Norton Sound red king crab stock assessment

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Executive summary

1. Stock

Red king crab, *Paralithodes camtschaticus*, in Norton Sound, Alaska.

2. Catches

The Norton Sound red king crab (NSRKC) stock supports three fisheries: male-only summer and winter directed commercial fisheries, and a year-round subsistence fishery. The summer commercial fishery began in 1977 and the highest catches occurred in 1977-1981, peaking in 1979 at 970,962 crab. From 1982 to the present, summer commercial catch has not exceeded 161,113 crab. The Norton Sound red king crab fishery began operating as super-exclusive in 1994, meaning that vessels registered for the fishery cannot participate in any other king crab fishery in the same registration year. From 1994 to 2026, the summer commercial fishery accounted for an average of 94% of commercially-harvested crab by weight each year.

In 2026, commercial fishers harvested 5,756 crab (0.008 kt; 16,794 lb) in winter and 80,726 crab (0.134 kt; 296,238 lb) in summer for a total commercial retained catch of 0.142 kt (313,033 lb). Crab per pot lift (catch per unit effort, CPUE) in the summer commercial fishery was 15.9, down 5% from the 2025 CPUE of 16.8 but above the 1994-present time series average of 14.2, while average weight was the highest in the time series at 3.7 lb (Figure 1). The Guideline Harvest Level (GHL) of 268,000 lb was exceeded by 16.8%. A factor contributing to this overage was the increase in catch at the end of the 10-day summer commercial fishery, during the period between the fishery closure announcement on 23 June 2026 and the closure at noon on 25 June 2026, beyond that projected based on catches prior to the closure announcement (Figures 2 and 3).

The relative of abundance of males in the largest size bin ($\geq$ 134 mm carapace length) in the 2026 summer commercial fishery retained catch, 34%, was the highest in the time series; the only other years in which this percentage exceeded 20% were 1981 (32%) and 1982 (31%) (Figure 4, Table 6). Potential drivers of this pattern include reduced natural mortality on large males or changes in movement patterns leading to increased availability of large males to the fishery.

Winter 2026 subsistence fishers caught 6,767 male crab and 351 female crab, and retained 5,025 male crab (0.007 kt; 14,662 lb), with 100% of permits returned. Summer subsistence fishers caught 113 male crab and 0 female crab, and retained 95 (0.0002 kt; 349 lb) male crab, with 100% of permits returned. In total, a harvest of 91,602 male crab (0.149 kt; 328,043 lb) was reported for the commercial and subsistence fisheries in 2026. Discard mortality data are not available because vessels participating in the 2026 NSRKC fisheries did not have observers on board. The discard mortality estimate from model 26.0, the base model with updated data, is 0.005 kt (10,585 lb). Combining retained and discard mortality, total fishing mortality in 2026 was 0.154 kt (338,628 lb).

For 2026, the OFL was 0.193 kt (426,000 lb) and the ABC was 0.135 kt (298,000 lb). The GHL was 268,000 lb. Total fishing mortality exceeded the ABC by 13.6% but was below the OFL, so overfishing did not occur.

3. Data sources

The data sources used in this assessment are summarized in Figure 5 and include retained catch, discards, total catch, size compositions, and catch per unit effort (CPUE) from the summer commercial fishery; retained catch, total catch, and size compositions from the winter commercial fishery; retained catch from the winter subsistence fishery; growth information from a tagging study; size compositions from the winter pot survey; and abundance and size compositions from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound (NS) trawl survey (1976-1991), the NOAA Northern Bering Sea (NBS) trawl survey (2010-2025), and the Alaska Department of Fish and Game (ADF&G) trawl survey (1996-2024). Note that no new fishery-independent survey data were available for the 2026 assessment.

4. Stock abundance

Abundance of the Norton Sound red king crab stock has been monitored by the NOAA NS trawl survey (1976-1991), the NOAA NBS trawl survey (2010-2025), and the ADF&G trawl survey (1996-2024; next scheduled for 2027). In 2025, estimated abundance from the NOAA NBS trawl survey was 1.63 million crab (CV = 0.64). The 2026 estimate of mature male abundance (MMA) from the base model (26.0) is 1.20 million crab, and the MMA estimate from the authors' recommended model (26.1.d) is 1.41 million crab.

5. Recruitment

Recruitment is based on the estimated number of male crab 64-93 mm in carapace length (CL) in each year. As estimated by the base model, 26.0, average recruitment over 1976-2025 was 746,287 crab. Data from the NBS trawl survey appear to show a recruitment pulse first apparent in 2019 moving though the population (Figure 6).

6. Management performance

The tables below show the status and catch specifications for 2027 based on the recommended model (26.1.d), as well as the historical record of status and catch specifications based on the model accepted for each year from 2022 to 2026, in both 1,000 t and million lb (Tables 1 - 2). The minimum stock size threshold (MSST) is calculated as $B_{MSY}/2$. The ABC for 2027 is calculated as (1 - 0.3) * OFL, using the recommended ABC buffer of 30%. The GHL listed is the total commercial GHL, including summer, winter, and Community Development Quota (CDQ) commercial fisheries. Harvest specifications for this stock in the 2026 fishing season were set in December 2025. **For status and catch specifications for all of the alternative models presented in this document, please see Section F: Calculation of the OFL**. Estimated mature male biomass in 2026 was above the estimated MSST so the stock was not overfished. Total catch in 2026 was below the OFL so overfishing did not occur.

Table 1: Status and catch specifications (1,000 t) for the recommended model, 26.1.d. For status and catch specifications for all of the alternative models presented in this document, please see Section F: Calculation of the OFL.

Year	MSST	Biomass (MMB_{mating})	GHL	Retained catch	Total catch	OFL	ABC	Model
2022/22	0.95	2.42	0.15	0.15	0.16	0.30	0.18	21.0
2023/23	1.20	2.40	0.178	0.192	0.201	0.292	0.204	21.0
2024/24	1.00	2.50	0.219	0.209	0.215	0.332	0.233	21.0
2025/25	0.98	2.15	0.186	0.164	0.168	0.284	0.199	24.0
2026/26	1.00	1.56	0.130	0.149	0.154	0.193	0.135	25.0a2
2027/27	1.30	1.59				0.143	0.100	26.1.d

Table 2: Status and catch specifications (million lb) for the recommended model, 26.1.d. For status and catch specifications for all of the alternative models presented in this document, please see Section F: Calculation of the OFL

Year	MSST	Biomass (MMB_{mating})	GHL	Retained catch	Total catch	OFL	ABC	Model
2022/22	2.08	5.33	0.34	0.34	0.36	0.67	0.40	21.0
2023/23	2.65	5.29	0.392	0.425	0.444	0.643	0.450	21.0
2024/24	2.2	5.52	0.483	0.460	0.474	0.733	0.513	21.0
2025/25	2.16	4.72	0.410	0.361	0.369	0.628	0.440	24.0
2026/26	2.21	3.43	0.268	0.328	0.339	0.426	0.298	25.0a2
2027/27	2.86	3.50				0.315	0.221	26.1.d

7. Basis for the OFL

Estimated mature-male biomass (MMB) is used as the measure of biomass for this Tier 4 stock, with males measuring $\geq$ 94 mm CL considered mature. The B_{MSY} proxy is obtained by averaging estimated MMB over a specific reference period, here 1980 to the most recent year.

Table 3: Basis for the OFL (1,000 t) from the recommended model, 26.1.d. For the basis for the OFL for all of the alternative models presented in this document, please see Section F: Calculation of the OFL.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality
2022/22	4a	1.90	2.42	1.3	0.18	1980-2021	0.18
2023/23	4a	1.98	2.40	1.2	0.18	1980-2022	0.18
2024/24	4a	2.02	2.50	1.2	0.18	1980-2023	0.18
2025/25	4a	1.96	2.15	1.09	0.18	1980-2024	0.18
2026/26	4b	2.00	1.56	0.78	0.17	1980-2025	0.23
2027/27	4b	2.60	1.59	0.61	0.13	1980-2026	0.23

Table 4: Basis for the OFL (million lb) from the recommended model, 26.1.d. For the basis for the OFL for all of the alternative models presented in this document, please see Section F: Calculation of the OFL.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality
2022/22	4a	4.17	5.33	1.3	0.18	1980-2021	0.18
2023/23	4a	4.37	5.29	1.2	0.18	1980-2022	0.18
2024/24	4a	4.45	5.52	1.2	0.18	1980-2023	0.18
2025/25	4a	4.33	4.72	1.09	0.18	1980-2024	0.18
2026/26	4b	4.42	3.43	0.78	0.17	1980-2025	0.23
2027/27	4b	5.72	3.50	0.61	0.13	1980-2026	0.23

8. Probability density function (PDF) of the OFL

The PDFs of the OFL for the models to be considered for harvest specifications are shown in Figures 7, 8, 9, and 10.

9. Basis for the ABC recommendation

The CPT and SSC recommended an ABC buffer of 30% for setting harvest specifications for 2026 for the following reasons: 1) uncertainty in the biological characteristics of the stock, 2) difficulty in managing to a total mortality due to lack of information about discards, 3) the model's overestimation of the abundance of the largest male crab, 4) the use of a higher natural mortality value for larger males in order to correct for this overestimation of abundance rather than the size-independent M used by other Bering Sea and Aleutian Islands (BSAI) king crab stock assessment models, and 5) a retrospective pattern in model-estimated mature male biomass (Appendix A). While the retrospective pattern is improved relative to the 2025 assessment for all models presented for harvest specifications, an important additional concern for setting harvest specifications for 2027 is the increased uncertainty due to the lack of fishery-independent survey data in 2026. The authors recommend retaining the 30% buffer for 2027 harvest specifications.

10. Summary of rebuilding analyses

The NSRKC stock is not currently subject to a rebuilding plan.

A. Summary of major changes

1. Changes to the management of the fishery

There are no changes to the management of the fishery.

2. Changes to the input data

Time series that have been updated since the 2025 SAFE report (Stern and Palof 2025) include retained catch from the winter commercial fishery, retained catch from the winter subsistence fishery, total catch from the winter subsistence fishery, retained catch from the summer commercial fishery, CPUE from the summer commercial fishery, and size composition information from the summer commercial fishery retained catch. Note that neither the ADF&G trawl survey nor the NOAA NBS trawl survey occurred in 2026 so no new fishery-independent data were available for the 2026 assessment. Other changes to the input data include the model-based indices of abundance that are used in models 26.1.nd, 26.1.d, 26.2.nd, and 26.2.d in place of the design-based ADF&G and NOAA NBS trawl survey indices of abundance. The development of the model-based indices of abundance is described in Appendix B.

3. Changes to the assessment methodology

This assessment has used the Generalized size-structured Model for Assessing Crustacean Stocks (GMACS) framework since 2024. The model used for 2025 harvest specifications was accepted by the Crab Plan Team (CPT) in November 2024 and is detailed in the 2024 SAFE document (Hamazaki 2024). The model used for 2026 harvest specifications, 25.0a2, was accepted by the CPT in November 2025 and is detailed in the 2025 SAFE document (Stern and Palof 2025). Model 25.0a2 was the base model entering the 2026 assessment year.

In the proposed models document presented in May 2026, we first bridged model 25.0a2 to a newer GMACS version and then explored the incorporation of a model-based index of abundance based on data from the ADF&G and NOAA NBS trawl surveys. Model 25.0a2 used GMACS version 2.20.20 while the May 2026 new base model, 26.0, was model 25.0a2 transitioned to GMACS version 2.20.34a with some slight modifications. In model 25.0a2, both of the parameters for the recruitment size distribution were estimated in phase 3 of the model; however, in GMACS version 2.20.34a, model convergence issues arose that were solved by moving estimation of the alpha parameter of the recruitment size distribution to phase 5. One change not related to the transition was also implemented for model 26.0: the upper bound for the β parameter of growth was reduced from 20 to 1 in order to avoid allowing negative growth at the bound. The estimated value of the β parameter in the base model was 0.29. A bridging analysis showed that these minor changes did not influence model results.

Also in May 2026, in response to suggestions from the SSC and CPT, we developed and presented models including a model-based index of abundance based on the ADF&G and NOAA NBS trawl survey time series, exploring different catchability and selectivity configurations for the models incorporating the model-based index. In the base model, catchability is fixed at 1 for the ADF&G survey and estimated for the other two surveys, while selectivity is estimated for the historical Norton Sound survey and mirrored to those estimates for the ADF&G and NOAA NBS trawl surveys. The four models that included the model-based index of abundance were configured as follows. Model 26.1 had catchability fixed at 1 for the model-based index and estimated for the historical survey, while the selectivity configuration was as in the base model. Model 26.2 estimated catchability for both the model-based index and the historical survey, while selectivity was again configured as in the base model. Model 26.3 estimated catchability for both the model-based index and the historical survey, and estimated selectivity for all three surveys. Model 26.4 estimated catchability for both the model-based index and the historical survey, and fixed selectivity for all three surveys and all size bins at 1 or close to 1, matching the estimated selectivities. After reviewing these model alternatives, the SSC and CPT requested seeing models 26.0, 26.1, and 26.2 as options for harvest specifications. Additionally, the review bodies requested two model runs each for 26.1 and 26.2, using model-based indices generated by spatiotemporal models that either included or excluded consideration of survey station depth.

Accordingly, in this document, we present as candidates for harvest specifications an updated version of the

base model, 26.0, as well as two runs each of models 26.1 and 26.2, one using a model-based index derived from a spatiotemporal model that does not include depth (26.1.nd, 26.2.nd) and one using a model-based index derived from a spatiotemporal model that includes depth (26.1.d, 26.2.d). We describe the development of the model-based indices in detail in Appendix B.

B. Responses to SSC and CPT comments

SSC comments specific to NSRKC assessment, June 2026

The SSC concurs with the CPT and the author that the base model (Model 26.0) and two alternatives, models 26.1 and 26.2, come forward for the fall 2026 assessment. The SSC also concurs with the CPT's request that the author revisit the MBI and present two versions, one including survey-station depth as a covariate and one excluding it, so the influence of depth on the index scale and the resulting reference points can be evaluated in the assessment. In future MBI iterations, the authors should consider additional data available through ADF&G and NOAA, including survey data previously dropped in survey estimates and tagging data. In addition, size composition data should be incorporated into the MBI such that the previous issues with abundance in the largest size bin can be assessed.

We present models 26.0, 26.1, and 26.2 in this document. Models 26.1.nd and 26.2.nd use model-based indicies derived from spatiotemporal models that exclude survey station depth and models 26.1.d and 26.2d use model-based indicies dervied from spatiotemporal models that include survey station depth. This allows for the requested evaluation of the influence of depth on the index scale and reference points. Developing model-based size composition estimates is a high priority for us and we hope to present the initial results in the next assessment cycle. We request more information about the additional data available through ADF&G and NOAA to which the SSC refers, as we were under the impression that all of the available trawl survey data were already included in the model. Pot survey data were previously deemed unreliable for purposes of estimating population abundance, and additionally are difficult to incorporate into a spatiotemporal model-based index due to the lack of area-swept estimates. However, if the SSC is aware of additional trawl survey data for NSRKC, we would be eager to learn about these data sets. We have not yet explored how tagging data would be incorporated into a model-based index, but can investigate this idea further if the SSC wishes.

The MBI is predicted within the NBS survey stratum, but the survey observations extend beyond that stratum (Appendix D, Fig. 9); the author should report how sensitive the index and reference points are to the choice of prediction area.

The figure overlaying the NBS survey stratum on the cumulative survey observations was perhaps misleading, and we apologize for the confusion. We present a new figure in Appendix B displaying the NBS bottom trawl survey stratum for NSRKC with ADFG and/or NOAA NBS survey tow locations by year, which shows that the stratum includes nearly all survey stations at which crab have been observed. Some tow locations that were surveyed prospectively in 2006 and 2008 fall outside the stratum but almost all of these tow locations had no observed crab and were not sampled in subsequent years. Excluding these stations from the prediction area is not expected to impact estimated abundance. We are happy to show sensitivity analyses for exclusion of these stations in future but did not prioritize those analyses for this assessment cycle.

The author should assess whether depth and survey identity are correlated in the combined dataset (for example, by comparing the depth distributions of the NBS and ADF&G stations, or by estimating the depth effect within each survey separately) to determine whether the depth covariate captures real bathymetric structure or partly absorbs a difference in scale between the two surveys.

In Appendix B, we show a plot comparing the depth and abundance per area distributions of the NBS and ADF&G survey data, showing that ADF&G survey stations both have a shallower depth range and tend to observe higher abundance than NBS stations. We also plot the depth effect of each survey separately for a model in which depth is included as a separate covariate, showing that the relationships between depth and abundance per area are similar but not identical between the surveys. Accordingly, we explored using an interaction between depth and survey in the spatiotemporal models, and show full evaluations of those models

in Appendix B. The spatiotemporal model we selected to generate the model-based index that includes depth is a delta-gamma distribution family model with the model formula abundance per area ~ year + survey + s(depth, by = survey), including a smooth of depth by survey. Including the smooth of depth by survey in the spatiotemporal model led to improved out-of-sample predictive skill, suggesting that this interaction contributes to explaining variation in observed abundance per area.

The selected delta-gamma index model with depth had the smallest cross-validation out-of-sample negative log-likelihood but ranked only second-smallest in root mean square error (RMSE) and mean absolute error (MAE), whereas the delta-gamma model without depth had smaller values for those two metrics. The author should reconcile which selection criterion governs and justifies the inclusion of depth on more than the negative log-likelihood result alone.

The spatiotemporal model we selected to generate the model-based index including depth, the delta-gamma distribution family model with the model formula abundance per area ~ year + survey + s(depth, by = survey), had the smallest cross-validation out-of-sample negative log-likelihood (NLL), the smallest RMSE, and the smallest MAE (Appendix B). The spatiotemporal model we selected to generate the model-based index excluding depth, the delta-gamma distribution family model with the model formula abundance per area ~ year + survey, had a NLL only slightly larger than the Tweedie distribution family model (4132 vs. 4131) and had substantially lower MAE and RMSE. In this document, we compare the stock assessment model results when using a model-based index based on a spatiotemporal model that includes versus excludes depth.

CPT comments specific to NSRKC assessment, May 2026

For the assessment in November, the CPT recommended that the authors bring forward models 26.0, 26.1, and 26.2. It also requested that they revisit the MBI and provide two model-based indices of abundance: one with and one without depth as a covariate. For the MBI with depth as a covariate, a diagnostic plot of the marginal effect of depth should be provided (if possible: Caitlin noted she encountered difficulties in doing so for this meeting). Assessment model results should be presented for each MBI for a total of five model runs to be presented for the November assessment (model 26.0; models 26.1 and 26.2 times 2 MBIs).

We have implemented all of these recommendations in this document.

SSC comments specific to NSRKC assessment, December 2025

The SSC prioritizes further exploration of model-based index of abundance for this stock, given the concern about the apparent lack of overlap between the survey stock distributions. However, the SSC supports further work to update the standardization of the fishery CPUE index planned by the author as a lower priority as well. Authors should prioritize aligning the footprint of the NBS bottom trawl survey abundance index and the length compositions.

We present four model alternatives exploring the incorporation of a model-based index of abundance in this document, as well as a detailed description of model-based index development (Appendix B). The prediction area for the model-based index is the NBS bottom trawl survey stratum for Norton Sound red king crab and thus the spatial domain of this index aligns with the area over which NBS survey length composition data are collected. The authors do not present an update of the fishery CPUE index standardization in this document, but have begun work on this task and plan to present results in the near future.

The SSC recommends refining projections for this and other Tier 4 stocks so that FMSY reference points more closely align with achieving the resultant BMSY reference point.

The projections presented in this document use the Tier 4 definition of B_{MSY} for comparison to projected abundances, as this is the only B_{MSY} proxy value we calculate currently. However, refining projections for Tier 4 stocks remains an ongoing goal.

CPT comments specific to NSRKC assessment, November 2025

Provide more detail on the CPUE standardization analysis in future assessments and update the full time series with each assessment cycle

The full CPUE time series has been updated for this assessment. The CPUE standardization analysis methods simply replicate those used in previous iterations of this assessment, but the authors plan to update these methods and provide bridging analyses in a future assessment cycle.

Jittering plots should display a larger proportion of the jitter runs, especially if many of the runs converge to likelihood values not near the MLE. Further guidance on this will be discussed at the Jan modeling workshop.

This document includes a summary table of jittering results rather than jittering plots.

Remove the projections plots awaiting guidance to be developed during the January 2026 modeling workshop on the appropriate way to use the GMACS projection module for tier 4 stocks.

Following CPT discussion, projection plots are provided, with text added to the figure captions stating that the B_{MSY} proxy for Tier 4 stocks is simply the average biomass over a specified time period.

CPT comments on assessments in general, May 2026

Draft Crab Risk Table Guidelines, to be applied for Fall 2026: 1. Assessment authors should identify a historical buffer based on long-term, persistent considerations that encompass uncertainty relative to the OFL and max ABC, and that also incorporates information specific to tier level. These persistent considerations should be documented in the top row of the risk table and carried over each year a new risk table is developed. 2. The second row of the risk table should be used to evaluate uncertainty within a given year relative to the previous year and should capture uncertainties that are not already incorporated in the assessment model, tier level, or the OFL harvest control rule.

The authors have completed a risk table for NSRKC in accordance with these guidelines (Appendix A).

SSC comments on assessments in general, October 2025

The SSC recommends continued progress towards making SAFE documents as consistent in structure and content as practicable. The SSC recognizes that assessments vary among stocks, however documents that are as similar as possible will facilitate review and ensure accessibility to a wide audience.

We have attempted to make this document consistent with other BSAI crab SAFE documents.

The SSC notes that crab stock assessment authors currently use the OFL for catch projections. The SSC recommends that the authors and CPT provide a justification if catches are set to the OFL in projections, or use a more realistic estimate of future catches as is done in groundfish assessments.

This item is a topic of CPT discussion, as setting the catch equal to the OFL in projections is currently standard for projections in GMACS.

CPT comments on assessments in general, September 2025

The CPT proposed that using "minimal to moderate concern", "substantial concern", and "extreme concern" to correspond with levels 1, 2, and 3 in the risk table would more effectively describe concern levels and allow them to be tracked year to year.

This recommendation was superseded and we have followed the most recent guidance in the NSRKC risk table presented here (Appendix A).

SSC comments specific to NSRKC assessment, June 2025

One of the more long-standing recommendations echoed by both the SSC and CPT for this stock is the development of model-based indices of abundance. The SSC... concurs with the CPT suggestion that this be

explored further in a research model framework. Given that selectivities are assumed to be the same across all three surveys in this assessment, the SSC suggests a single model-based index that includes all three surveys and a broad prediction grid reflecting the distribution of the stock could be a viable option for the future.

We present the development of a model-based index of abundance for NSRKC in Appendix B. The three surveys could not all be included in a single model-based index due to complete lack of temporal overlap between the historical survey and the two ongoing surveys, which led to failures in spatiotemporal model convergence. However, data from the two ongoing surveys were used to produce a single model-based index of abundance. In accordance with the SSC's recommendation, we used a prediction grid that seems to reflect the distribution of the stock: the NOAA NBS trawl survey stratum for NSRKC. We present models incorporating the model-based index in this document.

SSC comments on assessments in general, June 2025

The SSC notes that a historical retrospective is different from a within model retrospective and requests that crab assessments include a plot comparing the model-estimated time series of mature male biomass from the current assessment with the time series from the ten previous assessments (i.e., historical retrospective).

A historical retrospective plot (using the base model estimates) is included in this assessment (Figure 11).

The SSC recommended that the CPT provide GMACS version updates in each CPT report with information on changes between versions and that authors clearly identify which GMACS versions were used and a brief summary of the effects on the assessment.

The GMACS version used in this assessment is 2.20.44 and a bridging analysis demonstrating the effects on model outputs of the transition from GMACS version 2.20.34a is presented in this document.

The SSC recommends that each crab SAFE chapter include a clear description of the buffers used in harvest specification over the most recent five years, as a basis for comparing the current year's buffer recommendations.

The buffers and buffer justifications used in harvest specifications for NSRKC over the most recent five years are presented in Appendix A.

The SSC recommends that both new and ongoing concerns regarding the stock should be recorded in the risk table, not just new concerns... The CPT intends to include the uncertainty due to the tier level in the risk table, since this uncertainty plays a role in the buffer consideration. The SSC suggests that if the CPT follows this course, that the tier level concern be listed separately in the risk table.

We have followed these recommendations in the risk table for this stock.

CPT comments specific to NSRKC assessment, May 2025

The CPT highlighted the need for continued work on model-based abundance estimates for NSRKC, as survey area consistency has been a reoccurring issue in the assessment... The CPT encouraged the continued development of assessments based on model-based survey indices as a research topic separate from models for management consideration. Specifically, CPT encouraged explorations of the sensitivities of selectivity for joint model-based indices spanning multiple trawl survey time series. In discussion of the appropriate prediction model, the CPT noted that this decision depends on assumptions related to catchability (Q) for different surveys with areas inside and outside of the different prediction areas. The CPT also discussed the possibility of matching the prediction area to the area that matches the fishery, and this comparison might be informed by evaluating the proportion of the fishery that has occurred outside the prediction area. This analysis might be useful for identifying areas that have only rarely been fished that might not be important for prediction area considerations. Further updates on NSRKC model based indices will be reviewed as research models to ensure that inclusion of the model based indices coincides with how they are used in the assessment model.

We present the development of model-based indices of abundance for NSRKC in Appendix B and present models incorporating model-based indices in this document. We explored different configurations for catchability in the models presented here, and hope that these address the CPT's concerns. Following the

SSC's recommendation, we used a prediction grid that seems to reflect the distribution of the stock: the NOAA NBS trawl survey stratum for NSRKC.

CPT comments on assessments in general, May 2025

Given that baseline buffers or buffer ranges are not specified by tier level for crab stocks, buffers should consider uncertainty associated with tier level if warranted... The risk table should also be used to evaluate additional uncertainty, on a stock-by-stock basis, that is not already incorporated in the assessment model, tier level, or harvest control rules.

We have followed these guidelines in completing the risk table for NSRKC (Appendix A).

At their discretion, assessment authors should coordinate with ESP authors (and ESR authors when an ESP is not available) to discuss ecosystem considerations prior to completion of a risk table.

An Ecosystem and Socioeconomic Profile (ESP) has not yet been created for NSRKC. We coordinated with Ecosystem Status Report (ESR) author Dr. Ebett Siddon, who provided important information on ecosystem considerations that is included in the risk table appendix (Appendix A).

Risk tables should be conducted for all annual crab stock assessments (Snow crab, Tanner crab, BBRKC, NSRKC, and AIGKC). A full risk table will be contained as an appendix in each individual SAFE chapter with rationale given for risk table scoring.

We provide a full risk table and rationale for scoring in Appendix A.

C. Introduction

1. Scientific name

Red king crab, *Paralithodes camtschaticus*, in Norton Sound, Alaska.

2. General distribution

Red king crab are distributed throughout the North Pacific, from the Gulf of Alaska and northern British Columbia, including populations in Southeast Alaska and around Kodiak Island, to the Bering and Chukchi Seas, the Sea of Okhotsk, the Kuril Islands, and Hokkaido (Stevens and Lovrich 2014). Norton Sound red king crab (NSRKC) is one of the northernmost red king crab populations that supports a commercial fishery (Powell et al. 1983). For management purposes, the NSRKC stock is defined as those red king crab in the Norton Sound Section (Q3) of ADF&G Registration Area Q (Menard et al. 2022). The Norton Sound Section consists of all waters in Registration Area Q north of the latitude of Cape Romanzof (61° 49' N latitude), east of the International Dateline, and south of 66° N latitude (Figure 12; Menard et al. 2022). Data from the NOAA NBS and Eastern Bering Sea trawl surveys indicate that the NSRKC stock is usually separated from the Bristol Bay red king crab stock by areas in which no red king crab were found, although this is not the case in all survey years (Figure 13; Markowitz et al. 2023).

3. Evidence of stock structure

Red king crab from Norton Sound and the Chukchi Sea form a distinct genetic subgroup within the Gulf of Alaska-Eastern Bering Sea-Norton Sound/Chukchi Sea genetic grouping, based on analysis of genetic structure using whole genome sequencing (St. John et al. 2025). An earlier analysis using SNP loci as well as mitochondrial DNA found that Norton Sound red king crab fell within the Okhotsk Sea/Norton Sound/Aleutian Islands evolutionary lineage and were genetically isolated from southeastern Bering Sea red king crab populations; this study did not include samples from Chukchi Sea red king crab (Grant and Cheng 2012).

4. Life history

Female NSRKC attain 50% sexual maturity at 68 mm CL (Powell et al. 1983). Female NSRKC mature at smaller sizes and have higher fecundity than RKC females studied in Kodiak, Adak, Bristol Bay, and the Pribilof Islands (Powell et al. 1983; Otto et al. 1989). Male NSRKC attain 50% maturity at 50-59 mm CL and 95% maturity at 70-79 mm CL (Paul et al. 1991). Examination of grasping pairs found that male crab were nearly always larger than the female crab with which they mated (Powell and Nickerson 1965), suggesting that functional maturity of male crab may occur at a larger size than physiological maturity.

NSRKC molt annually until reaching approximately 110 mm CL, after which they molt biennially (Bell et al. 2016). The timing of molting may be more variable for NSRKC than for other RKC stocks in Alaska due to the lack of deep water refugia commonly used by molting crab (Powell et al. 1983). Norton Sound is uniformly shallow, with depth typically 10-35 m (Powell et al. 1983). The growth increment for legal male crab, defined as 103-115 mm CL, was estimated as 11 mm using tagging data (Bell et al. 2016). The growth increment for sublegal male crab, defined as $<$ 103 mm CL, was estimated to be slightly larger at 13 mm (Bell et al. 2016). Mating occurs immediately after female crab have molted, likely in April-June (Powell et al. 1983) or January-June (Otto et al. 1989). Norton Sound red king crab migrate from offshore to nearshore waters in late winter and early spring before moving back to offshore waters in the summer (Bell et al. 2016).

Little information is available to estimate NSRKC natural mortality. Based on tagging information, Powell et al. (1983) estimated a natural mortality rate of at least 0.37. The natural mortality rate of 0.23, used for males with CL $\leq$ 123 mm, is borrowed from the Bristol Bay red king crab stock assessment (Palof 2026).

5. Management history

A complete summary of the management history is provided in the ADF&G Annual Management Report for the Norton Sound, Port Clarence, and Arctic/Kotzebue management areas (Menard et al. 2022).

A distinguishing characteristic of the NSRKC fisheries is that all fisheries, surveys, research, and management are primarily conducted by local residents of Norton Sound. Commercial fisheries are designated as super-exclusive: a vessel registered for the Norton Sound crab fishery may not be used to take king crabs in any other registration areas. The NSRKC commercial fisheries occur in summer (June – August) and winter (December – May), while the subsistence fishery is open year-round. The majority of NSRKC harvest occurs during the summer commercial fishery; the winter commercial and subsistence fisheries occur through the ice and take a much smaller harvest. In Norton Sound, a legal crab is defined as $\geq$ 4.75 inches carapace width (CW; Menard et al. 2022), which is approximately equivalent to $\geq$ 104 mm CL. In 2005 and 2006, commercial buyers, specifically the Norton Sound Economic Development Corporation (NSEDC), accepted only legal crab of $\geq$ 5 inches CW. This preference became permanent in 2008.

6. ADF&G harvest strategy

Since 1997, NSRKC has been managed based on a guideline harvest level (GHL). From 1999 to 2011, the GHL for the summer commercial fishery was determined using model estimated biomass: (1) 0% harvest rate of legal crab when estimated legal biomass $<$ 1.5 million lb; (2) $\leq$ 5% of legal male biomass when the estimated legal biomass falls within the range 1.5-2.5 million lb; and (3) $\leq$ 10% of legal male biomass when estimated legal biomass $>$ 2.5 million lb. In 2012, the summer commercial fishery GHL was revised to (1) 0% harvest rate of legal crab when estimated legal biomass $<$ 1.25 million lb; (2) $\leq$ 7% of legal male biomass when the estimated legal biomass falls within the range 1.25-2.0 million lb; (3) $\leq$ 13% of legal male biomass when the estimated legal biomass falls within the range 2.0-3.0 million lb; and (4) $\leq$ 15% of legal male biomass when estimated legal biomass $>$3.0 million lb. In 2015 the Board of Fisheries passed regulations revising the GHL to include summer and winter commercial fisheries and setting the GHL for the winter commercial fishery at 8% of the total GHL. The Community Development Quota (CDQ) harvest share is 7.5% of the GHL and can be harvested in both summer and winter.

7. History of the basis and estimates for B_{MSY}

NSRKC is a Tier 4 crab stock, meaning that the information necessary to reliably estimate B_{MSY} is lacking and instead a B_{MSY} proxy is obtained by averaging estimated biomass over a specific reference period (NPFMC 2024). For NSRKC, the B_{MSY} proxy is calculated as the mean model-estimated mature male biomass (MMB) from 1980 to the present. The choice of this time period was based on a hypothesized shift in stock productivity due to a climatic regime shift indexed by the Pacific Decadal Oscillation (PDO) in 1976-77.

8. History of the target fishery

The large vessel commercial fishery for NSRKC began in 1977, with legal size set at $\geq$ 5 inches CW. In 1978, legal size was changed to $\geq$ 4.75 inches CW. The fishery was closed in the 1991 season due to staff constraints. The large vessel commercial fishery ended in 1993, when the fishery was restricted to small vessels. Other important changes in regulations in the 1990s include super exclusive designation (1994), implementation of the CDQ allocation (1998), and implementation of the GHL (1999). In the 2000s, changes in the fishery included implementation of the North Pacific License Limitation Program (2000); revision of the summer commercial fishery closure areas intended to protect crab accessed by the inshore subsistence fishery (2002; Figure 14); expansion of the Norton Sound Section (Q3) of Registration Area Q to include the portion of the former St. Lawrence Island Section south of 66° N latitude and west of 168° W longitude (2006); changes in escape ring requirements for pots and the start date of the open access fishery (2008); and the market-preferred size of $\geq$ 5 inches CW becoming the standard commercial retained size. In the 2010s, the BOF adopted a revised GHL for the summer commercial fishery (2012), the winter GHL for commercial fisheries was established and modified winter fishing season dates were implemented (2016), and the NSEDC stopped purchasing crab harvested in the winter commercial fishery. In 2020, the BOF closed the summer commercial fishery east of 167° W longitude. In 2020-2021, the summer commercial fisheries opened but, as the NSEDC was not purchasing crab harvested in these fisheries, commercial harvests were very small.

The timing of the winter commercial fishing season has changed over time in response to ice stability. The winter commercial fishery period was originally January 1 to April 30, before changing in 1985 to November 15 to May 15. In 2015, the period was changed to January 15 to April 30 after fisheries opened on November 15 in 2014, such that the January 15 starting date was in effect in 2016. In 2021, the period was changed to February 1 to April 30. The NSEDC stopped purchasing winter fishery crab in 2019, and since then winter commercial catches have been harvested by catcher-seller permit holders.

The subsistence fishery has a long history; however, harvest information for the winter subsistence fishery is available only since the 1977/78 season. The majority of subsistence crab harvest occurs in winter using hand lines and pots through nearshore ice. Subsistence harvesters must obtain a permit before fishing and record daily effort and catch. There are no size or sex-specific harvest limits, but the majority of retained catch is males of near legal size. Summer subsistence fishery harvest has been monitored since 2004. The summer subsistence fishery harvest is not currently included in the assessment model. Harvest in both the winter commercial and subsistence fisheries is influenced by the availability of stable ice conditions. Small harvests can occur due to poor ice conditions, regardless of crab abundance.

D. Data

1. Summary of new information

Time series that have been updated since the 2025 SAFE report (Stern and Palof 2025) include retained catch from the winter commercial fishery, retained catch from the winter subsistence fishery, total catch from the winter subsistence fishery, retained catch from the summer commercial fishery, CPUE from the summer commercial fishery, and size composition information from the summer commercial fishery retained catch. Note that neither the ADF&G trawl survey nor the NOAA NBS trawl survey occurred in 2026 so no new fishery-independent data were available for the 2026 assessment. Other changes to the input data include the model-based indices of abundance that are used in models 26.1.nd, 26.1.d, 26.2.nd, and 26.2.d in place

of the design-based ADF&G and NOAA NBS trawl survey indices of abundance. The development of the model-based indices of abundance is described in Appendix B.

2. Data which should be presented as time series

The data sources used in this assessment are summarized in Figure 5 and include retained catch, discards, total catch, size compositions, and CPUE from the summer commercial fishery; retained catch, total catch, and size compositions from the winter commercial fishery; retained catch from the winter subsistence fishery; growth information from a tagging study; size compositions from the winter pot survey; and abundance and size compositions from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound (NS) trawl survey (1976-1991), the NOAA Northern Bering Sea (NBS) trawl survey (2010-2025), and the Alaska Department of Fish and Game (ADF&G) trawl survey (1996-2024). Data included in the assessment model are displayed in Appendix C.

a. Total catch

Catch data used for the assessment model are shown in Appendix C. These include summer commercial fishery retained catch, winter commercial fishery retained catch, and winter subsistence fishery retained catch. Winter subsistence fishery total catch is included but is not currently fitted by the model; the emphasis is set to 0 for this data set due to large changes in model output observed when emphasis was set to 1. Summer subsistence total and retained catch are not included in the model; the authors plan to explore including these time series in future assessment cycles.

b. Information on bycatch and discards

Bycatch information is not currently included in the model. Bycatch mortality in the federal groundfish fisheries occurred in the fixed gear fisheries and totaled 13 kg in 2018, 24 kg in 2019, and 4 kg in 2020. Bycatch mortality for other years was zero. Previous investigations showed that this bycatch occurred west of 168° longitude, raising questions about whether the documented bycatch should be included in the model. The NSRKC fisheries are not systematically observed and discard information is available only for the summer commercial fishery and only in a subset of years (1987-1990, 1992, 1994, 2012-2019). Size composition data from the discarded catch are included for that subset of years.

c. Catch-at-length for fisheries, bycatch, and discards

Catch-at-length time series used in the assessment model are shown in Appendix C and include catch-at-length data from the summer commercial fishery retained, discarded, and total catch as well as the winter commercial fishery retained catch. Length measurements are not collected for the subsistence harvest.

d. Survey abundance estimates

Survey abundance estimates used for the assessment model are shown in Appendix C and include estimates from the NOAA Norton Sound, ADF&G, and NOAA NBS trawl surveys. The spatial area over which abundance is estimated is inconsistent among the three surveys. The base model currently uses design-based estimates of abundance from the ADF&G survey and NOAA NBS survey that are calculated using a smaller spatial area (maximum 5,641 nm^2 or 19,348 km^2) than are those for the NOAA Norton Sound survey (7,600 nm^2 or 26,067 km^2) (Hamazaki 2024). The abundance estimate from the ADF&G trawl survey is unexpanded, meaning it may underestimate stock abundance (Hamazaki 2024). To address these concerns, we developed a spatiotemporal model-based index of abundance based on the ADF&G and NOAA NBS survey time series (Appendix B); this index is included in place of the design-based ADF&G and NOAA NBS trawl survey indices in models 26.1.nd, 26.1.d, 26.2.nd, and 26.2.d.

e. Survey catch-at-length

Survey size composition data used for the assessment model are shown in Appendix C and include catch-at-length data from the NOAA Norton Sound survey, the ADF&G trawl survey, the NOAA NBS trawl survey,

and the winter pot survey. When replicating past years' data processing methods for the 2025 assessment, the authors observed that the spatial restrictions applied to the NOAA NBS trawl survey data set when calculating abundance estimates were not applied to the size composition data, meaning that the population of crab from which size composition data were drawn was different from the population of crab used to estimate abundance. The authors intend to explore reconciling the size composition and abundance NOAA NBS survey data sets used in the assessment model for the base model. For the models including the model-based index of abundance, this issue does not apply, because the spatial area used for estimating abundance in the model-based index matches the NOAA NBS trawl survey stratum for NSRKC.

f. Catch-per-unit-effort time series

Standardized summer commercial fishery CPUE is included in the NSRKC assessment model as three separate indices of abundances, reflecting three time periods among which the fishery differed in important aspects: the large scale commercial fishery (1977-1992; industry-preferred male size $>$ 4.75 inches CL); the small vessel commercial fishery with industry-preferred male size $>$ 4.75 inches CL (1993-2007), and the small vessel commercial fishery with industry-preferred male size $>$ 5 inches CL (2008-2026). The methods for CPUE standardization were developed by Bishop and colleagues (2013) and are summarized in Appendix B of Hamazaki (2024). Standardized CPUE is not calculated for 1991, 2020, or 2021; a commercial fishery was closed in 1991 and very few crab were harvested during the 2020 and 2021 commercial fisheries. The authors followed the historical CPUE standardization methods and updated the entire CPUE time series. The authors plan to review and update the CPUE standardization methods in a future assessment cycle.

g. Other time series data

Norton Sound red king crab tagging was initially conducted as a part of mark-recapture abundance survey in 1980-1982 and 1985 (Brannian 1987). From 1986 to 2012, crabs were tagged during the winter pot survey. The winter pot surveys tagged mostly sublegal crab and very few were recovered. Tagging resumed from 2012-2015 for a spring migration movement survey. In all of these studies, most of the tagged crab were recovered by commercial fishermen, although subsistence fishermen also recovered some tags.

3. Data which may be aggregated over time

a. Growth-per-molt; frequency of molting

Growth is estimated using tagging data.

b. Weight-at-length

Weight-at-length is input as a vector, with the following weights in lb specified by size class: size class 1 = 0.52, size class 2 = 0.82, size class 3 = 1.20, size class 4 = 1.70, size class 5 = 2.32, size class 6 = 2.99, size class 7 = 3.68, size class 8 = 4.37 (see control files in Appendix C).

4. Data sources that were available but were excluded from the assessment

- Retained catch from the summer subsistence fishery, 2005-present.
- Environmental covariates from trawl surveys, including surface and bottom temperatures.
- Data on females from trawl surveys, including abundance estimates and length measurements.
- Tag recovery locations from tagging studies conducted over 2012-2019.
- Satellite tag migration tracking information from a 2016 NOAA study and a 2020-2021 ADF&G study.
- Monthly hormone level data collected in 2014-2015.

- Data from lab studies of NSRKC functional maturity and mating success collected in 2021-2022.
- Abundance and size composition data from summer pot surveys conducted in 1980-1982 and 1985.
- CPUE from the winter pot surveys conducted in 1987, 1989-1991, 1993, 1995-2000, and 2002-2012.
- CPUE and size compositions from the preseason spring pot surveys conducted in 2011-2015.
- CPUE and size compositions from the postseason fall pot surveys conducted in 2013-2015.

E. Analytic approach

1. History of modeling approaches for this stock

The GMACS version of the NSRKC stock assessment model, model 24.0, was recommended by the CPT and the SSC in November and December 2024, respectively, for 2025 harvest specifications. The history of model development prior to the transition to GMACS is detailed in Hamazaki (2024).

Following the transition to GMACS, changes made in 2025 included correcting errors in the input data file and transitioning the model to a GMACS version (2.20.20) with the ability to correctly calculate the OFL for stocks with multiple fisheries occurring in different seasons. A bridging analysis documenting the effects of these changes was presented in Stern and Palof (2025b). The model accepted in 2025 for 2026 harvest specifications incorporated additional changes including the removal of shell condition, such that "newshell" and "oldshell" males were aggregated, leading to improved size composition fits; changing the fixed value of M for males $\leq$ 123 mm CL from the value of 0.18 used in the base model to 0.23, the M value estimated in the most recent Bristol Bay red king crab (BBRKC) stock assessment (Palof 2026); and shifting the functional form of selectivity for the winter commercial fishery from using the same, dome-shaped functional form used for the winter pot survey, to using the same, asymptotic functional form used for the summer commercial fishery (Stern and Palof 2025).

2. Model description

a. Description of overall modeling approach

The model is a male-only size-structured model based on abundance that combines data from surveys, fishery catches and discards, and mark-recovery studies using a maximum likelihood modeling framework to estimate population dynamics under fisheries. The model estimates abundances of male crab with CL $\geq$ 64 mm in 10 mm length intervals (8 length classes). Few crab measuring $<$ 64 mm CL were caught during surveys or fisheries. Natural mortality is set to a fixed value of 0.23 for males with CL $\leq$ 123 mm and estimated for males with CL $>$ 123 mm. The timeline of events in the model is as follows:

- Model year starts on February 1
- The initial population date is February 1, 1976
- Instantaneous fishing mortality occurs on February 1 for winter fisheries
- Instantaneous fishing mortality occurs on July 1 for summer fisheries
- Instantaneous molting and recruitment occur on July 1

b. Reference software used

The Generalized size-structured Model for Assessing Crustacean Stocks (GMACS) version 2.20.44, compiled with AD Model Builder 13.2 http://www.admb-project.org/. GMACS source code and information is available at https://github.com/GMACS-project.

c. Description of all likelihood components

Likelihood components are shown in Tables 7 - 8.

d. Description of how the state of the population at the start of the first year of the assessment period is determined and the size-range that the model covers

The first year of the assessment period was set to 1976, when the first Norton Sound trawl survey was conducted. The model covers 8 length classes, beginning at CL of 64 mm, with a length class increment of 10 mm.

e. Parameter estimation framework

A maximum likelihood approach was used to estimate parameters. Parameters estimated outside of the model include M for males with CL $\leq$ 123 mm, and the discard mortality rate (set at 0.2). Priors, bounds, and constraints on parameters are detailed in the model control files, shown in Appendix C. Recruitment during the projected year is the average of the past 5 years to reflect the most recent recruitment conditions.

f. Definition of model outputs

Mature male biomass is defined as the biomass of males with CL $\geq$ 94 mm. Male recruit biomass is defined as the biomass of males with CL of 64-93 mm.

g. Critical assumptions and consequences of assumption failures

- Instantaneous annual natural mortality (M) is fixed for males with CL $\leq$ 123 mm and increases for males with CL $>$ 123 mm. M is constant over time. Estimating a higher M for larger males is an approach employed to rectify the model's historical overestimation of large male abundance. Models using size-independent M were presented at the May 2025 CPT meeting but not recommended by the CPT or SSC. The authors plan to continue exploring model runs with size-independent M in future iterations of this assessment, as well as exploring the effects of using model-based size composition estimates.

- Modeled male size at maturity is 94 mm CL. According to a past assessment, this size at maturity was inferred from BBRKC data, incorporating the smaller size of NSRKC (Hamazaki 2024). The authors have not yet located more detailed documentation of the methods used to arrive at this estimate for size at maturity. Studies of NSRKC size at functional maturity in the lab are ongoing, and observations of mating pairs in the wild are needed.

- Molting occurs after the summer fishery. Recruitment occurs immediately afterwards.

- Molting probability is a descending logistic function of crab size.

- Growth increment is a function of length and is constant over time. Molted crab do not shrink.

- ADF&G trawl survey abundance has the same scale as the population, i.e., catchability (q) is equal to 1. Note that one of the alternative model configurations presented in this document has a fixed catchability of 1 for the model-based index (26.1 models), while the other alternative model configuration estimates catchability for the model-based index (26.2 models).

- Survey selectivity is an asymptotic, one-parameter logistic function equal to 1.0 at the length class 134 mm CL and is the same across years and surveys.

- Winter pot survey selectivity is a dome-shaped function combining a reverse logistic function starting from length class 84 mm CL and a model estimate for length classes with CL $<$ 84 mm. This assumption is likely based upon the observed percentages of crab by size class that were caught in the winter pot survey. The survey selectivity is constant over time.

- Fisheries occur twice annually, on February 1 and on the midpoint of the summer commercial fishery period, and are instantaneous.

- Fishery selectivity is the same for the summer commercial, winter commercial, and subsistence fisheries and is an asymptotic, one-parameter logistic function of length, with selectivity for length class 134 mm CL set to 1.0. Fishery selectivity is constant over time.

- Retention probability is a logistic function with an asymptote $<$ 1.0; not all legal-sized crab are retained.

- The winter subsistence fishery retains crab $>$ 94 mm CL. By regulation, the subsistence fishery has no size limit for retention. The size of crab caught in the subsistence fishery is not recorded.

- The discard handling mortality rate for all fisheries is 20%, consistent with other BSAI king crab stocks.

h. Changes to any of the above since the previous assessment

In the base model, catchability is fixed at 1 for the ADF&G survey index and estimated for the NOAA NBS and historical Norton Sound survey indices. After adding the model-based index in place of the ADF&G and NOAA NBS surveys, we retained estimation of catchability for the historical Norton Sound survey index while either fixing catchability for the model-based index at 1 (models 26.1.nd and 26.1.d) or allowing the model to estimate catchability for the model-based index (models 26.2.nd and 26.2.d).

i. Outline of methods used to validate the code to implement the model and whether the code is available

Files needed to implement the model are available on the GMACS GitHub model repository and GMACS source code is available at https://github.com/GMACS-project. Results are compared to those of previous assessments. GMACS code is validated by CPT members.

3. Model selection and evaluation

a. Alternative model configurations

The model configurations evaluated in this report are the following:

Model 26.0 - May: Model 25.0a2, the model recommended for harvest specifications by the CPT and SSC in 2025 (Stern and Palof 2025), transitioned to a newer GMACS version, 2.20.34a. The estimation phase for the alpha parameter of the recruitment size distribution was changed from phase 3 in model 25.0a2 to phase 5 in model 26.0 to aid in model convergence. Additionally, the upper bound on the β parameter for growth was lowered in order to avoid estimation of negative growth, with the aim of reducing the likelihood of failed model runs. These small changes did not alter model results.

Model 26.0 - November: Model 26.0 - May transitioned to GMACS version 2.20.44.

Model 26.0 - updated: Model 26.0 - Nov updated with data including retained catch from the winter commercial fishery, retained catch from the winter subsistence fishery, total catch from the winter subsistence fishery, retained catch from the summer commercial fishery, CPUE from the summer commercial fishery, and

size composition information from the summer commercial fishery retained catch. All three standardized CPUE indices of abundance were also updated.

Model 26.1: Model 26.0 with a model-based index of abundance added in place of the design-based indices of abundance from the ADF&G and NOAA NBS trawl surveys. Development of the model-based indices of abundance is described in Appendix B. Catchability for the model-based index was fixed at 1 while, as in the base model, catchability for the historical Norton Sound survey index was estimated. Two model runs for model 26.1 are presented. In model 26.1.nd, the model-based index of abundance is derived using a spatiotemporal model that does not include depth. In model 26.1d, the model-based index of abundance is derived using a spatiotemporal model that does include depth.

Model 26.2: Model 26.1 with catchability for the model-based index estimated. Two model runs for model 26.2 are presented. In model 26.2.nd, the model-based index of abundance is derived using a spatiotemporal model that does not include depth. In model 26.2d, the model-based index of abundance is derived using a spatiotemporal model that does include depth.

b. Progression of results

The impacts of the transition to GMACS version 2.20.44 can be observed by comparing models 26.0.May and 26.0.Nov, which showed no discernible differences in their likelihood components, verifying that the transition to GMACS version 2.20.44 did not have unexpected or concerning effects on the base model fits (Table 7).

The impacts of updating data time series can be observed by comparing models 26.0.Nov and 26.0.up (Table 7). Note that the time series updated were retained catch from the winter commercial fishery, retained catch from the winter subsistence fishery, total catch from the winter subsistence fishery, retained catch from the summer commercial fishery, CPUE from the summer commercial fishery, size composition information from the summer commercial fishery retained catch, and all three standardized CPUE indices of abundance. Fits to index and size composition time series from the three trawl surveys were slightly worse for the model with updated data, while the fit to the winter pot survey size composition time series was slightly better. Fits were otherwise similar, raising no concerns about the model's response to the addition of updated data. For results from all the alternative models, please see below.

c. Model numbering conventions

We have endeavored to follow the conventions for numbering models.

d. Evidence of search for balance between realistic and simpler models

Models 26.1 and 26.2 represent simplifications of the base model in that they include a single, model-based index of abundance in place of two design-based indices of abundance. Estimation of catchability for the model-based index of abundance (model 26.2) adds a parameter compared to assuming a catchability of 1 for the model-based index (model 26.1) and is not recommended for harvest specifications at this time, although futher explorations of estimating catchability are warranted in future.

e. Convergence status/criteria

We used the default ADMB convergence criteria (available at http://www.admb-project.org/).

f. Sample sizes for length composition data

Input sample sizes for length composition data are shown in Appendix C.

g. Credible parameter estimates

All estimated parameters seem to be credible and within bounds.

h. Model selection criteria

A variety of model selection criteria are considered, including likelihood values (when comparable among models), analysis of residuals, and retrospective analysis.

i. Residual analysis

Residual plots are presented below.

j. Model evaluation

Model evaluation is provided under Results below.

k. Jittering

Jittering analyses were performed for models 26.0.up, 26.1.nd, 26.1.d, 26.2.nd, and 26.2.d. We performed 200 jitter runs for each model using GMACS, with starting parameter values for the jitter runs randomly selected within a range of 0.3 standard deviations from the existing initial parameter values. Jittering results are discussed in the "Model convergence" section of the Results section and shown in Table 9.

4. Results

Model convergence

We evaluated model convergence by using parameter jittering to find the parameter values that minimized the model objective function, checking that the model Hessian was invertible and that the maximum gradient at the candidate maximum likelihood estimate (MLE) was close to zero. Starting parameter values for the jitter runs were randomly selected within a range of 0.3 standard deviations from the existing initial parameter values. We performed 200 jitter runs for each of models 26.0.up, 26.1.nd, 26.1.d, 26.2.nd, and 26.2.d.

For each model, the jittering analysis appeared to identify the set of parameters corresponding to the minimum objective function value, with the majority of successfully completed model runs converging to the same minimum objective function value (Table 9). Similar percentages of model runs converged to the MLE for all models, ranging from 83-91%. Absolute values of maximum gradients at the MLE were < 0.00005 for all models.

Fits to fishery catch data

Fits to fishery catch data were nearly identical among the models (Figure 15 and Tables 7 - 8), demonstrating that adding the model-based index and changing the configuration of catchability have little effect on fits to catch data. Note that subsistence total catch was not fitted in any of these models (emphasis set to 0), due to the previously-reported finding that including these data leads to differences in model fit and references points. Approaches to including subsistence total catch data will be explored further in future iterations of this assessment.

Fits to abundance indices

Fits to the historical Norton Sound survey index were slightly better for the models including the model-based index than for the base model, and better for the models that fixed model-based index catchability at 1 than for those that estimated catchability for the model-based index (Figures 16 - 18 and Tables 7 - 8).

Fits to the fishery CPUE indices from 1993-2006 and 2007-2026 were worse for the models including the model-based index than for the base model, but better for the fishery CPUE index from 1977-1992 (Figures 19 - 27 and Tables 7 - 8). Differences among the models that included the model-based index in fits to the fishery CPUE indices were relatively small.

Since the models including the model-based index did not include the ADF&G and NBS survey indices, fits to those indices are only shown for the base model (Figures 28 - 29).

Among models including the model-based index, fit to the model-based index was best for the model that had model-based index catchability fixed at 1 and used a model-based index that took depth into account, followed by the model that estimated model-based index catchability and used a model-based index that took depth into account (Figures 30 - 31 and Table 8). Estimated catchability values are shown in Table 10.

Fits to size compositions

Fits to size composition time series were generally similar among the models (Figures 32 - 39 and Tables 7 - 8), as were One-Step-Ahead residuals patterns (Figures 40 - 79). Of note is that the relative abundance of large males in the summer commercial fishery retained catch size compositions was higher in 2026 than has been observed for many years, and all models had difficulty fitting these 2026 data, although other years in the timeseries with atypical size compositions also had poor fits based on visual inspection (e.g., 1982, 2022; Figures 33).

Estimated population quantities

Recruitment

Recruitment estimates were generally higher across the time series for the models including the model-based index with fixed catchability, intermediate for the base model, and lower for the models including the model-based index with estimated catchability (Figure 80). Recruitment estimates for each model are displayed in Tables 17 - 21. All models estimate that recruitment has increased year-on-year since 2024, but note that terminal year estimates of recruitment are highly uncertain and the lack of fishery-independent survey data for 2026 exacerbates this uncertainty.

Mature male biomass

Mature male biomass (MMB) estimates were generally higher across the time series for the models including the model-based index with fixed catchability, intermediate for the base model, and lower for the models including the model-based index with estimated catchability (Figure 81). MMB estimates for each model are displayed in Tables 17 - 21. All models estimate the MMB has decreased each year since 2023 and project a further decline in 2027.

Estimated fishery selectivity

Estimated selectivities for the subsistence, summer commercial, and winter commercial fisheries are nearly identical among the models (Figure 82).

Estimated survey selectivity

In all models, survey selectivity is estimated for the NOAA Norton Sound trawl survey while selectivity for the ADF&G and NOAA NBS trawl surveys is mirrored to that of the NOAA Norton Sound trawl survey, meaning that the estimated values are assigned to the surveys without estimated selectivity. Estimated selectivity is 1 or very close to 1 for all size bins.

Estimated fishing mortality

Fully-selected fishing mortality rates in the summer commercial, winter commercial, and subsistence fisheries, estimated using model 26.0.up, are shown in Table 16. For all three of the subsistence, winter commercial, and summer commercial fisheries, estimated fishing mortality was generally higher across the time series for the models including the model-based index with estimated catchability, intermediate for the base model, and lower for the models including the model-based index with fixed catchability (Figure 83).

Estimated natural mortality

Estimated natural mortality for males with CL > 123 mm was higher for the models including the model-based index with fixed catchability, intermediate for the base model, and lower for the models including the model-based index with estimated catchability (Figure 84).

Retrospective analyses

Retrospective analyses for models were performed by sequentially removing each of the most recent 10 years of data, fitting the model, and recording the estimated MMB. Comparing the estimated MMB time series as each year of data is removed permits identification of retrospective patterns, in which estimates show consistent deviations with each "peel" (removal of a year of data). The Mohn's ρ value for the base model (26.0.up) was 0.099, indicating that MMB estimates generally increased as each year of data was removed (Figure 85). Adding the model-based index, with catchability for the model-based index fixed at 1 and depth excluded from the spatiotemporal model (model 26.1.nd), led to a slightly increased Mohn's ρ of 0.108 (Figure 86), while including depth in the spatiotemporal model slightly increased Mohn's ρ to 0.113 (Figure 87). Estimating catchability for the model-based index reduced Mohn's ρ to -0.007 when depth was excluded from the spatiotemporal model (model 26.2.nd; Figure 88) and -0.23 when depth was included in the spatiotemporal model (model 26.2.d; Figure 89).

All of these Mohn's ρ values represent improvements relative to the model selected for harvest specifications in 2025, 25.0a2, which had a Mohn's ρ value of 0.126, indicating that the models presented here all have improved stability in their estimates of MMB.

Uncertainty and sensitivity analyses

Uncertainty for parameters and derived quantities was estimated using the covariance matrix obtained by inverting the model Hessian matrix at the MLE. Estimated standard errors of parameters for each model are summarized in Tables 11 - 15. The probability density function of the OFL for each model is shown in Figures 7 - 10.

Comparison of alternative model scenarios

Variation among the design-based indices of abundance in the spatial domain and in the temporal and spatial distributions of survey sampling have been long-standing concerns for this stock (Hamazaki 2024). Historical approaches to NSRKC abundance estimation have focused on calculating abundance over the area targeted for commercial harvest, but survey observations indicate that the stock range is likely larger and may be more accurately captured by the NOAA NBS survey stratum (Hamazaki 2024; Appendix B). Survey sampling has not been evenly distributed across the potential stock range or across time, meaning that taking into account both spatial and temporal variation is likely important to derive consistent estimates of stock abundance (Appendix B).

Here, we employed a spatiotemporal modeling approach to develop a single index of abundance based on the ADF&G and NOAA NBS trawl survey time series. While the lack of overlap in time means that the historical Norton Sound trawl survey could not be combined with the other two surveys in a single model, the ongoing ADF&G and NOAA NBS trawl surveys have both spatial and temporal overlap. Spatiotemporal models account for the spatiotemporal processes that underlie survey observations by including both spatial and spatiotemporal random effects (Thorson et al. 2021; Yalcin et al. 2023), and using these methods to produce annual estimates of abundance provides the opportunity to improve the consistency of the abundance time series. Another expected benefit of using a spatiotemporal model-based index of abundance is reduced interannual variability in abundance estimates. Design-based indices of abundance can inflate temporal variability by failing to account for spatial dependence (Shelton et al. 2014; Thorson et al. 2015), potentially leading to increased uncertainty in stock assessment model outputs (Cao et al. 2017). In other stocks, substitution of model-based for design-based indices has led to improved retrospective patterns, reflecting the importance of accounting for spatial variation in survey catch (Cao et al. 2017, Chen et al. 2024).

We found that using a spatiotemporal model-based index of abundance in place of two design-based indices of abundances led to less extreme retrospective patterns for the NSRKC stock assessment model when catchability for the model-based index was estimated in the model, but similar retrospective patterns when catchability for the model-based index was fixed. Despite the improvements in the retrospective pattern, we do not recommend selecting a model that estimates catchability for the model-based index for harvest specifications, as we think further evaluation is necessary to ensure that estimating this additional parameter is not causing unexpected effects on model results. We recommend selecting model 26.1 for harvest specifications, because using a model-based index of abundance represents a more rigorous way to estimate abundance for this stock given the variation in survey station sampling over time. Between models 26.1.nd and 26.1.d, we recommend model 26.1.d for harvest specifications. This model uses a model-based index derived from a spatiotemporal model that included a smooth of depth by survey, and had improved out-of-sample predictive skill, RMSE, and MAE compared to the spatiotemporal model that included only the effects of year and survey (Appendix B). Using the spatiotemporal model with the best out-of-sample predictive skill to generate the model-based index used in the stock assessment is the authors' recommendation.

Stock projections

We used Markov Chain Monte Carlo (MCMC) simulations in GMACS to generate parameter value draws, using 1,000,000 iterations with a thinning interval of 1,000. After generating draws, we ran projections using the ADMB MCMC evaluation routine. We projected to the year 2031 using a constant fishing mortality rate of either 0, 0.10, or 0.15, all fishing mortality rates within the range of those estimated for recent years (Table 16). Annual recruitment in the projections was a random draw from recruitment estimates during 1978-2025, with the 2026 estimated recruitment left out due to the large uncertainty in the terminal year's recruitment estimate.

Projections for each model are shown in Figures 90 - 93. At a fishing mortality rate of F=0.10, close to those estimated to have been applied in the past 5 years (Table 16), all models project a near-term decline in MMB followed by stabilization and a slow increase. The stock is projected to stay above the minimum stock size threshold (MSST) through 2031 for F=0.10, but all models except the base model project that the stock would dip below the MSST at the higher fishing mortality rate of F=0.15.

F. Calculation of the OFL

The overfishing level (OFL) is the total catch associated with the F_{OFL} fishing mortality. The NSRKC stock is currently managed as Tier 4, and only a Tier 4 analysis is presented here. Thus, given stock estimates or suitable proxy values of B_{MSY} and F_{MSY}, along with two additional parameters α and β, F_{OFL} is determined by the control rule

$$F_{OFL} = \begin{cases} F_{MSY}, & \text{when } B/B_{MSY} > 1 \\ F_{MSY}\frac{(B/B_{MSY}-\alpha)}{(1-\alpha)}, & \text{when } \beta < B/B_{MSY} \leq 1 \end{cases} \tag{1}$$

$$F_{OFL} < F_{MSY} \text{ with directed fishery } F = 0 \text{ when } B/B_{MSY} \leq \beta$$

where B is quantified as mature male biomass (MMB) at mating and, under Tier 4, $F_{MSY} = \gamma M$. The default value of 1.0 is used for γ unless otherwise recommended. The B_{MSY} proxy for NSRKC is obtained by averaging estimated MMB over 1980 to the most recent year; this reference period was chosen based on a hypothesized shift in stock productivity due to a climatic regime shift indexed by the Pacific Decadal Oscillation (PDO) in 1976-77.

Table 5: Comparisons of management measures for the models to be considered for harvest specifications. Biomass and OFL are in 1,000 tons. Model 26.0.up is the new base model. Model 26.1 is 26.0 with a model-based index (MBI) included in place of the ADFG and NBS trawl survey indices of abundance, with depth either excluded from (26.1.nd) or included in (26.1.d) the spatiotemporal model used to produce the index of abundance. Model 26.2 is 26.1 with catchability (q) for the MBI estimated, with depth either excluded from (26.2.nd) or included in (26.2.d) the spatiotemporal model used to produce the index of abundance. The author-recommended model is 26.1.d.

Model	MMB_{2027}	B_{MSY}	MMB/B_{MSY}	F_{OFL}	OFL_{2027}	ABC_{2027}	MSST	M
26.0.up	1.35	1.93	0.70	0.153	0.142	0.100	0.96	0.23
26.1.nd	1.52	2.29	0.66	0.144	0.151	0.106	1.15	0.23
26.1.d	1.59	2.60	0.61	0.131	0.143	0.100	1.30	0.23
26.2.nd	1.06	1.68	0.63	0.135	0.099	0.070	0.84	0.23
26.2.d	0.94	1.66	0.56	0.119	0.077	0.054	0.83	0.23

G. Calculation of the ABC

The ABC is calculated as the OFL multiplied by (1 - the ABC buffer). For this stock, the ABC buffer was 10% in 2011-2014, 20% in 2015-2019, 30% in 2020, 40% in 2021-2022, and 30% in 2023-2026 (Appendix A). The CPT and SSC recommended an ABC buffer of 30% for setting harvest specifications for 2026 for the following reasons: 1) uncertainty in the biological characteristics of the stock, 2) difficulty in managing to a total mortality due to lack of information about discards, 3) the model's overestimation of the abundance of the largest male crab, 4) the use of a higher natural mortality value for larger males in order to correct for this overestimation of abundance rather than the size-independent M used by other Bering Sea and Aleutian Islands (BSAI) king crab stock assessment models, and 5) a retrospective pattern in model-estimated mature male biomass (Appendix A). While the retrospective pattern in MMB is improved, an important additional concern for setting harvest specifications for 2027 is the increased uncertainty due to the lack of fishery-independent survey data in 2026. The authors recommend retaining the 30% buffer for 2027 harvest specifications.

H. Rebuilding analyses

This stock is not currently subject to a rebuilding plan.

I. Data gaps and research priorities

A key research priority for some time has been incorporating a spatiotemporal model-based index of abundance into the stock assessment model in order to ensure that abundance information from the trawl surveys is combined in a spatially consistent framework; we address that priority in this document. Other priorities include exploring model-based estimation of size compositions, updating the CPUE standardization methods and documentation, and investigating ways to incorporate the winter subsistence total catch data and the summer subsistence catch data into the model. Addressing uncertainty in the biological characteristics of the stock and acquiring information on discards continue to be priorities for this assessment.

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Tables

Table 6: Proportion of the number of Norton Sound red king crab legal males retained in the summer commercial fishery in each size bin over 1977-2026. Size bins are defined in male carapace length (mm).

Year	104-113	114-123	124-133	134+
1977	0.48	0.38	0.08	0.05
1978	0.19	0.49	0.28	0.04
1979	0.26	0.39	0.27	0.08
1980	0.10	0.32	0.39	0.19
1981	0.08	0.21	0.40	0.32
1982	0.21	0.20	0.26	0.33
1983	0.47	0.38	0.09	0.06
1984	0.54	0.37	0.08	0.01
1985	0.37	0.43	0.18	0.02
1986	0.39	0.45	0.15	0.02
1987	0.21	0.36	0.31	0.12
1988	0.27	0.41	0.26	0.06
1989	0.22	0.45	0.26	0.07
1990	0.18	0.43	0.31	0.08
1992	0.29	0.40	0.20	0.11
1993	0.25	0.44	0.26	0.04
1994	0.30	0.35	0.28	0.07
1995	0.33	0.38	0.23	0.07
1996	0.36	0.39	0.18	0.07
1997	0.44	0.40	0.13	0.04
1998	0.36	0.41	0.17	0.06
1999	0.34	0.31	0.24	0.10
2000	0.36	0.47	0.15	0.02
2001	0.25	0.43	0.24	0.08
2002	0.28	0.34	0.30	0.09
2003	0.44	0.36	0.16	0.04
2004	0.41	0.43	0.12	0.04
2005	0.28	0.52	0.18	0.03
2006	0.23	0.49	0.24	0.04
2007	0.39	0.40	0.17	0.04
2008	0.44	0.44	0.09	0.02
2009	0.43	0.41	0.13	0.03
2010	0.44	0.42	0.12	0.01
2011	0.38	0.46	0.13	0.03
2012	0.27	0.51	0.20	0.02
2013	0.25	0.42	0.27	0.07
2014	0.33	0.33	0.26	0.09
2015	0.51	0.32	0.13	0.04
2016	0.27	0.50	0.19	0.04
2017	0.20	0.50	0.26	0.03
2018	0.12	0.40	0.39	0.10
2019	0.33	0.34	0.28	0.05
2022	0.60	0.36	0.04	0.00
2023	0.33	0.51	0.15	0.01
2024	0.14	0.44	0.35	0.07
2025	0.10	0.32	0.39	0.18
2026	0.08	0.21	0.38	0.34

Table 7: Comparisons of negative log-likelihood values for models 26.0.May, which used GMACS version 2.20.34a; model 26.0.Nov, which is 26.0.May transitioned to GMACS version 2.20.44, and 26.0.up, which is 26.0.Nov with updated data from 2026. Note that subsistence total catch data are not fitted in this model.

Component	26.0.May	26.0.Nov	26.0.up
Winter comm. retained catch	-121.629	-121.629	-124.216
Subsistence retained catch	-124.217	-124.217	-126.804
Subsistence total catch	0.000	0.000	0.000
Summer comm. retained catch	-119.035	-119.035	-121.620
NMFS trawl survey 1976-1991	-3.178	-3.178	-2.887
ADF&G trawl survey	-4.568	-4.564	-4.012
NOAA NBS survey	-5.631	-5.632	-5.561
Fishery CPUE 1977-1992	-5.631	-5.632	-5.561
Fishery CPUE 1993-2006	-3.621	-3.625	-0.842
Fishery CPUE 2007-2025	-6.886	-6.887	-12.838
Winter com. retained size comp.	22.607	22.691	22.814
Summer com. retained size comp.	279.509	279.507	288.073
Summer com. discard size comp.	107.712	107.716	107.843
Summer com. total size comp	78.912	78.924	79.048
NMFS trawl survey size comp.	45.169	45.173	45.665
ADF&G trawl survey size comp.	115.988	115.957	116.654
NBS trawl survey size comp.	57.490	57.483	57.226
Winter pot survey size comp.	302.630	302.635	301.307
Recruitment deviations	51.154	51.155	52.422
Tagging	1689.510	1689.521	1689.565
F penalty	14.211	14.211	14.211
Prior	91.170	91.246	91.074
Total	2509.499	2509.668	2509.674
Total estimated parameters	229.000	230.000	234.000

Table 8: Comparisons of negative log-likelihood values for the models that include a model-based index of abundance (MBI) in place of the design-based indices of abundance for the ADFG and NOAA NBS trawl surveys. The models differ in whether the MBI had depth excluded (nd) or included (d) and whether catchability for the MBI was fixed (26.1 models) or estimated (26.2 models). Note that subsistence total catch data are not fitted in these models.

Component	26.1.nd	26.1.d	26.2.nd	26.2.d
Winter comm. retained catch	-124.22	-124.22	-124.22	-124.22
Subsistence retained catch	-126.80	-126.80	-126.80	-126.80
Subsistence total catch	0.00	0.00	0.00	0.00
Summer comm. retained catch	-121.62	-121.63	-121.62	-121.62
NMFS trawl survey 1976-1991	-4.18	-4.53	-3.26	-3.32
Model-based index	-3.74	-6.73	-2.97	-5.67
Fishery CPUE 1977-1992	-1.36	-1.21	-1.62	-1.61
Fishery CPUE 1993-2006	-1.15	-1.18	-0.99	-0.97
Fishery CPUE 2007-2026	-1.67	-1.61	-1.74	-1.72
Winter com. retained size comp.	22.47	22.56	22.22	22.21
Summer com. retained size comp.	288.74	289.07	288.32	288.45
Summer com. discard size comp.	107.60	107.53	107.70	107.66
Summer com. total size comp	78.29	78.23	78.56	78.57
NMFS trawl survey size comp.	45.15	45.05	45.38	45.35
ADF&G trawl survey size comp.	117.64	118.30	116.85	117.15
NBS trawl survey size comp.	58.88	59.30	58.50	58.75
Winter pot survey size comp.	301.24	301.47	300.84	300.85
Recruitment deviations	51.40	51.47	51.41	51.49
Tagging	1689.66	1689.77	1689.45	1689.47
F penalty	14.21	14.21	14.21	14.21
Prior	90.57	90.76	90.75	90.76
Total	2537.62	2536.33	2537.51	2535.55
Total estimated parameters	233.00	233.00	234.00	234.00

Table 9: Summary of convergence diagnostics from jitter runs. OF = objective function. MLE = maximum likelihood estimate.

Model	% of 200 jitter runs that ran successfully	% successful runs that had min. OF value	Max. gradient at MLE
26.0.up	63	85	-0.00000088
26.1.d	66	83	-0.00000388
26.1.nd	60	87	-0.00002175
26.2.d	58	89	-0.00000524
26.2.nd	60	91	-0.00002406

Table 10: Comparisons of catchability values among the base model (26.0.up) and models including a model-based index of abundance (MBI) in place of the design-based indices of abundance for the ADFG and NOAA NBS trawl surveys. Model 26.0.up has catchability for the ADFG survey fixed at 1. Models 26.1.nd and 26.1.d have catchability for the MBI fixed at 1. Models 26.2.nd and 26.2.d have catchability for the MBI estimated.

Index	26.0.up	26.1.nd	26.1.d	26.2.nd	26.2.d
Historical survey	0.8348	0.6977	0.6243	0.8699	0.8641
ADFG survey	1.0000				
NBS survey	0.6854				
Model-based		1.0000	1.0000	1.4419	1.6858
CPUE series 1	0.0008	0.0007	0.0006	0.0009	0.0009
CPUE series 2	0.0014	0.0012	0.0010	0.0016	0.0016
CPUE series 3	0.0011	0.0009	0.0008	0.0013	0.0014

Table 11: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 26.0, the base model with updated GMACS version and data.

Parameter	Estimate	SE
Log(Rinitial):	9.1785	0.1299
Log(Rbar):	6.4422	0.1500
Recruitment_ra-males:	72.8078	2.6908
Recruitment_rb-males:	0.0865	0.7004
Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1210	0.4327
Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4237	0.4199
Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6266	0.4059
Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6052	0.3968
Scaled_logN_for_male_mature_mature_newshell_class_6:	0.2734	0.4034
Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3282	0.4380
Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.5391	0.4676
Alpha_male:	40.1452	2.7879
Beta_male:	0.2867	0.0317
Gscale_male:	4.8477	0.2738
Molt_probability_mu_base_male_period_1:	134.9273	9.4556
Molt_probability_CV_base_male_period_1:	0.0716	0.0118
Sel_Winter_Com_male_base_Dec_Logistic_mean:	0.5615	0.0440
Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.1019	0.0391
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	-11.5041	33.3053
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	4.7979	0.0492
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par1:	-2.2973	0.4260
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par2:	-2.7881	0.4922
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par3:	-0.8195	0.2955
Ret_Winter_Com_male_base_Logistic_mean:	-0.1827	0.2665
Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6070	0.0109
Ret_Subsistence_male_base_class_1:	0.0000	0.0842
Ret_Summer_Com_male_base_Logistic_cv:	4.6458	0.0082
Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8584	0.1347
Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6661	0.0076
Log_vn_aggregated_size_comp1:	0.8621	0.1671
Log_fbar_Winter_Com:	-6.4657	0.7129
Log_fbar_Subsistence:	-6.0650	2.2378
Log_fbar_Summer_Com:	-2.1389	0.7142
Survey_q_survey_1:	0.8348	0.1536
Survey_q_survey_3:	0.6854	0.1229
Survey_q_survey_4:	0.0008	0.0002
Survey_q_survey_5:	0.0014	0.0002
Survey_q_survey_6:	0.0011	0.0001
Log_add_cvt_survey_4:	-1.2878	0.1597

Table 12: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 26.1.nd, the model with a model-based index that does not include an effect of depth.

Parameter	Estimate	SE
Log(Rinitial):	9.2669	0.1545
Log(Rbar):	6.6002	0.1513
Recruitment_ra-males:	72.8156	2.5625
Recruitment_rb-males:	0.0806	0.6264
Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1405	0.4313
Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4102	0.4192
Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6337	0.4055
Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6277	0.3971
Scaled_logN_for_male_mature_mature_newshell_class_6:	0.3020	0.4042
Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3007	0.4395
Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.5127	0.4696
Alpha_male:	39.9483	2.7792
Beta_male:	0.2847	0.0316
Gscale_male:	4.8433	0.2746
Molt_probability_mu_base_male_period_1:	134.5835	9.1430
Molt_probability_CV_base_male_period_1:	0.0717	0.0116
Sel_Winter_Com_male_base_Dec_Logistic_mean:	0.5766	0.0439
Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.1004	0.0392
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	-11.5047	31.1847
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	4.7930	0.0488
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par1:	-2.2855	0.4093
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par2:	-2.8059	0.4923
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par3:	-0.8299	0.2955
Ret_Winter_Com_male_base_Logistic_mean:	-0.1930	0.2663
Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6071	0.0109
Ret_Subsistence_male_base_class_1:	0.0001	0.0884
Ret_Summer_Com_male_base_Logistic_cv:	4.6440	0.0081
Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8553	0.1353
Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6658	0.0077
Log_vn_aggregated_size_comp1:	0.8667	0.1682
Log_fbar_Winter_Com:	-6.6445	0.7134
Log_fbar_Subsistence:	-6.2389	2.2379
Log_fbar_Summer_Com:	-2.3235	0.7149
Survey_q_survey_1:	0.6977	0.1474
Survey_q_survey_3:	0.0007	0.0002
Survey_q_survey_4:	0.0012	0.0003
Survey_q_survey_5:	0.0009	0.0002
Log_add_cvt_survey_3:	-0.7431	0.3032

Table 13: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 26.1.d, the model with a model-based index that includes depth.

Parameter	Estimate	SE
Log(Rinitial):	9.3434	0.1685
Log(Rbar):	6.7125	0.1527
Recruitment_ra-males:	72.8142	2.5523
Recruitment_rb-males:	0.0794	0.6131
Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1500	0.4305
Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4029	0.4188
Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6349	0.4051
Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6368	0.3969
Scaled_logN_for_male_mature_mature_newshell_class_6:	0.3162	0.4043
Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.2835	0.4405
Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.4949	0.4711
Alpha_male:	39.8392	2.7636
Beta_male:	0.2836	0.0314
Gscale_male:	4.8423	0.2745
Molt_probability_mu_base_male_period_1:	134.5523	9.0371
Molt_probability_CV_base_male_period_1:	0.0718	0.0116
Sel_Winter_Com_male_base_Dec_Logistic_mean:	0.5972	0.0436
Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.1024	0.0394
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	-11.5057	27.2536
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	4.7881	0.0508
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par1:	-2.2981	0.4059
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par2:	-2.8152	0.4960
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par3:	-0.8370	0.3014
Ret_Winter_Com_male_base_Logistic_mean:	-0.2037	0.2729
Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6069	0.0110
Ret_Subsistence_male_base_class_1:	0.0000	0.0847
Ret_Summer_Com_male_base_Logistic_cv:	4.6437	0.0081
Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8569	0.1356
Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6652	0.0077
Log_vn_aggregated_size_comp1:	0.8662	0.1682
Log_fbar_Winter_Com:	-6.7734	0.7137
Log_fbar_Subsistence:	-6.3644	2.2381
Log_fbar_Summer_Com:	-2.4594	0.7152
Survey_q_survey_1:	0.6243	0.1384
Survey_q_survey_3:	0.0006	0.0002
Survey_q_survey_4:	0.0010	0.0002
Survey_q_survey_5:	0.0008	0.0002
Log_add_cvt_survey_3:	-0.7258	0.3013

Table 14: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 26.2.nd, the model with a model-based index that does not include an effect of depth, with catchability for the model-based index estimated.

Parameter	Estimate	SE
Log(Rinitial):	9.1208	0.1622
Log(Rbar):	6.3244	0.2341
Recruitment_ra-males:	72.8250	2.5360
Recruitment_rb-males:	0.0820	0.6404
Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1166	0.4336
Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4278	0.4205
Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6297	0.4066
Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6048	0.3980
Scaled_logN_for_male_mature_mature_newshell_class_6:	0.2669	0.4046
Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3438	0.4383
Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.5581	0.4673
Alpha_male:	40.1999	2.8226
Beta_male:	0.2873	0.0321
Gscale_male:	4.8462	0.2744
Molt_probability_mu_base_male_period_1:	134.6007	9.3291
Molt_probability_CV_base_male_period_1:	0.0714	0.0115
Sel_Winter_Com_male_base_Dec_Logistic_mean:	0.5244	0.0606
Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.0976	0.0390
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	-11.5007	46.1074
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	4.8035	0.0451
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par1:	-2.2479	0.4146
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par2:	-2.7828	0.4844
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par3:	-0.8120	0.2826
Ret_Winter_Com_male_base_Logistic_mean:	-0.1675	0.2523
Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6078	0.0109
Ret_Subsistence_male_base_class_1:	0.0001	0.1046
Ret_Summer_Com_male_base_Logistic_cv:	4.6446	0.0081
Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8529	0.1347
Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6678	0.0078
Log_vn_aggregated_size_comp1:	0.8668	0.1681
Log_fbar_Winter_Com:	-6.3302	0.7436
Log_fbar_Subsistence:	-5.9340	2.2470
Log_fbar_Summer_Com:	-1.9954	0.7483
Survey_q_survey_1:	0.8699	0.2102
Survey_q_survey_2:	1.4419	0.3675
Survey_q_survey_3:	0.0009	0.0002
Survey_q_survey_4:	0.0016	0.0006
Survey_q_survey_5:	0.0013	0.0005
Log_add_cvt_survey_3:	-0.7763	0.3080

Table 15: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 26.2.d, the model with a model-based index that includes depth, with catchability for the model-based index estimated.

Parameter	Estimate	SE
Log(Rinitial):	9.1250	0.1619
Log(Rbar):	6.3111	0.2297
Recruitment_ra-males:	72.8278	2.5069
Recruitment_rb-males:	0.0810	0.6274
Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1169	0.4336
Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4272	0.4204
Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6292	0.4065
Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6047	0.3979
Scaled_logN_for_male_mature_mature_newshell_class_6:	0.2671	0.4045
Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3434	0.4383
Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.5577	0.4672
Alpha_male:	40.1713	2.8220
Beta_male:	0.2870	0.0321
Gscale_male:	4.8448	0.2745
Molt_probability_mu_base_male_period_1:	134.5190	9.2621
Molt_probability_CV_base_male_period_1:	0.0714	0.0115
Sel_Winter_Com_male_base_Dec_Logistic_mean:	0.5250	0.0603
Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.0984	0.0390
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	-11.5014	43.5059
Sel_Winter_Pot_male_base_Dec_Logistic_cv:	4.8023	0.0452
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par1:	-2.2476	0.4118
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par2:	-2.7831	0.4847
Sel_Winter_Pot_male_base_Dec_Logistic_extra_par3:	-0.8119	0.2832
Ret_Winter_Com_male_base_Logistic_mean:	-0.1687	0.2530
Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6078	0.0109
Ret_Subsistence_male_base_class_1:	0.0001	0.1064
Ret_Summer_Com_male_base_Logistic_cv:	4.6445	0.0081
Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8531	0.1348
Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6679	0.0078
Log_vn_aggregated_size_comp1:	0.8664	0.1681
Log_fbar_Winter_Com:	-6.3193	0.7418
Log_fbar_Subsistence:	-5.9231	2.2465
Log_fbar_Summer_Com:	-1.9867	0.7465
Survey_q_survey_1:	0.8641	0.2075
Survey_q_survey_2:	1.6858	0.4170
Survey_q_survey_3:	0.0009	0.0002
Survey_q_survey_4:	0.0016	0.0005
Survey_q_survey_5:	0.0014	0.0005
Log_add_cvt_survey_3:	-0.7749	0.3078

Table 16: Fully-selected fishing mortality rates in the Norton Sound red king crab summer commercial, winter commercial, and subsistence fisheries, estimated using model 26.0.

Year	Summer_Com	Winter_Com	Subsistence
1978	0.1858	0.0020	0.0024
1979	0.4541	0.0001	0.0001
1980	0.2904	0.0000	0.0001
1981	0.6719	0.0000	0.0003
1982	0.1478	0.0000	0.0013
1983	0.1881	0.0005	0.0072
1984	0.1518	0.0007	0.0067
1985	0.1409	0.0008	0.0046
1986	0.1451	0.0014	0.0037
1987	0.0909	0.0007	0.0031
1988	0.0658	0.0003	0.0015
1989	0.0721	0.0003	0.0036
1990	0.0589	0.0027	0.0078
1991	0.0000	0.0031	0.0052
1992	0.0282	0.0065	0.0089
1993	0.1512	0.0017	0.0009
1994	0.1758	0.0068	0.0043
1995	0.2233	0.0110	0.0068
1996	0.1798	0.0030	0.0023
1997	0.0710	0.0001	0.0009
1998	0.0181	0.0012	0.0076
1999	0.0100	0.0023	0.0051
2000	0.1192	0.0024	0.0040
2001	0.1214	0.0010	0.0002
2002	0.1152	0.0025	0.0016
2003	0.1052	0.0055	0.0026
2004	0.1174	0.0004	0.0007
2005	0.1410	0.0016	0.0026
2006	0.1734	0.0001	0.0009
2007	0.1288	0.0028	0.0071
2008	0.1686	0.0045	0.0055
2009	0.1465	0.0034	0.0025
2010	0.1366	0.0030	0.0035
2011	0.1257	0.0021	0.0036
2012	0.1706	0.0068	0.0047
2013	0.1697	0.0200	0.0054
2014	0.1712	0.0131	0.0020
2015	0.1513	0.0288	0.0042
2016	0.1462	0.0223	0.0036
2017	0.1864	0.0257	0.0054
2018	0.1749	0.0128	0.0053
2019	0.0552	0.0017	0.0020
2020	0.0000	0.0001	0.0004
2021	0.0000	0.0002	0.0013
2022	0.0799	0.0012	0.0027
2023	0.0867	0.0016	0.0020
2024	0.0933	0.0024	0.0022
2025	0.0907	0.0018	0.0012
2026	0.1042	0.0055	0.0043

Table 17: Norton Sound red king crab estimated recruit male biomass (RMB), mature male biomass (MMB), and legal male biomass (LMB), in kt and million lb, from model 26.0. Recruits are defined as males 64-93 mm carapace length (CL), mature males are those >= 94 mm CL, and legal males are those >= 103 mm CL.

Year	RMB (kt)	MMB (kt)	LMB (kt)	RMB (mill lb)	MMB (mill lb)	LMB (mill lb)
1976	1.39	7.47	6.04	3.06	16.47	13.31
1977	0.59	7.89	6.87	1.29	17.40	15.14
1978	0.21	7.00	6.56	0.46	15.44	14.46
1979	0.15	4.88	4.72	0.32	10.77	10.40
1980	0.22	2.53	2.42	0.49	5.57	5.33
1981	0.55	1.60	1.44	1.21	3.52	3.17
1982	0.68	1.16	0.78	1.50	2.56	1.72
1983	0.61	1.65	1.17	1.34	3.64	2.58
1984	0.62	1.96	1.52	1.36	4.33	3.36
1985	0.56	2.21	1.76	1.23	4.87	3.88
1986	0.52	2.34	1.94	1.14	5.16	4.27
1987	0.45	2.32	1.95	0.99	5.12	4.29
1988	0.36	2.31	1.98	0.80	5.09	4.38
1989	0.37	2.20	1.93	0.81	4.84	4.25
1990	0.31	2.05	1.78	0.67	4.52	3.93
1991	0.27	1.89	1.67	0.59	4.17	3.69
1992	0.24	1.78	1.58	0.52	3.93	3.49
1993	0.19	1.61	1.44	0.41	3.55	3.18
1994	0.19	1.31	1.18	0.42	2.89	2.59
1995	0.24	1.07	0.93	0.52	2.36	2.06
1996	0.31	0.94	0.77	0.69	2.07	1.69
1997	0.52	0.99	0.76	1.16	2.18	1.68
1998	0.51	1.32	0.94	1.12	2.91	2.06
1999	0.27	1.74	1.38	0.60	3.83	3.03
2000	0.26	1.84	1.63	0.58	4.05	3.60
2001	0.49	1.65	1.46	1.09	3.64	3.21
2002	0.60	1.69	1.33	1.31	3.72	2.92
2003	0.47	1.92	1.50	1.04	4.24	3.31
2004	0.34	2.05	1.71	0.75	4.53	3.77
2005	0.40	1.97	1.72	0.87	4.35	3.80
2006	0.53	1.85	1.56	1.17	4.07	3.43
2007	0.64	1.87	1.49	1.41	4.12	3.28
2008	0.68	2.08	1.62	1.49	4.59	3.57
2009	0.60	2.31	1.83	1.33	5.09	4.03
2010	0.40	2.47	2.03	0.88	5.44	4.48
2011	0.30	2.37	2.08	0.66	5.22	4.59
2012	0.40	2.08	1.85	0.87	4.59	4.09
2013	0.72	1.85	1.56	1.59	4.07	3.44
2014	0.61	1.99	1.46	1.34	4.38	3.22
2015	0.23	2.22	1.80	0.51	4.90	3.98
2016	0.13	1.96	1.79	0.29	4.33	3.94
2017	0.16	1.54	1.44	0.36	3.40	3.18
2018	0.26	1.15	1.03	0.57	2.54	2.28
2019	0.74	1.01	0.82	1.63	2.22	1.82
2020	1.12	1.46	0.92	2.47	3.23	2.02
2021	0.90	2.51	1.71	1.98	5.54	3.76
2022	0.52	3.35	2.70	1.14	7.40	5.95
2023	0.24	3.40	3.02	0.52	7.50	6.65
2024	0.14	2.92	2.74	0.30	6.44	6.05
2025	0.16	2.24	2.13	0.36	4.93	4.70
2026	0.23	1.69	1.57	0.51	3.73	3.47
2027	0.29	1.35	1.18	0.65	2.97	2.61

Table 18: Norton Sound red king crab estimated recruit male biomass (RMB), mature male biomass (MMB), and legal male biomass (LMB), in kt and million lb, from model 26.1.nd. Recruits are defined as males 64-93 mm carapace length (CL), mature males are those >= 94 mm CL, and legal males are those >= 103 mm CL.

Year	RMB (kt)	MMB (kt)	LMB (kt)	RMB (mill lb)	MMB (mill lb)	LMB (mill lb)
1976	1.49	8.27	6.71	3.28	18.23	14.78
1977	0.63	8.63	7.53	1.40	19.02	16.61
1978	0.23	7.62	7.14	0.51	16.81	15.74
1979	0.17	5.36	5.17	0.38	11.81	11.40
1980	0.28	2.87	2.75	0.62	6.34	6.06
1981	0.64	1.89	1.68	1.41	4.16	3.71
1982	0.79	1.47	1.02	1.73	3.24	2.26
1983	0.74	2.01	1.45	1.62	4.43	3.20
1984	0.75	2.39	1.86	1.65	5.28	4.11
1985	0.66	2.72	2.18	1.47	5.99	4.80
1986	0.63	2.89	2.41	1.38	6.36	5.31
1987	0.55	2.88	2.43	1.22	6.36	5.35
1988	0.47	2.87	2.47	1.03	6.33	5.45
1989	0.49	2.75	2.40	1.08	6.06	5.30
1990	0.42	2.61	2.25	0.93	5.76	4.97
1991	0.37	2.47	2.16	0.81	5.44	4.77
1992	0.32	2.35	2.07	0.71	5.18	4.57
1993	0.25	2.16	1.92	0.56	4.76	4.24
1994	0.25	1.81	1.63	0.54	4.00	3.59
1995	0.29	1.51	1.34	0.65	3.34	2.94
1996	0.41	1.33	1.12	0.90	2.94	2.47
1997	0.67	1.38	1.09	1.48	3.04	2.39
1998	0.60	1.78	1.29	1.33	3.92	2.84
1999	0.29	2.24	1.81	0.64	4.93	3.99
2000	0.25	2.28	2.06	0.55	5.02	4.53
2001	0.45	1.98	1.80	0.98	4.37	3.96
2002	0.52	1.86	1.54	1.15	4.11	3.40
2003	0.41	1.94	1.57	0.90	4.28	3.46
2004	0.31	1.94	1.64	0.68	4.27	3.62
2005	0.39	1.79	1.57	0.87	3.95	3.45
2006	0.56	1.67	1.38	1.23	3.68	3.04
2007	0.71	1.74	1.34	1.56	3.84	2.96
2008	0.74	2.05	1.54	1.64	4.52	3.40
2009	0.65	2.38	1.85	1.44	5.25	4.09
2010	0.44	2.60	2.13	0.97	5.74	4.70
2011	0.36	2.54	2.22	0.78	5.60	4.90
2012	0.49	2.28	2.01	1.08	5.02	4.43
2013	0.96	2.10	1.75	2.11	4.63	3.85
2014	0.84	2.42	1.73	1.85	5.33	3.80
2015	0.33	2.89	2.31	0.72	6.36	5.08
2016	0.19	2.67	2.42	0.41	5.89	5.34
2017	0.23	2.19	2.05	0.51	4.83	4.52
2018	0.34	1.72	1.55	0.76	3.80	3.42
2019	0.89	1.53	1.28	1.96	3.36	2.82
2020	1.24	2.00	1.35	2.73	4.40	2.97
2021	0.92	3.08	2.19	2.02	6.79	4.84
2022	0.54	3.84	3.17	1.19	8.47	7.00
2023	0.28	3.78	3.38	0.61	8.34	7.45
2024	0.16	3.23	3.03	0.36	7.13	6.67
2025	0.18	2.49	2.36	0.41	5.48	5.20
2026	0.26	1.89	1.76	0.57	4.17	3.88
2027	0.34	1.52	1.33	0.75	3.35	2.94

Table 19: Norton Sound red king crab recruit male biomass (RMB), estimated mature male biomass (MMB), and legal male biomass (LMB), in kt and million lb, from model 26.1.d. Recruits are defined as males 64-93 mm carapace length (CL), mature males are those >= 94 mm CL, and legal males are those >= 103 mm CL.

Year	RMB (kt)	MMB (kt)	LMB (kt)	RMB (mill lb)	MMB (mill lb)	LMB (mill lb)
1976	1.59	8.99	7.31	3.50	19.82	16.11
1977	0.68	9.29	8.12	1.50	20.48	17.90
1978	0.25	8.17	7.66	0.54	18.02	16.88
1979	0.19	5.76	5.57	0.41	12.71	12.27
1980	0.31	3.16	3.02	0.69	6.96	6.67
1981	0.71	2.10	1.87	1.56	4.62	4.13
1982	0.87	1.68	1.18	1.92	3.69	2.61
1983	0.82	2.26	1.64	1.80	4.98	3.62
1984	0.83	2.69	2.10	1.84	5.94	4.64
1985	0.74	3.06	2.46	1.64	6.74	5.41
1986	0.71	3.25	2.72	1.56	7.17	5.99
1987	0.63	3.26	2.75	1.38	7.19	6.06
1988	0.53	3.25	2.80	1.17	7.17	6.17
1989	0.56	3.11	2.72	1.24	6.86	6.00
1990	0.49	2.96	2.56	1.07	6.54	5.63
1991	0.42	2.81	2.46	0.94	6.19	5.42
1992	0.37	2.67	2.35	0.82	5.88	5.19
1993	0.30	2.46	2.19	0.65	5.42	4.82
1994	0.29	2.09	1.87	0.64	4.60	4.13
1995	0.35	1.77	1.56	0.77	3.89	3.43
1996	0.49	1.58	1.33	1.08	3.48	2.93
1997	0.82	1.66	1.30	1.81	3.65	2.88
1998	0.74	2.15	1.55	1.62	4.74	3.42
1999	0.35	2.72	2.20	0.78	5.99	4.84
2000	0.29	2.76	2.50	0.65	6.10	5.50
2001	0.52	2.43	2.21	1.16	5.35	4.86
2002	0.61	2.27	1.89	1.35	5.01	4.18
2003	0.47	2.35	1.92	1.03	5.18	4.22
2004	0.35	2.33	1.99	0.76	5.13	4.39
2005	0.44	2.14	1.88	0.97	4.71	4.15
2006	0.62	1.97	1.65	1.37	4.35	3.64
2007	0.79	2.03	1.59	1.75	4.48	3.50
2008	0.84	2.36	1.79	1.85	5.21	3.95
2009	0.73	2.74	2.14	1.61	6.04	4.72
2010	0.49	2.99	2.46	1.08	6.58	5.42
2011	0.39	2.91	2.55	0.87	6.41	5.62
2012	0.54	2.60	2.30	1.20	5.72	5.07
2013	1.05	2.39	2.00	2.31	5.27	4.41
2014	0.92	2.72	1.97	2.02	6.00	4.33
2015	0.36	3.22	2.59	0.78	7.11	5.71
2016	0.20	2.98	2.71	0.45	6.58	5.98
2017	0.26	2.45	2.29	0.56	5.39	5.05
2018	0.38	1.92	1.74	0.83	4.24	3.83
2019	0.95	1.70	1.43	2.09	3.74	3.14
2020	1.31	2.18	1.49	2.89	4.81	3.28
2021	0.95	3.30	2.37	2.11	7.28	5.22
2022	0.56	4.07	3.38	1.23	8.98	7.44
2023	0.29	3.98	3.56	0.63	8.77	7.85
2024	0.17	3.38	3.17	0.38	7.46	6.98
2025	0.20	2.59	2.46	0.44	5.71	5.41
2026	0.29	1.97	1.82	0.63	4.34	4.02
2027	0.38	1.59	1.38	0.83	3.50	3.05

Table 20: Norton Sound red king crab estimated recruit male biomass (RMB), mature male biomass (MMB), and legal male biomass (LMB), in kt and million lb, from model 26.2.nd. Recruits are defined as males 64-93 mm carapace length (CL), mature males are those >= 94 mm CL, and legal males are those >= 103 mm CL.

Year	RMB (kt)	MMB (kt)	LMB (kt)	RMB (mill lb)	MMB (mill lb)	LMB (mill lb)
1976	1.32	7.02	5.66	2.91	15.48	12.47
1977	0.56	7.50	6.53	1.22	16.54	14.40
1978	0.20	6.71	6.28	0.44	14.79	13.85
1979	0.15	4.69	4.53	0.32	10.34	9.99
1980	0.23	2.42	2.31	0.51	5.33	5.09
1981	0.52	1.55	1.38	1.16	3.42	3.05
1982	0.64	1.13	0.77	1.41	2.50	1.70
1983	0.59	1.59	1.13	1.31	3.50	2.50
1984	0.60	1.89	1.46	1.32	4.17	3.22
1985	0.53	2.13	1.70	1.17	4.71	3.75
1986	0.49	2.26	1.88	1.08	4.98	4.14
1987	0.43	2.24	1.88	0.94	4.94	4.15
1988	0.36	2.22	1.92	0.79	4.90	4.22
1989	0.37	2.13	1.87	0.82	4.70	4.11
1990	0.32	2.02	1.75	0.70	4.46	3.85
1991	0.28	1.90	1.67	0.61	4.20	3.69
1992	0.24	1.83	1.62	0.54	4.02	3.57
1993	0.19	1.68	1.50	0.42	3.70	3.31
1994	0.18	1.38	1.24	0.40	3.05	2.74
1995	0.21	1.13	0.99	0.47	2.48	2.19
1996	0.29	0.96	0.80	0.64	2.11	1.77
1997	0.48	0.97	0.76	1.06	2.15	1.68
1998	0.44	1.26	0.91	0.96	2.79	2.01
1999	0.22	1.61	1.30	0.47	3.55	2.86
2000	0.18	1.65	1.49	0.41	3.65	3.29
2001	0.33	1.42	1.28	0.73	3.13	2.82
2002	0.39	1.33	1.09	0.86	2.94	2.40
2003	0.31	1.39	1.12	0.68	3.07	2.46
2004	0.24	1.39	1.17	0.53	3.07	2.58
2005	0.30	1.29	1.11	0.66	2.84	2.46
2006	0.42	1.18	0.97	0.92	2.61	2.13
2007	0.53	1.22	0.92	1.18	2.69	2.04
2008	0.56	1.45	1.07	1.23	3.20	2.35
2009	0.49	1.68	1.28	1.09	3.70	2.83
2010	0.34	1.84	1.48	0.74	4.05	3.26
2011	0.27	1.79	1.55	0.59	3.94	3.41
2012	0.37	1.60	1.40	0.82	3.52	3.08
2013	0.72	1.46	1.19	1.59	3.22	2.63
2014	0.63	1.70	1.18	1.38	3.74	2.59
2015	0.24	2.04	1.61	0.53	4.50	3.55
2016	0.14	1.87	1.68	0.30	4.12	3.71
2017	0.17	1.50	1.40	0.37	3.32	3.09
2018	0.24	1.15	1.03	0.53	2.54	2.27
2019	0.62	1.01	0.84	1.37	2.23	1.85
2020	0.88	1.37	0.91	1.94	3.03	2.01
2021	0.66	2.17	1.54	1.45	4.79	3.39
2022	0.39	2.75	2.26	0.87	6.06	4.99
2023	0.20	2.69	2.40	0.44	5.93	5.28
2024	0.12	2.28	2.13	0.26	5.02	4.70
2025	0.13	1.74	1.64	0.30	3.83	3.63
2026	0.19	1.32	1.22	0.42	2.91	2.69
2027	0.25	1.06	0.92	0.56	2.33	2.02

Table 21: Norton Sound red king crab estimated recruit male biomass (RMB), mature male biomass (MMB), and legal male biomass (LMB), in kt and million lb, from model 26.2.d. Recruits are defined as males 64-93 mm carapace length (CL), mature males are those >= 94 mm CL, and legal males are those >= 103 mm CL.

Year	RMB (kt)	MMB (kt)	LMB (kt)	RMB (mill lb)	MMB (mill lb)	LMB (mill lb)
1976	1.32	7.05	5.68	2.92	15.54	12.53
1977	0.56	7.53	6.56	1.23	16.61	14.46
1978	0.20	6.73	6.31	0.44	14.84	13.91
1979	0.15	4.71	4.55	0.32	10.38	10.03
1980	0.23	2.43	2.32	0.52	5.35	5.12
1981	0.53	1.56	1.39	1.16	3.44	3.07
1982	0.64	1.14	0.78	1.42	2.52	1.71
1983	0.60	1.60	1.14	1.32	3.52	2.52
1984	0.60	1.90	1.47	1.33	4.19	3.24
1985	0.53	2.15	1.71	1.18	4.74	3.77
1986	0.49	2.27	1.89	1.09	5.01	4.17
1987	0.43	2.26	1.89	0.95	4.97	4.18
1988	0.36	2.24	1.93	0.80	4.94	4.26
1989	0.38	2.15	1.88	0.83	4.74	4.15
1990	0.32	2.04	1.76	0.71	4.50	3.89
1991	0.28	1.93	1.69	0.62	4.25	3.73
1992	0.25	1.85	1.64	0.55	4.07	3.61
1993	0.19	1.70	1.52	0.43	3.75	3.35
1994	0.19	1.41	1.26	0.41	3.10	2.79
1995	0.22	1.15	1.01	0.48	2.54	2.24
1996	0.30	0.98	0.83	0.67	2.17	1.82
1997	0.51	1.01	0.79	1.12	2.22	1.74
1998	0.46	1.31	0.94	1.01	2.90	2.08
1999	0.23	1.68	1.36	0.50	3.71	2.99
2000	0.19	1.73	1.56	0.42	3.82	3.44
2001	0.34	1.49	1.35	0.75	3.29	2.98
2002	0.40	1.40	1.15	0.88	3.08	2.54
2003	0.31	1.46	1.17	0.69	3.21	2.58
2004	0.23	1.45	1.22	0.52	3.19	2.69
2005	0.29	1.32	1.15	0.64	2.91	2.54
2006	0.40	1.20	0.99	0.89	2.64	2.18
2007	0.52	1.21	0.93	1.16	2.68	2.04
2008	0.56	1.43	1.05	1.22	3.15	2.32
2009	0.49	1.65	1.26	1.07	3.64	2.78
2010	0.33	1.80	1.45	0.73	3.98	3.20
2011	0.26	1.75	1.52	0.58	3.87	3.35
2012	0.36	1.56	1.37	0.79	3.44	3.01
2013	0.70	1.42	1.16	1.54	3.13	2.56
2014	0.60	1.64	1.14	1.33	3.62	2.51
2015	0.23	1.96	1.55	0.51	4.33	3.42
2016	0.13	1.79	1.61	0.29	3.94	3.55
2017	0.16	1.43	1.33	0.35	3.16	2.94
2018	0.23	1.09	0.97	0.51	2.39	2.14
2019	0.57	0.95	0.78	1.27	2.09	1.73
2020	0.80	1.28	0.85	1.77	2.82	1.88
2021	0.60	2.01	1.43	1.32	4.42	3.15
2022	0.35	2.52	2.09	0.78	5.57	4.60
2023	0.18	2.44	2.18	0.40	5.39	4.81
2024	0.11	2.05	1.92	0.24	4.52	4.22
2025	0.13	1.54	1.46	0.28	3.40	3.22
2026	0.18	1.16	1.07	0.41	2.57	2.37
2027	0.25	0.94	0.80	0.55	2.07	1.77

Figures



Figure 1: Norton Sound red king crab summer commercial fishery catch per unit effort (CPUE), retained catch in lb, retained catch in number of crab, and mean weight in lb during 1977-2026.

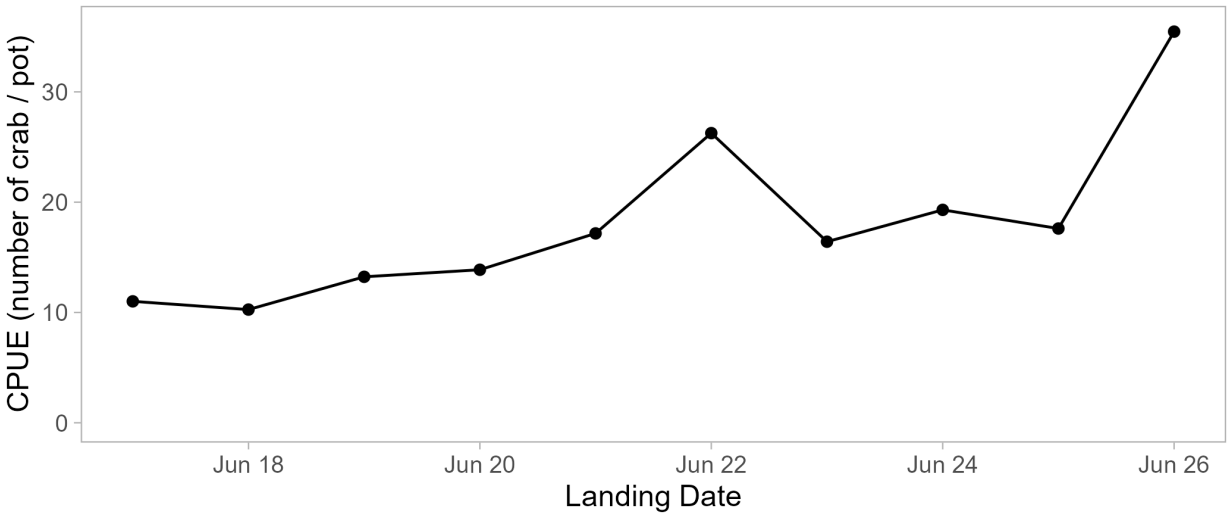


Figure 2: Norton Sound red king crab summer commercial fishery daily average catch per unit effort (CPUE) during the 2026 fishery.

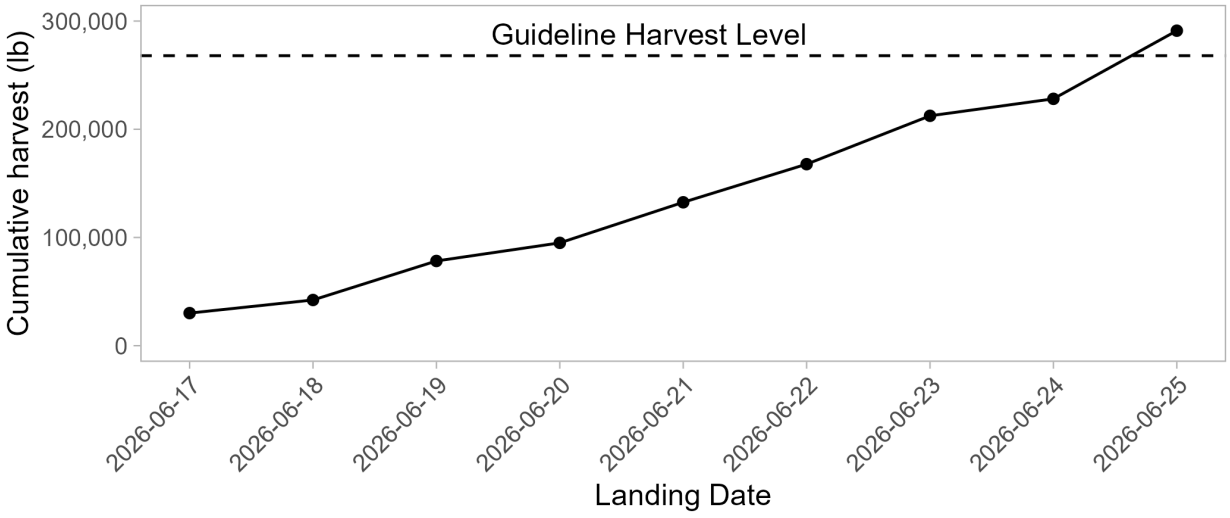


Figure 3: Norton Sound red king crab summer commercial fishery daily cumulative retained catch (lb) during the 2026 fishery.

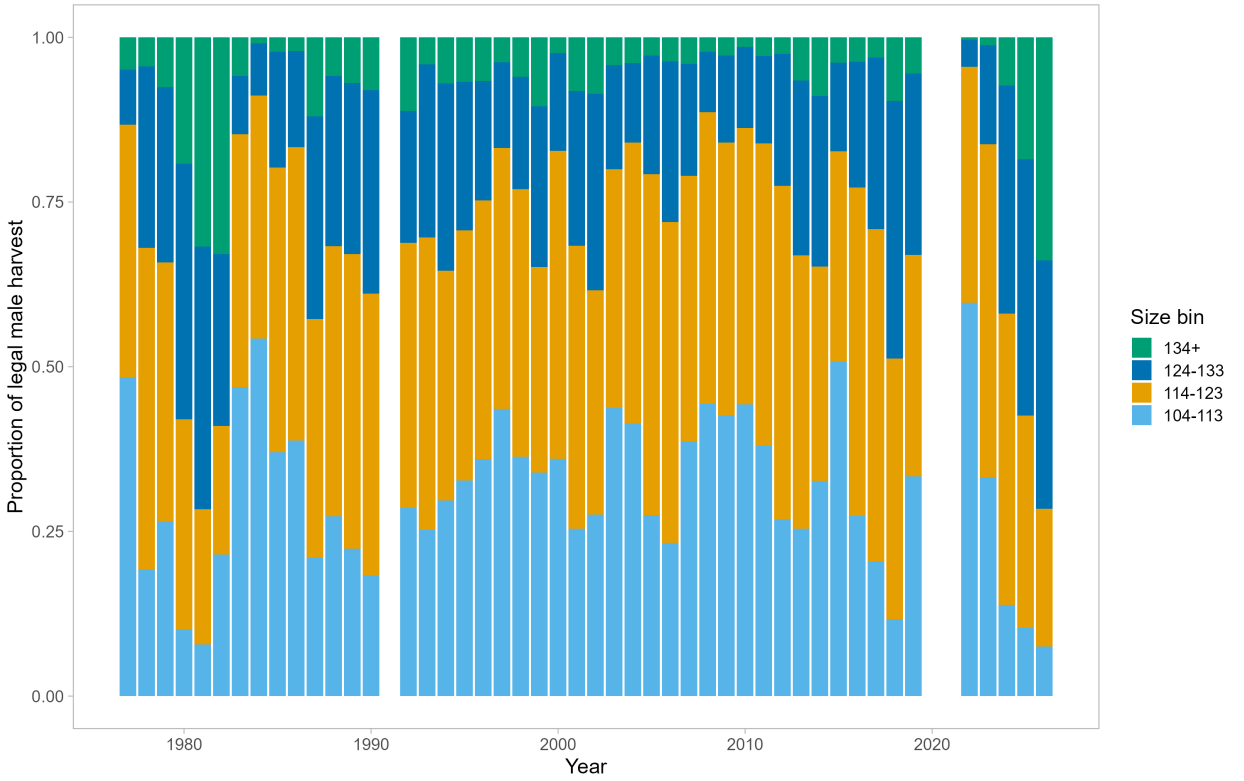


Figure 4: Proportion of Norton Sound red king crab summer commercial fishery legal male retained catch in each size bin over 1977-2026. Size bins are defined in male carapace length (mm).

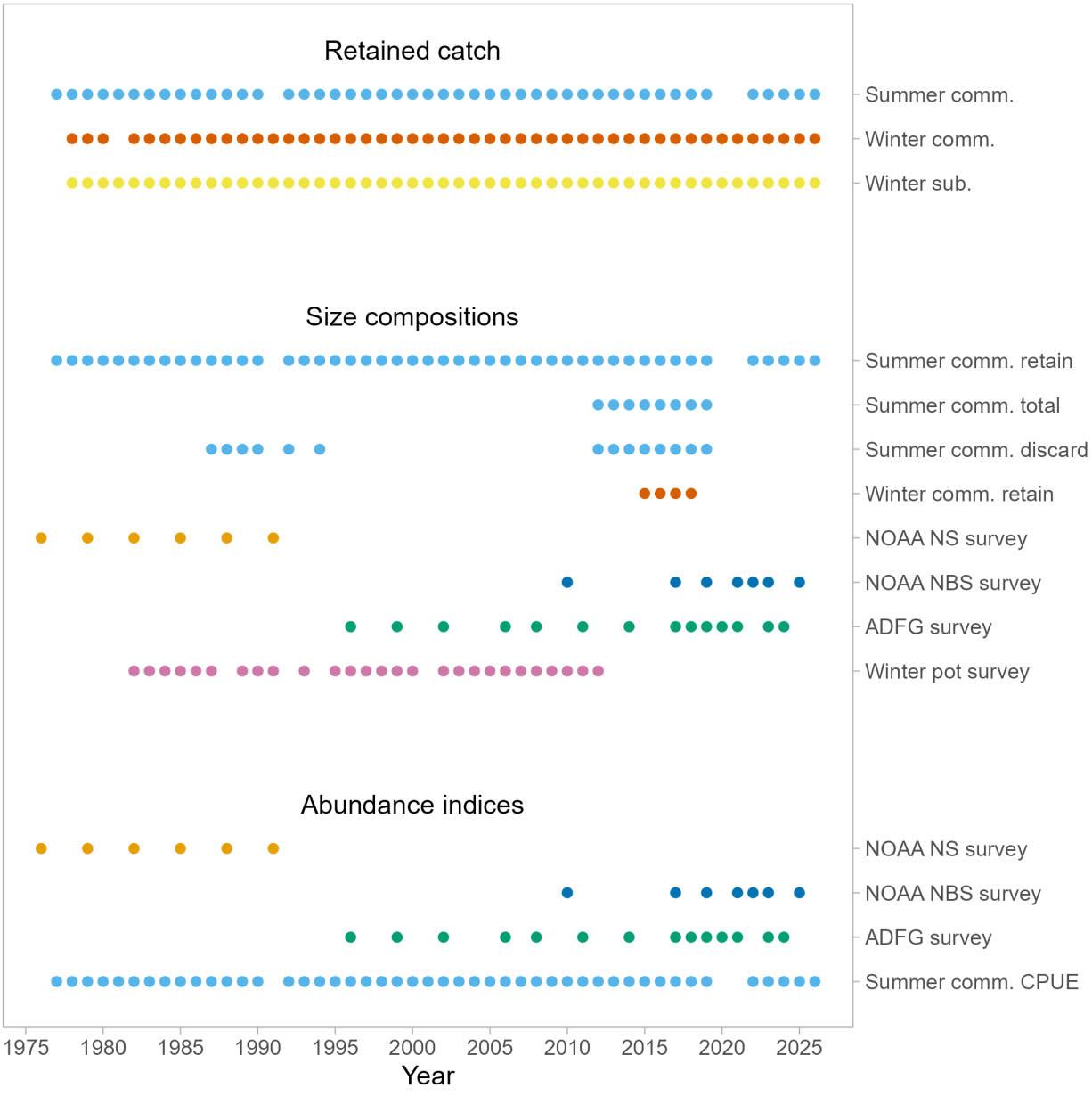


Figure 5: Data sources available for the Norton Sound red king crab stock assessment. Acronyms and abbreviations: National Oceanic and Atmospheric Administration, NOAA; Norton Sound, NS; Northern Bering Sea, NBS; Alaska Department of Fish and Game, ADFG; catch per unit effort, CPUE; comm., commercial; sub., subsistence.

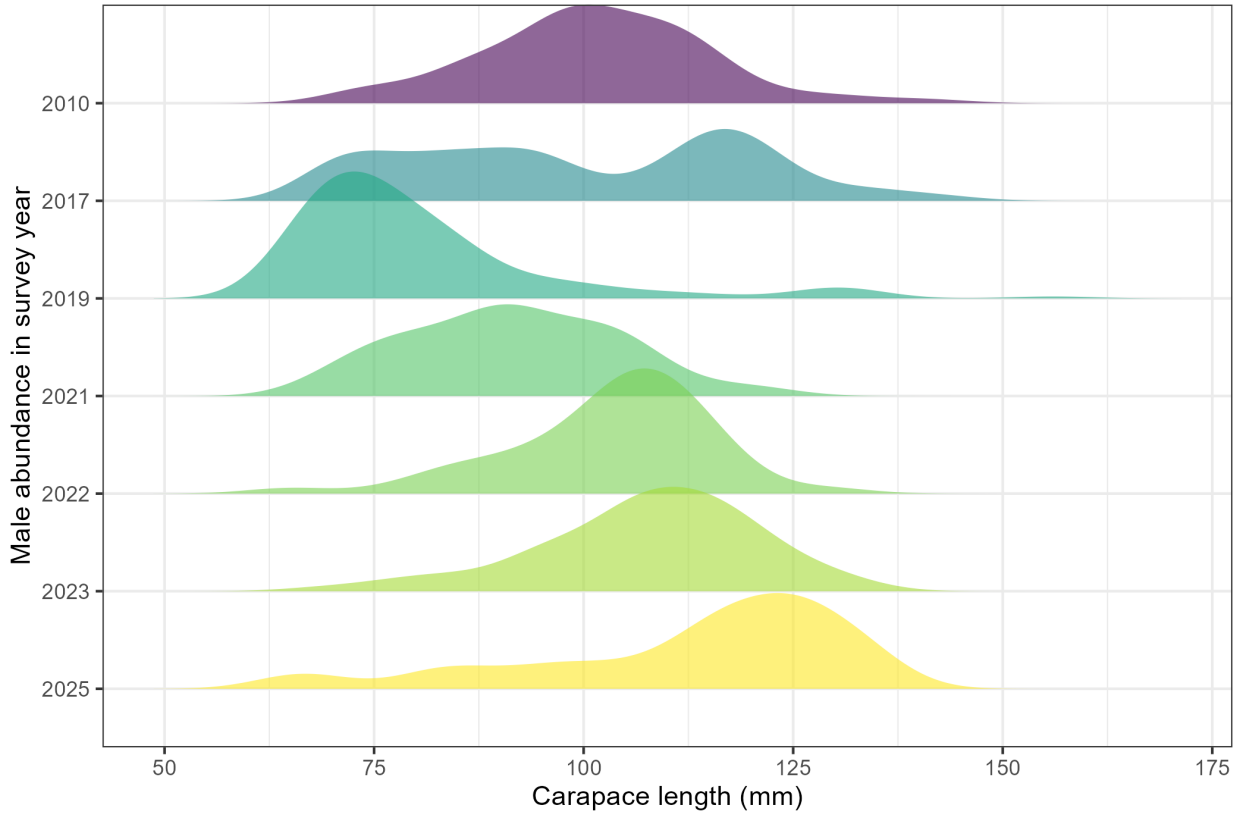


Figure 6: National Oceanic and Atmospheric Administration Northern Bering Sea trawl survey abundances by carapace length for male Norton Sound red king crab from 2010 to 2025.

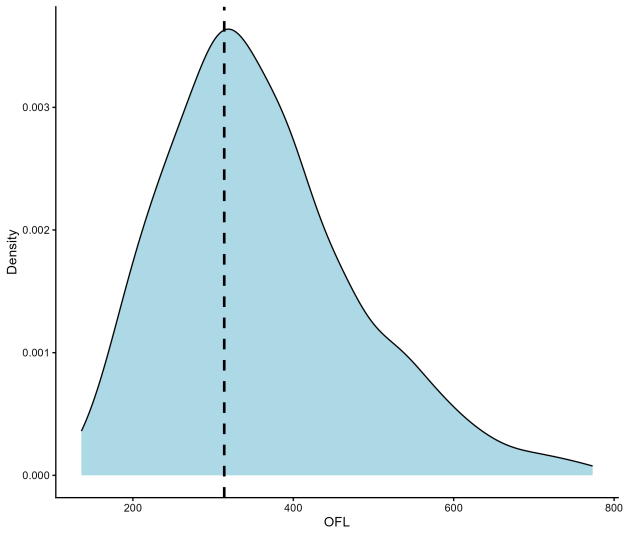


Figure 7: The probability density function of the OFL for model 26.0, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

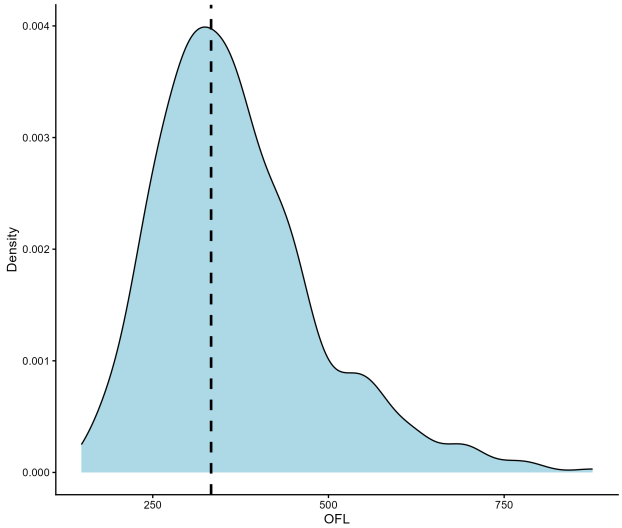


Figure 8: The probability density function of the OFL for model 26.1.nd, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

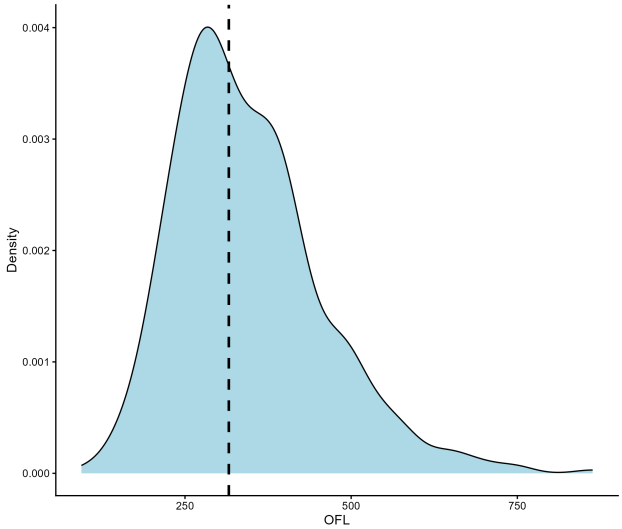


Figure 9: The probability density function of the OFL for model 26.1.d, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

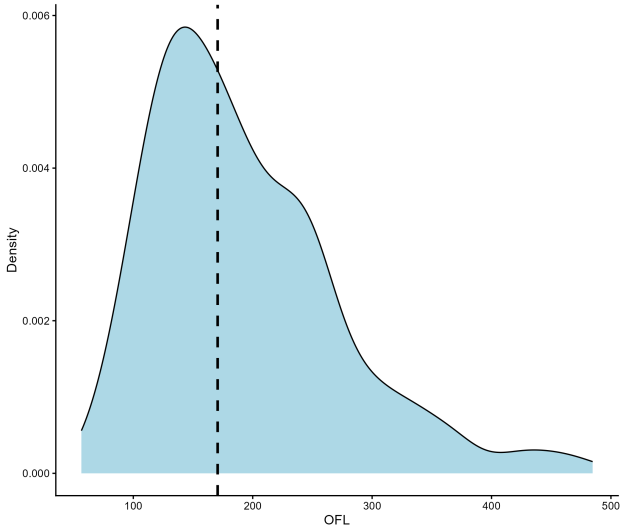


Figure 10: The probability density function of the OFL for model 26.2.d, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

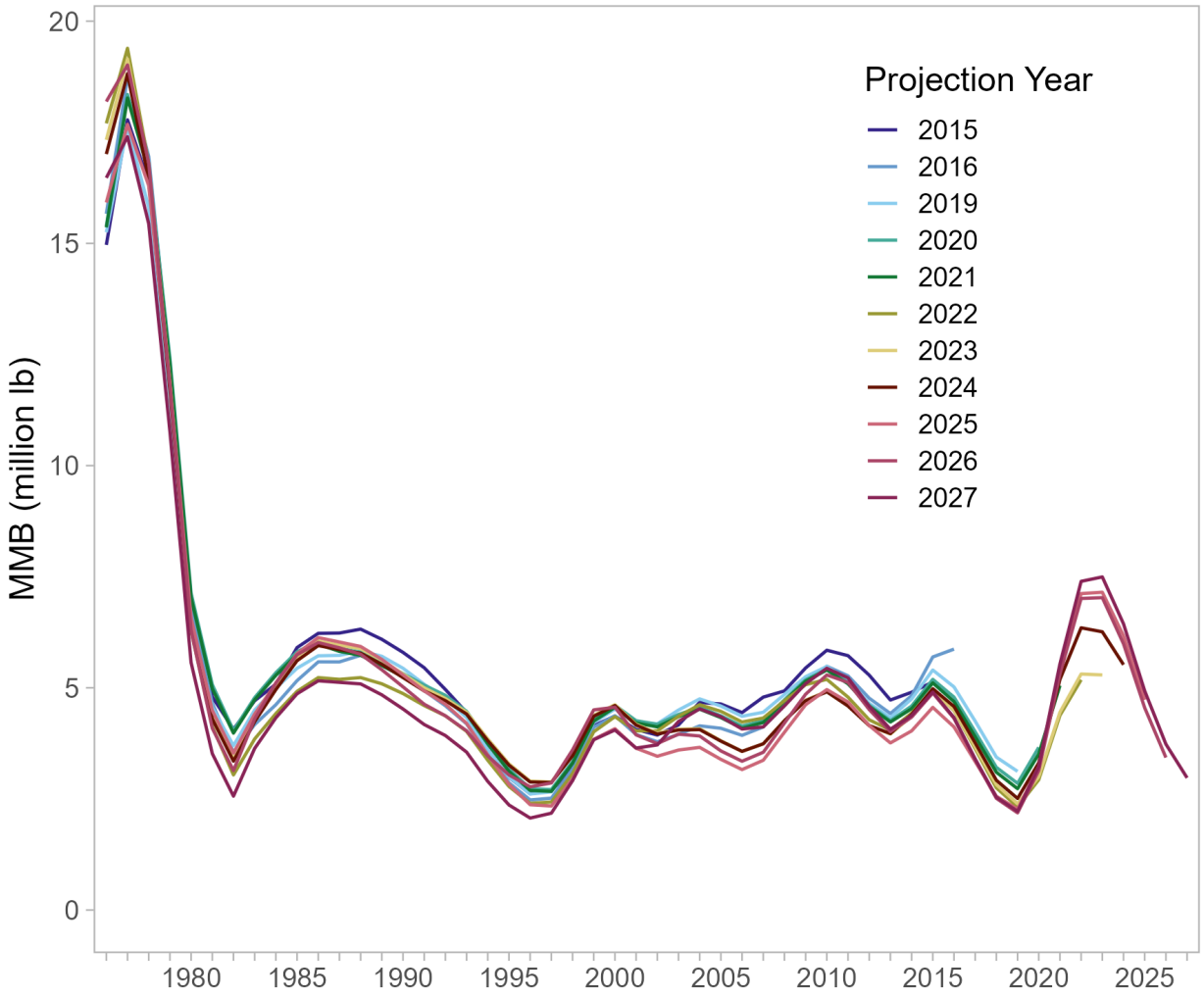


Figure 11: Comparison of historical estimates of mature male biomass of Norton Sound red king crab using the model selected in each year. Data were compiled from reported MMB values for the chosen model in the published SAFE document from the assessment year. The legend shows the year for which model projections were made.

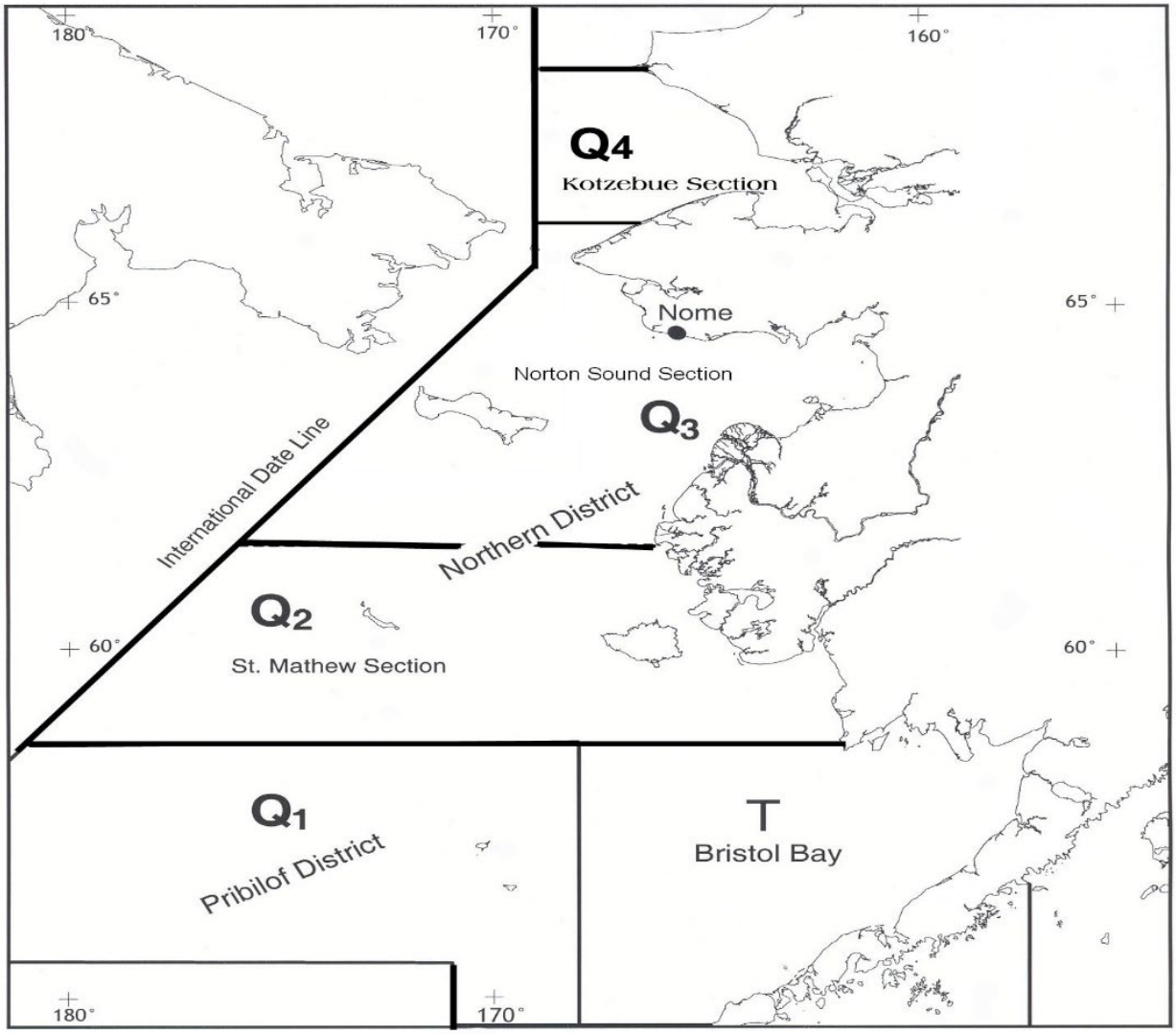


Figure 12: King crab fishing districts and sections of Alaska Department of Fish and Game Registration Area Q. Source: Menard et al. (2022).

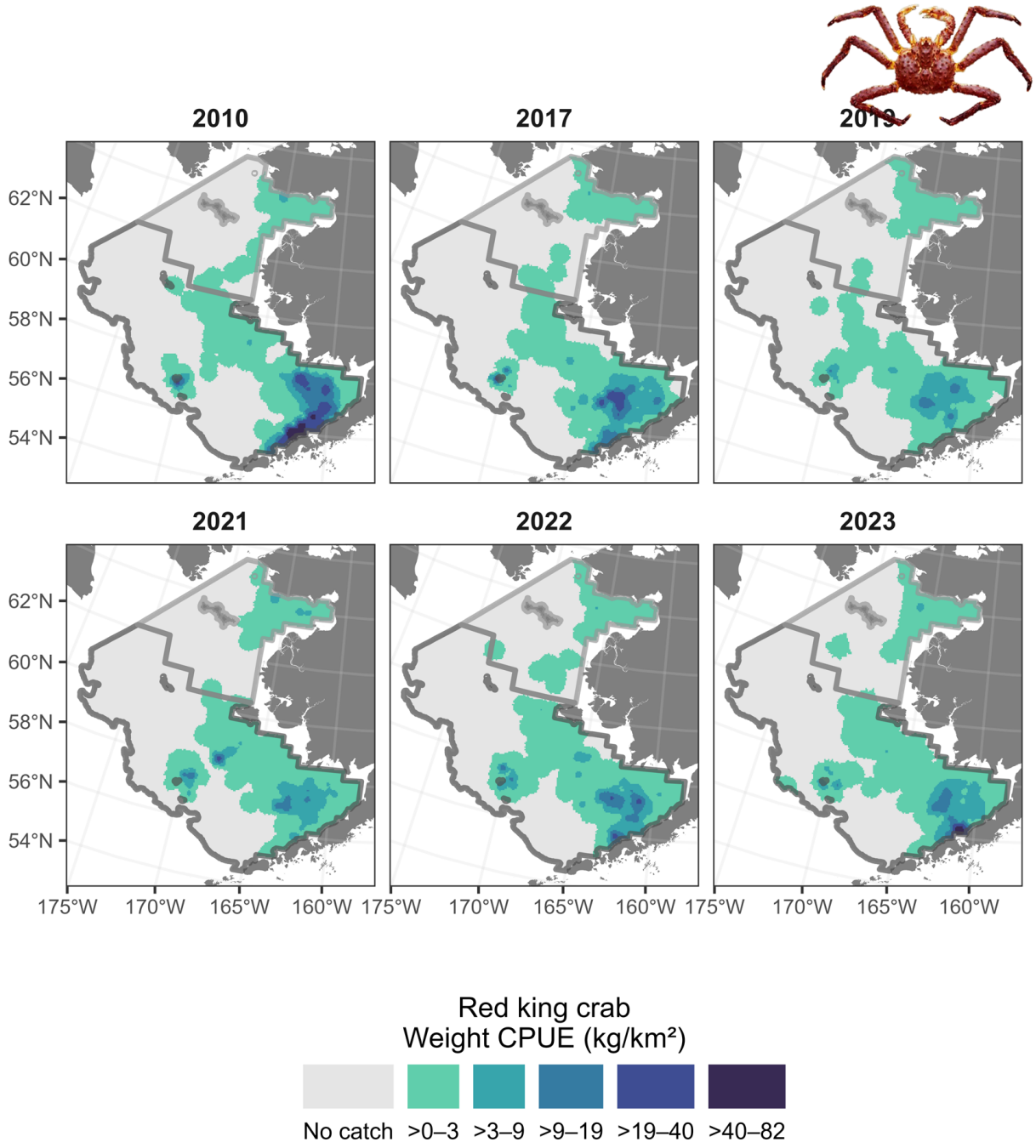


Figure 13: Distribution of red king crab from the 2010, 2017, 2019, and 2021-2023 Eastern and Northern Bering Sea trawl surveys. Source: Markowitz et al. (2023).

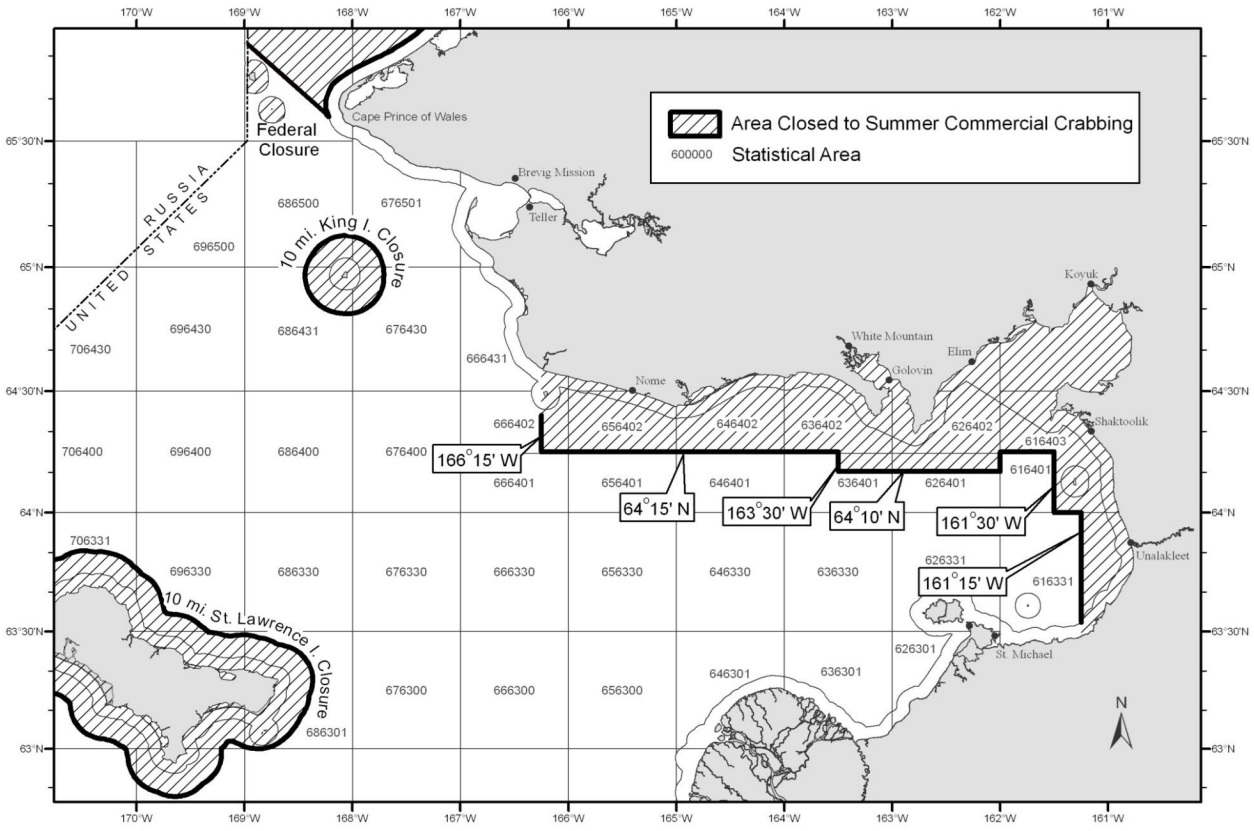


Figure 14: Waters closed to the Norton Sound summer commercial crab fishery. Source: Menard et al. (2022).

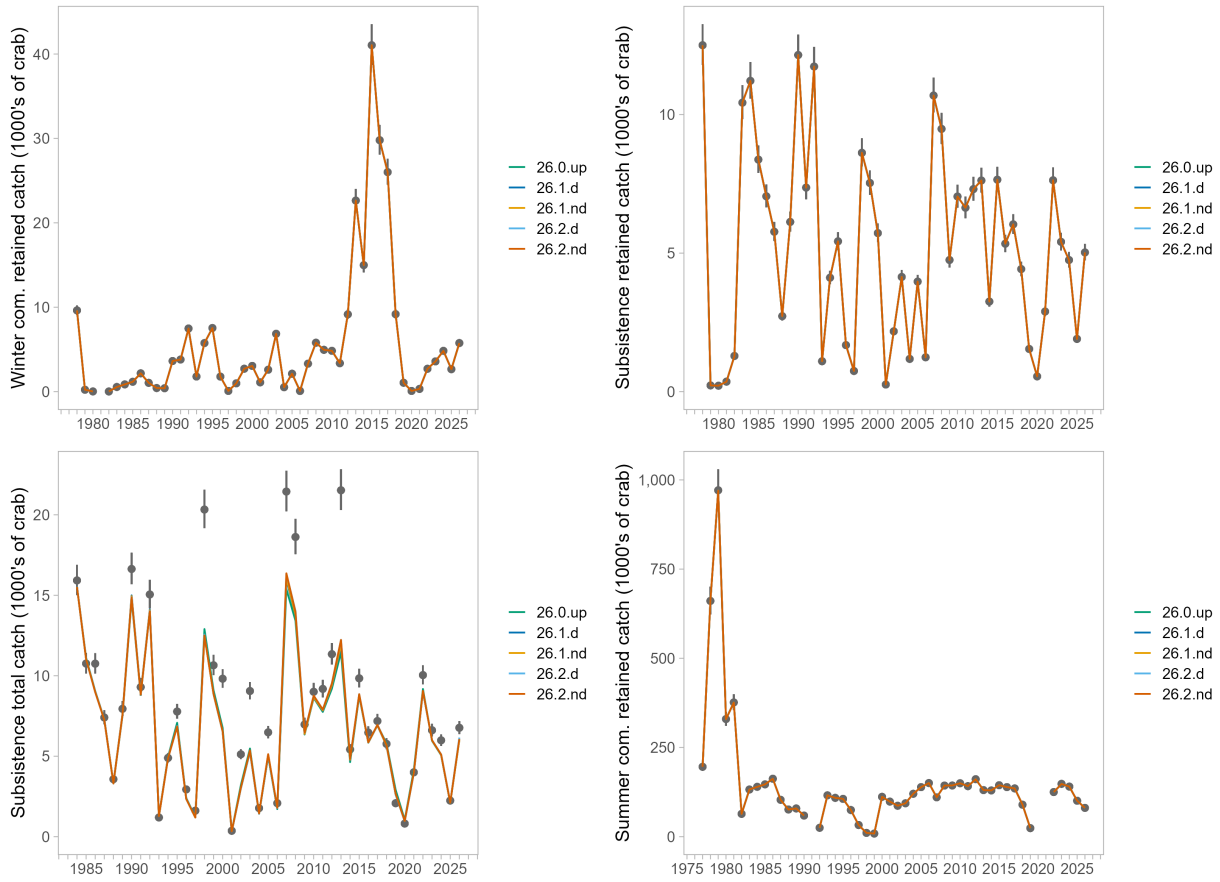


Figure 15: Observed and model-estimated catch of male red king crab caught in the winter commercial, summer commercial, and subsistence fisheries for the updated base model (26.0.up) and the models including the model-based index of abundance. Note that subsistence total catch was not fitted in these models (emphasis set to 0).

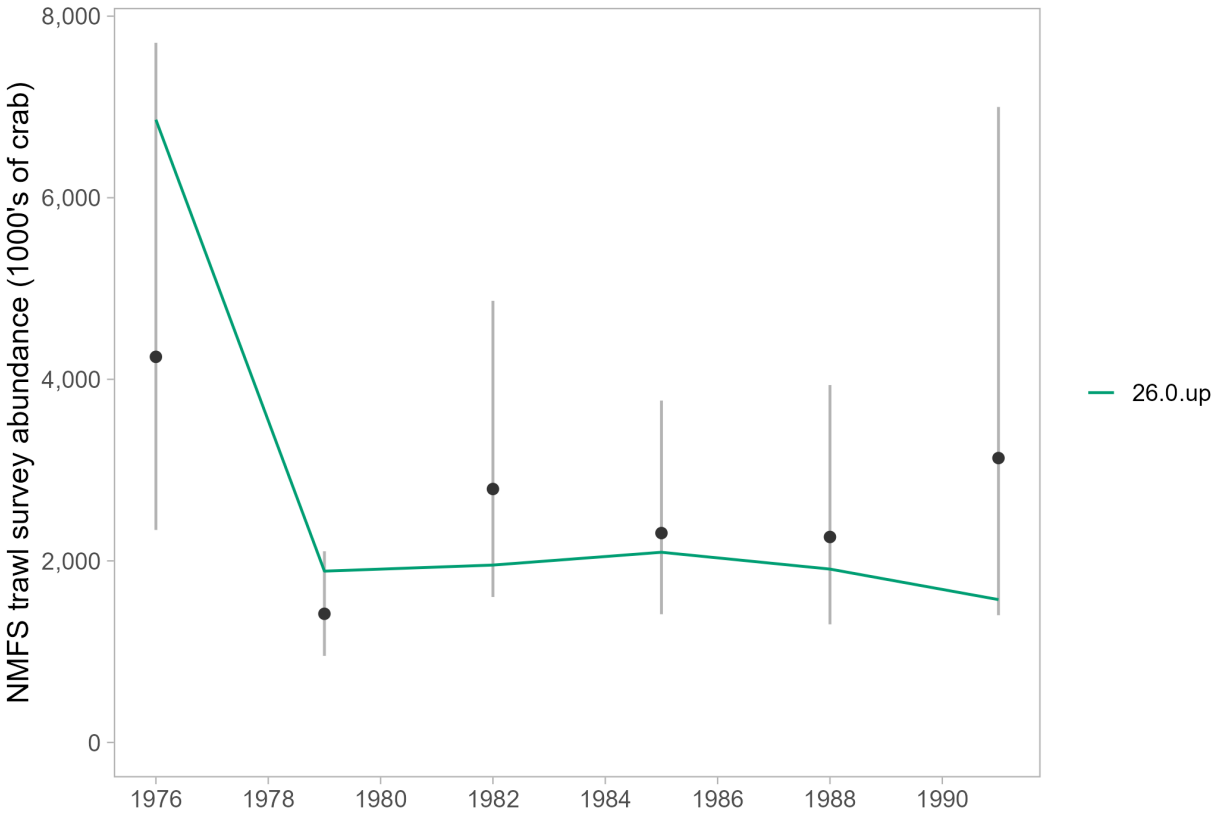


Figure 16: Model fits to the design-based index of abundance from the historical National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for the updated base model. Note that this design-based index of abundance for the historical survey was used in all models in this document, while the design-based indices of abundance for the ADFG and NBS trawl surveys were only included in the base model.

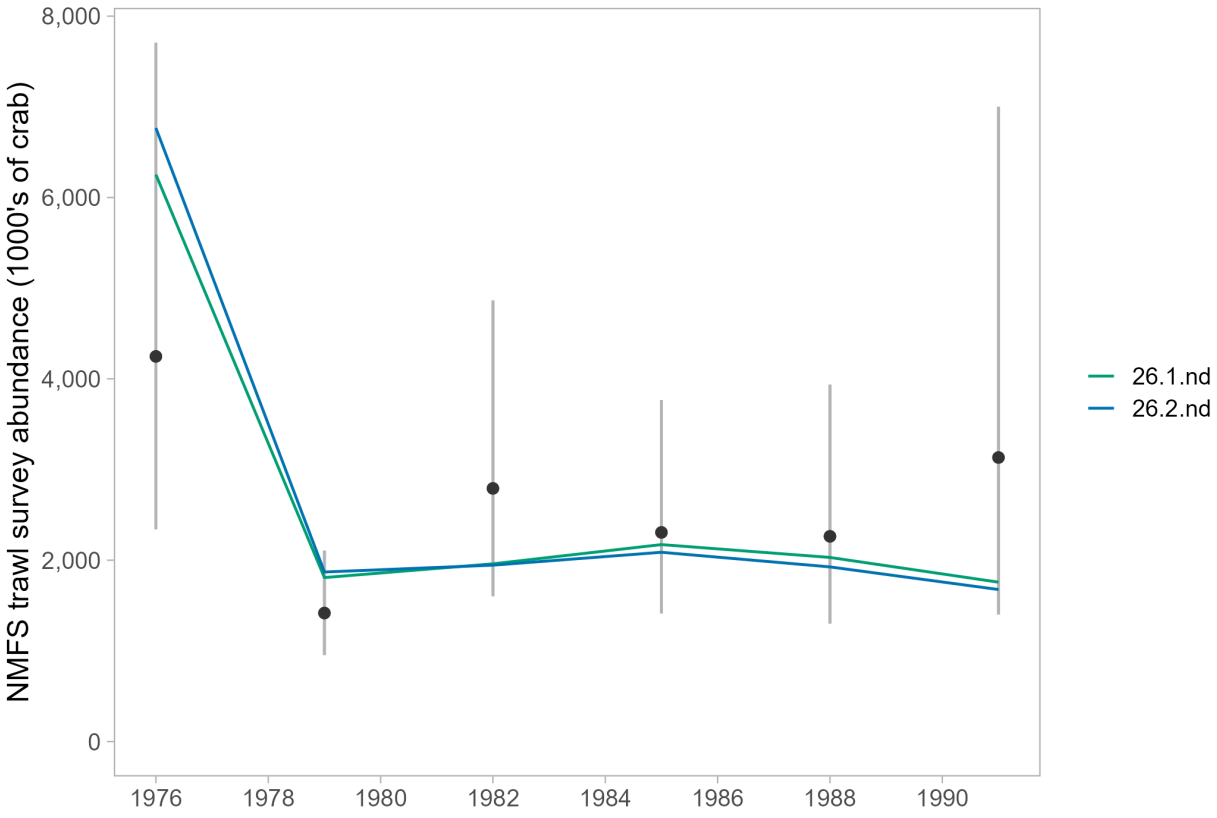


Figure 17: Model fits to the design-based index of abundance from the historical National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for the models that included a model-based index of abundance that did not account for depth in place of the design-based indices for the ADFG and NBS trawl surveys. These models still included the design-based index of abundance from the historical survey shown here, as the data from the historical survey was not included in the model-based index.

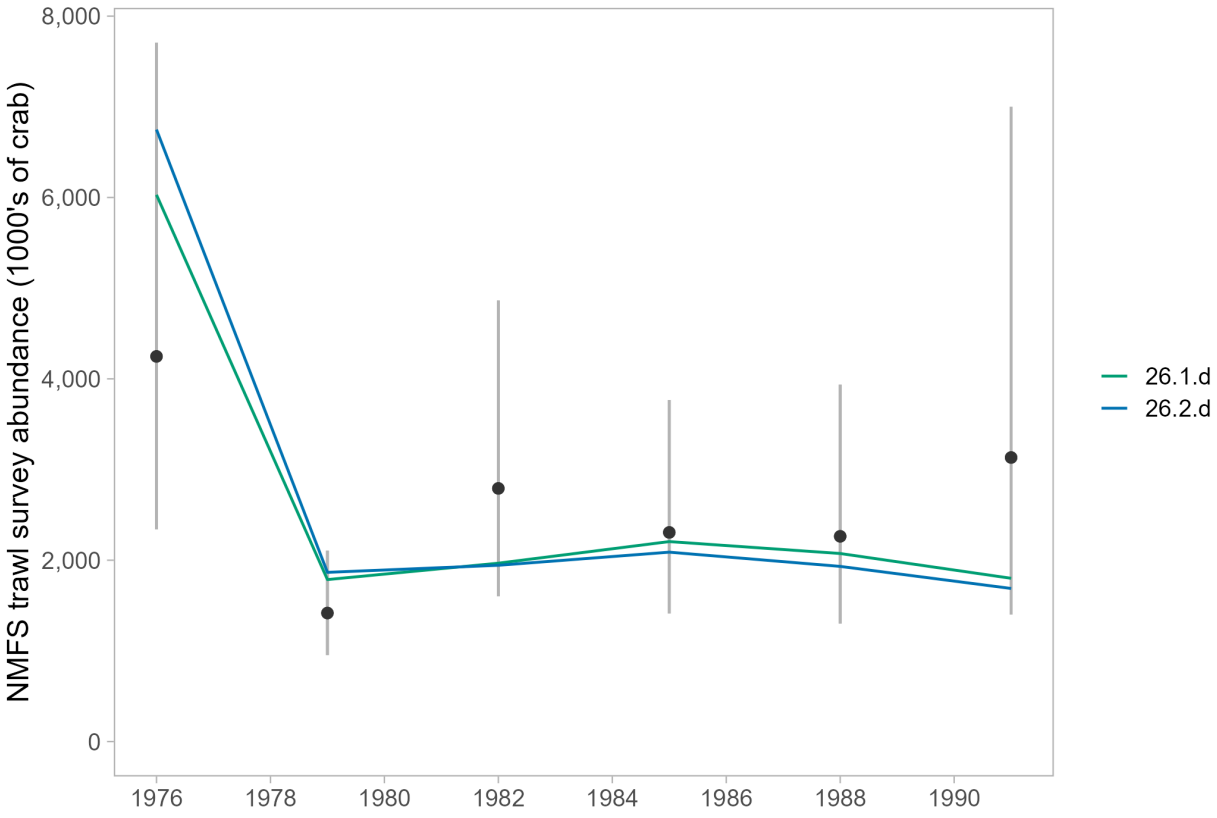


Figure 18: Model fits to the design-based index of abundance from the historical National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for the models that included a model-based index of abundance that accounted for depth in place of the design-based indices for the ADFG and NBS trawl surveys. These models still included the design-based index of abundance from the historical survey shown here, as the data from the historical survey was not included in the model-based index.

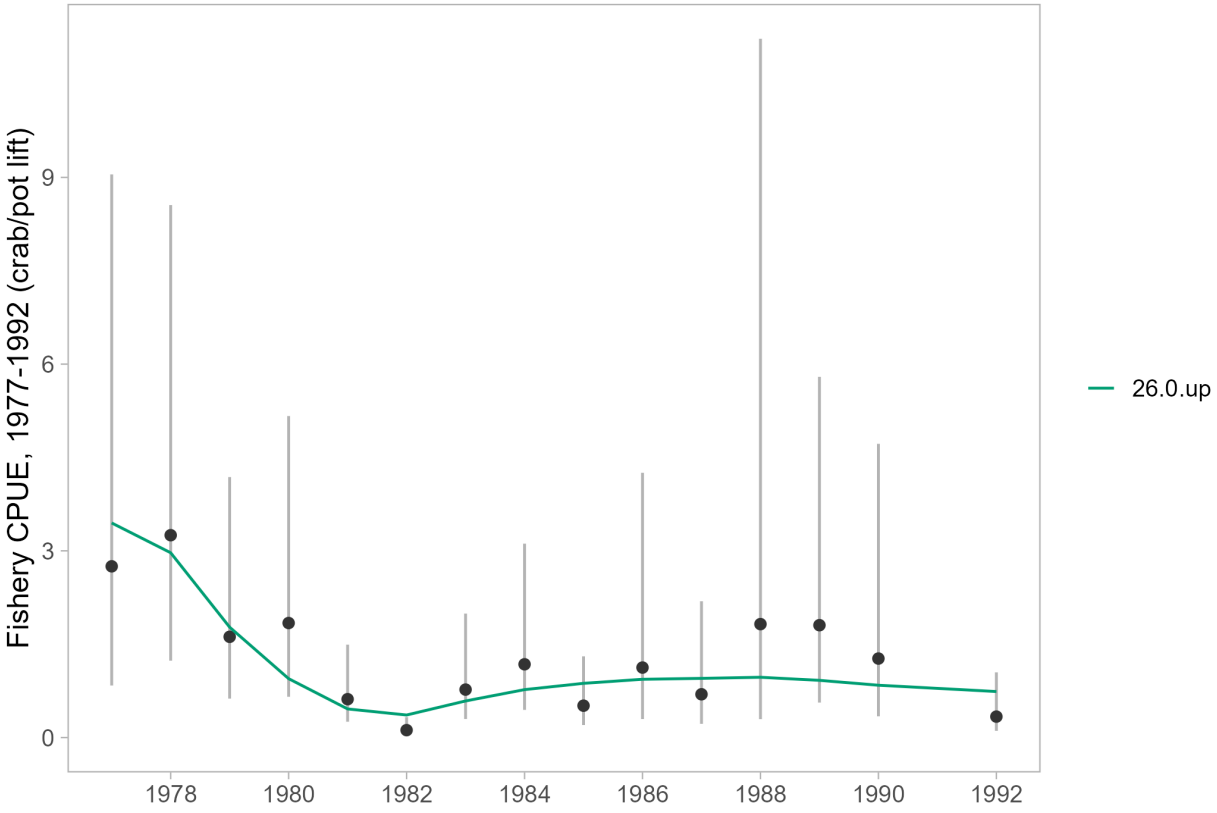


Figure 19: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1977-1992) for the updated base model.

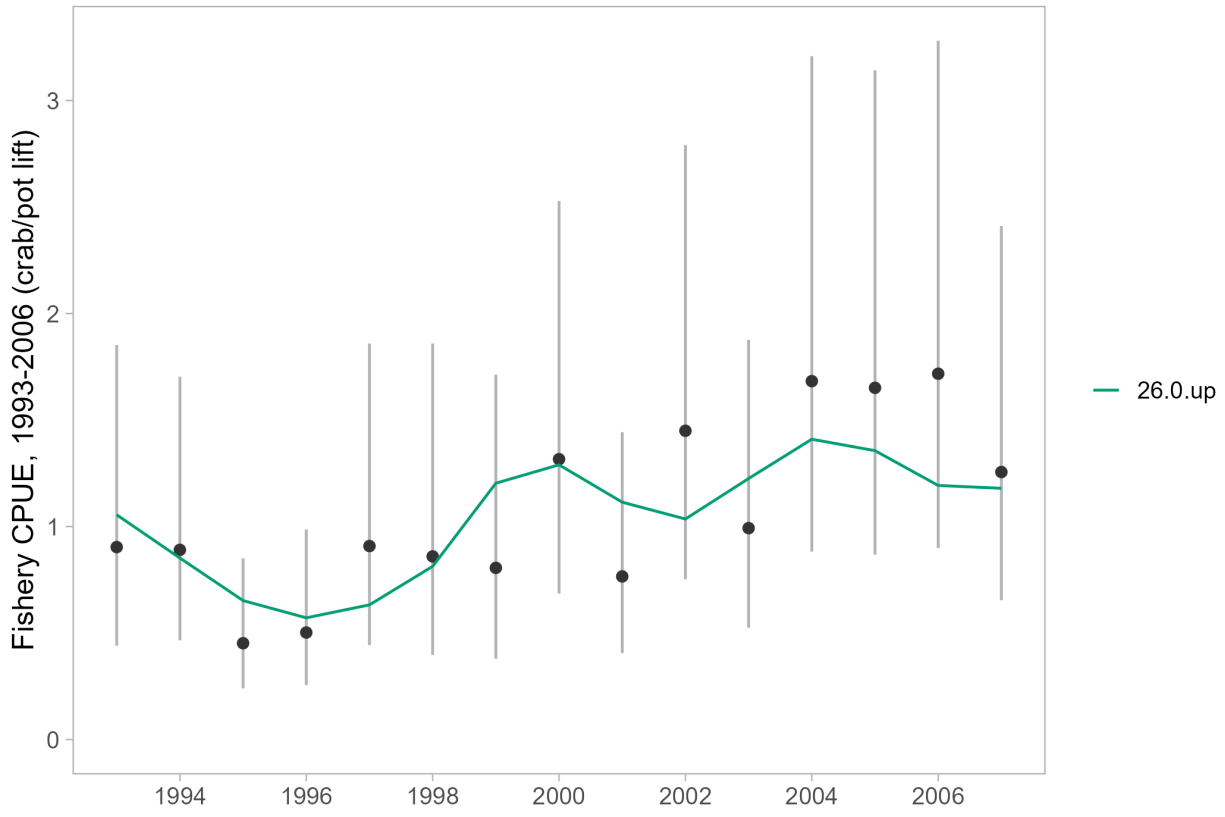


Figure 20: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1993-2006) for the updated base model.

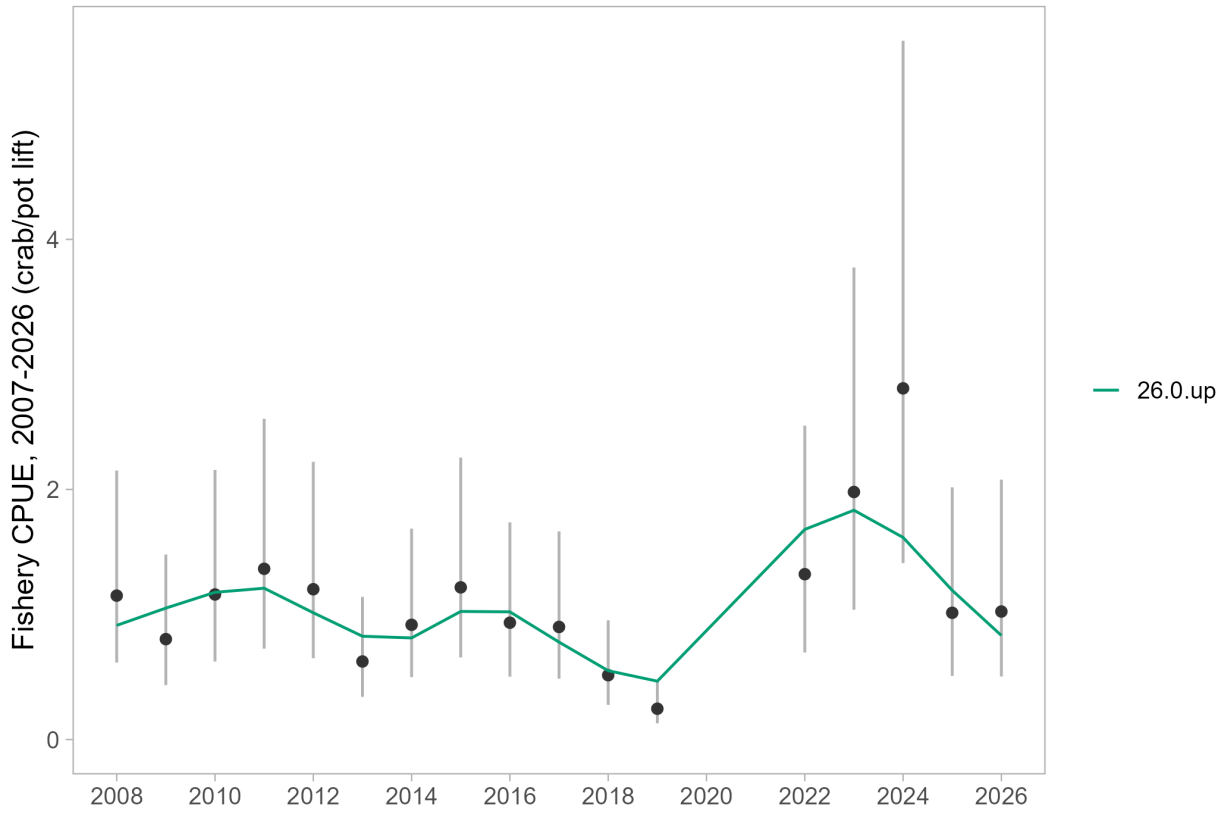


Figure 21: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (2007-2026) for the updated base model.

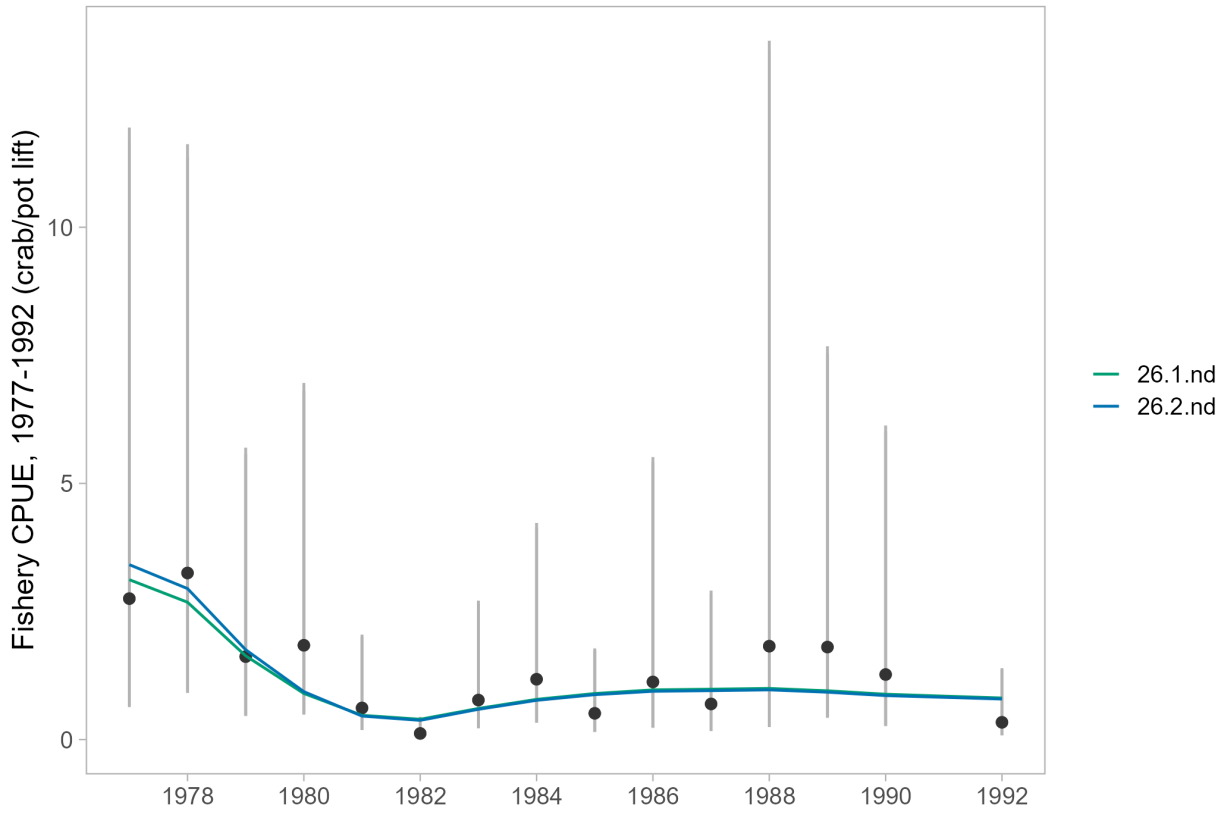


Figure 22: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1977-1992) for the models including the model-based index of abundance that did not account for depth.

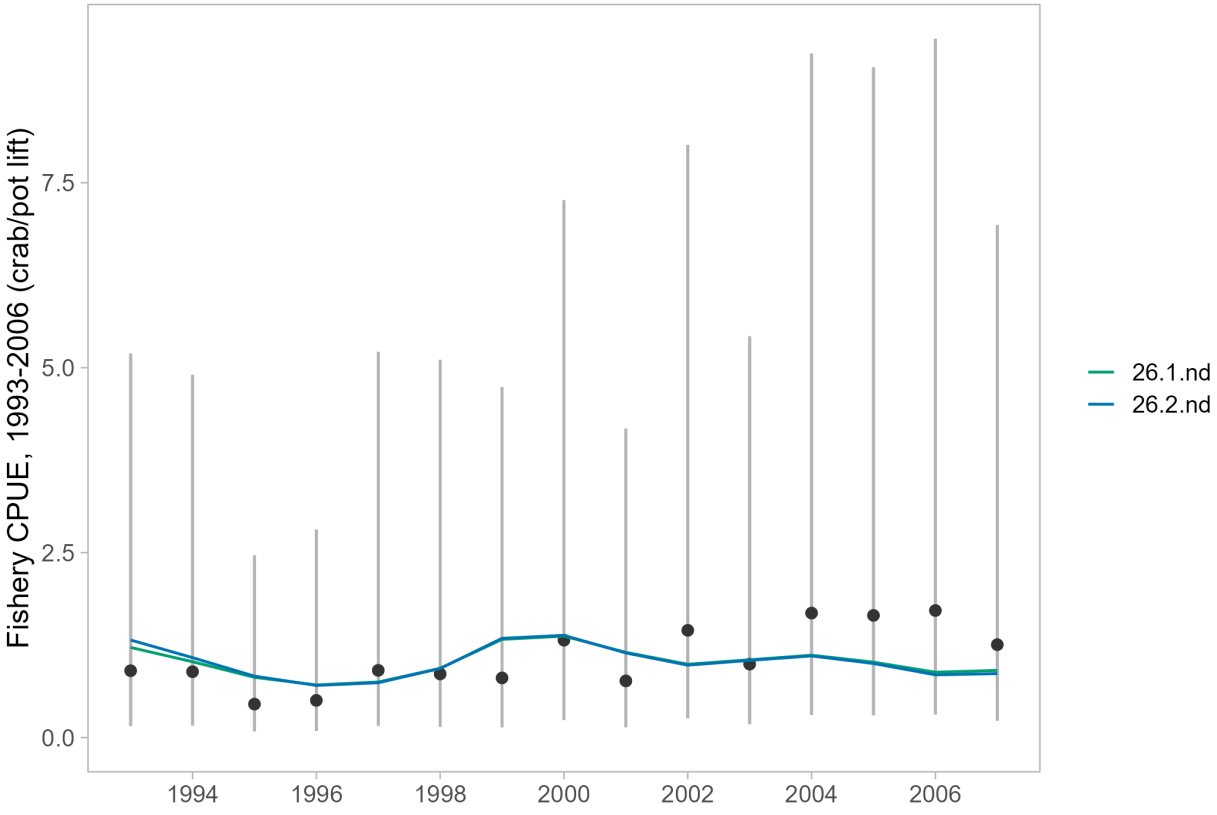


Figure 23: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1993-2006) for the models including the model-based index of abundance that did not account for depth.

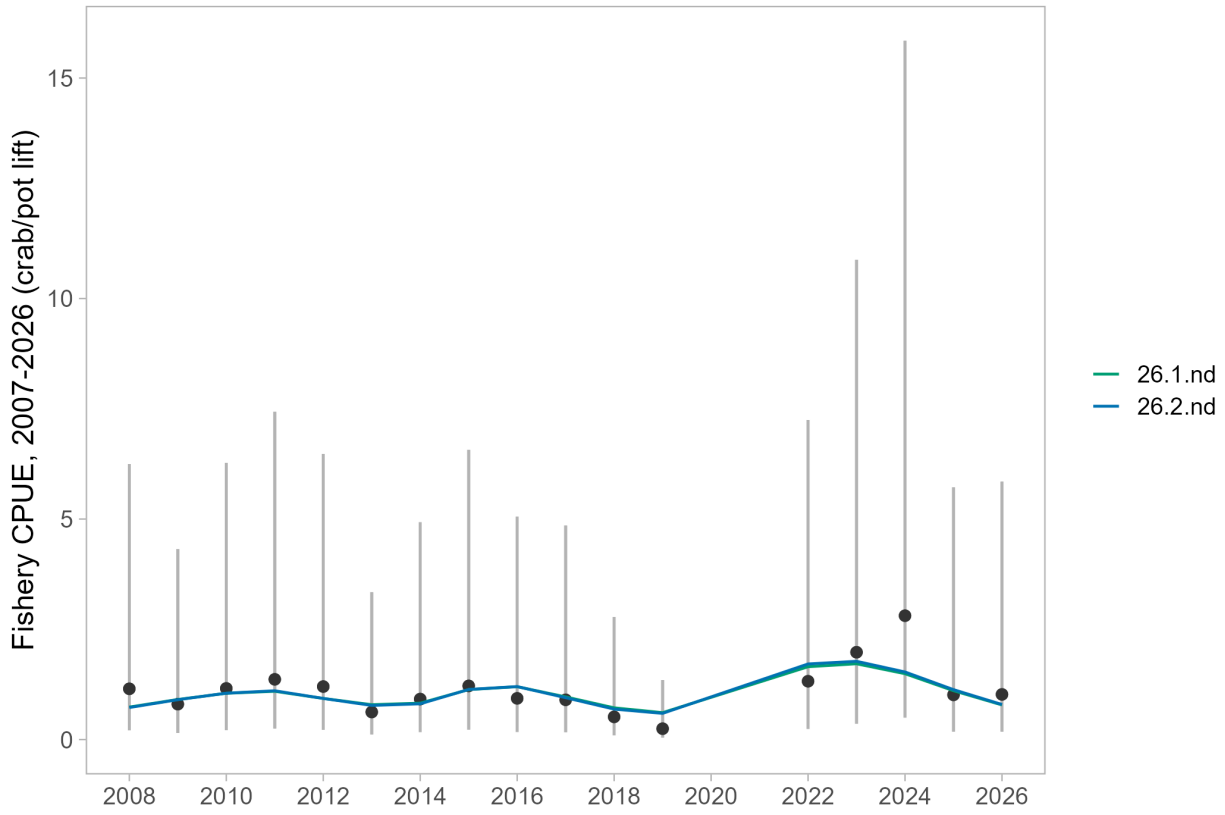


Figure 24: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (2007-2026) for the models including the model-based index of abundance that did not account for depth.

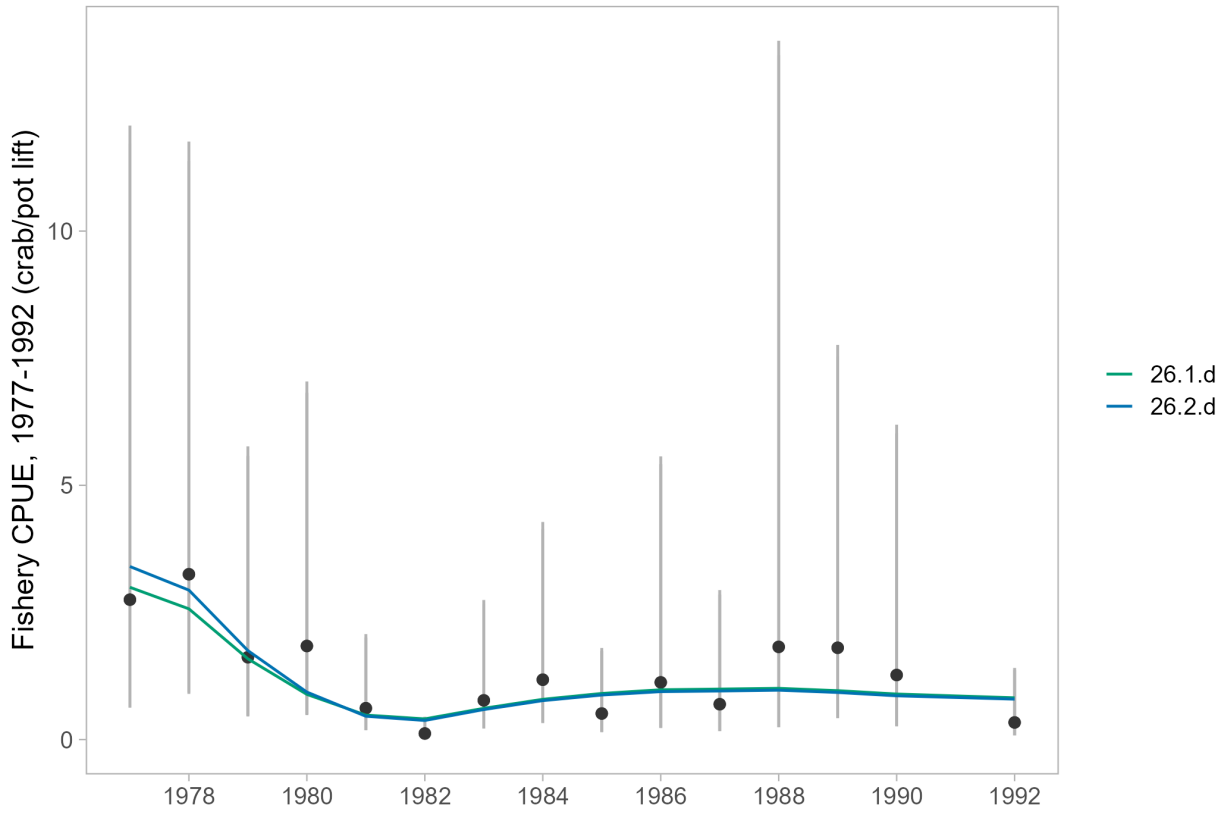


Figure 25: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1977-1992) for the models including the model-based index of abundance that accounted for depth.

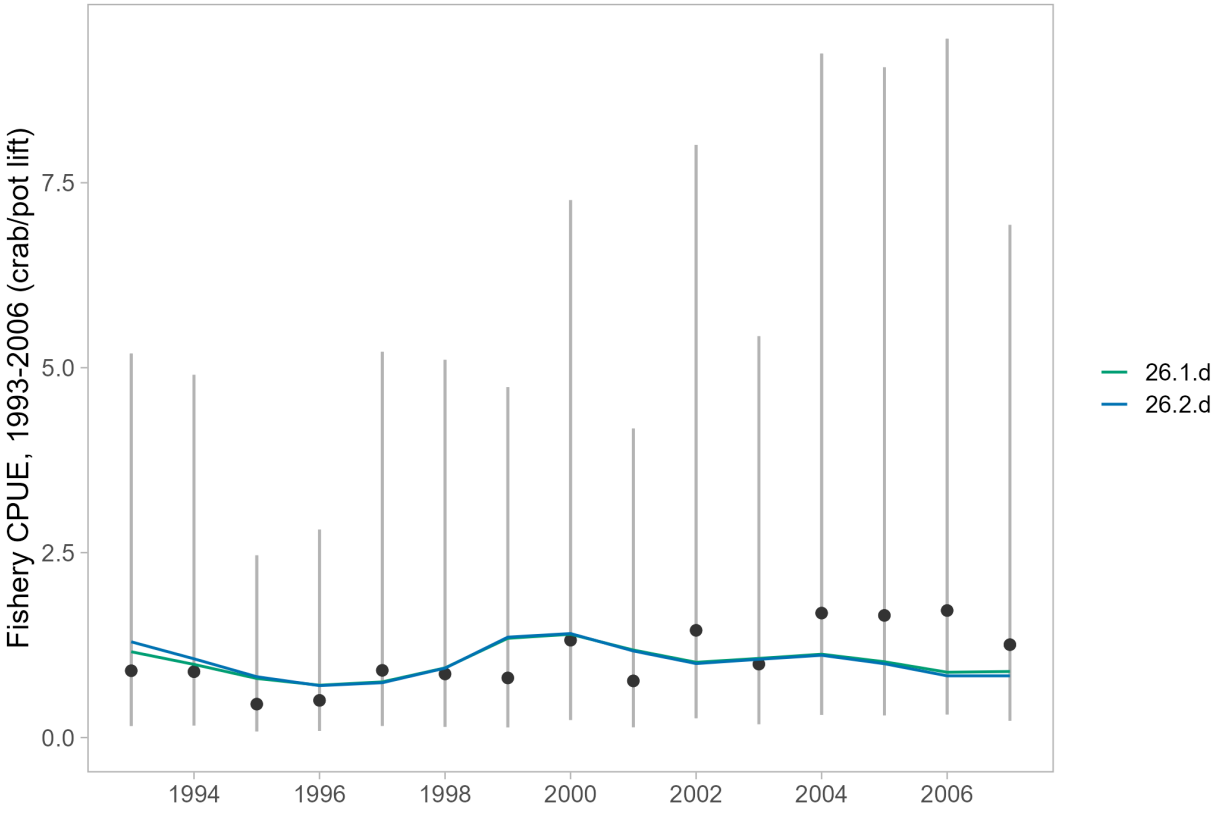


Figure 26: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1993-2006) for the models including the model-based index of abundance that accounted for depth.

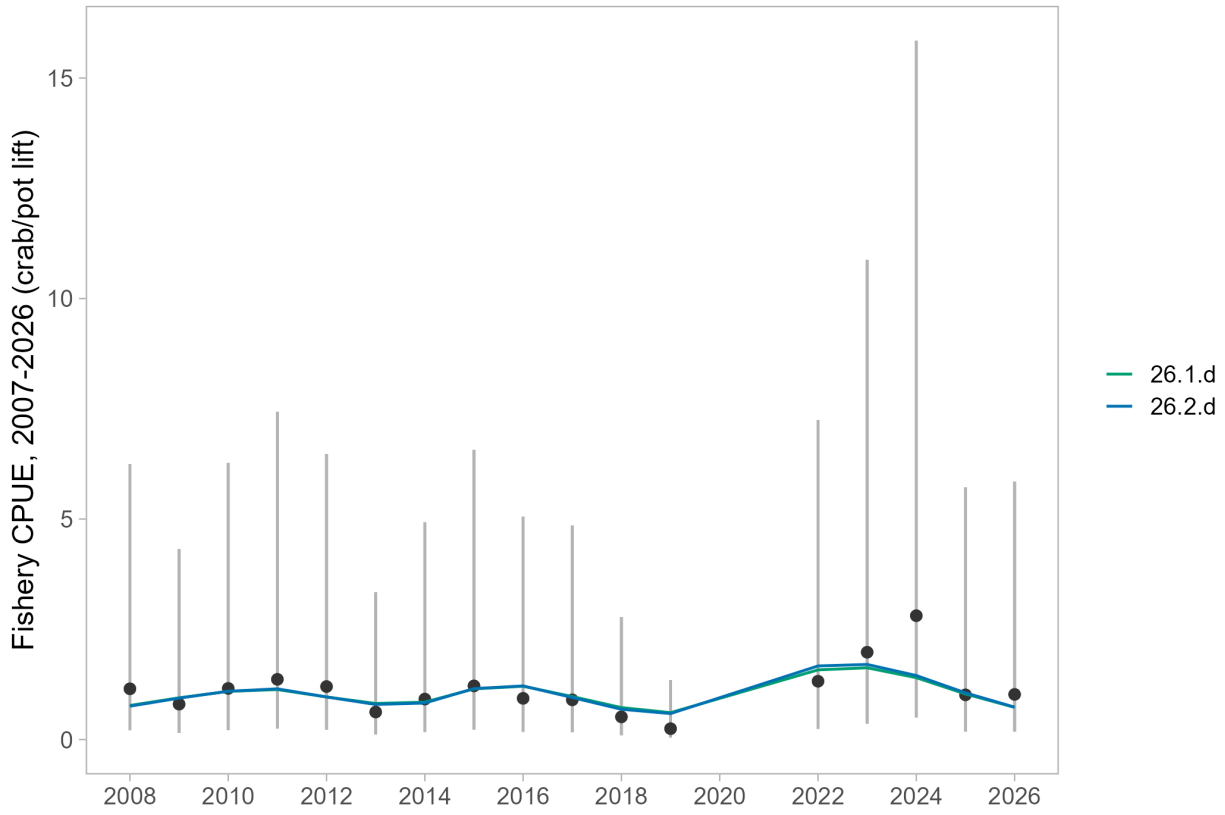


Figure 27: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (2007-2026) for the models including the model-based index of abundance that accounted for depth.

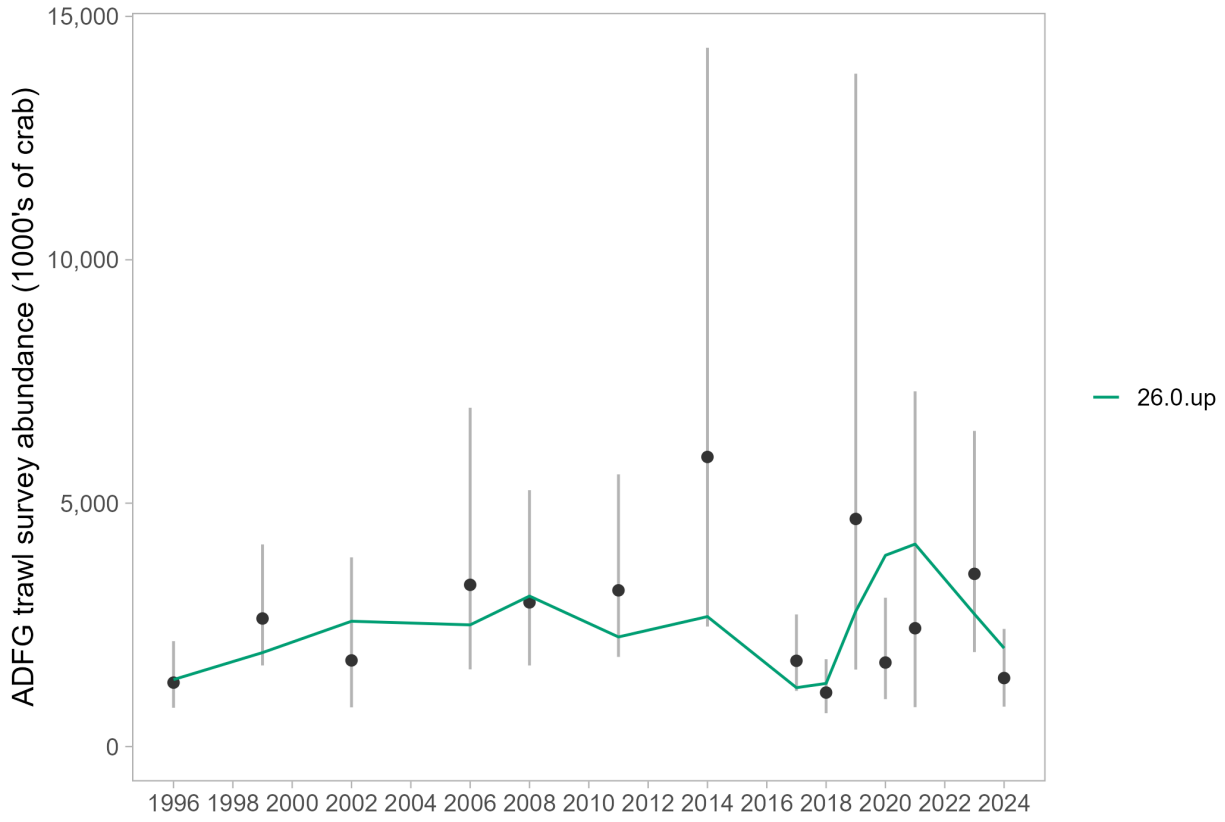


Figure 28: Model fits to the design-based index of abundance from the Alaska Department of Fish and Game (ADFG) trawl survey for the base model.

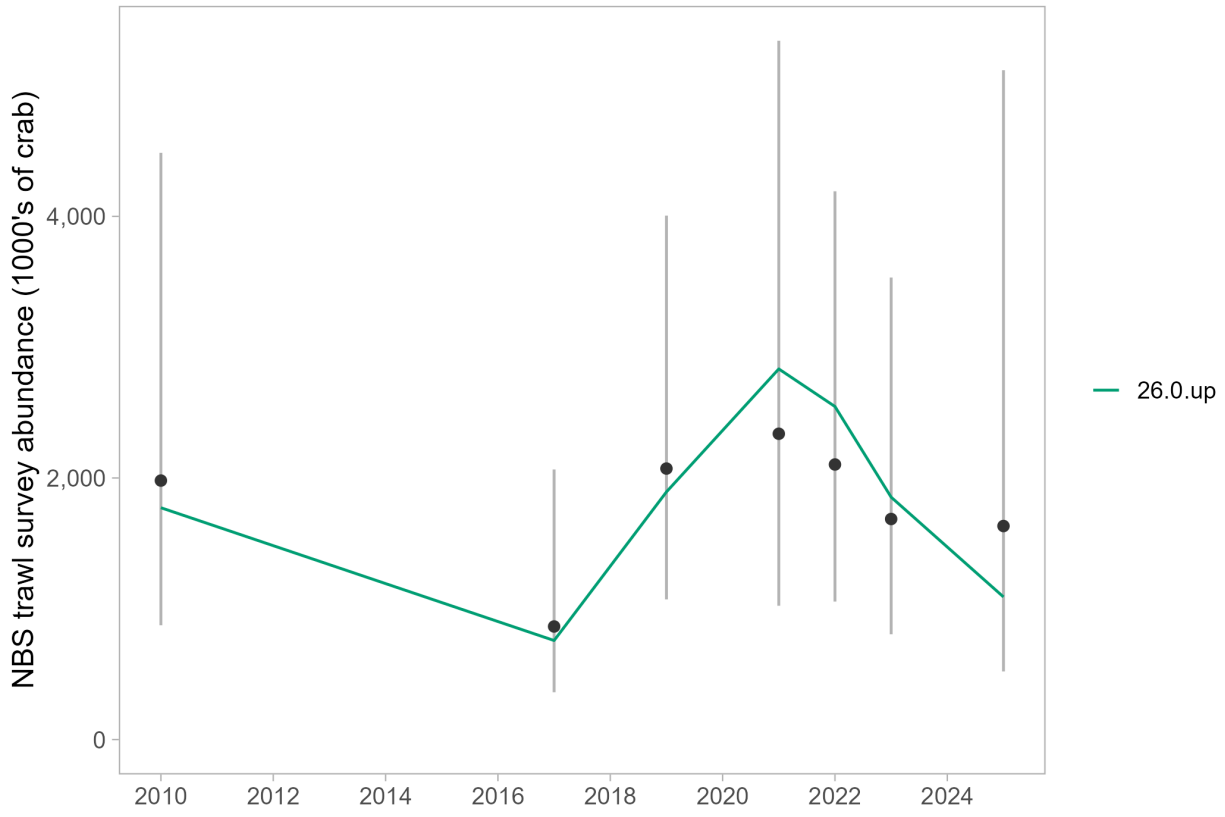


Figure 29: Model fits to the design-based index of abundance from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for the base model.

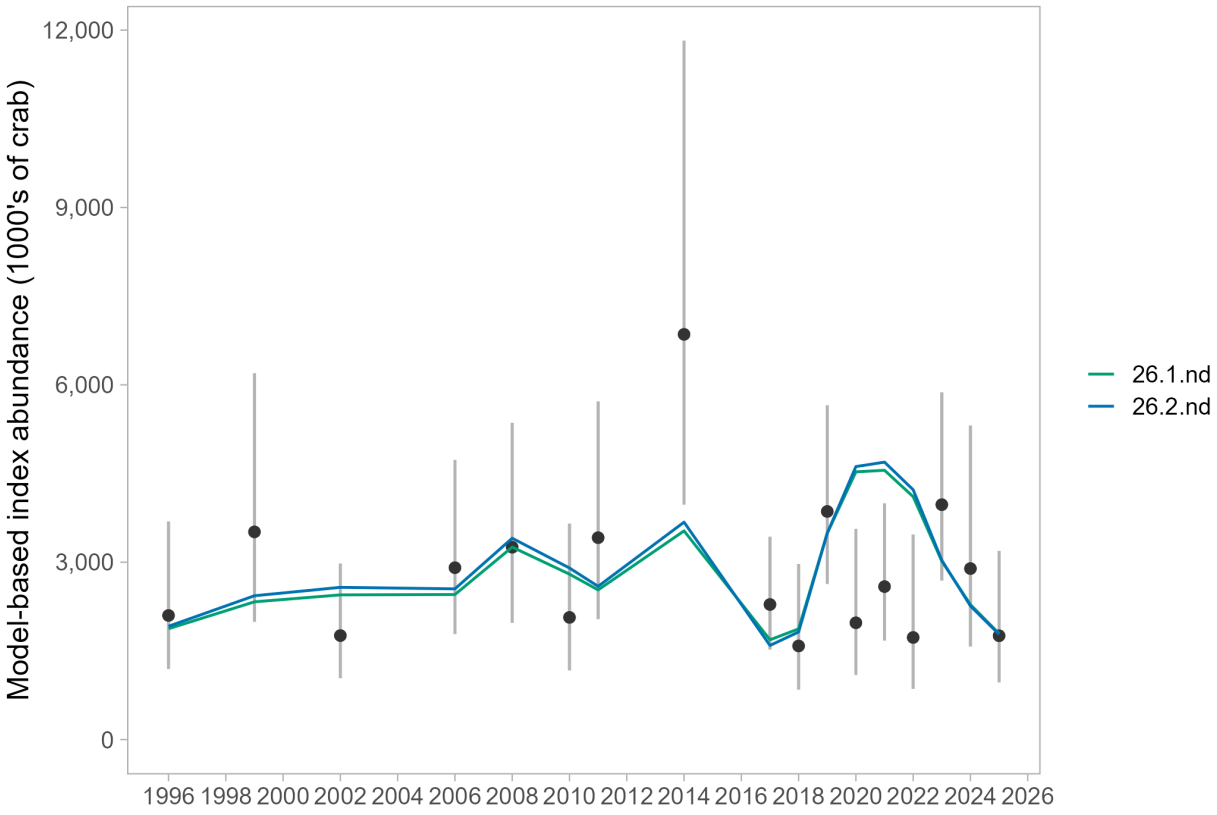


Figure 30: Model fits to the model-based index of abundance that did not account for depth for the models that included this index.

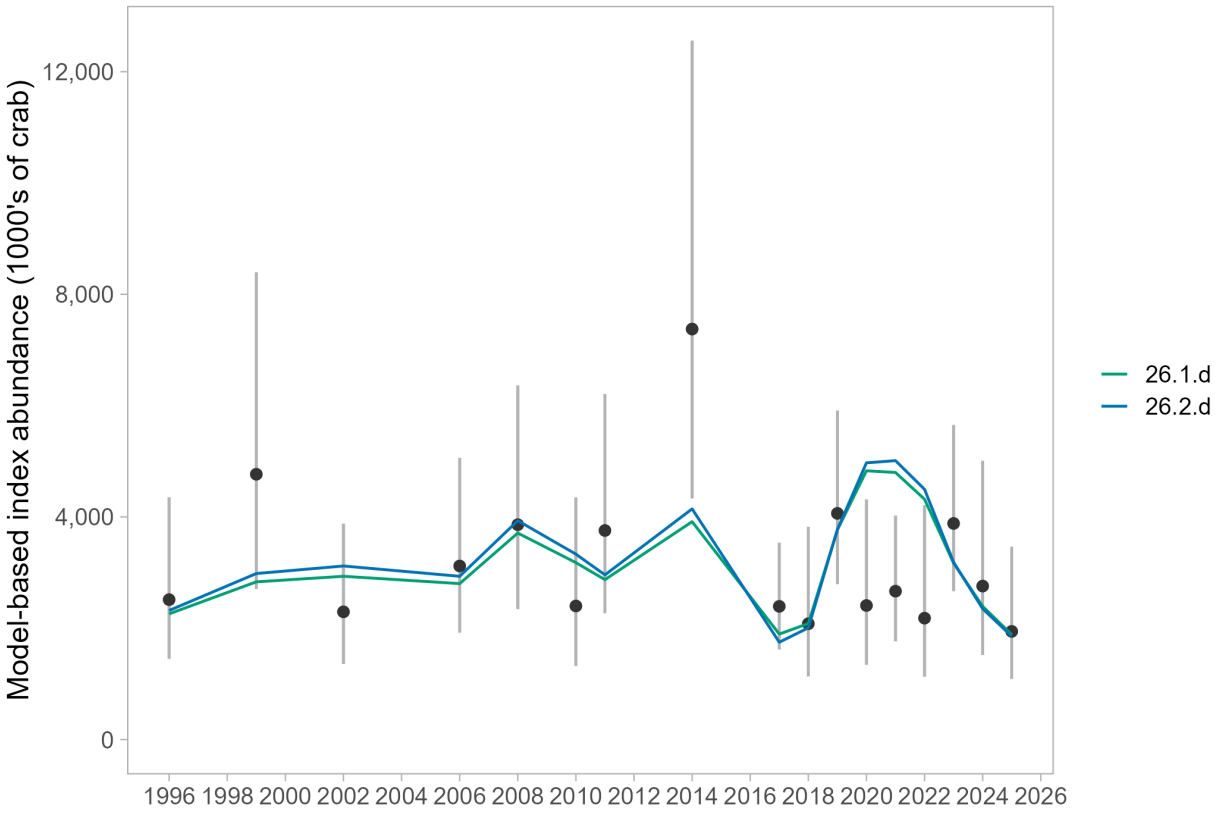


Figure 31: Model fits to the model-based index of abundance that accounted for depth for the models that included this index.

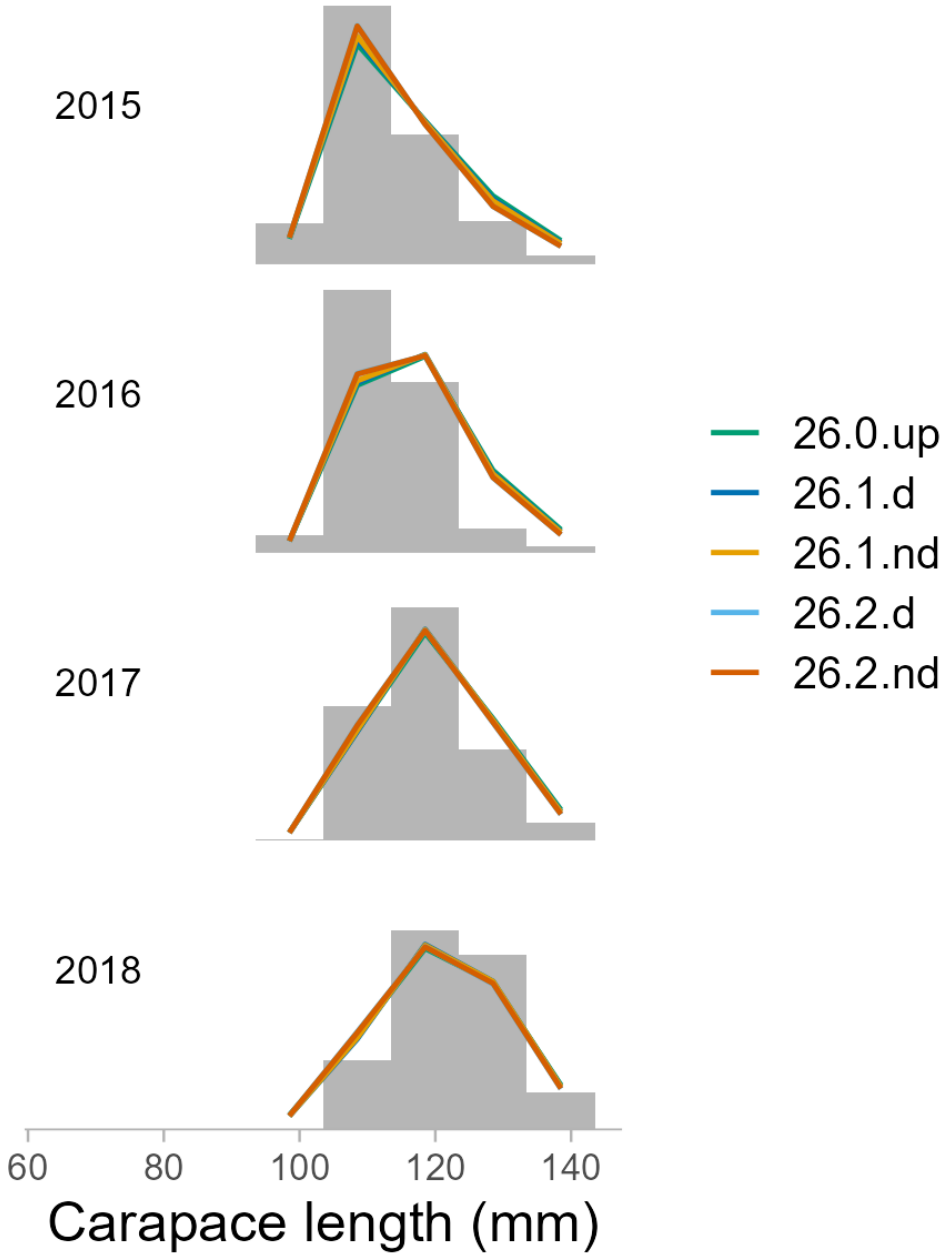


Figure 32: Annual observed and model-estimated size frequencies of male red king crab retained in the directed winter commercial fishery for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

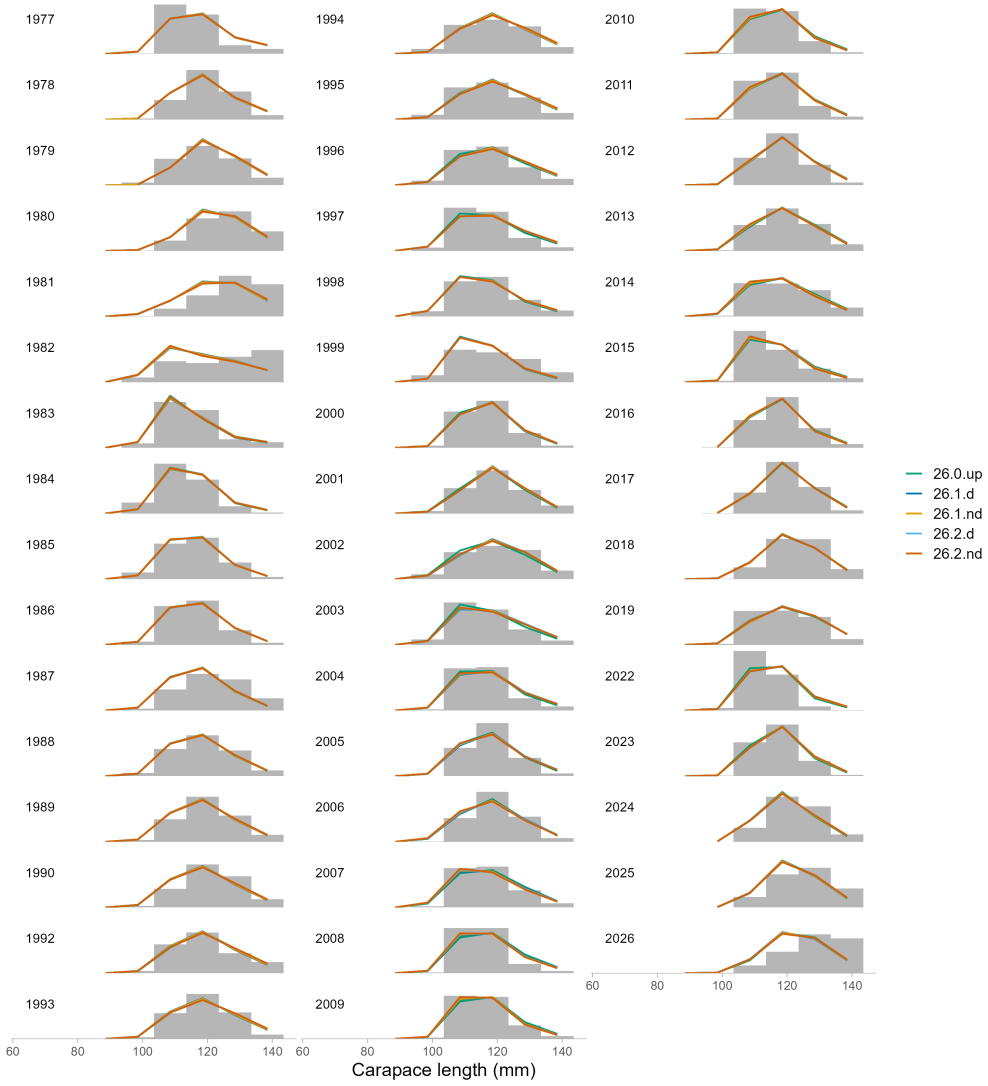


Figure 33: Annual observed and model-estimated size frequencies of male red king crab retained in the directed summer commercial fishery for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

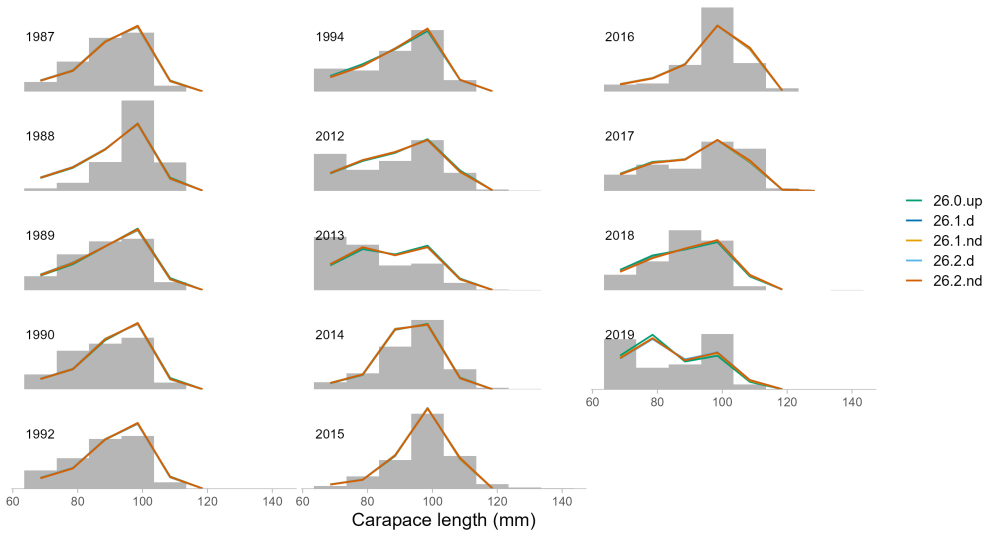


Figure 34: Annual observed and model-estimated size frequencies of male red king crab discarded in the directed summer commercial fishery for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

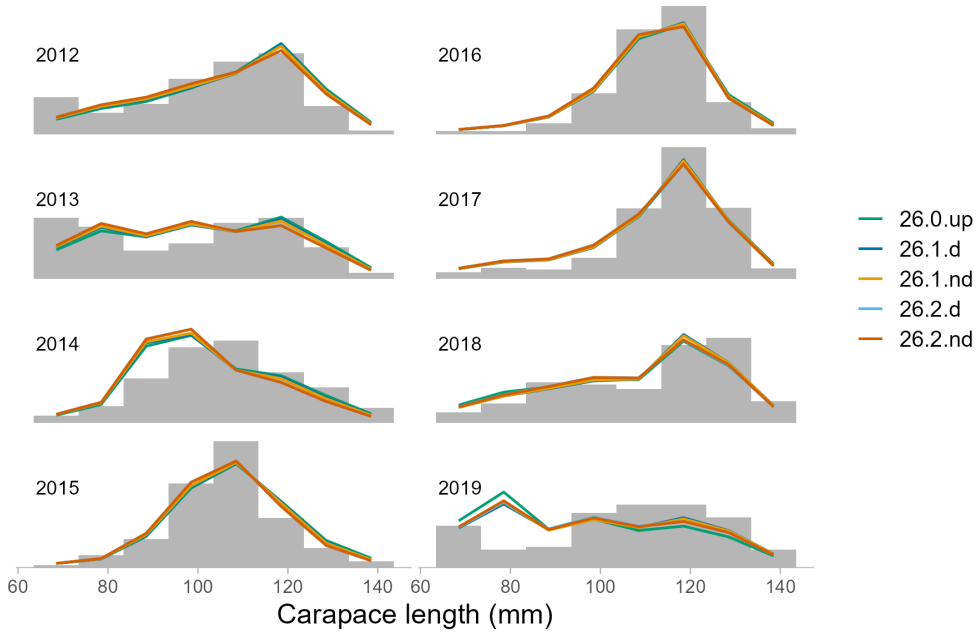


Figure 35: Annual observed and model-estimated size frequencies of all male red king crab caught in the directed summer commercial fishery for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

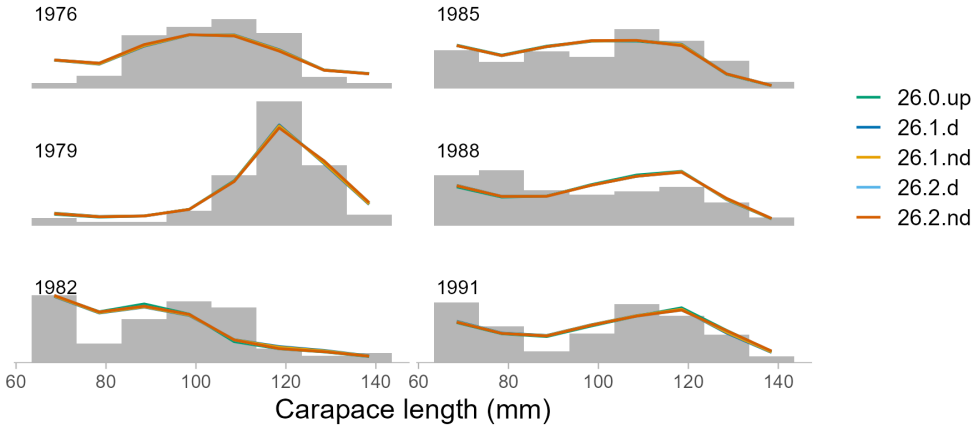


Figure 36: Annual observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

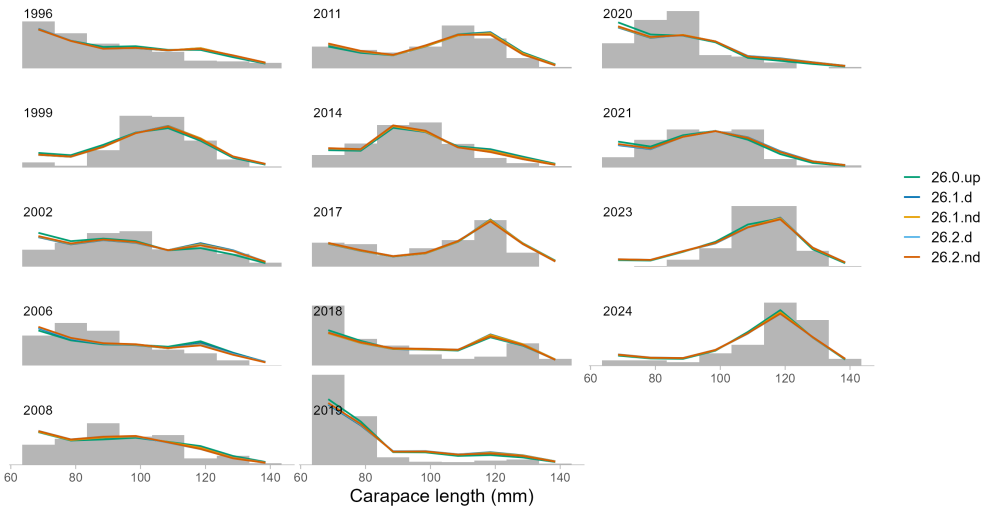


Figure 37: Annual observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) trawl survey for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

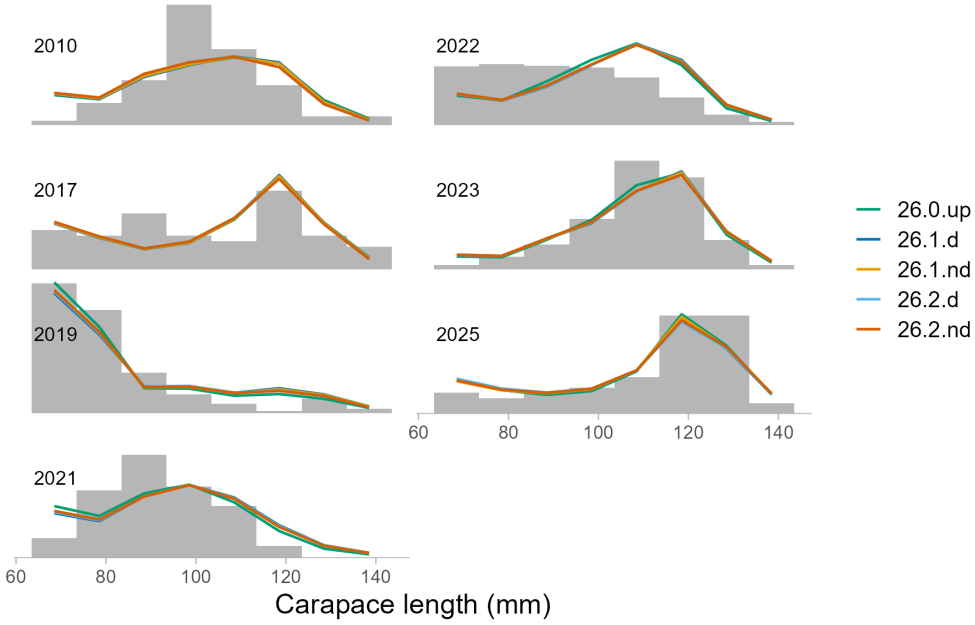


Figure 38: Annual observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

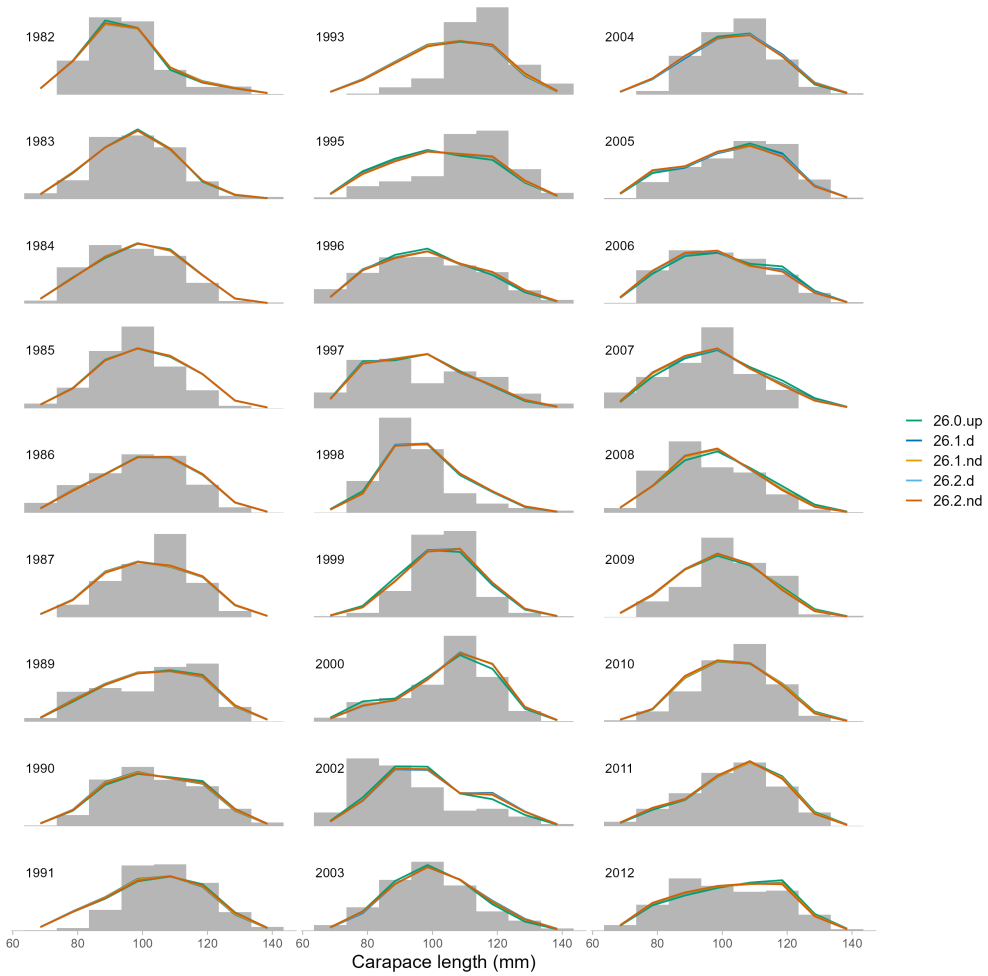


Figure 39: Annual observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) winter pot survey for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

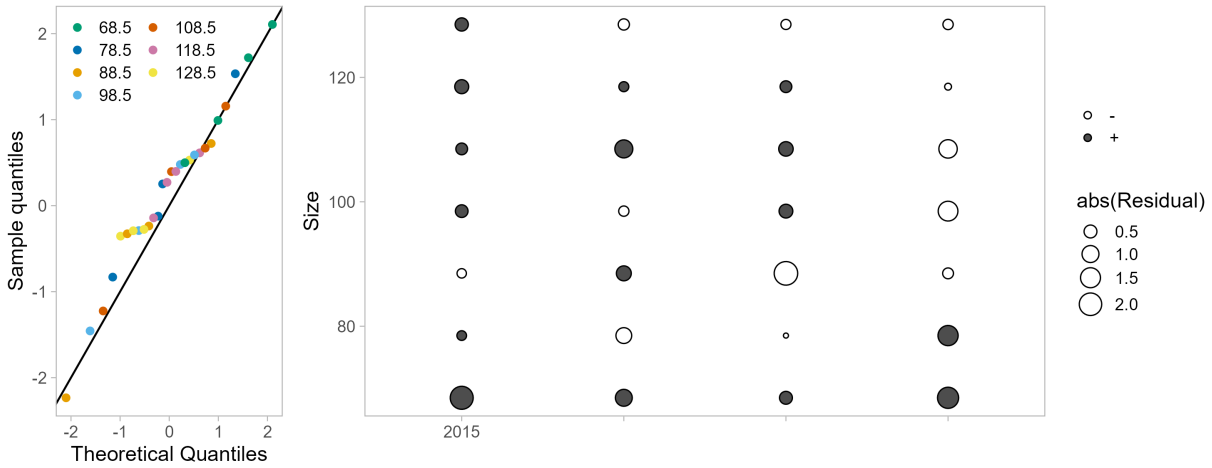


Figure 40: One-Step-Ahead residuals for model 26.0 fits to size composition data from the winter commercial fishery retained catch.

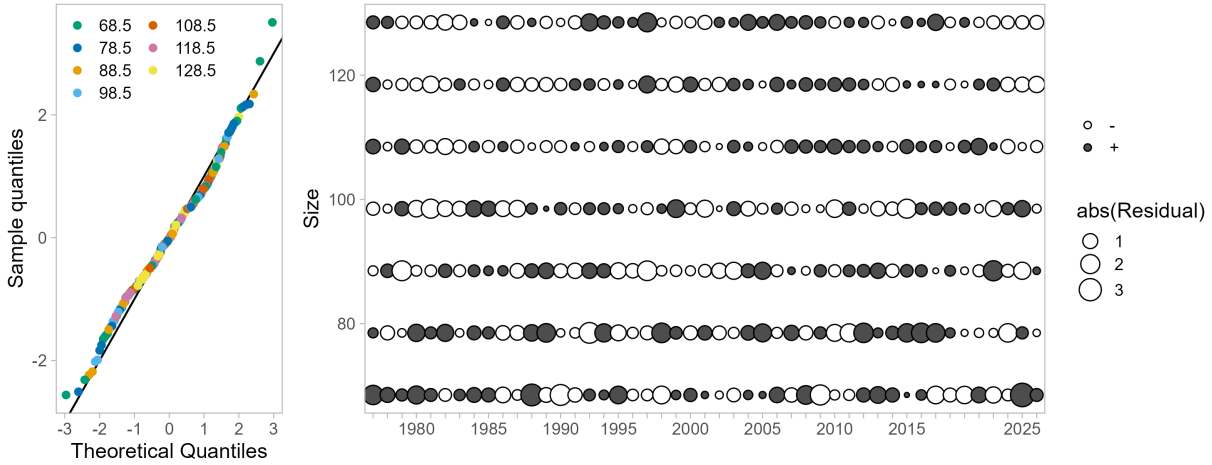


Figure 41: One-Step-Ahead residuals for model 26.0 fits to size composition data from the summer commercial fishery retained catch.

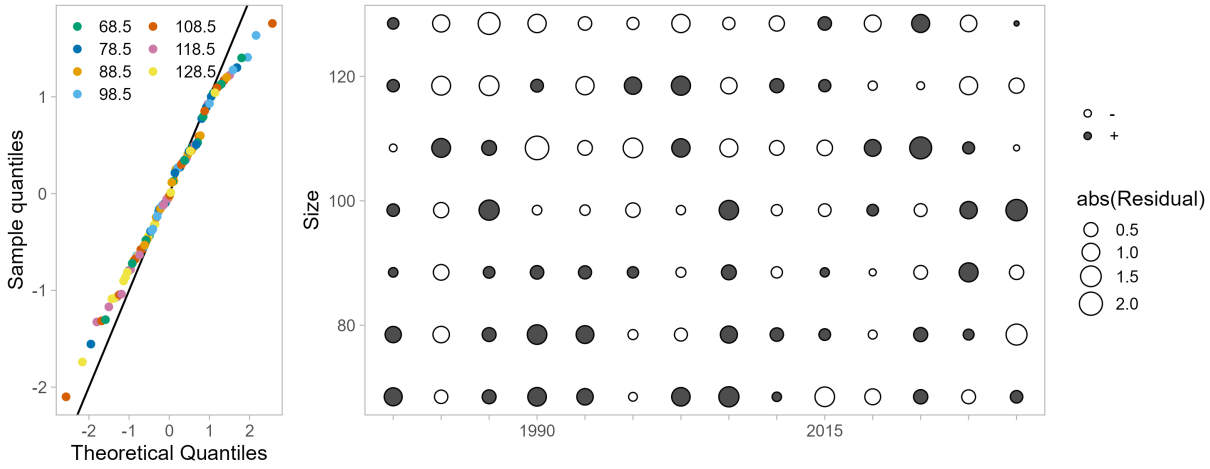


Figure 42: One-Step-Ahead residuals for model 26.0 fits to size composition data from the summer commercial fishery discarded catch.

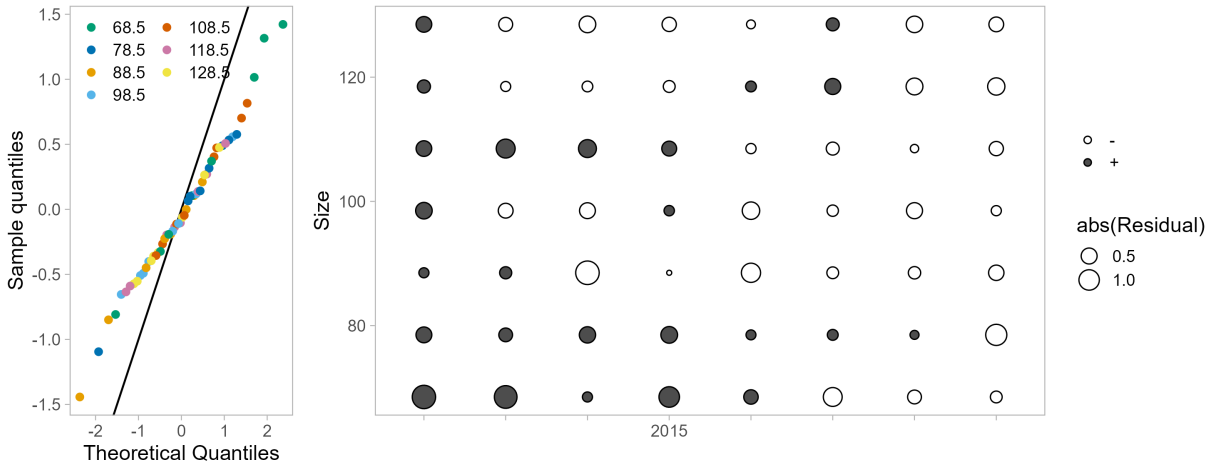


Figure 43: One-Step-Ahead residuals for model 26.0 fits to size composition data from the summer commercial fishery total catch.

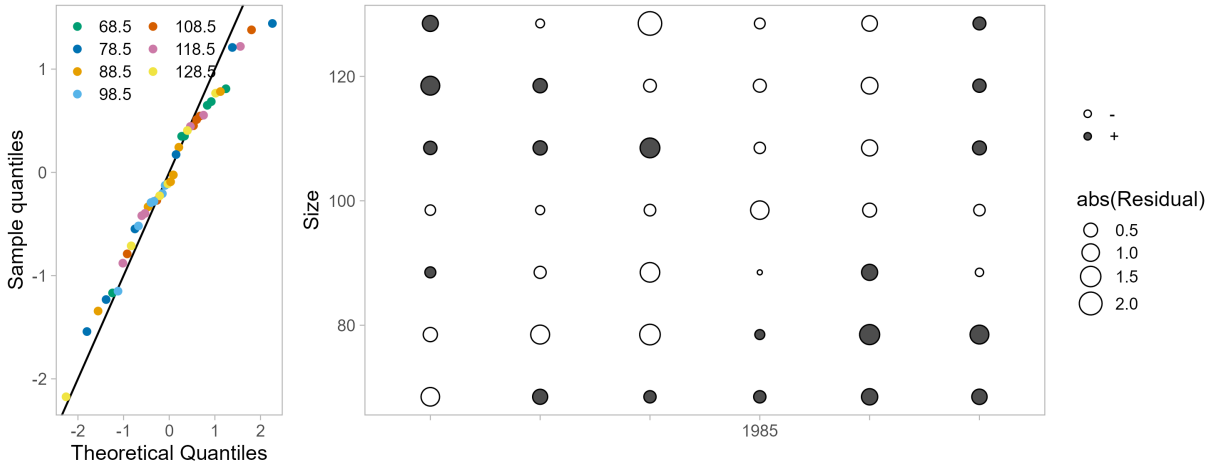


Figure 44: One-Step-Ahead residuals for model 26.0 fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

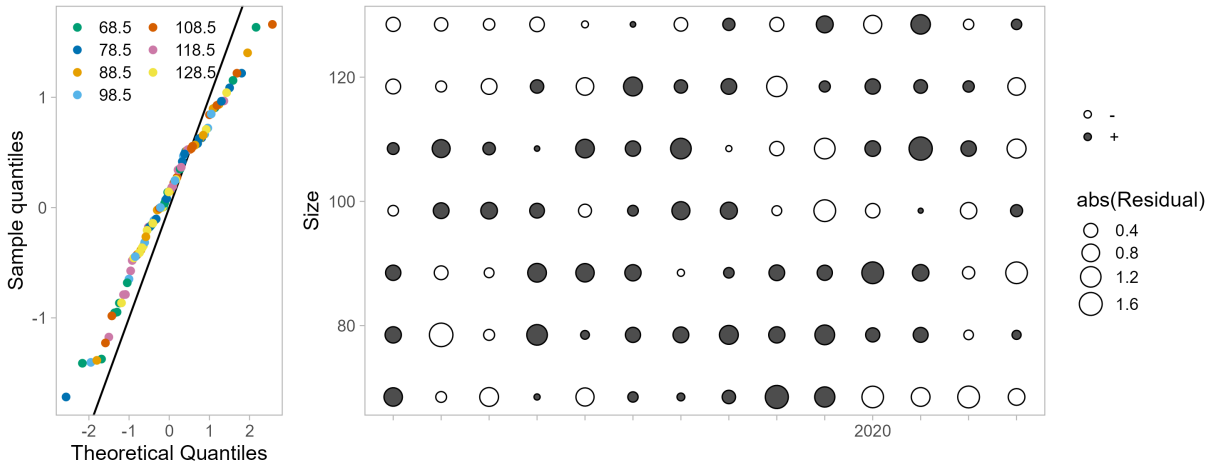


Figure 45: One-Step-Ahead residuals for model 26.0 fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

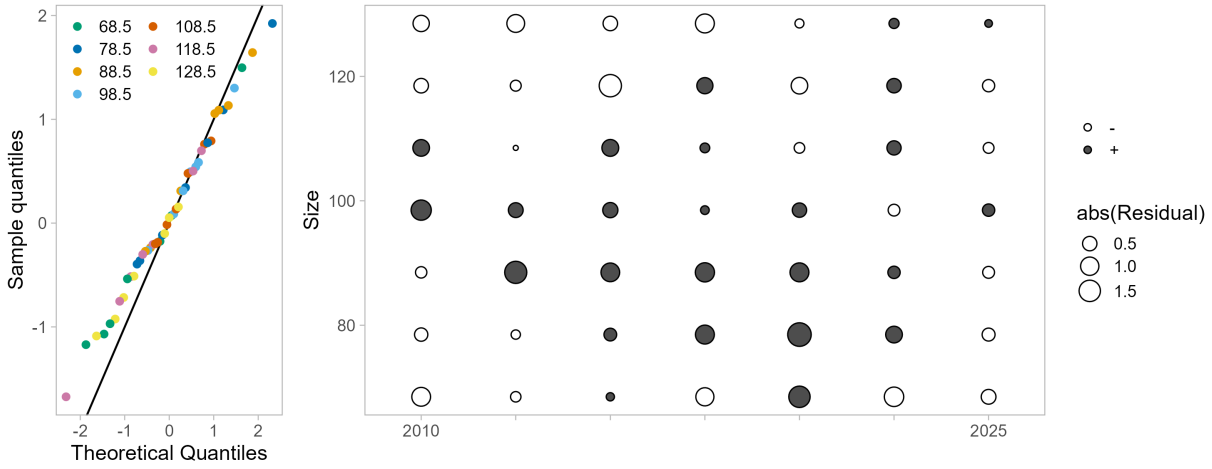


Figure 46: One-Step-Ahead residuals for model 26.0 fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

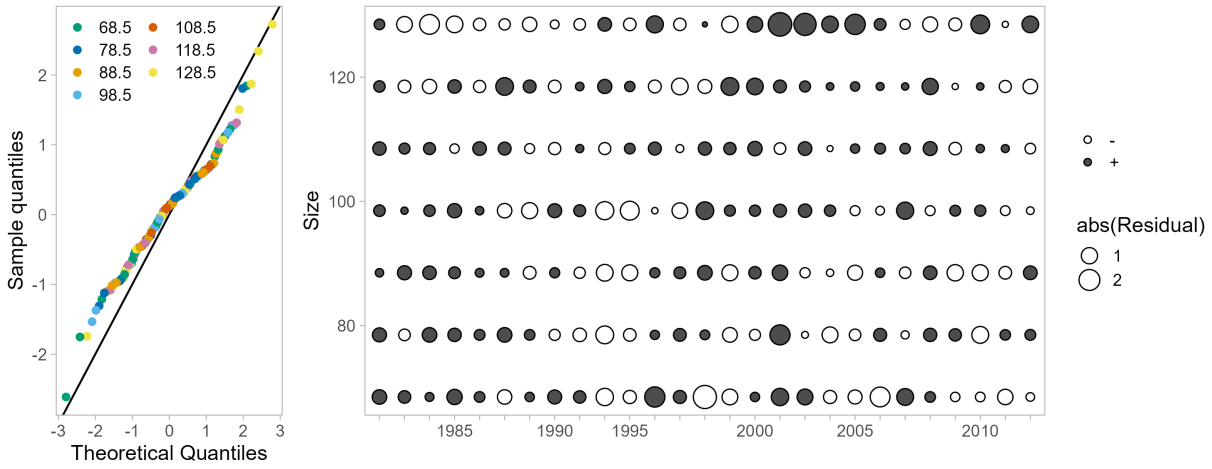


Figure 47: One-Step-Ahead residuals for model 26.0 fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

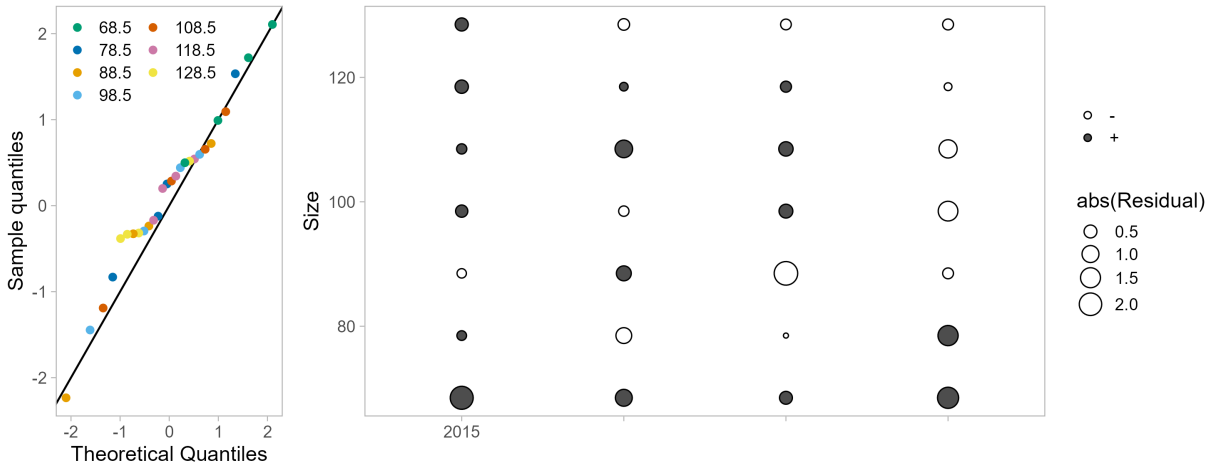


Figure 48: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the winter commercial fishery retained catch.

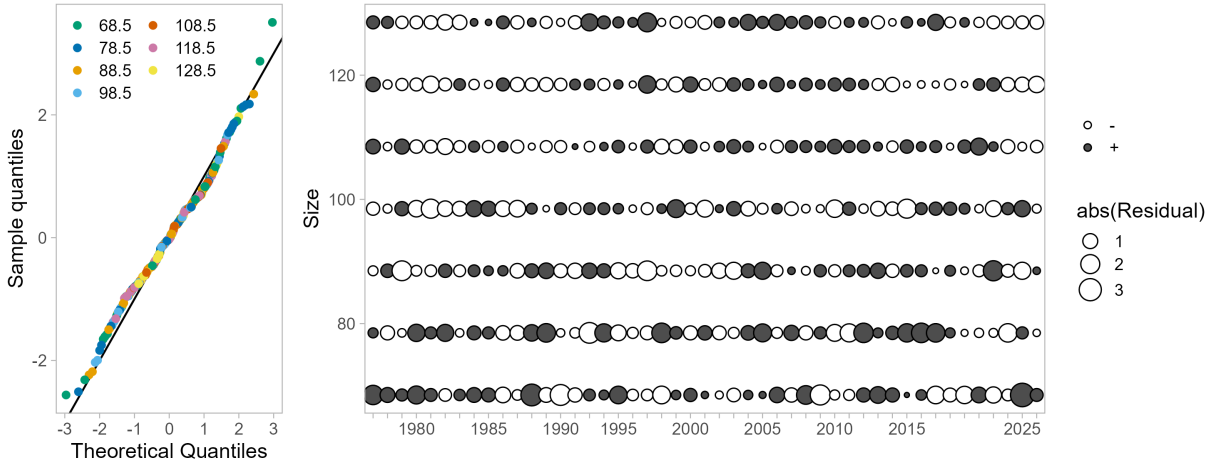


Figure 49: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the summer commercial fishery retained catch.

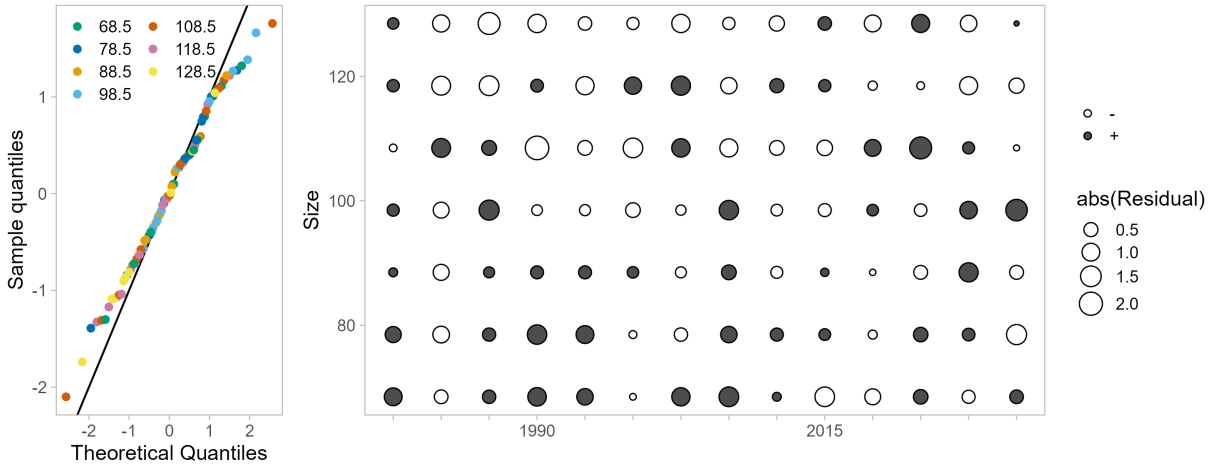


Figure 50: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the summer commercial fishery discarded catch.

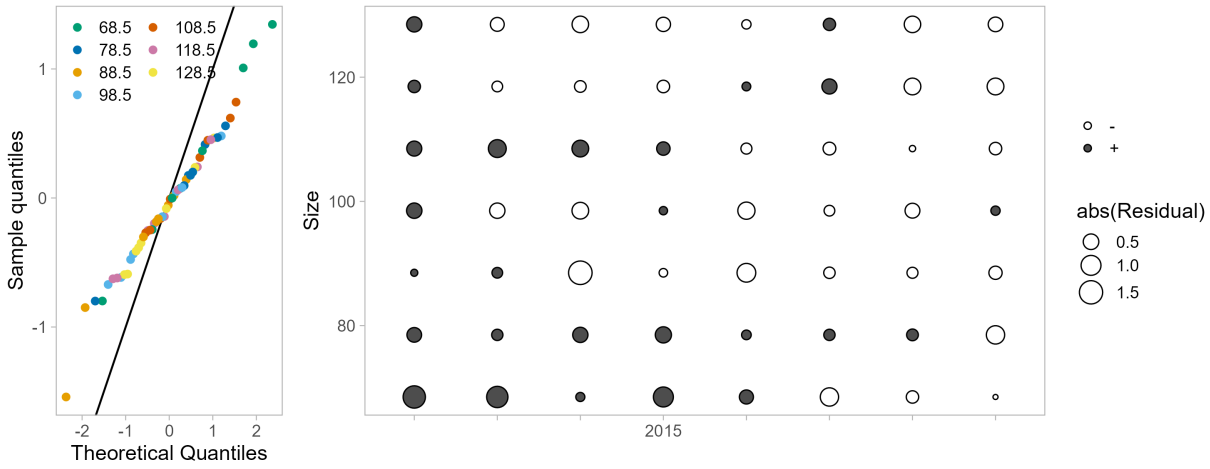


Figure 51: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the summer commercial fishery total catch.

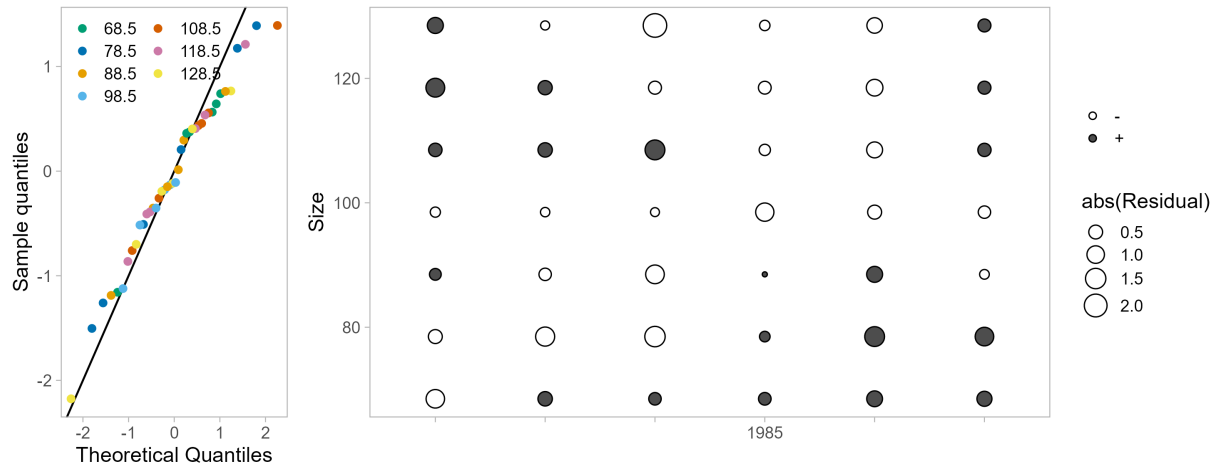


Figure 52: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

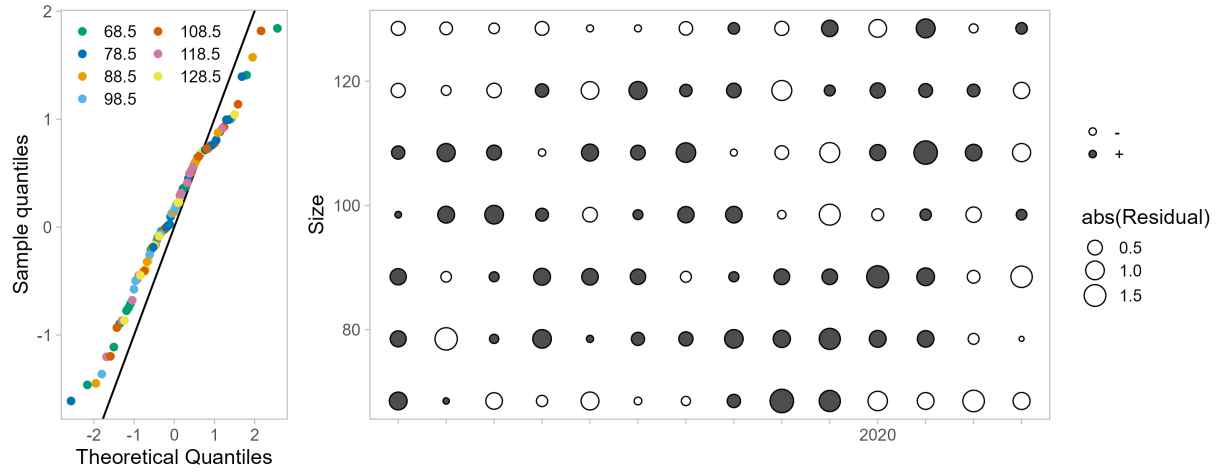


Figure 53: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

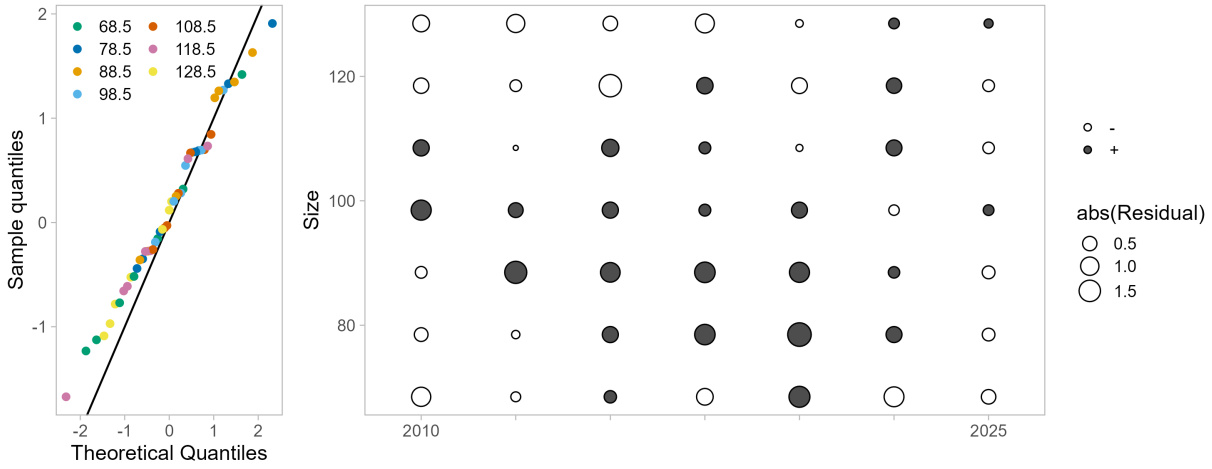


Figure 54: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

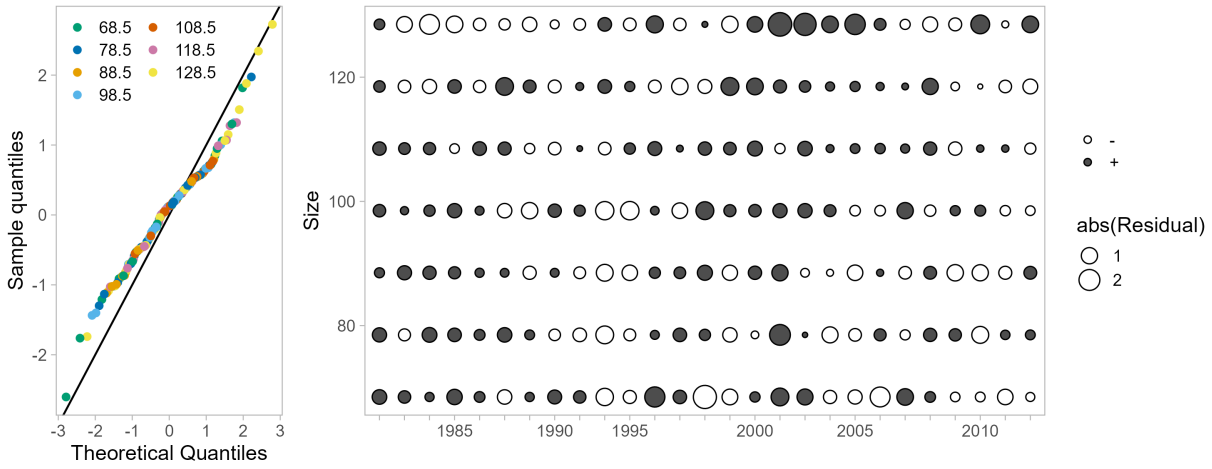


Figure 55: One-Step-Ahead residuals for model 26.1.nd fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

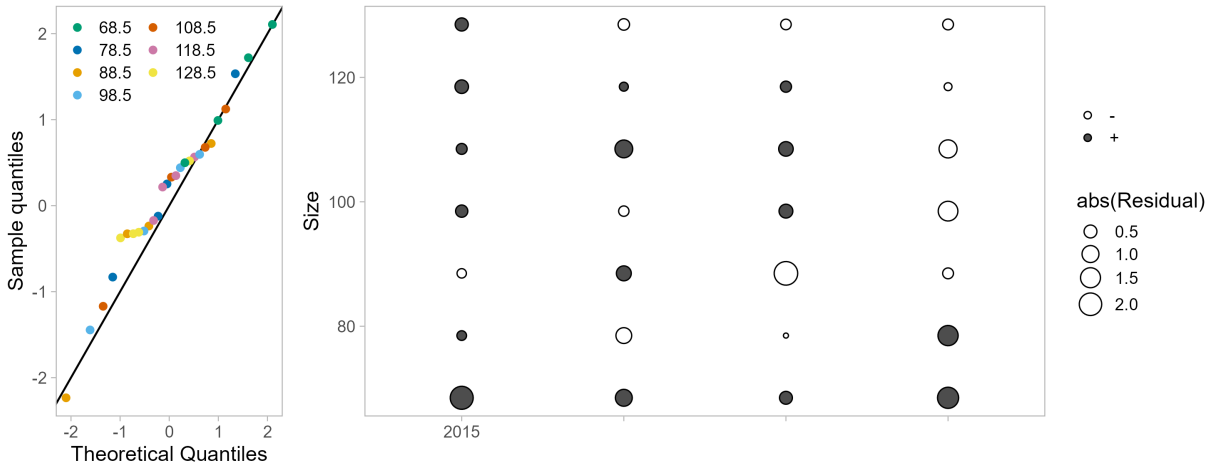


Figure 56: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the winter commercial fishery retained catch.

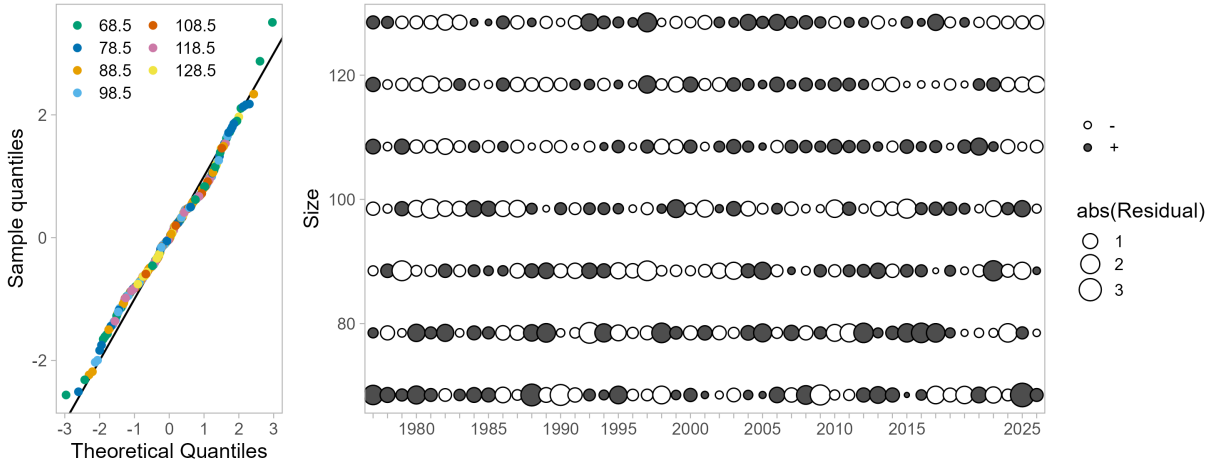


Figure 57: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the summer commercial fishery retained catch.

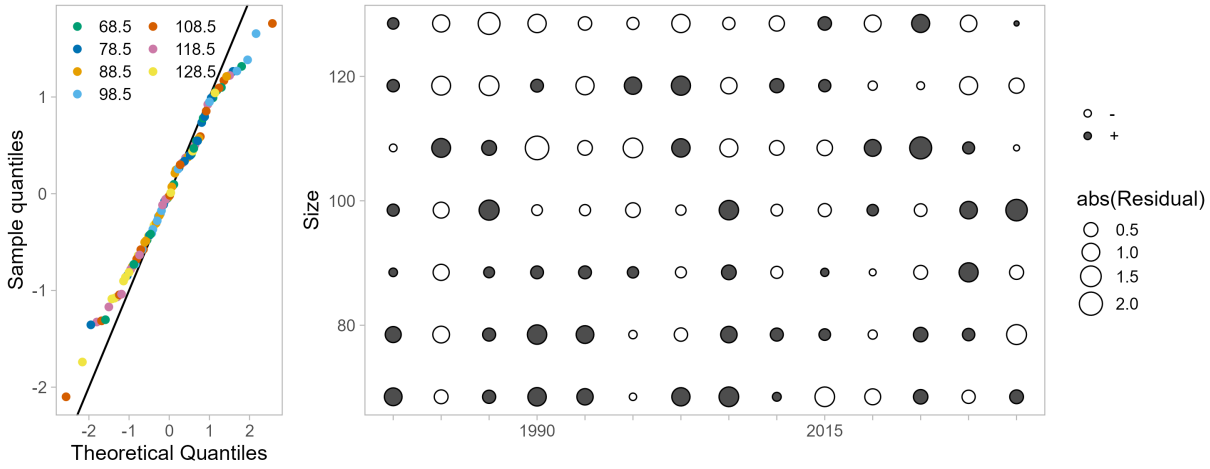


Figure 58: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the summer commercial fishery discarded catch.

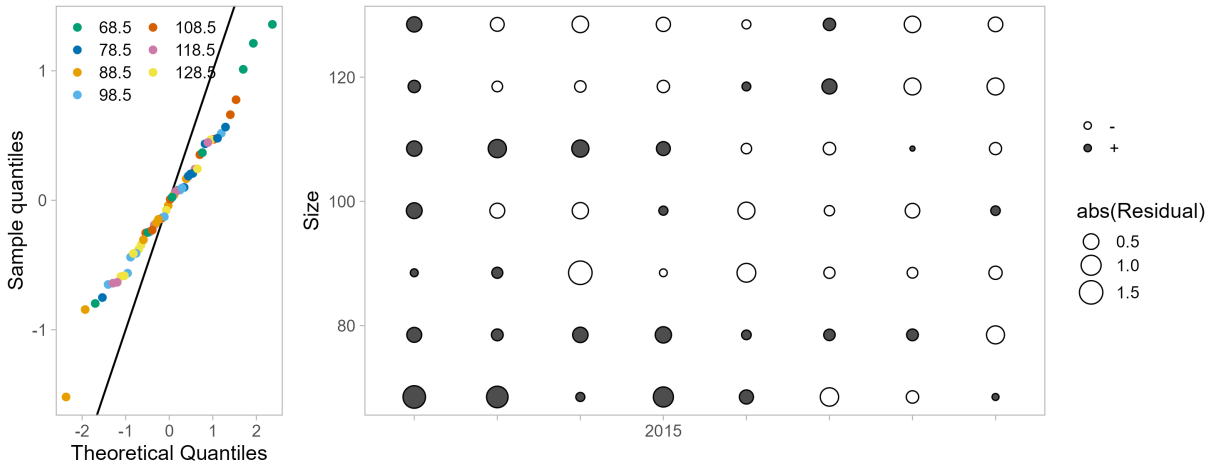


Figure 59: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the summer commercial fishery total catch.

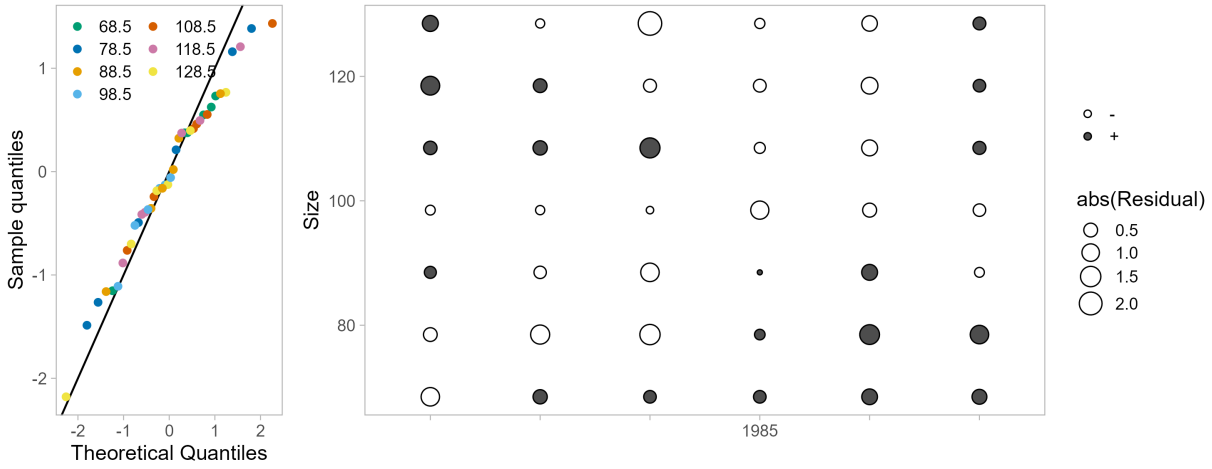


Figure 60: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

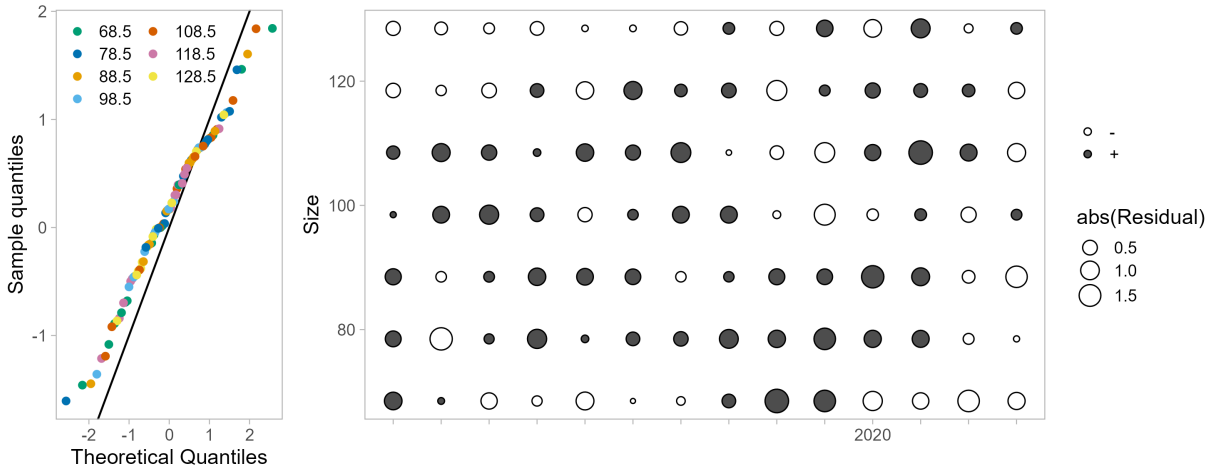


Figure 61: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

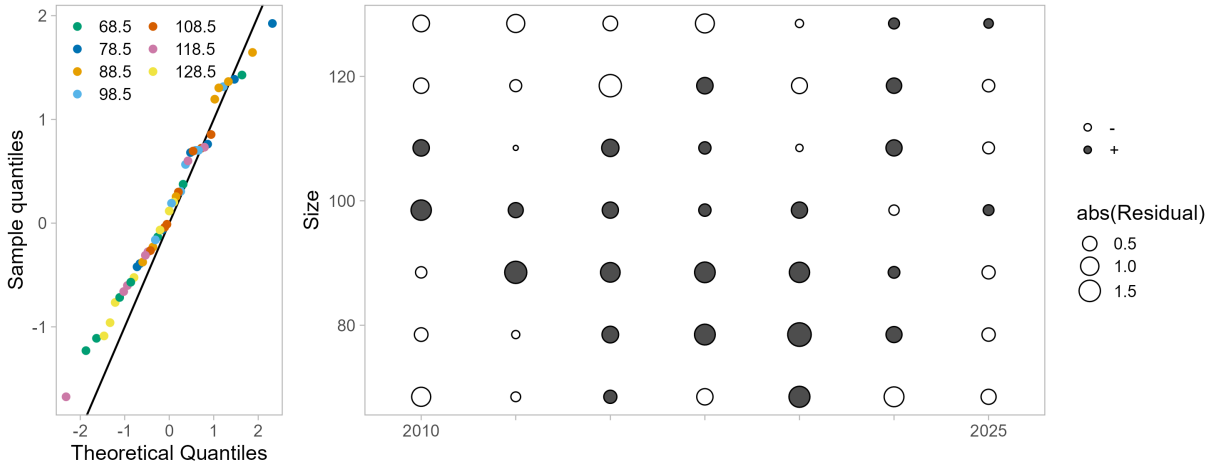


Figure 62: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

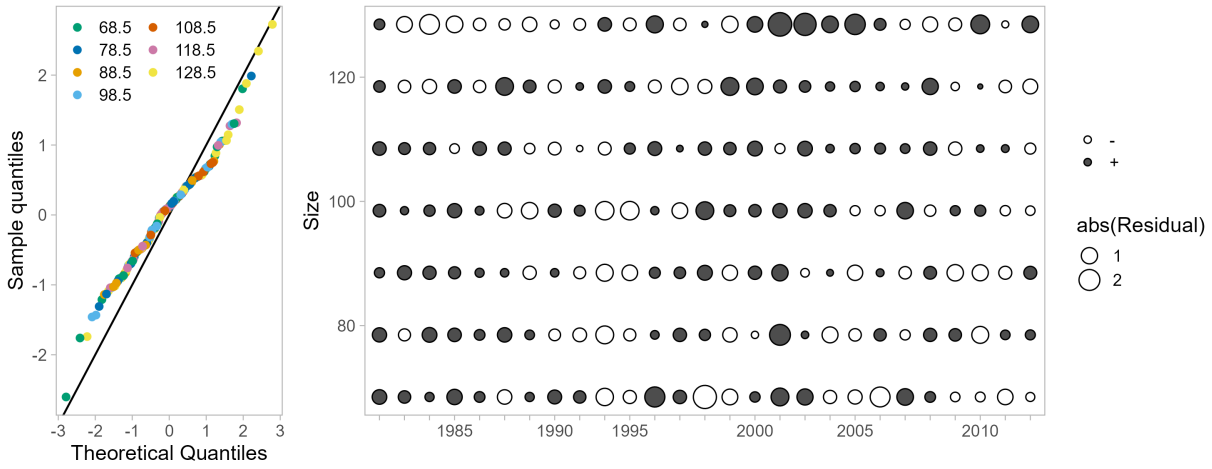


Figure 63: One-Step-Ahead residuals for model 26.1.d fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

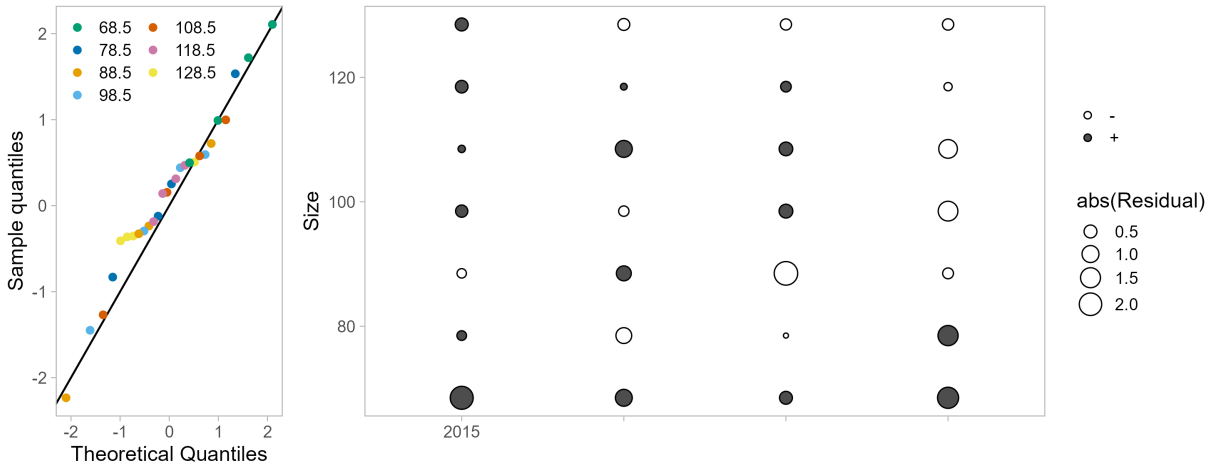


Figure 64: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the winter commercial fishery retained catch.

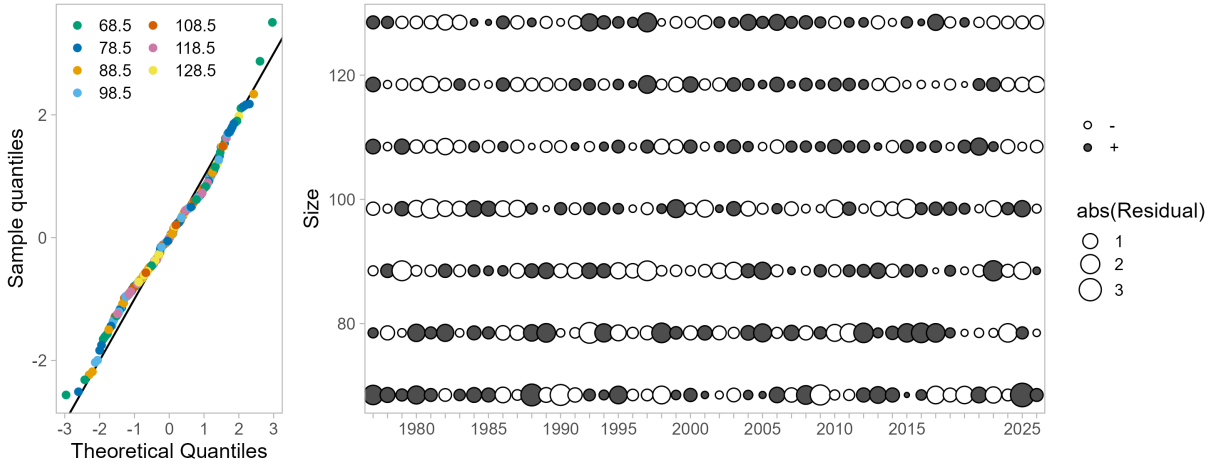


Figure 65: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the summer commercial fishery retained catch.

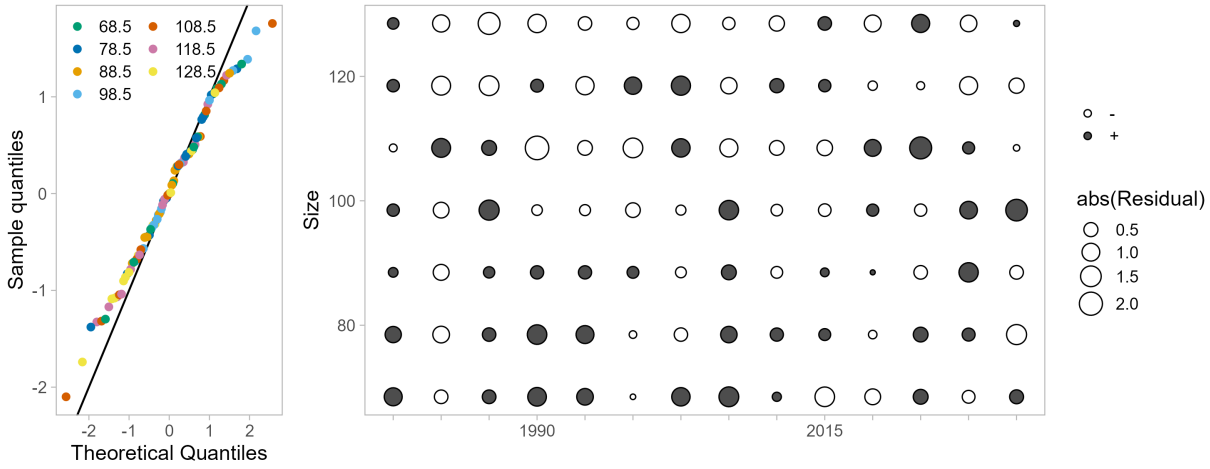


Figure 66: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the summer commercial fishery discarded catch.

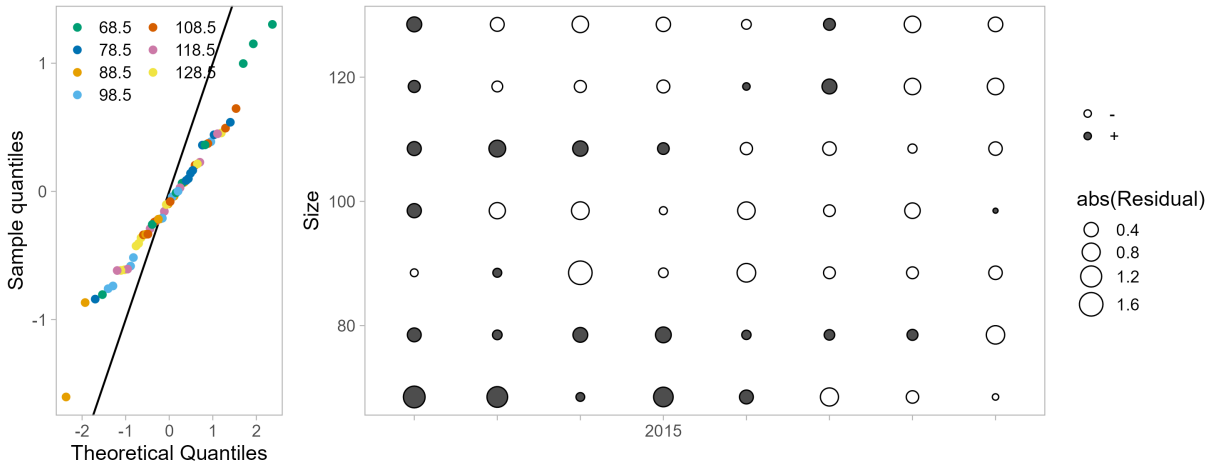


Figure 67: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the summer commercial fishery total catch.

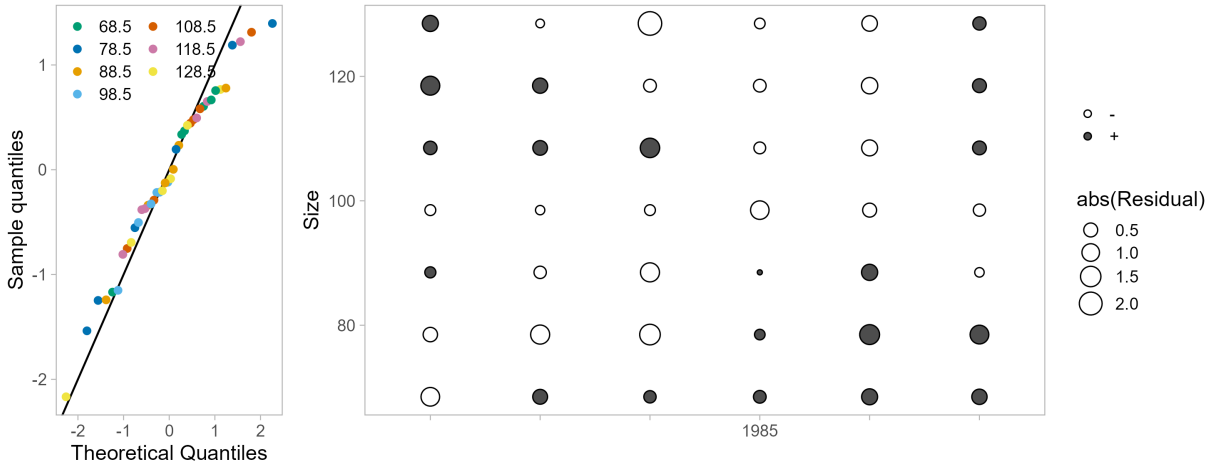


Figure 68: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

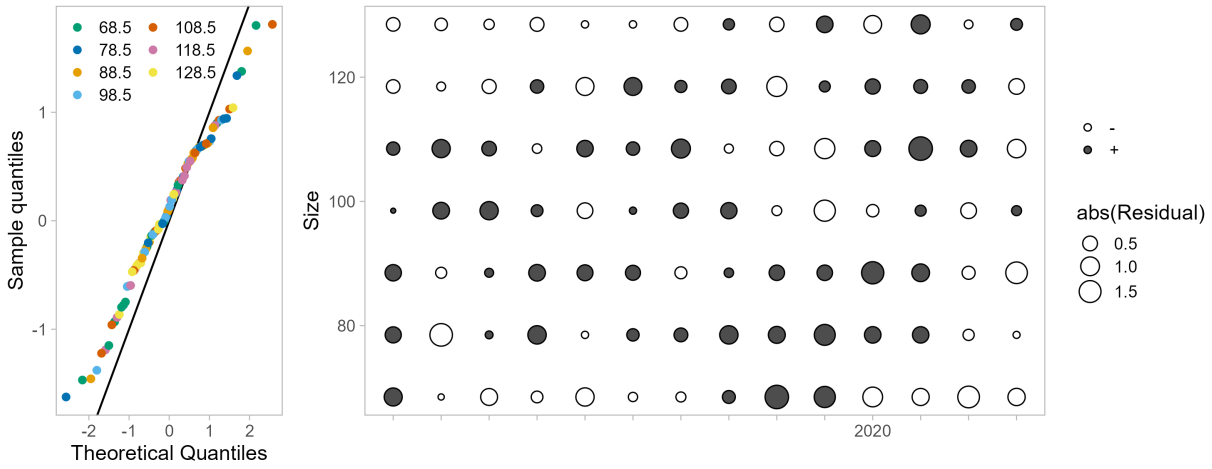


Figure 69: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

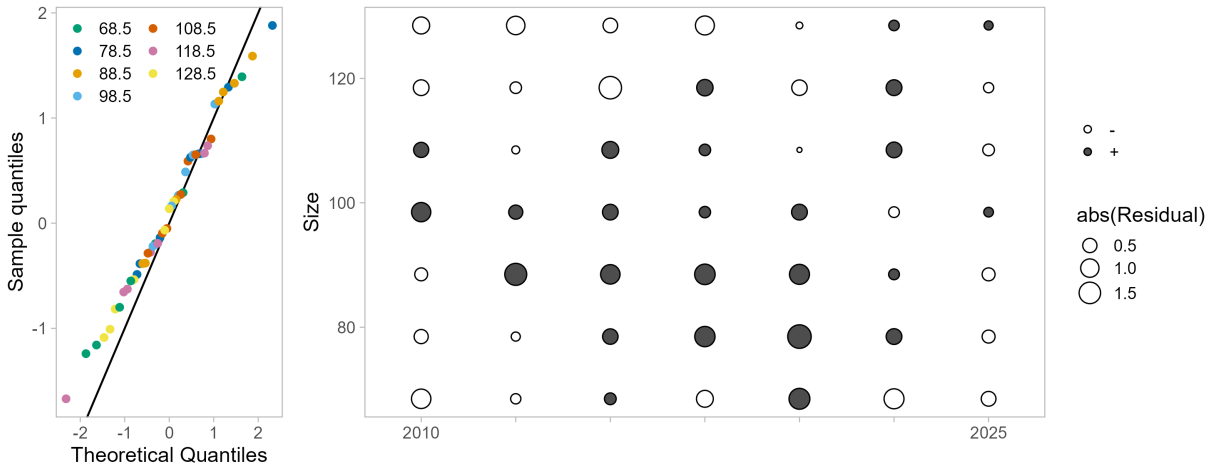


Figure 70: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

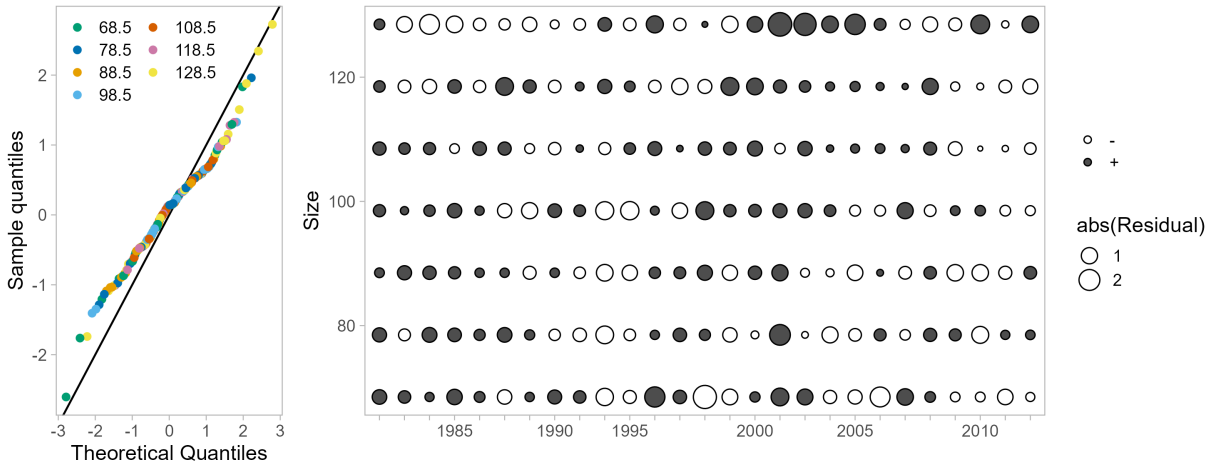


Figure 71: One-Step-Ahead residuals for model 26.2.nd fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

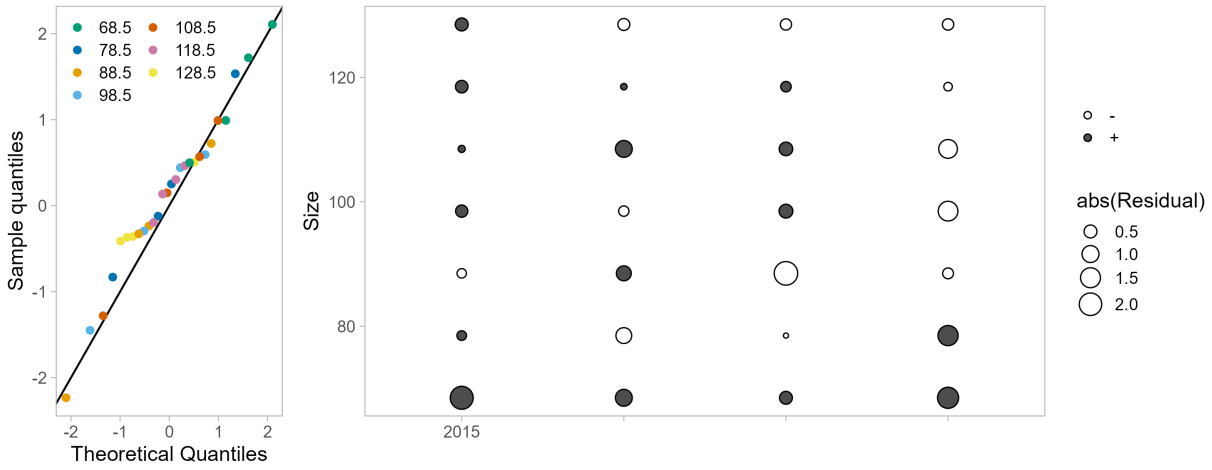


Figure 72: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the winter commercial fishery retained catch.

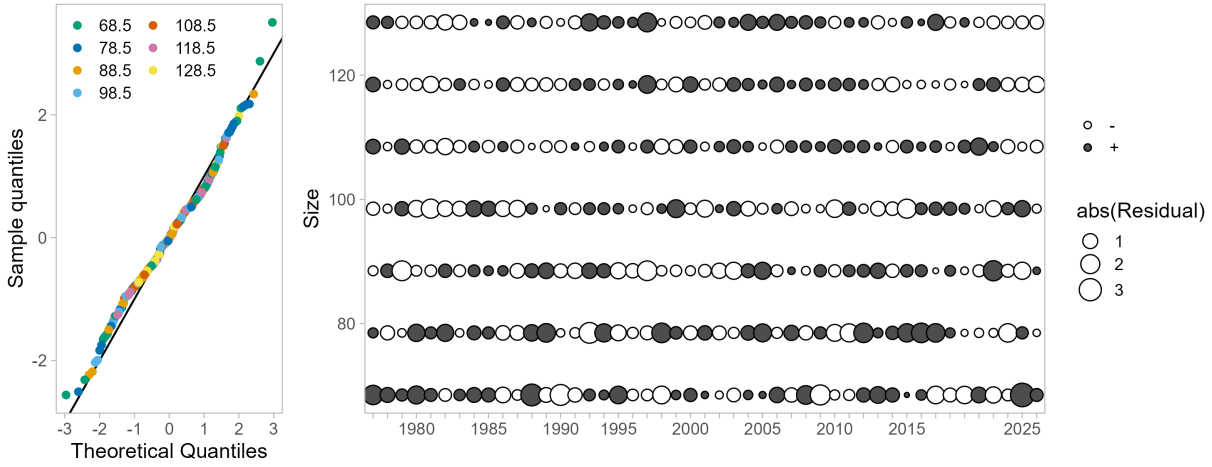


Figure 73: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the summer commercial fishery retained catch.

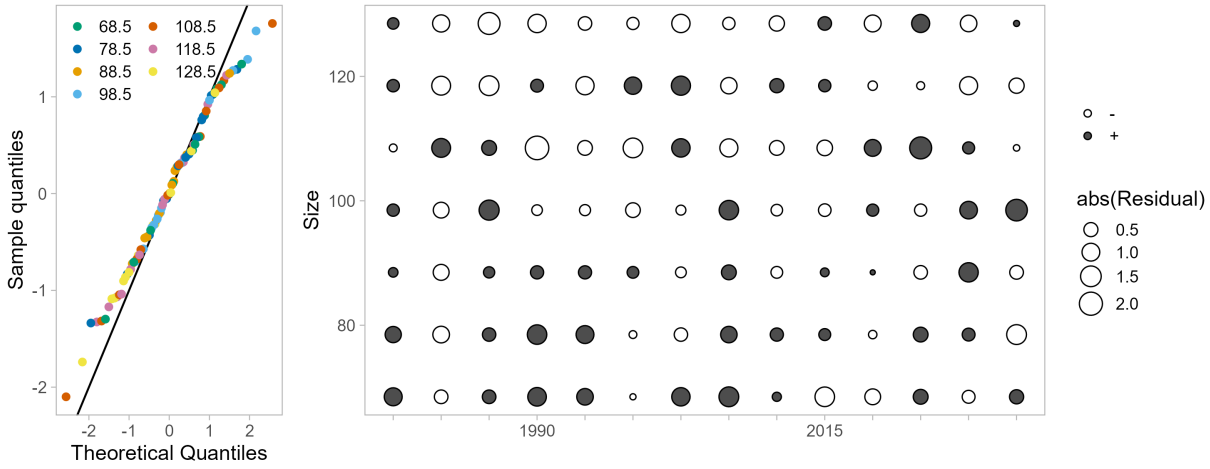


Figure 74: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the summer commercial fishery discarded catch.

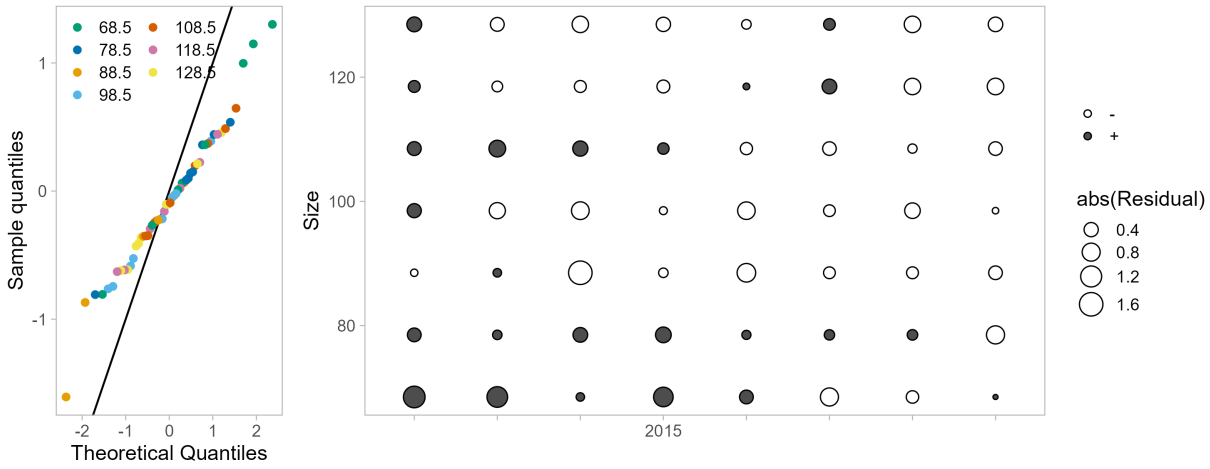


Figure 75: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the summer commercial fishery total catch.

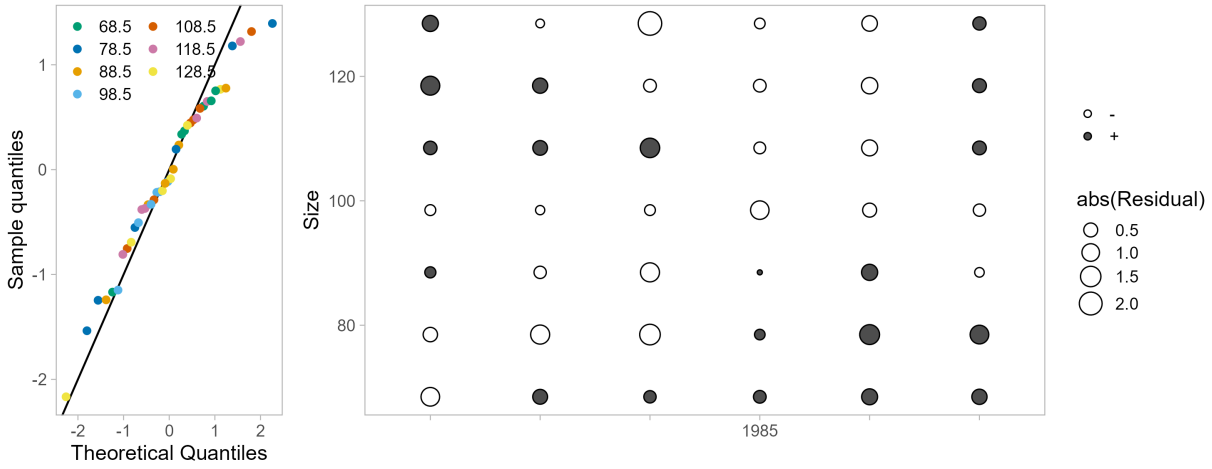


Figure 76: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

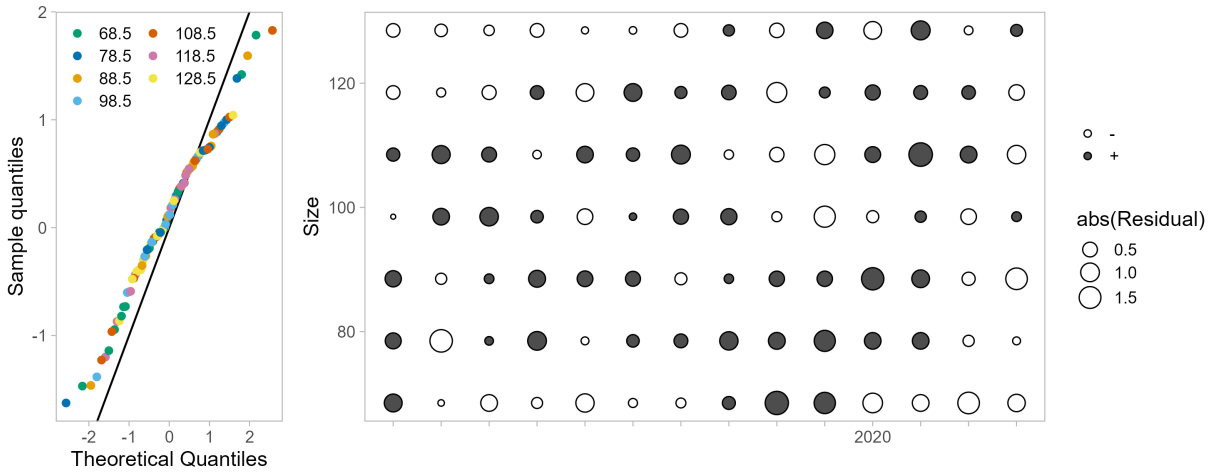


Figure 77: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

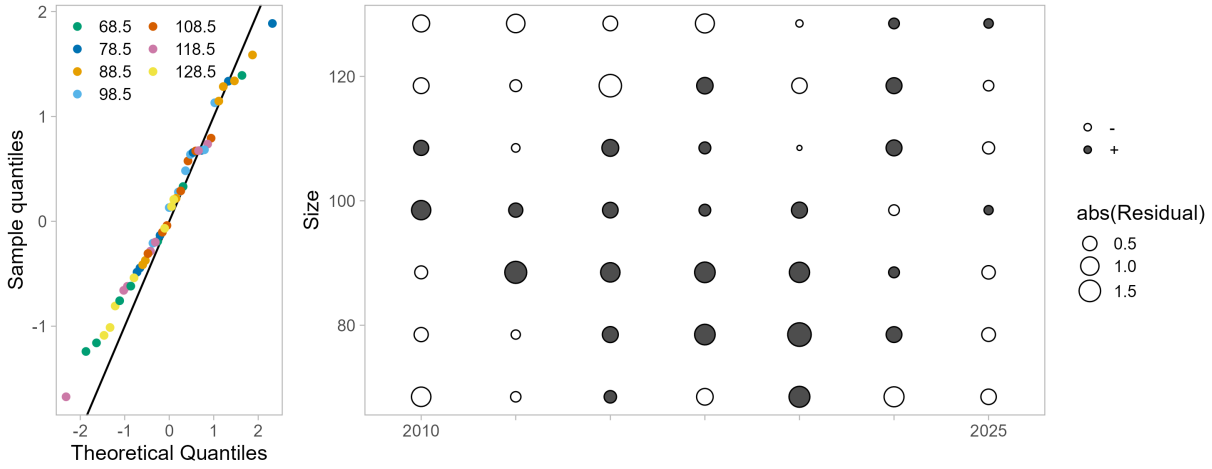


Figure 78: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

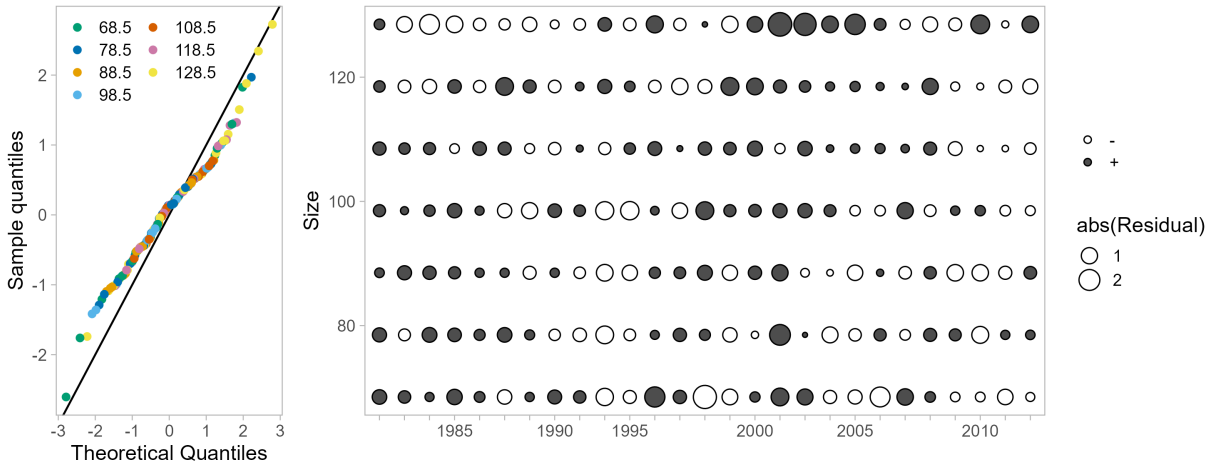


Figure 79: One-Step-Ahead residuals for model 26.2.d fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

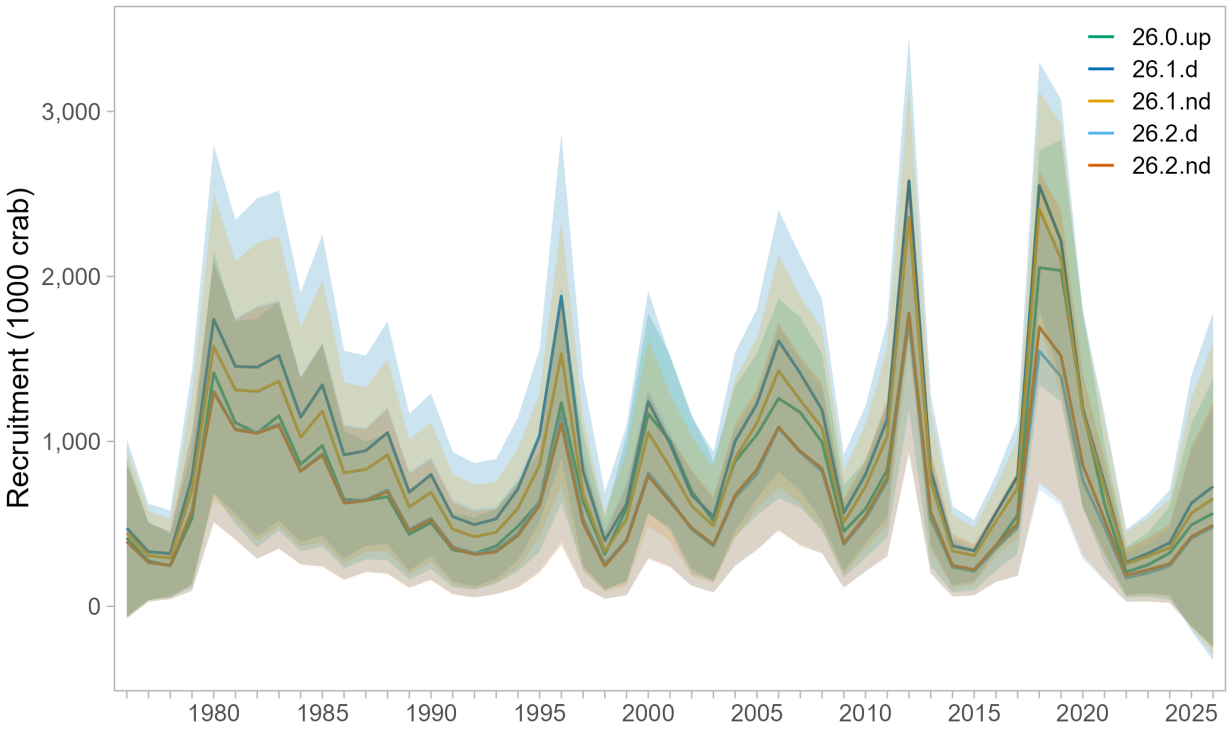


Figure 80: Estimated recruitment (1000 lb) over 1976-2025 for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models).

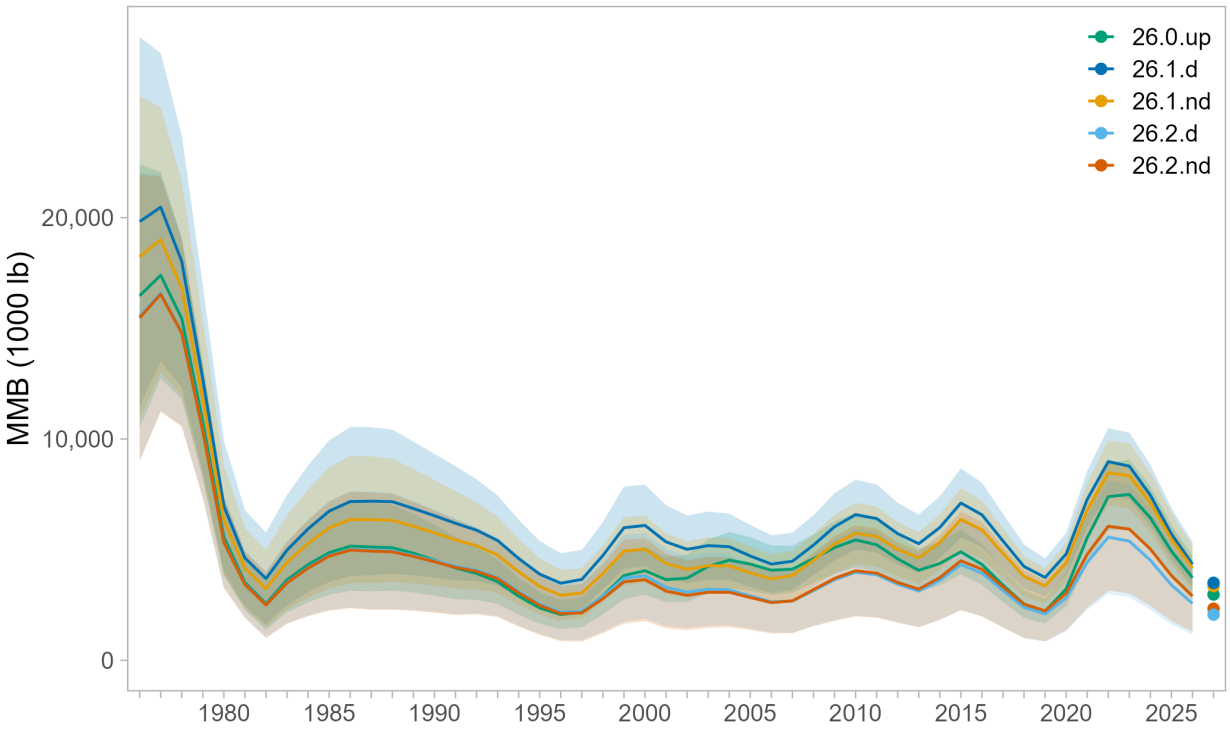


Figure 81: Comparisons of estimated mature male biomass (MMB) time series over 1976-2026 for the updated base model (26.0.up) and the models including a model-based index of abundance with depth excluded (nd) or included (d) and catchability for the model-based index fixed (26.1 models) or estimated (26.2 models). Points represent projected values for 2027.

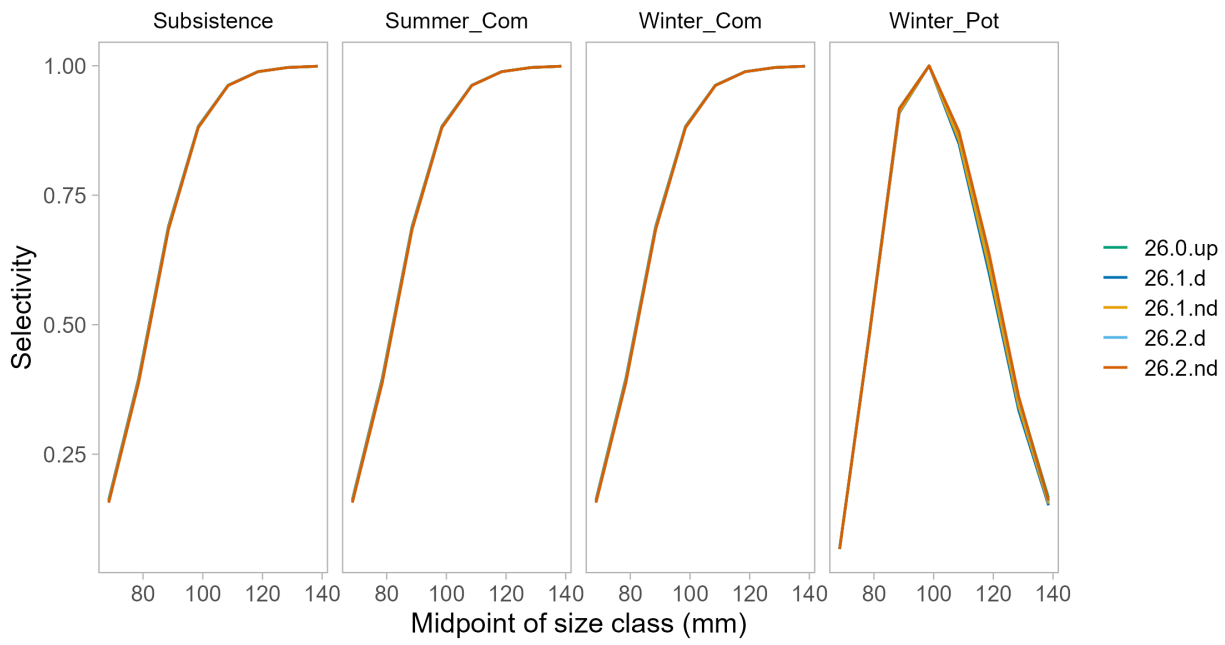


Figure 82: Comparisons of estimated capture selectivities in the summer commercial, winter commercial, and winter subsistence fisheries, as well as the winter pot survey, for the updated base model (26.0) and the models including a model-based index of abundance.

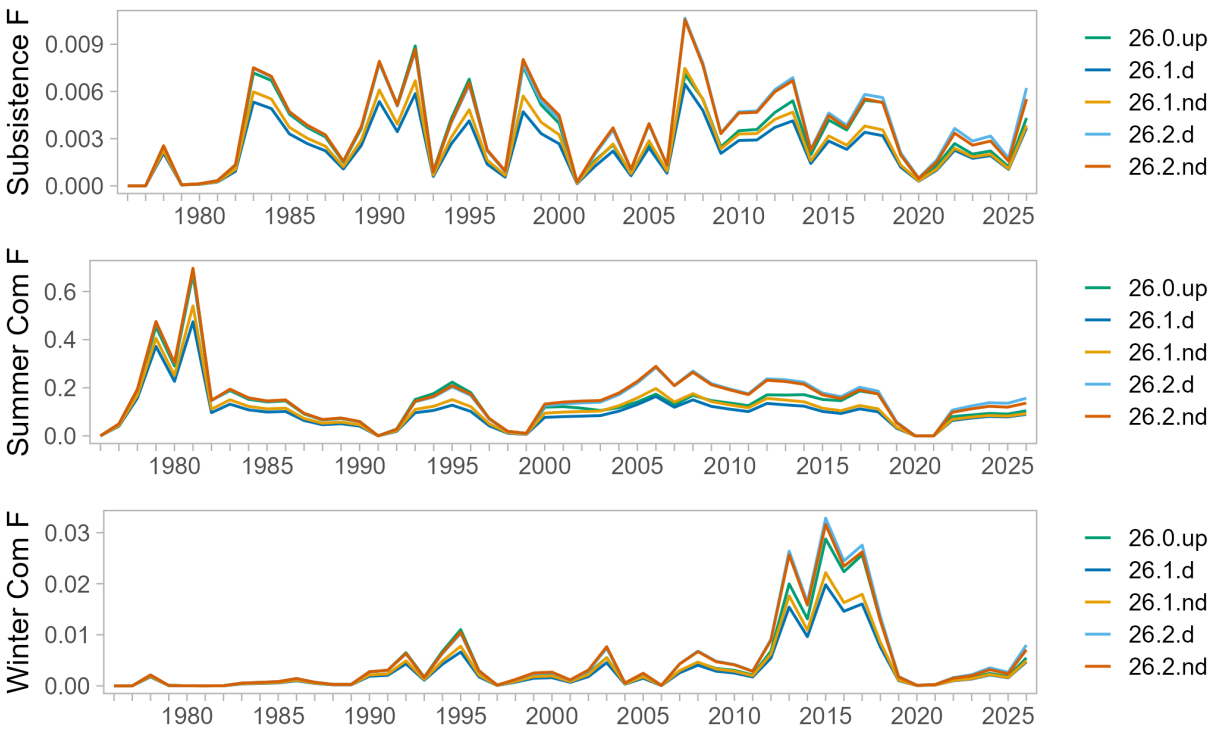


Figure 83: Comparison of estimated fishing mortality (F) for the subsistence, summer commercial, and winter commercial fisheries for the new base model (26.0) and the models including the model-based index of abundance (26.1 - 26.4).

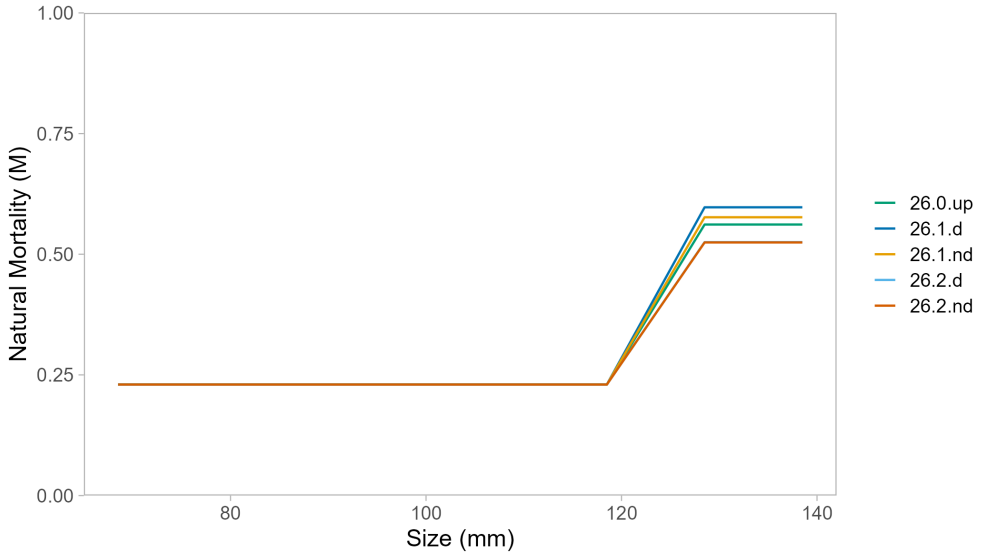


Figure 84: Natural mortality estimates for the updated base model (26.0.up) and the models including a model-based index of abundance (26.1.nd, 26.1.d, 26.2.nd, 26.2.d).

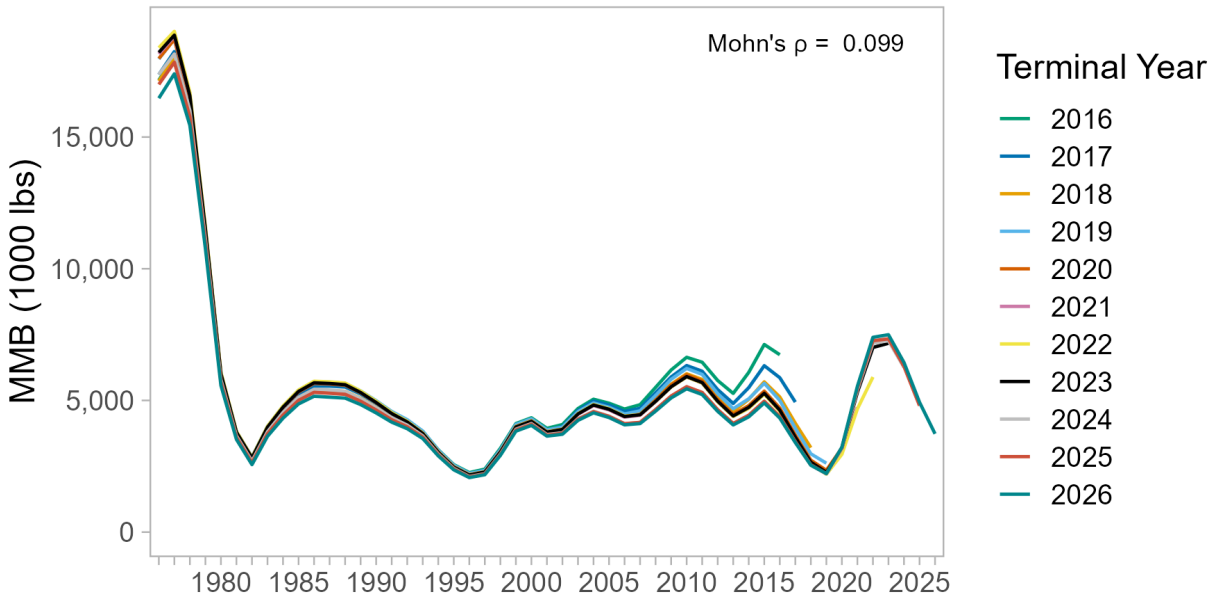


Figure 85: Retrospective patterns in estimated mature male biomass (MMB) for the base model with updated data and GMACS version (26.0.up).

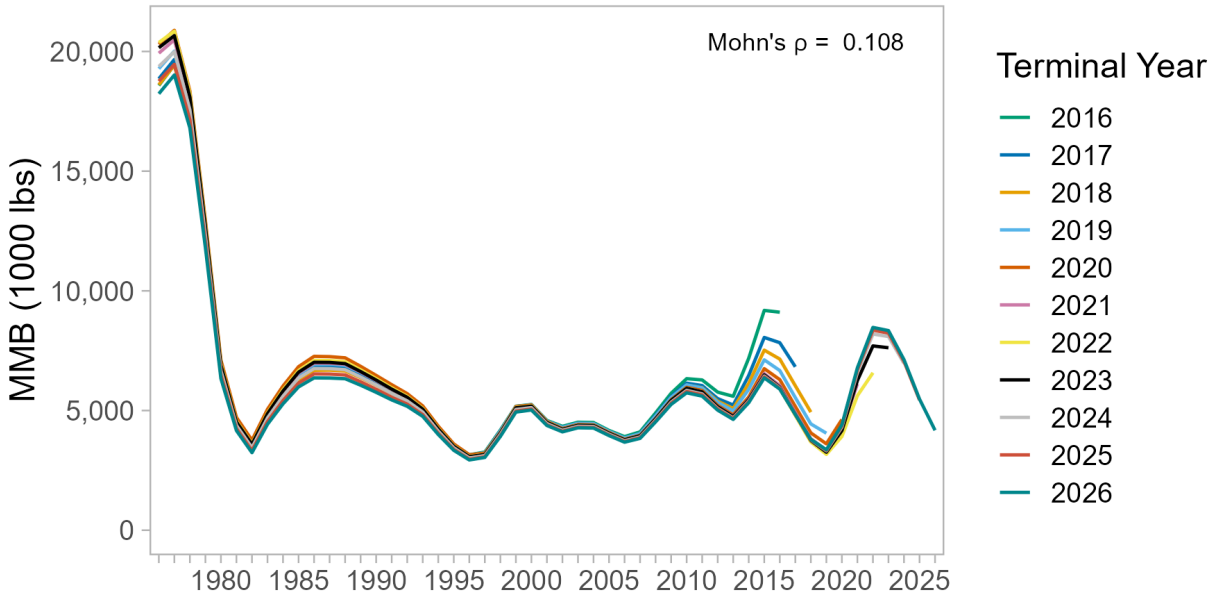


Figure 86: Retrospective patterns in estimated mature male biomass (MMB) for the model using a model-based index of abundance that does not take into account depth (26.1.nd).

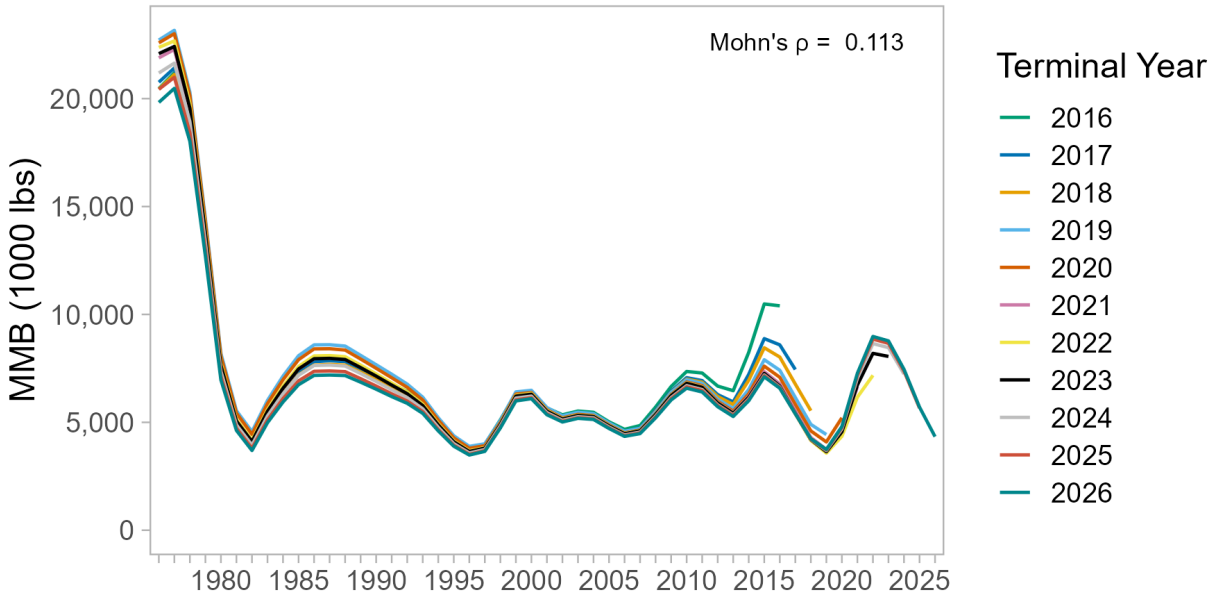


Figure 87: Retrospective patterns in estimated mature male biomass (MMB) for the model using a model-based index of abundance that takes into account depth (26.1.d).

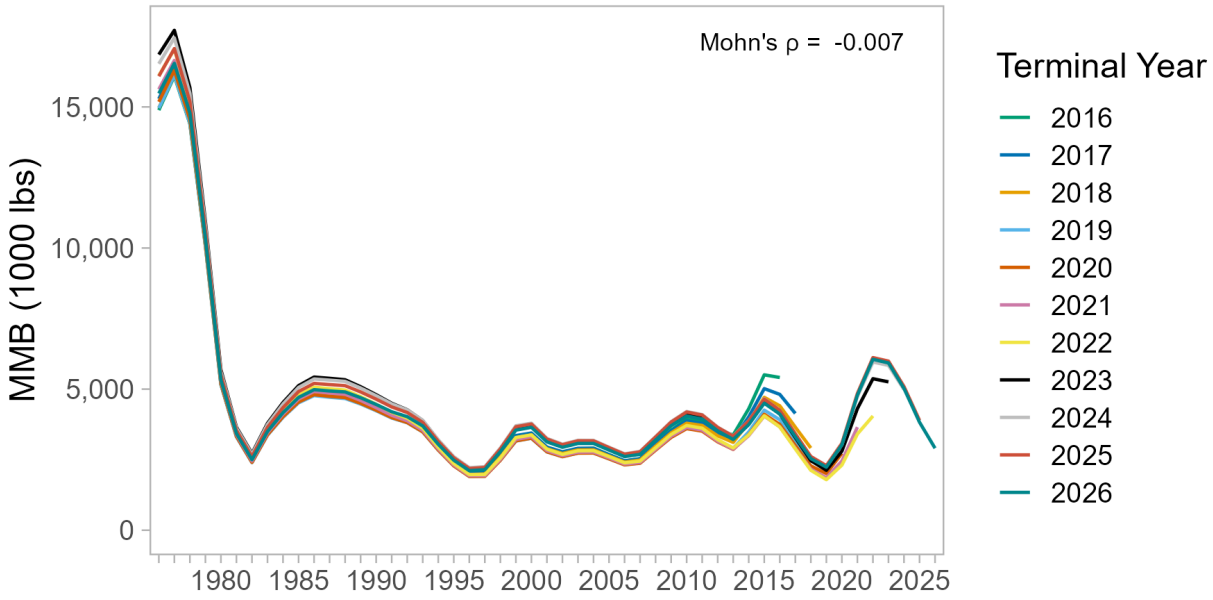


Figure 88: Retrospective patterns in estimated mature male biomass (MMB) for model 26.2.nd, which uses a model-based index of abundance that does not take into account depth, and also estimates catchability for that index.

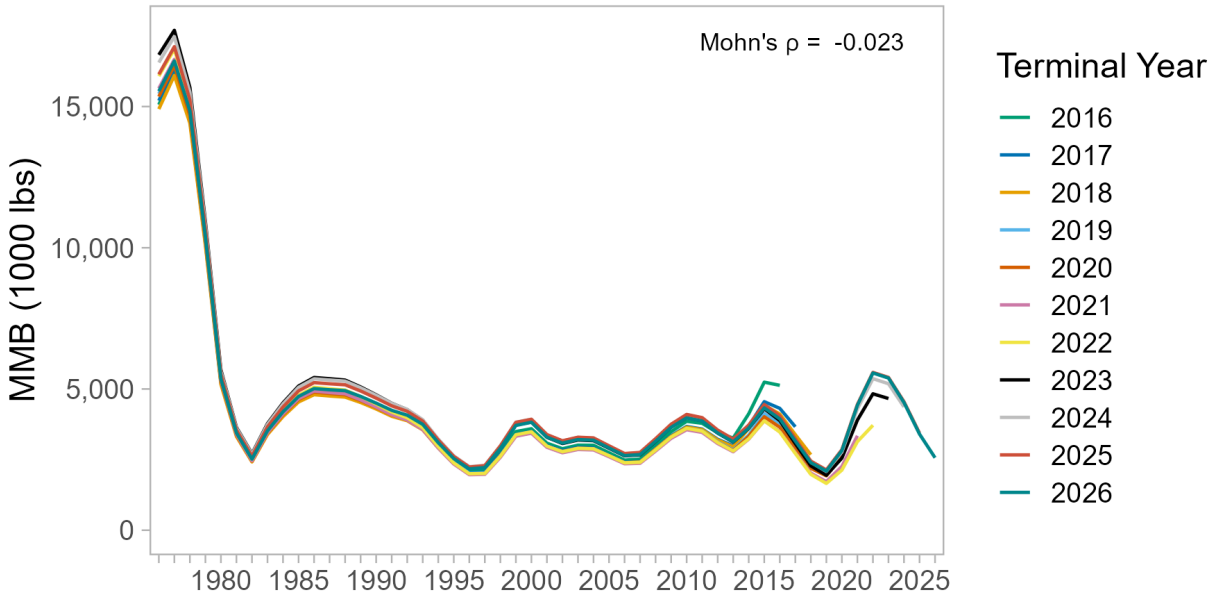


Figure 89: Retrospective patterns in estimated mature male biomass (MMB) for model 26.2.d, which uses a model-based index of abundance that takes into account depth, and also estimates catchability for that index.

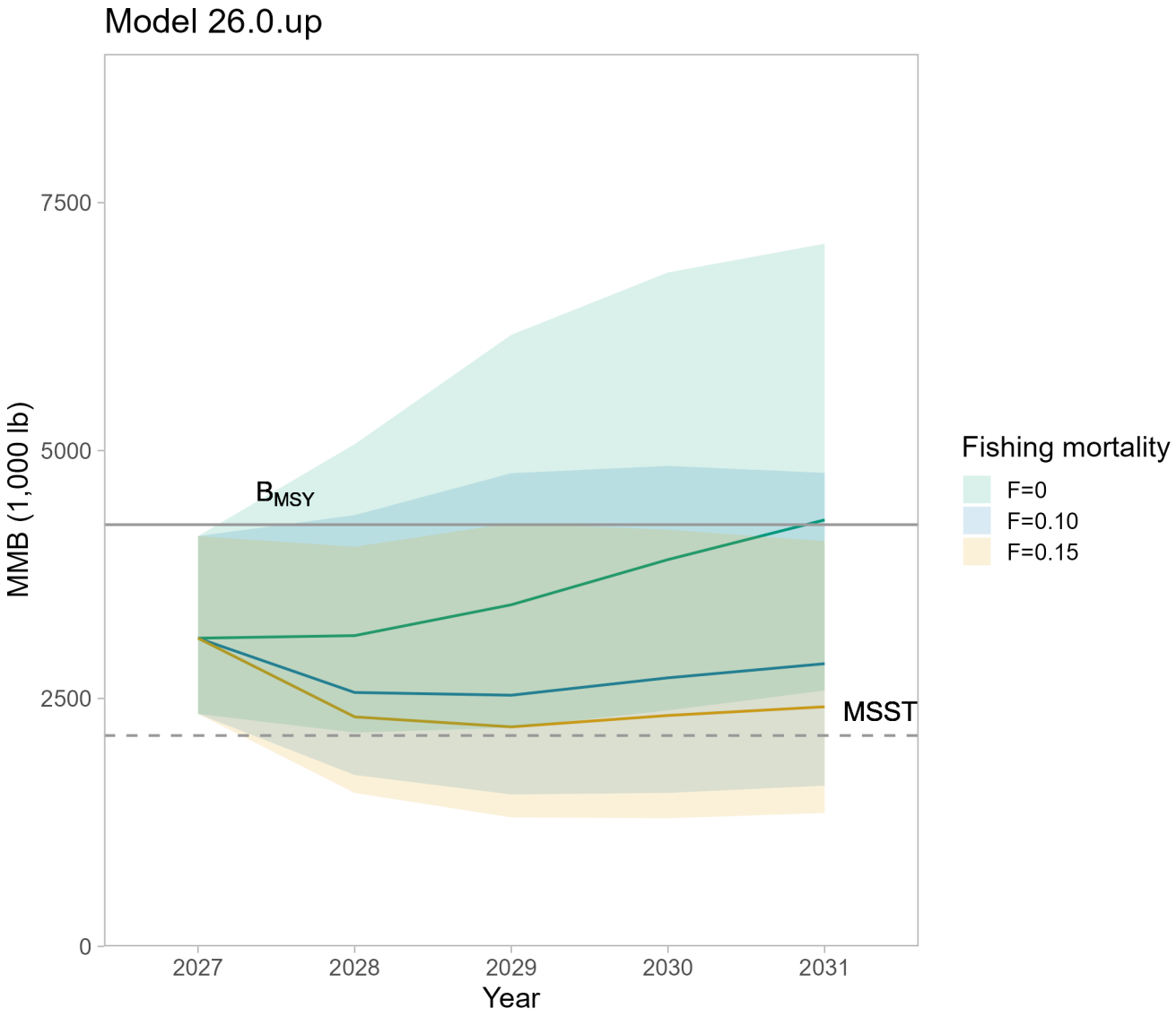


Figure 90: Mature male biomass (MMB) projections from the base model with updated data and GMACS version (26.0.up) for the next five years. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY}, which is equal to time series mean MMB for this Tier 4 stock, while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$).

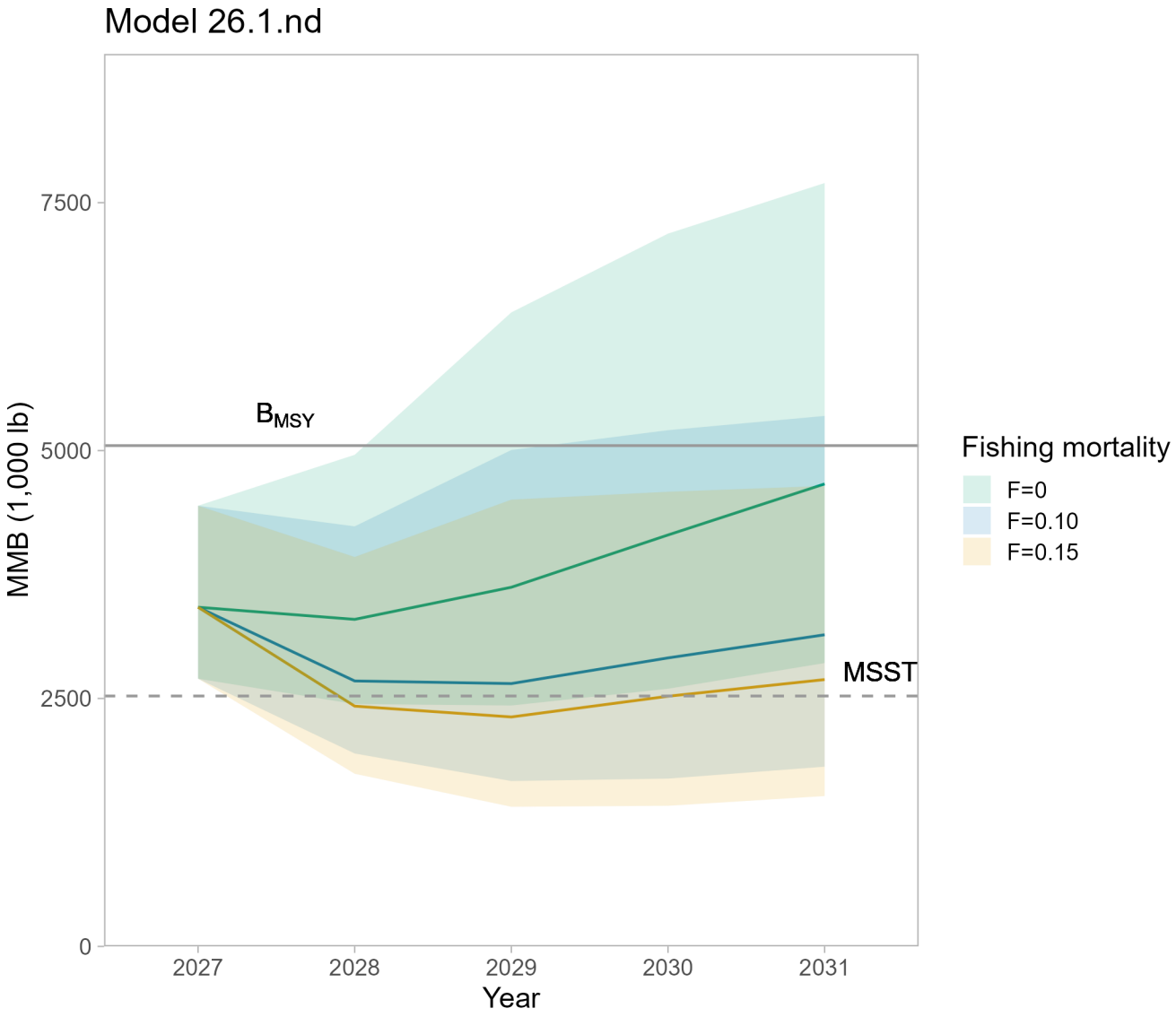


Figure 91: Mature male biomass (MMB) projections from the model using a model-based index of abundance that does not take into account depth (26.1.nd) for the next five years. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY}, which is equal to time series mean MMB for this Tier 4 stock, while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$).

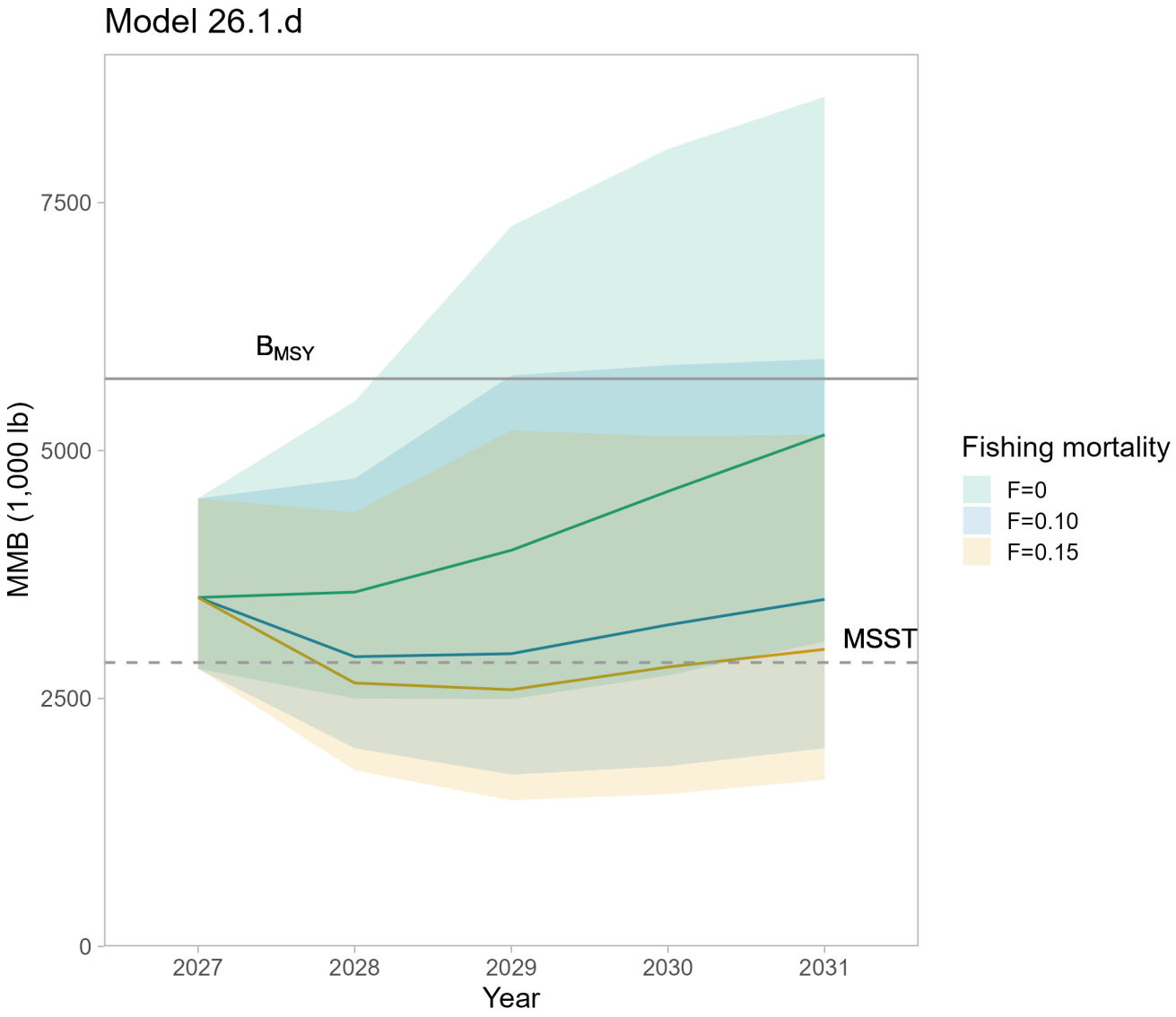


Figure 92: Mature male biomass (MMB) projections from the model using a model-based index of abundance that takes into account depth (26.1.d) for the next five years. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY}, which is equal to time series mean MMB for this Tier 4 stock, while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$).

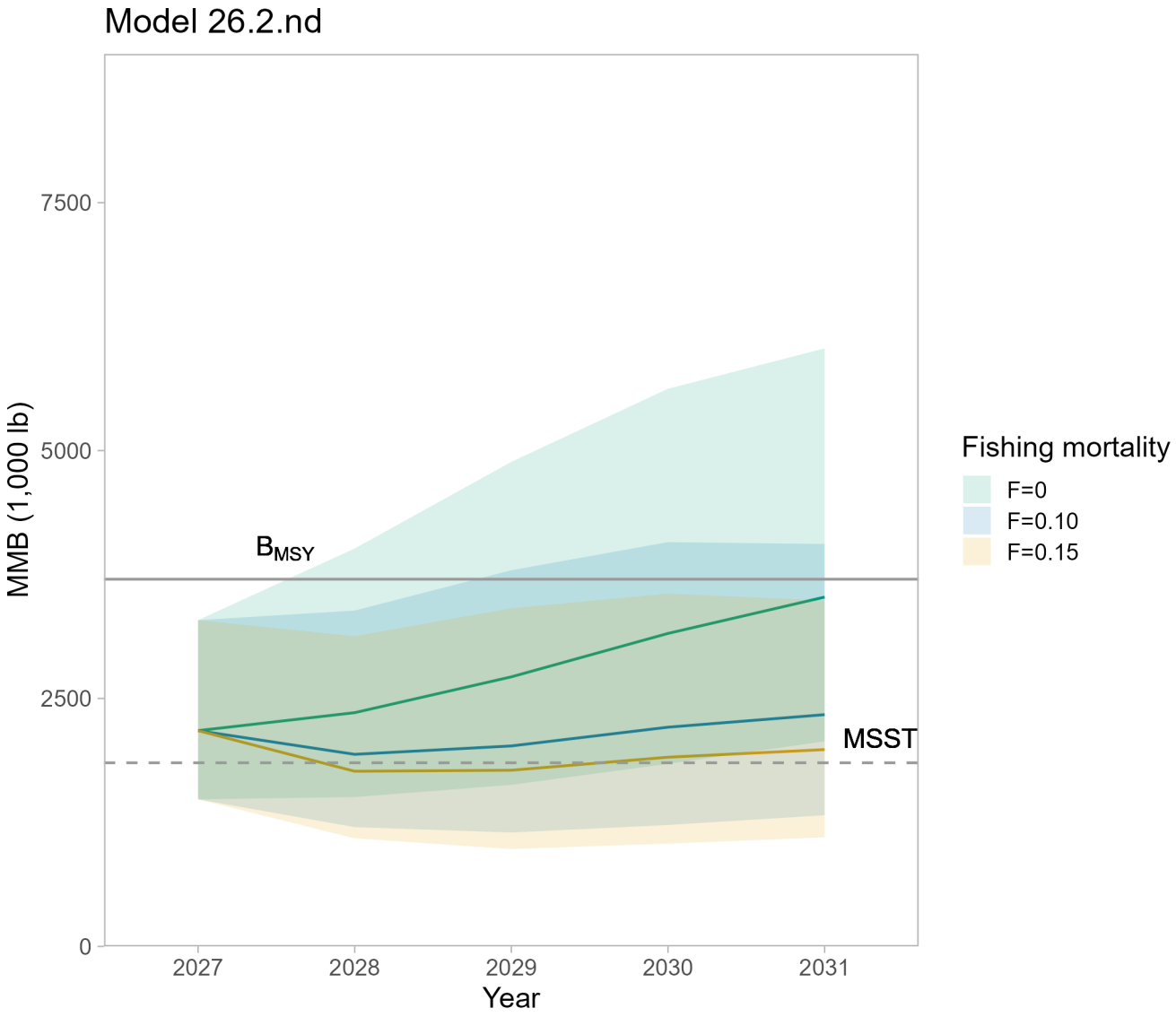


Figure 93: Mature male biomass (MMB) projections from the model using a model-based index of abundance that does not take into account depth (26.2.nd) for the next five years. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY}, which is equal to time series mean MMB for this Tier 4 stock, while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$).

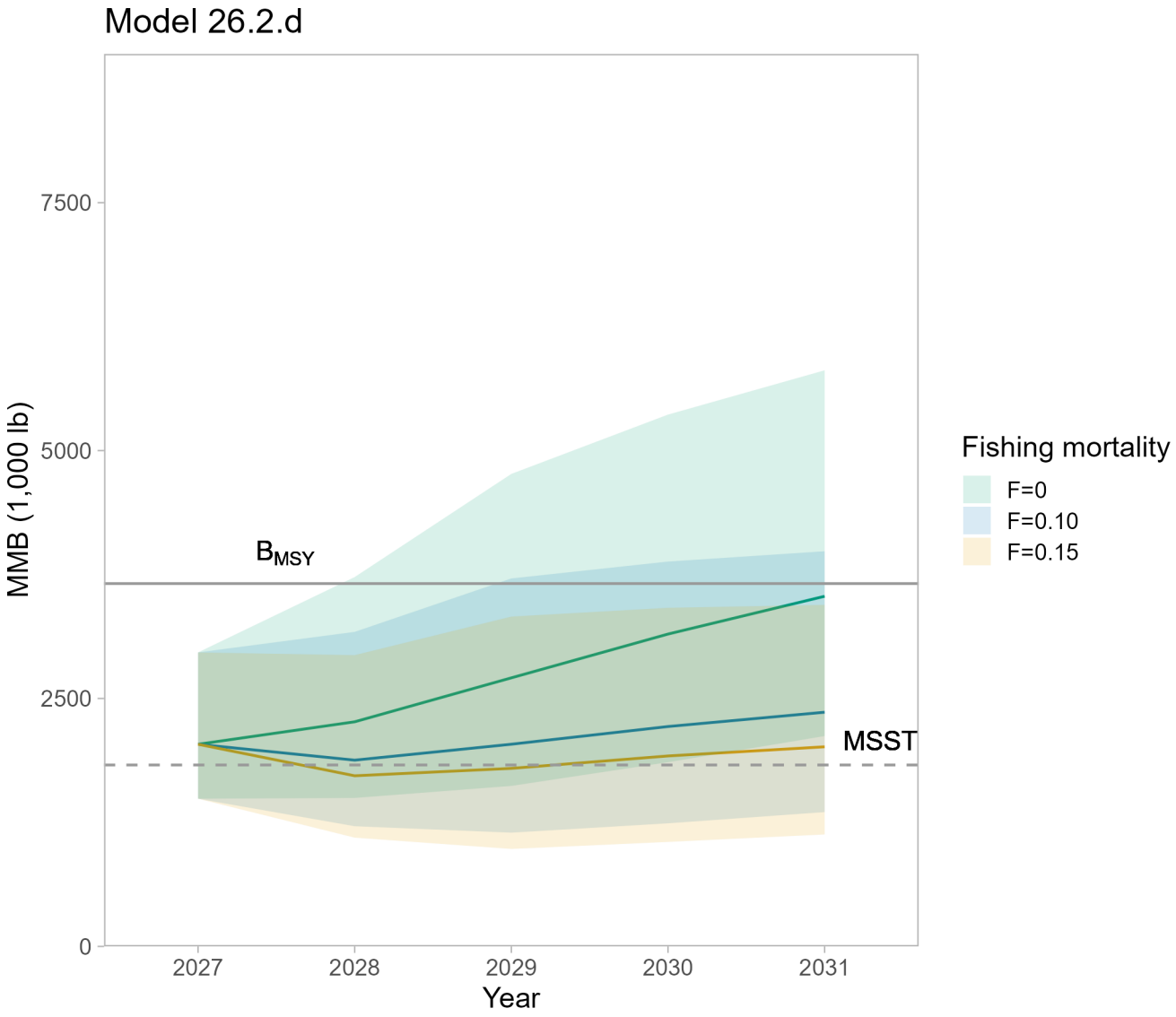


Figure 94: Mature male biomass (MMB) projections from the model using a model-based index of abundance that takes into account depth (26.2.d) for the next five years. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY}, which is equal to time series mean MMB for this Tier 4 stock, while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$).