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

1) Catches for 1991-2017 were updated, and a preliminary catch estimate for 2018 were incorporated.
2) Commercial fishery size compositions for 1991-2017 were updated, and a preliminary size composition from the 2018 commercial fishery was incorporated.
3) The numeric abundance estimate and size composition from the 2018 EBS shelf bottom trawl survey "standard" area were incorporated into some of the models.
4) The 1987-2017 time series of numerical abundance and size composition from the EBS shelf bottom trawl survey "expanded" area (= standard area + strata 82 and 90) were incorporated into some of the models, in lieu of the corresponding time series from the standard area.
5) The age composition from the 2017 EBS shelf bottom trawl survey standard area was incorporated into some of the models.
6) The 1994-2017 time series of age compositions from the EBS shelf bottom trawl survey expanded area was incorporated into some of the models, in lieu of the corresponding time series from the standard area.
7) Age compositions from the 2010-2012 and 2017 fisheries were incorporated into some of the models.
8) The time series of numerical abundance and size composition from the northern Bering Sea (NBS) bottom trawl surveys were incorporated into some of the models

Changes in the Assessment Methodology

Many changes have been made or considered in the stock assessment model since the 2017 assessment (Thompson 2017). Sixteen models requested by either the BSAI Plan Team, the SSC, or various Alaska Fisheries Science Center (AFSC) scientists were presented in this year's preliminary assessment (Appendix 2.1). After reviewing the preliminary assessment, the SSC and Team requested that two (SSC) or three (Team) models from the preliminary assessment and several new models be presented in this final assessment. All of the models requested by the SSC and all but two of the models requested by the Team are included in this final assessment, along with two other new models. The list of models is as follows:

- Model 16.6 (the base model, requested by both the Team and SSC)
- Model 16.6i (the author's recommended model, requested by the SSC)
- Model 16.6j (requested by both the Team and SSC)
- Model 16.6k (requested by both the Team and SSC)
- Model 17.2 (requested by both the Team and SSC)
- Model 18.6 (requested by both the Team and SSC)
- Model 18.7 (added by author)
- Model 18.8 (added by author)

For details regarding model structures, see "Responses to SSC and Plan Team Comments Specific to this Assessment" in this section (specifically comments BPT12 and SSC13), and also the "Description of Alternative Models" subsection of the "Analytic Approach" section.

Summary of Results

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

Quantity	As estimated or *specified last* year for:		As estimated or *recommended this* year for:	
	2018	2019	2019*	2020*
M (natural mortality rate)	0.36	0.36	0.34	0.34
Tier	3a	3a	3a	3b
Projected total (age 0+) biomass (t)	918,000	762,000	824,000	683,000
Projected female spawning biomass (t)	292,000	262,000	290,000	246,000
$B_{100\%}$	593,000	593,000	658,000	658,000
$B_{40\%}$	237,000	237,000	263,000	263,000
$B_{35\%}$	207,000	207,000	230,000	230,000
F_{OFL}	0.38	0.38	0.38	0.35
$maxF_{ABC}$	0.31	0.31	0.31	0.29
F_{ABC}	0.31	0.31	0.31	0.29
OFL (t)	238,000	201,000	216,000	164,000
maxABC (t)	201,000	170,000	181,000	137,000
ABC (t)	201,000	170,000	181,000	137,000
Status	As determined *last* year for:		As determined *this* year for:	
	2016	2017	2017	2018
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 201,000 t, 181,000 t, and 137,000 t in 2018, 2019, and 2020, respectively.

Responses to SSC and Plan Team Comments on Assessments in General

Since last year's assessment was completed, the SSC has made several comments on assessments in general. Some of these were addressed in the preliminary assessment (Appendix 2.1). Those original responses are not repeated here, but additional responses to some of the previously addressed comments

are included below, along with responses to comments made at the October 2018 SSC meeting. Note that numbering of comments here is continuous with numbering of comments in the preliminary assessment.

Comments from the December 2017 SSC meeting

SSC3: "The SSC reminds authors of the need to balance the desire to improve model fit with increased risk of model misspecification." This recommendation was subsequently clarified in the minutes of the June 2018 SSC meeting as follows: *"In the absence of strict objective guidelines, the SSC recommends that thorough documentation of model evaluation and the logical basis for changes in model complexity be provided in all cases."* Model evaluation is documented thoroughly in this assessment. Although a change from Model 16.6 to Model 16.6i is recommended here, this does not involve a change in model complexity, as the only difference between the two models is in the data used (see "Description of Alternative Models" subsection, under "Analytic Approach"). Model complexity is also addressed in the "Choice of Final Model" subsection, under "Model Evaluation," under "Results."

SSC4: "Report a consistent metric (or set of metrics) to describe fish condition among assessments and ecosystem documents where possible." The index of fish condition used in this assessment is the same as that reported in this year's BSAI ESR, in conformity with the policy noted in response to this comment in Appendix 2.1.

SSC5: "Projections ... clearly illustrate the lack of uncertainty propagation in the 'proj' program used by assessment authors. The SSC encourages authors to investigate alternative methods for projection that incorporate uncertainty in model parameters in addition to recruitment deviations. Further, the SSC noted that projections made on the basis of fishing mortality rates (Fs) only will tend to underestimate the uncertainty (and perhaps introduce bias if the population distribution is skewed). Instead, a two-stage approach that first includes a projection using F to find the catch associated with that F and then a second projection using that fixed catch may produce differing results that may warrant consideration." Given the recent decision by AFSC program leadership to drop the requirement for use of the previously standard projection model (see response to this comment in Appendix 2.1), projections in this assessment are instead based on the Stock Synthesis program (Methot and Wetzel 2013), thus allowing for incorporation of uncertainty in model parameters. The two-stage approach requested by the SSC was used to create Figure 2.30.

Comments from the October 2018 SSC meeting

SSC9 (follow-up on comment SSC1; see Appendix 2.1): *"A regression analysis of ecosystem indicators correlated with historical spawning biomass was presented in response to the SSCs request for a method to predict the likelihood of impending stock decline. The SSC cautions that testing a large number of indicators (as was done in this case) is likely to produce a statistically significant relationship even if one does not exist. Stock assessment authors are encouraged to work with ESR analysts to identify a small subset of indicators prior to analysis, and preferably based on mechanistic hypotheses."* Because the analysis conducted in response to comment SSC1 in the preliminary assessment (see "Ecosystem considerations" section in Appendix 2.1) involved extensive cross-validation, the SSC's conclusion regarding the likelihood of finding a statistically significant result even if one does not exist may be debatable. Nevertheless, next year's analysis will conform to the new requested approach.

SSC10 (follow-up on comment SSC2; see Appendix 2.1): "The SSC recognized that because formal criteria for these categorizations have not been developed by the PT, they will not be presented in December 2018." In conformity with this comment, determinations regarding the "current and future condition" of the stock and its ecosystem are not presented here.

SSC11: "The SSC supports the PT recommendation to make the use of model-based survey estimates at the individual author's discretion for 2018." Model-based survey estimates for EBS Pacific cod are still under development, and not used in this assessment.

Responses to SSC and Plan Team Comments Specific to this Assessment

Since last year's assessment was completed, the BSAI Plan Team and the SSC have made several comments specific to this assessment. Some of these were addressed in the preliminary assessment (Appendix 2.1). Those original responses are not repeated here, but an additional response to one of the previously addressed comments is included below, along with responses to comments made at the September 2018 Team meeting and the October 2018 SSC meeting. Note that numbering of comments here is continuous with numbering of comments in the preliminary assessment.

Comments from the November 2017 Team meeting

BPT2: The Team recommends presenting in the next assessment document, the fishery CPUE for each of the separate sectors (pot, trawl, longline), as has been done in the past. This information would be useful to compare to estimated trends from the assessment. The requested data are presented in Table 2.2, along with an update of last year's analysis of longline fishery CPUE by year and month in Figure 2.1.

Comments from the September 2018 Team meeting

BPT8: "The Plan Team recommends to not consider models with linkages to environmental covariates for further review in 2018 but encourages continued investigations in the future of the relationships between environmental covariates and various stock assessment parameters as well as the mechanisms behind those relationships." Models with linkages to environmental covariates are not included in this final assessment. Investigations of such models, as well as the mechanisms behind the modeled relationships, will continue in the future. See also comment SSC12.

BPT9: "Given the recently realized importance of the Northern Bering Sea for Pacific cod, the Plan Team was pragmatic and focused on investigating models that included northern areas. The intention was not to downweight the importance of investigating environmental linkages, and the Plan Team recognizes the excellent work done by the author to investigate the linkages and the importance of understanding parameter linkages to environmental covariates. If range expansion of Pacific cod is occurring, linking various parameters to environmental covariates and understanding those relationships and the potential effects on the stock may be very important. Similarly, the two-area models with migration seemed particularly useful for describing the observations in the Northern Bering Sea, but there is a paucity of data to describe the migration process. Therefore, the Plan Team recommends suspending the investigation of two-area models for Bering Sea Pacific cod in 2017 but encourages further development of the models in the future if data suggest that they are warranted." Investigation of two-area models has been suspended, but will resume in the future if data suggest that it is warranted. See also comment SSC12.

BPT10: "The Plan Team recommends not including Model 17.6 for 2018 runs for a number of reasons. First, even though many diagnostics showed that model 17.6 fit the data well, it tended to fit certain data very well and other data not very well. There is the concern that this model may be overparameterized and chasing noise. Second, the predictions of the model were outliers that were not congruent with any other models and did not agree with anecdotal trends in fishery performance. Lastly, plausibility of parameter estimates were suspect given current knowledge of the Pacific cod stock." Model 17.6 is not included in this final assessment.

BPT11: "Given recent and projected warm conditions and recent distributional trends, the Plan Team recommends that the NBS survey extension is conducted again in 2019 (and future years as needed) in order to support assessment estimates of fish biomass, to continue to monitor potential range expansion

of Pacific cod, and to understand the dynamics and behavior of the Pacific cod stock in relation to environmental conditions. The ten-fold increase in the Pacific cod biomass in the Northern Bering Sea and distributional shifts between 2010 and 2017 is an important event to understand and monitor. Also, these observations led the Plan Team to recommend models that included data from northwestern EBS and Northern Bering Sea areas." The AFSC plans to conduct a survey of the NBS in 2019.

BPT12: "The Plan Team requests that five models (described below) be brought back in November, with 2018 data included, for further evaluation.

A. Model 16.6: the base model
B. Model 16.6b, which includes the two northwestern Eastern Bering Sea strata in the EBS survey index and is modeled with a change in catchability from the early period without those northwestern strata.
C. A combination of Models 16.6b and 16.6g which includes the northwestern strata in the EBS survey index and modeled with time-varying catchability, and the Northern Bering Sea survey observations with estimated selectivity and time-varying catchability.
D. Model 17.2 as it was structured and parameterized in 2017, but with 2018 data included.
E. Same as Model 17.2 but including the northwestern strata in the EBS survey index and modeled with time-varying catchability, and the Northern Bering Sea survey observations with estimated selectivity and time-varying catchability."

With the exception of the model described under "B," the above models are included in this assessment. The model described under "C" is labeled Model 16.6k and the model described under "E" is labeled Model 18.6. See comment SSC13.

BPT13: "Additionally, if time allows, the Plan Team recommends that the author consider the following two models.

F. Same as Model 16.6 but including the northwestern strata in the EBS survey index modeled with time-varying catchability.
G. Same as Model 16.6 but adding the NBS survey estimates to the EBS survey estimates (with the northwestern strata) and model catchability as time-varying. Size compositions should be combined by weighting by the abundance estimates from each area (if available)."

The model described under "G" is included in this assessment, where it is labeled Model 16.6j, but the model described under "F" is not. See comment SSC13.

BPT14: "The final model in the above list (a potential model for consideration) simply adds the NBS survey estimates to the EBS survey estimates. This may not be statistically satisfactory. Therefore, the Plan Team encourages continued research on statistical methods (e.g., geospatial analysis) to combine the Bering Sea surveys into a single comprehensive biomass index, noting that it may be possible to include environmental covariates in this analysis, such as the cold pool and ice cover. Relatedly, the Plan Team recommends investigating model-based approaches to estimate a consistent time-series for the NBS survey given that the survey design changed in 2018." As noted under comment SSC11 above, model-based estimates for EBS Pacific cod are still under development. Some of the efforts to date have included the NBS survey data (Jim Thorson, AFSC, pers. commun.). See also comment SSC14.

BPT15: "Finally, the Plan Team asks that the author provide a clear rationale for a reduction in the ABC from maxABC if one is proposed. For example, some concerns may be the possibility of an uncertain but potentially dramatic increase in mortality in the northern areas if ice cover returns quickly. An ensemble of models may not capture factors that are of concern, as the magnitude of this potential mortality is unknown." No reduction from maxABC is proposed.

<u>Comments from the October 2018 SSC meeting</u>

SSC12: "The author provided several entirely new models for 2018, including models with environmental covariates to growth and mortality, as well as a two-area model with migration. The SSC supports the PT

recommendation to suspend development of these models (18.x) for 2018, but encourages future investigations. This choice was made pragmatically, to focus efforts on the treatment of the Northern Bering Sea data, and to reduce the workload on the assessment author, recognizing the importance of improved understanding of the environmental and ecosystem drivers on life history and movement. These models represent helpful exploratory analyses to identify linkages and how they might be included in stock assessment models. Some additional vetting of covariates using model output to refine mechanistic hypotheses might also be an avenue for future work." Development of models with environmental covariates or migration has been suspended. See also comments BPT8 and BPT9.

SSC13: "The SSC requests that six models be prepared for presentation in November and December, four of those requested by the PT, one that was modified from the PT recommended model, and one additional model:

A. *Model 16.6: the base model, including 2018 data (PT).*
B. *A variant of Model 16.6g, which includes the northwestern strata in the EBS survey index and models the 1982-2018 expanded survey series with time-varying catchability, and the Northern Bering Sea survey observations with estimated selectivity and time-varying catchability (modified from PT).*
C. *Model 17.2 as it was structured and parameterized in 2017, but with 2018 data included (PT).*
D. *Model 17.2 but including the northwestern strata in the EBS survey index and modeled with time-varying catchability, and the Northern Bering Sea survey observations with estimated selectivity and time-varying catchability (PT).*
E. *Model 16.6 but adding the NBS survey estimates to the EBS survey estimates (with the northwestern strata) and model catchability as time-varying. Size compositions should be combined by weighting by the abundance estimates from each area (if available; PT).*
F. *Additional SSC request: Model 16.6 including the northwestern survey strata and the NBS biomass estimates added to the EBS estimates and treated as a single survey index without changes in selectivity or catchability.*

The SSC acknowledges that there may be an additional model that seems important to bring forward identified during investigation of the requested model, and leaves this to the author's discretion, noting that this not specifically requested."

Post-meeting discussion with the SSC members who drafted this recommendation resulted in a determination that the model described under "B" above was really no different than the model described under "C" in comment BPT12. All of the SSC's requested models are included in this assessment, as are two additional new models. Model numbers were assigned as follows:

- Model 16.6 (previously numbered, requested by both the Team and SSC)
- Model 16.6i = SSC's "F"
- Model 16.6j = Team's "G" and SSC's "E"
- Model 16.6k = Team's "C" and SSC's "B"
- Model 17.2 (previously numbered, requested by both the Team and SSC)
- Model 18.6 = Team's "E" and SSC's "D"
- Model 18.7 (added by author)
- Model 18.8 (added by author)

SSC14: "The SSC supports exploration of a geospatial model that includes all of the survey data (and perhaps environmental covariates), generating a single index that can be used in the assessment with little technical 'overhead' invested in time-varying catchability." See comment BPT14.

SSC15: "The SSC requests that future presentations of a model ensemble include a preferred model set and weighting approach recommended by the author, including a rationale for these choices, rather than solely an array of alternatives. The SSC leaves the further development of an ensemble of Pacific cod

models for 2018 to the author's discretion: if some or all of the requested models seems reasonable for use in an ensemble in December, and a weighting scheme is identified, the SSC will consider it in December. A set of base case results from a single model should also be presented." Choosing which models to include in an ensemble and choosing an approach for weighting those models are both difficult problems. For example, last year's preliminary and final assessments and this year's preliminary assessment contained many alternative approaches to model weighting, none of which have garnered enthusiastic support. Unfortunately, the number and nature of the models requested for inclusion in this year's final assessment precluded development of new approaches that might be more acceptable. Lacking a convincing rationale either for a preferred ensemble or a preferred approach to model weighting, model averaging is not pursued in this year's final assessment. If ensemble modeling is pursued in the future, both a preferred model set and a preferred weighting approach, including a rationale for each of those choices, will be included.

SSC16: "Because stock structure and migratory connectivity between the U.S. waters of the Bering Sea and the western regions of the Bering Sea (Russian waters) are poorly understood, the SSC recommends not changing the name of this assessment to the 'Bering Sea' Pacific cod assessment, but retaining 'Eastern Bering Sea,' for the time being." The title of this assessment is the same as in previous years.

SSC17: "If a migration-based model is pursued in the future, the SSC suggests that a more mechanistic approach to incorporating migration in the model would be fruitful. For example, migration is most likely linked to the size and location of the cold pool, which used to impede the northward migration of Pacific cod, as well as to the size of the cod stock." This year's preliminary assessment included three models that featured migration. Of those, Model 18.2 adopted an entirely mechanistic approach, where time-variability in the parameters governing the migration rates took the form of deterministic functions of environmental covariates. Although the size of the cold pool was not among the covariates considered, mean bottom temperature was among those considered (note that the correlation between the size of the cold pool and mean bottom temperature is –0.96). When compared to purely random deviations in the migration parameters, mean bottom temperature exhibited correlations that were 0.25, 0.32, and 0.42 lower than those exhibited by the covariates that were chosen for use in Model 18.2. Nevertheless, if migration-based models are pursued in the future, mechanistic linkages between the migration parameters and the size and location of the cold pool will be considered.

INTRODUCTION

General

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., in prep.).

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.

Review of Life History

Spawning, eggs, and larvae
Pacific cod in the EBS form large spawning aggregations, and typically spawn once per year (Sakurai and Hattori 1996, Stark 2007), from late February or early March through early to mid-April (Neidetcher et al. 2014). Shimada and Kimura (1994) identified major spawning areas between Unalaska and Unimak Islands, and seaward of the Pribilof Islands along the shelf edge. Neidetcher et al. (2014) identified spawning concentrations north of Unimak Island, in the vicinity of the Pribilof Islands, at the shelf break near Zhemchug Canyon, and adjacent to islands in the central and western Aleutian Islands along the continental shelf. In their tagging study, Shimada and Kimura observed a few travel distances in excess of 500 nmi, with a large number of travel distances in excess of 100 nmi, which they inferred to be part of an annual migration between summer feeding grounds and winter spawning grounds. Shimada and Kimura and Neidetcher et al. speculated that variations in spawning time may be temperature-related.

In a laboratory study, eggs hatched between 16-28 days after spawning, with peak hatching occurring on day 21 (Abookire et al. 2007). Settlement in the Gulf of Alaska is reported to occur from July onward (Blackburn and Jackson 1982, Abookire et al. 2007, Laurel et al. 2007), which, given a mean spawning date of mid-March (Neidetcher et al. 2014), and assuming that settlement occurs immediately after transformation, and subtracting about 20 days for the egg stage, implies that the larval life stage might last about 90 days. In the laboratory study by Hurst et al. (2010), postflexion larvae were all younger than 106 days post-hatching, and juveniles were all older than 131 days post-hatching, so it might be inferred that transformation typically takes place between 106 and 131 days after hatching.

Several studies have demonstrated an impact of temperature on survival and hatching of eggs and development of embryos and larvae (e.g., Laurel et al. 2008, Hurst et al. 2010, Laurel et al. 2011, Laurel et al. 2012, Bian et al. 2014, Bian et al. 2016). Temperature has been (negatively) related to recruitment of Pacific cod (e.g., Doyle et al. 2009, Hurst et al. 2012).

Pacific cod eggs are demersal (Thomson 1963), but Pacific cod larvae move quickly to surface waters after hatching (Rugen and Matarese 1988, Hurst et al. 2009), and appear to be capable of traveling considerable distances. Rugen and Materese concluded that larval Pacific cod were transported from waters near the Kenai peninsula and Kodiak Island to locations as far as Unimak Island. In the Gulf of Alaska, it is thought that movement of larvae has a significant shoreward component (Rugen and Materese, Abookire et al. 2001 and 2007, Laurel et al. 2007), but it is not obvious that this is always the case elsewhere in the species' range (Hurst et al. 2012), although Hurst et al. (2015) found that age 0 Pacific cod in the EBS were most abundant in waters along the Alaska peninsula to depths of 50 m.

Laurel et al. (2011) investigated the match-mismatch hypothesis for Pacific cod in the Gulf of Alaska. Their results showed that cold environments allow Pacific cod larvae to bridge gaps in prey availability (i.e., timing and magnitude), but negatively impact survival over longer periods. Under warmer conditions, mismatches in prey significantly impacted growth and survival. However, both yolk reserves and compensatory growth mechanisms reduced the severity of mismatches occurring in the first 3 weeks of development.

Doyle et al. (2009) found that larval retention of Pacific cod during the month of April was key to late spring abundance in the Gulf of Alaska, but it is unknown whether this result holds elsewhere in the species' range. Neidetcher et al. (2014) speculated that spawning locations in the EBS are the product of "an accumulation of conditions beneficial to Pacific cod productivity," with no consistent basis in topography, current structure, or water column hydrology.

Juveniles
Juveniles usually tend to settle near the seafloor (Abookire et al. 2007, Laurel et al. 2007).

Some studies of Pacific cod in the Gulf of Alaska, and also some studies of Atlantic cod, suggest that young-of-the-year cod are dependent on eelgrass, but this may not be the case elsewhere in the species' range. In contrast to other parts of the range of Pacific cod, where sheltered embayments are key nursery grounds, Hurst et al. (2015) found that habitat use of age 0 Pacific cod in the EBS occurs along a gradient from coastal-demersal (bottom depths < 50 m) to shelf-pelagic (bottom depths 60-80 m), with densities near the coastal waters of the Alaska peninsula much higher than elsewhere. Hurst et al. (2012) and Parker-Stetter et al. (2013) also observed age 0 Pacific cod in the shelf-pelagic zone. Hurst et al. (2012) found evidence of density-dependent habitat selection at the local scale, but no consistent shift in distribution of juvenile Pacific cod in response to interannual climate variability. Hurst et al. (2015) state, "The ability to utilize a mosaic of habitats as nursery areas may contribute to the persistence of the Pacific cod population in the Bering Sea,"

Hurst et al. (2015) suggested that habitat use by age 0 Pacific cod in the EBS is related to temperature and the distribution of large-bodied demersal predators. Gotceitas et al. (1997) found that the habitat distribution of age 0 Atlantic cod was influenced by predators.

Leslie matrix analysis of a Pacific cod stock occurring off Korea estimated the instantaneous natural mortality rate of 0-year-olds at 2.49% per day (Jung et al. 2009). This may be compared to a mean estimate for age 0 Atlantic cod (*Gadus morhua*) in Newfoundland of 4.17% per day, with a 95% confidence interval ranging from about 3.31% to 5.03% (Robert Gregory, DFO, *pers. commun.*); and age 0 Greenland cod (*Gadus ogac*) of 2.12% per day, with a 95% confidence interval ranging from about 1.56% to 2.68% (Robert Gregory and Corey Morris, DFO, *pers. commun.*).

Adults
Adult Pacific cod in the EBS are strongly associated with the seafloor (Nichol et al. 2007), suggesting that fishing activity has the potential to disturb habitat. Nichol et al. (2013) observed frequent diel vertical migration. Patterns varied significantly by location, bottom depth, and time of year, with daily depth changes averaging 8 m.

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

At least one study (Ueda et al. 2006) indicates that age 2 Pacific cod may congregate more, relative to age 1 Pacific cod, in areas where trawling efficiency is reduced (e.g., areas of rough substrate), causing their selectivity to decrease. Also, Atlantic cod have been shown to dive in response to a passing vessel (Ona and Godø 1990, Handegard and Tjøstheim 2005), which may complicate attempts to estimate catchability (Q) or selectivity. It is not known whether Pacific cod exhibit a similar response.

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

FISHERY

Description of the Directed Fishery

During the early 1960s, a Japanese longline fishery harvested EBS Pacific cod for the frozen fish market. Beginning in 1964, the Japanese trawl fishery for walleye pollock (*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 1992). The breakdown of catch by gear during the most recent complete five-year period (2013-2017) is as follows: longline gear accounted for an average of 53% of the catch, trawl gear accounted for an average of 30%, and pot gear accounted for an average of 17%.

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 (2013-2017).

Catches of Pacific cod taken in the EBS for the periods 1964-1980, 1981-1990, and 1991-2017 are shown in Tables 2.1a, 2.1b, and 2.1c, respectively. The catches in Tables 2.1a and 2.1b are broken down by fleet sector (foreign, joint venture, domestic annual processing). The catches in Table 2.1b are also broken down by gear to the extent possible. The catches in Table 2.1c are broken down by gear.

Appendix 2.2 contains an economic performance report on the BSAI Pacific cod fishery.

Effort and CPUE

Catch-per-unit-effort (CPUE) data from the 1991-2018 fisheries are shown in Table 2.2, with trawl fishery data shown in Table 2.2a, longline fishery data shown in Table 2.2b, and pot fishery data shown in Table 2.2c. Data in each panel have been normalized to an overall mean of 1.0.

As in the 2017 assessment (Thompson 2017), the time series of catch-per-unit-effort (CPUE) data from the longline fishery was analyzed using a model that estimates a time series of year and month effects. This enables the average (across months) CPUE for 2018 to be estimated even though data for the last few months of the year are not yet available. The estimated year and month effects are shown in the two upper panels of Figure 2.1 and the overall fit to the time series (inverse-variance-weighted $R^2 = 0.91$) is shown in the lower panel. The CPUE for 2018 is estimated to be about 12% below average for the time series, and about 1% below the CPUE for 2017.

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 1991-2018 in Table 2.3. 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 1.4%.

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 2.4. 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 2017 TAC averaged about 85% of ABC (ABC was not specified prior to 1980), and from 1980 through 2017, commercial catch averaged about 93% of TAC. In 10 of these 38 years, TAC equaled ABC exactly, and in 10 of these 38 years, catch exceeded TAC (by an average of 3.6%). However, five of those overages occurred in 2007, 2008, 2010, 2016, and 2017, 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, 2016, and 2017 by up to 6.3%, the overall target catch (Federal TAC plus State GHL) was *not* exceeded.

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

Changes in ABC over time are typically attributable to three factors: 1) changes in resource abundance, 2) changes in management strategy, and 3) changes in the stock assessment model. Assessments conducted prior to 1985 consisted of simple projections of current survey numbers at age. In 1985, the assessment was expanded to consider all survey numbers at age from 1979-1985. From 1985-1991, the assessment was conducted using an *ad hoc* separable age-structured model. In 1992, the assessment was conducted using the Stock Synthesis modeling software (Methot 1986, 1990) with age-based data. All assessments from 1993 through 2003 continued to use the Stock Synthesis modeling software, but with length-based data. Age data based on a revised ageing protocol were added to the model in the 2004 assessment. At about that time, a major upgrade in the Stock Synthesis architecture resulted in a substantially new product, at that time labeled "SS2" (Methot 2005). The assessment was migrated to SS2 in 2005. Changes to model structure were made annually through 2011, then the base model remained constant through 2015, and then a new base model was adopted in 2016 (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.

The time series shown in Table 2.4 can be used to estimate a statistical relationship between ABC and realized catch, which can be helpful for making multi-year forecasts. Because four years have elapsed since such a relationship was most recently estimated (Thompson 2014), it was re-estimated for the present assessment, 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 (Figure 2.2). 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 2019 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

Table 2.5 lists all implemented amendments to the BSAI Groundfish FMP that reference Pacific cod explicitly.

DATA

The first two subsections below describe fishery and survey data that are used in the current stock assessment models. The third subsection describes survey data that are not used in the current stock assessment models, but that may help to provide some context for the survey 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	1977-2018
Fishery	Catch size composition	1977-2018
Fishery	Catch age composition	2010-2017
EBS shelf bottom trawl survey (standard area)	Survey numerical abundance	1982-2018
EBS shelf bottom trawl survey (standard area)	Survey size composition	1982-2018
EBS shelf bottom trawl survey (standard area)	Survey age composition	1994-2017
EBS shelf bottom trawl survey (expanded area)	Survey numerical abundance	1987-2018
EBS shelf bottom trawl survey (expanded area)	Survey size composition	1987-2018
EBS shelf bottom trawl survey (expanded area)	Survey age composition	1994-2017
NBS shelf bottom trawl survey (truncated area)	Survey numerical abundance	2010, 2017-2018
NBS shelf bottom trawl survey (truncated area)	Survey size composition	2010, 2017-2018

Fishery Data Used in the Models

Catch Biomass

Catch estimates for the period 1977-2018 are shown Tables 2.1a, 2.1b, and 2.1c. However, the estimate for 2018 is complete only through October 23. To obtain an estimate of the year-end catch for 2018, the method developed in the 2014 assessment was used (Thompson 2014). After comparing 12 alternative estimators in that assessment, it turned out that the best choice was simply to set the current year's catch during August-December equal to the previous year's catch during those same months, unless this would cause the catch to exceed the ABC, in which case the year-end catch was set equal to the ABC. This procedure resulted in an estimated year-end 2018 catch of 201,000 t, equal to the 2018 ABC.

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

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

Size and Age Composition
Fishery size compositions are presently available from 1977 through the first part of 2018, and are parsed into 1-cm bins for use in the assessment models.

The size composition data in Model 16.6 are based on the data used in Model 11.5, which was the base model from 2011-2015. Model 11.5 was structured with respect to both gear and season, whereas Model 16.6 is structured with only a single gear and a single season. When Model 16.6 was being developed during the 2016 assessment (Thompson 2016), the gear-and-season-specific catch proportions in each year were used to create a weighted average size composition from the size composition data used in Model 11.5, in an attempt to make the data files for the two models as comparable as possible. The same procedure was retained for updating the size composition data used this year in Model 16.6, resulting in the values shown in Table 2.6a. The column labeled "N" on the first page of Table 2.6a gives the sample sizes specified in the SS data file, which have a mean value of 300 and are proportional to the numbers of fish measured in each year (the average number of fish measured across the time series is 199,945 per year). The age-specific values in each row (year) of this table sum to the number of fish measured in that year. The size composition data in Table 2.6a were also used in Models 16.6i, 16.6j, 16,6k, and 18.7.

The 1991-2017 size composition data used last year in Model 17.2 were compiled differently, with each year's record computed by using the week/gear/area catch proportions to create a weighted average, as described in Appendix A of the minutes from the June 2017 Pacific cod models subcommittee meeting and again in the 2017 preliminary assessment (Appendix 2.1 of Thompson 2017). A similar procedure was used to update the size composition data used this year in Model 17.2, resulting in the values shown in Table 2.6b. The only difference in the procedure used this year was that that the catch proportions were based on a month/gear/area stratification rather than the weak/gear/area stratification used last year. The column labeled "N" on the first page of Table 2.6b gives the sample sizes specified in the SS data file, which are equal to the number of hauls or sets sampled in each year. The size composition data in Table 2.6b were also used in Models 18.6 and 18.8.

In the 2017 assessment, four years' worth of fishery age data were available, spanning the years 2013-2016. For this year's assessment, four additional years' worth of fishery age data have become available, representing the 2010-2012 and 2017 fisheries. To generate each year's age-length key, approximately 1000 otoliths from that year's fishery were carefully sub-sampled and aged. Selection of otoliths for the fishery age composition data proceeded as follows: Given a desired total annual sample size of 1000 otoliths, the objectives were, first, to distribute the sample so as to reflect the proportion of the total catch in each gear/area/week combination as closely as possible, and second, conditional on achieving the first objective, to maximize the number of hauls sampled. The resulting age compositions were as follow, where "N" represents the number of hauls or sets sampled for length (rows sum to unity):

Year	N	0	1	2	3	4	5
2010	6514	0.00000	0.00000	0.01451	0.12663	0.40272	0.19933
2011	8804	0.00000	0.00000	0.00896	0.17771	0.24526	0.36574
2012	9287	0.00000	0.00000	0.01222	0.03449	0.34814	0.27280
2013	11126	0.00000	0.00000	0.01186	0.14670	0.11057	0.48885
2014	12165	0.00000	0.00000	0.00848	0.11993	0.29149	0.18957
2015	11309	0.00000	0.00000	0.00642	0.06708	0.32891	0.34409
2016	9773	0.00000	0.00000	0.00228	0.08529	0.20348	0.40852
2017	7154	0.00000	0.00000	0.00000	0.04490	0.31790	0.33394

Year	6	7	8	9	10	11	12+
2010	0.10861	0.06656	0.05559	0.02089	0.00236	0.00188	0.00092
2011	0.12472	0.04414	0.01514	0.01091	0.00538	0.00096	0.00108
2012	0.22332	0.07956	0.01908	0.00672	0.00368	0.00000	0.00000
2013	0.17873	0.04982	0.01175	0.00127	0.00000	0.00000	0.00044
2014	0.27767	0.08306	0.02777	0.00065	0.00085	0.00000	0.00053
2015	0.13146	0.08672	0.02311	0.00860	0.00000	0.00184	0.00176
2016	0.21609	0.05773	0.02615	0.00000	0.00046	0.00000	0.00000
2017	0.23197	0.05912	0.00375	0.00842	0.00000	0.00000	0.00000

Survey Data Used in the Models

Overview of Survey Areas

EBS Shelf Bottom Trawl Survey

Strata 10-62 of the EBS shelf bottom trawl survey (green area in Figure 2.5a) have been sampled annually since 1982, and have historically comprised the "standard" survey area used in the EBS Pacific cod assessment. Strata 82 and 90 of the EBS shelf bottom trawl survey (pink area in Figure 2.5a) have been sampled annually since 1987, but have historically not been used in the EBS Pacific cod assessment, because the survey biomass of Pacific cod estimated in those two strata has typically been a tiny fraction (range = 0.5-8.6%, average = 3.3%) of the survey biomass estimated in the standard area and because the resulting 1986-1987 break in the time series might require estimating a separate catchability coefficient or separate set of selectivity parameters. However, beginning with this year's preliminary assessment (Appendix 2.1), models using the "expanded" area (= standard area plus strata 82 and 90) have been considered along with models using the traditional standard area.

NBS Bottom Trawl Survey

Bottom trawl surveys of the NBS (blue area in Figure 2.5a) were conducted in 2010 and 2017. In 2018, a rapid-response survey covered a "truncated" portion of the NBS (Figure 2.5b). This survey was prompted by unusually warm bottom temperatures on the EBS shelf and concerns that many fish populations had shifted north outside of the EBS survey area. The rapid response NBS survey excluded Norton Sound and nearshore areas, so the total area covered (158,286 km^2) was smaller than the total area covered in the 2010 and 2017 NBS surveys (200,207 km^2). Because of limited time and funding, the 2018 survey utilized a 30×30 nautical mile sampling grid rather than the standard 20×20 nautical mile sampling grid, resulting in a lower sampling density. To make the estimates comparable between the 2018 NBS survey and the 2010 and 2017 NBS surveys, only those stations within the area sampled in 2018 (N=49) were included in the survey estimates for 2010 (N=108) and 2017 (N=110).

Abundance
Area-swept estimates of abundance (in 1000s of fish) obtained from the EBS standard area, EBS expanded area, NBS, and EBS expanded area + NBS are shown in Table 2.7, together with their respective log-scale standard deviations ("Sigma"). Abundance estimates and 95% confidence intervals for the same four time series are shown in Figure 2.3. The abundance estimates from the EBS standard and expanded areas have declined precipitously since 2014 (78% declines in both areas), and the 2018 estimates constitute the all-time low for both areas.

Size and Age Composition
The size compositions (in 1-cm bins) from the bottom trawl surveys for the years 1982-2018 are shown in Table 2.8:

- Table 2.8a shows the time series as configured for use in Model 16.6 (EBS standard area, with sample sizes scaled proportionally to the number of fish measured and normalized to a mean value of 300).
- Table 2.8b shows the time series as configured for Models 16.6i and 16.6j (EBS expanded area + NBS, with sample sizes scaled proportionally to the number of fish measured and normalized to a mean value of 300).
- Table 2.8c shows the time series as configured for Models 16.6k and 18.7 (EBS expanded area and NBS separately, with sample sizes for each area scaled proportionally to the number of fish measured and normalized to a mean value of 300).
- Table 2.8d shows the time series as configured for Model 17.2 (EBS standard area, with sample sizes equal to the number of hauls or sets sampled for length).
- Table 2.8e shows the time series as configured for Models 18.6 and 18.8 (EBS expanded area and NBS separately, with sample sizes equal to the number of hauls or sets sampled for length).

In Tables 2.8a-c, the values in each row sum to the number of fish measured. The average numbers of fish measured for length in the EBS standard area, EBS expanded area, and NBS are 12,026, 12,296, and 2,167, respectively. In Tables 2.8d-e, the values in each row sum to the number of hauls or sets sampled for length.

Recent size compositions are compared in Figure 2.4. The size compositions from the eight most recent surveys of the EBS standard area are shown in Figure 2.4a along with the 1987-2016 mean size composition. While the size compositions from 2011-2016 show clear indications of year classes that are larger than the long-term mean, the 2017 size composition lies entirely below the long-term mean at all sizes below about 52 cm, and the 2018 size composition lies far below the long-term mean at all sizes below about 63 cm. The size compositions from the eight most recent surveys of the EBS expanded area are shown in Figure 2.4b along with the 1987-2016 mean size composition. The 2017 and 2018 size compositions from the expanded area are slightly larger relative to the long-term average than the corresponding size compositions from the standard area. The size compositions from the 2010, 2017, and 2018 EBS expanded area are compared to their NBS counterparts in Figure 2.4c. The within-year size compositions from the two areas are more similar in 2017 and 2018 than in 2010, although this may be due at least in part to the much smaller number of fish measured in the 2010 NBS survey.

Age compositions from the 1994-2017 EBS surveys are shown in Table 2.9, where the values in each row sum to unity. Table 2.9a shows the age compositions for the EBS standard area, with sample sizes as specified in the SS data files for Model 16.6 ("N1," representing the number of fish measured for length after normalizing to a mean value of 300) and Model 17.2 ("N2," representing the number of hauls or sets sampled for length). Table 2.9b shows the age compositions for the EBS expanded area, with samples as specified in the SS data files for Models 16.6i, 16.6j, 16.6k, and 18.7 ("N1," representing the number of

fish measured for length after normalizing to a mean value of 300) and Models 18.6 and 18.8 ("N2," representing the number of hauls or sets sampled for length).

Survey Data Provided for Context Only

Other results from the EBS and NBS shelf bottom trawl surveys, or results from other surveys, may provide some helpful context for the results provided in the previous section. These include estimates of biomass and condition factor from the EBS and NBS shelf bottom trawl surveys and results from the NMFS longline survey and the International Pacific Halibut Commission (IPHC) longline survey. The areas covered by the latter two surveys are shown in Figures 2.5c and 2.5d, respectively.

Other Results from the EBS and NBS Shelf Bottom Trawl Surveys
Area-swept estimates of biomass obtained from the EBS standard area, EBS expanded area, NBS, and EBS expanded area + NBS are shown in Table 2.10, together with their respective standard errors. Biomass estimates, 95% confidence intervals, and the long-term average biomass are shown in Figure 2.6. As with the estimates of abundance (Table 2.7), the biomass estimates from the EBS standard and expanded areas have declined precipitously since 2014 (56% decline in the standard area and 54% decline in the expanded area), although, unlike the 2018 estimates of abundance, the 2018 biomass estimates do not constitute the all-time lows for the respective time series.

The time series of condition factor estimates, expressed as mean log-scale weight-length residual, are shown along with their respective 95% confidence intervals for the EBS and NBS shelf bottom trawl surveys in Table 2.11 and Figure 2.7. The 2011, 2016, and 2018 estimates for the EBS are all slightly positive, but all other estimates from 2008 onward have been negative, and sometimes strongly so.

NMFS Longline Survey
The NMFS longline survey time series (1982-2017, 2-year intervals after 1997) of relative population number (RPN) and relative population weight (RPW) for the EBS are shown, after rescaling relative to the respective mean, in Figure 2.8. RPN for 2017 was down 11% from 2015, and RPW was up 2%. Both are 26-30% below the long-term average. The EBS was not surveyed during 2018.

IPHC Longline Survey
The IPHC longline survey time series (1997-2018) of RPN is shown in Figure 2.9. RPN has declined by 35% since 2015, and the 2018 estimate is about 20% below the long-term average.

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 V3.30.08.03 was used to run the base model in last year's assessment. SS V3.30.12.00 (beta release, including various minor incremental upgrades through August 3, 2018) was used to run all of the models in this final assessment.

Description of Alternative Models

List of Models

Beginning with the final 2015 assessment, model numbering has followed the protocol given by Option A in the SAFE chapter guidelines. The goal of this protocol is to make it easy to distinguish between major and minor changes in models and to identify the years in which major model changes were introduced. Names of models constituting *major* changes get linked to the year that they are introduced (e.g., the current base model, Model 16.6, is one of several models introduced in 2016 that constituted a major change from the then-current base model), while names of models constituting *minor* changes from the original form of the current base model get linked to the name of the current base model (e.g., Model 16.6i refers to a model that constitutes a minor change from Model 16.6, regardless of the fact that it was introduced this year). 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 the current naming convention in Table 2.11 of the 2015 assessment (Thompson 2015).

This year's preliminary assessment included Model 16.6, which was newly adopted as the base model in 2016 (it replaced Model 11.5, which had been the base model since 2011), two models that were introduced in the 2017 assessment (Models 17.2 and 17.6), and 13 new models (Models 16.6a-16.6h and Models 18.1-18.5).

For this final assessment, eight models are presented (see comments BPT12, BPT13, and SSC13 in the "Responses to SSC and Plan Team Comments Specific to this Assessment" subsection of the Executive Summary), with features summarized in the table below. The first four rows following the header row list data sets that are included in the models, the next six rows describe the various ways in which catchability is treated in the models, and the final five rows describe miscellaneous features that are included in three of the models.

Feaure	16.6	16.6i	16.6j	16.6k	17.2	18.6	18.7	18.8
EBS survey strata 82 and 90		x	x	x		x	x	x
NBS survey as separate data set				x		x	x	x
Summed EBS and NBS data sets		x	x					
Fishery agecomps					x	x		x
EBS catchability estimated	x			x	x	x		
Annnually varying EBS catchability				x		x	x	x
NBS catchability estimated				x		x		
Annnually varying NBS catchability				x		x	x	x
EBS+NBS catchability estimated		x	x					
Annually varying EBS+NBS catchability			x					
Prior distribution for natural mortality					x	x		x
Flat-topped double normal selectivity					x	x		x
Annually varying fishery selectivity					x	x		x
Composition N = number of hauls					x	x		x
Harmonic mean composition weights					x	x		x

In greater detail, the features of the eight models are as follow:

- 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.

Models 16.6, 16.6i-16.6k, 17.2, and 18.6 were all requested by either the SSC or both the Team and SSC. Models 18.7 and 18.8 were added by the author after discovering that the results from Models 16.6k and 18.6 suggested that those models may not perform as expected by the Team and SSC.

Selectivity

Models 17.2, 18.6, and 18.8 all feature "age-based, flat-topped, double normal selectivity." There are multiple ways to configure double normal selectivity so as to achieve a flat-topped functional form. As described in the preliminary assessment, the parameter governing the point at which the flat-topped

portion of the function begins ("peak age") and the "ascending width" parameter were the only two parameters estimated internally in the approach adopted here. The others were fixed as follows:

- The parameter defining the length of the flat-topped portion of the curve (as a logit transform between the beginning of the flat-topped portion and the maximum age) was fixed at a value of 10.0, thereby eliminating any descending limb.
- Given the above, the parameters defining the "descending width" and selectivity at the maximum age are rendered essentially superfluous, and were both fixed at a value of 10.0.
- The parameter defining the selectivity at age 0 was fixed at a value of -10.0, corresponding to a selectivity indistinguishable from 0.0.

Prior Distribution for the Natural Mortality Rate
At its December 2016 meeting, the SSC requested that a prior distribution for the natural mortality (*M*) rate be developed, using "the variety of estimates referenced" in the 2016 EBS, AI, and GOA Pacific cod assessments. In response, a prior distribution based on all such estimates, including the estimates of *M* derived in the 2016 EBS and GOA Pacific cod assessments themselves, was developed and applied to Models 17.1-17.6 in the 2017 preliminary assessment (Thompson 2017).

At its October 2017 meeting, the SSC clarified that only a subset of the referenced estimates should be used; specifically, those remaining after removing all estimates from studies "that contained an appreciable amount of the data that is currently used in the stock assessment model." The table below lists all values of *M* referenced in the 2016 EBS, AI, and GOA Pacific cod assessments, including the estimates of *M* derived in the 2016 EBS and GOA Pacific cod assessments themselves. The final column indicates whether the respective value was used in developing the prior distribution that was applied to Models 17.1-17.6 in the 2017 final assessment (Thompson 2017).

Area	Author	Year	Value	Use?
EBS	Low	1974	0.30-0.45	1
EBS	Wespestad et al.	1982	0.7	0
EBS	Bakkala and Wespestad	1985	0.45	0
EBS	Thompson and Shimada	1990	0.29	0
EBS	Thompson and Methot	1993	0.37	0
EBS	Shimada and Kimura	1994	0.96	1
EBS	Shi et al.	2007	0.40-0.50	1
EBS	Thompson et al.	2007	0.34	0
EBS	Thompson	2016	0.36	0
GOA	Thompson and Zenger	1993	0.27	0
GOA	Thompson and Zenger	1995	0.50	0
GOA	Thompson et al.	2007	0.38	0
GOA	Barbeaux et al.	2016	0.47	1
BC	Ketchen	1964	0.56-0.63	1
BC	Fournier	1983	0.65	1
Korea	Jung et al.	2009	0.82	1
Japan	Ueda et al.	2004	0.20	1

Given the data listed above (using only those values with a "1" in the final column, and taking the midpoint of any estimate identified as a range), and assuming a lognormal distribution, the maximum likelihood estimates of μ and σ are -0.6666 and 0.4930, respectively. The resulting distribution has an

arithmetic mean of 0.5798, a geometric mean of 0.5134, a harmonic mean of 0.4547, a mode of 0.4027, and a 95% credibility interval extending from 0.1954 to 1.3493 (Figure 2.10).

Time-Varying Parameters
The procedures for tuning the "sigma" terms have been consistent since the 2017 preliminary assessment (Thompson 2017) and were described again in this year's preliminary assessment (Appendix 2.1). Briefly, the procedures are as follow:

- Recruitment in Models 16.6 and 16.6x: Sigma is estimated internally, using a penalized likelihood approach.
- Catchability: Sigma is estimated iteratively by equating the root-mean-squared-error of the estimated survey abundance equal to the average (design-based) log-scale standard error.
- Selectivity: Sigma is estimated by a procedure that produces the restricted maximum likelihood estimates of the sigma terms in a linear-normal model.

The deviation "type" (additive or multiplicative), range of years, and models using each of the various time-varying parameters other than recruitment is shown below (the first three rows below the header row pertain to catchability deviations, and the final two rows pertain to fishery selectivity deviations):

Parameter	Type	Year range	16.6	16.6i	16.6j	16.6k	17.2	18.6	18.7	18.8
EBS catchability	add.	1982-2018				x		x	x	x
NBS catchability	add.	2010-2018				x		x	x	x
EBS+NBS catchability	add.	1982-2018			x					
Fishery peak age	mult.	1977-2018					x	x		x
Fishery ascend. width	add.	1977-2018					x	x		x

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. Following the procedure established in the 2016 assessment (Thompson 2016), when running a jitter test, the bounds for each parameter in the model were adjusted to match the 99.9% confidence interval (based on the normal approximation obtained by inverting the Hessian matrix). A jitter rate (equal to half the standard deviation of the logit-scale distribution from which "jittered" parameter values are drawn) was set at 1.0 for all models. Standardizing the jittering process in this manner will not explore parameter space as thoroughly as possible; however, it makes the jitter rate more interpretable, and shows the extent to which the identified minimum (local or otherwise) is well behaved.

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

1. The model was re-run starting from the final parameter file from the best jitter run.
2. The resulting new control file, 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.

Parameters Estimated Outside the Assessment Model

Variability in Estimated Age
Variability in estimated age in the assessment models is based on the standard deviation of estimated age between "reader" and "tester" age determinations (note that this is not the same as ageing *bias*, which is estimated internally). Weighted least squares regression, without an intercept, has been used in the past

several assessments to estimate a proportional relationship between standard deviation and age. The regression has traditionally been computed over ages 1 through 13, yielding a slope parameter that is used to estimate standard deviation at age as the product of slope and age. To maintain consistency between models, only survey age data were used to estimate the slope parameter.

For the survey-only data, the estimated slope was 0.085, giving a weighted R^2 of 0.98. This regression corresponds to a standard deviation at age 1 of 0.085 and a standard deviation at age 20 of 1.692.

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 2018) as α = 5.58883E-06 (mean-unbiased) and β = 3.188509.

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 2.12. Although values were calculated for 1977 (the initial year in the model), they were not used in the data files, because SS computes $B_{100\%}$ on the basis of the biology in the initial year, and it seemed more important to have $B_{100\%}$ represent a long-term average than to get the weight-length relationship in 1977 exactly right. Schedules of weight at length (up to 100 cm) are shown for the base parameter values and the offset-adjusted parameter values for each year in Figure 2.11.

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 follows a recommendation from the maturity study's author (James Stark, AFSC, pers. commun.). The age-based parameters were retained for the models in the present assessment.

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

Parameters Estimated Inside the Assessment Model

A total of 79 parameters were estimated inside SS for Model 16.6. These consist of the following:

1. instantaneous natural mortality rate (M)
2. all three von Bertalanffy growth parameters, plus the Richards growth parameter
3. standard deviation of length at ages 1 and 20
4. mean ageing bias at ages 1 and 20
5. log mean recruitment since the 1976-1977 regime shift
6. offset for log-scale mean recruitment before the 1976-1977 regime shift
7. standard deviation of the log-scale recruitment deviations (σ_R)
8. initial (equilibrium) fishing mortality
9. log catchability for the trawl survey
10. deviations for log-scale initial (i.e., 1977) abundance, ages 1-20

11. log-scale recruitment deviations, 1977-2017
12. base values of both selectivity parameters for both the fishery and survey

Parameter counts for the full set of models were as follow:

Model:	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
Count:	79	79	116	128	162	211	126	209

All parameters estimated internally in Model 16.6 were also estimated internally by all of the other models, except:

- In Models 17.2, 18.6, and 18.8, σ_R was estimated by the tuning procedure described in the preliminary assessment (Appendix 2.1).
- The definitions of the selectivity parameters differ in some of the models (logistic in Model 16.6, flat-topped double normal in Models 17.2, 18.6, and 18.8), although the number of base values remain the same (2 for the fishery and 2 for the survey).
- Log EBS survey catchability and log NBS survey catchability were not estimated in Models 18.7 and 18.8.

In addition, the following parameters were also estimated internally by one or more of the models:

- Deviations for log EBS survey catchability, 1982-2018 (Models 16.6k, 18.6, 18.7, 18.8).
- Deviations for log NBS survey catchability, 1982-2018 (Models 16.6k, 18.6, 18.7, 18.8).
- Deviations for log EBS+NBS survey catchability, 1982-2018 (Model 16.6j)
- Deviations for fishery selectivity parameters, 1977-2017 (Models 17.2, 18.6, 18.8).

In all models, uniform prior distributions were used for all parameters except for *M* in Models 17.2, 18.6, and 18.8. It should also be noted that vectors of deviations were constrained by input standard deviations, which are somewhat analogous to a joint prior distribution.

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

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

Objective Function Components

All models in this assessment include likelihood components for catch, initial (equilibrium) catch, trawl survey relative abundance, recruitment, "softbounds" (analogous to a very weak prior distribution designed to keep parameters from hitting bounds), fishery and survey size composition, and survey age composition (although the identity and number of surveys differ between models). In addition, all models except Models 16.6 and 16.6i include a component for parameter deviations; and Models 17.2, 18.6, and 18.8 include components for the prior distribution on *M* and fishery age composition.

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. For many years, the Pacific cod assessments assumed a multinomial sample size equal to the square root of the true length sample size, rather than the true length sample size itself. Given the true length sample sizes observed in the EBS Pacific cod data, this procedure tended to give values somewhat below 400 while still providing SS with usable information regarding the appropriate effort to devote to fitting individual length samples.

Although the "square root rule" for specifying multinomial sample sizes gave reasonable values, the rule itself was largely *ad hoc*. In an attempt to move toward a more statistically based specification, the 2007 assessment used the harmonic means from a bootstrap analysis of the available fishery length data from 1990-2006 (Thompson et al. 2007). The harmonic means were smaller than the actual sample sizes, but still ranged well into the thousands. A multinomial sample size in the thousands would likely overemphasize the size composition data. As a compromise, the harmonic means were rescaled proportionally in the 2007 assessment so that the average value (across all samples) was 300. However, the question then remained of what to do about years not covered by the bootstrap analysis (2007 and pre-1990) and what to do about the survey samples. The solution adopted in the 2007 assessment was based on an observed consistency in the ratios between the harmonic means (the raw harmonic means, not the rescaled harmonic means) and the actual sample sizes: Whenever the actual sample size exceeded about 400 fish, for the years prior to 1999 the ratio was very consistently close to 0.16, and for the years after 1998 the ratio was very consistently close to 0.34.

This consistency was used to specify the missing values as follows: For fishery data, records with actual sample sizes less than 400 were omitted. Then, the sample sizes for fishery length compositions from years prior to 1999 were tentatively set at 16% of the actual sample size, and the sample sizes for fishery length compositions from 2007 were tentatively set at 34% of the actual sample size. For the pre-1982 trawl survey, length compositions were tentatively set at 16% of an assumed sample size of 10,000. For the post-1981 trawl survey length compositions, sample sizes were tentatively set at 34% of the actual sample size. Then, with sample sizes for fishery length compositions from 1990-2007 tentatively set at their bootstrap harmonic means (not rescaled), all sample sizes were adjusted proportionally so that the average was 300.

The same procedure was used in the 2008 and 2009 assessments. For the 2010 assessment, however, this procedure had to be modified somewhat, because the bootstrap values for the 1990-2006 size composition data did not match the new bin and seasonal structures. To be as consistent as possible with the approach used to set sample sizes in the 2008 and 2009 assessments, the 2010 and 2011 assessments set sample sizes by applying the 16/34% rule for *all* size composition records with actual sample sizes greater than 400 (not just those lying outside the set of 1990-2006 fishery data), then rescaling proportionally to achieve an average sample size of 300. The same procedure was used for the 2012-2016 assessments and Model 16.6 in the 2017 assessment, except that the pre-1982 trawl survey data were no longer used. All models in this year's assessment except Models 17.2, 18.6, and 18.8 use the same procedure as the 2012-

2016 assessments. Models 17.2, 18.6, and 18.8, on the other hand, simply set the input sample size equal to the number of hauls (or sets) sampled for length.

Input sample sizes for size composition data are shown for all models in Tables 2.6 (fishery) and 2.8 (survey).

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 and fleet (fishery or survey). In all models except 17.2, 18.6, and 18.8, input sample sizes were specified by scaling the number of otoliths read in each year such that the average across all years was equal to 300. In Models 17.2, 18.6, and 18.8, the input sample sizes were set equal to the number of hauls or sets sampled for length.

Input sample sizes for fishery age composition data (used only in Models 17.2, 18.6, and 18.8) were given in the "Data" section, but are reproduced here for ease of reference:

Year:	2010	2011	2012	2013	2014	2015	2016	2017
N:	6514	8804	9287	11126	12165	11309	9773	7154

Input sample sizes for survey age composition data are shown for all models in Table 2.9.

Note that the age compositions for both the fishery and the survey are used in the marginal forms, not in conditional-age-at-length form.

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

The "sigma" parameters are shown in Table 2.7.

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

RESULTS

Model Evaluation

The models used in this assessment are described under "Description of Alternative Models" above.

Goodness of Fit, Parameter Estimates, and Derived Quantities

Goodness of Fit
Table 2.13 shows the objective function value for each data component in each model, along with the number of parameters in each model, broken down into "free" parameters, parameters with prior distributions, 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, because these counts include parameters with prior distributions and constrained deviations.
- Five data files are used among the eight models (Models 16.6 and 17.2 use data files unique to each of those two models, Models 16.6i and 16.6j share a common data file, Models 16.6k and 18.7 share a common data file, and Models 18.6 and 18.8 share a common data file).
- The data are often weighted differently between models.

The table below provides alternative measures of how well the models fit the survey abundance data:

	EBS(std), EBS(exp), or EBS(exp)+NBS					NBS				
Model	σave	RMSE	MNR	SDNR	Corr.	σave	RMSE	MNR	SDNR	Corr.
16.6	0.106	0.192	0.141	1.853	0.833					
16.6i	0.106	0.182	0.107	1.772	0.798					
16.6j	0.106	0.106	0.065	0.891	0.933					
16.6k	0.105	0.105	0.085	0.894	0.952	0.162	0.162	-0.054	0.895	0.997
17.2	0.106	0.206	0.200	2.008	0.820					
18.6	0.105	0.105	0.106	0.871	0.956	0.162	0.162	-0.052	0.895	0.997
18.7	0.105	0.105	0.244	0.805	0.955	0.162	0.162	-0.339	0.816	0.999
18.8	0.105	0.105	0.250	0.745	0.955	0.162	0.162	-0.204	0.864	0.998

The column labeled "σave" in each half of the table shows the average of the log-scale standard errors arising from the sampling variability in the survey data. The four right-hand columns in each half of the table show root mean squared errors (RMSE; values closer to σave are better), mean normalized residuals (MNR; values closer to zero are better), standard deviations of normalized residuals (SDNR; values closer to unity are better), and correlations between observed and estimated values (values to unity are better).

Note that the models with time-varying catchability (16.6j, 16.6k, 18.6, 18.7, and 18.8) tune the respective constraints on the amount of time variability so that σave=RMSE. Models 16.6j and 16.6k do the best job of achieving an MNR close to zero and an SDNR close to unity for the "main" survey index (EBS(exp)+NBS and EBS(exp), respectively), while Models 16.6k and 18.6 do the best job of achieving an MNR close to zero and an SDNR close to unity for the NBS survey index.

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

Fits to the fishery age composition data are shown for Models 17.2, 18.6, and 18.8 in Figure 2.13. Fits to the survey age composition data are shown for all models in Figure 2.14, and time-aggregated fits to the fishery and survey age composition data are shown in Figure 2.15.

Fits to the fishery size composition data are shown for all models in Figure 2.16. Fits to the survey size composition data are shown for all models in Figure 2.17, and time-aggregated fits to the fishery and survey size composition data are shown in Figure 2.18.

Table 2.14 shows effective sample sizes for each model and data component, following a procedure very similar to the one introduced in last year's assessment (Thompson 2017).

- Cells shaded gray represent constants associated with the data. The quantities in this category consist of:

  - The number of years represented in the particular data type ("Years").
  - The average sample size for the particular data type as specified in the data file ("N"), which, in the case of survey index data, consists of the average number of stations (hauls) sampled over the time series.
  - The average log-scale standard error of the survey index ("SEave").
- Cells shaded blue (the "Mult" column) represent values specified by the modeler that are used to modify the sample sizes for the given data component (compositional data only).
- Cells shaded tan represent model results. The quantities in this category consist of:
  - The harmonic mean of the effective sample size ("Harm."; compositional data only).
  - The root-mean-squared-error of the model's log-scale survey index estimates ("RMSE"; survey index data only).
- Cells shaded green represent a pair of aggregate sample sizes computed from the other columns.
  - For composition data, these cells contain:
    - The aggregate effective sample size *assigned* to the particular data type ("ΣNeff1"), computed as Years×N×Mult.
    - The aggregate effective sample size *achieved* for the particular data type ("ΣNeff2"), computed as Years×Harm.
  - For survey index data, these cells contain the same two quantities (ΣNeff1 and ΣNeff2), but they are computed differently than for composition data:
    - ΣNeff1 = Years×N.
    - ΣNeff2 = Years×N×((SEave+SEextra)/RMSE)^2.

By expressing ΣNeff1 and ΣNeff2 in units of hauls for both composition data and index data, the values for the two data types are comparable.

The ratio ΣNeff2/ΣNeff1 for a given data component provides a measure of how well the model is tuned with respect to that component (specifically, the ratio should equal unity). Red font in any pair of {ΣNeff1, ΣNeff2} values indicates that the respective model was tuned so that the two values are equal. Only Models 18.6 and 18.8 are tuned in this manner for all components.

Table 2.15 breaks down the effective sample sizes for the composition data, by providing values for each year of data. In each part of Table 2.15, the row labeled "Mean" represents the arithmetic mean in the case of input sample size and the harmonic mean in the case of effective sample size. Table 2.15a shows the values for the fishery size composition data (the cells shaded gray for 2010-2017 under Models 17.2, 18.6, and 18.8 indicate that those data are "turned off" to avoid double-counting, given that fishery age composition data are fit for those years in those models), Table 2.15b shows the values for the survey size composition data (the final four rows in the table correspond to the NBS survey), and Table 2.15c shows the values for the age composition data (both fishery and survey for Models 17.2, 18.6, and 18.8). Note that the average input sample sizes in Models 17.2, 18.6, and 18.8 have all been tuned so that they match the respective harmonic mean effective sample sizes.

<u>Parameter Estimates</u>

Table 2.16 displays all of the parameters (except fishing mortality rates, because these are functions of other parameters) estimated either internally or iteratively in the model, along with the standard deviations of internally estimated parameters. Table 2.16 consists of the following parts:

- Table 2.16a shows parameters common to all (or nearly all) models.
- Table 2.16b shows log catchability (base values if time-varying) and selectivity parameters.
- Table 2.16c shows initial (1977) age composition deviations for all models.
- Table 2.16d shows annual log-scale recruitment deviations for all models.

- These are plotted in Figure 2.19.
- Table 2.16e shows catchability deviations for models with time-varying catchability.
- Table 2.16f shows selectivity deviations for models with time-varying fishery selectivity.
- Table 2.16g shows iteratively estimated parameters (standard deviations not available).

Table 2.17 shows estimates of fishing mortality for all models and years.

Table 2.18 and Figure 2.20 show back-transformed catchability for all models and years.

Derived Quantities

Figure 2.21 shows the time series of female spawning biomass relative to $B_{100\%}$ as estimated by each model.

Figure 2.22 shows the time series of total biomass as estimated by each model.

Figures 2.23 and 2.24 show fishery selectivity and survey selectivity as estimated by the models.

Figure 2.25 shows the schedules of mid-year length at age implied by the growth parameters as estimated by the models.

Table 2.19 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 (2019 and 2020) 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.

Retrospective Performance

Retrospective analyses for all of the models are shown in Figure 2.26. Values of ρ (Mohn 1999, equation corrected in the 2013 Retrospective Working Group report) are shown below for spawning biomass, together with lower and upper bounds on acceptable levels defined as a function of *M*, based on results reported by Hurtado-Ferro et al. (2015):

Model:	16.6	16.6i	16.6j	16.6k	17.2	18.6	18.7	18.8
ρ:	0.315	0.207	0.288	0.397	0.475	0.555	0.301	0.477
M:	0.354	0.340	0.340	0.345	0.356	0.364	0.398	0.471
Min:	-0.204	-0.199	-0.199	-0.201	-0.205	-0.207	-0.219	-0.245
Max:	0.277	0.270	0.270	0.273	0.278	0.282	0.299	0.335

Model 16.6i exhibits the lowest value of ρ among all the models, and the only value that falls within the acceptable range implied by Hurtado-Ferro et al. (2015), although the ρ value from Model 18.7 is extremely close to the upper bound of the range.

Choice of Final Model

Criteria

The following criteria were used to choose the final model for this assessment:

1. Are catchability estimates plausible?
2. Is retrospective performance acceptable?
3. Are changes in the complexity of model structure justified?
4. Are changes in model structure appropriately incremental?

Evaluation of the Models Relative to the Criteria

The models were evaluated in terms of the above criteria as follows:

1. Are catchability estimates plausible? Field studies have indicated that bottom trawl survey catchability of EBS Pacific cod is unlikely to be much greater than unity (Somerton 2004). Because the EBS and NBS surveys take place at nearly the same time and in disjoint areas, it is therefore reasonable to prefer models with catchability estimates exhibiting the following characteristics:
    a. For models that use the EBS standard area survey data and exclude the NBS survey data (i.e., Models 16.6 and 17.2), the model estimate of catchability should approximate the ratio of the EBS standard area survey abundance to the combined EBS expanded area and NBS survey abundances.
    b. For models the use the EBS expanded area survey data and NBS survey data separately (i.e., Models 16.6k and 18.6-18.8), the model estimate of catchability for each survey should approximate the ratio of the survey abundance in the respective area to the combined EBS expanded area and NBS survey abundances.
    c. For models that combine the EBS expanded area survey data and NBS survey data into a single index (i.e., Models 16.6i and 16.6j), the model estimate of catchability should approximate unity.

   Because the NBS surveys took place only in 2010, 2017, and 2018, the above comparisons need to be made only in those years. The following table makes those comparisons, using results from Tables 2.7 and 2.18, where "Rel. Abund." denotes relative area-specific survey abundance and "Abs. Diff." denotes the absolute value of the difference between relative area-specific abundance and area-specific catchability, "RMSD" denotes the root-mean-squared difference across all three years, and the color scale extends from red=low to green=high within each row:

		EBS(std)		EBS(exp)				NBS				EBS+NBS	
Year	Quantity	16.6	17.2	16.6k	18.6	18.7	18.8	16.6k	18.6	18.7	18.8	16.6i	16.6j
2010	Rel. Abund.	0.98	0.98	0.99	0.99	0.99	0.99	0.01	0.01	0.01	0.01	1.00	1.00
2010	Catchability	0.97	1.14	1.07	1.23	0.79	0.85	0.01	0.03	0.01	0.02	1.03	1.06
2010	Abs. Diff.	0.01	0.16	0.07	0.24	0.21	0.14	0.01	0.02	0.00	0.01	0.03	0.06
2017	Rel. Abund.	0.69	0.69	0.73	0.73	0.73	0.73	0.27	0.27	0.27	0.27	1.00	1.00
2017	Catchability	0.97	1.14	0.93	1.08	0.67	0.67	0.37	0.60	0.28	0.39	1.03	0.99
2017	Abs. Diff.	0.28	0.45	0.20	0.35	0.06	0.05	0.10	0.33	0.01	0.11	0.03	0.01
2018	Rel. Abund.	0.49	0.49	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	1.00	1.00
2018	Catchability	0.97	1.14	0.89	1.09	0.64	0.67	0.81	1.35	0.64	0.87	1.03	1.17
2018	Abs. Diff.	0.48	0.65	0.39	0.58	0.13	0.17	0.32	0.85	0.15	0.37	0.03	0.17
All	RMSD	0.32	0.47	0.26	0.42	0.14	0.13	0.19	0.53	0.09	0.22	0.03	0.10

   The above table illustrates why Models 18.7 and 18.8 were added to the set of models for this assessment: Their closest counterparts, Models 16.6k and 18.6 respectively, tended not to satisfy the desired approximations. More specifically, Models 16.6k and 18.6 tended to estimate area-specific catchabilities much larger than the respective area-specific relative abundances, particularly in 2017 and 2018 when EBS survey abundances were the smallest and NBS survey abundances were the largest. The lowest RMSD is obtained by Model 16.6i (0.03 for the combined areas), followed by Model 16.6j (0.10 for the combined areas) and Model 18.7 (0.14 for the EBS expanded area and 0.09 for the NBS).

2. Is retrospective performance acceptable? As noted above under "Retrospective Performance," Model 16.6i exhibits the lowest value of ρ among all the models, and the only value that falls within the

acceptable range implied by Hurtado-Ferro et al. (2015), although the ρ value from Model 18.7 is extremely close to the upper bound of the range.

3. Are changes in the complexity of model structure justified? Although many changes from the base model are embodied among the alternative models, not all of them constitute changes in structural complexity. For example, the only difference between Models 16.6 and 16.6i is that the latter uses the combined EBS expanded area and NBS surveys in lieu of the EBS standard area survey used in the former. The features that would most likely qualify as changes in structural complexity are:
    a. Addition of a second survey, with concomitant need to estimate an additional catchability coefficient and selectivity parameters (Models 16.6k and 18.6-18.8).
    b. Addition of randomly time-varying catchability (Models 16.6j, 16.6k, and 18.6-18.8).
    c. Addition of randomly time-varying fishery selectivity (Models 17.2, 18.6, and 18.8).

    The SSC minutes from June 2018 offer this guidance on justifying additional complexity: "Existing assessments should be periodically evaluated for 'complexity creep' and consistency with similar assessments." This begs the question of which assessments qualify as "similar," but, as a first approximation, the set of other Tier 3 BSAI assessments could be viewed as similar to the EBS Pacific cod assessment. Features "a" through "c" above can be evaluated with respect to similar assessments as follows:
    a. Some similar assessments include multiple surveys (typically bottom trawl surveys of the EBS shelf, EBS slope, and Aleutian Islands; or some subset of these).
    b. Few, if any, similar assessments include randomly time-varying catchability.
    c. Some similar assessments include randomly time-varying fishery selectivity.

    Given the above evaluation, the only models that have levels of complexity consistent with similar assessments are Models 16.6, 16.6i, and 17.2.

4. Are changes in model structure appropriately incremental? The SSC has often expressed a preference for incremental changes in model structure:
    - SSC minutes, June 2012: "…The SSC encourages the authors to evaluate changes in one or a few structural elements at a time."
    - SSC minutes, June 2013: "...The SSC recommends that model changes be kept to a minimum to ensure that we can track model sensitivities to specific changes in model structure."
    - SSC minutes, December 2013: "…The SSC discussed the need for a more incremental approach to implementing changes to the model…."
    - SSC minutes, December 2015: "...The SSC has repeatedly stressed the need to incrementally evaluate model changes...."

    Given the relatively stable level of the combined EBS and NBS survey biomass over the last few years (Figure 2.6), the stock does not appear to be in an emergency situation that might render an incremental approach inappropriate. On the contrary, given the uncertain effects of the large and potentially unprecedented movements of Pacific cod from the EBS and NBS that appear to have taken place in the last few years, an incremental approach to changes in model structure might be especially important at this particular time, with the understanding that additional changes might be called for in the future as more information becomes available. While it is difficult to determine exactly which of the eight candidate models in this assessment qualify as involving only incremental changes in model structure, it is clear that Model 16.6 would qualify by definition, and Model 16.6i would likely qualify also.

On the basis of the above evaluations of the models relative to the criteria, Model 16.6i is chosen as the final model for this assessment.

Final Parameter Estimates and Associated Schedules
As noted previously, estimates of all statistically estimated parameters (except fishing mortality rates) are shown for all models in Table 2.16. Estimates of annual fishing mortality rates are shown for all models in Table 2.17.

Schedules of begin-year length at age, mid-year length at age, and selectivity at age (both fishery and survey) from Model 16.6i are shown in Table 2.20.

Time-Varying Weight at Age
Schedules of time-varying weight at age from Model 16.6i are shown in Table 2.21. Note that model-estimated weights at ages 1-6 are lower than average for 2014-2017, although ages 1 and 2 are rarely encountered in the fishery. For ages 3-6, the decreases relative to the respective averages for the time series are all less than 10%.

Time Series Results

Definitions
The biomass estimates presented here will be defined in three ways: 1) age 0+ biomass, consisting of the biomass of all fish aged 0 years or greater in January of a given year; 2) age 3+ biomass, consisting of the biomass of all fish aged 3 years or greater in January of a given year; and 3) spawning biomass, consisting of the biomass of all spawning females in a given year. The recruitment estimates presented here will be defined as numbers of age 0 fish in a given year. To supplement the full-selection fishing mortality rates already shown in Table 2.17, an alternative "effective" fishing mortality rate will be provided here, defined for each age and time as $-\ln(N_{a+1,t+1}/N_{a,t})-M$, where N = number of fish, a = age measured in years, t = time measured in years, and M = instantaneous natural mortality rate. In addition, the ratio of full-selection fishing mortality to $F_{35\%}$ will be provided.

Biomass
Table 2.22 shows the time series of age 0+, age 3+, and female spawning biomass since 1977 as estimated last year in the model accepted by the SSC and this year (projections through 2019 are also shown for this year's assessment). The estimated spawning biomass time series are accompanied by their respective standard deviations.

The estimated time series of age 0+ and female spawning biomass are shown, together with the observed time series of trawl survey biomass, in Figure 2.27. Confidence intervals are shown for estimates of female spawning biomass and for the trawl survey biomass estimates.

Recruitment and Numbers at Age
Table 2.23 shows the time series of age 0 recruitment (1000s of fish) for the years since 1977 as estimated last year in the model accepted by the SSC and this year. Both 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 0.99.

For the time series as a whole, the largest year class appears to have been the 2008 cohort, and the year classes spawned between 2008 and 2013 include the top three year classes of all time (2008, 2011, and 2013). The set of year classes comprising the top ten is exactly the same this year as in the model accepted by the SSC last year.

In the model accepted by the SSC last year, the 2014 and 2016 cohorts were estimated to be two of the three smallest in the time series. This year, the 2014, 2016, and 2017 cohorts are estimated to be three of the six smallest in the time series, and the 2017 cohort is estimated to be the smallest in the time series.

Recruitment estimates for the entire time series (1977-2017) are shown in Figure 2.28, along with their respective 95% confidence intervals.

The coefficient of autocorrelation for this year's estimated recruitment time series is –0.07.

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

The estimated time series of numbers at age is shown in Table 2.24.

Fishing Mortality
Table 2.25 shows "effective" fishing mortality by age and year for ages 1-19 and years since 1977.

Figure 2.29 plots the estimated/projected trajectory of relative fishing mortality ($F/F_{35\%}$) and relative female spawning biomass ($B/B_{35\%}$) from 1977 through 2020 based on full-selection fishing mortality, overlaid with the current harvest control rules. In 2016, the base model changed from Model 11.5 (which had served as the base model from 2011-2015) to Model 16.6, which generally gave lower estimates of relative spawning biomass than either Model 11.5 or previous models. Model 16.6i likewise gives lower estimates than previous models, to the extent 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 1991-2017.

In response to comment SSC5, Figure 2.30 shows the distribution of projected 2019 fishing mortality relative to $F_{35\%}$, conditional on 2019 catch being equal to the 2019 maximum permissible ABC, as estimated by Model 16.6i.

Harvest Recommendations

The results presented in this section are based on Model 16.6i. Because this model differs from Model 16.6 (the model adopted as the base model last year by the SSC), a set of parallel results for the items in this section, but based on Model 16.6, is provided in Appendix 2.5.

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

$F_{OFL} = 0$

$F_{ABC} = 0$

Model 16.6i's estimates $F_{35\%}$ and $F_{40\%}$ are 0.38 and 0.31, respectively.

Model 16.6i's estimates of $B_{100\%}$, $B_{40\%}$, and $B_{35\%}$ are 658,000 t, 263,000 t, and 230,000 t, respectively.

Specification of OFL and Maximum Permissible ABC
Given the assumptions of Scenario 2 (below), female spawning biomass for 2019 and 2020 is estimated by Model 16.6i to be 290,000 t and 246,000 t, respectively, the first of which is above the $B_{40\%}$ value of 263,000 t but the second of which is below, thereby placing Pacific cod in Tier 3a for 2019 but Tier 3b for 2020. Given this, Model 16.6i estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2019 and 2020 as follows:

Year	Overfishing Level	Maximum Permissible ABC
2019	OFL = 216,000 t	maxABC = 181,000 t
2020	OFL = 164,000 t	maxABC = 137,000 t
2019	*FOFL* = 0.38	*maxFABC* = 0.31
2020	*FOFL* = 0.35	*maxFABC* = 0.29

The age 0+ biomass projections for 2019 and 2020 from Model 16.6i are 823,000 t and 683,000 t.

For comparison, the age 3+ biomass projections for 2019 and 2020 from Model 16.6i are 812,000 t and 642,000 t.

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).

In previous years, the standard harvest scenarios were made using the AFSC's "Proj" program. For this year's assessment, however, the projections were made within SS.

Year-end catch for 2018 was estimated to equal the 2018 ABC (201,000 t), using the method described under "Catch Biomass" in the "Data" section. 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 2019 and 2020, 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 2019 recommended in the assessment to the *max* F_{ABC} for 2019, and where catches for 2019 and 2020 are estimated at their most likely values given the 2019 and 2020 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 2013-2017 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 2018 or 2) above 1/2 of its MSY level in 2018 and expected to be above its MSY level in 2028 under this scenario, then the stock is not overfished.)
>
> *Scenario 7*: In 2019 and 2020, 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 2020 or 2) above 1/2 of its MSY level in 2020 and expected to be above its MSY level in 2030 under this scenario, then the stock is not approaching an overfished condition.)

Projections corresponding to the standard scenarios are shown for Model 16.6i in Table 2.26.

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 2019, it does not provide the best estimate of OFL for 2020, because the mean 2019 catch under Scenario 6 is predicated on the 2019 catch being equal to the 2019 OFL, whereas the actual 2019 catch will likely be less than the 2019 OFL. Table 2.19 contains the appropriate one- and two-year ahead projections for both ABC and OFL under Model 16.6i.

ABC Recommendation
Since 2005, the SSC has set ABC at the maximum permissible level every year with the exceptions of the 2007, 2014, and 2015 assessment cycles, when, in each case, the SSC held the ABCs for the next two years constant at the then-current level. Specifications for 2006-2011 were set under Tier 3b, and specifications for 2012-2018 (and preliminary specifications for 2019) were set under Tier 3a.

The recommended ABCs for 2019 and 2020 are 181,000 t (Tier 3a) and 137,000 t (Tier 3b), respectively, representing the maximum permissible levels under Model 16.6i.

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 (2017) is 237,858 t. This is less than the 2017 OFL of 284,000 t. Therefore, the EBS Pacific cod stock is not being subjected to overfishing.

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

Is the stock currently overfished? This depends on the stock's estimated spawning biomass in 2018:

a. If spawning biomass for 2018 is estimated to be below ½ $B_{35\%}$, the stock is below its MSST.
b. If spawning biomass for 2018 is estimated to be above $B_{35\%}$, the stock is above its MSST.
c. If spawning biomass for 2018 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 2.26e). If the mean spawning biomass for 2028 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 2.26f):

a. If the mean spawning biomass for 2020 is below ½ $B_{35\%}$, the stock is approaching an overfished condition.
b. If the mean spawning biomass for 2020 is above $B_{35\%}$, the stock is not approaching an overfished condition.
c. If the mean spawning biomass for 2020 is above 1/2 $B_{35\%}$ but below $B_{35\%}$, the determination depends on the mean spawning biomass for 2030. If the mean spawning biomass for 2030 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 2.26e and 2.26f, the stock is not overfished and is not approaching an overfished condition.

ECOSYSTEM CONSIDERATIONS

Ecosystem Effects on the Stock

A primary ecosystem phenomenon affecting the Pacific cod stock seems to be the occurrence of periodic "regime shifts," in which central tendencies of key variables in the physical environment change on a scale spanning several years to a few decades (Zador, 2011). One well-documented example of such a regime shift occurred in 1977, and shifts occurring in 1989 and 1999 have also been suggested (e.g., Hare and Mantua 2000). As in previous assessments, an attempt was made in the present assessment to estimate the change in mean recruitment of EBS Pacific cod associated with the 1977 regime shift. According to Model 16.6i, pre-1977 mean recruitment was only about 31% of post-1976 mean recruitment. Establishing a link between environment and recruitment within a particular regime is more difficult. In the 2004 assessment (Thompson and Dorn 2004), for example, the correlations between age 1 recruits spawned since 1977 and monthly values of the Pacific Decadal Oscillation (Mantua et al. 1997) were computed and found to be very weak.

In the 2012 assessment, annual log-scale recruitment deviations estimated by the assessment model were regressed against each of several environmental indices summarized by Zador (2011). The highest univariate correlation was obtained for the spring-summer North Pacific Index (NPI), which was developed by Trenberth and Hurrell (1994). The NPI is the area-weighted sea level pressure over the region 30°N-65°N, 160°E-140°W. Further investigations were conducted with monthly NPI data from the Climate Analysis Section of the National Center for Atmospheric Research. The best univariate model obtained in the 2012 analysis was a linear regression of recruitment deviations from 1977-2011 against the October-December average NPI (from the same year). Vestfals et al. (2014) have also noted a positive correlation between Pacific cod recruitment and the NPI, although not the October-December average NPI in particular.

In each assessment since 2012, the regression analysis has been updated. This year's regression resulted in a correlation of 0.38 (R^2=0.15), a substantial reduction from the correlation of 0.53 (R^2=0.28) obtained in the 2017 analysis (Thompson 2017). The time series, regression line, and 95% confidence interval from this year's regression are shown in the upper panel of Figure 2.31. According to this regression, the probability of the 2017 year class being higher than the median for the time series is 77%. However, the datum for 2017 (magenta diamond in the upper panel) falls not only well below the predicted value from the regression, but even well below the lower 95% confidence interval of the regression; in fact, the error for 2017 is by far the largest (in absolute value) in the time series.

In each assessment since 2013, the main regression analysis has been accompanied by a cross-validation analysis involving creation of 100,000 "training" data sets, each one obtained by randomly sub-sampling 50% of the data without replacement. A regression was performed on each of the training sets, and then the performance of each regression was computed against the corresponding "test" (i.e., non-training) data set. When the NPI *was not* included as an explanatory variable (i.e., only the intercept of the regression was estimated), the RMSE (computed across all 100,000 test data sets) was 0.68, but when the NPI *was* included as an explanatory variable, the RMSE was reduced to 0.66. The distribution of slope parameter estimates from the cross-validation is shown in the middle panel of Figure 2.31. Note that nearly the entire distribution is well above zero, indicating that the observed correlation is very unlikely to be entirely spurious. In previous analyses, two years, 1990 and 2002 (yellow and green diamonds in the upper panel), turned out to be far more influential than any other year in determining the magnitude of the estimated slope, and both of these influences were negative. This year, however, the 2016 datum proved

to be the most influential by far, and its influence was likewise negative (lower panel of Figure 2.31). In other words, the positive slope is not due to the influence of outliers; if anything, the outliers are making the relationship appear less strong than would be the case without them.

Nevertheless, the marked degradation in the performance of the relationship observed this year calls into question whether this analysis should continue to be updated in the future.

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

Abookire et al. (2007) found that young-of-the-year Pacific cod near Kodiak Island fed mainly on small calanoid copepods, mysids, and gammarid amphipods. Moss et al. (2016) found that age 0 Pacific cod in the central Gulf of Alaska consumed mostly copepods and amphipods. Poltev and Stominok (2008) found that young-of-the-year walleye pollock played a major role in the diet of juvenile Pacific cod near the Kuril Islands and Kamchatka. Strasburger et al. (2014) found that age 0 (juvenile) Pacific cod in the southeastern Bering Sea consumed primarily euphausiids, snow and Tanner crab larvae, amphipods, sea snails, and arrow worms. Farley et al. (2016) found that diet of age 0 (juvenile) Pacific cod in the EBS varied with temperature, with high proportions of age 0 walleye pollock during warm years and a shift to euphausiids and large copepods during cool years.

Fishery Effects on the Ecosystem

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

Incidental Catch Taken in the Pacific Cod Fisheries

Incidental catches taken in the Pacific cod fisheries, expressed as proportions of total incidental EBS catches (i.e., across all targets) for the respective species, are summarized in Tables 2.27-2.30. Catches for 2017 in each of these tables are incomplete. Table 2.27 shows incidental catch of FMP species taken from 1991-2017 by each of the three main gear types. Table 2.28 shows incidental catch of certain species of squid and members of the former "other species" complex taken from 2003-2017, aggregated across gear types. Table 2.29 shows incidental catch of prohibited species taken from 1991-2017, aggregated across gear types. Note that all entries for 2003 are marked "n/a" in Table 2.29 due to problems in the database for that year, which are under investigation. Table 2.30 shows incidental catch of non-target species groups taken from 2003-2017, aggregated across gear types.

Steller Sea Lions

Sinclair and Zeppelin (2002) showed that Pacific cod was one of the four most important prey items of Steller sea lions in terms of frequency of occurrence averaged over years, seasons, and sites, and was

especially important in winter. Pitcher (1981) and Calkins (1998) also showed Pacific cod to be an important winter prey item in the GOA and BSAI, respectively. Furthermore, the size ranges of Pacific cod harvested by the fisheries and consumed by Steller sea lions overlap, and the fishery has operated to some extent in the same areas used by Steller sea lion as foraging grounds (Livingston (ed.), 2002).

One of the main research emphases of the AFSC Fisheries Interaction Team (now disbanded) was to determine the effectiveness of management measures designed to mitigate the impacts of the Pacific cod fisheries (among others) on Steller sea lions. A study conducted in 2002-2005 using pot fishing gear demonstrated that the local concentration of cod in the Unimak Pass area is very dynamic, so that fishery removals did not create a measurable decline in fish abundance (Conners and Munro 2008). A preliminary tagging study in 2003–2004 showed some cod remaining in the vicinity of the release area in the southeast Bering Sea for several months, while other fish moved distances of 150 km or more north-northwest along the shelf, some within a matter of two weeks (Rand et al. 2015).

Seabirds

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

Fishery Usage of Habitat

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

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

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

Impacts of the Pacific cod fisheries on essential fish habitat were further analyzed in an environmental impact statement by NMFS (2005), followed by "5-year reviews" in 2010 and 2017 (NMFS 2010 and 2017, respectively).

DATA GAPS AND RESEARCH PRIORITIES

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

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Ongoing contributions: Rick Methot developed the Stock Synthesis software used to conduct the Pacific cod assessments over the last many years. Numerous AFSC personnel and countless fishery observers collected nearly all of the raw data that were used in this assessment.

Reviewers: Anne Hollowed and the BSAI Groundfish Plan Team provided reviews of 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 1991-2018 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 2014-2018 include the State-managed fishery. Catches for 2018 are through October 23.

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	41,300	81,840	19,725	142,866
2011	64,088	117,075	28,064	209,226
2012	75,536	128,513	28,738	232,787
2013	81,619	124,823	30,262	236,704
2014	72,262	127,271	39,195	238,728
2015	66,680	128,217	37,942	232,838
2016	72,598	127,937	47,086	247,620
2017	68,906	122,768	46,184	237,858
2018	58,859	77,808	36,794	173,461

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

Year	1	2	3	4	5	6	7	8	9	10	11	12
1991	1.043	1.380	1.475	1.286	0.684	0.515	0.735					
1992	1.471	1.310	1.327	0.913	0.558	0.419		1.457				
1993	1.195	1.319	1.341	1.011	0.782	1.220		1.195	0.774	1.111	0.772	
1994	0.649	1.277	1.530	0.861	0.609	0.681		1.050	0.925	1.341		
1995	1.217	2.144	1.443	1.097			1.372	1.198		0.975		
1996	0.810	1.242	0.922	0.674	0.621	0.811		1.067		0.782	0.683	
1997	1.531	1.737	1.343	0.832	0.513		0.718	0.589	0.201		0.724	
1998	1.219	1.434	0.854	0.476	0.428	0.687	0.744	0.568	0.653	1.132	0.390	
1999	0.582	1.185	0.883	0.692	0.377		0.342	0.442	0.658	0.396	0.300	
2000	0.765	0.812	0.957	0.518	0.949	0.314	0.357	0.306	0.463			
2001	0.407	0.630	0.678	0.365	0.441	1.620	1.334	0.449	0.322	0.218		
2002	0.687	0.871	0.852	0.402	0.639	1.277	0.845	0.317	0.333	0.454		
2003	0.574	0.566	0.841	0.494	0.370	1.498	1.204	0.417	0.489			
2004	1.588	1.479	1.298	0.641	0.777	0.766	0.755	0.559	0.422	0.263		
2005	0.793	1.084	1.487	0.520	0.658	0.525	0.340					
2006	0.812	0.820	1.055	1.518	0.713		0.463	0.612				
2007	0.483	0.767	1.197	0.980	0.841	1.090	0.534	0.356				
2008	0.379	0.649	0.936	0.989	0.550	0.284	1.835	1.600	0.585	1.421		
2009	0.406	0.923	1.278	1.472	0.257	0.751	1.069	1.257	1.080	1.313	0.656	
2010	0.758	0.957	1.352	0.749	0.380	1.084	0.673	1.830	1.807	1.428	0.926	
2011	1.335	1.121	2.079	0.918	1.272	0.680	1.212	1.391	1.296	1.268	0.488	
2012	2.920	2.145	2.818	1.239	3.029	1.285	0.335	1.122	0.975	1.319		1.218
2013	1.904	1.437	1.003	2.038	1.025	0.606	1.274	1.517	2.237	1.341	0.397	
2014	1.314	1.319	1.392	1.497	1.529	0.566	0.558	1.199	1.440		0.561	
2015	0.432	1.344	1.782	1.353	1.390	1.250	0.874	2.260	0.532	1.087		
2016	1.122	1.579	2.400	1.055	0.576	0.737	0.818	0.626	0.620	0.748	1.296	
2017	0.940	2.113	1.962	1.386	0.674	0.802	0.537	0.346	0.222			
2018	1.262	1.803	5.703	4.137	0.477	0.586	0.321	0.459				

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

Year	1	2	3	4	5	6	7	8	9	10	11	12
1991	1.909	2.138	1.915	1.734	1.771	1.538	1.171	1.284	1.121	0.882	0.928	1.098
1992	1.382	1.733	1.549	1.571	1.141	0.893	0.882	0.959	0.891			
1993	1.155	1.229	1.308	1.136	1.007	0.628						
1994	1.314	1.335	1.426	1.265	1.297				1.062	1.025		
1995	1.518	1.730	1.595	1.465	1.382				1.127	0.977	1.164	1.197
1996	1.610	1.578	1.415	1.330	1.220				0.951	1.023	1.072	
1997	1.738	1.857	1.493	1.531	1.196				1.076	1.044	0.998	1.129
1998	1.553	1.689	1.257	0.996	0.906				0.689	0.743	0.901	0.933
1999	1.319	1.386	1.159	1.071	1.221	0.927		0.831	0.917	0.845	0.941	1.080
2000	1.534	1.102	1.193	0.967	1.098			0.859	0.749	0.673	0.717	0.830
2001	1.072	1.059	1.027	0.919	0.948	1.020	0.797	0.764	0.705	0.719	0.712	0.912
2002	1.239	1.234	1.226	1.245	0.992		0.700	0.711	0.678	0.643	0.693	0.768
2003	0.912	0.971	1.038	0.834	0.788	0.665	0.654	0.629	0.610	0.630	0.623	0.731
2004	0.944	1.116	1.083	1.007	0.701	0.606	0.663	0.591	0.551	0.564	0.715	0.964
2005	1.129	1.150	1.231	1.254		0.688	0.700	0.622	0.579	0.599	0.642	0.807
2006	1.306	1.454	1.490	1.171			0.663	0.808	0.706	0.613	0.779	0.806
2007	1.300	1.386	1.260				0.722	0.851	0.674	0.651		1.153
2008	1.424	1.495	1.367	1.510		0.440	0.636	0.660	0.545	0.488	0.636	1.245
2009	1.578	1.733	2.108			0.674	0.699	0.670	0.623	0.607	0.659	1.029
2010	1.349	1.583	1.662				0.730	0.699	0.620	0.603	0.750	0.940
2011	1.253	1.340	1.379	1.139	0.826	0.722	0.600	0.635	0.674	0.701	0.751	0.888
2012	1.422	1.398	1.078	1.093	0.909	0.921	0.666	0.602	0.554	0.596	0.701	1.042
2013	1.379	1.298	1.212	1.165	0.928	0.675	0.733	0.664	0.627	0.648	0.780	0.989
2014	1.012	1.181	0.946	0.957	0.782	0.661	0.581	0.627	0.648	0.696	0.772	0.832
2015	0.950	1.156	1.101	0.959	0.883	0.779	0.834	0.717	0.642	0.672	0.772	0.937
2016	1.132	1.297	1.046	0.980	0.925	0.756	0.763	0.754	0.738	0.691	0.789	0.929
2017	1.010	1.350	1.182	1.053	0.898	0.790	0.672	0.553	0.580	0.672	0.884	1.016
2018	1.504	1.549	1.297	1.276	0.846	0.691	0.543	0.528	0.718			

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

Year	1	2	3	4	5	6	7	8	9	10	11	12
1991							0.878	0.971	1.723	1.312		1.014
1992					1.034	0.795	0.827	0.436	0.369			
1993				1.168	1.243							
1994			1.083	1.268	1.059				1.418	1.309		
1995			1.123	1.345	1.020	0.905	0.971	1.017	0.607	0.782	0.833	0.707
1996			0.979	1.029	0.770	0.805	0.718	0.676	0.685	0.687	0.739	
1997			1.033	1.298	0.644	0.657	0.598	0.696	0.460	0.729	0.528	0.586
1998				1.063	0.707	0.591	0.758	0.486	0.466	0.412	0.409	0.697
1999			0.669	0.935	0.659	0.550			0.472	0.548		
2000		0.778	0.621									
2001		0.990	0.889						0.617	0.694	0.526	
2002		1.122	0.845						0.588	0.574	0.686	
2003		1.012							0.791	0.858	0.841	
2004	0.853	1.098	0.933						0.666	0.699	0.910	
2005	1.336	1.127							0.651	0.590		
2006	1.143	1.123		1.751					0.672	0.923	0.520	
2007	0.867	1.108							0.855	1.274		
2008	1.119								0.846	0.601		
2009	1.259											
2010	1.180								1.163	1.035	1.439	
2011	1.806								1.138	1.054		
2012	1.965								0.786	1.167		
2013	1.786	1.709							1.309	1.120	1.232	
2014	1.342	1.745							1.239	0.898	0.783	1.418
2015	1.264	1.855	1.888	1.397					1.317	1.045	0.908	1.188
2016	1.216	1.513	1.588	1.654					1.380	1.006	0.986	1.088
2017	1.285	2.360							0.973	0.965	1.010	0.761
2018	1.239		2.493									

Table 2.3—Discards (t) and discard rates (%) of Pacific cod in the Pacific cod fishery, by area, gear, and year for the period 1991-2018 (2018 data are current through September 23). The small amounts of discards taken by other gear types have been merged proportionally into the gear types shown. Note that Amendment 49, which mandated increased retention and utilization, was implemented in 1998.

	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	154	1,403	22	1,578	1.08	1.72	0.11	1.37
2011	121	1,861	36	2,018	0.42	1.59	0.13	1.16
2012	136	1,761	44	1,941	0.38	1.37	0.15	1.01
2013	220	3,066	90	3,376	0.58	2.46	0.30	1.75
2014	192	2,893	155	3,241	0.50	2.28	0.40	1.58
2015	141	2,374	104	2,619	0.43	1.85	0.27	1.32
2016	119	2,547	86	2,752	0.29	1.99	0.18	1.28
2017	257	1,934	79	2,270	0.67	1.58	0.17	1.09
2018	144	1,076	41	1,261	0.40	1.50	0.13	0.90

Table 2.4—History of BSAI (1977-2013) and EBS (2014-2018) Pacific cod catch, TAC, ABC, and OFL (t). Catch for 2018 is through October 23. 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	238,669	246,897	255,000	299,000
2015	232,803	240,000	255,000	346,000
2016	247,605	238,680	255,000	390,000
2017	237,858	223,704	239,000	284,000
2018	173,461	188,136	201,000	238,000

Table 2.5 (page 1 of 2)—Amendments to the BSAI Fishery Management Plan (FMP) that reference Pacific cod explicitly (excerpted from Appendix A of the FMP).

Amendment 2, implemented January 12, 1982:

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

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

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

Amendment 10, implemented March 16, 1987:

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

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

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

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

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

Amendment 49, implemented January 3, 1998:

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

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

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

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

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

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

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

(Continued on next page.)

Table 2.5 (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 113, implemented November 23, 2016:

1. Reserves up to 5,000 mt of TAC in the AI non-CDQ Pacific cod fishery exclusively for harvest by vessels directed fishing for AI Pacific cod for processing by Aleutian Islands shoreplants from January 1 until March 15.
2. Limits the amount of the trawl CV sector's BSAI Pacific cod A-season allocation that can be caught in the Bering Sea subarea before March 21
3. Imposes the Aleutian Islands Catcher Vessel Harvest Set-Aside if NMFS is notified in advance as specified in regulations implementing the FMP amendment and certain performance measures are met.

Table 2.6a (page 1 of 5)—Fishery survey size composition as used in Models 16.6, 16.6i-k, and 18.7; by year and cm (input N in column 2).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1977	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	5	9	14	9	24
1978	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	2	6	9	39	46	39	39	25	18	16	6	7
1979	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	9	24	44	32	71	105	149	178
1980	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	15	13	31	35	33	54	87	110
1981	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2	2	2	3	2	9	7	21	46	56	125	230	320	356	420
1982	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	3	1	2	2	4	10	29	56	66	56
1983	56	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	12	14	4	18	28	25	47	88	120	131	114	87	84
1984	137	0	0	0	0	0	0	0	0	2	0	2	0	3	6	8	13	47	77	86	95	112	83	109	179	246	375	475	518	499	494	480	502	515	528
1985	203	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	4	4	0	0	1	0	1	2	13	30	36	50	72	140	165	170
1986	177	0	0	0	0	0	0	0	0	2	2	5	5	12	21	4	6	12	26	24	35	45	59	47	89	129	147	179	306	437	606	723	762	852	820
1987	337	0	0	0	0	0	0	0	0	0	0	2	1	2	8	18	21	15	15	33	14	23	36	77	84	131	222	309	380	391	431	504	513	507	536
1988	105	0	1	0	0	0	1	0	0	0	0	0	0	1	1	2	2	1	3	1	4	13	11	7	14	27	59	113	218	303	436	527	648	727	678
1989	69	0	0	0	0	0	0	0	0	0	0	0	0	0	3	1	0	4	6	3	3	2	1	1	2	9	22	58	113	96	190	203	266	339	322
1990	258	0	0	0	0	0	0	0	0	0	0	0	0	0	7	4	2	1	6	2	15	49	36	66	132	166	343	363	595	485	574	545	554	547	529
1991	355	0	0	0	0	0	0	0	0	0	2	0	2	2	6	1	6	6	10	8	11	14	40	86	153	281	424	619	808	904	875	836	808	827	797
1992	368	0	0	0	0	0	0	0	0	2	0	3	5	6	3	12	2	13	8	16	16	29	28	68	76	117	167	306	379	463	669	784	921	1001	1040
1993	231	0	0	0	0	1	0	0	0	0	0	0	1	3	4	1	4	5	10	13	9	21	20	37	63	100	179	375	536	642	747	754	782	783	828
1994	370	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	1	6	7	17	9	19	45	75	128	220	416	620	948	1167	1473	1687	1740	1743	1459
1995	367	0	0	0	0	0	0	0	0	0	0	0	0	9	12	14	16	22	23	22	28	40	46	80	77	111	119	151	167	213	239	222	288	344	450
1996	461	0	0	0	0	0	2	0	0	3	3	3	5	11	5	16	16	8	23	12	5	14	11	53	81	199	289	443	582	684	716	724	729	693	663
1997	500	0	2	2	0	8	0	2	0	2	5	0	2	8	17	29	50	49	59	47	53	23	42	55	78	154	266	393	665	902	1136	1236	1443	1432	1362
1998	444	0	0	0	0	0	1	0	0	0	1	0	3	3	4	4	1	1	11	11	15	9	55	107	212	316	474	613	637	685	699	659	625	603	701
1999	402	0	2	3	2	0	1	1	2	0	0	0	0	1	0	2	5	3	4	0	4	2	4	4	24	43	76	144	204	211	182	197	206	181	253
2000	423	0	1	2	1	2	1	0	2	0	9	0	0	0	0	1	0	1	1	1	0	2	3	1	4	18	31	51	51	68	60	59	85	106	143
2001	446	0	1	6	0	1	0	0	0	0	0	0	0	1	1	0	0	2	3	4	2	2	1	3	6	4	9	11	21	37	45	73	102	152	233
2002	488	0	4	5	4	0	4	0	0	0	0	2	2	0	4	2	3	6	8	5	8	10	10	21	18	38	45	92	134	196	226	294	342	399	490
2003	609	0	4	7	7	0	0	1	0	0	0	0	3	1	0	0	1	1	3	2	0	1	1	2	3	3	11	13	40	66	121	162	226	291	331
2004	495	0	0	1	1	1	1	0	0	0	1	1	0	0	0	0	0	2	0	0	4	2	0	4	5	8	9	25	31	40	70	104	125	172	192
2005	484	0	4	2	5	0	1	0	0	0	0	0	0	1	1	2	2	0	4	3	3	5	3	8	10	5	15	35	55	63	78	126	156	185	205
2006	382	0	0	2	4	1	0	0	0	0	0	0	0	0	0	2	0	1	4	4	6	1	1	3	2	7	2	10	20	37	54	78	98	107	168
2007	298	0	0	2	1	1	1	0	0	0	0	1	2	1	0	3	3	2	4	2	6	6	7	11	6	19	20	34	65	57	72	94	103	114	111
2008	353	0	3	0	0	0	0	0	0	0	0	0	0	1	1	0	3	2	1	4	3	6	18	27	26	45	42	49	43	45	49	65	68	107	146
2009	313	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	1	0	0	2	1	2	4	4	14	9	9	18	26	43	54
2010	276	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	3	4	3	5	12	13	15	23	10	20	26	32	57	76
2011	361	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	2	3	2	4	19	24	28	0	41	39	39	64	100
2012	398	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	0	1	3	24	29	42	38	48	60	52	80	83	77	97
2013	500	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1	8	4	9	28	39	59	82	76	127	149	156	236	256	355
2014	494	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4	0	1	0	2	0	0	0	5	10	18	32	40	47	93	106	109	104	96	131
2015	454	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	3	3	5	18	28	52	81	96	103	154	143	157
2016	395	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	4	3	4	17	21	20	39	49	69
2017	338	0	0	0	1	0	0	1	0	0	1	0	0	0	0	0	1	1	0	1	1	3	4	0	0	0	1	0	4	1	7	5	14	16	35
2018	184	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5	8	12	13	12	32

Table 2.6a (page 2 of 6)—Fishery survey size composition as used in Models 16.6, 16.6i-k, and 18.7; by year and cm.

Year	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60
1977	25	28	20	15	27	20	10	14	10	6	14	21	35	54	94	80	95	91	77	73	69	62	72
1978	22	19	15	9	13	20	30	46	68	88	124	155	197	274	321	390	505	587	670	759	709	737	724
1979	281	388	380	495	566	560	495	490	472	409	383	284	265	257	307	322	351	372	392	432	482	483	509
1980	182	214	374	451	526	582	545	575	526	561	470	466	384	425	401	373	378	407	404	372	357	394	354
1981	363	277	266	177	167	212	256	305	364	456	421	410	405	392	400	396	358	298	306	263	248	241	224
1982	73	66	42	30	43	81	104	153	123	175	155	155	198	156	257	234	342	344	329	308	339	374	350
1983	73	102	99	161	250	320	380	386	449	435	469	459	414	512	580	677	866	1176	1251	1470	1507	1757	1818
1984	613	547	507	508	532	640	730	875	858	807	841	867	926	957	1040	1028	1350	1568	1861	2341	2448	2764	3150
1985	297	349	553	814	1144	1549	1782	1829	1994	2249	2384	2816	3143	3428	3799	4000	4120	3936	3616	3478	3218	2995	3030
1986	766	735	821	718	776	910	1098	1383	1376	1639	1864	2084	2333	2733	3020	3122	3822	4008	4318	4724	4923	5037	5280
1987	583	705	963	1244	1526	1969	2203	2461	3040	3266	3450	3864	4497	4863	5769	6518	7352	8110	8385	8803	9046	9110	9390
1988	745	667	808	895	1170	1496	1979	2220	2432	2588	2537	2378	2395	2168	2338	2396	2435	2331	2345	2294	2272	2099	2190
1989	411	379	309	344	340	383	495	549	677	778	783	948	1028	973	1095	1125	1164	1162	1162	1186	1203	1225	1282
1990	420	467	443	398	359	389	387	386	506	639	657	951	1091	1662	1787	2081	2300	2682	3137	3553	4006	4604	5057
1991	802	846	872	1017	1127	1423	1782	2148	2805	3162	3446	4116	3862	3821	4129	3971	4053	4106	4392	4428	4905	5206	5906
1992	1248	1445	1974	2584	3480	4098	5186	6016	6236	6613	7094	7309	7687	7506	7760	7670	7535	7703	7387	7599	7546	7671	8136
1993	1052	1657	2406	3230	4071	4489	4941	4973	5205	5038	4940	5282	5574	6022	6632	7078	7476	7720	7867	7797	7538	7180	7198
1994	1214	1098	1037	1189	1565	2087	2615	3673	3995	4805	5622	6408	7799	8180	9370	9922	10571	11707	11662	12491	12553	12456	14184
1995	705	1251	2202	3227	4486	5539	6571	6618	6785	6507	6124	5989	6248	6181	6746	7423	8288	9013	9707	10160	10881	11531	12136
1996	614	674	809	1048	1504	2044	2882	3832	4625	5611	6770	8236	9810	10937	12031	12968	13520	14183	14219	14293	14292	14216	14156
1997	1279	1230	1240	1416	1633	2096	2839	3874	4501	5348	5836	6577	7136	7552	8159	9096	10485	11672	12372	13731	14636	16243	17601
1998	664	843	1217	1607	2095	2585	3207	3948	4342	4655	5178	5569	6089	6624	6992	7612	8152	9143	9411	10132	10689	11163	12626
1999	365	608	1061	1547	2320	2876	3247	3716	3851	3977	4108	4047	4199	4084	4240	4396	4228	4596	4605	4410	4615	4640	5067
2000	216	305	505	749	980	1323	1523	1916	2271	2741	3181	3631	4119	4725	5206	5598	6014	6293	6725	6818	6946	7187	7472
2001	279	441	531	833	1036	1271	1557	1817	2196	2620	2851	3342	3620	4052	4667	5193	5838	6438	6817	7368	7518	7820	8310
2002	518	739	1002	1382	1865	2378	2662	3141	3458	4019	4298	4796	5163	5416	5747	6002	6370	6619	6750	7092	7420	7491	8020
2003	411	564	800	1124	1591	2203	2848	3635	3985	4790	5421	5968	6823	7324	8599	8858	9525	9734	10056	10132	9933	9785	10164
2004	240	251	369	439	621	821	1102	1492	1931	2400	2759	3372	4028	4620	5114	5898	6414	7098	7739	8288	8455	9132	9869
2005	236	309	376	649	727	940	1236	1648	2026	2309	2632	3047	3291	3643	4127	4423	4855	5278	5835	6087	6328	6547	7162
2006	198	221	275	373	467	605	693	969	1273	1577	1967	2324	2820	3178	3667	4033	4398	4813	5038	5203	5274	5199	5551
2007	145	193	219	245	310	424	481	697	870	1055	1315	1538	1949	2129	2465	2741	3024	3351	3590	3837	4128	4249	5015
2008	209	355	556	722	884	1125	1181	1490	1603	1806	1955	2257	2671	2866	3376	3811	4052	4515	4741	5027	5244	5477	5935
2009	151	233	443	638	737	1017	1232	1641	2039	2474	3294	3794	4683	5172	5444	5682	5225	4930	4779	4412	4206	4080	4385
2010	125	199	335	436	552	638	779	871	998	1226	1547	2012	2544	3016	3516	4057	4276	4758	4791	5078	5313	5378	5747
2011	168	314	564	791	1061	1428	1709	2096	2398	2847	3490	4074	4440	4686	4747	4877	4810	4857	4810	5135	5392	5758	6331
2012	106	129	207	383	527	693	817	1139	1221	1444	1822	2559	3648	4571	5428	6162	7003	7609	7791	7961	7930	8278	8833
2013	366	499	663	941	1242	1599	1962	2316	2536	2866	3185	3353	4126	4823	5403	5905	6378	6919	7299	7580	7868	8489	9308
2014	232	377	689	1070	1514	1962	2221	2418	2563	2701	3026	3541	4573	4831	5350	5871	6369	6717	6926	7317	7461	7697	8488
2015	176	194	239	360	489	787	966	1327	1622	2004	2419	2712	3442	4189	4872	5675	6529	7177	8002	8373	8826	8836	9107
2016	72	101	173	309	503	785	1153	1585	2024	2404	2717	2929	3317	3580	3683	3948	4103	4474	4792	5114	5481	5976	6693
2017	59	52	89	96	136	181	222	377	429	620	861	1210	1645	2151	2643	3306	4064	4620	5079	5373	5874	5888	6292
2018	38	51	87	105	131	121	161	181	214	255	342	426	586	653	835	1025	1151	1389	1605	1975	2387	2739	3159

Table 2.6a (page 3 of 5)—Fishery survey size composition as used in Models 16.6, 16.6i-k, and 18.7; by year and cm.

Year	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81
1977	74	79	79	87	86	99	72	59	55	48	46	35	25	18	28	21	20	20	11	12	8
1978	655	604	506	452	364	266	210	212	193	179	146	119	135	122	92	91	75	69	48	40	25
1979	540	578	569	601	593	578	518	493	372	373	347	254	230	208	154	116	122	84	57	44	48
1980	364	288	255	244	227	178	192	215	205	252	236	225	240	216	209	196	192	152	130	107	90
1981	211	176	178	133	143	136	107	105	93	92	76	72	63	56	49	50	35	25	24	14	17
1982	391	440	443	466	517	503	483	503	476	519	482	512	404	374	338	284	289	198	198	150	169
1983	2022	2157	1931	2064	2147	2228	2022	2008	2058	1958	1791	1722	1601	1550	1443	1300	1294	1236	1154	1060	912
1984	3530	3898	4142	4662	4730	4782	5030	5250	5148	5105	4997	4921	4802	4519	4215	4103	3772	3462	3243	2872	2589
1985	2966	3117	3620	4129	4872	5353	6162	6694	7257	7928	7753	8034	7786	7471	7099	6625	6201	5544	4910	4668	3919
1986	5373	5681	5652	5836	5687	5381	5546	4977	4473	4102	3989	3928	3892	4017	4077	3766	3866	3750	3680	3522	3227
1987	8970	9075	9318	9746	9626	10088	10242	10313	9949	10298	9905	9665	9720	9205	9010	8061	7867	7265	6348	6167	5208
1988	2135	1935	1903	2017	2135	2125	2143	2451	2358	2629	2628	2651	2698	2590	2758	2320	2296	2092	1877	1728	1504
1989	1386	1356	1496	1571	1622	1635	1647	1772	1870	2008	1963	1933	2065	2028	2157	1864	1903	1811	1741	1668	1541
1990	5616	6618	6885	7328	8015	8401	8516	8576	9101	8913	8845	9097	8656	8773	8567	8258	7802	7310	7000	6290	6013
1991	6331	7227	7937	8735	9464	9865	10601	11000	11416	11644	11314	11903	11148	11422	11459	10707	9878	9570	9045	8551	7700
1992	8081	8769	8721	9306	9994	9599	9976	10170	9912	9981	8789	9055	8219	8085	8097	7129	6853	6653	6136	6318	5252
1993	6611	6333	5941	5371	5014	4629	4491	4231	3972	3957	3584	3614	3422	3291	3171	2998	2711	2728	2503	2448	2164
1994	13134	13285	13223	13298	13378	12484	12655	12002	10739	10961	8449	7744	7138	6205	5913	4678	4344	3794	3144	3338	2647
1995	12354	13073	13374	12997	13854	13029	13192	12691	11914	11667	9681	8940	7894	7100	6388	5378	4789	4160	3644	3282	2640
1996	13776	13773	13961	13948	14225	13818	13699	13352	13133	13690	11934	11601	10765	10453	9858	8704	8035	7300	6571	6212	5336
1997	17907	19064	19352	19804	19896	19353	18877	18329	17416	16958	14269	13415	12175	10942	10341	8909	8026	7127	6520	5705	4660
1998	13107	14087	15017	15734	16331	16696	17257	16947	16647	17092	15108	14732	13818	12526	11319	10119	8929	7889	6906	6209	5107
1999	4884	5314	5598	5319	5620	5549	5621	5645	5345	5666	5067	5261	4595	4341	4007	3690	3134	2981	2626	2535	2107
2000	7557	7655	7612	7331	6791	6575	6350	5794	5403	5170	4314	4245	3891	3642	3270	2966	2690	2544	2298	2091	1870
2001	8324	8395	8693	8447	8440	8033	7913	7531	7240	7075	5977	5247	4588	4086	3505	2921	2413	2052	1849	1644	1397
2002	8193	8400	8426	8462	8161	8068	7955	7931	7263	6971	6159	5640	4753	4410	3703	3296	2833	2501	2122	1764	1560
2003	9786	9728	9893	9362	9428	9048	8768	8807	7942	8359	6967	6593	5965	5587	5023	4452	3905	3460	3035	2895	2371
2004	9817	9822	9937	9724	9319	8820	8333	7954	7367	7209	6113	5429	4806	4505	3855	3564	2990	2820	2459	2336	2036
2005	7314	7552	7866	8039	8118	8013	8285	8294	7912	8395	7086	6742	6282	5813	5434	4943	4394	4238	3574	3504	3066
2006	5298	5488	5443	5457	5350	5303	5347	5347	5051	5605	4635	4631	4424	4439	4068	3843	3549	3513	3211	3137	2778
2007	4732	4904	4804	4956	4789	4504	4512	4509	3969	4316	3591	3331	3123	2930	2908	2507	2450	2285	2069	2229	2014
2008	5870	5731	6142	6046	5971	6195	5947	5813	5243	5287	4557	4161	3848	3440	2950	2640	2291	2099	1802	1836	1529
2009	4360	4487	4689	4756	4775	4615	4670	4652	4335	4506	3649	3435	3164	2813	2400	2178	1797	1741	1362	1197	1086
2010	5737	5922	5892	5666	5273	4835	4481	4088	3530	3524	2800	2619	2333	2139	1916	1757	1375	1263	1085	1053	868
2011	6505	6894	7259	7275	7444	6684	6417	6043	5600	5255	4056	3558	3024	2739	2372	1921	1508	1384	1185	1155	923
2012	8156	8018	8145	7697	7589	6843	6592	6213	5778	6123	4688	3924	3594	3095	2765	2130	1753	1548	1236	1106	849
2013	9582	10016	10248	10584	10589	10150	9834	9035	8521	8248	6722	6170	5366	4561	3896	3156	2561	2195	1688	1415	1157
2014	8183	8320	8820	8760	9107	8904	9015	8770	8487	8425	7270	6592	6153	5455	4772	3990	3276	2856	2389	2061	1582
2015	8930	8949	8812	8887	8510	7966	7868	7529	6762	6894	5544	5125	4753	4219	3739	3247	2822	2411	2100	1924	1516
2016	6632	7299	7870	8027	8314	8235	8051	7753	7080	7076	5946	5227	4804	4534	3763	3249	2703	2531	2077	1734	1420
2017	6272	6380	6471	6454	6420	6514	6255	6189	6059	6333	5188	5002	4738	4369	3949	3630	2977	2685	2171	2001	1464
2018	3650	3943	4327	4506	4640	4550	4394	4209	3868	3625	2988	2790	2701	2323	2062	1798	1608	1489	1242	1190	1032

Table 2.6a (page 4 of 5)—Fishery survey size composition as used in Models 16.6, 16.6i-k, and 18.7; by year and cm.

Year	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107
1977	7	2	7	1	5	2	0	0	1	0	3	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0
1978	46	36	27	25	16	15	14	9	5	2	4	3	4	4	1	0	0	1	1	0	0	0	0	0	0	0
1979	41	22	22	25	11	13	9	9	6	8	8	4	8	2	2	2	3	0	2	1	1	0	2	0	0	2
1980	74	54	39	36	38	33	34	14	29	17	18	15	5	10	8	5	3	2	2	2	0	2	3	2	0	0
1981	6	12	5	7	7	6	4	2	5	2	2	0	3	0	0	1	0	2	0	0	0	0	0	0	0	0
1982	87	86	75	42	31	43	30	31	37	18	25	12	20	26	12	12	7	10	1	6	0	6	0	1	3	0
1983	714	628	550	490	437	352	296	212	202	159	137	112	62	53	46	37	36	24	24	19	17	5	6	7	4	0
1984	2366	2199	1899	1655	1307	1230	1053	784	689	504	437	318	258	196	130	122	76	54	47	42	33	22	10	10	6	3
1985	3638	3155	2803	2608	2161	1782	1607	1406	1235	929	805	697	596	469	327	265	210	197	114	101	66	63	27	33	23	9
1986	2890	2827	2411	2200	1885	1579	1347	1084	968	750	612	556	444	391	284	240	175	152	148	113	76	56	39	44	25	17
1987	4814	4675	4025	3786	3417	3130	2758	2484	2338	1980	1703	1562	1194	1135	746	731	551	461	398	283	260	200	134	132	64	42
1988	1198	1054	921	890	783	623	557	477	534	406	321	323	245	304	191	141	126	112	103	99	79	49	40	28	23	18
1989	1456	1291	1227	1090	944	903	807	669	593	485	378	413	321	310	197	211	190	177	133	131	73	70	61	49	35	23
1990	5461	5035	4599	4342	3915	3448	3149	3102	2434	2352	2206	2075	1704	1675	1367	1234	1067	891	606	557	463	466	313	233	166	139
1991	7487	6817	6402	6014	5336	4767	4393	4216	3686	3020	2851	2403	2123	1936	1702	1480	1342	1125	898	733	654	569	436	371	252	183
1992	5035	4772	4461	4209	3541	3382	3238	3032	2776	2187	2110	1879	1648	1580	1368	1199	1048	1008	867	662	507	519	386	318	189	169
1993	1969	1935	1726	1553	1460	1234	1155	1023	1019	762	764	677	564	530	448	357	393	322	236	201	184	151	117	90	59	41
1994	2468	2201	2003	1930	1707	1517	1365	1266	1379	916	904	770	715	644	550	498	429	342	369	254	237	182	168	136	110	70
1995	2509	2212	1980	1795	1508	1353	1221	1159	1114	718	757	736	623	538	495	375	358	302	293	231	201	143	128	103	76	47
1996	4850	4313	4032	3498	3097	2746	2442	2233	2139	1587	1545	1347	1216	1109	954	783	621	601	588	428	354	326	241	209	157	142
1997	4275	4055	3675	3383	3073	2756	2539	2352	2055	1672	1477	1271	1073	1067	889	695	610	495	447	335	290	248	219	175	116	112
1998	4621	4189	3541	3034	2591	2199	2011	1669	1760	1315	1166	1101	956	900	741	678	590	507	435	297	267	210	222	150	109	95
1999	1881	1663	1413	1277	1047	854	765	673	640	533	429	379	301	239	234	180	152	161	170	101	95	68	52	61	45	32
2000	1637	1533	1287	1195	1052	971	829	726	696	537	491	410	367	314	295	232	209	156	147	111	103	73	60	53	31	17
2001	1159	974	913	774	703	556	501	436	453	353	335	271	252	225	210	185	147	105	110	93	67	65	40	39	32	22
2002	1299	1120	950	779	673	591	466	420	398	289	270	234	235	216	146	159	113	95	74	67	57	38	35	36	33	13
2003	2001	1731	1428	1290	985	879	756	592	518	418	334	297	241	206	166	156	117	96	83	75	63	43	31	26	18	15
2004	1732	1567	1375	1176	1067	862	792	681	579	502	394	346	272	261	213	154	124	107	104	81	60	53	31	28	16	16
2005	2673	2342	2188	1879	1560	1452	1331	1137	1151	838	756	630	553	463	383	290	263	179	154	99	106	64	74	36	30	13
2006	2737	2551	2391	2012	1891	1733	1504	1443	1375	1045	957	852	768	655	508	481	439	367	308	228	186	140	123	88	79	67
2007	1831	1825	1750	1625	1474	1466	1396	1286	1232	1049	880	871	753	690	592	473	428	366	333	257	185	152	135	92	60	54
2008	1393	1359	1222	1132	1051	952	1023	851	910	795	765	646	592	568	478	441	374	293	297	190	175	138	110	84	36	37
2009	926	707	678	529	493	454	389	370	353	283	266	219	214	194	177	165	137	113	109	83	68	62	47	39	28	20
2010	639	608	514	448	378	299	268	189	207	128	123	101	101	63	48	56	45	35	46	38	25	21	26	15	11	8
2011	759	638	590	486	382	371	308	241	230	174	142	111	99	93	63	76	59	44	49	30	28	24	10	19	13	8
2012	731	566	508	383	349	236	213	223	175	130	111	81	93	59	43	70	36	32	32	23	20	15	10	14	6	5
2013	993	719	558	502	376	323	248	218	192	129	111	103	113	70	51	37	38	28	39	19	20	12	9	11	7	4
2014	1257	1055	843	683	535	457	374	292	277	207	162	147	108	100	74	62	57	50	20	27	19	16	15	5	5	3
2015	1398	1161	979	836	708	593	467	416	343	232	178	168	142	105	69	69	52	42	45	21	20	16	9	2	3	6
2016	1243	987	867	703	637	471	436	347	309	221	203	154	138	120	85	79	39	41	39	24	20	9	14	7	4	3
2017	1315	1082	959	772	629	517	434	363	308	240	173	167	116	102	94	70	48	45	20	24	32	23	9	9	5	10
2018	892	765	604	508	403	343	279	234	191	156	111	86	85	78	57	41	43	28	20	16	7	13	10	4	7	1

Table 2.6a (page 5 of 5)—Fishery survey size composition as used in Models 16.6, 16.6i-k, and 18.7; by year and cm.

Year	108	109	110	111	112	113	114	115	116	117	118	119	120+
1977	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0	0	0	2	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0	0	1	0	0	0	0	0	0	0	0	0	0
1983	6	0	4	0	0	2	0	0	0	0	0	0	0
1984	1	3	2	0	3	1	0	1	0	0	0	0	0
1985	8	5	5	3	2	4	4	4	0	0	2	0	0
1986	7	9	11	2	1	0	2	1	1	0	2	2	5
1987	25	23	26	14	9	5	7	6	1	3	3	0	0
1988	8	8	7	3	5	0	0	1	0	0	0	0	0
1989	12	21	12	7	7	5	1	1	0	3	0	2	19
1990	114	71	68	39	17	23	18	12	8	5	0	2	0
1991	149	74	64	40	39	17	17	8	2	0	4	1	4
1992	98	88	76	55	26	21	15	14	3	3	0	1	2
1993	36	42	28	5	10	3	5	5	6	7	2	0	4
1994	53	42	62	27	21	15	12	15	8	0	7	1	11
1995	35	24	44	11	16	8	7	10	7	0	2	1	12
1996	90	66	75	54	46	23	22	15	10	3	6	7	27
1997	79	66	62	19	25	12	6	9	5	8	2	1	13
1998	71	59	57	22	21	28	18	3	6	9	6	2	10
1999	28	20	27	12	10	4	1	3	4	2	1	2	16
2000	29	16	26	10	8	6	13	4	1	2	0	2	12
2001	19	14	11	4	5	7	5	3	1	0	0	1	0
2002	10	4	14	3	2	6	0	4	0	1	0	0	0
2003	14	4	9	4	4	0	1	2	1	0	0	1	1
2004	11	9	13	4	4	1	0	1	0	0	1	0	3
2005	10	12	6	4	4	4	0	2	0	0	2	0	0
2006	33	26	26	16	12	11	3	7	3	5	3	0	1
2007	33	25	22	8	10	7	7	5	2	2	0	0	4
2008	30	15	12	9	7	1	0	0	0	0	1	0	4
2009	12	13	10	9	8	0	4	0	0	1	0	0	0
2010	3	9	8	2	0	1	1	1	0	0	0	1	2
2011	6	2	1	2	3	2	0	0	0	0	0	0	3
2012	4	2	2	1	1	2	0	0	0	0	0	0	0
2013	8	3	0	0	1	0	1	1	0	1	0	0	0
2014	1	5	1	0	0	0	0	2	0	0	0	0	1
2015	4	0	0	0	0	0	0	0	0	0	0	0	1
2016	6	4	2	0	0	0	0	0	1	0	0	0	0
2017	5	0	0	0	4	0	0	0	0	0	0	0	0
2018	0	0	1	1	0	0	0	1	0	0	0	0	0

Table 2.6b (page 1 of 6)—Fishery survey size composition as used in Models 17.2, 18.6, and 18.8; by year and cm (input N in column 2).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1977	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	160	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.08	0.03
1979	235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	208	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1981	148	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0	0.03	0.03	0.03	0.03	0.04
1982	187	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0
1983	782	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.11	0.17	0.19
1984	1913	0	0	0	0	0	0	0	0	0.03	0	0.03	0	0.04	0.08	0.11	0.18	0.65	1.06	1.19	1.31	1.55	1.15	1.51
1985	2825	0	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0	0	0	0	0	0.06	0.06	0	0	0.01
1986	2496	0	0	0	0	0	0	0	0	0.03	0.03	0.07	0.07	0.17	0.29	0.06	0.08	0.17	0.36	0.34	0.49	0.63	0.82	0.66
1987	4726	0	0	0	0	0	0	0	0	0	0	0.03	0.01	0.03	0.11	0.25	0.29	0.21	0.21	0.46	0.19	0.32	0.5	1.07
1988	1458	0	0.01	0	0	0	0.01	0	0	0	0	0	0	0.01	0.01	0.03	0.03	0.01	0.04	0.01	0.06	0.18	0.15	0.1
1989	966	0	0	0	0	0	0	0	0	0	0	0	0	0	0.04	0.01	0	0.06	0.08	0.04	0.04	0.03	0.01	0.01
1990	3601	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.06	0.03	0.01	0.08	0.03	0.21	0.68	0.5	0.91
1991	5188	0	0	0	0	0	0	0	0	0	0	0.02	0.03	0.04	0.05	0.01	0.04	0	0.15	0.07	0.21	0.38	0.37	0.82
1992	5322	0	0	0	0	0	0	0	0	0.02	0	0.02	0.1	0.1	0.02	0.2	0	0.11	0.07	0.14	0.06	0.21	0.15	0.52
1993	2993	0	0	0	0	0	0	0	0	0	0	0	0.02	0.01	0.07	0.02	0.08	0.03	0.13	0.09	0.06	0.11	0.16	0.26
1994	4687	0	0	0	0	0	0	0	0	0	0.02	0	0.04	0.01	0	0	0.04	0.1	0.15	0.36	0.21	0.45	0.88	1.74
1995	5215	0	0	0	0	0	0	0	0	0	0	0	0	0.24	0.37	0.43	0.48	0.59	0.69	0.63	0.7	1.13	1.24	2.09
1996	6618	0	0	0	0	0	0.06	0	0	0.08	0.07	0.07	0.13	0.3	0.11	0.4	0.41	0.2	0.54	0.31	0.17	0.26	0.38	1.17
1997	7278	0	0.03	0.02	0	0.16	0	0.03	0	0.03	0.07	0	0.01	0.13	0.32	0.64	1.16	1.05	1.22	0.97	1.06	0.44	0.84	1.17
1998	6838	0	0	0	0	0	0.01	0	0	0	0.02	0	0.11	0.07	0.16	0.11	0	0.02	0.16	0.21	0.26	0.26	1.45	2.98
1999	9231	0	0	0.09	0.05	0.13	0.05	0.09	0.07	0	0	0	0	0.06	0	0.17	0.14	0.09	0.21	0	0.15	0.09	0.2	0.34
2000	9731	0	0.08	0.12	0.04	0.06	0.04	0	0.01	0	0.17	0	0	0	0	0.06	0	0.12	0.02	0.09	0	0.1	0.16	0.13
2001	10364	0	0.13	0.32	0	0.01	0	0	0	0	0	0	0	0.12	0.1	0.05	0.09	0.2	0.17	0.19	0.07	0.12	0.11	0.32
2002	11472	0	0.16	0.24	0.07	0	0.15	0	0	0	0	0.01	0.08	0	0.09	0.21	0.12	0.49	0.53	0.44	0.42	0.79	0.76	0.97
2003	14341	0	0.06	0.14	0.49	0	0	0.05	0	0	0	0	0.23	0.13	0	0.01	0.16	0.26	0.04	0.08	0	0.09	0.01	0.19
2004	12242	0	0	0.17	0.06	0.09	0.04	0	0	0	0.17	0.09	0.01	0	0.01	0	0.01	0.07	0	0.02	0.25	0.03	0.01	0.13
2005	11568	0	0.15	0.04	0.29	0	0.03	0	0	0	0	0	0	0.02	0.02	0.16	0.06	0	0.03	0.03	0.1	0.41	0.06	0.32
2006	8849	0	0	0.08	0.17	0.1	0	0	0	0	0	0	0	0.02	0	0.11	0	0.12	0.2	0.15	0.18	0.07	0.01	0.01
2007	6901	0	0	0.12	0.08	0.01	0.01	0	0	0	0	0.1	0.21	0.01	0	0.29	0.24	0.17	0.4	0.24	0.41	0.58	0.74	0.98
2008	8320	0	0.07	0	0	0	0.02	0	0.02	0	0	0	0	0.14	0.17	0	0.26	0.24	0.08	0.14	0.37	0.97	1.65	2.97
2009	7482	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.03	0.03	0	0	0.01	0.06	0.03	0.03	0.1
2010	6514	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.27	0.09	0.09	0.15	0.24	0.18
2011	8804	0.05	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.02	0.03	0.26
2012	9287	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0.28	0.32	0.01	0.05	0.44
2013	11126	0	0.01	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0.16	0	0	0	0.14	0.23	0.12	0.32
2014	12165	0	0	0	0	0	0	0	0	0	0	0.09	0	0.18	0.05	0.38	0.09	0.02	0	0.09	0	0	0.01	0.49
2015	11309	0	0	0	0.18	0	0	0.02	0	0	0	0	0	0	0	0	0	0	0	0.12	0.11	0	0	0.11
2016	9773	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.05	0	0	0	0	0	0.23	0	0
2017	7154	0	0	0	0.13	0	0	0.09	0	0	0.1	0	0	0	0	0	0	0	0	0.13	0	0	0	0
2018	3267	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.6b (page 2 of 6)—Fishery survey size composition as used in Models 17.2, 18.6, and 18.8; by year and cm.

Year	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46
1977	0	0	0	0	0.03	0.03	0.07	0.13	0.2	0.13	0.34	0.36	0.4	0.29	0.22	0.39	0.29	0.14	0.2	0.14
1978	0.08	0.12	0.54	0.64	0.54	0.54	0.35	0.25	0.22	0.08	0.1	0.3	0.26	0.21	0.12	0.18	0.28	0.42	0.64	0.94
1979	0.04	0	0	0.12	0.33	0.61	0.44	0.98	1.45	2.05	2.45	3.87	5.34	5.23	6.81	7.79	7.71	6.81	6.74	6.5
1980	0.03	0	0.03	0.21	0.18	0.43	0.49	0.46	0.75	1.21	1.53	2.53	2.97	5.2	6.27	7.31	8.09	7.58	7.99	7.31
1981	0.03	0.12	0.1	0.29	0.63	0.77	1.72	3.17	4.41	4.91	5.79	5.01	3.82	3.67	2.44	2.3	2.92	3.53	4.21	5.02
1982	0	0.04	0.01	0.03	0.03	0.06	0.14	0.4	0.78	0.92	0.78	1.02	0.92	0.59	0.42	0.6	1.13	1.45	2.13	1.71
1983	0.06	0.25	0.39	0.34	0.65	1.21	1.66	1.81	1.57	1.2	1.16	1.01	1.41	1.37	2.22	3.45	4.41	5.24	5.32	6.19
1984	2.47	3.4	5.18	6.56	7.16	6.9	6.83	6.63	6.94	7.12	7.3	8.47	7.56	7.01	7.02	7.35	8.84	10.09	12.09	11.86
1985	0	0.01	0.03	0.18	0.41	0.5	0.69	0.99	1.93	2.28	2.35	4.1	4.82	7.63	11.23	15.79	21.38	24.59	25.24	27.52
1986	1.24	1.8	2.05	2.5	4.28	6.11	8.47	10.1	10.65	11.91	11.46	10.7	10.27	11.47	10.03	10.84	12.72	15.34	19.33	19.23
1987	1.17	1.82	3.08	4.29	5.27	5.43	5.98	6.99	7.12	7.04	7.44	8.09	9.78	13.36	17.26	21.18	27.32	30.57	34.15	42.19
1988	0.19	0.37	0.81	1.56	3.01	4.18	6.02	7.27	8.94	10.04	9.36	10.28	9.21	11.15	12.35	16.15	20.65	27.32	30.64	33.57
1989	0.03	0.12	0.3	0.8	1.56	1.32	2.62	2.8	3.67	4.68	4.44	5.67	5.23	4.26	4.75	4.69	5.28	6.83	7.58	9.34
1990	1.82	2.29	4.73	5.01	8.21	6.69	7.92	7.52	7.65	7.55	7.3	5.8	6.44	6.11	5.49	4.95	5.37	5.34	5.33	6.98
1991	1.46	2.26	3.59	4.94	6.98	8.95	8.56	9.62	9.6	9.97	9.43	11.76	12.61	14.06	16.42	18.46	22	25.73	29.95	40.03
1992	0.84	1.22	2.15	3.78	4.93	6.18	8.8	9.93	11.72	11.83	11.95	13.7	15.8	22.17	29.85	40.37	49.41	60.86	72.63	76.74
1993	0.53	0.92	1.94	4.03	6.66	8.14	9.51	9.54	10.05	9.2	9.16	12.13	20.28	29.78	40.63	52.22	56.44	61.17	62.56	64.95
1994	3.05	4.95	9.3	12.61	19.31	23.13	27.93	32.67	31.64	31.35	25.64	19.77	17.29	15.08	16.78	20	28.04	37.11	46.24	54.52
1995	1.83	2.61	2.53	3.23	3.42	3.97	4.26	3.85	5.08	5.95	7.55	11.51	21.1	34.53	52.16	73.61	89.35	105.87	105.09	108.65
1996	1.97	4.6	6.75	10.24	12.85	15.04	15.8	15.84	14.48	13.54	13.15	11.23	10.77	12.71	15.93	22.96	29.73	42.82	56.78	68.4
1997	1.64	2.99	5.45	7.53	12.6	16.72	21.47	22.78	25.46	24.9	24	22.33	20.69	19.46	20.96	22.27	27.18	36.87	51.72	59.93
1998	5.51	7.7	11.75	14.47	14.01	15.65	14.71	13.93	11.83	11.1	11.85	11.43	12.6	16.3	19.79	24.75	30.68	40.14	50.68	56.96
1999	1.57	2.95	3.88	8.69	12.55	13.95	10.45	12.43	11.08	10.69	12.29	17	27.43	45.1	71.26	107.39	135.54	154.86	174.77	180.19
2000	0.36	1.19	2.17	3.33	3.12	5.4	4.15	3.93	5.81	5.59	9.02	11.74	15.36	25.41	34.81	46.84	62.11	66.88	90.26	107.09
2001	0.35	0.06	0.12	0.62	0.95	1.78	2.15	3.25	4.83	6.96	10.81	11.06	16.5	19.82	31.61	38.16	49.08	61.27	72.69	91.59
2002	1.35	2.42	2.94	5.54	8.86	13.98	14.84	20.19	20.86	22.86	27.59	27.79	35.15	42.9	59	76.24	96.67	113.41	129.2	146.85
2003	0.07	0.25	0.61	0.71	2.31	4.57	7.62	9.49	13.6	14.18	16.41	19.4	25.9	38.45	51.8	69.18	96.91	115.84	144.67	158.09
2004	0.26	0.45	0.35	1.07	1.56	2.42	4.51	6.7	8.16	9.91	9.92	12.47	14.05	19.37	21.18	27.04	34.24	42.13	60.27	79.46
2005	0.35	0.25	1.02	2.94	3.45	4.19	5.05	8.01	10.29	12.1	10.66	14.84	17.41	23.64	36.77	37.31	46.06	57.37	72.65	89.44
2006	0.1	0.26	0.08	0.36	1.72	2.22	3.56	4.26	5.63	5.76	8.87	9.76	10.82	12.82	16.02	19.25	26.51	30.01	40.39	55
2007	0.9	1.6	1.5	2.34	4.04	3.63	4.09	5.06	5.6	6.02	6.24	7.53	9.91	10.92	12.5	15.49	17.16	19.4	24.53	34.63
2008	2.4	4.71	3.64	3.72	2.96	3.01	3.58	4.16	3.78	5.11	6.15	6.68	10.65	15.29	22.05	27.87	32.12	35.45	48.23	57.58
2009	0.07	0.31	0.42	0.48	0.71	0.74	0.68	1.28	1.46	2.1	2.85	6.28	10.84	17.02	25.81	30.43	38.35	47.2	61.62	72.92
2010	0.42	1.09	1.12	1.14	1.7	0.58	1.43	1.43	1.92	3.16	3.8	6.16	8.41	15.84	18.22	26.48	27.54	32.96	39.46	48.48
2011	0.33	0.16	0.63	1.71	1.58	1.9	2.55	2.21	2.21	3.93	7.12	10.69	18.96	32.38	45.01	55.86	74.59	82.73	97.15	108.28
2012	1.23	2.05	2.53	2.71	3.29	4.27	4.91	6.45	5.68	6.18	6.37	5.13	6.27	9.36	14.77	23.24	27.41	35.42	51.72	55.11
2013	0.59	1.14	1.21	2.21	1.89	3.56	3.94	4.82	7.52	8.47	11.32	10.84	16.25	23.9	36.51	49.73	67.03	85.88	98.55	109.08
2014	0.64	2.3	1.95	3.65	4.25	6.3	7.5	8.13	6.55	5.71	7.45	13.63	19.63	38.13	58.62	79.17	99.12	109.06	113.08	117.79
2015	0.42	0.36	1.26	2.29	4.86	5.64	9.73	6.24	12.49	10.58	11.97	10.75	10.66	10	14.24	17.8	35.65	41.66	59.41	80.09
2016	0	0.02	0.51	0.1	0.47	1.6	1.84	1.27	2.2	3.13	4.56	4.66	5.65	9.76	16.07	24.83	39.27	58.11	76.57	102.44
2017	0	0	0.03	0	0.07	0	0.12	0.03	0.37	0.37	0.56	1.76	1.06	2.33	2.92	4.03	6.59	8.18	14.21	15.32
2018	0	0	0	0	0	0.02	0	0.11	0.27	0.17	0.56	0.89	1.22	3.31	4.12	5.32	5.65	6.93	7.52	9.56

Table 2.6b (page 3 of 6)—Fishery survey size composition as used in Models 17.2, 18.6, and 18.8; by year and cm.

Year	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
1977	0.09	0.2	0.3	0.5	0.78	1.35	1.15	1.36	1.31	1.11	1.05	0.99	0.89	1.03	1.06	1.13	1.13
1978	1.22	1.72	2.15	2.73	3.79	4.44	5.4	6.99	8.13	9.27	10.51	9.81	10.2	10.02	9.07	8.36	7
1979	5.63	5.27	3.91	3.65	3.54	4.23	4.43	4.83	5.12	5.4	5.95	6.63	6.65	7.01	7.43	7.96	7.83
1980	7.8	6.53	6.48	5.34	5.91	5.57	5.19	5.25	5.66	5.62	5.17	4.96	5.48	4.92	5.06	4	3.54
1981	6.29	5.81	5.66	5.59	5.41	5.52	5.46	4.94	4.11	4.22	3.63	3.42	3.32	3.09	2.91	2.43	2.46
1982	2.44	2.16	2.16	2.76	2.17	3.58	3.26	4.76	4.79	4.58	4.29	4.72	5.21	4.88	5.45	6.13	6.17
1983	6	6.47	6.33	5.71	7.06	8	9.34	11.95	16.22	17.26	20.28	20.79	24.24	25.08	27.89	29.75	26.64
1984	11.15	11.62	11.98	12.8	13.22	14.37	14.2	18.65	21.67	25.71	32.35	33.83	38.19	43.53	48.78	53.86	57.23
1985	31.04	32.9	38.87	43.38	47.31	52.43	55.21	56.86	54.32	49.91	48	44.41	41.34	41.82	40.94	43.02	49.96
1986	22.9	26.05	29.12	32.6	38.19	42.2	43.63	53.41	56.01	60.34	66.01	68.79	70.38	73.78	75.08	79.38	78.98
1987	45.32	47.88	53.62	62.41	67.48	80.06	90.45	102.02	112.54	116.36	122.16	125.53	126.42	130.31	124.48	125.93	129.31
1988	35.72	35.02	32.82	33.06	29.93	32.27	33.07	33.61	32.18	32.37	31.67	31.36	28.97	30.23	29.47	26.71	26.27
1989	10.74	10.8	13.08	14.18	13.43	15.11	15.52	16.06	16.03	16.03	16.36	16.6	16.9	17.69	19.12	18.71	20.64
1990	8.82	9.07	13.12	15.06	22.94	24.66	28.72	31.74	37.01	43.29	49.03	55.28	63.54	69.79	77.5	91.33	95.01
1991	47.34	51.12	61.17	58.24	60.84	62.69	61.34	60.94	62.57	65.72	68.35	75.87	81.56	90.74	97.08	111.78	123.51
1992	82	90.51	94.35	102.85	103.79	109.98	106.57	109.3	110.06	102.56	106.83	105.81	108.69	117.62	116.55	126.41	129.99
1993	64.72	62.73	64.95	70.41	75.38	83.75	89.16	93.02	98.6	100.25	100.07	97.99	93.19	91.6	87.17	82.78	77.28
1994	65.7	72.01	84.19	99.41	104.78	116.14	127.14	135.39	143.8	146.49	154.13	152.56	156.19	169.17	159.6	158.03	161.25
1995	99.33	91.02	84.15	83.69	82.39	85.66	93	101.49	109.8	122.16	127.09	135.65	141.46	151.03	153.9	165.64	173.55
1996	80.38	96.55	116.41	137.5	156.03	171.01	184.78	192.77	201.3	203.73	200.18	198.03	194.69	192.06	184	185.31	185.41
1997	71.88	79.84	87.91	95.79	100.79	108.7	121.57	140.64	159.32	169.49	193.59	208.69	232.98	251.96	263.33	280.82	286.64
1998	62.87	73.08	80.22	85.08	94.78	100.55	107.41	116.56	129.82	135.46	146.75	155.6	169.54	188.52	200.92	217.61	232.29
1999	182.36	190.27	185.38	184.8	185.96	187.47	193.62	183.6	201.18	201.49	194.66	200.44	204.18	231.93	228.93	239.98	258.99
2000	129.4	149.31	175.93	198.36	227.34	250.35	269.34	283.62	300.3	318.73	323.63	326.6	339.17	347.47	352.25	355.16	351.59
2001	111.92	125.27	148.19	168.33	190.28	222.42	248.13	282.45	307.29	332.06	366.41	382.41	399.35	428.72	431.15	434.91	454.27
2002	169.54	192.78	209.83	226.43	244.55	267.37	278.1	298.11	310.28	319.04	337.1	354.27	361.29	387.97	409.09	429.43	437.3
2003	201.38	230.24	257.54	296.59	330.8	398.71	412.04	446.18	468.12	487.49	511.33	492.1	488.26	511.82	494.82	498.1	512.63
2004	100.86	118.79	153.56	195.83	223.65	252.61	298.02	325.18	372.23	410.28	439.19	461.74	497.42	556.14	550.99	549.41	566.12
2005	103.64	116.61	139.71	151.72	164.66	187.87	196.25	221.4	245.03	263.22	278.99	295.47	310.13	352.82	356.27	388.24	414.7
2006	67.17	87.84	106.29	128.64	147.43	169.59	184.15	205.64	224.92	239.9	247.49	249.57	250.26	259.4	251.33	263.23	255.86
2007	40.67	51.63	62.15	80.9	84.78	101.03	116.35	129.78	147.49	161.87	172.15	197.14	203.08	248.13	237.85	242.82	243.07
2008	66.38	76.12	90.73	106.13	114.6	138.5	156.43	165.31	186.99	196.35	223.08	231.56	248.49	285.13	293.84	293.92	329.84
2009	90.39	117.69	133.41	160.14	181.64	192.87	198.53	181.92	174.74	175.84	175	177.98	181.03	199.96	205.82	227.87	243.56
2010	58.41	76.27	90.43	116.01	132.81	154.55	178.05	193.77	225.13	218.67	229.1	235.01	243.15	249.93	254.74	258.53	264.75
2011	125.27	147.79	167.17	179.59	186.54	188.79	204.8	207.16	221.94	229.53	255.67	279.49	301.37	329.81	345.49	368.45	397.99
2012	67.9	86.58	119.72	169.69	216.65	244.32	274.13	306.26	316.25	325.87	324.69	336.83	349.27	377.79	366.16	378.4	396.4
2013	116.65	122.8	126.98	142.18	168.39	189.47	214.6	245.81	273.69	310.01	334.56	362.56	403.98	460.39	469.14	501.51	518.06
2014	116.4	123.1	136.53	172.56	183.29	209.98	238.57	271.86	308.21	332.97	358.44	370.71	374.29	415.3	396.02	395.75	434.19
2015	94.32	113.33	127.89	164.41	201.91	235.28	275.82	327.57	362.42	397	413.26	432.3	426.5	437.17	435.05	443.16	456.39
2016	119.29	131.54	142.89	150.15	163.55	168.64	180.2	194.2	213.93	241.27	264.01	281.98	321.84	358.11	352.12	389.37	430.6
2017	22.03	32.83	49.84	70.53	86.79	114.14	151.12	184.44	218.52	237.71	266.22	289.23	299.59	320.67	314.57	325.77	322.59
2018	10.24	14.14	18.42	22.66	26.06	35.18	41.73	48.57	58.39	65.65	84.31	99.6	117.86	129.93	149.38	158.23	173.22

Table 2.6b (page 4 of 6)—Fishery survey size composition as used in Models 17.2, 18.6, and 18.8; by year and cm.

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
1977	1.25	1.23	1.42	1.03	0.85	0.79	0.69	0.66	0.5	0.36	0.26	0.4	0.3	0.29	0.29	0.16	0.17
1978	6.26	5.04	3.68	2.91	2.93	2.67	2.48	2.02	1.65	1.87	1.69	1.27	1.26	1.04	0.96	0.66	0.55
1979	8.27	8.16	7.96	7.13	6.79	5.12	5.13	4.78	3.5	3.17	2.86	2.12	1.6	1.68	1.16	0.78	0.61
1980	3.39	3.16	2.47	2.67	2.99	2.85	3.5	3.28	3.13	3.34	3	2.91	2.72	2.67	2.11	1.81	1.49
1981	1.83	1.97	1.88	1.48	1.45	1.28	1.27	1.05	0.99	0.87	0.77	0.68	0.69	0.48	0.34	0.33	0.19
1982	6.49	7.2	7.01	6.73	7.01	6.63	7.23	6.71	7.13	5.63	5.21	4.71	3.96	4.03	2.76	2.76	2.09
1983	28.47	29.62	30.73	27.89	27.7	28.39	27.01	24.7	23.75	22.08	21.38	19.9	17.93	17.85	17.05	15.92	14.62
1984	64.42	65.36	66.08	69.5	72.54	71.13	70.54	69.05	68	66.35	62.44	58.24	56.69	52.12	47.84	44.81	39.68
1985	56.99	67.24	73.88	85.05	92.39	100.16	109.42	107	110.88	107.46	103.11	97.98	91.44	85.58	76.52	67.77	64.43
1986	81.55	79.47	75.19	77.5	69.55	62.5	57.32	55.74	54.89	54.39	56.13	56.97	52.62	54.02	52.4	51.42	49.21
1987	135.25	133.58	139.99	142.13	143.11	138.06	142.91	137.45	134.12	134.89	127.74	125.03	111.86	109.17	100.82	88.09	85.58
1988	27.84	29.47	29.33	29.58	33.83	32.55	36.29	36.28	36.59	37.24	35.75	38.07	32.02	31.69	28.88	25.91	23.85
1989	21.68	22.38	22.56	22.73	24.45	25.8	27.71	27.09	26.67	28.49	27.98	29.76	25.72	26.26	24.99	24.02	23.02
1990	101.13	110.61	115.94	117.52	118.35	125.6	123	122.06	125.54	119.45	121.07	118.23	113.96	107.67	100.88	96.6	86.8
1991	131.34	143.08	148.42	161.97	162.09	168.83	169.37	164.29	170.71	160.49	163.1	157.5	152.61	142.28	136.31	125.8	120.95
1992	137.57	148.25	141.29	148.87	154.21	146.87	152.8	129.37	136.4	126.2	120.34	121.51	103.74	102.69	99.4	93.01	98.32
1993	70.12	65.57	60.6	58	55.17	52.09	51.98	45.86	46.66	44.41	43.41	41.47	39.29	35.95	35.68	32.73	31.74
1994	159.4	158.79	151.69	150.17	143.4	130.1	130.52	101.94	92.22	85.22	74.08	71.3	56.73	52.92	44	38	39.4
1995	169.22	180.12	174.94	179.08	175.24	167.89	164.4	138.94	131.31	116.27	105.18	96.17	83.02	75.39	67.45	59.46	54.77
1996	187.4	189.46	184.21	185.25	184.27	183.92	192.91	172.02	167.14	154.81	150.44	141.19	126.33	117.51	105.14	95.21	90.85
1997	292.84	297.57	286.51	279.41	272.9	259.95	250.2	212.43	197.76	179.33	159.45	148.14	129.25	115.83	102.78	95.79	82.3
1998	245.01	257.76	264.61	272.59	266.76	262.93	270.39	242.64	234.06	220.55	199.43	178.92	158.57	139.59	122.37	105.09	92.67
1999	249.73	274.99	271.24	276.39	281.42	269.39	290.65	261.56	267.48	235.47	233.97	205.93	198.43	166.67	162.76	139.39	134.35
2000	341.48	319.08	310.7	303.1	277.75	261.88	256.69	217.47	215.87	196.43	184.14	169.46	152.48	139.61	131.25	113.52	109.69
2001	437.64	438.28	415.47	397.42	378.74	363.6	342.68	289.96	250.45	221.99	191.16	168.29	134.76	109.86	97.64	86.42	78.1
2002	437.82	431.42	423.74	417.67	418.7	384.85	370.66	334.56	301.05	254.68	240.38	193.83	173.11	144.12	126.59	109.07	88.51
2003	491.8	496.13	480.18	464.37	462.34	421.45	451.41	372.41	353.53	318.4	300.24	263.45	234.06	201.05	179.22	160.29	149.1
2004	532.49	513.49	485.64	451.15	430.37	392.98	383.03	317.24	272.89	249.16	223.29	198.81	179.09	147.49	143.33	120.43	112.81
2005	436.76	442.24	443.68	470.05	449.3	436.75	468.47	387.43	373.29	344.34	302.1	286.19	249.74	214.42	208.36	167.47	166.82
2006	258.88	255.11	259.92	264.55	261.27	254.24	276.15	231.36	234.64	225.24	222.78	212.33	197.08	185.69	183.85	166.48	164.13
2007	246.97	240.07	222.55	223.81	229.43	197.63	221.12	180.6	164.99	157.52	146.6	145.38	128.89	128.54	116.32	108.44	116.66
2008	330.38	325.89	335.94	327.4	329.11	296.82	299.01	259.07	235.56	217.41	190.53	158.12	145.32	126.07	113.52	100.75	103.66
2009	259.7	272.97	268.1	278.42	291.08	274.31	295.64	248.89	244.12	225.34	194.68	180.73	160.03	125.42	128.44	102.04	86.17
2010	261.5	248.47	231.36	233.22	210.98	197.82	210.44	166.99	160.38	143.03	136.7	127.35	117.19	90.43	85.39	71.93	69.91
2011	394.45	407.04	366.96	358.08	334.55	307.28	283.02	226.1	193.36	167.54	151.71	130.48	106.31	87.5	83.21	71.8	69.46
2012	390.35	396.36	368.97	363.36	350.48	330.56	339.6	270.52	234.01	215.02	188.05	166.22	130.13	105.85	94.77	70.05	63.64
2013	528.07	512.56	493.43	469.93	439.07	415.49	410.06	337.74	320.49	274.81	242.33	203.74	175.06	139	134.19	92.53	85.32
2014	430.29	453.26	456.4	474.56	479.28	487.95	489.59	433.56	404.52	385.53	339.81	305.8	261.55	211.82	178.47	146.85	132.9
2015	469.37	465.04	445.11	445.2	422.78	386.15	394.01	312.27	291.13	273.63	232.75	204.84	180.93	160.99	137.26	119.08	112.68
2016	435.33	453.8	440.52	433.55	411.47	378.8	368.02	312.63	270.76	243.16	231.76	197.6	169.83	143.03	137.01	112.37	93.06
2017	322.29	308.66	312.92	295.1	281.24	269.63	279.29	216.56	205.16	189.52	170.56	149.76	140.74	110.23	99.58	78.47	69.38
2018	179.43	183.32	176.44	168.66	159.02	141.58	133.91	109.91	97.75	95.39	77.04	68.74	58.2	51.17	41.85	36.03	34.52

Table 2.6b (page 5 of 6)—Fishery survey size composition as used in Models 17.2, 18.6, and 18.8; by year and cm.

Year	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1977	0.11	0.1	0.03	0.1	0.01	0.07	0.03	0	0	0.01	0	0.04	0	0	0.03	0	0.01	0	0	0
1978	0.35	0.64	0.5	0.37	0.35	0.22	0.21	0.19	0.12	0.07	0.03	0.06	0.04	0.06	0.06	0.01	0	0	0.01	0.01
1979	0.66	0.56	0.3	0.3	0.34	0.15	0.18	0.12	0.12	0.08	0.11	0.11	0.06	0.11	0.03	0.03	0.03	0.04	0	0.03
1980	1.25	1.03	0.75	0.54	0.5	0.53	0.46	0.47	0.19	0.4	0.24	0.25	0.21	0.07	0.14	0.11	0.07	0.04	0.03	0.03
1981	0.23	0.08	0.17	0.07	0.1	0.1	0.08	0.06	0.03	0.07	0.03	0.03	0	0.04	0	0	0.01	0	0.03	0
1982	2.35	1.21	1.2	1.04	0.59	0.43	0.6	0.42	0.43	0.52	0.25	0.35	0.17	0.28	0.36	0.17	0.17	0.1	0.14	0.01
1983	12.58	9.85	8.66	7.59	6.76	6.03	4.86	4.08	2.92	2.79	2.19	1.89	1.54	0.86	0.73	0.63	0.51	0.5	0.33	0.33
1984	35.77	32.69	30.39	26.24	22.87	18.06	17	14.55	10.83	9.52	6.96	6.04	4.39	3.56	2.71	1.8	1.69	1.05	0.75	0.65
1985	54.09	50.21	43.54	38.69	35.99	29.83	24.59	22.18	19.41	17.05	12.82	11.11	9.62	8.23	6.47	4.51	3.66	2.9	2.72	1.57
1986	45.09	40.38	39.5	33.69	30.74	26.34	22.06	18.82	15.15	13.53	10.48	8.55	7.77	6.2	5.46	3.97	3.35	2.45	2.12	2.07
1987	72.27	66.8	64.88	55.86	52.54	47.42	43.44	38.27	34.47	32.44	27.48	23.63	21.68	16.57	15.75	10.35	10.14	7.65	6.4	5.52
1988	20.76	16.54	14.55	12.71	12.29	10.81	8.6	7.69	6.58	7.37	5.6	4.43	4.46	3.38	4.2	2.64	1.95	1.74	1.55	1.42
1989	21.26	20.09	17.81	16.93	15.04	13.03	12.46	11.14	9.23	8.18	6.69	5.22	5.7	4.43	4.28	2.72	2.91	2.62	2.44	1.84
1990	82.98	75.36	69.48	63.47	59.92	54.03	47.58	43.46	42.81	33.59	32.46	30.44	28.64	23.52	23.12	18.86	17.03	14.72	12.3	8.36
1991	109.67	104.75	95.44	89.34	83.01	75.82	66.89	61.41	57.58	51.49	40.1	38.15	32.02	26.76	25.85	23.73	21.28	18.06	16.14	12.14
1992	81.89	76.81	71.28	69.41	64.19	53.14	53.04	50.36	46.46	42.35	32.71	31.58	28.53	25.34	24.59	19.87	18.23	15.34	15.07	13.29
1993	28.14	26.51	24.92	22.75	20.14	18.51	16.38	15.04	13.73	13.08	10.13	10.03	9.16	7.42	6.96	5.86	4.86	4.72	4.1	3.02
1994	32.78	28.87	26.98	24.55	23.74	20.32	17.6	16.54	15.66	15.67	11.21	10.77	10.09	9.13	8.3	7.04	6.45	5.67	4.72	4.73
1995	43.25	41.9	38.16	34.99	31.31	26.93	24.53	21.84	21.19	20.64	12.17	14.01	14.96	12.04	9.58	9.32	6.58	6.83	5.28	5.34
1996	78.98	72.11	62.93	60.9	52.01	46.68	41.93	36.13	34	32.18	23.99	22.8	20.93	18.37	16.04	14.69	12.18	9.34	9.32	9.22
1997	66.1	61.32	57.21	51.76	46.74	41.65	38.19	34.99	31.24	27.55	22.16	19.59	16.08	13.89	14.01	11.56	8.77	7.92	6.24	5.38
1998	77.18	70.75	62.28	53.14	45.16	39.07	31.83	29.74	25.41	25.39	18.74	17.31	16.24	14.6	13.47	11.04	10.16	8.38	7.16	6.1
1999	110.67	100.83	89.59	75.66	69.84	54.77	49.7	39.46	35.89	35.29	30.09	23.61	20.09	15.85	12.94	12.41	10.16	8.44	8.56	8.03
2000	97.19	85.67	82.48	68.89	64.44	55.22	49.04	44.35	38.72	38.45	27.26	26.51	22.05	19.54	16.85	15.55	13.3	11.91	9.21	8.46
2001	65.98	53.88	46.82	44.55	36.39	34.1	26.12	25.28	21.16	21.52	17.11	15.08	13.98	12.8	10.67	8.65	8.91	6.74	5.1	5.44
2002	79.06	64.69	52.14	45.3	37.16	32.25	29.52	21.44	20.18	19.17	15.53	13.98	12.3	12.68	10.43	7.87	8.37	6.37	4.86	4.18
2003	116.81	102.3	86.55	71.01	60.5	44.55	39.52	33.55	26.16	23.36	18.63	12.91	13.52	9.94	9.59	8.07	5.9	5.1	4.1	4.01
2004	94.97	77.9	70.47	64.09	50.36	48.08	37.98	32.52	30.7	26.05	19.95	17.59	15.64	11.47	11.39	9.14	7.99	5.06	5.07	4.81
2005	145.02	123.74	107.62	100.54	85.81	71.39	64.35	59.92	49.85	50.99	37.37	33.51	26.56	23.93	21.16	16.35	13.31	10.4	7.92	6.8
2006	143.67	141.98	134.12	123.87	101.43	95.54	88.23	75.67	74.33	69.63	52.46	46.86	42.67	34.83	30.95	23.87	24.29	21.11	15.77	14.91
2007	108.44	94.88	95.69	93.21	87.13	75.14	76.98	73.48	65.65	66.97	52.89	45.82	44.01	37.68	33.38	29.68	23.48	21.83	16.59	15.65
2008	82.01	73.44	74.32	66.54	56.89	55.03	50.74	53.7	45.87	47.79	43	39.17	32.36	30.39	29.18	24.27	20.88	18.87	13.68	14.67
2009	74.93	59.74	45.97	41.15	31.15	29.64	25.42	24.32	19.02	21.43	17.66	16.28	13.1	13.47	11.83	10.95	9.19	7.51	5.48	5.17
2010	59.15	43.07	38.91	33.16	25.66	23.25	17.72	15.09	10.69	14.67	7.35	6.74	5.34	4.96	3.87	2.88	2.43	2.72	1.53	1.93
2011	56.57	49.25	39.36	36.48	30.78	24.04	23.66	19.53	14.95	15.11	10.91	10.27	6.65	6.85	6.13	4.02	4.68	4.41	2.63	3.19
2012	48.86	41.4	32.16	27.47	20.88	17.69	12.39	11.03	12.87	9.69	7.3	5.73	3.75	4.65	3.18	2.51	4.12	1.9	1.82	1.93
2013	68.44	59.37	40.89	32.25	30.85	21.04	17.6	13.78	10.46	9.89	6.67	5.95	5.94	6.11	3.25	2.41	1.73	1.84	1.35	1.67
2014	100.42	82.44	70.67	55.06	47.45	34.39	31.08	23.21	18.65	17.69	13.32	11.62	9.93	6.4	5.85	4.5	3.98	3.29	2.92	1.61
2015	90.38	81.74	70.34	60.05	47.79	41.27	36.76	27.07	24.33	20.68	12.27	9.08	8.9	7.95	5.7	3.76	3.46	3.6	2.58	2.55
2016	78.4	67.89	54.71	46.38	39.77	37.8	28.41	23.8	19.43	17.52	12.13	11.66	9.13	8.49	6.97	4.1	4.74	2.32	1.76	2.07
2017	51	45	35.16	30.56	24.64	19.42	14.42	12.93	10.7	9.17	7.25	5.26	5.69	3.22	3.4	2.33	2.15	1.69	1.28	0.45
2018	27.32	25.74	19.42	16.03	11.26	10.74	7.99	5.39	6.69	5.15	3	2.83	1.88	1.92	2.65	1.58	1.43	1.14	0.66	0.55

Table 2.6b (page 6 of 6)—Fishery survey size composition as used in Models 17.2, 18.6, and 18.8; by year and cm.

Year	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120+
1977	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1978	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1979	0.01	0.01	0	0.03	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0
1980	0.03	0	0.03	0.04	0.03	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1982	0.08	0	0.08	0	0.01	0.04	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0
1983	0.26	0.23	0.07	0.08	0.1	0.06	0	0.08	0	0.06	0	0	0.03	0	0	0	0	0	0	0
1984	0.58	0.46	0.3	0.14	0.14	0.08	0.04	0.01	0.04	0.03	0	0.04	0.01	0	0.01	0	0	0	0	0
1985	1.39	0.91	0.87	0.37	0.46	0.32	0.12	0.11	0.07	0.07	0.04	0.03	0.06	0.06	0.06	0	0	0.03	0	0
1986	1.58	1.06	0.78	0.54	0.61	0.35	0.24	0.1	0.13	0.15	0.03	0.01	0	0.03	0.01	0.01	0	0.03	0.03	0.07
1987	3.93	3.61	2.78	1.86	1.83	0.89	0.58	0.35	0.32	0.36	0.19	0.12	0.07	0.1	0.08	0.01	0.04	0.04	0	0
1988	1.37	1.09	0.68	0.55	0.39	0.32	0.25	0.11	0.11	0.1	0.04	0.07	0	0	0.01	0	0	0	0	0
1989	1.81	1.01	0.97	0.84	0.68	0.48	0.32	0.17	0.29	0.17	0.1	0.1	0.07	0.01	0.01	0	0.04	0	0.03	0.26
1990	7.69	6.39	6.43	4.32	3.22	2.29	1.92	1.57	0.98	0.94	0.54	0.23	0.32	0.25	0.17	0.11	0.07	0	0.03	0
1991	10.24	8.66	7.9	5.91	4.96	3.3	2.55	2.26	1.08	1.06	0.67	0.47	0.25	0.23	0.13	0.01	0	0	0.01	0.07
1992	9.57	8.07	7.76	5.89	4.65	2.67	2.52	1.45	1.31	1.25	0.73	0.42	0.37	0.24	0.18	0.04	0.04	0	0.01	0.03
1993	2.66	2.41	2.04	1.46	1.2	0.79	0.48	0.4	0.5	0.27	0.04	0.15	0	0.09	0.07	0.09	0.11	0.03	0	0.05
1994	3.62	3.14	2.48	2.27	1.87	1.57	1.06	0.76	0.72	0.79	0.35	0.33	0.27	0.2	0.16	0.08	0	0.15	0	0.08
1995	4.23	3.48	2.76	2.22	1.95	1.34	0.72	0.54	0.46	0.66	0.16	0.25	0.14	0.15	0.15	0.14	0	0.04	0.02	0.15
1996	6.76	5.42	4.95	3.65	3.11	2.45	1.95	1.38	1.01	1.01	0.84	0.65	0.31	0.33	0.19	0.11	0.05	0.12	0.08	0.42
1997	4.2	3.74	3.22	2.92	2.27	1.57	1.13	1.09	0.77	0.88	0.25	0.35	0.12	0.08	0.09	0.05	0.06	0.02	0.01	0.15
1998	4.34	3.53	2.92	3.06	2.11	1.36	1.14	0.88	0.75	0.71	0.27	0.21	0.42	0.19	0.03	0.07	0.08	0.06	0.05	0.07
1999	5.71	4.54	2.78	2.44	2.79	2.71	1.25	0.95	1.27	1.31	0.6	0.51	0.14	0.1	0.12	0.32	0.08	0	0.09	0.3
2000	6.24	5.27	3.89	3.15	3.05	1.66	1.13	1.5	0.79	1.46	0.58	0.39	0.33	0.5	0.29	0.01	0.09	0	0.17	0.54
2001	5.2	2.93	3.18	2.41	2.18	1.43	1.24	1.13	0.77	0.68	0.12	0.17	0.27	0.15	0.03	0.06	0.01	0	0.08	0
2002	3.52	2.57	2.15	1.85	2.05	1.83	0.81	0.5	0.26	0.5	0.17	0.24	0.34	0	0.14	0.02	0.09	0	0	0.07
2003	3.58	2.71	2.14	1.72	1.11	1	0.83	0.88	0.11	0.4	0.23	0.2	0	0.04	0.07	0.03	0.08	0	0.1	0.08
2004	4.96	2.73	2.32	1.66	1.54	0.86	1.22	0.63	0.59	0.91	0.21	0.14	0.11	0.03	0.06	0	0.01	0.11	0	0.25
2005	4.76	4.99	3.61	3.22	1.29	1.46	0.57	0.73	0.47	0.14	0.15	0.15	0.06	0.02	0.09	0	0.01	0.06	0	0.01
2006	9.09	8.38	6.96	5.18	4.11	3.91	3.1	1.13	0.8	1.06	0.57	0.36	0.44	0.02	0.22	0.13	0.15	0.07	0	0.09
2007	13.48	7.19	7.33	5.78	3.83	3.11	2.05	1.49	0.88	1.24	0.45	0.38	0.24	0.25	0.27	0.1	0.17	0	0.01	0.14
2008	10.18	8.79	6.49	5.73	4	1.71	1.74	1.56	1.11	0.64	0.36	0.39	0.18	0	0.02	0	0	0.01	0	0.08
2009	5.72	3.67	3.12	2.56	1.86	2.35	0.44	0.52	0.53	0.39	0.55	0.34	0	0.21	0	0	0.03	0	0	0
2010	2.09	1.39	0.7	1.08	0.81	0.5	0.38	0.19	0.39	0.27	0.1	0.01	0.01	0.01	0.05	0	0	0	0.09	0.06
2011	1.43	1.72	0.99	0.62	1	0.74	0.41	0.56	0.06	0.09	0.23	0.26	0.17	0	0	0	0	0	0	0.16
2012	1.12	1.21	0.59	0.43	1.3	0.18	0.21	0.07	0.11	0.26	0.03	0.03	0.04	0	0	0	0	0	0	0
2013	0.78	1.11	0.68	0.27	0.41	0.29	0.11	0.42	0.12	0	0	0.02	0.01	0.07	0.08	0	0.02	0	0	0.02
2014	1.88	1.15	0.85	0.79	0.33	0.21	0.22	0.12	0.26	0.05	0.03	0	0	0	0.12	0	0	0	0	0.16
2015	1.13	0.91	1.08	0.55	0.04	0.17	0.29	0.26	0	0.01	0.01	0	0.02	0.01	0	0	0	0	0	0.57
2016	1.56	1.01	0.48	1.12	0.32	0.2	0.13	0.57	0.27	0.04	0	0	0	0	0	0.08	0	0	0	0
2017	0.92	0.93	1.05	0.43	0.44	0.17	0.12	0.08	0	0	0	0.03	0	0	0	0	0	0	0	0
2018	0.38	0.19	0.46	0.13	0.02	0.21	0.12	0	0	0	0.01	0	0	0	0	0	0	0	0	0

Table 2.7—Total abundance estimates (1000s), with log-scale standard errors ("Sigma"), as estimated by shelf bottom trawl surveys of the EBS "standard" and "expanded" areas, the NBS, and the combined EBS "expanded" area and the NBS; 1982-2018.

	EBS (standard)		EBS (expanded)		NBS		EBS(exp.) + NBS	
Year	Estimate	Sigma	Estimate	Sigma	Estimate	Sigma	Estimate	Sigma
1982	583,781	0.065						
1983	752,456	0.107						
1984	651,058	0.072						
1985	841,108	0.134						
1986	838,217	0.100						
1987	677,054	0.065	697,075	0.064			697,075	0.064
1988	507,560	0.070	512,095	0.069			512,095	0.069
1989	292,247	0.068	301,748	0.066			301,748	0.066
1990	423,835	0.086	438,107	0.084			438,107	0.084
1991	488,892	0.104	496,765	0.103			496,765	0.103
1992	577,560	0.118	585,436	0.117			585,436	0.117
1993	810,608	0.122	814,187	0.121			814,187	0.121
1994	1,232,175	0.123	1,255,544	0.121			1,255,544	0.121
1995	757,910	0.099	761,681	0.099			761,681	0.099
1996	607,198	0.145	614,493	0.143			614,493	0.143
1997	485,643	0.145	493,660	0.143			493,660	0.143
1998	514,339	0.091	522,586	0.090			522,586	0.090
1999	488,337	0.093	542,229	0.100			542,229	0.100
2000	483,808	0.091	488,605	0.090			488,605	0.090
2001	960,917	0.095	974,016	0.094			974,016	0.094
2002	536,342	0.100	544,602	0.099			544,602	0.099
2003	498,873	0.124	516,468	0.120			516,468	0.120
2004	397,948	0.086	404,687	0.085			404,687	0.085
2005	450,705	0.140	464,647	0.136			464,647	0.136
2006	394,024	0.060	407,584	0.059			407,584	0.059
2007	733,402	0.263	753,821	0.256			753,821	0.256
2008	476,697	0.103	492,643	0.101			492,643	0.101
2009	716,637	0.087	721,812	0.087			721,812	0.087
2010	887,836	0.131	896,301	0.130	6,671	0.184	902,972	0.129
2011	836,840	0.094	844,482	0.094			844,482	0.094
2012	987,973	0.093	991,342	0.092			991,342	0.092
2013	750,889	0.165	760,225	0.163			760,225	0.163
2014	1,122,144	0.127	1,129,255	0.127			1,129,255	0.127
2015	982,470	0.115	985,698	0.115			985,698	0.115
2016	640,359	0.096	660,996	0.093			660,996	0.093
2017	346,693	0.090	364,129	0.088	137,182	0.123	501,311	0.073
2018	241,365	0.073	248,542	0.071	243,638	0.180	492,180	0.097

Table 2.8a (page 1 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm (input N in column 2).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	258	0	0	0	0	0	0.63	7.8	9	19.05	25.93	52.1	59.16	109.14	66.31	50.64	51.75	45.95
1983	322	0	0	0	0	0	7.13	95.81	290.44	454.74	457.65	483.72	461.36	433.44	394.31	252.29	249.7	119.74
1984	297	0	0	0	0	0	6.36	24.71	36.02	54.53	43.47	27.23	25.26	25.66	30.05	46.06	31.51	64
1985	413	0	0	0	0	0	4.38	55.87	101.59	179.48	144.71	215.93	287.18	304.38	372.09	503.12	507.05	526.31
1986	376	0	0	0	0	0.54	22.68	37.91	93.08	133.34	130	201.57	174.63	176.87	149.92	92.58	34.43	26.51
1987	226	0	0	0	0	0	0	11.88	3.21	6.26	21.19	33.08	52.46	70.54	94.43	105.26	105.12	133.76
1988	163	0	0	0	0	0	0	0.35	5.22	4.95	18.67	8.95	18	17.51	15.05	27.92	18.21	12.03
1989	101	0	0	0	0	0	1.09	1.09	7.84	19.52	15.21	28.82	35.61	44.62	43.47	41.7	27.13	16.26
1990	126	0	0	0	0	0	23.52	65.27	95.06	140.49	137.24	168.85	215.71	236.69	187.18	136.31	106.9	81.62
1991	166	0	0	0	0	0	6.03	29.03	88.31	105.67	131.83	128.45	153.67	124.88	128.04	120.31	100.7	126.97
1992	243	0	0	0	0	0	0	0.76	17.25	83.98	189.48	197.02	180.69	155.46	205.08	228.75	241.01	255.84
1993	254	0	0	0	0	0.74	2.45	29.01	80.62	190.36	422.86	292.55	403	353.54	320.24	317.94	342.71	310.89
1994	302	0	0	0	0	0	2.94	8.89	4.83	23.6	37.11	67.73	81.01	88.37	88.67	102.56	120.73	98.54
1995	238	0	0	0	0	0.37	3.34	12.28	15.64	13.91	20.11	43.49	39.15	44.31	58.75	62.39	85.01	71.81
1996	223	0	0	0	0	0	0.95	1.53	11.02	9.17	22.24	32.27	46.72	62.38	51.73	64.61	67.21	62.06
1997	231	0	0	0	0	0	8.71	18	66.83	117.42	171.98	198.33	197.96	201.94	218.34	291.79	232.48	224.53
1998	227	0	0	0	0	0	1.23	4.2	22.6	51.5	81.61	113.48	101.36	132.05	88.42	43.97	21.53	6
1999	256	0	0	0	0	0	0.69	13.4	47.67	89.34	97.76	108.73	83.57	101.15	69.97	37.49	26.52	37
2000	294	0	0	0	3.91	9.72	22.17	49.12	94.77	130.77	285.25	457.39	557.05	423.25	266.12	261.99	135.42	83.54
2001	456	0	0	0	0	4.53	5.91	25.37	59.23	119.99	192.53	293.92	423.67	620.41	669.14	721.91	639.17	624.26
2002	284	0	0	0	0	0.6	2.69	5.53	20.04	41.07	59.94	75.54	96.24	150.69	106.23	157.19	105.21	67.66
2003	274	0	0	1.12	0	0.62	2.52	4.74	10.41	50.75	83.66	124.73	186.1	210.43	186.44	225.89	230.2	255.23
2004	250	0	1.45	0	0	0	0.71	3.61	18.5	42.33	81.34	144.02	99.99	183.1	176.71	203.34	199.15	127.52
2005	276	0	0	0	0	0	0	0.82	3.94	22.46	43.08	87.08	137.99	200.9	248.4	304.33	284.18	301.37
2006	297	0	0.84	0	4.33	7.34	40.36	100.94	336.73	405.4	427.52	453.37	401.79	343.32	330.32	359.31	280.69	243.7
2007	314	0	0	0	0	7.4	7.4	129.22	481.08	1163.82	1425.64	1398.61	1141.51	730.93	715.46	511.63	326.15	400.59
2008	334	0	0	0.78	0	0	5.87	57.13	177.84	368.03	399.54	410.07	368.61	328.1	238.83	158.58	78.88	42.12
2009	438	0.63	0	0.49	7.52	38.48	113.39	430.24	1043.08	1136	1167	943.02	798.72	698.18	521.17	493.79	341.28	235.45
2010	359	0	0	0	0	0	1.35	9.2	34.18	46.37	56.23	97.26	97.11	109.24	89.86	59.44	29.12	32.03
2011	480	0	0	0	0	0	7.1	18.49	71.5	134.46	243.4	289.36	364.18	390.36	564.15	592.7	855.57	837.92
2012	381	0	0	6.9	0	0.59	87.62	451.75	817.55	872.12	670.68	504.81	497.08	369.53	488.55	471.78	247.8	153.27
2013	450	0	0	0	0	0.71	9.14	49.03	114.02	144.15	203.78	218.39	278.46	235.64	174.24	124.57	34.49	21.16
2014	433	0	0	0	1.34	0	0.49	9.31	88.49	115.18	235.59	335.8	459.71	512.32	648.46	491.24	599.59	483.27
2015	473	0	0	0	0	0	0	10.9	41.74	41.92	85.36	77.08	52.25	47.41	57.04	57.43	59.94	73.87
2016	412	0	0	0	0	0.77	0	5.18	16.41	26.14	53.2	59.84	39.49	21.98	51.28	64.61	97.38	148.96
2017	260	0	0	0	0	0	0	1.91	1.93	12.28	33.47	43.63	43.58	58.09	53.54	66.23	80.21	91.1
2018	210	0	0	0	0	0	0	0	0	2.75	4.83	5.39	18.7	19.06	37.15	33.97	53.18	45.08

Table 2.8a (page 2 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm.

Year	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
1982	19.42	8.46	8.78	2.05	8.06	17.89	24.83	39.62	67.18	86.57	123.05	193.11	220.73	239.91	305.24	316.7	236.84
1983	73.96	44.2	28.52	8.7	5.14	18.02	33.83	45.8	55.67	100.41	125.16	145.74	173.46	165.42	212.96	145.4	127.05
1984	71.97	90.37	124.61	230.58	311.66	379.02	460.29	574.23	599.61	646.78	569.4	477.17	393.84	345.07	295.05	220.31	154.5
1985	646.65	559.17	555.06	321.31	212.29	130.27	91.1	100.45	106.48	159.21	219.62	215.87	271.92	299.71	308.61	311.54	287.7
1986	20.22	21.84	71.65	114.14	218.28	360.04	449.13	697.14	628.75	616.37	638.29	653.29	580.01	557.09	447.98	401.96	348.78
1987	107.95	70.02	53.23	41.19	54.89	66.23	101.93	107.95	174.84	239.19	263.25	283.77	254.13	243.93	180.71	204.88	175.12
1988	17.52	23.11	31.66	45.35	51.32	58.41	57.5	72.8	55.54	82.3	81.24	90.95	119.21	126.69	179.03	143.52	130.03
1989	7.93	8.84	12.38	1.45	6.31	6.42	14.63	5.54	13.93	12.59	9.95	13.64	15.32	28.82	13.64	44.11	45.15
1990	52.07	31.58	37.76	38.66	29.92	42.86	69.78	70.4	87.37	93.9	88.89	84.28	107.77	113.44	72.85	103.24	87.73
1991	80.77	67.35	67.86	73.75	94.01	91.06	156.02	180.8	249.13	267.82	305.91	271.39	350.11	289.31	236.01	245.62	183.8
1992	222.64	234.21	115.11	122.81	139.86	188.46	272.77	297.65	311.79	361.32	385.91	359.5	320.07	314.79	248.88	222.23	181.84
1993	320.93	215.17	134.18	96.9	61.4	54.59	66.42	85.3	94.28	172.69	206.05	230.26	289.57	314.26	238.97	245.46	226.78
1994	91.6	80.75	116.7	106.81	151.61	136.72	182.27	284.7	382.17	490.4	567.54	649.88	680.87	597.08	571.14	418.69	321.74
1995	36.19	25.16	19.95	38.97	49.2	93.76	113.45	166.66	204.04	240.52	229.55	258	237.54	208.89	163.65	228.7	262.28
1996	53.03	34.97	19.55	21.45	22.91	56.55	62.96	126.19	159.19	189.34	223.18	268.69	231.26	244.41	186.46	195.2	163.73
1997	232.25	182.55	107.51	59.22	42.29	42.02	35.08	72.41	112.18	105.84	158.05	229.09	237.61	228.51	179.29	163.15	159.63
1998	4.19	16.73	23.79	55.76	70.3	177.02	267.68	369.33	479.58	581.61	609.2	596.09	497.63	521.64	335.73	252.54	221.51
1999	43.64	34.54	47.42	97.52	98.41	175.25	203.71	198.44	277.26	239.76	263.52	275	214.52	203.07	176.15	170.97	214.13
2000	31.29	8.75	11.71	23.57	37.14	74.21	113.72	162.74	188.94	210.76	247.56	292.02	212.47	188.89	176.61	180.41	166.71
2001	415.07	329.37	206.26	128.57	106.07	150.99	212.8	295.85	344.61	477.95	619.08	784.39	778.51	868.21	760.36	659.71	482.56
2002	48.85	32.98	16.45	39.84	60.13	100.76	152.24	228.37	254.21	412.18	450.02	526.69	524.77	493.57	361.86	380	296.21
2003	228.48	214.84	180.56	197.93	139.89	108.76	60.12	52.08	53.06	71.55	52.05	103.94	130.92	286.38	195.81	289.37	217.88
2004	135.79	104.82	61.32	52.83	68.52	87.12	97.96	178.23	185.33	207.2	225.03	258.71	284.85	299.85	293.6	316.94	296.14
2005	289.73	361.82	361.85	387.5	376.32	288.78	209.65	136.57	135.3	141.54	114.77	158.44	178.17	197.09	196.78	207.1	230.77
2006	146.52	105.28	65.37	53.61	56.55	55.01	64.59	85.77	115.25	167.95	189.53	246.79	243.05	264.01	245.62	303.55	263.77
2007	229.91	121.23	122.09	41.96	43.86	65.05	86.29	123.71	116.88	154.42	122.49	140.04	147.51	123.89	113.95	92.56	93.36
2008	22.06	41.7	73.7	170.55	322.72	504.28	578.61	743.75	783.73	756.82	717.11	588.05	485.32	359.06	296.32	210.85	169.15
2009	122.72	37.26	29.84	35.48	88.26	100.39	185.6	272.06	361.14	425.74	501.91	468.53	364.23	328.21	237.06	229.62	230.53
2010	17.77	26.13	60.82	116.76	245.46	374.74	468.56	689.06	835.59	809.51	764.26	764.94	626.99	521.41	355.81	320.45	205.48
2011	804.79	506.68	270.87	103.55	32.59	34.77	51.57	45.79	53.42	68.39	114.83	129.04	177.85	155.07	219.47	216.61	257.38
2012	56.88	37.28	12.39	33.52	44.35	70.04	100.57	212.28	308.43	320.66	426.34	419.53	464.57	333.06	368.5	226.21	188.13
2013	62.46	84.63	263.44	391.87	642.9	772.9	966.36	1060.54	826.79	893.86	641.19	647.84	408.5	305.27	236.66	177.54	171.27
2014	513.6	303.91	215.24	109.3	101.18	89.77	70.7	94.87	218.38	243.44	413.33	326.26	477.24	453.96	491.15	343.92	306.9
2015	85.06	69.37	77.35	75.61	78.19	80.94	121.68	177.04	276.68	385.07	524.14	721.71	905.7	1055.24	1114.52	987.13	938.8
2016	223.62	271.28	255.85	224.69	151.29	107.24	56.68	34.67	39.32	66.61	85.58	103.16	128.82	176.61	160.49	225.82	246.53
2017	117.13	125.76	147.54	163.91	169.33	151.67	126.85	90.51	86.74	84.49	106.07	81.98	102.46	106.01	116.93	121.76	149.97
2018	55.03	94.51	101.48	128.89	100.46	81.92	41.43	41.55	42.63	38.42	44.05	76.2	91.2	107.65	148.03	165.78	183.2

Table 2.8a (page 3 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm.

Year	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
1982	196.61	144.08	145.93	125.82	137.31	180.15	202.53	281.74	302.28	272.08	328.35	328.52	280.26	284.37	269.85	254.09	238.75
1983	107.45	60.92	62.12	86.33	94.13	142.53	157.08	212.11	269.26	300.94	287.62	298.19	315.88	253.78	248.09	246.27	224.99
1984	106.57	101.57	87.99	58.63	93.66	75.15	91.32	93.91	96.4	108.26	133.79	105.81	109.43	94.8	108.86	141.86	129
1985	342.62	351.31	388.84	413.42	514.19	499.92	513.93	482.48	470.1	359.07	322.98	243.7	192.44	167.73	128.47	96.34	93.41
1986	332.11	220.42	194.41	137.72	125.77	136.16	163.18	185.05	216.02	204.94	245.53	217.54	247.93	268.96	258.36	275.24	288.1
1987	149.88	162.41	193.02	183.12	255.78	284.82	287.83	287.61	280.89	281.45	219.98	218.55	231.68	136.73	138.34	115.99	104.43
1988	140.43	93.81	122.21	109.75	158.75	147.59	131.08	211.99	184.3	195.71	184.42	164.16	204.99	177.03	152.64	166.61	166.5
1989	55.58	47.53	51.86	41.84	47.46	47.38	57.54	72.8	68.37	72.77	75.63	72.59	82.58	104.81	97.44	107.68	102.24
1990	61.58	52.26	61.1	46.83	42.72	34.88	34.56	28.47	31.93	44.21	35.31	37.12	23.11	47	28.23	56.96	48.92
1991	162.67	134.24	111	79.11	63.67	59.75	56.9	48.3	57.43	49.49	57.29	69.54	45.9	57.77	39.1	67.05	83.95
1992	154.04	128.88	186.2	150.67	223.35	194.7	227.28	249.92	192.65	192.11	165.77	147.48	159.38	123.52	110.55	91.93	80.99
1993	195.5	152.45	160.72	182.22	183.22	220.64	220.65	233.84	269.91	206.53	184.9	192.68	158.72	150.72	129.31	113	117.87
1994	255.55	174.09	102.45	117.67	100.98	196.13	167.34	145.86	206.48	227.07	234.31	265.69	153.1	167.88	204.31	167.19	160.99
1995	252.14	331.31	398.33	391.4	439.73	444.21	415.23	360.96	352.95	309.08	209.36	199.27	161.37	149.36	120.69	103.37	114.11
1996	153.21	163.42	149.79	171.63	208.57	232.14	281.02	254.6	285.27	312.47	293.78	289.59	314.81	265.72	275.28	274.82	238.18
1997	141.76	149	139.86	128.21	130.54	139.2	138.86	175.44	199.66	234.9	156.29	176.55	138.18	154.07	184.98	192.1	164.45
1998	161	142.38	130.11	98.05	115.22	113.4	130.15	123.48	164.38	115.59	111.22	129.1	108.87	90.94	85.97	79.74	79.77
1999	259.35	275.06	341.39	434.26	454.65	522.08	498.09	451.44	352.88	364.71	278.24	208.39	177.45	147.45	126.42	128.86	104.22
2000	190.78	213.42	245.54	255.3	289.72	293.29	332.61	295.02	340.21	307.56	374.9	327.5	336.3	250.49	301.6	229.12	244.9
2001	385.79	283.64	205.5	177.92	166.25	143.05	147.75	175.28	215.59	264.17	216.46	250.37	236.03	216.61	247.48	257.65	241.93
2002	280	237.66	274.6	245.53	386.66	340.56	429.8	373.19	369.19	264.26	313.76	178.33	215.4	173.82	158.04	130.12	154.06
2003	248.86	263.66	288.6	327.11	310.28	353.03	413.42	385.44	417.83	376.04	353.67	251.42	249.94	212.3	222.93	235.49	179.47
2004	307.67	240.69	228.99	199.94	196.54	178.2	170.9	146.43	139.61	143.09	164.33	161.08	193.71	187.68	153.22	171.84	161.6
2005	288.45	252.05	203.87	194.28	203.32	206.98	215.98	167.27	205.33	168.52	192.98	131.43	170.6	126.44	144.39	129.06	134.57
2006	298.72	252.8	244.1	208.87	200.29	160.84	171.38	145.03	151.55	127.31	157.03	146.83	191.14	169.21	175.05	145.63	174.42
2007	76.31	60.53	73.38	77.23	74.5	68.48	82.26	75.71	85.06	79.2	79.9	60.51	75.15	73.87	81.59	67.78	71.79
2008	158.74	139.86	136.98	122.92	150.41	135.28	144.93	145.27	146.28	118.53	141.98	127.08	130.65	133.61	141.43	119.71	113.59
2009	242.04	323.91	325.92	388.71	408.14	407.07	372.72	359.1	300.72	310.44	265.6	194.03	157.45	154.74	125.45	110.1	100.12
2010	184.91	125.08	146.23	151.68	240.43	256.25	449.48	298.97	321.21	309.72	304.55	240.64	261.21	206.5	285.52	222.02	301.95
2011	271.63	381.15	432.63	636.37	757.24	812.84	874.83	825.01	747.14	599.52	483.31	328.36	330.31	262.61	250.63	174.7	217.3
2012	116.32	96.53	72.72	54.63	75.54	70.45	101.85	96.25	155.26	132.33	233.56	223.55	285.32	339.78	451.53	384.39	486.31
2013	143.1	123.62	180.82	150.31	226.29	287.16	355.37	424.53	511.01	400.27	379.73	343.11	320.13	253.48	254.98	191.6	206.42
2014	181.35	187.8	143.5	200.09	278.3	437.97	451.79	646.73	666.43	599.84	551.79	485.29	419.29	281.4	213.11	200.19	203.45
2015	766.5	575.47	497.86	286.17	267.53	199.9	376.89	373.28	500.06	473.68	469.4	426.31	453.97	320.43	352.3	347.09	317.69
2016	293.1	277.29	326.2	380.07	461.87	565.86	598.79	796.34	875.02	846.54	865.95	746.58	671.89	527.5	401.2	413.85	289.56
2017	137.04	146.04	157.16	172.1	154.58	181.27	216.49	179.59	234.8	216.33	224.19	250.41	303.45	281.94	316.41	321.67	369.85
2018	178.64	226.7	215.41	215.45	222.37	227.33	192.49	157.57	143.7	155.63	143.58	174.62	154.42	163.33	183.05	172.71	188.27

Table 2.8a (page 4 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm.

Year	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
1982	278.05	258.11	267.2	224.8	260.3	264.05	261.17	224.63	227.07	202.3	193.28	189.68	197.96	121.92	172.13	124.38	131.84
1983	298.31	276.51	257.68	262.27	245.39	262.11	245.27	200.79	223.91	195.71	200.21	190.92	165.77	188.13	176.12	144.78	180.56
1984	156.38	166.66	196.93	198.21	154.27	215.07	168.75	199.51	202.19	188.35	161.44	197.28	182.73	180.52	170.66	152.75	144.56
1985	102.95	101.16	103.84	85.07	86.95	90.4	84.55	148.18	109.85	109.52	112.68	170.59	122.95	134.43	146.23	146.58	135.02
1986	299.44	225.84	251.74	250.74	175.49	170.71	119.51	145.91	110.84	80.71	98.9	75.65	84.42	70.36	86.91	104.85	98.67
1987	127.44	122.07	85.82	107.43	79.94	120.88	118.44	107.38	114.3	105.49	115.35	108.31	116.29	114.89	96.23	101.13	82.02
1988	173.02	146.43	142.17	150.75	128.88	132.15	110.21	137.49	109.6	77.4	82.19	66.09	92.04	70.41	70.25	54.22	77.43
1989	96.79	134.7	121.09	90.51	91.96	81.39	119.73	76.74	94.18	100.22	75.97	69.19	99.48	87.99	56.27	82.94	43.3
1990	60.75	53.38	67.69	66.19	68.9	77.64	81.48	81.4	71.01	71.6	49.04	73.12	50.12	55.29	31.09	58.26	39.54
1991	54.11	70.31	37.7	31.66	39.36	38.56	32.16	48.53	41.19	40.34	24.77	42.13	38.48	44.55	42.92	44.98	30.51
1992	59.02	65.42	29.74	43.84	52.79	52.18	68.72	46.7	36.39	26.33	32.28	31.28	48.6	36.04	33.04	24.67	14.4
1993	107.67	88.11	63.82	65.71	78.59	65.87	56.54	57.75	52.43	35.68	65.98	36.7	36.47	61.14	28.18	27.83	14.19
1994	155.24	194.57	222.7	223.95	143.79	194.5	135.66	180.95	144.92	159.4	141.99	112.08	74.39	117.96	54.9	90.38	43.18
1995	100.42	92.29	97.59	90.89	76.33	97.51	104.78	109.88	105.35	91.86	73.83	56.52	63.06	75.38	74.62	72.35	52.97
1996	247.49	200.95	162.57	148.38	128.85	137.41	96.25	92.01	83.53	76.58	55.98	58.49	58.18	54.7	54.58	44.06	55.06
1997	171.46	127.55	219.54	169.15	177.67	126	133.33	109.97	114.09	117.91	103.4	101.76	94.36	81.79	70.79	57.32	63.08
1998	69.98	59.07	76.28	86.81	73.24	63.72	75.17	84.39	82.34	71.5	62.62	94.19	56.11	61.23	45.97	44.23	50.48
1999	104.28	83.12	93.07	82.05	76.36	63.76	104.59	76.67	83.66	71.61	85.29	55.96	62.4	43.47	55.07	62.36	44.02
2000	185.39	193.02	175.49	152.39	152.4	142.26	107.14	96.88	86.26	81.65	51.86	62.26	55.69	50.04	34.15	47.47	31.97
2001	221.6	206.21	211.82	177.92	196.3	173.85	140.52	186.2	123.93	146.07	142.01	100.42	78.23	99.53	63.63	73.08	53.84
2002	122.34	147.55	84.95	103.77	114.94	118.29	95.83	105.87	101.72	94.21	53.62	100.37	68.51	60.78	62.52	54.8	45.06
2003	167.68	150.84	134.57	112.78	130.42	124.8	105.29	87.03	63.86	85.72	57.74	65.18	62.57	59.76	61.04	69.07	42.78
2004	176.16	158.11	179.1	135.19	147.91	157.89	140.39	135.06	131.49	113.74	97.49	95.25	81.66	99.39	77.14	60.51	68.71
2005	111.01	111.05	100.67	98.4	99.66	117.34	83.65	118.22	82.43	126.88	104.15	111.89	100.82	100.58	77.13	83.23	74.13
2006	136.96	182.2	105.59	128.11	90.51	97.19	104.69	95.36	106.5	89.96	88.34	98.53	60.75	96.16	51.27	71.4	59.99
2007	59.14	54.3	48.22	51.79	46.68	60.81	49.84	60.37	48.98	49.39	45.16	45.88	32.36	43.06	39.87	31.32	23.59
2008	106.13	117.42	95.23	119.34	108.33	118.86	95.91	85.32	84.86	92.68	65.05	74.56	66.94	74.79	46.64	55.35	36.43
2009	88.48	80.5	84.03	91.31	94.68	76.93	90.78	82.57	56.56	69.33	76.05	56.26	40.56	51.34	32.29	42.82	30.96
2010	293.12	271.01	184.39	271.39	217.64	195.54	138.51	175.06	113.37	130.21	78.19	81.28	56.25	42.15	31.71	36.96	32.36
2011	213.1	250.95	174.49	261.2	227.92	284.71	215.35	278.26	173.82	235.62	162.52	193.78	143.82	150.67	108.57	119.11	57.85
2012	368.35	376.64	260.02	235.52	200.29	195.33	115.37	142.88	102.52	123.38	92.37	93.96	75.01	78.08	54.65	86.31	44.29
2013	133.74	189.2	139.47	210.8	190	230.17	189.25	208.91	199.39	230.3	209.95	190.4	160.65	139.16	133.78	107.39	102.5
2014	179.8	163.03	189.1	245.48	244.01	195.77	188.61	199.96	133.38	137.73	108.62	104.82	61.48	61.59	50.83	64.71	54.97
2015	336.82	388.64	337.2	433.34	330.94	299.97	218.87	244.59	158.45	167.53	113.2	107	111.17	97.7	81.37	65.49	61.47
2016	287.62	271.89	262.25	243.22	258.98	242.31	221.6	227.69	223.85	207.54	220.89	240.13	186.43	168.37	155.29	164.47	132.49
2017	384.04	349.21	351.67	294.19	237.04	221.6	215.77	173.31	208.24	152.72	147.92	129.94	121.48	99.71	127.71	107.57	87.88
2018	172.55	174.45	155.23	173.28	198.59	172.36	188.83	178.78	213.19	201.18	180.14	161.42	180.64	138.19	142.55	136.17	97.23

Table 2.8a (page 5 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm.

Year	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91
1982	73.13	72.66	72.02	64.47	44.59	34.26	36.76	29.71	19.95	26.6	23.93	12.31	7.54	6.54	9.08	2.69	6.19	4.17	0.6	2.48
1983	125.85	121.73	77.8	80.69	78.79	67.52	58.74	39.2	48.39	32.22	28.94	23.84	17.64	11.91	1.16	6.75	8.04	2.85	11.49	0.6
1984	83.16	119.37	97.71	104.22	75.12	82.28	56.08	67.92	46.1	39.92	31.7	32.79	27	21.63	27.92	12.14	16.23	18.67	12.2	9.34
1985	134.74	119.63	137.75	107.01	135.1	99.33	95.34	58.95	75.29	59.03	50.06	48.18	21.18	37.31	21.95	21.88	16.22	13.76	10.27	8.04
1986	89.32	70.31	89.99	86.11	69.33	81.28	71.16	62.16	83.79	55.63	53.36	42.8	28.86	26.28	34.86	18.31	21.19	18.25	30.09	9.82
1987	51.98	79.12	46.01	49.05	48.19	20.48	37.66	29.08	28.69	38.47	24.73	25.66	25.48	25.58	7.44	6.33	13.19	8.19	8.78	11.16
1988	56.13	55.85	37.13	52.65	47.2	32.05	27.47	36.83	47.28	41.58	35.45	20.35	19.69	7.34	17.97	9.97	4.06	10.12	1.54	10.3
1989	75.99	81.92	68.92	63.58	59.13	44.29	62.43	44.44	26.23	21.83	35.15	25.25	30.78	36.48	17.69	24.68	17.08	5.87	17.64	12.57
1990	48.9	47.73	48.66	44.6	30.11	34.41	34.71	22.6	33.88	35.58	9.27	21.55	17	21.42	17.73	8.97	9.85	16.89	10.44	5.03
1991	28.94	23.87	37.65	30.47	25.82	13.27	15.18	17.64	20.21	31.19	22.5	20.14	11.22	11.86	7.99	11.83	6.9	7.25	5.56	2.63
1992	22.08	23.24	21.43	15.62	24.97	15.27	18.51	25.15	29.44	14.7	17.33	14.96	11.84	13.02	14.59	6.74	10	7.58	13.01	5.56
1993	14.84	15.39	14.11	16.16	12.16	11.55	10.68	11.96	12.33	11.02	9.19	4.6	11.56	10.31	4.3	7.08	7.61	7.5	4.03	3.36
1994	59.42	26.59	35.94	17.57	26.22	11.75	18.91	7.74	7.92	9.21	10.91	4.54	8	7.18	8.1	5.84	3.4	5.42	30.72	11.7
1995	56.96	47.26	37.7	29.99	23.55	38.88	21.18	25.84	22.6	20.87	18.74	12.43	13.48	10.72	7.84	8.16	7.84	7.7	4.54	11.97
1996	60.39	30.89	43.09	34.99	26.93	28.41	33.67	21.36	20.97	23.64	24.03	14.55	24.06	9.59	13.08	21.56	16.79	8.89	3.11	2.5
1997	54.86	29.75	18.65	31.52	20.91	28.59	16.29	11.25	10.34	8.83	12.61	17.41	12.64	10.02	8.36	9.3	9.62	4.39	3.05	8.22
1998	53.16	36.38	50.38	27.98	35.22	20.52	19.92	23.97	12.24	15.64	8.88	14.57	10.3	8.19	9.5	7.07	3.71	2.96	4.78	5.12
1999	40.35	45.57	33.15	24.77	25.17	20.74	22.96	24.13	21.73	17.33	11.43	15.26	13.25	10.62	10.01	15.16	14.04	5.59	14.29	5.44
2000	36.53	29.26	32.75	27.74	20.91	11.54	12.98	20.63	21.27	11.46	17.01	18.12	8.08	9.05	5	8.24	25.28	6.26	6.89	6.94
2001	48.29	31.12	35.92	24.09	18.39	25.28	18.64	29.3	16.41	16.21	11.7	10.6	12.01	5.15	9.77	5.68	6.05	5.13	6.58	4.34
2002	33.33	33.67	30.12	23.26	29.4	22.69	12.54	9.88	18.84	13.37	5.69	6.09	2.26	6.61	1.61	3.42	4.68	1.46	2.07	3.39
2003	51.03	35.9	36.34	32.52	31.34	24	25.49	14.75	16.29	18.9	19.56	10.3	12.63	6.66	8.5	5.09	6.17	4.75	3.47	3.93
2004	55.55	54.42	31.88	47.55	42.66	40.24	43.26	30.01	25.99	22.38	22.12	14.89	21.07	10.41	24.29	11.7	18.28	14.11	12.04	5.64
2005	69.94	58.55	72.2	51.47	71.95	53.87	64.57	48.85	44.28	40.34	40.32	32.09	24.59	17.49	27.85	20.44	23.23	14.17	10.23	14.45
2006	58.41	63.61	67.03	56.65	58.88	42.52	57.02	44.05	57.7	50.05	51.4	36.66	42.17	39.33	34.01	19.67	35.42	15.67	22.93	15.19
2007	32	23.3	37.83	21.28	18.74	13.65	12.19	17.47	16.75	18.18	9.97	10.46	8.84	25.03	10.68	7.95	8.85	14.81	10.19	13.14
2008	40.98	23.92	45.35	19.58	24.32	22.58	23.71	13.36	16.58	12.28	17.17	14.47	12.83	8.74	20.64	11.91	10.75	8.62	12.28	5.39
2009	22.52	25.85	13.6	18.09	14.68	15.88	14.8	4.68	14.19	6.95	8.07	4.55	4.26	7.75	6.29	6.22	3.59	4.27	5.11	0.7
2010	17.93	12.28	13.01	16.17	19.45	5.09	14.26	4.48	3.26	8.25	4.48	4.5	1.29	5.84	8.56	0.48	4.68	0.99	4.11	2
2011	73.54	48.47	47.63	25.37	23.47	19.64	14.59	13.45	16.84	6.32	13.57	9.4	6.85	2.6	3.51	4	4.1	3.43	1.36	5.03
2012	56.12	28.12	34.1	25.42	23.56	22.87	20.98	7.07	12.11	4.97	8.5	7.26	7.66	4.6	4.88	4.93	1.02	1.3	2.95	2.13
2013	90.42	50.56	61.67	43.05	30.43	42.9	28.95	30.02	8.23	28.93	12.11	23.53	11.35	10.04	6.71	7.31	4.31	3.31	4.89	3.59
2014	52.25	64.71	48.81	42.11	39.49	28.31	27.87	19.77	15.16	15.98	7.86	7.71	8.1	3.64	4.12	5.71	3.37	1.04	5.98	2.19
2015	61.89	56.67	45.47	54.89	43.41	35.48	23.58	24.42	20.03	22.9	14.39	7.43	12.12	7.17	17.42	9.4	5.94	2.79	4.31	1.22
2016	93.34	83.58	67.47	50.03	44.98	46.16	35.46	23.81	23.86	34.32	15.79	18.37	20.99	15.91	9.56	8.84	7.47	7.56	5.08	6.02
2017	75.12	93.77	70.41	79.65	76.03	68.33	55.77	59.31	58.45	17.31	33.29	29.1	18.9	10.67	8.72	13.35	9.06	13.2	3.3	7.08
2018	94.07	89.26	67.87	56.43	53.97	66.18	45.67	49.75	51.07	36.59	34.64	35.13	24.58	13.21	17.94	21.29	13.4	11.22	9.49	5.9

Table 2.8a (page 6 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm.

Year	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
1982	3.49	0	2.48	0	1.04	2.15	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0.56	2.24	4.04	0	2.83	0	1.14	0	0	0	0	0	1.16	0	0	0	0	0	0	0	0	0	0
1984	4.02	7.47	5.87	0	3.66	2.69	2.21	0.58	0.58	0	0	0	0.87	0	0	0	0	0	0	0	0	0	0
1985	7.17	8.48	4.28	1.17	3.32	7.01	2.01	3.53	1.78	0	3.27	0	0	0	0	0	0	0	0	0	0	0	0
1986	16.23	13.1	4.58	4.01	5.84	2.5	7.26	1.61	4.1	2.69	0	3.85	2.19	0	0	0	0	0	0	0	0	0	0
1987	5.17	8.94	8.85	1.32	3.47	5.24	2.81	1.06	0.51	2.18	2.56	0	0.92	0	0	0	0	0	0.4	0	0	0	0
1988	1.64	3.75	4.29	4.32	3.46	0.69	2.84	5.15	2.13	0.48	1.87	0	0	0.2	0	0	0	0	2.51	0	0	0	0
1989	7.76	9.8	11.78	13.29	5.87	4.34	8.52	4.67	4.11	9.1	0.25	9.27	2.76	0	0	0	0	0	0	0	0	0	0
1990	4.2	4.26	6.05	9.91	9.11	2.34	1.36	1.16	4.17	0	5.37	0.38	0	0.91	1.04	0.39	0	0	0	0	0	0	0
1991	4.97	3.78	1.38	5.52	7.16	3	1.95	2.59	0	0.47	0.29	5.25	0.79	0.4	1.28	0	0	0	0	0	0	0	0
1992	7.18	7.05	4.51	7.16	8.22	2.93	9.31	1.41	4.21	2.95	2.81	2.75	2.64	1.17	0.52	0.61	0	0.47	0	0.48	0	0	0
1993	3.67	7.4	2.53	7.04	4.99	4.7	3.64	3.55	1.27	2.02	1.88	0.64	8.48	2.48	0	0.99	0.29	0	0.3	0	0.3	0	0
1994	8.08	2.35	0.45	2.91	5.6	3.36	1.36	0.64	1.99	8.42	5.24	2.85	0.77	6.23	0	0	0.67	0	0.69	0	0	0	0
1995	3.54	4.45	3.69	10.33	1.13	3.35	1.9	2.95	5.11	0.86	3.41	0.33	0	1.44	0	0.58	0	0.34	0	0.78	0	0	0
1996	6.45	9.61	2.93	4.67	4.52	2.76	2.14	1.93	3.77	1.28	1.72	0	0.43	0	0	0	2.97	0	0	0	0	0	0
1997	7.56	2.01	5.68	3.42	2.41	3.7	0	1.09	1.84	0	0	0.72	1.56	0	0	0.32	0	0	0	0	0.31	0	0.58
1998	9.34	2.86	6.08	2.54	1.24	2.02	1.99	0.49	0.57	0.81	8.14	0	0	0	0.48	0	0.48	0	0.48	0	0	0	0
1999	4.49	4.69	4.84	1.99	4.83	5.61	5.76	2.92	2.21	1.21	0	1.9	0.52	0	0.59	1.21	0	0	0	0	0	0	0
2000	3.51	4.06	9.48	2.29	7.43	4.65	3.06	0.93	0.44	2.66	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	3.71	2.15	3.88	5.34	0.54	2.16	0.46	4.52	0.54	1.25	0	1.62	0.81	2.67	0.56	0	1.1	0	0	0	0	0	0
2002	4.69	4.79	0.89	3.31	1.54	3.1	5.63	0.95	1.33	0	0	1.13	0	1.82	0	0	0	0	0	0	0	0.58	0
2003	2.51	1.64	1.12	0	0.92	0.65	0.32	0	0	0.71	0	0.41	0	0	0	0	0	0	0	0	0	0	0
2004	3.68	7.18	3.52	2.75	4.21	3.83	2.03	1.62	0	0.66	0	4.74	0	1.15	0	0	1.62	0	0.77	0	0	0	0
2005	9.94	7.71	3.61	9.09	5.1	2.83	3.6	0.44	3.61	2.07	0.4	0.77	0.41	0	0	0	0	0	0	0	0	0	0
2006	18.01	10.07	9.64	6.23	10.94	8.8	1.42	7.37	4.99	2.59	2.48	2.55	1.51	0	0.91	0	0	2.22	0	0	0	0	0
2007	8.39	3.31	7.88	3.66	5.52	2.31	2.78	2.5	2.84	1.78	7.91	1.3	2.39	1.03	1.96	0	0.52	0.49	0	0	0.52	0	0
2008	10.46	10.92	10.47	9.36	3.35	8.93	9.05	2.55	4.51	3.34	7.37	1.28	1.37	0	0	0.5	0	0	0.84	0	0	0	0
2009	1.11	1.14	1.94	3.54	4.99	2.53	3.29	0.59	2.17	1.45	0.93	0	0.72	2.13	0	0	0.74	0	0	0	0	0	0
2010	1.3	3.72	0.95	0	3.54	1.91	0.78	2.74	2.1	0	0	0	0	0.96	0	0	0.86	0	0.43	0	0	0	0
2011	3.14	4.23	6.97	1.49	0.66	0	1.15	0	2.23	1.48	1.06	0	1.58	0.66	0	0	0	0	0	0	0	0	0
2012	1.14	3.58	3.19	1.83	0.45	0	1.72	1.8	1.28	0.48	0	0.29	0.71	0	0.33	0	0.38	0	0.26	0	0	0	0
2013	4.28	4.7	1.43	1.58	0.37	1.41	0.46	1.24	0.68	0.73	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	2.81	2.07	0.47	0	2.83	0.86	2.11	0	1.51	0	0	1.55	0	0	0	0.47	0	0	0	0	0	0	0
2015	1.79	1.52	0.38	1.81	0.74	1.23	1	1.83	1.25	0	0	0.58	0.56	0.92	0	0	0	0	0	0	0	0	0
2016	4.8	3.38	1.56	2.91	1.54	2.21	2.07	0	1.44	2.79	1.54	1	2	0	0	0	0	0	0	0	0	0	0
2017	7.57	1.19	5.52	4.74	0.48	3.64	0.54	0	0.51	0	0	0	0	0.59	0	0	0	0	0	0	0	0	0
2018	4.24	4.02	4.69	3.91	2.9	3.34	4.93	3.81	0.68	0	2.23	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.8a (page 7 of 7)—Trawl survey size composition as used in Model 16.6, by year and cm.

Year	115	116	117	118	119	120+
1982	0	0	0	0	0	0
1983	0	0	0	0	0	0
1984	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	0	0	0	0	0	0
1992	0	0	0.53	0	0	0
1993	1.45	0	0	0	0	0
1994	0	0	0	0	0	0
1995	0	0	0	0	0	0
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0	0	0	0
1999	0	0	0	0	0	0
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	0	0	0	0	0	0
2006	0	0	0	0	0	0
2007	0	0	0	0	0	0
2008	0	0	0	0	0	0
2009	0	0	0	0	0	0
2010	0	0	0	0	0	0
2011	0	0	0	0	0	0
2012	0	0	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	0	0	0	0	0

Table 2.8b (page 1 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1982	249	0	0	0	0	0	0.63	7.8	9	19.05	25.93	52.1	59.16	109.14	66.31	50.64	51.75	45.95	19.42
1983	311	0	0	0	0	0	7.13	95.81	290.44	454.74	457.65	483.72	461.36	433.44	394.31	252.29	249.7	119.74	73.96
1984	287	0	0	0	0	0	6.36	24.71	36.02	54.53	43.47	27.23	25.26	25.66	30.05	46.06	31.51	64	71.97
1985	399	0	0	0	0	0	4.38	55.87	101.59	179.48	144.71	215.93	287.18	304.38	372.09	503.12	507.05	526.31	646.65
1986	363	0	0	0	0	0.54	22.68	37.91	93.08	133.34	130	201.57	174.63	176.87	149.92	92.58	34.43	26.51	20.22
1987	224	0	0	0	0	0	0	11.84	3.2	6.24	21.11	32.96	53.16	70.28	94.08	104.87	104.73	133.26	107.55
1988	160	0	0	0	0	0	0	0.36	5.26	4.99	18.82	9.02	19.88	17.65	15.58	28.16	19.27	12.69	18.12
1989	100	0	0	0	0	0	1.08	1.08	7.79	19.41	15.12	28.66	35.42	44.37	43.23	41.47	26.98	16.17	7.89
1990	128	0	0	0	0	0	23.98	66.57	96.94	143.28	139.96	172.78	219.99	242.22	192.69	140.17	110.23	84.07	53.1
1991	165	0	0	0	0	0	6.11	29.46	89.6	107.21	133.76	130.32	156.35	126.7	130.48	123.02	102.61	128.82	82.61
1992	239	0	0	0	0	0	0	0.76	17.36	84.53	191.26	198.3	182.41	157.01	206.42	232.35	245.28	259.63	225.11
1993	248	0	0	0	0	0.74	2.47	29.18	81.09	191.48	426.09	294.68	405.36	355.61	322.11	320.21	347.25	312.71	322.81
1994	306	0	0	0	0	0	3.02	9.13	4.95	24.23	38.1	70.19	83.16	90.72	91.82	107.71	125.89	101.96	95.99
1995	232	0	0	0	0	0.37	3.36	12.36	15.74	14	20.24	43.78	39.4	44.6	59.13	62.79	85.57	72.27	36.76
1996	221	0	0	0	0	0	0.96	1.55	11.17	9.29	22.53	33.1	47.77	63.19	53.26	65.91	68.55	63.33	53.72
1997	227	0	0	0	0	0	8.71	17.99	67.44	118.02	171.97	198.93	197.94	204.31	218.94	294.66	233.08	224.52	232.23
1998	226	0	0	0	0	0	1.25	4.26	22.91	52.22	82.75	115.07	102.78	134.38	89.65	45.07	21.83	6.57	4.24
1999	264	0	0	0	0	0	0.67	12.91	45.93	86.08	94.19	104.77	80.52	97.46	67.42	36.12	25.55	38.01	44.81
2000	288	0	0	0	3.92	9.75	22.23	49.26	95.03	131.13	286.04	460.14	558.6	424.43	266.86	263.38	137.19	83.78	31.37
2001	451	0	0	0	0	4.57	5.98	25.65	59.87	121.3	195.21	297.11	429.46	628.92	678.16	730.36	649.07	633.39	420.79
2002	281	0	0	0	0	0.61	2.71	5.57	20.85	41.41	60.43	76.16	99.61	152.56	107.1	158.46	106.06	68.21	49.25
2003	280	0	0	1.15	0	0.63	2.57	4.83	10.62	51.78	86.04	127.28	189.91	215.99	191.52	231.8	235.49	262.38	234.39
2004	247	0	1.46	0	0	0	0.71	3.62	18.58	43.35	81.66	145.38	101.23	186.28	179.75	204.99	199.93	128.02	137.18
2005	278	0	0	0	0	0	0	0.83	3.98	22.67	44.23	87.9	139.29	202.79	250.74	307.19	287.55	305.01	292.46
2006	296	0	0.84	0	4.32	7.32	40.24	100.63	335.71	404.17	427.1	455.24	402.33	344.81	329.32	359.05	281.5	244.62	146.08
2007	318	0	0	0	0	7.54	7.55	131.8	490.68	1187.05	1459.03	1434.6	1172.34	755.94	741.12	546.15	355.8	428.01	243.96
2008	334	0	0	0.74	0	0	5.59	54.35	169.2	350.15	380.13	390.14	351.52	312.15	227.23	150.87	75.81	40.08	20.99
2009	428	0.58	0	0.46	7.03	35.98	106.02	402.3	975.35	1062.23	1092.53	882.44	748.73	654.83	489.11	466.61	324.97	223.26	116.63
2010	356	0	1.05	0	0	0	1.28	10.72	34.25	46.95	55.11	92.85	91.73	103.18	86.32	56.62	27.98	30.26	21.06
2011	469	0	0	0	0	0	6.91	18.01	69.65	130.98	237.83	283.33	356.94	380.95	550.24	579.48	837.59	819.03	790.94
2012	371	0	0	5.83	0	0.5	74.06	381.83	691.01	737.12	566.87	426.68	420.52	313.61	412.93	399.21	210.25	129.9	48.07
2013	441	0	0	0	0	0.7	8.9	47.72	110.96	140.3	198.32	212.54	272.8	233.29	172.88	121.24	34.33	20.59	60.78
2014	424	0	0	0	1.19	0	0.44	8.27	78.62	102.33	209.72	299.8	408.84	455.18	576.93	437.28	533.13	430.18	456.72
2015	459	0	0	0	0	0	0	10.77	41.22	41.4	84.32	76.14	51.61	46.83	56.34	56.72	59.76	72.97	84.02
2016	414	0	0	0	0	0.76	0	5.12	16.21	25.82	52.56	59.11	39.01	22.51	50.65	63.82	96.19	147.14	220.9
2017	350	0	0	0	0	0	0	1.88	1.9	12.1	33.82	53.31	48.24	69.1	62.55	69.95	85.49	96.21	123.63
2018	267	0	0	0	0	0	0	0	1.56	5.91	16.68	21.58	37.35	43.76	48.11	41.59	55.52	48.68	59.3

Table 2.8b (page 2 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1982	8.46	8.78	2.05	8.06	17.89	24.83	39.62	67.18	86.57	123.05	193.11	220.73	239.91	305.24	316.7	236.84	196.61
1983	44.2	28.52	8.7	5.14	18.02	33.83	45.8	55.67	100.41	125.16	145.74	173.46	165.42	212.96	145.4	127.05	107.45
1984	90.37	124.61	230.58	311.66	379.02	460.29	574.23	599.61	646.78	569.4	477.17	393.84	345.07	295.05	220.31	154.5	106.57
1985	559.17	555.06	321.31	212.29	130.27	91.1	100.45	106.48	159.21	219.62	215.87	271.92	299.71	308.61	311.54	287.7	342.62
1986	21.84	71.65	114.14	218.28	360.04	449.13	697.14	628.75	616.37	638.29	653.29	580.01	557.09	447.98	401.96	348.78	332.11
1987	69.76	53.03	41.03	56.29	67.59	104.96	108.44	174.19	241.06	265.9	285.04	256.36	249.04	182.88	205.69	177.41	155.63
1988	23.3	31.92	47.27	52.61	59.71	58.43	74.26	56	85.11	81.91	92.17	120.6	127.74	180.51	144.71	131.1	141.6
1989	8.79	12.31	1.44	6.28	6.39	14.55	5.51	13.85	12.52	11.63	13.56	15.23	29.72	13.56	44.72	46.6	61.47
1990	33.04	39.29	41.23	32.47	46.65	73.5	73.57	93.04	98.71	93.22	87.14	111.5	116.1	74.69	107.07	89.47	62.8
1991	69.33	69.29	77.23	96.47	98.35	165.12	189.01	261.95	279.03	312.57	278.2	357.18	295.73	240.34	250.08	187.35	165.68
1992	237.29	118.8	124.66	142.31	194.32	280.21	303.19	319.08	368.35	389.95	367.86	326.96	318.42	257.17	232.93	188.96	158.65
1993	216.43	134.96	98.53	62.09	57.13	67.17	88.24	94.83	174.73	208	236.24	291.96	318.59	241.03	246.89	228.11	197.7
1994	87.7	129.59	118.67	175.45	157.18	207.4	305.88	407.78	521.07	597.65	675.65	704.95	619.74	588.33	431.64	332.79	265.78
1995	25.62	20.08	39.23	49.85	94.75	115.9	168.09	206.88	243.54	231.38	261.39	240.46	212.04	165.81	231.23	264.36	255.2
1996	35.43	20.25	22.62	23.66	57.75	63.79	128.82	161.74	192.23	226.97	272.19	234.74	248.02	189.38	197.75	166.8	156.56
1997	183.1	108.06	59.21	42.28	42.01	36.27	73.05	112.78	106.38	158.04	230.86	237.59	228.5	181.06	163.13	160.19	141.75
1998	19.4	24.12	58.01	72.24	185.1	275.48	380.63	489.36	595.38	619.2	607.48	506.53	529.95	342.89	257.54	224.61	163.73
1999	38.57	56.18	103.32	107.88	184.21	202.38	198.34	275.25	243.21	258.02	270.61	213.67	206.65	198.85	208.97	270.33	352.63
2000	8.78	11.74	23.63	37.25	75.14	114.04	163.86	189.47	214.77	251.04	294.18	216.44	190.77	179.9	184.38	168.61	193.42
2001	337.11	211.51	135.36	112.51	158.88	221.56	306.73	358.09	492.03	632.19	798.63	793.76	880.94	772.83	670.56	493.14	398.45
2002	33.25	17.18	41.38	62.47	103.92	156.44	234.5	260.27	417.94	456.98	533.39	530.12	500.68	367.34	383.09	300.35	283.52
2003	222.37	184.91	202.64	142.75	111.64	63.35	54.44	56.14	75.01	54.97	109.91	134.27	292.23	200.48	296.52	225.48	255.96
2004	105.23	64.07	53.89	71.19	89.07	102.94	179.73	189.48	210.51	228.31	263.88	286.71	302.63	295.83	321.3	298.09	310.69
2005	367.54	366.81	394.48	382.42	292.2	212.32	142.56	141.88	148.14	120.41	163.23	183.57	202.82	199.39	211.54	234.6	293.58
2006	106.62	65.17	55.02	60.53	56.51	64.4	89.67	118.17	172.6	195.95	249.05	253.67	268.63	258.94	316.37	271.39	305.36
2007	127.76	127.78	44.44	50.14	71.49	95.09	130.9	126.65	163.05	127.33	143.81	151.47	127.73	118.14	96.97	97.33	78.33
2008	40.52	75.8	168.18	313.35	487.49	558.09	723.55	765.35	745.66	700.52	575.74	483.95	353.16	292.94	202.98	172.85	159.02
2009	34.84	27.91	35.56	82.53	95.18	174.67	256.93	340.81	399.97	472.35	440.35	343.06	308.73	222.96	216.54	216.12	228.2
2010	26.95	59.88	115.81	237.16	357.73	450.98	657.91	797.36	783.43	728.24	730.17	599.55	501.99	342.57	311.58	200.33	178.83
2011	495.7	266.59	102.24	36.01	35.22	52.97	45.29	53.48	68.67	112.55	127.09	175.11	151.73	216.5	211	253.48	265.95
2012	31.51	10.47	28.7	37.89	60.04	85.44	180.18	260.69	271.02	361.21	356.49	393	285.59	311.8	191.99	159.01	100.77
2013	82.37	256.39	382.14	625.69	752.97	941.24	1032.14	804.65	871.29	624.02	630.49	398.24	297.86	230.32	172.79	167.3	139.27
2014	270.83	191.65	97.54	90.33	80.19	63.24	84.29	194.45	216.29	368.08	290.71	424.02	404.59	438.04	306.42	273.1	161.13
2015	68.52	76.4	74.68	77.24	81.2	120.71	177.16	277.29	381.46	518.27	713.99	895.67	1043.46	1100.87	975.04	927.84	757.11
2016	267.98	252.73	221.96	150.19	105.93	55.99	35.84	38.84	67.34	85.32	103.5	129.76	176.08	161.76	224.67	245.88	291.93
2017	131.4	157.27	188.4	183.33	181.02	162.7	141.22	141.25	156.77	181.72	167.48	171.32	177.03	157.21	157.43	182.84	165.78
2018	97.89	105.26	135.08	104.3	89.39	43.49	47.12	53.65	55.26	66.91	98.43	102.08	125.57	170.24	180.69	207.3	203.22

Table 2.8b (page 3 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1982	144.08	145.93	125.82	137.31	180.15	202.53	281.74	302.28	272.08	328.35	328.52	280.26	284.37	269.85	254.09	238.75	278.05
1983	60.92	62.12	86.33	94.13	142.53	157.08	212.11	269.26	300.94	287.62	298.19	315.88	253.78	248.09	246.27	224.99	298.31
1984	101.57	87.99	58.63	93.66	75.15	91.32	93.91	96.4	108.26	133.79	105.81	109.43	94.8	108.86	141.86	129	156.38
1985	351.31	388.84	413.42	514.19	499.92	513.93	482.48	470.1	359.07	322.98	243.7	192.44	167.73	128.47	96.34	93.41	102.95
1986	220.42	194.41	137.72	125.77	136.16	163.18	185.05	216.02	204.94	245.53	217.54	247.93	268.96	258.36	275.24	288.1	299.44
1987	173.81	206.04	198.61	264.83	299.39	299.85	298.17	292.37	286.67	232.81	233.77	237.09	141.26	143.94	119.33	105.07	132.41
1988	94.99	123.22	112.44	162.12	150.07	132.56	214.54	185.82	198.72	186.34	165.97	207.54	178.95	154.3	170.63	171.27	174.86
1989	48.56	53.27	41.61	48.9	48.18	57.23	75.98	69.12	74.06	78.84	72.19	84.47	106.57	96.9	108.79	103.28	98.43
1990	53.68	63.1	48.54	43.57	38.1	35.64	31.39	34.88	48.81	37.57	39.03	28.59	49.69	32.52	59.65	54.33	68.63
1991	136.63	114.15	81.99	66.78	60.62	58.17	49.46	59.35	50.21	60.03	71.88	46.57	59.05	40.32	70.37	85.17	55.78
1992	134.07	194.82	153.18	226.33	197.54	230.83	255.9	195.15	193.89	169.28	148.92	160.42	124.84	111.79	92.53	82	59.41
1993	153.67	162.03	186.74	184.95	222.65	223.37	235.57	272.88	208.4	187.33	194.47	159.96	152.3	130.06	115.11	119.55	108.68
1994	181.44	108.37	121.42	106.75	203.55	172.88	152.76	213.48	234.46	243.02	275.51	158.69	173.89	210.35	174.07	166.06	161.17
1995	338.31	401.31	397.26	442.6	448.89	419.41	363.68	355.99	313.17	211.47	201.65	163.46	151.07	122.6	105.12	115.96	101.44
1996	165.55	153.32	175.7	212.12	236.51	285.66	258.4	290.83	320.09	299.68	295.27	322.4	270.29	281.61	281.08	246.27	256.15
1997	150.96	141.07	131.32	131.72	142.84	140.56	175.43	202.55	239.13	156.28	177.38	140.42	158.53	187.35	194.15	170.98	175.42
1998	144.9	132.95	100.43	125.45	117.95	135.51	128.21	175.79	118.66	114.73	136.44	113.33	92.72	90.11	84.34	82.32	73.94
1999	326.22	417.4	471.67	530.44	573.15	571.2	479.82	365.31	374.86	286.53	213.87	183.44	161.15	144.3	128.33	108.73	113.48
2000	216.73	248.41	256.7	293.31	299.54	337.61	298.03	353.54	316.46	383.44	334.5	343.2	254.12	305.3	232.6	249.76	189.06
2001	289.32	212.51	182.59	169.62	147.79	154.17	180.31	222.77	272.95	220.93	257.92	248.21	227.64	257.23	264.79	254	228.5
2002	240.73	280.84	250.63	398.06	349.54	438.6	384.35	381.92	268.66	320.61	184.85	224.54	179.88	162.9	133.08	159.25	124.62
2003	272.8	301.1	339.54	328.81	369.09	439.05	409.33	440.55	405.18	375.45	275.94	274.48	231.36	246.68	258.93	200.81	185.73
2004	242.43	235.22	203.91	198.85	179.64	173.84	150.2	145.35	145.15	168.4	163.96	197.55	192.42	154.57	175.63	168.32	181.49
2005	258.14	215.23	208.11	216.04	217.95	227.29	175.74	224.87	180.83	203.14	139.59	179.07	132.15	154.1	137.25	143.83	118.89
2006	268.41	250.94	219.07	206.49	170.12	176.61	153.05	157.42	143.02	171.3	160.52	209.07	181.2	185.17	166.4	191.27	143.35
2007	64.79	77.77	81.33	84.72	71.38	92.01	84.33	91.42	88.56	85.93	64.13	83.05	77.43	93.58	73.49	75.15	65.19
2008	141.74	135.06	124.07	150.33	135.43	147.33	140.93	142.82	117.78	139.79	127.28	129.24	131.33	149.95	119.41	114.63	103.26
2009	304.09	307.98	365.99	382.29	383.26	350.43	339.56	282.48	292.88	249.62	182.66	147.88	147.87	118.56	104.82	94.87	85.27
2010	123.34	140.07	145.44	228.77	243.4	428.26	282.87	308.65	293.48	292.03	227.3	250.74	196.79	273.26	210.15	286.12	279.56
2011	374.03	422.84	623.86	739.04	795.82	854.23	810.64	729.87	588.15	474.29	325.51	327.79	260.11	245.42	174.66	216.65	208.97
2012	82	63.11	46.17	64.22	59.55	86.46	81.75	134	111.84	198.87	188.94	241.6	287.98	382.76	324.89	412.94	311.73
2013	120.31	177.91	146.96	223.96	286.25	350.86	419.84	510.27	397.69	377.65	353.58	319.11	259.85	251.71	194.21	202.87	133.76
2014	167.27	127.49	179.03	249.41	391.27	403.08	577.48	594.55	536.18	491.89	433.57	374.2	252.08	191.81	179.53	184.08	163.89
2015	570.11	491.76	282.67	264.8	198.59	372.82	369.25	494.52	468.47	465.34	422.23	450.14	317.05	349.24	344.05	315.49	334.37
2016	281.2	327.97	382.64	461.07	581.98	607.53	811.18	887.54	861.5	877.55	761.95	687.38	536.8	415.95	418.21	296.77	295.9
2017	161.06	178.37	191.38	182.57	210.59	263.71	234.61	286.87	262.16	276.32	319.68	389.23	369.33	428.49	435.21	489.8	536.85
2018	257.19	261.71	270.41	273.53	275.75	252.41	219.27	187.39	204.87	184.73	218.6	198.2	194.05	218.06	214.87	232.7	223.15

Table 2.8b (page 4 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
1982	258.11	267.2	224.8	260.3	264.05	261.17	224.63	227.07	202.3	193.28	189.68	197.96	121.92	172.13	124.38	131.84	73.13
1983	276.51	257.68	262.27	245.39	262.11	245.27	200.79	223.91	195.71	200.21	190.92	165.77	188.13	176.12	144.78	180.56	125.85
1984	166.66	196.93	198.21	154.27	215.07	168.75	199.51	202.19	188.35	161.44	197.28	182.73	180.52	170.66	152.75	144.56	83.16
1985	101.16	103.84	85.07	86.95	90.4	84.55	148.18	109.85	109.52	112.68	170.59	122.95	134.43	146.23	146.58	135.02	134.74
1986	225.84	251.74	250.74	175.49	170.71	119.51	145.91	110.84	80.71	98.9	75.65	84.42	70.36	86.91	104.85	98.67	89.32
1987	123.71	86.55	112.91	80.68	124.24	120.33	110.53	113.88	111.05	117.95	109.9	115.86	117.87	97.48	103.65	81.72	53.52
1988	150.68	144.14	154.18	129.95	134.04	112.73	139.43	111.36	78.04	84.07	67.04	93.2	71	72.21	55.07	78.87	56.99
1989	139.6	122.94	91.3	99.24	89.5	123.82	79.6	93.66	102.71	76.57	71.56	105.19	91.66	57.89	84.79	44.98	78.99
1990	58.2	69.81	70.59	75.54	81.06	85.05	86.83	77.95	77.87	54.39	79.74	55.02	61.69	37.71	64.26	44.92	54.04
1991	72.67	39.59	34.73	40.37	40.65	33.27	49.69	46.6	40.93	25.13	43.19	39.93	47.55	44.88	46.52	32.68	30.71
1992	65.85	31.96	44.84	53.14	54.01	69.66	47.01	36.63	27.5	32.49	32	50.4	38.5	34.75	26.15	15.91	23.72
1993	88.62	64.19	67.11	79.99	66.62	56.87	58.41	53.11	36.26	66.37	36.91	36.69	61.5	28.67	28.65	14.93	14.93
1994	200.79	231.38	230.64	149.92	199.97	141.67	186.81	149.73	165.17	146.37	118.09	76.69	121.71	56.36	93.88	45.4	61.3
1995	92.89	98.6	91.48	77.53	98.9	105.46	112.12	107.48	93.53	75.41	56.89	64.58	75.87	75.11	73.19	53.68	58.06
1996	205.59	167.93	155.32	134.6	143.12	101.62	94.57	87.23	80.78	58.47	61.36	62.09	57.59	57.31	47.61	56.67	63.56
1997	128.74	222.38	177.71	181.02	137.53	136.41	111.69	116.89	127.42	107.45	106.61	97.7	89.92	73.15	60.98	63.93	57.2
1998	63.92	79.31	92.38	75.79	67.07	77.21	88.12	86.02	74.04	66.41	97.94	57.37	64.08	50.49	47.32	56.07	56.33
1999	87.37	93.24	89.1	82.9	63.64	106.48	79.24	90.5	75.41	86.77	56.19	61.94	46.16	54.65	60.71	44.1	44.34
2000	196.38	175.98	156.66	153.56	142.66	107.44	97.84	87.22	81.88	53.35	62.43	57.2	50.18	34.24	48.35	32.05	37.3
2001	216.2	225.6	185.03	205.19	180.69	146.06	192.76	128.66	150.53	145.32	102.66	79.08	101.73	64.88	73.88	54.43	48.82
2002	154.51	88.17	113.06	117.17	124.77	103.95	111.7	104.35	99.15	56.57	104.89	69.8	64.28	65.36	57.65	45.43	35.47
2003	171.16	145.7	125.25	141.5	136.26	111.13	95.87	70.93	93.9	67.21	69.02	68.96	64.84	66.79	72.45	46.9	52.67
2004	163.67	185.29	141.02	151.5	164.55	144.82	138.19	132.71	117.68	100.99	96.38	86.59	105.04	82.31	62.29	70.49	59.51
2005	115.1	105.37	105.41	106.03	123	89.66	127.01	90.99	134.16	114.57	116.67	111.85	111.85	86.4	93.21	80.17	75.89
2006	186.32	111.91	132.09	94.53	102.63	107.08	100.56	111.37	95.67	90.25	103.93	63.9	101.08	51.97	72	63.37	61.46
2007	65.7	57.9	59.37	57.35	69.63	58.14	66.68	55.09	55.65	50.23	50.97	34.04	45.85	44.56	33.66	24.65	34.55
2008	118.06	90.6	123.85	104.65	120.88	92.76	88.68	83.12	105.71	64.25	80.71	66.78	86.49	47.97	58.5	34.66	48.16
2009	76.49	78.57	87.3	90.97	71.94	85.49	78.52	53.55	66.1	73.03	54.44	41.09	49.82	32.68	41.2	32.08	21.06
2010	257.34	175.53	258.5	206.86	186	136.65	168.23	110.43	126.23	78.92	81.71	56.5	46.05	32.6	38.74	36.06	21.08
2011	245.87	172.06	258.25	224.11	278.88	213.62	274.38	176.3	232.88	160.71	190.08	141.47	151.3	108.73	118.94	58.51	73.19
2012	319.87	221.58	200.61	169.28	166.92	97.92	122.28	86.99	104.29	78.07	80.16	63.4	66.83	46.57	74.45	37.82	48.25
2013	187.32	141.6	212.36	190.52	231.52	192.09	208.71	206.17	226.66	209.57	188.61	160.11	140.78	132.19	105.24	104.46	90.19
2014	147.68	173.67	222.1	221.68	177.16	170.77	180.94	120.6	124.43	96.9	94.79	55.01	55.52	47.17	59.46	50.45	47.22
2015	385.01	334.78	431.48	329.79	299.8	217.35	243.89	156.5	165.47	112.39	107.47	112.66	97.09	80.92	65.76	61.81	61.68
2016	284.94	277.75	254.05	269.24	259.61	228.84	237.39	239.76	215.07	226.65	251.16	195.03	180.33	164.31	171.01	144.04	94.55
2017	552.48	514.48	462.85	398	368.99	352.17	306.83	339.42	272.87	242.34	201.72	214.59	190.18	193.58	187.79	134.02	136.1
2018	233.04	212.65	249.51	267.88	268.6	283.36	267.9	294.7	324.53	290.6	261.74	282.89	223.83	225.76	202.02	171.37	162.23

Table 2.8b (page 5 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
1982	72.66	72.02	64.47	44.59	34.26	36.76	29.71	19.95	26.6	23.93	12.31	7.54	6.54	9.08	2.69	6.19	4.17	0.6	2.48	3.49
1983	121.73	77.8	80.69	78.79	67.52	58.74	39.2	48.39	32.22	28.94	23.84	17.64	11.91	1.16	6.75	8.04	2.85	11.49	0.6	0.56
1984	119.37	97.71	104.22	75.12	82.28	56.08	67.92	46.1	39.92	31.7	32.79	27	21.63	27.92	12.14	16.23	18.67	12.2	9.34	4.02
1985	119.63	137.75	107.01	135.1	99.33	95.34	58.95	75.29	59.03	50.06	48.18	21.18	37.31	21.95	21.88	16.22	13.76	10.27	8.04	7.17
1986	70.31	89.99	86.11	69.33	81.28	71.16	62.16	83.79	55.63	53.36	42.8	28.86	26.28	34.86	18.31	21.19	18.25	30.09	9.82	16.23
1987	80.06	45.84	50.68	48.53	21.23	39.61	31.08	32.99	38.33	24.63	25.56	27.38	28.99	7.41	8.04	13.14	8.66	8.75	11.12	5.15
1988	56.71	38.24	53.94	48.4	32.31	28.9	37.13	48.87	43.71	35.75	20.51	22.04	9.58	18.92	10.05	5.47	10.21	1.95	12.17	2.05
1989	86.82	69.67	68.55	62.27	49.28	63.1	46.44	27.11	22.83	35.81	26.23	33.02	36.28	17.59	26.66	18.1	5.84	17.55	12.5	7.71
1990	54.19	52.19	45.48	32.02	38.19	38.39	25.69	36.46	36.29	11.24	23.86	20.14	21.84	18.08	12.79	11.54	17.61	11.97	5.13	4.28
1991	24.66	40.99	31.8	27.07	13.46	16.3	18.78	20.95	32.52	23.27	22.34	13.29	12.91	8.1	13.9	7	7.36	5.64	4.57	5.68
1992	25.57	22.04	18.6	26.66	15.89	18.63	26.29	30.12	14.79	18.65	15.58	11.92	13.59	14.69	6.78	10.06	7.63	13.09	5.59	7.22
1993	15.81	14.52	16.63	12.23	11.95	10.74	12.41	13.1	11.37	9.25	4.96	12.33	10.37	4.32	7.12	7.99	7.55	4.06	3.38	3.69
1994	27.61	36.89	18.04	27.67	12.06	19.9	8.7	8.13	9.46	12.27	4.96	8.21	7.37	8.31	6.31	3.49	5.57	31.54	12.01	8.62
1995	47.57	38.32	30.19	23.7	39.13	22.03	26.01	22.75	21.01	18.86	12.51	13.56	10.79	7.89	8.21	7.89	7.75	4.57	12.05	3.57
1996	34.13	46.69	36.79	27.29	29.23	34.57	22.54	21.24	24.4	24.81	15.19	25.81	9.72	14.17	21.84	17.47	9.46	4.1	2.54	6.53
1997	32.02	22.95	31.52	23.99	29.97	19.37	12.37	10.34	10.02	12.61	19.07	12.64	10.59	8.35	9.3	9.62	4.39	3.05	8.75	7.56
1998	39.91	53.1	28.85	36.19	21.29	20.7	24.31	12.41	16.86	9.49	15.76	10.91	8.3	9.63	7.67	3.77	3.51	5.32	5.19	9.47
1999	44.97	33.16	25.54	24.25	21.05	22.12	23.76	20.93	16.69	12.15	15.33	12.77	10.23	9.64	15.12	13.53	5.39	13.77	5.24	4.32
2000	30.09	32.84	27.82	21.65	11.58	13.76	20.68	21.33	12.19	17.06	18.17	8.1	9.07	5.01	8.27	26.05	6.28	6.91	6.96	3.52
2001	32.05	36.84	24.35	18.59	25.56	19.41	29.62	17.16	16.39	11.83	10.72	12.71	5.21	10.41	5.75	6.11	5.18	6.65	4.39	3.75
2002	35.11	31.54	23.45	29.63	22.88	12.64	9.96	19	13.47	5.74	6.14	2.87	6.66	1.63	3.44	4.72	1.47	2.09	3.42	4.73
2003	40.52	40.96	35.68	33.28	25.78	26.6	16.4	17.91	19.93	19.96	10.51	13.58	6.79	9.34	5.19	6.29	4.84	3.54	4.01	2.57
2004	61.23	33.45	49.36	45.16	41.19	43.43	30.13	26.09	23.32	22.21	14.95	21.92	10.45	25.15	11.74	18.35	14.9	12.09	5.66	3.7
2005	62.11	86.94	54.26	77.25	59.06	66.74	51.68	47.83	44.45	40.7	33.16	25.61	17.65	28.12	20.64	24.25	14.3	10.33	15.38	10.04
2006	68.3	71.21	57.29	62.73	45.98	59.3	46.32	59.2	52.66	53.14	38.17	44.51	39.21	35.55	20.42	35.32	15.62	23.67	15.96	17.96
2007	24.8	39.07	23.32	20.64	14.96	13.45	19.32	17.08	20.45	10.69	12.19	9.02	27.57	11.93	9.14	9.91	15.1	10.39	13.92	9.59
2008	25.05	46.27	19.45	27.62	24.32	25.45	12.71	16.62	12.45	18.71	14.56	12.97	9.09	19.64	11.33	10.23	8.21	15.71	5.12	9.96
2009	24.83	13.89	18.23	16.3	16.12	15.71	5.03	13.27	7.15	8.84	4.25	3.98	7.24	5.88	5.82	3.36	3.99	4.78	0.66	1.04
2010	24.25	17.5	18.24	25.43	13.35	20.07	8.02	11.64	12.82	11.51	9.02	4.03	12.94	10.98	1.35	6.51	1.93	3.89	3.9	4.16
2011	48.06	46.4	26.12	25.7	22.2	14.94	13.1	17.09	6.15	14.56	10.01	6.68	2.53	3.42	4.63	4.63	3.34	1.32	4.9	3.06
2012	24.18	28.82	21.48	20.29	19.33	17.73	5.98	10.63	4.54	7.19	6.14	6.48	3.89	4.12	4.17	0.86	1.09	2.5	2.21	0.97
2013	49.21	62.5	44.33	30.24	42.48	28.18	30.45	9.27	29.43	11.78	22.9	11.04	10.41	6.53	7.11	4.84	3.22	4.76	3.49	4.17
2014	58.3	43.75	38.61	35.9	26.35	25.15	17.56	14.64	14.61	7.39	7.26	7.2	3.24	4.04	5.07	3	1.31	5.72	1.94	2.5
2015	56.56	46.08	54.22	43.43	35.59	24.42	24.12	19.78	24.3	14.77	7.33	11.97	7.08	17.2	9.84	5.87	2.76	4.25	1.21	1.77
2016	87.35	68.92	50.22	46.76	47.88	36.65	25.78	24.34	36.18	16.37	18.92	21.55	16.48	10.21	8.73	7.38	8.23	5.02	5.95	4.74
2017	143.34	112.58	115.75	99.33	94.62	71.31	78.56	75.71	31.66	44.59	38.96	24.58	13.73	12.01	15.04	12.43	18.99	6.9	6.97	7.46
2018	133.1	99.32	75.58	70.33	91.34	55.98	59.22	60.24	46.28	41.28	38.03	33.11	13.9	21.77	21.23	14.46	11.18	11.28	7.38	4.23

Table 2.8b (page 6 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
1982	0	2.48	0	1.04	2.15	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	2.24	4.04	0	2.83	0	1.14	0	0	0	0	0	1.16	0	0	0	0	0	0	0	0	0	0	0	0
1984	7.47	5.87	0	3.66	2.69	2.21	0.58	0.58	0	0	0	0.87	0	0	0	0	0	0	0	0	0	0	0	0
1985	8.48	4.28	1.17	3.32	7.01	2.01	3.53	1.78	0	3.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	13.1	4.58	4.01	5.84	2.5	7.26	1.61	4.1	2.69	0	3.85	2.19	0	0	0	0	0	0	0	0	0	0	0	0
1987	10.14	8.82	1.32	5.07	5.22	2.8	1.05	0.51	2.17	2.55	0	0.92	0	0	0	0	0	0.4	0	0	0	0	0	0
1988	3.78	4.32	4.35	3.49	0.69	2.86	5.19	2.15	0.49	1.89	0	0	0.2	0	0	0	0	2.53	0	0	0	0	0	0
1989	9.75	11.72	13.21	7.97	4.31	8.47	4.64	4.08	9.05	0.25	9.22	2.75	0	0	0	0	0	0	0	0	0	0	0	0
1990	4.34	6.17	11.49	9.29	2.38	1.39	1.18	4.26	0	5.47	0.39	0	0.93	1.06	0.4	0	0	0	0	0	0	0	0	0
1991	3.84	1.4	6.04	7.27	3.04	1.98	2.63	0	0.47	0.29	5.33	0.8	0.41	1.3	0	0	0	0	0	0	0	0	0	0
1992	7.09	4.54	7.21	8.28	2.95	9.37	1.94	4.24	2.96	2.83	2.77	2.66	1.18	0.52	0.62	0	0.48	0	0.48	0	0	0	0	0
1993	7.44	2.54	7.08	5.02	4.72	3.66	3.57	1.28	2.03	1.89	0.64	8.53	2.5	0	1	0.29	0	0.3	0	0.3	0	0	1.46	0
1994	2.41	1.21	3.29	5.75	3.75	1.4	0.66	2.04	8.64	5.38	2.93	0.79	6.4	0	0	0.69	0	0.71	0	0	0	0	0	0
1995	4.48	3.71	10.4	1.13	3.38	1.91	2.97	5.15	0.87	3.44	0.7	0	1.45	0	0.58	0	0.34	0	0.78	0	0	0	0	0
1996	9.73	2.97	4.74	5.04	2.79	2.62	1.96	3.82	1.3	1.74	0	0.43	0	0	0	3.01	0	0	0	0	0	0	0	0
1997	2.01	5.68	3.42	2.41	3.7	0	1.09	1.84	0	0	0.72	1.56	0	0	0.32	0	3.09	0	0	0.31	0	0.58	0	0
1998	3.39	6.16	2.58	1.26	2.05	2.01	0.5	0.57	0.82	8.25	0	0	0	0.49	0	0.48	0	0.48	0	0	0	0	0	0
1999	4.52	4.66	1.92	4.65	5.41	5.55	2.81	2.13	1.16	0	1.83	0.5	0	0.57	1.16	0	0	0	0	0	0	0	0	0
2000	4.07	9.51	2.29	7.45	4.66	3.06	0.94	0.45	2.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	2.17	3.92	5.39	0.54	2.19	0.46	4.57	0.55	1.27	0	2.16	0.82	2.7	0.57	0	1.11	0	0	0	0	0	0	0	0
2002	4.83	0.9	3.34	1.55	3.12	5.68	0.96	1.34	0	0	1.14	0	1.83	0	0	0	0	0	0	0	0.59	0	0	0
2003	1.68	1.74	0	0.94	0.66	0.32	0	0	0.73	0	0.42	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	7.21	4.27	3.83	4.23	3.85	2.85	1.63	0	0.66	0	4.76	0	1.15	0	0	1.63	0	0.77	0	0	0	0	0	0
2005	7.78	4.44	9.17	5.15	2.86	3.64	0.44	3.64	2.09	0.4	0.78	0.42	0	0	0	0	0	0	0	0	0	0	0	0
2006	10.04	9.61	6.21	11.99	8.77	1.42	7.35	4.98	2.58	2.48	2.54	1.5	0	0.91	0	0	2.21	0	0	0	0	0	0	0
2007	3.37	8.04	4.26	5.63	2.35	2.83	2.55	2.9	1.82	8.06	1.32	2.43	1.05	2	0	0.53	0.5	0	0	0.53	0	0	0	0
2008	10.39	9.96	8.9	3.19	8.49	8.61	2.43	4.29	3.18	7.01	1.21	1.3	0	0	0.48	0	0	0.8	0	0	0	0	0	0
2009	1.07	2.38	3.31	4.67	2.36	3.07	0.55	2.03	1.36	0.87	0	0.67	2	0	0	0.69	0	0	0	0	0	0	0	0
2010	3.51	0.9	0	3.34	1.81	0.74	2.59	1.98	0	0	0	0	0.91	0	0	0.82	0	0.4	0	0	0	0	0	0
2011	4.12	6.79	2.09	0.65	0	1.12	0	2.17	1.44	1.03	0	1.54	0.64	0	0	0	0	0	0	0	0	0	0	0
2012	3.02	2.7	1.55	0.75	0	1.45	1.52	1.08	0.41	0	0.24	0.6	0	0.28	0	0.32	0	0.22	0	0	0	0	0	0
2013	4.57	1.39	1.54	0.36	1.37	0.45	1.21	0.66	0.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	1.84	0.42	0	2.51	0.77	1.87	0	1.34	0	0	1.38	0	0	0	0.42	0	0	0	0	0	0	0	0	0
2015	1.51	0.38	1.78	0.73	1.21	0.99	1.81	1.23	0	0	0.57	0.55	0.91	0	0	0	0	0	0	0	0	0	0	0
2016	3.34	1.54	2.87	2.32	2.19	2.05	0	1.42	2.76	1.52	0.99	1.98	0	0	0	0	0	0	0	0	0	0	0	0
2017	5.67	5.44	6.76	0.47	3.59	0.53	0	0.5	0.88	0	0	0	0.59	0	0	0	0	0	0	0	0	0	0	0
2018	5.16	4.68	3.9	2.89	4.13	4.92	3.8	0.68	0	2.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.8b (page 7 of 7)—Trawl survey size composition as used in Models 16.6i-j, by year and cm.

Year	117	118	119	120+
1982	0	0	0	0
1983	0	0	0	0
1984	0	0	0	0
1985	0	0	0	0
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	0.53	0	0	0
1993	0	0	0	0
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0
2015	0	0	0	0
2016	0	0	0	0
2017	0	0	0	0
2018	0	0	0	0

Table 2.8c (page 1 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1982	258	0	0	0	0	0	0.63	7.8	9	19.05	25.93	52.1	59.16	109.14	66.31	50.64	51.75	45.95	19.42
1983	321	0	0	0	0	0	7.13	95.81	290.44	454.74	457.65	483.72	461.36	433.44	394.31	252.29	249.7	119.74	73.96
1984	297	0	0	0	0	0	6.36	24.71	36.02	54.53	43.47	27.23	25.26	25.66	30.05	46.06	31.51	64	71.97
1985	413	0	0	0	0	0	4.38	55.87	101.59	179.48	144.71	215.93	287.18	304.38	372.09	503.12	507.05	526.31	646.65
1986	376	0	0	0	0	0.54	22.68	37.91	93.08	133.34	130	201.57	174.63	176.87	149.92	92.58	34.43	26.51	20.22
1987	232	0	0	0	0	0	0	11.84	3.2	6.24	21.11	32.96	53.16	70.28	94.08	104.87	104.73	133.26	107.55
1988	165	0	0	0	0	0	0	0.36	5.26	4.99	18.82	9.02	19.88	17.65	15.58	28.16	19.27	12.69	18.12
1989	104	0	0	0	0	0	1.08	1.08	7.79	19.41	15.12	28.66	35.42	44.37	43.23	41.47	26.98	16.17	7.89
1990	133	0	0	0	0	0	23.98	66.57	96.94	143.28	139.96	172.78	219.99	242.22	192.69	140.17	110.23	84.07	53.1
1991	171	0	0	0	0	0	6.11	29.46	89.6	107.21	133.76	130.32	156.35	126.7	130.48	123.02	102.61	128.82	82.61
1992	248	0	0	0	0	0	0	0.76	17.36	84.53	191.26	198.3	182.41	157.01	206.42	232.35	245.28	259.63	225.11
1993	257	0	0	0	0	0.74	2.47	29.18	81.09	191.48	426.09	294.68	405.36	355.61	322.11	320.21	347.25	312.71	322.81
1994	316	0	0	0	0	0	3.02	9.13	4.95	24.23	38.1	70.19	83.16	90.72	91.82	107.71	125.89	101.96	95.99
1995	240	0	0	0	0	0.37	3.36	12.36	15.74	14	20.24	43.78	39.4	44.6	59.13	62.79	85.57	72.27	36.76
1996	228	0	0	0	0	0	0.96	1.55	11.17	9.29	22.53	33.1	47.77	63.19	53.26	65.91	68.55	63.33	53.72
1997	234	0	0	0	0	0	8.71	17.99	67.44	118.02	171.97	198.93	197.94	204.31	218.94	294.66	233.08	224.52	232.23
1998	234	0	0	0	0	0	1.25	4.26	22.91	52.22	82.75	115.07	102.78	134.38	89.65	45.07	21.83	6.57	4.24
1999	273	0	0	0	0	0	0.67	12.91	45.93	86.08	94.19	104.77	80.52	97.46	67.42	36.12	25.55	38.01	44.81
2000	297	0	0	0	3.92	9.75	22.23	49.26	95.03	131.13	286.04	460.14	558.6	424.43	266.86	263.38	137.19	83.78	31.37
2001	466	0	0	0	0	4.57	5.98	25.65	59.87	121.3	195.21	297.11	429.46	628.92	678.16	730.36	649.07	633.39	420.79
2002	291	0	0	0	0	0.61	2.71	5.57	20.85	41.41	60.43	76.16	99.61	152.56	107.1	158.46	106.06	68.21	49.25
2003	289	0	0	1.15	0	0.63	2.57	4.83	10.62	51.78	86.04	127.28	189.91	215.99	191.52	231.8	235.49	262.38	234.39
2004	255	0	1.46	0	0	0	0.71	3.62	18.58	43.35	81.66	145.38	101.23	186.28	179.75	204.99	199.93	128.02	137.18
2005	287	0	0	0	0	0	0	0.83	3.98	22.67	44.23	87.9	139.29	202.79	250.74	307.19	287.55	305.01	292.46
2006	306	0	0.84	0	4.32	7.32	40.24	100.63	335.71	404.17	427.1	455.24	402.33	344.81	329.32	359.05	281.5	244.62	146.08
2007	329	0	0	0	0	7.54	7.55	131.8	490.68	1187.05	1459.03	1434.6	1172.34	755.94	741.12	546.15	355.8	428.01	243.96
2008	328	0	0	0.74	0	0	5.59	54.35	169.2	350.15	380.13	390.14	351.52	312.15	227.23	150.87	75.81	40.08	20.99
2009	412	0.58	0	0.46	7.03	35.98	106.02	402.3	975.35	1062.23	1092.53	882.44	748.73	654.83	489.11	466.61	324.97	223.26	116.63
2010	342	0	0	0	0	0	1.28	8.69	32.28	43.8	53.11	91.87	91.73	103.18	85.35	56.62	27.98	30.26	17.26
2011	471	0	0	0	0	0	6.91	18.01	69.65	130.98	237.83	283.33	356.94	380.95	550.24	579.48	837.59	819.03	790.94
2012	323	0	0	5.83	0	0.5	74.06	381.83	691.01	737.12	566.87	426.68	420.52	313.61	412.93	399.21	210.25	129.9	48.07
2013	443	0	0	0	0	0.7	8.9	47.72	110.96	140.3	198.32	212.54	272.8	233.29	172.88	121.24	34.33	20.59	60.78
2014	387	0	0	0	1.19	0	0.44	8.27	78.62	102.33	209.72	299.8	408.84	455.18	576.93	437.28	533.13	430.18	456.72
2015	468	0	0	0	0	0	0	10.77	41.22	41.4	84.32	76.14	51.61	46.83	56.34	56.72	59.76	72.97	84.02
2016	420	0	0	0	0	0.76	0	5.12	16.21	25.82	52.56	59.11	39.01	22.51	50.65	63.82	96.19	147.14	220.9
2017	269	0	0	0	0	0	0	1.88	1.9	12.1	32.97	42.98	42.94	57.24	52.75	65.26	79.03	89.75	116.28
2018	215	0	0	0	0	0	0	0	0	2.74	4.82	5.37	18.65	19.01	37.05	33.88	53.04	44.95	54.88
2010	27	0	1.05	0	0	0	0	2.03	1.97	3.15	2	0.98	0	0	0.97	0	0	0	3.8
2017	525	0	0	0	0	0	0	0	0	0	0.85	10.33	5.3	11.86	9.8	4.69	6.46	6.46	7.35
2018	348	0	0	0	0	0	0	0	1.56	3.17	11.86	16.21	18.7	24.75	11.06	7.71	2.48	3.73	4.42

Table 2.8c (page 2 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
1982	8.46	8.78	2.05	8.06	17.89	24.83	39.62	67.18	86.57	123.05	193.11	220.73	239.91	305.24	316.7	236.84	196.61
1983	44.2	28.52	8.7	5.14	18.02	33.83	45.8	55.67	100.41	125.16	145.74	173.46	165.42	212.96	145.4	127.05	107.45
1984	90.37	124.61	230.58	311.66	379.02	460.29	574.23	599.61	646.78	569.4	477.17	393.84	345.07	295.05	220.31	154.5	106.57
1985	559.17	555.06	321.31	212.29	130.27	91.1	100.45	106.48	159.21	219.62	215.87	271.92	299.71	308.61	311.54	287.7	342.62
1986	21.84	71.65	114.14	218.28	360.04	449.13	697.14	628.75	616.37	638.29	653.29	580.01	557.09	447.98	401.96	348.78	332.11
1987	69.76	53.03	41.03	56.29	67.59	104.96	108.44	174.19	241.06	265.9	285.04	256.36	249.04	182.88	205.69	177.41	155.63
1988	23.3	31.92	47.27	52.61	59.71	58.43	74.26	56	85.11	81.91	92.17	120.6	127.74	180.51	144.71	131.1	141.6
1989	8.79	12.31	1.44	6.28	6.39	14.55	5.51	13.85	12.52	11.63	13.56	15.23	29.72	13.56	44.72	46.6	61.47
1990	33.04	39.29	41.23	32.47	46.65	73.5	73.57	93.04	98.71	93.22	87.14	111.5	116.1	74.69	107.07	89.47	62.8
1991	69.33	69.29	77.23	96.47	98.35	165.12	189.01	261.95	279.03	312.57	278.2	357.18	295.73	240.34	250.08	187.35	165.68
1992	237.29	118.8	124.66	142.31	194.32	280.21	303.19	319.08	368.35	389.95	367.86	326.96	318.42	257.17	232.93	188.96	158.65
1993	216.43	134.96	98.53	62.09	57.13	67.17	88.24	94.83	174.73	208	236.24	291.96	318.59	241.03	246.89	228.11	197.7
1994	87.7	129.59	118.67	175.45	157.18	207.4	305.88	407.78	521.07	597.65	675.65	704.95	619.74	588.33	431.64	332.79	265.78
1995	25.62	20.08	39.23	49.85	94.75	115.9	168.09	206.88	243.54	231.38	261.39	240.46	212.04	165.81	231.23	264.36	255.2
1996	35.43	20.25	22.62	23.66	57.75	63.79	128.82	161.74	192.23	226.97	272.19	234.74	248.02	189.38	197.75	166.8	156.56
1997	183.1	108.06	59.21	42.28	42.01	36.27	73.05	112.78	106.38	158.04	230.86	237.59	228.5	181.06	163.13	160.19	141.75
1998	19.4	24.12	58.01	72.24	185.1	275.48	380.63	489.36	595.38	619.2	607.48	506.53	529.95	342.89	257.54	224.61	163.73
1999	38.57	56.18	103.32	107.88	184.21	202.38	198.34	275.25	243.21	258.02	270.61	213.67	206.65	198.85	208.97	270.33	352.63
2000	8.78	11.74	23.63	37.25	75.14	114.04	163.86	189.47	214.77	251.04	294.18	216.44	190.77	179.9	184.38	168.61	193.42
2001	337.11	211.51	135.36	112.51	158.88	221.56	306.73	358.09	492.03	632.19	798.63	793.76	880.94	772.83	670.56	493.14	398.45
2002	33.25	17.18	41.38	62.47	103.92	156.44	234.5	260.27	417.94	456.98	533.39	530.12	500.68	367.34	383.09	300.35	283.52
2003	222.37	184.91	202.64	142.75	111.64	63.35	54.44	56.14	75.01	54.97	109.91	134.27	292.23	200.48	296.52	225.48	255.96
2004	105.23	64.07	53.89	71.19	89.07	102.94	179.73	189.48	210.51	228.31	263.88	286.71	302.63	295.83	321.3	298.09	310.69
2005	367.54	366.81	394.48	382.42	292.2	212.32	142.56	141.88	148.14	120.41	163.23	183.57	202.82	199.39	211.54	234.6	293.58
2006	106.62	65.17	55.02	60.53	56.51	64.4	89.67	118.17	172.6	195.95	249.05	253.67	268.63	258.94	316.37	271.39	305.36
2007	127.76	127.78	44.44	50.14	71.49	95.09	130.9	126.65	163.05	127.33	143.81	151.47	127.73	118.14	96.97	97.33	78.33
2008	40.52	75.8	168.18	313.35	487.49	558.09	723.55	765.35	745.66	700.52	575.74	483.95	353.16	292.94	202.98	172.85	159.02
2009	34.84	27.91	35.56	82.53	95.18	174.67	256.93	340.81	399.97	472.35	440.35	343.06	308.73	222.96	216.54	216.12	228.2
2010	25.16	57.93	110.76	232.33	356.67	443.49	654.83	791.16	775.45	725.98	728.1	597.5	500.93	342.57	311.58	199.31	177.87
2011	495.7	266.59	102.24	36.01	35.22	52.97	45.29	53.48	68.67	112.55	127.09	175.11	151.73	216.5	211	253.48	265.95
2012	31.51	10.47	28.7	37.89	60.04	85.44	180.18	260.69	271.02	361.21	356.49	393	285.59	311.8	191.99	159.01	100.77
2013	82.37	256.39	382.14	625.69	752.97	941.24	1032.14	804.65	871.29	624.02	630.49	398.24	297.86	230.32	172.79	167.3	139.27
2014	270.83	191.65	97.54	90.33	80.19	63.24	84.29	194.45	216.29	368.08	290.71	424.02	404.59	438.04	306.42	273.1	161.13
2015	68.52	76.4	74.68	77.24	81.2	120.71	177.16	277.29	381.46	518.27	713.99	895.67	1043.46	1100.87	975.04	927.84	757.11
2016	267.98	252.73	221.96	150.19	105.93	55.99	35.84	38.84	67.34	85.32	103.5	129.76	176.08	161.76	224.67	245.88	291.93
2017	123.9	146.28	163.41	168.62	154.24	126.74	90.06	91.68	85.03	110.77	85.21	104.52	107.14	116.1	119.96	147.76	135.9
2018	94.25	101.21	128.54	100.19	81.7	41.31	41.44	43.72	40.66	43.93	75.99	90.95	108.45	147.63	165.33	183.74	178.15
2010	1.79	1.95	5.05	4.83	1.06	7.49	3.08	6.2	7.98	2.26	2.07	2.05	1.06	0	0	1.02	0.96
2017	7.5	10.99	24.99	14.71	26.78	35.96	51.16	49.57	71.74	70.95	82.27	66.8	69.89	41.11	37.47	35.08	29.88
2018	3.64	4.05	6.54	4.11	7.69	2.18	5.68	9.93	14.6	22.98	22.44	11.13	17.12	22.61	15.36	23.56	25.07

Table 2.8c (page 3 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1982	144.08	145.93	125.82	137.31	180.15	202.53	281.74	302.28	272.08	328.35	328.52	280.26	284.37	269.85	254.09	238.75	278.05
1983	60.92	62.12	86.33	94.13	142.53	157.08	212.11	269.26	300.94	287.62	298.19	315.88	253.78	248.09	246.27	224.99	298.31
1984	101.57	87.99	58.63	93.66	75.15	91.32	93.91	96.4	108.26	133.79	105.81	109.43	94.8	108.86	141.86	129	156.38
1985	351.31	388.84	413.42	514.19	499.92	513.93	482.48	470.1	359.07	322.98	243.7	192.44	167.73	128.47	96.34	93.41	102.95
1986	220.42	194.41	137.72	125.77	136.16	163.18	185.05	216.02	204.94	245.53	217.54	247.93	268.96	258.36	275.24	288.1	299.44
1987	173.81	206.04	198.61	264.83	299.39	299.85	298.17	292.37	286.67	232.81	233.77	237.09	141.26	143.94	119.33	105.07	132.41
1988	94.99	123.22	112.44	162.12	150.07	132.56	214.54	185.82	198.72	186.34	165.97	207.54	178.95	154.3	170.63	171.27	174.86
1989	48.56	53.27	41.61	48.9	48.18	57.23	75.98	69.12	74.06	78.84	72.19	84.47	106.57	96.9	108.79	103.28	98.43
1990	53.68	63.1	48.54	43.57	38.1	35.64	31.39	34.88	48.81	37.57	39.03	28.59	49.69	32.52	59.65	54.33	68.63
1991	136.63	114.15	81.99	66.78	60.62	58.17	49.46	59.35	50.21	60.03	71.88	46.57	59.05	40.32	70.37	85.17	55.78
1992	134.07	194.82	153.18	226.33	197.54	230.83	255.9	195.15	193.89	169.28	148.92	160.42	124.84	111.79	92.53	82	59.41
1993	153.67	162.03	186.74	184.95	222.65	223.37	235.57	272.88	208.4	187.33	194.47	159.96	152.3	130.06	115.11	119.55	108.68
1994	181.44	108.37	121.42	106.75	203.55	172.88	152.76	213.48	234.46	243.02	275.51	158.69	173.89	210.35	174.07	166.06	161.17
1995	338.31	401.31	397.26	442.6	448.89	419.41	363.68	355.99	313.17	211.47	201.65	163.46	151.07	122.6	105.12	115.96	101.44
1996	165.55	153.32	175.7	212.12	236.51	285.66	258.4	290.83	320.09	299.68	295.27	322.4	270.29	281.61	281.08	246.27	256.15
1997	150.96	141.07	131.32	131.72	142.84	140.56	175.43	202.55	239.13	156.28	177.38	140.42	158.53	187.35	194.15	170.98	175.42
1998	144.9	132.95	100.43	125.45	117.95	135.51	128.21	175.79	118.66	114.73	136.44	113.33	92.72	90.11	84.34	82.32	73.94
1999	326.22	417.4	471.67	530.44	573.15	571.2	479.82	365.31	374.86	286.53	213.87	183.44	161.15	144.3	128.33	108.73	113.48
2000	216.73	248.41	256.7	293.31	299.54	337.61	298.03	353.54	316.46	383.44	334.5	343.2	254.12	305.3	232.6	249.76	189.06
2001	289.32	212.51	182.59	169.62	147.79	154.17	180.31	222.77	272.95	220.93	257.92	248.21	227.64	257.23	264.79	254	228.5
2002	240.73	280.84	250.63	398.06	349.54	438.6	384.35	381.92	268.66	320.61	184.85	224.54	179.88	162.9	133.08	159.25	124.62
2003	272.8	301.1	339.54	328.81	369.09	439.05	409.33	440.55	405.18	375.45	275.94	274.48	231.36	246.68	258.93	200.81	185.73
2004	242.43	235.22	203.91	198.85	179.64	173.84	150.2	145.35	145.15	168.4	163.96	197.55	192.42	154.57	175.63	168.32	181.49
2005	258.14	215.23	208.11	216.04	217.95	227.29	175.74	224.87	180.83	203.14	139.59	179.07	132.15	154.1	137.25	143.83	118.89
2006	268.41	250.94	219.07	206.49	170.12	176.61	153.05	157.42	143.02	171.3	160.52	209.07	181.2	185.17	166.4	191.27	143.35
2007	64.79	77.77	81.33	84.72	71.38	92.01	84.33	91.42	88.56	85.93	64.13	83.05	77.43	93.58	73.49	75.15	65.19
2008	141.74	135.06	124.07	150.33	135.43	147.33	140.93	142.82	117.78	139.79	127.28	129.24	131.33	149.95	119.41	114.63	103.26
2009	304.09	307.98	365.99	382.29	383.26	350.43	339.56	282.48	292.88	249.62	182.66	147.88	147.87	118.56	104.82	94.87	85.27
2010	123.34	139	144.55	228.77	243.4	427.24	282.87	308.65	292.55	292.03	227.3	250.74	195.88	273.26	210.15	286.12	278.53
2011	374.03	422.84	623.86	739.04	795.82	854.23	810.64	729.87	588.15	474.29	325.51	327.79	260.11	245.42	174.66	216.65	208.97
2012	82	63.11	46.17	64.22	59.55	86.46	81.75	134	111.84	198.87	188.94	241.6	287.98	382.76	324.89	412.94	311.73
2013	120.31	177.91	146.96	223.96	286.25	350.86	419.84	510.27	397.69	377.65	353.58	319.11	259.85	251.71	194.21	202.87	133.76
2014	167.27	127.49	179.03	249.41	391.27	403.08	577.48	594.55	536.18	491.89	433.57	374.2	252.08	191.81	179.53	184.08	163.89
2015	570.11	491.76	282.67	264.8	198.59	372.82	369.25	494.52	468.47	465.34	422.23	450.14	317.05	349.24	344.05	315.49	334.37
2016	281.2	327.97	382.64	461.07	581.98	607.53	811.18	887.54	861.5	877.55	761.95	687.38	536.8	415.95	418.21	296.77	295.9
2017	143.88	154.84	171.34	153.18	179.51	222.81	183.05	234.04	217.5	226.16	263.12	309.58	282.14	331.14	334.48	385.8	412.2
2018	228.27	215.94	217.03	222.87	231.31	194.12	162.67	147.83	159.82	146.51	177.7	158.44	163.95	186.86	173.45	189.96	174.3
2010	0	1.07	0.89	0	0	1.02	0	0	0.93	0	0	0	0.91	0	0	0	1.03
2017	17.18	23.53	20.04	29.39	31.08	40.9	51.56	52.83	44.66	50.16	56.56	79.65	87.19	97.35	100.73	104	124.65
2018	28.92	45.77	53.38	50.66	44.44	58.29	56.6	39.56	45.05	38.22	40.9	39.76	30.1	31.2	41.42	42.74	48.85

Table 2.8c (page 4 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72
1982	258.11	267.2	224.8	260.3	264.05	261.17	224.63	227.07	202.3	193.28	189.68	197.96	121.92	172.13	124.38	131.84	73.13
1983	276.51	257.68	262.27	245.39	262.11	245.27	200.79	223.91	195.71	200.21	190.92	165.77	188.13	176.12	144.78	180.56	125.85
1984	166.66	196.93	198.21	154.27	215.07	168.75	199.51	202.19	188.35	161.44	197.28	182.73	180.52	170.66	152.75	144.56	83.16
1985	101.16	103.84	85.07	86.95	90.4	84.55	148.18	109.85	109.52	112.68	170.59	122.95	134.43	146.23	146.58	135.02	134.74
1986	225.84	251.74	250.74	175.49	170.71	119.51	145.91	110.84	80.71	98.9	75.65	84.42	70.36	86.91	104.85	98.67	89.32
1987	123.71	86.55	112.91	80.68	124.24	120.33	110.53	113.88	111.05	117.95	109.9	115.86	117.87	97.48	103.65	81.72	53.52
1988	150.68	144.14	154.18	129.95	134.04	112.73	139.43	111.36	78.04	84.07	67.04	93.2	71	72.21	55.07	78.87	56.99
1989	139.6	122.94	91.3	99.24	89.5	123.82	79.6	93.66	102.71	76.57	71.56	105.19	91.66	57.89	84.79	44.98	78.99
1990	58.2	69.81	70.59	75.54	81.06	85.05	86.83	77.95	77.87	54.39	79.74	55.02	61.69	37.71	64.26	44.92	54.04
1991	72.67	39.59	34.73	40.37	40.65	33.27	49.69	46.6	40.93	25.13	43.19	39.93	47.55	44.88	46.52	32.68	30.71
1992	65.85	31.96	44.84	53.14	54.01	69.66	47.01	36.63	27.5	32.49	32	50.4	38.5	34.75	26.15	15.91	23.72
1993	88.62	64.19	67.11	79.99	66.62	56.87	58.41	53.11	36.26	66.37	36.91	36.69	61.5	28.67	28.65	14.93	14.93
1994	200.79	231.38	230.64	149.92	199.97	141.67	186.81	149.73	165.17	146.37	118.09	76.69	121.71	56.36	93.88	45.4	61.3
1995	92.89	98.6	91.48	77.53	98.9	105.46	112.12	107.48	93.53	75.41	56.89	64.58	75.87	75.11	73.19	53.68	58.06
1996	205.59	167.93	155.32	134.6	143.12	101.62	94.57	87.23	80.78	58.47	61.36	62.09	57.59	57.31	47.61	56.67	63.56
1997	128.74	222.38	177.71	181.02	137.53	136.41	111.69	116.89	127.42	107.45	106.61	97.7	89.92	73.15	60.98	63.93	57.2
1998	63.92	79.31	92.38	75.79	67.07	77.21	88.12	86.02	74.04	66.41	97.94	57.37	64.08	50.49	47.32	56.07	56.33
1999	87.37	93.24	89.1	82.9	63.64	106.48	79.24	90.5	75.41	86.77	56.19	61.94	46.16	54.65	60.71	44.1	44.34
2000	196.38	175.98	156.66	153.56	142.66	107.44	97.84	87.22	81.88	53.35	62.43	57.2	50.18	34.24	48.35	32.05	37.3
2001	216.2	225.6	185.03	205.19	180.69	146.06	192.76	128.66	150.53	145.32	102.66	79.08	101.73	64.88	73.88	54.43	48.82
2002	154.51	88.17	113.06	117.17	124.77	103.95	111.7	104.35	99.15	56.57	104.89	69.8	64.28	65.36	57.65	45.43	35.47
2003	171.16	145.7	125.25	141.5	136.26	111.13	95.87	70.93	93.9	67.21	69.02	68.96	64.84	66.79	72.45	46.9	52.67
2004	163.67	185.29	141.02	151.5	164.55	144.82	138.19	132.71	117.68	100.99	96.38	86.59	105.04	82.31	62.29	70.49	59.51
2005	115.1	105.37	105.41	106.03	123	89.66	127.01	90.99	134.16	114.57	116.67	111.85	111.85	86.4	93.21	80.17	75.89
2006	186.32	111.91	132.09	94.53	102.63	107.08	100.56	111.37	95.67	90.25	103.93	63.9	101.08	51.97	72	63.37	61.46
2007	65.7	57.9	59.37	57.35	69.63	58.14	66.68	55.09	55.65	50.23	50.97	34.04	45.85	44.56	33.66	24.65	34.55
2008	118.06	90.6	123.85	104.65	120.88	92.76	88.68	83.12	105.71	64.25	80.71	66.78	86.49	47.97	58.5	34.66	48.16
2009	76.49	78.57	87.3	90.97	71.94	85.49	78.52	53.55	66.1	73.03	54.44	41.09	49.82	32.68	41.2	32.08	21.06
2010	257.34	175.53	258.5	206.86	186	135.68	166.18	107.55	123.49	75.21	78.89	54.52	41.16	30.78	36.78	32.31	17.37
2011	245.87	172.06	258.25	224.11	278.88	213.62	274.38	176.3	232.88	160.71	190.08	141.47	151.3	108.73	118.94	58.51	73.19
2012	319.87	221.58	200.61	169.28	166.92	97.92	122.28	86.99	104.29	78.07	80.16	63.4	66.83	46.57	74.45	37.82	48.25
2013	187.32	141.6	212.36	190.52	231.52	192.09	208.71	206.17	226.66	209.57	188.61	160.11	140.78	132.19	105.24	104.46	90.19
2014	147.68	173.67	222.1	221.68	177.16	170.77	180.94	120.6	124.43	96.9	94.79	55.01	55.52	47.17	59.46	50.45	47.22
2015	385.01	334.78	431.48	329.79	299.8	217.35	243.89	156.5	165.47	112.39	107.47	112.66	97.09	80.92	65.76	61.81	61.68
2016	284.94	277.75	254.05	269.24	259.61	228.84	237.39	239.76	215.07	226.65	251.16	195.03	180.33	164.31	171.01	144.04	94.55
2017	379.9	369.65	324.04	254.45	239.37	228.9	184.75	216.91	169.77	150.23	131.54	131.95	120.81	141.48	125.7	91.83	78.48
2018	175.1	159.33	176.12	203.49	183.89	199.54	182.65	221.51	213.79	192.56	169.65	194.51	148.71	155.37	144.63	103.53	103.5
2010	0	0	0	0	0	0.97	2.05	2.88	2.74	3.71	2.82	1.98	4.89	1.82	1.96	3.75	3.71
2017	172.58	144.83	138.81	143.55	129.62	123.27	122.08	122.51	103.1	92.11	70.18	82.64	69.37	52.1	62.09	42.19	57.62
2018	57.94	53.32	73.39	64.39	84.71	83.82	85.25	73.19	110.74	98.04	92.09	88.38	75.12	70.39	57.39	67.84	58.73

Table 2.8c (page 5 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
1982	72.66	72.02	64.47	44.59	34.26	36.76	29.71	19.95	26.6	23.93	12.31	7.54	6.54	9.08	2.69	6.19	4.17	0.6	2.48	3.49
1983	121.73	77.8	80.69	78.79	67.52	58.74	39.2	48.39	32.22	28.94	23.84	17.64	11.91	1.16	6.75	8.04	2.85	11.49	0.6	0.56
1984	119.37	97.71	104.22	75.12	82.28	56.08	67.92	46.1	39.92	31.7	32.79	27	21.63	27.92	12.14	16.23	18.67	12.2	9.34	4.02
1985	119.63	137.75	107.01	135.1	99.33	95.34	58.95	75.29	59.03	50.06	48.18	21.18	37.31	21.95	21.88	16.22	13.76	10.27	8.04	7.17
1986	70.31	89.99	86.11	69.33	81.28	71.16	62.16	83.79	55.63	53.36	42.8	28.86	26.28	34.86	18.31	21.19	18.25	30.09	9.82	16.23
1987	80.06	45.84	50.68	48.53	21.23	39.61	31.08	32.99	38.33	24.63	25.56	27.38	28.99	7.41	8.04	13.14	8.66	8.75	11.12	5.15
1988	56.71	38.24	53.94	48.4	32.31	28.9	37.13	48.87	43.71	35.75	20.51	22.04	9.58	18.92	10.05	5.47	10.21	1.95	12.17	2.05
1989	86.82	69.67	68.55	62.27	49.28	63.1	46.44	27.11	22.83	35.81	26.23	33.02	36.28	17.59	26.66	18.1	5.84	17.55	12.5	7.71
1990	54.19	52.19	45.48	32.02	38.19	38.39	25.69	36.46	36.29	11.24	23.86	20.14	21.84	18.08	12.79	11.54	17.61	11.97	5.13	4.28
1991	24.66	40.99	31.8	27.07	13.46	16.3	18.78	20.95	32.52	23.27	22.34	13.29	12.91	8.1	13.9	7	7.36	5.64	4.57	5.68
1992	25.57	22.04	18.6	26.66	15.89	18.63	26.29	30.12	14.79	18.65	15.58	11.92	13.59	14.69	6.78	10.06	7.63	13.09	5.59	7.22
1993	15.81	14.52	16.63	12.23	11.95	10.74	12.41	13.1	11.37	9.25	4.96	12.33	10.37	4.32	7.12	7.99	7.55	4.06	3.38	3.69
1994	27.61	36.89	18.04	27.67	12.06	19.9	8.7	8.13	9.46	12.27	4.96	8.21	7.37	8.31	6.31	3.49	5.57	31.54	12.01	8.62
1995	47.57	38.32	30.19	23.7	39.13	22.03	26.01	22.75	21.01	18.86	12.51	13.56	10.79	7.89	8.21	7.89	7.75	4.57	12.05	3.57
1996	34.13	46.69	36.79	27.29	29.23	34.57	22.54	21.24	24.4	24.81	15.19	25.81	9.72	14.17	21.84	17.47	9.46	4.1	2.54	6.53
1997	32.02	22.95	31.52	23.99	29.97	19.37	12.37	10.34	10.02	12.61	19.07	12.64	10.59	8.35	9.3	9.62	4.39	3.05	8.75	7.56
1998	39.91	53.1	28.85	36.19	21.29	20.7	24.31	12.41	16.86	9.49	15.76	10.91	8.3	9.63	7.67	3.77	3.51	5.32	5.19	9.47
1999	44.97	33.16	25.54	24.25	21.05	22.12	23.76	20.93	16.69	12.15	15.33	12.77	10.23	9.64	15.12	13.53	5.39	13.77	5.24	4.32
2000	30.09	32.84	27.82	21.65	11.58	13.76	20.68	21.33	12.19	17.06	18.17	8.1	9.07	5.01	8.27	26.05	6.28	6.91	6.96	3.52
2001	32.05	36.84	24.35	18.59	25.56	19.41	29.62	17.16	16.39	11.83	10.72	12.71	5.21	10.41	5.75	6.11	5.18	6.65	4.39	3.75
2002	35.11	31.54	23.45	29.63	22.88	12.64	9.96	19	13.47	5.74	6.14	2.87	6.66	1.63	3.44	4.72	1.47	2.09	3.42	4.73
2003	40.52	40.96	35.68	33.28	25.78	26.6	16.4	17.91	19.93	19.96	10.51	13.58	6.79	9.34	5.19	6.29	4.84	3.54	4.01	2.57
2004	61.23	33.45	49.36	45.16	41.19	43.43	30.13	26.09	23.32	22.21	14.95	21.92	10.45	25.15	11.74	18.35	14.9	12.09	5.66	3.7
2005	62.11	86.94	54.26	77.25	59.06	66.74	51.68	47.83	44.45	40.7	33.16	25.61	17.65	28.12	20.64	24.25	14.3	10.33	15.38	10.04
2006	68.3	71.21	57.29	62.73	45.98	59.3	46.32	59.2	52.66	53.14	38.17	44.51	39.21	35.55	20.42	35.32	15.62	23.67	15.96	17.96
2007	24.8	39.07	23.32	20.64	14.96	13.45	19.32	17.08	20.45	10.69	12.19	9.02	27.57	11.93	9.14	9.91	15.1	10.39	13.92	9.59
2008	25.05	46.27	19.45	27.62	24.32	25.45	12.71	16.62	12.45	18.71	14.56	12.97	9.09	19.64	11.33	10.23	8.21	15.71	5.12	9.96
2009	24.83	13.89	18.23	16.3	16.12	15.71	5.03	13.27	7.15	8.84	4.25	3.98	7.24	5.88	5.82	3.36	3.99	4.78	0.66	1.04
2010	12.04	12.76	15.27	18.86	4.81	13.47	4.24	3.08	7.79	4.23	4.25	1.22	5.51	8.09	0.45	4.42	0.94	3.89	1.89	1.23
2011	48.06	46.4	26.12	25.7	22.2	14.94	13.1	17.09	6.15	14.56	10.01	6.68	2.53	3.42	4.63	4.63	3.34	1.32	4.9	3.06
2012	24.18	28.82	21.48	20.29	19.33	17.73	5.98	10.63	4.54	7.19	6.14	6.48	3.89	4.12	4.17	0.86	1.09	2.5	2.21	0.97
2013	49.21	62.5	44.33	30.24	42.48	28.18	30.45	9.27	29.43	11.78	22.9	11.04	10.41	6.53	7.11	4.84	3.22	4.76	3.49	4.17
2014	58.3	43.75	38.61	35.9	26.35	25.15	17.56	14.64	14.61	7.39	7.26	7.2	3.24	4.04	5.07	3	1.31	5.72	1.94	2.5
2015	56.56	46.08	54.22	43.43	35.59	24.42	24.12	19.78	24.3	14.77	7.33	11.97	7.08	17.2	9.84	5.87	2.76	4.25	1.21	1.77
2016	87.35	68.92	50.22	46.76	47.88	36.65	25.78	24.34	36.18	16.37	18.92	21.55	16.48	10.21	8.73	7.38	8.23	5.02	5.95	4.74
2017	105.52	73.9	84.11	78.52	70.84	58.44	60.24	59.36	17.97	34.92	29.54	19.51	10.51	9.49	13.15	9.84	14.77	3.25	6.97	7.46
2018	97.81	71	60.65	58.23	70.42	46.58	54.07	57.41	39.74	35.57	35.03	28.94	13.18	18.91	21.23	14.46	11.18	10.56	5.89	4.23
2010	12.21	4.74	2.97	6.57	8.54	6.6	3.78	8.56	5.03	7.28	4.77	2.81	7.43	2.89	0.9	2.09	0.99	0	2.01	2.93
2017	37.82	38.68	31.64	20.81	23.78	12.87	18.32	16.35	13.69	9.67	9.42	5.07	3.22	2.52	1.89	2.59	4.22	3.65	0	0
2018	35.29	28.32	14.93	12.1	20.92	9.4	5.15	2.83	6.54	5.71	3	4.17	0.72	2.86	0	0	0	0.72	1.49	0

Table 2.8c (page 6 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116
1982	0	2.48	0	1.04	2.15	0.65	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	2.24	4.04	0	2.83	0	1.14	0	0	0	0	0	1.16	0	0	0	0	0	0	0	0	0	0	0	0
1984	7.47	5.87	0	3.66	2.69	2.21	0.58	0.58	0	0	0	0.87	0	0	0	0	0	0	0	0	0	0	0	0
1985	8.48	4.28	1.17	3.32	7.01	2.01	3.53	1.78	0	3.27	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1986	13.1	4.58	4.01	5.84	2.5	7.26	1.61	4.1	2.69	0	3.85	2.19	0	0	0	0	0	0	0	0	0	0	0	0
1987	10.14	8.82	1.32	5.07	5.22	2.8	1.05	0.51	2.17	2.55	0	0.92	0	0	0	0	0	0.4	0	0	0	0	0	0
1988	3.78	4.32	4.35	3.49	0.69	2.86	5.19	2.15	0.49	1.89	0	0	0.2	0	0	0	0	2.53	0	0	0	0	0	0
1989	9.75	11.72	13.21	7.97	4.31	8.47	4.64	4.08	9.05	0.25	9.22	2.75	0	0	0	0	0	0	0	0	0	0	0	0
1990	4.34	6.17	11.49	9.29	2.38	1.39	1.18	4.26	0	5.47	0.39	0	0.93	1.06	0.4	0	0	0	0	0	0	0	0	0
1991	3.84	1.4	6.04	7.27	3.04	1.98	2.63	0	0.47	0.29	5.33	0.8	0.41	1.3	0	0	0	0	0	0	0	0	0	0
1992	7.09	4.54	7.21	8.28	2.95	9.37	1.94	4.24	2.96	2.83	2.77	2.66	1.18	0.52	0.62	0	0.48	0	0.48	0	0	0	0	0
1993	7.44	2.54	7.08	5.02	4.72	3.66	3.57	1.28	2.03	1.89	0.64	8.53	2.5	0	1	0.29	0	0.3	0	0.3	0	0	1.46	0
1994	2.41	1.21	3.29	5.75	3.75	1.4	0.66	2.04	8.64	5.38	2.93	0.79	6.4	0	0	0.69	0	0.71	0	0	0	0	0	0
1995	4.48	3.71	10.4	1.13	3.38	1.91	2.97	5.15	0.87	3.44	0.7	0	1.45	0	0.58	0	0.34	0	0.78	0	0	0	0	0
1996	9.73	2.97	4.74	5.04	2.79	2.62	1.96	3.82	1.3	1.74	0	0.43	0	0	0	3.01	0	0	0	0	0	0	0	0
1997	2.01	5.68	3.42	2.41	3.7	0	1.09	1.84	0	0	0.72	1.56	0	0	0.32	0	3.09	0	0	0.31	0	0.58	0	0
1998	3.39	6.16	2.58	1.26	2.05	2.01	0.5	0.57	0.82	8.25	0	0	0	0.49	0	0.48	0	0.48	0	0	0	0	0	0
1999	4.52	4.66	1.92	4.65	5.41	5.55	2.81	2.13	1.16	0	1.83	0.5	0	0.57	1.16	0	0	0	0	0	0	0	0	0
2000	4.07	9.51	2.29	7.45	4.66	3.06	0.94	0.45	2.67	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	2.17	3.92	5.39	0.54	2.19	0.46	4.57	0.55	1.27	0	2.16	0.82	2.7	0.57	0	1.11	0	0	0	0	0	0	0	0
2002	4.83	0.9	3.34	1.55	3.12	5.68	0.96	1.34	0	0	1.14	0	1.83	0	0	0	0	0	0	0	0.59	0	0	0
2003	1.68	1.74	0	0.94	0.66	0.32	0	0	0.73	0	0.42	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	7.21	4.27	3.83	4.23	3.85	2.85	1.63	0	0.66	0	4.76	0	1.15	0	0	1.63	0	0.77	0	0	0	0	0	0
2005	7.78	4.44	9.17	5.15	2.86	3.64	0.44	3.64	2.09	0.4	0.78	0.42	0	0	0	0	0	0	0	0	0	0	0	0
2006	10.04	9.61	6.21	11.99	8.77	1.42	7.35	4.98	2.58	2.48	2.54	1.5	0	0.91	0	0	2.21	0	0	0	0	0	0	0
2007	3.37	8.04	4.26	5.63	2.35	2.83	2.55	2.9	1.82	8.06	1.32	2.43	1.05	2	0	0.53	0.5	0	0	0.53	0	0	0	0
2008	10.39	9.96	8.9	3.19	8.49	8.61	2.43	4.29	3.18	7.01	1.21	1.3	0	0	0.48	0	0	0.8	0	0	0	0	0	0
2009	1.07	2.38	3.31	4.67	2.36	3.07	0.55	2.03	1.36	0.87	0	0.67	2	0	0	0.69	0	0	0	0	0	0	0	0
2010	3.51	0.9	0	3.34	1.81	0.74	2.59	1.98	0	0	0	0	0.91	0	0	0.82	0	0.4	0	0	0	0	0	0
2011	4.12	6.79	2.09	0.65	0	1.12	0	2.17	1.44	1.03	0	1.54	0.64	0	0	0	0	0	0	0	0	0	0	0
2012	3.02	2.7	1.55	0.75	0	1.45	1.52	1.08	0.41	0	0.24	0.6	0	0.28	0	0.32	0	0.22	0	0	0	0	0	0
2013	4.57	1.39	1.54	0.36	1.37	0.45	1.21	0.66	0.71	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	1.84	0.42	0	2.51	0.77	1.87	0	1.34	0	0	1.38	0	0	0	0.42	0	0	0	0	0	0	0	0	0
2015	1.51	0.38	1.78	0.73	1.21	0.99	1.81	1.23	0	0	0.57	0.55	0.91	0	0	0	0	0	0	0	0	0	0	0
2016	3.34	1.54	2.87	2.32	2.19	2.05	0	1.42	2.76	1.52	0.99	1.98	0	0	0	0	0	0	0	0	0	0	0	0
2017	2.95	5.44	4.67	0.47	3.59	0.53	0	0.5	0	0	0	0	0.59	0	0	0	0	0	0	0	0	0	0	0
2018	4.01	4.68	3.9	2.89	3.33	4.92	3.8	0.68	0	2.23	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	2.72	0	2.09	0	0	0	0	0	0.88	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2018	1.15	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.8c (page 7 of 7)—Trawl survey size composition as used in Models 16.6k and 18.7, by year and cm (last 3 rows are NBS).

Year	117	118	119	120+
1982	0	0	0	0
1983	0	0	0	0
1984	0	0	0	0
1985	0	0	0	0
1986	0	0	0	0
1987	0	0	0	0
1988	0	0	0	0
1989	0	0	0	0
1990	0	0	0	0
1991	0	0	0	0
1992	0.53	0	0	0
1993	0	0	0	0
1994	0	0	0	0
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
2001	0	0	0	0
2002	0	0	0	0
2003	0	0	0	0
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
2014	0	0	0	0
2015	0	0	0	0
2016	0	0	0	0
2017	0	0	0	0
2018	0	0	0	0
2010	0	0	0	0
2017	0	0	0	0
2018	0	0	0	0

Table 2.8d (page 1 of 6)—Trawl survey size composition as used in Model 17.2, by year and cm.

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1982	308	0	0	0	0	0	0.02	0.23	0.26	0.56	0.76	1.52	1.73	3.19	1.94	1.48	1.51	1.34	0.57	0.25	0.26	0.06
1983	255	0	0	0	0	0	0.14	1.86	5.63	8.82	8.88	9.38	8.95	8.41	7.65	4.89	4.84	2.32	1.43	0.86	0.55	0.17
1984	264	0	0	0	0	0	0.14	0.54	0.78	1.19	0.95	0.59	0.55	0.56	0.65	1	0.69	1.39	1.56	1.96	2.71	5.01
1985	342	0	0	0	0	0	0.09	1.13	2.06	3.64	2.93	4.37	5.82	6.17	7.54	10.19	10.27	10.66	13.1	11.33	11.24	6.51
1986	349	0	0	0	0	0.01	0.51	0.86	2.11	3.03	2.95	4.57	3.96	4.01	3.4	2.1	0.78	0.6	0.46	0.5	1.63	2.59
1987	327	0	0	0	0	0	0	0.42	0.11	0.22	0.75	1.17	1.86	2.5	3.34	3.72	3.72	4.73	3.82	2.48	1.88	1.46
1988	328	0	0	0	0	0	0	0.02	0.26	0.24	0.92	0.44	0.89	0.86	0.74	1.38	0.9	0.59	0.86	1.14	1.56	2.24
1989	280	0	0	0	0	0	0.07	0.07	0.53	1.32	1.03	1.95	2.41	3.02	2.94	2.82	1.84	1.1	0.54	0.6	0.84	0.1
1990	318	0	0	0	0	0	1.45	4.03	5.87	8.68	8.48	10.43	13.32	14.62	11.56	8.42	6.6	5.04	3.22	1.95	2.33	2.39
1991	296	0	0	0	0	0	0.26	1.27	3.85	4.61	5.75	5.6	6.7	5.44	5.58	5.24	4.39	5.53	3.52	2.94	2.96	3.21
1992	319	0	0	0	0	0	0	0.02	0.55	2.7	6.09	6.33	5.81	5	6.59	7.35	7.74	8.22	7.15	7.53	3.7	3.95
1993	348	0	0	0	0	0.02	0.08	0.97	2.7	6.37	14.16	9.8	13.49	11.84	10.72	10.65	11.48	10.41	10.75	7.2	4.49	3.24
1994	345	0	0	0	0	0	0.08	0.25	0.13	0.66	1.04	1.89	2.26	2.47	2.47	2.86	3.37	2.75	2.56	2.25	3.26	2.98
1995	334	0	0	0	0	0.01	0.11	0.42	0.54	0.48	0.69	1.5	1.35	1.52	2.02	2.15	2.92	2.47	1.25	0.87	0.69	1.34
1996	340	0	0	0	0	0	0.04	0.06	0.41	0.34	0.83	1.2	1.74	2.33	1.93	2.41	2.51	2.31	1.98	1.3	0.73	0.8
1997	350	0	0	0	0	0	0.32	0.67	2.48	4.36	6.38	7.36	7.34	7.49	8.1	10.82	8.62	8.33	8.61	6.77	3.99	2.2
1998	343	0	0	0	0	0	0.05	0.16	0.83	1.9	3.01	4.19	3.74	4.87	3.26	1.62	0.79	0.22	0.15	0.62	0.88	2.06
1999	316	0	0	0	0	0	0.02	0.41	1.44	2.7	2.96	3.29	2.53	3.06	2.12	1.13	0.8	1.12	1.32	1.04	1.43	2.95
2000	342	0	0	0	0.11	0.28	0.63	1.4	2.7	3.72	8.12	13.02	15.85	12.05	7.57	7.46	3.85	2.38	0.89	0.25	0.33	0.67
2001	347	0	0	0	0	0.08	0.11	0.47	1.1	2.24	3.59	5.48	7.9	11.56	12.47	13.45	11.91	11.63	7.74	6.14	3.84	2.4
2002	344	0	0	0	0	0.02	0.08	0.16	0.59	1.22	1.77	2.24	2.85	4.46	3.14	4.65	3.11	2	1.45	0.98	0.49	1.18
2003	343	0	0	0.03	0	0.02	0.08	0.15	0.32	1.55	2.56	3.82	5.7	6.44	5.71	6.92	7.05	7.81	7	6.58	5.53	6.06
2004	343	0	0.05	0	0	0	0.02	0.12	0.62	1.42	2.73	4.83	3.35	6.14	5.93	6.82	6.68	4.28	4.56	3.52	2.06	1.77
2005	342	0	0	0	0	0	0	0.02	0.12	0.68	1.3	2.64	4.18	6.08	7.52	9.22	8.61	9.13	8.77	10.96	10.96	11.73
2006	344	0	0.02	0	0.12	0.21	1.14	2.86	9.53	11.48	12.1	12.84	11.38	9.72	9.35	10.17	7.95	6.9	4.15	2.98	1.85	1.52
2007	348	0	0	0	0	0.2	0.2	3.51	13.06	31.59	38.7	37.96	30.98	19.84	19.42	13.89	8.85	10.87	6.24	3.29	3.31	1.14
2008	327	0	0	0.02	0	0	0.14	1.37	4.26	8.81	9.57	9.82	8.82	7.85	5.72	3.8	1.89	1.01	0.53	1	1.76	4.08
2009	345	0.01	0	0.01	0.14	0.74	2.18	8.29	20.1	21.89	22.48	18.17	15.39	13.45	10.04	9.51	6.57	4.54	2.36	0.72	0.57	0.68
2010	327	0	0	0	0	0	0.03	0.2	0.76	1.03	1.25	2.16	2.16	2.43	2	1.32	0.65	0.71	0.4	0.58	1.35	2.6
2011	349	0	0	0	0	0	0.13	0.33	1.27	2.39	4.33	5.15	6.48	6.94	10.04	10.54	15.22	14.91	14.32	9.01	4.82	1.84
2012	342	0	0	0.15	0	0.01	1.92	9.92	17.94	19.14	14.72	11.08	10.91	8.11	10.72	10.35	5.44	3.36	1.25	0.82	0.27	0.74
2013	341	0	0	0	0	0.01	0.17	0.91	2.11	2.67	3.78	4.05	5.16	4.37	3.23	2.31	0.64	0.39	1.16	1.57	4.88	7.26
2014	354	0	0	0	0.03	0	0.01	0.19	1.77	2.3	4.71	6.71	9.19	10.24	12.97	9.82	11.99	9.66	10.27	6.08	4.3	2.19
2015	341	0	0	0	0	0	0	0.19	0.74	0.74	1.51	1.36	0.92	0.84	1.01	1.01	1.06	1.3	1.5	1.22	1.37	1.33
2016	356	0	0	0	0	0.02	0	0.11	0.35	0.55	1.12	1.26	0.83	0.46	1.08	1.37	2.06	3.15	4.73	5.73	5.41	4.75
2017	351	0	0	0	0	0	0	0.06	0.06	0.41	1.1	1.44	1.44	1.92	1.77	2.19	2.65	3.01	3.87	4.15	4.87	5.41
2018	344	0	0	0	0	0	0	0	0	0.11	0.19	0.22	0.75	0.76	1.49	1.36	2.13	1.81	2.21	3.79	4.07	5.17

Table 2.8d (page 2 of 6)—Trawl survey size composition as used in Model 17.2, by year and cm.

Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
1982	0.24	0.52	0.73	1.16	1.96	2.53	3.59	5.64	6.45	7.01	8.91	9.25	6.92	5.74	4.21	4.26	3.67	4.01	5.26	5.91
1983	0.1	0.35	0.66	0.89	1.08	1.95	2.43	2.83	3.36	3.21	4.13	2.82	2.46	2.08	1.18	1.2	1.67	1.83	2.76	3.05
1984	6.78	8.24	10.01	12.49	13.04	14.06	12.38	10.37	8.56	7.5	6.42	4.79	3.36	2.32	2.21	1.91	1.27	2.04	1.63	1.99
1985	4.3	2.64	1.85	2.03	2.16	3.22	4.45	4.37	5.51	6.07	6.25	6.31	5.83	6.94	7.12	7.88	8.37	10.42	10.13	10.41
1986	4.95	8.17	10.19	15.82	14.27	13.99	14.49	14.83	13.16	12.64	10.17	9.12	7.92	7.54	5	4.41	3.13	2.85	3.09	3.7
1987	1.94	2.34	3.61	3.82	6.18	8.46	9.31	10.04	8.99	8.63	6.39	7.25	6.19	5.3	5.74	6.83	6.48	9.05	10.07	10.18
1988	2.53	2.88	2.84	3.59	2.74	4.06	4.01	4.49	5.88	6.25	8.83	7.08	6.41	6.93	4.63	6.03	5.41	7.83	7.28	6.47
1989	0.43	0.44	0.99	0.38	0.94	0.85	0.67	0.92	1.04	1.95	0.92	2.99	3.06	3.76	3.22	3.51	2.83	3.21	3.21	3.9
1990	1.85	2.65	4.31	4.35	5.4	5.8	5.49	5.21	6.66	7.01	4.5	6.38	5.42	3.8	3.23	3.77	2.89	2.64	2.15	2.13
1991	4.1	3.97	6.8	7.88	10.86	11.67	13.33	11.83	15.26	12.61	10.29	10.71	8.01	7.09	5.85	4.84	3.45	2.78	2.6	2.48
1992	4.49	6.06	8.76	9.56	10.02	11.61	12.4	11.55	10.28	10.11	8	7.14	5.84	4.95	4.14	5.98	4.84	7.18	6.26	7.3
1993	2.06	1.83	2.22	2.86	3.16	5.78	6.9	7.71	9.7	10.52	8	8.22	7.59	6.55	5.1	5.38	6.1	6.13	7.39	7.39
1994	4.23	3.82	5.09	7.95	10.67	13.69	15.84	18.14	19	16.66	15.94	11.68	8.98	7.13	4.86	2.86	3.28	2.82	5.47	4.67
1995	1.69	3.23	3.9	5.73	7.02	8.28	7.9	8.88	8.17	7.19	5.63	7.87	9.02	8.67	11.4	13.7	13.47	15.13	15.28	14.29
1996	0.85	2.11	2.35	4.71	5.94	7.06	8.32	10.02	8.62	9.11	6.95	7.28	6.11	5.71	6.09	5.59	6.4	7.78	8.66	10.48
1997	1.57	1.56	1.3	2.69	4.16	3.93	5.86	8.5	8.81	8.48	6.65	6.05	5.92	5.26	5.53	5.19	4.76	4.84	5.16	5.15
1998	2.59	6.53	9.88	13.63	17.7	21.47	22.49	22	18.37	19.25	12.39	9.32	8.18	5.94	5.25	4.8	3.62	4.25	4.19	4.8
1999	2.97	5.3	6.16	6	8.38	7.25	7.97	8.31	6.48	6.14	5.33	5.17	6.47	7.84	8.32	10.32	13.13	13.74	15.78	15.06
2000	1.06	2.11	3.24	4.63	5.38	6	7.05	8.31	6.05	5.38	5.03	5.13	4.74	5.43	6.07	6.99	7.27	8.25	8.35	9.47
2001	1.98	2.81	3.97	5.51	6.42	8.91	11.54	14.62	14.51	16.18	14.17	12.29	8.99	7.19	5.29	3.83	3.32	3.1	2.67	2.75
2002	1.78	2.98	4.51	6.76	7.52	12.2	13.32	15.59	15.53	14.61	10.71	11.25	8.77	8.29	7.03	8.13	7.27	11.44	10.08	12.72
2003	4.28	3.33	1.84	1.59	1.62	2.19	1.59	3.18	4.01	8.77	6	8.86	6.67	7.62	8.07	8.84	10.01	9.5	10.81	12.66
2004	2.3	2.92	3.29	5.98	6.22	6.95	7.55	8.68	9.56	10.06	9.85	10.63	9.94	10.32	8.08	7.68	6.71	6.59	5.98	5.73
2005	11.4	8.74	6.35	4.14	4.1	4.29	3.48	4.8	5.4	5.97	5.96	6.27	6.99	8.73	7.63	6.17	5.88	6.16	6.27	6.54
2006	1.6	1.56	1.83	2.43	3.26	4.76	5.37	6.99	6.88	7.47	6.95	8.59	7.47	8.46	7.16	6.91	5.91	5.67	4.55	4.85
2007	1.19	1.77	2.34	3.36	3.17	4.19	3.32	3.8	4	3.36	3.09	2.51	2.53	2.07	1.64	1.99	2.1	2.02	1.86	2.23
2008	7.73	12.07	13.85	17.81	18.76	18.12	17.17	14.08	11.62	8.6	7.09	5.05	4.05	3.8	3.35	3.28	2.94	3.6	3.24	3.47
2009	1.7	1.93	3.58	5.24	6.96	8.2	9.67	9.03	7.02	6.32	4.57	4.42	4.44	4.66	6.24	6.28	7.49	7.86	7.84	7.18
2010	5.46	8.34	10.43	15.34	18.6	18.02	17.01	17.03	13.96	11.61	7.92	7.13	4.57	4.12	2.78	3.25	3.38	5.35	5.7	10
2011	0.58	0.62	0.92	0.81	0.95	1.22	2.04	2.3	3.16	2.76	3.9	3.85	4.58	4.83	6.78	7.7	11.32	13.47	14.46	15.56
2012	0.97	1.54	2.21	4.66	6.77	7.04	9.36	9.21	10.2	7.31	8.09	4.96	4.13	2.55	2.12	1.6	1.2	1.66	1.55	2.24
2013	11.92	14.33	17.91	19.66	15.32	16.57	11.88	12.01	7.57	5.66	4.39	3.29	3.17	2.65	2.29	3.35	2.79	4.19	5.32	6.59
2014	2.02	1.79	1.41	1.9	4.37	4.87	8.26	6.52	9.54	9.08	9.82	6.88	6.14	3.63	3.75	2.87	4	5.56	8.76	9.03
2015	1.38	1.43	2.15	3.12	4.88	6.8	9.25	12.74	15.98	18.62	19.67	17.42	16.57	13.53	10.16	8.79	5.05	4.72	3.53	6.65
2016	3.2	2.27	1.2	0.73	0.83	1.41	1.81	2.18	2.72	3.73	3.39	4.77	5.21	6.2	5.86	6.9	8.03	9.76	11.96	12.66
2017	5.59	5.01	4.19	2.99	2.86	2.79	3.5	2.71	3.38	3.5	3.86	4.02	4.95	4.52	4.82	5.19	5.68	5.1	5.98	7.15
2018	4.03	3.29	1.66	1.67	1.71	1.54	1.77	3.06	3.66	4.32	5.94	6.65	7.35	7.17	9.09	8.64	8.64	8.92	9.12	7.72

Table 2.8d (page 3 of 6)—Trawl survey size composition as used in Model 17.2, by year and cm.

Year	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
1982	8.23	8.83	7.95	9.59	9.59	8.18	8.3	7.88	7.42	6.97	8.12	7.54	7.8	6.56	7.6	7.71	7.63	6.56	6.63	5.91	5.64	5.54
1983	4.11	5.22	5.84	5.58	5.78	6.13	4.92	4.81	4.78	4.36	5.79	5.36	5	5.09	4.76	5.08	4.76	3.89	4.34	3.8	3.88	3.7
1984	2.04	2.1	2.35	2.91	2.3	2.38	2.06	2.37	3.08	2.8	3.4	3.62	4.28	4.31	3.35	4.68	3.67	4.34	4.4	4.1	3.51	4.29
1985	9.77	9.52	7.27	6.54	4.94	3.9	3.4	2.6	1.95	1.89	2.09	2.05	2.1	1.72	1.76	1.83	1.71	3	2.23	2.22	2.28	3.46
1986	4.2	4.9	4.65	5.57	4.94	5.63	6.1	5.86	6.25	6.54	6.8	5.13	5.71	5.69	3.98	3.87	2.71	3.31	2.52	1.83	2.24	1.72
1987	10.17	9.94	9.96	7.78	7.73	8.19	4.84	4.89	4.1	3.69	4.51	4.32	3.04	3.8	2.83	4.28	4.19	3.8	4.04	3.73	4.08	3.83
1988	10.46	9.09	9.65	9.1	8.1	10.11	8.73	7.53	8.22	8.21	8.53	7.22	7.01	7.44	6.36	6.52	5.44	6.78	5.41	3.82	4.05	3.26
1989	4.93	4.63	4.93	5.12	4.92	5.59	7.1	6.6	7.29	6.92	6.55	9.12	8.2	6.13	6.23	5.51	8.11	5.2	6.38	6.79	5.14	4.69
1990	1.76	1.97	2.73	2.18	2.29	1.43	2.9	1.74	3.52	3.02	3.75	3.3	4.18	4.09	4.26	4.79	5.03	5.03	4.39	4.42	3.03	4.52
1991	2.11	2.5	2.16	2.5	3.03	2	2.52	1.7	2.92	3.66	2.36	3.06	1.64	1.38	1.72	1.68	1.4	2.12	1.8	1.76	1.08	1.84
1992	8.03	6.19	6.17	5.33	4.74	5.12	3.97	3.55	2.95	2.6	1.9	2.1	0.96	1.41	1.7	1.68	2.21	1.5	1.17	0.85	1.04	1.01
1993	7.83	9.04	6.92	6.19	6.45	5.31	5.05	4.33	3.78	3.95	3.61	2.95	2.14	2.2	2.63	2.21	1.89	1.93	1.76	1.19	2.21	1.23
1994	4.07	5.76	6.34	6.54	7.41	4.27	4.69	5.7	4.67	4.49	4.33	5.43	6.22	6.25	4.01	5.43	3.79	5.05	4.04	4.45	3.96	3.13
1995	12.42	12.14	10.63	7.2	6.86	5.55	5.14	4.15	3.56	3.93	3.45	3.18	3.36	3.13	2.63	3.35	3.6	3.78	3.62	3.16	2.54	1.94
1996	9.49	10.64	11.65	10.95	10.8	11.74	9.91	10.26	10.25	8.88	9.23	7.49	6.06	5.53	4.8	5.12	3.59	3.43	3.11	2.86	2.09	2.18
1997	6.51	7.41	8.71	5.8	6.55	5.13	5.71	6.86	7.13	6.1	6.36	4.73	8.14	6.27	6.59	4.67	4.95	4.08	4.23	4.37	3.84	3.77
1998	4.56	6.07	4.27	4.11	4.76	4.02	3.36	3.17	2.94	2.94	2.58	2.18	2.82	3.2	2.7	2.35	2.77	3.11	3.04	2.64	2.31	3.48
1999	13.65	10.67	11.03	8.41	6.3	5.36	4.46	3.82	3.9	3.15	3.15	2.51	2.81	2.48	2.31	1.93	3.16	2.32	2.53	2.16	2.58	1.69
2000	8.4	9.68	8.75	10.67	9.32	9.57	7.13	8.58	6.52	6.97	5.28	5.49	4.99	4.34	4.34	4.05	3.05	2.76	2.45	2.32	1.48	1.77
2001	3.27	4.02	4.92	4.03	4.67	4.4	4.04	4.61	4.8	4.51	4.13	3.84	3.95	3.32	3.66	3.24	2.62	3.47	2.31	2.72	2.65	1.87
2002	11.05	10.93	7.82	9.29	5.28	6.38	5.14	4.68	3.85	4.56	3.62	4.37	2.51	3.07	3.4	3.5	2.84	3.13	3.01	2.79	1.59	2.97
2003	11.8	12.79	11.51	10.83	7.7	7.65	6.5	6.83	7.21	5.49	5.13	4.62	4.12	3.45	3.99	3.82	3.22	2.66	1.96	2.62	1.77	2
2004	4.91	4.68	4.8	5.51	5.4	6.5	6.3	5.14	5.77	5.42	5.91	5.3	6.01	4.54	4.96	5.3	4.71	4.53	4.41	3.82	3.27	3.2
2005	5.07	6.22	5.1	5.84	3.98	5.17	3.83	4.37	3.91	4.08	3.36	3.36	3.05	2.98	3.02	3.55	2.53	3.58	2.5	3.84	3.15	3.39
2006	4.11	4.29	3.6	4.45	4.16	5.41	4.79	4.96	4.12	4.94	3.88	5.16	2.99	3.63	2.56	2.75	2.96	2.7	3.02	2.55	2.5	2.79
2007	2.06	2.31	2.15	2.17	1.64	2.04	2.01	2.21	1.84	1.95	1.61	1.47	1.31	1.41	1.27	1.65	1.35	1.64	1.33	1.34	1.23	1.25
2008	3.48	3.5	2.84	3.4	3.04	3.13	3.2	3.39	2.87	2.72	2.54	2.81	2.28	2.86	2.59	2.85	2.3	2.04	2.03	2.22	1.56	1.78
2009	6.92	5.79	5.98	5.12	3.74	3.03	2.98	2.42	2.12	1.93	1.7	1.55	1.62	1.76	1.82	1.48	1.75	1.59	1.09	1.34	1.47	1.08
2010	6.65	7.15	6.89	6.78	5.36	5.81	4.6	6.36	4.94	6.72	6.52	6.03	4.1	6.04	4.84	4.35	3.08	3.9	2.52	2.9	1.74	1.81
2011	14.68	13.29	10.67	8.6	5.84	5.88	4.67	4.46	3.11	3.87	3.79	4.46	3.1	4.65	4.05	5.07	3.83	4.95	3.09	4.19	2.89	3.45
2012	2.11	3.41	2.9	5.13	4.91	6.26	7.46	9.91	8.44	10.67	8.08	8.27	5.71	5.17	4.4	4.29	2.53	3.14	2.25	2.71	2.03	2.06
2013	7.87	9.47	7.42	7.04	6.36	5.93	4.7	4.73	3.55	3.83	2.48	3.51	2.58	3.91	3.52	4.27	3.51	3.87	3.7	4.27	3.89	3.53
2014	12.93	13.32	11.99	11.03	9.7	8.38	5.63	4.26	4	4.07	3.59	3.26	3.78	4.91	4.88	3.91	3.77	4	2.67	2.75	2.17	2.1
2015	6.59	8.83	8.36	8.28	7.52	8.01	5.66	6.22	6.13	5.61	5.94	6.86	5.95	7.65	5.84	5.29	3.86	4.32	2.8	2.96	2	1.89
2016	16.83	18.5	17.89	18.3	15.78	14.2	11.15	8.48	8.75	6.12	6.08	5.75	5.54	5.14	5.47	5.12	4.68	4.81	4.73	4.39	4.67	5.08
2017	5.93	7.75	7.14	7.4	8.27	10.02	9.31	10.44	10.62	12.21	12.68	11.53	11.61	9.71	7.82	7.31	7.12	5.72	6.87	5.04	4.88	4.29
2018	6.32	5.76	6.24	5.76	7.01	6.19	6.55	7.34	6.93	7.55	6.92	7	6.23	6.95	7.97	6.91	7.58	7.17	8.55	8.07	7.23	6.48

Table 2.8d (page 4 of 6)—Trawl survey size composition as used in Model 17.2, by year and cm.

Year	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
1982	5.78	3.56	5.03	3.63	3.85	2.14	2.12	2.1	1.88	1.3	1	1.07	0.87	0.58	0.78	0.7	0.36	0.22	0.19	0.27	0.08	0.18	0.12	0.02
1983	3.22	3.65	3.42	2.81	3.5	2.44	2.36	1.51	1.56	1.53	1.31	1.14	0.76	0.94	0.62	0.56	0.46	0.34	0.23	0.02	0.13	0.16	0.06	0.22
1984	3.97	3.92	3.71	3.32	3.14	1.81	2.6	2.12	2.27	1.63	1.79	1.22	1.48	1	0.87	0.69	0.71	0.59	0.47	0.61	0.26	0.35	0.41	0.27
1985	2.49	2.72	2.96	2.97	2.73	2.73	2.42	2.79	2.17	2.74	2.01	1.93	1.19	1.53	1.2	1.01	0.98	0.43	0.76	0.44	0.44	0.33	0.28	0.21
1986	1.92	1.6	1.97	2.38	2.24	2.03	1.6	2.04	1.95	1.57	1.84	1.61	1.41	1.9	1.26	1.21	0.97	0.65	0.6	0.79	0.42	0.48	0.41	0.68
1987	4.11	4.06	3.4	3.58	2.9	1.84	2.8	1.63	1.73	1.7	0.72	1.33	1.03	1.01	1.36	0.87	0.91	0.9	0.9	0.26	0.22	0.47	0.29	0.31
1988	4.54	3.47	3.46	2.67	3.82	2.77	2.75	1.83	2.6	2.33	1.58	1.35	1.82	2.33	2.05	1.75	1	0.97	0.36	0.89	0.49	0.2	0.5	0.08
1989	6.74	5.96	3.81	5.62	2.93	5.15	5.55	4.67	4.31	4	3	4.23	3.01	1.78	1.48	2.38	1.71	2.08	2.47	1.2	1.67	1.16	0.4	1.19
1990	3.1	3.41	1.92	3.6	2.44	3.02	2.95	3.01	2.75	1.86	2.13	2.14	1.4	2.09	2.2	0.57	1.33	1.05	1.32	1.09	0.55	0.61	1.04	0.64
1991	1.68	1.94	1.87	1.96	1.33	1.26	1.04	1.64	1.33	1.13	0.58	0.66	0.77	0.88	1.36	0.98	0.88	0.49	0.52	0.35	0.52	0.3	0.32	0.24
1992	1.56	1.16	1.06	0.79	0.46	0.71	0.75	0.69	0.5	0.8	0.49	0.59	0.81	0.95	0.47	0.56	0.48	0.38	0.42	0.47	0.22	0.32	0.24	0.42
1993	1.22	2.05	0.94	0.93	0.48	0.5	0.52	0.47	0.54	0.41	0.39	0.36	0.4	0.41	0.37	0.31	0.15	0.39	0.35	0.14	0.24	0.25	0.25	0.14
1994	2.08	3.29	1.53	2.52	1.21	1.66	0.74	1	0.49	0.73	0.33	0.53	0.22	0.22	0.26	0.3	0.13	0.22	0.2	0.23	0.16	0.09	0.15	0.86
1995	2.17	2.59	2.57	2.49	1.82	1.96	1.63	1.3	1.03	0.81	1.34	0.73	0.89	0.78	0.72	0.64	0.43	0.46	0.37	0.27	0.28	0.27	0.26	0.16
1996	2.17	2.04	2.04	1.64	2.05	2.25	1.15	1.61	1.3	1	1.06	1.26	0.8	0.78	0.88	0.9	0.54	0.9	0.36	0.49	0.8	0.63	0.33	0.12
1997	3.5	3.03	2.63	2.13	2.34	2.03	1.1	0.69	1.17	0.78	1.06	0.6	0.42	0.38	0.33	0.47	0.65	0.47	0.37	0.31	0.35	0.36	0.16	0.11
1998	2.07	2.26	1.7	1.63	1.86	1.96	1.34	1.86	1.03	1.3	0.76	0.74	0.88	0.45	0.58	0.33	0.54	0.38	0.3	0.35	0.26	0.14	0.11	0.18
1999	1.89	1.31	1.66	1.89	1.33	1.22	1.38	1	0.75	0.76	0.63	0.69	0.73	0.66	0.52	0.35	0.46	0.4	0.32	0.3	0.46	0.42	0.17	0.43
2000	1.58	1.42	0.97	1.35	0.91	1.04	0.83	0.93	0.79	0.59	0.33	0.37	0.59	0.61	0.33	0.48	0.52	0.23	0.26	0.14	0.23	0.72	0.18	0.2
2001	1.46	1.85	1.19	1.36	1	0.9	0.58	0.67	0.45	0.34	0.47	0.35	0.55	0.31	0.3	0.22	0.2	0.22	0.1	0.18	0.11	0.11	0.1	0.12
2002	2.03	1.8	1.85	1.62	1.33	0.99	1	0.89	0.69	0.87	0.67	0.37	0.29	0.56	0.4	0.17	0.18	0.07	0.2	0.05	0.1	0.14	0.04	0.06
2003	1.92	1.83	1.87	2.11	1.31	1.56	1.1	1.11	1	0.96	0.73	0.78	0.45	0.5	0.58	0.6	0.32	0.39	0.2	0.26	0.16	0.19	0.15	0.11
2004	2.74	3.33	2.59	2.03	2.31	1.86	1.83	1.07	1.6	1.43	1.35	1.45	1.01	0.87	0.75	0.74	0.5	0.71	0.35	0.81	0.39	0.61	0.47	0.4
2005	3.05	3.05	2.34	2.52	2.24	2.12	1.77	2.19	1.56	2.18	1.63	1.96	1.48	1.34	1.22	1.22	0.97	0.74	0.53	0.84	0.62	0.7	0.43	0.31
2006	1.72	2.72	1.45	2.02	1.7	1.65	1.8	1.9	1.6	1.67	1.2	1.61	1.25	1.63	1.42	1.46	1.04	1.19	1.11	0.96	0.56	1	0.44	0.65
2007	0.88	1.17	1.08	0.85	0.64	0.87	0.63	1.03	0.58	0.51	0.37	0.33	0.47	0.45	0.49	0.27	0.28	0.24	0.68	0.29	0.22	0.24	0.4	0.28
2008	1.6	1.79	1.12	1.33	0.87	0.98	0.57	1.09	0.47	0.58	0.54	0.57	0.32	0.4	0.29	0.41	0.35	0.31	0.21	0.49	0.29	0.26	0.21	0.29
2009	0.78	0.99	0.62	0.82	0.6	0.43	0.5	0.26	0.35	0.28	0.31	0.29	0.09	0.27	0.13	0.16	0.09	0.08	0.15	0.12	0.12	0.07	0.08	0.1
2010	1.25	0.94	0.71	0.82	0.72	0.4	0.27	0.29	0.36	0.43	0.11	0.32	0.1	0.07	0.18	0.1	0.1	0.03	0.13	0.19	0.01	0.1	0.02	0.09
2011	2.56	2.68	1.93	2.12	1.03	1.31	0.86	0.85	0.45	0.42	0.35	0.26	0.24	0.3	0.11	0.24	0.17	0.12	0.05	0.06	0.07	0.07	0.06	0.02
2012	1.65	1.71	1.2	1.89	0.97	1.23	0.62	0.75	0.56	0.52	0.5	0.46	0.16	0.27	0.11	0.19	0.16	0.17	0.1	0.11	0.11	0.02	0.03	0.06
2013	2.98	2.58	2.48	1.99	1.9	1.68	0.94	1.14	0.8	0.56	0.8	0.54	0.56	0.15	0.54	0.22	0.44	0.21	0.19	0.12	0.14	0.08	0.06	0.09
2014	1.23	1.23	1.02	1.29	1.1	1.04	1.29	0.98	0.84	0.79	0.57	0.56	0.4	0.3	0.32	0.16	0.15	0.16	0.07	0.08	0.11	0.07	0.02	0.12
2015	1.96	1.72	1.44	1.16	1.08	1.09	1	0.8	0.97	0.77	0.63	0.42	0.43	0.35	0.4	0.25	0.13	0.21	0.13	0.31	0.17	0.1	0.05	0.08
2016	3.94	3.56	3.28	3.48	2.8	1.97	1.77	1.43	1.06	0.95	0.98	0.75	0.5	0.5	0.73	0.33	0.39	0.44	0.34	0.2	0.19	0.16	0.16	0.11
2017	4.01	3.29	4.22	3.55	2.9	2.48	3.09	2.32	2.63	2.51	2.26	1.84	1.96	1.93	0.57	1.1	0.96	0.62	0.35	0.29	0.44	0.3	0.44	0.11
2018	7.25	5.54	5.72	5.46	3.9	3.77	3.58	2.72	2.26	2.17	2.65	1.83	2	2.05	1.47	1.39	1.41	0.99	0.53	0.72	0.85	0.54	0.45	0.38

Table 2.8d (page 5 of 6)—Trawl survey size composition as used in Model 17.2, by year and cm.

Year	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
1982	0.07	0.1	0	0.07	0	0.03	0.06	0.02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1983	0.01	0.01	0.04	0.08	0	0.05	0	0.02	0	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0
1984	0.2	0.09	0.16	0.13	0	0.08	0.06	0.05	0.01	0.01	0	0	0	0.02	0	0	0	0	0	0	0	0	0	0
1985	0.16	0.15	0.17	0.09	0.02	0.07	0.14	0.04	0.07	0.04	0	0.07	0	0	0	0	0	0	0	0	0	0	0	0
1986	0.22	0.37	0.3	0.1	0.09	0.13	0.06	0.16	0.04	0.09	0.06	0	0.09	0.05	0	0	0	0	0	0	0	0	0	0
1987	0.39	0.18	0.32	0.31	0.05	0.12	0.19	0.1	0.04	0.02	0.08	0.09	0	0.03	0	0	0	0	0	0.01	0	0	0	0
1988	0.51	0.08	0.18	0.21	0.21	0.17	0.03	0.14	0.25	0.11	0.02	0.09	0	0	0.01	0	0	0	0	0.12	0	0	0	0
1989	0.85	0.53	0.66	0.8	0.9	0.4	0.29	0.58	0.32	0.28	0.62	0.02	0.63	0.19	0	0	0	0	0	0	0	0	0	0
1990	0.31	0.26	0.26	0.37	0.61	0.56	0.14	0.08	0.07	0.26	0	0.33	0.02	0	0.06	0.06	0.02	0	0	0	0	0	0	0
1991	0.11	0.22	0.16	0.06	0.24	0.31	0.13	0.08	0.11	0	0.02	0.01	0.23	0.03	0.02	0.06	0	0	0	0	0	0	0	0
1992	0.18	0.23	0.23	0.15	0.23	0.26	0.09	0.3	0.05	0.14	0.09	0.09	0.09	0.08	0.04	0.02	0.02	0	0.02	0	0.02	0	0	0
1993	0.11	0.12	0.25	0.08	0.24	0.17	0.16	0.12	0.12	0.04	0.07	0.06	0.02	0.28	0.08	0	0.03	0.01	0	0.01	0	0.01	0	0
1994	0.33	0.23	0.07	0.01	0.08	0.16	0.09	0.04	0.02	0.06	0.23	0.15	0.08	0.02	0.17	0	0	0.02	0	0.02	0	0	0	0
1995	0.41	0.12	0.15	0.13	0.36	0.04	0.12	0.07	0.1	0.18	0.03	0.12	0.01	0	0.05	0	0.02	0	0.01	0	0.03	0	0	0
1996	0.09	0.24	0.36	0.11	0.17	0.17	0.1	0.08	0.07	0.14	0.05	0.06	0	0.02	0	0	0	0.11	0	0	0	0	0	0
1997	0.3	0.28	0.07	0.21	0.13	0.09	0.14	0	0.04	0.07	0	0	0.03	0.06	0	0	0.01	0	0	0	0	0.01	0	0.02
1998	0.19	0.34	0.11	0.22	0.09	0.05	0.07	0.07	0.02	0.02	0.03	0.3	0	0	0	0.02	0	0.02	0	0.02	0	0	0	0
1999	0.16	0.14	0.14	0.15	0.06	0.15	0.17	0.17	0.09	0.07	0.04	0	0.06	0.02	0	0.02	0.04	0	0	0	0	0	0	0
2000	0.2	0.1	0.12	0.27	0.07	0.21	0.13	0.09	0.03	0.01	0.08	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0.08	0.07	0.04	0.07	0.1	0.01	0.04	0.01	0.08	0.01	0.02	0	0.03	0.02	0.05	0.01	0	0.02	0	0	0	0	0	0
2002	0.1	0.14	0.14	0.03	0.1	0.05	0.09	0.17	0.03	0.04	0	0	0.03	0	0.05	0	0	0	0	0	0	0	0.02	0
2003	0.12	0.08	0.05	0.03	0	0.03	0.02	0.01	0	0	0.02	0	0.01	0	0	0	0	0	0	0	0	0	0	0
2004	0.19	0.12	0.24	0.12	0.09	0.14	0.13	0.07	0.05	0	0.02	0	0.16	0	0.04	0	0	0.05	0	0.03	0	0	0	0
2005	0.44	0.3	0.23	0.11	0.28	0.15	0.09	0.11	0.01	0.11	0.06	0.01	0.02	0.01	0	0	0	0	0	0	0	0	0	0
2006	0.43	0.51	0.29	0.27	0.18	0.31	0.25	0.04	0.21	0.14	0.07	0.07	0.07	0.04	0	0.03	0	0	0.06	0	0	0	0	0
2007	0.36	0.23	0.09	0.21	0.1	0.15	0.06	0.08	0.07	0.08	0.05	0.21	0.04	0.06	0.03	0.05	0	0.01	0.01	0	0	0.01	0	0
2008	0.13	0.25	0.26	0.25	0.22	0.08	0.21	0.22	0.06	0.11	0.08	0.18	0.03	0.03	0	0	0.01	0	0	0.02	0	0	0	0
2009	0.01	0.02	0.02	0.04	0.07	0.1	0.05	0.06	0.01	0.04	0.03	0.02	0	0.01	0.04	0	0	0.01	0	0	0	0	0	0
2010	0.04	0.03	0.08	0.02	0	0.08	0.04	0.02	0.06	0.05	0	0	0	0	0.02	0	0	0.02	0	0.01	0	0	0	0
2011	0.09	0.06	0.08	0.12	0.03	0.01	0	0.02	0	0.04	0.03	0.02	0	0.03	0.01	0	0	0	0	0	0	0	0	0
2012	0.05	0.03	0.08	0.07	0.04	0.01	0	0.04	0.04	0.03	0.01	0	0.01	0.02	0	0.01	0	0.01	0	0.01	0	0	0	0
2013	0.07	0.08	0.09	0.03	0.03	0.01	0.03	0.01	0.02	0.01	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0.04	0.06	0.04	0.01	0	0.06	0.02	0.04	0	0.03	0	0	0.03	0	0	0	0.01	0	0	0	0	0	0	0
2015	0.02	0.03	0.03	0.01	0.03	0.01	0.02	0.02	0.03	0.02	0	0	0.01	0.01	0.02	0	0	0	0	0	0	0	0	0
2016	0.13	0.1	0.07	0.03	0.06	0.03	0.05	0.04	0	0.03	0.06	0.03	0.02	0.04	0	0	0	0	0	0	0	0	0	0
2017	0.23	0.25	0.04	0.18	0.16	0.02	0.12	0.02	0	0.02	0	0	0	0	0.02	0	0	0	0	0	0	0	0	0
2018	0.24	0.17	0.16	0.19	0.16	0.12	0.13	0.2	0.15	0.03	0	0.09	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.8d (page 6 of 6)—Trawl survey size composition as used in Model 17.2, by year and cm.

Year	115	116	117	118	119	120+
1982	0	0	0	0	0	0
1983	0	0	0	0	0	0
1984	0	0	0	0	0	0
1985	0	0	0	0	0	0
1986	0	0	0	0	0	0
1987	0	0	0	0	0	0
1988	0	0	0	0	0	0
1989	0	0	0	0	0	0
1990	0	0	0	0	0	0
1991	0	0	0	0	0	0
1992	0	0	0.02	0	0	0
1993	0.05	0	0	0	0	0
1994	0	0	0	0	0	0
1995	0	0	0	0	0	0
1996	0	0	0	0	0	0
1997	0	0	0	0	0	0
1998	0	0	0	0	0	0
1999	0	0	0	0	0	0
2000	0	0	0	0	0	0
2001	0	0	0	0	0	0
2002	0	0	0	0	0	0
2003	0	0	0	0	0	0
2004	0	0	0	0	0	0
2005	0	0	0	0	0	0
2006	0	0	0	0	0	0
2007	0	0	0	0	0	0
2008	0	0	0	0	0	0
2009	0	0	0	0	0	0
2010	0	0	0	0	0	0
2011	0	0	0	0	0	0
2012	0	0	0	0	0	0
2013	0	0	0	0	0	0
2014	0	0	0	0	0	0
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018	0	0	0	0	0	0

Table 2.8e (page 1 of 6)—Trawl survey size composition as used in Models 18.6 and 18.8, by year and cm (last 3 rows are NBS).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1982	308	0	0	0	0	0	0.02	0.23	0.26	0.56	0.76	1.52	1.73	3.19	1.94	1.48	1.51	1.34	0.57	0.25	0.26	0.06
1983	255	0	0	0	0	0	0.14	1.86	5.63	8.82	8.88	9.38	8.95	8.41	7.65	4.89	4.84	2.32	1.43	0.86	0.55	0.17
1984	264	0	0	0	0	0	0.14	0.54	0.78	1.19	0.95	0.59	0.55	0.56	0.65	1	0.69	1.39	1.56	1.96	2.71	5.01
1985	342	0	0	0	0	0	0.09	1.13	2.06	3.64	2.93	4.37	5.82	6.17	7.54	10.19	10.27	10.66	13.1	11.33	11.24	6.51
1986	349	0	0	0	0	0.01	0.51	0.86	2.11	3.03	2.95	4.57	3.96	4.01	3.4	2.1	0.78	0.6	0.46	0.5	1.63	2.59
1987	339	0	0	0	0	0	0	0.42	0.11	0.22	0.75	1.18	1.9	2.51	3.36	3.75	3.74	4.76	3.84	2.49	1.9	1.47
1988	339	0	0	0	0	0	0	0.02	0.26	0.25	0.94	0.45	1	0.88	0.78	1.41	0.97	0.64	0.91	1.17	1.6	2.37
1989	293	0	0	0	0	0	0.07	0.07	0.54	1.34	1.04	1.98	2.44	3.06	2.98	2.86	1.86	1.12	0.54	0.61	0.85	0.1
1990	329	0	0	0	0	0	1.45	4.03	5.88	8.68	8.48	10.47	13.33	14.68	11.68	8.5	6.68	5.1	3.22	2	2.38	2.5
1991	313	0	0	0	0	0	0.27	1.32	4.01	4.79	5.98	5.83	6.99	5.66	5.83	5.5	4.59	5.76	3.69	3.1	3.1	3.45
1992	332	0	0	0	0	0	0	0.02	0.57	2.77	6.27	6.5	5.98	5.15	6.77	7.62	8.04	8.51	7.38	7.78	3.89	4.09
1993	363	0	0	0	0	0.03	0.09	1.01	2.8	6.62	14.73	10.19	14.01	12.29	11.14	11.07	12	10.81	11.16	7.48	4.67	3.41
1994	364	0	0	0	0	0	0.09	0.26	0.14	0.68	1.07	1.98	2.34	2.55	2.58	3.03	3.54	2.87	2.7	2.47	3.65	3.34
1995	347	0	0	0	0	0.01	0.12	0.44	0.56	0.49	0.72	1.55	1.39	1.58	2.09	2.22	3.02	2.55	1.3	0.91	0.71	1.39
1996	359	0	0	0	0	0	0.04	0.06	0.43	0.36	0.87	1.27	1.83	2.43	2.05	2.53	2.63	2.43	2.06	1.36	0.78	0.87
1997	369	0	0	0	0	0	0.34	0.69	2.59	4.54	6.62	7.65	7.62	7.86	8.42	11.34	8.97	8.64	8.93	7.04	4.16	2.28
1998	362	0	0	0	0	0	0.05	0.16	0.87	1.97	3.13	4.35	3.89	5.08	3.39	1.7	0.83	0.25	0.16	0.73	0.91	2.19
1999	336	0	0	0	0	0	0.02	0.39	1.38	2.59	2.83	3.15	2.42	2.93	2.03	1.09	0.77	1.14	1.35	1.16	1.69	3.1
2000	355	0	0	0	0.11	0.28	0.65	1.44	2.77	3.83	8.34	13.42	16.29	12.38	7.78	7.68	4	2.44	0.92	0.26	0.34	0.69
2001	366	0	0	0	0	0.09	0.11	0.49	1.15	2.33	3.74	5.7	8.24	12.07	13.01	14.01	12.45	12.15	8.07	6.47	4.06	2.6
2002	364	0	0	0	0	0.02	0.08	0.17	0.64	1.27	1.85	2.33	3.05	4.67	3.28	4.85	3.25	2.09	1.51	1.02	0.53	1.27
2003	363	0	0	0.04	0	0.02	0.08	0.15	0.33	1.59	2.64	3.9	5.82	6.62	5.87	7.11	7.22	8.05	7.19	6.82	5.67	6.22
2004	361	0	0.05	0	0	0	0.02	0.13	0.64	1.5	2.82	5.03	3.5	6.44	6.22	7.09	6.92	4.43	4.74	3.64	2.22	1.86
2005	360	0	0	0	0	0	0	0.03	0.12	0.69	1.35	2.69	4.27	6.21	7.68	9.41	8.81	9.34	8.96	11.26	11.24	12.08
2006	354	0	0.02	0	0.12	0.21	1.14	2.84	9.48	11.42	12.07	12.86	11.37	9.74	9.3	10.14	7.95	6.91	4.13	3.01	1.84	1.55
2007	368	0	0	0	0	0.21	0.21	3.61	13.43	32.5	39.95	39.28	32.1	20.7	20.29	14.95	9.74	11.72	6.68	3.5	3.5	1.22
2008	338	0	0	0.02	0	0	0.14	1.37	4.26	8.81	9.57	9.82	8.85	7.86	5.72	3.8	1.91	1.01	0.53	1.02	1.91	4.23
2009	360	0.01	0	0.01	0.15	0.77	2.26	8.59	20.82	22.67	23.32	18.84	15.98	13.98	10.44	9.96	6.94	4.77	2.49	0.74	0.6	0.76
2010	342	0	0	0	0	0	0.03	0.21	0.79	1.07	1.3	2.24	2.24	2.52	2.08	1.38	0.68	0.74	0.42	0.61	1.41	2.7
2011	368	0	0	0	0	0	0.13	0.34	1.33	2.5	4.54	5.41	6.81	7.27	10.5	11.06	15.98	15.63	15.09	9.46	5.09	1.95
2012	356	0	0	0.16	0	0.01	2	10.29	18.62	19.86	15.27	11.49	11.33	8.45	11.12	10.75	5.66	3.5	1.29	0.85	0.28	0.77
2013	354	0	0	0	0	0.01	0.17	0.93	2.17	2.74	3.87	4.15	5.33	4.56	3.38	2.37	0.67	0.4	1.19	1.61	5.01	7.46
2014	373	0	0	0	0.03	0	0.01	0.19	1.85	2.41	4.94	7.06	9.63	10.73	13.59	10.3	12.56	10.14	10.76	6.38	4.52	2.3
2015	354	0	0	0	0	0	0	0.2	0.76	0.77	1.56	1.41	0.95	0.87	1.04	1.05	1.1	1.35	1.55	1.27	1.41	1.38
2016	376	0	0	0	0	0.02	0	0.11	0.35	0.57	1.15	1.29	0.85	0.49	1.11	1.4	2.11	3.22	4.84	5.87	5.53	4.86
2017	369	0	0	0	0	0	0	0.06	0.06	0.41	1.11	1.44	1.44	1.92	1.77	2.19	2.65	3.01	3.9	4.15	4.91	5.48
2018	364	0	0	0	0	0	0	0	0	0.11	0.2	0.22	0.77	0.79	1.53	1.4	2.19	1.86	2.27	3.9	4.18	5.31
2010	6	0	1.05	0	0	0	0	2.03	1.97	3.15	2	0.98	0	0	0.97	0	0	0	3.8	1.79	1.95	5.05
2017	119	0	0	0	0	0	0	0	0	0	0.85	10.33	5.3	11.86	9.8	4.69	6.46	6.46	7.35	7.5	10.99	24.99
2018	79	0	0	0	0	0	0	0	1.56	3.17	11.86	16.21	18.7	24.75	11.06	7.71	2.48	3.73	4.42	3.64	4.05	6.54

Table 2.8e (page 2 of 6)—Trawl survey size composition as used in Models 18.6 and 18.8, by year and cm (last 3 rows are NBS).

Year	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
1982	0.24	0.52	0.73	1.16	1.96	2.53	3.59	5.64	6.45	7.01	8.91	9.25	6.92	5.74	4.21	4.26	3.67	4.01	5.26	5.91
1983	0.1	0.35	0.66	0.89	1.08	1.95	2.43	2.83	3.36	3.21	4.13	2.82	2.46	2.08	1.18	1.2	1.67	1.83	2.76	3.05
1984	6.78	8.24	10.01	12.49	13.04	14.06	12.38	10.37	8.56	7.5	6.42	4.79	3.36	2.32	2.21	1.91	1.27	2.04	1.63	1.99
1985	4.3	2.64	1.85	2.03	2.16	3.22	4.45	4.37	5.51	6.07	6.25	6.31	5.83	6.94	7.12	7.88	8.37	10.42	10.13	10.41
1986	4.95	8.17	10.19	15.82	14.27	13.99	14.49	14.83	13.16	12.64	10.17	9.12	7.92	7.54	5	4.41	3.13	2.85	3.09	3.7
1987	2.01	2.42	3.75	3.88	6.23	8.62	9.51	10.19	9.16	8.9	6.54	7.35	6.34	5.56	6.21	7.37	7.1	9.47	10.7	10.72
1988	2.64	2.99	2.93	3.72	2.81	4.26	4.1	4.62	6.04	6.4	9.05	7.25	6.57	7.1	4.76	6.17	5.63	8.12	7.52	6.64
1989	0.43	0.44	1	0.38	0.96	0.86	0.8	0.94	1.05	2.05	0.94	3.09	3.22	4.24	3.35	3.68	2.87	3.37	3.32	3.95
1990	1.97	2.83	4.45	4.46	5.64	5.98	5.65	5.28	6.76	7.04	4.53	6.49	5.42	3.81	3.25	3.82	2.94	2.64	2.31	2.16
1991	4.31	4.4	7.38	8.45	11.71	12.47	13.97	12.44	15.97	13.22	10.75	11.18	8.38	7.41	6.11	5.1	3.67	2.99	2.71	2.6
1992	4.66	6.37	9.18	9.94	10.46	12.07	12.78	12.06	10.72	10.44	8.43	7.63	6.19	5.2	4.39	6.39	5.02	7.42	6.47	7.57
1993	2.15	1.98	2.32	3.05	3.28	6.04	7.19	8.17	10.09	11.01	8.33	8.54	7.89	6.83	5.31	5.6	6.46	6.39	7.7	7.72
1994	4.94	4.42	5.84	8.61	11.48	14.67	16.82	19.02	19.84	17.45	16.56	12.15	9.37	7.48	5.11	3.05	3.42	3	5.73	4.87
1995	1.76	3.35	4.1	5.94	7.31	8.61	8.18	9.24	8.5	7.49	5.86	8.17	9.34	9.02	11.95	14.18	14.04	15.64	15.86	14.82
1996	0.91	2.22	2.45	4.95	6.21	7.38	8.72	10.45	9.01	9.52	7.27	7.59	6.41	6.01	6.36	5.89	6.75	8.15	9.08	10.97
1997	1.63	1.62	1.4	2.81	4.34	4.09	6.08	8.88	9.14	8.79	6.97	6.28	6.16	5.45	5.81	5.43	5.05	5.07	5.5	5.41
1998	2.73	7	10.42	14.39	18.5	22.51	23.41	22.97	19.15	20.04	12.96	9.74	8.49	6.19	5.48	5.03	3.8	4.74	4.46	5.12
1999	3.24	5.53	6.08	5.96	8.27	7.31	7.75	8.13	6.42	6.21	5.97	6.28	8.12	10.59	9.8	12.54	14.17	15.94	17.22	17.16
2000	1.09	2.19	3.33	4.78	5.53	6.26	7.32	8.58	6.31	5.56	5.25	5.38	4.92	5.64	6.32	7.25	7.49	8.56	8.74	9.85
2001	2.16	3.05	4.25	5.88	6.87	9.44	12.13	15.32	15.23	16.9	14.83	12.86	9.46	7.64	5.55	4.08	3.5	3.25	2.84	2.96
2002	1.91	3.18	4.79	7.17	7.96	12.79	13.98	16.32	16.22	15.32	11.24	11.72	9.19	8.67	7.37	8.59	7.67	12.18	10.69	13.42
2003	4.38	3.42	1.94	1.67	1.72	2.3	1.69	3.37	4.12	8.96	6.15	9.09	6.92	7.85	8.37	9.24	10.41	10.09	11.32	13.47
2004	2.46	3.08	3.56	6.22	6.55	7.28	7.9	9.13	9.92	10.47	10.23	11.11	10.31	10.75	8.39	8.14	7.05	6.88	6.21	6.01
2005	11.71	8.95	6.5	4.37	4.35	4.54	3.69	5	5.62	6.21	6.11	6.48	7.19	8.99	7.91	6.59	6.37	6.62	6.68	6.96
2006	1.71	1.6	1.82	2.53	3.34	4.88	5.54	7.04	7.17	7.59	7.32	8.94	7.67	8.63	7.58	7.09	6.19	5.83	4.81	4.99
2007	1.37	1.96	2.6	3.58	3.47	4.46	3.49	3.94	4.15	3.5	3.23	2.65	2.66	2.14	1.77	2.13	2.23	2.32	1.95	2.52
2008	7.89	12.27	14.05	18.21	19.26	18.77	17.63	14.49	12.18	8.89	7.37	5.11	4.35	4	3.57	3.4	3.12	3.78	3.41	3.71
2009	1.76	2.03	3.73	5.48	7.27	8.54	10.08	9.4	7.32	6.59	4.76	4.62	4.61	4.87	6.49	6.57	7.81	8.16	8.18	7.48
2010	5.67	8.71	10.83	15.99	19.31	18.93	17.72	17.78	14.59	12.23	8.36	7.61	4.87	4.34	3.01	3.39	3.53	5.58	5.94	10.43
2011	0.69	0.67	1.01	0.86	1.02	1.31	2.15	2.43	3.34	2.9	4.13	4.03	4.84	5.08	7.14	8.07	11.91	14.1	15.19	16.3
2012	1.02	1.62	2.3	4.85	7.02	7.3	9.73	9.6	10.59	7.69	8.4	5.17	4.28	2.71	2.21	1.7	1.24	1.73	1.6	2.33
2013	12.22	14.7	18.38	20.16	15.71	17.01	12.19	12.31	7.78	5.82	4.5	3.37	3.27	2.72	2.35	3.47	2.87	4.37	5.59	6.85
2014	2.13	1.89	1.49	1.99	4.58	5.1	8.67	6.85	9.99	9.53	10.32	7.22	6.44	3.8	3.94	3	4.22	5.88	9.22	9.5
2015	1.43	1.5	2.23	3.28	5.13	7.05	9.58	13.2	16.56	19.29	20.35	18.03	17.15	14	10.54	9.09	5.23	4.9	3.67	6.89
2016	3.29	2.32	1.23	0.78	0.85	1.47	1.87	2.27	2.84	3.86	3.54	4.92	5.38	6.39	6.16	7.18	8.38	10.1	12.74	13.3
2017	5.65	5.17	4.25	3.02	3.07	2.85	3.71	2.86	3.5	3.59	3.89	4.02	4.95	4.56	4.82	5.19	5.75	5.14	6.02	7.47
2018	4.14	3.38	1.71	1.71	1.81	1.68	1.82	3.14	3.76	4.48	6.1	6.83	7.59	7.36	9.44	8.93	8.97	9.21	9.56	8.02
2010	4.83	1.06	7.49	3.08	6.2	7.98	2.26	2.07	2.05	1.06	0	0	1.02	0.96	0	1.07	0.89	0	0	1.02
2017	14.71	26.78	35.96	51.16	49.57	71.74	70.95	82.27	66.8	69.89	41.11	37.47	35.08	29.88	17.18	23.53	20.04	29.39	31.08	40.9
2018	4.11	7.69	2.18	5.68	9.93	14.6	22.98	22.44	11.13	17.12	22.61	15.36	23.56	25.07	28.92	45.77	53.38	50.66	44.44	58.29

Table 2.8e (page 3 of 6)—Trawl survey size composition as used in Models 18.6 and 18.8, by year and cm (last 3 rows are NBS).

Year	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
1982	8.23	8.83	7.95	9.59	9.59	8.18	8.3	7.88	7.42	6.97	8.12	7.54	7.8	6.56	7.6	7.71	7.63	6.56	6.63
1983	4.11	5.22	5.84	5.58	5.78	6.13	4.92	4.81	4.78	4.36	5.79	5.36	5	5.09	4.76	5.08	4.76	3.89	4.34
1984	2.04	2.1	2.35	2.91	2.3	2.38	2.06	2.37	3.08	2.8	3.4	3.62	4.28	4.31	3.35	4.68	3.67	4.34	4.4
1985	9.77	9.52	7.27	6.54	4.94	3.9	3.4	2.6	1.95	1.89	2.09	2.05	2.1	1.72	1.76	1.83	1.71	3	2.23
1986	4.2	4.9	4.65	5.57	4.94	5.63	6.1	5.86	6.25	6.54	6.8	5.13	5.71	5.69	3.98	3.87	2.71	3.31	2.52
1987	10.66	10.45	10.25	8.32	8.36	8.48	5.05	5.15	4.27	3.76	4.73	4.42	3.09	4.04	2.88	4.44	4.3	3.95	4.07
1988	10.75	9.31	9.96	9.34	8.32	10.4	8.97	7.73	8.55	8.58	8.76	7.55	7.22	7.73	6.51	6.72	5.65	6.99	5.58
1989	5.24	4.77	5.11	5.44	4.98	5.83	7.35	6.69	7.51	7.13	6.79	9.63	8.48	6.3	6.85	6.18	8.54	5.49	6.46
1990	1.9	2.11	2.96	2.28	2.37	1.73	3.01	1.97	3.62	3.29	4.16	3.53	4.23	4.28	4.58	4.91	5.16	5.26	4.72
1991	2.21	2.65	2.24	2.68	3.21	2.08	2.64	1.8	3.15	3.81	2.49	3.25	1.77	1.55	1.8	1.82	1.49	2.22	2.08
1992	8.39	6.4	6.36	5.55	4.88	5.26	4.09	3.66	3.03	2.69	1.95	2.16	1.05	1.47	1.74	1.77	2.28	1.54	1.2
1993	8.14	9.43	7.2	6.48	6.72	5.53	5.27	4.5	3.98	4.13	3.76	3.06	2.22	2.32	2.77	2.3	1.97	2.02	1.84
1994	4.3	6.01	6.6	6.84	7.76	4.47	4.89	5.92	4.9	4.67	4.54	5.65	6.51	6.49	4.22	5.63	3.99	5.26	4.21
1995	12.85	12.58	11.07	7.47	7.13	5.78	5.34	4.33	3.71	4.1	3.58	3.28	3.48	3.23	2.74	3.49	3.73	3.96	3.8
1996	9.92	11.17	12.29	11.51	11.34	12.38	10.38	10.81	10.79	9.46	9.84	7.9	6.45	5.96	5.17	5.5	3.9	3.63	3.35
1997	6.75	7.79	9.2	6.01	6.82	5.4	6.1	7.21	7.47	6.58	6.75	4.95	8.56	6.84	6.96	5.29	5.25	4.3	4.5
1998	4.85	6.65	4.49	4.34	5.16	4.29	3.51	3.41	3.19	3.11	2.8	2.42	3	3.49	2.87	2.54	2.92	3.33	3.25
1999	14.42	10.98	11.26	8.61	6.43	5.51	4.84	4.34	3.86	3.27	3.41	2.63	2.8	2.68	2.49	1.91	3.2	2.38	2.72
2000	8.69	10.31	9.23	11.18	9.76	10.01	7.41	8.91	6.78	7.29	5.51	5.73	5.13	4.57	4.48	4.16	3.13	2.85	2.54
2001	3.46	4.27	5.24	4.24	4.95	4.76	4.37	4.93	5.08	4.87	4.38	4.15	4.33	3.55	3.94	3.47	2.8	3.7	2.47
2002	11.76	11.69	8.22	9.81	5.66	6.87	5.5	4.98	4.07	4.87	3.81	4.73	2.7	3.46	3.58	3.82	3.18	3.42	3.19
2003	12.55	13.51	12.43	11.52	8.46	8.42	7.1	7.57	7.94	6.16	5.7	5.25	4.47	3.84	4.34	4.18	3.41	2.94	2.18
2004	5.2	5.03	5.02	5.82	5.67	6.83	6.66	5.35	6.07	5.82	6.28	5.66	6.41	4.88	5.24	5.69	5.01	4.78	4.59
2005	5.38	6.89	5.54	6.22	4.28	5.48	4.05	4.72	4.2	4.41	3.64	3.53	3.23	3.23	3.25	3.77	2.75	3.89	2.79
2006	4.32	4.45	4.04	4.84	4.54	5.91	5.12	5.23	4.7	5.4	4.05	5.26	3.16	3.73	2.67	2.9	3.03	2.84	3.15
2007	2.31	2.5	2.42	2.35	1.76	2.27	2.12	2.56	2.01	2.06	1.78	1.8	1.59	1.63	1.57	1.91	1.59	1.83	1.51
2008	3.55	3.59	2.96	3.52	3.2	3.25	3.31	3.77	3.01	2.88	2.6	2.97	2.28	3.12	2.63	3.04	2.33	2.23	2.09
2009	7.25	6.03	6.25	5.33	3.9	3.16	3.16	2.53	2.24	2.02	1.82	1.63	1.68	1.86	1.94	1.54	1.82	1.68	1.14
2010	6.91	7.54	7.14	7.13	5.55	6.12	4.78	6.67	5.13	6.99	6.8	6.28	4.29	6.31	5.05	4.54	3.31	4.06	2.63
2011	15.47	13.93	11.22	9.05	6.21	6.26	4.96	4.68	3.33	4.13	3.99	4.69	3.28	4.93	4.28	5.32	4.08	5.24	3.36
2012	2.2	3.61	3.01	5.36	5.09	6.51	7.76	10.31	8.75	11.12	8.4	8.62	5.97	5.4	4.56	4.5	2.64	3.29	2.34
2013	8.2	9.96	7.77	7.37	6.9	6.23	5.07	4.92	3.79	3.96	2.61	3.66	2.77	4.15	3.72	4.52	3.75	4.08	4.03
2014	13.61	14.01	12.63	11.59	10.22	8.82	5.94	4.52	4.23	4.34	3.86	3.48	4.09	5.23	5.22	4.17	4.02	4.26	2.84
2015	6.83	9.14	8.66	8.6	7.81	8.32	5.86	6.46	6.36	5.83	6.18	7.12	6.19	7.98	6.1	5.54	4.02	4.51	2.89
2016	17.76	19.43	18.86	19.21	16.68	15.05	11.75	9.11	9.16	6.5	6.48	6.24	6.08	5.56	5.89	5.68	5.01	5.2	5.25
2017	6.14	7.85	7.29	7.58	8.82	10.38	9.46	11.1	11.22	12.94	13.82	12.74	12.4	10.87	8.53	8.03	7.68	6.2	7.27
2018	6.72	6.11	6.61	6.06	7.35	6.55	6.78	7.72	7.17	7.85	7.2	7.24	6.59	7.28	8.41	7.6	8.25	7.55	9.16
2010	0	0	0.93	0	0	0	0.91	0	0	0	1.03	0	0	0	0	0	0.97	2.05	2.88
2017	51.56	52.83	44.66	50.16	56.56	79.65	87.19	97.35	100.73	104	124.65	172.58	144.83	138.81	143.55	129.62	123.27	122.08	122.51
2018	56.6	39.56	45.05	38.22	40.9	39.76	30.1	31.2	41.42	42.74	48.85	57.94	53.32	73.39	64.39	84.71	83.82	85.25	73.19

Table 2.8e (page 4 of 6)—Trawl survey size composition as used in Models 18.6 and 18.8, by year and cm (last 3 rows are NBS).

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84
1982	5.91	5.64	5.54	5.78	3.56	5.03	3.63	3.85	2.14	2.12	2.1	1.88	1.3	1	1.07	0.87	0.58	0.78	0.7	0.36	0.22
1983	3.8	3.88	3.7	3.22	3.65	3.42	2.81	3.5	2.44	2.36	1.51	1.56	1.53	1.31	1.14	0.76	0.94	0.62	0.56	0.46	0.34
1984	4.1	3.51	4.29	3.97	3.92	3.71	3.32	3.14	1.81	2.6	2.12	2.27	1.63	1.79	1.22	1.48	1	0.87	0.69	0.71	0.59
1985	2.22	2.28	3.46	2.49	2.72	2.96	2.97	2.73	2.73	2.42	2.79	2.17	2.74	2.01	1.93	1.19	1.53	1.2	1.01	0.98	0.43
1986	1.83	2.24	1.72	1.92	1.6	1.97	2.38	2.24	2.03	1.6	2.04	1.95	1.57	1.84	1.61	1.41	1.9	1.26	1.21	0.97	0.65
1987	3.97	4.22	3.93	4.14	4.21	3.48	3.71	2.92	1.91	2.86	1.64	1.81	1.73	0.76	1.42	1.11	1.18	1.37	0.88	0.91	0.98
1988	3.91	4.21	3.36	4.67	3.56	3.62	2.76	3.95	2.86	2.84	1.92	2.7	2.43	1.62	1.45	1.86	2.45	2.19	1.79	1.03	1.1
1989	7.09	5.28	4.94	7.26	6.33	3.99	5.85	3.1	5.45	5.99	4.81	4.73	4.3	3.4	4.35	3.2	1.87	1.58	2.47	1.81	2.28
1990	4.72	3.3	4.83	3.33	3.74	2.29	3.89	2.72	3.28	3.28	3.16	2.76	1.94	2.31	2.33	1.56	2.21	2.2	0.68	1.45	1.22
1991	1.83	1.12	1.93	1.79	2.13	2.01	2.08	1.46	1.37	1.1	1.83	1.42	1.21	0.6	0.73	0.84	0.94	1.45	1.04	1	0.59
1992	0.9	1.06	1.05	1.65	1.26	1.14	0.86	0.52	0.78	0.84	0.72	0.61	0.87	0.52	0.61	0.86	0.99	0.48	0.61	0.51	0.39
1993	1.25	2.29	1.28	1.27	2.13	0.99	0.99	0.52	0.52	0.55	0.5	0.57	0.42	0.41	0.37	0.43	0.45	0.39	0.32	0.17	0.43
1994	4.65	4.12	3.32	2.16	3.43	1.59	2.64	1.28	1.73	0.78	1.04	0.51	0.78	0.34	0.56	0.24	0.23	0.27	0.35	0.14	0.23
1995	3.3	2.66	2.01	2.28	2.68	2.65	2.59	1.9	2.05	1.68	1.35	1.07	0.84	1.38	0.78	0.92	0.8	0.74	0.67	0.44	0.48
1996	3.1	2.25	2.36	2.38	2.21	2.2	1.83	2.18	2.44	1.31	1.79	1.41	1.05	1.12	1.33	0.87	0.82	0.94	0.95	0.58	0.99
1997	4.9	4.13	4.1	3.76	3.46	2.81	2.35	2.46	2.2	1.23	0.88	1.21	0.92	1.15	0.75	0.48	0.4	0.39	0.49	0.73	0.49
1998	2.8	2.51	3.7	2.17	2.42	1.91	1.79	2.12	2.13	1.51	2.01	1.09	1.37	0.8	0.78	0.92	0.47	0.64	0.36	0.6	0.41
1999	2.27	2.61	1.69	1.86	1.39	1.64	1.82	1.33	1.33	1.35	1	0.77	0.73	0.63	0.66	0.71	0.63	0.5	0.37	0.46	0.38
2000	2.39	1.56	1.82	1.67	1.46	1	1.41	0.93	1.09	0.88	0.96	0.81	0.63	0.34	0.4	0.6	0.62	0.36	0.5	0.53	0.24
2001	2.89	2.79	1.97	1.52	1.95	1.24	1.42	1.04	0.94	0.61	0.71	0.47	0.36	0.49	0.37	0.57	0.33	0.31	0.23	0.21	0.24
2002	3.03	1.73	3.21	2.14	1.97	2	1.76	1.39	1.09	1.07	0.96	0.72	0.91	0.7	0.39	0.3	0.58	0.41	0.18	0.19	0.09
2003	2.88	2.06	2.12	2.12	1.99	2.05	2.22	1.44	1.62	1.24	1.26	1.09	1.02	0.79	0.82	0.5	0.55	0.61	0.61	0.32	0.42
2004	4.07	3.49	3.33	3	3.63	2.85	2.15	2.44	2.06	2.12	1.16	1.71	1.56	1.42	1.5	1.04	0.9	0.81	0.77	0.52	0.76
2005	4.11	3.51	3.57	3.43	3.43	2.65	2.86	2.46	2.32	1.9	2.66	1.66	2.37	1.81	2.04	1.58	1.47	1.36	1.25	1.02	0.78
2006	2.7	2.55	2.94	1.81	2.86	1.47	2.03	1.79	1.74	1.93	2.01	1.62	1.77	1.3	1.68	1.31	1.67	1.49	1.5	1.08	1.26
2007	1.52	1.38	1.4	0.93	1.26	1.22	0.92	0.67	0.95	0.68	1.07	0.64	0.57	0.41	0.37	0.53	0.47	0.56	0.29	0.33	0.25
2008	2.66	1.62	2.03	1.68	2.18	1.21	1.47	0.87	1.21	0.63	1.16	0.49	0.7	0.61	0.64	0.32	0.42	0.31	0.47	0.37	0.33
2009	1.41	1.56	1.16	0.88	1.06	0.7	0.88	0.68	0.45	0.53	0.3	0.39	0.35	0.34	0.34	0.11	0.28	0.15	0.19	0.09	0.08
2010	3.01	1.84	1.93	1.33	1	0.75	0.9	0.79	0.42	0.29	0.31	0.37	0.46	0.12	0.33	0.1	0.08	0.19	0.1	0.1	0.03
2011	4.44	3.07	3.63	2.7	2.89	2.08	2.27	1.12	1.4	0.92	0.89	0.5	0.49	0.42	0.29	0.25	0.33	0.12	0.28	0.19	0.13
2012	2.81	2.1	2.16	1.71	1.8	1.25	2.01	1.02	1.3	0.65	0.78	0.58	0.55	0.52	0.48	0.16	0.29	0.12	0.19	0.17	0.17
2013	4.43	4.09	3.68	3.13	2.75	2.58	2.06	2.04	1.76	0.96	1.22	0.87	0.59	0.83	0.55	0.59	0.18	0.57	0.23	0.45	0.22
2014	2.93	2.28	2.23	1.3	1.31	1.11	1.4	1.19	1.11	1.37	1.03	0.91	0.85	0.62	0.59	0.41	0.34	0.34	0.17	0.17	0.17
2015	3.06	2.08	1.99	2.08	1.79	1.5	1.22	1.14	1.14	1.05	0.85	1	0.8	0.66	0.45	0.45	0.37	0.45	0.27	0.14	0.22
2016	4.71	4.96	5.5	4.27	3.95	3.6	3.74	3.15	2.07	1.91	1.51	1.1	1.02	1.05	0.8	0.56	0.53	0.79	0.36	0.41	0.47
2017	5.69	5.04	4.41	4.42	4.05	4.74	4.22	3.08	2.63	3.54	2.48	2.82	2.63	2.38	1.96	2.02	1.99	0.6	1.17	0.99	0.65
2018	8.84	7.96	7.01	8.04	6.15	6.42	5.98	4.28	4.28	4.04	2.93	2.51	2.41	2.91	1.93	2.24	2.37	1.64	1.47	1.45	1.2
2010	2.74	3.71	2.82	1.98	4.89	1.82	1.96	3.75	3.71	12.21	4.74	2.97	6.57	8.54	6.6	3.78	8.56	5.03	7.28	4.77	2.81
2017	103.1	92.11	70.18	82.64	69.37	52.1	62.09	42.19	57.62	37.82	38.68	31.64	20.81	23.78	12.87	18.32	16.35	13.69	9.67	9.42	5.07
2018	110.74	98.04	92.09	88.38	75.12	70.39	57.39	67.84	58.73	35.29	28.32	14.93	12.1	20.92	9.4	5.15	2.83	6.54	5.71	3	4.17

Table 2.8e (page 5 of 6)—Trawl survey size composition as used in Models 18.6 and 18.8, by year and cm (last 3 rows are NBS).

Year	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
1982	0.19	0.27	0.08	0.18	0.12	0.02	0.07	0.1	0	0.07	0	0.03	0.06	0.02	0	0	0	0	0	0	0	0	0	0
1983	0.23	0.02	0.13	0.16	0.06	0.22	0.01	0.01	0.04	0.08	0	0.05	0	0.02	0	0	0	0	0	0.02	0	0	0	0
1984	0.47	0.61	0.26	0.35	0.41	0.27	0.2	0.09	0.16	0.13	0	0.08	0.06	0.05	0.01	0.01	0	0	0	0.02	0	0	0	0
1985	0.76	0.44	0.44	0.33	0.28	0.21	0.16	0.15	0.17	0.09	0.02	0.07	0.14	0.04	0.07	0.04	0	0.07	0	0	0	0	0	0
1986	0.6	0.79	0.42	0.48	0.41	0.68	0.22	0.37	0.3	0.1	0.09	0.13	0.06	0.16	0.04	0.09	0.06	0	0.09	0.05	0	0	0	0
1987	1.04	0.26	0.29	0.47	0.31	0.31	0.4	0.18	0.36	0.32	0.05	0.18	0.19	0.1	0.04	0.02	0.08	0.09	0	0.03	0	0	0	0
1988	0.48	0.95	0.5	0.27	0.51	0.1	0.61	0.1	0.19	0.22	0.22	0.17	0.03	0.14	0.26	0.11	0.02	0.09	0	0	0.01	0	0	0
1989	2.5	1.21	1.84	1.25	0.4	1.21	0.86	0.53	0.67	0.81	0.91	0.55	0.3	0.58	0.32	0.28	0.62	0.02	0.64	0.19	0	0	0	0
1990	1.32	1.1	0.78	0.7	1.07	0.73	0.31	0.26	0.26	0.37	0.7	0.56	0.14	0.08	0.07	0.26	0	0.33	0.02	0	0.06	0.06	0.02	0
1991	0.58	0.36	0.62	0.31	0.33	0.25	0.2	0.25	0.17	0.06	0.27	0.33	0.14	0.09	0.12	0	0.02	0.01	0.24	0.04	0.02	0.06	0	0
1992	0.45	0.48	0.22	0.33	0.25	0.43	0.18	0.24	0.23	0.15	0.24	0.27	0.1	0.31	0.06	0.14	0.1	0.09	0.09	0.09	0.04	0.02	0.02	0
1993	0.36	0.15	0.25	0.28	0.26	0.14	0.12	0.13	0.26	0.09	0.24	0.17	0.16	0.13	0.12	0.04	0.07	0.07	0.02	0.29	0.09	0	0.03	0.01
1994	0.21	0.23	0.18	0.1	0.16	0.89	0.34	0.24	0.07	0.03	0.09	0.16	0.11	0.04	0.02	0.06	0.24	0.15	0.08	0.02	0.18	0	0	0.02
1995	0.38	0.28	0.29	0.28	0.27	0.16	0.43	0.13	0.16	0.13	0.37	0.04	0.12	0.07	0.1	0.18	0.03	0.12	0.02	0	0.05	0	0.02	0
1996	0.37	0.54	0.84	0.67	0.36	0.16	0.1	0.25	0.37	0.11	0.18	0.19	0.11	0.1	0.08	0.15	0.05	0.07	0	0.02	0	0	0	0.12
1997	0.41	0.32	0.36	0.37	0.17	0.12	0.34	0.29	0.08	0.22	0.13	0.09	0.14	0	0.04	0.07	0	0	0.03	0.06	0	0	0.01	0
1998	0.31	0.36	0.29	0.14	0.13	0.2	0.2	0.36	0.13	0.23	0.1	0.05	0.08	0.08	0.02	0.02	0.03	0.31	0	0	0	0.02	0	0.02
1999	0.31	0.29	0.45	0.41	0.16	0.41	0.16	0.13	0.14	0.14	0.06	0.14	0.16	0.17	0.08	0.06	0.03	0	0.05	0.02	0	0.02	0.03	0
2000	0.26	0.15	0.24	0.76	0.18	0.2	0.2	0.1	0.12	0.28	0.07	0.22	0.14	0.09	0.03	0.01	0.08	0	0	0	0	0	0	0
2001	0.1	0.2	0.11	0.12	0.1	0.13	0.08	0.07	0.04	0.08	0.1	0.01	0.04	0.01	0.09	0.01	0.02	0	0.04	0.02	0.05	0.01	0	0.02
2002	0.2	0.05	0.11	0.14	0.04	0.06	0.1	0.14	0.15	0.03	0.1	0.05	0.1	0.17	0.03	0.04	0	0	0.03	0	0.06	0	0	0
2003	0.21	0.29	0.16	0.19	0.15	0.11	0.12	0.08	0.05	0.05	0	0.03	0.02	0.01	0	0	0.02	0	0.01	0	0	0	0	0
2004	0.36	0.87	0.41	0.63	0.52	0.42	0.2	0.13	0.25	0.15	0.13	0.15	0.13	0.1	0.06	0	0.02	0	0.16	0	0.04	0	0	0.06
2005	0.54	0.86	0.63	0.74	0.44	0.32	0.47	0.31	0.24	0.14	0.28	0.16	0.09	0.11	0.01	0.11	0.06	0.01	0.02	0.01	0	0	0	0
2006	1.11	1	0.58	1	0.44	0.67	0.45	0.51	0.28	0.27	0.18	0.34	0.25	0.04	0.21	0.14	0.07	0.07	0.07	0.04	0	0.03	0	0
2007	0.75	0.33	0.25	0.27	0.41	0.28	0.38	0.26	0.09	0.22	0.12	0.15	0.06	0.08	0.07	0.08	0.05	0.22	0.04	0.07	0.03	0.05	0	0.01
2008	0.23	0.49	0.29	0.26	0.21	0.4	0.13	0.25	0.26	0.25	0.22	0.08	0.21	0.22	0.06	0.11	0.08	0.18	0.03	0.03	0	0	0.01	0
2009	0.15	0.13	0.12	0.07	0.09	0.1	0.01	0.02	0.02	0.05	0.07	0.1	0.05	0.07	0.01	0.04	0.03	0.02	0	0.01	0.04	0	0	0.01
2010	0.13	0.2	0.01	0.11	0.02	0.09	0.05	0.03	0.09	0.02	0	0.08	0.04	0.02	0.06	0.05	0	0	0	0	0.02	0	0	0.02
2011	0.05	0.07	0.09	0.09	0.06	0.03	0.09	0.06	0.08	0.13	0.04	0.01	0	0.02	0	0.04	0.03	0.02	0	0.03	0.01	0	0	0
2012	0.1	0.11	0.11	0.02	0.03	0.07	0.06	0.03	0.08	0.07	0.04	0.02	0	0.04	0.04	0.03	0.01	0	0.01	0.02	0	0.01	0	0.01
2013	0.2	0.13	0.14	0.09	0.06	0.09	0.07	0.08	0.09	0.03	0.03	0.01	0.03	0.01	0.02	0.01	0.01	0	0	0	0	0	0	0
2014	0.08	0.1	0.12	0.07	0.03	0.13	0.05	0.06	0.04	0.01	0	0.06	0.02	0.04	0	0.03	0	0	0.03	0	0	0	0.01	0
2015	0.13	0.32	0.18	0.11	0.05	0.08	0.02	0.03	0.03	0.01	0.03	0.01	0.02	0.02	0.03	0.02	0	0	0.01	0.01	0.02	0	0	0
2016	0.36	0.22	0.19	0.16	0.18	0.11	0.13	0.1	0.07	0.03	0.06	0.05	0.05	0.04	0	0.03	0.06	0.03	0.02	0.04	0	0	0	0
2017	0.35	0.32	0.44	0.33	0.5	0.11	0.23	0.25	0.1	0.18	0.16	0.02	0.12	0.02	0	0.02	0	0	0	0	0.02	0	0	0
2018	0.54	0.78	0.88	0.6	0.46	0.44	0.24	0.17	0.17	0.19	0.16	0.12	0.14	0.2	0.16	0.03	0	0.09	0	0	0	0	0	0
2010	7.43	2.89	0.9	2.09	0.99	0	2.01	2.93	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	3.22	2.52	1.89	2.59	4.22	3.65	0	0	2.72	0	2.09	0	0	0	0	0	0.88	0	0	0	0	0	0	0
2018	0.72	2.86	0	0	0	0.72	1.49	0	1.15	0	0	0	0.8	0	0	0	0	0	0	0	0	0	0	0

Table 2.8e (page 6 of 6)—Trawl survey size composition as used in Models 18.6 and 18.8, by year and cm (last 3 rows are NBS).

Year	109	110	111	112	113	114	115	116	117	118	119	120+
1982	0	0	0	0	0	0	0	0	0	0	0	0
1983	0	0	0	0	0	0	0	0	0	0	0	0
1984	0	0	0	0	0	0	0	0	0	0	0	0
1985	0	0	0	0	0	0	0	0	0	0	0	0
1986	0	0	0	0	0	0	0	0	0	0	0	0
1987	0	0.01	0	0	0	0	0	0	0	0	0	0
1988	0	0.13	0	0	0	0	0	0	0	0	0	0
1989	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0
1992	0.02	0	0.02	0	0	0	0	0	0.02	0	0	0
1993	0	0.01	0	0.01	0	0	0.05	0	0	0	0	0
1994	0	0.02	0	0	0	0	0	0	0	0	0	0
1995	0.01	0	0.03	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0
1997	0.12	0	0	0.01	0	0.02	0	0	0	0	0	0
1998	0	0.02	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0.02	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0.03	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0
2006	0.06	0	0	0	0	0	0	0	0	0	0	0
2007	0.01	0	0	0.01	0	0	0	0	0	0	0	0
2008	0	0.02	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0.01	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0.01	0	0	0	0	0	0	0	0	0	0
2013	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0	0	0	0	0	0
2016	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0
2018	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.9a—Trawl survey age compositions, expressed as within-year proportions, as used in Models 16.6 and 17.2. N1 is the input sample size used in Model 16.6 and N2 is the input sample size used in Model 17.2.

	Input N		Age												
Year	N1	N2	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	302	345	0.00000	0.08966	0.38644	0.17034	0.12269	0.11685	0.07911	0.02019	0.00695	0.00461	0.00135	0.00099	0.00082
1995	293	334	0.00001	0.05500	0.26331	0.41952	0.09985	0.07910	0.04938	0.01579	0.00862	0.00583	0.00154	0.00085	0.00120
1996	298	340	0.00001	0.05685	0.20547	0.20124	0.29291	0.13709	0.05923	0.02895	0.01015	0.00429	0.00179	0.00108	0.00093
1997	307	350	0.00000	0.25378	0.16698	0.18265	0.15729	0.12176	0.07961	0.02222	0.01031	0.00297	0.00129	0.00079	0.00035
1998	301	343	0.00000	0.07621	0.43727	0.20376	0.11360	0.05770	0.06102	0.02881	0.01602	0.00399	0.00078	0.00060	0.00021
1999	277	316	0.00000	0.07310	0.18981	0.32874	0.22983	0.07846	0.05563	0.02565	0.01097	0.00482	0.00113	0.00133	0.00052
2000	300	342	0.00002	0.23238	0.12660	0.15041	0.24317	0.14809	0.06215	0.01379	0.01347	0.00539	0.00284	0.00126	0.00043
2001	304	347	0.00001	0.28722	0.23564	0.19285	0.09179	0.08478	0.06894	0.02642	0.00765	0.00213	0.00147	0.00080	0.00029
2002	302	344	0.00006	0.07930	0.18698	0.31571	0.23407	0.07361	0.06013	0.03410	0.01031	0.00372	0.00104	0.00052	0.00046
2003	301	343	0.00001	0.17022	0.15255	0.24784	0.21338	0.12345	0.04234	0.03121	0.01386	0.00363	0.00049	0.00056	0.00046
2004	301	343	0.00002	0.14240	0.16514	0.26874	0.12822	0.12898	0.09224	0.04087	0.01916	0.00876	0.00220	0.00257	0.00070
2005	300	342	0.00000	0.17816	0.24016	0.20898	0.12354	0.06688	0.08214	0.05723	0.02428	0.01074	0.00367	0.00360	0.00062
2006	302	344	0.00000	0.31466	0.14271	0.16575	0.12625	0.09574	0.06413	0.04702	0.02868	0.00985	0.00301	0.00139	0.00083
2007	305	348	0.00000	0.69159	0.09571	0.06825	0.04362	0.04978	0.01841	0.01467	0.00860	0.00507	0.00177	0.00154	0.00098
2008	287	327	0.00014	0.20735	0.44301	0.14650	0.08417	0.05031	0.03538	0.01072	0.01052	0.00600	0.00278	0.00142	0.00169
2009	302	345	0.00067	0.45244	0.18939	0.23077	0.06441	0.02914	0.01513	0.01001	0.00419	0.00207	0.00085	0.00058	0.00035
2010	287	327	0.00000	0.04622	0.47943	0.17944	0.20303	0.06442	0.01483	0.00781	0.00252	0.00127	0.00037	0.00053	0.00013
2011	306	349	0.00003	0.28969	0.07312	0.38691	0.11156	0.09609	0.02823	0.00706	0.00338	0.00174	0.00104	0.00064	0.00049
2012	300	342	0.00005	0.36523	0.23438	0.05848	0.23730	0.06184	0.03081	0.00745	0.00208	0.00158	0.00047	0.00016	0.00016
2013	299	341	0.00000	0.10646	0.42201	0.17866	0.10995	0.11506	0.05152	0.01108	0.00370	0.00086	0.00020	0.00029	0.00022
2014	310	354	0.00005	0.27814	0.18690	0.23744	0.19814	0.04825	0.03634	0.01038	0.00231	0.00090	0.00074	0.00014	0.00028
2015	299	341	0.00000	0.06385	0.42468	0.20182	0.19371	0.08222	0.01880	0.01144	0.00240	0.00054	0.00025	0.00015	0.00014
2016	312	356	0.00000	0.10869	0.09243	0.35992	0.22312	0.14834	0.04974	0.01161	0.00403	0.00129	0.00041	0.00030	0.00012
2017	308	351	0.00000	0.12569	0.15499	0.18274	0.29501	0.13695	0.07520	0.02031	0.00464	0.00299	0.00059	0.00050	0.00040

Table 2.9a—Trawl survey age compositions, expressed as within-year proportions, as used in Models 16.6i-k and M18.6-8. N1 is the input sample size used in Models 16.6i-k and N2 is the input sample size used in Models 18.6-8.

	Input N		Age												
Year	N1	N2	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	304	364	0.00000	0.08914	0.38230	0.17153	0.12383	0.11819	0.07989	0.02042	0.00696	0.00461	0.00134	0.00098	0.00081
1995	290	347	0.00001	0.05519	0.26324	0.41973	0.09973	0.07896	0.04928	0.01577	0.00866	0.00585	0.00153	0.00086	0.00119
1996	300	359	0.00001	0.05713	0.20734	0.20255	0.29296	0.13582	0.05791	0.02851	0.00989	0.00423	0.00175	0.00104	0.00087
1997	308	369	0.00000	0.25694	0.16895	0.18376	0.15721	0.11962	0.07672	0.02154	0.00986	0.00302	0.00125	0.00080	0.00035
1998	302	362	0.00000	0.07704	0.44071	0.20401	0.11228	0.05650	0.05983	0.02825	0.01581	0.00397	0.00077	0.00059	0.00021
1999	281	336	0.00000	0.07949	0.19948	0.30278	0.23192	0.08057	0.05813	0.02715	0.01197	0.00521	0.00126	0.00147	0.00057
2000	297	355	0.00002	0.23440	0.12706	0.14994	0.24187	0.14760	0.06186	0.01382	0.01357	0.00538	0.00282	0.00124	0.00043
2001	306	366	0.00001	0.28965	0.23541	0.19357	0.09079	0.08356	0.06842	0.02625	0.00766	0.00214	0.00147	0.00080	0.00028
2002	304	364	0.00006	0.08016	0.18790	0.31773	0.23340	0.07210	0.05899	0.03372	0.01015	0.00375	0.00105	0.00052	0.00046
2003	303	363	0.00001	0.17536	0.15619	0.25046	0.20932	0.11884	0.04110	0.03009	0.01355	0.00360	0.00050	0.00052	0.00046
2004	302	361	0.00002	0.14394	0.16563	0.27089	0.12813	0.12790	0.09080	0.03994	0.01888	0.00856	0.00216	0.00254	0.00063
2005	301	360	0.00000	0.18334	0.24441	0.20925	0.12112	0.06527	0.07946	0.05496	0.02381	0.01047	0.00363	0.00365	0.00064
2006	296	354	0.00000	0.32441	0.14277	0.16496	0.12141	0.09298	0.06340	0.04645	0.02848	0.00986	0.00301	0.00141	0.00085
2007	307	368	0.00000	0.70068	0.09548	0.06708	0.04134	0.04593	0.01758	0.01428	0.00838	0.00504	0.00174	0.00150	0.00097
2008	282	338	0.00014	0.21331	0.44525	0.14489	0.08267	0.04860	0.03300	0.01034	0.01024	0.00570	0.00272	0.00138	0.00175
2009	301	360	0.00068	0.45428	0.18941	0.23091	0.06415	0.02879	0.01466	0.00944	0.00393	0.00203	0.00083	0.00057	0.00033
2010	286	342	0.00000	0.04654	0.47937	0.17931	0.20324	0.06443	0.01459	0.00770	0.00254	0.00125	0.00037	0.00053	0.00013
2011	307	368	0.00003	0.29080	0.07295	0.38796	0.11104	0.09553	0.02786	0.00693	0.00332	0.00161	0.00096	0.00056	0.00044
2012	297	356	0.00005	0.36623	0.23417	0.05827	0.23714	0.06170	0.03065	0.00743	0.00205	0.00154	0.00047	0.00016	0.00016
2013	296	354	0.00000	0.10724	0.42698	0.17804	0.10837	0.11292	0.05041	0.01094	0.00359	0.00081	0.00019	0.00029	0.00022
2014	312	373	0.00005	0.27947	0.18759	0.23783	0.19702	0.04776	0.03582	0.01020	0.00225	0.00088	0.00071	0.00013	0.00028
2015	296	354	0.00000	0.06386	0.42549	0.20207	0.19335	0.08190	0.01861	0.01123	0.00240	0.00055	0.00025	0.00015	0.00015
2016	314	376	0.00000	0.11204	0.09417	0.36104	0.22136	0.14504	0.04878	0.01145	0.00403	0.00127	0.00042	0.00029	0.00012
2017	308	369	0.00000	0.13105	0.15981	0.18675	0.28780	0.13281	0.07296	0.01997	0.00456	0.00288	0.00051	0.00048	0.00040

Table 2.10—Total biomass estimates (t), with standard errors, as estimated by shelf bottom trawl surveys of the EBS "standard" and "expanded" areas, the NBS, and the combined EBS "expanded" area and the NBS; 1982-2018.

	EBS (standard)		EBS (expanded)		NBS		EBS(exp.) + NBS	
Year	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
1982	1,013,061	73,621						
1983	1,187,096	120,958						
1984	1,013,558	62,513						
1985	1,001,112	55,845						
1986	1,118,006	69,626						
1987	1,027,518	63,670	1,064,600	63,998			1,064,600	63,998
1988	960,962	76,961	976,152	77,490			976,152	77,490
1989	833,473	62,713	868,804	62,883			868,804	62,883
1990	691,256	51,455	728,996	52,790			728,996	52,790
1991	514,407	38,039	530,488	38,367			530,488	38,367
1992	529,049	44,616	538,862	44,674			538,862	44,674
1993	663,308	53,143	669,305	53,151			669,305	53,151
1994	1,360,790	247,737	1,377,095	247,764			1,377,095	247,764
1995	1,002,961	91,622	1,008,293	91,637			1,008,293	91,637
1996	889,366	87,521	909,133	87,574			909,133	87,574
1997	604,439	68,120	627,151	68,411			627,151	68,411
1998	534,150	42,937	550,504	43,013			550,504	43,013
1999	569,765	49,471	618,679	56,577			618,679	56,577
2000	531,171	43,160	537,563	43,172			537,563	43,172
2001	811,816	73,211	827,176	73,336			827,176	73,336
2002	584,565	63,820	597,943	63,845			597,943	63,845
2003	590,973	62,121	625,659	62,403			625,659	62,403
2004	562,309	33,739	578,064	33,833			578,064	33,833
2005	606,050	43,056	638,764	43,470			638,764	43,470
2006	517,698	28,341	544,035	28,965			544,035	28,965
2007	423,704	34,811	450,337	35,084			450,337	35,084
2008	403,125	26,822	427,503	27,847			427,503	27,847
2009	421,291	34,969	430,084	35,061			430,084	35,061
2010	860,210	102,307	870,639	102,350	26,140	6,516	896,778	102,557
2011	896,039	66,843	911,082	66,919			911,082	66,919
2012	890,665	100,473	896,401	100,487			896,401	100,487
2013	791,958	73,952	811,667	74,203			811,667	74,203
2014	1,079,712	153,299	1,095,270	153,347			1,095,270	153,347
2015	1,102,261	150,981	1,109,115	150,994			1,109,115	150,994
2016	944,621	76,948	986,013	77,381			986,013	77,381
2017	598,260	46,278	643,953	49,976	289,264	37,034	933,217	62,202
2018	482,354	29,290	506,943	29,419	564,684	127,264	1,071,627	130,620

Table 2.11—Mean condition factor (based on log weight-length residuals), with number of observations (N), standard deviation, and standard error, as estimated from EBS and NBS trawl survey data.

	EBS				NBS			
Year	Mean	N	St. dev.	St. err.	Mean	N	St. dev.	St. err.
1976	0.0544	608	0.1530	0.0062				
1984	-0.0371	33	0.0915	0.0159				
1993	0.0297	579	0.1140	0.0047				
1998	0.0454	365	0.0930	0.0049				
1999	-0.0356	842	0.1194	0.0041				
2000	0.0014	876	0.1175	0.0040				
2001	0.0077	944	0.1013	0.0033				
2002	0.0092	881	0.0957	0.0032				
2003	0.0487	1275	0.1034	0.0029				
2004	0.0300	1016	0.2790	0.0088				
2005	0.0136	1312	0.1120	0.0031				
2006	0.0001	1316	0.1226	0.0034				
2007	0.0056	1447	0.1083	0.0028				
2008	-0.0060	1229	0.1022	0.0029				
2009	-0.0209	1425	0.0994	0.0026				
2010	-0.0019	1474	0.1073	0.0028	0.0223	176	0.0991	0.0075
2011	0.0040	1265	0.1021	0.0029				
2012	-0.0294	1304	0.1057	0.0029				
2013	-0.0084	1423	0.0922	0.0024				
2014	-0.0070	1441	0.0961	0.0025				
2015	-0.0316	1825	0.0940	0.0022				
2016	0.0045	1630	0.0970	0.0024				
2017	-0.0164	1764	0.1137	0.0027	-0.0165	368	0.1165	0.0061
2018	0.0021	1675	0.0904	0.0022	0.0066	323	0.0942	0.0052

Table 2.12—Annual offsets to the base values of the α and β weight-at-length parameters.

Year:	1978	1979	1980	1981	1982	1983	1984	1985
α offset:	-2.35E-06	1.49E-06	-1.34E-07	8.25E-07	2.85E-06	4.61E-07	1.17E-05	-9.04E-07
β offset:	1.35E-01	-5.34E-02	2.07E-03	-3.80E-02	-9.09E-02	-9.15E-03	-2.83E-01	5.23E-02

Year:	1986	1987	1988	1989	1990	1991	1992	1993
α offset:	-2.14E-06	-8.91E-08	-2.07E-06	-1.15E-06	1.32E-06	1.80E-06	3.50E-07	2.79E-06
β offset:	1.25E-01	1.08E-02	1.28E-01	7.55E-02	-3.57E-02	-6.73E-02	-2.33E-02	-7.86E-02

Year:	1994	1995	1996	1997	1998	1999	2000	2001
α offset:	6.11E-07	-8.56E-07	7.75E-06	1.31E-06	1.73E-06	1.99E-06	2.24E-06	4.12E-06
β offset:	-2.31E-02	4.29E-02	-2.05E-01	-6.07E-02	-7.65E-02	-7.46E-02	-7.00E-02	-1.28E-01

Year:	2002	2003	2004	2005	2006	2007	2008	2009
α offset:	1.51E-06	-2.11E-07	2.19E-06	1.25E-07	1.07E-06	5.42E-07	1.24E-06	-5.94E-07
β offset:	-5.46E-02	9.74E-03	-7.81E-02	-1.25E-03	-3.93E-02	-1.59E-02	-4.68E-02	3.17E-02

Year:	2010	2011	2012	2013	2014	2015	2016	2017
α offset:	-1.96E-07	-3.33E-07	3.12E-06	-5.22E-07	-1.82E-06	-2.05E-06	-1.78E-06	-2.10E-06
β offset:	8.25E-03	1.01E-02	-1.15E-01	1.91E-02	8.60E-02	9.59E-02	8.35E-02	1.07E-01

Table 2.13—Objective function components and parameter counts.

Aggregated components

Component	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
Equil. catch	0.00	0.00	0.00	0.00	0.03	0.03	0.00	0.00
Survey indices	-20.66	-26.54	-70.09	-74.35	-9.27	-75.02	-76.21	-77.86
Sizecomps	1459.61	1427.42	1426.85	1550.13	1508.06	1543.16	1556.02	1542.63
Agecomps	267.75	271.94	270.10	276.85	99.12	98.83	282.14	102.70
Recruitment	1.27	-2.57	-2.52	-3.23	-3.50	-4.33	-3.09	-0.60
Initial recruitment	7.23	9.27	9.11	8.66	13.77	13.54	4.18	4.45
Priors					0.28	0.24		0.02
"Softbounds"	0.01	0.01	0.01	0.01	0.00	0.00	0.01	0.00
Parameter devs			-71.39	-60.89	-93.96	-149.95	-53.72	-138.81
Total	1715.20	1679.54	1562.07	1697.17	1514.53	1426.51	1709.32	1432.54

Survey index breakdown

Subcomponent	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
EBS(std) survey	-20.66				-9.27			
EBS(exp) survey				-70.05		-70.72	-71.88	-73.54
EBS(exp)+NBS		-26.54	-70.09					
NBS survey				-4.30		-4.30	-4.33	-4.32
Total	-20.66	-26.54	-70.09	-74.35	-9.27	-75.02	-76.21	-77.86

Sizecomp breakdown

Subcomponent	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
Fishery	386.12	382.83	382.06	380.28	447.25	446.10	385.44	443.22
EBS(std) survey	1073.49				1060.81			
EBS(exp) survey				1055.28		1068.85	1054.34	1070.03
EBS(exp)+NBS		1044.59	1044.79					
NBS survey				114.57		28.21	116.25	29.39
Total	1459.61	1427.42	1426.85	1550.13	1508.06	1543.16	1556.02	1542.63

Agecomp breakdown

Subcomponent	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
Fishery					41.33	41.86		45.09
EBS(std) survey	267.75				57.78			
EBS(exp) survey		271.94	270.10	276.85		56.97	282.14	57.61
Total	267.75	271.94	270.10	276.85	99.12	98.83	282.14	102.70

Parameter counts

Type	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
Parameter devs	61	61	98	107	145	191	107	191
Parms with priors					1	1		1
Unconstrained	18	18	18	21	16	19	19	17
Total	79	79	116	128	162	211	126	209

Table 2.14 (1 of 2)—Input and output effective sample sizes. See text for details.

		Model 16.6						Model 16.6i					
Type	Fleet	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2
Size	Fishery	42	300	1.0000	559	12599	23459	42	300	1.0000	583	12600	24502
Size	EBS(std) survey	37	300	1.0000	312	11098	11527	n/a	n/a	n/a	n/a	n/a	n/a
Size	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	EBS(exp)+NBS	n/a	n/a	n/a	n/a	n/a	n/a	37	300	1.0000	321	11101	11886
Age	Fishery	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	EBS(std) survey	24	300	1.0000	62	7203	1495	n/a	n/a	n/a	n/a	n/a	n/a
Age	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	24	300	1.0000	61	7200	1456
				SEave	RMSE					SEave	RMSE		
Index	EBS(std) survey	37	353	0.1065	0.1917	13061	4028	n/a	n/a	n/a	n/a	n/a	n/a
Index	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	EBS(exp)+NBS	n/a	n/a	n/a	n/a	n/a	n/a	37	378	0.1056	0.1819	13986	4717
					Sum:	43961	40509				Sum:	44887	42561

		Model 16.6j						Model 16.6k					
Type	Fleet	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2
Size	Fishery	42	300	1.0000	581	12600	24404	42	300	1.0000	582	12600	24427
Size	EBS(std) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	37	300	1.0000	317	11101	11724
Size	NBS survey	n/a	n/a	n/a	n/a	n/a	n/a	3	300	1.0000	82	900	246
Size	EBS(exp)+NBS	37	300	1.0000	321	11101	11869	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fishery	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	EBS(std) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	EBS(exp) survey	24	300	1.0000	61	7200	1468	24	300	1.0000	60	7200	1429
				SEave	RMSE					SEave	RMSE		
Index	EBS(std) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	37	371	0.1054	0.1053	13727	13734
Index	NBS survey	n/a	n/a	n/a	n/a	n/a	n/a	3	89	0.1623	0.1624	267	267
Index	EBS(exp)+NBS	37	378	0.1056	0.1056	13986	13989	n/a	n/a	n/a	n/a	n/a	n/a
					Sum:	44887	51730				Sum:	45795	51828

Table 2.14 (2 of 2)—Input and output effective sample sizes. See text for details.

		Model 17.2						Model 18.6					
Type	Fleet	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2
Size	Fishery	34	5225	0.2517	1315	44713	44724	34	5225	0.2549	1332	45283	45278
Size	EBS(std) survey	37	332	0.8871	295	10904	10904	n/a	n/a	n/a	n/a	n/a	n/a
Size	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	37	346	0.8701	301	11139	11144
Size	NBS survey	n/a	n/a	n/a	n/a	n/a	n/a	3	68	1.3015	89	266	266
Size	EBS(exp)+NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fishery	8	9516	0.0273	260	2078	2082	8	9516	0.0292	279	2223	2230
Age	EBS(std) survey	24	342	0.1402	48	1151	1151	n/a	n/a	n/a	n/a	n/a	n/a
Age	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	24	359	0.1281	46	1104	1104
				SEave	RMSE					SEave	RMSE		
Index	EBS(std) survey	37	353	0.1065	0.2065	13061	3474	n/a	n/a	n/a	n/a	n/a	n/a
Index	EBS(exp) survey	n/a	n/a	n/a	n/a	n/a	n/a	37	371	0.1054	0.1054	13727	13719
Index	NBS survey	n/a	n/a	n/a	n/a	n/a	n/a	3	89	0.1623	0.1624	267	267
Index	EBS(exp)+NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					Sum:	71907	62336				Sum:	74008	74007

		Model 18.7						Model 18.8					
Type	Fleet	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2	Years	N	Mult.	Harm.	ΣNeff1	ΣNeff2
Size	Fishery	42	300	1.0000	569	12600	23917	34	5225	0.2398	1253	42600	42605
Size	EBS(std) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	EBS(exp) survey	37	300	1.0000	317	11100	11728	37	346	0.8841	306	11318	11324
Size	NBS survey	3	300	1.0000	81	900	244	3	68	1.2940	88	264	264
Size	EBS(exp)+NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fishery	n/a	n/a	n/a	n/a	n/a	n/a	8	9516	0.0324	309	2467	2470
Age	EBS(std) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	EBS(exp) survey	24	300	1.0000	59	7200	1416	24	359	0.1239	45	1068	1068
				SEave	RMSE					SEave	RMSE		
Index	EBS(std) survey	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	EBS(exp) survey	37	371	0.1054	0.1054	13727	13720	37	371	0.1054	0.1053	13727	13729
Index	NBS survey	3	89	0.1623	0.1623	267	267	3	89	0.1623	0.1624	267	267
Index	EBS(exp)+NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					Sum:	45794	51292				Sum:	71711	71727

Table 2.15a—Input N and output effective N for each fishery sizecomp. "Mean" refers to arithmetic mean and harmonic mean for input N and output effective N, respectively.

	Effective sample size (Neff)						Model 17.2		Model 18.6		Model 18.8	
Year	Ninp	16.6	16.6i	16.6j	16.6k	18.7	Ninp	Neff	Ninp	Neff	Ninp	Neff
1977	2	127	154	153	152	162	8	254	8	270	7	230
1978	11	91	104	103	103	98	40	273	41	269	38	229
1979	17	191	211	210	208	190	59	891	60	904	56	832
1980	15	293	299	295	291	257	52	471	53	474	50	536
1981	11	90	89	88	87	86	37	280	38	279	35	288
1982	13	268	262	261	272	269	47	720	48	727	45	698
1983	56	1115	1093	1092	1097	1104	197	3009	199	2999	188	2924
1984	137	981	969	964	1003	955	482	7209	488	7636	459	7183
1985	203	753	757	751	774	749	711	1111	720	1121	677	1069
1986	177	1024	1043	1033	1008	1020	628	1207	636	1226	599	1118
1987	337	1245	1210	1207	1196	1292	1190	1387	1205	1374	1133	1383
1988	105	413	411	410	409	401	367	813	372	809	350	807
1989	69	256	251	253	254	253	243	704	246	686	232	657
1990	258	1039	1034	1014	1089	921	906	18462	918	17798	864	16831
1991	355	3162	3175	3218	3396	2931	1306	6371	1322	6253	1244	5768
1992	368	1600	1556	1737	1700	1727	1340	2485	1357	2601	1276	2521
1993	231	1310	1285	1198	1164	1229	753	3072	763	3295	718	3272
1994	370	2616	2603	2926	2952	2821	1180	5362	1195	5565	1124	5271
1995	367	1798	1796	1753	1820	1797	1313	3204	1329	3351	1251	3263
1996	461	2225	2156	2461	2330	2604	1666	10987	1687	11566	1587	12511
1997	500	1907	1842	1888	2061	1904	1832	8078	1855	8114	1745	8004
1998	444	4017	3886	3900	4344	3994	1721	9195	1743	9481	1640	10361
1999	402	1125	1159	1182	1215	1115	2323	2520	2353	2523	2214	2620
2000	423	1891	1890	1853	1775	1772	2449	6897	2480	6800	2333	5990
2001	446	6015	5988	5871	5589	4979	2609	15542	2642	14117	2485	12358
2002	488	883	909	909	875	889	2888	9078	2924	9356	2751	8726
2003	609	3603	3781	3683	3689	3257	3610	7683	3656	7712	3439	6989
2004	495	11992	12646	12444	13711	9913	3081	7968	3120	7862	2936	7256
2005	484	3207	3126	3119	3110	2921	2912	8347	2949	8397	2774	7658
2006	382	2508	2504	2484	2535	2338	2227	7754	2256	7694	2122	6668
2007	298	3730	3664	3666	3746	3464	1737	5460	1759	5451	1655	4766
2008	353	3922	4033	4005	3745	3511	2094	9064	2121	9262	1995	8607
2009	313	745	751	736	729	715	1883	1168	1907	1173	1794	1158
2010	276	306	309	296	314	308	1640	236	1660	235	1562	268
2011	361	1744	1735	1662	1780	1585	2216	620	2244	662	2111	695
2012	398	779	788	799	821	855	2338	917	2367	968	2227	1087
2013	500	2495	2450	2420	2202	2350	2800	1765	2836	1881	2668	1864
2014	494	1061	1043	1058	994	1160	3062	370	3101	385	2917	422
2015	454	818	832	824	818	820	2846	527	2883	561	2712	604
2016	395	1600	1680	1627	1616	1452	2460	1503	2491	1665	2344	1702
2017	338	674	732	732	660	725	1801	410	1824	459	1716	454
2018	184	866	931	920	1124	963	822	2929	833	3513	783	2403
Mean	300	559	583	581	582	569	1315	1315	1332	1332	1253	1253

Table 2.15b—Input N and output effective N for each survey sizecomp. "Mean" refers to arithmetic mean and harmonic mean for input N and output effective N, respectively. Last 4 rows are NBS.

	M16.6		M16.6i		M16.6j		M16.6k		M17.2		M18.6		M18.7		M18.8	
Year	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff
1982	258	648	249	661	249	659	258	645	273	427	268	429	258	690	272	475
1983	322	454	311	464	311	463	321	447	226	429	222	428	321	457	225	456
1984	297	390	287	387	287	389	297	383	234	316	230	311	297	364	233	313
1985	413	255	399	260	399	261	413	264	303	287	298	291	413	270	302	292
1986	376	1096	363	1093	363	1087	376	1053	310	646	304	634	376	1069	309	669
1987	226	1090	224	1174	224	1167	232	1235	290	1558	295	1648	232	1235	300	1706
1988	163	1007	160	1015	160	983	165	959	291	1111	295	1142	165	1010	300	1336
1989	101	389	100	401	100	355	104	354	248	401	255	384	104	327	259	402
1990	126	930	128	992	128	1033	133	984	282	1006	286	1070	133	924	291	1080
1991	166	861	165	911	165	896	171	850	263	789	272	751	171	984	277	786
1992	243	600	239	591	239	581	248	610	283	519	289	507	248	590	294	468
1993	254	635	248	621	248	610	257	622	309	543	316	527	257	659	321	552
1994	302	587	306	647	306	642	316	648	306	710	317	752	316	675	322	773
1995	238	431	232	436	232	431	240	425	296	482	302	489	240	425	307	526
1996	223	478	221	501	221	491	228	480	302	466	312	487	228	483	317	504
1997	231	398	227	430	227	418	234	408	310	539	321	550	234	380	326	468
1998	227	310	226	318	226	320	234	321	304	209	315	215	234	342	320	228
1999	256	347	264	299	264	300	273	296	280	259	292	228	273	304	297	253
2000	294	357	288	361	288	363	297	350	303	403	309	411	297	354	314	436
2001	456	392	451	402	451	400	466	415	308	331	318	338	466	424	324	329
2002	284	704	281	722	281	713	291	728	305	640	317	649	291	773	322	638
2003	274	377	280	401	280	399	289	400	304	328	316	357	289	410	321	381
2004	250	734	247	760	247	763	255	763	304	636	314	665	255	858	319	727
2005	276	199	278	211	278	211	287	212	303	190	313	202	287	212	318	200
2006	297	375	296	400	296	401	306	395	305	273	308	288	306	414	313	298
2007	314	53	318	56	318	57	329	55	309	47	320	50	329	57	325	52
2008	334	211	334	218	334	218	328	217	290	211	294	221	328	203	299	217
2009	438	127	428	129	428	128	412	126	306	120	313	120	412	127	318	120
2010	359	378	356	391	356	395	342	397	290	410	298	433	342	354	302	421
2011	480	265	469	272	469	272	471	277	310	275	320	280	471	278	325	282
2012	381	158	371	158	371	158	323	157	303	157	310	158	323	155	315	157
2013	450	146	441	145	441	146	443	146	303	143	308	144	443	140	313	140
2014	433	451	424	452	424	452	387	470	314	491	325	497	387	461	330	486
2015	473	209	459	210	459	210	468	214	303	217	308	221	468	220	313	222
2016	412	323	414	321	414	319	420	343	316	414	327	418	420	333	332	417
2017	260	739	350	1094	350	1108	269	659	311	701	321	664	269	613	326	670
2018	210	526	267	737	267	759	215	579	305	594	317	718	215	564	322	727
Mean	300	312	300	321	300	321	300	317	295	295	301	301	300	317	306	306
2010							27	30			8	32	27	30	8	32
2017							525	657			155	784	525	629	154	813
2018							348	529			103	912	348	521	102	797
Mean							300	82			89	89	300	81	88	88

Table 2.15c--Input N and output effective N for each agecomp. "Mean" refers to arithmetic mean and harmonic mean for input N and output effective N, respectively.

	EBS survey (standard)				EBS survey (expanded)												Fishery					
	Model 16.6		Model 17.2		Model 16.6k		Model 18.6		Model 18.7		Model 18.8		Model 16.6i		Model 16.6j		Model 17.2		Model 18.6		Model 18.8	
Year	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff	Ninp	Neff
1994	302	209	48	179	304	208	47	170	304	196	45	136	304	214	304	226						
1995	293	34	47	53	290	34	44	55	290	35	43	62	290	35	290	35						
1996	298	97	48	122	300	96	46	121	300	88	44	103	300	103	300	98						
1997	307	61	49	104	308	65	47	111	308	58	46	82	308	72	308	69						
1998	301	104	48	39	302	99	46	39	302	112	45	41	302	107	302	107						
1999	277	55	44	23	281	56	43	25	281	57	42	24	281	58	281	57						
2000	300	53	48	27	297	56	45	28	297	55	44	27	297	59	297	59						
2001	304	39	49	24	306	39	47	24	306	36	45	23	306	37	306	37						
2002	302	40	48	53	304	40	47	55	304	37	45	52	304	42	304	42						
2003	301	1045	48	337	303	854	47	281	303	1021	45	264	303	683	303	704						
2004	301	36	48	27	302	35	46	27	302	35	45	27	302	35	302	35						
2005	300	186	48	145	301	162	46	131	301	194	45	109	301	155	301	152						
2006	302	52	48	27	296	44	45	23	296	44	44	23	296	43	296	44						
2007	305	10	49	8	307	9	47	7	307	9	46	8	307	9	307	9						
2008	287	138	46	180	282	127	43	163	282	102	42	137	282	127	282	125						
2009	302	97	48	61	301	86	46	53	301	93	45	46	301	92	301	91						
2010	287	381	46	740	286	451	44	981	286	295	42	535	286	407	286	441	178	64	190	68	211	86
2011	306	106	49	135	307	108	47	129	307	107	46	135	307	115	307	115	240	283	257	284	285	281
2012	300	73	48	78	297	72	46	77	297	65	44	80	297	77	297	78	254	1697	271	1536	301	1185
2013	299	110	48	91	296	101	45	85	296	104	44	70	296	109	296	109	304	424	325	466	360	461
2014	310	371	50	163	312	428	48	153	312	411	46	116	312	391	312	387	332	450	355	513	394	661
2015	299	215	48	1646	296	269	45	1523	296	346	44	2318	296	309	296	302	309	723	330	740	366	841
2016	312	412	50	205	314	528	48	197	314	437	47	112	314	408	314	410	267	1016	285	948	317	1298
2017	308	86	49	72	308	59	47	53	308	60	46	59	308	72	308	72	195	246	209	296	232	235
Mean	300	62	48	48	300	60	46	46	300	59	44	45	300	61	300	61	260	260	278	279	308	309

Table 2.16a—Scalar parameters estimated by the models (a blank under "StD." means that the parameter was not estimated internally in the respective model). Color scale extends from red=low to green=high for each row.

	Model 16.6		Model 16.6i		Model 16.6j		Model 16.6k		Model 17.2		Model 18.6		Model 18.7		Model 18.8	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Natural mortality (M)	0.354	0.012	0.340	0.012	0.340	0.013	0.345	0.013	0.356	0.020	0.364	0.023	0.398	0.007	0.471	0.011
Length at age 1.5 (cm)	16.358	0.087	16.377	0.088	16.378	0.089	16.423	0.088	16.458	0.091	16.479	0.091	16.418	0.088	16.468	0.090
Asymptotic length (cm)	100.60	1.952	100.62	1.955	100.71	1.986	100.09	1.850	109.05	1.923	108.79	1.915	98.444	1.666	106.34	1.629
Brody growth coefficient (K)	0.196	0.012	0.195	0.012	0.194	0.012	0.202	0.012	0.175	0.009	0.176	0.009	0.201	0.011	0.182	0.009
Richards growth coefficient	1.036	0.047	1.039	0.047	1.043	0.047	1.008	0.045	1.041	0.038	1.036	0.038	1.046	0.044	1.032	0.037
SD of length at age 1 (cm)	3.447	0.057	3.456	0.058	3.457	0.058	3.468	0.058	3.488	0.058	3.495	0.058	3.474	0.058	3.496	0.057
SD of length at age 20 (cm)	9.622	0.272	9.532	0.272	9.509	0.274	9.250	0.259	9.037	0.234	8.907	0.230	9.169	0.252	8.773	0.220
Ageing bias at age 1	0.337	0.012	0.335	0.012	0.335	0.013	0.335	0.013	0.340	0.029	0.334	0.031	0.347	0.011	0.347	0.028
Ageing bias at age 20	0.198	0.143	0.157	0.145	0.133	0.146	0.166	0.145	-0.491	0.191	-0.547	0.197	0.126	0.140	-0.793	0.200
ln(mean post-1976 recruits)	13.047	0.099	12.984	0.097	12.986	0.106	12.972	0.104	12.948	0.136	13.006	0.160	13.413	0.056	13.848	0.070
SD of ln(recruitment) devs	0.684	0.072	0.656	0.067	0.655	0.067	0.637	0.063	0.645	_	0.634	_	0.604	0.059	0.661	_
ln(pre-1977 recruits offset)	-1.120	0.216	-1.158	0.201	-1.147	0.203	-1.106	0.200	-1.465	0.053	-1.467	0.068	-0.867	0.214	-1.215	0.232
Initial fishing mortality rate	0.107	0.033	0.190	0.075	0.186	0.073	0.186	0.071	0.866	0.706	0.738	0.582	0.120	0.037	0.212	0.097

Table 2.16b—Catchability and selectivity parameters etimated by the models (a blank under "Est." means that the parameter was not used in the respective model, and a blank under "St.D." means that the parameter was not estimated internally in the respective model).

	Model 16.6		Model 16.6i		Model 16.6j		Model 16.6k		Model 17.2		Model 18.6		Model 18.7		Model 18.8	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
EBS(std) survey lnQ	-0.032	0.059							0.133	0.063						
EBS(exp) survey lnQ							0.029	0.066			0.173	0.076	-0.301	_	-0.301	_
NBS survey lnQ							-1.807	0.362			-1.256	0.427	-1.347	_	-1.347	_
EBS(exp)+NBS survey lnQ			0.030	0.059	0.036	0.067										
Inflection (fishery)	4.355	0.044	4.346	0.044	4.352	0.044	4.322	0.042					4.334	0.043		
95% width (fishery)	1.178	0.031	1.180	0.031	1.184	0.031	1.183	0.030					1.179	0.031		
Inflection (EBS(std) survey)	1.006	0.006														
95% width (EBS(std) survey)	0.284	0.055														
Inflection (EBS(exp) survey)							1.004	0.006					1.018	0.006		
95% width (EBS(exp) survey)							0.284	0.055					0.285	0.055		
Inflection (NBS survey)							1.860	0.125					1.923	0.118		
95% width (NBS survey)							1.136	0.140					1.151	0.134		
Inflection (EBS(exp)+NBS)			1.006	0.006	1.005	0.006										
95% width (EBS(exp)+NBS)			0.285	0.055	0.285	0.055										
Peak age (fishery)									5.755	0.124	5.756	0.123			5.716	0.124
Asc. width (fishery)									0.931	0.076	0.930	0.076			0.880	0.077
Peak age (EBS(std) survey)									2.548	0.163						
Asc. width (EBS(std) survey)									1.319	0.236						
Peak age (EBS(exp) survey)											2.662	0.165			3.014	0.126
Asc. width (EBS(exp) survey)											1.442	0.220			1.558	0.150
Peak age (NBS survey)											6.776	1.910			6.473	1.317
Asc. width (NBS survey)											3.360	0.933			2.968	0.666

Table 2.16c—Initial age composition deviations estimated by the models.

	Model 16.6		Model 16.6i		Model 16.6j		Model 16.6k		Model 17.2		Model 18.6		Model 18.7		Model 18.8	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Initial age 20 ln(recruits) dev	-0.015	0.679	-0.005	0.655	-0.005	0.654	-0.004	0.636	0.000	0.645	0.000	0.634	-0.004	0.603	0.000	0.661
Initial age 19 ln(recruits) dev	-0.009	0.682	-0.003	0.655	-0.003	0.654	-0.003	0.636	0.000	0.645	0.000	0.634	-0.002	0.603	0.000	0.661
Initial age 18 ln(recruits) dev	-0.014	0.680	-0.005	0.654	-0.006	0.654	-0.005	0.636	0.000	0.645	0.000	0.633	-0.004	0.603	-0.001	0.660
Initial age 17 ln(recruits) dev	-0.022	0.677	-0.009	0.653	-0.009	0.652	-0.008	0.635	0.000	0.645	0.000	0.633	-0.007	0.602	-0.002	0.660
Initial age 16 ln(recruits) dev	-0.033	0.674	-0.015	0.651	-0.016	0.650	-0.014	0.633	0.000	0.645	0.000	0.633	-0.011	0.601	-0.004	0.660
Initial age 15 ln(recruits) dev	-0.051	0.668	-0.025	0.649	-0.026	0.647	-0.023	0.631	0.000	0.645	0.000	0.633	-0.019	0.599	-0.007	0.659
Initial age 14 ln(recruits) dev	-0.078	0.660	-0.041	0.644	-0.042	0.643	-0.037	0.626	0.000	0.645	0.000	0.633	-0.031	0.595	-0.013	0.657
Initial age 13 ln(recruits) dev	-0.116	0.650	-0.066	0.638	-0.068	0.636	-0.061	0.620	0.000	0.645	0.000	0.633	-0.049	0.590	-0.025	0.653
Initial age 12 ln(recruits) dev	-0.169	0.637	-0.105	0.628	-0.107	0.627	-0.096	0.612	0.000	0.645	-0.001	0.633	-0.078	0.583	-0.048	0.647
Initial age 11 ln(recruits) dev	-0.240	0.620	-0.161	0.616	-0.163	0.615	-0.149	0.600	-0.001	0.644	-0.004	0.633	-0.121	0.572	-0.086	0.637
Initial age 10 ln(recruits) dev	-0.330	0.602	-0.238	0.601	-0.241	0.599	-0.222	0.586	-0.003	0.644	-0.010	0.632	-0.183	0.559	-0.150	0.622
Initial age 9 ln(recruits) dev	-0.437	0.582	-0.338	0.583	-0.341	0.581	-0.318	0.568	-0.009	0.644	-0.025	0.633	-0.264	0.543	-0.245	0.603
Initial age 8 ln(recruits) dev	-0.555	0.561	-0.457	0.562	-0.459	0.560	-0.433	0.548	-0.025	0.651	-0.059	0.647	-0.363	0.525	-0.368	0.581
Initial age 7 ln(recruits) dev	-0.668	0.542	-0.580	0.540	-0.581	0.538	-0.555	0.527	-0.056	0.687	-0.121	0.688	-0.468	0.506	-0.499	0.556
Initial age 6 ln(recruits) dev	-0.742	0.526	-0.674	0.519	-0.675	0.518	-0.650	0.506	-0.105	0.764	-0.203	0.729	-0.550	0.491	-0.584	0.531
Initial age 5 ln(recruits) dev	-0.689	0.520	-0.656	0.505	-0.654	0.504	-0.639	0.493	-0.165	0.719	-0.260	0.651	-0.527	0.483	-0.524	0.506
Initial age 4 ln(recruits) dev	-0.257	0.502	-0.273	0.486	-0.266	0.485	-0.276	0.477	0.192	0.440	0.155	0.427	-0.174	0.469	0.094	0.430
Initial age 3 ln(recruits) dev	-0.061	0.484	-0.083	0.467	-0.083	0.467	-0.062	0.452	0.667	0.248	0.670	0.254	-0.040	0.457	0.698	0.329
Initial age 2 ln(recruits) dev	-0.156	0.547	-0.170	0.522	-0.168	0.523	-0.175	0.508	-0.466	0.443	-0.449	0.439	-0.102	0.506	-0.415	0.484
Initial age 1 ln(recruits) dev	0.833	0.510	0.803	0.494	0.816	0.493	0.795	0.477	1.256	0.219	1.276	0.223	0.840	0.493	1.375	0.319

Table 2.16d—Annual log-scale recruitment deviations estimated by the stock assessment models. Color scale extends from red=low to green=high for each column.

	Model 16.6		Model 16.6i		Model 16.6j		Model 16.6k		Model 17.2		Model 18.6		Model 18.7		Model 18.8	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	0.943	0.211	0.855	0.209	0.863	0.212	0.866	0.208	0.459	0.154	0.466	0.158	1.116	0.215	0.812	0.165
1978	0.551	0.238	0.456	0.238	0.462	0.239	0.511	0.226	0.527	0.137	0.533	0.142	0.658	0.250	0.871	0.142
1979	0.556	0.137	0.467	0.138	0.472	0.140	0.515	0.134	0.511	0.103	0.511	0.108	0.641	0.140	0.742	0.111
1980	-0.205	0.134	-0.273	0.134	-0.265	0.136	-0.219	0.131	-0.259	0.124	-0.257	0.127	-0.139	0.135	-0.040	0.126
1981	-0.808	0.140	-0.860	0.141	-0.855	0.142	-0.822	0.138	-0.343	0.104	-0.319	0.105	-0.744	0.138	-0.189	0.108
1982	0.857	0.050	0.788	0.051	0.792	0.053	0.817	0.052	0.771	0.053	0.771	0.057	0.886	0.053	0.924	0.056
1983	-0.496	0.124	-0.554	0.125	-0.551	0.126	-0.507	0.121	-0.317	0.106	-0.293	0.106	-0.470	0.122	-0.205	0.109
1984	0.851	0.050	0.797	0.051	0.796	0.052	0.820	0.051	0.729	0.049	0.738	0.051	0.842	0.053	0.832	0.052
1985	-0.147	0.095	-0.202	0.095	-0.199	0.097	-0.151	0.094	0.136	0.065	0.153	0.067	-0.162	0.096	0.192	0.070
1986	-0.557	0.117	-0.614	0.118	-0.594	0.119	-0.550	0.116	-0.337	0.078	-0.310	0.078	-0.579	0.118	-0.311	0.081
1987	-1.165	0.185	-1.193	0.181	-1.117	0.179	-1.081	0.173	-0.879	0.102	-0.828	0.100	-1.121	0.177	-0.890	0.107
1988	-0.278	0.101	-0.331	0.100	-0.259	0.101	-0.250	0.099	-0.260	0.067	-0.237	0.067	-0.248	0.100	-0.277	0.071
1989	0.605	0.058	0.549	0.058	0.545	0.059	0.560	0.058	0.528	0.044	0.507	0.045	0.553	0.060	0.457	0.048
1990	0.446	0.062	0.388	0.062	0.382	0.063	0.414	0.061	0.424	0.046	0.404	0.047	0.381	0.063	0.320	0.049
1991	-0.002	0.076	-0.055	0.076	-0.065	0.077	-0.038	0.075	-0.083	0.062	-0.104	0.062	-0.071	0.077	-0.180	0.064
1992	0.840	0.038	0.785	0.038	0.777	0.039	0.802	0.038	0.780	0.033	0.760	0.035	0.774	0.040	0.694	0.037
1993	-0.045	0.059	-0.099	0.059	-0.107	0.060	-0.073	0.059	-0.156	0.059	-0.172	0.060	-0.108	0.060	-0.260	0.062
1994	-0.249	0.063	-0.298	0.062	-0.296	0.063	-0.269	0.062	-0.348	0.054	-0.359	0.054	-0.293	0.064	-0.425	0.057
1995	-0.337	0.071	-0.379	0.070	-0.372	0.070	-0.355	0.069	-0.407	0.056	-0.412	0.056	-0.381	0.072	-0.462	0.061
1996	0.682	0.038	0.626	0.038	0.635	0.039	0.657	0.038	0.518	0.035	0.516	0.036	0.654	0.040	0.511	0.041
1997	-0.115	0.061	-0.159	0.061	-0.155	0.062	-0.120	0.060	0.148	0.045	0.147	0.045	-0.148	0.062	0.105	0.050
1998	-0.136	0.064	-0.180	0.064	-0.175	0.065	-0.154	0.063	0.067	0.048	0.062	0.048	-0.205	0.065	-0.001	0.052
1999	0.588	0.040	0.537	0.040	0.535	0.041	0.558	0.040	0.636	0.034	0.624	0.035	0.513	0.041	0.557	0.038
2000	0.314	0.044	0.265	0.044	0.260	0.045	0.297	0.044	0.249	0.044	0.236	0.045	0.244	0.044	0.143	0.047
2001	-0.491	0.068	-0.530	0.067	-0.525	0.068	-0.496	0.067	-0.646	0.067	-0.651	0.067	-0.569	0.068	-0.764	0.070
2002	-0.198	0.053	-0.238	0.053	-0.238	0.054	-0.204	0.053	-0.113	0.047	-0.115	0.048	-0.259	0.054	-0.201	0.052
2003	-0.370	0.057	-0.402	0.057	-0.406	0.058	-0.376	0.057	-0.226	0.051	-0.229	0.053	-0.440	0.057	-0.337	0.055
2004	-0.539	0.062	-0.564	0.062	-0.577	0.063	-0.546	0.062	-0.531	0.062	-0.541	0.064	-0.608	0.063	-0.662	0.066
2005	-0.254	0.056	-0.282	0.055	-0.288	0.057	-0.273	0.056	-0.357	0.065	-0.380	0.067	-0.323	0.057	-0.467	0.069
2006	0.868	0.034	0.842	0.034	0.852	0.034	0.848	0.034	0.771	0.041	0.760	0.042	0.825	0.036	0.680	0.044
2007	0.040	0.056	0.018	0.056	0.026	0.056	0.008	0.056	0.037	0.066	0.022	0.066	-0.022	0.058	-0.053	0.066
2008	1.157	0.031	1.150	0.031	1.149	0.031	1.123	0.031	1.081	0.038	1.055	0.040	1.102	0.032	0.967	0.040
2009	-0.902	0.112	-0.877	0.111	-0.888	0.112	-0.880	0.110	-0.930	0.128	-0.949	0.126	-0.941	0.112	-1.060	0.126
2010	0.605	0.042	0.648	0.043	0.642	0.044	0.592	0.042	0.538	0.050	0.519	0.050	0.576	0.045	0.463	0.053
2011	0.964	0.038	1.042	0.039	1.033	0.042	0.950	0.039	0.889	0.043	0.866	0.044	0.956	0.043	0.836	0.051
2012	0.105	0.062	0.234	0.063	0.224	0.066	0.152	0.063	0.173	0.070	0.182	0.070	0.146	0.067	0.190	0.076
2013	0.850	0.044	1.029	0.045	1.013	0.053	0.885	0.050	0.870	0.048	0.865	0.056	0.900	0.055	0.897	0.065
2014	-0.888	0.094	-0.695	0.094	-0.711	0.099	-0.991	0.097	-0.891	0.119	-0.944	0.123	-1.002	0.101	-0.922	0.129
2015	-0.640	0.083	-0.362	0.079	-0.380	0.089	-0.484	0.083	-0.620	0.092	-0.517	0.096	-0.470	0.086	-0.481	0.102
2016	-1.041	0.114	-0.803	0.113	-0.839	0.122	-1.145	0.120	-1.219	0.130	-1.283	0.140	-1.118	0.121	-1.241	0.145
2017	-1.958	0.290	-1.528	0.269	-1.595	0.273	-1.391	0.211	-1.923	0.244	-1.798	0.226	-1.347	0.210	-1.765	0.230

Table 2.16e—Catchability devs (~N(0,1)) as estimated by those models that allow time-varying catchability.

	EBS(exp) survey								NBS survey								EBS+NBS	
	Model 16.6k		Model 18.6		Model 18.7		Model 18.8		Model 16.6k		Model 18.6		Model 18.7		Model 18.8		Model 16.6j	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1982	-0.349	0.638	-0.325	0.648	-0.957	0.588	-1.616	0.548									-0.300	0.647
1983	0.424	0.752	0.394	0.733	0.146	0.708	-0.346	0.649									0.453	0.761
1984	-0.475	0.639	-0.554	0.615	-0.780	0.592	-1.199	0.531									-0.453	0.648
1985	0.391	0.809	0.356	0.787	0.337	0.769	-0.029	0.710									0.404	0.816
1986	0.390	0.724	0.264	0.696	0.364	0.678	-0.046	0.612									0.410	0.733
1987	0.518	0.581	-0.187	0.554	0.653	0.536	-0.394	0.477									0.558	0.591
1988	0.121	0.605	-0.723	0.571	0.427	0.556	-0.645	0.492									0.148	0.616
1989	-2.429	0.595	-3.098	0.554	-1.895	0.544	-2.476	0.474									-2.456	0.606
1990	-0.955	0.668	-1.160	0.632	-0.660	0.619	-0.683	0.542									-0.979	0.679
1991	-1.112	0.731	-1.132	0.699	-0.916	0.684	-0.696	0.610									-1.119	0.740
1992	-0.283	0.769	-0.311	0.739	-0.080	0.724	0.059	0.653									-0.284	0.777
1993	0.494	0.778	0.571	0.750	0.748	0.733	0.963	0.664									0.496	0.786
1994	2.139	0.777	2.319	0.750	2.404	0.733	2.746	0.664									2.130	0.786
1995	0.999	0.716	1.168	0.686	1.311	0.667	1.575	0.594									1.000	0.726
1996	0.546	0.823	0.737	0.799	0.794	0.784	1.140	0.721									0.534	0.831
1997	-0.455	0.823	-0.119	0.799	-0.311	0.784	0.141	0.723									-0.453	0.830
1998	-0.748	0.686	-0.421	0.654	-0.557	0.637	-0.098	0.567									-0.751	0.696
1999	-0.044	0.720	-0.291	0.688	0.208	0.671	-0.026	0.600									-0.048	0.729
2000	-1.147	0.685	-1.540	0.652	-0.770	0.633	-1.060	0.561									-1.153	0.695
2001	2.009	0.699	1.721	0.667	2.317	0.647	2.063	0.574									2.021	0.709
2002	-0.514	0.716	-0.668	0.685	-0.114	0.664	-0.152	0.592									-0.504	0.726
2003	-0.011	0.776	-0.118	0.748	0.381	0.727	0.371	0.660									-0.002	0.784
2004	-0.704	0.669	-0.925	0.639	-0.146	0.610	-0.136	0.539									-0.691	0.679
2005	0.576	0.811	0.388	0.787	0.945	0.768	0.904	0.705									0.582	0.819
2006	0.804	0.560	0.602	0.539	1.383	0.498	1.353	0.439									0.822	0.570
2007	0.467	0.931	0.571	0.920	0.615	0.912	0.870	0.878									0.444	0.935
2008	-1.229	0.723	-0.971	0.700	-0.978	0.674	-0.380	0.608									-1.339	0.732
2009	-0.673	0.673	-0.434	0.646	-0.357	0.621	0.129	0.554									-0.870	0.682
2010	0.350	0.797	0.528	0.774	0.536	0.755	0.982	0.692	-4.092	0.628	-4.037	0.631	-4.955	0.308	-4.414	0.442	0.221	0.803
2011	0.677	0.698	0.872	0.671	0.983	0.648	1.288	0.582	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.401	0.708
2012	0.694	0.692	1.141	0.665	0.886	0.646	1.511	0.579	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.286	0.703
2013	-0.387	0.855	-0.203	0.834	-0.334	0.822	-0.034	0.768	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	-0.633	0.862
2014	0.861	0.795	1.058	0.768	0.984	0.757	1.152	0.698	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.413	0.805
2015	0.901	0.773	1.082	0.746	0.979	0.735	1.114	0.679	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	0.264	0.785
2016	0.593	0.725	0.680	0.701	0.721	0.687	0.575	0.640	0.000	1.000	0.000	1.000	0.000	1.000	0.000	1.000	-0.335	0.739
2017	-1.021	0.734	-0.674	0.717	-0.888	0.695	-0.663	0.655	1.377	0.610	1.325	0.611	0.145	0.221	0.686	0.379	-0.461	0.712
2018	-1.416	0.747	-0.601	0.755	-1.289	0.700	-0.694	0.676	2.714	0.624	2.712	0.626	1.459	0.300	2.062	0.409	1.242	0.792

Table 2.16f—Fishery selectivity devs (~N(0,1)) as estimated by those Models 17.2, 18.6, and 18.8.

	Age of peak selectivity (multiplicative devs)						Selectivity ascending width (additive devs)					
	Model 17.2		Model 18.6		Model 18.8		Model 17.2		Model 18.6		Model 18.8	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	-0.205	0.790	-0.179	0.773	-0.102	0.740	0.034	0.891	-0.013	0.867	-0.087	0.827
1978	-0.119	0.700	-0.158	0.696	-0.466	0.639	-0.284	0.648	-0.301	0.648	-0.382	0.643
1979	-0.911	0.708	-0.933	0.703	-1.059	0.650	-0.523	0.705	-0.532	0.704	-0.557	0.677
1980	-0.072	0.703	-0.103	0.702	-0.313	0.695	0.119	0.638	0.119	0.640	0.057	0.649
1981	-1.189	0.805	-1.211	0.793	-1.184	0.789	0.790	0.756	0.790	0.753	0.817	0.745
1982	0.713	0.633	0.708	0.630	0.704	0.627	0.159	0.676	0.172	0.676	0.205	0.682
1983	1.252	0.559	1.242	0.556	1.154	0.558	0.965	0.556	0.976	0.554	0.977	0.558
1984	1.886	0.448	1.866	0.443	1.672	0.480	2.098	0.367	2.090	0.366	1.985	0.396
1985	-0.236	0.453	-0.228	0.448	-0.422	0.477	-0.261	0.549	-0.262	0.543	-0.467	0.594
1986	0.390	0.312	0.394	0.311	0.357	0.322	0.769	0.335	0.765	0.334	0.736	0.343
1987	0.444	0.326	0.469	0.326	0.453	0.324	0.536	0.337	0.552	0.336	0.520	0.336
1988	-0.090	0.508	-0.054	0.504	0.095	0.503	1.395	0.534	1.413	0.529	1.490	0.518
1989	1.494	0.516	1.494	0.514	1.577	0.523	2.039	0.500	2.045	0.498	2.083	0.496
1990	1.963	0.332	1.979	0.331	2.070	0.336	1.852	0.317	1.865	0.317	1.926	0.315
1991	0.038	0.326	0.074	0.323	0.013	0.333	0.222	0.338	0.265	0.336	0.201	0.343
1992	-0.806	0.277	-0.800	0.277	-0.802	0.276	-1.020	0.339	-0.971	0.339	-0.969	0.338
1993	-0.289	0.339	-0.410	0.339	-0.414	0.338	0.294	0.351	0.232	0.355	0.208	0.351
1994	-0.041	0.321	-0.149	0.316	-0.071	0.316	0.631	0.302	0.560	0.301	0.567	0.297
1995	-0.423	0.341	-0.469	0.337	-0.254	0.340	-0.015	0.379	-0.055	0.378	0.102	0.368
1996	1.012	0.294	0.967	0.289	1.115	0.295	1.108	0.305	1.083	0.303	1.168	0.301
1997	0.937	0.286	0.902	0.283	0.968	0.288	1.208	0.268	1.186	0.266	1.192	0.265
1998	0.218	0.263	0.204	0.261	0.214	0.264	0.274	0.272	0.256	0.270	0.236	0.270
1999	-0.346	0.265	-0.335	0.263	-0.333	0.268	-0.360	0.289	-0.357	0.287	-0.382	0.291
2000	-0.199	0.240	-0.182	0.239	-0.177	0.242	-1.075	0.309	-1.053	0.306	-1.021	0.310
2001	-0.299	0.274	-0.292	0.273	-0.390	0.274	-0.946	0.315	-0.928	0.314	-0.990	0.320
2002	-0.711	0.255	-0.723	0.253	-0.803	0.252	-0.882	0.299	-0.886	0.298	-0.961	0.299
2003	-0.672	0.231	-0.685	0.229	-0.711	0.230	-1.117	0.299	-1.115	0.296	-1.133	0.298
2004	-1.111	0.225	-1.128	0.224	-1.066	0.224	-1.542	0.318	-1.554	0.316	-1.476	0.311
2005	-1.224	0.281	-1.242	0.280	-1.141	0.290	-1.536	0.385	-1.568	0.385	-1.452	0.390
2006	-0.971	0.248	-0.963	0.247	-0.841	0.255	-1.897	0.377	-1.889	0.374	-1.723	0.381
2007	0.491	0.255	0.502	0.255	0.578	0.260	-0.178	0.308	-0.155	0.307	-0.072	0.307
2008	-0.049	0.257	-0.077	0.257	-0.103	0.257	-0.664	0.283	-0.677	0.283	-0.725	0.284
2009	-0.835	0.290	-0.904	0.288	-0.830	0.285	-2.118	0.384	-2.196	0.386	-2.099	0.378
2010	0.389	0.487	0.338	0.472	0.605	0.470	0.513	0.457	0.474	0.449	0.617	0.431
2011	-0.176	0.604	-0.134	0.595	0.111	0.584	0.307	0.600	0.337	0.589	0.510	0.547
2012	0.817	0.439	0.842	0.434	0.840	0.418	0.605	0.461	0.616	0.455	0.631	0.433
2013	-0.907	0.551	-0.869	0.551	-0.895	0.493	-0.337	0.595	-0.321	0.590	-0.406	0.531
2014	-0.168	0.366	-0.134	0.358	-0.116	0.343	-0.121	0.421	-0.115	0.411	-0.136	0.389
2015	0.220	0.408	0.279	0.397	0.233	0.380	0.075	0.426	0.081	0.416	0.026	0.396
2016	0.332	0.491	0.474	0.448	0.417	0.446	0.218	0.504	0.294	0.456	0.247	0.456
2017	0.017	0.447	0.120	0.444	-0.015	0.427	0.068	0.619	0.097	0.611	-0.002	0.598
2018	-0.564	0.367	-0.493	0.382	-0.667	0.341	-1.405	0.533	-1.320	0.530	-1.459	0.509

Table 2.16g—Iteratively tuned parameters. A blank indicates that the parameter was either not used or not tuned iteratively in the respective model.

Quantity	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
ln(recruitment) dev sigma					0.6447	0.6335		0.6608
EBS(std) survey lnQ dev sigma								
EBS(exp) survey lnQ dev sigma				0.1008		0.1101	0.1160	0.1406
NBS survey lnQ dev sigma				0.5882		0.5821	0.6200	0.5833
EBS(exp)+NBS survey lnQ dev sigma			0.0981					
Fishery sel. peak age dev sigma					0.1171	0.1168		0.1150
Fishery sel. ascend. width dev sigma					0.4114	0.4088		0.4103
Fishery sizecomp multiplier					0.2517	0.2549		0.2398
EBS(std) survey sizecomp multiplier					0.8871			
EBS(exp) survey sizecomp multiplier						0.8701		0.8841
NBS survey sizecomp multiplier						1.3015		1.2940
EBS(exp)+NBS sizecomp multiplier								
Fishery agecomp multiplier					0.0273	0.0292		0.0324
EBS(std) survey agecomp multiplier					0.1402			
EBS(exp) survey agecomp multiplier						0.1281		0.1239

Table 2.17—Annual fishing mortality rates as estimated by the models.

	Model 16.6		Model 16.6i		Model 16.6j		Model 16.6k		Model 17.2		Model 18.6		Model 18.7		Model 18.8	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	0.183	0.059	0.312	0.117	0.306	0.115	0.295	0.109	0.819	0.371	0.770	0.356	0.169	0.054	0.302	0.133
1978	0.335	0.113	0.411	0.162	0.402	0.159	0.385	0.149	0.909	0.416	0.830	0.391	0.208	0.066	0.279	0.112
1979	0.274	0.093	0.325	0.125	0.317	0.122	0.302	0.113	0.430	0.129	0.399	0.126	0.158	0.047	0.154	0.047
1980	0.317	0.093	0.359	0.114	0.350	0.113	0.334	0.104	0.496	0.176	0.454	0.165	0.177	0.044	0.170	0.055
1981	0.209	0.038	0.227	0.042	0.223	0.043	0.215	0.041	0.166	0.033	0.157	0.033	0.123	0.018	0.072	0.013
1982	0.111	0.013	0.119	0.014	0.118	0.015	0.116	0.015	0.236	0.065	0.223	0.063	0.071	0.006	0.104	0.026
1983	0.125	0.012	0.134	0.012	0.132	0.014	0.130	0.014	0.245	0.049	0.234	0.049	0.086	0.006	0.113	0.020
1984	0.168	0.013	0.179	0.014	0.177	0.016	0.175	0.016	0.300	0.044	0.288	0.047	0.119	0.007	0.147	0.018
1985	0.186	0.014	0.196	0.015	0.194	0.017	0.192	0.017	0.238	0.022	0.231	0.027	0.134	0.007	0.130	0.010
1986	0.188	0.013	0.197	0.014	0.195	0.016	0.192	0.016	0.232	0.020	0.225	0.025	0.138	0.007	0.132	0.009
1987	0.200	0.013	0.208	0.013	0.207	0.016	0.204	0.015	0.253	0.022	0.247	0.027	0.151	0.007	0.152	0.011
1988	0.266	0.016	0.276	0.017	0.274	0.019	0.270	0.019	0.266	0.020	0.259	0.024	0.204	0.009	0.170	0.011
1989	0.224	0.012	0.231	0.013	0.230	0.015	0.227	0.014	0.297	0.028	0.287	0.030	0.176	0.007	0.193	0.017
1990	0.251	0.013	0.257	0.013	0.256	0.015	0.253	0.015	0.356	0.029	0.344	0.032	0.201	0.008	0.239	0.018
1991	0.445	0.024	0.453	0.024	0.448	0.027	0.444	0.027	0.461	0.027	0.440	0.032	0.353	0.016	0.311	0.015
1992	0.535	0.035	0.543	0.036	0.526	0.038	0.521	0.037	0.498	0.031	0.465	0.035	0.403	0.022	0.331	0.018
1993	0.406	0.027	0.412	0.028	0.395	0.029	0.389	0.028	0.353	0.028	0.323	0.028	0.300	0.016	0.235	0.017
1994	0.437	0.025	0.446	0.026	0.434	0.027	0.429	0.027	0.422	0.031	0.396	0.030	0.337	0.015	0.303	0.020
1995	0.552	0.031	0.566	0.032	0.555	0.034	0.549	0.033	0.543	0.031	0.522	0.032	0.431	0.018	0.411	0.023
1996	0.514	0.031	0.530	0.031	0.524	0.033	0.515	0.032	0.707	0.049	0.678	0.049	0.401	0.018	0.525	0.035
1997	0.561	0.033	0.580	0.034	0.579	0.036	0.570	0.036	0.825	0.064	0.800	0.065	0.442	0.019	0.597	0.044
1998	0.447	0.028	0.464	0.029	0.464	0.031	0.458	0.031	0.608	0.036	0.595	0.039	0.348	0.016	0.430	0.022
1999	0.458	0.031	0.475	0.032	0.475	0.034	0.469	0.034	0.619	0.039	0.608	0.043	0.353	0.017	0.431	0.024
2000	0.443	0.030	0.458	0.031	0.457	0.033	0.449	0.032	0.755	0.059	0.737	0.064	0.340	0.017	0.496	0.033
2001	0.353	0.021	0.364	0.022	0.362	0.023	0.357	0.023	0.518	0.048	0.502	0.051	0.276	0.012	0.331	0.025
2002	0.424	0.025	0.435	0.025	0.432	0.027	0.428	0.026	0.479	0.032	0.463	0.035	0.334	0.014	0.323	0.016
2003	0.459	0.026	0.470	0.027	0.467	0.029	0.460	0.028	0.485	0.031	0.468	0.033	0.364	0.015	0.335	0.016
2004	0.434	0.022	0.444	0.023	0.443	0.024	0.436	0.024	0.410	0.020	0.399	0.022	0.351	0.013	0.300	0.010
2005	0.442	0.021	0.452	0.022	0.451	0.023	0.445	0.023	0.447	0.019	0.436	0.022	0.362	0.013	0.338	0.011
2006	0.509	0.026	0.517	0.027	0.517	0.028	0.509	0.027	0.572	0.026	0.557	0.029	0.413	0.016	0.437	0.018
2007	0.497	0.027	0.502	0.028	0.503	0.029	0.494	0.028	0.695	0.043	0.672	0.045	0.399	0.017	0.522	0.031
2008	0.617	0.037	0.619	0.038	0.621	0.039	0.608	0.037	0.734	0.054	0.701	0.053	0.488	0.023	0.542	0.037
2009	0.775	0.055	0.768	0.056	0.776	0.058	0.755	0.054	0.900	0.081	0.850	0.075	0.590	0.033	0.655	0.054
2010	0.609	0.042	0.600	0.043	0.604	0.045	0.592	0.041	0.769	0.131	0.733	0.118	0.462	0.025	0.600	0.098
2011	0.629	0.039	0.618	0.040	0.617	0.042	0.623	0.039	0.660	0.100	0.652	0.098	0.485	0.023	0.516	0.080
2012	0.614	0.040	0.595	0.041	0.594	0.043	0.611	0.040	0.972	0.149	0.963	0.147	0.470	0.023	0.682	0.091
2013	0.515	0.032	0.490	0.033	0.490	0.035	0.522	0.034	0.551	0.044	0.549	0.047	0.399	0.018	0.400	0.028
2014	0.619	0.044	0.566	0.043	0.568	0.047	0.623	0.046	0.807	0.074	0.810	0.074	0.462	0.024	0.565	0.048
2015	0.563	0.042	0.492	0.039	0.496	0.043	0.561	0.044	0.881	0.131	0.904	0.134	0.414	0.024	0.582	0.078
2016	0.517	0.040	0.427	0.034	0.433	0.039	0.512	0.042	0.821	0.130	0.859	0.138	0.375	0.023	0.528	0.075
2017	0.503	0.044	0.384	0.032	0.392	0.039	0.484	0.046	0.697	0.093	0.710	0.105	0.350	0.026	0.415	0.051
2018	0.412	0.039	0.292	0.025	0.299	0.031	0.391	0.042	0.537	0.075	0.531	0.090	0.283	0.024	0.306	0.036

Table 2.18—Back-transformed catchability parameters. Color scale extends from red=low to green=high (or constant) for each column.

	EBS(std) survey Q				EBS(exp) survey Q								NBS survey Q								EBS(exp)+NBS survey Q			
	Model 16.6		Model 17.2		Model 16.6k		Model 18.6		Model 18.7		Model 18.8		Model 16.6k		Model 18.6		Model 18.7		Model 18.8		Model 16.6i		Model 16.6j	
Year	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.	Med.	StD.
1982	0.968	0.057	1.143	0.072	0.993	0.095	1.122	0.121	0.662	0.051	0.591	0.057									1.031	0.061	1.006	0.096
1983	0.968	0.057	1.143	0.072	1.074	0.104	1.214	0.129	0.753	0.061	0.705	0.067									1.031	0.061	1.083	0.105
1984	0.968	0.057	1.143	0.072	0.981	0.096	1.095	0.118	0.676	0.051	0.626	0.055									1.031	0.061	0.991	0.096
1985	0.968	0.057	1.143	0.072	1.070	0.109	1.209	0.134	0.770	0.066	0.737	0.074									1.031	0.061	1.078	0.109
1986	0.968	0.057	1.143	0.072	1.070	0.102	1.197	0.125	0.772	0.059	0.735	0.063									1.031	0.061	1.079	0.102
1987	0.968	0.057	1.143	0.072	1.084	0.091	1.139	0.113	0.798	0.046	0.700	0.049									1.031	0.061	1.095	0.092
1988	0.968	0.057	1.143	0.072	1.042	0.093	1.075	0.115	0.778	0.048	0.676	0.051									1.031	0.061	1.051	0.094
1989	0.968	0.057	1.143	0.072	0.806	0.092	0.831	0.113	0.594	0.047	0.524	0.049									1.031	0.061	0.814	0.093
1990	0.968	0.057	1.143	0.072	0.935	0.098	1.025	0.120	0.686	0.053	0.673	0.056									1.031	0.061	0.941	0.098
1991	0.968	0.057	1.143	0.072	0.920	0.103	1.028	0.126	0.665	0.059	0.672	0.063									1.031	0.061	0.929	0.103
1992	0.968	0.057	1.143	0.072	1.000	0.106	1.124	0.129	0.733	0.062	0.746	0.068									1.031	0.061	1.008	0.106
1993	0.968	0.057	1.143	0.072	1.082	0.106	1.237	0.130	0.807	0.063	0.846	0.069									1.031	0.061	1.088	0.107
1994	0.968	0.057	1.143	0.072	1.277	0.106	1.496	0.131	0.978	0.063	1.085	0.069									1.031	0.061	1.277	0.107
1995	0.968	0.057	1.143	0.072	1.138	0.101	1.320	0.124	0.862	0.057	0.922	0.062									1.031	0.061	1.143	0.102
1996	0.968	0.057	1.143	0.072	1.087	0.110	1.260	0.135	0.812	0.068	0.868	0.075									1.031	0.061	1.092	0.110
1997	0.968	0.057	1.143	0.072	0.983	0.110	1.148	0.135	0.714	0.068	0.755	0.075									1.031	0.061	0.991	0.110
1998	0.968	0.057	1.143	0.072	0.954	0.099	1.111	0.122	0.694	0.055	0.730	0.059									1.031	0.061	0.963	0.100
1999	0.968	0.057	1.143	0.072	1.024	0.102	1.127	0.125	0.758	0.058	0.737	0.062									1.031	0.061	1.031	0.102
2000	0.968	0.057	1.143	0.072	0.917	0.099	0.984	0.121	0.677	0.055	0.638	0.058									1.031	0.061	0.925	0.100
2001	0.968	0.057	1.143	0.072	1.260	0.100	1.402	0.123	0.968	0.056	0.987	0.060									1.031	0.061	1.263	0.101
2002	0.968	0.057	1.143	0.072	0.977	0.101	1.081	0.124	0.730	0.057	0.725	0.061									1.031	0.061	0.986	0.102
2003	0.968	0.057	1.143	0.072	1.028	0.106	1.148	0.130	0.774	0.063	0.779	0.068									1.031	0.061	1.036	0.106
2004	0.968	0.057	1.143	0.072	0.959	0.098	1.052	0.120	0.728	0.053	0.726	0.056									1.031	0.061	0.968	0.098
2005	0.968	0.057	1.143	0.072	1.091	0.109	1.213	0.134	0.826	0.066	0.840	0.073									1.031	0.061	1.097	0.109
2006	0.968	0.057	1.143	0.072	1.116	0.090	1.241	0.112	0.869	0.043	0.894	0.045									1.031	0.061	1.123	0.091
2007	0.968	0.057	1.143	0.072	1.079	0.119	1.237	0.147	0.795	0.079	0.836	0.092									1.031	0.061	1.082	0.119
2008	0.968	0.057	1.143	0.072	0.909	0.102	1.046	0.126	0.661	0.058	0.702	0.063									1.031	0.061	0.909	0.102
2009	0.968	0.057	1.143	0.072	0.962	0.098	1.109	0.121	0.710	0.054	0.754	0.057									1.031	0.061	0.951	0.099
2010	0.968	0.057	1.143	0.072	1.066	0.108	1.231	0.133	0.788	0.065	0.849	0.072	0.015	0.104	0.026	0.200	0.012	0.051	0.020	0.071	1.031	0.061	1.059	0.108
2011	0.968	0.057	1.143	0.072	1.102	0.100	1.278	0.123	0.830	0.056	0.886	0.060	0.164	0.163	0.278	0.299	0.260	0.216	0.260	0.197	1.031	0.061	1.078	0.101
2012	0.968	0.057	1.143	0.072	1.104	0.100	1.316	0.123	0.820	0.056	0.914	0.060	0.164	0.163	0.278	0.299	0.260	0.216	0.260	0.197	1.031	0.061	1.066	0.100
2013	0.968	0.057	1.143	0.072	0.990	0.113	1.137	0.139	0.712	0.071	0.737	0.080	0.164	0.163	0.278	0.299	0.260	0.216	0.260	0.197	1.031	0.061	0.974	0.113
2014	0.968	0.057	1.143	0.072	1.122	0.108	1.304	0.132	0.830	0.065	0.869	0.073	0.164	0.163	0.278	0.299	0.260	0.216	0.260	0.197	1.031	0.061	1.079	0.108
2015	0.968	0.057	1.143	0.072	1.127	0.106	1.308	0.130	0.829	0.063	0.864	0.070	0.164	0.163	0.278	0.299	0.260	0.216	0.260	0.197	1.031	0.061	1.063	0.106
2016	0.968	0.057	1.143	0.072	1.092	0.102	1.252	0.126	0.805	0.059	0.802	0.066	0.164	0.163	0.278	0.299	0.260	0.216	0.260	0.197	1.031	0.061	1.003	0.103
2017	0.968	0.057	1.143	0.072	0.928	0.103	1.081	0.127	0.668	0.060	0.675	0.068	0.369	0.102	0.601	0.196	0.284	0.036	0.389	0.060	1.031	0.061	0.990	0.101
2018	0.968	0.057	1.143	0.072	0.892	0.104	1.089	0.131	0.637	0.060	0.672	0.070	0.810	0.104	1.350	0.199	0.642	0.050	0.870	0.065	1.031	0.061	1.170	0.107

Table 2.19—Summary of key management reference points. All biomass figures are in t. Color scale extends from red=low to green=high for each row.

Year	Quantity	M16.6	M16.6i	M16.6j	M16.6k	M17.2	M18.6	M18.7	M18.8
n/a	B100%	623,000	658,000	656,000	623,000	609,000	598,000	594,000	556,000
n/a	B40%	249,000	263,000	263,000	249,000	244,000	239,000	238,000	222,000
n/a	B35%	218,000	230,000	230,000	218,000	213,000	209,000	208,000	195,000
n/a	F40%	0.32	0.31	0.31	0.31	0.31	0.32	0.38	0.46
n/a	F35%	0.40	0.38	0.38	0.38	0.37	0.39	0.47	0.58
2019	Female spawning biomass	195,000	290,000	283,000	206,000	141,000	145,000	290,000	249,000
2019	Relative spawning biomass	0.23	0.44	0.43	0.33	0.23	0.24	0.49	0.45
2019	Pr(B/B100%<0.2)	0.17	0.00	0.00	0.00	0.19	0.16	0.00	0.00
2019	maxFABC	0.25	0.31	0.31	0.25	0.17	0.18	0.38	0.46
2019	maxABC	103,000	181,000	177,000	111,000	53,900	59,900	212,000	216,000
2019	Catch	103,000	181,000	177,000	111,000	53,900	59,900	206,000	208,000
2019	FOFL	0.31	0.38	0.38	0.31	0.21	0.22	0.47	0.58
2019	OFL	123,000	216,000	211,000	132,000	60,900	72,000	253,000	257,000
2019	Pr(maxABC>truOFL)	0.24	0.07	0.11	0.26	0.30	0.32	0.03	0.07
2020	Female spawning biomass	176,000	246,000	240,000	187,000	146,000	148,000	221,000	180,000
2020	Relative spawning biomass	0.20	0.38	0.37	0.30	0.24	0.25	0.37	0.32
2020	Pr(B/B100%<0.2)	0.38	0.00	0.00	0.00	0.04	0.04	0.00	0.00
2020	maxFABC	0.22	0.29	0.28	0.23	0.18	0.19	0.35	0.37
2020	maxABC	78,900	137,000	131,000	86,100	53,800	58,600	144,000	123,000
2020	Catch	78,900	137,000	131,000	86,100	53,800	58,600	144,000	123,000
2020	FOFL	0.28	0.35	0.34	0.28	0.21	0.23	0.44	0.46
2020	OFL	94,800	164,000	157,000	103,000	64,600	70,400	173,000	147,000
2020	Pr(maxABC>truOFL)	0.25	0.23	0.27	0.28	0.28	0.34	0.22	0.31

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 2.20—Schedules of length (cm) and selectivity at age as defined by parameter estimates from Model 16.6i.

	Begin-year length		Mid-year length		Selectivity	
Age	Mean	SD	Mean	SD	Fishery	Survey
0	0.001	3.456	5.460	3.456	0.000	0.000
1	10.918	3.456	16.377	3.456	0.000	0.485
2	24.509	4.043	31.793	4.568	0.003	1.000
3	38.342	5.041	44.244	5.466	0.034	1.000
4	49.571	5.851	54.383	6.198	0.297	1.000
5	58.733	6.511	62.667	6.795	0.836	1.000
6	66.228	7.052	69.451	7.284	0.984	1.000
7	72.369	7.495	75.012	7.685	0.999	1.000
8	77.406	7.858	79.574	8.015	1.000	1.000
9	81.540	8.156	83.320	8.285	1.000	1.000
10	84.934	8.401	86.397	8.507	1.000	1.000
11	87.723	8.602	88.925	8.689	1.000	1.000
12	90.015	8.768	91.003	8.839	1.000	1.000
13	91.899	8.903	92.711	8.962	1.000	1.000
14	93.447	9.015	94.115	9.063	1.000	1.000
15	94.720	9.107	95.269	9.147	1.000	1.000
16	95.767	9.182	96.219	9.215	1.000	1.000
17	96.628	9.245	97.000	9.271	1.000	1.000
18	97.336	9.296	97.642	9.318	1.000	1.000
19	97.919	9.338	98.170	9.356	1.000	1.000
20	98.864	9.532	99.027	9.532	1.000	1.000

Table 2.21—Mid-year weight (kg) at age as defined by input weight-at-length parameters and length-at-age parameters estimated by Model 16.6i.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1977	0.02	0.16	0.66	1.49	2.55	3.72	4.93	6.10	7.19	8.18	9.06	9.84	10.50	11.07	11.56	11.96	12.31	12.59	12.83	13.23
1978	0.01	0.15	0.63	1.47	2.56	3.81	5.10	6.37	7.56	8.65	9.63	10.48	11.23	11.86	12.40	12.86	13.24	13.56	13.83	14.27
1979	0.02	0.18	0.69	1.53	2.59	3.76	4.96	6.11	7.19	8.16	9.03	9.78	10.44	10.99	11.47	11.86	12.20	12.47	12.70	13.09
1980	0.02	0.16	0.65	1.47	2.51	3.66	4.85	6.00	7.08	8.06	8.93	9.69	10.35	10.91	11.39	11.79	12.13	12.41	12.64	13.03
1981	0.02	0.17	0.66	1.47	2.50	3.64	4.80	5.92	6.97	7.92	8.77	9.50	10.14	10.68	11.15	11.53	11.86	12.13	12.36	12.73
1982	0.02	0.18	0.72	1.57	2.64	3.82	5.02	6.18	7.25	8.22	9.09	9.84	10.48	11.04	11.51	11.90	12.23	12.50	12.73	13.12
1983	0.02	0.17	0.70	1.56	2.65	3.87	5.13	6.34	7.47	8.50	9.42	10.22	10.91	11.50	12.00	12.42	12.77	13.07	13.31	13.72
1984	0.02	0.20	0.73	1.52	2.47	3.49	4.51	5.48	6.37	7.17	7.87	8.48	9.00	9.45	9.82	10.14	10.40	10.62	10.80	11.11
1985	0.01	0.16	0.68	1.53	2.64	3.89	5.17	6.42	7.60	8.66	9.61	10.45	11.17	11.78	12.31	12.75	13.12	13.43	13.68	14.11
1986	0.01	0.15	0.65	1.50	2.62	3.89	5.21	6.50	7.71	8.82	9.81	10.68	11.43	12.08	12.63	13.09	13.48	13.80	14.07	14.53
1987	0.02	0.17	0.68	1.53	2.62	3.83	5.08	6.29	7.42	8.45	9.36	10.16	10.85	11.44	11.95	12.37	12.72	13.02	13.27	13.68
1988	0.01	0.16	0.67	1.55	2.71	4.02	5.38	6.71	7.97	9.12	10.14	11.04	11.82	12.49	13.06	13.53	13.94	14.27	14.55	15.02
1989	0.01	0.17	0.70	1.59	2.76	4.07	5.42	6.74	7.98	9.11	10.11	11.00	11.76	12.42	12.97	13.44	13.83	14.16	14.43	14.89
1990	0.02	0.18	0.72	1.60	2.72	3.95	5.22	6.44	7.59	8.62	9.54	10.34	11.04	11.63	12.13	12.55	12.91	13.20	13.45	13.86
1991	0.02	0.17	0.69	1.51	2.55	3.70	4.88	6.01	7.06	8.01	8.86	9.60	10.23	10.78	11.24	11.63	11.95	12.22	12.45	12.82
1992	0.02	0.16	0.65	1.44	2.46	3.58	4.73	5.85	6.89	7.83	8.67	9.41	10.04	10.58	11.04	11.43	11.75	12.02	12.24	12.62
1993	0.02	0.19	0.75	1.64	2.76	4.00	5.26	6.48	7.61	8.63	9.54	10.33	11.02	11.60	12.09	12.51	12.86	13.15	13.39	13.79
1994	0.02	0.17	0.68	1.51	2.57	3.74	4.95	6.11	7.20	8.19	9.06	9.83	10.49	11.06	11.54	11.94	12.28	12.56	12.79	13.19
1995	0.01	0.16	0.66	1.49	2.57	3.78	5.02	6.23	7.36	8.39	9.31	10.12	10.81	11.41	11.91	12.34	12.70	12.99	13.24	13.66
1996	0.02	0.20	0.74	1.58	2.61	3.73	4.85	5.92	6.91	7.80	8.59	9.27	9.86	10.36	10.78	11.13	11.43	11.68	11.89	12.23
1997	0.02	0.17	0.66	1.45	2.45	3.56	4.68	5.77	6.78	7.70	8.52	9.23	9.84	10.37	10.81	11.18	11.50	11.76	11.98	12.34
1998	0.02	0.17	0.66	1.44	2.44	3.53	4.64	5.71	6.71	7.61	8.42	9.11	9.72	10.23	10.67	11.04	11.34	11.60	11.81	12.17
1999	0.02	0.18	0.68	1.51	2.54	3.68	4.84	5.97	7.01	7.95	8.79	9.52	10.15	10.69	11.14	11.53	11.85	12.11	12.34	12.71
2000	0.02	0.18	0.72	1.58	2.67	3.88	5.10	6.28	7.38	8.38	9.26	10.03	10.70	11.27	11.75	12.15	12.49	12.77	13.01	13.40
2001	0.02	0.19	0.72	1.56	2.61	3.76	4.92	6.04	7.08	8.02	8.84	9.57	10.19	10.72	11.17	11.55	11.86	12.13	12.35	12.71
2002	0.02	0.18	0.69	1.53	2.58	3.75	4.94	6.10	7.17	8.14	9.00	9.76	10.41	10.96	11.43	11.83	12.16	12.44	12.67	13.05
2003	0.02	0.16	0.66	1.49	2.55	3.73	4.94	6.12	7.22	8.22	9.11	9.89	10.56	11.14	11.63	12.04	12.38	12.67	12.91	13.31
2004	0.02	0.18	0.69	1.52	2.57	3.72	4.90	6.03	7.08	8.03	8.88	9.61	10.25	10.79	11.25	11.64	11.96	12.23	12.46	12.83
2005	0.02	0.17	0.68	1.52	2.59	3.78	5.01	6.20	7.31	8.32	9.21	10.00	10.68	11.26	11.75	12.16	12.51	12.80	13.04	13.44
2006	0.02	0.17	0.68	1.52	2.58	3.75	4.95	6.11	7.19	8.18	9.05	9.81	10.46	11.02	11.50	11.90	12.24	12.52	12.75	13.14
2007	0.02	0.17	0.69	1.54	2.62	3.82	5.05	6.24	7.35	8.36	9.26	10.04	10.72	11.30	11.79	12.20	12.55	12.84	13.08	13.48
2008	0.02	0.17	0.68	1.51	2.57	3.73	4.92	6.07	7.14	8.11	8.97	9.73	10.38	10.93	11.40	11.80	12.13	12.41	12.64	13.02
2009	0.02	0.16	0.67	1.51	2.59	3.80	5.05	6.26	7.39	8.42	9.34	10.15	10.84	11.44	11.94	12.37	12.72	13.02	13.27	13.68
2010	0.02	0.16	0.66	1.49	2.54	3.72	4.93	6.10	7.19	8.19	9.08	9.85	10.52	11.09	11.58	11.99	12.33	12.62	12.86	13.26
2011	0.01	0.16	0.65	1.46	2.49	3.65	4.84	5.99	7.07	8.05	8.92	9.68	10.34	10.90	11.38	11.78	12.12	12.40	12.64	13.03
2012	0.02	0.18	0.68	1.48	2.48	3.57	4.68	5.75	6.74	7.64	8.43	9.12	9.72	10.23	10.66	11.02	11.32	11.58	11.79	12.14
2013	0.01	0.16	0.65	1.46	2.50	3.66	4.85	6.01	7.09	8.08	8.96	9.72	10.39	10.95	11.44	11.84	12.18	12.47	12.70	13.10
2014	0.01	0.15	0.62	1.41	2.45	3.61	4.82	6.00	7.10	8.11	9.01	9.80	10.48	11.07	11.57	11.98	12.34	12.63	12.87	13.28
2015	0.01	0.14	0.60	1.38	2.39	3.53	4.72	5.88	6.96	7.96	8.84	9.62	10.29	10.86	11.35	11.77	12.11	12.40	12.64	13.05
2016	0.01	0.15	0.62	1.41	2.44	3.60	4.81	5.98	7.08	8.09	8.98	9.77	10.45	11.03	11.53	11.94	12.29	12.59	12.83	13.24
2017	0.01	0.15	0.62	1.42	2.46	3.65	4.88	6.08	7.21	8.24	9.16	9.96	10.66	11.26	11.77	12.20	12.56	12.86	13.11	13.53
2018	0.02	0.16	0.66	1.49	2.55	3.72	4.93	6.10	7.19	8.18	9.06	9.84	10.50	11.07	11.56	11.96	12.31	12.59	12.83	13.23

Table 2.22—Time series of EBS Pacific cod age 0+ biomass, age 3+ biomass, female spawning biomass (t), and standard deviation of spawning biomass ("SB SD") as estimated by the SSC's accepted model in last year's assessment and Model 16.6i in this year's assessment.

	Last year's assessment				This year's assessment			
Year	Age 0+	Age 3+	Spawn.	SB SD	Age 0+	Age 3+	Spawn.	SB SD
1977	207,132	194,439	61,586	21,918	186,620	175,929	56,343	19,684
1978	227,167	197,083	60,116	21,854	202,963	174,822	54,375	19,392
1979	333,444	233,975	60,785	21,018	290,308	205,649	54,020	18,331
1980	523,962	463,227	80,964	21,306	451,229	417,649	71,221	18,399
1981	771,031	711,666	132,204	23,045	665,330	612,973	115,332	19,672
1982	1,039,930	1,008,840	229,463	28,623	906,021	826,858	200,351	24,308
1983	1,170,700	1,145,330	328,886	33,255	1,034,070	1,008,200	290,059	28,413
1984	1,132,230	1,036,250	351,055	30,365	1,010,460	1,017,060	312,996	26,220
1985	1,216,380	1,187,840	398,877	31,842	1,092,330	982,419	358,279	27,867
1986	1,212,610	1,140,890	386,293	28,738	1,095,860	1,035,460	349,352	25,477
1987	1,238,960	1,207,800	376,676	25,366	1,127,740	1,108,440	343,533	22,696
1988	1,265,790	1,246,910	399,216	24,412	1,160,170	1,098,010	366,902	21,984
1989	1,157,460	1,146,520	386,517	22,147	1,066,060	1,040,510	356,688	19,986
1990	982,512	949,578	351,648	18,487	913,659	909,382	326,482	16,708
1991	807,767	738,279	281,550	14,248	756,962	743,979	262,913	12,922
1992	696,107	644,488	199,553	11,563	649,704	626,460	186,394	10,541
1993	803,768	756,262	185,048	11,683	747,847	625,306	173,578	10,691
1994	833,540	755,268	193,737	10,885	777,724	763,159	182,470	9,931
1995	886,880	854,705	215,526	11,417	827,716	801,241	202,656	10,312
1996	889,291	855,130	215,284	11,852	827,777	776,280	201,202	10,593
1997	767,572	736,356	207,113	11,423	715,100	733,624	193,372	10,156
1998	669,601	602,754	182,989	11,194	618,216	562,040	169,279	9,933
1999	699,559	666,101	177,842	11,463	644,510	588,633	163,841	10,220
2000	756,669	718,191	184,566	11,984	699,653	631,795	169,954	10,756
2001	768,518	697,950	191,590	11,696	714,392	665,504	177,481	10,572
2002	800,226	752,232	204,574	11,634	747,995	714,727	191,153	10,617
2003	797,992	775,587	203,997	11,255	749,296	740,696	191,754	10,348
2004	774,525	743,943	207,254	10,703	730,652	696,913	195,989	9,876
2005	701,954	677,671	205,281	10,083	664,952	636,978	195,047	9,333
2006	605,913	583,334	181,100	8,997	575,974	557,768	172,594	8,363
2007	533,749	497,741	152,916	8,146	508,416	468,937	146,162	7,616
2008	539,085	447,217	130,419	7,312	499,841	432,152	124,906	6,862
2009	598,145	552,263	119,939	7,438	565,723	524,552	115,291	6,985
2010	730,854	621,763	129,029	8,267	678,212	594,863	122,822	7,690
2011	874,836	853,044	170,785	10,183	818,946	814,669	162,726	9,371
2012	937,927	859,433	202,684	12,605	885,599	812,574	192,460	11,449
2013	961,906	872,235	228,430	14,915	916,688	830,410	217,833	13,472
2014	992,621	949,547	235,287	16,842	954,799	935,942	225,546	15,110
2015	1,019,330	945,406	237,765	18,801	997,176	946,579	230,986	16,742
2016	1,070,600	1,057,200	267,363	22,233	1,071,670	1,033,660	265,757	19,667
2017	1,047,990	1,029,530	290,295	26,300	1,045,740	1,016,160	290,364	22,721
2018	918,112	902,793	292,244	28,456	965,220	926,582	303,676	25,143
2019					823,559	812,296	290,205	25,792

Table 2.23—Time series of age 0 recruitment (1000s of fish), with standard deviations, as estimated by the SSC's accepted model in last year's assessment and Model 16.6i in this year's assessment.

	Last year's values		This year's values	
Year	Recruits	Std. dev.	Recruits	Std. dev.
1977	1,060,550	264,204	825,468	203,175
1978	672,100	188,015	553,645	146,769
1979	680,430	124,506	559,855	99,066
1980	314,757	54,723	267,150	45,239
1981	173,530	31,321	148,585	26,326
1982	922,389	108,029	772,190	88,432
1983	235,765	39,082	201,748	32,837
1984	912,141	102,671	779,242	85,869
1985	346,868	46,026	286,881	38,806
1986	231,571	31,713	189,896	28,223
1987	96,735	19,599	106,532	21,604
1988	268,840	35,658	252,215	34,235
1989	724,715	79,217	608,156	65,443
1990	593,602	65,760	517,445	55,750
1991	379,554	45,051	332,437	38,600
1992	889,718	87,181	769,721	73,524
1993	368,234	39,818	317,834	33,722
1994	300,692	33,230	260,675	28,355
1995	274,890	31,169	240,271	26,926
1996	761,014	77,342	656,826	65,485
1997	340,470	37,309	299,540	32,544
1998	328,956	34,859	293,149	30,842
1999	686,150	65,891	600,535	56,944
2000	524,643	51,096	457,627	44,040
2001	236,417	24,834	206,697	21,754
2002	312,665	31,396	276,764	27,628
2003	264,148	26,623	234,954	23,554
2004	222,208	23,355	199,734	20,871
2005	299,311	30,775	264,694	26,978
2006	929,721	90,296	815,063	77,717
2007	405,265	43,775	357,509	37,854
2008	1,269,150	126,738	1,108,580	107,114
2009	160,901	23,566	146,002	20,834
2010	746,165	78,511	671,321	68,503
2011	1,090,300	118,453	995,183	104,072
2012	464,146	54,710	443,680	50,392
2013	1,034,000	115,645	982,145	105,381
2014	158,385	22,995	175,220	23,225
2015	209,787	29,966	244,408	29,663
2016	120,011	30,279	157,246	23,261
2017			76,186	22,424
Average	500,272		430,561	

Table 2.24—Numbers (1000s) at age as estimated by Model 16.6i.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1977	825468	175318	47124	36586	21400	9811	5852	3798	2529	1676	1090	694	432	264	160	95	57	34	20	12	17
1978	553645	587535	124776	33511	25769	13883	5377	3063	1979	1317	873	568	361	225	138	83	50	30	18	10	15
1979	559855	394061	418145	88706	23524	16234	7005	2553	1446	934	621	412	268	170	106	65	39	23	14	8	12
1980	267150	398482	280457	297344	62451	15203	8802	3620	1313	743	480	319	212	138	88	55	33	20	12	7	10
1981	148585	190146	283601	199414	209098	39957	8013	4399	1800	653	369	239	159	105	68	44	27	17	10	6	9
1982	772190	105757	135332	201726	140858	139149	23528	4563	2497	1021	370	210	135	90	60	39	25	15	9	6	8
1983	201748	549616	75272	96291	143008	96779	89656	14895	2884	1578	645	234	132	86	57	38	25	16	10	6	9
1984	779242	143596	391184	53555	68229	97830	61596	55947	9277	1796	982	402	146	82	53	35	23	15	10	6	9
1985	286881	554634	102202	278288	37890	46053	59955	36765	33306	5522	1069	585	239	87	49	32	21	14	9	6	9
1986	189896	204190	394750	72703	196772	25443	27814	35175	21508	19480	3229	625	342	140	51	29	19	12	8	5	9
1987	106532	135161	145329	280810	51405	132095	15355	16304	20560	12569	11383	1887	365	200	82	30	17	11	7	5	8
1988	252215	75825	96198	103378	198475	34395	78983	8903	9425	11882	7263	6578	1091	211	115	47	17	10	6	4	7
1989	608156	179517	53966	68416	72902	130173	19439	42857	4811	5092	6419	3924	3554	589	114	62	26	9	5	3	6
1990	517445	432862	127767	38386	48320	48455	76385	11025	24224	2719	2877	3627	2217	2008	333	64	35	14	5	3	5
1991	332437	368297	308077	90873	27087	31867	27816	42216	6070	13334	1496	1584	1996	1220	1105	183	35	19	8	3	5
1992	769721	236614	262112	218994	63702	16855	15528	12676	19112	2747	6033	677	717	903	552	500	83	16	9	4	3
1993	317834	547854	168392	186272	153053	38598	7619	6478	5247	7906	1136	2495	280	296	374	228	207	34	7	4	3
1994	260675	226221	389904	119714	130759	96414	19469	3616	3057	2474	3728	536	1177	132	140	176	108	98	16	3	3
1995	240271	185537	160999	277166	83941	81541	47264	8936	1649	1393	1128	1699	244	536	60	64	80	49	44	7	3
1996	656826	171014	132041	114408	193557	50508	36143	19269	3613	666	563	456	686	99	217	24	26	32	20	18	4
1997	299540	467500	121706	93840	79994	117736	23084	15275	8081	1514	279	236	191	288	41	91	10	11	14	8	9
1998	293149	213199	332704	86482	65501	47932	51574	9281	6090	3220	603	111	94	76	115	16	36	4	4	5	7
1999	600535	208651	151731	236492	60602	40626	23142	23251	4156	2725	1441	270	50	42	34	51	7	16	2	2	6
2000	457627	427435	148494	107850	165660	37464	19434	10320	10297	1839	1206	638	119	22	19	15	23	3	7	1	3
2001	206697	325720	304200	105554	75590	102929	18178	8813	4649	4636	828	543	287	54	10	8	7	10	1	3	2
2002	276764	147118	231816	216293	74217	48302	54051	9047	4363	2300	2294	410	269	142	27	5	4	3	5	1	3
2003	234954	196989	104703	164792	151712	46424	23886	25064	4169	2009	1059	1056	189	124	65	12	2	2	2	2	1
2004	199734	167230	140194	74424	115456	93942	22310	10709	11161	1855	894	471	470	84	55	29	5	1	1	1	2
2005	264694	142163	119016	99658	52188	72041	46131	10261	4894	5097	847	408	215	215	38	25	13	2	0	0	1
2006	815063	188398	101175	84602	69864	32486	35139	21048	4651	2217	2309	384	185	98	97	17	11	6	1	0	1
2007	357509	580127	134078	71906	59178	42654	15003	15035	8938	1974	941	980	163	79	41	41	7	5	3	0	0
2008	1108580	254459	412864	95295	50323	36288	19942	6512	6479	3849	850	405	422	70	34	18	18	3	2	1	0
2009	146002	789038	181088	293342	66432	29813	15395	7722	2499	2484	1476	326	155	162	27	13	7	7	1	1	1
2010	671321	103918	561507	128609	203468	37650	11163	5146	2552	825	820	487	108	51	53	9	4	2	2	0	0
2011	995183	477816	73954	398975	89711	121208	16224	4402	2012	997	322	320	190	42	20	21	3	2	1	1	0
2012	443680	708326	340043	52545	278138	53161	51458	6287	1691	772	383	124	123	73	16	8	8	1	1	0	0
2013	982145	315791	504090	241619	36659	165953	23010	20400	2471	664	303	150	49	48	29	6	3	3	1	0	0
2014	175220	699048	224743	358290	169164	22561	78387	10109	8899	1077	289	132	66	21	21	13	3	1	1	0	0
2015	244408	124714	497491	159705	250212	101797	10003	31967	4089	3597	435	117	53	26	9	9	5	1	1	1	0
2016	157246	173959	88757	353598	111808	153921	48024	4388	13925	1780	1566	190	51	23	12	4	4	2	0	0	0
2017	76186	111921	123805	63097	248088	70106	76631	22447	2038	6465	826	727	88	24	11	5	2	2	1	0	0
2018	435409	54226	79654	88023	44333	157558	36184	37369	10885	988	3133	401	352	43	11	5	3	1	1	0	0

Table 2.25—Model 16.6i estimates of "effective" fishing mortality (= -ln($N_{a+1,t+1}/N_{a,t}$)-M) at age and year. Color scale applies to the entire matrix.

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1977	0.000	0.001	0.011	0.093	0.261	0.307	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312	0.312
1978	0.000	0.001	0.014	0.122	0.344	0.405	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411	0.411
1979	0.000	0.001	0.011	0.097	0.272	0.320	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325	0.325
1980	0.000	0.001	0.012	0.107	0.300	0.354	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
1981	0.000	0.001	0.008	0.067	0.190	0.223	0.226	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227	0.227
1982	0.000	0.000	0.004	0.035	0.100	0.117	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119	0.119
1983	0.000	0.000	0.004	0.040	0.112	0.132	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134	0.134
1984	0.000	0.001	0.006	0.053	0.150	0.176	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179	0.179
1985	0.000	0.001	0.007	0.058	0.164	0.193	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196	0.196
1986	0.000	0.001	0.007	0.059	0.165	0.194	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197	0.197
1987	0.000	0.001	0.007	0.062	0.174	0.205	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208	0.208
1988	0.000	0.001	0.009	0.082	0.231	0.271	0.275	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276	0.276
1989	0.000	0.001	0.008	0.068	0.193	0.227	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231	0.231
1990	0.000	0.001	0.009	0.076	0.215	0.253	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257	0.257
1991	0.000	0.001	0.015	0.134	0.379	0.446	0.452	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453	0.453
1992	0.000	0.002	0.018	0.161	0.454	0.534	0.542	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543	0.543
1993	0.000	0.001	0.014	0.122	0.344	0.405	0.411	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412	0.412
1994	0.000	0.001	0.015	0.132	0.373	0.439	0.445	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446	0.446
1995	0.000	0.002	0.019	0.168	0.474	0.557	0.565	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566
1996	0.000	0.002	0.018	0.157	0.443	0.521	0.529	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530	0.530
1997	0.000	0.002	0.020	0.172	0.485	0.571	0.580	0.580	0.580	0.580	0.580	0.580	0.580	0.580	0.580	0.580	0.580	0.580	0.580
1998	0.000	0.001	0.016	0.138	0.388	0.457	0.463	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464	0.464
1999	0.000	0.001	0.016	0.141	0.397	0.468	0.474	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475	0.475
2000	0.000	0.001	0.015	0.136	0.383	0.451	0.457	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458	0.458
2001	0.000	0.001	0.012	0.108	0.304	0.358	0.363	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364	0.364
2002	0.000	0.001	0.015	0.129	0.364	0.428	0.435	0.435	0.435	0.435	0.435	0.435	0.435	0.435	0.435	0.435	0.435	0.435	0.435
2003	0.000	0.001	0.016	0.139	0.393	0.462	0.469	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
2004	0.000	0.001	0.015	0.132	0.371	0.437	0.443	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444	0.444
2005	0.000	0.001	0.015	0.134	0.378	0.445	0.451	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452	0.452
2006	0.000	0.001	0.017	0.153	0.433	0.509	0.516	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517	0.517
2007	0.000	0.001	0.017	0.149	0.420	0.495	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502	0.502
2008	0.000	0.002	0.021	0.184	0.517	0.609	0.618	0.619	0.619	0.619	0.619	0.619	0.619	0.619	0.619	0.619	0.619	0.619	0.619
2009	0.000	0.002	0.026	0.228	0.642	0.756	0.767	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768	0.768
2010	0.000	0.002	0.020	0.178	0.502	0.590	0.599	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600
2011	0.000	0.002	0.021	0.183	0.517	0.608	0.617	0.618	0.618	0.618	0.618	0.618	0.618	0.618	0.618	0.618	0.618	0.618	0.618
2012	0.000	0.002	0.020	0.176	0.497	0.585	0.594	0.595	0.595	0.595	0.595	0.595	0.595	0.595	0.595	0.595	0.595	0.595	0.595
2013	0.000	0.001	0.016	0.145	0.410	0.482	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490	0.490
2014	0.000	0.002	0.019	0.168	0.473	0.557	0.565	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566	0.566
2015	0.000	0.001	0.017	0.146	0.411	0.484	0.491	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492	0.492
2016	0.000	0.001	0.014	0.127	0.357	0.421	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427	0.427
2017	0.000	0.001	0.013	0.114	0.321	0.378	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384	0.384
2018	0.000	0.001	0.010	0.087	0.244	0.287	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292	0.292

Table 2.26a—Model 16.6i projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = max\ F_{ABC}$ in 2019-2030 (Scenarios 1-2), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	290,000	25,800	248,000	333,000
2020	246,000	17,700	217,000	276,000
2021	205,000	10,700	187,000	222,000
2022	187,000	9,330	172,000	202,000
2023	197,000	9,140	182,000	212,000
2024	222,000	10,100	205,000	238,000
2025	243,000	11,600	224,000	262,000
2026	256,000	12,800	235,000	277,000
2027	261,000	13,500	239,000	283,000
2028	263,000	13,900	240,000	285,000
2029	263,000	14,000	240,000	286,000
2030	262,000	14,000	239,000	285,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.31	0.016	0.281	0.332
2020	0.29	0.036	0.227	0.346
2021	0.24	0.019	0.204	0.267
2022	0.21	0.014	0.191	0.236
2023	0.23	0.014	0.203	0.249
2024	0.26	0.016	0.230	0.282
2025	0.28	0.017	0.255	0.311
2026	0.30	0.017	0.270	0.326
2027	0.30	0.016	0.278	0.331
2028	0.31	0.016	0.281	0.332
2029	0.31	0.016	0.281	0.332
2030	0.31	0.016	0.281	0.332

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	181,000	19,600	149,000	214,000
2020	137,000	22,100	101,000	174,000
2021	91,100	8,410	77,300	105,000
2022	74,500	4,990	66,300	82,800
2023	92,600	5,170	84,100	101,000
2024	122,000	6,600	111,000	133,000
2025	146,000	7,600	133,000	158,000
2026	159,000	7,840	146,000	172,000
2027	164,000	7,760	151,000	177,000
2028	165,000	7,600	153,000	178,000
2029	165,000	7,580	153,000	178,000
2030	165,000	7,570	153,000	177,000

Table 2.26b—Model 16.6i projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that the upper bound on F_{ABC} is set the most recent five-year average fishing mortality rate in 2019-2030 (Scenario 3), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	290,000	25,800	248,000	333,000
2020	215,000	16,200	188,000	241,000
2021	157,000	10,100	140,000	173,000
2022	129,000	7,060	118,000	141,000
2023	136,000	6,270	126,000	146,000
2024	156,000	6,930	144,000	167,000
2025	172,000	7,810	159,000	185,000
2026	183,000	8,430	169,000	197,000
2027	189,000	8,770	175,000	203,000
2028	192,000	8,950	177,000	207,000
2029	194,000	9,040	179,000	209,000
2030	194,000	9,080	180,000	209,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.47	0.000	0.470	0.470
2020	0.47	0.000	0.470	0.470
2021	0.47	0.000	0.470	0.470
2022	0.47	0.000	0.470	0.470
2023	0.47	0.000	0.470	0.470
2024	0.47	0.000	0.470	0.470
2025	0.47	0.000	0.470	0.470
2026	0.47	0.000	0.470	0.470
2027	0.47	0.000	0.470	0.470
2028	0.47	0.000	0.470	0.470
2029	0.47	0.000	0.470	0.470
2030	0.47	0.000	0.470	0.470

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	260,000	21,200	225,000	295,000
2020	183,000	12,700	162,000	204,000
2021	128,000	7,980	114,000	141,000
2022	106,000	5,920	95,900	115,000
2023	130,000	5,780	120,000	139,000
2024	153,000	6,510	143,000	164,000
2025	168,000	7,200	156,000	180,000
2026	176,000	7,630	164,000	189,000
2027	181,000	7,860	168,000	193,000
2028	183,000	7,980	170,000	196,000
2029	184,000	8,040	171,000	197,000
2030	184,000	8,060	171,000	198,000

Table 2.26c—Model 16.6i projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that the upper bound on F_{ABC} is set at $F_{60\%}$ in 2019-2030 (Scenario 4), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	290,000	25,800	248,000	333,000
2020	284,000	21,100	249,000	319,000
2021	262,000	16,900	234,000	290,000
2022	245,000	14,000	222,000	268,000
2023	251,000	11,600	232,000	270,000
2024	275,000	11,600	255,000	294,000
2025	302,000	12,900	281,000	324,000
2026	328,000	14,500	304,000	352,000
2027	348,000	16,100	321,000	374,000
2028	362,000	17,300	334,000	391,000
2029	373,000	18,300	343,000	403,000
2030	380,000	19,100	348,000	411,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.14	0.006	0.132	0.154
2020	0.14	0.006	0.132	0.154
2021	0.14	0.006	0.132	0.153
2022	0.13	0.013	0.112	0.154
2023	0.14	0.011	0.119	0.153
2024	0.14	0.006	0.132	0.154
2025	0.14	0.006	0.132	0.154
2026	0.14	0.006	0.132	0.154
2027	0.14	0.006	0.132	0.154
2028	0.14	0.006	0.132	0.154
2029	0.14	0.006	0.132	0.154
2030	0.14	0.006	0.132	0.154

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	90,600	9,700	74,700	107,000
2020	83,500	7,440	71,200	95,700
2021	72,700	5,530	63,600	81,800
2022	61,800	7,580	49,300	74,300
2023	70,900	5,920	61,200	80,600
2024	85,100	4,030	78,400	91,700
2025	93,900	4,450	86,600	101,000
2026	101,000	4,760	93,000	109,000
2027	106,000	4,970	97,700	114,000
2028	109,000	5,100	101,000	118,000
2029	112,000	5,170	103,000	120,000
2030	113,000	5,220	105,000	122,000

Table 2.26d—Model 16.6i projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = 0$ in 2019-2030 (Scenario 5), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	290,000	25,800	248,000	333,000
2020	322,000	24,700	281,000	362,000
2021	333,000	22,500	296,000	369,000
2022	338,000	20,100	305,000	371,000
2023	355,000	18,300	325,000	385,000
2024	390,000	17,300	361,000	418,000
2025	434,000	17,700	404,000	463,000
2026	477,000	19,300	446,000	509,000
2027	516,000	21,400	481,000	552,000
2028	549,000	23,600	510,000	588,000
2029	575,000	25,700	533,000	617,000
2030	595,000	27,500	550,000	641,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.00	0.000	0.000	0.000
2020	0.00	0.000	0.000	0.000
2021	0.00	0.000	0.000	0.000
2022	0.00	0.000	0.000	0.000
2023	0.00	0.000	0.000	0.000
2024	0.00	0.000	0.000	0.000
2025	0.00	0.000	0.000	0.000
2026	0.00	0.000	0.000	0.000
2027	0.00	0.000	0.000	0.000
2028	0.00	0.000	0.000	0.000
2029	0.00	0.000	0.000	0.000
2030	0.00	0.000	0.000	0.000

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0	0	0	0
2020	0	0	0	0
2021	0	0	0	0
2022	0	0	0	0
2023	0	0	0	0
2024	0	0	0	0
2025	0	0	0	0
2026	0	0	0	0
2027	0	0	0	0
2028	0	0	0	0
2029	0	0	0	0
2030	0	0	0	0

Table 2.26e—Model 16.6i projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = F_{OFL}$ in 2019-2030 (Scenario 6), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	290,000	25,800	248,000	333,000
2020	232,000	16,400	205,000	259,000
2021	188,000	9,830	172,000	204,000
2022	172,000	8,770	157,000	186,000
2023	184,000	8,600	169,000	198,000
2024	208,000	9,570	193,000	224,000
2025	229,000	11,000	210,000	247,000
2026	239,000	12,100	219,000	259,000
2027	242,000	12,700	221,000	263,000
2028	243,000	13,000	222,000	264,000
2029	243,000	13,000	222,000	264,000
2030	243,000	13,000	221,000	264,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.38	0.020	0.343	0.408
2020	0.33	0.041	0.262	0.397
2021	0.26	0.020	0.229	0.296
2022	0.24	0.015	0.214	0.262
2023	0.26	0.016	0.230	0.283
2024	0.29	0.019	0.262	0.324
2025	0.32	0.020	0.291	0.356
2026	0.34	0.019	0.307	0.371
2027	0.34	0.019	0.314	0.375
2028	0.35	0.018	0.315	0.376
2029	0.35	0.018	0.315	0.375
2030	0.34	0.018	0.315	0.375

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	216,000	23,400	177,000	254,000
2020	147,000	22,900	109,000	184,000
2021	92,600	7,820	79,800	105,000
2022	76,000	4,820	68,100	83,900
2023	98,000	5,440	89,000	107,000
2024	131,000	7,220	119,000	143,000
2025	156,000	8,160	142,000	169,000
2026	168,000	8,230	154,000	181,000
2027	171,000	8,070	158,000	185,000
2028	172,000	7,950	159,000	185,000
2029	172,000	7,890	159,000	185,000
2030	171,000	7,870	158,000	184,000

Table 2.26f—Model 16.6i projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = max\ F_{ABC}$ in each year 2019-2020 and $F = F_{OFL}$ thereafter (Scenario 7), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	290,000	25,800	248,000	333,000
2020	246,000	18,700	216,000	277,000
2021	205,000	13,500	183,000	227,000
2022	180,000	8,300	166,000	193,000
2023	187,000	8,110	174,000	201,000
2024	210,000	9,390	194,000	225,000
2025	229,000	11,000	211,000	247,000
2026	239,000	12,200	219,000	259,000
2027	242,000	12,800	221,000	263,000
2028	243,000	13,000	222,000	264,000
2029	243,000	13,000	222,000	264,000
2030	243,000	13,000	221,000	264,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.31	0.000	0.307	0.307
2020	0.29	0.000	0.286	0.286
2021	0.29	0.037	0.228	0.348
2022	0.25	0.021	0.215	0.285
2023	0.26	0.019	0.231	0.292
2024	0.30	0.020	0.263	0.328
2025	0.32	0.020	0.291	0.357
2026	0.34	0.019	0.307	0.371
2027	0.34	0.019	0.314	0.375
2028	0.35	0.018	0.315	0.375
2029	0.35	0.018	0.315	0.375
2030	0.34	0.018	0.315	0.375

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	181,000	14,800	157,000	206,000
2020	137,000	9,620	122,000	153,000
2021	109,000	17,100	80,900	137,000
2022	82,700	7,410	70,600	94,900
2023	101,000	6,470	90,600	112,000
2024	132,000	7,440	120,000	144,000
2025	156,000	8,120	143,000	169,000
2026	168,000	8,190	154,000	181,000
2027	171,000	8,060	158,000	185,000
2028	172,000	7,940	159,000	185,000
2029	172,000	7,890	159,000	184,000
2030	171,000	7,870	158,000	184,000

Table 2.27a (page 1 of 2)—Incidental catch (t) of FMP species taken in the EBS trawl fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both pages of the table).

Species/group	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Alaska Plaice												0.03	0.03	0.05
Arrowtooth Flounder	0.06	0.24	0.21	0.16	0.20	0.26	0.24	0.11	0.12	0.11	0.19	0.38	0.43	0.52
Atka Mackerel	0.12	0.20	0.01	0.02	0.01	0.11	0.22	0.82	0.11	0.19	0.27	0.35	0.75	0.76
Flathead Sole					0.32	0.30	0.29	0.16	0.21	0.19	0.11	0.22	0.23	0.33
Flounder	0.02	0.07	0.13	0.14										
Greenland Turbot	0.02	0.03	0.04	0.02	0.06	0.06	0.02	0.09	0.01	0.05	0.03	0.04	0.11	0.17
Kamchatka Flounder														
Northern Rockfish												0.40	0.24	0.59
Octopus														
Other Flatfish					0.06	0.07	0.06	0.04	0.03	0.05	0.05	0.14	0.33	0.49
Other Rockfish	0.04	0.28	0.23	0.05	0.14	0.11	0.07	0.35	0.14	0.19	0.02	0.11	0.28	0.33
Other Species													0.12	0.12
Pacific Cod	0.08	0.14	0.17	0.16	0.20	0.12	0.17	0.03	0.12	0.06	0.06	0.16	0.09	0.07
Pacific Ocean Perch	0.21	0.24	0.27	0.23	0.29	0.19	0.39	0.27	0.14	0.53	0.04	0.02	0.04	0.26
Pollock	0.05	0.12	0.24	0.20	0.21	0.25	0.30	0.23	0.45	0.30	0.18	0.27	0.38	0.39
Rock Sole	0.04	0.08	0.12	0.18	0.34	0.31	0.30	0.22	0.31	0.19	0.27	0.22	0.27	0.30
Rougheye Rockfish														0.12
Sablefish	0.01	0.01	conf	0.01	0.00	0.04	0.00	0.03	0.06	0.08	0.04	0.10	0.19	0.32
Sculpin														
Shark														
Sharpchin/Northern Rockfish		0.29	0.30								0.12			
Shortraker Rockfish														conf
Shortraker/Rougheye Rockfish		0.02	conf								conf	0.05	0.05	
Short/Rough/Sharp/North Rockfish	0.26	0.58	0.18	0.12	0.17	0.13	0.45	0.27	0.16	0.28	0.46			
Skate														
Squid	0.01	0.03	0.00	0.28	0.00	conf	0.00	0.01	0.00	0.00	0.01	0.00	0.02	0.01
Yellowfin Sole	0.00	0.01	0.03	0.04	0.01	0.05	0.02	0.02	0.03	0.07	0.05	0.09	0.06	0.11

Table 2.27a (page 2 of 2)—Incidental catch (t) of FMP species taken in the EBS trawl fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both pages of the table).

Species/group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Alaska Plaice	0.04	0.02	0.03	0.00	0.01	0.00	0.01	0.01	0.05	0.02	0.00	0.00	0.00	0.00
Arrowtooth Flounder	0.41	0.45	0.23	0.08	0.08	0.07	0.06	0.07	0.07	0.08	0.08	0.08	0.07	0.14
Atka Mackerel	0.36	0.24	0.17	0.10	0.40	0.39	0.33	0.27	0.06	0.09	0.03	0.84	0.00	0.03
Flathead Sole	0.23	0.41	0.39	0.11	0.07	0.06	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.07
Flounder														
Greenland Turbot	0.05	0.11	0.21	0.01	0.00	0.03	0.00	0.02	0.01	0.01	0.02	0.00	conf	0.09
Kamchatka Flounder							0.01	0.01	0.02	0.04	0.02	0.02	0.01	0.04
Northern Rockfish	0.31	0.28	0.08	0.05	0.03	0.20	0.12	0.11	0.01	0.01	0.00	conf	0.20	0.00
Octopus							0.03	0.01	0.02	0.02	0.01	0.00	0.06	0.19
Other Flatfish	0.35	0.20	0.07	0.03	0.03	0.04	0.03	0.03	0.03	0.01	0.07	0.12	0.04	0.04
Other Rockfish	0.32	0.24	0.06	0.06	0.02	0.03	0.03	0.32	0.03	0.03	0.07	0.04	0.01	0.02
Other Species	0.07	0.11	0.17	0.04	0.03	0.03								
Pacific Cod	0.03	0.08	0.12	0.01	0.06	0.06	0.05	0.05	0.05	0.05	0.05	0.04	0.09	0.09
Pacific Ocean Perch	0.22	0.08	0.04	0.01	0.01	0.00	0.01	0.07	0.00	conf	0.00	0.00	0.00	0.00
Pollock	0.36	0.53	0.75	0.43	0.37	0.31	0.41	0.29	0.22	0.17	0.05	0.10	0.04	0.10
Rock Sole	0.37	0.35	0.27	0.14	0.07	0.12	0.18	0.16	0.07	0.21	0.30	0.25	0.14	0.30
Rougheye Rockfish	0.05			conf		conf						conf	conf	
Sablefish	0.09	0.00	0.00	0.00	conf	conf	conf	conf	0.02		0.01	0.00	0.01	conf
Sculpin							0.07	0.07	0.07	0.07	0.07	0.12	0.05	0.10
Shark									0.00	0.00	0.01	conf	0.01	conf
Sharpchin/Northern Rockfish														
Shortraker Rockfish		conf	conf		conf				conf			conf	conf	
Shortraker/Rougheye Rockfish														
Short/Rough/Sharp/North Rockfish														
Skate							0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Squid	0.00	conf	0.00	conf		0.00								
Yellowfin Sole	0.11	0.08	0.03	0.01	0.00	0.01	0.01	0.01	0.06	0.02	0.00	0.00	0.00	0.01

Table 2.27b (page 1 of 2)—Incidental catch (t) of FMP species taken in the EBS longline fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both pages of the table).

Species/group	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Alaska Plaice												0.00	0.00	0.00
Arrowtooth Flounder	0.11	0.15	0.08	0.10	0.20	0.15	0.23	0.11	0.08	0.14	0.14	0.11	0.11	0.09
Atka Mackerel	0.00	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.01
Flathead Sole		conf			0.03	0.03	0.03	0.05	0.06	0.06	0.08	0.09	0.09	0.11
Flounder	0.01	0.01	0.01	0.01										
Greenland Turbot	0.10	0.20	0.05	0.09	0.14	0.19	0.19	0.07	0.04	0.12	0.05	0.08	0.17	0.11
Kamchatka Flounder														
Northern Rockfish												0.08	0.09	0.05
Octopus														
Other Flatfish					0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.06	0.04	0.06
Other Rockfish	0.03	0.12	0.14	0.08	0.06	0.20	0.11	0.08	0.20	0.12	0.35	0.25	0.11	0.23
Other Species													0.56	0.65
Pacific Cod	0.09	0.08	0.07	0.10	0.09	0.11	0.16	0.70	0.42	0.69	0.62	0.58	0.65	0.75
Pacific Ocean Perch	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
Pollock	0.01	0.02	0.02	0.02	0.03	0.03	0.04	0.04	0.02	0.05	0.06	0.04	0.05	0.03
Rock Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rougheye Rockfish														0.14
Sablefish	0.05	0.73	0.07	0.08	0.12	0.13	0.12	0.08	0.08	0.39	0.32	0.20	0.30	0.16
Sculpin														
Shark														
Sharpchin/Northern Rockfish		0.01	0.01								0.05			
Shortraker Rockfish														0.12
Shortraker/Rougheye Rockfish		0.10	0.19								0.74	0.19	0.20	
Short/Rough/Sharp/North Rockfish	0.03	0.05	0.04	0.11	0.18	0.18	0.05	0.14	0.03	0.19	0.05			
Skate														
Squid										0.00		conf	conf	conf
Yellowfin Sole	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.07	0.05	0.05	0.04

Table 2.27b (page 2 of 2)—Incidental catch (t) of FMP species taken in the EBS longline fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both pages of the table).

Species/group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Alaska Plaice	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Arrowtooth Flounder	0.14	0.12	0.16	0.18	0.20	0.16	0.22	0.28	0.14	0.21	0.33	0.26	0.38	0.23
Atka Mackerel	0.00	0.00	0.01	0.01	0.01	0.02	0.01	0.01	0.13	0.17	0.02	0.05	0.11	0.01
Flathead Sole	0.14	0.11	0.06	0.14	0.12	0.14	0.18	0.17	0.24	0.39	0.39	0.36	0.53	0.41
Flounder														
Greenland Turbot	0.12	0.13	0.15	0.11	0.15	0.14	0.14	0.11	0.01	0.02	0.13	0.43	0.46	0.20
Kamchatka Flounder							0.13	0.11	0.07	0.09	0.13	0.19	0.14	0.17
Northern Rockfish	0.08	0.04	0.11	0.30	0.56	0.68	0.37	0.16	0.38	0.43	0.48	0.35	0.53	0.19
Octopus							0.05	0.12	0.11	0.06	0.08	0.08	0.12	0.11
Other Flatfish	0.09	0.07	0.01	0.01	0.06	0.07	0.02	0.03	0.01	0.01	0.04	0.02	0.02	0.00
Other Rockfish	0.26	0.24	0.24	0.19	0.16	0.58	0.37	0.20	0.37	0.49	0.51	0.23	0.34	0.26
Other Species	0.68	0.56	0.44	0.51	0.51	0.53								
Pacific Cod	0.82	0.63	0.68	0.63	0.73	0.51	0.78	0.66	0.63	0.77	0.78	0.81	0.64	0.70
Pacific Ocean Perch	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Pollock	0.03	0.03	0.03	0.11	0.10	0.23	0.18	0.09	0.11	0.04	0.06	0.08	0.09	0.04
Rock Sole	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.03	0.05	0.02	0.03	0.02
Rougheye Rockfish	0.33	0.68	0.48	0.39	0.31	0.18	0.27	0.19	0.17	0.26	0.45	0.37	0.09	0.26
Sablefish	0.22	0.21	0.16	0.03	0.04	0.04	0.16	0.02	0.10	0.07	0.26	0.71	0.19	0.04
Sculpin							0.25	0.25	0.17	0.31	0.38	0.35	0.38	0.33
Shark							0.31	0.33	0.40	0.42	0.44	0.38	0.28	0.21
Sharpchin/Northern Rockfish														
Shortraker Rockfish	0.31	0.20	0.63	0.12	0.64	0.31	0.28	0.23	0.09	0.09	0.23	0.12	0.13	0.15
Shortraker/Rougheye Rockfish														
Short/Rough/Sharp/North Rockfish														
Skate							0.76	0.76	0.78	0.82	0.89	0.91	0.89	0.82
Squid	conf			conf	conf	conf	0.00		0.00	0.00	0.00	conf	0.00	
Yellowfin Sole	0.07	0.05	0.02	0.06	0.09	0.03	0.14	0.20	0.23	0.39	0.47	0.36	0.37	0.33

Table 2.27c (page 1 of 2)—Incidental catch (t) of FMP species taken in the EBS pot fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both pages of the table).

Species/group	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Alaska Plaice												conf	conf	conf
Arrowtooth Flounder	0.00	0.00	conf	conf	0.00	0.00	0.00	0.00	conf	conf	conf	0.02	0.00	0.00
Atka Mackerel	0.00	0.03	conf	0.05	0.23	0.11	0.29	0.03	conf	conf	conf	conf	0.06	0.03
Flathead Sole					conf	0.00	conf	conf	0.00	conf	conf	conf	0.00	0.00
Flounder	conf	0.00	conf	conf										
Greenland Turbot	conf	conf		conf	0.00	0.00	conf	conf	conf		conf	conf	0.00	
Kamchatka Flounder														
Northern Rockfish												conf	0.02	0.01
Octopus														
Other Flatfish					conf	0.00	0.00	conf	conf	conf	conf	conf	0.00	0.00
Other Rockfish	0.00	0.00	conf	0.01	0.02	0.04	0.06	0.03	conf	conf	conf	conf	0.07	0.04
Other Species													0.02	0.01
Pacific Cod	0.00	0.00	0.00	0.01	0.01	0.02	0.00	0.01	0.02	0.02	0.02	0.03	0.06	0.02
Pacific Ocean Perch	conf	conf	conf	conf	0.00	0.00	conf	conf	conf	conf	conf	conf	0.00	0.00
Pollock	0.00	0.00	conf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	conf	0.00	0.00	0.00
Rock Sole	0.00	0.00	conf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	conf	conf	0.00	0.00
Rougheye Rockfish														0.00
Sablefish	conf	conf		conf	conf	conf	conf	conf	conf		conf	conf	0.00	0.01
Sculpin														
Shark														
Sharpchin/Northern Rockfish		conf	conf								conf			
Shortraker Rockfish														
Shortraker/Rougheye Rockfish														
Short/Rough/Sharp/North Rockfish											conf			
Skate														
Squid					conf	conf			conf		conf	conf		
Yellowfin Sole	0.00	0.00	conf	conf	0.00	0.01	0.00	0.00	0.00	0.00	conf	0.00	0.01	0.01

Table 2.27c (page 2 of 2)—Incidental catch (t) of FMP species taken in the EBS pot fishery for Pacific cod, expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both pages of the table).

Species/group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Alaska Plaice	conf	conf	conf					0.00	conf	conf	conf	conf	conf	conf
Arrowtooth Flounder	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Atka Mackerel	0.17	0.29	0.11	0.68	0.03	0.56	0.11	0.05	0.19	0.35	0.07	0.08	0.08	0.10
Flathead Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Flounder														
Greenland Turbot	conf	0.00	conf	conf	conf		0.00			conf	conf	conf	conf	conf
Kamchatka Flounder							0.00	0.00	0.00	conf	0.00	0.00	0.00	0.00
Northern Rockfish	0.02	0.01	0.02	0.11	0.06	0.02	0.02	0.01	0.00	0.01	0.01	0.00	0.00	0.00
Octopus							0.88	0.81	0.85	0.90	0.85	0.87	0.77	0.45
Other Flatfish	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Other Rockfish	0.10	0.12	0.01	0.02	0.00	0.02	0.04	0.02	0.12	0.06	0.05	0.04	0.04	0.02
Other Species	0.01	0.02	0.01	0.02	0.01	0.01								
Pacific Cod	0.02	0.03	0.02	0.08	0.01	0.01	0.02	0.02	0.02	0.04	0.03	0.03	0.03	0.03
Pacific Ocean Perch	0.00	0.00	conf	0.00	0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00
Pollock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rock Sole	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rougheye Rockfish	0.01													
Sablefish	0.00	0.08					conf		0.00			0.01	0.01	0.02
Sculpin							0.03	0.02	0.06	0.07	0.06	0.07	0.04	0.03
Shark							conf	0.00						
Sharpchin/Northern Rockfish														
Shortraker Rockfish						0.00				conf				
Shortraker/Rougheye Rockfish														
Short/Rough/Sharp/North Rockfish														
Skate							0.00	conf		0.00	conf	conf	conf	0.00
Squid	conf		conf			conf				conf		0.00		
Yellowfin Sole	0.01	0.01	0.02	0.02	0.01	0.00	0.01	0.01	0.05	0.08	0.08	0.03	0.04	0.05

Table 2.28—Incidental catch (t) of selected members of the former "Other Species" complex taken in the EBS fisheries for Pacific cod (all gears), expressed as a proportion of the incidental catch of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both halves of the table).

Species Common Name	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
octopus, North Pacific									conf	conf	conf	0.73	0.81	0.82
Pacific sleeper shark									conf	conf	0.05	0.09	0.50	0.56
shark, other												conf	0.66	0.35
shark, salmon									conf				conf	conf
shark, spiny dogfish										0.91	0.42	0.92	0.99	0.97
skate, Alaskan														
skate, big														0.84
skate, longnose												conf	0.71	0.55
skate, other									0.16	0.04	conf	0.43	0.81	0.85
squid, majestic	0.01	0.03	0.00	0.28	0.00	conf	0.00	0.01	0.00	0.00	0.01	0.00	0.02	0.01

Species Common Name	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
octopus, North Pacific	0.88	0.94	0.89	0.90	0.66	0.86	0.97	0.94	0.98	0.97	0.94	0.95	0.95	0.75
Pacific sleeper shark	0.60	0.41	0.20	0.17	0.30	0.58	0.50	0.22	0.39	0.61	0.61	0.55	0.54	0.44
shark, other	0.52	0.01	0.16	0.42	0.72	0.48	0.75	0.41	0.79	0.74	0.61	0.48	0.65	conf
shark, salmon	0.07	0.02							0.01		conf	conf	conf	conf
shark, spiny dogfish	0.98	0.97	0.83	0.63	0.95	0.93	0.93	0.98	0.80	0.88	0.89	0.87	0.92	0.86
skate, Alaskan						0.26								
skate, big	0.72	0.92	0.73	0.71	0.51	0.73								
skate, longnose	0.97	0.67	0.37	1.00	0.67	0.49								
skate, other	0.85	0.78	0.75	0.70	0.67	0.93	0.77	0.77	0.79	0.83	0.90	0.92	0.90	0.83
squid, majestic	0.00	conf	0.00	conf	conf	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	conf

Table 2.29—Incidental catch (herring and halibut in t, salmon and crab in number of individuals) of all prohibited species and discard mortality (halibut only, in t) taken in the EBS fisheries for Pacific cod (all gears), expressed as a proportion of the incidental catch or mortality of that species taken in all FMP EBS fisheries, 1991-2018 (2018 data current through September 23). Color scale extends from red=low to green=high for each row (computed across both halves of the table).

Incidental catch

Species Group Name	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Bairdi Tanner Crab	0.20	0.10	0.07	0.13	0.14	0.22	0.15	0.10	0.17	0.16	0.14	0.29	0.24	0.31
Blue King Crab													0.91	0.94
Chinook Salmon	0.09	0.12	0.13	0.18	0.34	0.09	0.09	0.04	0.14	0.20	0.08	0.04	0.04	0.09
Golden (Brown) King Crab													0.01	0.00
Halibut	0.52	0.64	0.49	0.67	0.71	0.74	0.71	0.68	0.66	0.69	0.63	0.67	0.67	0.71
Herring	conf	0.01	0.03	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.02	0.02	0.01	0.01
Non-Chinook Salmon	0.00	0.00	0.00	0.01	0.04	0.00	0.01	0.01	0.00	0.00	0.03	0.01	0.01	0.01
Opilio Tanner (Snow) Crab	0.02	0.02	0.02	0.04	0.05	0.10	0.17	0.17	0.33	0.12	0.12	0.34	0.27	0.14
Other King Crab	0.02	0.12	0.01	0.08	0.16	0.66	0.54	0.73	0.35	0.33	0.58	0.69		
Red King Crab	0.31	0.07	0.01	0.01	0.17	0.78	0.36	0.23	0.18	0.38	0.26	0.32	0.14	0.14
Species Group Name	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Bairdi Tanner Crab	0.19	0.41	0.60	0.67	0.54	0.40	0.21	0.22	0.26	0.50	0.61	0.61	0.51	0.45
Blue King Crab	0.95	0.70	1.00	0.87	0.89	1.00	0.60	0.80	0.37	0.74	0.84	0.83	0.99	0.94
Chinook Salmon	0.04	0.03	0.04	0.03	0.02	0.04	0.00	0.05	0.04	0.05	0.05	0.08	0.05	0.09
Golden (Brown) King Crab	0.21	0.01	0.00	0.00	0.01	0.02	0.00	0.02	0.03	0.03	0.02	0.02	0.71	0.25
Halibut	0.64	0.67	0.62	0.55	0.60	0.65	0.68	0.69	0.67	0.64	0.67	0.62	0.73	0.67
Herring	0.03	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
Non-Chinook Salmon	0.00	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Opilio Tanner (Snow) Crab	0.08	0.34	0.54	0.47	0.54	0.24	0.16	0.08	0.06	0.20	0.23	0.21	0.49	0.03
Other King Crab														
Red King Crab	0.16	0.15	0.33	0.29	0.10	0.06	0.35	0.26	0.76	0.82	0.90	0.40	0.37	0.49

Discard mortality

Species Group Name	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Halibut				0.46	0.50	0.53	0.47	0.44	0.46	0.42	0.34	0.43	0.47	0.55
Species Group Name	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Halibut	0.49	0.48	0.39	0.26	0.23	0.25	0.27	0.31	0.26	0.23	0.27	0.25	0.24	0.22

Table 2.30a (page 1 of 2)—Incidental catch (t) of non-target species groups—other than birds—taken in the EBS fisheries for Pacific cod (all gears), expressed as a proportion of the incidental catch of that species group taken in all FMP EBS fisheries, 2003-2018 (2018 data are current through October 14). Color scale extends from red=low to green=high for each row.

Species Group Name	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Benthic urochordata	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.04	0.20	0.28	0.21	0.30	0.27	0.05	0.07	0.58
Bivalves	0.42	0.85	0.74	0.77	0.62	0.85	0.85	0.47	0.82	0.92	0.89	0.80	0.81	0.77	0.86	0.80
Bristlemouths																
Brittle star Unident.	0.02	0.02	0.01	0.02	0.04	0.01	0.05	0.01	0.07	0.06	0.09	0.04	0.08	0.05	0.40	0.13
Capelin		0.02			0.00	0.00		0.00	0.00	0.00	0.10	0.02	0.00		0.00	
Corals Bryozoans - Corals Bryozoans Unident.	0.51	0.48	0.40	0.10	0.88	0.15	0.85	0.24	0.50	0.92	0.25	0.48	0.60	0.37	0.81	0.32
Corals Bryozoans - Red Tree Coral	0.90	0.66	0.46	0.01	0.99	0.02	conf								1.00	
Dark Rockfish						0.98	0.96									
Deep sea smelts (bathylagidae)																
Eelpouts	0.23	0.37	0.47	0.30	0.11	0.09	0.04	0.05	0.05	0.14	0.16	0.28	0.58	0.50	0.62	0.40
Eulachon		0.00	0.00	0.00	0.00	conf		0.00	0.00	0.00					0.00	
Giant Grenadier	0.03	0.08	0.12	0.06	0.07	0.08	0.07	0.12	0.28	0.21	0.12	0.20	0.04	0.16	0.11	0.19
Greenlings	0.75	0.66	0.58	0.65	0.20	0.73	0.74	0.78	0.64	0.77	1.00	0.84	0.69	0.62	0.53	0.35
Grenadier - Pacific Grenadier		0.70	0.00					0.05								
Grenadier - Ratail Grenadier Unident.	0.09	0.11	0.14	0.10	0.23	0.40	0.08									
Grenadier - Rattail Grenadier Unident.								0.19	0.04	0.04	0.76	0.07	0.62	0.09	0.01	
Gunnels		1.00	1.00		0.03									0.01		
Hermit crab Unident.	0.05	0.05	0.02	0.04	0.03	0.03	0.06	0.02	0.03	0.06	0.08	0.07	0.15	0.17	0.37	0.33
Invertebrate Unident.	0.03	0.01	0.01	0.08	0.22	0.02	0.24	0.41	0.38	0.21	0.25	0.31	0.28	0.51	0.47	0.40
Lanternfishes (myctophidae)		0.06														0.00
Large Sculpins	0.62	0.60	0.50	0.45	0.37											
Large Sculpins - Bigmouth Sculpin						0.35	0.46									
Large Sculpins - Brown Irish Lord						1.00	1.00									
Large Sculpins - Great Sculpin						0.19	0.16									
Large Sculpins - Hemilepidotus Unident.						0.90	0.99									
Large Sculpins - Myoxocephalus Unident.						0.24	0.62									
Large Sculpins - Plain Sculpin						0.01	0.01									
Large Sculpins - Red Irish Lord						0.11	0.64									
Large Sculpins - Warty Sculpin						0.22	0.15									
Large Sculpins - Yellow Irish Lord						0.52	0.33									
Misc crabs	0.15	0.12	0.16	0.46	0.38	0.18	0.12	0.19	0.11	0.15	0.20	0.22	0.20	0.16	0.42	0.49
Misc crustaceans	0.26	0.21	0.51	0.17	0.21	0.03	0.02	0.05	0.04	0.03	0.11	0.09	0.06	0.15	0.02	0.02
Misc deep fish																0.11
Misc fish	0.48	0.43	0.40	0.28	0.19	0.15	0.19	0.20	0.24	0.36	0.24	0.62	0.45	0.52	0.27	0.31
Misc inverts (worms etc)	0.07	0.02	0.01	0.06	0.33	0.01	0.02	0.00	conf	0.00	0.00	0.02	conf		0.00	

Table 2.30a (page 2 of 2)—Incidental catch (t) of non-target species groups—other than birds—taken in the EBS fisheries for Pacific cod (all gears), expressed as a proportion of the incidental catch of that species group taken in all FMP EBS fisheries, 2003-2018 (2018 data are current through October 14). Color scale extends from red=low to green=high for each row.

Species Group Name	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Other Sculpins	0.49	0.65	0.56	0.57	0.41	0.70	0.59									
Other osmerids	0.01	0.06	0.00	0.01	0.00		0.00	conf	0.00	0.00	0.00		conf		0.00	
Pacific Hake																
Pacific Sand lance	0.45	0.34	0.60	0.04	0.12	0.21		conf	0.01	conf		0.02	0.09	0.09	0.21	0.08
Pacific Sandfish								0.28				0.07	0.19	0.32	0.84	0.14
Pandalid shrimp	0.09	0.17	0.01	0.02	0.09	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Polychaete Unident.	0.13	0.02	0.73	0.00	0.01	0.00	0.10	0.04	0.08	0.37	0.04	0.29	0.42	0.48	0.03	0.00
Scypho jellies	0.10	0.09	0.07	0.02	0.04	0.01	0.01	0.01	0.02	0.02	0.05	0.01	0.02	0.01	0.01	0.02
Sea anemone Unident.	0.68	0.62	0.86	0.79	0.35	0.51	0.74	0.62	0.76	0.86	0.76	0.81	0.86	0.88	0.80	0.68
Sea pens whips	0.87	0.90	0.93	0.87	0.63	0.86	0.92	0.87	0.90	0.91	0.96	0.96	0.96	0.96	0.95	0.91
Sea star	0.11	0.14	0.16	0.12	0.09	0.07	0.15	0.11	0.09	0.20	0.16	0.23	0.21	0.19	0.26	0.13
Snails	0.13	0.07	0.10	0.08	0.10	0.09	0.25	0.17	0.17	0.25	0.31	0.43	0.46	0.69	0.66	0.72
Sponge Unident.	0.03	0.10	0.07	0.15	0.08	0.08	0.07	0.03	0.06	0.15	0.09	0.09	0.17	0.15	0.18	0.26
State-managed Rockfish								0.96	0.98	0.79	0.98	0.29	0.77	0.23	0.67	0.74
Stichaeidae	0.17	0.06	0.14	0.07	0.01	conf	0.00	0.00					0.03			
Surf smelt																
urchins dollars cucumbers	0.37	0.49	0.50	0.43	0.26	0.17	0.08	0.15	0.35	0.41	0.26	0.38	0.48	0.59	0.24	0.34

Table 2.30b—Incidental catch (t) of bird species groups taken in the EBS fisheries for Pacific cod (all gears), expressed as a proportion of the incidental catch of that species group taken in all FMP EBS fisheries, 2003-2018 (2018 data are current through October 14).

Species Group Name	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Auklets	0.99									1.00		0.33	1.00	1.00	1.00	
Black-footed Albatross	1.00	1.00	1.00	0.97	1.00	1.00	1.00	1.00								
Cormorant				1.00												
Gull	1.00	1.00	1.00	0.97	0.59	0.99	0.90	0.89	1.00	1.00	0.96	1.00	1.00	0.97	1.00	1.00
Kittiwake	1.00	0.31	0.44				0.34		1.00	1.00	1.00	1.00	1.00	1.00	0.59	1.00
Laysan Albatross	0.65	0.76	0.36	0.01	0.00	0.67	0.00	0.31	0.94	0.71	0.20	0.73	0.17	0.69	0.27	0.13
Murre	0.57	0.41	0.01	0.64	0.73	1.00	1.00			1.00				0.22	0.90	
Northern Fulmar	0.94	0.91	0.86	0.57	0.74	0.75	0.86	0.85	0.86	0.79	0.87	0.83	0.84	0.93	0.80	0.96
Other	1.00															
Other Alcid		1.00														1.00
Puffin								1.00						1.00		
Shearwaters	0.89	0.99	0.36	0.95	0.94	0.99	0.87	0.85	0.72	0.90	0.69	0.37	0.67	0.93	0.96	1.00
Short-tailed Albatross								1.00	1.00			0.42				
Storm Petrels	1.00			0.33												
Unidentified	0.99	0.96	0.99	0.97	0.96	1.00	0.92	0.94	1.00	0.95	0.94	1.00	0.94	0.98	0.92	1.00
Unidentified Albatross												0.93				

FIGURES

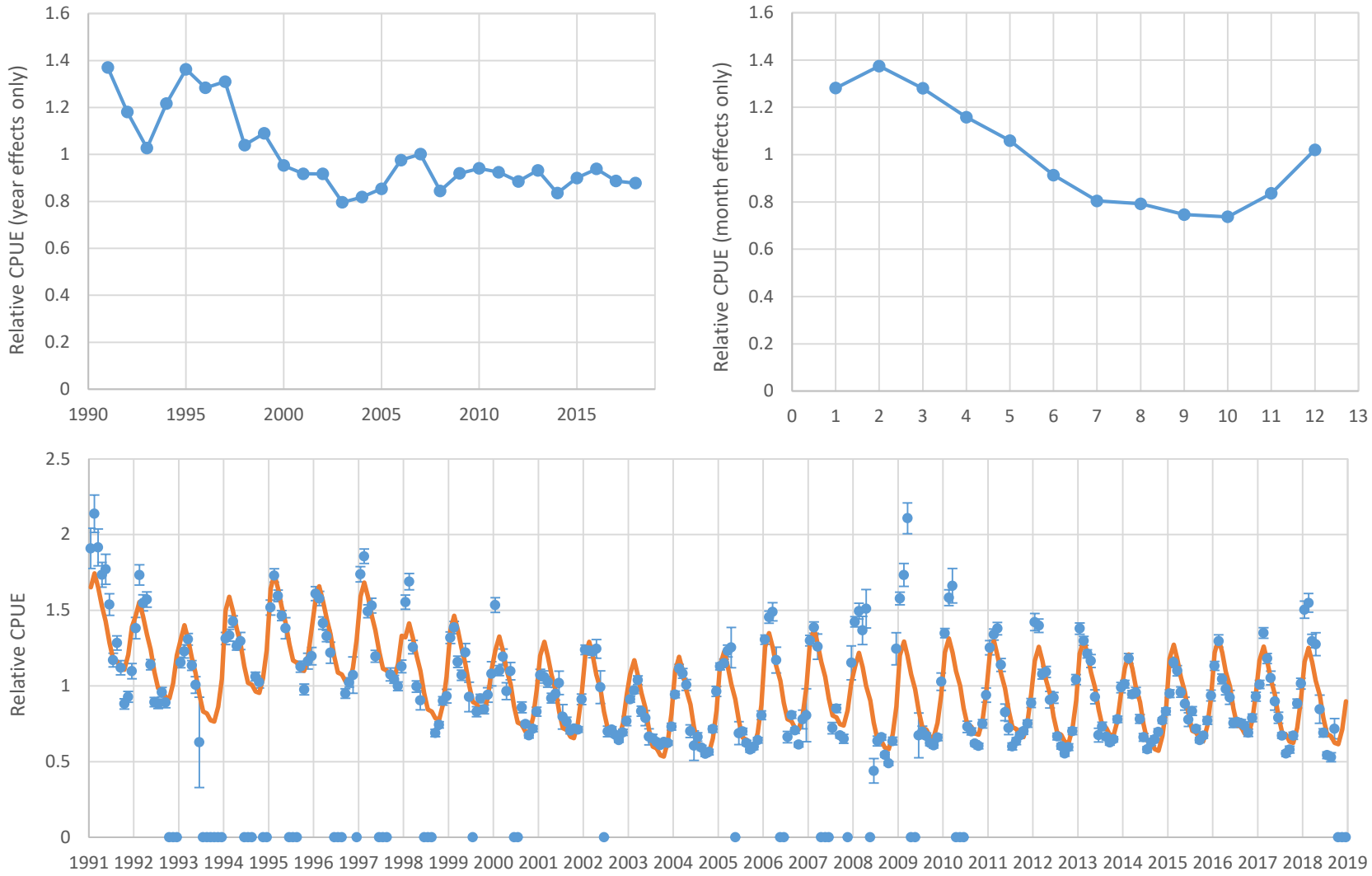

Figure 2.1—Longline fishery CPUE. Upper left panel: year effects, upper right panel: month effects, lower panel: monthly data and model fit.

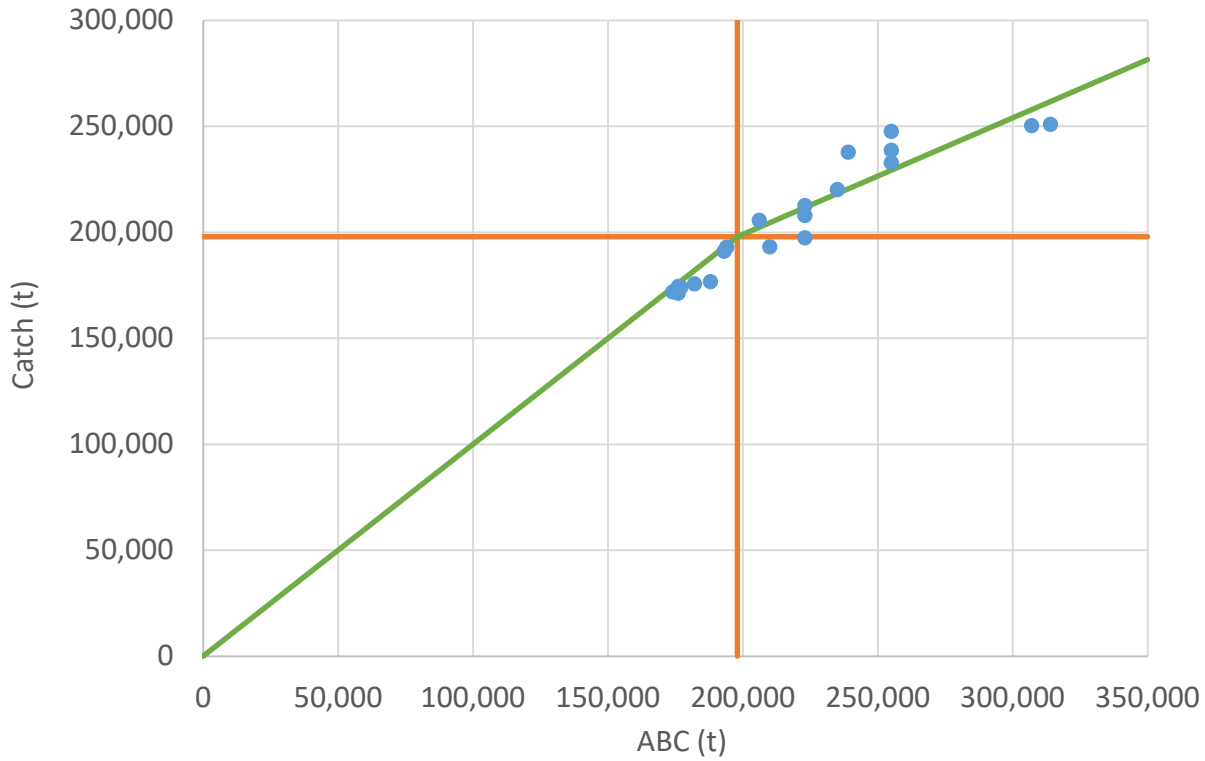

Figure 2.2—The most recent 20 complete years of ABCs and total catches, together with the best fitting two-segment linear model, where the first segment is constrained to pass through the origin.

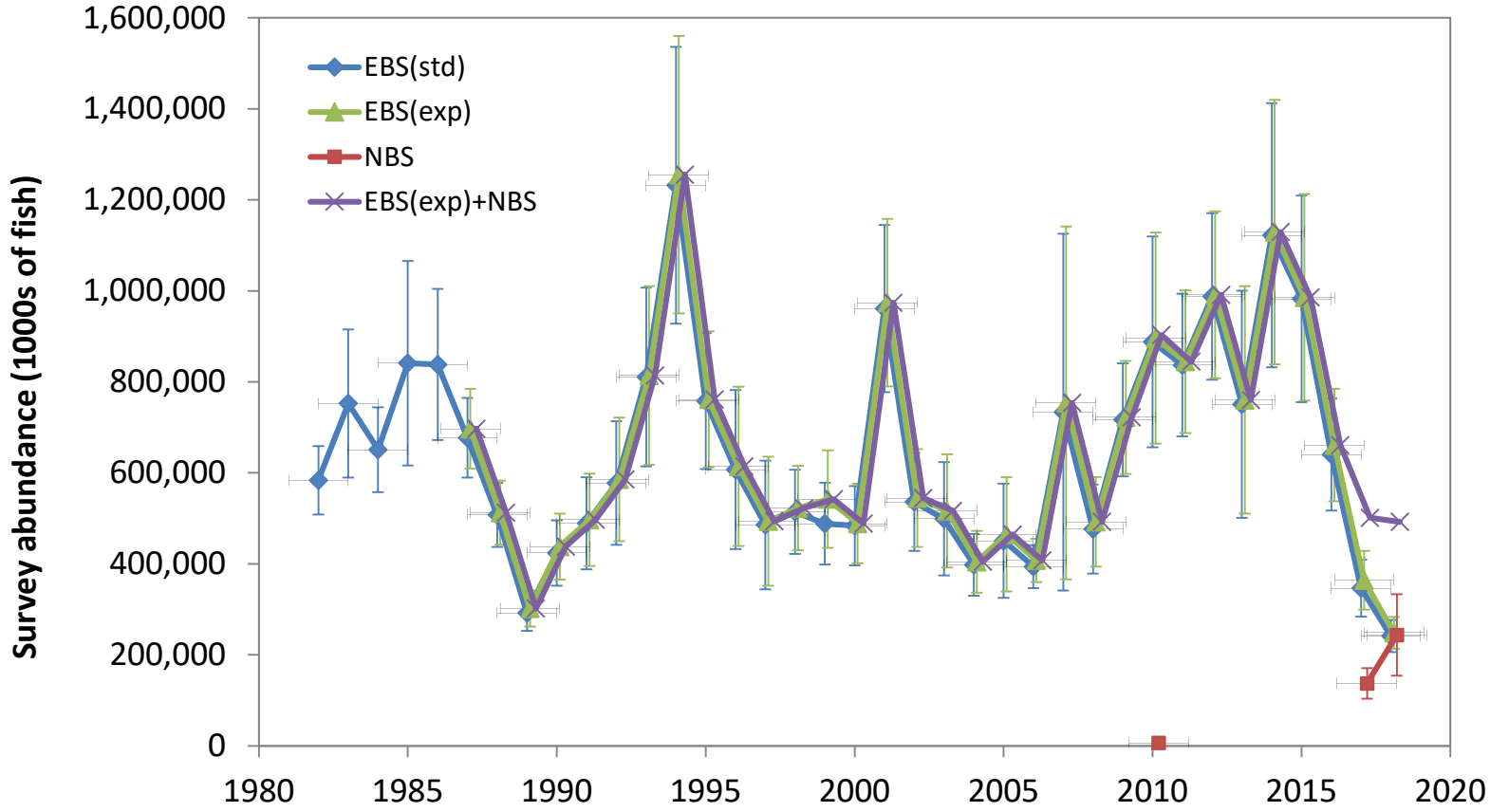

Figure 2.3—EBS trawl survey (standard and expanded areas), NBS trawl survey, and combined EBS (expanded) and NBS trawl survey numerical abundance estimates, with 95% confidence intervals.

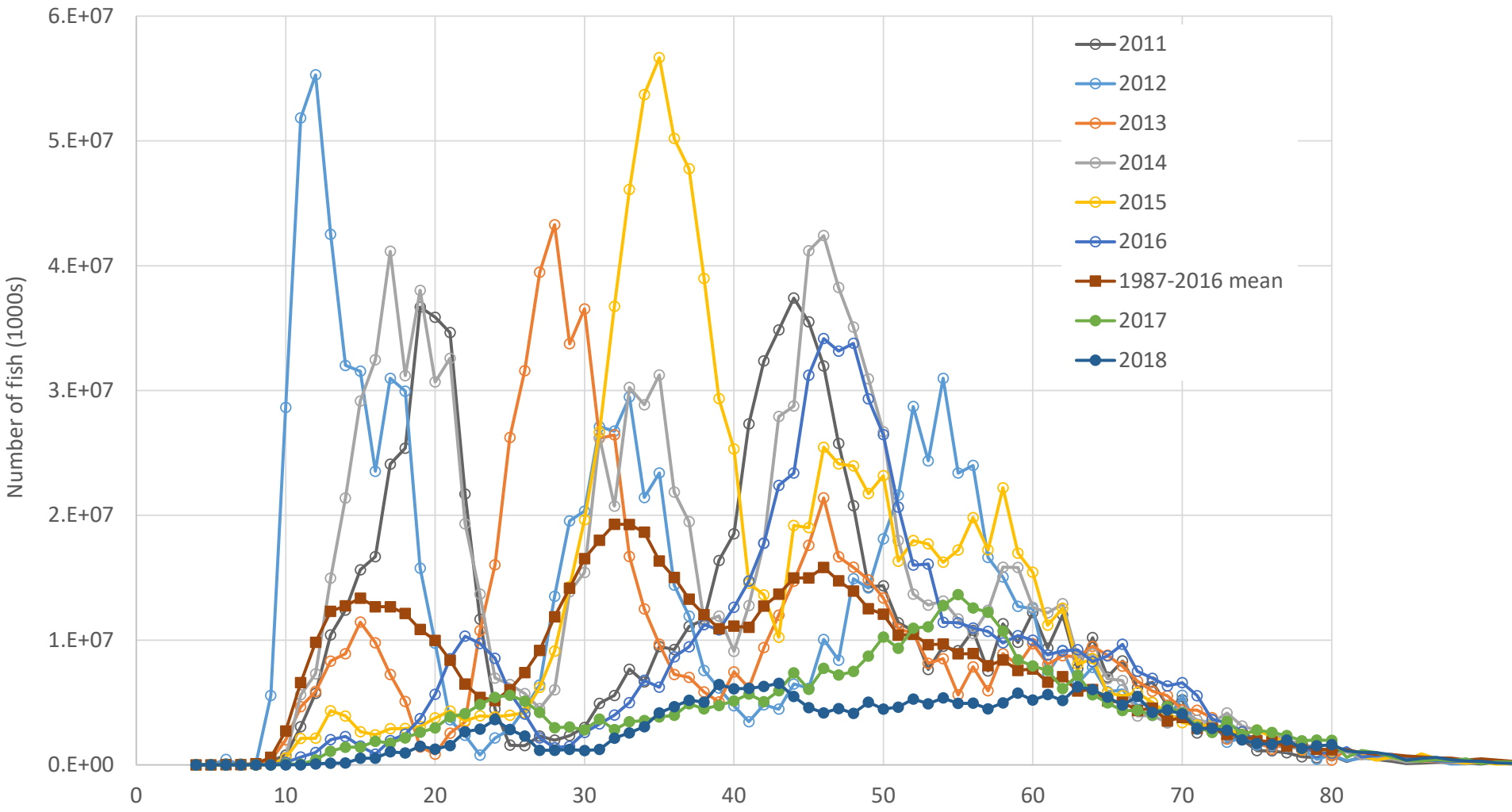

Figure 2.4a—Comparison of recent size compositions from the EBS shelf bottom trawl survey (expanded area), along with the 1987-2016 mean.

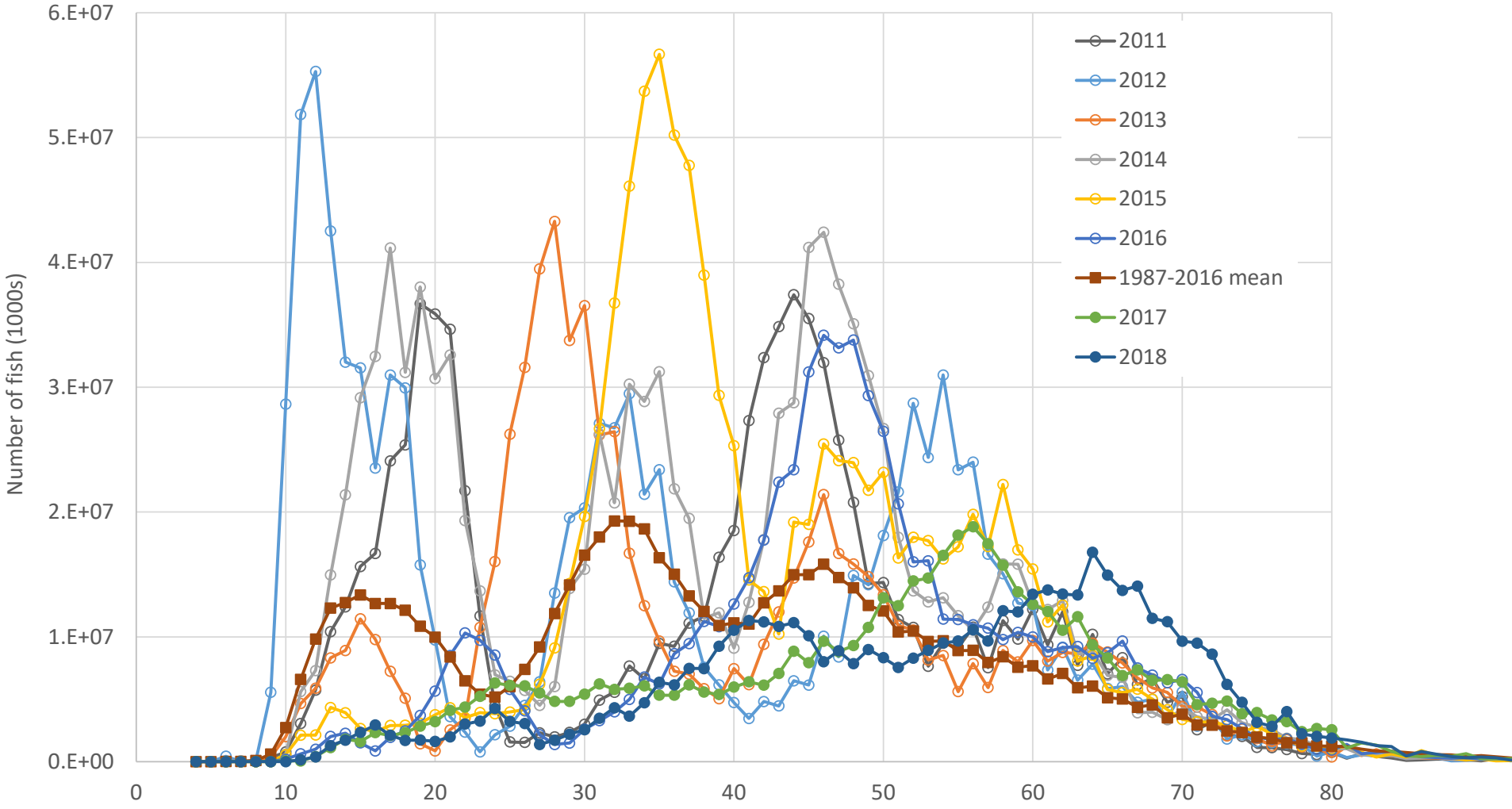

Figure 2.4b—Comparison of recent size compositions from the combined EBS (expanded area) and NBS shelf bottom trawl surveys, along with the 1987-2016 mean.

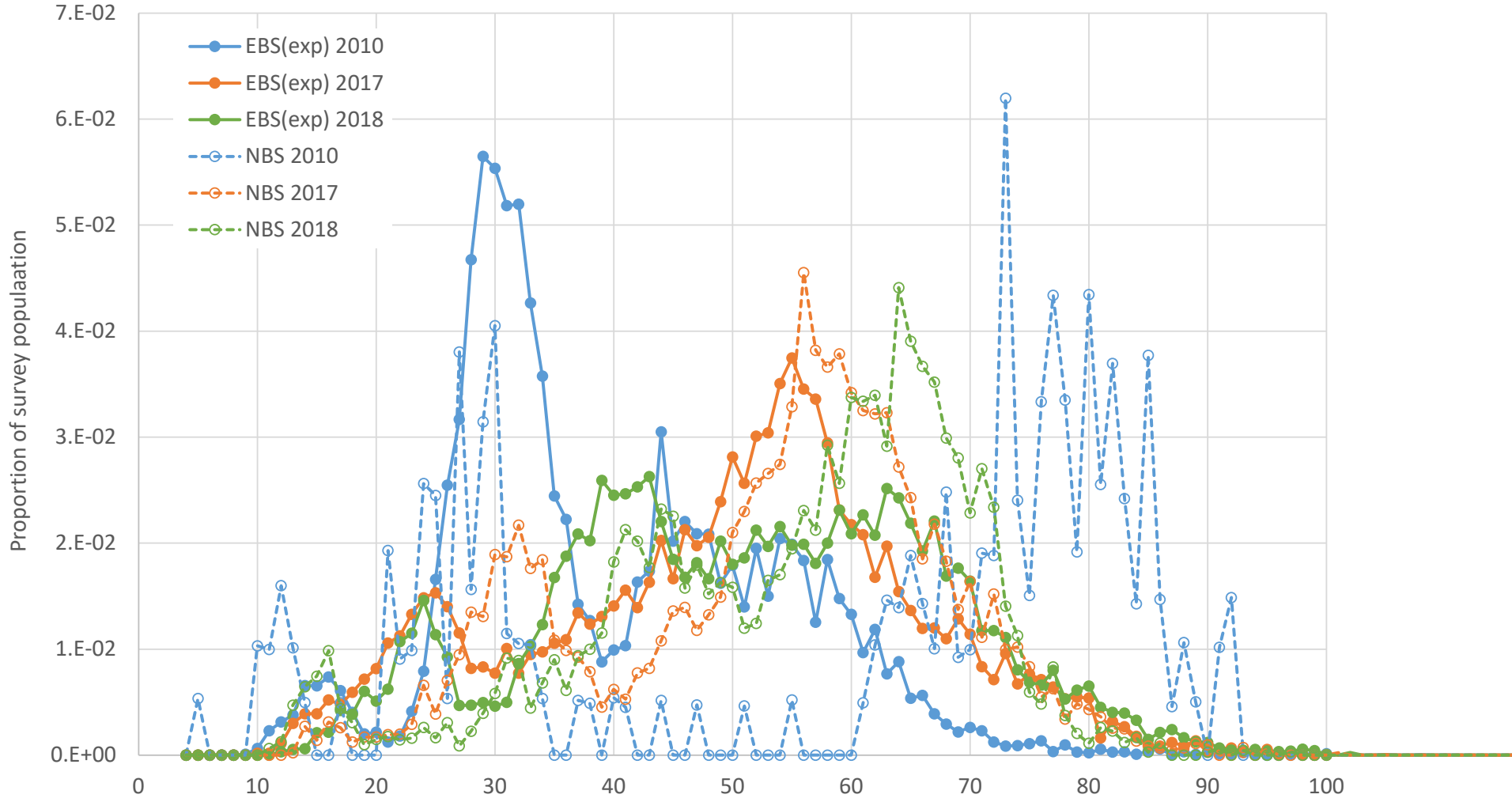

Figure 2.4c—Comparison of size compositions between the EBS (expanded area) and NBS shelf bottom trawl surveys, 2010-2018.

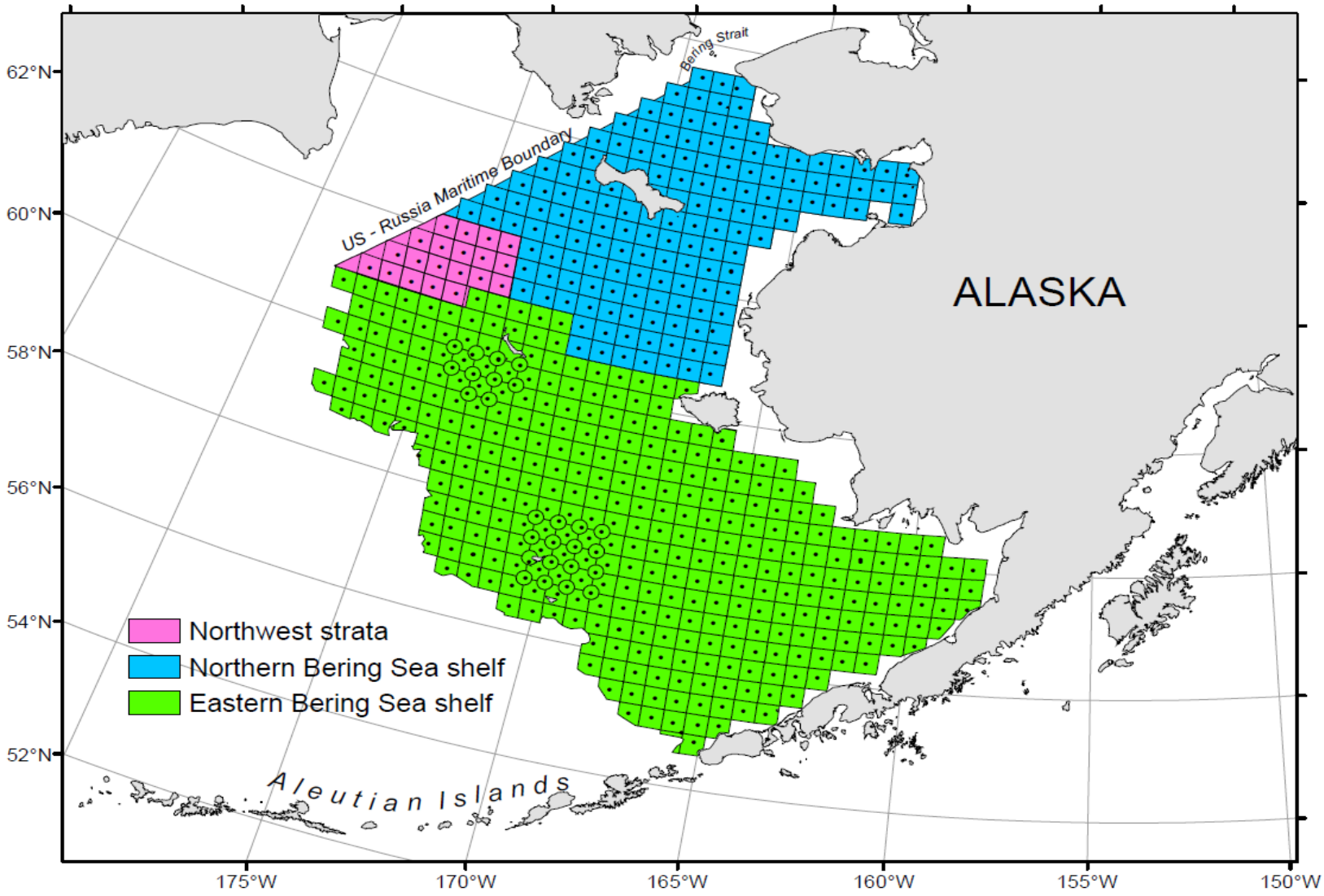

Figure 2.5a—Map of EBS shelf trawl survey standard area, EBS shelf trawl survey northwest strata, and NBS trawl survey area.

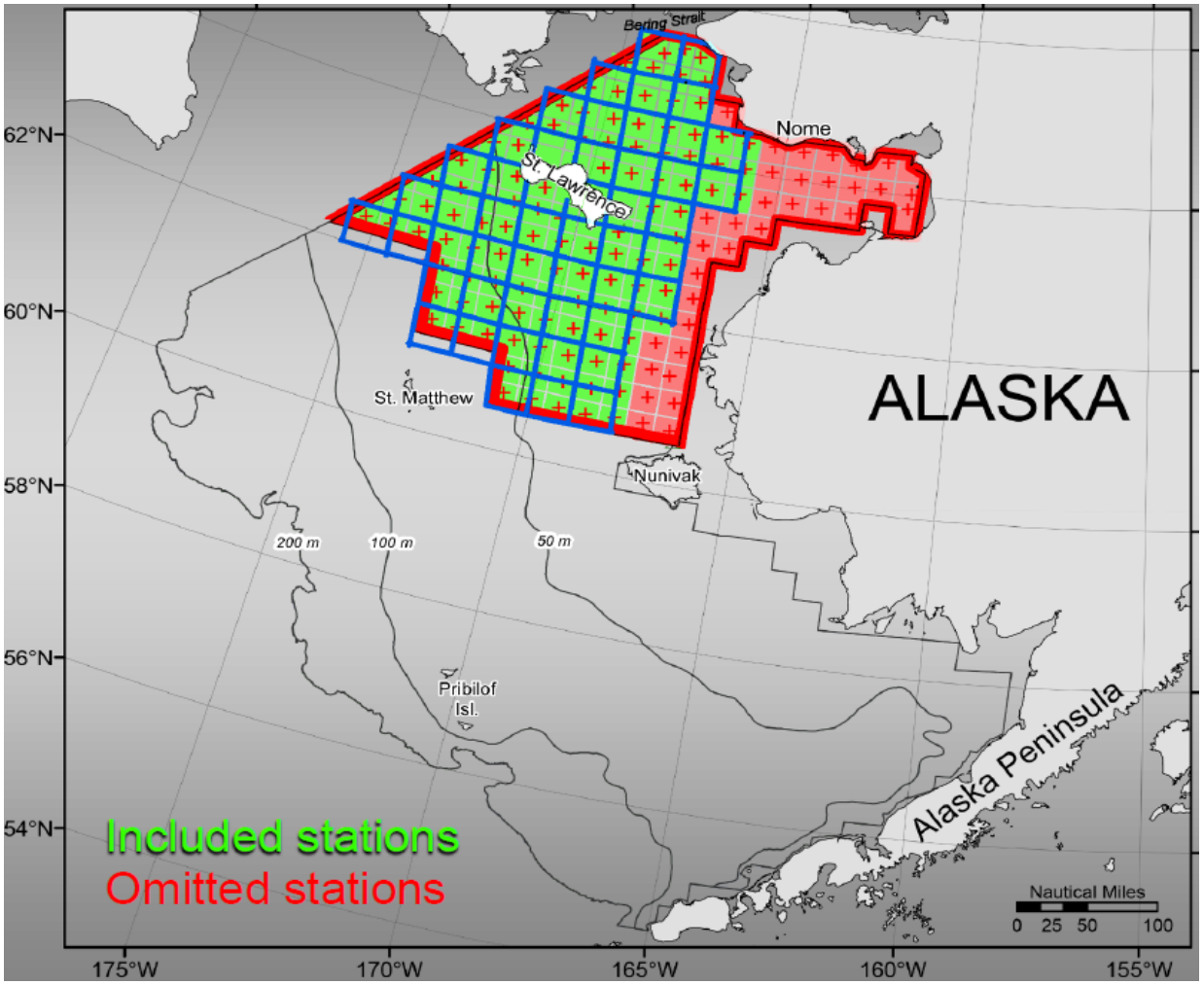

Figure 2.5b—Map of "truncated" NBS trawl survey area.

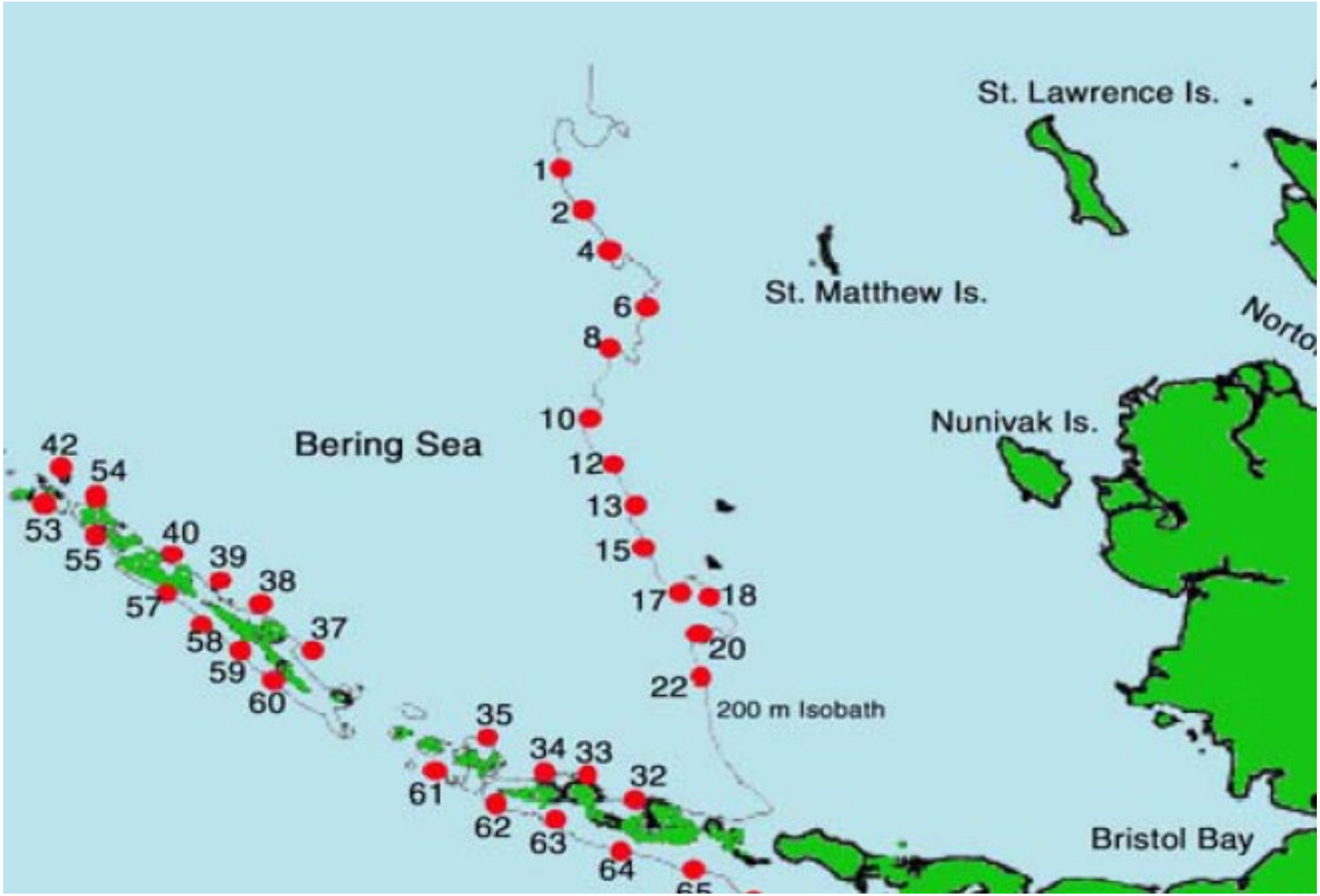

Figure 2.5c—Map of NMFS longline survey area in the EBS and AI.

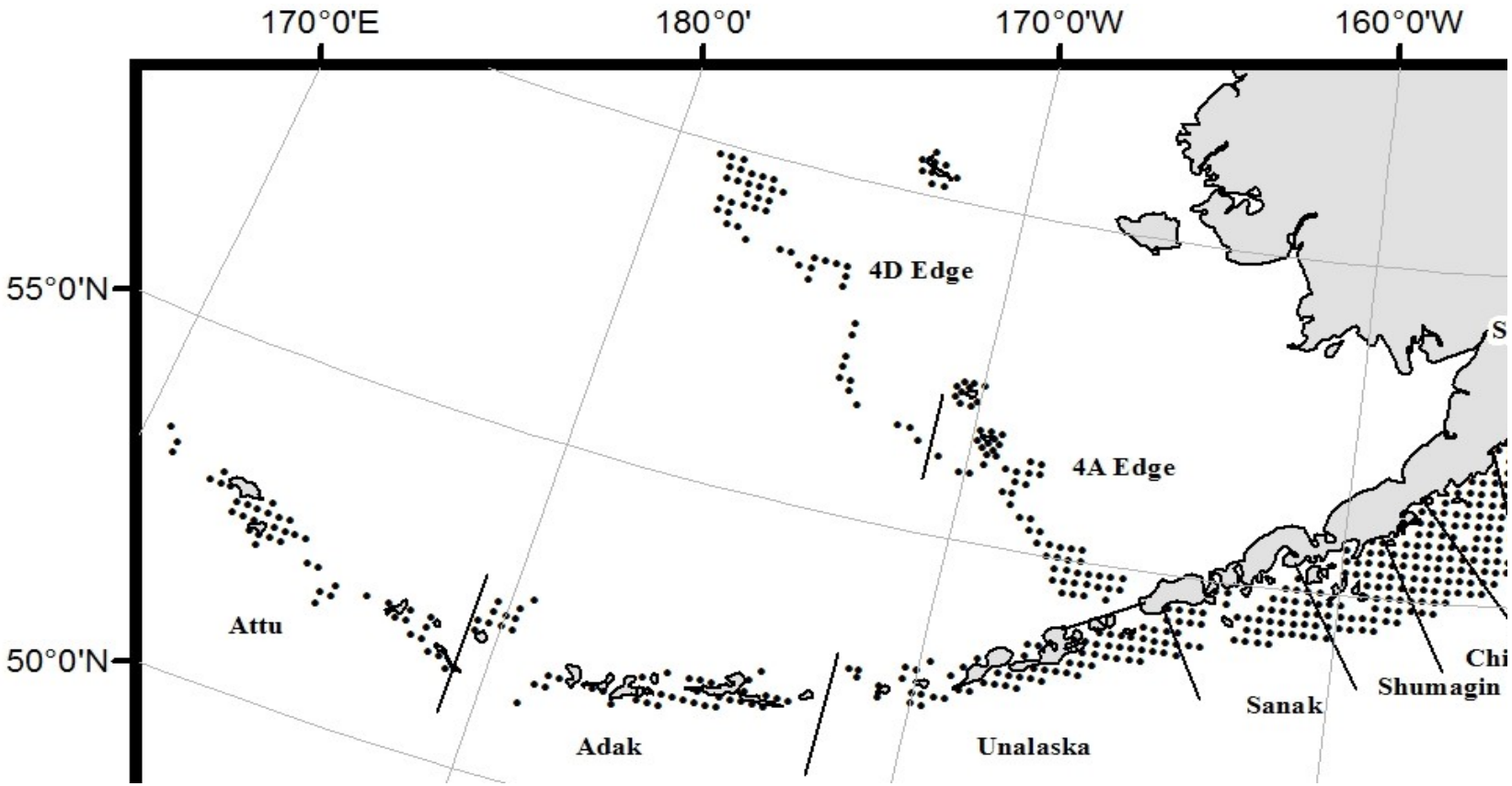

Figure 2.5d—Map of IPHC longline survey area in the EBS and AI.

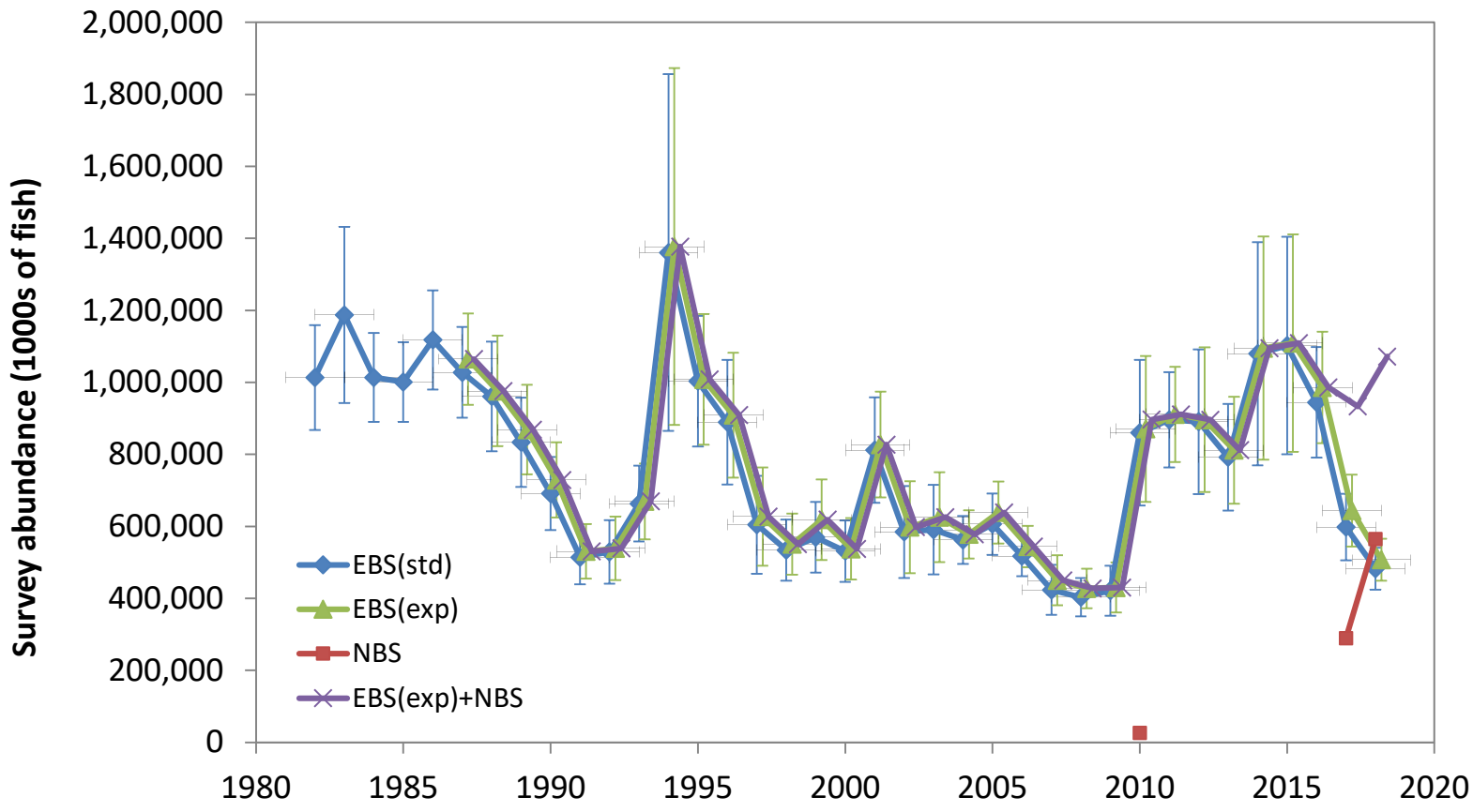

Figure 2.6—EBS trawl survey (standard and expanded areas), NBS trawl survey, and combined EBS (expanded) and NBS trawl survey biomass estimates, with 95% confidence intervals.

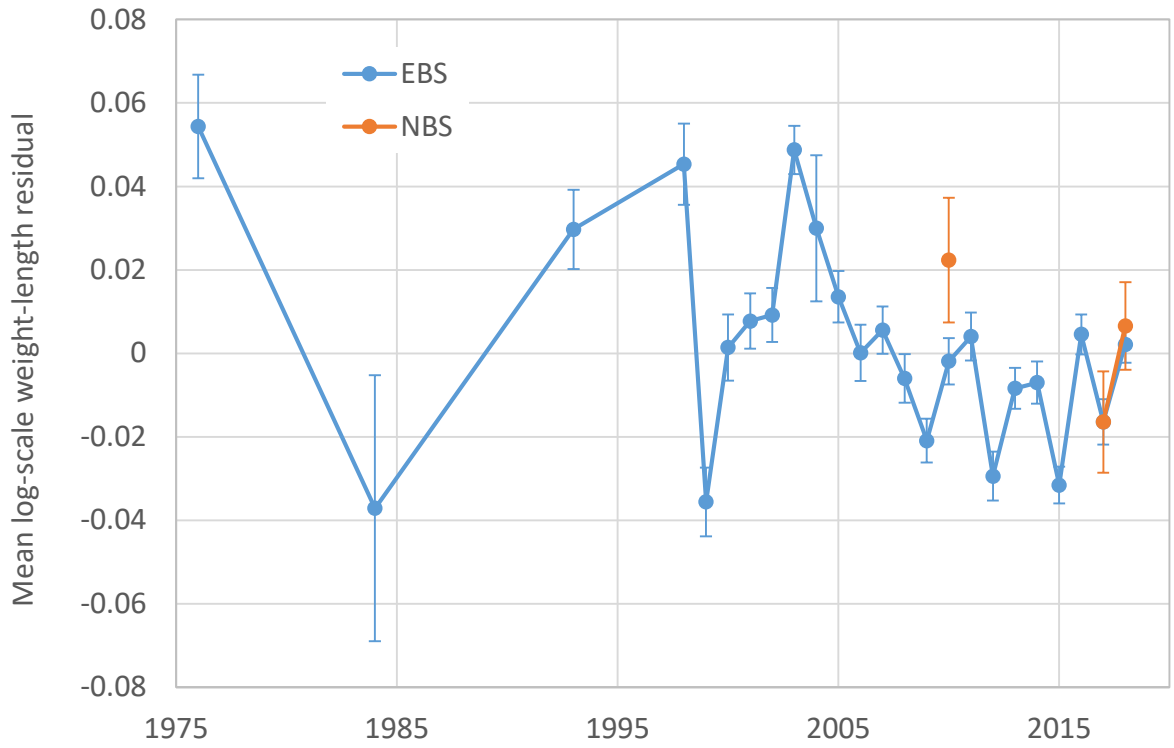

Figure 2.7—Mean condition factor (based on log weight-length residuals), with 95% confidence intervals, as estimated from EBS and NBS trawl survey data.

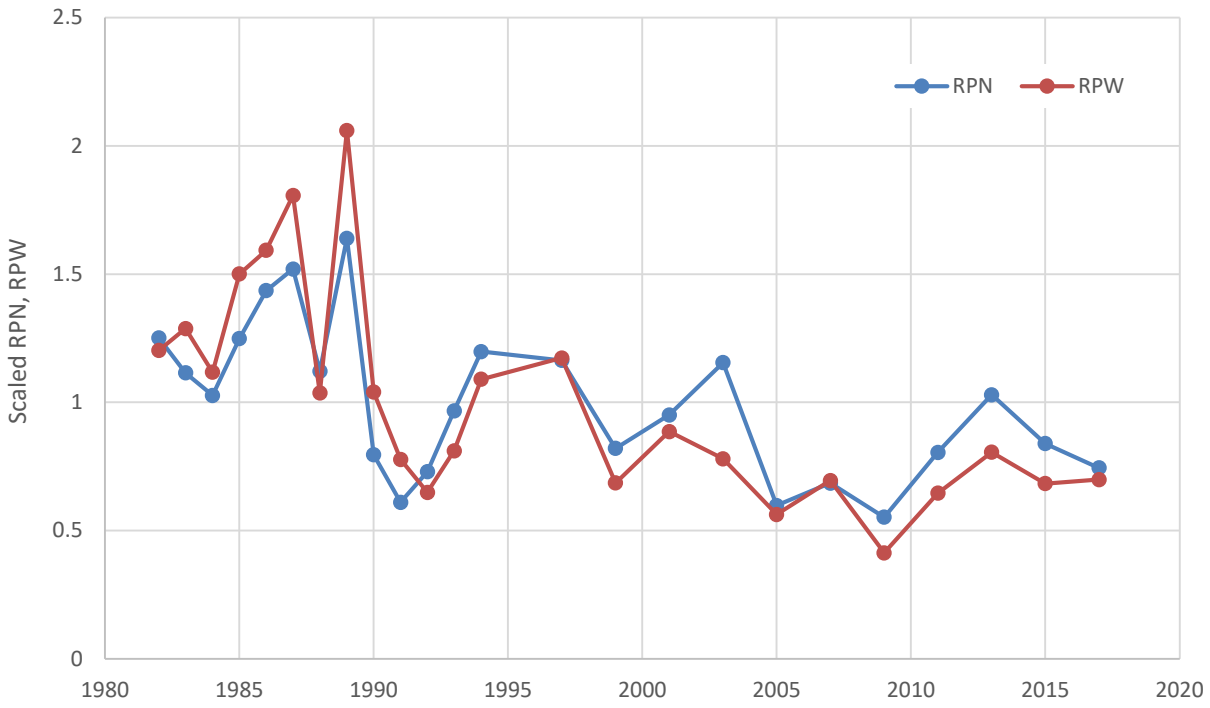

Figure 2.8—NMFS longline survey RPN and RPW, rescaled so that the average of each is 1.0.

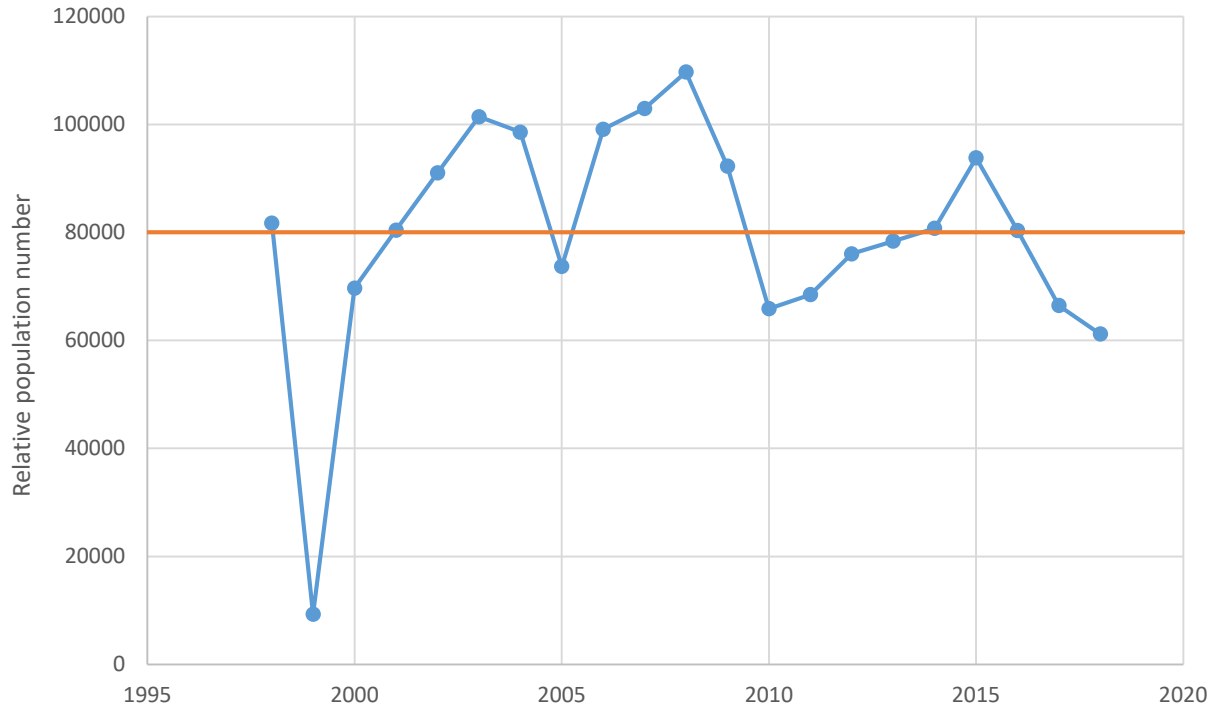

Figure 2.9—IPHC longline survey RPN. Orange line = long-term average.

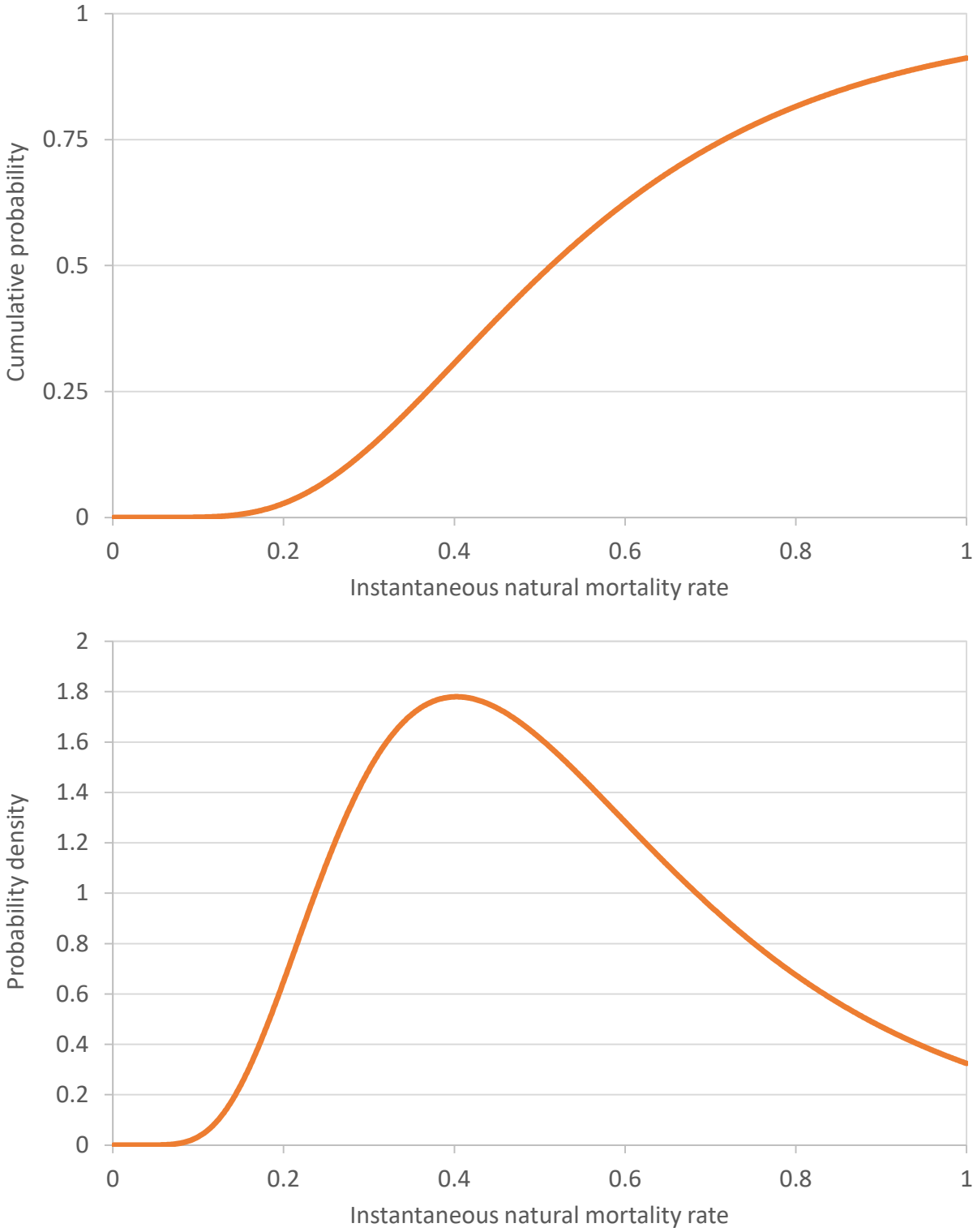

Figure 2.10—Prior distribution for the natural mortality rate. Upper panel: cumulative distribution function; lower panel: probability density function.

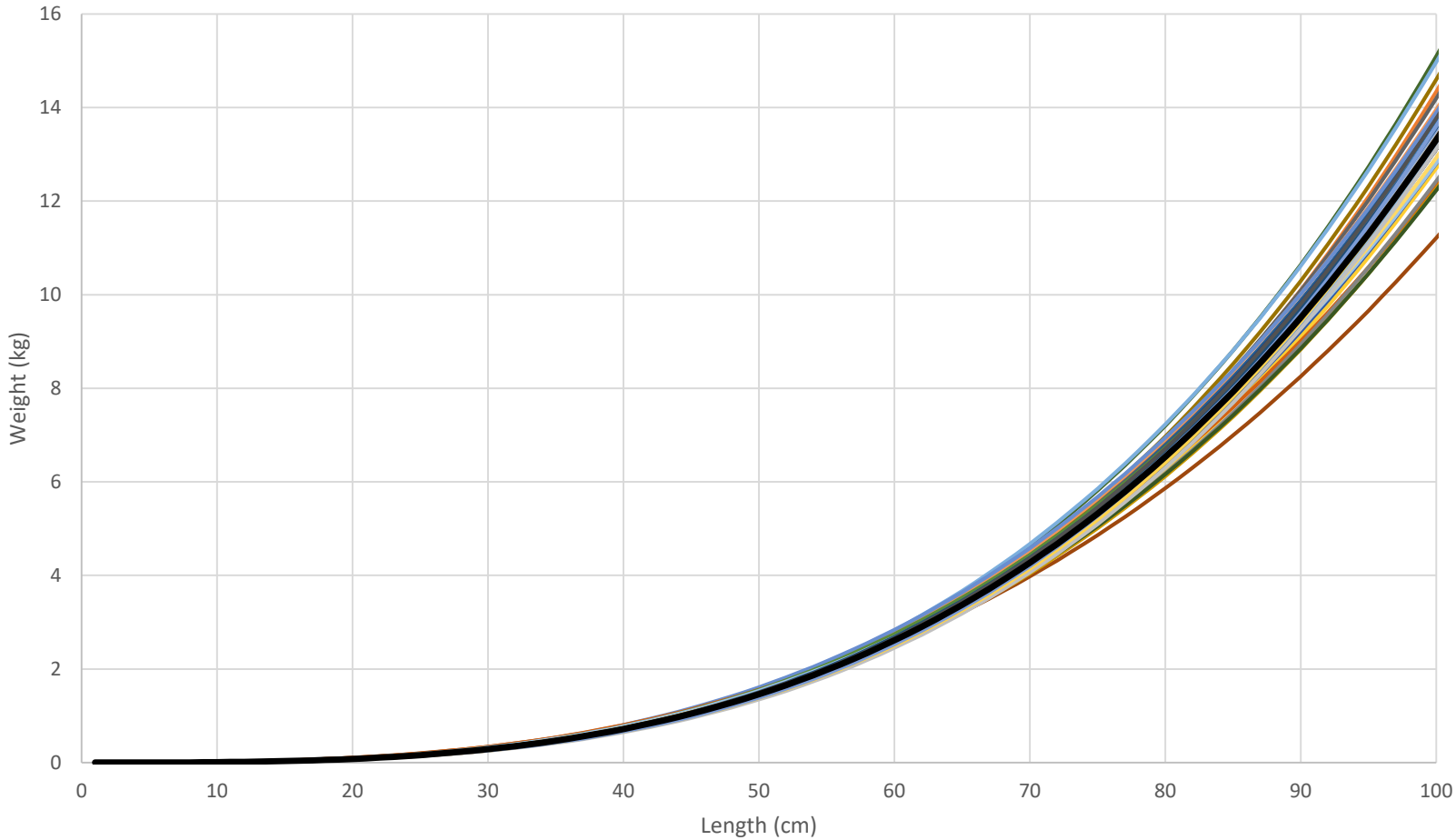

Figure 2.11—Weight-at-length relationships for each year from 1978-2017. Solid black curve represents base parameter values. The curve that is noticeably lower than the others at lengths greater than about 70 cm represents the 1984 relationship.

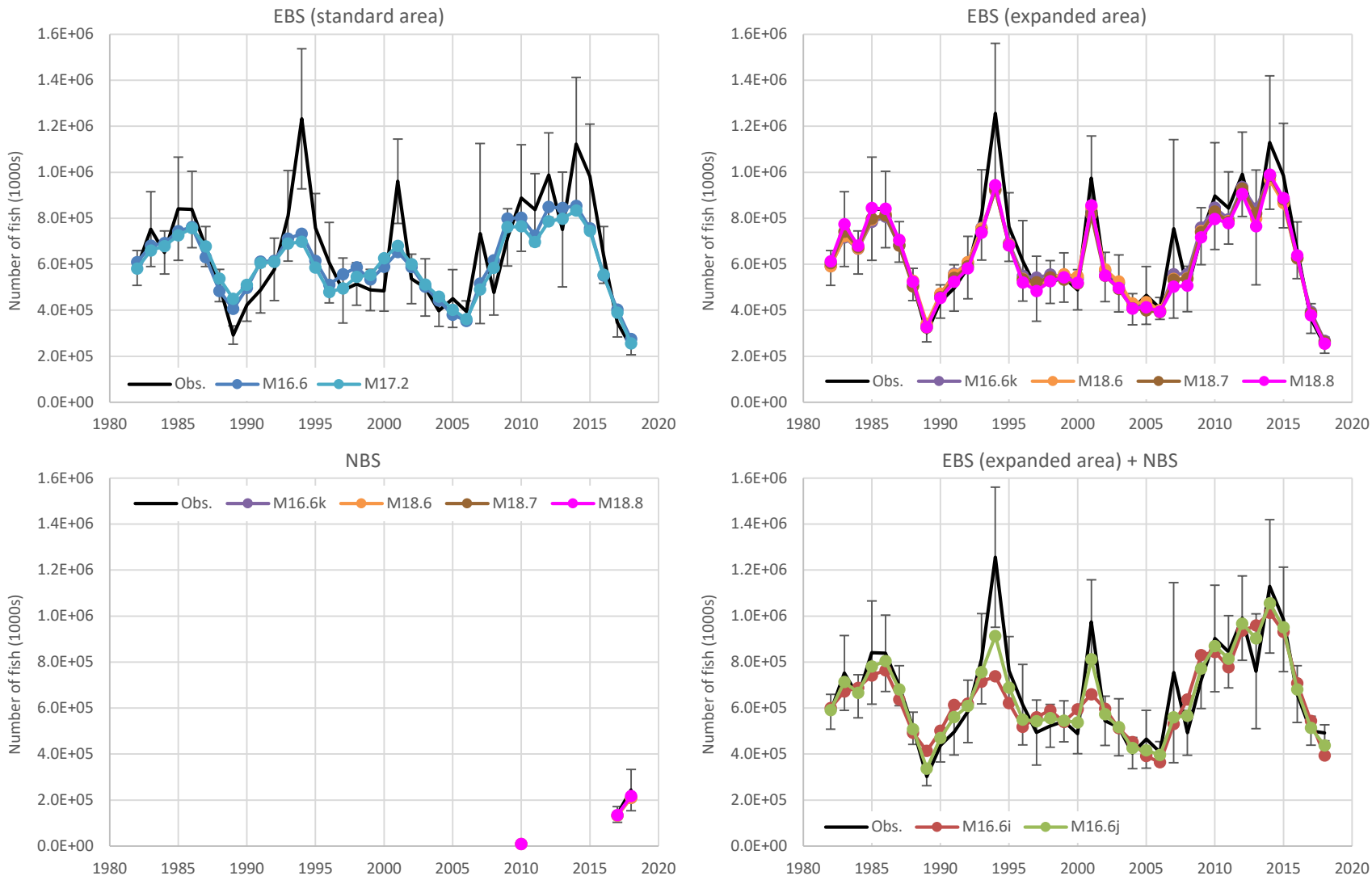

Figure 2.12—Model fits to the EBS (standard and expanded areas), NBS, and combined EBS (expanded) and NBS shelf bottom trawl survey abundance time series.

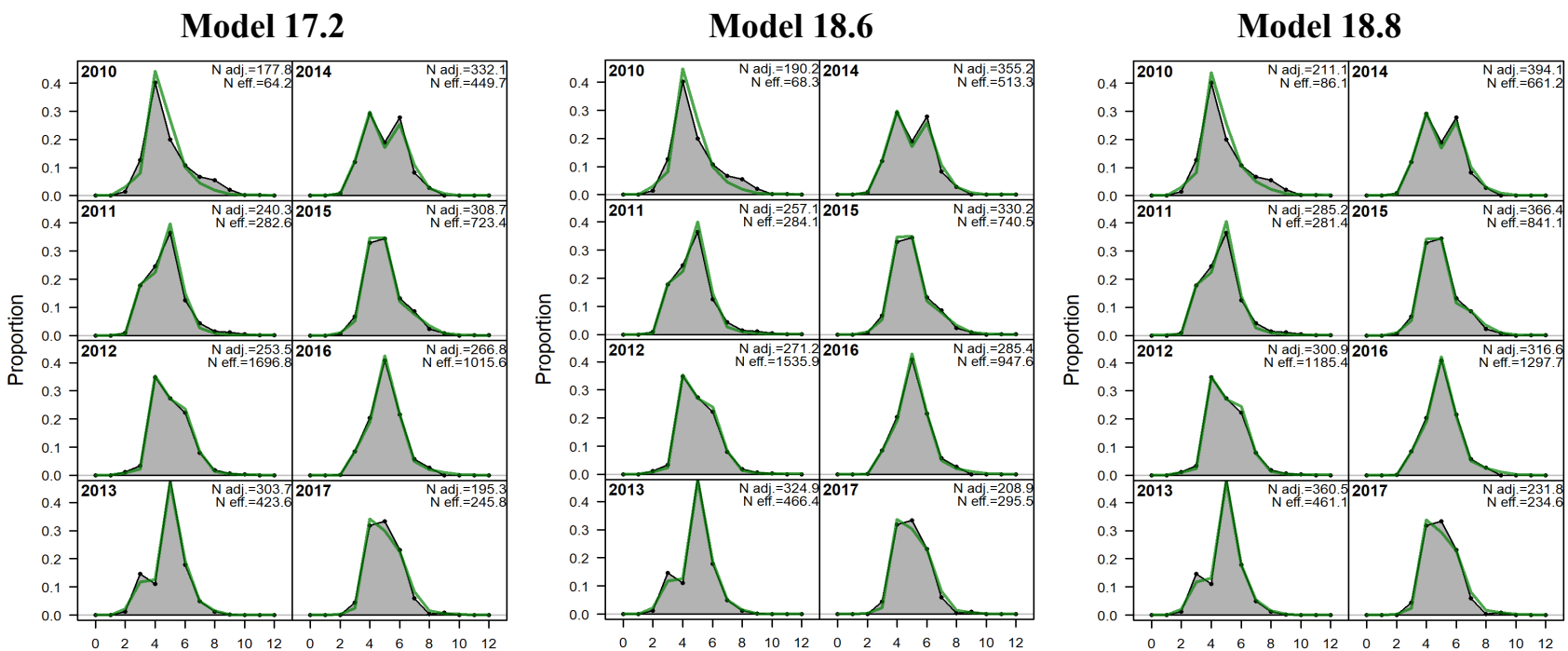

Figure 2.13—Model fits to the fishery age composition data.

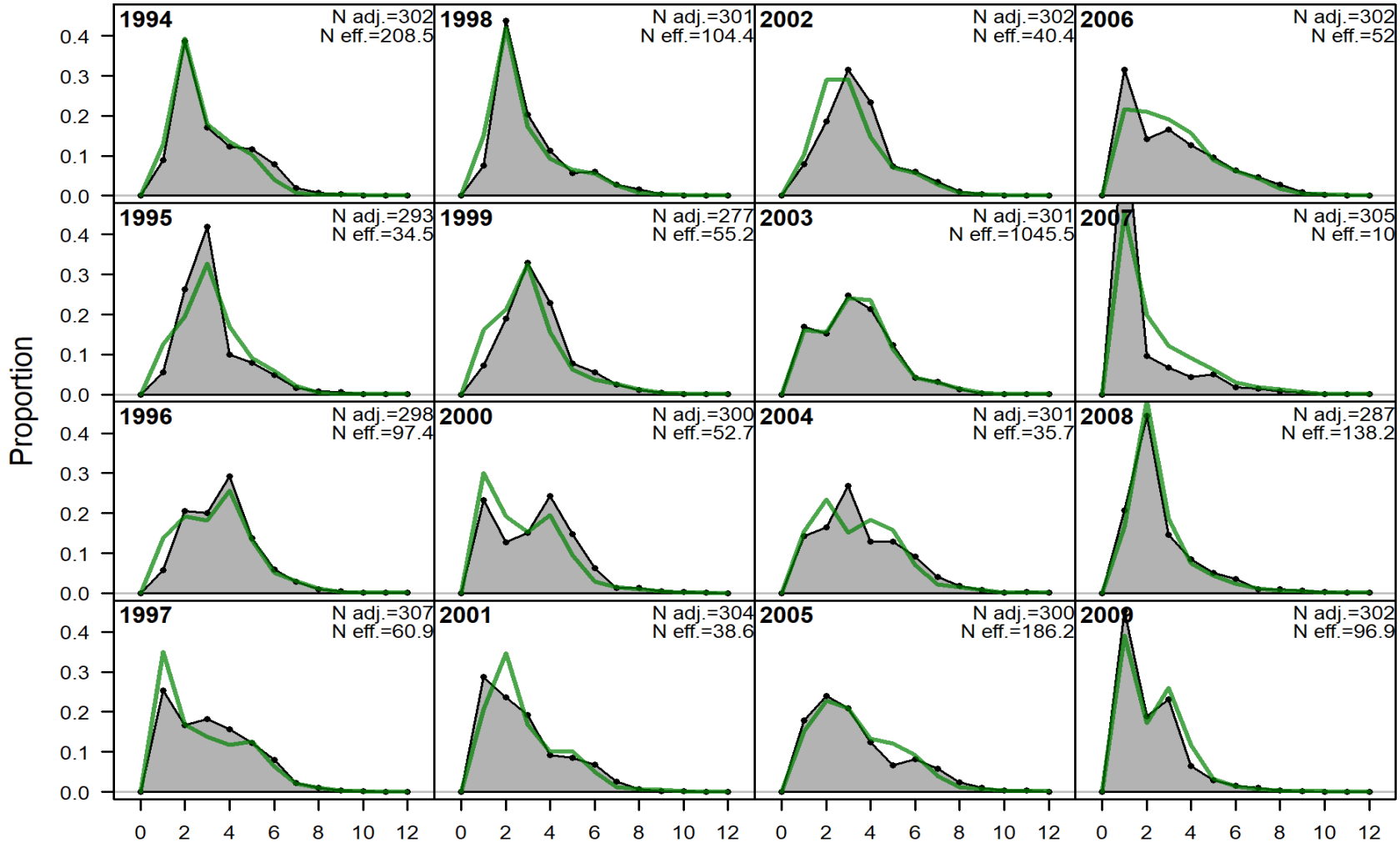

Figure 2.14a (1 of 2)—Model 16.6 fits to the survey age composition data.

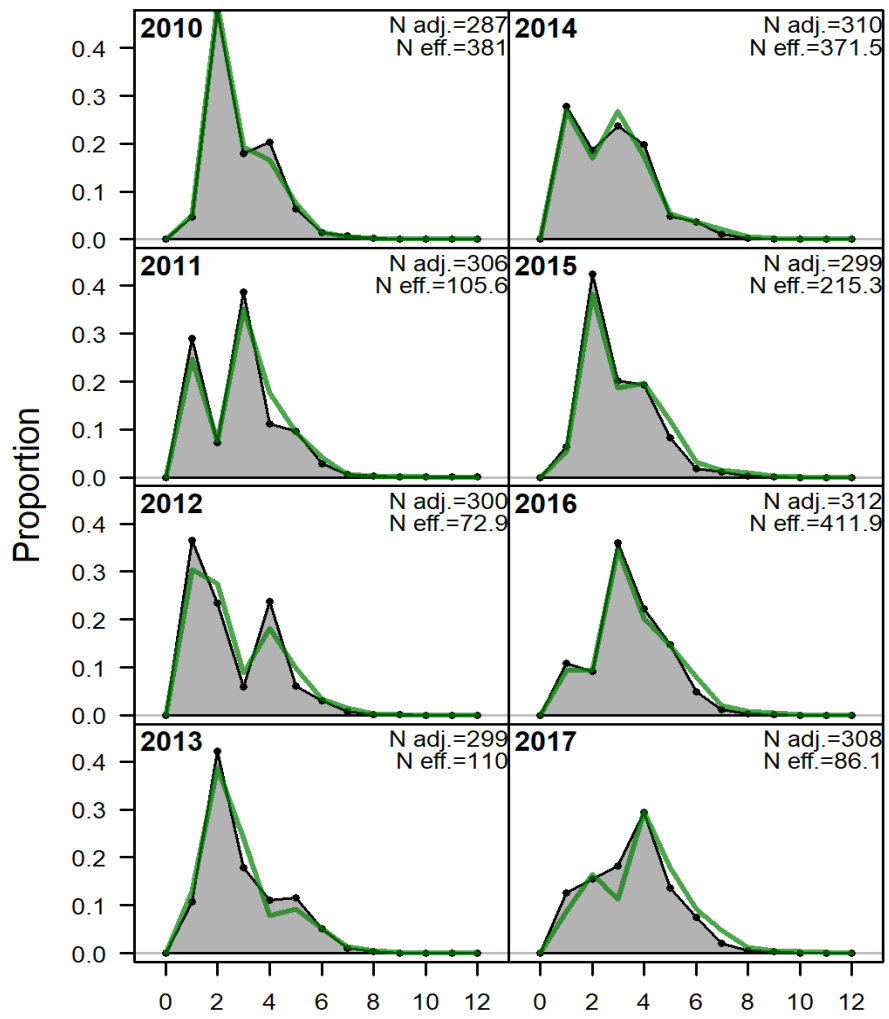

Figure 2.14a (2 of 2)—Model 16.6 fits to the survey age composition data.

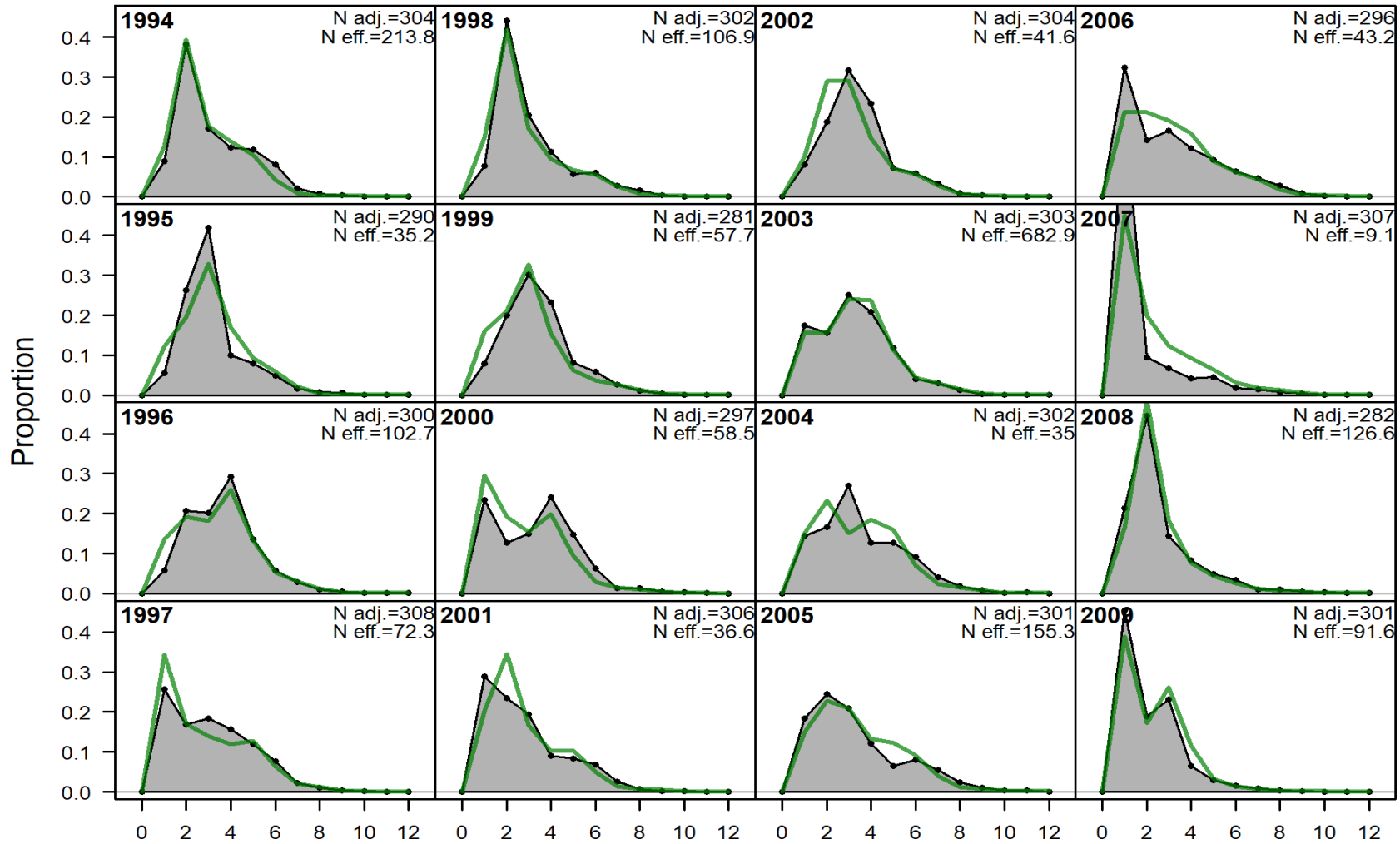

Figure 2.14b (1 of 2)—Model 16.6i fits to the survey age composition data.

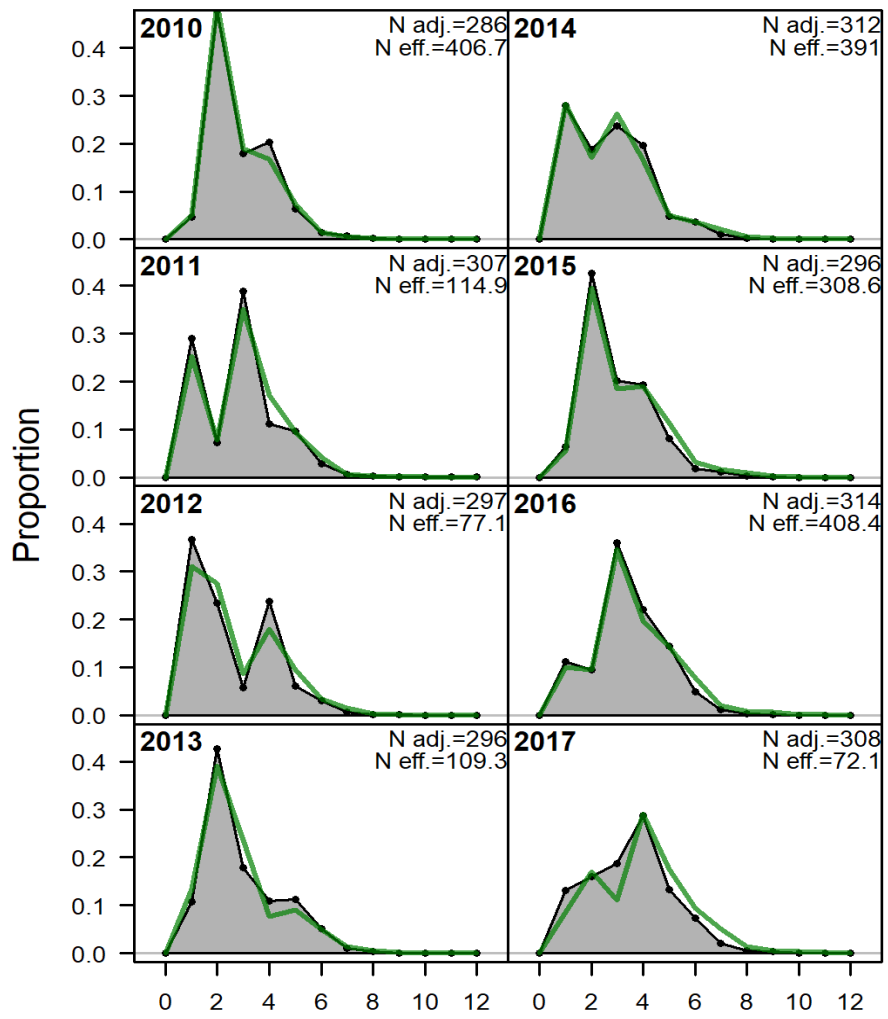

Figure 2.14b (2 of 2)—Model 16.6i fits to the survey age composition data.

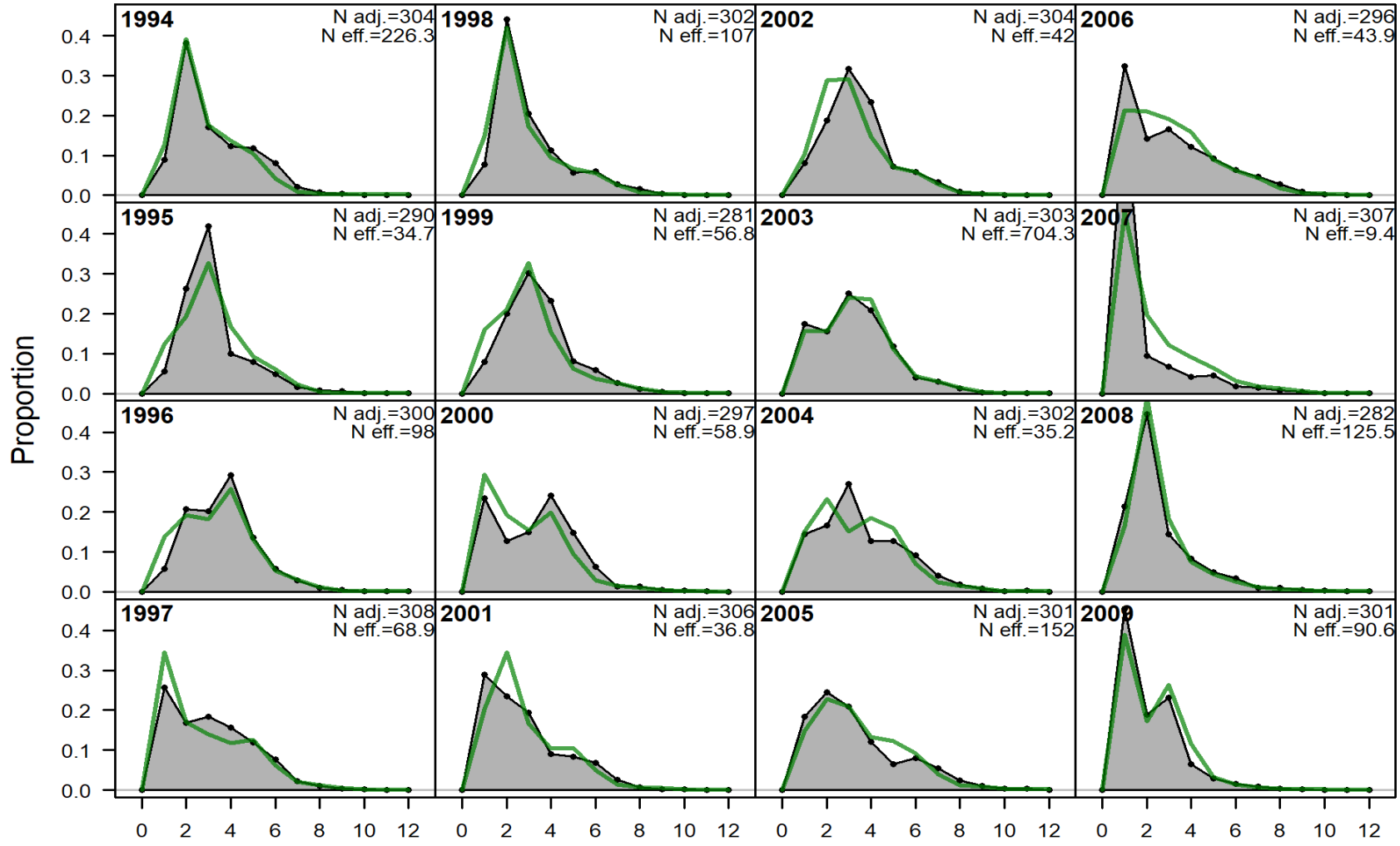

Figure 2.14c (1 of 2)—Model 16.6j fits to the survey age composition data.

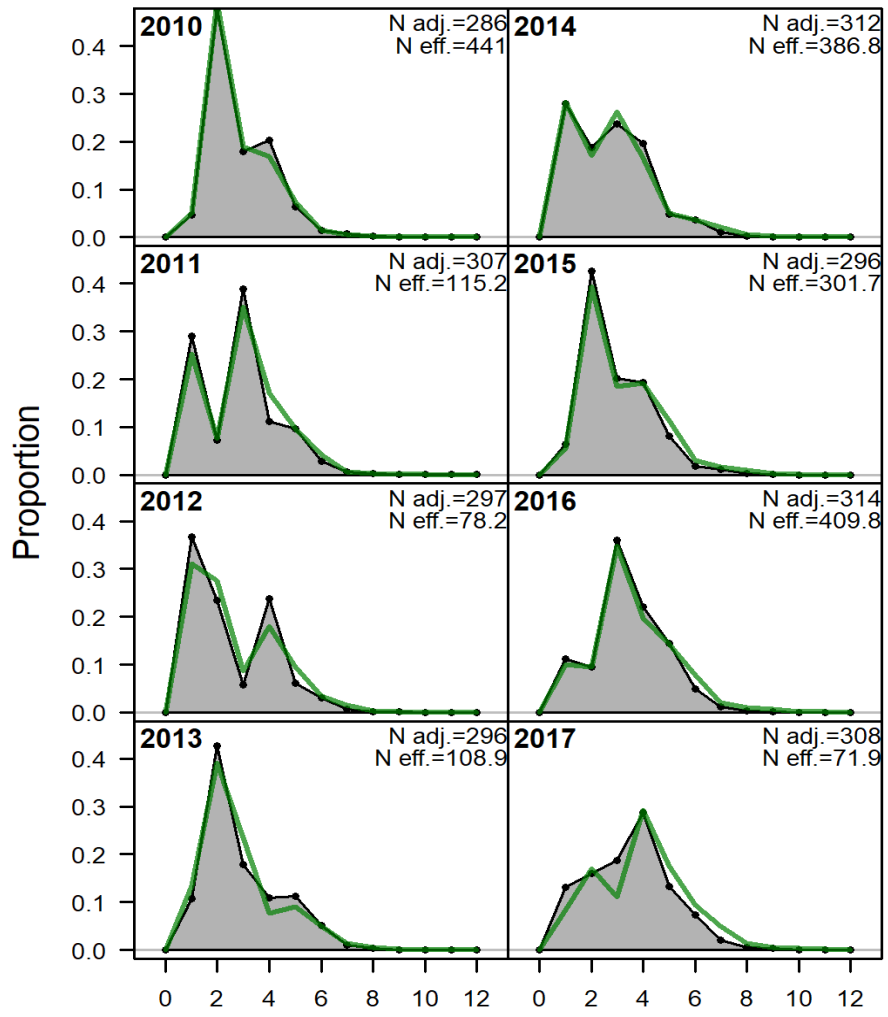

Figure 2.14c (2 of 2)—Model 16.6j fits to the survey age composition data.

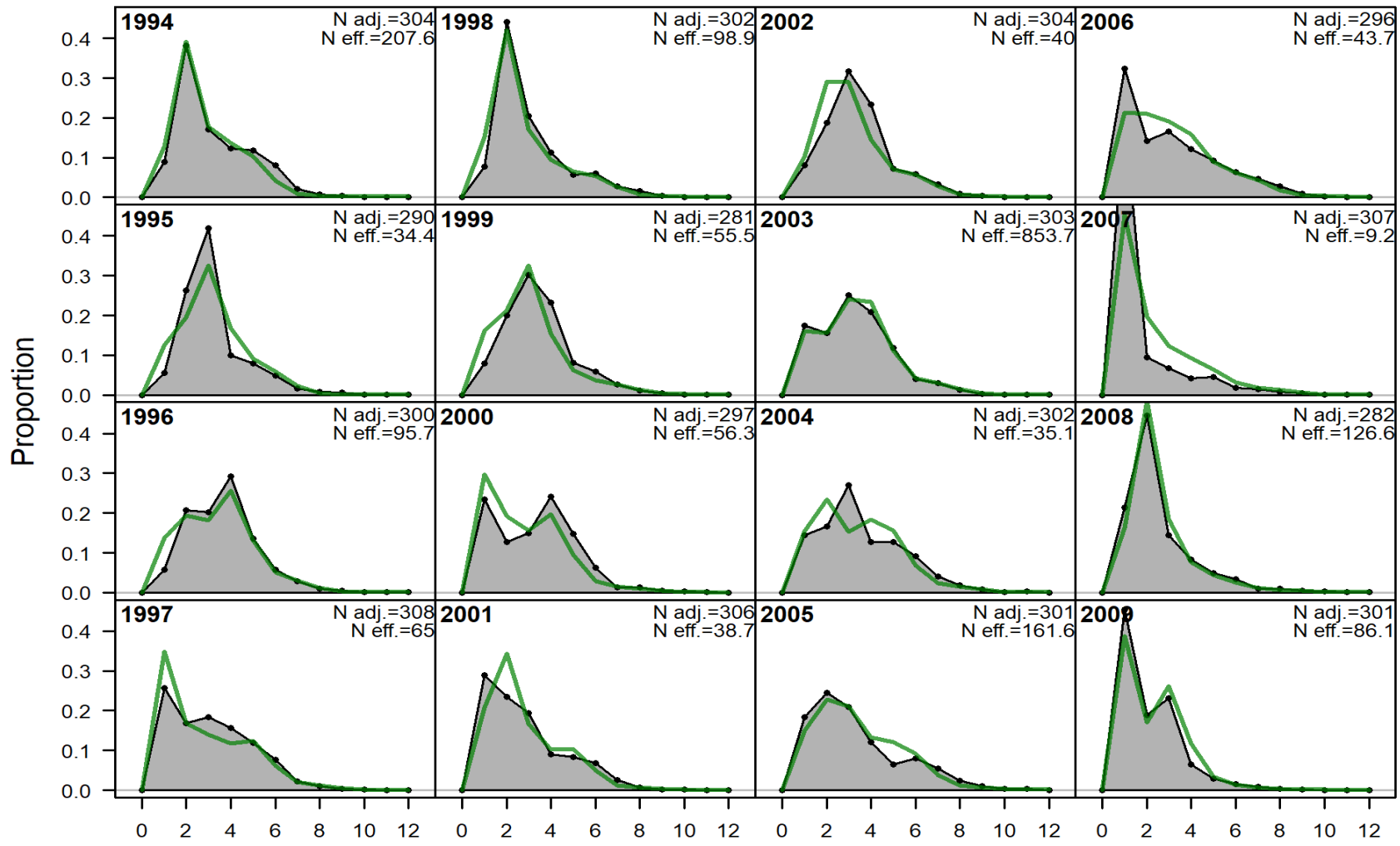

Figure 2.14d (1 of 2)—Model 16.6k fits to the survey age composition data.

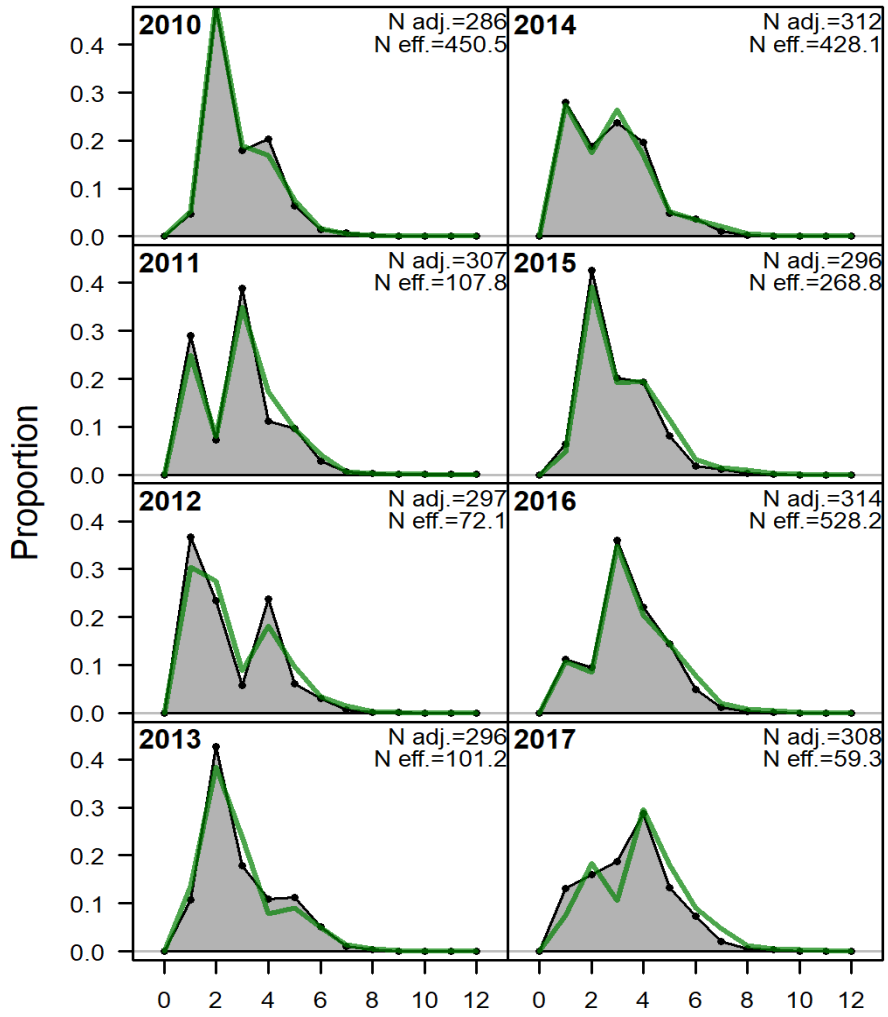

Figure 2.14d (2 of 2)—Model 16.6k fits to the survey age composition data.

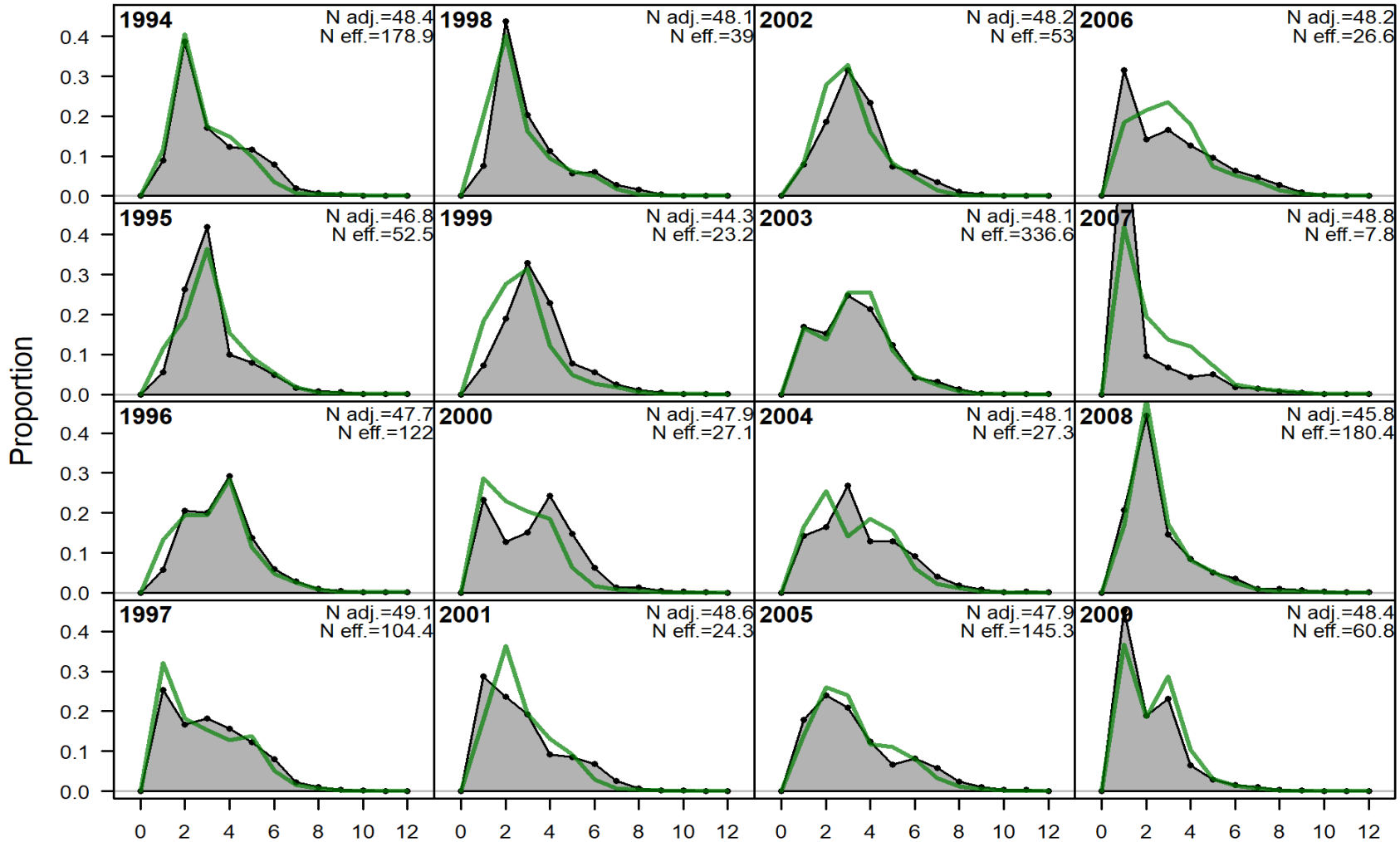

Figure 2.14e (1 of 2)—Model 17.2 fits to the survey age composition data.

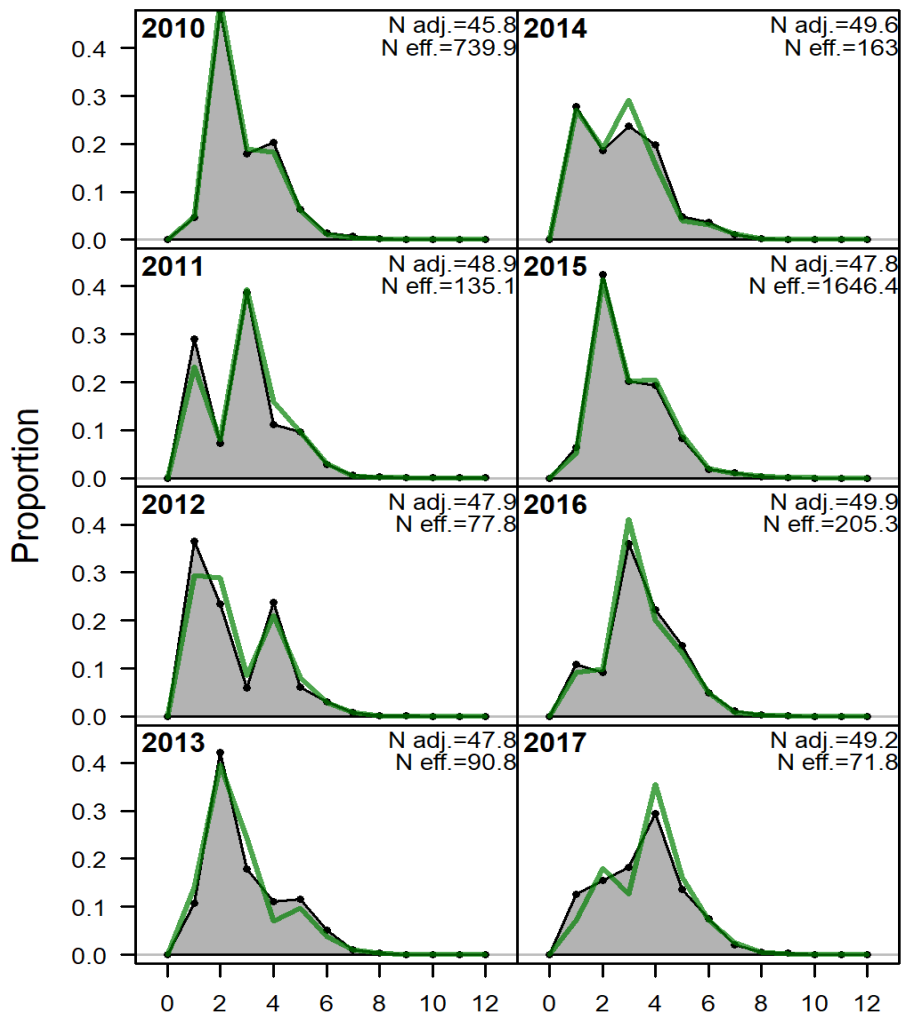

Figure 2.14e (2 of 2)—Model 17.2 fits to the survey age composition data.

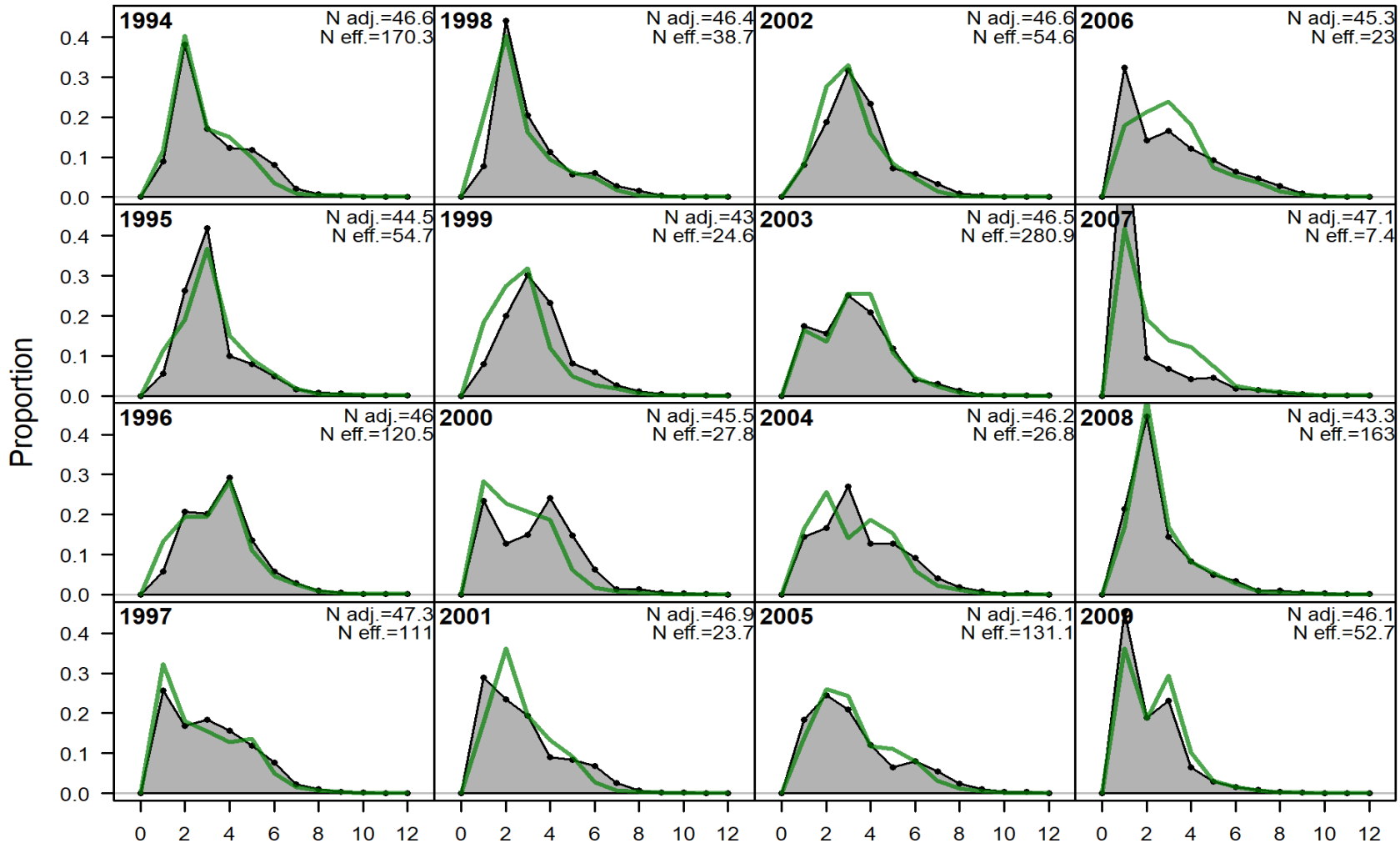

Figure 2.14f (1 of 2)—Model 18.6 fits to the survey age composition data.

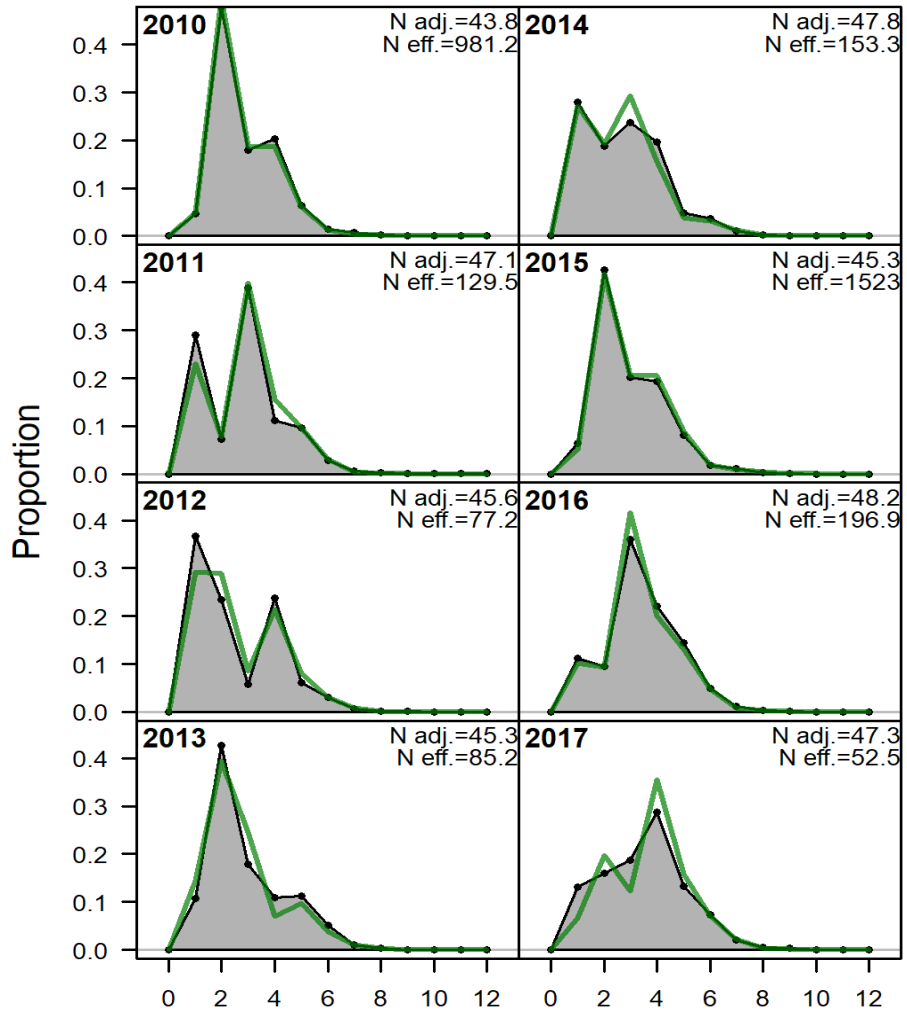

Figure 2.14f (2 of 2)—Model 18.6 fits to the survey age composition data.

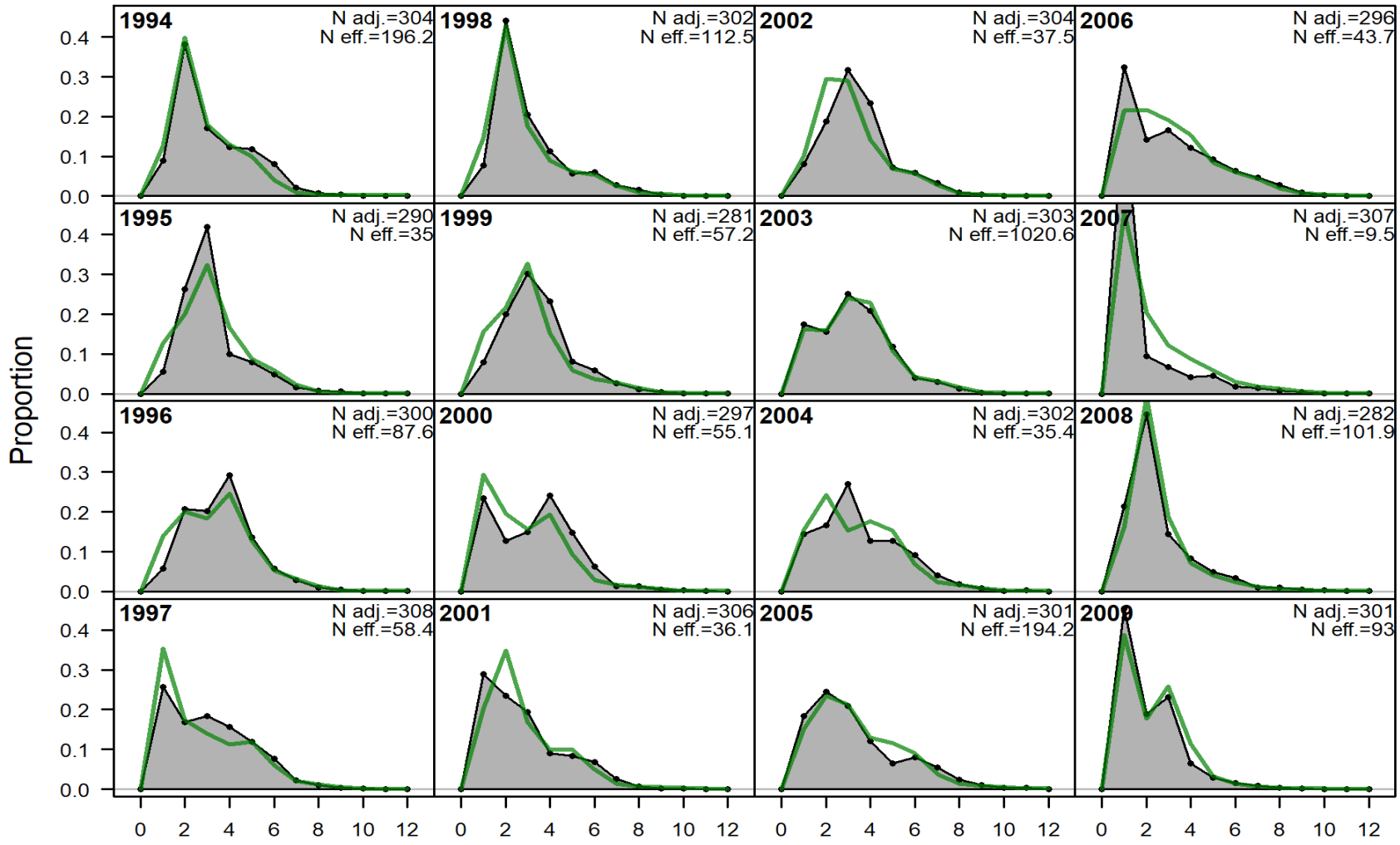

Figure 2.14g (1 of 2)—Model 18.7 fits to the survey age composition data.

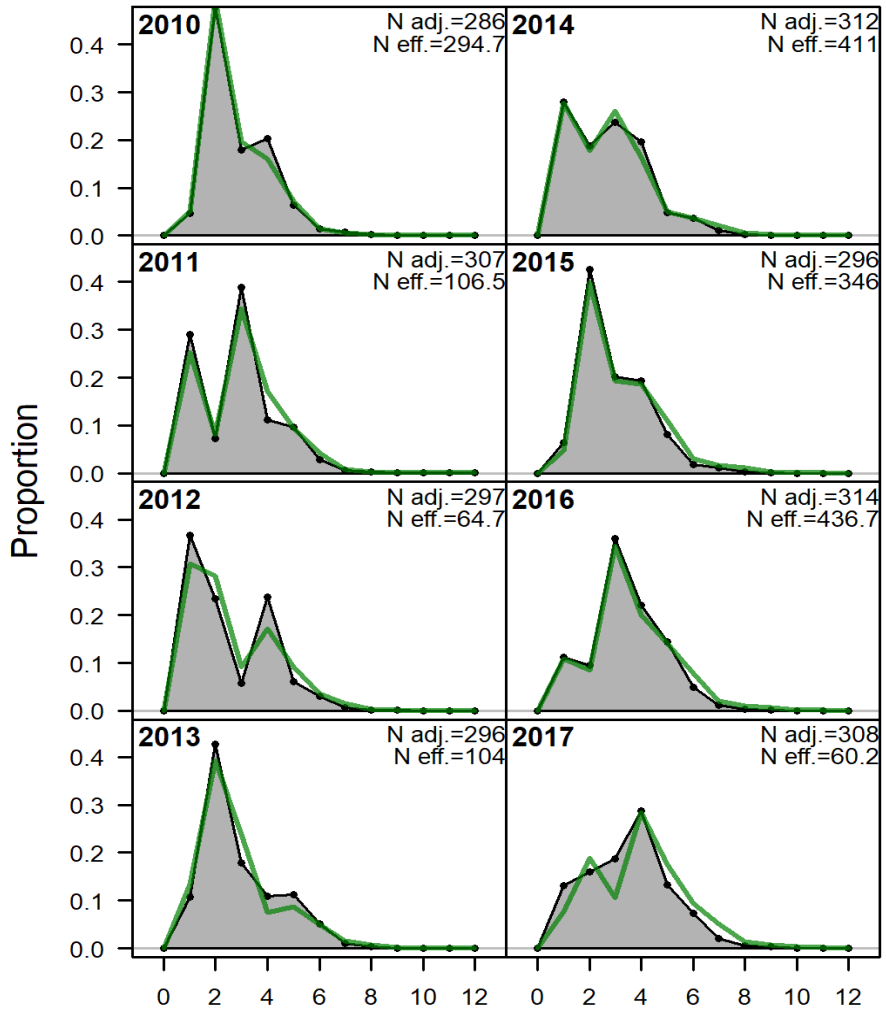

Figure 2.14g (2 of 2)—Model 18.7 fits to the survey age composition data.

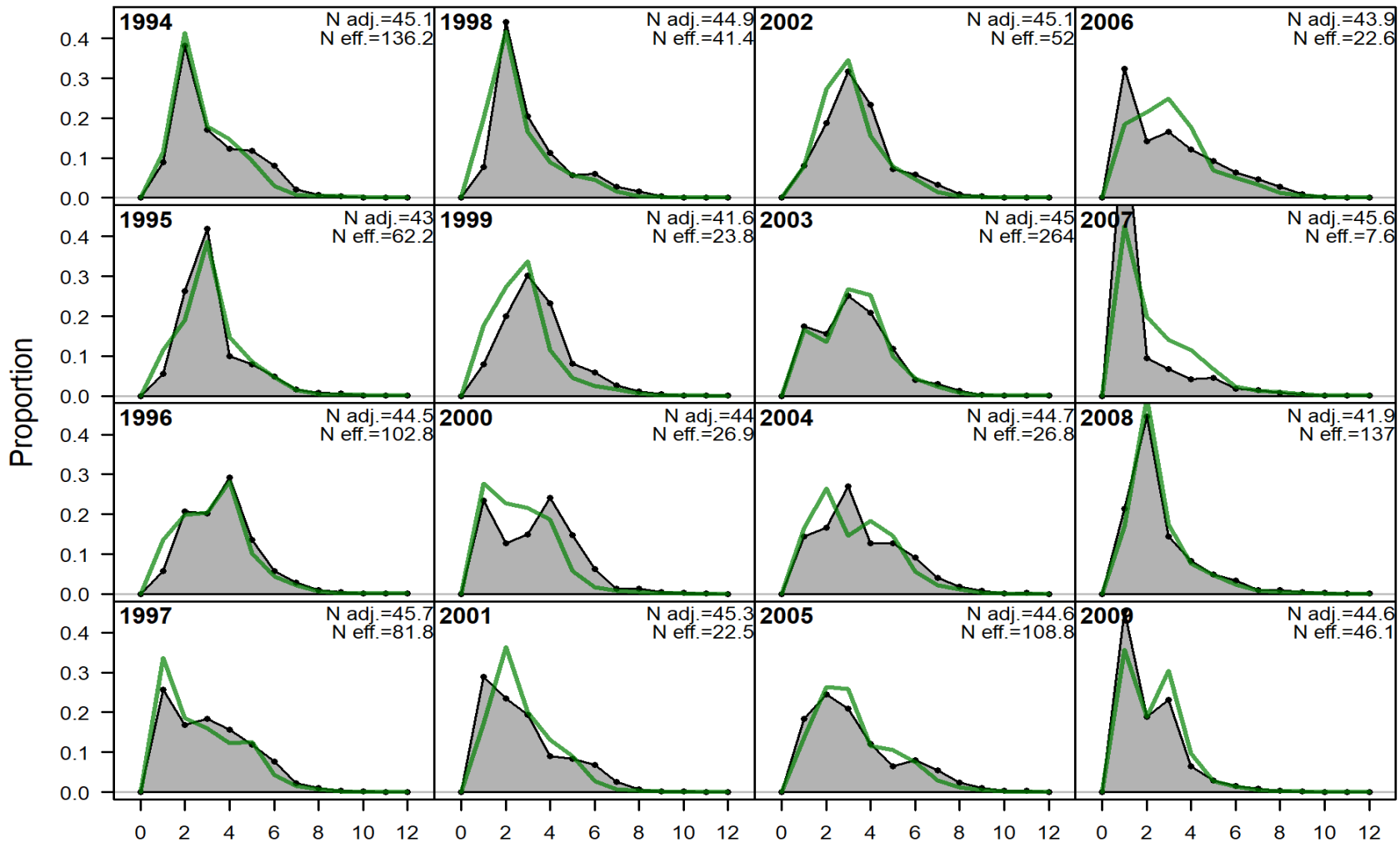

Figure 2.14h (1 of 2)—Model 18.8 fits to the survey age composition data.

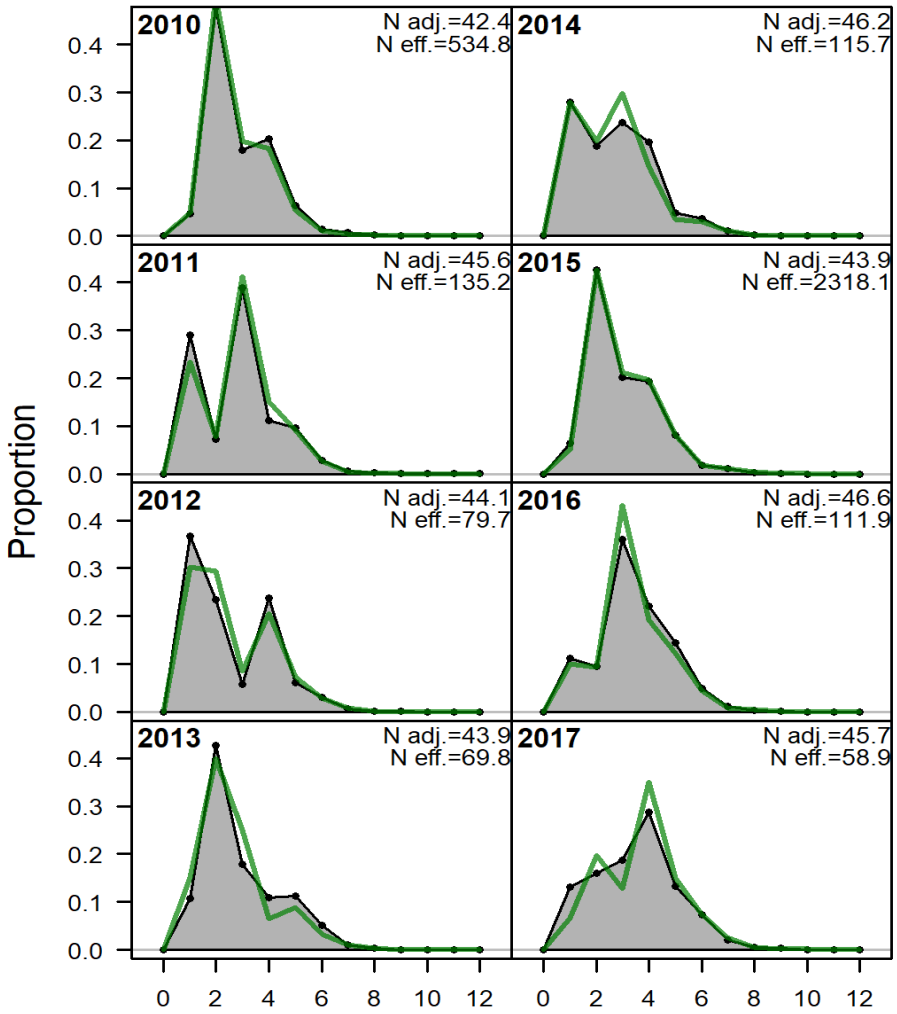

Figure 2.14h (2 of 2)—Model 18.8 fits to the survey age composition data.

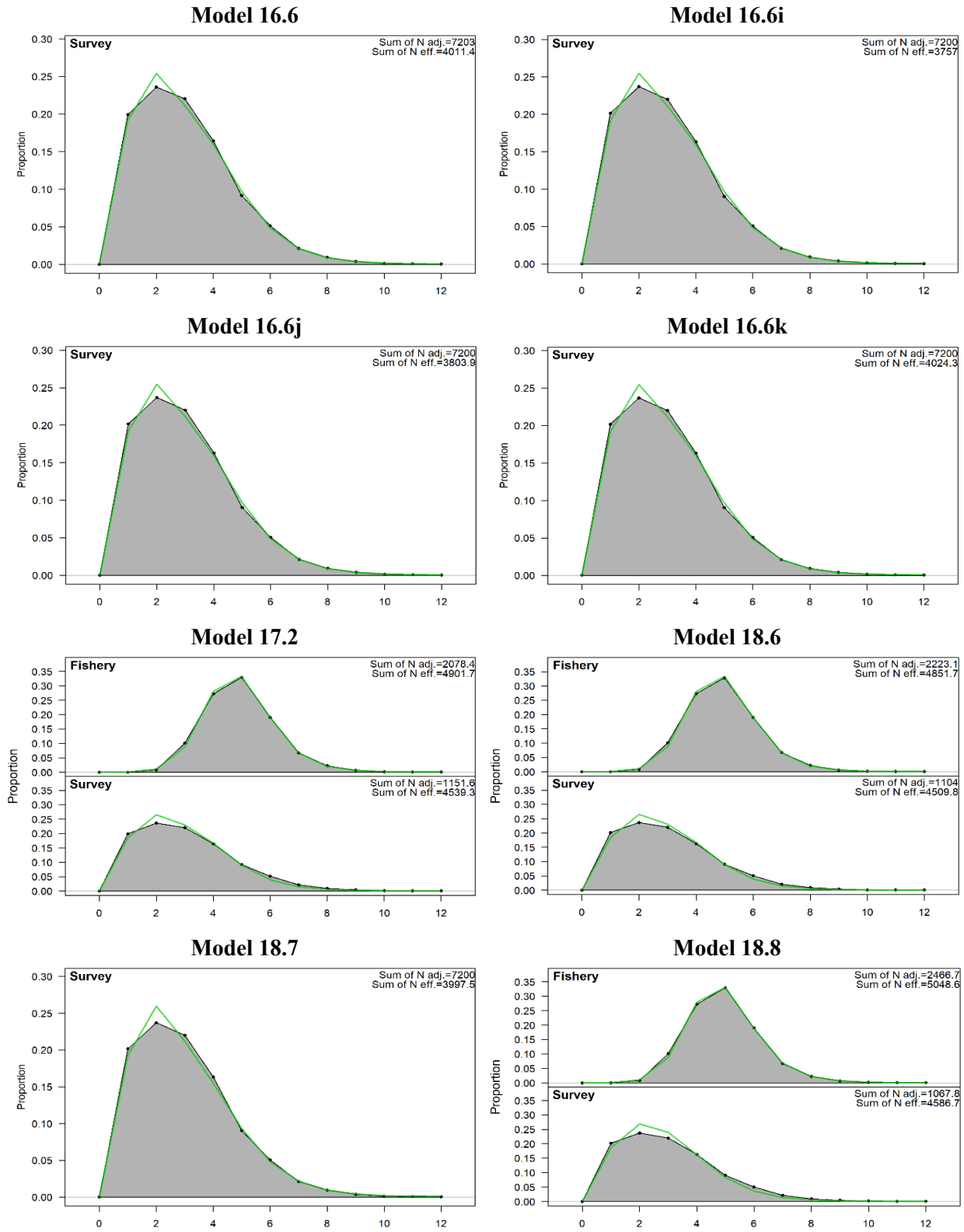

Figure 2.15—Time-aggregated age composition fits.

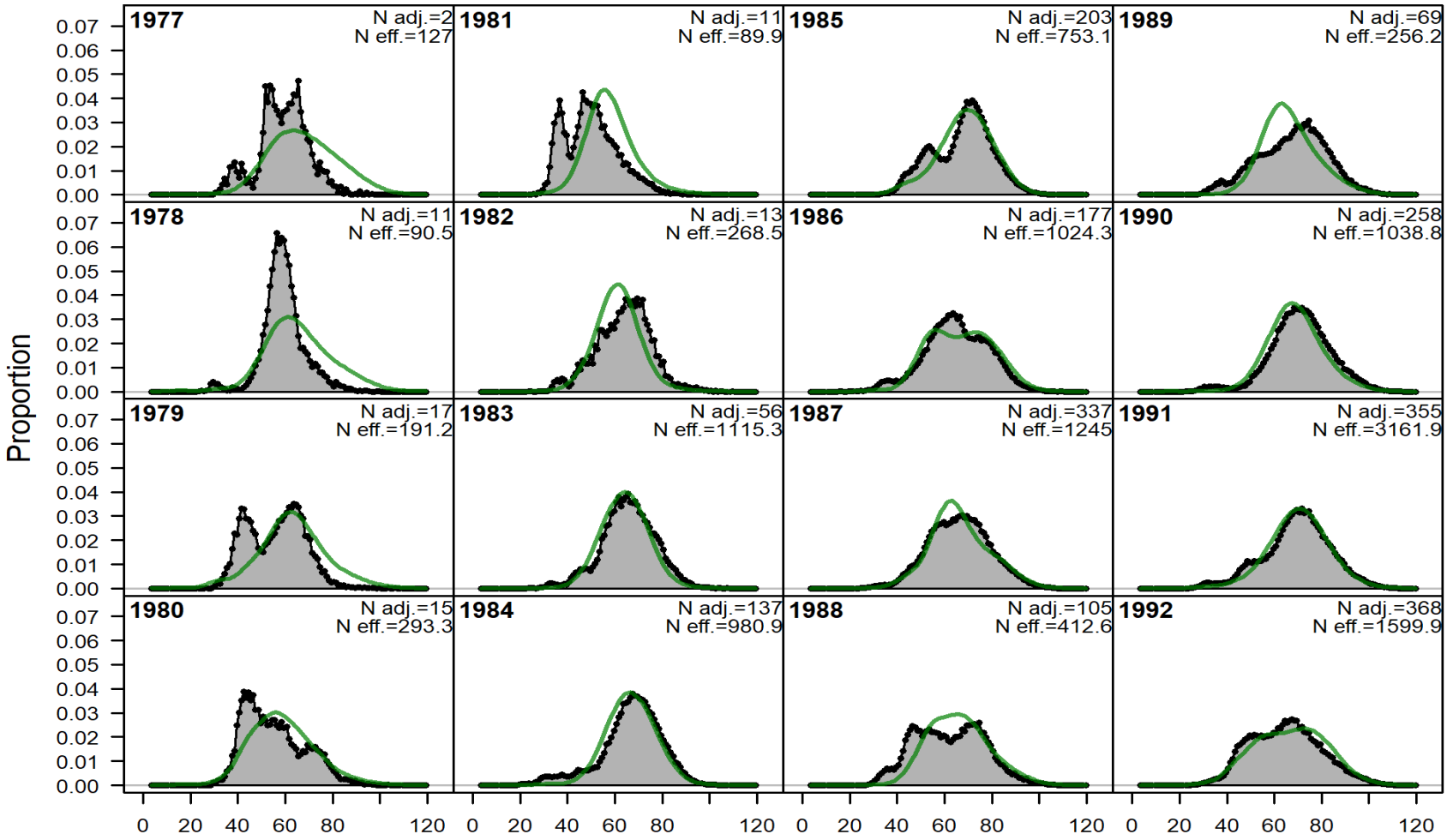

Figure 2.16a (1 of 3)—Model 16.6 fits to the fishery size composition data.

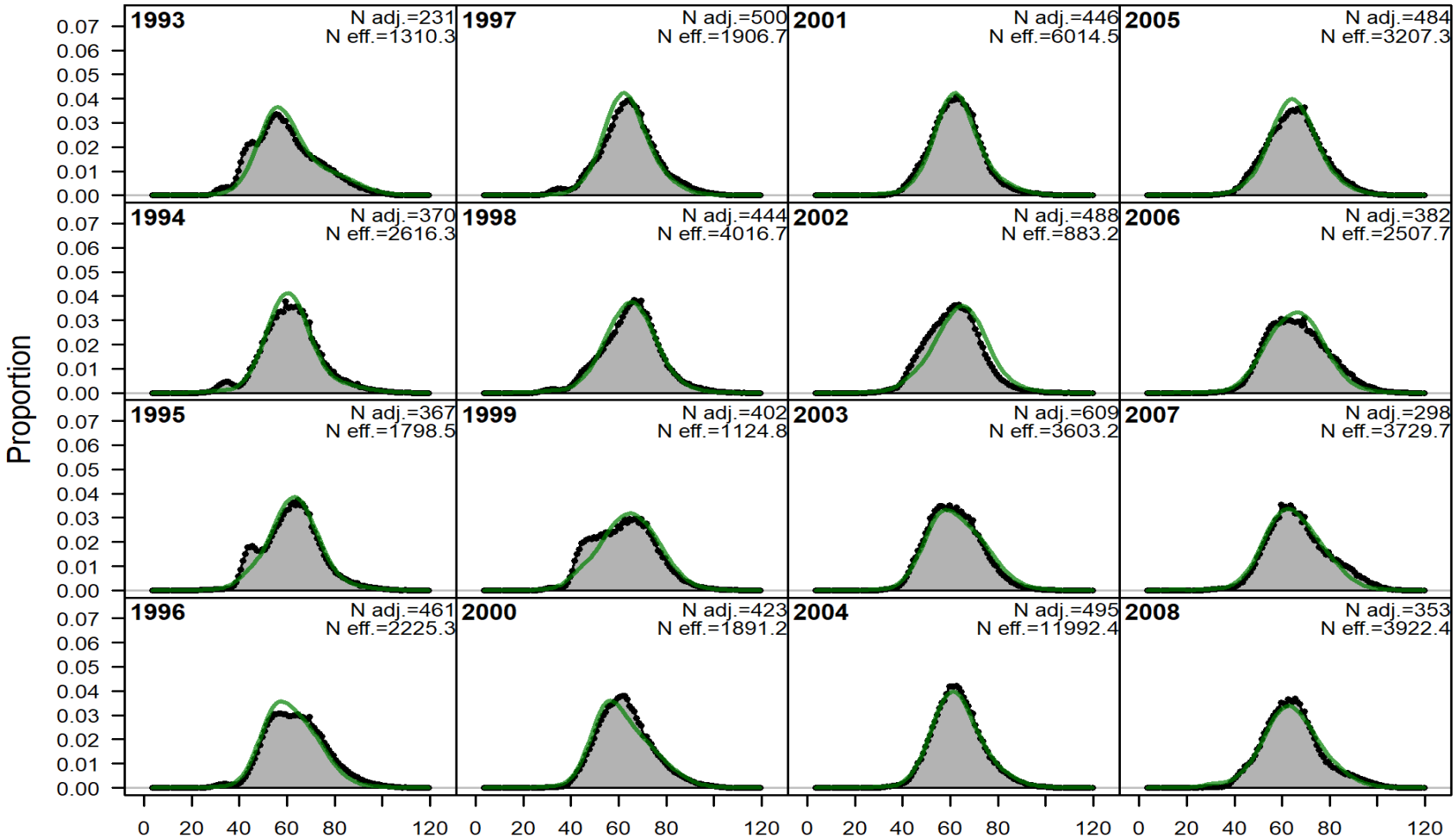

Figure 2.16a (2 of 3)—Model 16.6 fits to the fishery size composition data.

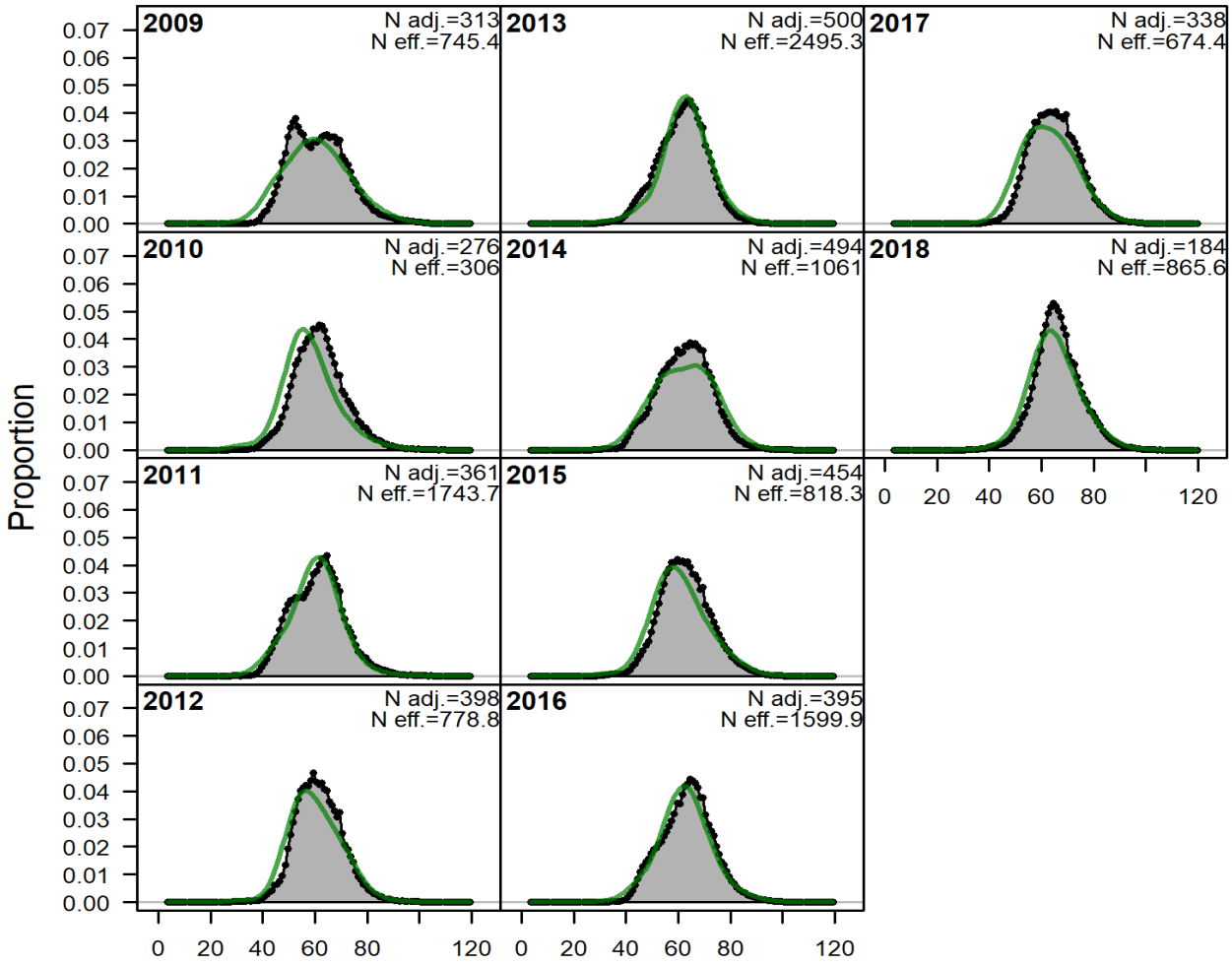

Figure 2.16a (3 of 3)—Model 16.6 fits to the fishery size composition data.

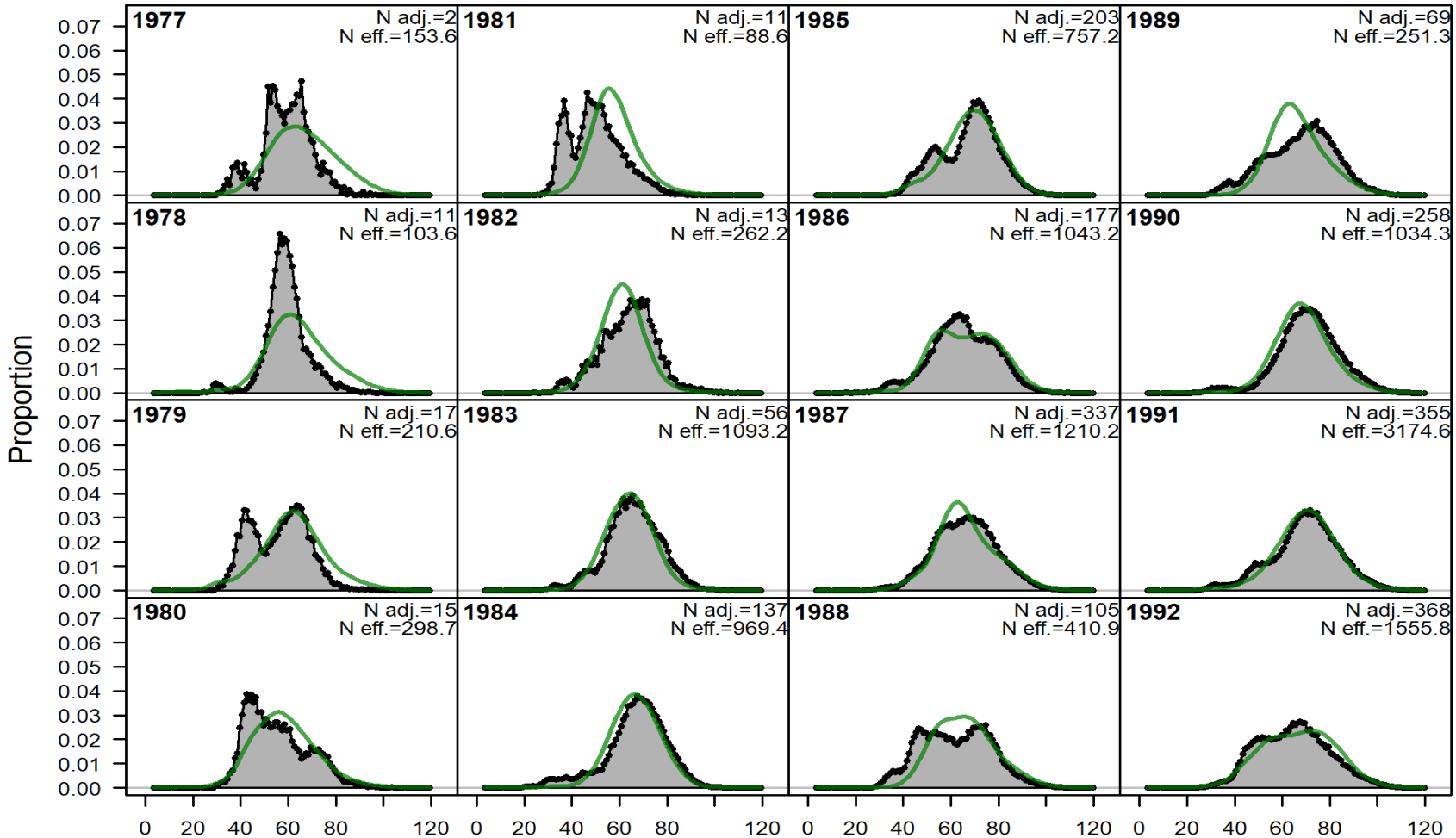

Figure 2.16b (1 of 3)—Model 17.1 fits to the fishery size composition data.

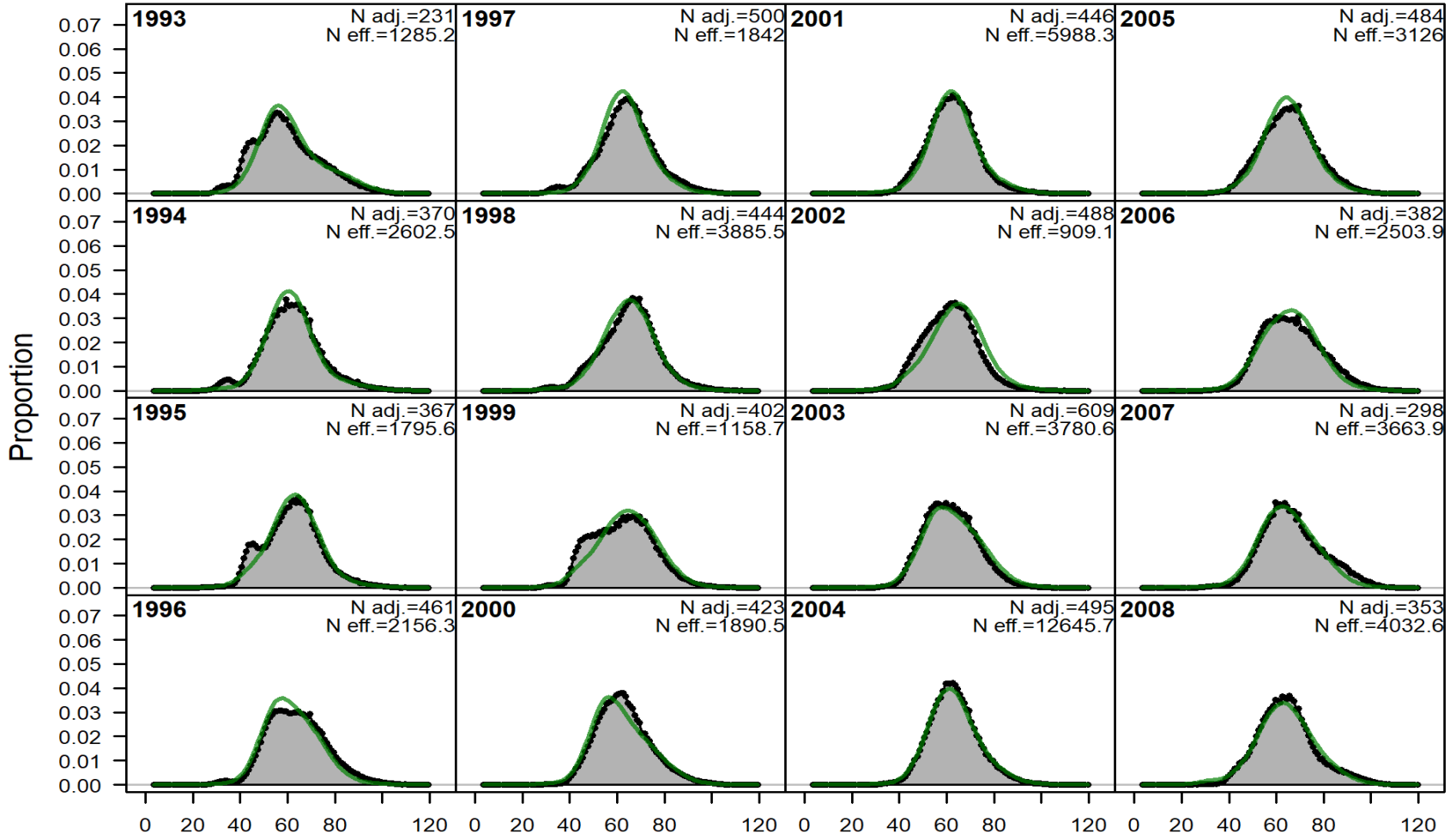

Figure 2.16b (2 of 3)—Model 16.6i fits to the fishery size composition data.

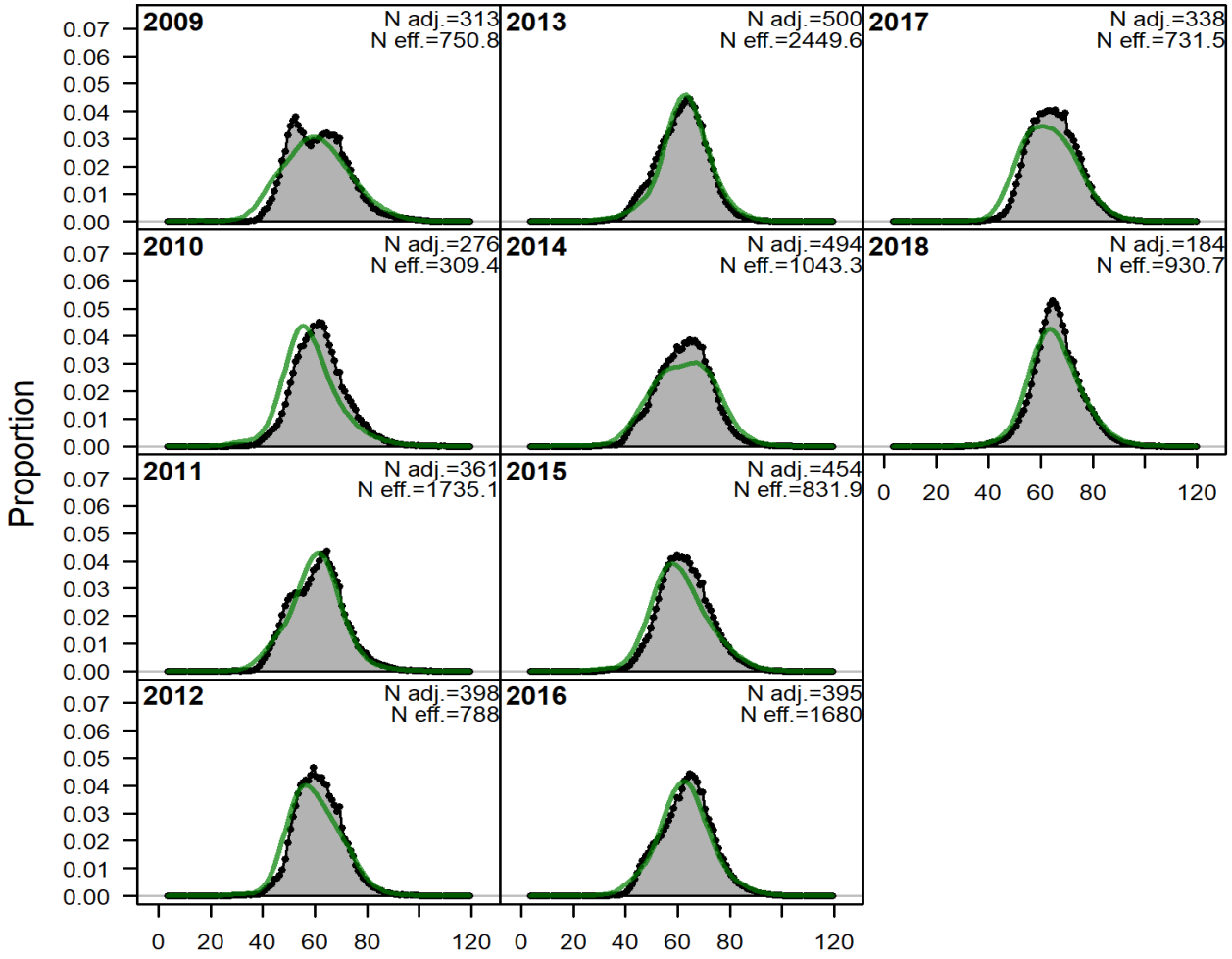

Figure 2.16b (3 of 3)—Model 16.6i fits to the fishery size composition data.

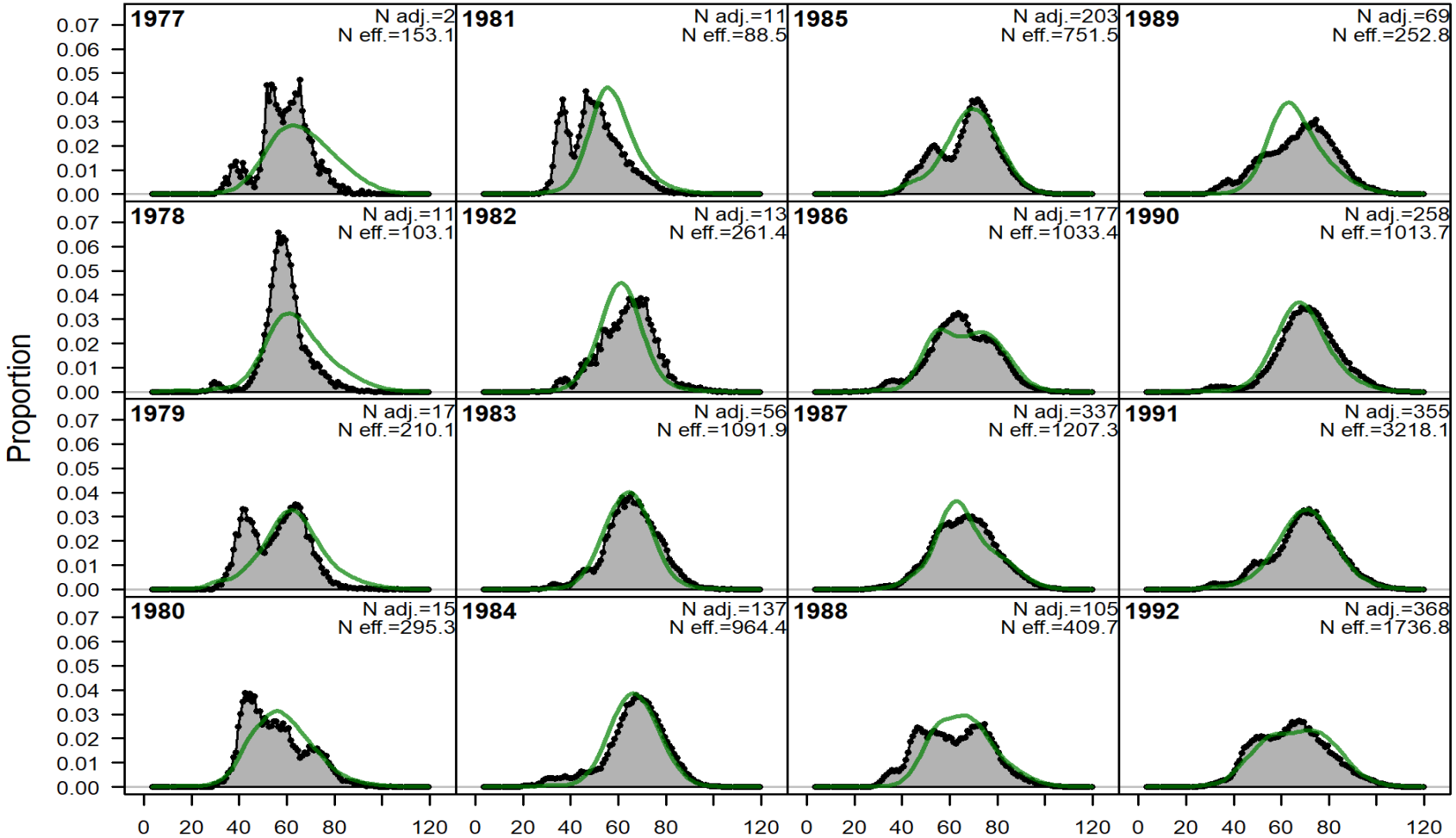

Figure 2.16c (1 of 3)—Model 16.6j fits to the fishery size composition data.

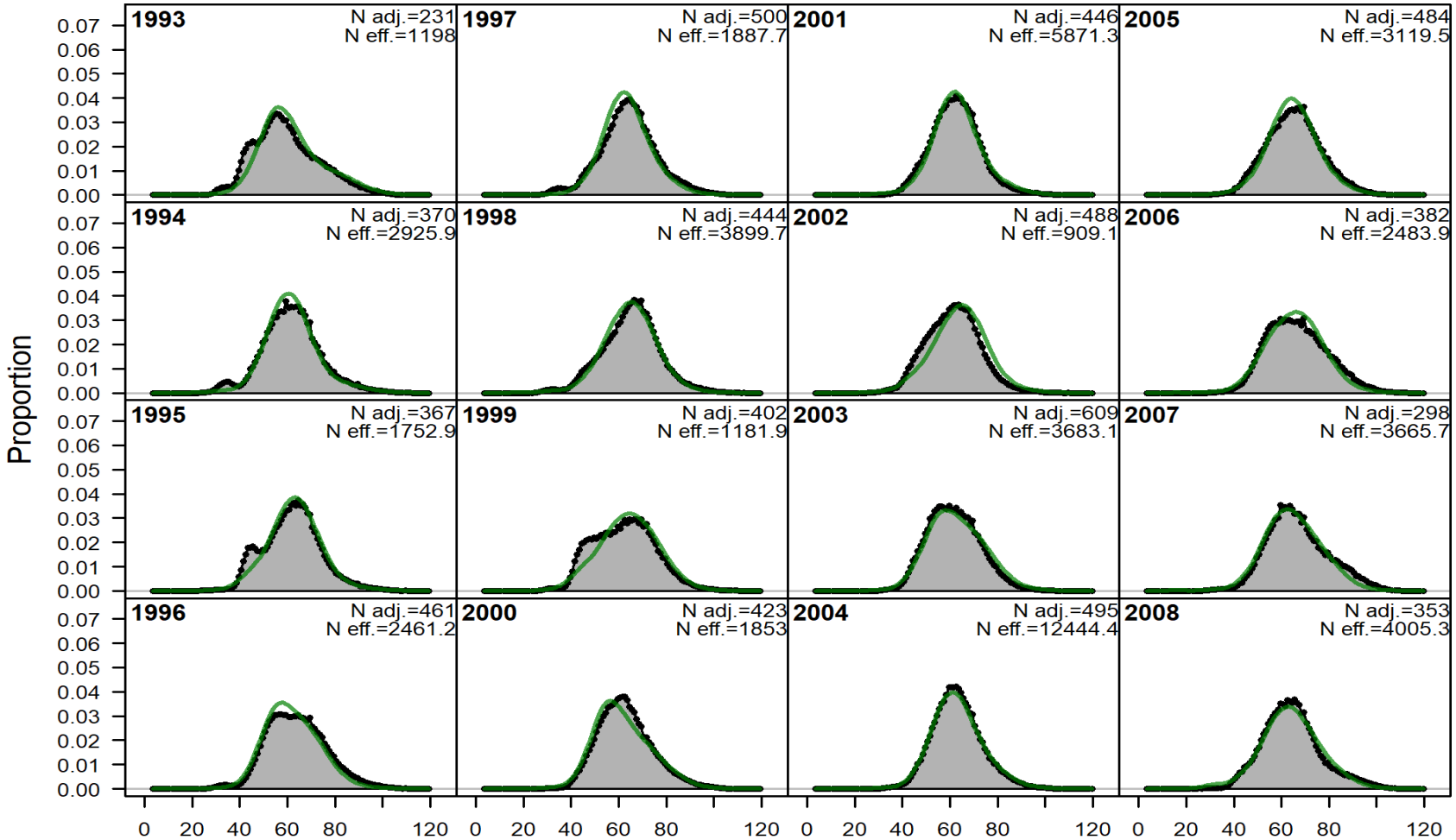

Figure 2.16c (2 of 3)—Model 16.6j fits to the fishery size composition data.

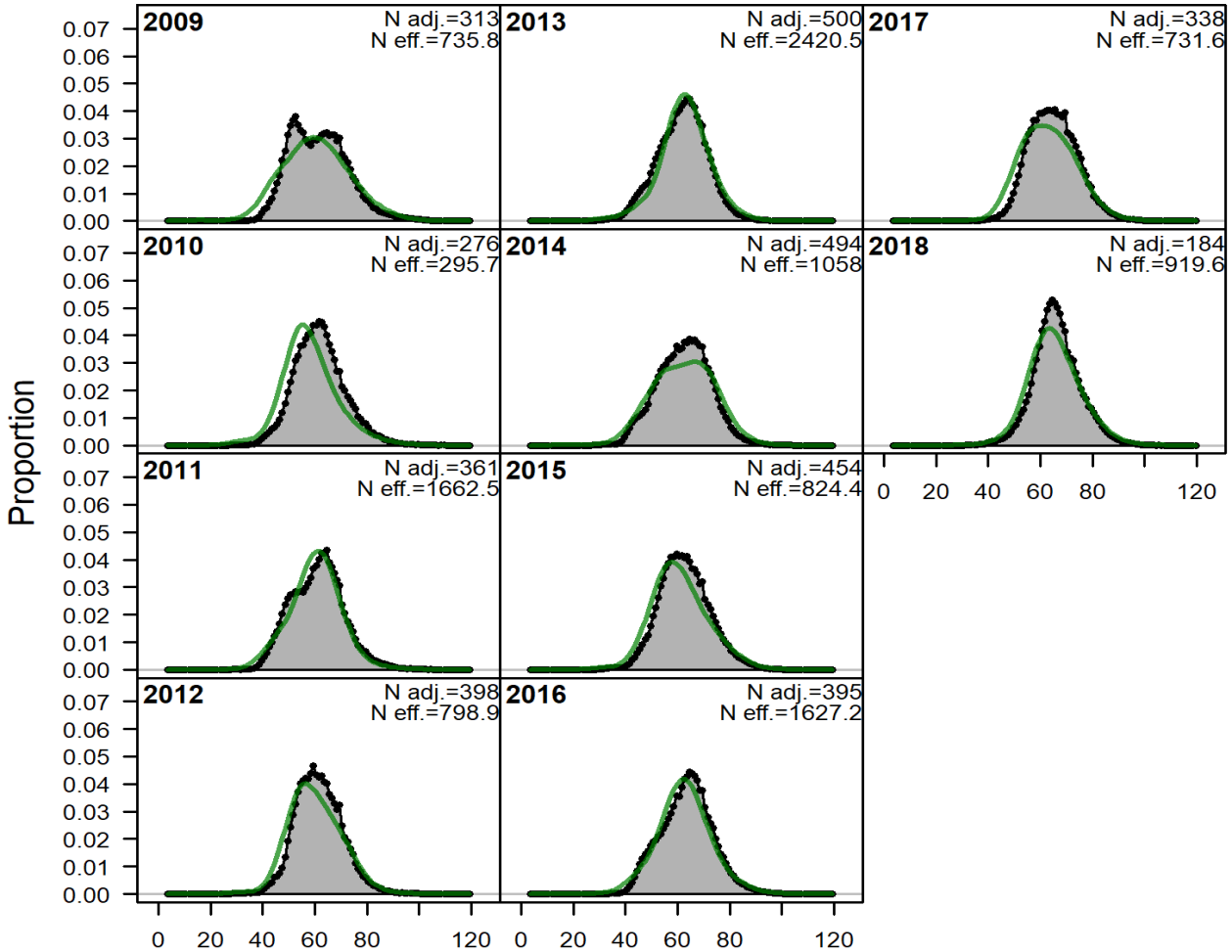

Figure 2.16c (3 of 3)—Model 16.6j fits to the fishery size composition data.

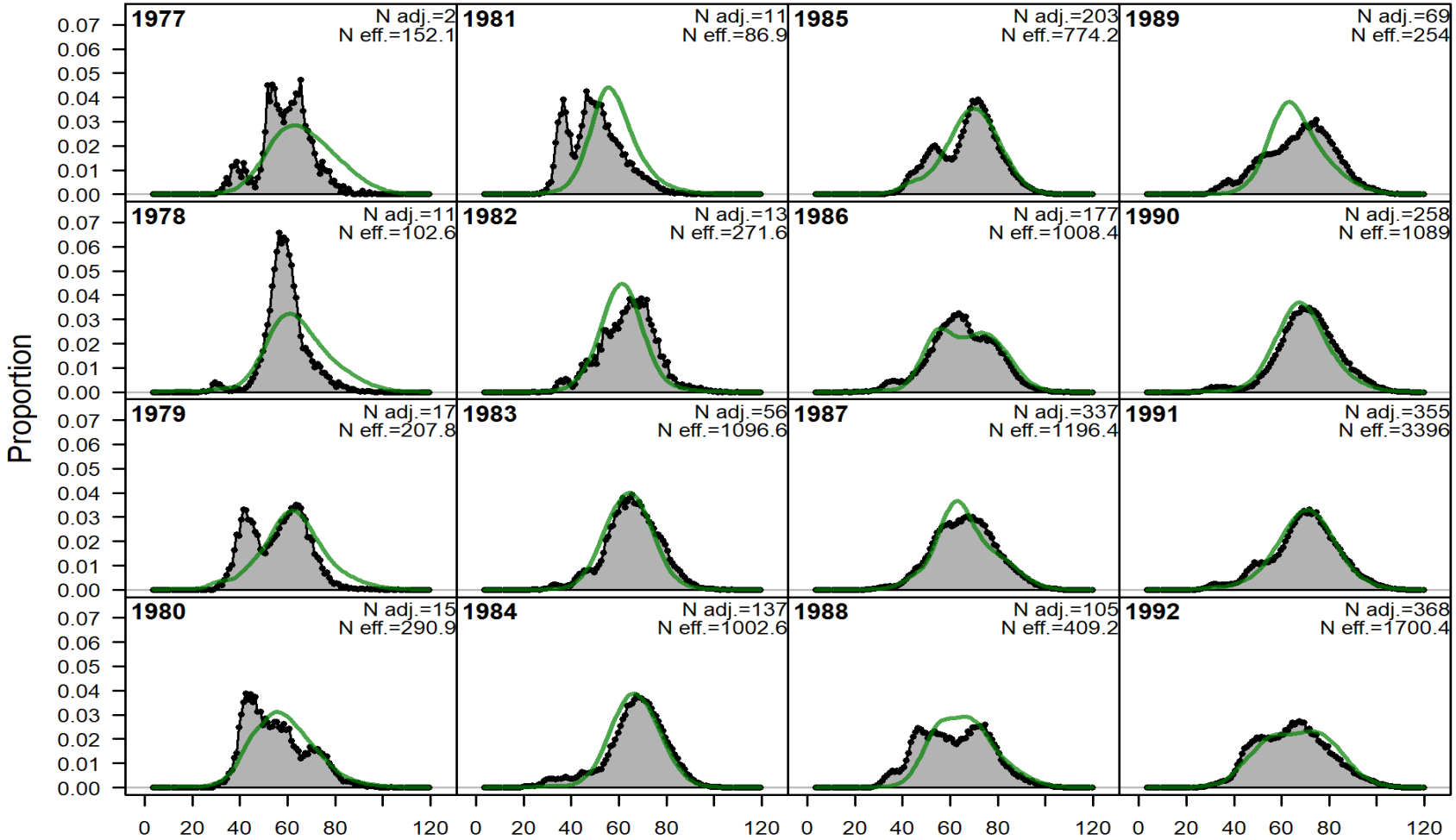

Figure 2.16d (1 of 3)—Model 16.6k fits to the fishery size composition data.

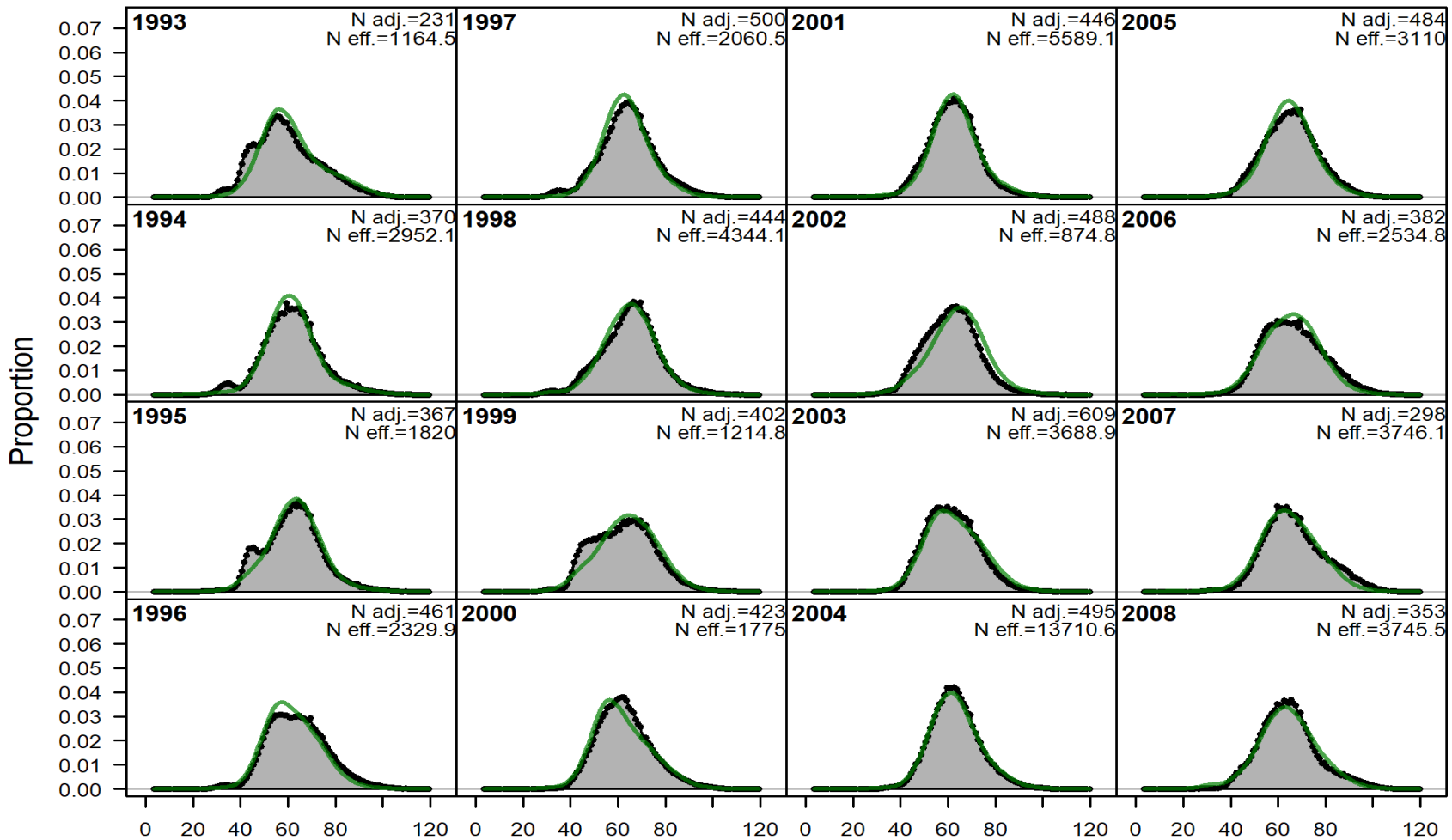

Figure 2.16d (2 of 3)—Model 16.6k fits to the fishery size composition data.

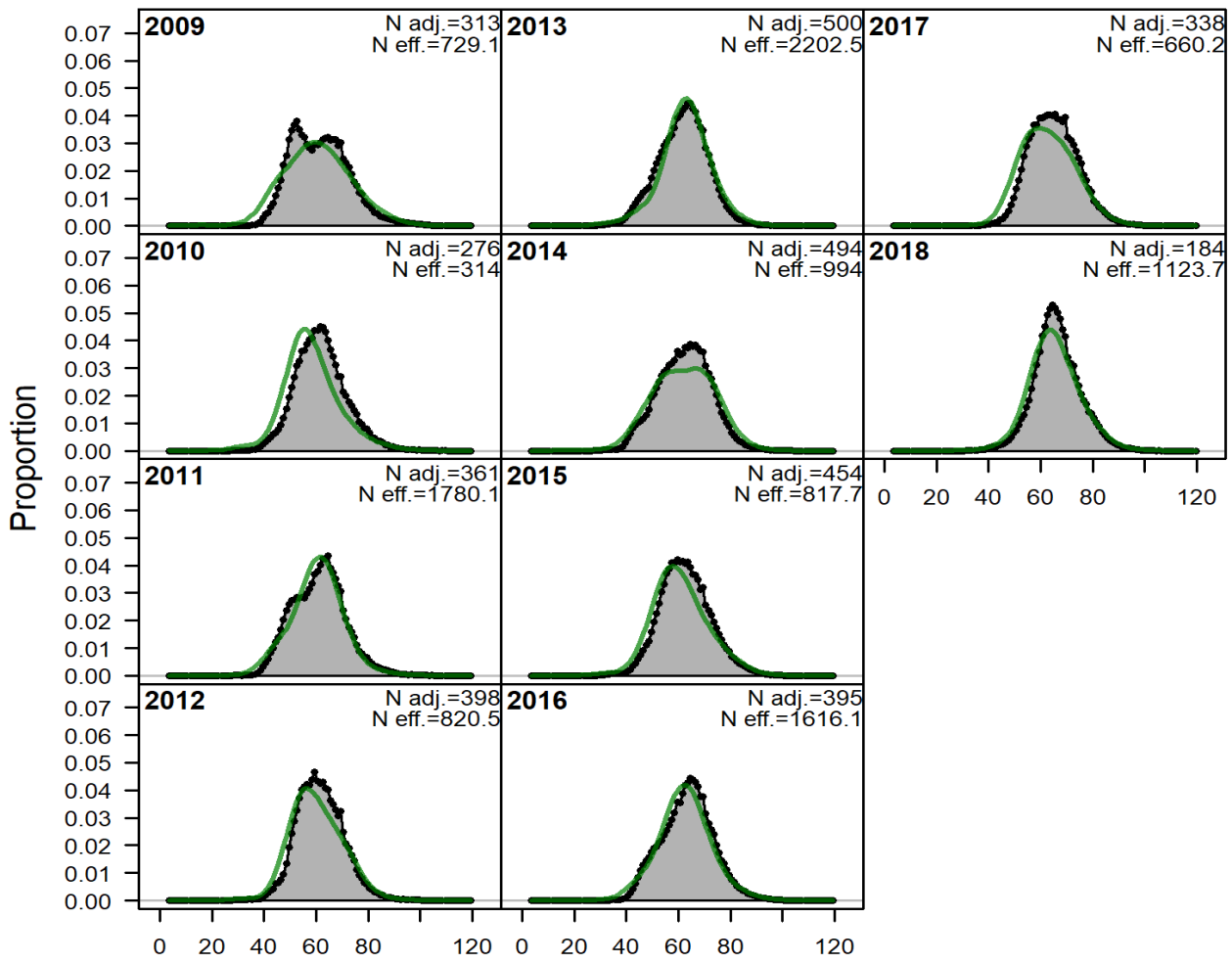

Figure 2.16d (3 of 3)—Model 16.6k fits to the fishery size composition data.

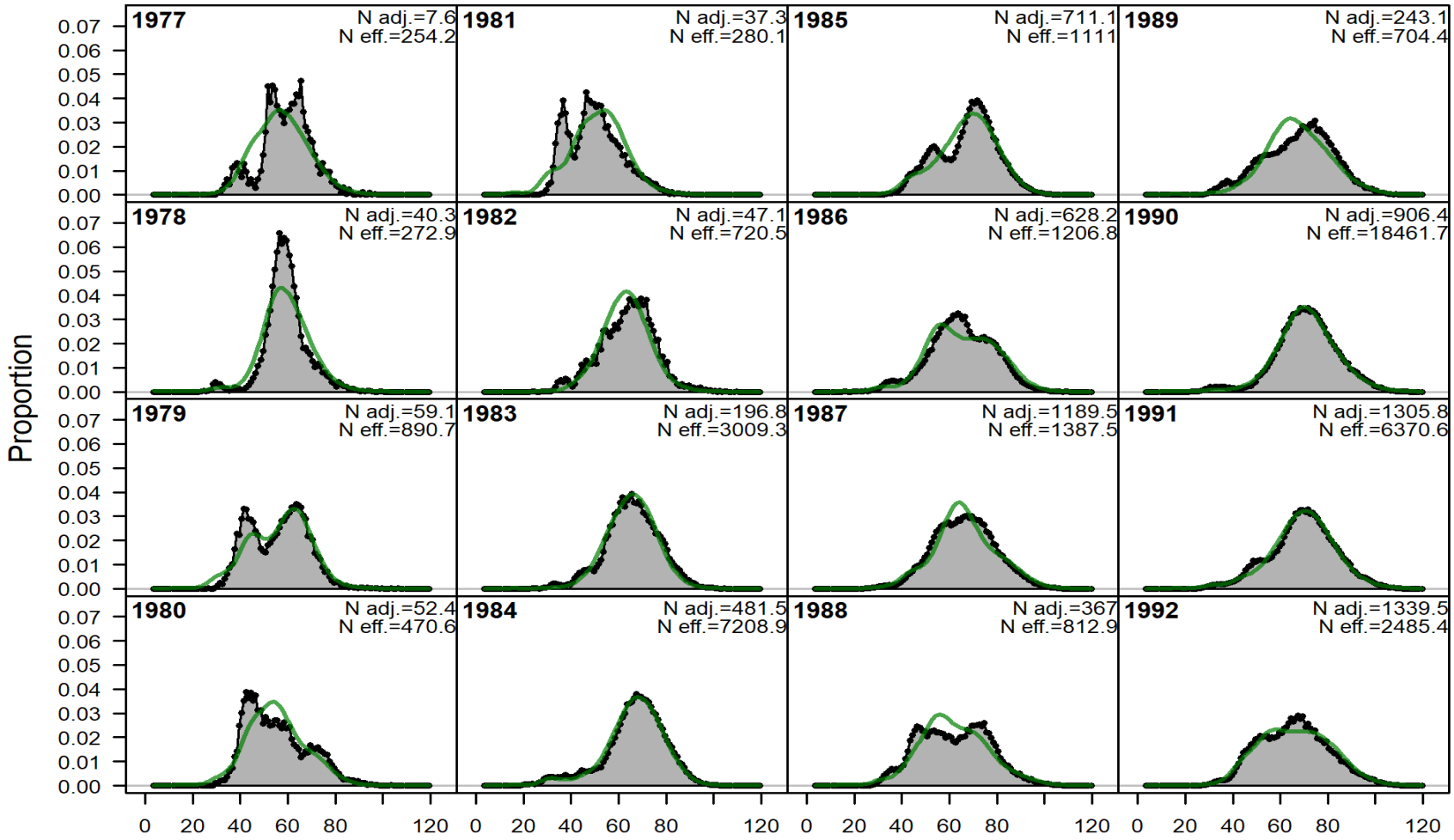

Figure 2.16e (1 of 3)—Model 17.2 fits to the fishery size composition data.

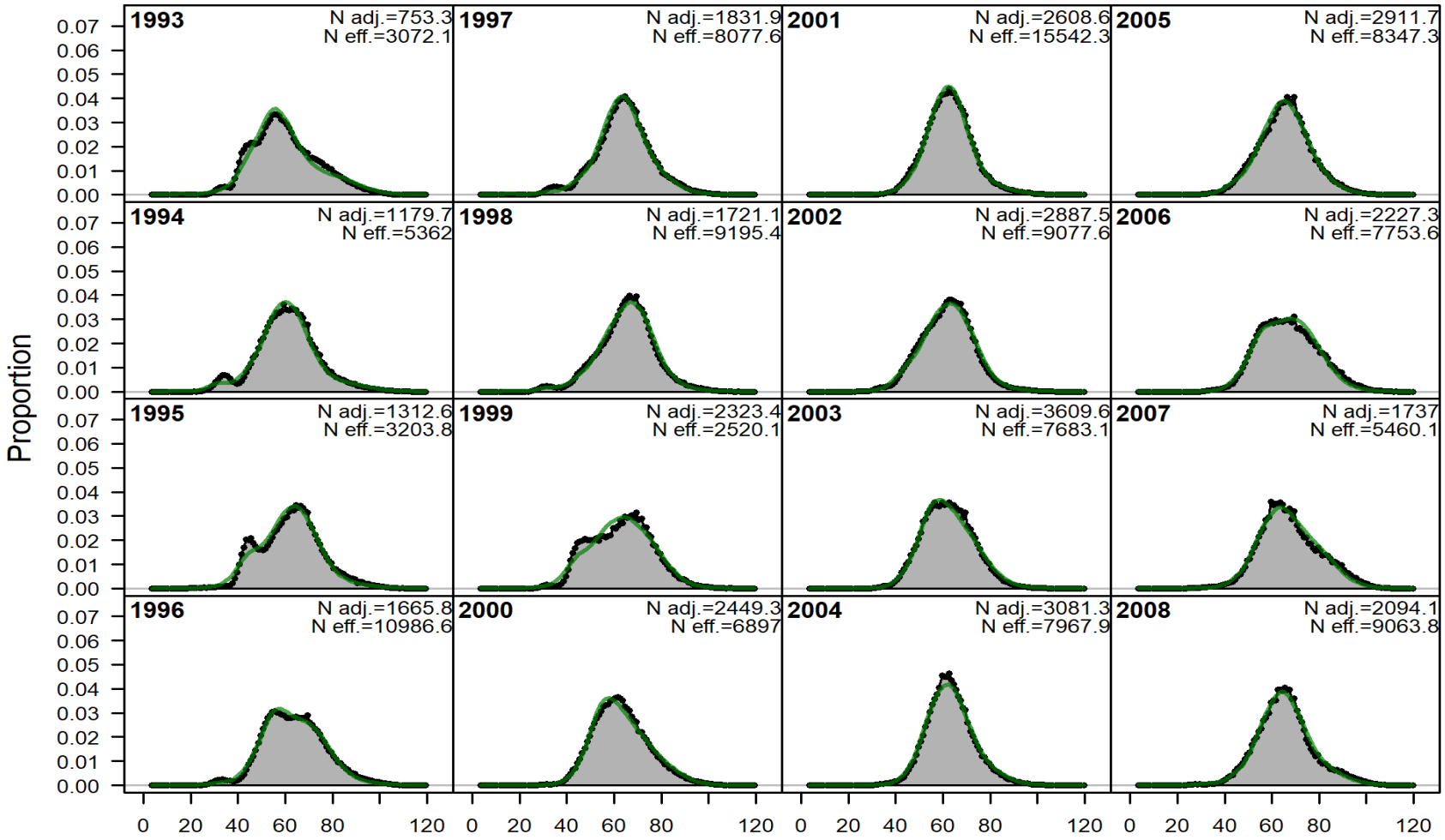

Figure 2.16e (2 of 3)—Model 17.2 fits to the fishery size composition data.

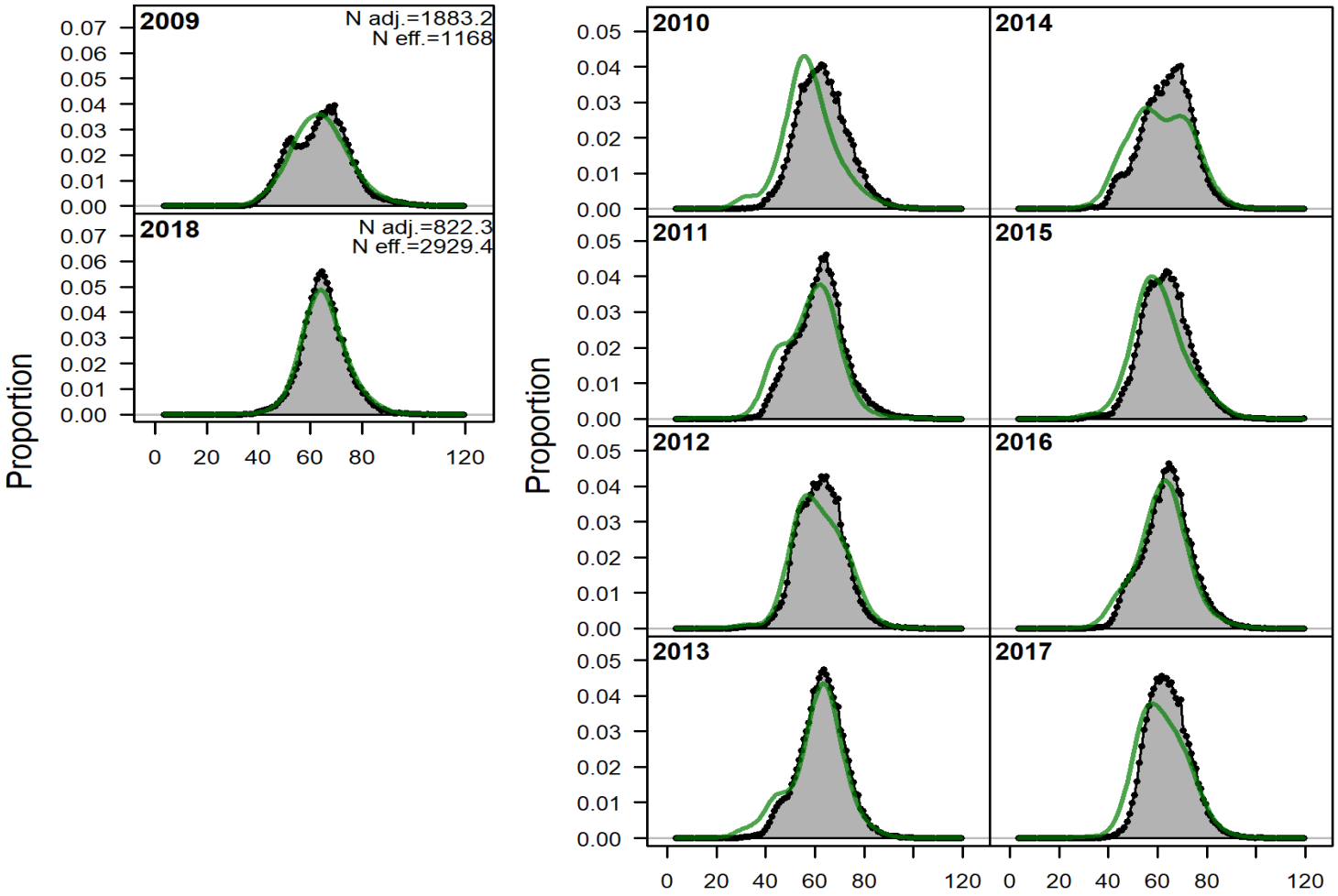

Figure 2.16e (3 of 3)—Model 17.2 fits to the fishery size composition data. Size compositions for 2010-2017 are left in the data file, but "turned off" to avoid double-counting, due to the availability of age compositions for those years, so the panels for 2010-2017 are "ghost" fits.

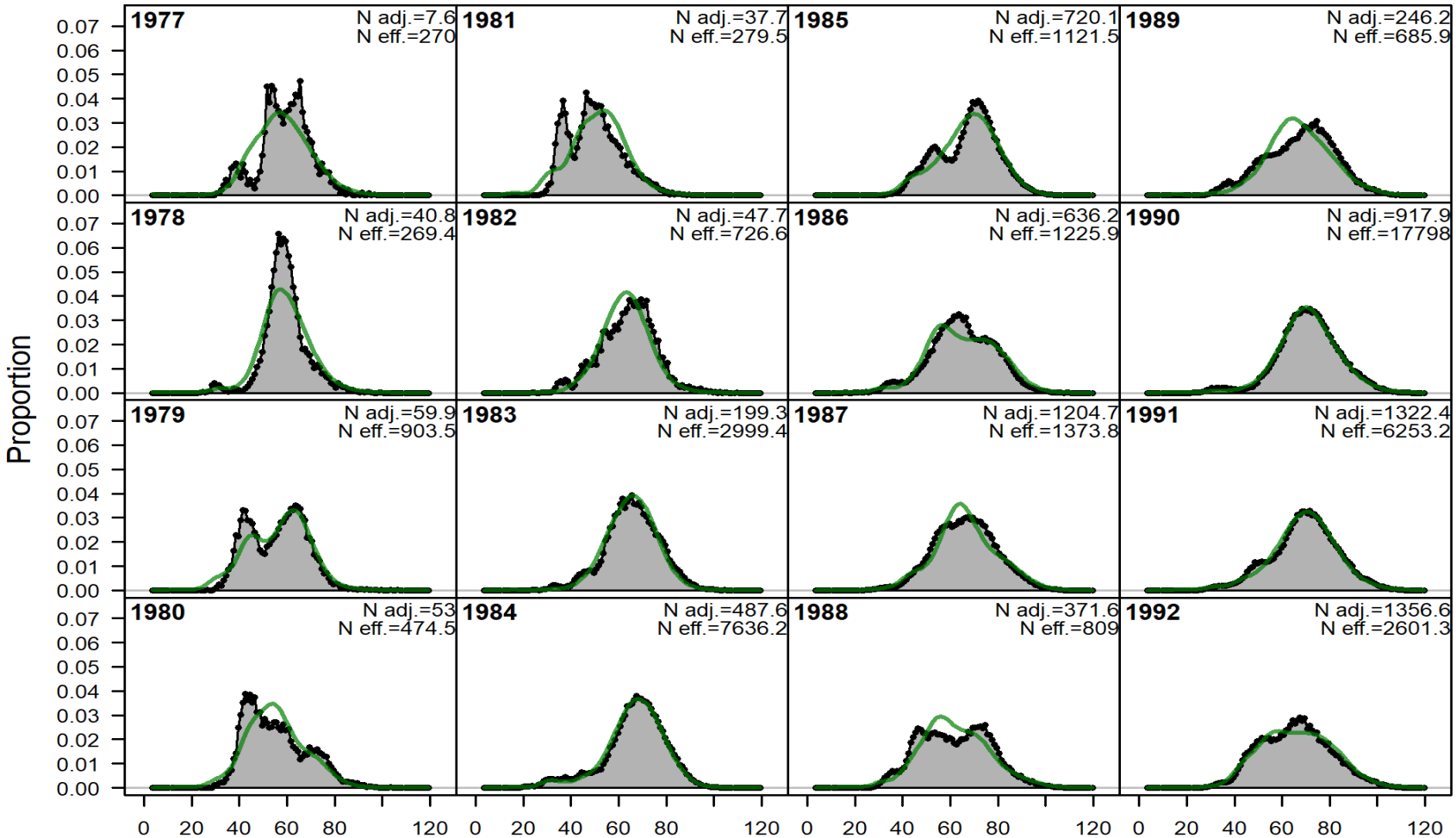

Figure 2.16f (1 of 3)—Model 18.6 fits to the fishery size composition data.

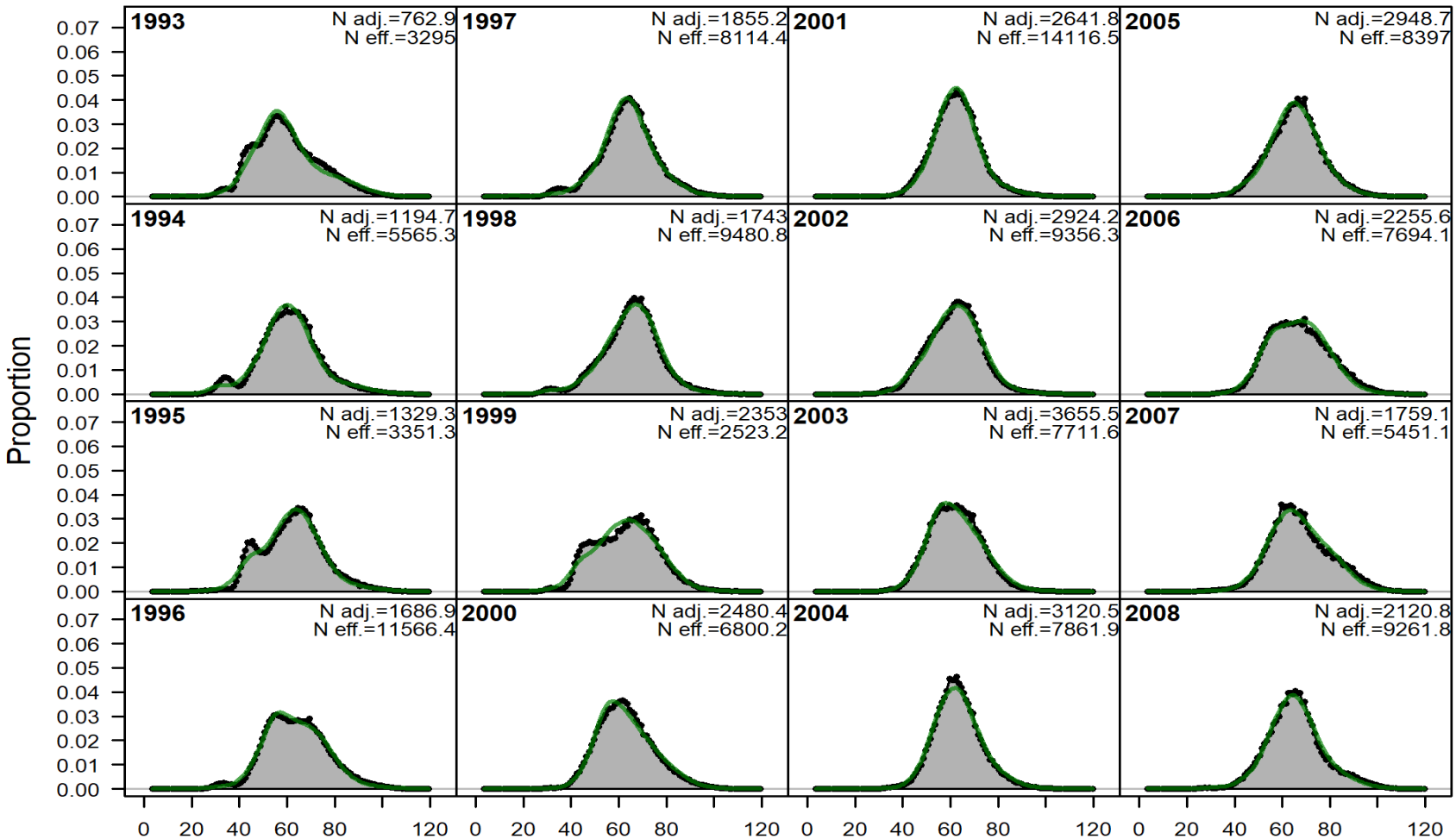

Figure 2.16f (2 of 3)—Model 18.6 fits to the fishery size composition data.

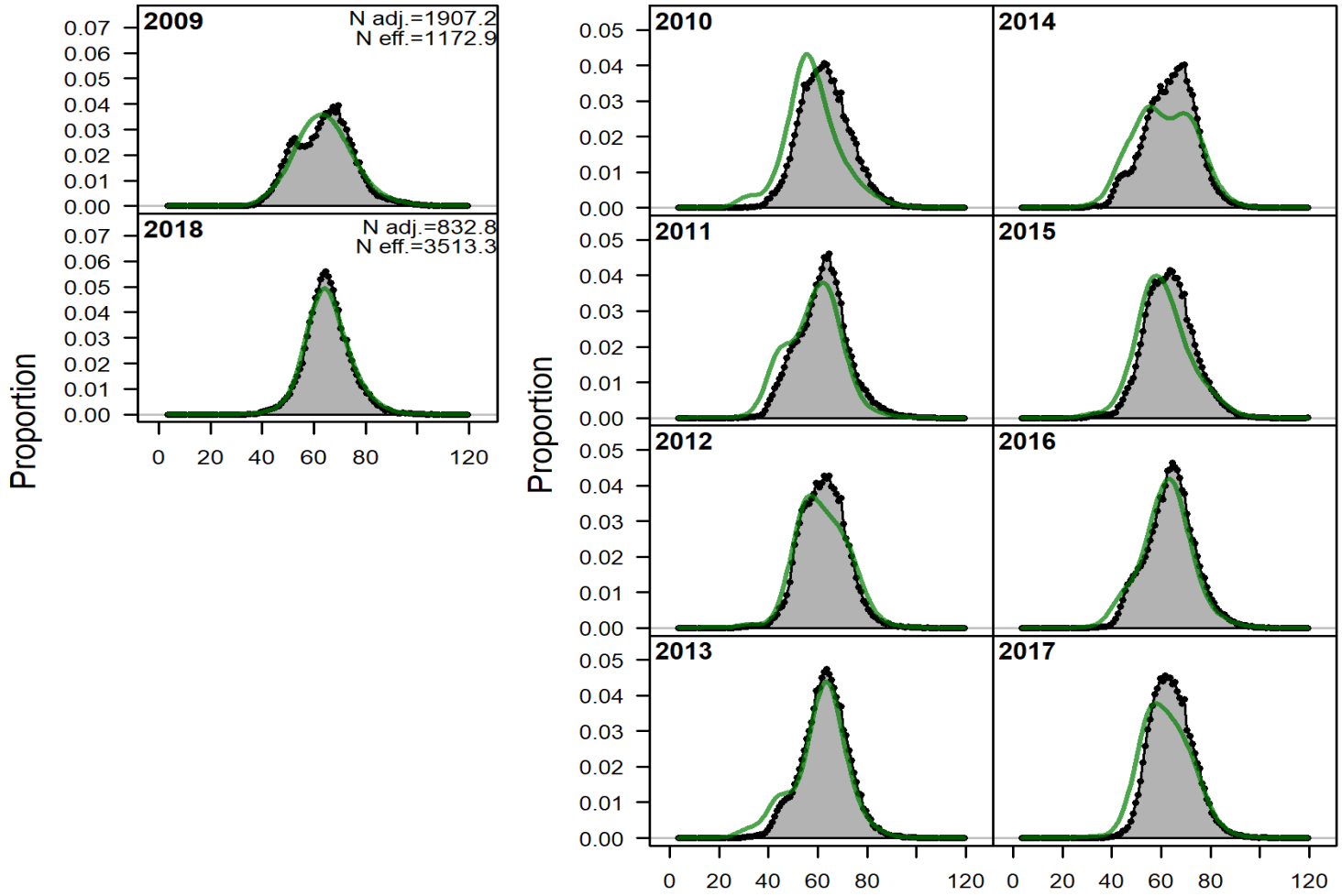

Figure 2.16f (3 of 3)—Model 18.6 fits to the fishery size composition data. Size compositions for 2010-2017 are left in the data file, but "turned off" to avoid double-counting, due to the availability of age compositions for those years, so the panels for 2010-2017 are "ghost" fits.

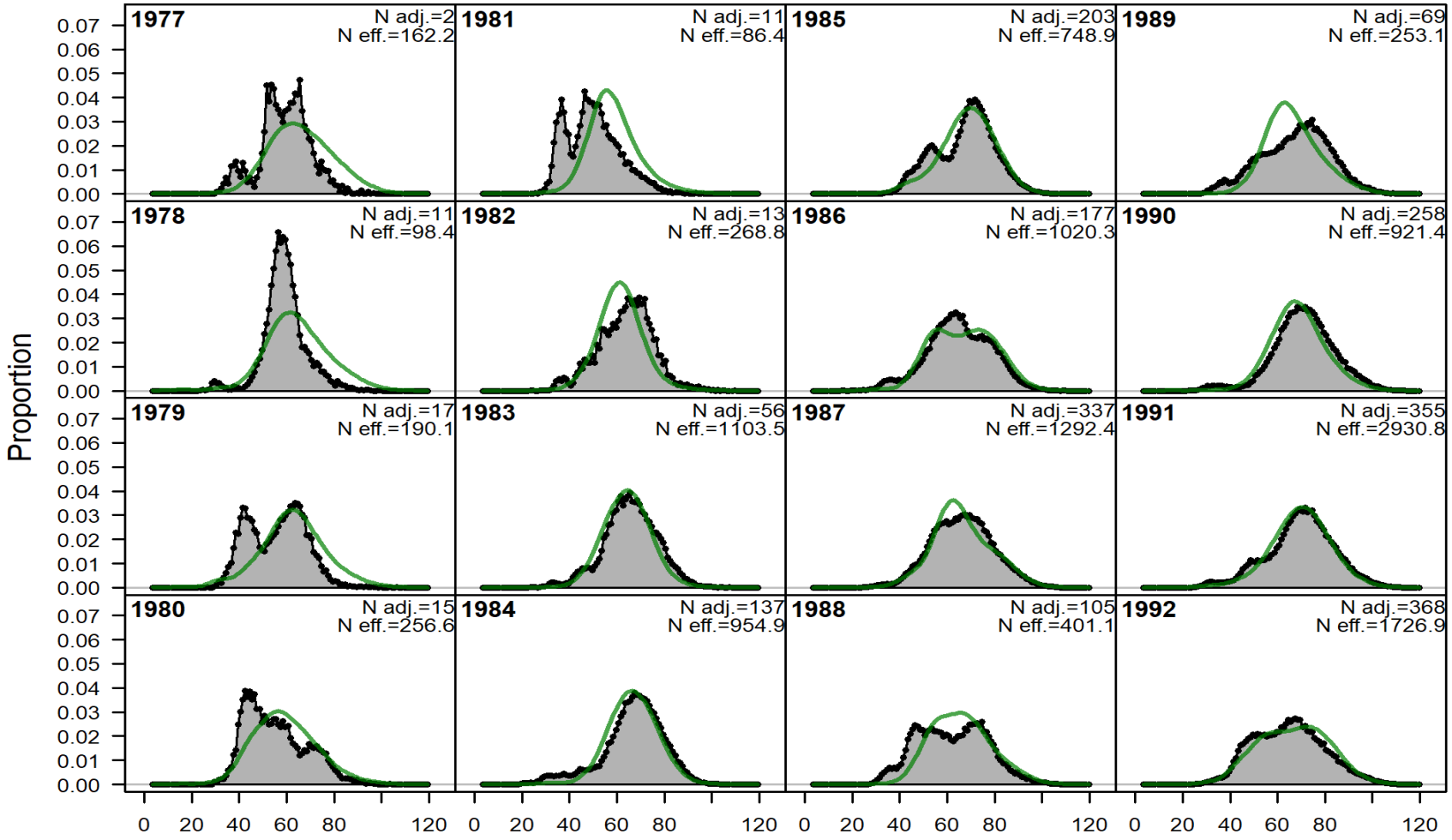

Figure 2.16g (1 of 3)—Model 18.7 fits to the fishery size composition data.

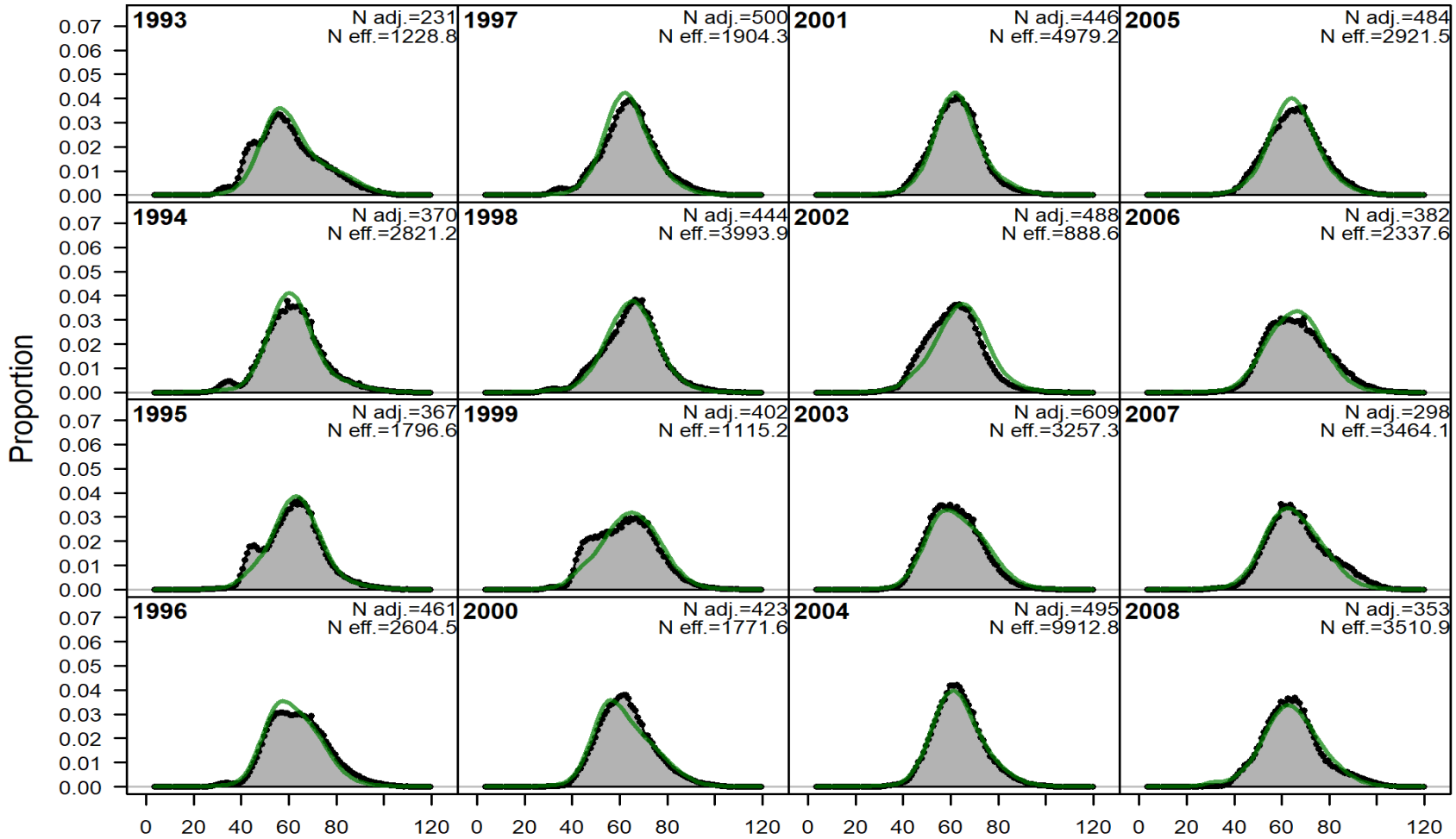

Figure 2.16g (2 of 3)—Model 18.7 fits to the fishery size composition data.

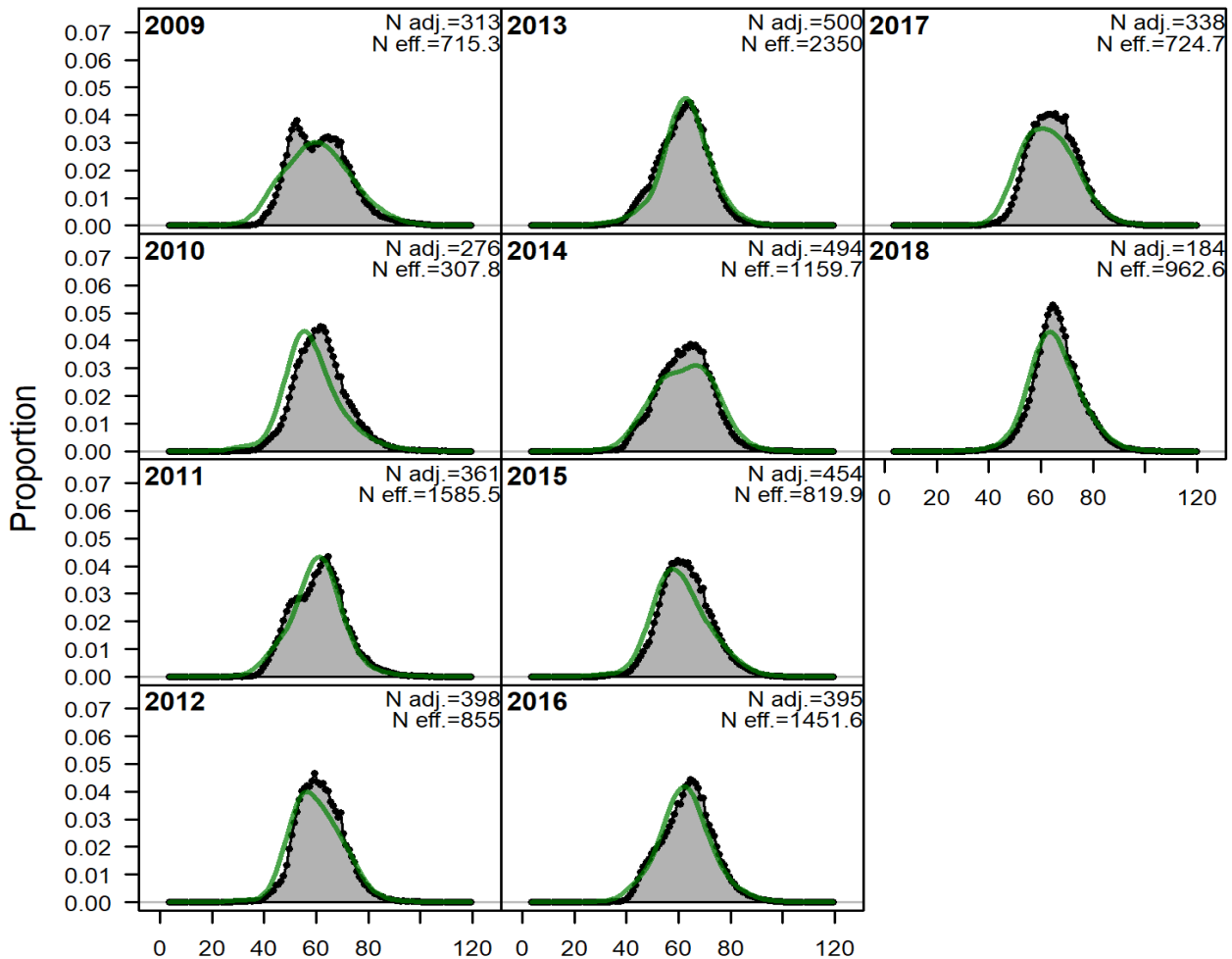

Figure 2.16g (3 of 3)—Model 18.7 fits to the fishery size composition data.

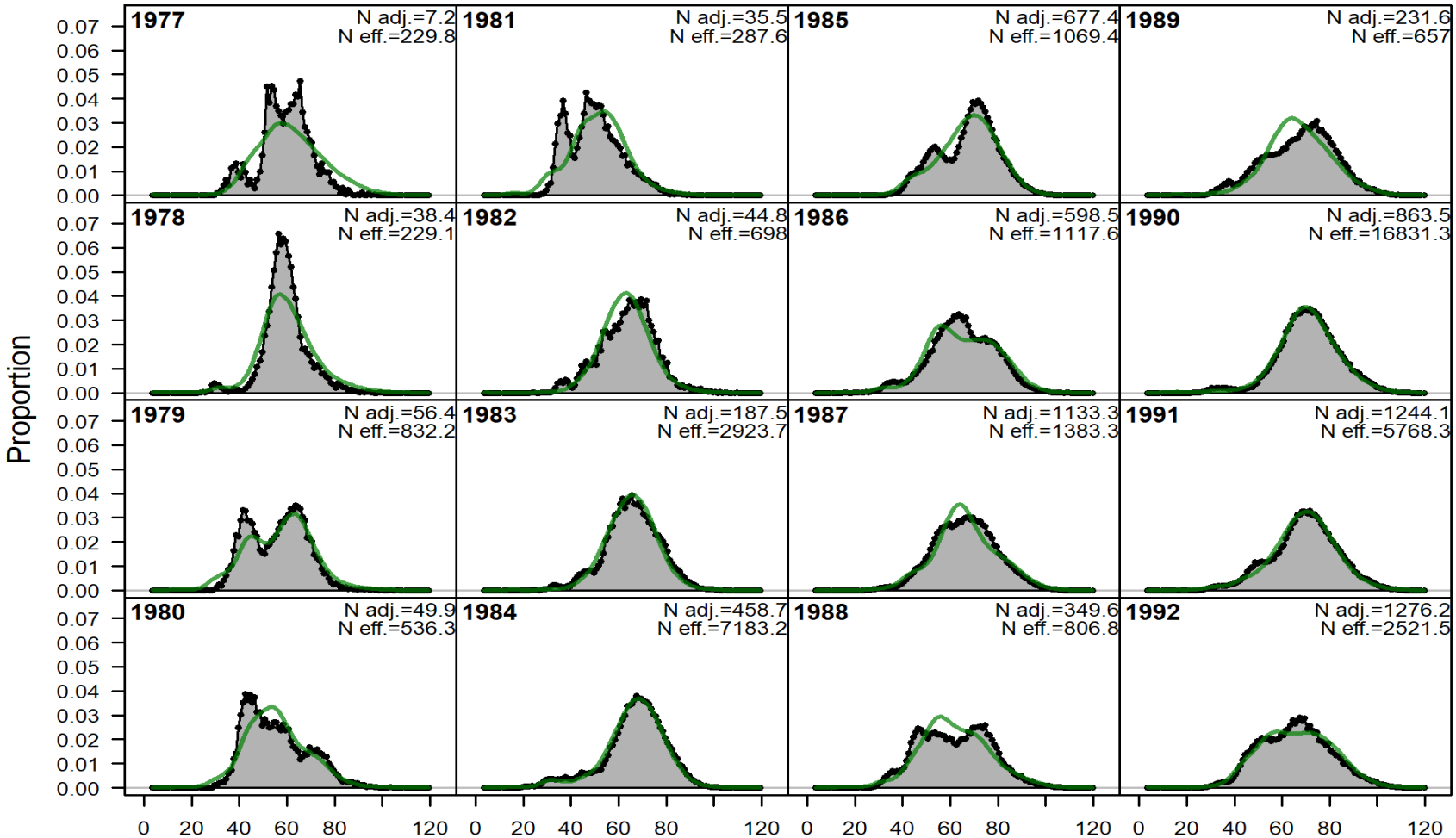

Figure 2.16h (1 of 3)—Model 18.8 fits to the fishery size composition data.

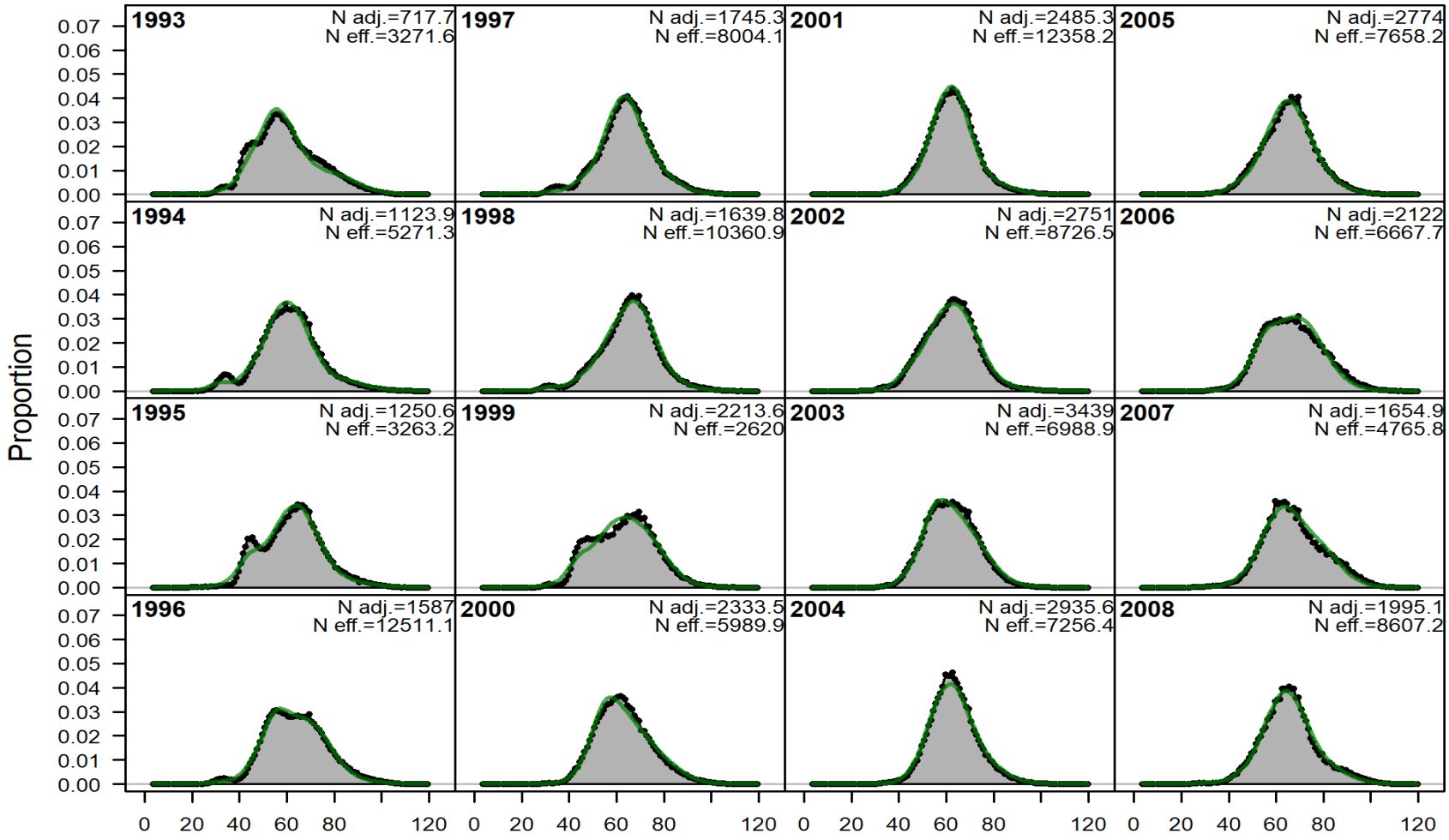

Figure 2.16h (2 of 3)—Model 18.8 fits to the fishery size composition data.

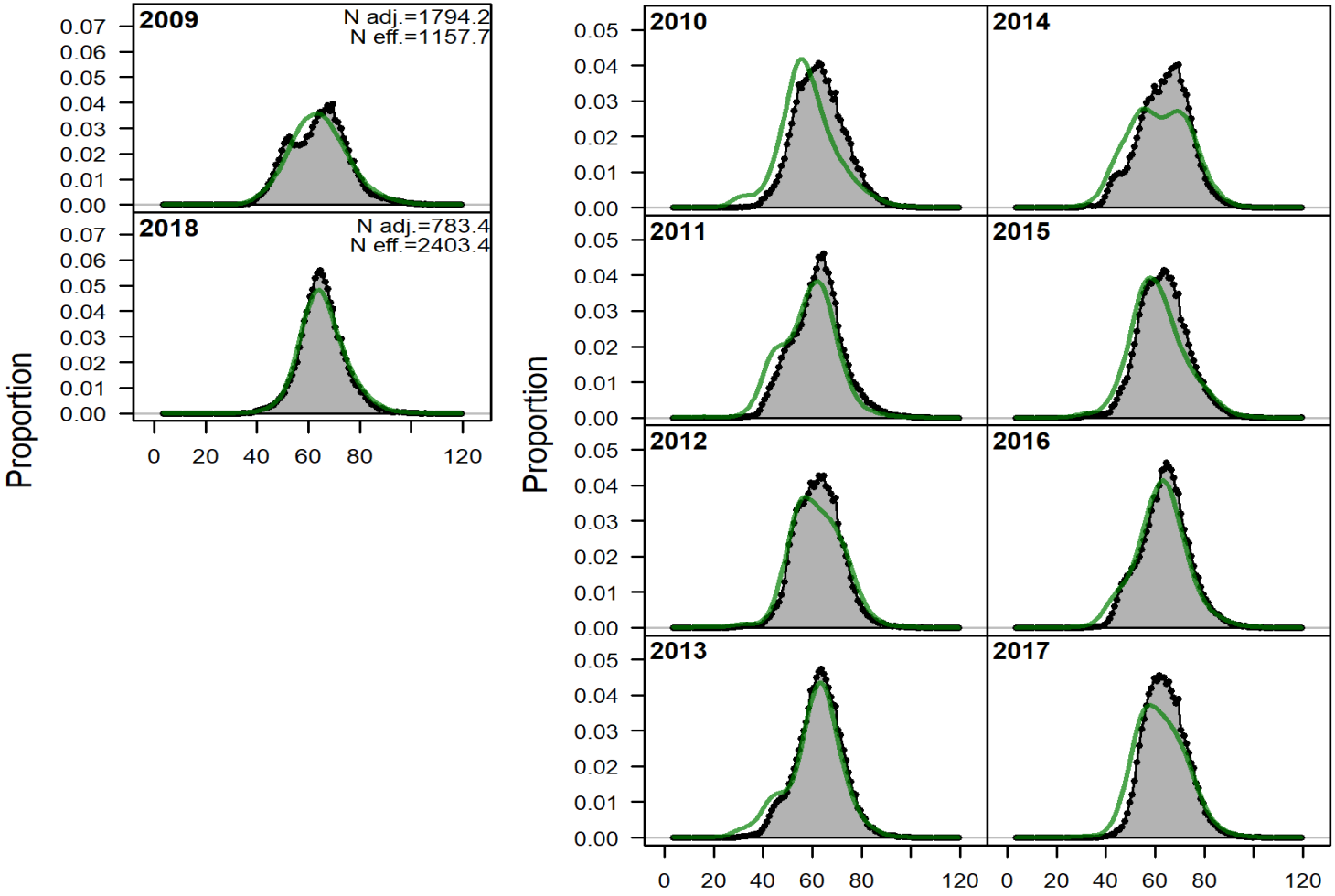

Figure 2.16h (3 of 3)—Model 18.8 fits to the fishery size composition data. Size compositions for 2010-2017 are left in the data file, but "turned off" to avoid double-counting, due to the availability of age compositions for those years, so the panels for 2010-2017 are "ghost" fits.

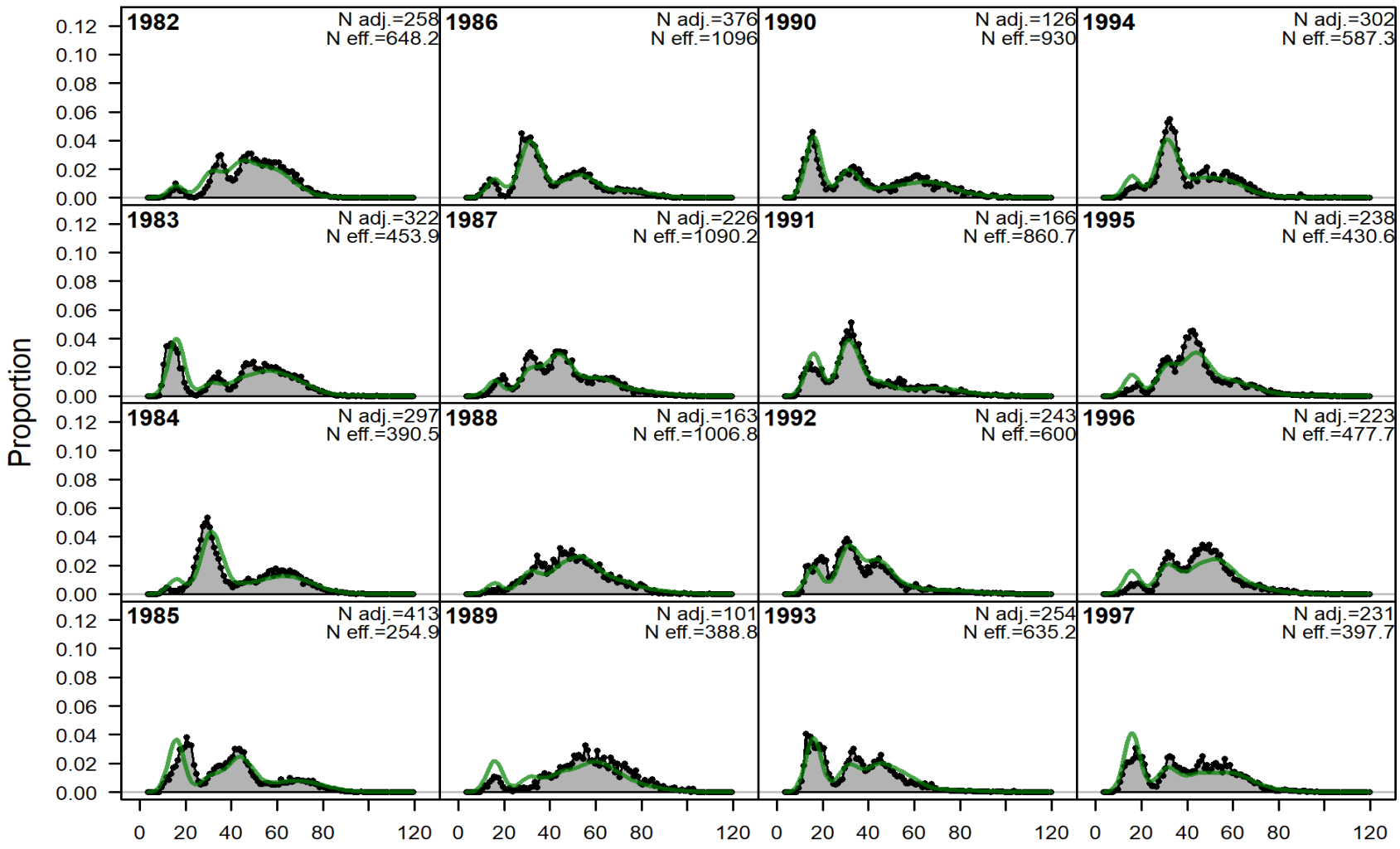

Figure 2.17a (1 of 3)—Model 16.6 fits to the survey size composition data.

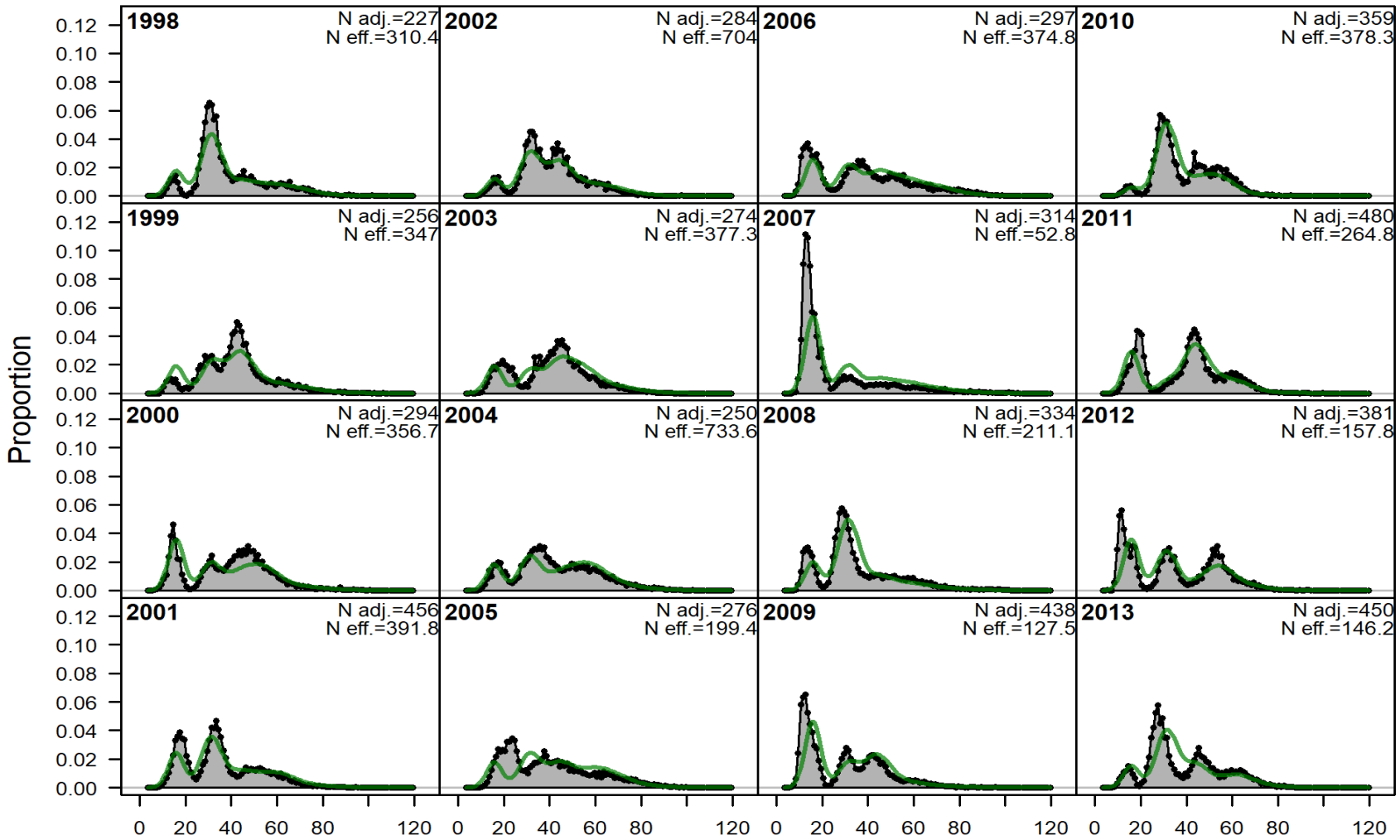

Figure 2.17a (2 of 3)—Model 16.6 fits to the survey size composition data.

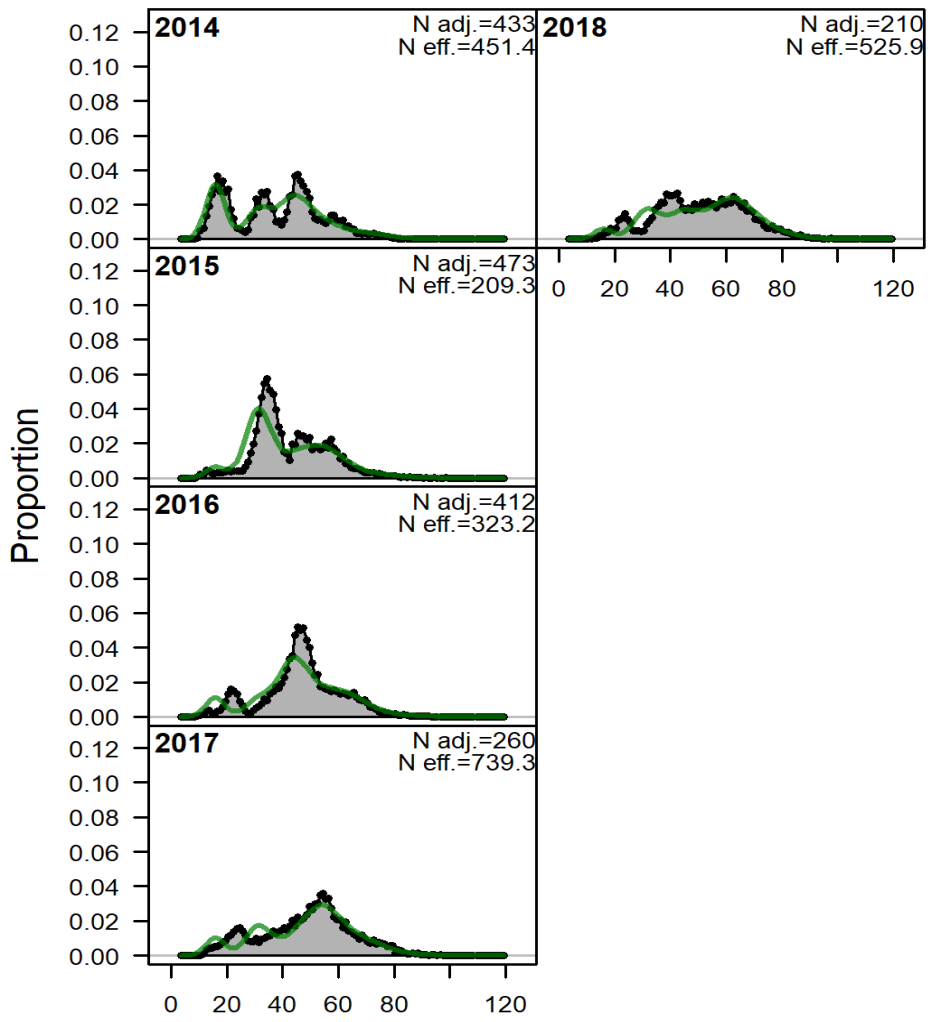

Figure 2.17a (3 of 3)—Model 16.6 fits to the survey size composition data.

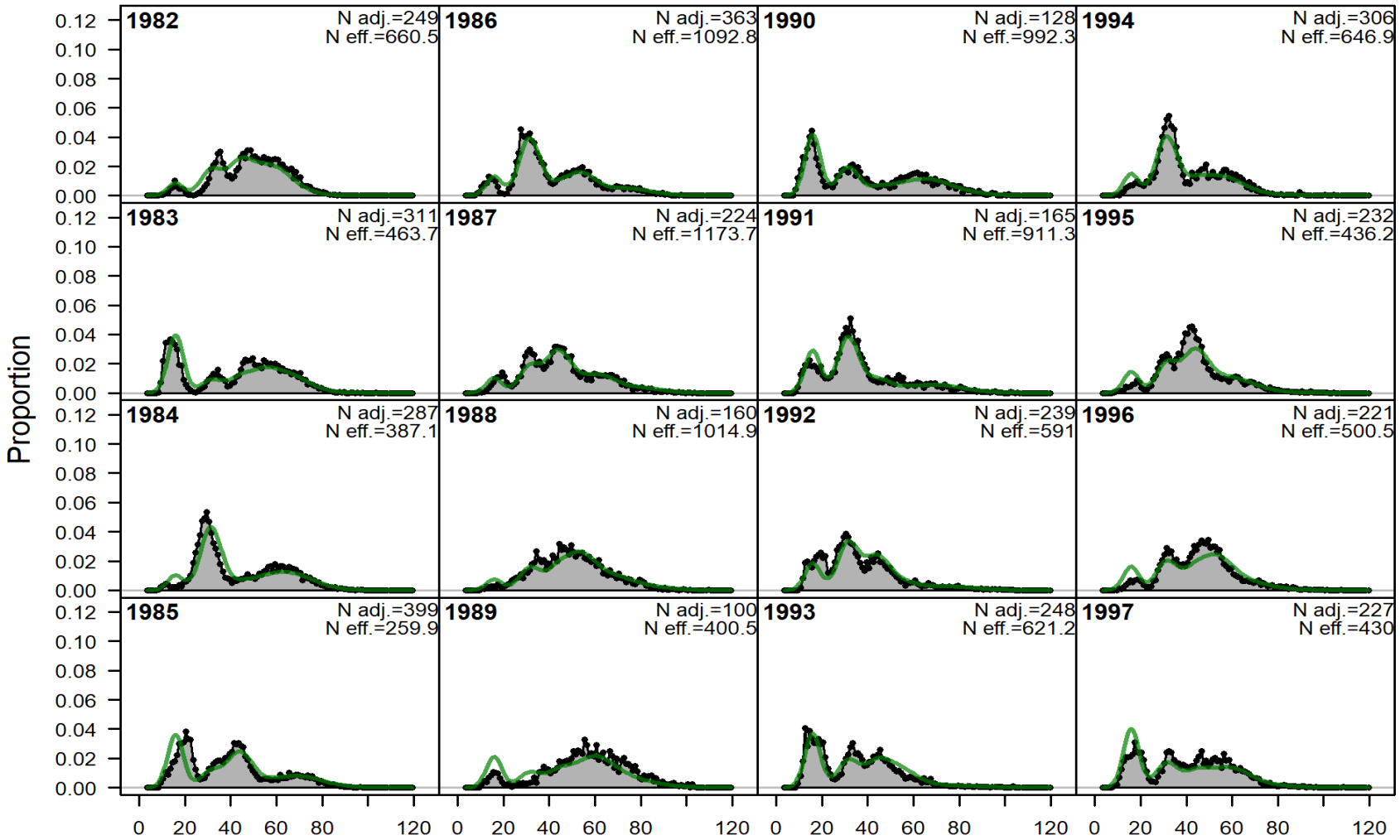

Figure 2.17b (1 of 3)—Model 16.6i fits to the survey size composition data.

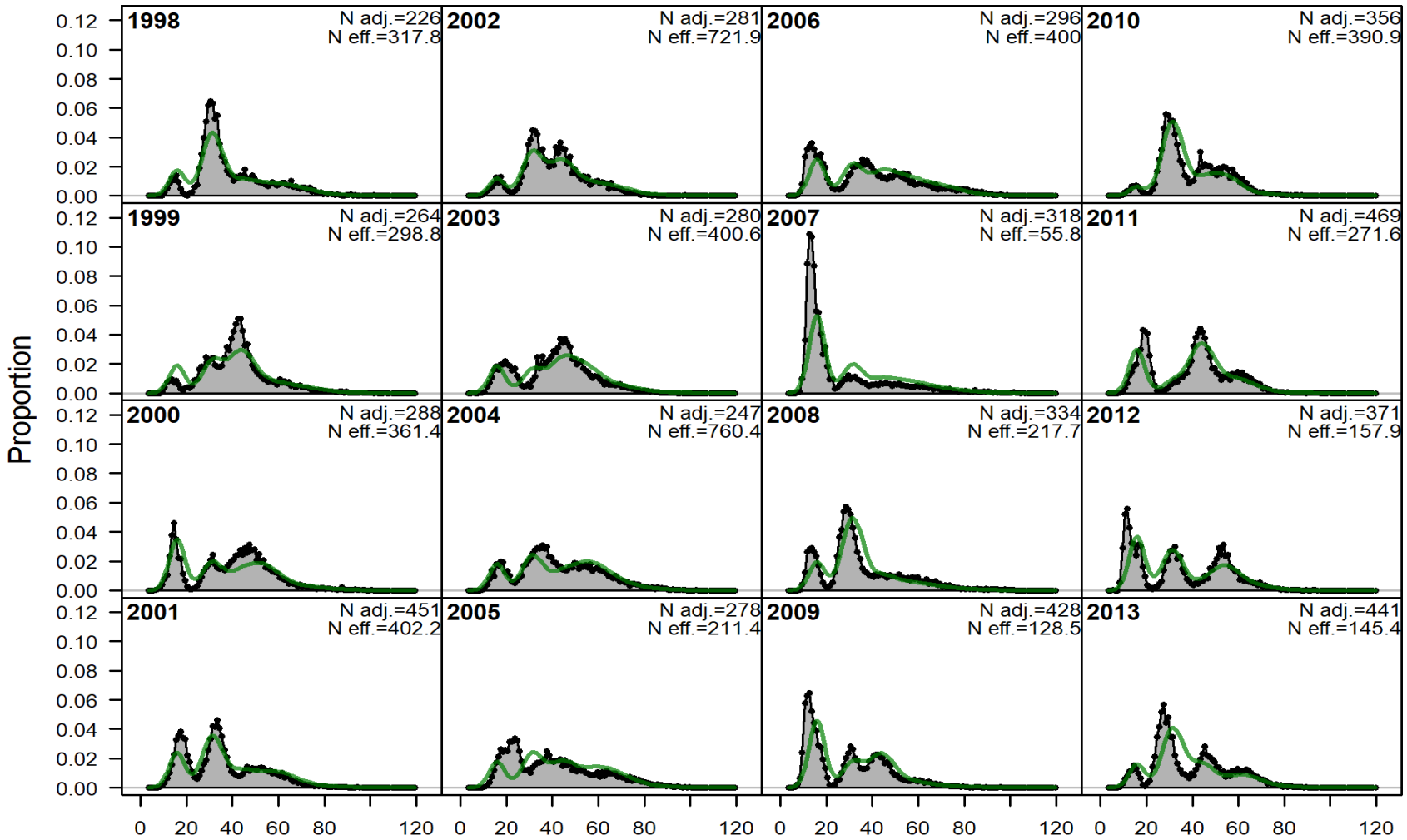

Figure 2.17b (page 2 of 3)—Model 16.6i fits to the survey size composition data.

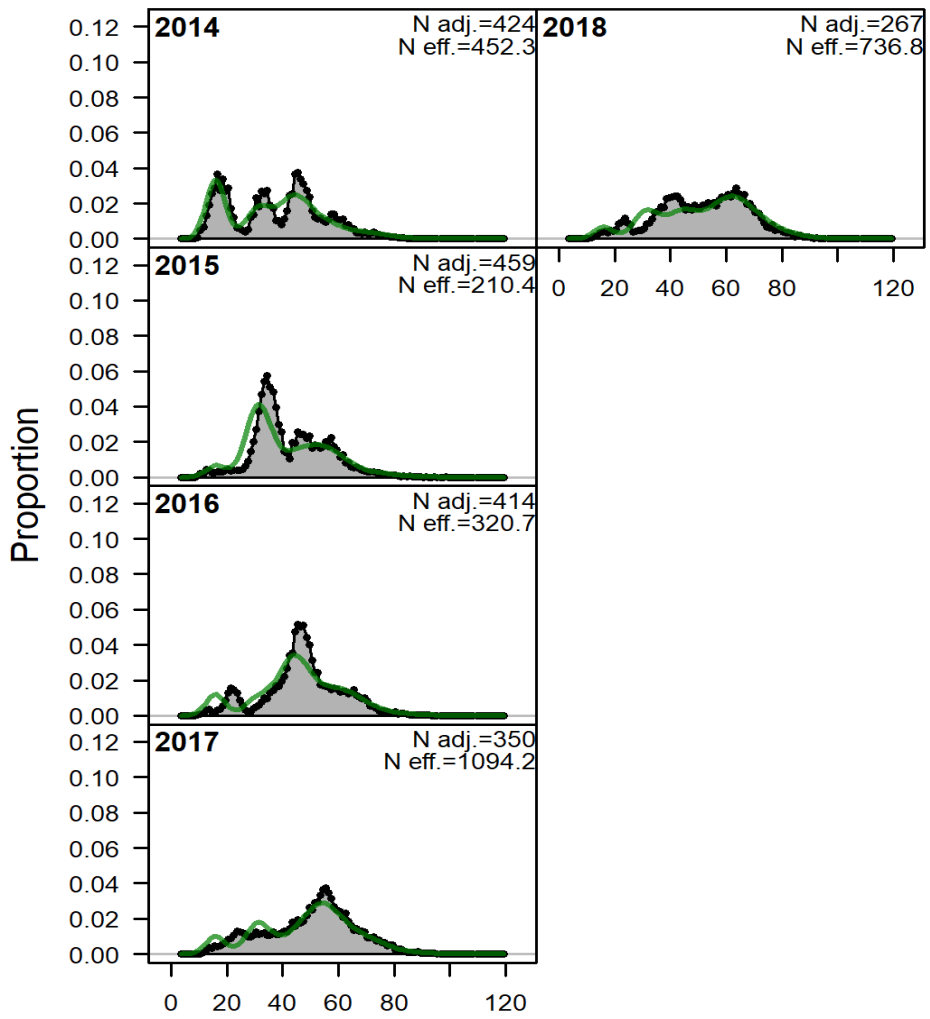

Figure 2.17b (3 of 3)—Model 16.6i fits to the survey size composition data.

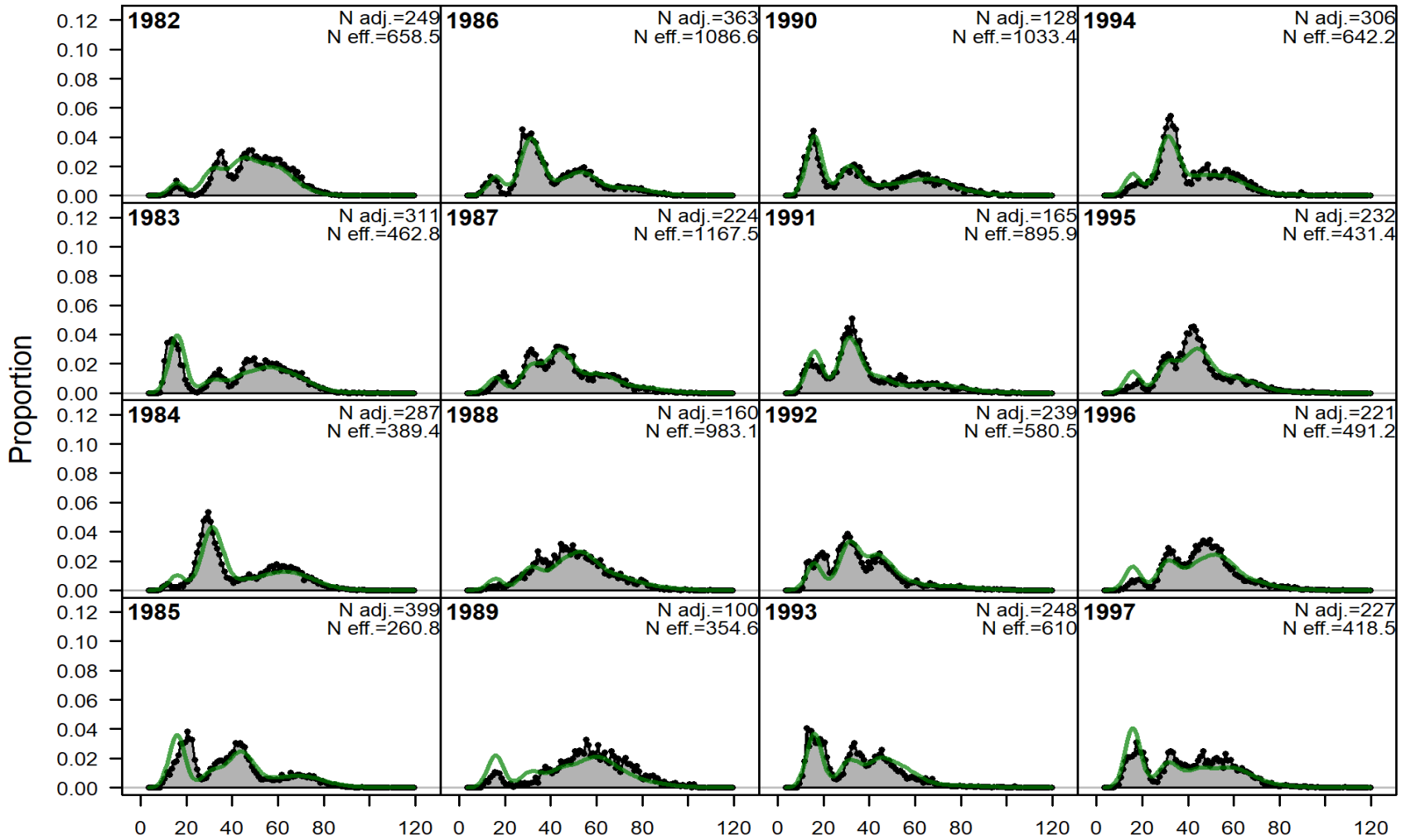

Figure 2.17c (1 of 3)—Model 16.6j fits to the survey size composition data.

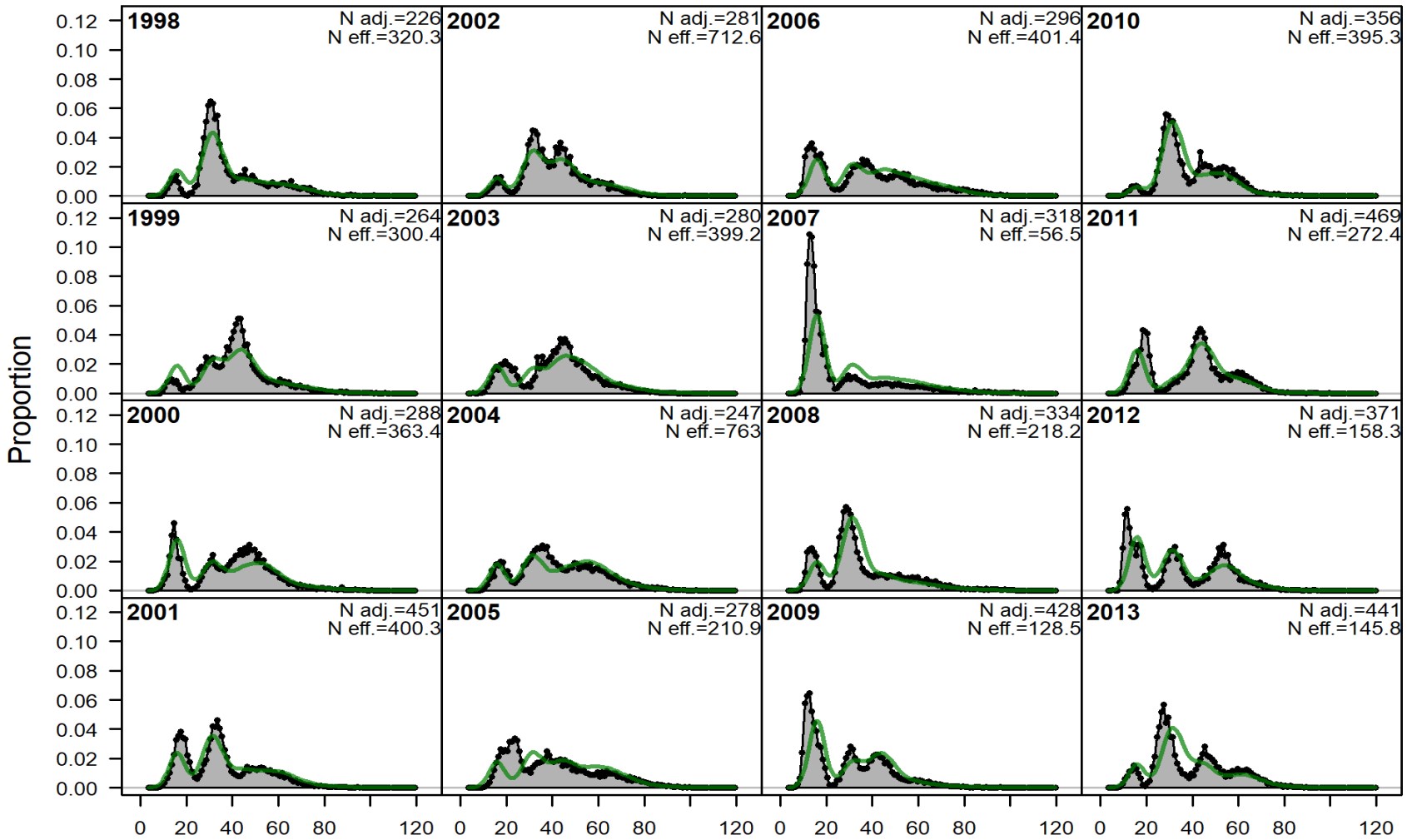

Figure 2.17c (2 of 3)—Model 16.6j fits to the survey size composition data.

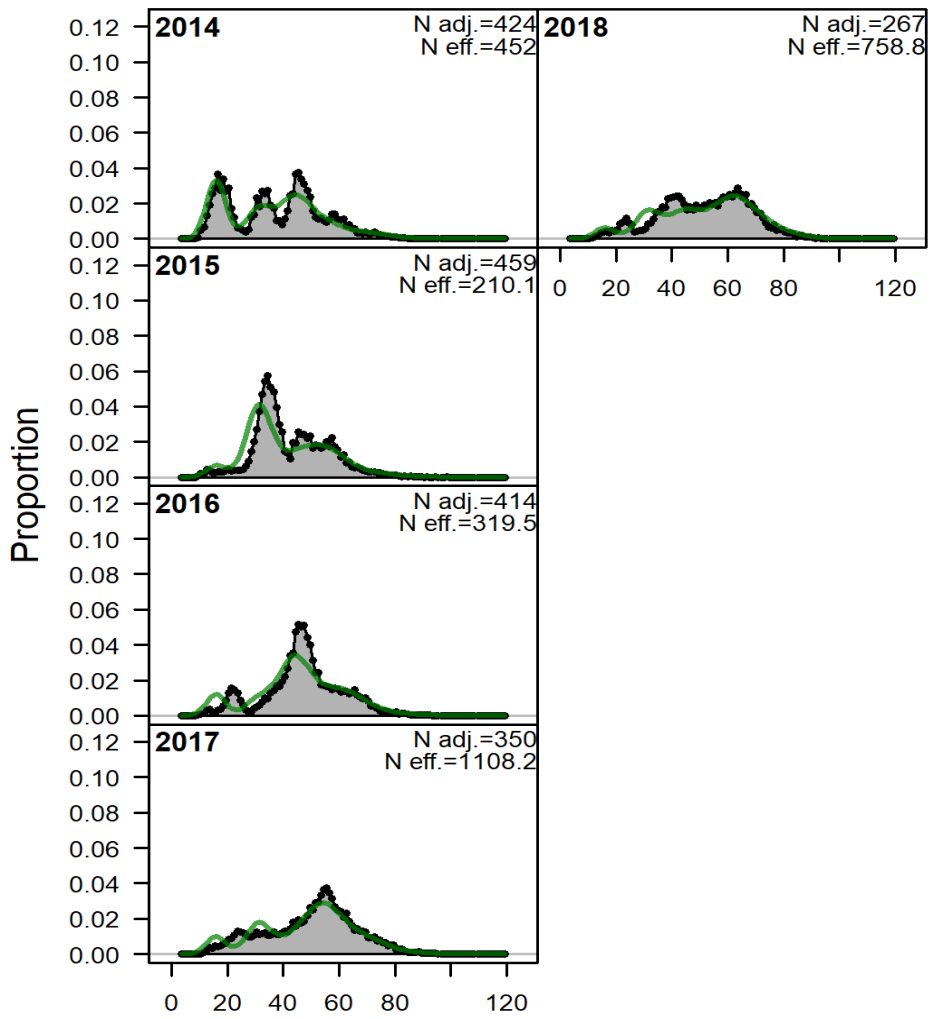

Figure 2.17c (3 of 3)—Model 16.6j fits to the survey size composition data.

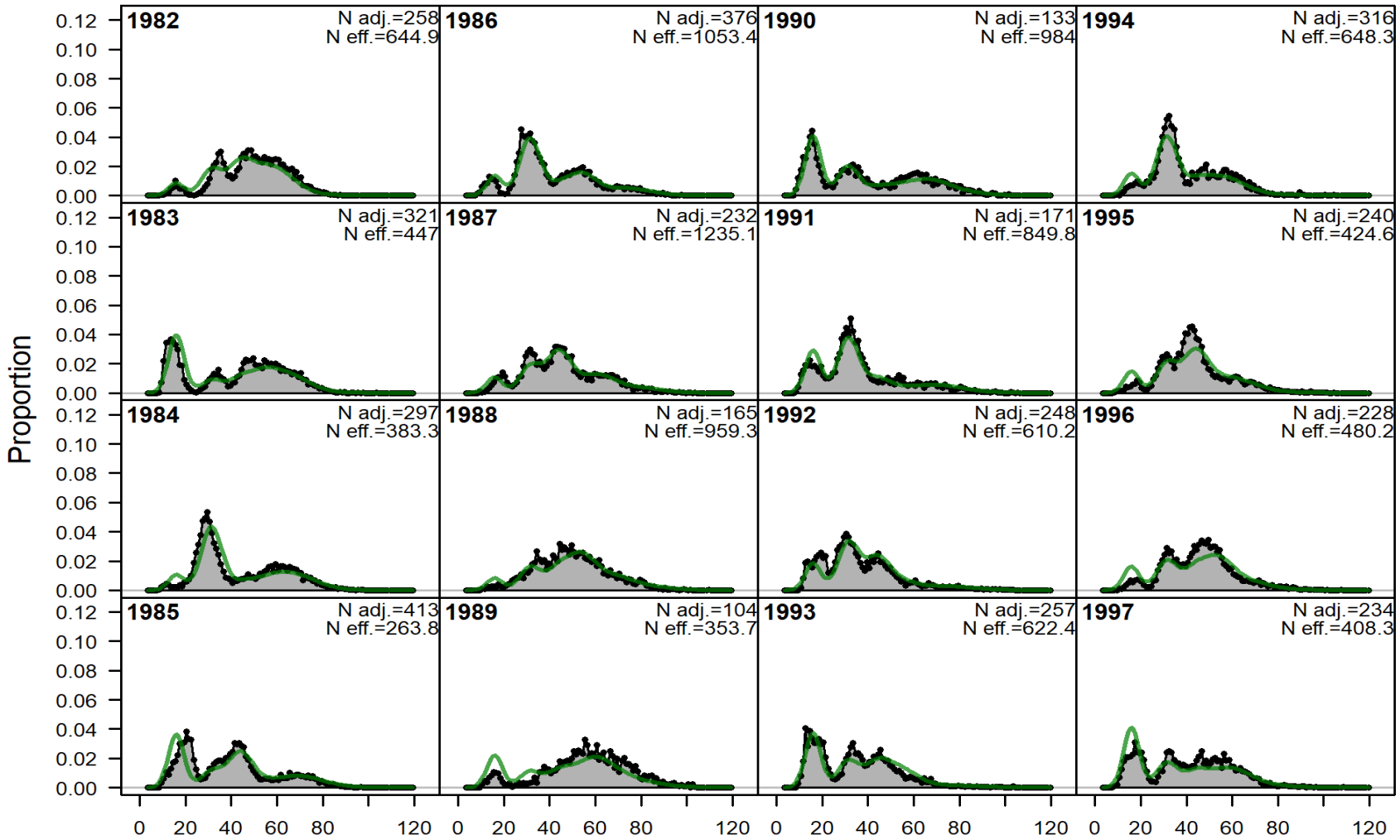

Figure 2.17d (1 of 3)—Model 16.6k fits to the survey size composition data.

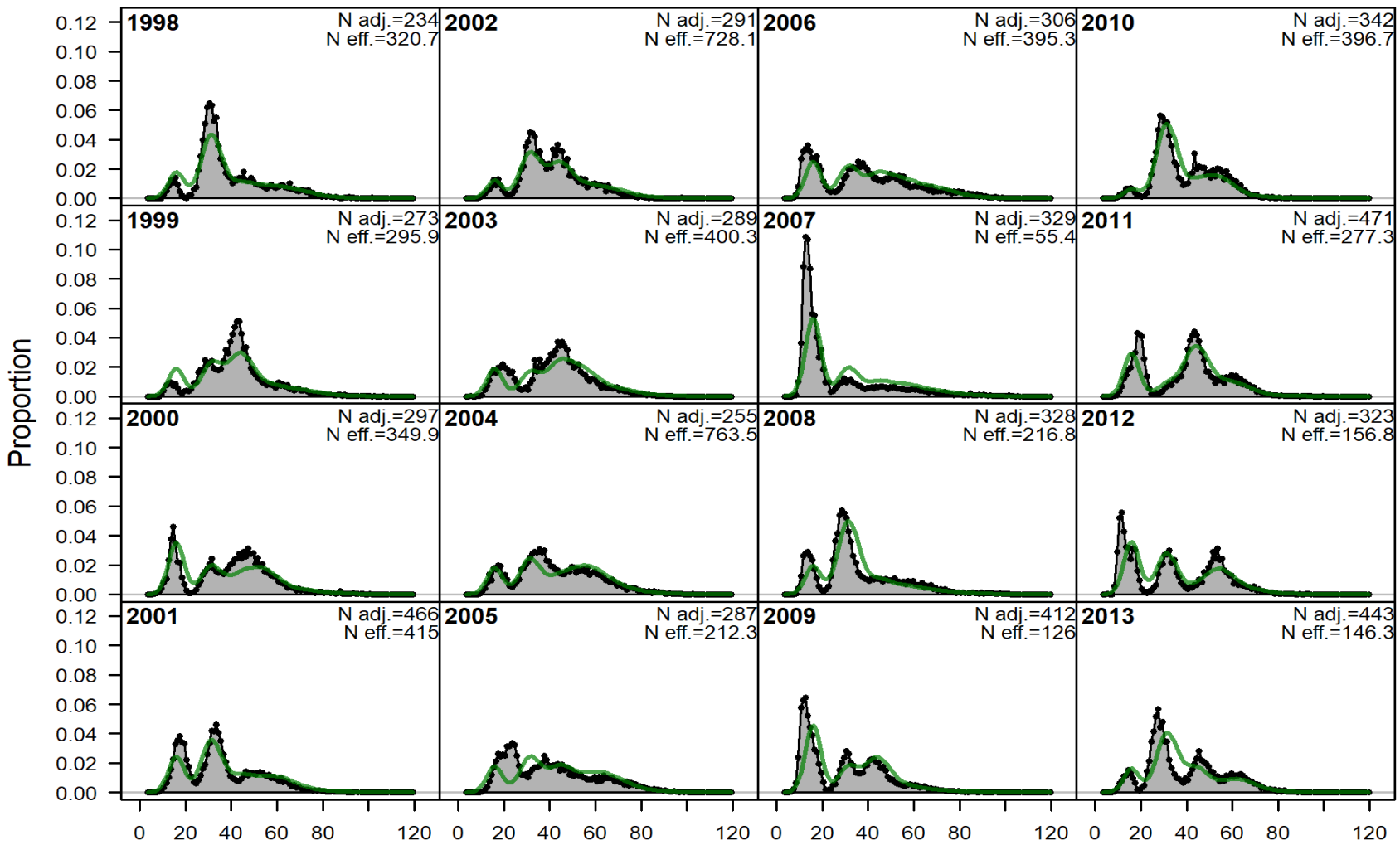

Figure 2.17d (2 of 3)—Model 16.6k fits to the survey size composition data.

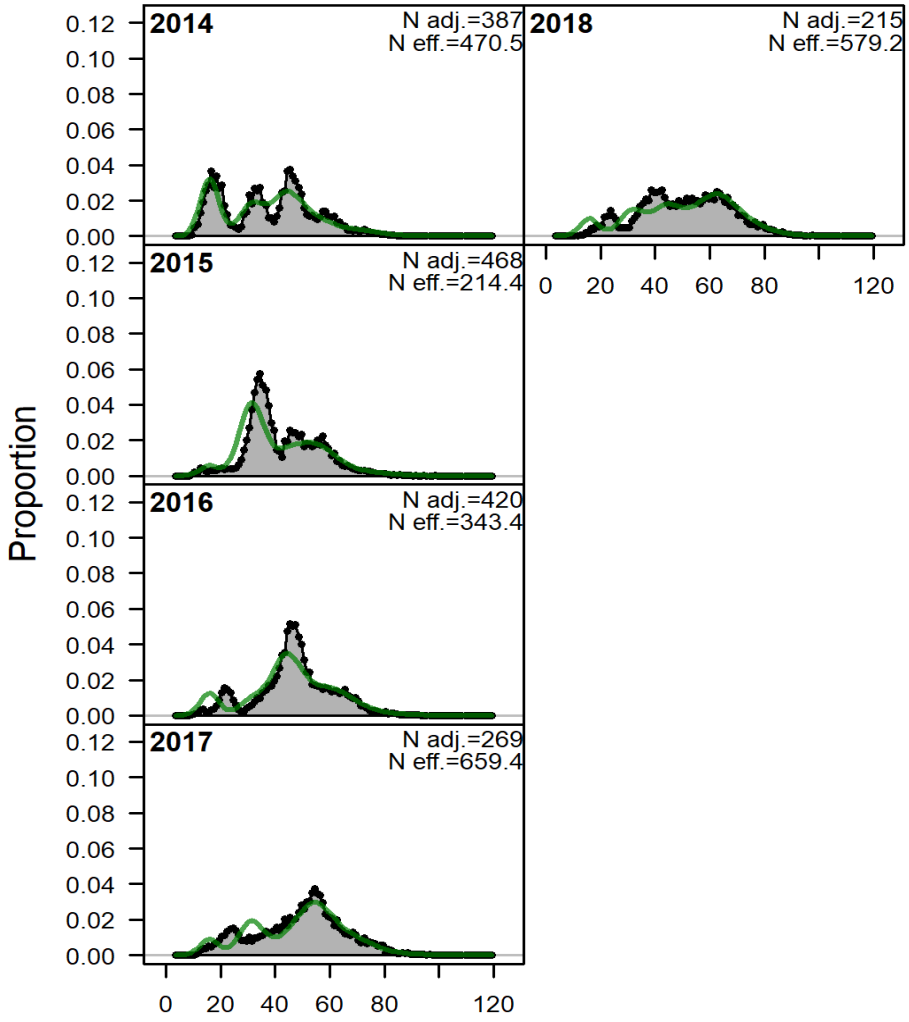

Figure 2.17d (3 of 3)—Model 16.6k fits to the survey size composition data.

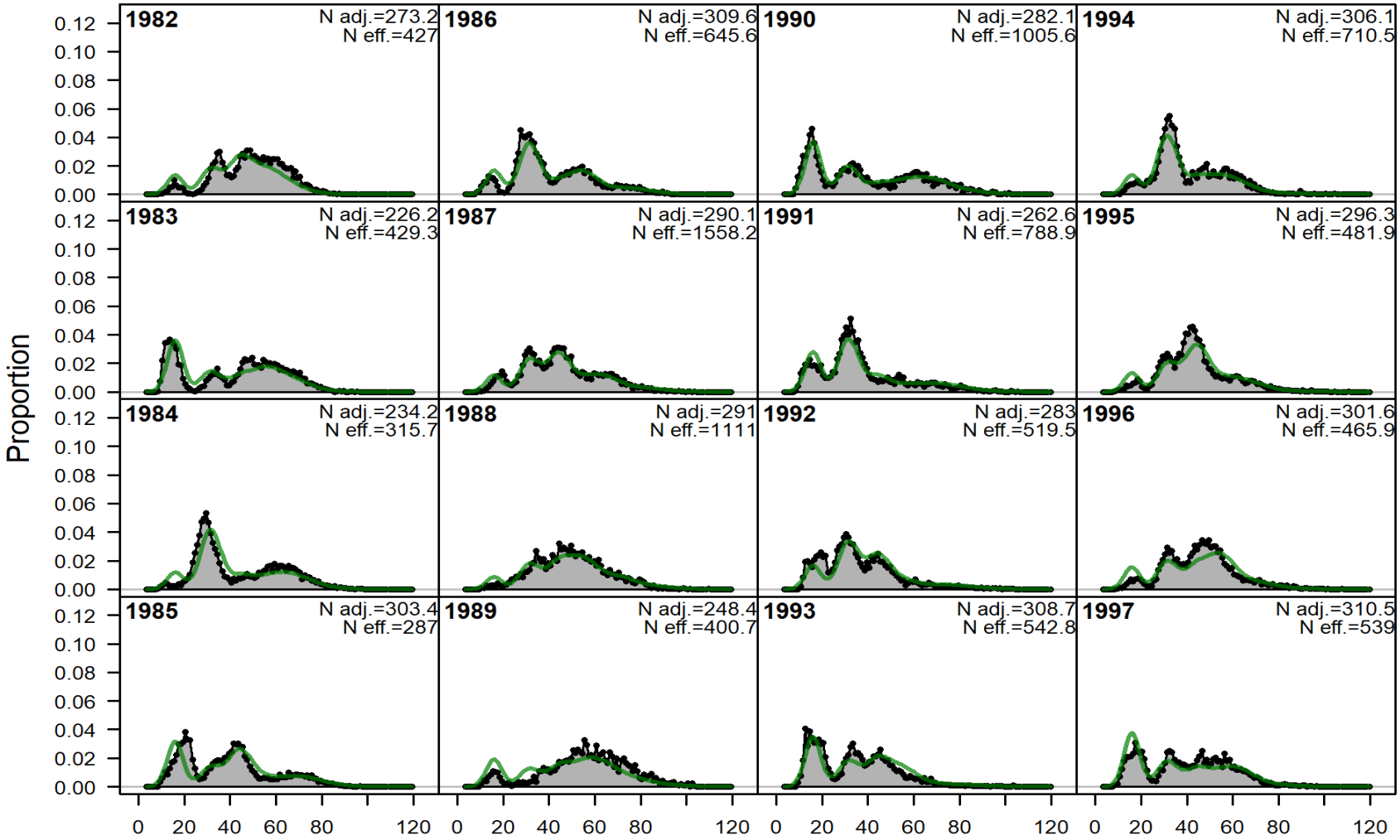

Figure 2.17e (1 of 3)—Model 17.2 fits to the survey size composition data.

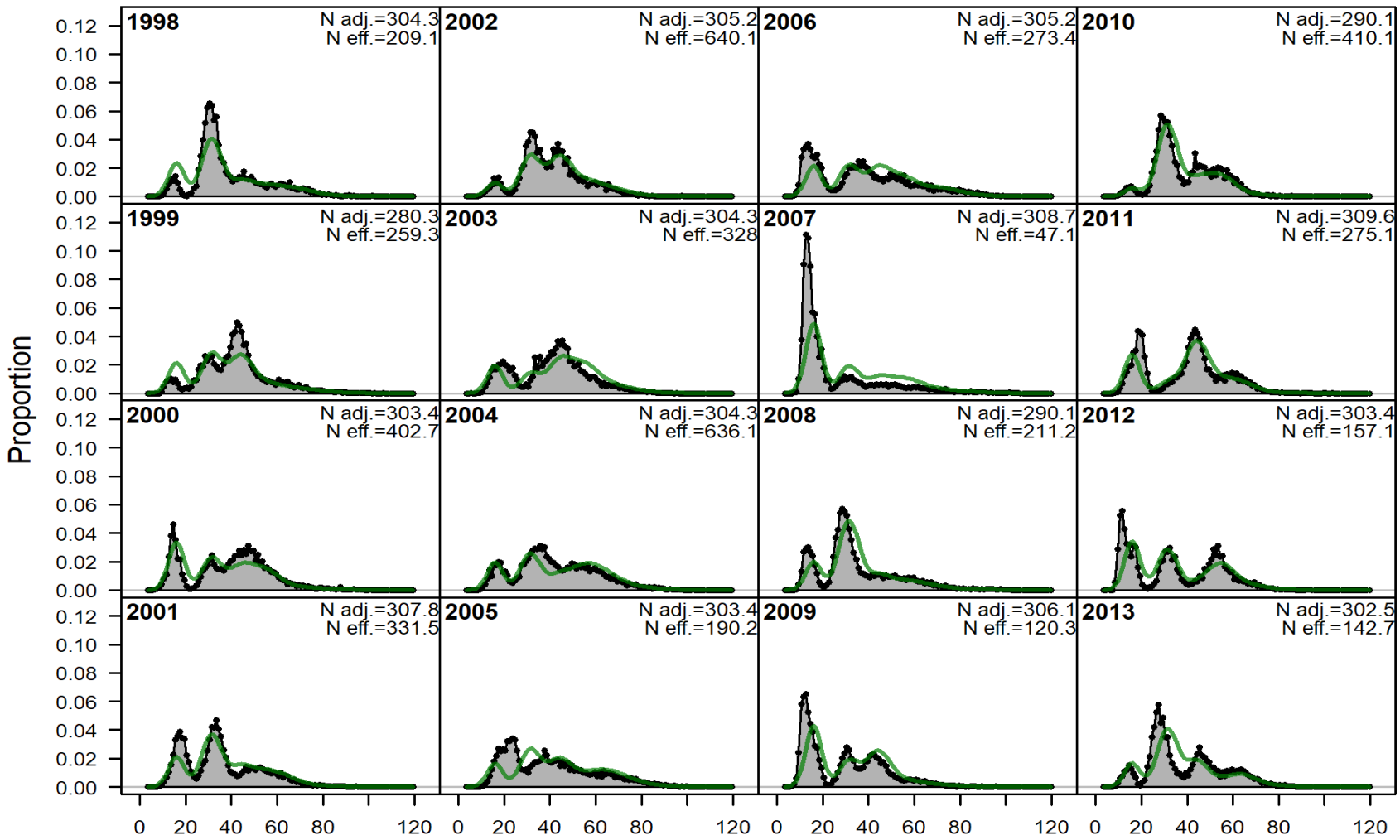

Figure 2.17e (2 of 3)—Model 17.2 fits to the survey size composition data.

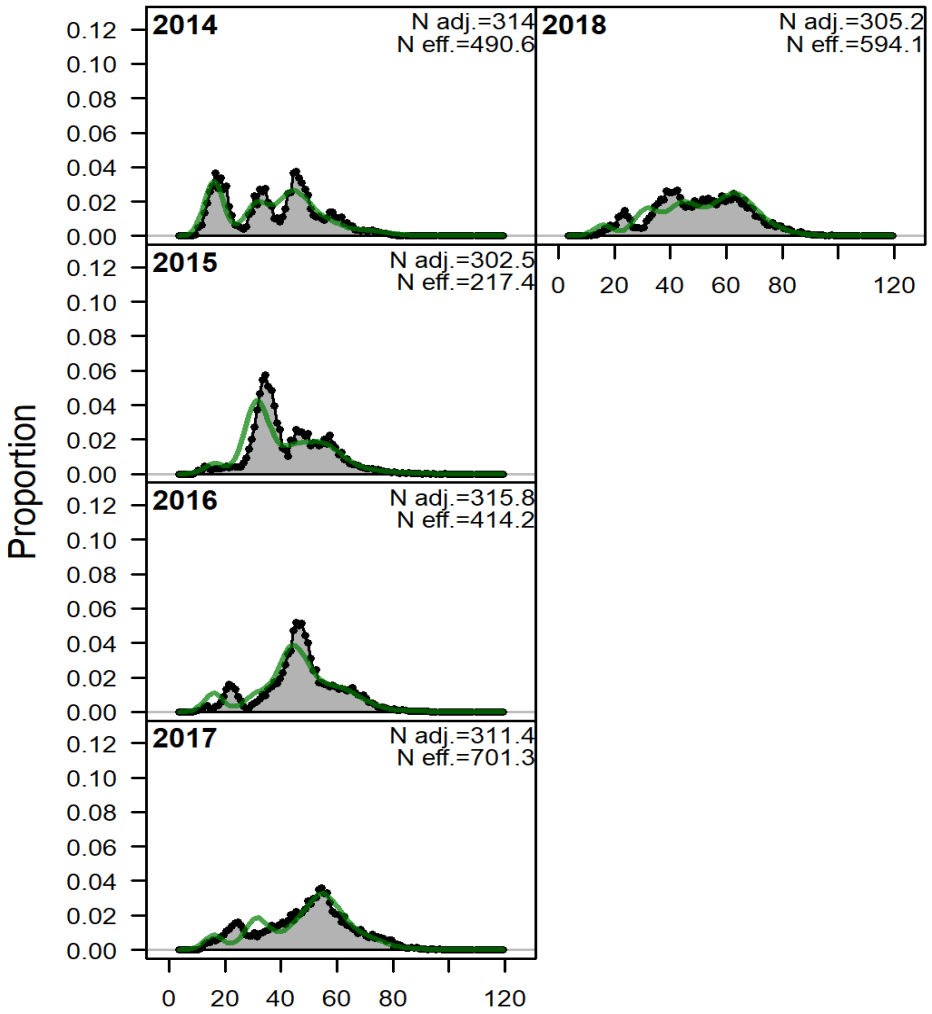

Figure 2.17e (3 of 3)—Model 17.2 fits to the survey size composition data.

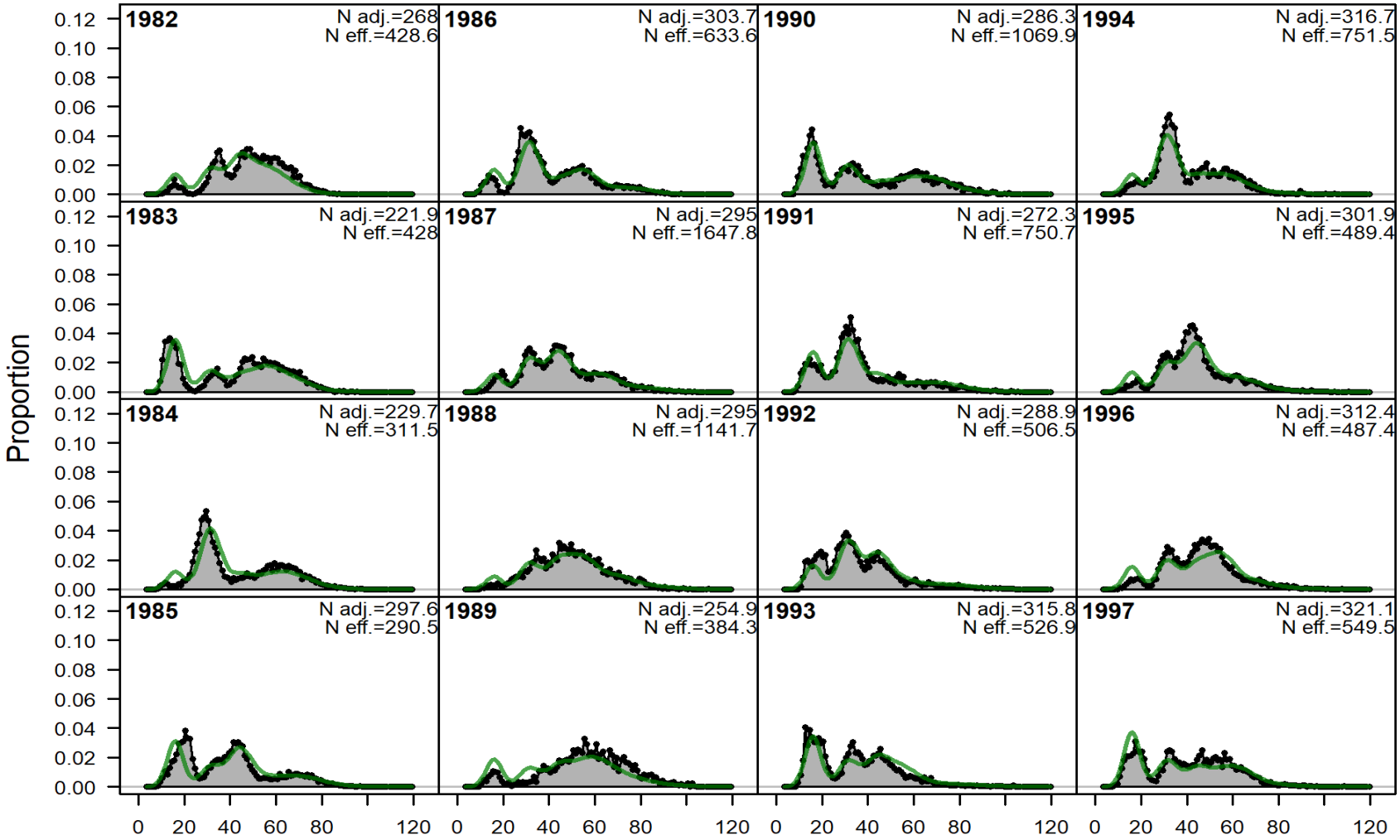

Figure 2.17f (1 of 3)—Model 18.6 fits to the survey size composition data.

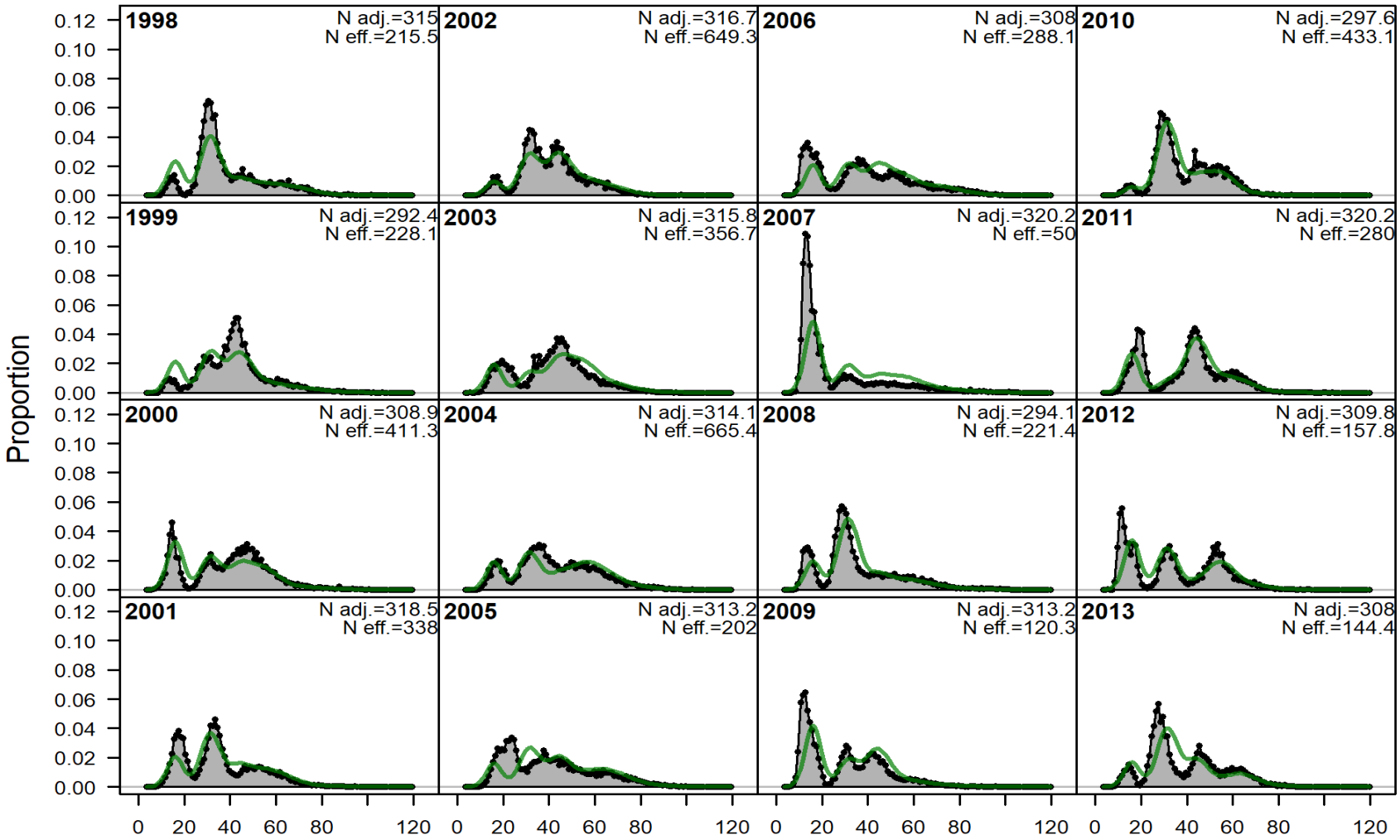

Figure 2.17f (2 of 3)—Model 18.6 fits to the survey size composition data.

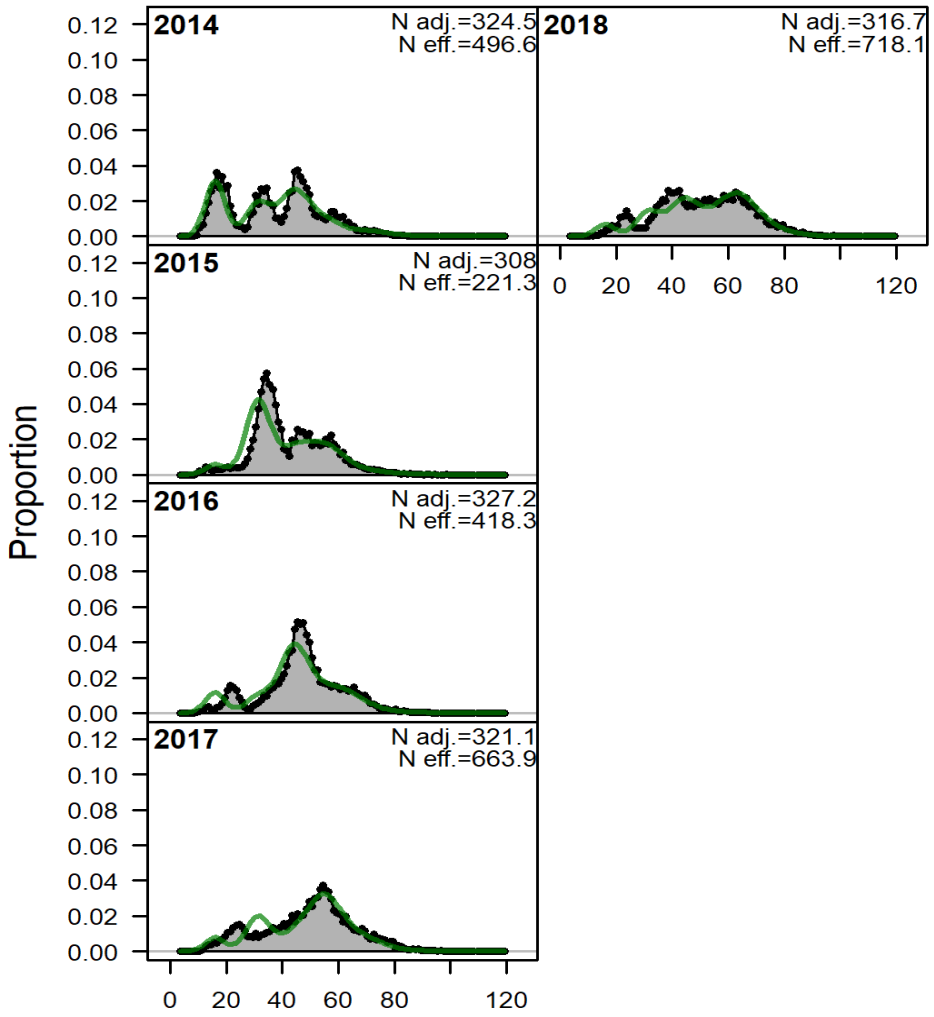

Figure 2.17f (3 of 3)—Model 18.6 fits to the survey size composition data.

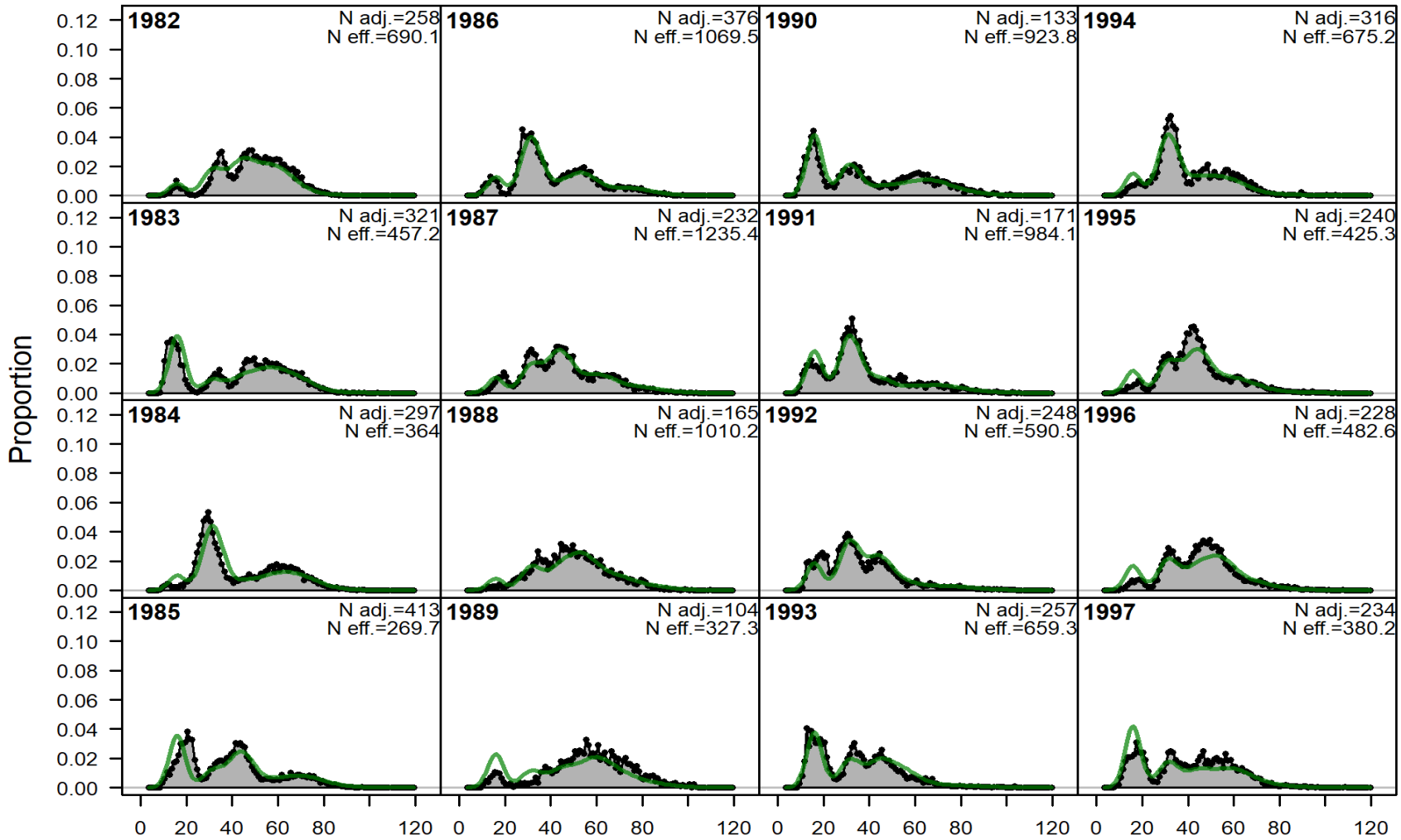

Figure 2.17g (1 of 3)—Model 18.7 fits to the survey size composition data.

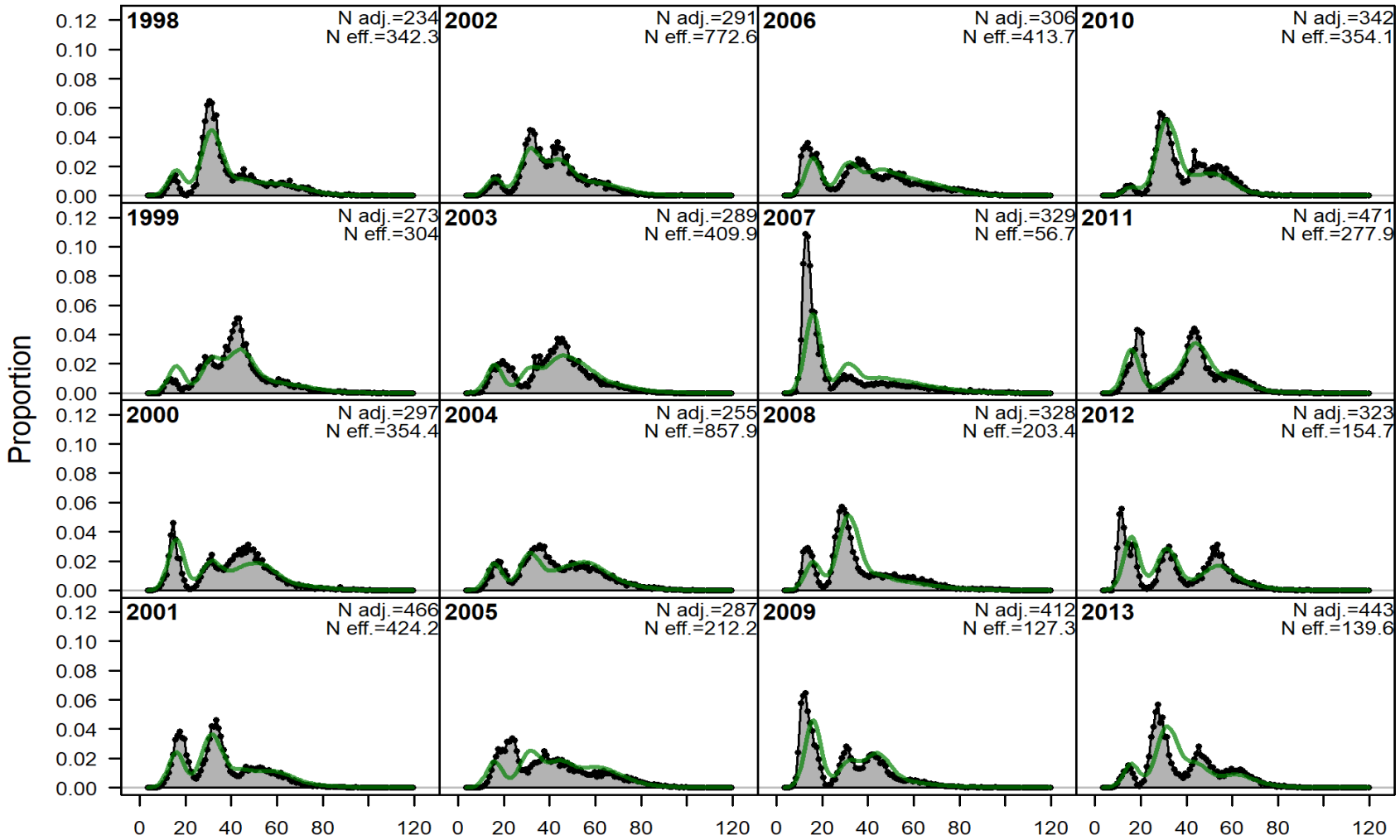

Figure 2.17g (2 of 3)—Model 18.7 fits to the survey size composition data.

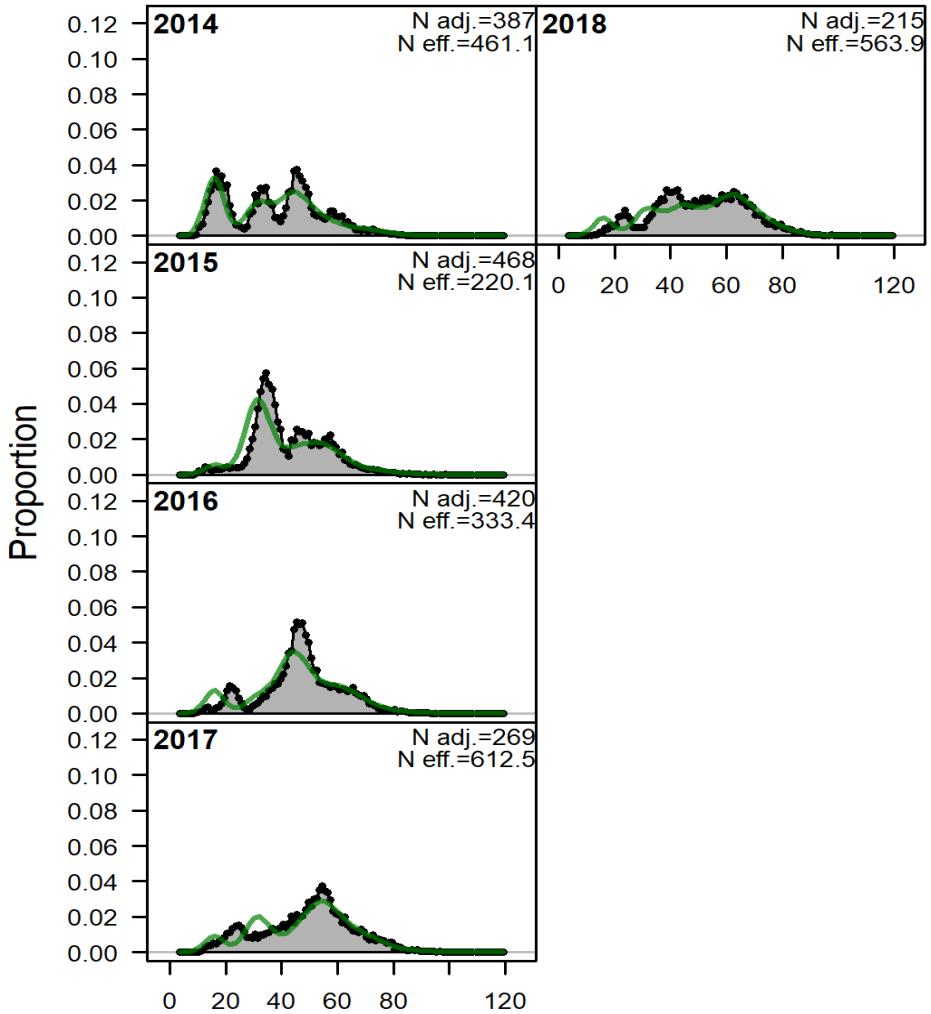

Figure 2.17g (3 of 3)—Model 18.7 fits to the survey size composition data.

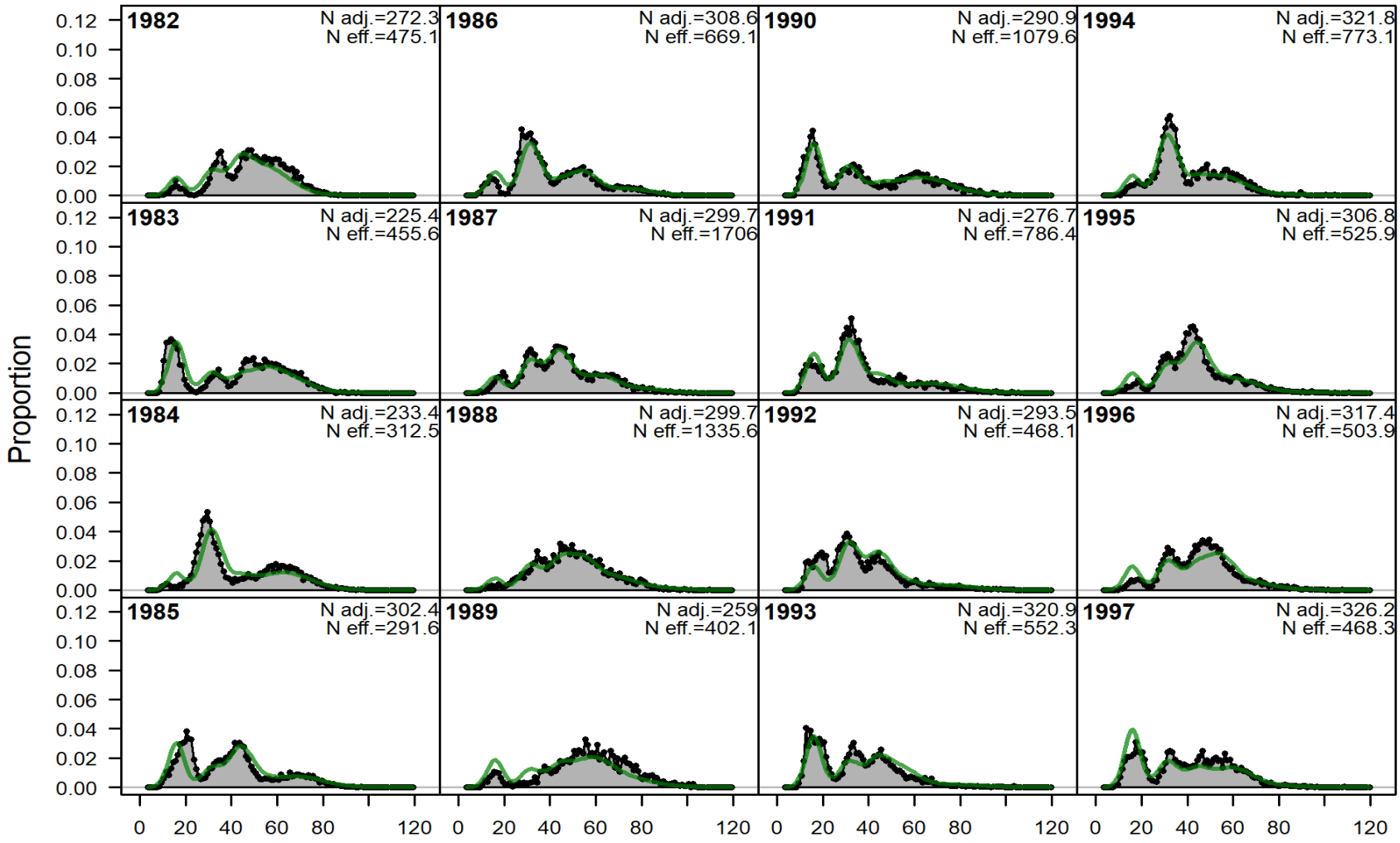

Figure 2.17h (1 of 3)—Model 18.8 fits to the survey size composition data.

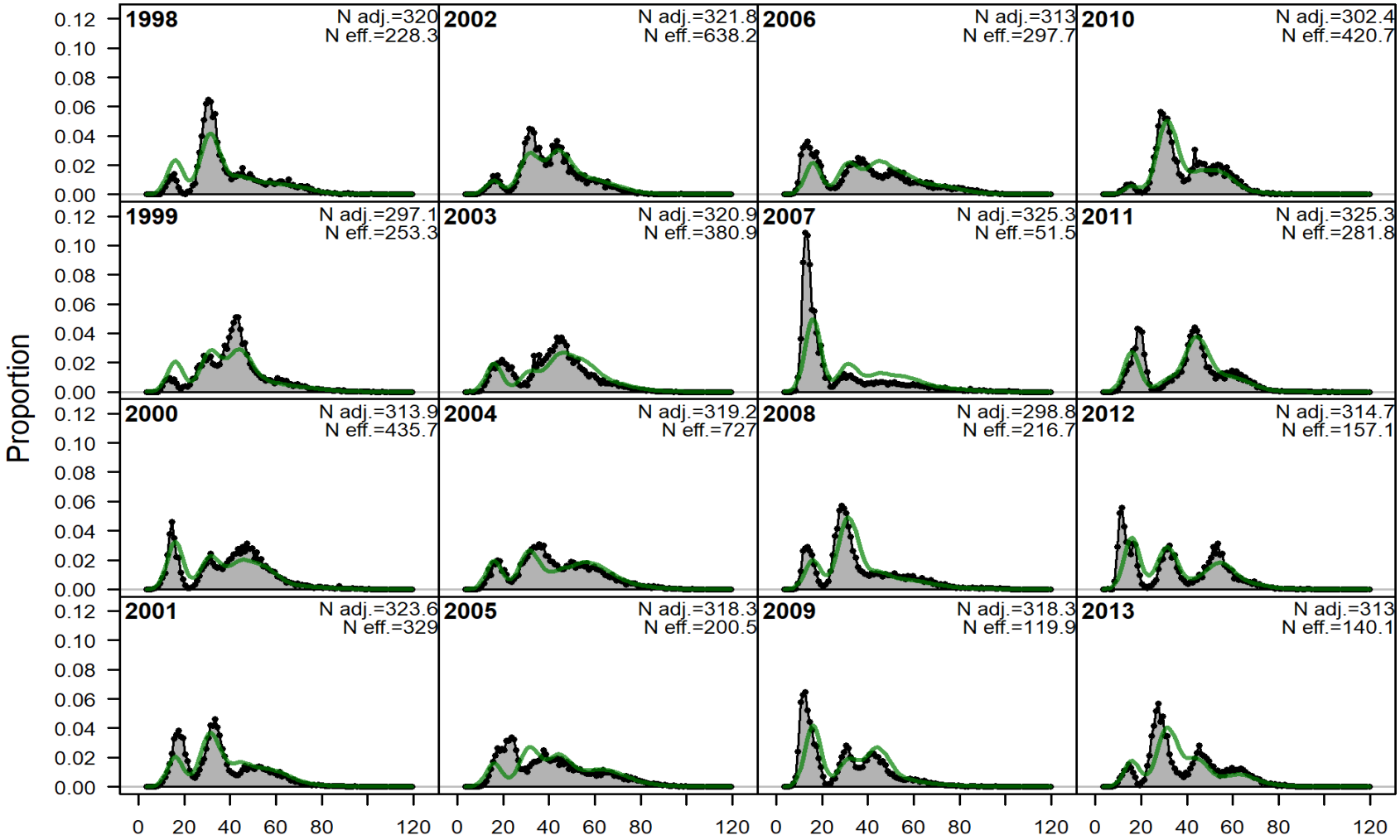

Figure 2.17h (2 of 3)—Model 18.8 fits to the survey size composition data.

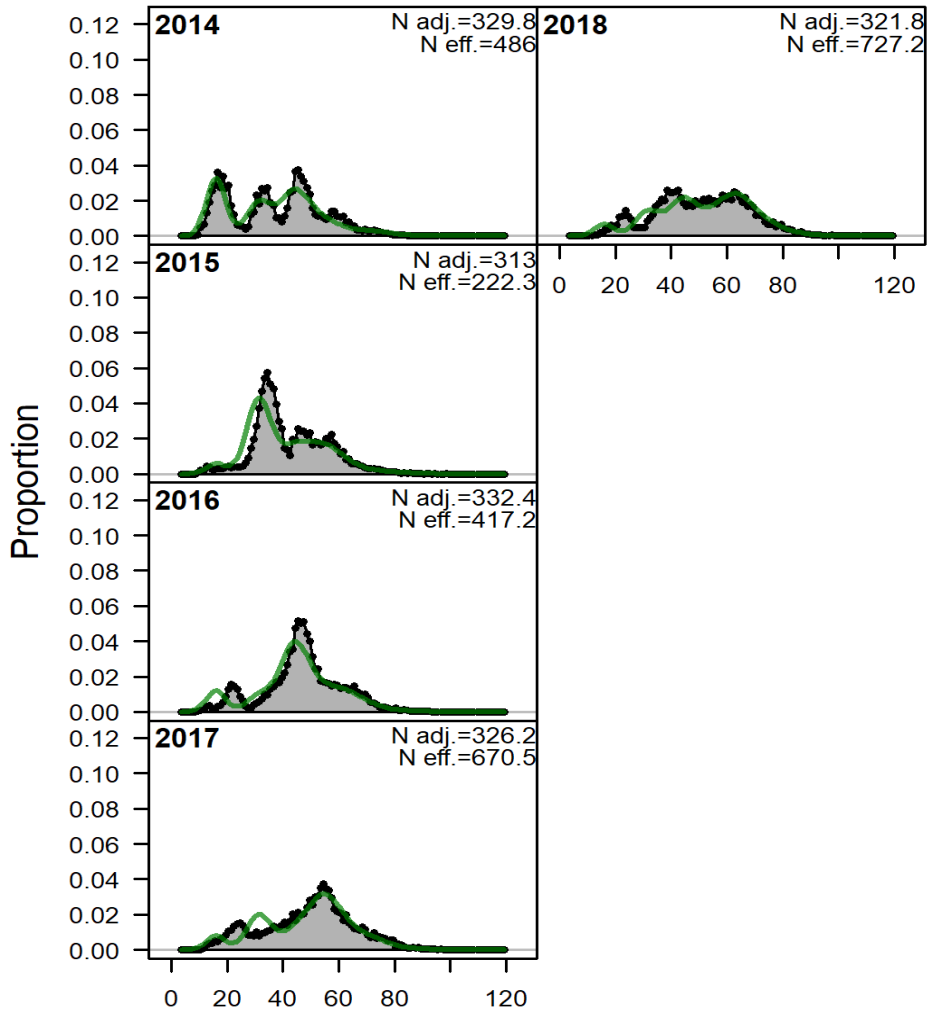

Figure 2.17h (3 of 3)—Model 18.8 fits to the survey size composition data.

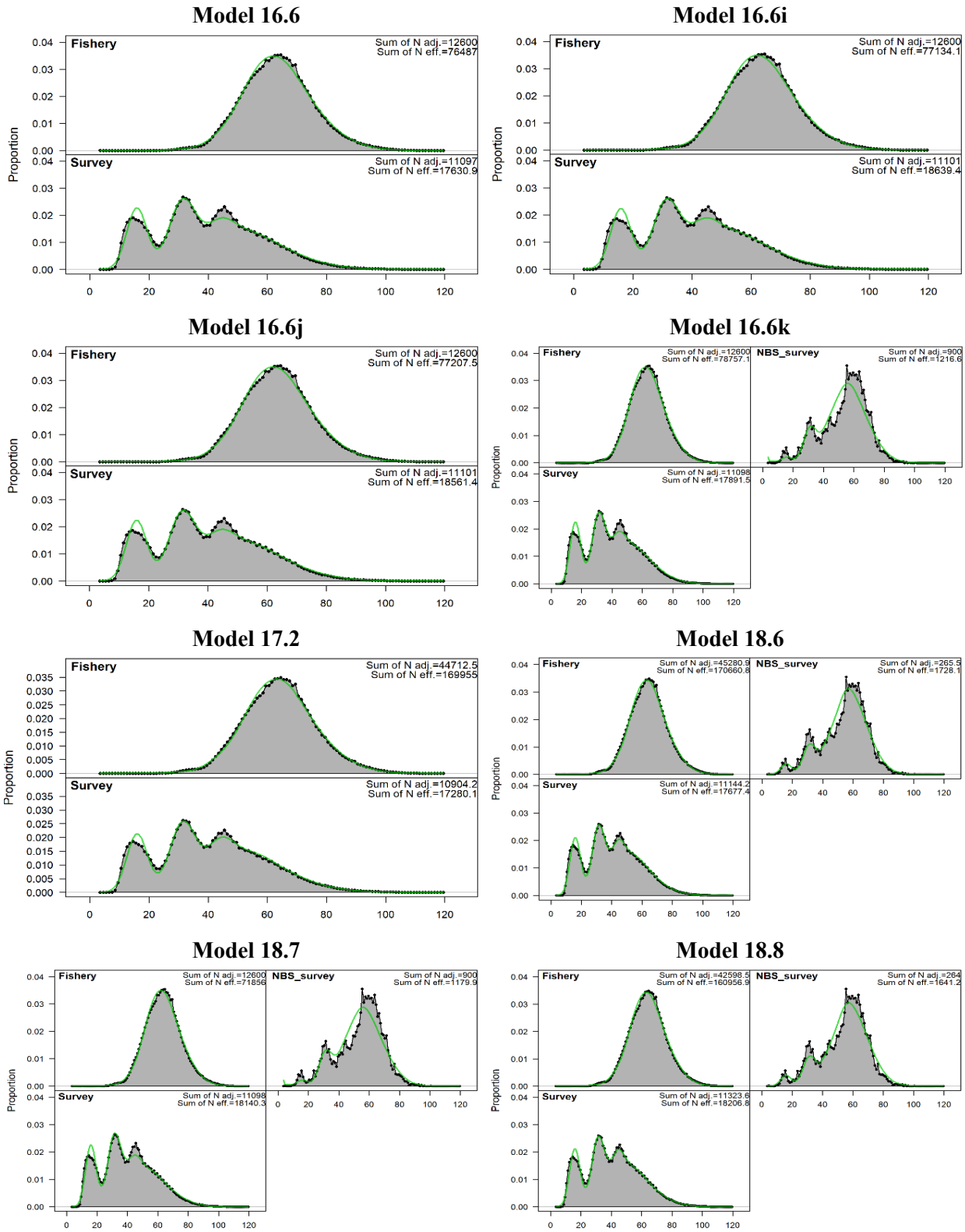

Figure 2.18—Time-aggregated fits to the size composition data.

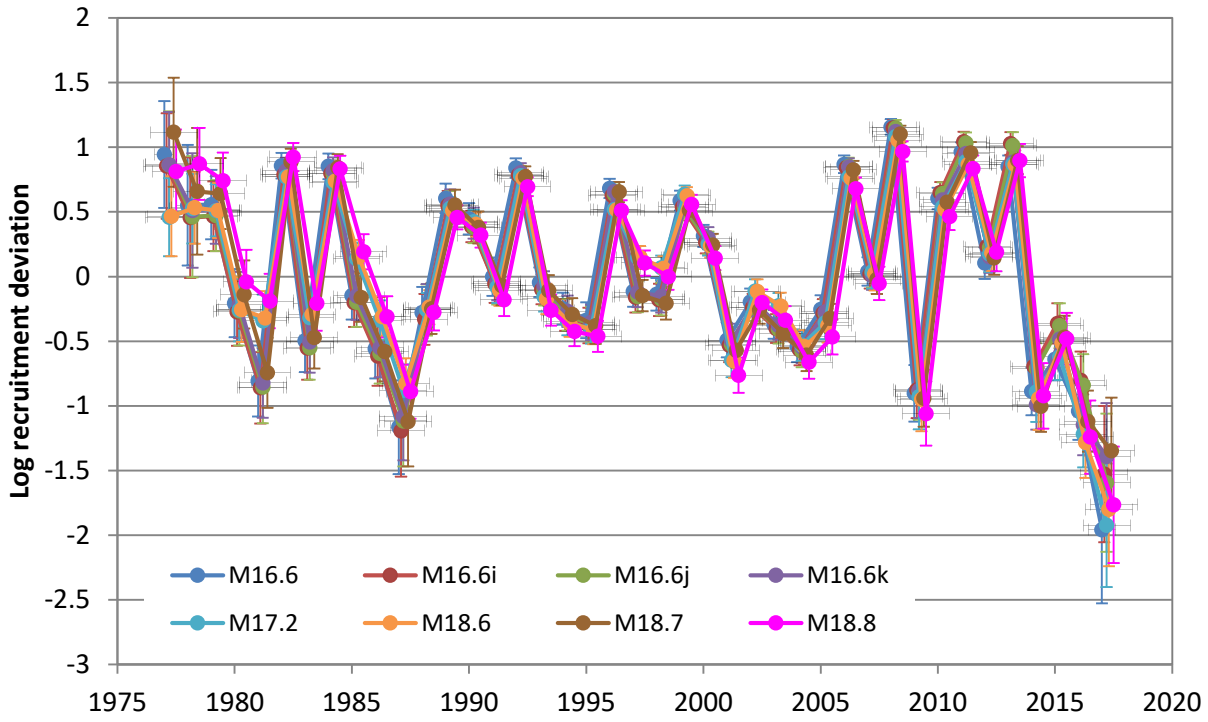

Figure 2.19—Recruitment deviations as estimated by the models. Series have been offset along the vertical axis by small amounts to prevent over-plotting.

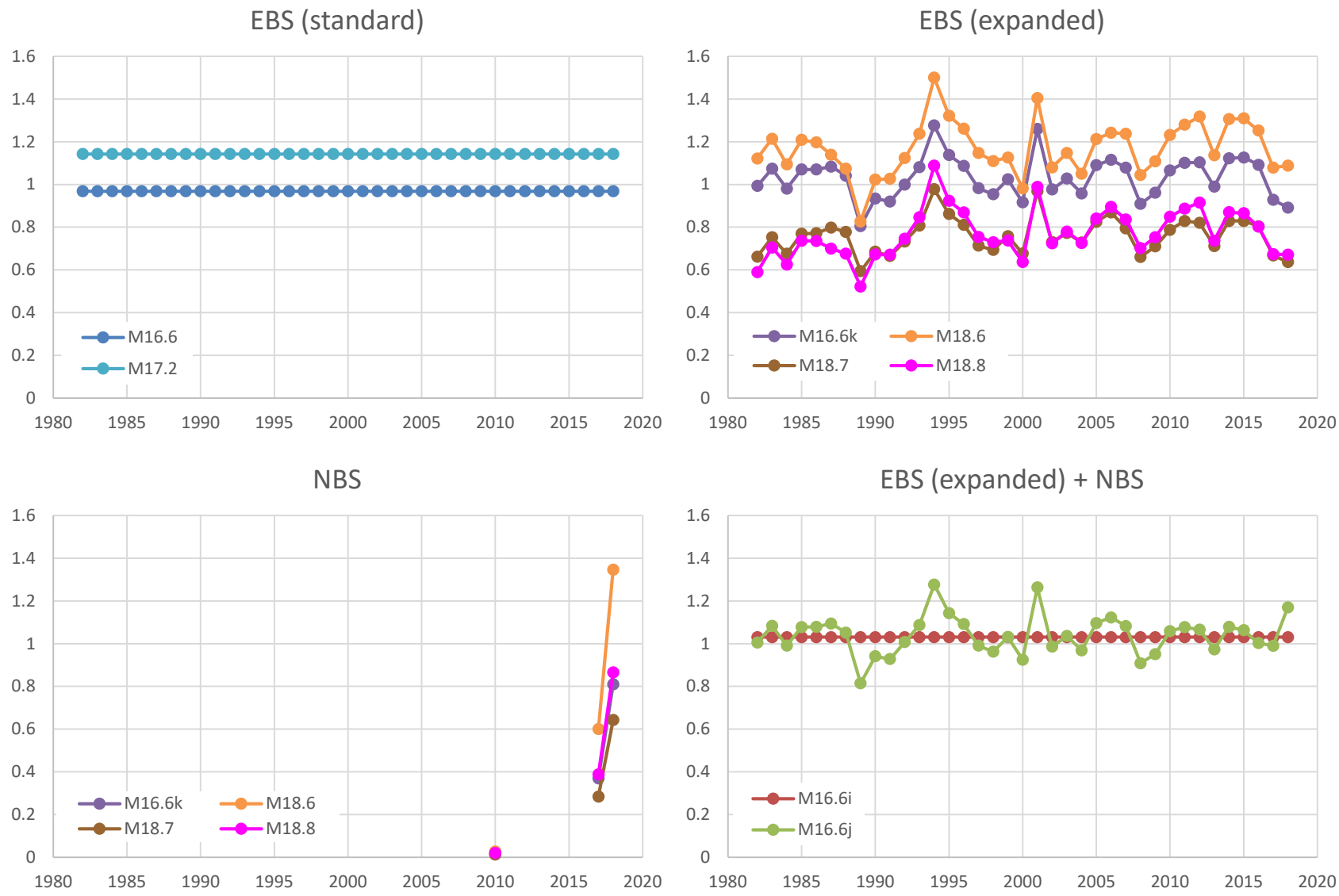

Figure 2.20—Back-transformed bottom trawl survey catchability as estimated by the models.

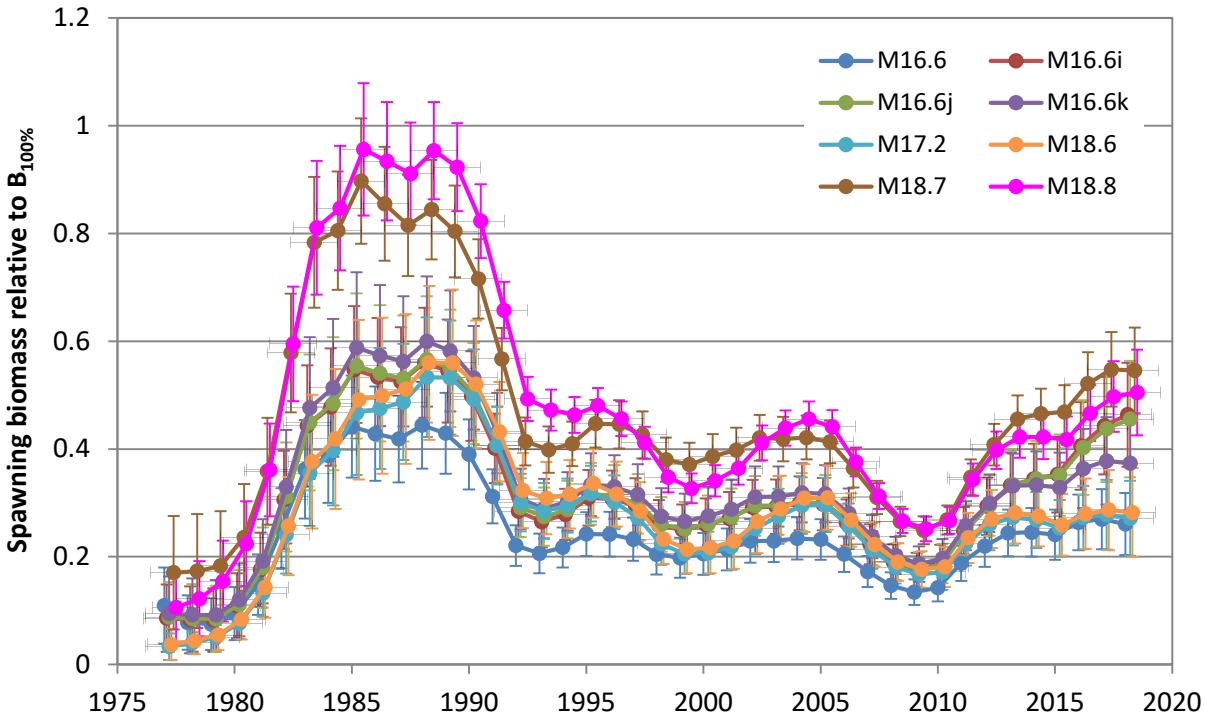

Figure 2.21—Spawning biomass relative to $B_{100\%}$ as estimated by the models.

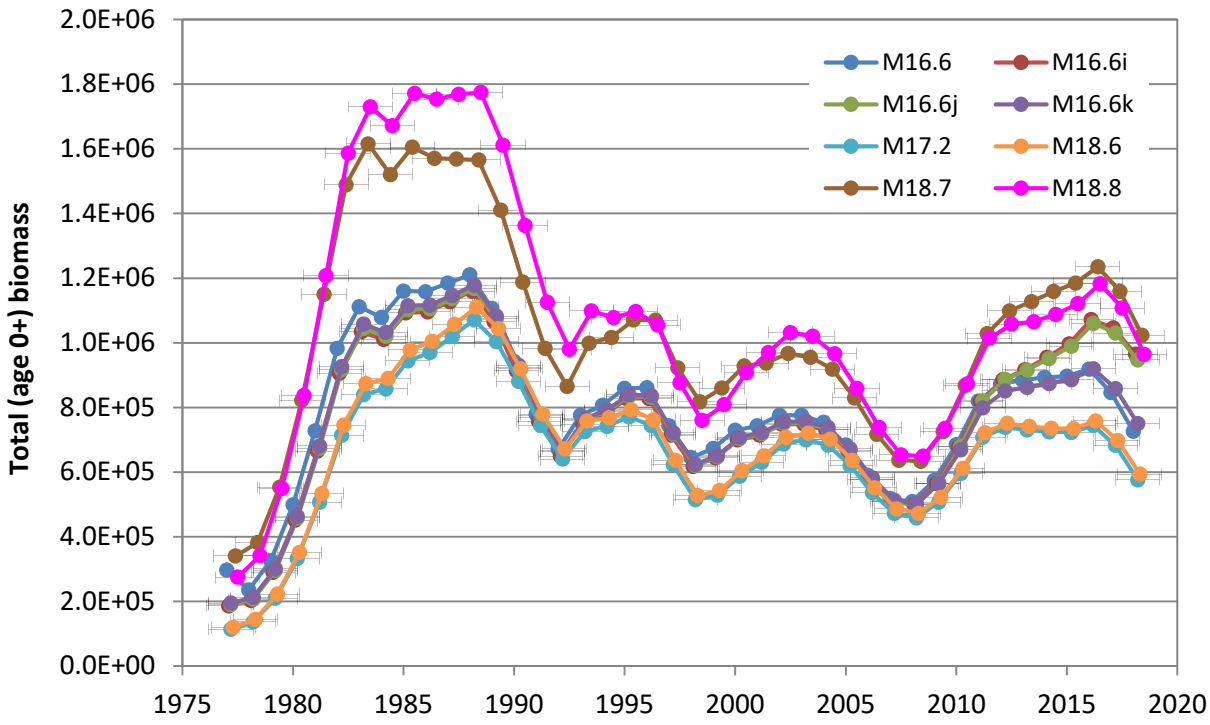

Figure 2.22—Total biomass as estimated by the models. Survey biomass shown for comparison.

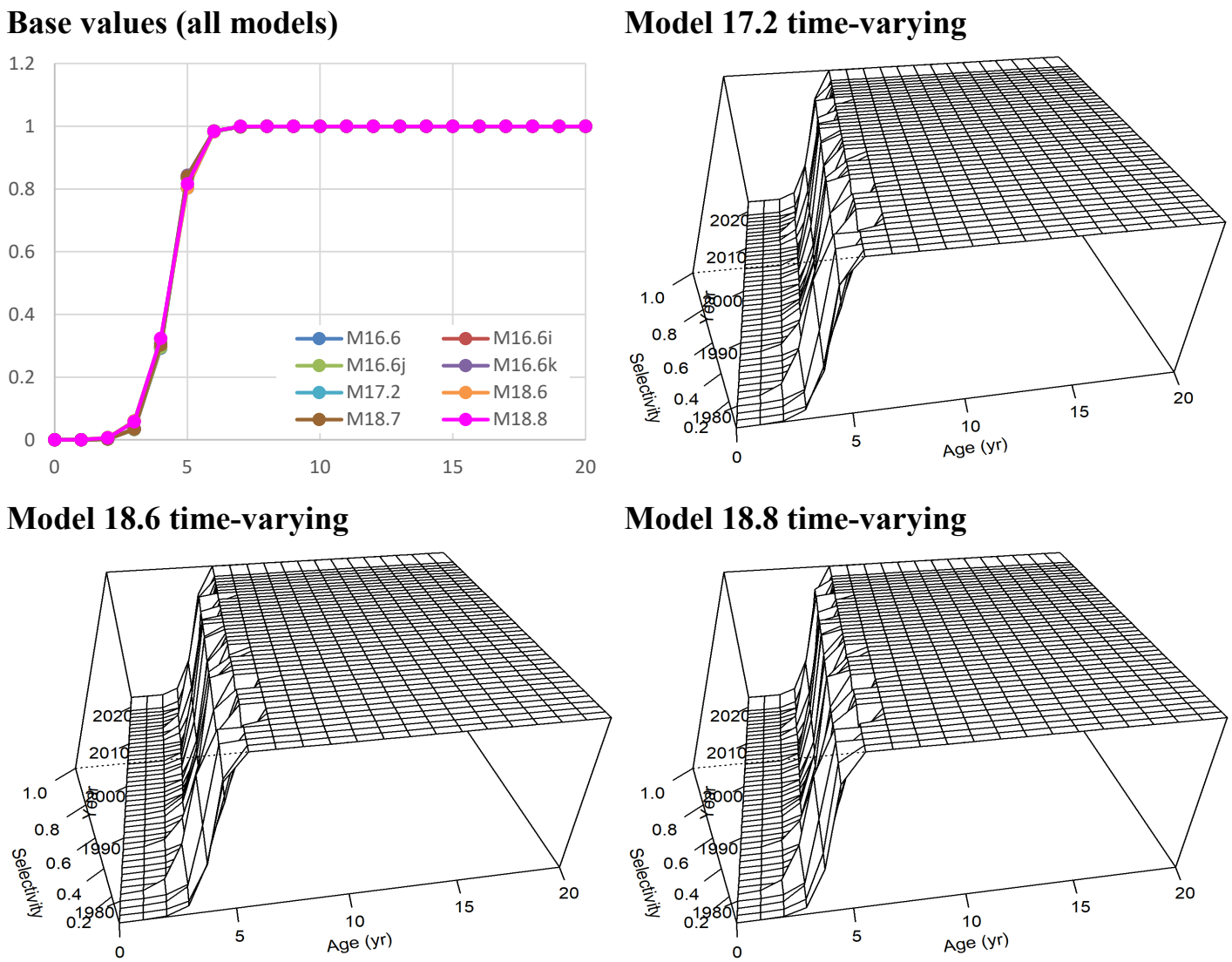

Figure 2.23—Fishery selectivity as estimated by the models.

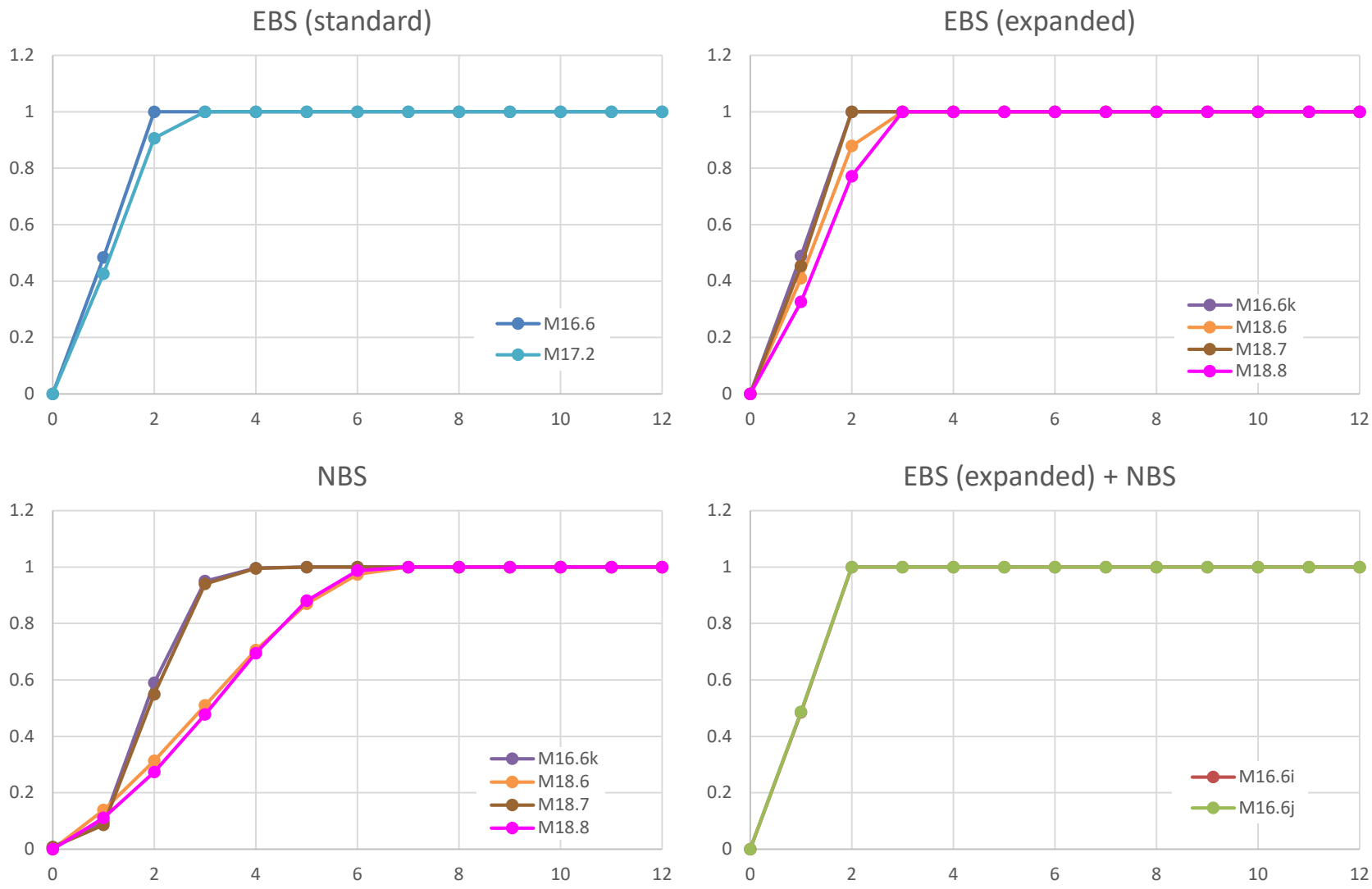

Figure 2.24—Survey selectivity as estimated by the models.

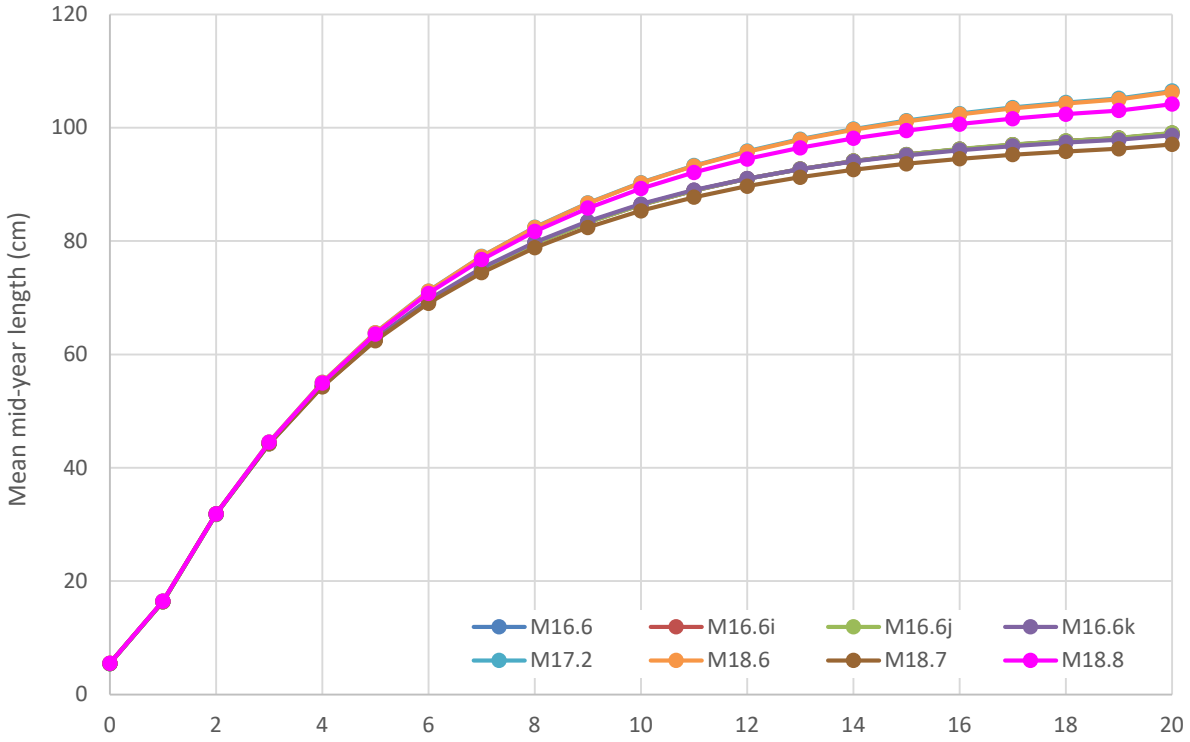

Figure 2.25—Mean length at age as estimated by the models.

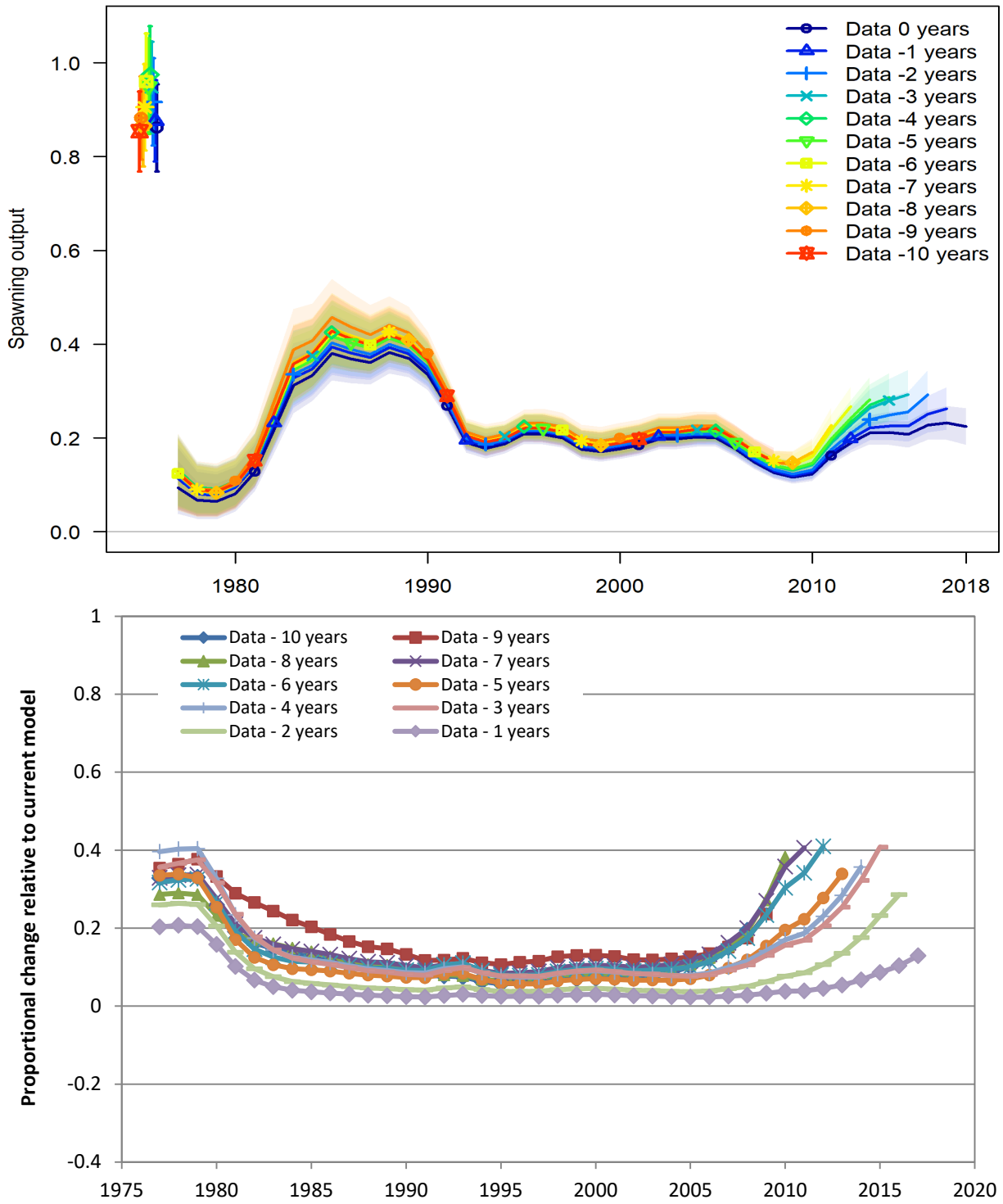

Figure 2.26a—Retrospective analysis of spawning biomass estimates from Model 16.6. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.315$.

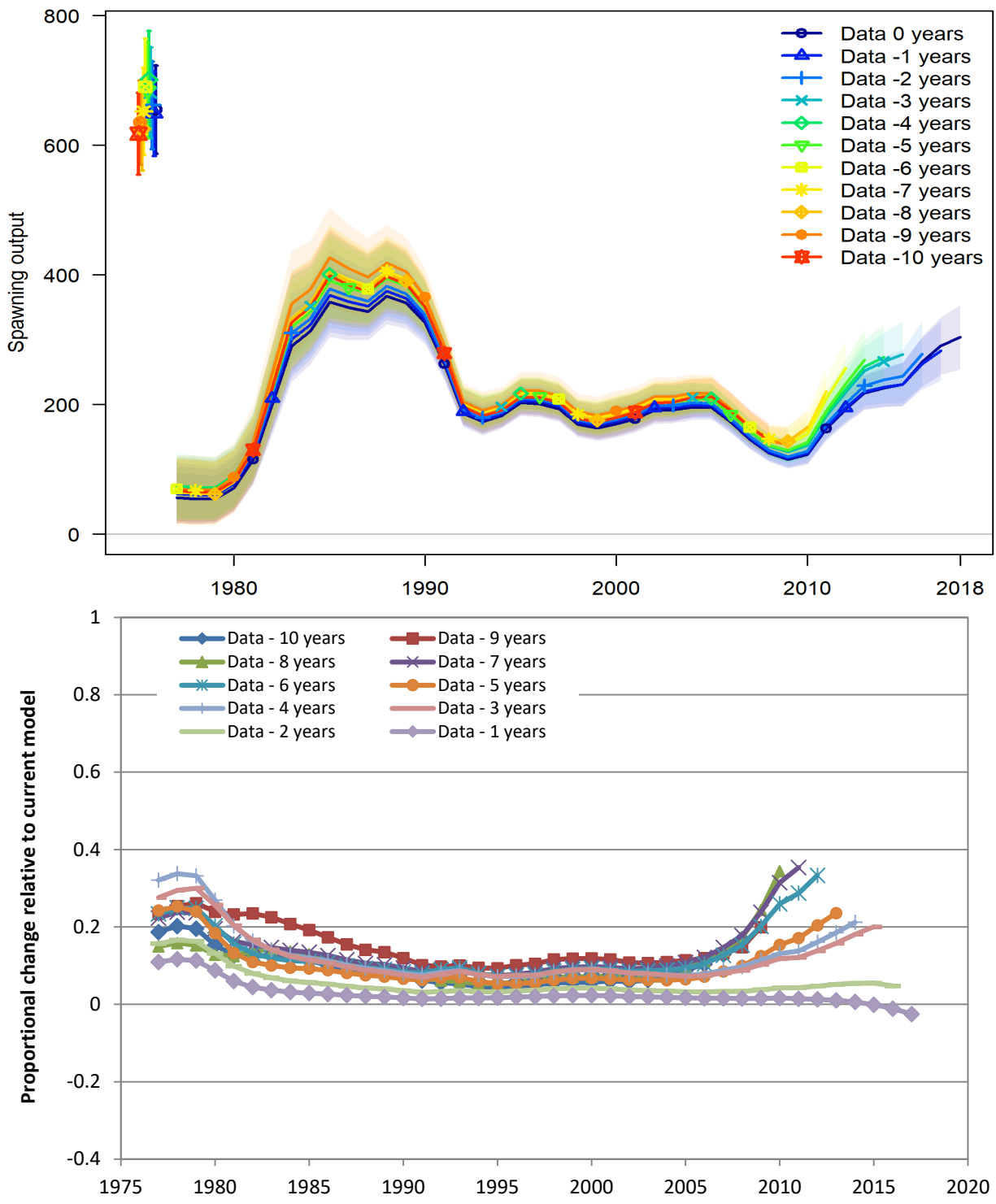

Figure 2.26b—Retrospective analysis of spawning biomass estimates from Model 16.6i. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.207$.

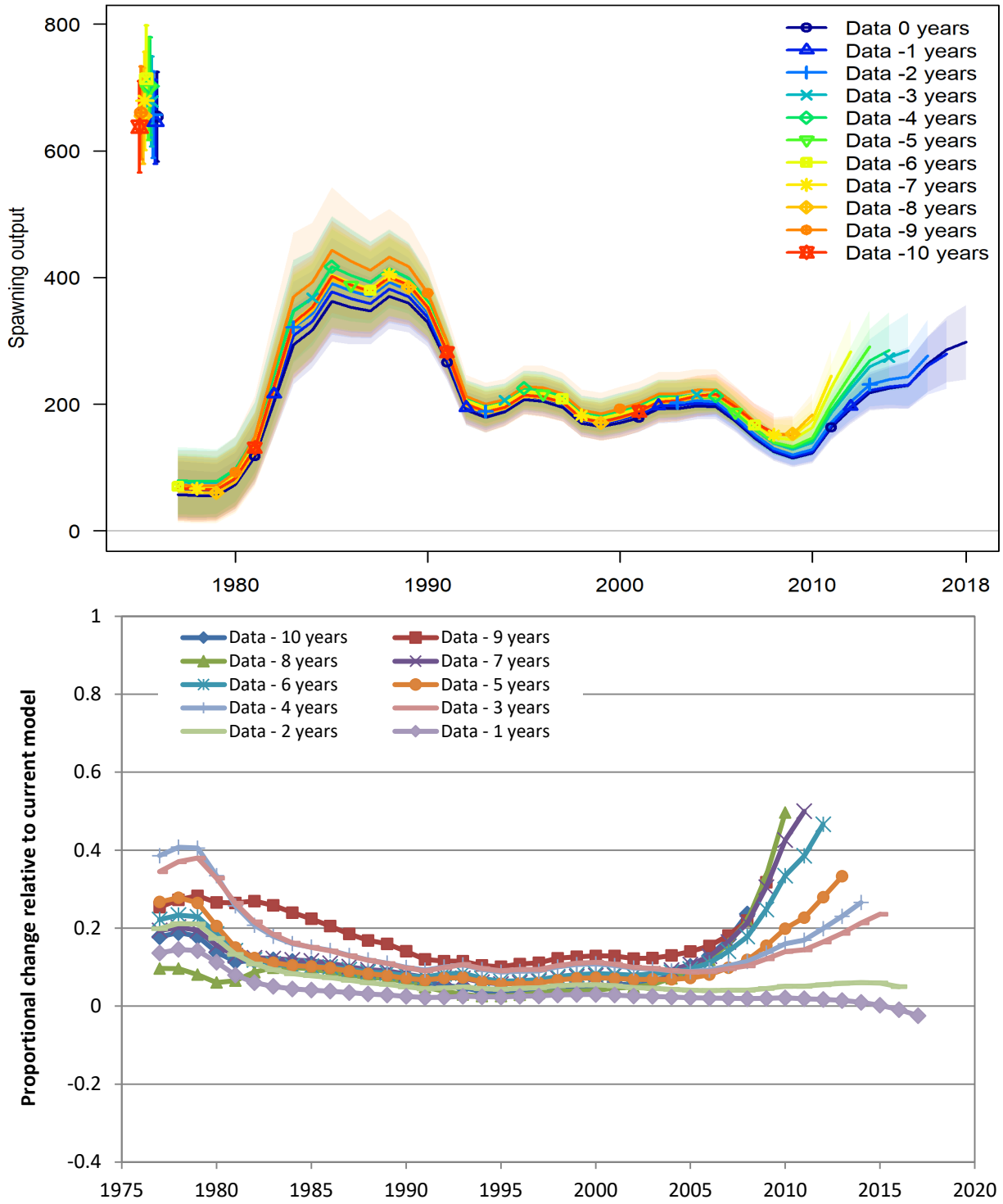

Figure 2.26c—Retrospective analysis of spawning biomass estimates from Model 16.6j. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.288$.

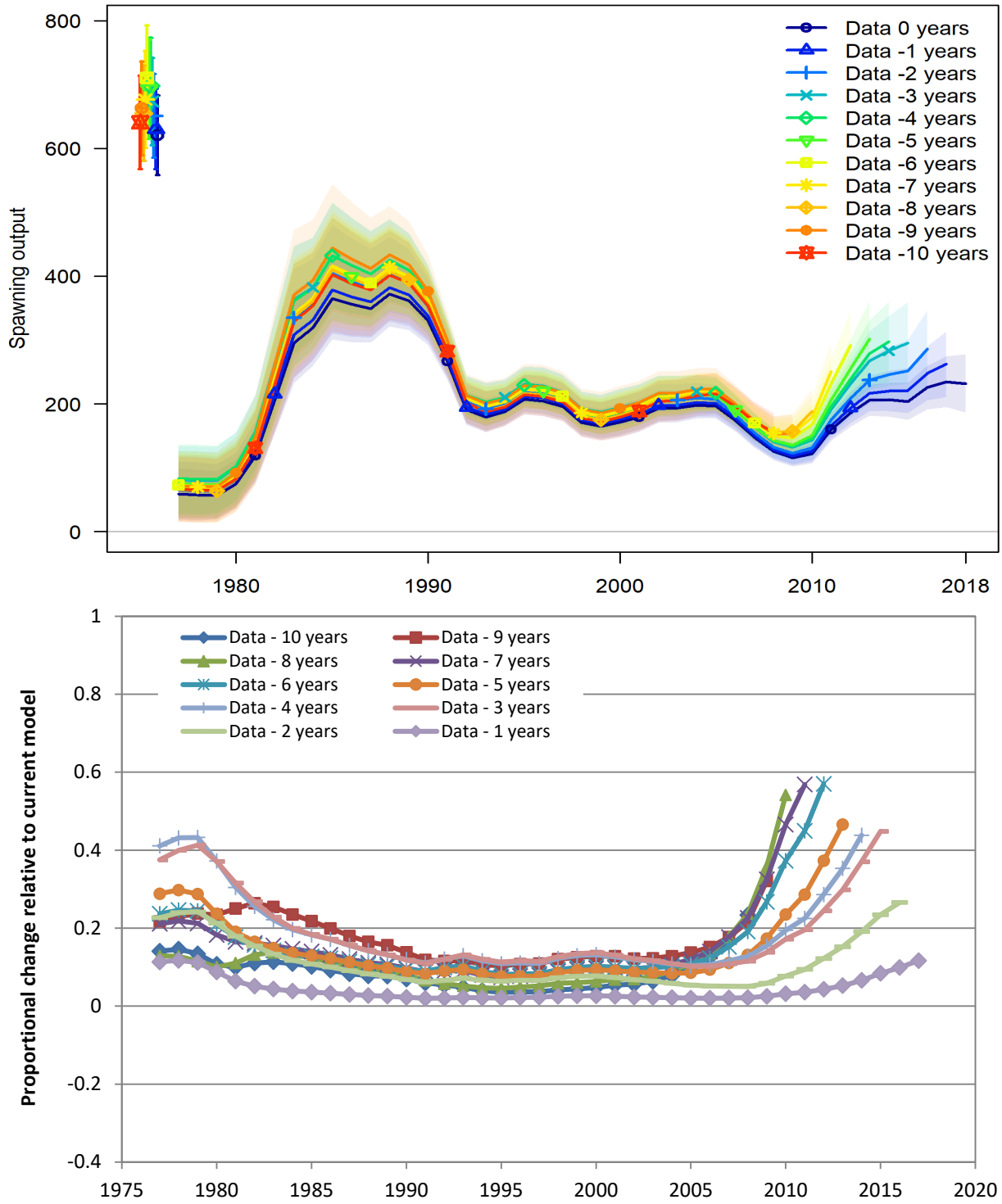

Figure 2.26d—Retrospective analysis of spawning biomass estimates from Model 16.6k. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.397$.

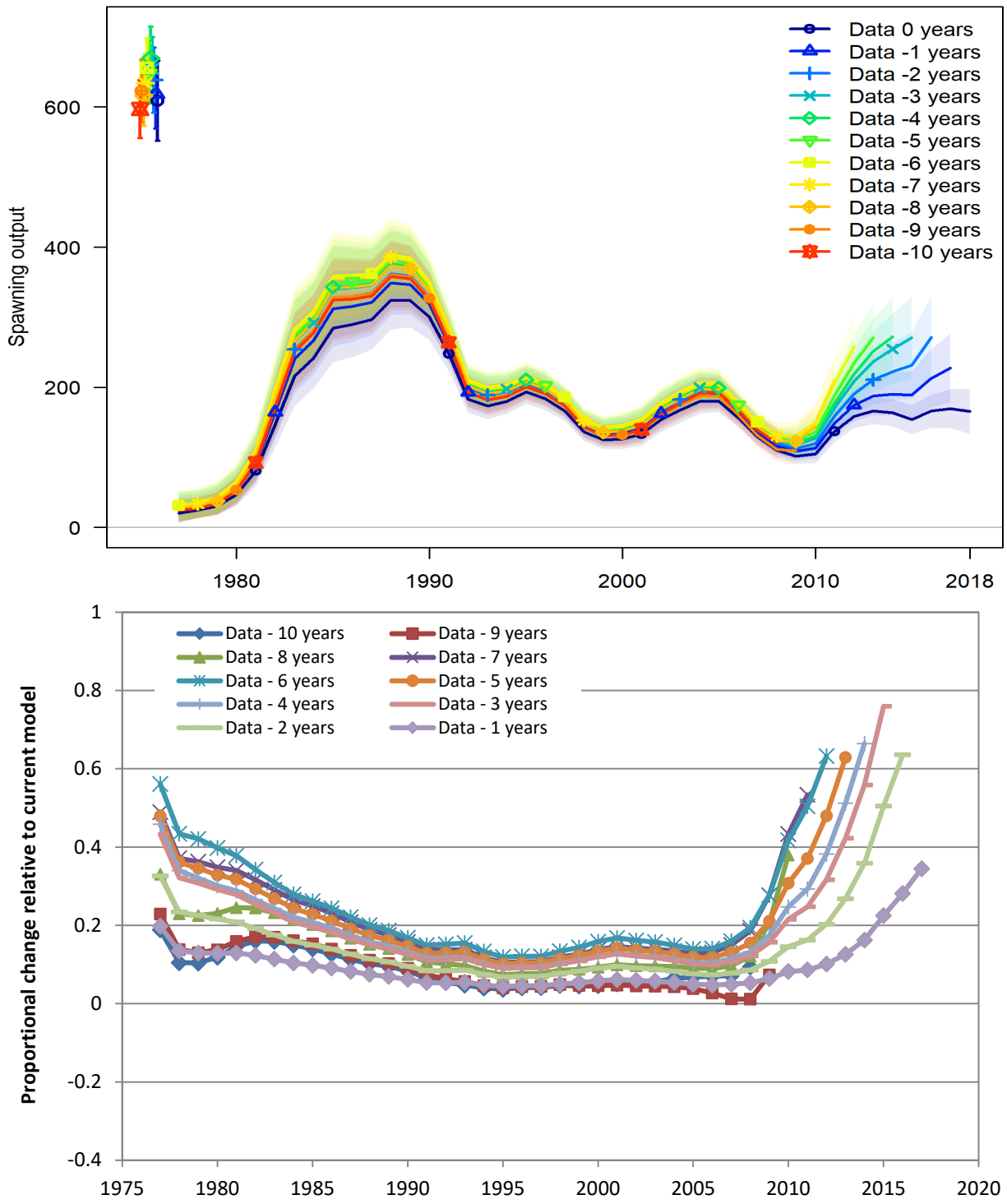

Figure 2.26e—Retrospective analysis of spawning biomass estimates from Model 17.2. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.493$.

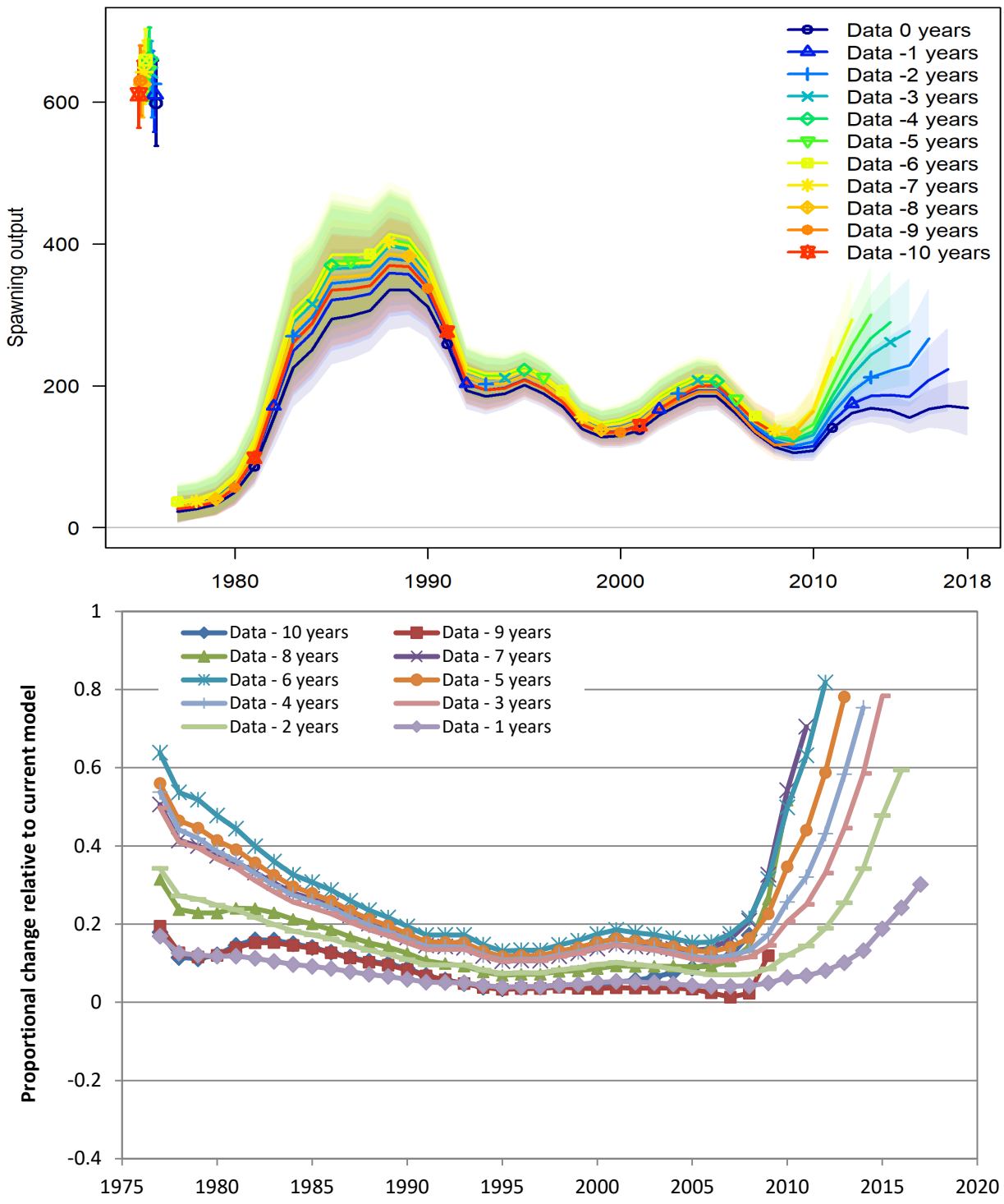

Figure 2.26f—Retrospective analysis of spawning biomass estimates from Model 18.6. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.552$.

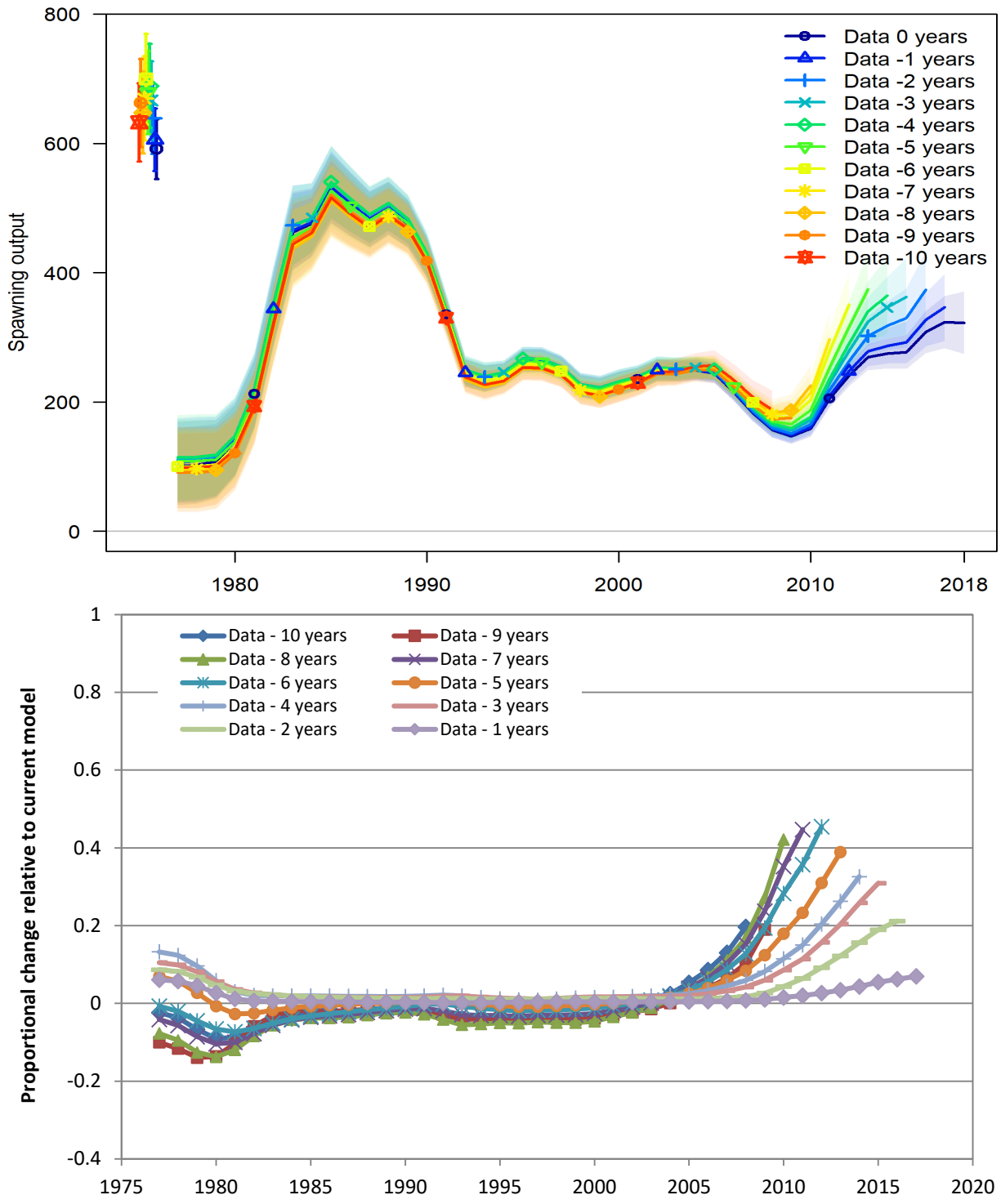

Figure 2.26g—Retrospective analysis of spawning biomass estimates from Model 18.7. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.301$.

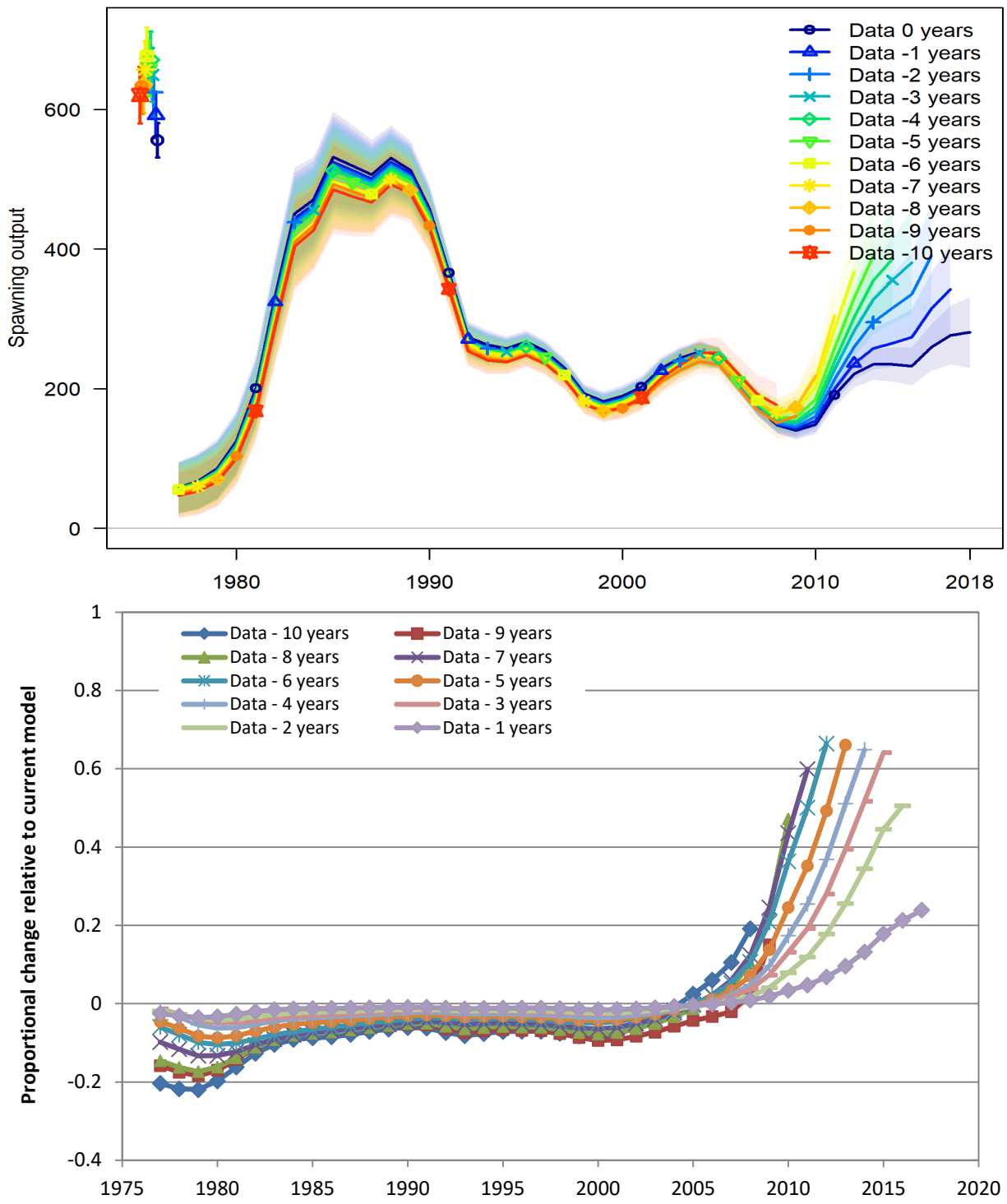

Figure 2.26h—Retrospective analysis of spawning biomass estimates from Model 18.8. Top panel: spawning biomass time series with 95% confidence intervals from the current version of the model (2018) and 10 retrospective runs (2008-2017) obtained by dropping one year of data at a time. Bottom panel: change in spawning biomass relative to the current version of the model for each of 10 retrospective runs. Mohn's $\rho = 0.470$.

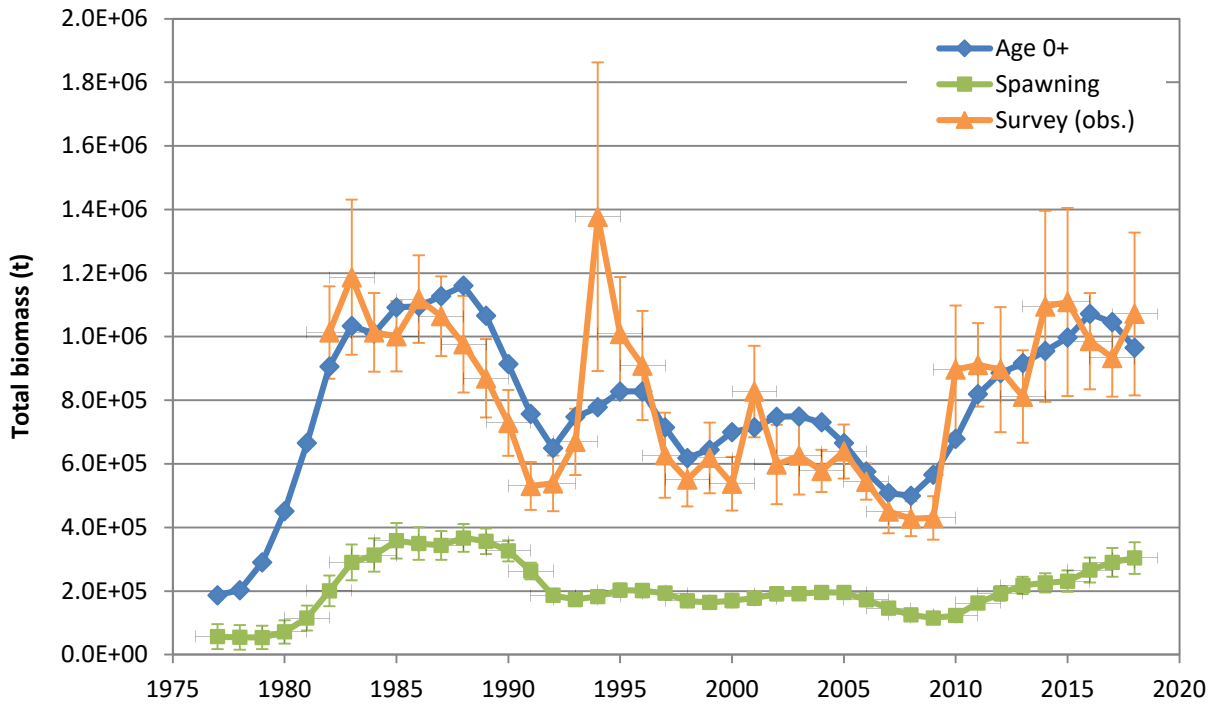

Figure 2.27—Time series of age 0+ and female spawning biomass as estimated by Model 16.6i. Survey biomass for the EBS expanded area and NBS combined is shown for comparison.

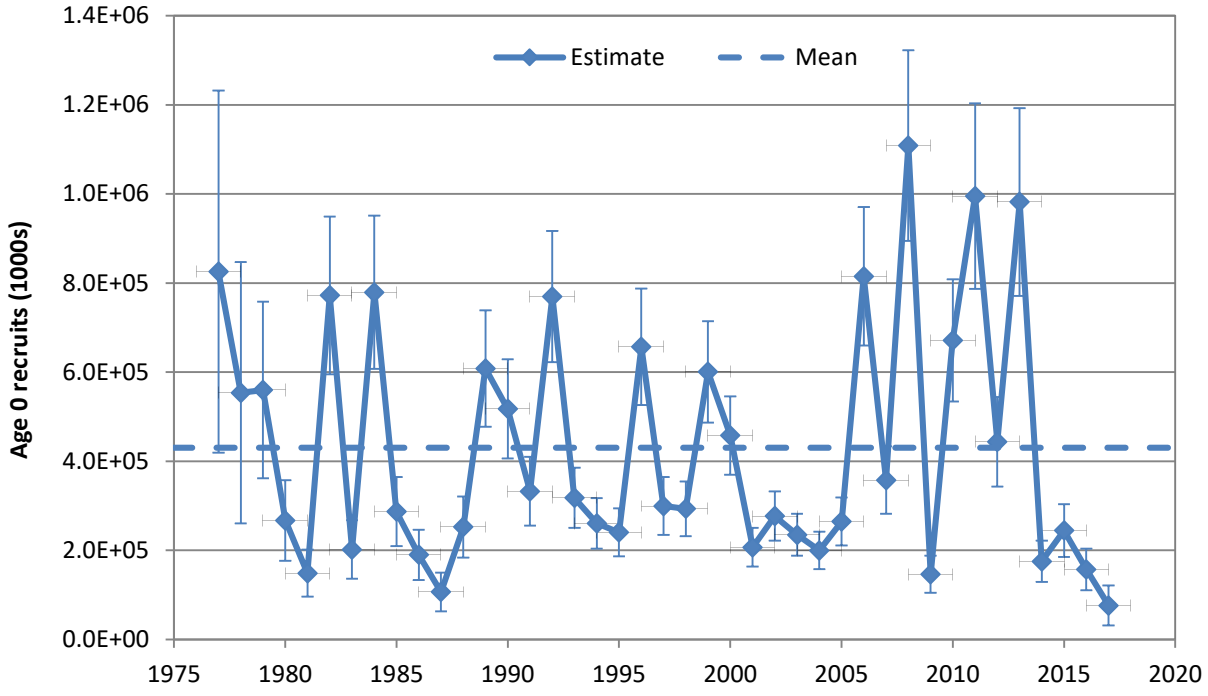

Figure 2.28—Time series of recruitment at age 0 as estimated Model 16.6i.

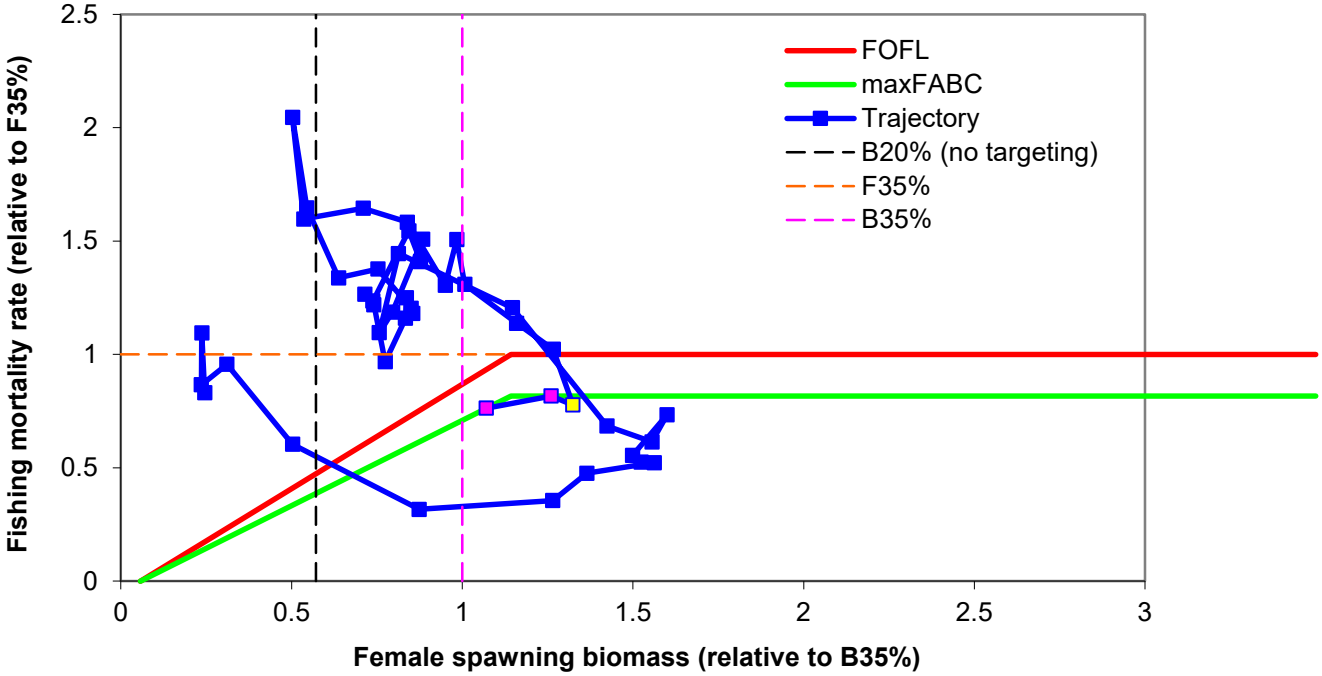

Figure 2.29—Trajectory of Pacific cod fishing mortality and female spawning biomass as estimated by Model 16.6i, 1977-2020 (yellow square = current year, magenta squares = first two projection years).

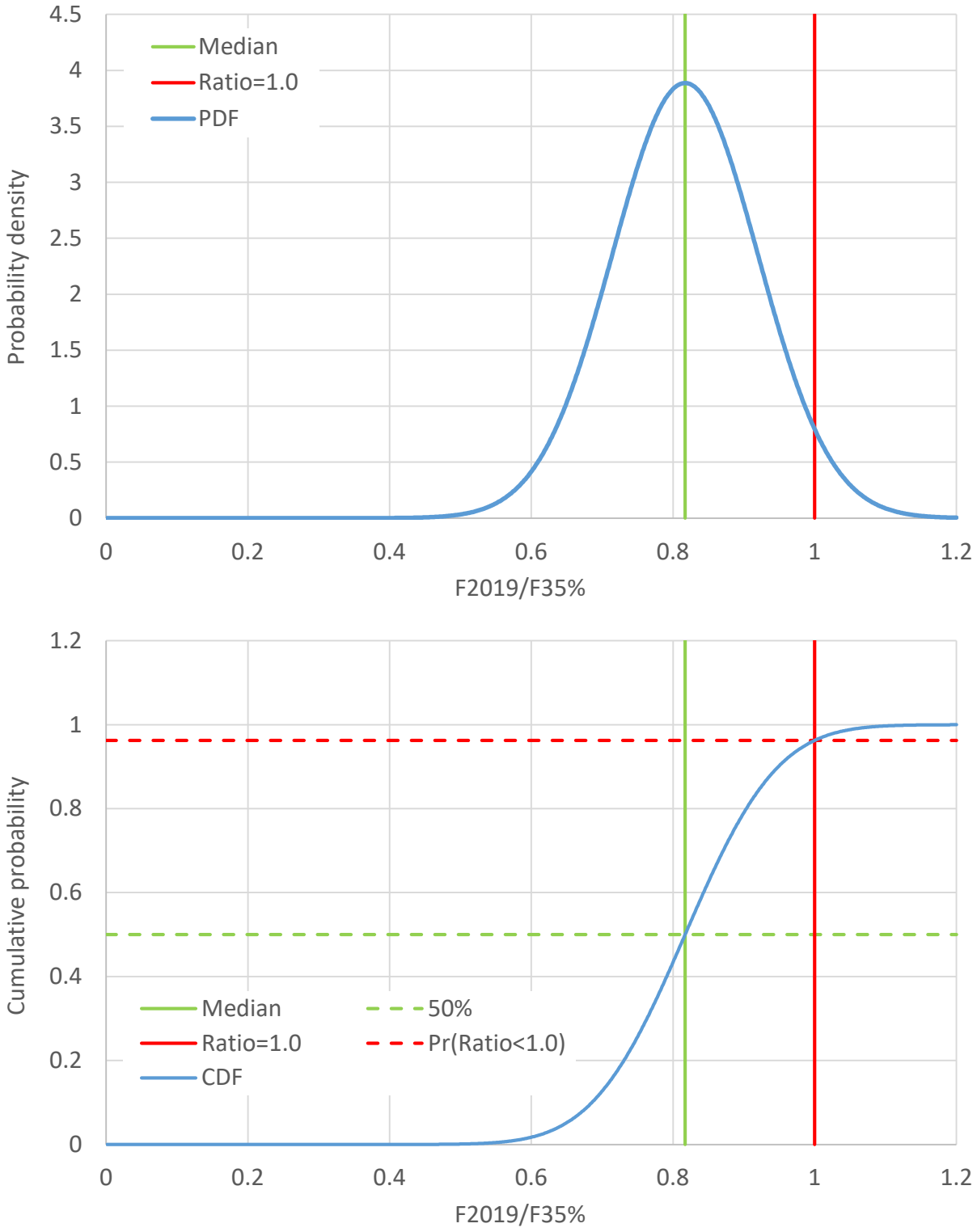

Figure 2.30—Distribution of projected 2019 fishing mortality relative to $F_{35\%}$, conditional on 2019 catch being equal to the 2019 maximum permissible ABC, as estimated by Model 16.6i.

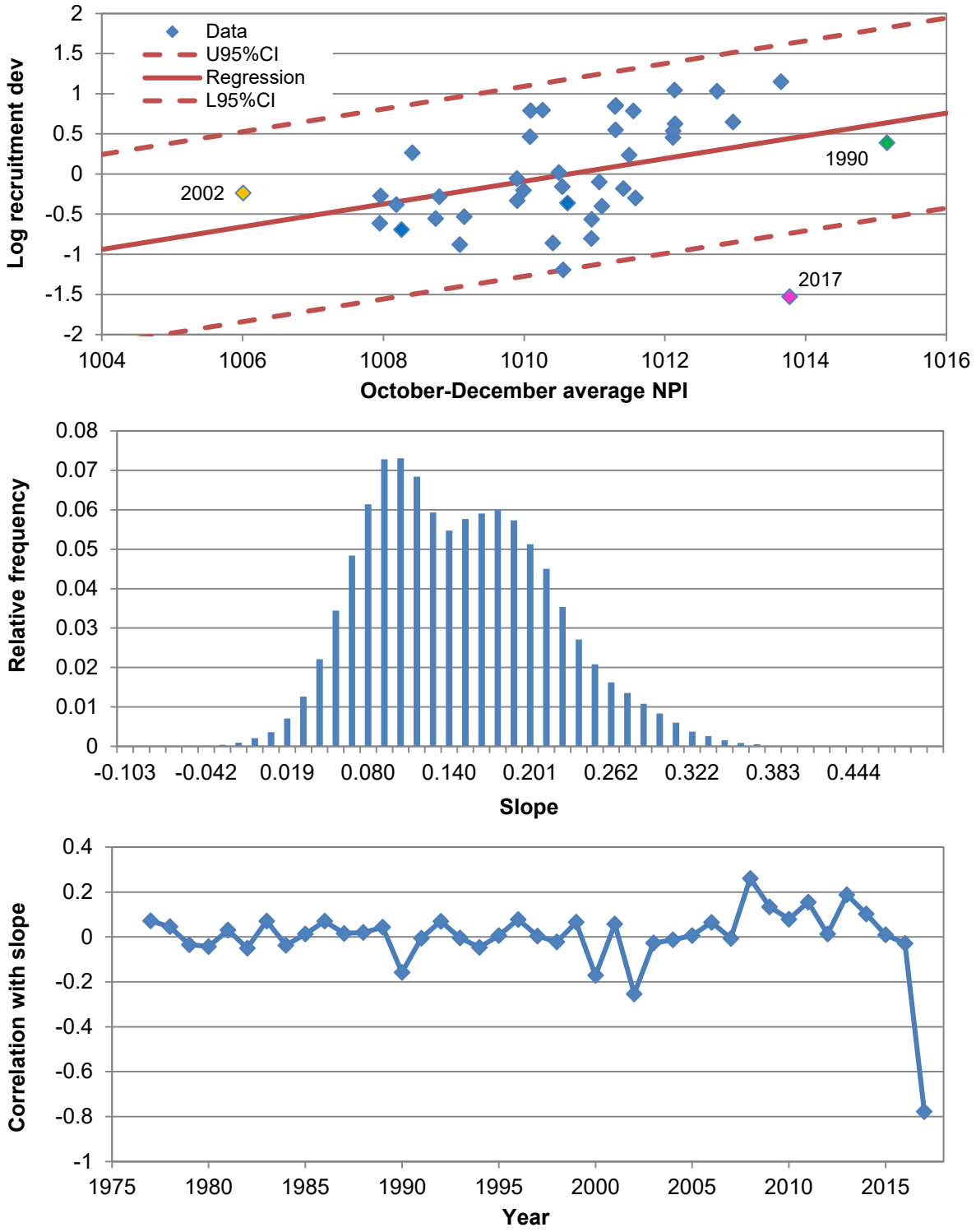

Figure 2.31—Environmental effects on recruitment. Upper panel: Estimated log recruitment deviations (age 0) versus same-year October-December average of the NPI, with regression line and 95% confidence interval. Middle panel: Distribution of the regression slope, as generated by a cross-validation analysis. Lower panel: Correlation between individual data points and regression slope. See text for details.

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

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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," Thompson 2017), and to respond to suggestions made by various scientists at the Alaska Fisheries Science Center (AFSC) for development of alternative models to include in the assessment. Comments from the Team and SSC are shown below. Suggestions from AFSC scientists are addressed in the "Model structures" section.

Responses to Team and SSC comments on assessments in general

Comments from the October 2017 SSC meeting

SSC1: "The SSC recommends that, for those sets of environmental and fisheries observations that support the inference of an impending severe decline in stock biomass, the issue of concern be brought to the SSC, with an integrated analysis of the indices in future stock assessment cycles. To be of greatest value, to the extent possible, this information should be presented at the October Council meeting so that there is sufficient time for the Plan Teams and industry to react to the possible reduction in fishing opportunity."

To facilitate a coordinated response to this request, the co-chairs and coordinators of the BSAI and GOA Groundfish Plan Teams, with concurrence from stock assessment program leadership at the AFSC, have suggested that authors address it by using the previous year's Ecosystem Status Report (ESR) as follows:

> "No later than the summer of each year, the lead author of each assessment should review the previous year's ESR and determine whether any factor or set of factors described in that ESR implies an impending severe decline in stock/complex biomass, where "severe decline" means a decline of at least 20% (or any alternative value that may be established by the SSC), and where biomass is measured as spawning biomass for Tiers 1-3 and survey biomass as smoothed by the standard Tier 5 random effects model for Tiers 4-5. If an author determines that an impending severe decline is likely and if that decline was not anticipated in the most recent stock assessment, he or she should summarize that evidence in a document that will be reviewed by the respective Team in September of that year and by the SSC in October of that year, including a description of at least one plausible mechanism linking the factor or set of factors to an impending severe decline in biomass, and also including an estimate or range of estimates regarding likely impacts on ABC. In the event that new survey or relevant ESR data become available after the document is produced but prior to the October Council meeting of that year, the document should be amended to include those data prior to its review by the SSC, and the degree to which they corroborate or refute the predicted severe decline should be noted, with the estimate or range of estimates regarding likely impacts on ABC modified in light of the new data as necessary."

This suggestion was followed, and the results are addressed in the "Ecosystem considerations" section.

SSC2: "The SSC also recommends explicit consideration and documentation of ecosystem and stock assessment status for each stock ... during the December Council meeting to aid in identifying stocks of concern."

This recommendation was subsequently clarified, at some length, in the minutes of the December 2017 SSC meeting and then re-clarified in the minutes of the June 2018 SSC meeting. In the interest of efficiency, the clarification from the December 2017 minutes is not included here. The relevant portion of the clarification from the June 2018 minutes reads as follows:

"This request was recently clarified by the SSC by replacing the terms 'ecosystem status' and 'stock assessment status' with 'Ecosystem Status Report information' and 'Stock Assessment Information,' where the potential determinations for each will consist of 'Okay' and 'Not Okay,' and by issuing the following guidance:

- *The SSC clarifies that 'stock assessment status' is a fundamental requirement of the SAFEs and is not really very useful to this exercise, because virtually all stocks are never overfished nor is overfishing occurring.*
- *Rather the SSC suggests that recent trends in recruitment and stock abundance could indicate warning signs well before a critical official status determination is reached. It may also be useful to consider some sort of ratio of how close a stock is to a limit or target reference point (e.g., B/B35). Thus, additional results for the stock assessments will need to be considered to make the 'Okay' or 'Not Okay' determinations.*
- *The SSC retracts its previous request for development of an ecosystem status for each stock/complex. Instead, while considering ecosystem status report information, it may be useful to attempt to develop thresholds for action concerning broad-scale ecosystem changes that are likely to impact multiple stocks/complexes.*
- *Implementation of these stock and ecosystem determinations will be an iterative process and will require a dialogue between the stock assessment authors, Plan Teams, ecosystem modelers, ESR editors, and the SSC."*

The iterative process described in the final bullet above is scheduled to begin at this year's September meeting of the Joint BSAI and GOA Plan Teams. In the event that a procedure for making the requested determinations is established in time to be implemented in the final draft of this assessment, the determinations will appear there.

<u>Comments from the December 2017 SSC meeting</u>
SSC3: "The SSC reminds authors of the need to balance the desire to improve model fit with increased risk of model misspecification." This recommendation was subsequently clarified in the minutes of the June 2018 SSC meeting as follows: *"In the absence of strict objective guidelines, the SSC recommends that thorough documentation of model evaluation and the logical basis for changes in model complexity be provided in all cases."* Model evaluation is documented thoroughly in this preliminary assessment. However, in conformity with past practice, this preliminary assessment does not contain a recommendation for a final model, so there are as yet no "changes" in model complexity. If a more complex model (relative to the current base model) is recommended in the final draft of this assessment, the logical basis for the changes in model complexity will be provided.

SSC4: "Report a consistent metric (or set of metrics) to describe fish condition among assessments and ecosystem documents where possible." The authors of all assessments that reported fish condition in the respective 2017 SAFE report chapters, along with ESR editors and the authors of the groundfish condition sections of the BSAI and GOA ESRs, discussed this recommendation and agreed to adopt the

"weight-length residual" method currently used in the ESRs as the standard method. The index of fish condition used in this preliminary assessment was the same as that reported in last year's BSAI ESR.

SSC5: "Projections ... clearly illustrate the lack of uncertainty propagation in the 'proj' program used by assessment authors. The SSC encourages authors to investigate alternative methods for projection that incorporate uncertainty in model parameters in addition to recruitment deviations. Further, the SSC noted that projections made on the basis of fishing mortality rates (Fs) only will tend to underestimate the uncertainty (and perhaps introduce bias if the population distribution is skewed). Instead, a two-stage approach that first includes a projection using F to find the catch associated with that F and then a second projection using that fixed catch may produce differing results that may warrant consideration." Following a consensus recommendation from the co-chairs and coordinators of the BSAI and GOA Groundfish Plan Teams, stock assessment program leadership at the AFSC has agreed to take the following steps:

- Notify assessment authors that, for the purpose of the standard projection scenarios, the previous requirements for use of the standard Tier 3 projection model and measurement of spawning biomass at the time of peak spawning no longer apply, thereby enabling authors to use Stock Synthesis (SS) or other software to make the projections.
- Task one or more individuals with modifying the current standard projection code so as to accommodate this request for non-SS Tier 3 assessments, with the understanding that it may not be possible to accomplish this in time for use in the 2018 assessments.
- Task the authors of Tier 1 assessments with modifying their projection code so as to accommodate this request for Tier 1 assessments, with the understanding that it may not be possible to accomplish this in time for use in the 2018 assessments.

Because the models used in the EBS Pacific cod assessment are developed using SS, step #1 in the above list should make it possible to respond to this request in the final draft of the assessment.

Responses to Team and SSC comments specific to this assessment

<u>Comments from the November 2017 Team meeting</u>
BPT1: The Team recommends making a direct comparison between the EBS trawl survey length compositions and the NBS survey length compositions for 2010 and 2017, within each year. The NBS survey showed different length compositions between 2010 and 2017, and this comparison would provide a better understanding of the relationship between the stocks in the two areas. This comparison is presented in the "Data" section, under "Northern Bering Sea survey" (see also Figure 2.1.1).

BPT2: The Team recommends presenting in the next assessment document, the fishery CPUE for each of the separate sectors (pot, trawl, longline), as has been done in the past. This information would be useful to compare to estimated trends from the assessment. The requested data will be presented in the final draft of this year's assessment.

BPT3: The Team recommends reporting the fishery CPUE by area in the NBS areas to provide a context for the genetics proposal. A better understanding of the fishery CPUE in the northern areas would provide insight into population trends in these areas that would supplement the occasional surveys in those areas. The Team leaves it up to the analyst to determine the areas based on personal preference and data availability. The requested data are reported in the "Data" section, under "Northern Bering Sea fishery catch per unit effort."

BPT4: The Team recommends investigating the utility of dropping the first five years in the EBS shelf survey (starting the series in 1987) and thus allowing for the incorporation of the northwest strata (areas

82 and 90) into the survey index time-series. The Pacific cod abundance has potentially increased in the northwest strata, these areas are becoming more important to the fishery, and this change may provide an improved index of abundance for Pacific cod. A model incorporating this suggestion has been included in this preliminary assessment, as described under "Model structures."

BPT5: "The Team recommends funding the genetics proposal presented by Ingrid Spies as soon as possible. This proposal will answer questions related to the genetic relationship of Pacific cod caught in the NBS relative to other areas. In addition, the Team would like to understand how the results of this study may affect the assessment and management paradigm, and assumptions of spawning connectivity (or lack thereof) between EBS and NBS Pacific cod." Part 1 of the genetics study was funded earlier this year. Results indicate 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 (Ingrid Spies, AFSC, pers. commun.). In addition, analyses indicated that the NBS samples were unlikely to be from a population that was not sampled, such as Russia. This preliminary assessment only begins to answer the question of how the results of the genetic study may affect the subjects listed above by the Team.

BPT6: "The Team recommends that models 17.2 and 17.6 remain as candidate model structures for continuing to understand the relationships between data and model choices. Models 16.6, 17.2, and 17.6 are structurally different models that represent a range of model uncertainty." Models 17.2 and 17.6 are included here, and have been updated with two new years' worth of age data.

BPT7: "The Team recommends continuing an investigation of why the various models show very different results. This could be accomplished by looking at the effect of model outputs when including individual features (expanding on the evaluation of effects presented). From this work we may gain a better understanding of both the range of model structural uncertainty and the linkages from the model back to the biology and ecology of the stock. Using Model 16.6 as the base model, the Team would like to see the effects of the features included in Models 17.2, 17.3, and 17.6. The effect can be measured with the average difference in spawning biomass, the relative change in the 2016 spawning biomass (not absolute value), the change in the estimate of natural mortality (M), and the unfished equilibrium biomass ($B_{100\%}$). Additionally, and if possible, a look at Mohn's rho for some of the features (at the author's discretion) would be helpful to understand which features affect the retrospective behavior." Although the issue of *why* the various models show different results is not a focus of this preliminary assessment (and Model 17.3 is not included at all, given that it was not listed as a candidate model in Comment BPT6), average difference in spawning biomass (ADSB), projected spawning biomass, natural mortality, unfished equilibrium biomass, and ρ (Mohn 1999) are presented for all models (see especially Table 2.1.10). Readers are also referred to the "Initial steps toward a bridging analysis between Models 16.6 and 17.6" subsection in last year's final assessment (Thompson 2017, especially table 2.11).

<u>Comments from the December 2017 SSC meeting</u>

SSC6: The SSC has encouraged the additional work on model averaging conducted during 2017, and the author and Plan Teams have made good progress on the topic, even if neither are ready to move forward with it. Remaining concerns include clearly identifying criteria for including models in an ensemble, specifically delineating between alternative plausible hypotheses and sensitivity analyses (which should not be included), as well as continued exploration of specific methods for calculating averaged results. The SSC supports the Plan Team's recommendation to conduct a spring workshop to address these and other issues which would not be limited to just Pacific cod. An immense list of issues pertaining to model averaging, including those listed above, were addressed at the June workshop, either in presentations or discussion. Once any recommendations resulting from that workshop, or modifications or additions thereto, have been officially adopted, they will be incorporated into the assessment. In the meantime, this

preliminary assessment continues the exploration of specific methods for calculating averaged results (see "Model averaging" section).

SSC7: Discontinue work on development of empirical weight at age; analysis to date suggests that this may not be a fruitful avenue given data available. Development of empirical weight at age has been discontinued.

SSC8: The SSC disagreed with the Plan Team's recommendation to drop the first 5 years of EBS trawl data in order to use the NW strata. Instead it encourages treatment of these data by allowing catchability to change after the first 5 years of the EBS survey in the model, or through geostatistical modelling approaches." A model incorporating this suggestion (inclusion of data from the two NW strata beginning in 1987, with a change in catchability) has been included in this preliminary assessment, as described under "Model structures."

Data

For the current base model, the data file used in this preliminary assessment was identical to the data file used in last year's assessment (Thompson 2017). With one exception, all other models in this preliminary assessment modify that data file in various ways, as described in the "List of alternative models" subsection of the "Models" section. With the exception of the data described below in the "Northern Bering Sea fishery CPUE" subsection, all data types described in this section were, at a minimum, analyzed in the context of developing the alternative models presented, and many of the data types were incorporated into one or more of the alternative models, as described in the "List of alternative models" subsection of the "Models" section.

Fishery age composition for 2010 and 2011
The procedure established in last year's assessment for selecting otoliths to be used in developing the fishery age composition data is as follows: Given a desired total annual sample size of 1000 otoliths, the objectives were, first, to distribute the sample so as to reflect the proportion of the total catch in each gear/area/week combination as closely as possible, and second, conditional on achieving the first objective, to maximize the number of hauls sampled.

This year, otoliths were requested to be read from the 2010, 2011, 2012, and 2017 fishery collections, to complement the existing fishery age data for each year from 2013-2016. Selection of otoliths for 2012 and 2017 followed the procedure established last year. For the 2010 and 2011 requests, however, the procedure was modified somewhat, because some otoliths from those years have already been aged, and it seemed appropriate, in the interest of efficiency, to leverage the existing collections to the maximum extent possible while still meeting the goal of matching the proportion of the total catch in each gear/area/week combination as closely as possible. For the 2010 collection, 411 previously aged otoliths were selected for use, and 589 new otoliths were requested (total = 1000). For the 2011 collection, 499 previously aged otoliths were selected for use, and 541 new otoliths were requested (total = 1040).

The resulting age compositions were as follow (rows sum to unity; note that ages 0 and 1 were both unrepresented in the otolith collections for both years):

Year	N	2	3	4	5	6	7	8	9	10	11	12+
2010	6514	0.0145	0.1266	0.4027	0.1993	0.1086	0.0666	0.0556	0.0209	0.0024	0.0019	0.0009
2011	8804	0.0090	0.1777	0.2453	0.3657	0.1247	0.0441	0.0151	0.0109	0.0054	0.0010	0.0011

These data were appended to the fishery age composition data used last year in Models 17.2 and 17.6, and the corresponding fishery size composition records were turned "off." Models 17.2 and 17.6 are the only models in this preliminary assessment that use fishery age composition data.

The fishery age composition data for 2012 and 2017 are scheduled to be available in time for use in the final draft of this year's assessment.

Partitions in the EBS shelf bottom trawl survey time series
The "standard" area covered by the EBS shelf bottom trawl survey was established in 1982. In 1987, however, two northwestern strata (82 and 90) were added to the standard area, resulting in an "expanded" survey area that has been covered annually ever since. Because relatively few Pacific cod were typically found in the two northwestern strata (biomass in the expanded area was 3.2% higher than in the standard area on average over the 1987-2017 time series, while abundance was 2.2% higher on average), and because including data from both survey areas would likely require estimating two catchability coefficients, two sets of selectivity parameters, or both, the EBS Pacific cod assessment has always used data from the standard area only. However, at the request of the Team and SSC (see comments BPT4 and SSC8), this preliminary assessment includes two models that include the data from the expanded area.

Table 2.1.1 compares the biomass and abundance indices from the two areas, Table 2.1.2 compares the age compositions from the two areas, and Table 2.1.3 shows the size compositions from the expanded area (the size of this matrix makes a comparison with the size compositions from the standard area, which were presented in last year's assessment, too unwieldy to include).

Another partition in the EBS survey time series that will need to be addressed at some point is the switch from length-stratified to random sampling of otoliths. Samples were collected using a length-stratified design exclusively through 2014, then both random and stratified samples were collected in 2015 and 2016, and a random design has been in use exclusively since 2017. This issue was discussed during the June 2017 of the BSAI Team's subcommittee on Pacific cod models, but not included in any of the subcommittee's requested models (https://www.npfmc.org/wp-content/PDFdocuments/membership/PlanTeam/Groundfish/BSAIPcod_subcommittee617minutes.pdf).

Northern Bering Sea survey
As discussed in last year's assessment, the time series for the northern Bering Sea (NBS) survey is very short. As of last year, the survey had been conducted only twice, in 2010 and again in 2017. Estimates of biomass (t) and abundance (1000s of fish), along with the corresponding lognormal sigma parameters (similar to a coefficient of variation) from those two years are shown below:

	Biomass		Abundance	
Year	Estimate	Sigma	Estimate	Sigma
2010	28,425	0.226	8,881	0.196
2017	286,310	0.131	135,065	0.128

Table 2.1.4 shows the size compositions from the 2010 and 2011 NBS surveys. At the request of the Team (see comment BPT1), Figure 2.1.1 compares the EBS and NBS sizecomps for 2010 and 2017.

This year, a partial survey of the NBS was also conducted. Results were not available in time for inclusion in this preliminary assessment. There may be issues of comparability between the 2010/2017 and 2018 surveys, but if these can be resolved, it should be possible to include the results from the 2018 partial survey in one or more of the models included in the final draft of this assessment.

Northern Bering Sea fishery catch per unit effort

Observer data

For the years 1988-2018, the data from longliners targeting Pacific cod in the NBS survey area come from a total of 12 observed hauls. There are no years in which hauls from more than two vessels were observed, so confidentiality restrictions prohibit these data from being broken down by year.

If the query is expanded by removing the restriction that the hauls need to have targeted Pacific cod, the sample size increases to 27, but the same confidentiality problems arise with respect to annual reporting.

The Team requested that fishery catch per unit effort (CPUE) be reported "by area" within the NBS (see comment BPT3). Aggregating the data over the entire time series and splitting the NBS at 170º W gives approximately equal sample sizes (both in terms of number of hauls and number vessels) over the course of the time series, and does not give rise to issues of confidentiality. The table below shows mean CPUE (in kg per 1000 hooks), along with the corresponding standard errors and approximate 95% confidence bounds for the means:

Subarea	N	Mean	Std. Err.	M-2SE	M+2SE
West of 170	15	129.1	26.9	75.3	182.9
East of 170	12	89.2	21.4	46.3	132.0
Overall	27	111.3	17.8	75.7	147.0

Given the very small sample size, and the inability to use year-disaggregated data, the observer NBS CPUE data were not used in any of the models included in this preliminary assessment.

Fish ticket data

A query of Alaska Department of Fish and Game (ADFG) fish ticket data yielded 552 records of Pacific cod taken in ADFG statistical areas north of 60º30′ in the U.S. portion of the Bering Sea by longline gear, spanning the years 1991-1993 and 1998-2017. These data were then winnowed as follows:

- All records from each ADFG statistical area that was not located predominantly within the NBS survey area were removed. This reduced the number of records to 173, covering the years 2001-2002 and 2006-2017.
- Confidentiality constraints reduced the sample size to 164, covering the years 2006-2012 and 2016-2017.
- All records in this data subset corresponded to vessels making shoreside deliveries except for 2016, when records for 4 catcher-processors were included. The average landing for those 4 catcher-processors in 2016 was 18 times higher than the average landing from any other year, so the analysis was then restricted to vessels making shoreside deliveries only. When the data for the 4 catcher-processors in 2016 were removed, the number of records was reduced to 154, covering the years 2006-2012 and 2017 (2016 was removed due to the confidentiality constraint, as data for only 1 vessel delivering shoreside in 2016 were available).
- In 2017, there are two records that were listed as delivering shoreside in the "processing sector" field, but they are identified as "floating catcher-processors" elsewhere. The average landing for those two records is 350 times higher than the average for the remaining 2017 records, which suggests that their listing as delivering shoreside is an error. When those two records were removed, the total number of records dropped to 152, which was the final data set used to compute fishery catch per ticket in the NBS.

The resulting time series of mean Pacific cod catch per ticket, with approximate 95% confidence intervals, is shown in Figure 2.1.2.

The ADFG fish ticket data were not included in any of the models presented in this preliminary assessment for the following reasons.

- The time series is short (8 years).
- The units are catch rather than catch per unit effort.
- The confidence intervals are wide enough that the data may not contain much information.
- Across the time series, the two small ADFG statistical areas just southwest of Nome (#666401 and #666402, which together comprise a half-degree-latitude × one-degree-longitude block) account for between 56% and 92% of the records in each year, so this might not be a good index of the overall NBS (all but two of the catches in the time series were delivered to Nome; the other two were delivered to Dutch Harbor).

Environmental indices
A total of 13 time series representing various environmental indices were examined in the process of developing the models included in this assessment, although, as noted above, not all of them were ultimately included in any of the models. The list of indices is as follows (the first 10 indices in the list below are those used in the ecosystem "Report Card" section of the ESR (Siddon and Zador 2017), and the last three have been suggested as potentially having particular importance for Pacific cod):

1. North Pacific Index ("NPI")
2. Benthic forager biomass ("bnthc_frgr")
3. St. Paul northern fur seal pups born ("fr_sl_pps")
4. Ice retreat index ("IRI")
5. Pelagic forager biomass ("plgc_frgr")
6. Habitat impacted by trawls ("trwl_mpct")
7. Euphausiid biomass ("ephsd")
8. Apex predator biomass ("apx_prd")
9. Motile epifauna biomass ("mtl_epfn")
10. Multivariate seabird breeding index ("brd_brdng")
11. Fish condition ("fsh_cndtn")
12. Mean bottom temperature in the EBS shelf bottom trawl survey ("bttm_tmp")
13. Age 1 walleye pollock abundance ("pllck_1")

Data for indices #1-10 listed above were obtained from the ESR website: https://access.afsc.noaa.gov/reem/ecoweb/Index.php?ID=9, data for #11 and #12 were obtained from the authors of the respective ESR chapters (Boldt et al. 2017 and Lauth 2017), and data for #13 were taken from Table 28 of the 2017 EBS walleye pollock assessment (Ianelli et al. 2017).

Table 2.1.5 shows the time series of each index, as z-scores, for the years 1977-2017 (or as many of those years for which data exist).

In addition to being used in the process of assessment model development, indices #1-12 were also used to address comment SSC1 (see "Ecosystem considerations" section).

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 V3.30.08.03 was used to run the base model in last year's assessment. SS V3.30.12.00 (beta release, including various minor incremental upgrades through August 3, 2018) was used to run all of the other models in this preliminary assessment.

Base model
Model 16.6 was adopted by the SSC in 2016 as the new base model. In contrast to the previous base model (Model 11.5, which had been in use since 2011), Model 16.6 is a very simple model. Its main structural features are as follow:

- One fishery, one gear type, one season per year.
- 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.

List of alternative models
A total of 15 alternative models are presented here in addition to the base model. These differ either in terms of model structure, data used, or both. Table 2.1.6 lists differences in model structure relative to the base model and Table 2.1.7 lists the data used in the various models. Two of the alternative models were presented in the 2016 assessment, and the other 13 are new (8 of which constitute minor changes from the base model and 5 of which constitute major changes). The list of alternative models is 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.

Additional details about various features of the alternative models

Choice of growth parameter to covary environmentally in Models 16.6c and 16.6d
Models 16.6c and 16.6d were developed in response to requests from AFSC scientists. The requests that gave rise to these two models specified that "growth" be linked to a particular environmental covariate, but they did not specify *which* of the four growth parameters should be linked. The specific parameter to link was chosen in each case by running four preliminary versions of the respective model with one of the four growth parameters linked to the specified environmental covariate, and choosing the parameter that gave the smallest negative log likelihood.

Prior distribution for *M* in Models 17.2 and 17.6
Following a pair of requests from the SSC, Models 17.2 and 17.6 include a prior distribution for *M*. The procedure for developing this prior distribution was described in last year's assessment. The distribution is lognormal, with μ and σ values of -0.6666 and 0.4930, respectively. The distribution has an arithmetic mean of 0.5798, a geometric mean of 0.5134, a harmonic mean of 0.4547, a mode of 0.4027, and a 95% credibility interval extending from 0.1954 to 1.3493.

Selectivity in Models 17.2 and 17.6
Models 17.2 and 17.6 also feature flat-topped, double normal selectivity for the fishery and survey. There are multiple ways to configure double normal selectivity so as to achieve a flat-topped functional form. As described in last year's assessment, the parameter governing the point at which the flat-topped portion of the function begins and the "ascending width" parameter are the only two parameters estimated internally. The others are fixed as follows:

- The parameter defining the length of the flat-topped portion of the curve (as a logit transform between the beginning of the flat-topped portion and the maximum age) was fixed at a value of 10.0, thereby eliminating any descending limb.
- Given the above, the parameters defining the "descending width" and selectivity at the maximum age are rendered essentially superfluous, and were both fixed at a value of 10.0.
- The parameter defining the selectivity at age 0 was fixed at a value of -10.0, corresponding to a selectivity indistinguishable from 0.0.

Models 17.2 and 17.6 also feature random annual time variability in selectivity (fishery only in the case of Model 17.2; both fishery and survey in Model 17.6). In both models, development began with both parameters of the relevant selectivity curve(s) being allowed to vary over time. The process of tuning the input standard deviations of the time-varying parameters is described in a later subsection.

The *dev*s pertaining to the parameter defining the beginning of the flat top were of the multiplicative type, because this parameter is logically constrained to be positive; while the *dev*s pertaining to the "ascending width" parameter were of the additive type, because this parameter is expressed on a log scale and so can take either positive or negative values.

The ranges of years for which selectivity *dev*s were estimated were 1977-2016 for the fishery and 1982-2016 for the survey, corresponding to the full ranges of years spanned by the fishery data and survey data

used in the model, respectively. However, it should be noted that including survey selectivity *dev*s for 2015 or 2016 may result in confounding with the recruitment *dev* for 2015.

Length at age 1.5 (*Lmin*) in Model 17.6

Random annual variability in *Lmin* is a feature of Model 17.6, for which multiplicative *dev*s were estimated. The process of tuning the input standard deviations of this dev vector was the same one used for the selectivity *dev* vectors, and is described in a later subsection.

Care needs to be taken when interpreting the years for which these *dev*s were estimated. Each *dev* becomes "active" in the year for which it is estimated, meaning that it governs the parameters of the mean-length-at-age relationship for fish recruiting at age 0 in that year. However, its impact on the mean length of age 1.5 fish does not occur until the *following* year.

Migration parameters in Models 18.1, 18.2, and 18.5

Models 18.1, 18.2, and 18.5 all feature parameters governing the rates at which fish in the EBS in year y either stay in the EBS in year y+1 or move to the NBS and the rates at which fish in the NBS in year y either stay in the NBS in year y+1 or move to the EBS. These rates also vary with age. The user specifies the age endpoints of a range (which SS labels "A" and "B"), below which the rate takes the value of the lower endpoint, above which the rate takes the value of the upper endpoint, and within which the rate varies linearly between the endpoints. To simplify matters, it was assumed that the age range would be the same for all parameters.

For a two area model, it might be guessed that 8 parameters are required, representing 2 source areas × 2 destination areas × 2 age range endpoints. However, because the parameters for each endpoint are back-transformed via a multivariate logistic equation, half of the parameters cancel, so the destination=source parameter for each area and each age range endpoint can be fixed at 0, meaning that only 4 parameters need to be estimated.

Random variation in migation parameters was assumed in all three models that involve migration. The procedure for tuning the extent of random variability in migration parameters is described in a later subsection. In order to simplify the tuning process for the input standard deviations of the *dev* vectors for the migration parameters, the same input standard deviation was used for all migration parameters.

For Model 18.1, once the input standard deviations of the migration *dev* vectors had converged, a series of runs that profiled over a range of values for the endpoints of the age range were made, and new values of the endpoints were chosen if any were found that resulted a lower negative log likelihood than the existing endpoint values. The process was then repeated (i.e., tune the input standard deviations for the migration *dev* vectors, then profile over a range of endpoint values) until no further improvement could be made. Models 18.2 and 18.5 used the same endpoints as Model 18.1.

It was also necessary to specify a range of years for which years over which the migration parameters would be allowed to vary. Like the *Lmin* parameter discussed in the preceding subsection, the effects of the migration parameters estimated in year y are not manifested until year y+1 (at least in a single-season model such as the ones under consideration here). It was clear that the changes needed to encompass the years of the two NBS surveys, 2010 and 2017, so the range of years for which migration parameters needed to be specified had to span at least the range {2009, 2016}. The final choice of year range was based on trial and error, using Model 18.1 and focusing on the reasonableness of resulting parameter estimates such as the EBS survey Q (see "Results" section). Once a final range of years had been chosen for Model 18.1, the same range was assumed in Models 18.2 and 18.5.

Nutrition deficit index in Models 18.4 and 18.5

The original request for development of Models 18.4 and 18.5 called for use of a nutrition deficit index (as a covariate of age-dependent *M*), to be developed by the creators of the CEATTLE model (Holsman et al. 2017) on the basis of either diet data or bioenergetics. The basic idea was that natural mortality might be expected to vary directly with the difference between nutrition demand and nutrition supply.

Unfortunately, development of the requested index turned out to be much more complicated than anticipated. As time for producing this preliminary assessment began to run short, a "placeholder" nutrition deficit index was constructed so that development of Models 18.4 and 18.5 could proceed. 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 placeholder for the nutrition deficit index are shown in Table 2.1.8 (moving from left to right).

After the point at which it was too late to make any changes to the models, the efforts to develop a nutrition index on the basis of either diet data or bioenergetics finally proved successful. Six alternative indices were developed; the first three are based on diet and the second three are based on bioenergetics (indices and descriptions courtesy of K. Holsman, AFSC, pers. commun.):

- consumedG: Lognormal mean weight of prey in stomach samples in terms of grams of food per gram of predator. This reflects how much fish are eating in a given year. Low values indicate less food consumed due to: 1) consumption of more energetically valuable prey, 2) lack of available prey that leads to lower rates, or 3) less need to forage as much (i.e., lower energetic demand or more ideal conditions).
- meanPreyED: Gravimetric-mean energy density of each prey item in the diet, so it reflects the relative energetic quality of the prey. Lower values indicate a switch to lower density prey that may be offset by consuming more prey.
- RFR (relative foraging rate): An index of observed prey consumption (grams of food per gram of predator per day) relative to a bioenergetics model-based theoretical maximum consumption rate (grams of food per predator per day). The value is typically 0 to 1, but can be higher than 1 if lab experiment-based consumption rates are less than rates in the wild due to schooling behavior or lab behavioral stress, of if the estimated energy densities of the prey or predator are inaccurate. RFR can go up when: 1) more prey is available, or 2) prey quality drops so fish must forage more to meet energetic demand.
- Cmax: Theoretical maximum consumption rate of a fish given its weight and temperature. Cmax tends to be low at cold and very warm conditions.
- maxG: Theoretical scope for growth if fish are able to consume prey at their maxium consumption rate (i.e., RFR=1). Lower values can result when: 1) cold conditions lead to slower growth potential; 2) prey energy is low; or 3) warm conditions result in metabolic demand becoming a large proportion of the energy budget, which means that the energy available for growth declines.
- Gpotential: Similar to maxG, this is theoretical scope for growth, given observed consumption rates and diet composition. Lower values can result under the same conditions listed for maxG.

The diet/bioenergetics-derived indices were presented in two forms: a version structured in terms of 20-cm size bins and another version for the population as a whole.

To help guide Team and SSC discussions regarding which, if any, of the indices should be used in models to be included in the final draft of this assessment, each index was correlated against the time series of instantaneous total mortality rates at age, which was estimated by a selectivity-adjusted catch-curve analysis of the raw EBS survey age composition data (where the data are expressed in numbers of fish rather than proportions, and where survey selectivity at age was taken from Model 16.6). For the version of the indices structured in terms of 20-cm size bins, this required converting from size bins to ages, which was done by using the (static) distribution of length at each age and the numbers-at-year-and-age matrix (both from Model 16.6) to create year-specific tables of age×bin weights, which were then used to give a weighted average (across bins) value for each age in that year.

Table 2.1.9 shows the correlations of each index with catch-curve-generated total mortality rate at each age 1-13. The data in the upper and lower portions of the table are identical; only the color coding is different. The upper portion of the table shows which correlations are positive (green) and which are negative (red). The placeholder index did not perform too badly, giving positive correlations for 7 of the 13 ages, doing at least as well as any of the population versions of the diet/bioenergetics-derived indices, which gave positive correlations for between 4 and 7 of the 13 ages. Three of the six age-specific versions of the diet/bioenergetics-derived indices gave a larger number of positive correlations than the placeholder index (the age-specific version of meanPreyED was the champion in this regard, giving positive correlations for 11 of the 13 ages). Notably, all six of the age-specific versions of the diet/bioenergetics-derived indices gave positive correlations for all ages from 5 to 9. The lower portion of Table 2.1.9 shows how the performances of the various indices compare with each other for a given age. Color coding goes from red (low) to green (high). The placeholder index at age 3 had the highest correlation (0.573) of any index at any age. The placeholder index tied with the age-specific version of the meanPreyED index for the highest number of best performances (3).

<u>Age-dependent *M* in Models 18.4 and 18.5</u>
SS implements *n* age breakpoints for *M* as follows (note that age breakpoints need not be integers):

- *M* for ages from 0 through breakpoint age 1 are equal to the 1st *M* parameter.
- For all $1<k<n$, *M* for ages from breakpoint age $k-1$ through breakpoint age *k* follow a linear interpolation between the kth-1 and kth *M* parameters.
- *M* for ages from breakpoint age *n* and above are equal to the nth *M* parameter.

In developing Model 18.4, the number and locations of breakpoints were guided by these considerations:

- *M* within at least one age range had to vary directly with the nutrition deficit index (the rows in Table 2.1.9 corresponding to the placeholder index proved helpful in exploring alternative ranges where this result would likely obtain).
- Any age range within which *M* did not vary directly with the nutrition deficit index should not be linked to that index.
- Base values of *M* must be a non-increasing function of age.

The number and locations of breakpoints for Model 18.5 were set equal to those for Model 18.4.

<u>Ricker recruitment in Model 18.5</u>
The request that gave rise to Model 18.5 called for at least one change in stock-recruitment steepness during the time series. All recent versions of the EBS Pacific cod model have assumed that recruitment is independent of spawning biomass, and this assumption is accommodated easily in SS by choosing the Beverton-Holt form of the stock-recruitment relationship with steepness fixed at 1.0 (steepness is traditionally defined as the ratio of recruitment at 20% of equilibrium unfished spawning biomass to

recruitment at equilibrium unfished spawning biomass, where the measure of recruitment in both the numerator and denominator is the value from the stock-recruitment curve).

However, given that steepness values other than 1.0 were to be entertained in Model 18.5, it seemed appropriate to test whether the Ricker form of the stock-recruitment relationship might be more appropriate than the Beverton-Holt form. Comparing runs based on an early version of Model 18.5, with steepness estimated using the Beverton-Holt form in one case and the Ricker form in the other, indicated that the Ricker form gave a much lower negative log-likelihood, so the Ricker form was chosen.

The parameter labeled "beta" in the SS report file (but *h* in the user manual and Methot and Wetzel 2013) represents the ratio of equilibrium unfished spawning biomass to the spawning biomass associated with the peak of the stock-recruitment curve. It is related to the traditional definition of steepness as follows:

$$steepness = \left(\frac{1}{5}\right)\exp\left(\frac{4\beta}{5}\right).$$

As initial tuning of Model 18.5 proceeded, a single value of β was used for the entire time series. Once the tuning had converged, the time series of recruitment *dev*s was examined for breakpoints. The optimal number and locations of breakpoints was chosen on the basis of AIC. Once the breakpoints were chosen, the model was reconfigured with block-specific β parameters that were estimated internally.

In the event that Model 18.5 (or any model involving an internally estimated value of stock-recruitment steepness) is adopted by the SSC for use in setting harvest specifications, it will be necessary for the SSC also to determine whether the point estimate of F_{MSY} or the probability density function of F_{MSY} resulting from the model is reliable. If the respective determination is affirmative, then this stock will move from Tier 3 to Tier 2 or Tier 1 management.

<u>Tuning the extent of random variability in parameters other than *Q* in Models 17.2 and 17.6</u>
Like all of the models, Models 17.2 and 17.6 feature random annual variation in recruitment. However, unlike the other models, the extent of annual variation in recruitment is not estimated internally in Models 17.2 and 17.6. Models 17.2 and 17.6 also feature random annual variation in fishery selectivity parameters, and Model 17.6 also features random annual variation in survey selectivity parameters and in *Lmin*. This section describes the methods used to tune the input standard deviations governing the extent of random variability in those parameters.

Deriving statistically valid estimates of the input standard deviations that are used to constrain *dev* vectors is a perennial problem in stock assessments that use a penalized likelihood approach. SS V3.30 includes, as a change from SS V3.24, the ability treat these standard deviations as additional parameters to be estimated internally. Unfortunately, the maximum likelihood estimates based on the penalized likelihood tend to be biased (Thompson 2016a). An alternative procedure was introduced in the 2015 assessment (Thompson 2015), which constituted a multivariate generalization of one of the methods mentioned by Methot and Taylor (2011), viz., the third method listed on p. 1749), and proceeded as follows:

1. Set initial guesses for the σ*dev*s.
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 σdevs corresponding to **V1**+**V2**.
8. Return to step 2 and repeat until the σdevs converge.

However, this method will not work in SS V3.30, because the functional form of the penalty term has been changed. In previous versions of SS, the penalty term was

$$-n \cdot \ln(\sigma dev) - \left(\frac{1}{2}\right) \cdot \sum_{i=1}^{n} \left(\frac{dev_i}{\sigma dev}\right)^2,$$

and the *dev*-adjusted parameter for year *i* (for the case of additive devs) took the form $parameter_i = base_value + dev_i$.

In SS V3.30, on the other hand, σdev is removed from the denominator in the summation, so the penalty term is now

$$-n \cdot \ln(\sigma dev) - \left(\frac{1}{2}\right) \cdot \sum_{i=1}^{n} (dev_i)^2,$$

and the *dev*-adjusted parameter for year *i* takes the form $parameter_i = base_value + \sigma dev \cdot dev_i$.

Note that, once the appropriate constant was added, the old form of the penalty term took the form of a sum of logged $N(0,\sigma dev)$ probability density functions. However, the new form of the penalty term takes the form of a sum of logged $N(0,1)$ probability density functions *minus* the quantity $n \cdot \ln(\sigma dev)$, meaning that the exponentiated penalty term no longer integrates to unity.

Further complicating matters is the fact that the new form of the penalty term in V3.30 does not apply to recruitment *dev*s, which still use the old form of the penalty term.

However, the most significant problem posed by the new form of the penalty term with respect to the above algorithm for estimating the σdevs is that, with the exception of σ_R, none of the σdevs appears in either **V1** or **V2**. To remedy this situation, the following changes were made to the algorithm (note that these changes assume implicitly that the *dev* vectors are all independent, which is not the case in the original algorithm):

- To obtain a covariance matrix analogous to the one in step #3 above:
  - Form a diagonal matrix consisting of the variances of the *dev* vectors.
- To obtain a covariance matrix analogous to the one in step #4 above:
  - Let *ndev* represent the number of non-recruitment *dev* vectors in the model, indexed k=1,...,*ndev*.
  - Read the Hessian matrix **H** returned by ADMB.
  - For each row *i* in **H**, set $dvec_i=k$ if the parameter represented by row *i* is an element of the *k*th *dev* vector; otherwise, set $dvec_i=0$.
  - For each row *i* and column *j* in **H**, if $dvec_i>0$, then multiply $\mathbf{H}_{i,j}$ by $dvec_i$, and if $dvec_j>0$, then multiply $\mathbf{H}_{i,j}$ by $dvec_j$.

  - Invert **H**.
- Because (given the above changes) it is now assumed implicitly that the *dev* vectors are all independent, it is no longer necessary to use only those years common to all *dev* vectors.

The above changes to the algorithm for estimating the σ*dev*s should be considered experimental at this point.

Another new feature of randomly time-varying parameters in SS V3.30 is the requirement either to specify or to estimate the degree of autocorrelation among the *dev*s in the log likelihood. Except as specified otherwise in the next subsection, all autocorrelation terms in all models were fixed at zero. Initial explorations allowing the recruitment autocorrelation term to be estimated internally resulted in values close to zero.

<u>Tuning based on matching the sampling variance in survey indices (several models)</u>
Randomly varying catchability (either EBS, NBS, or both) is a feature of Models 16.6e, 16.6g, 16.6h, and 17.6; and randomly varying migration parameters is a feature of Models 18.1 and 18.5.

Tuning of the input standard deviations for the *Q dev*s and migration parameter *dev*s followed a different procedure than the one described above for recruitment, selectivity parameters, and *Lmin* in Models 17.2 or 17.6. The procedure for tuning the input standard deviations for these *dev* vectors was analogous to a procedure that was often used historically (in assessment models for other stocks developed under certain older versions of SS) to estimate the amount of survey index measurement error, which was to inflate the standard errors specified in the data file by adding a constant chosen so as to equate the root-mean-squared-error (model estimates versus data) with the mean (across years) standard error specified in the data file. Here, however, the equivalence was achieved by tuning the input standard deviation rather than the standard errors. The reasons for using this procedure rather than the one described above were twofold: 1) it maintains consistency with historical precedents for dealing with survey index data; and 2) estimates of the amount of observation error are available due to the statistical design of the survey.

The table below shows the models for which the index RMSE and mean log-scale sigma from the two areas (EBS, NBS) were used to tune the input standard deviations for various *dev* vectors:

	Input standard deviation being tuned						
Quantities used for tuning	EBS *Q dev* s			NBS *Q dev* s		Migration *dev* s	
EBS RMSE and mean(sigma)	16.6e	16.6g	17.6				
NBS RMSE and mean(sigma)				16.6g	16.6h	18.1	18.5

It might be wondered why the fit to the NBS survey index, which contains only two points, was used to tune the input standard deviations for the *dev* vectors associated with the migration parameters, rather than using the EBS survey index, which contains 36 points. The reason is that the contrast between the two estimates of abundance in the NBS survey is so great that it seemed like the more important of the two survey time series to fit.

Catchability and migration parameters are expressed on a log scale in SS, so additive *dev*s were estimated for these.

Unlike the other parameters for which random annual variability was allowed, the autocorrelation coefficient for *Q* was allowed to be estimated freely in Model 17.6 rather than fixed at zero, because early explorations indicated that the amount of autocorrelation was likely to be substantial and because internal

estimation of the autocorrelation coefficient would not complicate the estimation of the input standard deviation.

Choice of environmental covariates (several models)
Environmental covariates are used to calibrate at least one parameter in Models 16.6c, 16.6d, 16.6f, 16.6h, 18.2, 18.3, 18.4, and 18.5. With respect to the method used to choose the respective covariate(s), these models can be categorized as follows:

- Models 16.6c, 16.6d, 18.3, and 18.4 were developed in response to requests from AFSC scientists, and those requests specified, at least to some extent, which covariates to use.
    - The requests that gave rise to Models 16.6c and 16.6c specified that a growth parameter be linked to fish condition and bottom temperature, respectively.
    - The request that gave rise to Model 18.3 specified that *M* be linked to fish condition.
    - The request that gave rise to Model 18.4 specified that *M* be linked to nutrition deficit, although the precise form of the nutrition deficit index was not specified.
- Models 16.6f, 16.6h, and 18.2 (along with the link between *M* and nutrition deficit in Model 18.5) constitute environmentally linked counterparts to Models 16.6e, 16.6g, and 18.1, respectively. More specifically, each environmentally-linked parameter in Models 16.6f, 16.6h, and 18.2 corresponds to a *dev* vector for the same parameter in Models 16.6e, 16.6g, and 18.1, respectively. For each pair of models ({16.6e, 16.6f}, {16.6g, 16.6h}, and {18.1, 18.2}), the model with the *dev* vector for the parameter of interest was developed first; then the environmental covariate for that parameter in the corresponding model was chosen from the first 12 indices in Table 2.1.5 on the basis of maximum correlation with the respective *dev* vector.
- Model 18.5 is an omnibus model that borrows some features from other models, in addition to adding some features not included elsewhere. The environmental covariate for EBS survey *Q* was borrowed from Model 18.2, and the environmental covariate for *M* was borrowed from Model 18.4.

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. Following the procedure established in the 2016 assessment (Thompson 2016b), when running a jitter test, the bounds for each parameter in the model were adjusted to match the 99.9% confidence interval (based on the normal approximation obtained by inverting the Hessian matrix). A jitter rate (equal to half the standard deviation of the logit-scale distribution from which "jittered" parameter values are drawn) was set at 1.0 for all models. Standardizing the jittering process in this manner will not explore parameter space as thoroughly as possible; however, it makes the jitter rate more interpretable, and shows the extent to which the identified minimum (local or otherwise) is well behaved.

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

4. The model was re-run starting from the final parameter file from the best jitter run.
5. The resulting new control file, with the parameter estimates from the best jitter run incorporated as starting values, became the new base run.
6. 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.

Results

Note: In all tables with color scales, red and green correspond to the minimum and maximum values within the given row or column (whether the scale varies horizontally or vertically varies by table). Also, in the context of the EBS survey, "std." denotes the standard survey area and "exp." denotes the expanded survey area.

Overview

Table 2.1.10 presents an overview of some key results for the models. Several of the rows in the table provide values that the Team requested for use in understanding differences between the models (see comment BPT7); specifically, average difference in spawning biomass (ADSB, representing the root-mean-squared relative differences between the time series of spawning biomass estimated by a given alternative model and the time series estimated by the current base model, using only data that were available that were available when the current base model was first adopted), projected spawning biomass, natural mortality, unfished equilibrium biomass, and Mohn's ρ.

Table 2.1.10 is divided into four sections: dimensions, diagnostics, base values, and 2019 quantities. The "dimensions" portion reproduces some key elements of Table 2.1.7 that might help readers to understand why some cells in the rest of the table are blank. The "diagnostics" portion lists ADSB and Mohn's ρ, the first of which is a measure of how "different" a given alternative model is from the current base model, and the second of which is a measure of retrospective bias. The "base values" section lists some key time-invariant quantities, which in some cases are the base values for time-varying parameters (note that *M* varies with age in Models 18.4 and 18.5; the values listed here are for ages 6+). The "2019 quantities" portion lists several quantities relevant to management of the fishery in 2019 (biomass, OFL, and maxABC are all in units of 1000s of t), but it is important to note that these estimates will change once the data sets are updated for the final draft of this assessment ("depletion" is the ratio of spawning biomass in 2019 to equilibrium unfished spawning biomass).

Goodness of fit

Table 2.1.11 shows negative log likelihood values and parameter counts for the models. The 16 models involve a total of 13 unique data sets (Models 16.6 and 16.6e share a common data set, Models 16.6c and 18.3 share a common data set, and Models 17.2 and 17.6 share a common data set). Because the data sets are different for nearly all models, and because the input standard deviations for various dev vectors are tuned to different values in many of the models, it is difficult to compare the negative log likelihoods across models in a meaningful way. Likewise, because all of the models involve *dev* vectors and the input standard deviations for those are not constant across models, comparing parameter counts is also difficult.

Table 2.1.12 shows the model fits to each year of the EBS survey index in terms of negative log likelihood. Table 2.1.12a lists the negative log likelihood values, which helps to show whether there are certain observations (years) that tend to be fit well or poorly by multiple models (i.e., lots of green or red in a row), and also whether a given model tends to be fairly consistent in its ability to predict the survey index (uniform color in a column) or whether its performance is variable across years (mix of colors in a column). The observed survey index is also shown for reference (e.g., does a model, or group of models, tend to do worse when the index changes dramatically in a single year?). Table 2.1.12b subtracts the row minimum from each row in Table 2.1.12a, thus showing, for each observation (year), how the models compare relative to the best model performance for that particular observation. The second row from the bottom lists the number of times that each model did better than any other model, and the bottom row shows the negative log likelihood from each model's worst performance.

Table 2.1.13 shows effective sample sizes for each model and data component, following the procedure introduced in last year's assessment.

- Cells shaded gray represent constants associated with the data (if a cell that is shaded gray for Model 16.6 is shaded yellow for some other model, it indicates an instance where the data in the other model differ from the data used in Model 16.6). The quantities in this category consist of:
    - The number of years represented in the particular data type ("Yrs").
    - The average sample size for the particular data type as specified in the data file ("N"), which, in the case of survey index data, consists of the average number of stations (hauls) sampled over the time series.
    - The average log-scale standard error of the survey index ("SEave").
- Cells shaded blue (the "Mult" column) represent values specified by the modeler that are used to modify the sample sizes for the given data component (compositional data only).
- Cells shaded gold (the "N×Mult" column) represent the product of the "N" and "Mult" values (compositional data only).
- Cells shaded tan represent model results. The quantities in this category consist of:
    - The harmonic mean of the effective sample size ("Har"; compositional data only).
    - The root-mean-squared-error of the model's log-scale survey index estimates ("RMSE"; survey index data only).
- Cells shaded green represent a pair of aggregate sample sizes computed from the other columns.
    - For composition data, these cells contain:
        - The aggregate effective sample size *assigned* to the particular data type ("ΣNeff1"), computed as Yrs×N×Mult.
        - The aggregate effective sample size *achieved* for the particular data type ("ΣNeff2"), computed as Yrs×Har.
    - For survey index data, these cells contain the same two quantities (ΣNeff1 and ΣNeff2), and ΣNeff1 is computed as in the case of composition data, but ΣNeff2 is computed as:
        - $\text{Yrs}\times\text{N}\times((\text{SEave}+\text{SEextra})/\text{RMSE})^2$.

By expressing ΣNeff1 and ΣNeff2 in units of hauls for both composition data and index data, the values for the two data types are comparable.

The ratio ΣNeff2/ΣNeff1 for a given data component provides a measure of how well the model is tuned with respect to that component (specifically, the ratio should equal unity). Red font in any pair of horizontally adjacent cells indicates that the respective model was tuned so that the value in the right-hand cell matched (approximately) the value in the left-hand cell. Only Model 17.6 achieves ratios equal (approximately) to unity for all components.

Parameter estimates, derived time series, and retrospective analysis
Table 2.1.14 lists virtually all of the parameters and constants estimated or used in the SS control files. For parameters estimated internally, both estimates ("Est.") and standard deviations ("StD") are listed. Table 2.1.14a lists the internally estimated parameters (other than *dev*s) that are common to all or nearly all of the models. Table 2.1.14b lists the internally estimated parameters (other than *dev*s) that are used in only a few of the models. Table 2.1.14c lists those parameters whose values were estimated iteratively, through the procedures described in the "Models" section. Table 2.1.14d lists the "early" recruitment *dev*s (that, along with the other parameters active at the start of the model, determine the initial numbers-at-age vector). Table 2.1.14e lists the "main" recruitment *dev*s (i.e., those for the years 1977-2016), and the color scales show a very high degree of consistency across models (at least qualitatively). Table

2.1.14f lists the remaining *dev* vectors estimated by the models. Table 2.1.14g lists miscellaneous constants specified in the SS control files.

Some values from Table 2.1.14 that might be difficult to interpret include the following:

- The age range for the linear ramp between sets of migration "A" and "B" parameters shown in Table 2.1.14b was {4,8}.
- The value of the "A" parameter for migration from the NBS to the EBS proved difficult to estimate internally. The parameter seemed to converge on a very large value in Models 18.1 and 18.2 (81.638 and 81.774, respectively), with an immense standard deviation that, in some runs, caused the Hessian not to be positive definite. Moreover, the *dev*s estimated for that parameter were all negligible. Therefore, this parameter was fixed at the (apparently) converged values (the value for Model 18.5 was set equal to the value from Model 18.1), as shown in Table 2.1.14c, and the associated *dev* vector was removed from all three migration models.
- The values of the Ricker β parameter shown in Table 2.1.14b for the four time blocks (1977-1979, 1980-2005, 2006-2013, and 2014-2016) correspond to steepness values (as traditionally defined) of 2.832, 1.043, 2.320, and 0.200. Figure 2.1.3 shows the estimated spawning biomass and recruitment time series along with the estimated Ricker stock-recruitment curves for the four specified time blocks.
- In Models 18.4 and 18.5, three breakpoints were specified for the age-dependent *M* schedule: 2, 5, and 6; with dependence on the nutrition deficit index active only on the parameter representing *M* at age 5 (but therefore influencing *M* at all ages from 2 through 5). The base value of *M* at age 5 and the *M* at ages 6+ conformed to the desired non-increasing form in both models, but if *M* for ages 0-2 was estimated freely, the resulting value was much lower than the base value of *M* at age 5 or *M* at ages 6+. Therefore, the values of *M* at ages 0-2 in Models 18.4 and 18.5 were tuned iteratively to match the corresponding base value of *M* at age 5, which tended to push the base values of *M* at age 5 downward, so that in the end there was little difference between *M* at ages 0-2, the base value of *M* at age 5, and *M* at ages 6+ in either model.

Table 2.1.15 shows the time series of estimated apical fishing mortality rates, along with their estimated standard deviations. As with the time series of recruitment *dev*s in Table 2.1.14e, the color scales show a very high degree of consistency across models (at least qualitatively).

Table 2.1.16 shows time-varying biology parameters after adjustments (i.e., after the applying the *dev*s to the corresponding base value).

Table 2.1.17 shows the time series of migration probabilities (EBS to EBS, EBS to NBS, NBS to EBS, and NBS to NBS) for each age over the time series 2006-2017. The row for EBS to EBS is highlighted with a color scale in each year. Migration probabilities for each source area sum to 1.0 at each age.

Table 2.1.18 shows catchability for all models, by year, and in the NBS as well as the EBS for the five models that estimate *Q* for the NBS. Models with time-varying catchability are shown with color scales. The entries for 1987-2017 under Models 16.6a and 16.6b are shown in italics, to indicate that those two estimates of EBS *Q* are based on the expanded survey area rather than the standard area.

Table 2.1.19 shows selectivity for all models. Table 2.1.19a shows base values of fishery selectivity at age, Table 2.1.19b shows based values of EBS survey selectivity at age, Table 2.1.19c shows base values

of NBS survey selectivity at age, Table 2.1.19d shows fishery selectivity by age and year for Model 17.2, Table 2.1.19e shows fishery selectivity by age and year for Model 17.6, and Table 2.1.19f shows survey selectivity by age and year for Model 17.6.

Table 2.1.20 shows the time series of recruitment for all models, along with standard deviations. Note that recruitment is assumed equal to the mean for 2017-2019 in all models except Model 18.5, where the stock-recruitment relationship causes recruitment in those years to vary even though no recruitment data are available for those years. As with the time series of recruitment *dev*s in Table 2.1.14e, the color scales show a very high degree of consistency across models (at least qualitatively).

Table 2.1.21 shows the time series of depletion for all models, along with standard deviations. The color scales again show a very high degree of consistency across models (at least qualitatively), except that Model 17.6 does not show as much of an upward trend in recent years as the other models.

Table 2.1.22 shows the time series of spawning biomass for all models, along with standard deviations. As with the depletion time series shown in Table 2.1.21, Model 17.6 does not show as much of an upward trend in recent years as the other models.

Table 2.1.23 shows the time series of spawning biomass in both the EBS and NBS for the three models that produce such estimates (SS does not produce standard deviations for these quantities). The area-specific values in this table sum to the value of the point estimates for the respective model in Table 2.1.22.

Table 2.1.24 shows age 0+ biomass for all models (SS does not produce standard deviations for this quantity). Model 17.6 does not show as much of an upward trend in the 2011-2016 time frame as the other models.

Table 2.1.25 shows the time series of age 0+ biomass in both the EBS and NBS for the three models that produce such estimates (SS does not produce standard deviations for these quantities). The area-specific values in this table sum to the value of the point estimates for the respective model in Table 2.1.24.

Mohn's ρ, along with boundaries on acceptable values thereof as suggested by regressions against *M* based on the results of Hurtado-Ferro et al. (2015), are shown below (values shaded red fall outside of the acceptable range):

Model:	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g
M:	0.359	0.348	0.347	0.354	0.363	0.361	0.354	0.353
Min ρ:	-0.206	-0.202	-0.201	-0.204	-0.207	-0.206	-0.204	-0.204
Max ρ:	0.279	0.274	0.274	0.277	0.282	0.280	0.277	0.277
ρ:	0.243	0.202	0.217	0.304	0.222	0.323	0.291	0.359

Model:	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
M:	0.348	0.374	0.312	0.305	0.331	0.349	0.381	0.294
Min ρ:	-0.202	-0.211	-0.189	-0.187	-0.196	-0.202	-0.213	-0.183
Max ρ:	0.274	0.287	0.256	0.252	0.266	0.274	0.290	0.247
ρ:	0.319	0.309	0.069	0.452	0.370	0.118	0.451	0.724

Note that the ρ values for 7 out of the 13 models fall outside the acceptable range. The values for Models 16.6, 16.6a, 16.6b, 16.6d, 17.6, and 18.3 fall within the acceptable range. Model 17.6 has the smallest retrospective bias of any model, and Model 18.5 has the largest.

In response to internal (AFSC) reviews of a previous draft of this document, Attachment 2.1.1 provides a bridging analysis between Models 17.2 and 17.6, showing how incorporation of each feature (cumulatively) affects each parameter in the model.

Model averaging

Unweighted averages

Table 2.1.26 shows the means and standard deviations of the OFL and maxABC distributions for 2019 in each model, based on the Hessian approximation, where means and standard deviations ("SDev") are expressed in t. The right-most pair of columns shows the probability that the mean maxABC exceeds the true-but-unknown OFL for the respective model. The first of those two columns ("Sam.") is based on the averaged sample distribution (i.e., the average (across models) of the normal distributions of 2019 OFL). The second of those two columns ("Pop.") is based on an attempt to estimate the population distribution from which the sample of models was drawn, and was derived by fitting a 3-parameter "t" distribution to the mean, standard deviation, and kurtosis of the averaged sample distribution (this method, using a simpler functional form, was introduced in last year's assessment, and presented at both the National Stock Assessment Workshop and the BSAI Team's Assessment Methods Workshop earlier this year). The average maxABC across all models is 159,962 t, which represents a 20.3% chance of exceeding the true-but-unknown OFL if the averaged sample distribution is used and a 26.7% chance of exceeding the true-but-unknown OFL if the estimated population distribution is used.

Figure 2.1.4 shows the probability density functions (upper panel) and cumulative distribution functions (lower panel) for the following:

- The averaged sample distribution of maxABC.
- The estimated population distribution of maxABC.
- The averaged sample distribution of OFL.
- The estimated population distribution of OFL.

Although the means of the averaged sample distribution and the estimated population (of either OFL or maxABC) are equal by design, the medians are not:

- The median of the averaged sample distribution of maxABC is 168,187 t; the mean is 159,962 t.
- The median of the averaged sample distribution of maxABC is 199,157 t; the mean is 189,727 t.

Weighted averages

Last year's assessment presented a method for model weighting that was based, in part, on the ΣNeff2 statistic presented in Table 2.1.13. These are reproduced in Table 2.1.27, with a color scale for each row, and without the other columns of Table 2.1.13. In the context of the models presented here, one difficulty with this measure is that the models do not all use the same data components. Taking the sum of the component-specific ΣNeff2 values might unfairly penalize some models that do not attempt to fit certain information-rich data components, while taking the average of the component-specific ΣNeff2 values might unfairly penalize some models that attempt to fit certain difficult-to-fit data components. Also, the fact that Model 17.6 is the only model that is fully tuned may complicate the interpretation of the ΣNeff2

statistics from the other models (e.g., a model might be able to achieve a high ΣNeff2 value for a compositional data component by giving it an immense average input sample size, even though the harmonic mean effective sample size, while high, is much lower than the average input sample size).

In last year's assessment, the ΣNeff2 values were adjusted by dividing them by an estimate of the "effective" number of parameters. The procedure for computing the effective number of parameters was very time-consuming and, given that the method did not receive much support during the reviews of last year's assessment, the computation was not undertaken here. However, if the Team or SSC wishes to see this method revived for the final draft of the assessment, it might be possible to do if the number of models is sufficiently small.

Last year's assessment also included a set of ad hoc adjustments to the model weights based on ΣNeff2 per effective parameter that resulted from SSC recommendations. Specifically, the SSC suggested that model weightings based on goodness off fit should be modified based on three factors: 1) retrospective performance, 2) model convergence behavior, and 3) general plausibility. These were implemented in last year's assessment as follows:

- Retrospective performance: Mohn's ρ was used to form the basis of a multiplicative adjustment factor, defined as exp(−|ρ|).
- Model convergence behavior: Model convergence behavior was measured on the basis of the RMSE from each model's "jitter" test, where the squared error for each jitter run was defined as the squared proportional difference between the ending year spawning biomass estimated in that run and the ending year spawning biomass estimated in the final (converged) run). The RMSE was used to create a multiplicative adjustment factor, defined as exp(−RMSE).
- General plausibility: Two quantities were used to measure "general plausibility:" First, because conventional wisdom is that the EBS Pacific cod stock was not heavily exploited prior to the rapid increase in biomass resulting from the 1977 regime shift (Wespestad et al. 1982), estimates of the initial (pre-1977) fishing mortality rate *Finit* that exceed the natural mortality rate were penalized. Second, because field studies to date provide little, if any, evidence that catchability in the EBS bottom trawl survey exceeds unity (Weinberg et al. 2016), estimates of catchability that exceed unity were penalized. Two multiplicative adjustments were defined as exp(−max(0,*Finit*−*M*)) and exp(−max(0,ln(*Q*))).

As it turned out, the SSC's requested adjustments, particularly the pair of "general plausibility" adjustments, had a large influence on the final model weights in last year's assessment. Some alternative adjustments are provided in Table 2.1.28. These all have functional forms broadly similar to those used last year, but with a couple of modifications. Each of the multiplicative adjustments used in last year's assessment took the form exp(−*X*), where *X* was specific to the factor responsible for the adjustment (retrospective performance, convergence behavior, and general plausibility). In contrast, the multiplicative adjustments in Table 2.1.28 take the form $\exp\left(-\alpha(X - X_{min})\right)$, where α is a parameter whose value is to be specified and X_{min} is the minimum value of X across all models. Setting α=1 gives a set of multiplicative adjustments that are proportional to the ones that would be generated using last year's formulas (the only difference is that they are now normalized so that one model has a multiplicative adjustment equal to 1.0), whereas setting α<1 reduces the impact of the multiplicative adjustments.

A method for model weighting based on 10-fold cross-validation is also presented here. For each model, each component of the respective data set (except for any that consisted of fewer than 10 records) was partitioned into 10 subsets of approximately equal size. A set of 10 training data sets was then created for each model by "turning off" one of the subsets in each of the constituent components. Each model was then fit to each of the training data sets and used to predict the respective data subset that was "turned off" (i.e., the testing data subset). Following a suggestion by Stewart and Martell (2015), the fit to the survey index was singled out here as an appropriate basis for model weighting.

Specifically, the negative log likelihood for each survey index observation in the testing data subset for each of the 10 runs was recorded and, because the data subsets were complementary (i.e., each observation was omitted in exactly one of the training data subsets), once all 10 runs had been made, a complete time series of negative log likelihoods for the survey index was obtained for the model.

Table 2.1.29 shows the time series of "testing" negative log likelihoods for the EBS survey index for each model. This table is constructed similarly to Table 2.1.12, which measured the fits of the models to the EBS survey index in terms of negative log likelihood. Table 2.1.29a lists the negative log likelihood values, which helps to show whether there are certain observations (years) that tend to be fit well or poorly by multiple models (i.e., lots of green or red in a row), and also whether a given model tends to be fairly consistent in its ability to predict the survey index (uniform color in a column) or whether its performance is variable across years (mix of colors in a column). Table 2.1.29b subtracts the row minimum from each row in Table 2.1.29a, thus showing, for each observation (year), how the models compare relative to the best model performance for that particular observation. The second row from the bottom lists the number of times that each model did better than any other model, and the bottom row shows the negative log likelihood from each model's worst performance.

Table 2.1.30 uses the total "testing" negative log likelihood ($-lnL$) for each model (i.e., the bottom row of Table 2.1.29) to compute a set of model weights, where the weight for model i is proportional to $\exp(-lnL_i - \min(lnL))$. The left half of the table is sorted in order of model number, and the right half is sorted in order of negative log likelihood. Note that, if these weights were to be used, 98.68% of the weight would be given to Model 17.6. Model 16.6g had the second lowest negative log likelihood, but it lagged 7.1798 points behind Model 17.6. Model 17.2 fared the worst, being 24.0568 points behind Model 17.6.

Implications of the NBS-EBS connection

Results of genetic studies to date indicate 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 (Ingrid Spies, AFSC, pers. commun.). In addition, analyses indicated that the NBS samples were unlikely to be from a population that was not sampled, such as Russia. Nevertheless, questions remain about what these findings imply with respect to both the assessment of Pacific cod in the region and management of the fishery. In terms of basic biology, the extent to which fish in the NBS are spawning there, as opposed to returning to the EBS to spawn or not spawning at all; the viability of eggs or larvae (if any) that result from spawning in the NBS; and the persistence of the substantial biomass that was observed in the NBS during the 2017 are all unknown.

There are also issues regarding the design of appropriate stock assessment models and interpretation of stock assessment results. For example:

- Of the 11 models presented here that do not involve NBS survey data, only Model 18.4 estimates an EBS survey Q less than 0.913 and only Model 18.4 estimates an M higher than 0.374, which could be interpreted as confirmation that the fish in the EBS behave as

a stand-alone stock. In other words, if persistent "leakage" of fish into the NBS were occurring, it might be expected that the models would tend to estimate lower values for *Q*, higher values for *M*, or both.

- On the other hand, all three of the 2-area migration models presented here project a substantial 2019 biomass in the NBS (between 38% and 100% of the EBS spawning biomass, and between 32% and 82% of the EBS age 0+ biomass), although it should be noted that migration models are very challenging to develop, especially in cases like this where there are no data on migration *per se* and where the amount of data from one of the two areas is extremely small.
- Catches from the NBS have historically been very small, and the area is currently closed to trawling. If catches in the NBS are assumed to be close to zero and the NBS fish are part of the same spawning stock as the EBS fish, then the EBS can be fished more heavily than would be the case if the EBS fish constituted a single, stand-alone stock.
- On the other hand, preliminary model runs with a fishery and equal effort in each of the two areas have resulted in higher overall maxABC values than similar model runs with a fishery in the EBS only (although the part of the overall maxABC that comes out of the EBS in the two-fishery model is smaller than in the model with a fishery in the EBS only); but, again, this is predicated on the assumption that the NBS and EBS fish are part of the same spawning stock.
- It is not immediately how to configure a model in SS that allows migration back and forth between the two areas but that does not include the NBS fish as part of the spawning biomass.

Ecosystem considerations

To address the SSC's request for use of last year's Ecosystem Status Report (ESR, Siddon and Zador, editors (2017)) in predicting whether a (previously unanticipated) severe decline in biomass is imminent, the time series of relative changes in spawning biomass ($=B(t)/B(t\text{-}1)-1$) from last year's assessment (using Model 16.6) was computed as shown below:

Year:	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Δ(SB):	-0.024	0.011	0.332	0.633	0.736	0.433	0.067	0.136	-0.032	-0.025
Year:	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Δ(SB):	0.060	-0.032	-0.090	-0.199	-0.291	-0.073	0.047	0.112	-0.001	-0.038
Year:	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Δ(SB):	-0.116	-0.028	0.038	0.038	0.068	-0.003	0.016	-0.010	-0.118	-0.156
Year:	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Δ(SB):	-0.147	-0.080	0.076	0.324	0.187	0.127	0.030	0.011	0.124	0.086

Note that a decline in excess of 20% has been observed only once during the time series (between 1991 and 1992).

Using a cross-validation approach, the relative change in spawning biomass was then regressed against each of the first 12 environmental variables in Table 2.1.5 (although the fish condition indices for 1984 and 1993 were not used in the analysis, because they were isolated by several years from the other points in the time series).

A range of time lags between a given environmental variable and subsequent changes in spawning biomass (up to 10, if possible) was examined, as was a range of sizes for the training sets (which necessarily varied between indices because of differences in the total number of records). For each environmental variable, the combination of time lag and training set size that gave the highest median testing R^2 was chosen.

The next step in the analysis was to generate 10,000 pairs of training and testing data subsets (some redundancy was likely for indices with shorter time series).

For each variable, the parameter values estimated in the training sets were used to generate a distribution of projected changes in spawning biomass from 2017 to 2018, from which a mean and standard deviation ("2018 μ" and "2018 σ") were computed.

Six variables had a median testing R^2 greater than 0. The R^2 values were used to compute weights for the results corresponding to each of the seven variables as follows (the weighted average for 2018 σ was actually the root-mean-weighted-squared value):

Variable	nlags	R^2	weight	2018 μ	2018 σ
Benthic forager biomass	6	0.204	0.200	-0.032	0.095
Pelagic forager biomass	4	0.052	0.051	-0.072	0.106
Apex predator biomass	1	0.044	0.043	-0.005	0.123
Motile epifauna biomass	6	0.531	0.521	0.182	0.078
Multivariate seabird breeding	2	0.085	0.083	-0.208	0.122
Mean bottom temperature	3	0.104	0.102	-0.069	0.103
R^2-weighted mean	n/a	n/a	n/a	0.060	0.092

The R^2-weighted mean values of 2018 μ and 2018 σ imply a 25.8% chance that the 2018 spawning biomass estimated by Model 16.6 will decline, but only a 0.2% chance that it will decline by more than 20%.

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Tables

Table 2.1.1. Comparison of EBS survey indices in the "standard" and "expanded" areas. Biomass is in t; abundance is in 1000s of fish.

	Standard area				Expanded area			
	Biomass		Abundance		Biomass		Abundance	
Year	Estimate	Sigma	Estimate	Sigma	Estimate	Sigma	Estimate	Sigma
1987	1,027,518	0.062	677,054	0.065	1,064,600	0.060	697,075	0.064
1988	960,962	0.080	507,560	0.070	976,152	0.079	512,095	0.069
1989	833,473	0.075	292,247	0.068	868,804	0.072	301,748	0.066
1990	691,256	0.074	423,835	0.086	728,996	0.072	438,107	0.084
1991	514,407	0.074	488,892	0.104	530,488	0.072	496,765	0.103
1992	529,049	0.084	577,560	0.118	538,862	0.083	585,436	0.117
1993	663,308	0.080	810,608	0.122	669,305	0.079	814,187	0.121
1994	1,360,790	0.181	1,232,175	0.123	1,377,095	0.178	1,255,544	0.121
1995	1,002,961	0.091	757,910	0.099	1,008,293	0.091	761,681	0.099
1996	889,366	0.098	607,198	0.145	909,133	0.096	614,493	0.143
1997	604,439	0.112	485,643	0.145	627,151	0.109	493,660	0.143
1998	534,150	0.080	514,339	0.091	550,504	0.078	522,586	0.090
1999	569,765	0.087	488,337	0.093	618,679	0.091	542,229	0.100
2000	531,171	0.081	483,808	0.091	537,563	0.080	488,605	0.090
2001	811,816	0.090	960,917	0.095	827,176	0.088	974,016	0.094
2002	584,565	0.109	536,342	0.100	597,943	0.106	544,602	0.099
2003	590,973	0.105	498,873	0.124	625,659	0.099	516,468	0.120
2004	562,309	0.060	397,948	0.086	578,064	0.058	404,687	0.085
2005	606,050	0.071	450,705	0.140	638,764	0.068	464,647	0.136
2006	517,698	0.055	394,024	0.060	544,035	0.053	407,584	0.059
2007	423,704	0.082	733,402	0.263	450,337	0.078	753,821	0.256
2008	403,125	0.066	476,697	0.103	427,503	0.065	492,643	0.101
2009	421,291	0.083	716,637	0.087	430,084	0.081	721,812	0.087
2010	860,210	0.119	887,836	0.131	870,639	0.117	896,301	0.130
2011	896,039	0.074	836,840	0.094	911,082	0.073	844,482	0.094
2012	890,665	0.112	987,973	0.093	896,401	0.112	991,342	0.092
2013	791,958	0.093	750,889	0.165	811,667	0.091	760,225	0.163
2014	1,079,712	0.141	1,122,144	0.127	1,095,270	0.139	1,129,255	0.127
2015	1,102,261	0.136	982,470	0.115	1,109,115	0.136	985,698	0.115
2016	944,621	0.081	640,359	0.096	986,013	0.078	660,996	0.093
2017	598,260	0.077	346,693	0.090	643,953	0.077	364,129	0.088

Table 2.1.2. Comparison of age compositions in the "standard" and "expanded" EBS survey areas.

Standard area proportions at age

Year	N	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	346	0.000	0.089	0.382	0.171	0.123	0.118	0.080	0.021	0.007	0.005	0.001	0.001	0.001
1995	335	0.000	0.053	0.264	0.421	0.100	0.079	0.049	0.016	0.009	0.006	0.002	0.001	0.001
1996	341	0.000	0.056	0.208	0.203	0.293	0.136	0.058	0.029	0.010	0.004	0.002	0.001	0.001
1997	351	0.000	0.256	0.169	0.183	0.157	0.120	0.077	0.022	0.010	0.003	0.001	0.001	0.000
1998	344	0.000	0.077	0.441	0.204	0.112	0.057	0.060	0.028	0.016	0.004	0.001	0.001	0.000
1999	320	0.000	0.079	0.200	0.303	0.232	0.081	0.058	0.027	0.012	0.005	0.001	0.002	0.001
2000	343	0.000	0.234	0.127	0.150	0.242	0.148	0.062	0.014	0.014	0.005	0.003	0.001	0.000
2001	348	0.000	0.289	0.236	0.194	0.091	0.084	0.068	0.026	0.008	0.002	0.002	0.001	0.000
2002	344	0.000	0.080	0.188	0.318	0.233	0.072	0.059	0.034	0.010	0.004	0.001	0.001	0.000
2003	345	0.000	0.175	0.156	0.251	0.209	0.119	0.041	0.030	0.014	0.004	0.001	0.001	0.000
2004	345	0.000	0.144	0.166	0.271	0.128	0.128	0.091	0.040	0.019	0.009	0.002	0.003	0.001
2005	344	0.000	0.183	0.244	0.209	0.121	0.065	0.079	0.055	0.024	0.010	0.004	0.004	0.001
2006	344	0.000	0.324	0.143	0.165	0.121	0.093	0.063	0.046	0.028	0.010	0.003	0.001	0.001
2007	348	0.000	0.700	0.096	0.067	0.041	0.046	0.018	0.014	0.008	0.005	0.002	0.002	0.001
2008	330	0.000	0.213	0.445	0.145	0.083	0.049	0.033	0.010	0.010	0.006	0.003	0.001	0.002
2009	347	0.001	0.454	0.189	0.231	0.064	0.029	0.015	0.009	0.004	0.002	0.001	0.001	0.000
2010	328	0.000	0.047	0.479	0.179	0.203	0.064	0.015	0.008	0.003	0.001	0.000	0.001	0.000
2011	350	0.000	0.290	0.073	0.388	0.111	0.096	0.028	0.007	0.003	0.002	0.001	0.001	0.000
2012	343	0.000	0.366	0.234	0.058	0.237	0.062	0.031	0.007	0.002	0.002	0.000	0.000	0.000
2013	343	0.000	0.107	0.427	0.178	0.108	0.113	0.050	0.011	0.004	0.001	0.000	0.000	0.000
2014	355	0.000	0.279	0.188	0.238	0.197	0.048	0.036	0.010	0.002	0.001	0.001	0.000	0.000
2015	341	0.000	0.064	0.425	0.202	0.193	0.082	0.019	0.011	0.002	0.001	0.000	0.000	0.000
2016	356	0.000	0.112	0.094	0.361	0.221	0.145	0.049	0.012	0.004	0.001	0.000	0.000	0.000

Expanded area proportions at age

Year	N	0	1	2	3	4	5	6	7	8	9	10	11	12+
1994	346	0.000	0.090	0.387	0.170	0.123	0.117	0.079	0.020	0.007	0.005	0.001	0.001	0.000
1995	335	0.000	0.055	0.263	0.420	0.100	0.079	0.049	0.016	0.009	0.006	0.002	0.001	0.001
1996	341	0.000	0.057	0.206	0.201	0.293	0.137	0.059	0.029	0.010	0.004	0.002	0.001	0.000
1997	351	0.000	0.254	0.167	0.183	0.157	0.122	0.080	0.022	0.010	0.003	0.001	0.001	0.000
1998	344	0.000	0.076	0.437	0.204	0.114	0.058	0.061	0.029	0.016	0.004	0.001	0.001	0.000
1999	320	0.000	0.073	0.190	0.329	0.230	0.078	0.056	0.026	0.011	0.005	0.001	0.001	0.000
2000	343	0.000	0.232	0.127	0.150	0.243	0.148	0.062	0.014	0.013	0.005	0.003	0.001	0.000
2001	348	0.000	0.287	0.236	0.193	0.092	0.085	0.069	0.026	0.008	0.002	0.001	0.001	0.000
2002	344	0.000	0.079	0.187	0.316	0.234	0.074	0.060	0.034	0.010	0.004	0.001	0.001	0.000
2003	345	0.000	0.170	0.153	0.248	0.213	0.124	0.042	0.031	0.014	0.004	0.000	0.001	0.000
2004	345	0.000	0.142	0.165	0.269	0.128	0.129	0.092	0.041	0.019	0.009	0.002	0.003	0.000
2005	344	0.000	0.178	0.240	0.209	0.124	0.067	0.082	0.057	0.024	0.011	0.004	0.004	0.000
2006	344	0.000	0.315	0.143	0.166	0.126	0.096	0.064	0.047	0.029	0.010	0.003	0.001	0.001
2007	348	0.000	0.692	0.096	0.068	0.044	0.050	0.018	0.015	0.009	0.005	0.002	0.002	0.001
2008	330	0.000	0.208	0.443	0.147	0.084	0.050	0.035	0.011	0.011	0.006	0.003	0.001	0.001
2009	347	0.001	0.453	0.189	0.231	0.064	0.029	0.015	0.010	0.004	0.002	0.001	0.001	0.000
2010	328	0.000	0.046	0.479	0.179	0.203	0.064	0.015	0.008	0.003	0.001	0.000	0.001	0.000
2011	350	0.000	0.290	0.073	0.387	0.112	0.096	0.028	0.007	0.003	0.002	0.001	0.001	0.000
2012	343	0.000	0.365	0.234	0.058	0.237	0.062	0.031	0.007	0.002	0.002	0.000	0.000	0.000
2013	343	0.000	0.106	0.422	0.179	0.110	0.115	0.052	0.011	0.004	0.001	0.000	0.000	0.000
2014	355	0.000	0.278	0.187	0.237	0.198	0.048	0.036	0.010	0.002	0.001	0.001	0.000	0.000
2015	341	0.000	0.064	0.425	0.202	0.194	0.082	0.019	0.011	0.002	0.001	0.000	0.000	0.000
2016	356	0.000	0.109	0.092	0.360	0.223	0.148	0.050	0.012	0.004	0.001	0.000	0.000	0.000

Table 2.1.3. Size compositions from the EBS "expanded" area (page 1 of 4).

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1987	234	0	0	0	0	0	0	12	3	6	21	33	53	70	94	105	105	133	108	70	53	41	56	68	105	108	174	241	266	285	256
1988	167	0	0	0	0	0	0	0	5	5	19	9	20	18	16	28	19	13	18	23	32	47	53	60	58	74	56	85	82	92	121
1989	105	0	0	0	0	0	1	1	8	19	15	29	35	44	43	41	27	16	8	9	12	1	6	6	15	6	14	13	12	14	15
1990	134	0	0	0	0	0	24	67	97	143	140	173	220	242	193	140	110	84	53	33	39	41	32	47	73	74	93	99	93	87	111
1991	173	0	0	0	0	0	6	29	90	107	134	130	156	127	130	123	103	129	83	69	69	77	96	98	165	189	262	279	313	278	357
1992	250	0	0	0	0	0	0	1	17	85	191	198	182	157	206	232	245	260	225	237	119	125	142	194	280	303	319	368	390	368	327
1993	259	0	0	0	0	1	2	29	81	191	426	295	405	356	322	320	347	313	323	216	135	99	62	57	67	88	95	175	208	236	292
1994	319	0	0	0	0	0	3	9	5	24	38	70	83	91	92	108	126	102	96	88	130	119	175	157	207	306	408	521	598	676	705
1995	242	0	0	0	0	0	3	12	16	14	20	44	39	45	59	63	86	72	37	26	20	39	50	95	116	168	207	244	231	261	240
1996	231	0	0	0	0	0	1	2	11	9	23	33	48	63	53	66	69	63	54	35	20	23	24	58	64	129	162	192	227	272	235
1997	232	0	0	0	0	0	9	18	66	116	168	195	194	200	214	289	228	220	228	179	106	58	41	41	36	72	110	104	155	226	233
1998	236	0	0	0	0	0	1	4	23	52	83	115	103	134	90	45	22	7	4	19	24	58	72	185	275	381	489	595	619	607	507
1999	276	0	0	0	0	0	1	13	46	86	94	105	81	97	67	36	26	38	45	39	56	103	108	184	202	198	275	243	258	271	214
2000	300	0	0	0	4	10	22	49	95	131	286	460	559	424	267	263	137	84	31	9	12	24	37	75	114	164	189	215	251	294	216
2001	471	0	0	0	0	5	6	26	60	121	195	297	429	629	678	730	649	633	421	337	212	135	113	159	222	307	358	492	632	799	794
2002	293	0	0	0	0	1	3	6	21	41	60	76	100	153	107	158	106	68	49	33	17	41	62	104	156	234	260	418	457	533	530
2003	292	0	0	1	0	1	3	5	11	52	86	127	190	216	192	232	235	262	234	222	185	203	143	112	63	54	56	75	55	110	134
2004	257	0	1	0	0	0	1	4	19	43	82	145	101	186	180	205	200	128	137	105	64	54	71	89	103	180	189	211	228	264	287
2005	290	0	0	0	0	0	0	1	4	23	44	88	139	203	251	307	288	305	292	368	367	394	382	292	212	143	142	148	120	163	184
2006	309	0	1	0	4	7	40	101	336	404	427	455	402	345	329	359	281	245	146	107	65	55	61	57	64	90	118	173	196	249	254
2007	332	0	0	0	0	8	8	132	491	1187	1459	1435	1172	756	741	546	356	428	244	128	128	44	50	71	95	131	127	163	127	144	151
2008	331	0	0	1	0	0	6	54	169	350	380	390	352	312	227	151	76	40	21	41	76	168	313	487	558	724	765	746	701	576	484
2009	416	1	0	0	7	36	106	402	975	1062	1093	882	749	655	489	467	325	223	117	35	28	36	83	95	175	257	341	400	472	440	343
2010	346	0	0	0	0	0	1	9	32	44	53	92	92	103	85	57	28	30	17	25	58	111	232	357	443	655	791	775	726	728	597
2011	476	0	0	0	0	0	7	18	70	131	238	283	357	381	550	579	838	819	791	496	267	102	36	35	53	45	53	69	113	127	175
2012	326	0	0	6	0	0	74	382	691	737	567	427	421	314	413	399	210	130	48	32	10	29	38	60	85	180	261	271	361	356	393
2013	447	0	0	0	0	1	9	48	111	140	198	213	273	233	173	121	34	21	61	82	256	382	626	753	941	1032	805	871	624	630	398
2014	390	0	0	0	1	0	0	8	79	102	210	300	409	455	577	437	533	430	457	271	192	98	90	80	63	84	194	216	368	291	424
2015	472	0	0	0	0	0	0	11	41	41	84	76	52	47	56	57	60	73	84	69	76	75	77	81	121	177	277	381	518	714	896
2016	424	0	0	0	0	1	0	5	16	26	53	59	39	23	51	64	96	147	221	268	253	222	150	106	56	36	39	67	85	104	130
2017	271	0	0	0	0	0	0	2	2	12	33	43	43	57	53	65	79	90	116	124	146	163	169	154	127	90	92	85	111	85	105

Table 2.1.3. Size compositions from the EBS “expanded” area (page 2 of 4).

Year	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63
1987	249	183	206	177	156	174	206	199	265	299	300	298	292	287	233	234	237	141	144	119	105	132	124	87	113	81	124	120	111	114
1988	128	181	145	131	142	95	123	112	162	150	133	215	186	199	186	166	208	179	154	171	171	175	151	144	154	130	134	113	139	111
1989	30	14	45	47	61	49	53	42	49	48	57	76	69	74	79	72	84	107	97	109	103	98	140	123	91	99	89	124	80	94
1990	116	75	107	89	63	54	63	49	44	38	36	31	35	49	38	39	29	50	33	60	54	69	58	70	71	76	81	85	87	78
1991	296	240	250	187	166	137	114	82	67	61	58	49	59	50	60	72	47	59	40	70	85	56	73	40	35	40	41	33	50	47
1992	318	257	233	189	159	134	195	153	226	198	231	256	195	194	169	149	160	125	112	93	82	59	66	32	45	53	54	70	47	37
1993	319	241	247	228	198	154	162	187	185	223	223	236	273	208	187	194	160	152	130	115	120	109	89	64	67	80	67	57	58	53
1994	620	588	432	333	266	181	108	121	107	204	173	153	213	234	243	276	159	174	210	174	166	161	201	231	231	150	200	142	187	150
1995	212	166	231	264	255	338	401	397	443	449	419	364	356	313	211	202	163	151	123	105	116	101	93	99	91	78	99	105	112	107
1996	248	189	198	167	157	166	153	176	212	237	286	258	291	320	300	295	322	270	282	281	246	256	206	168	155	135	143	102	95	87
1997	224	177	160	157	139	148	138	129	129	140	138	172	198	234	153	174	138	155	184	190	167	172	126	218	174	177	135	134	109	115
1998	530	343	258	225	164	145	133	100	125	118	136	128	176	119	115	136	113	93	90	84	82	74	64	79	92	76	67	77	88	86
1999	207	199	209	270	353	326	417	472	530	573	571	480	365	375	287	214	183	161	144	128	109	113	87	93	89	83	64	106	79	91
2000	191	180	184	169	193	217	248	257	293	300	338	298	354	316	383	334	343	254	305	233	250	189	196	176	157	154	143	107	98	87
2001	881	773	671	493	398	289	213	183	170	148	154	180	223	273	221	258	248	228	257	265	254	228	216	226	185	205	181	146	193	129
2002	501	367	383	300	284	241	281	251	398	350	439	384	382	269	321	185	225	180	163	133	159	125	155	88	113	117	125	104	112	104
2003	292	200	297	225	256	273	301	340	329	369	439	409	441	405	375	276	274	231	247	259	201	186	171	146	125	142	136	111	96	71
2004	303	296	321	298	311	242	235	204	199	180	174	150	145	145	168	164	198	192	155	176	168	181	164	185	141	152	165	145	138	133
2005	203	199	212	235	294	258	215	208	216	218	227	176	225	181	203	140	179	132	154	137	144	119	115	105	105	106	123	90	127	91
2006	269	259	316	271	305	268	251	219	206	170	177	153	157	143	171	161	209	181	185	166	191	143	186	112	132	95	103	107	101	111
2007	128	118	97	97	78	65	78	81	85	71	92	84	91	89	86	64	83	77	94	73	75	65	66	58	59	57	70	58	67	55
2008	353	293	203	173	159	142	135	124	150	135	147	141	143	118	140	127	129	131	150	119	115	103	118	91	124	105	121	93	89	83
2009	309	223	217	216	228	304	308	366	382	383	350	340	282	293	250	183	148	148	119	105	95	85	76	79	87	91	72	85	79	54
2010	501	343	312	199	178	123	139	145	229	243	427	283	309	293	292	227	251	196	273	210	286	279	257	176	258	207	186	136	166	108
2011	152	216	211	253	266	374	423	624	739	796	854	811	730	588	474	326	328	260	245	175	217	209	246	172	258	224	279	214	274	176
2012	286	312	192	159	101	82	63	46	64	60	86	82	134	112	199	189	242	288	383	325	413	312	320	222	201	169	167	98	122	87
2013	298	230	173	167	139	120	178	147	224	286	351	420	510	398	378	354	319	260	252	194	203	134	187	142	212	191	232	192	209	206
2014	405	438	306	273	161	167	127	179	249	391	403	577	595	536	492	434	374	252	192	180	184	164	148	174	222	222	177	171	181	121
2015	1043	1101	975	928	757	570	492	283	265	199	373	369	495	468	465	422	450	317	349	344	315	334	385	335	431	330	300	217	244	157
2016	176	162	225	246	292	281	328	383	461	582	608	811	888	862	878	762	687	537	416	418	297	296	285	278	254	269	260	229	237	240
2017	107	116	120	148	136	144	155	171	153	180	223	183	234	218	226	263	310	282	331	334	386	412	380	370	324	254	239	229	185	217

Table 2.1.3. Size compositions from the EBS “expanded” area (page 3 of 4).

Year	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
1987	111	118	110	116	118	97	104	82	54	80	46	51	49	21	40	31	33	38	25	26	27	29	7	8	13	9	9	11	5	10	9	1	5	5	3	1	1
1988	78	84	67	93	71	72	55	79	57	57	38	54	48	32	29	37	49	44	36	21	22	10	19	10	5	10	2	12	2	4	4	4	3	1	3	5	2
1989	103	77	72	105	92	58	85	45	79	87	70	69	62	49	63	46	27	23	36	26	33	36	18	27	18	6	18	12	8	10	12	13	8	4	8	5	4
1990	78	54	80	55	62	38	64	45	54	54	52	45	32	38	38	26	36	36	11	24	20	22	18	13	12	18	12	5	4	4	6	11	9	2	1	1	4
1991	41	25	43	40	48	45	47	33	31	25	41	32	27	13	16	19	21	33	23	22	13	13	8	14	7	7	6	5	6	4	1	6	7	3	2	3	0
1992	27	32	32	50	38	35	26	16	24	26	22	19	27	16	19	26	30	15	19	16	12	14	15	7	10	8	13	6	7	7	5	7	8	3	9	2	4
1993	36	66	37	37	61	29	29	15	15	16	15	17	12	12	11	12	13	11	9	5	12	10	4	7	8	8	4	3	4	7	3	7	5	5	4	4	1
1994	165	146	118	77	122	56	94	45	61	28	37	18	28	12	20	9	8	9	12	5	8	7	8	6	3	6	32	12	9	2	1	3	6	4	1	1	2
1995	94	75	57	65	76	75	73	54	58	48	38	30	24	39	22	26	23	21	19	13	14	11	8	8	8	8	5	12	4	4	4	10	1	3	2	3	5
1996	81	58	61	62	58	57	48	57	64	34	47	37	27	29	35	23	21	24	25	15	26	10	14	22	17	9	4	3	7	10	3	5	5	3	3	2	4
1997	125	105	104	96	88	72	60	63	56	31	22	31	24	29	19	12	10	10	12	19	12	10	8	9	9	4	3	9	7	2	6	3	2	4	0	1	2
1998	74	66	98	57	64	50	47	56	56	40	53	29	36	21	21	24	12	17	9	16	11	8	10	8	4	4	5	5	9	3	6	3	1	2	2	0	1
1999	75	87	56	62	46	55	61	44	44	45	33	26	24	21	22	24	21	17	12	15	13	10	10	15	14	5	14	5	4	5	5	2	5	5	6	3	2
2000	82	53	62	57	50	34	48	32	37	30	33	28	22	12	14	21	21	12	17	18	8	9	5	8	26	6	7	7	4	4	10	2	7	5	3	1	0
2001	151	145	103	79	102	65	74	54	49	32	37	24	19	26	19	30	17	16	12	11	13	5	10	6	6	5	7	4	4	2	4	5	1	2	0	5	1
2002	99	57	105	70	64	65	58	45	35	35	32	23	30	23	13	10	19	13	6	6	3	7	2	3	5	1	2	3	5	5	1	3	2	3	6	1	1
2003	94	67	69	69	65	67	72	47	53	41	41	36	33	26	27	16	18	20	20	11	14	7	9	5	6	5	4	4	3	2	2	0	1	1	0	0	0
2004	118	101	96	87	105	82	62	70	60	61	33	49	45	41	43	30	26	23	22	15	22	10	25	12	18	15	12	6	4	7	4	4	4	4	3	2	0
2005	134	115	117	112	112	86	93	80	76	62	87	54	77	59	67	52	48	44	41	33	26	18	28	21	24	14	10	15	10	8	4	9	5	3	4	0	4
2006	96	90	104	64	101	52	72	63	61	68	71	57	63	46	59	46	59	53	53	38	45	39	36	20	35	16	24	16	18	10	10	6	12	9	1	7	5
2007	56	50	51	34	46	45	34	25	35	25	39	23	21	15	13	19	17	20	11	12	9	28	12	9	10	15	10	14	10	3	8	4	6	2	3	3	3
2008	106	64	81	67	86	48	59	35	48	25	46	19	28	24	25	13	17	12	19	15	13	9	20	11	10	8	16	5	10	10	10	9	3	8	9	2	4
2009	66	73	54	41	50	33	41	32	21	25	14	18	16	16	16	5	13	7	9	4	4	7	6	6	3	4	5	1	1	1	2	3	5	2	3	1	2
2010	123	75	79	55	41	31	37	32	17	12	13	15	19	5	13	4	3	8	4	4	1	6	8	0	4	1	4	2	1	4	1	0	3	2	1	3	2
2011	233	161	190	141	151	109	119	59	73	48	46	26	26	22	15	13	17	6	15	10	7	3	3	5	5	3	1	5	3	4	7	2	1	0	1	0	2
2012	104	78	80	63	67	47	74	38	48	24	29	21	20	19	18	6	11	5	7	6	6	4	4	4	1	1	2	2	1	3	3	2	1	0	1	2	1
2013	227	210	189	160	141	132	105	104	90	49	62	44	30	42	28	30	9	29	12	23	11	10	7	7	5	3	5	3	4	5	1	2	0	1	0	1	1
2014	124	97	95	55	56	47	59	50	47	58	44	39	36	26	25	18	15	15	7	7	7	3	4	5	3	1	6	2	3	2	0	0	3	1	2	0	1
2015	165	112	107	113	97	81	66	62	62	57	46	54	43	36	24	24	20	24	15	7	12	7	17	10	6	3	4	1	2	2	0	2	1	1	1	2	1
2016	215	227	251	195	180	164	171	144	95	87	69	50	47	48	37	26	24	36	16	19	22	16	10	9	7	8	5	6	5	3	2	3	2	2	2	0	1
2017	170	150	132	132	121	141	126	92	78	106	74	84	79	71	58	60	59	18	35	30	20	11	9	13	10	15	3	7	7	3	5	5	0	4	1	0	0

Table 2.1.3. Size compositions from the EBS “expanded” area (page 4 of 4).

Year	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120+
1987	2	3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1988	0	2	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0
1989	9	0	9	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1990	0	5	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	5	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	3	3	3	3	1	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0
1993	2	2	1	9	2	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
1994	9	5	3	1	6	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0
1995	1	3	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
1996	1	2	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	1	2	0	0	0	0	3	0	0	0	0	1	0	0	0	0	0	0
1998	1	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	1	0	2	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	1	0	2	1	3	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	1	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
2003	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	1	0	5	0	1	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0
2005	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	3	2	3	2	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
2007	2	8	1	2	1	2	0	1	0	0	0	1	0	0	0	0	0	0	0	0
2008	3	7	1	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2009	1	1	0	1	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
2011	1	1	0	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2012	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2013	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2014	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2015	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2016	3	2	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.1.4. NBS survey size compositions.

Year	N	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2010	39	0	1.03	0	0	0	0	2.97	3.89	4.06	13.6	12.6	11.7	1.97	4.91	0.98	0
2017	561	0	0	0	0	0	0	0	0	0	0.85	10.4	5.31	11.9	9.83	4.7	6.47

Year	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
2010	0	5.68	2.73	1.9	5.91	5.67	1.03	7.31	4.87	6.04	8.73	2.21	2.02	2	1.03	0.98	0
2017	6.48	7.36	7.52	11	25.1	14.8	26.8	36	51.3	50.6	71.9	71.1	82.5	67.8	70.1	41.2	37.6

Year	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53
2010	0.99	0.94	0	1.04	0.87	0	0	0.99	0	0	0.91	0	0	0	0.89	0	0
2017	35.2	30	17.2	23.6	20.1	29.5	31.2	41	51.7	53	45.7	50.3	57.5	80.8	89.2	99.4	101

Year	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70
2010	0	1	0	0	0	0	0.98	0.95	2	3.79	3.66	4.56	3.72	1.93	4.77	1.77	2.9
2017	105	126	179	149	144	147	136	126	127	125	109	96.8	71.2	87.5	71.3	54	63.1

Year	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87
2010	3.66	3.62	12.9	7.57	3.88	9.15	8.34	6.44	4.63	8.35	4.91	9.03	6.63	2.74	7.25	2.82	0.88
2017	45	58.7	37.9	38.8	33.5	20.9	23.8	13.8	19.2	16.4	13.7	9.69	9.44	5.08	3.23	2.53	1.9

Year	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
2010	2.04	1.95	0	1.96	2.86	0	0	0	0	0	0	0	0	0	0	0	0
2017	2.6	4.23	3.66	0	0	2.73	0	2.09	0	0	0	0	0	0.89	0	0	0

Year	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2017	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2.1.5. Environmental variable time series (as z-scores). See text for definitions.

Year	NPI	bnthc_frgr	fr_sl_pps	IRI	plgc_frgr	trwl_mpct	ephsd	apx_prd	mtl_epfn	brd_brdng	fsh_cndtn	bttm_tmp	pllck_l
1977	-1.104		1.479										
1978	-0.865		1.733										
1979	0.943		1.708										
1980	-0.333		0.810	-0.507									
1981	-1.779		0.290										
1982	0.965	0.905	0.805	-0.392	-0.743			0.153	0.067			-0.275	-0.412
1983	-2.214	0.607	0.002	-1.150	0.367			1.500	-0.582			0.628	1.936
1984	-0.959	0.412	0.159	-0.147	-0.263			0.280	-1.107		-1.496	-0.199	-0.591
1985	0.700	-1.895	0.350	-0.176	-0.754			0.666	-2.708			-0.157	0.800
1986	-1.620	-1.907	0.039	-0.286	-0.048			1.160	-2.350			-0.766	-0.597
1987	-1.098	-0.508	0.123		-0.395			0.083	-0.544			0.864	-1.052
1988	-0.134	-0.066	0.776	-0.052	1.223			-0.064	0.077			-0.169	-1.183
1989	1.473	-0.310	0.122	-1.027	0.451			-0.425	0.095			0.564	-0.816
1990	1.100	-0.238	0.757	-0.791	1.081			-0.531	0.594			-0.060	1.776
1991	1.251	0.208		-1.076	0.127			-1.408	0.162			0.238	0.166
1992	-0.881	0.498	0.354	0.591	0.269			-1.044	-0.390			-0.580	-0.043
1993	0.142	0.703			3.087			-0.106	-0.340		1.186	0.670	1.595
1994	0.856	2.573	0.560	-0.697	0.694			2.959	-0.502			-1.110	-0.516
1995	0.057	0.165		0.558	1.248			1.152	-0.210			-0.904	-0.853
1996	-0.295	0.233	0.092		-0.790			0.888	-0.609	-0.660		1.108	-0.013
1997	0.105	1.463		-0.020	0.502			-0.404	-0.145	-0.554		0.292	0.561
1998	-1.316	0.401	0.284	-1.091	-1.258			-0.926	-0.612	-1.065	1.833	0.930	-0.525
1999	0.450	-2.190		0.479	-1.065			-1.398	-1.130	-0.150	-1.404	-2.001	-0.445
2000	0.005	-1.279	-0.151		-0.253			-1.296	-0.911	1.301	0.068	-0.408	0.184
2001	-0.601	-0.487			-0.765			0.061	-0.424	0.524	0.380	0.092	0.834
2002	0.339	-0.641	-0.429		-0.275			-1.076	-0.607	0.955	0.385	0.898	0.041
2003	-1.499	-0.070			1.834	0.834		-0.414	-0.068	0.334	1.916	1.574	-0.584
2004	0.058	0.774	-0.917	-1.143	-0.040	0.924	-0.967	-0.336	0.058	0.114	1.361	1.064	-1.126
2005	-0.126	1.480			0.001	0.733		0.139	1.001	-1.108	0.574	1.168	-1.254
2006	0.745	0.971	-1.192	-1.135	-1.194	0.729	-0.155	-0.356	1.064	-0.440	0.103	-0.747	-0.758
2007	0.620	0.267		0.485	-0.900	1.062	0.658	-1.052	0.554	-0.124	0.263	-0.852	0.191
2008	0.387	0.215	-1.347	1.510	-1.251	1.152	0.901	-1.234	-0.098	0.764	-0.180	-1.447	-0.612
2009	2.240	-1.119		1.523	-1.670	0.389	1.586	-1.572	-0.257	0.791	-0.838	-1.335	2.142
2010	-0.865	0.643	-1.540	2.003	-0.417	-0.288	0.674	0.672	0.740	1.070	-0.166	-1.159	-0.085
2011	1.201	0.665		-0.034	-0.747	-0.493		0.789	1.101	-0.030	-0.027	-0.037	-0.697
2012	0.841	-0.350	-1.472	2.342	-0.231	-0.998	-0.475	0.215	1.328	0.702	-1.503	-1.786	-0.816
2013	0.836	-0.380		0.737	0.417	-1.300		-0.067	1.226	0.956	-0.236	-0.749	2.584
2014	0.610	0.176	-1.580		1.153	-1.366	-0.851	1.226	0.738	1.288	-0.287	0.869	1.178
2015	-0.255	-1.676			1.441			1.192	1.274	-0.532	-1.397	1.036	-0.387
2016	-0.822	-0.232	-1.817		-0.353	-1.379	-1.370	0.948	1.708	-2.517	0.252	2.347	-0.319
2017	0.841	-0.010		-0.503	-0.483			-0.376	1.807	-1.618	-0.788	0.400	-0.303

Table 2.1.6. Structural differences between models.

	EBS survey area	EBS survey area	Growth covariates	Growth covariates	Time-vary Q, w/o NBS	Time-vary Q, w/o NBS	Time-vary Q, with NBS	Time-vary Q, with NBS	Previous models	Previous models	Migration	Migration	M covariates	M covariates	Omnibus
Feature	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Separate Q for EBS survey 1982-1986		x													
K linked to environmental covariate			x												
Lmin linked to environmental covariate				x											
Randomly time-varying EBS Q					x		x			x					
EBS Q linked to environmental covariate						x		x							x
NBS Q and selectivity estimated							x	x							x
Randomly time-varying NBS Q							x	x							
Adjust timing of fishery and survey									x	x					
Prior distribution for M									x	x					
Flat-topped double normal selectivity									x	x					
Randomly time-varying fishery selex									x	x					
Harmonic mean composition weighting									x	x					
Randomly time-varying survey selex										x					
Randomly time-varying *Lmin*										x					
EBS-NBS migration											x	x			x
Randomly time-varying migration											x				x
Migration linked to environ. covariate												x			
M linked to environmental covariate													x	x	x
Age-varying M														x	x
Block-specific steepness estimated															x

Table 2.1.7. Data structures used in the models. Environmental variables 1-3 are constant across models (#1 indexes the 1977 regime shift, and #2 and #3 are year-specific weight-at-length parameters).

			EBS survey							
Category	Model	Comp. N	1982-1986	1987-2017	Fishery ages	NBS	Areas	Env. var. 4	Env. var. 5	Env. var. 6
Base model	16.6	mean=300	yes	standard	no	no	1	n/a	n/a	n/a
EBS survey area	16.6a	mean=300	no	expanded	no	no	1	n/a	n/a	n/a
EBS survey area	16.6b	mean=300	yes	expanded	no	no	1	n/a	n/a	n/a
K covariates	16.6c	mean=300	yes	standard	no	no	1	fsh_cndtn	n/a	n/a
K covariates	16.6d	mean=300	yes	standard	no	no	1	bttm_tmp	n/a	n/a
Time-vary Q, w/o NBS	16.6e	mean=300	yes	standard	no	no	1	n/a	n/a	n/a
Time-vary Q, w/o NBS	16.6f	mean=300	yes	standard	no	no	1	NPI	n/a	n/a
Time-vary Q, with NBS	16.6g	mean=300	yes	standard	no	yes	1	n/a	n/a	n/a
Time-vary Q, with NBS	16.6h	mean=300	yes	standard	no	yes	1	NPI	n/a	n/a
Previous models	17.2	no. hauls	yes	standard	yes	no	1	n/a	n/a	n/a
Previous models	17.6	no. hauls	yes	standard	yes	no	1	n/a	n/a	n/a
Migration	18.1	mean=300	yes	standard	no	yes	2	n/a	n/a	n/a
Migration	18.2	mean=300	yes	standard	no	yes	2	NPI	bnthc_frgr	brd_brdng
M covariates	18.3	mean=300	yes	standard	no	no	1	fsh_cndtn	n/a	n/a
M covariates	18.4	mean=300	yes	standard	no	no	1	ntrtn_dfct	n/a	n/a
Omnibus	18.5	mean=300	yes	standard	no	yes	2	NPI	ntrtn_dfct	n/a

Table 2.1.8. Development of the placeholder nutrition deficit index.

Year	Z-scores			Average of euphausiids and age 1 pollock	Re-normalized average prey	Bottom temp. minus average prey	Re-normalized difference
	Bottom temp.	Euphausiids	Age 1 pollock				
1982	-0.275		-0.412	-0.412	-0.432	0.157	0.102
1983	0.628		1.936	1.936	2.015	-1.388	-0.903
1984	-0.199		-0.591	-0.591	-0.619	0.420	0.273
1985	-0.157		0.800	0.800	0.831	-0.988	-0.643
1986	-0.766		-0.597	-0.597	-0.625	-0.141	-0.091
1987	0.864		-1.052	-1.052	-1.099	1.963	1.277
1988	-0.169		-1.183	-1.183	-1.236	1.067	0.694
1989	0.564		-0.816	-0.816	-0.854	1.417	0.922
1990	-0.060		1.776	1.776	1.848	-1.908	-1.241
1991	0.238		0.166	0.166	0.170	0.069	0.045
1992	-0.580		-0.043	-0.043	-0.048	-0.532	-0.346
1993	0.670		1.595	1.595	1.660	-0.989	-0.643
1994	-1.110		-0.516	-0.516	-0.541	-0.569	-0.370
1995	-0.904		-0.853	-0.853	-0.892	-0.012	-0.008
1996	1.108		-0.013	-0.013	-0.017	1.125	0.732
1997	0.292		0.561	0.561	0.581	-0.289	-0.188
1998	0.930		-0.525	-0.525	-0.550	1.480	0.963
1999	-2.001		-0.445	-0.445	-0.467	-1.534	-0.998
2000	-0.408		0.184	0.184	0.188	-0.596	-0.388
2001	0.092		0.834	0.834	0.866	-0.774	-0.504
2002	0.898		0.041	0.041	0.040	0.858	0.558
2003	1.574		-0.584	-0.584	-0.612	2.186	1.422
2004	1.064	-0.967	-1.126	-1.046	-1.094	2.158	1.404
2005	1.168		-1.254	-1.254	-1.310	2.478	1.612
2006	-0.747	-0.155	-0.758	-0.456	-0.479	-0.269	-0.175
2007	-0.852	0.658	0.191	0.424	0.439	-1.292	-0.840
2008	-1.447	0.901	-0.612	0.145	0.148	-1.595	-1.037
2009	-1.335	1.586	2.142	1.864	1.940	-3.275	-2.130
2010	-1.159	0.674	-0.085	0.294	0.304	-1.463	-0.951
2011	-0.037		-0.697	-0.697	-0.729	0.692	0.450
2012	-1.786	-0.475	-0.816	-0.645	-0.676	-1.110	-0.722
2013	-0.749		2.584	2.584	2.691	-3.440	-2.237
2014	0.869	-0.851	1.178	0.163	0.167	0.702	0.456
2015	1.036		-0.387	-0.387	-0.406	1.442	0.938
2016	2.347	-1.370	-0.319	-0.845	-0.883	3.231	2.101
2017	0.400		-0.303	-0.303	-0.319	0.719	0.468

Table 2.1.9. Evaluation of alternative nutrition deficit indices.

Color coding for positive and negative correlations

Type	Index	1	2	3	4	5	6	7	8	9	10	11	12	13
Population	Placeholder	0.118	-0.030	0.573	0.350	-0.004	-0.105	0.082	-0.022	0.204	-0.094	0.189	-0.360	0.049
Population	consumedG	-0.118	0.124	0.472	0.041	0.022	-0.081	-0.025	0.002	0.008	-0.331	-0.309	0.052	-0.379
Population	meanPreyED	-0.091	-0.087	0.078	-0.113	-0.315	-0.086	-0.576	-0.016	0.198	-0.047	-0.131	0.001	0.153
Population	RFR	0.006	0.145	0.410	-0.060	0.140	-0.027	-0.023	-0.003	-0.078	-0.265	-0.452	0.094	-0.489
Population	Cmax	-0.215	0.006	-0.136	0.206	-0.137	-0.095	0.023	-0.112	0.176	-0.117	0.287	-0.225	0.276
Population	maxG	-0.142	0.081	-0.016	0.110	-0.211	-0.181	-0.272	-0.285	0.241	-0.248	0.178	-0.372	0.275
Population	Gpotential	0.004	0.129	0.435	-0.051	-0.108	-0.104	-0.226	-0.157	0.159	-0.182	-0.170	-0.085	-0.062
Age-specific	consumedG	-0.236	0.351	-0.044	-0.147	0.154	0.173	0.188	0.172	0.011	-0.159	-0.381	-0.247	-0.070
Age-specific	meanPreyED	0.090	0.167	-0.147	0.020	0.136	0.245	0.167	0.353	0.171	0.257	-0.318	0.042	0.154
Age-specific	RFR	-0.168	0.354	-0.060	-0.203	0.193	0.220	0.167	0.177	0.013	-0.102	-0.436	-0.251	-0.011
Age-specific	Cmax	-0.019	0.177	-0.191	0.111	0.189	0.245	0.311	0.346	0.150	0.241	-0.184	-0.084	0.052
Age-specific	maxG	-0.158	0.068	-0.204	0.087	0.038	0.112	0.072	0.187	0.127	0.063	-0.196	-0.015	-0.016
Age-specific	Gpotential	-0.081	0.141	-0.347	-0.038	0.008	0.097	0.083	0.085	0.002	-0.160	-0.277	-0.219	0.031

Color coding for within-age performance

Type	Index	1	2	3	4	5	6	7	8	9	10	11	12	13
Population	Placeholder	0.118	-0.030	0.573	0.350	-0.004	-0.105	0.082	-0.022	0.204	-0.094	0.189	-0.360	0.049
Population	consumedG	-0.118	0.124	0.472	0.041	0.022	-0.081	-0.025	0.002	0.008	-0.331	-0.309	0.052	-0.379
Population	meanPreyED	-0.091	-0.087	0.078	-0.113	-0.315	-0.086	-0.576	-0.016	0.198	-0.047	-0.131	0.001	0.153
Population	RFR	0.006	0.145	0.410	-0.060	0.140	-0.027	-0.023	-0.003	-0.078	-0.265	-0.452	0.094	-0.489
Population	Cmax	-0.215	0.006	-0.136	0.206	-0.137	-0.095	0.023	-0.112	0.176	-0.117	0.287	-0.225	0.276
Population	maxG	-0.142	0.081	-0.016	0.110	-0.211	-0.181	-0.272	-0.285	0.241	-0.248	0.178	-0.372	0.275
Population	Gpotential	0.004	0.129	0.435	-0.051	-0.108	-0.104	-0.226	-0.157	0.159	-0.182	-0.170	-0.085	-0.062
Age-specific	consumedG	-0.236	0.351	-0.044	-0.147	0.154	0.173	0.188	0.172	0.011	-0.159	-0.381	-0.247	-0.070
Age-specific	meanPreyED	0.090	0.167	-0.147	0.020	0.136	0.245	0.167	0.353	0.171	0.257	-0.318	0.042	0.154
Age-specific	RFR	-0.168	0.354	-0.060	-0.203	0.193	0.220	0.167	0.177	0.013	-0.102	-0.436	-0.251	-0.011
Age-specific	Cmax	-0.019	0.177	-0.191	0.111	0.189	0.245	0.311	0.346	0.150	0.241	-0.184	-0.084	0.052
Age-specific	maxG	-0.158	0.068	-0.204	0.087	0.038	0.112	0.072	0.187	0.127	0.063	-0.196	-0.015	-0.016
Age-specific	Gpotential	-0.081	0.141	-0.347	-0.038	0.008	0.097	0.083	0.085	0.002	-0.160	-0.277	-0.219	0.031

Table 2.1.10. Overview of major results.

Dimensions	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
EBS exp. area data used?	no	yes	yes	no	no	no	no	no	no	no	no	no	no	no	no	no
NBS data used?	no	no	no	no	no	no	no	yes	yes	no	no	yes	yes	no	no	yes
Separate area for NBS?	no	no	no	no	no	no	no	no	no	no	no	yes	yes	no	no	yes
Diagnostics	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
ADSB	n/a	0.102	0.098	0.070	0.043	0.034	0.065	0.031	0.054	0.117	0.174	1.076	0.595	0.185	0.145	1.106
Mohn's ρ	0.243	0.202	0.217	0.304	0.222	0.323	0.291	0.359	0.319	0.309	0.069	0.452	0.370	0.118	0.451	0.724
Base values	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Natural mortality rate	0.359	0.348	0.347	0.354	0.363	0.361	0.354	0.353	0.348	0.374	0.312	0.305	0.331	0.349	0.381	0.294
EBS std. area catchability	0.929		0.995	0.943	0.913	0.917	0.952	0.954	0.980	1.043	1.200	1.240	1.074	1.008	0.816	1.286
EBS exp. area catchability		0.994	0.990													
NBS catchability								0.058	0.060			0.457	1.030			0.526
Unfished equil. sp. biom.	629	645	645	637	627	631	638	640	645	604	703	753	684	626	619	484
2019 quantities	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Depletion	0.424	0.392	0.401	0.418	0.431	0.443	0.424	0.448	0.428	0.356	0.208	0.529	0.481	0.327	0.461	0.741
EBS spawning biomass												199	239			188
NBS spawning biomass												199	90			170
Spawning biomass	267	253	259	266	270	279	270	287	276	215	147	399	329	205	285	358
EBS age 0+ biomass												589	690			541
NBS age 0+ biomass												483	220			409
Age 0+ biomass	775	731	746	774	797	810	781	813	782	657	488	1,072	910	614	835	950
OFL	209	186	196	206	214	220	209	220	208	155	53	197	212	133	237	179
maxABC	175	156	165	173	180	185	175	185	175	130	45	170	180	111	199	154

Table 2.1.11. Negative log likelihoods and parameter counts (p. 1 of 2).

Aggregated components

Component	M16.6	M16.6a	M16.6b	M16.6c	M16.6d	M16.6e	M16.6f	M16.6g
Equil. catch	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Survey indices	-23.31	-12.75	-22.82	-22.03	-22.87	-67.01	-28.12	-70.73
Sizecomps	1407.14	1264.39	1393.55	1394.61	1374.57	1408.18	1407.07	1514.86
Agecomps	293.08	285.75	285.77	290.24	296.43	290.40	292.65	294.04
Recruitment	5.14	-6.14	-3.23	-3.05	-4.03	-3.42	-2.97	-1.80
Initial recruitment		8.49	8.86	8.24	7.82	7.61	8.33	7.93
Priors	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
"Softbounds"	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Parameter devs	0.00	0.00	0.00	0.00	0.00	-68.21	0.00	-64.95
Total	1682.06	1539.75	1662.14	1668.02	1651.92	1567.57	1676.97	1679.36

Survey index breakdown

Sub-component	M16.6	M16.6a	M16.6b	M16.6c	M16.6d	M16.6e	M16.6f	M16.6g
EBS std. index	-23.31		-10.12	-22.03	-22.87	-67.01	-28.12	-67.86
EBS exp. index		-12.75	-12.70					
NBS index								-2.86
Total	-23.31	-12.75	-22.82	-22.03	-22.87	-67.01	-28.12	-70.73

Sizecomp breakdown

Sub-component	M16.6	M16.6a	M16.6b	M16.6c	M16.6d	M16.6e	M16.6f	M16.6g
Fish. sizecomp	376.60	361.11	373.84	372.51	384.99	376.48	375.62	370.43
EBS std. sizecomp	1030.55		128.22	1022.10	989.57	1031.70	1031.45	1038.32
EBS exp. sizecomp		903.27	891.49					
NBS sizecomp								106.11
Total	1407.14	1264.39	1393.55	1394.61	1374.57	1408.18	1407.07	1514.86

Agecomp breakdown

Sub-component	M16.6	M16.6a	M16.6b	M16.6c	M16.6d	M16.6e	M16.6f	M16.6g
Fish. agecomp								
EBS std. agecomp	293.08			290.24	296.43	290.40	292.65	294.04
EBS exp. agecomp		285.75	285.77					
Total	293.08	285.75	285.77	290.24	296.43	290.40	292.65	294.04

Parameter counts

Type	M16.6	M16.6a	M16.6b	M16.6c	M16.6d	M16.6e	M16.6f	M16.6g
Parameter devs	60	60	60	60	60	96	60	104
Parms with priors								
Unconstrained parms	18	18	19	19	19	18	19	21
Total	78	78	79	79	79	114	79	125

Table 2.1.11. Negative log likelihoods and parameter counts (p. 2 of 2).

Aggregated components

Component	M16.6h	M17.2	M17.6	M18.1	M18.2	M18.3	M18.4	M18.5
Equil. catch	0.00	0.02	0.05	0.00	0.00	0.01	0.00	0.00
Survey indices	-32.52	-8.13	-64.60	-33.70	-24.74	-14.51	-25.35	-37.01
Sizecomps	1513.45	1481.27	1356.05	1443.81	1451.84	1400.21	1400.45	1438.15
Agecomps	296.32	81.65	89.96	288.84	288.66	275.25	300.69	292.20
Recruitment	-1.28	-9.29	-6.76	-1.42	-1.28	-1.23	-2.31	-15.25
Initial recruitment	8.41	14.70	9.93	4.65	6.27	8.26	5.74	3.66
Priors	0.00	0.21	0.51	0.00	0.00	0.00	0.00	0.00
"Softbounds"	0.01	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Parameter devs	3.11	-92.18	-400.01	0.67	0.00	0.00	0.00	-0.37
Total	1787.49	1468.26	985.12	1702.85	1720.77	1667.99	1679.22	1681.39

Survey ndex breakdown

Sub-component	M16.6h	M17.2	M17.6	M18.1	M18.2	M18.3	M18.4	M18.5
EBS std. index	-29.66	-8.13	-64.60	-30.84	-21.12	-14.51	-25.35	-34.15
EBS exp. index								
NBS index	-2.85			-2.86	-3.62			-2.86
Total	-32.52	-8.13	-64.60	-33.70	-24.74	-14.51	-25.35	-37.01

Sizecomp breakdown

Sub-component	M16.6h	M17.2	M17.6	M18.1	M18.2	M18.3	M18.4	M18.5
Fish. sizecomp	369.98	459.54	314.05	369.96	372.40	374.56	373.43	363.72
EBS std. sizecomp	1038.35	1021.73	1041.99	1012.42	1019.96	1025.65	1027.02	1012.30
EBS exp. sizecomp								
NBS sizecomp	105.11			61.43	59.48			62.13
Total	1513.45	1481.27	1356.05	1443.81	1451.84	1400.21	1400.45	1438.15

Agecomp breakdown

Sub-component	M16.6h	M17.2	M17.6	M18.1	M18.2	M18.3	M18.4	M18.5
Fish. agecomp		27.35	27.16					
EBS std. agecomp	296.32	54.30	62.80	288.84	288.66	275.25	300.69	292.20
EBS exp. agecomp								
Total	296.32	81.65	89.96	288.84	288.66	275.25	300.69	292.20

Parameter counts

Type	M16.6h	M17.2	M17.6	M18.1	M18.2	M18.3	M18.4	M18.5
Parameter devs	68	142	286	90	60	60	60	90
Parms with priors		1	1					
Unconstrained parms	22	16	17	24	27	19	20	43
Total	90	159	304	114	87	79	80	133

Table 2.1.12a. Fit to survey indices, measured in terms of negative log likelihood.

	Obs.	Negative log likelihood															
Year	abund.	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
1982	583781	-2.448		-2.543	-2.543	-2.409	-2.680	-2.731	-2.708	-2.701	-2.625	-2.513	-0.263	-1.599	-2.552	-1.692	-1.459
1983	752456	-1.825		-1.776	-1.776	-1.851	-2.160	-2.226	-2.126	-2.234	-1.714	-1.529	-2.101	-1.961	-1.790	-2.103	-2.228
1984	651058	-2.183		-2.261	-2.261	-2.146	-2.548	-1.485	-2.580	-1.687	-2.235	-2.554	-2.214	-2.263	-2.213	-1.271	-1.894
1985	841108	-1.597		-1.565	-1.565	-1.609	-1.874	-1.260	-1.848	-1.194	-1.491	-1.860	-1.539	-1.525	-1.622	-1.856	-1.525
1986	838217	-1.908		-1.862	-1.862	-1.883	-2.227	-2.299	-2.212	-2.293	-1.851	-1.910	-1.839	-1.825	-1.968	-2.234	-2.206
1987	677054	-2.322	-1.821	-2.287	-2.287	-2.280	-2.710	-2.733	-2.709	-2.732	-2.733	-2.732	-2.090	-2.169	-2.473	-2.587	-2.535
1988	507560	-2.429	-2.463	-2.438	-2.438	-2.404	-2.648	-2.518	-2.649	-2.534	-2.370	-2.593	-2.340	-2.316	-2.552	-2.365	-2.356
1989	292247	6.943	8.391	7.322	7.322	6.554	-1.537	3.176	-1.590	3.253	16.256	-1.512	5.150	5.430	7.964	4.946	3.011
1990	423835	-1.175	-1.145	-1.041	-1.041	-1.234	-2.136	-1.846	-2.174	-1.919	-0.457	-2.179	-2.066	-1.830	-0.992	-1.650	-2.309
1991	488892	-0.189	-0.132	-0.064	-0.064	-0.239	-1.637	-1.139	-1.707	-1.243	-0.397	-1.942	-0.996	-0.805	-0.092	-0.528	-1.497
1992	577560	-2.052	-2.047	-2.018	-2.018	-2.055	-2.102	-1.758	-2.110	-1.796	-2.085	-1.582	-2.096	-2.096	-2.041	-2.097	-2.061
1993	810608	-1.383	-1.552	-1.518	-1.518	-1.402	-1.844	-1.390	-1.839	-1.355	-0.967	-2.102	-1.534	-1.396	-1.324	-1.334	-1.576
1994	1E+06	7.256	7.531	6.687	6.687	7.372	1.323	8.673	1.262	8.788	9.380	2.525	6.995	7.265	7.816	6.914	7.081
1995	757910	0.167	-0.184	-0.273	-0.273	0.358	-1.695	0.079	-1.711	0.107	1.697	-1.634	-0.280	0.083	0.785	-0.020	-0.616
1996	607198	-1.128	-1.199	-1.373	-1.373	-1.010	-1.565	-1.319	-1.567	-1.305	-0.352	-1.350	-1.436	-1.212	-0.717	-1.113	-1.550
1997	485643	-1.560	-1.501	-1.326	-1.326	-1.596	-1.743	-1.553	-1.762	-1.578	-1.930	-1.915	-1.542	-1.589	-1.880	-1.577	-1.526
1998	514339	-1.497	-1.397	-0.991	-0.991	-1.519	-2.185	-0.098	-2.215	-0.224	-2.225	-2.355	-1.458	-1.578	-2.029	-1.453	-1.012
1999	488337	-2.055	-2.301	-1.604	-1.604	-2.104	-2.291	-2.191	-2.300	-2.207	-1.598	-2.364	-1.962	-2.072	-2.325	-1.997	-1.933
2000	483808	-0.512	-0.017	0.635	0.635	-0.777	-1.990	-0.354	-2.010	-0.376	1.087	-1.707	-0.498	-0.627	-2.223	0.104	0.445
2001	960917	6.657	6.280	5.074	5.074	7.234	-0.338	5.043	-0.435	4.999	5.169	-1.174	7.655	7.270	14.386	4.645	4.649
2002	536342	-2.008	-1.937	-1.727	-1.727	-2.100	-2.229	-2.089	-2.221	-2.058	-1.941	-2.089	-2.138	-2.100	-2.049	-1.542	-1.692
2003	498873	-2.085	-2.113	-2.083	-2.083	-2.076	-2.086	-1.887	-2.087	-1.841	-2.085	-2.081	-2.080	-2.076	-1.705	-2.086	-1.969
2004	397948	-1.932	-1.715	-1.829	-1.829	-1.980	-2.361	-1.846	-2.334	-1.690	-1.721	-2.034	-2.215	-2.125	-2.074	-2.142	-2.108
2005	450705	-1.078	-1.102	-1.048	-1.048	-1.131	-1.563	-1.247	-1.645	-1.369	-1.305	-1.966	-0.758	-0.846	-1.444	-0.464	-0.573
2006	394024	-0.618	-0.569	-0.031	-0.031	-1.169	-2.647	0.327	-2.700	-0.292	-0.036	-2.702	-0.049	0.104	-2.397	2.722	2.429
2007	733402	-0.406	-0.413	-0.223	-0.223	-0.519	-0.644	-0.313	-0.670	-0.329	0.194	-1.313	-0.463	-0.384	-0.883	-0.007	-0.144
2008	476697	0.888	0.768	-0.026	-0.026	1.361	-1.369	0.706	-1.435	0.569	-0.459	-1.269	-0.595	2.562	4.762	-0.307	-1.240
2009	716637	-1.521	-1.246	-2.060	-2.060	-1.265	-2.241	-2.428	-2.281	-2.441	-2.175	-1.588	-2.329	-0.428	1.481	-2.049	-2.136
2010	887836	-1.837	-1.864	-1.562	-1.562	-1.888	-1.971	-2.016	-1.959	-2.002	-1.387	-1.774	-1.425	-1.975	-2.013	-1.702	-1.542
2011	836840	-1.590	-1.760	-0.971	-0.971	-1.698	-2.217	-0.847	-2.231	-0.848	-0.722	-2.309	-1.854	2.490	-2.363	-1.148	-1.536
2012	987973	-1.729	-1.904	-1.276	-1.276	-1.731	-2.262	-1.342	-2.285	-1.410	-0.657	-2.352	-2.056	-2.358	-2.363	-1.794	-2.103
2013	750889	-1.218	-1.212	-1.398	-1.398	-1.289	-1.443	-1.392	-1.380	-1.314	-1.422	-1.577	-0.420	-0.329	-0.893	-0.893	-0.281
2014	1E+06	-0.963	-1.080	-0.725	-0.725	-0.857	-1.712	-0.779	-1.827	-1.045	-0.659	-1.233	-2.025	-1.900	-1.302	-1.424	-2.050
2015	982470	-1.177	-1.253	-1.029	-1.029	-1.097	-1.914	-1.506	-1.997	-1.665	-0.805	-1.225	-2.159	-2.075	-0.856	-1.580	-2.159
2016	640359	-2.209	-2.077	-2.169	-2.169	-2.180	-2.335	-2.334	-2.343	-2.298	-2.104	-2.100	-1.450	-2.122	-1.609	-2.190	-1.541
2017	346693	1.415	0.284	1.343	1.343	1.752	-1.429	0.800	-1.476	0.601	0.594	-2.008	-2.371	-0.736	-0.961	0.519	-2.406
Sum		-23.306	-12.752	-22.033	-22.033	-22.866	-67.010	-28.121	-67.862	-29.661	-8.131	-64.602	-30.838	-21.115	-14.508	-25.354	-34.149

Table 2.1.12b. Fit to survey indices, measured in terms of negative log likelihood (after subtracting minimum for each row).

Year	Obs. abund.	Negative log likelihood minus row minimum															
		16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
1982	583781	0.283		0.188	0.188	0.322	0.051	0.000	0.023	0.030	0.106	0.217	2.468	1.132	0.179	1.039	1.272
1983	752456	0.409		0.458	0.458	0.383	0.074	0.009	0.108	0.000	0.520	0.705	0.133	0.273	0.444	0.131	0.006
1984	651058	0.398		0.320	0.320	0.434	0.032	1.095	0.000	0.894	0.346	0.026	0.367	0.317	0.367	1.310	0.687
1985	841108	0.278		0.310	0.310	0.265	0.000	0.614	0.027	0.680	0.384	0.014	0.335	0.350	0.252	0.019	0.349
1986	838217	0.391		0.437	0.437	0.416	0.072	0.000	0.087	0.006	0.448	0.389	0.460	0.474	0.331	0.065	0.093
1987	677054	0.411	0.912	0.446	0.446	0.453	0.023	0.000	0.024	0.001	0.000	0.001	0.643	0.564	0.260	0.146	0.198
1988	507560	0.220	0.186	0.212	0.212	0.245	0.001	0.131	0.000	0.115	0.279	0.057	0.310	0.334	0.097	0.284	0.293
1989	292247	8.533	9.981	8.911	8.911	8.143	0.053	4.766	0.000	4.843	17.846	0.078	6.740	7.020	9.553	6.535	4.600
1990	423835	1.134	1.164	1.269	1.269	1.075	0.173	0.464	0.135	0.390	1.852	0.130	0.243	0.479	1.318	0.659	0.000
1991	488892	1.753	1.811	1.878	1.878	1.703	0.305	0.803	0.235	0.699	1.545	0.000	0.946	1.137	1.850	1.414	0.445
1992	577560	0.058	0.063	0.092	0.092	0.055	0.008	0.352	0.000	0.314	0.025	0.528	0.014	0.014	0.069	0.013	0.049
1993	810608	0.719	0.549	0.583	0.583	0.700	0.257	0.712	0.263	0.747	1.134	0.000	0.568	0.706	0.778	0.768	0.525
1994	1E+06	5.994	6.269	5.425	5.425	6.110	0.061	7.411	0.000	7.526	8.118	1.262	5.732	6.003	6.554	5.652	5.819
1995	757910	1.878	1.527	1.438	1.438	2.069	0.016	1.790	0.000	1.818	3.408	0.078	1.431	1.794	2.497	1.691	1.095
1996	607198	0.439	0.368	0.195	0.195	0.557	0.003	0.248	0.000	0.262	1.215	0.218	0.131	0.355	0.851	0.454	0.017
1997	485643	0.371	0.429	0.604	0.604	0.335	0.187	0.377	0.168	0.352	0.000	0.016	0.388	0.341	0.050	0.353	0.404
1998	514339	0.858	0.958	1.364	1.364	0.836	0.170	2.257	0.140	2.131	0.130	0.000	0.897	0.777	0.326	0.902	1.343
1999	488337	0.308	0.062	0.760	0.760	0.260	0.073	0.172	0.064	0.157	0.765	0.000	0.402	0.292	0.039	0.367	0.430
2000	483808	1.712	2.206	2.858	2.858	1.446	0.234	1.869	0.213	1.847	3.310	0.516	1.725	1.596	0.000	2.328	2.668
2001	960917	7.832	7.454	6.249	6.249	8.409	0.836	6.217	0.739	6.174	6.343	0.000	8.829	8.444	15.560	5.820	5.824
2002	536342	0.221	0.292	0.502	0.502	0.128	0.000	0.140	0.008	0.171	0.288	0.140	0.091	0.129	0.180	0.687	0.537
2003	498873	0.029	0.000	0.031	0.031	0.038	0.027	0.227	0.026	0.272	0.028	0.032	0.033	0.037	0.408	0.028	0.144
2004	397948	0.429	0.646	0.532	0.532	0.381	0.000	0.515	0.027	0.672	0.640	0.328	0.146	0.236	0.288	0.219	0.253
2005	450705	0.888	0.864	0.918	0.918	0.835	0.403	0.719	0.321	0.597	0.661	0.000	1.208	1.120	0.522	1.502	1.393
2006	394024	2.083	2.132	2.671	2.671	1.533	0.055	3.029	0.002	2.410	2.666	0.000	2.653	2.805	0.305	5.424	5.131
2007	733402	0.908	0.900	1.090	1.090	0.795	0.670	1.000	0.644	0.984	1.507	0.000	0.850	0.929	0.431	1.306	1.169
2008	476697	2.323	2.204	1.409	1.409	2.797	0.067	2.142	0.000	2.005	0.976	0.166	0.841	3.997	6.198	1.128	0.195
2009	716637	0.921	1.196	0.381	0.381	1.176	0.200	0.014	0.161	0.000	0.267	0.853	0.113	2.013	3.923	0.393	0.305
2010	887836	0.180	0.152	0.455	0.455	0.128	0.046	0.000	0.057	0.015	0.629	0.243	0.592	0.041	0.003	0.315	0.474
2011	836840	0.773	0.603	1.392	1.392	0.665	0.146	1.516	0.132	1.515	1.641	0.054	0.509	4.853	0.000	1.215	0.827
2012	987973	0.635	0.459	1.087	1.087	0.633	0.101	1.022	0.078	0.954	1.706	0.012	0.307	0.006	0.000	0.569	0.261
2013	750889	0.358	0.365	0.179	0.179	0.288	0.133	0.184	0.197	0.263	0.155	0.000	1.157	1.247	0.684	0.684	1.295
2014	1E+06	1.087	0.970	1.325	1.325	1.193	0.338	1.271	0.223	1.005	1.391	0.817	0.025	0.149	0.748	0.626	0.000
2015	982470	0.982	0.907	1.131	1.131	1.062	0.245	0.654	0.162	0.494	1.354	0.934	0.001	0.084	1.303	0.580	0.000
2016	640359	0.134	0.266	0.174	0.174	0.163	0.009	0.010	0.000	0.045	0.240	0.243	0.893	0.222	0.734	0.153	0.803
2017	346693	3.821	2.690	3.749	3.749	4.158	0.977	3.207	0.931	3.008	3.000	0.398	0.035	1.670	1.445	2.926	0.000
0s:		0	1	0	0	0	3	3	9	2	2	9	0	0	3	0	4
Max:		8.533	9.981	8.911	8.911	8.409	0.977	7.411	0.931	7.526	17.846	1.262	8.829	8.444	15.560	6.535	5.824

Table 2.1.13. Effective sample sizes, input and output (p. 1 of 4).

Base model

				Model 16.6				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	582	12299	23850
Size	Std.	36	300	1.0000	300	308	10798	11086
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	61	7889	1395
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1886	12260	3978
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	43246	40309

Minor change models that use data from the expanded EBS survey area

				Model 16.6a				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	572	12299	23439
Size	Std.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	Exp.	31	300	1.0000	300	304	9298	9427
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Exp.	23	343	1.0000	343	63	7889	1452
					SEave	RMSE		
Index	Std.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	Exp.	31	341	n/a	0.1080	0.1969	10557	3177
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	40043	37496

				Model 16.6b				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	580	12299	23779
Size	Std.	5	331	1.0000	331	453	1653	2264
Size	Exp.	31	295	1.0000	295	302	9149	9373
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Exp.	23	343	1.0000	343	63	7889	1443
					SEave	RMSE		
Index	Std.	5	341	n/a	0.0956	0.0849	1703	2161
Index	Exp.	31	341	n/a	0.1080	0.1973	10557	3166
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	43250	42185

Table 2.1.13. Effective sample sizes, input and output (p. 2 of 4).

Minor change models with growth covariates

				Model 16.6c					Model 16.6d				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	586	12299	24015	1.0000	300	570	12299	23389
Size	Std.	36	300	1.0000	300	310	10798	11171	1.0000	300	321	10798	11546
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	61	7889	1392	1.0000	343	60	7889	1384
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE				SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1906	12260	3895	n/a	0.1074	0.1889	12260	3966
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	43246	40473			Sum:	43246	40285

Minor change models with time-varying Q, without NBS survey data

				Model 16.6e					Model 16.6f				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	576	12299	23606	1.0000	300	581	12299	23835
Size	Std.	36	300	1.0000	300	308	10798	11088	1.0000	300	308	10798	11078
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	61	7889	1408	1.0000	343	61	7889	1399
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE				SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1096	12260	11782	n/a	0.1074	0.1853	12260	4119
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	43246	47885			Sum:	43246	40431

Minor change models with time-varying Q, with NBS survey data

				Model 16.6g					Model 16.6h				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	583	12299	23899	1.0000	300	588	12299	24110
Size	Std.	36	300	1.0000	300	307	10798	11056	1.0000	300	307	10798	11045
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	2	300	1.0000	300	52	600	105	1.0000	300	53	600	106
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	61	7889	1392	1.0000	343	60	7889	1383
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE				SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1071	12260	12332	n/a	0.1074	0.1835	12260	4201
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	2	88	n/a	0.1620	0.1617	176	177	n/a	0.1620	0.1626	176	175
						Sum:	44022	48960			Sum:	44022	41020

Table 2.1.13. Effective sample sizes, input and output (p. 3 of 4).

Previous major change models

				Model 17.2					Model 17.6				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	35	5400	0.2416	1305	1305	45662	45671	0.1475	797	796	27878	27866
Size	Std.	36	336	0.8665	291	291	10470	10471	1.6603	557	557	20061	20062
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	6	9948	0.0225	224	223	1343	1339	0.0217	216	215	1295	1293
Age	Std.	23	343	0.1353	46	46	1067	1068	0.3172	109	109	2502	2506
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE				SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.2098	12260	3215	n/a	0.1074	0.1075	12260	12246
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	70802	61763			Sum:	63996	63973

Major change models with migration

				Model 18.1					Model 18.2				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	540	12299	22152	1.0000	300	555	12299	22741
Size	Std.	36	300	1.0000	300	315	10798	11334	1.0000	300	312	10798	11239
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	2	300	1.0000	300	103	600	206	1.0000	300	135	600	269
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	66	7889	1511	1.0000	343	63	7889	1454
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE				SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1776	12260	4487	n/a	0.1074	0.1926	12260	3814
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	2	88	n/a	0.1620	0.1619	176	176	n/a	0.1620	0.0457	176	2216
						Sum:	44022	39866			Sum:	44022	41732

Major change models with M covariates

				Model 18.3					Model 18.4				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	629	12299	25802	1.0000	300	577	12299	23640
Size	Std.	36	300	1.0000	300	310	10798	11155	1.0000	300	309	10798	11118
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	65	7889	1496	1.0000	343	59	7889	1367
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE				SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1988	12260	3580	n/a	0.1074	0.1876	12260	4021
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
						Sum:	43246	42033			Sum:	43246	40146

Table 2.1.13. Effective sample sizes, input and output (p. 4 of 4).

Major change omnibus model

				Model 18.5				
Type	Fleet	Yrs	N	Mult	N×Mult	Har	ΣNeff1	ΣNeff2
Size	Fish.	41	300	1.0000	300	546	12299	22373
Size	Std.	36	300	1.0000	300	315	10798	11326
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	2	300	1.0000	300	104	600	208
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	23	343	1.0000	343	65	7889	1490
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
					SEave	RMSE		
Index	Std.	36	341	n/a	0.1074	0.1763	12260	4552
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	2	88	n/a	0.1620	0.1620	176	176
						Sum:	44022	40124

Table 2.1.14a. Internally estimated parameters common to all, or nearly all, models.

	Model 16.6		Model 16.6a		Model 16.6b		Model 16.6c		Model 16.6d		Model 16.6e		Model 16.6f		Model 16.6g	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Natural mortality (M)	0.359	0.012	0.348	0.014	0.347	0.014	0.354	0.012	0.363	0.012	0.361	0.014	0.354	0.012	0.353	0.014
Length at age 1.5 (cm)	16.418	0.088	16.312	0.093	16.375	0.088	16.407	0.088	16.695	0.092	16.419	0.088	16.422	0.088	16.409	0.088
Asymptotic length (cm)	99.64	1.921	102.30	2.388	100.14	2.014	100.00	1.919	100.10	1.936	99.48	1.930	100.06	1.959	98.55	1.796
Brody growth coefficient (K)	0.198	0.012	0.184	0.013	0.196	0.012	0.198	0.012	0.195	0.012	0.198	0.012	0.196	0.012	0.208	0.012
Richards growth coefficient	1.038	0.048	1.084	0.050	1.038	0.048	1.029	0.048	1.053	0.048	1.043	0.048	1.044	0.048	1.000	0.047
SD of length at age 1 (cm)	3.438	0.058	3.410	0.061	3.429	0.058	3.431	0.058	3.427	0.056	3.439	0.058	3.439	0.058	3.440	0.058
SD of length at age 20 (cm)	9.789	0.277	9.751	0.312	9.754	0.279	9.679	0.276	9.712	0.278	9.751	0.278	9.784	0.280	9.515	0.264
Ageing bias at age 1	0.332	0.012	0.334	0.013	0.332	0.012	0.331	0.012	0.335	0.012	0.333	0.012	0.331	0.012	0.331	0.012
Ageing bias at age 20	0.281	0.142	0.264	0.144	0.259	0.142	0.233	0.143	0.284	0.141	0.254	0.142	0.261	0.143	0.262	0.144
ln(mean post-1976 recruits)	13.123	0.100	13.031	0.110	13.040	0.110	13.092	0.101	13.151	0.100	13.149	0.111	13.091	0.101	13.089	0.110
SD of ln(recruitment) devs	0.644	0.066	0.616	0.069	0.647	0.066	0.644	0.066	0.631	0.065	0.636	0.065	0.646	0.066	0.655	0.068
ln(pre-1977 recruits offset)	-1.122	0.212	-1.068	0.255	-1.144	0.207	-1.126	0.209	-1.108	0.212	-1.093	0.214	-1.133	0.209	-1.118	0.213
Initial fishing mortality rate	0.180	0.069	0.162	0.071	0.186	0.073	0.180	0.069	0.174	0.066	0.168	0.063	0.182	0.070	0.173	0.066
ln(EBS std. area catchability)	-0.074	0.061			-0.005	0.099	-0.058	0.062	-0.091	0.062	-0.086	0.071	-0.050	0.062	-0.047	0.070
Select. inflection (fishery)	4.349	0.045	4.360	0.047	4.361	0.045	4.355	0.045	4.338	0.045	4.353	0.046	4.354	0.045	4.308	0.044
Select. 95% width (fishery)	1.164	0.032	1.179	0.032	1.173	0.032	1.169	0.031	1.171	0.031	1.167	0.032	1.168	0.032	1.158	0.031
Select. inflection (EBS sur.)	1.009	0.006	1.003	0.006	1.006	0.006	1.007	0.006	1.008	0.006	1.010	0.006	1.007	0.006	1.007	0.006
Select. 95% width (EBS sur.)	0.287	0.052	0.288	0.052	0.287	0.052	0.287	0.052	0.288	0.051	0.287	0.052	0.287	0.052	0.287	0.051

	Model 16.6h		Model 17.2		Model 17.6		Model 18.1		Model 18.2		Model 18.3		Model 18.4		Model 18.5	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Natural mortality (M)	0.348	0.012	0.374	0.018	0.312	0.012	0.305	0.014	0.331	0.013	0.349	0.012				
Length at age 1.5 (cm)	16.411	0.088	16.445	0.092	16.946	0.288	16.415	0.088	16.415	0.089	16.410	0.088	16.422	0.089	16.422	0.088
Asymptotic length (cm)	98.987	1.811	109.18	1.867	108.41	2.022	93.32	1.308	95.26	1.511	99.89	1.983	99.60	2.148	93.74	1.509
Brody growth coefficient (K)	0.206	0.012	0.171	0.009	0.170	0.009	0.241	0.011	0.229	0.012	0.200	0.012	0.194	0.012	0.238	0.012
Richards growth coefficient	1.002	0.047	1.071	0.037	1.017	0.037	0.899	0.045	0.934	0.047	1.020	0.049	1.067	0.048	0.909	0.045
SD of length at age 1 (cm)	3.440	0.058	3.492	0.058	3.130	0.039	3.438	0.057	3.437	0.058	3.430	0.058	3.454	0.058	3.445	0.057
SD of length at age 20 (cm)	9.545	0.266	8.675	0.227	9.459	0.232	9.049	0.247	9.319	0.252	9.915	0.281	9.576	0.290	8.943	0.252
Ageing bias at age 1	0.330	0.013	0.337	0.030	0.357	0.017	0.316	0.014	0.323	0.013	0.325	0.013	0.337	0.011	0.315	0.014
Ageing bias at age 20	0.269	0.144	-0.405	0.212	-0.327	0.161	0.407	0.151	0.394	0.146	0.321	0.143	0.274	0.141	0.388	0.153
ln(mean post-1976 recruits)	13.048	0.101	13.113	0.129	12.735	0.085	12.874	0.112	12.997	0.106	13.015	0.101	13.337	0.090	12.346	0.199
SD of ln(recruitment) devs	0.664	0.068					0.632	0.067	0.646	0.068	0.659	0.063	0.632	0.065	0.504	0.055
ln(pre-1977 recruits offset)	-1.148	0.208	-1.442	0.135	-0.977	0.201	-0.693	0.197	-0.908	0.214	-1.337	0.192	-1.006	0.224	-0.471	0.155
Initial fishing mortality rate	0.183	0.072	0.469	0.316	1.691	0.886	0.129	0.033	0.150	0.046	0.313	0.173	0.144	0.051	0.178	0.054
ln(EBS std. area catchability)	-0.021	0.062	0.042	0.063	0.182	0.056	0.215	0.080	0.072	0.068	0.008	0.059	-0.204	0.082	0.251	0.118
Select. inflection (fishery)	4.309	0.043					4.420	0.049	4.386	0.048	4.347	0.045	4.349	0.045	4.426	0.049
Select. 95% width (fishery)	1.159	0.031					1.200	0.033	1.184	0.032	1.158	0.032	1.168	0.031	1.212	0.033
Select. inflection (EBS sur.)	1.005	0.006					1.009	0.006	1.008	0.006	1.007	0.006	1.017	0.005	1.005	0.005
Select. 95% width (EBS sur.)	0.287	0.051					0.300	0.055	0.296	0.055	0.287	0.051	0.288	0.052	0.299	0.055

Table 2.1.14b. Internally estimated parameters common to only a few models (p. 1 of 2).

	Model 16.6		Model 16.6a		Model 16.6b		Model 16.6c		Model 16.6d		Model 16.6e		Model 16.6f		Model 16.6g	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
M at age 5																
M at ages 6+																
Environmental link to M																
Environmental link to M(2-5)																
Environmental link to L(1.5)									0.619	0.079						
Environmental link to K							-0.006	0.001								
Migration "A" EBS to NBS																
Migration "B" EBS to NBS																
Migration "B" NBS to EBS																
Env. link to "A" EBS to NBS																
Env. link to "B" EBS to NBS																
Env. link to "B" NBS to EBS																
Ricker "beta" 1977-1979																
Ricker "beta" 1980-2005																
Ricker "beta" 2006-2013																
Ricker "beta" 2014-2016																

	Model 16.6h		Model 17.2		Model 17.6		Model 18.1		Model 18.2		Model 18.3		Model 18.4		Model 18.5	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
M at ages 2-5													0.386	0.028	0.297	0.050
M at ages 6+													0.381	0.027	0.294	0.028
Environmental link to M											-0.061	0.011				
Environmental link to M(2-5)													0.054	0.017	0.049	0.018
Environmental link to L(1.5)																
Environmental link to K																
Migration "A" EBS to NBS							-1.448	0.261	-2.241	0.186					-1.526	0.303
Migration "B" EBS to NBS							1.571	0.506	0.070	0.369					1.469	0.783
Migration "B" NBS to EBS							0.272	0.340	1.964	1.286					0.456	0.414
Env. link to "A" EBS to NBS									-1.469	0.115						
Env. link to "B" EBS to NBS									-0.778	0.270						
Env. link to "B" NBS to EBS									-1.007	0.793						
Ricker "beta" 1977-1979															3.313	0.430
Ricker "beta" 1980-2005															2.064	0.353
Ricker "beta" 2006-2013															3.064	0.353
Ricker "beta" 2014-2016															0.000	0.001

Table 2.1.14b. Internally estimated parameters common to only a few models (p. 2 of 2).

	Model 16.6		Model 16.6a		Model 16.6b		Model 16.6c		Model 16.6d		Model 16.6e		Model 16.6f		Model 16.6g	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
ln(EBS exp. area catchability)			-0.006	0.065	-0.010	0.064										
ln(NBS Q)															-2.840	0.396
ln(EBS Q) autocorrelation																
Env. link to ln(EBS Q)													-0.053	0.017		
Select. inflection (NBS sur.)															1.116	0.125
Select. 95% width (NBS sur.)															0.390	0.280
Select. peak age (fishery)																
Select. asc. wid. (fishery)																
Select. peak age (EBS sur.)																
Select. asc. wid. (EBS sur.)																

	Model 16.6h		Model 17.2		Model 17.6		Model 18.1		Model 18.2		Model 18.3		Model 18.4		Model 18.5	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
ln(EBS exp. area catchability)																
ln(NBS Q)	-2.808	0.394					-0.783	0.192	0.029	0.182					-0.643	0.213
ln(EBS Q) autocorrelation					0.465	0.128										
Env. link to ln(EBS Q)	-0.053	0.017													-0.021	0.019
Select. inflection (NBS sur.)	1.101	0.119					0.959	0.117	1.063	0.146					0.968	0.128
Select. 95% width (NBS sur.)	0.374	0.298					0.394	0.140	0.491	0.132					0.442	0.152
Select. peak age (fishery)			5.740	0.123	5.884	0.133										
Select. asc. wid. (fishery)			0.922	0.076	1.014	0.079										
Select. peak age (EBS sur.)			2.531	0.152	1.032	0.011										
Select. asc. wid. (EBS sur.)			1.228	0.219	-8.218	1.299										

Table 2.1.14c. Iteratively estimated parameters.

Quantity	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
M for ages 0-2															0.386	0.298
Logit prop. recruits in NBS												-0.426	-0.826			-0.505
Migration "A" NBS to EBS												81.638	81.774			81.638
SD of L(1.5) devs											0.097					
SD of "A" EBS to NBS devs												0.494				0.504
SD of "B" EBS to NBS devs												0.494				0.504
SD of "B" NBS to EBS devs												0.494				0.504
SD of ln(recruitment) devs										0.577	0.593					
SD of ln(EBS Q) devs						0.100		0.102			0.089					
SD of ln(NBS Q) devs								0.523	0.523							

Table 2.1.14d. "Early" recruitment *dev*s.

	Model 16.6		Model 16.6a		Model 16.6b		Model 16.6c		Model 16.6d		Model 16.6e		Model 16.6f		Model 16.6g	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Initial age 20 ln(recruits) dev	-0.004	0.643	-0.006	0.614	-0.004	0.646	-0.004	0.643	-0.004	0.630	-0.004	0.634	-0.004	0.645	-0.005	0.653
Initial age 19 ln(recruits) dev	-0.003	0.644	-0.004	0.614	-0.003	0.646	-0.003	0.643	-0.003	0.630	-0.003	0.635	-0.003	0.645	-0.003	0.654
Initial age 18 ln(recruits) dev	-0.004	0.643	-0.006	0.614	-0.005	0.646	-0.005	0.643	-0.004	0.630	-0.005	0.634	-0.005	0.644	-0.005	0.653
Initial age 17 ln(recruits) dev	-0.008	0.642	-0.010	0.612	-0.009	0.645	-0.008	0.642	-0.007	0.629	-0.008	0.633	-0.008	0.643	-0.009	0.652
Initial age 16 ln(recruits) dev	-0.013	0.641	-0.017	0.611	-0.014	0.643	-0.014	0.640	-0.012	0.628	-0.014	0.632	-0.013	0.642	-0.014	0.650
Initial age 15 ln(recruits) dev	-0.021	0.638	-0.028	0.608	-0.024	0.640	-0.023	0.637	-0.021	0.625	-0.022	0.629	-0.022	0.639	-0.024	0.647
Initial age 14 ln(recruits) dev	-0.035	0.634	-0.044	0.603	-0.039	0.636	-0.037	0.633	-0.034	0.621	-0.037	0.625	-0.037	0.635	-0.039	0.643
Initial age 13 ln(recruits) dev	-0.057	0.628	-0.070	0.597	-0.063	0.630	-0.060	0.627	-0.055	0.616	-0.060	0.619	-0.060	0.629	-0.063	0.636
Initial age 12 ln(recruits) dev	-0.091	0.620	-0.108	0.588	-0.100	0.621	-0.096	0.618	-0.088	0.607	-0.095	0.610	-0.095	0.620	-0.099	0.627
Initial age 11 ln(recruits) dev	-0.142	0.608	-0.163	0.576	-0.154	0.609	-0.149	0.607	-0.138	0.596	-0.146	0.598	-0.148	0.608	-0.153	0.615
Initial age 10 ln(recruits) dev	-0.214	0.593	-0.238	0.561	-0.229	0.594	-0.222	0.592	-0.208	0.582	-0.218	0.583	-0.221	0.593	-0.227	0.599
Initial age 9 ln(recruits) dev	-0.309	0.575	-0.334	0.544	-0.327	0.576	-0.319	0.574	-0.301	0.564	-0.312	0.566	-0.318	0.575	-0.324	0.581
Initial age 8 ln(recruits) dev	-0.423	0.555	-0.446	0.525	-0.444	0.555	-0.434	0.553	-0.413	0.544	-0.425	0.546	-0.433	0.555	-0.440	0.560
Initial age 7 ln(recruits) dev	-0.544	0.533	-0.562	0.506	-0.566	0.534	-0.555	0.532	-0.533	0.523	-0.543	0.525	-0.554	0.533	-0.560	0.539
Initial age 6 ln(recruits) dev	-0.639	0.513	-0.650	0.488	-0.660	0.513	-0.649	0.511	-0.628	0.504	-0.635	0.506	-0.648	0.513	-0.654	0.519
Initial age 5 ln(recruits) dev	-0.624	0.501	-0.628	0.479	-0.642	0.500	-0.633	0.499	-0.618	0.492	-0.618	0.495	-0.632	0.500	-0.640	0.506
Initial age 4 ln(recruits) dev	-0.262	0.484	-0.266	0.463	-0.269	0.482	-0.261	0.481	-0.272	0.477	-0.256	0.479	-0.264	0.483	-0.277	0.490
Initial age 3 ln(recruits) dev	-0.096	0.469	-0.110	0.451	-0.104	0.468	-0.097	0.466	-0.089	0.460	-0.104	0.466	-0.100	0.468	-0.078	0.467
Initial age 2 ln(recruits) dev	-0.139	0.520	-0.156	0.499	-0.150	0.520	-0.147	0.518	-0.149	0.511	-0.135	0.516	-0.145	0.520	-0.167	0.522
Initial age 1 ln(recruits) dev	0.755	0.519	0.739	0.511	0.774	0.509	0.781	0.507	0.725	0.510	0.752	0.517	0.762	0.515	0.765	0.504

	Model 16.6h		Model 17.2		Model 17.6		Model 18.1		Model 18.2		Model 18.3		Model 18.4		Model 18.5	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Initial age 20 ln(recruits) dev	-0.004	0.662	0.000	0.577	0.000	0.593	-0.043	0.619	-0.018	0.640	0.000	0.659	-0.004	0.630	-0.021	0.499
Initial age 19 ln(recruits) dev	-0.003	0.663	0.000	0.577	0.000	0.593	-0.019	0.626	-0.010	0.643	0.000	0.659	-0.003	0.631	-0.010	0.502
Initial age 18 ln(recruits) dev	-0.005	0.662	0.000	0.577	0.000	0.593	-0.026	0.624	-0.014	0.641	-0.001	0.659	-0.005	0.630	-0.014	0.501
Initial age 17 ln(recruits) dev	-0.008	0.661	0.000	0.577	0.000	0.593	-0.037	0.620	-0.022	0.639	-0.001	0.658	-0.008	0.629	-0.020	0.499
Initial age 16 ln(recruits) dev	-0.014	0.659	0.000	0.577	0.000	0.593	-0.052	0.616	-0.033	0.636	-0.003	0.658	-0.013	0.628	-0.028	0.497
Initial age 15 ln(recruits) dev	-0.023	0.656	-0.001	0.577	0.000	0.593	-0.072	0.611	-0.049	0.631	-0.005	0.657	-0.021	0.625	-0.040	0.495
Initial age 14 ln(recruits) dev	-0.039	0.652	-0.002	0.576	0.000	0.593	-0.099	0.603	-0.072	0.624	-0.009	0.656	-0.035	0.621	-0.056	0.491
Initial age 13 ln(recruits) dev	-0.062	0.646	-0.005	0.576	0.000	0.593	-0.134	0.595	-0.104	0.616	-0.017	0.654	-0.056	0.616	-0.078	0.486
Initial age 12 ln(recruits) dev	-0.099	0.636	-0.011	0.575	0.000	0.593	-0.180	0.584	-0.148	0.605	-0.032	0.651	-0.089	0.607	-0.107	0.480
Initial age 11 ln(recruits) dev	-0.153	0.624	-0.025	0.573	0.000	0.593	-0.236	0.572	-0.207	0.592	-0.057	0.646	-0.137	0.596	-0.145	0.473
Initial age 10 ln(recruits) dev	-0.229	0.609	-0.052	0.573	0.000	0.593	-0.303	0.558	-0.281	0.577	-0.099	0.639	-0.206	0.582	-0.193	0.464
Initial age 9 ln(recruits) dev	-0.327	0.590	-0.102	0.578	0.001	0.593	-0.378	0.545	-0.368	0.560	-0.165	0.631	-0.295	0.564	-0.247	0.455
Initial age 8 ln(recruits) dev	-0.444	0.569	-0.185	0.589	0.006	0.595	-0.462	0.531	-0.468	0.543	-0.258	0.619	-0.402	0.545	-0.313	0.445
Initial age 7 ln(recruits) dev	-0.567	0.547	-0.297	0.596	0.032	0.602	-0.544	0.517	-0.570	0.526	-0.372	0.600	-0.515	0.525	-0.383	0.434
Initial age 6 ln(recruits) dev	-0.663	0.526	-0.403	0.578	0.135	0.630	-0.623	0.502	-0.655	0.509	-0.479	0.572	-0.601	0.507	-0.452	0.422
Initial age 5 ln(recruits) dev	-0.650	0.512	-0.423	0.514	0.424	0.687	-0.636	0.490	-0.647	0.498	-0.494	0.544	-0.578	0.498	-0.470	0.412
Initial age 4 ln(recruits) dev	-0.281	0.495	0.039	0.406	1.394	0.488	-0.290	0.470	-0.296	0.480	-0.141	0.522	-0.212	0.481	-0.208	0.403
Initial age 3 ln(recruits) dev	-0.072	0.469	0.599	0.280	0.376	0.390	-0.171	0.456	-0.146	0.463	0.059	0.488	-0.073	0.469	-0.112	0.396
Initial age 2 ln(recruits) dev	-0.172	0.526	-0.396	0.416	-0.398	0.427	-0.205	0.500	-0.195	0.512	-0.041	0.543	-0.117	0.521	-0.068	0.423
Initial age 1 ln(recruits) dev	0.775	0.503	1.214	0.256	0.900	0.305	0.673	0.476	0.690	0.503	0.868	0.536	0.803	0.514	0.530	0.456

Table 2.1.14e. "Main" recruitment *dev*s (p. 1 of 2).

	Model 16.6		Model 16.6a		Model 16.6b		Model 16.6c		Model 16.6d		Model 16.6e		Model 16.6f		Model 16.6g	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
ln(recruits) dev 1977	0.959	0.210	0.777	0.307	0.909	0.211	0.928	0.209	0.946	0.208	0.971	0.214	0.937	0.209	0.913	0.213
ln(recruits) dev 1978	0.503	0.252	0.520	0.357	0.464	0.248	0.493	0.245	0.498	0.249	0.510	0.256	0.490	0.250	0.507	0.244
ln(recruits) dev 1979	0.515	0.143	0.082	0.329	0.483	0.143	0.503	0.140	0.521	0.140	0.520	0.146	0.499	0.143	0.510	0.141
ln(recruits) dev 1980	-0.256	0.138	-0.705	0.402	-0.284	0.139	-0.261	0.137	-0.254	0.135	-0.246	0.140	-0.258	0.137	-0.242	0.137
ln(recruits) dev 1981	-0.851	0.142	0.461	0.165	-0.873	0.143	-0.846	0.142	-0.840	0.140	-0.847	0.144	-0.867	0.143	-0.848	0.142
ln(recruits) dev 1982	0.819	0.051	0.297	0.195	0.798	0.054	0.813	0.051	0.809	0.051	0.820	0.054	0.794	0.051	0.810	0.054
ln(recruits) dev 1983	-0.545	0.126	-0.006	0.229	-0.562	0.126	-0.548	0.125	-0.514	0.122	-0.546	0.127	-0.558	0.126	-0.532	0.124
ln(recruits) dev 1984	0.808	0.050	0.636	0.102	0.803	0.050	0.801	0.050	0.791	0.051	0.800	0.052	0.797	0.050	0.797	0.052
ln(recruits) dev 1985	-0.159	0.090	-0.041	0.108	-0.211	0.096	-0.161	0.089	-0.165	0.089	-0.162	0.091	-0.172	0.090	-0.138	0.090
ln(recruits) dev 1986	-0.563	0.102	-0.678	0.122	-0.623	0.119	-0.562	0.101	-0.555	0.100	-0.554	0.103	-0.557	0.101	-0.538	0.102
ln(recruits) dev 1987	-1.436	0.180	-1.202	0.177	-1.216	0.184	-1.416	0.178	-1.418	0.175	-1.389	0.179	-1.407	0.179	-1.371	0.177
ln(recruits) dev 1988	-0.414	0.095	-0.354	0.099	-0.332	0.100	-0.403	0.095	-0.447	0.096	-0.359	0.096	-0.390	0.095	-0.363	0.095
ln(recruits) dev 1989	0.578	0.057	0.532	0.057	0.552	0.057	0.583	0.056	0.573	0.056	0.566	0.059	0.581	0.056	0.559	0.058
ln(recruits) dev 1990	0.378	0.063	0.370	0.061	0.383	0.062	0.386	0.063	0.364	0.063	0.359	0.064	0.372	0.063	0.370	0.063
ln(recruits) dev 1991	-0.069	0.076	-0.085	0.075	-0.070	0.076	-0.051	0.076	-0.058	0.075	-0.092	0.077	-0.074	0.076	-0.085	0.077
ln(recruits) dev 1992	0.783	0.038	0.774	0.038	0.788	0.037	0.802	0.038	0.774	0.038	0.763	0.039	0.782	0.038	0.768	0.039
ln(recruits) dev 1993	-0.099	0.057	-0.111	0.057	-0.098	0.057	-0.080	0.057	-0.129	0.058	-0.119	0.058	-0.104	0.057	-0.105	0.058
ln(recruits) dev 1994	-0.302	0.062	-0.317	0.061	-0.304	0.061	-0.275	0.062	-0.323	0.062	-0.312	0.062	-0.305	0.061	-0.305	0.062
ln(recruits) dev 1995	-0.391	0.069	-0.409	0.069	-0.391	0.069	-0.327	0.069	-0.424	0.070	-0.395	0.070	-0.392	0.069	-0.391	0.069
ln(recruits) dev 1996	0.627	0.037	0.625	0.037	0.642	0.037	0.650	0.038	0.626	0.037	0.625	0.038	0.621	0.037	0.626	0.038
ln(recruits) dev 1997	-0.177	0.059	-0.186	0.060	-0.178	0.060	-0.157	0.060	-0.175	0.059	-0.184	0.060	-0.182	0.059	-0.170	0.060
ln(recruits) dev 1998	-0.212	0.063	-0.216	0.063	-0.201	0.063	-0.124	0.063	-0.251	0.064	-0.219	0.064	-0.208	0.063	-0.207	0.063
ln(recruits) dev 1999	0.523	0.039	0.519	0.039	0.535	0.039	0.558	0.040	0.494	0.039	0.507	0.041	0.520	0.039	0.517	0.040
ln(recruits) dev 2000	0.255	0.043	0.243	0.043	0.253	0.043	0.256	0.043	0.248	0.043	0.237	0.044	0.252	0.043	0.258	0.044
ln(recruits) dev 2001	-0.542	0.066	-0.552	0.066	-0.539	0.066	-0.535	0.066	-0.567	0.066	-0.553	0.067	-0.542	0.066	-0.527	0.066
ln(recruits) dev 2002	-0.263	0.052	-0.260	0.052	-0.250	0.052	-0.296	0.054	-0.250	0.051	-0.277	0.054	-0.262	0.052	-0.250	0.053
ln(recruits) dev 2003	-0.431	0.056	-0.425	0.055	-0.412	0.055	-0.453	0.056	-0.433	0.055	-0.449	0.057	-0.427	0.056	-0.419	0.057
ln(recruits) dev 2004	-0.604	0.061	-0.603	0.061	-0.593	0.061	-0.635	0.062	-0.561	0.060	-0.630	0.063	-0.596	0.061	-0.596	0.062
ln(recruits) dev 2005	-0.306	0.055	-0.320	0.055	-0.304	0.055	-0.340	0.055	-0.291	0.054	-0.324	0.056	-0.297	0.055	-0.302	0.056
ln(recruits) dev 2006	0.827	0.034	0.821	0.034	0.838	0.034	0.782	0.035	0.837	0.034	0.829	0.035	0.832	0.034	0.828	0.034
ln(recruits) dev 2007	-0.003	0.056	-0.015	0.055	0.000	0.056	-0.036	0.056	-0.005	0.057	-0.002	0.057	0.004	0.056	-0.007	0.056
ln(recruits) dev 2008	1.138	0.031	1.117	0.031	1.134	0.031	1.096	0.032	1.138	0.032	1.133	0.032	1.143	0.031	1.124	0.032
ln(recruits) dev 2009	-0.927	0.114	-0.919	0.109	-0.917	0.110	-0.966	0.114	-0.904	0.113	-0.942	0.115	-0.925	0.114	-0.814	0.105
ln(recruits) dev 2010	0.607	0.044	0.594	0.044	0.613	0.044	0.585	0.044	0.593	0.044	0.602	0.047	0.616	0.044	0.613	0.046
ln(recruits) dev 2011	0.986	0.043	0.965	0.042	0.985	0.042	0.970	0.042	0.964	0.043	0.987	0.048	0.992	0.043	1.017	0.046
ln(recruits) dev 2012	0.132	0.066	0.119	0.067	0.141	0.067	0.105	0.067	0.077	0.068	0.135	0.072	0.140	0.066	0.206	0.069
ln(recruits) dev 2013	0.933	0.051	0.913	0.052	0.934	0.052	0.940	0.051	0.935	0.051	0.941	0.061	0.939	0.052	0.982	0.061
ln(recruits) dev 2014	-0.943	0.107	-0.976	0.107	-0.958	0.107	-0.914	0.105	-0.939	0.107	-0.928	0.113	-0.937	0.107	-1.022	0.112
ln(recruits) dev 2015	-0.662	0.105	-0.713	0.107	-0.684	0.107	-0.668	0.106	-0.645	0.104	-0.628	0.114	-0.650	0.105	-0.592	0.096
ln(recruits) dev 2016	-1.220	0.225	-1.270	0.229	-1.253	0.234	-1.196	0.222	-1.040	0.208	-1.148	0.230	-1.200	0.225	-1.580	0.284

Table 2.1.14e. "Main" recruitment *dev*s (p. 2 of 2).

	Model 16.6h		Model 17.2		Model 17.6		Model 18.1		Model 18.2		Model 18.3		Model 18.4		Model 18.5	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
ln(recruits) dev 1977	0.893	0.209	0.461	0.152	0.505	0.160	1.058	0.219	1.012	0.215	0.975	0.198	1.050	0.217	0.347	0.319
ln(recruits) dev 1978	0.497	0.239	0.503	0.137	0.471	0.133	0.544	0.245	0.536	0.250	0.479	0.251	0.546	0.259	-0.205	0.348
ln(recruits) dev 1979	0.499	0.139	0.485	0.101	0.432	0.088	0.483	0.143	0.513	0.142	0.522	0.141	0.548	0.145	-0.253	0.305
ln(recruits) dev 1980	-0.246	0.134	-0.280	0.120	-0.786	0.158	-0.247	0.135	-0.248	0.136	-0.253	0.138	-0.234	0.138	-0.128	0.196
ln(recruits) dev 1981	-0.861	0.141	-0.367	0.102	-0.609	0.117	-0.870	0.142	-0.856	0.142	-0.851	0.143	-0.810	0.142	-0.783	0.178
ln(recruits) dev 1982	0.789	0.051	0.724	0.053	0.766	0.050	0.781	0.052	0.802	0.051	0.826	0.051	0.857	0.052	0.853	0.092
ln(recruits) dev 1983	-0.540	0.123	-0.333	0.103	-0.375	0.103	-0.564	0.124	-0.547	0.125	-0.533	0.126	-0.492	0.126	-0.311	0.150
ln(recruits) dev 1984	0.796	0.050	0.669	0.049	0.661	0.052	0.781	0.051	0.796	0.051	0.823	0.050	0.857	0.052	1.089	0.120
ln(recruits) dev 1985	-0.148	0.088	0.085	0.064	0.102	0.065	-0.195	0.089	-0.168	0.089	-0.138	0.090	-0.133	0.089	0.245	0.177
ln(recruits) dev 1986	-0.543	0.101	-0.389	0.076	-0.440	0.080	-0.636	0.103	-0.597	0.102	-0.542	0.102	-0.582	0.102	-0.239	0.182
ln(recruits) dev 1987	-1.391	0.176	-0.949	0.100	-1.254	0.135	-1.475	0.175	-1.462	0.177	-1.417	0.181	-1.460	0.178	-1.063	0.212
ln(recruits) dev 1988	-0.393	0.094	-0.333	0.067	-0.186	0.072	-0.494	0.097	-0.458	0.096	-0.400	0.095	-0.436	0.095	-0.099	0.184
ln(recruits) dev 1989	0.575	0.056	0.458	0.044	0.496	0.048	0.535	0.058	0.553	0.058	0.589	0.056	0.549	0.058	0.864	0.154
ln(recruits) dev 1990	0.383	0.062	0.345	0.047	0.403	0.052	0.362	0.063	0.377	0.063	0.390	0.062	0.350	0.064	0.591	0.123
ln(recruits) dev 1991	-0.066	0.076	-0.153	0.061	-0.243	0.075	-0.073	0.076	-0.072	0.076	-0.068	0.076	-0.074	0.077	0.059	0.096
ln(recruits) dev 1992	0.787	0.038	0.698	0.034	0.718	0.037	0.778	0.040	0.782	0.039	0.766	0.037	0.788	0.039	0.843	0.083
ln(recruits) dev 1993	-0.090	0.057	-0.225	0.059	-0.158	0.060	-0.094	0.058	-0.090	0.058	-0.128	0.057	-0.088	0.059	-0.029	0.103
ln(recruits) dev 1994	-0.297	0.061	-0.417	0.054	-0.338	0.057	-0.297	0.062	-0.300	0.062	-0.357	0.062	-0.299	0.062	-0.239	0.106
ln(recruits) dev 1995	-0.388	0.068	-0.464	0.057	-0.355	0.062	-0.385	0.068	-0.390	0.069	-0.462	0.069	-0.404	0.070	-0.329	0.100
ln(recruits) dev 1996	0.623	0.037	0.454	0.036	0.618	0.038	0.605	0.039	0.619	0.038	0.524	0.041	0.617	0.039	0.647	0.085
ln(recruits) dev 1997	-0.168	0.059	0.084	0.045	0.001	0.058	-0.204	0.060	-0.184	0.060	-0.300	0.063	-0.173	0.061	-0.142	0.100
ln(recruits) dev 1998	-0.198	0.062	-0.002	0.048	-0.144	0.067	-0.247	0.063	-0.230	0.063	-0.356	0.067	-0.198	0.066	-0.155	0.113
ln(recruits) dev 1999	0.530	0.039	0.546	0.035	0.576	0.040	0.475	0.041	0.503	0.040	0.446	0.041	0.570	0.046	0.589	0.107
ln(recruits) dev 2000	0.272	0.043	0.160	0.046	0.170	0.048	0.209	0.045	0.240	0.044	0.052	0.057	0.307	0.050	0.323	0.101
ln(recruits) dev 2001	-0.518	0.065	-0.728	0.067	-0.691	0.076	-0.577	0.066	-0.555	0.066	-0.757	0.077	-0.524	0.069	-0.476	0.105
ln(recruits) dev 2002	-0.237	0.052	-0.204	0.048	-0.036	0.047	-0.311	0.053	-0.287	0.053	-0.472	0.065	-0.285	0.054	-0.254	0.090
ln(recruits) dev 2003	-0.399	0.055	-0.335	0.051	-0.146	0.051	-0.473	0.057	-0.451	0.056	-0.613	0.065	-0.498	0.059	-0.449	0.094
ln(recruits) dev 2004	-0.566	0.061	-0.647	0.061	-0.675	0.061	-0.623	0.062	-0.616	0.061	-0.660	0.062	-0.683	0.064	-0.614	0.100
ln(recruits) dev 2005	-0.279	0.054	-0.477	0.065	-0.428	0.058	-0.307	0.055	-0.309	0.055	-0.253	0.055	-0.393	0.059	-0.313	0.103
ln(recruits) dev 2006	0.829	0.034	0.665	0.042	0.794	0.040	0.851	0.037	0.839	0.035	0.950	0.041	0.753	0.041	0.269	0.151
ln(recruits) dev 2007	-0.003	0.056	0.161	0.057	0.081	0.070	0.043	0.059	0.028	0.057	0.149	0.063	-0.055	0.059	-0.547	0.174
ln(recruits) dev 2008	1.132	0.031	0.993	0.037	1.073	0.036	1.155	0.035	1.166	0.033	1.336	0.048	1.094	0.035	0.562	0.187
ln(recruits) dev 2009	-0.802	0.105	-0.960	0.129	-1.021	0.144	-0.772	0.105	-0.784	0.109	-0.712	0.121	-0.979	0.116	-1.322	0.213
ln(recruits) dev 2010	0.622	0.044	0.543	0.053	0.525	0.053	0.636	0.047	0.614	0.046	0.770	0.053	0.601	0.045	0.078	0.189
ln(recruits) dev 2011	1.017	0.042	0.935	0.049	0.876	0.047	1.042	0.045	1.030	0.043	1.152	0.052	1.030	0.046	0.532	0.158
ln(recruits) dev 2012	0.203	0.064	0.211	0.075	0.009	0.083	0.251	0.067	0.204	0.065	0.300	0.073	0.176	0.069	-0.197	0.148
ln(recruits) dev 2013	0.973	0.051	0.869	0.060	0.778	0.072	1.055	0.056	0.995	0.051	0.999	0.052	0.959	0.052	0.647	0.134
ln(recruits) dev 2014	-1.038	0.105	-0.905	0.137	-0.792	0.127	-0.884	0.107	-0.971	0.105	-0.888	0.107	-0.944	0.106	-0.015	0.172
ln(recruits) dev 2015	-0.611	0.086	-0.745	0.126	-1.016	0.147	-0.390	0.092	-0.519	0.086	-0.623	0.106	-0.682	0.105	0.425	0.169
ln(recruits) dev 2016	-1.639	0.278	-1.135	0.206	-0.360	0.470	-1.524	0.279	-1.518	0.304	-1.262	0.226	-1.227	0.223	-0.803	0.288

Table 2.1.14f. Other *dev*s (1 of 4).

	Model 17.6			Model 18.1		Model 18.5	
Quantity	Est.	StD.	Quantity	Est.	StD.	Est.	StD.
L at age 1.5 dev 1981	-0.754	0.404	Mig. "A" EBS to NBS dev 2007	1.101	0.644	0.988	0.690
L at age 1.5 dev 1982	-0.847	0.251	Mig. "A" EBS to NBS dev 2008	2.345	0.608	1.861	0.688
L at age 1.5 dev 1983	0.939	0.403	Mig. "A" EBS to NBS dev 2009	-4.481	0.598	-4.531	0.603
L at age 1.5 dev 1984	0.366	0.214	Mig. "A" EBS to NBS dev 2010	0.219	0.648	0.052	0.680
L at age 1.5 dev 1985	-1.297	0.352	Mig. "A" EBS to NBS dev 2011	0.680	0.800	0.358	0.853
L at age 1.5 dev 1986	0.210	0.236	Mig. "A" EBS to NBS dev 2012	-0.185	0.845	-0.292	0.842
L at age 1.5 dev 1987	-0.039	0.320	Mig. "A" EBS to NBS dev 2013	-0.630	0.852	-0.585	0.843
L at age 1.5 dev 1988	-0.194	0.301	Mig. "A" EBS to NBS dev 2014	-0.388	0.802	-0.362	0.805
L at age 1.5 dev 1989	-0.859	0.233	Mig. "A" EBS to NBS dev 2015	-0.472	0.660	-0.348	0.680
L at age 1.5 dev 1990	-0.035	0.243	Mig. "A" EBS to NBS dev 2016	3.066	0.508	2.919	0.521
L at age 1.5 dev 1991	0.503	0.218	Mig. "B" EBS to NBS dev 2007	-0.997	0.852	-1.039	0.846
L at age 1.5 dev 1992	-0.039	0.209	Mig. "B" EBS to NBS dev 2008	-0.516	0.921	-0.569	0.915
L at age 1.5 dev 1993	0.648	0.291	Mig. "B" EBS to NBS dev 2009	-0.199	0.938	-0.199	0.923
L at age 1.5 dev 1994	0.414	0.228	Mig. "B" EBS to NBS dev 2010	-1.350	0.880	-1.181	0.901
L at age 1.5 dev 1995	0.401	0.285	Mig. "B" EBS to NBS dev 2011	-0.651	0.922	-0.677	0.908
L at age 1.5 dev 1996	0.250	0.221	Mig. "B" EBS to NBS dev 2012	0.025	0.876	-0.107	0.882
L at age 1.5 dev 1997	-0.295	0.289	Mig. "B" EBS to NBS dev 2013	-0.310	0.825	-0.175	0.832
L at age 1.5 dev 1998	-0.162	0.226	Mig. "B" EBS to NBS dev 2014	-0.352	0.871	-0.195	0.866
L at age 1.5 dev 1999	-0.935	0.231	Mig. "B" EBS to NBS dev 2015	0.320	0.872	0.393	0.864
L at age 1.5 dev 2000	0.594	0.217	Mig. "B" EBS to NBS dev 2016	0.295	0.911	0.150	0.917
L at age 1.5 dev 2001	0.765	0.230	Mig. "B" NBS to EBS dev 2007	0.817	0.760	0.879	0.792
L at age 1.5 dev 2002	0.957	0.215	Mig. "B" NBS to EBS dev 2008	-0.186	0.838	-0.017	0.872
L at age 1.5 dev 2003	0.520	0.258	Mig. "B" NBS to EBS dev 2009	-0.062	0.846	-0.117	0.873
L at age 1.5 dev 2004	1.323	0.218	Mig. "B" NBS to EBS dev 2010	0.354	0.920	0.346	0.931
L at age 1.5 dev 2005	-1.094	0.231	Mig. "B" NBS to EBS dev 2011	-0.129	0.955	-0.113	0.963
L at age 1.5 dev 2006	-1.219	0.204	Mig. "B" NBS to EBS dev 2012	-0.301	0.980	-0.241	0.988
L at age 1.5 dev 2007	-1.497	0.259	Mig. "B" NBS to EBS dev 2013	-0.758	0.928	-0.688	0.956
L at age 1.5 dev 2008	-1.628	0.209	Mig. "B" NBS to EBS dev 2014	-0.580	0.935	-0.593	0.965
L at age 1.5 dev 2009	-0.284	0.313	Mig. "B" NBS to EBS dev 2015	-0.306	0.859	-0.491	0.876
L at age 1.5 dev 2010	0.303	0.205	Mig. "B" NBS to EBS dev 2016	0.525	0.918	0.675	0.919
L at age 1.5 dev 2011	-1.883	0.233					
L at age 1.5 dev 2012	0.227	0.260					
L at age 1.5 dev 2013	-0.231	0.213					
L at age 1.5 dev 2014	0.291	0.333					
L at age 1.5 dev 2015	1.989	0.209					
L at age 1.5 dev 2016	1.817	0.261					

Table 2.1.14f. Other *dev*s (2 of 4).

	Model 16.6e		Model 16.6g		Model 17.6	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.
ln(EBS Q) dev 1982	-0.503	0.649	-0.352	0.639	1.040	0.664
ln(EBS Q) dev 1983	0.362	0.756	0.445	0.750	1.190	0.786
ln(EBS Q) dev 1984	-0.566	0.645	-0.451	0.637	0.410	0.707
ln(EBS Q) dev 1985	0.388	0.811	0.433	0.806	0.696	0.817
ln(EBS Q) dev 1986	0.389	0.727	0.434	0.720	0.798	0.762
ln(EBS Q) dev 1987	0.332	0.590	0.347	0.582	0.064	0.656
ln(EBS Q) dev 1988	0.215	0.614	0.206	0.606	-0.528	0.678
ln(EBS Q) dev 1989	-2.232	0.610	-2.224	0.602	-2.225	0.660
ln(EBS Q) dev 1990	-0.927	0.681	-0.886	0.673	-1.913	0.737
ln(EBS Q) dev 1991	-1.076	0.737	-1.035	0.731	-1.488	0.769
ln(EBS Q) dev 1992	-0.226	0.774	-0.201	0.768	-0.824	0.791
ln(EBS Q) dev 1993	0.590	0.783	0.608	0.777	0.672	0.803
ln(EBS Q) dev 1994	2.126	0.785	2.149	0.779	2.501	0.801
ln(EBS Q) dev 1995	1.123	0.720	1.130	0.713	2.166	0.753
ln(EBS Q) dev 1996	0.590	0.829	0.600	0.824	1.402	0.831
ln(EBS Q) dev 1997	-0.422	0.829	-0.409	0.824	0.385	0.833
ln(EBS Q) dev 1998	-0.715	0.693	-0.677	0.686	-0.209	0.730
ln(EBS Q) dev 1999	-0.442	0.700	-0.426	0.693	-0.453	0.731
ln(EBS Q) dev 2000	-0.992	0.693	-0.986	0.686	-0.734	0.731
ln(EBS Q) dev 2001	2.113	0.706	2.103	0.699	0.468	0.775
ln(EBS Q) dev 2002	-0.384	0.724	-0.413	0.717	-0.465	0.752
ln(EBS Q) dev 2003	0.038	0.788	-0.004	0.782	-0.704	0.803
ln(EBS Q) dev 2004	-0.499	0.678	-0.579	0.670	-1.244	0.725
ln(EBS Q) dev 2005	0.641	0.821	0.584	0.816	-0.953	0.829
ln(EBS Q) dev 2006	0.961	0.572	0.811	0.563	-1.253	0.642
ln(EBS Q) dev 2007	0.447	0.936	0.448	0.933	-1.143	0.919
ln(EBS Q) dev 2008	-1.306	0.732	-1.282	0.726	-1.856	0.775
ln(EBS Q) dev 2009	-0.728	0.676	-0.666	0.669	-1.651	0.741
ln(EBS Q) dev 2010	0.268	0.802	0.298	0.796	-0.211	0.821
ln(EBS Q) dev 2011	0.578	0.704	0.561	0.697	0.277	0.750
ln(EBS Q) dev 2012	0.511	0.707	0.465	0.698	0.404	0.749
ln(EBS Q) dev 2013	-0.513	0.862	-0.568	0.857	0.431	0.866
ln(EBS Q) dev 2014	0.660	0.806	0.552	0.800	1.334	0.830
ln(EBS Q) dev 2015	0.613	0.790	0.510	0.783	1.536	0.836
ln(EBS Q) dev 2016	0.138	0.763	0.018	0.755	0.899	0.854
ln(EBS Q) dev 2017	-1.555	0.779	-1.548	0.770	-0.274	0.900

	Model 16.6g		Model 16.6h	
Quantity	Est.	StD.	Est.	StD.
ln(NBS Q) dev 2010	-2.865	0.741	-2.880	0.740
ln(NBS Q) dev 2011	0.000	1.000	0.000	1.000
ln(NBS Q) dev 2012	0.000	1.000	0.000	1.000
ln(NBS Q) dev 2013	0.000	1.000	0.000	1.000
ln(NBS Q) dev 2014	0.000	1.000	0.000	1.000
ln(NBS Q) dev 2015	0.000	1.000	0.000	1.000
ln(NBS Q) dev 2016	0.000	1.000	0.000	1.000
ln(NBS Q) dev 2017	2.865	0.741	2.880	0.740

Table 2.1.14f. Other *dev*s (3 of 4).

	Model 17.2		Model 17.6			Model 17.2		Model 17.6	
Quantity	Est.	StD.	Est.	StD.	Quantity	Est.	StD.	Est.	StD.
Select. peak age (fish.) dev 1977	-0.239	0.765	-1.210	0.998	Select. asc. wid. (fish.) dev 1977	-0.002	0.853	1.761	0.855
Select. peak age (fish.) dev 1978	-0.322	0.690	0.219	0.787	Select. asc. wid. (fish.) dev 1978	-0.339	0.651	-0.238	0.693
Select. peak age (fish.) dev 1979	-0.977	0.695	-0.406	0.728	Select. asc. wid. (fish.) dev 1979	-0.496	0.690	-0.225	0.686
Select. peak age (fish.) dev 1980	-0.206	0.715	0.088	0.723	Select. asc. wid. (fish.) dev 1980	0.113	0.647	0.144	0.675
Select. peak age (fish.) dev 1981	-1.203	0.801	-0.984	0.849	Select. asc. wid. (fish.) dev 1981	0.836	0.748	0.786	0.796
Select. peak age (fish.) dev 1982	0.683	0.635	0.634	0.676	Select. asc. wid. (fish.) dev 1982	0.191	0.675	-0.020	0.735
Select. peak age (fish.) dev 1983	1.193	0.561	1.122	0.602	Select. asc. wid. (fish.) dev 1983	0.963	0.555	0.662	0.659
Select. peak age (fish.) dev 1984	1.828	0.440	1.757	0.507	Select. asc. wid. (fish.) dev 1984	2.060	0.365	2.027	0.421
Select. peak age (fish.) dev 1985	-0.257	0.460	-0.480	0.494	Select. asc. wid. (fish.) dev 1985	-0.256	0.551	-0.541	0.628
Select. peak age (fish.) dev 1986	0.373	0.322	0.314	0.355	Select. asc. wid. (fish.) dev 1986	0.772	0.341	0.565	0.410
Select. peak age (fish.) dev 1987	0.452	0.330	0.629	0.347	Select. asc. wid. (fish.) dev 1987	0.567	0.338	0.564	0.369
Select. peak age (fish.) dev 1988	-0.109	0.521	-0.319	0.565	Select. asc. wid. (fish.) dev 1988	1.409	0.537	1.128	0.631
Select. peak age (fish.) dev 1989	1.443	0.524	0.928	0.575	Select. asc. wid. (fish.) dev 1989	2.009	0.500	1.447	0.599
Select. peak age (fish.) dev 1990	1.959	0.336	1.988	0.376	Select. asc. wid. (fish.) dev 1990	1.844	0.318	1.782	0.374
Select. peak age (fish.) dev 1991	0.019	0.332	0.133	0.395	Select. asc. wid. (fish.) dev 1991	0.219	0.341	0.280	0.415
Select. peak age (fish.) dev 1992	-0.797	0.279	-0.678	0.313	Select. asc. wid. (fish.) dev 1992	-0.965	0.337	-0.918	0.396
Select. peak age (fish.) dev 1993	-0.303	0.344	-0.225	0.398	Select. asc. wid. (fish.) dev 1993	0.318	0.351	0.350	0.421
Select. peak age (fish.) dev 1994	-0.058	0.327	0.070	0.374	Select. asc. wid. (fish.) dev 1994	0.631	0.304	0.762	0.353
Select. peak age (fish.) dev 1995	-0.399	0.347	-0.358	0.403	Select. asc. wid. (fish.) dev 1995	0.033	0.378	0.125	0.443
Select. peak age (fish.) dev 1996	1.030	0.298	0.796	0.339	Select. asc. wid. (fish.) dev 1996	1.142	0.305	0.905	0.367
Select. peak age (fish.) dev 1997	0.907	0.289	0.843	0.315	Select. asc. wid. (fish.) dev 1997	1.192	0.269	1.015	0.307
Select. peak age (fish.) dev 1998	0.204	0.266	0.419	0.312	Select. asc. wid. (fish.) dev 1998	0.269	0.273	0.341	0.320
Select. peak age (fish.) dev 1999	-0.315	0.269	-0.074	0.305	Select. asc. wid. (fish.) dev 1999	-0.300	0.289	-0.192	0.339
Select. peak age (fish.) dev 2000	-0.151	0.242	-0.114	0.284	Select. asc. wid. (fish.) dev 2000	-0.936	0.300	-1.176	0.400
Select. peak age (fish.) dev 2001	-0.338	0.277	0.199	0.291	Select. asc. wid. (fish.) dev 2001	-0.915	0.316	-0.475	0.334
Select. peak age (fish.) dev 2002	-0.731	0.257	-0.515	0.301	Select. asc. wid. (fish.) dev 2002	-0.837	0.298	-0.514	0.351
Select. peak age (fish.) dev 2003	-0.674	0.234	-0.710	0.263	Select. asc. wid. (fish.) dev 2003	-1.016	0.295	-1.050	0.358
Select. peak age (fish.) dev 2004	-1.137	0.229	-1.142	0.255	Select. asc. wid. (fish.) dev 2004	-1.481	0.315	-1.497	0.368
Select. peak age (fish.) dev 2005	-1.247	0.286	-1.058	0.309	Select. asc. wid. (fish.) dev 2005	-1.512	0.387	-1.294	0.407
Select. peak age (fish.) dev 2006	-0.934	0.253	-0.892	0.277	Select. asc. wid. (fish.) dev 2006	-1.769	0.373	-1.816	0.420
Select. peak age (fish.) dev 2007	0.516	0.259	0.457	0.293	Select. asc. wid. (fish.) dev 2007	-0.106	0.305	-0.404	0.386
Select. peak age (fish.) dev 2008	-0.086	0.261	0.116	0.281	Select. asc. wid. (fish.) dev 2008	-0.673	0.284	-0.647	0.328
Select. peak age (fish.) dev 2009	-0.790	0.296	-1.076	0.327	Select. asc. wid. (fish.) dev 2009	-2.030	0.379	-2.768	0.513
Select. peak age (fish.) dev 2010	0.405	0.464	0.389	0.499	Select. asc. wid. (fish.) dev 2010	0.352	0.452	0.557	0.482
Select. peak age (fish.) dev 2011	0.903	0.505	0.284	0.579	Select. asc. wid. (fish.) dev 2011	1.025	0.442	0.807	0.533
Select. peak age (fish.) dev 2012	0.216	0.282	0.397	0.351	Select. asc. wid. (fish.) dev 2012	-0.620	0.350	-0.683	0.468
Select. peak age (fish.) dev 2013	-0.895	0.551	-0.940	0.595	Select. asc. wid. (fish.) dev 2013	-0.362	0.589	-0.281	0.636
Select. peak age (fish.) dev 2014	-0.166	0.385	-0.282	0.393	Select. asc. wid. (fish.) dev 2014	-0.143	0.441	-0.085	0.465
Select. peak age (fish.) dev 2015	0.212	0.426	0.004	0.442	Select. asc. wid. (fish.) dev 2015	0.121	0.447	0.143	0.470
Select. peak age (fish.) dev 2016	0.060	0.533	-0.739	0.551	Select. asc. wid. (fish.) dev 2016	0.143	0.562	-0.480	0.665
Select. peak age (fish.) dev 2017	-0.071	0.379	0.415	0.412	Select. asc. wid. (fish.) dev 2017	-1.454	0.626	-0.846	0.601

Table 2.1.14f. Other *dev*s (4 of 4).

Quantity	Model 17.6 Est.	Model 17.6 StD.	Quantity	Model 17.6 Est.	Model 17.6 StD.
Select. peak age (sur.) dev 1982	0.633	0.339	Select. asc. wid. (sur.) dev 1982	0.000	1.000
Select. peak age (sur.) dev 1983	-0.050	0.220	Select. asc. wid. (sur.) dev 1983	0.001	1.000
Select. peak age (sur.) dev 1984	0.566	0.378	Select. asc. wid. (sur.) dev 1984	0.000	1.000
Select. peak age (sur.) dev 1985	-0.196	0.215	Select. asc. wid. (sur.) dev 1985	0.005	1.000
Select. peak age (sur.) dev 1986	0.408	0.279	Select. asc. wid. (sur.) dev 1986	0.000	1.000
Select. peak age (sur.) dev 1987	-0.100	0.235	Select. asc. wid. (sur.) dev 1987	0.003	1.000
Select. peak age (sur.) dev 1988	0.557	0.408	Select. asc. wid. (sur.) dev 1988	0.000	1.000
Select. peak age (sur.) dev 1989	1.030	0.282	Select. asc. wid. (sur.) dev 1989	0.000	1.000
Select. peak age (sur.) dev 1990	-0.177	0.217	Select. asc. wid. (sur.) dev 1990	0.005	1.000
Select. peak age (sur.) dev 1991	-0.060	0.222	Select. asc. wid. (sur.) dev 1991	0.002	1.000
Select. peak age (sur.) dev 1992	-0.493	0.212	Select. asc. wid. (sur.) dev 1992	0.003	1.000
Select. peak age (sur.) dev 1993	-0.279	0.197	Select. asc. wid. (sur.) dev 1993	0.006	1.000
Select. peak age (sur.) dev 1994	0.207	0.272	Select. asc. wid. (sur.) dev 1994	-0.001	1.000
Select. peak age (sur.) dev 1995	0.676	0.288	Select. asc. wid. (sur.) dev 1995	0.000	1.000
Select. peak age (sur.) dev 1996	0.876	0.283	Select. asc. wid. (sur.) dev 1996	0.000	1.000
Select. peak age (sur.) dev 1997	0.164	0.214	Select. asc. wid. (sur.) dev 1997	-0.001	1.000
Select. peak age (sur.) dev 1998	0.812	0.266	Select. asc. wid. (sur.) dev 1998	0.000	1.000
Select. peak age (sur.) dev 1999	0.687	0.277	Select. asc. wid. (sur.) dev 1999	0.000	1.000
Select. peak age (sur.) dev 2000	0.036	0.202	Select. asc. wid. (sur.) dev 2000	-0.001	1.000
Select. peak age (sur.) dev 2001	-0.474	0.188	Select. asc. wid. (sur.) dev 2001	0.004	1.000
Select. peak age (sur.) dev 2002	-0.160	0.226	Select. asc. wid. (sur.) dev 2002	0.004	1.000
Select. peak age (sur.) dev 2003	-0.225	0.209	Select. asc. wid. (sur.) dev 2003	0.005	1.000
Select. peak age (sur.) dev 2004	-0.071	0.222	Select. asc. wid. (sur.) dev 2004	0.002	1.000
Select. peak age (sur.) dev 2005	-0.575	0.206	Select. asc. wid. (sur.) dev 2005	0.000	1.000
Select. peak age (sur.) dev 2006	-0.574	0.210	Select. asc. wid. (sur.) dev 2006	0.000	1.000
Select. peak age (sur.) dev 2007	-0.579	0.193	Select. asc. wid. (sur.) dev 2007	0.000	1.000
Select. peak age (sur.) dev 2008	-0.213	0.213	Select. asc. wid. (sur.) dev 2008	0.005	1.000
Select. peak age (sur.) dev 2009	-0.299	0.192	Select. asc. wid. (sur.) dev 2009	0.006	1.000
Select. peak age (sur.) dev 2010	-0.187	0.234	Select. asc. wid. (sur.) dev 2010	0.005	1.000
Select. peak age (sur.) dev 2011	-0.295	0.194	Select. asc. wid. (sur.) dev 2011	0.006	1.000
Select. peak age (sur.) dev 2012	-0.975	0.465	Select. asc. wid. (sur.) dev 2012	-0.046	0.999
Select. peak age (sur.) dev 2013	-0.036	0.231	Select. asc. wid. (sur.) dev 2013	0.001	1.000
Select. peak age (sur.) dev 2014	-0.201	0.213	Select. asc. wid. (sur.) dev 2014	0.005	1.000
Select. peak age (sur.) dev 2015	0.026	0.269	Select. asc. wid. (sur.) dev 2015	0.000	1.000
Select. peak age (sur.) dev 2016	-0.844	0.337	Select. asc. wid. (sur.) dev 2016	-0.020	0.999
Select. peak age (sur.) dev 2017	0.384	0.649	Select. asc. wid. (sur.) dev 2017	0.000	1.000

Table 2.1.14g. Miscellaneous constants in the SS control files.

Quantity	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Weight-at-length multiplier	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06	6E-06
Weight-at-length exponent	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186	3.186
Maturity A50%	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883	4.883
Maturity logistic slope	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965	-0.965
Migration "A" EBS to EBS												0	0			0
Migration "B" EBS to EBS												0	0			0
Migration "A" NBS to NBS												0	0			0
Migration "B" NBS to NBS												0	0			0
SD of ageing error at age 1	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.085	0.082	0.082	0.085	0.085	0.085	0.085	0.085
SD of ageing error at age 20	1.695	1.695	1.695	1.695	1.695	1.695	1.695	1.695	1.695	1.632	1.632	1.695	1.695	1.695	1.695	1.695
Proportion female	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
"A" EBS to NBS dev auto.												0				0
"B" EBS to NBS dev auto.												0				0
"B" NBS to EBS dev auto.												0				0
Beverton-Holt "steepness"	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	
Recruit dev autocorrelation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ln(EBS Q) dev autocorr.						0		0								
ln(NBS Q) dev autocorr.								0	0							
Select. top logit (fish.)										10	10					
Select. descend. width (fish.)										10	10					
Select. start logit (fish.)										-10	-10					
Select. end logit (fish.)										10	10					
Select. top logit (sur.)										10	10					
Select. descend. width (sur.)										10	10					
Select. start logit (sur.)										-10	-10					
Select. end logit (sur.)										10	10					
Sel. peak age (fish.) dev auto.										0	0					
Sel. asc. wid. (fish.) dev auto.										0	0					
Sel. peak age (sur.) dev auto.											0					
Sel. asc. wid. (sur.) dev. auto.											0					

Table 2.1.15. Fishing mortality (p. 1 of 2).

	Model 16.6		Model 16.6a		Model 16.6b		Model 16.6c		Model 16.6d		Model 16.6e		Model 16.6f		Model 16.6g	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Fishing mortality 1977	0.284	0.109	0.251	0.119	0.301	0.115	0.287	0.109	0.271	0.102	0.263	0.100	0.291	0.111	0.278	0.106
Fishing mortality 1978	0.370	0.148	0.324	0.163	0.395	0.160	0.374	0.148	0.350	0.138	0.340	0.135	0.379	0.152	0.361	0.143
Fishing mortality 1979	0.290	0.113	0.256	0.129	0.313	0.124	0.294	0.114	0.274	0.105	0.266	0.103	0.299	0.117	0.283	0.110
Fishing mortality 1980	0.321	0.106	0.295	0.132	0.347	0.116	0.326	0.106	0.305	0.098	0.297	0.098	0.331	0.109	0.312	0.102
Fishing mortality 1981	0.201	0.039	0.208	0.058	0.218	0.044	0.206	0.039	0.194	0.037	0.190	0.038	0.208	0.040	0.197	0.039
Fishing mortality 1982	0.104	0.013	0.116	0.020	0.113	0.015	0.107	0.013	0.102	0.013	0.100	0.014	0.107	0.013	0.105	0.014
Fishing mortality 1983	0.118	0.011	0.134	0.018	0.127	0.014	0.122	0.012	0.116	0.011	0.114	0.013	0.122	0.012	0.119	0.013
Fishing mortality 1984	0.160	0.013	0.193	0.023	0.171	0.017	0.164	0.014	0.158	0.013	0.155	0.015	0.164	0.014	0.161	0.016
Fishing mortality 1985	0.177	0.014	0.209	0.024	0.189	0.018	0.181	0.014	0.175	0.014	0.171	0.016	0.181	0.014	0.178	0.016
Fishing mortality 1986	0.180	0.013	0.187	0.019	0.191	0.017	0.183	0.013	0.177	0.013	0.174	0.015	0.184	0.013	0.179	0.015
Fishing mortality 1987	0.191	0.012	0.207	0.019	0.202	0.016	0.194	0.013	0.188	0.012	0.185	0.015	0.196	0.013	0.190	0.015
Fishing mortality 1988	0.255	0.016	0.270	0.022	0.268	0.020	0.258	0.016	0.251	0.015	0.247	0.018	0.261	0.016	0.253	0.018
Fishing mortality 1989	0.214	0.012	0.230	0.016	0.225	0.015	0.217	0.012	0.212	0.012	0.209	0.014	0.220	0.012	0.213	0.014
Fishing mortality 1990	0.239	0.012	0.253	0.016	0.251	0.015	0.241	0.013	0.237	0.012	0.233	0.014	0.244	0.013	0.237	0.014
Fishing mortality 1991	0.421	0.023	0.445	0.028	0.442	0.027	0.423	0.023	0.417	0.023	0.407	0.026	0.430	0.024	0.415	0.026
Fishing mortality 1992	0.513	0.035	0.532	0.040	0.531	0.039	0.513	0.035	0.506	0.034	0.487	0.037	0.522	0.035	0.496	0.037
Fishing mortality 1993	0.393	0.027	0.405	0.031	0.404	0.030	0.394	0.027	0.386	0.027	0.371	0.028	0.398	0.028	0.374	0.028
Fishing mortality 1994	0.420	0.025	0.439	0.029	0.436	0.028	0.421	0.026	0.413	0.025	0.403	0.027	0.425	0.026	0.408	0.027
Fishing mortality 1995	0.532	0.031	0.557	0.036	0.552	0.035	0.530	0.031	0.524	0.031	0.515	0.033	0.538	0.031	0.523	0.033
Fishing mortality 1996	0.497	0.031	0.522	0.036	0.518	0.034	0.491	0.031	0.486	0.030	0.485	0.033	0.504	0.031	0.490	0.032
Fishing mortality 1997	0.540	0.033	0.568	0.038	0.563	0.037	0.530	0.033	0.535	0.033	0.532	0.036	0.549	0.033	0.540	0.035
Fishing mortality 1998	0.429	0.028	0.451	0.033	0.446	0.031	0.420	0.028	0.427	0.028	0.423	0.030	0.436	0.028	0.432	0.030
Fishing mortality 1999	0.438	0.030	0.461	0.035	0.456	0.034	0.425	0.030	0.437	0.031	0.432	0.033	0.445	0.031	0.441	0.033
Fishing mortality 2000	0.424	0.030	0.446	0.035	0.441	0.033	0.407	0.029	0.418	0.029	0.417	0.032	0.432	0.030	0.421	0.031
Fishing mortality 2001	0.338	0.021	0.353	0.024	0.349	0.023	0.326	0.020	0.333	0.021	0.332	0.022	0.345	0.021	0.337	0.022
Fishing mortality 2002	0.409	0.024	0.423	0.028	0.419	0.027	0.388	0.023	0.405	0.024	0.401	0.026	0.416	0.025	0.407	0.026
Fishing mortality 2003	0.445	0.026	0.460	0.030	0.456	0.029	0.422	0.024	0.443	0.027	0.437	0.028	0.453	0.027	0.439	0.028
Fishing mortality 2004	0.422	0.023	0.436	0.026	0.432	0.025	0.411	0.021	0.422	0.023	0.416	0.024	0.429	0.023	0.417	0.024
Fishing mortality 2005	0.430	0.022	0.443	0.024	0.440	0.024	0.428	0.021	0.429	0.022	0.426	0.023	0.437	0.022	0.427	0.023
Fishing mortality 2006	0.494	0.026	0.507	0.029	0.503	0.028	0.498	0.025	0.489	0.027	0.489	0.028	0.501	0.027	0.487	0.027
Fishing mortality 2007	0.483	0.028	0.493	0.030	0.490	0.029	0.497	0.027	0.472	0.028	0.478	0.029	0.489	0.028	0.472	0.028
Fishing mortality 2008	0.599	0.038	0.609	0.040	0.606	0.039	0.627	0.039	0.577	0.037	0.595	0.039	0.606	0.038	0.583	0.038
Fishing mortality 2009	0.747	0.056	0.761	0.059	0.757	0.057	0.795	0.060	0.704	0.053	0.744	0.058	0.753	0.056	0.718	0.054
Fishing mortality 2010	0.580	0.043	0.601	0.047	0.597	0.045	0.621	0.047	0.548	0.041	0.575	0.045	0.585	0.044	0.554	0.042
Fishing mortality 2011	0.594	0.040	0.617	0.044	0.611	0.043	0.639	0.044	0.570	0.039	0.583	0.043	0.598	0.041	0.578	0.041
Fishing mortality 2012	0.567	0.041	0.595	0.045	0.589	0.044	0.611	0.045	0.546	0.039	0.554	0.043	0.570	0.042	0.553	0.042
Fishing mortality 2013	0.468	0.033	0.493	0.036	0.486	0.035	0.501	0.037	0.455	0.032	0.456	0.036	0.469	0.034	0.464	0.035
Fishing mortality 2014	0.546	0.045	0.576	0.049	0.569	0.047	0.587	0.050	0.530	0.043	0.530	0.048	0.545	0.045	0.534	0.047
Fishing mortality 2015	0.483	0.042	0.513	0.046	0.505	0.044	0.509	0.046	0.475	0.041	0.469	0.046	0.482	0.043	0.464	0.044
Fishing mortality 2016	0.430	0.039	0.457	0.042	0.449	0.040	0.447	0.042	0.429	0.039	0.417	0.044	0.429	0.039	0.409	0.041
Fishing mortality 2017	0.365	0.036	0.388	0.038	0.380	0.037	0.375	0.038	0.364	0.035	0.353	0.041	0.363	0.036	0.339	0.037

Table 2.1.15. Fishing mortality (p. 2 of 2).

	Model 16.6h		Model 17.2		Model 17.6		Model 18.1		Model 18.2		Model 18.3		Model 18.4		Model 18.5	
Quantity	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
Fishing mortality 1977	0.301	0.114	0.565	0.270	0.487	0.148	0.202	0.062	0.241	0.082	0.454	0.204	0.216	0.080	0.225	0.077
Fishing mortality 1978	0.394	0.157	0.613	0.295	1.210	0.689	0.294	0.088	0.330	0.116	0.592	0.268	0.271	0.103	0.330	0.117
Fishing mortality 1979	0.309	0.120	0.325	0.108	0.530	0.181	0.206	0.060	0.246	0.084	0.453	0.195	0.209	0.077	0.232	0.077
Fishing mortality 1980	0.340	0.110	0.363	0.131	0.538	0.197	0.252	0.066	0.288	0.086	0.468	0.164	0.232	0.073	0.292	0.093
Fishing mortality 1981	0.211	0.039	0.140	0.027	0.175	0.039	0.187	0.034	0.197	0.037	0.249	0.048	0.153	0.032	0.215	0.049
Fishing mortality 1982	0.111	0.013	0.194	0.051	0.230	0.070	0.114	0.015	0.109	0.014	0.118	0.014	0.084	0.012	0.125	0.022
Fishing mortality 1983	0.125	0.012	0.206	0.039	0.241	0.049	0.144	0.016	0.132	0.013	0.131	0.012	0.099	0.012	0.153	0.023
Fishing mortality 1984	0.168	0.014	0.258	0.036	0.291	0.041	0.211	0.021	0.187	0.017	0.175	0.014	0.135	0.014	0.218	0.030
Fishing mortality 1985	0.185	0.014	0.212	0.020	0.246	0.020	0.263	0.025	0.220	0.019	0.193	0.015	0.151	0.014	0.268	0.035
Fishing mortality 1986	0.186	0.014	0.207	0.018	0.248	0.021	0.268	0.024	0.225	0.018	0.195	0.014	0.153	0.013	0.269	0.032
Fishing mortality 1987	0.199	0.013	0.228	0.019	0.280	0.026	0.290	0.025	0.237	0.018	0.206	0.013	0.166	0.013	0.293	0.035
Fishing mortality 1988	0.264	0.016	0.242	0.018	0.274	0.021	0.385	0.032	0.319	0.023	0.273	0.016	0.228	0.017	0.397	0.045
Fishing mortality 1989	0.221	0.012	0.269	0.025	0.287	0.028	0.312	0.024	0.265	0.018	0.228	0.012	0.196	0.014	0.327	0.035
Fishing mortality 1990	0.247	0.013	0.326	0.026	0.366	0.032	0.378	0.030	0.305	0.020	0.254	0.012	0.224	0.014	0.397	0.045
Fishing mortality 1991	0.434	0.024	0.426	0.025	0.461	0.027	0.668	0.053	0.550	0.039	0.449	0.023	0.391	0.025	0.694	0.075
Fishing mortality 1992	0.525	0.035	0.459	0.029	0.506	0.033	0.822	0.075	0.664	0.054	0.557	0.037	0.471	0.036	0.837	0.097
Fishing mortality 1993	0.397	0.027	0.324	0.026	0.357	0.032	0.546	0.045	0.471	0.035	0.430	0.029	0.356	0.029	0.560	0.060
Fishing mortality 1994	0.425	0.025	0.392	0.028	0.431	0.035	0.610	0.052	0.510	0.036	0.457	0.026	0.377	0.028	0.618	0.074
Fishing mortality 1995	0.542	0.031	0.510	0.029	0.546	0.034	0.770	0.064	0.655	0.046	0.585	0.032	0.472	0.035	0.780	0.090
Fishing mortality 1996	0.504	0.031	0.653	0.045	0.690	0.050	0.679	0.054	0.598	0.043	0.557	0.033	0.438	0.035	0.694	0.076
Fishing mortality 1997	0.552	0.033	0.757	0.058	0.863	0.071	0.789	0.072	0.662	0.049	0.620	0.037	0.481	0.039	0.814	0.105
Fishing mortality 1998	0.440	0.028	0.561	0.034	0.642	0.043	0.583	0.047	0.514	0.038	0.482	0.030	0.379	0.032	0.604	0.065
Fishing mortality 1999	0.450	0.031	0.568	0.037	0.636	0.041	0.611	0.056	0.531	0.042	0.488	0.032	0.387	0.034	0.636	0.081
Fishing mortality 2000	0.432	0.030	0.676	0.054	0.758	0.060	0.595	0.051	0.510	0.039	0.508	0.036	0.368	0.032	0.603	0.070
Fishing mortality 2001	0.346	0.021	0.461	0.042	0.564	0.056	0.472	0.039	0.402	0.028	0.411	0.027	0.291	0.023	0.469	0.053
Fishing mortality 2002	0.419	0.025	0.436	0.029	0.476	0.031	0.594	0.049	0.500	0.035	0.506	0.035	0.347	0.026	0.580	0.065
Fishing mortality 2003	0.451	0.026	0.443	0.028	0.490	0.030	0.637	0.049	0.548	0.038	0.538	0.036	0.381	0.028	0.628	0.065
Fishing mortality 2004	0.427	0.023	0.384	0.018	0.420	0.020	0.637	0.052	0.521	0.034	0.464	0.026	0.377	0.025	0.646	0.071
Fishing mortality 2005	0.436	0.022	0.425	0.018	0.458	0.020	0.649	0.049	0.536	0.034	0.443	0.023	0.402	0.026	0.682	0.070
Fishing mortality 2006	0.497	0.026	0.546	0.025	0.568	0.027	0.750	0.058	0.625	0.042	0.492	0.027	0.477	0.033	0.813	0.088
Fishing mortality 2007	0.481	0.027	0.662	0.042	0.663	0.047	0.736	0.060	0.608	0.042	0.469	0.027	0.466	0.034	0.791	0.086
Fishing mortality 2008	0.591	0.037	0.711	0.053	0.686	0.050	0.894	0.105	0.688	0.050	0.570	0.036	0.568	0.045	0.940	0.137
Fishing mortality 2009	0.724	0.053	0.905	0.085	0.822	0.065	1.240	0.167	0.901	0.077	0.717	0.053	0.679	0.062	1.245	0.200
Fishing mortality 2010	0.561	0.040	0.812	0.133	0.784	0.124	0.603	0.054	0.624	0.048	0.572	0.041	0.509	0.047	0.624	0.069
Fishing mortality 2011	0.590	0.039	0.895	0.163	0.764	0.124	0.877	0.112	0.898	0.098	0.580	0.037	0.526	0.047	0.886	0.143
Fishing mortality 2012	0.565	0.040	0.889	0.107	1.155	0.131	0.721	0.089	0.559	0.045	0.566	0.037	0.511	0.049	0.756	0.112
Fishing mortality 2013	0.474	0.033	0.496	0.044	0.548	0.046	0.606	0.075	0.512	0.042	0.492	0.031	0.406	0.039	0.618	0.094
Fishing mortality 2014	0.546	0.044	0.684	0.071	0.763	0.060	0.709	0.086	0.608	0.055	0.588	0.043	0.441	0.047	0.692	0.104
Fishing mortality 2015	0.476	0.040	0.680	0.105	0.798	0.107	0.607	0.075	0.525	0.050	0.549	0.044	0.397	0.044	0.603	0.092
Fishing mortality 2016	0.421	0.037	0.549	0.087	0.646	0.072	0.568	0.069	0.610	0.066	0.520	0.046	0.374	0.042	0.602	0.093
Fishing mortality 2017	0.351	0.033	0.548	0.083	0.972	0.158	0.581	0.077	0.433	0.046	0.460	0.047	0.334	0.039	0.605	0.098

Table 2.1.16. Biology parameters after adjustments.

	16.6c	16.6d	17.6	18.1			18.2			18.3	18.4	18.5			
				Mig A	Migration B		Mig A	Migration B					Mig A	Migration B	
Year	K	L(1.5)	L(1.5)	EBS-NBS	EBS-NBS	NBS-EBS	EBS-NBS	EBS-NBS	NBS-EBS	M	M(5)	M(5)	EBS-NBS	EBS-NBS	NBS-EBS
1977	0.20	16.69	16.95	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1978	0.20	16.69	16.95	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1979	0.20	16.69	16.95	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1980	0.20	16.69	16.95	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1981	0.20	16.69	15.75	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1982	0.20	16.52	15.60	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1983	0.20	17.08	18.57	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.34	0.25	-1.53	1.47	0.46
1984	0.20	16.57	17.56	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.40	0.31	-1.53	1.47	0.46
1985	0.20	16.60	14.94	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.35	0.27	-1.53	1.47	0.46
1986	0.20	16.22	17.30	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.38	0.29	-1.53	1.47	0.46
1987	0.20	17.23	16.88	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.45	0.36	-1.53	1.47	0.46
1988	0.20	16.59	16.63	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.42	0.33	-1.53	1.47	0.46
1989	0.20	17.04	15.59	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.44	0.34	-1.53	1.47	0.46
1990	0.20	16.66	16.89	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.32	0.24	-1.53	1.47	0.46
1991	0.20	16.84	17.80	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1992	0.20	16.34	16.88	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.37	0.28	-1.53	1.47	0.46
1993	0.20	17.11	18.05	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.35	0.27	-1.53	1.47	0.46
1994	0.20	16.01	17.64	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.37	0.28	-1.53	1.47	0.46
1995	0.20	16.14	17.62	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.39	0.30	-1.53	1.47	0.46
1996	0.20	17.38	17.36	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.43	0.33	-1.53	1.47	0.46
1997	0.20	16.88	16.47	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.38	0.29	-1.53	1.47	0.46
1998	0.19	17.27	16.68	-1.45	1.57	0.27	-2.24	0.07	1.96	0.23	0.44	0.34	-1.53	1.47	0.46
1999	0.21	15.46	15.47	-1.45	1.57	0.27	-2.24	0.07	1.96	0.44	0.33	0.25	-1.53	1.47	0.46
2000	0.20	16.44	17.95	-1.45	1.57	0.27	-2.24	0.07	1.96	0.35	0.36	0.28	-1.53	1.47	0.46
2001	0.20	16.75	18.26	-1.45	1.57	0.27	-2.24	0.07	1.96	0.33	0.36	0.27	-1.53	1.47	0.46
2002	0.20	17.25	18.60	-1.45	1.57	0.27	-2.24	0.07	1.96	0.33	0.42	0.32	-1.53	1.47	0.46
2003	0.18	17.67	17.82	-1.45	1.57	0.27	-2.24	0.07	1.96	0.23	0.46	0.37	-1.53	1.47	0.46
2004	0.19	17.35	19.27	-1.45	1.57	0.27	-2.24	0.07	1.96	0.26	0.46	0.37	-1.53	1.47	0.46
2005	0.19	17.42	15.23	-1.45	1.57	0.27	-2.24	0.07	1.96	0.31	0.47	0.38	-1.53	1.47	0.46
2006	0.20	16.23	15.05	-1.45	1.57	0.27	-2.24	0.07	1.96	0.34	0.38	0.29	-1.53	1.47	0.46
2007	0.20	16.17	14.65	-0.90	1.08	0.68	-3.15	-0.14	2.09	0.33	0.34	0.26	-1.03	0.94	0.90
2008	0.20	15.80	14.46	-0.29	1.32	0.18	-2.81	-0.10	1.20	0.36	0.33	0.25	-0.59	1.18	0.45
2009	0.20	15.87	16.48	-3.66	1.47	0.24	-5.53	0.94	1.17	0.40	0.27	0.19	-3.81	1.37	0.40
2010	0.20	15.98	17.45	-1.34	0.91	0.45	-0.97	-0.43	0.89	0.36	0.33	0.25	-1.50	0.87	0.63
2011	0.20	16.67	14.11	-1.11	1.25	0.21	-4.00	-0.45	1.99	0.35	0.41	0.32	-1.35	1.13	0.40
2012	0.21	15.59	17.32	-1.54	1.58	0.12	-3.48	0.34	1.26	0.44	0.35	0.26	-1.67	1.41	0.33
2013	0.20	16.23	16.57	-1.76	1.42	-0.10	-3.47	0.37	1.00	0.36	0.26	0.19	-1.82	1.38	0.11
2014	0.20	17.23	17.43	-1.64	1.40	-0.01	-3.14	-0.07	0.67	0.37	0.41	0.32	-1.71	1.37	0.16
2015	0.21	17.34	20.56	-1.68	1.73	0.12	-1.87	1.37	2.50	0.44	0.44	0.34	-1.70	1.67	0.21
2016	0.20	18.15	20.22	0.07	1.72	0.53	-1.03	0.25	4.50	0.33	0.50	0.40	-0.05	1.54	0.80
2017	0.20	16.94	16.95	-1.45	1.57	0.27	-2.24	0.07	1.96	0.40	0.41	0.32	-1.53	1.47	0.46

Table 2.1.17a. Migration rates (Model 18.1).

Year	Source	Dest.	0	1	2	3	4	5	6	7	8	9	10	11	12
2007	EBS	EBS	0.712	0.712	0.712	0.712	0.712	0.601	0.478	0.358	0.254	0.254	0.254	0.254	0.254
2007	EBS	NBS	0.288	0.288	0.288	0.288	0.288	0.399	0.522	0.642	0.746	0.746	0.746	0.746	0.746
2007	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.663	0.663	0.663	0.663	0.663
2007	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.337	0.337	0.337	0.337	0.337
2008	EBS	EBS	0.572	0.572	0.572	0.572	0.572	0.472	0.374	0.286	0.211	0.211	0.211	0.211	0.211
2008	EBS	NBS	0.428	0.428	0.428	0.428	0.428	0.528	0.626	0.714	0.789	0.789	0.789	0.789	0.789
2008	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.545	0.545	0.545	0.545	0.545
2008	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.455	0.455	0.455	0.455	0.455
2009	EBS	EBS	0.975	0.975	0.975	0.975	0.975	0.915	0.749	0.453	0.186	0.186	0.186	0.186	0.186
2009	EBS	NBS	0.025	0.025	0.025	0.025	0.025	0.085	0.251	0.547	0.814	0.814	0.814	0.814	0.814
2009	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.560	0.560	0.560	0.560	0.560
2009	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.440	0.440	0.440	0.440	0.440
2010	EBS	EBS	0.792	0.792	0.792	0.792	0.792	0.685	0.554	0.415	0.288	0.288	0.288	0.288	0.288
2010	EBS	NBS	0.208	0.208	0.208	0.208	0.208	0.315	0.446	0.585	0.712	0.712	0.712	0.712	0.712
2010	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.610	0.610	0.610	0.610	0.610
2010	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.390	0.390	0.390	0.390	0.390
2011	EBS	EBS	0.753	0.753	0.753	0.753	0.753	0.628	0.483	0.341	0.223	0.223	0.223	0.223	0.223
2011	EBS	NBS	0.247	0.247	0.247	0.247	0.247	0.372	0.517	0.659	0.777	0.777	0.777	0.777	0.777
2011	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.552	0.552	0.552	0.552	0.552
2011	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.448	0.448	0.448	0.448	0.448
2012	EBS	EBS	0.823	0.823	0.823	0.823	0.823	0.681	0.494	0.309	0.170	0.170	0.170	0.170	0.170
2012	EBS	NBS	0.177	0.177	0.177	0.177	0.177	0.319	0.506	0.691	0.830	0.830	0.830	0.830	0.830
2012	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.531	0.531	0.531	0.531	0.531
2012	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.469	0.469	0.469	0.469	0.469
2013	EBS	EBS	0.853	0.853	0.853	0.853	0.853	0.724	0.542	0.349	0.195	0.195	0.195	0.195	0.195
2013	EBS	NBS	0.147	0.147	0.147	0.147	0.147	0.276	0.458	0.651	0.805	0.805	0.805	0.805	0.805
2013	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.474	0.474	0.474	0.474	0.474
2013	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.526	0.526	0.526	0.526	0.526
2014	EBS	EBS	0.837	0.837	0.837	0.837	0.837	0.707	0.530	0.346	0.198	0.198	0.198	0.198	0.198
2014	EBS	NBS	0.163	0.163	0.163	0.163	0.163	0.293	0.470	0.654	0.802	0.802	0.802	0.802	0.802
2014	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.496	0.496	0.496	0.496	0.496
2014	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.504	0.504	0.504	0.504	0.504
2015	EBS	EBS	0.843	0.843	0.843	0.843	0.843	0.696	0.494	0.294	0.151	0.151	0.151	0.151	0.151
2015	EBS	NBS	0.157	0.157	0.157	0.157	0.157	0.304	0.506	0.706	0.849	0.849	0.849	0.849	0.849
2015	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.530	0.530	0.530	0.530	0.530
2015	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.470	0.470	0.470	0.470	0.470
2016	EBS	EBS	0.484	0.484	0.484	0.484	0.484	0.383	0.291	0.213	0.152	0.152	0.152	0.152	0.152
2016	EBS	NBS	0.516	0.516	0.516	0.516	0.516	0.617	0.709	0.787	0.848	0.848	0.848	0.848	0.848
2016	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.630	0.630	0.630	0.630	0.630
2016	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.370	0.370	0.370	0.370	0.370

Table 2.1.17b. Migration rates (Model 18.2).

Year	Source	Dest.	0	1	2	3	4	5	6	7	8	9	10	11	12
2007	EBS	EBS	0.959	0.959	0.959	0.959	0.959	0.917	0.838	0.709	0.535	0.535	0.535	0.535	0.535
2007	EBS	NBS	0.041	0.041	0.041	0.041	0.041	0.083	0.162	0.291	0.465	0.465	0.465	0.465	0.465
2007	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.890	0.890	0.890	0.890	0.890
2007	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.110	0.110	0.110	0.110	0.110
2008	EBS	EBS	0.943	0.943	0.943	0.943	0.943	0.894	0.811	0.685	0.524	0.524	0.524	0.524	0.524
2008	EBS	NBS	0.057	0.057	0.057	0.057	0.057	0.106	0.189	0.315	0.476	0.476	0.476	0.476	0.476
2008	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.768	0.768	0.768	0.768	0.768
2008	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.232	0.232	0.232	0.232	0.232
2009	EBS	EBS	0.996	0.996	0.996	0.996	0.996	0.980	0.909	0.663	0.281	0.281	0.281	0.281	0.281
2009	EBS	NBS	0.004	0.004	0.004	0.004	0.004	0.020	0.091	0.337	0.719	0.719	0.719	0.719	0.719
2009	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.763	0.763	0.763	0.763	0.763
2009	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.237	0.237	0.237	0.237	0.237
2010	EBS	EBS	0.725	0.725	0.725	0.725	0.725	0.697	0.668	0.638	0.606	0.606	0.606	0.606	0.606
2010	EBS	NBS	0.275	0.275	0.275	0.275	0.275	0.303	0.332	0.362	0.394	0.394	0.394	0.394	0.394
2010	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.708	0.708	0.708	0.708	0.708
2010	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.292	0.292	0.292	0.292	0.292
2011	EBS	EBS	0.982	0.982	0.982	0.982	0.982	0.958	0.903	0.792	0.610	0.610	0.610	0.610	0.610
2011	EBS	NBS	0.018	0.018	0.018	0.018	0.018	0.042	0.097	0.208	0.390	0.390	0.390	0.390	0.390
2011	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.880	0.880	0.880	0.880	0.880
2011	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.120	0.120	0.120	0.120	0.120
2012	EBS	EBS	0.970	0.970	0.970	0.970	0.970	0.926	0.827	0.649	0.415	0.415	0.415	0.415	0.415
2012	EBS	NBS	0.030	0.030	0.030	0.030	0.030	0.074	0.173	0.351	0.585	0.585	0.585	0.585	0.585
2012	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.779	0.779	0.779	0.779	0.779
2012	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.221	0.221	0.221	0.221	0.221
2013	EBS	EBS	0.970	0.970	0.970	0.970	0.970	0.925	0.825	0.644	0.410	0.410	0.410	0.410	0.410
2013	EBS	NBS	0.030	0.030	0.030	0.030	0.030	0.075	0.175	0.356	0.590	0.590	0.590	0.590	0.590
2013	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.731	0.731	0.731	0.731	0.731
2013	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.269	0.269	0.269	0.269	0.269
2014	EBS	EBS	0.958	0.958	0.958	0.958	0.958	0.914	0.832	0.697	0.517	0.517	0.517	0.517	0.517
2014	EBS	NBS	0.042	0.042	0.042	0.042	0.042	0.086	0.168	0.303	0.483	0.483	0.483	0.483	0.483
2014	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.661	0.661	0.661	0.661	0.661
2014	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.339	0.339	0.339	0.339	0.339
2015	EBS	EBS	0.866	0.866	0.866	0.866	0.866	0.742	0.561	0.363	0.202	0.202	0.202	0.202	0.202
2015	EBS	NBS	0.134	0.134	0.134	0.134	0.134	0.258	0.439	0.637	0.798	0.798	0.798	0.798	0.798
2015	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.924	0.924	0.924	0.924	0.924
2015	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.076	0.076	0.076	0.076	0.076
2016	EBS	EBS	0.738	0.738	0.738	0.738	0.738	0.671	0.597	0.518	0.438	0.438	0.438	0.438	0.438
2016	EBS	NBS	0.262	0.262	0.262	0.262	0.262	0.329	0.403	0.482	0.562	0.562	0.562	0.562	0.562
2016	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.989	0.989	0.989	0.989	0.989
2016	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.011	0.011	0.011	0.011	0.011

Table 2.1.17c. Migration rates (Model 18.3).

Year	Source	Dest.	0	1	2	3	4	5	6	7	8	9	10	11	12
2007	EBS	EBS	0.737	0.737	0.737	0.737	0.737	0.631	0.510	0.389	0.280	0.280	0.280	0.280	0.280
2007	EBS	NBS	0.263	0.263	0.263	0.263	0.263	0.369	0.490	0.611	0.720	0.720	0.720	0.720	0.720
2007	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.711	0.711	0.711	0.711	0.711
2007	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.289	0.289	0.289	0.289	0.289
2008	EBS	EBS	0.643	0.643	0.643	0.643	0.643	0.536	0.426	0.323	0.235	0.235	0.235	0.235	0.235
2008	EBS	NBS	0.357	0.357	0.357	0.357	0.357	0.464	0.574	0.677	0.765	0.765	0.765	0.765	0.765
2008	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.610	0.610	0.610	0.610	0.610
2008	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.390	0.390	0.390	0.390	0.390
2009	EBS	EBS	0.978	0.978	0.978	0.978	0.978	0.925	0.772	0.482	0.203	0.203	0.203	0.203	0.203
2009	EBS	NBS	0.022	0.022	0.022	0.022	0.022	0.075	0.228	0.518	0.797	0.797	0.797	0.797	0.797
2009	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.598	0.598	0.598	0.598	0.598
2009	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.402	0.402	0.402	0.402	0.402
2010	EBS	EBS	0.818	0.818	0.818	0.818	0.818	0.712	0.578	0.430	0.295	0.295	0.295	0.295	0.295
2010	EBS	NBS	0.182	0.182	0.182	0.182	0.182	0.288	0.422	0.570	0.705	0.705	0.705	0.705	0.705
2010	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.653	0.653	0.653	0.653	0.653
2010	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.347	0.347	0.347	0.347	0.347
2011	EBS	EBS	0.793	0.793	0.793	0.793	0.793	0.674	0.527	0.375	0.245	0.245	0.245	0.245	0.245
2011	EBS	NBS	0.207	0.207	0.207	0.207	0.207	0.326	0.473	0.625	0.755	0.755	0.755	0.755	0.755
2011	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.598	0.598	0.598	0.598	0.598
2011	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.402	0.402	0.402	0.402	0.402
2012	EBS	EBS	0.842	0.842	0.842	0.842	0.842	0.711	0.532	0.345	0.195	0.195	0.195	0.195	0.195
2012	EBS	NBS	0.158	0.158	0.158	0.158	0.158	0.289	0.468	0.655	0.805	0.805	0.805	0.805	0.805
2012	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.583	0.583	0.583	0.583	0.583
2012	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.417	0.417	0.417	0.417	0.417
2013	EBS	EBS	0.861	0.861	0.861	0.861	0.861	0.735	0.555	0.359	0.201	0.201	0.201	0.201	0.201
2013	EBS	NBS	0.139	0.139	0.139	0.139	0.139	0.265	0.445	0.641	0.799	0.799	0.799	0.799	0.799
2013	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.527	0.527	0.527	0.527	0.527
2013	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.473	0.473	0.473	0.473	0.473
2014	EBS	EBS	0.847	0.847	0.847	0.847	0.847	0.719	0.542	0.354	0.203	0.203	0.203	0.203	0.203
2014	EBS	NBS	0.153	0.153	0.153	0.153	0.153	0.281	0.458	0.646	0.797	0.797	0.797	0.797	0.797
2014	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.539	0.539	0.539	0.539	0.539
2014	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.461	0.461	0.461	0.461	0.461
2015	EBS	EBS	0.846	0.846	0.846	0.846	0.846	0.703	0.504	0.305	0.159	0.159	0.159	0.159	0.159
2015	EBS	NBS	0.154	0.154	0.154	0.154	0.154	0.297	0.496	0.695	0.841	0.841	0.841	0.841	0.841
2015	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.552	0.552	0.552	0.552	0.552
2015	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.448	0.448	0.448	0.448	0.448
2016	EBS	EBS	0.514	0.514	0.514	0.514	0.514	0.415	0.322	0.241	0.176	0.176	0.176	0.176	0.176
2016	EBS	NBS	0.486	0.486	0.486	0.486	0.486	0.585	0.678	0.759	0.824	0.824	0.824	0.824	0.824
2016	NBS	EBS	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.689	0.689	0.689	0.689	0.689
2016	NBS	NBS	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.311	0.311	0.311	0.311	0.311

Table 2.1.18. Catchability.

Area	Year	M16.6	M16.6a	M16.6b	M16.6c	M16.6d	M16.6e	M16.6f	M16.6g	M16.6h	M17.2	M17.6	M18.1	M18.2	M18.3	M18.4	M18.5
EBS	1982	0.929		0.995	0.943	0.913	0.872	0.904	0.920	0.931	1.043	1.316	1.240	1.074	1.008	0.816	1.260
EBS	1983	0.929		0.995	0.943	0.913	0.951	1.070	0.998	1.101	1.043	1.334	1.240	1.074	1.008	0.816	1.348
EBS	1984	0.929		0.995	0.943	0.913	0.867	1.001	0.911	1.030	1.043	1.244	1.240	1.074	1.008	0.816	1.312
EBS	1985	0.929		0.995	0.943	0.913	0.954	0.917	0.997	0.944	1.043	1.276	1.240	1.074	1.008	0.816	1.267
EBS	1986	0.929		0.995	0.943	0.913	0.954	1.037	0.997	1.067	1.043	1.288	1.240	1.074	1.008	0.816	1.331
EBS	1987	0.929	*0.994*	*0.990*	0.943	0.913	0.948	1.008	0.988	1.038	1.043	1.207	1.240	1.074	1.008	0.816	1.316
EBS	1988	0.929	*0.994*	*0.990*	0.943	0.913	0.937	0.958	0.974	0.986	1.043	1.145	1.240	1.074	1.008	0.816	1.290
EBS	1989	0.929	*0.994*	*0.990*	0.943	0.913	0.734	0.880	0.760	0.906	1.043	0.984	1.240	1.074	1.008	0.816	1.246
EBS	1990	0.929	*0.994*	*0.990*	0.943	0.913	0.836	0.898	0.872	0.924	1.043	1.012	1.240	1.074	1.008	0.816	1.256
EBS	1991	0.929	*0.994*	*0.990*	0.943	0.913	0.824	0.891	0.858	0.917	1.043	1.051	1.240	1.074	1.008	0.816	1.252
EBS	1992	0.929	*0.994*	*0.990*	0.943	0.913	0.897	0.997	0.935	1.026	1.043	1.115	1.240	1.074	1.008	0.816	1.310
EBS	1993	0.929	*0.994*	*0.990*	0.943	0.913	0.973	0.944	1.015	0.972	1.043	1.274	1.240	1.074	1.008	0.816	1.282
EBS	1994	0.929	*0.994*	*0.990*	0.943	0.913	1.134	0.909	1.188	0.936	1.043	1.499	1.240	1.074	1.008	0.816	1.263
EBS	1995	0.929	*0.994*	*0.990*	0.943	0.913	1.026	0.949	1.071	0.977	1.043	1.455	1.240	1.074	1.008	0.816	1.284
EBS	1996	0.929	*0.994*	*0.990*	0.943	0.913	0.973	0.966	1.014	0.995	1.043	1.359	1.240	1.074	1.008	0.816	1.294
EBS	1997	0.929	*0.994*	*0.990*	0.943	0.913	0.879	0.946	0.915	0.974	1.043	1.242	1.240	1.074	1.008	0.816	1.283
EBS	1998	0.929	*0.994*	*0.990*	0.943	0.913	0.854	1.020	0.890	1.050	1.043	1.178	1.240	1.074	1.008	0.816	1.322
EBS	1999	0.929	*0.994*	*0.990*	0.943	0.913	0.878	0.929	0.913	0.957	1.043	1.152	1.240	1.074	1.008	0.816	1.274
EBS	2000	0.929	*0.994*	*0.990*	0.943	0.913	0.831	0.951	0.863	0.979	1.043	1.124	1.240	1.074	1.008	0.816	1.286
EBS	2001	0.929	*0.994*	*0.990*	0.943	0.913	1.133	0.982	1.182	1.011	1.043	1.251	1.240	1.074	1.008	0.816	1.302
EBS	2002	0.929	*0.994*	*0.990*	0.943	0.913	0.883	0.935	0.915	0.962	1.043	1.151	1.240	1.074	1.008	0.816	1.277
EBS	2003	0.929	*0.994*	*0.990*	0.943	0.913	0.921	1.030	0.954	1.060	1.043	1.127	1.240	1.074	1.008	0.816	1.328
EBS	2004	0.929	*0.994*	*0.990*	0.943	0.913	0.873	0.949	0.899	0.977	1.043	1.074	1.240	1.074	1.008	0.816	1.284
EBS	2005	0.929	*0.994*	*0.990*	0.943	0.913	0.978	0.958	1.013	0.986	1.043	1.102	1.240	1.074	1.008	0.816	1.289
EBS	2006	0.929	*0.994*	*0.990*	0.943	0.913	1.010	0.915	1.036	0.942	1.043	1.073	1.240	1.074	1.008	0.816	1.266
EBS	2007	0.929	*0.994*	*0.990*	0.943	0.913	0.959	0.921	0.999	0.948	1.043	1.084	1.240	1.074	1.008	0.816	1.269
EBS	2008	0.929	*0.994*	*0.990*	0.943	0.913	0.805	0.932	0.837	0.960	1.043	1.017	1.240	1.074	1.008	0.816	1.275
EBS	2009	0.929	*0.994*	*0.990*	0.943	0.913	0.853	0.845	0.891	0.870	1.043	1.036	1.240	1.074	1.008	0.816	1.226
EBS	2010	0.929	*0.994*	*0.990*	0.943	0.913	0.942	0.996	0.983	1.025	1.043	1.178	1.240	1.074	1.008	0.816	1.310
EBS	2011	0.929	*0.994*	*0.990*	0.943	0.913	0.972	0.893	1.010	0.919	1.043	1.230	1.240	1.074	1.008	0.816	1.253
EBS	2012	0.929	*0.994*	*0.990*	0.943	0.913	0.965	0.910	1.000	0.937	1.043	1.244	1.240	1.074	1.008	0.816	1.263
EBS	2013	0.929	*0.994*	*0.990*	0.943	0.913	0.871	0.910	0.900	0.937	1.043	1.247	1.240	1.074	1.008	0.816	1.263
EBS	2014	0.929	*0.994*	*0.990*	0.943	0.913	0.980	0.921	1.009	0.948	1.043	1.351	1.240	1.074	1.008	0.816	1.269
EBS	2015	0.929	*0.994*	*0.990*	0.943	0.913	0.975	0.964	1.005	0.993	1.043	1.375	1.240	1.074	1.008	0.816	1.293
EBS	2016	0.929	*0.994*	*0.990*	0.943	0.913	0.930	0.994	0.956	1.023	1.043	1.300	1.240	1.074	1.008	0.816	1.309
EBS	2017	0.929	*0.994*	*0.990*	0.943	0.913	0.785	0.910	0.815	0.937	1.043	1.171	1.240	1.074	1.008	0.816	1.263
NBS	2010								0.013	0.013			0.457	1.030			0.526
NBS	2017								0.261	0.272			0.457	1.030			0.526

Table 2.1.19a. Base values of fishery selectivity.

Age	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000
2	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.008	0.012	0.003	0.003	0.003	0.003	0.003
3	0.032	0.032	0.032	0.032	0.034	0.032	0.032	0.035	0.035	0.063	0.067	0.030	0.031	0.031	0.032	0.030
4	0.292	0.289	0.288	0.290	0.300	0.291	0.290	0.314	0.313	0.322	0.297	0.263	0.277	0.292	0.293	0.262
5	0.838	0.832	0.833	0.835	0.841	0.837	0.836	0.853	0.852	0.796	0.743	0.806	0.822	0.840	0.838	0.801
6	0.985	0.984	0.984	0.984	0.985	0.985	0.984	0.987	0.987	0.982	0.976	0.980	0.982	0.985	0.985	0.979
7	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	0.999	1.000	0.999	0.998	0.999	0.999	0.999	0.998
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	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 2.1.19b. Base values of EBS survey selectivity.

Age	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
1	0.477	0.493	0.484	0.481	0.479	0.475	0.482	0.482	0.487	0.414	0.467	0.479	0.479	0.482	0.455	0.489
2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.907	1.000	1.000	1.000	1.000	1.000	1.000
3	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
4	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
5	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
7	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
8	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
9	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
11	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
12	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
13	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
14	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
15	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
16	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
17	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
18	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
19	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
20	1.000	1.000	1.000	1.000	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 2.1.19c. NBS survey selectivity.

Age	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
0								0.000	0.000			0.001	0.002			0.002
1								0.294	0.311			0.577	0.406			0.552
2								0.999	0.999			1.000	0.996			0.999
3								1.000	1.000			1.000	1.000			1.000
4								1.000	1.000			1.000	1.000			1.000
5								1.000	1.000			1.000	1.000			1.000
6								1.000	1.000			1.000	1.000			1.000
7								1.000	1.000			1.000	1.000			1.000
8								1.000	1.000			1.000	1.000			1.000
9								1.000	1.000			1.000	1.000			1.000
10								1.000	1.000			1.000	1.000			1.000
11								1.000	1.000			1.000	1.000			1.000
12								1.000	1.000			1.000	1.000			1.000
13								1.000	1.000			1.000	1.000			1.000
14								1.000	1.000			1.000	1.000			1.000
15								1.000	1.000			1.000	1.000			1.000
16								1.000	1.000			1.000	1.000			1.000
17								1.000	1.000			1.000	1.000			1.000
18								1.000	1.000			1.000	1.000			1.000
19								1.000	1.000			1.000	1.000			1.000
20								1.000	1.000			1.000	1.000			1.000

Table 2.1.19d. Time-varying fishery selectivity in Model 17.2.

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	0.006	0.070	0.368	0.873	1.000	1.000	1.000	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	0.000	0.000	0.003	0.054	0.343	0.879	1.000	1.000	1.000	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	0.000	0.000	0.009	0.110	0.538	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
1980	0.000	0.000	0.007	0.076	0.376	0.870	1.000	1.000	1.000	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	0.000	0.010	0.079	0.325	0.756	1.000	1.000	1.000	1.000	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	0.000	0.000	0.002	0.023	0.166	0.583	0.984	1.000	1.000	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	0.000	0.000	0.004	0.032	0.167	0.509	0.912	1.000	1.000	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	0.000	0.002	0.012	0.058	0.197	0.476	0.817	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
1985	0.000	0.000	0.004	0.054	0.335	0.865	1.000	1.000	1.000	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	0.000	0.001	0.010	0.075	0.317	0.752	1.000	1.000	1.000	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	0.000	0.000	0.006	0.054	0.267	0.708	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
1988	0.000	0.007	0.049	0.205	0.538	0.905	1.000	1.000	1.000	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	0.000	0.003	0.019	0.083	0.261	0.576	0.899	1.000	1.000	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	0.000	0.001	0.007	0.038	0.149	0.407	0.766	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
1991	0.000	0.000	0.006	0.064	0.328	0.814	1.000	1.000	1.000	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	0.000	0.000	0.002	0.052	0.405	0.968	1.000	1.000	1.000	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	0.000	0.001	0.013	0.105	0.436	0.902	1.000	1.000	1.000	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	0.000	0.001	0.015	0.107	0.411	0.860	1.000	1.000	1.000	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	0.000	0.000	0.009	0.089	0.423	0.913	1.000	1.000	1.000	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	0.000	0.001	0.007	0.051	0.221	0.587	0.948	1.000	1.000	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	0.000	0.001	0.010	0.063	0.254	0.632	0.967	1.000	1.000	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	0.000	0.000	0.005	0.053	0.285	0.760	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
1999	0.000	0.000	0.004	0.056	0.346	0.879	1.000	1.000	1.000	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	0.000	0.000	0.000	0.017	0.207	0.786	1.000	1.000	1.000	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	0.000	0.000	0.001	0.025	0.262	0.855	1.000	1.000	1.000	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	0.000	0.000	0.002	0.055	0.401	0.959	1.000	1.000	1.000	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	0.000	0.000	0.001	0.040	0.354	0.944	1.000	1.000	1.000	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	0.000	0.000	0.001	0.048	0.457	0.999	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2005	0.000	0.000	0.001	0.056	0.497	1.000	1.000	1.000	1.000	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	0.000	0.000	0.000	0.022	0.334	0.982	1.000	1.000	1.000	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	0.000	0.000	0.001	0.019	0.162	0.609	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
2008	0.000	0.000	0.001	0.023	0.226	0.782	1.000	1.000	1.000	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	0.000	0.000	0.000	0.010	0.244	0.950	1.000	1.000	1.000	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	0.000	0.000	0.004	0.044	0.247	0.701	1.000	1.000	1.000	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	0.000	0.001	0.007	0.052	0.231	0.613	0.965	1.000	1.000	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	0.000	0.000	0.000	0.014	0.161	0.669	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
2013	0.000	0.000	0.010	0.112	0.528	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
2014	0.000	0.000	0.004	0.054	0.325	0.845	1.000	1.000	1.000	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	0.000	0.000	0.003	0.043	0.262	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
2016	0.000	0.000	0.005	0.055	0.305	0.796	1.000	1.000	1.000	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	0.000	0.000	0.000	0.005	0.125	0.706	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

Table 2.1.19e. Time-varying fishery selectivity in Model 17.6.

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	0.042	0.176	0.455	0.807	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
1978	0.000	0.000	0.002	0.025	0.190	0.649	1.000	1.000	1.000	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	0.000	0.000	0.006	0.067	0.358	0.864	1.000	1.000	1.000	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	0.000	0.000	0.005	0.051	0.274	0.736	1.000	1.000	1.000	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	0.000	0.008	0.063	0.268	0.669	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
1982	0.000	0.000	0.001	0.017	0.134	0.517	0.958	1.000	1.000	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	0.000	0.000	0.002	0.022	0.129	0.440	0.866	1.000	1.000	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	0.000	0.002	0.013	0.057	0.188	0.449	0.781	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
1985	0.000	0.000	0.003	0.052	0.334	0.869	1.000	1.000	1.000	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	0.000	0.001	0.008	0.062	0.278	0.703	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
1987	0.000	0.000	0.004	0.040	0.207	0.596	0.967	1.000	1.000	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	0.000	0.006	0.046	0.197	0.530	0.904	1.000	1.000	1.000	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	0.000	0.002	0.015	0.077	0.266	0.610	0.937	1.000	1.000	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	0.000	0.001	0.005	0.031	0.124	0.350	0.692	0.965	1.000	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	0.000	0.000	0.006	0.057	0.282	0.734	1.000	1.000	1.000	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	0.000	0.000	0.002	0.044	0.340	0.908	1.000	1.000	1.000	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	0.000	0.001	0.013	0.096	0.391	0.846	1.000	1.000	1.000	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	0.000	0.002	0.016	0.102	0.371	0.793	1.000	1.000	1.000	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	0.000	0.001	0.010	0.091	0.396	0.869	1.000	1.000	1.000	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	0.000	0.001	0.007	0.049	0.218	0.583	0.947	1.000	1.000	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	0.000	0.001	0.008	0.053	0.223	0.582	0.941	1.000	1.000	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	0.000	0.000	0.004	0.041	0.222	0.643	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
1999	0.000	0.000	0.003	0.043	0.268	0.762	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
2000	0.000	0.000	0.000	0.010	0.148	0.684	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
2001	0.000	0.000	0.001	0.018	0.164	0.630	1.000	1.000	1.000	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	0.000	0.000	0.004	0.056	0.348	0.880	1.000	1.000	1.000	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	0.000	0.000	0.002	0.040	0.331	0.912	1.000	1.000	1.000	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	0.000	0.000	0.001	0.047	0.421	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
2005	0.000	0.000	0.002	0.052	0.419	0.979	1.000	1.000	1.000	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	0.000	0.000	0.000	0.018	0.280	0.937	1.000	1.000	1.000	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	0.000	0.000	0.001	0.012	0.123	0.534	0.982	1.000	1.000	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	0.000	0.000	0.001	0.016	0.161	0.644	1.000	1.000	1.000	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	0.000	0.000	0.000	0.005	0.210	0.967	1.000	1.000	1.000	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	0.000	0.000	0.007	0.056	0.259	0.677	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
2011	0.000	0.001	0.013	0.083	0.322	0.735	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
2012	0.000	0.000	0.000	0.008	0.105	0.520	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
2013	0.000	0.001	0.013	0.125	0.523	0.973	1.000	1.000	1.000	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	0.000	0.000	0.006	0.066	0.342	0.836	1.000	1.000	1.000	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	0.000	0.000	0.006	0.058	0.296	0.764	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
2016	0.000	0.000	0.006	0.080	0.426	0.935	1.000	1.000	1.000	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	0.000	0.000	0.000	0.006	0.087	0.489	0.984	1.000	1.000	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 2.1.19f. Time-varying survey selectivity in Model 17.6.

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1982	0.000	0.218	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.388	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.230	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.514	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.260	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.421	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.231	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.158	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.492	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.394	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.958	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.631	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.302	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.211	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.179	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.313	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.189	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.209	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.350	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2001	0.000	0.938	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.474	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.550	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.401	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.535	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.663	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.503	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.658	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.676	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	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
2014	0.000	0.520	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	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	0.000	0.772	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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	0.000	0.265	1.000	1.000	1.000	1.000	1.000	1.000	1.000	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 2.1.20. Recruitment (p. 1 of 4).

	16.6		16.6a		16.6b		16.6c	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	1,060,480	264,211	820,881	283,244	926,594	242,798	996,992	248,457
1978	672,148	188,012	634,774	244,892	594,186	169,572	645,366	176,654
1979	680,408	124,504	409,622	143,143	605,466	118,982	652,091	118,415
1980	314,763	54,722	186,448	80,752	281,199	53,116	303,722	52,699
1981	173,532	31,321	598,493	125,801	156,040	30,143	169,188	30,479
1982	922,404	108,027	507,754	117,848	829,440	112,063	888,805	104,847
1983	235,725	39,078	375,131	97,457	212,901	37,455	227,947	37,763
1984	912,156	102,669	712,704	107,950	833,662	102,901	878,523	99,554
1985	346,865	46,025	362,321	54,214	302,413	43,409	335,505	44,579
1986	231,572	31,713	191,560	30,832	200,266	30,971	224,745	30,832
1987	96,734	19,599	113,428	23,158	110,714	23,239	95,629	19,207
1988	268,840	35,657	264,822	38,454	267,919	38,691	263,558	35,031
1989	724,715	79,214	642,424	77,926	648,807	77,589	706,541	77,859
1990	593,602	65,758	546,436	66,104	547,648	65,685	580,114	64,730
1991	379,553	45,050	346,836	44,499	348,239	44,303	374,450	44,659
1992	889,717	87,178	818,117	90,737	821,554	89,772	879,118	87,265
1993	368,233	39,817	337,962	40,425	338,585	40,001	363,963	39,711
1994	300,691	33,229	275,048	33,512	275,465	33,194	299,389	33,444
1995	274,890	31,168	250,645	31,140	252,535	30,993	284,351	32,325
1996	761,012	77,339	704,890	81,483	709,748	80,698	754,947	77,777
1997	340,470	37,308	313,409	38,241	312,603	37,728	336,967	37,364
1998	328,955	34,858	304,017	35,471	305,500	35,247	348,109	36,760
1999	686,149	65,889	634,180	69,167	637,575	68,526	688,778	66,270
2000	524,642	51,095	481,073	52,980	481,052	52,247	509,192	49,767
2001	236,417	24,833	217,351	25,099	217,974	24,896	230,975	24,220
2002	312,664	31,395	290,988	32,541	290,903	32,127	293,139	29,782
2003	264,148	26,622	246,737	27,482	247,366	27,221	250,573	25,295
2004	222,208	23,354	206,474	23,747	206,406	23,473	208,951	22,006
2005	299,311	30,774	274,118	31,038	275,494	30,799	280,538	28,849
2006	929,719	90,292	858,185	93,927	863,479	93,072	861,777	83,875
2007	405,265	43,773	371,944	43,906	373,519	43,572	380,159	40,921
2008	1,269,140	126,733	1,153,530	127,617	1,161,040	126,586	1,179,100	118,420
2009	160,912	23,567	150,627	22,476	149,372	22,224	149,998	21,956
2010	746,163	78,508	683,445	78,280	689,142	77,908	707,732	75,007
2011	1,090,310	118,450	991,191	117,145	1,000,190	116,576	1,039,760	114,177
2012	464,148	54,708	425,251	53,350	430,081	53,351	437,766	52,322
2013	1,034,000	115,642	940,467	112,868	950,586	112,318	1,009,070	114,293
2014	158,380	22,994	142,282	21,504	143,308	21,481	157,994	22,849
2015	209,793	29,965	184,967	27,671	188,514	27,913	202,190	29,209
2016	120,010	30,278	106,054	27,753	106,654	28,112	119,246	29,804
2017	500,400	50,156	456,203	50,014	460,558	50,546	485,137	48,800
2018	500,400	50,156	456,203	50,014	460,558	50,546	485,137	48,800
2019	500,400	50,156	456,203	50,014	460,558	50,546	485,137	48,800

Table 2.1.20. Recruitment (p. 2 of 4).

	16.6d		16.6e		16.6f		16.6g	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	1,085,490	268,895	1,108,020	292,579	1,004,080	250,753	971,896	255,308
1978	694,174	192,519	698,738	203,661	642,189	178,601	648,005	181,871
1979	710,272	128,302	705,537	139,701	647,962	118,972	649,875	126,244
1980	327,000	56,267	327,951	61,875	304,083	52,854	306,172	56,820
1981	182,019	32,530	179,954	34,646	165,382	29,971	167,100	31,894
1982	946,880	111,035	952,874	126,640	870,111	103,152	876,786	116,169
1983	252,226	41,104	243,105	42,740	225,217	37,461	229,262	39,722
1984	930,010	104,923	933,724	115,970	873,299	98,958	865,614	107,133
1985	357,447	47,533	356,788	50,675	331,216	44,243	339,716	47,691
1986	242,142	32,815	241,185	34,948	225,337	30,916	227,711	32,739
1987	102,101	20,289	104,618	21,595	96,396	19,430	99,000	20,169
1988	269,673	35,899	292,995	41,166	266,547	35,401	271,322	37,885
1989	747,629	81,541	738,761	88,821	703,586	77,439	682,112	81,567
1990	607,029	67,303	600,734	72,430	570,714	63,673	564,585	67,408
1991	398,032	47,031	382,735	48,762	365,587	43,610	358,491	45,232
1992	914,580	89,537	899,763	97,424	859,789	84,818	841,106	90,457
1993	370,524	40,275	372,678	43,878	354,620	38,553	351,411	40,982
1994	305,418	33,795	307,050	36,818	289,979	32,217	287,710	34,244
1995	275,850	31,427	282,589	34,556	265,807	30,249	263,952	32,088
1996	788,871	80,107	784,111	88,388	732,218	75,023	729,942	82,064
1997	353,982	38,665	349,210	41,583	327,972	36,179	329,094	39,006
1998	327,986	35,126	337,104	38,524	319,474	33,979	317,126	36,143
1999	691,125	66,571	696,801	73,484	662,179	64,160	654,373	69,074
2000	540,244	52,759	531,839	56,740	506,162	49,747	505,000	53,855
2001	239,256	25,316	241,425	27,144	228,962	24,189	230,371	25,868
2002	328,315	33,052	318,115	34,529	302,917	30,678	303,903	33,021
2003	273,587	27,717	267,741	29,037	256,865	26,093	256,719	27,868
2004	240,582	25,317	223,462	25,116	216,922	22,975	214,958	24,110
2005	315,228	32,627	303,529	33,694	292,312	30,320	288,476	31,973
2006	974,146	95,187	961,670	103,981	903,958	88,962	892,564	96,533
2007	419,665	45,583	418,870	49,496	394,978	43,098	387,445	45,568
2008	1,315,240	131,733	1,303,030	145,203	1,234,530	124,980	1,199,990	132,626
2009	170,735	24,980	163,502	25,163	156,010	22,989	172,877	25,325
2010	762,905	80,379	766,205	89,426	728,662	77,626	720,219	83,425
2011	1,106,230	120,181	1,125,540	137,205	1,060,930	116,792	1,078,990	130,271
2012	455,452	54,054	480,326	62,599	452,447	53,846	479,580	61,642
2013	1,074,660	119,819	1,075,320	136,720	1,006,850	113,926	1,041,700	131,580
2014	164,922	23,982	165,867	26,164	154,128	22,529	140,452	21,900
2015	221,190	31,322	223,975	35,177	205,401	29,527	215,761	30,210
2016	149,035	35,201	133,123	34,845	118,564	29,972	80,357	25,223
2017	514,662	51,452	513,577	56,818	484,749	48,862	483,362	53,352
2018	514,662	51,452	513,577	56,818	484,749	48,862	483,362	53,352
2019	514,662	51,452	513,577	56,818	484,749	48,862	483,362	53,352

Table 2.1.20. Recruitment (p. 3 of 4).

	16.6h		17.2		17.6		18.1	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	909,234	226,863	664,653	146,389	472,907	94,940	919,599	243,154
1978	611,931	164,256	693,170	146,296	456,997	78,839	550,366	152,434
1979	613,372	110,660	680,782	123,833	439,556	61,198	517,630	99,447
1980	291,278	49,826	316,953	60,538	129,955	24,843	249,373	44,714
1981	157,388	28,298	290,525	51,495	155,420	23,731	133,838	25,217
1982	819,683	97,222	864,501	131,889	613,851	67,853	697,482	89,837
1983	217,044	35,597	300,512	53,508	196,308	27,603	181,679	31,328
1984	825,755	93,556	818,100	119,458	552,068	58,440	697,154	87,102
1985	321,269	42,479	456,316	67,716	315,967	34,445	262,805	37,532
1986	216,393	29,510	284,039	42,014	183,506	21,207	168,982	25,125
1987	92,703	18,459	162,353	26,100	81,484	12,516	73,042	15,034
1988	251,395	33,241	300,593	41,698	236,788	25,834	194,942	27,983
1989	661,958	72,685	662,813	84,757	468,391	44,327	545,088	65,518
1990	546,223	60,489	591,692	75,149	426,293	39,574	458,796	55,506
1991	348,641	41,290	359,625	47,692	223,829	23,924	296,748	37,851
1992	818,415	80,456	842,366	102,451	584,662	49,473	695,051	75,994
1993	340,518	36,773	334,609	44,276	243,493	23,273	290,759	34,238
1994	276,679	30,584	276,309	35,800	203,296	19,458	237,254	28,539
1995	252,699	28,653	263,508	34,708	199,931	20,292	217,299	26,560
1996	694,613	71,123	660,066	84,213	529,358	50,578	584,723	65,328
1997	314,657	34,589	455,929	59,875	285,406	28,703	260,357	30,924
1998	305,515	32,439	418,173	54,486	247,153	25,782	249,428	28,940
1999	632,395	61,382	723,635	89,459	507,984	45,498	513,519	54,859
2000	488,588	48,024	492,080	62,037	336,776	30,345	393,489	42,529
2001	221,755	23,405	202,459	26,765	143,024	15,029	179,285	20,597
2002	293,701	29,774	341,839	42,375	274,949	25,362	234,095	26,169
2003	249,804	25,401	299,896	37,825	246,325	22,764	199,059	22,466
2004	211,469	22,345	219,403	28,623	145,187	13,844	171,238	20,051
2005	281,690	29,181	260,133	35,178	185,821	16,655	234,992	27,090
2006	853,257	84,119	814,814	101,537	630,672	51,370	748,246	83,015
2007	371,456	40,420	492,296	65,297	309,179	31,844	333,321	40,319
2008	1,155,360	116,266	1,131,760	140,996	833,649	69,135	1,013,420	116,087
2009	167,037	23,375	160,546	28,734	102,661	16,515	147,530	22,112
2010	693,929	73,558	721,144	97,053	481,076	43,422	603,306	72,337
2011	1,029,440	112,586	1,067,850	147,658	686,648	60,058	905,055	110,531
2012	456,332	53,714	517,436	79,508	287,412	31,866	410,427	53,417
2013	985,053	111,082	999,495	143,966	621,083	65,162	917,186	115,423
2014	131,955	19,090	169,634	32,856	129,277	18,972	131,911	20,250
2015	202,157	25,583	198,907	36,718	102,059	16,417	216,227	29,654
2016	72,280	22,053	134,675	33,583	205,260	99,156	69,564	21,582
2017	464,138	46,969	495,128	63,763	340,172	28,872	389,840	43,743
2018	464,138	46,969	495,128	63,763	340,172	28,872	389,840	43,743
2019	464,138	46,969	495,128	63,763	340,172	28,872	389,840	43,743

Table 2.1.20. Recruitment (p. 4 of 4).

	18.2		18.3		18.4		18.5	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	985,555	253,376	983,901	241,016	1,450,070	368,082	866,951	208,389
1978	611,829	170,954	626,537	173,446	876,251	249,812	499,690	128,974
1979	597,943	111,750	638,754	114,967	878,441	157,420	475,434	91,491
1980	279,432	49,363	294,493	50,641	401,735	68,647	226,405	41,442
1981	152,071	28,059	161,572	28,904	225,761	39,752	127,909	24,131
1982	798,848	98,164	866,308	98,480	1,195,760	130,974	645,715	87,655
1983	207,231	35,027	221,818	36,299	310,231	49,403	172,674	30,199
1984	794,114	94,393	861,575	94,088	1,195,420	125,669	661,986	85,852
1985	302,731	41,774	328,337	42,678	444,385	55,153	248,075	35,911
1986	197,040	28,208	219,087	29,516	283,731	36,408	156,584	23,280
1987	83,033	17,008	90,647	18,365	117,868	23,281	71,035	14,249
1988	226,436	31,284	252,730	32,855	328,378	40,597	181,997	25,929
1989	622,458	71,250	679,797	71,918	878,881	86,523	501,048	60,623
1990	521,882	60,457	556,271	59,652	720,225	72,664	421,212	52,080
1991	333,306	41,046	351,970	40,502	471,620	51,853	279,234	35,884
1992	783,024	81,173	812,793	76,467	1,116,350	96,659	659,325	72,622
1993	327,316	37,005	332,376	34,826	464,754	45,613	276,261	32,785
1994	265,385	30,714	265,154	28,687	376,489	37,979	223,888	27,110
1995	242,521	28,566	239,034	26,650	339,049	35,867	204,359	25,266
1996	665,112	70,807	644,096	65,319	941,094	84,034	542,484	61,389
1997	297,992	34,037	282,688	31,451	426,964	42,040	246,842	29,379
1998	284,414	31,609	267,415	29,442	416,567	40,481	242,966	28,072
1999	592,223	59,989	593,274	57,885	897,878	75,200	510,076	54,202
2000	455,133	46,757	405,020	44,228	689,859	58,382	392,387	42,038
2001	205,543	22,598	180,296	21,235	300,538	28,429	176,676	19,912
2002	268,823	28,526	239,997	27,174	381,813	32,791	220,376	23,824
2003	227,994	24,331	207,808	23,097	308,518	27,347	181,386	20,301
2004	193,465	21,482	195,776	20,893	256,462	24,385	153,887	18,149
2005	262,794	28,605	291,141	29,394	342,729	32,549	207,906	24,825
2006	828,642	85,486	964,728	91,454	1,077,350	95,389	659,804	76,145
2007	368,212	42,117	431,572	45,635	480,499	48,660	300,473	37,938
2008	1,149,300	124,560	1,409,180	138,148	1,515,440	138,993	911,698	108,948
2009	163,456	24,130	180,476	26,201	190,663	27,641	137,306	21,181
2010	661,755	75,175	801,614	80,459	925,824	91,792	561,406	70,303
2011	1,003,170	115,800	1,174,930	121,043	1,421,460	145,466	870,296	110,982
2012	439,315	54,358	500,465	56,452	605,436	69,150	399,573	54,151
2013	968,607	114,535	1,017,320	107,171	1,323,750	139,158	864,862	112,545
2014	135,646	20,074	153,903	21,646	197,543	27,895	119,699	19,086
2015	213,189	27,596	201,037	27,910	256,691	35,745	194,555	27,669
2016	78,473	26,205	106,299	26,868	148,862	36,854	63,680	20,338
2017	441,036	46,859	472,760	46,302	619,680	55,818	172,217	43,339
2018	441,036	46,859	472,760	46,302	619,680	55,818	176,314	44,535
2019	441,036	46,859	472,760	46,302	619,680	55,818	170,378	42,783

Table 2.1.21. Depletion (p. 1 of 2).

	16.6		16.6a		16.6b		16.6c		16.6d		16.6e		16.6f		16.6g	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	0.098	0.037	0.107	0.051	0.091	0.035	0.096	0.036	0.103	0.038	0.105	0.040	0.095	0.036	0.097	0.037
1978	0.095	0.037	0.105	0.052	0.088	0.034	0.093	0.036	0.101	0.038	0.103	0.040	0.092	0.035	0.095	0.037
1979	0.097	0.035	0.105	0.051	0.088	0.033	0.094	0.034	0.102	0.037	0.105	0.039	0.093	0.034	0.095	0.036
1980	0.129	0.037	0.131	0.053	0.116	0.035	0.125	0.036	0.135	0.038	0.138	0.040	0.123	0.035	0.125	0.037
1981	0.210	0.042	0.198	0.058	0.189	0.041	0.203	0.040	0.217	0.043	0.222	0.047	0.201	0.040	0.202	0.043
1982	0.365	0.054	0.325	0.070	0.329	0.056	0.351	0.053	0.374	0.055	0.381	0.063	0.349	0.053	0.350	0.058
1983	0.523	0.066	0.452	0.080	0.475	0.070	0.503	0.064	0.533	0.067	0.543	0.076	0.502	0.064	0.502	0.072
1984	0.558	0.062	0.473	0.073	0.510	0.069	0.539	0.061	0.568	0.063	0.577	0.073	0.537	0.061	0.539	0.069
1985	0.634	0.067	0.536	0.079	0.581	0.075	0.614	0.066	0.645	0.067	0.655	0.078	0.611	0.066	0.615	0.075
1986	0.614	0.061	0.537	0.075	0.564	0.070	0.596	0.061	0.625	0.061	0.634	0.072	0.592	0.060	0.597	0.070
1987	0.598	0.056	0.542	0.070	0.552	0.064	0.583	0.055	0.609	0.056	0.617	0.066	0.577	0.055	0.584	0.064
1988	0.634	0.055	0.580	0.069	0.588	0.064	0.619	0.055	0.644	0.055	0.652	0.065	0.611	0.055	0.619	0.064
1989	0.614	0.052	0.563	0.063	0.570	0.060	0.600	0.052	0.622	0.051	0.630	0.060	0.591	0.051	0.601	0.059
1990	0.559	0.044	0.513	0.053	0.520	0.051	0.547	0.045	0.565	0.044	0.573	0.051	0.538	0.044	0.548	0.051
1991	0.447	0.034	0.414	0.040	0.418	0.039	0.439	0.034	0.452	0.034	0.460	0.039	0.432	0.034	0.442	0.039
1992	0.317	0.026	0.295	0.030	0.297	0.029	0.312	0.026	0.321	0.026	0.329	0.030	0.307	0.026	0.315	0.029
1993	0.294	0.025	0.276	0.029	0.277	0.028	0.290	0.026	0.299	0.025	0.308	0.029	0.286	0.025	0.294	0.029
1994	0.308	0.025	0.289	0.029	0.291	0.028	0.304	0.025	0.313	0.025	0.321	0.029	0.300	0.025	0.306	0.028
1995	0.342	0.027	0.321	0.031	0.323	0.030	0.340	0.028	0.348	0.027	0.353	0.031	0.334	0.027	0.337	0.030
1996	0.342	0.028	0.319	0.032	0.322	0.031	0.341	0.029	0.347	0.028	0.350	0.031	0.333	0.028	0.334	0.031
1997	0.329	0.027	0.307	0.031	0.310	0.030	0.330	0.028	0.333	0.027	0.335	0.030	0.320	0.027	0.320	0.029
1998	0.291	0.026	0.270	0.029	0.273	0.028	0.295	0.027	0.294	0.025	0.295	0.028	0.282	0.025	0.281	0.027
1999	0.283	0.026	0.263	0.029	0.265	0.028	0.283	0.026	0.285	0.025	0.286	0.028	0.274	0.025	0.272	0.027
2000	0.293	0.027	0.273	0.030	0.276	0.029	0.300	0.028	0.297	0.027	0.298	0.029	0.284	0.026	0.283	0.028
2001	0.304	0.027	0.285	0.030	0.288	0.029	0.313	0.028	0.308	0.027	0.309	0.029	0.295	0.027	0.295	0.029
2002	0.325	0.027	0.306	0.031	0.309	0.030	0.336	0.029	0.329	0.027	0.331	0.030	0.315	0.027	0.316	0.029
2003	0.324	0.027	0.306	0.030	0.309	0.029	0.337	0.028	0.327	0.027	0.330	0.029	0.315	0.027	0.316	0.029
2004	0.329	0.026	0.312	0.030	0.314	0.029	0.335	0.027	0.332	0.026	0.334	0.028	0.320	0.026	0.322	0.028
2005	0.326	0.025	0.310	0.029	0.312	0.028	0.325	0.025	0.329	0.025	0.330	0.027	0.317	0.025	0.319	0.027
2006	0.288	0.022	0.274	0.025	0.276	0.024	0.283	0.022	0.291	0.022	0.290	0.024	0.280	0.022	0.282	0.024
2007	0.243	0.019	0.232	0.022	0.234	0.021	0.236	0.019	0.248	0.020	0.245	0.020	0.237	0.019	0.240	0.021
2008	0.207	0.017	0.198	0.019	0.200	0.018	0.198	0.016	0.213	0.017	0.209	0.018	0.202	0.017	0.205	0.018
2009	0.191	0.016	0.182	0.018	0.183	0.018	0.179	0.015	0.198	0.017	0.192	0.017	0.186	0.016	0.189	0.017
2010	0.205	0.018	0.194	0.020	0.196	0.019	0.192	0.017	0.214	0.019	0.207	0.019	0.201	0.018	0.203	0.019
2011	0.271	0.023	0.256	0.026	0.258	0.025	0.253	0.022	0.281	0.023	0.275	0.025	0.266	0.023	0.267	0.025
2012	0.322	0.028	0.302	0.031	0.305	0.030	0.297	0.027	0.332	0.028	0.328	0.030	0.316	0.028	0.316	0.030
2013	0.363	0.032	0.338	0.035	0.342	0.034	0.339	0.031	0.373	0.033	0.371	0.035	0.357	0.033	0.356	0.035
2014	0.374	0.035	0.347	0.037	0.351	0.036	0.348	0.034	0.383	0.035	0.383	0.038	0.368	0.036	0.368	0.038
2015	0.378	0.037	0.349	0.039	0.354	0.038	0.353	0.036	0.385	0.037	0.388	0.042	0.373	0.038	0.376	0.041
2016	0.425	0.043	0.392	0.045	0.398	0.044	0.407	0.043	0.430	0.043	0.437	0.049	0.420	0.044	0.429	0.048
2017	0.461	0.049	0.425	0.050	0.433	0.049	0.443	0.049	0.466	0.049	0.476	0.056	0.457	0.050	0.474	0.056
2018	0.464	0.051	0.428	0.052	0.437	0.051	0.454	0.052	0.470	0.051	0.482	0.060	0.462	0.052	0.485	0.060
2019	0.424	0.050	0.392	0.050	0.401	0.049	0.418	0.051	0.431	0.050	0.443	0.061	0.424	0.051	0.448	0.060

Table 2.1.21. Depletion (p. 2 of 2).

	16.6h		17.2		17.6		18.1		18.2		18.3		18.4		18.5	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	0.090	0.034	0.049	0.020	0.018	0.004	0.201	0.063	0.141	0.050	0.084	0.032	0.129	0.047	0.266	0.078
1978	0.087	0.033	0.055	0.019	0.031	0.006	0.200	0.064	0.138	0.050	0.081	0.032	0.130	0.048	0.266	0.079
1979	0.087	0.032	0.066	0.019	0.042	0.008	0.197	0.061	0.138	0.048	0.082	0.031	0.135	0.048	0.263	0.078
1980	0.115	0.033	0.098	0.022	0.066	0.011	0.223	0.061	0.167	0.049	0.112	0.032	0.178	0.050	0.299	0.077
1981	0.188	0.038	0.162	0.028	0.117	0.017	0.299	0.064	0.245	0.053	0.190	0.037	0.280	0.060	0.402	0.080
1982	0.328	0.050	0.284	0.041	0.212	0.028	0.449	0.075	0.400	0.065	0.338	0.050	0.464	0.081	0.619	0.092
1983	0.476	0.062	0.410	0.053	0.312	0.038	0.602	0.084	0.557	0.075	0.491	0.062	0.639	0.098	0.845	0.101
1984	0.512	0.060	0.452	0.054	0.345	0.040	0.624	0.076	0.591	0.070	0.529	0.059	0.678	0.092	0.906	0.093
1985	0.586	0.064	0.528	0.060	0.399	0.045	0.710	0.082	0.670	0.075	0.603	0.064	0.760	0.095	1.039	0.098
1986	0.569	0.059	0.534	0.057	0.399	0.044	0.685	0.074	0.646	0.068	0.585	0.059	0.735	0.086	1.017	0.089
1987	0.556	0.054	0.543	0.054	0.407	0.043	0.656	0.066	0.626	0.062	0.572	0.054	0.713	0.077	0.986	0.081
1988	0.590	0.055	0.589	0.054	0.448	0.044	0.679	0.064	0.653	0.060	0.608	0.054	0.730	0.074	1.008	0.078
1989	0.573	0.051	0.584	0.051	0.452	0.043	0.652	0.059	0.630	0.056	0.590	0.050	0.694	0.069	0.960	0.072
1990	0.523	0.044	0.537	0.044	0.425	0.038	0.591	0.051	0.574	0.049	0.538	0.044	0.610	0.058	0.857	0.063
1991	0.421	0.034	0.441	0.034	0.355	0.030	0.481	0.041	0.463	0.038	0.430	0.034	0.488	0.044	0.702	0.051
1992	0.298	0.026	0.327	0.026	0.265	0.023	0.357	0.032	0.334	0.029	0.302	0.025	0.349	0.032	0.517	0.039
1993	0.276	0.025	0.312	0.025	0.251	0.022	0.331	0.031	0.309	0.029	0.277	0.024	0.328	0.032	0.480	0.038
1994	0.290	0.025	0.319	0.024	0.260	0.021	0.323	0.029	0.312	0.027	0.291	0.024	0.347	0.034	0.476	0.036
1995	0.323	0.027	0.341	0.024	0.278	0.021	0.345	0.030	0.340	0.029	0.323	0.026	0.391	0.038	0.516	0.039
1996	0.322	0.028	0.324	0.024	0.262	0.020	0.341	0.030	0.340	0.030	0.318	0.027	0.395	0.040	0.513	0.040
1997	0.310	0.027	0.293	0.021	0.235	0.018	0.330	0.030	0.329	0.029	0.301	0.025	0.375	0.039	0.491	0.039
1998	0.273	0.025	0.243	0.019	0.193	0.015	0.302	0.029	0.296	0.028	0.257	0.023	0.336	0.037	0.449	0.037
1999	0.265	0.025	0.224	0.018	0.181	0.015	0.299	0.030	0.290	0.028	0.273	0.024	0.323	0.036	0.438	0.037
2000	0.274	0.026	0.229	0.020	0.188	0.016	0.311	0.031	0.301	0.029	0.258	0.024	0.341	0.038	0.460	0.039
2001	0.285	0.026	0.241	0.021	0.200	0.018	0.316	0.030	0.310	0.029	0.261	0.024	0.358	0.038	0.476	0.040
2002	0.306	0.027	0.277	0.023	0.228	0.020	0.331	0.030	0.328	0.029	0.277	0.025	0.388	0.040	0.511	0.041
2003	0.305	0.027	0.300	0.025	0.242	0.020	0.327	0.029	0.325	0.028	0.270	0.025	0.388	0.038	0.509	0.041
2004	0.312	0.026	0.318	0.025	0.255	0.021	0.328	0.028	0.329	0.028	0.297	0.026	0.385	0.037	0.504	0.040
2005	0.310	0.026	0.315	0.023	0.256	0.020	0.324	0.027	0.325	0.027	0.317	0.026	0.364	0.034	0.484	0.037
2006	0.275	0.023	0.271	0.019	0.226	0.017	0.289	0.025	0.289	0.024	0.291	0.024	0.307	0.029	0.417	0.033
2007	0.234	0.020	0.224	0.016	0.194	0.015	0.250	0.022	0.247	0.021	0.250	0.021	0.256	0.025	0.354	0.029
2008	0.201	0.017	0.189	0.014	0.170	0.013	0.215	0.020	0.211	0.018	0.220	0.019	0.220	0.022	0.304	0.025
2009	0.186	0.017	0.172	0.014	0.154	0.012	0.198	0.019	0.194	0.018	0.204	0.018	0.206	0.022	0.280	0.025
2010	0.199	0.018	0.178	0.016	0.150	0.012	0.207	0.021	0.206	0.019	0.213	0.019	0.233	0.026	0.301	0.027
2011	0.261	0.023	0.236	0.020	0.191	0.014	0.266	0.025	0.268	0.024	0.282	0.024	0.312	0.034	0.394	0.035
2012	0.307	0.028	0.281	0.025	0.223	0.016	0.318	0.031	0.321	0.030	0.340	0.030	0.361	0.041	0.462	0.042
2013	0.346	0.032	0.303	0.028	0.232	0.017	0.365	0.037	0.367	0.035	0.357	0.031	0.410	0.048	0.530	0.051
2014	0.357	0.035	0.310	0.030	0.234	0.018	0.388	0.041	0.387	0.039	0.363	0.033	0.459	0.055	0.600	0.059
2015	0.364	0.038	0.310	0.033	0.221	0.018	0.404	0.045	0.397	0.042	0.360	0.034	0.471	0.059	0.628	0.066
2016	0.414	0.044	0.353	0.040	0.235	0.020	0.460	0.052	0.450	0.048	0.370	0.037	0.515	0.066	0.701	0.075
2017	0.456	0.050	0.389	0.047	0.245	0.024	0.518	0.060	0.499	0.055	0.398	0.043	0.523	0.070	0.749	0.084
2018	0.465	0.052	0.388	0.050	0.231	0.029	0.542	0.064	0.510	0.058	0.373	0.044	0.512	0.071	0.766	0.091
2019	0.428	0.051	0.356	0.049	0.208	0.033	0.529	0.065	0.481	0.057	0.327	0.044	0.461	0.066	0.741	0.093

Table 2.1.22. Spawning biomass (p. 1 of 4).

	16.6		16.6a		16.6b		16.6c	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	61,554	21,890	69,243	30,736	58,533	20,878	61,105	21,533
1978	60,086	21,828	67,932	31,495	56,703	20,749	59,544	21,430
1979	60,759	20,996	67,531	30,993	56,660	19,906	59,985	20,541
1980	80,942	21,286	84,796	31,673	75,025	20,379	79,480	20,798
1981	132,189	23,030	127,829	32,932	122,113	22,726	128,993	22,506
1982	229,453	28,613	209,532	37,417	212,414	29,412	223,313	27,979
1983	328,878	33,248	291,795	41,022	306,304	35,262	320,614	32,590
1984	351,050	30,361	305,088	36,366	328,865	33,177	343,281	29,886
1985	398,873	31,838	345,906	38,831	374,929	35,623	391,108	31,479
1986	386,291	28,735	346,777	36,322	364,160	32,900	379,784	28,527
1987	376,674	25,363	350,065	32,731	356,512	29,563	371,210	25,259
1988	399,213	24,410	374,267	31,195	379,402	28,638	394,206	24,364
1989	386,514	22,145	363,107	27,197	368,027	25,740	382,136	22,143
1990	351,645	18,486	331,324	21,628	335,823	20,990	348,481	18,515
1991	281,548	14,247	267,320	15,974	269,686	15,696	279,901	14,296
1992	199,551	11,561	190,507	12,568	191,513	12,391	198,940	11,628
1993	185,046	11,682	178,066	12,588	178,909	12,401	184,828	11,795
1994	193,736	10,884	186,755	11,694	187,915	11,515	193,810	11,038
1995	215,525	11,416	207,169	12,154	208,694	11,978	216,270	11,637
1996	215,283	11,851	206,010	12,571	207,756	12,395	217,169	12,166
1997	207,112	11,422	198,083	12,097	199,830	11,927	210,371	11,820
1998	182,988	11,193	174,400	11,819	176,150	11,660	187,827	11,671
1999	177,841	11,462	169,416	12,107	171,148	11,941	180,041	11,764
2000	184,565	11,983	176,059	12,727	177,871	12,539	191,195	12,575
2001	191,589	11,695	183,712	12,509	185,595	12,311	199,530	12,320
2002	204,573	11,633	197,452	12,467	199,344	12,268	213,940	12,229
2003	203,996	11,254	197,582	12,070	199,348	11,877	214,699	11,769
2004	207,254	10,702	201,179	11,490	202,904	11,311	213,587	10,766
2005	205,280	10,082	199,763	10,768	201,394	10,614	207,221	9,817
2006	181,099	8,996	176,687	9,506	178,048	9,388	180,327	8,599
2007	152,915	8,146	149,627	8,511	150,691	8,414	150,261	7,709
2008	130,418	7,311	128,030	7,565	128,851	7,484	125,892	6,873
2009	119,938	7,437	117,579	7,654	118,279	7,570	113,784	6,986
2010	129,028	8,267	125,327	8,521	126,194	8,424	122,027	7,802
2011	170,784	10,182	165,057	10,442	166,396	10,335	160,991	9,637
2012	202,683	12,605	194,700	12,779	196,638	12,676	188,952	11,996
2013	228,430	14,914	218,243	14,891	220,725	14,799	215,621	14,365
2014	235,287	16,841	223,924	16,544	226,784	16,481	221,427	16,354
2015	237,765	18,800	225,280	18,249	228,520	18,212	224,538	18,412
2016	267,364	22,232	252,982	21,354	257,067	21,358	259,182	22,203
2017	290,296	26,299	274,359	25,081	279,496	25,136	282,197	26,395
2018	292,246	28,455	276,495	27,058	282,249	27,149	289,016	28,920
2019	266,950	28,832	252,809	27,603	258,686	27,712	265,958	29,418

Table 2.1.22. Spawning biomass (p. 2 of 4).

	16.6d		16.6e		16.6f		16.6g	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	64,343	22,724	66,288	23,548	60,415	21,404	62,249	22,129
1978	63,063	22,702	65,065	23,624	58,798	21,297	60,632	22,071
1979	63,909	21,835	65,997	22,904	59,168	20,420	60,956	21,268
1980	84,468	22,079	87,057	23,496	78,607	20,687	80,245	21,774
1981	136,268	23,772	140,148	26,147	128,177	22,396	129,505	24,151
1982	234,342	29,342	240,525	33,459	222,718	27,884	223,814	30,955
1983	334,237	33,937	342,433	39,563	320,143	32,487	321,656	36,850
1984	355,948	30,918	364,202	36,748	342,729	29,743	344,808	34,484
1985	404,317	32,399	413,464	38,992	390,099	31,251	393,513	36,867
1986	391,523	29,222	400,244	35,542	377,977	28,242	382,253	33,814
1987	381,468	25,777	389,446	31,528	368,185	24,940	373,524	30,134
1988	403,655	24,792	411,670	30,287	389,877	24,009	396,498	29,072
1989	390,162	22,487	397,817	27,282	377,215	21,786	384,646	26,267
1990	354,223	18,778	361,410	22,538	343,723	18,190	351,036	21,754
1991	283,427	14,487	289,991	17,182	275,906	14,020	282,617	16,605
1992	201,316	11,767	207,709	13,788	195,878	11,381	201,937	13,322
1993	187,304	11,903	194,520	13,827	182,360	11,528	188,186	13,333
1994	196,141	11,103	202,246	12,759	191,681	10,766	195,764	12,269
1995	218,023	11,645	222,976	13,188	213,353	11,288	215,970	12,650
1996	217,742	12,065	221,036	13,510	212,702	11,695	213,770	12,925
1997	209,025	11,609	211,215	12,897	204,421	11,249	204,713	12,334
1998	184,136	11,367	186,053	12,526	180,320	11,010	179,822	11,984
1999	178,786	11,639	180,705	12,757	175,105	11,274	174,329	12,226
2000	185,861	12,176	187,816	13,331	181,556	11,791	181,116	12,809
2001	193,370	11,892	195,277	13,036	188,410	11,512	188,829	12,568
2002	206,172	11,837	208,598	12,936	201,348	11,457	202,279	12,533
2003	204,993	11,467	207,941	12,464	200,857	11,091	202,183	12,137
2004	207,818	10,941	210,687	11,803	204,170	10,552	205,810	11,555
2005	205,992	10,367	208,071	11,028	202,361	9,945	204,315	10,862
2006	182,412	9,319	183,266	9,728	178,658	8,880	180,832	9,635
2007	155,283	8,500	154,597	8,706	150,978	8,051	153,511	8,661
2008	133,714	7,671	131,627	7,755	129,045	7,246	131,474	7,723
2009	124,223	7,822	120,981	7,904	118,899	7,399	121,176	7,841
2010	133,939	8,666	130,647	8,952	128,078	8,270	129,849	8,783
2011	176,083	10,595	173,762	11,265	169,782	10,232	170,966	10,926
2012	208,259	13,011	207,174	14,184	201,776	12,715	202,036	13,633
2013	233,867	15,296	234,007	17,012	227,793	15,099	227,656	16,274
2014	239,956	17,146	241,626	19,437	235,199	17,101	235,286	18,596
2015	241,124	19,030	244,810	22,080	238,082	19,133	240,506	21,186
2016	269,488	22,412	275,782	26,654	268,101	22,647	274,500	25,757
2017	292,084	26,455	300,589	32,194	291,737	26,807	303,274	31,394
2018	294,837	28,601	303,854	35,569	294,577	29,041	310,239	34,991
2019	270,450	28,977	279,315	36,879	270,373	29,622	286,707	36,517

Table 2.1.22. Spawning biomass (p. 3 of 4).

	16.6h		17.2		17.6		18.1	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	57,913	20,497	29,540	11,783	12,950	2,454	151,655	45,902
1978	56,035	20,287	33,256	10,757	22,028	3,571	150,314	45,954
1979	56,025	19,358	40,108	10,874	29,353	5,008	148,102	44,197
1980	74,279	19,600	59,071	12,128	46,712	6,530	168,242	43,726
1981	121,293	21,210	98,137	14,881	82,612	9,294	224,877	45,258
1982	211,816	26,489	171,653	20,515	149,372	14,180	338,460	51,782
1983	306,712	31,044	247,906	25,587	219,158	18,654	453,093	56,847
1984	330,425	28,597	273,145	25,082	242,463	18,994	470,175	50,986
1985	377,773	30,227	319,255	27,696	280,679	21,594	534,630	54,482
1986	367,031	27,443	322,958	26,105	280,743	20,944	515,805	49,766
1987	358,586	24,314	328,155	23,804	286,374	19,572	494,335	43,922
1988	380,760	23,479	356,037	23,341	315,298	19,638	511,310	42,175
1989	369,388	21,350	353,190	21,420	318,154	18,277	490,747	38,658
1990	337,570	17,859	324,344	17,952	298,593	15,686	445,351	33,277
1991	271,535	13,773	266,462	13,652	249,969	12,361	362,569	26,992
1992	192,354	11,174	197,853	10,820	186,086	10,077	268,628	22,476
1993	178,266	11,292	188,478	10,683	176,540	9,936	249,273	21,942
1994	187,317	10,519	192,929	9,535	182,534	8,679	243,009	19,065
1995	208,542	11,008	206,134	9,219	195,817	8,123	259,489	18,909
1996	207,695	11,383	195,741	8,845	183,983	7,414	256,841	18,921
1997	200,054	10,948	177,159	8,031	165,042	6,556	248,826	18,575
1998	176,122	10,720	146,578	7,410	135,922	5,960	227,673	18,679
1999	170,766	10,988	135,535	7,476	127,492	6,100	225,483	19,365
2000	176,982	11,510	138,135	8,285	131,943	6,845	234,034	20,033
2001	184,047	11,263	145,870	8,994	140,436	7,481	238,092	19,148
2002	197,057	11,251	167,366	9,733	160,296	8,134	249,396	18,774
2003	196,998	10,933	181,175	9,927	170,395	8,310	246,410	18,055
2004	201,034	10,447	192,158	9,533	179,393	8,029	246,786	17,181
2005	200,123	9,895	190,622	8,494	180,265	7,379	244,070	16,622
2006	177,411	8,874	163,963	7,045	159,242	6,446	217,923	15,287
2007	150,781	8,072	135,066	6,193	136,575	5,922	188,403	14,256
2008	129,540	7,266	113,921	5,643	119,386	5,392	162,160	12,843
2009	119,688	7,392	103,881	5,875	108,342	5,332	148,937	12,825
2010	128,058	8,181	107,481	6,785	105,527	5,313	156,135	13,504
2011	168,089	10,022	142,857	8,468	134,230	5,639	199,965	15,978
2012	198,016	12,349	169,637	10,552	156,635	6,361	239,780	19,837
2013	222,889	14,590	183,344	12,463	163,157	7,111	275,090	24,070
2014	230,109	16,509	187,542	13,777	164,589	7,660	292,372	27,514
2015	234,645	18,491	187,521	15,740	155,346	8,488	304,117	30,728
2016	267,132	21,989	213,049	19,456	165,493	10,700	346,419	35,983
2017	293,961	26,191	234,934	23,833	172,287	14,647	390,203	42,488
2018	299,662	28,537	234,705	26,392	162,198	19,300	408,270	46,421
2019	275,850	29,232	215,395	26,740	146,654	23,205	398,582	48,383

Table 2.1.22. Spawning biomass (p. 4 of 4).

	18.2		18.3		18.4		18.5	
Year	Est.	StD.	Est.	StD.	Est.	StD.	Est.	StD.
1977	96,667	32,475	52,708	19,202	80,124	27,952	128,411	43,546
1978	94,618	32,453	50,835	18,914	80,259	28,297	128,813	44,342
1979	94,193	31,398	51,197	18,075	83,528	27,849	127,145	43,528
1980	114,114	31,325	70,084	18,426	109,875	29,091	144,410	44,268
1981	167,926	32,936	118,715	20,172	173,069	33,614	194,413	48,190
1982	273,532	38,974	211,575	25,534	287,514	43,624	299,495	58,350
1983	381,152	43,973	307,816	30,056	395,811	50,127	408,829	65,429
1984	404,307	40,038	331,402	27,626	419,932	45,766	438,370	60,191
1985	458,614	42,373	377,752	29,087	470,337	46,375	502,670	63,545
1986	442,149	38,428	366,466	26,325	455,090	41,216	491,849	57,797
1987	428,132	33,935	358,418	23,249	441,629	36,567	477,016	51,434
1988	446,582	32,498	381,072	22,366	452,099	33,712	487,461	48,024
1989	430,891	29,702	369,522	20,229	429,859	30,503	464,370	43,766
1990	392,454	25,320	336,941	16,827	377,318	24,613	414,308	36,270
1991	316,668	20,102	269,663	12,935	302,143	18,455	339,326	28,587
1992	228,795	16,465	189,317	10,479	215,782	14,707	250,283	23,429
1993	211,599	16,187	173,811	10,515	203,103	15,562	232,115	23,639
1994	213,339	14,401	182,284	9,687	214,784	15,491	230,159	21,523
1995	232,606	14,649	202,071	10,052	241,819	16,848	249,536	21,591
1996	232,719	15,056	198,931	10,330	244,746	18,118	248,156	22,291
1997	225,061	14,738	188,313	9,919	232,247	17,528	237,527	21,793
1998	202,613	14,755	160,977	9,819	208,217	17,049	217,079	21,413
1999	198,765	15,239	170,738	10,103	200,130	16,942	211,850	21,832
2000	206,287	15,837	161,497	10,393	211,297	17,970	222,565	22,992
2001	212,236	15,283	163,631	10,472	221,333	17,916	229,976	22,518
2002	224,398	15,062	173,290	10,854	240,214	17,982	247,018	22,100
2003	222,561	14,496	169,209	11,129	240,326	17,427	246,169	21,380
2004	225,132	13,802	186,334	10,434	238,084	16,176	243,684	20,083
2005	222,742	13,201	198,524	9,977	225,622	14,296	234,133	18,235
2006	197,893	11,978	182,290	9,254	190,184	12,289	201,589	16,038
2007	168,994	10,997	156,646	8,565	158,438	11,093	171,147	14,757
2008	144,723	9,852	137,516	7,976	136,139	9,927	147,152	13,250
2009	132,563	9,833	127,939	8,072	127,712	10,306	135,255	13,463
2010	140,671	10,575	133,240	8,301	143,936	12,414	145,758	15,394
2011	183,436	12,775	176,437	10,048	193,194	16,108	190,754	19,342
2012	219,661	15,840	213,287	12,456	223,642	19,573	223,295	23,555
2013	251,262	19,099	223,703	13,112	254,000	23,480	256,566	28,872
2014	265,004	21,847	227,135	14,522	284,049	27,834	290,131	33,877
2015	271,915	24,328	225,559	15,923	291,354	30,751	303,531	38,168
2016	307,658	28,420	231,965	18,400	318,638	34,131	339,221	43,365
2017	341,785	33,285	249,215	22,267	323,814	36,483	362,082	48,153
2018	348,981	35,699	233,812	24,448	317,106	37,394	370,697	51,178
2019	329,222	36,403	204,892	25,613	285,467	35,861	358,216	51,654

Table 2.1.23. Area-specific spawning biomass.

	18.1		18.2		18.5	
Year	EBS	NBS	EBS	NBS	EBS	NBS
1977	84,092	67,563	71,949	24,717	75,116	53,295
1978	75,356	74,958	67,595	27,023	67,468	61,345
1979	84,237	63,865	71,419	22,775	75,099	52,047
1980	99,464	68,778	89,025	25,089	87,427	56,983
1981	145,770	79,107	137,431	30,496	130,049	64,365
1982	218,659	119,801	222,946	50,586	199,665	99,830
1983	280,485	172,608	299,982	81,171	260,102	148,728
1984	275,148	195,028	304,387	99,920	265,669	172,701
1985	277,616	257,017	326,641	131,974	270,355	232,316
1986	269,643	246,161	314,894	127,256	266,974	224,875
1987	258,378	235,957	308,456	119,676	258,854	218,162
1988	279,791	231,521	327,960	118,622	274,463	212,998
1989	278,452	212,295	319,830	111,061	270,261	194,109
1990	233,473	211,878	282,273	110,181	223,984	190,325
1991	196,235	166,334	227,099	89,568	189,963	149,363
1992	140,858	127,770	164,248	64,546	137,874	112,409
1993	145,545	103,729	161,992	49,607	140,979	91,137
1994	147,872	95,138	167,606	45,733	144,857	85,302
1995	166,596	92,893	185,358	47,248	164,433	85,104
1996	171,965	84,877	187,305	45,415	169,568	78,588
1997	157,072	91,753	177,653	47,408	153,340	84,187
1998	144,276	83,397	158,685	43,928	141,002	76,077
1999	137,121	88,362	152,559	46,206	131,915	79,936
2000	141,795	92,240	159,471	46,816	139,246	83,320
2001	147,622	90,471	166,852	45,385	147,026	82,951
2002	152,712	96,685	174,083	50,316	155,374	91,644
2003	155,607	90,803	173,590	48,971	158,795	87,374
2004	150,576	96,210	175,255	49,877	151,828	91,856
2005	150,209	93,861	172,765	49,976	146,985	87,148
2006	132,721	85,202	151,275	46,618	125,412	76,177
2007	111,412	76,991	128,089	40,905	104,855	66,293
2008	100,294	61,866	118,085	26,638	95,337	51,815
2009	86,409	62,529	105,539	27,024	83,850	51,405
2010	128,431	27,704	122,738	17,933	122,298	23,461
2011	130,475	69,491	127,761	55,675	129,066	61,688
2012	172,560	67,220	208,052	11,609	165,084	58,211
2013	187,620	87,470	209,568	41,693	179,341	77,225
2014	191,907	100,465	215,295	49,708	194,187	95,945
2015	202,601	101,516	224,201	47,714	205,605	97,925
2016	215,334	131,085	202,467	105,191	210,917	128,304
2017	206,622	183,581	259,319	82,466	202,227	159,855
2018	283,818	124,452	272,200	76,782	257,827	112,871
2019	199,474	199,108	239,224	89,999	188,490	169,726

Table 2.1.24. Age 0+ biomass (p. 1 of 2).

Year	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g
1977	207,053	223,703	194,605	204,040	216,890	221,236	202,175	207,014
1978	227,094	242,044	212,101	223,399	238,205	242,903	221,210	225,988
1979	333,391	330,012	306,967	324,937	348,601	354,298	323,005	325,546
1980	523,923	488,089	480,026	507,226	543,061	551,351	506,626	507,005
1981	771,004	690,206	707,420	745,783	793,936	805,597	746,028	746,949
1982	1,039,910	901,336	959,234	1,008,300	1,065,460	1,081,430	1,008,500	1,012,590
1983	1,170,690	1,017,360	1,087,980	1,139,680	1,195,600	1,213,360	1,138,960	1,146,890
1984	1,132,220	1,016,250	1,057,850	1,106,030	1,155,260	1,171,010	1,103,250	1,112,390
1985	1,216,370	1,104,160	1,139,990	1,190,660	1,239,600	1,256,880	1,185,330	1,198,190
1986	1,212,600	1,117,600	1,140,190	1,189,120	1,232,340	1,250,890	1,181,180	1,196,290
1987	1,238,960	1,151,320	1,169,550	1,216,700	1,257,610	1,274,330	1,206,830	1,223,460
1988	1,265,790	1,183,290	1,198,910	1,245,680	1,283,040	1,299,160	1,234,240	1,254,030
1989	1,157,460	1,086,920	1,098,790	1,141,740	1,171,980	1,187,720	1,130,070	1,151,320
1990	982,506	931,441	939,009	972,291	994,778	1,010,260	962,298	982,375
1991	807,762	772,936	777,301	801,288	819,673	834,179	794,179	810,205
1992	696,104	666,206	669,312	690,725	707,911	721,729	685,469	697,013
1993	803,765	767,587	771,672	798,324	819,239	830,614	792,004	800,531
1994	833,536	796,915	801,368	830,375	846,275	855,324	821,913	826,212
1995	886,877	848,336	853,066	886,849	896,042	904,933	874,320	875,540
1996	889,288	849,635	855,001	893,996	898,159	903,356	875,929	874,268
1997	767,569	733,461	738,665	777,235	776,338	778,297	756,038	754,210
1998	669,598	637,525	642,519	680,792	682,065	679,841	658,346	655,963
1999	699,556	666,671	671,687	692,438	712,233	711,454	686,959	685,424
2000	756,666	723,153	728,708	775,958	765,714	770,250	742,922	743,473
2001	768,515	736,862	742,377	793,979	777,191	782,285	754,924	756,439
2002	800,224	769,837	774,941	825,335	810,534	813,299	786,602	788,739
2003	797,989	769,360	774,193	819,553	809,845	809,412	784,808	788,300
2004	774,522	748,429	753,104	772,181	788,047	784,115	762,412	767,199
2005	701,952	680,342	684,384	686,559	716,949	709,720	691,661	697,623
2006	605,911	588,909	592,137	587,411	621,192	611,870	597,727	604,091
2007	533,747	519,266	521,988	514,277	548,470	538,412	527,244	533,351
2008	539,084	522,632	525,039	512,846	551,661	544,637	533,193	537,129
2009	598,143	577,121	579,846	565,793	610,347	606,495	591,900	594,515
2010	730,852	700,957	704,934	696,381	743,536	743,933	723,606	722,990
2011	874,834	837,277	842,674	829,103	890,087	891,555	867,221	864,618
2012	937,925	894,998	902,280	884,206	951,529	957,043	931,074	928,821
2013	961,906	915,238	923,588	925,464	970,935	983,285	956,223	956,655
2014	992,622	941,797	951,458	953,289	1,001,530	1,016,750	987,816	995,594
2015	1,019,330	965,164	976,716	983,143	1,034,600	1,046,580	1,015,580	1,034,700
2016	1,070,610	1,013,060	1,026,910	1,061,320	1,091,030	1,102,300	1,068,310	1,100,390
2017	1,047,990	990,839	1,006,960	1,034,600	1,069,820	1,083,270	1,048,420	1,089,600
2018	918,116	867,804	884,134	917,186	938,675	953,984	922,045	962,703
2019	774,678	731,012	746,232	773,859	796,631	810,480	781,088	813,439

Table 2.1.24. Age 0+ biomass (p. 2 of 2).

Year	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
1977	193,350	141,105	101,274	267,334	232,650	180,828	271,084	239,619
1978	210,611	167,993	129,242	265,111	242,639	198,279	302,248	234,955
1979	304,194	255,666	204,766	374,907	346,695	296,726	446,215	329,493
1980	477,205	397,325	324,536	529,233	517,897	477,561	681,472	471,320
1981	707,555	594,484	484,456	736,756	746,820	714,402	970,794	673,778
1982	964,329	822,814	669,377	916,547	975,194	974,010	1,271,000	851,703
1983	1,097,420	954,107	783,514	962,650	1,054,540	1,104,960	1,389,340	901,167
1984	1,066,920	964,143	800,242	869,916	978,921	1,073,580	1,349,880	842,440
1985	1,149,380	1,056,260	877,750	858,835	1,006,110	1,155,680	1,432,650	833,934
1986	1,147,780	1,078,450	901,283	864,013	1,002,920	1,154,710	1,431,680	851,349
1987	1,175,520	1,124,650	952,317	868,744	1,028,280	1,183,690	1,456,790	863,928
1988	1,206,890	1,170,860	1,007,990	904,366	1,052,730	1,213,080	1,433,320	879,543
1989	1,108,380	1,092,030	952,751	833,540	963,358	1,110,740	1,284,320	804,566
1990	945,624	951,908	843,227	661,634	795,251	943,403	1,053,970	631,071
1991	778,997	801,338	723,914	561,658	653,818	773,775	877,495	543,757
1992	668,862	692,210	623,228	495,493	576,158	661,918	763,032	480,411
1993	771,287	784,177	703,115	615,930	695,625	761,014	888,160	593,225
1994	801,714	794,709	718,773	627,539	717,139	787,653	930,855	612,685
1995	854,005	823,068	743,491	675,133	761,097	832,272	1,000,980	664,351
1996	855,966	793,480	715,139	702,607	776,853	823,711	1,009,910	691,254
1997	739,720	663,785	603,303	583,105	661,368	699,814	857,699	567,159
1998	641,991	555,289	504,490	518,898	578,105	591,061	761,008	505,535
1999	669,048	574,411	519,370	534,432	600,950	673,495	785,583	512,686
2000	724,633	639,279	573,733	580,623	655,666	663,478	864,548	569,913
2001	737,227	684,768	615,912	579,321	663,181	657,050	889,340	578,387
2002	769,876	741,284	667,393	591,278	679,687	677,433	942,766	602,619
2003	770,849	749,374	676,557	600,781	680,315	666,774	936,666	612,669
2004	751,722	725,127	668,279	565,215	657,699	703,130	882,425	566,858
2005	684,614	653,412	613,523	510,105	590,551	682,003	768,070	496,681
2006	593,861	561,764	534,883	443,476	508,040	609,470	635,917	417,185
2007	525,386	490,641	468,291	390,169	448,814	544,441	556,804	365,876
2008	529,243	486,697	446,383	389,976	487,620	566,037	570,187	369,240
2009	584,421	529,690	467,503	401,011	532,882	634,580	640,389	390,057
2010	708,732	645,835	566,466	703,263	703,940	753,144	808,993	662,579
2011	847,231	768,945	674,592	659,706	636,486	907,110	976,074	644,684
2012	909,733	811,459	705,354	765,345	946,595	989,743	1,026,360	731,609
2013	935,861	822,486	700,610	783,424	899,910	944,623	1,076,880	751,146
2014	971,857	847,984	691,914	824,622	926,904	965,630	1,191,090	828,615
2015	1,007,260	875,087	701,815	864,619	967,543	977,939	1,222,310	866,843
2016	1,068,010	923,425	723,272	889,467	850,028	941,719	1,254,160	864,955
2017	1,054,200	900,177	684,141	693,813	890,136	918,160	1,156,590	674,061
2018	928,706	783,446	582,723	892,776	858,174	751,082	993,123	810,930
2019	781,790	657,067	487,566	589,406	689,675	613,667	834,544	540,515

Table 2.1.25. Area-specific age 0+ biomass.

	18.1		18.2		18.5	
Year	EBS	NBS	EBS	NBS	EBS	NBS
1977	267,334	157,670	232,650	59,369	239,619	125,770
1978	265,111	182,018	242,639	68,121	234,955	149,585
1979	374,907	177,173	346,695	69,068	329,493	144,703
1980	529,233	211,141	517,897	87,065	471,320	176,185
1981	736,756	260,020	746,820	112,850	673,778	215,263
1982	916,547	377,078	975,194	171,563	851,703	320,524
1983	962,650	479,397	1,054,540	233,844	901,167	417,527
1984	869,916	502,847	978,921	262,452	842,440	449,386
1985	858,835	615,310	1,006,110	321,508	833,934	557,775
1986	864,013	581,802	1,002,920	305,796	851,349	532,754
1987	868,744	576,753	1,028,280	297,744	863,928	533,746
1988	904,366	560,718	1,052,730	293,326	879,543	514,354
1989	833,540	516,976	963,358	274,408	804,566	471,206
1990	661,634	496,854	795,251	262,314	631,071	445,207
1991	561,658	386,794	653,818	211,412	543,757	348,128
1992	495,493	307,169	576,158	159,405	480,411	271,390
1993	615,930	278,945	695,625	140,205	593,225	246,893
1994	627,539	275,702	717,139	139,066	612,685	249,126
1995	675,133	276,095	761,097	145,811	664,351	254,177
1996	702,607	257,264	776,853	140,673	691,254	238,444
1997	583,105	263,140	661,368	138,527	567,159	241,080
1998	518,898	231,196	578,105	124,602	505,535	211,216
1999	534,432	244,431	600,950	130,799	512,686	220,893
2000	580,623	256,895	655,666	134,400	569,913	233,486
2001	579,321	260,650	663,181	135,095	578,387	240,952
2002	591,278	271,460	679,687	145,505	602,619	258,810
2003	600,781	254,476	680,315	140,207	612,669	245,023
2004	565,215	266,979	657,699	141,808	566,858	253,697
2005	510,105	251,694	590,551	136,920	496,681	232,548
2006	443,476	220,997	508,040	123,050	417,185	196,723
2007	390,169	199,541	448,814	108,081	365,876	172,414
2008	389,976	193,182	487,620	68,294	369,240	162,906
2009	401,011	236,623	532,882	77,567	390,057	191,582
2010	703,263	67,412	703,940	40,379	662,579	57,676
2011	659,706	267,483	636,486	261,271	644,684	232,919
2012	765,345	251,282	946,595	33,931	731,609	211,992
2013	783,424	279,329	899,910	115,859	751,146	246,637
2014	824,622	289,999	926,904	129,685	828,615	278,712
2015	864,619	304,647	967,543	128,792	866,843	292,193
2016	889,467	376,744	850,028	318,871	864,955	366,104
2017	693,813	608,381	890,136	283,899	674,061	528,959
2018	892,776	315,463	858,174	197,968	810,930	285,470
2019	589,406	482,545	689,675	219,825	540,515	409,366

Table 2.1.26. OFL and maxABC distribution parameters forecast for 2019.

	2019 OFL			2019 maxABC			Pr(ABC>OFL)	
Model	Mean	SDev	CV	Mean	SDev	CV	Sam.	Pop.
16.6	208,725	25,907	0.124	175,394	21,705	0.124	0.287	0.381
16.6a	186,345	44,764	0.240	156,497	38,104	0.243	0.189	0.245
16.6b	195,995	24,755	0.126	164,711	20,736	0.126	0.225	0.300
16.6c	206,168	26,255	0.127	173,237	21,998	0.127	0.273	0.364
16.6d	214,405	26,410	0.123	180,120	22,121	0.123	0.321	0.419
16.6e	220,429	32,303	0.147	185,156	27,067	0.146	0.363	0.460
16.6f	208,647	26,222	0.126	175,316	21,967	0.125	0.286	0.380
16.6g	219,645	31,185	0.142	184,787	26,172	0.142	0.359	0.457
16.6h	208,201	25,457	0.122	175,189	21,357	0.122	0.286	0.379
17.2	154,825	42,277	0.273	129,953	35,909	0.276	0.120	0.114
17.6	53,480	17,399	0.325	44,529	14,564	0.327	0.019	0.004
18.1	197,498	24,185	0.122	169,944	20,693	0.122	0.253	0.339
18.2	211,915	24,892	0.117	180,412	21,137	0.117	0.323	0.421
18.3	133,196	34,616	0.260	111,286	29,251	0.263	0.092	0.061
18.4	237,280	39,559	0.167	199,107	33,130	0.166	0.499	0.576
18.5	178,873	30,100	0.168	153,757	25,702	0.167	0.179	0.228
Average	189,727	52,872	0.279	159,962	44,672	0.279	0.203	0.267

Table 2.1.27. Summary of effective sample size model weightings.

Type	Fleet	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g
Size	Fish.	23,850	23,439	23,779	24,015	23,389	23,606	23,835	23,899
Size	Std.	11,086	n/a	2,264	11,171	11,546	11,088	11,078	11,056
Size	Exp.	n/a	9,427	9,373	n/a	n/a	n/a	n/a	n/a
Size	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	105
Age	Fish.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Age	Std.	1,395	n/a	n/a	1,392	1,384	1,408	1,399	1,392
Age	Exp.	n/a	1,452	1,443	n/a	n/a	n/a	n/a	n/a
Index	Std.	3,978	n/a	2,161	3,895	3,966	11,782	4,119	12,332
Index	Exp.	n/a	3,177	3,166	n/a	n/a	n/a	n/a	n/a
Index	NBS	n/a	n/a	n/a	n/a	n/a	n/a	n/a	177
	Sum:	40,309	37,496	42,185	40,473	40,285	47,885	40,431	48,960

Type	Fleet	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Size	Fish.	24,110	45,671	27,866	22,152	22,741	25,802	23,640	22,373
Size	Std.	11,045	10,471	20,062	11,334	11,239	11,155	11,118	11,326
Size	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Size	NBS	106	n/a	n/a	206	269	n/a	n/a	208
Age	Fish.	n/a	1,339	1,293	n/a	n/a	n/a	n/a	n/a
Age	Std.	1,383	1,068	2,506	1,511	1,454	1,496	1,367	1,490
Age	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	Std.	4,201	3,215	12,246	4,487	3,814	3,580	4,021	4,552
Index	Exp.	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Index	NBS	175	n/a	n/a	176	2,216	n/a	n/a	176
	Sum:	41,020	61,763	63,973	39,866	41,732	42,033	40,146	40,124

Table 2.1.28. Options for multiplicative adjustments to model weights.

Model:	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
abs(ρ):	0.243	0.202	0.217	0.304	0.222	0.323	0.291	0.359	0.319	0.309	0.069	0.452	0.370	0.118	0.451	0.724
Adjust (α=1.0):	0.841	0.875	0.863	0.791	0.858	0.776	0.801	0.748	0.779	0.787	1.000	0.682	0.740	0.952	0.683	0.520
Adjust (α=0.8):	0.870	0.899	0.888	0.829	0.885	0.817	0.838	0.793	0.819	0.826	1.000	0.736	0.786	0.961	0.737	0.593
Adjust (α=0.6):	0.901	0.923	0.915	0.869	0.912	0.859	0.876	0.840	0.861	0.866	1.000	0.795	0.835	0.971	0.795	0.675
Adjust (α=0.4):	0.933	0.948	0.943	0.911	0.941	0.904	0.915	0.890	0.905	0.909	1.000	0.858	0.887	0.981	0.858	0.770
Adjust (α=0.2):	0.966	0.974	0.971	0.954	0.970	0.951	0.957	0.944	0.951	0.953	1.000	0.926	0.942	0.990	0.927	0.877

Model:	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Jitter score:	0.000	0.000	0.000	0.000	2.110	0.000	0.000	0.000	0.004	0.001	0.125	0.000	0.000	0.000	0.000	0.000
Adjust (α=1.0):	1.000	1.000	1.000	1.000	0.121	1.000	1.000	1.000	0.996	0.999	0.883	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.8):	1.000	1.000	1.000	1.000	0.185	1.000	1.000	1.000	0.997	1.000	0.905	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.6):	1.000	1.000	1.000	1.000	0.282	1.000	1.000	1.000	0.998	1.000	0.928	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.4):	1.000	1.000	1.000	1.000	0.430	1.000	1.000	1.000	0.998	1.000	0.951	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.2):	1.000	1.000	1.000	1.000	0.656	1.000	1.000	1.000	0.999	1.000	0.975	1.000	1.000	1.000	1.000	1.000

Model:	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
Finit - M:	-0.179	-0.186	-0.161	-0.174	-0.189	-0.192	-0.172	-0.180	-0.165	0.094	1.379	-0.176	-0.182	-0.036	-0.237	-0.116
Adjust (α=1.0):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.910	0.252	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.8):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.927	0.332	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.6):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.945	0.437	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.4):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.963	0.576	1.000	1.000	1.000	1.000	1.000
Adjust (α=0.2):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.981	0.759	1.000	1.000	1.000	1.000	1.000

Model:	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
ln(EBS *Q*):	-0.074	-0.006	-0.005	-0.058	-0.091	-0.086	-0.050	-0.047	-0.021	0.042	0.182	0.215	0.072	0.008	-0.204	0.251
Adjust (α=1.0):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.959	0.833	0.807	0.931	0.992	1.000	0.778
Adjust (α=0.8):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.967	0.864	0.842	0.944	0.994	1.000	0.818
Adjust (α=0.6):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.975	0.896	0.879	0.958	0.995	1.000	0.860
Adjust (α=0.4):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.983	0.930	0.918	0.972	0.997	1.000	0.904
Adjust (α=0.2):	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	0.992	0.964	0.958	0.986	0.998	1.000	0.951

Table 2.1.29a. Cross-validation negative log likelihoods for the EBS survey index.

Year	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
1982	-1.982		-2.2257	-2.080	-1.866	-1.644	-2.492	-2.169	-2.647	-2.3705	-1.7589	4.035	0.449	-2.317	0.728	3.470
1983	-1.678		-1.6989	-1.643	-1.703	-1.832	-2.138	-1.656	-1.652	-1.7908	-0.7986	-1.931	-1.771	-1.496	-2.004	-2.010
1984	-1.414		-1.7609	-1.502	-1.386	-0.883	-1.478	-1.390	-1.742	-2.0507	-1.8605	-1.549	-0.991	-1.574	0.244	-1.354
1985	-1.417		-1.5855	-1.368	0.000	-1.459	-1.315	-1.356	-1.251	-1.5988	-1.7547	-1.420	-1.385	-1.439	-1.718	-1.519
1986	-1.876		-1.5008	-1.845	-1.805	-2.025	-1.849	-1.941	-1.779	-1.6689	-1.2082	-1.727	-1.828	-1.944	-2.235	-1.774
1987	-2.201	-1.837	-2.0314	-2.158	-2.174	-2.391	-2.577	-2.370	-2.342	-2.7278	-2.7289	-1.826	-1.975	-2.322	-2.438	-2.125
1988	-2.376	-2.411	-2.4883	-2.414	-2.316	-2.545	-2.413	-2.560	-2.445	-2.5259	-2.324	-2.263	-2.211	-2.409	-2.338	-2.424
1989	11.617	15.335	15.982	12.000	11.062	11.783	11.651	11.748	11.692	23.59	17.651	9.393	10.175	12.562	9.317	9.197
1990	-1.459	-0.936	-0.8894	-1.329	-1.486	-1.153	-1.256	-1.275	-1.369	-1.7879	-2.1228	-2.230	-1.977	-1.168	-1.852	-2.358
1991	-0.095	1.203	0.1834	0.016	0.000	0.059	0.027	-0.165	-0.158	-0.3754	-1.0776	-1.010	-0.722	-0.016	-0.345	-1.181
1992	-1.985	-2.015	-1.8701	-1.973	-1.971	-1.964	-1.915	-1.998	-1.946	-2.0945	-1.4311	-2.028	-2.028	-1.929	-1.994	-2.043
1993	-1.505	-1.464	-1.6891	-1.527	-1.544	-1.493	-1.629	-1.443	-1.593	-0.858	-2.0024	-1.685	-1.572	-1.610	-1.449	-1.744
1994	7.407	6.120	6.8897	6.921	0.000	7.465	7.331	7.641	7.462	10.719	8.8381	7.373	7.482	7.952	7.353	7.062
1995	0.433	-0.177	0.0058	0.014	0.642	0.395	0.304	0.433	0.308	1.2883	-0.4323	-0.017	0.233	0.970	0.487	-0.140
1996	-1.014	-1.283	-1.2106	-1.284	-0.895	-0.996	-1.070	-0.978	-1.050	-0.3048	-1.0509	-1.369	-1.120	-0.414	-0.860	-1.410
1997	-1.662	-1.498	-1.4513	-1.505	-1.667	-1.633	-1.637	-1.668	-1.658	-1.925	-1.931	-1.647	-1.671	-1.867	-1.670	-1.604
1998	-0.535	-1.059	0.0475	-0.171	-0.506	-0.427	-0.439	-0.613	-0.586	-1.9435	-1.8306	-0.247	-0.468	-0.727	-0.425	-0.249
1999	-1.835	-1.520	-1.6294	-0.906	-1.907	-1.669	-1.752	-1.753	-1.808	-1.4767	-2.2579	-1.783	-1.976	-2.218	-1.800	-1.301
2000	-0.218	0.436	0.3646	0.830	-0.480	-0.165	-0.099	-0.203	0.048	-0.925	-1.3228	0.038	-0.187	-1.807	0.486	1.163
2001	7.841	8.114	6.6955	6.007	8.581	7.777	7.617	7.627	7.508	6.0661	1.7465	8.836	8.551	19.043	7.740	6.250
2002	-2.016	-1.751	-1.7901	-1.706	-2.090	-2.006	-1.973	-1.942	-1.918	-1.6797	-1.5017	-2.102	-2.061	-2.238	-1.160	-1.045
2003	-2.084	-2.061	-2.0801	-2.072	-2.077	-2.087	-2.087	-2.086	-2.083	-2.0555	-1.9599	-2.076	-2.064	-1.801	-2.044	-1.982
2004	-1.479	-1.199	-0.8142	-1.440	-1.528	-1.690	-1.420	-1.455	-1.197	-1.5697	-0.8204	-1.908	-1.886	-1.236	-1.830	-1.726
2005	-1.238	-1.307	-1.4952	-1.253	-1.281	-1.260	-1.347	-1.430	-1.479	-1.2497	-1.9648	-1.039	-1.114	-1.433	-0.544	-0.754
2006	5.262	0.546	3.1863	6.018	4.138	4.873	4.489	2.983	2.729	2.8055	-1.4636	5.849	5.871	0.035	13.718	6.684
2007	-0.418	-0.476	-0.5588	-0.314	-0.536	-0.439	-0.496	-0.460	-0.504	-0.0558	-1.3291	-0.484	-0.385	-0.818	-0.188	-0.270
2008	0.966	2.614	1.4171	0.052	1.214	1.179	1.318	0.981	1.123	0.7368	2.8013	1.964	2.696	5.538	0.016	1.151
2009	-1.359	-0.405	-0.7313	-1.654	-0.868	-1.056	-1.110	-1.369	-1.372	-1.9175	2.4415	-1.573	0.006	0.492	-2.051	1.228
2010	-1.913	-1.797	-1.9672	-1.683	-1.949	-1.939	-1.956	-1.907	-1.915	-1.6709	-1.7259	-1.333	-1.971	-1.956	-1.783	-1.592
2011	-1.692	-1.852	-2.021	-1.426	-1.910	-1.880	-1.870	-1.849	-1.852	0.4274	-2.0951	-1.177	5.746	-2.209	-1.150	-0.105
2012	-1.173	-1.837	-1.5755	-1.058	-1.200	-1.522	-1.448	-1.634	-1.498	-0.1628	-1.397	0.462	-2.296	-2.094	-1.309	0.256
2013	-1.188	-0.965	-1.0945	-1.409	-1.271	-1.145	-1.067	-0.861	-0.880	-1.4597	-1.6251	0.190	0.154	-0.968	-0.488	0.559
2014	-0.421	-0.813	-0.7719	-0.383	-0.338	-0.795	-0.641	-1.161	-0.929	-0.1232	1.0508	-1.782	-1.548	-0.304	-1.155	-1.898
2015	-0.806	-0.915	-1.114	-0.598	-0.748	-1.150	-1.044	-1.474	-1.318	-0.6717	-0.1242	-2.131	-1.517	-0.430	-1.298	-2.160
2016	-2.010	-1.908	-2.1426	-1.847	-2.001	-2.201	-2.262	-2.319	-2.327	-2.0511	-1.8687	2.639	-1.873	-0.997	-1.914	1.444
2017	7.394	6.908	7.8307	7.334	8.206	7.364	8.144	8.678	7.170	8.9449	0.6696	-1.511	0.691	1.256	5.427	-2.176
Sum	-0.125	9.792	2.415	0.644	-5.662	-0.554	-1.896	-3.390	-5.259	13.487	-10.570	0.932	3.457	6.107	7.475	1.520

Table 2.1.29b. Cross-validation negative log likelihoods (after subtracting minimum for each row).

Year	16.6	16.6a	16.6b	16.6c	16.6d	16.6e	16.6f	16.6g	16.6h	17.2	17.6	18.1	18.2	18.3	18.4	18.5
1982	0.6654		0.4215	0.5677	0.7810	1.0029	0.1554	0.4786	0.0000	0.2767	0.8883	6.6821	3.0958	0.3302	3.3752	6.1172
1983	0.4601		0.4388	0.4944	0.4343	0.3053	0.0000	0.4815	0.4855	0.3469	1.3391	0.2065	0.3671	0.6418	0.1340	0.1275
1984	0.6370		0.2898	0.5489	0.6650	1.1677	0.5730	0.6607	0.3091	0.0000	0.1901	0.5020	1.0594	0.4762	2.2951	0.6967
1985	0.3376		0.1692	0.3872	1.7547	0.2958	0.4400	0.3986	0.5035	0.1559	0.0000	0.3347	0.3694	0.3152	0.0363	0.2356
1986	0.3596		0.7345	0.3906	0.4298	0.2104	0.3863	0.2944	0.4565	0.5664	1.0271	0.5086	0.4077	0.2918	0.0000	0.4609
1987	0.5283	0.8920	0.6974	0.5704	0.5546	0.3378	0.1515	0.3587	0.3865	0.0011	0.0000	0.9032	0.7540	0.4070	0.2904	0.6036
1988	0.1847	0.1491	0.0720	0.1461	0.2445	0.0155	0.1472	0.0000	0.1158	0.0344	0.2364	0.2974	0.3493	0.1508	0.2220	0.1364
1989	2.4197	6.1377	6.7846	2.8030	1.8648	2.5852	2.4536	2.5509	2.4944	14.3925	8.4531	0.1960	0.9774	3.3646	0.1192	0.0000
1990	0.8993	1.4218	1.4687	1.0293	0.8721	1.2046	1.1018	1.0828	0.9894	0.5701	0.2353	0.1279	0.3814	1.1905	0.5060	0.0000
1991	1.0863	2.3839	1.3645	1.1975	1.1810	1.2399	1.2083	1.0162	1.0235	0.8057	0.1035	0.1706	0.4594	1.1649	0.8364	0.0000
1992	0.1092	0.0792	0.2244	0.1210	0.1231	0.1305	0.1799	0.0965	0.1483	0.0000	0.6635	0.0663	0.0664	0.1658	0.1005	0.0518
1993	0.4974	0.5387	0.3133	0.4754	0.4580	0.5097	0.3737	0.5590	0.4099	1.1443	0.0000	0.3170	0.4302	0.3927	0.5535	0.2588
1994	7.4072	6.1204	6.8897	6.9206	0.0000	7.4647	7.3313	7.6405	7.4617	10.7194	8.8381	7.3730	7.4816	7.9525	7.3531	7.0615
1995	0.8655	0.2551	0.4381	0.4460	1.0740	0.8277	0.7362	0.8652	0.7401	1.7206	0.0000	0.4157	0.6653	1.4025	0.9195	0.2920
1996	0.3953	0.1270	0.1990	0.1259	0.5148	0.4138	0.3394	0.4320	0.3597	1.1048	0.3587	0.0408	0.2895	0.9957	0.5500	0.0000
1997	0.2689	0.4328	0.4797	0.4256	0.2637	0.2978	0.2944	0.2633	0.2734	0.0059	0.0000	0.2841	0.2604	0.0643	0.2607	0.3268
1998	1.4088	0.8841	1.9910	1.7729	1.4378	1.5162	1.5043	1.3310	1.3572	0.0000	0.1130	1.6967	1.4755	1.2170	1.5182	1.6946
1999	0.4231	0.7377	0.6285	1.3517	0.3505	0.5889	0.5063	0.5048	0.4494	0.7812	0.0000	0.4753	0.2822	0.0396	0.4578	0.9573
2000	1.5886	2.2429	2.1714	2.6372	1.3266	1.6416	1.7075	1.6035	1.8550	0.8818	0.4840	1.8446	1.6202	0.0000	2.2925	2.9693
2001	6.0950	6.3673	4.9490	4.2604	6.8349	6.0309	5.8708	5.8805	5.7612	4.3196	0.0000	7.0897	6.8044	17.2964	5.9939	4.5040
2002	0.2220	0.4874	0.4481	0.5320	0.1479	0.2323	0.2647	0.2962	0.3204	0.5585	0.7365	0.1364	0.1769	0.0000	1.0781	1.1933
2003	0.0029	0.0266	0.0073	0.0157	0.0107	0.0008	0.0000	0.0018	0.0048	0.0319	0.1275	0.0112	0.0230	0.2866	0.0435	0.1054
2004	0.4295	0.7096	1.0941	0.4678	0.3804	0.2187	0.4883	0.4537	0.7113	0.3385	1.0879	0.0000	0.0224	0.6726	0.0784	0.1821
2005	0.7267	0.6583	0.4696	0.7115	0.6837	0.7043	0.6182	0.5352	0.4858	0.7151	0.0000	0.9260	0.8513	0.5314	1.4209	1.2108
2006	6.7258	2.0099	4.6499	7.4814	5.6012	6.3365	5.9525	4.4471	4.1926	4.2691	0.0000	7.3123	7.3344	1.4984	15.1821	8.1481
2007	0.9113	0.8535	0.7702	1.0153	0.7934	0.8900	0.8336	0.8695	0.8246	1.2733	0.0000	0.8453	0.9441	0.5108	1.1412	1.0586
2008	0.9505	2.5982	1.4012	0.0356	1.1984	1.1626	1.3016	0.9653	1.1066	0.7208	2.7854	1.9485	2.6798	5.5218	0.0000	1.1354
2009	0.6912	1.6459	1.3192	0.3969	1.1821	0.9946	0.9403	0.6811	0.6788	0.1330	4.4920	0.4774	2.0564	2.5424	0.0000	3.2790
2010	0.0580	0.1737	0.0035	0.2875	0.0213	0.0320	0.0151	0.0641	0.0557	0.2999	0.2448	0.6375	0.0000	0.0145	0.1878	0.3785
2011	0.5176	0.3575	0.1882	0.7831	0.2988	0.3294	0.3394	0.3607	0.3577	2.6366	0.1141	1.0321	7.9550	0.0000	1.0592	2.1043
2012	1.1233	0.4593	0.7207	1.2385	1.0959	0.7746	0.8486	0.6622	0.7979	2.1335	0.8993	2.7585	0.0000	0.2024	0.9872	2.5524
2013	0.4368	0.6600	0.5306	0.2166	0.3543	0.4805	0.5581	0.7645	0.7449	0.1654	0.0000	1.8152	1.7789	0.6570	1.1374	2.1841
2014	1.4772	1.0850	1.1263	1.5153	1.5601	1.1033	1.2574	0.7377	0.9688	1.7750	2.9490	0.1159	0.3502	1.5947	0.7432	0.0000
2015	1.3543	1.2455	1.0465	1.5622	1.4129	1.0107	1.1168	0.6866	0.8424	1.4888	2.0363	0.0291	0.6437	1.7303	0.8624	0.0000
2016	0.3175	0.4193	0.1845	0.4799	0.3263	0.1258	0.0650	0.0078	0.0000	0.2760	0.4584	4.9660	0.4540	1.3301	0.4132	3.7715
2017	9.5708	9.0841	10.0071	9.5103	10.3823	9.5399	10.3206	10.8548	9.3463	11.1213	2.8460	0.6653	2.8676	3.4322	7.6031	0.0000
No. 0s:	0	0	0	0	1	0	2	1	2	3	11	1	2	3	3	7
Max:	9.5708	9.0841	10.0071	9.5103	10.3823	9.5399	10.3206	10.8548	9.3463	14.3925	8.8381	7.3730	7.9550	17.2964	15.1821	8.1481

Table 2.1.30. Model weights based on cross-validation negative log likelihoods.

Sorted in order of model number					Sorted in order of negative log likelihood				
Model	-lnL	Δ(-lnL)	Exp(-Δ)	Weight	Model	-lnL	Δ(-lnL)	Exp(-Δ)	Weight
16.6	-0.1254	10.4446	0.0000	0.0000	17.6	-10.5700	0.0000	1.0000	0.9868
16.6a	9.7917	20.3617	0.0000	0.0000	16.6g	-3.3902	7.1798	0.0008	0.0008
16.6b	2.4149	12.9849	0.0000	0.0000	16.6f	-1.8964	8.6736	0.0002	0.0002
16.6c	0.6439	11.2139	0.0000	0.0000	16.6e	-0.5542	10.0158	0.0000	0.0000
16.6d	-5.6623	4.9077	0.0074	0.0073	16.6	-0.1254	10.4446	0.0000	0.0000
16.6e	-0.5542	10.0158	0.0000	0.0000	16.6c	0.6439	11.2139	0.0000	0.0000
16.6f	-1.8964	8.6736	0.0002	0.0002	18.1	0.9316	11.5016	0.0000	0.0000
16.6g	-3.3902	7.1798	0.0008	0.0008	18.5	1.5202	12.0902	0.0000	0.0000
16.6h	-5.2589	5.3111	0.0049	0.0049	16.6b	2.4149	12.9849	0.0000	0.0000
17.2	13.4868	24.0568	0.0000	0.0000	16.6d	-5.6623	4.9077	0.0074	0.0073
17.6	-10.5700	0.0000	1.0000	0.9868	16.6h	-5.2589	5.3111	0.0049	0.0049
18.1	0.9316	11.5016	0.0000	0.0000	18.2	3.4571	14.0271	0.0000	0.0000
18.2	3.4571	14.0271	0.0000	0.0000	18.3	6.1074	16.6774	0.0000	0.0000
18.3	6.1074	16.6774	0.0000	0.0000	18.4	7.4747	18.0447	0.0000	0.0000
18.4	7.4747	18.0447	0.0000	0.0000	16.6a	9.7917	20.3617	0.0000	0.0000
18.5	1.5202	12.0902	0.0000	0.0000	17.2	13.4868	24.0568	0.0000	0.0000

Figures

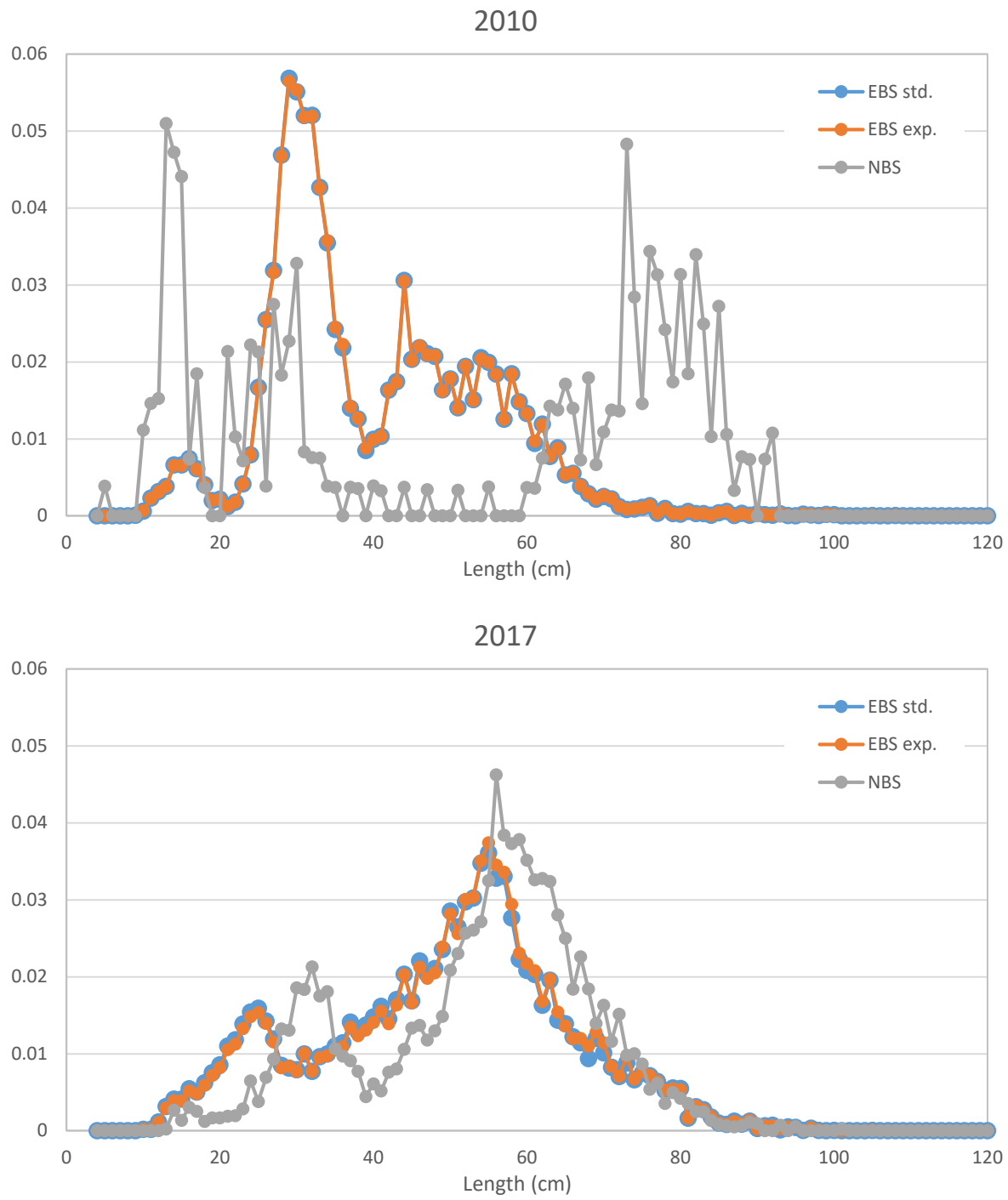

Figure 2.1.1. Comparison of EBS and NBS size compositions for 2010 and 2017.

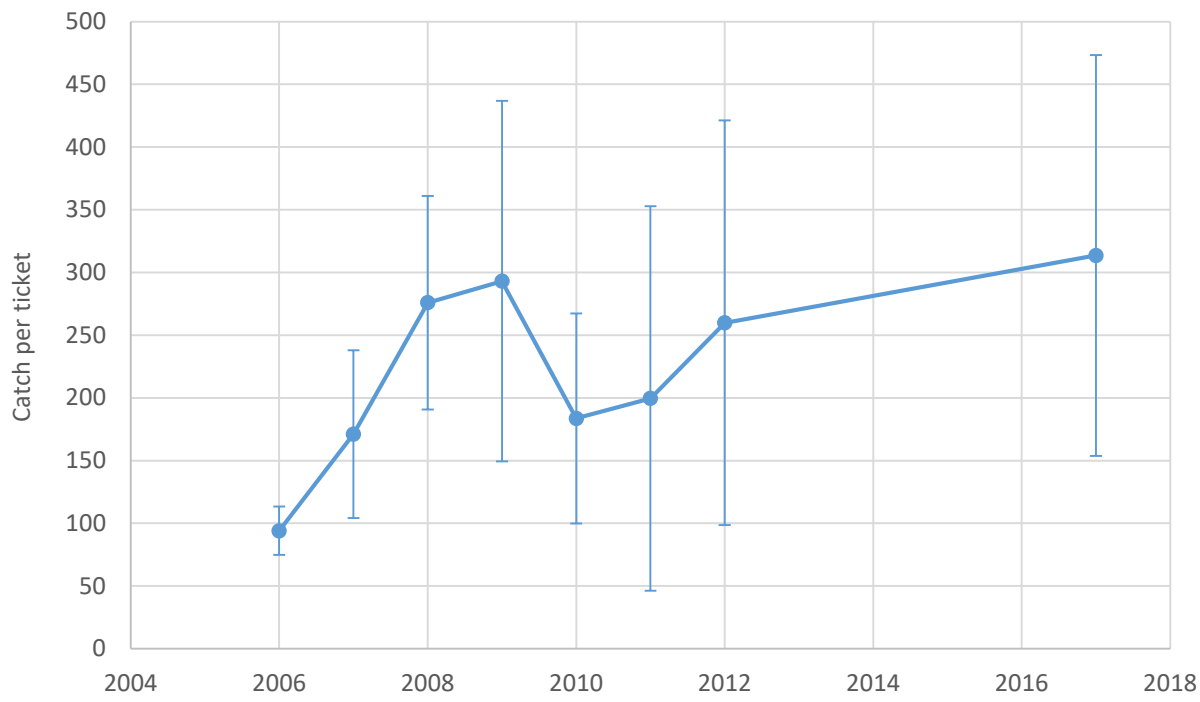

Figure 2.1.2. NBS fishery catch per fish ticket.

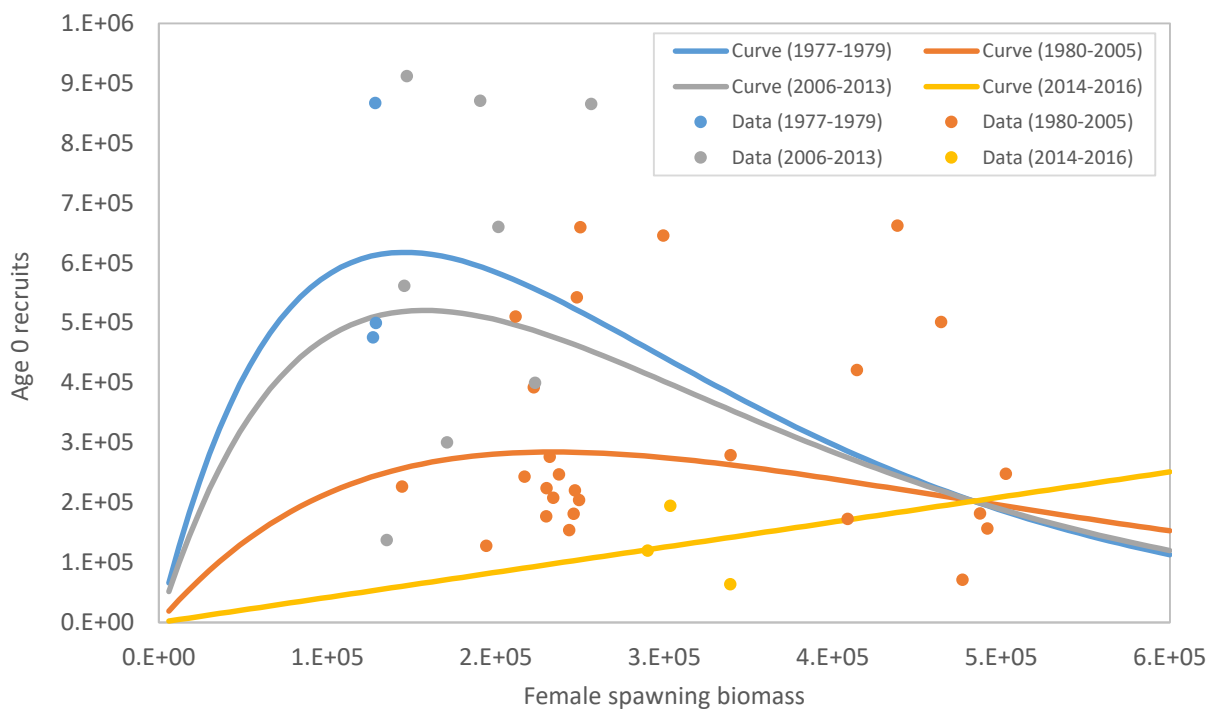

Figure 2.1.3. Ricker stock-recruitment relationships for 4 time blocks.

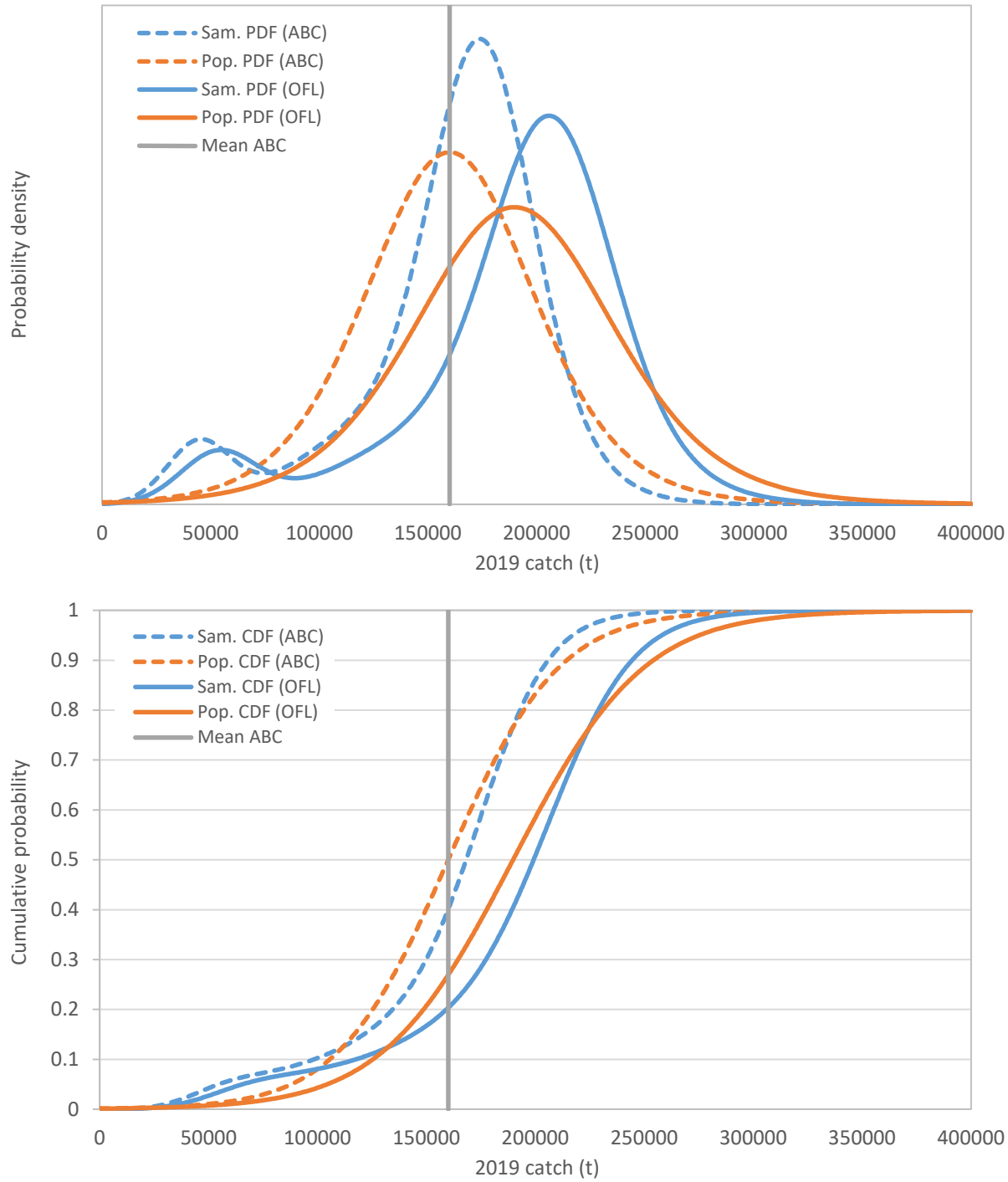

Figure 2.1.4. Distributions resulting from model averaging.

Attachment 2.1.1: Bridging analysis from Model 17.2 to Model 17.6

Introduction
As noted in the main text of Appendix 2.1 (see response to comment BPT7), last year's assessment included initial steps toward a bridging analysis between Models 16.6 and 17.6 (see subsection of the same name in Thompson 2017, especially Table 2.11). However, an internal (AFSC) review of this year's preliminary assessment resulted in a request for a second bridging analysis, this time running from Model 17.2 to Model 17.6.

Counting likelihood emphases for composition data and input "sigma" parameters that constrain parameter deviations (which are all estimated iteratively in both Model 17.2 and Model 17.6—see main text), there are 11 features that distinguish Model 17.6 from Model 17.2. Listed in the order in which they appear in the SS control file, these are as follow:

1. Model 17.6 has time-varying *Lmin*; Model 17.2 does not.
2. Model 17.6 has ln(recruitment) $\sigma = 0.5928$; Model 17.2 has 0.5771.
3. Model 17.6 has time-varying *Q*; Model 17.2 does not.
4. Model 17.6 has time-varying survey selectivity peak age; Model 17.2 does not.
5. Model 17.6 has time-varying survey selectivity ascending width; Model 17.2 does not.
6. Model 17.6 has fishery peak age deviation $\sigma = 0.1187$, Model 17.2 has 0.1155.
7. Model 17.6 has fishery ascending width deviation $\sigma = 0.4088$, Model 17.2 has 0.4123.
8. Model 17.6 has fishery sizecomp emphasis = 0.1475; Model 17.2 has 0.2416.
9. Model 17.6 has survey sizecomp emphasis = 1.6603; Model 17.2 has 0.8665.
10. Model 17.6 has fishery agecomp emphasis = 0.0217; Model 17.2 has 0.0225.
11. Model 17.6 has survey agecomp emphasis = 0.3172; Model 17.2 has 0.1353.

Methods
Starting from Model 17.2, 11 exploratory runs were made, with one of the 11 features changing from the respective Model 17.2 version to its Model 17.6 counterpart in each.

From this first batch of exploratory runs, the run that resulted in the largest proportional change (absolute value) in 2018 spawning biomass relative to Model 17.2 was denoted "Bridging run 1."

Bridging run 1 was then used as the starting point for a second batch of exploratory runs, with one of the remaining 10 features changing from the respective Model 17.2 version to its Model 17.6 counterpart in each. From this batch of exploratory runs, the run that resulted in the largest proportional change (absolute value) in 2018 spawning biomass relative to Bridging run 1 was denoted "Bridging run 2."

The above procedure was repeated until 10 of the 11 features had been changed from their respective Model 17.2 versions to their Model 17.6 counterparts. Changing the last remaining feature from its Model 17.2 version to its Model 17.6 counterpart resulted in Model 17.6, by definition.

Results
Relative to the 2018 spawning biomass estimated in Model 17.2, allowing time-variability in the ascending width parameter of the survey selectivity function had the biggest impact of the 11 features that distinguish Model 17.6 from Model 17.2, resulting in a *decrease* of 18.5% in Bridging run 1. Changing the survey sizecomp emphasis from 0.8665 (the Model 17.2 value) to 1.6603 (the Model 17.6 value) caused the biggest change in 2018 spawning biomass relative to Bridging run 1, an *increase* of 36.7%. Further steps in the process continued to show a mix of decreases and increases relative to the respective preceding run.

The full sequence of features added during the process of developing the bridging runs is shown below (the color scale runs from red=low to green=high):

Run	Feature changed from preceding run	SB2018	Change
Model 17.2	None (starting point = Model 17.2)	234,705	n/a
Bridging run 1	Turn on time-varying survey selectivity asc. width	191,298	-0.185
Bridging run 2	Change survey sizecomp emphasis	261,465	0.367
Bridging run 3	Turn on time-varying Lmin	179,454	-0.314
Bridging run 4	Turn on time-varying Q	169,748	-0.054
Bridging run 5	Change survey agecomp emphasis	193,042	0.137
Bridging run 6	Turn on time-varying survey selectivity peak age	159,586	-0.173
Bridging run 7	Change fishery sizecomp emphasis	170,705	0.070
Bridging run 8	Change fishery agecomp emphasis	161,866	-0.052
Bridging run 9	Change fishery peak age dev sigma	170,752	0.055
Bridging run 10	Change sigmaR	162,491	-0.048
Model 17.6	Change fishery asc. width dev sigma	162,198	-0.003

Table 2.1.1.1 provides a detailed presentation of the impacts of each step in the bridging analysis, showing the impact of every bridging run on every estimated parameter. In all pages of this table, the color scale extends across bridging runs for each row, where red=low and green=high.

The upper portion of Table 2.1.1.1a shows all of the time-invariant estimated parameters (except for the autocorrelation of deviations in ln(Q), which appears in Table 2.1.1.1h). The lower portion of Table 2.1.1.1a shows, in step-wise fashion, the quantities which either appear for the first time in a particular bridging run and then remain in all subsequent bridging runs (e.g., the σ term for the survey selectivity ascending width parameter appears in Bridging run 1 and then remains in all subsequent bridging runs) or that change from the Model 17.2 value to the Model 17.6 value at some point in the process and then remain at the Model 17.6 value in all subsequent bridging runs (e.g., the likelihood emphasis for the survey sizecomp data changes from the Model 17.2 value of 0.8665 to the Model 17.6 value of 1.6603 in Bridging run 2 and then remains at that value in all subsequent bridging runs).

Like Table 2.1.1.1a, Tables 2.1.1.1b-2.1.1.1e pertain to parameters that are common to Models 17.2 and 17.6 and all the bridging runs; the difference being that all pages of Table 2.1.1.1 following Table 2.1.1.1a pertain to time-varying parameters. Table 2.1.1.1b shows the "early" recruitment deviations that structure the initial (1977) numbers-at-age vector. Table 2.1.1.1c shows the recruitment deviations for the main (1977-2016) portion of the time series. Table 2.1.1.1d shows the fishery selectivity peak age deviations. Table 2.1.1.1e shows the fishery selectivity ascending width deviations.

Tables 2.1.1.1f-2.1.1.1i pertain to time-varying parameters that are common to Model 17.6 and a subset of the bridging runs, but not Model 17.2 or the other bridging runs, and are organized in order of the number of bridging runs in which the parameters are estimated (from most to least). Table 2.1.1.1f shows the survey selectivity ascending width deviations. Table 2.1.1.1g shows the deviations for length at age 1.5. Table 2.1.1.1h pertains to log catchability deviations; the first row shows the estimated autocorrelation among the deviations and the remaining rows show the deviations themselves. Table 2.1.1.1i shows the survey selectivity peak age deviations.

Discussion

Bridging analyses are often difficult to interpret, because the order in which features are added can have an impact on the perception of the various features' respective importance. The method adopted here is to

add the feature, at each step of the bridging analysis, that provides the largest impact on 2018 spawning biomass relative to the previous bridging run.

For this analysis, the correlations between rank orders of the impacts of the features common to any pair of adjacent bridging runs varied widely, as shown in the table below (as an aid to reading this table, using the first row as an example, the correlation between the ranks of the 10 features examined in Bridging run 2 and the ranks of those same features in Bridging run 1 was 0.83).

Bridging runs compared		No. ranks compared	Correlation
1	2	10	0.83
2	3	9	0.03
3	4	8	-0.14
4	5	7	0.89
5	6	6	0.54
6	7	5	-0.90
7	8	4	-0.40
8	9	3	0.50
9	10	2	1.00

Three of the nine correlations in the above table are negative, and only four are greater than 0.50 (one of which involved the ranks of only two features, where a correlation of 1.00 could have been achieved easily just by random chance). This suggests that interpreting the "final" importance of any single model feature on the difference in results between Model 17.2 and Model 17.6 is difficult at best.

Reference

Thompson, G. G. 2017. Assessment of the Pacific cod stock in the eastern Bering Sea. *In* Plan Team for the Groundfish Fisheries of the Bering Sea and Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 229-515. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501.

Table
Table 2.1.1.1a—Main parameters. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
Natural mortality (M)	0.3744	0.2073	0.3710	0.2035	0.1927	0.3489	0.3135	0.3376	0.3121	0.3350	0.3134	0.3123
Length at age 1.5 (cm)	16.4454	0.0000	0.0000	0.9297	0.9361	3.8434	16.9604	16.9647	16.9443	16.9647	16.9408	16.9457
Asymptotic length (cm)	109.1790	94.7823	102.7290	88.7880	89.1908	95.6643	109.0650	106.9510	108.4370	107.0670	108.3680	108.4180
Brody growth coefficient (K)	0.1714	0.3094	0.2105	0.3982	0.3954	0.2845	0.1702	0.1743	0.1706	0.1732	0.1707	0.1704
Richards growth coefficient	1.0706	0.4480	0.9078	0.1681	0.1705	0.5946	1.0155	1.0190	1.0167	1.0227	1.0170	1.0180
SD of length at age 1 (cm)	3.4923	2.1786	2.4389	1.5907	1.6042	2.1398	3.1440	3.1363	3.1298	3.1353	3.1298	3.1296
SD of length at age 20 (cm)	8.6749	9.0800	8.7923	9.7222	9.7114	9.0068	9.2613	9.3403	9.4556	9.3526	9.4550	9.4591
Ageing bias at age 1	0.3366	-1.9230	-0.7634	-1.9291	-1.9380	-0.7862	0.3543	0.3605	0.3565	0.3609	0.3567	0.3567
Ageing bias at age 20	-0.4049	-1.6124	-1.1629	-1.5518	-1.5248	-0.7048	-0.3184	-0.3429	-0.3233	-0.3442	-0.3227	-0.3262
ln(mean post-1976 recruits)	13.1126	12.3566	13.4167	12.2750	12.1885	13.1847	12.7322	12.9068	12.7262	12.8926	12.7456	12.7372
ln(pre-1977 recruits offset)	-1.4416	-0.2365	-1.2555	-0.2216	-0.1969	-1.3121	-1.1225	-1.2648	-0.9496	-1.2662	-0.9852	-0.9794
Initial fishing mortality rate	0.4688	1.5970	0.2765	1.8701	1.8781	0.3648	1.4953	0.2676	1.7148	0.2676	1.6817	1.6882
ln(EBS std. area catchability)	0.0418	0.5806	0.0506	0.6239	0.6746	0.2014	0.1948	0.0836	0.1834	0.0877	0.1784	0.1810
Select. peak age (fishery)	5.7405	7.3879	6.5985	7.2167	7.2295	6.3808	5.8968	5.8439	5.8842	5.8530	5.8826	5.8845
Select. asc. wid. (fishery)	0.9224	0.6942	0.8097	0.5418	0.5519	0.6745	1.0246	0.9748	1.0151	0.9804	1.0130	1.0144
Select. peak age (EBS sur.)	2.5308	2.9902	2.3055	2.9904	2.9906	2.2967	1.0354	1.0270	1.0383	1.0398	1.0437	1.0366
Select. asc. wid. (EBS sur.)	1.2279	-9.9999	-2.3387	-10.0000	-10.0000	-2.3273	-7.5042	-8.8091	-7.3322	-7.2893	-6.8926	-7.4939
Select. asc. wid. σ (EBS sur.)	n/a	0.1594	0.1594	0.1594	0.1594	0.1594	0.1594	0.1594	0.1594	0.1594	0.1594	0.1594
Sizecomp emphasis (EBS sur.)	0.8665	0.8665	1.6603	1.6603	1.6603	1.6603	1.6603	1.6603	1.6603	1.6603	1.6603	1.6603
Length at age 1.5 σ	n/a	n/a	n/a	0.0973	0.0973	0.0973	0.0973	0.0973	0.0973	0.0973	0.0973	0.0973
ln(EBS std. area Q) σ	n/a	n/a	n/a	n/a	0.0889	0.0889	0.0889	0.0889	0.0889	0.0889	0.0889	0.0889
Agecomp emphasis (EBS sur.)	0.1353	0.1353	0.1353	0.1353	0.1353	0.3172	0.3172	0.3172	0.3172	0.3172	0.3172	0.3172
Select. peak age σ (EBS sur.)	n/a	n/a	n/a	n/a	n/a	n/a	0.0544	0.0544	0.0544	0.0544	0.0544	0.0544
Sizecomp emphasis (fishery)	0.2416	0.2416	0.2416	0.2416	0.2416	0.2416	0.2416	0.1475	0.1475	0.1475	0.1475	0.1475
Agecomp emphasis (fishery)	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0225	0.0217	0.0217	0.0217	0.0217
Select. peak age σ (fishery)	0.1155	0.1155	0.1155	0.1155	0.1155	0.1155	0.1155	0.1155	0.1155	0.1187	0.1187	0.1187
SD of ln(recruitment) devs	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5771	0.5928	0.5928
Select. asc. wid. σ (fishery)	0.4123	0.4123	0.4123	0.4123	0.4123	0.4123	0.4123	0.4123	0.4123	0.4123	0.4123	0.4088

Table 2.1.1.1b—Early recruitment deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
Initial age 20 dev	0.000	0.000	-0.002	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001	0.000	0.000
Initial age 19 dev	0.000	0.000	-0.001	0.000	0.000	0.000	0.000	-0.001	0.000	-0.001	0.000	0.000
Initial age 18 dev	0.000	0.000	-0.003	0.000	0.000	-0.001	0.000	-0.002	0.000	-0.002	0.000	0.000
Initial age 17 dev	0.000	0.000	-0.005	0.000	0.000	-0.002	0.000	-0.004	0.000	-0.004	0.000	0.000
Initial age 16 dev	0.000	0.000	-0.009	0.000	0.000	-0.003	0.000	-0.007	0.000	-0.007	0.000	0.000
Initial age 15 dev	-0.001	0.000	-0.017	0.000	0.000	-0.007	0.000	-0.012	0.000	-0.012	0.000	0.000
Initial age 14 dev	-0.002	0.000	-0.032	0.000	0.000	-0.013	0.000	-0.021	0.000	-0.022	0.000	0.000
Initial age 13 dev	-0.005	0.000	-0.058	0.000	0.000	-0.026	0.000	-0.037	0.000	-0.038	0.000	0.000
Initial age 12 dev	-0.011	0.000	-0.101	0.000	0.000	-0.050	0.000	-0.063	0.000	-0.064	0.000	0.000
Initial age 11 dev	-0.025	0.001	-0.169	0.000	0.000	-0.093	0.000	-0.105	0.000	-0.107	0.000	0.000
Initial age 10 dev	-0.052	0.005	-0.268	0.001	0.001	-0.163	0.000	-0.169	0.000	-0.170	0.000	0.000
Initial age 9 dev	-0.102	0.025	-0.394	0.009	0.009	-0.268	0.003	-0.257	0.001	-0.258	0.001	0.001
Initial age 8 dev	-0.185	0.108	-0.530	0.050	0.051	-0.396	0.013	-0.366	0.006	-0.367	0.006	0.006
Initial age 7 dev	-0.297	0.338	-0.630	0.214	0.220	-0.510	0.055	-0.479	0.030	-0.479	0.032	0.032
Initial age 6 dev	-0.403	1.321	-0.604	1.304	1.272	-0.518	0.205	-0.558	0.127	-0.556	0.135	0.135
Initial age 5 dev	-0.423	0.506	-0.144	0.527	0.509	-0.219	0.577	-0.522	0.404	-0.518	0.424	0.424
Initial age 4 dev	0.039	-0.991	0.467	-1.005	-1.024	0.538	1.037	0.023	1.407	0.033	1.389	1.394
Initial age 3 dev	0.599	-0.177	-0.513	-0.378	-0.412	-0.488	0.402	0.248	0.377	0.243	0.380	0.376
Initial age 2 dev	-0.396	0.467	1.037	0.460	0.409	0.897	-0.514	-0.323	-0.393	-0.322	-0.394	-0.396
Initial age 1 dev	1.214	0.594	1.789	0.698	0.633	1.757	1.021	1.153	0.866	1.160	0.908	0.904

Table 2.1.1.1c—Main recruitment deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
ln(rec.) dev 1977	0.461	0.359	0.631	0.382	0.342	0.709	0.413	0.609	0.504	0.604	0.506	0.505
ln(rec.) dev 1978	0.503	-0.464	0.572	-0.386	-0.427	0.420	0.455	0.542	0.468	0.537	0.471	0.471
ln(rec.) dev 1979	0.485	-0.598	-0.326	-0.793	-0.823	-0.179	0.412	0.500	0.430	0.493	0.433	0.432
ln(rec.) dev 1980	-0.280	0.608	-0.509	0.711	0.688	-0.393	-0.788	-0.724	-0.785	-0.735	-0.787	-0.787
ln(rec.) dev 1981	-0.367	-0.434	0.783	-0.814	-0.817	0.800	-0.445	-0.573	-0.608	-0.572	-0.606	-0.608
ln(rec.) dev 1982	0.724	0.611	-0.272	0.757	0.757	-0.554	0.728	0.808	0.763	0.805	0.765	0.766
ln(rec.) dev 1983	-0.333	0.114	0.716	0.150	0.159	0.766	-0.328	-0.344	-0.373	-0.346	-0.372	-0.374
ln(rec.) dev 1984	0.669	-0.405	0.170	-0.311	-0.289	0.230	0.615	0.686	0.658	0.684	0.658	0.660
ln(rec.) dev 1985	0.085	-0.933	-0.377	-1.321	-1.266	-0.327	0.105	0.117	0.102	0.114	0.102	0.102
ln(rec.) dev 1986	-0.389	-0.332	-1.182	-0.317	-0.291	-1.197	-0.423	-0.434	-0.442	-0.439	-0.444	-0.442
ln(rec.) dev 1987	-0.949	0.509	-0.230	0.578	0.575	-0.190	-1.077	-1.276	-1.249	-1.272	-1.253	-1.253
ln(rec.) dev 1988	-0.333	0.475	0.466	0.464	0.460	0.517	-0.185	-0.190	-0.189	-0.185	-0.189	-0.187
ln(rec.) dev 1989	0.458	-0.051	0.424	-0.007	-0.012	0.410	0.477	0.494	0.494	0.497	0.493	0.496
ln(rec.) dev 1990	0.345	0.826	-0.138	0.865	0.860	-0.143	0.368	0.377	0.401	0.393	0.399	0.401
ln(rec.) dev 1991	-0.153	-0.043	0.729	0.043	0.049	0.730	-0.214	-0.201	-0.243	-0.252	-0.243	-0.243
ln(rec.) dev 1992	0.698	-0.305	-0.132	-0.245	-0.236	-0.052	0.695	0.702	0.716	0.708	0.715	0.717
ln(rec.) dev 1993	-0.225	-0.435	-0.392	-0.528	-0.518	-0.348	-0.189	-0.169	-0.158	-0.173	-0.160	-0.159
ln(rec.) dev 1994	-0.417	0.479	-0.481	0.561	0.558	-0.509	-0.359	-0.348	-0.340	-0.348	-0.341	-0.339
ln(rec.) dev 1995	-0.464	0.142	0.504	0.134	0.139	0.525	-0.340	-0.360	-0.357	-0.357	-0.358	-0.356
ln(rec.) dev 1996	0.454	0.042	0.146	-0.023	-0.017	0.154	0.570	0.631	0.616	0.633	0.616	0.618
ln(rec.) dev 1997	0.084	0.654	-0.039	0.616	0.612	-0.010	0.036	0.002	0.000	0.001	-0.001	0.000
ln(rec.) dev 1998	-0.002	0.352	0.606	0.542	0.542	0.580	-0.099	-0.151	-0.145	-0.149	-0.146	-0.144
ln(rec.) dev 1999	0.546	-0.609	0.237	-0.663	-0.649	0.350	0.563	0.561	0.574	0.572	0.573	0.577
ln(rec.) dev 2000	0.160	-0.132	-0.669	-0.071	-0.067	-0.693	0.144	0.183	0.170	0.156	0.169	0.166
ln(rec.) dev 2001	-0.728	-0.185	-0.187	-0.361	-0.354	-0.180	-0.723	-0.721	-0.692	-0.712	-0.695	-0.691
ln(rec.) dev 2002	-0.204	-0.449	-0.274	-0.212	-0.207	-0.439	-0.047	-0.041	-0.038	-0.041	-0.039	-0.037
ln(rec.) dev 2003	-0.335	-0.407	-0.610	-0.252	-0.249	-0.362	-0.123	-0.156	-0.147	-0.158	-0.149	-0.147
ln(rec.) dev 2004	-0.647	0.751	-0.468	0.843	0.847	-0.361	-0.701	-0.693	-0.676	-0.694	-0.678	-0.676
ln(rec.) dev 2005	-0.477	0.281	0.705	0.266	0.278	0.745	-0.444	-0.460	-0.430	-0.454	-0.432	-0.429
ln(rec.) dev 2006	0.665	1.128	0.195	1.174	1.174	0.231	0.770	0.768	0.792	0.773	0.790	0.793
ln(rec.) dev 2007	0.161	-1.056	1.034	-1.416	-1.417	1.075	0.112	0.067	0.080	0.064	0.078	0.080
ln(rec.) dev 2008	0.993	0.617	-1.035	0.669	0.668	-1.264	1.051	1.057	1.071	1.058	1.070	1.072
ln(rec.) dev 2009	-0.960	0.991	0.507	1.074	1.069	0.534	-1.004	-1.045	-1.018	-1.049	-1.024	-1.022
ln(rec.) dev 2010	0.543	0.225	0.909	-0.065	-0.069	0.934	0.512	0.502	0.521	0.503	0.519	0.522
ln(rec.) dev 2011	0.935	0.872	0.216	0.935	0.916	-0.049	0.867	0.852	0.877	0.857	0.876	0.878
ln(rec.) dev 2012	0.211	-0.930	0.829	-0.848	-0.859	0.789	-0.006	-0.018	0.007	-0.019	0.005	0.007
ln(rec.) dev 2013	0.869	-0.737	-0.925	-0.808	-0.812	-0.928	0.767	0.751	0.777	0.754	0.776	0.778
ln(rec.) dev 2014	-0.905	-1.195	-0.819	-0.968	-0.960	-0.924	-0.777	-0.829	-0.789	-0.827	-0.797	-0.792
ln(rec.) dev 2015	-0.745	-0.165	-1.081	-0.173	-0.174	-1.127	-1.038	-1.063	-1.031	-1.083	-1.004	-1.028
ln(rec.) dev 2016	-1.135	-0.173	-0.234	-0.181	-0.182	-0.270	-0.351	-0.414	-0.310	-0.340	-0.294	-0.329

Table 2.1.1.1d—Fishery selectivity peak age deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
Peak(fis.) dev1977	-0.239	-1.620	-0.347	-1.448	-1.440	-0.443	-0.694	-0.462	-1.207	-0.480	-1.198	-1.210
Peak(fis.) dev1978	-0.322	0.086	-0.470	0.084	0.081	-0.353	0.062	-0.395	0.224	-0.392	0.217	0.220
Peak(fis.) dev1979	-0.977	-0.778	-1.034	-0.810	-0.819	-1.042	-1.166	-0.732	-0.398	-0.724	-0.408	-0.405
Peak(fis.) dev1980	-0.206	-0.177	-0.313	-0.177	-0.186	-0.339	0.744	-0.133	0.089	-0.128	0.089	0.089
Peak(fis.) dev1981	-1.203	-1.191	-1.213	-1.144	-1.155	-1.180	1.405	-0.946	-0.964	-0.958	-0.978	-0.984
Peak(fis.) dev1982	0.683	0.596	0.682	0.602	0.608	0.717	2.074	0.661	0.636	0.660	0.635	0.634
Peak(fis.) dev1983	1.193	1.016	1.129	1.015	1.031	1.107	-0.451	1.095	1.134	1.091	1.125	1.122
Peak(fis.) dev1984	1.828	1.433	1.481	1.189	1.226	1.175	0.337	1.727	1.786	1.710	1.759	1.757
Peak(fis.) dev1985	-0.257	-0.605	-0.898	-0.759	-0.743	-0.837	0.623	-0.550	-0.488	-0.536	-0.485	-0.481
Peak(fis.) dev1986	0.373	0.269	0.294	0.480	0.525	0.479	-0.182	0.311	0.321	0.304	0.314	0.313
Peak(fis.) dev1987	0.452	-0.126	0.342	0.097	0.223	0.351	1.368	0.612	0.643	0.605	0.627	0.629
Peak(fis.) dev1988	-0.109	-0.502	-0.172	-0.423	-0.336	-0.164	2.116	-0.290	-0.316	-0.295	-0.311	-0.319
Peak(fis.) dev1989	1.443	0.799	1.170	0.491	0.498	0.989	0.184	0.965	0.942	0.954	0.937	0.928
Peak(fis.) dev1990	1.959	1.460	1.787	1.535	1.560	1.752	-0.684	2.060	2.030	2.024	1.991	1.989
Peak(fis.) dev1991	0.019	-0.089	-0.200	-0.581	-0.544	-0.522	-0.309	0.097	0.135	0.103	0.129	0.133
Peak(fis.) dev1992	-0.797	-0.633	-0.627	-0.831	-0.810	-0.608	-0.026	-0.688	-0.694	-0.673	-0.678	-0.677
Peak(fis.) dev1993	-0.303	-0.193	-0.227	-0.064	-0.097	-0.172	-0.416	-0.233	-0.229	-0.230	-0.225	-0.225
Peak(fis.) dev1994	-0.058	-0.026	0.019	0.067	0.030	0.037	0.839	0.085	0.070	0.097	0.070	0.070
Peak(fis.) dev1995	-0.399	-0.476	-0.395	-0.526	-0.562	-0.458	0.831	-0.285	-0.368	-0.293	-0.356	-0.356
Peak(fis.) dev1996	1.030	0.812	0.898	1.009	0.969	0.997	0.324	0.898	0.814	0.852	0.800	0.797
Peak(fis.) dev1997	0.907	0.816	0.842	0.894	0.874	0.838	-0.125	0.913	0.861	0.888	0.845	0.843
Peak(fis.) dev1998	0.204	0.328	0.272	0.306	0.300	0.252	-0.133	0.459	0.427	0.455	0.419	0.420
Peak(fis.) dev1999	-0.315	-0.304	-0.313	-0.439	-0.445	-0.349	0.123	-0.060	-0.079	-0.048	-0.075	-0.073
Peak(fis.) dev2000	-0.151	-0.057	-0.093	0.036	0.020	0.041	-0.490	-0.088	-0.120	-0.085	-0.116	-0.114
Peak(fis.) dev2001	-0.338	-0.111	-0.208	-0.182	-0.182	-0.247	-0.717	0.194	0.201	0.201	0.196	0.200
Peak(fis.) dev2002	-0.731	-0.376	-0.667	-0.428	-0.416	-0.500	-1.306	-0.546	-0.529	-0.525	-0.517	-0.515
Peak(fis.) dev2003	-0.674	-0.280	-0.528	-0.287	-0.293	-0.372	-1.349	-0.728	-0.731	-0.697	-0.712	-0.708
Peak(fis.) dev2004	-1.137	-0.577	-0.806	-0.497	-0.511	-0.707	-1.079	-1.117	-1.174	-1.105	-1.142	-1.143
Peak(fis.) dev2005	-1.247	-0.864	-0.945	-0.926	-0.946	-0.962	0.420	-1.018	-1.089	-1.003	-1.060	-1.059
Peak(fis.) dev2006	-0.934	-0.687	-0.756	-0.603	-0.621	-0.639	0.077	-0.863	-0.920	-0.838	-0.895	-0.891
Peak(fis.) dev2007	0.516	0.407	0.474	0.289	0.267	0.347	-1.386	0.512	0.465	0.504	0.456	0.458
Peak(fis.) dev2008	-0.086	0.222	0.006	0.103	0.091	-0.073	0.371	0.111	0.116	0.118	0.113	0.117
Peak(fis.) dev2009	-0.790	-0.523	-0.681	-0.566	-0.586	-0.738	0.528	-1.118	-1.110	-1.072	-1.085	-1.075
Peak(fis.) dev2010	0.405	0.178	0.424	0.345	0.301	0.499	0.437	0.439	0.396	0.426	0.392	0.389
Peak(fis.) dev2011	0.903	0.998	0.927	1.305	1.292	1.040	-0.941	0.283	0.291	0.265	0.288	0.281
Peak(fis.) dev2012	0.216	0.394	0.293	-0.045	-0.057	-0.222	-0.276	0.459	0.401	0.450	0.396	0.398
Peak(fis.) dev2013	-0.895	-0.536	-0.593	-0.576	-0.586	-0.687	0.074	-1.000	-0.948	-0.978	-0.945	-0.942
Peak(fis.) dev2014	-0.166	-0.053	-0.088	0.092	0.078	0.111	-0.724	-0.290	-0.290	-0.289	-0.286	-0.285
Peak(fis.) dev2015	0.212	0.327	0.247	0.634	0.620	0.581	0.421	-0.027	0.005	-0.033	0.003	0.003
Peak(fis.) dev2016	0.060	0.425	0.206	0.457	0.463	-0.049	1.452	-0.767	-0.752	-0.772	-0.742	-0.742
Peak(fis.) dev2017	-0.071	0.216	0.083	0.284	0.278	0.349	-0.262	0.457	0.419	0.446	0.411	0.415

Table 2.1.1.1e—Fishery selectivity ascending width deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
Wid.(fis.) dev1977	-0.002	2.048	0.009	2.061	2.053	0.054	-0.411	0.208	1.846	0.213	1.757	1.759
Wid.(fis.) dev1978	-0.339	-0.044	-0.349	-0.001	-0.001	-0.229	0.173	-0.301	-0.248	-0.309	-0.238	-0.239
Wid.(fis.) dev1979	-0.496	-0.590	-0.662	-0.609	-0.605	-0.693	0.800	-0.276	-0.212	-0.290	-0.226	-0.225
Wid.(fis.) dev1980	0.113	0.059	0.040	0.007	0.007	-0.029	0.089	0.115	0.142	0.114	0.144	0.144
Wid.(fis.) dev1981	0.836	0.338	0.635	0.374	0.379	0.629	0.964	0.842	0.811	0.818	0.788	0.786
Wid.(fis.) dev1982	0.191	0.238	0.286	0.209	0.207	0.313	2.190	0.017	-0.032	0.027	-0.019	-0.020
Wid.(fis.) dev1983	0.963	1.115	1.150	1.188	1.185	1.290	-0.512	0.685	0.640	0.702	0.662	0.662
Wid.(fis.) dev1984	2.060	2.395	2.155	2.350	2.365	1.992	0.595	2.026	1.995	2.043	2.014	2.027
Wid.(fis.) dev1985	-0.256	-1.076	-1.277	-1.522	-1.496	-1.399	0.581	-0.563	-0.532	-0.566	-0.543	-0.541
Wid.(fis.) dev1986	0.772	0.939	0.810	1.311	1.327	1.084	1.296	0.606	0.556	0.604	0.560	0.564
Wid.(fis.) dev1987	0.567	-0.024	0.551	0.412	0.575	0.642	1.839	0.579	0.554	0.583	0.558	0.563
Wid.(fis.) dev1988	1.409	0.931	1.338	1.192	1.267	1.424	1.836	1.184	1.130	1.172	1.128	1.128
Wid.(fis.) dev1989	2.009	1.874	2.003	1.747	1.740	1.994	0.315	1.489	1.427	1.500	1.445	1.447
Wid.(fis.) dev1990	1.844	2.072	2.055	2.442	2.441	2.191	-0.855	1.836	1.754	1.846	1.771	1.782
Wid.(fis.) dev1991	0.219	0.188	0.042	-0.402	-0.347	-0.336	0.336	0.280	0.274	0.285	0.275	0.280
Wid.(fis.) dev1992	-0.965	-1.191	-0.943	-1.686	-1.618	-0.978	0.701	-0.870	-0.909	-0.874	-0.911	-0.917
Wid.(fis.) dev1993	0.318	0.357	0.372	0.533	0.508	0.459	0.100	0.381	0.348	0.377	0.348	0.350
Wid.(fis.) dev1994	0.631	0.802	0.763	1.046	1.015	0.900	0.964	0.786	0.752	0.805	0.755	0.762
Wid.(fis.) dev1995	0.033	-0.293	-0.024	-0.384	-0.429	-0.102	1.014	0.212	0.122	0.207	0.125	0.127
Wid.(fis.) dev1996	1.142	1.226	1.192	1.589	1.544	1.396	0.256	1.000	0.892	0.981	0.901	0.906
Wid.(fis.) dev1997	1.192	1.517	1.315	1.804	1.779	1.460	-0.234	1.081	1.001	1.075	1.008	1.015
Wid.(fis.) dev1998	0.269	0.628	0.443	0.785	0.777	0.507	-1.137	0.398	0.333	0.401	0.338	0.341
Wid.(fis.) dev1999	-0.300	-0.422	-0.348	-0.614	-0.612	-0.408	-0.546	-0.146	-0.195	-0.137	-0.192	-0.191
Wid.(fis.) dev2000	-0.936	-1.136	-0.960	-1.016	-1.037	-0.820	-0.459	-1.095	-1.170	-1.097	-1.167	-1.176
Wid.(fis.) dev2001	-0.915	-0.947	-0.823	-1.085	-1.085	-0.972	-0.947	-0.425	-0.476	-0.420	-0.473	-0.475
Wid.(fis.) dev2002	-0.837	-0.815	-0.934	-0.876	-0.843	-0.768	-1.572	-0.488	-0.512	-0.486	-0.512	-0.515
Wid.(fis.) dev2003	-1.016	-1.051	-1.075	-1.140	-1.134	-0.899	-1.598	-1.008	-1.043	-0.993	-1.043	-1.047
Wid.(fis.) dev2004	-1.481	-1.404	-1.350	-1.272	-1.287	-1.183	-2.047	-1.400	-1.486	-1.416	-1.484	-1.497
Wid.(fis.) dev2005	-1.512	-1.666	-1.387	-1.756	-1.790	-1.376	-0.449	-1.173	-1.285	-1.195	-1.286	-1.296
Wid.(fis.) dev2006	-1.769	-2.129	-1.787	-1.707	-1.730	-1.394	-0.651	-1.706	-1.805	-1.706	-1.804	-1.814
Wid.(fis.) dev2007	-0.106	-0.180	-0.040	-0.109	-0.142	-0.027	-3.205	-0.303	-0.407	-0.302	-0.400	-0.403
Wid.(fis.) dev2008	-0.673	-0.281	-0.540	-0.499	-0.509	-0.703	0.483	-0.604	-0.646	-0.600	-0.643	-0.647
Wid.(fis.) dev2009	-2.030	-2.208	-2.108	-2.814	-2.841	-2.634	0.929	-2.740	-2.752	-2.718	-2.759	-2.766
Wid.(fis.) dev2010	0.352	0.013	0.342	0.263	0.218	0.538	-0.581	0.607	0.547	0.609	0.554	0.557
Wid.(fis.) dev2011	1.025	1.161	1.086	1.544	1.523	1.264	-0.275	0.815	0.797	0.811	0.803	0.806
Wid.(fis.) dev2012	-0.620	-0.695	-0.488	-2.353	-2.355	-2.342	-0.097	-0.592	-0.687	-0.592	-0.678	-0.683
Wid.(fis.) dev2013	-0.362	-0.190	-0.153	-0.262	-0.263	-0.293	0.172	-0.293	-0.263	-0.294	-0.284	-0.282
Wid.(fis.) dev2014	-0.143	-0.254	-0.146	-0.094	-0.102	0.083	-0.452	-0.059	-0.087	-0.062	-0.089	-0.089
Wid.(fis.) dev2015	0.121	-0.040	0.034	0.379	0.360	0.514	-0.794	0.150	0.140	0.149	0.140	0.141
Wid.(fis.) dev2016	0.143	0.347	0.173	0.556	0.572	-0.018	0.801	-0.484	-0.468	-0.497	-0.480	-0.482
Wid.(fis.) dev2017	-1.454	-1.615	-1.398	-1.592	-1.614	-1.131	0.001	-0.770	-0.847	-0.770	-0.842	-0.844

Table 2.1.1.1f—Survey selectivity ascending width deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
Wid.(sur.) dev1982		-0.370	-1.899	-0.539	-0.631	-2.356	-0.001	0.000	-0.002	-0.002	-0.009	-0.001
Wid.(sur.) dev1983		0.000	-0.042	-0.451	-0.574	-0.249	0.005	0.000	0.000	0.000	-0.001	0.000
Wid.(sur.) dev1984		-0.366	-2.362	-0.455	-0.523	-1.793	-0.003	0.000	-0.003	-0.003	-0.011	-0.001
Wid.(sur.) dev1985		0.134	0.930	-0.147	-0.256	0.759	0.000	0.004	0.005	0.005	0.005	0.005
Wid.(sur.) dev1986		-0.538	-1.784	-1.014	-1.114	-2.140	0.000	0.000	-0.005	-0.005	-0.011	-0.003
Wid.(sur.) dev1987		-0.163	-0.354	-0.392	-0.448	-0.389	0.000	0.001	0.001	0.002	0.001	0.002
Wid.(sur.) dev1988		-0.401	-1.533	-0.352	-0.384	-1.122	0.004	0.000	-0.003	-0.003	-0.010	-0.001
Wid.(sur.) dev1989		-0.982	-3.609	-1.426	-1.337	-3.483	0.000	0.000	0.000	0.000	-0.002	0.000
Wid.(sur.) dev1990		-0.203	0.579	-0.406	-0.149	0.594	0.000	0.003	0.004	0.004	0.005	0.004
Wid.(sur.) dev1991		-0.599	-0.828	-0.966	-0.910	-0.838	0.007	0.000	0.000	0.000	-0.001	0.000
Wid.(sur.) dev1992		0.432	2.443	0.795	0.859	2.483	-0.005	0.000	0.006	0.007	0.009	0.005
Wid.(sur.) dev1993		0.370	1.808	0.579	0.609	1.773	0.000	0.004	0.008	0.008	0.009	0.007
Wid.(sur.) dev1994		-0.461	-1.662	-0.947	-1.026	-1.964	0.000	0.000	-0.006	-0.006	-0.008	-0.005
Wid.(sur.) dev1995		-0.535	-2.206	-0.974	-1.052	-2.506	-0.004	0.000	-0.001	-0.001	-0.009	0.000
Wid.(sur.) dev1996		-0.629	-2.740	-0.891	-0.935	-2.681	0.000	0.000	0.000	0.000	-0.004	0.000
Wid.(sur.) dev1997		-0.591	-1.340	-1.174	-1.171	-1.543	0.000	0.000	-0.005	-0.005	-0.007	-0.004
Wid.(sur.) dev1998		-1.169	-3.776	-1.796	-1.870	-4.128	-0.003	0.000	0.000	0.000	-0.006	0.000
Wid.(sur.) dev1999		-0.983	-2.985	-1.449	-1.496	-3.361	0.005	0.000	-0.001	-0.001	-0.009	0.000
Wid.(sur.) dev2000		-0.894	-1.186	-1.244	-1.204	-1.163	0.003	0.000	-0.003	-0.003	-0.004	-0.002
Wid.(sur.) dev2001		0.898	3.146	0.783	0.729	2.694	0.005	0.000	0.007	0.008	0.009	-0.010
Wid.(sur.) dev2002		-0.147	0.041	-0.087	-0.087	0.230	-0.001	0.003	0.004	0.004	0.004	0.004
Wid.(sur.) dev2003		0.226	1.238	0.512	0.566	1.578	0.000	0.004	0.006	0.006	0.007	0.006
Wid.(sur.) dev2004		-0.396	-0.413	-0.047	0.018	0.556	0.001	0.000	0.000	0.000	-0.001	0.000
Wid.(sur.) dev2005		0.561	2.685	1.366	1.416	3.012	0.000	0.000	0.001	0.001	0.001	0.001
Wid.(sur.) dev2006		1.761	4.251	2.661	2.728	4.024	0.004	0.000	0.001	0.002	0.002	0.001
Wid.(sur.) dev2007		3.240	5.616	4.687	4.696	5.609	0.007	0.000	0.000	0.000	0.000	0.000
Wid.(sur.) dev2008		-0.321	0.280	-0.409	-0.361	0.084	0.004	0.004	0.006	0.006	0.007	0.006
Wid.(sur.) dev2009		0.525	2.321	0.930	1.176	2.328	0.007	0.004	0.008	0.008	0.009	0.007
Wid.(sur.) dev2010		-0.005	0.283	0.144	0.155	0.597	0.007	0.004	0.005	0.005	0.005	0.005
Wid.(sur.) dev2011		0.613	2.203	0.972	1.003	2.087	-0.001	0.004	0.008	0.008	0.010	0.008
Wid.(sur.) dev2012		0.671	2.176	0.760	0.778	1.897	0.004	-0.027	0.008	0.008	0.010	0.007
Wid.(sur.) dev2013		-0.453	-1.290	-0.403	-0.404	-0.712	-0.003	0.000	-0.001	-0.001	-0.002	0.000
Wid.(sur.) dev2014		0.135	0.953	-0.042	0.002	0.826	-0.038	0.004	0.005	0.005	0.006	0.005
Wid.(sur.) dev2015		-0.138	-0.575	-0.313	-0.332	-0.562	-0.004	0.000	-0.003	-0.002	-0.004	-0.002
Wid.(sur.) dev2016		-0.066	0.073	-0.054	-0.069	0.276	-0.655	-0.013	-0.044	-0.050	0.011	-0.038
Wid.(sur.) dev2017		-0.097	-0.442	-0.079	-0.082	-0.415	-0.822	0.000	-0.005	-0.005	-0.011	-0.003

Table 2.1.1.1g—Length at age 1.5 deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
L(1.5) dev 1981				-0.154	-0.108	3.338	1.009	-0.739	-0.749	-0.745	-0.752	-0.754
L(1.5) dev 1982				-2.769	-2.701	0.280	0.370	-0.851	-0.845	-0.856	-0.844	-0.848
L(1.5) dev 1983				-0.877	-0.780	-2.943	-1.263	0.930	0.935	0.924	0.933	0.936
L(1.5) dev 1984				1.920	1.967	-0.779	0.174	0.349	0.364	0.352	0.365	0.365
L(1.5) dev 1985				-0.964	-0.902	1.642	-0.048	-1.289	-1.297	-1.295	-1.297	-1.298
L(1.5) dev 1986				1.641	1.686	-1.059	-0.164	0.178	0.210	0.183	0.210	0.210
L(1.5) dev 1987				0.693	0.668	1.462	-0.844	-0.063	-0.037	-0.064	-0.039	-0.040
L(1.5) dev 1988				1.474	1.355	1.275	-0.031	-0.208	-0.192	-0.214	-0.194	-0.196
L(1.5) dev 1989				-0.968	-1.057	1.126	0.483	-0.865	-0.857	-0.866	-0.855	-0.859
L(1.5) dev 1990				-1.555	-1.624	-1.247	-0.034	-0.041	-0.036	-0.040	-0.034	-0.036
L(1.5) dev 1991				1.207	1.173	-1.712	0.674	0.472	0.503	0.490	0.504	0.503
L(1.5) dev 1992				0.087	0.099	1.147	0.455	-0.055	-0.038	-0.055	-0.037	-0.039
L(1.5) dev 1993				1.234	1.277	0.060	0.394	0.648	0.649	0.630	0.650	0.647
L(1.5) dev 1994				1.372	1.428	1.274	0.254	0.344	0.413	0.381	0.412	0.414
L(1.5) dev 1995				1.564	1.581	1.186	-0.292	0.387	0.403	0.387	0.404	0.401
L(1.5) dev 1996				0.520	0.521	1.312	-0.135	0.239	0.252	0.238	0.253	0.250
L(1.5) dev 1997				-1.225	-1.249	0.249	-0.920	-0.290	-0.295	-0.293	-0.293	-0.296
L(1.5) dev 1998				0.357	0.298	-1.456	0.594	-0.188	-0.163	-0.179	-0.161	-0.162
L(1.5) dev 1999				-0.315	-0.338	-0.142	0.748	-0.949	-0.934	-0.950	-0.932	-0.935
L(1.5) dev 2000				1.709	1.695	-0.701	0.961	0.579	0.595	0.584	0.597	0.595
L(1.5) dev 2001				-0.641	-0.653	1.250	0.488	0.759	0.765	0.749	0.767	0.763
L(1.5) dev 2002				2.297	2.261	-0.320	1.259	0.952	0.958	0.939	0.960	0.955
L(1.5) dev 2003				0.333	0.291	2.206	-1.051	0.507	0.521	0.517	0.523	0.521
L(1.5) dev 2004				4.773	4.724	0.915	-1.214	1.331	1.323	1.333	1.326	1.324
L(1.5) dev 2005				-3.026	-3.043	4.610	-1.565	-1.088	-1.093	-1.090	-1.091	-1.094
L(1.5) dev 2006				-4.417	-4.433	-2.650	-1.656	-1.223	-1.218	-1.225	-1.215	-1.219
L(1.5) dev 2007				-3.363	-3.393	-4.238	-0.258	-1.501	-1.496	-1.500	-1.494	-1.496
L(1.5) dev 2008				-3.971	-3.977	-3.013	0.282	-1.647	-1.627	-1.645	-1.625	-1.628
L(1.5) dev 2009				-1.277	-1.291	-4.344	-1.886	-0.283	-0.282	-0.288	-0.280	-0.284
L(1.5) dev 2010				2.349	2.350	-1.001	0.219	0.276	0.303	0.283	0.305	0.304
L(1.5) dev 2011				-5.241	-5.225	2.120	-0.256	-1.891	-1.882	-1.892	-1.880	-1.883
L(1.5) dev 2012				-1.764	-1.773	-5.318	0.292	0.197	0.227	0.202	0.229	0.227
L(1.5) dev 2013				2.706	2.700	-1.457	1.952	-0.256	-0.231	-0.251	-0.229	-0.231
L(1.5) dev 2014				-1.279	-1.265	2.328	1.824	0.278	0.290	0.273	0.290	0.287
L(1.5) dev 2015				1.987	2.000	-1.291	1.154	1.966	1.990	1.977	1.989	1.991
L(1.5) dev 2016				3.475	3.488	0.935	1.150	1.829	1.823	1.835	1.810	1.821

Table 2.1.1.1h—Log survey catchability deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
ln(Q) dev autocor.					0.368	0.439	0.467	0.468	0.466	0.473	0.465	0.466
ln(Q) dev 1982					1.589	-0.062	0.403	0.558	1.043	0.604	1.025	1.036
ln(Q) dev 1983					1.618	0.252	0.682	0.773	1.191	0.807	1.174	1.185
ln(Q) dev 1984					1.156	-0.387	0.837	-0.014	0.416	0.030	0.398	0.408
ln(Q) dev 1985					1.196	0.230	0.089	0.396	0.698	0.424	0.685	0.693
ln(Q) dev 1986					0.912	0.231	-0.567	0.545	0.800	0.571	0.789	0.796
ln(Q) dev 1987					0.061	-0.548	-2.408	-0.127	0.063	-0.104	0.053	0.061
ln(Q) dev 1988					-0.832	-1.118	-2.079	-0.632	-0.528	-0.615	-0.529	-0.528
ln(Q) dev 1989					-3.164	-2.720	-1.549	-2.235	-2.228	-2.228	-2.225	-2.225
ln(Q) dev 1990					-1.959	-2.017	-0.742	-1.896	-1.916	-1.913	-1.914	-1.915
ln(Q) dev 1991					-1.436	-1.482	0.683	-1.461	-1.489	-1.497	-1.488	-1.490
ln(Q) dev 1992					-0.447	-0.570	2.518	-0.701	-0.822	-0.798	-0.819	-0.821
ln(Q) dev 1993					0.651	0.820	2.211	0.738	0.671	0.732	0.674	0.674
ln(Q) dev 1994					2.027	2.449	1.451	2.559	2.500	2.563	2.504	2.502
ln(Q) dev 1995					1.249	1.997	0.432	2.248	2.166	2.261	2.171	2.169
ln(Q) dev 1996					0.670	1.378	-0.112	1.471	1.401	1.481	1.406	1.404
ln(Q) dev 1997					-0.094	0.586	-0.452	0.417	0.385	0.423	0.387	0.386
ln(Q) dev 1998					-0.401	0.138	-0.817	-0.254	-0.206	-0.253	-0.207	-0.209
ln(Q) dev 1999					-0.672	-0.388	0.403	-0.479	-0.452	-0.488	-0.453	-0.456
ln(Q) dev 2000					-0.959	-0.779	-0.483	-0.696	-0.734	-0.732	-0.734	-0.740
ln(Q) dev 2001					1.065	0.752	-0.692	0.609	0.468	0.470	0.471	0.445
ln(Q) dev 2002					-0.700	-0.568	-1.222	-0.397	-0.467	-0.411	-0.465	-0.468
ln(Q) dev 2003					-0.825	-0.555	-0.963	-0.624	-0.708	-0.621	-0.703	-0.704
ln(Q) dev 2004					-1.235	-0.767	-1.267	-1.167	-1.248	-1.155	-1.244	-1.243
ln(Q) dev 2005					-0.316	-0.100	-1.141	-0.906	-0.957	-0.897	-0.953	-0.953
ln(Q) dev 2006					-0.362	-0.172	-1.838	-1.186	-1.257	-1.176	-1.251	-1.252
ln(Q) dev 2007					-0.380	-0.434	-1.679	-1.085	-1.146	-1.091	-1.141	-1.145
ln(Q) dev 2008					-1.567	-1.476	-0.220	-1.741	-1.858	-1.751	-1.852	-1.856
ln(Q) dev 2009					-1.273	-1.316	0.275	-1.503	-1.652	-1.508	-1.644	-1.648
ln(Q) dev 2010					0.014	0.017	0.419	-0.083	-0.210	-0.089	-0.204	-0.208
ln(Q) dev 2011					0.425	0.678	0.432	0.451	0.281	0.448	0.290	0.285
ln(Q) dev 2012					0.479	0.764	1.328	0.572	0.425	0.582	0.432	0.428
ln(Q) dev 2013					0.119	0.507	1.523	0.574	0.435	0.579	0.440	0.438
ln(Q) dev 2014					1.055	1.442	0.875	1.496	1.330	1.492	1.336	1.333
ln(Q) dev 2015					1.251	1.672	-0.282	1.721	1.529	1.711	1.537	1.532
ln(Q) dev 2016					0.691	1.340	-0.987	1.146	0.886	1.126	0.906	0.893
ln(Q) dev 2017					-0.677	0.164	0.084	-0.004	-0.272	-0.002	-0.276	-0.268

Table 2.1.1.1i—Survey selectivity peak age deviations. See text for details.

	Model (17.2, 17.6) or bridging run (BR_#)											
Parameter	17.2	BR_1	BR_2	BR_3	BR_4	BR_5	BR_6	BR_7	BR_8	BR_9	BR_10	17.6
Peak(sur.) dev1982							0.537	0.747	0.538	0.537	0.482	0.561
Peak(sur.) dev1983							-0.145	0.008	0.011	0.014	0.030	0.004
Peak(sur.) dev1984							0.394	0.680	0.479	0.475	0.435	0.497
Peak(sur.) dev1985							-0.004	-0.177	-0.140	-0.145	-0.129	-0.145
Peak(sur.) dev1986							0.712	0.531	0.332	0.330	0.311	0.346
Peak(sur.) dev1987							0.972	-0.072	-0.035	-0.039	-0.017	-0.043
Peak(sur.) dev1988							-0.118	0.651	0.476	0.458	0.432	0.492
Peak(sur.) dev1989							-0.005	1.164	0.924	0.943	0.836	0.954
Peak(sur.) dev1990							-2.077	-0.153	-0.118	-0.115	-0.105	-0.124
Peak(sur.) dev1991							-0.234	-0.030	0.002	-0.001	0.021	-0.006
Peak(sur.) dev1992							0.183	-1.808	-0.547	-0.537	-0.601	-0.531
Peak(sur.) dev1993							0.615	-0.247	-0.246	-0.244	-0.249	-0.246
Peak(sur.) dev1994							0.864	0.344	0.187	0.193	0.192	0.187
Peak(sur.) dev1995							0.150	0.820	0.574	0.596	0.510	0.600
Peak(sur.) dev1996							0.834	1.026	0.771	0.805	0.689	0.800
Peak(sur.) dev1997							0.702	0.338	0.157	0.188	0.167	0.157
Peak(sur.) dev1998							0.083	0.942	0.707	0.713	0.627	0.734
Peak(sur.) dev1999							-0.511	0.813	0.585	0.589	0.518	0.611
Peak(sur.) dev2000							-0.096	0.135	0.076	0.082	0.094	0.072
Peak(sur.) dev2001							-0.156	-1.987	-0.523	-0.522	-0.575	-0.803
Peak(sur.) dev2002							0.030	-0.148	-0.098	-0.103	-0.084	-0.104
Peak(sur.) dev2003							-0.630	-0.195	-0.175	-0.169	-0.168	-0.179
Peak(sur.) dev2004							-0.627	-0.021	-0.007	-0.004	0.012	-0.015
Peak(sur.) dev2005							-0.637	-0.486	-0.676	-0.699	-0.762	-0.649
Peak(sur.) dev2006							-0.120	-0.484	-0.673	-0.688	-0.757	-0.647
Peak(sur.) dev2007							-0.258	-0.488	-0.687	-0.714	-0.781	-0.658
Peak(sur.) dev2008							-0.101	-0.187	-0.160	-0.161	-0.152	-0.165
Peak(sur.) dev2009							-0.247	-0.259	-0.273	-0.270	-0.280	-0.272
Peak(sur.) dev2010							-0.253	-0.167	-0.127	-0.135	-0.117	-0.135
Peak(sur.) dev2011							0.032	-0.257	-0.270	-0.267	-0.276	-0.268
Peak(sur.) dev2012							-0.130	-0.796	-0.276	-0.276	-0.283	-0.275
Peak(sur.) dev2013							0.100	0.026	0.022	0.021	0.041	0.014
Peak(sur.) dev2014							-1.018	-0.177	-0.146	-0.145	-0.135	-0.151
Peak(sur.) dev2015							0.358	0.111	0.071	0.067	0.085	0.063
Peak(sur.) dev2016							0.000	-0.695	-1.096	-1.149	-0.364	-1.036
Peak(sur.) dev2017							0.000	0.498	0.361	0.375	0.353	0.357

APPENDIX 2.2: BSAI PACIFIC COD ECONOMIC PERFORMANCE REPORT FOR 2017

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Pacific cod is the second largest species in terms of catch in the Bering Sea & Aleutian Island (BSAI) region. Pacific cod accounted for 13% of the BSAI's FMP groundfish harvest and 83% of the total Pacific cod harvest in Alaska. Retained catch of Pacific cod decreased 3% to 249.8 thousand t in 2017 and was higher than the 2008-2012 average (Table 1). Catches in 2018 will be lower due to a 15% reduction in the 2018 TAC. The products made from BSAI Pacific cod had a first-wholesale value of $437 million in 2017, which was up from $370 million in 2016 and above the 2008-2012 average of $310 million (Table 2). The higher revenue is the result of increased strong first-wholesale fillet and headed-and-gutted (H&G) prices for Pacific cod products.

Cod is an iconic fishery with a long history of production across much of the globe. Global catch was consistently over 2 million t through the 1980s, but began to taper off in the 1990s as cod stocks began to collapse in the northwest Atlantic Ocean. Over roughly the same period, the U.S. catch of Pacific cod (caught in Alaska) grew to approximately 250 thousand tons where it remained throughout the early to mid-2000s. European catch of Atlantic cod in the Barents Sea (conducted mostly by Russia, Norway, and Iceland) slowed and global catch hit a low in 2007 at 1.13 million t. U.S. Pacific cod's share of global catch was at a high at just over 20% in the early 2000s. Since 2007 global catch has grown to roughly 1.8 million t in recent years as catch in the Barents Sea has rebounded and U.S. catch has remained strong at over 300 thousand t since 2011 (Table 3). European Atlantic cod and U.S. Pacific cod remain the two major sources supplying the cod market over the past decade accounting for roughly 75% and 20%, respectively. Atlantic cod and Pacific cod are substitutes in the global market. Because of cod's long history global demand is present in a number of geographical regions, but Europe, China, Japan, and the U.S. are the primary markets for many Pacific cod products. The market for cod is also indirectly affected by activity in the pollock fisheries which experienced a similar period of decline in 2008-2010 before rebounding. Cod and pollock are commonly used to produce breaded fish portions. Alaska caught Pacific cod in the BSAI became certified by the Marine Stewardship Council (MSC) in 2010, a NGO based third-party sustainability certification, which some buyers seek.

The Pacific cod total allowable catch (TAC) is allocated to multiple sectors (fleets). CDQ entities receive 10% of the total BSAI quota. The largest sectoral allocation goes to the Freezer longline CPs which receive roughly 44% of the total BSAI cod quota (48.7% non-CDQ quota). While not an official catch share program, the Freezer longline CPs have formed a voluntary cooperative that allows them to form private contracts among members to distribute the sectoral allocation. The remaining large sectors are the trawl CPs, trawl CVs, the pot gear CVs and some smaller sideboard limits to cover the catch of Pacific cod while targeting other species. The CVs (collectively referred to as the inshore sector) make deliveries to shore-based processors, and catcher/processors process catch at-sea before going directly to the wholesale markets. Among the at-sea CPs, catch is distributed approximately three-quarters to the hook-and-line and one quarter to trawl. The inshore sector accounts for 25%-30% of the total BSAI Pacific cod catch of which approximately two-thirds is caught by the trawl and one-third by the pot gear sectors. The retained catch of the inshore sector increased 2% increase to 87.7 thousand t. The value of these deliveries

(shoreside ex-vessel value) totaled $53.8 million in 2017, which was up 21% from 2016, as ex-vessel prices also increased 20% to $0.32 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 but recently has been about $0.04 per pound.

The first-wholesale value of Pacific cod products was up 13% to $436.8 million in 2017, and revenues in recent years have remained high as result of strong catch levels (Table 2). The average price of Pacific cod products in 2017 increased 19% to $1.66. 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 75%-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. Head & gut prices bottomed out at $1.05 per pound in 2013, a year in which Barents Sea cod catch increased roughly 240 thousand t (an increase that is approximately the size of Alaska's cod total catch) but rebounded to $1.37 in 2015. The H&G price was up 22% at $1.58 per pound in 2017. Fillet prices steady declined from over $3 in 2011 to $2.67 in 2015. Fillet prices have rebounded since then and increased 14% in 2017 to $3.75 from 2016. Changes in global catch and production account for much the trends in the cod markets. In particular, average first-wholesale prices peaked at over $1.80 per pound in 2007-2008 and subsequent declined precipitously in 2009 to $1.20 per pound as markets priced in consecutive years of approximately 100 thousand t increases in the Barents Sea cod catch in 2009-2011; coupled with reduced demand from the recession. Average first-wholesale prices since have fluctuated between approximately $1.20 and $1.55 per pound. Media reports indicate that prior to the announcement of reduction in the Pacific cod catch in 2018 prices were high with tight supplies and strong demand. Following the announcement of significant catch reductions for 2018 prices escalated to higher level. These price increases are reflected in the highly exported H&G product type which rose 22%.

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 3). China's rise as re-processor is fairly recent. Between 2001 and 2011 exports to China have increased nearly 10 fold. Japan and Europe (mostly Germany and the Netherlands) are also important export destinations. Approximately 30% of Alaska's cod production is estimated to remain in the U.S.. Because U.S. cod production is approximately 20% of global production and the BSAI is approximately 75-80% of U.S. production, the BSAI Pacific cod is a significant component of the broader global cod market. However, strong demand and tight supply in 2017-2018 from the U.S. and globally have contributed to strong prices. With the Barents Sea quota reduced by 13% 2018 the global cod supply will remain constrained which has resulted in high price levels continuing through 2018. High cod prices have incentivized increased demand for substitute products such haddock and pollock which cod relieve some of the upward pressure of cod prices. Furthermore, media reports indicate that significant price increase have yet to filter through to the retail level.

Table 1. 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); 2008-2012 average and 2013-2017.

	Avg 08-12	2013	2014	2015	2016	2017
Total catch K mt	197.96	250.2	249.3	242.1	260.9	253
Retained catch K mt	194.8	243.5	244.4	238.9	257.6	249.8
Vessels #	180	175	156	149	162	170
CP H&L share of BSAI catch	54%	50%	50%	54%	49%	50%
CP trawl share of BSAI catch	15%	18%	14%	15%	14%	13%
Shoreside retained catch K mt	55.9	71.1	79.0	68.3	85.9	87.7
Shoreside catcher vessels #	124.4	125	109	100	110	125
CV pot gear share of BSAI catch	10%	11%	14%	12%	15%	17%
CV trawl share of BSAI catch	18%	18%	17%	16%	18%	18%
Shoreside ex-vessel value M $	$36.9	$36.8	$44.6	$34.0	$44.4	$53.8
Shoreside ex-vessel price lb $	$0.299	$0.243	$0.274	$0.248	$0.263	$0.316
Shoreside fixed gear ex-vessel price premium	$0.06	$0.01	$0.03	$0.03	$0.03	$0.04

Source: NMFS Alaska Region Blend and Catch-accounting System estimates; NMFS Alaska Region At-sea Production Reports; and ADF&G Commercial Operators Annual Reports (COAR). Data compiled and provided by the Alaska Fisheries Information Network (AKFIN).

Table 2. 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); 2008-2012 average and 2013-2017.

		Avg 08-12	2013	2014	2015	2016	2017
All products	volume K mt	95.63	121.70	123.51	120.47	126.40	119.50
All products	Value M $	$ 310.9	$ 303.7	$ 353.8	$ 365.1	$ 386.9	$ 436.8
All products	price lb $	$ 1.47	$ 1.13	$ 1.30	$ 1.37	$ 1.39	$ 1.66
Fillets	volume K mt	5.45	8.79	8.42	6.28	10.03	10.01
Fillets	value share	12%	18%	14%	10%	19%	19%
Fillets	price lb $	$ 3.06	$ 2.84	$ 2.68	$ 2.67	$ 3.29	$ 3.75
Head & Gut	volume K mt	78.91	97.76	100.56	100.82	98.68	92.34
Head & Gut	value share	82%	74%	79%	83%	73%	74%
Head & Gut	price lb $	$ 1.46	$ 1.05	$ 1.26	$ 1.36	$ 1.30	$ 1.58
At-sea	value share	74%	69%	69%	76%	70%	70%
At-sea	price premium ($/lb)	-$0.02	-$0.28	-$0.01	$0.07	-$0.29	-$0.34

Source: NMFS Alaska Region Blend and Catch-accounting System estimates; NMFS Alaska Region At-sea Production Reports; and ADF&G Commercial Operators Annual Reports (COAR). Data compiled and provided by the Alaska Fisheries Information Network (AKFIN).

Table 3. 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 Germany and Netherlands; 2008-2012 average and 2013-2018.

		Avg 08-12	2013	2014	2015	2016	2017	2018 (thru July)
Global cod catch K mt		1,366	1,831	1,853	1,763	1,792	-	-
U.S. P. cod share of global catch		19.3%	16.9%	17.6%	18.0%	17.9%	-	-
Europe share of global catch		72.8%	76.7%	75.9%	74.8%	74.8%	-	-
Pacific cod share of U.S. catch		97.2%	99.3%	99.3%	99.5%	99.5%	-	-
U.S. cod consumption K mt (est.)		83	105	115	108	114	119	-
Share of U.S. cod not exported		27%	31%	31%	26%	29%	33%	-
Export volume K mt		94.4	101.8	107.3	113.2	105.3	92.8	51.6
Export value M US$		$302.9	$308.0	$314.2	$335.0	$312.0	$295.3	$176.1
Export price lb US$		$1.456	$1.373	$1.328	$1.342	$1.344	$1.444	$1.547
Frozen (H&G)	volume Share	69%	91%	92%	91%	94%	94%	92%
	value share	69%	89%	91%	90%	92%	92%	92%
Fillets	volume Share	12%	4%	2%	3%	3%	4%	5%
	value share	15%	5%	4%	4%	4%	5%	6%
China	volume Share	33%	51%	54%	53%	55%	52%	53%
	value share	31%	48%	51%	51%	52%	50%	52%
Japan	volume Share	18%	13%	16%	13%	14%	16%	13%
	value share	18%	13%	16%	14%	15%	18%	15%
Netherlands & Germany	volume Share	10%	8%	9%	8%	5%	3%	1%
	value share	11%	9%	10%	8%	5%	3%	1%

Notes: 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.

Source: FAO Fisheries & Aquaculture Dept. 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. U.S. Department of Agriculture http://www.ers.usda.gov/data-products/agricultural-exchange-rate-data-set.aspx

APPENDIX 2.3: HISTORY OF PREVIOUS EBS PACIFIC COD MODEL STRUCTURES DEVELOPED UNDER STOCK SYNTHESIS

For 2005 and beyond, the SSC's accepted model from the final assessment is shown in **bold red**.

Pre-2005

Timeline

- Pre-1985: Simple projections of current survey numbers at age
- 1985: Projections based on 1979-1985 survey numbers at age
- 1986-1991: *ad hoc* separable age-structured FORTRAN model
- 1992: FORTRAN-based Stock Synthesis (SS), with age-based data
    - Strong 1989 cohort "disappears;" production ageing ceased
- 1993-2003: Models continued to be developed using SS, with length-based data only
- 2001: CIE review of code for proposed "ALASKA" (Age-, Length-, and Area-Structured Kalman Assessment) model and methodology for decision-theoretic estimation of OFL and ABC
    - Although review was favorable, use of ALASKA was postponed "temporarily"
- 2004: Models continued to be developed using SS, with length- *and* age-based data
    - New age data, based on revised ageing protocol
    - Agecomp data used in "marginal" form

Main features of the early Stock Synthesis EBS Pacific cod models

- Start year = 1977
- Three seasons (Jan-May, Jun-Aug, Sep-Dec)
- Four fisheries (Jan-May trawl, Jun-Dec trawl, longline, pot)
- *M* constant at 0.37
- *Q* constant at 1.00
- Efforts at internal estimation of *M*, *Q* unsuccessful
- Double-logistic selectivity for all fleets (fisheries and survey)
- No fleets constrained to exhibit asymptotic selectivity
- Sizecomp input sample size = square root of true sample size
- Survey index standard deviations set to values reported by RACE Division

2005

This assessment marked the first application of ADMB-based Stock Synthesis to EBS Pacific cod

Three models were included:

- Model 1 was identical to the 2004 final model (configured under FORTRAN-based SS), except for use of new maturity schedule developed by Stark
- **Model 2** was configured under ADMB-based SS, and was designed to be as close as possible to Model 1 given the limitations of the respective software packages, except:
    - Nonuniform priors used throughout
    - *M* fixed at 0.37, *Q* fixed at 1.00
- Model 3 was identical to Model 2 except that *M* and *Q* were estimated internally

Weight-length and length-age data examined for evidence of sexual dimorphism; none found.

2006

Nine models were included, consisting of 2005 final model and a 3-way factorial design of alternative models (the factorial models all differed from the 2005 final model in that they estimated trawl survey *Q*

internally—in the 2005 final model, it was fixed at 1.0; and they estimated all selectivity parameters except for selectivity at the minimum size bin internally—in the 2005 final model, a few selectivity parameters were fixed externally):

- Model 0 was identical to 2005 final model
- Model A1 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double logistic selectivity
    - Prior emphasis = 1.0
- Model A2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double logistic selectivity
    - Prior emphasis = 0.5
- **Model B1** was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double normal (four parameter) selectivity
    - Prior emphasis = 1.0
- Model B2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data omitted
    - Double normal (four parameter) selectivity
    - Prior emphasis = 0.5
- Model C1 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double logistic selectivity
    - Prior emphasis = 1.0
- Model C2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double logistic selectivity
    - Prior emphasis = 0.5
- Model D1 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double normal (four parameter) selectivity
    - Prior emphasis = 1.0
- Model D2 was identical to Model 0 except as noted above, with:
    - NMFS longline survey data included
    - Double normal (four parameter) selectivity
    - Prior emphasis = 0.5

2007

Technical workshop

SS introduced a six-parameter form of the double normal selectivity curve (the previous version used only four parameters). This functional form is constructed from two underlying and linearly rescaled normal distributions, with a horizontal line segment joining the two peaks. As configured in SS, the equation uses the following six parameters:

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

6. *final_selectivity* (at maximum length/age)

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

Model 0 was prepared ahead of workshop:

- *M* estimated internally
- Length-at-age parameters estimated internally
- Disequilibrium initial age structure
- Regime shift recruitment offset estimated internally
- Start year changed from 1964 to 1976
- New six-parameter double normal selectivity function used
- Prior distributions reflect 50% CV for most parameters

Twenty-one other models were prepared ahead of workshop, each of which was based on Model 0:

- Two models to examine inside/outside growth estimation:
    - Model 1 was identical to Model 0 except length-at-age parameters estimated outside the model
    - Model 2 was identical to Model 0 except standard deviation of length at age 12 estimated internally
- Two models to examine *M* conditional on *Q,* vice-versa:
    - Model 3 was identical to Model 0 except *M* fixed at 0.37 and *Q* free
    - Model 4 was identical to Model 0 except *Q* fixed at 0.75 and *M* free
- Six models to examine effects of prior distributions:
    - Model 5 was identical to Model 0 except 30% CV instead of 50%
    - Model 6 was identical to Model 0 except 40% CV instead of 50%
    - Model 7 was identical to Model 0 except emphasis = 0.2 instead of 1.0
    - Model 8 was identical to Model 0 except emphasis = 0.4 instead of 1.0
    - Model 9 was identical to Model 0 except emphasis = 0.6 instead of 1.0
    - Model 10 was identical to Model 0 except emphasis = 0.8 instead of 1.0
- Four models to examine effects of asymptotic selectivity:
    - Model 11 was identical to Model 0 except Jan-May trawl fishery selectivity forced asymptotic
    - Model 12 was identical to Model 0 except longline fishery selectivity forced asymptotic
    - Model 13 was identical to Model 0 except pot fishery selectivity forced asymptotic
    - Model 14 was identical to Model 0 except shelf trawl survey selectivity forced asymptotic
- One model to examine estimation of stock-recruit relationship:
    - Model 15 was identical to Model 0 except parameters of a Ricker stock-recruitment relationship estimated internally
- Six models to address EBS-specific comments from the public:
    - Model 16 was identical to Model 0 except input *N* determined by iterative re-weighting
    - Model 17 was identical to Model 0 except input *N* for mean-size-at-age data decreased by an order of magnitude
    - Model 18 was identical to Model 0 except standard error from the shelf trawl survey doubled
    - Model 19 was identical to Model 0 except all age data removed
    - Model 20 was identical to Model 0 except slope survey data removed
    - Model 21 was identical to Model 0 except start year changed to 1982

An immense factorial grid of fixed *M*×*Q* models also prepared ahead of workshop, for which only partial results were presented

Eight models were developed during the workshop itself:

- Model 22 was identical to Model 0 except "old" (pre-Stark) maturity schedule used
- Model 23 was identical to Model 0 except priors turned off and separate *M* estimated for ages 1-2
- Model 24 was identical to Model 0 except priors turned off and longline fishery CPUE included as an index of abundance
- Model 25 was identical to Model 0 except priors turned off and Pcod bycatch from IPHC survey included as an index of abundance
- Model 26 was identical to Model 0 except priors turned off and either *Q* (=0.75) or *M* (=0.37) fixed
- Model 27 was identical to Model 0 except all priors turned off other than that for Jan-May trawl selectivity in largest size bin
- Model 28 was identical to Model 0 except survey selectivity forced asymptotic and *Q* fixed at 0.5
- Model 29 was identical to Model 0 except separate *M* estimated for ages 9+

Preliminary assessment
In general:

- Agecomp data presented as "age conditioned on length" (i.e., not marginals)
- Length-at-age SD a linear function of age
- Annual *dev*s for length at age 1, sigma=0.11
- Annual *dev*s for recruitment, sigma=0.6, 1973-2005
- Annual *dev*s for ascending selectivity, sigma=0.4
- All parameters estimated internally
- Except selectivity parameters pinned against bounds
- Uniform priors used exclusively
- Monotone selectivity for Jan-May trawl fishery
- All other selectivities new "double normal"

Four models were included, all of which were identical to the 2006 final model except as specified above and below:

- Model 1:
    - Estimated effect of 1976 regime shift on median recruitment
    - Added a large constant to fishery CPUE sigmas
- Model 2 was identical to Model 1 except age-dependent *M* estimated for ages 8+
- Model 3 was identical to Model 1 except that it did not add the large constant to longline CPUE sigmas
- Model 4 was identical to Model 1 except:
    - Effect of regime shift assumed to be zero
    - Did not add large constant to longline CPUE sigmas
    - Zero emphasis placed on initial catch and age composition
    - Iteratively re-weighted input sigmas and input *N*

Also attempted but not included:

- Simplified model with only a single fishery and no seasons

Final assessment
Four models were included:

- **Model 1** (comparisons to 2006 final model in parentheses):
  - *M* fixed at 0.34 (*M* fixed at 0.37 in 2006)
  - Length-at-age parameters estimated internally (fixed at point estimates from data in 2006)
  - Start year set at 1977 (start year set at 1964 in 2006)
  - Three age groups in initial state vector estimated (initial state vector assumed to be in equilibrium in 2006)
  - 6-parameter double normal selectivity (4-parameter version used in 2006)
  - Uniform priors used exclusively (informative normal priors used for many parameters in 2006)
  - Fishery selectivities constant across all years (approximately decadal "time blocks" used in 2006)
  - Ascending limb of survey selectivity varies annually with σ=0.2 (survey selectivity assumed to be constant in 2006)
  - Survey selectivity based on age (length-based selectivity used in 2006)
  - Some fishery selectivities forced asymptotic (all selectivities free in 2006)
  - Fishery CPUE data included for comparison (not included in 2006)
  - Age-based maturity schedule (length-based schedule used in 2006)
  - All fisheries seasonally structured (trawl partially seasonal, other gears non-seasonal in 2006)
  - Trawl survey abundance measured in numbers (abundance measured in biomass in 2006)
  - Multinomial *N* based on rescaled bootstrap (sample size set equal to square root of actual *N* in 2006)
- Model 2 was identical to Model 1 except *M* fixed at 0.37
- Model 3 was identical to Model 1 except *M* estimated internally
- Model 4 was identical to Model 1 except:
  - *M* estimated internally
  - Survey selectivities forced to be asymptotic
  - Age data ignored
  - Start year set at 1982; 1977 regime shift ignored
  - Length-based maturity used
  - Length-based survey selectivity used
  - Sigma=0.4 for annual deviations in selectivity parameters
  - Initial catch ignored in estimating initial fishing mortality

2008

Preliminary assessment
Five models were included:

- Model 1 was identical to the 2007 final model
- Model 2 was identical to Model 1 except growth parameter *L2* estimated externally
- Model 3 was identical to Model 1 except exponential-logistic selectivity used instead of double normal
- Model 4 was identical to 2007 Model 4
- Model 5 was identical to Model 1 except:
  - Fishery selectivity blocks (5 yr, 10 yr, 20 yr, or no blocks) chosen by AIC
  - Lower bound of descending "width" = 5.0
  - Regime-specific recruitment "dev" vectors
  - "SigmaR" set equal (iteratively) to stdev(dev) from current regime

- Seasonal weight-length, based on fishery data
- Number of free initial ages chosen by AIC
- Size-at-age data used if modes ambiguous

Final assessment
Eight models were included:

- Model A1 was identical to Model 5 from September except lower bound on selectivity descending "width" parameter relaxed so as not to be constraining
- Model A2 was identical to Model A1, except without age data
- **Model B1** was identical to Model A1, except:
  - "Asymptotic algorithm" used to determine which fisheries will be forced to exhibit asymptotic selectivity
  - "Constant-parameters-across-blocks algorithm" used to determine which selectivity parameters can be held constant across blocks
- Model B2 was identical to Model B1, except without age data
- Model C1 was identical to Model B1, except with M estimated internally
- Model D2 was identical to Model B1, except:
  - No age data
  - Maturity modeled as function of length rather than age
  - M estimated iteratively, based on mat. at len and len. at age
- Model E2 was identical to Model B1, except:
  - No age data
  - Post-1981 trawl survey selectivity forced to be asymptotic
  - *M* estimated internally
- Model F2 was identical to Model 4 from the final assessment for 2007, except start year = 1977

2009

Preliminary assessment
Eight models were included, based on factorial design of the following:

- Selectivity functional form: double normal or exponential-logistic?
- Catchability: free or fixed at 1.0?
- Survey selectivity estimation: free or forced asymptotic?

Partial results were presented for a model with a prior distribution for *Q* based on archival tags (the prior had virtually no impact, which was why only partial results were presented)

Other features explored but not included in the above models:

- Fixing trawl survey catchability at the mean of the above normal prior distribution
- Allowing trawl survey catchability to vary as a random walk
- Fixing trawl survey catchability at a value of 1.00 for the pre-1982 portion of the time series, but allowing it to be estimated freely for the post-1981 portion of the time series
- Reducing the number of survey selectivity parameters subject to annual deviations
- Use of additive, rather than multiplicative, deviations for certain survey selectivity parameters
- Decreasing the value of the σ parameter used to constrain annual survey selectivity deviations
- Turning off annual deviations in survey selectivity parameters for the three most recent years
- Turning off all annual deviations in survey selectivity parameters

- Forcing trawl survey selectivity to peak at age 6.5, the approximate mid-point of the size range of 60-81 cm spanned by the results of Nichol et al. (2007)
- Imposing a beta prior distribution on the shape parameter of the exponential-logistic selectivity function in the trawl survey.

Final assessment
Fourteen models were included (all new since the preliminary assessment except for Model A1):

- Models without mean-size-at-age data:
    - Model A1 was identical to the 2008 final model, with the addition of new data, including the first available fishery agecomp data (from the 2008 Jan-May longline fishery)
    - Model A2 was identical to Model A1, except all agecomp data omitted
    - Model A3 was identical to Model A1, except 2008 Jan-May longline fishery agecomp data omitted
    - Model F2 was identical to Model F2 from the final assessment for 2008
- Models with mean-size-at-age data and agecomp data:
    - **Model B1** was identical to Model A1 except:
        - Survey selectivity held constant for most recent two years
        - Cohort-specific growth included
        - Input standard deviations of all "dev" vectors were set iteratively by matching the standard deviations of the set of estimated *dev*s
        - Standard deviation of length at age was estimated outside the model as a linear function of mean length at age
        - Selectivity at maximum size or age was treated as a controllable parameter
        - *Q* for the post-1981 trawl survey was fixed at the value that sets the average (weighted by numbers at length) of the product of *Q* and selectivity for the 60-81 cm size range equal to the point estimate of 0.47 obtained by Nichol et al. (2007)
        - Potential ageing bias was accounted for in the ageing error matrix by examining alternative bias values in increments of 0.1 for ages 2 and above (age-specific bias values were also examined, but did not improve the fit significantly).
    - Model C1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - *Catchability itself* (rather than the average product of catchability and selectivity for the 60-81 cm size range) set equal to 0.47
    - Model D1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - Selectivity at maximum size or age was removed from the set of controllable parameters (instead, selectivity at maximum size or age becomes a function of other selectivity parameters)
    - Model E1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - Selectivity at maximum size or age for all non-asymptotic fleets was set equal to a single value that was constant across fleets
    - Model G1 was identical to Model B1 except:
        - Input standard deviations for all "dev" vectors and the amount of ageing bias fixed at the values obtained iteratively in Model B1
        - Survey selectivity was held constant across all years (i.e., no selectivity *dev*s are estimated for any years)

- Models with mean-size-at-age data and without agecomp data:
    - Models B2, C2, D2, E2, and G2 were identical to their B1, C1, D1, E1, and G1 counterparts except that agecomp data were ignored and the corresponding sizecomp data were active.

2010

Preliminary assessment
Six models were included:

- Model 1 was identical to the 2009 final model
- Model 2 was identical to Model 1 except:
    - Input standard deviations for all "dev" vectors fixed at the values obtained iteratively in Model 1
    - IPHC survey data omitted
    - Fishery age data omitted
    - Traditional 3-or-5 cm size bins replaced with 1 cm size bins
    - Traditional 3-season structure replaced with new, 5-season structure
    - Spawn time changed from beginning of season 1 to beginning of season 2
- Model 3 was identical to Model 2 except:
    - Non-uniform prior distributions used for selectivity parameters and Q
- Model 4 was identical to Model 2 except:
    - All age data omitted
    - Maturity schedule was length-based rather than age-based
- Model 5 was identical to Model 4 except:
    - Parameters governing spread of lengths at age around mean length at age estimated internally
- Model 6 was identical to Model 5 except:
    - Cohort-specific growth replaced by annual variability in each of the three von Bertalanffy parameters

Final assessment
Three models were included:

- Model A was identical to Model 1 from the preliminary assessment
- **Model B** was identical Model 2 from the preliminary assessment, except cohort-specific growth replaced by constant growth
- Model C: same as Model 4 from the preliminary assessment, except cohort-specific growth replaced by constant growth

2011

CIE review
Exploratory model developed prior to review, which was the same as the 2010 final model, except:

- All sizecomp data turned on
- Nine season × gear fisheries consolidated into five seasonal fisheries
- Pre-1982 trawl survey data omitted
- Mean-size-at-age data omitted
- Fishery CPUE data omitted
- Average input N set to 100 for all fisheries and the survey
- First reference age for length-at-age relationship set at 0.833333
- Richards growth implemented
- Ageing bias estimated internally

    - Selectivities modeled as random walks with age (constant for ages 8+)

Twelve new models were developed during the review itself:

- Model 1 was identical to the 2010 final model except:
    - Length at age 0 constrained to be positive
    - Richards growth implemented
- Model 2 was identical to the 2010 final model except length at age 0 constrained to be positive
- Model 3 was identical to the 2010 final model except:
    - All time blocks removed
    - All selectivity parameters freed except fishery selectivity at initial age
    - All selectivity parameters initialized at mid-point of bounds
- Model 4 was identical to the 2010 final model except:
    - All time blocks removed
    - Emphasis on fishery sizecomps set to 0.001
- Model 5 was identical to the 2010 final model except:
    - Richards growth implemented
    - Ageing bias estimated internally
- Model 6 was identical to Model 4 except time blocks included
- Model 7 was identical to the 2010 final model except *Q* estimated internally
- Model 8 was identical to the 2010 final model except *M* estimated internally with an informative prior
- Model 9 was identical to the 2010 final model except tail compression increased
- Model 10 was identical to the 2010 final model except mean-size-at-age data turned off
- Model 11 was the same the "exploratory" model except:
    - Pre-1982 trawl survey data included
    - All time blocks removed
    - Fishery CPUE data included (but not used for estimation)
    - Input *N* set as in the 2010 final model
    - First reference age for length-at-age relationship set at as in the 2010 final model
- Model 12 was identical to Model 11 except two iterations of survey variance and input *N* re-weighting added

Preliminary assessment
Seven models were included:

- Model 1 was identical to the 2010 final model
- Model 2a was identical to Model 1 except for use of spline-based selectivity
- Model 2b was identical to Model 1 except for omission of pre-1982 survey data
- Model 3 was identical to Model 2b except:
    - Ageing bias estimated internally rather than by trial and error
    - First reference age for length-at-age relationship (*amin*) set at 1.0
    - Standard deviation of length at age *amin* tuned iteratively to match the value predicted externally by regression
- Model 4 was identical to Model 2b except:
    - All agecomp data turned off
    - All sizecomp data turned on
    - First reference age for length-at-age relationship (*amin*) set at 1.0
    - Parameters governing standard deviation of length at age estimated internally
- Model A was identical to Model 2b except:

- First reference age in the mean length-at-age relationship was set at 1.41667, to coincide with age 1 at the time of year when the survey takes place (in Models 1-2b, first reference age was set at 0; in Models 3-4, it was set at 1)
- Richards growth equation was used (in Models 1-4, von Bertalanffy was used)
- Ageing bias was estimated internally (as in Model 3; in Models 1-2 and 4, ageing bias was left at the values specified in the 2009 and 2010 assessments—although this was irrelevant for Model 4, which did not attempt to fit the age data)
- σ_R was estimated internally (in Models 1-4, this parameter was left at the value used in the 2009 and 2010 assessments)
- Fishery selectivity curves were defined for each of the five seasons, but were not stratified by gear type (in Models 1-4, seasons 1-2 and 4-5 were lumped into a pair of "super" seasons, and fisheries were also *gear*-specific)
- Selectivity curve for the fishery that came closest to being asymptotic on its own (in this case, the season 4 fishery) was forced to be asymptotic by fixing both *width_of_peak_region* and *final_selectivity* at a value of 10.0 and *descending_width* at a value of 0.0 (in Models 1-4, the Jan-Apr trawl fishery was forced to exhibit asymptotic selectivity)
- Survey selectivity was modeled as a function of length (in Models 1-4, survey selectivity was modeled as a function of age)
- Number of estimated year class strengths in the initial numbers-at-age vector was set at 10 (in Models 1-4, only 3 elements were estimated)
- The following parameters were tuned iteratively:
    - Standard deviation of length at the first reference age was tuned iteratively to match the value from the regression of standard deviation against length at age presented in the final assessment for 2010 (as in Model 3; in Models 1-2, this parameter was set at 0.01 because the first reference age was 0; in Model 4, it was estimated internally)
    - Base value for *Q* was tuned iteratively to set the average of the product of *Q* and survey selectivity across the 60-81 cm range equal to 0.47, corresponding to the Nichol et al. (2007) estimate (in Models 1-4, the base value was left at the value used in the 2009 and 2010 assessments)
    - *Q* was given annual (but not random walk) *dev*s, with σdev tuned iteratively to set the root-mean-squared-standardized-residual of the survey abundance estimates equal to 1.0 (in Models 1-4, *Q* was constant)
    - All estimated selectivity parameters were given annual random walk *dev*s with *σdev* tuned iteratively to match the standard deviation of the estimated *dev*s, except that the *dev*s for any selectivity parameter with a tuned σdev less than 0.005 were removed (in Models 1-4, certain fishery selectivity parameters were estimated independently in pre-specified blocks of years; the only time-varying selectivity parameter for the survey was *ascending_width*, which had annual—but not random walk—*dev*s with *σdev* set at the value used in the 2009 and 2010 assessments)
    - Age composition "variance adjustment" multiplier was tuned iteratively to set the mean effective sample size equal to the mean input sample size (in Models 1-4, this multiplier was fixed at 1.0)

- Model 5 was identical to Model A except that it used the time series of selectivity parameters estimated (using random walk *dev*s) in Model A to identify appropriate breakpoints for defining block-specific selectivity parameters

Other model features explored but not included in any of the above:

- Annually varying Brody growth parameter
- Annually varying length at the first reference age
- Internal estimation of standard deviation of length at age

- Ordinary (not random walk) *dev*s for annually varying selectivity parameters
- One selectivity parameter for each age (up to some age-plus group) and fleet, either with ordinary or random walk *dev*s or constant
- Not forcing any fleet to exhibit asymptotic selectivity
- Internal estimation of survey catchability
- Iterative re-weighting of size composition likelihood components
- Internal estimation of the natural mortality rate
- Changing the SS parameter *comp_tail_compression* (the tails of each age or size composition record are compressed until the specified amount was reached; sometimes referred to as "dynamic binning")
- Changing the SS parameter *add_to_comp* (this amount was added to each element of each age or size composition vector—both observed and expected, which avoids taking the logarithm of zero and may also have robustness-related attributes)
- Internal estimation of ageing error variances

Final assessment
Five models were included:

- Model 1 was identical to the 2010 final model (and Model 1 from the preliminary assessment)
- Model 2b was identical to Model 2b from the preliminary assessment
- Model 3 was identical to Model 3 from the preliminary assessment
- Model 4 was identical to Model 4 from the preliminary assessment
- **Model 3b** was identical to Model 3 from the preliminary assessment except:
    - Parameters governing variability in length at age estimated internally
    - All sizecomp data turned on
    - Mean-size-at-age data turned off

2012

Preliminary assessment
Five primary and nine secondary models were included (names of secondary models have decimal points; full results presented for primary models only):

- Model 1 was identical to the 2011 final model
    - Model 1.1: Same as Model 1, except survey catchability estimated internally
    - Model 1.2: Same as Model 1, except ageing bias parameters fixed at GOA values
    - Model 1.3 Same as Model 1, except with revised weight-length representation
- Model 2 was identical to Model 1, except survey catchability re-tuned to match archival tag data
- Model 3 was identical to Model 1, except new fishery selectivity period beginning in 2008
- Model 4 was identical to Model 4 from the final assessment for 2011
    - Model Pre5.1: Same as Model 1.3, except for three minor changes to the data file
    - Model Pre5.2: Same as Model Pre5.1, except ages 1-10 in the initial vector estimated individually
    - Model Pre5.3: Same as Model Pre5.2, except Richards growth curve used
    - Model Pre5.4: Same as Model Pre5.3, except σ for recruitment *dev*s estimated internally as a free parameter
    - Model Pre5.5: Same as Model Pre5.4, except survey selectivity modeled as a function of length
    - Model Pre5.6: Same as Model Pre5.5, except fisheries defined by season only (not season-and-gear)
- Model 5: Same as Model Pre5.6, except four quantities estimated iteratively:
    - Survey catchability tuned to match archival tag data

- Agecomp *N* tuned to set the mean ratio of effective *N* to input *N* equal to 1
- Selectivity *dev* sigmas tuned according to the new method described in Annex 2.1.1 of the SAFE chapter

Final assessment
Four models were included:

- **Model 1** was identical to the 2011 final model
- Model 2 was identical to Model 1 except *Q* was estimated freely
- Model 3 was identical to Model 1 except:
  - Ageing bias was not estimated
  - All agecomp data are ignored
- Model 4 was identical to Model 5 from the the preliminary assessment

2013

Preliminary assessment
Four models were included:

- Model 1 was identical to the 2012 final model
- Model 2 was identical to Model 4 from the final 2012 assessment except *Q* estimated internally using a non-constraining uniform prior distribution
- Model 3 was identical to Model 4 from the final 2012 assessment except:
  - *Q* estimated internally using a prior distribution based on archival tagging data
  - Survey selectivity forced asymptotic
- Model 4 was identical to Model 4 from the final 2012 assessment

Final assessment
Due to a protracted government shutdown during the peak of the final assessment season, only one model was presented:

- The **unnumbered model** was identical to the 2012 final model

2014

Preliminary assessment
Six models were included:

- Model 1 was identical to the 2011-2013 final models
- Model 2 was the identical to Model 5 from the 2012 preliminary assessment (also identical to Model 4 in the 2012 final assessment and the 2013 preliminary assessment)
- Model 3 was identical to Model 2, except that survey catchability *Q* was fixed at 1.0
- Model 4 was identical to Model 2, except that *Q* was estimated with a uniform prior and with an internally estimated constant added to each year's log-scale survey abundance standard deviation
- Model 5 was identical to Model 2, except that Q was fixed at 1.0, survey selectivity was forced to be asymptotic, and the natural mortality rate *M* was estimated freely
- Model 6 was a substantially new model, with the following differences from Model 1:
  - Each year consisted of a single season instead of five
  - A single fishery was defined instead of nine season-and-gear-specific fisheries
  - The survey was assumed to sample age 1 fish at true age 1.5 instead of 1.41667
  - Initial abundances were estimated for the first ten age groups instead of the first three
  - The natural mortality rate was estimated internally

- The base value of survey catchability was estimated internally
- Length at age 1.5 was allowed to vary annually
- Survey catchability was allowed to vary annually
- Selectivity for both the fishery and the survey were allowed to vary annually
- Selectivity for both the fishery and survey was modeled using a random walk with respect to age (SS selectivity-at-age pattern #17) instead of the usual double normal
- Several quantities were tuned iteratively: prior distributions for selectivity parameters, catchability, and time-varying parameters other than catchability

Final assessment
Two models were included:

- **Model 1** was identical to the 2011-2013 final models
- Model 2 was identical to Model 2 from the preliminary assessment, except that the *L1* growth parameter was not allowed to vary with time

2015

Preliminary assessment
Eight models were included.

Group A:

- Model 0 was the same as Model 1 from the 2014 final assessment.
- Model 7 was the same as Model 0, but with composition data weighted by Equation TA1.8 of Francis (2011).
- Model 8 was the same as Model 0, but with Richards growth (Model 0 used von Bertalanffy growth, which is a special case of Richards growth).

Subgroup B1:

- Model 2 was the same as Model 2 from the 2014 final assessment.
- Model 3 was the same as Model 2, but with composition data weighted by tuning the mean input sample size to the harmonic mean of the effective sample size, and with time-varying survey catchability (*Q*) turned off.
- Model 4 was the same as Model 2, but with 20 age groups estimated in the initial numbers-at-age vector (Model 2 estimated 10 age groups in the initial numbers-at-age vector).

For all models in Subgroup B1, selectivity prior distributions and the parameters governing time-variability in recruitment, selectivity, and survey catchability were *not* re-tuned. That is, they were left at the values estimated for Model 2 during the 2014 assessment, except that time variability in survey catchability was turned off in Model 3. Note that the tuning for Model 2 was performed during the 2014 *preliminary* assessment (where it was labeled Model 6), and was not updated during the final 2014 assessment.

Subgroup B2:

- Model 5 was based on Model 2, but had a number of differences (described below), one of which was that SS runs were accepted even if the gradient was large, so long as the estimated covariance matrix of the parameters appeared reasonable.

- Model 6 was the same as Model 5, except that SS runs were accepted only if the gradient was small. In the event that a large gradient was obtained, age-specific selectivity *dev* vectors were removed, one at a time, until the large gradient disappeared.

Except for some procedures related to iterative tuning (see next set paragraph), the differences between Model 5 and Model 2 were as follow:

- Composition data were given a weight of unity if the harmonic mean of the effective sample size was greater than the mean input sample size of 300; otherwise, composition data were weighted by tuning the mean input sample size to the harmonic mean of the effective sample size.
- 20 age groups were estimated in the initial numbers-at-age vector.
- Selectivity at ages 9+ was constrained to equal selectivity at age 8 for both the fishery and the survey.
- A superfluous selectivity parameter was fixed at the mean of the prior (in Model 2, the estimate of this parameter automatically went to the mean of the prior).
- The SS feature known as "Fballpark" was turned off (this feature, which functions something like a very weak prior distribution on the fishing mortality rate in some specified year, did not appear to be providing any benefit in terms of model performance, and what little impact it had on resulting estimates was not easily justified).
- SS runs were accepted even if the gradient was large, so long as the estimated covariance matrix of the parameters appeared reasonable (i.e., all values were numeric, no values were unbelievably large).

Iterative tuning of prior distributions for selectivity parameters and time-varying catchability in Model 5 proceeded as in Model 2, except that all iterative tuning procedures were undertaken simultaneously, rather than in the phased approach used for Model 2. For time-varying recruitment and selectivity, the approach used in Model 2, which was based on the method of Thompson and Lauth (2012), was not retained in Model 5. For a univariate model, *if* the method of Thompson and Lauth (2012) returns a non-zero estimate of σ, there is reason to believe that this estimate will be unbiased. However, the method carries a fairly high probability of returning a "false negative;" that is, returning a zero estimate for σ when the true value is non-zero (Thompson in prep.). To reduce this bias toward under-parameterization, the following algorithm was used in Model 5 (Thompson in prep.; note that this is a multivariate generalization of one of the methods mentioned by Methot and Taylor (2011, *viz*., the third method listed on p. 1749)):

1. Set initial guesses for the σs.
2. Run SS.
3. Compute the covariance matrix (**V1**) of the set of *dev* vectors (e.g., element $\{i,j\}$ is equal to the covariance between the subsets of the *i*th *dev* vector and the *j*th *dev* vector consisting of years that those two vectors have in common).
4. Compute the covariance matrix of the parameters (the negative inverse of the Hessian matrix).
5. Extract the part of the covariance matrix of the parameters corresponding to the *dev* vectors, using only those years common to all *dev* vectors.
6. Average the values in the matrix obtained in step 5 across years to obtain an "average" covariance matrix (**V2**).
7. Compute the vector of σs corresponding to **V1**+**V2**.
8. Return to step 2 and repeat until the σs converge.

To speed the above algorithm, the σs obtained in step 7 were sometimes substituted with values obtained by extrapolation or interpolation based on previous runs.

As noted above, the procedure used in Model 5 for iterative tuning of time-varying *Q* was the same as that used in Model 2. However, unlike Model 2, this procedure resulted in time-varying *Q* being "tuned out" in Model 5. Model 6, which also used this procedure, ended up retaining time-varying *Q*.

Final assessment
The final assessment included the same two models that were featured in the 2014 final assessment:

- **Model 11.5** was identical to the 2011-2014 final models
- Model 14.2 was identical to Model 2 from the 2014 final assessment

2016

Preliminary assessment
Six models were presented in this preliminary assessment, including Model 11.5 and five variants of Model 15.6, which was introduced in the 2015 preliminary assessment (where it was labeled "Model 6"). As described by the Joint Team Subcommittee (with subsequent re-numbering to adhere to the established model numbering convention), the full set of models consisted of the following:

- Model 11.5: BS Model 11.5, the final model from 2015
- Model 16.1: Like BS Model 15.6, but simplified as follows:
    - Weight abundance indices more heavily than sizecomps.
    - Use the simplest selectivity form that gives a reasonable fit.
    - Do not allow survey selectivity to vary with time.
    - Do not allow survey catchability to vary with time.
    - Force trawl survey selectivity to be asymptotic.
    - Do not allow strange selectivity patterns.
    - Use empirical weight at age.
- Model 16.2: Like Model 15.6, but including the IPHC longline survey data and other features, specifically:
    - Do not allow strange selectivity patterns.
    - Estimate catchability of new surveys internally with non-restrictive priors.
    - Include additional data sets to increase confidence in model results.
    - Include IPHC longline survey, with 'extra SD.'
- Model 16.3: Like Model 16.2 above, but including the NMFS longline survey instead of the IPHC longline survey.
- Model 16.4: Like Models 16.2 and 16.3 above, but including both the IPHC and NMFS longline survey data and two features not included in either Model 16.2 or 16.3, specifically:
    - Start including fishery agecomp data.
    - Use empirical weight at age.
- Model 16.5: Like Model 16.4 above, but including two features not included in Model 16.4, specifically:
    - Use either Francis or harmonic mean weighting.
    - Explore age-specific M (e.g., using Lorenzen function)."

Note that some points in the above lists of features may be somewhat duplicative, but were included by the JTS in order to address specific comments made by CIE reviewers. For Model 6, harmonic mean weighting (Punt in press) and the age-specific natural mortality function proposed by Lorenzen (1996, 2011) were used.

In the minutes of its May 2016 meeting, the JTS recognized that some of the terms used in the descriptions of its requested models were somewhat subjective and that, in making those requests, the assessment author would need to determine:

1. How to measure the "weight" assigned to abundance indices and size composition data in the same units (Model 16.1).
2. What constitutes a "reasonable fit" to the size/age composition data (Model 16.1).
3. What constitutes a "strange" selectivity pattern (Models 16.1-16.5).

These issues were addressed as follows:

1. The relative "weight" assigned to abundance indices and size composition data was determined by comparing the average spawning biomasses from three models:
   A. a model with a specified set of likelihood "emphasis" (λ) values, with each $\lambda \geq 1.0$;
   B. a model in which λ for the abundance data was set equal to 0.01 while each λ for the size composition data (fishery and survey) was left at the value specified in model A; and
   C. a model in which each λ for the size composition data (fishery and survey) was set equal to 0.01 while each λ for the abundance data was left at the value specified in model B.

   Model B was taken to represent model A with the *abundance* data "turned off," while model C was taken to represent model A with the *size composition* data "turned off" (a λ value of 0.01 rather than 0 was used for to represent "turning off" a data component because some parameters might prove inestimable if that data component were removed entirely). The abundance data in model A were determined to receive greater weight than the size composition data in that model if the absolute value of the proportional change in spawning biomass between models B and A exceeded the analogous value between models C and A. The JTS requested that this criterion (giving greater weight to abundance data than size composition data) be included in Model 16.1 only. As it turned out, the default λ value of 1.0 for all data components was sufficient to satisfy this criterion, so no adjustments to any of the λ values were necessary.
2. To focus on the ability of a particular functional form to fit the data, independent of the absolute values of the sample sizes specified for the associated multinomial distribution or λ values, weighted coefficients of determination (R^2), computed on both the raw and logit scales, were used to measure goodness of fit (the equations below are written in terms of age composition; the equations for size compositions are analogous):

$$R^2 = \sum_{y=ymin}^{ymax} \left(w_y \cdot \left(1 - \frac{\sum_{a=0}^{amax} \left(Pobs_{a,y} - Pest_{a,y} \right)^2}{\sum_{a=0}^{amax} \left(Pobs_{a,y} - Pobs_{ave,y} \right)^2} \right) \right) ,$$

and

$$R^2 = \sum_{y=ymin}^{ymax} \left(w_y \cdot \left(1 - \frac{\sum_{a=0}^{amax} \left(logit\left(Pobs_{a,y} \right) - logit\left(Pest_{a,y} \right) \right)^2}{\sum_{a=0}^{amax} \left(logit\left(Pobs_{a,y} \right) - logit\left(Pobs_{ave,y} \right) \right)^2} \right) \right) ,$$

where

$$w_y = \frac{n_y}{\sum_{i=ymin}^{ymax} n_i} \quad ,$$

$Pobs_{a,y}$ represents the observed proportion at age a in year y, $Pobs_{ave,y}$ represents the average (across ages) observed proportion in year y, $Pest_{a,y}$ represents the estimated proportion at age a in year y, and n_y represents the specified multinomial sample size in year y. To guard against the possibility of achieving misleadingly high R^2 values by extending the size or age range beyond the sizes or ages actually observed, the data were filtered by removing all records with $Pobs_{a,y} < 0.001$ prior to computing the R^2 values. A fit was determined to be "reasonable" if it yielded *both* an R^2 value of at least 0.99 on the raw scale *and* an R^2 value of at least 0.70 on the logit scale. As with #1 above, the JTS requested that this criterion (simplest selectivity function that gives a reasonable fit) be included in Model 16.1 only. Because the "random walk with respect to age" selectivity function gave a reasonable fit, the function was simplified in successive steps first by removing all time-variability, then by switching to a double-normal function, and finally by switching to a logistic function. The logistic function (for both the fishery and the survey) gave a reasonable fit to the fishery size composition data, the survey size composition data, and the survey age composition data, so it was retained as the final functional form.

3. In general, a "strange" selectivity pattern was defined here as one which was non-monotonic (i.e., where the signs of adjacent first differences changed), particularly if the first differences associated with sign changes were large (in absolute value), and particularly if sign changes in first differences occurred at relatively early ages. Specifically, an index of "strangeness" was defined as follows:
   A. Age-specific weighting factors P_a were calculated as the equilibrium unfished numbers at age expressed as a proportion of equilibrium unfished numbers.
   B. For each year, age-specific first differences in selectivity $\Delta_{a,y}$ were calculated.
   C. "Strangeness" was then calculated as:

$$\left(\frac{1}{ymax - ymin + 1}\right) \cdot \sum_{y=ymin}^{ymax} \sqrt{\sum_{a=2}^{amax} \left(P_a \cdot \left(\left(sign\left(\Delta_{a,y}\right) \neq sign\left(\Delta_{a-1,y}\right)\right) \cdot \left(\Delta_a\right)^2\right)\right)} \quad ,$$

   where the expression $sign\left(\Delta_{a,y}\right) \neq sign\left(\Delta_{a-1,y}\right)$ returned a value of 1 if the sign of $\Delta_{a,y}$ differed from the sign of $\Delta_{a-1,y}$ and a value of 0 otherwise. This index attains a minimum of 0 when selectivity is constant across age (or varies monotonically) and a maximum of 1 if selectivity alternates between values of 0 and 1 at all pairs of adjacent ages.

A time series of selectivity at age (for a given fleet) was determined to be "strange" if the index described above exceeded a value of 0.05. If a model produced a "strange" selectivity pattern, the standard deviations of the prior distributions for the selectivity parameters and the standard deviations of any selectivity *dev* vectors were decreased proportionally relative to the values estimated for Model 15.6 in last year's assessment until the threshold value of 0.05 was satisfied.

Final assessment

The final assessment included Models 11.5 and Model 16.1 from the preliminary assessment, and four variants of Model 16.1:

- **Model 16.6**: Model 16.1 without empirical weight at age
- Model 16.7: Model 16.1 without empirical weight at age and including the NMFS LL survey
- Model 16.8: Model 16.1 with time-varying survey selectivity

- Model 16.9: Model 16.1 with time-varying fishery selectivity

Empirical weight at age was first explored for the EBS Pacific cod stock in this year's preliminary assessment. Some key similarities and differences between the models *without* empirical weight at age (Models 11.5, 16.6, and 16.7) and those *with* empirical weight at age (Models 16.1, 16.8, and 16.9) are as follow: All six models estimate (internally) a time-invariant relationship between mean length and age, which is used for fitting the size composition data, among other things. Models *without* empirical weight at age use externally estimated parameters describing a weight-at-length relationship (seasonally varying but constant across years in the case of Model 11.5, annually varying in the cases of Models 16.6 and 16.7) in combination with the internally estimated length-at-age relationship to compute weight at age. Models *with* empirical weight at age bypass the link between weight at age and length at age, and instead use externally estimated, time-varying schedules of weight at age directly.

In Model 16.7, logistic selectivity was assumed for the NMFS longline survey, just as for fishery and trawl survey selectivity.

Time-varying selectivity in Models 16.8 and 16.9 was implemented in the form of annual deviations from a base selectivity function. The "sigma" parameters governing the extent to which selectivity *dev*s can vary from zero (specified as inputs to the model, not estimated internally) in Models 16.8 and 16.9 were set at large values to maximize those models' ability to fit the data, essentially treating each *dev* as an unconstrained parameter. Values of the sigma parameters were increased across several trial runs of each model until the resulting estimate of 2016 spawning biomass did not change (to 3 significant digits) with further increases.

2017

Preliminary assessment
The Joint Team Subcommittee (with subsequent re-numbering to adhere to the established model numbering convention) requested the following six models, all of which were included:

- Model 16.6 (last year's final model), after translating from SS V3.24u to V3.30.
- Model 17.1: Same as Model 16.6, but with the following features added:
    1. Adjust timing of the fishery and survey in SS.
    2. Do not use currently available fishery agecomp data, but do add new fishery agecomps.
    3. Switch to haul-based input sample size and catch-weighted sizecomp data.
    4. Develop a prior distribution for natural mortality based on previous estimates.
    5. Switch to age-based, flat-topped, double normal selectivity.
    6. Allow random time variability in selectivity, with σs fixed at the restricted MLEs.
- Model 17.2: Same as Model 17.1, but with the following features added:
    1. Use harmonic mean weighting of composition data.
    2. Allow time-varying selectivity for the fishery but not the survey.
- Model 17.3: Same as Model 17.1, but with the following features added:
    1. Use harmonic mean weighting of composition data.
    2. Estimate survey index standard error internally ('extra SD' option in SS).
- Model 17.4: Same as Model 17.1, but with the following feature added:
    1. Use Francis weighting.
- Model 17.5: Same as Model 17.1, but with the following feature added:
    1. Give less weight to fishery comps than survey comps, less to sizecomps than agecomps."

In addition to the above six models, a seventh model, designated Model 17.6, was also included in the preliminary assessment. It was similar to Model 17.2, except that it includes annually time-varying length at age 1.5, trawl survey catchability, and survey selectivity.

Final assessment
The SSC requested the following six models, of which the first five were included in the preliminary assessment:

- **Model 16.6**
- Model 17.1
- Model 17.2
- Model 17.3
- Model 17.6
- Model 17.7, which was the same as Model 17.6, but with all sizecomp and agecomp multipliers capped at a value of 1.0.

APPENDIX 2.4: SUPPLEMENTAL CATCH DATA

NMFS Alaska Region has made substantial progress in developing a database documenting many of the removals of FMP species that have resulted from activities outside of fisheries prosecuted under the BSAI Groundfish FMP, including removals resulting from scientific research, subsistence fishing, personal use, recreational fishing, exempted fishing permit activities, and commercial fisheries other than those managed under the BSAI groundfish FMP. Estimates for EBS Pacific cod from this dataset are shown in Table 2.4.1.

Although many sources of removal are documented in Table 2.4.1, the time series is highly incomplete for many of these. Cells shaded gray represent data contained in the NMFS database. Other entries represent extrapolations for years in which the respective activity was known or presumed to have taken place, where each extrapolated value consists of the time series average of the official data for the corresponding activity. In the case of surveys, years with missing values were identified from the literature or by contacting individuals knowledgeable about the survey (the NMFS database contains names of contact persons for most activities); in the case of fisheries, it was assumed that the activity occurred every year.

In the 2012 analysis (Attachment 2.4 of Thompson and Lauth 2012), the supplemental catch data were used to provide estimates of potential impacts of these data in the event that they were included in the catch time series used in the assessment model. The results of that analysis indicated that $F_{40\%}$ increased by about 0.01 and that the one-year-ahead catch corresponding to harvesting at $F_{40\%}$ decreased by about 4,000 t. Note that this is a separate issue from the effects of taking other removals "off the top" when specifying an ABC for the groundfish fishery; the former accounts for the impact on reference points, while the latter accounts for the fact that "other" removals will continue to occur.

The average of the total removals in Table 2.4.1 for the last three complete years (2015-2017) is 8,150 t.

It should be emphasized that these calculations are provided purely for purposes of comparison and discussion, as NMFS and the Council continue to refine policy pertaining to treatment of removals from sources other than the directed groundfish fishery.

Reference

Thompson, G. G., and R. R. Lauth. 2012. Assessment of the Pacific cod stock in the Eastern Bering Sea and Aleutian Islands Area. *In* Plan Team for the Groundfish Fisheries of the Bering Sea/Aleutian Islands (compiler), Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions, p. 245-544. North Pacific Fishery Management Council, 605 W. 4th Avenue Suite 306, Anchorage, AK 99501

Table 2.4.1—Total removals of Pacific cod (t) from activities not related to directed fishing. Cells shaded gray represent data contained in the NMFS database. Other entries represent extrapolations for years in which the respective activity was known or presumed to have taken place.

Activity	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Annual Longline Survey			28	28	28	28	28	28	28	28	28	28	28	28
Bait for Crab Fishery	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646
Bering Sea Acoustic Survey			0			0			0			0		
Bering Sea Slope Survey			1		1	1			1			1		
EBS Trawl Survey	38	38	38	38	38	38	38	38	38	38	38	38	38	38
IPHC Annual Longline Survey														
Large-Mesh Trawl Survey														1
NBS Trawl Survey			5		5	5			5			5		
Pollock EFP 11-01														
Pribilof Islands Crab Survey														
Sport fishery	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
Summer EBS Survey w/ Russia														

Activity	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Annual Longline Survey	28	28	28	28			38		30		36		30	
Bait for Crab Fishery	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646	6646
Bering Sea Acoustic Survey	0			0		0	0		0	0		0		0
Bering Sea Slope Survey	1									1		1		1
EBS Trawl Survey	38	38	38	38	38	38	38	38	38	38	38	38	38	38
IPHC Annual Longline Survey								37	37	37	37	37	37	37
Large-Mesh Trawl Survey	1			1	1				1	1			1	1
NBS Trawl Survey	5													
Pollock EFP 11-01														
Pribilof Islands Crab Survey													5	
Sport fishery	2	2	2	2	2	2	2	2	2	2	2	2	2	2
St. Mathews Crab Survey					7			7			7			7
Subsistence Fishery	2	0	2	5	2	2	2	1	0	2	2	2	2	2
Summer EBS Survey w/ Russia				0								0		0

Activity	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Annual Longline Survey	23		25		20		24		27		32		25
Bait for Crab Fishery	6646	6646	6646	6646	6646	1737	4544	6697	6618	9452	10233	8481	5406
Bering Sea Acoustic Survey		0	0	0	0	0		0		0		0	0
Bering Sea Slope Survey				1		2		1	1	1		1	
EBS Trawl Survey	38	38	38	38	38	38	42	52	33	39	39	36	24
IPHC Annual Longline Survey	37	37	37	37	37	32	20	17	29	52	59	47	37
Large-Mesh Trawl Survey	1	1	1	1	1	1	1	2	1	1	1	1	1
NBS Trawl Survey						1							9
Pollock EFP 11-01							11	307					
Pribilof Islands Crab Survey	5			5			5					5	
Sport fishery	2	2	2	2	2	2	2	2	2	2	2	2	2
St. Mathews Crab Survey			7			9			7				5
Subsistence Fishery	2	2	2	2	2	2	2	2	2	2	2		2
Summer EBS Survey w/ Russia			0	0	0	0		0					

APPENDIX 2.5: PARALLEL RESULTS FOR THE "HARVEST RECOMMENDATIONS" SECTION, BASED ON MODEL 16.6

The results presented in the "Harvest Recommendations" section of the main text are based on Model 16.6i. Because the structure of this model differs substantively from Model 16.6 (the current base model), a set of parallel results for the items in that section, based on Model 16.6, is provided here.

Amendment 56 Reference Points
Model 16.6's estimates of $B_{100\%}$, $B_{40\%}$, and $B_{35\%}$ are 623,000 t, 249,000 t, and 230,000 t, respectively.

Specification of OFL and Maximum Permissible ABC
Given the assumptions of Scenario 1 (below), female spawning biomass for 2019 and 2020 is estimated by Model 16.6 to be below the $B_{40\%}$ value of 249,000 t, thereby placing Pacific cod in sub-tier "b" of Tier 3 for both 2019 and 2020. Given this, Model 16.6 estimates OFL, maximum permissible ABC, and the associated fishing mortality rates for 2019 and 2020 as follows:

Year	Overfishing Level	Maximum Permissible ABC
2019	OFL = 123,000 t	maxABC = 103,000 t
2020	OFL = 94,800 t	maxABC = 78,900 t
2019	*FOFL* = 0.31	*maxFABC* = 0.23
2020	*FOFL* = 0.28	*maxFABC* = 0.22

The age 0+ biomass projections for 2019 and 2020 from Model 16.6 are 570,000 t and 506,000 t. For comparison, the age 3+ biomass projections for 2019 and 2020 from Model 16.6 are 561,000 t and 463,000 t.

Standard Harvest Scenarios, Projection Methodology, and Projection Results
The standard harvest scenarios and projection methodology were the same as described for Model 16.6i in the main text. Projections corresponding to the standard harvest scenarios are shown for Model 16.6 in Table 2.5.1.

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 Tables 2.5.1, the stock is not overfished and is not approaching an overfished condition.

Table 2.5.1a—Model 16.6 projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = max\ F_{ABC}$ in 2019-2030 (Scenarios 1-2), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	195,000	20,500	162,000	229,000
2020	176,000	10,900	158,000	194,000
2021	157,000	7,710	144,000	169,000
2022	152,000	7,100	140,000	164,000
2023	172,000	7,670	159,000	184,000
2024	203,000	9,470	188,000	219,000
2025	229,000	11,400	210,000	247,000
2026	242,000	12,800	221,000	263,000
2027	247,000	13,500	224,000	269,000
2028	248,000	13,800	225,000	270,000
2029	248,000	13,900	225,000	270,000
2030	247,000	13,800	225,000	270,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.25	0.043	0.180	0.321
2020	0.22	0.025	0.182	0.266
2021	0.20	0.016	0.171	0.223
2022	0.19	0.013	0.170	0.212
2023	0.22	0.015	0.194	0.242
2024	0.26	0.017	0.233	0.290
2025	0.30	0.018	0.266	0.326
2026	0.31	0.018	0.285	0.343
2027	0.32	0.017	0.293	0.348
2028	0.32	0.016	0.295	0.349
2029	0.32	0.016	0.295	0.349
2030	0.32	0.016	0.295	0.348

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	103,000	24,600	62,200	143,000
2020	78,900	10,900	61,000	96,900
2021	58,600	5,080	50,200	66,900
2022	53,900	3,470	48,200	59,700
2023	79,000	4,760	71,200	86,900
2024	115,000	7,020	103,000	127,000
2025	143,000	8,260	130,000	157,000
2026	157,000	8,480	143,000	171,000
2027	162,000	8,380	148,000	176,000
2028	163,000	8,220	149,000	176,000
2029	163,000	8,200	149,000	176,000
2030	162,000	8,190	149,000	176,000

Table 2.5.1b—Model 16.6 projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that the upper bound on F_{ABC} is set the most recent five-year average fishing mortality rate in 2019-2030 (Scenario 3), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	195,000	20,500	162,000	229,000
2020	138,000	12,000	119,000	158,000
2021	100,000	7,080	88,400	112,000
2022	89,800	4,980	81,600	98,000
2023	109,000	5,400	100,000	118,000
2024	135,000	6,850	124,000	146,000
2025	153,000	7,950	140,000	166,000
2026	164,000	8,560	149,000	178,000
2027	169,000	8,870	154,000	183,000
2028	171,000	9,010	156,000	186,000
2029	172,000	9,070	157,000	187,000
2030	173,000	9,100	158,000	188,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.54	0.000	0.540	0.540
2020	0.54	0.000	0.540	0.540
2021	0.54	0.000	0.540	0.540
2022	0.54	0.000	0.540	0.540
2023	0.54	0.000	0.540	0.540
2024	0.54	0.000	0.540	0.540
2025	0.54	0.000	0.540	0.540
2026	0.54	0.000	0.540	0.540
2027	0.54	0.000	0.540	0.540
2028	0.54	0.000	0.540	0.540
2029	0.54	0.000	0.540	0.540
2030	0.54	0.000	0.540	0.540

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	196,000	18,700	166,000	227,000
2020	133,000	10,400	116,000	150,000
2021	90,400	6,030	80,500	100,000
2022	82,100	4,520	74,700	89,500
2023	121,000	5,760	111,000	130,000
2024	152,000	7,200	140,000	164,000
2025	169,000	8,110	156,000	182,000
2026	178,000	8,570	163,000	192,000
2027	182,000	8,790	167,000	196,000
2028	184,000	8,890	169,000	198,000
2029	184,000	8,930	170,000	199,000
2030	185,000	8,950	170,000	199,000

Table 2.5.1c—Model 16.6 projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that the upper bound on F_{ABC} is set at $F_{60\%}$ in 2019-2030 (Scenario 4), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	195,000	20,500	162,000	229,000
2020	198,000	15,000	173,000	222,000
2021	189,000	10,800	171,000	207,000
2022	187,000	8,900	173,000	202,000
2023	207,000	8,840	192,000	222,000
2024	242,000	10,500	225,000	259,000
2025	276,000	12,900	255,000	297,000
2026	304,000	14,800	280,000	329,000
2027	325,000	16,400	298,000	352,000
2028	340,000	17,600	311,000	369,000
2029	350,000	18,500	320,000	381,000
2030	357,000	19,200	325,000	389,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.12	0.019	0.084	0.148
2020	0.12	0.015	0.092	0.143
2021	0.11	0.011	0.093	0.131
2022	0.11	0.009	0.096	0.126
2023	0.12	0.009	0.109	0.138
2024	0.15	0.010	0.130	0.161
2025	0.15	0.007	0.139	0.161
2026	0.15	0.007	0.139	0.161
2027	0.15	0.007	0.139	0.161
2028	0.15	0.007	0.139	0.161
2029	0.15	0.007	0.139	0.161
2030	0.15	0.007	0.139	0.161

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	50,400	12,400	30,000	70,700
2020	48,300	8,590	34,200	62,400
2021	41,400	5,350	32,600	50,200
2022	39,500	3,730	33,400	45,600
2023	54,200	3,910	47,800	60,600
2024	77,500	4,910	69,400	85,600
2025	90,700	4,720	82,900	98,500
2026	98,400	5,130	90,000	107,000
2027	104,000	5,380	95,100	113,000
2028	108,000	5,530	98,600	117,000
2029	110,000	5,610	101,000	119,000
2030	112,000	5,660	102,000	121,000

Table 2.5.1d—Model 16.6 projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = 0$ in 2019-2030 (Scenario 5), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	195,000	20,500	162,000	229,000
2020	218,000	19,600	186,000	250,000
2021	228,000	17,500	200,000	257,000
2022	239,000	15,300	214,000	265,000
2023	267,000	13,900	244,000	289,000
2024	312,000	13,800	290,000	335,000
2025	367,000	15,300	341,000	392,000
2026	419,000	17,800	390,000	448,000
2027	464,000	20,600	431,000	498,000
2028	502,000	23,200	463,000	540,000
2029	531,000	25,500	489,000	573,000
2030	553,000	27,500	508,000	598,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.00	0.000	0.000	0.000
2020	0.00	0.000	0.000	0.000
2021	0.00	0.000	0.000	0.000
2022	0.00	0.000	0.000	0.000
2023	0.00	0.000	0.000	0.000
2024	0.00	0.000	0.000	0.000
2025	0.00	0.000	0.000	0.000
2026	0.00	0.000	0.000	0.000
2027	0.00	0.000	0.000	0.000
2028	0.00	0.000	0.000	0.000
2029	0.00	0.000	0.000	0.000
2030	0.00	0.000	0.000	0.000

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0	0	0	0
2020	0	0	0	0
2021	0	0	0	0
2022	0	0	0	0
2023	0	0	0	0
2024	0	0	0	0
2025	0	0	0	0
2026	0	0	0	0
2027	0	0	0	0
2028	0	0	0	0
2029	0	0	0	0
2030	0	0	0	0

Table 2.5.1e—Model 16.6 projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = F_{OFL}$ in 2019-2030 (Scenario 6), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	195,000	20,500	162,000	229,000
2020	168,000	9,650	152,000	184,000
2021	146,000	7,200	134,000	158,000
2022	142,000	6,800	130,000	153,000
2023	162,000	7,380	150,000	174,000
2024	193,000	9,130	178,000	208,000
2025	215,000	11,000	197,000	233,000
2026	226,000	12,100	206,000	246,000
2027	229,000	12,700	208,000	250,000
2028	229,000	12,800	208,000	250,000
2029	229,000	12,800	208,000	250,000
2030	229,000	12,800	208,000	250,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.31	0.053	0.220	0.395
2020	0.26	0.028	0.215	0.307
2021	0.22	0.017	0.197	0.251
2022	0.22	0.014	0.194	0.240
2023	0.25	0.017	0.224	0.279
2024	0.30	0.021	0.269	0.337
2025	0.34	0.021	0.306	0.376
2026	0.36	0.021	0.325	0.392
2027	0.36	0.020	0.331	0.396
2028	0.36	0.019	0.333	0.396
2029	0.36	0.019	0.332	0.395
2030	0.36	0.019	0.332	0.395

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	123,000	29,100	75,000	171,000
2020	86,500	10,600	69,000	104,000
2021	61,400	4,590	53,900	69,000
2022	56,600	3,330	51,200	62,100
2023	85,700	5,130	77,300	94,200
2024	126,000	7,750	113,000	138,000
2025	154,000	8,860	139,000	169,000
2026	166,000	8,890	152,000	181,000
2027	169,000	8,710	155,000	184,000
2028	169,000	8,580	155,000	183,000
2029	169,000	8,530	155,000	183,000
2030	168,000	8,520	154,000	182,000

Table 2.5.1f—Model 16.6 projections for spawning biomass (t), fishing mortality, and catch (t) under the assumption that $F = max\ F_{ABC}$ in each year 2019-2020 and $F = F_{OFL}$ thereafter (Scenario 7), including effects of parameter uncertainty.

Female spawning biomass projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	195,000	20,500	162,000	229,000
2020	176,000	15,600	151,000	202,000
2021	157,000	11,600	137,000	176,000
2022	147,000	6,930	136,000	159,000
2023	165,000	6,980	153,000	176,000
2024	194,000	8,930	179,000	208,000
2025	216,000	10,900	198,000	234,000
2026	226,000	12,200	206,000	246,000
2027	229,000	12,700	208,000	250,000
2028	229,000	12,900	208,000	250,000
2029	229,000	12,800	208,000	250,000
2030	229,000	12,800	208,000	250,000

Fishing mortality projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	0.25	0.000	0.251	0.251
2020	0.22	0.000	0.224	0.224
2021	0.24	0.034	0.187	0.298
2022	0.23	0.022	0.190	0.262
2023	0.26	0.020	0.223	0.289
2024	0.30	0.021	0.269	0.340
2025	0.34	0.021	0.306	0.377
2026	0.36	0.020	0.325	0.392
2027	0.36	0.020	0.331	0.396
2028	0.36	0.019	0.333	0.395
2029	0.36	0.019	0.332	0.395
2030	0.36	0.019	0.332	0.394

Catch projections:

Year	Mean	St. Dev.	L90%CI	U90%CI
2019	103,000	9,790	86,500	119,000
2020	78,900	6,300	68,600	89,300
2021	70,500	12,600	49,700	91,300
2022	61,000	6,280	50,700	71,300
2023	88,200	6,400	77,700	98,700
2024	126,000	8,010	113,000	140,000
2025	154,000	8,830	140,000	169,000
2026	166,000	8,860	152,000	181,000
2027	169,000	8,700	155,000	184,000
2028	169,000	8,580	155,000	183,000
2029	169,000	8,530	155,000	183,000
2030	168,000	8,520	154,000	182,000