0.06	0.49	1.25	2.26	3.20	4.25	5.21	6.20	7.29	8.42	9.53	10.35	11.38	12.20	12.77	13.38	14.00	14.53	14.92	15.71
1996	0.01	0.07	0.61	1.38	2.30	3.30	4.17	5.13	6.03	6.92	7.85	8.76	9.62	10.24	11.01	11.61	12.03	12.48	12.93	13.32	13.83
1997	0.01	0.06	0.50	1.22	2.07	3.00	4.00	4.88	5.90	6.82	7.72	8.62	9.49	10.30	10.88	11.59	12.15	12.54	12.96	13.38	13.83
1998	0.00	0.06	0.49	1.25	2.13	3.02	3.92	4.91	5.80	6.81	7.70	8.55	9.38	10.15	10.87	11.38	12.02	12.51	12.85	13.23	13.80
1999	0.00	0.05	0.48	1.26	2.20	3.16	4.07	5.02	6.09	7.04	8.08	8.97	9.79	10.57	11.30	11.98	12.45	13.04	13.50	13.82	14.47
2000	0.01	0.04	0.64	1.29	2.28	3.32	4.32	5.30	6.34	7.49	8.48	9.51	10.37	11.15	11.90	12.58	13.22	13.66	14.22	14.65	15.47
2001	0.01	0.10	0.61	1.47	2.21	3.20	4.15	5.05	5.97	6.97	8.05	8.95	9.86	10.60	11.26	11.89	12.47	13.00	13.37	13.83	14.72
2002	0.01	0.08	0.58	1.33	2.31	3.08	4.07	5.04	6.03	7.04	8.08	9.15	10.00	10.86	11.56	12.18	12.76	13.30	13.79	14.14	14.91
2003	0.00	0.08	0.53	1.34	2.23	3.27	4.03	5.03	6.09	7.17	8.21	9.24	10.25	11.05	11.84	12.48	13.04	13.58	14.07	14.53	15.41
2004	0.01	0.07	0.65	1.33	2.29	3.21	4.21	4.95	5.97	7.04	8.07	9.02	9.91	10.77	11.44	12.10	12.63	13.10	13.55	13.96	14.67
2005	0.00	0.11	0.52	1.44	2.25	3.29	4.24	5.29	6.11	7.24	8.36	9.40	10.32	11.18	12.01	12.64	13.27	13.78	14.22	14.65	15.52
2006	0.00	0.06	0.53	1.32	2.41	3.25	4.27	5.24	6.34	7.16	8.24	9.27	10.18	10.97	11.71	12.41	12.96	13.49	13.92	14.31	15.25
2007	0.00	0.05	0.50	1.32	2.27	3.44	4.29	5.37	6.39	7.54	8.37	9.42	10.40	11.25	11.99	12.66	13.31	13.81	14.30	14.70	15.80
2008	0.00	0.03	0.47	1.21	2.19	3.18	4.34	5.18	6.28	7.32	8.45	9.25	10.24	11.14	11.91	12.58	13.20	13.78	14.23	14.68	15.57
2009	0.00	0.03	0.52	1.25	2.18	3.21	4.17	5.29	6.15	7.25	8.26	9.32	10.05	10.95	11.75	12.44	13.03	13.58	14.09	14.49	15.15
2010	0.00	0.04	0.60	1.31	2.17	3.11	4.08	5.00	6.13	6.97	8.02	8.94	9.88	10.51	11.28	11.96	12.54	13.04	13.50	13.93	14.50
2011	0.00	0.05	0.50	1.35	2.17	3.05	3.97	4.96	5.94	7.13	7.98	8.99	9.83	10.69	11.25	11.93	12.54	13.06	13.50	13.91	14.58
2012	0.00	0.03	0.54	1.19	2.18	3.03	3.90	4.84	5.88	6.91	8.10	8.91	9.84	10.61	11.37	11.87	12.48	13.01	13.47	13.87	14.39
2013	0.00	0.06	0.51	1.30	2.09	3.17	4.02	4.91	5.90	7.01	8.08	9.26	10.03	10.91	11.63	12.34	12.80	13.36	13.86	14.28	14.94
2014	0.00	0.04	0.54	1.27	2.21	3.05	4.10	4.94	5.88	6.95	8.09	9.14	10.26	10.99	11.80	12.46	13.11	13.54	14.05	14.51	15.27
2015	0.00	0.04	0.65	1.30	2.15	3.11	3.91	4.96	5.85	6.84	7.90	8.98	9.93	10.92	11.56	12.27	12.85	13.42	13.79	14.24	15.05
2016	0.00	0.10	0.69	1.48	2.24	3.14	4.11	4.95	6.10	7.05	8.05	9.08	10.09	10.95	11.85	12.42	13.06	13.58	14.09	14.43	15.04
2017	0.00	0.10	0.69	1.53	2.45	3.24	4.13	5.14	6.04	7.27	8.25	9.25	10.23	11.17	11.97	12.80	13.32	13.91	14.38	14.85	15.50
2018	0.01	0.12	0.75	1.49	2.44	3.38	4.16	5.08	6.14	7.07	8.27	9.18	10.06	10.92	11.73	12.42	13.12	13.57	14.06	14.46	15.22
2019	0.00	0.16	0.47	1.59	2.46	3.47	4.41	5.22	6.21	7.36	8.33	9.53	10.41	11.26	12.06	12.83	13.47	14.13	14.54	15.01	15.65
2020	0.01	0.03	0.69	1.21	2.54	3.43	4.43	5.41	6.28	7.31	8.44	9.34	10.42	11.20	11.94	12.64	13.31	13.86	14.44	14.80	15.49
2021	0.01	0.11	0.85	1.48	2.06	3.33	4.14	5.08	6.02	6.82	7.75	8.72	9.48	10.37	11.01	11.61	12.18	12.72	13.17	13.64	14.33

Table 2.27b (page 1 of 5)—Weight (kg) at age (survey, Model 19.12a).

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	0.08	0.43	1.10	1.97	2.97	4.05	5.16	6.27	7.34	8.38	9.35	10.27	11.12	11.90	12.62	13.26	13.85	14.37	14.83	15.91
1978	0.01	0.06	0.34	1.02	1.91	2.96	4.12	5.33	6.56	7.77	8.94	10.05	11.11	12.09	13.00	13.84	14.60	15.28	15.90	16.45	17.73
1979	0.02	0.06	0.43	1.02	1.96	2.96	4.05	5.17	6.28	7.37	8.42	9.41	10.33	11.20	11.99	12.72	13.37	13.97	14.50	14.97	16.00
1980	0.02	0.07	0.36	1.04	1.80	2.88	3.95	5.06	6.17	7.26	8.31	9.31	10.25	11.12	11.92	12.65	13.32	13.92	14.46	14.94	15.95
1981	0.02	0.06	0.32	0.99	1.89	2.77	3.92	5.00	6.09	7.15	8.17	9.13	10.04	10.88	11.66	12.37	13.01	13.59	14.11	14.57	15.53
1982	0.02	0.05	0.36	0.98	1.93	3.03	4.02	5.23	6.35	7.44	8.48	9.46	10.38	11.24	12.03	12.75	13.40	13.98	14.51	14.97	15.93
1983	0.01	0.04	0.42	0.97	1.82	2.96	4.19	5.24	6.52	7.67	8.77	9.82	10.80	11.71	12.55	13.32	14.02	14.65	15.22	15.72	16.75
1984	0.02	0.10	0.44	1.10	1.76	2.64	3.67	4.70	5.54	6.52	7.37	8.18	8.92	9.61	10.24	10.81	11.33	11.80	12.21	12.58	13.34
1985	0.01	0.06	0.30	1.04	1.97	2.86	3.99	5.31	6.62	7.69	8.94	10.03	11.05	12.01	12.89	13.69	14.43	15.09	15.68	16.21	17.30
1986	0.01	0.03	0.35	0.88	1.90	3.02	4.00	5.22	6.59	7.93	9.01	10.24	11.31	12.31	13.24	14.09	14.86	15.55	16.18	16.73	17.90
1987	0.02	0.06	0.34	1.02	1.76	2.95	4.12	5.10	6.26	7.52	8.72	9.67	10.75	11.66	12.50	13.28	13.98	14.61	15.18	15.68	16.75
1988	0.01	0.05	0.32	0.97	1.94	2.87	4.29	5.61	6.70	7.96	9.32	10.60	11.60	12.73	13.69	14.56	15.36	16.08	16.73	17.30	18.54
1989	0.02	0.05	0.34	0.97	1.91	3.09	4.12	5.60	6.92	7.98	9.19	10.47	11.65	12.57	13.59	14.44	15.22	15.92	16.55	17.12	18.34
1990	0.02	0.05	0.39	1.00	1.88	2.96	4.17	5.18	6.57	7.77	8.71	9.76	10.85	11.85	12.62	13.46	14.16	14.79	15.36	15.86	16.97
1991	0.01	0.06	0.40	1.00	1.78	2.74	3.83	5.00	5.93	7.19	8.25	9.07	9.97	10.91	11.76	12.40	13.10	13.67	14.19	14.65	15.66
1992	0.02	0.06	0.35	0.99	1.76	2.65	3.68	4.78	5.93	6.84	8.03	9.03	9.79	10.63	11.49	12.26	12.84	13.47	13.99	14.45	15.44
1993	0.02	0.06	0.45	1.10	2.05	3.05	4.11	5.28	6.49	7.72	8.66	9.89	10.90	11.67	12.50	13.35	14.10	14.66	15.26	15.76	16.73
1994	0.02	0.07	0.36	1.05	1.85	2.90	3.92	4.98	6.09	7.24	8.38	9.24	10.36	11.27	11.96	12.70	13.44	14.10	14.59	15.12	15.94
1995	0.02	0.05	0.34	0.96	1.90	2.86	4.02	5.12	6.22	7.36	8.51	9.64	10.49	11.59	12.47	13.13	13.84	14.55	15.18	15.64	16.59
1996	0.03	0.08	0.42	1.05	1.90	2.95	3.91	5.00	5.98	6.92	7.87	8.80	9.70	10.37	11.22	11.89	12.39	12.91	13.44	13.90	14.53
1997	0.01	0.06	0.35	0.96	1.75	2.69	3.80	4.78	5.87	6.84	7.76	8.68	9.59	10.45	11.09	11.90	12.53	13.00	13.50	13.99	14.56
1998	0.01	0.05	0.34	0.95	1.76	2.67	3.68	4.81	5.78	6.83	7.75	8.62	9.48	10.31	11.10	11.68	12.40	12.97	13.39	13.83	14.54
1999	0.01	0.05	0.32	0.95	1.82	2.81	3.83	4.92	6.10	7.10	8.15	9.06	9.91	10.74	11.54	12.30	12.85	13.53	14.06	14.45	15.24
2000	0.02	0.05	0.45	0.96	1.87	2.94	4.06	5.18	6.33	7.54	8.55	9.60	10.50	11.33	12.15	12.92	13.64	14.17	14.81	15.31	16.30
2001	0.02	0.07	0.42	1.13	1.79	2.81	3.92	5.02	6.08	7.14	8.23	9.13	10.05	10.83	11.55	12.24	12.89	13.50	13.94	14.47	15.53
2002	0.02	0.07	0.42	1.04	1.97	2.74	3.86	5.03	6.16	7.22	8.27	9.35	10.23	11.12	11.88	12.56	13.22	13.84	14.41	14.82	15.71
2003	0.02	0.07	0.37	1.04	1.87	2.94	3.79	4.97	6.17	7.30	8.36	9.39	10.43	11.27	12.13	12.85	13.49	14.11	14.69	15.22	16.24
2004	0.02	0.07	0.47	1.03	1.93	2.88	4.02	4.87	6.02	7.14	8.18	9.13	10.05	10.97	11.70	12.44	13.04	13.59	14.11	14.59	15.41
2005	0.02	0.08	0.36	1.13	1.88	2.95	4.02	5.24	6.14	7.32	8.46	9.51	10.46	11.37	12.28	13.00	13.72	14.31	14.83	15.33	16.33
2006	0.02	0.04	0.36	1.00	2.03	2.88	4.03	5.10	6.30	7.15	8.26	9.32	10.27	11.13	11.94	12.74	13.37	13.99	14.50	14.96	16.03
2007	0.02	0.04	0.32	0.99	1.87	3.09	4.03	5.24	6.35	7.55	8.39	9.48	10.50	11.41	12.23	12.99	13.74	14.32	14.90	15.37	16.64
2008	0.02	0.03	0.30	0.90	1.80	2.82	4.13	5.10	6.31	7.39	8.55	9.36	10.38	11.34	12.19	12.94	13.65	14.33	14.86	15.38	16.35
2009	0.01	0.03	0.33	0.90	1.73	2.80	3.91	5.25	6.22	7.39	8.42	9.51	10.26	11.20	12.07	12.84	13.51	14.13	14.73	15.20	15.94
2010	0.02	0.05	0.38	0.94	1.71	2.67	3.80	4.92	6.21	7.11	8.19	9.12	10.10	10.76	11.58	12.34	13.00	13.58	14.11	14.62	15.27
2011	0.02	0.06	0.30	0.98	1.72	2.62	3.66	4.83	5.95	7.21	8.08	9.11	9.99	10.90	11.52	12.28	12.97	13.57	14.09	14.57	15.37
2012	0.01	0.03	0.35	0.87	1.79	2.65	3.63	4.72	5.89	6.98	8.20	9.02	9.99	10.80	11.64	12.20	12.90	13.52	14.06	14.52	15.15
2013	0.01	0.06	0.34	0.97	1.69	2.81	3.78	4.83	5.96	7.14	8.23	9.42	10.22	11.15	11.93	12.72	13.25	13.90	14.48	14.97	15.77
2014	0.01	0.04	0.35	0.90	1.76	2.61	3.84	4.86	5.94	7.07	8.24	9.30	10.45	11.22	12.11	12.84	13.59	14.08	14.68	15.22	16.14
2015	0.02	0.05	0.42	0.92	1.68	2.68	3.60	4.87	5.88	6.92	8.00	9.10	10.09	11.15	11.84	12.64	13.30	13.97	14.40	14.93	15.88
2016	0.02	0.09	0.45	1.08	1.77	2.69	3.81	4.79	6.09	7.10	8.13	9.17	10.23	11.16	12.14	12.79	13.53	14.13	14.73	15.12	15.85
2017	0.01	0.10	0.44	1.11	1.96	2.78	3.81	5.01	6.03	7.34	8.34	9.35	10.36	11.37	12.25	13.18	13.79	14.47	15.03	15.58	16.36
2018	0.03	0.11	0.53	1.14	2.03	3.02	3.91	4.97	6.14	7.12	8.35	9.27	10.19	11.10	11.99	12.77	13.58	14.10	14.68	15.15	16.05
2019	0.02	0.10	0.30	1.24	2.05	3.11	4.21	5.16	6.27	7.47	8.45	9.67	10.58	11.47	12.35	13.20	13.94	14.71	15.20	15.74	16.49
2020	0.02	0.04	0.49	0.88	2.14	3.07	4.20	5.33	6.27	7.34	8.49	9.41	10.54	11.38	12.19	12.98	13.75	14.40	15.07	15.50	16.33
2021	0.02	0.10	0.62	1.10	1.59	2.95	3.87	4.95	5.98	6.83	7.78	8.78	9.57	10.53	11.23	11.91	12.57	13.20	13.74	14.28	15.11

Table 2.27b (page 2 of 5)—Weight (kg) at age (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	0.08	0.43	1.08	1.94	2.94	4.03	5.17	6.33	7.49	8.63	9.74	10.80	11.80	12.75	13.64	14.45	15.19	15.86	16.47	17.97
1978	0.01	0.06	0.34	1.01	1.87	2.92	4.09	5.34	6.63	7.93	9.23	10.49	11.72	12.89	13.99	15.03	15.99	16.87	17.67	18.38	20.18
1979	0.02	0.06	0.43	1.00	1.93	2.93	4.03	5.18	6.35	7.52	8.68	9.79	10.87	11.89	12.85	13.75	14.58	15.33	16.02	16.63	18.08
1980	0.02	0.07	0.36	1.02	1.77	2.84	3.93	5.07	6.24	7.42	8.57	9.70	10.78	11.82	12.79	13.70	14.54	15.31	16.00	16.62	18.05
1981	0.02	0.06	0.32	0.97	1.86	2.74	3.89	5.01	6.16	7.30	8.42	9.51	10.56	11.56	12.50	13.38	14.19	14.93	15.59	16.19	17.54
1982	0.02	0.05	0.35	0.96	1.90	2.99	3.99	5.24	6.42	7.59	8.74	9.85	10.91	11.93	12.88	13.77	14.59	15.34	16.01	16.62	17.97
1983	0.02	0.04	0.47	0.95	1.79	2.91	4.16	5.25	6.59	7.83	9.04	10.23	11.36	12.45	13.47	14.43	15.31	16.11	16.84	17.49	18.95
1984	0.02	0.12	0.44	1.15	1.73	2.60	3.64	4.70	5.59	6.65	7.59	8.49	9.35	10.16	10.92	11.63	12.28	12.87	13.40	13.87	14.94
1985	0.01	0.06	0.30	1.03	2.03	2.81	3.95	5.30	6.69	7.85	9.22	10.46	11.64	12.78	13.85	14.85	15.77	16.62	17.38	18.07	19.62
1986	0.01	0.03	0.35	0.87	1.88	3.08	3.97	5.21	6.65	8.10	9.29	10.69	11.93	13.12	14.24	15.30	16.27	17.16	17.97	18.69	20.36
1987	0.02	0.06	0.34	1.01	1.73	2.92	4.20	5.10	6.31	7.67	8.99	10.07	11.31	12.40	13.42	14.38	15.26	16.07	16.80	17.46	18.99
1988	0.02	0.05	0.32	0.95	1.90	2.82	4.26	5.74	6.75	8.10	9.61	11.06	12.23	13.57	14.73	15.82	16.83	17.75	18.58	19.33	21.12
1989	0.02	0.05	0.34	0.96	1.88	3.05	4.08	5.61	7.12	8.13	9.45	10.90	12.27	13.37	14.61	15.67	16.65	17.55	18.36	19.09	20.87
1990	0.02	0.05	0.39	0.99	1.85	2.92	4.14	5.18	6.65	8.04	8.95	10.13	11.40	12.59	13.52	14.56	15.44	16.25	16.98	17.63	19.24
1991	0.01	0.06	0.41	0.99	1.76	2.71	3.81	5.01	5.98	7.34	8.60	9.42	10.46	11.57	12.59	13.39	14.27	15.01	15.67	16.27	17.74
1992	0.02	0.06	0.35	0.99	1.74	2.62	3.65	4.79	5.99	6.96	8.28	9.50	10.28	11.27	12.31	13.27	14.00	14.80	15.47	16.06	17.51
1993	0.02	0.06	0.43	1.08	2.03	3.02	4.09	5.28	6.56	7.87	8.90	10.30	11.56	12.36	13.36	14.41	15.35	16.07	16.85	17.49	18.91
1994	0.02	0.07	0.36	1.01	1.82	2.88	3.90	4.98	6.15	7.38	8.63	9.60	10.90	12.06	12.80	13.71	14.66	15.50	16.13	16.82	18.01
1995	0.01	0.06	0.35	0.96	1.85	2.82	4.02	5.14	6.28	7.51	8.77	10.04	11.02	12.33	13.48	14.21	15.10	16.01	16.82	17.42	18.78
1996	0.03	0.08	0.42	1.04	1.88	2.89	3.89	5.02	6.04	7.05	8.09	9.14	10.17	10.96	11.98	12.88	13.43	14.10	14.77	15.36	16.25
1997	0.01	0.06	0.35	0.95	1.73	2.67	3.75	4.79	5.95	6.98	7.98	9.02	10.07	11.09	11.86	12.86	13.72	14.25	14.89	15.52	16.32
1998	0.01	0.05	0.34	0.94	1.73	2.64	3.67	4.79	5.84	6.99	7.99	8.96	9.95	10.93	11.89	12.60	13.51	14.29	14.76	15.33	16.29
1999	0.01	0.05	0.32	0.94	1.79	2.77	3.81	4.94	6.14	7.23	8.41	9.43	10.40	11.39	12.35	13.29	13.97	14.85	15.58	16.02	17.12
2000	0.02	0.04	0.44	0.95	1.84	2.90	4.03	5.19	6.40	7.66	8.80	10.01	11.04	12.02	13.00	13.95	14.86	15.52	16.36	17.05	18.38
2001	0.02	0.07	0.42	1.10	1.77	2.78	3.90	5.03	6.14	7.29	8.45	9.48	10.57	11.48	12.34	13.20	14.01	14.78	15.34	16.04	17.54
2002	0.02	0.07	0.41	1.03	1.92	2.71	3.83	5.03	6.22	7.37	8.53	9.71	10.74	11.82	12.73	13.57	14.40	15.18	15.92	16.45	17.85
2003	0.02	0.07	0.37	1.02	1.83	2.89	3.76	4.98	6.23	7.45	8.62	9.78	10.95	11.97	13.03	13.91	14.72	15.51	16.25	16.94	18.54
2004	0.02	0.07	0.46	1.01	1.90	2.85	3.98	4.88	6.07	7.28	8.42	9.50	10.56	11.61	12.52	13.45	14.20	14.90	15.57	16.19	17.54
2005	0.02	0.08	0.36	1.11	1.85	2.92	3.99	5.23	6.20	7.46	8.72	9.90	11.01	12.09	13.15	14.06	14.98	15.73	16.40	17.05	18.65
2006	0.02	0.04	0.36	0.98	1.99	2.84	4.00	5.11	6.35	7.29	8.51	9.69	10.80	11.81	12.80	13.76	14.57	15.38	16.02	16.61	18.29
2007	0.02	0.04	0.33	0.98	1.84	3.04	4.00	5.25	6.41	7.69	8.64	9.86	11.04	12.12	13.11	14.06	14.97	15.73	16.49	17.09	19.03
2008	0.02	0.03	0.30	0.90	1.77	2.78	4.09	5.10	6.38	7.54	8.80	9.74	10.92	12.05	13.08	14.01	14.90	15.75	16.45	17.14	18.81
2009	0.01	0.03	0.33	0.89	1.72	2.77	3.88	5.26	6.28	7.55	8.68	9.89	10.78	11.89	12.94	13.89	14.74	15.54	16.29	16.90	18.19
2010	0.02	0.05	0.38	0.92	1.68	2.66	3.78	4.92	6.27	7.25	8.44	9.50	10.60	11.41	12.40	13.34	14.17	14.90	15.59	16.23	17.30
2011	0.02	0.06	0.30	0.96	1.68	2.59	3.66	4.84	6.00	7.36	8.32	9.49	10.51	11.57	12.34	13.28	14.15	14.91	15.59	16.21	17.42
2012	0.01	0.03	0.36	0.86	1.76	2.61	3.61	4.74	5.95	7.12	8.45	9.39	10.51	11.48	12.48	13.19	14.06	14.86	15.55	16.16	17.10
2013	0.01	0.06	0.34	0.97	1.67	2.77	3.74	4.83	6.03	7.29	8.47	9.81	10.74	11.85	12.80	13.77	14.45	15.27	16.02	16.66	17.80
2014	0.01	0.05	0.34	0.89	1.74	2.58	3.81	4.85	6.00	7.23	8.50	9.69	11.01	11.93	13.01	13.93	14.86	15.50	16.28	16.97	18.28
2015	0.02	0.05	0.42	0.90	1.65	2.65	3.58	4.87	5.92	7.06	8.26	9.49	10.62	11.87	12.72	13.72	14.55	15.39	15.97	16.65	18.02
2016	0.02	0.09	0.46	1.07	1.73	2.65	3.80	4.80	6.15	7.23	8.38	9.57	10.77	11.86	13.06	13.86	14.79	15.57	16.33	16.85	17.92
2017	0.01	0.10	0.44	1.10	1.93	2.73	3.78	5.03	6.09	7.48	8.58	9.73	10.92	12.10	13.16	14.31	15.08	15.96	16.68	17.39	18.53
2018	0.03	0.11	0.52	1.12	2.01	2.98	3.87	4.97	6.22	7.26	8.60	9.64	10.71	11.80	12.86	13.82	14.83	15.50	16.26	16.87	18.16
2019	0.01	0.10	0.30	1.21	2.02	3.09	4.19	5.15	6.33	7.64	8.71	10.07	11.11	12.18	13.26	14.31	15.23	16.20	16.84	17.55	18.71
2020	0.02	0.04	0.47	0.88	2.10	3.03	4.20	5.35	6.32	7.49	8.77	9.80	11.09	12.07	13.07	14.06	15.01	15.84	16.71	17.27	18.51
2021	0.02	0.10	0.54	1.07	1.58	2.92	3.85	4.99	6.06	6.96	8.01	9.15	10.06	11.19	12.03	12.89	13.72	14.52	15.20	15.91	17.13

Table 2.27b (page 3 of 5)—Weight (kg) at age (survey, Model 21.1).

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	1.07	1.93	2.91	3.92	4.94	5.92	6.84	7.70	8.49	9.21	9.85	10.42	10.92	11.36	11.75	12.08	12.37	12.92
1978	0.01	0.05	0.33	0.99	1.87	2.89	3.98	5.08	6.17	7.20	8.17	9.07	9.89	10.62	11.28	11.86	12.37	12.82	13.21	13.55	14.20
1979	0.02	0.06	0.42	1.02	1.92	2.90	3.92	4.94	5.93	6.87	7.74	8.54	9.26	9.91	10.49	10.99	11.44	11.83	12.17	12.47	13.05
1980	0.02	0.07	0.35	1.04	1.81	2.81	3.82	4.84	5.82	6.76	7.63	8.43	9.16	9.82	10.40	10.91	11.36	11.76	12.10	12.40	13.00
1981	0.02	0.06	0.31	0.99	1.90	2.76	3.79	4.78	5.75	6.66	7.51	8.29	8.99	9.62	10.19	10.69	11.12	11.50	11.84	12.12	12.71
1982	0.02	0.05	0.35	0.98	1.94	3.00	3.94	5.01	6.00	6.93	7.80	8.60	9.32	9.97	10.54	11.05	11.49	11.88	12.22	12.51	13.12
1983	0.01	0.04	0.41	0.98	1.83	2.94	4.09	5.06	6.15	7.13	8.06	8.90	9.67	10.36	10.97	11.51	11.99	12.40	12.77	13.08	13.74
1984	0.02	0.10	0.43	1.10	1.79	2.64	3.62	4.55	5.30	6.11	6.81	7.46	8.03	8.55	9.01	9.41	9.76	10.06	10.33	10.56	11.04
1985	0.01	0.06	0.29	1.05	1.98	2.86	3.92	5.13	6.28	7.20	8.19	9.06	9.86	10.57	11.20	11.76	12.26	12.69	13.07	13.39	14.09
1986	0.01	0.03	0.35	0.88	1.91	2.99	3.93	5.03	6.26	7.40	8.30	9.26	10.09	10.84	11.51	12.10	12.63	13.08	13.48	13.83	14.58
1987	0.02	0.06	0.34	1.03	1.77	2.94	4.03	4.94	5.96	7.05	8.04	8.81	9.61	10.29	10.91	11.45	11.92	12.34	12.70	13.01	13.70
1988	0.02	0.05	0.32	0.98	1.96	2.85	4.20	5.40	6.37	7.45	8.58	9.60	10.38	11.19	11.88	12.49	13.03	13.50	13.91	14.26	15.06
1989	0.02	0.05	0.33	0.99	1.94	3.09	4.05	5.41	6.57	7.49	8.47	9.50	10.40	11.08	11.78	12.38	12.90	13.36	13.75	14.10	14.88
1990	0.02	0.05	0.38	1.01	1.90	2.95	4.10	5.01	6.25	7.28	8.07	8.91	9.78	10.52	11.08	11.65	12.13	12.55	12.91	13.22	13.94
1991	0.01	0.06	0.39	1.01	1.80	2.76	3.79	4.85	5.67	6.74	7.62	8.28	8.97	9.67	10.27	10.72	11.18	11.55	11.88	12.17	12.82
1992	0.02	0.06	0.35	1.00	1.77	2.64	3.62	4.63	5.66	6.42	7.42	8.23	8.83	9.45	10.08	10.61	11.01	11.41	11.74	12.03	12.67
1993	0.02	0.06	0.46	1.11	2.06	3.03	4.04	5.13	6.20	7.25	8.03	9.02	9.81	10.39	10.99	11.58	12.09	12.46	12.83	13.14	13.77
1994	0.01	0.07	0.36	1.09	1.88	2.90	3.86	4.83	5.83	6.80	7.74	8.42	9.28	9.95	10.45	10.96	11.46	11.89	12.20	12.51	13.04
1995	0.02	0.06	0.34	0.98	1.95	2.86	3.96	4.95	5.92	6.92	7.86	8.76	9.41	10.23	10.86	11.32	11.80	12.26	12.65	12.93	13.54
1996	0.03	0.08	0.41	1.07	1.92	2.97	3.85	4.85	5.71	6.52	7.32	8.07	8.77	9.27	9.89	10.36	10.70	11.04	11.38	11.66	12.07
1997	0.01	0.06	0.35	0.97	1.78	2.70	3.77	4.64	5.60	6.42	7.18	7.93	8.63	9.28	9.73	10.29	10.72	11.03	11.34	11.65	12.01
1998	0.01	0.05	0.34	0.96	1.79	2.70	3.66	4.71	5.54	6.42	7.17	7.85	8.51	9.12	9.68	10.07	10.55	10.91	11.17	11.44	11.88
1999	0.01	0.05	0.31	0.96	1.84	2.80	3.78	4.78	5.85	6.67	7.54	8.26	8.92	9.56	10.14	10.67	11.03	11.48	11.82	12.06	12.57
2000	0.02	0.05	0.45	0.97	1.88	2.92	3.98	5.02	6.04	7.11	7.93	8.78	9.48	10.11	10.72	11.26	11.75	12.10	12.51	12.82	13.46
2001	0.02	0.07	0.42	1.14	1.80	2.80	3.85	4.86	5.81	6.72	7.67	8.37	9.09	9.68	10.21	10.71	11.15	11.56	11.83	12.17	12.85
2002	0.02	0.07	0.41	1.06	1.98	2.73	3.80	4.87	5.87	6.79	7.67	8.56	9.21	9.89	10.43	10.91	11.37	11.77	12.14	12.39	12.99
2003	0.02	0.07	0.37	1.05	1.89	2.93	3.72	4.82	5.88	6.85	7.73	8.56	9.39	9.99	10.61	11.11	11.55	11.96	12.33	12.65	13.32
2004	0.02	0.07	0.47	1.04	1.95	2.88	3.95	4.72	5.75	6.71	7.58	8.35	9.06	9.76	10.27	10.79	11.20	11.56	11.90	12.20	12.75
2005	0.02	0.08	0.36	1.15	1.89	2.94	3.95	5.06	5.84	6.88	7.83	8.68	9.42	10.11	10.78	11.26	11.75	12.14	12.47	12.79	13.45
2006	0.02	0.04	0.35	1.00	2.03	2.86	3.94	4.93	6.00	6.73	7.68	8.54	9.30	9.96	10.55	11.13	11.55	11.96	12.29	12.57	13.30
2007	0.02	0.04	0.31	0.99	1.87	3.05	3.94	5.06	6.05	7.10	7.80	8.71	9.52	10.22	10.82	11.37	11.89	12.27	12.64	12.93	13.78
2008	0.02	0.03	0.29	0.90	1.80	2.79	4.03	4.92	6.00	6.94	7.91	8.56	9.38	10.11	10.73	11.27	11.75	12.21	12.53	12.86	13.58
2009	0.01	0.03	0.33	0.90	1.73	2.78	3.83	5.07	5.92	6.93	7.80	8.67	9.25	9.97	10.61	11.15	11.61	12.02	12.41	12.69	13.24
2010	0.02	0.05	0.38	0.96	1.72	2.66	3.74	4.76	5.91	6.67	7.57	8.33	9.08	9.57	10.18	10.71	11.15	11.53	11.87	12.19	12.65
2011	0.01	0.06	0.29	0.99	1.74	2.60	3.59	4.67	5.66	6.76	7.47	8.30	8.99	9.67	10.11	10.65	11.12	11.51	11.85	12.14	12.67
2012	0.01	0.03	0.36	0.87	1.79	2.64	3.55	4.55	5.61	6.56	7.59	8.26	9.02	9.64	10.25	10.64	11.13	11.54	11.89	12.18	12.61
2013	0.01	0.06	0.34	1.00	1.71	2.82	3.74	4.69	5.68	6.70	7.59	8.54	9.15	9.83	10.39	10.93	11.28	11.70	12.07	12.37	12.88
2014	0.01	0.05	0.35	0.91	1.79	2.60	3.77	4.71	5.65	6.62	7.61	8.46	9.35	9.92	10.56	11.08	11.58	11.89	12.28	12.61	13.21
2015	0.01	0.05	0.42	0.94	1.70	2.69	3.54	4.71	5.61	6.49	7.38	8.26	9.02	9.81	10.30	10.85	11.30	11.72	11.99	12.32	12.95
2016	0.02	0.09	0.45	1.10	1.81	2.70	3.77	4.65	5.80	6.67	7.50	8.33	9.14	9.82	10.53	10.97	11.45	11.84	12.22	12.45	12.94
2017	0.02	0.09	0.44	1.13	1.99	2.80	3.77	4.87	5.74	6.87	7.70	8.48	9.25	10.00	10.62	11.26	11.66	12.10	12.44	12.78	13.28
2018	0.03	0.11	0.53	1.16	2.05	3.01	3.86	4.81	5.87	6.68	7.70	8.45	9.14	9.81	10.46	11.00	11.54	11.87	12.24	12.53	13.11
2019	0.01	0.10	0.29	1.25	2.05	3.07	4.11	4.99	5.96	7.02	7.82	8.83	9.55	10.21	10.85	11.46	11.97	12.47	12.78	13.12	13.64
2020	0.02	0.04	0.48	0.88	2.16	3.05	4.11	5.14	5.98	6.89	7.85	8.57	9.46	10.09	10.66	11.21	11.74	12.17	12.60	12.86	13.40
2021	0.02	0.10	0.61	1.11	1.61	2.97	3.83	4.79	5.69	6.41	7.18	7.97	8.56	9.27	9.77	10.23	10.66	11.07	11.40	11.73	12.27

Table 2.27b (page 4 of 5)—Weight (kg) at age (survey, Model 21.2).

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	0.43	1.09	1.95	2.94	4.00	5.10	6.20	7.28	8.32	9.30	10.23	11.10	11.90	12.63	13.30	13.91	14.46	14.95	16.12
1978	0.01	0.06	0.34	1.01	1.88	2.92	4.06	5.27	6.48	7.69	8.87	9.99	11.06	12.06	13.00	13.86	14.64	15.36	16.00	16.58	17.98
1979	0.02	0.06	0.43	1.01	1.93	2.93	4.00	5.11	6.22	7.31	8.36	9.35	10.29	11.17	11.99	12.73	13.42	14.03	14.59	15.09	16.21
1980	0.02	0.07	0.36	1.03	1.79	2.84	3.90	5.00	6.11	7.20	8.25	9.26	10.20	11.09	11.91	12.67	13.36	13.99	14.55	15.06	16.16
1981	0.02	0.06	0.32	0.98	1.87	2.75	3.87	4.95	6.03	7.09	8.11	9.08	10.00	10.86	11.65	12.38	13.05	13.65	14.20	14.69	15.73
1982	0.02	0.05	0.36	0.98	1.92	3.00	3.98	5.18	6.29	7.37	8.42	9.41	10.34	11.22	12.02	12.76	13.44	14.05	14.60	15.09	16.14
1983	0.01	0.04	0.42	0.97	1.82	2.93	4.14	5.20	6.45	7.60	8.70	9.76	10.76	11.69	12.55	13.34	14.07	14.73	15.32	15.85	16.98
1984	0.02	0.10	0.44	1.09	1.76	2.62	3.63	4.65	5.50	6.47	7.33	8.13	8.89	9.59	10.24	10.83	11.36	11.85	12.29	12.67	13.50
1985	0.01	0.06	0.31	1.04	1.96	2.84	3.96	5.25	6.55	7.63	8.87	9.97	11.01	11.98	12.88	13.71	14.47	15.16	15.78	16.34	17.54
1986	0.01	0.03	0.35	0.88	1.89	2.99	3.97	5.17	6.53	7.86	8.95	10.18	11.27	12.28	13.23	14.10	14.90	15.63	16.28	16.87	18.15
1987	0.02	0.06	0.34	1.02	1.75	2.93	4.09	5.06	6.21	7.46	8.66	9.63	10.70	11.63	12.50	13.30	14.02	14.68	15.27	15.81	16.97
1988	0.02	0.05	0.32	0.96	1.92	2.85	4.25	5.56	6.64	7.90	9.26	10.54	11.56	12.70	13.68	14.58	15.41	16.16	16.84	17.45	18.80
1989	0.02	0.05	0.34	0.97	1.90	3.06	4.08	5.55	6.87	7.93	9.14	10.41	11.61	12.55	13.58	14.46	15.27	16.00	16.66	17.26	18.59
1990	0.02	0.05	0.39	1.00	1.86	2.93	4.13	5.14	6.52	7.72	8.66	9.72	10.82	11.83	12.62	13.48	14.20	14.86	15.46	15.99	17.20
1991	0.01	0.06	0.40	0.99	1.77	2.72	3.80	4.96	5.89	7.14	8.20	9.03	9.95	10.89	11.75	12.42	13.14	13.74	14.28	14.77	15.88
1992	0.02	0.06	0.36	0.99	1.75	2.63	3.64	4.74	5.88	6.79	7.99	8.99	9.77	10.62	11.49	12.28	12.88	13.54	14.08	14.56	15.65
1993	0.02	0.06	0.45	1.09	2.03	3.02	4.08	5.23	6.44	7.66	8.61	9.85	10.87	11.65	12.50	13.37	14.14	14.73	15.36	15.88	16.94
1994	0.02	0.07	0.36	1.05	1.84	2.87	3.88	4.93	6.04	7.18	8.32	9.20	10.33	11.26	11.96	12.72	13.49	14.17	14.69	15.24	16.14
1995	0.02	0.06	0.34	0.96	1.89	2.84	3.99	5.07	6.17	7.30	8.45	9.59	10.46	11.57	12.48	13.16	13.89	14.63	15.28	15.77	16.80
1996	0.03	0.08	0.42	1.05	1.89	2.93	3.88	4.96	5.93	6.87	7.82	8.76	9.68	10.36	11.22	11.91	12.43	12.98	13.53	14.00	14.68
1997	0.01	0.06	0.35	0.96	1.74	2.68	3.77	4.74	5.82	6.78	7.71	8.64	9.55	10.44	11.10	11.92	12.58	13.07	13.59	14.10	14.72
1998	0.01	0.05	0.34	0.94	1.75	2.65	3.65	4.77	5.74	6.79	7.70	8.58	9.45	10.29	11.10	11.70	12.45	13.04	13.48	13.94	14.70
1999	0.01	0.05	0.32	0.96	1.81	2.79	3.80	4.88	6.06	7.04	8.10	9.01	9.88	10.72	11.54	12.32	12.89	13.60	14.16	14.57	15.41
2000	0.02	0.05	0.45	0.97	1.86	2.91	4.03	5.13	6.28	7.49	8.50	9.56	10.47	11.32	12.15	12.94	13.69	14.24	14.91	15.44	16.49
2001	0.02	0.07	0.41	1.12	1.79	2.80	3.89	4.98	6.03	7.09	8.19	9.09	10.02	10.81	11.55	12.26	12.94	13.57	14.03	14.59	15.72
2002	0.02	0.06	0.40	1.02	1.95	2.72	3.84	4.98	6.11	7.17	8.23	9.32	10.20	11.11	11.88	12.58	13.27	13.91	14.51	14.94	15.90
2003	0.02	0.06	0.36	1.02	1.83	2.91	3.76	4.94	6.11	7.25	8.30	9.35	10.41	11.26	12.14	12.87	13.54	14.18	14.79	15.35	16.44
2004	0.02	0.07	0.46	1.01	1.89	2.84	3.98	4.84	5.98	7.09	8.13	9.09	10.02	10.96	11.70	12.46	13.09	13.66	14.20	14.71	15.59
2005	0.02	0.08	0.35	1.12	1.85	2.90	3.96	5.19	6.09	7.27	8.41	9.47	10.43	11.36	12.29	13.02	13.77	14.38	14.93	15.46	16.53
2006	0.02	0.04	0.36	0.98	2.00	2.84	3.96	5.03	6.24	7.11	8.22	9.27	10.24	11.11	11.95	12.77	13.42	14.07	14.60	15.08	16.23
2007	0.02	0.04	0.33	0.99	1.84	3.05	3.97	5.16	6.27	7.49	8.35	9.44	10.46	11.40	12.23	13.02	13.80	14.40	15.01	15.50	16.86
2008	0.02	0.04	0.31	0.91	1.79	2.77	4.07	5.03	6.22	7.31	8.49	9.32	10.36	11.32	12.20	12.97	13.70	14.41	14.96	15.51	16.57
2009	0.01	0.03	0.34	0.91	1.75	2.78	3.85	5.19	6.14	7.31	8.35	9.46	10.23	11.19	12.07	12.86	13.56	14.21	14.84	15.32	16.14
2010	0.02	0.05	0.39	0.94	1.71	2.68	3.77	4.85	6.14	7.04	8.11	9.06	10.06	10.74	11.59	12.36	13.05	13.65	14.20	14.74	15.45
2011	0.02	0.06	0.31	0.98	1.71	2.61	3.66	4.79	5.87	7.14	8.01	9.04	9.94	10.88	11.52	12.31	13.02	13.65	14.19	14.69	15.55
2012	0.01	0.03	0.35	0.88	1.79	2.64	3.62	4.70	5.84	6.91	8.13	8.96	9.93	10.77	11.64	12.23	12.95	13.59	14.16	14.64	15.34
2013	0.01	0.05	0.34	0.96	1.70	2.80	3.75	4.80	5.93	7.09	8.16	9.36	10.17	11.11	11.91	12.74	13.30	13.97	14.57	15.10	15.99
2014	0.01	0.04	0.33	0.90	1.74	2.61	3.82	4.82	5.90	7.04	8.19	9.23	10.41	11.18	12.09	12.85	13.64	14.16	14.79	15.35	16.38
2015	0.02	0.05	0.41	0.89	1.67	2.65	3.59	4.83	5.83	6.89	7.98	9.06	10.04	11.12	11.83	12.65	13.34	14.04	14.50	15.06	16.15
2016	0.02	0.09	0.44	1.05	1.73	2.67	3.76	4.77	6.05	7.06	8.10	9.15	10.19	11.12	12.14	12.80	13.56	14.19	14.83	15.25	16.10
2017	0.02	0.09	0.44	1.09	1.91	2.72	3.78	4.95	6.00	7.29	8.29	9.32	10.35	11.35	12.23	13.20	13.82	14.53	15.12	15.71	16.62
2018	0.03	0.11	0.53	1.13	2.00	2.96	3.83	4.92	6.08	7.09	8.31	9.24	10.17	11.10	11.99	12.77	13.62	14.16	14.77	15.27	16.30
2019	0.02	0.10	0.30	1.23	2.03	3.06	4.13	5.07	6.21	7.40	8.42	9.64	10.55	11.46	12.37	13.23	13.98	14.78	15.29	15.86	16.71
2020	0.02	0.04	0.49	0.89	2.13	3.03	4.14	5.24	6.17	7.29	8.43	9.39	10.52	11.36	12.20	13.02	13.80	14.46	15.17	15.62	16.49
2021	0.02	0.10	0.61	1.09	1.59	2.93	3.83	4.88	5.90	6.74	7.73	8.72	9.55	10.53	11.24	11.94	12.63	13.27	13.82	14.40	15.24

Table 2.27b (page 5 of 5)—Weight (kg) at age (survey, ensemble).

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	0.42	1.08	1.95	2.94	4.01	5.10	6.19	7.26	8.28	9.25	10.17	11.02	11.80	12.52	13.17	13.75	14.28	14.75	15.84
1978	0.01	0.06	0.33	1.01	1.88	2.92	4.07	5.26	6.48	7.67	8.83	9.94	10.99	11.97	12.88	13.72	14.49	15.18	15.80	16.35	17.65
1979	0.02	0.06	0.43	1.02	1.94	2.93	4.00	5.11	6.21	7.29	8.32	9.31	10.23	11.09	11.89	12.61	13.28	13.87	14.41	14.88	15.94
1980	0.02	0.07	0.36	1.04	1.80	2.84	3.90	5.00	6.10	7.18	8.22	9.21	10.14	11.01	11.81	12.55	13.22	13.82	14.37	14.85	15.90
1981	0.02	0.06	0.32	0.98	1.88	2.76	3.87	4.95	6.02	7.07	8.08	9.04	9.94	10.78	11.56	12.27	12.91	13.50	14.02	14.48	15.48
1982	0.02	0.05	0.36	0.98	1.92	3.01	3.99	5.18	6.28	7.35	8.38	9.36	10.28	11.14	11.93	12.65	13.30	13.89	14.42	14.89	15.90
1983	0.01	0.04	0.43	0.97	1.81	2.94	4.15	5.20	6.44	7.58	8.67	9.71	10.69	11.60	12.45	13.22	13.92	14.56	15.13	15.63	16.72
1984	0.02	0.11	0.44	1.11	1.76	2.62	3.64	4.66	5.49	6.45	7.30	8.09	8.83	9.52	10.15	10.72	11.24	11.71	12.13	12.50	13.29
1985	0.01	0.06	0.30	1.04	1.99	2.84	3.95	5.25	6.55	7.61	8.84	9.92	10.94	11.89	12.77	13.58	14.31	14.98	15.57	16.11	17.26
1986	0.01	0.03	0.35	0.88	1.90	3.02	3.97	5.16	6.52	7.84	8.91	10.13	11.20	12.20	13.12	13.97	14.75	15.45	16.08	16.64	17.87
1987	0.02	0.06	0.34	1.02	1.75	2.94	4.12	5.06	6.19	7.45	8.63	9.58	10.64	11.55	12.39	13.17	13.87	14.51	15.08	15.59	16.72
1988	0.01	0.05	0.32	0.97	1.93	2.85	4.25	5.59	6.63	7.87	9.22	10.49	11.49	12.61	13.56	14.44	15.25	15.97	16.62	17.20	18.51
1989	0.02	0.05	0.34	0.98	1.91	3.07	4.09	5.55	6.89	7.90	9.09	10.36	11.53	12.45	13.46	14.32	15.10	15.80	16.44	17.00	18.30
1990	0.02	0.05	0.39	1.00	1.87	2.94	4.14	5.13	6.51	7.72	8.62	9.66	10.75	11.75	12.52	13.36	14.06	14.70	15.27	15.77	16.95
1991	0.01	0.06	0.40	1.00	1.78	2.73	3.81	4.96	5.88	7.12	8.20	8.98	9.88	10.81	11.65	12.29	12.99	13.57	14.09	14.56	15.63
1992	0.02	0.06	0.35	0.99	1.75	2.64	3.65	4.74	5.88	6.77	7.96	8.97	9.70	10.54	11.40	12.17	12.75	13.38	13.90	14.37	15.42
1993	0.02	0.06	0.44	1.09	2.04	3.03	4.08	5.24	6.43	7.64	8.58	9.80	10.83	11.56	12.39	13.24	14.00	14.56	15.17	15.66	16.70
1994	0.01	0.07	0.36	1.05	1.85	2.89	3.90	4.94	6.04	7.17	8.29	9.15	10.26	11.19	11.85	12.59	13.34	14.00	14.49	15.02	15.89
1995	0.02	0.06	0.34	0.97	1.90	2.85	4.00	5.08	6.16	7.29	8.42	9.54	10.39	11.48	12.39	13.02	13.73	14.45	15.07	15.54	16.54
1996	0.03	0.08	0.42	1.05	1.90	2.93	3.89	4.96	5.92	6.85	7.80	8.72	9.62	10.28	11.13	11.82	12.30	12.83	13.36	13.81	14.47
1997	0.01	0.06	0.35	0.96	1.75	2.69	3.77	4.74	5.82	6.77	7.68	8.60	9.50	10.36	11.00	11.80	12.46	12.91	13.41	13.90	14.50
1998	0.01	0.05	0.34	0.95	1.76	2.66	3.66	4.77	5.73	6.78	7.68	8.53	9.38	10.21	11.00	11.57	12.30	12.88	13.28	13.72	14.45
1999	0.01	0.05	0.32	0.95	1.82	2.79	3.81	4.89	6.04	7.03	8.08	8.97	9.81	10.65	11.45	12.21	12.76	13.44	13.99	14.36	15.18
2000	0.02	0.05	0.45	0.96	1.86	2.92	4.03	5.14	6.27	7.47	8.47	9.52	10.41	11.24	12.06	12.83	13.56	14.08	14.73	15.25	16.26
2001	0.02	0.07	0.42	1.12	1.79	2.80	3.89	4.98	6.03	7.08	8.16	9.04	9.97	10.75	11.46	12.16	12.82	13.43	13.86	14.40	15.51
2002	0.02	0.07	0.41	1.04	1.95	2.72	3.84	4.99	6.10	7.16	8.20	9.26	10.13	11.03	11.78	12.47	13.13	13.76	14.33	14.74	15.72
2003	0.02	0.07	0.37	1.03	1.86	2.92	3.76	4.93	6.11	7.23	8.28	9.30	10.33	11.17	12.04	12.75	13.40	14.02	14.60	15.14	16.25
2004	0.02	0.07	0.47	1.03	1.92	2.87	3.99	4.83	5.97	7.07	8.10	9.05	9.96	10.87	11.60	12.35	12.95	13.50	14.03	14.51	15.43
2005	0.02	0.08	0.36	1.13	1.87	2.93	3.98	5.19	6.08	7.25	8.38	9.42	10.37	11.28	12.18	12.90	13.63	14.22	14.75	15.25	16.36
2006	0.02	0.04	0.36	0.99	2.01	2.86	3.99	5.05	6.24	7.09	8.19	9.24	10.19	11.05	11.86	12.66	13.29	13.93	14.44	14.89	16.08
2007	0.02	0.04	0.32	0.99	1.86	3.06	3.99	5.19	6.29	7.47	8.32	9.40	10.42	11.33	12.15	12.92	13.67	14.26	14.85	15.32	16.69
2008	0.02	0.03	0.30	0.90	1.79	2.79	4.09	5.04	6.24	7.32	8.47	9.27	10.30	11.25	12.11	12.86	13.57	14.25	14.79	15.32	16.45
2009	0.01	0.03	0.33	0.90	1.73	2.78	3.87	5.20	6.15	7.32	8.34	9.42	10.17	11.11	11.98	12.75	13.42	14.05	14.65	15.12	15.99
2010	0.02	0.05	0.38	0.94	1.71	2.67	3.78	4.87	6.14	7.04	8.11	9.03	10.00	10.66	11.49	12.25	12.91	13.49	14.03	14.53	15.27
2011	0.02	0.06	0.30	0.98	1.71	2.61	3.64	4.79	5.89	7.14	8.00	9.02	9.90	10.80	11.42	12.19	12.88	13.49	14.01	14.49	15.36
2012	0.01	0.03	0.35	0.87	1.78	2.63	3.61	4.68	5.84	6.91	8.12	8.94	9.90	10.72	11.56	12.13	12.83	13.45	14.00	14.46	15.15
2013	0.01	0.06	0.34	0.97	1.69	2.80	3.75	4.79	5.91	7.07	8.14	9.32	10.11	11.04	11.82	12.61	13.14	13.79	14.37	14.87	15.72
2014	0.01	0.04	0.34	0.90	1.76	2.60	3.81	4.82	5.88	7.01	8.16	9.20	10.35	11.12	12.00	12.74	13.49	13.99	14.60	15.14	16.11
2015	0.02	0.05	0.42	0.92	1.67	2.67	3.58	4.82	5.82	6.86	7.93	9.01	9.98	11.04	11.73	12.53	13.20	13.86	14.30	14.84	15.85
2016	0.02	0.09	0.45	1.08	1.76	2.68	3.79	4.76	6.03	7.03	8.05	9.09	10.12	11.04	12.03	12.67	13.41	14.02	14.62	15.02	15.80
2017	0.02	0.10	0.44	1.11	1.95	2.76	3.79	4.97	5.97	7.26	8.25	9.25	10.26	11.25	12.13	13.06	13.67	14.35	14.91	15.47	16.31
2018	0.03	0.11	0.53	1.14	2.02	3.00	3.87	4.92	6.09	7.05	8.26	9.18	10.09	11.00	11.88	12.66	13.47	13.99	14.58	15.05	16.01
2019	0.01	0.10	0.30	1.23	2.04	3.09	4.17	5.10	6.21	7.40	8.38	9.58	10.49	11.38	12.26	13.12	13.86	14.63	15.12	15.67	16.50
2020	0.02	0.04	0.48	0.88	2.13	3.05	4.17	5.27	6.20	7.27	8.41	9.32	10.44	11.27	12.09	12.88	13.65	14.30	14.98	15.41	16.30
2021	0.02	0.10	0.59	1.09	1.59	2.94	3.85	4.91	5.92	6.75	7.70	8.69	9.47	10.43	11.12	11.80	12.46	13.09	13.63	14.17	15.05

Table 2.28a (page 1 of 5)—Selectivity at age (fishery, Model 19.12a).

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	0.013	0.107	0.332	0.602	0.794	0.875	0.894	0.892	0.887	0.884	0.882	0.881	0.880	0.880	0.879	0.879	0.879	0.879	0.879
1978	0.000	0.000	0.010	0.108	0.333	0.603	0.793	0.873	0.891	0.888	0.883	0.879	0.877	0.875	0.875	0.874	0.874	0.874	0.874	0.874	0.874
1979	0.000	0.000	0.016	0.103	0.347	0.614	0.800	0.876	0.892	0.889	0.883	0.879	0.877	0.876	0.875	0.875	0.874	0.874	0.874	0.874	0.874
1980	0.000	0.000	0.012	0.116	0.320	0.611	0.799	0.879	0.898	0.897	0.892	0.889	0.887	0.886	0.885	0.885	0.885	0.885	0.884	0.884	0.884
1981	0.000	0.000	0.015	0.129	0.384	0.621	0.816	0.886	0.900	0.897	0.892	0.888	0.886	0.885	0.884	0.884	0.883	0.883	0.883	0.883	0.883
1982	0.000	0.000	0.007	0.075	0.301	0.597	0.777	0.877	0.899	0.899	0.896	0.893	0.891	0.890	0.890	0.889	0.889	0.889	0.889	0.889	0.889
1983	0.000	0.000	0.013	0.084	0.287	0.585	0.799	0.879	0.908	0.911	0.909	0.907	0.905	0.904	0.904	0.904	0.903	0.903	0.903	0.903	0.903
1984	0.000	0.001	0.019	0.136	0.330	0.592	0.806	0.897	0.918	0.921	0.919	0.917	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914
1985	0.000	0.000	0.006	0.093	0.319	0.550	0.762	0.874	0.902	0.904	0.901	0.898	0.897	0.896	0.895	0.895	0.895	0.894	0.894	0.894	0.894
1986	0.000	0.000	0.015	0.092	0.347	0.623	0.782	0.872	0.894	0.891	0.886	0.882	0.880	0.879	0.878	0.878	0.877	0.877	0.877	0.877	0.877
1987	0.000	0.000	0.007	0.088	0.263	0.581	0.788	0.867	0.897	0.900	0.897	0.894	0.892	0.891	0.891	0.890	0.890	0.890	0.890	0.890	0.890
1988	0.000	0.001	0.031	0.169	0.427	0.641	0.837	0.899	0.908	0.904	0.897	0.893	0.891	0.889	0.889	0.888	0.888	0.888	0.888	0.888	0.888
1989	0.000	0.000	0.016	0.114	0.345	0.625	0.788	0.893	0.915	0.915	0.913	0.910	0.909	0.908	0.907	0.907	0.907	0.907	0.907	0.907	0.907
1990	0.000	0.000	0.011	0.086	0.292	0.571	0.792	0.882	0.929	0.938	0.939	0.939	0.938	0.938	0.938	0.937	0.937	0.937	0.937	0.937	0.937
1991	0.000	0.000	0.011	0.091	0.287	0.556	0.775	0.883	0.912	0.921	0.920	0.919	0.918	0.917	0.916	0.916	0.916	0.916	0.916	0.916	0.916
1992	0.000	0.000	0.008	0.090	0.289	0.545	0.758	0.861	0.886	0.885	0.879	0.875	0.873	0.872	0.871	0.870	0.870	0.870	0.870	0.870	0.870
1993	0.000	0.001	0.027	0.142	0.389	0.632	0.803	0.883	0.901	0.898	0.893	0.888	0.886	0.885	0.884	0.883	0.883	0.883	0.883	0.883	0.883
1994	0.000	0.000	0.012	0.114	0.326	0.604	0.787	0.871	0.896	0.896	0.891	0.888	0.885	0.884	0.883	0.883	0.883	0.883	0.882	0.882	0.882
1995	0.000	0.000	0.014	0.109	0.355	0.605	0.801	0.878	0.898	0.897	0.892	0.888	0.886	0.885	0.884	0.884	0.883	0.883	0.883	0.883	0.883
1996	0.000	0.000	0.008	0.078	0.283	0.580	0.777	0.888	0.924	0.934	0.937	0.937	0.936	0.936	0.936	0.935	0.935	0.935	0.935	0.935	0.935
1997	0.000	0.000	0.017	0.121	0.343	0.609	0.814	0.894	0.921	0.925	0.924	0.923	0.921	0.921	0.920	0.920	0.920	0.920	0.920	0.920	0.920
1998	0.000	0.000	0.007	0.086	0.299	0.566	0.776	0.881	0.908	0.912	0.911	0.909	0.907	0.906	0.906	0.906	0.905	0.905	0.905	0.905	0.905
1999	0.000	0.000	0.007	0.085	0.305	0.580	0.778	0.873	0.900	0.900	0.896	0.893	0.892	0.890	0.890	0.889	0.889	0.889	0.889	0.889	0.889
2000	0.000	0.000	0.012	0.071	0.279	0.565	0.774	0.868	0.894	0.894	0.891	0.887	0.885	0.884	0.884	0.883	0.883	0.883	0.883	0.883	0.883
2001	0.000	0.000	0.009	0.097	0.260	0.544	0.759	0.837	0.841	0.826	0.812	0.804	0.799	0.797	0.796	0.795	0.794	0.794	0.794	0.794	0.793
2002	0.000	0.000	0.017	0.116	0.361	0.569	0.769	0.828	0.812	0.784	0.763	0.750	0.744	0.740	0.739	0.738	0.737	0.736	0.736	0.736	0.736
2003	0.000	0.000	0.014	0.117	0.336	0.620	0.770	0.865	0.884	0.879	0.872	0.867	0.864	0.862	0.861	0.861	0.861	0.860	0.860	0.860	0.860
2004	0.000	0.000	0.022	0.114	0.355	0.610	0.807	0.870	0.895	0.893	0.888	0.884	0.882	0.880	0.880	0.879	0.879	0.879	0.879	0.879	0.879
2005	0.000	0.001	0.014	0.139	0.339	0.619	0.800	0.889	0.907	0.911	0.908	0.905	0.904	0.903	0.902	0.902	0.902	0.901	0.901	0.901	0.901
2006	0.000	0.000	0.009	0.092	0.354	0.586	0.798	0.891	0.926	0.932	0.934	0.933	0.933	0.932	0.932	0.932	0.932	0.932	0.932	0.932	0.932
2007	0.000	0.000	0.007	0.085	0.299	0.619	0.786	0.888	0.918	0.925	0.924	0.923	0.922	0.922	0.921	0.921	0.921	0.921	0.921	0.921	0.921
2008	0.000	0.000	0.006	0.074	0.290	0.568	0.794	0.852	0.861	0.851	0.841	0.836	0.832	0.829	0.828	0.828	0.827	0.827	0.827	0.827	0.827
2009	0.000	0.000	0.004	0.052	0.229	0.523	0.738	0.821	0.816	0.795	0.780	0.769	0.765	0.762	0.760	0.759	0.758	0.758	0.758	0.757	0.757
2010	0.000	0.000	0.003	0.046	0.203	0.477	0.721	0.813	0.819	0.805	0.790	0.782	0.777	0.775	0.773	0.772	0.772	0.771	0.771	0.771	0.771
2011	0.000	0.000	0.002	0.056	0.219	0.478	0.718	0.847	0.882	0.885	0.882	0.879	0.877	0.876	0.875	0.875	0.875	0.875	0.875	0.874	0.874
2012	0.000	0.000	0.007	0.060	0.283	0.533	0.744	0.858	0.895	0.899	0.897	0.894	0.893	0.892	0.891	0.891	0.891	0.890	0.890	0.890	0.890
2013	0.000	0.000	0.007	0.084	0.261	0.572	0.758	0.851	0.876	0.873	0.867	0.861	0.859	0.857	0.857	0.856	0.856	0.856	0.855	0.855	0.855
2014	0.000	0.000	0.004	0.055	0.248	0.491	0.747	0.836	0.860	0.857	0.849	0.844	0.840	0.839	0.838	0.837	0.837	0.836	0.836	0.836	0.836
2015	0.000	0.000	0.006	0.053	0.222	0.510	0.714	0.846	0.874	0.877	0.873	0.869	0.867	0.865	0.865	0.864	0.864	0.864	0.864	0.864	0.864
2016	0.000	0.000	0.007	0.074	0.236	0.498	0.739	0.844	0.891	0.897	0.896	0.894	0.893	0.892	0.891	0.891	0.890	0.890	0.890	0.890	0.890
2017	0.000	0.000	0.006	0.078	0.283	0.515	0.735	0.864	0.904	0.920	0.921	0.921	0.921	0.920	0.920	0.920	0.919	0.919	0.919	0.919	0.919
2018	0.000	0.000	0.018	0.110	0.346	0.611	0.774	0.871	0.905	0.911	0.910	0.908	0.907	0.906	0.905	0.905	0.905	0.905	0.905	0.905	0.905
2019	0.000	0.001	0.005	0.136	0.352	0.625	0.799	0.861	0.879	0.876	0.870	0.865	0.862	0.861	0.860	0.859	0.859	0.859	0.859	0.859	0.859
2020	0.000	0.000	0.017	0.067	0.382	0.623	0.810	0.886	0.906	0.910	0.908	0.907	0.905	0.904	0.904	0.903	0.903	0.903	0.903	0.903	0.903
2021	0.000	0.000	0.016	0.080	0.198	0.596	0.778	0.879	0.911	0.918	0.920	0.919	0.919	0.918	0.918	0.918	0.918	0.918	0.918	0.917	0.917

Table 2.28a (page 2 of 5)—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	0.013	0.105	0.327	0.602	0.812	0.925	0.972	0.989	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.452
1978	0.000	0.000	0.010	0.105	0.326	0.601	0.812	0.925	0.972	0.989	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.452
1979	0.000	0.000	0.016	0.101	0.341	0.613	0.818	0.927	0.973	0.989	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.459
1980	0.000	0.000	0.012	0.113	0.314	0.610	0.817	0.927	0.973	0.989	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.463
1981	0.000	0.000	0.014	0.123	0.374	0.616	0.832	0.933	0.975	0.990	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.465
1982	0.000	0.000	0.007	0.072	0.293	0.593	0.791	0.922	0.971	0.988	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.466
1983	0.000	0.000	0.016	0.079	0.276	0.578	0.812	0.917	0.972	0.989	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.466
1984	0.000	0.001	0.018	0.146	0.318	0.584	0.815	0.932	0.972	0.990	0.990	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.465
1985	0.000	0.000	0.006	0.091	0.336	0.545	0.773	0.915	0.971	0.987	0.990	0.978	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.464
1986	0.000	0.000	0.015	0.091	0.345	0.645	0.796	0.915	0.972	0.990	0.991	0.979	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.463
1987	0.000	0.000	0.008	0.089	0.261	0.584	0.822	0.908	0.965	0.988	0.990	0.980	0.953	0.914	0.864	0.807	0.748	0.689	0.633	0.581	0.460
1988	0.000	0.001	0.030	0.164	0.419	0.635	0.852	0.949	0.975	0.990	0.991	0.979	0.956	0.914	0.864	0.807	0.748	0.689	0.633	0.582	0.459
1989	0.000	0.000	0.015	0.110	0.337	0.621	0.796	0.931	0.978	0.988	0.991	0.980	0.953	0.918	0.864	0.808	0.748	0.689	0.633	0.582	0.457
1990	0.000	0.000	0.010	0.082	0.282	0.564	0.799	0.905	0.971	0.989	0.990	0.981	0.956	0.914	0.869	0.807	0.748	0.689	0.633	0.582	0.454
1991	0.000	0.000	0.011	0.088	0.280	0.552	0.785	0.918	0.964	0.988	0.990	0.981	0.959	0.918	0.864	0.812	0.747	0.688	0.632	0.581	0.453
1992	0.000	0.000	0.009	0.092	0.289	0.547	0.775	0.910	0.969	0.986	0.990	0.977	0.958	0.922	0.868	0.807	0.752	0.688	0.632	0.581	0.456
1993	0.000	0.001	0.028	0.146	0.397	0.640	0.821	0.927	0.974	0.990	0.991	0.980	0.951	0.922	0.874	0.812	0.747	0.694	0.633	0.582	0.466
1994	0.000	0.000	0.014	0.115	0.330	0.615	0.808	0.917	0.969	0.988	0.990	0.982	0.955	0.911	0.873	0.818	0.752	0.688	0.637	0.581	0.482
1995	0.000	0.000	0.015	0.114	0.350	0.609	0.824	0.925	0.970	0.988	0.991	0.980	0.960	0.916	0.860	0.817	0.758	0.693	0.632	0.585	0.478
1996	0.000	0.000	0.008	0.077	0.280	0.571	0.787	0.918	0.967	0.986	0.990	0.981	0.955	0.923	0.866	0.803	0.758	0.699	0.637	0.581	0.495
1997	0.000	0.000	0.015	0.113	0.331	0.603	0.819	0.924	0.974	0.989	0.991	0.981	0.957	0.918	0.876	0.810	0.743	0.699	0.643	0.586	0.512
1998	0.000	0.000	0.006	0.078	0.284	0.556	0.785	0.917	0.968	0.988	0.990	0.981	0.958	0.920	0.868	0.820	0.750	0.684	0.642	0.591	0.502
1999	0.000	0.000	0.006	0.076	0.288	0.567	0.787	0.914	0.970	0.987	0.990	0.980	0.958	0.922	0.872	0.812	0.762	0.692	0.630	0.592	0.495
2000	0.000	0.000	0.009	0.063	0.259	0.549	0.782	0.909	0.966	0.987	0.990	0.979	0.956	0.922	0.874	0.816	0.754	0.703	0.637	0.580	0.471
2001	0.000	0.000	0.008	0.089	0.249	0.536	0.780	0.911	0.966	0.987	0.990	0.980	0.954	0.918	0.873	0.817	0.756	0.693	0.645	0.584	0.450
2002	0.000	0.000	0.018	0.116	0.355	0.572	0.798	0.922	0.971	0.988	0.991	0.980	0.956	0.916	0.869	0.817	0.758	0.697	0.637	0.593	0.474
2003	0.000	0.000	0.013	0.115	0.330	0.616	0.785	0.915	0.970	0.988	0.990	0.980	0.955	0.918	0.866	0.813	0.757	0.698	0.640	0.585	0.455
2004	0.000	0.000	0.021	0.109	0.347	0.607	0.822	0.913	0.969	0.988	0.990	0.980	0.956	0.917	0.869	0.809	0.753	0.698	0.642	0.589	0.471
2005	0.000	0.001	0.013	0.132	0.328	0.615	0.813	0.929	0.967	0.988	0.990	0.980	0.957	0.919	0.867	0.812	0.749	0.694	0.642	0.590	0.461
2006	0.000	0.000	0.008	0.084	0.338	0.575	0.805	0.918	0.971	0.986	0.990	0.980	0.956	0.919	0.870	0.811	0.753	0.691	0.639	0.590	0.450
2007	0.000	0.000	0.006	0.077	0.281	0.606	0.791	0.920	0.969	0.988	0.990	0.981	0.957	0.919	0.870	0.813	0.751	0.694	0.635	0.587	0.431
2008	0.000	0.000	0.006	0.070	0.279	0.560	0.817	0.915	0.970	0.988	0.990	0.981	0.958	0.919	0.869	0.814	0.754	0.692	0.638	0.584	0.450
2009	0.000	0.000	0.004	0.050	0.228	0.522	0.766	0.920	0.965	0.987	0.989	0.978	0.959	0.921	0.870	0.813	0.755	0.695	0.636	0.587	0.481
2010	0.000	0.000	0.004	0.045	0.203	0.483	0.750	0.897	0.968	0.985	0.989	0.979	0.953	0.923	0.873	0.814	0.753	0.695	0.639	0.584	0.491
2011	0.000	0.000	0.003	0.058	0.218	0.484	0.741	0.898	0.962	0.987	0.989	0.978	0.955	0.914	0.875	0.817	0.754	0.694	0.639	0.587	0.483
2012	0.000	0.000	0.007	0.061	0.278	0.529	0.758	0.901	0.965	0.987	0.989	0.980	0.954	0.917	0.864	0.819	0.757	0.695	0.638	0.587	0.505
2013	0.000	0.000	0.007	0.085	0.260	0.571	0.774	0.903	0.964	0.987	0.990	0.977	0.955	0.915	0.867	0.807	0.760	0.698	0.639	0.586	0.492
2014	0.000	0.000	0.005	0.055	0.250	0.494	0.770	0.895	0.959	0.984	0.989	0.980	0.951	0.917	0.865	0.810	0.748	0.700	0.642	0.587	0.484
2015	0.000	0.000	0.006	0.052	0.219	0.513	0.732	0.901	0.958	0.983	0.989	0.980	0.956	0.911	0.868	0.808	0.751	0.689	0.644	0.590	0.480
2016	0.000	0.000	0.007	0.073	0.229	0.496	0.758	0.886	0.963	0.984	0.989	0.981	0.957	0.919	0.861	0.812	0.749	0.692	0.633	0.592	0.506
2017	0.000	0.000	0.006	0.076	0.275	0.505	0.744	0.899	0.956	0.985	0.989	0.981	0.958	0.919	0.870	0.803	0.752	0.690	0.636	0.582	0.493
2018	0.000	0.000	0.017	0.106	0.342	0.610	0.785	0.908	0.967	0.985	0.990	0.981	0.959	0.922	0.871	0.813	0.743	0.693	0.634	0.584	0.480
2019	0.000	0.001	0.006	0.136	0.351	0.635	0.827	0.916	0.967	0.988	0.990	0.979	0.958	0.923	0.874	0.814	0.754	0.685	0.637	0.583	0.492
2020	0.000	0.000	0.017	0.071	0.382	0.628	0.834	0.932	0.969	0.987	0.990	0.981	0.955	0.921	0.875	0.818	0.755	0.696	0.630	0.586	0.489
2021	0.000	0.000	0.013	0.081	0.207	0.605	0.801	0.923	0.970	0.985	0.989	0.979	0.959	0.917	0.873	0.819	0.759	0.697	0.640	0.579	0.474

Table 2.28a (page 3 of 5)—Selectivity at age (fishery, Model 21.1).

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	0.015	0.135	0.411	0.698	0.855	0.879	0.838	0.786	0.744	0.715	0.695	0.682	0.674	0.668	0.664	0.662	0.660	0.658	0.657
1978	0.000	0.000	0.014	0.136	0.412	0.698	0.854	0.875	0.830	0.774	0.729	0.698	0.677	0.664	0.655	0.649	0.645	0.642	0.640	0.638	0.636
1979	0.000	0.000	0.022	0.143	0.432	0.712	0.861	0.878	0.831	0.775	0.729	0.698	0.677	0.664	0.655	0.649	0.645	0.642	0.640	0.638	0.636
1980	0.000	0.000	0.018	0.162	0.418	0.712	0.863	0.884	0.844	0.793	0.752	0.724	0.705	0.693	0.684	0.679	0.675	0.673	0.671	0.669	0.667
1981	0.000	0.001	0.021	0.177	0.484	0.727	0.874	0.889	0.845	0.794	0.752	0.723	0.704	0.692	0.684	0.678	0.674	0.672	0.670	0.668	0.667
1982	0.000	0.000	0.010	0.106	0.396	0.706	0.851	0.885	0.849	0.802	0.763	0.736	0.718	0.706	0.699	0.693	0.690	0.687	0.685	0.684	0.682
1983	0.000	0.000	0.019	0.122	0.381	0.698	0.867	0.895	0.866	0.826	0.792	0.769	0.753	0.743	0.736	0.731	0.728	0.726	0.724	0.723	0.722
1984	0.000	0.001	0.029	0.189	0.431	0.703	0.875	0.907	0.883	0.846	0.817	0.796	0.782	0.773	0.767	0.763	0.760	0.758	0.756	0.755	0.754
1985	0.000	0.000	0.008	0.127	0.411	0.662	0.840	0.887	0.852	0.811	0.772	0.746	0.729	0.718	0.710	0.705	0.702	0.699	0.697	0.696	0.694
1986	0.000	0.000	0.021	0.124	0.442	0.726	0.854	0.884	0.839	0.781	0.741	0.709	0.689	0.676	0.668	0.662	0.658	0.655	0.653	0.652	0.650
1987	0.000	0.000	0.010	0.120	0.341	0.687	0.854	0.878	0.843	0.786	0.740	0.713	0.692	0.680	0.671	0.665	0.661	0.659	0.657	0.655	0.653
1988	0.000	0.002	0.044	0.225	0.528	0.739	0.889	0.888	0.843	0.785	0.733	0.699	0.681	0.666	0.657	0.651	0.647	0.644	0.642	0.641	0.639
1989	0.000	0.000	0.023	0.160	0.445	0.733	0.862	0.903	0.872	0.838	0.805	0.779	0.762	0.753	0.746	0.742	0.739	0.737	0.735	0.734	0.733
1990	0.000	0.000	0.016	0.126	0.394	0.691	0.870	0.915	0.911	0.888	0.871	0.857	0.846	0.839	0.835	0.832	0.830	0.829	0.828	0.827	0.826
1991	0.000	0.000	0.016	0.124	0.374	0.670	0.853	0.901	0.886	0.847	0.817	0.800	0.786	0.776	0.769	0.766	0.763	0.761	0.759	0.758	0.757
1992	0.000	0.000	0.011	0.125	0.378	0.657	0.839	0.880	0.842	0.800	0.750	0.721	0.705	0.692	0.682	0.676	0.673	0.670	0.668	0.667	0.665
1993	0.000	0.001	0.039	0.189	0.485	0.732	0.866	0.884	0.835	0.772	0.731	0.692	0.670	0.658	0.648	0.641	0.637	0.634	0.632	0.630	0.628
1994	0.000	0.000	0.016	0.159	0.415	0.708	0.852	0.874	0.827	0.764	0.712	0.683	0.655	0.640	0.632	0.625	0.620	0.617	0.615	0.613	0.611
1995	0.000	0.000	0.018	0.144	0.455	0.708	0.863	0.879	0.837	0.780	0.732	0.698	0.680	0.663	0.654	0.649	0.644	0.641	0.639	0.637	0.635
1996	0.000	0.000	0.011	0.111	0.375	0.701	0.856	0.914	0.909	0.889	0.869	0.853	0.843	0.837	0.832	0.829	0.827	0.826	0.825	0.824	0.823
1997	0.000	0.001	0.023	0.165	0.442	0.718	0.883	0.911	0.889	0.859	0.833	0.812	0.799	0.789	0.785	0.780	0.777	0.776	0.774	0.773	0.773
1998	0.000	0.000	0.010	0.119	0.389	0.678	0.852	0.894	0.869	0.829	0.798	0.776	0.759	0.749	0.741	0.737	0.734	0.731	0.730	0.729	0.728
1999	0.000	0.000	0.010	0.117	0.396	0.689	0.853	0.890	0.855	0.815	0.778	0.754	0.737	0.726	0.718	0.712	0.710	0.707	0.705	0.704	0.702
2000	0.000	0.000	0.017	0.101	0.371	0.680	0.851	0.885	0.853	0.801	0.767	0.738	0.722	0.710	0.702	0.697	0.693	0.691	0.688	0.687	0.685
2001	0.000	0.000	0.012	0.134	0.340	0.657	0.836	0.850	0.786	0.710	0.643	0.606	0.578	0.561	0.549	0.541	0.535	0.531	0.529	0.526	0.523
2002	0.000	0.000	0.022	0.155	0.455	0.673	0.841	0.840	0.756	0.666	0.594	0.540	0.511	0.490	0.477	0.468	0.461	0.456	0.453	0.451	0.448
2003	0.000	0.000	0.017	0.154	0.426	0.723	0.841	0.871	0.818	0.754	0.703	0.667	0.642	0.628	0.618	0.611	0.607	0.604	0.601	0.599	0.597
2004	0.000	0.000	0.029	0.150	0.445	0.714	0.870	0.889	0.856	0.806	0.766	0.739	0.721	0.708	0.701	0.695	0.692	0.689	0.687	0.686	0.684
2005	0.000	0.001	0.017	0.185	0.428	0.722	0.867	0.895	0.872	0.828	0.792	0.767	0.751	0.740	0.733	0.728	0.725	0.723	0.721	0.720	0.718
2006	0.000	0.000	0.012	0.126	0.455	0.695	0.870	0.917	0.910	0.893	0.872	0.857	0.847	0.841	0.836	0.833	0.832	0.830	0.829	0.829	0.827
2007	0.000	0.000	0.009	0.120	0.394	0.731	0.863	0.913	0.902	0.876	0.859	0.842	0.830	0.823	0.818	0.815	0.812	0.811	0.810	0.809	0.808
2008	0.000	0.000	0.009	0.103	0.383	0.682	0.863	0.874	0.826	0.771	0.723	0.699	0.675	0.660	0.651	0.645	0.641	0.637	0.635	0.634	0.631
2009	0.000	0.000	0.005	0.071	0.305	0.637	0.819	0.824	0.756	0.667	0.603	0.554	0.531	0.508	0.494	0.485	0.479	0.474	0.471	0.469	0.466
2010	0.000	0.000	0.005	0.066	0.276	0.590	0.804	0.822	0.729	0.654	0.580	0.533	0.499	0.483	0.468	0.457	0.451	0.446	0.443	0.440	0.438
2011	0.000	0.000	0.003	0.079	0.299	0.590	0.801	0.850	0.800	0.723	0.679	0.640	0.617	0.600	0.592	0.584	0.579	0.575	0.573	0.571	0.569
2012	0.000	0.000	0.010	0.085	0.375	0.651	0.825	0.871	0.830	0.773	0.720	0.695	0.673	0.660	0.650	0.645	0.641	0.638	0.635	0.634	0.633
2013	0.000	0.000	0.009	0.116	0.339	0.680	0.833	0.859	0.807	0.733	0.676	0.631	0.611	0.594	0.583	0.576	0.572	0.568	0.565	0.563	0.562
2014	0.000	0.000	0.006	0.076	0.335	0.602	0.826	0.856	0.816	0.755	0.699	0.662	0.635	0.622	0.612	0.605	0.600	0.598	0.595	0.593	0.591
2015	0.000	0.000	0.008	0.077	0.302	0.630	0.803	0.864	0.832	0.784	0.740	0.705	0.684	0.668	0.661	0.655	0.651	0.648	0.647	0.645	0.643
2016	0.000	0.000	0.009	0.105	0.321	0.613	0.822	0.866	0.834	0.790	0.751	0.720	0.698	0.685	0.675	0.670	0.666	0.663	0.661	0.660	0.659
2017	0.000	0.000	0.009	0.112	0.381	0.636	0.822	0.885	0.873	0.835	0.807	0.786	0.771	0.760	0.753	0.748	0.746	0.744	0.742	0.741	0.740
2018	0.000	0.000	0.024	0.150	0.442	0.719	0.849	0.888	0.863	0.828	0.789	0.767	0.751	0.740	0.732	0.727	0.723	0.721	0.720	0.719	0.717
2019	0.000	0.001	0.006	0.183	0.447	0.729	0.861	0.871	0.830	0.771	0.732	0.694	0.675	0.662	0.652	0.645	0.640	0.637	0.635	0.634	0.632
2020	0.000	0.000	0.022	0.090	0.487	0.730	0.874	0.900	0.881	0.850	0.820	0.803	0.787	0.778	0.773	0.768	0.765	0.763	0.762	0.761	0.760
2021	0.000	0.000	0.021	0.110	0.264	0.710	0.853	0.898	0.884	0.862	0.839	0.821	0.811	0.801	0.796	0.793	0.790	0.789	0.787	0.786	0.785

Table 2.28a (page 4 of 5)—Selectivity at age (fishery, Model 21.2).

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	0.108	0.331	0.599	0.787	0.857	0.862	0.851	0.841	0.835	0.831	0.829	0.828	0.828	0.827	0.827	0.827	0.827	0.827
1978	0.000	0.000	0.011	0.108	0.331	0.599	0.781	0.841	0.834	0.815	0.800	0.791	0.786	0.784	0.782	0.782	0.781	0.781	0.781	0.781	0.781
1979	0.000	0.000	0.017	0.107	0.348	0.612	0.790	0.846	0.840	0.821	0.806	0.797	0.793	0.790	0.789	0.788	0.788	0.788	0.788	0.787	0.787
1980	0.000	0.000	0.013	0.120	0.324	0.611	0.797	0.872	0.884	0.878	0.871	0.866	0.863	0.862	0.861	0.861	0.861	0.860	0.860	0.860	0.860
1981	0.000	0.001	0.018	0.140	0.395	0.629	0.816	0.879	0.884	0.874	0.866	0.861	0.858	0.856	0.855	0.855	0.854	0.854	0.854	0.854	0.854
1982	0.000	0.000	0.007	0.077	0.299	0.592	0.774	0.872	0.893	0.891	0.887	0.883	0.881	0.880	0.879	0.879	0.879	0.879	0.879	0.879	0.879
1983	0.000	0.000	0.014	0.086	0.290	0.583	0.799	0.884	0.916	0.920	0.919	0.917	0.916	0.916	0.915	0.915	0.915	0.915	0.915	0.915	0.915
1984	0.000	0.001	0.021	0.140	0.334	0.595	0.808	0.904	0.930	0.937	0.937	0.936	0.935	0.935	0.934	0.934	0.934	0.934	0.934	0.934	0.934
1985	0.000	0.000	0.006	0.094	0.319	0.549	0.762	0.875	0.905	0.907	0.905	0.902	0.901	0.900	0.899	0.899	0.899	0.899	0.899	0.899	0.899
1986	0.000	0.000	0.016	0.095	0.349	0.622	0.780	0.864	0.879	0.871	0.863	0.857	0.855	0.853	0.852	0.852	0.851	0.851	0.851	0.851	0.851
1987	0.000	0.000	0.008	0.089	0.264	0.579	0.786	0.864	0.892	0.893	0.889	0.886	0.884	0.883	0.882	0.882	0.882	0.881	0.881	0.881	0.881
1988	0.000	0.002	0.037	0.184	0.444	0.653	0.842	0.899	0.904	0.897	0.889	0.884	0.882	0.881	0.880	0.880	0.879	0.879	0.879	0.879	0.879
1989	0.000	0.000	0.019	0.123	0.356	0.633	0.795	0.900	0.924	0.927	0.925	0.923	0.922	0.921	0.921	0.921	0.921	0.920	0.920	0.920	0.920
1990	0.000	0.000	0.011	0.089	0.293	0.570	0.794	0.889	0.942	0.955	0.958	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959	0.959
1991	0.000	0.000	0.012	0.092	0.288	0.555	0.776	0.889	0.921	0.932	0.933	0.933	0.932	0.931	0.931	0.931	0.931	0.931	0.931	0.931	0.931
1992	0.000	0.000	0.009	0.091	0.288	0.543	0.753	0.849	0.864	0.856	0.845	0.839	0.836	0.834	0.833	0.832	0.832	0.832	0.832	0.832	0.831
1993	0.000	0.001	0.029	0.147	0.392	0.633	0.801	0.874	0.884	0.874	0.866	0.859	0.855	0.854	0.853	0.852	0.852	0.852	0.852	0.852	0.852
1994	0.000	0.000	0.012	0.115	0.324	0.601	0.782	0.861	0.877	0.870	0.861	0.856	0.852	0.851	0.850	0.849	0.849	0.849	0.849	0.849	0.849
1995	0.000	0.000	0.015	0.113	0.359	0.606	0.800	0.874	0.889	0.885	0.879	0.874	0.871	0.870	0.869	0.868	0.868	0.868	0.868	0.868	0.868
1996	0.000	0.000	0.010	0.090	0.302	0.596	0.789	0.903	0.944	0.958	0.963	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965	0.965
1997	0.000	0.001	0.022	0.141	0.368	0.628	0.829	0.911	0.946	0.955	0.957	0.958	0.957	0.957	0.957	0.957	0.957	0.957	0.957	0.957	0.957
1998	0.000	0.000	0.010	0.095	0.313	0.576	0.785	0.894	0.924	0.932	0.933	0.932	0.931	0.931	0.930	0.930	0.930	0.930	0.930	0.930	0.930
1999	0.000	0.000	0.009	0.092	0.312	0.584	0.771	0.842	0.839	0.822	0.806	0.798	0.793	0.791	0.789	0.788	0.788	0.788	0.788	0.787	0.787
2000	0.000	0.000	0.017	0.090	0.310	0.588	0.792	0.886	0.917	0.923	0.922	0.920	0.919	0.918	0.918	0.918	0.918	0.918	0.917	0.917	0.917
2001	0.000	0.000	0.007	0.090	0.250	0.532	0.722	0.735	0.665	0.593	0.544	0.521	0.507	0.501	0.498	0.496	0.494	0.494	0.493	0.493	0.493
2002	0.000	0.000	0.019	0.122	0.371	0.579	0.770	0.814	0.781	0.742	0.714	0.698	0.691	0.686	0.684	0.683	0.683	0.682	0.682	0.682	0.682
2003	0.000	0.000	0.008	0.090	0.293	0.583	0.723	0.757	0.696	0.632	0.593	0.570	0.557	0.552	0.548	0.547	0.546	0.545	0.545	0.544	0.544
2004	0.000	0.000	0.011	0.075	0.288	0.550	0.741	0.760	0.708	0.647	0.608	0.588	0.576	0.570	0.567	0.565	0.564	0.564	0.564	0.563	0.563
2005	0.000	0.000	0.004	0.084	0.255	0.539	0.721	0.753	0.713	0.654	0.615	0.594	0.584	0.578	0.575	0.573	0.572	0.572	0.571	0.571	0.571
2006	0.000	0.000	0.006	0.069	0.312	0.546	0.777	0.891	0.942	0.955	0.961	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963
2007	0.000	0.000	0.006	0.076	0.276	0.599	0.777	0.898	0.943	0.960	0.964	0.966	0.967	0.967	0.967	0.967	0.967	0.967	0.967	0.967	0.967
2008	0.000	0.000	0.009	0.088	0.309	0.578	0.817	0.901	0.945	0.958	0.962	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963	0.963
2009	0.000	0.000	0.011	0.090	0.300	0.583	0.791	0.916	0.949	0.965	0.970	0.971	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972	0.972
2010	0.000	0.000	0.016	0.100	0.303	0.575	0.795	0.905	0.956	0.967	0.972	0.974	0.974	0.974	0.975	0.975	0.975	0.975	0.975	0.975	0.975
2011	0.000	0.000	0.007	0.096	0.285	0.544	0.765	0.881	0.917	0.925	0.925	0.924	0.923	0.922	0.922	0.922	0.922	0.922	0.922	0.922	0.922
2012	0.000	0.000	0.013	0.090	0.333	0.574	0.763	0.840	0.840	0.821	0.803	0.796	0.791	0.789	0.787	0.787	0.786	0.786	0.786	0.786	0.786
2013	0.000	0.000	0.010	0.097	0.288	0.589	0.747	0.782	0.738	0.682	0.648	0.625	0.618	0.612	0.610	0.608	0.607	0.607	0.606	0.606	0.606
2014	0.000	0.000	0.004	0.058	0.250	0.498	0.719	0.745	0.695	0.633	0.590	0.568	0.554	0.550	0.546	0.545	0.544	0.543	0.543	0.542	0.542
2015	0.000	0.000	0.006	0.050	0.222	0.502	0.694	0.758	0.724	0.679	0.645	0.625	0.615	0.609	0.607	0.605	0.605	0.604	0.604	0.604	0.604
2016	0.000	0.000	0.007	0.072	0.228	0.497	0.728	0.819	0.838	0.828	0.818	0.810	0.805	0.803	0.802	0.801	0.801	0.801	0.801	0.800	0.800
2017	0.000	0.000	0.002	0.044	0.210	0.434	0.655	0.723	0.693	0.638	0.607	0.587	0.576	0.570	0.567	0.565	0.564	0.564	0.564	0.563	0.563
2018	0.000	0.000	0.009	0.076	0.285	0.551	0.715	0.788	0.778	0.751	0.726	0.714	0.707	0.703	0.701	0.700	0.699	0.699	0.699	0.699	0.699
2019	0.000	0.000	0.002	0.093	0.285	0.561	0.729	0.757	0.721	0.673	0.643	0.621	0.613	0.607	0.604	0.603	0.602	0.601	0.601	0.601	0.601
2020	0.000	0.000	0.011	0.052	0.342	0.586	0.774	0.838	0.842	0.830	0.818	0.811	0.806	0.804	0.803	0.803	0.802	0.802	0.802	0.802	0.802
2021	0.000	0.000	0.012	0.070	0.184	0.578	0.772	0.889	0.934	0.948	0.955	0.957	0.958	0.958	0.958	0.958	0.958	0.958	0.958	0.958	0.958

Table 2.28a (page 5 of 5)—Selectivity at age (fishery, ensemble).

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	0.113	0.349	0.624	0.812	0.887	0.898	0.888	0.876	0.863	0.850	0.836	0.819	0.801	0.783	0.766	0.750	0.735	0.697
1978	0.000	0.000	0.011	0.113	0.349	0.624	0.811	0.883	0.890	0.878	0.864	0.851	0.837	0.822	0.805	0.787	0.769	0.752	0.735	0.720	0.683
1979	0.000	0.000	0.018	0.112	0.365	0.636	0.817	0.886	0.892	0.879	0.865	0.852	0.838	0.823	0.807	0.789	0.771	0.753	0.737	0.722	0.686
1980	0.000	0.000	0.014	0.126	0.342	0.634	0.819	0.893	0.904	0.896	0.884	0.872	0.860	0.845	0.829	0.811	0.793	0.776	0.759	0.745	0.710
1981	0.000	0.001	0.017	0.140	0.406	0.645	0.834	0.899	0.906	0.896	0.883	0.871	0.858	0.844	0.827	0.809	0.792	0.774	0.758	0.743	0.709
1982	0.000	0.000	0.008	0.082	0.321	0.620	0.798	0.891	0.907	0.901	0.890	0.879	0.867	0.853	0.837	0.819	0.801	0.784	0.767	0.753	0.719
1983	0.000	0.000	0.016	0.092	0.306	0.609	0.819	0.895	0.918	0.915	0.907	0.897	0.885	0.872	0.856	0.838	0.820	0.803	0.787	0.772	0.739
1984	0.000	0.001	0.021	0.152	0.351	0.616	0.825	0.911	0.927	0.926	0.919	0.910	0.899	0.885	0.870	0.852	0.835	0.817	0.801	0.786	0.753
1985	0.000	0.000	0.006	0.101	0.345	0.574	0.783	0.889	0.911	0.907	0.897	0.886	0.875	0.860	0.844	0.827	0.809	0.791	0.775	0.760	0.726
1986	0.000	0.000	0.017	0.099	0.369	0.653	0.803	0.886	0.901	0.890	0.878	0.865	0.852	0.838	0.821	0.803	0.785	0.768	0.751	0.737	0.702
1987	0.000	0.000	0.008	0.096	0.281	0.606	0.813	0.881	0.903	0.897	0.886	0.875	0.862	0.847	0.831	0.813	0.795	0.778	0.761	0.746	0.712
1988	0.000	0.001	0.035	0.183	0.451	0.664	0.854	0.911	0.911	0.900	0.885	0.871	0.859	0.843	0.827	0.809	0.791	0.773	0.757	0.742	0.707
1989	0.000	0.000	0.018	0.125	0.368	0.650	0.809	0.907	0.924	0.920	0.912	0.902	0.890	0.877	0.860	0.843	0.825	0.808	0.792	0.777	0.741
1990	0.000	0.000	0.012	0.095	0.313	0.597	0.812	0.898	0.939	0.944	0.941	0.935	0.925	0.912	0.898	0.880	0.862	0.845	0.829	0.814	0.778
1991	0.000	0.000	0.012	0.098	0.305	0.581	0.796	0.898	0.922	0.925	0.918	0.911	0.901	0.887	0.870	0.854	0.835	0.818	0.802	0.787	0.750
1992	0.000	0.000	0.009	0.099	0.309	0.571	0.781	0.877	0.896	0.889	0.875	0.862	0.852	0.838	0.820	0.801	0.785	0.766	0.749	0.734	0.698
1993	0.000	0.001	0.030	0.155	0.414	0.658	0.822	0.894	0.903	0.891	0.879	0.864	0.849	0.837	0.821	0.802	0.782	0.766	0.748	0.733	0.700
1994	0.000	0.000	0.013	0.125	0.347	0.631	0.807	0.883	0.897	0.887	0.873	0.862	0.846	0.830	0.817	0.799	0.779	0.760	0.745	0.729	0.700
1995	0.000	0.000	0.015	0.119	0.377	0.630	0.822	0.891	0.903	0.894	0.881	0.868	0.857	0.840	0.821	0.808	0.790	0.771	0.753	0.739	0.708
1996	0.000	0.000	0.009	0.087	0.306	0.608	0.800	0.905	0.936	0.943	0.941	0.935	0.925	0.914	0.897	0.878	0.865	0.848	0.830	0.814	0.789
1997	0.000	0.000	0.019	0.132	0.367	0.636	0.834	0.909	0.933	0.933	0.927	0.920	0.909	0.896	0.882	0.862	0.843	0.830	0.814	0.797	0.776
1998	0.000	0.000	0.008	0.093	0.318	0.591	0.798	0.896	0.919	0.918	0.911	0.902	0.892	0.878	0.861	0.846	0.826	0.806	0.794	0.779	0.754
1999	0.000	0.000	0.008	0.091	0.322	0.602	0.797	0.883	0.899	0.892	0.880	0.870	0.858	0.844	0.828	0.809	0.794	0.774	0.756	0.744	0.717
2000	0.000	0.000	0.013	0.079	0.300	0.591	0.797	0.887	0.909	0.904	0.895	0.884	0.873	0.860	0.845	0.827	0.808	0.793	0.774	0.757	0.726
2001	0.000	0.000	0.009	0.102	0.274	0.566	0.777	0.844	0.834	0.806	0.778	0.761	0.743	0.727	0.710	0.692	0.673	0.654	0.640	0.621	0.583
2002	0.000	0.000	0.019	0.126	0.383	0.596	0.794	0.855	0.839	0.808	0.780	0.758	0.741	0.723	0.706	0.688	0.670	0.651	0.633	0.620	0.586
2003	0.000	0.000	0.014	0.120	0.348	0.636	0.783	0.862	0.861	0.839	0.819	0.803	0.787	0.772	0.753	0.736	0.719	0.702	0.685	0.668	0.631
2004	0.000	0.000	0.021	0.115	0.362	0.623	0.815	0.868	0.875	0.859	0.842	0.828	0.814	0.798	0.783	0.764	0.747	0.731	0.714	0.699	0.665
2005	0.000	0.001	0.013	0.138	0.342	0.628	0.806	0.879	0.883	0.870	0.855	0.842	0.830	0.815	0.798	0.781	0.762	0.746	0.730	0.715	0.678
2006	0.000	0.000	0.009	0.093	0.366	0.601	0.813	0.905	0.938	0.942	0.940	0.934	0.925	0.913	0.898	0.880	0.863	0.845	0.830	0.816	0.776
2007	0.000	0.000	0.007	0.089	0.312	0.638	0.803	0.905	0.933	0.937	0.935	0.928	0.918	0.906	0.891	0.874	0.855	0.839	0.822	0.808	0.763
2008	0.000	0.000	0.007	0.082	0.312	0.594	0.821	0.883	0.898	0.889	0.876	0.867	0.853	0.838	0.822	0.804	0.786	0.768	0.752	0.736	0.697
2009	0.000	0.000	0.005	0.062	0.258	0.559	0.774	0.866	0.867	0.849	0.830	0.813	0.801	0.784	0.765	0.747	0.728	0.710	0.693	0.678	0.648
2010	0.000	0.000	0.006	0.059	0.237	0.521	0.761	0.855	0.864	0.849	0.829	0.813	0.796	0.783	0.765	0.745	0.726	0.709	0.692	0.676	0.648
2011	0.000	0.000	0.003	0.068	0.248	0.517	0.752	0.868	0.891	0.883	0.873	0.860	0.847	0.831	0.818	0.799	0.780	0.762	0.746	0.730	0.700
2012	0.000	0.000	0.008	0.071	0.312	0.566	0.770	0.870	0.891	0.882	0.866	0.856	0.842	0.828	0.810	0.796	0.777	0.759	0.742	0.727	0.704
2013	0.000	0.000	0.008	0.094	0.283	0.599	0.778	0.856	0.862	0.841	0.821	0.801	0.788	0.771	0.755	0.736	0.721	0.702	0.685	0.669	0.642
2014	0.000	0.000	0.005	0.060	0.269	0.519	0.767	0.842	0.850	0.832	0.811	0.794	0.776	0.762	0.744	0.727	0.707	0.693	0.676	0.660	0.630
2015	0.000	0.000	0.007	0.058	0.240	0.538	0.736	0.851	0.863	0.852	0.837	0.822	0.808	0.790	0.775	0.756	0.739	0.720	0.707	0.691	0.660
2016	0.000	0.000	0.007	0.081	0.252	0.524	0.762	0.857	0.889	0.885	0.876	0.864	0.851	0.836	0.817	0.802	0.783	0.766	0.749	0.737	0.712
2017	0.000	0.000	0.006	0.080	0.291	0.527	0.744	0.855	0.876	0.871	0.861	0.851	0.839	0.824	0.808	0.787	0.772	0.754	0.738	0.722	0.697
2018	0.000	0.000	0.018	0.112	0.357	0.626	0.784	0.871	0.892	0.886	0.873	0.863	0.852	0.838	0.821	0.803	0.782	0.767	0.750	0.736	0.706
2019	0.000	0.000	0.005	0.140	0.362	0.641	0.810	0.861	0.866	0.849	0.834	0.817	0.804	0.790	0.773	0.754	0.735	0.715	0.701	0.685	0.659
2020	0.000	0.000	0.017	0.071	0.399	0.643	0.826	0.894	0.907	0.905	0.896	0.888	0.875	0.863	0.848	0.831	0.812	0.795	0.776	0.763	0.735
2021	0.000	0.000	0.015	0.086	0.213	0.622	0.801	0.898	0.925	0.929	0.927	0.920	0.912	0.897	0.884	0.868	0.850	0.832	0.815	0.798	0.768

Table 2.28b (page 1 of 5)—Selectivity at age (survey, Model 19.12a). Gray cells are calculated, but not used, due to lack of a survey in 2020.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.013	0.558	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	0.558	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	0.013	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	0.010	0.575	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	0.412	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	0.004	0.231	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	0.434	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.004	0.260	0.987	1.000	1.000	1.000	1.000	1.000	1.000	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	0.417	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	0.286	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
1987	0.007	0.421	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	0.254	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	0.137	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
1990	0.021	0.384	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.019	0.293	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	0.011	0.504	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
1993	0.030	0.465	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	0.008	0.438	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
1995	0.004	0.218	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	0.204	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
1997	0.008	0.267	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	0.010	0.175	0.919	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	0.217	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
2000	0.017	0.269	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.030	0.820	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.011	0.443	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	0.492	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	0.374	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.008	0.748	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	0.744	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.033	0.806	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.012	0.443	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.046	0.464	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.309	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.005	0.478	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
2012	0.066	0.645	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.008	0.270	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
2014	0.011	0.364	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	0.015	0.344	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
2016	0.007	0.439	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	0.008	0.422	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
2018	0.002	0.446	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	0.013	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	1.000
2020	0.024	0.198	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2021	0.031	0.539	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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 2.28b (page 2 of 5)—Selectivity at age (survey, Model 19.12). Gray cells are calculated, but not used, due to lack of a survey in 2020.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.014	0.578	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.010	0.578	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	0.014	0.411	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.010	0.587	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	0.418	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	0.004	0.221	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	0.053	0.409	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.007	0.401	0.987	1.000	1.000	1.000	1.000	1.000	1.000	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	0.426	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	0.288	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.409	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	0.254	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	0.147	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
1990	0.024	0.416	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.341	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	0.014	0.651	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.031	0.499	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	0.334	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	0.004	0.214	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
1996	0.002	0.196	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	0.274	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	0.010	0.174	0.912	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	0.232	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	0.304	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.026	0.777	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.447	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	0.493	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	0.373	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.008	0.719	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	0.029	0.740	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.830	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.534	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.050	0.605	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.336	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.005	0.469	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	0.076	0.694	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.322	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	0.362	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	0.015	0.335	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
2016	0.008	0.428	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
2017	0.013	0.530	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	0.002	0.459	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	0.017	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	1.000
2020	0.023	0.232	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2021	0.025	0.510	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 2.28b (page 3 of 5)—Selectivity at age (survey, Model 21.1). Gray cells are calculated, but not used, due to lack of a survey in 2020.

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	0.463	0.999	0.994	0.948	0.867	0.781	0.704	0.642	0.591	0.552	0.522	0.498	0.479	0.464	0.452	0.442	0.434	0.428	0.423	0.414
1978	0.010	0.463	0.999	0.994	0.948	0.867	0.781	0.704	0.642	0.591	0.552	0.522	0.498	0.479	0.464	0.452	0.442	0.434	0.428	0.423	0.414
1979	0.014	0.388	0.999	0.995	0.948	0.867	0.781	0.704	0.642	0.591	0.552	0.522	0.498	0.479	0.464	0.452	0.442	0.434	0.428	0.423	0.414
1980	0.010	0.545	0.999	0.993	0.950	0.867	0.781	0.704	0.642	0.591	0.552	0.522	0.498	0.479	0.464	0.452	0.442	0.434	0.428	0.423	0.413
1981	0.007	0.408	0.997	0.995	0.944	0.871	0.781	0.704	0.642	0.591	0.552	0.522	0.498	0.479	0.464	0.452	0.442	0.434	0.428	0.423	0.413
1982	0.004	0.229	0.998	0.995	0.944	0.854	0.774	0.694	0.632	0.583	0.544	0.514	0.491	0.472	0.458	0.446	0.437	0.429	0.423	0.418	0.409
1983	0.047	0.452	1.000	0.995	0.950	0.859	0.765	0.695	0.630	0.581	0.543	0.513	0.489	0.471	0.457	0.445	0.436	0.429	0.422	0.417	0.408
1984	0.004	0.262	0.988	0.998	0.977	0.918	0.833	0.753	0.694	0.638	0.596	0.562	0.534	0.513	0.495	0.481	0.470	0.461	0.453	0.447	0.435
1985	0.008	0.427	0.992	0.996	0.954	0.890	0.808	0.723	0.654	0.608	0.565	0.534	0.509	0.489	0.473	0.460	0.450	0.442	0.435	0.430	0.419
1986	0.024	0.298	1.000	0.995	0.936	0.847	0.771	0.695	0.625	0.573	0.538	0.508	0.485	0.467	0.453	0.442	0.433	0.425	0.419	0.415	0.405
1987	0.008	0.433	0.998	0.994	0.958	0.865	0.776	0.710	0.647	0.591	0.549	0.521	0.496	0.477	0.462	0.451	0.441	0.433	0.427	0.422	0.412
1988	0.005	0.284	0.997	0.995	0.949	0.881	0.780	0.701	0.647	0.597	0.553	0.520	0.498	0.478	0.463	0.451	0.442	0.434	0.428	0.422	0.412
1989	0.003	0.146	0.987	0.998	0.968	0.895	0.826	0.736	0.670	0.625	0.583	0.546	0.519	0.500	0.483	0.469	0.459	0.450	0.443	0.437	0.425
1990	0.023	0.411	1.000	0.994	0.944	0.857	0.763	0.698	0.623	0.573	0.541	0.511	0.485	0.466	0.453	0.442	0.433	0.425	0.419	0.414	0.405
1991	0.020	0.320	0.996	0.998	0.971	0.904	0.821	0.739	0.684	0.622	0.579	0.551	0.524	0.501	0.483	0.471	0.460	0.451	0.444	0.438	0.426
1992	0.011	0.521	0.999	0.992	0.946	0.868	0.780	0.700	0.633	0.590	0.544	0.513	0.493	0.475	0.458	0.446	0.437	0.429	0.423	0.418	0.408
1993	0.034	0.486	1.000	0.995	0.950	0.875	0.795	0.717	0.650	0.596	0.562	0.525	0.500	0.483	0.468	0.454	0.444	0.436	0.430	0.424	0.415
1994	0.013	0.414	0.990	0.998	0.971	0.904	0.829	0.758	0.692	0.637	0.591	0.562	0.530	0.508	0.493	0.479	0.467	0.457	0.450	0.444	0.434
1995	0.005	0.229	0.993	0.997	0.959	0.893	0.808	0.736	0.675	0.622	0.578	0.543	0.521	0.497	0.480	0.469	0.458	0.448	0.441	0.436	0.426
1996	0.003	0.211	0.996	0.997	0.960	0.876	0.799	0.720	0.660	0.611	0.570	0.536	0.509	0.492	0.473	0.460	0.451	0.443	0.436	0.430	0.422
1997	0.009	0.282	0.994	0.998	0.966	0.897	0.806	0.737	0.670	0.621	0.582	0.548	0.521	0.499	0.484	0.469	0.458	0.450	0.443	0.437	0.430
1998	0.011	0.190	0.931	0.999	0.988	0.945	0.878	0.800	0.742	0.685	0.642	0.607	0.576	0.551	0.530	0.516	0.500	0.489	0.482	0.474	0.463
1999	0.006	0.242	0.993	0.997	0.958	0.882	0.799	0.722	0.651	0.605	0.563	0.533	0.509	0.489	0.473	0.459	0.451	0.441	0.434	0.429	0.420
2000	0.018	0.288	1.000	0.993	0.937	0.844	0.754	0.678	0.616	0.562	0.529	0.499	0.479	0.462	0.448	0.437	0.427	0.421	0.415	0.410	0.401
2001	0.032	0.808	1.000	0.985	0.937	0.843	0.749	0.671	0.610	0.562	0.522	0.496	0.474	0.458	0.445	0.434	0.425	0.418	0.413	0.408	0.398
2002	0.012	0.489	1.000	0.993	0.939	0.875	0.783	0.702	0.638	0.589	0.549	0.515	0.494	0.475	0.461	0.450	0.440	0.432	0.425	0.421	0.411
2003	0.010	0.512	0.999	0.994	0.948	0.863	0.797	0.714	0.647	0.596	0.556	0.525	0.498	0.481	0.465	0.453	0.444	0.436	0.429	0.424	0.413
2004	0.014	0.393	1.000	0.995	0.947	0.870	0.779	0.720	0.651	0.598	0.557	0.526	0.502	0.480	0.466	0.454	0.445	0.437	0.430	0.425	0.416
2005	0.009	0.755	0.999	0.988	0.940	0.851	0.766	0.685	0.637	0.584	0.543	0.512	0.489	0.471	0.455	0.444	0.435	0.428	0.422	0.417	0.408
2006	0.031	0.756	1.000	0.981	0.888	0.804	0.709	0.637	0.575	0.541	0.504	0.476	0.456	0.441	0.429	0.418	0.411	0.405	0.400	0.397	0.388
2007	0.035	0.819	1.000	0.975	0.889	0.768	0.692	0.615	0.560	0.516	0.491	0.464	0.445	0.430	0.419	0.410	0.402	0.397	0.393	0.389	0.381
2008	0.013	0.452	1.000	0.988	0.915	0.817	0.710	0.647	0.585	0.542	0.505	0.485	0.463	0.446	0.433	0.423	0.415	0.408	0.404	0.399	0.391
2009	0.051	0.489	1.000	0.993	0.939	0.843	0.751	0.661	0.611	0.561	0.526	0.496	0.479	0.460	0.446	0.435	0.426	0.419	0.413	0.409	0.402
2010	0.009	0.302	0.999	0.995	0.956	0.877	0.783	0.704	0.630	0.589	0.548	0.519	0.494	0.479	0.463	0.450	0.441	0.433	0.427	0.421	0.414
2011	0.006	0.489	0.997	0.993	0.949	0.874	0.786	0.702	0.637	0.579	0.547	0.515	0.492	0.473	0.462	0.449	0.439	0.431	0.425	0.420	0.411
2012	0.070	0.619	1.000	0.986	0.903	0.813	0.728	0.650	0.584	0.538	0.498	0.477	0.456	0.441	0.428	0.421	0.413	0.406	0.401	0.397	0.392
2013	0.009	0.286	0.985	0.998	0.979	0.909	0.838	0.768	0.701	0.642	0.598	0.558	0.535	0.512	0.496	0.481	0.472	0.462	0.454	0.448	0.438
2014	0.013	0.375	0.999	0.995	0.946	0.876	0.777	0.706	0.647	0.595	0.551	0.520	0.492	0.476	0.461	0.449	0.439	0.433	0.427	0.421	0.412
2015	0.016	0.346	0.999	0.997	0.966	0.893	0.823	0.735	0.676	0.626	0.583	0.547	0.520	0.496	0.482	0.468	0.458	0.449	0.443	0.437	0.426
2016	0.008	0.451	0.997	0.997	0.973	0.915	0.834	0.769	0.694	0.645	0.604	0.569	0.538	0.516	0.495	0.483	0.471	0.462	0.454	0.449	0.440
2017	0.008	0.447	0.995	0.997	0.968	0.917	0.847	0.769	0.713	0.650	0.610	0.577	0.548	0.523	0.504	0.487	0.477	0.467	0.460	0.453	0.443
2018	0.003	0.443	0.999	0.995	0.954	0.882	0.816	0.745	0.677	0.632	0.583	0.552	0.527	0.505	0.487	0.473	0.460	0.453	0.445	0.439	0.429
2019	0.014	0.986	1.000	0.968	0.895	0.799	0.713	0.652	0.596	0.547	0.517	0.485	0.466	0.451	0.437	0.426	0.418	0.410	0.406	0.402	0.396
2020	0.024	0.199	1.000	0.997	0.925	0.850	0.764	0.692	0.641	0.594	0.552	0.526	0.498	0.480	0.466	0.453	0.443	0.435	0.427	0.423	0.415
2021	0.027	0.444	0.999	0.998	0.988	0.912	0.848	0.777	0.716	0.672	0.630	0.592	0.566	0.539	0.521	0.507	0.494	0.482	0.473	0.465	0.453

Table 2.28b (page 4 of 5)—Selectivity at age (survey, Model 21.2). Gray cells are calculated, but not used, due to lack of a survey in 2020.

1977	0.014	0.548	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	0.010	0.548	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	0.014	0.400	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.010	0.571	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	0.007	0.415	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	0.240	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	0.046	0.452	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.272	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	0.431	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
1986	0.024	0.299	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.007	0.424	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	0.253	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	0.139	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
1990	0.022	0.387	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.019	0.295	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	0.011	0.500	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
1993	0.031	0.467	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	0.009	0.465	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
1995	0.005	0.226	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	0.003	0.211	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
1997	0.009	0.288	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
1998	0.012	0.194	0.946	1.000	1.000	1.000	1.000	1.000	1.000	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	0.239	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	0.019	0.291	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.799	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.009	0.380	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	0.007	0.384	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
2004	0.011	0.303	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	0.668	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	0.026	0.640	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.800	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.507	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.056	0.530	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.343	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.007	0.533	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	0.078	0.732	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.306	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
2014	0.011	0.398	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	0.333	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.006	0.406	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	0.008	0.416	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
2018	0.003	0.435	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	0.014	0.987	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.026	0.222	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2021	0.032	0.564	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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 2.28b (page 5 of 5)—Selectivity at age (survey, ensemble). Gray cells are calculated, but not used, due to lack of a survey in 2020.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.013	0.540	0.999	0.999	0.988	0.969	0.949	0.932	0.917	0.905	0.896	0.889	0.884	0.879	0.876	0.873	0.871	0.869	0.868	0.866	0.864
1978	0.010	0.540	0.999	0.999	0.988	0.969	0.949	0.932	0.917	0.905	0.896	0.889	0.884	0.879	0.876	0.873	0.871	0.869	0.868	0.866	0.864
1979	0.014	0.399	1.000	0.999	0.988	0.969	0.949	0.932	0.917	0.905	0.896	0.889	0.884	0.879	0.876	0.873	0.871	0.869	0.868	0.866	0.864
1980	0.010	0.571	0.999	0.998	0.989	0.969	0.949	0.932	0.917	0.905	0.896	0.889	0.884	0.879	0.876	0.873	0.871	0.869	0.868	0.866	0.864
1981	0.007	0.414	0.997	0.999	0.987	0.970	0.949	0.932	0.917	0.905	0.896	0.889	0.884	0.879	0.876	0.873	0.871	0.869	0.868	0.866	0.864
1982	0.004	0.229	0.998	0.999	0.987	0.966	0.948	0.929	0.915	0.903	0.894	0.887	0.882	0.878	0.874	0.872	0.870	0.868	0.866	0.865	0.863
1983	0.048	0.434	1.000	0.999	0.988	0.967	0.946	0.929	0.914	0.903	0.894	0.887	0.882	0.878	0.874	0.872	0.869	0.868	0.866	0.865	0.863
1984	0.005	0.303	0.987	1.000	0.995	0.981	0.961	0.943	0.929	0.916	0.906	0.898	0.892	0.887	0.883	0.880	0.877	0.875	0.873	0.872	0.869
1985	0.008	0.424	0.991	0.999	0.989	0.974	0.955	0.936	0.920	0.909	0.899	0.892	0.886	0.882	0.878	0.875	0.873	0.871	0.869	0.868	0.865
1986	0.023	0.292	1.000	0.999	0.985	0.964	0.947	0.929	0.913	0.901	0.893	0.886	0.881	0.877	0.873	0.871	0.869	0.867	0.866	0.864	0.862
1987	0.007	0.421	0.998	0.999	0.990	0.969	0.948	0.933	0.918	0.905	0.896	0.889	0.883	0.879	0.876	0.873	0.871	0.869	0.867	0.866	0.864
1988	0.004	0.261	0.997	0.999	0.988	0.973	0.949	0.931	0.918	0.907	0.896	0.889	0.884	0.879	0.876	0.873	0.871	0.869	0.867	0.866	0.864
1989	0.003	0.142	0.991	1.000	0.993	0.976	0.960	0.939	0.924	0.913	0.904	0.895	0.888	0.884	0.880	0.877	0.875	0.873	0.871	0.870	0.867
1990	0.023	0.400	1.000	0.999	0.987	0.967	0.945	0.930	0.913	0.901	0.894	0.887	0.881	0.876	0.873	0.871	0.869	0.867	0.866	0.864	0.862
1991	0.021	0.313	0.995	0.999	0.993	0.978	0.958	0.940	0.927	0.912	0.902	0.896	0.890	0.884	0.880	0.878	0.875	0.873	0.871	0.870	0.867
1992	0.012	0.549	0.999	0.998	0.987	0.969	0.949	0.931	0.915	0.905	0.894	0.887	0.883	0.878	0.875	0.872	0.870	0.868	0.866	0.865	0.863
1993	0.032	0.480	0.999	0.999	0.988	0.971	0.952	0.934	0.919	0.906	0.899	0.890	0.884	0.880	0.877	0.874	0.871	0.870	0.868	0.867	0.864
1994	0.009	0.408	0.995	0.999	0.993	0.978	0.960	0.944	0.929	0.916	0.905	0.899	0.891	0.886	0.883	0.879	0.877	0.874	0.873	0.871	0.869
1995	0.004	0.221	0.993	0.999	0.990	0.975	0.955	0.939	0.925	0.912	0.902	0.894	0.889	0.883	0.880	0.877	0.874	0.872	0.870	0.869	0.867
1996	0.002	0.205	0.996	0.999	0.991	0.971	0.954	0.935	0.921	0.910	0.900	0.893	0.886	0.882	0.878	0.875	0.873	0.871	0.869	0.868	0.866
1997	0.009	0.276	0.993	0.999	0.992	0.976	0.955	0.939	0.924	0.912	0.903	0.895	0.889	0.884	0.881	0.877	0.874	0.873	0.871	0.870	0.868
1998	0.011	0.181	0.924	0.999	0.997	0.987	0.972	0.954	0.940	0.927	0.917	0.909	0.902	0.896	0.891	0.888	0.884	0.882	0.880	0.878	0.876
1999	0.006	0.231	0.993	0.999	0.990	0.973	0.953	0.936	0.919	0.908	0.899	0.892	0.886	0.882	0.878	0.875	0.873	0.870	0.869	0.868	0.866
2000	0.018	0.287	1.000	0.998	0.985	0.964	0.943	0.925	0.911	0.899	0.891	0.884	0.879	0.875	0.872	0.870	0.867	0.866	0.864	0.863	0.861
2001	0.029	0.802	1.000	0.997	0.986	0.964	0.942	0.924	0.910	0.899	0.889	0.883	0.878	0.874	0.871	0.869	0.867	0.865	0.864	0.863	0.861
2002	0.011	0.444	0.999	0.998	0.986	0.971	0.950	0.931	0.916	0.905	0.896	0.888	0.883	0.878	0.875	0.873	0.870	0.868	0.867	0.866	0.864
2003	0.010	0.479	0.998	0.999	0.988	0.968	0.953	0.934	0.918	0.906	0.897	0.890	0.884	0.880	0.876	0.873	0.871	0.869	0.868	0.867	0.864
2004	0.013	0.366	1.000	0.999	0.988	0.970	0.949	0.935	0.919	0.907	0.897	0.890	0.885	0.880	0.876	0.874	0.871	0.870	0.868	0.867	0.865
2005	0.008	0.728	0.999	0.997	0.986	0.965	0.946	0.927	0.916	0.904	0.894	0.887	0.882	0.877	0.874	0.871	0.869	0.868	0.866	0.865	0.863
2006	0.029	0.728	1.000	0.996	0.974	0.955	0.933	0.916	0.902	0.894	0.885	0.879	0.874	0.870	0.868	0.865	0.864	0.862	0.861	0.860	0.858
2007	0.036	0.815	1.000	0.994	0.974	0.946	0.929	0.911	0.898	0.888	0.882	0.876	0.871	0.868	0.865	0.863	0.862	0.860	0.859	0.859	0.857
2008	0.013	0.482	1.000	0.997	0.980	0.958	0.933	0.918	0.904	0.894	0.885	0.881	0.876	0.872	0.869	0.866	0.865	0.863	0.862	0.861	0.859
2009	0.050	0.521	1.000	0.998	0.986	0.964	0.942	0.922	0.910	0.898	0.890	0.883	0.879	0.875	0.872	0.869	0.867	0.866	0.864	0.863	0.861
2010	0.009	0.321	1.000	0.999	0.990	0.972	0.950	0.932	0.914	0.905	0.895	0.889	0.883	0.879	0.876	0.873	0.870	0.869	0.867	0.866	0.864
2011	0.006	0.487	0.998	0.998	0.988	0.971	0.951	0.931	0.916	0.902	0.895	0.888	0.882	0.878	0.875	0.872	0.870	0.868	0.867	0.866	0.864
2012	0.072	0.668	1.000	0.997	0.978	0.957	0.937	0.919	0.904	0.893	0.884	0.879	0.874	0.871	0.868	0.866	0.864	0.862	0.861	0.860	0.859
2013	0.009	0.295	0.989	1.000	0.995	0.979	0.962	0.946	0.931	0.917	0.907	0.898	0.892	0.887	0.883	0.880	0.878	0.875	0.874	0.872	0.870
2014	0.011	0.371	0.999	0.999	0.987	0.971	0.948	0.932	0.918	0.906	0.896	0.889	0.882	0.879	0.875	0.872	0.870	0.869	0.867	0.866	0.864
2015	0.016	0.340	0.999	0.999	0.992	0.975	0.959	0.939	0.925	0.913	0.903	0.895	0.889	0.883	0.880	0.877	0.874	0.872	0.871	0.870	0.867
2016	0.008	0.433	0.997	0.999	0.994	0.980	0.961	0.947	0.929	0.918	0.908	0.900	0.893	0.888	0.883	0.880	0.878	0.875	0.874	0.872	0.870
2017	0.009	0.457	0.994	0.999	0.993	0.981	0.964	0.946	0.933	0.919	0.910	0.902	0.895	0.890	0.885	0.881	0.879	0.877	0.875	0.873	0.871
2018	0.002	0.447	0.999	0.999	0.989	0.973	0.957	0.941	0.925	0.915	0.903	0.896	0.890	0.885	0.881	0.878	0.875	0.873	0.871	0.870	0.868
2019	0.015	0.988	1.000	0.992	0.976	0.953	0.934	0.919	0.907	0.895	0.888	0.881	0.876	0.873	0.870	0.867	0.865	0.863	0.862	0.861	0.860
2020	0.024	0.212	1.000	0.999	0.983	0.965	0.945	0.929	0.917	0.906	0.896	0.890	0.884	0.880	0.876	0.873	0.871	0.869	0.867	0.866	0.864
2021	0.029	0.513	0.999	1.000	0.997	0.980	0.965	0.948	0.934	0.924	0.914	0.905	0.900	0.893	0.889	0.886	0.883	0.880	0.878	0.876	0.873

Table 2.29—Management reference points.

Feature 1: Time-vary *Q*?		no	yes	no	no	n/a
Feature 2: Survey dome?		no	no	yes	no	n/a
Feature 3: Fishery CPUE?		no	no	no	yes	n/a
Year	Quantity	M19.12a	M19.12	M21.1	M21.2	Ensemble
n/a	B100%	648,370	667,265	774,300	671,275	686,761
n/a	B40%	259,348	266,906	309,720	268,510	274,704
n/a	B35%	226,930	233,543	271,005	234,946	240,366
n/a	F40%	0.36	0.31	0.31	0.35	0.33
n/a	F35%	0.45	0.38	0.37	0.43	0.41
2022	Female spawning biomass	259,007	231,344	326,101	218,078	259,789
2022	Relative spawning biomass	0.40	0.35	0.42	0.32	0.38
2022	Pr(B/B100%<0.2)	0.00	0.00	0.00	0.00	0.00
2022	maxFABC	0.36	0.27	0.31	0.28	0.31
2022	maxABC	174,668	123,899	183,492	121,830	153,383
2022	Catch	174,668	123,899	183,492	121,830	153,383
2022	FOFL	0.44	0.33	0.37	0.35	0.38
2022	OFL	208,791	148,656	216,920	146,026	183,012
2022	Pr(maxABC>truOFL)	0.15	0.21	0.08	0.17	0.28
2023	Female spawning biomass	246,645	231,535	308,632	234,058	254,585
2023	Relative spawning biomass	0.38	0.35	0.40	0.35	0.37
2023	Pr(B/B100%<0.2)	0.00	0.00	0.00	0.00	0.00
2023	maxFABC	0.34	0.27	0.30	0.31	0.31
2023	maxABC	162,093	125,080	177,937	141,112	151,709
2023	Catch	162,093	125,080	177,937	141,112	151,709
2023	FOFL	0.42	0.33	0.37	0.37	0.37
2023	OFL	193,813	150,021	210,114	168,680	180,909
2023	Pr(maxABC>truOFL)	0.15	0.20	0.21	0.15	0.24

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—Age 0+ biomass (t) time series.

Year	M19.12a	M19.12	M21.1	M21.2	Ensemble
1977	358719	297249	581033	378804	396115
1978	386008	318267	622371	405771	424820
1979	529489	428562	776831	543577	560456
1980	750356	602024	1013160	755995	770008
1981	1005210	808185	1291590	1003870	1015307
1982	1282090	1040290	1605300	1277060	1287369
1983	1389060	1147420	1735400	1387270	1400287
1984	1332330	1124340	1624290	1335640	1341386
1985	1424720	1215370	1752500	1435500	1442943
1986	1409520	1216140	1721260	1425920	1429514
1987	1425850	1243800	1704260	1445940	1441967
1988	1446630	1274510	1731670	1472770	1468123
1989	1320670	1174010	1591930	1351490	1346997
1990	1121190	1011070	1360090	1155120	1150931
1991	929319	850846	1123290	964943	957936
1992	798587	732659	956892	836776	822942
1993	895573	815384	1044020	942683	915094
1994	902355	813580	1029790	953445	915240
1995	958770	847029	1082460	1017340	965520
1996	968630	834807	1086580	1030680	968361
1997	847082	719644	968638	906039	848942
1998	749920	625852	869018	804436	751421
1999	791874	663020	911927	839077	791004
2000	861479	730234	987359	895104	858992
2001	885502	761426	1002910	896314	879248
2002	925248	803640	1041290	918451	916414
2003	915187	799164	1035420	904268	908216
2004	887256	778659	1008820	891985	885340
2005	813545	715917	940926	851196	821638
2006	714236	631714	838362	795514	733216
2007	630981	563531	752977	757061	661297
2008	578302	527832	688350	737585	616269
2009	606733	567588	703425	789102	648714
2010	703644	662662	783153	876792	739571
2011	826504	775502	903602	968708	853813
2012	872064	814395	955525	971973	891828
2013	938061	867808	1027400	989684	947478
2014	974577	890525	1071300	972462	972731
2015	1069330	962982	1167460	998235	1049856
2016	1201370	1071630	1314940	1071030	1168845
2017	1212880	1079350	1348990	1051600	1179287
2018	1153810	1028540	1304900	986007	1124935
2019	1047100	938274	1209690	889702	1027314
2020	939477	844414	1091190	804533	924865
2021	855450	753400	985197	752553	839163
2022	894113	779275	1036560	808109	879978
2023	839218	767041	983010	819098	848615

Table 2.31—Biomass (t) time series comparison (last year's base model and this year's ensemble).

	M19.12a from last year			Ensemble from this year		
Year	Age 0+	Spawn.	SB SD	Age 0+	Spawn.	SB SD
1977	319,795	94,759	26,015	396,115	122,264	52,237
1978	344,512	96,809	25,764	424,820	126,023	54,177
1979	470,781	98,527	24,549	560,456	127,850	53,845
1980	669,759	120,579	24,910	770,008	151,907	57,240
1981	903,652	177,750	26,802	1,015,307	213,874	66,232
1982	1,158,560	277,948	31,867	1,287,369	322,624	82,994
1983	1,261,780	370,543	34,913	1,400,287	422,322	95,053
1984	1,218,190	376,036	30,487	1,341,386	424,971	85,960
1985	1,307,340	421,481	31,676	1,442,943	479,008	94,913
1986	1,298,170	412,760	28,833	1,429,514	469,401	89,175
1987	1,317,970	403,932	25,558	1,441,967	455,980	79,887
1988	1,339,020	427,604	24,788	1,468,123	480,751	79,527
1989	1,220,500	415,652	22,817	1,346,997	467,544	74,557
1990	1,035,380	372,877	19,401	1,150,931	421,347	64,940
1991	861,355	297,203	15,339	957,936	340,304	53,035
1992	743,115	215,632	12,826	822,942	253,822	43,940
1993	842,138	204,815	13,246	915,094	240,900	41,994
1994	856,283	208,736	12,442	915,240	237,208	36,503
1995	912,444	223,394	13,075	965,520	247,922	36,332
1996	922,799	224,482	13,922	968,361	244,713	36,894
1997	804,452	220,544	14,032	848,942	238,879	38,851
1998	709,192	197,660	14,009	751,421	215,265	39,820
1999	747,401	192,145	14,513	791,004	210,063	41,245
2000	813,440	201,843	15,419	858,992	220,810	42,914
2001	836,115	210,456	15,073	879,248	228,831	40,974
2002	873,165	224,871	14,829	916,414	243,297	40,077
2003	861,948	229,952	14,359	908,216	248,245	39,118
2004	832,922	234,237	13,702	885,340	252,719	38,515
2005	760,608	228,483	12,998	821,638	249,015	38,621
2006	665,127	201,696	11,775	733,216	224,646	36,325
2007	587,975	175,465	10,913	661,297	201,706	35,309
2008	550,820	150,420	9,687	616,269	179,012	33,902
2009	586,477	134,746	9,299	648,714	160,665	33,272
2010	684,027	131,558	9,230	739,571	154,846	32,372
2011	814,318	158,756	9,967	853,813	178,480	31,658
2012	875,833	188,043	11,287	891,828	204,422	30,418
2013	906,451	212,858	12,898	947,478	229,809	30,648
2014	930,673	216,417	14,091	972,731	233,355	30,737
2015	1,008,490	222,203	15,526	1,049,856	239,466	32,786
2016	1,123,180	255,903	18,225	1,168,845	274,395	39,368
2017	1,121,510	296,945	21,339	1,179,287	317,056	48,323
2018	1,052,380	324,018	23,200	1,124,935	347,091	54,834
2019	941,834	322,372	23,424	1,027,314	351,095	57,349
2020	769,925	270,954	20,724	924,865	314,774	54,046
2021	754,000	228,219	18,820	839,163	254,718	45,541
2022				879,978	259,789	45,693

Table 2.32—Age 0 recruitment (1000s of fish) time series comparison (last year's base model and this year's ensemble).

	M19.12a from last year		Ensemble from this year	
Year	Recruits	Std. dev.	Recruits	Std. dev.
1977	1,132,170	290,954	1,139,930	341,005
1978	739,151	201,877	772,923	230,146
1979	770,519	129,404	766,237	160,196
1980	186,118	47,240	194,592	56,165
1981	210,027	42,072	208,982	45,768
1982	1,000,660	115,766	981,579	145,219
1983	270,127	50,727	259,746	59,257
1984	902,189	103,078	902,784	138,038
1985	407,253	54,359	413,649	68,350
1986	224,399	32,914	224,392	38,112
1987	69,366	17,327	76,749	19,459
1988	324,687	41,323	313,689	49,090
1989	646,249	72,120	612,363	87,333
1990	633,733	72,174	598,178	89,176
1991	372,504	49,912	366,780	68,232
1992	1,001,350	102,612	965,855	154,643
1993	374,074	45,552	360,228	52,800
1994	315,110	38,012	305,256	48,201
1995	269,846	34,029	269,568	40,673
1996	875,470	92,401	857,884	117,904
1997	384,661	45,593	361,730	51,972
1998	289,356	36,743	288,922	44,002
1999	716,621	71,340	693,162	96,111
2000	512,671	52,438	513,889	71,570
2001	208,749	27,441	207,559	37,281
2002	342,846	36,868	366,838	70,697
2003	324,024	34,424	337,255	68,255
2004	234,255	28,663	239,590	45,739
2005	288,127	33,264	286,405	50,533
2006	847,621	79,110	816,750	103,863
2007	334,827	42,459	325,725	47,709
2008	1,238,610	118,737	1,186,460	153,542
2009	168,461	31,596	168,096	35,294
2010	772,262	81,681	747,881	100,979
2011	986,556	104,599	963,160	132,664
2012	469,167	62,012	454,473	77,665
2013	1,259,200	136,735	1,213,290	175,823
2014	220,895	32,747	223,305	38,290
2015	293,300	34,382	307,928	42,365
2016	180,633	26,187	218,994	39,829
2017	127,111	27,711	137,711	31,723
2018	749,855	77,312	752,933	99,978
2019			229,133	77,536
2020			412,309	131,526
Average	516,067		501,020	

Table 2.33 (page 1 of 5)—Numbers at age (1000s of fish, Model 19.12a).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1271110	254695	85980	79661	33237	16848	10503	7063	4875	3377	2321	1574	1052	693	450	290	186	118	75	48	81
1978	862348	886058	177536	59804	54544	21917	10618	6411	4253	2926	2027	1395	947	633	417	271	175	112	71	45	77
1979	861806	601121	617623	123495	40786	35535	13517	6300	3742	2474	1703	1181	813	552	369	243	158	102	65	42	71
1980	218173	600744	419016	429517	84795	27025	22643	8382	3863	2290	1514	1043	724	499	339	226	149	97	63	40	69
1981	227729	152083	418747	291546	294168	56307	17168	13980	5113	2350	1393	922	635	441	304	206	138	91	59	38	67
1982	1078230	158745	106009	291406	200277	196312	36581	10909	8812	3218	1479	878	581	401	278	192	130	87	57	37	66
1983	292051	751613	110657	73851	201798	135978	129888	23825	7043	5678	2073	954	566	375	258	179	124	84	56	37	67
1984	999197	203582	523928	77029	51024	136458	89098	83198	15131	4460	3594	1313	604	358	237	164	114	78	53	36	66
1985	456529	696516	141902	364198	52647	33906	87287	55253	50919	9233	2720	2193	801	369	219	145	100	69	48	32	62
1986	243310	318236	485515	98823	250106	34866	21637	53835	33472	30707	5566	1641	1323	483	222	132	87	60	42	29	57
1987	81708	169606	221831	337655	67923	165277	22086	13373	32820	20334	18664	3386	998	806	294	136	80	53	37	26	52
1988	341087	56957	118226	154429	231684	45177	103864	13375	7986	19493	12070	11085	2012	594	479	175	81	48	32	22	46
1989	666201	237760	39694	81877	103892	147620	27522	60715	7716	4599	11236	6967	6404	1163	343	277	101	47	28	18	39
1990	655796	464391	165729	27584	55803	67647	90936	16417	35472	4489	2675	6539	4057	3730	677	200	161	59	27	16	34
1991	406765	457139	323709	115253	18862	36452	41520	53134	9402	20105	2539	1513	3698	2294	2110	383	113	91	33	15	28
1992	1076410	283543	318645	224696	77653	11806	20618	21629	26575	4652	9916	1253	747	1826	1133	1042	189	56	45	16	21
1993	391489	750330	197641	221361	150932	48044	6571	10511	10568	12850	2251	4808	608	363	888	551	507	92	27	22	18
1994	336299	272894	522943	136710	148160	94163	27958	3643	5695	5696	6933	1216	2601	329	197	481	299	275	50	15	22
1995	293119	234424	190207	362876	91194	91108	52011	14392	1815	2812	2812	3429	602	1289	163	97	239	148	136	25	18
1996	947846	204324	163393	131710	240018	53588	47468	24660	6577	822	1273	1276	1559	274	587	74	44	109	68	62	20
1997	396333	660714	142424	113503	88645	147343	28775	23328	11532	3027	376	583	584	714	125	269	34	20	50	31	37
1998	319907	276269	460489	98471	74522	52162	76037	13421	10461	5101	1336	166	258	258	316	56	119	15	9	22	30
1999	777180	222998	192573	320058	66365	46202	29132	39112	6623	5109	2487	652	81	126	126	154	27	58	7	4	26
2000	556536	541750	155441	133870	216201	41315	25974	15215	19721	3307	2551	1243	326	41	63	63	77	14	29	4	15
2001	220108	387945	377633	107889	90950	136325	23505	13704	7763	9968	1671	1291	630	165	21	32	32	39	7	15	10
2002	377520	153431	270413	262472	72834	58203	79449	12761	7251	4102	5294	892	690	337	89	11	17	17	21	4	13
2003	343610	263158	106942	187336	175526	44604	33083	42049	6612	3779	2159	2807	475	369	180	47	6	9	9	11	9
2004	245681	239520	183420	74181	125205	108473	24889	17498	21491	3357	1922	1101	1434	243	189	92	24	3	5	5	10
2005	291383	171256	166947	126825	49589	76619	60432	12897	8860	10784	1685	967	555	723	123	95	47	12	2	2	8
2006	857502	203114	119352	115771	83818	30362	42132	31010	6396	4364	5305	830	477	274	357	60	47	23	6	1	5
2007	355237	597739	141579	82881	77709	50479	16623	21132	14970	3043	2071	2516	394	226	130	169	29	22	11	3	3
2008	1321290	247626	416653	98430	55879	48172	27601	8514	10397	7280	1476	1005	1221	191	110	63	82	14	11	5	3
2009	186905	921033	172608	289546	66217	33847	25511	13105	3931	4779	3362	685	467	569	89	51	29	38	7	5	4
2010	831713	130285	642012	120024	195336	39898	16926	11125	5421	1632	2010	1428	293	200	245	38	22	13	17	3	4
2011	1072160	579758	90816	446562	81328	119981	20673	7535	4674	2270	689	857	612	126	86	105	17	10	5	7	3
2012	520041	747368	404120	63206	298628	48220	58708	8467	2805	1696	822	250	311	223	46	31	38	6	3	2	4
2013	1369630	362502	520955	280548	42428	174434	24097	25717	3453	1118	674	327	100	124	89	18	13	15	2	1	2
2014	247139	954721	252677	361690	186665	25582	88492	11018	11167	1479	479	290	141	43	54	39	8	5	7	1	2
2015	334755	172272	665494	175677	243974	112164	13292	39437	4655	4651	617	201	122	60	18	23	16	3	2	3	1
2016	246594	233346	120084	462332	118874	150299	58869	6226	17160	1995	1990	264	86	53	26	8	10	7	1	1	2
2017	151766	171892	162654	83437	310744	73788	82016	28526	2865	7718	895	893	119	39	24	12	4	4	3	1	1
2018	816738	105791	119818	113103	56427	194067	42119	42993	14226	1407	3767	436	435	58	19	12	6	2	2	2	1
2019	273593	569325	73740	83102	76425	35679	113846	23598	23442	7681	758	2031	235	235	31	10	6	3	1	1	1
2020	428652	190715	396810	51328	55870	48522	21064	64170	13086	12937	4242	420	1125	130	130	17	6	3	2	1	1
2021	560357	298801	132941	275366	35140	35158	28623	11817	35270	7155	7066	2318	229	615	71	71	9	3	2	1	1

Table 2.33 (page 2 of 5)—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	911851	214114	67149	62676	27172	13639	8509	5766	4028	2830	1975	1359	920	614	406	267	175	115	76	50	101
1978	661056	650260	152683	47764	43798	18190	8658	5186	3439	2380	1667	1163	802	546	367	245	163	108	72	48	98
1979	658404	471412	463691	108615	33219	28883	11231	5083	2963	1942	1339	938	656	455	313	213	144	97	65	44	93
1980	158744	469522	336164	329757	76103	22318	18503	6941	3082	1782	1165	803	564	396	277	192	132	90	61	42	89
1981	192530	113204	334809	239203	230334	51226	14225	11353	4174	1837	1060	692	478	337	239	168	118	82	57	39	85
1982	893237	137297	80724	238293	167673	155891	33518	9031	7107	2597	1141	658	431	299	212	151	107	76	53	37	83
1983	215666	636988	97910	57525	168636	115906	104381	21976	5840	4571	1668	733	423	278	193	138	99	71	50	35	81
1984	805170	153796	454247	69682	40614	116139	76844	67190	13960	3684	2878	1050	462	267	176	124	89	64	46	33	78
1985	371390	574184	109661	322926	48483	27446	75036	47745	40929	8446	2222	1736	634	280	163	109	77	56	41	30	73
1986	210853	264846	409454	78121	226539	32539	17740	46545	28863	24493	5040	1326	1038	381	169	100	67	48	35	26	67
1987	74818	150364	188864	291240	54871	152478	20827	11070	28471	17489	14797	3044	802	631	233	105	62	42	30	23	61
1988	296020	53355	107225	134478	204150	37203	97122	12670	6623	16847	10303	8714	1796	476	377	141	64	38	26	19	54
1989	570834	211095	38039	75937	92359	132251	22934	56973	7269	3777	9575	5854	4965	1029	275	220	83	38	23	16	47
1990	546757	407073	150529	27037	52883	61246	82482	13771	33234	4197	2176	5513	3379	2882	602	163	132	51	24	15	40
1991	304015	389903	290286	107082	18900	35207	38065	48410	7876	18707	2352	1219	3095	1909	1645	347	95	78	30	14	35
1992	813451	216797	278034	206064	73712	12048	20124	19815	23898	3817	8978	1128	587	1503	942	830	179	50	42	17	29
1993	327260	580084	154593	197547	141309	46496	6811	10326	9602	11295	1791	4205	531	279	725	465	420	93	27	23	26
1994	269490	233373	413579	109337	134899	89598	27434	3809	5596	5132	6007	952	2244	286	151	399	261	240	54	16	30
1995	246811	192177	166402	293290	74450	84229	49857	14123	1877	2701	2457	2874	457	1089	141	76	205	137	130	30	27
1996	783772	176004	137024	117720	197122	44254	43756	23165	6226	808	1152	1047	1231	198	482	64	35	98	68	67	30
1997	339638	558918	125506	97329	80675	121601	23484	20761	10270	2691	346	492	449	535	87	220	30	17	49	35	52
1998	274069	242199	398507	88712	64916	47285	60658	10308	8559	4112	1068	137	196	182	222	37	97	14	8	24	45
1999	629264	195442	172710	283302	60923	40396	25816	29666	4733	3835	1825	473	61	88	83	104	18	48	7	4	38
2000	456365	448738	139369	122810	195147	38111	22250	12863	13954	2171	1744	829	216	28	41	40	51	9	25	4	24
2001	187027	325441	319998	98984	85209	124227	21361	11262	6157	6514	1004	806	385	101	13	20	20	26	5	14	16
2002	317794	133372	232068	227511	68279	55338	72427	11362	5703	3054	3206	494	398	192	51	7	11	11	14	3	17
2003	295294	226623	95099	164361	155153	42448	31636	37936	5673	2793	1486	1559	241	196	96	26	4	6	6	8	12
2004	216244	210579	161590	67456	111980	97006	23685	16501	18787	2749	1343	714	752	117	97	48	13	2	3	3	12
2005	267491	154206	150152	114249	45999	69285	53946	12059	8096	9008	1307	638	341	362	58	48	25	7	1	2	9
2006	788594	190751	109943	106490	76994	28497	37954	27146	5774	3813	4205	610	299	161	174	28	24	13	4	1	6
2007	309801	562358	136022	78097	73009	46874	15529	18564	12593	2613	1714	1886	275	136	75	83	14	12	7	2	4
2008	1089350	220924	401014	96743	53826	45973	25563	7804	8810	5848	1203	788	871	128	65	36	41	7	6	4	3
2009	152223	776831	157540	285116	66533	33231	24564	11961	3471	3808	2505	515	339	379	57	29	17	20	4	3	4
2010	708779	108552	553959	112080	196861	40980	16939	10704	4721	1331	1439	945	196	130	149	23	12	7	9	2	4
2011	893575	505438	77409	394154	77751	123855	21685	7599	4385	1851	516	557	368	77	53	62	10	6	3	4	3
2012	407734	637218	360425	55098	269314	47172	61714	8929	2786	1533	635	177	192	129	28	20	24	4	2	2	3
2013	1114300	290760	454398	255857	37776	160396	23894	26948	3555	1064	577	239	67	74	51	11	8	11	2	1	2
2014	209125	794622	207333	322649	173717	23181	82222	10889	11400	1451	429	232	97	27	31	22	5	4	5	1	2
2015	294448	149129	566645	147443	222356	106147	12181	36425	4465	4495	563	166	90	38	11	13	10	2	2	2	1
2016	187406	209974	106344	402565	101974	139389	55940	5644	15280	1811	1796	224	66	37	16	5	6	4	1	1	2
2017	121012	133641	149731	75551	276021	64335	76251	26597	2506	6512	763	755	95	28	16	7	2	3	2	1	2
2018	699280	86295	95299	106505	52139	174783	36875	39427	12860	1182	3033	355	352	45	14	8	4	1	1	1	1
2019	153551	498669	61535	67605	73507	33443	103192	20625	21230	6798	621	1592	187	187	24	7	4	2	1	1	1
2020	353167	109500	355556	43806	46420	47538	19983	58444	11395	11564	3682	336	864	102	103	13	4	3	1	0	1
2021	457862	251849	78086	252344	30621	29744	28429	11278	32091	6193	6253	1989	182	472	56	57	8	2	1	1	1

Table 2.33 (page 3 of 5)—Numbers at age (1000s of fish, Model 21.1).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1201620	321491	103113	105731	47094	24624	16075	11429	8386	6205	4581	3359	2441	1757	1253	887	624	437	305	212	464
1978	763151	868304	232307	74399	75405	32700	16627	10689	7582	5585	4154	3080	2265	1648	1188	848	601	423	296	207	459
1979	734709	551459	627429	167601	52921	51949	21792	10882	6979	4976	3690	2758	2052	1513	1103	796	568	403	284	199	447
1980	189840	530907	398481	452550	119687	36900	35394	14666	7313	4708	3373	2510	1881	1402	1035	755	545	389	276	194	442
1981	196513	137180	383624	287493	322427	83386	25058	23721	9810	4909	3175	2282	1703	1278	954	704	514	371	265	188	434
1982	918777	142002	99123	276787	205126	225059	57203	17010	16086	6673	3352	2174	1566	1170	879	656	485	354	256	183	429
1983	254594	663918	102612	71585	198776	144851	156083	39337	11675	11063	4602	2317	1505	1085	811	610	456	337	246	178	425
1984	845286	183972	479748	74041	51258	139600	99333	#####	26581	7906	7514	3134	1580	1028	742	555	417	312	230	168	412
1985	389940	610809	132928	345608	52427	35359	93515	65320	69261	17464	5215	4973	2078	1050	683	494	369	278	208	153	387
1986	206249	281774	441367	95963	245854	36014	23550	60934	42318	45063	11420	3427	3278	1373	694	452	327	245	184	138	358
1987	69251	149037	203609	318120	68301	168334	23817	15333	39531	27605	29605	7539	2271	2177	914	463	302	218	163	123	331
1988	281932	50041	107694	146923	225937	46996	110200	15224	9767	25306	17818	19234	4917	1485	1427	599	304	198	143	107	299
1989	556402	203722	36148	77231	102101	148950	29865	68234	9428	6096	15954	11334	####	3156	956	920	387	196	128	93	263
1990	546389	402059	147201	26028	54419	68787	95902	18844	42775	5939	3861	10157	7246	7889	2026	614	591	249	126	82	229
1991	355546	394824	290523	106069	18405	36742	44127	59648	11629	26417	3682	2401	6332	4526	4933	1268	385	370	156	79	195
1992	921721	256919	285290	208981	73903	11916	21806	24819	33072	6477	14883	2093	1371	3632	2604	2843	731	222	214	90	159
1993	349848	666038	185642	205401	145126	47344	6983	12058	13547	18269	3627	8466	1202	792	2105	1514	###	426	130	125	145
1994	288988	252799	481188	132961	142188	93931	28964	4144	7127	8097	11078	2220	5228	746	493	1313	945	###	267	81	169
1995	255582	208823	182652	346055	91507	90468	54620	16115	2291	3996	4629	6435	1301	3090	443	293	783	565	619	160	150
1996	811010	184683	150881	131097	236723	55621	49954	28435	8337	1204	2147	2532	3566	726	1735	250	166	443	320	351	176
1997	341301	586038	133449	108642	91294	150923	31800	27110	15138	4446	646	1160	1375	1944	396	949	137	91	243	175	289
1998	267868	246623	423394	95587	73780	55890	83294	16500	13920	7835	2328	342	618	737	1045	213	512	74	49	131	251
1999	653791	193562	178205	305023	66681	47517	33040	46776	9151	7777	4430	1328	196	357	426	606	124	298	43	29	223
2000	493433	472432	139865	128419	213304	43133	28322	18808	26355	5206	4474	2576	777	115	210	252	359	73	177	25	149
2001	186580	356556	341376	100599	90322	139495	25966	16284	10713	15144	3033	2631	1526	463	69	126	151	215	44	106	105
2002	329327	134823	257637	245913	70241	59829	85225	15155	9470	6332	9127	1859	1628	951	290	43	79	95	136	28	133
2003	296025	237972	97414	184980	169958	44521	35614	48327	8598	5504	3777	5558	1150	1016	597	182	27	50	60	86	102
2004	211568	213908	171943	70041	127860	108623	26126	20199	27175	4909	3201	2229	3313	691	612	361	111	17	30	37	115
2005	248886	152879	154557	123213	48454	81184	63786	14664	11274	15315	2807	1852	1299	1942	406	361	213	65	10	18	90
2006	726947	179846	110448	111098	84221	30777	47203	35504	8092	6266	8624	1598	1062	749	1123	236	210	124	38	6	63
2007	306558	525295	129951	79503	77217	52864	17933	26050	19313	4412	3434	4757	886	590	417	626	132	117	69	21	38
2008	1126850	221520	379566	93649	55493	49811	30946	10105	14468	10760	2477	1937	2697	504	337	238	358	75	67	40	34
2009	165635	814265	160067	273408	65227	34954	28183	16404	5337	7774	5896	1381	1089	1529	287	193	137	205	43	39	42
2010	702779	119688	588381	115371	190969	40750	18647	13784	8007	2689	4088	3197	766	611	868	164	110	79	118	25	47
2011	938714	507828	86486	424256	80860	121494	22431	9301	6820	4135	1438	2261	1807	440	353	505	96	65	46	70	42
2012	442419	678315	366950	62405	293689	49645	63635	10473	4230	3186	2014	717	1152	933	229	185	266	51	34	24	59
2013	1173290	319692	490142	263973	43348	178213	26504	31333	5047	2077	1607	1041	375	609	496	122	99	142	27	18	45
2014	216585	847821	230999	352764	181452	27076	96139	13388	15652	2578	1095	868	574	209	341	279	69	56	81	15	36
2015	286842	156504	612629	166486	246279	112678	14897	47795	6565	7815	1324	577	465	311	114	187	153	38	31	44	28
2016	209382	207272	113089	441171	116523	157090	62734	7722	24161	3363	4083	704	311	253	170	62	103	85	21	17	40
2017	133633	151299	149772	81454	306681	74778	90472	33440	4050	12822	1814	2235	390	174	142	96	35	58	48	12	33
2018	696787	96564	109327	107944	56964	198263	44860	51407	18651	2267	7258	1035	1283	225	101	82	56	20	34	28	26
2019	236051	503502	69774	78576	75429	37290	122008	26817	30462	11115	1362	4397	630	784	138	62	51	34	13	21	33
2020	467307	170572	363788	50349	54567	49460	23001	73138	16041	18382	6793	839	2733	393	491	86	39	32	22	8	34
2021	485877	337678	123255	261636	35690	35525	30563	13781	43582	9597	11071	4118	511	1669	241	300	53	24	20	13	26

Table 2.33 (page 4 of 5)—Numbers at age (1000s of fish, Model 21.2).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1194030	258496	86423	78130	34577	17726	11168	7589	5296	3717	2596	1793	1222	822	546	359	235	153	99	64	114
1978	807466	840266	181903	60686	54045	23086	11342	6937	4662	3250	2286	1599	1105	754	507	337	222	145	94	61	110
1979	812365	568230	591287	127730	41803	35624	14434	6840	4135	2782	1947	1373	962	666	454	306	203	134	87	57	103
1980	217405	571678	399864	415088	88534	28003	22986	9082	4269	2583	1743	1222	863	605	419	286	192	128	84	55	101
1981	218740	152992	402284	280845	287072	59436	18033	14407	5631	2642	1600	1081	759	536	376	260	178	119	79	52	97
1982	1035790	153932	107657	282525	194619	193420	39026	11599	9203	3595	1689	1024	692	486	343	241	167	114	77	51	95
1983	280641	728908	108325	75713	197495	133428	129265	25669	7564	5991	2341	1100	667	451	317	224	157	109	74	50	95
1984	965795	197493	512944	76119	52800	134817	88317	83644	16463	4835	3828	1496	703	426	288	202	143	100	69	47	93
1985	437160	679649	138968	359893	52506	35426	87149	55382	51739	10146	2977	2357	921	433	263	177	125	88	62	43	86
1986	236717	307639	478274	97699	249518	35137	22861	54375	33943	31562	6187	1816	1438	562	264	160	108	76	54	38	79
1987	81019	166583	216488	335756	67768	166475	22486	14280	33533	20884	19445	3816	1121	888	347	163	99	67	47	33	72
1988	335800	57015	117226	152145	232625	45538	105853	13789	8638	20184	12569	11712	2300	676	536	209	98	60	40	28	63
1989	658446	236304	40109	81869	103127	149572	28056	62760	8081	5057	11834	7381	6885	1353	398	315	123	58	35	24	54
1990	648127	463361	166282	28126	56285	67849	93379	16986	37244	4774	2986	6990	4361	4069	800	235	186	73	34	21	46
1991	413173	456099	326070	116737	19424	37224	42310	55534	9899	21464	2744	1715	4014	2505	2337	459	135	107	42	20	38
1992	1076430	290756	320952	228494	79517	12346	21530	22639	28547	5031	10865	1389	868	2032	1268	1183	233	68	54	21	29
1993	371521	757503	204601	225094	155156	49957	7012	11259	11401	14291	2526	5479	702	439	1029	643	600	118	35	27	26
1994	329775	261443	532970	142855	152286	98270	29657	3979	6265	6327	7953	1409	3062	393	246	576	360	336	66	19	30
1995	283041	232067	183963	373401	96413	95281	55608	15716	2049	3208	3248	4096	727	1582	203	127	298	186	174	34	25
1996	878722	199179	163291	128608	249936	57873	51262	27450	7510	972	1525	1549	1957	348	757	97	61	143	89	83	29
1997	362218	618369	140160	114438	87331	156040	32155	26378	13501	3634	468	732	743	939	167	363	47	29	68	43	54
1998	284838	254895	435044	97677	75757	52402	83616	15799	12502	6304	1690	217	340	345	436	78	169	22	14	32	45
1999	697592	200445	179366	305131	66520	47866	30243	44913	8174	6401	3219	863	111	174	176	223	40	86	11	7	39
2000	559127	490908	141051	125842	208053	42054	27559	16329	23667	4311	3397	1717	462	59	93	95	120	21	46	6	25
2001	247525	393466	345450	98717	86086	132805	24595	15115	8694	12478	2269	1789	905	243	31	49	50	63	11	24	16
2002	481147	174187	276878	242464	67279	55429	77358	13389	8190	4830	7112	1316	1046	531	143	18	29	29	37	7	24
2003	452839	338589	122564	193524	163366	41476	31726	41366	7050	4363	2609	3879	722	575	293	79	10	16	16	21	17
2004	306094	318669	238259	85944	131033	101368	22726	16370	21036	3680	2341	1424	2138	400	320	163	44	6	9	9	21
2005	360579	215403	224246	166854	58461	81001	55680	11455	8181	10762	1935	1252	769	1160	218	174	89	24	3	5	16
2006	911335	253744	151576	157484	112904	36512	44282	27955	5667	4124	5575	1021	667	412	623	117	94	48	13	2	11
2007	323614	641321	178561	106428	107865	70247	20715	22930	13840	2749	1991	2685	491	321	198	300	56	45	23	6	6
2008	1179490	227733	451300	125413	73033	69293	40559	11279	11995	7133	1409	1019	1373	251	164	101	153	29	23	12	6
2009	162996	830028	160254	316621	85669	46305	40117	21657	5854	6134	3632	716	518	698	128	83	51	78	15	12	9
2010	718694	114703	584084	112322	215691	54069	26376	21188	10930	2919	3041	1798	354	256	345	63	41	25	39	7	10
2011	909822	505756	80714	408885	76460	137266	31452	14264	11047	5604	1491	1551	916	181	131	176	32	21	13	20	9
2012	426978	640255	355885	56609	275258	47151	75078	15532	6677	5086	2570	684	712	421	83	60	81	15	10	6	13
2013	1142200	300470	450535	248916	38159	165251	25232	36725	7322	3148	2420	1233	329	343	203	40	29	39	7	5	9
2014	211783	803778	211429	315405	166794	23228	86459	12193	17437	3556	1572	1229	633	170	178	105	21	15	20	4	7
2015	309369	149034	565618	148390	214196	100753	12066	39256	5448	8033	1700	772	612	318	85	90	53	10	8	10	6
2016	233768	217706	104875	396634	101252	131546	52080	5546	17348	2457	3725	805	370	295	154	41	43	26	5	4	8
2017	145146	164505	153198	73529	268190	62791	70267	24473	2479	7672	1093	1666	362	167	133	69	19	20	12	2	5
2018	801040	102141	115763	107682	50483	167808	34651	34254	11486	1183	3776	547	843	184	85	68	36	10	10	6	4
2019	263804	563703	71876	81179	73610	31858	95639	18546	17825	6002	624	2013	293	453	99	46	37	19	5	5	5
2020	405845	185643	396670	50541	55154	46491	18119	51032	9791	9538	3271	344	1119	163	253	55	26	21	11	3	6
2021	537217	285599	130639	278067	34916	34352	26548	9672	26631	5103	4991	1719	181	590	86	134	29	14	11	6	5

Table 2.33 (page 5 of 5)—Numbers at age (1000s of fish, ensemble).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1139930	259270	84670	80613	34948	17885	11339	7794	5518	3934	2793	1963	1365	938	640	433	293	197	133	89	181
1978	772923	807218	183892	59910	56237	23552	11575	7142	4861	3441	2461	1753	1237	864	596	408	278	188	127	86	177
1979	766237	547216	571709	130193	41617	37461	14938	7106	4336	2954	2101	1510	1081	766	537	373	257	176	120	81	170
1980	194592	542381	387488	404068	91035	28139	24477	9546	4508	2755	1884	1345	970	697	496	349	243	168	115	79	167
1981	208982	137735	383984	273929	281375	61661	18304	15561	6021	2846	1746	1198	859	621	448	320	226	158	110	75	162
1982	981579	147961	97506	271430	191181	190994	40898	11905	10078	3905	1852	1140	785	564	409	296	212	150	105	73	160
1983	259746	694903	104778	69000	190948	131899	128600	27202	7861	6663	2589	1231	760	524	378	275	199	143	101	71	158
1984	902784	183866	492043	74095	48418	131134	87854	83932	17674	5100	4338	1690	806	499	345	249	182	132	95	68	154
1985	413649	639059	130166	347438	51389	32663	85224	55472	52465	11069	3200	2734	1070	512	318	221	160	117	85	61	144
1986	224392	292833	452454	92088	242324	34516	21178	53498	34290	32410	6877	1994	1714	674	324	202	141	102	75	55	133
1987	76749	158865	207342	319620	64275	162549	22196	13325	33258	21302	20230	4323	1258	1087	429	207	130	91	66	49	123
1988	313689	54341	112492	146636	222686	43392	103750	13672	8121	20203	12983	12404	2672	780	679	269	130	82	57	42	110
1989	612363	222054	38472	79111	100070	143889	26850	61737	8047	4789	11957	7732	7443	1618	475	416	166	81	51	36	96
1990	598178	433492	157211	27159	54734	66126	90095	16323	36826	4790	2860	7161	4654	4509	989	291	257	103	50	32	83
1991	366780	423424	306922	111054	18862	36295	41275	53704	9568	21398	2785	1669	4190	2737	2670	591	175	155	62	31	70
1992	965855	259622	299767	216401	75978	11991	20906	22022	27651	4901	10959	1435	866	2187	1442	1423	319	95	85	34	57
1993	360228	683632	183800	211526	147564	47764	6809	10943	11124	13906	2485	5597	740	451	1147	765	764	174	52	47	51
1994	305256	255080	483880	129097	143703	93503	28328	3863	6094	6198	7801	1406	3185	424	260	666	448	451	104	31	60
1995	269568	216091	180640	340976	87386	89707	52609	14938	1982	3121	3205	4080	744	1699	228	142	365	248	253	59	52
1996	857884	190860	152984	127069	228734	52128	47627	25579	7042	932	1483	1548	1998	369	852	116	73	189	130	134	60
1997	361730	607357	135156	107938	86772	142321	28541	23988	12340	3362	446	716	756	986	184	428	59	37	97	68	103
1998	288922	256121	429997	94896	71828	51680	74623	13650	11065	5656	1549	207	337	362	478	91	212	29	19	49	88
1999	693162	204551	181376	303616	64917	45137	29282	39179	6932	5583	2872	793	107	177	192	256	49	116	16	10	77
2000	513889	490700	144843	128112	208174	40950	25726	15566	20282	3593	2909	1514	422	58	96	106	142	27	65	9	50
2001	207559	363842	347436	102125	88354	133028	23649	13845	8147	10608	1898	1547	814	229	32	53	59	80	16	37	35
2002	366838	146917	257645	245331	70003	57298	78439	13024	7483	4443	5894	1074	884	471	134	19	32	35	48	9	44
2003	337255	259646	104001	181303	166398	43445	33030	42219	6879	3997	2418	3270	606	504	272	78	11	19	21	29	33
2004	239590	238694	183794	73292	123043	104052	24469	17650	21962	3598	2124	1306	1794	337	283	154	44	6	11	12	37
2005	286405	169590	168955	129156	49800	76330	58565	12825	9088	11325	1880	1126	702	977	186	157	86	25	4	6	28
2006	816750	202739	120043	119076	86871	30964	42481	30438	6489	4608	5806	977	594	375	527	101	86	48	14	2	20
2007	325725	578247	143535	84705	81338	53336	17304	21844	15110	3188	2272	2884	490	301	192	272	53	45	25	7	12
2008	1186460	230641	409455	101388	58095	51484	29979	9146	11158	7654	1619	1162	1489	256	159	102	146	29	25	14	11
2009	168096	839997	163341	289110	69354	36027	28321	14984	4450	5425	3751	803	583	759	132	83	54	78	16	13	14
2010	747881	119030	594810	115392	198186	42789	18920	13316	6749	2008	2503	1763	385	285	379	67	43	29	42	8	15
2011	963160	529515	84301	420156	79383	124344	23183	9096	6162	3144	948	1214	871	194	146	198	36	23	16	23	13
2012	454473	682031	374970	59605	285217	48072	63460	10253	3782	2566	1339	411	540	394	89	68	94	17	11	8	18
2013	1213290	321751	483043	264365	40600	169773	24788	29221	4503	1667	1157	620	193	259	192	44	34	47	9	6	13
2014	223305	859041	227823	340732	178431	24849	88139	11728	13328	2075	792	566	312	98	135	101	23	18	26	5	11
2015	307928	158129	608336	160928	233348	108651	13141	40486	5177	5909	948	374	275	155	50	69	52	12	10	14	8
2016	218994	218031	111998	429380	110558	145613	57788	6292	18279	2337	2712	446	181	135	78	25	36	27	6	5	12
2017	137711	155008	154405	79068	292767	69478	80357	28433	2972	8549	1104	1295	216	89	67	40	13	19	15	4	9
2018	752933	97499	109737	109120	54331	185135	40006	42456	14401	1504	4368	571	677	114	47	36	22	7	11	8	7
2019	229133	533054	69039	77326	74891	34773	109642	22648	23493	7942	837	2451	323	385	65	27	21	13	4	6	9
2020	412309	162114	377414	48831	52762	48117	20709	62407	12735	13235	4510	480	1422	189	227	39	16	13	8	3	10
2021	510082	292236	114720	266098	33945	33569	28667	11757	34837	7102	7413	2540	273	814	109	131	22	9	7	5	7

Table 2.34—Some statistics of the ABC and OFL distributions for 2022 and 2023.

Feature			M19.12a	M19.12	M21.1	M21.2	
Allow catchability to vary?			no	yes	no	no	
Allow domed survey selectivity?			no	no	yes	no	
Use fishery CPUE?			no	no	no	yes	
Model weight:			0.3158	0.2842	0.2316	0.1684	
Year	Quantity	Statistic	M19.12a	M19.12	M21.1	M21.2	Ensemble
2022	ABC	mean	174,668	123,899	183,492	121,830	153,383
2022	ABC	sdev	27,890	25,761	20,255	21,088	37,039
2022	OFL	mean	208,791	148,656	216,920	146,026	183,012
2022	OFL	sdev	33,005	30,698	23,918	25,144	43,506
2023	ABC	mean	162,093	125,080	177,937	141,112	151,709
2023	ABC	sdev	15,395	16,255	27,109	15,539	27,832
2023	OFL	mean	177,493	139,552	195,398	158,080	167,587
2023	OFL	sdev	15,680	16,956	29,422	16,488	29,229

Table 2.35a—Standard harvest scenarios 1 and 2 (female spawning biomass and catch in 1000s of t).

Time-vary *Q* ?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	M19.12a		M19.12		M21.1		M21.2		Ensemble	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2022	259.0	18.5	231.3	21.0	326.1	34.1	218.1	15.9	259.8	45.7
B2023	246.6	10.3	231.5	14.0	308.6	27.0	234.1	10.6	254.6	34.6
B2024	231.6	9.7	226.6	12.8	289.1	21.0	233.4	9.6	243.8	28.6
B2025	224.4	11.7	225.0	13.8	281.8	21.4	231.2	11.2	239.0	28.0
B2026	231.5	11.5	233.7	13.7	287.5	21.0	239.1	11.2	246.4	27.1
B2027	243.3	9.0	246.6	11.4	296.6	18.0	250.9	8.9	257.9	24.7
B2028	252.1	6.9	257.0	9.5	303.3	15.7	259.9	7.0	266.7	22.8
B2029	256.7	6.1	262.9	8.7	307.0	14.8	264.6	6.2	271.4	21.9
B2030	258.4	6.0	265.5	8.6	308.6	14.5	266.5	6.0	273.4	21.7
B2031	258.8	6.0	266.4	8.7	309.2	14.5	267.0	6.0	274.0	21.7
B2032	258.7	6.0	266.5	8.8	309.3	14.6	267.0	6.0	274.0	21.8
B2033	258.6	6.0	266.3	8.8	309.3	14.6	266.9	6.0	274.0	21.9
F2022	0.363	0.042	0.267	0.039	0.306	0.016	0.284	0.035	0.309	0.053
F2023	0.345	0.026	0.267	0.027	0.304	0.031	0.307	0.027	0.307	0.041
F2024	0.323	0.020	0.261	0.021	0.284	0.022	0.306	0.021	0.293	0.032
F2025	0.312	0.019	0.259	0.019	0.277	0.020	0.303	0.019	0.287	0.029
F2026	0.322	0.020	0.270	0.019	0.283	0.019	0.313	0.019	0.297	0.030
F2027	0.340	0.018	0.286	0.018	0.292	0.017	0.330	0.017	0.312	0.030
F2028	0.353	0.017	0.299	0.017	0.299	0.016	0.342	0.017	0.323	0.031
F2029	0.360	0.017	0.306	0.017	0.303	0.015	0.349	0.016	0.329	0.031
F2030	0.362	0.016	0.309	0.017	0.304	0.015	0.352	0.016	0.332	0.031
F2031	0.363	0.016	0.310	0.016	0.305	0.015	0.352	0.016	0.333	0.030
F2032	0.363	0.016	0.310	0.016	0.305	0.015	0.352	0.016	0.333	0.030
F2033	0.363	0.016	0.310	0.016	0.305	0.015	0.352	0.016	0.333	0.030
C2022	174.7	27.9	123.9	25.8	183.5	20.3	121.8	21.1	153.4	37.0
C2023	162.1	15.4	125.1	16.3	177.9	27.1	141.1	15.5	151.7	27.8
C2024	142.4	13.9	119.0	14.0	157.7	21.8	137.7	14.2	138.5	21.4
C2025	135.5	14.3	118.2	13.7	154.1	20.9	135.2	14.1	134.8	20.4
C2026	147.0	15.3	129.2	14.7	164.3	21.1	146.8	14.8	145.9	20.8
C2027	163.3	11.9	144.6	11.9	176.1	16.0	162.7	11.8	160.9	17.3
C2028	174.9	9.8	156.7	9.4	183.9	12.9	174.0	10.0	171.6	14.6
C2029	180.4	8.9	163.5	8.0	187.7	11.8	179.5	9.2	177.1	13.2
C2030	182.2	8.6	166.3	7.4	189.1	11.5	181.5	8.9	179.2	12.5
C2031	182.5	8.5	167.1	7.1	189.5	11.4	181.9	8.8	179.7	12.3
C2032	182.4	8.4	167.2	7.0	189.5	11.4	181.8	8.7	179.6	12.2
C2033	182.2	8.4	167.0	7.0	189.5	11.4	181.7	8.7	179.5	12.2

Table 2.35b—Standard harvest scenario 3 (female spawning biomass and catch in 1000s of t).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	M19.12a		M19.12		M21.1		M21.2		Ensemble	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2022	259.0	18.5	231.3	21.0	326.1	34.1	218.1	15.9	259.8	45.7
B2023	250.1	14.9	216.6	16.6	317.8	28.2	213.4	13.1	250.1	44.4
B2024	234.8	13.4	200.7	14.4	305.2	24.8	198.9	11.9	235.4	44.5
B2025	224.3	14.3	191.5	14.2	298.8	25.3	188.4	12.6	226.2	45.8
B2026	227.4	14.7	195.6	13.8	303.2	25.6	192.1	12.5	230.0	46.1
B2027	237.8	12.9	206.5	11.7	312.2	23.3	202.1	10.8	240.1	44.8
B2028	248.2	11.0	217.1	9.4	321.1	20.5	211.2	9.3	250.0	43.7
B2029	256.0	9.6	224.9	7.9	328.1	18.2	217.5	8.5	257.4	43.1
B2030	261.2	8.8	229.9	7.1	333.2	16.6	221.3	8.1	262.2	43.1
B2031	264.4	8.4	232.9	6.6	336.7	15.7	223.5	7.9	265.3	43.3
B2032	266.4	8.3	234.6	6.4	339.1	15.1	224.7	7.8	267.2	43.6
B2033	267.5	8.2	235.6	6.3	340.7	14.8	225.4	7.8	268.3	43.8
F2022	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2023	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2024	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2025	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2026	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2027	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2028	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2029	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2030	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2031	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2032	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
F2033	0.340	0.000	0.370	0.000	0.260	0.000	0.450	0.000	0.349	0.061
C2022	164.7	10.5	165.7	14.4	158.3	14.3	183.9	12.3	166.8	15.3
C2023	162.1	9.5	157.3	12.1	158.2	13.7	182.5	11.3	163.3	14.6
C2024	151.1	10.0	145.3	12.0	152.5	14.5	167.8	11.9	152.6	14.1
C2025	146.2	10.2	141.1	11.8	152.5	14.6	161.6	12.0	148.8	14.0
C2026	151.8	11.0	147.4	12.3	158.3	15.3	169.2	12.3	155.0	14.8
C2027	160.2	8.8	156.8	9.8	164.6	12.8	179.5	9.9	163.5	12.9
C2028	166.9	7.4	164.6	8.0	169.1	11.1	186.9	8.6	170.1	11.7
C2029	171.3	6.6	169.8	6.9	172.0	10.1	191.4	8.0	174.4	11.0
C2030	174.0	6.2	172.9	6.3	173.9	9.5	193.8	7.8	177.0	10.6
C2031	175.7	6.0	174.8	6.0	175.1	9.2	195.2	7.6	178.6	10.4
C2032	176.6	5.9	175.8	5.8	175.8	9.1	195.9	7.6	179.4	10.2
C2033	177.1	5.8	176.3	5.8	176.3	9.0	196.3	7.6	179.9	10.1

Table 2.35c—Standard harvest scenario 4 (female spawning biomass and catch in 1000s of t).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	M19.12a		M19.12		M21.1		M21.2		Ensemble	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2022	259.0	18.5	231.3	21.0	326.1	34.1	218.1	15.9	259.8	45.7
B2023	277.4	13.9	254.4	17.6	341.5	29.9	255.1	13.6	282.0	39.4
B2024	285.0	13.5	267.4	16.1	349.9	27.7	274.9	12.3	293.4	36.7
B2025	290.4	15.6	277.4	17.9	359.4	29.3	286.9	14.5	302.1	37.7
B2026	303.2	17.2	293.6	19.2	375.4	31.1	303.8	16.2	317.3	38.7
B2027	320.9	16.4	314.3	18.5	394.1	30.2	324.3	15.6	336.6	38.0
B2028	338.4	14.4	334.8	16.8	411.3	28.0	343.7	14.0	355.1	36.3
B2029	352.8	12.5	352.1	15.0	425.4	25.8	359.7	12.2	370.6	34.7
B2030	363.7	11.0	365.7	13.7	436.3	24.2	371.8	10.9	382.4	33.6
B2031	371.5	10.1	375.7	12.9	444.4	23.1	380.5	10.0	391.1	33.0
B2032	376.9	9.6	382.9	12.6	450.3	22.5	386.6	9.5	397.2	32.6
B2033	380.5	9.3	387.9	12.5	454.5	22.1	390.8	9.3	401.5	32.6
F2022	0.168	0.019	0.124	0.017	0.148	0.007	0.133	0.016	0.145	0.024
F2023	0.168	0.008	0.138	0.015	0.148	0.007	0.157	0.015	0.153	0.017
F2024	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2025	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2026	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2027	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2028	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2029	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2030	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2031	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2032	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
F2033	0.168	0.008	0.145	0.007	0.148	0.007	0.166	0.007	0.157	0.013
C2022	85.9	14.0	60.5	12.7	93.5	10.4	59.6	10.4	76.0	19.1
C2023	93.1	6.9	73.4	11.1	99.9	10.1	82.0	10.3	87.2	14.1
C2024	94.4	7.3	79.9	6.6	101.8	10.8	90.8	7.0	91.4	11.4
C2025	95.9	7.5	82.6	6.9	105.0	11.0	93.6	7.4	93.8	11.6
C2026	101.1	8.4	88.0	7.7	110.9	11.9	99.5	8.2	99.4	12.3
C2027	107.6	7.7	94.5	7.2	116.7	10.7	106.6	7.7	105.8	11.6
C2028	113.3	7.1	100.4	6.7	121.2	9.8	112.7	7.2	111.4	10.9
C2029	117.5	6.7	105.1	6.2	124.5	9.2	117.2	6.9	115.5	10.2
C2030	120.5	6.4	108.6	5.8	126.7	8.7	120.3	6.6	118.5	9.6
C2031	122.5	6.2	111.0	5.5	128.2	8.5	122.5	6.5	120.6	9.3
C2032	123.9	6.0	112.7	5.3	129.3	8.3	124.0	6.4	122.0	9.0
C2033	124.8	5.9	113.9	5.2	130.1	8.2	125.0	6.3	122.9	8.8

Table 2.35d—Standard harvest scenario 5 (female spawning biomass and catch in 1000s of t).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	M19.12a		M19.12		M21.1		M21.2		Ensemble	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2022	259.0	18.5	231.3	21.0	326.1	34.1	218.1	15.9	259.8	45.7
B2023	307.7	18.2	276.6	21.6	376.0	33.3	275.6	16.7	309.3	45.5
B2024	347.4	18.4	316.1	22.5	421.2	33.7	324.4	17.5	351.7	46.6
B2025	382.3	20.5	353.2	24.2	465.0	37.1	367.1	19.6	390.6	49.8
B2026	419.5	22.9	393.4	26.1	511.2	41.4	410.8	22.0	431.8	53.3
B2027	458.5	23.6	435.9	26.6	557.2	43.5	455.2	22.8	474.4	55.2
B2028	495.6	22.8	477.2	25.8	599.6	43.4	497.0	22.1	514.7	55.7
B2029	528.4	21.1	514.5	24.3	636.5	42.1	533.9	20.6	550.4	55.4
B2030	555.8	19.2	546.6	22.7	667.2	40.5	564.8	18.9	580.5	54.8
B2031	577.9	17.6	573.1	21.4	692.1	39.0	589.8	17.3	605.0	54.3
B2032	595.3	16.3	594.6	20.4	711.8	37.9	609.6	16.0	624.5	53.9
B2033	608.7	15.4	611.6	19.9	727.2	37.2	625.0	15.1	639.7	53.7
F2022	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
F2024	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
F2026	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
F2028	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
F2030	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
F2032	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
F2033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C2022	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
C2024	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
C2026	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
C2028	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
C2030	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
C2032	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
C2033	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2.35e—Standard harvest scenario 6 (female spawning biomass and catch in 1000s of t).

Time-vary *Q*?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	M19.12a		M19.12		M21.1		M21.2		Ensemble	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2022	259.0	18.5	231.3	21.0	326.1	34.1	218.1	15.9	259.8	45.7
B2023	235.0	9.2	222.7	12.8	296.5	26.0	225.9	9.6	244.2	33.1
B2024	215.2	9.3	212.9	12.1	271.0	19.7	219.6	9.0	228.2	27.0
B2025	207.3	11.2	209.4	13.2	262.0	20.3	215.0	10.7	221.8	26.4
B2026	214.8	10.7	217.6	12.7	267.6	19.5	222.4	10.4	229.1	25.3
B2027	226.5	8.0	230.0	10.4	276.3	16.5	233.9	8.0	240.3	22.8
B2028	234.6	6.2	239.4	8.6	282.3	14.4	242.0	6.3	248.3	21.1
B2029	238.2	5.7	244.3	8.1	285.4	13.7	245.8	5.7	252.2	20.5
B2030	239.3	5.6	246.2	8.1	286.6	13.6	247.1	5.6	253.5	20.4
B2031	239.4	5.6	246.5	8.2	286.9	13.6	247.2	5.6	253.7	20.5
B2032	239.2	5.7	246.5	8.3	286.9	13.7	247.1	5.6	253.7	20.5
B2033	239.1	5.7	246.3	8.3	286.9	13.7	247.0	5.6	253.6	20.6
F2022	0.445	0.052	0.327	0.048	0.368	0.020	0.347	0.043	0.377	0.065
F2023	0.401	0.029	0.314	0.030	0.352	0.035	0.360	0.030	0.358	0.046
F2024	0.366	0.022	0.299	0.023	0.320	0.024	0.350	0.023	0.334	0.035
F2025	0.351	0.022	0.294	0.021	0.309	0.022	0.342	0.021	0.324	0.033
F2026	0.365	0.022	0.307	0.021	0.315	0.022	0.354	0.021	0.335	0.034
F2027	0.386	0.021	0.325	0.021	0.326	0.019	0.374	0.020	0.353	0.035
F2028	0.401	0.020	0.339	0.020	0.334	0.018	0.387	0.019	0.366	0.036
F2029	0.407	0.019	0.347	0.020	0.338	0.018	0.394	0.019	0.372	0.036
F2030	0.409	0.019	0.349	0.019	0.339	0.018	0.396	0.018	0.374	0.036
F2031	0.409	0.019	0.350	0.019	0.340	0.018	0.396	0.018	0.374	0.035
F2032	0.409	0.019	0.350	0.019	0.340	0.017	0.396	0.018	0.374	0.035
F2033	0.409	0.019	0.350	0.019	0.340	0.017	0.396	0.018	0.374	0.035
C2022	208.8	33.0	148.7	30.7	216.9	23.9	146.0	25.1	183.0	43.5
C2023	177.5	15.7	139.6	17.0	195.4	29.4	158.1	16.5	167.6	29.2
C2024	149.2	14.4	127.1	14.4	166.0	22.7	146.9	14.8	146.4	21.9
C2025	140.9	15.1	124.3	14.2	160.7	21.7	141.8	14.7	140.9	21.1
C2026	154.5	15.9	136.4	15.2	172.0	21.6	154.5	15.3	153.4	21.3
C2027	172.6	12.1	153.1	12.0	184.7	16.1	171.7	12.0	169.7	17.5
C2028	184.4	10.1	165.5	9.5	192.6	13.1	183.1	10.3	180.7	14.8
C2029	189.2	9.4	171.7	8.2	196.0	12.3	188.1	9.6	185.6	13.5
C2030	190.4	9.0	173.9	7.7	197.1	12.0	189.5	9.4	187.1	13.0
C2031	190.4	8.9	174.3	7.4	197.3	12.0	189.6	9.2	187.3	12.8
C2032	190.1	8.9	174.2	7.4	197.2	12.0	189.3	9.2	187.1	12.8
C2033	189.9	8.9	173.9	7.4	197.1	12.0	189.2	9.2	186.9	12.8

Table 2.35f—Standard harvest scenario 7 (female spawning biomass and catch in 1000s of t).

Time-vary *Q* ?	no		yes		no		no		n/a	
Survey dome?	no		no		yes		no		n/a	
Fishery CPUE?	no		no		no		yes		n/a	
Model:	M19.12a		M19.12		M21.1		M21.2		Ensemble	
Quantity	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
B2022	259.0	18.5	231.3	21.0	326.1	34.1	218.1	15.9	259.8	45.7
B2023	246.6	18.3	231.5	21.6	308.6	33.1	234.1	16.9	254.6	38.2
B2024	220.6	10.7	217.6	14.2	277.3	22.2	223.9	10.7	233.4	28.5
B2025	209.4	11.0	211.6	13.2	265.1	20.8	216.9	10.6	224.2	26.8
B2026	215.5	10.6	218.5	12.6	268.8	19.6	223.1	10.3	230.0	25.5
B2027	226.6	8.0	230.2	10.4	276.6	16.5	234.0	8.0	240.5	22.9
B2028	234.5	6.2	239.4	8.7	282.3	14.4	241.9	6.3	248.2	21.1
B2029	238.2	5.7	244.3	8.1	285.3	13.7	245.7	5.7	252.1	20.5
B2030	239.3	5.6	246.1	8.1	286.5	13.6	247.0	5.6	253.5	20.4
B2031	239.4	5.6	246.5	8.2	286.9	13.6	247.2	5.6	253.7	20.5
B2032	239.2	5.7	246.4	8.3	286.9	13.7	247.1	5.6	253.7	20.5
B2033	239.1	5.7	246.3	8.3	286.9	13.7	247.0	5.6	253.6	20.6
F2022	0.363	0.026	0.267	0.026	0.306	0.030	0.284	0.021	0.309	0.047
F2023	0.422	0.049	0.327	0.047	0.367	0.046	0.374	0.045	0.374	0.060
F2024	0.375	0.029	0.306	0.030	0.328	0.028	0.357	0.030	0.342	0.041
F2025	0.355	0.024	0.297	0.024	0.312	0.023	0.345	0.023	0.327	0.034
F2026	0.366	0.023	0.308	0.022	0.317	0.022	0.356	0.022	0.336	0.034
F2027	0.386	0.020	0.325	0.021	0.327	0.019	0.374	0.020	0.353	0.035
F2028	0.401	0.019	0.339	0.020	0.334	0.018	0.387	0.019	0.366	0.035
F2029	0.407	0.019	0.347	0.019	0.338	0.018	0.394	0.018	0.372	0.036
F2030	0.409	0.019	0.349	0.019	0.339	0.018	0.396	0.018	0.374	0.036
F2031	0.409	0.019	0.350	0.019	0.340	0.018	0.396	0.018	0.374	0.035
F2032	0.409	0.019	0.350	0.019	0.340	0.017	0.396	0.018	0.374	0.035
F2033	0.409	0.019	0.350	0.019	0.340	0.017	0.396	0.018	0.374	0.035
C2022	174.7	0.0	123.9	0.0	183.5	0.0	121.8	0.0	153.4	27.7
C2023	193.8	30.3	150.0	29.5	210.1	40.2	168.7	26.8	180.9	39.7
C2024	155.8	18.7	132.2	19.5	172.8	26.6	152.1	18.9	152.4	25.7
C2025	143.4	15.9	126.6	15.6	163.6	22.8	143.9	15.8	143.4	22.0
C2026	155.2	15.9	137.3	15.5	173.0	21.7	155.2	15.5	154.2	21.5
C2027	172.7	11.9	153.3	12.0	184.9	15.9	171.8	11.9	169.8	17.4
C2028	184.2	9.9	165.4	9.3	192.5	12.9	183.0	10.1	180.6	14.7
C2029	189.1	9.2	171.6	8.1	195.9	12.1	188.0	9.5	185.5	13.4
C2030	190.4	9.0	173.9	7.6	197.0	12.0	189.4	9.3	187.1	12.9
C2031	190.4	8.9	174.3	7.4	197.2	12.0	189.5	9.2	187.2	12.8
C2032	190.1	8.9	174.1	7.4	197.2	12.0	189.3	9.2	187.1	12.8
C2033	189.9	8.9	173.9	7.4	197.1	12.0	189.2	9.2	186.9	12.8

FIGURES

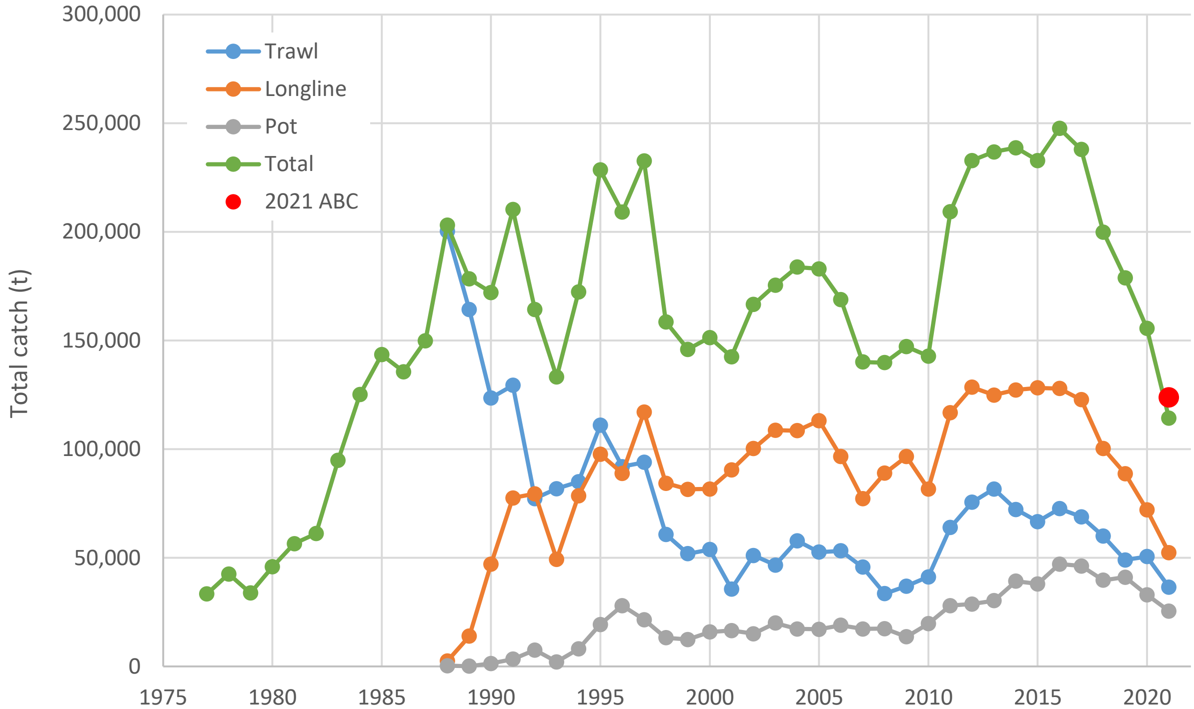

Figure 2.1. Total catch and catch by gear type. Data for 2021 are current through September 26.

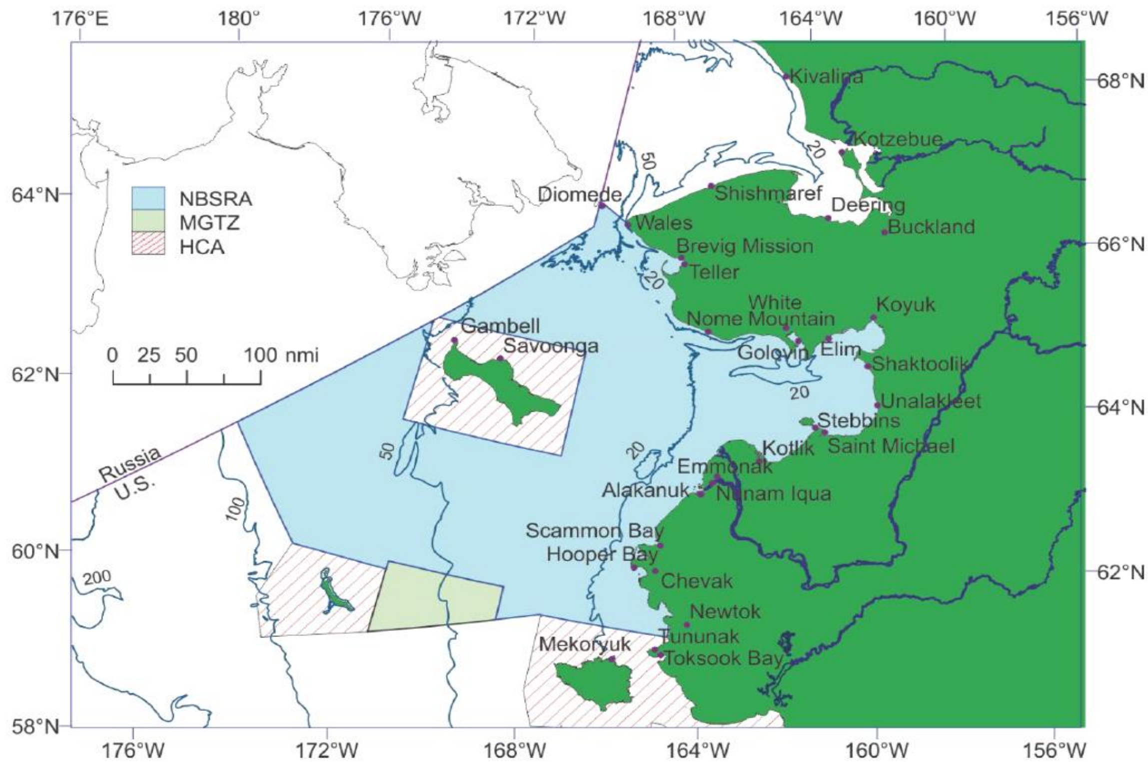

Figure 2.2a. The Northern Bering Sea Research Area (NBSRA) and bordering communities, Modified Gear Trawl Zone (MGTZ), and adjacent Habitat Conservation Areas (HCA).

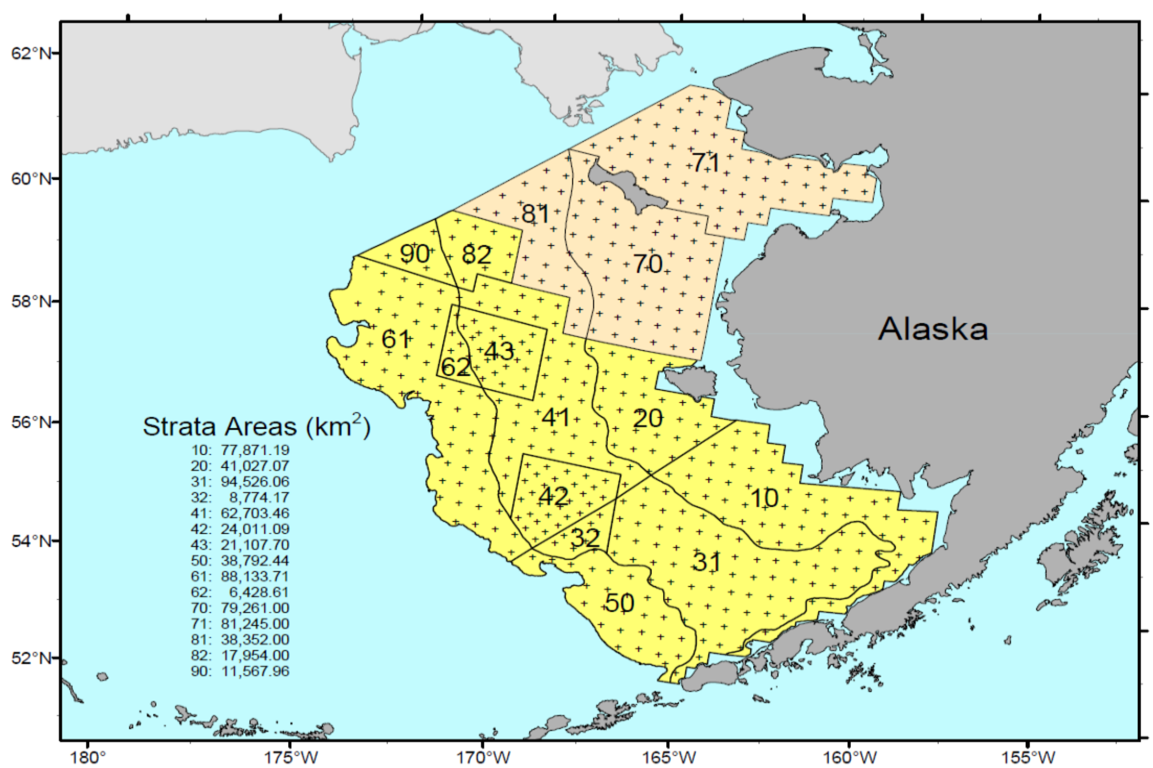

Figure 2.2b. AFSC bottom trawl survey areas (yellow=EBS, beige=NBS).

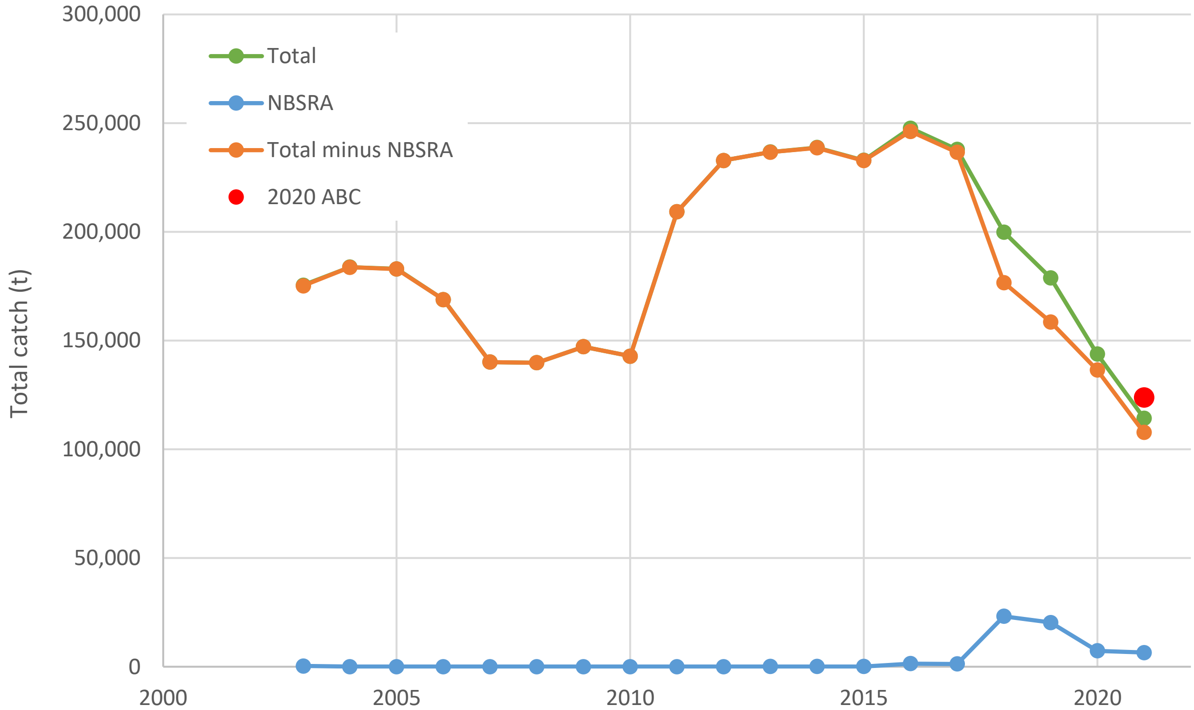

Figure 2.3. Catch time series by area, 2003-2020 (catch data for NBSRA not available prior to 2003). Data for 2021 are current through October 17.

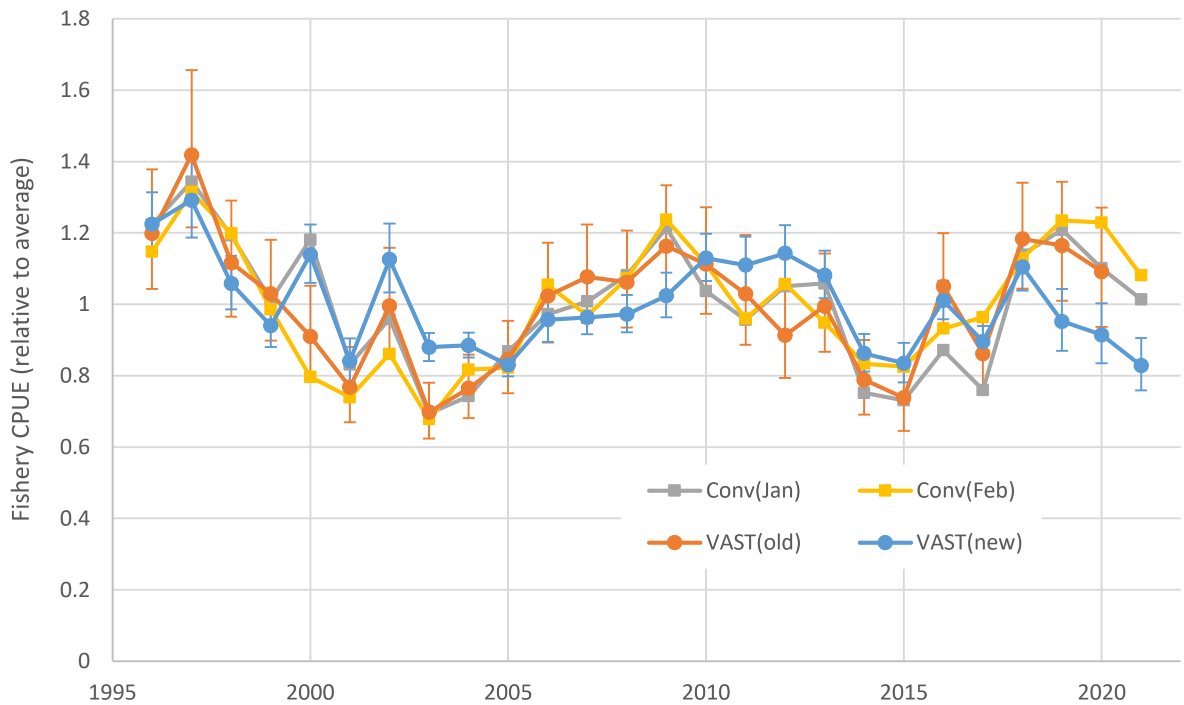

Figure 2.4. Comparison of January-February longline fishery CPUE indices.

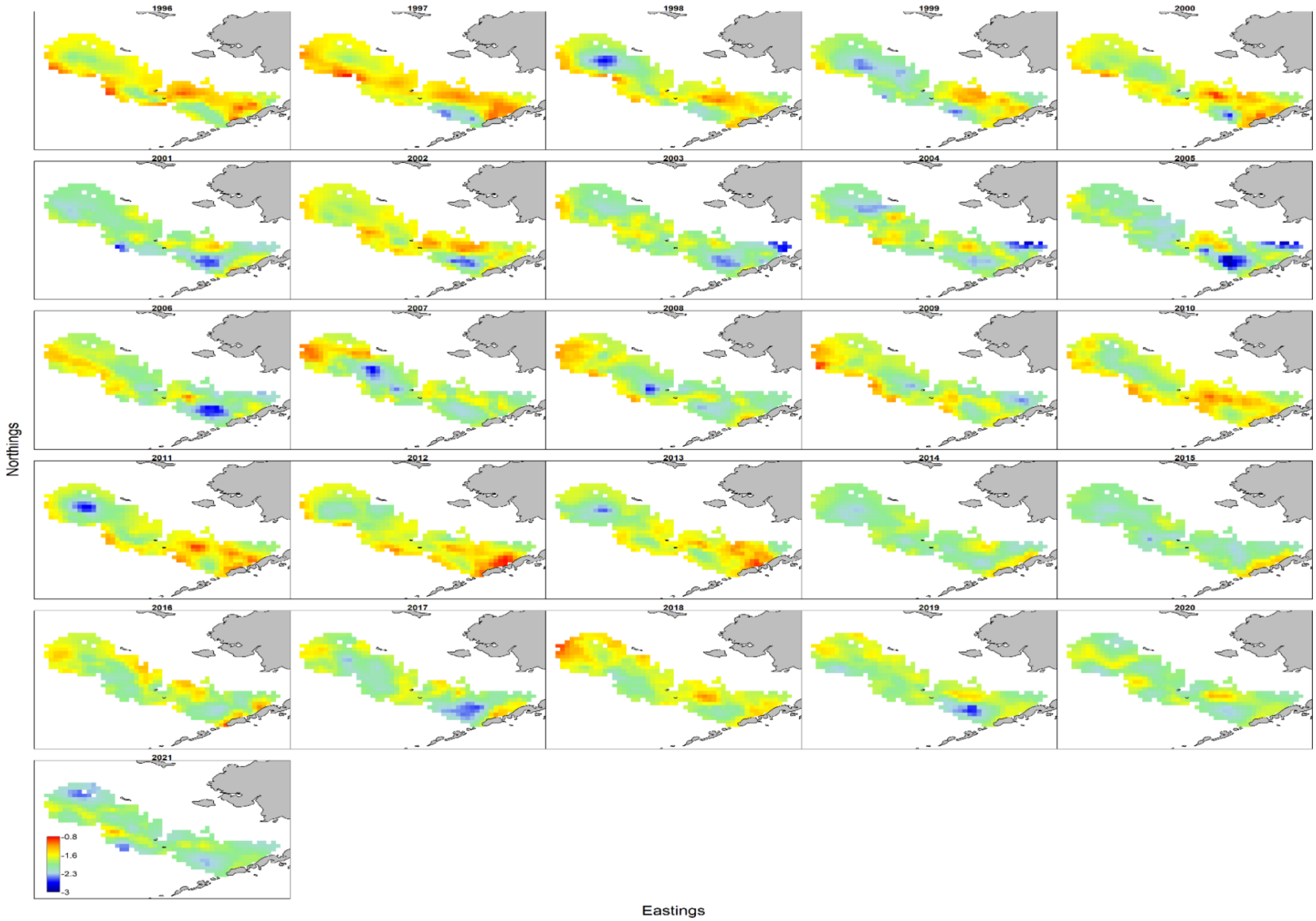

Figure 2.5a. VAST fishery CPUE log density maps by year.

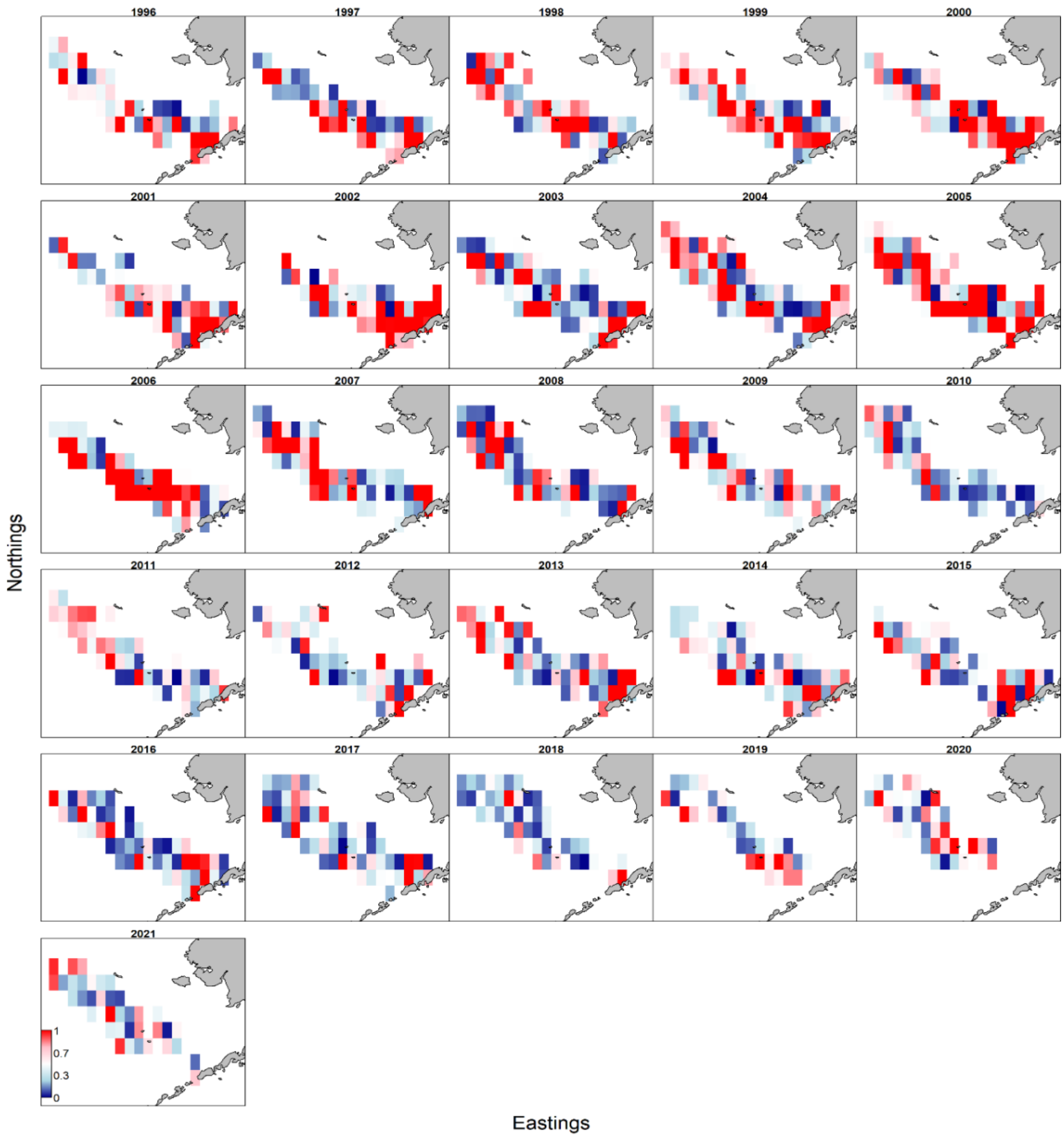

Figure 2.5b. VAST fishery CPUE quantile residual maps by year.

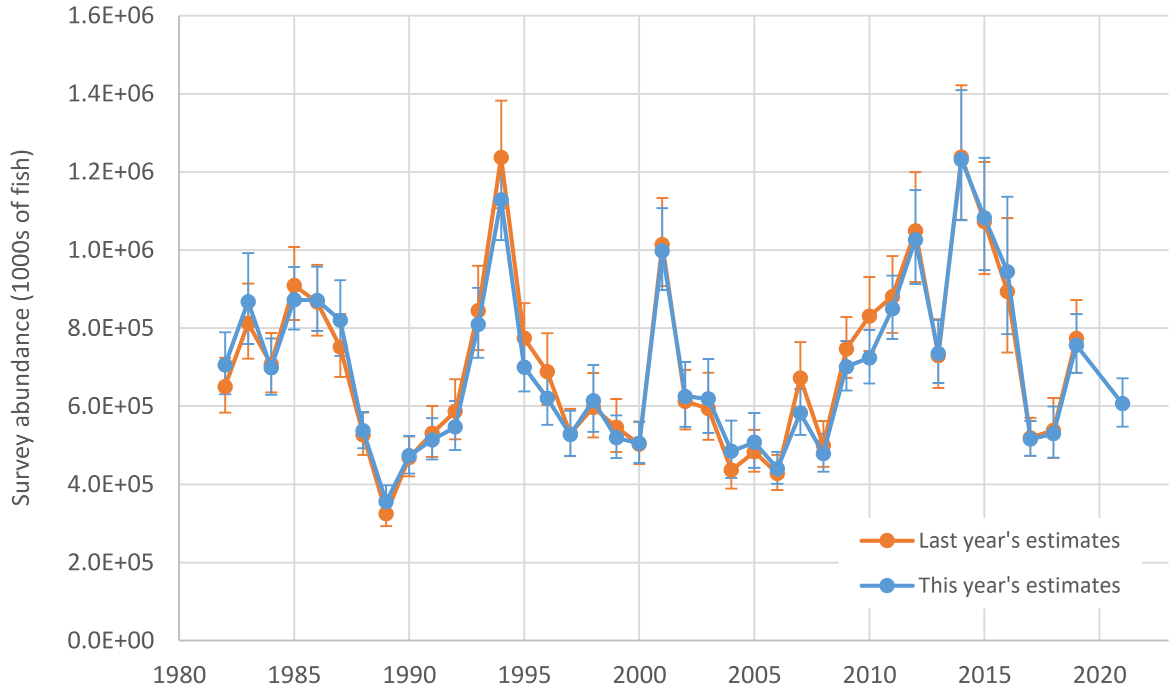

Figure 2.6a. Survey abundance (1000s of fish) time series (VAST).

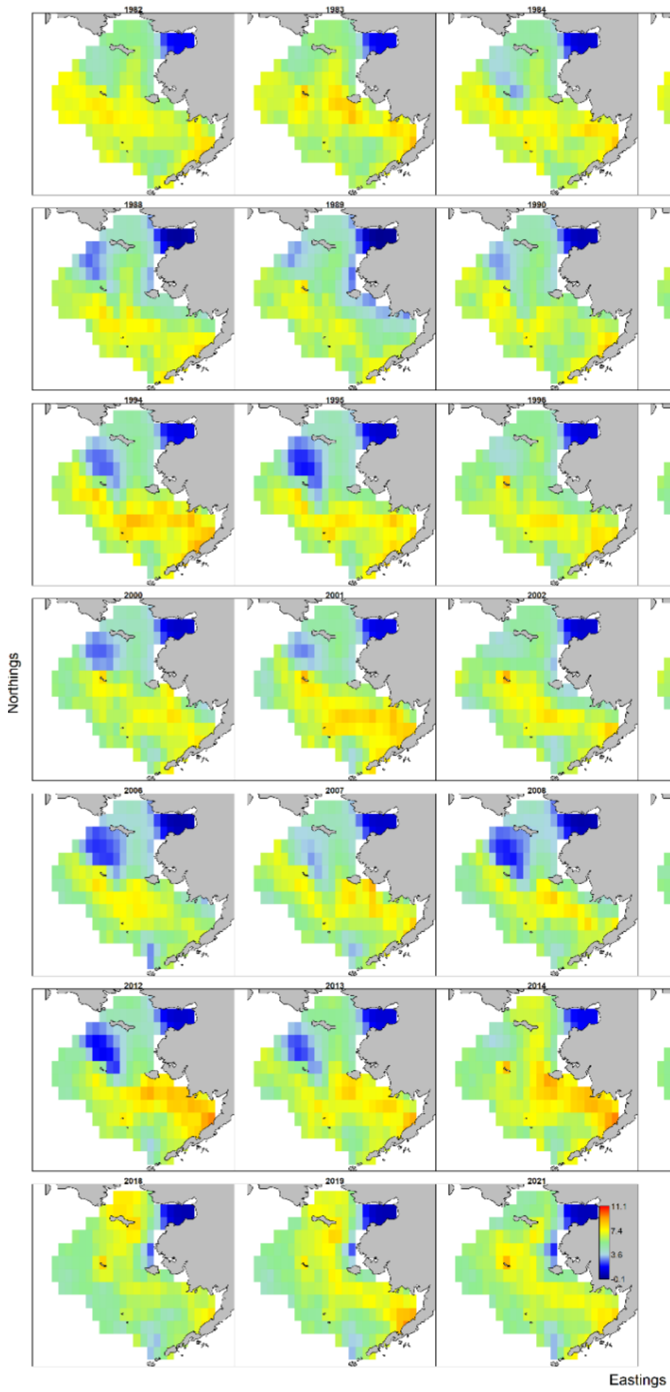

Figure 2.6b. Survey abundance log density maps by year (VAST).

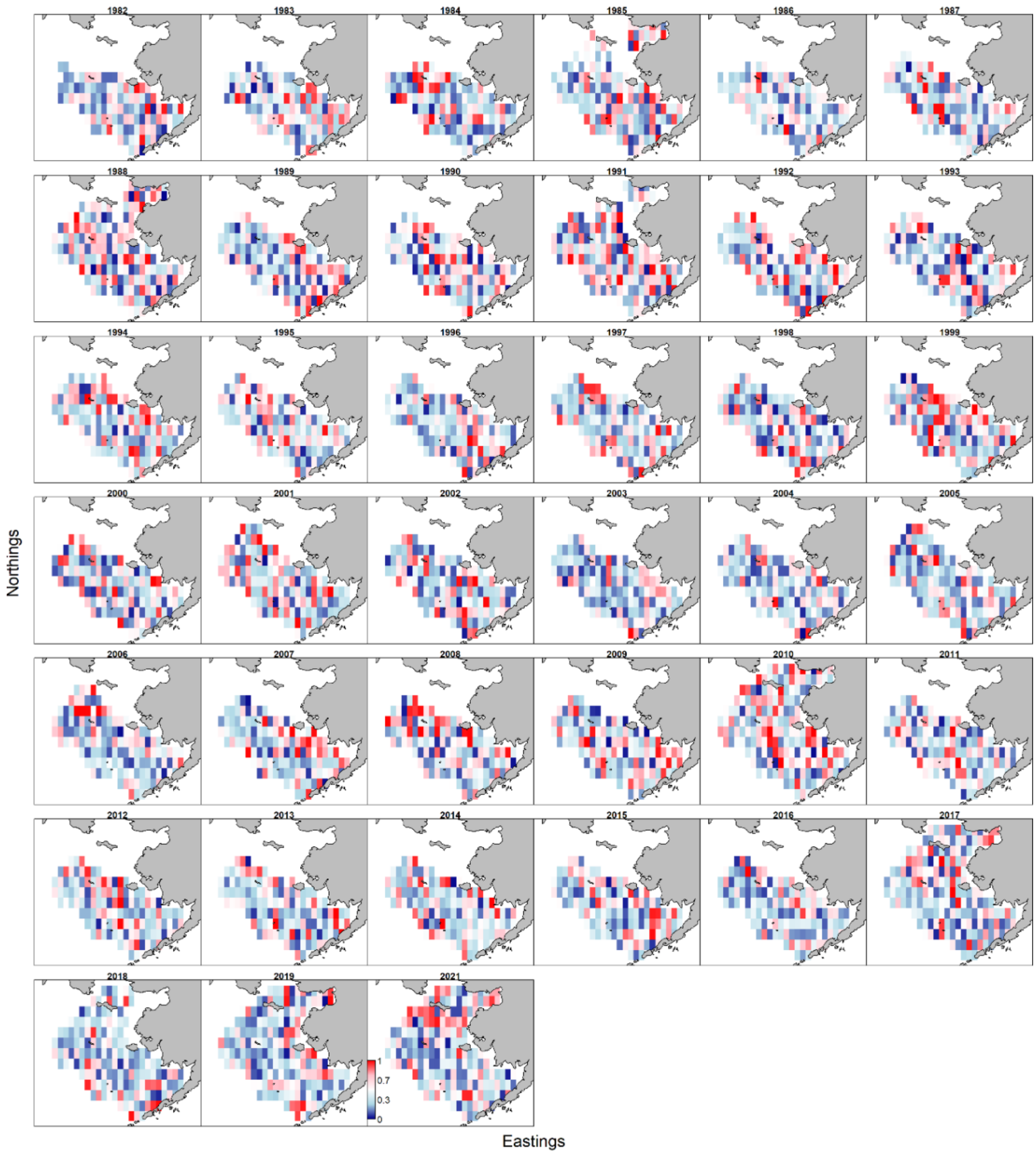

Figure 2.6c. Survey abundance quantile residual maps by year (VAST).

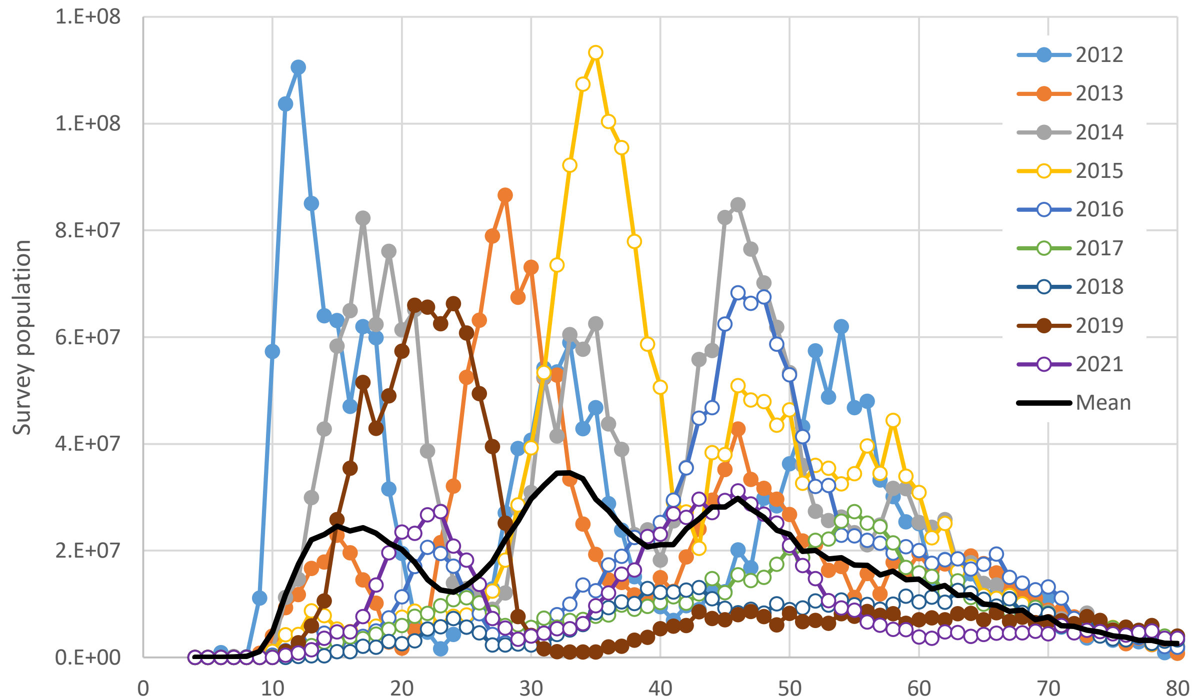

Figure 2.7a. Recent survey size compositions, truncated at 80 cm (EBS only).

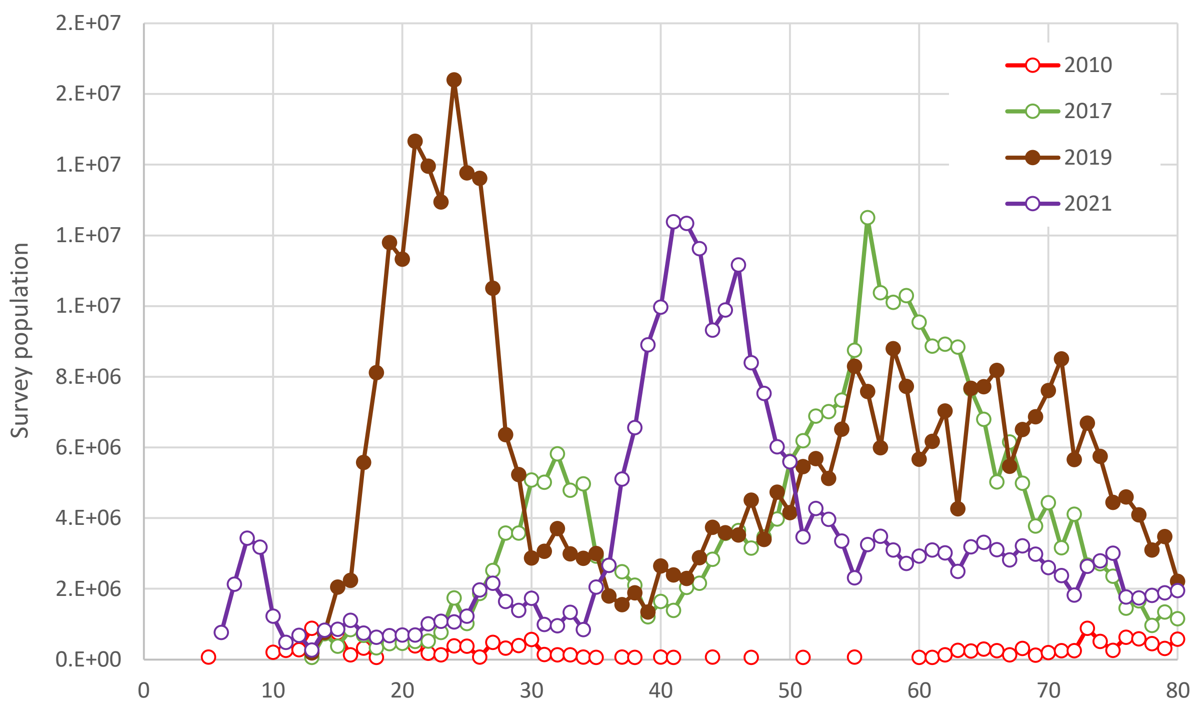

Figure 2.7b. Recent survey size compositions, truncated at 80 cm (NBS only).

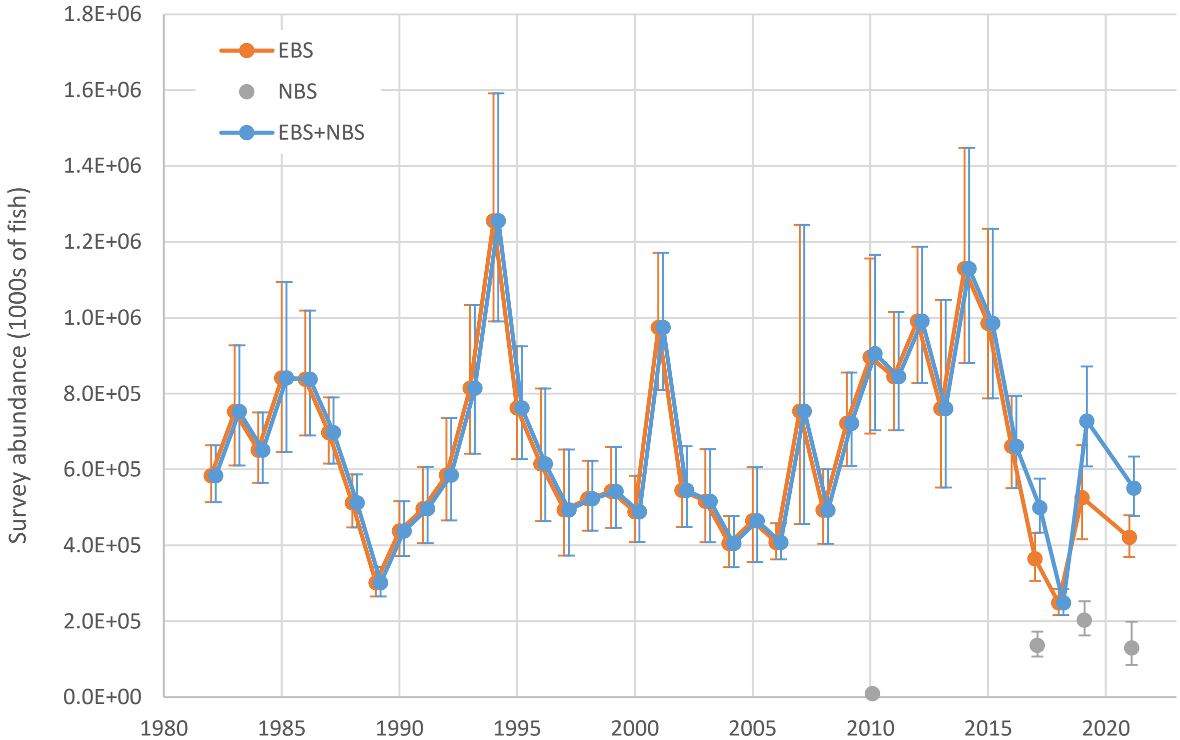

Figure 2.8a. Survey abundance (1000s of fish) time series (design-based).

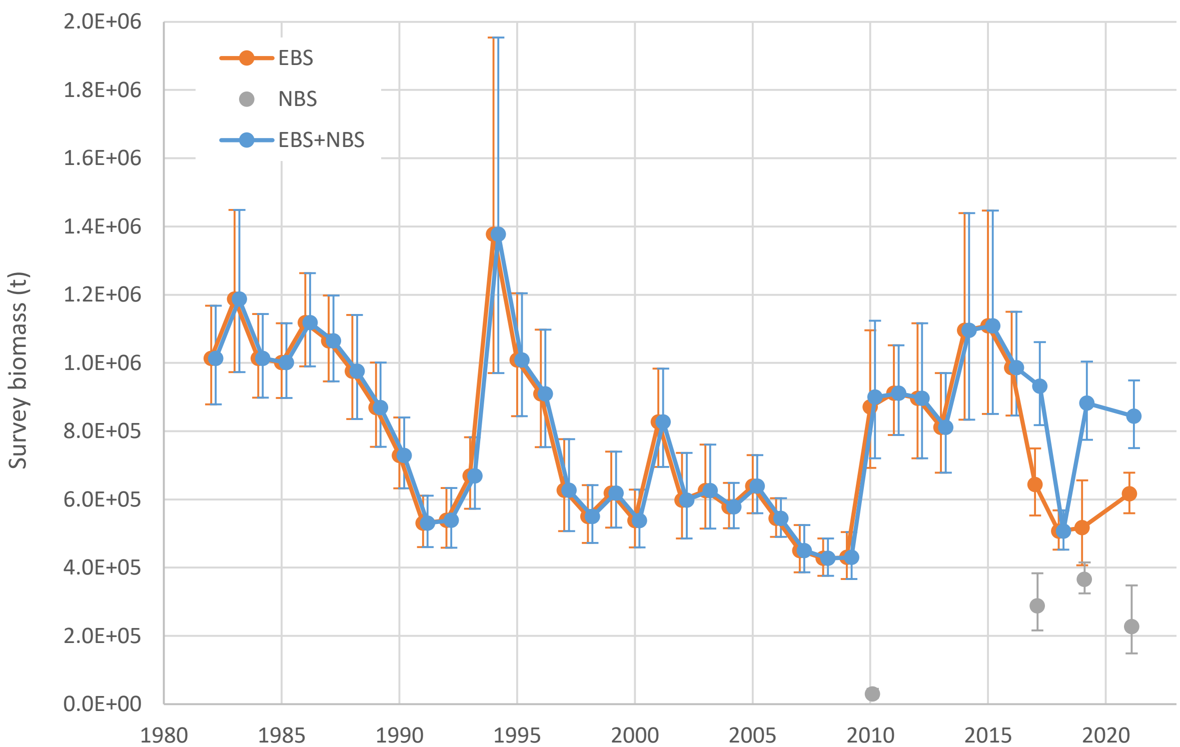

Figure 2.8b. Survey biomass (t) time series (design-based).

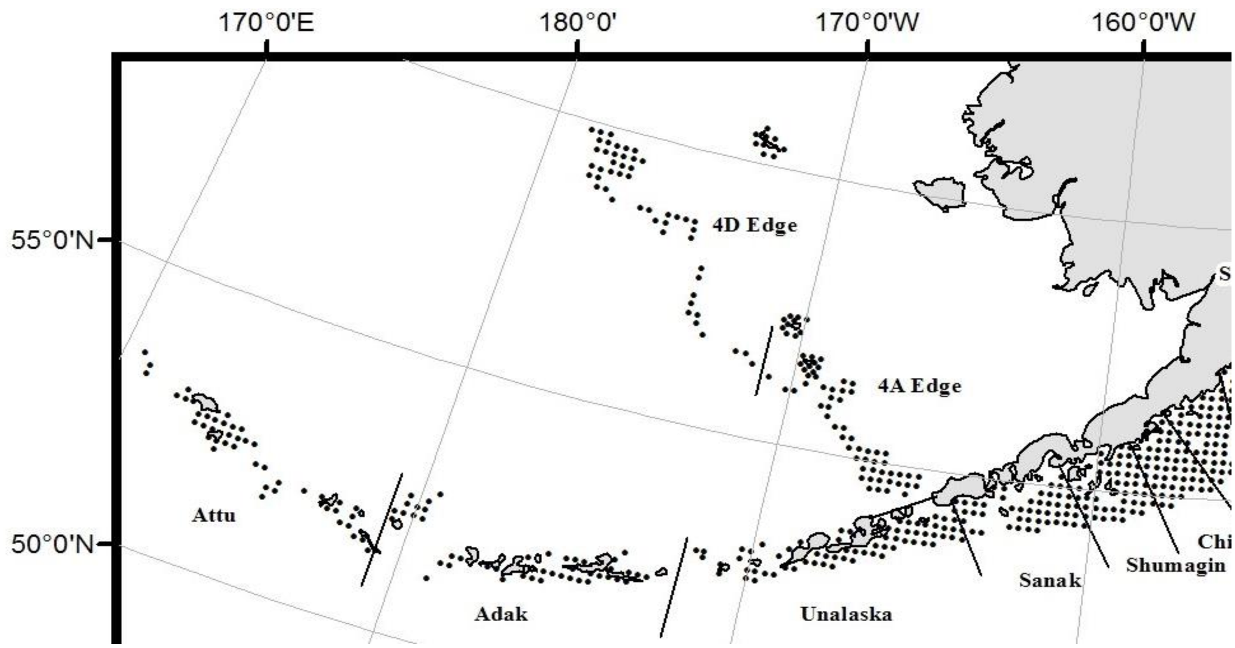

Figure 2.9a. Locations of IPHC survey stations in the BSAI region.

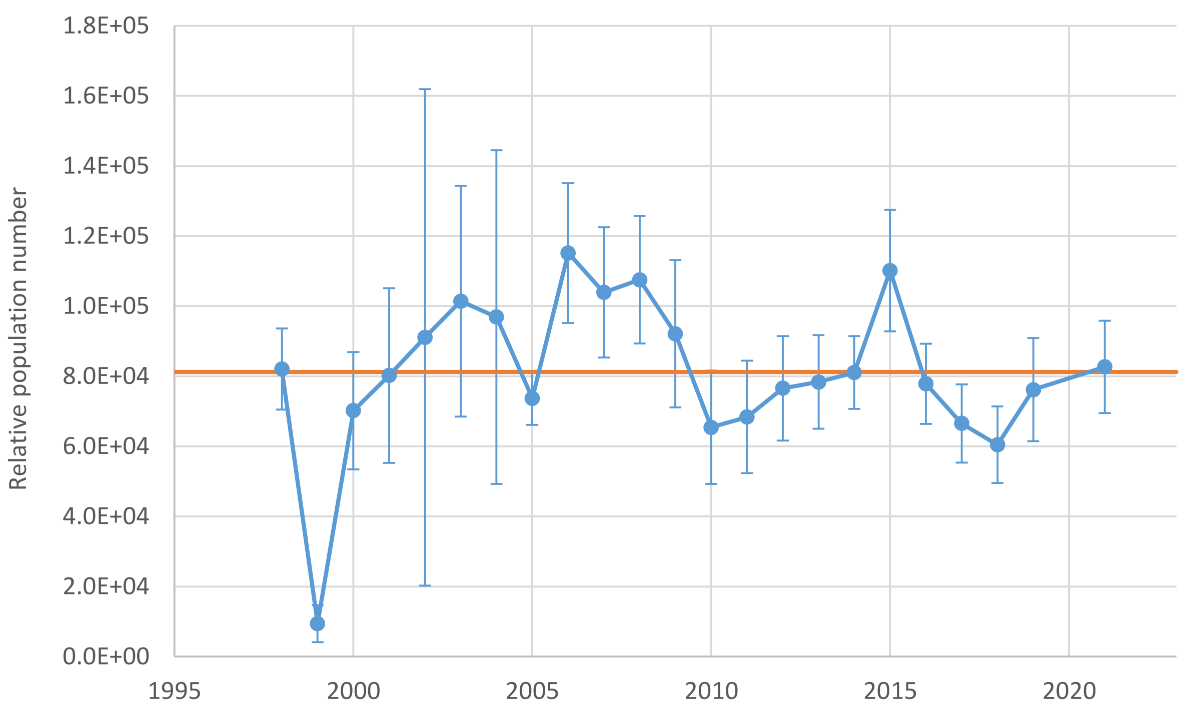

Figure 2.9b. IPHC survey relative population number (no EBS Pacific cod data collected in 2020).

Figure 2.10a. Locations of AFSC longline survey stations in the EBS region.

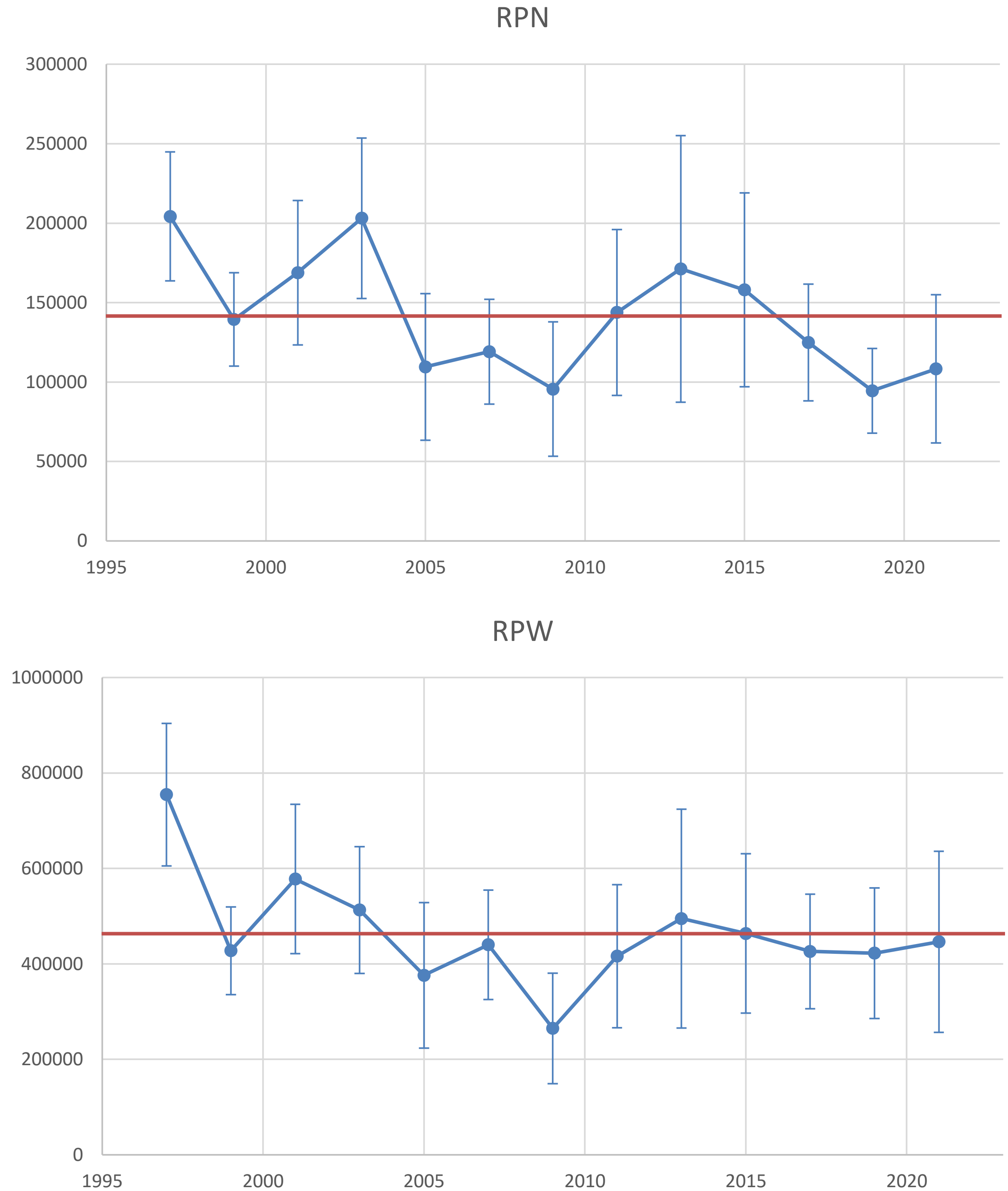

Figure 2.10b. AFSC longline survey relative population number (top) and weight (bottom).

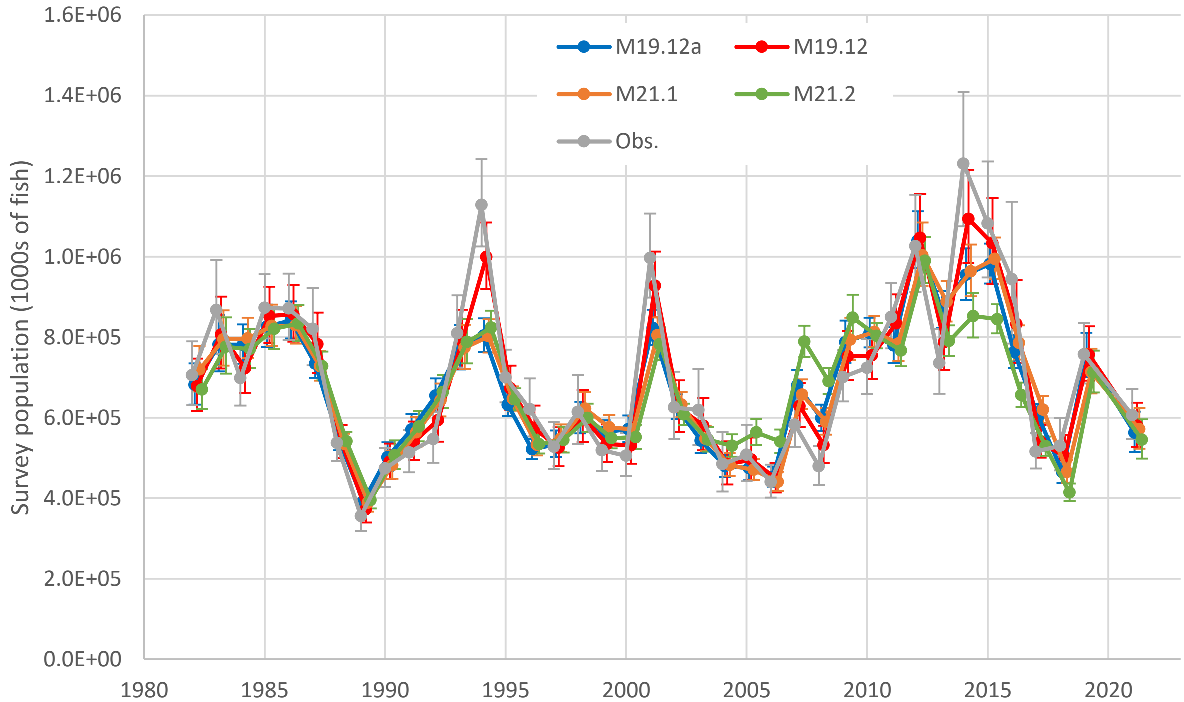

Figure 2.11a. Fits to the survey index data.

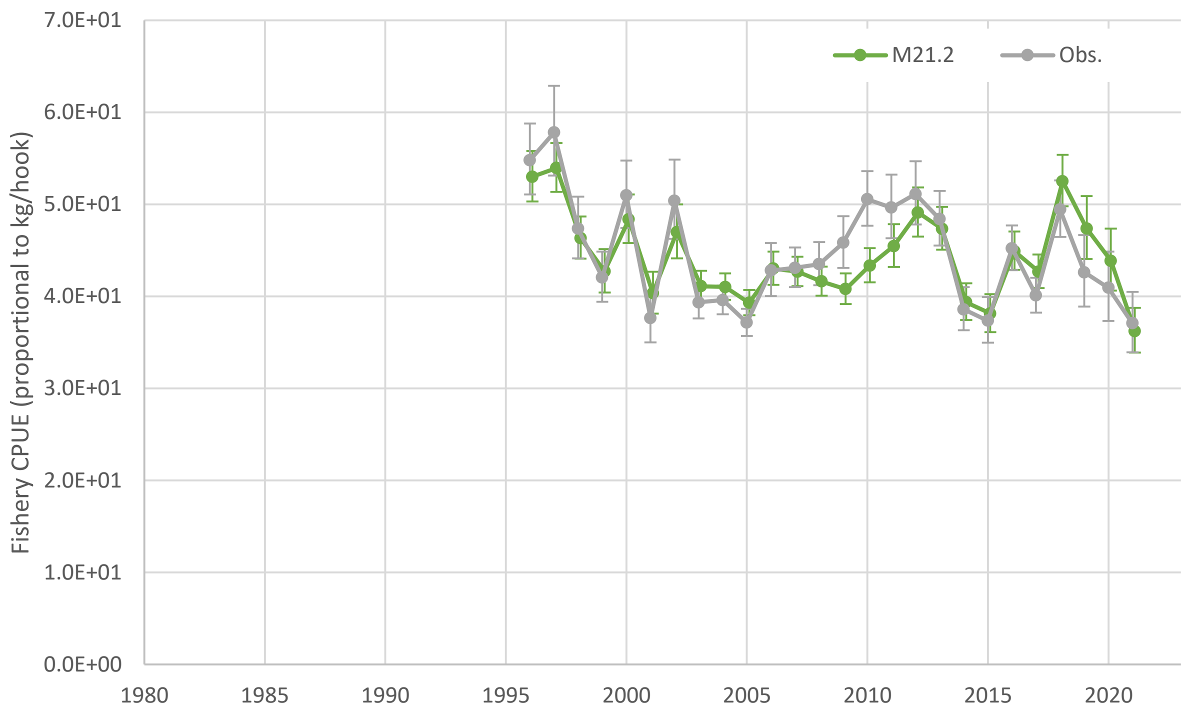

Figure 2.11b. Fit to the fishery CPUE index data (Model 21.2 only).

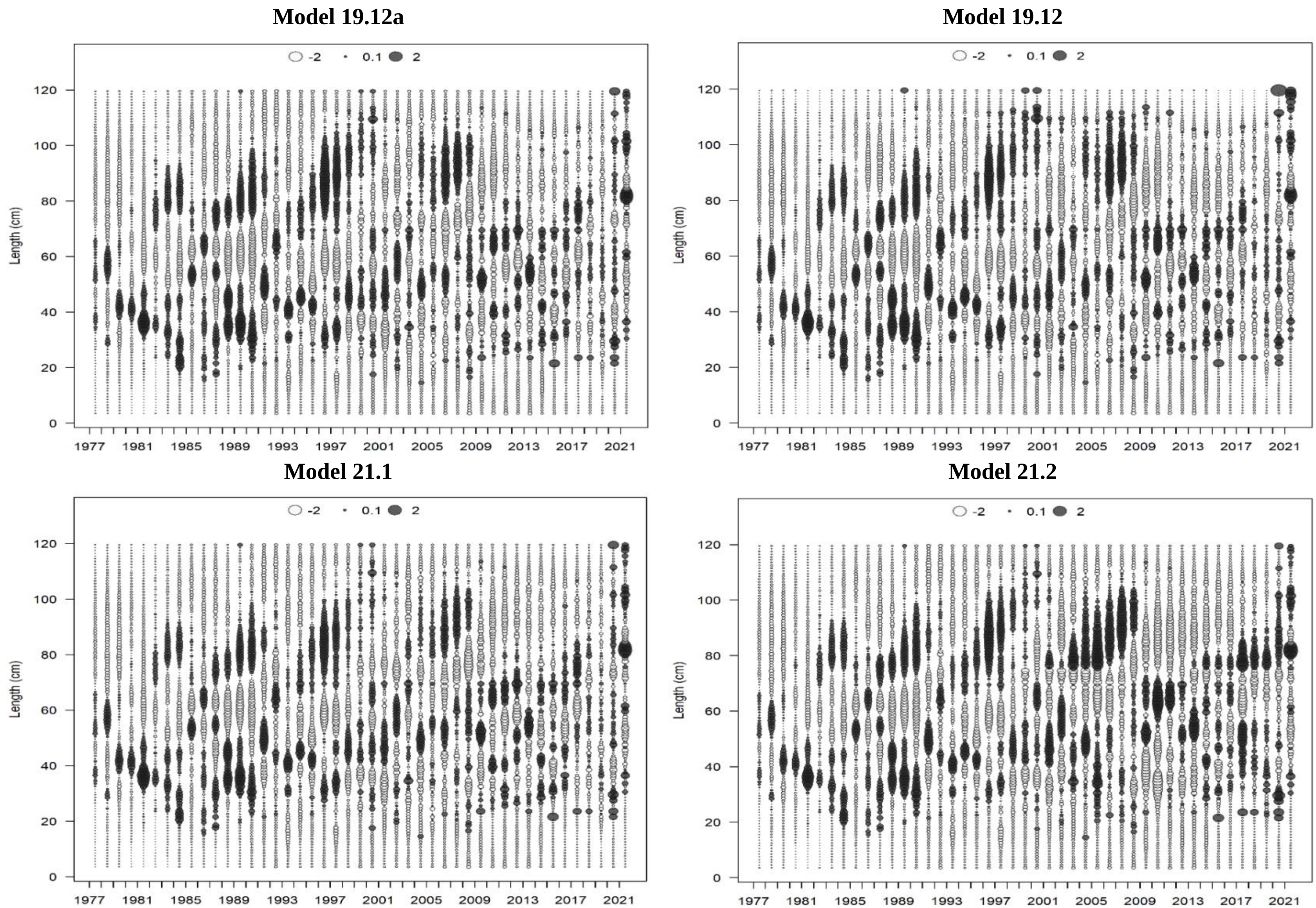

Figure 2.12a. Residual plots of model fits to the fishery size composition data.

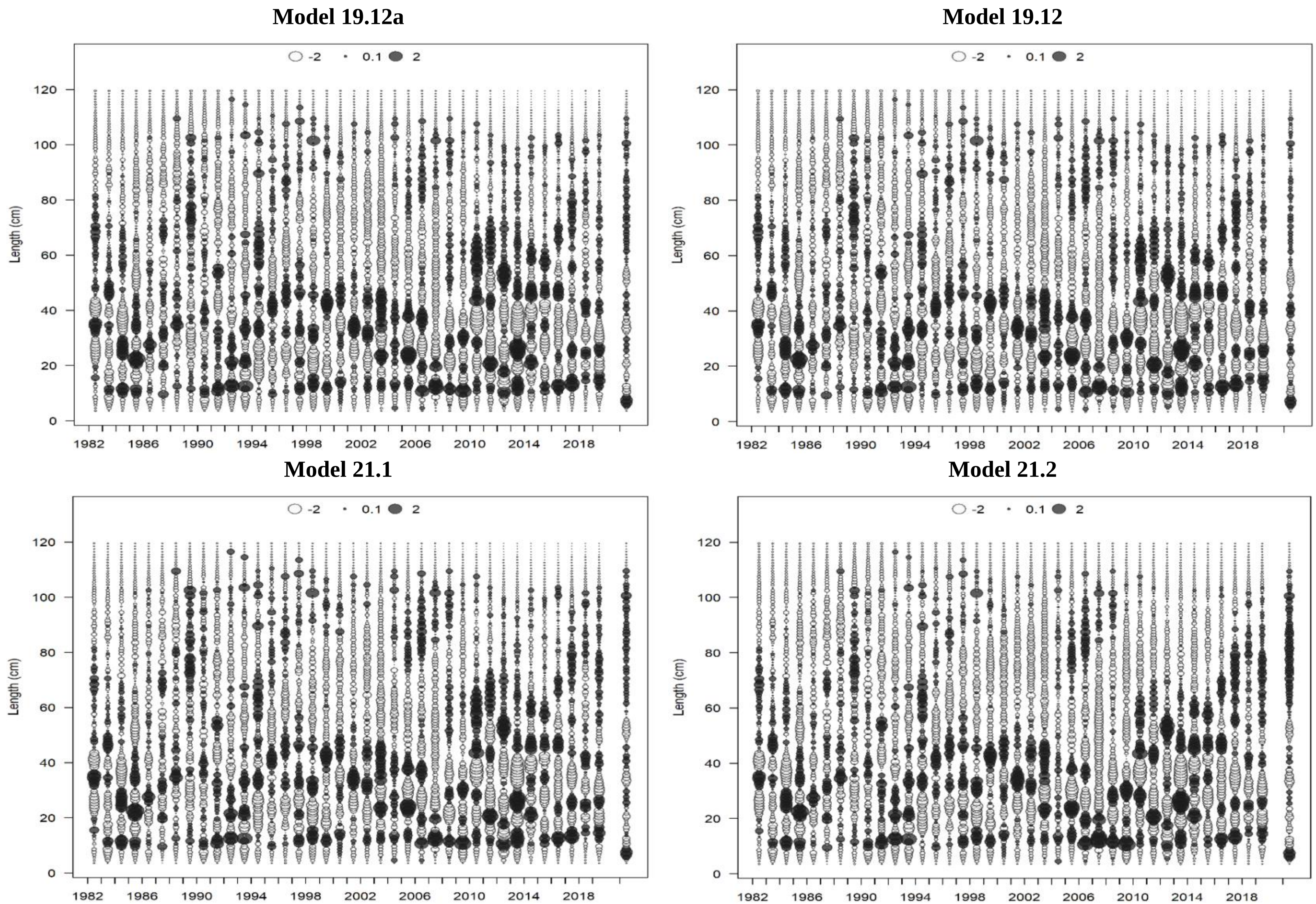

Figure 2.12b. Residual plots of model fits to the survey size composition data.

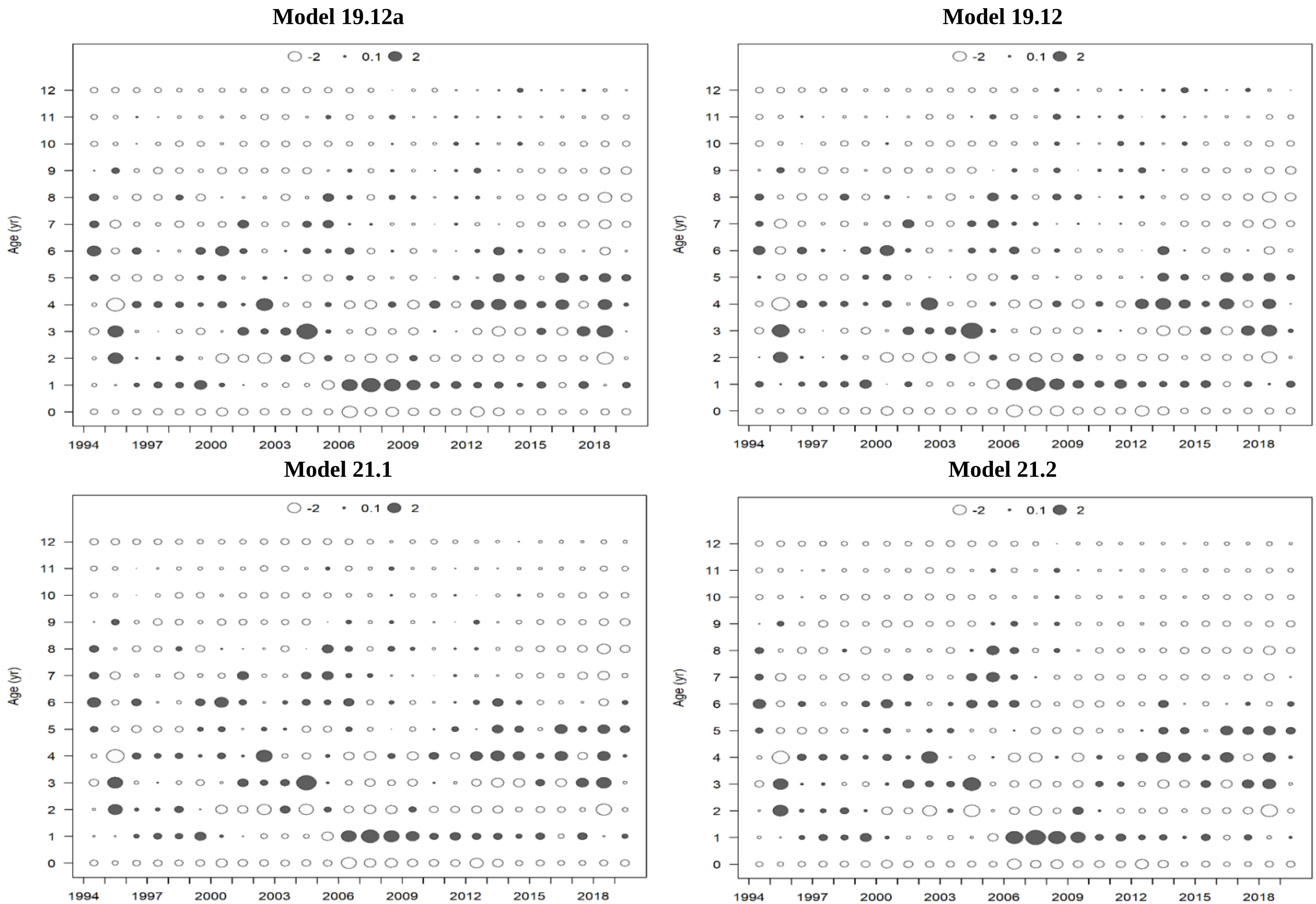

Figure 2.13. Residual plots of model fits to the survey age composition data.

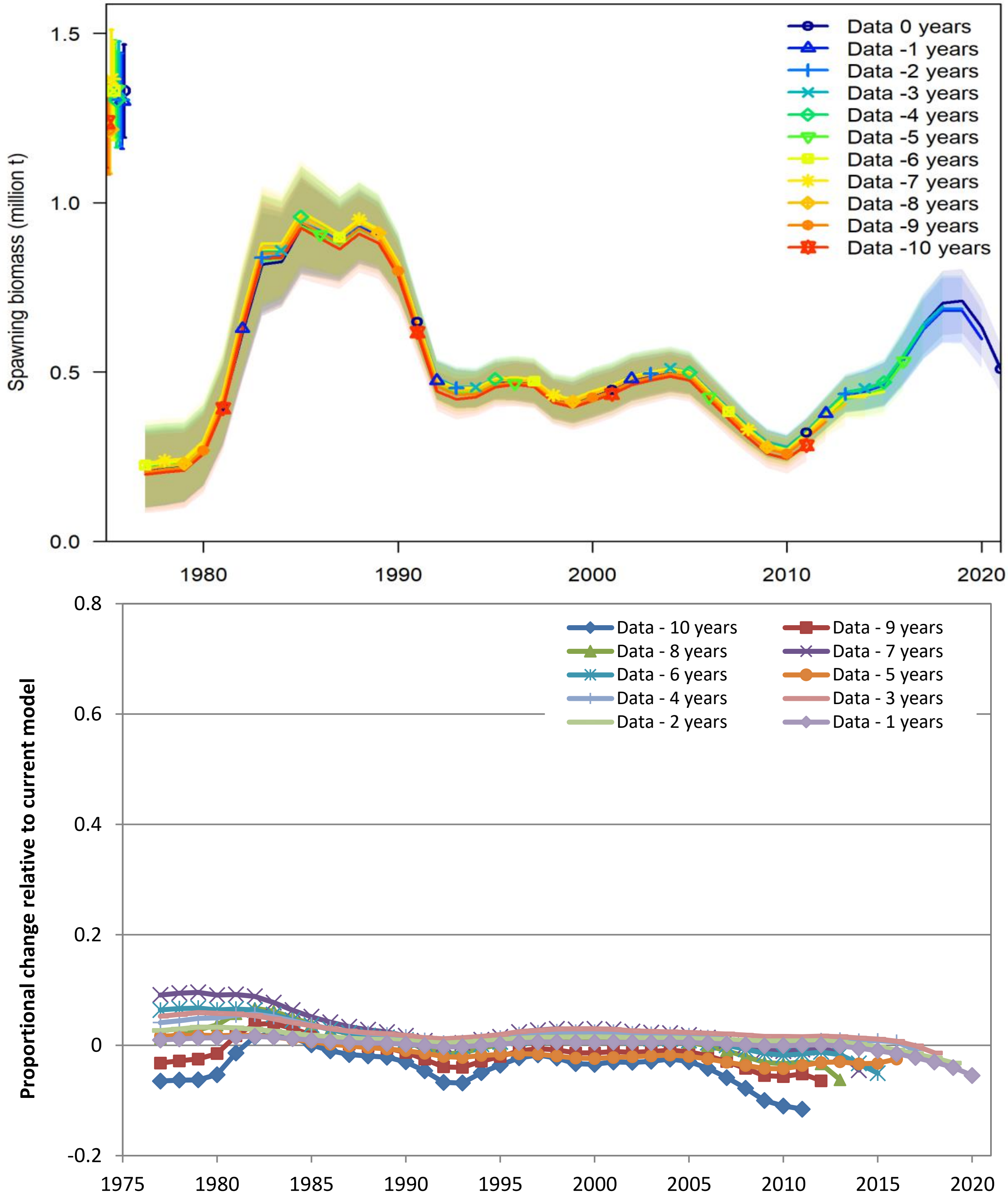

Figure 2.14a. Retrospective analysis of Model 19.12a.

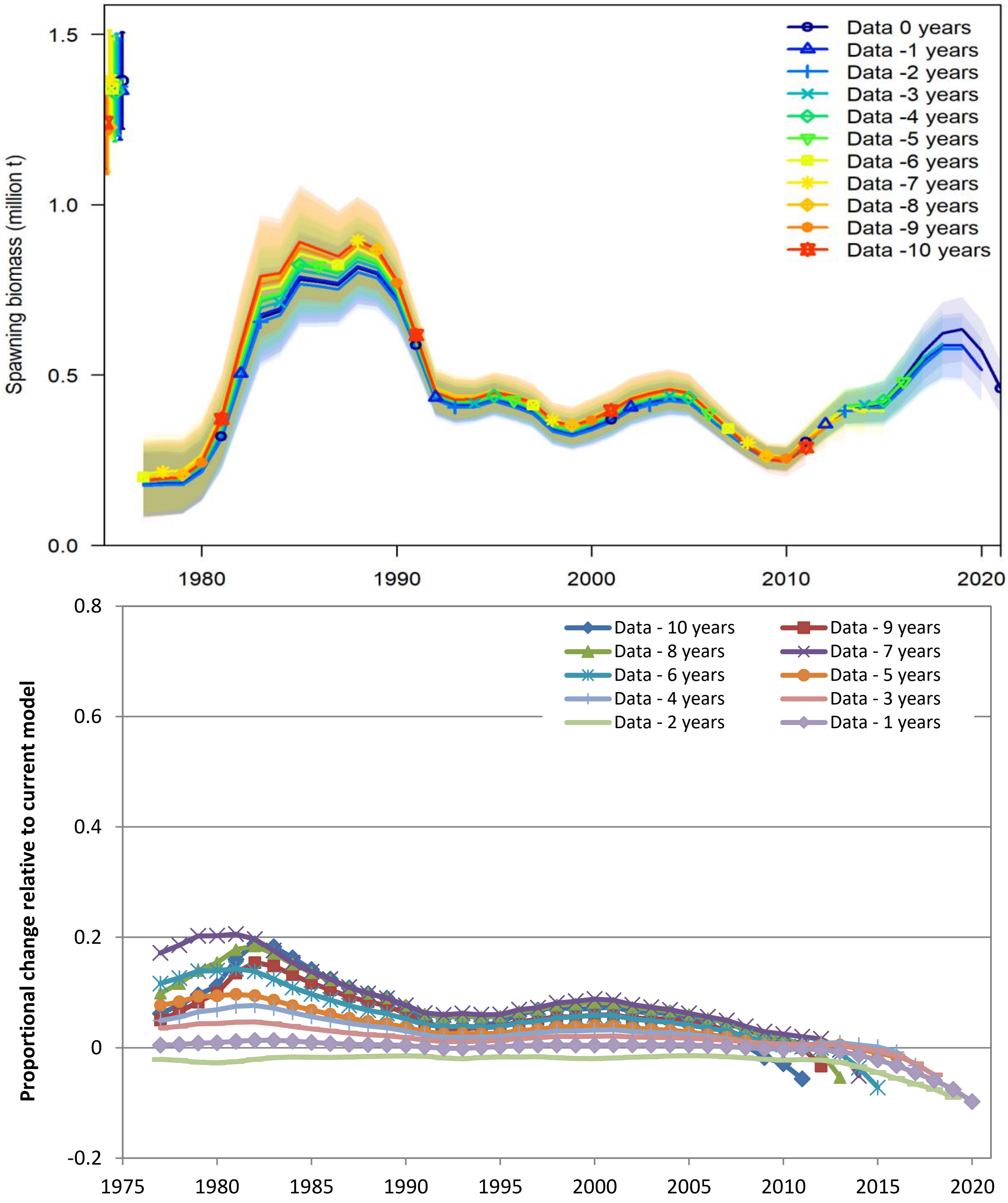

Figure 2.14b. Retrospective analysis of Model 19.12.

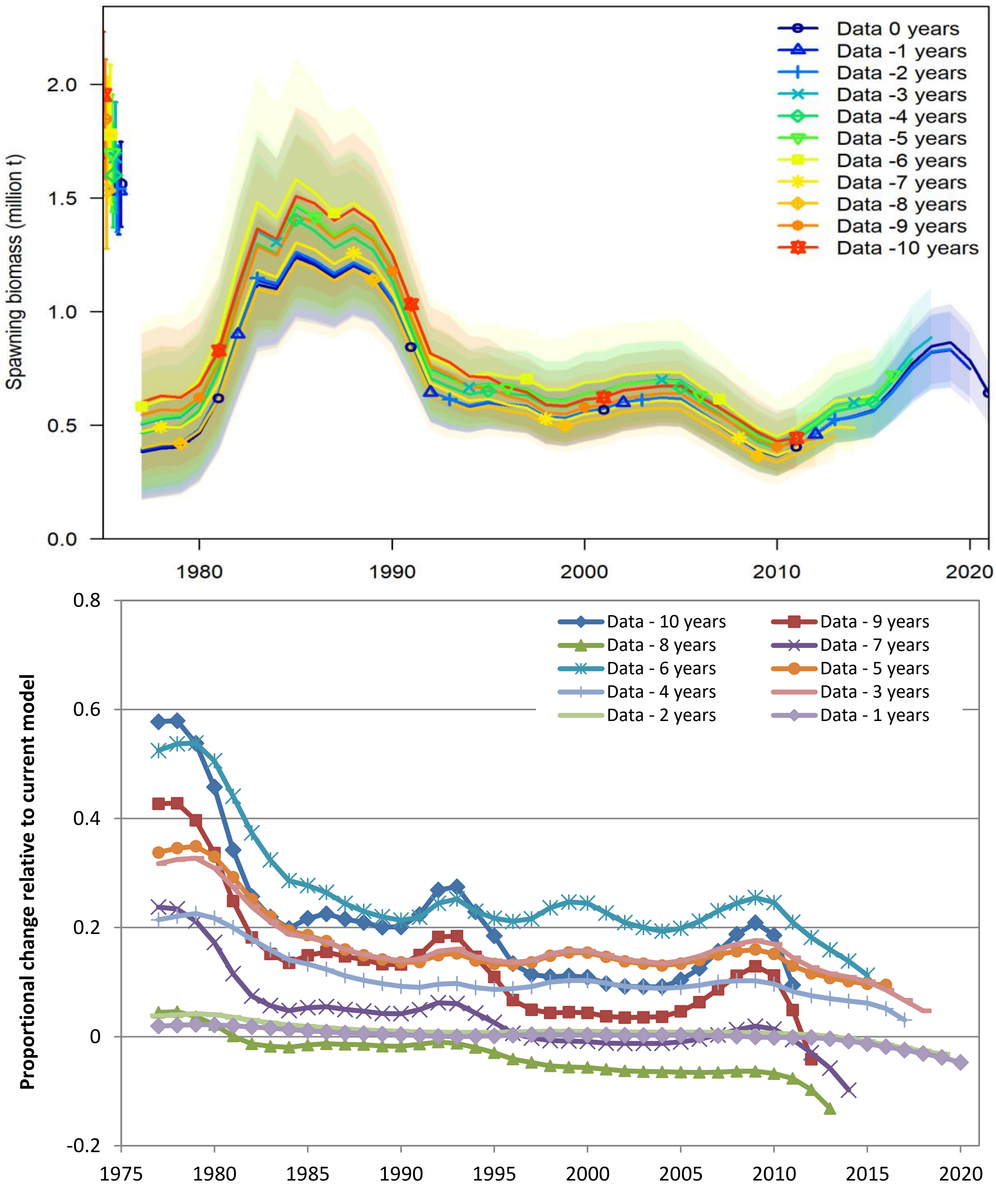

Figure 2.14c. Retrospective analysis of Model 21.1.

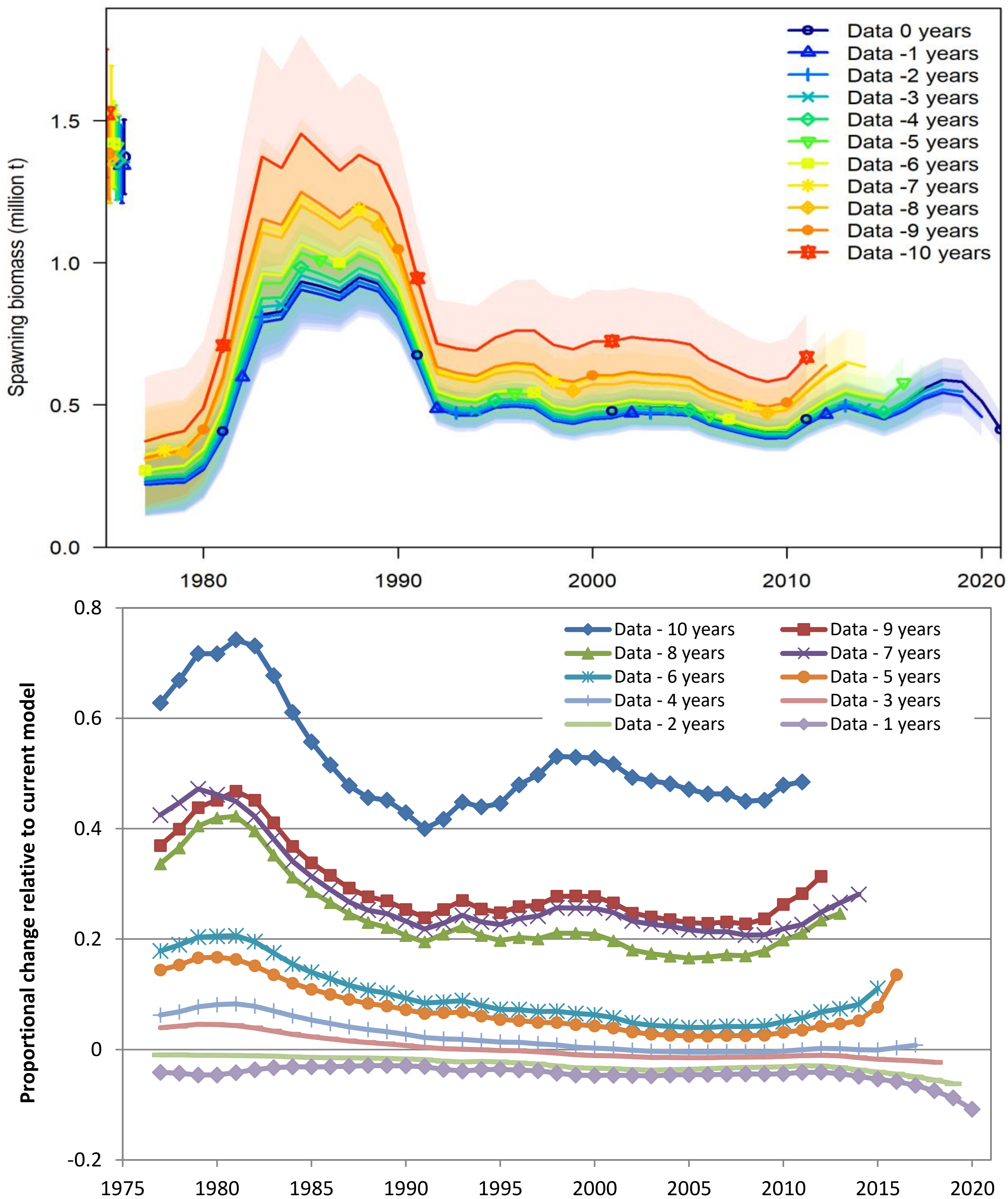

Figure 2.14d. Retrospective analysis of Model 21.2.

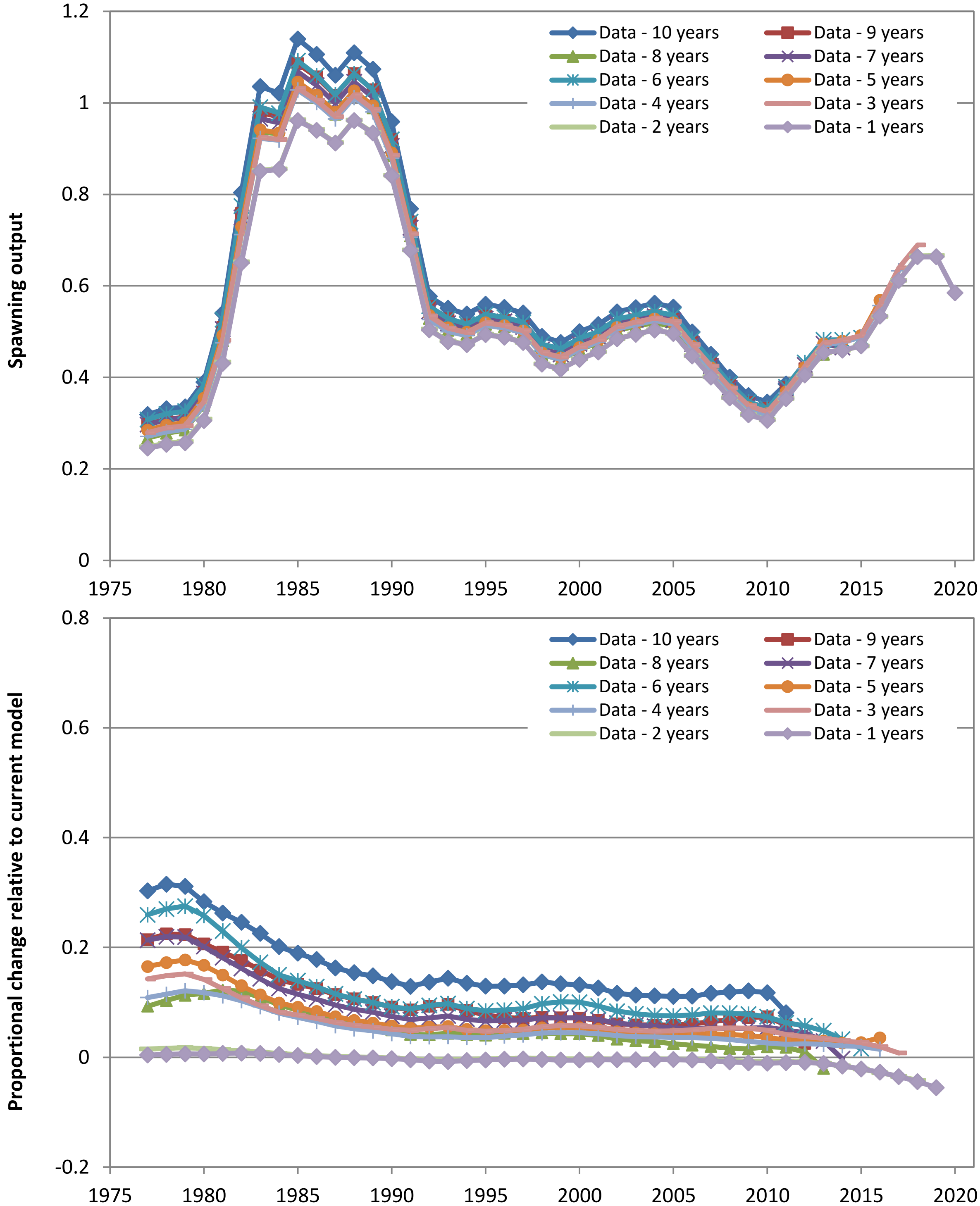

Figure 2.14e. Retrospective analysis of the ensemble.

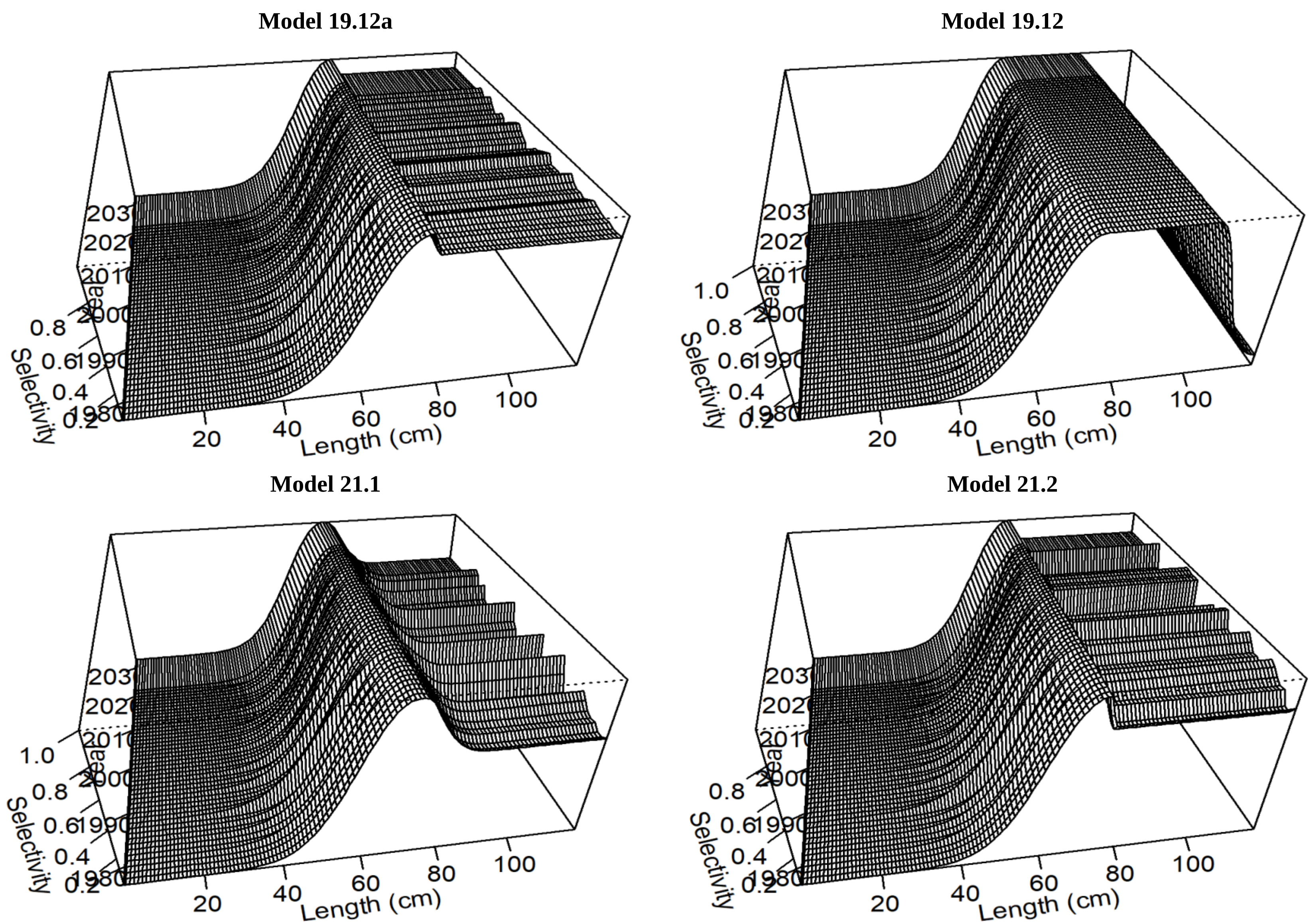

Figure 2.15a. Selectivity at age for the fishery.

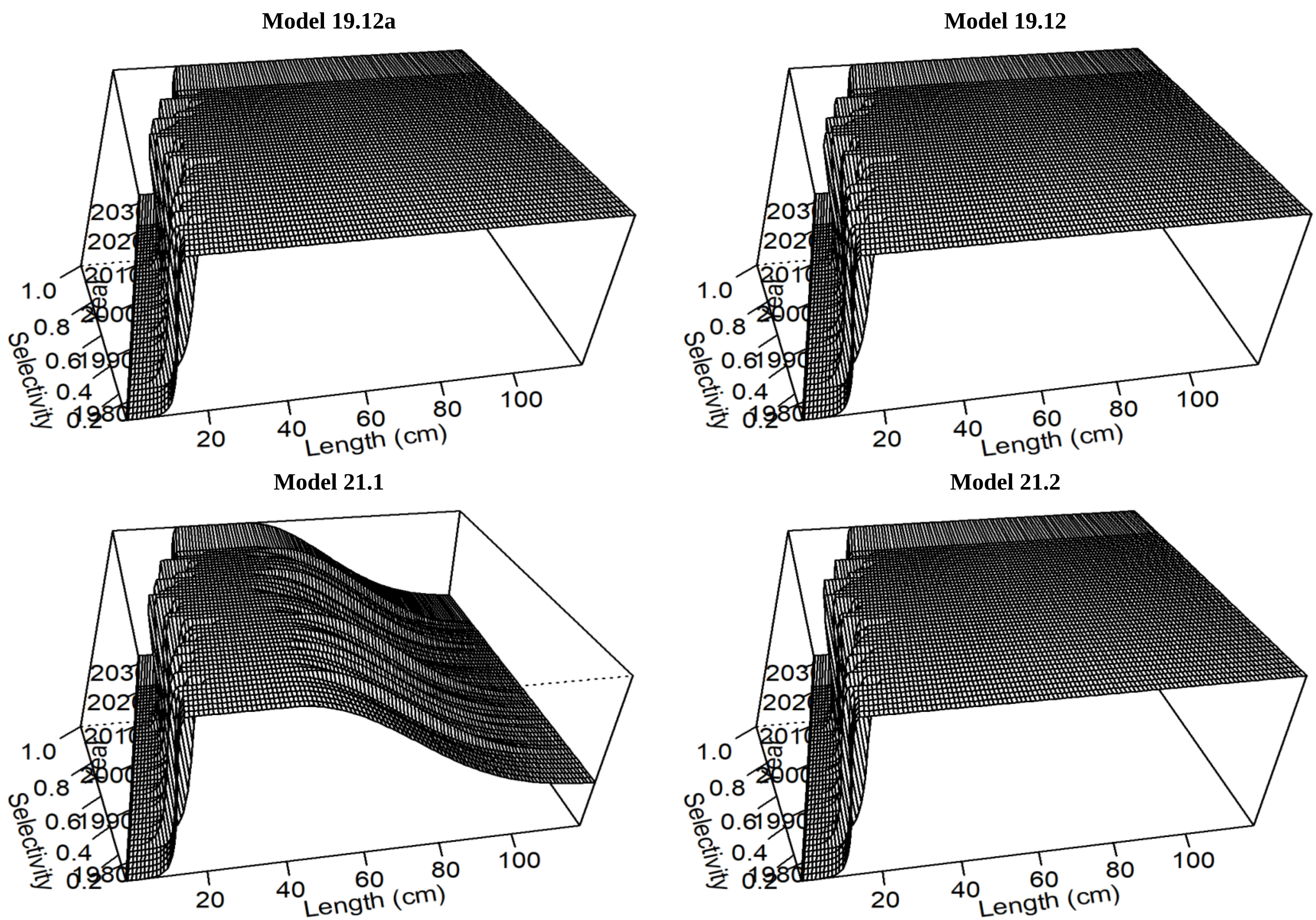

Figure 2.15b. Selectivity at age for the survey.

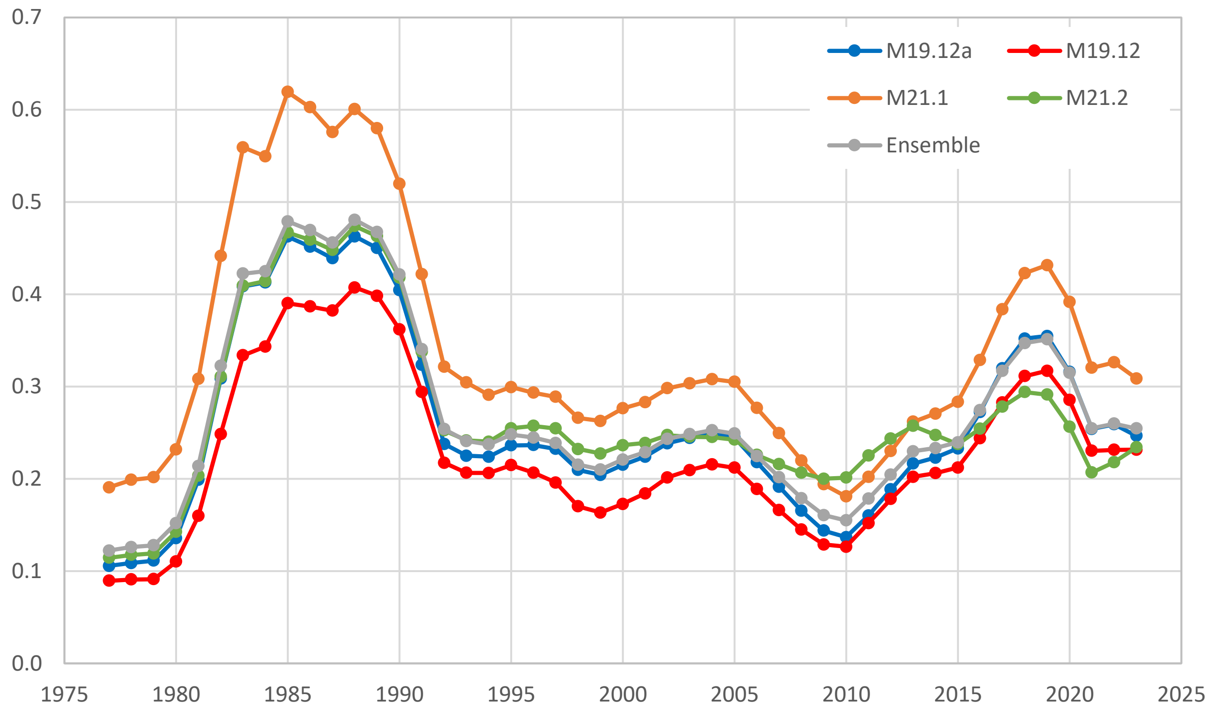

Figure 2.16. Female spawning biomass (millions of t) time series.

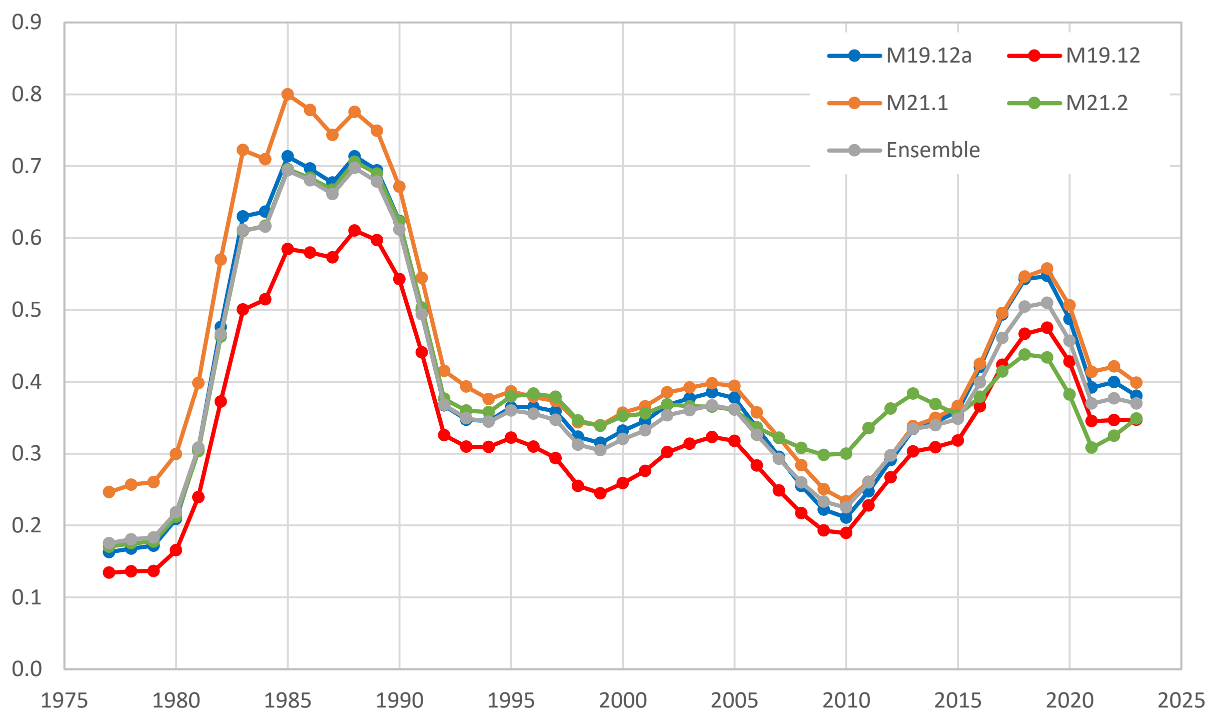

Figure 2.17. Relative spawning biomass time series.

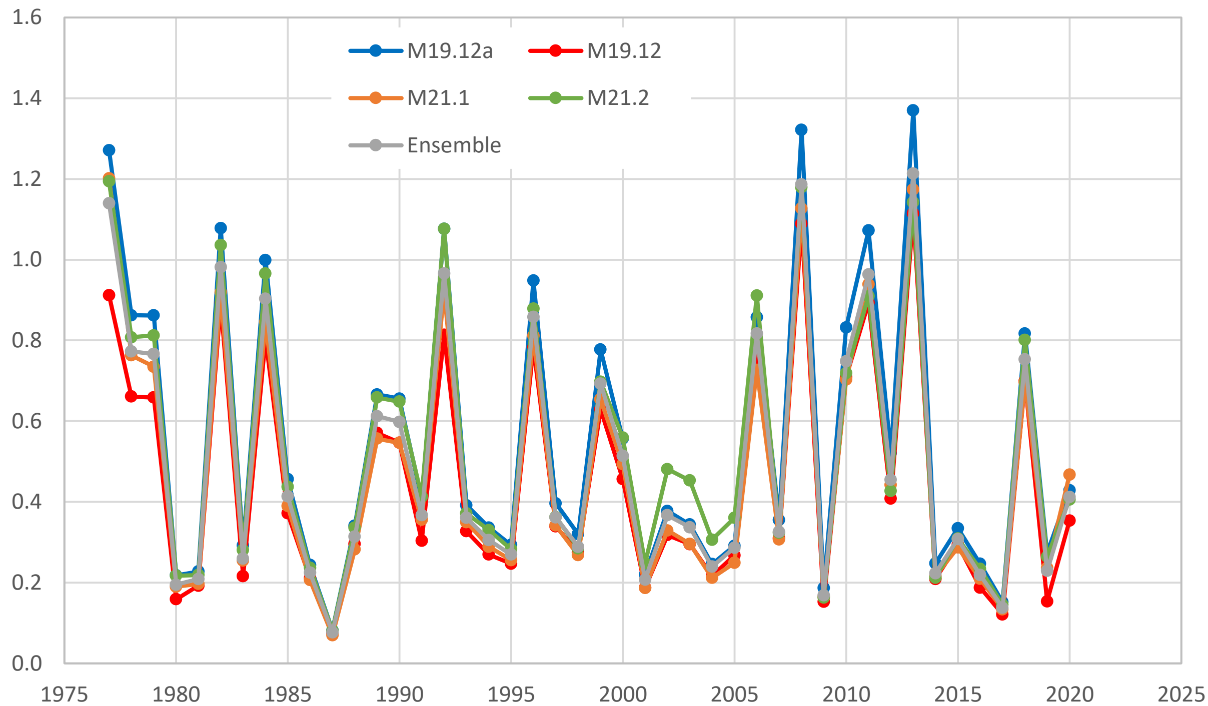

Figure 2.18. Recruitment (billions of fish) time series.

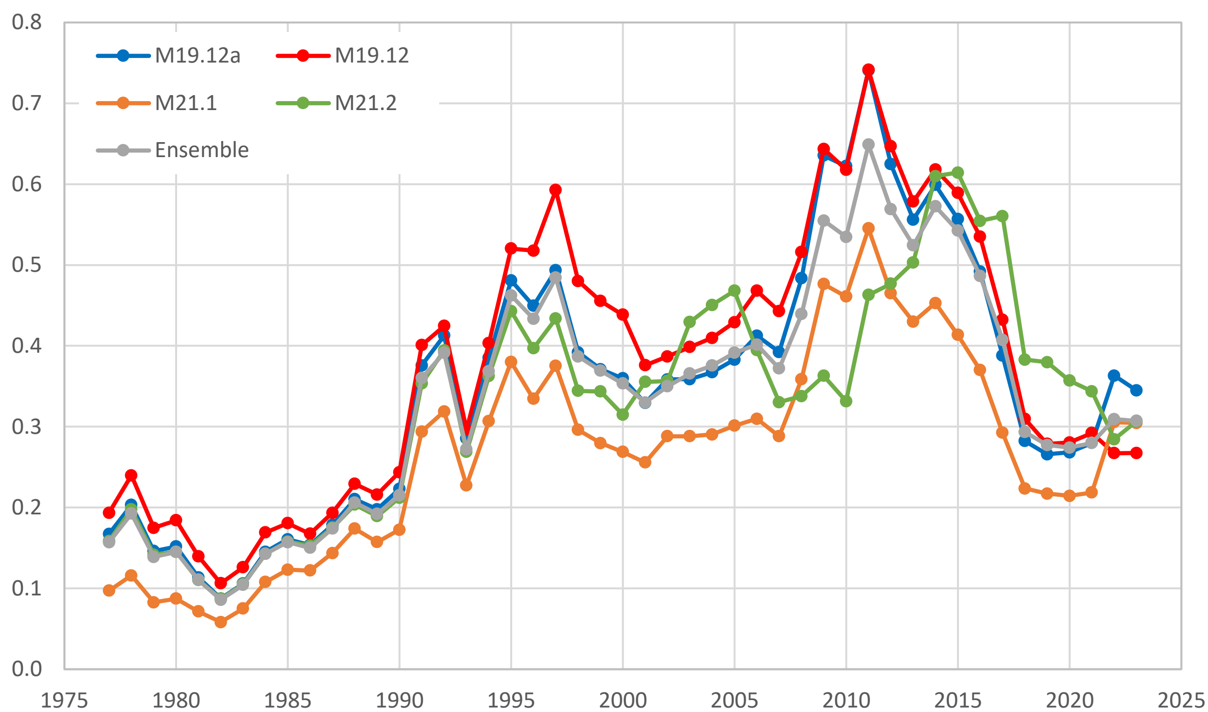

Figure 2.19. Full selection fishing mortality time series.

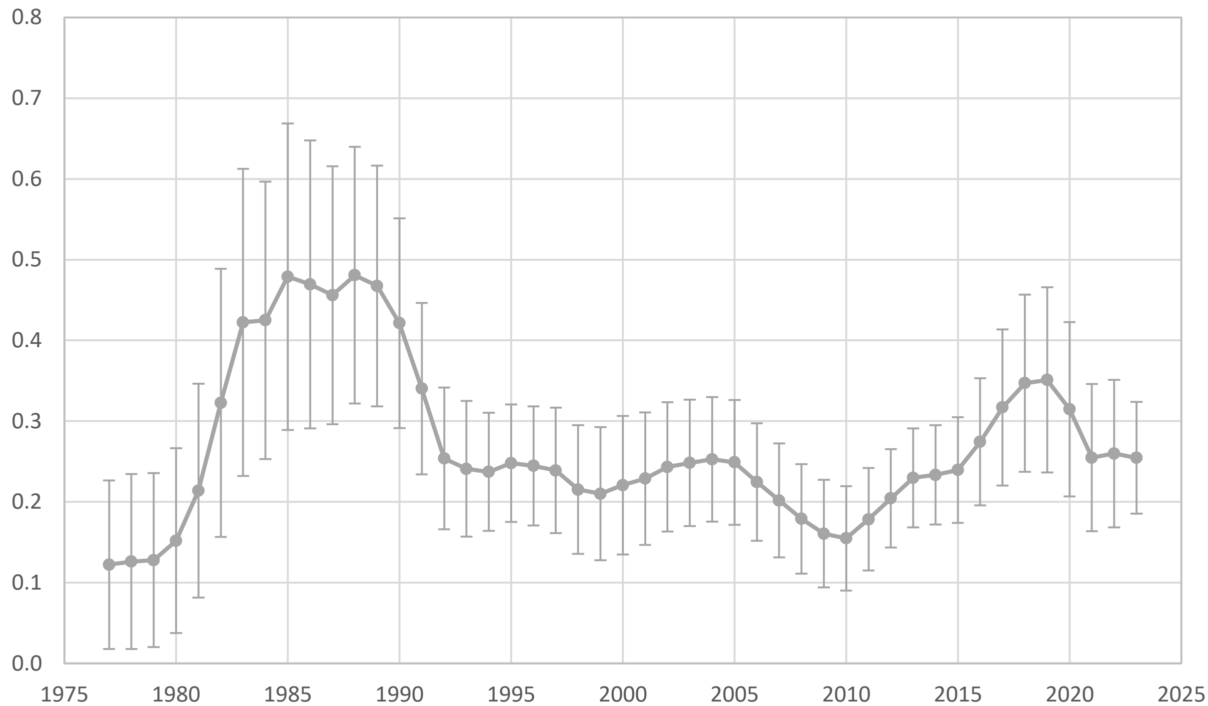

Figure 2.20. Ensemble estimates of female spawning biomass (millions of t), +/– 2 standard deviations.

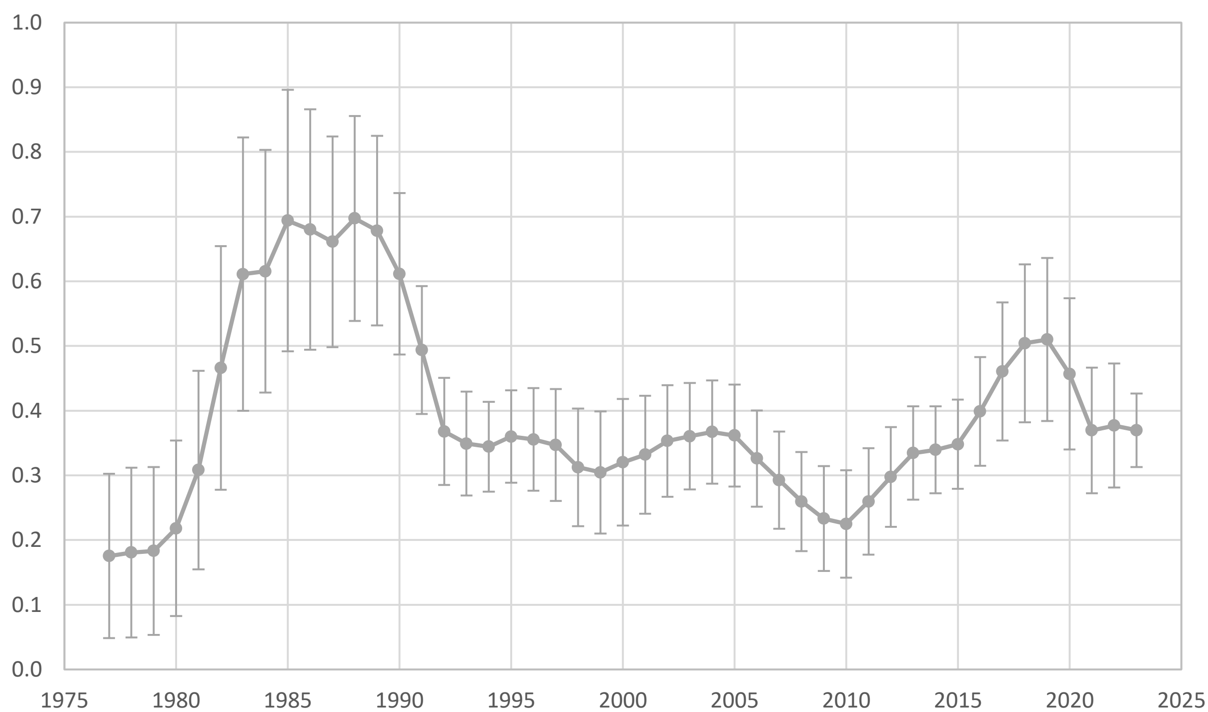

Figure 2.21. Ensemble estimates of relative spawning biomass, +/– 2 standard deviations.

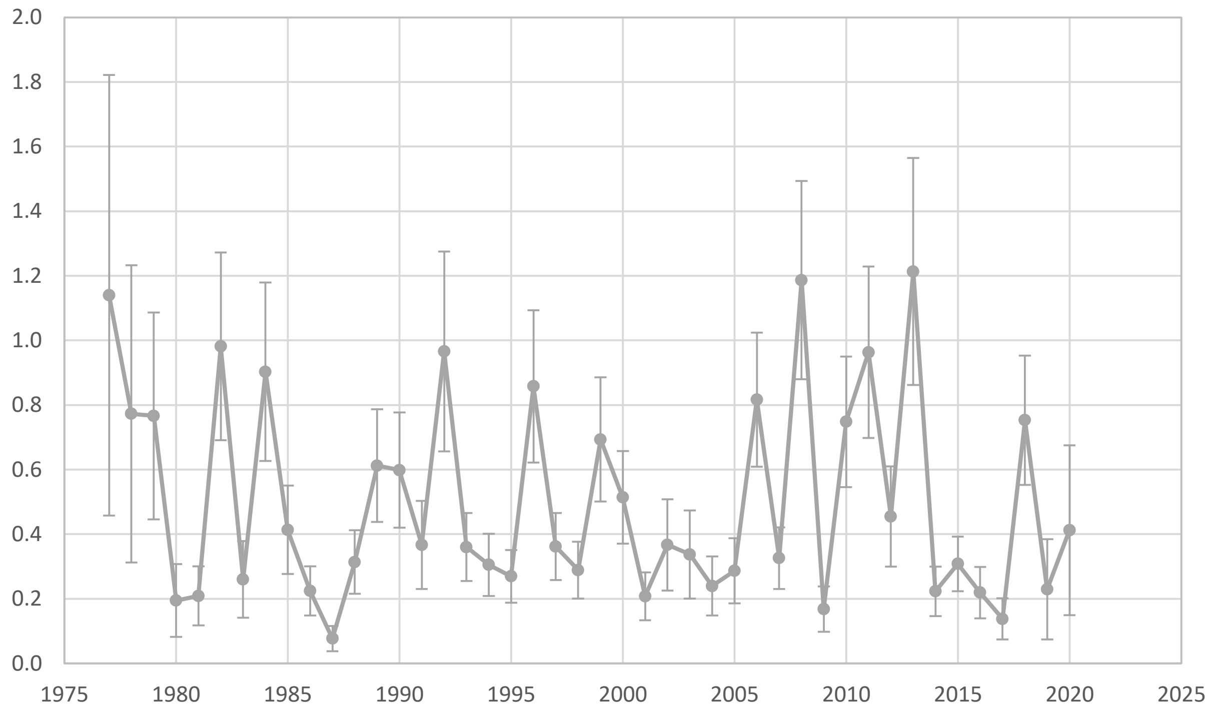

Figure 2.22. Ensemble estimates of recruitment (billions of fish), +/– 2 standard deviations.

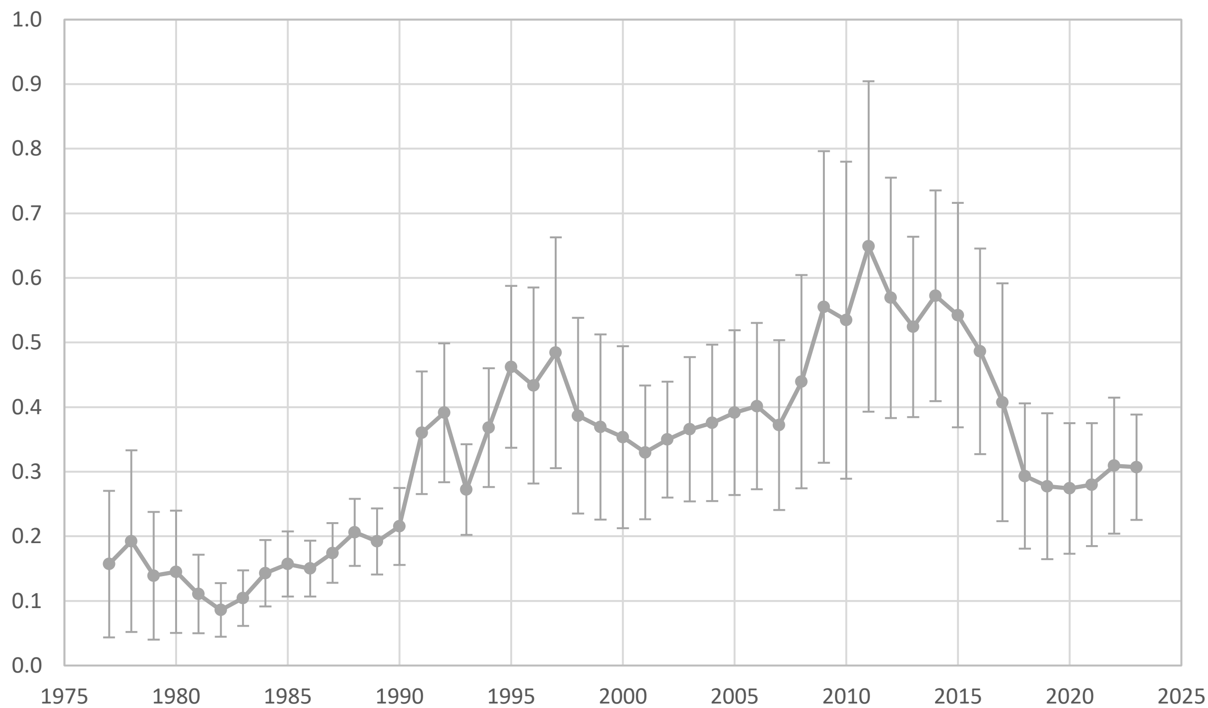

Figure 2.23. Ensemble estimates of full selection fishing mortality, +/– 2 standard deviations.

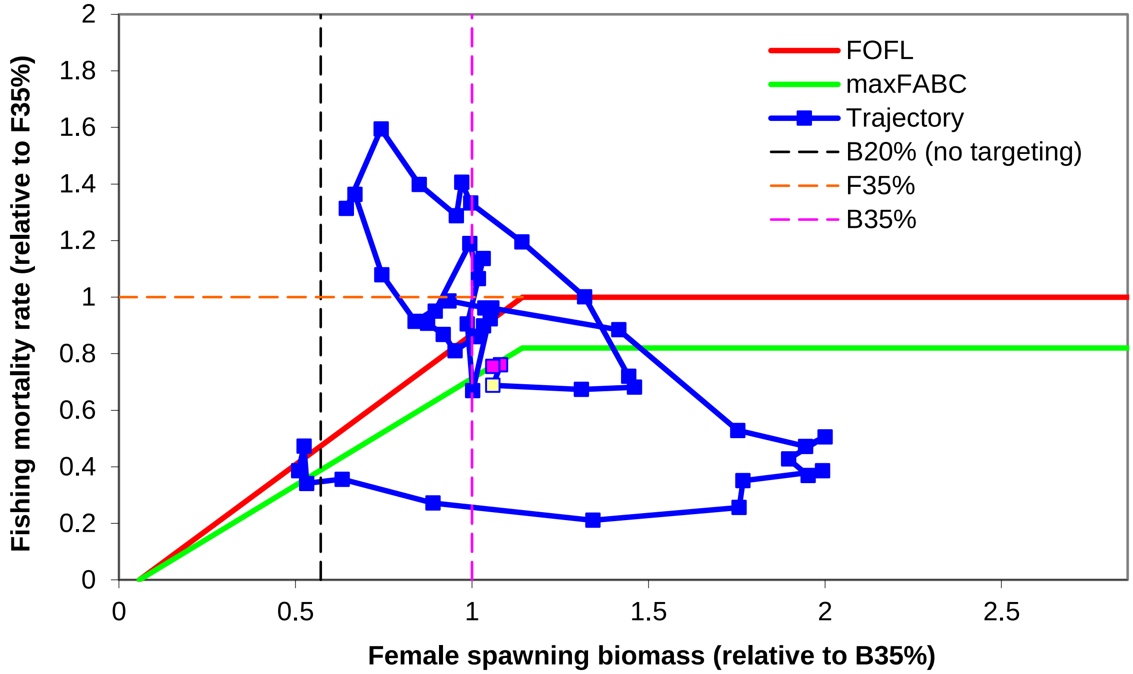

Figure 2.24. Phase plane for the ensemble.

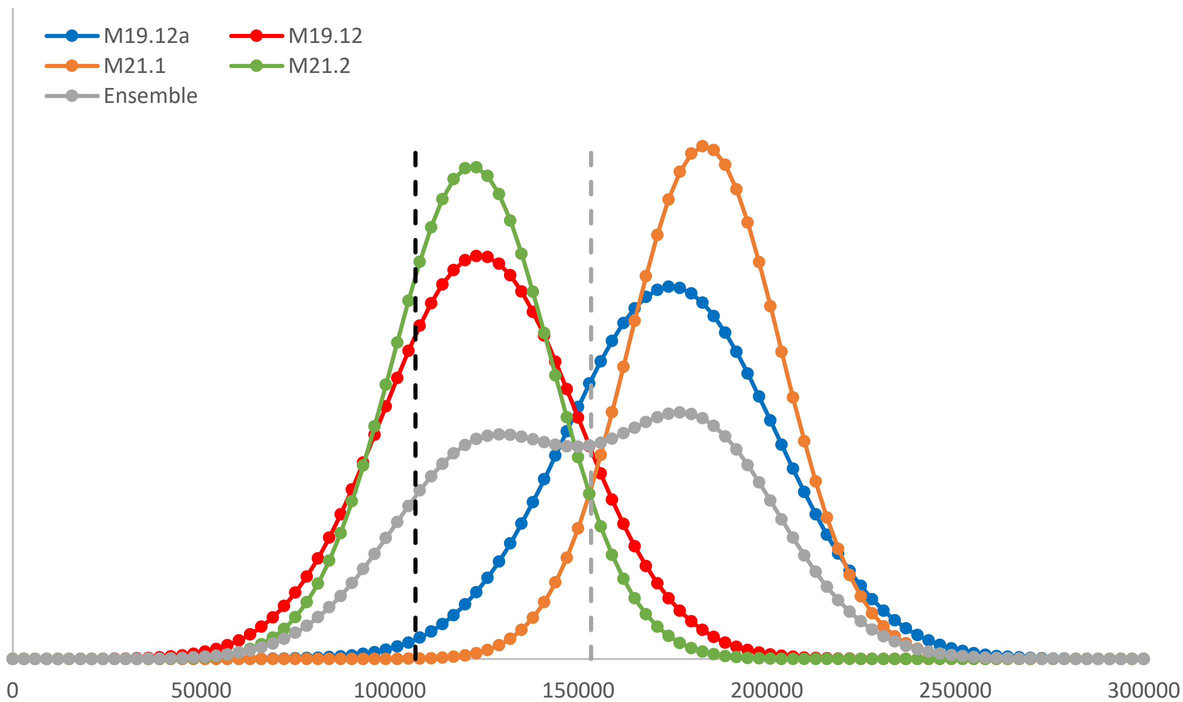

Figure 2.25a. Individual model and ensemble distributions of 2022 ABC. Vertical dashed lines: black = current specified value; gray = ensemble mean.

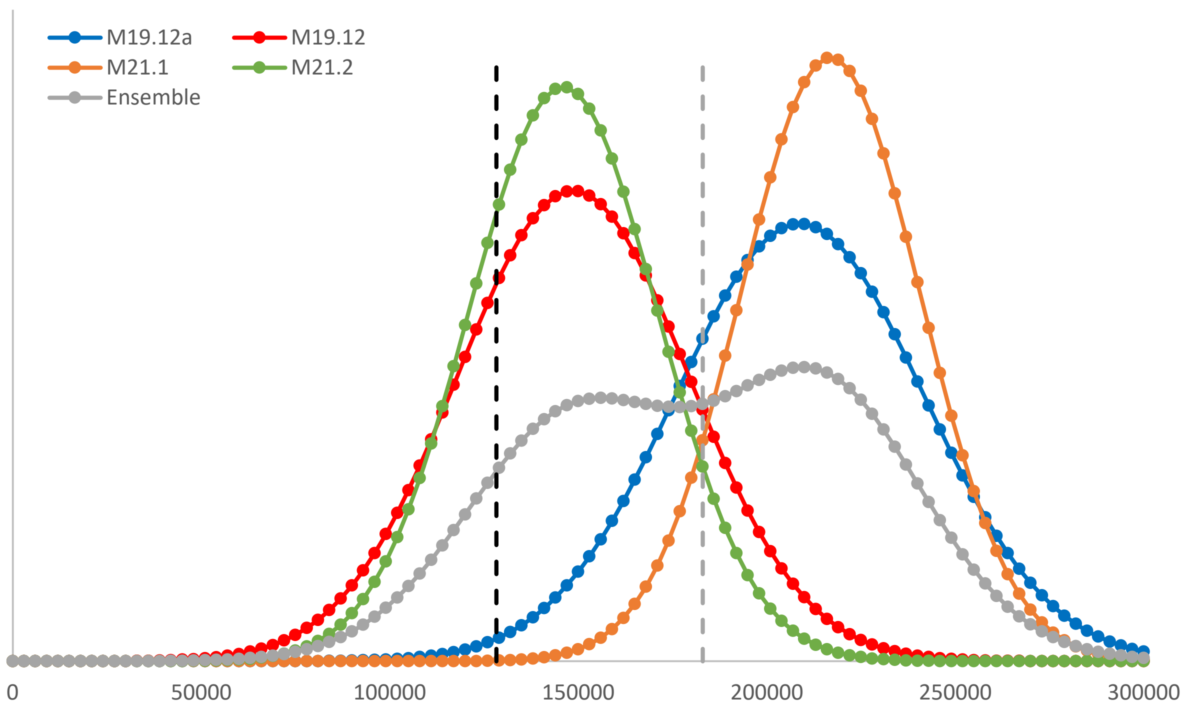

Figure 2.25b. Individual model and ensemble distributions of 2022 OFL. Vertical dashed lines: black = current specified value; gray = ensemble mean.

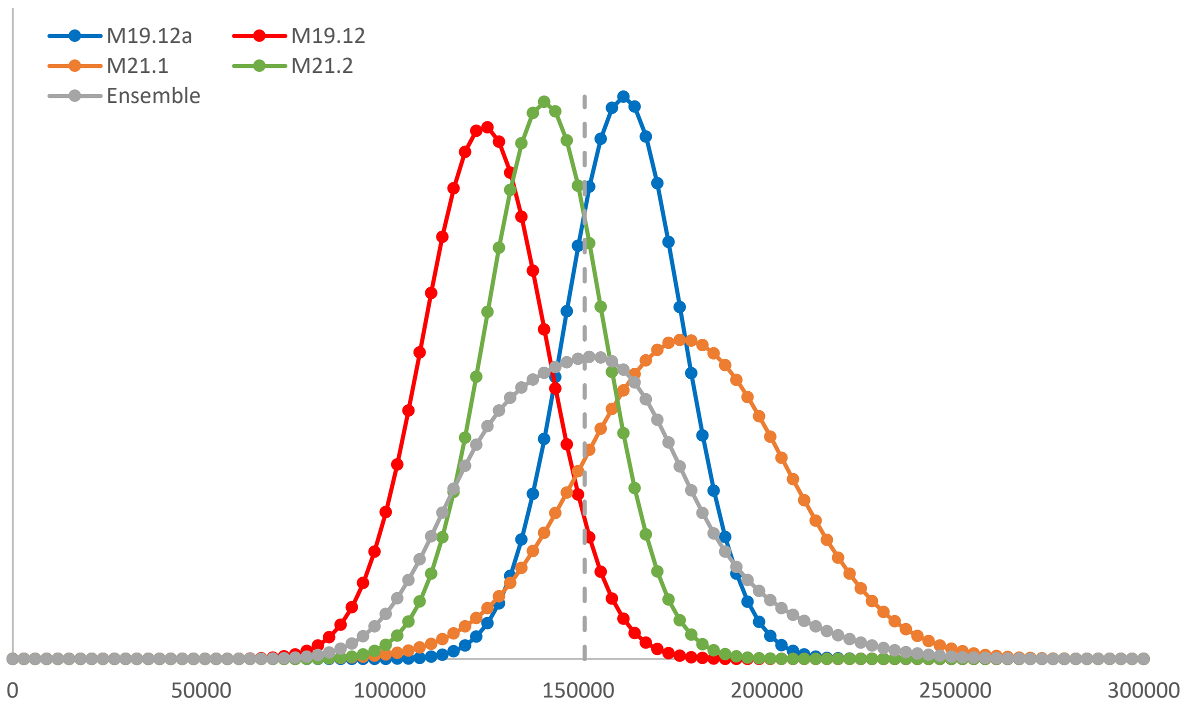

Figure 2.25c. Individual model and ensemble distributions of 2023 ABC. Vertical dashed gray line = ensemble mean.

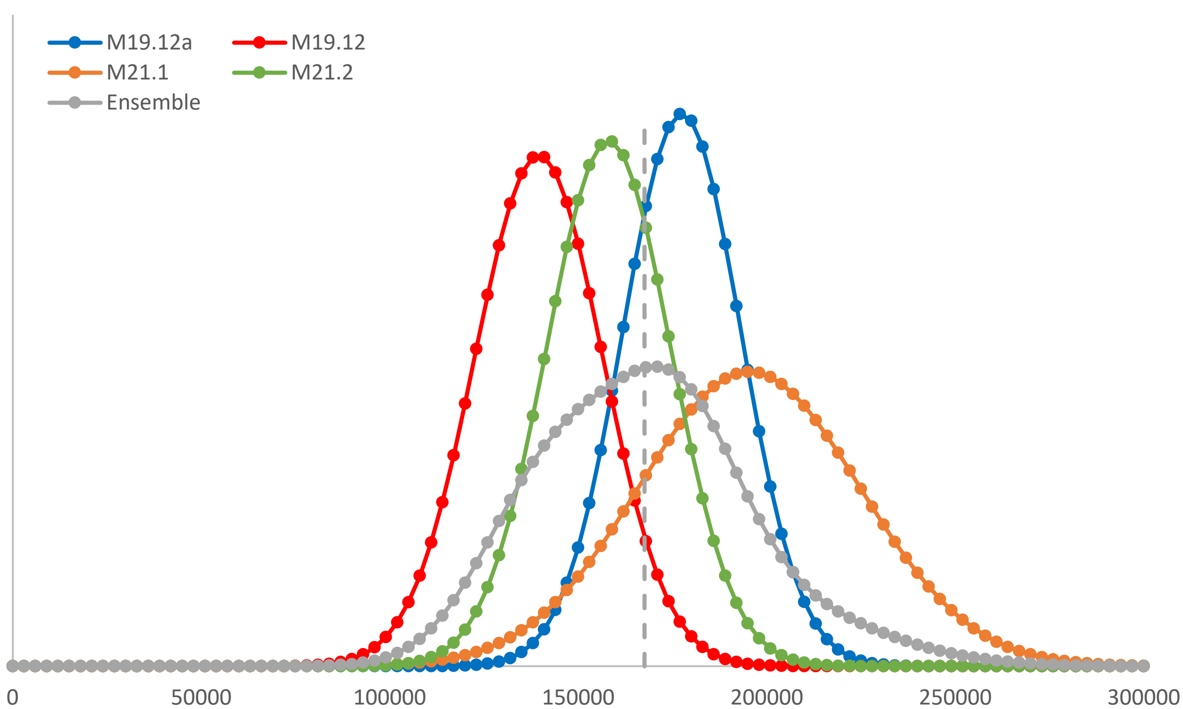

Figure 2.25d. Individual model and ensemble distributions of 2023 OFL. Vertical dashed gray line = ensemble mean.

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

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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 et al. 2020). In addition, comments from this year's review of the assessment by members of the Center for Independent Experts (CIE) are addressed (Attachment 2.1.1).

A note on table formatting: All tables presented in this preliminary assessment that include "color scales" follow the convention red=low and green=high. Depending on the context, color scales may extend across a row, a column, or the entire table.

Responses to Team and SSC comments on assessments in general

Note that, although the SSC made a number of generic recommendations regarding the "risk table" during its June 2021 meeting, those recommendations are not addressed here, because: 1) they will not be finalized until the SSC's October meeting and therefore may undergo changes, and 2) the risk table is typically not updated until the final draft of the assessment. The final draft of this year's assessment will address any final recommendations on the risk table adopted by the SSC at its October meeting.

Comments from the December 2020 SSC meeting

SSC1: "The SSC cautions against standardized model fitting (e.g., a single error distribution, set of covariates, number of knots), 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. For each species, assessment documents should describe why the particular error distributions, covariates, and number of knots were chosen for that individual species." *Response:* An evaluation of alternative configurations for the VAST model of trawl survey index data is presented under "VAST estimates of survey abundance" in the "Data" section.

SSC2: "In general, …the SSC recommends the continued inclusion of community engagement and dependency indices at varying scales in ESPs, ESRs, and SAFEs. For ESPs specifically, changes in patterns of community engagement and dependency at the stock level have the potential to inform not only stock assessments and analyses that support fishery management, but they may also function as early indicators of larger ecosystem changes." *Response:* See response listed in the revised ESP (https://apps-afsc.fisheries.noaa.gov/Plan_Team/2021/EBSPcod_esp.pdf).

Responses to Team and SSC comments specific to this assessment

Comments from the November 2020 BSAI Groundfish Plan Team meeting
GPT1: "The Team recommended that the fishery CPUE be standardized using alternative statistical methods and that it be discussed at the CIE review in 2021. This should also include a discussion of historical changes in the fishery that may affect the relationship of the index to abundance." *Response:* A first attempt at standardizing fishery CPUE using alternative statistical methods has been completed (see "VAST estimates of fishery catch per unit effort" in the "Data" section). This comment was forwarded to the CIE reviewers for their consideration (Attachment 2.1.1). In response, one result of the CIE review was the inclusion in this preliminary assessment of a model incorporating the new index of fishery CPUE (see "Alternative models" in the "Models" section).

GPT2: "The Team recommended collating fishery information in the ESP. Although the CPUE index was of concern to the Team, the Team recognizes that fishery performance has been improving and that these observations should not be ignored. Inclusion of fishery performance in the ESP and evaluation of the CPUE index with those performance metrics may help provide important insights." *Response:* Collating *all* fishery information in the ESP could prove awkward, because some of it is routinely used by the assessment models (e.g., catch and fishery size composition), and it seems more appropriate to collate such data in the main text of the assessment. Moreover, because fishery CPUE data are used in one of the assessment models, it seems more efficient to collate all fishery CPUE information in the main text than to split this information into two parts, with one part placed in the main text and the other in the ESP. The revised ESP (https://apps-afsc.fisheries.noaa.gov/Plan_Team/2021/EBSPcod_esp.pdf) continues to include aspects of fishery performance other than fishery CPUE.

GPT3: "The Team recommended the following topics could be considered for the 2021 CIE review: development of a fishery CPUE index, incorporation of dome-shaped survey selectivity, models to include in an ensemble, whether to apply the sloping HCR before or after ensemble averaging of SSB and other reference points, and development of movement models." *Response:* These topics were considered during the CIE review (Attachment 2.1.1). In response, some results of the CIE review were the inclusion in this preliminary assessment of: 1) a model incorporating a new index of fishery CPUE (see response to comment GPT1), 2) a model incorporating dome-shaped survey selectivity, 3) a set of models to include in an ensemble, 4) a simple conceptual model (*not* part of the ensemble) addressing movement of Pacific cod between American and Russian jurisdictions (Attachment 2.1.2), and 5) further analysis of whether to apply the harvest control rule before or after model averaging (Attachment 2.1.3)

Comments from the December 2020 SSC meeting
SSC3: "The SSC supports items proposed by the BSAI GPT for inclusion in the CIE review of this assessment planned for 2021. Proposed topics include: development of a standardized fishery CPUE index using alternative statistical methods, incorporation of dome-shaped survey selectivity, discussion of models to include in an ensemble, whether to apply the sloping harvest control rule before or after ensemble averaging of SSB and other reference points, and development of movement models." *Response:* See response to comment GPT3.

SSC4: "The SSC also recommends consideration of suggestions offered by Alistair Dunn (public comment) about other factors that could be included in the CIE review if time is available including: inclusion of other survey information (e.g., the IPHC and sablefish surveys), and considerations about how best to include the fishery age and size composition data. Additionally, Mr. Dunn suggested that the analysis of fishery CPUE data suggested by the GPT could include development of spatiotemporal analyses of fleet-specific CPUE indices that may help inform the assessment. *Response:* These topics were considered during the CIE review (Attachment 2.1.1). Although most of them did not result in very many specific recommendations from the reviewers, it may be noted that the new fishery CPUE index mentioned in response to comment GPT1 does involve a spatiotemporal, fleet-specific analysis.

SSC5: "The SSC also encourages review of further efforts to include fishery age data in future analyses." *Response:* This comment was forwarded for consideration during the CIE review. Although some specific recommendations were received (Attachment 2.1.1), time was insufficient to implement them in this preliminary assessment.

SSC6: "If time allows, the CIE could comment on avenues for incorporating spatial dynamics and movement." *Response:* This comment was forwarded for consideration during the CIE review. In response, one result of the CIE review was the inclusion in this preliminary assessment of a conceptual model (*not* part of the ensemble) addressing movement of Pacific cod between American and Russian jurisdictions (Attachment 2.1.2).

SSC7: "In addition, the SSC would like the CIE review to include an evaluation of the use of ensemble modeling in the NPFMC management system, and specifically whether the structural uncertainty and historical challenges in identifying a robust base model make Pacific cod a good application for ensemble modeling. The SSC acknowledges the trade-off between review capacity and the addition of models comprising an ensemble, but also recognizes that the goals of developing an ensemble that describes a range of structural uncertainties differs from those of refining a single best model." *Response:* This comment was forwarded for consideration during the CIE review. The reviewers were unanimous in their conclusion that the EBS Pacific cod assessment is a good candidate for ensemble modeling, in part *because* of the structural uncertainty associated with it.

SSC8: "For community harvest revenue indicators, the SSC recommends that the analysts consider aggregating small communities that cannot be individually disclosed into a single indicator that can be displayed along with the limited number of larger community indicators that can be disclosed, for consistency with other ESPs and for the sake of a more comprehensive portrayal of EBS Pacific cod community engagement trends." *Response:* See response listed in the revised ESP (https://apps-afsc.fisheries.noaa.gov/Plan_Team/2021/EBSPcod_esp.pdf).

Data

This section is divided into two parts. The first part provides updates of certain data that were presented in last year's assessment, and that here incorporate year-to-date results for informational purposes only (i.e., either last year's data continue to be used in the assessment models presented in this preliminary assessment, or the data are not used in the assessment models at all). The second part provides methodological updates of data that *are* included in at least one of the assessment models presented here, but that do not include any current-year data.

Data updates provided for informational purposes only

Catch

Table 2.1.1 and Figure 2.1.1 update the time series of catch through August of 2021, both by gear and overall. These data correspond to catches taken throughout the portion of the Bering Sea covered by the Fishery Management Plan, which includes the areas covered by the EBS and NBS bottom trawl surveys (Figure 2.1.2). Figure 2.1.3 partitions the catches since 2003 into those taken in the Northern Bering Sea Research Area, which approximates the NBS survey area, and those taken in the remainder of the FMP area. Note that the catch data used in the assessment models presented here *do not* include these updates.

Fishery catch per unit effort (CPUE)
The methods used to summarize the information presented *in this subsection* are similar to those that have been used in the last several assessments, as distinguished from both the method used to devise the all-gear CPUE index that was used in Model 20.9 from last year's assessment (and which is *not* used in this preliminary assessment) and the method described below under "Data updates used in the models."

Table 2.1.2 shows simple year-and-month averages of catch (in weight) per unit effort for four gear types: longline, bottom trawl, pot, and pelagic trawl. The values have been normalized so that the average across all non-empty cells is unity (empty cells indicate either that there are no data, or that presentation of the data is precluded due to confidentiality restrictions). For the first three gear types, the data represent hauls/sets/lifts that satisfy the Regional Office's definition of a Pacific cod target, whereas the data for pelagic trawl gear include all hauls (because the majority of the Pacific cod taken by pelagic trawl gear consists of incidental catch). For all three of the gear types that target Pacific cod, Table 2.1.2 indicates that 2021 is shaping up to be an above-average year with respect to fishery CPUE. Relative to the 1996-2020 monthly averages, the 2021 monthly averages for the various gear types may be summarized as follows (reporting only those months where data are available and can be presented):

- Longline CPUE was above average for every month from January-August except for May.
- Bottom trawl CPUE was above average for every month from February-April; in particular, CPUE for February was extremely high (more than triple the 1996-2020 average), repeating the performance observed in 2020.
- Pot CPUE was above average for January.
- Pelagic trawl CPUE (including incidental catches) was mixed from January-March, with January being below average and February-March being above average; in particular, CPUE for March was more than double the 1996-2020 average.

Figure 2.1.4 shows the results of the conventional model that estimates "year" and "month" effects for each gear. For n years of data, where year "n" is the current year, the model initially estimates the year and month effects (with each vector normalized to a mean of zero) for the first n–1 years of the time series, after which the year effect for the current year is estimated freely, conditional on the month effects that were estimated for the first n–1 years (which means that the full set of year effects, through year n, will no longer have a mean of zero). Because the estimated year effect for the current year is conditional on the vector of month effects, the fact that the data for the current year do not span the entire year should not cause the estimate of the current year effect to be biased. The year and month effects shown in Figure 2.1.4 have been incremented by 1.0 in order to represent values relative to the respective average. The estimated year effects for 2021 (shown in the top left panel of each page of Figure 2.1.4) for all four gear types confirm that this is shaping up to be an above-average year with respect to fishery CPUE. The fits to the data are shown in the bottom panel of each page of Figure 2.1.4. The inverse-variance-weighted R^2 values were as follow:

- Longline: 0.902
- Bottom trawl: 0.949
- Pot: 0.853
- Pelagic trawl (includes incidental catch): 0.918

Tagging
During the summers of 2017–2019, the distribution of Pacific cod appeared to shift northward into the NBS in conjunction with unprecedented increases in seawater temperature and decreases in sea ice extent (Stevenson and Lauth 2019). To determine whether this northward shift in distribution was seasonal or year-round, and to assess seasonal movement between management areas, a tagging study was initiated in

the NBS during the summer of 2019 (Principal investigators: S. McDermott, D. Nichol, S. Kotwicki, and L. Dawson). Thirty-eight Pacific cod were tagged with Pop-up Satellite Archival Tags (PSATs) and 86 with conventional tags near St. Lawrence Island in a collaboration between NOAA, the Norton Sound Economic Development Corporation, and the village of Savoonga. PSATs were programmed to pop up throughout the year (range 90 - 360 days) to provide information on seasonal movement. Movement pathways were reconstructed with a hidden Markov model based on maximum daily depth and light-based longitude. The model output provides gridded probability estimates of individual fish locations for each day; location probabilities for individual fish were summarized for each month and the peak spawning period (February 15 - March 31). Monthly and peak spawning period location probabilities from all tagged fish were then combined to provide overall tagged fish location probability distributions and the proportion of the overall probability in each management region. Recovery locations were obtained for 33 PSATs and 2 conventional tags (Figure 2.1.5a), and movement pathways were reconstructed for 31 fish tagged with PSATs. Overall location probability in the NBS declined beginning in November as tagged fish moved south and west ahead of the oncoming winter sea ice (Figure 2.1.5a, Figure 2.1.5b). Most (77%) of the overall location probability during the spawning period was in the EBS, where tagged fish occupied traditional spawning grounds (Neidetcher et al. 2014). However, the finding of some probability in the Gulf of Alaska (GOA, 7%) and in Russian waters (16%) indicated greater movement between management areas than expected. Tagged animals traveled 400 - 1000 km from their release locations to reach areas occupied during the spawning period. Four (3 PSAT and 1 conventional tag) of 5 recovery locations obtained the following summer were in the NBS. No evidence from geolocation or temperature records was found to suggest that any tagged fish lived in the NBS during the winter. These movement results, combined with a recent genetics study (Spies et al. 2020), suggest that the northward shift in distribution observed during the summers of 2017–2019 is related to an expansion of summer foraging habitat and does not currently represent a separate spawning population. This research provides important insights into mechanisms that may underlie the spatial dynamics of Pacific cod in a changing climate. Additional tags were deployed in the GOA in the winter and in the EBS and NBS the summer of 2021 to increase sample size, characterize activity patterns during summer, and assess seasonal movement patterns in years with differing environmental conditions.

<u>Western Bering Sea (WBS) catch and survey biomass</u>
Table 2.1.3 shows catches (t) taken in the WBS, obtained by summing the values in Tables 6-12 of Lajus et al. (2019).

Recently, basin-wide Bering Sea biomass indices have been 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 by applying VAST (Thorson and Barnett 2017) to multiple spatially unbalanced survey data products from the WBS, NBS, and EBS. 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 and spatiotemporal random effects for encounter probability and 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.

Figure 2.1.6 shows results for a representative subset of years from the overall time series. Pacific cod expanded across the Bering Sea from 2016 – 2019. Pacific cod density exhibited estimated hotspots emerging in the NBS, north of St. Lawrence Island, that span the Convention Line, particularly in warmer years when the cold pool extent is lower than the long-term average.

Data updates used in the models

The data used in the assessment models described in this preliminary assessment include some updates due to methodological improvements, and one model includes an entirely new data set. These are described below. As in last year's assessment, survey index and age composition data do not extend beyond 2019.

VAST estimates of survey abundance

The software versions of dependent programs used to generate VAST (Thorson and Barnett 2017) estimates were:

- Microsoft Open R (4.0.2)
- INLA (21.02.23)
- TMB (1.7.18)
- TMBhelper (1.3.0)
- VAST (3.6.1)
- FishStatsUtils (2.8.0)

The data consisted of observations of numerical abundance per unit area from all grid cells and corner stations in the 83-112 bottom trawl survey of the EBS, 1982-2021, including 83-112 samples available in the NBS in 1982, 1985, 1988, 1991, 2010, and 2017-2021. NBS samples collected prior to 2010 and in 2018 did not follow the 20 nautical mile sampling grid that was used in 2010, 2017, 2019, and 2021 surveys. Assimilating these data therefore required extrapolating into unsampled areas. In the 2019 and 2020 assessments, this extrapolation was facilitated by including a spatially varying response to cold-pool extent (Thorson 2019b). This spatially varying response was estimated for both linear predictors of the delta-model, and detailed comparison of results for EBS pollock has shown that it has a small but notable effect (O'Leary et al. 2020). 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 indicates that population densities in the NBS increased progressively after 2014 when cold-pool-extent declined prior to 2017.

Population density was extrapolated to the entire EBS and NBS in each year, using extrapolation grids available within FishStatsUtils. 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. Bilinear interpolation was used to interpolate densities from a specified number of "knots" to these extrapolation grid cells; knots were approximately evenly distributed over space, in proportion to the dimensions of the extrapolation grid. Geometric anisotropy (how spatial autocorrelation declines with differing rates over distance in some cardinal directions than others) was estimated, and included a spatial and spatio-temporal term for both linear predictors. To facilitate interpolation of density between unsampled years, the spatio-temporal fields were structured over time as an AR(1) process (where the magnitude of autocorrelation was estimated as a fixed effect for each linear predictor). However, temporal correlation for intercepts was not included, which were treated as fixed effects for each linear predictor and year. Finally, epsilon bias-correction was used to correct for retransformation bias (Thorson and Kristensen 2016). In general, VAST settings conformed to the recommendations of Thorson (2019a).

In response to a request from the SSC (see comment SSC1), alternative configurations for the use of covariates, number of knots, and error distribution were explored. Specifically, VAST estimates were obtained for each of the following configurations (differences in configurations #2-4 with respect to configuration #1 are shown in italics):

1. Cold pool used as a covariate, 750 knots, Poisson-linked delta-gamma distribution.
2. Cold pool *not* used as a covariate, 750 knots, Poisson-linked delta-gamma distribution.
3. Cold pool used as a covariate, *100* knots, Poisson-linked delta-gamma distribution.
4. Cold pool used as a covariate, 750 knots, *Tweedie* distribution.

Comparisons of the Poisson-linked delta-gamma and Tweedie distributions within VAST have previously been provided by Thorson (2018) and Thorson et al. (2021). Use of the Poisson-linked delta-gamma distribution has become something of a standard in applications of VAST to EBS and GOA survey index data, whereas use of the Tweedie distribution has been far less common, suggesting that a brief description of the latter may be useful here: In its unconstrained form, the Tweedie distribution is extremely flexible, and incorporates several better-known distributions as special cases, including the normal, Poisson, gamma, and inverse Gaussian distributions (Jørgensen 1987). In particular, VAST uses the subset of special cases corresponding to the compound Poisson-gamma distributions. Use of the Tweedie distribution has the advantage of needing to estimate only half as many parameters as alternative distributions, because the Tweedie distribution does not treat zeros as a special case (Foster and Bravington 2013), and so does not need to estimate parameters for the first linear predictor in VAST.

The point estimates from the four VAST configurations, together with the associated lognormal “sigma” terms, are shown for the combined EBS and NBS survey areas, the EBS survey area, and the NBS survey area in Table 2.1.4 and Figure 2.1.7. For all areas and VAST configurations, the point estimates are very similar, with correlations ranging from 0.968-0.998 in the combined EBS and NBS, 0.988-0.993 in the EBS, and 0.898-0.992 in the NBS (Table 2.1.5). In all three areas, the estimates from configuration #4 (Tweedie distribution) were the least similar to the others. For all three areas, the lognormal sigmas were very similar for configurations #1-3 (Poisson-linked delta-gamma distribution), but substantially lower for configuration #4, particularly in the NBS. In the NBS, the lognormal sigmas from all four configurations were nearly identical in all *survey* years except 1982, and the plots of the lognormal sigmas against time for configurations #1-3 tended to be dome-shaped within multi-year gaps in the time series, whereas the plot tended to be essentially flat within multi-year gaps for configuration #4.

Model fits were checked for evidence of non-convergence by confirming that: 1) the derivative of the marginal likelihood with respect to each fixed effect was sufficiently small (approximately <0.0001), and 2) the Hessian matrix was positive definite.

Normally, model fit would be evaluated further by: 1) computing Dunn-Smyth “Probability-Integral Transform” (PIT) residuals (Dunn and Smyth 1996) and visualizing these using a quantile-quantile plot within the DHARMa R package, and 2) inspected the residuals for evidence of spatio-temporal patterns. In preparing this preliminary assessment, however, technical difficulties precluded taking these additional steps. Therefore, the choice of a final configuration was based primarily on comparison of AIC values, which were as follow:

Configuration	Cold pool?	Knots	Distribution	AIC	ΔAIC
1	Yes	750	P-link Δ-gamma	220372.7	0
2	No	750	P-link Δ-gamma	220480.6	107.9
3	Yes	100	P-link Δ-gamma	222030.2	1657.5
4	Yes	750	Tweedie	222268.2	1895.5

Given the above, configuration #1 was used to derive the survey abundance data used in this preliminary assessment.

VAST estimates of survey age composition

The software versions of dependent programs used to generate VAST (Thorson and Barnett 2017) estimates of survey age composition were the same as those listed above for survey abundance.

The data consisted of observations of numerical abundance-at-age at each sampling location. This was made possible by applying year-specific and region-specific (EBS and NBS) unstratified age-length keys to records of numerical abundance and length composition. The VAST configuration included a conventional delta-model with logit-link for encounter probability and log-link for positive catch rates, following a gamma distribution. A cold-pool covariate was not included. The same extrapolation grid as implemented for abundance indices was used here, but with only 50 knots for the spatial and spatiotemporal fields. This reduction in the spatial resolution of the model, relative to that used for abundance indices, was necessary due to the increased computational load of fitting multiple age categories and using epsilon bias-correction. The diagnostics used for checking convergence and model fit were the same as those used for the survey abundance index.

The resulting age compositions, expressed as within-year proportions at age, are shown in Table 2.1.6a. The differences relative to the age compositions used in last year's assessment, which are due to refinements in the data set, are shown in Table 2.1.6b. These are generally very small, the largest (in absolute value) being a decrease of 4.4% in the proportion at age 1 in 2011 and an increase of 2.3% in the proportion at age 1 in 2012.

VAST estimates of fishery catch per unit effort

Developing an index from fishery catch-and-effort (CPUE) data has been a goal in fisheries for at least sixty years (Beverton and Holt 1957). Analysts have identified many overlapping concerns that will cause an abundance index from fishery CPUE data to be uninformative about abundance changes, including:

1. Spatial targeting causing sampled CPUE not to represent changes in population density for the average fish (Walters 2003).
2. Spatial or interannual variation in fishing gear performance, either via changes in mechanical configuration, time-of-day deployment, or unmeasured fine-scale variation (Abbott et al. 2015).
3. Improvements in technology and associated changes over time in fishing gear and power (Robins et al. 1998, Hannesson 2007).

These mechanisms may in turn change due to a variety of institutional and structural incentives, including:

A. Changing costs for labor and fuel.
B. Changing access to capital markets and buy-back programs.
C. Changing co-production and limits on (or incentives to avoid) incidental catch.

Because of the above concerns, past EBS Pacific cod assessment models have, for the most part, not included use of fishery CPUE data. The main exception occurred in last year's assessment, when a composite (all-gear) fishery CPUE index was developed and used in Model 20.9. The index was developed in a fairly simplistic way, and proved to be "of concern" to the Team (comment GPT2), who recommended pursuing "alternative statistical methods" for developing a fishery CPUE index (comment GPT1). The SSC similarly recommended "development of spatiotemporal analyses of fleet-specific CPUE indices" (comment SSC4).

During recent decades, researchers have developed methods to use high-resolution spatial and timing information to account for challenge #1 above (spatial targeting), where these methods implicitly impute or predict the CPUE that would have arisen in unsampled locations. This imputation occurs either structurally (Carruthers et al. 2011), via post-stratification and area-weighting (Campbell 2016), or using area-weighting within spatio-temporal statistical models (Thorson 2019a). Spatio-temporal models for fishery CPUE data have been tested successfully using operating models mimicking fishery-dependent CPUE data that were developed independently and that do not match the estimation model (Grüss et al. 2019, Thorson et al. 2017a).

For this preliminary assessment, a univariate spatio-temporal model was developed for fishery longline CPUE data measured in cod biomass, restricting data to sets that target and catch Pacific cod (i.e., no observations of zero catch) during January and February and using log-hooks as offset (the January-February period was chosen because no fishing occurs in the NBS during those months, meaning that the "footprint" of the EBS bottom trawl survey could be used to conduct the analysis). This was implemented using VAST (Thorson and Barnett 2017), specifying a gamma distribution for positive catches and "turning off" the first linear predictor; that is, specifying intercepts to attain 100% encounter probabilities within the delta-gamma modelling framework. Both a spatial term ("omega") and spatio-temporal components ("epsilon") were estimated for the single log-linked linear predictor used in the gamma distribution, and geometric anisotropy was included when estimating those spatial and spatio-temporal components (Thorson et al. 2015). Densities were predicted across the entire EBS bottom trawl survey area, distributing 100 knots across this spatial domain and using bilinear interpolation between knots. No catchability or density covariates were included, although future exploration could account for challenge #2 (changes in gear configuration/deployment) and #3 (changes in fishing power), using auxiliary variables as catchability covariates. The model converged successfully, with no evidence of poor fit based on standard Dunn-Smyth PIT residuals (Dunn and Smyth 1996). Epsilon bias correction was used to account for retransformation bias (Thorson and Kristensen 2016) when calculating the index of biomass.

The resulting fishery CPUE index is listed in Table 2.1.7 and shown (on the original scale) in Figure 2.1.8a and compared with the final VAST survey index (both on normalized scales) in Figure 2.1.8b. Maps of log density, log density standard error, and model residuals are shown in Figures 2.1.9a, 2.1.9b, and 2.9c, respectively; and a residual quantile-quantile plot is shown in Figure 2.1.9d.

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 V3.30.17.01 was used to run all of the models in this preliminary assessment. Using this version to run the current base model (Model 19.12a) with last year's data set gave a 2020 spawning biomass that was within 0.0002% of the value obtained in last year's assessment (using SS V3.30.16.02). The objective function values, however, were not close. This is because SS V3.30.17.01 adds a large constant to the objective function for models that use the Dirichlet-Multinomial option for compositional data, in order to make the objective function values for such models similar to those for models that do not use the Dirichlet-multinomial option. Because all of the models in both last year's assessment and this preliminary assessment use the Dirichlet-multinomial option, objective function values for the models in this preliminary assessment will appear very different from those in last year's assessment.

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, 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." In any instances where parameter estimates are pinned against either bound, those parameters are fixed in the final run of that model (typically at the bound, but perhaps at their final estimated value).

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 an input standard deviation (σ) specific to that parameter. For all models in this preliminary assessment, each σ was tuned iteratively as follows:

- For a vector of deviations associated with log catchability, σ was tuned to set the root-mean-squared-standardized-residual (RMSSR) equal to unity.
- For the vector of 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 of deviations, σ was tuned to set the variance of the estimates plus the sum of the estimates' variances equal to unity.

All models were run using the "-hess_step" option in ADMB, with 2 steps specified. This resulted in all model gradients equaling 0 in the final pass. As an additional check on convergence, the final versions of all models successfully passed a "jitter" test of 50 runs with the jitter rate set at 0.1.

Base model

At the conclusion of last year's assessment cycle, Model 19.12a was adopted by the SSC as the new base model, supplanting Model 19.12, which had been adopted as the base model at the conclusion of the 2019 assessment cycle. Model 19.12a 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 ($W = \exp(\ln(\alpha_t)+\beta_t\ln(L))$), 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
    - 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:
        - 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. (2017b), 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 recommended by the CIE reviewers

The CIE reviewers recommended that this year's assessment be based on an ensemble of five models, consisting of the current base model and four alternative models (Attachment 2.1.1). Although this preliminary assessment is structured accordingly, the authors recognize that the Team, the SSC, or the authors themselves may recommend use of a different ensemble, or no ensemble at all, in the final assessment.

The CIE reviewers developed their set of alternative models by adding features, one at a time, to the base model as follows:

Feature 1: Allow catchability to vary?	no	yes	no	no	no
Feature 2: Allow domed survey selectivity?	no	no	yes	no	no
Feature 3: Use fishery CPUE?	no	no	no	yes	no
Feature 4: Estimate survey CV internally?	no	no	no	no	yes
Model (quotes indicate CIE review name):	19.12a	19.12	"20.8a"	"20.9a"	"21.cie"

Models "20.8a," "20.9a," and "21.cie" were developed during the meeting; model numbering for this group is provisional only, and follows the convention adopted during the meeting. Final model names will be assigned in the "Results" section, following the protocol described therein.

The parameter sets for the five models are compared in Table 2.1.8. Except for the fact that Model 19.12 includes a vector of deviations for log catchability, overall parameter counts for the models differ by only a few. (Note that parameter counts in Table 2.1.8 may differ slightly from those of the final model runs, due to the possibility that a few parameters may end up fixed at a bound.)

Results

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 base model that emerged from the 2019 assessment, 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 that emerged from the 2020 assessment, Model 19.12a, referred to a model that constituted a minor change from Model 19.12, 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 data from only 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.

Implications of data updates for names of the existing models

The updated survey abundance and age composition data described in the "Data" section are used by all of the models in the ensemble, including Models 19.12a and 19.12, which raises the question of whether use of these updated data sets should result in new names for those two models.

The SSC has stressed that model names should not change simply as a result of routine incrementing of existing time series (e.g., adding the most recent catch or survey index datum). In keeping with the spirit of that policy, it seems that *any* sufficiently minor adjustments to existing time series should likewise not result in a new model name. Of course, this begs the question of how to determine which adjustments are "sufficiently minor." Building upon the existing protocol for model naming, the criterion adopted in this preliminary assessment is that, *based on revisions to existing data alone*, a value of ADSB<0.05 does not merit a new model name.

Figure 2.1.10 shows the results of a simple "bridging" analysis for Models 19.12a and 19.12, in which estimated spawning biomass time series are compared for model runs with last year's ("original") data, last year's data with updated survey index values, and last year's data with both updated survey index and age composition values. Visually, the differences between the time series are almost imperceptible. The ADSB values are all below the 5% cutoff, as shown below:

Update type	M19.12a	M19.12
Updated index data only	0.0243	0.0072
Updated index and agecomp data	0.0228	0.0095

On the basis of the above results, Models 19.12a and 19.12 are *not* assigned new names in this preliminary assessment.

<u>Names of the new models</u>
Per the model numbering protocol given by Option A in the SAFE chapter guidelines, ADSB values were computed for the three new models. All values exceeded the cutoff of 0.1 distinguishing "major" from "minor" changes, thus resulting in the following set of final model names:

Feature 1: Allow catchability to vary?	no	yes	no	no	no
Feature 2: Allow domed survey selectivty?	no	no	yes	no	no
Feature 3: Use fishery CPUE?	no	no	no	yes	no
Feature 4: Estimate survey CV internally?	no	no	no	no	yes
CIE review model name:	19.12a	19.12	"20.8a"	"20.9a"	"21.cie"
Average difference in spawning biomass:	n/a	n/a	0.4047	0.1299	0.1175
Final model name:	19.12a	19.12	21.1	21.2	21.3

Results of the individual models

<u>Goodness of fit</u>
Table 2.1.9 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 AIC may be misleading, because:

- The total parameter counts overestimate the number of "effective" parameters, as these counts include parameters with constrained deviations.
- Models sometimes use different data files (specifically, Model 21.2 uses a different data file than the other models).
- The data are weighted differently between models, due to tuning of the σ terms for deviations.

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:	Survey					Fishery
Model:	M19.12a	M19.12	M21.1	M21.2	M21.3	M21.2
RMSSR:	2.301	1.002	2.298	2.425	1.002	2.561

Ideally, RMSSR values should equal unity, and this was the standard that was used to tune the σ term for the log catchability devs in Model 19.12. Model 21.3 also achieved a value near unity, but this was accomplished by adding an estimated constant to the log-scale survey standard errors rather than tuning variability in log catchability. The other models under-fit the survey index data substantially, and Model 21.2 likewise under-fit the fishery CPUE data substantially.

Fits to the trawl survey abundance data are shown for all models in Figure 2.1.11a, where the 95% confidence intervals for the survey are based on the lognormal sigmas estimated by VAST. Fits for the two models with RMSSR values near unity (Models 19.12 and 21.3) are shown in Figure 2.1.11b, where 95% confidence errors for the survey are shown both for the lognormal sigmas estimated by VAST and also for the additional standard error estimated by Model 21.3. Figure 2.1.11c shows Model 21.2's fit to the fishery CPUE index.

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 2.1.10. 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. (2017b), which uses the Dirichlet-multinomial distribution to model compositional data, is expressed as a function of an internally estimated parameter ($\ln(\theta)$), so iterative tuning is not required.

Size composition: By the McAllister-Ianelli measure, both the fishery and survey size composition data were *over*fit by all of the models. The Dirichlet-multinomial parameter was constrained by the upper bound for both the fishery and survey size composition data in all models, meaning that, by the Thorson et al. measure, the effective sample size was equal to the average input sample size.

Age composition: By the McAllister-Ianelli measure, the age composition data were *under*fit by all of the models. 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. By both measures, Models 19.12 and 21.3 exhibited slightly better fits than the other models.

Residual plots for the size and age composition data are shown in Figures 2.1.12 and 2.1.13, respectively.

<u>Retrospective behavior</u>
Retrospective analyses of all models are shown in Figure 2.1.14. Values of ρ (Mohn 1999, Hurtado-Ferro et al. 2015) for spawning biomass are shown below:

Model:	M19.12a	M19.12	M21.1	M21.2	M21.3
Mohn's ρ	-0.0500	-0.0352	0.0326	0.0875	-0.0535

Parameter estimates
Table 2.1.11 displays the values of all estimated 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. Standard deviations are based on the inverse of the Hessian matrix, and assume a normal distribution.

Table 2.1.11a shows all time-invariant estimated parameters (color scales are row-specific). A blank cell in Table 2.1.11a indicates that the respective parameter (row) is not used in the respective model (column). As noted under "Goodness of fit" above, the Dirichlet-multinomial parameters for size composition ended up being pinned at the upper bound for all models, so those were fixed at the bound and omitted from the table. The two other cases where a parameter was pinned at a bound are indicated in Table 2.1.11a by the presence of a "_" symbol in the SD column. Natural mortality ranges from 0.309 (Model 21.1) to 0.348 (Model 19.12a). The Brody growth coefficient (K) ranges from 0.097 (Model 21.3) to 0.158 (Model 21.1). Similar to last year's assessment, the sign of the ageing bias flips from all positive (pre-2008) to very near zero at age 1 but negative at older ages (post-2007) in all models. Initial fishing mortality ranges from 0.074 (Model 21.1) to 0.137 (Model 21.3). Log survey catchability (base value in the case of Model 19.12) ranges from -0.030 (Model 21.2) to 0.146 (Model 21.3).

Tables 2.1.11b-2.1.11f show time series of annual parameter deviations. Color scales are column-specific in all these portions of Table 2.1.11, and show that, in general, time trends between models are very similar. Table 2.1.11b shows log deviations for the initial numbers-at-age vector, Table 2.1.11c shows log recruitment (at age 0) deviations, Table 2.1.11d shows deviations for mean length at age 1.5, Table 2.1.11e shows deviations for the time-varying selectivity parameters, and Table 2.1.11f shows deviations for log survey catchability (Model 19.12 only).

Tuning of annually varying parameters
As noted in the "Parameter estimation" subsection of the "Models" 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, deviations 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, deviations are modeled in SS as being normal$(0,\sigma^2)$, and sigma was tuned so that it matched the square root of the sum, again with a tolerance of +/- 0.01.

Table 2.1.12 shows the values of the iteratively tuned "sigma" quantities for parameters with annual deviations (other than log catchabilities). Model 21.3 had the highest sigma values for four of the six parameters common to all models, while sigma values for Model 19.12a 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 survey selectivity tended to have larger values than those associated with other parameters.

For Model 19.12 (the only model that includes annual deviations for log survey catchability), sigma was tuned so as to set RMSSR=1.0 (tolerance = +/- 0.01), resulting in a value of 0.0839.

Derived quantities
Figure 2.1.15 shows selectivity for all models. Figure 2.1.15a shows selectivity for the fishery, and Figure 2.1.15b shows selectivity for the survey. Note that the shapes of the fishery selectivity schedules cluster into two groups: one for the two models that give RMSSR=1.0 for the survey index (Models 19.12 and 21.3), and another for the remaining models.

Table 2.1.13 shows back-transformed survey catchability for Model 19.12. Estimates tended to be lower than average during the period 2004-2013 (except for 2005 and 2011), and higher than average for the period 2014-2019 (except for 2017).

Results of the CIE ensemble

Model weights

For the last few years, the Team and SSC have expressed interest in using a model averaging approach for the EBS Pacific cod assessment. However, the question of how to weight the models has proved to be difficult. The last two assessments have computed model weights as an emphasis-weighted average of a set of ranking criteria, and this general approach was also adopted, with some modifications, by the CIE reviewers (Attachment 2.1.1). Table 2.1.14 shows the ranking criteria, other aspects of thee system, and final model weights recommended by the CIE reviewers. Each reviewer assigned a score of 0, 1, or 2 for each criterion/model combination, after which the reviewer scores for each criterion/model combination were averaged (shown in the columns associated with the five models). Each criterion was then assigned an emphasis ("Emph."). Criteria for which all models exhibited the same score were assigned an emphasis of 0 and the scores ignored, to avoid skewing the weights toward equality. The reviewers nevertheless recommended keeping the criteria with emphasis=0 in the table in the event that, for some future set of models, at least one of the models were to exhibit a score different from the others.

The criteria to which the CIE reviewers assigned an emphasis greater than zero, along with the reviewers' rationales for any cases where a score less than the maximum of 2 was assigned, were as follow:

- General plausibility: The CIE reviewers judged all of the alternative models to be less plausible than the base model for the following reasons: 1) the amount of time-variability in survey catchability estimated by Model 19.12 (σ = 0.0839), 2) the low survey selectivity at larger sizes estimated by Model 21.1 (base selectivity = 0.3096 at 120 cm), 3) the use of fishery CPUE data in Model 21.2 (which may not be reflective of population size), and 4) the large extra standard deviation for the survey index estimated by Model 21.3 ("extra" SD = 0.1518).
- Acceptable retrospective bias: The values of ρ for spawning biomass shown above under "Retrospective performance" are repeated below, together with bounds on acceptable levels defined as a function of M, based on results reported by Hurtado-Ferro et al. (2015):

Model:	M19.12a	M19.12	M21.1	M21.2	M21.3
Time-vary Q?	no	yes	no	no	no
Survey dome?	no	no	yes	no	no
Fishery CPUE?	no	no	no	yes	no
Extra SE?	no	no	no	no	yes
M	0.3479	0.3313	0.3088	0.3433	0.3277
Mohn's ρ	-0.0500	-0.0352	0.0326	0.0875	-0.0535
ρmin	-0.2018	-0.1959	-0.1881	-0.2001	-0.1947
ρmax	0.2740	0.2656	0.2544	0.2716	0.2639

  By the above criterion, all models exhibited values of ρ well within the acceptable range. Nevertheless, the CIE reviewers noted that Model 21.2 had the highest (absolute value) of ρ, and that, while Model 21.1 had a low value of ρ, the degree to which survey selectivity at large sizes varied with retrospective peel was concerning.
- Uses properly vetted data: The CIE reviewers felt that the fishery CPUE data used by Model 21.2 had been less fully vetted than the other data components, as the Powerpoint file describing the development of this data set was less detailed than the reviewers would have liked.

- Acceptable residual patterns: The CIE reviewers were concerned by the recent string of several positive residuals in Model 21.3's fit to the survey index.
- Comparable complexity: The CIE reviewers assigned Models 19.12 and 21.1 a lower score than the others because: 1) Model 19.12 estimates 38 annual log catchability deviations that the other models do not, and 2) Model 21.1 estimates three survey selectivity parameters that the other models do not.
- Fits consistent with variances: The CIE reviewers assigned lower scores to Models 19.12a, 21.1, and 21.2 because all three exhibited a survey index RMSSR much greater than unity and Model 21.2 also exhibited a fishery CPUE RMSSR much greater than unity.

The criteria to which the CIE reviewers assigned an emphasis of zero (because all models scored the same) were as follow:

- Deviation sigmas estimated appropriately: All models tune the σ terms for the respective deviation vectors in a statistically reasonable manner.
- Incremental changes: Each of the alternative models involves only a single changes relative to the base model, and were deemed to exhibit suitably incremental changes from the base model.
- Objective criterion for sample sizes: All models use the Dirichlet-multinomial approach to scale the input sample sizes.
- Change in ageing criteria addressed: All models estimate ageing bias separately for pre-2008 and post-2007 time blocks.
- Density dependence (other than recruitment) addressed: None of the models address density dependence in quantities other than recruitment (steepness is fixed at 1.0 in all models, implying density dependent survival of age 0 fish).
- Regime shifts addressed: All models estimate an offset in mean recruitment for year classes spawned prior to the 1976-1977 regime shift (Hare and Mantua 2000).

Multiplying the average score for each criterion/model combination by the emphasis for that criterion and then computing the weighted average across criteria gives the row of values labeled "Average emphasis" in Table 2.1.14, and rescaling those so that they sum to unity gives the last row of values, which are the CIE reviewers' recommended model weights. The weights span the range 0.1311 – 0.2459, with Model 21.2 receiving the lowest weight and Model 19.12a the highest.

The CIE reviewers anticipated that the Team or SSC would provide their own scores for the criteria listed in Table 2.1.14 after reviewing this preliminary assessment, thus resulting a revised set of model weights.

Derived quantities

Mohn's (1999) ρ for the ensemble was 0.0037 (based on the weighted average of the individual models' retrospective "peels," as distinguished from the weighted average of the individual models' ρ values).

In the following tables and figures, results are shown for all models and the ensemble (point estimates and standard deviations in the case of tables, point estimates in the case of figures).

Table	Figure	Quantity
2.1.15	2.1.16	female spawning biomass (millions of t)
2.1.16	2.1.17	female spawning biomass relative to $B_{100\%}$
2.1.17	2.1.18	age 0 recruitment (billions of fish)
2.1.18	2.1.19	full-selection instantaneous fishing mortality

Some caveats for the above sets of tables and figures:

- For individual models, the Hessian approximation to the distribution was used, implying that each distribution is normal, and the distribution for the ensemble was computed as the weighted average of the individual model distributions.
- The 2021-2022 fishing mortality rates shown in Table 2.1.18 and Figure 2.1.19 are those resulting from application of the *maxABC* harvest control rule to each model (i.e., they were *not* conditioned on the 2021 ABC that was actually specified).

In the following tables, point estimates for each age and year are shown for all models and the ensemble.

Table	Quantity
2.1.19	mid-year population length (cm)
2.1.20	mid-year fishery weight (kg)
2.1.21	mid-year survey weight (kg)
2.1.22	fishery selectivity
2.1.23	survey selectivity
2.1.24	population numbers (billions of fish)

The following figures show point estimates and error bars corresponding to +/– two standard deviations, for the ensemble only:

Figure	Quantity
2.1.20	female spawning biomass (millions of t)
2.1.21	female spawning biomass relative to $B_{100\%}$
2.1.22	age 0 recruitment (billions of fish)
2.1.23	full-selection instantaneous fishing mortality

Some caveats for the above set of figures:

- The distributions for the ensemble, being averages of normal distributions, are themselves *not* normal, meaning that, while the standard deviations are correct (given the Hessian approximations of the distributions for the individual models), the ensemble error bars shown in the figures may or may not approximate the 95% confidence intervals.
- As in Table 2.1.18 and Figure 2.1.19, the 2021-2022 fishing mortality rates shown in Figure 2.1.23 are those resulting from application of the *maxABC* harvest control rule to each model (i.e., they were *not* conditioned on the 2021 ABC that was actually specified).

Table 2.1.24 lists the means and standard deviations of the 2021 ABC, 2021 OFL, 2022 ABC, and 2022 OFL distributions for all models and the ensemble, and Figure 2.1.24 shows the distributions of those quantities (again, these values result from application of the *maxABC* harvest control rule to each model; i.e., they were *not* conditioned on the 2021 ABC that was actually specified).

Discussion

Ensemble evaluation
As noted in the "Models" section, although this preliminary assessment is based on the ensemble (both the set of models and their respective weights) recommended by the CIE reviewers (Attachment 2.1.1), the authors recognize that the Team, the SSC, or the authors themselves may recommend use of a different ensemble, or no ensemble at all, in the final assessment. As noted under "Model weights" in the "Results" section, it should be emphasized that the CIE reviewers anticipated that the Team or SSC would

provide their own scores for the criteria listed in Table 2.1.14 after reviewing this preliminary assessment, thus resulting a revised set of model weights.

Model 19.12a

This is the base model for the current assessment, having been adopted by the SSC at the conclusion of the 2020 assessment cycle. In many respects, it performs very well. The CIE reviewers gave it (unanimously) the highest possible score for all but one of the ranking criteria, and it was explicitly endorsed as the single best model in the ensemble by at least two of the CIE reviewers. It is also the most parsimonious of all the models in the ensemble. However, while this model clearly tracks the survey index to an appreciable degree (correlation = 0.853), the fit to those data is less than fully satisfactory, statistically speaking (RMSSR = 2.301).

Model 19.12

Although Model 19.12 was adopted by the SSC as the base model at the conclusion of the 2019 assessment cycle, it was supplanted by Model 19.12a at the conclusion of the 2020 cycle. The only difference with respect to Model 19.12a is that Model 19.12 includes randomly varying survey catchability. A key consideration for the SSC last year was that the only justification that was provided for including randomly varying survey catchability was that it provided a statistically satisfactory fit to the survey index (RMSSR = 0.999 in last year's assessment, RMSSR = 1.002 here). The question of time-varying survey catchability has been addressed several times in recent assessments, but has always been controversial, with 2019 being the only assessment year in which a model with this feature was adopted by the SSC.

Arguments against use of time-varying catchability have typically centered on: 1) the danger of over-parameterization, 2) the decreased impact of the survey index on model results, and 3) the lack of an identified mechanism contributing to the time variability.

- With respect to the issue of over-parameterization, it has been suggested that the pattern of time-varying catchability estimated by Model 19.12 simply matches the time trend of the survey index. While they clearly covary (correlation = 0.622), the relationship is far from perfect, and the relative variability in the catchability time series is much less than in the survey index time series (Figure 2.1.25a).
- With respect to the issue of survey impact, it is true that allowing for time-varying catchability decreases the impact of the survey on the results. For example, Figure 2.1.25b compares the fits to the survey index achieved by Model 19.12a and by an "adjusted" version of Model 19.12 in which the effect of time-varying catchability has been removed (this was achieved by multiplying the model's estimate of the survey index in each year *t* by the ratio $Q_t/\bar{Q}$, *not* by re-running the model with constant Q, which would just give the same results as Model 19.12). The "adjusted" version of Model 19.12 gives RMSSR=2.892, compared to 2.303 in Model 19.12; and a correlation (with respect to the data) of 0.772, compared to 0.853 in Model 19.12a. However, the really important question is not whether the survey data have *less* impact in Model 19.12 than in Model 19.12a, but whether those data have the *appropriate* impact.
- With respect to the issue of an identified mechanism, although some amount of temperature dependence seems like a plausible hypothesis, it has not been proven, and even if it were, it would likely not explain all of the time-variability estimated by Model 19.12a.

The main argument in favor of time-varying catchability is that it is one of the few ways to achieve a fit to the survey index data that is consistent with the uncertainty in those data (as estimated outside the assessment model). In fact, Wilberg et al. (2010) concluded that time-varying catchability should be the "default assumption" for stock assessments, particularly if the survey does not cover the whole range of the stock. It should also be noted that recent analyses of stock-wide (EBS, NBS, and WBS) survey data, outside the context of assessment modeling, have begun to demonstrate the existence of regionally time-varying catchability. For example, O'Leary et al. (2021) estimated that "availability" (which is related to catchability) in the 2017 EBS survey was 27% lower than in 2010.

Model 21.1

This model differs with respect to Model 19.12a by allowing for the possibility of dome-shaped survey selectivity. This was a regular feature of EBS Pacific cod assessments prior to 2016, and as recently as September 2015 the Team stated, "Dome-shaped survey selectivity seems inescapable." However, Weinberg et al. (2016) concluded, "The results of our experiment do not support the use of a dome-shaped survey selectivity function." Following recommendations from the 2016 CIE review, the Joint Team Subcommittee on Pacific cod models (meeting in May 2016) suggested simplifying the existing base model (Model 11.5) in various ways, including use of "the simplest selectivity form that gives a reasonable fit." A "reasonable fit" to the size and age composition data was defined as one that achieved both $R^2 \geq 0.99$ on the raw scale and $R^2 \geq 0.70$ on the logit scale, where each year's contribution to the score was weighted by that year's proportion of the aggregate (across years) sample size (Thompson 2016). All functional forms considered in the 2016 assessment were found to achieve a reasonable fit, of which a logistic equation was the simplest. Although both the Team and the SSC recommended adopting a model with asymptotic selectivity at the conclusion of the 2016 assessment cycle, the SSC noted, "In spite of the concerns over dome-shaped survey selectivity in the survey, there are many potential mechanisms relating to the availability of larger fish to the survey gear that could result in these patterns, regardless of the efficiency of the trawl gear to capture large fish in its path" (October, 2016). In this preliminary assessment, allowing for dome-shaped survey selectivity resulted in a pronounced decrease in survey selectivity at larger sizes (Figure 2.1.15), consistent with pre-2016 assessments. While this had a substantial effect on estimates of quantities such as spawning biomass (Figure 2.1.16), fishing mortality (Figure 2.1.19), and ABC and OFL (Figure 2.1.24), it resulted in little improvement in goodness of fit relative to Model 19.12a.

Model 21.2

This model differs with respect to Model 19.12a by including a new fishery CPUE index as a measure of abundance (see "VAST estimates of fishery catch per unit effort" in the "Data" section). As noted previously, use of fishery CPUE data in this manner has long been associated with a number of concerns. Because of these, most previous EBS Pacific cod assessment models have not included use of fishery CPUE data, the main exception being the development and use of a composite (all-gear) fishery CPUE index in last year's assessment (Model 20.9). The new index described in the "Data" section was provided in response to Team and SSC recommendations, and was originally intended simply as the first step in what was anticipated to be a multi-year process of index development. As suggested by the spatial pattern of standard errors for the log density in Figure 2.1.9b, fishery CPUE data are lacking in much of the area, which results in a large variance in the overall index from integrating over that imprecision. Although the CIE reviewers assigned Model 21.2 a score of 0 under the "Uses properly vetted data" criterion (Table 2.1.14), they nevertheless recommended including Model 21.2 in this year's ensemble, rather than waiting for the index to be developed further. In the context of the assessment models, one factor complicating the interpretation of the new index is that it is specific to the longline fishery, whereas the assessment models combine all gear types into a single fishery. In terms of its impacts on the quantities of greatest significance to management, Model 21.2 is, generally speaking, the closest of the alternative models in the ensemble to the base model. In terms of goodness of fit, Model 21.2 generally performs slightly less well than the base model, because it has the added task of fitting the fishery CPUE index. The fit of Model 21.2 to the fishery CPUE index (RMSSR = 2.561, Figure 2.1.11c) is roughly similar to its fit to the survey index (RMSSR = 2.425, Figure 2.1.11a).

Model 21.3

This model differs with respect to Model 19.12a by including a parameter (“extra SD”) that is added to the log-scale standard errors of the survey index. Another model incorporating the “extra SD” feature was considered, but not accepted, during the 2017 assessment cycle (Model 17.3, Thompson 2017). The “extra SD” parameter was estimated at a value of 0.1518. Summing the “extra SD” term with the log-scale standard errors (average = 0.0665) gives values that are higher than the original by a factor of 3.2822, on average. Relative to the base model, the impacts on spawning biomass (Figure 2.1.16), spawning biomass relative to $B_{100\%}$ (Figure 2.1.17), and ABC and OFL (Figure 2.1.24) are quite substantial, and all in the negative (lower) direction. In particular, Model 21.3 estimates that spawning biomass is currently below the $B_{20\%}$ threshold that results in closure of the directed fishery. As with Model 19.12, the resulting fit to the survey index is very good (RMSSR = 1.002, Figure 2.1.11b), but the mechanisms by which those two models achieve that result are different. Similar to Model 19.12, one argument against use of Model 21.3 might be the decreased impact of the survey index on model results. The CIE reviewers noted the recent string of positive residuals in the fit to the survey index (six years, Figure 2.1.11) when assigning it a score of 1 under the “Acceptable residual patterns” criterion (Table 2.1.14). Wilberg et al. (2010) noted that inflating the standard deviations of the index data will often produce trends in residuals if catchability is actually time-varying.

ABC and OFL

As noted previously, the 2021-2022 fishing mortality rates, ABCs, and OFLs shown in Tables 2.1.18 and 2.1.24 and Figures 2.1.19, 2.1.23, and 2.1.24 were based on application of the respective harvest control rule to each model rather than conditioning them on the 2021 ABC that was actually specified. This was done in order to enable comparison of these results with those derived in last year’s assessment, as distinguished from making the best current prediction of 2022 values (the latter will occur in the final assessment).

One of the take-home messages from Figure 2.1.24 is that the configuration of the ensemble (both the set of models and their associated weights) can have a significant impact on ABC and OFL. In each panel of Figure 2.1.24, the black vertical dashed line represents the value that is currently specified and the gray vertical dashed line represents the mean of the ensemble distribution, and there is a substantial decrease (gray relative to black) in every case, ranging from 18% to 25%. A small part of each difference is due to use of the updates described in the “Data” section (recall that “updates” in this context refers to use of updated methodology; in no case are 2021 data included in any of the models), but most of each difference is due to the choice of models and weights in the CIE reviewers’ recommended ensemble.

It should also be emphasized that the plots in Figure 2.1.24 are based on the Hessian approximation, which results in normal distributions. The fact that non-negligible portions of the normal distributions for Model 21.3 consist of negative ABC and OFL values suggests that the Hessian approximation may not be appropriate for that model.

Preliminary exploration of interjurisdictional issues

Previous attempts at incorporating movement into assessment models of the EBS Pacific cod stock (Thompson 2018, Thompson et al. 2020) have failed to move beyond the “preliminary assessment” stage, as both the Team and SSC have been skeptical of the possibility of estimating movement rates given present data limitations. Likewise, for the near term at least, none of the CIE reviewers recommended development of an assessment model incorporating movement.

The CIE reviewers did make many other recommendations related to movement, however. Unlike most previous discussions of this topic by the Team or SSC, which focused primarily on movement between the EBS and NBS, the CIE reviewers’ interest in movement focused primarily on movement between American and Russian jurisdictions. Development of a “simulation study” and “analytical models,” rather than an assessment model, were recommended as ways to increase understanding of the interjurisdictional issues involved, including the possibility of disproportionate harvesting. Attachment 2.1.2 was developed in response to these recommendations.

Attachment 2.1.2 develops a very simple, deterministic, age-structured, two-area model, with results focused primarily on age-aggregated (but area-specific) equilibrium outcomes. The primary goals are to understand which variables determine both relative and absolute biomasses and yields in the two areas, how various outcomes may be independent of specific parameters, and how various parameters covary in order to result in particular outcomes.

In general, the results shown in Attachment 2.1.2 illustrate the intuitive principle that, the more the stock is concentrated in the EBS (where, in context of Attachment 2.1.2, this term is taken to include the NBS)—either due to recruitment being concentrated in that area, fish tending not to stray from that area once they arrive, or both—the smaller the impacts of fishing in the WBS.

Another pair of intuitive results is that, if the exploitation rate in the EBS is left constant, increased fishing in the WBS will result in reduced equilibrium yield in the EBS and, if the exploitation rate in the EBS is adjusted in order to achieve a target level of overall (i.e., across areas) relative spawning per recruit, the reduction in EBS yield will be even greater. However, reported WBS catches in recent years (Lajus et al. 2019) do not appear to be particularly high relative to estimates of WBS survey biomass (O'Leary et al. 2021).

One more result that may have some generality is that, for some quantities, certain parameters may have very little impact; perhaps unintuitively so. For example, under the right conditions, the equilibrium biomass *proportions* (as distinguished from the biomasses themselves) are entirely independent of the exploitation rate in either area.

Use of harvest control rules in model averaging
For the last three years, the senior author of the assessment and various members of the Team and SSC have spent considerable time and effort debating the issue of whether, in the context of ensemble modeling, the harvest control rules should be applied *before* or *after* model averaging. At the request of the Team and SSC, this issue was considered yet again during the CIE review, but the responses of the reviewers were, generally speaking, somewhat nuanced. None of the reviewers gave an unqualified endorsement of either approach, and one of them suggested that a conclusion would have to await "further investigations and examples."

Attachment 2.1.3 was developed in response to this suggestion. The bulk of that attachment evaluates the properties of the two procedures in the context of a highly simplified system. A central focus of the analysis is the relative uncertainty in ABC or OFL resulting from the two procedures. In brief, the uncertainty associated with the "before" approach is very likely to be greater, and perhaps substantially so, than the uncertainty associated with the "after" approach. This is because the "before" approach incorporates both the *within*-model and *between*-model uncertainty in F_{ABC} or F_{OFL}, whereas the "after" approach ignores both of these. In addition, the attachment summarizes various theoretical arguments for and against each procedure, ultimately concluding that the "before" approach is superior. Similarly, Burnham and Anderson (2002) concluded that *parameters* in nonlinear models "should not be averaged" and that, instead, "model averaging the *expected response variable*" is the appropriate course of action.

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Tables

Table 2.1.1. Catch (t) time series, by gear.

Year	Longline	Trawl	Pot	Other	Total
1991	77,505	129,393	3,343	0	210,241
1992	79,404	77,261	7,512	33	164,210
1993	49,295	81,791	2,098	2	133,186
1994	78,564	84,932	8,037	730	172,263
1995	97,666	110,958	19,275	599	228,498
1996	88,883	91,912	28,006	267	209,067
1997	117,010	93,925	21,493	173	232,601
1998	84,324	60,781	13,233	192	158,529
1999	81,464	51,903	12,400	100	145,867
2000	81,642	53,817	15,849	68	151,376
2001	90,361	35,657	16,472	52	142,542
2002	100,271	51,067	15,052	166	166,555
2003	108,673	46,675	19,940	155	175,443
2004	108,481	57,793	17,242	231	183,748
2005	113,125	52,608	17,102	104	182,940
2006	96,565	53,209	18,960	84	168,818
2007	77,136	45,673	17,238	82	140,129
2008	88,924	33,493	17,366	19	139,802
2009	96,598	36,956	13,608	13	147,174
2010	81,618	41,205	19,678	344	142,845
2011	116,794	63,929	27,996	505	209,224
2012	128,460	75,508	28,727	85	232,781
2013	124,820	81,614	30,251	15	236,699
2014	127,270	72,262	39,194	2	238,728
2015	128,201	66,672	37,937	28	232,838
2016	127,918	72,577	47,077	47	247,619
2017	122,762	68,881	46,181	13	237,838
2018	100,213	59,967	39,686	0	199,866
2019	88,778	49,023	41,053	50	178,904
2020	72,061	50,566	32,971	38	155,637
2021	43,360	33,434	21,702	20	98,517

Table 2.1.2a. Longline fishery mean CPUE by year and month, Pacific cod target hauls only (catch is in weight; values have been normalized to an overall mean of 1.0).

Year	1	2	3	4	5	6	7	8	9	10	11	12
1996	1.646	1.665	1.480	1.366	1.263				0.986	1.040	1.086	
1997	1.807	1.908	1.597	1.576	1.242				1.081	1.085	1.033	1.142
1998	1.605	1.740	1.300	1.031	0.959				0.691	0.751	0.907	0.973
1999	1.361	1.431	1.202	1.090	1.232			0.817	0.960	0.863	0.974	1.086
2000	1.588	1.156	1.202	1.059	1.142			0.865	0.769	0.688	0.715	0.846
2001	1.118	1.073	1.065	0.949	0.943	1.052	0.865	0.782	0.729	0.734	0.724	0.878
2002	1.290	1.249	1.267	1.310			0.666	0.727	0.685	0.659	0.705	0.784
2003	0.933	0.984	1.071	0.864	0.838		0.651	0.643	0.632	0.629	0.651	0.750
2004	0.999	1.186	1.136	1.098	0.780		0.657	0.605	0.576	0.565	0.715	0.966
2005	1.168	1.193	1.272	1.261			0.711	0.640	0.580	0.620	0.641	0.815
2006	1.308	1.530	1.521	1.453			0.686	0.811	0.747	0.630	0.790	0.835
2007	1.356	1.406	1.339				0.711	0.873	0.729	0.649	0.807	1.185
2008	1.455	1.556	1.463	1.525			0.646	0.682	0.578	0.488	0.619	1.262
2009	1.632	1.795	2.194				0.650	0.713	0.646	0.625	0.685	1.034
2010	1.395	1.616	1.734				0.752	0.728	0.652	0.617	0.779	0.934
2011	1.287	1.393	1.390	1.248	0.851	0.821	0.611	0.652	0.683	0.725	0.767	0.909
2012	1.413	1.534	1.119	1.137	0.935	0.950	0.693	0.623	0.585	0.620	0.671	1.044
2013	1.424	1.377	1.257	1.234	0.994	0.688	0.766	0.689	0.652	0.647	0.800	1.023
2014	1.012	1.210	1.020	1.018	0.797	0.684	0.575	0.649	0.663	0.719	0.790	0.853
2015	0.983	1.197	1.125	1.017	0.952	0.804	0.847	0.772	0.655	0.699	0.788	0.961
2016	1.172	1.353	1.096	1.008	0.971	0.773	0.795	0.775	0.774	0.728	0.794	0.947
2017	1.022	1.399	1.220	1.130	0.977	0.856	0.713	0.574	0.595	0.668	0.898	1.044
2018	1.532	1.639	1.351	1.342	0.866	0.708	0.570	0.571	0.798	0.794	0.711	0.986
2019	1.626	1.792	1.383	1.369	0.907	0.905	0.678	0.679	0.791	0.844	0.930	0.974
2020	1.481	1.784	1.598	1.293	1.467	1.020	0.802	0.741	0.785	0.924	0.922	0.986
2021	1.364	1.569	1.532	1.247	0.735	1.043	0.941	0.823				

Table 2.1.2b. Bottom trawl fishery mean CPUE by year and month, Pacific cod target hauls only (catch is in weight; values have been normalized to an overall mean of 1.0).

Year	1	2	3	4	5	6	7	8	9	10	11	12
1996	0.520	0.789	0.967	1.024		0.357					0.724	
1997	1.123	1.644	1.219	0.834	0.409	0.168	0.480	0.490				
1998	1.045	1.516	0.818	0.488	0.355			0.401	0.365	0.158	0.173	
1999	0.563	1.121	0.775	0.821	0.471				0.365	0.324		
2000	0.790	0.781	0.843	0.550	0.617	0.253	0.247					
2001	0.271	0.592	0.702	0.361	0.332	1.012	1.354	0.333	0.342	0.161		
2002	0.755	0.910	0.806	0.403	0.485	0.943	0.689	0.281	0.317	0.304	0.630	
2003	0.418	0.555	0.766	0.459	0.288	0.893	0.958	0.412	0.435			
2004	1.098	1.286	1.290	0.640	0.548	0.532	0.637	0.384	0.403	0.217		
2005	0.700	0.866	1.609	0.566	0.418	0.335	0.208	0.146				
2006	0.668	0.831	0.956	1.061	0.573		0.179	0.344	0.173			
2007	0.458	0.632	1.033	0.809	0.674	0.821	0.449		0.008			
2008	0.392	0.553	0.644	0.714	0.934	0.176		1.817	0.280			
2009	0.438	0.871	1.323	1.811	0.788	0.600		0.507		1.079		
2010	0.544	1.004	1.236		0.400		1.034	0.629		0.949		
2011	1.089	1.213	2.047	0.867	0.892		1.123	0.924	1.243	1.056		
2012	2.120	2.500	1.703	1.033	1.333	0.964		0.798	0.677			
2013	1.447	1.710	1.106	2.027	0.568	0.493		1.244	1.533			
2014	1.306	1.302	1.513	1.296	1.519			0.763	1.270			
2015	0.438	1.376	1.777	1.180	1.464		1.288	2.590				
2016	0.923	1.543	2.133	1.140		0.588	0.961	0.618	0.558	0.735		
2017	0.982	2.124	2.146	1.899		0.386			0.132			
2018	1.394	1.646	6.402	5.496								
2019	1.351	1.763	3.977	6.247	0.187				0.364			
2020	0.687	4.678	1.575	0.710	0.440							
2021		4.616	2.813	1.962								

Table 2.1.2c. Pot fishery mean CPUE by year and month, Pacific cod target hauls only (catch is in weight; values have been normalized to an overall mean of 1.0).

Year	1	2	3	4	5	6	7	8	9	10	11	12
1996			0.929				0.593	0.614	0.516	0.576		
1997			1.066	1.245	0.682	0.636	0.524	0.689	0.379	0.700	0.493	0.545
1998				1.005	0.682	0.584	0.689	0.473	0.406	0.370		0.658
1999				0.880	0.621	0.486			0.427	0.512		
2000		0.743	0.593									
2001			0.839						0.574	0.675	0.419	
2002		1.110	0.853						0.559	0.538	0.635	
2003		0.970	0.904						0.742	0.809	0.777	
2004	0.805	1.035	0.936						0.632	0.522	0.873	
2005	1.439	1.062							0.675	0.521		
2006	1.103	0.945							0.632	0.869	0.454	0.492
2007	0.816								0.815	1.203		
2008	1.056								0.828	0.548		
2009	1.189											
2010	1.114								1.111	0.953	1.358	
2011	1.704								1.086	0.988		
2012	1.866								0.742	1.055		
2013	1.635	1.728							1.253	1.043	1.150	
2014	1.244	1.565	2.079						1.132	0.942	0.707	1.334
2015	1.193	1.751	1.796	1.699					1.207	1.035	0.853	1.122
2016	1.152	1.421	1.505	1.443					1.302	1.035	0.843	1.054
2017	1.205	2.048							0.918	0.929	0.911	0.839
2018	1.162		2.356						1.156	1.324	0.720	1.146
2019	1.232		2.788						1.764		1.718	
2020	1.224								1.742			
2021	1.446											

Table 2.1.2d. Pelagic trawl fishery mean Pacific cod CPUE by year and month, all hauls—regardless of target (catch is in weight; values have been normalized to an overall mean of 1.0).

Year	1	2	3	4	5	6	7	8	9	10	11	12
1996	2.432	1.167	0.842					0.263	0.530	0.436	0.603	
1997	4.976	1.911	2.422	2.522				0.381	0.514	0.464		
1998	2.558	1.384	4.247					0.130	0.430	0.677	0.459	
1999	1.570	0.964	0.623				0.389	0.441	0.412	0.395	0.228	
2000	4.365	0.736	0.654	0.336			0.283	0.248	0.379	0.298	0.629	
2001	1.272	0.595	0.456	0.621		0.225	0.294	0.481	0.286	0.335	0.116	
2002	2.036	1.682	0.982	1.691		0.280	0.250	0.366	0.465	0.416		
2003	3.236	1.493	0.772	1.301		0.272	0.278	0.357	0.432	0.306		
2004	1.978	1.884	0.968			0.495	0.254	0.231	0.376	0.202		
2005	2.619	1.522	1.541			0.296	0.244	0.279	0.449	0.309		
2006	2.649	1.673	1.428			0.304	0.354	0.459	0.349	0.295	0.443	
2007	1.003	1.054	1.272			0.307	0.407	0.405	0.269	0.288	0.339	
2008	1.204	1.002	1.674			0.604	0.424	0.378	0.206	0.141	0.078	
2009	1.080	1.467	1.648	3.581		0.298	0.451	0.383	0.211	0.290		
2010	1.241	1.828	1.523	2.103		0.481	0.531	0.326	0.361	0.323		
2011	1.379	1.735	1.472	1.164		0.417	0.378	0.249	0.253	0.332	0.411	
2012	3.047	2.766	1.681	0.830		0.327	0.617	0.264	0.331	0.409	0.411	
2013	1.099	1.275	1.765	1.479		0.682	0.512	0.454	0.349	0.427		
2014	0.731	0.600	0.739	2.210		0.354	0.345	0.371	0.421			
2015	0.613	1.519	1.729	1.962		0.485	0.839	0.812	0.964	1.260		
2016	0.651	1.142	1.218	2.102		0.644	0.437	0.330	0.253	0.225		
2017	1.050	1.487	1.973	4.658		0.659	0.387	0.367	0.311	1.940		
2018	0.596	2.026	1.758	2.362		0.360	0.133	0.162	0.199			
2019	1.810	2.870	3.096	4.441		0.390	0.204	0.196	0.127	0.064		
2020	0.995	3.646	3.290	2.955	2.764	0.200	0.196	0.292	0.216	0.141		
2021	1.333	1.827	3.571	2.240	2.196	0.664						

Table 2.1.3. Western Bering Sea catch (t).

Year	Catch
2001	42,000
2002	31,600
2003	36,300
2004	46,300
2005	34,800
2006	28,700
2007	34,504
2008	43,154
2009	34,301
2010	46,020
2011	47,038
2012	54,560
2013	53,163
2014	53,130
2015	55,930
2016	58,340
2017	70,320
2018	61,450

Table 2.1.4. Comparison of configurations for VAST estimates of the survey index.

	Cold pool?	Yes		No		Yes		Yes	
	Knots:	750		750		100		750	
	Distribution:	P-link Δ-gamma		P-link Δ-gamma		P-link Δ-gamma		Tweedie	
Area	Year	Est.	Sigma	Est.	Sigma	Est.	Sigma	Est.	Sigma
EBS+NBS	1982	638301	0.054	647144	0.056	670574	0.062	736081	0.068
EBS+NBS	1983	896361	0.082	891402	0.081	910960	0.088	942060	0.077
EBS+NBS	1984	680494	0.053	681124	0.053	706241	0.059	746312	0.058
EBS+NBS	1985	880950	0.048	883642	0.049	997611	0.056	929340	0.051
EBS+NBS	1986	870246	0.050	874564	0.052	901021	0.056	937501	0.048
EBS+NBS	1987	817756	0.067	791661	0.059	828025	0.071	811543	0.064
EBS+NBS	1988	539668	0.046	541439	0.046	562918	0.052	548239	0.048
EBS+NBS	1989	353903	0.060	346850	0.057	336870	0.058	344278	0.057
EBS+NBS	1990	472346	0.055	473651	0.055	486150	0.059	507147	0.060
EBS+NBS	1991	518984	0.054	522790	0.055	532537	0.060	549861	0.055
EBS+NBS	1992	546007	0.062	554494	0.063	587472	0.068	587560	0.056
EBS+NBS	1993	823858	0.063	814274	0.061	816977	0.068	871939	0.059
EBS+NBS	1994	1143009	0.051	1148294	0.052	1238136	0.056	1243283	0.048
EBS+NBS	1995	703347	0.050	707505	0.050	739381	0.055	751058	0.049
EBS+NBS	1996	646006	0.075	632858	0.070	709021	0.079	644801	0.062
EBS+NBS	1997	544664	0.068	553649	0.074	554297	0.073	532938	0.053
EBS+NBS	1998	660275	0.096	628229	0.086	626609	0.097	637767	0.069
EBS+NBS	1999	532079	0.058	528878	0.059	557655	0.067	548843	0.053
EBS+NBS	2000	516305	0.060	518065	0.061	517236	0.061	522535	0.051
EBS+NBS	2001	1035971	0.059	1042461	0.060	1047952	0.061	1016133	0.049
EBS+NBS	2002	667313	0.084	654892	0.082	649547	0.082	627537	0.060
EBS+NBS	2003	661229	0.103	626216	0.090	622994	0.103	623623	0.065
EBS+NBS	2004	500962	0.086	492343	0.082	451537	0.071	468784	0.058
EBS+NBS	2005	523294	0.081	509431	0.075	505118	0.075	512824	0.059
EBS+NBS	2006	446364	0.051	448638	0.052	445457	0.056	436770	0.043
EBS+NBS	2007	614865	0.061	627277	0.068	707535	0.070	700702	0.058
EBS+NBS	2008	487941	0.056	489708	0.057	518148	0.062	511925	0.055
EBS+NBS	2009	718208	0.050	725837	0.053	775986	0.056	767992	0.050
EBS+NBS	2010	740143	0.051	743297	0.051	773959	0.055	804113	0.048
EBS+NBS	2011	861528	0.054	852899	0.052	904648	0.057	865958	0.047
EBS+NBS	2012	1051115	0.064	1050167	0.064	1068602	0.069	1038860	0.049
EBS+NBS	2013	741318	0.061	749649	0.064	741633	0.063	797384	0.054
EBS+NBS	2014	1316205	0.096	1302307	0.096	1305998	0.089	1316338	0.062
EBS+NBS	2015	1142591	0.093	1144105	0.095	1118469	0.084	1050099	0.058
EBS+NBS	2016	1042775	0.156	988717	0.149	947856	0.131	831053	0.074
EBS+NBS	2017	523384	0.046	525384	0.046	519894	0.048	500158	0.037
EBS+NBS	2018	544275	0.068	529139	0.065	526869	0.071	488939	0.049
EBS+NBS	2019	773120	0.056	767441	0.056	770276	0.061	729799	0.041

Table 2.1.5. Correlations between survey index estimates resulting from alternative VAST configurations.

Area	Cold pool?	Knots	Distribution	Yes / 750 / P-link Δ-gamma	No / 750 / P-link Δ-gamma	Yes / 100 / P-link Δ-gamma	Yes / 750 / Tweedie
EBS+NBS	Yes	750	P-link Δ-gamma	1.000	0.998	0.985	0.968
EBS+NBS	No	750	P-link Δ-gamma	0.998	1.000	0.990	0.977
EBS+NBS	Yes	100	P-link Δ-gamma	0.985	0.990	1.000	0.987
EBS+NBS	Yes	750	Tweedie	0.968	0.977	0.987	1.000
EBS	Yes	750	P-link Δ-gamma	1.000	1.000	0.991	0.988
EBS	No	750	P-link Δ-gamma	1.000	1.000	0.992	0.989
EBS	Yes	100	P-link Δ-gamma	0.991	0.992	1.000	0.993
EBS	Yes	750	Tweedie	0.988	0.989	0.993	1.000
NBS	Yes	750	P-link Δ-gamma	1.000	0.992	0.982	0.898
NBS	No	750	P-link Δ-gamma	0.992	1.000	0.983	0.901
NBS	Yes	100	P-link Δ-gamma	0.982	0.983	1.000	0.946
NBS	Yes	750	Tweedie	0.898	0.901	0.946	1.000

Table 2.1.6a. Updated VAST estimates of survey age composition.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00025	0.10960	0.36178	0.16724	0.11357	0.11841	0.08868	0.02324	0.00894	0.00437	0.00148	0.00115	0.00128
1995	0.00016	0.06394	0.24421	0.41964	0.10467	0.07786	0.05798	0.01463	0.00731	0.00548	0.00141	0.00142	0.00128
1996	0.00003	0.06777	0.18147	0.17359	0.28545	0.15581	0.08064	0.03683	0.00964	0.00364	0.00189	0.00163	0.00160
1997	0.00029	0.27106	0.16713	0.14830	0.14075	0.12328	0.10537	0.02746	0.01106	0.00218	0.00172	0.00081	0.00058
1998	0.00007	0.07735	0.42642	0.19449	0.11092	0.06057	0.06975	0.03585	0.01884	0.00370	0.00078	0.00082	0.00043
1999	0.00010	0.10650	0.18680	0.29143	0.21182	0.07817	0.06794	0.03386	0.01407	0.00600	0.00119	0.00144	0.00067
2000	0.00000	0.20120	0.10995	0.15719	0.23899	0.17274	0.07443	0.01709	0.01716	0.00498	0.00393	0.00167	0.00068
2001	0.00004	0.27894	0.22734	0.17678	0.08903	0.09894	0.08474	0.03119	0.00801	0.00185	0.00160	0.00110	0.00045
2002	0.00023	0.07471	0.17881	0.29519	0.24556	0.07753	0.06866	0.04348	0.01062	0.00309	0.00103	0.00049	0.00060
2003	0.00001	0.16659	0.14230	0.23106	0.21247	0.13663	0.05220	0.03584	0.01724	0.00374	0.00051	0.00063	0.00079
2004	0.00005	0.13003	0.15148	0.26514	0.12787	0.13909	0.10903	0.04254	0.02159	0.00817	0.00225	0.00196	0.00080
2005	0.00000	0.14653	0.22804	0.20325	0.12604	0.07255	0.10355	0.07164	0.02821	0.01106	0.00411	0.00445	0.00057
2006	0.00000	0.33628	0.13637	0.15493	0.10952	0.09310	0.06940	0.05420	0.02987	0.01053	0.00353	0.00137	0.00090
2007	0.00000	0.66394	0.09784	0.07039	0.04857	0.05437	0.02432	0.02031	0.00992	0.00602	0.00207	0.00120	0.00105
2008	0.00000	0.21988	0.41153	0.14618	0.08927	0.05506	0.03663	0.01380	0.01322	0.00739	0.00320	0.00231	0.00154
2009	0.00000	0.48663	0.17650	0.21229	0.05935	0.02726	0.01581	0.01123	0.00611	0.00222	0.00127	0.00082	0.00052
2010	0.00000	0.05070	0.49801	0.17026	0.18543	0.06049	0.01713	0.01047	0.00416	0.00185	0.00070	0.00064	0.00016
2011	0.00008	0.30585	0.06959	0.36466	0.11080	0.09755	0.03340	0.00929	0.00408	0.00197	0.00139	0.00077	0.00056
2012	0.00000	0.36834	0.24105	0.05898	0.21603	0.06419	0.03542	0.00961	0.00306	0.00213	0.00073	0.00018	0.00027
2013	0.00000	0.10458	0.35269	0.19492	0.12110	0.13941	0.06485	0.01571	0.00449	0.00124	0.00029	0.00037	0.00035
2014	0.00004	0.28420	0.17128	0.22332	0.19972	0.05718	0.04679	0.01231	0.00252	0.00099	0.00093	0.00010	0.00061
2015	0.00002	0.05978	0.41467	0.20764	0.19774	0.08474	0.01977	0.01199	0.00257	0.00049	0.00027	0.00011	0.00020
2016	0.00000	0.08644	0.09400	0.35140	0.22860	0.16502	0.05655	0.01214	0.00359	0.00136	0.00049	0.00027	0.00014
2017	0.00007	0.10561	0.17242	0.15945	0.29978	0.15092	0.08353	0.02037	0.00305	0.00299	0.00061	0.00053	0.00067
2018	0.00003	0.07259	0.09656	0.25352	0.16826	0.28695	0.08715	0.02951	0.00258	0.00174	0.00051	0.00022	0.00038
2019	0.00001	0.58946	0.07873	0.08517	0.07615	0.05909	0.07176	0.03172	0.00630	0.00082	0.00032	0.00023	0.00025

Table 2.1.6b. Differences between updated VAST estimates of survey age composition and last year's estimates.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	0.00002	0.00273	-0.02990	0.00037	0.00364	0.00825	0.01082	0.00278	0.00098	0.00008	0.00009	0.00003	0.00009
1995	0.00000	-0.00205	-0.00946	0.00579	0.00184	0.00087	0.00267	0.00057	0.00005	0.00012	-0.00007	-0.00019	-0.00015
1996	-0.00001	-0.00701	-0.01105	-0.00435	0.00436	0.00862	0.00676	0.00228	0.00031	0.00006	0.00002	0.00003	-0.00004
1997	-0.00002	-0.01809	0.00829	0.00150	0.00055	0.00246	0.00520	0.00094	-0.00019	-0.00021	-0.00016	-0.00019	-0.00009
1998	0.00000	-0.01096	0.00026	0.00054	0.00125	0.00103	0.00411	0.00230	0.00118	0.00019	0.00006	0.00002	0.00002
1999	0.00002	0.01209	-0.02326	-0.01498	0.00325	0.00463	0.01029	0.00517	0.00162	0.00088	0.00014	0.00009	0.00006
2000	0.00000	-0.02159	-0.00443	-0.00323	0.00433	0.01389	0.00811	0.00145	0.00112	0.00001	0.00019	0.00016	-0.00001
2001	0.00000	-0.01097	-0.00518	-0.00096	0.00344	0.00503	0.00599	0.00206	0.00031	0.00008	0.00013	0.00005	0.00003
2002	-0.00027	-0.00961	-0.01234	0.00306	0.00818	0.00405	0.00347	0.00299	0.00028	0.00017	0.00005	0.00000	-0.00003
2003	0.00000	-0.00797	-0.01017	0.00171	0.00372	0.00695	0.00329	0.00155	0.00069	0.00010	0.00002	0.00006	0.00005
2004	0.00001	-0.01518	0.00266	0.00311	-0.00254	0.00305	0.00631	0.00159	0.00051	0.00035	0.00008	0.00003	0.00003
2005	0.00000	-0.01026	-0.00128	0.00026	-0.00211	0.00160	0.00548	0.00444	0.00128	0.00020	0.00017	0.00021	0.00003
2006	0.00000	-0.00863	-0.00421	-0.00636	-0.00049	0.00530	0.00579	0.00509	0.00202	0.00092	0.00030	0.00012	0.00015
2007	0.00000	-0.00765	-0.00482	-0.00134	0.00190	0.00389	0.00329	0.00270	0.00104	0.00046	0.00026	0.00017	0.00011
2008	0.00000	0.01516	-0.01594	-0.00353	-0.00204	0.00051	0.00222	0.00128	0.00141	0.00050	0.00023	0.00013	0.00009
2009	0.00000	-0.00320	0.00315	-0.00030	-0.00174	-0.00003	0.00034	0.00069	0.00051	0.00021	0.00019	0.00009	0.00008
2010	0.00000	0.00162	0.02010	-0.01069	-0.01115	-0.00225	0.00086	0.00090	0.00042	0.00012	0.00006	0.00002	-0.00002
2011	-0.00001	-0.04395	-0.00093	0.02246	0.00859	0.00822	0.00358	0.00099	0.00052	0.00021	0.00013	0.00008	0.00009
2012	0.00000	0.02335	-0.01121	-0.00197	-0.01191	-0.00093	0.00166	0.00035	0.00026	0.00021	0.00010	0.00002	0.00005
2013	0.00000	-0.00027	-0.02689	-0.00066	0.00488	0.01274	0.00743	0.00182	0.00056	0.00020	0.00006	0.00005	0.00008
2014	0.00001	0.01249	0.00945	-0.01408	-0.01014	-0.00042	0.00211	0.00030	0.00014	0.00004	0.00004	0.00001	0.00005
2015	0.00000	-0.00162	-0.01068	0.00643	0.00374	0.00113	0.00061	0.00019	0.00015	0.00001	0.00002	0.00001	0.00001
2016	0.00000	0.00363	0.00589	0.00292	-0.00852	-0.00351	-0.00036	-0.00012	0.00003	0.00003	0.00000	0.00001	0.00001
2017	0.00000	-0.00154	0.00684	0.00507	-0.00604	-0.00227	-0.00104	-0.00092	-0.00012	0.00004	0.00001	-0.00002	-0.00001
2018	-0.00001	-0.00305	0.00346	0.01128	0.00171	-0.01095	-0.00242	-0.00003	0.00002	-0.00003	0.00000	0.00001	0.00001
2019	0.00000	0.00141	-0.00067	-0.00041	-0.00087	-0.00019	0.00107	-0.00006	-0.00025	-0.00001	-0.00001	0.00001	0.00001

Table 2.1.7. VAST fishery CPUE index (units are proportional to kg/hook).

Year	Estimate	SD	Sigma
1996	367	25.1	0.071
1997	434	32.9	0.079
1998	341	24.3	0.074
1999	315	21.2	0.070
2000	278	19.9	0.074
2001	235	15.7	0.070
2002	304	22.6	0.077
2003	213	11.8	0.057
2004	234	13.4	0.059
2005	259	15.3	0.061
2006	313	21.0	0.070
2007	329	20.8	0.065
2008	325	20.4	0.065
2009	356	23.9	0.070
2010	340	22.4	0.068
2011	315	23.0	0.076
2012	279	19.3	0.072
2013	304	20.7	0.071
2014	241	15.6	0.067
2015	226	14.9	0.069
2016	321	21.0	0.068
2017	264	14.7	0.058
2018	362	22.3	0.064
2019	356	24.9	0.073
2020	334	25.0	0.078

Table 2.1.8. Potential parameter counts in the models ("potential" because any parameters that ended up bounded in the estimation will be turned off for the final run).

Model	19.12a	19.12	"20.8a"	"20.9a"	"21.cie"
Feature 1: Allow catchability to vary?	no	yes	no	no	no
Feature 2: Allow domed survey selectivty?	no	no	yes	no	no
Feature 3: Use fishery CPUE?	no	no	no	yes	no
Feature 4: Estimate survey CV internally?	no	no	no	no	yes
"Early" recruitment deviations	20	20	20	20	20
"Main" recruitment deviations	43	43	43	43	43
Length at age 1.5 deviations	43	43	43	43	43
Selectivity (fishery) deviations	88	88	88	88	88
Selectivity (survey) deviations	76	76	76	76	76
Log catchability (survey) deviations		38			
Annual deviations	270	308	270	270	270
Natural mortality	1	1	1	1	1
Growth	6	6	6	6	6
Ageing error	4	4	4	4	4
Stock-recruitment	2	2	2	2	2
Initial fishing mortality	1	1	1	1	1
Dirichlet-multinomial coefficients	3	3	3	3	3
Log catchability (survey)	1	1	1	1	1
Selectivity (fishery)	5	5	5	5	5
Selectivity (survey, ascending)	2	2	2	2	2
Selectivity (survey, top and descending)			3		
Log catchability (fishery)				1	
"Extra" survey standard deviation					1
True parameters	25	25	28	26	26
Total parameters	295	333	298	296	296

Table 2.1.9. Objective function values and final parameter counts.

Model:	M19.12a	M19.12	M21.1	M21.2	M21.3
Allow catchability to vary?	no	yes	no	no	no
Allow domed survey selectivty?	no	no	yes	no	no
Use fishery CPUE?	no	no	no	yes	no
Estimate survey CV internally?	no	no	no	no	yes
Objective function components					
Equilibrium catch:	0.00	0.00	0.00	0.00	0.00
Indices:	-3.87	-85.40	-4.15	21.64	-38.90
Sizecomps:	9335.21	9305.66	9321.96	9397.42	9291.17
Agecomps:	781.34	775.10	781.33	779.74	770.37
Recruitment:	-1.37	-1.75	-1.52	-1.83	-0.07
Initial recruitment:	5.08	6.38	3.25	5.05	6.35
Softbounds:	0.01	0.00	0.01	0.00	0.00
Parameter devs:	66.98	96.85	70.77	71.28	63.39
Total:	10183.38	10096.84	10171.64	10273.31	10092.32
Subcomponents					
Index(fishery)	n/a	n/a	n/a	14.42	n/a
Index(survey)	-3.87	-85.40	-4.15	7.22	-38.90
Sizecomp(fishery)	4209.07	4205.60	4200.23	4251.67	4203.97
Sizecomp(survey)	5126.13	5100.05	5121.73	5145.75	5087.20
Parameter counts					
True parameters	22	23	26	23	24
Parameter devs	269	307	269	269	269
Total	291	330	295	292	293

Table 2.1.10. Fits to compositional data. Note that Nave for the size composition data does not equal Nave for the age composition data because the time series are of different lengths.

Size composition data

	Fleet:	Fishery				
	Model:	M19.12a	M19.12	M21.1	M21.2	M21.3
	Nave:	356	356	356	356	356
McAllister-Ianelli	Neff:	815	813	809	809	820
	Ratio:	2.292	2.286	2.275	2.275	2.305
Thorson et al.	ln(θ):	10.000	10.000	10.000	9.989	10.000
	Neff:	356	356	356	356	356
	Ratio:	1.000	1.000	1.000	1.000	1.000

	Fleet:	EBS+NBS survey				
	Model:	M19.12a	M19.12	M21.1	M21.2	M21.3
	Nave:	356	356	356	356	356
McAllister-Ianelli	Neff:	596	621	603	570	636
	Ratio:	1.676	1.744	1.695	1.603	1.787
Thorson et al.	ln(θ):	10.000	10.000	10.000	9.982	10.000
	Neff:	356	356	356	356	356
	Ratio:	1.000	1.000	1.000	1.000	1.000

Age composition data

	Fleet:	EBS+NBS survey				
	Model:	M19.12a	M19.12	M21.1	M21.2	M21.3
	Nave:	373	373	373	373	373
McAllister-Ianelli	Neff:	101	111	100	93	118
	Ratio:	0.272	0.299	0.268	0.250	0.316
Thorson et al.	ln(θ):	-0.133	0.091	-0.291	-0.331	0.191
	Neff:	174	195	160	156	204
	Ratio:	0.468	0.524	0.429	0.419	0.549

Table 2.1.11a. Time-invariant parameters.

Feature	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Allow catchability to vary?	no		yes		no		no		no	
Allow domed survey selectivty?	no		no		yes		no		no	
Use fishery CPUE?	no		no		no		yes		no	
Estimate survey CV internally?	no		no		no		no		yes	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
Natural mortality	0.348	0.011	0.331	0.012	0.309	0.015	0.343	0.011	0.328	0.013
Mean length at age 1.5	14.777	0.387	14.877	0.392	14.819	0.374	14.645	0.391	15.004	0.399
Asymptotic length	112.948	3.052	120.718	5.047	103.223	2.670	116.248	3.482	122.377	5.471
Brody growth coefficient	0.118	0.009	0.099	0.011	0.158	0.013	0.104	0.009	0.097	0.011
Richards growth coefficient	1.439	0.042	1.498	0.047	1.287	0.052	1.517	0.042	1.491	0.048
SD(length at age 1)	3.485	0.067	3.501	0.066	3.507	0.069	3.506	0.069	3.476	0.065
SD(length at age 20)	9.905	0.380	10.071	0.463	9.062	0.365	10.167	0.432	10.182	0.485
Mean ageing bias at age 1	0.343	0.017	0.338	0.016	0.338	0.018	0.344	0.018	0.338	0.016
Mean ageing bias at age 20	1.116	0.226	1.195	0.221	1.214	0.241	1.100	0.236	1.205	0.218
Mean bias at age 1 (2008+)	0.002	0.025	0.007	0.024	0.004	0.026	0.005	0.026	0.005	0.025
Mean bias at age 20 (2008+)	-1.708	0.317	-1.924	0.317	-1.820	0.339	-1.882	0.343	-2.066	0.329
ln(mean post-1976 recruits)	13.129	0.096	12.979	0.099	12.940	0.117	13.130	0.098	12.921	0.106
ln(pre-1977 recruits offset)	-0.908	0.192	-0.945	0.182	-0.627	0.189	-0.880	0.188	-0.957	0.185
Pre-1977 fishing mortality	0.122	0.037	0.127	0.037	0.074	0.020	0.117	0.035	0.137	0.042
ln(Dirichlet-multinomial coef. for agecomps)	-0.133	0.192	0.091	0.221	-0.291	0.186	-0.331	0.176	0.191	0.240
ln(survey catchability)	0.003	0.062	0.099	0.064	0.094	0.078	-0.030	0.064	0.146	0.075
Fishery selectivity: begin flattop	74.984	0.039	74.867	0.515	72.179	0.718	75.949	0.061	74.990	0.519
Fishery selectivity: logit(flatop width)	-9.739	7.362	0.280	0.516	-9.669	9.085	-9.833	_	0.249	0.499
Fishery selectivity: ln(ascending SD)	5.914	0.028	5.909	0.038	5.853	0.042	5.968	0.031	5.911	0.037
Fishery selectivity: ln(descending SD)	-10.000	_	4.575	1.418	3.988	0.511	-8.275	14.966	4.595	1.341
Fishery selectivity: logit(ending value)	2.101	0.301	-2.828	3.088	0.765	0.333	1.856	0.271	-2.940	3.042
Survey selectivity: begin flattop	20.875	0.780	20.672	0.820	20.800	0.770	20.291	0.733	20.602	0.871
Survey selectivity: ln(ascending SD)	3.522	0.153	3.475	0.161	3.536	0.150	3.412	0.149	3.451	0.174
Survey selectivity: logit(flattop width)					-1.239	0.217				
Survey selectivity: ln(descending SD)					7.421	0.551				
Survey selectivity: logit(ending value)					-0.802	0.668				
ln(fishery catchability)							-5.952	0.064		
"Extra" survey standard deviation									0.152	0.030

Table 2.1.11b. Initial numbers-at-age deviations ("early" recruitment deviations).

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Parameter	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
ln(InitN)_offset_at_20	-0.016	0.671	-0.018	0.661	-0.050	0.658	-0.020	0.662	-0.018	0.679
ln(InitN)_offset_at_19	-0.009	0.674	-0.009	0.663	-0.022	0.666	-0.011	0.665	-0.009	0.682
ln(InitN)_offset_at_18	-0.014	0.672	-0.014	0.662	-0.031	0.663	-0.017	0.663	-0.014	0.681
ln(InitN)_offset_at_17	-0.021	0.670	-0.022	0.659	-0.043	0.659	-0.025	0.660	-0.021	0.678
ln(InitN)_offset_at_16	-0.032	0.666	-0.033	0.656	-0.060	0.654	-0.038	0.656	-0.033	0.674
ln(InitN)_offset_at_15	-0.049	0.661	-0.051	0.651	-0.082	0.648	-0.057	0.651	-0.051	0.669
ln(InitN)_offset_at_14	-0.073	0.654	-0.078	0.643	-0.112	0.640	-0.083	0.643	-0.077	0.661
ln(InitN)_offset_at_13	-0.107	0.644	-0.116	0.633	-0.150	0.629	-0.121	0.633	-0.117	0.651
ln(InitN)_offset_at_12	-0.155	0.632	-0.170	0.620	-0.199	0.617	-0.171	0.620	-0.172	0.637
ln(InitN)_offset_at_11	-0.217	0.617	-0.242	0.603	-0.258	0.603	-0.235	0.605	-0.245	0.620
ln(InitN)_offset_at_10	-0.295	0.600	-0.330	0.585	-0.328	0.588	-0.314	0.588	-0.335	0.602
ln(InitN)_offset_at_09	-0.387	0.582	-0.432	0.566	-0.406	0.573	-0.405	0.571	-0.440	0.581
ln(InitN)_offset_at_08	-0.485	0.563	-0.539	0.547	-0.489	0.557	-0.501	0.553	-0.548	0.562
ln(InitN)_offset_at_07	-0.575	0.546	-0.632	0.530	-0.564	0.542	-0.587	0.537	-0.642	0.544
ln(InitN)_offset_at_06	-0.626	0.533	-0.679	0.517	-0.603	0.532	-0.632	0.525	-0.689	0.531
ln(InitN)_offset_at_05	-0.575	0.531	-0.615	0.516	-0.543	0.532	-0.572	0.525	-0.620	0.529
ln(InitN)_offset_at_04	-0.280	0.546	-0.299	0.529	-0.243	0.547	-0.269	0.542	-0.289	0.543
ln(InitN)_offset_at_03	0.179	0.489	0.139	0.477	0.190	0.487	0.173	0.493	0.168	0.484
ln(InitN)_offset_at_02	-0.095	0.564	-0.110	0.551	-0.123	0.560	-0.066	0.564	-0.108	0.567
ln(InitN)_offset_at_01	0.752	0.551	0.793	0.527	0.767	0.522	0.825	0.546	0.857	0.531

Table 2.1.11c. Log recruitment deviations.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.970	0.223	0.864	0.227	1.032	0.242	0.987	0.230	0.872	0.233
1978	0.557	0.243	0.522	0.229	0.579	0.249	0.513	0.260	0.553	0.226
1979	0.591	0.130	0.549	0.129	0.566	0.132	0.571	0.134	0.571	0.131
1980	-0.796	0.224	-0.858	0.239	-0.784	0.222	-0.785	0.222	-0.927	0.259
1981	-0.682	0.167	-0.668	0.169	-0.694	0.166	-0.695	0.171	-0.633	0.172
1982	0.855	0.055	0.869	0.058	0.841	0.056	0.859	0.056	0.922	0.063
1983	-0.423	0.151	-0.531	0.161	-0.418	0.148	-0.453	0.156	-0.531	0.165
1984	0.788	0.057	0.775	0.061	0.765	0.058	0.788	0.057	0.815	0.065
1985	0.003	0.089	0.008	0.092	-0.011	0.088	-0.026	0.091	0.055	0.096
1986	-0.604	0.109	-0.550	0.111	-0.627	0.109	-0.617	0.110	-0.491	0.114
1987	-1.696	0.221	-1.583	0.222	-1.719	0.216	-1.700	0.222	-1.511	0.229
1988	-0.272	0.088	-0.217	0.093	-0.317	0.089	-0.253	0.089	-0.161	0.098
1989	0.405	0.060	0.446	0.063	0.373	0.061	0.415	0.061	0.504	0.066
1990	0.390	0.068	0.405	0.070	0.357	0.070	0.392	0.069	0.470	0.068
1991	-0.100	0.091	-0.186	0.099	-0.087	0.089	-0.087	0.092	-0.230	0.089
1992	0.866	0.043	0.789	0.045	0.860	0.043	0.899	0.042	0.808	0.047
1993	-0.126	0.078	-0.100	0.077	-0.093	0.077	-0.138	0.082	-0.050	0.079
1994	-0.296	0.075	-0.310	0.075	-0.295	0.076	-0.255	0.075	-0.278	0.077
1995	-0.404	0.081	-0.388	0.081	-0.391	0.082	-0.425	0.086	-0.342	0.083
1996	0.748	0.043	0.752	0.043	0.744	0.044	0.682	0.043	0.798	0.047
1997	-0.100	0.075	-0.064	0.075	-0.102	0.075	-0.205	0.083	-0.013	0.076
1998	-0.330	0.089	-0.297	0.090	-0.358	0.092	-0.390	0.091	-0.247	0.092
1999	0.548	0.048	0.532	0.049	0.524	0.049	0.539	0.048	0.565	0.052
2000	0.232	0.054	0.229	0.054	0.258	0.054	0.284	0.054	0.269	0.057
2001	-0.712	0.104	-0.681	0.106	-0.726	0.106	-0.601	0.106	-0.632	0.108
2002	-0.152	0.061	-0.134	0.061	-0.143	0.062	0.019	0.060	-0.088	0.063
2003	-0.255	0.068	-0.219	0.067	-0.256	0.066	-0.080	0.066	-0.166	0.069
2004	-0.580	0.084	-0.522	0.084	-0.581	0.079	-0.463	0.081	-0.467	0.087
2005	-0.399	0.074	-0.315	0.072	-0.406	0.073	-0.308	0.076	-0.250	0.074
2006	0.675	0.041	0.764	0.041	0.665	0.043	0.694	0.040	0.834	0.043
2007	-0.233	0.087	-0.170	0.086	-0.225	0.087	-0.321	0.091	-0.111	0.085
2008	1.075	0.039	1.067	0.039	1.067	0.040	0.993	0.039	1.082	0.039
2009	-0.884	0.164	-0.883	0.156	-0.850	0.161	-0.928	0.162	-0.882	0.155
2010	0.608	0.053	0.630	0.051	0.597	0.054	0.544	0.052	0.627	0.050
2011	0.845	0.049	0.845	0.047	0.857	0.049	0.793	0.047	0.812	0.048
2012	0.102	0.091	0.066	0.092	0.105	0.091	0.052	0.097	-0.013	0.096
2013	1.098	0.046	1.062	0.051	1.099	0.046	1.076	0.043	0.941	0.068
2014	-0.614	0.113	-0.618	0.112	-0.588	0.112	-0.655	0.118	-0.748	0.122
2015	-0.333	0.074	-0.326	0.080	-0.333	0.074	-0.331	0.075	-0.488	0.108
2016	-0.809	0.106	-0.914	0.115	-0.803	0.106	-0.807	0.108	-1.150	0.152
2017	-1.166	0.200	-1.226	0.202	-1.102	0.192	-1.197	0.204	-1.440	0.223
2018	0.608	0.069	0.581	0.089	0.622	0.071	0.623	0.070	0.350	0.145

Table 2.1.11d. Length at age 1.5 deviations.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.389	0.963	0.421	0.957	0.096	0.973	0.655	0.965	0.398	0.954
1978	-0.114	0.945	-0.118	0.942	-0.171	0.940	-0.097	0.950	-0.119	0.938
1979	0.453	1.008	0.465	1.014	0.377	0.998	0.460	1.027	0.477	1.016
1980	-0.050	0.937	-0.077	0.924	-0.085	0.933	-0.037	0.950	-0.089	0.911
1981	-1.042	0.470	-1.113	0.475	-1.105	0.485	-0.960	0.470	-1.202	0.473
1982	-0.837	0.300	-0.931	0.307	-0.774	0.307	-0.821	0.296	-1.018	0.320
1983	0.677	0.700	1.134	0.805	0.612	0.642	0.601	0.741	1.381	0.777
1984	0.431	0.230	0.419	0.234	0.375	0.235	0.531	0.230	0.399	0.235
1985	-1.491	0.429	-1.585	0.433	-1.500	0.438	-1.439	0.411	-1.627	0.435
1986	0.143	0.271	0.135	0.271	0.154	0.269	0.178	0.277	0.145	0.266
1987	-0.546	0.441	-0.536	0.444	-0.502	0.426	-0.608	0.459	-0.484	0.435
1988	-0.906	0.425	-0.892	0.429	-0.807	0.418	-0.992	0.423	-0.845	0.430
1989	-0.827	0.277	-0.794	0.279	-0.840	0.280	-0.796	0.276	-0.784	0.279
1990	-0.126	0.313	-0.068	0.307	-0.180	0.309	-0.176	0.314	-0.010	0.301
1991	0.429	0.248	0.549	0.259	0.412	0.250	0.480	0.253	0.694	0.259
1992	0.040	0.231	-0.002	0.233	0.049	0.231	0.060	0.232	-0.047	0.231
1993	0.563	0.350	0.320	0.371	0.783	0.343	0.546	0.352	0.230	0.394
1994	-0.233	0.281	-0.134	0.283	-0.188	0.275	-0.207	0.288	-0.039	0.276
1995	-0.307	0.355	-0.232	0.368	-0.249	0.354	-0.295	0.359	-0.182	0.374
1996	-0.055	0.257	-0.073	0.259	-0.071	0.258	-0.080	0.258	-0.081	0.258
1997	-0.202	0.321	-0.205	0.319	-0.184	0.327	-0.969	0.450	-0.192	0.313
1998	-0.757	0.307	-0.772	0.312	-0.685	0.294	-0.586	0.296	-0.737	0.305
1999	-1.325	0.262	-1.303	0.260	-1.334	0.265	-1.313	0.263	-1.292	0.258
2000	0.908	0.239	0.762	0.241	0.907	0.241	0.879	0.242	0.661	0.240
2001	0.364	0.269	0.347	0.271	0.411	0.268	0.200	0.279	0.332	0.267
2002	0.703	0.234	0.678	0.234	0.680	0.237	0.629	0.240	0.640	0.232
2003	0.209	0.294	0.145	0.294	0.198	0.300	0.161	0.296	0.095	0.293
2004	1.444	0.248	1.361	0.245	1.461	0.248	1.543	0.251	1.284	0.242
2005	-0.135	0.275	-0.166	0.277	-0.132	0.280	-0.098	0.281	-0.201	0.276
2006	-0.293	0.216	-0.286	0.215	-0.295	0.219	-0.190	0.217	-0.304	0.213
2007	-1.164	0.303	-0.995	0.306	-1.197	0.309	-0.899	0.310	-0.926	0.303
2008	-1.316	0.245	-1.249	0.235	-1.337	0.238	-1.202	0.239	-1.116	0.239
2009	-0.647	0.388	-0.794	0.381	-0.549	0.387	-0.725	0.394	-0.835	0.372
2010	0.359	0.209	0.285	0.209	0.343	0.210	0.442	0.211	0.259	0.207
2011	-1.132	0.272	-1.088	0.279	-1.160	0.276	-1.017	0.274	-1.030	0.277
2012	0.193	0.315	0.264	0.314	0.289	0.310	0.017	0.355	0.305	0.315
2013	-0.276	0.228	-0.294	0.228	-0.276	0.230	-0.287	0.230	-0.282	0.226
2014	0.265	0.404	0.169	0.405	0.342	0.401	0.070	0.420	0.123	0.402
2015	1.767	0.217	1.770	0.216	1.770	0.218	1.780	0.221	1.754	0.213
2016	1.801	0.333	1.905	0.323	1.799	0.350	1.779	0.338	1.936	0.319
2017	1.308	0.335	1.303	0.329	1.311	0.339	1.343	0.343	1.266	0.322
2018	2.527	0.190	2.459	0.190	2.574	0.193	2.584	0.193	2.371	0.189
2019	-1.016	0.942	-1.015	0.935	-1.123	0.942	-0.963	0.947	-1.121	0.908

Table 2.1.11e (page 1 of 4). Deviations for the log standard deviation of the first normal pdf in the double-normal fishery selectivity curve.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.137	0.976	0.162	0.977	0.122	0.976	0.152	0.970	0.157	0.979
1978	0.119	0.904	0.119	0.905	0.114	0.904	0.112	0.881	0.099	0.911
1979	0.408	0.805	0.424	0.810	0.496	0.803	0.394	0.777	0.394	0.821
1980	0.335	0.854	0.348	0.854	0.480	0.849	0.352	0.830	0.328	0.862
1981	1.050	0.869	1.037	0.870	1.136	0.860	1.087	0.850	1.016	0.877
1982	-0.083	0.934	-0.092	0.935	-0.001	0.933	-0.098	0.920	-0.092	0.939
1983	0.133	0.827	0.093	0.828	0.274	0.830	0.123	0.797	0.078	0.836
1984	0.901	0.603	0.866	0.607	1.028	0.598	0.806	0.565	0.854	0.619
1985	-0.187	0.538	-0.171	0.541	-0.177	0.544	-0.170	0.501	-0.200	0.553
1986	0.596	0.550	0.659	0.555	0.610	0.550	0.536	0.516	0.638	0.569
1987	-0.185	0.462	-0.094	0.466	-0.218	0.466	-0.191	0.431	-0.115	0.479
1988	2.319	0.685	2.315	0.684	2.320	0.685	2.269	0.658	2.281	0.692
1989	1.079	0.792	1.053	0.792	1.156	0.792	1.081	0.764	1.013	0.800
1990	0.192	0.604	0.109	0.605	0.384	0.605	0.119	0.561	0.074	0.618
1991	0.033	0.424	0.003	0.428	0.042	0.423	0.023	0.393	-0.026	0.439
1992	-0.283	0.389	-0.192	0.392	-0.259	0.389	-0.237	0.364	-0.193	0.406
1993	1.463	0.490	1.674	0.502	1.405	0.484	1.321	0.458	1.791	0.519
1994	0.460	0.419	0.669	0.428	0.369	0.412	0.314	0.388	0.781	0.442
1995	0.744	0.419	0.889	0.421	0.600	0.415	0.594	0.389	0.966	0.431
1996	-0.297	0.424	-0.298	0.424	-0.284	0.425	-0.330	0.390	-0.288	0.434
1997	0.944	0.418	0.808	0.418	0.943	0.415	1.184	0.362	0.792	0.428
1998	-0.101	0.377	-0.264	0.377	-0.122	0.374	0.275	0.329	-0.308	0.387
1999	0.073	0.333	-0.115	0.327	0.059	0.333	0.461	0.288	-0.168	0.335
2000	-0.199	0.362	-0.455	0.355	-0.110	0.364	-0.001	0.303	-0.532	0.364
2001	-0.291	0.345	-0.419	0.344	-0.299	0.341	-0.537	0.288	-0.461	0.354
2002	0.640	0.327	0.703	0.324	0.537	0.320	0.368	0.275	0.732	0.333
2003	0.471	0.337	0.480	0.334	0.357	0.335	-0.636	0.262	0.493	0.343
2004	0.634	0.359	0.610	0.359	0.515	0.357	-0.522	0.285	0.618	0.368
2005	0.605	0.357	0.553	0.356	0.492	0.356	-0.207	0.293	0.554	0.366
2006	0.068	0.389	-0.067	0.386	0.047	0.391	-0.046	0.327	-0.098	0.395
2007	-0.070	0.416	-0.265	0.411	-0.013	0.418	0.426	0.349	-0.313	0.421
2008	-0.111	0.341	-0.226	0.337	-0.073	0.335	0.613	0.295	-0.274	0.346
2009	-1.004	0.342	-1.017	0.337	-1.025	0.335	0.449	0.298	-1.064	0.347
2010	-1.535	0.356	-1.461	0.359	-1.527	0.349	-0.126	0.293	-1.456	0.372
2011	-1.450	0.333	-1.284	0.340	-1.468	0.331	-0.684	0.287	-1.192	0.353
2012	-0.560	0.367	-0.502	0.368	-0.525	0.364	-0.545	0.301	-0.406	0.380
2013	-0.253	0.315	-0.191	0.318	-0.336	0.311	-0.269	0.271	-0.072	0.330
2014	-1.255	0.312	-1.151	0.313	-1.297	0.309	-1.344	0.259	-1.051	0.325
2015	-1.658	0.313	-1.594	0.316	-1.648	0.310	-1.927	0.259	-1.520	0.329
2016	-1.730	0.340	-1.681	0.344	-1.743	0.341	-1.753	0.275	-1.601	0.360
2017	-1.706	0.424	-1.765	0.425	-1.645	0.432	-2.671	0.304	-1.761	0.440
2018	-0.476	0.497	-0.494	0.503	-0.526	0.500	-1.018	0.394	-0.496	0.518
2019	-0.222	0.559	-0.108	0.563	-0.347	0.564	-0.314	0.469	-0.162	0.580
2020	0.248	0.566	0.329	0.573	0.157	0.557	0.569	0.488	0.193	0.591

Table 2.1.11e (page 2 of 4). Deviations for the logit of fishery selectivity at maximum length.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	-0.068	1.022	-0.005	0.998	-0.128	1.020	-0.132	1.063	-0.005	0.998
1978	-0.108	1.034	-0.004	0.999	-0.223	1.026	-0.216	1.096	-0.003	0.999
1979	-0.115	1.035	-0.003	0.999	-0.246	1.027	-0.224	1.098	-0.002	0.999
1980	0.004	0.996	-0.001	1.000	-0.046	0.999	0.004	0.990	0.000	1.000
1981	-0.013	1.003	0.001	1.000	-0.044	1.003	-0.018	1.005	0.001	1.000
1982	0.060	0.979	0.000	1.000	0.057	0.984	0.092	0.953	0.000	1.000
1983	0.243	0.920	-0.001	1.000	0.312	0.919	0.349	0.848	0.000	1.000
1984	0.408	0.870	-0.003	0.999	0.550	0.846	0.541	0.781	-0.003	0.999
1985	0.130	0.904	-0.006	0.998	0.131	0.818	0.201	0.803	-0.005	0.998
1986	-0.058	0.946	-0.003	0.999	-0.134	0.827	-0.042	0.827	-0.003	0.999
1987	0.150	0.882	-0.009	0.997	-0.092	0.739	0.067	0.758	-0.008	0.997
1988	0.054	0.952	-0.002	0.999	-0.225	0.912	0.075	0.886	-0.001	1.000
1989	0.286	0.902	0.011	1.000	0.380	0.875	0.395	0.822	0.011	1.000
1990	0.836	0.791	-0.002	0.998	1.214	0.745	0.940	0.699	-0.001	0.999
1991	0.448	0.828	-0.024	0.993	0.630	0.721	0.598	0.724	-0.023	0.994
1992	-0.133	0.893	-0.018	0.994	-0.030	0.698	-0.057	0.710	-0.018	0.995
1993	0.016	0.945	-0.006	0.998	-0.228	0.839	-0.039	0.857	-0.007	0.998
1994	0.022	0.929	-0.010	0.997	-0.339	0.798	-0.090	0.819	-0.011	0.997
1995	-0.015	0.930	-0.020	0.995	-0.242	0.808	0.018	0.813	-0.018	0.995
1996	0.779	0.798	-0.012	0.996	1.179	0.751	0.908	0.704	-0.011	0.996
1997	0.494	0.835	-0.008	0.997	0.728	0.767	0.762	0.721	-0.007	0.997
1998	0.289	0.855	-0.001	0.999	0.414	0.763	0.598	0.733	-0.001	0.999
1999	0.098	0.853	0.044	1.004	0.281	0.718	0.269	0.705	0.042	1.003
2000	0.075	0.864	0.075	1.021	0.205	0.716	-0.392	0.569	0.071	1.019
2001	-0.671	0.881	0.001	1.000	-0.819	0.654	-1.327	0.377	0.001	1.000
2002	-1.206	0.758	0.000	1.000	-1.347	0.612	-1.305	0.382	0.000	1.000
2003	-0.252	0.822	-0.012	0.996	-0.449	0.626	-1.158	0.347	-0.010	0.997
2004	-0.093	0.841	-0.002	0.999	0.072	0.669	-0.647	0.456	-0.002	0.999
2005	0.192	0.826	-0.008	0.997	0.298	0.678	0.363	0.685	-0.007	0.998
2006	0.693	0.792	0.013	1.004	1.227	0.710	1.232	0.654	0.013	1.004
2007	0.509	0.820	0.009	1.003	1.054	0.728	1.219	0.659	0.008	1.002
2008	-0.561	0.864	0.003	1.001	-0.233	0.683	0.721	0.710	0.003	1.001
2009	-1.052	0.872	0.012	1.003	-1.241	0.650	0.335	0.751	0.010	1.003
2010	-0.925	1.009	-0.003	0.999	-1.365	0.744	-0.525	0.695	-0.004	0.999
2011	-0.103	0.943	-0.002	0.999	-0.566	0.821	-0.853	0.578	-0.002	0.999
2012	0.028	0.921	-0.006	0.998	-0.249	0.861	-1.060	0.527	-0.006	0.998
2013	-0.402	0.942	-0.005	0.998	-0.721	0.797	-1.156	0.465	-0.005	0.998
2014	-0.602	0.865	-0.004	0.999	-0.570	0.734	-1.075	0.418	-0.005	0.999
2015	-0.257	0.892	-0.004	0.999	-0.209	0.746	-0.852	0.475	-0.004	0.999
2016	0.102	0.885	-0.003	0.999	-0.063	0.790	0.068	0.752	-0.003	0.999
2017	0.509	0.832	-0.001	1.000	0.495	0.802	-0.002	0.721	-0.001	1.000
2018	0.382	0.851	-0.002	0.999	0.473	0.798	0.508	0.748	-0.002	0.999
2019	-0.313	0.929	-0.002	0.999	-0.270	0.786	0.178	0.754	-0.002	0.999
2020	0.136	0.907	0.021	1.004	0.378	0.820	0.728	0.731	0.020	1.004

Table 2.1.11e (page 3 of 4). Deviations for the first size at which survey selectivity reaches 1.0.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.173	0.432	-0.158	0.427	-0.176	0.427	-0.078	0.451	-0.163	0.412
1983	-0.335	0.483	-0.180	0.467	-0.234	0.501	-0.352	0.486	-0.012	0.481
1984	1.185	0.392	1.157	0.385	1.129	0.367	1.289	0.449	1.145	0.331
1985	0.504	0.275	0.568	0.274	0.428	0.295	0.668	0.302	0.595	0.272
1986	-0.404	0.534	-0.373	0.507	-0.374	0.534	-0.409	0.488	-0.330	0.495
1987	-0.001	0.383	0.091	0.339	0.026	0.387	0.076	0.384	0.141	0.338
1988	0.101	0.537	0.180	0.525	0.024	0.504	0.117	0.538	0.232	0.518
1989	0.546	0.515	0.539	0.504	0.683	0.512	0.557	0.514	0.559	0.499
1990	-0.286	0.361	-0.289	0.351	-0.366	0.356	-0.230	0.371	-0.274	0.342
1991	0.994	0.473	0.899	0.444	0.762	0.437	0.988	0.472	0.919	0.430
1992	-0.094	0.359	-0.453	0.473	-0.179	0.353	0.000	0.375	-1.108	0.384
1993	0.208	0.347	0.124	0.327	0.132	0.338	0.317	0.354	0.145	0.317
1994	0.382	0.457	0.618	0.443	0.907	0.504	0.389	0.453	0.677	0.484
1995	0.584	0.436	0.751	0.440	0.608	0.434	0.714	0.451	0.879	0.448
1996	0.352	0.392	0.486	0.409	0.424	0.390	0.430	0.402	0.576	0.417
1997	0.777	0.351	0.782	0.340	0.714	0.334	0.784	0.349	0.800	0.332
1998	2.009	0.359	1.984	0.327	1.905	0.396	0.041	0.736	1.945	0.314
1999	0.344	0.523	0.303	0.528	0.289	0.520	0.465	0.529	0.353	0.497
2000	-0.606	0.304	-0.619	0.285	-0.659	0.299	-0.558	0.313	-0.593	0.277
2001	-0.839	0.369	-0.611	0.330	-0.771	0.371	-0.680	0.378	-0.501	0.321
2002	0.017	0.422	0.094	0.467	-0.126	0.429	0.130	0.424	0.155	0.441
2003	0.269	0.319	0.305	0.306	0.120	0.325	0.521	0.334	0.339	0.300
2004	0.231	0.369	0.248	0.350	0.143	0.352	0.425	0.380	0.261	0.338
2005	-0.194	0.494	-0.060	0.426	-0.248	0.405	-0.100	0.439	-0.006	0.404
2006	-1.652	0.298	-1.507	0.287	-1.693	0.303	-1.541	0.355	-1.425	0.279
2007	-2.414	0.255	-2.262	0.235	-2.463	0.250	-2.452	0.275	-2.135	0.221
2008	-1.459	0.302	-1.472	0.288	-1.454	0.306	-1.496	0.323	-1.442	0.279
2009	-0.809	0.531	-1.616	0.451	-1.009	0.494	-1.193	0.628	-1.844	0.353
2010	-0.377	0.450	-0.499	0.379	-0.140	0.516	-0.392	0.418	-0.534	0.358
2011	-0.085	0.262	-0.038	0.251	-0.096	0.263	-0.026	0.272	-0.037	0.242
2012	-2.124	0.388	-2.145	0.289	-2.012	0.363	-2.260	0.425	-2.099	0.289
2013	0.962	0.358	0.863	0.364	1.071	0.367	0.883	0.535	0.768	0.399
2014	-0.031	0.298	-0.008	0.285	-0.009	0.301	0.049	0.305	-0.013	0.275
2015	0.510	0.461	0.484	0.441	0.649	0.463	0.464	0.471	0.440	0.434
2016	1.185	0.335	1.198	0.326	1.156	0.331	1.368	0.345	1.134	0.323
2017	1.183	0.365	0.976	0.368	1.078	0.370	1.336	0.367	0.796	0.406
2018	0.826	0.354	0.820	0.339	0.948	0.335	0.973	0.367	0.781	0.328
2019	-1.286	0.291	-1.178	0.320	-1.188	0.322	-1.219	0.313	-1.125	0.290

Table 2.1.11e (page 4 of 4). Deviations for the log standard deviation of the first normal pdf in the double-normal survey selectivity curve.

	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1982	-0.503	0.586	-0.464	0.581	-0.529	0.588	-0.444	0.632	-0.442	0.549
1983	0.358	0.633	0.428	0.595	0.537	0.667	0.388	0.664	0.502	0.575
1984	0.787	0.435	0.905	0.433	0.722	0.420	0.899	0.500	0.941	0.376
1985	0.678	0.367	0.716	0.357	0.604	0.399	0.898	0.416	0.716	0.340
1986	-0.033	0.682	-0.049	0.647	0.017	0.689	0.000	0.657	-0.034	0.613
1987	-0.113	0.600	-0.043	0.527	-0.062	0.615	-0.059	0.625	0.019	0.503
1988	-0.110	0.672	-0.029	0.650	-0.208	0.651	-0.122	0.705	0.043	0.617
1989	0.166	0.598	0.222	0.583	0.314	0.593	0.128	0.633	0.284	0.555
1990	0.139	0.450	0.155	0.434	0.069	0.455	0.238	0.480	0.161	0.407
1991	1.259	0.518	1.261	0.492	1.038	0.496	1.305	0.541	1.281	0.465
1992	-0.041	0.451	-0.344	0.608	-0.170	0.455	0.048	0.488	-1.204	0.631
1993	0.739	0.446	0.660	0.418	0.660	0.443	0.892	0.471	0.640	0.391
1994	0.374	0.598	0.489	0.551	1.006	0.630	0.367	0.623	0.523	0.570
1995	0.328	0.553	0.509	0.537	0.331	0.557	0.424	0.593	0.649	0.514
1996	-0.215	0.515	-0.036	0.519	-0.156	0.515	-0.171	0.552	0.104	0.498
1997	0.778	0.415	0.797	0.397	0.712	0.407	0.878	0.437	0.803	0.374
1998	2.001	0.371	1.957	0.340	1.933	0.408	0.066	0.947	1.849	0.316
1999	0.350	0.585	0.338	0.592	0.279	0.595	0.490	0.612	0.396	0.537
2000	-0.654	0.420	-0.637	0.398	-0.743	0.424	-0.638	0.450	-0.576	0.376
2001	-0.453	0.558	-0.315	0.488	-0.368	0.571	-0.306	0.585	-0.235	0.455
2002	-0.028	0.545	0.059	0.592	-0.205	0.572	0.003	0.571	0.138	0.536
2003	0.273	0.424	0.319	0.402	0.071	0.448	0.439	0.455	0.354	0.378
2004	0.120	0.493	0.146	0.464	-0.003	0.489	0.251	0.519	0.173	0.434
2005	-0.284	0.676	-0.151	0.579	-0.369	0.586	-0.199	0.622	-0.076	0.528
2006	-1.504	0.441	-1.389	0.422	-1.572	0.458	-1.344	0.533	-1.294	0.401
2007	-2.433	0.529	-2.352	0.487	-2.553	0.528	-2.408	0.587	-2.211	0.442
2008	-1.542	0.475	-1.565	0.469	-1.558	0.485	-1.575	0.528	-1.512	0.456
2009	0.255	0.729	-0.815	0.707	0.005	0.702	-0.083	0.946	-1.166	0.580
2010	-0.585	0.596	-0.700	0.528	-0.301	0.651	-0.633	0.588	-0.699	0.498
2011	-0.130	0.358	-0.084	0.337	-0.140	0.365	-0.042	0.387	-0.049	0.314
2012	-1.532	0.644	-1.727	0.503	-1.340	0.592	-1.644	0.752	-1.718	0.512
2013	0.970	0.381	0.947	0.385	1.088	0.394	0.953	0.572	0.891	0.407
2014	-0.076	0.420	-0.025	0.397	-0.043	0.432	-0.019	0.447	0.015	0.373
2015	0.420	0.546	0.407	0.523	0.571	0.553	0.372	0.586	0.393	0.502
2016	0.768	0.457	0.843	0.438	0.768	0.464	0.897	0.487	0.843	0.419
2017	0.920	0.468	0.885	0.462	0.784	0.484	1.052	0.491	0.798	0.472
2018	0.123	0.421	0.177	0.399	0.241	0.403	0.211	0.453	0.204	0.374
2019	-1.569	0.531	-1.499	0.582	-1.427	0.575	-1.512	0.578	-1.502	0.529

Table 2.1.11f. Deviations for log survey catchability (Model 19.12 only).

	Model 19.12	
Year	Est.	SD
1982	0.159	0.682
1983	1.241	0.781
1984	-1.094	0.647
1985	0.832	0.631
1986	0.435	0.600
1987	0.779	0.665
1988	-0.283	0.552
1989	-1.221	0.643
1990	-1.110	0.675
1991	-1.474	0.646
1992	-1.953	0.671
1993	0.459	0.688
1994	3.558	0.585
1995	1.043	0.573
1996	1.495	0.695
1997	0.109	0.686
1998	0.500	0.778
1999	-0.759	0.624
2000	-1.223	0.645
2001	1.961	0.634
2002	0.217	0.729
2003	0.786	0.792
2004	0.028	0.741
2005	0.356	0.731
2006	-0.739	0.604
2007	-1.649	0.640
2008	-2.798	0.617
2009	-2.441	0.665
2010	-1.202	0.570
2011	0.539	0.614
2012	-0.264	0.664
2013	-1.408	0.637
2014	1.789	0.780
2015	0.976	0.767
2016	0.894	0.887
2017	-1.103	0.638
2018	1.793	0.740
2019	0.773	0.787

Table 2.1.12. Sigmas for time-varying parameters.

	Model 19.12a			Model 19.12			Model 21.1			Model 21.2			Model 21.3		
Parameter	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma	var_dev	ave_var	sigma
ln(Recruits)	0.4434	0.0125	0.6765	0.4312	0.0129	0.6664	0.4407	0.0126	0.6733	0.4334	0.0131	0.6682	0.4547	0.0144	0.6852
Length_at_1.5	0.7944	0.1985	0.1474	0.7991	0.2019	0.1486	0.8040	0.1967	0.1422	0.7951	0.2060	0.1480	0.7950	0.1985	0.1504
Sel_fsh_lnSD1	0.7089	0.2897	0.1559	0.7097	0.2913	0.1542	0.7112	0.2883	0.1734	0.7466	0.2496	0.1721	0.6994	0.3017	0.1482
Sel_fsh_logitEnd	0.1913	0.8072	0.7525	0.0002	0.9989	0.7640	0.3612	0.6457	0.6288	0.4351	0.5581	1.1255	0.0002	0.9989	0.7350
Sel_srv_PeakStart	0.8508	0.1589	0.2035	0.8552	0.1480	0.2204	0.8466	0.1569	0.2011	0.8208	0.1815	0.1875	0.8582	0.1395	0.2380
Sel_srv_lnSD1	0.7332	0.2752	0.7691	0.7521	0.2539	0.8365	0.7267	0.2789	0.7519	0.6631	0.3410	0.6889	0.7683	0.2272	0.9320

Table 2.1.13. Catchability time series (Model 19.12 only).

Year	19.12
1982	1.118
1983	1.225
1984	1.007
1985	1.183
1986	1.145
1987	1.178
1988	1.078
1989	0.996
1990	1.005
1991	0.975
1992	0.937
1993	1.147
1994	1.487
1995	1.204
1996	1.251
1997	1.114
1998	1.151
1999	1.035
2000	0.996
2001	1.301
2002	1.124
2003	1.179
2004	1.106
2005	1.137
2006	1.037
2007	0.961
2008	0.873
2009	0.899
2010	0.998
2011	1.155
2012	1.079
2013	0.981
2014	1.282
2015	1.198
2016	1.189
2017	1.006
2018	1.283
2019	1.177

Table 2.1.14. Ranking criteria and model weights as adopted by the CIE reviewers.

Feature	19.12a	19.12	21.1	21.2	21.3
Feature 1: Allow catchability to vary?	no	yes	no	no	no
Feature 2: Allow domed survey selectivity?	no	no	yes	no	no
Feature 3: Use fishery CPUE?	no	no	no	yes	no
Feature 4: Estimate survey CV internally?	no	no	no	no	yes

Criterion	Emph.	19.12a	19.12	21.1	21.2	21.3
General plausibility of the model	3	2	1	0.6667	1	1.3333
Acceptable retrospective bias	3	2	2	1.3333	1	2
Uses properly vetted data	3	2	2	2	0	2
Acceptable residual patterns	3	2	2	2	2	1
Comparable complexity	2	2	1	1	2	2
Fits consistent with variances	2	1	2	1	0	2
Dev sigmas estimated appropriately	0					
Incremental changes	0					
Objective criterion for sample sizes	0					
Change in ageing criteria addressed	0					
Density dependence (other than R) addressed	0					
Regime shifts addressed	0					

Quantity	19.12a	19.12	21.1	21.2	21.3
Average emphasis:	0.9375	0.8438	0.6875	0.5000	0.8438
Model weight:	0.2459	0.2213	0.1803	0.1311	0.2213

Table 2.1.15. Female spawning biomass (millions of t) time series for all models and the ensemble.

	no		yes		no		no		no		Time-vary *Q*?	
	no		no		yes		no		no		Survey dome?	
	no		no		no		yes		no		Fishery CPUE?	
	no		no		no		no		yes		Extra SD?	
	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.186	0.051	0.201	0.054	0.110	0.030	0.177	0.049	0.221	0.061	0.182	0.063
1978	0.229	0.061	0.252	0.067	0.132	0.035	0.219	0.059	0.278	0.077	0.226	0.079
1979	0.166	0.041	0.186	0.046	0.096	0.024	0.158	0.039	0.204	0.053	0.165	0.056
1980	0.173	0.036	0.196	0.042	0.102	0.022	0.165	0.035	0.213	0.047	0.173	0.053
1981	0.130	0.019	0.150	0.024	0.085	0.014	0.126	0.020	0.161	0.027	0.133	0.034
1982	0.099	0.012	0.113	0.015	0.068	0.010	0.099	0.013	0.120	0.017	0.101	0.022
1983	0.119	0.011	0.134	0.014	0.088	0.011	0.119	0.012	0.141	0.016	0.122	0.023
1984	0.163	0.013	0.180	0.017	0.126	0.013	0.161	0.014	0.189	0.019	0.166	0.027
1985	0.180	0.015	0.193	0.017	0.142	0.015	0.178	0.016	0.202	0.020	0.180	0.026
1986	0.171	0.014	0.179	0.015	0.139	0.015	0.170	0.016	0.187	0.018	0.170	0.022
1987	0.196	0.014	0.205	0.016	0.161	0.016	0.196	0.016	0.213	0.019	0.195	0.024
1988	0.229	0.015	0.242	0.017	0.194	0.019	0.227	0.018	0.251	0.020	0.230	0.026
1989	0.214	0.013	0.226	0.016	0.176	0.016	0.211	0.015	0.233	0.018	0.214	0.025
1990	0.240	0.013	0.254	0.016	0.192	0.016	0.236	0.014	0.261	0.018	0.239	0.028
1991	0.405	0.025	0.418	0.027	0.327	0.030	0.392	0.026	0.427	0.031	0.397	0.044
1992	0.446	0.035	0.445	0.033	0.355	0.037	0.433	0.039	0.451	0.037	0.429	0.051
1993	0.307	0.023	0.308	0.023	0.250	0.025	0.301	0.026	0.310	0.025	0.297	0.033
1994	0.410	0.027	0.416	0.028	0.336	0.031	0.409	0.031	0.417	0.030	0.399	0.042
1995	0.513	0.034	0.536	0.036	0.419	0.039	0.505	0.037	0.542	0.038	0.506	0.056
1996	0.483	0.033	0.534	0.038	0.374	0.038	0.470	0.034	0.548	0.040	0.487	0.070
1997	0.534	0.037	0.613	0.042	0.422	0.042	0.499	0.034	0.638	0.045	0.550	0.087
1998	0.428	0.032	0.499	0.037	0.335	0.036	0.392	0.029	0.523	0.039	0.443	0.076
1999	0.405	0.033	0.473	0.037	0.315	0.035	0.370	0.029	0.498	0.040	0.420	0.075
2000	0.389	0.032	0.454	0.038	0.300	0.033	0.383	0.031	0.478	0.041	0.406	0.071
2001	0.348	0.025	0.387	0.029	0.279	0.027	0.387	0.028	0.403	0.032	0.362	0.052
2002	0.377	0.027	0.398	0.028	0.312	0.028	0.417	0.030	0.411	0.029	0.383	0.046
2003	0.379	0.025	0.410	0.027	0.313	0.028	0.463	0.033	0.423	0.029	0.395	0.054
2004	0.388	0.024	0.421	0.026	0.317	0.028	0.449	0.031	0.434	0.028	0.401	0.052
2005	0.404	0.025	0.440	0.026	0.330	0.030	0.421	0.028	0.455	0.028	0.412	0.051
2006	0.436	0.028	0.481	0.030	0.341	0.034	0.411	0.027	0.497	0.032	0.439	0.062
2007	0.415	0.029	0.454	0.031	0.318	0.034	0.352	0.024	0.469	0.032	0.410	0.064
2008	0.510	0.038	0.533	0.038	0.393	0.041	0.389	0.027	0.548	0.040	0.487	0.075
2009	0.645	0.056	0.647	0.052	0.503	0.056	0.438	0.033	0.661	0.055	0.596	0.098
2010	0.623	0.051	0.615	0.051	0.480	0.053	0.450	0.035	0.619	0.053	0.572	0.087
2011	0.744	0.053	0.737	0.057	0.569	0.059	0.634	0.047	0.733	0.058	0.694	0.088
2012	0.643	0.043	0.656	0.048	0.499	0.049	0.644	0.045	0.662	0.049	0.624	0.076
2013	0.584	0.038	0.597	0.042	0.468	0.043	0.616	0.042	0.612	0.043	0.576	0.067
2014	0.640	0.049	0.649	0.051	0.502	0.052	0.712	0.054	0.679	0.053	0.635	0.084
2015	0.606	0.046	0.632	0.053	0.467	0.050	0.714	0.055	0.685	0.060	0.618	0.096
2016	0.545	0.042	0.585	0.051	0.424	0.045	0.620	0.047	0.665	0.064	0.568	0.095
2017	0.432	0.034	0.478	0.044	0.336	0.036	0.534	0.040	0.577	0.065	0.470	0.094
2018	0.314	0.024	0.346	0.032	0.255	0.025	0.351	0.025	0.441	0.057	0.344	0.071
2019	0.299	0.025	0.319	0.031	0.249	0.025	0.315	0.024	0.435	0.070	0.327	0.074
2020	0.320	0.028	0.345	0.038	0.263	0.029	0.324	0.025	0.518	0.114	0.360	0.107
2021	0.290	0.039	0.215	0.037	0.262	0.036	0.280	0.037	0.130	0.039	0.232	0.071
2022	0.265	0.024	0.210	0.026	0.238	0.023	0.263	0.024	0.144	0.032	0.221	0.053

Table 2.1.16. Spawning biomass relative to B100% time series for all models and the ensemble.

	no		yes		no		no		no		Time-vary *Q* ?	
	no		no		yes		no		no		Survey dome?	
	no		no		no		yes		no		Fishery CPUE?	
	no		no		no		no		yes		Extra SD?	
	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.186	0.051	0.201	0.054	0.110	0.030	0.177	0.049	0.221	0.061	0.182	0.000
1978	0.229	0.061	0.252	0.067	0.132	0.035	0.219	0.059	0.278	0.077	0.226	0.000
1979	0.166	0.041	0.186	0.046	0.096	0.024	0.158	0.039	0.204	0.053	0.165	0.000
1980	0.173	0.036	0.196	0.042	0.102	0.022	0.165	0.035	0.213	0.047	0.173	0.000
1981	0.130	0.019	0.150	0.024	0.085	0.014	0.126	0.020	0.161	0.027	0.133	0.000
1982	0.099	0.012	0.113	0.015	0.068	0.010	0.099	0.013	0.120	0.017	0.101	0.000
1983	0.119	0.011	0.134	0.014	0.088	0.011	0.119	0.012	0.141	0.016	0.122	0.000
1984	0.163	0.013	0.180	0.017	0.126	0.013	0.161	0.014	0.189	0.019	0.166	0.000
1985	0.180	0.015	0.193	0.017	0.142	0.015	0.178	0.016	0.202	0.020	0.180	0.000
1986	0.171	0.014	0.179	0.015	0.139	0.015	0.170	0.016	0.187	0.018	0.170	0.000
1987	0.196	0.014	0.205	0.016	0.161	0.016	0.196	0.016	0.213	0.019	0.195	0.000
1988	0.229	0.015	0.242	0.017	0.194	0.019	0.227	0.018	0.251	0.020	0.230	0.000
1989	0.214	0.013	0.226	0.016	0.176	0.016	0.211	0.015	0.233	0.018	0.214	0.000
1990	0.240	0.013	0.254	0.016	0.192	0.016	0.236	0.014	0.261	0.018	0.239	0.000
1991	0.405	0.025	0.418	0.027	0.327	0.030	0.392	0.026	0.427	0.031	0.397	0.000
1992	0.446	0.035	0.445	0.033	0.355	0.037	0.433	0.039	0.451	0.037	0.429	0.000
1993	0.307	0.023	0.308	0.023	0.250	0.025	0.301	0.026	0.310	0.025	0.297	0.000
1994	0.410	0.027	0.416	0.028	0.336	0.031	0.409	0.031	0.417	0.030	0.399	0.000
1995	0.513	0.034	0.536	0.036	0.419	0.039	0.505	0.037	0.542	0.038	0.506	0.000
1996	0.483	0.033	0.534	0.038	0.374	0.038	0.470	0.034	0.548	0.040	0.487	0.000
1997	0.534	0.037	0.613	0.042	0.422	0.042	0.499	0.034	0.638	0.045	0.550	0.000
1998	0.428	0.032	0.499	0.037	0.335	0.036	0.392	0.029	0.523	0.039	0.443	0.000
1999	0.405	0.033	0.473	0.037	0.315	0.035	0.370	0.029	0.498	0.040	0.420	0.000
2000	0.389	0.032	0.454	0.038	0.300	0.033	0.383	0.031	0.478	0.041	0.406	0.000
2001	0.348	0.025	0.387	0.029	0.279	0.027	0.387	0.028	0.403	0.032	0.362	0.000
2002	0.377	0.027	0.398	0.028	0.312	0.028	0.417	0.030	0.411	0.029	0.383	0.000
2003	0.379	0.025	0.410	0.027	0.313	0.028	0.463	0.033	0.423	0.029	0.395	0.000
2004	0.388	0.024	0.421	0.026	0.317	0.028	0.449	0.031	0.434	0.028	0.401	0.000
2005	0.404	0.025	0.440	0.026	0.330	0.030	0.421	0.028	0.455	0.028	0.412	0.000
2006	0.436	0.028	0.481	0.030	0.341	0.034	0.411	0.027	0.497	0.032	0.439	0.000
2007	0.415	0.029	0.454	0.031	0.318	0.034	0.352	0.024	0.469	0.032	0.410	0.000
2008	0.510	0.038	0.533	0.038	0.393	0.041	0.389	0.027	0.548	0.040	0.487	0.000
2009	0.645	0.056	0.647	0.052	0.503	0.056	0.438	0.033	0.661	0.055	0.596	0.000
2010	0.623	0.051	0.615	0.051	0.480	0.053	0.450	0.035	0.619	0.053	0.572	0.000
2011	0.744	0.053	0.737	0.057	0.569	0.059	0.634	0.047	0.733	0.058	0.694	0.000
2012	0.643	0.043	0.656	0.048	0.499	0.049	0.644	0.045	0.662	0.049	0.624	0.000
2013	0.584	0.038	0.597	0.042	0.468	0.043	0.616	0.042	0.612	0.043	0.576	0.000
2014	0.640	0.049	0.649	0.051	0.502	0.052	0.712	0.054	0.679	0.053	0.635	0.000
2015	0.606	0.046	0.632	0.053	0.467	0.050	0.714	0.055	0.685	0.060	0.618	0.000
2016	0.545	0.042	0.585	0.051	0.424	0.045	0.620	0.047	0.665	0.064	0.568	0.000
2017	0.432	0.034	0.478	0.044	0.336	0.036	0.534	0.040	0.577	0.065	0.470	0.000
2018	0.314	0.024	0.346	0.032	0.255	0.025	0.351	0.025	0.441	0.057	0.344	0.000
2019	0.299	0.025	0.319	0.031	0.249	0.025	0.315	0.024	0.435	0.070	0.327	0.000
2020	0.320	0.028	0.345	0.038	0.263	0.029	0.324	0.025	0.518	0.114	0.360	0.000
2021	0.290	0.039	0.215	0.037	0.262	0.036	0.280	0.037	0.130	0.039	0.232	0.000
2022	0.265	0.024	0.210	0.026	0.238	0.023	0.263	0.024	0.144	0.032	0.221	0.000

Table 2.1.17. Age 0 recruitment (billions of fish) time series for all models and the ensemble.

	no		yes		no		no		no		Time-vary *Q*?	
	no		no		yes		no		no		Survey dome?	
	no		no		no		yes		no		Fishery CPUE?	
	no		no		no		no		yes		Extra SD?	
	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	1.056	0.269	0.823	0.218	0.933	0.262	1.082	0.283	0.773	0.213	0.923	0.276
1978	0.699	0.189	0.585	0.153	0.593	0.169	0.674	0.193	0.562	0.149	0.621	0.179
1979	0.723	0.121	0.601	0.105	0.585	0.110	0.713	0.123	0.572	0.106	0.637	0.130
1980	0.181	0.045	0.147	0.040	0.152	0.039	0.184	0.046	0.128	0.038	0.157	0.047
1981	0.202	0.041	0.178	0.036	0.166	0.036	0.201	0.042	0.172	0.036	0.183	0.041
1982	0.941	0.108	0.827	0.103	0.770	0.104	0.952	0.111	0.813	0.110	0.858	0.128
1983	0.262	0.049	0.204	0.040	0.219	0.043	0.256	0.049	0.190	0.039	0.225	0.053
1984	0.880	0.100	0.753	0.090	0.714	0.096	0.887	0.102	0.730	0.093	0.790	0.121
1985	0.402	0.054	0.350	0.048	0.329	0.050	0.393	0.054	0.342	0.049	0.362	0.058
1986	0.219	0.032	0.200	0.030	0.177	0.029	0.217	0.033	0.198	0.031	0.202	0.034
1987	0.073	0.018	0.071	0.017	0.060	0.015	0.074	0.018	0.071	0.018	0.070	0.018
1988	0.305	0.039	0.279	0.037	0.242	0.036	0.313	0.041	0.275	0.039	0.282	0.045
1989	0.600	0.066	0.542	0.061	0.482	0.064	0.610	0.068	0.535	0.064	0.553	0.078
1990	0.591	0.066	0.520	0.059	0.475	0.064	0.597	0.068	0.517	0.061	0.539	0.078
1991	0.362	0.048	0.288	0.040	0.305	0.044	0.370	0.050	0.257	0.034	0.313	0.061
1992	0.951	0.096	0.764	0.076	0.785	0.096	0.990	0.102	0.725	0.076	0.835	0.136
1993	0.353	0.043	0.314	0.038	0.303	0.041	0.351	0.044	0.308	0.038	0.325	0.046
1994	0.298	0.036	0.254	0.030	0.247	0.035	0.313	0.038	0.245	0.030	0.269	0.043
1995	0.267	0.034	0.235	0.030	0.225	0.032	0.264	0.034	0.230	0.030	0.244	0.036
1996	0.846	0.089	0.736	0.080	0.699	0.088	0.797	0.084	0.718	0.084	0.760	0.102
1997	0.362	0.043	0.325	0.040	0.300	0.041	0.329	0.042	0.319	0.041	0.329	0.047
1998	0.288	0.037	0.258	0.033	0.232	0.034	0.273	0.035	0.253	0.034	0.261	0.040
1999	0.692	0.069	0.591	0.060	0.561	0.069	0.691	0.071	0.569	0.061	0.619	0.088
2000	0.505	0.052	0.436	0.046	0.430	0.052	0.536	0.057	0.423	0.047	0.462	0.066
2001	0.196	0.026	0.175	0.024	0.161	0.025	0.221	0.031	0.172	0.024	0.183	0.032
2002	0.344	0.037	0.303	0.033	0.288	0.036	0.411	0.046	0.296	0.034	0.323	0.054
2003	0.310	0.033	0.279	0.030	0.257	0.032	0.372	0.042	0.274	0.031	0.294	0.049
2004	0.224	0.028	0.206	0.026	0.186	0.025	0.254	0.032	0.203	0.027	0.212	0.034
2005	0.269	0.030	0.253	0.029	0.221	0.029	0.296	0.036	0.252	0.030	0.257	0.037
2006	0.786	0.072	0.745	0.072	0.646	0.073	0.807	0.077	0.744	0.077	0.745	0.090
2007	0.317	0.040	0.293	0.037	0.265	0.037	0.293	0.038	0.289	0.037	0.293	0.041
2008	1.172	0.109	1.009	0.100	0.966	0.110	1.088	0.102	0.954	0.097	1.039	0.135
2009	0.165	0.031	0.143	0.026	0.142	0.028	0.159	0.030	0.134	0.024	0.149	0.030
2010	0.735	0.077	0.651	0.071	0.603	0.075	0.695	0.072	0.605	0.067	0.659	0.090
2011	0.931	0.098	0.808	0.087	0.783	0.096	0.891	0.091	0.728	0.081	0.827	0.119
2012	0.443	0.059	0.371	0.050	0.369	0.055	0.425	0.058	0.319	0.044	0.384	0.070
2013	1.200	0.130	1.003	0.116	0.998	0.125	1.182	0.126	0.829	0.107	1.035	0.185
2014	0.217	0.032	0.187	0.028	0.185	0.030	0.209	0.032	0.153	0.025	0.189	0.037
2015	0.287	0.033	0.250	0.031	0.238	0.032	0.289	0.034	0.198	0.030	0.251	0.047
2016	0.178	0.026	0.139	0.021	0.149	0.024	0.180	0.026	0.102	0.020	0.148	0.037
2017	0.125	0.027	0.102	0.023	0.110	0.024	0.122	0.027	0.077	0.019	0.106	0.030
2018	0.735	0.074	0.620	0.073	0.619	0.075	0.751	0.077	0.459	0.079	0.630	0.130

Table 2.1.18. Full-selection instantaneous fishing mortality time series for all models and the ensemble.

	no		yes		no		no		no		Time-vary *Q*?	
	no		no		yes		no		no		Survey dome?	
	no		no		no		yes		no		Fishery CPUE?	
	no		no		no		no		yes		Extra SD?	
	Model 19.12a		Model 19.12		Model 21.1		Model 21.2		Model 21.3		Ensemble	
Year	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD	Est.	SD
1977	0.186	0.051	0.201	0.054	0.110	0.030	0.177	0.049	0.221	0.061	0.182	0.063
1978	0.229	0.061	0.252	0.067	0.132	0.035	0.219	0.059	0.278	0.077	0.226	0.079
1979	0.166	0.041	0.186	0.046	0.096	0.024	0.158	0.039	0.204	0.053	0.165	0.056
1980	0.173	0.036	0.196	0.042	0.102	0.022	0.165	0.035	0.213	0.047	0.173	0.053
1981	0.130	0.019	0.150	0.024	0.085	0.014	0.126	0.020	0.161	0.027	0.133	0.034
1982	0.099	0.012	0.113	0.015	0.068	0.010	0.099	0.013	0.120	0.017	0.101	0.022
1983	0.119	0.011	0.134	0.014	0.088	0.011	0.119	0.012	0.141	0.016	0.122	0.023
1984	0.163	0.013	0.180	0.017	0.126	0.013	0.161	0.014	0.189	0.019	0.166	0.027
1985	0.180	0.015	0.193	0.017	0.142	0.015	0.178	0.016	0.202	0.020	0.180	0.026
1986	0.171	0.014	0.179	0.015	0.139	0.015	0.170	0.016	0.187	0.018	0.170	0.022
1987	0.196	0.014	0.205	0.016	0.161	0.016	0.196	0.016	0.213	0.019	0.195	0.024
1988	0.229	0.015	0.242	0.017	0.194	0.019	0.227	0.018	0.251	0.020	0.230	0.026
1989	0.214	0.013	0.226	0.016	0.176	0.016	0.211	0.015	0.233	0.018	0.214	0.025
1990	0.240	0.013	0.254	0.016	0.192	0.016	0.236	0.014	0.261	0.018	0.239	0.028
1991	0.405	0.025	0.418	0.027	0.327	0.030	0.392	0.026	0.427	0.031	0.397	0.044
1992	0.446	0.035	0.445	0.033	0.355	0.037	0.433	0.039	0.451	0.037	0.429	0.051
1993	0.307	0.023	0.308	0.023	0.250	0.025	0.301	0.026	0.310	0.025	0.297	0.033
1994	0.410	0.027	0.416	0.028	0.336	0.031	0.409	0.031	0.417	0.030	0.399	0.042
1995	0.513	0.034	0.536	0.036	0.419	0.039	0.505	0.037	0.542	0.038	0.506	0.056
1996	0.483	0.033	0.534	0.038	0.374	0.038	0.470	0.034	0.548	0.040	0.487	0.070
1997	0.534	0.037	0.613	0.042	0.422	0.042	0.499	0.034	0.638	0.045	0.550	0.087
1998	0.428	0.032	0.499	0.037	0.335	0.036	0.392	0.029	0.523	0.039	0.443	0.076
1999	0.405	0.033	0.473	0.037	0.315	0.035	0.370	0.029	0.498	0.040	0.420	0.075
2000	0.389	0.032	0.454	0.038	0.300	0.033	0.383	0.031	0.478	0.041	0.406	0.071
2001	0.348	0.025	0.387	0.029	0.279	0.027	0.387	0.028	0.403	0.032	0.362	0.052
2002	0.377	0.027	0.398	0.028	0.312	0.028	0.417	0.030	0.411	0.029	0.383	0.046
2003	0.379	0.025	0.410	0.027	0.313	0.028	0.463	0.033	0.423	0.029	0.395	0.054
2004	0.388	0.024	0.421	0.026	0.317	0.028	0.449	0.031	0.434	0.028	0.401	0.052
2005	0.404	0.025	0.440	0.026	0.330	0.030	0.421	0.028	0.455	0.028	0.412	0.051
2006	0.436	0.028	0.481	0.030	0.341	0.034	0.411	0.027	0.497	0.032	0.439	0.062
2007	0.415	0.029	0.454	0.031	0.318	0.034	0.352	0.024	0.469	0.032	0.410	0.064
2008	0.510	0.038	0.533	0.038	0.393	0.041	0.389	0.027	0.548	0.040	0.487	0.075
2009	0.645	0.056	0.647	0.052	0.503	0.056	0.438	0.033	0.661	0.055	0.596	0.098
2010	0.623	0.051	0.615	0.051	0.480	0.053	0.450	0.035	0.619	0.053	0.572	0.087
2011	0.744	0.053	0.737	0.057	0.569	0.059	0.634	0.047	0.733	0.058	0.694	0.088
2012	0.643	0.043	0.656	0.048	0.499	0.049	0.644	0.045	0.662	0.049	0.624	0.076
2013	0.584	0.038	0.597	0.042	0.468	0.043	0.616	0.042	0.612	0.043	0.576	0.067
2014	0.640	0.049	0.649	0.051	0.502	0.052	0.712	0.054	0.679	0.053	0.635	0.084
2015	0.606	0.046	0.632	0.053	0.467	0.050	0.714	0.055	0.685	0.060	0.618	0.096
2016	0.545	0.042	0.585	0.051	0.424	0.045	0.620	0.047	0.665	0.064	0.568	0.095
2017	0.432	0.034	0.478	0.044	0.336	0.036	0.534	0.040	0.577	0.065	0.470	0.094
2018	0.314	0.024	0.346	0.032	0.255	0.025	0.351	0.025	0.441	0.057	0.344	0.071
2019	0.299	0.025	0.319	0.031	0.249	0.025	0.315	0.024	0.435	0.070	0.327	0.074
2020	0.320	0.028	0.345	0.038	0.263	0.029	0.324	0.025	0.518	0.114	0.360	0.107
2021	0.290	0.039	0.215	0.037	0.262	0.036	0.280	0.037	0.130	0.039	0.232	0.071
2022	0.265	0.024	0.210	0.026	0.238	0.023	0.263	0.024	0.144	0.032	0.221	0.053

Table 2.1.19a. Mid-year length (cm) at age (Model 19.12a).

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	43.9	53.3	61.1	67.7	73.3	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.7
1978	4.8	15.6	31.3	43.9	53.3	61.1	67.7	73.3	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.7
1979	5.3	14.5	32.1	43.3	53.3	61.1	67.7	73.3	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.5
1980	4.9	15.8	31.4	44.0	52.9	61.1	67.7	73.3	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1981	4.2	14.7	30.2	43.4	53.4	60.7	67.7	73.3	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1982	4.4	12.7	30.4	42.4	52.9	61.2	67.4	73.3	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1983	5.4	13.1	32.5	42.6	52.1	60.8	67.7	73.0	78.1	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1984	5.2	16.3	32.1	44.2	52.3	60.1	67.4	73.3	77.9	82.3	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1985	4.0	15.7	29.7	43.9	53.6	60.3	66.9	73.1	78.2	82.1	86.0	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1986	5.0	11.9	31.7	42.1	53.4	61.3	67.0	72.6	77.9	82.4	85.8	89.1	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1987	4.5	15.1	30.8	43.6	51.8	61.1	67.9	72.7	77.5	82.1	86.0	89.0	91.9	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.4
1988	4.3	13.6	30.3	42.9	53.1	59.9	67.7	73.5	77.6	81.8	85.8	89.2	91.8	94.4	96.5	98.4	100.1	101.6	102.9	104.0	106.5
1989	4.4	12.9	30.4	42.6	52.5	60.9	66.6	73.3	78.3	81.9	85.5	89.0	92.0	94.3	96.5	98.4	100.1	101.6	102.9	104.0	106.5
1990	4.8	13.1	31.3	42.6	52.2	60.4	67.5	72.4	78.2	82.5	85.6	88.7	91.8	94.4	96.4	98.4	100.1	101.6	102.9	104.0	106.5
1991	5.2	14.5	32.1	43.3	52.3	60.2	67.1	73.2	77.4	82.3	86.1	88.8	91.6	94.3	96.5	98.3	100.1	101.6	102.9	104.0	106.5
1992	5.0	15.7	31.5	43.9	52.9	60.3	66.9	72.8	78.0	81.7	86.0	89.2	91.6	94.1	96.4	98.4	100.0	101.6	102.9	104.0	106.5
1993	5.4	14.9	32.3	43.5	53.4	60.7	67.0	72.6	77.7	82.2	85.4	89.2	92.0	94.1	96.2	98.3	100.1	101.5	102.9	104.0	106.2
1994	4.8	16.1	31.2	44.1	53.0	61.1	67.4	72.7	77.6	82.0	85.9	88.6	91.9	94.5	96.3	98.2	100.0	101.6	102.8	104.0	105.9
1995	4.7	14.3	31.1	43.2	53.5	60.8	67.7	73.0	77.6	81.8	85.6	89.1	91.5	94.4	96.6	98.2	99.9	101.5	102.9	103.9	106.0
1996	4.9	14.1	31.4	43.1	52.8	61.3	67.5	73.3	77.9	81.9	85.5	88.9	91.9	94.0	96.5	98.5	99.9	101.4	102.8	104.0	105.7
1997	4.8	14.7	31.2	43.4	52.7	60.6	67.8	73.1	78.2	82.1	85.6	88.8	91.7	94.3	96.2	98.4	100.1	101.4	102.7	103.9	105.4
1998	4.4	14.3	30.5	43.2	52.9	60.6	67.3	73.4	78.0	82.3	85.8	88.8	91.6	94.2	96.5	98.1	100.1	101.6	102.7	103.9	105.7
1999	4.1	13.2	29.9	42.7	52.8	60.8	67.3	73.0	78.2	82.2	86.0	89.0	91.6	94.1	96.3	98.4	99.8	101.6	102.9	103.9	105.8
2000	5.6	12.2	32.9	42.2	52.3	60.7	67.4	72.9	77.8	82.4	85.8	89.2	91.8	94.1	96.3	98.2	100.0	101.3	102.9	104.0	106.4
2001	5.2	16.9	32.0	44.5	51.9	60.3	67.3	73.1	77.8	82.1	86.0	89.0	91.9	94.3	96.3	98.2	99.9	101.5	102.6	104.0	106.7
2002	5.5	15.6	32.5	43.9	53.8	60.0	67.0	73.0	77.9	82.0	85.7	89.2	91.8	94.4	96.4	98.2	99.9	101.4	102.8	103.8	105.9
2003	5.1	16.4	31.8	44.3	53.3	61.5	66.7	72.7	77.9	82.1	85.7	89.0	92.0	94.3	96.5	98.3	99.9	101.4	102.7	104.0	106.3
2004	6.1	15.2	33.8	43.7	53.6	61.1	68.1	72.5	77.6	82.1	85.8	88.9	91.8	94.4	96.4	98.4	100.0	101.4	102.7	103.9	105.9
2005	4.8	18.3	31.3	45.2	53.1	61.4	67.7	73.6	77.4	81.9	85.8	89.0	91.7	94.2	96.6	98.3	100.1	101.5	102.7	103.9	106.1
2006	4.7	14.5	31.1	43.3	54.4	61.0	67.9	73.3	78.4	81.7	85.6	89.0	91.8	94.2	96.4	98.4	100.0	101.6	102.8	103.9	106.4
2007	4.2	14.2	30.0	43.1	52.8	62.0	67.6	73.5	78.1	82.6	85.4	88.8	91.8	94.3	96.4	98.3	100.1	101.5	102.9	103.9	106.8
2008	4.1	12.4	29.9	42.3	52.7	60.7	68.5	73.2	78.3	82.3	86.2	88.7	91.6	94.2	96.4	98.3	100.0	101.6	102.8	104.0	106.2
2009	4.5	12.2	30.6	42.2	52.1	60.6	67.4	74.0	78.0	82.5	86.0	89.3	91.5	94.1	96.4	98.3	100.0	101.5	102.9	104.0	105.6
2010	5.2	13.4	32.0	42.8	52.0	60.1	67.3	73.0	78.7	82.2	86.1	89.1	92.1	94.0	96.3	98.3	100.0	101.5	102.8	104.0	105.6
2011	4.2	15.6	30.1	43.8	52.4	60.0	66.8	72.9	77.9	82.8	85.9	89.3	91.9	94.5	96.2	98.2	100.0	101.5	102.8	103.9	105.8
2012	5.1	12.5	31.8	42.4	53.3	60.4	66.7	72.5	77.8	82.1	86.4	89.1	92.0	94.4	96.6	98.1	99.9	101.5	102.8	103.9	105.4
2013	4.7	15.2	31.1	43.7	52.1	61.1	67.1	72.5	77.5	82.0	85.8	89.5	91.9	94.5	96.5	98.5	99.8	101.4	102.8	103.9	105.8
2014	5.1	14.2	31.9	43.2	53.1	60.1	67.7	72.8	77.4	81.8	85.7	89.0	92.3	94.3	96.6	98.4	100.2	101.3	102.7	103.9	106.0
2015	6.4	15.4	34.4	43.7	52.7	61.0	66.8	73.3	77.7	81.7	85.5	88.9	91.8	94.7	96.5	98.5	100.1	101.6	102.7	103.9	106.0
2016	6.4	19.2	34.5	45.7	53.2	60.6	67.6	72.6	78.1	81.9	85.4	88.7	91.7	94.3	96.8	98.4	100.1	101.5	102.9	103.8	105.4
2017	6.0	19.3	33.6	45.8	54.8	61.0	67.3	73.2	77.5	82.3	85.6	88.7	91.6	94.2	96.4	98.6	100.1	101.6	102.8	104.1	105.7
2018	7.1	17.9	36.0	45.1	54.9	62.4	67.6	72.9	78.0	81.8	86.0	88.8	91.5	94.0	96.4	98.3	100.3	101.5	102.9	104.0	106.0
2019	4.2	21.4	30.2	47.0	54.3	62.4	68.8	73.2	77.8	82.2	85.5	89.1	91.7	94.0	96.2	98.3	100.0	101.7	102.8	104.0	105.7
2020	5.2	15.6	31.5	42.5	55.8	61.9	68.8	74.2	78.1	82.1	85.9	88.7	91.9	94.1	96.2	98.2	100.0	101.5	103.0	104.0	105.8

Table 2.1.19b. Mid-year 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	5.3	15.8	32.1	43.8	53.2	61.0	67.6	73.4	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.3
1978	4.9	15.8	31.3	43.8	53.2	61.0	67.6	73.4	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.3
1979	5.3	14.6	32.2	43.2	53.2	61.0	67.6	73.4	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.1
1980	4.9	15.9	31.4	43.8	52.7	61.0	67.6	73.4	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.0
1981	4.2	14.7	30.1	43.2	53.2	60.6	67.6	73.4	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	110.9
1982	4.3	12.6	30.3	42.3	52.7	61.0	67.3	73.4	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	110.9
1983	5.9	13.0	33.3	42.4	51.9	60.6	67.7	73.1	78.4	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	110.9
1984	5.3	17.6	32.1	44.7	52.0	59.9	67.3	73.4	78.2	82.9	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	110.9
1985	3.9	15.8	29.6	43.8	53.9	60.0	66.7	73.1	78.5	82.6	86.8	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.0
1986	5.1	11.8	31.7	41.9	53.1	61.6	66.8	72.6	78.2	82.9	86.6	90.2	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.0
1987	4.6	15.2	30.8	43.5	51.6	61.0	68.2	72.7	77.7	82.6	86.8	90.0	93.3	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.1
1988	4.3	13.7	30.4	42.8	52.9	59.6	67.6	73.9	77.8	82.2	86.6	90.2	93.1	96.1	98.5	100.7	102.7	104.4	106.0	107.5	111.1
1989	4.4	13.0	30.5	42.5	52.3	60.7	66.5	73.4	78.8	82.3	86.2	90.1	93.3	95.9	98.5	100.7	102.7	104.4	106.0	107.5	111.2
1990	4.9	13.2	31.4	42.5	52.1	60.3	67.4	72.4	78.4	83.2	86.3	89.7	93.2	96.1	98.4	100.7	102.7	104.4	106.0	107.5	111.3
1991	5.4	14.7	32.3	43.3	52.1	60.0	67.0	73.2	77.6	82.9	87.1	89.8	92.9	95.9	98.5	100.6	102.7	104.4	106.0	107.5	111.3
1992	5.0	16.1	31.5	43.9	52.7	60.1	66.8	72.9	78.3	82.1	86.8	90.5	92.9	95.7	98.4	100.7	102.6	104.4	106.0	107.5	111.2
1993	5.2	14.9	32.0	43.3	53.3	60.6	66.9	72.7	78.0	82.7	86.1	90.2	93.6	95.7	98.2	100.6	102.7	104.3	106.0	107.5	110.9
1994	4.9	15.6	31.3	43.7	52.8	61.1	67.3	72.8	77.8	82.5	86.6	89.6	93.3	96.3	98.2	100.4	102.6	104.5	105.9	107.5	110.4
1995	4.8	14.6	31.2	43.2	53.1	60.6	67.7	73.1	77.9	82.3	86.4	90.1	92.8	96.1	98.7	100.4	102.4	104.4	106.0	107.4	110.5
1996	4.9	14.4	31.4	43.1	52.7	60.9	67.4	73.5	78.2	82.4	86.3	89.9	93.2	95.6	98.5	100.9	102.4	104.2	106.0	107.5	110.0
1997	4.8	14.7	31.2	43.2	52.6	60.5	67.6	73.2	78.5	82.6	86.3	89.8	93.0	96.0	98.1	100.7	102.8	104.2	105.8	107.4	109.5
1998	4.4	14.4	30.5	43.1	52.7	60.5	67.3	73.3	78.2	82.9	86.6	89.8	92.9	95.8	98.4	100.3	102.7	104.6	105.8	107.3	109.8
1999	4.1	13.3	29.9	42.6	52.6	60.6	67.2	73.1	78.4	82.7	86.8	90.1	93.0	95.7	98.3	100.6	102.3	104.4	106.2	107.3	110.1
2000	5.6	12.3	32.6	42.1	52.1	60.5	67.3	73.0	78.2	82.8	86.6	90.3	93.2	95.7	98.2	100.5	102.6	104.1	106.0	107.6	110.9
2001	5.2	16.7	32.0	44.2	51.8	60.1	67.2	73.1	78.1	82.6	86.7	90.1	93.4	95.9	98.2	100.4	102.5	104.4	105.8	107.5	111.4
2002	5.5	15.7	32.5	43.7	53.5	59.8	66.9	73.0	78.2	82.6	86.5	90.2	93.2	96.1	98.4	100.5	102.4	104.3	106.0	107.2	110.7
2003	5.1	16.5	31.7	44.1	53.1	61.3	66.6	72.8	78.1	82.6	86.5	90.0	93.3	95.9	98.5	100.6	102.5	104.2	105.9	107.4	111.2
2004	6.1	15.2	33.7	43.5	53.4	60.9	67.9	72.5	77.9	82.6	86.6	90.0	93.1	96.0	98.4	100.7	102.6	104.2	105.8	107.3	110.8
2005	4.8	18.2	31.3	45.0	52.9	61.2	67.6	73.6	77.7	82.4	86.5	90.1	93.1	95.9	98.5	100.6	102.7	104.4	105.9	107.3	111.1
2006	4.8	14.5	31.1	43.1	54.1	60.7	67.8	73.4	78.6	82.2	86.3	90.0	93.2	95.9	98.4	100.7	102.6	104.5	106.0	107.3	111.4
2007	4.3	14.3	30.3	43.0	52.6	61.8	67.4	73.6	78.4	83.0	86.2	89.8	93.1	95.9	98.4	100.6	102.7	104.4	106.1	107.4	112.0
2008	4.1	12.8	30.0	42.4	52.5	60.5	68.4	73.2	78.6	82.8	86.9	89.7	93.0	95.9	98.4	100.6	102.6	104.4	106.0	107.5	111.4
2009	4.4	12.4	30.5	42.2	52.0	60.4	67.2	74.0	78.3	83.0	86.7	90.4	92.8	95.7	98.4	100.6	102.5	104.3	106.0	107.4	110.5
2010	5.2	13.2	31.9	42.5	51.8	60.0	67.2	73.1	79.0	82.7	86.9	90.2	93.4	95.6	98.2	100.6	102.6	104.3	105.9	107.4	110.2
2011	4.2	15.5	30.2	43.6	52.1	59.8	66.8	73.0	78.1	83.3	86.7	90.3	93.3	96.2	98.1	100.5	102.6	104.4	105.9	107.4	110.4
2012	5.2	12.7	31.9	42.3	53.0	60.1	66.7	72.7	78.1	82.6	87.2	90.1	93.4	96.0	98.6	100.4	102.5	104.3	106.0	107.4	109.7
2013	4.7	15.5	31.1	43.6	51.9	60.9	66.9	72.6	77.8	82.6	86.5	90.6	93.2	96.1	98.5	100.8	102.4	104.2	105.9	107.4	110.1
2014	5.1	14.2	31.7	43.0	53.0	59.9	67.5	72.8	77.7	82.3	86.5	90.0	93.7	96.0	98.6	100.7	102.8	104.2	105.9	107.4	110.4
2015	6.5	15.3	34.4	43.5	52.5	60.8	66.7	73.3	77.9	82.2	86.3	90.0	93.1	96.4	98.4	100.8	102.7	104.5	105.8	107.3	110.5
2016	6.6	19.4	34.7	45.6	52.9	60.4	67.5	72.6	78.4	82.4	86.2	89.8	93.1	95.9	98.8	100.6	102.7	104.4	106.1	107.2	109.7
2017	6.0	19.7	33.6	45.8	54.6	60.8	67.2	73.3	77.8	82.8	86.3	89.7	92.9	95.9	98.4	101.0	102.6	104.5	106.0	107.5	110.1
2018	7.1	18.1	35.9	44.9	54.8	62.2	67.5	73.0	78.4	82.3	86.7	89.8	92.9	95.7	98.3	100.6	102.9	104.4	106.1	107.4	110.5
2019	4.3	21.4	30.2	46.7	54.1	62.4	68.7	73.3	78.1	82.8	86.2	90.2	93.0	95.6	98.2	100.6	102.6	104.6	106.0	107.5	110.2
2020	5.3	15.8	31.5	42.3	55.6	61.8	68.9	74.3	78.3	82.5	86.7	89.8	93.3	95.7	98.1	100.4	102.5	104.3	106.2	107.4	110.3

Table 2.1.19c. Mid-year length (cm) at age (Model 21.1).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.0	15.0	31.5	43.8	53.5	61.4	67.9	73.4	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.3
1978	4.8	15.0	31.2	43.8	53.5	61.4	67.9	73.4	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.3
1979	5.2	14.5	32.0	43.5	53.5	61.4	67.9	73.4	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.4
1980	4.9	15.6	31.3	44.1	53.3	61.4	67.9	73.4	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.4
1981	4.2	14.6	29.9	43.6	53.8	61.2	67.9	73.4	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.4
1982	4.4	12.7	30.4	42.5	53.3	61.6	67.8	73.4	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.5
1983	5.4	13.3	32.3	42.9	52.5	61.3	68.1	73.2	77.9	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.5
1984	5.2	16.2	32.0	44.4	52.8	60.6	67.8	73.5	77.8	81.7	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.5
1985	4.0	15.6	29.5	44.1	54.0	60.8	67.2	73.3	78.0	81.6	85.0	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.5
1986	5.0	12.0	31.6	42.2	53.8	61.8	67.4	72.8	77.8	81.8	84.9	87.7	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.5
1987	4.6	15.1	30.7	43.9	52.2	61.6	68.3	72.9	77.4	81.7	85.1	87.6	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.6
1988	4.4	13.8	30.3	43.1	53.6	60.4	68.1	73.6	77.6	81.3	84.9	87.8	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.6
1989	4.4	13.2	30.3	42.8	53.0	61.4	67.1	73.5	78.2	81.4	84.6	87.6	90.1	91.9	93.6	95.1	96.3	97.3	98.2	98.9	100.6
1990	4.8	13.2	31.1	42.8	52.7	61.0	68.0	72.6	78.0	81.9	84.7	87.4	90.0	92.0	93.6	95.1	96.3	97.3	98.2	98.9	100.6
1991	5.2	14.4	32.0	43.5	52.7	60.8	67.6	73.4	77.3	81.8	85.1	87.5	89.8	91.9	93.7	95.0	96.3	97.3	98.2	98.9	100.6
1992	5.0	15.7	31.5	44.2	53.2	60.8	67.4	73.1	77.9	81.2	85.1	87.8	89.8	91.8	93.6	95.1	96.2	97.3	98.2	98.9	100.6
1993	5.5	14.9	32.6	43.7	53.8	61.2	67.4	72.9	77.7	81.8	84.5	87.8	90.1	91.8	93.5	95.0	96.3	97.3	98.2	98.9	100.5
1994	4.8	16.6	31.1	44.6	53.5	61.7	67.8	72.9	77.5	81.5	85.0	87.3	90.1	92.1	93.5	94.9	96.2	97.3	98.1	98.9	100.3
1995	4.8	14.4	31.0	43.5	54.2	61.4	68.1	73.2	77.5	81.4	84.8	87.7	89.7	92.0	93.7	94.9	96.1	97.3	98.2	98.9	100.3
1996	4.9	14.3	31.3	43.4	53.2	62.0	67.9	73.5	77.8	81.4	84.7	87.5	90.0	91.7	93.7	95.1	96.2	97.2	98.1	98.9	100.1
1997	4.8	14.7	31.1	43.6	53.2	61.2	68.4	73.3	78.1	81.6	84.7	87.5	89.9	92.0	93.4	95.1	96.3	97.2	98.1	98.9	99.9
1998	4.5	14.4	30.5	43.5	53.3	61.2	67.8	73.7	77.9	81.9	84.9	87.5	89.8	91.9	93.6	94.9	96.3	97.3	98.1	98.8	100.1
1999	4.1	13.4	29.7	43.0	53.2	61.3	67.7	73.2	78.2	81.7	85.1	87.6	89.8	91.8	93.5	95.1	96.1	97.3	98.2	98.8	100.2
2000	5.6	12.3	32.8	42.3	52.8	61.2	67.8	73.2	77.8	82.0	85.0	87.8	89.9	91.8	93.5	95.0	96.3	97.1	98.2	98.9	100.5
2001	5.2	16.9	32.0	44.8	52.3	60.9	67.8	73.3	77.8	81.6	85.2	87.7	90.1	91.9	93.5	94.9	96.2	97.3	98.0	98.9	100.7
2002	5.4	15.7	32.4	44.2	54.3	60.4	67.5	73.2	77.8	81.6	84.9	87.9	90.0	92.0	93.6	94.9	96.2	97.2	98.2	98.8	100.3
2003	5.1	16.3	31.7	44.5	53.8	62.1	67.1	73.0	77.8	81.7	84.9	87.6	90.2	92.0	93.7	95.0	96.2	97.2	98.1	98.9	100.5
2004	6.1	15.2	33.8	43.9	54.1	61.6	68.5	72.7	77.6	81.6	84.9	87.6	89.9	92.1	93.6	95.1	96.2	97.2	98.1	98.9	100.3
2005	4.8	18.2	31.2	45.6	53.6	61.9	68.1	73.8	77.4	81.5	84.9	87.7	89.9	91.9	93.8	95.0	96.3	97.3	98.1	98.8	100.4
2006	4.7	14.5	31.0	43.5	54.9	61.5	68.3	73.5	78.3	81.3	84.7	87.6	90.0	91.9	93.6	95.2	96.3	97.3	98.1	98.8	100.6
2007	4.2	14.2	29.8	43.4	53.3	62.6	68.0	73.7	78.1	82.1	84.6	87.5	89.9	91.9	93.6	95.0	96.3	97.3	98.2	98.9	100.8
2008	4.1	12.5	29.7	42.5	53.1	61.2	68.9	73.4	78.2	81.9	85.2	87.4	89.8	91.9	93.6	95.0	96.2	97.4	98.2	98.9	100.6
2009	4.6	12.3	30.6	42.3	52.4	61.1	67.8	74.2	78.0	82.0	85.1	87.9	89.7	91.8	93.6	95.0	96.2	97.3	98.2	98.9	100.2
2010	5.2	13.7	31.9	43.1	52.3	60.5	67.7	73.2	78.6	81.8	85.2	87.8	90.2	91.7	93.5	95.0	96.2	97.2	98.1	99.0	100.1
2011	4.2	15.6	29.9	44.1	52.9	60.4	67.2	73.2	77.8	82.3	85.0	87.9	90.1	92.1	93.4	95.0	96.2	97.3	98.1	98.9	100.2
2012	5.1	12.6	31.8	42.5	53.7	60.9	67.1	72.8	77.7	81.7	85.5	87.7	90.1	92.0	93.8	94.9	96.2	97.3	98.1	98.9	99.9
2013	4.8	15.4	31.0	44.0	52.5	61.6	67.5	72.7	77.4	81.6	84.9	88.1	90.0	92.1	93.7	95.2	96.1	97.2	98.1	98.9	100.1
2014	5.2	14.2	31.9	43.4	53.7	60.6	68.1	73.0	77.4	81.3	84.8	87.6	90.4	92.0	93.7	95.1	96.4	97.2	98.1	98.9	100.3
2015	6.4	15.6	34.4	44.1	53.2	61.6	67.2	73.5	77.6	81.3	84.6	87.6	90.0	92.3	93.7	95.1	96.3	97.4	98.0	98.8	100.3
2016	6.4	19.1	34.5	46.0	53.7	61.1	68.1	72.8	78.0	81.5	84.6	87.4	89.9	91.9	93.9	95.1	96.3	97.3	98.2	98.8	100.0
2017	6.0	19.1	33.5	46.1	55.3	61.6	67.7	73.5	77.4	81.8	84.8	87.4	89.7	91.9	93.6	95.3	96.3	97.3	98.2	99.0	100.1
2018	7.1	17.9	36.1	45.3	55.3	62.9	68.1	73.2	78.0	81.3	85.0	87.5	89.7	91.8	93.6	95.0	96.4	97.3	98.2	98.9	100.3
2019	4.2	21.4	29.9	47.3	54.8	62.9	69.2	73.5	77.8	81.8	84.6	87.8	89.9	91.7	93.4	95.0	96.2	97.4	98.2	98.9	100.1
2020	5.0	15.0	31.4	42.5	56.4	62.4	69.2	74.4	78.0	81.6	85.0	87.4	90.1	91.9	93.4	94.9	96.2	97.3	98.3	98.9	100.2

Table 2.1.19d. Mid-year length (cm) at age (Model 21.2).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.4	16.1	32.4	44.0	53.2	60.8	67.2	72.8	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	108.1
1978	4.8	16.1	31.4	44.0	53.2	60.8	67.2	72.8	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	108.1
1979	5.2	14.4	32.1	43.2	53.2	60.8	67.2	72.8	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.9
1980	4.9	15.7	31.4	43.7	52.5	60.8	67.2	72.8	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.7
1981	4.2	14.6	30.3	43.2	53.0	60.2	67.2	72.8	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.7
1982	4.3	12.7	30.5	42.4	52.5	60.6	66.8	72.8	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.6
1983	5.3	13.0	32.3	42.5	51.9	60.3	67.1	72.4	77.6	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.6
1984	5.3	16.0	32.2	43.9	52.0	59.7	66.8	72.7	77.3	81.9	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.6
1985	3.9	15.8	29.8	43.8	53.1	59.8	66.3	72.4	77.5	81.5	85.6	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.6
1986	5.0	11.8	31.7	42.0	53.0	60.7	66.4	72.0	77.3	81.8	85.3	88.8	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.7
1987	4.5	15.0	30.7	43.4	51.6	60.7	67.2	72.1	76.9	81.6	85.5	88.6	91.7	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.7
1988	4.2	13.4	30.3	42.7	52.7	59.4	67.2	72.8	77.0	81.3	85.3	88.8	91.5	94.3	96.6	98.6	100.4	102.1	103.5	104.8	107.8
1989	4.3	12.6	30.5	42.4	52.1	60.4	66.1	72.7	77.6	81.3	85.0	88.6	91.7	94.1	96.6	98.6	100.4	102.1	103.5	104.8	107.8
1990	4.8	13.0	31.3	42.5	51.8	59.9	66.9	71.8	77.6	81.8	85.1	88.4	91.5	94.3	96.4	98.6	100.4	102.1	103.5	104.8	107.8
1991	5.2	14.3	32.2	43.1	52.0	59.7	66.5	72.5	76.8	81.8	85.5	88.4	91.3	94.1	96.5	98.5	100.4	102.1	103.5	104.8	107.8
1992	4.9	15.7	31.6	43.8	52.4	59.8	66.3	72.2	77.4	81.1	85.5	88.8	91.3	93.9	96.4	98.6	100.3	102.1	103.5	104.8	107.7
1993	5.3	14.8	32.2	43.3	53.0	60.2	66.4	72.0	77.1	81.7	84.9	88.8	91.7	94.0	96.3	98.5	100.4	101.9	103.5	104.8	107.5
1994	4.7	15.9	31.2	43.8	52.6	60.6	66.7	72.1	76.9	81.4	85.4	88.3	91.7	94.3	96.3	98.3	100.3	102.0	103.4	104.8	107.1
1995	4.7	14.2	31.1	43.1	53.1	60.3	67.1	72.4	77.0	81.2	85.1	88.7	91.2	94.3	96.6	98.4	100.2	101.9	103.5	104.7	107.2
1996	4.8	14.0	31.4	43.0	52.4	60.7	66.9	72.7	77.2	81.3	85.0	88.5	91.6	93.8	96.6	98.6	100.2	101.8	103.4	104.8	106.7
1997	4.2	14.5	30.3	43.2	52.3	60.2	67.2	72.5	77.5	81.5	85.1	88.4	91.4	94.2	96.2	98.6	100.4	101.8	103.3	104.7	106.4
1998	4.5	12.7	30.8	42.4	52.5	60.1	66.7	72.7	77.4	81.8	85.3	88.4	91.3	94.0	96.5	98.3	100.4	102.1	103.3	104.6	106.8
1999	4.0	13.4	30.0	42.7	51.9	60.2	66.7	72.3	77.6	81.6	85.5	88.6	91.4	93.9	96.3	98.5	100.1	102.0	103.5	104.6	106.9
2000	5.6	12.1	32.8	42.1	52.1	59.7	66.8	72.3	77.2	81.8	85.3	88.8	91.5	94.0	96.3	98.4	100.4	101.8	103.5	104.8	107.6
2001	5.0	16.7	31.8	44.2	51.6	59.9	66.3	72.4	77.2	81.5	85.5	88.6	91.7	94.1	96.3	98.3	100.2	102.0	103.2	104.8	107.9
2002	5.4	15.1	32.4	43.5	53.4	59.5	66.5	72.0	77.3	81.5	85.3	88.8	91.6	94.3	96.4	98.4	100.2	101.9	103.4	104.6	107.0
2003	5.0	16.1	31.7	43.9	52.7	61.0	66.2	72.2	76.9	81.6	85.2	88.6	91.7	94.2	96.5	98.5	100.2	101.8	103.3	104.7	107.5
2004	6.1	15.0	33.9	43.4	53.1	60.4	67.4	71.9	77.1	81.2	85.3	88.5	91.5	94.3	96.5	98.6	100.3	101.8	103.3	104.7	107.0
2005	4.8	18.4	31.4	45.1	52.7	60.8	67.0	72.9	76.8	81.4	85.0	88.6	91.5	94.1	96.6	98.5	100.4	101.9	103.3	104.6	107.3
2006	4.7	14.4	31.2	43.2	54.1	60.4	67.2	72.6	77.8	81.1	85.1	88.4	91.5	94.1	96.4	98.6	100.3	102.0	103.4	104.6	107.6
2007	4.3	14.2	30.4	43.1	52.5	61.6	66.9	72.8	77.4	82.0	84.9	88.5	91.3	94.1	96.4	98.5	100.4	102.0	103.5	104.7	108.1
2008	4.1	12.8	30.1	42.4	52.4	60.2	67.9	72.5	77.6	81.7	85.7	88.3	91.4	93.9	96.4	98.4	100.3	102.0	103.4	104.8	107.3
2009	4.4	12.3	30.6	42.2	51.9	60.2	66.8	73.4	77.4	81.8	85.4	88.9	91.2	94.0	96.3	98.5	100.3	101.9	103.5	104.7	106.7
2010	5.2	13.2	32.1	42.6	51.7	59.7	66.7	72.4	78.1	81.6	85.6	88.7	91.8	93.9	96.3	98.3	100.3	101.9	103.4	104.8	106.7
2011	4.2	15.6	30.3	43.7	52.0	59.6	66.4	72.4	77.3	82.3	85.4	88.8	91.6	94.4	96.2	98.4	100.2	101.9	103.4	104.7	106.9
2012	4.9	12.6	31.5	42.3	53.0	59.8	66.2	72.0	77.2	81.5	86.0	88.7	91.7	94.2	96.6	98.3	100.2	101.8	103.4	104.7	106.5
2013	4.7	14.7	31.1	43.3	51.8	60.6	66.4	71.9	77.0	81.5	85.3	89.2	91.6	94.3	96.5	98.7	100.1	101.9	103.3	104.7	106.9
2014	4.9	14.0	31.6	43.0	52.6	59.7	67.1	72.1	76.9	81.3	85.3	88.6	92.0	94.2	96.6	98.5	100.5	101.8	103.3	104.6	107.1
2015	6.4	14.8	34.3	43.3	52.4	60.3	66.3	72.7	77.0	81.2	85.1	88.6	91.5	94.6	96.5	98.6	100.4	102.1	103.3	104.7	107.2
2016	6.4	19.1	34.3	45.4	52.6	60.1	66.8	72.0	77.5	81.3	85.0	88.4	91.5	94.1	96.8	98.5	100.4	102.0	103.5	104.6	106.6
2017	6.0	19.1	33.5	45.4	54.4	60.3	66.7	72.5	76.9	81.8	85.1	88.3	91.3	94.1	96.4	98.8	100.3	102.1	103.4	104.8	106.9
2018	7.2	17.9	35.9	44.8	54.4	61.8	66.9	72.3	77.3	81.2	85.5	88.4	91.3	93.9	96.4	98.5	100.6	102.0	103.5	104.7	107.2
2019	4.2	21.5	30.3	46.7	53.9	61.8	68.1	72.5	77.2	81.6	85.0	88.8	91.4	93.9	96.3	98.5	100.3	102.2	103.4	104.8	106.7
2020	5.4	16.1	31.5	42.4	55.4	61.4	68.1	73.6	77.4	81.5	85.3	88.4	91.7	94.0	96.2	98.3	100.3	101.9	103.7	104.7	106.8

Table 2.1.19e. Mid-year length (cm) at age (Model 21.3).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	5.3	15.9	32.0	43.7	53.1	60.9	67.6	73.4	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.3
1978	4.9	15.9	31.3	43.7	53.1	60.9	67.6	73.4	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.3
1979	5.4	14.7	32.2	43.1	53.1	60.9	67.6	73.4	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.1
1980	4.9	16.1	31.3	43.8	52.6	60.9	67.6	73.4	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.0
1981	4.2	14.8	29.9	43.1	53.1	60.5	67.6	73.4	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	111.9
1982	4.3	12.5	30.1	42.1	52.6	61.0	67.3	73.4	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	111.9
1983	6.2	12.9	33.7	42.2	51.7	60.5	67.7	73.1	78.5	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	111.9
1984	5.3	18.5	32.0	45.0	51.8	59.8	67.3	73.5	78.3	83.0	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	111.9
1985	3.9	15.9	29.5	43.7	54.1	59.9	66.6	73.1	78.6	82.8	87.0	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.0
1986	5.1	11.7	31.7	41.7	53.1	61.8	66.7	72.6	78.3	83.1	86.8	90.5	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.0
1987	4.7	15.3	30.8	43.4	51.4	60.9	68.4	72.7	77.8	82.8	87.0	90.3	93.7	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.1
1988	4.4	13.9	30.3	42.7	52.8	59.5	67.6	74.1	77.9	82.4	86.8	90.6	93.5	96.5	99.0	101.3	103.3	105.1	106.8	108.3	112.2
1989	4.4	13.2	30.4	42.4	52.3	60.7	66.4	73.4	79.1	82.4	86.4	90.3	93.7	96.3	99.0	101.3	103.3	105.1	106.8	108.3	112.3
1990	5.0	13.3	31.4	42.4	52.0	60.2	67.4	72.4	78.5	83.6	86.5	90.0	93.5	96.5	98.9	101.3	103.3	105.1	106.8	108.3	112.3
1991	5.6	15.0	32.5	43.2	52.0	60.0	67.0	73.3	77.6	83.0	87.5	90.1	93.2	96.3	99.0	101.2	103.3	105.1	106.8	108.3	112.3
1992	5.0	16.7	31.4	44.1	52.7	60.0	66.8	72.9	78.4	82.2	87.0	91.0	93.3	96.1	98.9	101.3	103.2	105.1	106.8	108.3	112.2
1993	5.2	14.9	31.8	43.2	53.4	60.6	66.9	72.7	78.1	82.9	86.3	90.5	94.1	96.1	98.6	101.2	103.3	105.0	106.8	108.3	111.9
1994	5.0	15.5	31.4	43.5	52.6	61.2	67.3	72.8	77.9	82.6	86.9	89.9	93.7	96.8	98.7	100.9	103.2	105.1	106.7	108.3	111.4
1995	4.9	14.9	31.2	43.2	52.9	60.5	67.8	73.2	78.0	82.5	86.6	90.4	93.1	96.5	99.3	101.0	103.0	105.0	106.8	108.2	111.5
1996	4.9	14.6	31.3	43.0	52.6	60.8	67.3	73.6	78.3	82.5	86.5	90.2	93.6	96.0	99.0	101.5	103.0	104.9	106.7	108.3	110.9
1997	4.9	14.8	31.2	43.1	52.5	60.6	67.5	73.2	78.7	82.8	86.5	90.1	93.4	96.4	98.6	101.3	103.6	104.9	106.5	108.2	110.4
1998	4.5	14.6	30.5	43.0	52.6	60.4	67.3	73.3	78.3	83.2	86.8	90.1	93.3	96.2	98.9	100.9	103.3	105.4	106.6	108.0	110.7
1999	4.1	13.4	29.8	42.5	52.5	60.5	67.2	73.2	78.4	82.8	87.1	90.4	93.3	96.2	98.8	101.2	102.9	105.1	107.0	108.1	111.0
2000	5.5	12.4	32.5	42.0	52.1	60.4	67.3	73.1	78.3	82.9	86.8	90.6	93.5	96.2	98.7	101.1	103.2	104.8	106.8	108.4	111.9
2001	5.3	16.6	31.9	44.0	51.6	60.1	67.2	73.1	78.2	82.8	86.9	90.4	93.8	96.4	98.7	101.0	103.1	105.1	106.5	108.3	112.4
2002	5.5	15.8	32.4	43.6	53.3	59.7	66.9	73.1	78.3	82.8	86.8	90.5	93.5	96.6	98.9	101.0	103.1	105.0	106.7	108.0	111.7
2003	5.1	16.5	31.6	44.0	53.0	61.1	66.6	72.8	78.2	82.8	86.8	90.4	93.6	96.4	99.1	101.2	103.1	104.9	106.6	108.2	112.3
2004	6.1	15.2	33.5	43.3	53.3	60.8	67.8	72.5	78.0	82.8	86.8	90.3	93.5	96.4	98.9	101.3	103.2	104.9	106.6	108.1	111.8
2005	4.9	18.2	31.2	44.9	52.8	61.1	67.6	73.6	77.7	82.5	86.8	90.4	93.5	96.4	99.0	101.2	103.4	105.1	106.6	108.1	112.1
2006	4.8	14.6	31.0	43.0	54.0	60.7	67.8	73.4	78.7	82.3	86.6	90.3	93.5	96.3	98.9	101.2	103.2	105.2	106.7	108.1	112.5
2007	4.4	14.3	30.2	42.9	52.5	61.7	67.4	73.6	78.5	83.2	86.4	90.1	93.5	96.4	98.9	101.2	103.3	105.0	106.8	108.2	113.1
2008	4.2	13.1	30.0	42.3	52.4	60.4	68.3	73.3	78.7	83.0	87.1	90.0	93.3	96.3	98.9	101.1	103.2	105.1	106.7	108.3	112.6
2009	4.4	12.7	30.4	42.1	51.9	60.4	67.2	74.1	78.4	83.1	87.0	90.6	93.2	96.2	98.9	101.2	103.2	105.0	106.7	108.2	111.6
2010	5.2	13.2	31.8	42.4	51.8	59.9	67.1	73.1	79.1	82.9	87.1	90.5	93.8	96.1	98.7	101.1	103.2	105.0	106.7	108.2	111.2
2011	4.3	15.6	30.1	43.5	52.0	59.8	66.8	73.0	78.2	83.5	86.9	90.6	93.7	96.6	98.6	101.0	103.2	105.0	106.7	108.2	111.5
2012	5.2	12.9	31.9	42.2	52.9	60.0	66.7	72.7	78.2	82.7	87.4	90.4	93.8	96.5	99.1	100.9	103.1	105.0	106.7	108.2	110.7
2013	4.8	15.7	31.1	43.6	51.8	60.8	66.8	72.6	77.9	82.7	86.8	90.9	93.6	96.6	99.0	101.3	103.0	104.9	106.7	108.2	111.1
2014	5.1	14.4	31.6	42.9	53.0	59.9	67.5	72.8	77.8	82.5	86.7	90.3	94.0	96.4	99.1	101.3	103.4	104.8	106.6	108.2	111.4
2015	6.5	15.3	34.4	43.4	52.4	60.8	66.7	73.4	77.9	82.4	86.5	90.3	93.5	96.8	98.9	101.3	103.3	105.2	106.5	108.1	111.5
2016	6.7	19.5	34.8	45.6	52.8	60.4	67.5	72.7	78.5	82.5	86.4	90.1	93.5	96.3	99.3	101.2	103.4	105.1	106.8	108.0	110.6
2017	6.1	20.1	33.5	45.9	54.6	60.7	67.2	73.4	77.9	83.0	86.5	90.0	93.3	96.3	98.9	101.5	103.2	105.2	106.8	108.3	111.0
2018	7.1	18.2	35.8	44.8	54.9	62.2	67.4	73.0	78.5	82.4	86.9	90.1	93.2	96.1	98.8	101.1	103.5	105.1	106.8	108.3	111.5
2019	4.2	21.4	30.0	46.6	54.0	62.4	68.8	73.3	78.2	83.0	86.5	90.5	93.3	96.1	98.7	101.1	103.2	105.3	106.7	108.3	111.2
2020	5.3	15.9	31.5	42.1	55.5	61.7	68.9	74.4	78.4	82.7	87.0	90.1	93.6	96.2	98.7	101.0	103.2	105.0	107.0	108.2	111.3

Table 2.1.19f. Mid-year length (cm) at age (ensemble).

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	15.7	32.0	43.8	53.2	61.0	67.6	73.3	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	108.0
1978	4.9	15.7	31.3	43.8	53.2	61.0	67.6	73.3	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	108.0
1979	5.3	14.6	32.1	43.3	53.2	61.0	67.6	73.3	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.8
1980	4.9	15.9	31.4	43.9	52.8	61.0	67.6	73.3	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.7
1981	4.2	14.7	30.1	43.3	53.3	60.7	67.6	73.3	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.7
1982	4.3	12.6	30.3	42.3	52.8	61.1	67.3	73.3	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.7
1983	5.7	13.0	32.9	42.5	52.0	60.7	67.7	73.0	78.2	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.7
1984	5.3	17.0	32.1	44.5	52.2	60.0	67.4	73.3	77.9	82.4	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.7
1985	3.9	15.8	29.6	43.9	53.8	60.2	66.8	73.0	78.2	82.2	86.1	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.7
1986	5.1	11.8	31.7	42.0	53.3	61.5	66.9	72.6	78.0	82.5	86.0	89.4	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.8
1987	4.6	15.2	30.8	43.6	51.7	61.1	68.0	72.6	77.5	82.2	86.2	89.2	92.3	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.8
1988	4.3	13.7	30.3	42.8	53.0	59.8	67.7	73.6	77.6	81.9	86.0	89.4	92.1	94.8	97.0	99.0	100.7	102.3	103.7	104.9	107.9
1989	4.4	13.0	30.4	42.5	52.4	60.9	66.6	73.3	78.5	81.9	85.6	89.2	92.3	94.6	97.0	99.0	100.7	102.3	103.7	104.9	107.9
1990	4.9	13.2	31.3	42.6	52.2	60.4	67.5	72.4	78.2	82.7	85.7	89.0	92.1	94.8	96.9	99.0	100.7	102.3	103.7	104.9	108.0
1991	5.3	14.6	32.2	43.3	52.2	60.2	67.1	73.2	77.4	82.4	86.4	89.0	91.9	94.7	97.0	98.9	100.7	102.3	103.7	104.9	108.0
1992	5.0	16.0	31.5	44.0	52.8	60.2	66.9	72.8	78.1	81.7	86.2	89.6	91.9	94.4	96.9	99.0	100.6	102.3	103.7	104.9	107.9
1993	5.3	14.9	32.2	43.4	53.4	60.7	66.9	72.6	77.8	82.3	85.5	89.4	92.4	94.5	96.7	98.9	100.7	102.2	103.7	104.9	107.6
1994	4.8	15.9	31.3	43.9	52.9	61.2	67.3	72.7	77.6	82.1	86.0	88.8	92.3	94.9	96.7	98.7	100.6	102.3	103.6	104.9	107.3
1995	4.8	14.5	31.1	43.2	53.3	60.8	67.7	73.0	77.6	81.9	85.8	89.3	91.8	94.8	97.1	98.7	100.5	102.2	103.7	104.8	107.4
1996	4.9	14.3	31.4	43.1	52.8	61.1	67.4	73.4	77.9	82.0	85.7	89.1	92.2	94.4	97.0	99.1	100.5	102.1	103.6	104.9	106.9
1997	4.7	14.7	31.1	43.3	52.7	60.6	67.7	73.1	78.3	82.2	85.7	89.0	92.0	94.7	96.6	99.0	100.8	102.1	103.5	104.8	106.6
1998	4.4	14.2	30.5	43.1	52.8	60.6	67.3	73.3	78.0	82.5	86.0	89.0	91.9	94.6	96.9	98.6	100.7	102.4	103.5	104.7	106.9
1999	4.1	13.3	29.9	42.7	52.6	60.7	67.2	73.0	78.2	82.3	86.2	89.2	91.9	94.5	96.8	98.9	100.4	102.3	103.8	104.7	107.0
2000	5.6	12.2	32.7	42.1	52.3	60.5	67.4	73.0	77.9	82.5	86.0	89.4	92.1	94.5	96.7	98.8	100.7	102.0	103.7	105.0	107.7
2001	5.2	16.7	32.0	44.3	51.9	60.3	67.2	73.0	77.9	82.2	86.2	89.3	92.3	94.6	96.8	98.7	100.6	102.2	103.4	104.9	108.1
2002	5.5	15.6	32.5	43.8	53.7	59.9	67.0	72.9	78.0	82.2	85.9	89.4	92.1	94.8	96.9	98.8	100.5	102.1	103.6	104.7	107.4
2003	5.1	16.4	31.7	44.2	53.2	61.4	66.7	72.7	77.9	82.2	85.9	89.2	92.3	94.7	97.0	98.9	100.5	102.1	103.5	104.9	107.8
2004	6.1	15.2	33.7	43.6	53.5	61.0	68.0	72.5	77.7	82.2	86.0	89.2	92.1	94.8	96.9	99.0	100.6	102.1	103.5	104.8	107.4
2005	4.8	18.3	31.3	45.1	53.0	61.3	67.6	73.6	77.5	82.0	85.9	89.2	92.1	94.6	97.0	98.9	100.8	102.2	103.5	104.7	107.7
2006	4.7	14.5	31.1	43.2	54.3	60.9	67.8	73.3	78.4	81.8	85.8	89.2	92.1	94.6	96.9	99.0	100.7	102.3	103.6	104.8	108.0
2007	4.2	14.2	30.1	43.1	52.8	62.0	67.5	73.5	78.2	82.6	85.6	89.1	92.1	94.7	96.9	98.9	100.7	102.2	103.7	104.8	108.5
2008	4.1	12.7	29.9	42.4	52.6	60.6	68.4	73.2	78.3	82.4	86.3	88.9	92.0	94.6	96.9	98.8	100.6	102.3	103.6	104.9	107.9
2009	4.5	12.4	30.5	42.2	52.1	60.5	67.3	74.0	78.1	82.6	86.1	89.5	91.8	94.5	96.9	98.9	100.6	102.2	103.7	104.8	107.2
2010	5.2	13.4	31.9	42.7	51.9	60.1	67.2	73.0	78.8	82.3	86.3	89.4	92.4	94.4	96.8	98.8	100.6	102.2	103.6	104.9	107.0
2011	4.2	15.6	30.1	43.8	52.3	59.9	66.8	72.9	77.9	82.9	86.1	89.5	92.2	94.9	96.7	98.8	100.6	102.2	103.6	104.8	107.2
2012	5.1	12.6	31.8	42.3	53.2	60.3	66.7	72.6	77.9	82.2	86.6	89.3	92.3	94.8	97.1	98.7	100.5	102.2	103.6	104.8	106.7
2013	4.7	15.3	31.1	43.6	52.0	61.0	67.0	72.5	77.6	82.2	85.9	89.8	92.2	94.8	97.0	99.1	100.5	102.1	103.6	104.8	107.1
2014	5.1	14.2	31.8	43.1	53.1	60.0	67.6	72.7	77.5	81.9	85.9	89.2	92.6	94.7	97.1	99.0	100.8	102.0	103.5	104.8	107.3
2015	6.4	15.3	34.4	43.6	52.6	60.9	66.8	73.3	77.7	81.8	85.7	89.2	92.1	95.1	96.9	99.0	100.7	102.3	103.5	104.8	107.3
2016	6.5	19.3	34.6	45.7	53.1	60.5	67.5	72.6	78.2	82.0	85.6	89.0	92.1	94.6	97.3	98.9	100.8	102.3	103.7	104.7	106.7
2017	6.0	19.5	33.5	45.8	54.8	60.9	67.2	73.2	77.5	82.4	85.8	88.9	91.9	94.6	96.9	99.2	100.7	102.3	103.7	104.9	107.0
2018	7.1	18.0	35.9	45.0	54.9	62.3	67.5	72.9	78.1	81.9	86.1	89.1	91.8	94.4	96.9	98.9	100.9	102.2	103.7	104.9	107.3
2019	4.2	21.4	30.1	46.9	54.2	62.4	68.7	73.2	77.9	82.4	85.6	89.4	92.0	94.4	96.7	98.8	100.6	102.5	103.6	104.9	107.0

Table 2.1.20a. Mid-year weight (kg) at age in the fishery (Model 19.12a).

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	0.59	1.38	2.31	3.29	4.26	5.24	6.27	7.34	8.39	9.39	10.34	11.22	12.03	12.77	13.44	14.04	14.58	15.06	16.18
1978	0.00	0.06	0.49	1.30	2.26	3.30	4.33	5.41	6.56	7.76	8.95	10.10	11.19	12.21	13.15	14.01	14.80	15.51	16.15	16.72	18.05
1979	0.01	0.06	0.57	1.31	2.29	3.27	4.24	5.24	6.28	7.36	8.43	9.45	10.40	11.30	12.12	12.87	13.55	14.16	14.71	15.20	16.28
1980	0.00	0.07	0.51	1.30	2.17	3.18	4.15	5.14	6.18	7.26	8.33	9.35	10.32	11.22	12.05	12.81	13.50	14.12	14.68	15.17	16.23
1981	0.00	0.06	0.46	1.24	2.18	3.08	4.09	5.06	6.09	7.14	8.18	9.17	10.11	10.98	11.78	12.52	13.18	13.78	14.32	14.80	15.79
1982	0.00	0.04	0.54	1.31	2.33	3.36	4.28	5.32	6.37	7.44	8.49	9.51	10.46	11.34	12.15	12.90	13.57	14.18	14.72	15.21	16.20
1983	0.01	0.04	0.60	1.29	2.23	3.33	4.40	5.39	6.54	7.67	8.79	9.87	10.88	11.82	12.69	13.49	14.21	14.86	15.45	15.97	17.04
1984	0.01	0.10	0.60	1.36	2.09	2.94	3.87	4.77	5.60	6.53	7.39	8.22	8.98	9.69	10.34	10.93	11.47	11.95	12.38	12.76	13.55
1985	0.00	0.07	0.47	1.39	2.39	3.28	4.30	5.45	6.64	7.74	8.96	10.08	11.13	12.12	13.03	13.86	14.62	15.31	15.92	16.47	17.61
1986	0.00	0.03	0.51	1.18	2.29	3.38	4.29	5.36	6.63	7.92	9.06	10.29	11.40	12.43	13.39	14.26	15.06	15.78	16.43	17.01	18.22
1987	0.00	0.06	0.52	1.36	2.19	3.36	4.39	5.27	6.34	7.57	8.74	9.76	10.82	11.77	12.64	13.44	14.17	14.82	15.41	15.93	17.04
1988	0.01	0.04	0.43	1.21	2.25	3.19	4.51	5.70	6.75	8.00	9.37	10.64	11.72	12.85	13.84	14.75	15.57	16.32	16.99	17.59	18.88
1989	0.00	0.04	0.48	1.27	2.29	3.45	4.41	5.75	6.99	8.05	9.26	10.56	11.74	12.72	13.74	14.63	15.43	16.16	16.81	17.39	18.67
1990	0.00	0.05	0.57	1.33	2.29	3.36	4.47	5.38	6.68	7.84	8.80	9.86	10.97	11.96	12.78	13.63	14.35	15.00	15.59	16.11	17.27
1991	0.01	0.06	0.58	1.31	2.18	3.13	4.12	5.16	6.03	7.26	8.32	9.16	10.09	11.04	11.88	12.57	13.27	13.87	14.41	14.88	15.94
1992	0.00	0.07	0.53	1.31	2.16	3.04	3.96	4.93	6.00	6.89	8.10	9.11	9.90	10.76	11.64	12.41	13.03	13.66	14.20	14.68	15.70
1993	0.01	0.07	0.60	1.37	2.39	3.38	4.36	5.41	6.55	7.76	8.73	9.98	11.02	11.81	12.67	13.53	14.28	14.88	15.49	16.00	17.00
1994	0.00	0.08	0.52	1.35	2.23	3.25	4.18	5.12	6.16	7.28	8.43	9.32	10.46	11.39	12.10	12.86	13.62	14.28	14.81	15.34	16.18
1995	0.00	0.05	0.49	1.25	2.26	3.22	4.27	5.25	6.28	7.41	8.57	9.73	10.61	11.73	12.64	13.32	14.05	14.78	15.40	15.90	16.87
1996	0.01	0.06	0.61	1.39	2.31	3.32	4.20	5.17	6.08	6.99	7.95	8.90	9.82	10.51	11.37	12.06	12.57	13.12	13.65	14.11	14.74
1997	0.01	0.06	0.49	1.23	2.08	3.01	4.02	4.92	5.96	6.92	7.85	8.81	9.74	10.63	11.30	12.13	12.79	13.28	13.80	14.31	14.89
1998	0.00	0.06	0.49	1.26	2.14	3.03	3.94	4.93	5.85	6.88	7.80	8.67	9.55	10.40	11.21	11.81	12.54	13.12	13.55	14.00	14.72
1999	0.00	0.05	0.48	1.26	2.21	3.18	4.10	5.07	6.17	7.15	8.22	9.15	10.02	10.88	11.70	12.48	13.05	13.75	14.29	14.69	15.50
2000	0.01	0.04	0.65	1.31	2.30	3.35	4.35	5.34	6.41	7.60	8.62	9.70	10.62	11.47	12.31	13.11	13.85	14.40	15.06	15.57	16.58
2001	0.01	0.10	0.61	1.47	2.22	3.21	4.19	5.14	6.11	7.15	8.27	9.19	10.15	10.96	11.70	12.41	13.09	13.71	14.16	14.71	15.79
2002	0.01	0.07	0.58	1.34	2.33	3.10	4.09	5.08	6.12	7.18	8.27	9.40	10.31	11.25	12.03	12.74	13.42	14.06	14.65	15.08	15.97
2003	0.00	0.08	0.53	1.34	2.24	3.29	4.06	5.11	6.22	7.34	8.41	9.47	10.55	11.42	12.30	13.04	13.71	14.35	14.94	15.49	16.52
2004	0.01	0.07	0.65	1.33	2.29	3.23	4.25	5.01	6.08	7.19	8.24	9.22	10.16	11.10	11.86	12.62	13.25	13.81	14.35	14.84	15.67
2005	0.00	0.11	0.52	1.44	2.25	3.31	4.27	5.37	6.22	7.38	8.53	9.61	10.58	11.52	12.44	13.18	13.92	14.53	15.07	15.59	16.60
2006	0.00	0.06	0.53	1.32	2.42	3.26	4.30	5.27	6.39	7.24	8.35	9.42	10.40	11.27	12.11	12.93	13.58	14.22	14.75	15.21	16.30
2007	0.00	0.05	0.49	1.32	2.28	3.46	4.32	5.41	6.45	7.63	8.49	9.59	10.64	11.58	12.41	13.21	13.98	14.58	15.18	15.66	16.94
2008	0.00	0.04	0.49	1.25	2.23	3.22	4.34	5.17	6.25	7.29	8.42	9.22	10.23	11.17	12.01	12.75	13.43	14.10	14.62	15.13	16.05
2009	0.00	0.03	0.53	1.28	2.23	3.30	4.27	5.44	6.36	7.56	8.65	9.82	10.63	11.64	12.58	13.40	14.12	14.79	15.43	15.93	16.71
2010	0.00	0.03	0.60	1.33	2.22	3.19	4.19	5.15	6.37	7.31	8.46	9.48	10.53	11.26	12.15	12.98	13.69	14.32	14.89	15.45	16.15
2011	0.00	0.05	0.50	1.38	2.22	3.12	4.07	5.09	6.13	7.40	8.30	9.38	10.31	11.26	11.92	12.72	13.45	14.09	14.64	15.14	15.97
2012	0.00	0.04	0.58	1.25	2.24	3.07	3.92	4.84	5.86	6.86	8.01	8.80	9.72	10.50	11.30	11.83	12.49	13.08	13.59	14.03	14.61
2013	0.00	0.06	0.51	1.30	2.11	3.20	4.06	4.98	6.02	7.18	8.28	9.50	10.33	11.29	12.10	12.91	13.46	14.13	14.72	15.24	16.05
2014	0.00	0.03	0.54	1.27	2.23	3.08	4.14	5.01	5.99	7.10	8.29	9.38	10.57	11.36	12.28	13.04	13.81	14.32	14.94	15.49	16.42
2015	0.00	0.04	0.65	1.30	2.16	3.14	3.96	5.03	5.96	6.98	8.07	9.20	10.20	11.29	12.01	12.84	13.52	14.20	14.65	15.20	16.15
2016	0.00	0.09	0.67	1.49	2.26	3.17	4.15	5.01	6.19	7.18	8.21	9.28	10.35	11.30	12.32	12.99	13.74	14.37	14.98	15.39	16.12
2017	0.00	0.10	0.63	1.50	2.45	3.25	4.17	5.22	6.16	7.43	8.43	9.45	10.50	11.53	12.43	13.39	14.01	14.72	15.29	15.86	16.64
2018	0.01	0.09	0.74	1.42	2.42	3.40	4.19	5.14	6.24	7.20	8.43	9.37	10.31	11.25	12.17	12.96	13.79	14.33	14.93	15.42	16.32
2019	0.00	0.16	0.47	1.58	2.38	3.46	4.45	5.29	6.32	7.51	8.51	9.76	10.70	11.61	12.52	13.41	14.16	14.95	15.46	16.02	16.79
2020	0.00	0.03	0.49	1.15	2.42	3.22	4.26	5.27	6.13	7.16	8.30	9.22	10.35	11.18	11.99	12.79	13.56	14.22	14.89	15.33	16.15

Table 2.1.20b. Mid-year weight (kg) at age in the 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	2.28	3.26	4.26	5.31	6.40	7.52	8.61	9.62	10.52	11.30	11.96	12.52	13.00	13.42	13.79	14.11	14.77
1978	0.00	0.06	0.49	1.28	2.23	3.26	4.34	5.49	6.71	7.96	9.20	10.36	11.39	12.29	13.06	13.71	14.28	14.77	15.20	15.58	16.36
1979	0.01	0.06	0.57	1.29	2.25	3.24	4.25	5.31	6.42	7.55	8.65	9.68	10.59	11.37	12.05	12.62	13.11	13.53	13.90	14.23	14.86
1980	0.00	0.07	0.51	1.28	2.13	3.15	4.15	5.20	6.31	7.44	8.55	9.58	10.50	11.29	11.97	12.55	13.05	13.48	13.85	14.19	14.79
1981	0.00	0.06	0.45	1.22	2.15	3.05	4.09	5.13	6.21	7.32	8.40	9.40	10.29	11.06	11.71	12.27	12.75	13.16	13.53	13.85	14.42
1982	0.00	0.04	0.53	1.28	2.28	3.33	4.28	5.39	6.49	7.62	8.72	9.73	10.64	11.42	12.08	12.65	13.14	13.56	13.92	14.25	14.83
1983	0.01	0.04	0.63	1.27	2.19	3.29	4.40	5.44	6.66	7.85	9.02	10.10	11.07	11.90	12.61	13.22	13.74	14.19	14.59	14.94	15.56
1984	0.01	0.12	0.59	1.38	2.05	2.90	3.86	4.81	5.68	6.67	7.57	8.40	9.13	9.76	10.29	10.75	11.13	11.47	11.76	12.02	12.48
1985	0.00	0.07	0.47	1.36	2.40	3.23	4.28	5.50	6.77	7.92	9.20	10.33	11.33	12.20	12.94	13.58	14.12	14.60	15.01	15.38	16.05
1986	0.00	0.03	0.50	1.15	2.25	3.39	4.27	5.42	6.77	8.12	9.31	10.55	11.60	12.51	13.29	13.96	14.53	15.03	15.46	15.85	16.57
1987	0.00	0.06	0.52	1.33	2.13	3.31	4.45	5.31	6.45	7.74	8.97	9.99	11.01	11.85	12.56	13.17	13.69	14.14	14.54	14.89	15.56
1988	0.01	0.05	0.43	1.19	2.21	3.15	4.51	5.85	6.88	8.19	9.62	10.91	11.93	12.94	13.74	14.43	15.02	15.54	15.99	16.39	17.18
1989	0.00	0.04	0.48	1.25	2.26	3.41	4.39	5.80	7.19	8.22	9.49	10.81	11.94	12.81	13.65	14.32	14.90	15.40	15.84	16.23	17.02
1990	0.00	0.05	0.57	1.31	2.26	3.32	4.45	5.40	6.77	8.07	8.99	10.08	11.15	12.04	12.71	13.35	13.88	14.33	14.72	15.08	15.80
1991	0.01	0.06	0.58	1.30	2.14	3.09	4.11	5.20	6.12	7.42	8.58	9.37	10.26	11.11	11.81	12.33	12.84	13.25	13.62	13.94	14.60
1992	0.00	0.07	0.52	1.30	2.12	3.00	3.95	4.99	6.12	7.05	8.31	9.39	10.08	10.84	11.57	12.16	12.61	13.05	13.41	13.73	14.37
1993	0.01	0.07	0.58	1.34	2.36	3.34	4.35	5.47	6.68	7.95	8.94	10.22	11.25	11.90	12.60	13.27	13.82	14.23	14.65	14.99	15.60
1994	0.01	0.07	0.52	1.30	2.18	3.22	4.18	5.17	6.28	7.45	8.65	9.54	10.64	11.51	12.04	12.62	13.18	13.64	13.99	14.35	14.83
1995	0.00	0.06	0.49	1.23	2.19	3.17	4.28	5.32	6.41	7.59	8.80	9.97	10.80	11.81	12.59	13.06	13.59	14.10	14.52	14.85	15.40
1996	0.01	0.07	0.61	1.37	2.28	3.26	4.18	5.21	6.16	7.13	8.13	9.09	9.97	10.58	11.31	11.86	12.20	12.58	12.94	13.26	13.57
1997	0.01	0.06	0.50	1.21	2.06	2.99	4.00	4.96	6.07	7.07	8.04	9.01	9.91	10.70	11.25	11.89	12.39	12.70	13.05	13.40	13.64
1998	0.00	0.06	0.50	1.24	2.11	3.01	3.95	4.96	5.94	7.04	7.99	8.88	9.72	10.48	11.14	11.59	12.14	12.56	12.82	13.12	13.47
1999	0.00	0.05	0.49	1.25	2.18	3.15	4.11	5.14	6.25	7.31	8.44	9.37	10.20	10.96	11.65	12.24	12.65	13.14	13.53	13.78	14.20
2000	0.01	0.04	0.64	1.30	2.27	3.32	4.36	5.41	6.54	7.74	8.83	9.94	10.81	11.57	12.26	12.87	13.41	13.79	14.25	14.61	15.18
2001	0.01	0.09	0.61	1.44	2.19	3.18	4.21	5.23	6.28	7.37	8.48	9.43	10.35	11.05	11.65	12.20	12.69	13.12	13.42	13.80	14.47
2002	0.01	0.08	0.58	1.31	2.27	3.07	4.12	5.22	6.34	7.45	8.57	9.64	10.52	11.35	11.98	12.51	13.01	13.45	13.85	14.13	14.72
2003	0.00	0.08	0.52	1.32	2.20	3.23	4.06	5.17	6.36	7.53	8.65	9.72	10.71	11.49	12.23	12.79	13.26	13.71	14.11	14.48	15.18
2004	0.01	0.07	0.64	1.30	2.26	3.19	4.24	5.07	6.20	7.36	8.46	9.45	10.35	11.16	11.79	12.38	12.83	13.22	13.58	13.91	14.48
2005	0.00	0.11	0.52	1.41	2.21	3.27	4.27	5.41	6.33	7.55	8.75	9.83	10.77	11.60	12.34	12.92	13.46	13.88	14.24	14.59	15.28
2006	0.00	0.06	0.53	1.30	2.37	3.22	4.29	5.31	6.47	7.38	8.54	9.64	10.57	11.36	12.05	12.65	13.13	13.59	13.94	14.25	15.01
2007	0.00	0.05	0.51	1.31	2.25	3.43	4.31	5.46	6.55	7.77	8.69	9.81	10.82	11.65	12.35	12.95	13.49	13.92	14.34	14.66	15.57
2008	0.00	0.04	0.49	1.25	2.20	3.18	4.36	5.25	6.41	7.49	8.64	9.46	10.43	11.26	11.94	12.51	13.01	13.46	13.81	14.16	14.87
2009	0.00	0.03	0.52	1.26	2.20	3.26	4.30	5.57	6.56	7.82	8.94	10.07	10.85	11.75	12.51	13.14	13.66	14.13	14.55	14.89	15.43
2010	0.00	0.03	0.59	1.29	2.17	3.16	4.21	5.26	6.56	7.54	8.73	9.74	10.71	11.36	12.10	12.73	13.24	13.68	14.07	14.43	14.85
2011	0.00	0.05	0.50	1.34	2.15	3.07	4.07	5.15	6.25	7.57	8.51	9.60	10.48	11.32	11.86	12.48	13.01	13.45	13.82	14.16	14.66
2012	0.00	0.04	0.58	1.23	2.20	3.02	3.92	4.90	5.97	7.02	8.21	9.00	9.88	10.57	11.21	11.63	12.11	12.52	12.86	13.16	13.45
2013	0.00	0.06	0.50	1.28	2.07	3.15	4.05	5.05	6.17	7.38	8.51	9.73	10.51	11.36	12.02	12.63	13.03	13.49	13.90	14.24	14.66
2014	0.00	0.04	0.53	1.24	2.18	3.03	4.14	5.08	6.15	7.33	8.54	9.62	10.74	11.44	12.19	12.77	13.31	13.67	14.09	14.46	14.97
2015	0.00	0.04	0.64	1.27	2.11	3.10	3.95	5.10	6.07	7.16	8.31	9.43	10.39	11.34	11.93	12.56	13.05	13.51	13.82	14.18	14.73
2016	0.00	0.10	0.68	1.46	2.20	3.12	4.15	5.06	6.30	7.33	8.43	9.52	10.54	11.38	12.21	12.71	13.26	13.69	14.10	14.37	14.74
2017	0.00	0.10	0.63	1.49	2.41	3.20	4.16	5.27	6.26	7.58	8.63	9.69	10.69	11.61	12.34	13.07	13.52	14.01	14.40	14.77	15.18
2018	0.01	0.10	0.73	1.40	2.40	3.36	4.17	5.18	6.35	7.36	8.63	9.58	10.50	11.34	12.09	12.70	13.30	13.67	14.08	14.41	14.92
2019	0.00	0.16	0.47	1.54	2.34	3.44	4.47	5.35	6.46	7.73	8.76	10.00	10.88	11.72	12.47	13.14	13.68	14.23	14.57	14.95	15.38
2020	0.00	0.04	0.48	1.13	2.37	3.18	4.28	5.33	6.23	7.33	8.52	9.45	10.52	11.25	11.93	12.55	13.11	13.56	14.02	14.31	14.78

Model 2.1.20c. Mid-year weight (kg) at age in the fishery (Model 21.1).

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	0.07	0.56	1.35	2.29	3.26	4.19	5.09	6.00	6.92	7.83	8.69	9.48	10.18	10.80	11.34	11.82	12.23	12.58	12.88	13.47
1978	0.00	0.06	0.48	1.28	2.24	3.26	4.27	5.24	6.24	7.27	8.30	9.28	10.18	10.99	11.71	12.35	12.90	13.37	13.79	14.14	14.84
1979	0.01	0.06	0.56	1.30	2.26	3.24	4.18	5.08	5.99	6.92	7.84	8.72	9.52	10.23	10.86	11.41	11.90	12.31	12.67	12.98	13.61
1980	0.01	0.07	0.50	1.29	2.16	3.15	4.08	4.99	5.91	6.85	7.77	8.65	9.45	10.16	10.80	11.35	11.84	12.26	12.62	12.93	13.58
1981	0.01	0.06	0.44	1.23	2.18	3.08	4.03	4.93	5.83	6.74	7.64	8.49	9.27	9.96	10.57	11.11	11.58	11.98	12.33	12.64	13.27
1982	0.00	0.05	0.53	1.29	2.32	3.35	4.24	5.18	6.10	7.04	7.96	8.82	9.61	10.31	10.93	11.48	11.95	12.36	12.72	13.02	13.68
1983	0.01	0.05	0.58	1.28	2.22	3.32	4.36	5.28	6.29	7.28	8.25	9.17	10.00	10.75	11.41	11.98	12.49	12.93	13.30	13.63	14.34
1984	0.01	0.10	0.58	1.35	2.09	2.93	3.84	4.69	5.43	6.24	7.00	7.70	8.33	8.90	9.39	9.82	10.20	10.52	10.81	11.05	11.58
1985	0.00	0.07	0.46	1.38	2.39	3.28	4.26	5.33	6.38	7.34	8.38	9.33	10.20	10.98	11.67	12.28	12.81	13.27	13.66	14.01	14.77
1986	0.00	0.03	0.50	1.17	2.29	3.37	4.26	5.24	6.36	7.46	8.45	9.47	10.39	11.21	11.94	12.58	13.14	13.62	14.04	14.40	15.22
1987	0.00	0.07	0.52	1.36	2.18	3.35	4.34	5.15	6.08	7.15	8.17	9.03	9.90	10.65	11.32	11.91	12.41	12.86	13.24	13.57	14.32
1988	0.01	0.05	0.42	1.20	2.26	3.20	4.47	5.56	6.47	7.53	8.72	9.80	10.70	11.58	12.33	13.00	13.57	14.08	14.51	14.89	15.75
1989	0.01	0.05	0.47	1.26	2.30	3.46	4.38	5.63	6.74	7.68	8.72	9.83	10.79	11.57	12.32	12.96	13.52	14.00	14.42	14.79	15.64
1990	0.01	0.05	0.55	1.31	2.29	3.35	4.44	5.30	6.50	7.55	8.39	9.28	10.19	10.96	11.57	12.16	12.66	13.09	13.47	13.79	14.56
1991	0.01	0.06	0.57	1.31	2.18	3.13	4.09	5.07	5.86	6.95	7.87	8.59	9.35	10.10	10.73	11.23	11.70	12.10	12.45	12.75	13.46
1992	0.00	0.07	0.52	1.31	2.16	3.03	3.94	4.83	5.77	6.54	7.59	8.45	9.11	9.79	10.46	11.02	11.46	11.87	12.22	12.52	13.22
1993	0.01	0.07	0.61	1.37	2.40	3.38	4.33	5.30	6.29	7.34	8.16	9.24	10.10	10.74	11.39	12.03	12.56	12.97	13.36	13.68	14.38
1994	0.01	0.09	0.51	1.37	2.24	3.25	4.14	4.99	5.90	6.86	7.85	8.61	9.57	10.31	10.86	11.42	11.96	12.40	12.75	13.07	13.67
1995	0.00	0.06	0.49	1.26	2.30	3.23	4.24	5.12	6.02	7.00	8.00	8.99	9.71	10.61	11.30	11.81	12.32	12.81	13.22	13.53	14.19
1996	0.01	0.07	0.60	1.39	2.31	3.34	4.17	5.09	5.93	6.75	7.60	8.40	9.15	9.69	10.34	10.83	11.19	11.55	11.90	12.18	12.62
1997	0.01	0.06	0.49	1.22	2.09	3.02	4.03	4.85	5.79	6.63	7.45	8.27	9.03	9.73	10.23	10.83	11.29	11.62	11.95	12.26	12.67
1998	0.00	0.06	0.49	1.26	2.14	3.03	3.92	4.86	5.66	6.57	7.36	8.11	8.85	9.52	10.13	10.55	11.07	11.46	11.74	12.01	12.50
1999	0.00	0.05	0.47	1.27	2.22	3.18	4.08	4.98	5.99	6.82	7.75	8.53	9.25	9.95	10.57	11.13	11.53	12.00	12.35	12.60	13.14
2000	0.01	0.04	0.64	1.29	2.30	3.34	4.32	5.24	6.20	7.26	8.12	9.04	9.79	10.47	11.12	11.70	12.22	12.58	13.01	13.33	13.99
2001	0.01	0.10	0.61	1.47	2.21	3.21	4.15	5.00	5.83	6.70	7.67	8.44	9.25	9.90	10.48	11.02	11.51	11.94	12.23	12.59	13.30
2002	0.01	0.08	0.58	1.35	2.34	3.10	4.07	4.96	5.80	6.65	7.56	8.53	9.28	10.05	10.67	11.21	11.71	12.16	12.55	12.83	13.47
2003	0.01	0.08	0.53	1.34	2.26	3.29	4.03	4.99	5.95	6.90	7.82	8.73	9.64	10.32	11.00	11.54	12.01	12.45	12.84	13.19	13.89
2004	0.01	0.07	0.64	1.33	2.30	3.24	4.22	4.93	5.88	6.84	7.75	8.59	9.37	10.13	10.69	11.24	11.68	12.06	12.41	12.72	13.30
2005	0.01	0.11	0.51	1.44	2.26	3.31	4.26	5.27	6.02	7.04	8.04	8.95	9.76	10.50	11.21	11.73	12.24	12.65	13.00	13.32	14.02
2006	0.00	0.06	0.52	1.32	2.43	3.26	4.28	5.21	6.23	6.98	7.96	8.87	9.66	10.35	10.97	11.57	12.00	12.42	12.76	13.05	13.79
2007	0.00	0.06	0.48	1.32	2.29	3.46	4.30	5.33	6.29	7.34	8.08	9.02	9.87	10.60	11.23	11.80	12.34	12.73	13.11	13.40	14.27
2008	0.00	0.04	0.48	1.24	2.23	3.21	4.31	5.07	6.02	6.91	7.88	8.55	9.40	10.15	10.79	11.33	11.82	12.28	12.60	12.92	13.62
2009	0.00	0.03	0.53	1.27	2.23	3.29	4.23	5.26	6.00	6.98	7.90	8.88	9.56	10.40	11.14	11.76	12.28	12.75	13.18	13.49	14.09
2010	0.00	0.03	0.60	1.34	2.21	3.17	4.13	4.97	5.97	6.72	7.68	8.55	9.44	10.03	10.76	11.38	11.90	12.34	12.73	13.09	13.60
2011	0.00	0.05	0.50	1.38	2.23	3.11	4.01	4.94	5.83	6.91	7.68	8.61	9.39	10.16	10.66	11.26	11.78	12.21	12.57	12.89	13.47
2012	0.00	0.04	0.58	1.24	2.24	3.07	3.88	4.72	5.62	6.48	7.48	8.16	8.92	9.55	10.16	10.55	11.02	11.42	11.75	12.03	12.44
2013	0.00	0.07	0.51	1.31	2.11	3.19	4.03	4.84	5.72	6.71	7.64	8.70	9.38	10.16	10.79	11.39	11.77	12.24	12.63	12.95	13.50
2014	0.00	0.04	0.55	1.27	2.24	3.06	4.10	4.89	5.73	6.67	7.69	8.61	9.60	10.23	10.94	11.50	12.04	12.38	12.79	13.14	13.77
2015	0.00	0.04	0.65	1.31	2.16	3.13	3.91	4.90	5.72	6.59	7.53	8.50	9.33	10.20	10.74	11.34	11.82	12.27	12.56	12.91	13.57
2016	0.00	0.10	0.67	1.49	2.27	3.15	4.11	4.88	5.93	6.79	7.67	8.59	9.48	10.24	11.01	11.49	12.02	12.44	12.84	13.09	13.61
2017	0.00	0.10	0.63	1.50	2.45	3.24	4.12	5.11	5.95	7.07	7.95	8.81	9.67	10.49	11.17	11.86	12.28	12.75	13.12	13.47	14.01
2018	0.01	0.10	0.74	1.42	2.43	3.39	4.17	5.04	6.04	6.88	7.95	8.76	9.52	10.26	10.96	11.53	12.11	12.46	12.85	13.15	13.77
2019	0.00	0.16	0.46	1.60	2.40	3.46	4.41	5.17	6.06	7.10	7.94	9.01	9.79	10.52	11.21	11.87	12.40	12.93	13.25	13.61	14.15
2020	0.00	0.04	0.48	1.14	2.44	3.22	4.23	5.16	5.94	6.83	7.83	8.59	9.52	10.19	10.79	11.37	11.91	12.34	12.78	13.05	13.61

Model 2.1.20d. Mid-year weight (kg) at age in the fishery (Model 21.2).

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	0.60	1.38	2.30	3.26	4.20	5.14	6.14	7.19	8.25	9.28	10.26	11.18	12.05	12.85	13.58	14.25	14.86	15.40	16.77
1978	0.00	0.07	0.49	1.30	2.24	3.26	4.27	5.30	6.40	7.58	8.78	9.96	11.09	12.17	13.17	14.11	14.97	15.76	16.47	17.12	18.74
1979	0.01	0.06	0.57	1.29	2.27	3.23	4.18	5.13	6.14	7.20	8.27	9.32	10.32	11.26	12.14	12.95	13.70	14.38	14.99	15.55	16.84
1980	0.00	0.07	0.51	1.28	2.13	3.14	4.09	5.05	6.06	7.12	8.19	9.24	10.24	11.19	12.07	12.89	13.65	14.34	14.96	15.52	16.78
1981	0.01	0.06	0.46	1.22	2.13	3.02	4.03	4.97	5.96	7.00	8.05	9.06	10.03	10.95	11.80	12.60	13.33	13.99	14.59	15.14	16.31
1982	0.00	0.04	0.54	1.30	2.29	3.30	4.21	5.24	6.25	7.31	8.37	9.40	10.38	11.31	12.18	12.98	13.72	14.39	15.00	15.55	16.72
1983	0.01	0.04	0.59	1.28	2.20	3.27	4.33	5.29	6.43	7.55	8.67	9.76	10.80	11.79	12.72	13.58	14.37	15.09	15.75	16.34	17.60
1984	0.01	0.10	0.60	1.33	2.06	2.90	3.81	4.68	5.49	6.43	7.30	8.14	8.93	9.67	10.36	11.00	11.59	12.12	12.60	13.03	13.95
1985	0.00	0.07	0.47	1.37	2.34	3.23	4.23	5.34	6.49	7.57	8.82	9.96	11.06	12.09	13.06	13.96	14.79	15.55	16.24	16.86	18.19
1986	0.00	0.03	0.51	1.17	2.26	3.30	4.21	5.25	6.46	7.72	8.87	10.16	11.31	12.39	13.41	14.36	15.24	16.03	16.76	17.42	18.84
1987	0.00	0.06	0.52	1.34	2.16	3.31	4.30	5.16	6.20	7.39	8.57	9.61	10.74	11.74	12.67	13.53	14.32	15.05	15.71	16.30	17.61
1988	0.01	0.04	0.43	1.18	2.20	3.13	4.41	5.55	6.58	7.81	9.18	10.48	11.60	12.81	13.87	14.85	15.75	16.58	17.33	18.01	19.53
1989	0.01	0.04	0.48	1.24	2.24	3.38	4.33	5.63	6.82	7.88	9.10	10.41	11.62	12.66	13.77	14.73	15.61	16.41	17.15	17.81	19.31
1990	0.00	0.05	0.56	1.32	2.25	3.30	4.39	5.30	6.56	7.68	8.65	9.74	10.87	11.91	12.79	13.72	14.51	15.23	15.89	16.48	17.83
1991	0.01	0.06	0.58	1.29	2.14	3.07	4.05	5.07	5.93	7.13	8.17	9.04	10.00	10.99	11.89	12.63	13.42	14.08	14.68	15.22	16.46
1992	0.00	0.07	0.53	1.29	2.12	2.99	3.89	4.82	5.86	6.74	7.95	8.96	9.80	10.71	11.64	12.47	13.16	13.87	14.47	15.01	16.21
1993	0.01	0.07	0.59	1.36	2.35	3.31	4.28	5.28	6.38	7.58	8.56	9.84	10.90	11.75	12.67	13.59	14.41	15.09	15.78	16.36	17.53
1994	0.00	0.08	0.52	1.33	2.20	3.20	4.10	5.01	6.00	7.10	8.26	9.18	10.36	11.32	12.10	12.92	13.75	14.48	15.08	15.69	16.67
1995	0.00	0.05	0.49	1.24	2.22	3.16	4.19	5.13	6.13	7.23	8.40	9.58	10.51	11.69	12.63	13.39	14.19	14.99	15.69	16.26	17.39
1996	0.01	0.06	0.61	1.38	2.28	3.27	4.13	5.08	5.96	6.88	7.82	8.78	9.74	10.46	11.38	12.11	12.69	13.29	13.88	14.40	15.13
1997	0.01	0.06	0.45	1.19	2.03	2.95	3.94	4.83	5.84	6.78	7.72	8.68	9.65	10.59	11.31	12.20	12.91	13.47	14.05	14.62	15.29
1998	0.00	0.04	0.49	1.18	2.08	2.96	3.86	4.84	5.73	6.75	7.66	8.56	9.46	10.35	11.22	11.86	12.67	13.30	13.79	14.30	15.13
1999	0.00	0.05	0.48	1.24	2.10	3.10	4.02	4.97	6.03	7.00	8.08	9.01	9.92	10.82	11.70	12.54	13.17	13.94	14.54	15.01	15.94
2000	0.01	0.04	0.63	1.28	2.26	3.22	4.25	5.18	6.20	7.36	8.41	9.53	10.49	11.40	12.30	13.16	13.98	14.59	15.33	15.90	17.08
2001	0.01	0.09	0.61	1.46	2.20	3.19	4.03	4.90	5.76	6.77	7.92	8.92	9.97	10.84	11.65	12.44	13.18	13.89	14.40	15.02	16.27
2002	0.01	0.07	0.58	1.32	2.29	3.06	4.01	4.83	5.81	6.84	7.96	9.14	10.13	11.15	11.99	12.77	13.53	14.24	14.91	15.39	16.43
2003	0.00	0.07	0.56	1.37	2.25	3.27	4.00	4.91	5.82	6.97	8.08	9.21	10.36	11.31	12.27	13.07	13.82	14.53	15.20	15.83	17.02
2004	0.01	0.06	0.68	1.36	2.31	3.21	4.18	4.89	5.89	6.88	8.02	9.03	10.03	11.03	11.84	12.68	13.36	13.99	14.59	15.16	16.11
2005	0.00	0.11	0.54	1.46	2.25	3.28	4.21	5.28	6.11	7.25	8.32	9.47	10.48	11.46	12.45	13.25	14.06	14.73	15.35	15.92	17.10
2006	0.00	0.06	0.54	1.31	2.38	3.21	4.23	5.17	6.28	7.12	8.24	9.24	10.31	11.23	12.12	13.00	13.71	14.43	15.01	15.54	16.80
2007	0.00	0.06	0.49	1.29	2.22	3.38	4.23	5.30	6.32	7.49	8.36	9.49	10.48	11.53	12.42	13.27	14.11	14.79	15.46	16.00	17.50
2008	0.00	0.05	0.47	1.22	2.16	3.13	4.27	5.10	6.17	7.18	8.31	9.13	10.17	11.08	12.02	12.81	13.57	14.30	14.88	15.46	16.53
2009	0.00	0.04	0.48	1.20	2.13	3.17	4.18	5.39	6.29	7.46	8.53	9.71	10.56	11.62	12.53	13.47	14.26	15.00	15.72	16.29	17.19
2010	0.00	0.04	0.56	1.24	2.10	3.08	4.07	5.01	6.20	7.11	8.27	9.30	10.41	11.19	12.16	12.98	13.82	14.52	15.17	15.79	16.60
2011	0.00	0.06	0.49	1.33	2.13	3.04	3.96	4.89	5.85	7.10	8.02	9.15	10.13	11.17	11.89	12.78	13.52	14.28	14.90	15.47	16.43
2012	0.00	0.04	0.56	1.25	2.21	3.02	3.83	4.65	5.56	6.54	7.74	8.57	9.56	10.39	11.27	11.87	12.60	13.21	13.82	14.32	14.99
2013	0.00	0.05	0.51	1.27	2.09	3.14	3.94	4.76	5.71	6.83	7.95	9.26	10.14	11.17	12.05	12.95	13.57	14.32	14.94	15.57	16.52
2014	0.00	0.03	0.53	1.27	2.19	3.05	4.05	4.81	5.72	6.80	8.00	9.14	10.41	11.26	12.24	13.07	13.93	14.51	15.22	15.80	16.94
2015	0.00	0.03	0.66	1.30	2.15	3.10	3.90	4.86	5.71	6.71	7.84	8.99	10.05	11.22	11.99	12.88	13.63	14.40	14.92	15.54	16.69
2016	0.00	0.09	0.67	1.47	2.22	3.13	4.08	4.93	6.06	7.01	8.06	9.16	10.26	11.25	12.34	13.05	13.87	14.56	15.26	15.73	16.64
2017	0.00	0.07	0.67	1.55	2.49	3.26	4.16	5.12	6.04	7.26	8.25	9.31	10.40	11.47	12.43	13.47	14.15	14.92	15.57	16.22	17.18
2018	0.01	0.09	0.75	1.43	2.41	3.37	4.13	5.06	6.11	7.08	8.30	9.24	10.22	11.21	12.18	13.03	13.94	14.53	15.20	15.76	16.83
2019	0.00	0.16	0.48	1.56	2.35	3.39	4.38	5.18	6.21	7.35	8.38	9.64	10.59	11.57	12.55	13.48	14.30	15.18	15.74	16.38	17.23
2020	0.00	0.04	0.48	1.13	2.36	3.14	4.17	5.17	6.00	7.03	8.14	9.11	10.26	11.12	12.00	12.87	13.70	14.42	15.19	15.67	16.57

Model 2.1.20e. Mid-year weight (kg) at age in the fishery (Model 21.3).

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	1.35	2.27	3.25	4.26	5.32	6.43	7.57	8.68	9.70	10.61	11.39	12.06	12.63	13.11	13.53	13.91	14.23	14.90
1978	0.00	0.06	0.49	1.27	2.21	3.25	4.34	5.50	6.73	8.01	9.27	10.45	11.50	12.40	13.18	13.84	14.41	14.90	15.33	15.72	16.52
1979	0.01	0.06	0.57	1.28	2.24	3.23	4.25	5.32	6.44	7.59	8.72	9.76	10.68	11.48	12.15	12.73	13.22	13.65	14.02	14.36	14.99
1980	0.00	0.07	0.50	1.28	2.12	3.14	4.15	5.21	6.33	7.49	8.62	9.67	10.59	11.40	12.08	12.66	13.16	13.59	13.97	14.31	14.93
1981	0.00	0.06	0.44	1.21	2.14	3.04	4.09	5.14	6.24	7.36	8.46	9.48	10.38	11.15	11.81	12.38	12.86	13.28	13.65	13.97	14.55
1982	0.00	0.04	0.52	1.27	2.27	3.32	4.28	5.40	6.52	7.66	8.78	9.81	10.73	11.52	12.19	12.76	13.25	13.67	14.04	14.38	14.96
1983	0.01	0.04	0.65	1.25	2.17	3.28	4.41	5.45	6.69	7.90	9.09	10.19	11.16	12.01	12.72	13.33	13.86	14.31	14.71	15.07	15.70
1984	0.01	0.14	0.59	1.41	2.03	2.89	3.86	4.82	5.70	6.70	7.62	8.46	9.20	9.84	10.38	10.83	11.22	11.56	11.85	12.12	12.58
1985	0.00	0.07	0.46	1.35	2.43	3.21	4.27	5.51	6.80	7.97	9.27	10.42	11.43	12.31	13.06	13.70	14.25	14.72	15.14	15.52	16.20
1986	0.00	0.03	0.50	1.14	2.24	3.43	4.26	5.42	6.80	8.18	9.38	10.65	11.71	12.63	13.41	14.08	14.66	15.16	15.61	16.00	16.73
1987	0.00	0.07	0.51	1.32	2.12	3.30	4.49	5.31	6.46	7.78	9.05	10.08	11.11	11.95	12.67	13.28	13.81	14.27	14.67	15.02	15.70
1988	0.01	0.05	0.43	1.18	2.21	3.13	4.51	5.92	6.89	8.23	9.70	11.01	12.05	13.06	13.87	14.56	15.16	15.68	16.14	16.54	17.35
1989	0.00	0.05	0.48	1.24	2.25	3.41	4.38	5.82	7.28	8.26	9.55	10.90	12.05	12.92	13.77	14.45	15.03	15.54	15.99	16.38	17.19
1990	0.00	0.05	0.57	1.30	2.25	3.32	4.45	5.40	6.80	8.17	9.05	10.15	11.25	12.15	12.82	13.47	14.00	14.45	14.85	15.21	15.95
1991	0.01	0.07	0.59	1.30	2.13	3.09	4.11	5.21	6.13	7.46	8.69	9.44	10.34	11.21	11.91	12.44	12.95	13.37	13.73	14.06	14.73
1992	0.00	0.08	0.52	1.30	2.12	2.99	3.95	5.00	6.14	7.08	8.37	9.51	10.16	10.93	11.67	12.27	12.71	13.16	13.52	13.85	14.50
1993	0.01	0.07	0.56	1.33	2.36	3.34	4.35	5.48	6.70	8.00	9.00	10.31	11.39	11.99	12.71	13.38	13.93	14.35	14.77	15.12	15.73
1994	0.01	0.07	0.52	1.28	2.16	3.23	4.18	5.18	6.30	7.50	8.72	9.61	10.74	11.64	12.14	12.72	13.29	13.75	14.11	14.47	14.95
1995	0.01	0.06	0.49	1.23	2.17	3.15	4.30	5.34	6.43	7.64	8.87	10.06	10.89	11.92	12.73	13.17	13.70	14.22	14.65	14.99	15.53
1996	0.01	0.07	0.60	1.36	2.27	3.24	4.17	5.24	6.19	7.16	8.19	9.17	10.06	10.67	11.40	11.98	12.29	12.68	13.05	13.37	13.67
1997	0.01	0.06	0.49	1.20	2.05	2.99	3.99	4.97	6.12	7.12	8.10	9.09	10.00	10.80	11.34	12.00	12.52	12.81	13.16	13.51	13.75
1998	0.00	0.06	0.49	1.24	2.10	3.00	3.95	4.96	5.96	7.11	8.06	8.95	9.81	10.57	11.24	11.69	12.24	12.68	12.93	13.24	13.57
1999	0.00	0.05	0.48	1.24	2.18	3.14	4.12	5.16	6.27	7.35	8.53	9.45	10.29	11.06	11.75	12.35	12.75	13.25	13.67	13.90	14.31
2000	0.01	0.04	0.63	1.29	2.26	3.31	4.36	5.42	6.58	7.78	8.89	10.05	10.91	11.67	12.37	12.98	13.53	13.90	14.37	14.76	15.31
2001	0.01	0.09	0.61	1.42	2.17	3.18	4.21	5.24	6.30	7.42	8.53	9.50	10.46	11.15	11.75	12.30	12.80	13.23	13.53	13.92	14.60
2002	0.01	0.08	0.57	1.30	2.25	3.05	4.11	5.23	6.36	7.50	8.64	9.71	10.61	11.47	12.09	12.62	13.12	13.57	13.97	14.25	14.86
2003	0.00	0.08	0.52	1.31	2.19	3.22	4.06	5.18	6.38	7.58	8.72	9.81	10.80	11.60	12.36	12.90	13.38	13.83	14.24	14.61	15.33
2004	0.01	0.07	0.63	1.29	2.24	3.19	4.23	5.08	6.22	7.41	8.52	9.53	10.45	11.25	11.89	12.50	12.94	13.33	13.70	14.04	14.62
2005	0.00	0.11	0.51	1.39	2.20	3.26	4.27	5.41	6.35	7.59	8.82	9.92	10.87	11.72	12.44	13.03	13.59	14.00	14.36	14.72	15.44
2006	0.00	0.06	0.53	1.29	2.36	3.21	4.29	5.32	6.49	7.42	8.61	9.72	10.66	11.46	12.16	12.76	13.24	13.72	14.06	14.38	15.17
2007	0.00	0.05	0.50	1.30	2.24	3.42	4.31	5.47	6.58	7.81	8.75	9.90	10.92	11.76	12.46	13.07	13.61	14.04	14.47	14.79	15.74
2008	0.00	0.04	0.49	1.24	2.19	3.17	4.35	5.26	6.44	7.54	8.70	9.54	10.52	11.36	12.05	12.62	13.13	13.57	13.93	14.30	15.04
2009	0.00	0.03	0.51	1.26	2.20	3.25	4.30	5.58	6.58	7.86	9.01	10.15	10.95	11.85	12.63	13.25	13.78	14.25	14.67	15.02	15.60
2010	0.00	0.03	0.58	1.27	2.16	3.15	4.20	5.26	6.58	7.58	8.79	9.82	10.80	11.46	12.20	12.84	13.36	13.80	14.20	14.55	15.01
2011	0.00	0.06	0.49	1.32	2.13	3.07	4.06	5.15	6.27	7.61	8.57	9.69	10.58	11.41	11.96	12.59	13.12	13.57	13.95	14.29	14.82
2012	0.00	0.04	0.57	1.22	2.18	3.00	3.92	4.91	5.99	7.05	8.26	9.07	9.97	10.66	11.30	11.73	12.21	12.62	12.97	13.27	13.58
2013	0.00	0.07	0.50	1.27	2.05	3.13	4.04	5.06	6.20	7.42	8.57	9.81	10.60	11.46	12.13	12.74	13.14	13.61	14.02	14.37	14.80
2014	0.00	0.04	0.52	1.22	2.17	3.02	4.14	5.08	6.18	7.37	8.60	9.71	10.84	11.54	12.30	12.88	13.42	13.79	14.21	14.59	15.11
2015	0.00	0.04	0.64	1.25	2.09	3.09	3.95	5.10	6.09	7.21	8.38	9.51	10.48	11.45	12.03	12.67	13.16	13.63	13.94	14.32	14.87
2016	0.00	0.10	0.67	1.45	2.18	3.10	4.15	5.07	6.32	7.36	8.50	9.61	10.63	11.48	12.32	12.82	13.38	13.81	14.22	14.51	14.87
2017	0.00	0.11	0.62	1.49	2.40	3.19	4.15	5.28	6.28	7.62	8.69	9.78	10.80	11.71	12.45	13.19	13.64	14.13	14.53	14.91	15.32
2018	0.01	0.10	0.72	1.39	2.40	3.36	4.17	5.19	6.39	7.41	8.70	9.66	10.60	11.45	12.20	12.81	13.41	13.79	14.20	14.54	15.05
2019	0.00	0.15	0.46	1.53	2.33	3.45	4.48	5.36	6.49	7.78	8.83	10.09	10.98	11.83	12.59	13.26	13.80	14.35	14.70	15.09	15.53
2020	0.00	0.03	0.48	1.12	2.37	3.18	4.31	5.36	6.25	7.38	8.60	9.53	10.61	11.35	12.05	12.67	13.22	13.68	14.14	14.44	14.92

Table 2.1.20f. Mid-year weight (kg) at age in the fishery (ensemble).

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	3.26	4.24	5.23	6.27	7.33	8.38	9.37	10.27	11.08	11.80	12.43	13.00	13.49	13.93	14.32	15.18
1978	0.00	0.06	0.49	1.29	2.24	3.27	4.32	5.40	6.55	7.75	8.94	10.07	11.11	12.04	12.88	13.62	14.28	14.86	15.37	15.83	16.85
1979	0.01	0.06	0.57	1.30	2.26	3.24	4.23	5.23	6.28	7.35	8.42	9.42	10.34	11.16	11.88	12.53	13.10	13.60	14.05	14.45	15.27
1980	0.00	0.07	0.51	1.29	2.14	3.15	4.13	5.13	6.18	7.26	8.32	9.33	10.25	11.08	11.81	12.47	13.04	13.55	14.00	14.41	15.22
1981	0.01	0.06	0.45	1.22	2.16	3.06	4.07	5.06	6.09	7.14	8.18	9.15	10.05	10.85	11.56	12.19	12.74	13.24	13.67	14.06	14.83
1982	0.00	0.04	0.53	1.29	2.30	3.34	4.26	5.32	6.36	7.44	8.49	9.49	10.39	11.21	11.93	12.57	13.13	13.63	14.07	14.46	15.24
1983	0.01	0.04	0.61	1.27	2.20	3.30	4.39	5.38	6.54	7.68	8.79	9.85	10.82	11.68	12.45	13.13	13.74	14.27	14.75	15.17	16.00
1984	0.01	0.11	0.59	1.37	2.06	2.91	3.85	4.76	5.60	6.53	7.40	8.21	8.94	9.59	10.17	10.68	11.13	11.52	11.87	12.18	12.80
1985	0.00	0.07	0.47	1.37	2.39	3.25	4.27	5.44	6.64	7.74	8.96	10.06	11.07	11.97	12.78	13.49	14.12	14.68	15.18	15.62	16.51
1986	0.00	0.03	0.51	1.16	2.27	3.38	4.26	5.35	6.63	7.91	9.05	10.26	11.32	12.27	13.11	13.87	14.53	15.12	15.65	16.11	17.07
1987	0.00	0.06	0.52	1.34	2.16	3.33	4.41	5.26	6.33	7.56	8.73	9.73	10.75	11.62	12.39	13.08	13.69	14.22	14.70	15.12	16.00
1988	0.01	0.04	0.43	1.19	2.23	3.16	4.49	5.74	6.74	7.98	9.35	10.61	11.64	12.68	13.56	14.33	15.02	15.64	16.18	16.66	17.69
1989	0.00	0.04	0.48	1.25	2.27	3.43	4.38	5.74	7.03	8.04	9.26	10.54	11.67	12.57	13.47	14.23	14.90	15.50	16.03	16.50	17.52
1990	0.00	0.05	0.56	1.32	2.27	3.33	4.45	5.36	6.68	7.89	8.80	9.85	10.92	11.83	12.56	13.28	13.88	14.42	14.89	15.31	16.24
1991	0.01	0.06	0.58	1.30	2.15	3.11	4.10	5.15	6.03	7.27	8.36	9.15	10.04	10.92	11.67	12.25	12.84	13.33	13.77	14.15	15.00
1992	0.00	0.07	0.52	1.30	2.14	3.01	3.94	4.93	6.00	6.88	8.09	9.12	9.84	10.64	11.42	12.08	12.60	13.12	13.55	13.94	14.76
1993	0.01	0.07	0.59	1.35	2.38	3.35	4.34	5.40	6.54	7.75	8.71	9.96	10.97	11.67	12.43	13.18	13.81	14.30	14.80	15.21	16.00
1994	0.01	0.08	0.52	1.32	2.20	3.23	4.16	5.10	6.15	7.27	8.41	9.29	10.39	11.27	11.87	12.53	13.17	13.71	14.14	14.56	15.22
1995	0.00	0.06	0.49	1.24	2.23	3.19	4.27	5.25	6.27	7.40	8.56	9.70	10.54	11.58	12.40	12.97	13.58	14.18	14.69	15.09	15.84
1996	0.01	0.07	0.61	1.38	2.29	3.29	4.17	5.17	6.08	7.00	7.96	8.90	9.78	10.41	11.18	11.78	12.19	12.64	13.08	13.45	13.91
1997	0.01	0.06	0.49	1.21	2.06	3.00	4.00	4.92	5.97	6.92	7.86	8.80	9.69	10.52	11.10	11.83	12.39	12.77	13.19	13.60	14.01
1998	0.00	0.05	0.49	1.24	2.12	3.01	3.93	4.92	5.84	6.89	7.80	8.67	9.51	10.29	11.01	11.51	12.14	12.62	12.96	13.32	13.84
1999	0.00	0.05	0.48	1.25	2.18	3.15	4.09	5.08	6.16	7.15	8.23	9.14	9.97	10.76	11.49	12.16	12.63	13.21	13.67	13.98	14.58
2000	0.01	0.04	0.64	1.29	2.28	3.32	4.34	5.34	6.41	7.58	8.61	9.69	10.56	11.35	12.10	12.78	13.41	13.85	14.39	14.82	15.59
2001	0.01	0.10	0.61	1.45	2.20	3.19	4.17	5.13	6.09	7.13	8.22	9.14	10.08	10.81	11.47	12.09	12.66	13.18	13.54	13.99	14.85
2002	0.01	0.08	0.58	1.32	2.29	3.08	4.09	5.09	6.12	7.17	8.25	9.33	10.21	11.09	11.78	12.39	12.97	13.50	13.98	14.32	15.06
2003	0.00	0.08	0.53	1.33	2.22	3.26	4.05	5.09	6.19	7.31	8.38	9.43	10.45	11.26	12.06	12.69	13.24	13.77	14.26	14.70	15.55
2004	0.01	0.07	0.64	1.32	2.28	3.21	4.23	5.01	6.08	7.17	8.23	9.20	10.11	10.96	11.64	12.30	12.82	13.28	13.72	14.12	14.81
2005	0.00	0.11	0.52	1.43	2.23	3.29	4.26	5.36	6.22	7.39	8.53	9.59	10.53	11.39	12.20	12.84	13.46	13.95	14.39	14.81	15.65
2006	0.00	0.06	0.53	1.31	2.39	3.23	4.28	5.27	6.39	7.25	8.37	9.41	10.35	11.16	11.90	12.59	13.14	13.67	14.09	14.47	15.38
2007	0.00	0.05	0.50	1.31	2.26	3.43	4.30	5.40	6.46	7.63	8.50	9.59	10.58	11.45	12.20	12.88	13.51	14.01	14.50	14.88	15.96
2008	0.00	0.04	0.49	1.24	2.21	3.19	4.33	5.18	6.28	7.31	8.42	9.21	10.18	11.04	11.79	12.42	13.00	13.54	13.96	14.38	15.19
2009	0.00	0.03	0.52	1.26	2.20	3.26	4.26	5.46	6.38	7.56	8.64	9.77	10.55	11.49	12.31	13.02	13.63	14.18	14.70	15.11	15.77
2010	0.00	0.03	0.59	1.30	2.18	3.16	4.17	5.15	6.37	7.29	8.43	9.42	10.42	11.09	11.90	12.60	13.21	13.73	14.20	14.64	15.21
2011	0.00	0.05	0.50	1.35	2.18	3.09	4.04	5.06	6.09	7.36	8.26	9.33	10.22	11.10	11.68	12.38	12.99	13.52	13.97	14.38	15.03
2012	0.00	0.04	0.57	1.24	2.21	3.04	3.90	4.82	5.83	6.83	7.98	8.76	9.65	10.37	11.07	11.54	12.09	12.57	12.99	13.35	13.79
2013	0.00	0.06	0.50	1.29	2.09	3.16	4.03	4.96	6.00	7.15	8.24	9.45	10.24	11.13	11.84	12.54	13.00	13.56	14.04	14.46	15.07
2014	0.00	0.04	0.53	1.25	2.20	3.05	4.12	5.00	5.99	7.09	8.27	9.34	10.47	11.20	12.02	12.67	13.31	13.73	14.24	14.68	15.40
2015	0.00	0.04	0.65	1.28	2.13	3.11	3.94	5.02	5.94	6.97	8.06	9.17	10.13	11.13	11.77	12.47	13.04	13.60	13.97	14.41	15.16
2016	0.00	0.10	0.67	1.47	2.23	3.13	4.14	5.00	6.18	7.16	8.20	9.26	10.29	11.16	12.06	12.63	13.26	13.77	14.27	14.60	15.15
2017	0.00	0.10	0.63	1.50	2.43	3.23	4.15	5.21	6.16	7.42	8.42	9.44	10.44	11.39	12.19	13.01	13.53	14.10	14.57	15.02	15.62
2018	0.01	0.10	0.73	1.41	2.41	3.38	4.17	5.13	6.25	7.21	8.43	9.35	10.26	11.13	11.94	12.62	13.32	13.75	14.24	14.64	15.34
2019	0.00	0.16	0.47	1.56	2.36	3.44	4.44	5.29	6.33	7.52	8.52	9.74	10.62	11.48	12.29	13.05	13.68	14.33	14.73	15.19	15.78

Table 2.1.21a. Mid-year weight (kg) at age in the survey (Model 19.12a).

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	1.06	1.92	2.93	4.02	5.14	6.26	7.36	8.41	9.41	10.35	11.23	12.03	12.77	13.44	14.04	14.58	15.06	16.19
1978	0.01	0.05	0.33	0.98	1.86	2.91	4.08	5.30	6.55	7.78	8.98	10.12	11.20	12.22	13.16	14.02	14.80	15.51	16.15	16.72	18.05
1979	0.02	0.06	0.40	1.01	1.91	2.92	4.01	5.14	6.28	7.39	8.45	9.47	10.42	11.31	12.12	12.87	13.55	14.17	14.71	15.20	16.28
1980	0.02	0.06	0.35	1.00	1.79	2.83	3.91	5.04	6.17	7.28	8.35	9.37	10.33	11.23	12.05	12.81	13.50	14.12	14.68	15.17	16.23
1981	0.02	0.06	0.32	0.97	1.85	2.77	3.88	4.98	6.08	7.16	8.20	9.19	10.12	10.99	11.79	12.52	13.18	13.78	14.32	14.80	15.79
1982	0.02	0.05	0.36	0.98	1.92	2.99	4.02	5.21	6.34	7.45	8.51	9.52	10.47	11.35	12.16	12.90	13.57	14.18	14.72	15.21	16.20
1983	0.01	0.04	0.41	0.97	1.82	2.95	4.15	5.26	6.51	7.68	8.81	9.88	10.89	11.83	12.70	13.49	14.21	14.87	15.45	15.97	17.04
1984	0.02	0.10	0.44	1.09	1.77	2.64	3.67	4.68	5.57	6.53	7.40	8.22	8.99	9.70	10.35	10.94	11.47	11.95	12.38	12.77	13.55
1985	0.01	0.06	0.30	1.04	1.97	2.86	4.00	5.32	6.61	7.75	8.98	10.09	11.15	12.13	13.04	13.87	14.63	15.31	15.92	16.47	17.61
1986	0.01	0.03	0.35	0.88	1.91	3.02	4.02	5.25	6.62	7.94	9.09	10.31	11.41	12.44	13.39	14.27	15.06	15.79	16.43	17.01	18.23
1987	0.02	0.06	0.34	1.02	1.76	2.97	4.13	5.13	6.30	7.57	8.76	9.77	10.83	11.78	12.65	13.44	14.17	14.82	15.41	15.93	17.04
1988	0.02	0.05	0.32	0.97	1.94	2.88	4.31	5.64	6.75	8.03	9.40	10.67	11.74	12.86	13.85	14.75	15.58	16.32	16.99	17.59	18.88
1989	0.02	0.05	0.34	0.98	1.92	3.10	4.14	5.64	6.97	8.06	9.28	10.57	11.75	12.73	13.74	14.63	15.43	16.16	16.81	17.39	18.67
1990	0.02	0.05	0.39	1.00	1.88	2.96	4.19	5.22	6.62	7.83	8.80	9.86	10.97	11.97	12.79	13.63	14.35	15.00	15.59	16.11	17.27
1991	0.01	0.06	0.40	1.00	1.78	2.75	3.85	5.03	5.98	7.26	8.33	9.17	10.10	11.04	11.89	12.57	13.27	13.87	14.41	14.88	15.94
1992	0.02	0.06	0.35	0.99	1.76	2.66	3.69	4.81	5.98	6.90	8.12	9.13	9.92	10.77	11.64	12.41	13.04	13.67	14.20	14.68	15.70
1993	0.02	0.06	0.44	1.10	2.05	3.06	4.13	5.31	6.54	7.79	8.75	10.01	11.03	11.82	12.67	13.53	14.28	14.89	15.49	16.00	17.00
1994	0.02	0.07	0.36	1.04	1.86	2.91	3.94	5.00	6.14	7.30	8.45	9.34	10.48	11.40	12.11	12.87	13.63	14.28	14.81	15.34	16.18
1995	0.02	0.05	0.34	0.96	1.90	2.87	4.04	5.15	6.26	7.43	8.60	9.75	10.63	11.74	12.64	13.33	14.06	14.78	15.41	15.90	16.87
1996	0.03	0.08	0.42	1.05	1.90	2.95	3.93	5.03	6.02	6.98	7.95	8.90	9.82	10.51	11.37	12.06	12.57	13.12	13.65	14.11	14.74
1997	0.01	0.06	0.35	0.96	1.75	2.70	3.81	4.82	5.93	6.92	7.86	8.82	9.75	10.64	11.31	12.14	12.79	13.28	13.80	14.31	14.89
1998	0.01	0.05	0.34	0.95	1.76	2.67	3.69	4.82	5.81	6.88	7.81	8.68	9.56	10.41	11.21	11.81	12.55	13.12	13.55	14.00	14.72
1999	0.01	0.05	0.32	0.95	1.83	2.82	3.85	4.96	6.15	7.16	8.24	9.16	10.03	10.89	11.71	12.48	13.05	13.75	14.29	14.70	15.50
2000	0.02	0.05	0.45	0.97	1.87	2.95	4.08	5.21	6.38	7.61	8.64	9.71	10.63	11.48	12.32	13.11	13.86	14.40	15.06	15.57	16.58
2001	0.02	0.07	0.42	1.13	1.80	2.83	3.94	5.06	6.13	7.20	8.31	9.23	10.18	10.97	11.71	12.42	13.09	13.72	14.17	14.72	15.79
2002	0.02	0.07	0.42	1.04	1.97	2.75	3.88	5.06	6.21	7.29	8.36	9.46	10.36	11.28	12.05	12.75	13.43	14.07	14.66	15.08	15.98
2003	0.02	0.07	0.37	1.04	1.87	2.95	3.81	5.01	6.22	7.37	8.44	9.50	10.56	11.43	12.31	13.04	13.71	14.35	14.94	15.49	16.52
2004	0.02	0.07	0.47	1.03	1.94	2.90	4.04	4.91	6.07	7.21	8.27	9.24	10.18	11.11	11.86	12.62	13.25	13.81	14.35	14.85	15.67
2005	0.02	0.08	0.36	1.13	1.88	2.97	4.04	5.27	6.19	7.39	8.55	9.62	10.59	11.52	12.45	13.19	13.93	14.53	15.07	15.59	16.60
2006	0.02	0.04	0.36	1.00	2.03	2.89	4.05	5.14	6.35	7.22	8.35	9.43	10.40	11.28	12.11	12.93	13.58	14.22	14.75	15.21	16.30
2007	0.01	0.04	0.32	0.99	1.87	3.10	4.06	5.28	6.41	7.62	8.49	9.60	10.64	11.58	12.42	13.21	13.98	14.58	15.18	15.66	16.94
2008	0.02	0.04	0.32	0.93	1.83	2.84	4.13	5.09	6.27	7.33	8.46	9.26	10.26	11.19	12.02	12.75	13.44	14.10	14.62	15.13	16.05
2009	0.01	0.03	0.33	0.91	1.76	2.86	4.00	5.40	6.41	7.64	8.73	9.87	10.67	11.67	12.59	13.41	14.13	14.80	15.44	15.94	16.72
2010	0.02	0.05	0.37	0.93	1.72	2.72	3.89	5.05	6.41	7.37	8.52	9.52	10.56	11.28	12.17	12.99	13.70	14.32	14.90	15.45	16.15
2011	0.02	0.06	0.30	0.99	1.74	2.66	3.74	4.95	6.09	7.41	8.32	9.40	10.32	11.27	11.92	12.73	13.46	14.09	14.64	15.15	15.97
2012	0.02	0.03	0.38	0.92	1.84	2.69	3.65	4.71	5.83	6.87	8.03	8.82	9.73	10.51	11.30	11.84	12.49	13.08	13.59	14.03	14.61
2013	0.01	0.06	0.34	0.97	1.70	2.82	3.80	4.86	6.01	7.22	8.31	9.53	10.35	11.30	12.11	12.92	13.46	14.13	14.73	15.24	16.05
2014	0.01	0.04	0.34	0.90	1.76	2.63	3.86	4.89	5.99	7.14	8.34	9.41	10.59	11.38	12.29	13.05	13.81	14.32	14.94	15.49	16.42
2015	0.02	0.05	0.42	0.92	1.68	2.69	3.63	4.90	5.93	6.99	8.10	9.22	10.22	11.30	12.02	12.84	13.52	14.20	14.65	15.20	16.15
2016	0.02	0.09	0.44	1.08	1.77	2.70	3.83	4.83	6.14	7.17	8.22	9.29	10.36	11.31	12.32	12.99	13.75	14.37	14.98	15.39	16.12
2017	0.01	0.09	0.40	1.09	1.96	2.78	3.83	5.05	6.08	7.41	8.43	9.46	10.50	11.53	12.43	13.39	14.01	14.72	15.29	15.86	16.64
2018	0.03	0.09	0.53	1.07	2.01	3.03	3.92	4.99	6.20	7.19	8.44	9.38	10.32	11.25	12.17	12.96	13.79	14.33	14.93	15.42	16.33
2019	0.02	0.10	0.30	1.24	1.97	3.09	4.23	5.19	6.31	7.55	8.55	9.79	10.72	11.63	12.53	13.41	14.17	14.95	15.46	16.02	16.79
2020	0.01	0.04	0.33	0.86	2.06	2.88	4.05	5.18	6.11	7.17	8.32	9.24	10.36	11.19	12.00	12.80	13.56	14.22	14.90	15.33	16.15

Table 2.1.21b. Mid-year weight (kg) at age in the 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	0.41	1.05	1.90	2.90	4.00	5.15	6.32	7.49	8.64	9.75	10.82	11.84	12.79	13.68	14.50	15.25	15.92	16.52	18.02
1978	0.01	0.05	0.33	0.97	1.84	2.88	4.06	5.32	6.62	7.93	9.24	10.51	11.75	12.93	14.04	15.08	16.05	16.93	17.73	18.45	20.24
1979	0.02	0.06	0.40	1.00	1.89	2.90	4.00	5.16	6.34	7.52	8.69	9.81	10.90	11.92	12.89	13.80	14.63	15.39	16.07	16.69	18.14
1980	0.02	0.06	0.35	0.99	1.77	2.81	3.90	5.05	6.23	7.42	8.58	9.72	10.81	11.85	12.83	13.75	14.59	15.36	16.06	16.68	18.12
1981	0.02	0.06	0.32	0.96	1.83	2.74	3.87	4.99	6.15	7.30	8.43	9.53	10.59	11.59	12.54	13.42	14.24	14.98	15.65	16.25	17.61
1982	0.02	0.05	0.35	0.96	1.89	2.96	4.00	5.23	6.41	7.59	8.75	9.87	10.94	11.96	12.92	13.82	14.64	15.39	16.07	16.67	18.04
1983	0.01	0.04	0.44	0.95	1.79	2.91	4.13	5.27	6.58	7.83	9.05	10.25	11.39	12.48	13.51	14.47	15.36	16.17	16.90	17.55	19.03
1984	0.02	0.11	0.44	1.12	1.74	2.61	3.65	4.69	5.62	6.65	7.59	8.50	9.37	10.19	10.96	11.67	12.32	12.91	13.44	13.92	15.00
1985	0.01	0.06	0.30	1.03	2.00	2.82	3.97	5.32	6.68	7.89	9.23	10.48	11.67	12.81	13.89	14.90	15.83	16.68	17.44	18.13	19.71
1986	0.01	0.03	0.35	0.87	1.88	3.05	3.99	5.24	6.68	8.10	9.34	10.71	11.96	13.16	14.29	15.35	16.33	17.22	18.04	18.76	20.46
1987	0.02	0.06	0.34	1.01	1.73	2.93	4.18	5.13	6.35	7.71	9.00	10.13	11.34	12.43	13.47	14.43	15.32	16.13	16.86	17.52	19.08
1988	0.02	0.05	0.32	0.96	1.91	2.84	4.28	5.73	6.80	8.16	9.66	11.08	12.30	13.61	14.78	15.87	16.89	17.81	18.65	19.40	21.23
1989	0.02	0.05	0.34	0.97	1.89	3.06	4.10	5.65	7.12	8.19	9.52	10.96	12.30	13.44	14.65	15.72	16.71	17.61	18.43	19.16	20.97
1990	0.02	0.05	0.39	0.99	1.86	2.93	4.17	5.21	6.69	8.05	9.02	10.20	11.46	12.62	13.59	14.61	15.50	16.31	17.04	17.69	19.33
1991	0.01	0.06	0.41	0.99	1.76	2.73	3.83	5.04	6.02	7.39	8.62	9.49	10.53	11.64	12.64	13.47	14.32	15.06	15.73	16.33	17.84
1992	0.02	0.06	0.35	0.99	1.74	2.63	3.67	4.82	6.04	7.01	8.34	9.53	10.35	11.34	12.38	13.31	14.07	14.86	15.52	16.12	17.60
1993	0.02	0.06	0.43	1.08	2.04	3.03	4.11	5.32	6.60	7.92	8.97	10.36	11.59	12.44	13.45	14.48	15.41	16.15	16.91	17.55	19.00
1994	0.02	0.07	0.36	1.01	1.83	2.89	3.92	5.01	6.19	7.42	8.68	9.66	10.96	12.09	12.86	13.78	14.71	15.53	16.19	16.85	18.08
1995	0.02	0.06	0.34	0.96	1.85	2.84	4.04	5.17	6.32	7.56	8.83	10.11	11.10	12.40	13.53	14.29	15.19	16.09	16.87	17.50	18.87
1996	0.03	0.08	0.42	1.04	1.89	2.90	3.91	5.06	6.08	7.09	8.15	9.20	10.24	11.03	12.06	12.93	13.51	14.18	14.84	15.42	16.31
1997	0.01	0.06	0.35	0.95	1.73	2.68	3.77	4.82	6.00	7.04	8.07	9.12	10.18	11.21	12.00	13.00	13.85	14.41	15.06	15.69	16.49
1998	0.01	0.05	0.34	0.94	1.74	2.65	3.68	4.80	5.86	7.02	8.02	8.99	9.98	10.96	11.91	12.62	13.53	14.28	14.78	15.34	16.30
1999	0.02	0.05	0.32	0.94	1.80	2.79	3.84	4.97	6.17	7.28	8.47	9.49	10.47	11.46	12.43	13.37	14.06	14.93	15.64	16.10	17.20
2000	0.02	0.05	0.44	0.96	1.85	2.92	4.06	5.23	6.45	7.71	8.86	10.08	11.11	12.10	13.08	14.04	14.95	15.61	16.44	17.12	18.46
2001	0.02	0.07	0.42	1.10	1.78	2.79	3.92	5.06	6.19	7.34	8.50	9.55	10.64	11.56	12.42	13.28	14.10	14.87	15.42	16.12	17.61
2002	0.02	0.07	0.41	1.03	1.92	2.72	3.86	5.07	6.26	7.42	8.59	9.77	10.82	11.90	12.81	13.65	14.49	15.27	16.01	16.53	17.93
2003	0.02	0.07	0.37	1.03	1.84	2.90	3.79	5.01	6.28	7.50	8.68	9.85	11.02	12.05	13.12	14.00	14.81	15.60	16.34	17.03	18.63
2004	0.02	0.07	0.46	1.02	1.91	2.86	4.00	4.91	6.12	7.33	8.48	9.57	10.64	11.69	12.60	13.53	14.29	14.98	15.65	16.28	17.62
2005	0.02	0.08	0.36	1.11	1.85	2.93	4.02	5.26	6.24	7.51	8.78	9.97	11.08	12.16	13.22	14.14	15.06	15.80	16.48	17.12	18.72
2006	0.02	0.04	0.36	0.98	1.99	2.85	4.02	5.14	6.39	7.34	8.57	9.76	10.87	11.89	12.88	13.84	14.65	15.46	16.11	16.69	18.38
2007	0.02	0.04	0.33	0.98	1.85	3.06	4.03	5.29	6.46	7.75	8.71	9.94	11.13	12.21	13.21	14.17	15.08	15.84	16.60	17.20	19.14
2008	0.02	0.04	0.32	0.93	1.81	2.81	4.10	5.08	6.33	7.46	8.68	9.58	10.71	11.79	12.78	13.67	14.51	15.30	15.96	16.61	18.20
2009	0.01	0.03	0.32	0.90	1.75	2.83	3.98	5.40	6.46	7.78	8.97	10.22	11.15	12.31	13.40	14.39	15.28	16.11	16.88	17.52	18.87
2010	0.02	0.04	0.37	0.92	1.70	2.71	3.87	5.06	6.47	7.50	8.76	9.87	11.04	11.89	12.94	13.93	14.80	15.58	16.30	16.97	18.11
2011	0.02	0.06	0.31	0.97	1.70	2.64	3.73	4.95	6.15	7.54	8.54	9.74	10.79	11.88	12.68	13.64	14.54	15.32	16.02	16.65	17.90
2012	0.02	0.03	0.39	0.91	1.81	2.65	3.63	4.72	5.88	6.99	8.24	9.12	10.17	11.07	11.99	12.66	13.45	14.18	14.82	15.37	16.23
2013	0.01	0.06	0.34	0.97	1.68	2.78	3.76	4.87	6.08	7.34	8.54	9.88	10.82	11.93	12.89	13.85	14.54	15.36	16.11	16.75	17.89
2014	0.01	0.04	0.34	0.89	1.75	2.60	3.83	4.88	6.04	7.28	8.57	9.76	11.09	12.02	13.10	14.02	14.94	15.60	16.37	17.06	18.36
2015	0.02	0.05	0.42	0.90	1.66	2.67	3.61	4.90	5.96	7.12	8.33	9.56	10.69	11.95	12.81	13.81	14.64	15.48	16.06	16.74	18.10
2016	0.02	0.09	0.44	1.07	1.73	2.67	3.82	4.84	6.19	7.28	8.44	9.64	10.85	11.94	13.14	13.95	14.88	15.66	16.42	16.94	18.00
2017	0.01	0.09	0.40	1.09	1.94	2.74	3.80	5.06	6.14	7.54	8.64	9.81	11.00	12.18	13.25	14.40	15.17	16.05	16.77	17.48	18.62
2018	0.03	0.09	0.52	1.06	2.00	3.00	3.88	5.00	6.27	7.32	8.66	9.71	10.79	11.88	12.95	13.90	14.92	15.59	16.35	16.96	18.25
2019	0.02	0.10	0.31	1.22	1.95	3.08	4.22	5.18	6.37	7.69	8.78	10.15	11.19	12.27	13.35	14.40	15.32	16.30	16.93	17.64	18.81
2020	0.01	0.04	0.33	0.85	2.03	2.85	4.06	5.20	6.15	7.30	8.55	9.57	10.83	11.79	12.77	13.74	14.67	15.48	16.33	16.87	18.09

Table 2.1.21c. Mid-year weight (kg) at age in the survey (Model 21.1).

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	0.06	0.39	1.05	1.91	2.89	3.91	4.93	5.91	6.84	7.71	8.50	9.22	9.86	10.43	10.94	11.38	11.77	12.11	12.40	12.95
1978	0.01	0.05	0.32	0.97	1.85	2.87	3.96	5.07	6.16	7.20	8.18	9.08	9.90	10.64	11.30	11.88	12.40	12.85	13.24	13.58	14.24
1979	0.02	0.06	0.39	1.01	1.90	2.88	3.90	4.93	5.93	6.87	7.74	8.54	9.27	9.92	10.50	11.01	11.46	11.86	12.20	12.50	13.09
1980	0.02	0.06	0.35	1.01	1.80	2.79	3.81	4.83	5.82	6.76	7.64	8.44	9.17	9.83	10.41	10.93	11.39	11.78	12.13	12.43	13.04
1981	0.02	0.06	0.31	0.98	1.86	2.75	3.78	4.77	5.74	6.66	7.51	8.29	9.00	9.64	10.20	10.70	11.14	11.53	11.86	12.15	12.76
1982	0.02	0.05	0.35	0.98	1.93	2.96	3.94	5.00	5.99	6.93	7.81	8.61	9.33	9.98	10.56	11.07	11.51	11.90	12.24	12.54	13.16
1983	0.01	0.04	0.41	0.98	1.83	2.93	4.05	5.07	6.14	7.13	8.06	8.91	9.68	10.37	10.98	11.53	12.01	12.43	12.79	13.11	13.78
1984	0.02	0.10	0.43	1.10	1.79	2.64	3.62	4.53	5.31	6.11	6.82	7.47	8.05	8.56	9.02	9.42	9.78	10.09	10.35	10.58	11.08
1985	0.01	0.06	0.30	1.05	1.98	2.86	3.92	5.13	6.26	7.22	8.20	9.07	9.87	10.58	11.22	11.78	12.28	12.71	13.09	13.42	14.14
1986	0.01	0.03	0.35	0.88	1.92	2.99	3.95	5.05	6.26	7.38	8.31	9.26	10.10	10.85	11.52	12.12	12.64	13.10	13.51	13.85	14.63
1987	0.02	0.06	0.34	1.03	1.77	2.95	4.04	4.96	5.98	7.06	8.03	8.82	9.62	10.31	10.92	11.46	11.94	12.36	12.73	13.04	13.75
1988	0.02	0.05	0.31	0.98	1.96	2.87	4.22	5.42	6.40	7.47	8.60	9.59	10.40	11.20	11.89	12.51	13.05	13.52	13.94	14.30	15.12
1989	0.02	0.05	0.33	0.99	1.94	3.09	4.07	5.43	6.59	7.52	8.50	9.52	10.40	11.11	11.81	12.40	12.93	13.39	13.79	14.14	14.94
1990	0.02	0.05	0.38	1.01	1.90	2.95	4.11	5.03	6.28	7.30	8.10	8.94	9.79	10.52	11.10	11.67	12.15	12.57	12.93	13.25	13.99
1991	0.01	0.06	0.40	1.01	1.80	2.76	3.80	4.87	5.69	6.77	7.64	8.31	9.00	9.70	10.29	10.75	11.20	11.58	11.91	12.20	12.87
1992	0.02	0.06	0.35	1.00	1.77	2.64	3.63	4.65	5.67	6.45	7.45	8.25	8.85	9.47	10.10	10.62	11.03	11.43	11.76	12.05	12.72
1993	0.02	0.06	0.45	1.11	2.07	3.04	4.06	5.14	6.22	7.28	8.06	9.05	9.83	10.42	11.01	11.61	12.10	12.49	12.85	13.16	13.82
1994	0.01	0.07	0.36	1.08	1.88	2.90	3.87	4.84	5.85	6.82	7.76	8.44	9.31	9.98	10.47	10.98	11.48	11.89	12.22	12.53	13.08
1995	0.02	0.06	0.34	0.98	1.95	2.87	3.97	4.97	5.95	6.94	7.89	8.79	9.45	10.26	10.89	11.36	11.83	12.29	12.67	12.97	13.59
1996	0.03	0.08	0.41	1.07	1.92	2.97	3.87	4.87	5.73	6.54	7.35	8.10	8.80	9.30	9.92	10.38	10.73	11.07	11.41	11.69	12.10
1997	0.01	0.06	0.35	0.97	1.77	2.70	3.78	4.66	5.63	6.46	7.23	7.99	8.69	9.34	9.80	10.37	10.80	11.11	11.43	11.73	12.11
1998	0.01	0.05	0.34	0.96	1.79	2.70	3.66	4.71	5.54	6.43	7.18	7.86	8.52	9.13	9.68	10.07	10.55	10.91	11.17	11.43	11.87
1999	0.02	0.05	0.32	0.97	1.84	2.81	3.79	4.79	5.86	6.69	7.57	8.29	8.95	9.59	10.17	10.70	11.07	11.52	11.85	12.10	12.60
2000	0.02	0.05	0.45	0.97	1.89	2.93	4.00	5.03	6.06	7.13	7.95	8.81	9.50	10.14	10.74	11.29	11.78	12.12	12.54	12.85	13.49
2001	0.02	0.07	0.42	1.14	1.80	2.81	3.86	4.88	5.83	6.75	7.68	8.39	9.12	9.70	10.23	10.73	11.18	11.58	11.86	12.20	12.88
2002	0.02	0.07	0.41	1.06	1.98	2.74	3.81	4.89	5.89	6.82	7.70	8.58	9.24	9.92	10.46	10.94	11.40	11.81	12.17	12.43	13.02
2003	0.02	0.07	0.36	1.05	1.89	2.94	3.74	4.84	5.90	6.88	7.76	8.59	9.41	10.02	10.64	11.14	11.58	11.99	12.36	12.69	13.35
2004	0.02	0.07	0.47	1.04	1.95	2.89	3.96	4.74	5.77	6.74	7.60	8.37	9.09	9.79	10.30	10.82	11.23	11.59	11.93	12.23	12.78
2005	0.02	0.08	0.36	1.15	1.90	2.95	3.96	5.08	5.87	6.90	7.86	8.70	9.44	10.13	10.80	11.28	11.77	12.16	12.50	12.81	13.47
2006	0.02	0.04	0.35	1.00	2.03	2.86	3.95	4.95	6.01	6.75	7.70	8.56	9.32	9.97	10.57	11.15	11.57	11.99	12.31	12.60	13.32
2007	0.01	0.04	0.32	1.00	1.87	3.06	3.96	5.08	6.08	7.12	7.83	8.74	9.55	10.25	10.85	11.40	11.93	12.31	12.68	12.98	13.82
2008	0.02	0.04	0.31	0.93	1.83	2.82	4.03	4.90	5.94	6.86	7.79	8.41	9.19	9.89	10.48	10.99	11.45	11.89	12.20	12.51	13.19
2009	0.01	0.03	0.33	0.91	1.76	2.84	3.91	5.19	6.07	7.12	8.02	8.92	9.52	10.27	10.93	11.49	11.97	12.40	12.81	13.10	13.66
2010	0.02	0.05	0.37	0.95	1.73	2.71	3.82	4.87	6.07	6.88	7.82	8.61	9.39	9.91	10.55	11.11	11.58	11.98	12.33	12.67	13.14
2011	0.02	0.06	0.30	1.00	1.76	2.65	3.67	4.77	5.78	6.90	7.63	8.48	9.19	9.88	10.33	10.89	11.37	11.78	12.12	12.42	12.96
2012	0.02	0.03	0.39	0.92	1.84	2.67	3.56	4.53	5.54	6.43	7.40	8.03	8.74	9.32	9.89	10.26	10.70	11.09	11.41	11.68	12.07
2013	0.01	0.06	0.33	1.00	1.72	2.82	3.75	4.70	5.71	6.73	7.63	8.58	9.18	9.87	10.43	10.97	11.32	11.75	12.11	12.42	12.92
2014	0.01	0.04	0.34	0.91	1.79	2.61	3.78	4.73	5.67	6.66	7.64	8.49	9.38	9.95	10.59	11.11	11.60	11.93	12.31	12.64	13.23
2015	0.02	0.05	0.42	0.94	1.70	2.70	3.56	4.73	5.63	6.51	7.42	8.30	9.05	9.84	10.34	10.89	11.33	11.76	12.03	12.36	12.97
2016	0.02	0.09	0.43	1.10	1.80	2.70	3.79	4.67	5.83	6.69	7.53	8.37	9.18	9.86	10.56	11.00	11.49	11.88	12.26	12.49	12.97
2017	0.01	0.09	0.40	1.11	1.99	2.80	3.77	4.89	5.77	6.89	7.73	8.51	9.30	10.05	10.67	11.31	11.71	12.15	12.50	12.84	13.34
2018	0.03	0.09	0.53	1.09	2.03	3.02	3.86	4.83	5.89	6.71	7.73	8.47	9.17	9.85	10.49	11.02	11.57	11.90	12.27	12.56	13.13
2019	0.02	0.10	0.30	1.25	1.98	3.06	4.12	5.00	5.98	7.04	7.85	8.85	9.56	10.23	10.88	11.49	11.99	12.50	12.81	13.15	13.66
2020	0.01	0.04	0.33	0.86	2.08	2.87	3.96	4.98	5.79	6.68	7.63	8.34	9.19	9.80	10.37	10.91	11.42	11.84	12.26	12.52	13.04

Table 2.1.21d. Mid-year weight (kg) at age in the survey (Model 21.2).

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	0.42	1.06	1.91	2.88	3.94	5.03	6.14	7.23	8.29	9.31	10.29	11.20	12.06	12.86	13.59	14.26	14.86	15.41	16.77
1978	0.01	0.05	0.33	0.99	1.84	2.86	3.99	5.19	6.41	7.64	8.84	10.01	11.13	12.19	13.19	14.12	14.98	15.76	16.48	17.12	18.75
1979	0.02	0.06	0.40	1.00	1.90	2.87	3.93	5.04	6.15	7.26	8.33	9.37	10.35	11.28	12.15	12.96	13.70	14.38	15.00	15.55	16.84
1980	0.02	0.06	0.35	0.99	1.76	2.79	3.84	4.93	6.05	7.15	8.23	9.27	10.26	11.20	12.08	12.90	13.65	14.34	14.96	15.53	16.78
1981	0.02	0.05	0.32	0.96	1.81	2.70	3.80	4.88	5.96	7.04	8.09	9.10	10.06	10.97	11.82	12.60	13.33	13.99	14.60	15.14	16.31
1982	0.02	0.05	0.36	0.97	1.88	2.91	3.91	5.11	6.22	7.32	8.39	9.42	10.40	11.32	12.19	12.99	13.72	14.39	15.00	15.55	16.72
1983	0.01	0.04	0.41	0.96	1.79	2.87	4.03	5.12	6.38	7.55	8.68	9.77	10.82	11.80	12.73	13.58	14.37	15.10	15.75	16.34	17.60
1984	0.03	0.10	0.44	1.07	1.73	2.59	3.58	4.56	5.44	6.43	7.31	8.14	8.94	9.68	10.37	11.01	11.59	12.12	12.60	13.03	13.95
1985	0.01	0.06	0.31	1.03	1.91	2.79	3.90	5.18	6.44	7.58	8.85	9.99	11.07	12.10	13.07	13.97	14.79	15.55	16.24	16.86	18.20
1986	0.01	0.03	0.35	0.88	1.87	2.92	3.91	5.11	6.45	7.76	8.92	10.20	11.33	12.41	13.43	14.37	15.24	16.04	16.76	17.42	18.85
1987	0.02	0.06	0.34	1.01	1.73	2.90	4.00	5.00	6.16	7.41	8.60	9.64	10.76	11.75	12.68	13.54	14.33	15.05	15.71	16.30	17.61
1988	0.02	0.05	0.31	0.95	1.90	2.81	4.20	5.47	6.58	7.86	9.23	10.52	11.63	12.83	13.88	14.86	15.76	16.59	17.34	18.01	19.53
1989	0.02	0.05	0.34	0.96	1.87	3.01	4.04	5.49	6.78	7.88	9.12	10.42	11.64	12.67	13.78	14.73	15.61	16.42	17.15	17.81	19.31
1990	0.02	0.04	0.38	0.99	1.84	2.88	4.08	5.09	6.47	7.65	8.64	9.74	10.87	11.91	12.79	13.72	14.51	15.23	15.89	16.48	17.83
1991	0.01	0.05	0.40	0.98	1.75	2.68	3.74	4.90	5.85	7.11	8.17	9.05	10.01	11.00	11.89	12.64	13.42	14.08	14.68	15.22	16.46
1992	0.02	0.06	0.35	0.98	1.72	2.60	3.59	4.68	5.84	6.76	7.98	9.00	9.83	10.73	11.65	12.48	13.16	13.88	14.47	15.01	16.22
1993	0.02	0.06	0.44	1.08	2.01	2.97	4.03	5.17	6.38	7.63	8.61	9.88	10.92	11.77	12.68	13.60	14.42	15.09	15.78	16.36	17.53
1994	0.02	0.07	0.36	1.03	1.82	2.83	3.83	4.88	5.98	7.13	8.30	9.22	10.39	11.34	12.11	12.93	13.76	14.49	15.08	15.69	16.67
1995	0.02	0.05	0.34	0.95	1.85	2.80	3.94	5.01	6.11	7.26	8.44	9.62	10.53	11.70	12.64	13.40	14.20	14.99	15.69	16.26	17.39
1996	0.03	0.08	0.41	1.04	1.87	2.88	3.83	4.91	5.88	6.84	7.81	8.78	9.74	10.47	11.38	12.11	12.69	13.29	13.88	14.40	15.13
1997	0.01	0.06	0.32	0.94	1.71	2.63	3.71	4.69	5.79	6.76	7.73	8.69	9.65	10.59	11.31	12.21	12.91	13.47	14.05	14.62	15.29
1998	0.02	0.05	0.34	0.89	1.72	2.61	3.60	4.69	5.67	6.74	7.66	8.57	9.47	10.36	11.22	11.87	12.67	13.30	13.79	14.30	15.13
1999	0.02	0.05	0.33	0.95	1.73	2.74	3.75	4.83	5.99	7.01	8.10	9.03	9.94	10.83	11.71	12.55	13.17	13.95	14.54	15.01	15.94
2000	0.02	0.04	0.44	0.96	1.85	2.81	3.97	5.08	6.23	7.44	8.49	9.59	10.53	11.43	12.32	13.17	13.99	14.59	15.34	15.91	17.09
2001	0.02	0.07	0.41	1.10	1.77	2.77	3.77	4.92	5.98	7.06	8.17	9.11	10.09	10.92	11.71	12.47	13.21	13.90	14.41	15.03	16.28
2002	0.02	0.06	0.41	1.01	1.91	2.69	3.79	4.86	6.05	7.13	8.22	9.33	10.26	11.23	12.05	12.81	13.55	14.26	14.92	15.40	16.44
2003	0.02	0.07	0.37	1.02	1.81	2.86	3.71	4.89	5.99	7.21	8.29	9.37	10.46	11.38	12.32	13.11	13.84	14.55	15.21	15.84	17.03
2004	0.02	0.07	0.47	1.01	1.88	2.80	3.92	4.78	5.94	6.99	8.12	9.11	10.09	11.06	11.87	12.69	13.37	14.00	14.60	15.16	16.12
2005	0.02	0.08	0.36	1.12	1.84	2.87	3.91	5.12	6.04	7.24	8.33	9.49	10.49	11.47	12.45	13.25	14.07	14.73	15.35	15.93	17.10
2006	0.02	0.04	0.36	0.99	1.99	2.81	3.92	4.98	6.18	7.07	8.22	9.23	10.31	11.23	12.12	13.00	13.71	14.43	15.01	15.54	16.80
2007	0.01	0.04	0.34	0.99	1.84	3.02	3.94	5.13	6.23	7.45	8.34	9.48	10.48	11.53	12.42	13.28	14.11	14.79	15.46	16.00	17.50
2008	0.02	0.04	0.32	0.94	1.80	2.77	4.02	4.94	6.11	7.16	8.31	9.13	10.18	11.08	12.02	12.82	13.57	14.30	14.88	15.46	16.53
2009	0.01	0.03	0.33	0.90	1.75	2.79	3.89	5.26	6.24	7.46	8.55	9.73	10.57	11.63	12.54	13.48	14.27	15.01	15.72	16.29	17.20
2010	0.02	0.05	0.38	0.92	1.70	2.68	3.80	4.92	6.27	7.21	8.36	9.37	10.46	11.23	12.18	13.00	13.83	14.52	15.17	15.79	16.61
2011	0.02	0.06	0.31	0.98	1.70	2.60	3.67	4.82	5.95	7.26	8.16	9.26	10.21	11.22	11.92	12.80	13.54	14.29	14.91	15.48	16.44
2012	0.02	0.03	0.38	0.92	1.80	2.62	3.56	4.61	5.70	6.73	7.90	8.69	9.64	10.45	11.30	11.89	12.62	13.22	13.83	14.33	15.00
2013	0.01	0.05	0.34	0.95	1.68	2.75	3.69	4.74	5.89	7.07	8.17	9.41	10.25	11.25	12.09	12.98	13.59	14.34	14.96	15.58	16.53
2014	0.02	0.04	0.33	0.89	1.71	2.57	3.76	4.75	5.85	7.01	8.19	9.28	10.50	11.32	12.28	13.10	13.95	14.53	15.23	15.81	16.95
2015	0.02	0.05	0.42	0.89	1.64	2.60	3.54	4.77	5.77	6.85	7.97	9.10	10.12	11.27	12.02	12.90	13.65	14.41	14.93	15.55	16.69
2016	0.02	0.09	0.43	1.06	1.71	2.63	3.70	4.71	6.00	7.00	8.08	9.18	10.27	11.26	12.34	13.05	13.88	14.56	15.27	15.74	16.64
2017	0.01	0.09	0.40	1.06	1.91	2.69	3.72	4.88	5.94	7.25	8.27	9.33	10.42	11.49	12.44	13.48	14.15	14.93	15.57	16.22	17.18
2018	0.03	0.09	0.52	1.06	1.95	2.94	3.79	4.86	6.02	7.05	8.30	9.25	10.23	11.22	12.18	13.03	13.94	14.53	15.21	15.76	16.83
2019	0.02	0.10	0.31	1.22	1.93	3.00	4.10	5.02	6.15	7.36	8.40	9.66	10.61	11.58	12.55	13.49	14.31	15.19	15.74	16.38	17.24
2020	0.01	0.04	0.33	0.85	2.01	2.80	3.93	5.03	5.93	7.01	8.14	9.11	10.27	11.13	12.01	12.88	13.70	14.42	15.19	15.67	16.57

Table 2.1.21e. Mid-year weight (kg) at age in the survey (Model 21.3).

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	1.04	1.89	2.89	4.00	5.16	6.35	7.54	8.71	9.86	10.96	12.00	12.99	13.91	14.76	15.54	16.24	16.86	18.40
1978	0.01	0.05	0.33	0.97	1.83	2.87	4.06	5.33	6.65	7.99	9.32	10.63	11.90	13.12	14.28	15.36	16.36	17.28	18.11	18.85	20.69
1979	0.02	0.06	0.40	0.99	1.88	2.89	3.99	5.17	6.37	7.57	8.76	9.91	11.03	12.09	13.10	14.03	14.90	15.69	16.40	17.03	18.52
1980	0.02	0.06	0.35	0.99	1.76	2.80	3.89	5.06	6.26	7.46	8.66	9.82	10.95	12.02	13.04	13.99	14.86	15.66	16.38	17.03	18.51
1981	0.02	0.06	0.31	0.95	1.82	2.73	3.86	5.00	6.17	7.34	8.50	9.63	10.72	11.76	12.74	13.66	14.50	15.27	15.96	16.58	17.99
1982	0.02	0.05	0.35	0.95	1.88	2.95	3.99	5.23	6.43	7.63	8.82	9.97	11.07	12.13	13.12	14.05	14.91	15.68	16.39	17.01	18.42
1983	0.02	0.04	0.46	0.94	1.77	2.90	4.13	5.27	6.61	7.87	9.13	10.35	11.53	12.66	13.73	14.73	15.65	16.48	17.24	17.92	19.44
1984	0.02	0.12	0.44	1.14	1.72	2.59	3.64	4.70	5.64	6.69	7.65	8.59	9.48	10.32	11.12	11.85	12.53	13.14	13.69	14.19	15.30
1985	0.01	0.06	0.30	1.02	2.03	2.80	3.95	5.33	6.71	7.94	9.31	10.59	11.82	13.00	14.12	15.16	16.13	17.01	17.80	18.51	20.15
1986	0.01	0.03	0.35	0.85	1.87	3.09	3.97	5.23	6.71	8.15	9.42	10.83	12.12	13.36	14.53	15.63	16.65	17.58	18.42	19.17	20.92
1987	0.02	0.06	0.34	1.00	1.71	2.92	4.23	5.12	6.36	7.75	9.09	10.23	11.48	12.61	13.68	14.68	15.60	16.45	17.20	17.88	19.49
1988	0.02	0.05	0.31	0.95	1.90	2.82	4.28	5.79	6.81	8.20	9.74	11.21	12.45	13.81	15.02	16.16	17.21	18.18	19.04	19.82	21.71
1989	0.02	0.05	0.33	0.96	1.88	3.05	4.09	5.66	7.21	8.23	9.59	11.08	12.47	13.64	14.89	16.00	17.03	17.97	18.81	19.57	21.44
1990	0.02	0.05	0.39	0.98	1.85	2.93	4.17	5.21	6.71	8.15	9.08	10.29	11.60	12.81	13.81	14.86	15.78	16.62	17.38	18.05	19.75
1991	0.01	0.06	0.41	0.99	1.75	2.72	3.83	5.05	6.04	7.43	8.74	9.57	10.65	11.80	12.84	13.69	14.59	15.35	16.05	16.66	18.22
1992	0.02	0.06	0.35	0.99	1.74	2.62	3.67	4.83	6.06	7.04	8.41	9.67	10.47	11.49	12.58	13.55	14.33	15.15	15.84	16.46	17.98
1993	0.02	0.06	0.42	1.07	2.05	3.03	4.11	5.33	6.63	7.98	9.03	10.47	11.78	12.60	13.64	14.73	15.69	16.46	17.25	17.91	19.39
1994	0.02	0.07	0.36	1.00	1.81	2.90	3.93	5.01	6.22	7.47	8.75	9.75	11.09	12.31	13.06	14.00	14.98	15.83	16.51	17.20	18.44
1995	0.01	0.06	0.35	0.96	1.83	2.82	4.06	5.18	6.35	7.61	8.91	10.22	11.23	12.58	13.79	14.53	15.46	16.41	17.22	17.86	19.27
1996	0.03	0.08	0.41	1.04	1.89	2.88	3.90	5.09	6.11	7.13	8.21	9.30	10.36	11.17	12.24	13.17	13.73	14.43	15.13	15.72	16.61
1997	0.01	0.06	0.35	0.94	1.73	2.68	3.75	4.82	6.05	7.09	8.13	9.22	10.31	11.37	12.17	13.23	14.14	14.68	15.35	16.01	16.83
1998	0.01	0.05	0.34	0.93	1.73	2.65	3.69	4.80	5.88	7.08	8.09	9.08	10.10	11.12	12.10	12.83	13.78	14.59	15.06	15.64	16.62
1999	0.01	0.05	0.32	0.93	1.79	2.78	3.84	4.99	6.19	7.32	8.57	9.60	10.60	11.62	12.63	13.60	14.30	15.21	15.98	16.42	17.55
2000	0.02	0.04	0.43	0.95	1.84	2.91	4.05	5.24	6.48	7.75	8.93	10.21	11.25	12.26	13.29	14.28	15.22	15.90	16.77	17.49	18.85
2001	0.02	0.07	0.41	1.09	1.76	2.79	3.92	5.07	6.22	7.39	8.57	9.64	10.79	11.72	12.61	13.50	14.35	15.15	15.72	16.44	17.97
2002	0.02	0.07	0.41	1.02	1.91	2.71	3.85	5.08	6.29	7.47	8.68	9.87	10.95	12.09	13.02	13.89	14.75	15.57	16.33	16.86	18.32
2003	0.02	0.07	0.36	1.02	1.83	2.88	3.78	5.02	6.30	7.55	8.76	9.97	11.15	12.22	13.35	14.25	15.08	15.91	16.68	17.38	19.05
2004	0.02	0.07	0.46	1.01	1.90	2.85	3.99	4.91	6.14	7.38	8.55	9.67	10.78	11.84	12.79	13.78	14.56	15.27	15.96	16.61	18.02
2005	0.02	0.08	0.35	1.10	1.84	2.92	4.01	5.26	6.26	7.56	8.86	10.07	11.22	12.35	13.43	14.38	15.36	16.12	16.81	17.48	19.15
2006	0.02	0.04	0.36	0.97	1.98	2.84	4.02	5.15	6.41	7.38	8.64	9.87	11.00	12.07	13.10	14.07	14.92	15.78	16.44	17.04	18.79
2007	0.02	0.04	0.33	0.97	1.83	3.04	4.02	5.30	6.49	7.78	8.78	10.04	11.26	12.39	13.43	14.42	15.35	16.15	16.96	17.56	19.58
2008	0.02	0.04	0.32	0.92	1.79	2.79	4.09	5.09	6.36	7.51	8.74	9.67	10.84	11.96	12.98	13.90	14.78	15.59	16.28	16.97	18.63
2009	0.01	0.03	0.32	0.90	1.74	2.81	3.97	5.41	6.48	7.83	9.04	10.32	11.29	12.48	13.62	14.64	15.57	16.43	17.22	17.89	19.34
2010	0.02	0.04	0.37	0.90	1.70	2.70	3.87	5.06	6.49	7.54	8.83	9.98	11.17	12.05	13.15	14.17	15.08	15.89	16.64	17.32	18.54
2011	0.02	0.06	0.31	0.96	1.69	2.63	3.73	4.96	6.17	7.59	8.61	9.84	10.93	12.05	12.87	13.88	14.81	15.62	16.34	17.00	18.34
2012	0.02	0.03	0.39	0.91	1.80	2.63	3.63	4.73	5.90	7.02	8.31	9.21	10.29	11.22	12.17	12.86	13.69	14.45	15.11	15.68	16.59
2013	0.01	0.06	0.33	0.96	1.67	2.77	3.75	4.88	6.10	7.39	8.60	9.99	10.95	12.11	13.09	14.09	14.81	15.67	16.44	17.10	18.29
2014	0.01	0.04	0.33	0.88	1.74	2.59	3.83	4.88	6.07	7.33	8.64	9.86	11.23	12.19	13.32	14.27	15.22	15.91	16.71	17.43	18.77
2015	0.02	0.05	0.42	0.89	1.65	2.67	3.61	4.91	5.98	7.17	8.40	9.66	10.83	12.12	13.01	14.05	14.92	15.78	16.39	17.10	18.50
2016	0.02	0.09	0.45	1.07	1.72	2.66	3.82	4.85	6.22	7.32	8.52	9.75	10.98	12.11	13.36	14.20	15.17	15.97	16.76	17.30	18.40
2017	0.01	0.09	0.40	1.09	1.93	2.73	3.80	5.08	6.16	7.59	8.71	9.92	11.14	12.36	13.46	14.66	15.46	16.38	17.12	17.85	19.03
2018	0.03	0.09	0.51	1.06	2.01	3.00	3.88	5.01	6.30	7.37	8.74	9.80	10.93	12.05	13.16	14.15	15.20	15.90	16.68	17.32	18.65
2019	0.02	0.10	0.30	1.21	1.94	3.09	4.22	5.19	6.40	7.75	8.86	10.25	11.33	12.46	13.57	14.66	15.61	16.62	17.28	18.01	19.25
2020	0.01	0.04	0.33	0.84	2.02	2.85	4.07	5.22	6.17	7.35	8.64	9.67	10.97	11.96	12.99	13.99	14.95	15.79	16.66	17.23	18.51

Table 2.1.21f. Mid-year weight (kg) at age in the survey (ensemble).

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	2.90	3.98	5.09	6.22	7.32	8.39	9.41	10.38	11.28	12.13	12.91	13.62	14.26	14.83	15.35	16.58
1978	0.01	0.05	0.33	0.98	1.84	2.88	4.04	5.26	6.50	7.74	8.95	10.12	11.23	12.28	13.27	14.18	15.01	15.77	16.45	17.06	18.52
1979	0.02	0.06	0.40	1.00	1.90	2.89	3.98	5.10	6.23	7.35	8.43	9.46	10.44	11.36	12.22	13.01	13.73	14.38	14.97	15.49	16.68
1980	0.02	0.06	0.35	1.00	1.78	2.81	3.88	4.99	6.12	7.24	8.33	9.37	10.36	11.29	12.15	12.95	13.68	14.34	14.94	15.47	16.65
1981	0.02	0.06	0.31	0.96	1.83	2.74	3.85	4.94	6.04	7.13	8.18	9.19	10.15	11.05	11.88	12.65	13.36	14.00	14.57	15.08	16.20
1982	0.02	0.05	0.35	0.97	1.90	2.96	3.98	5.17	6.30	7.41	8.49	9.52	10.49	11.41	12.26	13.04	13.75	14.40	14.98	15.49	16.62
1983	0.01	0.04	0.43	0.96	1.80	2.92	4.11	5.21	6.46	7.64	8.78	9.88	10.91	11.89	12.80	13.64	14.41	15.10	15.73	16.28	17.50
1984	0.02	0.11	0.44	1.11	1.75	2.61	3.64	4.64	5.53	6.50	7.38	8.22	9.00	9.74	10.42	11.04	11.60	12.11	12.57	12.98	13.86
1985	0.01	0.06	0.30	1.03	1.98	2.83	3.96	5.27	6.56	7.70	8.95	10.09	11.17	12.19	13.14	14.02	14.82	15.55	16.21	16.79	18.09
1986	0.01	0.03	0.35	0.87	1.89	3.02	3.98	5.19	6.57	7.90	9.06	10.31	11.44	12.51	13.51	14.43	15.28	16.05	16.74	17.36	18.75
1987	0.02	0.06	0.34	1.01	1.74	2.94	4.13	5.08	6.25	7.53	8.73	9.76	10.86	11.84	12.75	13.59	14.36	15.06	15.68	16.24	17.52
1988	0.02	0.05	0.31	0.96	1.92	2.85	4.27	5.63	6.69	7.97	9.37	10.66	11.77	12.93	13.97	14.92	15.80	16.59	17.31	17.95	19.43
1989	0.02	0.05	0.34	0.97	1.90	3.07	4.09	5.59	6.96	8.00	9.24	10.56	11.77	12.79	13.85	14.79	15.64	16.42	17.11	17.73	19.20
1990	0.02	0.05	0.39	0.99	1.87	2.94	4.15	5.16	6.57	7.83	8.76	9.85	10.99	12.03	12.89	13.78	14.55	15.24	15.87	16.42	17.76
1991	0.01	0.06	0.40	0.99	1.77	2.73	3.82	4.99	5.93	7.22	8.34	9.16	10.11	11.09	11.98	12.70	13.44	14.08	14.65	15.16	16.38
1992	0.02	0.06	0.35	0.99	1.75	2.63	3.66	4.77	5.94	6.86	8.09	9.16	9.93	10.82	11.73	12.55	13.21	13.88	14.45	14.96	16.15
1993	0.02	0.06	0.44	1.09	2.04	3.03	4.10	5.27	6.50	7.75	8.72	10.00	11.09	11.87	12.76	13.67	14.47	15.11	15.76	16.30	17.47
1994	0.02	0.07	0.36	1.03	1.84	2.89	3.91	4.96	6.09	7.26	8.42	9.32	10.50	11.49	12.19	12.99	13.80	14.50	15.06	15.62	16.61
1995	0.02	0.06	0.34	0.96	1.88	2.84	4.02	5.11	6.22	7.39	8.57	9.74	10.64	11.80	12.78	13.46	14.23	15.01	15.68	16.21	17.32
1996	0.03	0.08	0.41	1.05	1.89	2.92	3.89	5.00	5.98	6.94	7.92	8.89	9.84	10.55	11.46	12.20	12.72	13.30	13.87	14.36	15.08
1997	0.01	0.06	0.35	0.95	1.74	2.68	3.77	4.78	5.90	6.88	7.83	8.81	9.76	10.69	11.38	12.26	12.98	13.48	14.02	14.57	15.22
1998	0.01	0.05	0.34	0.94	1.75	2.66	3.67	4.78	5.77	6.86	7.78	8.68	9.57	10.45	11.29	11.91	12.69	13.33	13.76	14.24	15.03
1999	0.02	0.05	0.32	0.95	1.80	2.79	3.82	4.92	6.09	7.12	8.22	9.16	10.05	10.94	11.80	12.61	13.21	13.96	14.56	14.96	15.86
2000	0.02	0.05	0.44	0.96	1.86	2.91	4.04	5.17	6.34	7.55	8.61	9.72	10.66	11.54	12.42	13.25	14.04	14.62	15.33	15.89	17.01
2001	0.02	0.07	0.42	1.11	1.78	2.80	3.90	5.01	6.09	7.17	8.28	9.22	10.21	11.03	11.80	12.55	13.26	13.93	14.40	14.99	16.21
2002	0.02	0.07	0.41	1.03	1.94	2.72	3.85	5.01	6.16	7.25	8.34	9.44	10.38	11.35	12.14	12.88	13.61	14.28	14.91	15.36	16.46
2003	0.02	0.07	0.36	1.03	1.85	2.91	3.77	4.96	6.16	7.33	8.42	9.50	10.58	11.48	12.42	13.19	13.89	14.57	15.21	15.79	17.04
2004	0.02	0.07	0.47	1.02	1.92	2.87	3.99	4.86	6.02	7.16	8.24	9.23	10.20	11.16	11.95	12.77	13.42	14.02	14.59	15.12	16.16
2005	0.02	0.08	0.36	1.12	1.86	2.93	4.00	5.21	6.14	7.35	8.51	9.61	10.62	11.59	12.54	13.33	14.12	14.76	15.34	15.89	17.13
2006	0.02	0.04	0.36	0.99	2.00	2.86	4.00	5.09	6.29	7.18	8.33	9.42	10.43	11.35	12.22	13.07	13.77	14.47	15.02	15.52	16.84
2007	0.02	0.04	0.33	0.99	1.85	3.06	4.01	5.23	6.36	7.57	8.47	9.60	10.67	11.65	12.53	13.37	14.17	14.82	15.47	15.98	17.52
2008	0.02	0.04	0.32	0.93	1.81	2.81	4.08	5.03	6.22	7.29	8.43	9.25	10.28	11.25	12.12	12.90	13.63	14.32	14.88	15.44	16.64
2009	0.01	0.03	0.33	0.90	1.75	2.83	3.96	5.34	6.35	7.60	8.70	9.86	10.69	11.73	12.69	13.56	14.33	15.04	15.72	16.25	17.29
2010	0.02	0.05	0.37	0.92	1.71	2.70	3.86	5.01	6.36	7.33	8.50	9.52	10.58	11.33	12.27	13.12	13.88	14.55	15.17	15.74	16.63
2011	0.02	0.06	0.30	0.98	1.72	2.64	3.72	4.90	6.05	7.37	8.29	9.39	10.34	11.32	12.01	12.86	13.63	14.31	14.90	15.44	16.44
2012	0.02	0.03	0.38	0.91	1.82	2.65	3.61	4.67	5.79	6.83	8.01	8.81	9.76	10.57	11.39	11.97	12.66	13.29	13.84	14.30	15.00
2013	0.01	0.06	0.34	0.97	1.69	2.79	3.75	4.82	5.98	7.18	8.28	9.52	10.36	11.35	12.19	13.04	13.63	14.34	14.97	15.52	16.45
2014	0.01	0.04	0.34	0.90	1.75	2.60	3.82	4.84	5.94	7.11	8.31	9.40	10.61	11.43	12.39	13.19	13.99	14.55	15.21	15.80	16.87
2015	0.02	0.05	0.42	0.91	1.67	2.67	3.60	4.85	5.87	6.95	8.08	9.21	10.24	11.36	12.11	12.98	13.70	14.42	14.91	15.49	16.60
2016	0.02	0.09	0.44	1.08	1.75	2.67	3.80	4.79	6.09	7.12	8.19	9.29	10.38	11.36	12.42	13.12	13.92	14.59	15.24	15.68	16.54
2017	0.01	0.09	0.40	1.09	1.95	2.75	3.79	5.01	6.04	7.36	8.39	9.45	10.53	11.59	12.53	13.53	14.19	14.94	15.56	16.16	17.08
2018	0.03	0.09	0.52	1.07	2.00	3.00	3.87	4.95	6.16	7.16	8.41	9.36	10.34	11.31	12.26	13.09	13.97	14.55	15.19	15.71	16.76
2019	0.02	0.10	0.30	1.23	1.95	3.07	4.19	5.13	6.26	7.51	8.52	9.78	10.73	11.70	12.65	13.57	14.37	15.21	15.75	16.35	17.28

Table 2.1.22a. Selectivity at age in the fishery (Model 19.12a).

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	0.101	0.323	0.596	0.793	0.878	0.898	0.897	0.893	0.890	0.888	0.887	0.887	0.887	0.886	0.886	0.886	0.886	0.886
1978	0.000	0.000	0.010	0.101	0.322	0.595	0.792	0.877	0.896	0.895	0.890	0.887	0.885	0.884	0.884	0.883	0.883	0.883	0.883	0.883	0.883
1979	0.000	0.000	0.014	0.102	0.336	0.606	0.798	0.879	0.897	0.895	0.890	0.887	0.885	0.884	0.883	0.883	0.883	0.883	0.882	0.882	0.882
1980	0.000	0.000	0.012	0.109	0.318	0.604	0.798	0.882	0.902	0.902	0.898	0.895	0.894	0.893	0.892	0.892	0.892	0.892	0.891	0.891	0.891
1981	0.000	0.000	0.014	0.125	0.369	0.619	0.813	0.888	0.904	0.902	0.898	0.894	0.893	0.892	0.891	0.891	0.890	0.890	0.890	0.890	0.890
1982	0.000	0.000	0.007	0.076	0.300	0.589	0.781	0.879	0.903	0.904	0.901	0.899	0.897	0.897	0.896	0.896	0.896	0.896	0.895	0.895	0.895
1983	0.000	0.000	0.013	0.084	0.287	0.584	0.796	0.883	0.911	0.914	0.912	0.911	0.909	0.909	0.908	0.908	0.908	0.908	0.908	0.908	0.908
1984	0.000	0.001	0.019	0.133	0.329	0.593	0.807	0.897	0.920	0.923	0.922	0.920	0.919	0.918	0.918	0.918	0.918	0.918	0.918	0.918	0.918
1985	0.000	0.000	0.006	0.092	0.316	0.552	0.765	0.877	0.906	0.908	0.906	0.904	0.902	0.901	0.901	0.901	0.900	0.900	0.900	0.900	0.900
1986	0.000	0.000	0.015	0.091	0.346	0.622	0.786	0.876	0.900	0.899	0.894	0.891	0.889	0.888	0.888	0.887	0.887	0.887	0.887	0.887	0.887
1987	0.000	0.000	0.007	0.088	0.264	0.584	0.792	0.873	0.904	0.909	0.907	0.905	0.903	0.903	0.902	0.902	0.902	0.902	0.902	0.902	0.902
1988	0.000	0.001	0.030	0.165	0.424	0.641	0.839	0.902	0.912	0.908	0.903	0.899	0.897	0.896	0.896	0.895	0.895	0.895	0.895	0.895	0.895
1989	0.000	0.000	0.015	0.113	0.344	0.627	0.792	0.896	0.917	0.918	0.916	0.913	0.912	0.911	0.911	0.911	0.911	0.910	0.910	0.910	0.910
1990	0.000	0.000	0.011	0.086	0.293	0.574	0.796	0.886	0.931	0.939	0.940	0.940	0.940	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939
1991	0.000	0.000	0.011	0.090	0.287	0.560	0.780	0.887	0.915	0.924	0.923	0.922	0.921	0.921	0.920	0.920	0.920	0.920	0.920	0.920	0.920
1992	0.000	0.000	0.008	0.089	0.289	0.548	0.763	0.867	0.893	0.893	0.888	0.885	0.884	0.883	0.882	0.881	0.881	0.881	0.881	0.881	0.881
1993	0.000	0.001	0.026	0.141	0.389	0.635	0.806	0.888	0.907	0.904	0.900	0.896	0.895	0.894	0.893	0.893	0.893	0.892	0.892	0.892	0.892
1994	0.000	0.000	0.012	0.115	0.329	0.610	0.793	0.877	0.902	0.903	0.899	0.897	0.895	0.894	0.893	0.893	0.893	0.893	0.893	0.893	0.893
1995	0.000	0.000	0.014	0.111	0.358	0.611	0.807	0.883	0.902	0.902	0.898	0.894	0.893	0.891	0.891	0.890	0.890	0.890	0.890	0.890	0.890
1996	0.000	0.000	0.008	0.079	0.285	0.584	0.782	0.892	0.926	0.936	0.938	0.938	0.937	0.937	0.937	0.936	0.936	0.936	0.936	0.936	0.936
1997	0.000	0.000	0.016	0.121	0.343	0.612	0.817	0.897	0.924	0.927	0.926	0.925	0.924	0.923	0.923	0.923	0.922	0.922	0.922	0.922	0.922
1998	0.000	0.000	0.007	0.085	0.299	0.568	0.780	0.885	0.912	0.916	0.915	0.913	0.912	0.911	0.911	0.911	0.911	0.911	0.911	0.910	0.910
1999	0.000	0.000	0.007	0.083	0.304	0.581	0.782	0.878	0.905	0.907	0.904	0.902	0.900	0.899	0.899	0.898	0.898	0.898	0.898	0.898	0.898
2000	0.000	0.000	0.011	0.070	0.278	0.566	0.779	0.874	0.902	0.905	0.902	0.900	0.899	0.898	0.897	0.897	0.897	0.897	0.897	0.897	0.896
2001	0.000	0.000	0.009	0.097	0.262	0.548	0.767	0.852	0.863	0.854	0.844	0.839	0.836	0.834	0.833	0.832	0.832	0.832	0.832	0.832	0.832
2002	0.000	0.000	0.018	0.117	0.364	0.575	0.776	0.839	0.828	0.806	0.789	0.778	0.774	0.771	0.769	0.769	0.768	0.768	0.768	0.768	0.768
2003	0.000	0.000	0.014	0.118	0.338	0.624	0.775	0.871	0.890	0.886	0.881	0.877	0.874	0.873	0.872	0.872	0.872	0.871	0.871	0.871	0.871
2004	0.000	0.000	0.022	0.114	0.357	0.615	0.812	0.874	0.898	0.897	0.892	0.889	0.887	0.886	0.885	0.885	0.884	0.884	0.884	0.884	0.884
2005	0.000	0.001	0.014	0.139	0.340	0.623	0.805	0.892	0.909	0.913	0.910	0.908	0.906	0.905	0.905	0.905	0.905	0.904	0.904	0.904	0.904
2006	0.000	0.000	0.009	0.091	0.355	0.588	0.802	0.894	0.927	0.933	0.934	0.934	0.933	0.933	0.933	0.933	0.932	0.932	0.932	0.932	0.932
2007	0.000	0.000	0.007	0.085	0.299	0.621	0.789	0.891	0.920	0.926	0.926	0.925	0.924	0.924	0.924	0.923	0.923	0.923	0.923	0.923	0.923
2008	0.000	0.000	0.006	0.074	0.293	0.571	0.799	0.859	0.870	0.863	0.854	0.850	0.847	0.845	0.844	0.844	0.843	0.843	0.843	0.843	0.843
2009	0.000	0.000	0.004	0.052	0.233	0.529	0.746	0.834	0.833	0.817	0.805	0.797	0.793	0.791	0.789	0.789	0.788	0.788	0.788	0.788	0.788
2010	0.000	0.000	0.004	0.047	0.208	0.486	0.731	0.827	0.839	0.829	0.818	0.811	0.807	0.806	0.805	0.804	0.804	0.803	0.803	0.803	0.803
2011	0.000	0.000	0.002	0.059	0.224	0.487	0.728	0.855	0.888	0.892	0.890	0.887	0.886	0.885	0.884	0.884	0.884	0.883	0.883	0.883	0.883
2012	0.000	0.000	0.007	0.063	0.289	0.540	0.751	0.864	0.898	0.902	0.899	0.897	0.895	0.894	0.894	0.894	0.893	0.893	0.893	0.893	0.893
2013	0.000	0.000	0.008	0.086	0.267	0.579	0.765	0.856	0.879	0.875	0.868	0.863	0.861	0.860	0.859	0.859	0.858	0.858	0.858	0.858	0.858
2014	0.000	0.000	0.004	0.056	0.253	0.499	0.753	0.840	0.862	0.858	0.850	0.845	0.842	0.841	0.840	0.839	0.839	0.839	0.839	0.839	0.839
2015	0.000	0.000	0.006	0.053	0.224	0.516	0.722	0.852	0.879	0.882	0.879	0.875	0.873	0.872	0.872	0.871	0.871	0.871	0.871	0.871	0.871
2016	0.000	0.000	0.006	0.074	0.234	0.500	0.745	0.850	0.897	0.903	0.903	0.901	0.900	0.899	0.899	0.899	0.898	0.898	0.898	0.898	0.898
2017	0.000	0.000	0.005	0.075	0.284	0.516	0.740	0.869	0.908	0.923	0.925	0.925	0.924	0.924	0.923	0.923	0.923	0.923	0.923	0.923	0.923
2018	0.000	0.000	0.018	0.099	0.343	0.617	0.780	0.878	0.913	0.919	0.920	0.918	0.918	0.917	0.917	0.916	0.916	0.916	0.916	0.916	0.916
2019	0.000	0.001	0.006	0.140	0.336	0.627	0.806	0.866	0.884	0.881	0.876	0.871	0.869	0.868	0.867	0.867	0.866	0.866	0.866	0.866	0.866
2020	0.000	0.000	0.011	0.085	0.411	0.628	0.822	0.893	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

Table 2.1.22b. Selectivity at age in the 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	0.100	0.320	0.596	0.810	0.925	0.973	0.989	0.990	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.443
1978	0.000	0.000	0.010	0.099	0.318	0.594	0.809	0.924	0.972	0.989	0.990	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.443
1979	0.000	0.000	0.014	0.100	0.332	0.606	0.815	0.927	0.974	0.990	0.991	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.449
1980	0.000	0.000	0.012	0.107	0.313	0.603	0.814	0.926	0.973	0.989	0.991	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.453
1981	0.000	0.000	0.014	0.121	0.364	0.616	0.828	0.933	0.976	0.990	0.991	0.979	0.954	0.915	0.864	0.807	0.746	0.685	0.628	0.575	0.454
1982	0.000	0.000	0.007	0.073	0.294	0.587	0.794	0.922	0.972	0.989	0.990	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.455
1983	0.000	0.000	0.015	0.080	0.279	0.579	0.809	0.919	0.972	0.989	0.990	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.454
1984	0.000	0.001	0.018	0.139	0.319	0.587	0.816	0.931	0.973	0.990	0.991	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.454
1985	0.000	0.000	0.006	0.090	0.327	0.547	0.776	0.917	0.972	0.988	0.990	0.979	0.954	0.915	0.864	0.806	0.745	0.685	0.628	0.575	0.453
1986	0.000	0.000	0.015	0.090	0.344	0.637	0.799	0.918	0.973	0.990	0.991	0.979	0.954	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.451
1987	0.000	0.000	0.008	0.088	0.261	0.585	0.819	0.911	0.967	0.988	0.990	0.980	0.954	0.915	0.864	0.806	0.745	0.685	0.628	0.575	0.449
1988	0.000	0.001	0.029	0.162	0.417	0.636	0.853	0.948	0.976	0.991	0.992	0.980	0.956	0.915	0.864	0.806	0.746	0.685	0.628	0.575	0.446
1989	0.000	0.000	0.015	0.110	0.337	0.623	0.800	0.933	0.978	0.989	0.991	0.980	0.954	0.918	0.865	0.807	0.746	0.685	0.628	0.576	0.444
1990	0.000	0.000	0.010	0.082	0.284	0.568	0.803	0.909	0.972	0.990	0.991	0.981	0.956	0.915	0.867	0.806	0.746	0.685	0.628	0.575	0.442
1991	0.000	0.000	0.011	0.088	0.281	0.555	0.789	0.920	0.966	0.989	0.990	0.981	0.958	0.917	0.864	0.810	0.745	0.685	0.628	0.575	0.440
1992	0.000	0.000	0.009	0.092	0.289	0.549	0.779	0.913	0.970	0.987	0.990	0.978	0.958	0.921	0.867	0.806	0.749	0.685	0.628	0.575	0.444
1993	0.000	0.001	0.027	0.146	0.398	0.642	0.824	0.929	0.975	0.991	0.992	0.980	0.952	0.921	0.872	0.809	0.745	0.688	0.628	0.575	0.455
1994	0.000	0.000	0.014	0.115	0.332	0.619	0.812	0.920	0.970	0.989	0.991	0.982	0.954	0.911	0.871	0.815	0.749	0.685	0.631	0.575	0.470
1995	0.000	0.000	0.016	0.115	0.352	0.613	0.828	0.927	0.972	0.989	0.991	0.980	0.959	0.915	0.860	0.814	0.754	0.688	0.627	0.578	0.467
1996	0.000	0.000	0.008	0.078	0.283	0.574	0.791	0.921	0.969	0.987	0.991	0.981	0.955	0.922	0.864	0.801	0.753	0.694	0.631	0.575	0.486
1997	0.000	0.000	0.015	0.113	0.333	0.606	0.822	0.927	0.975	0.990	0.991	0.981	0.957	0.916	0.874	0.806	0.740	0.693	0.636	0.578	0.502
1998	0.000	0.000	0.007	0.079	0.286	0.560	0.790	0.919	0.970	0.989	0.990	0.981	0.958	0.919	0.866	0.817	0.746	0.680	0.635	0.583	0.491
1999	0.000	0.000	0.006	0.076	0.289	0.571	0.792	0.917	0.971	0.988	0.990	0.980	0.958	0.921	0.870	0.809	0.757	0.686	0.624	0.583	0.483
2000	0.000	0.000	0.009	0.063	0.261	0.553	0.786	0.913	0.968	0.988	0.990	0.979	0.956	0.920	0.871	0.813	0.748	0.697	0.629	0.573	0.458
2001	0.000	0.000	0.008	0.089	0.252	0.540	0.785	0.914	0.968	0.988	0.990	0.980	0.954	0.917	0.871	0.814	0.751	0.687	0.638	0.575	0.438
2002	0.000	0.000	0.018	0.117	0.356	0.576	0.802	0.925	0.973	0.989	0.991	0.980	0.956	0.914	0.867	0.813	0.753	0.691	0.630	0.585	0.462
2003	0.000	0.000	0.014	0.115	0.333	0.619	0.789	0.918	0.972	0.989	0.991	0.980	0.955	0.917	0.864	0.809	0.752	0.692	0.633	0.577	0.443
2004	0.000	0.000	0.021	0.110	0.349	0.611	0.826	0.916	0.971	0.989	0.991	0.980	0.956	0.916	0.867	0.806	0.749	0.692	0.635	0.580	0.459
2005	0.000	0.001	0.013	0.133	0.330	0.619	0.817	0.931	0.969	0.989	0.991	0.980	0.956	0.918	0.865	0.809	0.745	0.688	0.634	0.582	0.449
2006	0.000	0.000	0.009	0.085	0.340	0.579	0.810	0.922	0.973	0.987	0.991	0.980	0.956	0.918	0.868	0.807	0.748	0.685	0.631	0.582	0.437
2007	0.000	0.000	0.006	0.078	0.283	0.610	0.795	0.923	0.971	0.989	0.991	0.981	0.956	0.917	0.868	0.810	0.746	0.688	0.627	0.578	0.418
2008	0.000	0.000	0.006	0.071	0.282	0.564	0.821	0.918	0.972	0.989	0.990	0.982	0.958	0.918	0.867	0.810	0.749	0.686	0.631	0.575	0.437
2009	0.000	0.000	0.004	0.051	0.231	0.527	0.771	0.923	0.967	0.988	0.990	0.978	0.959	0.920	0.868	0.810	0.750	0.689	0.629	0.578	0.469
2010	0.000	0.000	0.004	0.046	0.208	0.490	0.757	0.902	0.970	0.986	0.990	0.979	0.953	0.922	0.870	0.810	0.749	0.689	0.631	0.576	0.479
2011	0.000	0.000	0.003	0.060	0.224	0.492	0.749	0.903	0.965	0.988	0.990	0.979	0.954	0.913	0.873	0.813	0.749	0.688	0.632	0.578	0.471
2012	0.000	0.000	0.008	0.064	0.284	0.536	0.766	0.906	0.968	0.988	0.990	0.980	0.953	0.915	0.862	0.816	0.752	0.689	0.631	0.579	0.494
2013	0.000	0.000	0.008	0.087	0.266	0.578	0.780	0.907	0.967	0.988	0.990	0.977	0.955	0.914	0.865	0.804	0.755	0.692	0.632	0.578	0.481
2014	0.000	0.000	0.005	0.057	0.254	0.502	0.776	0.900	0.961	0.986	0.990	0.980	0.951	0.916	0.863	0.807	0.743	0.694	0.634	0.579	0.473
2015	0.000	0.000	0.007	0.052	0.221	0.519	0.739	0.905	0.961	0.985	0.990	0.980	0.956	0.910	0.866	0.805	0.746	0.683	0.637	0.581	0.469
2016	0.000	0.000	0.007	0.073	0.229	0.499	0.762	0.890	0.965	0.985	0.990	0.981	0.956	0.918	0.858	0.808	0.744	0.686	0.626	0.583	0.496
2017	0.000	0.000	0.005	0.074	0.278	0.509	0.749	0.903	0.959	0.986	0.990	0.981	0.958	0.918	0.868	0.800	0.747	0.684	0.629	0.573	0.482
2018	0.000	0.000	0.018	0.097	0.342	0.617	0.790	0.912	0.970	0.987	0.990	0.981	0.959	0.921	0.868	0.810	0.739	0.687	0.626	0.576	0.468
2019	0.000	0.001	0.007	0.140	0.336	0.637	0.833	0.920	0.969	0.989	0.991	0.979	0.958	0.922	0.871	0.811	0.749	0.678	0.630	0.574	0.480
2020	0.000	0.000	0.012	0.086	0.408	0.631	0.844	0.939	0.972	0.989	0.991	0.981	0.955	0.920	0.873	0.814	0.750	0.689	0.622	0.577	0.476

Table 2.1.22c. Selectivity at age in the fishery (Model 21.1).

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	0.015	0.132	0.403	0.691	0.854	0.882	0.843	0.793	0.752	0.724	0.706	0.694	0.686	0.681	0.677	0.675	0.673	0.672	0.671
1978	0.000	0.000	0.014	0.131	0.403	0.691	0.853	0.879	0.838	0.785	0.742	0.713	0.694	0.681	0.673	0.668	0.664	0.662	0.660	0.659	0.657
1979	0.000	0.000	0.020	0.141	0.423	0.705	0.859	0.881	0.837	0.783	0.740	0.710	0.691	0.679	0.670	0.665	0.661	0.659	0.657	0.656	0.654
1980	0.000	0.000	0.018	0.153	0.414	0.704	0.860	0.887	0.849	0.800	0.761	0.733	0.716	0.704	0.697	0.692	0.688	0.686	0.684	0.683	0.682
1981	0.000	0.001	0.021	0.171	0.467	0.721	0.871	0.891	0.851	0.801	0.761	0.734	0.716	0.704	0.697	0.692	0.689	0.686	0.685	0.683	0.682
1982	0.000	0.000	0.011	0.106	0.391	0.694	0.850	0.887	0.854	0.808	0.771	0.745	0.728	0.717	0.710	0.705	0.702	0.700	0.698	0.697	0.695
1983	0.000	0.000	0.019	0.121	0.376	0.692	0.863	0.896	0.868	0.828	0.795	0.772	0.757	0.747	0.741	0.737	0.734	0.732	0.730	0.729	0.728
1984	0.000	0.001	0.028	0.184	0.426	0.698	0.872	0.906	0.883	0.846	0.817	0.796	0.782	0.774	0.768	0.764	0.762	0.760	0.759	0.758	0.756
1985	0.000	0.000	0.008	0.126	0.405	0.659	0.838	0.887	0.856	0.815	0.778	0.753	0.736	0.726	0.719	0.714	0.711	0.709	0.708	0.706	0.705
1986	0.000	0.000	0.021	0.123	0.438	0.722	0.854	0.886	0.845	0.791	0.753	0.723	0.705	0.693	0.685	0.680	0.677	0.674	0.672	0.671	0.669
1987	0.000	0.000	0.010	0.120	0.341	0.686	0.854	0.881	0.850	0.796	0.755	0.729	0.710	0.698	0.691	0.686	0.682	0.680	0.678	0.677	0.675
1988	0.000	0.002	0.043	0.220	0.522	0.736	0.888	0.890	0.847	0.792	0.744	0.712	0.694	0.681	0.673	0.668	0.664	0.662	0.660	0.659	0.657
1989	0.000	0.000	0.022	0.158	0.440	0.729	0.861	0.903	0.872	0.837	0.805	0.780	0.764	0.755	0.749	0.745	0.742	0.740	0.739	0.738	0.736
1990	0.000	0.000	0.016	0.125	0.390	0.687	0.868	0.914	0.909	0.886	0.869	0.854	0.843	0.837	0.833	0.830	0.828	0.827	0.826	0.826	0.825
1991	0.000	0.000	0.016	0.123	0.371	0.667	0.852	0.902	0.887	0.850	0.821	0.805	0.792	0.782	0.776	0.773	0.770	0.769	0.768	0.767	0.765
1992	0.000	0.000	0.011	0.123	0.374	0.654	0.838	0.882	0.848	0.807	0.761	0.734	0.719	0.707	0.699	0.694	0.691	0.688	0.687	0.685	0.684
1993	0.000	0.001	0.038	0.187	0.482	0.730	0.866	0.889	0.844	0.785	0.748	0.712	0.692	0.682	0.674	0.667	0.664	0.661	0.659	0.658	0.656
1994	0.000	0.000	0.016	0.158	0.415	0.708	0.853	0.878	0.836	0.778	0.730	0.703	0.679	0.666	0.658	0.653	0.648	0.646	0.644	0.642	0.641
1995	0.000	0.000	0.018	0.145	0.452	0.707	0.864	0.882	0.842	0.788	0.743	0.711	0.694	0.679	0.670	0.666	0.662	0.659	0.657	0.656	0.655
1996	0.000	0.000	0.011	0.110	0.372	0.696	0.855	0.913	0.907	0.886	0.866	0.851	0.840	0.835	0.830	0.827	0.825	0.824	0.823	0.822	0.822
1997	0.000	0.001	0.023	0.163	0.436	0.714	0.881	0.910	0.889	0.859	0.833	0.814	0.801	0.792	0.788	0.783	0.781	0.780	0.778	0.777	0.777
1998	0.000	0.000	0.010	0.117	0.384	0.673	0.850	0.896	0.873	0.834	0.805	0.784	0.769	0.759	0.753	0.749	0.746	0.744	0.743	0.742	0.741
1999	0.000	0.000	0.010	0.115	0.391	0.685	0.852	0.893	0.863	0.826	0.791	0.769	0.755	0.744	0.738	0.733	0.730	0.728	0.726	0.726	0.724
2000	0.000	0.000	0.017	0.099	0.367	0.675	0.850	0.890	0.863	0.816	0.785	0.760	0.745	0.736	0.729	0.724	0.721	0.719	0.717	0.716	0.714
2001	0.000	0.000	0.012	0.133	0.340	0.655	0.837	0.858	0.802	0.733	0.673	0.640	0.615	0.601	0.591	0.584	0.579	0.576	0.574	0.572	0.569
2002	0.000	0.000	0.023	0.156	0.454	0.674	0.844	0.846	0.769	0.685	0.619	0.569	0.544	0.524	0.513	0.505	0.500	0.496	0.493	0.491	0.489
2003	0.000	0.000	0.018	0.155	0.426	0.721	0.842	0.875	0.826	0.766	0.720	0.687	0.664	0.652	0.642	0.637	0.633	0.630	0.628	0.627	0.625
2004	0.000	0.000	0.029	0.150	0.444	0.713	0.870	0.891	0.859	0.811	0.773	0.747	0.730	0.718	0.712	0.707	0.704	0.702	0.700	0.699	0.697
2005	0.000	0.001	0.018	0.184	0.426	0.720	0.867	0.896	0.873	0.830	0.795	0.771	0.756	0.746	0.739	0.735	0.732	0.730	0.729	0.728	0.726
2006	0.000	0.000	0.013	0.124	0.451	0.692	0.869	0.916	0.908	0.890	0.869	0.854	0.844	0.838	0.834	0.831	0.830	0.828	0.827	0.827	0.826
2007	0.000	0.000	0.009	0.119	0.388	0.726	0.861	0.912	0.901	0.875	0.858	0.841	0.830	0.823	0.819	0.816	0.814	0.812	0.811	0.811	0.809
2008	0.000	0.000	0.009	0.102	0.380	0.678	0.864	0.877	0.833	0.782	0.738	0.715	0.694	0.681	0.672	0.667	0.663	0.660	0.659	0.657	0.656
2009	0.000	0.000	0.005	0.071	0.306	0.636	0.820	0.831	0.769	0.686	0.627	0.582	0.561	0.541	0.529	0.521	0.515	0.512	0.509	0.507	0.505
2010	0.000	0.000	0.005	0.067	0.277	0.593	0.807	0.830	0.747	0.678	0.610	0.568	0.538	0.524	0.511	0.502	0.497	0.493	0.490	0.488	0.486
2011	0.000	0.000	0.003	0.081	0.300	0.592	0.805	0.857	0.814	0.744	0.704	0.670	0.649	0.634	0.627	0.621	0.616	0.613	0.611	0.610	0.608
2012	0.000	0.000	0.010	0.088	0.377	0.650	0.826	0.874	0.836	0.783	0.733	0.710	0.689	0.678	0.669	0.665	0.661	0.658	0.657	0.655	0.654
2013	0.000	0.000	0.010	0.118	0.342	0.680	0.834	0.862	0.813	0.742	0.689	0.647	0.629	0.613	0.604	0.597	0.594	0.590	0.588	0.586	0.585
2014	0.000	0.000	0.006	0.077	0.335	0.604	0.827	0.858	0.820	0.760	0.706	0.672	0.646	0.635	0.625	0.619	0.615	0.613	0.611	0.609	0.607
2015	0.000	0.000	0.008	0.076	0.299	0.628	0.804	0.866	0.836	0.790	0.747	0.715	0.696	0.682	0.675	0.670	0.666	0.664	0.662	0.661	0.659
2016	0.000	0.000	0.008	0.103	0.314	0.608	0.822	0.869	0.841	0.799	0.762	0.734	0.714	0.702	0.693	0.689	0.686	0.684	0.682	0.681	0.680
2017	0.000	0.000	0.007	0.107	0.377	0.631	0.820	0.886	0.875	0.839	0.812	0.792	0.778	0.768	0.762	0.757	0.755	0.753	0.752	0.751	0.750
2018	0.000	0.000	0.025	0.135	0.436	0.719	0.850	0.894	0.874	0.843	0.809	0.789	0.776	0.766	0.760	0.756	0.752	0.751	0.750	0.749	0.748
2019	0.000	0.001	0.008	0.186	0.423	0.725	0.862	0.874	0.836	0.779	0.742	0.707	0.689	0.677	0.668	0.662	0.658	0.655	0.654	0.652	0.651
2020	0.000	0.000	0.015	0.112	0.510	0.727	0.877	0.895	0.870	0.834	0.800	0.781	0.764	0.755	0.749	0.745	0.742	0.740	0.738	0.737	0.736

Table 2.1.22d. Selectivity at age in the fishery (Model 21.2).

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	0.013	0.101	0.307	0.565	0.763	0.855	0.874	0.869	0.861	0.855	0.851	0.849	0.848	0.848	0.847	0.847	0.847	0.847	0.847
1978	0.000	0.000	0.010	0.099	0.305	0.563	0.761	0.850	0.867	0.860	0.850	0.843	0.839	0.837	0.836	0.835	0.835	0.834	0.834	0.834	0.834
1979	0.000	0.000	0.015	0.098	0.320	0.576	0.769	0.854	0.868	0.859	0.849	0.842	0.838	0.836	0.834	0.834	0.833	0.833	0.833	0.833	0.833
1980	0.000	0.000	0.013	0.105	0.298	0.574	0.770	0.863	0.886	0.884	0.877	0.872	0.869	0.868	0.867	0.866	0.866	0.866	0.866	0.866	0.866
1981	0.000	0.001	0.017	0.125	0.352	0.590	0.790	0.872	0.889	0.883	0.876	0.870	0.867	0.865	0.864	0.863	0.863	0.863	0.863	0.863	0.863
1982	0.000	0.000	0.008	0.073	0.276	0.548	0.746	0.860	0.889	0.891	0.886	0.882	0.880	0.878	0.878	0.877	0.877	0.877	0.877	0.877	0.877
1983	0.000	0.000	0.013	0.081	0.269	0.546	0.764	0.866	0.906	0.912	0.911	0.909	0.907	0.906	0.905	0.905	0.905	0.905	0.905	0.905	0.905
1984	0.000	0.001	0.020	0.124	0.308	0.559	0.777	0.884	0.918	0.926	0.926	0.925	0.923	0.923	0.922	0.922	0.922	0.922	0.922	0.922	0.922
1985	0.000	0.000	0.006	0.088	0.288	0.514	0.732	0.857	0.895	0.900	0.897	0.894	0.892	0.891	0.890	0.890	0.890	0.889	0.889	0.889	0.889
1986	0.000	0.000	0.015	0.088	0.324	0.581	0.753	0.855	0.883	0.880	0.873	0.867	0.864	0.862	0.861	0.860	0.860	0.860	0.860	0.859	0.859
1987	0.000	0.000	0.007	0.082	0.244	0.546	0.755	0.848	0.885	0.888	0.884	0.880	0.877	0.876	0.875	0.874	0.874	0.874	0.874	0.874	0.874
1988	0.000	0.001	0.033	0.167	0.411	0.619	0.819	0.889	0.901	0.896	0.887	0.882	0.879	0.877	0.876	0.875	0.875	0.875	0.875	0.875	0.875
1989	0.000	0.000	0.017	0.112	0.327	0.596	0.765	0.884	0.914	0.918	0.916	0.913	0.911	0.910	0.910	0.910	0.909	0.909	0.909	0.909	0.909
1990	0.000	0.000	0.010	0.081	0.268	0.533	0.762	0.868	0.929	0.945	0.948	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949	0.949
1991	0.000	0.000	0.012	0.085	0.267	0.521	0.745	0.872	0.912	0.928	0.929	0.929	0.928	0.927	0.927	0.927	0.926	0.926	0.926	0.926	0.926
1992	0.000	0.000	0.009	0.085	0.266	0.512	0.727	0.844	0.877	0.877	0.870	0.864	0.862	0.860	0.859	0.858	0.858	0.858	0.857	0.857	0.857
1993	0.000	0.001	0.027	0.136	0.366	0.599	0.777	0.866	0.888	0.882	0.875	0.868	0.864	0.862	0.861	0.861	0.860	0.860	0.860	0.860	0.860
1994	0.000	0.000	0.012	0.105	0.300	0.568	0.755	0.850	0.878	0.875	0.867	0.861	0.857	0.855	0.854	0.854	0.853	0.853	0.853	0.853	0.853
1995	0.000	0.000	0.014	0.104	0.328	0.570	0.774	0.862	0.887	0.886	0.880	0.874	0.872	0.870	0.869	0.868	0.868	0.868	0.867	0.867	0.867
1996	0.000	0.000	0.008	0.073	0.260	0.540	0.747	0.875	0.923	0.941	0.946	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947	0.947
1997	0.000	0.001	0.018	0.128	0.339	0.592	0.797	0.891	0.930	0.939	0.940	0.940	0.939	0.939	0.938	0.938	0.938	0.938	0.938	0.938	0.938
1998	0.000	0.000	0.010	0.084	0.295	0.547	0.759	0.879	0.917	0.928	0.929	0.929	0.928	0.927	0.927	0.927	0.926	0.926	0.926	0.926	0.926
1999	0.000	0.000	0.010	0.094	0.286	0.561	0.761	0.868	0.903	0.907	0.904	0.901	0.899	0.898	0.898	0.897	0.897	0.897	0.897	0.897	0.897
2000	0.000	0.000	0.013	0.073	0.269	0.519	0.744	0.835	0.851	0.838	0.825	0.816	0.811	0.808	0.807	0.806	0.805	0.805	0.805	0.805	0.805
2001	0.000	0.000	0.007	0.082	0.229	0.500	0.700	0.769	0.735	0.682	0.640	0.618	0.605	0.599	0.595	0.593	0.592	0.591	0.591	0.590	0.590
2002	0.000	0.000	0.015	0.101	0.325	0.530	0.733	0.785	0.743	0.689	0.648	0.623	0.611	0.604	0.601	0.599	0.598	0.597	0.597	0.596	0.596
2003	0.000	0.000	0.006	0.075	0.254	0.533	0.696	0.779	0.760	0.713	0.680	0.660	0.648	0.642	0.639	0.637	0.636	0.636	0.636	0.635	0.635
2004	0.000	0.000	0.011	0.072	0.271	0.520	0.740	0.810	0.822	0.803	0.783	0.771	0.764	0.760	0.758	0.757	0.757	0.756	0.756	0.756	0.756
2005	0.000	0.000	0.008	0.104	0.275	0.548	0.750	0.869	0.900	0.912	0.912	0.910	0.908	0.907	0.907	0.906	0.906	0.906	0.906	0.906	0.906
2006	0.000	0.000	0.009	0.084	0.324	0.543	0.767	0.882	0.937	0.952	0.960	0.962	0.962	0.963	0.963	0.963	0.962	0.962	0.962	0.962	0.962
2007	0.000	0.000	0.011	0.098	0.302	0.605	0.772	0.892	0.937	0.956	0.960	0.962	0.962	0.962	0.962	0.962	0.962	0.962	0.962	0.962	0.962
2008	0.000	0.000	0.012	0.096	0.310	0.568	0.800	0.883	0.925	0.936	0.937	0.937	0.936	0.936	0.936	0.935	0.935	0.935	0.935	0.935	0.935
2009	0.000	0.000	0.011	0.087	0.287	0.558	0.764	0.882	0.906	0.912	0.910	0.907	0.906	0.905	0.904	0.904	0.904	0.903	0.903	0.903	0.903
2010	0.000	0.000	0.010	0.074	0.252	0.515	0.736	0.828	0.835	0.820	0.803	0.794	0.787	0.785	0.783	0.782	0.781	0.781	0.780	0.780	0.780
2011	0.000	0.000	0.005	0.071	0.232	0.481	0.704	0.800	0.796	0.763	0.744	0.728	0.721	0.716	0.714	0.712	0.712	0.711	0.711	0.711	0.711
2012	0.000	0.000	0.007	0.060	0.265	0.497	0.702	0.787	0.771	0.732	0.697	0.683	0.672	0.667	0.664	0.663	0.662	0.661	0.661	0.661	0.661
2013	0.000	0.000	0.008	0.078	0.248	0.538	0.715	0.784	0.763	0.715	0.681	0.658	0.649	0.643	0.640	0.638	0.637	0.637	0.636	0.636	0.636
2014	0.000	0.000	0.004	0.048	0.216	0.452	0.699	0.772	0.766	0.729	0.698	0.679	0.667	0.663	0.660	0.659	0.658	0.657	0.657	0.657	0.657
2015	0.000	0.000	0.004	0.039	0.184	0.447	0.660	0.781	0.788	0.767	0.744	0.729	0.721	0.716	0.714	0.712	0.712	0.711	0.711	0.711	0.711
2016	0.000	0.000	0.005	0.062	0.198	0.449	0.695	0.819	0.876	0.883	0.882	0.879	0.877	0.875	0.875	0.874	0.874	0.874	0.874	0.874	0.874
2017	0.000	0.000	0.002	0.042	0.203	0.413	0.656	0.808	0.859	0.874	0.873	0.870	0.868	0.867	0.866	0.865	0.865	0.865	0.865	0.865	0.865
2018	0.000	0.000	0.013	0.075	0.282	0.548	0.723	0.850	0.904	0.918	0.922	0.921	0.921	0.920	0.920	0.919	0.919	0.919	0.919	0.919	0.919
2019	0.000	0.001	0.006	0.126	0.303	0.580	0.776	0.855	0.892	0.898	0.895	0.892	0.890	0.889	0.888	0.887	0.887	0.887	0.887	0.887	0.887
2020	0.000	0.000	0.015	0.094	0.400	0.605	0.804	0.896	0.924	0.936	0.938	0.937	0.937	0.936	0.936	0.936	0.936	0.936	0.936	0.936	0.936

Table 2.1.22e. Selectivity at age in the fishery (Model 21.3).

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	0.097	0.313	0.589	0.806	0.923	0.972	0.989	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.401
1978	0.000	0.000	0.010	0.095	0.310	0.587	0.805	0.923	0.972	0.989	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.401
1979	0.000	0.000	0.014	0.096	0.324	0.598	0.811	0.926	0.973	0.989	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.408
1980	0.000	0.000	0.011	0.104	0.306	0.596	0.810	0.925	0.973	0.989	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.411
1981	0.000	0.000	0.013	0.116	0.355	0.608	0.824	0.931	0.975	0.990	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.413
1982	0.000	0.000	0.007	0.070	0.288	0.582	0.791	0.921	0.972	0.989	0.989	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.413
1983	0.000	0.000	0.016	0.076	0.270	0.572	0.806	0.918	0.972	0.989	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.413
1984	0.000	0.001	0.017	0.141	0.309	0.576	0.812	0.930	0.973	0.990	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.412
1985	0.000	0.000	0.005	0.087	0.331	0.537	0.770	0.915	0.972	0.988	0.989	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.411
1986	0.000	0.000	0.014	0.085	0.335	0.640	0.793	0.915	0.972	0.990	0.990	0.976	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.409
1987	0.000	0.000	0.008	0.085	0.253	0.579	0.822	0.908	0.966	0.988	0.989	0.977	0.947	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.407
1988	0.000	0.001	0.027	0.154	0.406	0.624	0.849	0.949	0.975	0.990	0.991	0.976	0.949	0.903	0.847	0.783	0.717	0.652	0.591	0.536	0.404
1989	0.000	0.000	0.014	0.104	0.328	0.615	0.793	0.931	0.979	0.989	0.991	0.977	0.947	0.906	0.847	0.783	0.717	0.652	0.592	0.537	0.402
1990	0.000	0.000	0.010	0.078	0.277	0.561	0.799	0.906	0.972	0.990	0.990	0.979	0.949	0.903	0.850	0.783	0.717	0.652	0.591	0.536	0.399
1991	0.000	0.000	0.011	0.086	0.274	0.548	0.786	0.919	0.965	0.989	0.989	0.979	0.952	0.905	0.846	0.786	0.716	0.652	0.591	0.536	0.398
1992	0.000	0.000	0.008	0.092	0.285	0.543	0.776	0.912	0.970	0.987	0.989	0.974	0.952	0.910	0.850	0.782	0.720	0.652	0.591	0.536	0.402
1993	0.000	0.001	0.027	0.144	0.399	0.640	0.821	0.929	0.975	0.991	0.991	0.976	0.943	0.910	0.855	0.786	0.716	0.655	0.591	0.536	0.413
1994	0.000	0.000	0.015	0.113	0.329	0.622	0.812	0.920	0.971	0.989	0.990	0.980	0.947	0.897	0.855	0.792	0.720	0.651	0.595	0.536	0.430
1995	0.000	0.000	0.016	0.115	0.346	0.608	0.829	0.927	0.972	0.989	0.990	0.977	0.953	0.903	0.839	0.791	0.726	0.655	0.591	0.539	0.427
1996	0.000	0.000	0.008	0.076	0.280	0.567	0.788	0.922	0.969	0.987	0.990	0.978	0.948	0.912	0.846	0.775	0.726	0.662	0.594	0.536	0.447
1997	0.000	0.000	0.014	0.109	0.326	0.601	0.817	0.925	0.976	0.989	0.990	0.979	0.950	0.904	0.857	0.783	0.708	0.661	0.600	0.539	0.463
1998	0.000	0.000	0.006	0.076	0.278	0.554	0.787	0.917	0.969	0.989	0.990	0.978	0.951	0.907	0.848	0.795	0.717	0.644	0.600	0.545	0.451
1999	0.000	0.000	0.006	0.073	0.282	0.562	0.788	0.916	0.971	0.988	0.989	0.977	0.951	0.909	0.852	0.785	0.729	0.653	0.585	0.544	0.443
2000	0.000	0.000	0.008	0.059	0.253	0.545	0.781	0.911	0.968	0.988	0.989	0.975	0.949	0.909	0.854	0.789	0.719	0.665	0.593	0.531	0.416
2001	0.000	0.000	0.008	0.084	0.244	0.533	0.781	0.913	0.968	0.988	0.989	0.977	0.946	0.905	0.853	0.791	0.723	0.654	0.602	0.536	0.396
2002	0.000	0.000	0.017	0.114	0.348	0.569	0.799	0.924	0.973	0.989	0.990	0.977	0.949	0.901	0.849	0.790	0.725	0.658	0.593	0.546	0.420
2003	0.000	0.000	0.013	0.112	0.326	0.610	0.785	0.917	0.972	0.989	0.990	0.977	0.948	0.905	0.844	0.786	0.724	0.660	0.597	0.538	0.400
2004	0.000	0.000	0.020	0.106	0.342	0.605	0.821	0.914	0.970	0.989	0.990	0.977	0.949	0.904	0.849	0.781	0.720	0.659	0.599	0.541	0.415
2005	0.000	0.001	0.012	0.128	0.322	0.612	0.813	0.930	0.969	0.988	0.990	0.977	0.949	0.905	0.848	0.786	0.714	0.655	0.598	0.543	0.405
2006	0.000	0.000	0.008	0.081	0.332	0.570	0.806	0.920	0.973	0.987	0.990	0.977	0.949	0.906	0.849	0.784	0.720	0.650	0.594	0.543	0.393
2007	0.000	0.000	0.006	0.074	0.275	0.601	0.790	0.921	0.971	0.989	0.990	0.978	0.949	0.906	0.850	0.786	0.718	0.655	0.590	0.539	0.374
2008	0.000	0.000	0.006	0.068	0.274	0.555	0.816	0.916	0.972	0.988	0.989	0.979	0.951	0.906	0.850	0.787	0.720	0.653	0.594	0.535	0.391
2009	0.000	0.000	0.004	0.050	0.226	0.520	0.766	0.922	0.967	0.988	0.989	0.975	0.953	0.908	0.850	0.786	0.721	0.655	0.593	0.539	0.423
2010	0.000	0.000	0.004	0.045	0.206	0.487	0.754	0.901	0.970	0.986	0.989	0.976	0.946	0.911	0.853	0.787	0.720	0.656	0.594	0.537	0.435
2011	0.000	0.000	0.003	0.061	0.223	0.494	0.749	0.903	0.965	0.988	0.989	0.975	0.947	0.901	0.856	0.790	0.721	0.655	0.595	0.539	0.426
2012	0.000	0.000	0.008	0.064	0.283	0.533	0.766	0.906	0.968	0.988	0.989	0.977	0.946	0.903	0.845	0.793	0.724	0.656	0.594	0.540	0.451
2013	0.000	0.000	0.008	0.089	0.266	0.576	0.779	0.908	0.967	0.988	0.990	0.974	0.948	0.902	0.847	0.781	0.727	0.659	0.595	0.539	0.439
2014	0.000	0.000	0.005	0.058	0.256	0.502	0.776	0.899	0.962	0.986	0.989	0.977	0.943	0.905	0.845	0.783	0.715	0.662	0.598	0.540	0.431
2015	0.000	0.000	0.007	0.053	0.221	0.520	0.739	0.905	0.961	0.985	0.989	0.977	0.949	0.897	0.848	0.781	0.717	0.650	0.601	0.542	0.427
2016	0.000	0.000	0.007	0.075	0.228	0.498	0.764	0.891	0.965	0.985	0.989	0.978	0.950	0.906	0.840	0.785	0.715	0.652	0.590	0.545	0.455
2017	0.000	0.000	0.005	0.075	0.277	0.504	0.747	0.903	0.959	0.986	0.989	0.978	0.951	0.907	0.850	0.776	0.719	0.650	0.592	0.535	0.441
2018	0.000	0.000	0.017	0.094	0.341	0.613	0.786	0.911	0.970	0.987	0.989	0.978	0.952	0.909	0.851	0.787	0.709	0.654	0.590	0.537	0.427
2019	0.000	0.001	0.006	0.134	0.328	0.633	0.830	0.918	0.969	0.989	0.990	0.976	0.951	0.910	0.854	0.788	0.721	0.645	0.593	0.535	0.437
2020	0.000	0.000	0.011	0.078	0.394	0.620	0.841	0.938	0.972	0.988	0.990	0.979	0.948	0.909	0.855	0.791	0.722	0.656	0.585	0.539	0.433

Table 2.1.22f. Selectivity at age in the fishery (ensemble).

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	0.013	0.106	0.332	0.607	0.807	0.896	0.918	0.915	0.906	0.894	0.878	0.857	0.832	0.804	0.775	0.747	0.720	0.696	0.636
1978	0.000	0.000	0.011	0.104	0.331	0.606	0.805	0.894	0.916	0.912	0.902	0.890	0.874	0.852	0.827	0.799	0.770	0.742	0.715	0.691	0.632
1979	0.000	0.000	0.015	0.107	0.346	0.618	0.812	0.897	0.916	0.912	0.902	0.889	0.873	0.852	0.826	0.798	0.769	0.741	0.715	0.690	0.634
1980	0.000	0.000	0.013	0.115	0.329	0.616	0.812	0.900	0.922	0.920	0.911	0.900	0.884	0.863	0.837	0.809	0.781	0.752	0.726	0.702	0.647
1981	0.000	0.000	0.015	0.130	0.380	0.630	0.826	0.906	0.924	0.920	0.911	0.899	0.883	0.862	0.837	0.809	0.780	0.752	0.725	0.701	0.647
1982	0.000	0.000	0.008	0.079	0.309	0.601	0.794	0.897	0.923	0.923	0.915	0.904	0.888	0.867	0.842	0.814	0.785	0.757	0.731	0.707	0.653
1983	0.000	0.000	0.015	0.088	0.295	0.595	0.809	0.899	0.930	0.932	0.925	0.915	0.900	0.879	0.854	0.827	0.798	0.770	0.743	0.719	0.665
1984	0.000	0.001	0.020	0.144	0.337	0.602	0.818	0.912	0.937	0.939	0.934	0.924	0.909	0.889	0.864	0.836	0.808	0.779	0.753	0.729	0.674
1985	0.000	0.000	0.006	0.096	0.334	0.562	0.777	0.894	0.924	0.926	0.919	0.908	0.892	0.872	0.847	0.819	0.790	0.762	0.735	0.711	0.656
1986	0.000	0.000	0.016	0.095	0.357	0.642	0.798	0.893	0.920	0.917	0.909	0.896	0.880	0.859	0.833	0.805	0.776	0.748	0.722	0.698	0.642
1987	0.000	0.000	0.008	0.092	0.272	0.597	0.811	0.887	0.919	0.921	0.913	0.902	0.886	0.865	0.840	0.812	0.783	0.755	0.728	0.704	0.647
1988	0.000	0.001	0.032	0.172	0.434	0.650	0.851	0.919	0.927	0.922	0.911	0.898	0.883	0.861	0.835	0.807	0.778	0.750	0.724	0.700	0.641
1989	0.000	0.000	0.016	0.118	0.354	0.638	0.803	0.912	0.936	0.935	0.929	0.918	0.902	0.883	0.857	0.829	0.801	0.773	0.746	0.722	0.663
1990	0.000	0.000	0.011	0.090	0.302	0.585	0.807	0.898	0.945	0.953	0.951	0.944	0.929	0.909	0.886	0.857	0.828	0.800	0.774	0.750	0.690
1991	0.000	0.000	0.012	0.094	0.295	0.570	0.792	0.902	0.932	0.940	0.935	0.927	0.914	0.892	0.866	0.840	0.810	0.782	0.756	0.732	0.671
1992	0.000	0.000	0.009	0.096	0.300	0.561	0.778	0.887	0.917	0.917	0.908	0.895	0.883	0.863	0.835	0.806	0.779	0.749	0.723	0.699	0.639
1993	0.000	0.001	0.029	0.150	0.407	0.650	0.820	0.903	0.923	0.918	0.910	0.895	0.877	0.861	0.836	0.806	0.775	0.749	0.721	0.697	0.643
1994	0.000	0.000	0.014	0.121	0.341	0.627	0.807	0.893	0.917	0.915	0.905	0.894	0.876	0.852	0.832	0.805	0.773	0.744	0.719	0.693	0.646
1995	0.000	0.000	0.016	0.118	0.367	0.623	0.822	0.900	0.920	0.918	0.909	0.896	0.882	0.858	0.830	0.808	0.780	0.749	0.721	0.698	0.648
1996	0.000	0.000	0.008	0.083	0.296	0.592	0.794	0.907	0.941	0.950	0.949	0.942	0.927	0.911	0.883	0.852	0.831	0.803	0.774	0.749	0.709
1997	0.000	0.000	0.017	0.125	0.353	0.624	0.827	0.912	0.941	0.944	0.940	0.931	0.917	0.896	0.875	0.843	0.811	0.790	0.764	0.737	0.703
1998	0.000	0.000	0.008	0.087	0.306	0.579	0.794	0.901	0.931	0.935	0.930	0.921	0.907	0.887	0.861	0.837	0.804	0.773	0.753	0.729	0.687
1999	0.000	0.000	0.008	0.087	0.309	0.591	0.795	0.896	0.927	0.928	0.922	0.912	0.898	0.878	0.853	0.823	0.799	0.766	0.737	0.719	0.674
2000	0.000	0.000	0.011	0.072	0.283	0.572	0.789	0.889	0.918	0.917	0.910	0.898	0.883	0.864	0.840	0.811	0.781	0.757	0.726	0.699	0.648
2001	0.000	0.000	0.009	0.097	0.266	0.556	0.778	0.869	0.882	0.869	0.851	0.836	0.816	0.795	0.771	0.743	0.713	0.683	0.660	0.631	0.569
2002	0.000	0.000	0.018	0.121	0.370	0.586	0.793	0.871	0.870	0.850	0.829	0.809	0.790	0.765	0.740	0.714	0.684	0.655	0.627	0.606	0.550
2003	0.000	0.000	0.013	0.117	0.339	0.625	0.782	0.880	0.898	0.888	0.874	0.859	0.841	0.820	0.792	0.766	0.739	0.711	0.683	0.657	0.597
2004	0.000	0.000	0.021	0.113	0.356	0.617	0.818	0.887	0.913	0.910	0.900	0.888	0.872	0.850	0.825	0.795	0.769	0.742	0.716	0.691	0.636
2005	0.000	0.001	0.013	0.139	0.341	0.627	0.813	0.907	0.928	0.931	0.925	0.915	0.900	0.880	0.854	0.827	0.796	0.770	0.745	0.721	0.661
2006	0.000	0.000	0.009	0.092	0.360	0.595	0.812	0.908	0.945	0.952	0.951	0.943	0.930	0.910	0.886	0.858	0.830	0.800	0.776	0.753	0.688
2007	0.000	0.000	0.007	0.089	0.307	0.631	0.801	0.909	0.941	0.949	0.947	0.939	0.925	0.905	0.881	0.854	0.824	0.797	0.769	0.747	0.674
2008	0.000	0.000	0.007	0.080	0.304	0.585	0.820	0.891	0.916	0.913	0.904	0.895	0.879	0.857	0.831	0.804	0.775	0.745	0.720	0.694	0.631
2009	0.000	0.000	0.005	0.059	0.251	0.550	0.772	0.879	0.890	0.881	0.868	0.852	0.838	0.815	0.788	0.759	0.731	0.702	0.674	0.651	0.601
2010	0.000	0.000	0.005	0.053	0.226	0.510	0.756	0.861	0.880	0.870	0.854	0.839	0.819	0.801	0.774	0.744	0.715	0.686	0.659	0.634	0.590
2011	0.000	0.000	0.003	0.065	0.239	0.508	0.748	0.869	0.897	0.891	0.881	0.867	0.850	0.827	0.807	0.777	0.747	0.718	0.692	0.668	0.619
2012	0.000	0.000	0.008	0.068	0.299	0.552	0.765	0.874	0.901	0.896	0.882	0.871	0.853	0.832	0.805	0.783	0.752	0.723	0.696	0.672	0.633
2013	0.000	0.000	0.008	0.092	0.278	0.591	0.777	0.871	0.891	0.880	0.865	0.847	0.832	0.808	0.783	0.753	0.730	0.700	0.672	0.647	0.604
2014	0.000	0.000	0.005	0.059	0.264	0.513	0.769	0.861	0.886	0.880	0.866	0.851	0.830	0.811	0.784	0.756	0.726	0.703	0.675	0.650	0.602
2015	0.000	0.000	0.007	0.055	0.231	0.529	0.736	0.869	0.896	0.896	0.886	0.873	0.856	0.831	0.809	0.779	0.751	0.722	0.701	0.675	0.625
2016	0.000	0.000	0.007	0.078	0.241	0.512	0.760	0.867	0.914	0.918	0.913	0.903	0.887	0.866	0.837	0.813	0.782	0.755	0.727	0.708	0.669
2017	0.000	0.000	0.005	0.076	0.287	0.519	0.747	0.879	0.918	0.929	0.926	0.918	0.904	0.883	0.858	0.826	0.801	0.771	0.746	0.721	0.680
2018	0.000	0.000	0.018	0.101	0.351	0.626	0.789	0.892	0.930	0.935	0.931	0.923	0.909	0.889	0.863	0.836	0.802	0.778	0.750	0.727	0.679
2019	0.000	0.001	0.007	0.145	0.346	0.642	0.824	0.889	0.914	0.912	0.905	0.891	0.877	0.857	0.832	0.803	0.773	0.740	0.718	0.692	0.650

Table 2.1.23a. Selectivity at age in the survey (Model 19.12a).

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	0.484	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
1978	0.009	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
1979	0.012	0.385	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	0.497	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	0.397	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	0.216	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	0.441	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.004	0.252	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	0.429	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
1986	0.022	0.295	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.415	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	0.260	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	0.140	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
1990	0.021	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	0.019	0.299	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	0.011	0.521	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
1993	0.030	0.476	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	0.008	0.440	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
1995	0.004	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	0.202	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
1997	0.009	0.277	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	0.181	0.925	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	0.236	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	0.017	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
2001	0.029	0.807	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.467	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	0.494	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	0.381	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.008	0.745	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	0.029	0.740	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.036	0.824	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.013	0.475	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.048	0.496	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.009	0.328	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.488	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	0.682	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.292	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	0.015	0.346	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
2016	0.007	0.447	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
2017	0.009	0.486	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
2018	0.005	0.371	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	0.010	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
2020	0.010	0.244	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 2.1.23b. Selectivity at age in the 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	0.012	0.509	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	0.509	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	0.400	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	0.518	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	0.407	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	0.048	0.410	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.356	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	0.420	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	0.289	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.404	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	0.257	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	0.150	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
1990	0.024	0.418	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.344	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	0.031	0.504	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	0.334	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	0.004	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	0.198	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	0.280	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	0.916	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	0.251	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
2000	0.019	0.314	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.761	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.465	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	0.497	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	0.378	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.008	0.719	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	0.029	0.743	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.040	0.837	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.551	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.053	0.639	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.347	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.480	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	0.080	0.722	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.011	0.334	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
2014	0.010	0.366	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	0.343	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.452	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	0.013	0.590	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	0.378	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	0.254	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 2.1.23c. Selectivity at age in the survey (Model 21.1).

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	0.438	0.999	0.994	0.947	0.868	0.783	0.707	0.644	0.593	0.553	0.521	0.496	0.476	0.460	0.447	0.437	0.428	0.421	0.415	0.406
1978	0.010	0.438	0.999	0.994	0.947	0.868	0.783	0.707	0.644	0.593	0.553	0.521	0.496	0.476	0.460	0.447	0.437	0.428	0.421	0.415	0.406
1979	0.012	0.389	0.999	0.994	0.947	0.868	0.783	0.707	0.644	0.593	0.553	0.521	0.496	0.476	0.460	0.447	0.437	0.428	0.421	0.415	0.405
1980	0.010	0.492	0.999	0.993	0.949	0.868	0.783	0.707	0.644	0.593	0.553	0.521	0.496	0.476	0.460	0.447	0.437	0.428	0.421	0.415	0.405
1981	0.007	0.404	0.997	0.994	0.945	0.870	0.783	0.707	0.644	0.593	0.553	0.521	0.496	0.476	0.460	0.447	0.437	0.428	0.421	0.415	0.405
1982	0.004	0.222	0.998	0.995	0.944	0.859	0.778	0.700	0.637	0.586	0.547	0.515	0.491	0.471	0.455	0.443	0.433	0.424	0.418	0.412	0.402
1983	0.047	0.464	1.000	0.994	0.949	0.861	0.771	0.699	0.635	0.584	0.545	0.513	0.489	0.469	0.454	0.442	0.431	0.423	0.417	0.411	0.400
1984	0.004	0.259	0.989	0.998	0.976	0.919	0.837	0.759	0.698	0.643	0.599	0.564	0.536	0.513	0.494	0.480	0.467	0.457	0.449	0.442	0.429
1985	0.009	0.442	0.993	0.996	0.954	0.891	0.811	0.728	0.661	0.612	0.569	0.536	0.509	0.488	0.472	0.458	0.447	0.438	0.431	0.425	0.412
1986	0.024	0.311	1.000	0.995	0.936	0.849	0.775	0.700	0.630	0.578	0.541	0.509	0.485	0.466	0.451	0.438	0.429	0.421	0.414	0.409	0.398
1987	0.007	0.429	0.998	0.994	0.957	0.866	0.780	0.714	0.652	0.595	0.552	0.522	0.496	0.476	0.460	0.448	0.437	0.429	0.422	0.416	0.404
1988	0.005	0.292	0.997	0.995	0.948	0.881	0.782	0.704	0.650	0.599	0.554	0.521	0.497	0.476	0.460	0.448	0.437	0.429	0.422	0.416	0.404
1989	0.003	0.151	0.990	0.998	0.967	0.893	0.825	0.736	0.671	0.626	0.584	0.546	0.518	0.497	0.479	0.465	0.454	0.445	0.437	0.431	0.417
1990	0.023	0.415	1.000	0.993	0.945	0.860	0.768	0.702	0.628	0.577	0.543	0.513	0.486	0.466	0.451	0.439	0.429	0.421	0.414	0.409	0.397
1991	0.020	0.328	0.997	0.998	0.970	0.904	0.822	0.742	0.687	0.624	0.580	0.551	0.524	0.500	0.481	0.468	0.456	0.447	0.439	0.433	0.419
1992	0.012	0.539	0.999	0.992	0.945	0.869	0.783	0.704	0.636	0.593	0.545	0.514	0.492	0.473	0.456	0.442	0.433	0.424	0.418	0.412	0.401
1993	0.034	0.499	1.000	0.995	0.948	0.875	0.796	0.719	0.653	0.598	0.563	0.524	0.498	0.481	0.465	0.450	0.439	0.431	0.424	0.418	0.407
1994	0.012	0.419	0.992	0.997	0.969	0.900	0.827	0.756	0.691	0.635	0.589	0.559	0.526	0.503	0.488	0.474	0.461	0.450	0.443	0.436	0.425
1995	0.005	0.241	0.994	0.997	0.957	0.891	0.807	0.737	0.676	0.622	0.578	0.542	0.519	0.494	0.476	0.464	0.453	0.443	0.435	0.429	0.418
1996	0.002	0.211	0.996	0.996	0.959	0.878	0.802	0.724	0.664	0.614	0.572	0.537	0.509	0.491	0.471	0.457	0.448	0.439	0.431	0.424	0.416
1997	0.009	0.294	0.994	0.997	0.966	0.897	0.809	0.740	0.674	0.624	0.584	0.549	0.521	0.498	0.483	0.466	0.454	0.446	0.438	0.431	0.424
1998	0.012	0.198	0.940	0.999	0.987	0.943	0.877	0.800	0.742	0.685	0.642	0.606	0.574	0.548	0.526	0.512	0.496	0.484	0.476	0.468	0.456
1999	0.006	0.264	0.995	0.996	0.956	0.880	0.799	0.722	0.652	0.605	0.562	0.531	0.507	0.486	0.468	0.454	0.445	0.434	0.427	0.422	0.412
2000	0.019	0.305	1.000	0.993	0.937	0.847	0.758	0.683	0.620	0.566	0.531	0.500	0.478	0.461	0.446	0.433	0.423	0.416	0.409	0.404	0.394
2001	0.031	0.799	1.000	0.985	0.939	0.847	0.755	0.678	0.617	0.567	0.525	0.498	0.474	0.457	0.443	0.431	0.422	0.413	0.408	0.402	0.391
2002	0.013	0.513	1.000	0.992	0.938	0.875	0.784	0.704	0.640	0.590	0.549	0.515	0.492	0.472	0.457	0.445	0.435	0.426	0.419	0.414	0.404
2003	0.010	0.520	0.999	0.993	0.948	0.865	0.799	0.718	0.651	0.598	0.558	0.526	0.498	0.479	0.462	0.450	0.440	0.431	0.424	0.418	0.407
2004	0.014	0.404	1.000	0.994	0.947	0.870	0.782	0.723	0.654	0.600	0.558	0.527	0.501	0.478	0.464	0.450	0.440	0.432	0.425	0.419	0.409
2005	0.009	0.756	0.999	0.988	0.941	0.853	0.770	0.690	0.642	0.587	0.545	0.514	0.489	0.470	0.453	0.441	0.431	0.423	0.417	0.411	0.401
2006	0.031	0.752	1.000	0.981	0.891	0.810	0.716	0.644	0.582	0.546	0.507	0.478	0.456	0.439	0.426	0.414	0.407	0.400	0.395	0.390	0.381
2007	0.038	0.831	1.000	0.974	0.892	0.774	0.698	0.621	0.565	0.519	0.493	0.465	0.443	0.427	0.415	0.405	0.397	0.391	0.386	0.382	0.372
2008	0.014	0.483	1.000	0.987	0.916	0.821	0.715	0.653	0.590	0.545	0.507	0.485	0.462	0.443	0.430	0.419	0.410	0.403	0.397	0.393	0.383
2009	0.052	0.529	1.000	0.991	0.932	0.836	0.746	0.657	0.606	0.556	0.520	0.490	0.472	0.453	0.438	0.426	0.417	0.410	0.403	0.399	0.391
2010	0.009	0.324	0.999	0.994	0.953	0.873	0.781	0.703	0.629	0.587	0.545	0.515	0.490	0.474	0.457	0.444	0.434	0.425	0.419	0.412	0.405
2011	0.007	0.499	0.998	0.993	0.949	0.876	0.789	0.706	0.641	0.582	0.549	0.516	0.492	0.471	0.459	0.446	0.435	0.426	0.419	0.414	0.405
2012	0.076	0.678	1.000	0.982	0.897	0.808	0.723	0.645	0.580	0.534	0.493	0.471	0.449	0.433	0.420	0.412	0.403	0.396	0.391	0.386	0.381
2013	0.010	0.304	0.988	0.998	0.977	0.907	0.837	0.768	0.701	0.642	0.597	0.556	0.533	0.509	0.492	0.476	0.467	0.456	0.448	0.441	0.430
2014	0.011	0.367	0.999	0.994	0.946	0.877	0.781	0.711	0.651	0.598	0.554	0.521	0.492	0.475	0.459	0.446	0.435	0.429	0.421	0.415	0.406
2015	0.017	0.351	0.999	0.997	0.965	0.891	0.821	0.735	0.676	0.626	0.582	0.545	0.518	0.492	0.478	0.463	0.453	0.443	0.437	0.430	0.419
2016	0.008	0.464	0.997	0.997	0.972	0.915	0.835	0.771	0.697	0.648	0.606	0.569	0.538	0.514	0.493	0.480	0.467	0.458	0.449	0.444	0.434
2017	0.008	0.505	0.996	0.996	0.961	0.907	0.835	0.757	0.701	0.639	0.599	0.566	0.537	0.512	0.493	0.476	0.466	0.455	0.447	0.440	0.431
2018	0.006	0.352	0.999	0.996	0.958	0.888	0.824	0.755	0.686	0.640	0.590	0.558	0.532	0.509	0.489	0.474	0.460	0.452	0.443	0.437	0.426
2019	0.010	0.982	1.000	0.968	0.906	0.807	0.721	0.660	0.603	0.553	0.521	0.487	0.467	0.450	0.436	0.423	0.414	0.406	0.401	0.396	0.389
2020	0.011	0.247	0.999	0.996	0.923	0.856	0.766	0.693	0.642	0.595	0.552	0.524	0.495	0.477	0.462	0.448	0.437	0.428	0.420	0.415	0.407

Table 2.1.23d. Selectivity at age in the survey (Model 21.2).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	0.013	0.558	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.558	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	0.403	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	0.010	0.515	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	0.007	0.414	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	0.225	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	0.041	0.448	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.004	0.253	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
1985	0.008	0.443	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
1986	0.023	0.310	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.421	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	0.262	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	0.140	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
1990	0.021	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
1991	0.019	0.304	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
1992	0.011	0.527	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
1993	0.029	0.473	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	0.008	0.453	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
1995	0.004	0.229	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
1996	0.002	0.212	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
1997	0.007	0.300	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	0.008	0.259	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
1999	0.006	0.257	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
2000	0.017	0.283	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.416	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	0.008	0.435	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	0.012	0.348	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.008	0.761	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	0.029	0.723	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.042	0.832	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.050	0.561	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.327	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.007	0.515	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	0.707	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.298	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
2014	0.009	0.349	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	0.338	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.006	0.443	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
2017	0.008	0.483	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
2018	0.005	0.382	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	0.010	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	0.262	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 2.1.23e. Selectivity at age in the survey (Model 21.3).

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	0.519	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	0.519	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	0.410	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.536	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	0.416	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	0.003	0.211	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	0.048	0.371	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.007	0.416	0.987	1.000	1.000	1.000	1.000	1.000	1.000	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	0.989	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
1986	0.021	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	0.005	0.405	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	0.996	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
1989	0.003	0.156	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
1990	0.026	0.435	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.030	0.365	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	0.018	0.833	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.504	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	0.305	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	0.005	0.220	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
1996	0.002	0.193	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
1997	0.009	0.278	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	0.011	0.174	0.901	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	0.255	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
2000	0.018	0.329	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.023	0.741	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.463	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	0.492	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	0.709	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	0.029	0.754	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.042	0.849	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.017	0.593	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.059	0.726	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.366	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.495	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	0.086	0.758	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.012	0.371	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	0.011	0.388	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	0.017	0.354	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.010	0.475	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	0.016	0.666	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	0.005	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
2020	0.010	0.245	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 2.1.23f. Selectivity at age in the survey (ensemble).

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	0.498	0.999	0.999	0.991	0.976	0.961	0.947	0.936	0.927	0.919	0.914	0.909	0.905	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1978	0.009	0.498	0.999	0.999	0.991	0.976	0.961	0.947	0.936	0.927	0.919	0.914	0.909	0.905	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1979	0.012	0.397	0.999	0.999	0.991	0.976	0.961	0.947	0.936	0.927	0.919	0.914	0.909	0.905	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1980	0.010	0.512	0.999	0.999	0.991	0.976	0.961	0.947	0.936	0.927	0.919	0.914	0.909	0.905	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1981	0.006	0.407	0.998	0.999	0.990	0.977	0.961	0.947	0.936	0.927	0.919	0.914	0.909	0.905	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1982	0.004	0.217	0.998	0.999	0.990	0.975	0.960	0.946	0.935	0.925	0.918	0.913	0.908	0.905	0.902	0.900	0.898	0.896	0.895	0.894	0.892
1983	0.046	0.424	1.000	0.999	0.991	0.975	0.959	0.946	0.934	0.925	0.918	0.912	0.908	0.904	0.902	0.899	0.897	0.896	0.895	0.894	0.892
1984	0.005	0.313	0.988	1.000	0.996	0.985	0.971	0.957	0.946	0.936	0.928	0.921	0.916	0.912	0.909	0.906	0.904	0.902	0.901	0.899	0.897
1985	0.008	0.428	0.992	0.999	0.992	0.980	0.966	0.951	0.939	0.930	0.922	0.916	0.912	0.908	0.905	0.902	0.900	0.899	0.897	0.896	0.894
1986	0.022	0.296	1.000	0.999	0.988	0.973	0.959	0.946	0.933	0.924	0.917	0.912	0.907	0.904	0.901	0.899	0.897	0.896	0.894	0.893	0.891
1987	0.006	0.413	0.998	0.999	0.992	0.976	0.960	0.948	0.937	0.927	0.919	0.914	0.909	0.906	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1988	0.004	0.265	0.997	0.999	0.991	0.979	0.961	0.947	0.937	0.928	0.920	0.914	0.909	0.906	0.903	0.900	0.898	0.897	0.896	0.895	0.893
1989	0.003	0.148	0.992	1.000	0.994	0.981	0.968	0.952	0.941	0.933	0.925	0.918	0.913	0.909	0.906	0.904	0.902	0.900	0.898	0.897	0.895
1990	0.023	0.410	1.000	0.999	0.990	0.975	0.958	0.946	0.933	0.924	0.918	0.912	0.907	0.904	0.901	0.899	0.897	0.896	0.894	0.893	0.891
1991	0.023	0.329	0.996	1.000	0.995	0.983	0.968	0.953	0.944	0.932	0.924	0.919	0.914	0.910	0.906	0.904	0.902	0.900	0.899	0.898	0.895
1992	0.014	0.625	1.000	0.999	0.990	0.976	0.961	0.947	0.934	0.927	0.918	0.912	0.908	0.905	0.902	0.899	0.898	0.896	0.895	0.894	0.892
1993	0.031	0.492	0.999	0.999	0.991	0.978	0.963	0.949	0.937	0.927	0.921	0.914	0.910	0.906	0.904	0.901	0.899	0.897	0.896	0.895	0.893
1994	0.008	0.385	0.995	0.999	0.994	0.982	0.969	0.956	0.944	0.934	0.926	0.920	0.915	0.910	0.908	0.905	0.903	0.901	0.900	0.898	0.896
1995	0.004	0.228	0.993	0.999	0.992	0.980	0.965	0.953	0.942	0.932	0.924	0.917	0.913	0.909	0.906	0.903	0.901	0.900	0.898	0.897	0.895
1996	0.002	0.202	0.996	0.999	0.993	0.978	0.964	0.950	0.939	0.930	0.923	0.917	0.911	0.908	0.905	0.902	0.900	0.899	0.897	0.896	0.895
1997	0.009	0.284	0.993	1.000	0.994	0.981	0.966	0.953	0.941	0.932	0.925	0.919	0.914	0.909	0.907	0.904	0.902	0.900	0.899	0.897	0.896
1998	0.010	0.192	0.930	0.999	0.998	0.990	0.978	0.964	0.953	0.943	0.935	0.929	0.923	0.919	0.915	0.912	0.909	0.907	0.906	0.904	0.902
1999	0.006	0.251	0.995	0.999	0.992	0.978	0.964	0.950	0.937	0.929	0.921	0.916	0.911	0.907	0.904	0.902	0.900	0.898	0.897	0.896	0.894
2000	0.018	0.304	1.000	0.999	0.989	0.972	0.956	0.943	0.932	0.922	0.916	0.910	0.906	0.903	0.900	0.898	0.896	0.895	0.893	0.892	0.891
2001	0.027	0.776	1.000	0.997	0.989	0.972	0.956	0.942	0.931	0.922	0.914	0.910	0.905	0.902	0.900	0.897	0.896	0.894	0.893	0.892	0.890
2002	0.012	0.467	0.999	0.999	0.989	0.977	0.961	0.947	0.935	0.926	0.919	0.912	0.908	0.905	0.902	0.900	0.898	0.896	0.895	0.894	0.892
2003	0.010	0.491	0.998	0.999	0.991	0.976	0.964	0.949	0.937	0.928	0.920	0.914	0.909	0.906	0.903	0.901	0.899	0.897	0.896	0.895	0.893
2004	0.013	0.379	1.000	0.999	0.990	0.977	0.961	0.950	0.938	0.928	0.920	0.915	0.910	0.906	0.903	0.901	0.899	0.898	0.896	0.895	0.893
2005	0.008	0.735	0.999	0.998	0.989	0.974	0.959	0.944	0.935	0.926	0.918	0.912	0.908	0.904	0.901	0.899	0.897	0.896	0.895	0.894	0.892
2006	0.030	0.744	1.000	0.997	0.980	0.966	0.949	0.936	0.925	0.918	0.911	0.906	0.902	0.899	0.896	0.894	0.893	0.892	0.891	0.890	0.888
2007	0.039	0.835	1.000	0.995	0.980	0.959	0.946	0.932	0.922	0.913	0.909	0.903	0.900	0.897	0.895	0.893	0.891	0.890	0.889	0.889	0.887
2008	0.015	0.527	1.000	0.998	0.985	0.968	0.949	0.937	0.926	0.918	0.911	0.907	0.903	0.900	0.897	0.895	0.894	0.892	0.891	0.890	0.889
2009	0.052	0.593	1.000	0.998	0.988	0.970	0.954	0.938	0.929	0.920	0.913	0.908	0.905	0.901	0.899	0.897	0.895	0.894	0.892	0.892	0.890
2010	0.010	0.340	1.000	0.999	0.991	0.977	0.960	0.946	0.933	0.926	0.918	0.913	0.908	0.905	0.902	0.900	0.898	0.896	0.895	0.894	0.893
2011	0.006	0.493	0.998	0.999	0.991	0.978	0.962	0.947	0.935	0.925	0.919	0.913	0.908	0.905	0.902	0.900	0.898	0.897	0.895	0.894	0.893
2012	0.077	0.710	1.000	0.997	0.981	0.965	0.950	0.936	0.924	0.916	0.909	0.905	0.901	0.898	0.895	0.894	0.892	0.891	0.890	0.889	0.888
2013	0.010	0.322	0.991	1.000	0.996	0.983	0.971	0.958	0.946	0.935	0.927	0.920	0.916	0.912	0.908	0.906	0.904	0.902	0.900	0.899	0.897
2014	0.010	0.366	0.999	0.999	0.990	0.978	0.960	0.948	0.937	0.928	0.920	0.914	0.908	0.905	0.902	0.900	0.898	0.897	0.896	0.895	0.893
2015	0.016	0.347	1.000	0.999	0.994	0.980	0.968	0.952	0.942	0.933	0.925	0.918	0.913	0.908	0.906	0.903	0.901	0.900	0.898	0.897	0.895
2016	0.008	0.457	0.997	0.999	0.995	0.985	0.970	0.959	0.945	0.936	0.929	0.922	0.917	0.912	0.909	0.906	0.904	0.902	0.901	0.900	0.898
2017	0.011	0.552	0.996	0.999	0.993	0.983	0.970	0.956	0.946	0.935	0.928	0.922	0.916	0.912	0.909	0.905	0.904	0.902	0.900	0.899	0.897
2018	0.005	0.374	0.999	0.999	0.992	0.980	0.968	0.956	0.943	0.935	0.926	0.920	0.916	0.911	0.908	0.905	0.903	0.901	0.900	0.898	0.896
2019	0.009	0.985	1.000	0.994	0.983	0.965	0.950	0.939	0.928	0.919	0.914	0.908	0.904	0.901	0.898	0.896	0.894	0.893	0.892	0.891	0.890

Table 2.1.24a. Begin-year numbers at age (1000s of fish, Model 19.12a).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1055860	241691	73168	67905	29929	15121	9429	6361	4414	3081	2136	1462	985	654	429	278	179	115	73	47	80
1978	698615	745589	170663	51554	47055	19901	9556	5744	3814	2637	1841	1277	875	590	392	257	167	107	69	44	76
1979	722893	493320	526471	120234	35574	30863	12261	5628	3318	2193	1517	1060	736	504	340	226	148	96	62	40	69
1980	180521	510465	348345	370885	83476	23754	19701	7581	3433	2018	1334	924	646	448	307	207	138	90	59	38	66
1981	202423	127473	360447	245480	257008	55779	15107	12115	4594	2073	1219	806	558	390	271	186	125	83	55	35	63
1982	940997	142939	90010	254052	170552	172949	36334	9594	7619	2883	1301	765	507	351	245	171	117	79	52	34	62
1983	262195	664480	100935	63515	178050	116903	115202	23746	6210	4919	1861	840	494	327	227	159	110	76	51	34	62
1984	880029	185147	469213	71165	44402	121489	76992	73973	15091	3933	3115	1179	532	313	207	144	100	70	48	32	61
1985	401581	621424	130730	330316	49176	29716	77878	47660	45120	9171	2389	1892	716	324	190	126	87	61	42	29	57
1986	218832	283573	438805	92219	229421	32806	19001	47921	28743	27072	5500	1433	1136	430	194	114	76	52	37	25	51
1987	73430	154526	200240	309090	64121	152706	20833	11734	29140	17407	16399	3334	869	689	261	118	69	46	32	22	47
1988	304805	51852	109115	141196	214549	43001	96187	12599	6985	17240	10289	9697	1972	514	408	154	70	41	27	19	41
1989	599916	215232	36606	76527	95993	137462	26213	56025	7233	4002	9884	5906	5571	1134	296	234	89	40	24	16	34
1990	591325	423624	151977	25765	52750	62967	84875	15622	32652	4197	2321	5736	3429	3236	658	172	136	52	23	14	29
1991	362056	417559	299132	107046	17822	34720	38737	49511	8919	18440	2365	1308	3232	1933	1824	371	97	77	29	13	24
1992	951195	255661	294841	210273	72881	11205	19550	19954	24415	4349	8960	1150	636	1572	940	887	181	47	37	14	18
1993	352693	671673	180523	207448	142697	45250	6198	9826	9576	11580	2062	4258	547	303	749	448	423	86	22	18	15
1994	297828	249047	474207	126445	140264	89417	26296	3417	5284	5119	6195	1105	2284	294	163	402	241	227	46	12	18
1995	267213	210307	175842	333198	85181	86561	49175	13415	1684	2577	2496	3025	540	1117	144	80	197	118	111	23	15
1996	845833	188688	148487	123272	222267	50070	44691	22956	6024	749	1146	1112	1351	241	500	64	36	88	53	50	17
1997	362002	597271	133235	104459	83807	136751	26672	21630	10540	2720	337	515	500	607	108	224	29	16	40	24	30
1998	287697	255620	421681	93265	69159	49266	69636	12173	9460	4544	1171	145	222	215	262	47	97	12	7	17	23
1999	692380	203153	180496	296836	63500	42974	27291	35229	5887	4524	2169	559	69	106	103	125	22	46	6	3	19
2000	504684	488915	143449	127086	202655	39656	23986	14045	17438	2882	2214	1062	274	34	52	51	61	11	23	3	11
2001	196393	356376	345235	100849	87316	128435	22462	12507	7057	8666	1431	1100	528	136	17	26	25	31	5	11	7
2002	343943	138680	251638	243028	68844	56279	74918	12140	6563	3689	4544	753	580	279	72	9	14	13	16	3	10
2003	310233	242870	97917	176522	164192	42391	32000	39494	6249	3392	1923	2384	397	306	147	38	5	7	7	9	7
2004	224096	219067	171480	68783	119201	101990	23632	16842	20048	3149	1712	973	1208	201	155	75	19	2	4	4	8
2005	268577	158241	154675	120055	46462	73299	56744	12182	8472	9992	1570	855	487	605	101	78	37	10	1	2	6
2006	785800	189652	111714	108624	80133	28591	40233	28942	5998	4142	4879	768	418	238	296	49	38	18	5	1	4
2007	317096	554881	133913	78567	73713	48463	15617	20020	13836	2826	1946	2291	361	197	112	139	23	18	9	2	2
2008	1172310	223913	391808	94298	53558	45993	26453	7951	9770	6673	1359	936	1103	174	95	54	67	11	9	4	2
2009	165411	827807	158108	275782	64120	32581	24277	12430	3624	4428	3036	621	429	506	80	43	25	31	5	4	3
2010	735035	116802	584533	111364	188302	38956	16354	10596	5126	1496	1846	1276	262	181	214	34	18	11	13	2	3
2011	931428	519031	82477	411811	76369	116807	20320	7320	4468	2146	630	783	543	112	78	92	14	8	5	6	2
2012	443334	657710	366495	58136	278377	45636	57415	8345	2736	1629	780	229	286	198	41	28	34	5	3	2	3
2013	1200130	313052	464420	257625	39413	163236	22766	25007	3381	1084	644	309	91	113	79	16	11	13	2	1	2
2014	216689	847449	221044	326507	172968	23809	82229	10288	10717	1430	459	274	132	39	49	34	7	5	6	1	1
2015	286940	153011	598401	155649	222461	103912	12220	35866	4245	4361	583	188	113	54	16	20	14	3	2	2	1
2016	178257	202617	108044	420974	106425	137183	53688	5573	15115	1760	1805	242	78	47	23	7	8	6	1	1	1
2017	124742	125873	143071	76046	285578	66151	73766	25256	2475	6545	760	779	104	34	20	10	3	4	3	1	1
2018	735401	88084	88881	100818	51990	178315	37363	37830	12248	1180	3101	360	369	49	16	10	5	1	2	1	1
2019	503144	519293	62197	62402	69005	32959	103713	20649	20274	6491	624	1640	190	195	26	8	5	2	1	1	1
2020	503144	355290	366633	43837	42255	44069	19292	57537	11252	10989	3521	339	892	104	106	14	5	3	1	0	1

Table 2.1.24b. Begin-year 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	823249	214026	62270	57282	26196	13168	8223	5583	3913	2761	1935	1339	912	612	407	269	177	117	78	52	106
1978	584543	591102	153668	44602	40308	17638	8387	5017	3329	2310	1624	1139	789	540	366	245	164	110	73	49	103
1979	600751	419708	424400	110057	31235	26713	10901	4911	2853	1870	1292	908	639	445	308	211	144	98	66	45	97
1980	147013	431346	301346	303916	77568	21086	17140	6728	2969	1710	1117	772	544	384	270	188	130	90	62	42	93
1981	177794	105557	309698	215874	213683	52374	13451	10491	4028	1761	1011	661	457	324	230	164	115	81	56	39	88
1982	827405	127658	75787	221904	152214	145288	34287	8530	6549	2499	1090	626	410	285	203	145	104	74	52	37	85
1983	204043	594089	91660	54373	158009	105715	97607	22500	5517	4212	1604	700	402	264	184	132	95	69	49	35	83
1984	752943	146505	426560	65684	38622	109284	70225	62867	14279	3476	2648	1008	440	254	168	118	85	62	45	32	79
1985	349755	540621	105181	305271	45997	26181	70599	43526	38167	8604	2088	1591	607	266	155	103	73	53	39	29	73
1986	200206	251129	388164	75439	215411	31012	16919	43657	26195	22729	5107	1239	946	363	160	94	63	45	34	25	67
1987	71211	143750	180310	277963	53306	145465	19872	10533	26608	15809	13676	3072	747	573	221	99	58	40	29	22	60
1988	279200	51130	103212	129259	196004	36280	92639	12065	6275	15672	9270	8016	1805	441	341	133	60	36	25	18	53
1989	541701	200466	36703	73584	89248	127235	22339	54124	6889	3559	8858	5238	4543	1029	254	199	79	36	22	15	46
1990	520225	388946	143929	26264	51540	59374	79351	13386	31471	3965	2043	5082	3013	2628	600	150	119	48	22	14	39
1991	287980	373527	279262	103078	18468	34430	36902	46458	7631	17650	2214	1141	2844	1697	1496	346	88	71	29	14	34
1992	763617	206771	268183	199561	71334	11790	19600	19051	22704	3659	8382	1051	543	1368	830	748	177	46	38	16	28
1993	313785	548281	148455	191833	137557	45038	6631	9954	9116	10590	1694	3875	489	255	652	406	376	91	24	21	25
1994	254449	225298	393583	105695	131684	87374	26532	3694	5367	4846	5602	896	2057	262	138	358	227	214	53	14	28
1995	235301	182696	161745	280950	72340	82343	48476	13585	1808	2573	2305	2663	428	993	129	69	183	119	116	29	25
1996	735994	168946	131156	115169	189668	43013	42565	22335	5933	771	1087	973	1131	184	436	58	32	88	59	59	29
1997	325382	528446	121299	93783	79333	117116	22732	20034	9807	2540	327	460	414	488	81	198	27	15	44	30	48
1998	257591	233624	379362	86299	62825	46454	57993	9864	8150	3874	994	128	181	165	200	34	87	12	7	21	40
1999	590668	184952	167737	271503	59572	39119	25225	28085	4478	3609	1699	436	56	81	75	93	16	43	6	4	34
2000	436197	424103	132792	120077	188031	37305	21446	12457	13071	2031	1624	764	197	26	37	36	46	8	22	3	22
2001	175461	313191	304504	94951	83788	119936	20834	10773	5909	6045	931	743	351	92	12	18	18	23	4	12	14
2002	303317	125983	224864	217949	65871	54574	69853	11038	5428	2916	2960	455	365	174	46	6	9	10	13	2	16
2003	278732	217782	90445	160307	149389	41044	31160	36452	5486	2647	1412	1433	221	179	87	23	3	5	5	7	11
2004	205850	200131	156350	64582	109790	93591	22871	16189	17965	2645	1267	676	689	108	88	44	12	2	3	3	10
2005	253224	147800	143680	111268	44271	68058	51957	11602	7907	8575	1253	600	321	331	53	44	22	6	1	1	8
2006	744513	181816	106097	102576	75355	27482	37211	26035	5528	3706	3984	581	280	151	159	26	22	12	3	0	5
2007	292652	534564	130539	75869	70707	45939	14941	18103	12002	2486	1655	1777	261	127	70	75	13	11	6	2	3
2008	1008590	210126	383808	93467	52580	44636	25001	7476	8546	5544	1139	758	817	121	60	34	37	6	6	3	3
2009	143433	724175	150867	274709	64612	32482	23734	11590	3290	3655	2350	482	322	352	53	27	16	18	3	3	3
2010	651437	102985	519952	108062	190817	39952	16584	10353	4582	1264	1385	890	184	125	139	22	12	7	8	2	3
2011	807781	467733	73943	372453	75419	120575	21213	7474	4268	1811	495	541	350	73	51	59	10	5	3	4	3
2012	370599	579987	335824	52982	255844	45920	60220	8769	2758	1505	627	171	189	124	27	19	23	4	2	1	3
2013	1003000	266090	416422	239940	36485	152425	23190	26163	3475	1050	565	235	65	73	49	11	8	10	2	1	2
2014	187036	720153	191042	297605	163517	22347	77511	10447	10925	1401	418	225	94	26	30	21	5	4	5	1	2
2015	250308	134292	517061	136759	205967	99535	11586	33624	4183	4203	530	158	85	36	10	12	9	2	2	2	1
2016	138984	179721	96420	369728	95009	128598	51504	5217	13634	1637	1620	204	61	34	15	4	5	4	1	1	2
2017	101802	99791	129036	68965	254301	59668	68969	23672	2225	5567	661	652	82	25	14	6	2	2	2	1	1
2018	620133	73094	71648	92443	47796	159891	33597	34624	11041	1010	2495	296	293	37	12	7	3	1	1	1	1
2019	433073	445259	52480	51130	64190	30482	92723	18350	18130	5666	515	1271	151	151	20	6	4	2	1	1	1
2020	433073	310950	319637	37599	35105	41396	17859	51025	9822	9551	2967	270	668	80	81	11	3	2	1	0	1

Table 2.1.24c. Begin-year numbers at age (1000s of fish, Model 21.1).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	932875	280606	84628	84869	40057	21145	13889	9953	7380	5531	4143	3086	2278	1667	1208	869	620	440	311	219	495
1978	592716	685042	206054	62044	61430	28144	14395	9288	6635	4941	3723	2802	2093	1549	1134	823	592	423	300	212	487
1979	585250	435251	503038	151040	44777	42772	18863	9443	6072	4362	3271	2479	1872	1402	1039	762	553	398	284	202	471
1980	151644	429770	319613	368679	109426	31579	29365	12761	6375	4116	2972	2238	1701	1287	965	716	525	381	275	196	464
1981	165969	111358	315584	234279	266546	77034	21582	19751	8560	4293	2786	2020	1525	1161	880	660	490	359	261	188	452
1982	770222	121877	81770	231339	169559	188152	53218	14722	13450	5849	2946	1918	1394	1054	803	609	457	339	249	181	444
1983	218832	565602	89498	60003	168651	121228	131753	36869	10174	9316	4064	2052	1338	974	737	562	426	320	238	174	438
1984	713886	160696	415337	65611	43596	119826	83780	89704	25030	6923	6362	2783	1408	920	670	507	387	293	220	164	422
1985	328508	524230	117993	303931	47082	30347	80614	55143	58788	16452	4572	4217	1850	937	613	447	338	258	196	147	391
1986	177428	241235	384951	86551	219231	32639	20291	52544	35689	38219	10759	3005	2782	1223	621	406	296	224	171	130	357
1987	59549	130291	177143	281878	62479	151476	21681	13234	34115	23304	25143	7116	1996	1852	816	414	271	198	150	115	326
1988	241894	43729	95675	129876	203036	43426	99571	13871	8429	21840	15048	16345	4645	1307	1215	536	272	179	130	99	290
1989	482476	177627	32101	69680	91375	134718	27638	61526	8568	5250	13749	9563	10451	2981	841	783	346	176	115	84	251
1990	475057	354297	130428	23481	49769	62093	87005	17442	38542	5396	3327	8763	6122	6709	1916	541	504	223	113	74	216
1991	304671	348849	260164	95479	16834	33905	39954	54065	10743	23763	3342	2067	5460	3822	4194	1199	339	316	139	71	182
1992	784910	223729	256158	190080	67353	10952	20026	22216	29569	5904	13221	1877	1167	3096	2174	2390	684	193	180	80	145
1993	302780	576382	164282	187352	133610	43321	6379	10925	11932	16077	3257	7413	1062	664	1769	1246	1372	393	111	104	129
1994	247472	222338	423162	119491	131275	86961	26499	3771	6423	7094	9699	1983	4555	656	411	1098	774	854	245	69	145
1995	224790	181726	163248	309072	83211	83874	50349	14611	2062	3562	4012	5575	1150	2663	385	242	647	457	505	145	127
1996	699081	165069	133430	118963	213538	50551	45795	25745	7414	1064	1880	2158	3039	631	1472	214	135	360	255	281	152
1997	300006	513355	121211	97589	83848	136414	28606	24417	13435	3877	561	998	1152	1629	339	792	115	73	194	137	234
1998	232296	220301	376894	88152	66896	51209	74080	14481	12206	6776	1981	289	520	603	856	179	418	61	38	103	196
1999	561133	170582	161767	275837	62249	43180	30001	40897	7874	6689	3761	1110	163	295	343	488	102	239	35	22	171
2000	430007	412057	125259	118432	195361	40415	25553	16841	22662	4405	3786	2152	640	95	171	200	285	59	139	20	113
2001	160742	315767	302580	91525	84423	128517	24239	14542	9471	12851	2533	2197	1259	376	56	101	118	168	35	83	79
2002	287873	118037	231865	221427	64757	56380	78602	14091	8406	5561	7691	1541	1350	778	233	35	63	74	105	22	101
2003	257197	211393	86668	169053	154877	41279	33558	44370	7947	4857	3298	4657	948	837	485	146	22	40	46	66	78
2004	185934	188867	155214	63290	118264	99522	24185	18929	24772	4505	2806	1933	2758	565	501	291	88	13	24	28	87
2005	221382	136536	138676	112932	44315	75437	58284	13478	10479	13853	2558	1612	1120	1607	331	294	171	52	8	14	68
2006	646288	162567	100238	101245	78061	28278	43693	32166	7366	5771	7737	1446	918	641	923	190	169	99	30	4	47
2007	265203	474588	119371	73293	71265	49155	16399	23852	17280	3969	3128	4223	793	506	354	510	105	94	55	16	29
2008	965942	194747	348490	87396	51830	46259	28661	9161	13110	9531	2207	1749	2374	447	286	200	289	60	53	31	26
2009	141958	709319	143004	255032	61647	32773	26019	14984	4764	6936	5145	1212	969	1327	251	161	113	163	34	30	32
2010	603348	104243	520865	104733	180707	38815	17476	12645	7243	2376	3607	2756	664	537	742	142	91	64	93	19	35
2011	782957	443054	76548	381587	74486	116177	21449	8712	6235	3717	1260	1976	1541	377	306	427	82	53	37	54	32
2012	368933	574945	325340	56115	267575	46112	60915	9964	3929	2882	1788	620	992	782	193	158	220	42	27	19	44
2013	997664	270917	422188	237698	39443	162838	24490	29633	4732	1902	1432	911	320	516	410	101	83	116	22	14	34
2014	184626	732611	198930	308623	165187	24677	86985	12174	14536	2375	987	762	494	175	285	227	56	46	65	12	27
2015	238153	135576	537968	145651	218094	102553	13387	42196	5812	7075	1192	508	400	262	93	153	122	30	25	35	21
2016	148877	174881	99556	393499	103231	139288	56162	6754	20679	2888	3592	617	267	212	140	50	82	66	16	13	30
2017	110400	109325	128417	72860	276679	66368	79057	29119	3433	10636	1512	1910	332	145	116	77	27	45	36	9	24
2018	618776	81070	80279	94086	51622	179022	39432	44071	15876	1879	5893	845	1075	188	82	66	44	16	26	21	19
2019	416806	454386	59529	58577	66762	33927	109481	23323	25777	9334	1113	3522	508	648	113	50	40	26	9	16	24
2020	416806	306074	333616	43633	41069	44115	20795	64843	13774	15369	5644	679	2169	314	402	71	31	25	17	6	25

Table 2.1.24d. Begin-year numbers at age (1000s of fish, Model 21.2).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	1081730	270900	78832	70914	31972	16162	10098	6854	4795	3379	2372	1646	1127	761	507	335	219	142	92	60	106
1978	673708	767438	192183	55797	49420	21480	10372	6257	4178	2913	2055	1444	1004	687	464	310	204	134	87	56	101
1979	713380	477963	544435	136033	38734	32796	13470	6228	3684	2451	1711	1210	852	592	406	274	183	121	79	51	93
1980	183906	506109	339082	385353	95025	26124	21239	8462	3860	2278	1518	1062	751	529	368	252	171	114	75	49	90
1981	201225	130473	359046	240067	268729	64185	16862	13274	5208	2367	1398	932	652	462	325	226	155	105	70	46	86
1982	951982	142760	92559	254192	167665	182372	42275	10829	8438	3304	1502	888	593	415	294	207	144	99	67	45	84
1983	256214	675388	101281	65618	179042	115744	122554	27859	7056	5482	2146	976	577	385	270	191	135	94	64	43	83
1984	886642	181772	479152	71745	46108	123027	76950	79395	17831	4495	3489	1366	622	368	245	172	122	86	60	41	81
1985	392819	629030	128949	338867	49891	31127	79748	48158	48834	10908	2746	2132	835	380	225	150	105	74	52	37	74
1986	217471	278687	446256	91383	236676	33623	20150	49665	29327	29539	6593	1660	1290	505	230	136	91	64	45	32	67
1987	73688	154285	197711	315791	63869	158897	21606	12575	30463	17902	18042	4031	1016	790	310	141	83	56	39	28	61
1988	313081	52278	109456	140065	220442	43188	101276	13218	7553	18166	10668	10761	2406	607	472	185	84	50	33	23	53
1989	610357	222111	37078	77068	95679	142481	26630	59678	7666	4369	10519	6189	6251	1399	353	274	108	49	29	19	44
1990	596545	433018	157568	26210	53402	63350	89119	16071	35121	4484	2553	6150	3620	3658	819	207	161	63	29	17	37
1991	369659	423219	307199	111515	18243	35565	39628	52813	9289	20008	2545	1448	3487	2053	2074	464	117	91	36	16	31
1992	990273	262253	300239	216960	76531	11658	20573	20991	26617	4609	9867	1254	714	1720	1013	1023	229	58	45	18	23
1993	351082	702546	186045	212222	148353	48388	6627	10653	10332	12914	2237	4803	612	349	841	495	501	112	28	22	20
1994	312525	249072	498321	130936	144536	94269	28665	3721	5822	5610	7024	1219	2624	335	191	460	271	274	61	15	23
1995	263635	221720	176685	351841	89002	90688	53008	14929	1864	2884	2782	3495	608	1311	167	95	230	136	137	31	19
1996	797287	187034	157279	124473	236912	53519	48244	25441	6856	845	1308	1266	1595	278	600	77	44	105	62	63	23
1997	328524	565632	132686	111183	85339	148723	29463	24103	11965	3153	385	595	576	725	126	273	35	20	48	28	39
1998	273115	233068	401179	93306	74008	51120	78523	14043	10965	5338	1400	171	264	256	322	56	121	15	9	21	30
1999	691365	193760	165343	283456	64050	46770	29256	41360	7057	5428	2631	690	84	130	126	159	28	60	8	4	25
2000	535652	490488	137455	116862	194217	40877	26964	15665	21289	3585	2754	1336	351	43	66	64	81	14	30	4	15
2001	220976	380016	347967	97041	80636	124286	23772	14391	8072	10905	1846	1424	694	182	22	35	33	42	7	16	10
2002	410999	156771	269591	246192	66706	52352	72673	12865	7583	4310	5944	1022	796	389	103	13	19	19	24	4	15
2003	372135	291581	111210	190055	167450	41330	29777	37978	6581	3946	2294	3218	559	438	215	57	7	11	10	13	10
2004	253692	264010	206854	78662	130221	105591	22904	15303	18778	3283	2011	1187	1682	294	231	113	30	4	6	6	12
2005	296362	179981	187295	146012	54019	81793	59293	11653	7545	9208	1623	1004	596	846	148	116	57	15	2	3	9
2006	806782	210253	127672	132413	99138	34129	46069	30674	5734	3663	4449	784	485	288	410	72	56	28	7	1	6
2007	292501	572369	149157	90238	90770	61553	19365	23845	15145	2767	1757	2127	375	232	138	196	34	27	13	3	3
2008	1087940	207514	406039	105418	61854	57896	35289	10470	12360	7725	1402	889	1076	189	117	70	99	17	14	7	3
2009	159327	771836	147211	286770	72052	38891	32929	18337	5268	6117	3808	691	438	530	93	58	34	49	9	7	5
2010	694916	113034	547548	103918	195815	45078	21606	16714	8839	2513	2910	1813	329	209	253	45	28	16	23	4	6
2011	891288	493005	80189	386667	71302	124049	25371	11005	8170	4306	1232	1438	900	164	104	126	22	14	8	12	5
2012	424813	632319	349744	56728	262192	43656	64885	11519	4703	3498	1884	546	643	404	74	47	57	10	6	4	7
2013	1182410	301380	448583	247065	38712	156857	22493	29305	4926	2031	1549	853	249	296	187	34	22	26	5	3	5
2014	209388	838850	213800	316772	167046	23577	79880	10273	12823	2184	927	722	404	119	141	89	16	10	13	2	4
2015	289488	148548	595105	151298	217214	101625	12127	34456	4205	5273	922	400	316	178	52	63	40	7	5	6	3
2016	179844	205374	105385	420887	104377	135175	52396	5371	13991	1700	2164	384	169	134	76	22	27	17	3	2	4
2017	121752	127588	145697	74534	287313	65489	72628	24174	2294	5770	698	889	158	70	55	31	9	11	7	1	2
2018	751418	86376	90516	103263	51699	182846	37261	36293	11138	1028	2567	311	396	71	31	25	14	4	5	3	2
2019	504043	533091	61278	63936	71361	33217	106994	20503	19099	5751	528	1317	159	203	36	16	13	7	2	3	2
2020	504043	357594	378137	43390	43591	46011	19628	59432	11107	10229	3074	283	706	85	109	19	9	7	4	1	3

Table 2.1.24e. Begin-year numbers at age (1000s of fish, Model 21.3).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	773124	210752	57827	54849	24706	12242	7603	5141	3589	2523	1763	1215	824	552	365	241	159	105	70	47	97
1978	561998	557091	151856	41562	38684	16614	7745	4585	3021	2086	1461	1021	706	482	326	218	146	98	65	44	94
1979	572491	404960	401405	109133	29165	25571	10169	4462	2556	1661	1142	800	561	391	270	185	127	86	59	40	88
1980	127910	412521	291793	288439	77118	19674	16312	6212	2663	1511	979	673	472	333	234	164	114	79	54	38	84
1981	171617	92168	297237	209763	203314	52069	12490	9895	3677	1560	882	571	394	278	198	141	100	70	49	35	80
1982	812864	123663	66411	213745	148367	138369	34028	7883	6139	2265	959	542	352	244	173	125	90	64	46	32	77
1983	190084	585729	89108	47816	152731	103285	92985	22302	5086	3937	1450	614	347	226	158	113	82	59	43	31	74
1984	730098	136970	422058	64068	34087	105941	68645	59787	14115	3195	2467	908	385	219	144	101	73	53	39	28	71
1985	341520	526088	98683	303133	44952	23170	68467	42427	36136	8463	1909	1474	544	232	133	88	63	46	34	25	66
1986	197889	246090	379076	71033	214633	30302	14983	42246	25421	21409	4997	1127	873	324	139	81	54	39	29	22	60
1987	71330	142593	177323	272428	50382	145286	19378	9313	25665	15279	12826	2994	677	527	197	86	50	34	25	19	54
1988	275197	51399	102746	127570	192767	34400	92553	11721	5530	15055	8921	7487	1752	399	313	119	52	31	21	16	48
1989	535152	198297	37027	73536	88438	125464	21199	53912	6658	3120	8463	5014	4223	995	229	183	70	31	19	13	41
1990	517483	385615	142880	26594	51711	59022	78317	12694	31257	3817	1785	4839	2876	2440	580	135	110	43	19	12	35
1991	256943	372884	277857	102695	18775	34669	36743	45820	7223	17482	2125	994	2702	1618	1389	335	80	66	26	12	30
1992	725274	185144	268675	199240	71346	12038	19771	18936	22305	3448	8261	1004	472	1297	792	698	173	42	36	15	25
1993	307618	522608	133400	192890	137722	45201	6789	10040	9041	10374	1592	3809	466	221	620	389	353	90	23	20	24
1994	244711	221657	376488	95327	132945	87685	26713	3793	5425	4816	5499	844	2028	251	120	343	220	204	53	14	27
1995	229760	176330	159698	269631	65516	83517	48745	13720	1863	2608	2297	2622	404	985	124	61	177	117	112	30	24
1996	718346	165556	127035	114099	182563	39147	43294	22417	5981	793	1100	968	1113	174	435	57	28	86	59	59	30
1997	319156	517615	119289	91159	78848	112838	20684	20269	9749	2535	333	461	408	477	76	197	27	14	43	31	48
1998	252584	229971	372911	85182	61292	46158	55415	8855	8095	3771	972	128	178	161	193	32	86	12	7	21	42
1999	568847	182003	165703	267844	58997	38190	24901	26463	3950	3515	1621	418	55	78	72	89	15	43	6	3	35
2000	422930	409892	131141	119052	186122	36952	20799	12122	12084	1756	1549	714	185	25	36	34	44	8	22	3	22
2001	171786	304749	295350	94122	83388	118856	20520	10314	5649	5479	789	695	322	85	12	17	17	22	4	12	15
2002	296186	123784	219583	212158	65557	54450	69068	10791	5142	2754	2650	381	338	159	42	6	9	9	12	2	16
2003	273784	213421	89183	157101	145897	40944	31053	35840	5320	2484	1322	1271	184	165	79	22	3	5	5	7	11
2004	202601	197280	153765	63913	107972	91566	22788	16050	17519	2541	1178	626	606	89	81	40	11	2	3	3	11
2005	251862	145987	142138	109835	43981	67060	50729	11493	7774	8281	1191	552	295	289	43	40	20	6	1	1	8
2006	744414	181483	105169	101849	74675	27373	36588	25256	5428	3607	3808	547	255	138	138	21	20	11	3	0	6
2007	289440	536399	130765	75481	70493	45634	14859	17669	11521	2413	1592	1678	243	115	63	65	10	10	6	2	4
2008	953836	208561	386499	93968	52527	44650	24797	7392	8262	5265	1093	721	764	112	54	31	33	5	5	3	3
2009	133847	687302	150277	277630	65219	32570	23735	11420	3222	3494	2206	458	304	327	49	24	14	16	3	3	3
2010	605272	96446	495236	108034	193559	40477	16648	10311	4476	1226	1311	827	173	117	129	20	10	6	7	1	3
2011	728169	436136	69494	356009	75710	122754	21578	7525	4256	1770	480	513	326	70	48	55	9	5	3	4	2
2012	319187	524691	314254	49965	245352	46347	61611	8982	2799	1512	618	168	181	117	26	18	22	4	2	1	3
2013	828613	229994	378062	225253	34502	146560	23465	26735	3552	1062	567	231	63	70	46	11	8	10	2	1	2
2014	152945	597067	165712	271057	153702	21121	74228	10498	11050	1416	418	223	92	26	29	20	5	4	5	1	2
2015	198371	110206	430215	119014	187808	93051	10824	31574	4106	4141	522	154	83	35	10	12	8	2	2	2	1
2016	102415	142938	79409	308519	82724	116270	46964	4702	12236	1531	1519	191	57	31	14	4	5	4	1	1	2
2017	76607	73796	102991	56944	211457	51214	60152	20368	1873	4641	573	567	72	22	12	6	2	2	2	0	1
2018	458579	55200	53173	74011	39292	129910	27600	28181	8720	776	1894	234	232	30	9	5	3	1	1	1	1
2019	408829	330436	39773	38026	51153	24358	71410	14059	13587	4096	362	882	109	110	14	5	3	1	0	1	1
2020	408829	294589	238042	28583	25847	31960	13327	35865	6797	6424	1920	170	416	52	53	7	2	1	1	0	1

Table 2.1.24f. Begin-year numbers at age (1000s of fish, ensemble).

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20+
1977	923023	239569	70170	66118	30041	15275	9650	6631	4705	3367	2402	1697	1185	819	561	382	259	175	119	81	168
1978	620772	661630	171944	50252	46612	20366	9876	6033	4088	2894	2076	1487	1055	741	515	355	243	166	113	77	163
1979	636507	444988	474333	123152	35269	31174	12846	5978	3591	2429	1726	1244	896	640	452	317	220	152	105	72	155
1980	156698	456156	319032	339317	86956	23982	20329	8139	3746	2250	1527	1090	789	571	409	291	205	143	99	69	151
1981	183424	112297	326953	228294	238794	59140	15559	12793	5061	2329	1404	957	686	499	363	262	187	133	93	65	145
1982	858146	131470	80488	233939	161026	163152	39194	10066	8214	3251	1502	909	622	448	327	239	173	124	88	62	142
1983	224762	615073	94248	57660	166447	112041	110340	26057	6634	5412	2148	995	605	415	300	220	161	117	84	60	140
1984	789629	161081	440926	67456	40918	115249	74865	71923	16847	4281	3503	1395	649	396	273	198	145	107	78	56	135
1985	362493	565913	115453	315121	47254	27784	74923	47002	44545	10429	2657	2184	874	409	250	174	126	93	69	50	125
1986	202430	259822	405645	82685	222162	31932	18034	46784	28773	27191	6393	1636	1352	544	256	158	110	80	60	44	114
1987	70005	145098	186261	290059	58358	150051	20553	11313	28881	17711	16798	3974	1022	850	344	163	101	71	52	39	104
1988	282327	50183	104020	133349	204321	39711	95875	12597	6841	17360	10668	10174	2425	628	526	215	102	64	45	33	92
1989	552891	202337	35970	74050	91954	132707	24558	56608	7327	3982	10123	6258	6014	1448	377	319	131	63	39	28	79
1990	538966	396268	145030	25705	51800	61191	83142	14866	33468	4315	2353	5993	3725	3607	876	230	196	81	39	25	68
1991	313048	386279	284057	103705	18053	34608	38226	49273	8636	19219	2478	1357	3464	2167	2115	519	137	118	49	24	57
1992	834822	224341	276883	202696	71680	11533	19830	20073	24788	4311	9565	1240	685	1760	1115	1103	275	74	64	27	45
1993	324895	598240	160793	197773	139562	45256	6514	10208	9880	12080	2115	4714	618	345	895	576	578	147	40	35	41
1994	269319	232916	428695	114301	135685	88775	26788	3665	5610	5412	6650	1174	2631	348	196	512	333	338	87	24	46
1995	243742	193020	166989	305661	78133	85010	49640	13934	1843	2801	2721	3377	604	1365	183	104	275	182	187	49	40
1996	760480	174723	138342	118829	206612	46630	44576	23528	6354	833	1276	1258	1586	289	660	90	52	139	93	97	48
1997	328845	545129	125267	98796	81928	128623	25189	21802	10911	2905	380	588	588	752	139	321	44	26	70	48	76
1998	261361	235749	390757	89018	66244	48549	65879	11589	9561	4731	1264	167	262	267	348	66	153	22	13	35	63
1999	618730	187339	169034	279272	61480	41597	27051	33534	5658	4607	2291	617	82	131	136	180	34	81	12	7	54
2000	462029	443429	134300	120855	193338	38834	23392	13985	16734	2811	2290	1152	313	42	69	72	97	19	45	6	35
2001	183110	331170	317847	95874	84268	123905	22164	12252	7060	8429	1431	1172	597	164	22	37	40	54	10	25	24
2002	323066	131223	237407	227166	66441	55000	72872	12044	6464	3730	4526	782	646	334	93	13	21	23	32	6	30
2003	293749	231512	94045	169063	155615	41433	31594	38693	6224	3363	1974	2447	431	360	189	53	7	13	14	19	22
2004	212301	210503	165917	67080	115909	97851	23281	16697	19713	3165	1732	1032	1301	233	196	104	30	4	7	8	24
2005	256613	152155	150860	117968	46032	72258	54965	12065	8433	9893	1601	888	536	687	125	106	57	16	2	4	18
2006	745097	183928	109046	107575	79986	28746	40147	28291	5980	4158	4903	802	451	276	359	66	57	31	9	1	13
2007	292982	534109	131846	77866	74131	49120	15932	20268	13710	2858	1992	2369	392	223	139	183	34	30	16	5	8
2008	1039447	210054	382917	94255	53890	47004	27322	8271	10107	6765	1410	989	1190	200	115	73	97	18	16	9	7
2009	148534	745070	150620	273653	65066	33419	25486	13256	3883	4724	3182	670	476	583	100	59	38	51	10	9	9
2010	658807	106480	534146	107724	189638	40290	17361	11651	5730	1677	2083	1429	307	222	279	49	29	19	26	5	9
2011	827042	472219	76346	382003	75009	119793	21662	8134	5181	2555	759	971	679	149	110	141	25	15	10	14	8
2012	383916	592816	338527	54638	262011	45682	60575	9288	3228	2047	1037	315	415	296	66	50	65	12	7	5	11
2013	1035448	275148	424993	241569	37592	156244	23290	27043	3886	1343	870	455	141	191	139	32	24	32	6	4	8
2014	189280	742028	197221	303337	164433	23017	79964	10708	11801	1690	597	399	216	68	95	70	16	12	17	3	6
2015	250768	135666	531848	140987	209666	99995	11969	35377	4478	4886	712	259	178	100	32	46	34	8	6	9	5
2016	147691	179702	97255	379779	97809	130771	51993	5488	15006	1878	2070	309	116	82	47	15	23	17	4	3	7
2017	106034	105816	128797	69479	260875	61363	70496	24378	2435	6543	824	922	140	54	39	23	8	11	9	2	6
2018	629697	76000	75828	92139	48147	164247	34728	35909	11709	1159	3133	399	453	70	27	20	12	4	6	5	4
2019	451312	451217	54482	54024	63893	30716	95602	19145	19158	6194	618	1688	217	249	39	16	12	7	2	4	5
2020	451312	323470	323328	38985	37003	41061	17970	52866	10385	10351	3368	340	943	122	143	23	9	7	4	1	6

Table 2.1.25. Means and standard deviations of the ABC and OFL pdfs for all models and the ensemble.

Feature			19.12a	19.12	21.1	21.2	21.3	
Allow catchability to vary?			no	yes	no	no	no	
Allow domed survey selectivity?			no	no	yes	no	no	
Use fishery CPUE?			no	no	no	yes	no	
Estimate survey CV internally?			no	no	no	no	yes	
Model weight:			0.2459	0.2213	0.1803	0.1311	0.2213	
Year	Quantity	Statistic	19.12a	19.12	21.1	21.2	21.3	Ensemble
2021	ABC	mean	118044	83930	128897	110619	33599	92789
2021	ABC	sdev	22316	21641	26245	20106	17347	41186
2021	OFL	mean	141089	100683	152279	132399	40597	110785
2021	OFL	sdev	26414	25811	30727	23883	20857	48690
2022	ABC	mean	105613	82924	115920	102594	41566	87880
2022	ABC	sdev	12059	14233	15254	11607	15769	30379
2022	OFL	mean	117275	93561	128750	114476	48335	98472
2022	OFL	sdev	12304	15085	15880	11993	17699	32692

Figures

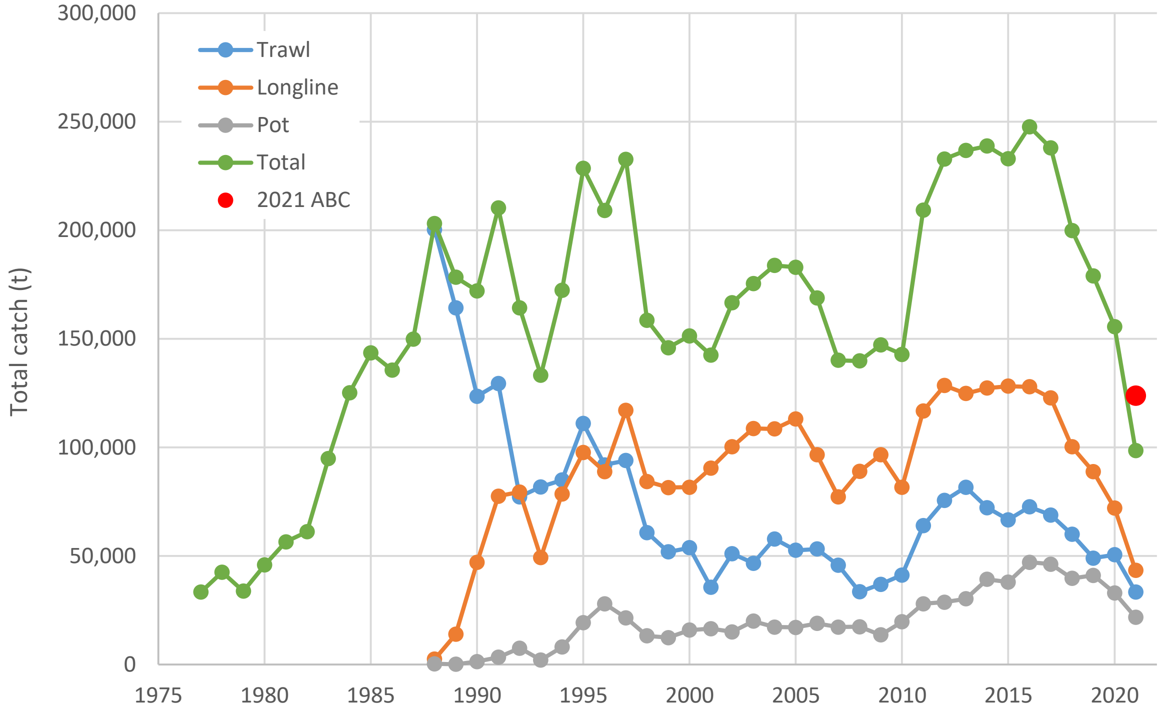


Figure 2.1.1. Catch (t) by gear. Data for 2021 are current through August.

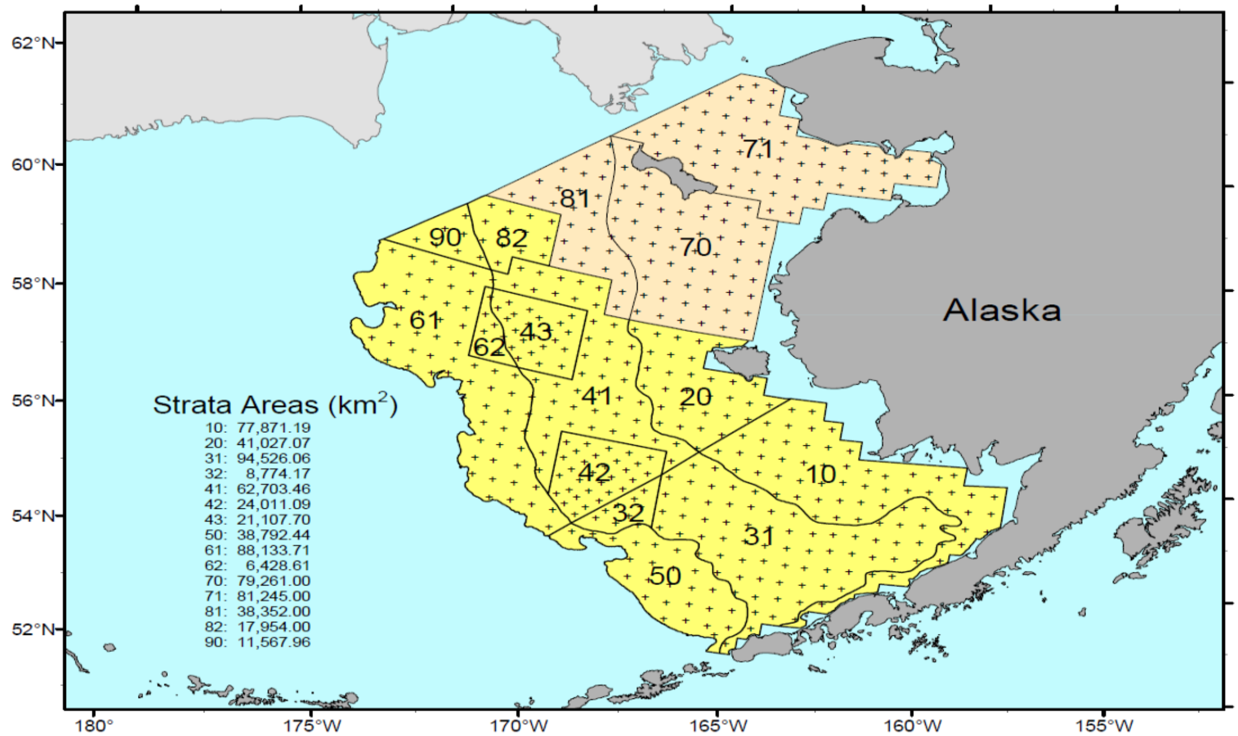


Figure 2.1.2. Map of the EBS (yellow) and NBS (tan) bottom trawl survey areas.

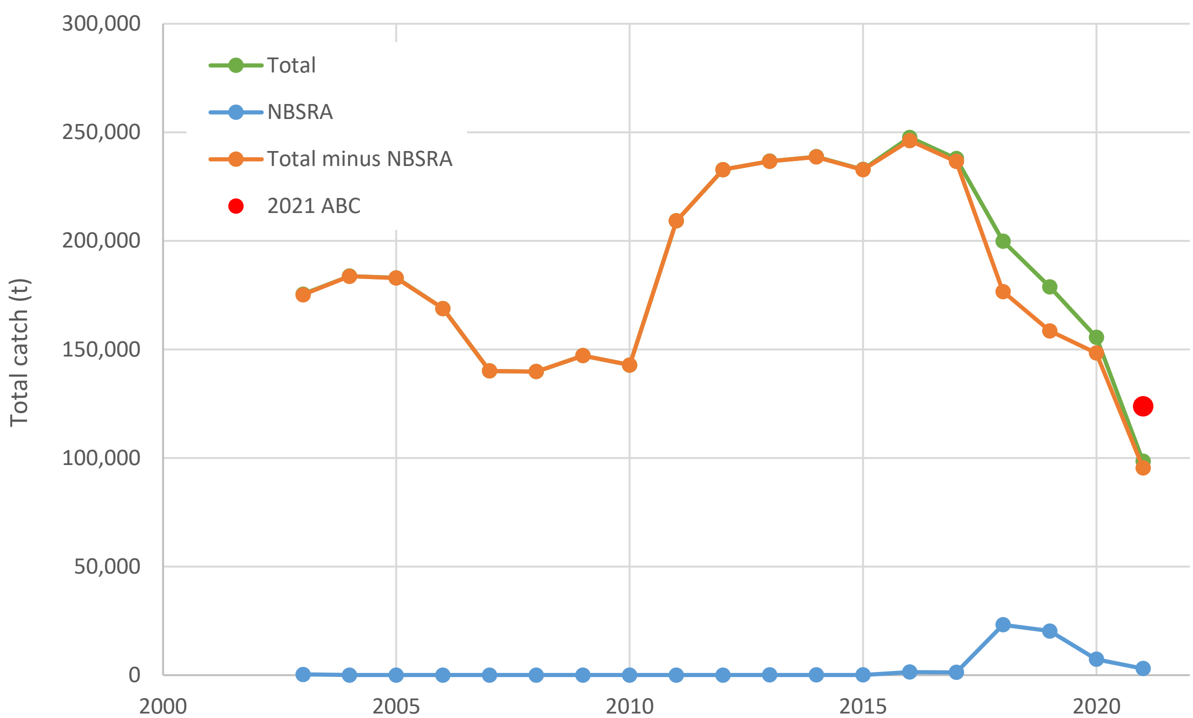


Figure 2.1.3. Catch by area (the Northern Bering Sea Research Area approximates the NBS survey area).

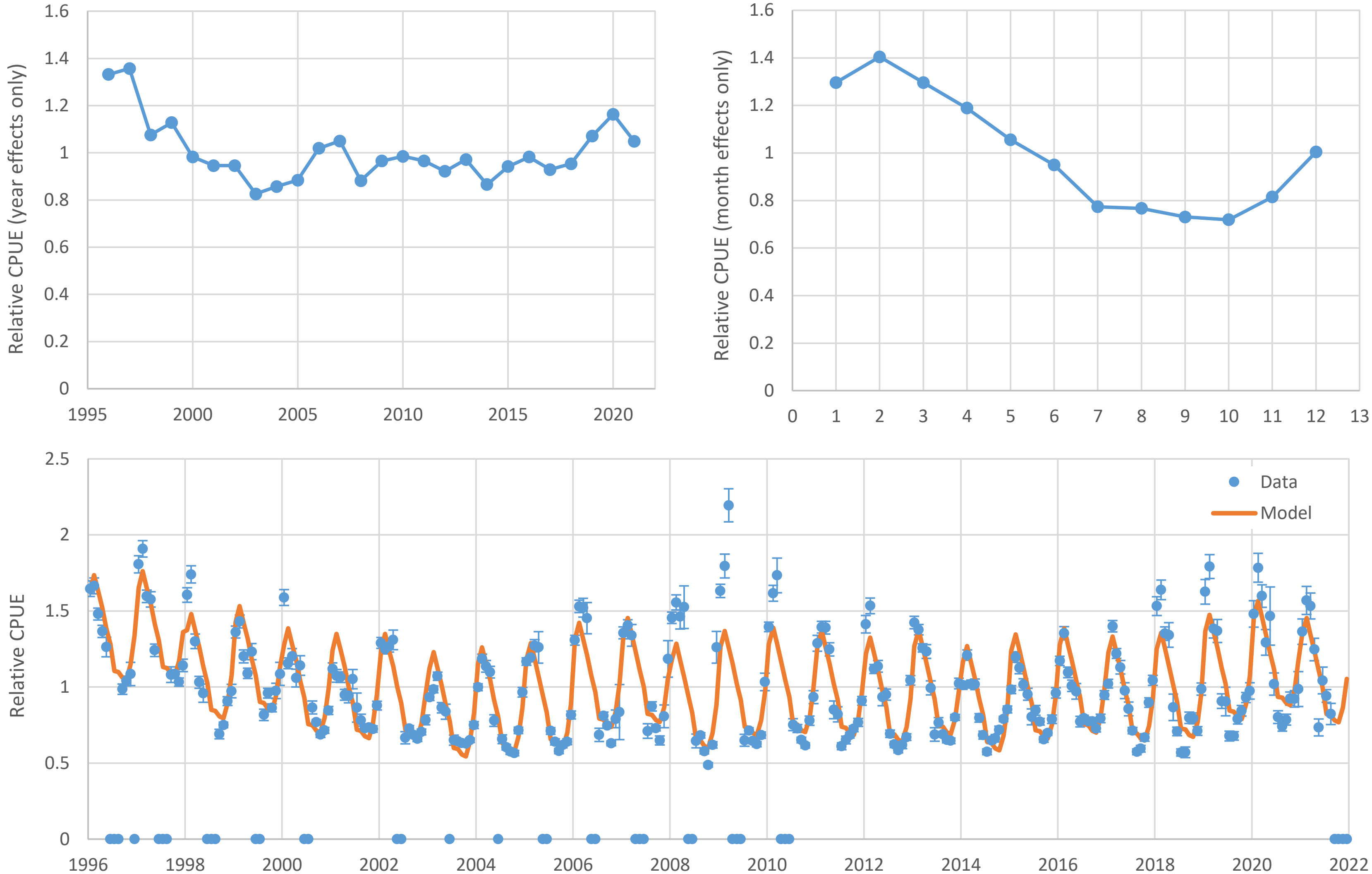


Figure 2.1.4a. Longline fishery CPUE (target only). Top left: year effects, top right: month effects, bottom: monthly data and model fit.

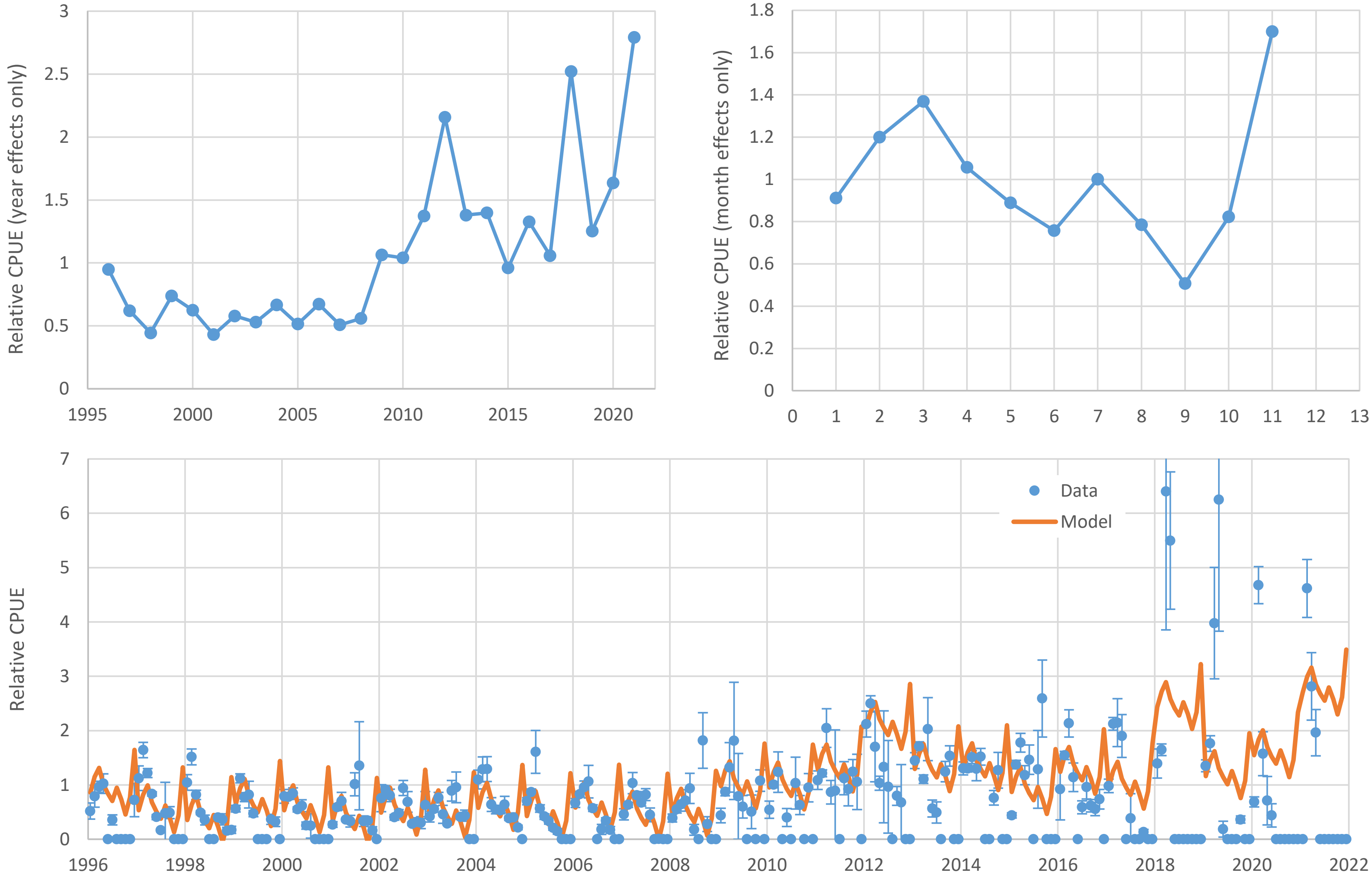


Figure 2.1.4b. Bottom trawl fishery CPUE (target only). Top left: year effects, top right: month effects, bottom: monthly data and model fit.

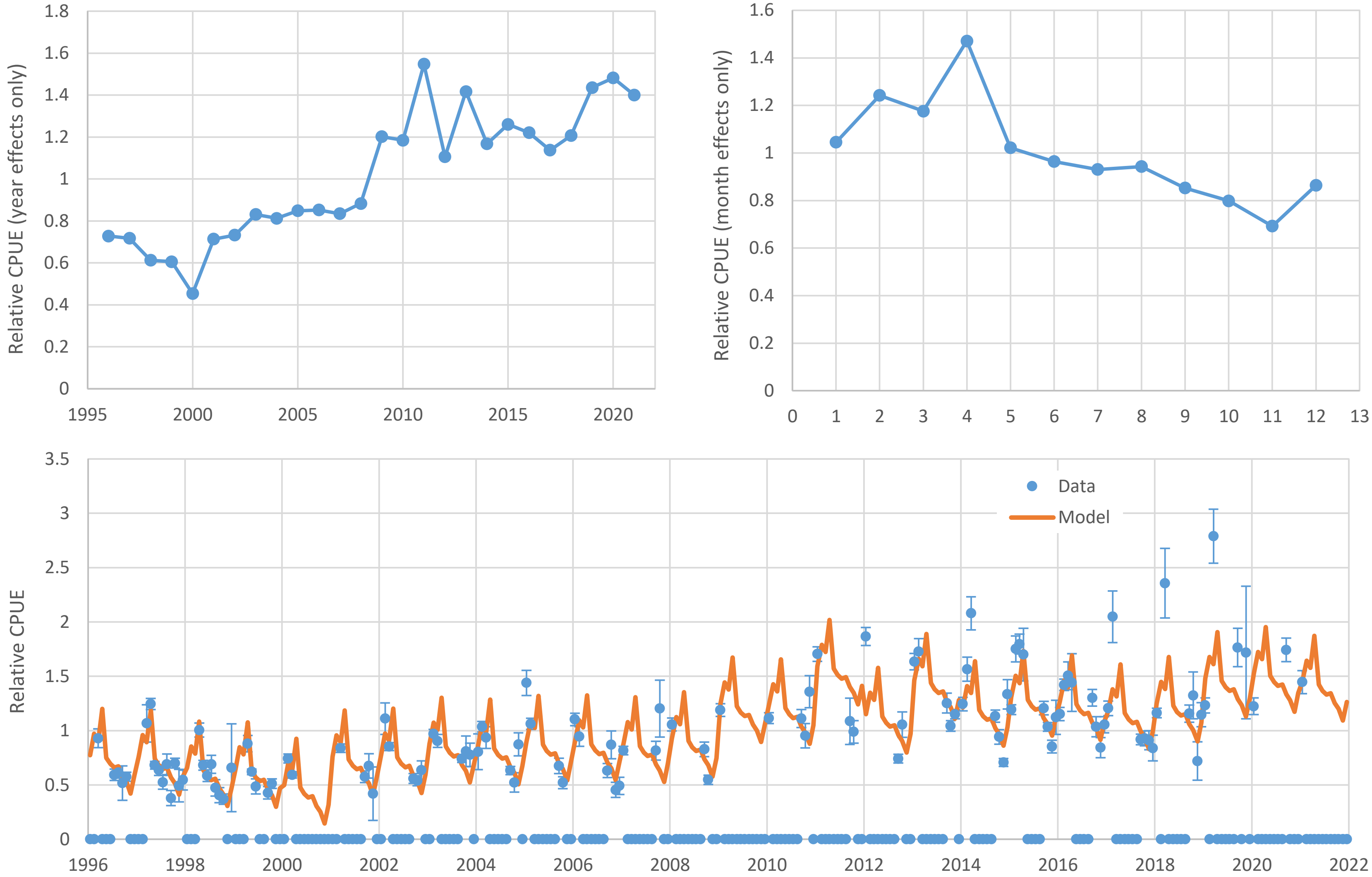


Figure 2.1.4c. Pot fishery CPUE (target only). Top left: year effects, top right: month effects, bottom: monthly data and model fit.

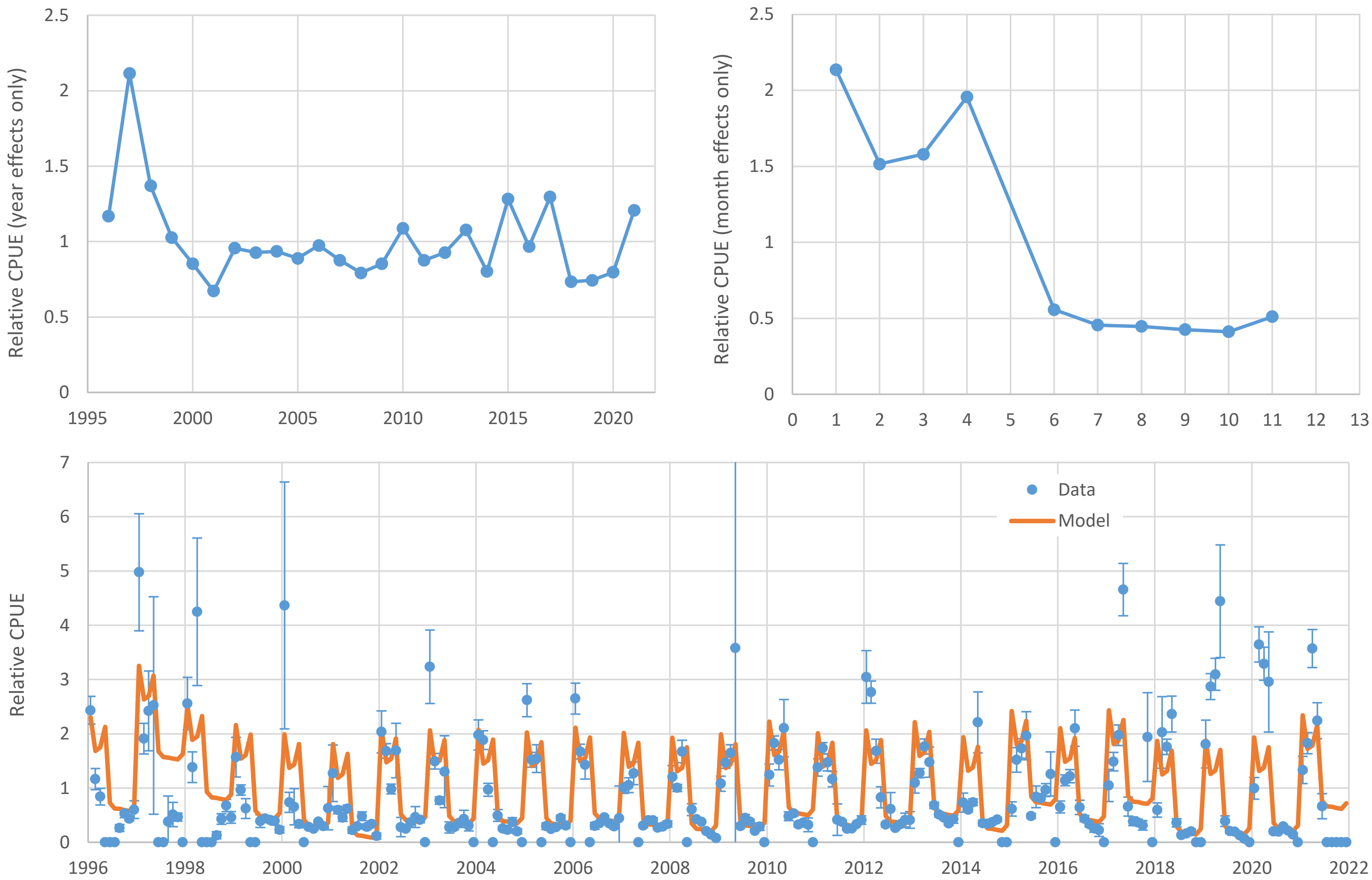


Figure 2.1.4d. Pelagic trawl fishery CPUE (includes bycatch). Top left: year effects, top right: month effects, bottom: monthly data and model fit.

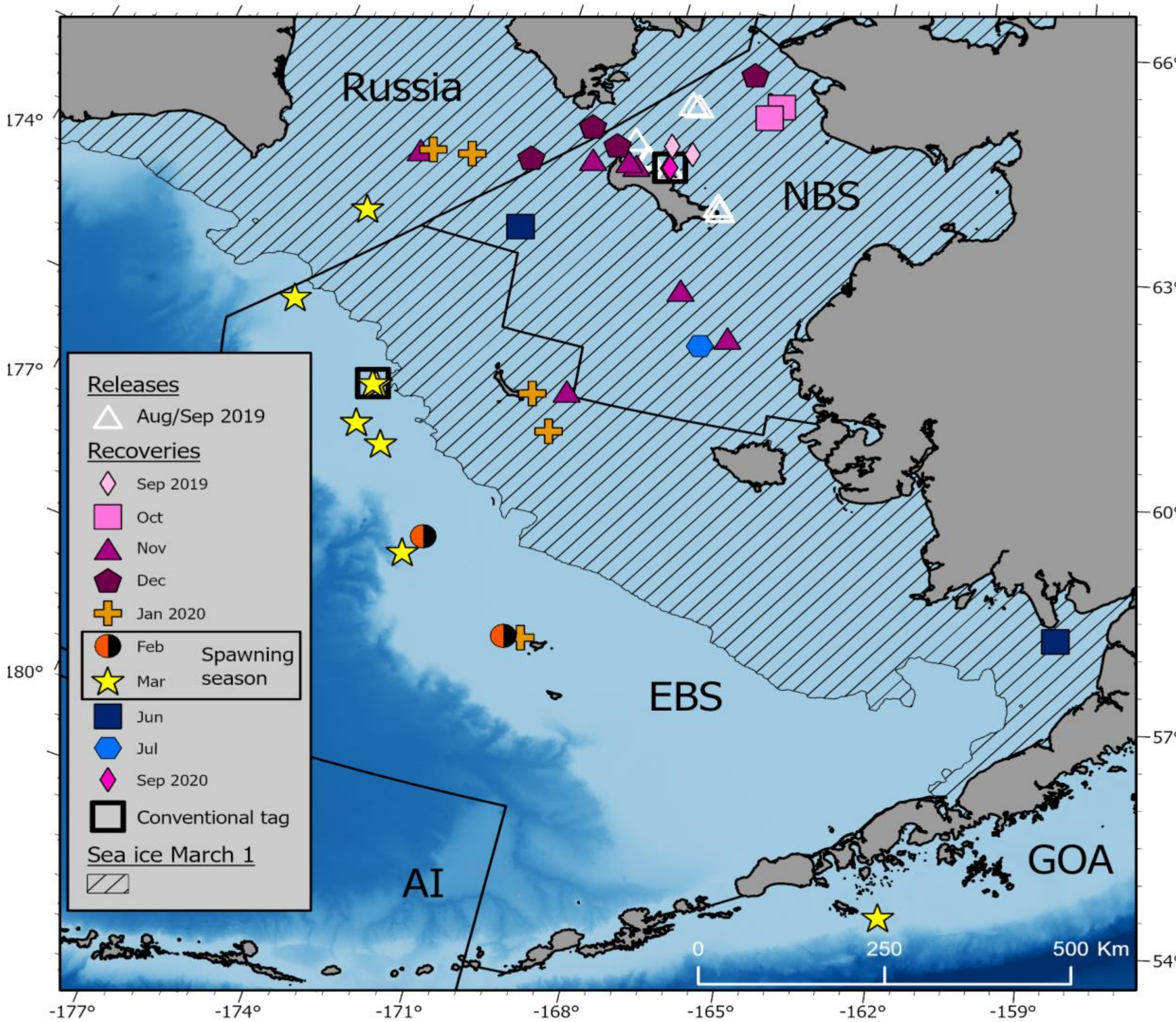


Figure 2.1.5a. Pacific cod tag release and monthly recovery locations by region (AI = Aleutian Islands, GOA = Gulf of Alaska). Conventional tag recoveries are indicated by black boxes around symbols. Tagged fish moved from the NBS to the EBS, Russia, and the GOA during the spawning period (February/March). Locations during spawning were largely beyond the edge of the sea ice extent (diagonal hatched lines indicate sea ice extent on March 1, 2020).

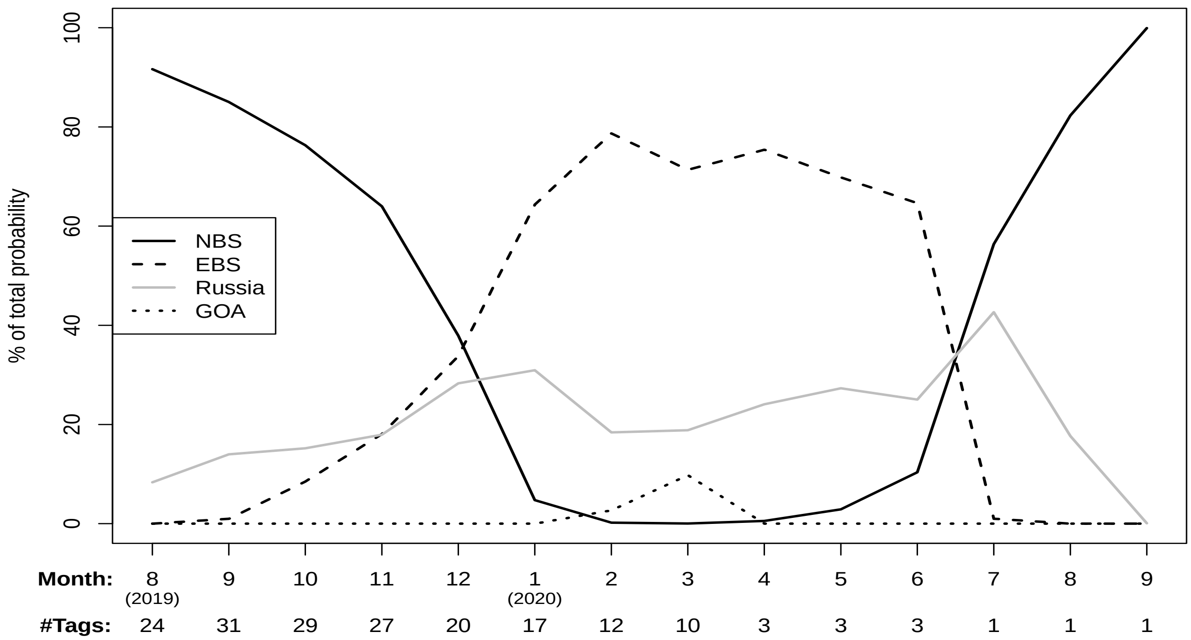


Figure 2.1.5b. Proportion of overall monthly location probability (all geolocated fish combined) by management area. Note that sample size declines over time due to the staggered pop-up schedule and early pop-ups.

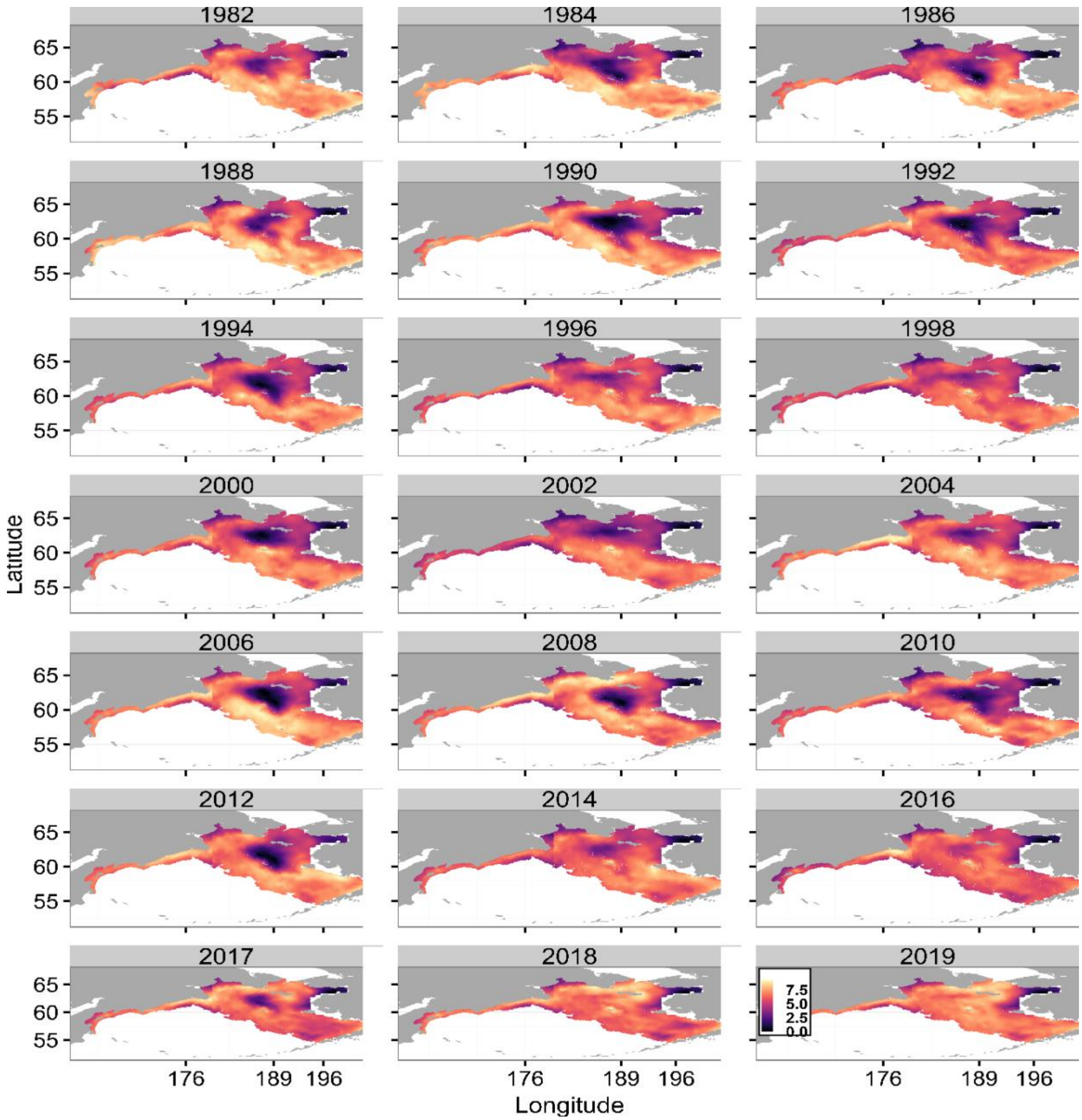
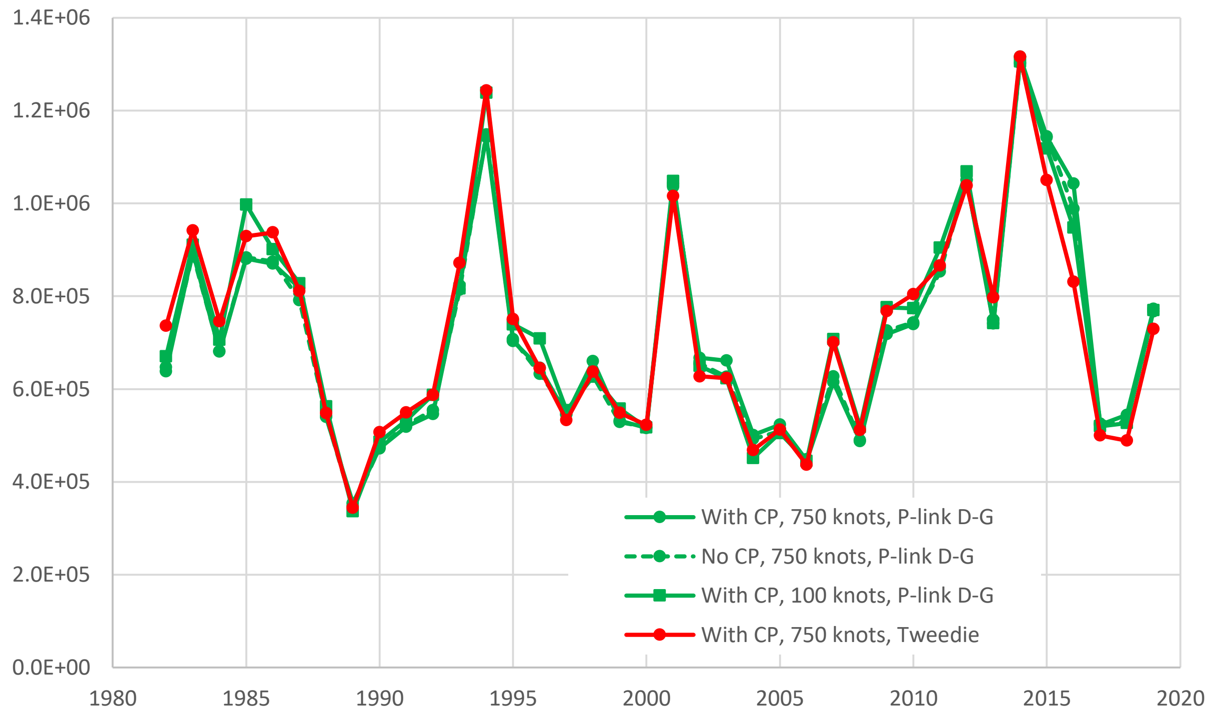


Figure 2.1.6. VAST estimates of survey density for U.S. and Russian data combined for selected years.



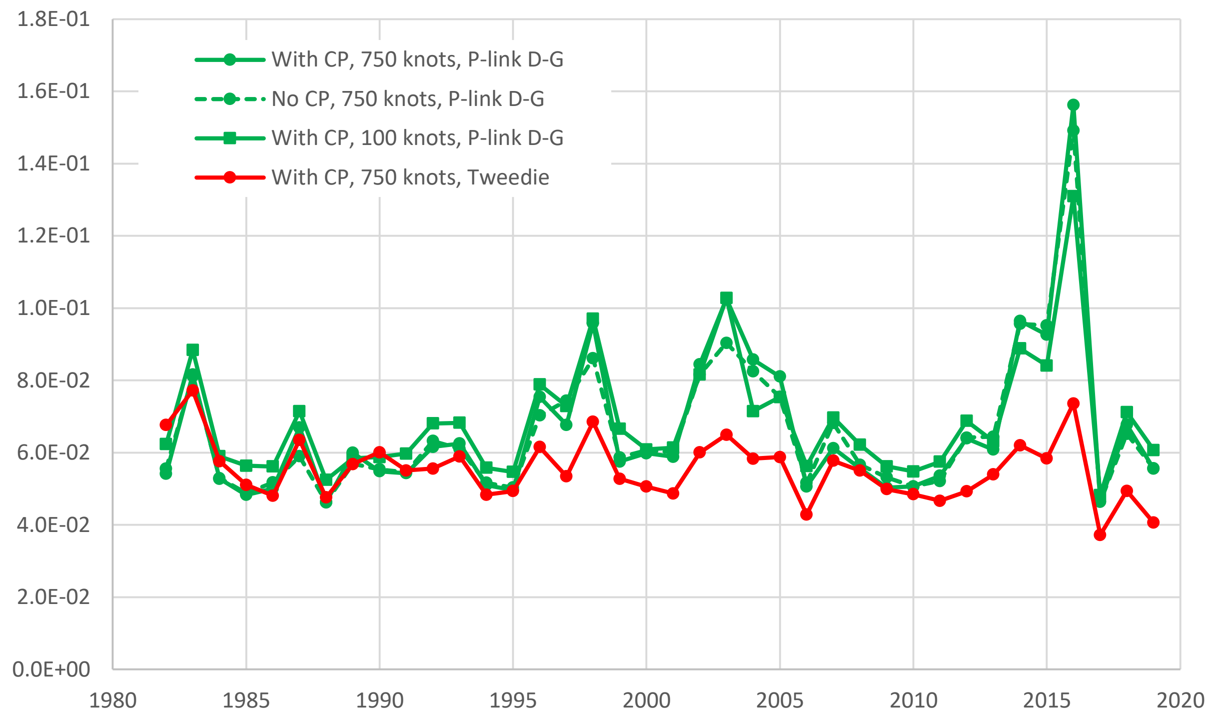


Figure 2.1.7a. VAST configuration comparison (survey index, EBS and NBS combined). Top: estimated abundance (1000s of fish), bottom: lognormal sigma. Solid = with cold pool, dashed = no cold pool; circles = 750 knots, squares = 100 knots; green = Poisson-linked delta-gamma, red = Tweedie.

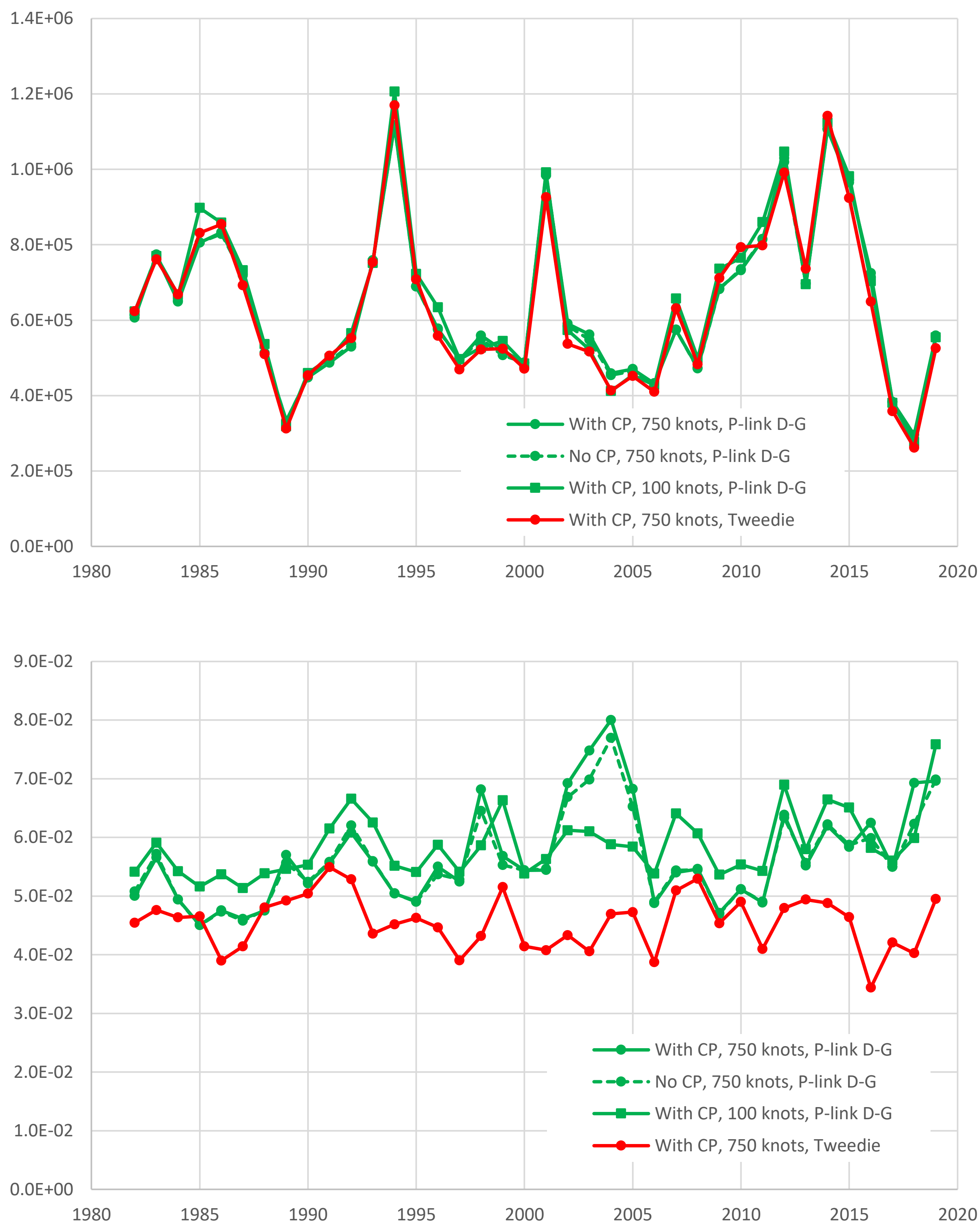


Figure 2.1.7b. VAST configuration comparison (survey index, EBS only). Top: estimated abundance (1000s of fish), bottom: lognormal sigma. Solid = with cold pool, dashed = no cold pool; circles = 750 knots, squares = 100 knots; green = Poisson-linked delta-gamma, red = Tweedie.

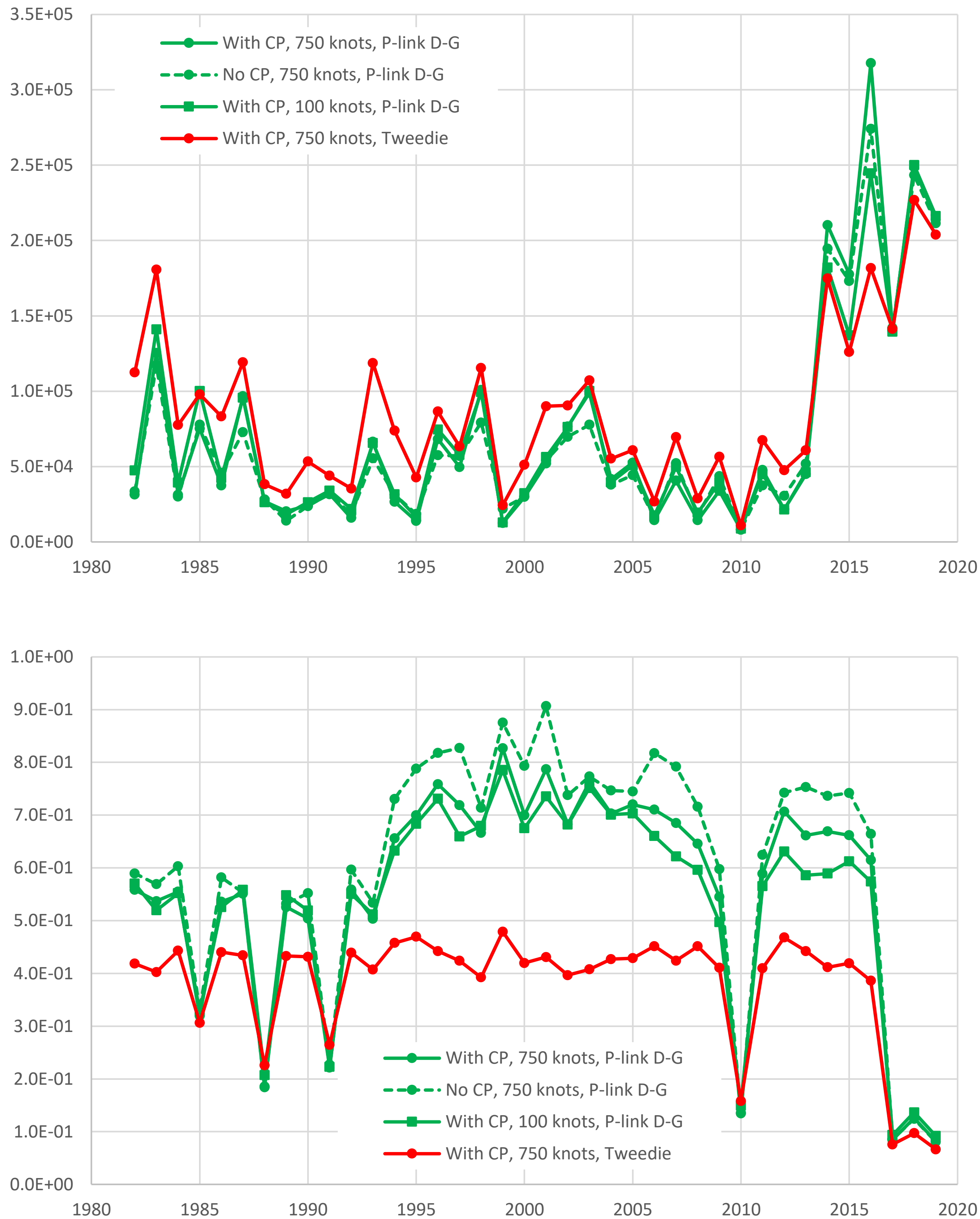


Figure 2.1.7c. VAST configuration comparison (survey index, NBS only). Top: estimated abundance (1000s of fish), bottom: lognormal sigma. Solid = with cold pool, dashed = no cold pool; circles = 750 knots, squares = 100 knots; green = Poisson-linked delta-gamma, red = Tweedie.

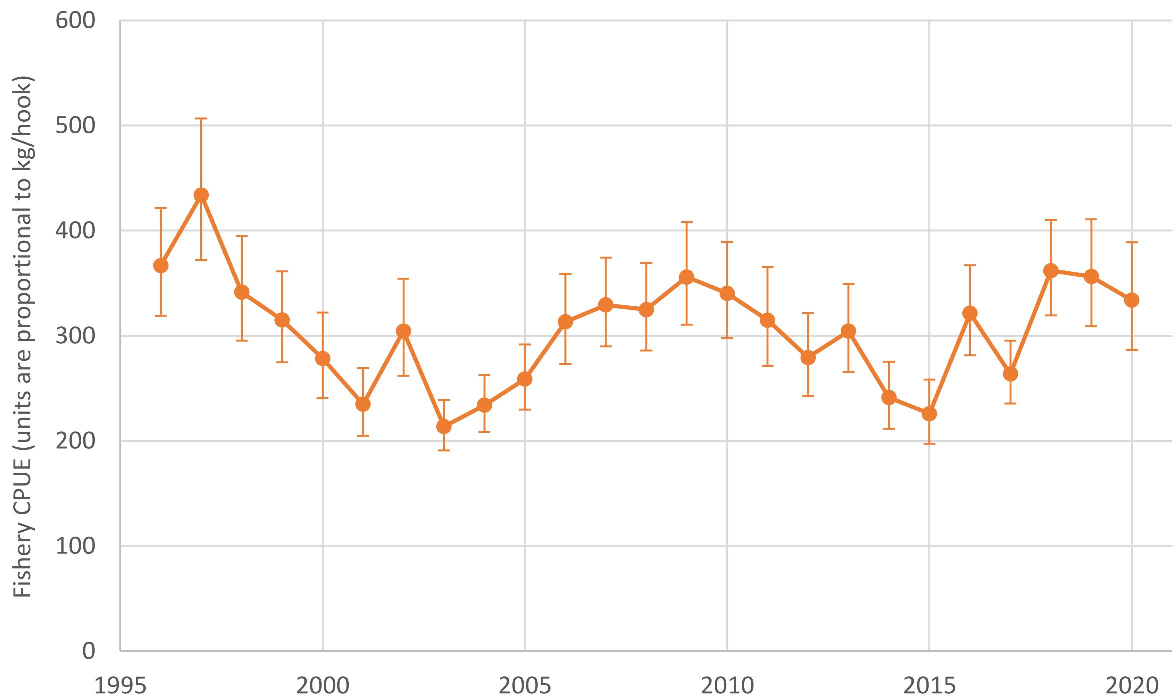


Figure 2.1.8a. VAST winter longline fishery CPUE index.

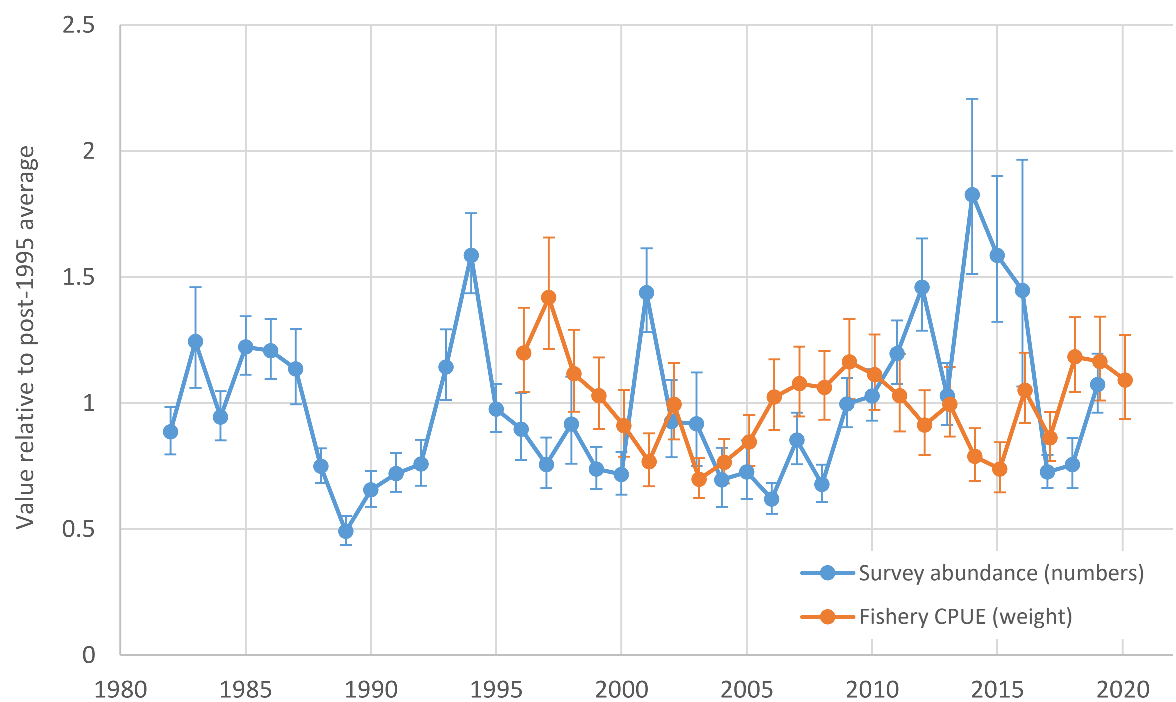


Figure 2.1.8b. Comparison of the VAST survey index (in numbers of fish) and VAST winter longline fishery CPUE index (proportional to weight per hook), both normalized to unity.

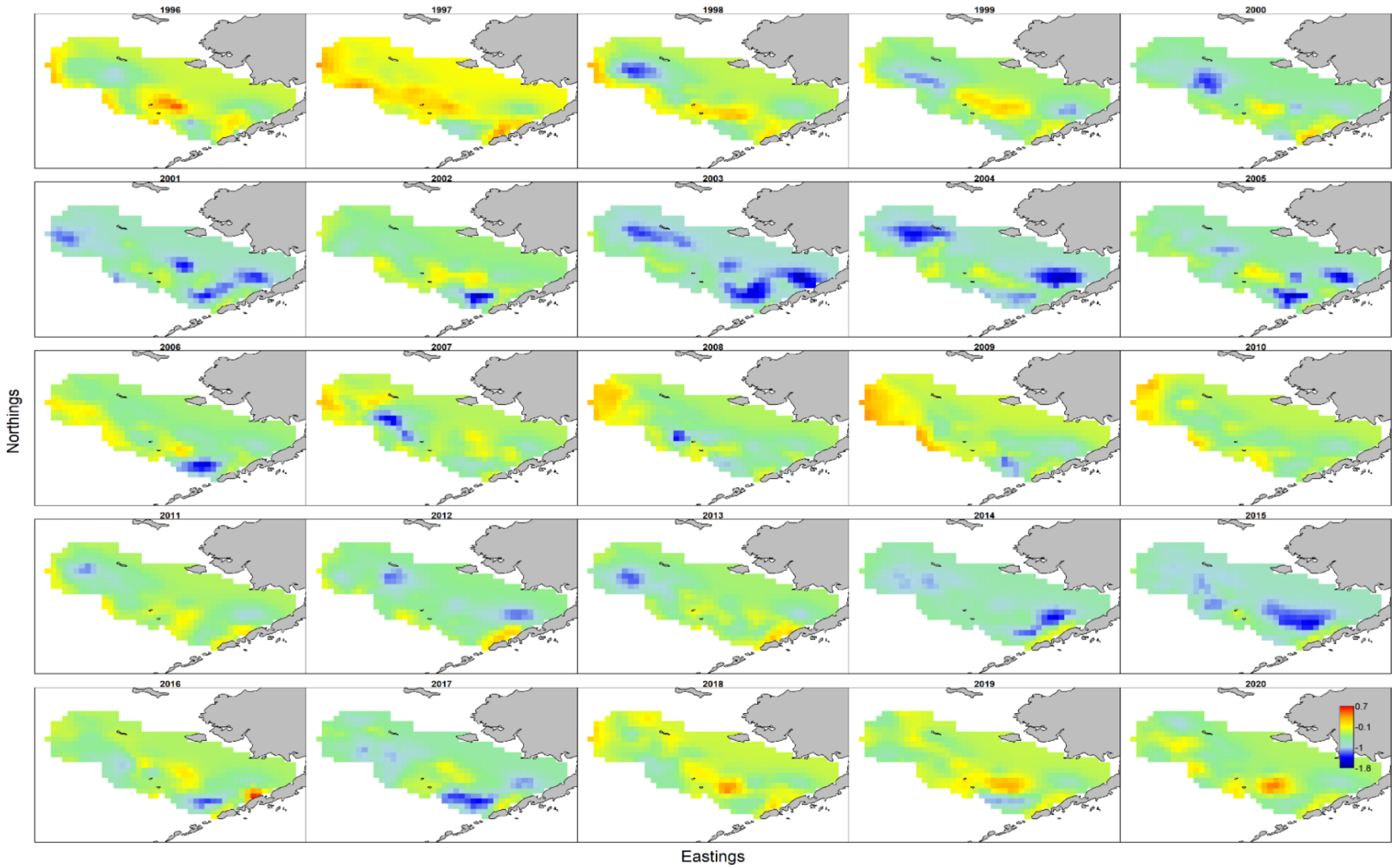


Figure 2.1.9a. VAST winter longline fishery CPUE log density maps, by year.

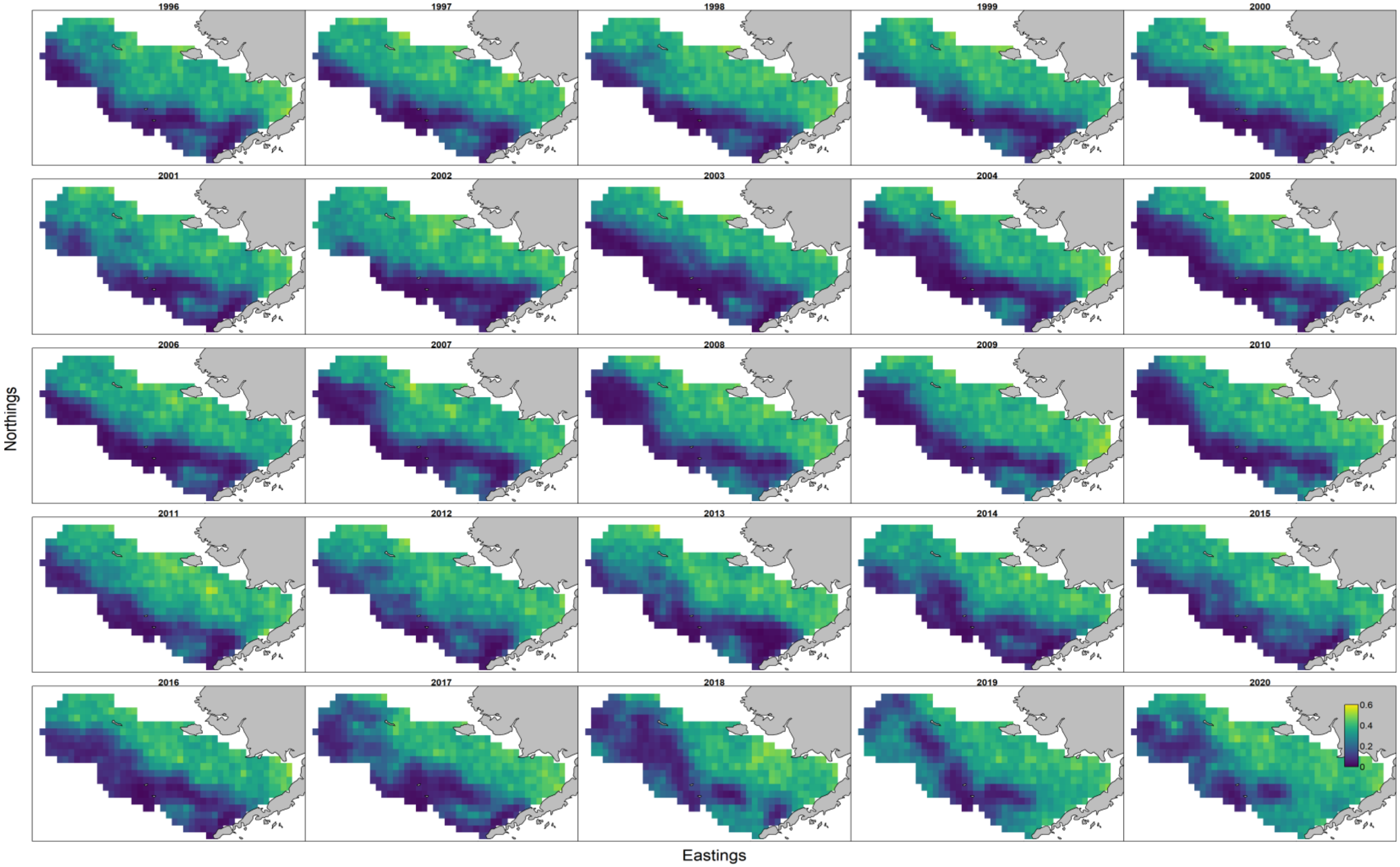


Figure 2.1.9b. VAST winter longline fishery CPUE log density standard error maps.

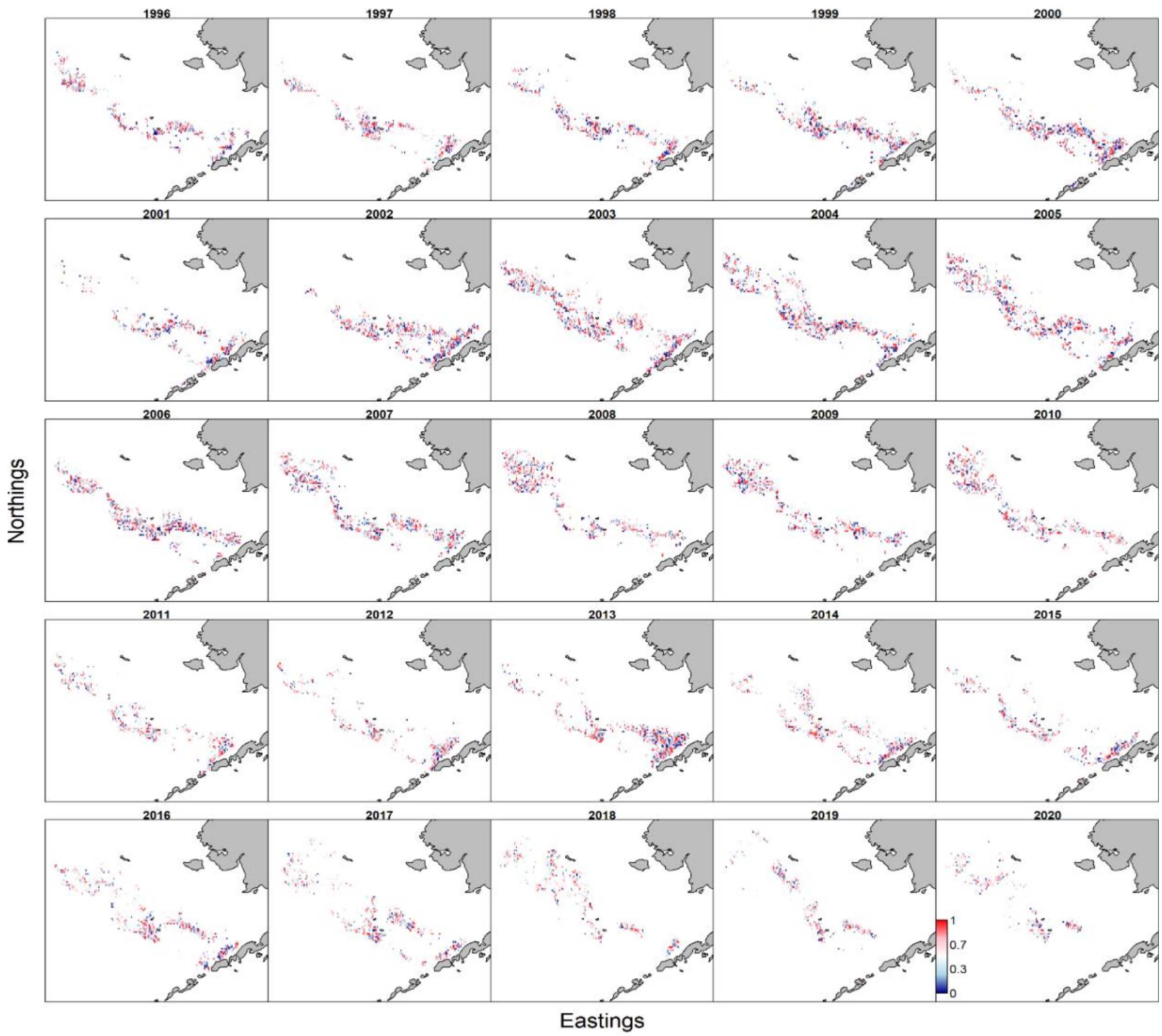


Figure 2.1.9c. VAST winter longline fishery CPUE residual maps, by year.

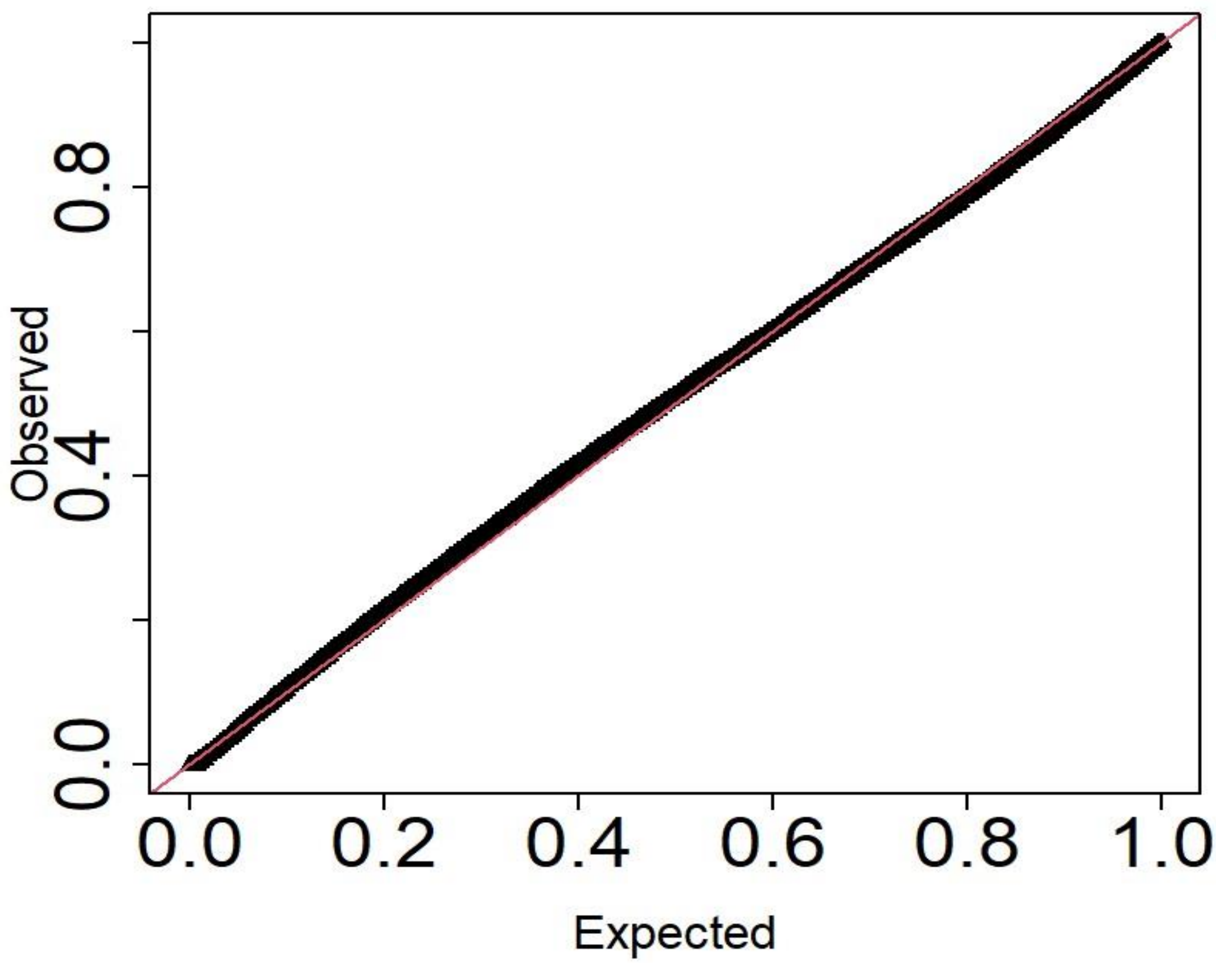


Figure 2.1.9d. VAST winter longline fishery CPUE residuals quantile-quantile plot.

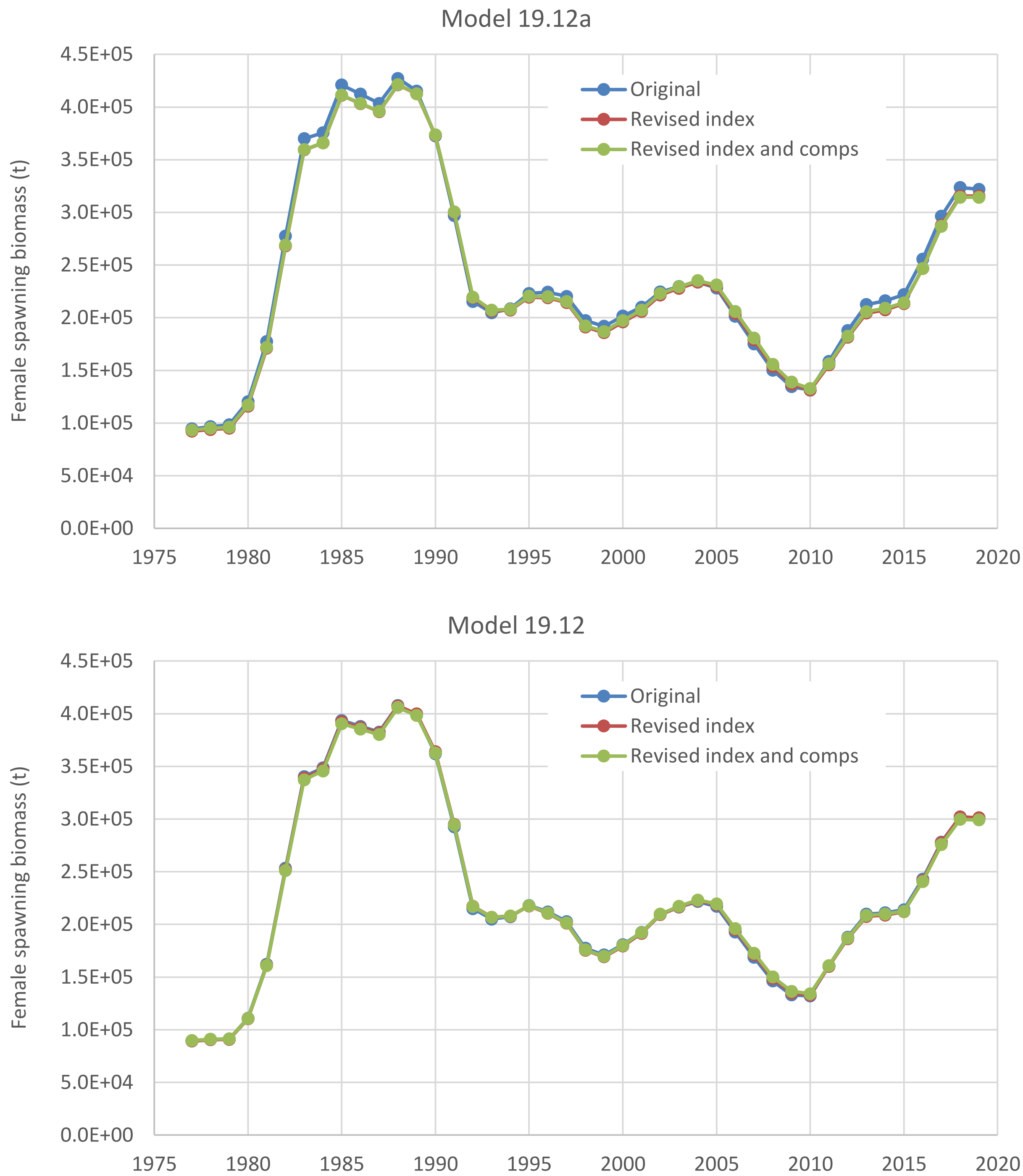


Figure 2.1.10. Data update bridging analysis, showing the effects of updating the survey index by itself and updating both the survey index and the agecomps. Top: Model 19.12a, bottom: Model 19.12.

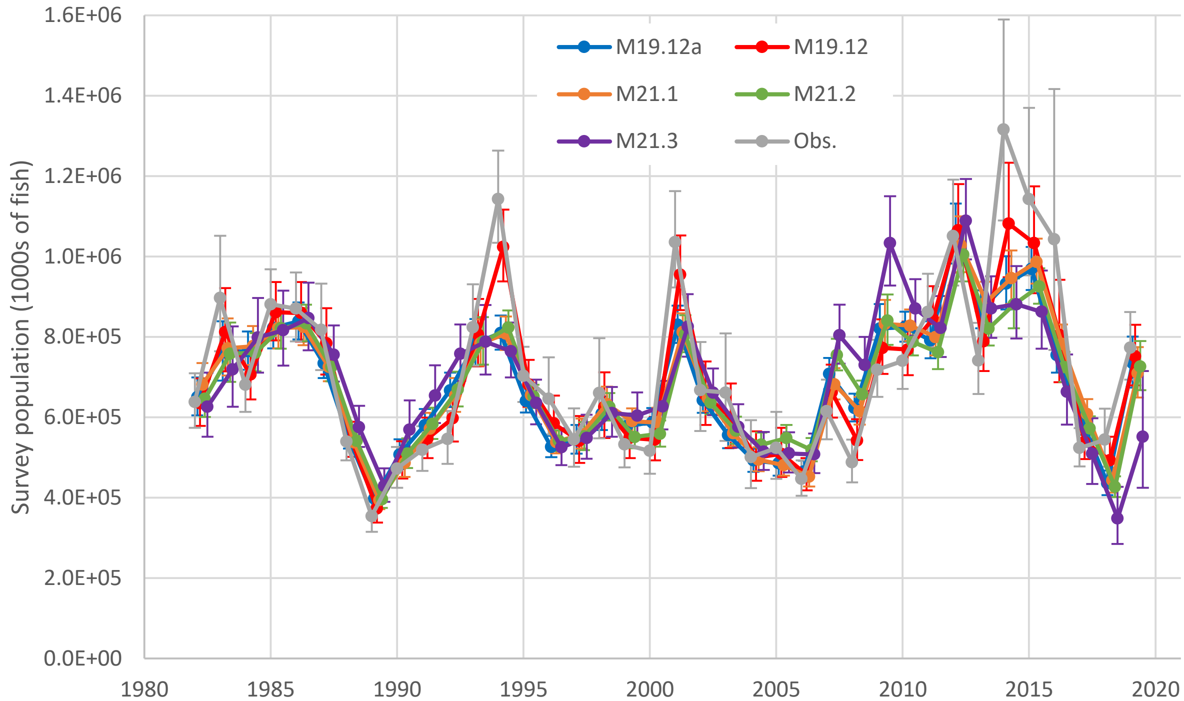


Figure 2.1.11a. Fits to “original” survey index data for all models and the ensemble.

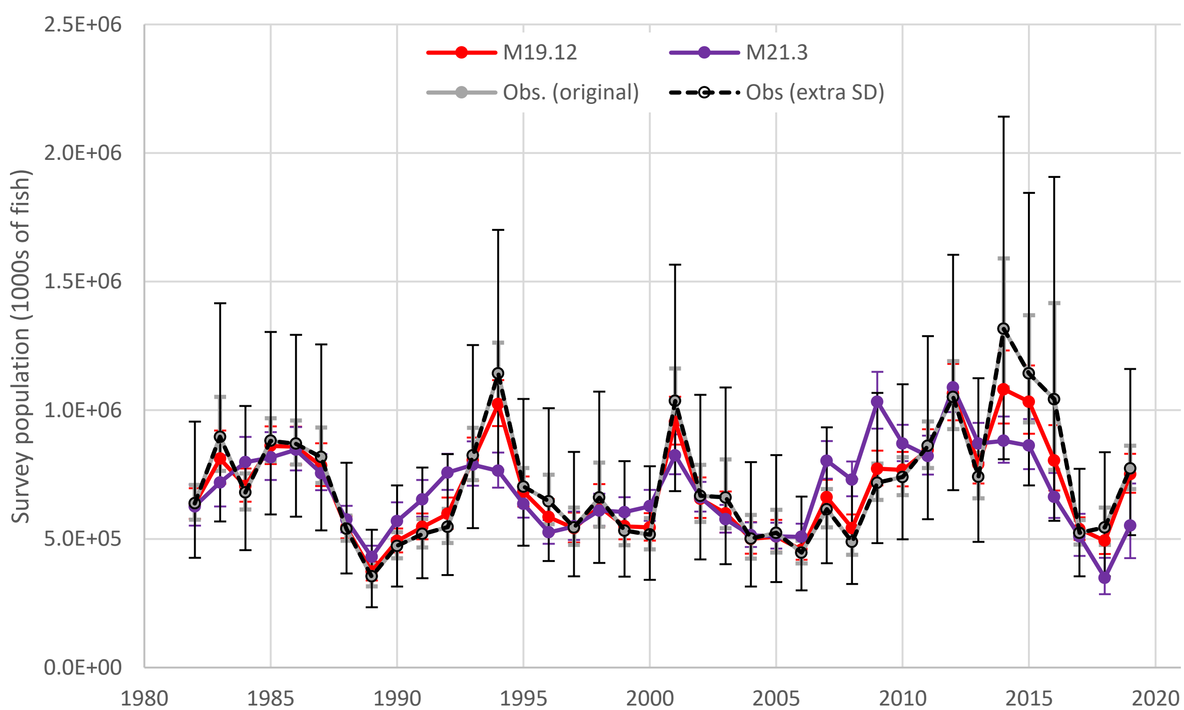


Figure 2.1.11b. Fits to survey index data, including “extra SD” adjustments, for Models 19.12 and 21.3.

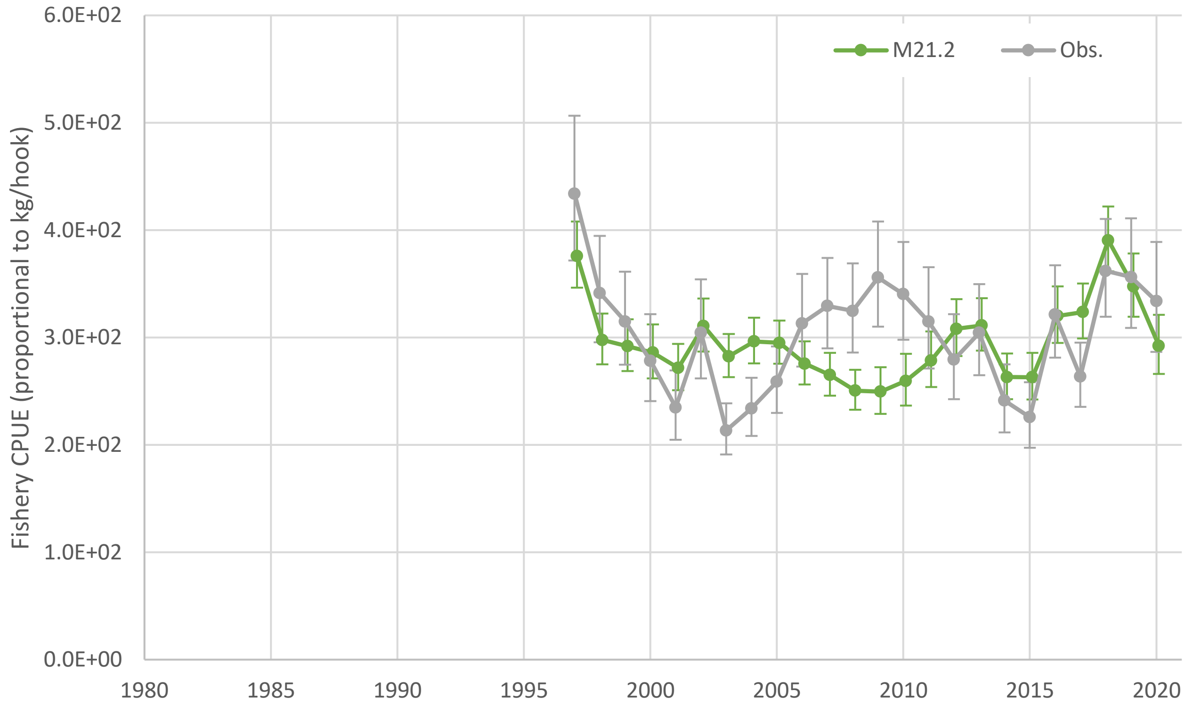


Figure 2.1.11c. Fit to VAST winter longline fishery CPUE index for Model 21.2.

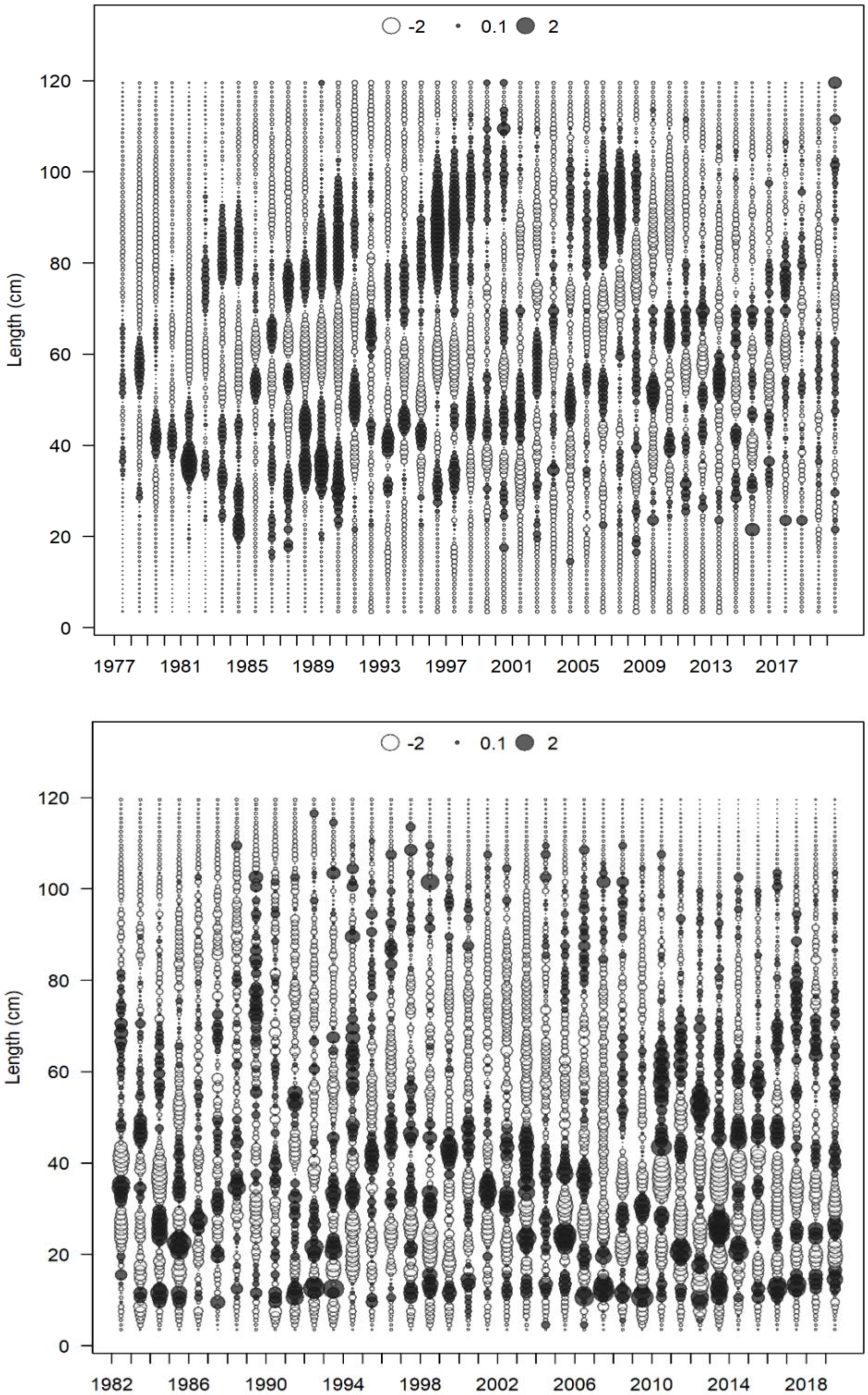
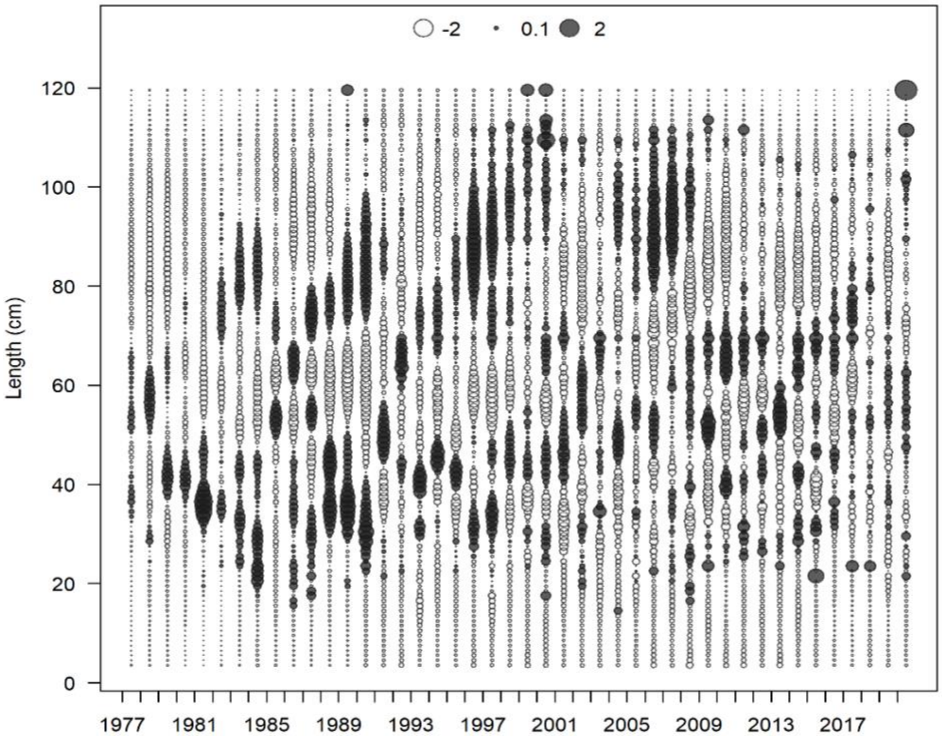


Figure 2.1.12a. Residuals from fit to sizecomp data (Model 19.12a). Top: fishery, bottom: survey.



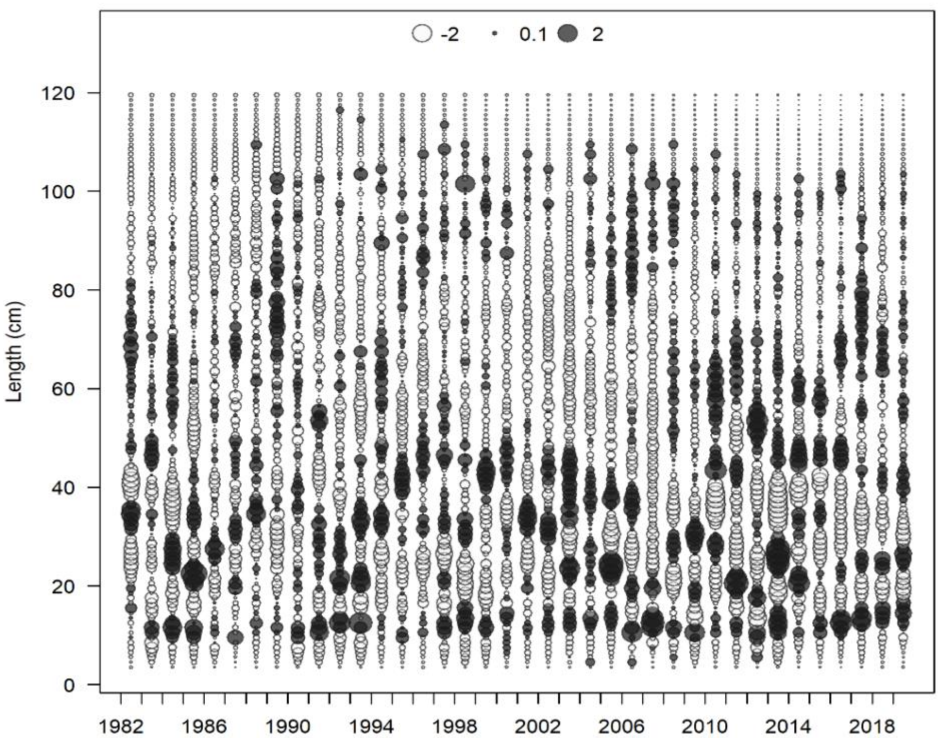


Figure 2.1.12b. Residuals from fit to sizecomp data (Model 19.12). Top: fishery, bottom: survey.

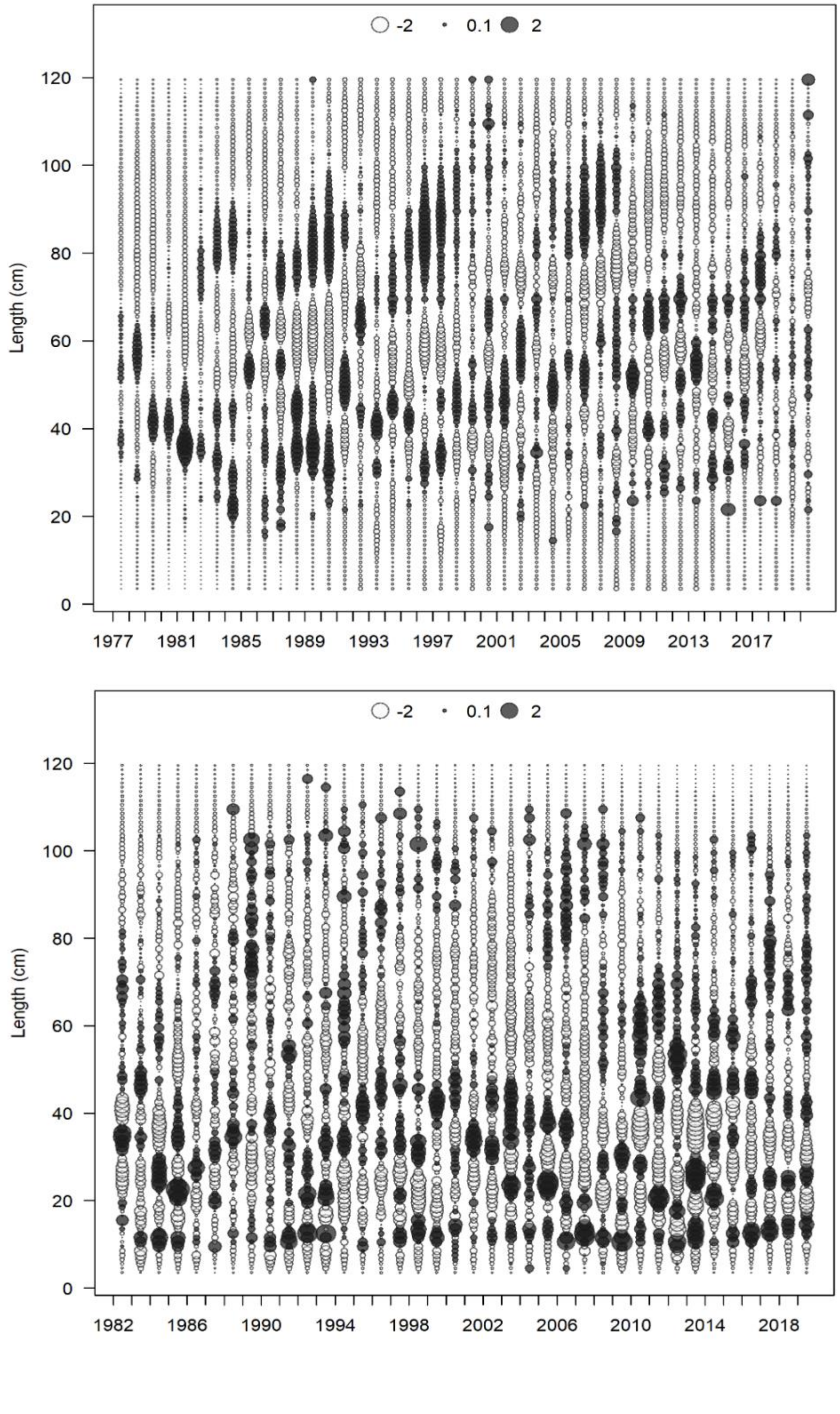
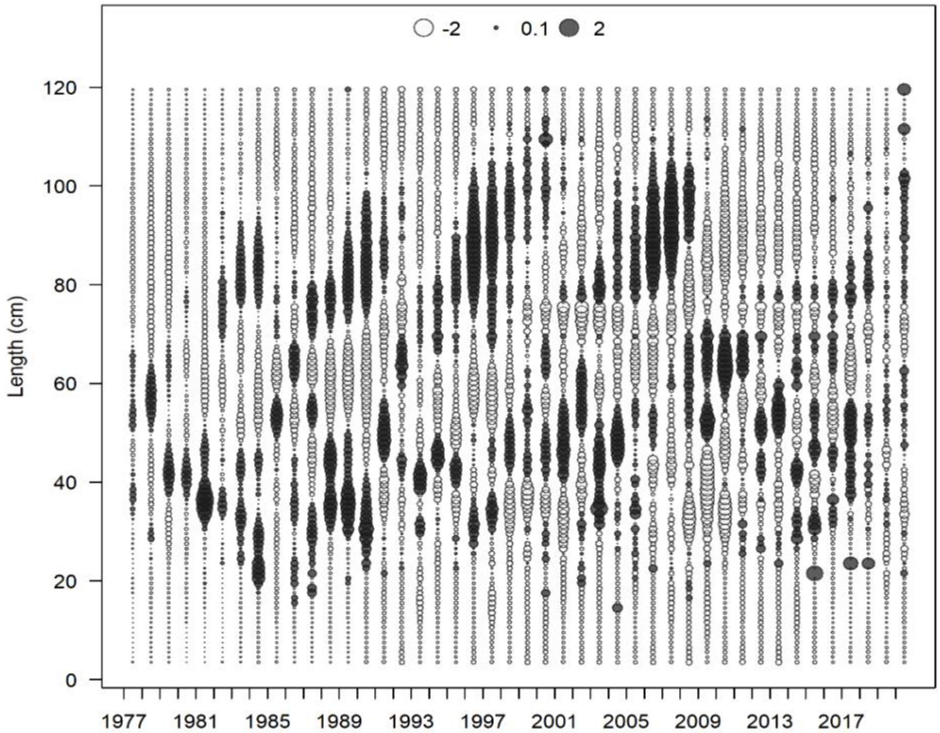


Figure 2.1.12c. Residuals from fit to sizecomp data (Model 21.1). Top: fishery, bottom: survey.



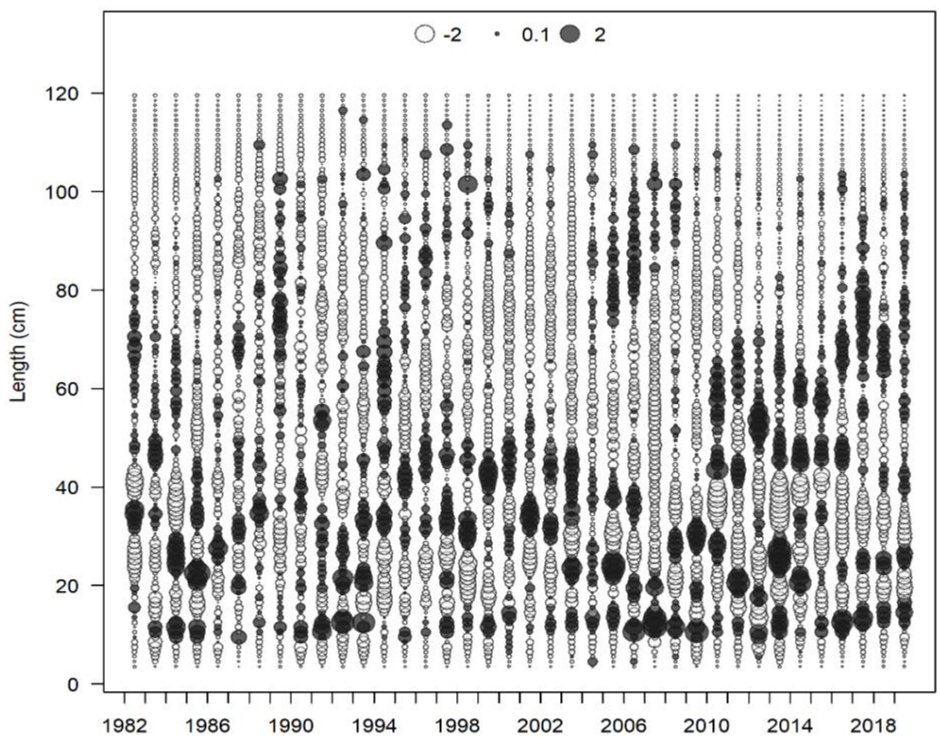


Figure 2.1.12d. Residuals from fit to sizecomp data (Model 21.2). Top: fishery, bottom: survey.

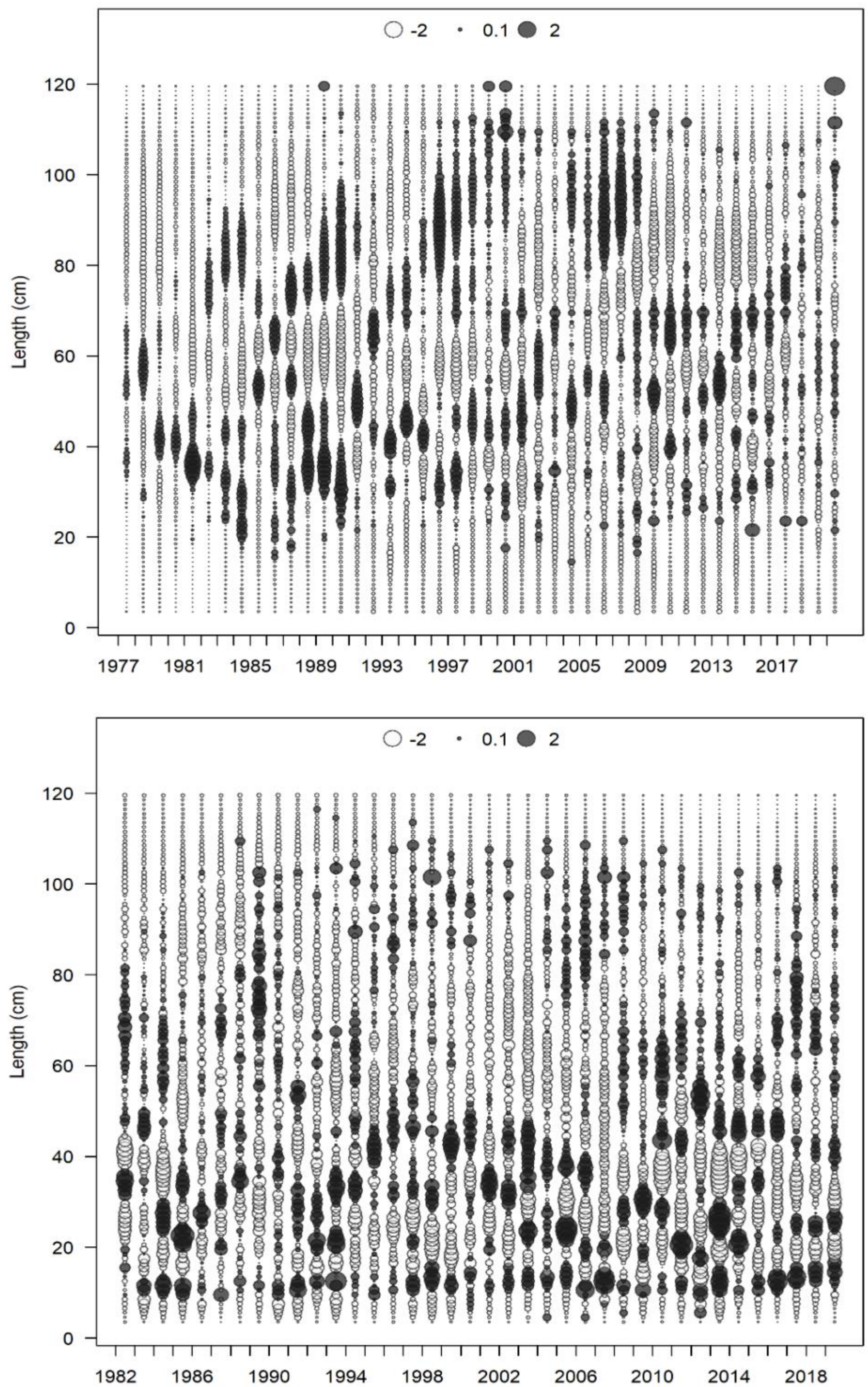
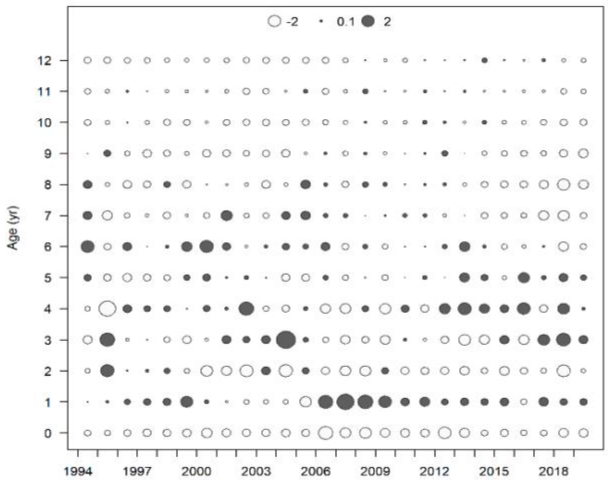
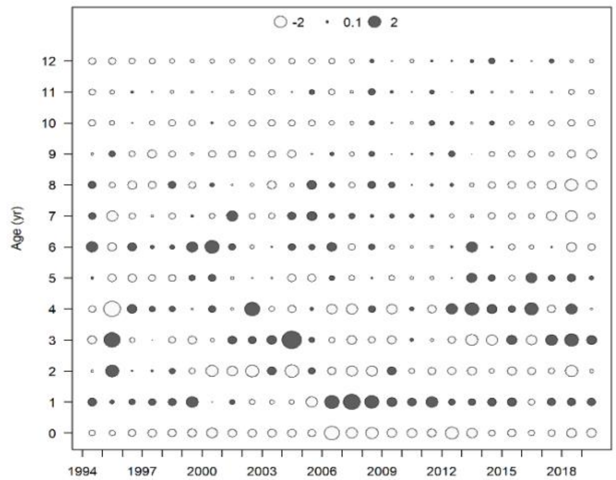


Figure 2.1.12. Residuals from fit to sizecomp data (Model 21.3). Top: fishery, bottom: survey.

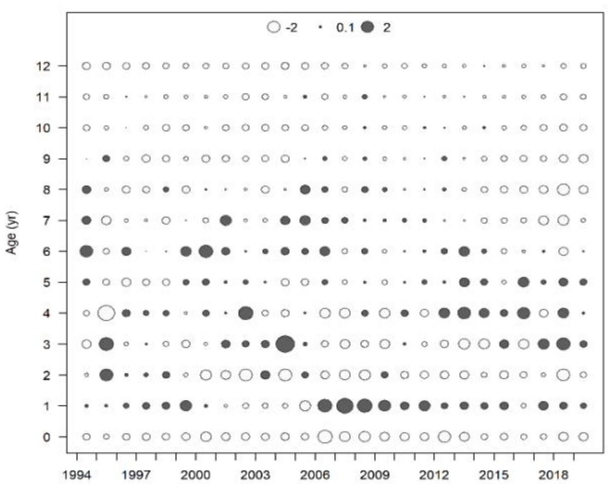
Model 19.12a



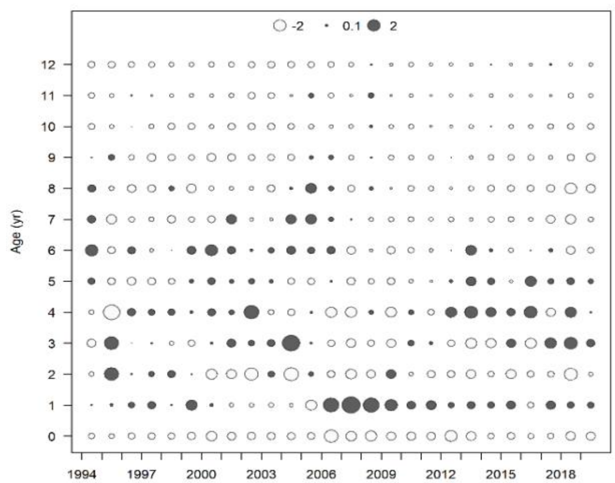
Model 19.12



Model 21.1



Model 21.2



Model 21.3

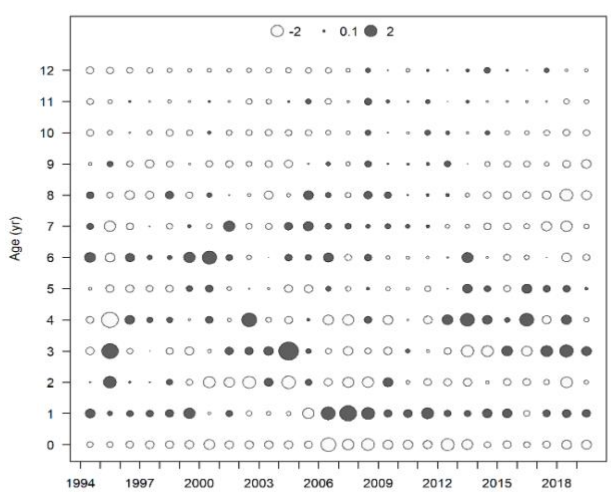


Figure 2.1.13. Residuals from fits to survey agecomp data (all models).

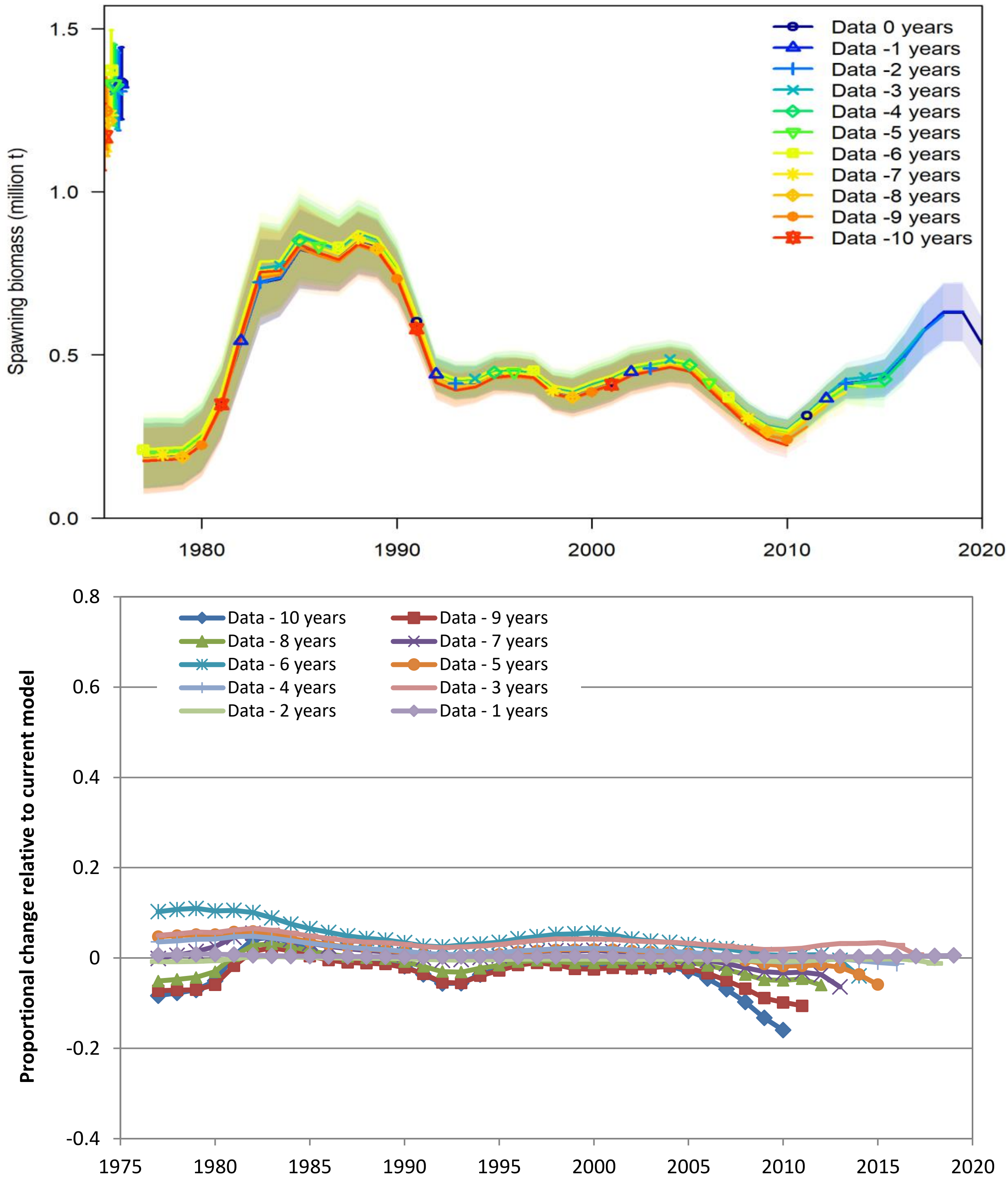


Figure 2.1.14a. Retrospective analysis of combined-sex spawning biomass (Model 19.12a).

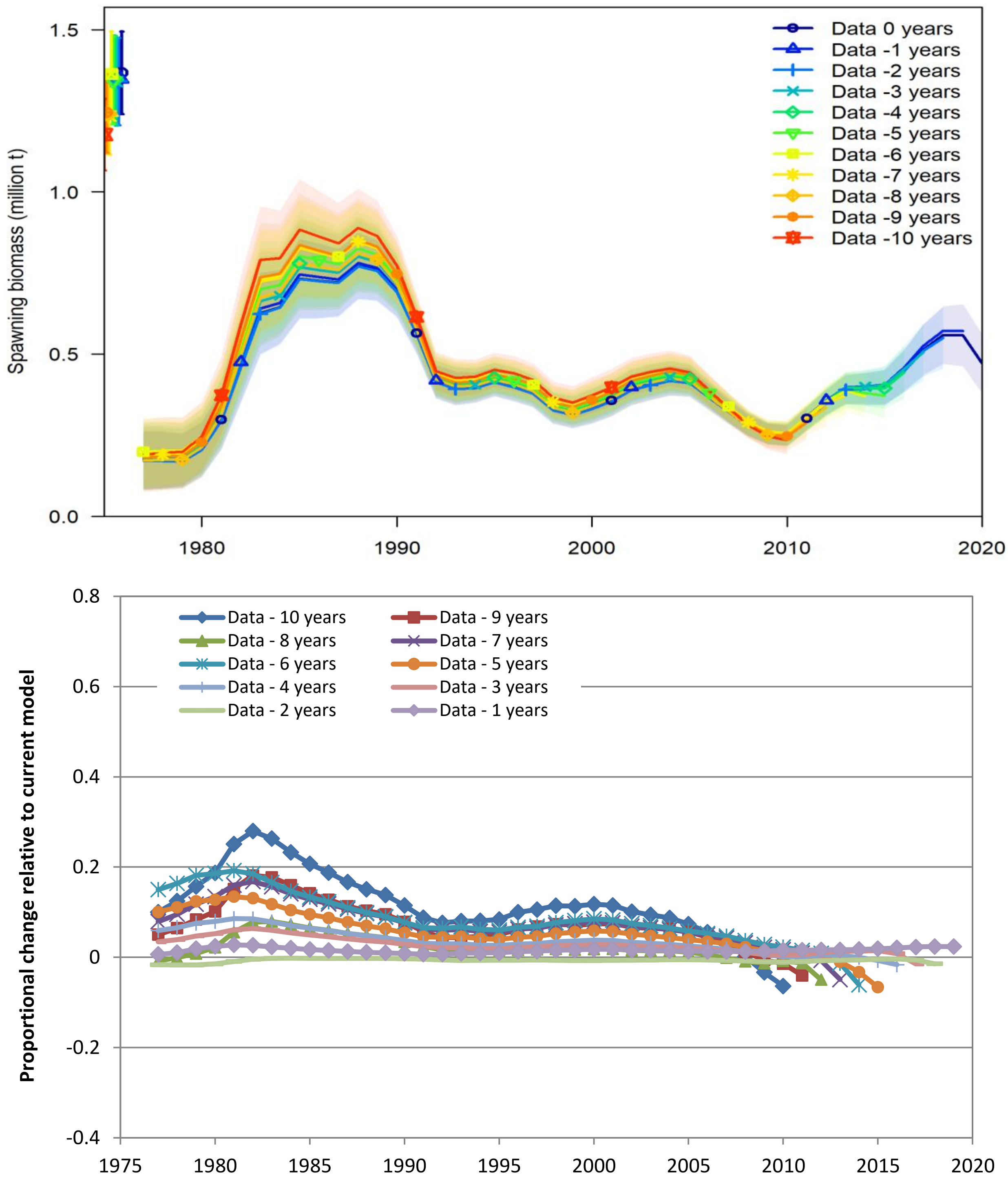


Figure 2.1.14b. Retrospective analysis of combined-sex spawning biomass (Model 19.12).

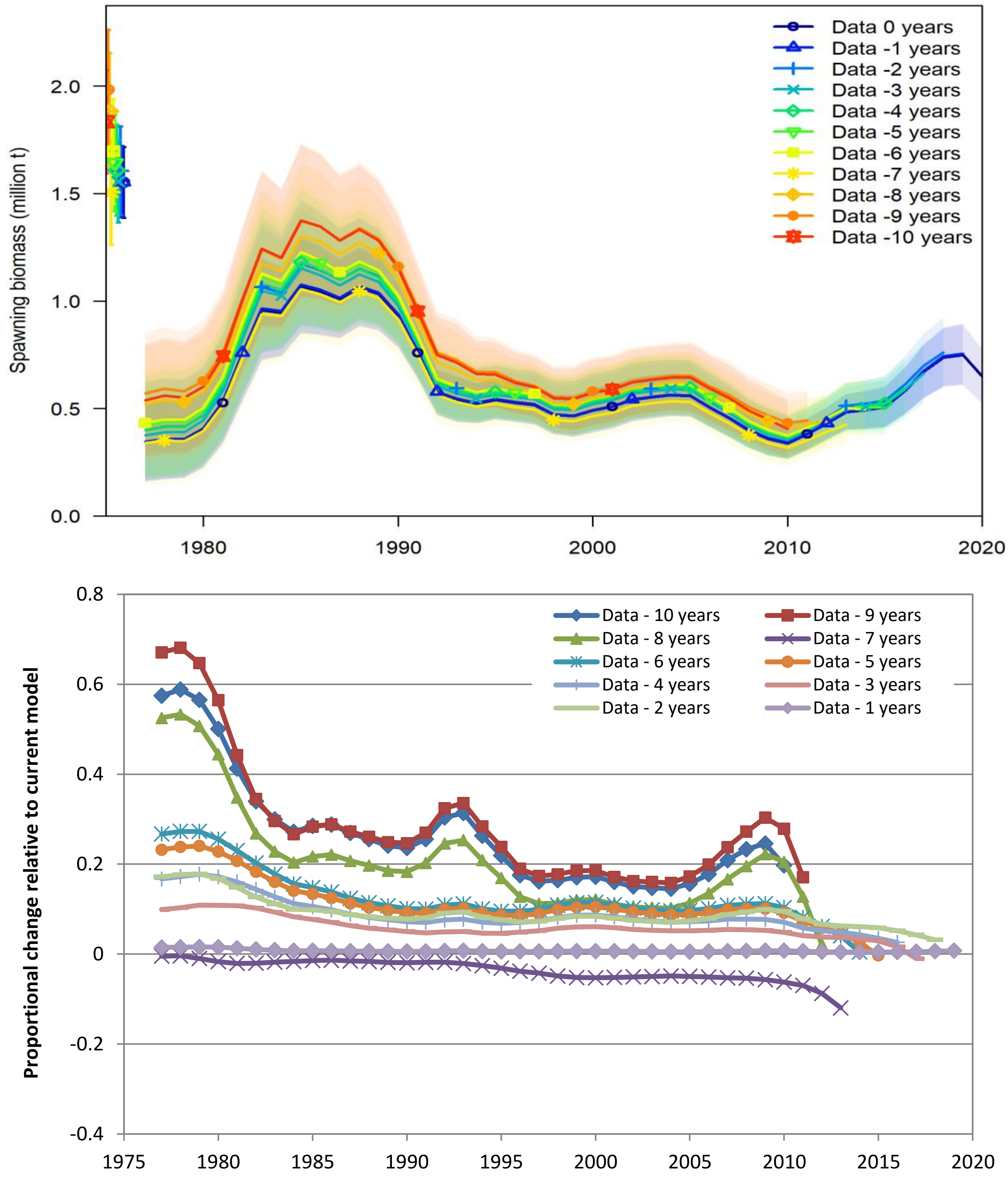


Figure 2.1.14c. Retrospective analysis of combined-sex spawning biomass (Model 21.1).

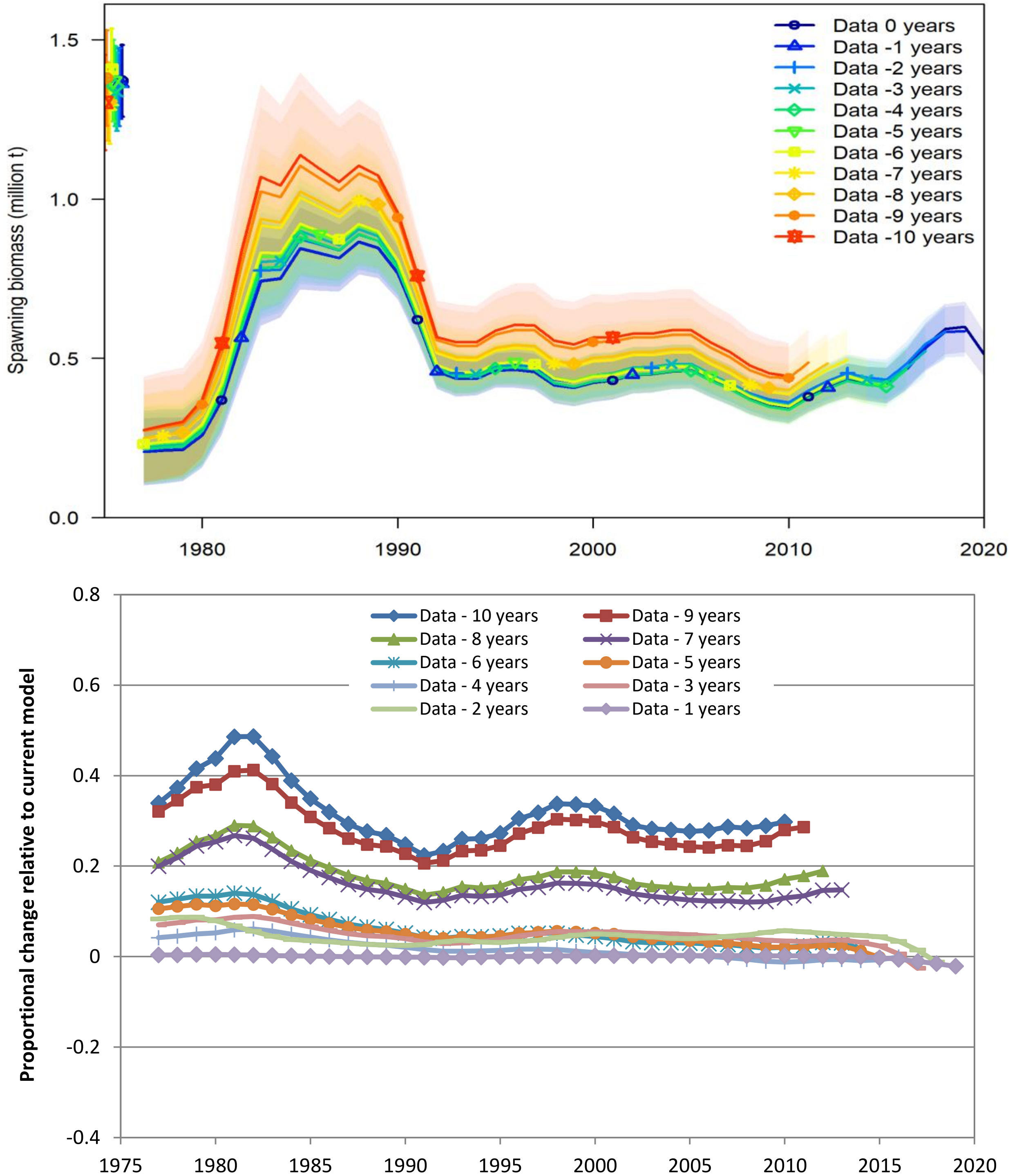
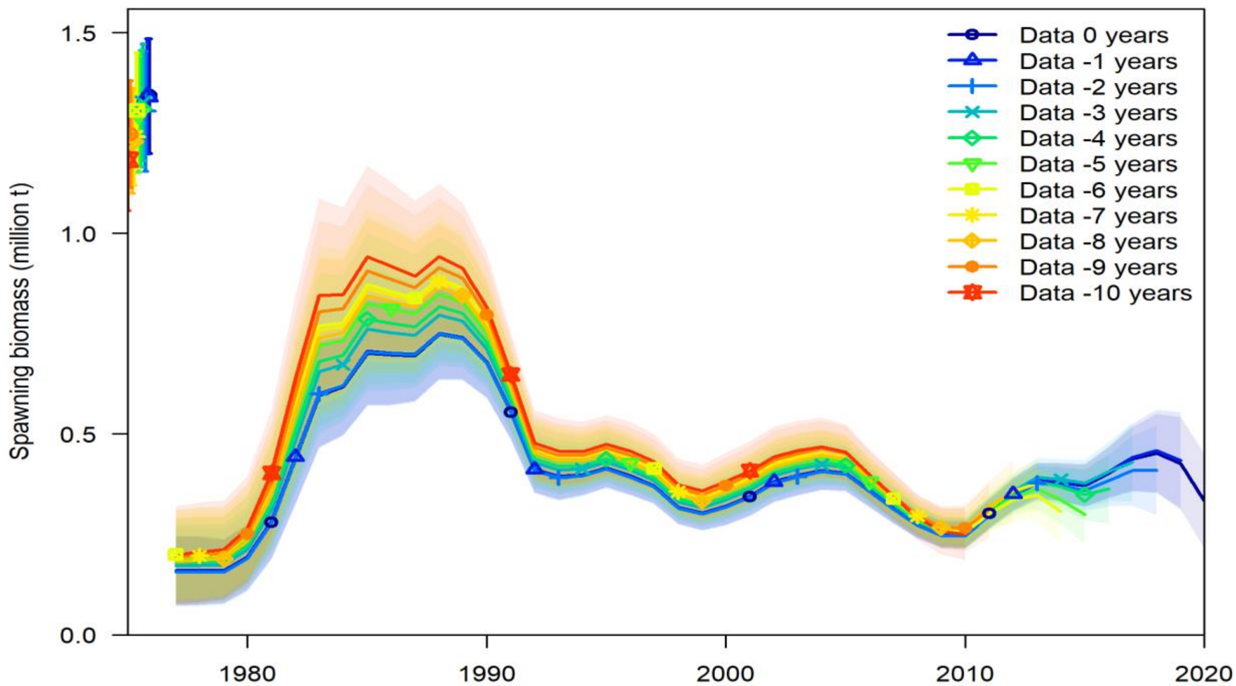


Figure 2.1.14d. Retrospective analysis of combined-sex spawning biomass (Model 21.2).



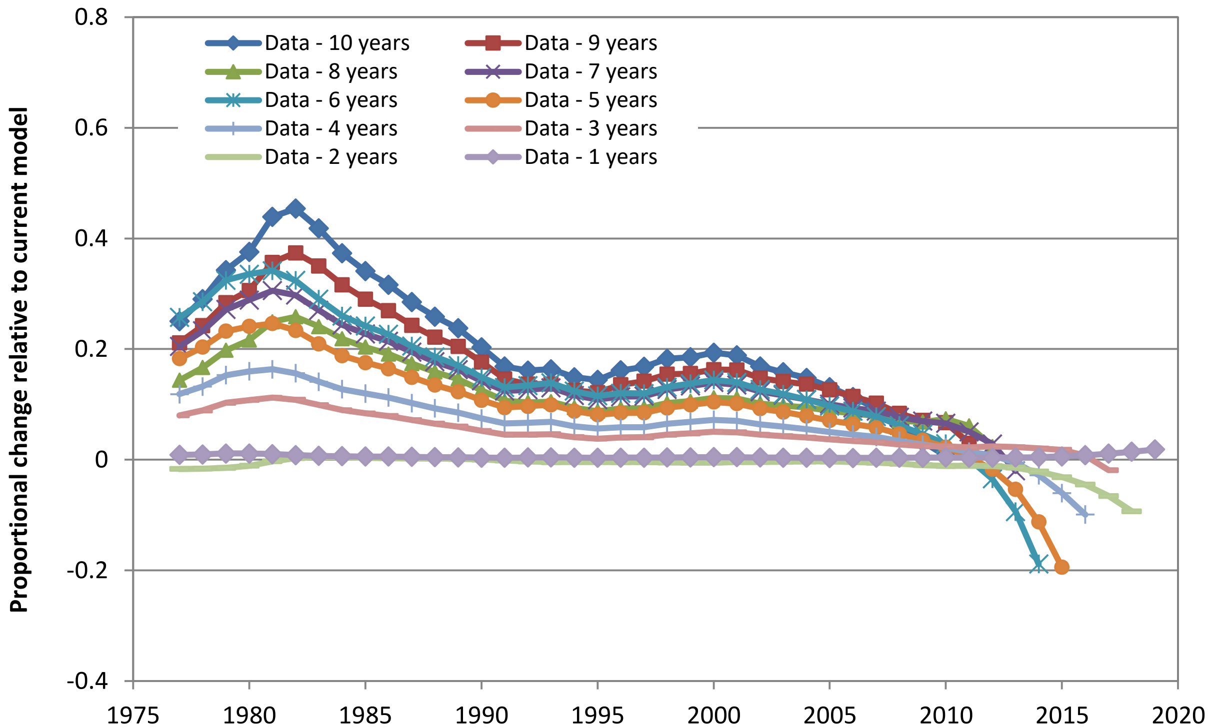


Figure 2.1.14e. Retrospective analysis of combined-sex spawning biomass (Model 21.3).

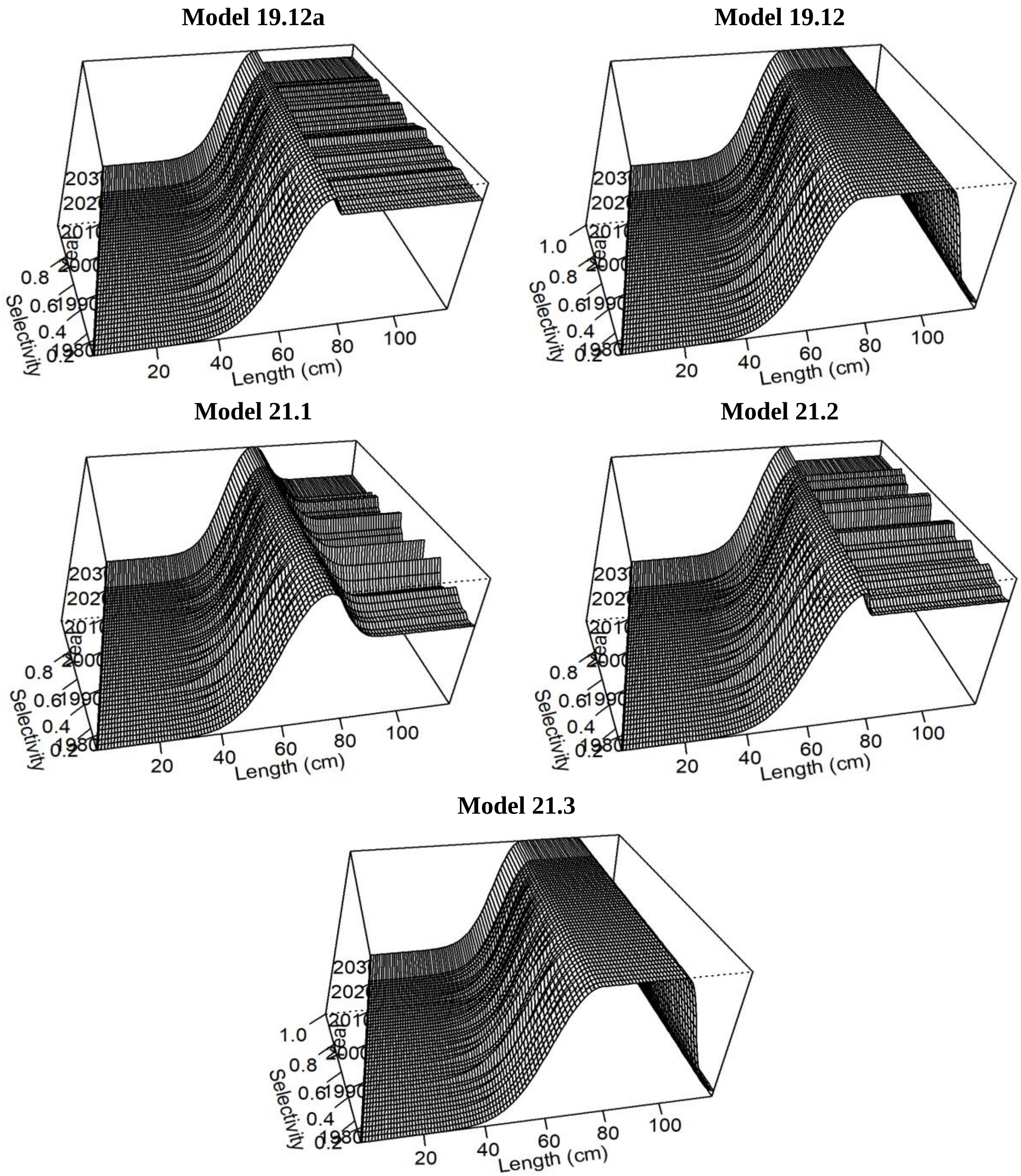


Figure 2.1.15a. Fishery selectivity as estimated by the models.

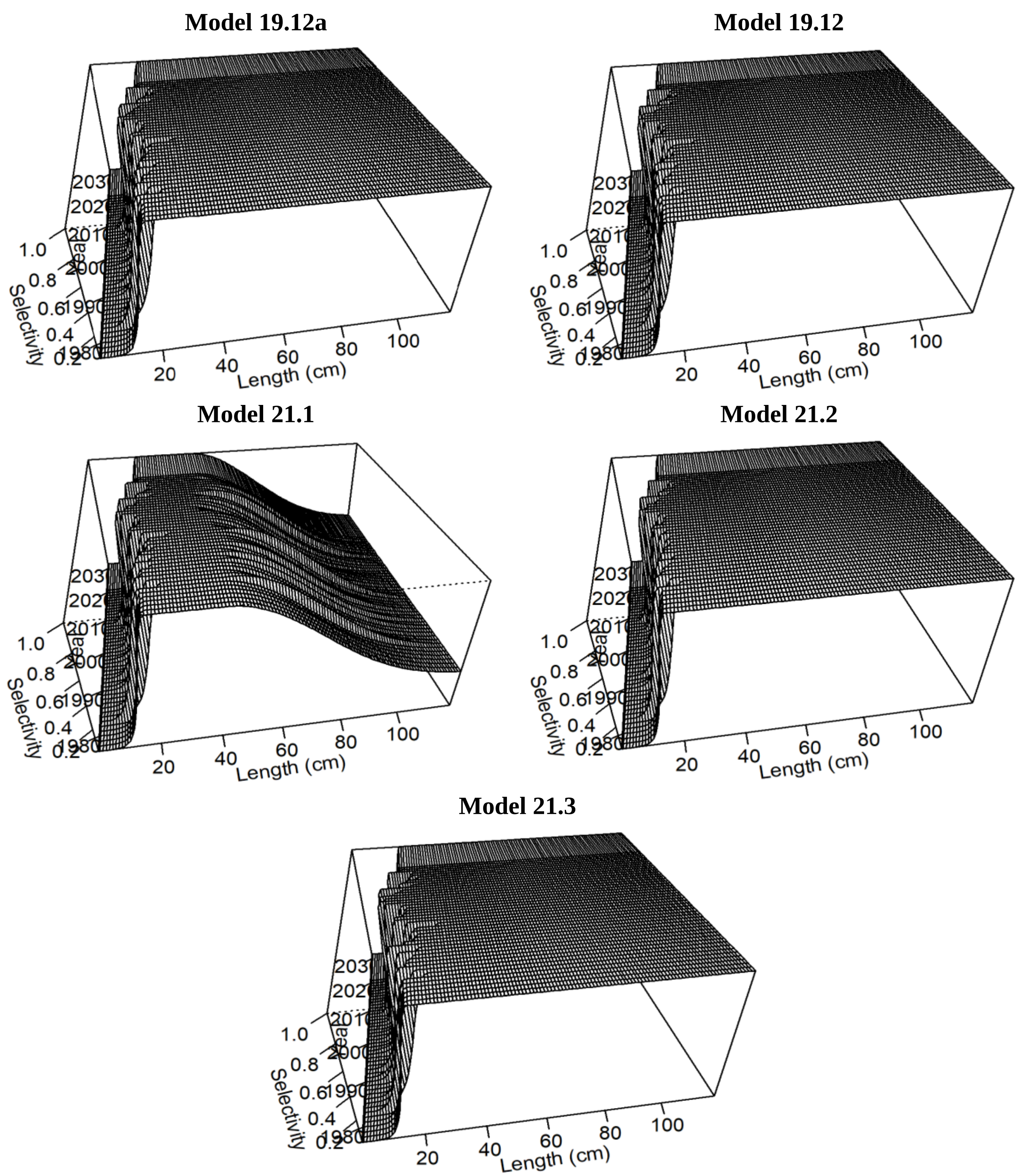


Figure 2.1.15b. Survey selectivity as estimated by the models.

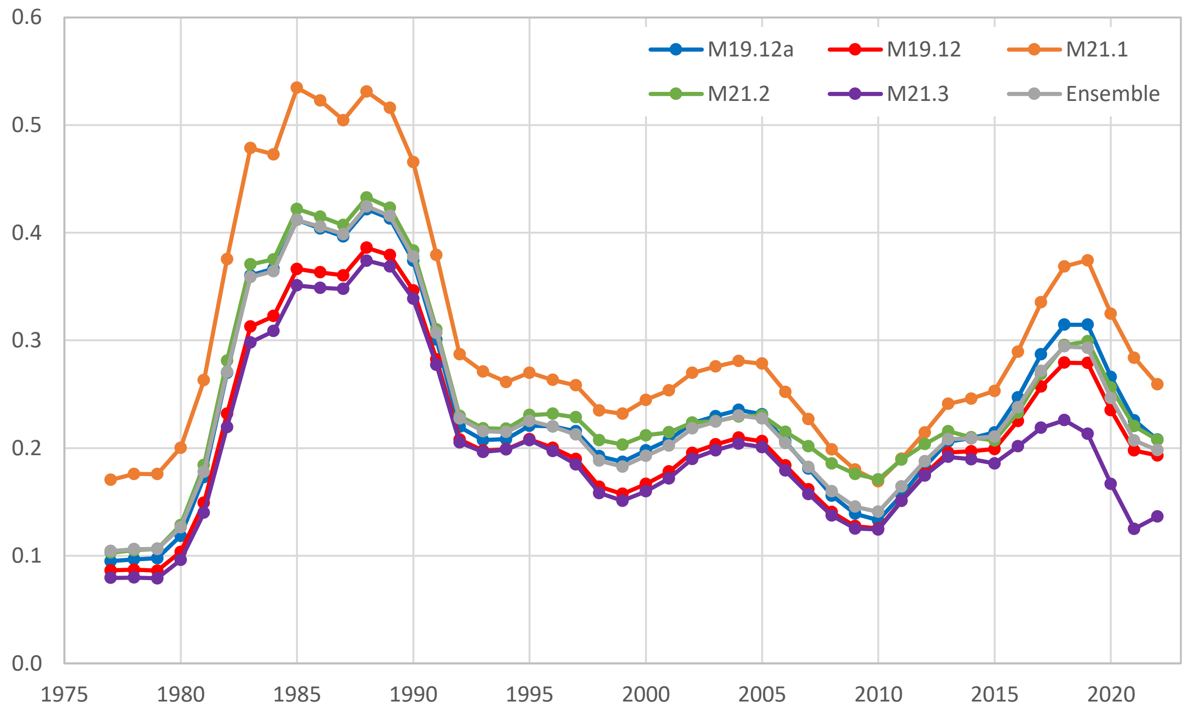


Figure 2.1.16. Female spawning biomass (millions of t) as estimated by the models and ensemble.

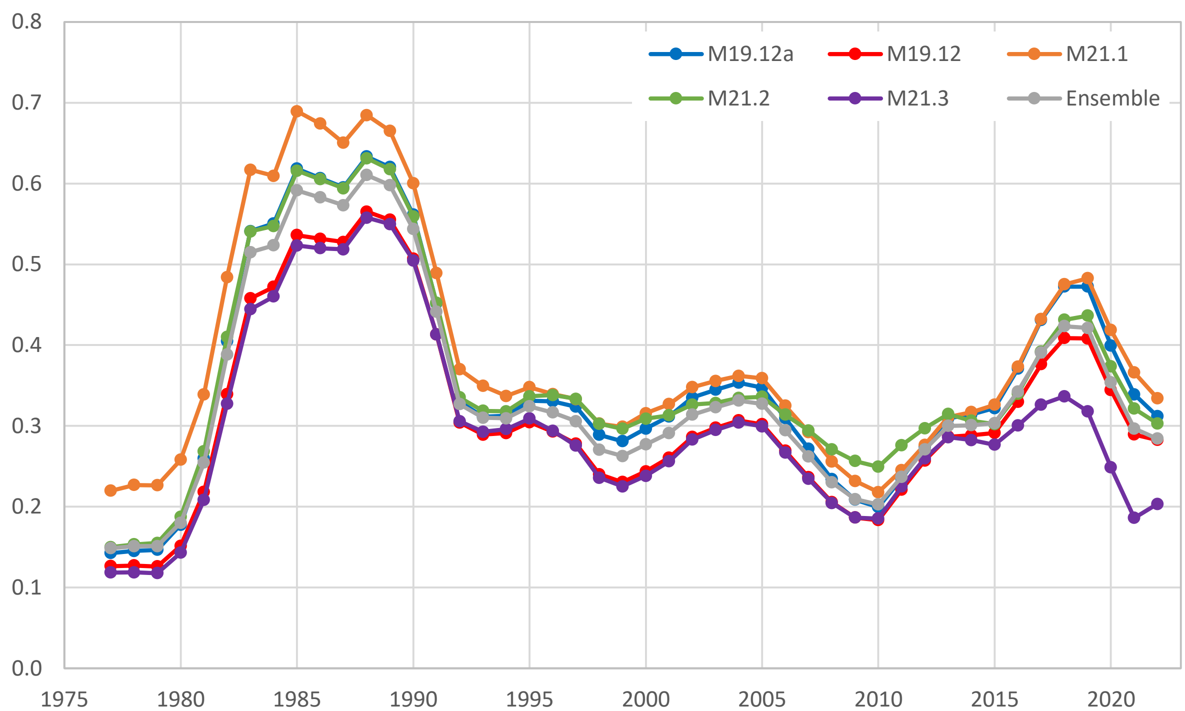


Figure 2.1.17. Relative (to $B_{100\%}$) spawning biomass as estimated by the models and ensemble.

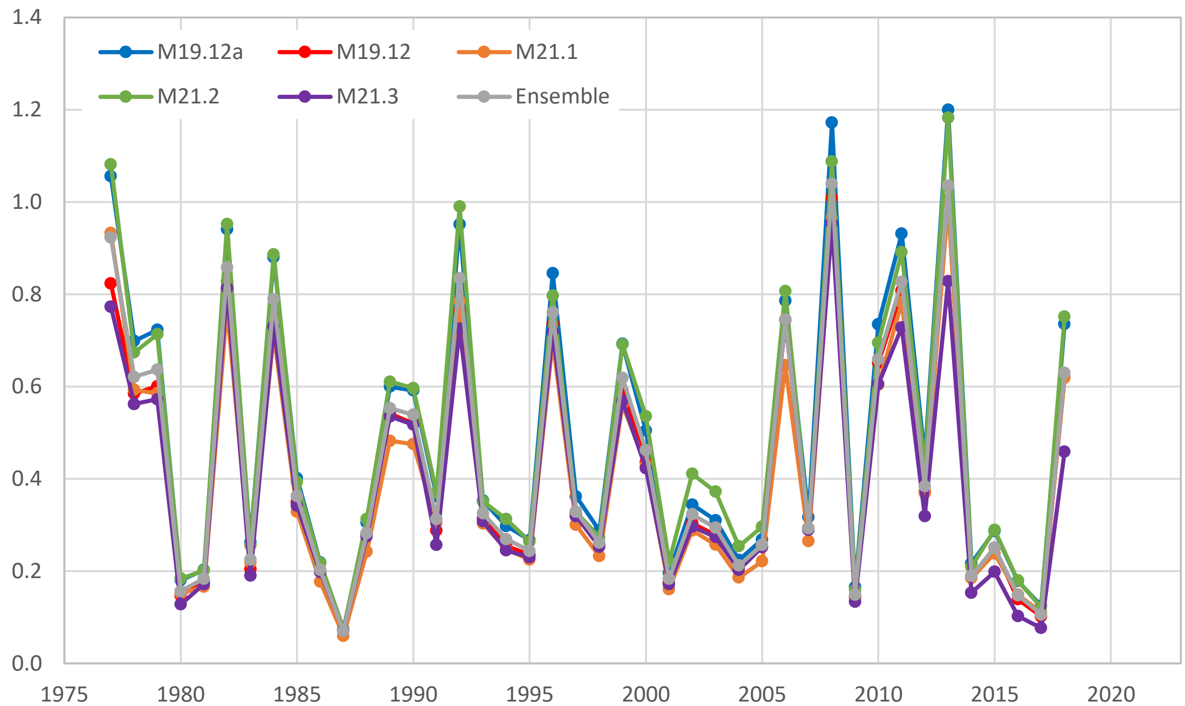


Figure 2.1.18. Age 0 recruitment (billions of fish) as estimated by the models and ensemble.

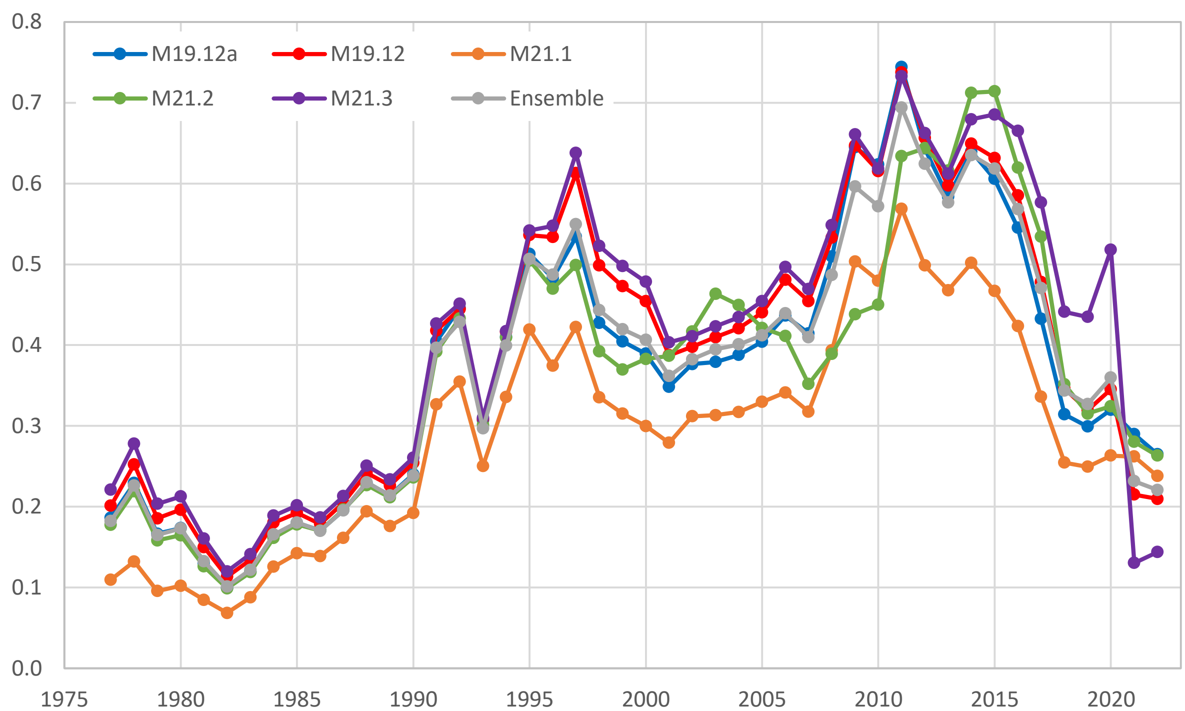


Figure 2.1.19. Full-selection instantaneous fishing mortality as estimated by the models and ensemble.

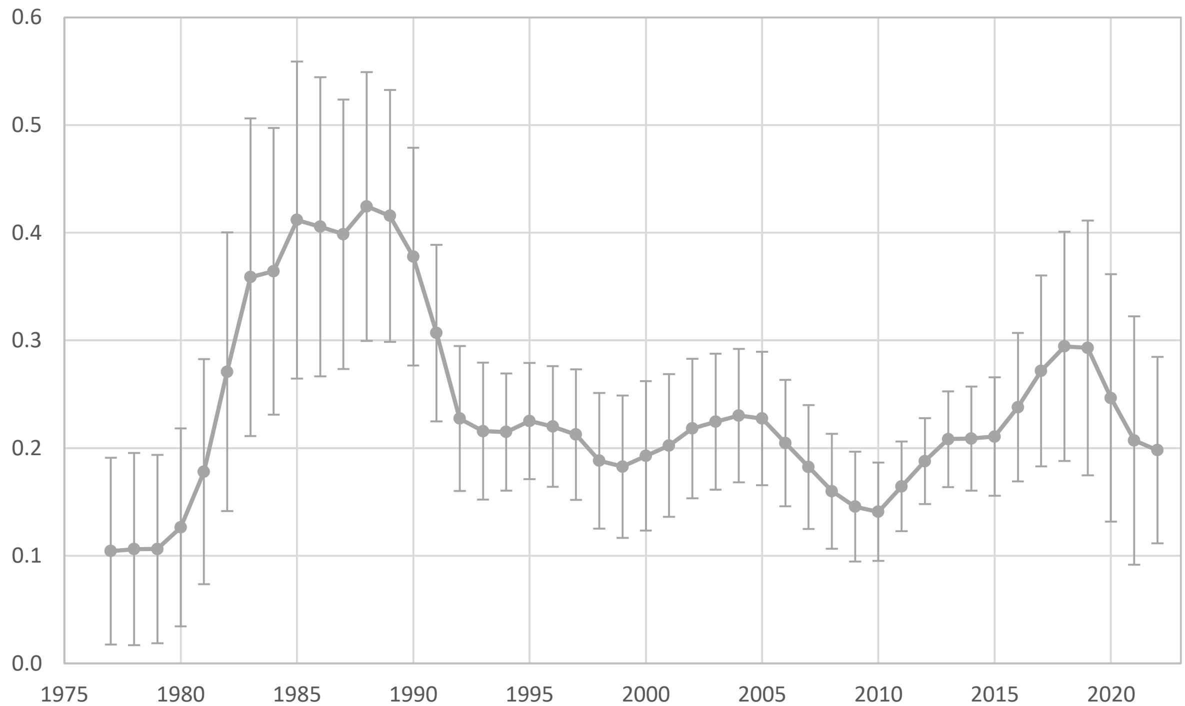


Figure 2.1.20. Female spawning biomass (millions of t), with error bars, as estimated by the ensemble.

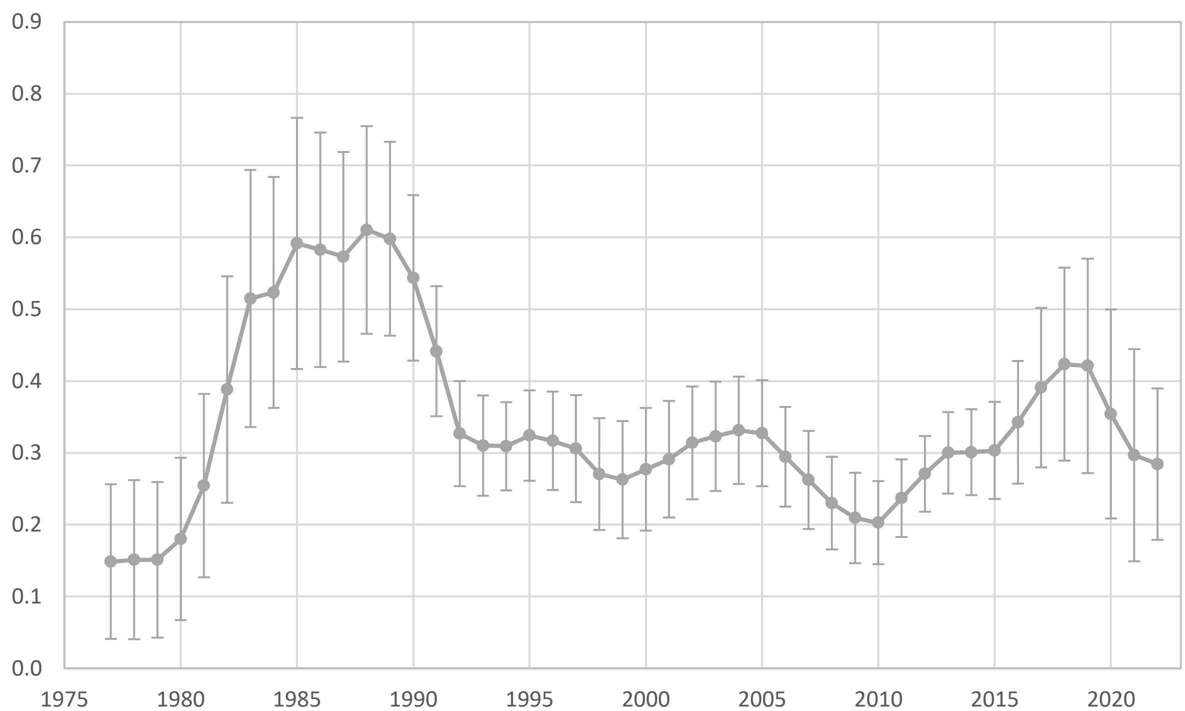


Figure 2.1.21. Relative (to $B_{100\%}$) spawning biomass, with error bars, as estimated by the ensemble.

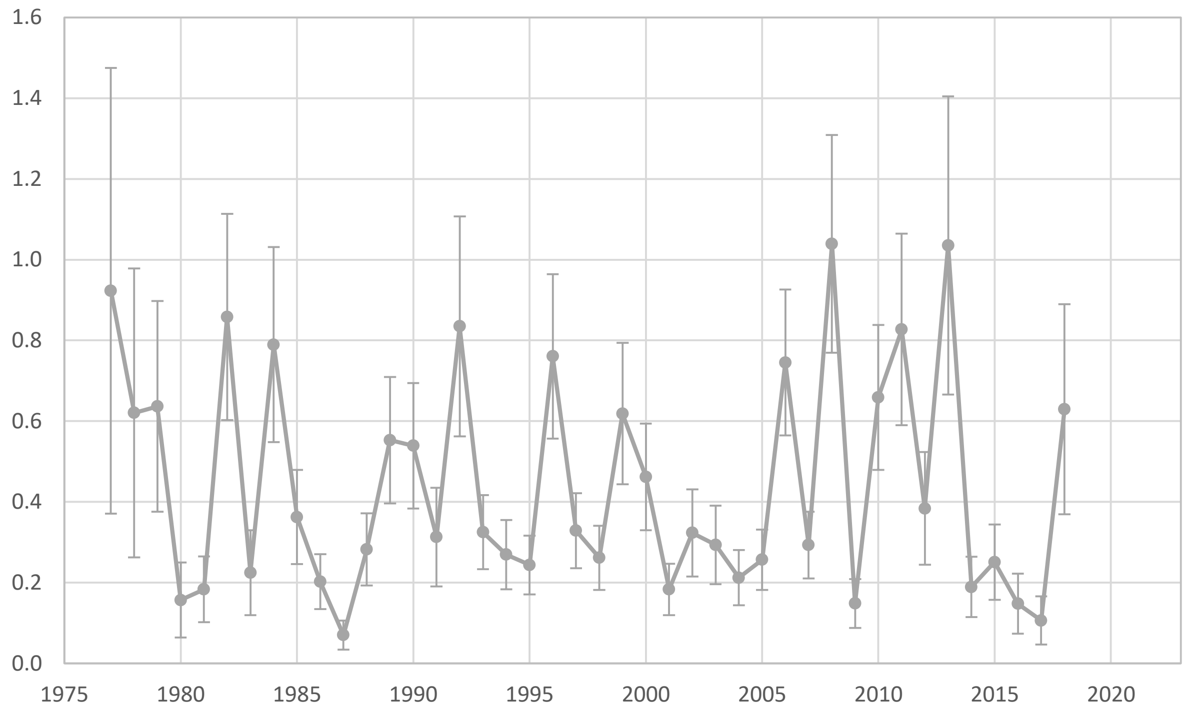


Figure 2.1.22. Age 0 recruitment (billions of fish), with error bars, as estimated by the ensemble.

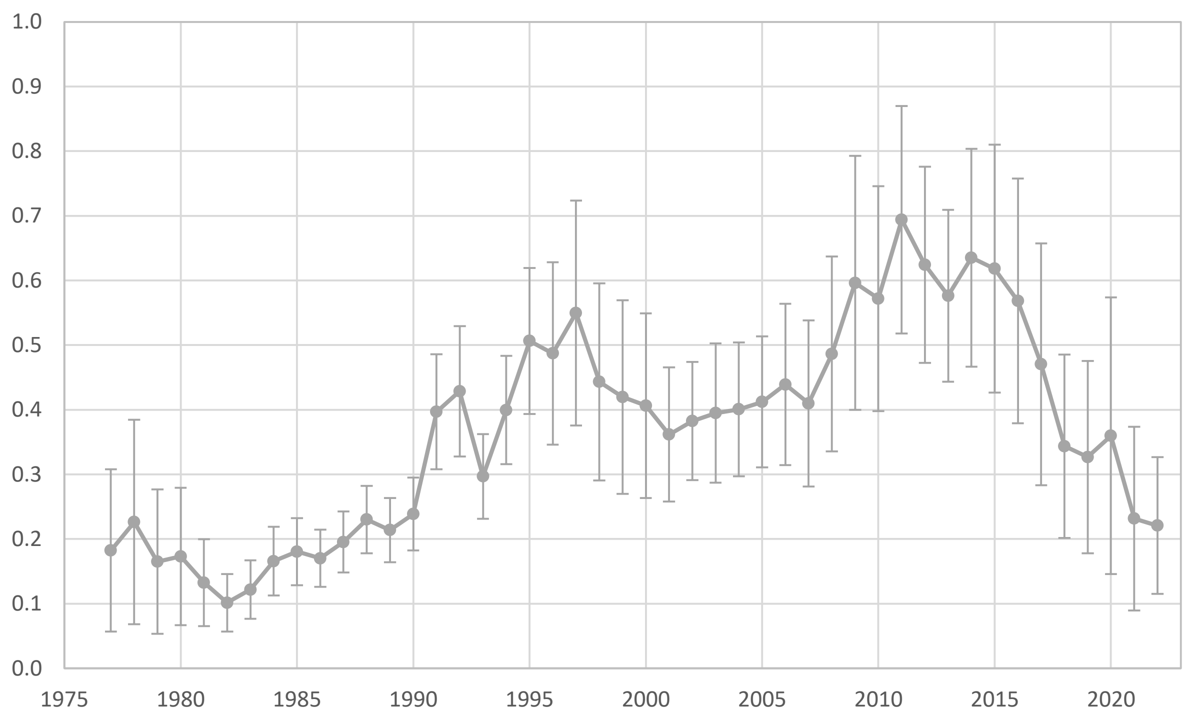


Figure 2.1.23. Full-selection fishing mortality, with error bars, as estimated by the ensemble.

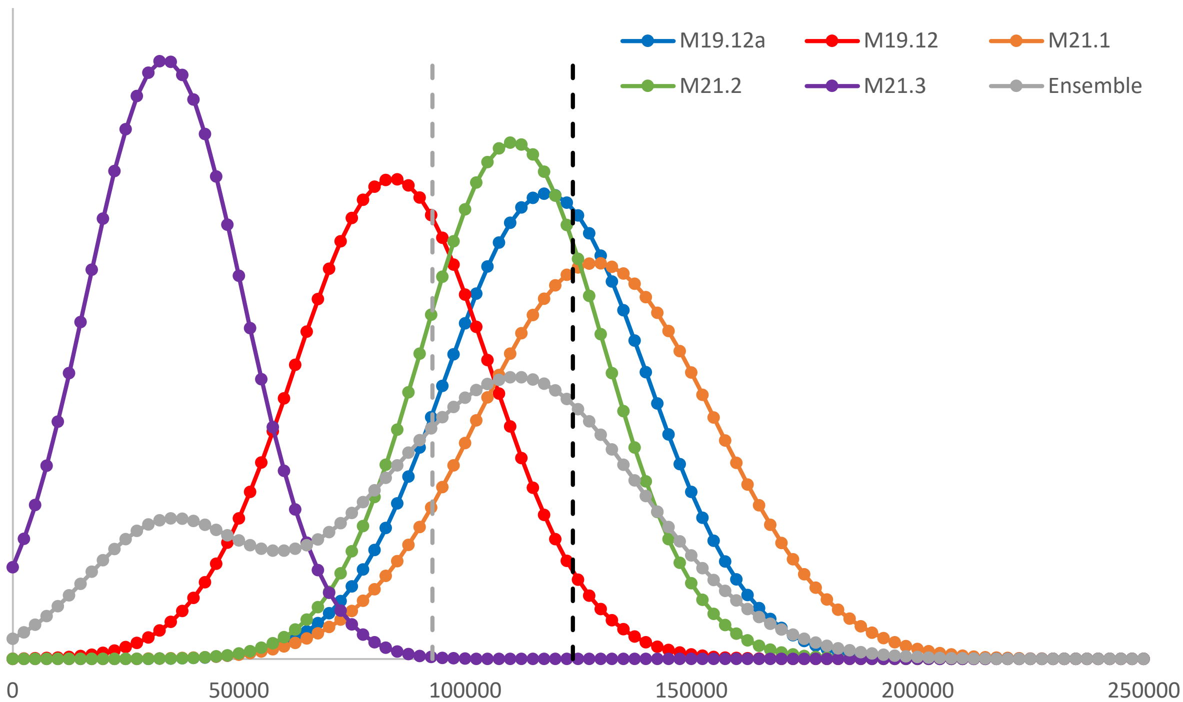


Figure 2.1.24a. Distributions of 2021 ABC as estimated by the models and ensemble. Vertical dashed lines: black = value as currently specified, gray = ensemble mean.

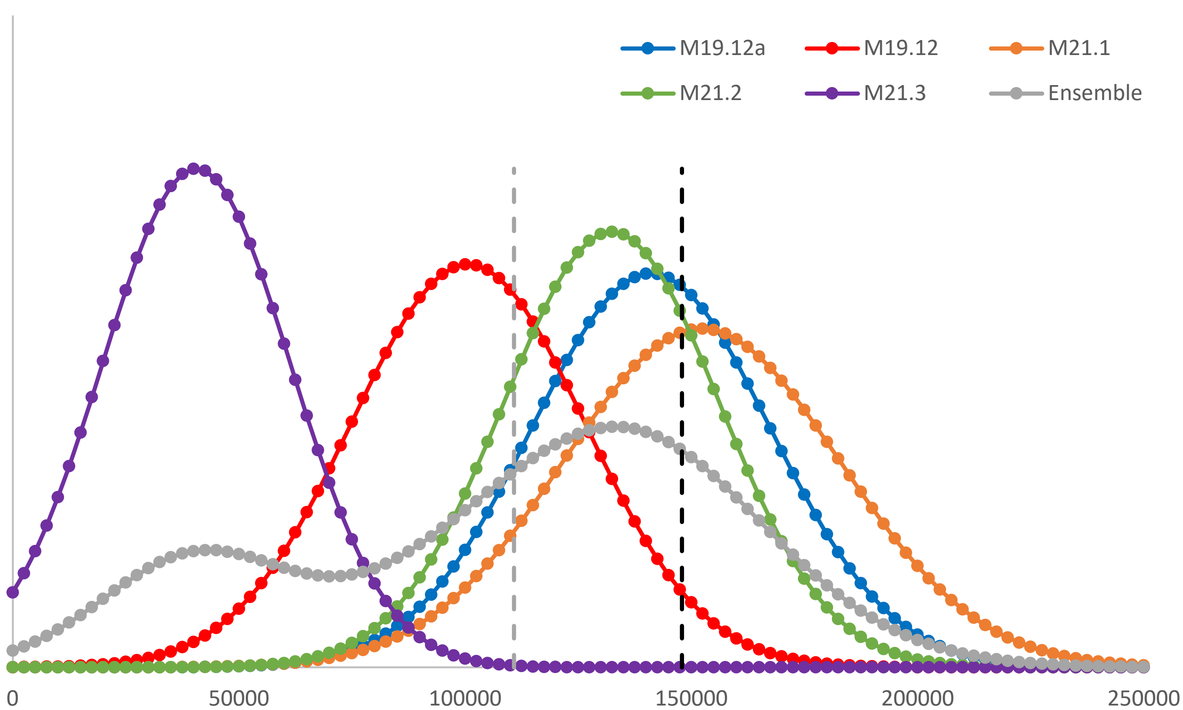


Figure 2.1.24b. Distributions of 2021 OFL as estimated by the models and ensemble. Vertical dashed lines: black = value as currently specified, gray = ensemble mean.

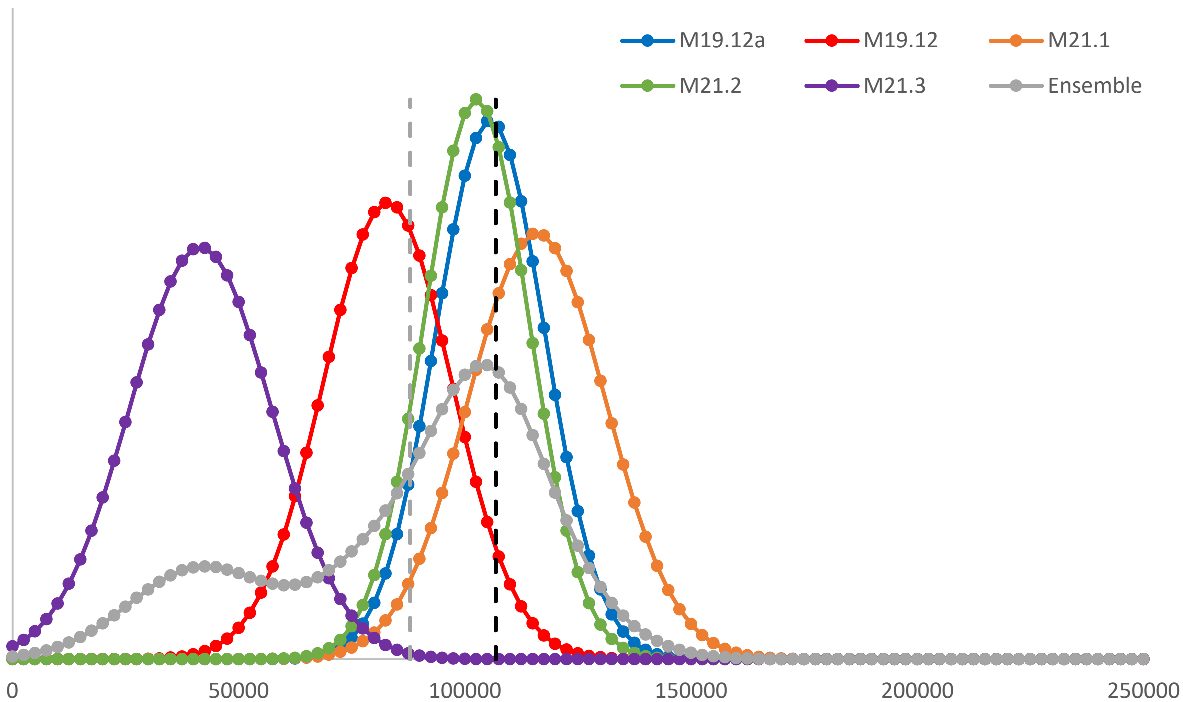


Figure 2.1.24c. Distributions of 2022 ABC as estimated by the models and ensemble. Vertical dashed lines: black = value as currently specified, gray = ensemble mean.

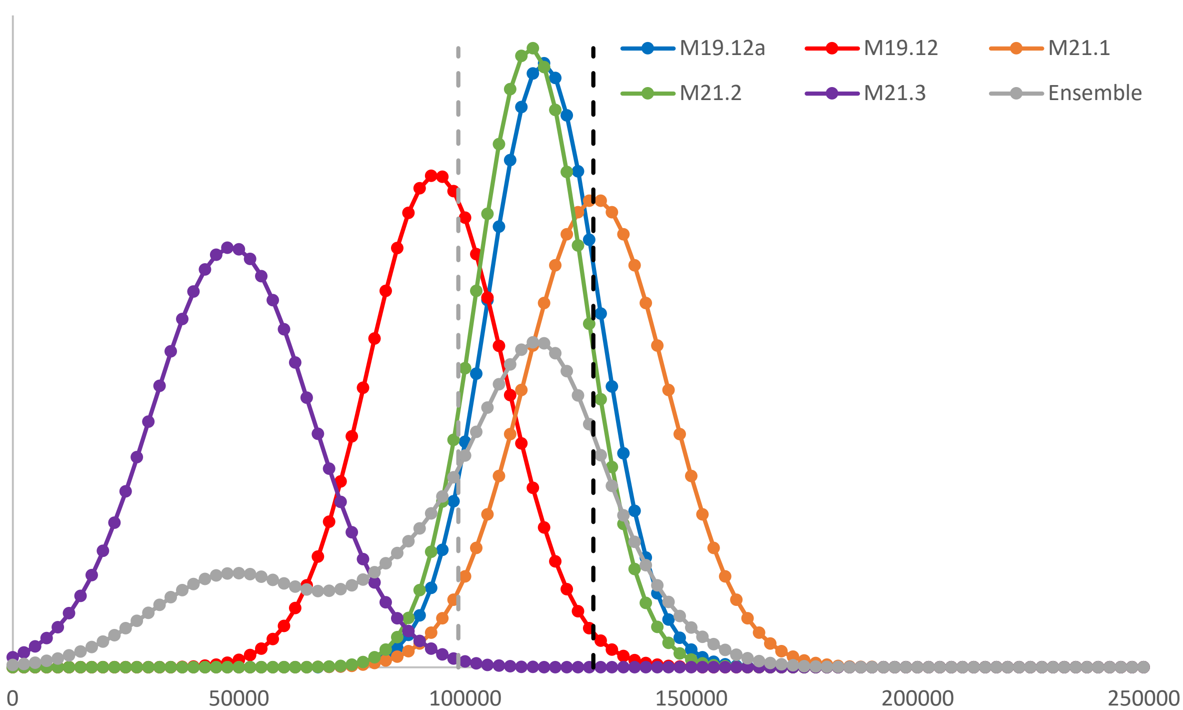


Figure 2.1.24d. Distributions of 2022 OFL as estimated by the models and ensemble. Vertical dashed lines: black = value as currently specified, gray = ensemble mean.

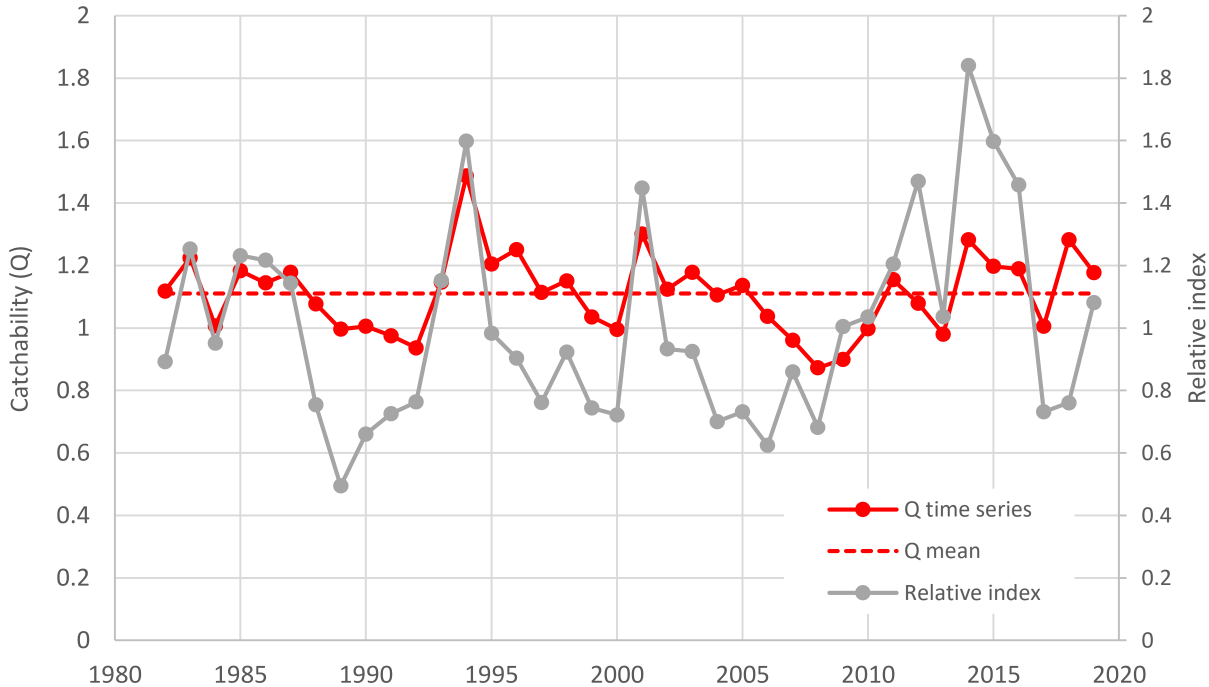


Figure 2.1.25a. Time-varying survey catchability estimated by Model 19.12, compared to survey index.

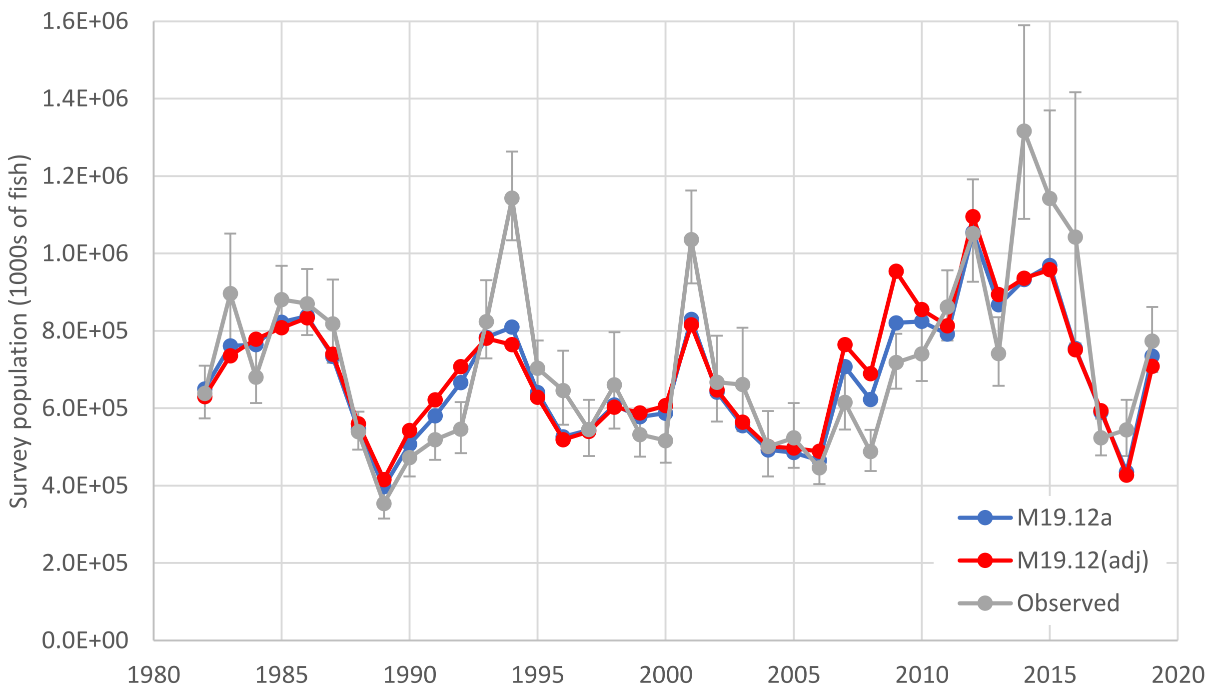


Figure 2.1.25b. Fits to survey index achieved by Model 19.12a and an "adjusted" Model 19.12 (see text).

Attachment 2.1.1: Summary of recommendations from the 2021 CIE review

Compiled by Grant Thompson, Steven Barbeaux, and Ingrid Spies

Resource Ecology and Fisheries Management Division
Alaska Fisheries Science Center
National Marine Fisheries Service
National Oceanic and Atmospheric Administration
7600 Sand Point Way NE., Seattle, WA 98115-6349

Introduction

A review of the stock assessment for Pacific cod in the Eastern Bering Sea was conducted by three reviewers contracted by the Center for Independent Experts (CIE) during the dates of April 26-30, 2021. The reviewers were Yan Jiao (Virginia Polytechnic Institute and State University), Arni Magnusson (General Fisheries Commission of the Mediterranean, FAO), and Henrik Sparholt (University of Copenhagen). The meeting was chaired by Ingrid Spies, and the assessment team consisted of Grant Thompson and Steven Barbeaux. The original terms of reference, plan for conduct of the meeting, background documents, and full reports of the reviewers can be found at https://apps-afsc.fisheries.noaa.gov/Plan_Team/2021_pcod_cie/ (note that the address previously used for this website is no longer valid).

The terms of reference consisted of six main topics, each of which included three subtopics recommended by either the Groundfish Plan Team, the Scientific and Statistical Committee, or Alistair Dunn (a consultant contracted by the Freezer Longline Coalition). In addition, the reviewers added a fourth subtopic of their own to the "Other" topic. As was understood going into the review, there was insufficient time to address all topics and subtopics, so the reviewers were asked to prioritize them. This resulted in some subtopics receiving no recommendations from the reviewers, as expected.

Most of the discussion during the meeting focused on the "Ensemble Modeling" topic, especially the development of specific models to include in the ensemble and the specification of model weights. The reviewers recommended adopting the following set of five models, where Model 19.12a is the current base model (Models "20.8a," "20.9a," and "21.cie" were developed during the meeting; model numbering for this group is provisional only, and follows the convention adopted during the meeting):

Feature 1: Allow catchability to vary?	no	yes	no	no	no
Feature 2: Allow domed survey selectivity?	no	no	yes	no	no
Feature 3: Use fishery CPUE?	no	no	no	yes	no
Feature 4: Estimate survey CV internally?	no	no	no	no	yes
Model (quotes indicate CIE review name):	19.12a	19.12	"20.8a"	"20.9a"	"21.cie"

The criteria in the table below were used to develop the model weights. Each reviewer assigned a score of 0, 1, or 2 for each criterion/model combination, after which the reviewer scores for each criterion/model combination were averaged (shown in the columns associated with the five models). Each criterion was then assigned an emphasis ("Emph.," with color scale extending from red=low to green=high). Criteria for which all models exhibited the same score were assigned an emphasis of 0 and the scores ignored, to avoid skewing the weights toward equality. The reviewers nevertheless recommended keeping the criteria with emphasis=0 in the table in the event that, for some future set of models, at least one of the models were to exhibit a score different from the others.

Criterion	Emph.	19.12a	19.12	20.8a	20.9a	21.cie
General plausibility of the model	3	2	1	0.6667	1	1.3333
Acceptable retrospective bias	3	2	2	1.3333	1	2
Uses properly vetted data	3	2	2	2	0	2
Acceptable residual patterns	3	2	2	2	2	1
Comparable complexity	2	2	1	1	2	2
Fits consistent with variances	2	1	2	1	0	2
Dev sigmas estimated appropriately	0					
Incremental changes	0					
Objective criterion for sample sizes	0					
Change in ageing criteria addressed	0					
Density dependence (other than R) addressed	0					
Regime shifts addressed	0					

Multiplying the average score for each criterion/model combination by the emphasis for that criterion and then computing the weighted average across criteria gives the first row of values in the table below, and rescaling those so that they sum to unity gives the second row of values, which are the reviewers' recommended model weights:

Quantity	19.12a	19.12	20.8a	20.9a	21.cie
Average emphasis:	0.9375	0.8438	0.6875	0.5000	0.8438
Model weight (Ensemble CIE):	0.2459	0.2213	0.1803	0.1311	0.2213

The remainder of this document is organized in order of the terms of reference as prioritized by the reviewers during the meeting, and consists primarily of excerpted recommendations from each reviewer for each topic and subtopic. To reduce duplication, the excerpts were taken primarily from the main body of each reviewer's report, ignoring essentially redundant recommendations in the Executive Summary or Conclusions sections. It should also be noted that substantial portions of the reviewers' reports were devoted to descriptions of the review process, the assessment background, and the structures and results of the models in the reviewers' consensus ensemble, which, while valuable, are not included in the list of recommendations presented here. A total of 50 recommendations were excerpted, distributed across topics, subtopics, and reviewers as shown in Table 2.1.1.1. For ease of reference here and elsewhere, each recommendation in the text is assigned an alphanumeric label containing the first letter of the reviewer's last name. Each recommendation is accompanied by a response from the compilers of this summary.

1. Ensemble modeling

<u>1a. Develop the models to include in an ensemble.</u>
Yan Jiao:

1a.J1: "Given the data available and the stock assessment developed by the assessment team, I support the recommended model ensemble as the best available science and its projected biomass for management consideration."

> *Response*: The CIE reviewers' consensus ensemble is included in the current preliminary assessment.

Arni Magnusson:

1a.M1: "This subtopic was an overarching question during the review workshop: given everything we know about the stock, which model(s) should be used as the basis of scientific advice. The model run that was presented as the base model (19.12a) was thoroughly scrutinized during the workshop and this reviewer agrees this model is the best model for advisory purposes."

> *Response*: As the current base model, Model 19.12a is included in the current preliminary assessment, and will also be included in this year's final assessment.

Henrik Sparholt:

1a.S1: "Model selection related to ensemble modeling involved a broad discussion of all the models considered. In relation to this, density dependence in growth, maturity and natural mortality, was considered important to include in assessment models in the future, because it can cause bias especially in the biological reference points estimations missing them. The extremely high level of complexity in the current SS models (in terms of data and mathematics, not so much in biology where maybe it is too simple) was a concern because it decreases transparency, increases the risk of coding and input errors, increases the risk of selecting a local instead of global maximum in the goal function and make high demands on expertise in statistics, mathematics, and computer skills. A simpler biomass dynamic model (Surplus Production Model) approach, which by design includes all density dependent factors (although not disentangled), was briefly discussed. This was based on a rough analysis by me at the meeting, using the female SSB and the catch time series as input data and various assumptions on the shape of the production curve and its height (Fmsy) from recent meta-analysis. Such an analysis could in the future be an important supplement to the current approach or might even be an alternative given the good quality of the time series of survey and catch data available for this stock."

> *Response*: Because the CIE reviewers' consensus ensemble did not include a biomass dynamic model, such a model is not included in the current preliminary assessment.

<u>1b. Evaluate the use of ensemble modeling in the NPFMC management system, and specifically whether the structural uncertainty and historical challenges in identifying a robust base model make Pacific cod a good application for ensemble modeling.</u>

Yan Jiao:

1b.J1: "The ensemble approach can be used to deal with situations with structural uncertainty, alternative hypothesis on key parameters, and the application of alternative datasets. The review panel suggested to investigate and compare the model goodness of fit (negative loglikelihood and # of parameters used) and retrospective error for each model considered in the ensemble."

> *Response*: Agreed. Objective function values, parameter counts, and retrospective errors are always reported for all models.

1b.J2: "The current weighting is based on the rank of the three reviewers. For future usage of this approach, it should be reasonable for AFSC and SSC members to participate in the weighting surveys."

> *Response*: Agreed. The model weights recommended by the Plan Team during last year's November meeting were based on such an exercise.

1b.J3: "The review panel and the assessment team also discussed the cross-conditional model averaging approach developed by Thompson (2021). Reviewers generally demonstrated interest in this approach. However, it is not possible to try this approach based on the EBS Pacific cod case in a short time."

Response: The reviewers' interest in the cross-conditional model averaging approach is appreciated. A manuscript describing the approach has been submitted to *Fisheries Research*.

Arni Magnusson:

1b.M1: "Overall, the model ensemble approach proved to be efficient and balanced, fueling constructive and insightful discussions."

Response: Agreed.

Henrik Sparholt:

1b.S1: "Precisely, because it is difficult to get good data on whether a selection curve is dome-shaped or not, the ensemble approach is especially suitable for this situation because several realistic levels of dome shapes can be included, and the ensemble results might reflect this uncertainty appropriately."

Response: Agreed.

1b.S2: "The panel also discussed a suggestion by Grant Thompson on a more objective approach to determine model weights in the ensemble approach. It is called "Cross-conditional model averaging" (CCMA)…. The method has an appealing objectivity aspect, which the above approach does not have. Time did not allow the panel to go into a deep analysis of the approach, but noted two other major issues, one is that of increased complexity, and the other that of a challenge of incorporating models structured differently from the SS models like e.g., biomass dynamic models."

Response: The reviewer's interest is appreciated. He is correct that the CCMA approach is more complicated than conventional model averaging. However, incorporation of biomass dynamic models, particularly if they use a subset of the data used by the age-structured models, should not pose a problem for the CCMA approach. See also response to recommendation 1b.J3.

<u>1c. Consider whether to apply the sloping harvest control rule before or after ensemble averaging of SSB and other reference points.</u>
Yan Jiao:

1c.J1: "The 'before' approach averages SSB and reference points from each model in the ensemble, so easy to perform."

Response: Averaging of SSB and reference points from each model is common to both the "before" and "after" approaches. The distinction is whether to average the harvest specifications (or their distributions): 1) as freely estimated in each model (the "before" approach), or 2) after re-running the models with the ABC or OFL fishing mortality rate fixed at the ensemble average (the "after" approach). The reviewer is correct that the "before" approach is simpler.

1c.J2: "The 'after' approach requires generating a 'new' model with averaged parameters, so computationally can be more complicated. I generally support the "after" approach. When Bayesian approaches are used, the computation of the "after" approach can be done by resampling the posterior runs of the parameters including the estimated F, and project into the next year etc., so not impossible. Bootstrap algorithm can be used to reach the goal also. After discussion with the assessment team, such an approach is currently not available in the SS3 existing functions but may be considered outside of the SS3 computation."

Response: This is just one interpretation of the "after" approach, and would likely require an immense amount of work. One aspect of this approach that appears intractable is how to "average" parameter values in models with fundamentally different structures.

1c.J3: "In the 'after' approach, unlike in the 'before' approach, F2021 is assumed as a constant rather than a function of internally estimated parameters, and so has zero standard deviation. The estimated standard deviation of the ensemble ABC in the 'after' approach is smaller because of this. If computation outside of SS3 is not available in a short time, the average uncertainty of F2021 from each model may be considered as an approximate measurement of F2021 in the 'after' approach when computing ABC in the future."

Response: Except in the case of a simple biomass dynamic model, it is unclear how an after-the-fact approximation of the uncertainty in F_{ABC} or F_{OFL} would be used to adjust a distribution of ABC or OFL that has been computed on the basis of a fixed value for F_{ABC} or F_{OFL}.

Arni Magnusson:

1c.M1: "Without going very deep into the statistical intricacies, the conclusion for this reviewer was that it did not make a big difference and would require further investigations and examples to produce convincing arguments for selecting one approach over the other."

Response: Attachment 2.1.3 describes further investigations and examples.

Henrik Sparholt:

1c.S1: "The panel discussed whether model averaging should be applied before or after application of the Harvest Control Rule and tended to the slight preference for calculating the goal parameter, e.g., the ABC, by each model, before averaging. However, based on a presentation by Grant Thompson at the meeting where all the pros and cons were listed, it was not easy to judge. It was not even easy to say which approach was the simplest one as at least the one where the averaging is done before the HCR is applied, can be conducted in many alternative ways. In terms of the often-suggested strategy, that of a module build approach where each element in the scientific advice is done separately, the philosophy of having the averaging done to reflect the best estimate of the current stock size and reference points estimates, even though they might not be completely consistent (understood as could be derived by one model), the averaging done before would be better. The panel did not reach a conclusion. I am inclined to favor the option of averaging the ABCs after the HCR has been applied to each model, because it seems simpler and because it can accommodate different model structures like cohort-based models mixed with biomass dynamic models."

Response: To be consistent with the terms of reference and the rest of the discussion on this subtopic, it should be noted that:

- The reviewer's reference to "the one where the averaging is done *before* the HCR is applied" actually corresponds to the "*after*" approach.
- The reviewer's reference to "averaging the ABCs *after* the HCR has been applied to each model" actually corresponds to the "*before*" approach.

The reviewer is correct that the "before" approach is simpler and, unlike the "after" approach, can accommodate models with fundamentally different structures. The current preliminary assessment uses the "before" approach to compute the ensemble ABC and OFL.

2. Movement

<u>2a. Comment on avenues for incorporating spatial dynamics and movement.</u>
Yan Jiao:

2a.J1: "The review panel found the satellite tag experiment and model developed very informative and may be further continued if possible. The satellite tagging study and the genetic study suggested that the EBS and NBS Pacific cod is appropriate to be managed as one stock but there is a seasonal movement of the individuals and how the movement rate may change given environmental factors or age groups needs further studies (Rand et al. 2014; Spies et al. 2020; Nielsen et al. 2021 presentation). The studies also suggest that the EBS cod may move to the Russian water and further communication or data exchange with the Russian fisheries management agency should help future studies on movement or changes in the spatial distribution of Pacific cod."

> *Response*: Agreed.

2a.J2: "Because the satellite tagging study was only for about one year, and years with NBS survey are limited also, the data available for the potential to incorporate movement is limited, a simulation study to look into the influence of movement on the stock assessment, how the model ensemble or base model without considering movement may perform should help in a short time before further tagging data available."

> *Response:* Attachment 2.1.2 describes, and reports results from, a simulation study with some of the reviewer's suggested features.

2a.J3: "I would also recommend an approach developed in Jiao et al. (2016), in which the spatial asynchrony was considered, and the area-specific population abundance indices were used to calibrate it."

> *Response*: The paper by Jiao et al. (2016) describes a method for incorporating surveys with little or no spatial overlap by accounting for spatial autocorrelation. Because this is precisely what the VAST model already does, and because the VAST estimates of the combined EBS and NBS surveys have already been accepted for use by the Plan Team and SSC, the approach of Jiao et al. (2016) is not used in the current preliminary assessment.

Arni Magnusson:

2a.M1: "There is clear evidence from the trawl surveys that the distribution of the EBS Pacific cod has shifted north and northwest. The northward shift poses a problem for the stock assessment if a substantial part of the population is outside the defined geographic range of the assessment, in Russian waters. This would cause a negative bias in the observed survey index and total catches, which have in fact both been declining in recent years. A bias could also affect the age and length composition data if, for example, older and larger fish are the ones making long-distance feeding migrations into Russian waters. A solution to these problems could be to combine US and Russian data from trawl surveys and the commercial fisheries."

> *Response*: Although movement into Russian waters does pose a problem for the assessment, whether this phenomenon causes a negative bias in the observed survey index and total catches is less clear, as the existence of such bias may depend on whether those time series are viewed as representative of the overall stock or just the portion residing in the U.S. EEZ. Attachment 2.1.2 is intended to begin the process of understanding potential implications of movement to and from Russian waters. Some of the input values used in that study were based on combining data from U.S. and Russian trawl surveys.

2a.M2: "In addition to biased estimates, the northward shift can also pose a problem for the management of the stock, if the fishing mortality rates (F) are higher on one side of the boundary. In a hypothetical scenario where F increases to high levels on the Russian side in the path of the feeding migrations, the population could decline on the US side even if a sustainable level of F is applied. A solution to this problem could be if the two countries agree on a similar target F for the shared stock."

> *Response*: Attachment 2.1.2 includes an examination of the impacts of, and potential management responses to, unequal harvest rates in the two national jurisdictions. In order for an international agreement on a target fishing mortality rate to be meaningful, it seems that it would have to be accompanied by international agreement on assessments of the portions of the overall stock residing within each nation's jurisdiction, both of which sound like difficult undertakings, unlikely to be achieved in the short term.

2a.M3: "Rather than adding spatial dynamics and movement into the stock assessment model, it is recommended that a variety of spatial analyses should be conducted to monitor and understand shifts in the geographic distribution of the stock. This applies both to shifts within US waters and the stock range extending into Russian waters. The approaches can include sophisticated analytical models, but also basic plots of densities in surveys, catches in the Western Bering Sea, and locations of tag recoveries."

> *Response*: Neither spatial dynamics nor movement have been added to any of the models in the current preliminary assessment. Attachment 2.1.2 is an example of a spatial analysis of the type recommended here. A table of catches in the WBS and plots of survey densities and tag recovery locations are also included in the current preliminary assessment.

Henrik Sparholt:

2a.S1: "The movement discussion mostly focused on whether cod in the Eastern Bering Sea may move into Russian waters, and there was a large emphasis placed on preliminary work by Cecilia O'Leary on this topic using data from Russian surveys in Russian waters and pop-up tags which showed that several fish moved from U.S. waters to Russian waters. Internal movements within the Eastern Bering Sea, including the Northern Bering Sea, were not regarded as one of the most important issues, because the survey now covers the area EBS + NBS and the VAST method can fill in the missing years in the past time series. Whether the entire EBS + NBS + WBS (Russian part of the Bering Sea) area has one stock only seems plausible, but it is an exceptionally large area and there might by sub-populations or even genetically distinct population. This seems to be an important future research topic to try to find out."

> *Response*: Agreed. Further work is merited to examine the relationship between cod from these regions, particularly incorporating the WBS that has not been done to date. Recent satellite tagging work combined with genetics will help determine whether there is a genetic predisposition for cod tagged in the EBS in summer to move into Russian waters versus move southward into the EBS. In addition, if samples were available from across the WBS, more genomics work could be done to explore this question.

2a.S2: "Even if biologically distinct, P.cod is one stock spanning the entire U.S. and Russian area, in terms of management it might be practical to keep the US part separate from the Russian part. Because the area is so huge and both countries are now running a sensible management of the fisheries (Russia got its fishery MSC certified a few years ago) it is unlikely that one part could severely impact the total stock and that way damage the fishery for the other part by its management or lack of management."

> *Response:* Attachment 2.1.2 addresses the issue of unequal harvest rates in the two national jurisdictions. See also the response to recommendation 2a.M2.

2a.S3: "Furthermore, it is not unlikely that there are in fact genetically separate sub-stocks (which then would be real stocks) in this huge area. In the North Sea, a similar sized area in the eastern Atlantic, it has recently been discovered by use of the now easily available genetics techniques that Atlantic cod (a remarkably similar species) is in fact made up of at least two genetically separate stocks (that mix outside spawning time) (ICES 2020)."

> *Response*: It is unlikely that Pacific cod in the Bering Sea consist of two groups that are as differentiated as the two ecotypes of Atlantic cod (Northeast Arctic cod, NEAC, and Norwegian Coastal Cod, NCC). Whole genome research indicates that there are large differences between cod found in the Aleutian Islands and Eastern Bering Sea that are likely due to local adaptation (Tarpey et al., *in prep*.), but differences within the Bering Sea are not as large as those found between NCC and NEAC. There is some indication of genetic differences among cod spawning along the Bering Sea shelf (Spies 2012; Spies et al. 2019); however, more work is needed to understand whether these differences are significant or whether cod that spawn along the eastern Bering Sea shelf represent a single stock. Similarly, cod that are fished on the Russian side of the Bering Sea shelf are likely genetically similar to cod on the U.S. side of the Bering Sea shelf, but more work remains to understand that relationship. Few studies have looked for large-scale differentiation among Pacific cod from the U.S. and Russia. Smirnova et al. (2018) found a break between Japan and Korean cod. Similarly, spatially distinct patterns have been found at a putative zona pellucida gene between spawning samples adjacent to the Bering Sea and samples further southward (Spies et al., *in prep*.).

<u>2b. Consider how to inform the dynamics of movement or abundance between the Northern Bering Sea and the Eastern Bering Sea, specifically from additional experiments and analyses, data analyses that include these assumptions (i.e., VAST), and how these can best be used within the different models as indices of abundance.</u>
Yan Jiao:

2b.J1: "The review panel was not able to evaluate the VAST or the ADT modeling approach because of lacking details on the model developed, data used, and results."

> *Response*: The current preliminary assessment provides details on the model developed, data used, and results.

Arni Magnusson:

2b.M1: "The reviewers agreed that it would be useful to gain better understanding of fish movement between the NBS and EBS areas, as well as identification of spawning areas within NBS. Overall, fish movement within the geographic range of the stock assessment may in many cases not pose any significant problems. Local depletion is one factor to consider, though, when an increase in stock abundance is mainly in the north, but most of the fishing takes place further south."

> *Response*: Agreed. Additional tagging work was conducted during this summer's bottom trawl surveys, with 16 pop-up satellite archival tags (PSATs) being deployed during the EBS survey, and up to 30 in the NBS (with 3 stationary tags). All tags were deployed using hook and line gear. The NBS locations were similar to those of the previous PSAT project, with one additional location in the northeast corner of the survey area, toward the Bering Strait.

Henrik Sparholt:

No recommendations.

<u>2c. Develop movement models.</u>
Yan Jiao:

2c.J1: "The review panel questioned whether we really need movement models for a stock whose distribution is covered almost entirely by the EBS and NBS bottom trawl surveys. The panel felt understanding the degree to which the stock ranges into Russian waters is of great concern also. Overall, the panel recommends further tagging studies."

> *Response*: Agreed for the most part, although movement between the EBS and the NBS could be important if fishery characteristics (e.g., selectivity) or life history characteristics (e.g., growth) differ between the two areas. With respect to movement between either the EBS and the NBS or the combined EBS and NBS and the WBS, the need for movement models may be of less immediate relevance than the lack of data sufficient to parameterize such models.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

3. Fishery CPUE

<u>3a. Discuss standardization of fishery CPUE using alternative statistical methods, including a discussion of historical changes in the fishery that may affect the relationship of the index to abundance.</u>
Yan Jiao:

No recommendations.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

<u>3b. Develop a fishery CPUE index.</u>
Yan Jiao:

3b.J1: "CIE review panel all agreed that the development of an appropriate index is important, but it cannot be accomplished during this meeting. I agree with this recommendation."

> *Response*: Agreed. Curry Cunningham (University of Alaska) will be supervising a graduate student with this as his or her thesis topic.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

3c. Consider how best to further analyze CPUE, including development of spatio-temporal analyses of fleet specific CPUE indices that may help inform the model or supplement the trawl survey biomass indices.
Yan Jiao:

3c.J1: "The VAST model did not provide enough details and it only uses one type of fishery data (hook-and-line) and only used two months of data (January and February). I feel that a model-based approach is necessary but the rationale of only using two-month data and only use one fishery need to be addressed. The fishery has a clear monthly pattern and likely important to be considered. Also, the first two months (January and February) of hook-and-line fishery may face gear saturation and it is unclear whether such factors were considered or not. The review panel feels that the model and approach are promising but further details are needed."

> *Response*: The current preliminary assessment provides details of the VAST fishery CPUE index, including a rationale for focusing on the January-February longline fishery. The reviewer is correct that the longline fishery CPUE data exhibit a clear monthly pattern. However, it is unclear that this renders selection of the January-February interval problematic, because: 1) the existing assessment models all use an annual time step, 2) the index is relative only, and 3) the monthly pattern appears to remain approximately constant across years (see Figure 2.4 in last year's stock assessment). The reviewer is correct that, at least in principle, gear saturation poses a potential problem.

3c.J2: "I would recommend a hierarchical Bayesian model or a mixed effect model to be considered. In such approaches, the fishery fleet can be considered as random effect when considering multiple fisheries in the fishery CPUE standardization."

> *Response*: This recommendation has been forwarded to Curry Cunningham for consideration in his graduate student's research (see response to recommendation 3b.J1).

3c.J3: "I feel fleet-specific fishery CPUE analysis for the fishery with better quality data, such as with larger spatial coverage, credible logbook records with spatial-temporal information, etc., is reasonable. The specific gear selectivity needs to be further considered since the current stock assessment models used one fleet that combines all the fishery types."

> *Response*: The first part of this recommendation has been forwarded to Curry Cunningham for consideration in his graduate student's research (see response to recommendation 3b.J1). Regarding the second part, given that the reviewers' consensus ensemble retains the combined-fishery format of the current base model, models with gear-specific selectivity are not included in the current preliminary assessment. Nevertheless, the reviewer is correct that this aspect of the reviewers' proposed model incorporating the fishery CPUE index is problematic.

Arni Magnusson:

3c.M1: "The VAST approach seems promising as method to analyze CPUE, calibrating the annual catch rate index from the commercial fishery in a way that gives appropriate weighting to data points based on their spatial location. However, it is not apparent that commercial CPUE will add useful information to the stock assessment, given that a high-quality survey is already in place."

> *Response*: Agreed.

Henrik Sparholt:

3c.S1: "Fishery CPUE has been given up in most data rich assessments in the northern hemisphere due to problems getting proper fleet definition…. For the fishery on P.cod in the EBS+NBS sufficient detailed data seems to be available and the issue with targeting seems to be less of a problem than usually, at least for the most important fleet component, the hook and line procession vessels…. Thus, it seems to be a potential option to try to develop a fishery CPUE index for this H&L PV fleet component…. Developing a quality CPUE index is, however, not something which is done 'overnight' and would rather be suitable for say, a PhD project."

> *Response*: Agreed. See the response to recommendation 3a.J1.

3c.S2: "Hyper-stability is an issue that needs special attention and the panel speculated that this might be tackled by somehow including 'other data' (maybe from the survey or from other fleets and where the focus should be on the special distribution of the stock by season) in the approach."

> *Response*: Agreed. Hyper-stability of fishery CPUE data is an issue, and the VAST modeling framework does, at least in principle, allow inclusion of survey CPUE data along with fishery CPUE data in a deriving an index of abundance. However, in keeping with the reviewers' consensus ensemble, the models presented in the current preliminary do not include a VAST index based on both fishery CPUE and survey CPUE data. This recommendation has been forwarded to Curry Cunningham for consideration in his graduate student's research (see response to recommendation 3b.J1).

3c.S3: "Variation in market conditions from year to year might also influence when a vessel decides to stop fishing at low catch rates, and this influences what to assume for not-fished space-time cells in the analysis (if it is cell based), and this is an important further complication."

> *Response*: This recommendation has been forwarded to Curry Cunningham for consideration in his graduate student's research (see response to recommendation 3b.J1).

3c.S4: "Technological development and improvements in fishing gears and thus in catchability are extra challenges. Usually, many aspects of the fishing operation are changing just in a single year, and of course even more so over a long time series and often these cannot be easily revealed and quantified. The panel speculated that the ambition could be to aim for a quite short CPUE timeseries – say 10 years – so that not too much technological creeping is going on in the time window considered. This could mean that for each future year the time series should be truncated by discarding data more than 11 years old."

> *Response*: This recommendation has been forwarded to Curry Cunningham for consideration in his graduate student's research (see response to recommendation 3b.J1).

4. Age data

<u>4a. Attempt to resolve problems with using fishery age compositions.</u>
Yan Jiao:

4a.J1: "I am wondering whether the number differences of age bin and size bin matters when using age composition and size compositions. For example, there are only 12 age groups but the size bin used in the model is 1cm, which implied that there are lots more size composition data to be fitted than that of age composition."

Response: This concern seems misplaced. First, note that the average input sample sizes for length data and age data are the same (per fleet), and that use of the Dirichlet-multinomial approach automatically adjusts the average sample sizes appropriately. Second, for a given sample size, an increase in the number of bins for a given multinomial data set would likely decrease, rather than increase, the leverage of that data set relative to the other data. For example:

- Let m and n represent the number of bins and the sample size, respectively.
- Let n be a power of 2; specifically, $n = 2^{jmax}$, for some positive integer *jmax*.
- Then, consider a range of values for m. Specifically, for j=1,2,…,*jmax*, set $m_j = 2^j$.
- For each m_j, let the samples be distributed evenly among the bins.
- This implies that the MLE of the proportions will always be $1/m_j$.
- Then, the log of the determinant of the Hessian matrix **H**, evaluated at the MLE, is:

$$\ln(|\mathbf{H}|) = -ln(m_j) - (m_j - 1) \cdot \left(ln(m_j) + ln(n)\right),$$

which is a monotone decreasing function of the number of bins.

4a.J2: "The future diagnostics may include checking the fitting to age and size compositions to see which year and age groups that the model did not fit well and where the retrospective error mainly caused by; checking the model performance when using larger size bins to match the number of age groups in the age composition data."

Response: See response to recommendation 4a.J1. Moreover, use of a coarser bin structure for size data is likely to degrade the model's ability to estimate growth parameters, so even if this suggestion were to eliminate the retrospective bias associated with use of the fishery age composition data, it is not clear that biased estimates of growth parameters is an acceptable cost.

Arni Magnusson:

4a.M1: "A good tool to examine discrepancies in the age data would be to fit a simple statistical catch-at-age model. Residual patterns and other diagnostics from that model can be used to guide the examination of possible errors in the age data, or at least pinpoint where exactly discrepancies occur in the age data. Findings from this examination can then be used to make informed choices to update the data preparation or consider making specific changes in the base model."

Response: Agreed.

Henrik Sparholt:

4a.S1: "The panel suggested that growth estimates from tagging studies could also be included in verification of the age readings. This has proven useful for other fish stocks."

Response: Agreed.

<u>4b. Consider how best to include the fisheries age and size composition data, including consideration of fleet specific age composition data in the model.</u>

Yan Jiao:

No recommendations.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

4b.S1: "The hope is that age data from the fishery can be included in the assessment models at some point in time. The panel speculated that maybe the used growth curve lacking seasonal variations in growth might contribute to the problem, and now the assessment model is based on years and not quarters of the year. Of course, this means that the model should go back to how it was some years ago, to be based on quarterly time steps or other changes to accommodate this seasonal growth pattern."

> *Response*: Agreed. However, since all of the CIE reviewers' recommended models were based on an annual time step, models with seasonal structure are not included in the current preliminary assessment.

4b.S2: "In order not to go against the aim for reducing model complexity one could think of stop including length data and use only age data. These should then be worked up by fleet and season before merged into annual data and entering the assessment model. This would also avoid the complexity of having to estimate growth. Maturity by age could then also be given by year, which is an unfortunate lack of biological complexity at the moment of the SS models. In that way density dependence in both growth and maturity would automatically be included in the part of the model assessing the historical stock development."

> *Response*: Because estimates of fishery weight at age are currently lacking for many years, eliminating the model's ability to estimate length-at-age parameters would likely prove problematic, because calculation of weight at age is currently based on applying weight at length parameters to length at age estimates.

4c. Investigate 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.
Yan Jiao:

4c.J1: "Some review panel members suggested that this may be diagnosed step by step. For example, one model scenario can be to turn off ageing bias and see what happens; another scenario can use the externally estimated growth with ageing uncertainty and see what happens."

> *Response*: Agreed, although external estimates of fishery length at age are currently lacking for many years.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

5. Compositional data

5a. Consider methods (e.g., bootstrapping) to estimate uncertainty and variance in the composition data, with the results then used to estimate initial sample sizes for each season, fleet, combination for input into the assessment model.
Yan Jiao:

No recommendations.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

5b. Review methods to scale the composition data and include consideration of methods that scale observer samples to the catch by vessel, location, and time of event.
Yan Jiao:

No recommendations.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

5b.S1: "The ad hoc approach used in the current models of scaling the hauls numbers from the fishery to the hauls numbers from the survey seems quite sensible although it would not reflect large persistent changes in sampling intensity in either of the two entities."

> *Response*: The current approach scales all of the fishery input sample sizes so that the average equals the average of the survey input sample sizes, meaning that inter-annual proportional changes in sampling intensity are still reflected in the time series of input sample sizes.

5c. Consider analyses of the size- and age- composition data to identify if there are specific locations or time periods when a recruitment signal may be apparent to assist in informing the assessment model of the strength of recent recruitment.
Yan Jiao:

5c.J1: "The review panel felt that this topic is meaningful and very useful for the assessment. The study may start from the age composition or size composition data to look into the overlap cross cohorts in the earlier age groups. The analysis may also look into the age or size groups with low or zero selectivity by the fishing gears but selected by the survey gears. Because the assessment models all used time-varying selectivity, it may confound with the cohort signals to be estimated. An external analysis with plots such as bubble plots, etc., is encouraged for future external analysis."

> *Response*: Although the analyses described in this recommendation may provide additional insights, it is worth noting that the existing survey time series has historically provided a remarkably reliable early indication of year class strengths.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

6. Other

6a. Consider incorporation of dome-shaped survey selectivity.
Yan Jiao:

6a.J1: "The CIE review panel found that existing studies based on field data do not suggest that a dome-shaped survey selectivity is largely possible (Weinberg et al. 2016). To address this hypothesis, a model (M20.8a) with dome-shaped survey selectivity was suggested to be included in this year's models of the ensemble or simply as a sensitivity run."

> *Response*: The CIE reviewers' recommended model with dome-shaped survey selectivity (or, more accurately, unconstrained survey selectivity parameters) is included in the current preliminary assessment.

Arni Magnusson:

6a.M1: "All in all, there is no convincing evidence that the survey is dome-shaped, but to take this possibility into account, one such model is included in the model ensemble. The commercial fleet selectivity is already estimated as dome-shaped and having the survey selectivity also dome-shaped can give the model more flexibility than is warranted by the data. The base model is therefore a more robust and useful basis for management purposes."

> *Response*: See response to recommendation 6a.J1. In keeping with the CIE reviewers' consensus regarding model weights, the base model is given more weight than the model with dome-shaped selectivity in the current preliminary assessment.

Henrik Sparholt:

6a.S1: "It is in general difficult to determine whether a selection is dome-shaped or not, but a study referred to from 2016 looking at underwater videos of the behavior of cod in front of the trawl gear during fishing operation indicated that large cod did not avoid the trawl more than young cod pointing towards a flat selection curve. Without going into the study in details it was noted that such studies are notoriously difficult to conduct. For instance, the potential spatial distribution of large cod in attractive habitat like rough areas and around shipwrecks, where fishing is difficult, might still result in a dome-shaped selection. The possibly hidden large fish probably come forward at spawning time and if it would be somehow possible to get absolute stock estimates of spawners at that time, maybe this could be used to obtain information about the amount of 'hiding' of large fish and then of extent of the dome-shape selection curve."

> *Response*: It is not clear how estimates of the total number of spawners could be obtained, except from the stock assessment model, but then the argument would be circular.

6a.S2: "Another possibility might be by the use of pop-up satellite tags and catch rates of these by size of cod, but many tags would probably be needed, and they are expensive. This type of study is probably best conducted separately from the annual stock assessment modelling."

> *Response*: The overall number of PSAT tags deployed, while increasing over time, is still far too small for this recommendation to be implemented, which will likely be the case for many years.

6b. Consider the diagnostic plots of fits and residuals (including normalised or Pearson residuals) for the age and size composition data and make recommendations on how the model fits may be improved.
Yan Jiao:

No recommendations.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

6c. Consider inclusion of other survey information (e.g., the IPHC and sablefish surveys).
Yan Jiao:

No recommendations.

Arni Magnusson:

No recommendations.

Henrik Sparholt:

No recommendations.

6d. Although not listed in the original set of recommendations for the 'other' category, the review panel suggested that consideration of density dependence in a variety of life history processes may be important in assessment models."
Yan Jiao:

No recommendations.

Arni Magnusson:

6d.M1: "The base model allows recruitment to be estimated freely, according to the information in the data about cohort sizes, and those recruitment fluctuations may or may not turn out be related to density dependence. The base model also incorporates time-varying length-weight coefficients estimated from the data, so changes in growth may or may not be related to density dependence. The review workshop did not identify a simple setting in the SS3 model settings that would allow specific examination of possible density-dependent effects. Overall, it seems that the base model has the flexibility to take density dependence into account, if the data suggest that is the case."

> *Response*: Because the time-varying weight-at-length parameters are estimated freely outside of the assessment model, the reviewer is correct that there is some potential for those estimates to reflect density dependence. Although the reviewer is correct that the consensus understanding during the meeting was that SS does not allow density-dependent effects, after the review meeting it was discovered that SS does now feature such an option, so inclusion of density-dependent effects in a future assessment is not outside the realm of possibility.

Henrik Sparholt:

6d.S1: "I presented a rough run using biomass dynamic models (Surplus Production Models - SPM). The SPMs by design includes all density dependent mechanisms, although not in a disentangled way. Such a disentangling is not needed for ABC advise, but of course it would be useful to = understand the population dynamics of the stock. The runs were based on the software SPiCT (Pedersen et al. 2016 and GitHub - DTUAqua/spict: Surplus Production model in Continuous Time), a software used extensively by ICES expert groups in recent years and on an ad hoc Excel software…. As expected, (due to the inclusion of all density dependent factors and not just that in egg survival to the recruitment stage), the B100% (and thus B40% and B35%) was generally estimated to be lower than by SS and Fmsy higher. MSY was generally estimated to be about the same. If this model is closer to the true population dynamic of the stock, it has of course implications for the annual advice. Therefore, it might be fruitful to analyse this approach in much more detail than done here for the current assessment."

> *Response*: Because models based on the SPiCT approach were not included in the CIE reviewers' consensus ensemble, neither are they included in the current preliminary assessment (see also response to recommendation 1a.S1).

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Table 2.1.1.1.
Counts of reviewer recommendations.

		Reviewer			
Topic	Subtopic	Jiao	Magnusson	Sparholt	Total
1	a	1	1	1	3
	b	3	1	2	6
	c	3	1	1	5
2	a	3	3	3	9
	b	1	1	0	2
	c	1	0	0	1
3	a	0	0	0	0
	b	1	0	0	1
	c	3	1	4	8
4	a	2	1	1	4
	b	0	0	2	2
	c	1	0	0	1
5	a	0	0	0	0
	b	0	0	1	1
	c	1	0	0	1
6	a	1	1	2	4
	b	0	0	0	0
	c	0	0	0	0
	d	0	1	1	2
Grand total:		21	11	18	50

Attachment 2.1.2: A simple, two-area model of the Pacific cod stock in the Bering Sea

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Introduction

A key concern identified by the 2021 CIE review of the stock assessment for Pacific cod (see Attachment 2.1.1) was the lack of understanding regarding the relationship between the fisheries for Pacific cod in the American and Russian portions of the Bering Sea, because the few data available to date suggest that Pacific cod move back and forth between the two areas (see, for example, Figure 2.1.5 in the main text). Because the amount of data available to describe this relationship is fairly small, the reviewers did not suggest attempting to create a full, statistical assessment model incorporating movement between the two areas. However, one reviewer did suggest development of "a simulation study to look into the influence of movement on the stock assessment," and another suggested development of "analytical models" to "understand shifts in the geographic distribution of the stock … extending into Russian waters." This attachment represents a first attempt at responding to these requests.

The study described here consists of developing a very simple, deterministic, age-structured, two-area model, with results focused primarily on age-aggregated (but area-specific) equilibrium outcomes. The primary goals are to understand which variables determine both relative and absolute biomasses and yields in the two areas, how various outcomes may be independent of specific parameters, and how various parameters covary in order to result in particular outcomes.

Area 1 will be defined here as the portion of the Bering Sea under the jurisdiction of the U.S.A., comprised of the Eastern Bering Sea (EBS) and Northern Bering Sea (NBS) survey areas; and area 2 will be defined as the Western Bering Sea (WBS), under the jurisdiction of Russia. From the perspective of managing the American fishery, exploitation by the Russian fishery represents an externality. In principle, harvest rates in the American fishery can be set independently of this externality, or they can be adjusted in light of this externality to achieve an overall (i.e., across areas) harvest objective, and this is among the outcomes explored here.

Methods

<u>Assumptions</u>

The model reflects the following assumptions:

- The stock occupies two areas, indexed 1 and 2.
- Fishery management is designed to achieve a target level of relative spawning per recruit (*rspr*).
- The harvest control rule consists of a single exploitation rate (i.e., no inflection points).
- All parameters are both age- and time-invariant.
- Individual body weight varies linearly with age.
- Time (t) is measured in discrete units of years.
- Population dynamics are entirely deterministic.
- Annual population dynamic processes occur as discrete steps, in the following order:
    - Recruitment
    - Growth

- Exploitation
- Natural mortality
- Movement

Constants
The model makes use of the following constants:

- *amax* is the maximum (terminal) age in the population.
- *arec* is the age of recruitment (to both the exploited and spawning stock).
- *nage* is the number of ages in the model, equal to *amax*–*arec*+1.
- *ntim* is the number of time periods (years) over which population dynamics are simulated by the model, equal to *nage*+2 to assurance convergence to the equilibrium state.
- $rspr_{targ}$ is the target level of *rspr*.

Parameters
The parameters used in the model are as follow:

- *v* is the area-invariant discrete annual natural mortality rate.
- w_{arec} is the area-invariant individual body weight at the age of recruitment (in kg).
- *k* is the area-invariant relative slope of the linear weight-at-age relationship.
- u_1 and u_2 are the area-specific discrete annual exploitation rates.
- $pstay_1$ and $pstay_2$ are the area-specific "staying" probabilities (i.e., the probability that a fish residing in area *i* in year *t* will stay in area *i* in year *t*+1).
- $prect_1$ is the proportion of each year's recruitment that resides in area 1.
- $rect_1$ is the number of individuals (in 1000s) recruiting to area 1 at the start of each year.

System dynamics
Define the following quantities:

- **I** is the identity matrix of order 2.
- **Pmove** is a 2×2 area transition matrix, defined as $\begin{bmatrix} pstay_1 & 1-pstay_2 \\ 1-pstay_1 & pstay_2 \end{bmatrix}$.
- *rtot* is the overall (i.e., across areas) number of individual fish (in 1000s) recruiting to the population each year, computed as $rect_1/prect_1$.
- **Rec** is a 2×*nage* recruitment matrix, the first column of which consists of *rtot*×**prect**, and the remaining elements of which are all zero.
- **w** is a *nage*×1 vector of individual body weights (in kg), with each element defined as $w_{a-arec+1} = w_{arec}\big(1 + k\cdot(a - arec)\big),\ \forall\, arec \le a \le amax$.
- **Inc** is a *nage*×*nage* age transition matrix that increments each age group by 1 each year, consisting of a lower shift matrix (i.e., a matrix comprised entirely of 0s except for the subdiagonal, which is comprised entirely of 1s).
- $\mathbf{Pop}_t$ is the 2×*nage* matrix of population size (in 1000s of fish) in each area and age at time *t*.
- $\mathbf{Cat}_t$ is the 2×*nage* matrix of catch (in 1000s of individuals) in each area and age at time *t*.
- $\mathbf{Bio}_t$ is the 2×*nage* matrix of stock biomass (in tons) in each area and age at time *t*.
- $\mathbf{Yld}_t$ is the 2×*nage* matrix of yield (in tons) in each area and age at time *t*.

Then, starting from an initial condition of $\mathbf{Pop}_1$, for each year *t* from 2 to *ntim*, the system dynamics are given as follows:

$$\mathbf{Pop}_t = \mathbf{Pmove}\cdot\big(\mathbf{I} - diag(\mathbf{u})\big)\cdot(1-v)\cdot\mathbf{Pop}_{t-1}\cdot\mathbf{Inc} + \mathbf{Rec}\,,$$

$$\mathbf{Cat}_t = diag(\mathbf{u}) \cdot \mathbf{Pop}_t \ ,$$

$$\mathbf{Bio}_t = \mathbf{Pop}_t \cdot diag(\mathbf{w}) \ , \text{and}$$

$$\mathbf{Yld}_t = \mathbf{Cat}_t \cdot diag(\mathbf{w}) \ .$$

Verification that the system reached had equilibrium by time t=*ntim* was accomplished by confirming that each of the above four matrices had the same value at times t=*ntim* and t=*ntim*–1.

<u>Age-aggregated system equilibria</u>
The first part of this subsection deals with the general case, in which the values of $pstay_1$, $pstay_2$, and $prect_1$ are independent.

For notational convenience, define the following pair of matrices:

$$\mathbf{G} = \mathbf{Pmove} \cdot \left(\mathbf{I} - diag(\mathbf{u})\right) \text{ and}$$

$$\mathbf{H} = \mathbf{I} - \mathbf{G} \cdot (1 - v) \ .$$

Then, the age-aggregated (but area-specific) 2×1 system equilibrium vectors can be written as follows:

$$\mathbf{pop} = \mathbf{H}^{-1} \cdot \mathbf{prect} \cdot rtot \ ,$$

$$\mathbf{cat} = diag(\mathbf{u}) \cdot \mathbf{pop} \ ,$$

$$\mathbf{bio} = \left(\mathbf{H}^{-1} + k \cdot \mathbf{G} \cdot \mathbf{H}^{-2} \cdot (1 - v)\right) \cdot \mathbf{prect} \cdot rtot \cdot w_{arec} \ , \text{and}$$

$$\mathbf{yld} = diag(\mathbf{u}) \cdot \mathbf{bio} \ .$$

Verification of the above equations was accomplished by confirming that each vector was equal to the vector obtained by summing the corresponding matrix at time t=*ntim* across age; for example,

$$pop_i = \sum_{j=1}^{nage} (\mathbf{Pop}_{ntim})_{i,j} \ , \text{for areas } i = 1{,}2 \ .$$

Equilibrium *rspr* in this model can be written as a quadratic function of u_1 and u_2, meaning that a closed-form solution for u_1 as a function of u_2 (or vice-versa), conditional on $rspr$=$rspr_{targ}$, is available. The value of u_1 that satisfies $rspr$=$rspr_{targ}$ for the special case where u_2=u_1 (denoted $\bar{u}$) is independent of **prect** and **pstay**.

Likewise, equilibrium bio_1 and bio_2 in this model can be written as quadratic functions of $pstay_1$ and $pstay_2$, meaning that, with $pbio_i$ defined as bio_i /(bio_1+bio_2) for i=1 or i=2, a closed-form solution for $pstay_1$ as a function of $pstay_2$ (or vice-versa), conditional a specified value of $pbio_1$ (or $pbio_2$), is available.

The remainder of this subsection deals with a particular special case. For a generic probability (or proportion) parameter p, consider the special case where $pstay_1$=$prect_1$=p and $pstay_2$=1–p, hereafter referred to as the “balanced” special case.

For notational convenience, let a composite parameter m be defined as follows:

$$m = \big(p \cdot (1 - u_1) + (1 - p) \cdot (1 - u_2)\big) \cdot (1 - v)\ .$$

Then, the age-aggregated system equilibria in this special case can be written quite simply as follows:

$$\mathbf{pop} = \begin{bmatrix} p \\ 1 - p \end{bmatrix} \cdot \left(\frac{1}{1 - m}\right) \cdot rtot\ ,$$

$$\mathbf{cat} = \begin{bmatrix} p \cdot u_1 \\ (1 - p) \cdot u_2 \end{bmatrix} \cdot \left(\frac{1}{1 - m}\right) \cdot rtot\ ,$$

$$\mathbf{bio} = \begin{bmatrix} p \\ 1 - p \end{bmatrix} \cdot \left(\frac{1 - (1 - k) \cdot m}{(1 - m)^2}\right) \cdot rtot \cdot w_{arec}\ , \text{and}$$

$$\mathbf{yld} = \begin{bmatrix} p \cdot u_1 \\ (1 - p) \cdot u_2 \end{bmatrix} \cdot \left(\frac{1 - (1 - k) \cdot m}{(1 - m)^2}\right) \cdot rtot \cdot w_{arec}\ .$$

Note that the area proportions of the system equilibria take very simple forms in this special case. For population and biomass, the proportions in areas 1 and 2 are simply p and $1–p$, respectively, which is the reason for referring to this as the "balanced" special case. For catch and yield, the area proportions are only slightly more complicated, being given by

$$\frac{p \cdot u_1}{p \cdot u_1 + (1 - p) \cdot u_2} \text{ and } \frac{(1 - p) \cdot u_2}{p \cdot u_1 + (1 - p) \cdot u_2}\ , \text{respectively.}$$

Input values

Values of constants and parameters that do not vary by area were estimated as follows:

- The discrete annual natural mortality rate (v) was estimated as $1 - \exp(-M)$, where M was set at the value of 0.354 estimated in last year's stock assessment by Model 19.12a (Thompson et al. 2020), giving v=0.30.
- The maximum age, *amax*, was set at 50 years, corresponding to the age at which only 1 out of a million recruits is still alive in the equilibrium unfished stock, given the estimated value of v. A relatively high value of *amax* seems appropriate, given the model's lack of an "age-plus" group.
- The age at recruitment, *arec*, was set as follows:
    1. Candidate values of *arec*=2, *arec*=3, and *arec*=4 were considered.
    2. Values of $rect_1$, w_{arec}, and k for each candidate value of *arec* were calculated on the basis of the results from Model 19.12a in last year's assessment (Thompson et al. 2020; see below for further details regarding calculation of w_{arec} and k).
    3. After setting $prect_1$=$pstay_1$=1.0, $pstay_2$=0.0, u_2=0, and u_1 at the value that satisfies $rspr$=$rspr_{targ}$, equilibrium yield and equilibrium biomass for area 1 were computed.
    4. The relative differences between the equilibrium yield and biomass values for area 1 computed in step 3 and the corresponding values from Model 19.12a in last year's assessment (Thompson et al. 2021) were computed.
    5. The relative differences computed in step 4 were used to compute a root-mean-squared-relative-error (*rmsre*) for each of the three candidate values of *arec*, giving: *rmsre*(*arec*=2) = 0.190, *rmsre*(*arec*=3) = 0.131, and *rmsre*(*arec*=4) = 0.186.
    6. Because an *arec* value of 3 years exhibited the lowest *rmsre* of the three candidate *arec* values, it was adopted for use here.
- The number of individuals (in 1000s) recruiting to area 1 at the start of each year, $rect_1$, was set at the estimate of equilibrium *unexploited* numbers at age 3 estimated in last year's stock assessment

by Model 19.12a (Thompson et al. 2020), giving a value of $rect_1$=182,351 (note that this value differs from Model 19.12a's corresponding estimate of equilibrium numbers at age 3 under F=$F_{40\%}$ by less than 0.4%).

- The parameters of the linear weight-at-age relationship (w_{arec} and k) were estimated from the begin-year base weights at ages 3-20 estimated in last year's stock assessment by Model 19.12a (Thompson et al. 2020) via ordinary least squares, giving w_{arec}=0.91 and k=1.04 (R^2=0.99).
- The target value of *rspr*, $rspr_{targ}$, was set at 40%, corresponding to the ABC harvest control rule.

Values of parameters that varied by area were estimated on the basis of the following data:

- Biomass proportions for areas 1 and 2 as estimated by O'Leary et al. (2021).
- Absolute biomass (in tons) for area 1 as estimated in Model 19.12a by Thompson et al. (2020).
- Catch (in tons) for area 2 as reported by Lajus et al. (2019).

Estimated biomass proportions are available only for those six years in which surveys were conducted in both parts of area 1 (i.e., EBS and NBS) and also in area 2 (WBS): 1985, 1988, 2001, 2005, 2010, and 2017. These were inflated to units of absolute biomass for the combined areas 1 and 2 by dividing the corresponding absolute biomass estimate for area 1 by the area 1 biomass proportion. These, in turn, were multiplied by the area 2 biomass proportions to obtain estimates of absolute biomass for area 2.

Area 2 exploitation rates were calculated by dividing each year's overall area 2 catch (obtained by summing the values for the various zones and subzones in Tables 6-12 of Lajus et al. (2019)) by the corresponding area 2 absolute biomass computed above. However, because the catch time series goes back only to 2001, the first two years of absolute biomass estimates (1985 and 1988) had to be dropped. Moreover, the exploitation rate calculated for 2001 was so high (=13.31) as to be obviously untenable (note that the catch for this year was not particularly high, being about 9% below the time series average, but the biomass estimate was extremely low, being about 98% below the time series average), so 2001 was also dropped from the time series.

This left the following time series of estimated biomass proportions and exploitation rates for area 2:

Quantity	2005	2010	2017
Biomass proportion	0.15	0.11	0.31
Exploitation rate	0.28	0.61	0.15

Because the "balanced" special case requires specification of fewer probabilities/proportions than the general case (1 rather than 3), most of the examples described here conform to the former. Example values of p were chosen by taking the complement of the minimum and maximum biomass proportion values in the table above (i.e., so as to correspond to area 1 rather than area 2), rounding slightly, and including one intermediate value, giving p = {0.70, 0.80, 0.90}.

In addition, some examples of "unbalanced" models were also developed, in which:

- $pstay_2$ = {0.0, 0.2, 0.4}, for the special case $prect_1$=$pstay_1$=0.8 ($pstay_2$=0.2 actually corresponds to the "balanced" special case, but is included in the set here for completeness).
- $pstay_2$ varied continuously within the range (0,1), with $pstay_1$ adjusted so as to achieve $pbio_1$=p.

In general, u_1 was held constant at $\bar{u} = 0.247$, except when adjusted so to achieve $rspr$=$rspr_{targ}$, conditional on u_2.

Most examples allowed u_2 to vary continuously within the range (0,1). However, examples were also developed by identifying the minimum and maximum exploitation rates in the table above, rounding the latter slightly, and including two intermediate values, giving u_2 = {0.15, 0.30, 0.45, 0.60}.

Results

Results are displayed in Figures 2.1.2.1-7, which employ consistent formatting conventions to the extent possible. Gray dashed lines represent quantities that do not vary between models (in particular, the gray vertical dashed line in Figures 2.1.2.1-6 represents $\bar{u}$). Results for area 1 and for the combined areas are represented by blue, orange, and green curves for *p* values of 0.7, 0.8, and 0.9, respectively; while the corresponding results for area 2 are represented by brown, red, and purple curves, respectively. In Figures 2.1.2.1-4, results for the case where u_1 is not adjusted in order to compensate for u_2 departures from $\bar{u}$ are represented by solid curves, while the corresponding results for the case where u_1 is adjusted in order to achieve $rspr$=$rspr_{targ}$ are represented by colored dashed curves. In Figures 2.1.2.5 and 2.1.2.6, the colored dashed and dotted curves correspond to unbalanced models, regardless of whether u_1 is adjusted. The color coding also remains the same in Figure 2.1.2.7, but symbols are used to distinguish between alternative values of u_2, with values of 0.15, 0.30, 0.45, and 0.60 being represented by squares, diamonds, triangles, and circles, respectively. Also, in Figure 2.1.2.7 only, labels of the form "*p*=0.*x*" mean that $prect_1$=$pstay_1$=$pbio_1$=0.*x*, but $pstay_2$ is actually variable (unlike the balanced case where *p*=0.*x* means that $prect_1$=$pstay_1$=0.*x* and $pstay_2$=1–0.*x*); and the horizontal dashed lines show how all curves intersect at the corresponding balanced value of $pstay_2$.

The upper panel of Figure 2.1.2.1 illustrates how *rspr* varies with u_2 for each of the three balanced models when u_1 is not adjusted, while the lower panel illustrates how u_1 would need to be adjusted in order to achieve $rspr$=$rspr_{targ}$ for each of the three balanced models. Note that, in both the upper and lower panels, the slope of the relationship varies inversely with *p*, which would be expected, because higher values of *p* imply that the stock is concentrated primarily in area 1, meaning that the impact of an increase in u_2 is smaller. In the lower panel, for *p*=0.7, the area 1 fishery with u_1 adjusted would shut down entirely if u_2 were to exceed a value of about 0.82.

Figure 2.1.2.2 shows how absolute biomass, both by area (upper panel) and overall (lower panel) varies with u_2, both when u_1 is not adjusted and when it is adjusted in order to achieve $rspr$=$rspr_{targ}$, for each of the three balanced models. Note that, by definition, all three models result in the same area 1 absolute biomass in the case where u_1 is adjusted in order to achieve $rspr$=$rspr_{targ}$ (horizontal gray dashed line in upper panel). Both the area 2 absolute biomass and the overall absolute biomass are also independent of u_2 when u_1 is adjusted, but the amounts differ between models (colored dashed lines in both panels).

Figure 2.1.2.3 is the absolute yield analogue of Figure 2.1.2.2. Here, however, the area-specific values vary with u_2 even in the case where u_1 is adjusted (colored dashed curves in the upper panel; the gray dashed line in the upper panel now represents the absolute yield at which the curves intersect, corresponding to $u_1 = u_2 = \bar{u}$). Absolute yield in area 1 decreases with increasing u_2 regardless of whether u_1 is adjusted, but the decreases are larger when u_1 is adjusted, with the differences between the unadjusted and adjusted yields varying inversely with *p*.

The upper panel of Figure 2.1.2.4 shows the *proportions* of the overall biomass present in each area, and illustrates the principle that, for balanced models, the biomass proportions are independent of the exploitation rate in either area, being equal simply to *p* and 1–*p* for areas 1 and 2, respectively. The lower panel of Figure 2.1.2.4 is the yield proportion analogue of the upper panel. In contrast to the biomass proportions, the yield proportions do depend on the exploitation rates in the two areas, with the qualitative shapes of the curves being roughly similar to the absolute yield curves in Figure 2.1.2.3, except that the intersection of the area 1 curves occurs at u_2=0 rather than at $u_2=\bar{u}$.

Figure 2.1.2.5 shows how two of the curves from the upper panel of Figure 2.1.2.4, specifically those for p=0.8 (implying $pstay_2$=0.2), change when the corresponding balanced model from Figure 2.1.2.4 is replaced by either of two unbalanced models; specifically, where $pstay_2$=0.0 or $pstay_2$=0.4. The upper panel represents the case where u_1 is unadjusted and the lower panel represents the case where u_1 is adjusted. The impacts of changing $pstay_2$ from a value of 0.2 to a value of 0.0 or 0.4 on the biomass proportions are small, regardless of whether u_1 is adjusted.

Figure 2.1.2.6 is the yield proportion analogue of Figure 2.1.2.5. Similar to the impacts on biomass proportions shown in Figure 2.1.2.5, the impacts of changing $pstay_2$ from a value of 0.2 to a value of 0.0 or 0.4 on the yield proportions are small, regardless of whether u_1 is adjusted.

Like Figures 2.1.2.5 and 2.1.2.6, Figure 2.1.2.7 explores some of the impacts of unbalanced models. Here, $prect_1$=$pbio_1$=p, but $pstay_1$ is allowed to vary and $pstay_2$ is adjusted so as to set the area 2 biomass proportion equal to $pbio_2$=1–$pbio_1$, for the usual values of p and various values of u_2. The necessary adjustments to $pstay_2$ are large relative to the associated changes in $pstay_1$, and become increasingly steep both with increasing p and increasing u_2. Looking at the problem from the opposite perspective, only a fairly narrow range of $pstay_1$ values is compatible with any of the p values examined, whereas all or nearly all of the feasible range of $pstay_2$ values is compatible (conditional on $pstay_1$).

Discussion

Given that the previous attempts at incorporating movement between the EBS and NBS survey areas into the stock assessment model have proven unsuccessful (Thompson 2018, Thompson et al. 2020), and given that the data limitations for statistical estimation of parameters governing movement between the combined EBS and NBS survey areas and the WBS are even more serious than those pertaining to movement between the EBS and NBS survey areas, it is reasonable to consider a simpler, less statistical, model, if only for heuristic purposes.

Although the input values used for the parameters and constants required by the model developed here were not estimated with the same statistical rigor as those in a modern, integrated stock assessment model, neither are they arbitrary, and for those parameters where it was necessary to resort to ranges of values rather than best point estimates (e.g., WBS biomass proportions ranging from 0.10-0.30 and WBS exploitation rates ranging from 0.15-0.60), those ranges seem reasonably likely to bracket the point estimates that would result from an integrated stock assessment model if it were possible to create one.

In general, the results shown here illustrate the intuitive principle that, the more the stock is concentrated in one area (either due to recruitment being concentrated in that area, fish tending not to stray from that area once they arrive, or both), the smaller the impacts of fishing in the other area.

Another pair of intuitive results is that, if the exploitation rate in area 1 is left constant, increased fishing in area 2 will result in reduced equilibrium yield in area 1 and, if the exploitation rate in area 1 is adjusted in order to achieve a target level of overall (i.e., across areas) relative spawning per recruit, the reduction in area 1 yield will be even greater.

One more result that may have some generality is that, for some quantities such as the inter-area biomass proportions, some parameters may have very little impact. For example, in a balanced model, the equilibrium biomass proportions are entirely independent of the exploitation rate in either area (upper panel of Figure 2.1.2.4). Although perfectly balanced models (in the sense used here) are almost certain not to occur in nature, modest departures therefrom may result in outcomes that are only slightly different from the balanced case (Figure 2.1.2.5).

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Figures

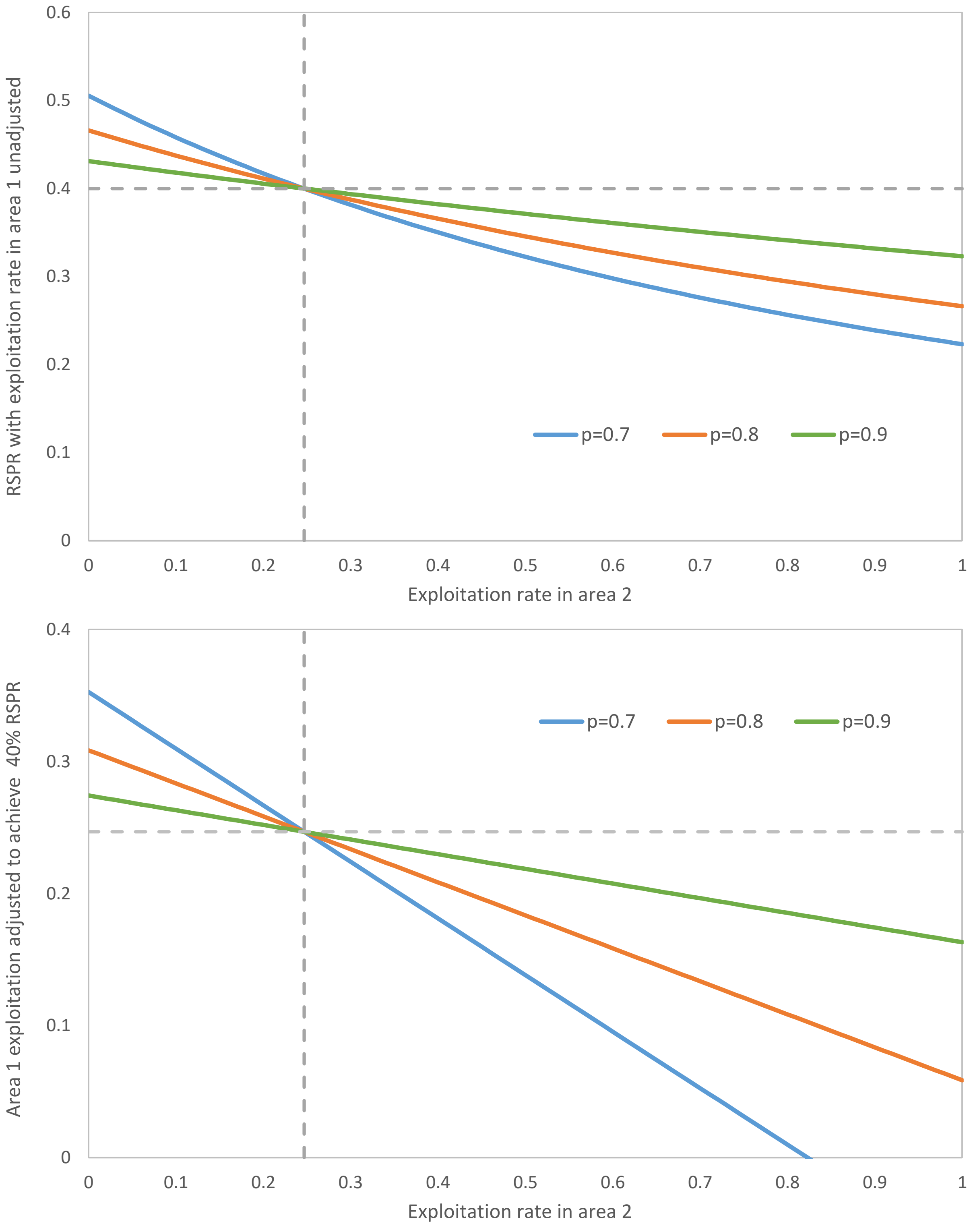

Figure 2.1.2.1. Equilibrium *rspr* with u_1 unadjusted (upper panel) and adjustments to u_1 necessary to achieve *rspr*=0.4 (lower panel) as functions of the exploitation rate in area 2 for three balanced models.

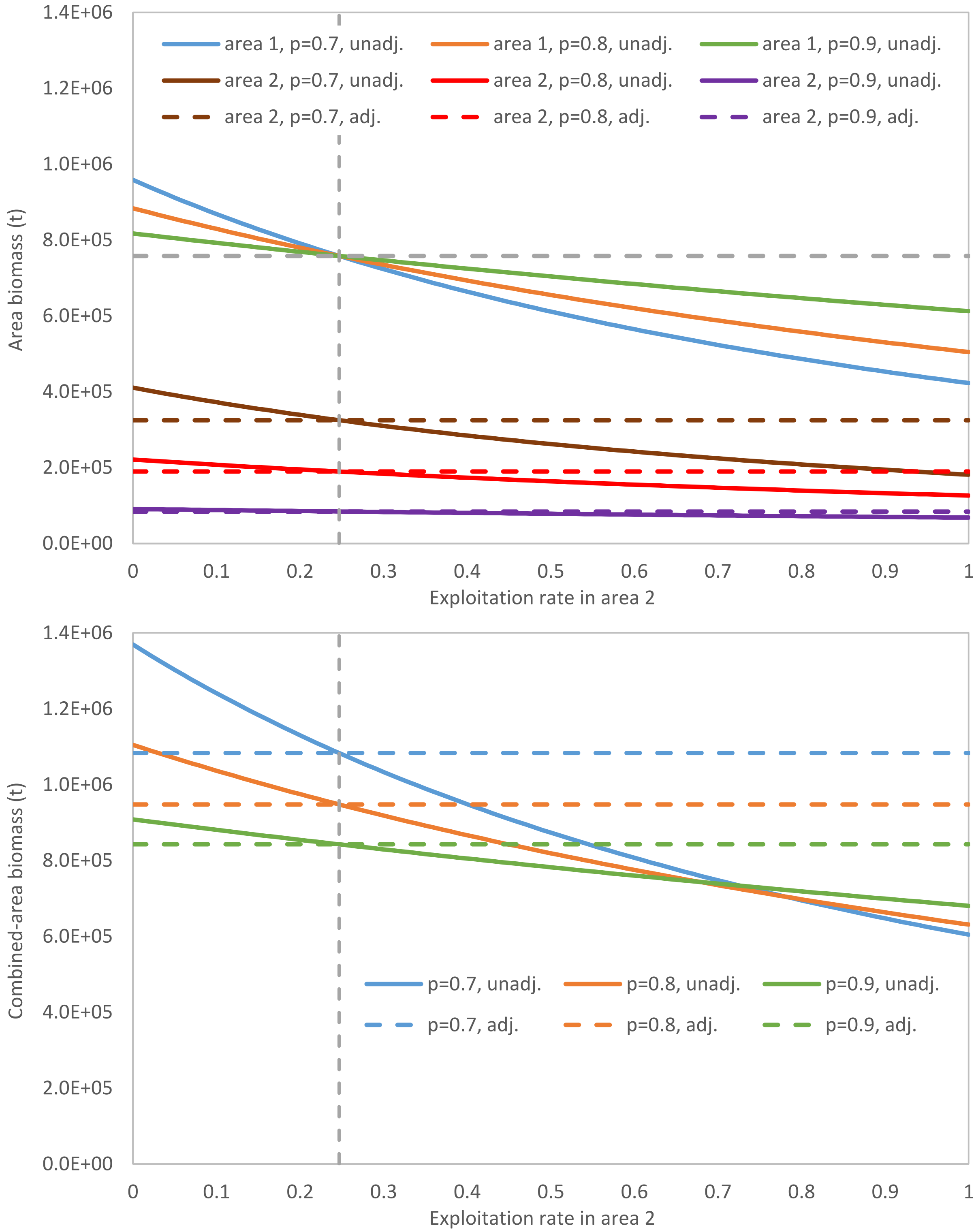

Figure 2.1.2.2. Equilibrium biomasses as functions of the area 2 exploitation rate for three balanced models.

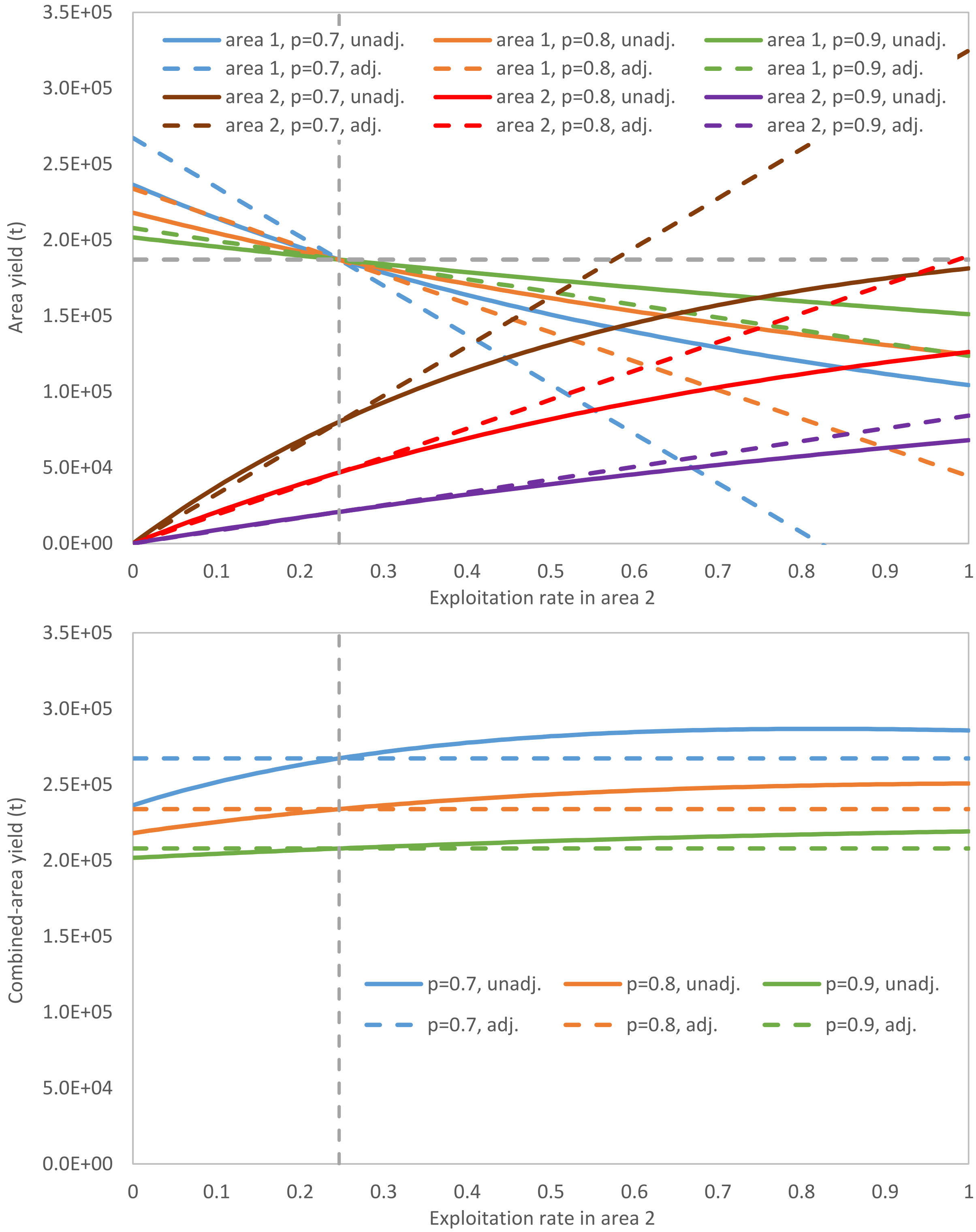

Figure 2.1.2.3. Equilibrium yields as functions of the area 2 exploitation rate for three balanced models.

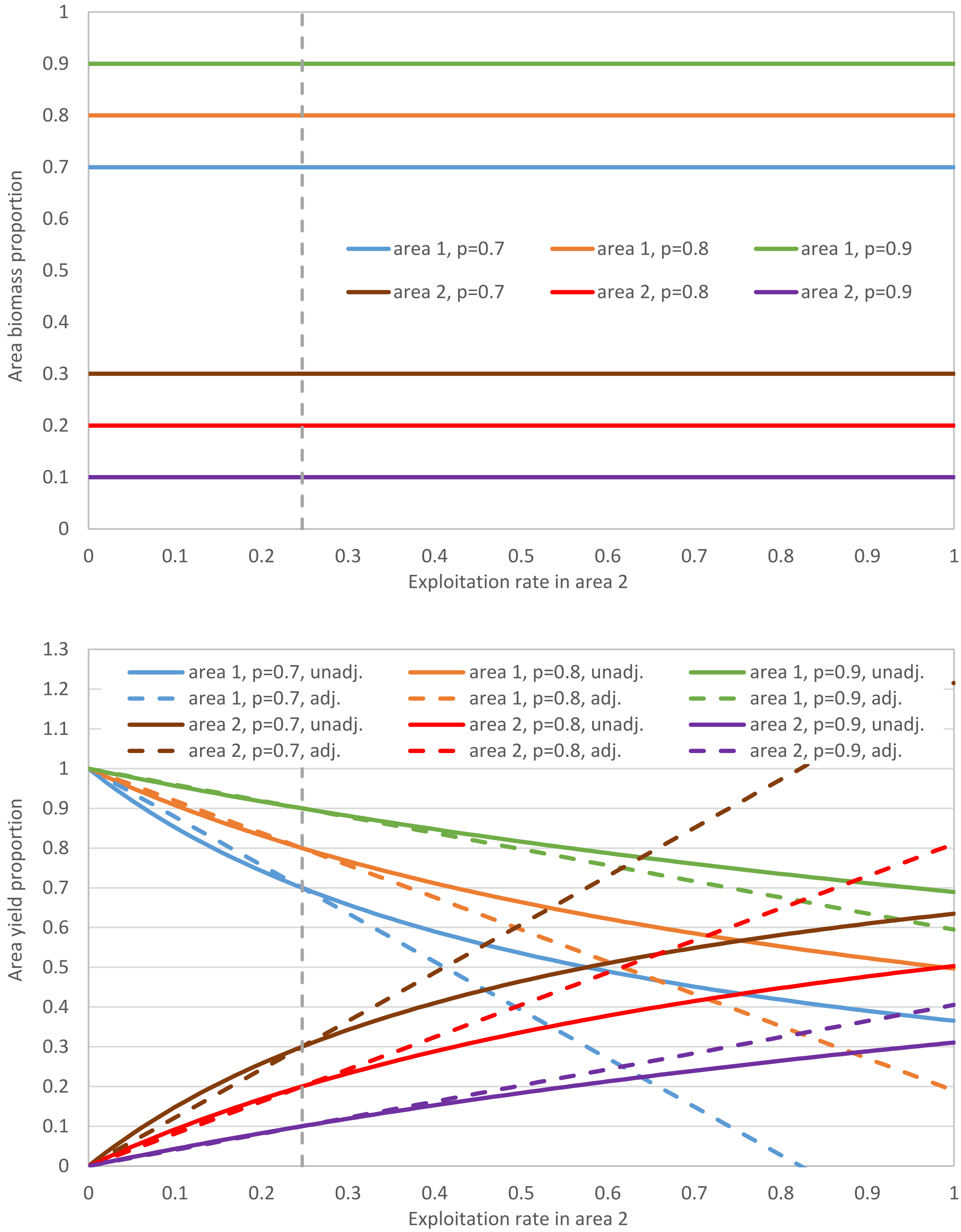

Figure 2.1.2.4. Equilibrium biomass proportions (upper panel) and yield proportions (lower panel) as functions of the exploitation rate in area 2 for three balanced models.

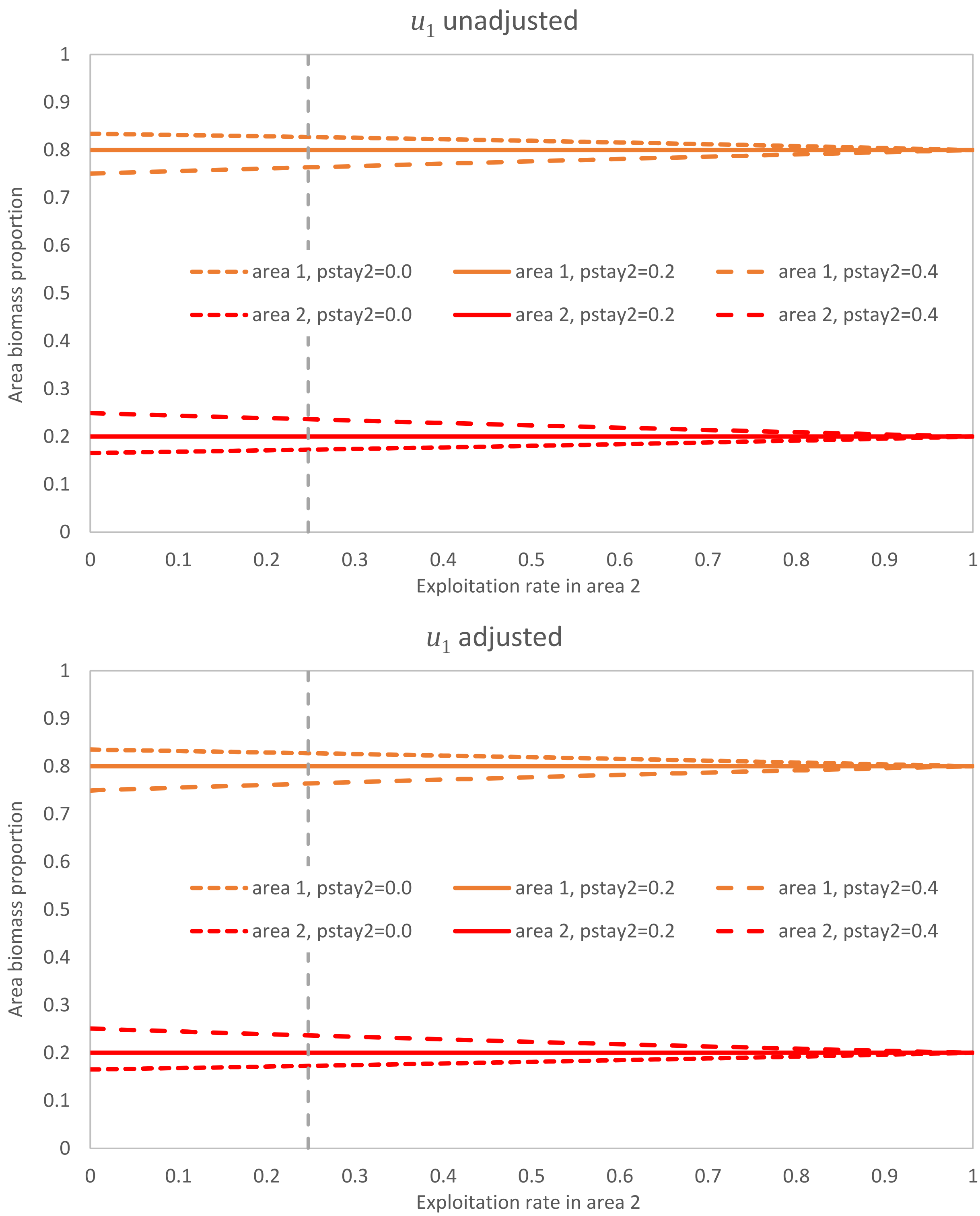

Figure 2.1.2.5. Equilibrium biomass proportions with u_1 unadjusted (upper panel) and with u_1 adjusted (lower panel) as functions of the exploitation rate in area 2 for one balanced and two unbalanced models.

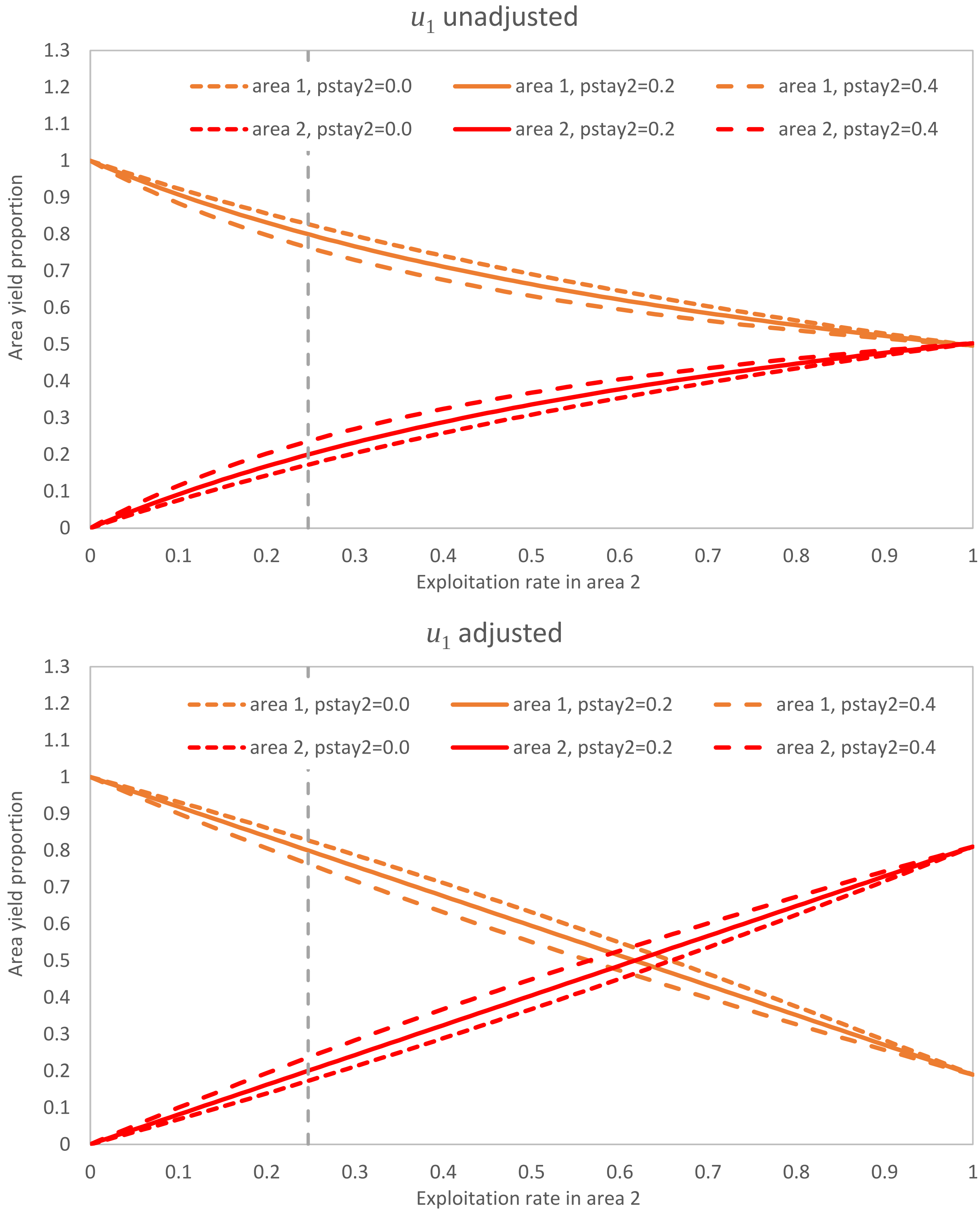

Figure 2.1.2.6. Equilibrium yield proportions with u_1 unadjusted (upper panel) and with u_1 adjusted (lower panel) as functions of the exploitation rate in area 2 for one balanced and two unbalanced models.

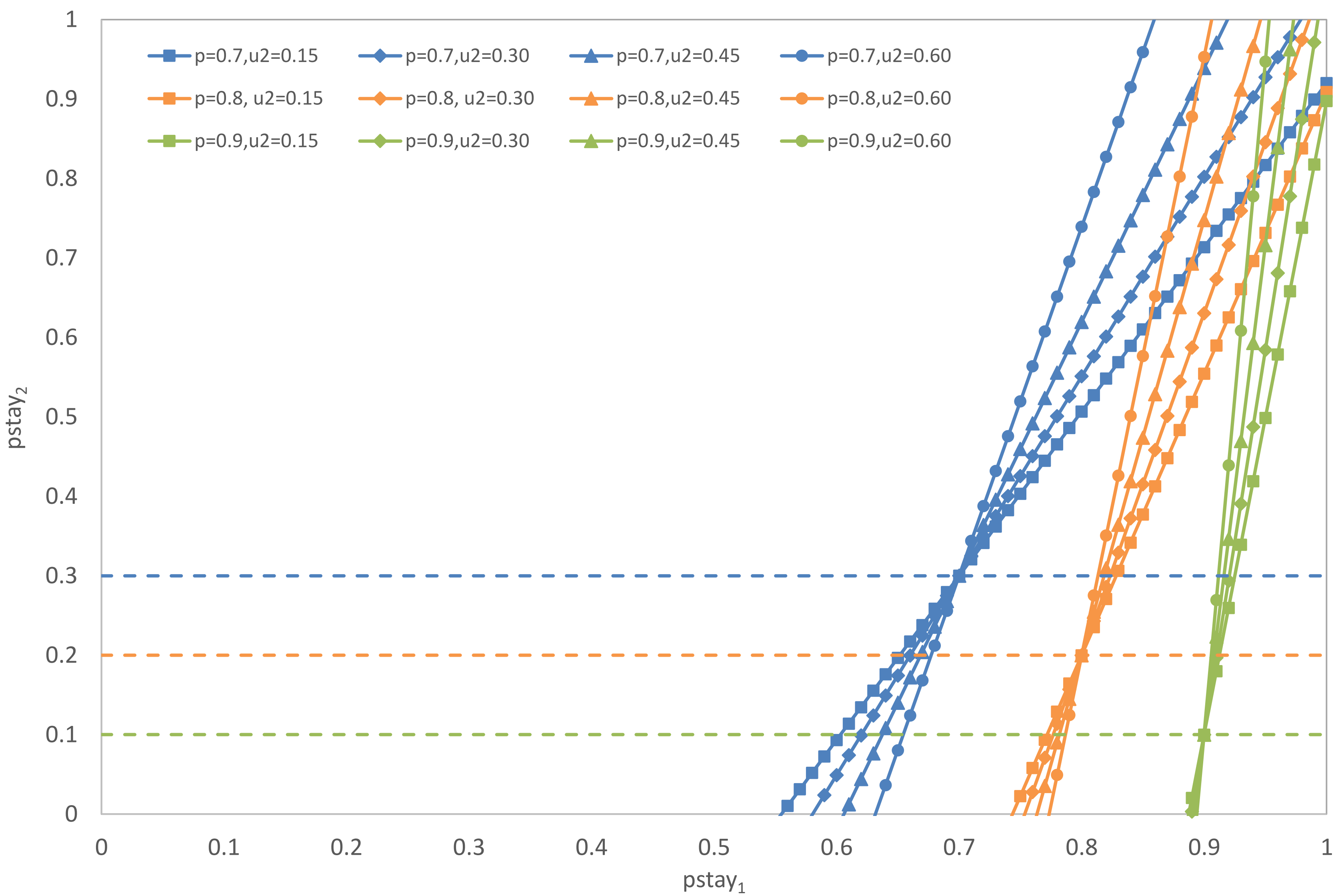

Figure 2.1.2.7. Adjustments to *pstay*$_2$ needed in order to set the proportion of biomass in area 2 equal to 1–*pbio*$_1$, as functions of *pstay*$_1$, for twelve unbalanced models (factorial design of three values of *prect*$_1$=*pbio*$_1$=*p* and four values of u_2).

Attachment 2.1.3: Application of the harvest control rule: Before or after model averaging?

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Introduction

For the last three years, members of the North Pacific Fishery Management Council's BSAI Groundfish Plan Team ("Team") and Scientific and Statistical Committee (SSC) have debated with assessment authors regarding the issue of whether, in the context of ensemble modeling, the harvest control rules that are used to set the overfishing level (*OFL*) and the upper limit on acceptable biological catch (*ABC*, used here in place of *maxABC* in the interest of brevity) should be applied *before* or *after* model averaging. The two approaches may be summarized as follows (for simplicity, the Tier 3 harvest control rules are assumed here):

- In the "before" approach:
    1. Compute the model-specific values of $F_{35\%}$ (for *OFL*) or $F_{40\%}$ (for *ABC*) and $B_{40\%}$.
    2. Use the values obtained in Step 1 to parameterize *model-specific* harvest control rules.
    3. Compute the model-specific projected female spawning biomass values.
    4. Evaluate each *model-specific* harvest control rule at the respective *model-specific* projected female spawning biomass.
    5. Apply the resulting *model-specific* F_{OFL} or F_{ABC} values to their respective models.
    6. Average the resulting model-specific *OFL*s or *ABC*s.
- In the "after" approach:
    1. Proceed as in Step 1 of the "before" approach, *but then average* the model-specific values of $F_{35\%}$ (for *OFL*) or $F_{40\%}$ (for *ABC*) and $B_{40\%}$.
    2. Use the values obtained in Step 1 to parameterize an *average* harvest control rule.
    3. Proceed as in Step 3 of the "before" approach, *but then average* the model-specific projected female spawning biomass values.
    4. Evaluate the *average* harvest control rule at the *average* projected female spawning biomass.
    5. Apply the resulting *average* F_{OFL} or F_{ABC} to each model in the ensemble.
    6. Proceed as in Step 6 of the "before" approach.

Methods

To investigate the properties of the two procedures, a highly simplified system was evaluated, focusing just on ABC, in the interest of simplicity.

<u>Assumptions</u>

- The harvest control rule used to set the upper limit on the fishing mortality limit corresponding to ABC consists of a simple linear relationship, viz., $F_{ABC} = F_{40\%} \times (B/B_{40\%})$, where B represents the projected level of female spawning biomass for the coming year, $F_{40\%}$ is the fishing mortality rate that sets equilibrium spawning biomass per recruit equal to 40% of the unfished equilibrium spawning biomass per recruit, and $B_{40\%}$ is the equilibrium spawning biomass when the stock is fished at a rate of $F_{40\%}$.

- Male spawning biomass is equal to female spawning biomass.
- Exploitable biomass for the stock is equal to the sum of female and male spawning biomass.
- The nature of the assessment models is such that catch is equal to the product of *F* and exploitable biomass.
- The set of models in the ensemble is immense.
- The set of $F_{40\%}$, $B_{40\%}$, and *B* estimates jointly follow a trivariate lognormal distribution.
- All models are weighted equally.
- The mean is used as the point estimate of any quantity.

Notation

- $[\mu_1 \quad \sigma_1]$, $[\mu_2 \quad \sigma_2]$, and $[\mu_3 \quad \sigma_3]$ represent the log-scale means and standard deviations of $F_{40\%}$, $B_{40\%}$, and *B*, respectively.
- ρ_{12}, ρ_{13}, and ρ_{23} represent the log-scale correlations between $F_{40\%}$ and $B_{40\%}$, $F_{40\%}$ and *B*, and $B_{40\%}$ and *B*, respectively.
- m_X and CV_X represent the mean and coefficient of variation of quantity *X*, respectively.
- Names of statistics pertaining to the special case where all correlations are zero have suffixes that begin with “0.”
- Names of statistics pertaining to the “before” and “after” approaches have suffixes that end with “*bef*” and “*aft*,” respectively.

Results

Special case: all correlations = 0
“Before” approach:

- $m_{0.FABC.bef} = \exp\left(\mu_1 - \mu_2 + \mu_3 + \frac{\sigma_1{}^2+\sigma_2{}^2+\sigma_3{}^2}{2}\right)$
- $CV_{0.FABC.bef} = \sqrt{\exp(\sigma_1{}^2 + \sigma_2{}^2 + \sigma_3{}^2) - 1}$
- $m_{0.ABC.bef} = 2\exp\left(\mu_1 - \mu_2 + 2\mu_3 + \frac{\sigma_1{}^2+\sigma_2{}^2}{2} + 2\sigma_3{}^2\right)$
- $CV_{0.ABC.bef} = \sqrt{\exp\left(\sigma_1{}^2 + \sigma_2{}^2 + 4\sigma_3{}^2\right) - 1}$

“After” approach:

- $m_{0.FABC.aft} = m_{0.FABC.bef}$
- $CV_{0.FABC.aft} = 0$
- $m_{0.ABC.aft} = m_{0.ABC.bef}\exp(-\sigma_3{}^2)$
- $CV_{0.ABC.aft} = \sqrt{\exp(\sigma_3{}^2) - 1}$

Ratios (“after” relative to “before”):

- $\frac{m_{0.FABC.aft}}{m_{0.FABC.bef}} = 1$
- $\frac{CV_{0.FABC.aft}}{CV_{0.FABC.bef}} = 0$
- $\frac{m_{ABC.aft}}{m_{ABC.bef}} = \exp(-\sigma_3{}^2)$
- $\frac{CV_{ABC.aft}}{CV_{ABC.bef}} = \sqrt{\frac{\exp(\sigma_3{}^2)-1}{\exp(\sigma_1{}^2+\sigma_2{}^2+4\sigma_3{}^2)-1}}$

The ratio of the ABC means is monotone decreasing w.r.t. σ_3 (Figure 2.1.3.1), and the ratio of the ABC CVs is monotone decreasing w.r.t. both σ_1 and σ_2. However, the latter ratio is non-monotone w.r.t. σ_3.

Let:

$$y = {\sigma_1}^2 + {\sigma_2}^2 \,,$$

$$u(y) = \left(\exp(-y)\left(\sqrt{1-\exp(-y)}+1\right)\right)^{1/3} \,,$$

and

$$v(y) = \frac{3}{2}\left(u(y) + \frac{\exp(-y)}{u(y)}\right) + 1 \,.$$

Then, the ratio of the ABC CVs reaches a maximum at

$$\sigma_3 = \sigma_{3.max}(y) = \sqrt{\ln\left(\frac{1}{3}\left(\sqrt{v(y)} + \sqrt{\frac{2}{\sqrt{v(y)}} - v(y) + 3} + 1\right)\right)} \,.$$

Figure 2.1.3.2 shows an example with *y* set at a value of 0.5. Here, the ratio of the ABC CVs increases w.r.t. σ_3 from a value of 0 at $\sigma_3 = 0$ to a value of about 0.288 at $\sigma_3 = \sigma_{3.max}(0.5) \approx 0.488$, then decreases w.r.t. σ_3 thereafter.

As *y* becomes large, $\sigma_{3.max}$ reaches an upper asymptote of $\sqrt{\ln(4/3)} \approx 0.536$ (Figure 2.1.3.3). Figure 2.1.3.4 shows the ratio of the ABC CVs as a function of *y* for various fixed values of σ_3 and also with σ_3 set according to the above formula. Note that the ratio of the ABC CVs can never exceed 0.5.

<u>General case: correlations potentially ≠ 0</u>
"Before" approach:

- $m_{FABC.bef} = m_{0,FABC.bef} \exp(-\rho_{12}\sigma_1\sigma_2 + \rho_{13}\sigma_1\sigma_3 - \rho_{23}\sigma_2\sigma_3)$
- $CV_{FABC.bef} = \sqrt{\exp\left({\sigma_1}^2 + {\sigma_2}^2 + 4{\sigma_3}^2 - 2\rho_{12}\sigma_1\sigma_2 + 2\rho_{13}\sigma_1\sigma_3 - 2\rho_{23}\sigma_2\sigma_3\right) - 1}$
- $m_{ABC.bef} = m_{0.ABC.bef} \exp({\sigma_3}^2 - \rho_{12}\sigma_1\sigma_2 + 2\rho_{13}\sigma_1\sigma_3 - 2\rho_{23}\sigma_2\sigma_3)$
- $CV_{ABC.bef} = \sqrt{\exp\left({\sigma_1}^2 + {\sigma_2}^2 + 4{\sigma_3}^2 - 2\rho_{12}\sigma_1\sigma_2 + 2\rho_{13}\sigma_1\sigma_3 - 2\rho_{23}\sigma_2\sigma_3\right) - 1}$

"After" approach:

- $m_{FABC.aft} = m_{0.FABC.bef}$
- $CV_{FABC.aft} = 0$
- $m_{ABC.aft} = m_{0.ABC.aft}$
- $CV_{ABC.aft} = CV_{0.ABC.aft}$

Ratios ("after" relative to "before"):

- $\frac{m_{FABC.aft}}{m_{FABC.bef}} = \exp(\rho_{12}\sigma_1\sigma_2 - \rho_{13}\sigma_1\sigma_3 + \rho_{23}\sigma_2\sigma_3)$
- $\frac{CV_{FABC.aft}}{CV_{FABC.bef}} = 0$
- $\frac{m_{ABC.aft}}{m_{ABC.bef}} = \exp(-{\sigma_3}^2 + \rho_{12}\sigma_1\sigma_2 - 2\rho_{13}\sigma_1\sigma_3 + 2\rho_{23}\sigma_2\sigma_3)$
- $\frac{CV_{ABC.aft}}{CV_{ABC.bef}} = \sqrt{\frac{\exp({\sigma_3}^2)-1}{\exp({\sigma_1}^2+{\sigma_2}^2+4{\sigma_3}^2-2\rho_{12}\sigma_1\sigma_2+4\rho_{13}\sigma_1\sigma_3-4\rho_{23}\sigma_2\sigma_3)-1}}$

Except for the ratio of the F_{ABC} CVs, which is still identically zero, the results for the general case are more ambiguous than in the special case where all correlations are zero, because they admit the possibility of being either less than or greater than unity, depending on the values of the σ and ρ terms.

As a first step toward getting some idea of likely values for the three non-zero ratios, distributions of the σ and ρ terms were simulated by assuming that:

- The three σ terms are i.i.d. lognormal random variables with mean *σmean* and standard deviation *σsdev*.
- For the three ρ terms, the quantities $(\rho + 1)/2$ are i.i.d. symmetric beta random variables with standard deviation *ρsdev*.

The hyperparameters *σmean*, *σsdev*, and *ρsdev* were set at values of either 0.2 or 0.4 in a factorial design. Values of each of the three σ terms and each of the three ρ terms were drawn from their respective hyperdistributions repeatedly, retaining only those combinations that resulted in a positive definite covariance matrix, until a sample of 100,000 parameter sets was obtained. These were then used to generate distributions of the three non-zero ratios. Table 2.1.3.1 shows some summary statistics from the distributions, and Figure 2.1.3.5 shows the 99% concentrations of the distributions (i.e., the distributions with the lower and upper 0.5% tails omitted). The results may be summarized as follows:

F_{ABC} ratio: Consistent with the zero-correlation special case, the distributions for the F_{ABC} ratio tended to be concentrated at values near unity across a broad range of hyperparameter values. For example, both the median and the mean were within the 1.00-1.08 range for all combinations of hyperparameter values, although in some cases there were outliers that resulted in the standard deviations being substantial. Specifically, for all cases in which *σsdev* was equal to 0.2, the standard deviation of the F_{ABC} ratio never exceeded 0.14, but for the two cases in which both *σsdev* and *ρsdev* were equal to 0.4, the standard deviation was in excess of 4.77. Given that the median is so close to unity for all combinations of hyperparameter values, it is not surprising that the proportion of simulations in which the F_{ABC} ratio exceeded unity ranged from 0.50-0.51.

ABC ratio: Also consistent with the zero-correlation special case, the distributions for the *ABC* ratio tended to be concentrated at values slightly less than unity across a broad range of hyperparameter values. In the zero-correlation special case, if σ_3 were set equal to 0.2 or 0.4, the *ABC* ratio would be about 0.96 or 0.85, respectively. In comparison, for the *σmean* =0.2 case, the median ratio ranges between 0.98 and 0.99 and the mean ratio ranges between 0.93 and 0.94, and for the *σmean* =0.4 case, the median ratio ranges between 0.88 and 0.92 and the mean ratio ranges between 0.84 and 0.88. The standard deviation of the ABC ratio ranges between 0.12 and 0.27 in all cases except where both *σsdev* and *ρsdev* were equal to 0.4, in which case the standard deviations were 0.89 (when *σmean*=0.2) and 1.83 (when *σmean*=0.4). The proportion of simulations in which the *ABC* ratio exceeded unity was invariably smaller than for the F_{ABC} ratio, ranging from 0.10-0.26.

CV_{ABC} ratio: Also consistent with the zero-correlation special case, the distributions for the CV_{ABC} ratio tended to be concentrated at values considerably less than unity across a broad range of hyperparameter values. In the zero-correlation special case, if σ_1, σ_2, and σ_3 were all set equal to 0.2 or all set equal to 0.4, the CV_{ABC} ratio would be about 0.39 or 0.33, respectively. In comparison, for the $\sigma mean$ =0.2 case, the median ratio ranges between 0.28 and 0.34 and the mean ratio ranges between 0.27 and 0.33, and for the $\sigma mean$ =0.4 case, the median ratio ranges between 0.26 and 0.30 and the mean ratio ranges between 0.25 and 0.32. The standard deviations were all within the 0.09-0.18 range. The coefficients of variation were uniformly larger for the CV_{ABC} ratio than their respective F_{ABC} ratio and *ABC* ratio counterparts, with the exception of the cases in which both $\sigma sdev$ and $\rho sdev$ were equal to 0.4. The proportion of simulations in which the CV_{ABC} ratio exceeded unity was invariably tiny, never reaching a value of 0.01 (recall that, in the zero-correlation special case, the CV_{ABC} ratio can never exceed 0.5).

Because the proportion of simulations in which the CV_{ABC} ratio exceeded unity was so small—but not necessarily zero—in all of these examples, it seemed appropriate to consider further the conditions under which a CV_{ABC} ratio in excess of unity can be obtained. Additional explorations involving alternative values for the parameters of the hyperdistributions tended to confirm the trends evident in Table 2.1.3.1, such that the proportion of simulations in which the CV_{ABC} ratio exceeded unity tended to be associated with high values of $\sigma mean$ and $\rho sdev$ and low values of $\sigma sdev$. For example, with $\sigma mean$ = 1.0, $\sigma sdev$ = 0.1, and $\rho sdev$ = 0.9 (note that the symmetric beta distribution is U-shaped for $\sqrt{1/3} < \rho sdev < 1$), about 13% of the simulations resulted in the CV_{ABC} ratio exceeding unity. For these hyperparameter values, the subset of simulations in which the CV_{ABC} ratio exceeded unity tended to be associated with fairly extreme values of the correlation coefficients, with ρ_{12} and ρ_{13} tending to be close to –1 and ρ_{23} tending to be close to +1; and with ρ_{12} and ρ_{13} strongly and positively correlated, and ρ_{12} and ρ_{23} strongly and negatively correlated. Specifically, the median values of ρ_{12}, ρ_{13}, and ρ_{23} were –0.97, –0.97, and 0.98, respectively, and the correlations between ρ_{12} and ρ_{13} and between ρ_{12} and ρ_{23} were 0.71 and –0.74, respectively (the only other correlation with an absolute value greater than about 0.05 was the correlation between ρ_{13} and ρ_{23}, with a value of –0.21).

The final analysis of the CV_{ABC} ratio consisted of exploring the proportion of the 3-dimensional potential correlation volume (i.e., the cube in $\{\rho_{12}, \rho_{13}, \rho_{23}\}$-space with sides spanning [–1,1] in all three dimensions) under which a ratio greater than unity is possible. The math is somewhat complicated and so is not presented here, but the results are shown in Figure 2.1.3.6, where the two axes represent the ratios σ_1/σ_3 and σ_2/σ_3. The main conclusion to be drawn from this figure is that no combination of σ parameters can result in a CV_{ABC} ratio greater than unity outside of a small subset of the potential correlation volume. Specifically, in no case does the size of this subset reach even 7% of the potential correlation volume.

In conclusion, while there are indeed parameter combinations for which the CV_{ABC} ratio exceeds unity, they are comparatively rare and typically involve extreme values of the ρ terms.

Discussion and conclusions

<u>Point estimates</u>
It will be assumed here that point estimation follows a decision-theoretic approach, such that the optimal estimator is that which minimizes the expected loss. This implies that the estimator will depend on both the form of the loss function and the weights assigned to the individual models in the ensemble. In the interest of simplicity, risk neutrality (i.e., squared error loss) and equal weighting will also be assumed, meaning that the optimal estimator of any quantity is simply the arithmetic mean of the individual model estimates. However, the conclusions are readily generalizable to alternative assumptions regarding the loss function and model weighting.

When nonlinearities are involved, two inevitable consequences of ensemble modeling, except in special cases are as follow:

- For given parameters values, a function evaluated at the average of the model-specific values of the argument will not equal the average of the function evaluated at the model-specific values of the argument. For example, considering the function $f(x) = x^{\beta}$ with β fixed at a value of 2 and model-specific values of x={10,20}, $((10+20)/2)^2 = 225 \neq (10^2+20^2)/2 = 250$.
- When evaluated at a given value of the argument, a function whose parameter values consist of the averages of their respective model-specific values will not equal the average of the functions with model-specific parameter values. For example, considering the same function as above but with x fixed at a value of 10 and model-specific values of β={2,4}, $10^{(2+4)/2} = 1000 \neq (10^2+10^4)/2 = 5050$.

It has been suggested that the "after" approach is preferable to the "before" approach because the ensemble ABC or OFL resulting from the "after" approach is generated by the ensemble fishing mortality rate prescribed by the ensemble harvest control rule, and is therefore internally consistent. However, as shown above, complete internal consistency is typically impossible in ensemble modeling when nonlinearities are involved. The alleged internal consistency of the "after" approach is ephemeral, because it relies on picking the "right" values to compare. As a counter-example, the individual model *ABC* or *OFL* values computed under the "after" approach, which form the basis of the ensemble ABC or OFL, will typically be *inconsistent* with respect to the harvest control rule as applied to those models.

Rather than chasing the unachievable goal of internal consistency of *results*, a better strategy is to focus on achieving internal consistency of *methods*. When it comes to *ABC* or *OFL*, the "before" approach uses the *same estimator* that is used for all other quantities (viz., the mean of the individual models' actual estimates of *ABC* or *OFL*), whereas the "after" approach *switches the estimator* to the mean of what the individual estimates *would have been* if they had all been generated by applying the F_{ABC} or F_{OFL} from the ensemble control rule. Note that there is no disagreement between the two approaches with respect to the estimates of the ensemble harvest control rule parameters (both estimate them as the averages of the model-specific values); the disagreement is entirely with respect to how those values should be used.

Treatment of uncertainty

The "before" approach treats the parameters of the respective harvest control rule, and the fishing mortality rate resulting therefrom, as random variables, just as any other quantity estimated by the assessment models, such that the set of values generated by the individual assessment models is treated as a distribution and the full uncertainty associated with them is retained when computing the distribution of *ABC* or *OFL*. The "after" approach, on the other hand, treats the parameters of the harvest control rule, and the fishing mortality rate resulting therefrom, as constants, meaning that both the *within*-model and *between*-model uncertainty in F_{ABC} or F_{OFL} is ignored when computing the distribution of *ABC* or *OFL*.

Extensions of the "after" approach can easily be imagined, wherein the point estimates of additional parameters or vectors of age- or size-specific rates (e.g., natural mortality, weight at age, selectivity at age, etc.) are averaged and then treated as constants when computing the distribution of *ABC* or *OFL*. In the extreme, the point estimates of all parameters could be averaged and then treated as constants, in which case the distribution of *ABC* or *OFL* would be reduced to a single point.

The results shown here demonstrate that the uncertainty in *ABC* or *OFL*, when measured by the coefficient of variation, will typically be substantially less under the "after" approach than under the "before" approach (although exceptions are possible). Because this reduction in uncertainty is a direct consequence of ignoring both the *within*-model and *between*-model uncertainty in F_{ABC} or F_{OFL}, when there is no logical reason why those uncertainties should be ignored while the analogous uncertainties associated with other quantities are not, the treatment of uncertainty afforded by the "before" approach seems altogether preferable.

Table 2.1.3.1.

Summary statistics from a factorial design of simulation studies.

Hyperparameter			FABC_ratio				ABC_ratio				ABC_CV_ratio			
σmean	σsdev	ρsdev	prop>1	median	mean	sdev	prop>1	median	mean	sdev	prop>1	median	mean	sdev
0.2	0.2	0.2	0.499	1.000	1.000	0.028	0.150	0.979	0.940	0.118	0.000	0.337	0.313	0.128
0.2	0.2	0.4	0.506	1.000	1.002	0.073	0.242	0.979	0.942	0.131	0.001	0.335	0.327	0.153
0.2	0.4	0.2	0.500	1.000	1.003	0.303	0.192	0.991	0.933	0.270	0.000	0.286	0.270	0.161
0.2	0.4	0.4	0.502	1.000	1.030	4.778	0.262	0.991	0.944	0.891	0.001	0.284	0.278	0.178
0.4	0.2	0.2	0.500	1.000	1.003	0.070	0.102	0.878	0.842	0.164	0.000	0.297	0.293	0.089
0.4	0.2	0.4	0.507	1.002	1.009	0.137	0.222	0.878	0.855	0.221	0.003	0.299	0.315	0.143
0.4	0.4	0.2	0.497	1.000	1.007	0.232	0.150	0.918	0.836	0.274	0.000	0.257	0.248	0.130
0.4	0.4	0.4	0.504	1.001	1.076	13.940	0.242	0.918	0.878	1.832	0.001	0.260	0.266	0.161

Figures

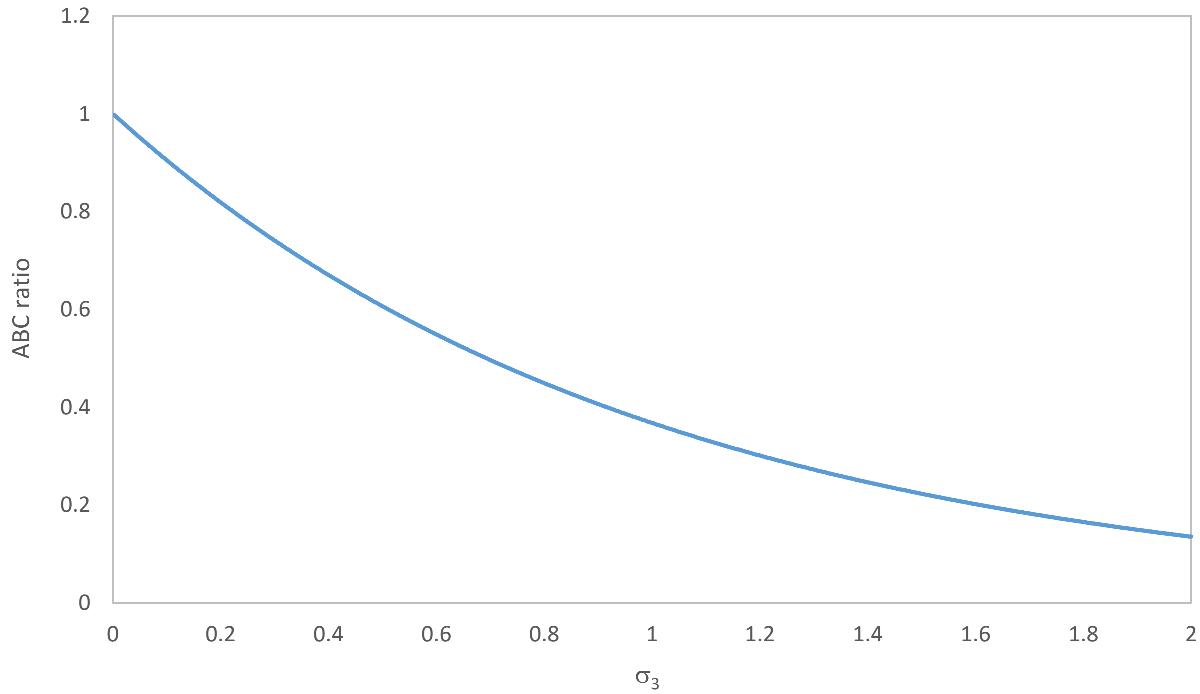

Figure 2.1.3.1. *ABC* ratio as a function of the log-scale standard deviation of female spawning biomass.

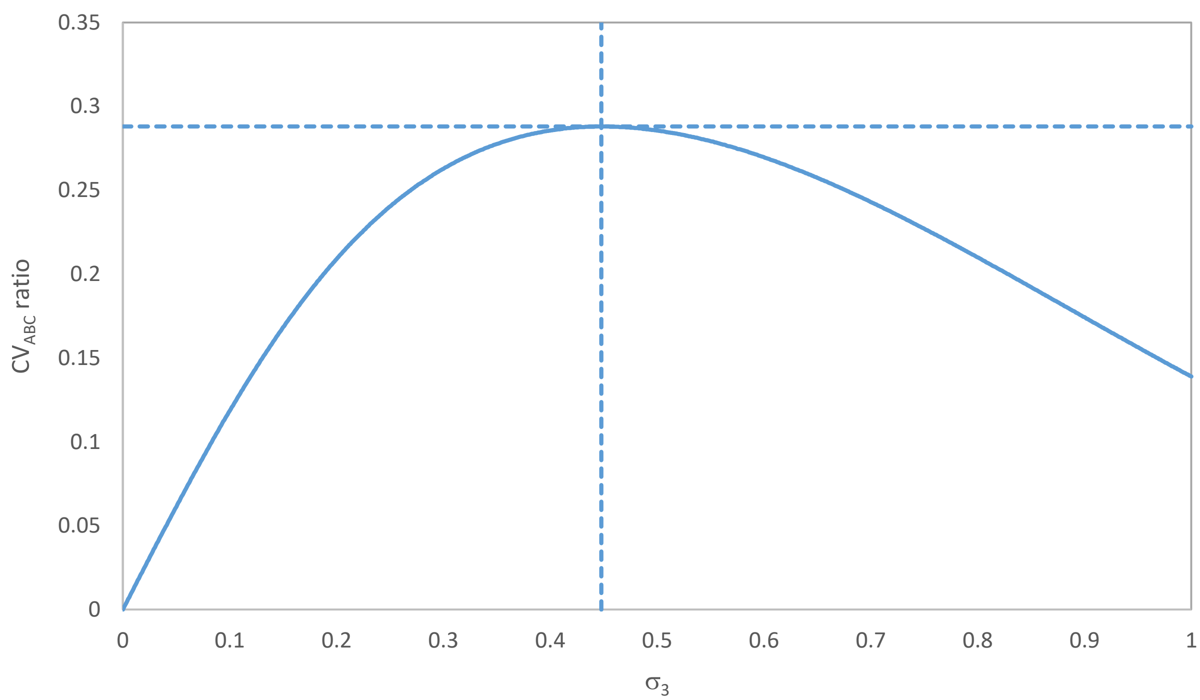

Figure 2.1.3.2. CV_{ABC} ratio as a function of the log-scale standard deviation of female spawning biomass for the special case where the sum of the log-scale variances of $F_{40\%}$ and $B_{40\%}$ equals 0.5.

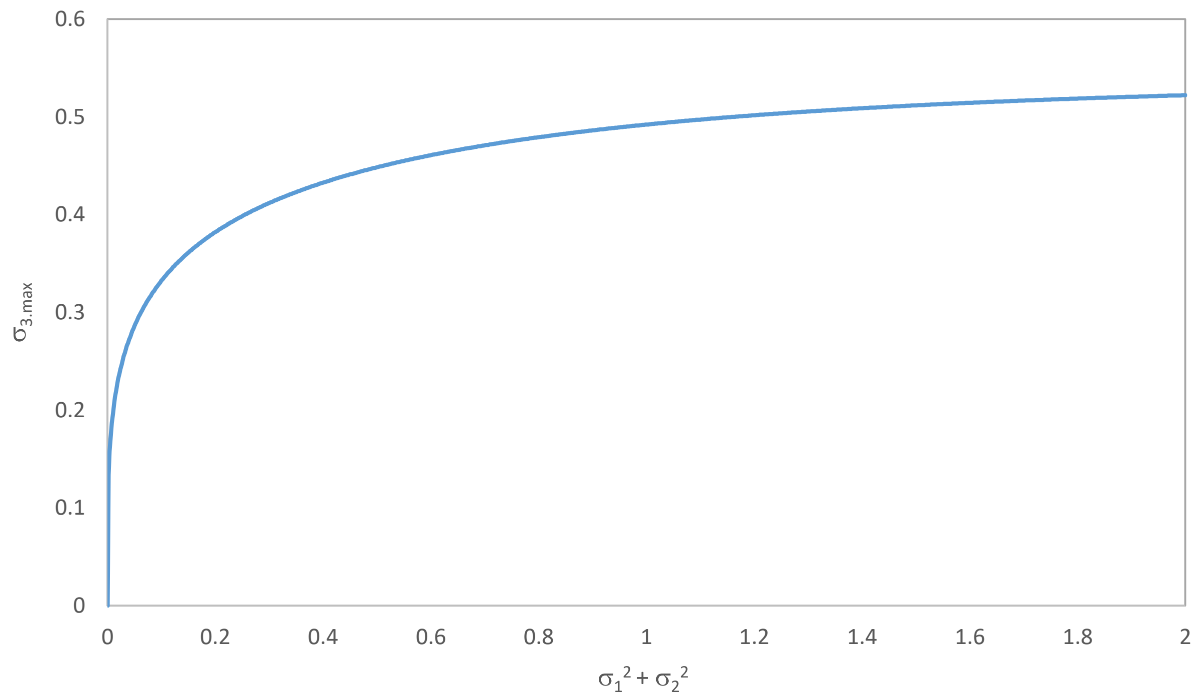

Figure 2.1.3.3. Log-scale standard deviation of female spawning biomass that maximizes the CV_{ABC} ratio as a function of the sum of the log-scale variances of $F_{40\%}$ and $B_{40\%}$.

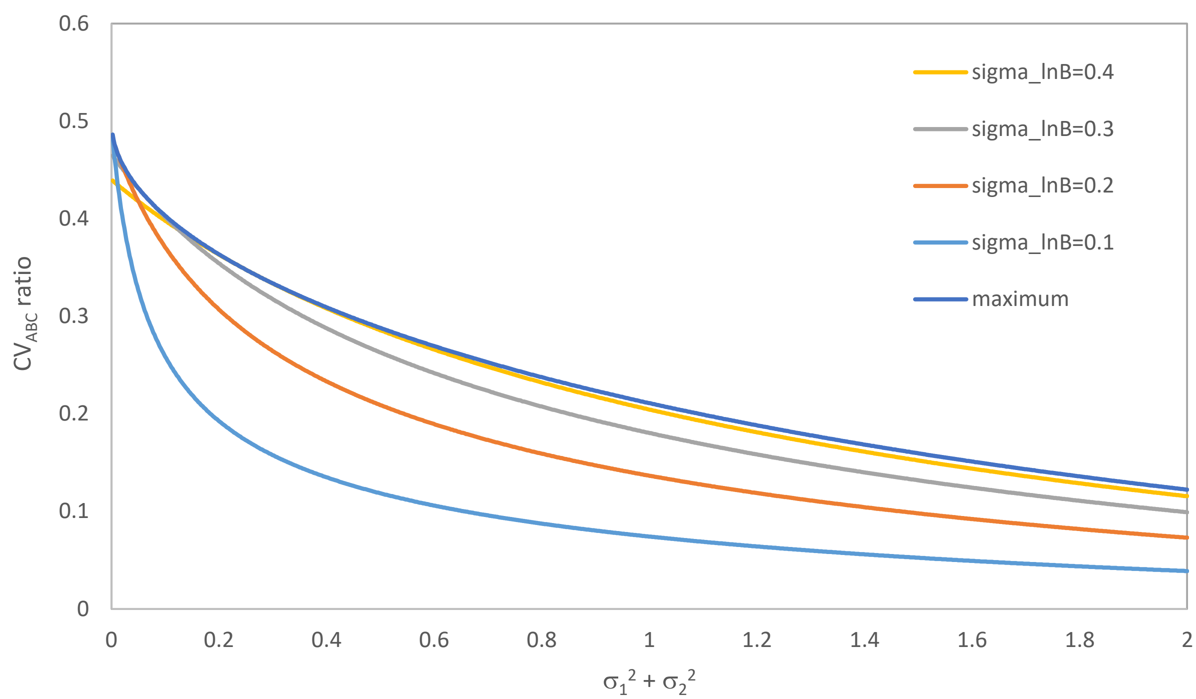

Figure 2.1.3.4. CV_{ABC} ratio as a function of the sum of the log-scale variances of $F_{40\%}$ and $B_{40\%}$.

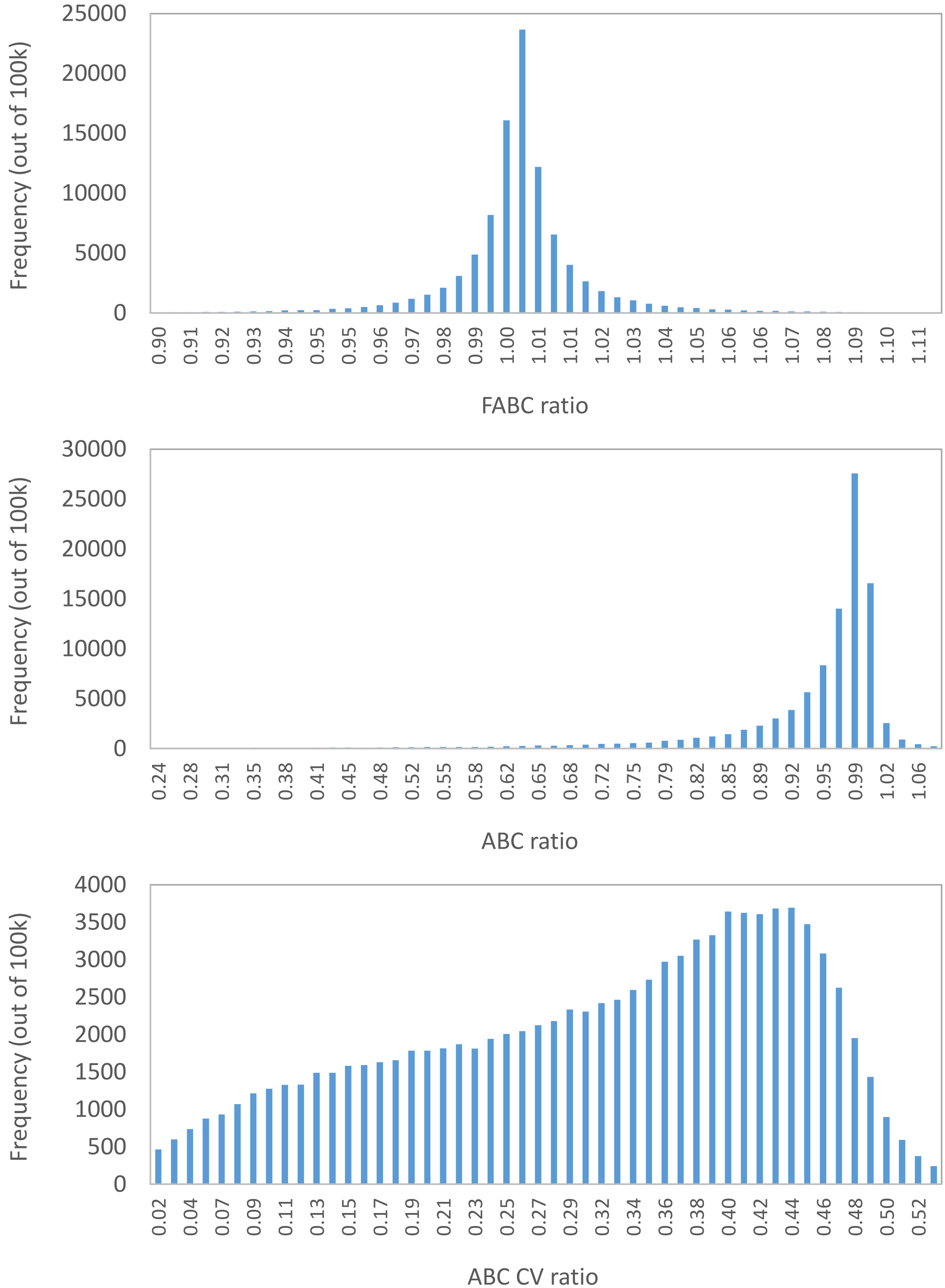

Figure 2.1.3.5a. Results of simulations for hyperparameter values σmean = 0.2, σsdev = 0.2, ρsdev = 0.2.

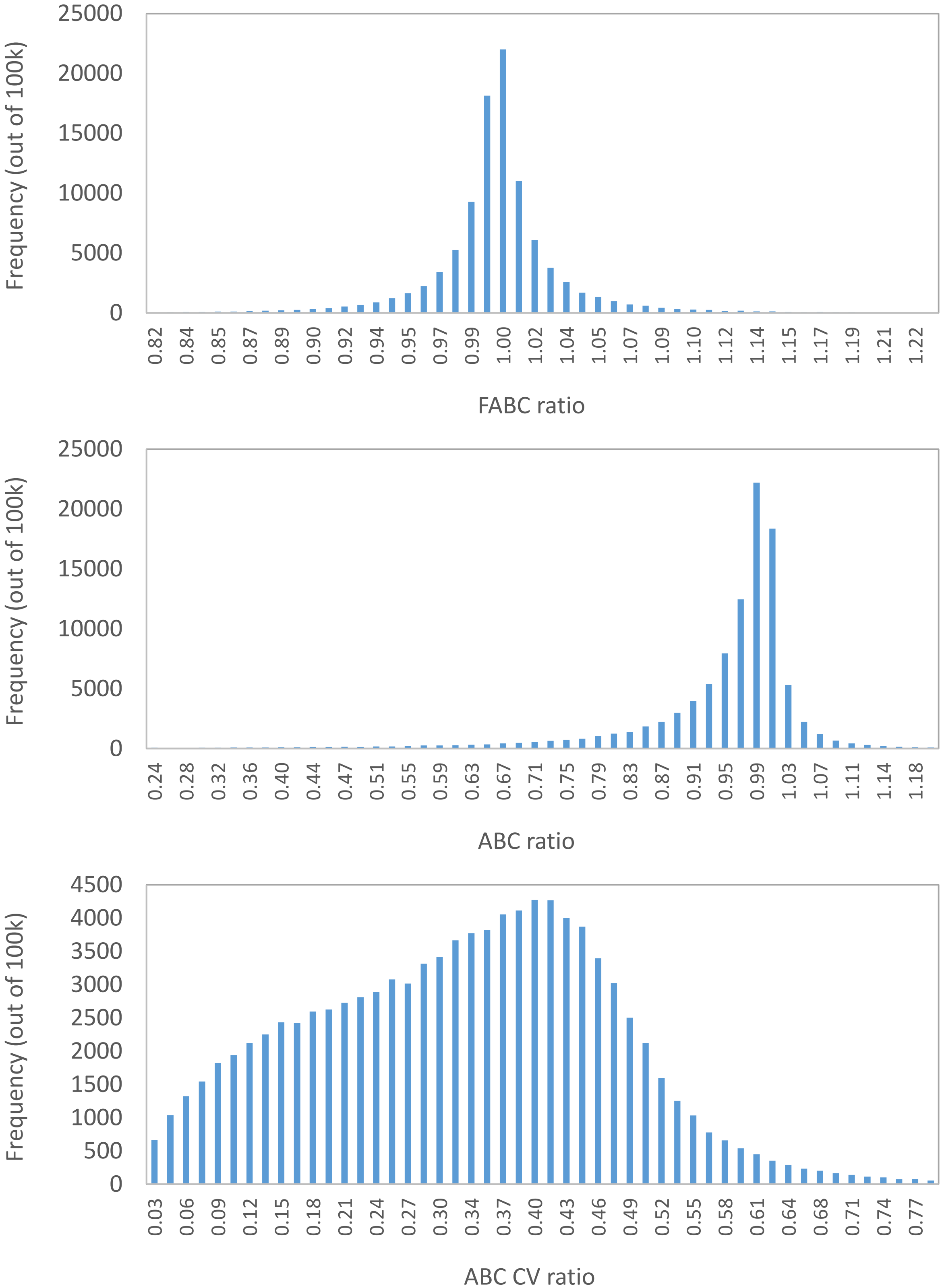

Figure 2.1.3.5b. Results of simulations for hyperparameter values σmean = 0.2, σsdev = 0.2, ρsdev = 0.4.

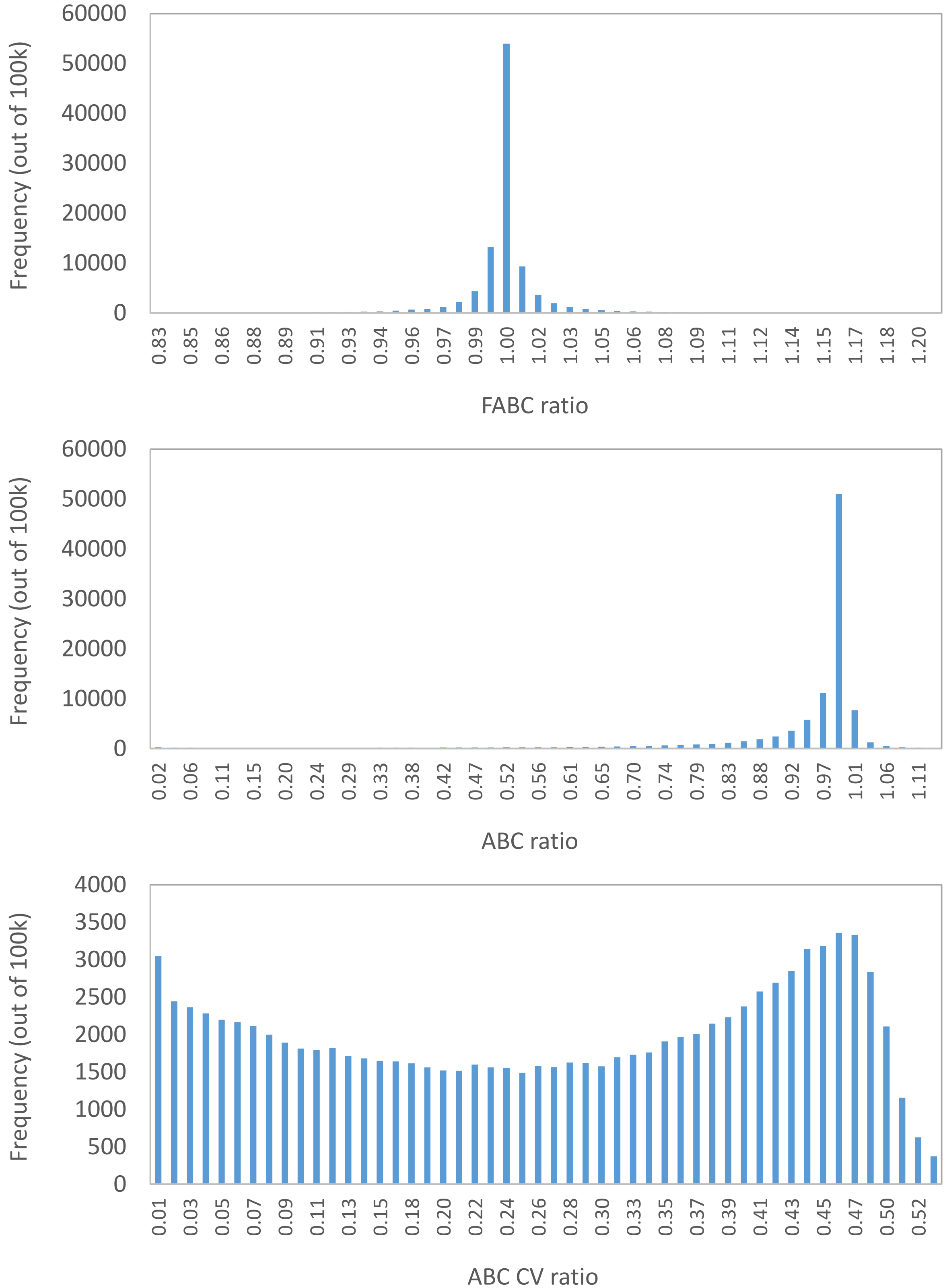

Figure 2.1.3.5c. Results of simulations for hyperparameter values σmean = 0.2, σsdev = 0.4, ρsdev = 0.2.

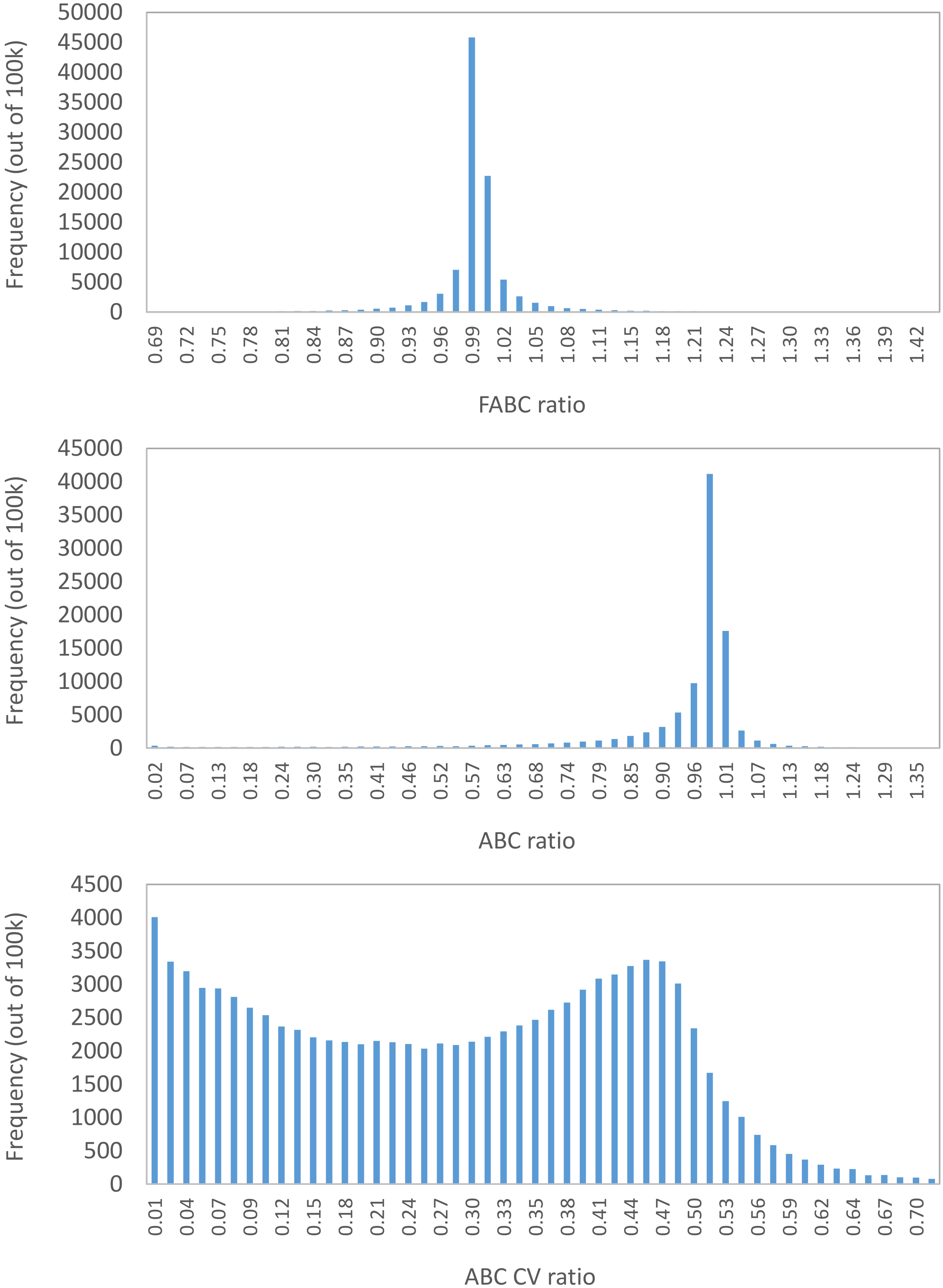

Figure 2.1.3.5d. Results of simulations for hyperparameter values σmean = 0.2, σsdev = 0.4, ρsdev = 0.4.

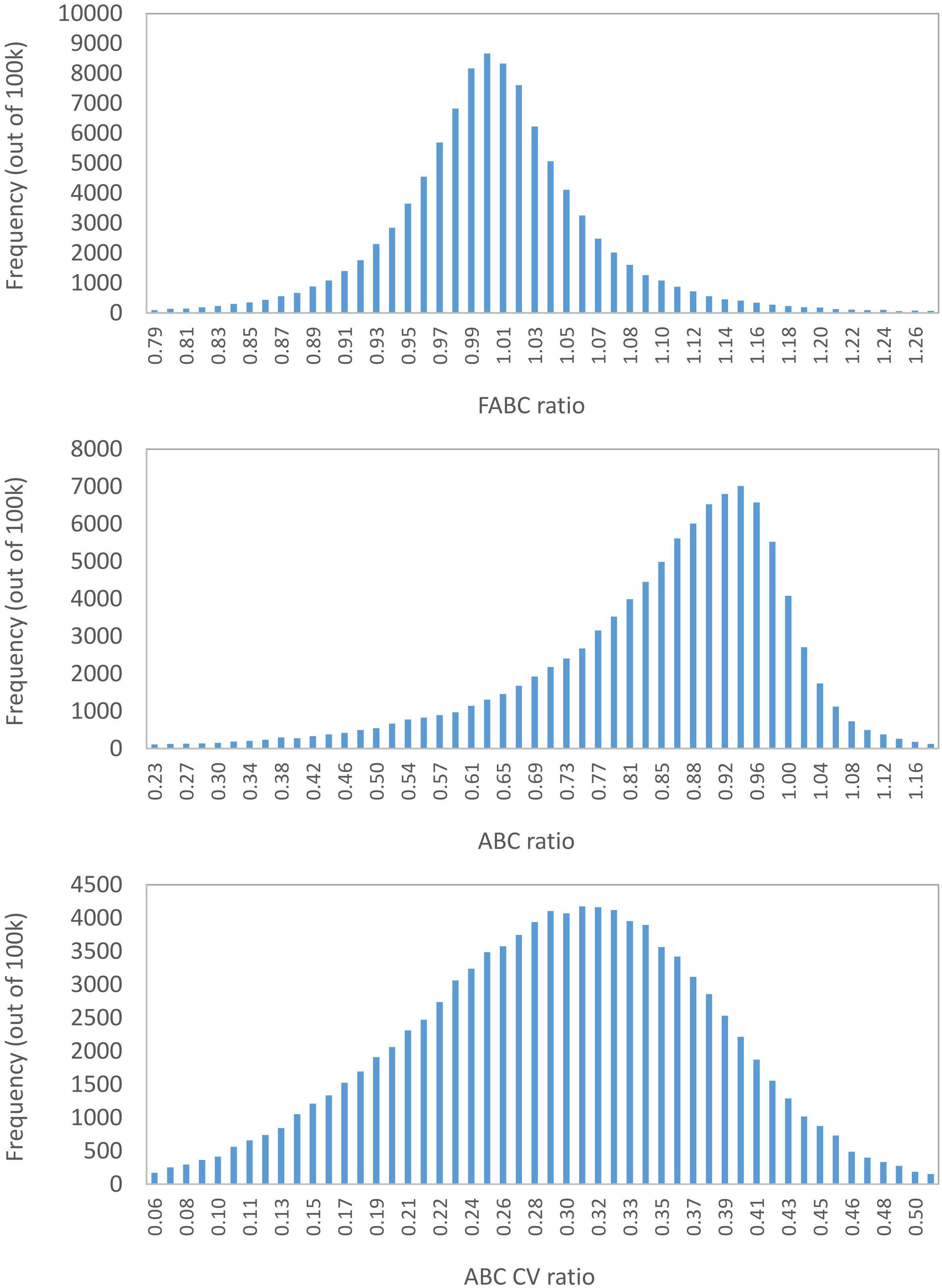

Figure 2.1.3.5e. Results of simulations for hyperparameter values σmean = 0.4, σsdev = 0.2, ρsdev = 0.2.

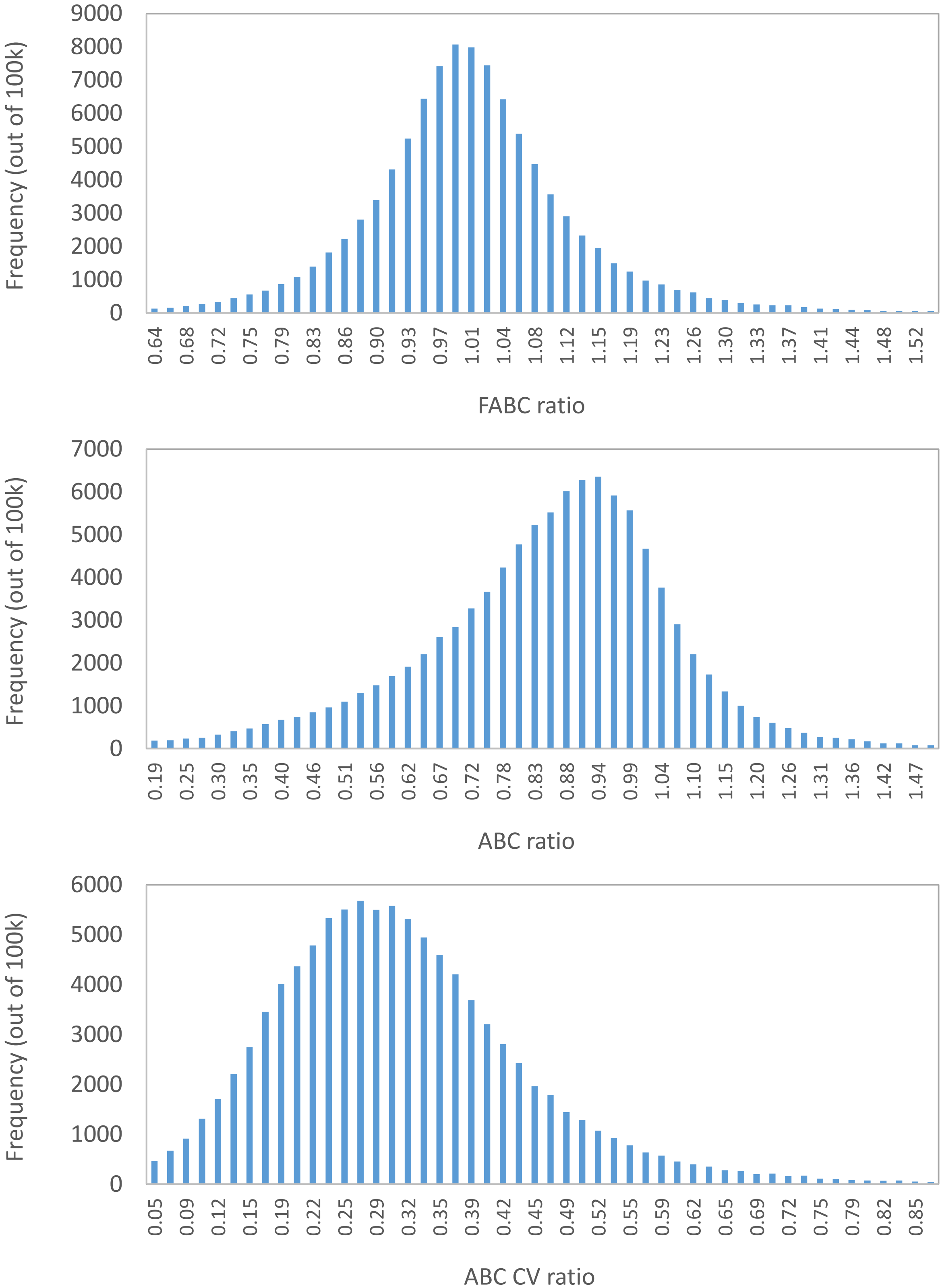

Figure 2.1.3.5f. Results of simulations for hyperparameter values σmean = 0.4, σsdev = 0.2, ρsdev = 0.4.

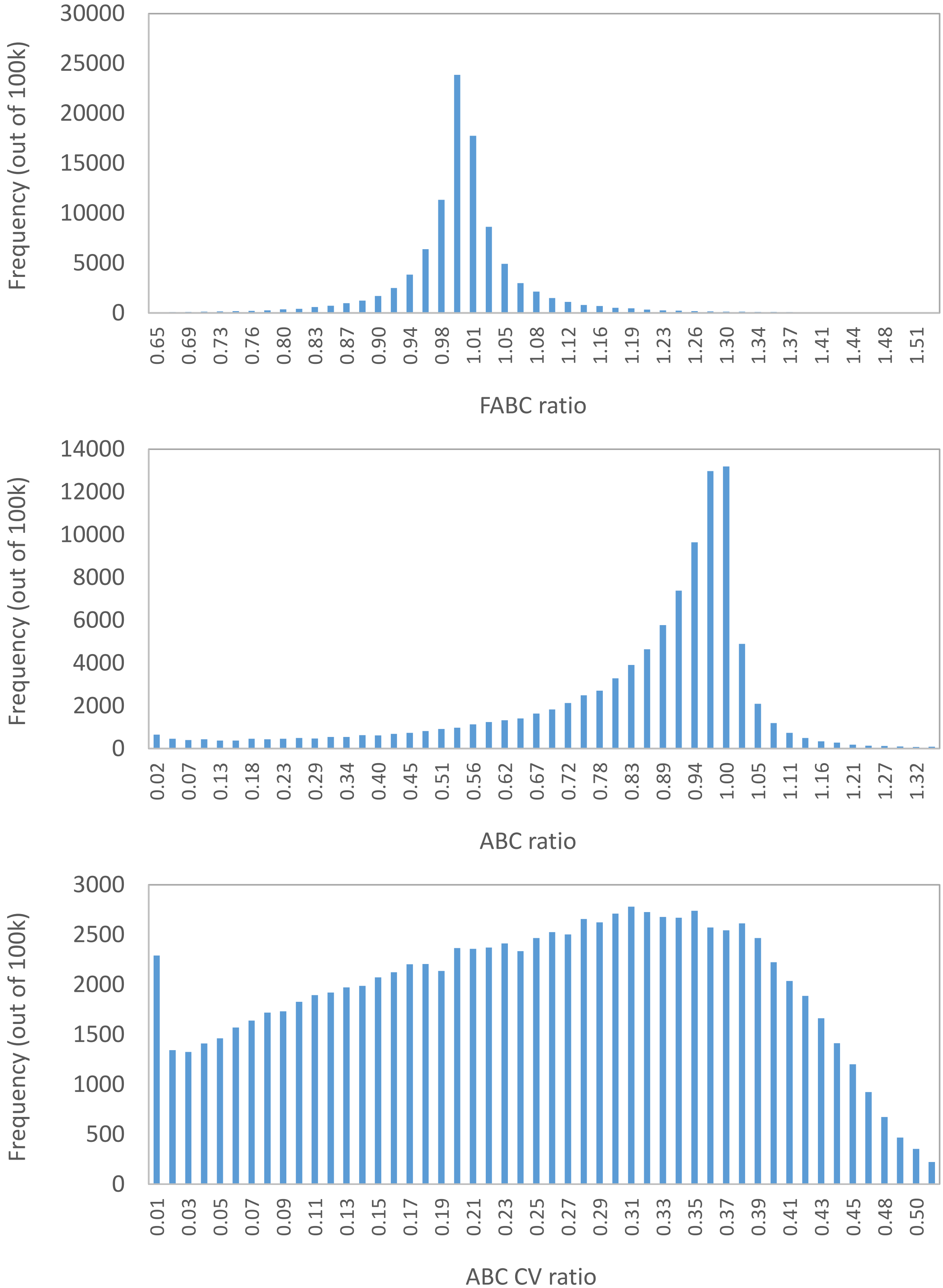

Figure 2.1.3.5g. Results of simulations for hyperparameter values σmean = 0.4, σsdev = 0.4, ρsdev = 0.2.

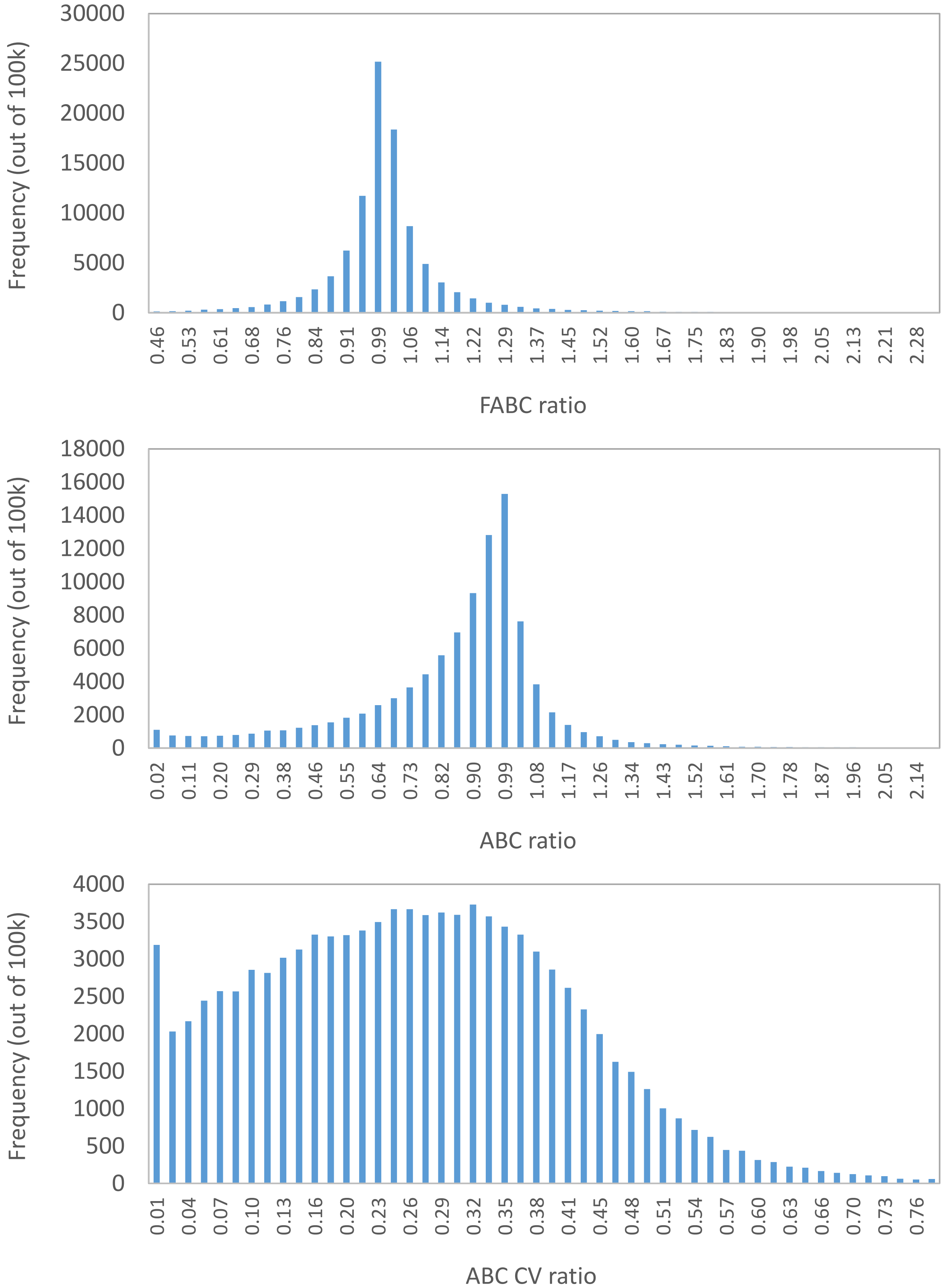

Figure 2.1.3.5h. Results of simulations for hyperparameter values σmean = 0.4, σsdev = 0.4, ρsdev = 0.4.

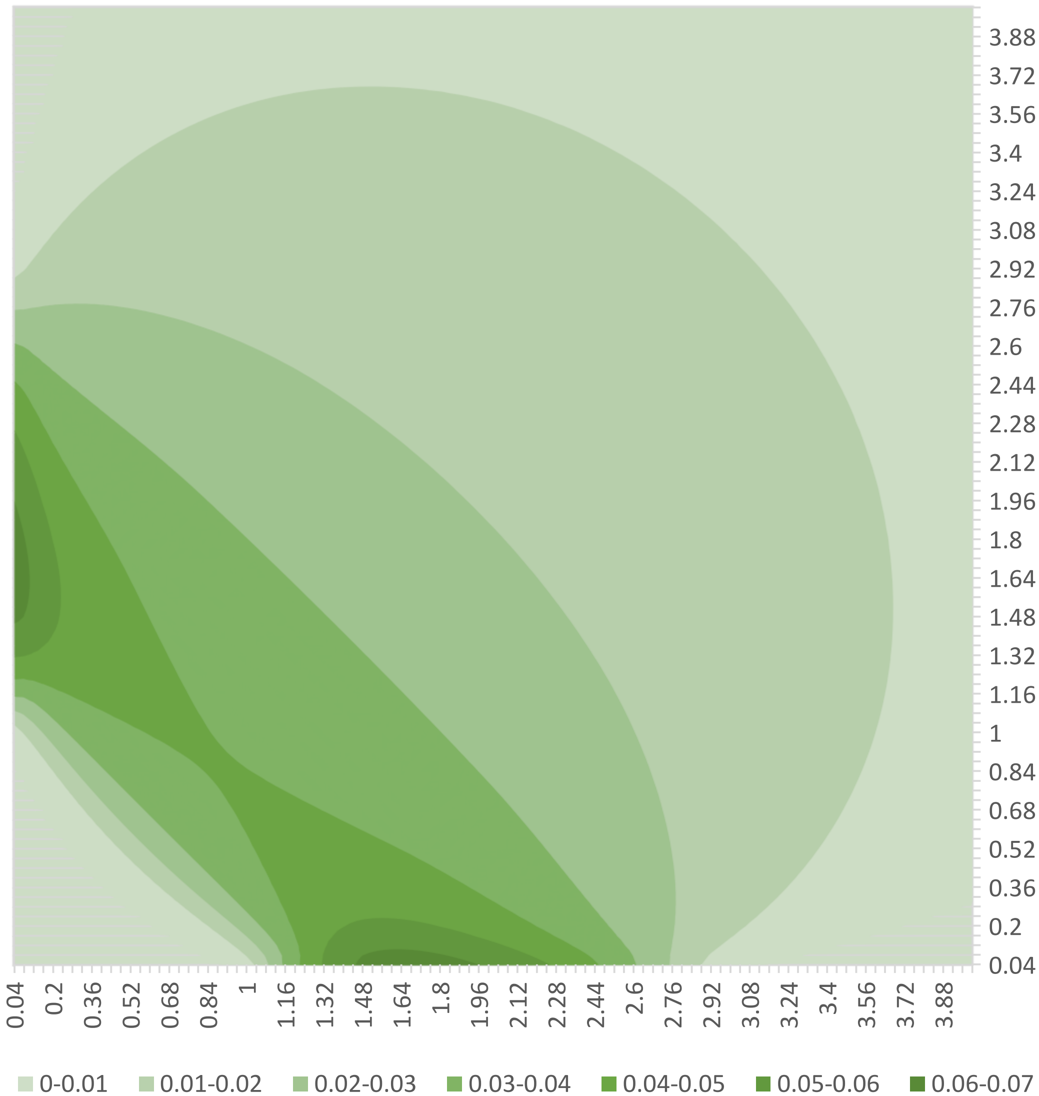

Figure 2.1.3.6. Contour plot showing the proportion of the 3-dimensional correlation volume under which the CV_{ABC} ratio exceeds unity, as a function of the ratios σ_1/σ_3 and σ_2/σ_3 (axes are interchangeable), where σ_1 is the log-scale standard deviation of $F_{40\%}$, σ_2 is the log-scale standard deviation of $B_{40\%}$, and σ_3 is the log-scale standard deviation of female spawning biomass.

APPENDIX 2.2: ECOSYSTEM AND SOCIOECONOMIC PROFILE

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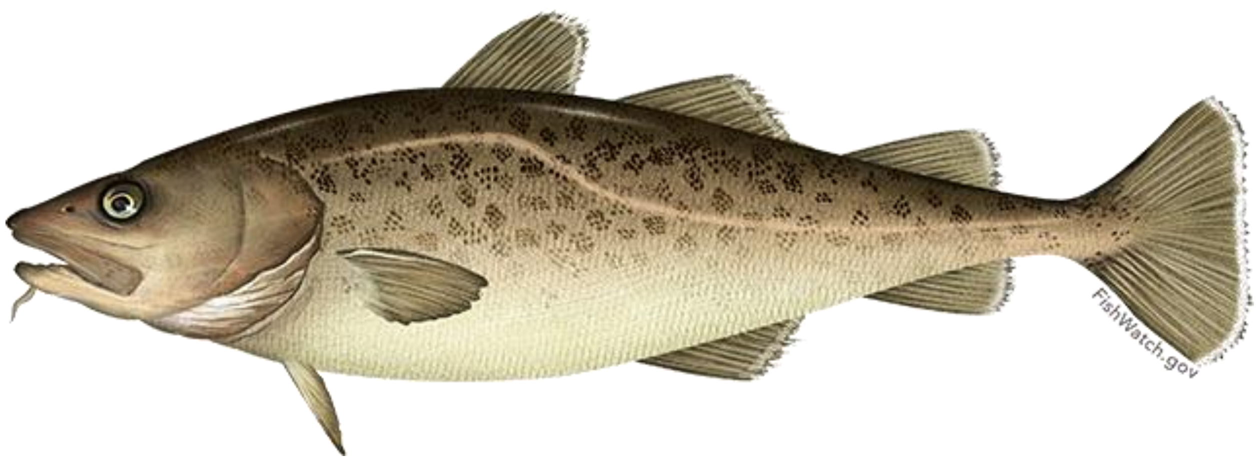
September 2021



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 initiatives and AFSC research priorities support 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 assessment 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 assessments 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 later left the NBS and moved southward into deeper waters in the EBS, including the EBS slope, as sea ice advanced in January to March. One fish was observed to have traveled as far south as the Gulf of Alaska and several moved into Russian waters
- Hatch timing and success is highly temperature dependent, with optimal hatch occurring in waters between 4-6^{o}C, which constrains the areas where spawning is likely to succeed
- High temperatures combined with low energy content of prey may lead to reduced summer growth potential (based on bioenergetics) during warm years in the eastern Bering Sea (EBS)
- Spatial mismatch of large Pacific cod in the NBS and smaller Pacific cod in the EBS 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
- 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 have historically been closely linked in the EBS 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 of adult Pacific cod in the EBS has been moderate to low since 2008, but condition in the NBS has been above average for juveniles from 2018 to 2019
- Center of gravity estimates suggest the summer distribution of Pacific cod has shifted north and west since 2012, but with an east and south shift in 2019, and a fairly stable area occupied over this time
- Arrowtooth flounder biomass has steadily increased over the time series but has stabilized since 2009, while other predator populations appear steady
- 2019/2020 gray whale unusual mortality event (UME) and 2019 shearwater seabird die-off event could reflect poor feeding conditions in the NBS during 2018/2019
- Overall, ecosystem indicators have been decreasing since 2013 with very low values for the time series persisting from 2017 to 2019
- The highest ranked predictor in the recruitment regression model was spring and summer sea surface temperature on the EBS shelf (inclusion probability > 0.5)

Socioeconomic Considerations

- Unalaska/Dutch Harbor was selected as a 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, a drop in 2009, and subsequent steady increase to 2019
- Processing regional quotient (RQ) in Unalaska/Dutch Harbor has an overall decreasing trend with a spike in 2018, while harvesting RQ showed an increasing trend through 2017 and average values 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)

"The JPT were in support of the current templates and the current 3-stage indicator analysis, but noted concerns of over-emphasizing weighting in the first stage and recommended that indicators should be appropriately caveated to not over-generalize indicators across species. The JPT also fully supported the development of the ESP dashboard on AFKIN that includes metadata for each data source, but suggested a staged approach to the integration of data that have not been thoroughly vetted and published.

The SSC endorses the recommendations, comments, and suggestions from the JPT, all of which are consistent with previous SSC recommendations and guidance." (SSC, October 2020)

We provide a simple score following the SSC recommendation and compare the 1:1 weighting of indicators in the "Beginning Stage: Traffic Light Test" with the results of the "Intermediate Stage, Importance Test" section. In the intermediate stage we use a 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 weigh the indicators in the beginning stage for a more informed score.

We have also initiated a new document called the request for indicators or RFI to initiate the ESP process once an ESP is recommended for a stock. The RFI begins with a summary of the dominant ecosystem and socioeconomic processes influencing the stock and then provides the requested list of potential indicators representing those dominant pressures. Instructions for how to contribute an indicator in response to the stock request are included along with details on the indicator review process and associated guideline criteria, the role and responsibilities of ESP teams and contributors, and use and acknowledgement of the indicator if selected for the ESP. The standardized structure of the RFIs and the included guideline criteria will help with vetting indicators and assist with the review of indicators by the ESP teams. We plan to create RFIs for those stocks that already have an ESP completed using the "Data Gaps and Research Priorities" section and intend to complete these in January to begin the 2022 ESP cycle.

"In general, however, the SSC recommends the continued inclusion of community engagement and dependency indices at varying scales in ESPs, ESRs, and SAFEs. For ESPs specifically, changes in patterns of community engagement and dependency at the stock level have the potential to inform not only stock assessments and analyses that support fishery management, but they may also function as early indicators of larger ecosystem changes." (SSC, December 2020)

Community indicators are currently available in the Annual Community and Participation Overview (ACEPO) report (Wise et al., 2021), that presents social and economic information for communities that are substantially engaged in the commercial groundfish and crab fisheries in Alaska. Moving forward, we plan to include socioeconomic indicators in the ESP that reflect the condition or health of the stock and will be evaluating how to reference the products available in the ACEPO report with what might inform on stock health. We plan to address this in the next full or partial ESP for EBS Pacific cod.

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)

In 2020, we developed a first draft of the ESP for GOA Pacific cod, but some delays in production occurred due to the limitations under COVID-19. In this final ESP report we have updated the life history tables and references and allowed for more internal review of the whole document from the Pacific cod ESP team.

"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 with 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 that the population is not expanding much but simply moving north. It may also be useful to look at the clustering of the stock over time to aid with interpretation of the area occupied indicator. Other VAST outputs may be of interest to understand movement dynamics and impact to the stock such as range-edge measures, condition and density analyses, spatial stomach contents, and empirical orthogonal function (EOF) analyses (J. Thorson, pers. commun.).

"The Team recommended collating fishery information in the ESP. Although the CPUE index was of concern to the Team, the Team recognizes that fishery performance has been improving and that these observations should not be ignored. Inclusion of fishery performance in the ESP and evaluation of the

CPUE index with those performance metrics may help provide important insights." (BSAI GPT, November 2020)

Please see response listed in the preliminary assessment of the Pacific cod stock in the eastern Bering Sea (https://apps-afsc.fisheries.noaa.gov/Plan_Team/2021/EBSPcod.pdf).

"For community harvest revenue indicators, the SSC recommends that the analysts consider aggregating small communities that cannot be individually disclosed into a single indicator that can be displayed along with the limited number of larger community indicators that can be disclosed, for consistency with other ESPs and for the sake of a more comprehensive portrayal of EBS Pacific cod community engagement trends. The SSC greatly appreciates the thoroughness of this ESP and looks forward to further development including the third stage (modeling) tests." (SSC, December 2020)

We plan to evaluate the information provided in the Economic SAFE and ACEPO report to determine what socioeconomic indicators could be provided in the ESP that are not redundant with those reports and related directly to stock health. This may result in a transition of indicators currently reported in this ESP to a different series of socioeconomic indicators in future ESPs and may include aggregating small communities or focusing more on dependency rather than engagement. Additional considerations should be given for the timing of the economic and community reports that are delayed by 1-2 years depending on the data source from the annual stock assessment cycle.

Introduction

Ecosystem-based science is becoming a component of effective marine conservation and resource management; however, a 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. Therefore, a 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 for 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 Thompson and Thorson (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

National initiatives and AFSC research priorities support conducting an ESP for the EBS Pacific cod stock. The high commercial importance of the stock and the early life history habitat requirements created a high score for both stock assessment and habitat assessment prioritization (Hollowed et al., 2016; McConnaughey et al., 2017). The vulnerability scores were in the low to moderate range 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 EBS Pacific cod suggest a data-rich stock with high quality data for catch, size/age composition, abundance, and life history categories. There was also a high ecosystem linkage target for this stock which means there is potential to use ecosystem information in configuring the operational stock assessment model in the near future (Lynch et al., 2018). These initiative scores and data classification levels suggest a high priority for conducting an ESP for EBS Pacific cod, particularly given the high level of life history information and previous explorations of ecosystem linkages with recruitment and movement (Thompson, 2018a,b; Thompson et al., 2020). Additionally, AFSC research priorities support studies that improve 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 improves understanding of Pacific cod dynamics in the Gulf of Alaska and the Bering Sea.

Data
Initial information for an EBS Pacific cod ESP 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 and susceptibility analysis conducted for all groundfish stocks in Alaska were also included (Ormseth and Spencer, 2011). Data derived from this effort served as the 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 (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 both juvenile (less than or equal to 46 cm) and adult life history stages 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). Remote sensing data were collected through coordination with CoastWatch personnel at the Southwest Fisheries Science Center (Simons, 2020). 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 derived from the 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 that were used to generate the baseline metrics for this second step of the ESP process and then provide more specific analyses on relevant ecosystem or socioeconomic processes. “Metrics,” in this context, are quantitative stock-specific measures that identify vulnerability or resilience of the stock with respect to biological or socioeconomic processes. Many decades’s worth of process studies on cod stocks around the world, including research conducted by the FOCI program, reveal 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 (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 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" appears 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 compare 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 (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 when compared to other stocks in the groundfish FMP. For socioeconomic metrics, commercial importance and non-catch value fell within the 90th percentile and constituent demand fell within the 80th percentile. 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; Neidetcher et al., 2014). Analysis of otolith elemental composition indicated that age-0 recruits on the southeastern Bering Sea 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 left the NBS and moved southward into deeper waters in the EBS and EBS slope as sea ice advanced in January to March. Tagged fish also traveled as far south as 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 weeks 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 of 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, changes in the species composition and biochemical characteristics (fatty acid composition) of lower trophic levels induced by ocean acidification may also impact the early growth and survival of cod larvae in the future.

Pacific cod larvae are known to occur in the southeastern Bering Sea 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 recent 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 southeastern Bering Sea (Hurst et al., 2018). These differences may have implications for the patterns of overwinter survival of age-0 Pacific cod, as observed in eastern Bering Sea walleye pollock (Heintz et al., 2013; Farley et al., 2016). 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 (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 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 (2015-2019), however, 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 that 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 (Siddon et al., 2019). 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 correlation between the Pacific cod and pollock recruitment time series (from 1977 onward) peaks in 2008, which might suggest a shift (or greater disparity) between drivers of age 0 survival in these two populations thereafter. 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 EBS 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 and Aleutian Islands 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 catcher/processors (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 catcher vessels (CVs), 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 hook-and-line and one quarter to trawl. Prior to 2016 the inshore sector accounted for 25-30% of the total retained catch of BSAI Pacific cod. 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 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 (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 (Table 2.2.3b). Revenues in recent years have remained high as price increases offset decreases in 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. Relative to 2018, the H&G price was down 14% to $1.60 per pound in 2019 and fillet prices decreased 5% in 2019 to $3.92.

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 (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 future 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, 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% in 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% (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 Pacific cod for at least one year. Only the At Sea processing sector emerged as Highly Engaged in processing BSAI Pacific cod, while Unalaska/Dutch Harbor appeared as Medium-High engagement. Harvesting engagement to some degree involved a number of communities; however Seattle metropolitan statistical area (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 Pacific cod processed in all communities was 419 million pounds, with $102.4 million in landed value. In 2019, 73% of retained catch 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 Pacific cod 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 vessels (down 32%); while the number of processors in Unalaska/Dutch Harbor declined by 8 (down 67%).

Focusing on 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 began 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 value 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% (Figure 2.2.4a).

Within the BSAI Pacific cod harvesting sector, eight communities were identified as being substantially engaged and only the Seattle MSA 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 Pacific cod 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 Pacific cod harvesting, the average value of harvest per vessel owned by residents from 2000 to 2019 was examined (Figure 2.2.4b). The average value for Seattle MSA decreased by 23% (down $13 million) since 2000. Within the past five years, Seattle MSA's vessels' 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) (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 represents the critical processes identified by the metric assessment. These indicators must be potentially 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 consisting of statistical tests that gradually increase in complexity, depending on the availability of data for 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. Egg and larval stages are particularly vulnerable to abiotic forces such as temperature and salinity. Laboratory studies focused on temperature effects have demonstrated impacts on 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).

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 sampling 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 been 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 EBSPacific 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 EBS 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 (Table 2.2.2b, 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 Figure 2.2.5a and Figure 2.2.5b, respectively.

Ecosystem Indicators:

1. Physical Indicators (Figure 2.2.5a.a-f)
    - North Pacific Index (NPI), November to March average: index is the area-weighted sea level pressure (SLP) 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 average daily sea-ice extent was computed for the period of 1981-2010 (following the current climatological standard), 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 southeastern Bering Sea 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. The peak timing was then averaged across all statistical areas in order to weight each stat area equally. This was done 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 data server (Simons, 2020) 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 (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 EBS shelf survey area (Ressler et al., 2019). Data available for variable years historically and biennially since 2012 (contact: P. Ressler).

3. Upper Trophic Indicators (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 EBS shelf bottom trawl survey, 1998 to present (contact: S. Rohan).
    - We calculate the effective area occupied and center of gravity for abundance (numbers) in the bottom trawl survey for the eastern and northern Bering Sea. 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. 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 the 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. Conner).
    - Arrowtooth flounder total biomass (metric tons) from the most recent stock assessment model (contact: K. Shotwell).

<u>Socioeconomic Indicators:</u>

1. Economic Indicators (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 (Figure 2.2.5b.d-e)
    - The 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 (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 availability of data for the stock (Shotwell et al., *In Review*). At this time, we report the results of the beginning and intermediate stage statistical tests of the indicator monitoring analysis for EBS Pacific cod and a review of current ecosystem linked modeling developments for the advanced stage.

Beginning Stage, Traffic Light Test:
The beginning 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 February 2020, we include a scoring calculation to this test. The indicator values are evaluated with respect to whether 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, because these qualitative indicators represent sequential events through the life history of the species, "stopping rules" should be considered wherein a mortality event in the early life history could govern a year class (e.g., see the "switch" model proposed for GOA pollock 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 in the order that 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 (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 temperatures, 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 that 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 dramatically in 2014 and continued to decline to a time-series low in 2018, but increased somewhat in 2019 and 2020 (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 (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 the 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, to subsequent match/mismatch with the spring bloom.

Spring to summer surface temperatures increased steadily from 2012 to 2020, with a time series high in 2019, somewhat mirroring the sea ice extent (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 (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 (Figure 2.2.5a.f). The timing was average or very late 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 (Figure 2.2.5a.g) steadily dropped from a high in 2009 to a low in 2016, with only a moderate increase in 2018 (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 southeastern Bering Sea 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 juvenile 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, 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 in summer (Figure 2.2.5a.j-l). COG eastings and northings suggest that the population has moved 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 (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 (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 (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 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 ecosystem indicators for the GOA Pacific 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 indicators were largely negative. It should be noted that 2020 data were available for only 7 of the potential 13 ecosystem indicators (Table 2.2.5a). Overall, socioeconomic indicators have been largely stable since 2012. Also note that 2020 data were available for only 2 of the potential 6 socioeconomic indicators (Table 2.2.4b). No community indicators were available in 2020, 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).

<u>Intermediate Stage, Importance Test:</u>
Bayesian adaptive sampling (BAS) was used for the intermediate 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 intermediate test, the full set of indicators is first winnowed to the predictors that could directly relate to recruitment and highly correlated covariates are removed (Figure 2.2.7a). We further restrict potential covariates to those that can provide the longest model run through the most recent year class that is well estimated in last year's operational stock assessment model. We then provide the mean relationship between each predictor variable and log EBS Pacific cod recruitment over time (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 (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 (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 multivariate statistical searches of processes governing recruitment required that the analysts consider the temporal sequence of mortality events. Temporal sequencing of mortality events will be considered in future versions of this statistical approach.

<u>Advanced Stage, Research Model Test:</u>
In the future, highly ranked predictor variables could be evaluated in the advanced stage statistical test, which is a modeling application that analyzes predictor performance and estimates risk 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 and Thorson, 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.

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 CEATTLE model could be compared 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 if future spatial models were developed for this stock.

Conclusion

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 later left the NBS and moved southward into deeper waters in the EBS, including the EBS slope, as sea ice advanced in January to March. One fish was observed to have traveled as far south as the Gulf of Alaska and several moved into Russian waters
- Hatch timing and success is highly temperature dependent with optimal hatch occurring in waters between 4-6^{o}C, which constrains the areas where spawning is likely to succeed. 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
- Spatial mismatch of large Pacific cod in the NBS and smaller Pacific cod in the EBS 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 EBS 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 EBS 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, and with a fairly stable area occupied over this time
- Arrowtooth flounder biomass has steadily increased over the time series but has stabilized since 2009, while other predator populations appear steady
- The 2019/2020 gray whale UME and 2019 shearwater seabird die-off event could reflect poor feeding conditions in the NBS during 2018/2019
- Overall, ecosystem indicators have been decreasing since 2013 with very low values for the time series persisting from 2017 to 2019
- The highest ranked predictor for recruitment in the regression model was spring and summer sea surface temperature on the EBS shelf (inclusion probability > 0.5)

Socioeconomic Considerations

- Unalaska/Dutch Harbor was selected as a 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, a drop in 2009, and steady increase to 2019

- Processing regional quotient (RQ) in Unalaska/Dutch Harbor has an overall decreasing trend with a spike in 2018, while harvesting RQ has an increasing trend through 2017 and average values 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. Gaps in indicator time series cause issues with updating the ESP 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 from the North Pacific Research Board's integrated ecosystem research program in the Arctic may be helpful for evaluating the northern 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, the timing of which will depend on how the ESP process matures.

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*Superscript numbers refer to references in Table 2.2.2a

Tables

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 and Zador, 2019; Siddon, 2020) and the Economic Status Report (Fissel et al., 2019, 2021) 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
EMA Late-Summer Survey	Surface trawl survey of juvenile groundfish and forage fish and bongo tows to sample zooplankton community composition from August-September on the eastern Bering Sea shelf, fixed-station grid	2002 – present	Eastern Bering Sea annual, 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 from June to August to monitor pollock on the eastern Bering Sea shelf and slope	2004 – 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	1977 – 2021	Alaska variable

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, 2020, Zador et al., 2019) and the Economic Status Report (Fissel et al., 2019, 2021) for more details.

Title	Description	Years	Extent
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

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)

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 3-6º 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)

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

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

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.

Table 2.2.4a. Beginning 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 creates 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

Table 2.2.4b. Beginning 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 creates 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

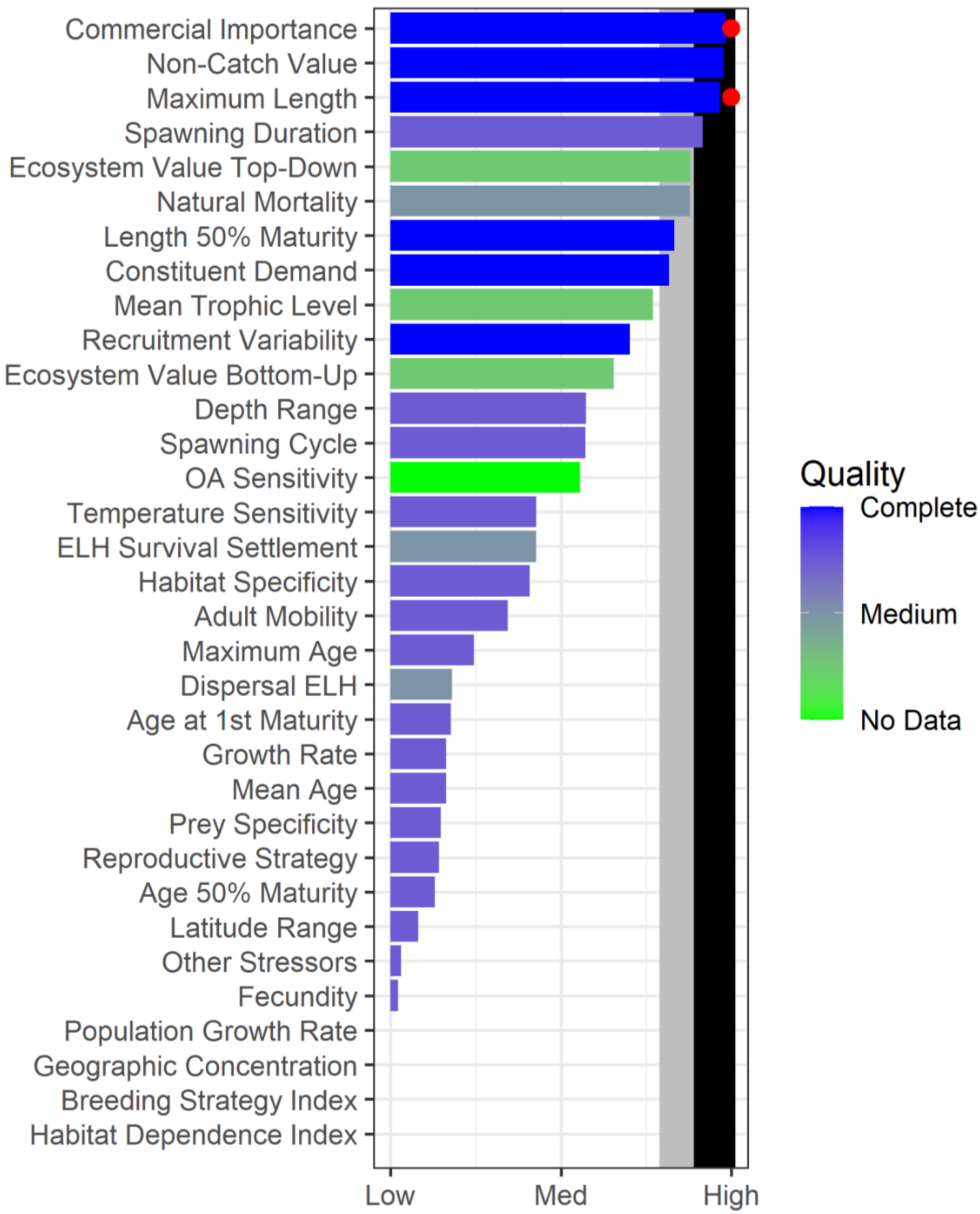


Figure 2.2.1. Baseline metrics for EBS Pacific cod graded as percentile rank over all groundfish in the FMP. Black bar indicates 90th percentile, gray bar indicates 80th percentile for all groundfish in Alaska. Red dots indicates value passes a national threshold for vulnerability. Higher rank values 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).

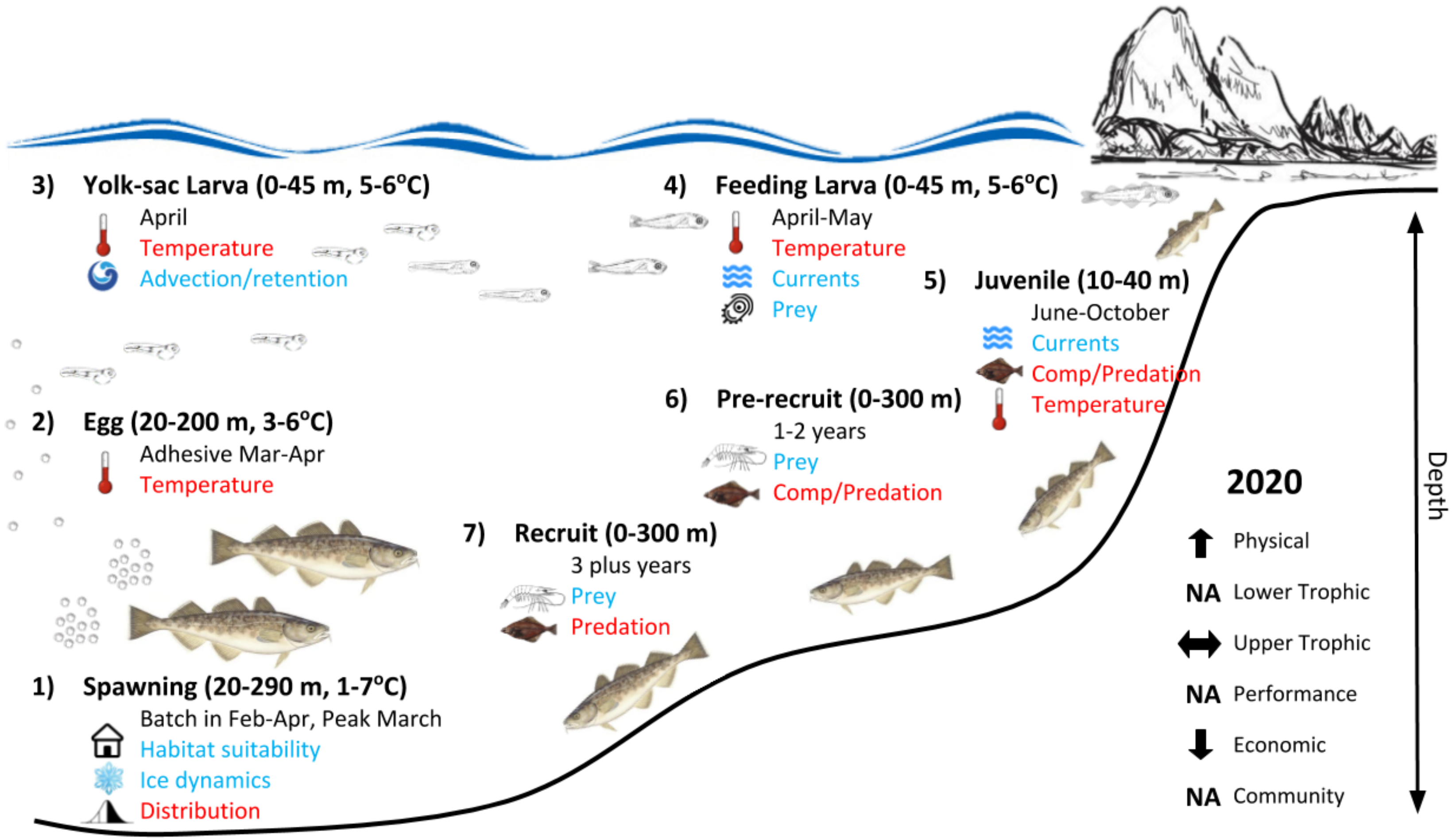


Figure 2.2.2: Life history conceptual model for EBS Pacific cod summarizing ecological information and key ecosystem processes affecting survival by life history stage. Red text means increases in process negatively affect survival, while blue text means increases in process positively affect survival.

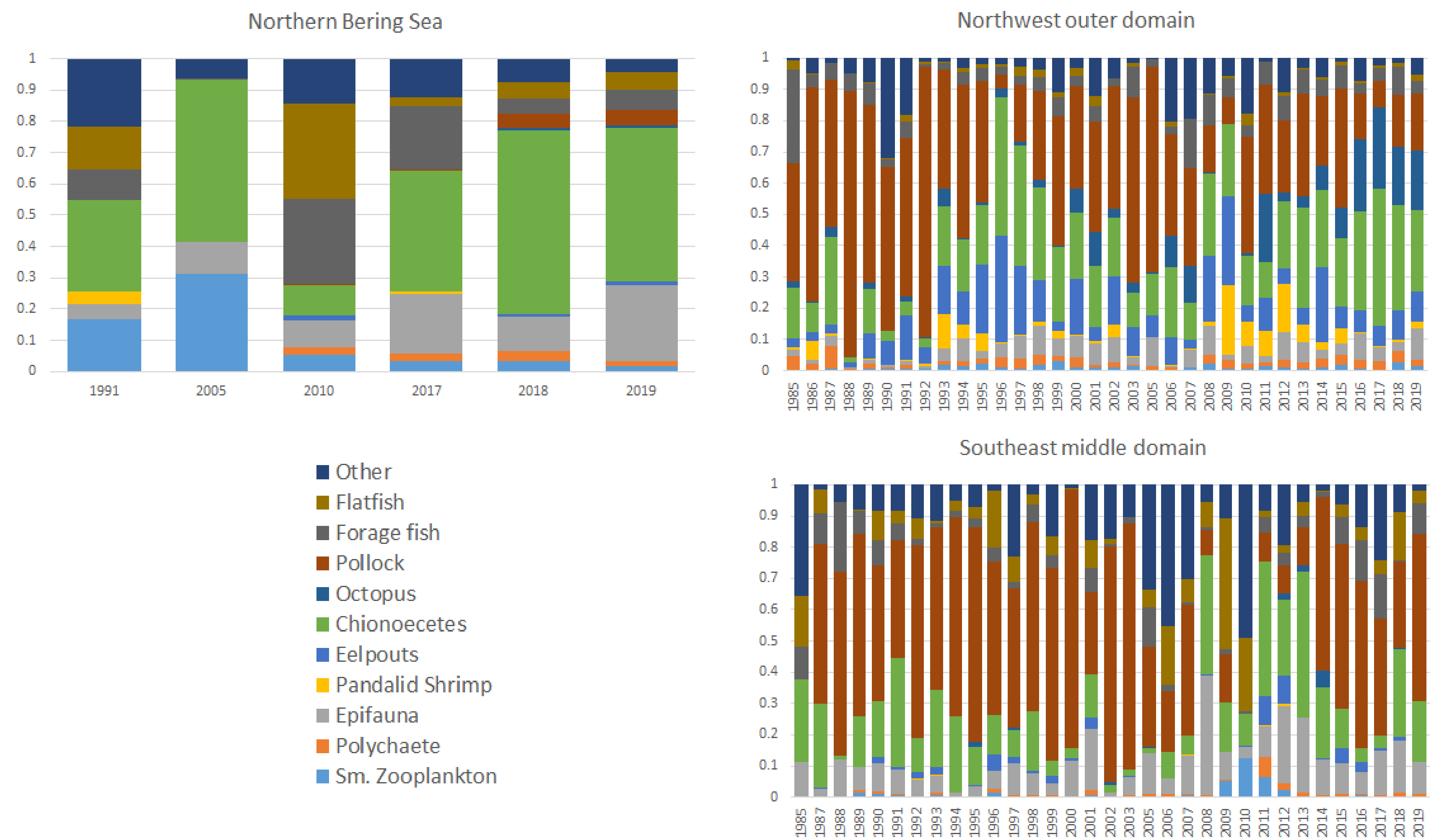


Figure 2.2.3: Diet proportions (proportion by weight) of eastern Bering Sea Pacific cod with fork lengths of 60+cm, by survey stratum, as sampled from Alaska Fisheries Science Center summer bottom-trawl surveys (reproduced from Aydin, 2020).

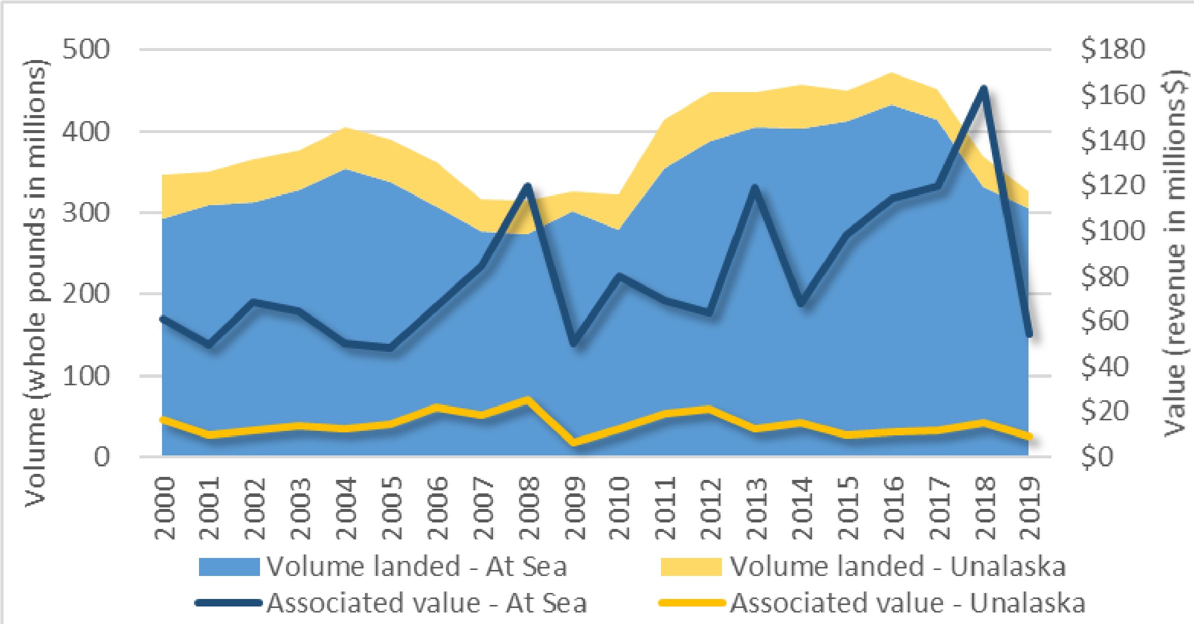


Figure 2.2.4a: Processing engagement: volume BSAI Pcod and value landed At Sea and in Unalaska/Dutch Harbor (2000-2019).

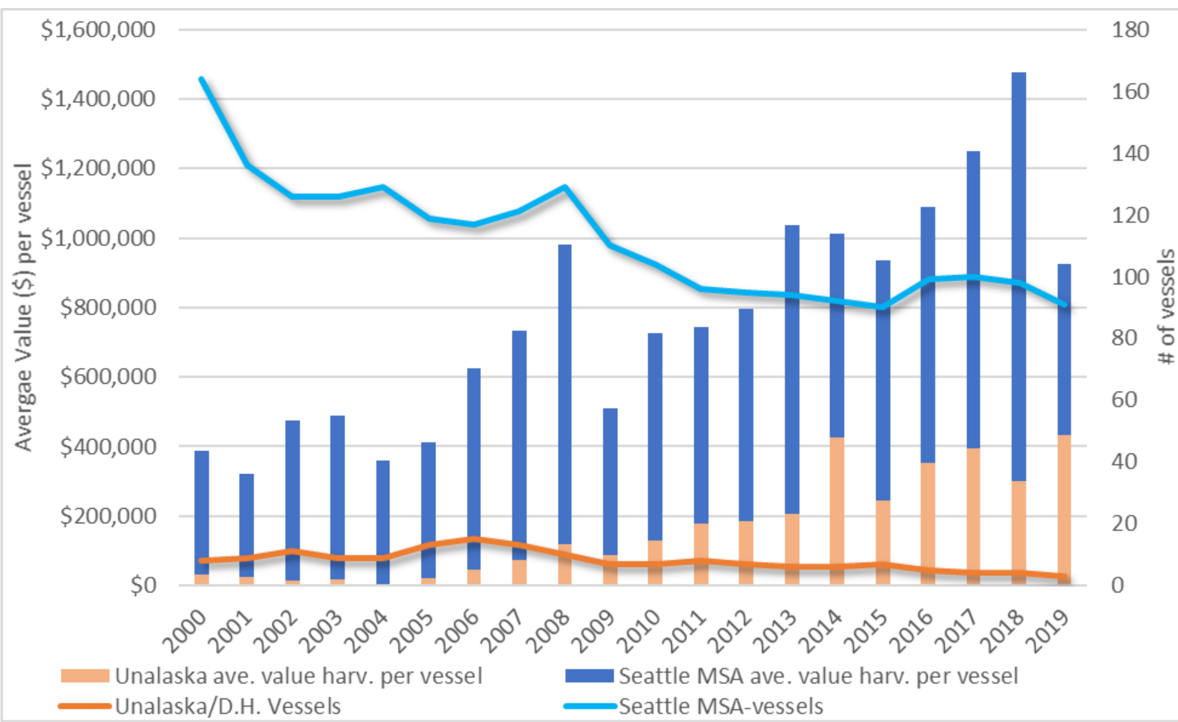


Figure 2.2.4b: Harvesting engagement: Average value of BSAI Pcod harvested by vessels owned by residents (2000-2019).

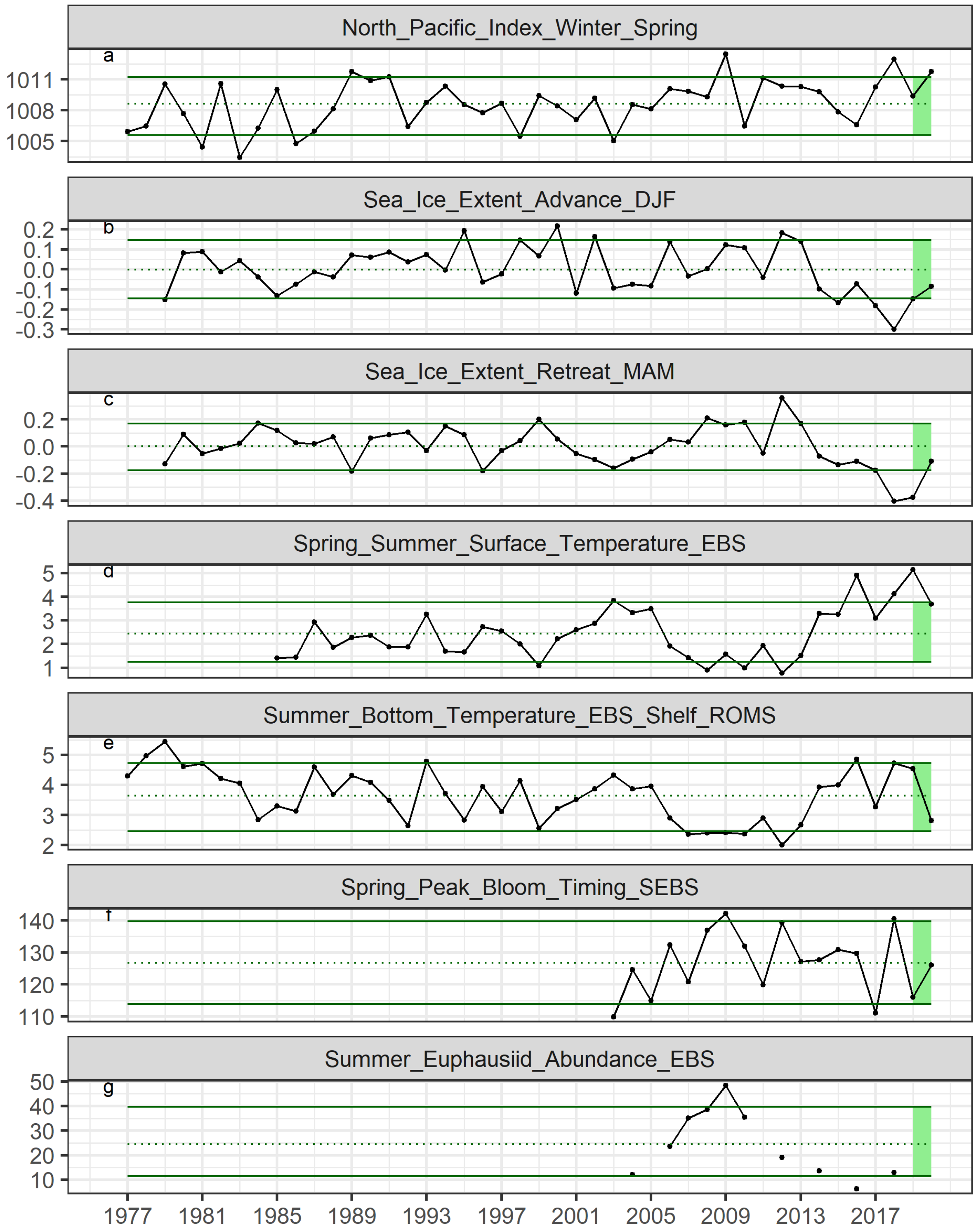


Figure 2.2.5a. Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is mean of time series. Light green shaded area represents most recent year for traffic light analysis.

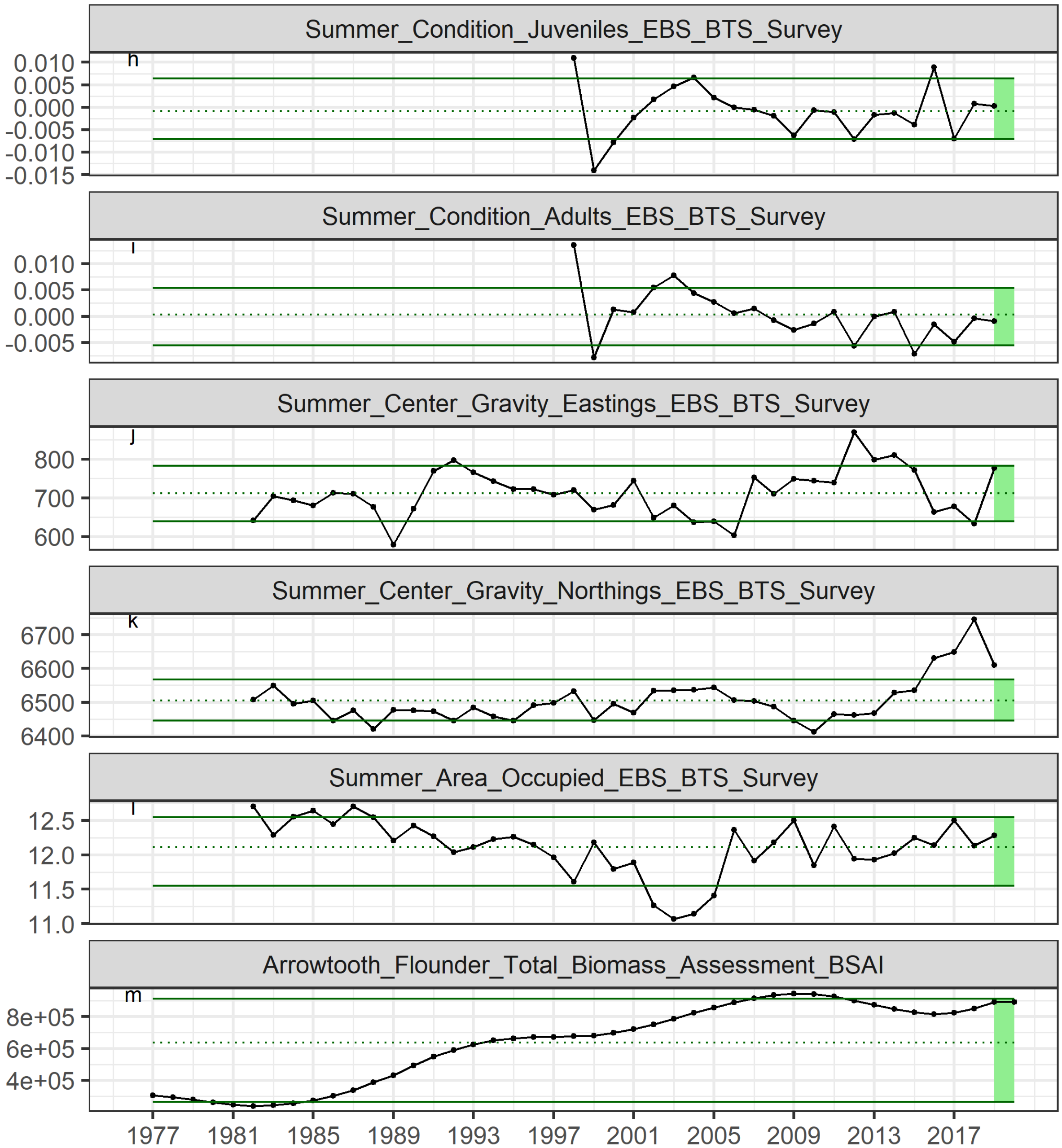


Figure 2.2.5a (cont.). Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is mean of time series. Light green shaded area represents most recent year for traffic light analysis.

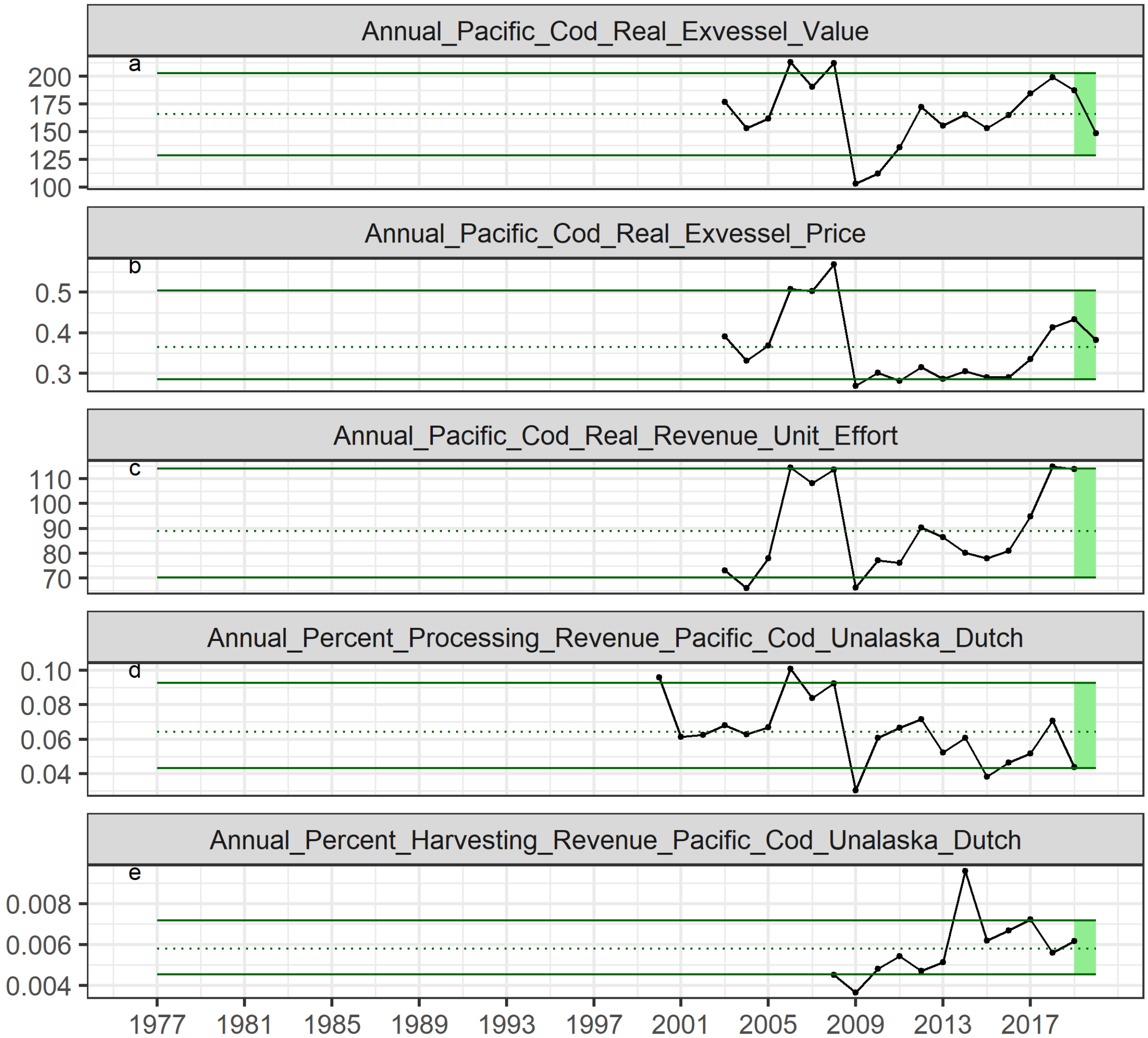


Figure 2.2.5b. Selected socioeconomic indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is mean of time series. Light green shaded area represents most recent year for traffic light analysis.

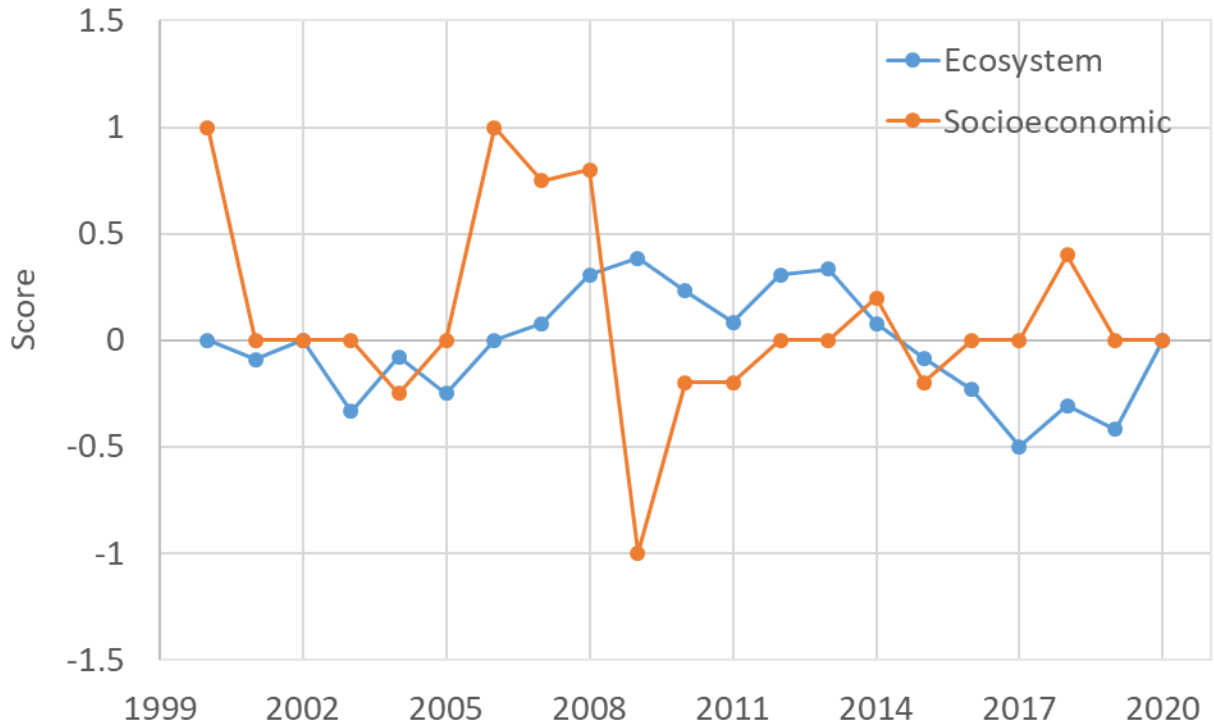


Figure 2.2.6: Beginning stage traffic light score for overall ecosystem and socioeconomic categories from 2000 to present.

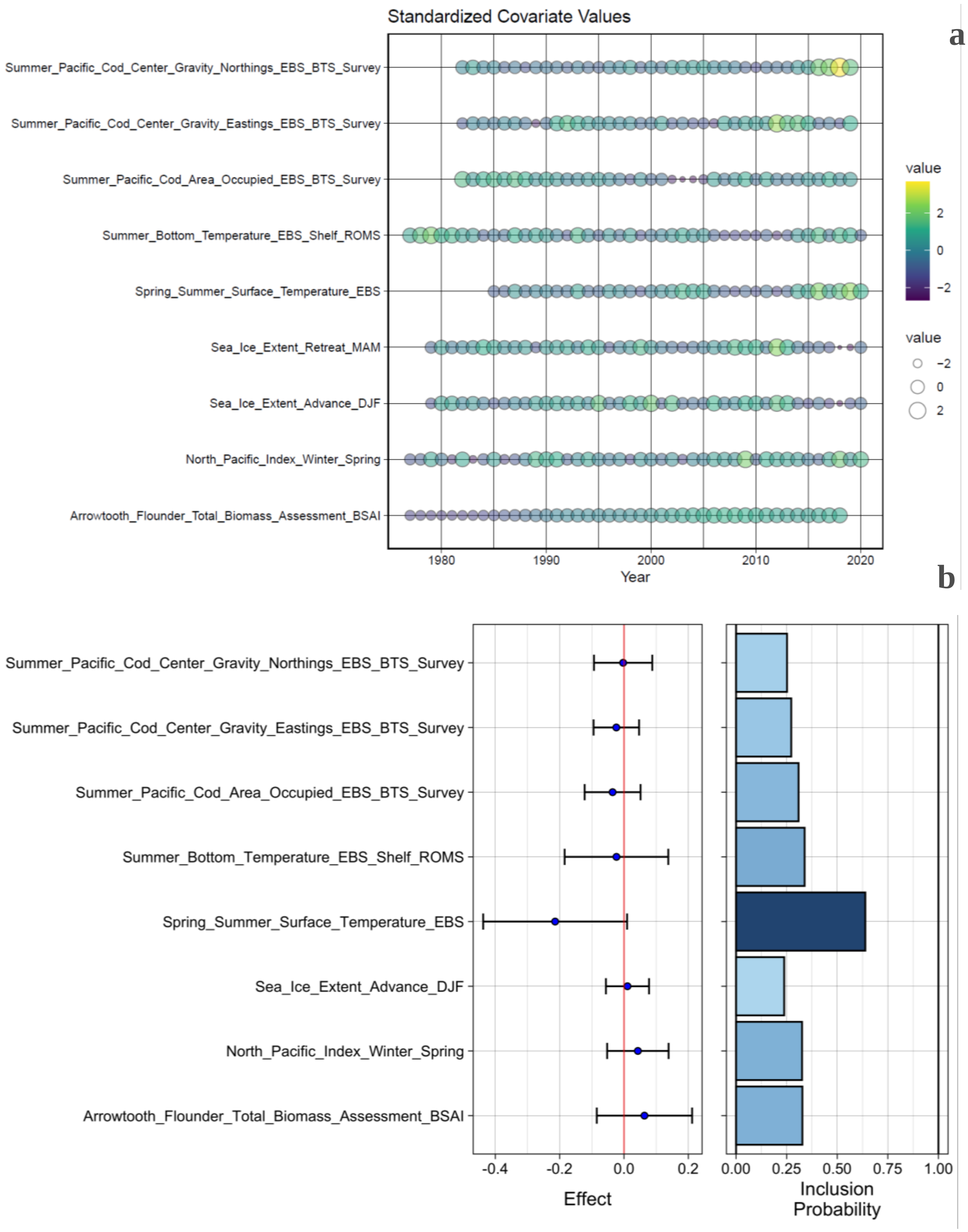
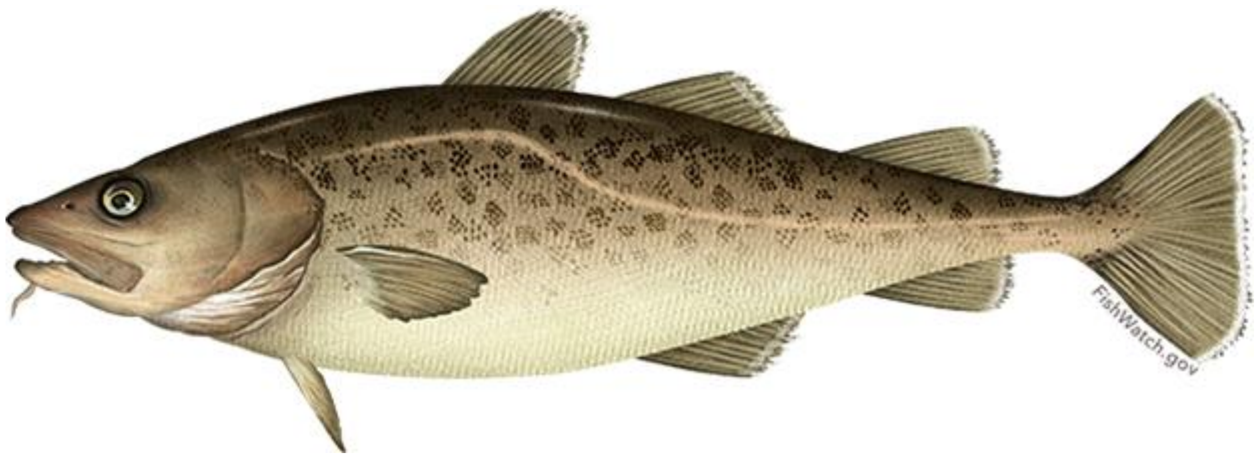


Figure 2.2.7: Bayesian adaptive sampling output showing (a) standardized covariates prior to subsetting and (b) the mean relationship and uncertainty (95% confidence intervals) with log EBS Pacific cod recruitment, in each estimated effect (left bottom graph), and marginal inclusion probabilities (right bottom graph) for each predictor variable of the subsetted covariate set.

Attachment 2.2.1 Ecosystem and Socioeconomic Profile of the Pacific cod stock in the Eastern Bering Sea - Report Card

S. Kalei Shotwell, Grant G. Thompson, Ben Fissel, Tom Hurst, Ben Laurel, Lauren Rogers, Elizabeth Siddon, and Abigail Tyrell

November 2021



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

Current Year Update

The ecosystem and socioeconomic profile or ESP is a standardized framework for compiling and evaluating relevant stock-specific ecosystem and socioeconomic indicators and communicating linkages and potential drivers of the stock within the stock assessment process (Shotwell et al., *In Review*). The ESP process creates a traceable pathway from the initial development of indicators to management advice and serves as an on-ramp for developing ecosystem-linked stock assessments.

When a full ESP is completed in the current year, we provide a shortened version of the report card as an attachment to the full ESP appendix. This allows for providing updated current year information for use in the main SAFE report. Please refer to the main text of this appendix for further information regarding the ecosystem and socioeconomic linkages for this stock.

Management Considerations

The following are the summary considerations from current year updates to the ecosystem and socioeconomic indicators evaluated for EBS Pacific cod:

- North Pacific Index remains high signifying a weak Aleutian Low, high sea level pressure, higher precipitation, increased downwelling, and generally calmer conditions
- Winter maximum ice cover was lower than the long-term average, but ice retreat speed is following the mean
- Spring and summer surface temperature decreased but still above average while bottom temperature increased to warmer than average
- Spring bloom peak timing was close to the long-term average, but bloom timing varies spatially and match would be dependent on spawning and movement of the Pacific cod population
- Condition for juvenile and adult Pacific cod in the EBS remains average, similar to 2018-2019, suggesting prey resources are sufficient
- Center of gravity estimates suggest the Pacific cod population has moved slightly more south and west in 2021, with a near average area occupied, although smaller than in the 2019 survey
- Arrowtooth flounder biomass has steadily increased over the time series but has stabilized since 2009, with a slight decrease in the 2021 bottom trawl survey
- Ex-vessel value and price at high levels with revenue-per-unit-effort at the highest in the time series in 2020
- Overall, ecosystem indicators were average to below average in 2021 with socioeconomic indicators high in 2020

Modeling Considerations

The following are the summary results from the intermediate and advanced stage monitoring analyses for EBS Pacific cod:

- Highest ranked predictor for recruitment regression model was spring and summer sea surface temperature on the southern EBS shelf (inclusion probability > 0.5)

Assessment

Ecosystem and Socioeconomic Processes
Please refer to the full detail of the ecosystem and socioeconomic processes section in the main text of this appendix. The conceptual model (Figure 2.2.1.1) is provided here for reference.

Indicator Suite
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). A short description and contact name for the indicator contributor are provided. Please refer to the full ESP document for detailed information regarding the ecosystem and socioeconomic indicator descriptions for this stock. Time series of the ecosystem and socioeconomic indicators are provided in Figure 2.2.1.2a and Figure 2.2.1.2b, respectively.

Ecosystem Indicators:

Physical Indicators (Figure 2.2.1.2a.a-e)

a.) North Pacific Index (NPI) calculated as the area-weighted sea level pressure (SLP) from November to March over the region 30°N-65°N, 160°E-140°W (contact: M. Wang).
b.) Anomalies of average daily sea-ice extent relative to 1978-2010 mean computed over ice-advance season of December through February (contact: M. Wang).
c.) Anomalies of average daily sea-ice extent relative to 1978-2010 mean computed over ice-retreat season of March through May (contact: M. Wang).
d.) Spring to summer (April-June) daily sea surface temperatures (SST) for the EBS shelf from the NOAA Coral Reef Watch Program (contact: J. Watson).
e.) Summer (July-September) bottom temperatures over the EBSshelf from the Bering 10K ROMS-NPZ model (contact K. Kearney).

Lower Trophic Indicators (Figure 2.2.1.2a.f-g)

f.) Peak timing of the spring bloom averaged across individual ADF&G statistical areas in the EBS from the MODIS satellite (contact: J. Nielsen).
g.) Summer euphausiid abundance for the EBS shelf from the AFSC acoustic survey (contact: P. Ressler).

Upper Trophic Indicators (Figure 2.2.1.2a.h-m)

h.) Summer condition for juvenile (<460 mm) Pacific cod from the AFSC EBS shelf bottom trawl survey (contact: S. Rohan).
i.) Summer condition for adult (>=460 mm) Pacific cod from the AFSC EBS shelf bottom trawl survey (contact: S. Rohan).
j.) Summer Pacific cod center of gravity eastings estimated by a spatio-temporal model using the package VAST on AFSC EBS bottom trawl survey data (contact: J. Conner)
k.) Summer Pacific cod center of gravity northings estimated by a spatio-temporal model using the package VAST on AFSC EBS bottom trawl survey data (contact: J. Conner)
l.) Summer Pacific cod area occupied estimated by a spatio-temporal model using the package VAST on AFSC EBS bottom trawl survey data (contact: J. Conner)
m.) Arrowtooth flounder total biomass from the most recent stock assessment model in the EBS (contact: K. Shotwell).

Socioeconomic Indicators:

Economic Indicators (Figure 2.2.1.2b.a-c)

a.) Annual estimated real ex-vessel value of EBS Pacific cod (contact: B. Fissel)
b.) Annual real ex-vessel price per pound of EBS Pacific cod from fish ticket information (contact: B. Fissel).

c.) Annual estimated real revenue per unit effort measured in weeks fished of EBS Pacific cod (contact: B. Fissel)

Community Indicators (Figure 2.2.1.2b.d-e)

d.) Regional quotient of Pacific cod for harvesting revenue of the highly engaged community of Unalaska Dutch Harbor (contact: S. Wise)

e.) Regional quotient of Pacific cod for processing revenue of the highly engaged community of Unalaska Dutch Harbor (contact: S. Wise)

Indicator Monitoring Analysis

There are up to three stages (beginning, intermediate, and advanced) of statistical analyses for monitoring the indicator suite listed in the previous section. The beginning stage is a relatively simple evaluation by traffic light scoring. This evaluates the current year trends relative to the mean of the whole time series, and provides a historical perspective on the utility of the whole indicator suite. The intermediate stage uses importance methods related to a stock assessment variable of interest (e.g., recruitment, biomass, catchability). These regression techniques provide a simple predictive performance for the variable of interest and are run separate from the stock assessment model. They provide the direction, magnitude, uncertainty of the effect, and an estimate of inclusion probability. The advanced stage is used for testing a research ecosystem linked model and output can be compared with the current operational model to understand information on retrospective patterns, prediction performance, and comparisons of other model output such as terminal spawning stock biomass or mean recruitment. This stage provides an on-ramp for introducing an alternative ecosystem linked stock assessment model to the current operational stock assessment model and can be used to understand the potential reduction in uncertainty by including the ecosystem information. Please refer to the indicator monitoring analysis section in the main text of this appendix for more details on the analysis stages.

Beginning Stage (Traffic Light Test):

We use a simple scoring calculation for this beginning stage traffic light evaluation. Indicator status is evaluated based on being greater than (“high”), less than (“low”), or within (“neutral”) one standard deviation of the long-term mean. A sign based on the anticipated relationship between the indicator and the stock (Figure 2.2.1.1) is also assigned to the indicator where possible. If a high value of an indicator generates good conditions for the stock and is also greater than one standard deviation above the mean, then that value receives a +1 score. If a high value generates poor conditions for the stock and is greater than one standard deviation above 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. The scores over time allow for comparison of the indicator performance and the history of stock productivity (Figure 2.2.1.3). We also provide five year indicator status tables with a color or text code for the relationship with the stock (Tables 2.2.1.1a,b) and evaluate the current year status in the historical indicator time series graphic (Figures 2.2.1.2a,b) for each ecosystem and socioeconomic indicator.

We evaluate the status and trends of the ecosystem and socioeconomic indicators to understand the pressures on the EBS Pacific cod stock regarding recruitment, movement, stock productivity, and stock health. We start with the physical indicators and proceed through the increasing trophic levels, economic, and community indicators as listed above. Here we concentrate on updates relative to the results presented in the main text of this appendix. Overall both the physical and lower trophic level indicators scored average for 2021, while the upper trophic indicators were below average (Figure 2.2.1.3). Compared to the results presented in the main text of this appendix, this is the same value for both physical and lower trophic indicators, and an improvement from well below average for the upper trophic indicators. We also note caution when comparing scores between odd to even years as there is one lower trophic indicator missing in even years due to an off-cycle year survey. Also, there have been survey cancellations due to COVID-19 or survey delays in 2020 and 2021 that have limited production of several indicators. Economic and community indicators are all lagged by at least one year due to timing of the availability of the current year information and the production of this report. Economic indicators scored well above average for 2020 (data received in 2021), which is an increase from above average in 2019. There were no updates for community indicators in 2021 for 2020.

For physical indicators (Figure 2.2.1.2a.a-e), the winter to spring North Pacific Index (NPI) decreased slightly but remains high in 2021 (Figure 2.2.1.2a.a). The NPI effectively represents the strength (rather than position) of the Aleutian Low with higher values signifying a weak Aleutian Low, high sea level pressure, higher precipitation, and increased downwelling (Weingartner, 2005; Rodionov et al., 2007). There were no updates available for sea ice extent at the spatial scale of the EBS due to a major revision in the indicator calculation. However, information available on the whole Bering Sea (reference UAF, ACCAP website https://uaf-accap.org) suggests that the maximum sea-ice extent in the Bering Sea was reached in early March, which was earlier than 2020, but later than 2017-2019. In early winter (November to mid-December, 2020), the Bering Sea ice extent was the lowest in the past 42 years (1979-2021). But as time progressed, the speed of ice advance was close to its average over the years 1981-2010 (referred to as the climatological mean). Although the winter maximum ice cover (March 2021) is lower than the 1981-2010 period mean, the ice retreat speed follows the mean (M. Wang, *pers. commun.*). Spring to summer surface temperatures decreased slightly from last year but remained very warm, while bottom temperatures increased from below average to above average (Figure 2.2.1.2a.d-e). When compared to previous years, conditions most closely resemble 2004 and 1982 in terms of summer bottom temperature patterns and were all classified as warmer than average, but not extreme.

For lower trophic indicators (Figure 2.2.1.2a.f-g), the timing of the spring bloom was slightly later than average. The bloom timing varies spatially, with blooms occurring earlier in the inner domain to later in the outer domain (Nielsen et al., 2021). 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. For upper trophic indicators (Figure 2.2.1.2a.h-m), condition of both juvenile and adult were average, similar to 2018-2019 (Figure 2.2.1.2a.h-i), suggesting prey resources were sufficient. Many factors may contribute to the variation in morphometric condition such as temperature-dependent metabolic rates, survey timing, stomach fullness of individual fish, migration patterns, and distribution of samples within survey strata (Rohan and Prohaska, 2021). The thermal environment remains warm this year and multiple benthic guilds were well below average (Whitehouse and Aydin, 2021). Center of gravity estimates for EBS Pacific cod have shifted from 2019, with the population center moving more west than average and slightly less north. Area occupied has decreased to near average, although smaller than in the 2019 survey (Figure 2.2.1.2a.j-k). There were no updates for arrowtooth flounder biomass as the stock assessment is currently in review; however, recent survey estimates are slightly lower than in 2020 from the bottom trawl survey (shelf habitat) and higher than 2020 on the longline survey (slope habitat) (Shotwell et al., 2021). Apex fish predators decreased in the BSAI this year to below average (Whitehouse and Aydin, 2021), suggesting low predation pressure on EBS Pacific cod.

Prior to 2016 the inshore sector accounted for 25-30% of the total retained catch of BSAI Pacific cod. Since 2016 this share has increased to 33-40%. In 2020, 45% of the retained catch was harvested by the hook-and-line sector, 23% by the pot sector, and 32% by the trawl sector. Retained catch of Pacific cod across all sectors decreased 14% to 170,000 t in 2020 and was below the 2011-2015 average (Fissel et al., 2021). The retained catch of the inshore sectors decreased 12% to 68,300 t. The value of these deliveries (shoreside ex-vessel value) totaled $53.4 million in 2020, which was down 14% from 2019. Ex-vessel prices decreased 7% to $0.39 per pound (Figure 2.2.1.2b). The fixed gear price premium has varied over time, recently varying in the range of $0.03-$0.06 per pound. In 2020 the fixed gear price premium increased to $0.28 per pound. The products made from BSAI Pacific cod had a first-wholesale value of $263.2 million in 2020, which was down from $346.5 million in 2019 and below the 2011-2015 average of $354 million (Fissel et al., 2021). Revenues through 2019 had remained high as price increases offset decreases in catch and production (Figure 2.2.1.2b). The lower revenue in 2020 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 2020 decreased 7% to $1.54 per pound. Relative to 2019, the H&G price was down 12% to $1.40 per pound in 2020 and fillet prices decreased 4% in 2019 to $3.76 per pound. Since 2016 reductions in global supply have put upward pressure on prices, resulting in significant year over year price increases in 2017 and 2018. In 2019 prices leveled off, decreasing slightly, as markets have adjusted. In 2020 COVID-19 closures resulted in increased demand for retail products and frozen products, and decreased foodservice and fresh products. Retail and foodservice are both significant components of the market for cod products. As such, the impact of COVID-19 on prices appears muted, with only marginal changes in first-wholesale and export prices. Cost pressure from COVID-19 mitigation efforts likely had impacts on net revenues as well as upstream impacts on ex-vessel prices, which decreased significantly.

The community indicators evaluated in the ESP are similar to those presented in the ACEPO report, but on the stock level rather than the community level. The indicators are separated into two categories of fisheries involvement: commercial processing and commercial harvesting (Wise et al., 2021). 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. At this time there are no updates to the community indicators. In the future we plan to evaluate how to reference the products available in the ACEPO report for use in the ESPs to inform on stock health.

Intermediate Stage (Importance Test):

Bayesian adaptive sampling (BAS) was used for the intermediate 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. In this stage, the full set of indicators is first winnowed to the predictors that could directly relate to recruitment and highly correlated covariates are removed. 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 (Figure 2.2.1.4a). This results in a model run from 1985 through the 2018 year-class. We then provide the mean relationship between each predictor variable and log EBS Pacific cod recruitment over time (Figure 2.2.1.4b, left side), with error bars describing the uncertainty (95% confidence intervals) in each estimated effect and the marginal inclusion probabilities for each predictor variable (Figure 2.2.1.4b, right side). A higher probability indicates that the variable is a better candidate predictor of EBS Pacific cod recruitment. The highest ranked predictor variables (inclusion probability > 0.5) based on this process continue to be the spring summer sea surface temperature index on the shelf (Figure 2.2.1.4).

Advanced Stage (Research Model Test):

Please refer to the full detail of the advanced stage research model test section in the main text of this appendix.

<u>Data Gaps and Future Research Priorities</u>
While the metric and indicator assessments provide a relevant set of proxy indicators for evaluation at this time, there are certainly areas for improvement. Gaps in indicator time series cause issues with updating

the ESP 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.

Refinements or updates to current indicators may also be helpful. More specific phytoplankton indicators tuned to the spatial and temporal distribution of EBS Pacific cod larvae as well as phytoplankton community structure information (e.g., hyperspectral information for size fractionation) could be more useful for understanding Pacific cod larval fluctuations. Current estimates of zooplankton biomass are only available at smaller spatial scales, and regional to basin-wide estimates of zooplankton biomass would help elucidate prey trends at the spatial scales relevant to fisheries management. The AFSC continues investigating environmental regulation of first 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 (first 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. The EBS CEATTLE model might also allow for a gap-free index of age-1 predation mortality and bioenergetics indices for EBS Pacific cod (e.g., annual ration, consumption). 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 northern Bering Sea bottom trawl survey and the AFSC longline survey that could be used for evaluating the northern and western edge of the EBS Pacific cod population. The North Pacific Research Board has funded an integrated ecosystem research program in the Arctic that may also be helpful for evaluating the northern edge of the EBS Pacific cod population.

We plan to evaluate the information provided in the Economic SAFE and ACEPO report to determine what socioeconomic indicators could be provided in the ESP that are not redundant with those reports and related directly to stock health. This may result in a transition of indicators currently reported in this ESP to a different series of socioeconomic indicators in future ESPs and may include a shift in focus from engagement to dependency. Additional considerations regarding the role of the indicators for use in the ESP should be given for the timing of the economic and community reports that are delayed by 1-2 years depending on the data source from the annual stock assessment cycle. The Scientific and Statistical Committee (SSC) recently recommended that local knowledge, traditional knowledge, and subsistence information may be helpful for understanding recent fluctuations in stock health, shifts in stock distributions, or changes in size or condition of species in the fishery. We could include this information as supportive evidence and perspective on many indicators monitored within the ESP.

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. The annual request for indicators (RFI) for the EBS Pacific cod ESP will include these data gaps and research priorities along with a list of potential new indicators that could be developed for the next full ESP assessment.

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Tables

Table 2.2.1.1a. First stage ecosystem indicator analysis for EBS Pacific cod, including indicator title and the indicator status of the last five years. The indicator status is designated with text, (greater than = “high”, less than = “low”, or within 1 standard deviation = “neutral” of long-term mean). Fill color of the cell is based on the sign of the anticipated relationship between the indicator and EBS Pacific cod (blue or italicized text = good conditions for EBS Pacific cod, red or bold text = poor conditions, white = average conditions). A gray fill and text = “NA” will appear if there were no data for that year.

Indicator category	Indicator	2017 Status	2018 Status	2019 Status	2020 Status	2021 Status
Physical	Winter Spring North Pacific Index Model	neutral	*high*	neutral	*high*	neutral
	Winter Sea Ice Advance BS Satellite	**low**	**low**	**low**	neutral	NA
	Spring Sea Ice Retreat BS Satellite	**low**	**low**	**low**	neutral	NA
	Spring Summer Temperature Surface SEBS Satellite	neutral	**high**	**high**	**high**	neutral
	Summer Temperature Bottom SEBS Model	neutral	**high**	**high**	neutral	neutral
Lower Trophic	Spring Chlorophyll a Peak SEBS Satellite	**low**	*high*	neutral	neutral	neutral
	Summer Euphausiid Abundance EBS Survey	NA	neutral	NA	NA	NA
Upper Trophic	Summer Pacific Cod Condition Juvenile EBS Survey	neutral	neutral	neutral	NA	neutral
	Summer Pacific Cod Condition Adult EBS Survey	**low**	neutral	neutral	NA	neutral
	Summer Pacific Cod Center Gravity East EBS Model	neutral	**low**	*high*	NA	neutral
	Summer Pacific Cod Center Gravity North EBS Model	**high**	**high**	**high**	NA	**high**
	Summer Pacific Cod Area Occupied EBS Model	neutral	neutral	neutral	NA	neutral
	Annual Arrowtooth Biomass EBS Model	neutral	neutral	**high**	**high**	NA

Table 2.2.1.1b. First stage socioeconomic indicator analysis for EBS Pacific cod, including indicator title and the indicator status of the last five years. The indicator status is designated with text, (greater than = "high", less than = "low", or within 1 standard deviation = "neutral" of long-term mean). Fill color of the cell is based on the sign of the anticipated relationship between the indicator and EBS Pacific cod (blue or italicized text = good conditions for EBS Pacific cod, red or bold text = poor conditions, white = average conditions). A gray fill and text = "NA" will appear if there were no data for that year.

Indicator category	**Indicator**	**2017 Status**	**2018 Status**	**2019 Status**	**2020 Status**	**2021 Status**
Economic	Annual Pacific Cod Real Exvessel Value EBS Fishery	neutral	*high*	neutral	neutral	NA
	Annual Pacific Cod Real Exvessel Price EBS Fishery	neutral	neutral	neutral	*high*	NA
	Annual Pacific Cod Real Revenue Per Unit Effort EBS Fishery	neutral	*high*	*high*	*high*	NA
Community	Annual Pacific Cod RQ Harvesting Revenue Dutch Harbor Fishery	neutral	neutral	neutral	NA	NA
	Annual Pacific Cod RQ Processing Revenue Dutch Harbor Fishery	neutral	neutral	**low**	NA	NA

Figures

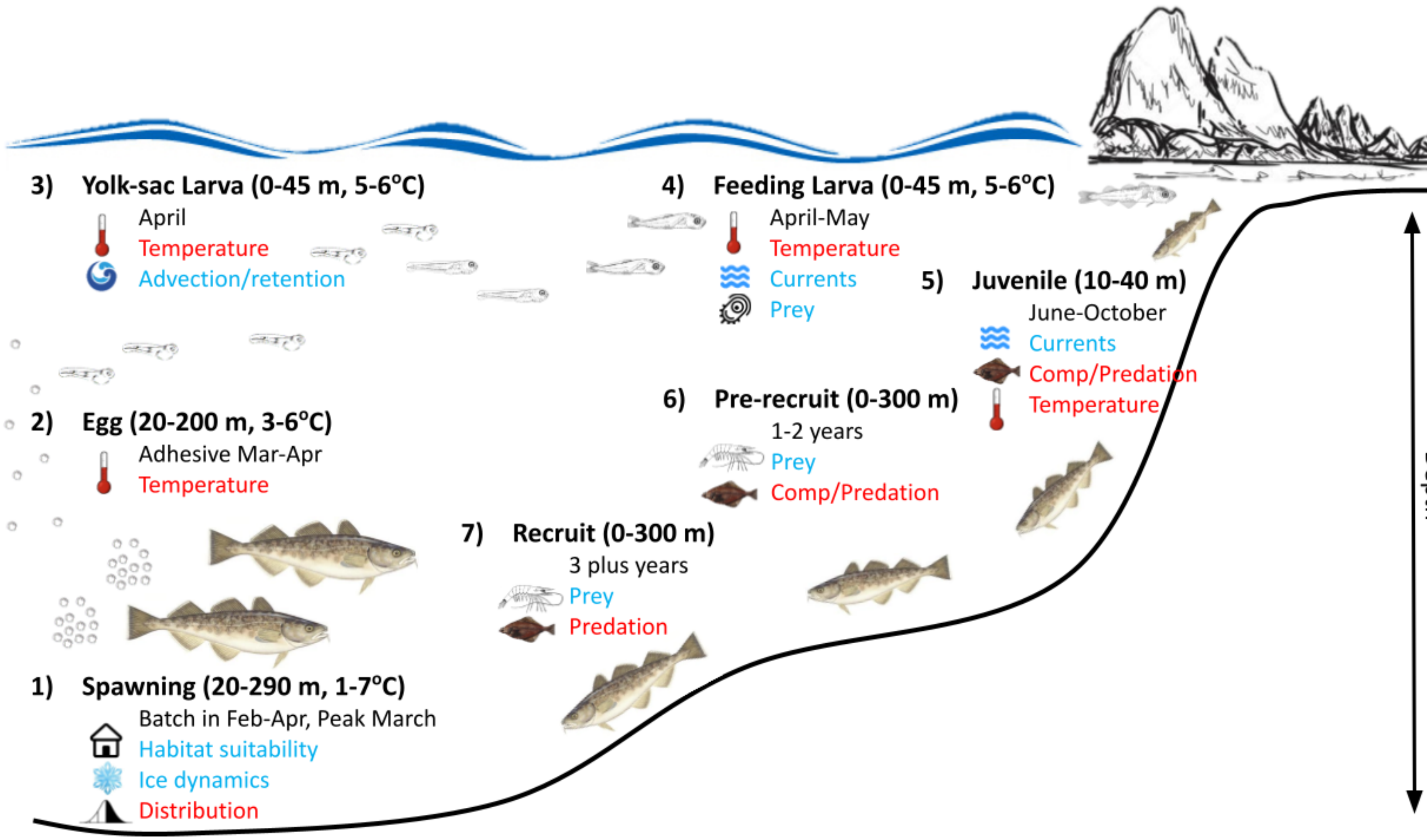


Figure 2.2.1.1: Life history conceptual model for EBS Pacific cod summarizing ecological information and key ecosystem processes affecting survival by life history stage. Red text means increases in process negatively affect survival, while blue text means increases in process positively affect survival.

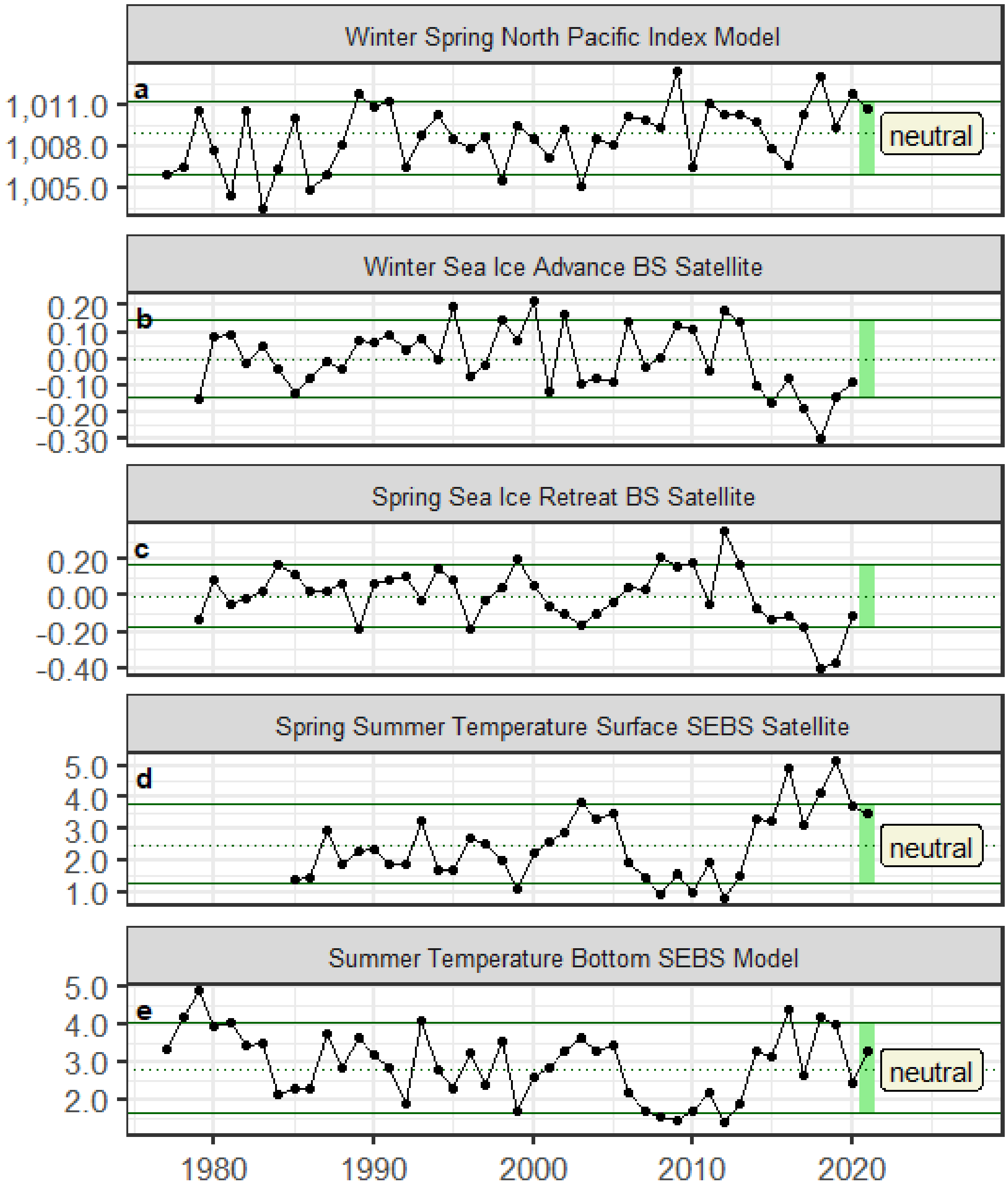


Figure 2.2.1.2a. Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is the mean of the time series. Light green shaded areas represent the most recent year of the traffic light analysis results. Text box follows the traffic light status table for the current year.

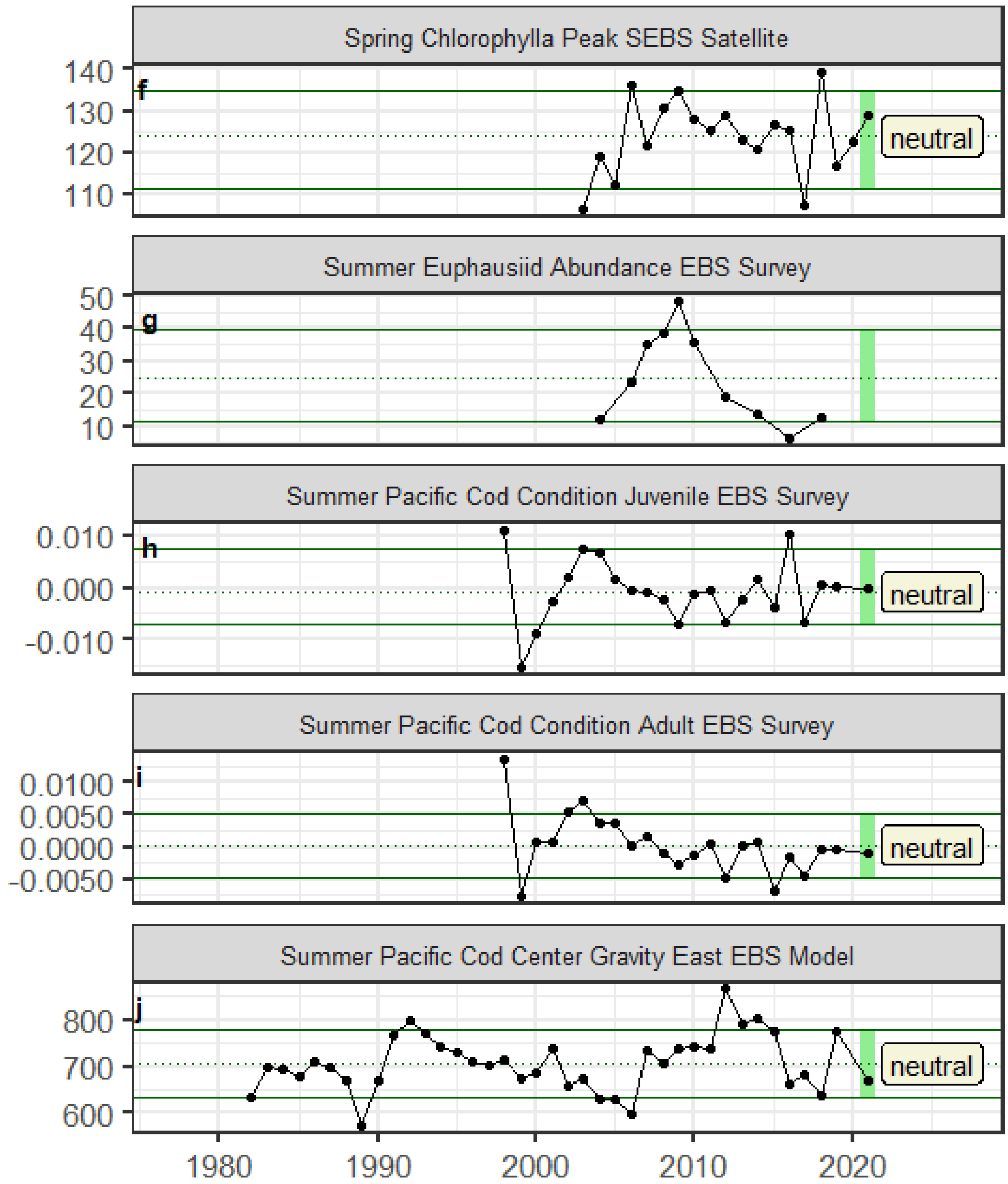


Figure 2.2.1.2a (cont.). Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is the mean of the time series. Light green shaded areas represent the most recent year of the traffic light analysis results. Text box follows the traffic light status table for the current year.

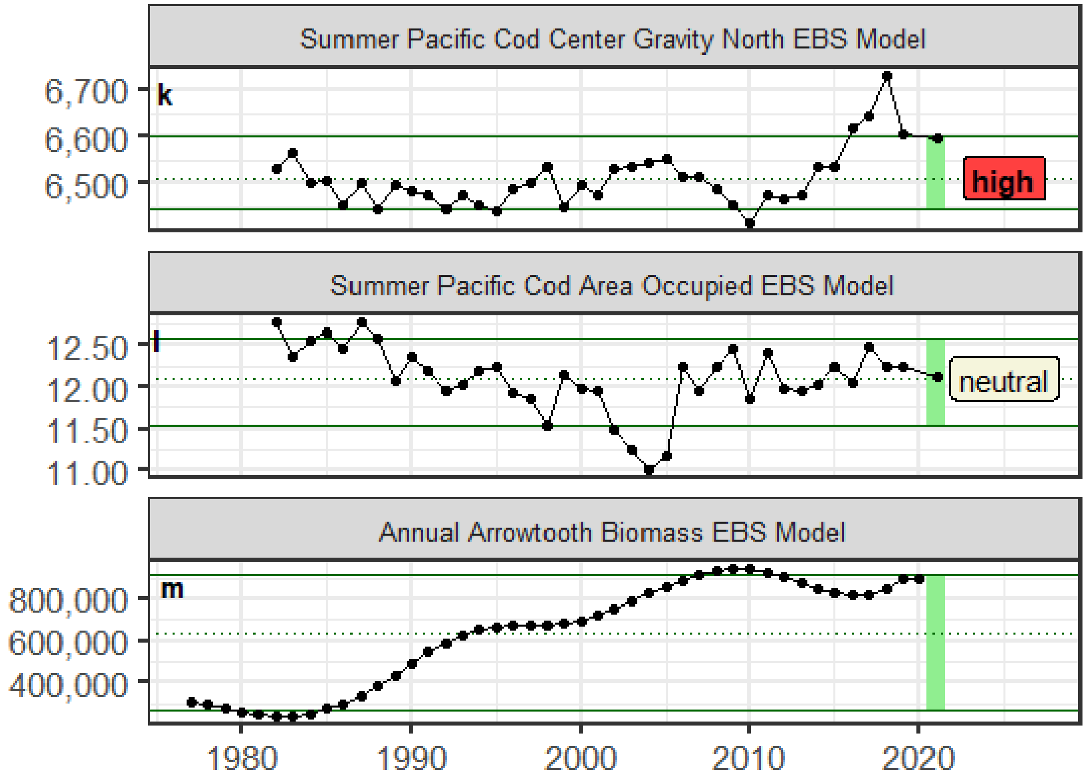


Figure 2.2.1.2a (cont.). Selected ecosystem indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is the mean of the time series. Light green shaded areas represent the most recent year of the traffic light analysis results. Text box follows the traffic light status table for the current year.

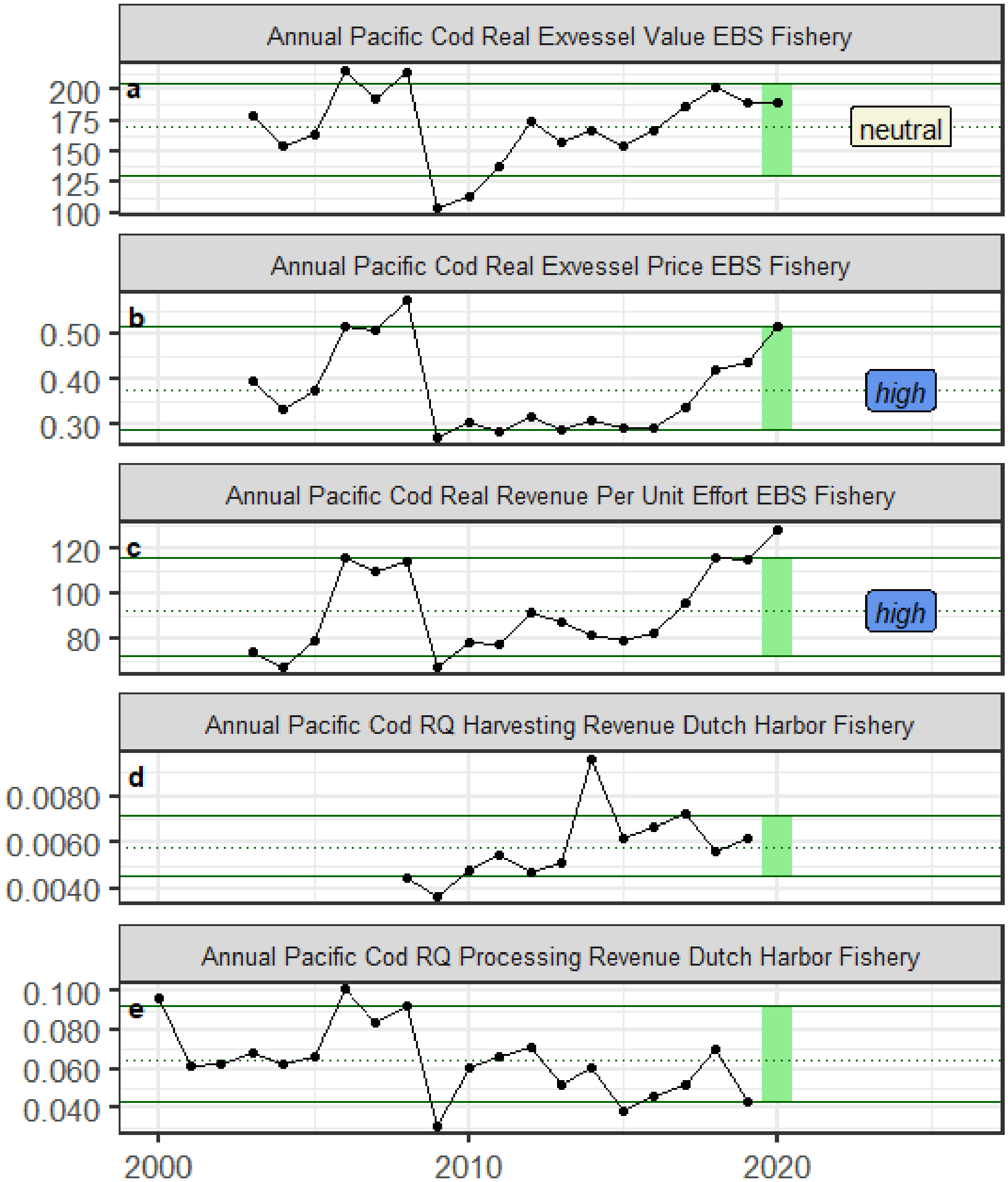


Figure 2.2.1.2b. Selected socioeconomic indicators for EBS Pacific cod with time series ranging from 1977 – present. Upper and lower solid green horizontal lines are 90th and 10th percentiles of time series. Dotted green horizontal line is the mean of the time series. Light green shaded areas represent the most recent year of the traffic light analysis results. Text box follows the traffic light status table for the current year.

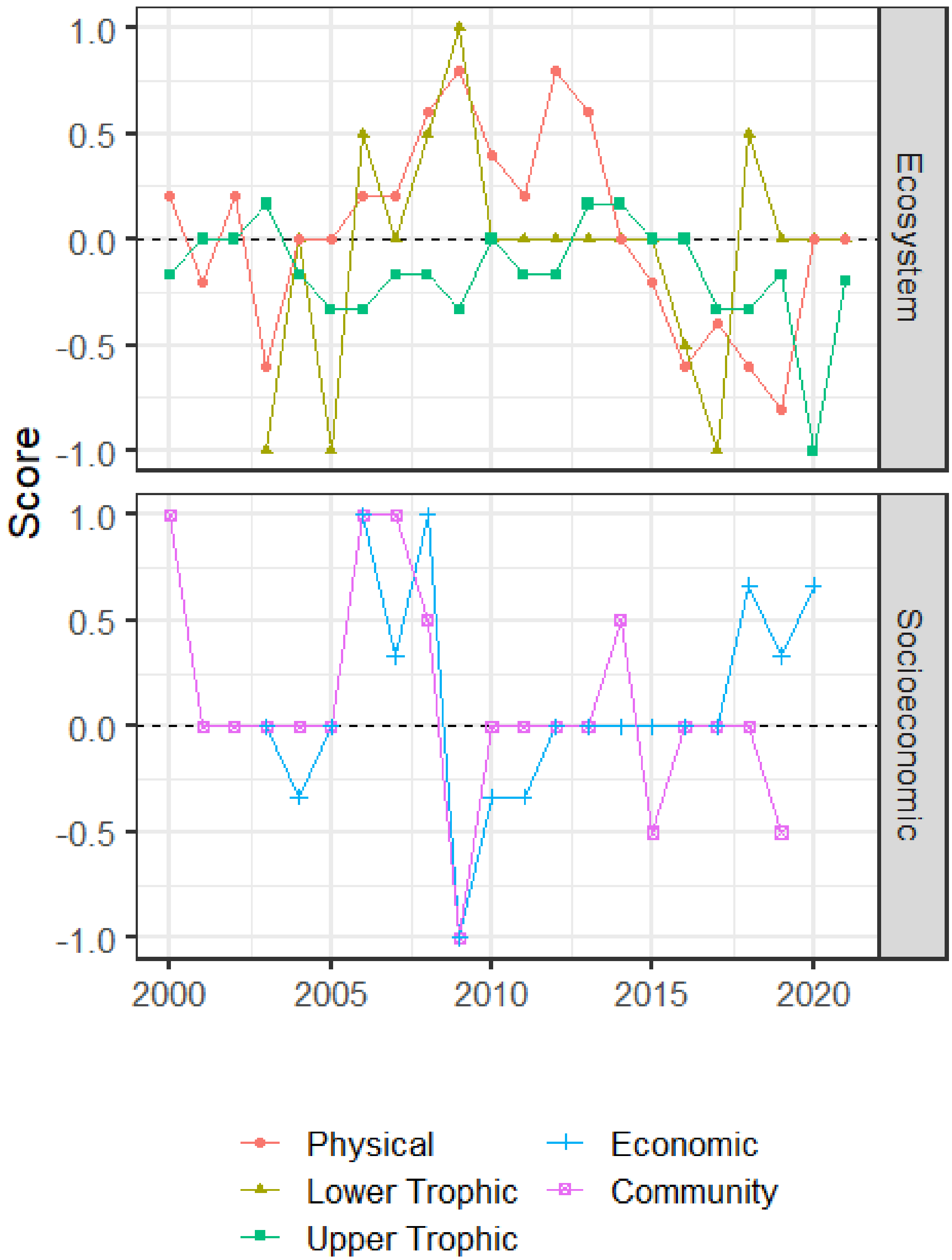


Figure 2.2.1.3: Simple summary traffic light score by category for ecosystem and socioeconomic indicators from 2000 to present

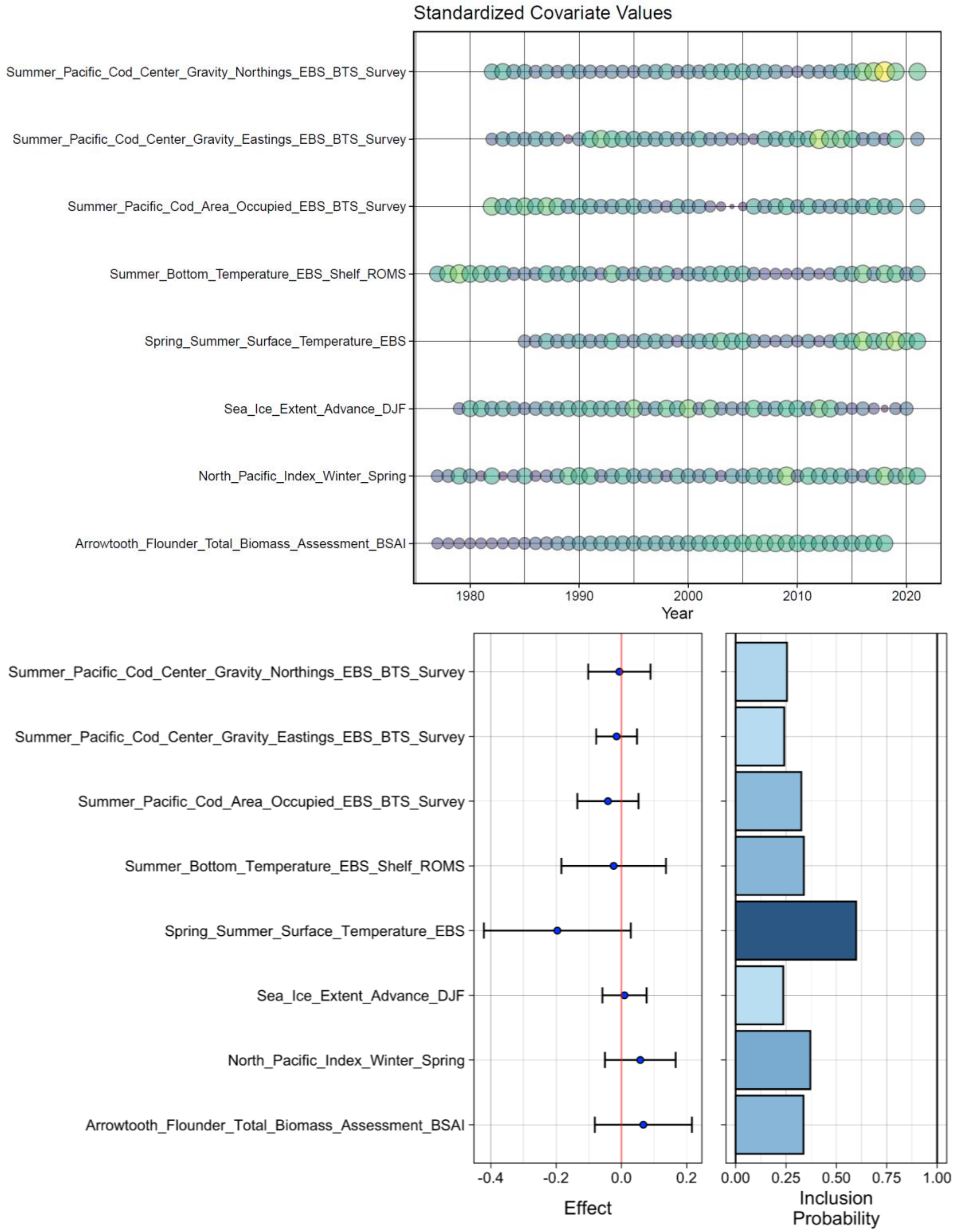


Figure 2.2.1.4: Bayesian adaptive sampling output showing (top graph) standardized covariates and (bottom graph) the mean relationship and uncertainty (95% confidence intervals) with log EBS Pacific cod recruitment, in each estimated effect (left bottom graph), and marginal inclusion probabilities (right 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 the 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

Model 19.12 was adopted by the SSC, although ABC was set at the ensemble weighted average.

2020

Preliminary assessment
The preliminary assessment 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) 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

Final assessment

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 comprised a 2×2 factorial design, where the factors were 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 were referred to in the assessment 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 were:

- 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 were referred to in the assessment as "Ensemble B," and the union of Ensembles A and B was referred to as "Ensemble AB" (note that the base model, 19.12, was 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	20.8	20.9	20.10

Model 19.12a was adopted by the SSC.

APPENDIX 2.4: BRIDGING ANALYSIS FOR MODEL 19.12a

This year's version of Model 19.12a projects a much higher maxABC for 2022 (174,668 t) than last year's version (106,852 t). An increase of this magnitude (63%) for same-year projections from back-to-back assessments is not typical for assessments of this stock. The increase from the 2021 ABC (123,805 t) is less dramatic (41%), but would still be unmatched in the ABC time series since 1995. It is therefore prudent to investigate this change carefully. This appendix describes a bridging analysis, showing how incremental changes to the data and other factors lead from last year's projection to this year's.

In the interest of brevity, "ABC" will frequently be used in place of "maxABC" in this appendix.

The primary files used by Stock Synthesis are a control file, which specifies the model structure, and a data file, which provides quantities that the model is attempting to fit. Because some of the changes in the data file, relative to last year's version, involve adding additional years to existing time series, analyzing the impacts of changes to the data is made easier if some minimal adjustments to the control file are made first, so that additional years of data can be added to the data file. Therefore, to begin this analysis, the following minimal changes were made to the control file:

- The terminal year for all vectors of deviations was extended to 2021.
- The base values of the weight-at-length parameters were updated through 2021.
- The environmental variable indicating that recruitment is still in the post-1976 regime was updated through 2021.

A new data file (Data_0.1) was created by adding the 2021 catch estimate to the time series, and the model was run. This resulted in a projected 2022 female spawning biomass of 398,989 t (a 3.1% decrease from last year's projection) and a projected 2022 ABC of 101,660 t (a 4.9% decrease from last year's projection).

From this starting point ("Pass 0"), the analysis proceeded through nine passes involving various combinations of changes to the input data. The elements of the data that were considered are as follow:

1. Include any revisions to the historic survey index data.
2. Add the 2021 survey index data.
3. Include any revisions to the historic fishery sizecomp data.
4. Add the 2021 fishery sizecomp data.
5. Include any revisions to the historic survey sizecomp data.
6. Add the 2021 survey sizecomp data.
7. Include any revisions to the historic survey agecomp data.
    - (Note that no additional years of survey agecomp data are available.)
8. Include any revisions to the historic weight-at-length parameter offsets.
9. Add the 2021 weight-at-length parameter offsets.

The analysis was designed to give some idea as to which changes in the data have the greatest impact on ABC. For "Pass 1," the analysis proceeded as follows:

- The base case consisted of the model run using Data_01.
- A new data file was created for each of the 9 elements by changing the base data file accordingly.
- The model was run for each new data file and the resulting 2022 ABC was calculated.
- The proportional change in 2022 ABC relative to the 2022 ABC from the base case was calculated for each model.

- The data file with the largest proportional change (absolute value) became the base case for the next pass.

The above process was repeated for Passes 2-9. Because one data element is incorporated into the base data file at each pass, the number of runs required decreases by 1 at each pass. The full results are shown Table 2.4.1a, and just the “old” and “new” base cases for each pass are shown in Table 2.4.1b. Looking simply at the impact on 2022 ABC, the first three passes account for a large portion of the change:

- Pass 1: Adding the 2021 survey sizecomp data increases 2022 ABC to 120,863 t.
- Pass 2: Adding the 2021 survey index data increases 2022 ABC to 143,835 t.
- Pass 3: Including revisions to the historic survey index data increases 2022 ABC to 164,366 t.

Table 2.4.2a shows how all time-invariant (“true”) parameters vary across passes, and also shows the correlations between individual parameters and 2022 ABC. Parameters with a correlation greater than 0.9 (absolute value) are:

Survey selectivity: begin flattop	0.927
Pre-1977 fishing mortality	-0.914
Fishery selectivity: logit(ending value)	-0.913
Asymptotic length	-0.912
Fishery selectivity: begin flattop	-0.911
ln(Dirichlet-multinomial coef. for agecomps)	-0.905

Log survey catchability also has a fairly strong correlation (-0.869), and is much lower in Passes 3-9 than in Passes 0-2.

Table 2.4.2b is structured similarly to Table 2.4.2a, but focuses on log recruitment deviations. Only two year classes have correlations greater than 0.9 (absolute value): 1993 (-0.913) and 1990 (-0.910). A total of 13 other year classes have correlations greater than 0.8 (absolute value), and all but three of those correlations are negative. Correlations are negative for all year classes from 1988-2014, and positive for all year classes from 2015-2020 (of which only the 2016 year class has a correlation in excess of 0.8).

Table 2.4.2c, in essence, combines the results from the “ln(mean post-1976 recruits)” from Table 2.4.2a with the results from Table 2.4.2b to show how year class strengths vary across passes. The strengths of all year classes in the time series are positively correlated with 2022 ABC. The correlation for the 2018 year class is the highest in the time series (0.972), and the correlations for the 2009-2016 year classes are all greater than 0.8.

Table 2.4.2d shows all parameters, of any kind, with correlations greater than 0.95 (absolute value). All of these are annual deviations, and the six with the strongest correlations are all annual deviations for length at age 1.5. Of the 25 parameters listed in this table, correlations are negative for all but one.

In an attempt to understand why these changes are occurring, another model run was made at each pass, with the parameter values fixed at the values estimated in the *previous* pass, thus enabling a comparison of model fits for a given data file. Table 2.4.3 shows how the individual components of the objective function (negative log likelihood) compare for the two runs at each pass. For example, in Pass 1, where the 2021 survey sizecomp data have been added to the data file from Pass 0, the run with all parameters estimated gives a negative log likelihood that is 63.47 points lower than the run with all parameters (including annual deviations) fixed at the values estimated in Pass 0, including an improvement of 71.59 points for the survey sizecomp data. However, 69.35 of those points come simply from the models’ fits to that one record (i.e., the 2021 survey sizecomp data). Similarly, in Pass 2, where the 2021 survey index data have been added to the data file from Pass 1, the run with all parameters estimated gives a negative log likelihood that is 14.44 points lower than the run with all parameters (including annual deviations) fixed at the values estimated in Pass 1, including an improvement of 18.97 points for the survey index data. However, 18.77 of those points come simply from the models' fits to that one record (i.e., the 2021 survey index data). In Pass 3, where revisions to the historic survey index data have been made to the data file from Pass 2, the run with all parameters estimated gives a negative log likelihood that is 10.46 points lower than the run with all parameters (including annual deviations) fixed at the values estimated in Pass 2, including an improvement of 23.99 points for the survey index data. However, this improvement is offset to some extent by an increase of 10.00 points for the survey sizecomp data.

Changes in negative log likelihood between the two runs at each pass are broken down by both component and year in the nine pages of Figure 2.4.1 (one page for each pass). Vertical axes are capped at +/– 2 in all pages for consistency. Often, major changes are confined to only a small number of years in the time series. Occasionally, changes are small across the entire time series. For example, in Figure 2.4.1d (Pass 4), which shows the effect of revising the historic weight-at-length parameter offsets, no negative log likelihood changes by more than 0.25 for any component in any year; nevertheless, this change in the data file resulted in a 3.8% increase in 2022 ABC (Table 2.4.1). Similarly, in Figure 2.4.1f (Pass 4), which shows the effect of adding the 2021 weight-at-length parameter offsets, no negative log likelihood changes by more than 0.05 for any component in any year; nevertheless, this change in the data file resulted in a 1.8% *de*crease in 2022 ABC (Table 2.4.1).

When plotted in terms of fit to the actual data, only a few of the changes in negative log likelihood depicted in Figure 2.4.1 are visually discernible. To avoid focusing on minutiae, Figure 2.4.2 plots goodness of fit only for those data types (and years, in the case of compositional data) where the change in negative log likelihood (ΔNLL) shown in the respective page of Figure 2.4.1 is less than –2.0. These are as follow:

- Figure 2.4.2a: Pass 1, 2021 survey sizecomp (ΔNLL = –69.35)
- Figure 2.4.2b: Pass 2, survey index (ΔNLL = –18.77 in 2021)
- Figure 2.4.2c: Pass 3, survey index (ΔNLL = –6.58 in 2008; see also 1992, 2007, 2009, 2010)
- Figure 2.4.2d: Pass 5, 2018 survey sizecomp (ΔNLL = –5.32)
- Figure 2.4.2e: Pass 8, 2021 fishery sizecomp (ΔNLL = –6.46)

In each page of Figure 2.4.2, "Exp_old" refers to the expected value with parameters fixed at the values estimated in the previous pass, and "Exp_new" refers to the expected value with parameters as estimated in the current pass.

Figure 2.4.2a examines the goodness of fit to the 2021 survey sizecomp data achieved in Pass 1, where the addition of those data comprises the change in the data file relative to Pass 0. The change in goodness of fit is readily detectable. First, there was no way for last year's model to anticipate the change in mean size at age 1.5 that is reflected in the 2021 survey sizecomp data, so there is a distinct mismatch between the first mode in the data and the first mode resulting from the parameters fixed at their Pass 0 values. Second, because there was no survey in 2020, last year's assessment assumed that the 2019 year class would be average, and when this was extrapolated forward to age 2, this resulted in a gap between the orange and gray curves across the 26-41 cm range. Third, somewhat more subtly but likely of much greater impact on 2022 ABC, when the parameters are fixed at their Pass 0 values, the model underestimates the proportions at *all* lengths between 44 and 84 cm, and at *nearly* all lengths between 38 and 104 cm.

Figure 2.4.2b examines the goodness of fit to the survey index time series achieved in Pass 2, where the addition of the 2021 survey index data comprises the change in the data file relative to Pass 1. Compared to Figure 2.4.2a, the change in goodness of fit depicted in Figure 2.4.2b is not so dramatic across the entire horizontal axis, but the difference in the fit at the endpoint (2021) is dramatic, and easily interpretable with respect to the impact on 2022 ABC. Even when the data file was adjusted by adding the 2021 survey size composition in Pass 1, when the parameters were fixed at the values estimated in that pass, the model still estimated a much lower 2021 survey abundance than was actually observed. When the model was fit to the Pass 2 data (with the 2021 survey index added), the model still estimated a slightly lower 2021 survey abundance than was actually observed, but it came much closer than the estimate from the Pass 1 model.

Figure 2.4.2c examines the goodness of fit to the survey index time series achieved in Pass 3, where revisions to the historic survey index data comprise the changes in the data file relative to Pass 2. Unlike Figure 2.4.2b, both model runs achieve very similar fits to at least five out of the six most recent points, but noticeably different fits to some earlier years, particularly the 2007-2010 period, where the run with parameters estimated in Pass 3 fits the data more closely than the run with parameters fixed at their Pass 2 values, with the Pass 3 parameters suggesting lower abundances in each of those years.

Figure 2.4.2d examines the goodness of fit to the 2018 survey sizecomp data achieved in Pass 5, where revisions to the historic survey sizecomp data comprise the changes in the data file relative to Pass 4 (recall that the main revision to the historic survey sizecomp data was the deletion of the 2018 NBS survey data, due to the nonstandard sampling design used in that year’s NBS survey). Visually, the change in goodness of fit is somewhat modest. When the parameters are fixed at their Pass 4 values, the location of the first mode is shifted well to the left of the data and the strength of the age 1 group appears to be underestimated, whereas the run with parameters estimated addresses both of those issues to a considerable extent.

Figure 2.4.2e examines the goodness of fit to the 2021 fishery sizecomp data achieved in Pass 8, where the addition of those data comprises the change in the data file relative to Pass 7. The change in goodness of fit is readily detectable. With parameters estimated, the model fits the data throughout the 37-58 cm range better than with parameters fixed at their Pass 7 values. For sizes greater than about 60 cm, the two model runs clearly exhibit differerent size compositions, but neither one dominates with respect to fitting the data.

The final aspect of the bridging analysis stepped through the mechanics of computing ABC. This was done by comparing each sequential pair of passes, and adding last year’s assessment results and this year’s final model as “bookends.” Results of each comparison are shown on one page of Table 2.4.4 and a corresponding page of Figure 2.4.3, specifically:

Table	Figure	Comparison	
2.4.4a	2.4.3a	2020	Pass 0
2.4.4b	2.4.3b	Pass 0	Pass 1
2.4.4c	2.4.3c	Pass 1	Pass 2
2.4.4d	2.4.3d	Pass 2	Pass 3
2.4.4e	2.4.3e	Pass 3	Pass 4
2.4.4f	2.4.3f	Pass 4	Pass 5
2.4.4g	2.4.3g	Pass 5	Pass 6
2.4.4h	2.4.3h	Pass 6	Pass 7
2.4.4i	2.4.3i	Pass 7	Pass 8
2.4.4j	2.4.3j	Pass 8	Pass 9
2.4.4k	2.4.3k	Pass 9	2021
2.4.4l	2.4.3l	2020	2021

In the above table, "2020" and "2021" refer to the final versions of Model 19.12a in the 2020 and 2021 assessments, respectively. The difference between Pass 9 and the final 2021 version is that the final 2021 version includes the retuned sigma terms for the vectors of deviations. So, each successive page of Table 2.4.4 and Figure 2.4.3 compares a successive pair of runs in the process of bridging between the final 2020 version and the final 2021 version, except that Table 2.4.4l and Figure 2.4.3l provide a "before" and fully aggregated "after" comparison.

Each page of Table 2.4.4 shows the following quantities, at each age 0-12, for both of the runs and for the difference between the runs (all quantities other than those labeled "equilibrium" pertain to 2022):

- Begin-year numbers (1000s)
- Fecundity
- Female spawning biomass (t)
- Equilbrium unexploited begin-year numberst (1000s)
- Equilibrium fecundity
- Equilibrium unexploited female spawning biomass (t)
- Relative spawning biomass
- F40% (constant across age)
- maxFABC (constant across age)
- Fishery selectivity
- Natural mortality (constant across age)
- maxFABC exploitation rate
- Mid-year fishery weight (kg)
- maxABC (t)

Sums are also given for the following quantities (and include ages 13-20, not shown in the table):

- Begin-year numbers (1000s)
- Female spawning biomass (t)
- Equilbrium unexploited begin-year numberst (1000s)
- Equilibrium unexploited female spawning biomass (t)
- maxABC (t)

Also shown in the "Sum" column is the ratio between age-aggregated spawning biomass and age-aggregated equilibrium unexploited spawning biomass.

Cells in the rows labeled "Diff." (for "Difference") are color-coded as follows: red = negative, yellow = zero (no change), and green = positive.

Each page of Figure 2.4.3 shows the following quantities, at each age 0-12, for both of the runs and for the difference between the runs (all quantities pertain to 2022):

- Begin-year numbers (1000s), labeled "Abundance"
- Female spawning biomass (t)
- Relative spawning biomass
- maxABC (t), labeled "ABC"

In addition, three of the four panels on each page of Figure 2.4.3 have a horizontal gray line showing the age-aggregated change (absolute value) between the runs. The horizontal gray line on the panel for relative spawning biomass corresponds to a value of 0.4.

As noted earlier, a good share of the increase in ABC between last year's version of Model 19.12a and this year's can be explained by the first three passes. Table 2.4.4b and Figure 2.4.3b compare Pass 1 to Pass 0. The 2022 ABC increased by 18.9% between these two passes. Except for ages 2, 3, and 5, every age group contributed toward this increase, but 55% of it is accounted for by the age 4 group (i.e., the 2018 year class), as the contribution of that group toward the 2022 ABC increased by 41.6% from Pass 0 to Pass 1. The increase in the contribution of the 2018 year class toward the 2022 ABC is due to several factors (some of which are interrelated):

- Total female spawning biomass increased by 7.8%
- Total unexploited equilibrium female spawning biomass decreased by 2.4%
- Relative spawning biomass increased by 10.5%
- maxFABC increased by 10.9%
- Begin-year numbers at age 4 increased by 0.4%
- Fishery selectivity at age 4 increased by 18.4%
- maxFABC exploitation rate at age 4 increased by 29.9%
- Mid-year fishery weight at age 4 increased by 8.6%

Table 2.4.4c and Figure 2.4.3c compare Pass 2 to Pass 1. The 2022 ABC increased by 19.0% between these two passes. Every age group contributed toward this increase, but 30% of it is accounted for by the age 4 group (i.e., the 2018 year class), as the contribution of that group toward the 2022 ABC increased by 19.4% from Pass 1 to Pass 2. The increase in the contribution of the 2018 year class toward the 2022 ABC is again due to several factors (some of which are interrelated):

- Total female spawning biomass increased by 11.8%
- Total unexploited equilibrium female spawning biomass increased by 4.7%
- Relative spawning biomass increased by 6.8%
- maxFABC increased by 5.3%
- Begin-year numbers at age 4 increased by 5.2%
- Fishery selectivity at age 4 increased by 5.6%
- maxFABC exploitation rate at age 4 increased by 10.8%
- Mid-year fishery weight at age 4 increased by 2.4%

Table 2.4.4d and Figure 2.4.3d compare Pass 3 to Pass 2. The 2022 ABC increased by 14.3% between these two passes. Once again, every age group contributed toward this increase, but 28% of it is accounted for by the age 4 group (i.e., the 2018 year class), as the contribution of that group toward the 2022 ABC increased by 13.5% from Pass 2 to Pass 3. The increase in the contribution of the 2018 year class toward the 2022 ABC is again due to several factors (some of which are interrelated):

- Total female spawning biomass increased by 5.3%
- Total unexploited equilibrium female spawning biomass decreased by 0.1%
- Relative spawning biomass increased by 5.3%
- maxFABC increased by 10.3%
- Begin-year numbers at age 4 increased by 2.2%
- Fishery selectivity at age 4 increased by 1.1%
- maxFABC exploitation rate at age 4 increased by 10.4%
- Mid-year fishery weight at age 4 increased by 0.6%

By comparison to the above, most of the changes described in Tables 2.4.4e-k and Figures 2.4.3e-k are small. Those tables and figures are included for purposes of completeness and full disclosure, but in the interest of drawing the discussion to a close, it may be most efficient to turn directly to the "before" and fully aggregated "after" comparison shown in Table 2.4.4l and Figure 2.4.3l. As noted previously, the 2022 ABC increased by 63% between last year's final version of Model 19.12a and this year's. Once again, every age group contributed toward this increase, but 35% of it is accounted for by the age 4 group (i.e., the 2018 year class), as the contgribution of that group toward the 2022 ABC increased by 90.4%. The increase in the contribution of the 2018 year class toward the 2022 ABC is again due to several factors (some of which are interrelated):

- Total female spawning biomass increased by 25.8%
- Total unexploited equilibrium female spawning biomass decreased by 0.6%
- Relative spawning biomass increased by 26.6%
- maxFABC increased by 33.6%
- Begin-year numbers at age 4 increased by 6.6%
- Fishery selectivity at age 4 increased by 23.8%
- maxFABC exploitation rate at age 4 increased by 60.7%
- Mid-year fishery weight at age 4 increased by 11.2%

As mentioned above, all age groups contributed to the increase in 2022 ABC. Besides the age 4 group, other groups accounting for at least 5% of the increase were ages 3 (6.4%), 5 (5.5%), 6 (13.3%), 7 (9.8%), and 9 (15.3%).

Although they obviously contribute to the initial numbers at age comparison in Table 2.4.4l, the relationship between the time series of year class strengths estimated in last year's version of Model 19.12a and this year's is not explicit there, and so is shown in Table 2.4.5. The strengths of all year classes in the 1977-2018 time series increased, by an average of 45 million fish in absolute terms and an average of 9.5% in relative terms. In absolute terms, the 1977, 1978, and 2013 year classes increased more than any other (by 139 million fish, 123 million fish, and 110 million fish, respectively). In relative terms, the 2016 and 2017 year classes increased more than any other (by 36.5% and 19.4%, respectively); but, in absolute terms, the changes for those two year classes were far more moderate, as they were two of the four smallest year classes in the time series, as estimated in last year's assessment. The 2018 year class, which accounts for a larger portion of the increase in 2022 ABC than any other year class, exhibited increases in strength that were not in the top 10 by either measure. In absolute terms, the 2018 year class ranked 11th out of 42 (an increase of 67 million fish), and in relative terms, it ranked 17th (an increase of 8.9%).

In conclusion, it is difficult to provide a simple explanation of why the estimate of 2022 ABC changed so dramatically between last year's version of Model 19.12a and this year's. Although it is perhaps best thought of as a complex, and often subtle, interaction between many factors, it seems safe to say that some pieces of the puzzle include the following:

- The bulk of the change is not attributable to any single element of the revised data file, although, taken in combination, the 2021 survey sizecomp data, the 2021 survey index data, and the revisions to the historic survey index data account for 85% of the change. In particular, the fact that the 2021 survey sizecomp data suggest larger proportions at nearly all lengths between 38 and 104 cm may cause the 2021 version of the model to estimate more fish in that size range, and the fact that the 2021 survey index came in at a much higher value than predicted by last year's version of the model may likewise cause the 2021 version of the model to estimate more fish.
- In terms of single parameters that may be particularly influential, the following may be noted:

Parameter	Last year	This year	Change
Survey catchability	0.986	0.920	-0.067
Mean recruitment (1000s)	527920	560341	0.061

- In terms of year class strengths (a derived quantity), the strengths of all year classes in the 1977-2018 time series increased from last year's version of Model 19.12a to this year's, by an average of 45 million fish in absolute terms and an average of 9.5% in relative terms. The 2018 year class, which accounts for a larger portion of the increase in 2022 ABC than any other year class, exhibited increases in strength that were not in the top 10 by either measure.
- Another consideration to keep in mind is the manner in which changes in spawning biomass within the range associated with the sloping portion of the harvest control rule translate into changes in ABC, because both last year's and this year's estimates of 2022 spawning biomass fall within that range. Within that range, as a first approximation, if spawning biomass increases from B1 to B2, then the ratio of ABC2 to ABC1 will be $(B2/B1)^2$ rather than just B2/B1. That is, the impact on ABC is much more than proportional to the change in spawning biomass.
- The fact that other models in the ensemble also showed large increases suggests that this result is not peculiar to Model 19.12a. For example, the estimate of 2022 ABC from Model 19.12 went up by 35% from last year's version, and by 49% from the version presented in Appendix 2.1. Model 21.1 did not exist last year, but the estimate from that model went up by 58% from the version presented in Appendix 2.1. Model 21.2 likewise did not exist last year and, unfortunately, the version presented in Appendix 2.1 used a data file with mis-specified units for the fishery CPUE index, so no comparison can be made for that model.

As a concluding exercise, the model was re-run with the data file from Pass 0, but starting from this year's final parameter file. The results were extremely similar to the original Pass 0 run, with differences that could easily be attributable to differences in the sigma values for the vectors of deviations and differences in the base values of the weight-at-length parameters, providing additional confirmation that last year's model had not converged to a location other than the global minimum of the negative log likelihood surface.

Table 2.4.1a. Development of data files used in the bridging analysis (full details).

Pass	Data file	Data file description	FSB	ABC	|ΔFSB|	|ΔABC|
0	2020	Pass_0 (= final 2020 data file)	411811	106852	0.000	0.000
0	Data_0.1	Pass_0 + update catch through 2021	398989	101660	0.031	0.049
1	Data_0.1	Pass_1 (= Pass_0 + update catch through 2021)	398989	101660	0.000	0.000
1	Data_1.1	Pass_1 + revise historic survey index	428362	119984	0.074	0.180
1	Data_1.2	Pass_1 + add 2021 survey index	384070	90817	0.037	0.107
1	Data_1.3	Pass_1 + revise historic fishery sizecomp	398589	101423	0.001	0.002
1	Data_1.4	Pass_1 + add 2021 fishery sizecomp	400095	102413	0.003	0.007
1	Data_1.4	Pass_1 + revise historic survey sizecomp	404387	105516	0.014	0.038
1	Data_1.5	Pass_1 + add 2021 survey sizecomp	430054	120863	0.078	0.189
1	Data_1.6	Pass_1 + revise historic survey agecomp	398140	100824	0.002	0.008
1	Data_1.7	Pass_1 + revise historic weight-length	409770	107166	0.027	0.054
1	Data_1.9	Pass_1 + add 2021 weight-length	392059	98534	0.017	0.031
2	Data_1.5	Pass_2 (= Pass_1 + add 2021 survey sizecomp)	430054	120863	0.000	0.000
2	Data_2.1	Pass_2 + revise historic survey index	459472	141127	0.068	0.168
2	Data_2.2	Pass_2 + add 2021 survey index	480909	143835	0.118	0.190
2	Data_2.3	Pass_2 + revise historic fishery sizecomp	429568	120560	0.001	0.003
2	Data_2.4	Pass_2 + add 2021 fishery sizecomp	432728	122443	0.006	0.013
2	Data_2.5	Pass_2 + revise historic survey sizecomp	435380	124947	0.012	0.034
2	Data_2.6	Pass_2 + revise historic survey agecomp	428605	119587	0.003	0.011
2	Data_2.7	Pass_2 + revise historic weight-length	439924	126386	0.023	0.046
2	Data_2.8	Pass_2 + add 2021 weight-length	423672	117748	0.015	0.026
3	Data_2.2	Pass_3 (= Pass_2 + add 2021 survey index)	480909	143835	0.000	0.000
3	Data_3.1	Pass_3 + revise historic survey index	506480	164366	0.053	0.143
3	Data_3.2	Pass_3 + revise historic fishery sizecomp	480367	143435	0.001	0.003
3	Data_3.3	Pass_3 + add 2021 fishery sizecomp	483361	144960	0.005	0.008
3	Data_3.4	Pass_3 + revise historic survey sizecomp	485315	148136	0.009	0.030
3	Data_3.5	Pass_3 + revise historic survey agecomp	479809	142678	0.002	0.008
3	Data_3.6	Pass_3 + revise historic weight-length	489620	149141	0.018	0.037
3	Data_3.7	Pass_3 + add 2021 weight-length	475292	140950	0.012	0.020
4	Data_3.1	Pass_4 (= Pass_3 + revise historic survey index)	506480	164366	0.000	0.000
4	Data_4.1	Pass_4 + revise historic fishery sizecomp	505791	163847	0.001	0.003
4	Data_4.2	Pass_4 + add 2021 fishery sizecomp	508222	165166	0.003	0.005
4	Data_4.3	Pass_4 + revise historic survey sizecomp	510556	168862	0.008	0.027
4	Data_4.4	Pass_4 + revise historic survey agecomp	503800	161481	0.005	0.018
4	Data_4.5	Pass_4 + revise historic weight-length	516100	170623	0.019	0.038
4	Data_4.6	Pass_4 + add 2021 weight-length	500763	161217	0.011	0.019
5	Data_4.5	Pass_5 (= Pass_4 + revise historic weight-length)	516100	170623	0.000	0.000
5	Data_5.1	Pass_5 + revise historic fishery sizecomp	515415	170097	0.001	0.003
5	Data_5.2	Pass_5 + add 2021 fishery sizecomp	517612	171276	0.003	0.004
5	Data_5.3	Pass_5 + revise historic survey sizecomp	520242	175164	0.008	0.027
5	Data_5.4	Pass_5 + revise historic survey agecomp	513410	167686	0.005	0.017
5	Data_5.5	Pass_5 + add 2021 weight-length	510419	167455	0.011	0.019
6	Data_5.3	Pass_6 (= Pass_5 + revise historic survey sizecomp)	520242	175164	0.000	0.000
6	Data_6.1	Pass_6 + revise historic fishery sizecomp	519590	174700	0.001	0.003
6	Data_6.2	Pass_6 + add 2021 fishery sizecomp	521842	175506	0.003	0.002
6	Data_6.3	Pass_6 + revise historic survey agecomp	517405	172105	0.005	0.017
6	Data_6.4	Pass_6 + add 2021 weight-length	514584	172030	0.011	0.018
7	Data_6.4	Pass_7 (= Pass_6 + add 2021 weight-length)	514584	172030	0.000	0.000
7	Data_7.1	Pass_7 + revise historic fishery sizecomp	513962	171502	0.001	0.003
7	Data_7.2	Pass_7 + add 2021 fishery sizecomp	516218	172745	0.003	0.004
7	Data_7.3	Pass_7 + revise historic survey agecomp	511736	168935	0.006	0.018
8	Data_7.3	Pass_8 (= Pass_7 + revise historic survey agecomp)	511736	168935	0.000	0.000
8	Data_8.1	Pass_8 + revise historic fishery sizecomp	511043	168383	0.001	0.003
8	Data_8.2	Pass_8 + add 2021 fishery sizecomp	513347	169599	0.003	0.004
9	Data_8.2	Pass_9 (= Pass_8 + add 2021 fishery sizecomp)	513347	169599	0.000	0.000
9	2021	Pass_9 + revise historic fishery sizecomp	512687	169060	0.001	0.003

Table 2.4.1b. Development of data files used in the bridging analysis (summary).

Pass	Data file	Data file description	FSB	ABC	ΔFSB	ΔABC	|ΔFSB|	|ΔABC|
0	2020	Pass_0 (= final 2020 data file)	411811	106852	0.000	0.000	0.000	0.000
0	Data_0.1	Pass_0 + update catch through 2021	398989	101660	-0.031	-0.049	0.031	0.049
1	Data_0.1	Pass_1 (= Pass_0 + update catch through 2021)	398989	101660	0.000	0.000	0.000	0.000
1	Data_1.5	Pass_1 + add 2021 survey sizecomp	430054	120863	0.078	0.189	0.078	0.189
2	Data_1.5	Pass_2 (= Pass_1 + add 2021 survey sizecomp)	430054	120863	0.000	0.000	0.000	0.000
2	Data_2.2	Pass_2 + add 2021 survey index	480909	143835	0.118	0.190	0.118	0.190
3	Data_2.2	Pass_3 (= Pass_2 + add 2021 survey index)	480909	143835	0.000	0.000	0.000	0.000
3	Data_3.1	Pass_3 + revise historic survey index	506480	164366	0.053	0.143	0.053	0.143
4	Data_3.1	Pass_4 (= Pass_3 + revise historic survey index)	506480	164366	0.000	0.000	0.000	0.000
4	Data_4.5	Pass_4 + revise historic weight-length	516100	170623	0.019	0.038	0.019	0.038
5	Data_4.5	Pass_5 (= Pass_4 + revise historic weight-length)	516100	170623	0.000	0.000	0.000	0.000
5	Data_5.3	Pass_5 + revise historic survey sizecomp	520242	175164	0.008	0.027	0.008	0.027
6	Data_5.3	Pass_6 (= Pass_5 + revise historic survey sizecomp)	520242	175164	0.000	0.000	0.000	0.000
6	Data_6.4	Pass_6 + add 2021 weight-length	514584	172030	-0.011	-0.018	0.011	0.018
7	Data_6.4	Pass_7 (= Pass_6 + add 2021 weight-length)	514584	172030	0.000	0.000	0.000	0.000
7	Data_7.3	Pass_7 + revise historic survey agecomp	511736	168935	-0.006	-0.018	0.006	0.018
8	Data_7.3	Pass_8 (= Pass_7 + revise historic survey agecomp)	511736	168935	0.000	0.000	0.000	0.000
8	Data_8.2	Pass_8 + add 2021 fishery sizecomp	513347	169599	0.003	0.004	0.003	0.004
9	Data_8.2	Pass_9 (= Pass_8 + add 2021 fishery sizecomp)	513347	169599	0.000	0.000	0.000	0.000
9	2021	Pass_9 + revise historic fishery sizecomp	512687	169060	-0.001	-0.003	0.001	0.003

Table 2.4.2a. Estimates of time-invariant parameters at each pass of the bridging analysis, and correlations with 2022 ABC.

Pass:	0	1	2	3	4	5	6	7	8	9		
ABC2022:	101660	120863	143835	164366	170623	175164	172030	168935	169599	169060	cor.	cor.
Natural mortality	0.354	0.353	0.349	0.357	0.358	0.361	0.361	0.359	0.359	0.359	0.705	0.705
Mean length at age 1.5	14.788	15.033	15.193	15.160	15.157	15.188	15.188	15.161	15.160	15.162	0.882	0.882
Asymptotic length	113.494	113.884	113.342	111.687	111.639	111.656	111.644	111.551	112.009	112.003	-0.912	0.912
Brody growth coefficient	0.117	0.115	0.117	0.121	0.121	0.121	0.121	0.121	0.120	0.120	0.883	0.883
Richards growth coefficient	1.444	1.449	1.440	1.433	1.434	1.431	1.431	1.433	1.438	1.439	-0.842	0.842
SD(length at age 1)	3.487	3.486	3.482	3.487	3.488	3.478	3.479	3.477	3.478	3.476	-0.542	0.542
SD(length at age 20)	9.947	10.041	9.915	9.846	9.845	9.909	9.907	9.927	9.941	9.970	-0.517	0.517
Mean ageing bias at age 1 (pre-2008)	0.338	0.339	0.338	0.339	0.340	0.340	0.340	0.347	0.347	0.347	0.497	0.497
Mean ageing bias at age 20 (pre 2008)	0.974	0.939	0.939	0.936	0.937	0.951	0.950	0.993	0.993	0.991	0.119	0.119
Mean bias at age 1 (2008+)	0.011	0.013	0.012	0.010	0.010	0.010	0.010	0.005	0.005	0.005	-0.565	0.565
Mean bias at age 20 (2008+)	-1.633	-1.656	-1.624	-1.537	-1.543	-1.513	-1.513	-1.557	-1.563	-1.562	0.886	0.886
ln(mean post-1976 recruits)	13.151	13.123	13.123	13.205	13.216	13.238	13.238	13.228	13.229	13.227	0.843	0.843
ln(pre-1977 recruits offset)	-0.886	-0.865	-0.900	-0.866	-0.863	-0.866	-0.865	-0.867	-0.872	-0.880	0.441	0.441
Pre-1977 fishing mortality	0.122	0.123	0.122	0.114	0.114	0.114	0.114	0.114	0.114	0.116	-0.914	0.914
ln(Dirichlet-multinomial coef. for agecomps)	-0.036	-0.062	-0.065	-0.158	-0.164	-0.167	-0.168	-0.123	-0.124	-0.123	-0.905	0.905
ln(survey catchability)	-0.013	-0.022	-0.002	-0.063	-0.071	-0.080	-0.080	-0.074	-0.075	-0.074	-0.869	0.869
Fishery selectivity: begin flattop	75.012	75.013	75.012	75.012	75.012	75.011	75.011	75.011	75.012	75.012	-0.911	0.911
Fishery selectivity: logit(flatop width)	-9.722	-9.747	-9.704	-9.664	-9.660	-9.635	-9.632	-9.615	-9.676	-9.672	0.845	0.845
Fishery selectivity: ln(ascending SD)	5.912	5.909	5.912	5.914	5.914	5.911	5.911	5.912	5.904	5.904	-0.089	0.089
Fishery selectivity: ln(descending SD)	-9.938	-9.928	-9.942	-9.957	-9.957	-9.958	-9.959	-9.960	-9.955	-9.960	-0.899	0.899
Fishery selectivity: logit(ending value)	2.133	2.141	2.125	2.042	2.042	2.020	2.019	2.007	2.038	2.038	-0.913	0.913
Survey selectivity: begin flattop	20.907	21.168	21.158	21.238	21.241	21.312	21.312	21.289	21.294	21.293	0.927	0.927
Survey selectivity: ln(ascending SD)	3.533	3.597	3.587	3.601	3.600	3.604	3.604	3.594	3.596	3.596	0.801	0.801

Table 2.4.2b. Estimates of log recruitment deviations at each pass of the bridging analysis.

Pass:	0	1	2	3	4	5	6	7	8	9		
ABC2022:	101660	120863	143835	164366	170623	175164	172030	168935	169599	169060	cor.	cor.
1977	1.016	1.054	0.984	1.037	1.041	1.047	1.047	1.045	1.043	1.046	0.402	0.402
1978	0.592	0.624	0.591	0.624	0.625	0.629	0.629	0.620	0.619	0.616	0.651	0.651
1979	0.631	0.662	0.618	0.657	0.658	0.661	0.661	0.656	0.655	0.655	0.522	0.522
1980	-0.783	-0.788	-0.802	-0.694	-0.694	-0.702	-0.702	-0.702	-0.703	-0.705	0.862	0.862
1981	-0.666	-0.629	-0.669	-0.682	-0.682	-0.685	-0.685	-0.692	-0.690	-0.690	-0.770	0.770
1982	0.894	0.928	0.884	0.879	0.879	0.877	0.877	0.874	0.875	0.875	-0.746	0.746
1983	-0.414	-0.407	-0.436	-0.422	-0.423	-0.425	-0.425	-0.428	-0.430	-0.431	-0.644	0.644
1984	0.790	0.822	0.781	0.805	0.805	0.803	0.803	0.801	0.800	0.800	0.105	0.105
1985	-0.005	0.015	-0.020	0.020	0.020	0.019	0.019	0.015	0.013	0.012	0.574	0.574
1986	-0.601	-0.579	-0.607	-0.597	-0.597	-0.601	-0.601	-0.604	-0.604	-0.605	-0.385	0.385
1987	-1.768	-1.744	-1.768	-1.697	-1.698	-1.704	-1.704	-1.707	-1.705	-1.705	0.874	0.874
1988	-0.234	-0.198	-0.238	-0.270	-0.270	-0.274	-0.275	-0.276	-0.275	-0.273	-0.859	0.859
1989	0.454	0.488	0.448	0.400	0.400	0.396	0.396	0.396	0.395	0.396	-0.893	0.893
1990	0.434	0.462	0.423	0.382	0.383	0.380	0.380	0.382	0.381	0.381	-0.910	0.910
1991	-0.096	-0.076	-0.106	-0.095	-0.094	-0.098	-0.098	-0.096	-0.098	-0.098	-0.404	0.404
1992	0.891	0.923	0.884	0.880	0.881	0.878	0.878	0.876	0.875	0.875	-0.723	0.723
1993	-0.092	-0.071	-0.105	-0.133	-0.132	-0.134	-0.134	-0.131	-0.133	-0.135	-0.913	0.913
1994	-0.264	-0.236	-0.270	-0.278	-0.276	-0.280	-0.280	-0.286	-0.287	-0.287	-0.767	0.767
1995	-0.419	-0.390	-0.424	-0.431	-0.430	-0.436	-0.436	-0.427	-0.427	-0.427	-0.718	0.718
1996	0.757	0.792	0.750	0.744	0.746	0.743	0.743	0.747	0.747	0.747	-0.688	0.688
1997	-0.064	-0.041	-0.075	-0.101	-0.099	-0.102	-0.103	-0.121	-0.121	-0.121	-0.857	0.857
1998	-0.348	-0.321	-0.352	-0.339	-0.339	-0.344	-0.344	-0.336	-0.337	-0.336	-0.022	0.022
1999	0.558	0.590	0.550	0.545	0.546	0.543	0.543	0.551	0.551	0.550	-0.685	0.685
2000	0.224	0.249	0.218	0.222	0.222	0.219	0.219	0.219	0.218	0.217	-0.583	0.583
2001	-0.673	-0.652	-0.684	-0.697	-0.696	-0.699	-0.699	-0.706	-0.707	-0.708	-0.864	0.864
2002	-0.178	-0.146	-0.179	-0.171	-0.169	-0.174	-0.175	-0.170	-0.170	-0.171	-0.210	0.210
2003	-0.234	-0.203	-0.238	-0.263	-0.261	-0.265	-0.266	-0.265	-0.264	-0.264	-0.850	0.850
2004	-0.557	-0.532	-0.560	-0.585	-0.582	-0.588	-0.588	-0.599	-0.598	-0.599	-0.846	0.846
2005	-0.350	-0.313	-0.349	-0.420	-0.418	-0.426	-0.427	-0.431	-0.429	-0.428	-0.890	0.890
2006	0.729	0.763	0.729	0.655	0.657	0.650	0.650	0.649	0.650	0.650	-0.896	0.896
2007	-0.199	-0.174	-0.204	-0.235	-0.235	-0.241	-0.241	-0.234	-0.234	-0.235	-0.892	0.892
2008	1.110	1.143	1.111	1.078	1.076	1.073	1.073	1.082	1.083	1.084	-0.839	0.839
2009	-0.882	-0.881	-0.897	-0.879	-0.882	-0.890	-0.890	-0.884	-0.883	-0.882	-0.092	0.092
2010	0.639	0.675	0.647	0.630	0.625	0.620	0.620	0.616	0.620	0.621	-0.754	0.754
2011	0.883	0.918	0.894	0.898	0.893	0.888	0.888	0.867	0.871	0.872	-0.418	0.418
2012	0.139	0.167	0.149	0.146	0.143	0.126	0.126	0.147	0.152	0.150	-0.347	0.347
2013	1.125	1.158	1.149	1.155	1.153	1.124	1.124	1.111	1.119	1.117	-0.279	0.279
2014	-0.615	-0.600	-0.589	-0.589	-0.593	-0.630	-0.629	-0.609	-0.602	-0.598	-0.088	0.088
2015	-0.334	-0.299	-0.294	-0.312	-0.313	-0.307	-0.306	-0.293	-0.291	-0.289	0.498	0.498
2016	-0.821	-0.781	-0.743	-0.722	-0.722	-0.593	-0.591	-0.599	-0.597	-0.602	0.847	0.847
2017	-1.172	-1.256	-1.181	-1.184	-1.185	-1.109	-1.108	-1.085	-1.099	-1.094	0.644	0.644
2018	0.604	0.641	0.675	0.648	0.647	0.634	0.634	0.626	0.620	0.620	0.163	0.163
2019	-0.585	-1.530	-0.633	-0.549	-0.548	-0.547	-0.545	-0.538	-0.571	-0.574	0.525	0.525
2020	-0.115	-0.229	-0.061	-0.062	-0.062	-0.058	-0.059	-0.060	-0.032	-0.029	0.727	0.727

Table 2.4.2c. Age 0 recruitment estimates (billions of fish) at each pass of the bridging analysis.

Pass:	0	1	2	3	4	5	6	7	8	9		
ABC2022:	101660	120863	143835	164366	170623	175164	172030	168935	169599	169060	cor.	cor.
1977	1.131	1.142	1.064	1.219	1.237	1.272	1.272	1.256	1.256	1.257	0.786	0.786
1978	0.740	0.743	0.718	0.807	0.816	0.837	0.838	0.821	0.821	0.818	0.856	0.856
1979	0.770	0.772	0.738	0.834	0.844	0.865	0.865	0.851	0.852	0.850	0.829	0.829
1980	0.187	0.181	0.178	0.216	0.218	0.221	0.221	0.219	0.219	0.218	0.867	0.867
1981	0.210	0.212	0.204	0.218	0.221	0.225	0.225	0.221	0.222	0.222	0.770	0.770
1982	1.001	1.007	0.963	1.040	1.051	1.073	1.074	1.059	1.061	1.059	0.761	0.761
1983	0.271	0.265	0.257	0.283	0.286	0.292	0.292	0.288	0.288	0.287	0.776	0.776
1984	0.902	0.905	0.868	0.966	0.976	0.996	0.997	0.984	0.985	0.983	0.824	0.824
1985	0.407	0.404	0.390	0.441	0.446	0.455	0.455	0.448	0.448	0.447	0.833	0.833
1986	0.224	0.223	0.217	0.238	0.240	0.245	0.245	0.241	0.242	0.241	0.826	0.826
1987	0.070	0.070	0.068	0.079	0.080	0.081	0.081	0.080	0.080	0.080	0.880	0.880
1988	0.324	0.327	0.314	0.330	0.333	0.339	0.339	0.335	0.336	0.336	0.686	0.686
1989	0.645	0.648	0.623	0.644	0.652	0.663	0.664	0.656	0.657	0.656	0.505	0.505
1990	0.632	0.631	0.607	0.633	0.640	0.653	0.653	0.647	0.648	0.646	0.570	0.570
1991	0.372	0.369	0.358	0.393	0.397	0.405	0.405	0.401	0.401	0.400	0.816	0.816
1992	0.998	1.002	0.963	1.041	1.054	1.074	1.074	1.061	1.062	1.059	0.786	0.786
1993	0.373	0.370	0.358	0.378	0.383	0.391	0.391	0.388	0.387	0.386	0.685	0.685
1994	0.314	0.314	0.304	0.327	0.331	0.337	0.337	0.332	0.332	0.331	0.785	0.785
1995	0.269	0.269	0.260	0.281	0.284	0.289	0.289	0.288	0.289	0.288	0.794	0.794
1996	0.873	0.878	0.842	0.909	0.921	0.938	0.939	0.933	0.934	0.932	0.779	0.779
1997	0.384	0.382	0.369	0.391	0.395	0.403	0.403	0.392	0.392	0.391	0.638	0.638
1998	0.289	0.289	0.280	0.308	0.311	0.317	0.317	0.316	0.316	0.316	0.832	0.832
1999	0.716	0.718	0.689	0.745	0.754	0.769	0.769	0.767	0.767	0.765	0.779	0.779
2000	0.512	0.511	0.495	0.539	0.545	0.556	0.556	0.550	0.550	0.549	0.815	0.815
2001	0.209	0.207	0.201	0.215	0.218	0.222	0.222	0.218	0.218	0.218	0.747	0.747
2002	0.343	0.344	0.332	0.364	0.369	0.375	0.375	0.373	0.373	0.372	0.836	0.836
2003	0.324	0.325	0.314	0.332	0.336	0.342	0.342	0.339	0.340	0.339	0.747	0.747
2004	0.235	0.234	0.227	0.241	0.244	0.248	0.248	0.243	0.243	0.243	0.748	0.748
2005	0.288	0.291	0.281	0.284	0.288	0.291	0.292	0.287	0.288	0.288	0.038	0.038
2006	0.848	0.853	0.825	0.832	0.842	0.855	0.856	0.846	0.848	0.846	0.019	0.019
2007	0.336	0.334	0.324	0.342	0.345	0.351	0.351	0.350	0.350	0.349	0.722	0.722
2008	1.242	1.248	1.208	1.270	1.281	1.305	1.305	1.304	1.307	1.305	0.742	0.742
2009	0.169	0.165	0.162	0.179	0.181	0.183	0.183	0.183	0.183	0.183	0.816	0.816
2010	0.776	0.781	0.760	0.812	0.816	0.829	0.830	0.818	0.823	0.822	0.828	0.828
2011	0.991	0.997	0.972	1.061	1.066	1.085	1.085	1.051	1.057	1.056	0.844	0.844
2012	0.470	0.470	0.462	0.500	0.504	0.506	0.507	0.512	0.515	0.513	0.848	0.848
2013	1.261	1.267	1.255	1.372	1.383	1.373	1.375	1.342	1.354	1.349	0.881	0.881
2014	0.221	0.218	0.221	0.240	0.241	0.238	0.238	0.240	0.242	0.243	0.886	0.886
2015	0.293	0.295	0.296	0.316	0.319	0.328	0.329	0.330	0.331	0.331	0.903	0.903
2016	0.180	0.182	0.189	0.210	0.212	0.247	0.247	0.243	0.244	0.242	0.860	0.860
2017	0.127	0.113	0.122	0.132	0.133	0.147	0.147	0.149	0.147	0.148	0.773	0.773
2018	0.749	0.755	0.781	0.826	0.834	0.841	0.842	0.826	0.823	0.821	0.972	0.972
2019	0.228	0.086	0.211	0.249	0.252	0.258	0.259	0.258	0.250	0.249	0.645	0.645
2020	0.365	0.316	0.374	0.406	0.410	0.421	0.421	0.416	0.429	0.429	0.857	0.857

Table 2.4.2d. Parameters with correlations (with respect to 2022 ABC) in excess of 0.95 (absolute value).

Pass:	0	1	2	3	4	5	6	7	8	9		
ABC2022:	101660	120863	143835	164366	170623	175164	172030	168935	169599	169060	cor.	cor.
Length at age 1.5 1991	0.477	0.402	0.328	0.252	0.252	0.237	0.236	0.245	0.248	0.248	-0.997	0.997
Length at age 1.5 1990	-0.063	-0.139	-0.202	-0.276	-0.276	-0.287	-0.287	-0.283	-0.282	-0.281	-0.996	0.996
Length at age 1.5 1984	0.452	0.382	0.311	0.253	0.255	0.240	0.240	0.254	0.259	0.260	-0.993	0.993
Length at age 1.5 2007	-1.159	-1.246	-1.306	-1.410	-1.410	-1.426	-1.426	-1.397	-1.397	-1.396	-0.993	0.993
Length at age 1.5 2006	-0.273	-0.383	-0.445	-0.514	-0.516	-0.531	-0.531	-0.520	-0.520	-0.520	-0.989	0.989
Length at age 1.5 1994	-0.227	-0.269	-0.354	-0.396	-0.396	-0.404	-0.404	-0.411	-0.409	-0.410	-0.989	0.989
Survey selectivity: begin flattop 1998	2.061	2.011	1.991	1.934	1.937	1.933	1.933	1.946	1.942	1.943	-0.985	0.985
Survey selectivity: begin flattop 1987	0.026	-0.009	-0.015	-0.066	-0.066	-0.072	-0.072	-0.075	-0.075	-0.075	-0.976	0.976
Survey selectivity: begin flattop 1990	-0.237	-0.280	-0.282	-0.346	-0.345	-0.349	-0.349	-0.349	-0.351	-0.351	-0.973	0.973
Length at age 1.5 1985	-1.497	-1.553	-1.600	-1.617	-1.617	-1.628	-1.628	-1.619	-1.615	-1.615	-0.972	0.972
Length at age 1.5 2008	-1.319	-1.390	-1.459	-1.480	-1.477	-1.484	-1.485	-1.481	-1.481	-1.480	-0.969	0.969
Survey selectivity: begin flattop 2006	-1.537	-1.584	-1.600	-1.746	-1.741	-1.757	-1.757	-1.754	-1.753	-1.754	-0.967	0.967
Survey selectivity: begin flattop 1991	1.048	1.035	1.019	0.963	0.963	0.961	0.961	0.956	0.953	0.956	-0.966	0.966
Survey selectivity: begin flattop 2005	-0.099	-0.171	-0.173	-0.279	-0.270	-0.268	-0.268	-0.260	-0.262	-0.263	-0.966	0.966
Survey selectivity: ln(ascending SD) 2006	-1.387	-1.444	-1.454	-1.609	-1.603	-1.608	-1.608	-1.599	-1.598	-1.598	-0.965	0.965
Length at age 1.5 1998	-0.747	-0.782	-0.862	-0.882	-0.883	-0.893	-0.893	-0.915	-0.912	-0.912	-0.965	0.965
Length at age 1.5 2001	0.370	0.301	0.230	0.215	0.215	0.201	0.201	0.184	0.187	0.186	-0.964	0.964
Survey selectivity: ln(ascending SD) 2016	0.747	0.720	0.718	0.675	0.674	0.652	0.653	0.668	0.671	0.666	-0.960	0.960
Survey selectivity: begin flattop 1982	-0.184	-0.208	-0.206	-0.248	-0.248	-0.256	-0.256	-0.257	-0.257	-0.257	-0.959	0.959
Length at age 1.5 1987	-0.537	-0.582	-0.654	-0.665	-0.666	-0.662	-0.663	-0.661	-0.662	-0.663	-0.958	0.958
Survey selectivity: begin flattop 1983	-0.258	-0.282	-0.285	-0.353	-0.353	-0.348	-0.348	-0.353	-0.355	-0.355	-0.955	0.955
Survey selectivity: begin flattop 1994	0.406	0.370	0.373	0.338	0.340	0.340	0.340	0.347	0.342	0.340	-0.954	0.954
Length at age 1.5 2015	1.755	1.693	1.602	1.597	1.597	1.582	1.582	1.597	1.607	1.598	-0.952	0.952
Length at age 1.5 2021	0.000	0.759	3.092	3.247	3.252	3.253	3.256	3.281	3.209	3.206	0.952	0.952
Survey selectivity: ln(ascending SD) 1998	2.033	1.966	1.962	1.922	1.924	1.925	1.925	1.921	1.918	1.918	-0.951	0.951

Table 2.4.3. Changes in negative log likelihood, where the value for each pass compares the run estimated in that path against a run with parameters fixed at the value from the preceding run.

Component	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Pass 6	Pass 7	Pass 8	Pass 9
Catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equil_catch	0.00	0.00	0.00	-0.09	0.00	0.00	0.00	0.00	0.00
Survey	0.39	-18.97	-23.99	0.18	-1.38	-0.03	0.20	0.45	0.30
Sizecomp(fishery)	0.79	0.28	0.88	0.16	-0.86	0.00	0.12	-6.25	-1.19
Sizecomp(survey)	-71.59	0.76	10.00	-0.03	-3.68	-0.02	-0.27	-0.60	0.60
Agecomp	1.14	0.08	4.07	-0.33	-0.69	0.04	-2.72	0.33	-0.14
Recruitment	2.88	-2.79	-0.67	-0.02	-0.41	0.00	-0.12	0.10	0.05
InitEQ_Regime	-0.17	0.52	-0.64	-0.06	-0.05	0.00	0.07	0.05	0.09
Softbounds	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parm_devs	3.10	5.69	-0.10	-0.07	1.32	0.02	1.26	1.07	0.18
Total	-63.47	-14.44	-10.46	-0.26	-5.75	0.00	-1.46	-4.85	-0.11

Data added	Pass 1	Pass 2	Pass 3	Pass 4	Pass 5	Pass 6	Pass 7	Pass 8	Pass 9
2021 survey sizecomp	-69.35								
2021 survey index		-18.77							
2021 fishery sizecomp								-6.46	

Table 2.4.4a. Comparison of quantities used in calculating 2022 ABC (Pass 0 versus last year's final version).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	Last	527908	370400	259877	181818	176168	19286	14768	13829	5533	16569	3264	3218	1039	1594122
	0	514741	361127	179673	78555	175963	19173	14628	13694	5471	16299	3201	3144	1009	1387107
	Diff.	-13167	-9273	-80204	-103263	-205	-114	-140	-135	-61	-270	-63	-75	-30	-207015
Fecundity at age	Last	0.000	0.000	0.003	0.062	0.403	1.143	2.890	3.987	5.413	6.676	7.654	8.735	9.849	
	0	0.000	0.000	0.003	0.062	0.394	1.149	2.887	3.986	5.414	6.678	7.658	8.741	9.859	
	Diff.	0.000	0.000	0.000	0.000	-0.008	0.006	-0.003	-0.001	0.000	0.002	0.004	0.006	0.010	
Spawning biomass at age (t)	Last	0	6	337	5607	35476	11020	21339	27568	14974	55304	12492	14056	5118	205905
	0	0	6	232	2418	34700	11012	21117	27291	14810	54417	12258	13739	4974	199494
	Diff.	0	0	-105	-3189	-776	-8	-222	-278	-164	-887	-235	-316	-144	-6411
Eq. unexpl. begin-yr nos. at age	Last	527908	370404	259892	182351	127946	89772	62988	44195	31009	21758	15266	10711	7516	1769392
	0	514741	361131	253362	177754	124708	87493	61383	43065	30214	21197	14872	10434	7320	1724882
	Diff.	-13167	-9273	-6530	-4597	-3238	-2280	-1605	-1130	-796	-560	-395	-278	-196	-44509
Equilibium fecundity at age	Last	0.000	0.000	0.003	0.066	0.412	1.250	2.452	3.790	5.130	6.417	7.631	8.776	9.838	
	0	0.000	0.000	0.003	0.065	0.414	1.259	2.460	3.799	5.135	6.416	7.632	8.777	9.843	
	Diff.	0.000	0.000	0.000	-0.001	0.002	0.009	0.007	0.010	0.004	-0.001	0.001	0.001	0.005	
Eq. unexpl. spawning bio. at age (t)	Last	0	8	383	5975	26345	56099	77237	83746	79545	69814	58250	47002	36969	652380
	0	0	7	369	5764	25818	55070	75491	81811	77571	68004	56751	45789	36024	636680
	Diff.	0	0	-14	-211	-527	-1029	-1746	-1935	-1974	-1810	-1499	-1213	-944	-15700
Relative spawning biomass at age	Last	0.000	0.824	0.881	0.938	1.347	0.196	0.276	0.329	0.188	0.792	0.214	0.299	0.138	0.316
	0	0.000	0.840	0.630	0.420	1.344	0.200	0.280	0.334	0.191	0.800	0.216	0.300	0.138	0.313
	Diff.	0.000	0.016	-0.251	-0.519	-0.003	0.004	0.003	0.004	0.003	0.008	0.002	0.001	0.000	-0.002
F40%	Last	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	0	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	Diff.	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	
maxFABC	Last	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	
	0	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	
	Diff.	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	
Fishery selectivity at age	Last	0.000	0.000	0.010	0.090	0.303	0.554	0.829	0.885	0.904	0.904	0.901	0.899	0.897	
	0	0.000	0.000	0.010	0.090	0.300	0.556	0.830	0.885	0.904	0.903	0.901	0.898	0.896	
	Diff.	0.000	0.000	0.000	0.000	-0.004	0.002	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	
Natural mortality	Last	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	0	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	Diff.	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	
maxFABC exploitation rate at age	Last	0.000	0.000	0.002	0.020	0.067	0.118	0.171	0.181	0.185	0.185	0.184	0.184	0.184	
	0	0.000	0.000	0.002	0.020	0.066	0.118	0.170	0.180	0.184	0.183	0.183	0.182	0.182	
	Diff.	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.002	
Mid-year weight at age (kg)	Last	0.004	0.058	0.533	1.302	2.229	3.125	4.514	5.343	6.489	7.581	8.462	9.456	10.492	
	0	0.004	0.058	0.531	1.299	2.212	3.127	4.510	5.340	6.487	7.581	8.465	9.462	10.502	
	Diff.	0.000	0.000	-0.002	-0.004	-0.017	0.002	-0.004	-0.003	-0.002	0.000	0.003	0.006	0.010	
maxABC at age (t)	Last	0	1	301	4827	26247	7125	11409	13398	6638	23213	5092	5597	2002	106849
	0	0	1	206	2065	25509	7056	11211	13167	6515	22659	4956	5426	1930	101657
	Diff.	0	0	-95	-2762	-738	-69	-199	-231	-123	-554	-136	-171	-73	-5192

Table 2.4.4b. Comparison of quantities used in calculating 2022 ABC (Pass 1 versus Pass 0).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	0	514741	361127	179673	78555	175963	19173	14628	13694	5471	16299	3201	3144	1009	1387107
	1	500205	351396	156170	29773	176610	17374	15286	14292	5635	17163	3369	3353	1083	1292169
	Diff.	-14536	-9731	-23503	-48783	647	-1799	658	598	163	864	168	210	74	-94937
Fecundity at age	0	0.000	0.000	0.003	0.062	0.394	1.149	2.887	3.986	5.414	6.678	7.658	8.741	9.859	
	1	0.000	0.000	0.003	0.075	0.524	1.155	2.850	3.952	5.365	6.630	7.607	8.689	9.813	
	Diff.	0.000	0.000	0.000	0.013	0.129	0.006	-0.038	-0.034	-0.048	-0.048	-0.051	-0.052	-0.046	
Spawning biomass at age (t)	0	0	6	232	2418	34700	11012	21117	27291	14810	54417	12258	13739	4974	199494
	1	0	6	209	1114	46233	10030	21780	28243	15116	56895	12813	14569	5316	215027
	Diff.	0	0	-23	-1304	11533	-981	663	952	306	2478	556	829	342	15533
Eq. unexpl. begin-yr nos. at age	0	514741	361131	253362	177754	124708	87493	61383	43065	30214	21197	14872	10434	7320	1724882
	1	500205	351400	246862	173423	121832	85588	60127	42240	29674	20846	14645	10288	7227	1681424
	Diff.	-14536	-9731	-6500	-4331	-2876	-1905	-1257	-826	-540	-351	-227	-146	-93	-43458
Equilibium fecundity at age	0	0.000	0.000	0.003	0.065	0.414	1.259	2.460	3.799	5.135	6.416	7.632	8.777	9.843	
	1	0.000	0.000	0.003	0.065	0.408	1.240	2.428	3.758	5.088	6.366	7.582	8.729	9.799	
	Diff.	0.000	0.000	0.000	0.000	-0.006	-0.019	-0.032	-0.042	-0.047	-0.050	-0.050	-0.048	-0.044	
Eq. unexpl. spawning bio. at age (t)	0	0	7	369	5764	25818	55070	75491	81811	77571	68004	56751	45789	36024	636680
	1	0	7	374	5650	24861	53065	72984	79362	75483	66356	55518	44903	35411	621193
	Diff.	0	0	6	-114	-957	-2005	-2507	-2449	-2088	-1648	-1233	-885	-613	-15487
Relative spawning biomass at age	0	0.000	0.840	0.630	0.420	1.344	0.200	0.280	0.334	0.191	0.800	0.216	0.300	0.138	0.313
	1	0.000	0.840	0.559	0.197	1.860	0.189	0.298	0.356	0.200	0.857	0.231	0.324	0.150	0.346
	Diff.	0.000	0.000	-0.072	-0.222	0.516	-0.011	0.019	0.022	0.009	0.057	0.015	0.024	0.012	0.033
F40%	0	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	1	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	Diff.	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	
maxFABC	0	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	
	1	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	
	Diff.	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	0.029	
Fishery selectivity at age	0	0.000	0.000	0.010	0.090	0.300	0.556	0.830	0.885	0.904	0.903	0.901	0.898	0.896	
	1	0.000	0.000	0.010	0.102	0.355	0.555	0.825	0.884	0.904	0.904	0.901	0.899	0.897	
	Diff.	0.000	0.000	0.000	0.012	0.055	0.000	-0.004	-0.002	0.000	0.001	0.001	0.001	0.001	
Natural mortality	0	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	1	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	
	Diff.	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	
maxFABC exploitation rate at age	0	0.000	0.000	0.002	0.020	0.066	0.118	0.170	0.180	0.184	0.183	0.183	0.182	0.182	
	1	0.000	0.000	0.002	0.025	0.085	0.130	0.186	0.197	0.201	0.201	0.201	0.200	0.200	
	Diff.	0.000	0.000	0.000	0.005	0.020	0.012	0.016	0.017	0.018	0.018	0.018	0.018	0.018	
Mid-year weight at age (kg)	0	0.004	0.058	0.531	1.299	2.212	3.127	4.510	5.340	6.487	7.581	8.465	9.462	10.502	
	1	0.004	0.061	0.535	1.366	2.402	3.132	4.482	5.314	6.447	7.539	8.419	9.415	10.461	
	Diff.	0.000	0.003	0.004	0.067	0.191	0.005	-0.028	-0.026	-0.040	-0.042	-0.046	-0.047	-0.041	
maxABC at age (t)	0	0	1	206	2065	25509	7056	11211	13167	6515	22659	4956	5426	1930	101657
	1	0	1	201	1029	36131	7048	12719	14977	7312	26037	5693	6321	2265	120861
	Diff.	0	0	-5	-1036	10621	-8	1509	1810	797	3379	737	895	336	19204

Table 2.4.4c. Comparison of quantities used in calculating 2022 ABC (Pass 2 versus Pass 1).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	1	500205	351396	156170	29773	176610	17374	15286	14292	5635	17163	3369	3353	1083	1292169
	2	500062	352833	186382	73585	185856	19283	16636	15239	6121	18443	3608	3590	1159	1383291
	Diff.	-143	1437	30212	43812	9246	1909	1349	947	486	1280	239	236	76	91122
Fecundity at age	1	0.000	0.000	0.003	0.075	0.524	1.155	2.850	3.952	5.365	6.630	7.607	8.689	9.813	
	2	0.000	0.000	0.003	0.166	0.568	1.168	2.874	3.976	5.390	6.657	7.636	8.711	9.829	
	Diff.	0.000	0.000	0.000	0.091	0.044	0.014	0.024	0.024	0.025	0.027	0.029	0.021	0.016	
Spawning biomass at age (t)	1	0	6	209	1114	46233	10030	21780	28243	15116	56895	12813	14569	5316	215027
	2	0	7	257	6098	52738	11266	23905	30298	16497	61384	13774	15634	5698	240454
	Diff.	0	0	48	4983	6505	1235	2124	2055	1381	4488	961	1066	382	25428
Eq. unexpl. begin-yr nos. at age	1	500205	351400	246862	173423	121832	85588	60127	42240	29674	20846	14645	10288	7227	1681424
	2	500062	352838	248959	175662	123945	87454	61707	43540	30721	21676	15295	10792	7615	1698514
	Diff.	-143	1438	2097	2239	2113	1866	1580	1300	1047	830	650	504	387	17090
Equilibium fecundity at age	1	0.000	0.000	0.003	0.065	0.408	1.240	2.428	3.758	5.088	6.366	7.582	8.729	9.799	
	2	0.000	0.000	0.003	0.066	0.413	1.254	2.451	3.788	5.120	6.399	7.612	8.754	9.817	
	Diff.	0.000	0.000	0.000	0.001	0.004	0.014	0.023	0.030	0.033	0.033	0.030	0.025	0.018	
Eq. unexpl. spawning bio. at age (t)	1	0	7	374	5650	24861	53065	72984	79362	75483	66356	55518	44903	35411	621193
	2	0	8	410	5790	25569	54819	75621	82456	78652	69354	58211	47236	37375	650170
	Diff.	0	0	36	140	708	1754	2637	3093	3170	2998	2693	2332	1964	28977
Relative spawning biomass at age	1	0.000	0.840	0.559	0.197	1.860	0.189	0.298	0.356	0.200	0.857	0.231	0.324	0.150	0.346
	2	0.000	0.858	0.626	1.053	2.063	0.206	0.316	0.367	0.210	0.885	0.237	0.331	0.152	0.370
	Diff.	0.000	0.019	0.068	0.856	0.203	0.016	0.018	0.012	0.009	0.028	0.006	0.007	0.002	0.024
F40%	1	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	2	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	
	Diff.	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	-0.006	
maxFABC	1	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	0.299	
	2	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	
	Diff.	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	
Fishery selectivity at age	1	0.000	0.000	0.010	0.102	0.355	0.555	0.825	0.884	0.904	0.904	0.901	0.899	0.897	
	2	0.000	0.000	0.010	0.175	0.375	0.561	0.829	0.885	0.904	0.903	0.900	0.897	0.896	
	Diff.	0.000	0.000	0.000	0.073	0.020	0.006	0.003	0.001	0.000	-0.001	-0.001	-0.001	-0.002	
Natural mortality	1	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	0.353	
	2	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	Diff.	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	
maxFABC exploitation rate at age	1	0.000	0.000	0.002	0.025	0.085	0.130	0.186	0.197	0.201	0.201	0.201	0.200	0.200	
	2	0.000	0.000	0.003	0.045	0.094	0.137	0.195	0.207	0.211	0.211	0.210	0.210	0.209	
	Diff.	0.000	0.000	0.000	0.020	0.009	0.008	0.010	0.010	0.010	0.009	0.009	0.009	0.009	
Mid-year weight at age (kg)	1	0.004	0.061	0.535	1.366	2.402	3.132	4.482	5.314	6.447	7.539	8.419	9.415	10.461	
	2	0.004	0.063	0.538	1.692	2.460	3.143	4.498	5.330	6.464	7.560	8.442	9.431	10.471	
	Diff.	0.000	0.002	0.003	0.325	0.058	0.011	0.015	0.015	0.018	0.020	0.023	0.016	0.010	
maxABC at age (t)	1	0	1	201	1029	36131	7048	12719	14977	7312	26037	5693	6321	2265	120861
	2	0	1	264	5655	43135	8325	14621	16813	8345	29375	6400	7095	2540	143834
	Diff.	0	0	63	4626	7004	1277	1902	1835	1033	3338	707	774	274	22972

Table 2.4.4d. Comparison of quantities used in calculating 2022 ABC (Pass 3 versus Pass 2).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	2	500062	352833	186382	73585	185856	19283	16636	15239	6121	18443	3608	3590	1159	1383291
	3	543179	379963	198713	84609	189985	20071	17775	15666	6440	19616	3818	3853	1224	1485424
	Diff.	43117	27130	12331	11024	4129	788	1140	427	319	1173	210	263	65	102133
Fecundity at age	2	0.000	0.000	0.003	0.166	0.568	1.168	2.874	3.976	5.390	6.657	7.636	8.711	9.829	
	3	0.000	0.000	0.003	0.178	0.577	1.176	2.882	3.974	5.365	6.614	7.576	8.622	9.709	
	Diff.	0.000	0.000	0.000	0.012	0.009	0.008	0.008	-0.003	-0.026	-0.043	-0.060	-0.088	-0.120	
Spawning biomass at age (t)	2	0	7	257	6098	52738	11266	23905	30298	16497	61384	13774	15634	5698	240454
	3	0	7	275	7514	54801	11802	25610	31125	17274	64869	14461	16612	5942	253241
	Diff.	0	0	18	1416	2063	537	1706	828	778	3485	687	978	245	12786
Eq. unexpl. begin-yr nos. at age	2	500062	352838	248959	175662	123945	87454	61707	43540	30721	21676	15295	10792	7615	1698514
	3	543179	379969	265798	185933	130065	90984	63646	44522	31144	21786	15240	10661	7458	1807748
	Diff.	43117	27131	16839	10271	6120	3530	1939	983	423	110	-54	-131	-157	109234
Equilibium fecundity at age	2	0.000	0.000	0.003	0.066	0.413	1.254	2.451	3.788	5.120	6.399	7.612	8.754	9.817	
	3	0.000	0.000	0.003	0.067	0.418	1.264	2.460	3.788	5.106	6.365	7.553	8.666	9.696	
	Diff.	0.000	0.000	0.000	0.001	0.006	0.011	0.009	0.001	-0.014	-0.034	-0.059	-0.088	-0.120	
Eq. unexpl. spawning bio. at age (t)	2	0	8	410	5790	25569	54819	75621	82456	78652	69354	58211	47236	37375	650170
	3	0	8	444	6216	27192	57521	78299	84328	79513	69332	57554	46194	36155	649485
	Diff.	0	1	33	426	1623	2702	2678	1873	861	-22	-657	-1042	-1219	-686
Relative spawning biomass at age	2	0.000	0.858	0.626	1.053	2.063	0.206	0.316	0.367	0.210	0.885	0.237	0.331	0.152	0.370
	3	0.000	0.860	0.620	1.209	2.015	0.205	0.327	0.369	0.217	0.936	0.251	0.360	0.164	0.390
	Diff.	0.000	0.001	-0.006	0.156	-0.047	0.000	0.011	0.002	0.008	0.051	0.015	0.029	0.012	0.020
F40%	2	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	0.342	
	3	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	
	Diff.	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	
maxFABC	2	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	0.315	
	3	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	
	Diff.	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.032	
Fishery selectivity at age	2	0.000	0.000	0.010	0.175	0.375	0.561	0.829	0.885	0.904	0.903	0.900	0.897	0.896	
	3	0.000	0.000	0.010	0.184	0.379	0.563	0.827	0.881	0.898	0.896	0.893	0.890	0.888	
	Diff.	0.000	0.000	0.000	0.009	0.004	0.002	-0.001	-0.004	-0.006	-0.006	-0.007	-0.007	-0.008	
Natural mortality	2	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	3	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	
	Diff.	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	
maxFABC exploitation rate at age	2	0.000	0.000	0.003	0.045	0.094	0.137	0.195	0.207	0.211	0.211	0.210	0.210	0.209	
	3	0.000	0.000	0.003	0.052	0.104	0.150	0.212	0.224	0.227	0.227	0.226	0.226	0.225	
	Diff.	0.000	0.000	0.000	0.007	0.010	0.013	0.016	0.017	0.017	0.016	0.016	0.016	0.016	
Mid-year weight at age (kg)	2	0.004	0.063	0.538	1.692	2.460	3.143	4.498	5.330	6.464	7.560	8.442	9.431	10.471	
	3	0.004	0.062	0.541	1.727	2.474	3.150	4.498	5.318	6.429	7.505	8.369	9.328	10.336	
	Diff.	0.000	0.000	0.003	0.035	0.014	0.007	0.000	-0.012	-0.036	-0.055	-0.073	-0.102	-0.135	
maxABC at age (t)	2	0	1	264	5655	43135	8325	14621	16813	8345	29375	6400	7095	2540	143834
	3	0	1	317	7630	48949	9490	16930	18634	9418	33424	7230	8110	2849	164366
	Diff.	0	0	53	1975	5814	1165	2309	1822	1073	4049	831	1016	309	20533

Table 2.4.4e. Comparison of quantities used in calculating 2022 ABC (Pass 4 versus Pass 3).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	3	543179	379963	198713	84609	189985	20071	17775	15666	6440	19616	3818	3853	1224	1485424
	4	548972	383623	200403	85392	191222	20207	18025	15951	6581	20155	3936	3989	1277	1500272
	Diff.	5793	3660	1690	783	1237	137	250	285	141	538	118	136	53	14847
Fecundity at age	3	0.000	0.000	0.003	0.178	0.577	1.176	2.882	3.974	5.365	6.614	7.576	8.622	9.709	
	4	0.000	0.000	0.003	0.178	0.577	1.175	2.879	3.970	5.359	6.606	7.567	8.612	9.696	
	Diff.	0.000	0.000	0.000	0.000	0.000	-0.001	-0.003	-0.004	-0.006	-0.007	-0.009	-0.010	-0.012	
Spawning biomass at age (t)	3	0	7	275	7514	54801	11802	25610	31125	17274	64869	14461	16612	5942	253241
	4	0	7	278	7593	55131	11874	25945	31659	17634	66573	14892	17179	6192	258050
	Diff.	0	0	3	79	331	72	335	533	360	1705	431	568	249	4810
Eq. unexpl. begin-yr nos. at age	3	543179	379969	265798	185933	130065	90984	63646	44522	31144	21786	15240	10661	7458	1807748
	4	548972	383628	268083	187340	130915	91485	63931	44675	31220	21817	15246	10654	7445	1822683
	Diff.	5793	3659	2285	1407	850	501	285	153	75	30	6	-7	-13	14936
Equilibium fecundity at age	3	0.000	0.000	0.003	0.067	0.418	1.264	2.460	3.788	5.106	6.365	7.553	8.666	9.696	
	4	0.000	0.000	0.003	0.067	0.419	1.265	2.461	3.787	5.104	6.360	7.547	8.658	9.687	
	Diff.	0.000	0.000	0.000	0.000	0.001	0.001	0.000	-0.001	-0.003	-0.004	-0.006	-0.008	-0.010	
Eq. unexpl. spawning bio. at age (t)	3	0	8	444	6216	27192	57521	78299	84328	79513	69332	57554	46194	36155	649485
	4	0	8	450	6281	27425	57877	78661	84599	79666	69382	57531	46121	36058	650079
	Diff.	0	0	6	65	233	356	362	271	152	50	-22	-73	-97	594
Relative spawning biomass at age	3	0.000	0.860	0.620	1.209	2.015	0.205	0.327	0.369	0.217	0.936	0.251	0.360	0.164	0.390
	4	0.000	0.854	0.617	1.209	2.010	0.205	0.330	0.374	0.221	0.960	0.259	0.372	0.172	0.397
	Diff.	0.000	-0.006	-0.003	0.000	-0.005	0.000	0.003	0.005	0.004	0.024	0.008	0.013	0.007	0.007
F40%	3	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	
	4	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	Diff.	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
maxFABC	3	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	0.347	
	4	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	
	Diff.	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	
Fishery selectivity at age	3	0.000	0.000	0.010	0.184	0.379	0.563	0.827	0.881	0.898	0.896	0.893	0.890	0.888	
	4	0.000	0.000	0.010	0.184	0.379	0.562	0.827	0.881	0.898	0.896	0.893	0.890	0.888	
	Diff.	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	
Natural mortality	3	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	0.357	
	4	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	
	Diff.	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
maxFABC exploitation rate at age	3	0.000	0.000	0.003	0.052	0.104	0.150	0.212	0.224	0.227	0.227	0.226	0.226	0.225	
	4	0.000	0.000	0.003	0.053	0.106	0.153	0.216	0.228	0.232	0.232	0.231	0.230	0.230	
	Diff.	0.000	0.000	0.000	0.001	0.002	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.005	
Mid-year weight at age (kg)	3	0.004	0.062	0.541	1.727	2.474	3.150	4.498	5.318	6.429	7.505	8.369	9.328	10.336	
	4	0.004	0.062	0.541	1.727	2.473	3.149	4.495	5.314	6.423	7.497	8.360	9.318	10.324	
	Diff.	0.000	0.000	0.000	0.001	-0.001	-0.001	-0.002	-0.004	-0.006	-0.008	-0.009	-0.010	-0.013	
maxABC at age (t)	3	0	1	317	7630	48949	9490	16930	18634	9418	33424	7230	8110	2849	164366
	4	0	1	327	7883	50323	9752	17506	19344	9812	35006	7598	8559	3030	170623
	Diff.	0	0	10	253	1375	262	576	710	394	1582	368	449	180	6257

Table 2.4.4f. Comparison of quantities used in calculating 2022 ABC (Pass 5 versus Pass 4).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	4	548972	383623	200403	85392	191222	20207	18025	15951	6581	20155	3936	3989	1277	1500272
	5	561138	391072	204561	86674	190981	22072	20689	15880	6315	19470	3827	3920	1256	1528388
	Diff.	12166	7449	4158	1282	-241	1864	2665	-71	-266	-684	-109	-70	-21	28116
Fecundity at age	4	0.000	0.000	0.003	0.178	0.577	1.175	2.879	3.970	5.359	6.606	7.567	8.612	9.696	
	5	0.000	0.000	0.003	0.179	0.577	1.155	2.885	4.073	5.392	6.618	7.584	8.629	9.714	
	Diff.	0.000	0.000	0.000	0.001	0.000	-0.020	0.006	0.103	0.033	0.011	0.017	0.017	0.018	
Spawning biomass at age (t)	4	0	7	278	7593	55131	11874	25945	31659	17634	66573	14892	17179	6192	258050
	5	0	7	284	7758	55095	12749	29847	32339	17027	64424	14510	16911	6103	260121
	Diff.	0	0	6	165	-36	875	3902	681	-608	-2150	-381	-268	-89	2071
Eq. unexpl. begin-yr nos. at age	4	548972	383628	268083	187340	130915	91485	63931	44675	31220	21817	15246	10654	7445	1822683
	5	561138	391077	272556	189954	132386	92264	64302	44815	31233	21767	15170	10573	7369	1851549
	Diff.	12166	7449	4473	2614	1471	779	372	139	13	-49	-75	-81	-76	28865
Equilibium fecundity at age	4	0.000	0.000	0.003	0.067	0.419	1.265	2.461	3.787	5.104	6.360	7.547	8.658	9.687	
	5	0.000	0.000	0.003	0.067	0.421	1.271	2.469	3.795	5.113	6.372	7.561	8.674	9.704	
	Diff.	0.000	0.000	0.000	0.000	0.002	0.005	0.008	0.008	0.010	0.012	0.014	0.016	0.018	
Eq. unexpl. spawning bio. at age (t)	4	0	8	450	6281	27425	57877	78661	84599	79666	69382	57531	46121	36058	650079
	5	0	9	462	6406	27866	58613	79375	85044	79852	69355	57353	45853	35752	650013
	Diff.	0	0	12	125	441	735	714	446	186	-27	-178	-267	-306	-66
Relative spawning biomass at age	4	0.000	0.854	0.617	1.209	2.010	0.205	0.330	0.374	0.221	0.960	0.259	0.372	0.172	0.397
	5	0.000	0.845	0.615	1.211	1.977	0.218	0.376	0.380	0.213	0.929	0.253	0.369	0.171	0.400
	Diff.	0.000	-0.008	-0.002	0.002	-0.033	0.012	0.046	0.006	-0.008	-0.031	-0.006	-0.004	-0.001	0.003
F40%	4	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	5	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	Diff.	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	
maxFABC	4	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	0.356	
	5	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	Diff.	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
Fishery selectivity at age	4	0.000	0.000	0.010	0.184	0.379	0.562	0.827	0.881	0.898	0.896	0.893	0.890	0.888	
	5	0.000	0.000	0.010	0.185	0.378	0.556	0.826	0.883	0.897	0.895	0.891	0.888	0.886	
	Diff.	0.000	0.000	0.000	0.000	-0.001	-0.006	-0.001	0.002	-0.002	-0.002	-0.002	-0.002	-0.002	
Natural mortality	4	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	0.358	
	5	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
maxFABC exploitation rate at age	4	0.000	0.000	0.003	0.053	0.106	0.153	0.216	0.228	0.232	0.232	0.231	0.230	0.230	
	5	0.000	0.000	0.003	0.054	0.108	0.154	0.219	0.232	0.235	0.235	0.234	0.233	0.233	
	Diff.	0.000	0.000	0.000	0.001	0.002	0.001	0.003	0.004	0.003	0.003	0.003	0.003	0.003	
Mid-year weight at age (kg)	4	0.004	0.062	0.541	1.727	2.473	3.149	4.495	5.314	6.423	7.497	8.360	9.318	10.324	
	5	0.004	0.062	0.542	1.732	2.477	3.134	4.502	5.394	6.452	7.508	8.376	9.335	10.341	
	Diff.	0.000	0.000	0.001	0.005	0.003	-0.015	0.007	0.080	0.029	0.011	0.016	0.017	0.018	
maxABC at age (t)	4	0	1	327	7883	50323	9752	17506	19344	9812	35006	7598	8559	3030	170623
	5	0	1	339	8183	51141	10676	20435	19891	9593	34344	7505	8541	3027	175164
	Diff.	0	0	11	300	818	924	2929	547	-219	-662	-93	-18	-3	4541

Table 2.4.4g. Comparison of quantities used in calculating 2022 ABC (Pass 6 versus Pass 5).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	5	561138	391072	204561	86674	190981	22072	20689	15880	6315	19470	3827	3920	1256	1528388
	6	561466	391292	204441	86815	190631	21974	20461	15648	6217	19166	3767	3860	1238	1527501
	Diff.	328	220	-120	142	-350	-98	-229	-232	-99	-304	-59	-60	-19	-886
Fecundity at age	5	0.000	0.000	0.003	0.179	0.577	1.155	2.885	4.073	5.392	6.618	7.584	8.629	9.714	
	6	0.000	0.000	0.003	0.179	0.577	1.155	2.885	4.073	5.392	6.617	7.583	8.628	9.713	
	Diff.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.001	
Spawning biomass at age (t)	5	0	7	284	7758	55095	12749	29847	32339	17027	64424	14510	16911	6103	260121
	6	0	7	284	7781	55007	12695	29515	31865	16758	63411	14283	16652	6011	257292
	Diff.	0	0	0	23	-88	-55	-332	-474	-268	-1013	-227	-259	-91	-2829
Eq. unexpl. begin-yr nos. at age	5	561138	391077	272556	189954	132386	92264	64302	44815	31233	21767	15170	10573	7369	1851549
	6	561466	391297	272703	190053	132452	92308	64332	44834	31246	21776	15176	10577	7371	1852540
	Diff.	328	220	147	99	66	44	30	20	13	9	6	4	2	991
Equilibium fecundity at age	5	0.000	0.000	0.003	0.067	0.421	1.271	2.469	3.795	5.113	6.372	7.561	8.674	9.704	
	6	0.000	0.000	0.003	0.067	0.420	1.268	2.464	3.789	5.105	6.362	7.549	8.660	9.689	
	Diff.	0.000	0.000	0.000	0.000	-0.001	-0.003	-0.004	-0.007	-0.009	-0.010	-0.012	-0.014	-0.015	
Eq. unexpl. spawning bio. at age (t)	5	0	9	462	6406	27866	58613	79375	85044	79852	69355	57353	45853	35752	650013
	6	0	9	458	6391	27839	58517	79267	84934	79751	69271	57284	45796	35708	649158
	Diff.	0	0	-4	-15	-27	-96	-108	-111	-101	-84	-69	-57	-44	-855
Relative spawning biomass at age	5	0.000	0.845	0.615	1.211	1.977	0.218	0.376	0.380	0.213	0.929	0.253	0.369	0.171	0.400
	6	0.000	0.850	0.620	1.218	1.976	0.217	0.372	0.375	0.210	0.915	0.249	0.364	0.168	0.396
	Diff.	0.000	0.005	0.005	0.007	-0.001	-0.001	-0.004	-0.005	-0.003	-0.013	-0.004	-0.005	-0.002	-0.004
F40%	5	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	6	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	Diff.	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	
maxFABC	5	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	6	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	Diff.	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	-0.004	
Fishery selectivity at age	5	0.000	0.000	0.010	0.185	0.378	0.556	0.826	0.883	0.897	0.895	0.891	0.888	0.886	
	6	0.000	0.000	0.010	0.185	0.378	0.556	0.826	0.883	0.897	0.894	0.891	0.888	0.886	
	Diff.	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	
Natural mortality	5	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	6	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	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	
maxFABC exploitation rate at age	5	0.000	0.000	0.003	0.054	0.108	0.154	0.219	0.232	0.235	0.235	0.234	0.233	0.233	
	6	0.000	0.000	0.003	0.054	0.107	0.153	0.218	0.230	0.233	0.233	0.232	0.231	0.231	
	Diff.	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	
Mid-year weight at age (kg)	5	0.004	0.062	0.542	1.732	2.477	3.134	4.502	5.394	6.452	7.508	8.376	9.335	10.341	
	6	0.004	0.062	0.542	1.733	2.477	3.134	4.502	5.393	6.451	7.507	8.375	9.333	10.340	
	Diff.	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	-0.001	-0.002	
maxABC at age (t)	5	0	1	339	8183	51141	10676	20435	19891	9593	34344	7505	8541	3027	175164
	6	0	1	335	8130	50594	10536	20037	19435	9363	33520	7326	8340	2957	172030
	Diff.	0	0	-3	-53	-547	-140	-398	-455	-230	-823	-180	-202	-70	-3135

Table 2.4.4h. Comparison of quantities used in calculating 2022 ABC (Pass 7 versus Pass 6).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	6	561466	391292	204441	86815	190631	21974	20461	15648	6217	19166	3767	3860	1238	1527501
	7	555473	387806	202747	86977	188287	22461	20273	15864	6335	18876	3835	3762	1234	1514462
	Diff.	-5993	-3486	-1694	161	-2344	487	-188	216	119	-290	68	-98	-4	-13039
Fecundity at age	6	0.000	0.000	0.003	0.179	0.577	1.155	2.885	4.073	5.392	6.617	7.583	8.628	9.713	
	7	0.000	0.000	0.003	0.180	0.577	1.147	2.879	4.060	5.383	6.605	7.568	8.612	9.685	
	Diff.	0.000	0.000	0.000	0.001	0.000	-0.008	-0.006	-0.012	-0.008	-0.012	-0.014	-0.016	-0.027	
Spawning biomass at age (t)	6	0	7	284	7781	55007	12695	29515	31865	16758	63411	14283	16652	6011	257292
	7	0	7	281	7839	54338	12884	29179	32206	17052	62334	14514	16201	5976	255868
	Diff.	0	0	-3	58	-668	189	-336	341	294	-1077	231	-451	-35	-1424
Eq. unexpl. begin-yr nos. at age	6	561466	391297	272703	190053	132452	92308	64332	44834	31246	21776	15176	10577	7371	1852540
	7	555473	387812	270756	189032	131976	92141	64329	44913	31356	21892	15284	10671	7450	1840317
	Diff.	-5993	-3485	-1947	-1021	-476	-168	-2	78	111	116	108	94	79	-12223
Equilibium fecundity at age	6	0.000	0.000	0.003	0.067	0.420	1.268	2.464	3.789	5.105	6.362	7.549	8.660	9.689	
	7	0.000	0.000	0.003	0.067	0.420	1.266	2.459	3.781	5.094	6.349	7.533	8.641	9.667	
	Diff.	0.000	0.000	0.000	0.000	-0.001	-0.002	-0.005	-0.008	-0.011	-0.014	-0.016	-0.019	-0.022	
Eq. unexpl. spawning bio. at age (t)	6	0	9	458	6391	27839	58517	79267	84934	79751	69271	57284	45796	35708	649158
	7	0	8	454	6349	27699	58308	79106	84908	79865	69491	57566	46103	36010	651355
	Diff.	0	0	-4	-41	-140	-210	-160	-26	114	220	283	306	302	2197
Relative spawning biomass at age	6	0.000	0.850	0.620	1.218	1.976	0.217	0.372	0.375	0.210	0.915	0.249	0.364	0.168	0.396
	7	0.000	0.850	0.618	1.235	1.962	0.221	0.369	0.379	0.214	0.897	0.252	0.351	0.166	0.393
	Diff.	0.000	0.000	-0.001	0.017	-0.014	0.004	-0.003	0.004	0.003	-0.018	0.003	-0.012	-0.002	-0.004
F40%	6	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	7	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	
maxFABC	6	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	7	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	Diff.	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	
Fishery selectivity at age	6	0.000	0.000	0.010	0.185	0.378	0.556	0.826	0.883	0.897	0.894	0.891	0.888	0.886	
	7	0.000	0.000	0.010	0.186	0.378	0.554	0.825	0.881	0.896	0.893	0.890	0.887	0.885	
	Diff.	0.000	0.000	0.000	0.001	0.000	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	
Natural mortality	6	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	7	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	Diff.	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	
maxFABC exploitation rate at age	6	0.000	0.000	0.003	0.054	0.107	0.153	0.218	0.230	0.233	0.233	0.232	0.231	0.231	
	7	0.000	0.000	0.003	0.054	0.106	0.151	0.215	0.227	0.230	0.230	0.229	0.228	0.228	
	Diff.	0.000	0.000	0.000	-0.001	-0.001	-0.002	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003	
Mid-year weight at age (kg)	6	0.004	0.062	0.542	1.733	2.477	3.134	4.502	5.393	6.451	7.507	8.375	9.333	10.340	
	7	0.004	0.062	0.542	1.736	2.477	3.126	4.496	5.382	6.442	7.494	8.360	9.316	10.312	
	Diff.	0.000	0.000	0.000	0.003	0.000	-0.008	-0.006	-0.011	-0.009	-0.013	-0.015	-0.017	-0.028	
maxABC at age (t)	6	0	1	335	8130	50594	10536	20037	19435	9363	33520	7326	8340	2957	172030
	7	0	1	328	8082	49330	10568	19568	19408	9407	32532	7348	8009	2901	168935
	Diff.	0	0	-7	-48	-1265	31	-469	-27	44	-988	23	-331	-55	-3095

Table 2.4.4i. Comparison of quantities used in calculating 2022 ABC (Pass 8 versus Pass 7).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	7	555473	387806	202747	86977	188287	22461	20273	15864	6335	18876	3835	3762	1234	1514462
	8	556274	388329	208913	84680	190106	22563	20588	15973	6371	18959	3844	3773	1239	1522143
	Diff.	801	523	6166	-2297	1819	102	315	109	36	83	8	10	5	7680
Fecundity at age	7	0.000	0.000	0.003	0.180	0.577	1.147	2.879	4.060	5.383	6.605	7.568	8.612	9.685	
	8	0.000	0.000	0.003	0.175	0.571	1.147	2.875	4.060	5.386	6.611	7.579	8.629	9.711	
	Diff.	0.000	0.000	0.000	-0.006	-0.006	-0.001	-0.004	0.000	0.002	0.007	0.011	0.017	0.026	
Spawning biomass at age (t)	7	0	7	281	7839	54338	12884	29179	32206	17052	62334	14514	16201	5976	255868
	8	0	7	289	7393	54264	12935	29596	32429	17157	62672	14567	16277	6015	256673
	Diff.	0	0	9	-446	-74	51	417	223	105	338	52	76	39	805
Eq. unexpl. begin-yr nos. at age	7	555473	387812	270756	189032	131976	92141	64329	44913	31356	21892	15284	10671	7450	1840317
	8	556274	388333	271095	189250	132115	92229	64385	44947	31377	21905	15292	10675	7452	1842561
	Diff.	801	521	339	218	139	89	56	35	21	13	7	4	2	2244
Equilibium fecundity at age	7	0.000	0.000	0.003	0.067	0.420	1.266	2.459	3.781	5.094	6.349	7.533	8.641	9.667	
	8	0.000	0.000	0.003	0.067	0.419	1.263	2.456	3.778	5.094	6.353	7.543	8.658	9.692	
	Diff.	0.000	0.000	0.000	0.000	-0.001	-0.003	-0.004	-0.003	0.000	0.004	0.010	0.017	0.025	
Eq. unexpl. spawning bio. at age (t)	7	0	8	454	6349	27699	58308	79106	84908	79865	69491	57566	46103	36010	651355
	8	0	8	453	6343	27651	58225	79056	84914	79921	69580	57671	46212	36114	652107
	Diff.	0	0	-1	-6	-48	-82	-51	6	56	89	105	109	104	752
Relative spawning biomass at age	7	0.000	0.850	0.618	1.235	1.962	0.221	0.369	0.379	0.214	0.897	0.252	0.351	0.166	0.393
	8	0.000	0.850	0.639	1.166	1.962	0.222	0.374	0.382	0.215	0.901	0.253	0.352	0.167	0.394
	Diff.	0.000	0.000	0.021	-0.069	0.001	0.001	0.006	0.003	0.001	0.004	0.000	0.001	0.001	0.001
F40%	7	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	8	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	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	
maxFABC	7	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	8	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	
	Diff.	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Fishery selectivity at age	7	0.000	0.000	0.010	0.186	0.378	0.554	0.825	0.881	0.896	0.893	0.890	0.887	0.885	
	8	0.000	0.000	0.010	0.180	0.373	0.552	0.825	0.882	0.898	0.896	0.893	0.890	0.888	
	Diff.	0.000	0.000	0.000	-0.006	-0.005	-0.002	0.000	0.001	0.002	0.002	0.003	0.003	0.003	
Natural mortality	7	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	8	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	Diff.	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	
maxFABC exploitation rate at age	7	0.000	0.000	0.003	0.054	0.106	0.151	0.215	0.227	0.230	0.230	0.229	0.228	0.228	
	8	0.000	0.000	0.003	0.052	0.105	0.150	0.215	0.228	0.232	0.231	0.230	0.230	0.229	
	Diff.	0.000	0.000	0.000	-0.002	-0.001	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	
Mid-year weight at age (kg)	7	0.004	0.062	0.542	1.736	2.477	3.126	4.496	5.382	6.442	7.494	8.360	9.316	10.312	
	8	0.004	0.062	0.543	1.722	2.470	3.127	4.497	5.386	6.449	7.505	8.375	9.337	10.342	
	Diff.	0.000	0.000	0.001	-0.014	-0.006	0.001	0.000	0.004	0.006	0.011	0.015	0.021	0.030	
maxABC at age (t)	7	0	1	328	8082	49330	10568	19568	19408	9407	32532	7348	8009	2901	168935
	8	0	1	329	7582	49203	10612	19920	19629	9514	32891	7418	8094	2937	169598
	Diff.	0	0	0	-500	-127	45	352	221	107	359	69	85	36	663

Table 2.4.4j. Comparison of quantities used in calculating 2022 ABC (Pass 9 versus Pass 8).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	8	556274	388329	208913	84680	190106	22563	20588	15973	6371	18959	3844	3773	1239	1522143
	9	554995	387559	209220	84297	189953	22670	20503	15996	6392	18927	3833	3773	1239	1519889
	Diff.	-1279	-770	307	-382	-153	108	-85	23	20	-32	-11	0	0	-2254
Fecundity at age	8	0.000	0.000	0.003	0.175	0.571	1.147	2.875	4.060	5.386	6.611	7.579	8.629	9.711	
	9	0.000	0.000	0.003	0.174	0.570	1.148	2.874	4.059	5.384	6.607	7.575	8.626	9.708	
	Diff.	0.000	0.000	0.000	0.000	-0.001	0.001	-0.002	-0.002	-0.002	-0.004	-0.004	-0.003	-0.003	
Spawning biomass at age (t)	8	0	7	289	7393	54264	12935	29596	32429	17157	62672	14567	16277	6015	256673
	9	0	7	290	7350	54165	13009	29457	32461	17206	62524	14519	16271	6012	256343
	Diff.	0	0	0	-44	-99	74	-139	33	49	-148	-48	-6	-2	-330
Eq. unexpl. begin-yr nos. at age	8	556274	388333	271095	189250	132115	92229	64385	44947	31377	21905	15292	10675	7452	1842561
	9	554995	387564	270643	188995	131979	92163	64359	44943	31385	21917	15305	10688	7463	1839675
	Diff.	-1279	-769	-452	-255	-136	-66	-26	-4	7	12	13	13	11	-2886
Equilibium fecundity at age	8	0.000	0.000	0.003	0.067	0.419	1.263	2.456	3.778	5.094	6.353	7.543	8.658	9.692	
	9	0.000	0.000	0.003	0.067	0.419	1.262	2.455	3.777	5.092	6.350	7.540	8.655	9.689	
	Diff.	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	-0.002	-0.002	-0.003	-0.003	-0.003	-0.003	
Eq. unexpl. spawning bio. at age (t)	8	0	8	453	6343	27651	58225	79056	84914	79921	69580	57671	46212	36114	652107
	9	0	8	452	6336	27621	58163	78987	84866	79903	69589	57699	46250	36157	652241
	Diff.	0	0	-1	-8	-30	-62	-69	-48	-18	9	28	39	42	134
Relative spawning biomass at age	8	0.000	0.850	0.639	1.166	1.962	0.222	0.374	0.382	0.215	0.901	0.253	0.352	0.167	0.394
	9	0.000	0.850	0.641	1.160	1.961	0.224	0.373	0.383	0.215	0.898	0.252	0.352	0.166	0.393
	Diff.	0.000	0.000	0.002	-0.005	-0.001	0.002	-0.001	0.001	0.001	-0.002	-0.001	0.000	0.000	-0.001
F40%	8	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	9	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	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	
maxFABC	8	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	0.355	
	9	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	Diff.	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	
Fishery selectivity at age	8	0.000	0.000	0.010	0.180	0.373	0.552	0.825	0.882	0.898	0.896	0.893	0.890	0.888	
	9	0.000	0.000	0.010	0.179	0.373	0.552	0.824	0.882	0.898	0.896	0.893	0.890	0.888	
	Diff.	0.000	0.000	0.000	0.000	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	
Natural mortality	8	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	9	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	Diff.	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	
maxFABC exploitation rate at age	8	0.000	0.000	0.003	0.052	0.105	0.150	0.215	0.228	0.232	0.231	0.230	0.230	0.229	
	9	0.000	0.000	0.003	0.052	0.104	0.150	0.215	0.228	0.231	0.231	0.230	0.229	0.229	
	Diff.	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	
Mid-year weight at age (kg)	8	0.004	0.062	0.543	1.722	2.470	3.127	4.497	5.386	6.449	7.505	8.375	9.337	10.342	
	9	0.004	0.062	0.543	1.722	2.470	3.129	4.496	5.386	6.448	7.502	8.372	9.335	10.339	
	Diff.	0.000	0.000	0.000	0.000	0.000	0.002	0.000	-0.001	-0.001	-0.004	-0.003	-0.003	-0.003	
maxABC at age (t)	8	0	1	329	7582	49203	10612	19920	19629	9514	32891	7418	8094	2937	169598
	9	0	1	328	7520	49013	10649	19790	19615	9525	32762	7381	8077	2931	169059
	Diff.	0	0	0	-62	-190	37	-130	-15	11	-129	-36	-16	-6	-539

Table 2.4.4k. Comparison of quantities used in calculating 2022 ABC (2021 final version versus Pass 9).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	9	554995	387559	209220	84297	189953	22670	20503	15996	6392	18927	3833	3773	1239	1519889
	Final	560357	390609	208283	92263	187700	23176	20742	16046	6441	19053	3857	3807	1249	1534124
	Diff.	5362	3050	-937	7965	-2253	506	239	50	49	126	24	35	11	14235
Fecundity at age	9	0.000	0.000	0.003	0.174	0.570	1.148	2.874	4.059	5.384	6.607	7.575	8.626	9.708	
	Final	0.000	0.000	0.003	0.192	0.577	1.117	2.871	4.062	5.390	6.603	7.569	8.618	9.699	
	Diff.	0.000	0.000	0.000	0.017	0.006	-0.031	-0.002	0.003	0.006	-0.004	-0.006	-0.008	-0.009	
Spawning biomass at age (t)	9	0	7	290	7350	54165	13009	29457	32461	17206	62524	14519	16271	6012	256343
	Final	0	7	289	8846	54115	12943	29778	32588	17358	62903	14599	16406	6058	259006
	Diff.	0	0	-1	1496	-50	-66	321	127	152	379	80	135	46	2663
Eq. unexpl. begin-yr nos. at age	9	554995	387564	270643	188995	131979	92163	64359	44943	31385	21917	15305	10688	7463	1839675
	Final	560357	390613	272289	189807	132311	92231	64293	44817	31241	21778	15181	10582	7377	1849851
	Diff.	5362	3049	1646	812	332	68	-67	-126	-144	-139	-124	-106	-87	10176
Equilibium fecundity at age	9	0.000	0.000	0.003	0.067	0.419	1.262	2.455	3.777	5.092	6.350	7.540	8.655	9.689	
	Final	0.000	0.000	0.003	0.067	0.420	1.265	2.457	3.778	5.092	6.350	7.538	8.653	9.687	
	Diff.	0.000	0.000	0.000	0.000	0.002	0.003	0.003	0.002	0.000	-0.001	-0.002	-0.002	-0.002	
Eq. unexpl. spawning bio. at age (t)	9	0	8	452	6336	27621	58163	78987	84866	79903	69589	57699	46250	36157	652241
	Final	0	9	466	6405	27791	58341	78992	84661	79544	69139	57220	45784	35728	648370
	Diff.	0	0	14	69	170	178	5	-204	-359	-450	-480	-467	-428	-3871
Relative spawning biomass at age	9	0.000	0.850	0.641	1.160	1.961	0.224	0.373	0.383	0.215	0.898	0.252	0.352	0.166	0.393
	Final	0.000	0.839	0.621	1.381	1.947	0.222	0.377	0.385	0.218	0.910	0.255	0.358	0.170	0.399
	Diff.	0.000	-0.011	-0.020	0.221	-0.014	-0.002	0.004	0.002	0.003	0.011	0.004	0.007	0.003	0.006
F40%	9	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Final	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	
	Diff.	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	
maxFABC	9	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	Final	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	Diff.	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	
Fishery selectivity at age	9	0.000	0.000	0.010	0.179	0.373	0.552	0.824	0.882	0.898	0.896	0.893	0.890	0.888	
	Final	0.000	0.000	0.010	0.191	0.376	0.544	0.824	0.882	0.897	0.895	0.892	0.889	0.887	
	Diff.	0.000	0.000	0.000	0.012	0.003	-0.008	0.000	0.000	0.000	0.000	-0.001	-0.001	-0.001	
Natural mortality	9	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	
	Final	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
maxFABC exploitation rate at age	9	0.000	0.000	0.003	0.052	0.104	0.150	0.215	0.228	0.231	0.231	0.230	0.229	0.229	
	Final	0.000	0.000	0.003	0.056	0.107	0.151	0.219	0.232	0.236	0.235	0.235	0.234	0.233	
	Diff.	0.000	0.000	0.000	0.005	0.003	0.001	0.004	0.005	0.005	0.005	0.005	0.004	0.004	
Mid-year weight at age (kg)	9	0.004	0.062	0.543	1.722	2.470	3.129	4.496	5.386	6.448	7.502	8.372	9.335	10.339	
	Final	0.004	0.062	0.544	1.767	2.478	3.100	4.494	5.387	6.452	7.497	8.365	9.327	10.330	
	Diff.	0.000	0.000	0.001	0.045	0.008	-0.029	-0.002	0.001	0.004	-0.005	-0.006	-0.008	-0.009	
maxABC at age (t)	9	0	1	328	7520	49013	10649	19790	19615	9525	32762	7381	8077	2931	169059
	Final	0	1	337	9188	49987	10869	20411	20074	9793	33607	7568	8304	3011	174667
	Diff.	0	0	9	1668	974	220	621	460	269	845	186	227	80	5608

Table 2.4.4l. Comparison of quantities used in calculating 2022 ABC (2021 final version versus 2020 final version).

Quantity	Pass	0	1	2	3	4	5	6	7	8	9	10	11	12	Sum
Begin-year numbers at age (1000s)	Last	527908	370400	259877	181818	176168	19286	14768	13829	5533	16569	3264	3218	1039	1594122
	Final	560357	390609	208283	92263	187700	23176	20742	16046	6441	19053	3857	3807	1249	1534124
	Diff.	32449	20209	-51594	-89556	11532	3890	5974	2217	908	2484	593	589	210	-59997
Fecundity at age	Last	0.000	0.000	0.003	0.062	0.403	1.143	2.890	3.987	5.413	6.676	7.654	8.735	9.849	
	Final	0.000	0.000	0.003	0.192	0.577	1.117	2.871	4.062	5.390	6.603	7.569	8.618	9.699	
	Diff.	0.000	0.000	0.000	0.130	0.174	-0.026	-0.019	0.075	-0.023	-0.073	-0.084	-0.117	-0.150	
Spawning biomass at age (t)	Last	0	6	337	5607	35476	11020	21339	27568	14974	55304	12492	14056	5118	205905
	Final	0	7	289	8846	54115	12943	29778	32588	17358	62903	14599	16406	6058	259006
	Diff.	0	1	-48	3239	18638	1924	8438	5019	2384	7599	2107	2350	940	53101
Eq. unexpl. begin-yr nos. at age	Last	527908	370404	259892	182351	127946	89772	62988	44195	31009	21758	15266	10711	7516	1769392
	Final	560357	390613	272289	189807	132311	92231	64293	44817	31241	21778	15181	10582	7377	1849851
	Diff.	32449	20209	12397	7456	4365	2459	1304	622	232	20	-85	-129	-139	80459
Equilibium fecundity at age	Last	0.000	0.000	0.003	0.066	0.412	1.250	2.452	3.790	5.130	6.417	7.631	8.776	9.838	
	Final	0.000	0.000	0.003	0.067	0.420	1.265	2.457	3.778	5.092	6.350	7.538	8.653	9.687	
	Diff.	0.000	0.000	0.000	0.002	0.008	0.015	0.005	-0.012	-0.038	-0.068	-0.093	-0.123	-0.151	
Eq. unexpl. spawning bio. at age (t)	Last	0	8	383	5975	26345	56099	77237	83746	79545	69814	58250	47002	36969	652380
	Final	0	9	466	6405	27791	58341	78992	84661	79544	69139	57220	45784	35728	648370
	Diff.	0	1	83	429	1446	2242	1756	915	-1	-674	-1030	-1218	-1240	-4010
Relative spawning biomass at age	Last	0.000	0.824	0.881	0.938	1.347	0.196	0.276	0.329	0.188	0.792	0.214	0.299	0.138	0.316
	Final	0.000	0.839	0.621	1.381	1.947	0.222	0.377	0.385	0.218	0.910	0.255	0.358	0.170	0.399
	Diff.	0.000	0.015	-0.260	0.443	0.601	0.025	0.101	0.056	0.030	0.118	0.041	0.059	0.031	0.084
F40%	Last	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	0.349	
	Final	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	
	Diff.	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	
maxFABC	Last	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	0.272	
	Final	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	0.363	
	Diff.	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	0.091	
Fishery selectivity at age	Last	0.000	0.000	0.010	0.090	0.303	0.554	0.829	0.885	0.904	0.904	0.901	0.899	0.897	
	Final	0.000	0.000	0.010	0.191	0.376	0.544	0.824	0.882	0.897	0.895	0.892	0.889	0.887	
	Diff.	0.000	0.000	0.000	0.101	0.072	-0.010	-0.006	-0.003	-0.007	-0.009	-0.009	-0.010	-0.010	
Natural mortality	Last	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	0.354	
	Final	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	0.361	
	Diff.	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	
maxFABC exploitation rate at age	Last	0.000	0.000	0.002	0.020	0.067	0.118	0.171	0.181	0.185	0.185	0.184	0.184	0.184	
	Final	0.000	0.000	0.003	0.056	0.107	0.151	0.219	0.232	0.236	0.235	0.235	0.234	0.233	
	Diff.	0.000	0.000	0.001	0.036	0.041	0.033	0.048	0.051	0.051	0.050	0.050	0.050	0.050	
Mid-year weight at age (kg)	Last	0.004	0.058	0.533	1.302	2.229	3.125	4.514	5.343	6.489	7.581	8.462	9.456	10.492	
	Final	0.004	0.062	0.544	1.767	2.478	3.100	4.494	5.387	6.452	7.497	8.365	9.327	10.330	
	Diff.	0.000	0.004	0.011	0.465	0.250	-0.025	-0.021	0.044	-0.037	-0.084	-0.097	-0.129	-0.162	
maxABC at age (t)	Last	0	1	301	4827	26247	7125	11409	13398	6638	23213	5092	5597	2002	106849
	Final	0	1	337	9188	49987	10869	20411	20074	9793	33607	7568	8304	3011	174667
	Diff.	0	0	36	4361	23740	3743	9001	6676	3156	10394	2476	2707	1009	67818

Table 2.4.5. Comparison of year class strengths (1000s of fish), 1977-2018.

Year	Last year	This year	Δ(abs)	Δ(rel)
1977	1132170	1271110	138940	0.123
1978	739151	862348	123197	0.167
1979	770519	861806	91287	0.118
1980	186118	218173	32055	0.172
1981	210027	227729	17702	0.084
1982	1000660	1078230	77570	0.078
1983	270127	292051	21924	0.081
1984	902189	999197	97008	0.108
1985	407253	456529	49276	0.121
1986	224399	243310	18911	0.084
1987	69366	81708	12343	0.178
1988	324687	341087	16400	0.051
1989	646249	666201	19952	0.031
1990	633733	655796	22063	0.035
1991	372504	406765	34261	0.092
1992	1001350	1076410	75060	0.075
1993	374074	391489	17415	0.047
1994	315110	336299	21189	0.067
1995	269846	293119	23273	0.086
1996	875470	947846	72376	0.083
1997	384661	396333	11672	0.030
1998	289356	319907	30551	0.106
1999	716621	777180	60559	0.085
2000	512671	556536	43865	0.086
2001	208749	220108	11359	0.054
2002	342846	377520	34674	0.101
2003	324024	343610	19586	0.060
2004	234255	245681	11426	0.049
2005	288127	291383	3256	0.011
2006	847621	857502	9881	0.012
2007	334827	355237	20410	0.061
2008	1238610	1321290	82680	0.067
2009	168461	186905	18444	0.109
2010	772262	831713	59451	0.077
2011	986556	1072160	85604	0.087
2012	469167	520041	50874	0.108
2013	1259200	1369630	110430	0.088
2014	220895	247139	26244	0.119
2015	293300	334755	41455	0.141
2016	180633	246594	65961	0.365
2017	127111	151766	24655	0.194
2018	749855	816738	66883	0.089

Figure 2.4.1a. Year by year comparison of negative log likelihoods (Pass 1).

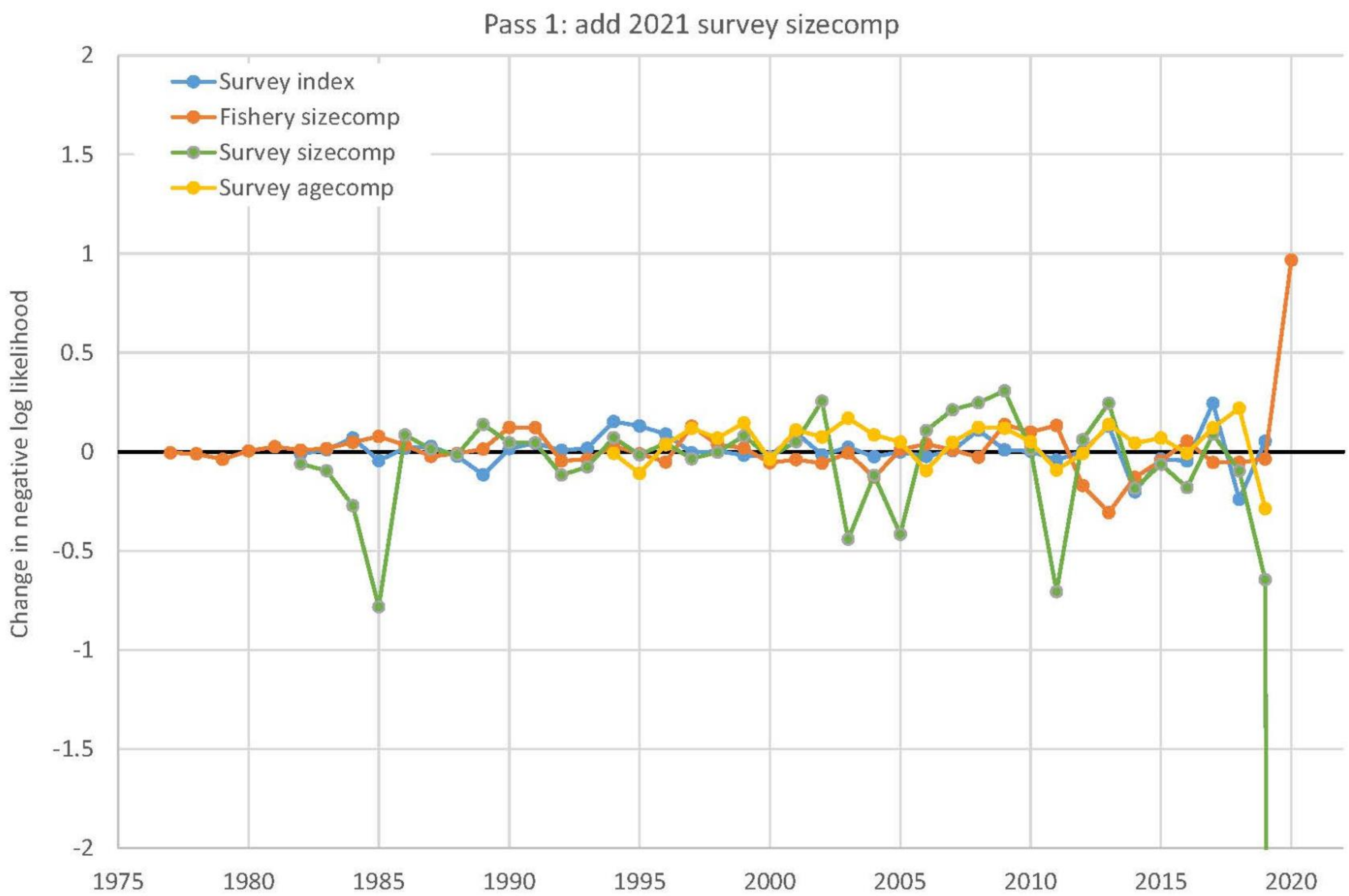


Figure 2.4.1b. Year by year comparison of negative log likelihoods (Pass 2).

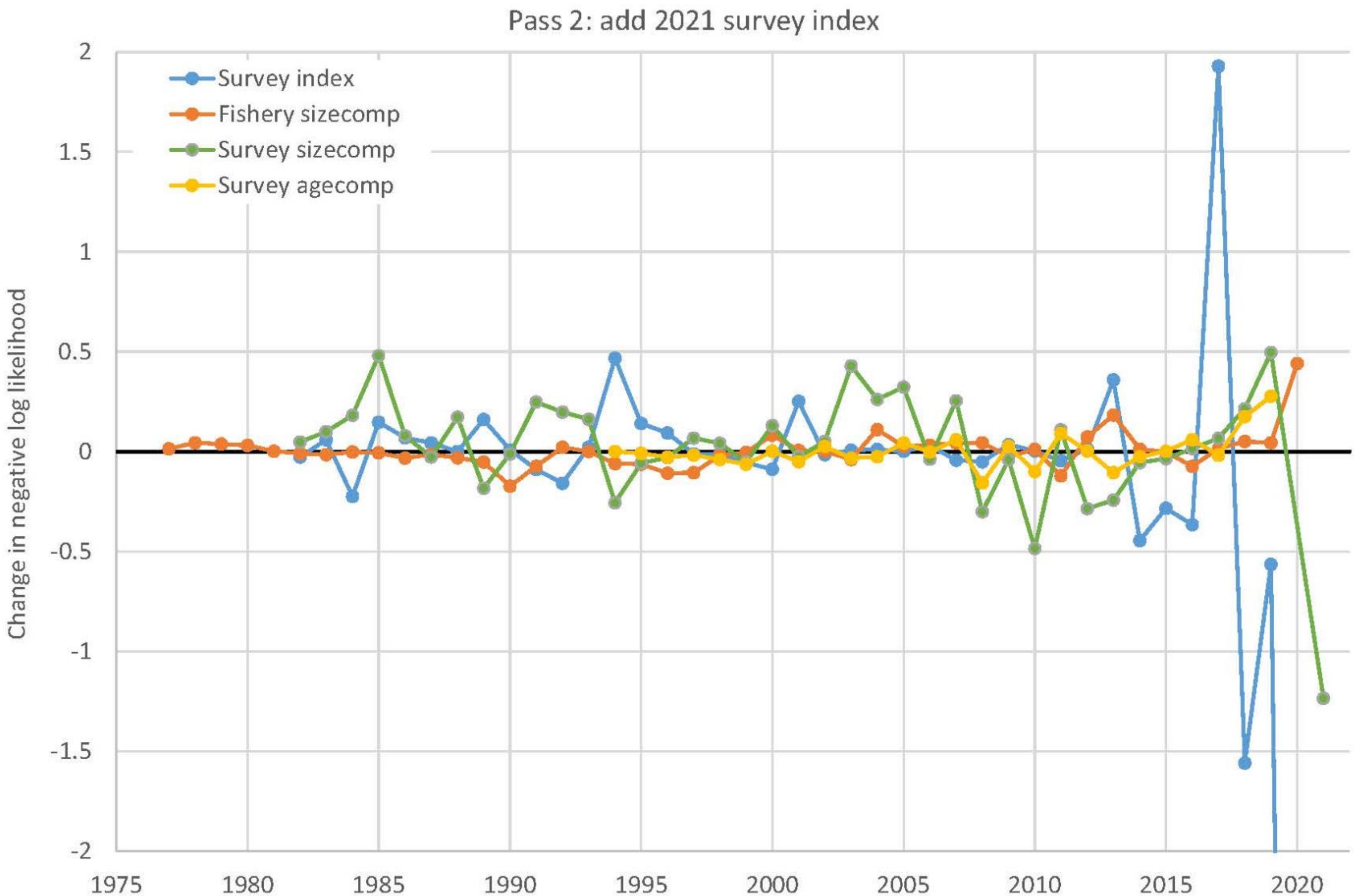


Figure 2.4.1c. Year by year comparison of negative log likelihoods (Pass 3).

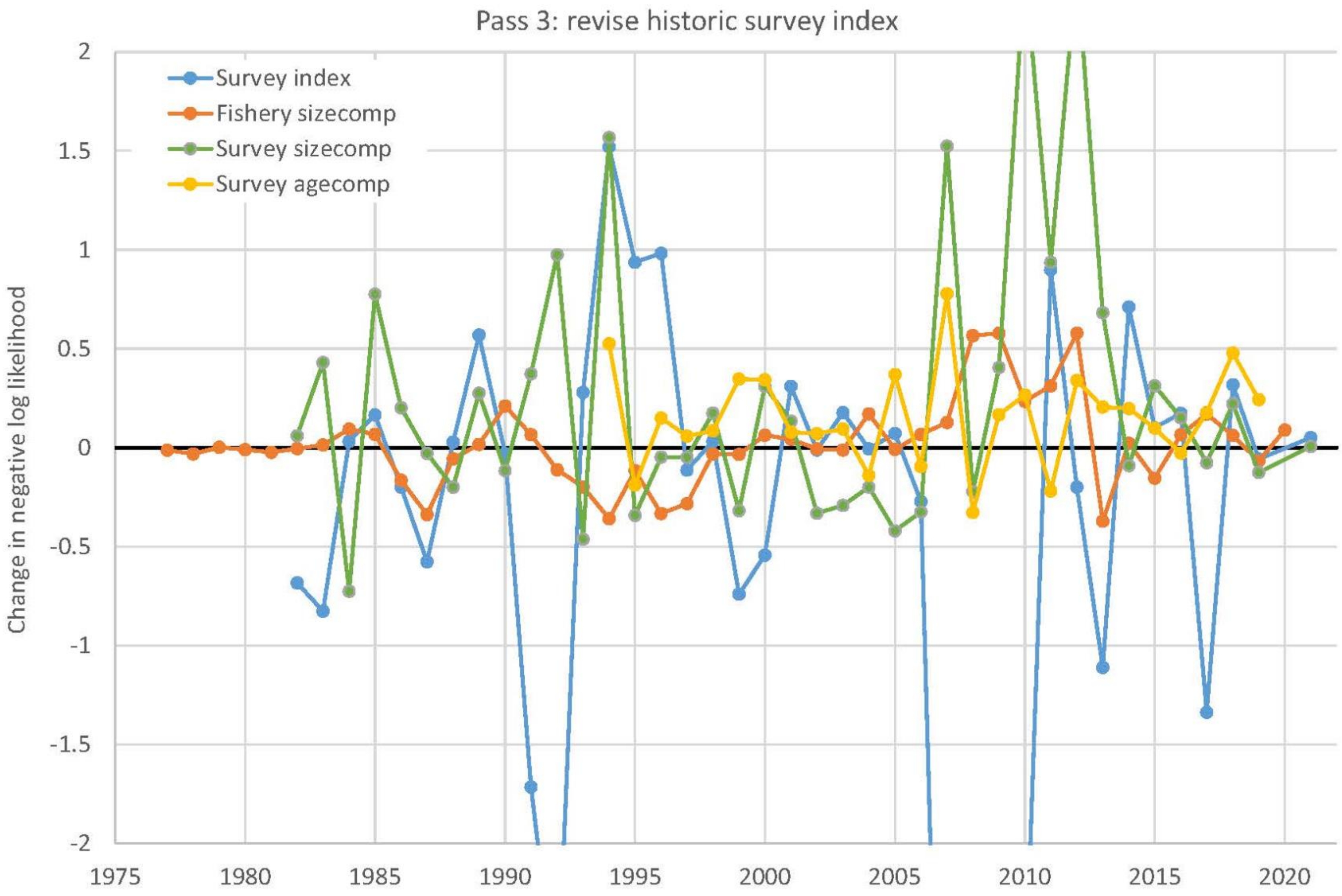


Figure 2.4.1d. Year by year comparison of negative log likelihoods (Pass 4).

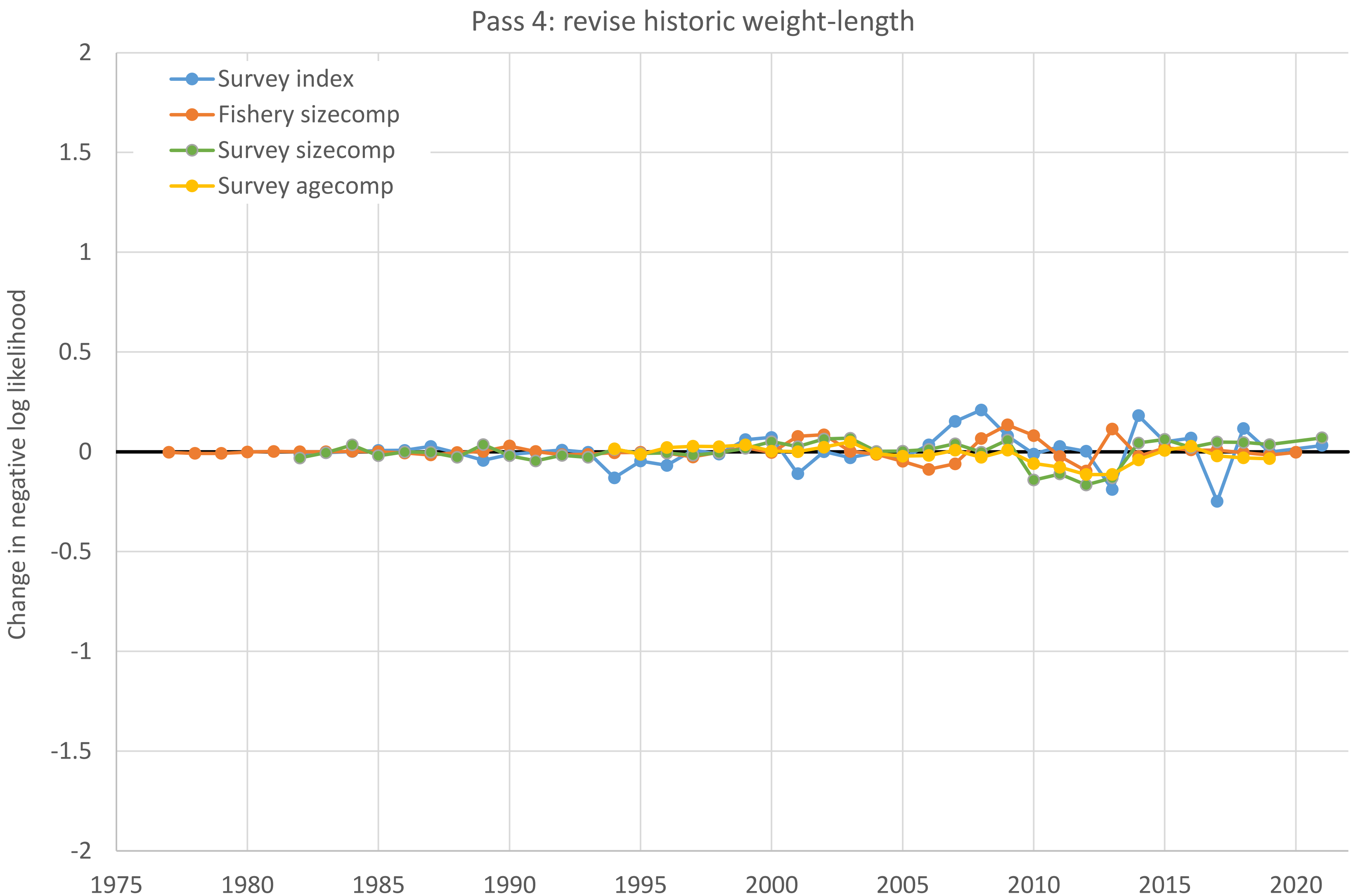


Figure 2.4.1e. Year by year comparison of negative log likelihoods (Pass 5).

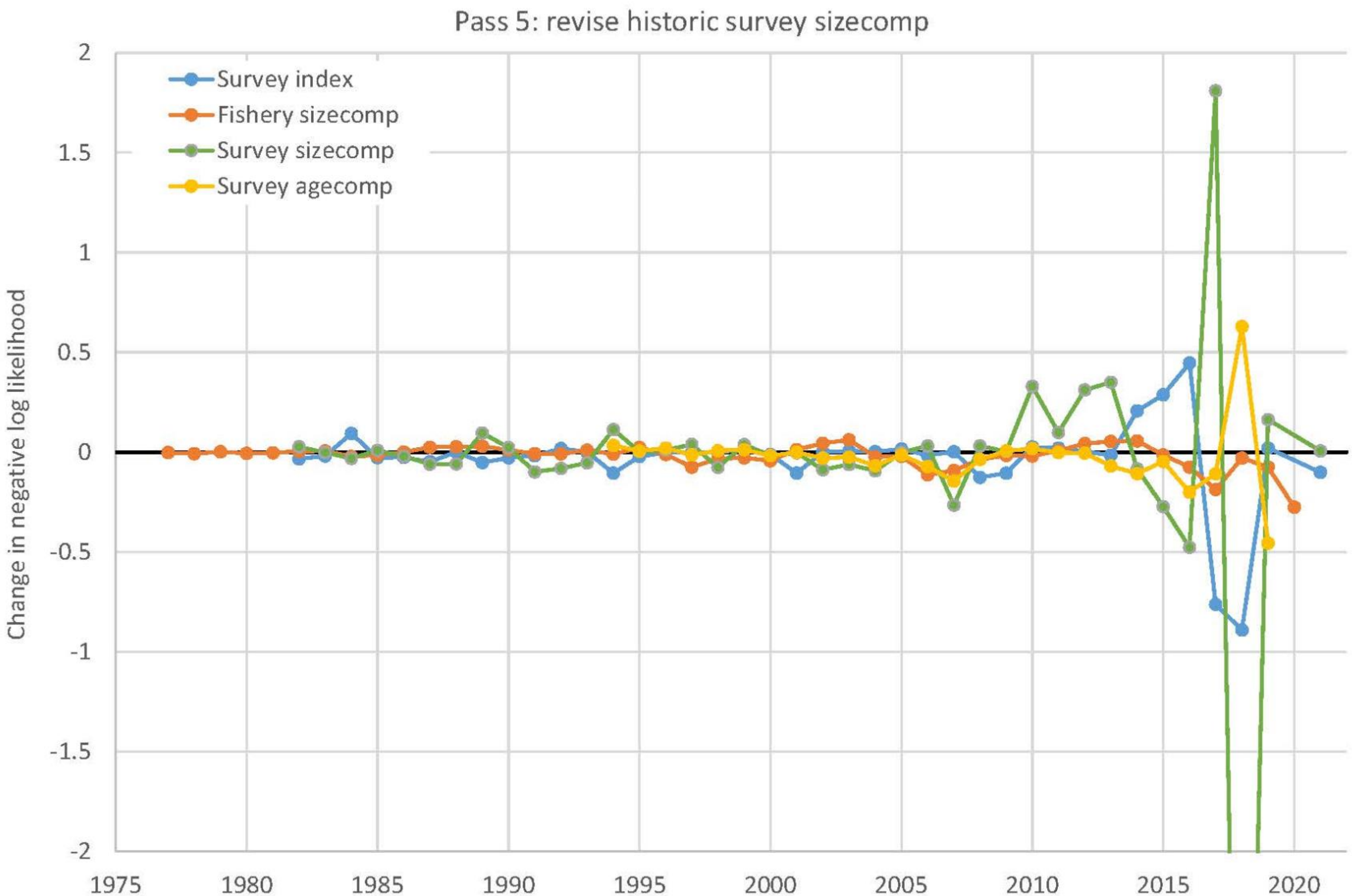


Figure 2.4.1f. Year by year comparison of negative log likelihoods (Pass 6).

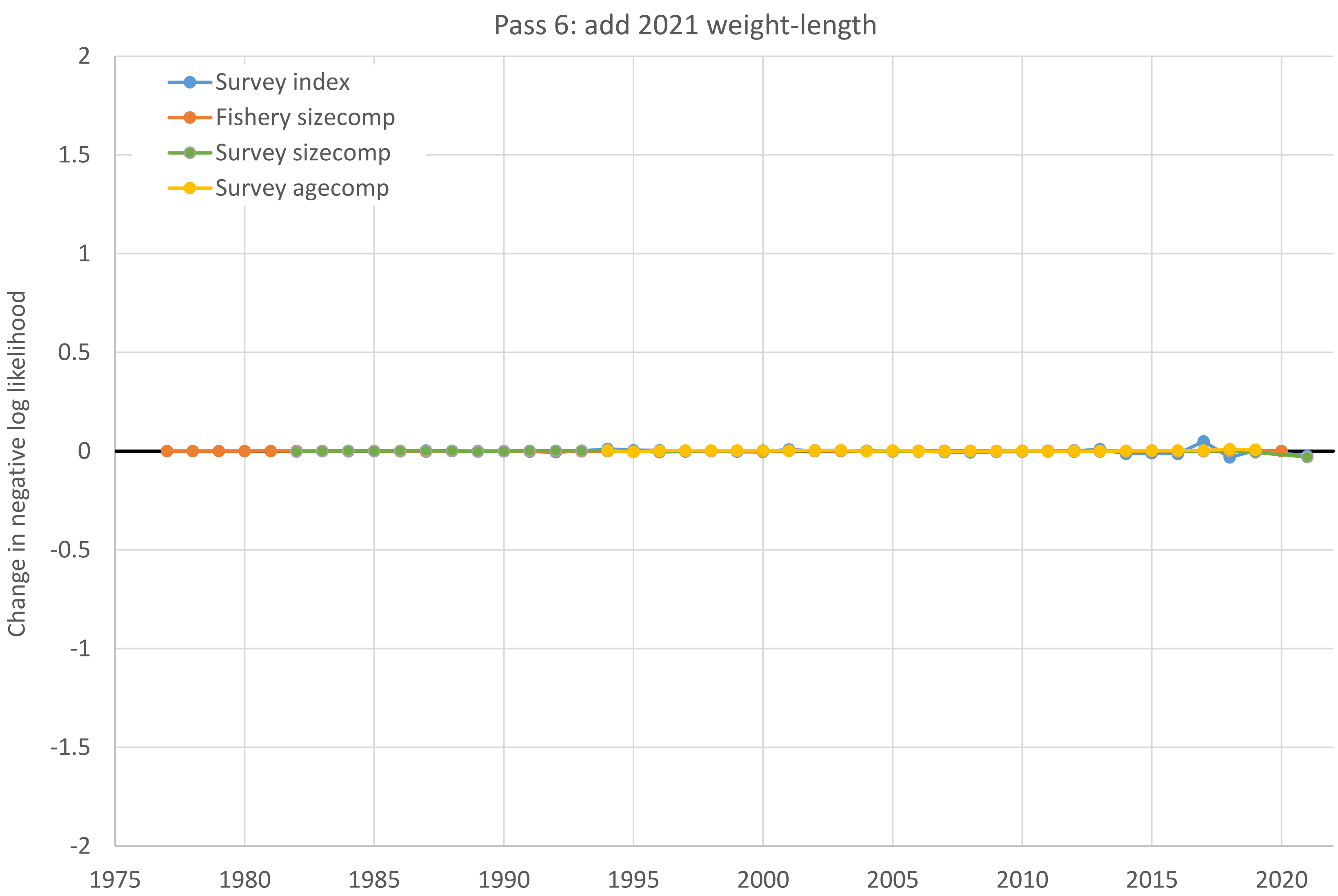


Figure 2.4.1g. Year by year comparison of negative log likelihoods (Pass 7).

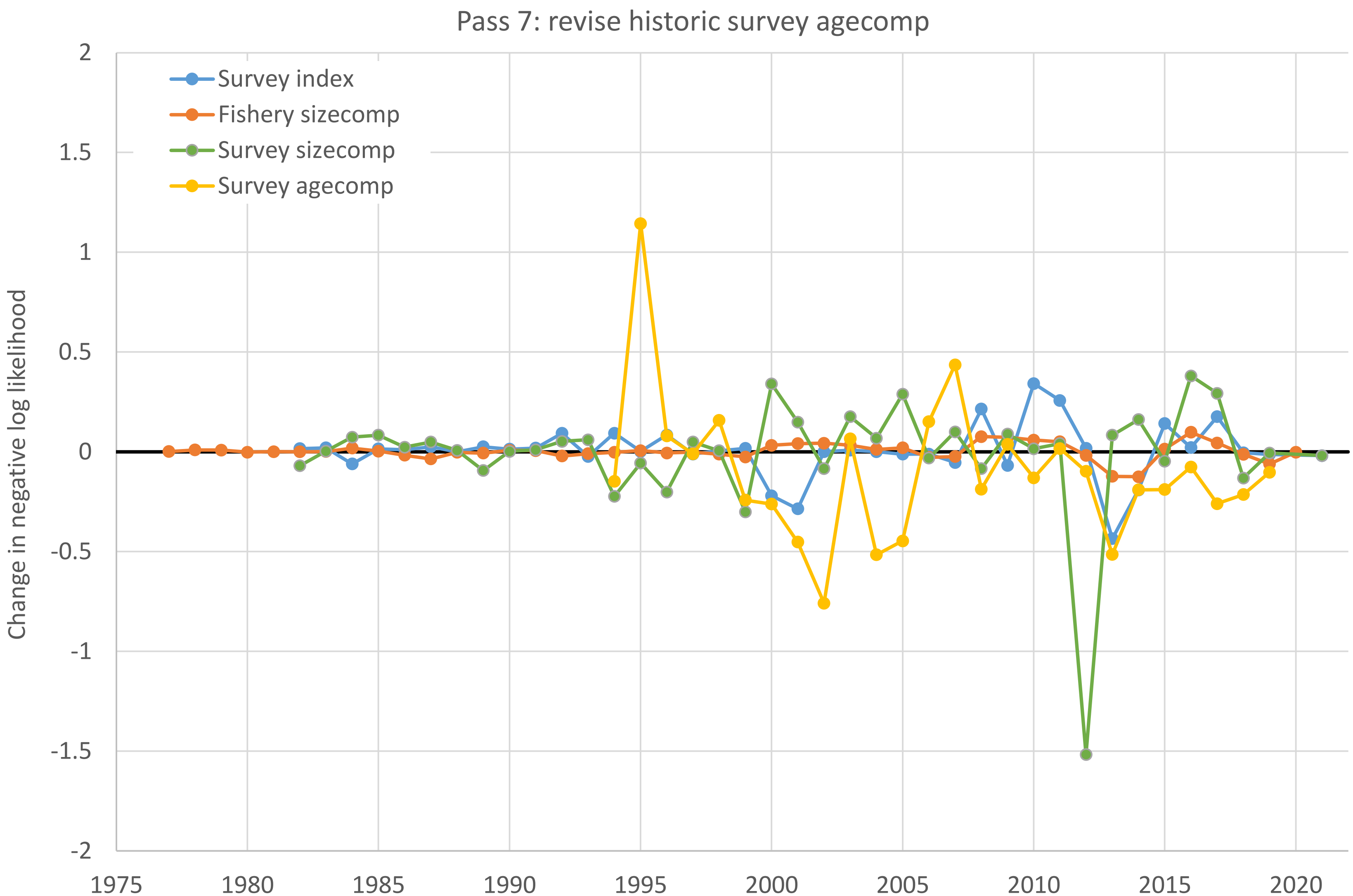


Figure 2.4.1h. Year by year comparison of negative log likelihoods (Pass 8).

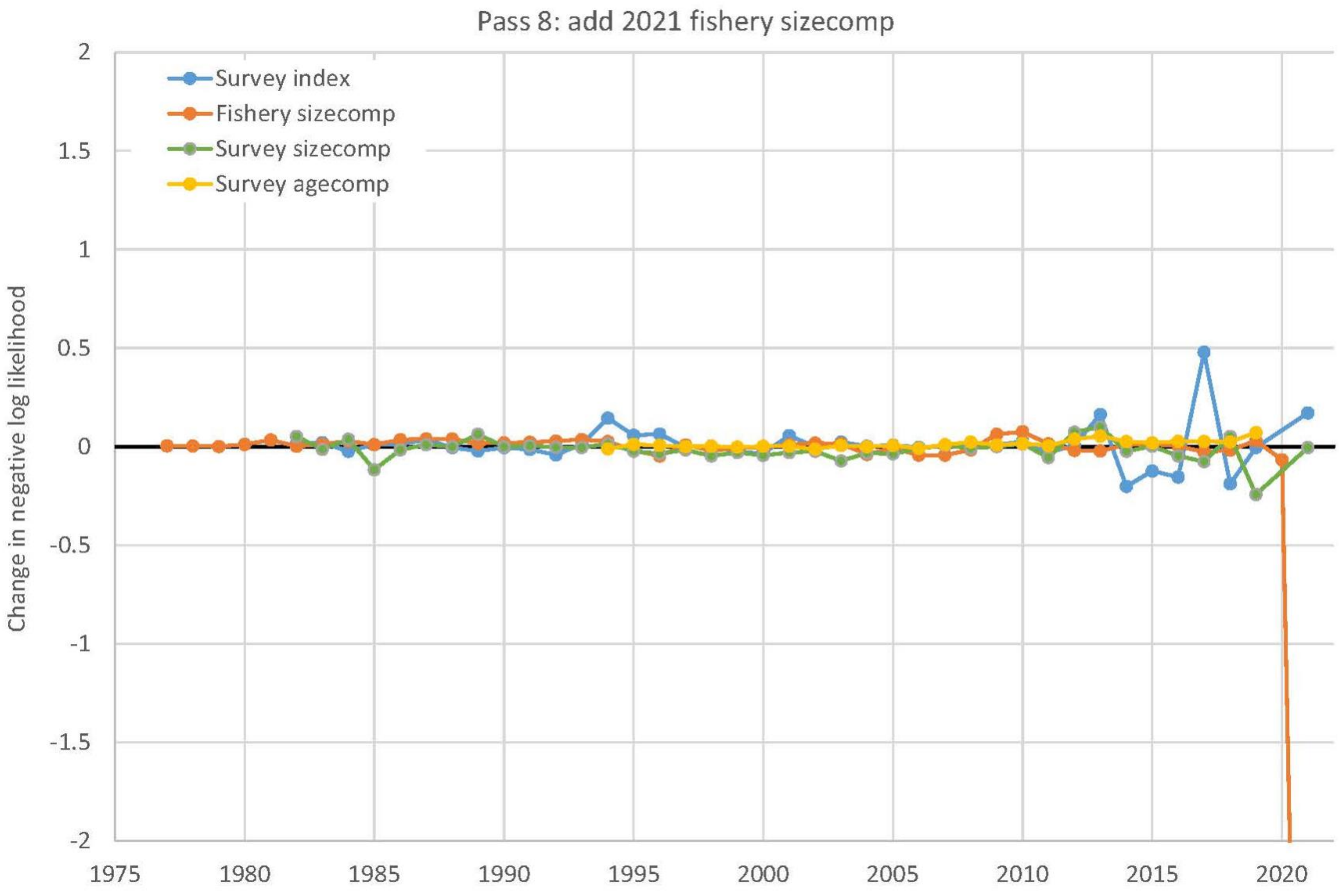


Figure 2.4.1i. Year by year comparison of negative log likelihoods (Pass 9).

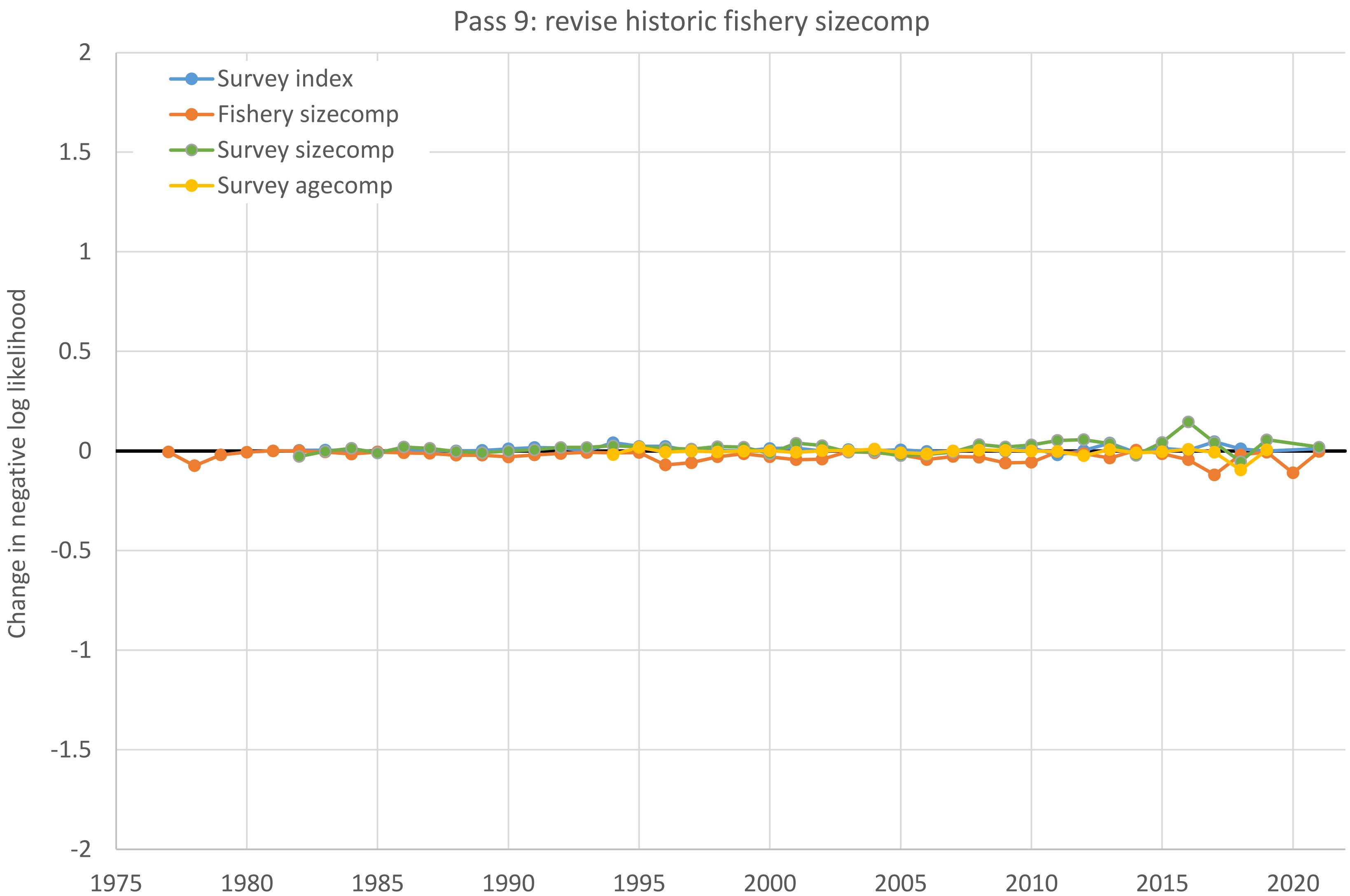


Figure 2.4.2a. Pass 1 2021 survey size composition comparison.

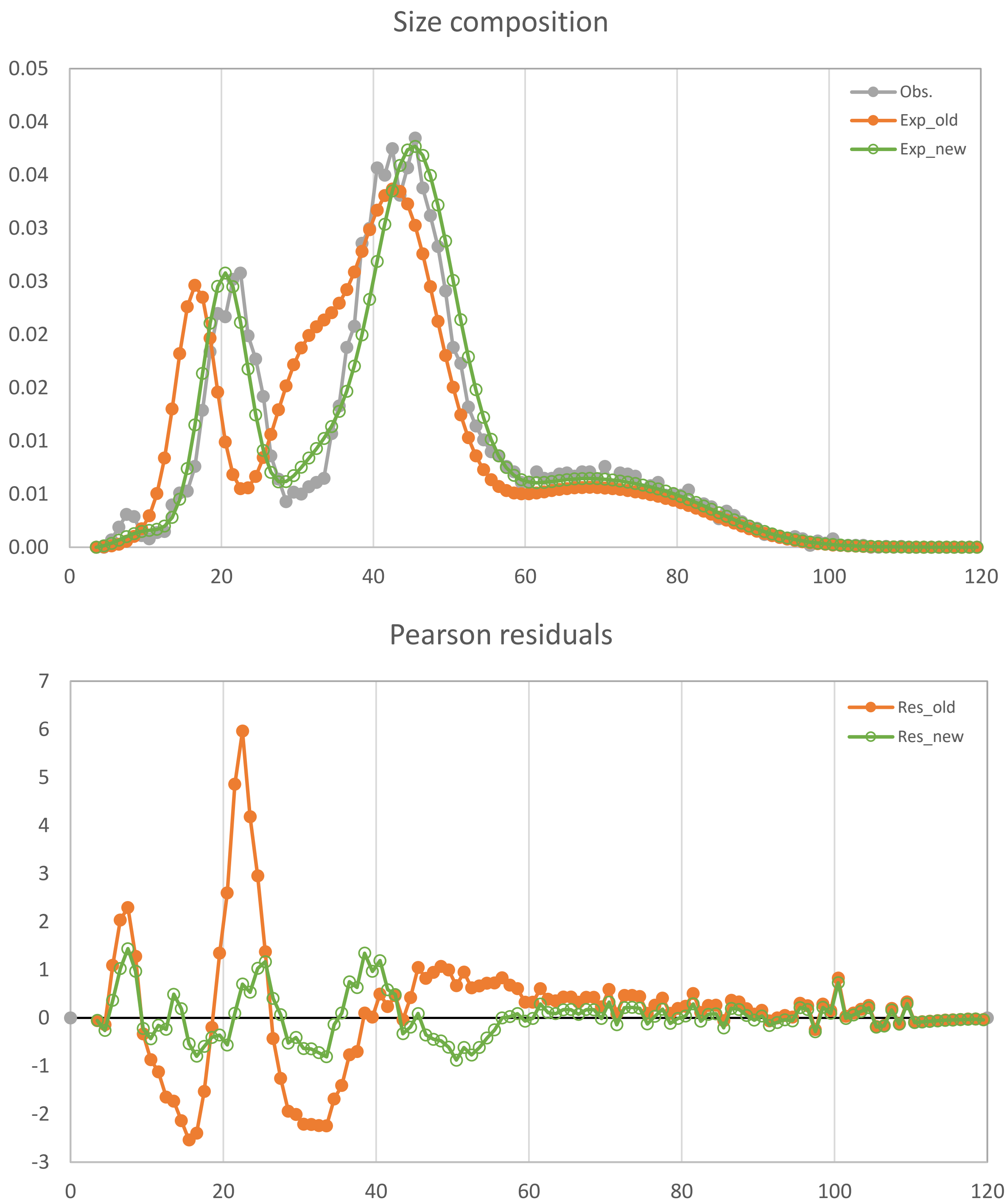


Figure 2.4.2b. Pass 2 survey index comparison.

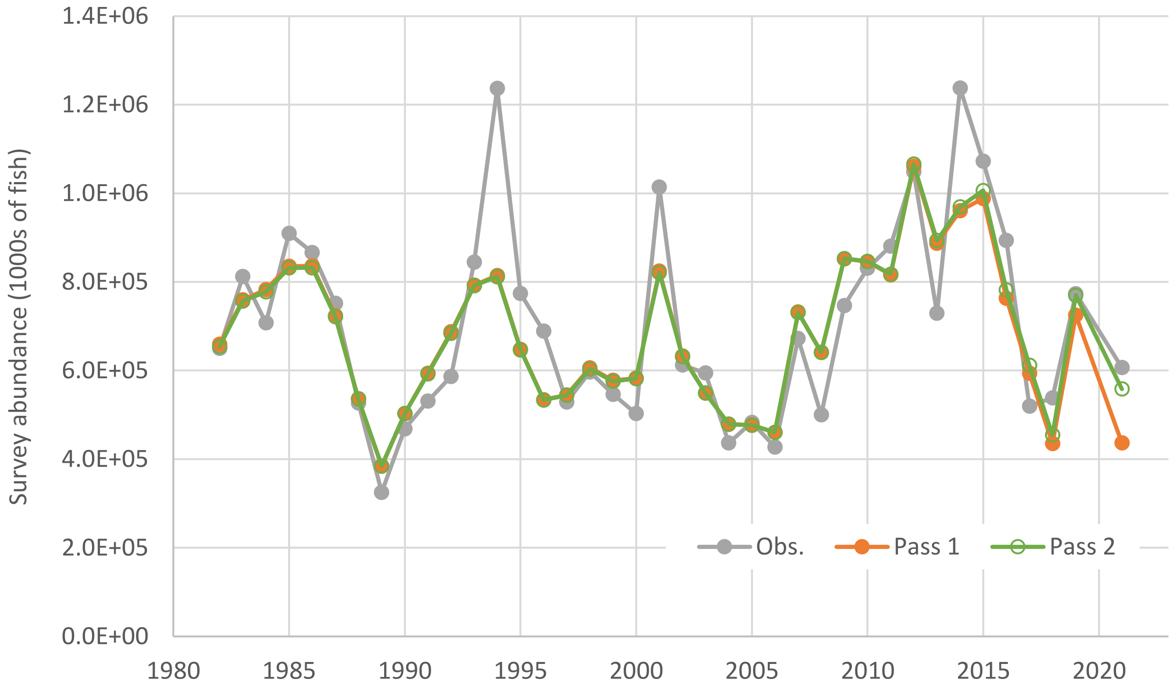


Figure 2.4.2c. Pass 3 survey index comparison.

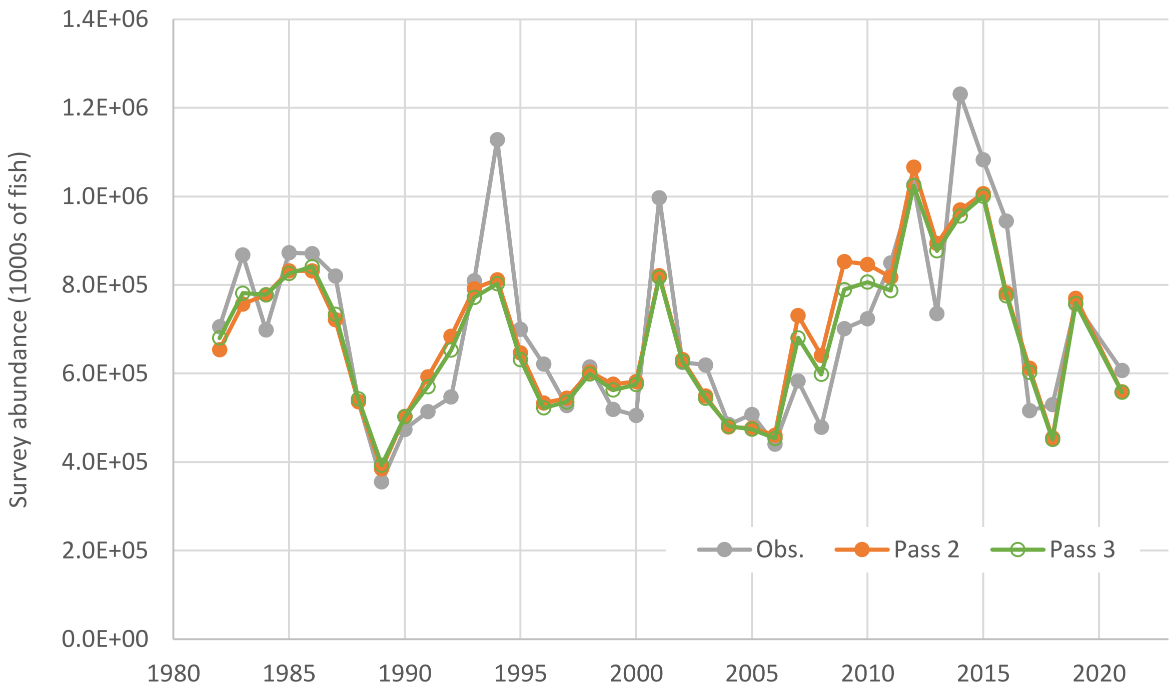


Figure 2.4.2d. Pass 5 2018 survey sizecomp comparison.

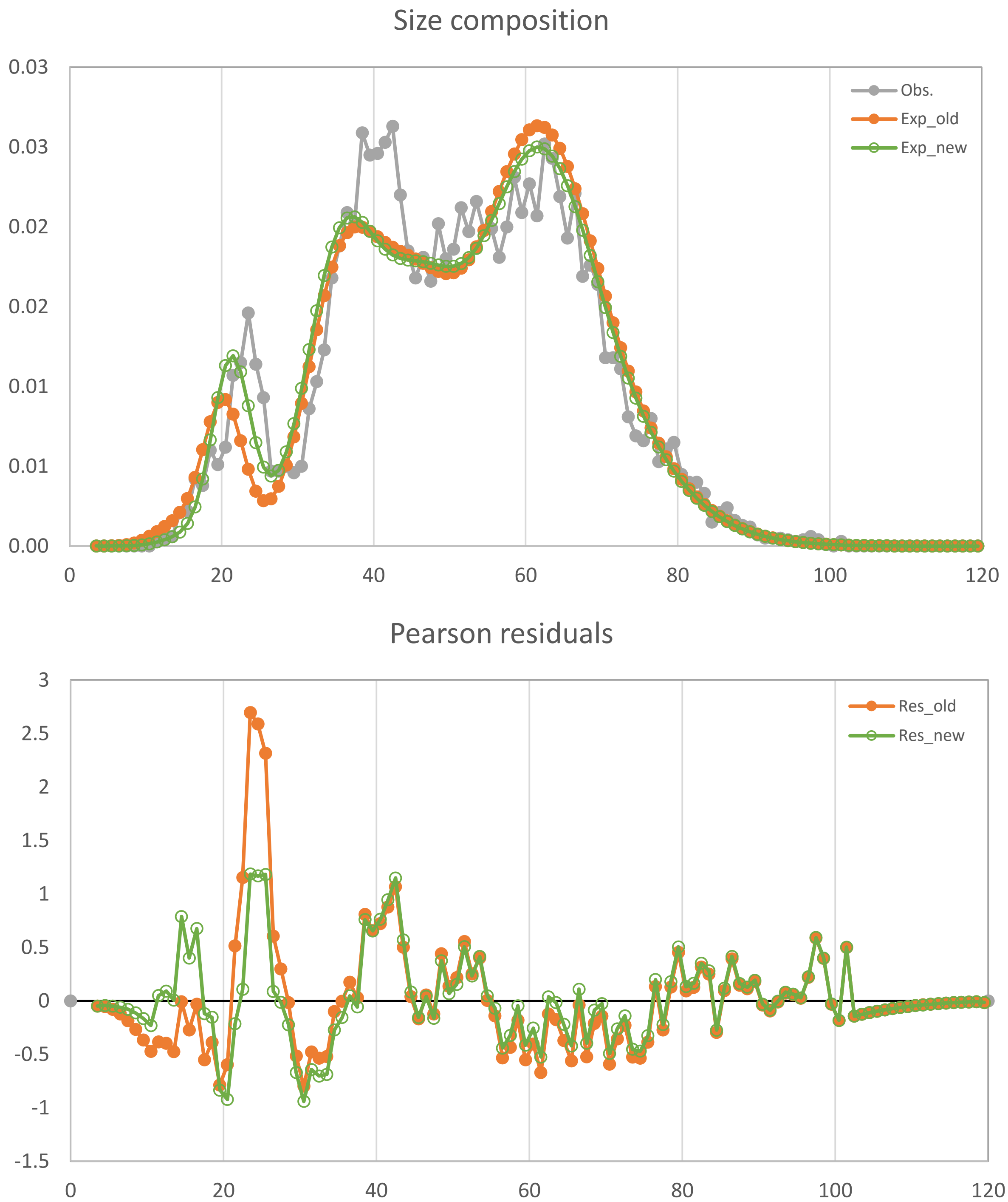


Figure 2.4.2e. Pass 8 2021 fishery sizecomp comparison.

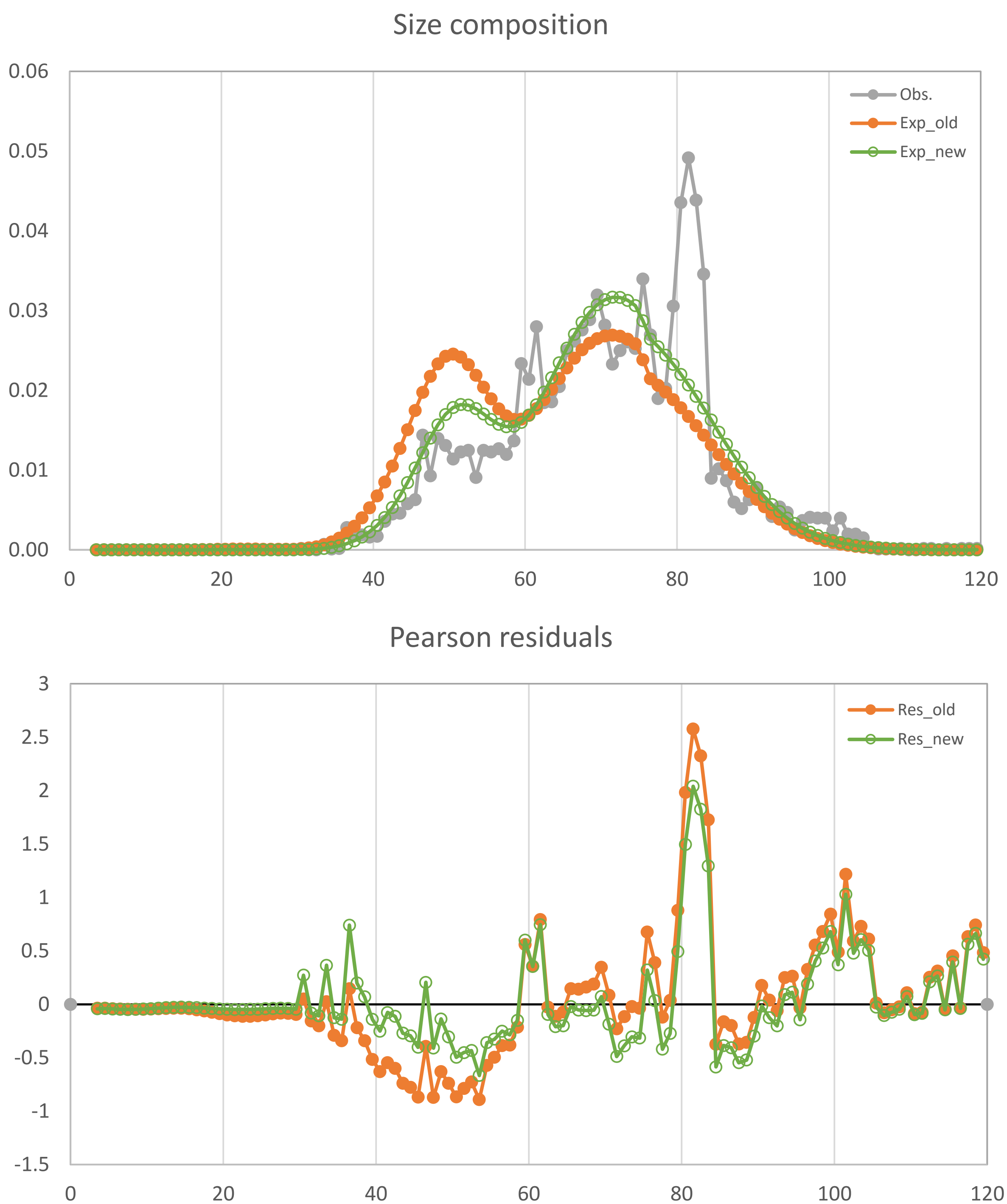


Figure 2.4.3a. Components of 2022 ABC (Pass 0 versus 2020 final version).

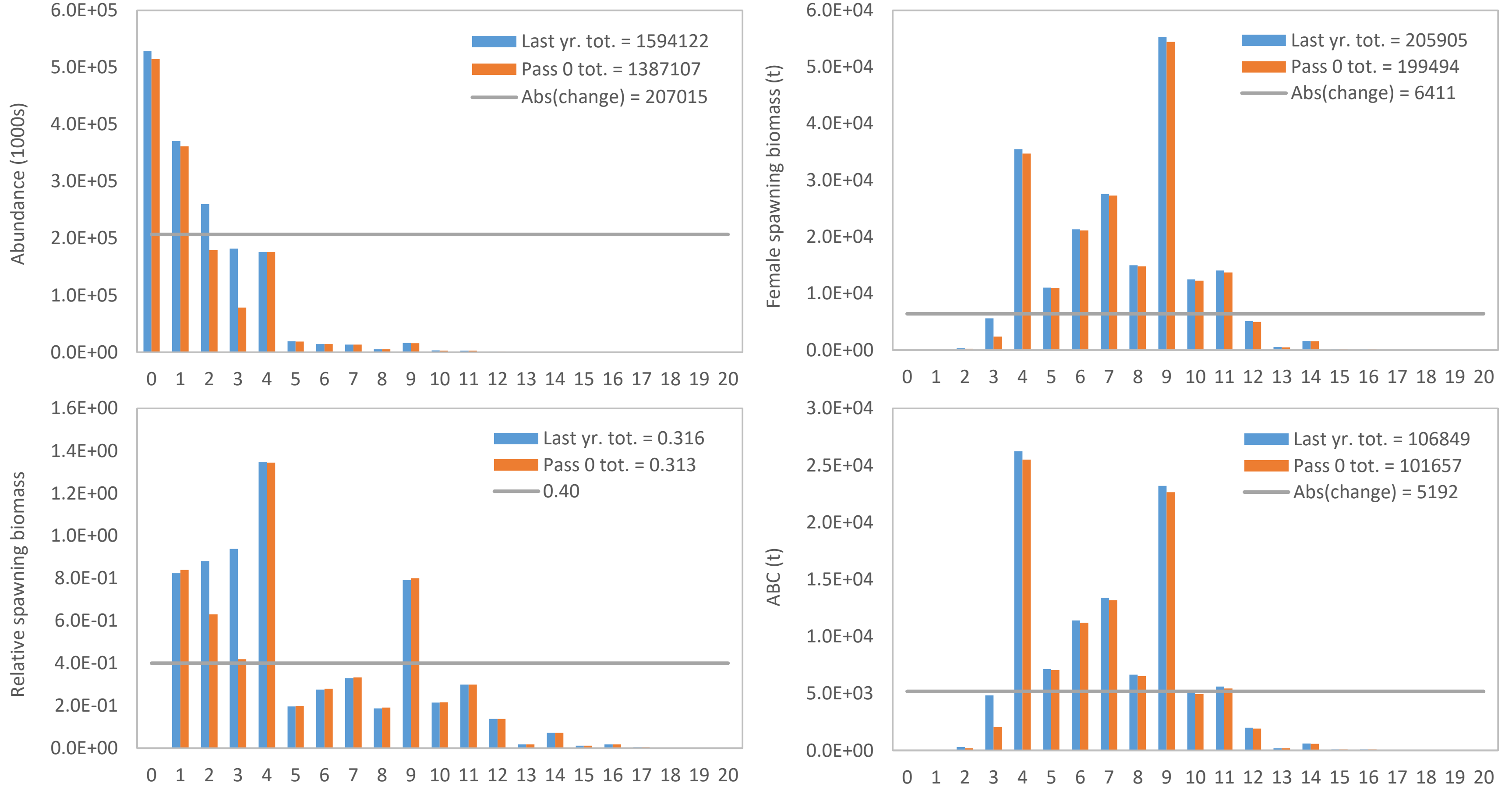


Figure 2.4.3b. Components of 2022 ABC (Pass 1 versus Pass 0).

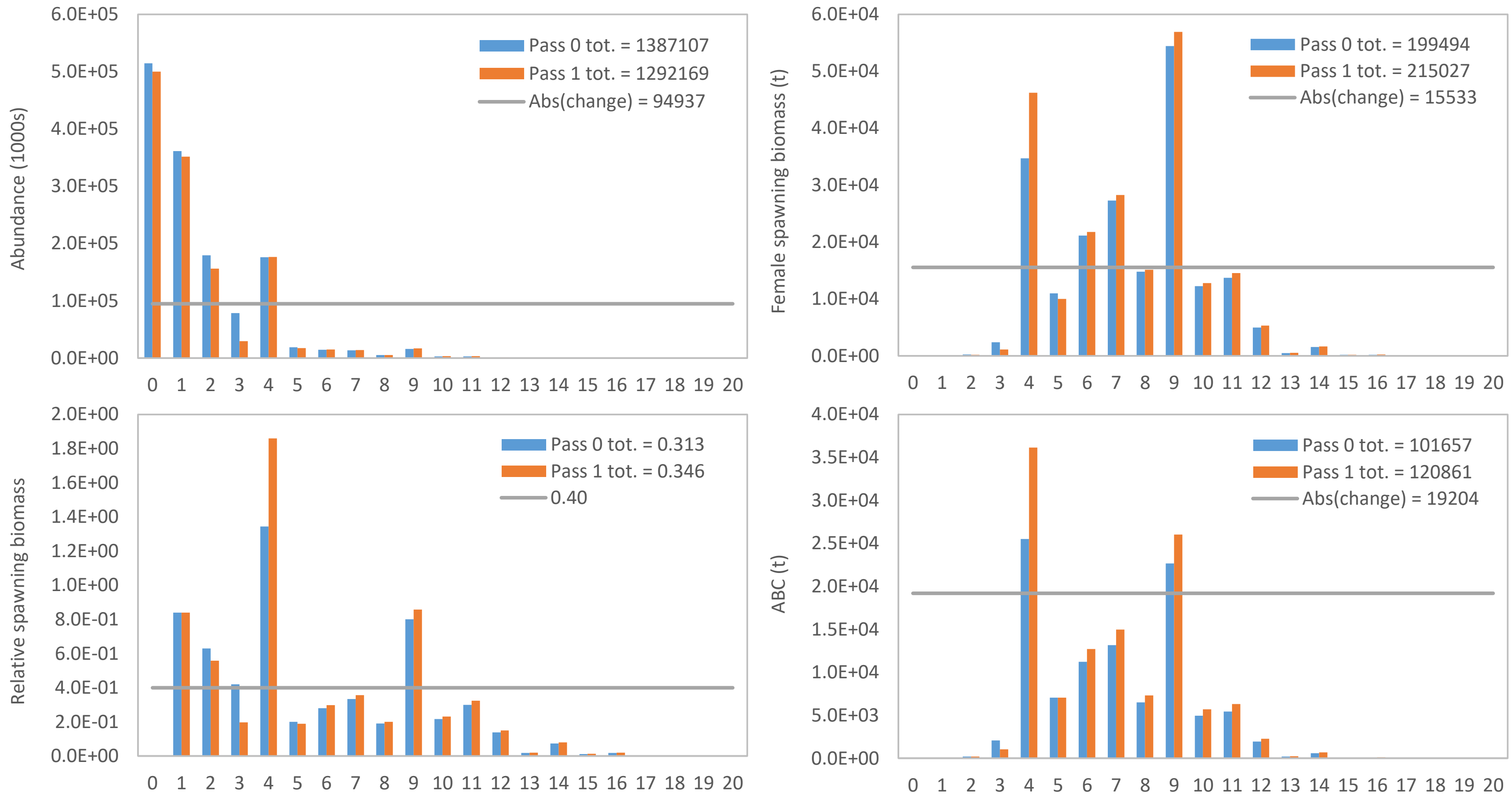


Figure 2.4.3c. Components of 2022 ABC (Pass 2 versus Pass 1).

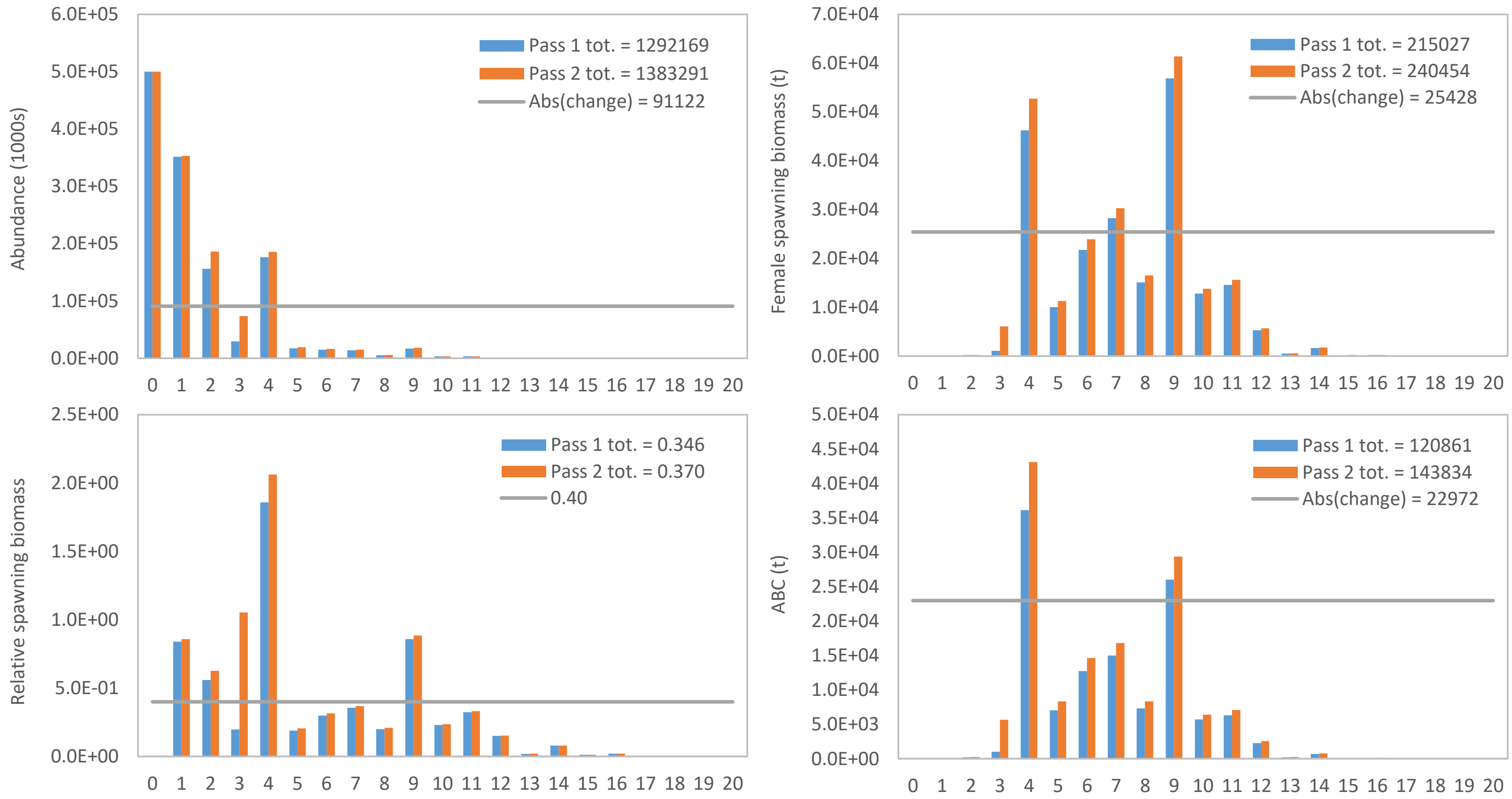


Figure 2.4.3d. Components of 2022 ABC (Pass 3 versus Pass 2).

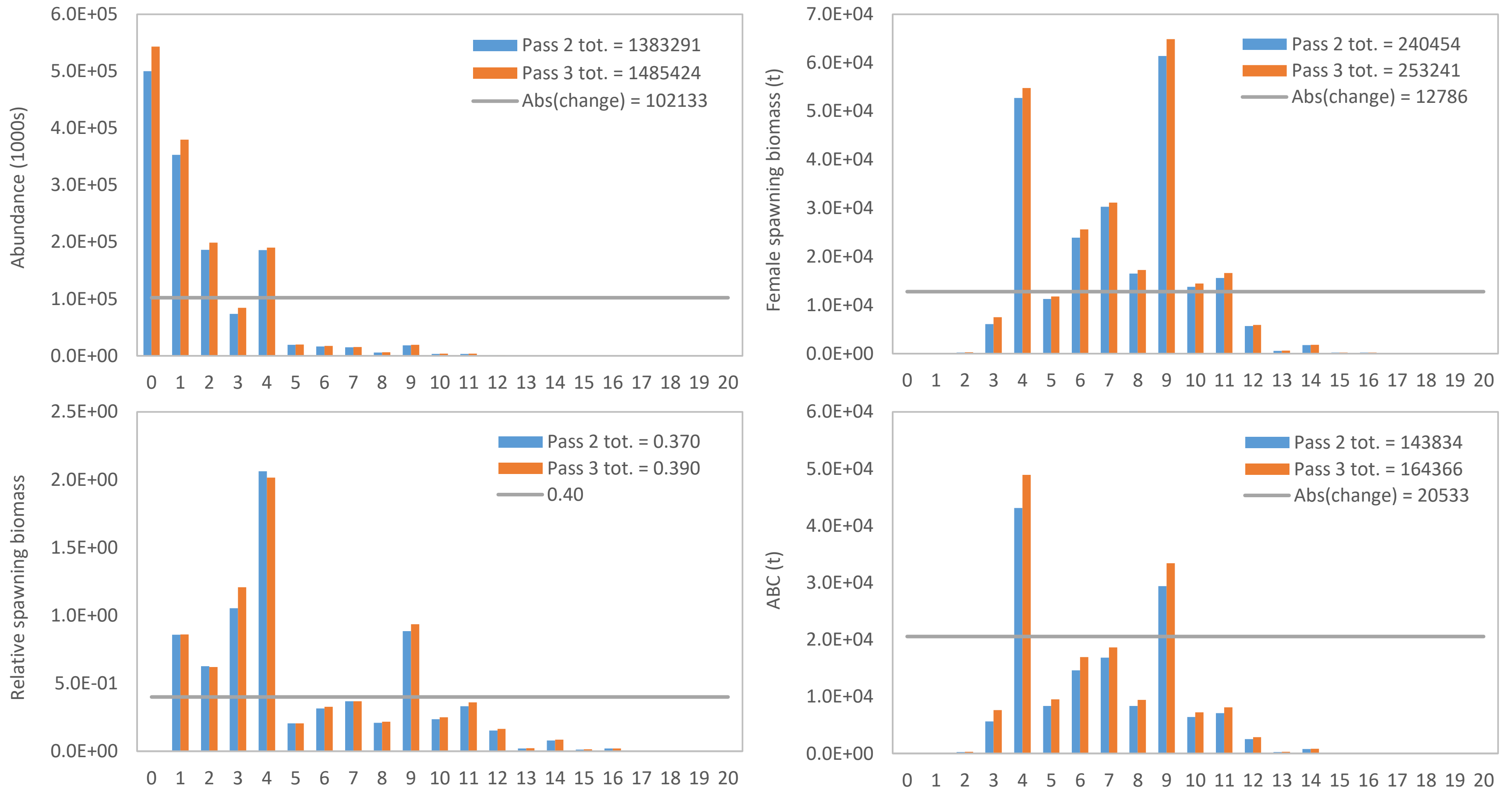


Figure 2.4.3e. Components of 2022 ABC (Pass 4 versus Pass 3).

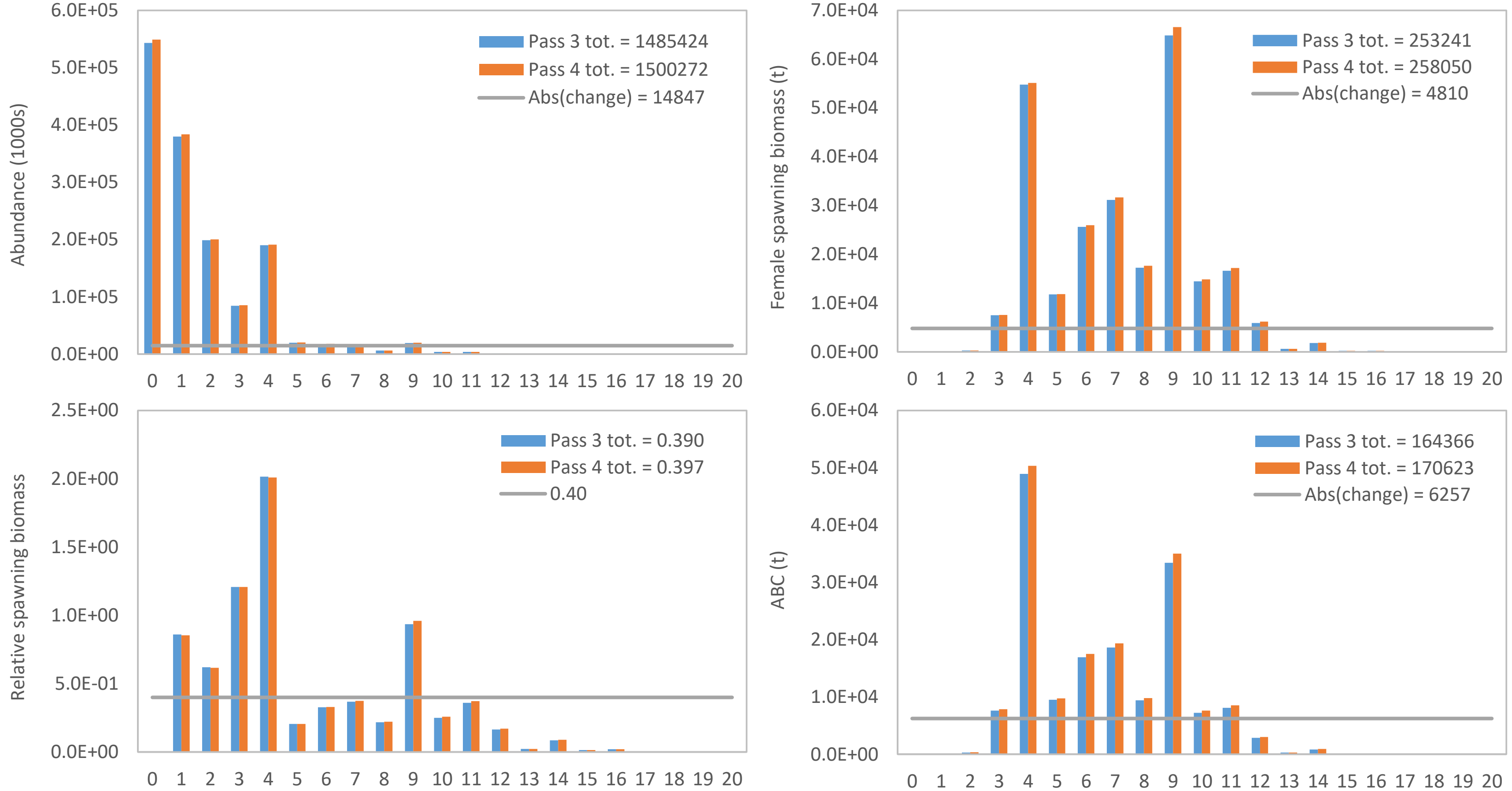


Figure 2.4.3f. Components of 2022 ABC (Pass 5 versus Pass 4).

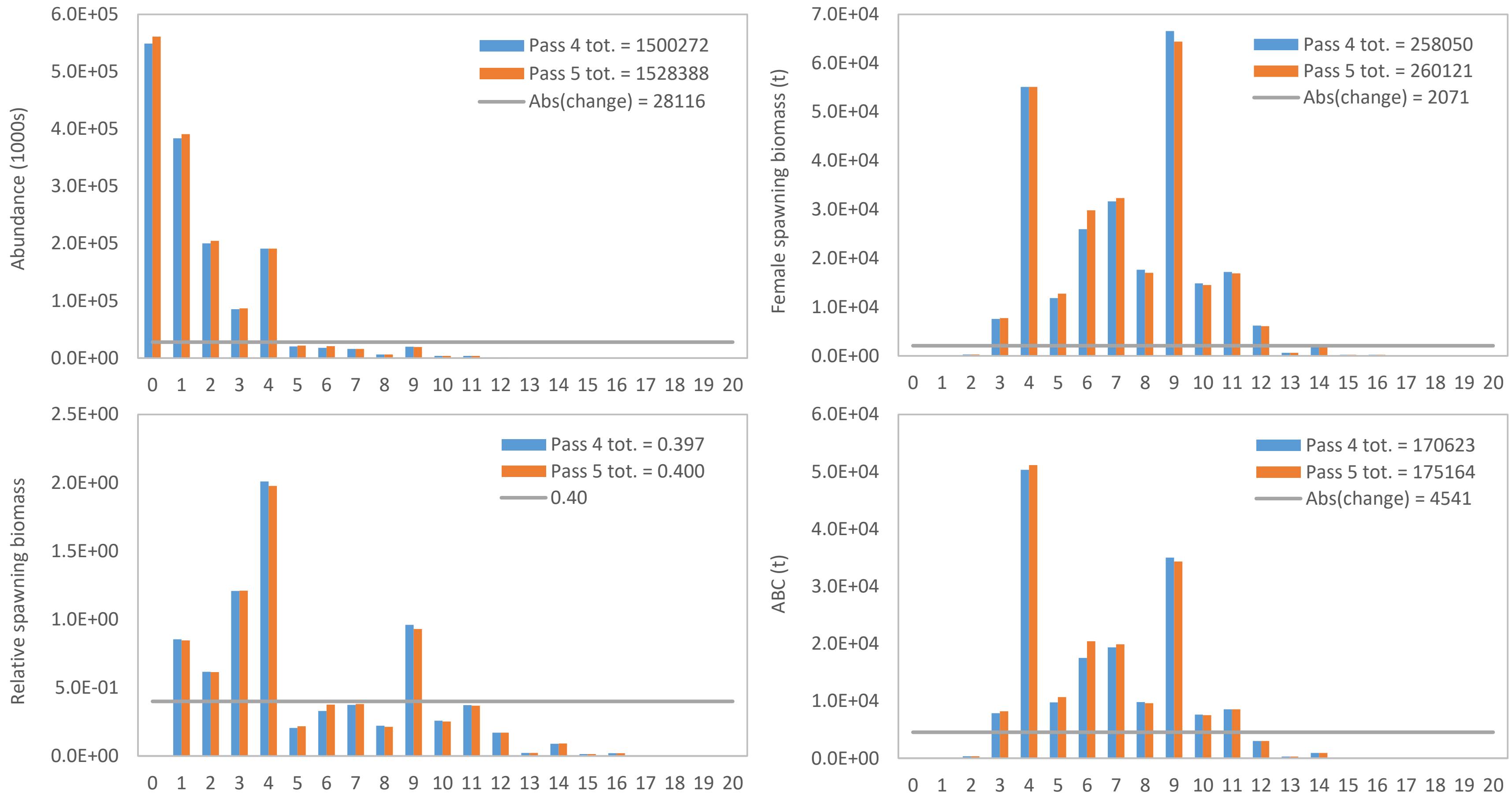


Figure 2.4.3g. Components of 2022 ABC (Pass 6 versus Pass 5).

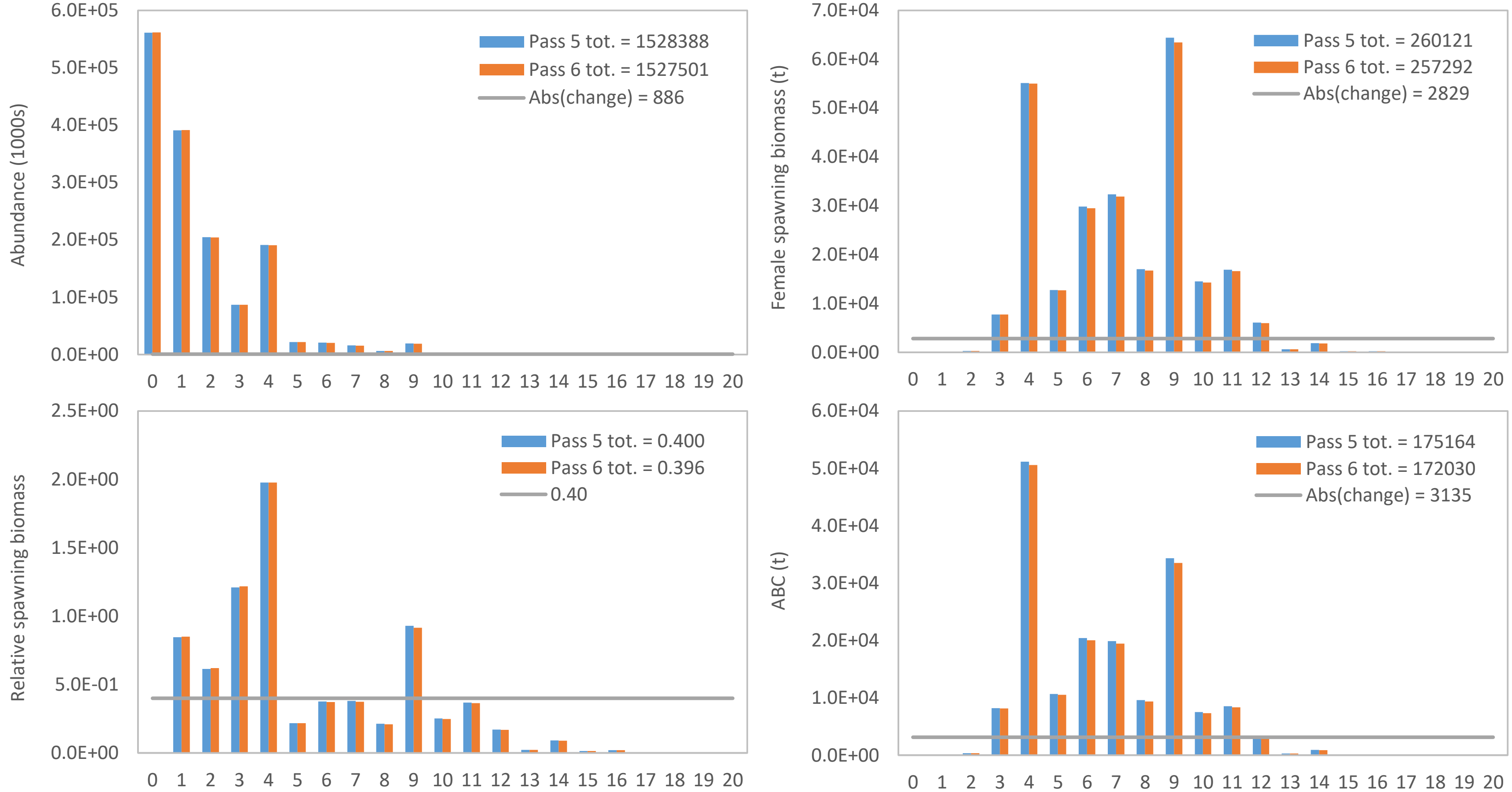


Figure 2.4.3h. Components of 2022 ABC (Pass 7 versus Pass 6).

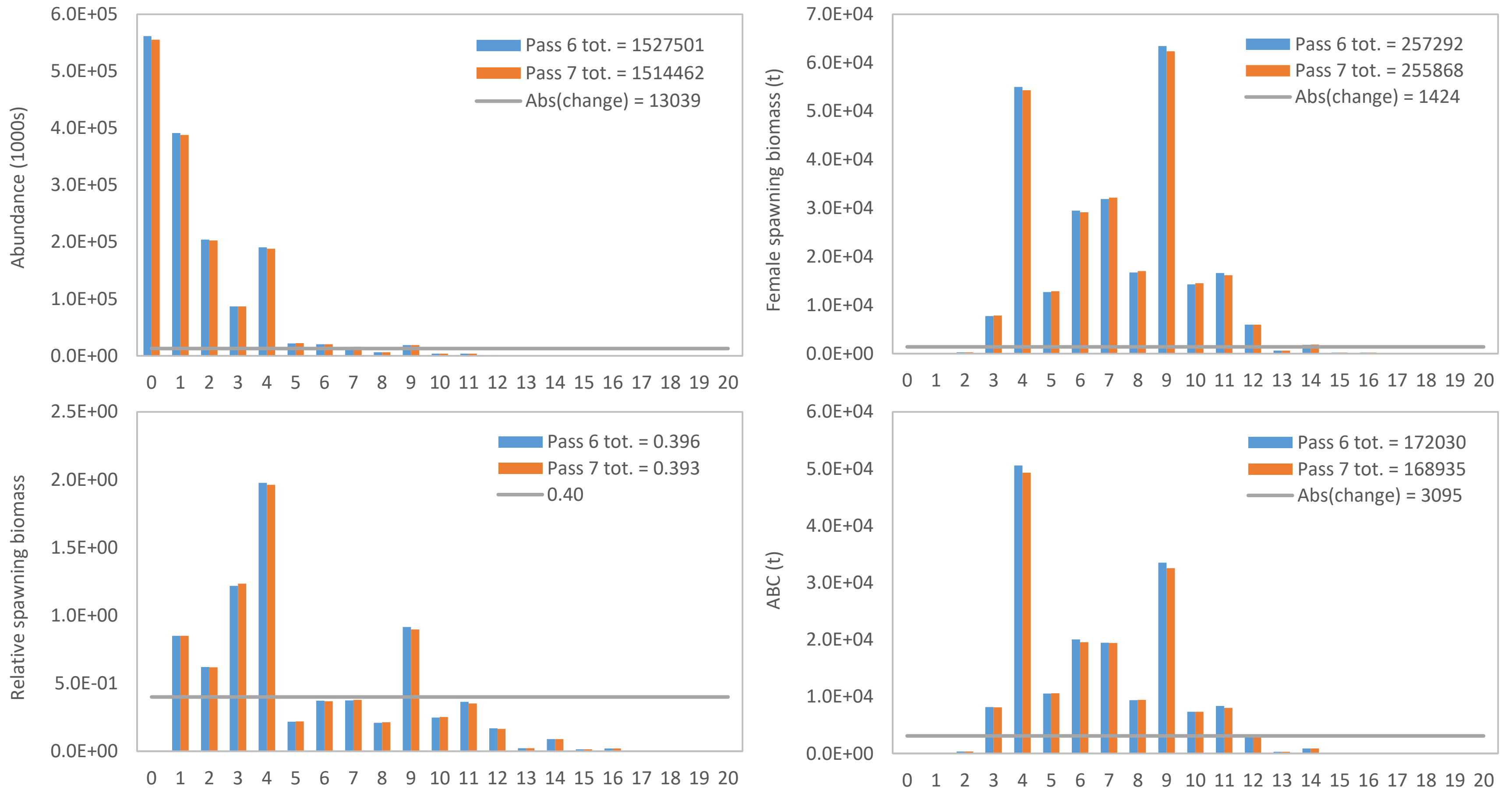


Figure 2.4.3i. Components of 2022 ABC (Pass 8 versus Pass 7).

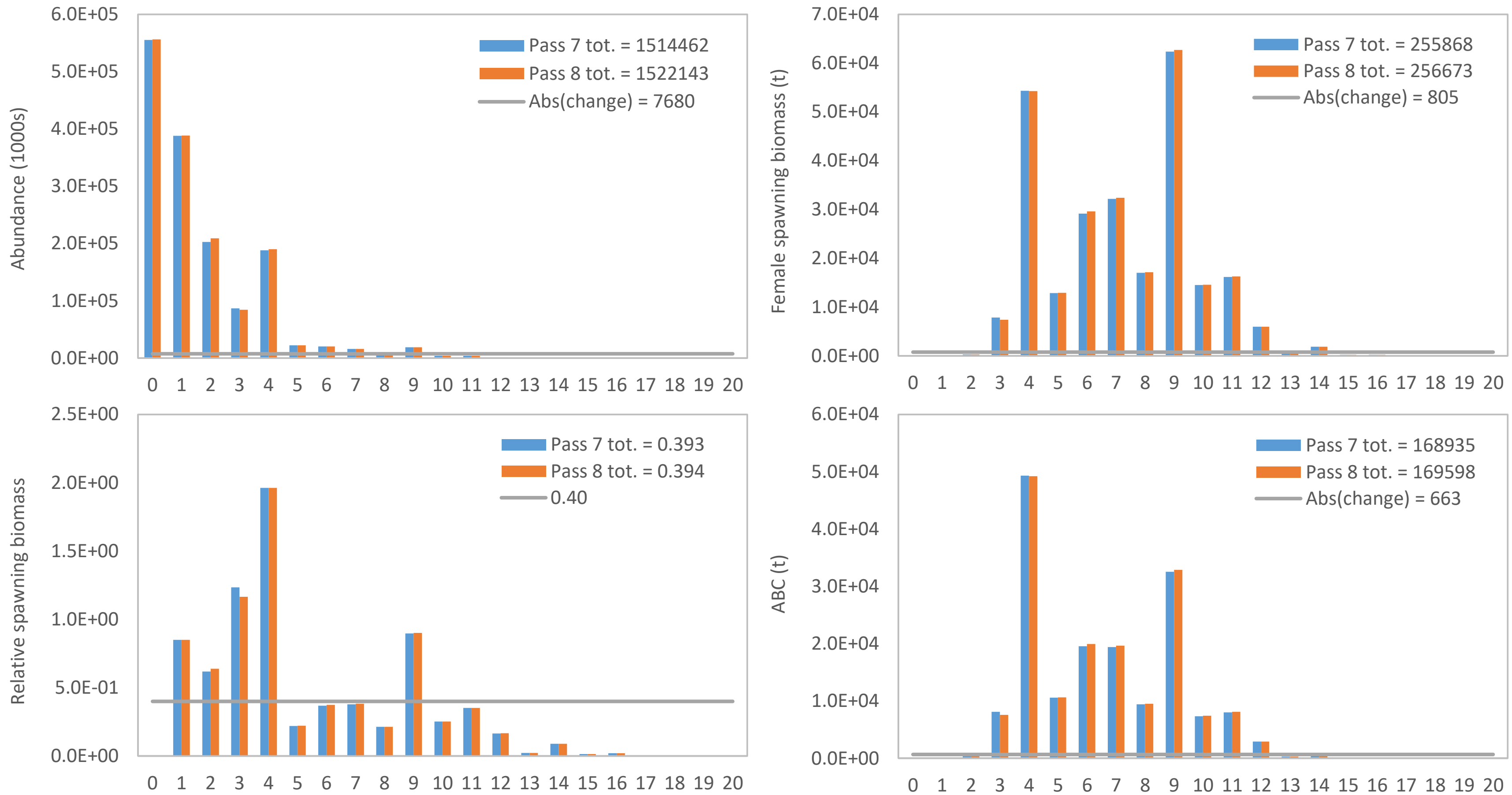


Figure 2.4.3j. Components of 2022 ABC (Pass 9 versus Pass 8).

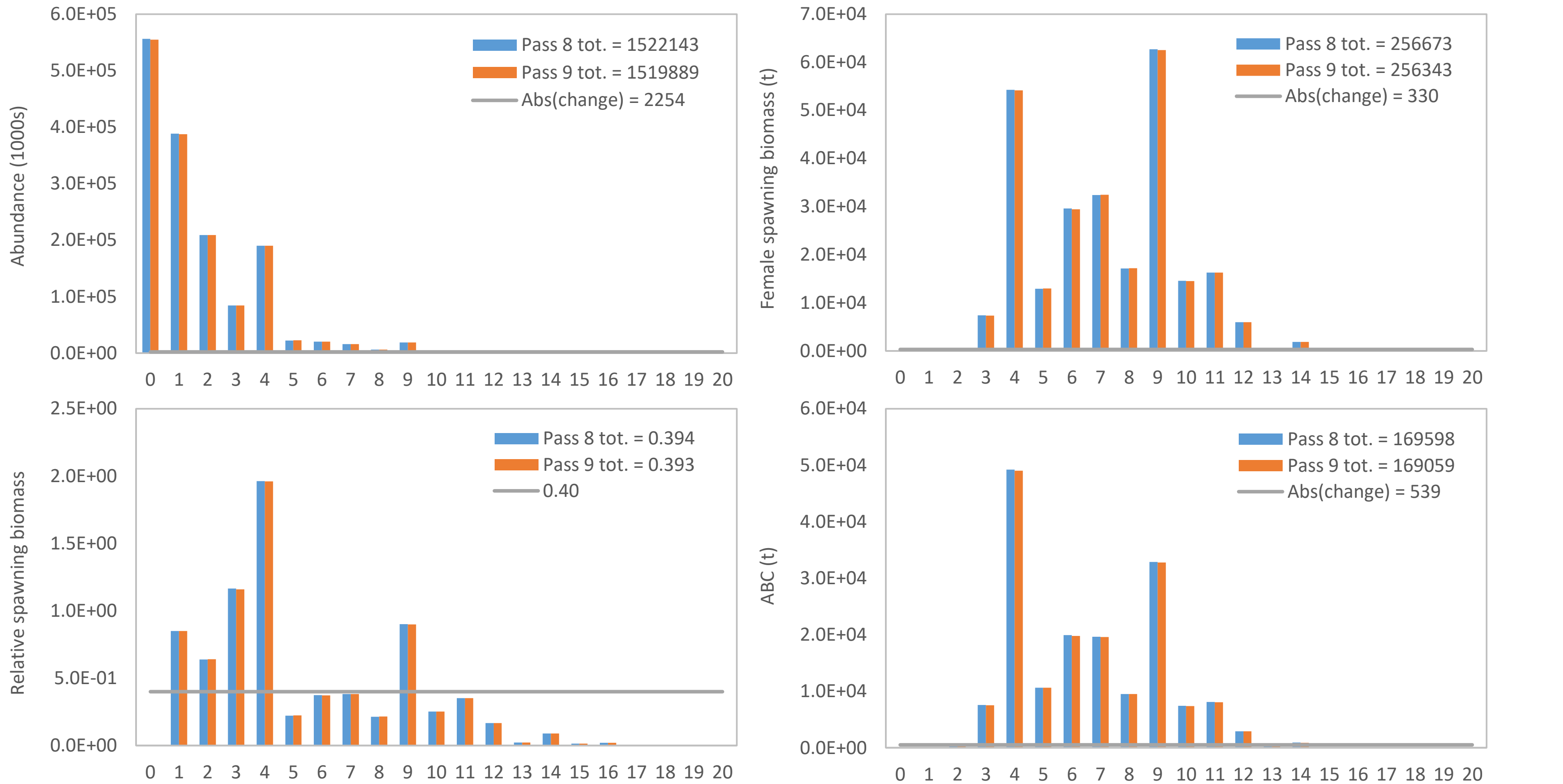


Figure 2.4.3k. Components of 2022 ABC (2021 final version versus Pass 9).

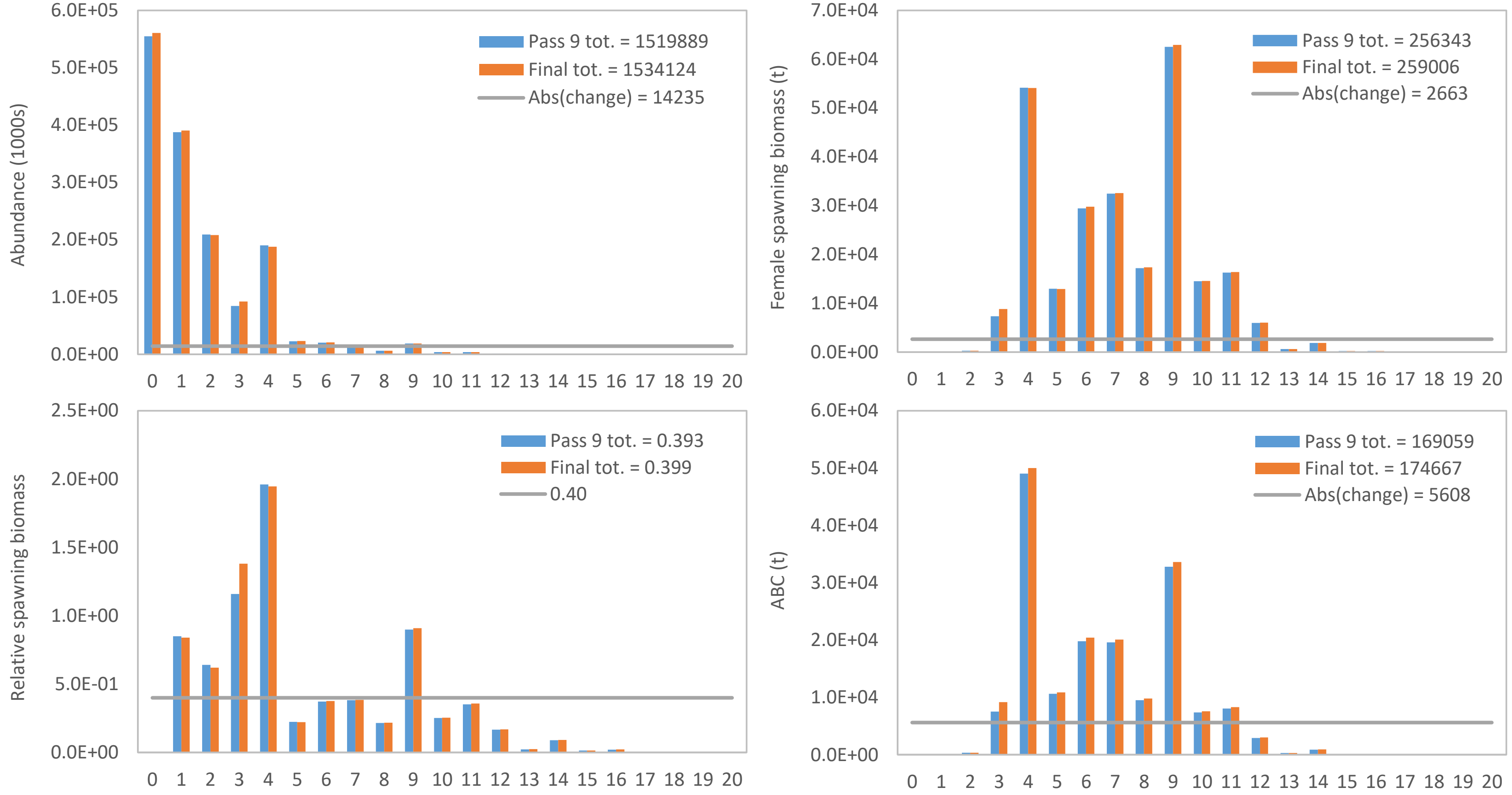
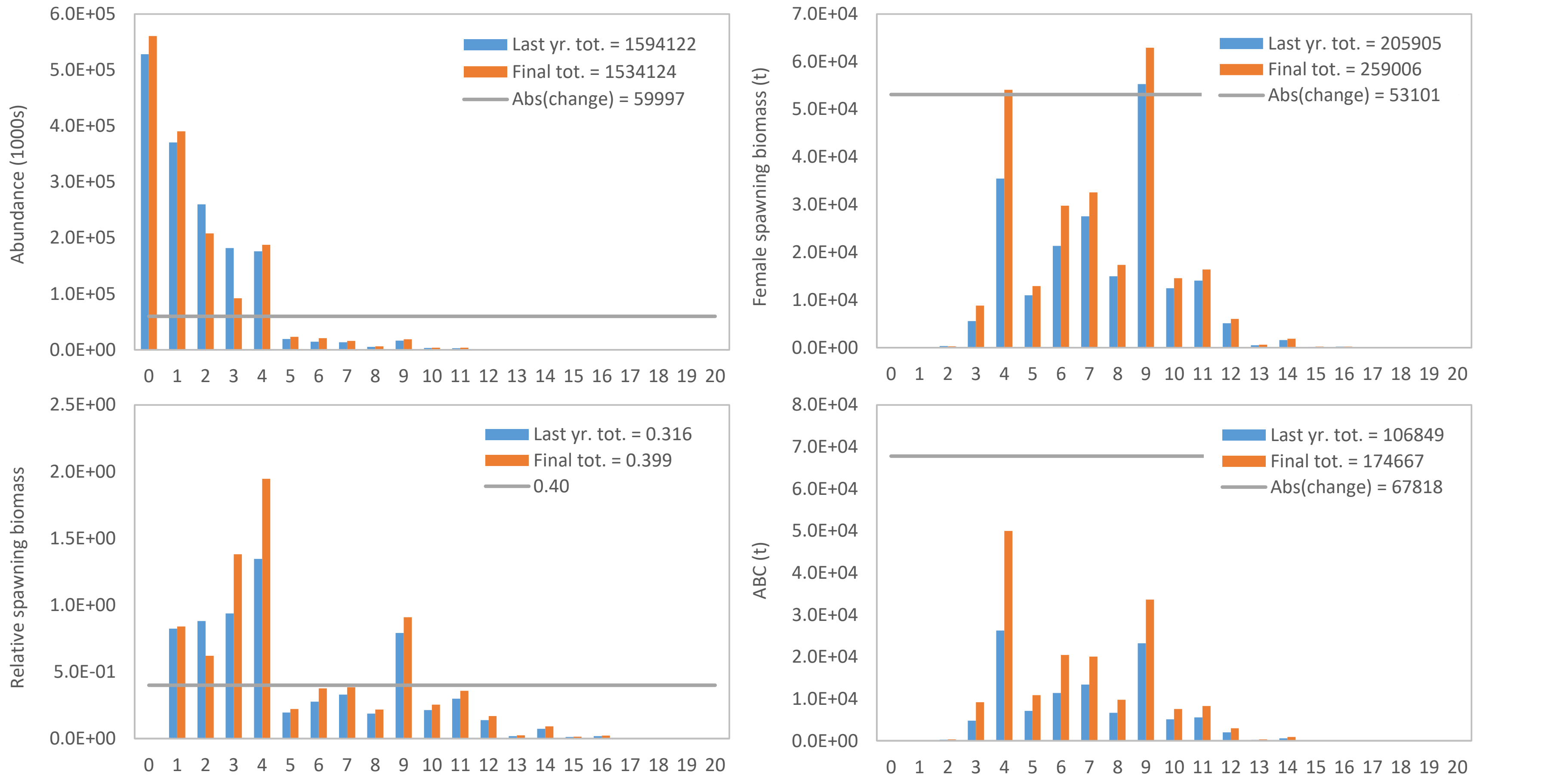


Figure 2.4.3l. Components of 2022 ABC (2021 final version versus 2020 final version).



APPENDIX 2.5: 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 2.5.1.

Although many sources of removal are documented in Table 2.5.1, 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 2.5.1 for the last three complete years (2018-2020) is 1102 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 2.5.1—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	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227
Bering Sea Slope Survey			1		1	1			1			1			1
Bristol Bay R. King Crab Tagging															
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	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227	1227
Bering Sea Slope Survey									1		1		1		
Bristol Bay R. King Crab Tagging															
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	2020
AFSC Annual Longline Survey	25		20		24		27		33		26		29	
AI Bottom Trawl Survey				2		1		2		2		3		
Bait for Crab Fishery	1227	1227	1227	413	1021	1551	1383	1751	2013	1424	864	886	864	1323
Bering Sea Slope Survey		1		2		1	1	1		1				
Bristol Bay R. King Crab Tagging														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	37
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	1
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	2
Summer EBS Survey w/ Russia	0	0	0	0		0								

APPENDIX 2.6: PARALLEL RESULTS FOR THE "HARVEST RECOMMENDATIONS" SECTION, BASED ON MODEL 19.12a

The results presented in the "Harvest Recommendations" section of the main text are based primarily on the SSC's recommended ensemble. Because the structure of that ensemble differs substantively from Model 19.12a (the current base model), a set of parallel results for the items in that section, based on Model 19.12a, is provided here.

Amendment 56 Reference Points

Model 19.12a's estimates of $B_{100\%}$, $B_{40\%}$, and $B_{35\%}$ are 648,370 t, 259,348 t, and 226,930 t, respectively, and Model 19.12a's estimates of $F_{40\%}$ and $F_{35\%}$ are 0.36 and 0.45, respectively.

Specification of OFL and Maximum Permissible ABC

Given the assumptions of Scenario 1 (below), female spawning biomass for 2022 and 2023 is estimated by Model 19.12a to be below the $B_{40\%}$ value of 259,348 t, thereby placing Pacific cod in sub-tier "b" of Tier 3 for both 2022 and 2023. Given this, Model 19.12a estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2022 and 2023 as follows:

Year	Overfishing Level	Maximum Permissible ABC
2022	OFL = 208,791 t	maxABC = 174,668 t
2023	OFL = 193,813 t	maxABC = 162,093 t
2022	F_{OFL} = 0.44	$maxF_{ABC}$ = 0.36
2023	F_{OFL} = 0.42	$maxF_{ABC}$ = 0.34

The age 0+ biomass projections for 2022 and 2023 from Model 19.12a are 894,113 t and 839,218 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 19.12a in Table 2.6.1.

Risk Table and ABC Recommendation

For Model 19.12a, the internal probability that a 2022 catch equal to the 2022 maxABC will exceed the true-but-unknown OFL is only 0.15 (Table 2.29), much lower than the ensemble probability (0.28). The risk table levels and intralevel values for all categories, except perhaps the assessment category, remain the same as in the main text. It could be argued that use of a single model rather than an ensemble warrants a higher interlevel rating than 0.0 for the assessment category, but even an interlevel rating of 1.0 would be insufficient to warrant an ABC reduction, given the extremely low internal probability associated with Model 19.12a. Therefore, the recommended ABCs for 2022 and 2023 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 2.6.1, the stock is not overfished and is not approaching an overfished condition.

Table 2.6.1. Results of the 7 standard harvest scenarios for Model 19.12a, 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
B2022	259.0	18.5	259.0	18.5	259.0	18.5	259.0	18.5	259.0	18.5	259.0	18.5
B2023	246.6	10.3	250.1	14.9	277.4	13.9	307.7	18.2	235.0	9.2	246.6	18.3
B2024	231.6	9.7	234.8	13.4	285.0	13.5	347.4	18.4	215.2	9.3	220.6	10.7
B2025	224.4	11.7	224.3	14.3	290.4	15.6	382.3	20.5	207.3	11.2	209.4	11.0
B2026	231.5	11.5	227.4	14.7	303.2	17.2	419.5	22.9	214.8	10.7	215.5	10.6
B2027	243.3	9.0	237.8	12.9	320.9	16.4	458.5	23.6	226.5	8.0	226.6	8.0
B2028	252.1	6.9	248.2	11.0	338.4	14.4	495.6	22.8	234.6	6.2	234.5	6.2
B2029	256.7	6.1	256.0	9.6	352.8	12.5	528.4	21.1	238.2	5.7	238.2	5.7
B2030	258.4	6.0	261.2	8.8	363.7	11.0	555.8	19.2	239.3	5.6	239.3	5.6
B2031	258.8	6.0	264.4	8.4	371.5	10.1	577.9	17.6	239.4	5.6	239.4	5.6
B2032	258.7	6.0	266.4	8.3	376.9	9.6	595.3	16.3	239.2	5.7	239.2	5.7
B2033	258.6	6.0	267.5	8.2	380.5	9.3	608.7	15.4	239.1	5.7	239.1	5.7
F2022	0.363	0.042	0.340	0.000	0.168	0.019	0.000	0.000	0.445	0.052	0.363	0.026
F2023	0.345	0.026	0.340	0.000	0.168	0.008	0.000	0.000	0.401	0.029	0.422	0.049
F2024	0.323	0.020	0.340	0.000	0.168	0.008	0.000	0.000	0.366	0.022	0.375	0.029
F2025	0.312	0.019	0.340	0.000	0.168	0.008	0.000	0.000	0.351	0.022	0.355	0.024
F2026	0.322	0.020	0.340	0.000	0.168	0.008	0.000	0.000	0.365	0.022	0.366	0.023
F2027	0.340	0.018	0.340	0.000	0.168	0.008	0.000	0.000	0.386	0.021	0.386	0.020
F2028	0.353	0.017	0.340	0.000	0.168	0.008	0.000	0.000	0.401	0.020	0.401	0.019
F2029	0.360	0.017	0.340	0.000	0.168	0.008	0.000	0.000	0.407	0.019	0.407	0.019
F2030	0.362	0.016	0.340	0.000	0.168	0.008	0.000	0.000	0.409	0.019	0.409	0.019
F2031	0.363	0.016	0.340	0.000	0.168	0.008	0.000	0.000	0.409	0.019	0.409	0.019
F2032	0.363	0.016	0.340	0.000	0.168	0.008	0.000	0.000	0.409	0.019	0.409	0.019
F2033	0.363	0.016	0.340	0.000	0.168	0.008	0.000	0.000	0.409	0.019	0.409	0.019
C2022	174.7	27.9	164.7	10.5	85.9	14.0	0.0	0.0	208.8	33.0	174.7	0.0
C2023	162.1	15.4	162.1	9.5	93.1	6.9	0.0	0.0	177.5	15.7	193.8	30.3
C2024	142.4	13.9	151.1	10.0	94.4	7.3	0.0	0.0	149.2	14.4	155.8	18.7
C2025	135.5	14.3	146.2	10.2	95.9	7.5	0.0	0.0	140.9	15.1	143.4	15.9
C2026	147.0	15.3	151.8	11.0	101.1	8.4	0.0	0.0	154.5	15.9	155.2	15.9
C2027	163.3	11.9	160.2	8.8	107.6	7.7	0.0	0.0	172.6	12.1	172.7	11.9
C2028	174.9	9.8	166.9	7.4	113.3	7.1	0.0	0.0	184.4	10.1	184.2	9.9
C2029	180.4	8.9	171.3	6.6	117.5	6.7	0.0	0.0	189.2	9.4	189.1	9.2
C2030	182.2	8.6	174.0	6.2	120.5	6.4	0.0	0.0	190.4	9.0	190.4	9.0
C2031	182.5	8.5	175.7	6.0	122.5	6.2	0.0	0.0	190.4	8.9	190.4	8.9
C2032	182.4	8.4	176.6	5.9	123.9	6.0	0.0	0.0	190.1	8.9	190.1	8.9
C2033	182.2	8.4	177.1	5.8	124.8	5.9	0.0	0.0	189.9	8.9	189.9	8.9