

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 2025, the summer commercial fishery has accounted for an average of 94% of commercially-harvested crab by weight each year.

In 2025, commercial fishers harvested 2,657 crab (7,360 lb) in winter and 100,758 crab (346,364 lb) in summer. Crab per pot lift (catch per unit effort, CPUE) in the summer commercial fishery was down 57% from 2024, and was 22% below the time series mean.

Winter 2025 subsistence fishers caught 2,239 male crab and 59 female crab, and retained 1,897 male crab (5,255 lb), with 100% of permits returned. Summer subsistence fishers caught 526 male crab and 29 female crab, and retained 467 (1,605 lb) male crab, with 100% of permits returned. In total, a harvest of 105,779 male crab (360,584 lb) was reported for the commercial and subsistence fisheries in 2025. Discard mortality data are not available because vessels participating in the 2025 NSRKC fisheries did not have observers on board. The discard mortality estimate from model 25.0a2, the author-recommended model, is 8,840 lb. Combining retained and discard mortality, total fishing mortality in 2025 was 369,427 lb (0.168 kt).

For 2025, the OFL was 0.284 kt (628,000 lb) and the ABC was 0.199 kt (440,000 lb). The GHl was 410,000 lb. Total fishing mortality was below the ABC and overfishing did not occur during 2025.
3. **Data sources:** The data sources used in this assessment are summarized in Figure 1 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-present), and the Alaska Department of Fish and Game (ADF&G) trawl survey (1996-present).
4. **Stock biomass:** 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 2026). In 2025, estimated abundance from the NOAA NBS trawl survey was 1.63 million crab (CV = 0.64).

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 authors' recommended model, 25.0a2, average recruitment over 1976-2024 was 772,504 lb. Data from the NBS trawl survey appear to show a recruitment pulse first apparent in 2019 moving through the population (Figure 2).
6. **Management performance:** The tables below show the status and catch specifications based on the model the authors recommend for harvest specifications (25.0a2) 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 is calculated as $(1 - 0.3) * OFL$, using the authors' recommended ABC buffer of 30%, which is the same buffer accepted for 2025 harvest specifications. 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 are set in December 2025.

Table 1: Status and catch specifications (1,000 t) for the author-recommended model, 25.0a2.

Year	MSST	Biomass (MMB_{mating})	GHl	Retained catch	Total catch	OFL	ABC	Model
2021/21	1.02	2.29	0.14	0.003	0.003	0.20	0.16	
2022/22	0.95	2.42	0.15	0.15	0.16	0.30	0.18	
2023/23	1.20	2.40	0.178	0.192	0.201	0.292	0.204	
2024/24	1.00	2.50	0.219	0.209	0.215	0.332	0.233	
2025/25	0.98	2.15	0.186	0.164	0.168	0.284	0.199	
2026/26	1.00	1.56				0.193	0.135	25.0a2

Table 2: Status and catch specifications (million lb) for the author-recommended model, 25.0a2.

Year	MSST	Biomass (MMB_{mating})	GHl	Retained catch	Total catch	OFL	ABC	Model
2021/21	2.25	5.05	0.31	0.007	0.007	0.59	0.35	
2022/22	2.08	5.33	0.34	0.34	0.36	0.67	0.40	
2023/23	2.65	5.29	0.392	0.425	0.444	0.643	0.450	
2024/24	2.2	5.52	0.483	0.460	0.474	0.733	0.513	
2025/25	2.16	4.72	0.410	0.361	0.369	0.628	0.440	
2026/26	2.21	3.43				0.426	0.298	25.0a2

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 ≥ 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 author-recommended model, 25.0a2.

Year	Tier	Biomass B_{MSY}	(MMB_{mat})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality	Model
2021/21	4a	2.05	2.29	1.1	0.18	1980-2020	0.18	
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	25.0a2

Table 4: Basis for the OFL (million lb) from the author-recommended model, 25.0a2.

Year	Tier	Biomass B_{MSY}	(MMB_{mat})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality	Model
2021/21	4a	4.53	5.05	1.1	0.18	1980-2020	0.18	
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	25.0a2

8. **Probability density function (PDF) of the OFL:** The PDFs of the OFL for models 24.0b6, 24.0b7, 25.0a1, and 25.0a2 are shown in Figures 3 - 6.
9. **Basis for the ABC recommendation:** The CPT and SSC recommended an ABC buffer of 30% for setting harvest specifications for 2025 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). Since these concerns remain largely unchanged, the authors recommend using a 30% ABC buffer for setting 2026 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

The following time series were updated with 2025 data: winter subsistence fishery total and retained catch, winter commercial fishery retained catch, summer commercial fishery retained catch and size compositions, NOAA NBS trawl survey abundance and size compositions, and standardized summer commercial fishery CPUE.

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).

In this document, we present six model options for 2026 harvest specifications (Figure 7). Model 24.0b was presented at the May 2025 CPT meeting and is the base model (Stern and Palof 2025). Model 25.0a was also presented at the May 2025 CPT meeting and is model 24.0b with shell condition removed and the fixed value of M for males ≤ 123 mm CL increased to 0.23 from the value of 0.18 used in the base model, where 0.23 is the M value estimated in the most recent Bristol Bay red king crab (BBRKC) stock assessment (Palof 2025).

In response to suggestions from the North Pacific Fishery Management Council (NPFMC) Scientific and Statistical Committee (SSC) and the CPT, we present four other models that represent two different approaches to addressing the potentially unrealistically high fishing mortality (F) values for some years of the winter commercial fishery that are estimated by models 24.0b and 25.0a. Model 24.0b6, based on model 24.0b, uses an upper bound on F borrowed from the current BBRKC model for the winter commercial fishery; use of this bound leads to lower, and likely more realistic, estimated F values. Model 25.0a1, based on model 25.0a, also uses the BBRKC upper bound on F for the winter commercial fishery. Model 24.0b7, based on model 24.0b, uses a different selectivity pattern for the winter commercial fishery than is used in model 24.0b: rather than using the same, dome-shaped functional form for selectivity for the winter commercial fishery as is used for the winter pot survey, this model uses the same, asymptotic functional form for selectivity for the winter commercial fishery as is used for the summer commercial fishery. This change in the functional

form for selectivity for the winter commercial fishery also leads to lower estimated F values. Model 25.0a2, based on model 25.0a, uses the same selectivity pattern configuration as model 24.0b7.

The approach of mirroring selectivity parameters for the winter commercial and subsistence fisheries to those estimated for the winter pot survey was likely taken due to observations suggesting that large males may migrate offshore in the spring and summer before returning to near-shore waters in the late winter (Powell et al. 1983; Bell et al. 2016), meaning that the availability of large males could be different in the winter versus summer. However, sharing selectivity parameters between the summer and winter commercial fisheries may still be more appropriate than sharing selectivity parameters between the winter commercial fishery and the winter pot survey. Escape rings are required for king crab pots used in the Norton Sound summer and winter commercial fisheries (Alaska Admin Code 5 AAC 34.925), meaning that commercial pots may be less likely to capture small crab than survey pots without escape rings. Due to the lack of observers, data on the size composition of discarded and total catch are unavailable for the winter commercial fishery, but the percentages of retained winter commercial catch in each size bin are more similar to those in the summer commercial fishery retained catch than those in the winter pot survey catch (see section E.2.h, below). The selectivity configuration in models 24.0b7 and 25.0a2 reflects this rationale.

B. Responses to SSC and CPT comments

The status of SSC and CPT recommendations is summarized in Table 7.

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 will likely be discussed during the January 2026 CPT modeling workshop, 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.

We have used the CPT’s proposed descriptions of the concern levels in the NSRKC risk table presented here (Appendix B).

SSC comments specific to NSRKC assessment, June 2025

... the CPT recommended bringing forward 24.0b as the base model and 25.0a, which does not include shell condition for males, a fixed M of 0.23 for males less than 123mm and an estimated male M for those greater than 123mm. The SSC concurs with the models to be brought forward but requests an additional model based on 24.0b that explores alternative parameterizations of selectivity or, if necessary, constraining F to address high values of F seen in 24.0b. The SSC was generally not in favor of the latter option, as F is indirectly linked to the scale of the population and may lead to unrepresentative changes in reference points.

We bring forward six models in this document: 24.0b, 25.0a, and two models based on each of these that represent different approaches to addressing the high estimated fishing mortality (F) values for the winter commercial fishery. In the first approach, we used an upper bound on F borrowed from the current Bristol Bay red king crab stock assessment model for the winter commercial fishery (models 24.0b6 and 25.0a1). Use of this bound leads to lower, and likely more realistic, estimated F values (Figure 8). In the second approach, we used a different selectivity pattern for the winter commercial fishery than is used in the base model: rather than using the same, dome-shaped functional form for selectivity for the winter commercial fishery as is used for the winter pot survey, we used the same, asymptotic functional form for selectivity for the winter commercial fishery as is used for the summer commercial fishery (models 24.0b7 and 25.0a2). This change in the functional form for selectivity for the winter commercial fishery also leads to lower estimated F values (Figure 9).

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 continue to pursue development of model-based indices of abundance for NSRKC in a research model framework and presented this work at the September 2025 CPT meeting (Stern 2025b). We plan to present further updates in 2026.

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 is included in this assessment (Figure 10).

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 2.20.20, the same version used for the proposed models in May 2025.

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, presented in Appendix B.

CPT comments specific to NSRKC assessment, May 2025

The CPT recommended that the author investigate how realistic the parameter space explored in the MLE solution (24.0b) is, suggesting that a better approach would be to place a prior on F that would penalize high F values.

We present models employing an upper bound on F in this document (models 24.0b6 and 25.0a1).

The CPT recommended bringing forward models 24.0b (base) and 25.0a (no shell condition, M fixed at 0.23 for males ≤ 123 mm CL and estimated for males > 123 mm CL) for setting specifications in November. When bringing forward model 24.0b, the author should ensure the solution is at the actual MLE, and confirm that this MLE includes realistic explorations of the parameter space. This may include a prior on F to penalize solutions based on unrealistically high values for the winter commercial fishery.

We bring forward six models in this document: 24.0b, 25.0a, and two models based on each of these that represent different approaches to addressing the high estimated fishing mortality (F) values for the winter commercial fishery.

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.

Work on model-based abundance estimates for NSRKC continues, with preliminary results and research-track assessment models presented at the September 2025 CPT meeting (Stern 2025b).

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 B).

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 useful information on ecosystem considerations; this information was used in completion of the risk table.

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 B.

SSC comments specific to NSRKC assessment, December 2024

In response to a CPT and SSC request in October, jittering results were presented at the CPT meeting and a table of the results was provided in the assessment. The author indicated that both models performed acceptably. The SSC supports the CPT recommendation related to the presentation of this analysis, and further requests a full suite of diagnostics and sensitivities per best practices for the next cycle for the new GMACS model.

We present jittering results for models 24.0b, 24.0b6, 24.0b7, 25.0a, 25.0a1, and 25.0a2 below. We welcome feedback on the presentation of the jittering analysis and suggestions for further diagnostics that would be helpful in evaluating model performance.

There were two issues discovered with Model 24.0 that the author and CPT have prioritized for further work during this transition. First, the inclusion of the winter subsistence total catch data were problematic and these data were removed from the GMACS model. Second, the calculation of the OFL in the GMACS framework did not accommodate multiple fisheries operating at different times of the year, so OFL needed to be calculated outside of the assessment model. The SSC supports the resolution of these issues to finalize this transition.

At the CPT modeling workshop in January 2025, André Punt modified GMACS to enable calculation of the OFL when multiple fisheries occur at different times of year; we thank Dr. Punt for resolving this issue. Using GMACS version 2.20.20, we are able to correctly calculate the OFL for the Norton Sound red king crab stock. We have not yet resolved the issues with including the winter subsistence total catch data in the model; only winter subsistence retained catch data are included in the models presented here.

In terms of the buffer, the CPT recommended a continuation of the 30% buffer as the move to GMACS didn't directly address all of the persistent issues with this assessment. These include uncertainty in the biological characteristics of the stock; a lack of information on discards which makes it difficult to manage to a total mortality; overestimation of the largest male crab which can only be resolved with the higher M at the larger sizes classes and whether that is appropriate. The SSC noted that the concern over parameters on bounds had been alleviated, but the move to GMACS resulted in a higher retrospective bias than the previous model. For these reasons, the SSC concurs with the use of the 30% buffer for this assessment. The SSC requests the authors focus on addressing these issues, following finalization of the transition to GMACS.

We address some of these issues in this document and plan to address the others in future. We investigated whether excluding shell condition improves estimation of the largest male crab (models 25.0a, 25.0a1, 25.0a2). In proposed models presented to the CPT in May 2025, we examined the effects on model fits to size compositions of using a size-independent M and of using the M value estimated for the Bristol Bay red king crab stock (Palof 2025) both with shell condition included and with shell condition excluded; models 25.0a, 25.0a1, and 25.0a2 in this document all use the M value borrowed from BBRKC. We show the retrospective patterns for all of the models presented in this document. We do not address uncertainty in the biological characteristics of the stock and the lack of information on discards here but will investigate these issues in a future assessment cycle.

The SSC looks forward to the presentation of the author's work implementing model-based methodologies to develop a combined index for this stock and appreciate the progress made on the SSC's past comments on index standardization.

Work on model-based abundance estimates for NSRKC continues, with results and research-track assessment models presented at the September 2025 CPT meeting (Stern 2025b). We plan to present further progress on this work in 2026.

The SSC would be interested in seeing a model that uses a prior for a size-independent natural mortality from Bristol Bay red king crab, as a continuation of the model considered for harvest specifications in February 2024.

We presented models using an upper bound for size-independent natural mortality from Bristol Bay red king crab in May 2025; the CPT and SSC did not recommend bringing forward those models for this document.

The SSC also supports the other recommendations from the CPT, such as including fits to catch data in the assessment, investigating the retrospective pattern and reviewing how shell condition influences size composition fits.

In this document, we present models (25.0a, 25.0a1, and 25.0a2) with shell condition removed from the size compositions, such that males with both shell conditions (newshell and oldshell) are combined, and show the effects of shell condition removal on size composition fits. We include plots of model fits to catch data. We present plots showing retrospective patterns for all six of the models.

There were multiple readability issues noted in the current document and the SSC requests that this assessment be aligned with current standards outlined in the crab SAFE guidelines.

We have endeavored to align this document with the crab SAFE guidelines and ensure that readability issues are addressed.

CPT comments specific to NSRKC assessment, November 2024

The main difference between the bespoke model and 24.0 is that fishing mortality (i.e., catch) is subtracted exactly in the bespoke model, whereas model 24.0 estimates fishing mortality as a rate, F . Hamachan noted that the fits to total catch during the winter subsistence fishery were poor and this dataset was ultimately removed from model 24.0, although it was included in the bespoke model. Catch during the winter subsistence fishery is typically very minor, and fits to retained winter subsistence catch are included in model 24.0. Fits to catch data were not shown, but are requested for future assessments.

We show fits to catch data below. We have not yet determined how best to include total catch from the winter subsistence fishery in the model, but plan to explore this issue in a future assessment cycle.

The CPT requested that jitter results be presented as plots during the next cycle, following guidance for all assessments to be discussed at the January modeling workshop.

We present jitter results in Figure 11 and Table 8.

Model 24.0 had greater retrospective bias than the bespoke model, but there was not clear evidence as to a potential reason other than differences in model structure. It was noted that this retrospective analysis evaluated the projection year for both the bespoke model and 24.0, which may be more aptly interpreted as a one step ahead residual analysis. All other BSAI crab assessments evaluate retrospective bias without including the projection year.

We present retrospective analyses excluding the projection year below.

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 ($61^{\circ} 49'$ 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 0.18, used for males with CL ≤ 123 mm in models 24.0b, 24.0b6, and 24.0b7, was calculated using $M = -\ln(p)/t_{max}$, assuming that a proportion (p) equal to 0.01 of crab reach the estimated maximum age (t_{max}) of 25 years old (Hoenig 1983; Hamazaki 2024).

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 ≥ 4.75 inches carapace width (CW; Menard et al. 2022), which is approximately equivalent to ≥ 104 mm CL. In 2005 and 2006, commercial buyers, specifically the Norton Sound Economic Development Corporation (NSEDC), accepted only legal crab of ≥ 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 ≥ 5 inches CW. In 1978, legal size was changed to ≥ 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 1990's include super exclusive designation (1994), implementation of the CDQ allocation (1998), and implementation of the GHL (1999). In the 2000's, 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 ≥ 5 inches CW becoming the standard commercial retained size. In the 2010's, 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 into 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

For this assessment, we replicated the methods used in 2024 to analyze the data used in the model as closely as possible. We updated only the 2025 values for the harvest and abundance time series and the size compositions. We plan to present model runs using recalculated time series in May 2026, with data processing methods updated such that all time series are fully reproducible.

1. Summary of new information

The following time series were updated with 2025 data: winter subsistence fishery total and retained catch, winter commercial fishery retained catch, summer commercial fishery retained catch and size compositions, NOAA NBS trawl survey abundance and size compositions, and standardized summer commercial fishery CPUE.

2. Data which should be presented as time series

The data sources used in this assessment are summarized in Figure 1 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-present), and the Alaska Department of Fish and Game (ADF&G) trawl survey (1996-present). All 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. The only bycatch mortality in the federal groundfish fisheries that the authors were able to find occurred in the fixed gear fisheries and totaled 13 kg in 2018, 24 kg in 2019, and 4 kg in 2020. Bycatch mortality for all 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 biomass 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 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 nm² or 19,348 km²) than are those for the NOAA Norton Sound survey (7,600 nm² or 26,067 km²) (Hamazaki 2024). The abundance estimate from the ADF&G trawl survey is unexpanded, meaning it is likely an underestimate of stock abundance (Hamazaki 2024). Work to develop a spatiotemporal model-based index of abundance for the NSRKC trawl surveys with a consistent spatial area used for estimating abundance continues with research-track models (Stern 2025a, Stern 2025b) and updates will be presented in future assessment cycles.

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 this assessment, the authors observed that the spatial restrictions applied to the NOAA NBS trawl survey data set when calculating abundance estimates are not applied to the size composition data, meaning that the population of crab from which size composition data are drawn is 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 in future assessment cycles.

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 (2008-2025). 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 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).

Model changes since model 24.0 was accepted for use in the assessment include 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 (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. The model assumes that newshell crab are molted and oldshell crab are unmolted. Natural mortality is set to a fixed value for males with CL \leq 123 mm and estimated for males with CL $>$ 123 mm. For models 24.0b, 24.0b6, and 24.0b7, the fixed value of M is 0.18, while for models 25.0a, 25.0a1, and 25.0a2, the fixed value of M is 0.23. The timeline of events in the model is as follows:

- Model starts on February 1
- The initial population date is February 1, 1976, with the population consisting of newshell crab only
- 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 2.20.20, compiled with AD Model Builder 13.2. 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 9 - 11.

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.
- 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 at the same time.
- 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.
- 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 (Table 12). The 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.
- Summer commercial fishery selectivity is an asymptotic, one-parameter logistic function of length, with selectivity for length class 134 mm CL set to 1.0. Selectivity is constant over time.
- Selectivity for the winter commercial and subsistence fisheries is similar to selectivity for the winter pot survey, such that selectivity parameters for these fisheries are mirrored to those estimated for the winter pot survey.
- 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 crab stocks.

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

- The M value for males with $CL \leq 123$ mm is set to 0.18 for models 24.0b, 24.0b6, and 24.0b7, and to 0.23 for models 25.0a, 25.0a1, and 25.0a2.
- In the base model, 24.0b, the bounds on F for the winter commercial fishery include an upper bound

of 10 on the estimated annual male F , as for all of the other gear types in the model. In models 24.0b6 and 25.0a1, the upper bound on the estimated annual male F for the winter commercial fishery is changed to 2.95, a value borrowed from the BBRKC stock assessment model. In the BBRKC stock assessment model, the upper bound on estimated annual male F is 2.95 for the pot fishery and 10 for all of the other gear types.

- In the base model, 24.0b, selectivity parameters for the winter commercial and subsistence fisheries are mirrored to those estimated for the winter pot survey. This approach was likely taken due to observations suggesting that large males may migrate offshore in the spring and summer before returning to near-shore waters in the late winter (Powell et al. 1983; Bell et al. 2016), meaning that the availability of large males could be different in the winter versus summer. However, sharing selectivity parameters between the summer and winter commercial fisheries may still be more appropriate than sharing selectivity parameters between the winter commercial fishery and the winter pot survey. Escape rings are required for king crab pots used in the Norton Sound summer and winter commercial fisheries (Alaska Admin Code 5 AAC 34.925), meaning that commercial pots may be less likely to capture small crab than survey pots without escape rings. Due to the lack of observers, data on the size composition of discarded and total catch are unavailable for the winter commercial fishery, but the percentages of retained winter commercial catch in each size bin are more similar to those in the summer commercial fishery retained catch than those in the winter pot survey catch (Table 12; Figures 46, 47, 53). Reflecting this rationale, models 24.0b7 and 25.0a2 are configured such that selectivity parameters for the winter commercial and subsistence fisheries are mirrored to those estimated for the summer commercial fishery.

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 24.0b - May 2025: The model recommended as the new base model by the CPT and SSC in May and June 2025, respectively, with only the data that were available in May 2025. A bridging analysis comparing the recommended model from the 2024 SAFE (24.0) with model 24.0b was presented in the proposed model runs document from May 2025 (Stern and Palof 2025) and is not repeated here.

Model 24.0b: Model 24.0b with updated data, including catch information from the 2025 commercial and subsistence fisheries, size compositions from the 2025 summer commercial retained catch, and abundance and size composition information from the 2025 NOAA NBS trawl survey.

Model 25.0a: Model 24.0b with two modifications: 1) size composition data are combined for all males rather than being split into separate data sets for newshell males and oldshell males; and 2) natural mortality for males with carapace length (CL) ≤ 123 mm is fixed at the value estimated in the most recent BBRKC stock assessment (Palof 2025) rather than at 0.18, as in model 24.0b. For both models 24.0b and 25.0a, natural mortality is estimated for males with CL > 123 mm.

Model 24.0b6: Model 24.0b with an upper bound on the fishing mortality rate (F) for the winter commercial fishery, as requested by the CPT, in order to restrict the model from producing what CPT and SSC members thought were unrealistically high estimated F values for this fishery in some years of the time series.

The value for the upper bound was taken from the upper bound used for the pot fishery fishing mortality rate in the most recent version of the BBRKC model.

Model 24.0b7: An alternative approach to restricting the model from producing high estimated F values for the winter commercial fishery, model 24.0b7 follows the SSC’s recommendation of modifying model 24.0b by changing selectivity rather than using a different upper bound for F . In the base model, the selectivity pattern for the winter commercial fishery is specified as dome-shaped, with selectivity parameters shared among the winter commercial fishery, subsistence fishery, and winter pot survey, while the selectivity pattern for the summer commercial fishery is specified as logistic. Model 24.0b7 differs from the base model in instead specifying a logistic selectivity pattern with shared parameters for the winter commercial fishery, subsistence fishery, and summer commercial fishery, while the selectivity pattern for the winter pot survey remains dome-shaped.

Model 25.0a1: Model 25.0a with the same upper bound on F for the winter commercial fishery as in model 24.0b6.

Model 25.0a2: Model 25.0a with the same fishery selectivity pattern configuration as model 24.0b7.

b. Progression of results

The impacts of adding 2025 data can be observed by comparing models 24.0b - May and 24.0b. Fits to all catches (winter commercial retained, summer commercial retained, and subsistence retained) were improved for model 24.0b compared to model 24.0b - May (Table 9). Fits to indices of abundance were similar, with model 24.0b showing slightly improved fits to the NOAA NBS trawl survey index and slightly worse fits to the NOAA NS and ADF&G trawl survey indices compared to model 24.0b - May. Model 24.0b showed worse fits to the summer commercial fishery retained catch size compositions as well as the NBS trawl survey size compositions, and slightly better fits to the summer commercial fishery discard and ADF&G trawl survey size compositions (Table 9). The estimated mature male biomass trajectory is very similar for models 24.0b and 24.0b - May (Figure 15). Overall, the addition of 2025 data does not seem to have had unexpected or concerning effects on the base model fits or estimates. For results from all the models to be considered for harvest specifications, 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 25.0a, 25.0a1, and 25.0a2 represent simplifications of the base model due to excluding shell condition.

e. Convergence status/criteria

We used the default ADMB convergence criteria.

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

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 and shown in Table 8 and Figure 11.

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 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 24.0b, 24.0b6, 24.0b7, 25.0a, 25.0a1, and 25.0a2.

For each model, the jittering analysis appeared to identify the set of parameters corresponding to the minimum objective function value, with many model runs converging to the same minimum objective function value (Table 8, Figure 11). Higher proportions of model runs converged to the MLE for models 24.0b6, 24.0b7, 25.0a1, and 25.0a2 than for models 24.0b and 25.0a. Maximum gradients at the MLE were small for all models.

Fits to fishery catch data

Fits to fishery catch data are nearly identical among all six models (Figures 16 - 17 and Tables 10 - 11), demonstrating that removing shell condition and changing the value of natural mortality for males with $CL \leq 123$ mm 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 reference points. Approaches to including subsistence total catch data will be explored further in future iterations of this assessment.

Fits to abundance indices

Compared to the base model (24.0b), both models representing approaches to reducing high F estimates for the winter commercial fishery (24.0b6 and 24.0b7) have overall poorer fits to the abundance indices, showing improved fits only to the fishery CPUE indices from 1977-1992 and 1993-2006 (Figures 18 - 23 and Table

10). Compared to model 25.0a1, both models representing approaches to reducing high F estimates for the winter commercial fishery (25.0a1 and 25.0a2) show improved fits to the NOAA NBS survey index as well as to the fishery CPUE indices from 1977-1992 and 1993-2006 but poorer fits to the other indices of abundance (Figures 24 - 29 and Table 11). Overall fits to index data were better for models 25.0a1 and 25.0a2 than for models 24.0b6 and 24.0b7.

Fits to size compositions

Fits to size composition time series were generally similar among models 24.0b, 24.0b6, and 24.0b7, with models 24.0b6 and 24.0b7 having better fits to the winter commercial fishery retained catch size compositions and slightly worse fits to the ADF&G and NOAA NBS trawl survey size compositions (Figures 30 - 45 and Table 10). Fits to size composition time series were also similar among models 25.0a, 25.0a1, and 25.0a2, with models 25.0a1 and 25.0a2 having better fits to the winter commercial fishery retained catch, summer commercial fishery discard, summer commercial fishery total, and NOAA NS trawl survey size compositions (Figures 46 - 61 and Table 11). One-Step-Ahead residuals for model fits to size composition time series are shown in Figures 62 - 101.

Estimated population quantities

Recruitment

The base model (24.0b) estimates a recruitment trajectory notably different from those estimated by models 24.0b6 and 24.0b7, with higher estimated recruitments in the years leading up to 2014 (Figure 102). This is consistent with model 24.0b's better fit to the high estimated abundance in the ADF&G trawl survey in 2014 (Figure 18). Model 25.0a similarly estimates higher recruitments in the years before 2014 than do models 25.0a1 and 25.0a2 (Figure 103). Both approaches to reducing high F estimates for the winter commercial fishery appear to have the effect of moderating the spike in estimated recruitment in the years leading up to 2014.

Mature male biomass

Models 24.0b and 25.0a estimate mature male biomass (MMB) trajectories that differ from those of models 24.0b6, 24.0b7, 25.0a1, and 25.0a2 in that the scale of the population is higher in the years leading up to 2014, reflecting the better fits of models 24.0b and 25.0a to the ADF&G trawl survey time series, which documents high estimated abundance in 2014 (Figures 104 - 105). Estimated MMB trajectories are similar among all six models for the years 2020-2025.

Estimated fishery selectivity

Note that, in models 24.0b, 24.0b6, 25.0a, and 25.0a1, selectivity for the winter pot survey is specified as dome-shaped, and selectivity for the winter commercial and subsistence fisheries is mirrored to the selectivity estimated for the winter pot survey. Selectivity for the summer commercial fishery is asymptotic. In models 24.0b7 and 25.0a2, selectivity for the winter pot survey is also specified as dome-shaped, but selectivity for the winter commercial and subsistence fisheries is mirrored to the selectivity estimated for the summer commercial fishery. See section E.2.h. for the rationale behind this change in selectivity for the winter commercial and subsistence fisheries.

Compared to model 24.0b6, which uses an upper bound borrowed from the BBRKC stock assessment model for the winter commercial fishery F , model 24.0b estimates notably higher selectivity for all but the largest size classes in the winter commercial and subsistence fisheries, as well as the winter pot survey (Figure 106). Model 24.0b7 estimates selectivity in the winter pot survey similar to that for model 24.0b6. Similarly, model

25.0a estimates notably higher selectivity for all but the largest size classes in the winter commercial and subsistence fisheries, as well as the winter pot survey, than does model 25.0a1, which uses an upper bound borrowed from the BBRKC stock assessment model for the winter commercial fishery F (Figure 107). Model 25.0a2 estimates selectivity in the winter pot survey similar to that for model 25.0a.

Estimated survey selectivity

In the base model, survey selectivity is estimated only for the NOAA Norton Sound trawl survey. 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. Survey selectivity for the NOAA Norton Sound trawl survey is estimated to be equal to 1 for all 8 size bins. Selectivity for the winter pot survey is discussed in the previous section.

Estimated fishing mortality

Both approaches to producing more realistic estimates of fully-selected fishing mortality in the winter commercial fishery appear to be effective: models 24.0b6 and 24.0b7 both produce low and consistent estimates of F for the winter commercial fishery, as do models 25.0a1 and 25.0a2 (Figures 8 - 9). The choice between these approaches may therefore depend upon whether placing an upper bound on F or changing the functional form of selectivity for the winter commercial fishery is deemed more appropriate.

Estimated natural mortality

Estimated natural mortality for males with CL > 123 mm is slightly higher for models 24.0b6 and 24.0b7 than for model 24.0b (Figure 108), and similarly is higher for models 25.0a1 and 25.0a2 than for model 25.0a (Figure 109).

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 model 24.0 reported in the 2024 SAFE was 0.201 (Hamazaki 2024), indicating that MMB estimates generally increased as each year of data was removed.

The retrospective pattern for the base model (24.0b) is less extreme (Mohn’s $\rho = 0.089$) than for models 24.0b6 (Mohn’s $\rho = 0.160$) and 24.0b7 (Mohn’s $\rho = 0.175$) (Figures 110 - 112). Similarly, the retrospective pattern for model 25.0a is less extreme (Mohn’s $\rho = 0.064$) than for models 25.0a1 (Mohn’s $\rho = 0.119$) and 25.0a2 (Mohn’s $\rho = 0.126$) (Figures 113 - 115). Retrospective patterns are less extreme for the models without shell condition and with a higher natural mortality value for males with CL \leq 123 mm (models 25.0a, 25.0a1, and 25.0a2), indicating that these models may have an improved ability to estimate stock biomass in the terminal year.

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 models 24.0b6, 24.0b7, 25.0a1, and 25.0a2 are summarized in Tables 13 - 16. Estimated standard deviations of mature male biomass and male recruitment for models 24.0b and 25.0 are listed in Tables 17 - 20. The probability density function of the OFL for models 24.0b6, 24.0b7, 25.0a1, and 25.0a2 is shown in Figures 3 - 6.

Comparison of alternative model scenarios

Both the base model (24.0b) and the version of that model updated to better align with other BSAI king crab assessment models (25.0a, with $M = 0.23$ and shell condition excluded as for BBRKC and St. Matthew Island blue king crab) estimate F values for the winter commercial fishery in approximately 2010 - 2020 that were considered unrealistically high by the CPT and SSC when the models were reviewed in May/June 2025. The authors do not recommend using either of these models for harvest specifications. The factors driving the high estimated F values remain unknown. The initial hypothesis that the model's attempt to fit the high ADF&G survey abundance estimate in 2014 led to high estimated recruitment followed by high estimated F was not supported: a model run with the 2014 ADF&G survey abundance estimate removed still estimated high F values for the winter commercial fishery in 2010 - 2020.

Models 24.0b6, 24.0b7, 25.0a1, and 25.0a2 use two alternative approaches for addressing the problems with F estimation, following CPT and SSC recommendations. Models 24.0b6 and 25.0a1 use an upper bound on F for the winter commercial fishery borrowed from the BBRKC stock assessment, while models 24.0b7 and 25.0a2 are configured such that selectivity for the winter commercial fishery shares parameters with the summer commercial fishery rather than the winter pot survey. Both of these approaches lead to lower and likely more realistic estimates of F for the winter commercial fishery. Models 24.0b6 and 24.0b7 have nearly identical fits to the data sources, as do models 25.0a1 and 25.0a2.

While the authors think that all four of these models are viable candidates to use for harvest specifications, the authors think that models 25.0a1 and 25.0a2 are preferable to models 24.0b6 and 24.0b7 for the following reasons. First, excluding shell condition eliminates a source of uncertainty unaccounted for in the models, which currently assume that newshell versus oldshell classifications are made with complete accuracy. Second, using the M value estimated in the most recent BBRKC stock assessment for NSRKC males with $CL \leq 123$ mm leverages the greater data availability for the BBRKC stock to better inform assessment of the NSRKC stock. Third, models 25.0a1 and 25.0a2 both have less extreme retrospective patterns than do models 24.0b6 and 24.0b7, potentially indicating improved ability to predict stock biomass in the terminal year.

The choice between models 25.0a1 and 25.0a2 rests primarily upon whether placing an upper bound on F or changing the functional form of selectivity for the winter commercial fishery is deemed more appropriate. Using an upper bound on F for the winter commercial fishery would align with the approach taken in the BBRKC stock assessment model, and the authors consider model 25.0a1 a good option for 2026 harvest specifications. However, as the SSC noted in June 2025, using an alternative parameterization of selectivity is likely the preferable approach given that F is indirectly linked to the scale of the population. In addition, sharing selectivity parameters between the summer and winter commercial fisheries may be more appropriate than sharing selectivity parameters between the winter commercial fishery and the winter pot survey. Escape rings are required for king crab pots used in the Norton Sound summer and winter commercial fisheries (Alaska Admin Code 5 AAC 34.925), meaning that commercial pots may be less likely to capture small crab than survey pots without escape rings. Due to the lack of observers, data on the size composition of discarded and total catch are unavailable for the winter commercial fishery, but the percentages of retained winter commercial catch in each size bin are more similar to those in the summer commercial fishery retained catch than those in the winter pot survey catch (Table 12; Figures 46, 47, 53). The authors thus recommend model 25.0a2 for 2026 harvest specifications.

Stock projections

Projections for this stock will be shown following the development of guidance on the appropriate way to use the GMACS projection module for tier 4 stocks; the CPT plans to take up this issue during the January 2026 modeling workshop.

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

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

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

where B is quantified as mature male biomass (MMB) at mating and, under Tier 4, $F_{MSY} = M$.

Table 5: Comparisons of management measures for models 24.0b, 24.0b6, and 24.0b7. Biomass and OFL are in 1,000 tons. Model 24.0b is the base model. Model 24.0b6 is model 24.0b with an upper bound on fishing mortality for the winter commercial fishery borrowed from the Bristol Bay red king crab assessment. Model 24.0b7 is model 24.0b with selectivity for the winter commercial fishery sharing parameters with selectivity for the summer commercial fishery rather than the winter pot survey.

Model	MMB ₂₀₂₆	B_{MSY}	MMB/B_{MSY}	F_{OFL}	OFL ₂₀₂₆	ABC ₂₀₂₆	MSST	M
24.0b	1.54	2.08	0.74	0.128	0.062	0.044	1.04	0.18
24.0b6	1.58	1.92	0.82	0.145	0.158	0.111	0.96	0.18
24.0b7	1.57	1.92	0.82	0.144	0.169	0.118	0.96	0.18

Table 6: Comparisons of management measures for model 25.0a, 25.0a1, and 25.0a2. Biomass and OFL are in 1,000 tons. Model 25.0a is model 24.0b with 1) shell condition removed, and 2) natural mortality for small males fixed at 0.23 rather than 0.18. Model 25.0a1 is model 25.0a with an upper bound on fishing mortality for the winter commercial fishery borrowed from the Bristol Bay red king crab assessment. Model 25.0a2 is model 25.0a with selectivity for the winter commercial fishery sharing parameters with selectivity for the summer commercial fishery rather than the winter pot survey.

Model	MMB ₂₀₂₆	B_{MSY}	MMB/B_{MSY}	F_{OFL}	OFL ₂₀₂₆	ABC ₂₀₂₆	MSST	M
25.0a	1.55	2.10	0.74	0.163	0.086	0.060	1.05	0.23
25.0a1	1.57	2.01	0.78	0.175	0.186	0.130	1.00	0.23
25.0a2	1.56	2.00	0.78	0.173	0.193	0.135	1.00	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 2023-2024 (Appendix A). The CPT and SSC recommended an ABC buffer of 30% for setting harvest specifications for 2025 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 using a size-independent M , as do other BSAI crab stock assessment models; and 5) a retrospective pattern in model-estimated mature male biomass. Given that these concerns are largely unchanged, the authors recommend using a 30% buffer again for the 2026 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 is 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. Other priorities include exploring 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 7: Status of recommendations made by the Scientific and Statistical Committee (SSC) and Crab Plan Team (CPT) for the Norton Sound red king crab assessment model and for Bering Sea/Aleutian Islands crab models in general. Recommendations addressed in the current document are listed first, followed by recommendations that will be addressed in future iterations of the assessment.

Recommendation	Date	Body	Status
Consistent structure, content for crab SAFE documents	10/2025	SSC	Addressed here
Use different descriptions of risk table concern levels	09/2025	CPT	Addressed here
Address high F using prior or selectivity parameterization	6/2025	CPT and SSC	Addressed here
Provide risk table that follows guidelines	6/2025	CPT and SSC	Addressed here
Develop model-based indices of abundance	6/2025	CPT and SSC	In progress
Provide historical retrospective plot	6/2025	SSC	Addressed here
Identify GMACS version used and track changes	6/2025	SSC	Addressed here
Summarize ABC buffer history over past 5 years	6/2025	SSC	Addressed here
Present jittering results as plots	12/2024	CPT and SSC	Addressed here
Full suite of diagnostics and sensitivities	12/2024	SSC	Addressed here
Calculate OFL within GMACS	12/2024	CPT and SSC	Addressed here
Address overestimation of largest male crab	12/2024	CPT and SSC	Addressed here
Evaluate use of size-dependent M	12/2024	CPT and SSC	Addressed in May 2025
Evaluate model-based indices of abundance	12/2024	CPT and SSC	In progress
Use prior from BBRKC for size-independent M	12/2024	SSC	Addressed here
Include fits to catch data	12/2024	CPT and SSC	Addressed here
Investigate retrospective patterns	12/2024	CPT and SSC	Addressed here
Review shell condition effects on size comp fits	12/2024	CPT and SSC	Addressed here
Align document with crab SAFE guidelines	12/2024	SSC	Addressed here
Additional residual diagnostics for size comp data	10/2024	SSC	Addressed here
Individual plots of fits to survey indices	9/2024	CPT	Addressed here
Use realistic estimate of future catches in projections	10/2025	SSC	Not yet addressed
Include winter subsistence total catch data	12/2024	CPT and SSC	Not yet addressed
Address uncertainty about stock biology	12/2024	CPT and SSC	Not yet addressed
Address lack of discard information	12/2024	CPT and SSC	Not yet addressed

Table 8: Summary of convergence diagnostics from jitter runs.

Model	Parameters	Jitter.runs	Converged.to.MLE	Objective.function.value	Max.gradient
24.0b	230	200	21	4226.31	0.000014
24.0b6	230	200	154	4228.64	0.000001
24.0b7	230	200	163	4228.91	0.000018
25.0a	230	200	9	2512.98	0.000008
25.0a1	230	200	106	2513.41	0.000213
25.0a2	230	200	107	2513.88	0.000278

Table 9: Comparisons of negative log-likelihood values for the base model, 24.0b, without 2025 data (24.0b - May) and with 2025 data (24.0b).

Component	24.0b - May	24.0b
Winter comm. retained catch	-119.03	-121.62
Subsistence retained catch	-121.63	-124.22
Subsistence total catch	0.00	0.00
Summer comm. retained catch	-116.45	-119.03
NMFS trawl survey 1976-1991	-3.57	-3.53
ADF&G trawl survey	-7.05	-6.91
NOAA NBS survey	-5.52	-5.62
Fishery CPUE 1977-1992	-2.70	-2.67
Fishery CPUE 1993-2006	-4.95	-4.93
Fishery CPUE 2007-2024	-13.24	-14.25
Winter com. retained size comp.	57.08	57.13
Summer com. retained size comp.	703.53	721.55
Summer com. discard size comp.	280.04	279.98
Summer com. total size comp	216.45	216.61
NMFS trawl survey size comp.	316.81	316.14
ADF&G trawl survey size comp.	280.61	278.95
NBS trawl survey size comp.	155.40	188.98
Winter pot survey size comp.	614.68	614.86
Recruitment deviations	52.33	54.30
Tagging	1724.14	1726.20
Growth	1724.14	1726.20
F penalty	14.21	14.21
Prior	95.34	95.22
Total	4180.59	4226.31
Total estimated parameters	226.00	230.00

Table 10: Comparisons of negative log-likelihood values for models 24.0b, 24.0b6, and 24.0b7. Model 24.0b is the base model. Model 24.0b6 is model 24.0b with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab stock assessment. Model 24.0b7 is model 24.0b with selectivity parameters for the winter commercial fishery shared with the summer commercial fishery.

Component	24.0b	24.0b6	24.0b7
Winter comm. retained catch	-121.62	-121.63	-121.63
Subsistence retained catch	-124.22	-124.22	-124.22
Subsistence total catch	0.00	0.00	0.00
Summer comm. retained catch	-119.03	-119.03	-119.03
NMFS trawl survey 1976-1991	-3.53	-3.27	-3.30
ADF&G trawl survey	-6.91	-3.81	-3.45
NOAA NBS survey	-5.62	-5.57	-5.54
Fishery CPUE 1977-1992	-2.67	-2.97	-2.98
Fishery CPUE 1993-2006	-4.93	-5.07	-5.07
Fishery CPUE 2007-2025	-14.25	-11.94	-11.63
Winter com. retained size comp.	57.13	50.99	50.98
Summer com. retained size comp.	721.55	721.54	721.61
Summer com. discard size comp.	279.98	279.64	279.50
Summer com. total size comp.	216.61	216.81	216.75
NMFS trawl survey size comp.	316.14	317.04	316.94
ADF&G trawl survey size comp.	278.95	281.12	281.18
NBS trawl survey size comp.	188.98	191.31	191.49
Winter pot survey size comp.	614.86	613.90	613.53
Recruitment deviations	54.30	52.79	52.78
Tagging	1726.20	1726.67	1726.66
Growth	1726.20	1726.67	1726.66
F penalty	14.21	14.21	14.21
Prior	95.22	95.37	95.36
Total	4226.31	4228.64	4228.91
Total estimated parameters	230.00	230.00	230.00

Table 11: Comparisons of negative log-likelihood values for models 25.0a, 25.0a1, and 25.0a2. Model 25.0a is model 24.0b with shell condition excluded and with natural mortality for small males fixed at 0.23 rather than 0.18. Model 25.0a1 is model 25.0a with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab stock assessment. Model 25.0a2 is model 25.0a with selectivity parameters for the winter commercial fishery shared with the summer commercial fishery.

Component	25.0a	25.0a1	25.0a2
Winter comm. retained catch	-121.63	-121.63	-121.63
Subsistence retained catch	-124.22	-124.22	-124.22
Subsistence total catch	0.00	0.00	0.00
Summer comm. retained catch	-119.04	-119.04	-119.03
NMFS trawl survey 1976-1991	-3.38	-3.17	-3.18
ADF&G trawl survey	-6.25	-4.74	-4.56
NOAA NBS survey	-5.55	-5.64	-5.63
Fishery CPUE 1977-1992	-3.34	-3.60	-3.63
Fishery CPUE 1993-2006	-6.85	-6.91	-6.89
Fishery CPUE 2007-2025	-15.39	-13.78	-13.63
Winter com. retained size comp.	26.04	22.30	22.69
Summer com. retained size comp.	279.38	279.54	279.51
Summer com. discard size comp.	108.11	107.75	107.72
Summer com. total size comp.	79.48	78.93	78.92
NMFS trawl survey size comp.	45.22	45.16	45.17
ADF&G trawl survey size comp.	114.51	116.03	115.96
NBS trawl survey size comp.	56.56	57.41	57.48
Winter pot survey size comp.	303.18	302.79	302.63
Recruitment deviations	51.71	51.20	51.16
Tagging	1688.88	1689.51	1689.52
Growth	1688.88	1689.51	1689.52
F penalty	14.21	14.21	14.21
Prior	95.23	95.44	95.46
Total	2512.98	2513.41	2513.88
Total estimated parameters	230.00	230.00	230.00

Table 12: Percentage of crab in each size bin by fleet. Totals may not sum to 100 due to rounding. SC = summer commercial fishery; WC = winter commercial fishery.

Size class midpoint	ADFG survey	NBS survey	NS survey	SC retain	SC discard	SC total	WC	Winter pot survey
68	16	12	14	0	12	6	0	2
78	15	14	9	0	16	6	0	10
88	16	15	11	0	24	8	0	20
98	15	17	14	2	37	15	3	24
108	16	16	20	31	10	23	38	23
118	14	15	20	39	1	24	38	15
128	7	9	10	21	0	13	17	5
138	2	2	3	7	0	3	4	1

Table 13: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 24.0b6, the base model with an upper bound on F for the winter commercial fishery.

Count	Parameter	Estimate	SE
1	Log(Rinitial):	9.1239	0.1135
2	Log(Rbar):	6.2575	0.1483
3	Recruitment_ra-males:	72.9231	1.9352
4	Recruitment_rb-males:	0.0696	0.4857
5	Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1780	0.4063
6	Scaled_logN_for_male_mature_mature_newshell_class_3:	0.6881	0.3732
7	Scaled_logN_for_male_mature_mature_newshell_class_4:	0.9128	0.3580
8	Scaled_logN_for_male_mature_mature_newshell_class_5:	0.8620	0.3369
9	Scaled_logN_for_male_mature_mature_newshell_class_6:	0.3188	0.3640
10	Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3687	0.4185
11	Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.6894	0.4531
12	Alpha_base_male:	35.0909	1.1375
13	Beta_base_male:	0.2227	0.0115
14	Gscale_base_male:	3.8465	0.1347
15	Molt_probability_mu_base_male_period_1:	124.8130	1.2174
16	Molt_probability_CV_base_male_period_1:	0.1273	0.0061
17	Sel_Winter_Com_male_base_Dec_Logistic_cv:	0.5709	0.0332
18	Sel_Winter_Com_male_base_Dec_Logistic_cv:	4.7647	0.0585
19	Sel_Winter_Com_male_base_Dec_Logistic_extra_par1:	-2.4900	0.3000
20	Sel_Winter_Com_male_base_Dec_Logistic_extra_par2:	-2.8142	0.3879
21	Sel_Winter_Com_male_base_Dec_Logistic_extra_par3:	-0.8678	0.2650
22	Sel_Summer_Com_male_base_Dec_Logistic_mean:	-0.3558	0.2507

23	Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.0900	0.0286
24	Ret_Winter_Com_male_base_Logistic_mean:	-11.5106	9.2059
25	Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6634	0.0211
26	Ret_Subistence_male_base_class_1:	1.0496	0.3034
27	Ret_Summer_Com_male_base_Logistic_cv:	4.6428	0.0058
28	Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8547	0.0967
29	Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6653	0.0055
30	Log_vn_aggregated_size_comp1:	0.8775	0.1217
31	Log_fbar_Winter_Com:	-5.5929	0.3320
32	Log_fbar_Subistence:	-5.5237	2.2481
33	Log_fbar_Summer_Com:	-2.1632	0.7136
225	Survey_q_survey_1:	0.7727	0.1371
226	Survey_q_survey_3:	0.7215	0.1291
227	Survey_q_survey_4:	0.0007	0.0001
228	Survey_q_survey_5:	0.0014	0.0002
229	Survey_q_survey_6:	0.0011	0.0001
230	Log_add_cvt_survey_4:	-1.0529	0.1460

Table 14: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 24.0b7, the base model with selectivity parameters for the winter commercial fishery shared with the summer commercial fishery.

Count	Parameter	Estimate	SE
1	Log(Rinitial):	9.1239	0.1135
2	Log(Rbar):	6.2575	0.1483
3	Recruitment_ra-males:	72.9231	1.9352
4	Recruitment_rb-males:	0.0696	0.4857
5	Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1780	0.4063
6	Scaled_logN_for_male_mature_mature_newshell_class_3:	0.6881	0.3732
7	Scaled_logN_for_male_mature_mature_newshell_class_4:	0.9128	0.3580
8	Scaled_logN_for_male_mature_mature_newshell_class_5:	0.8620	0.3369
9	Scaled_logN_for_male_mature_mature_newshell_class_6:	0.3188	0.3640
10	Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3687	0.4185
11	Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.6894	0.4531
12	Alpha_base_male:	35.0909	1.1375
13	Beta_base_male:	0.2227	0.0115
14	Gscale_base_male:	3.8465	0.1347
15	Molt_probability_mu_base_male_period_1:	124.8130	1.2174
16	Molt_probability_CV_base_male_period_1:	0.1273	0.0061
17	Sel_Winter_Com_male_base_Dec_Logistic_cv:	0.5709	0.0332
18	Sel_Winter_Com_male_base_Dec_Logistic_cv:	4.7647	0.0585
19	Sel_Winter_Com_male_base_Dec_Logistic_extra_par1:	-2.4900	0.3000
20	Sel_Winter_Com_male_base_Dec_Logistic_extra_par2:	-2.8142	0.3879
21	Sel_Winter_Com_male_base_Dec_Logistic_extra_par3:	-0.8678	0.2650
22	Sel_Summer_Com_male_base_Dec_Logistic_mean:	-0.3558	0.2507
23	Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.0900	0.0286
24	Ret_Winter_Com_male_base_Logistic_mean:	-11.5106	9.2059
25	Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6634	0.0211
26	Ret_Subsistence_male_base_class_1:	1.0496	0.3034
27	Ret_Summer_Com_male_base_Logistic_cv:	4.6428	0.0058
28	Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8547	0.0967
29	Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6653	0.0055
30	Log_vn_aggregated_size_comp1:	0.8775	0.1217
31	Log_fbar_Winter_Com:	-5.5929	0.3320
32	Log_fbar_Subsistence:	-5.5237	2.2481
33	Log_fbar_Summer_Com:	-2.1632	0.7136
225	Survey_q_survey_1:	0.7727	0.1371
226	Survey_q_survey_3:	0.7215	0.1291

227	Survey_q_survey_4:	0.0007	0.0001
228	Survey_q_survey_5:	0.0014	0.0002
229	Survey_q_survey_6:	0.0011	0.0001
230	Log_add_cvt_survey_4:	-1.0529	0.1460

Table 15: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 25.0a1, the model with no shell condition, M for small males fixed at 0.23, and an upper bound on F for the winter commercial fishery.

Count	Parameter	Estimate	SE
1	Log(Rinitial):	9.2582	0.1446
2	Log(Rbar):	6.4817	0.1512
3	Recruitment_ra-males:	72.8117	2.6585
4	Recruitment_rb-males:	0.0858	0.6896
5	Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1319	0.4318
6	Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4146	0.4194
7	Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6268	0.4055
8	Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6149	0.3965
9	Scaled_logN_for_male_mature_mature_newshell_class_6:	0.2889	0.4034
10	Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3106	0.4388
11	Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.5208	0.4688
12	Alpha_base_male:	40.1724	2.7598
13	Beta_base_male:	0.2869	0.0313
14	Gscale_base_male:	4.8490	0.2715
15	Molt_probability_mu_base_male_period_1:	134.7007	9.1566
16	Molt_probability_CV_base_male_period_1:	0.0712	0.0117
17	Sel_Winter_Com_male_base_Dec_Logistic_cv:	0.5784	0.0450
18	Sel_Winter_Com_male_base_Dec_Logistic_cv:	4.7807	0.0740
19	Sel_Winter_Com_male_base_Dec_Logistic_extra_par1:	-2.4805	0.4410
20	Sel_Winter_Com_male_base_Dec_Logistic_extra_par2:	-2.8525	0.5298
21	Sel_Winter_Com_male_base_Dec_Logistic_extra_par3:	-0.8835	0.3531
22	Sel_Summer_Com_male_base_Dec_Logistic_mean:	-0.2469	0.3302
23	Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.1010	0.0392
24	Ret_Winter_Com_male_base_Logistic_mean:	-11.5054	29.7938
25	Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6522	0.0351
26	Ret_Subsistence_male_base_class_1:	0.9395	0.5223
27	Ret_Summer_Com_male_base_Logistic_cv:	4.6445	0.0080
28	Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8513	0.1351
29	Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6654	0.0076
30	Log_vn_aggregated_size_comp1:	0.8616	0.1679
31	Log_fbar_Winter_Com:	-5.8385	0.3898
32	Log_fbar_Subsistence:	-5.6444	2.2551
33	Log_fbar_Summer_Com:	-2.1975	0.7147
225	Survey_q_survey_1:	0.7457	0.1461
226	Survey_q_survey_3:	0.7104	0.1278

227	Survey_q_survey_4:	0.0007	0.0002
228	Survey_q_survey_5:	0.0013	0.0002
229	Survey_q_survey_6:	0.0011	0.0001
230	Log_add_cvt_survey_4:	-1.1902	0.1565

Table 16: Summary of Norton Sound red king crab estimated model parameter values and standard errors (SE) for model 25.0a2, the model with no shell condition, M for small males fixed at 0.23, and selectivity parameters for the winter commercial fishery shared with the summer commercial fishery.

Count	Parameter	Estimate	SE
1	Log(Rinitial):	9.2686	0.1465
2	Log(Rbar):	6.4795	0.1514
3	Recruitment_ra-males:	72.8124	2.6401
4	Recruitment_rb-males:	0.0847	0.6769
5	Scaled_logN_for_male_mature_mature_newshell_class_2:	-0.1337	0.4316
6	Scaled_logN_for_male_mature_mature_newshell_class_3:	0.4131	0.4194
7	Scaled_logN_for_male_mature_mature_newshell_class_4:	0.6270	0.4054
8	Scaled_logN_for_male_mature_mature_newshell_class_5:	0.6167	0.3965
9	Scaled_logN_for_male_mature_mature_newshell_class_6:	0.2914	0.4034
10	Scaled_logN_for_male_mature_mature_newshell_class_7:	-0.3079	0.4389
11	Scaled_logN_for_male_mature_mature_newshell_class_8:	-0.5180	0.4690
12	Alpha_base_male:	40.1553	2.7687
13	Beta_base_male:	0.2867	0.0315
14	Gscale_base_male:	4.8483	0.2722
15	Molt_probability_mu_base_male_period_1:	134.6975	9.1943
16	Molt_probability_CV_base_male_period_1:	0.0713	0.0117
17	Sel_Winter_Com_male_base_Dec_Logistic_mean:	0.5804	0.0453
18	Sel_NMFS_Trawl_male_base_Dec_Logistic_mean:	-2.1011	0.0391
19	Sel_Winter_Pot_male_base_Dec_Logistic_cv:	-11.5049	31.0374
20	Sel_Winter_Pot_male_base_Dec_Logistic_cv:	4.7921	0.0525
21	Sel_Winter_Pot_male_base_Dec_Logistic_extra_par1:	-2.3194	0.4273
22	Sel_Winter_Pot_male_base_Dec_Logistic_extra_par2:	-2.7896	0.4981
23	Sel_Winter_Pot_male_base_Dec_Logistic_extra_par3:	-0.8198	0.3049
24	Ret_Winter_Com_male_base_Logistic_mean:	-0.1865	0.2770
25	Ret_Winter_Com_male_Logistic_cv_block_group_2_block_1:	4.6070	0.0109
26	Ret_Subistence_male_base_class_1:	0.0000	0.0864
27	Ret_Summer_Com_male_base_Logistic_cv:	4.6444	0.0080
28	Ret_Summer_Com_male_Logistic_mean_block_group_1_block_1:	0.8512	0.1352
29	Ret_Summer_Com_male_Logistic_cv_block_group_1_block_1:	4.6658	0.0076
30	Log_vn_aggregated_size_comp1:	0.8632	0.1682
31	Log_fbar_Winter_Com:	-6.5402	0.7134
32	Log_fbar_Subistence:	-6.1257	2.2379
33	Log_fbar_Summer_Com:	-2.1950	0.7148
225	Survey_q_survey_1:	0.7356	0.1452

226	Survey_q_survey_3:	0.7160	0.1289
227	Survey_q_survey_4:	0.0007	0.0002
228	Survey_q_survey_5:	0.0013	0.0002
229	Survey_q_survey_6:	0.0011	0.0001
230	Log_add_cvt_survey_4:	-1.1842	0.1562

Table 17: Norton Sound red king crab estimated mature male biomass (MMB), male recruit biomass, and standard deviations (SD) for model 24.0b6, in million lb.

Year	MMB	SD MMB	Male recruits	SD male recruits
1976	15.14	2.40	0.29	0.15
1977	16.94	2.03	0.22	0.09
1978	15.67	1.71	0.23	0.08
1979	11.39	1.30	0.86	0.24
1980	6.26	0.94	1.12	0.27
1981	4.27	0.71	1.02	0.24
1982	3.32	0.68	1.08	0.28
1983	4.16	0.77	1.12	0.27
1984	4.81	0.87	0.71	0.18
1985	5.44	0.97	0.87	0.22
1986	5.78	1.03	0.59	0.15
1987	5.69	1.02	0.62	0.14
1988	5.61	0.98	0.63	0.15
1989	5.35	0.90	0.44	0.11
1990	5.03	0.82	0.45	0.11
1991	4.70	0.73	0.36	0.10
1992	4.45	0.63	0.28	0.08
1993	4.05	0.54	0.28	0.08
1994	3.37	0.46	0.40	0.09
1995	2.74	0.38	0.57	0.11
1996	2.29	0.34	1.09	0.21
1997	2.27	0.34	0.50	0.13
1998	2.87	0.39	0.22	0.07
1999	3.74	0.47	0.45	0.12
2000	3.98	0.49	0.74	0.16
2001	3.55	0.46	0.70	0.14
2002	3.37	0.43	0.42	0.12
2003	3.52	0.44	0.34	0.10
2004	3.58	0.44	0.80	0.15
2005	3.32	0.41	0.94	0.17
2006	3.10	0.38	1.08	0.20
2007	3.32	0.39	0.99	0.18
2008	3.94	0.44	0.60	0.15
2009	4.55	0.49	0.36	0.09
2010	4.89	0.52	0.56	0.11
2011	4.63	0.50	0.75	0.14
2012	4.11	0.44	1.44	0.18
2013	3.73	0.41	0.44	0.10
2014	4.01	0.41	0.21	0.06
2015	4.53	0.43	0.20	0.04
2016	4.11	0.41	0.36	0.06
2017	3.34	0.36	0.52	0.09
2018	2.57	0.30	2.16	0.30
2019	2.30	0.28	1.53	0.26
2020	3.33	0.36	0.72	0.16
2021	5.64	0.58	0.45	0.11
2022	7.20	0.72	0.16	0.05
2023	7.09	0.75	0.18	0.06
2024	6.07	0.69	0.17	0.07
2025	4.67	0.58	0.32	0.22

Table 18: Norton Sound red king crab estimated mature male biomass (MMB), male recruits, and standard deviations (SD) for model 24.0b7, in million lb.

Year	MMB	SD MMB	Male recruits	SD male recruits
1976	15.27	2.44	0.29	0.15
1977	17.08	2.07	0.23	0.09
1978	15.80	1.75	0.23	0.08
1979	11.50	1.34	0.88	0.24
1980	6.35	0.97	1.14	0.27
1981	4.34	0.73	1.03	0.24
1982	3.39	0.71	1.09	0.29
1983	4.24	0.79	1.14	0.28
1984	4.90	0.89	0.72	0.19
1985	5.54	1.00	0.89	0.22
1986	5.89	1.06	0.59	0.15
1987	5.79	1.05	0.63	0.14
1988	5.71	1.00	0.64	0.15
1989	5.44	0.92	0.44	0.11
1990	5.11	0.83	0.45	0.11
1991	4.76	0.74	0.36	0.10
1992	4.50	0.64	0.27	0.08
1993	4.09	0.55	0.28	0.08
1994	3.40	0.46	0.40	0.09
1995	2.76	0.39	0.57	0.11
1996	2.30	0.35	1.09	0.21
1997	2.28	0.34	0.50	0.13
1998	2.88	0.39	0.22	0.07
1999	3.74	0.48	0.44	0.12
2000	3.99	0.49	0.74	0.16
2001	3.56	0.46	0.69	0.14
2002	3.37	0.43	0.42	0.12
2003	3.52	0.44	0.34	0.10
2004	3.57	0.44	0.79	0.15
2005	3.31	0.41	0.92	0.16
2006	3.08	0.38	1.05	0.20
2007	3.27	0.39	0.95	0.18
2008	3.87	0.42	0.57	0.14
2009	4.44	0.48	0.35	0.09
2010	4.75	0.50	0.53	0.10
2011	4.47	0.47	0.72	0.13
2012	3.94	0.42	1.44	0.18
2013	3.56	0.39	0.44	0.10
2014	3.85	0.39	0.22	0.06
2015	4.41	0.42	0.20	0.04
2016	4.03	0.40	0.36	0.06
2017	3.30	0.35	0.52	0.09
2018	2.56	0.30	2.15	0.29
2019	2.30	0.28	1.51	0.26
2020	3.33	0.36	0.71	0.16
2021	5.62	0.58	0.45	0.11
2022	7.17	0.72	0.16	0.05
2023	7.05	0.74	0.18	0.06
2024	6.04	0.69	0.17	0.07
2025	4.64	0.58	0.32	0.22

Table 19: Norton Sound red king crab estimated mature male biomass (MMB), male recruits, and standard deviations (SD) for model 25.0a1, in million lb.

Year	MMB	SD MMB	Male recruits	SD male recruits
1976	17.98	3.52	0.43	0.26
1977	18.82	2.83	0.30	0.13
1978	16.64	2.26	0.28	0.11
1979	11.67	1.62	0.65	0.26
1980	6.21	1.11	1.54	0.43
1981	4.03	0.80	1.26	0.37
1982	3.08	0.76	1.22	0.42
1983	4.23	0.92	1.25	0.40
1984	5.03	1.06	0.92	0.29
1985	5.65	1.18	1.03	0.34
1986	5.92	1.24	0.69	0.23
1987	5.80	1.21	0.70	0.20
1988	5.67	1.15	0.74	0.22
1989	5.33	1.05	0.50	0.16
1990	4.96	0.94	0.61	0.18
1991	4.58	0.84	0.46	0.16
1992	4.33	0.72	0.51	0.18
1993	4.00	0.63	0.48	0.16
1994	3.44	0.54	0.55	0.16
1995	3.03	0.48	0.72	0.18
1996	2.76	0.45	1.39	0.34
1997	2.85	0.46	0.62	0.21
1998	3.60	0.52	0.29	0.11
1999	4.49	0.64	0.50	0.19
2000	4.55	0.62	1.05	0.27
2001	3.93	0.56	0.76	0.20
2002	3.74	0.54	0.52	0.18
2003	3.95	0.57	0.47	0.17
2004	3.92	0.56	0.90	0.24
2005	3.58	0.51	1.08	0.26
2006	3.36	0.47	1.32	0.32
2007	3.58	0.49	1.20	0.30
2008	4.26	0.54	1.04	0.29
2009	4.93	0.62	0.47	0.15
2010	5.39	0.65	0.62	0.16
2011	5.25	0.64	0.87	0.22
2012	4.65	0.57	1.76	0.28
2013	4.17	0.53	0.53	0.15
2014	4.49	0.53	0.24	0.08
2015	5.00	0.54	0.21	0.06
2016	4.39	0.48	0.37	0.08
2017	3.41	0.39	0.54	0.12
2018	2.52	0.32	1.97	0.35
2019	2.19	0.28	1.92	0.38
2020	3.14	0.38	1.12	0.29
2021	5.33	0.60	0.60	0.18
2022	7.05	0.75	0.21	0.08
2023	7.08	0.78	0.25	0.10
2024	6.04	0.71	0.32	0.14
2025	4.59	0.59	0.47	0.33

Table 20: Norton Sound red king crab estimated mature male biomass (MMB), male recruits, and standard deviations (SD) for model 25.0a2, in million lb.

Year	MMB	SD MMB	Male recruits	SD male recruits
1976	18.19	3.59	0.43	0.25
1977	19.01	2.89	0.30	0.13
1978	16.81	2.31	0.28	0.11
1979	11.79	1.66	0.66	0.26
1980	6.29	1.15	1.56	0.44
1981	4.09	0.82	1.27	0.37
1982	3.14	0.78	1.24	0.42
1983	4.30	0.95	1.27	0.40
1984	5.11	1.09	0.93	0.30
1985	5.74	1.21	1.04	0.34
1986	6.02	1.27	0.70	0.23
1987	5.90	1.24	0.71	0.21
1988	5.75	1.18	0.74	0.23
1989	5.41	1.07	0.50	0.16
1990	5.02	0.96	0.61	0.18
1991	4.63	0.85	0.46	0.16
1992	4.37	0.74	0.50	0.18
1993	4.03	0.64	0.48	0.16
1994	3.47	0.54	0.55	0.16
1995	3.04	0.48	0.72	0.18
1996	2.77	0.46	1.39	0.34
1997	2.86	0.46	0.62	0.21
1998	3.60	0.53	0.29	0.11
1999	4.50	0.64	0.50	0.19
2000	4.56	0.63	1.05	0.27
2001	3.94	0.57	0.76	0.20
2002	3.74	0.54	0.52	0.18
2003	3.96	0.57	0.47	0.17
2004	3.92	0.56	0.89	0.24
2005	3.58	0.51	1.06	0.25
2006	3.35	0.47	1.30	0.32
2007	3.55	0.48	1.18	0.30
2008	4.21	0.53	1.00	0.28
2009	4.86	0.61	0.46	0.14
2010	5.29	0.64	0.60	0.15
2011	5.12	0.62	0.83	0.21
2012	4.51	0.55	1.75	0.28
2013	4.01	0.50	0.54	0.15
2014	4.34	0.51	0.24	0.08
2015	4.88	0.53	0.21	0.06
2016	4.31	0.47	0.37	0.08
2017	3.38	0.39	0.54	0.12
2018	2.51	0.32	1.97	0.35
2019	2.19	0.28	1.90	0.38
2020	3.14	0.38	1.11	0.28
2021	5.31	0.60	0.59	0.17
2022	7.01	0.75	0.21	0.08
2023	7.03	0.77	0.25	0.10
2024	5.99	0.70	0.31	0.14
2025	4.55	0.59	0.47	0.33

Figures

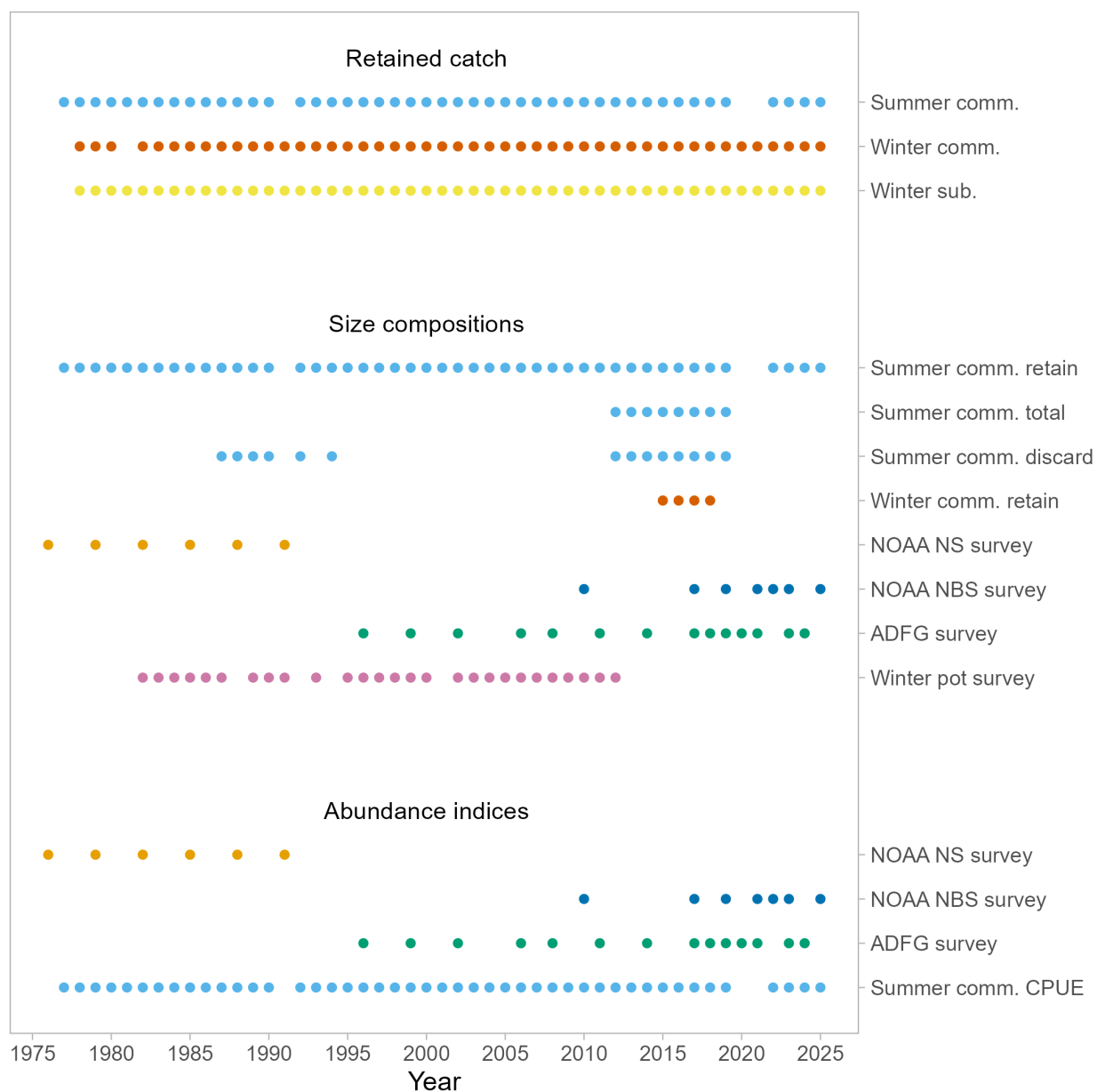


Figure 1: Data sources available for the Norton Sound red king crab stock assessment. Acronyms and abbreviations: National Oceanic and Atmospheric Administration, NOAA; Norton Sound, NS; Northern Bering Sea, NBS; Alaska Department of Fish and Game, ADFG; catch per unit effort, CPUE; comm., commercial; sub., subsistence.

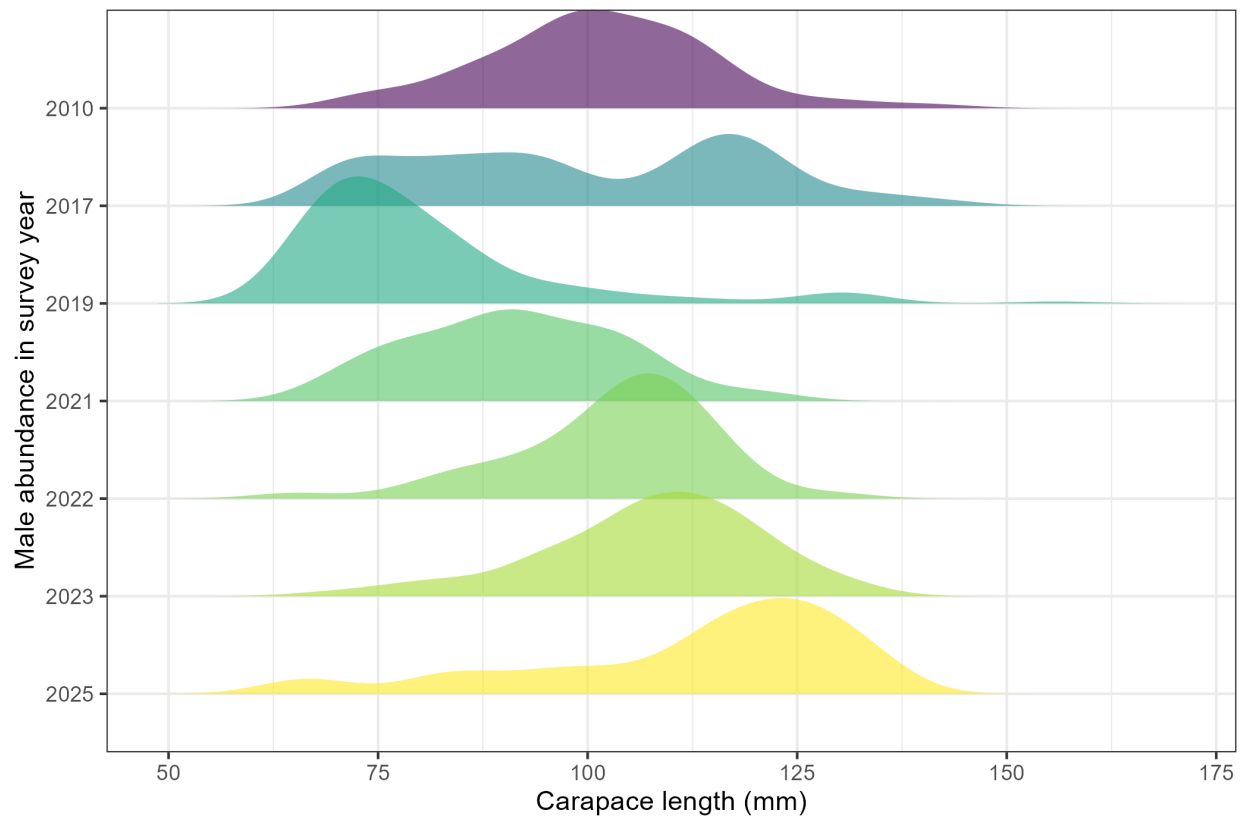


Figure 2: National Oceanic and Atmospheric Administration Northern Bering Sea trawl survey abundances by carapace length for male Norton Sound red king crab from 2010 to 2025.

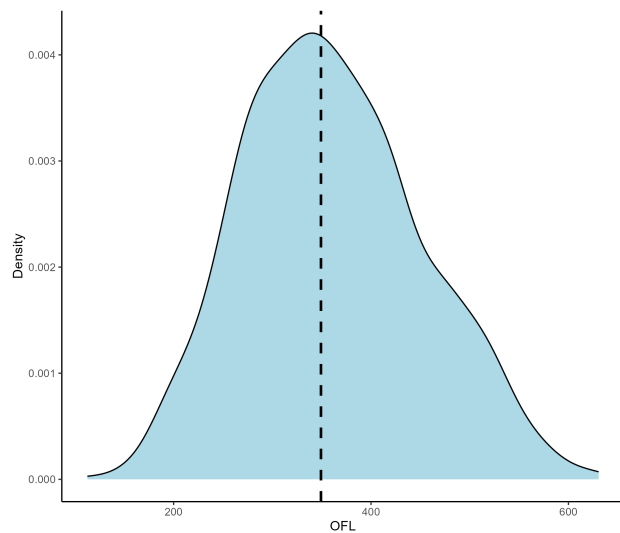


Figure 3: The probability density function of the OFL for model 24.0b6, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

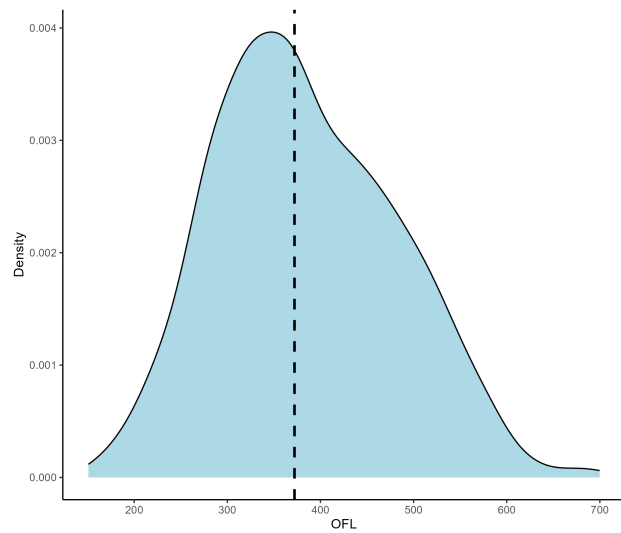


Figure 4: The probability density function of the OFL for model 24.0b7, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

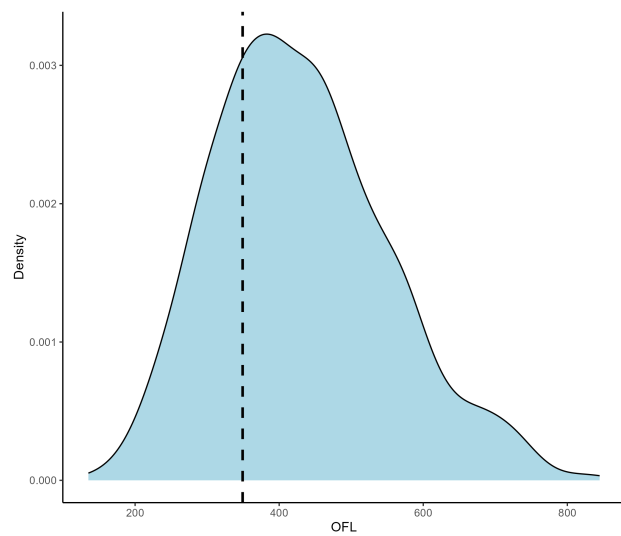


Figure 5: The probability density function of the OFL for model 25.0a1, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

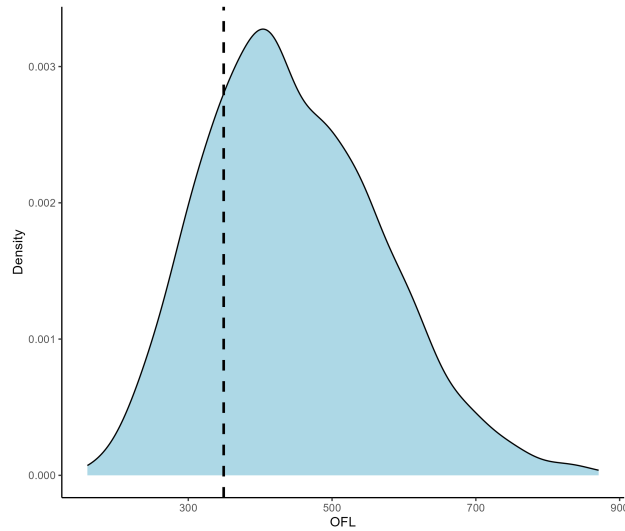


Figure 6: The probability density function of the OFL for model 25.0a2, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

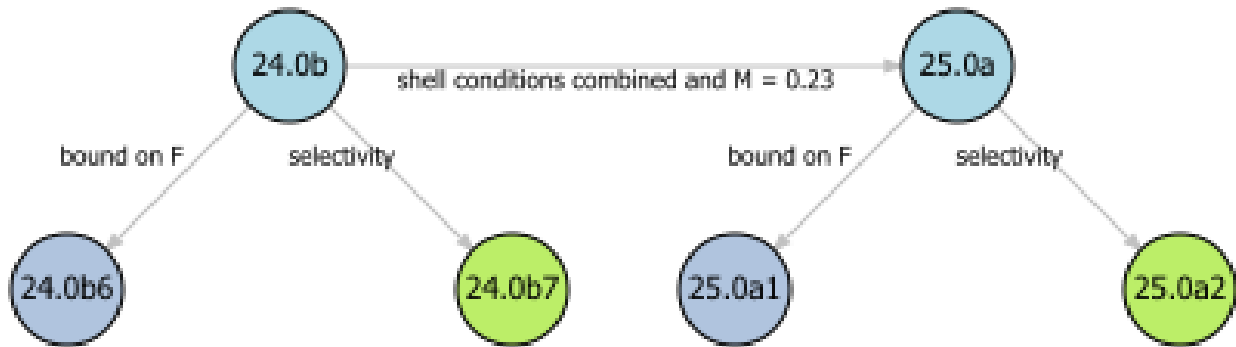


Figure 7: Flow chart of models presented in this document. Model 24.0b is the base model. Model 24.0b6 is model 24.0b with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab assessment model. Model 24.0b7 is model 24.0b with selectivity for the winter commercial fishery and subsistence fishery sharing parameters with selectivity for the summer commercial fishery rather than the winter pot survey. Model 25.0a is model 24.0b with shell condition excluded and a higher fixed M value of 0.23 for males with carapace length ≤ 123 mm. Model 25.0a1 is model 25.0a with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab assessment model. Model 25.0a2 is model 25.0a with selectivity for the winter commercial fishery and subsistence fishery sharing parameters with selectivity for the summer commercial fishery rather than the winter pot survey.

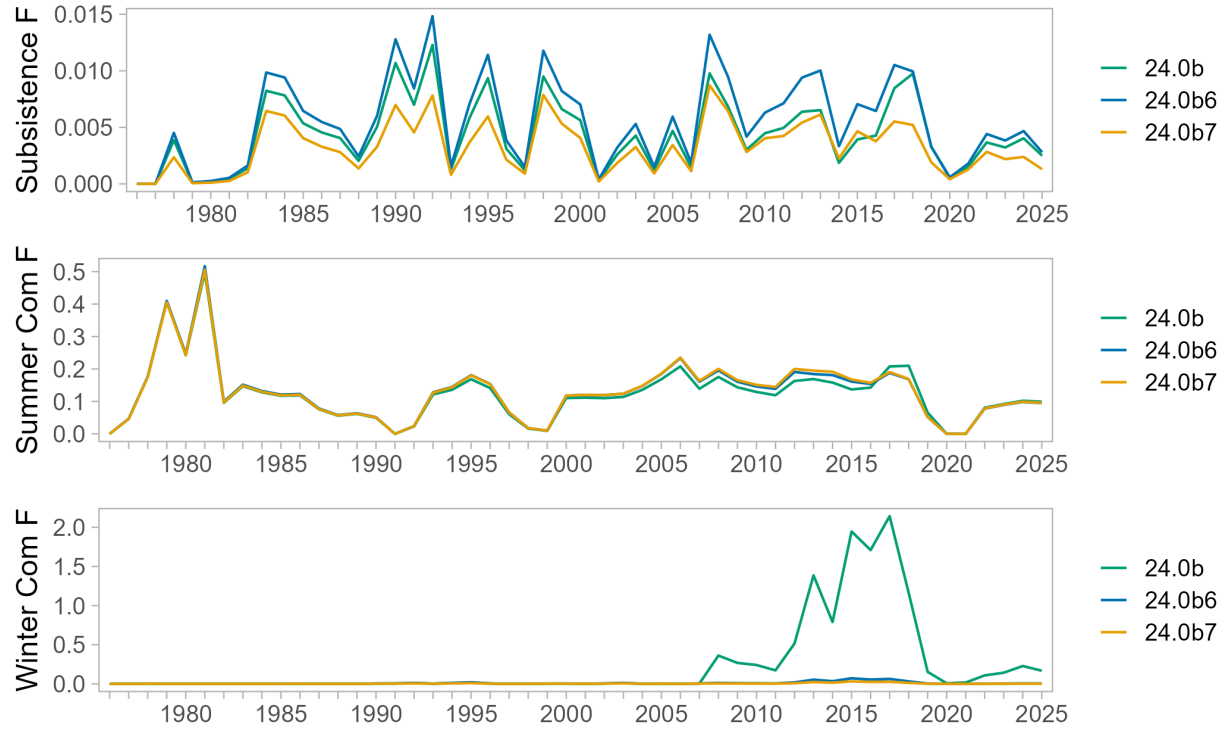


Figure 8: Comparison of estimated fishing mortality (F) for the subsistence, summer commercial, and winter commercial fisheries for the base model (24.0b), 24.0b with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab assessment model (24.0b6), and 24.0b with selectivity for the winter commercial fishery and subsistence fishery sharing parameters with selectivity for the summer commercial fishery rather than the winter pot survey (24.0b7). Note that the scale for F differs among the panels.

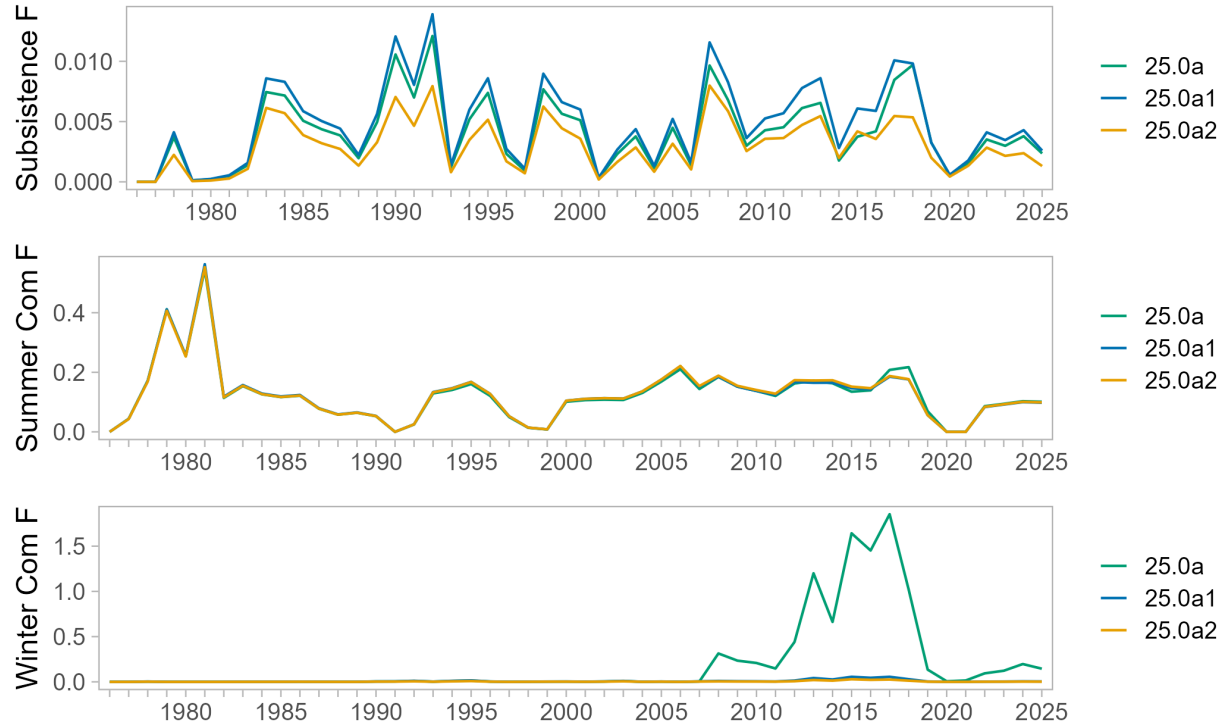


Figure 9: Comparison of estimated fishing mortality (F) for the subsistence, summer commercial, and winter commercial fisheries for the model with shell condition excluded and a higher fixed M value of 0.23 for males with carapace length ≤ 123 mm (model 25.0a), 25.0a with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab assessment model (25.0a1), and 25.0a with selectivity for the winter commercial fishery and subsistence fishery sharing parameters with selectivity for the summer commercial fishery rather than the winter pot survey (25.0a2). Note that the scale for F differs among the panels.

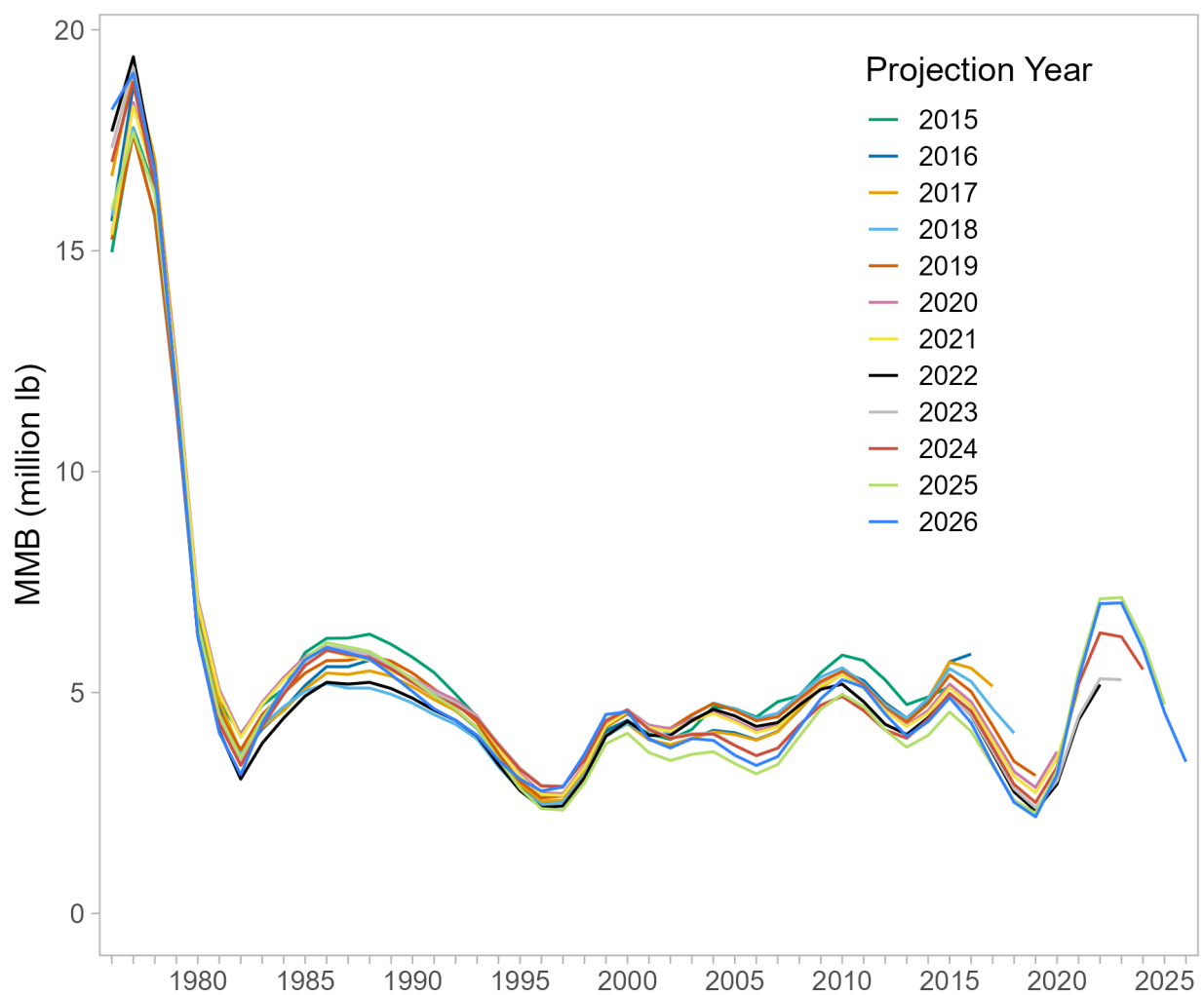


Figure 10: Comparison of historical estimates of mature male biomass of Norton Sound red king crab using the model selected in each year. Data were compiled from reported MMB values for the chosen model in the published SAFE document from the assessment year. The legend shows the year for which model projections were made.

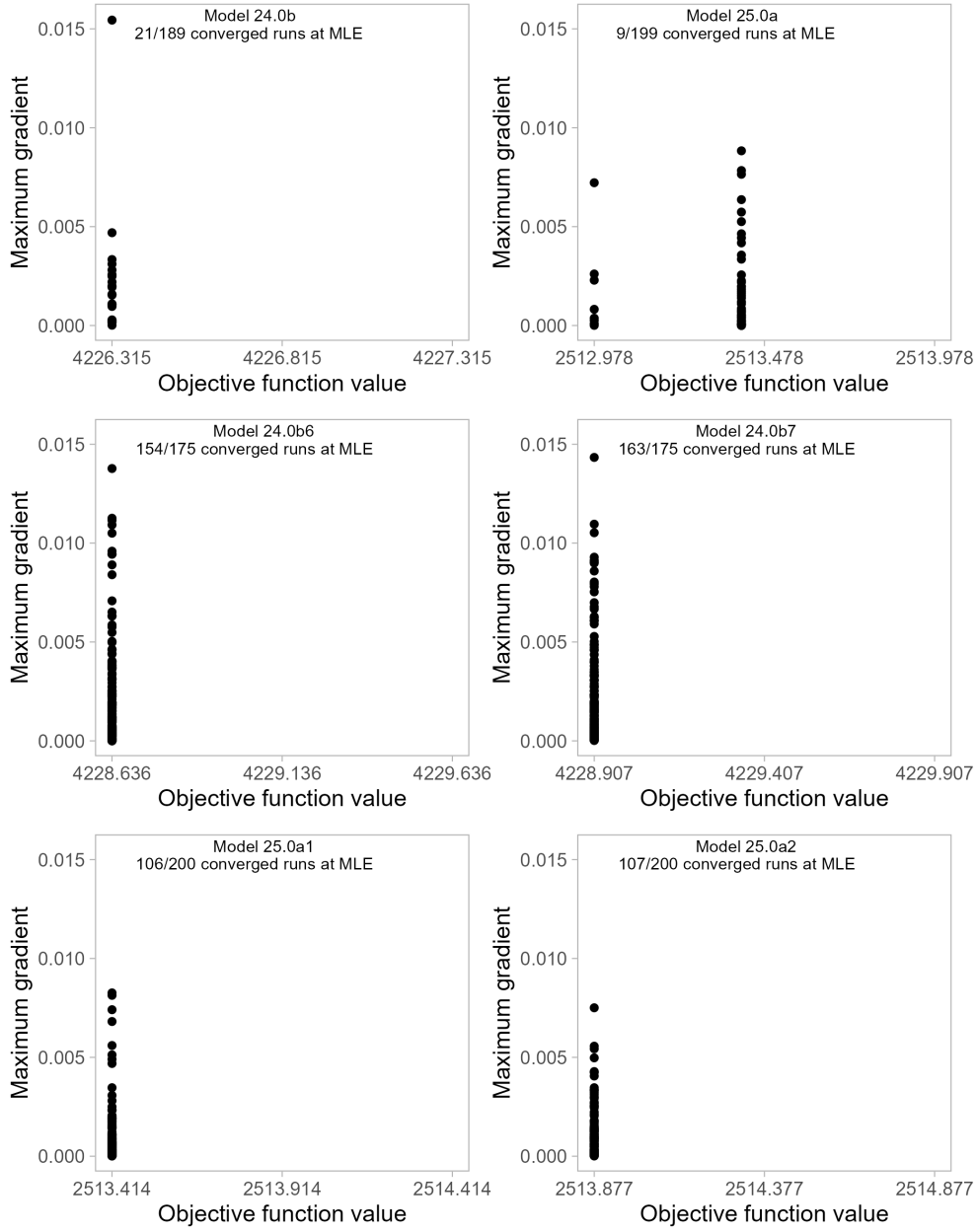


Figure 11: Results from 200 jitter runs for the six models presented as candidates for harvest specifications.

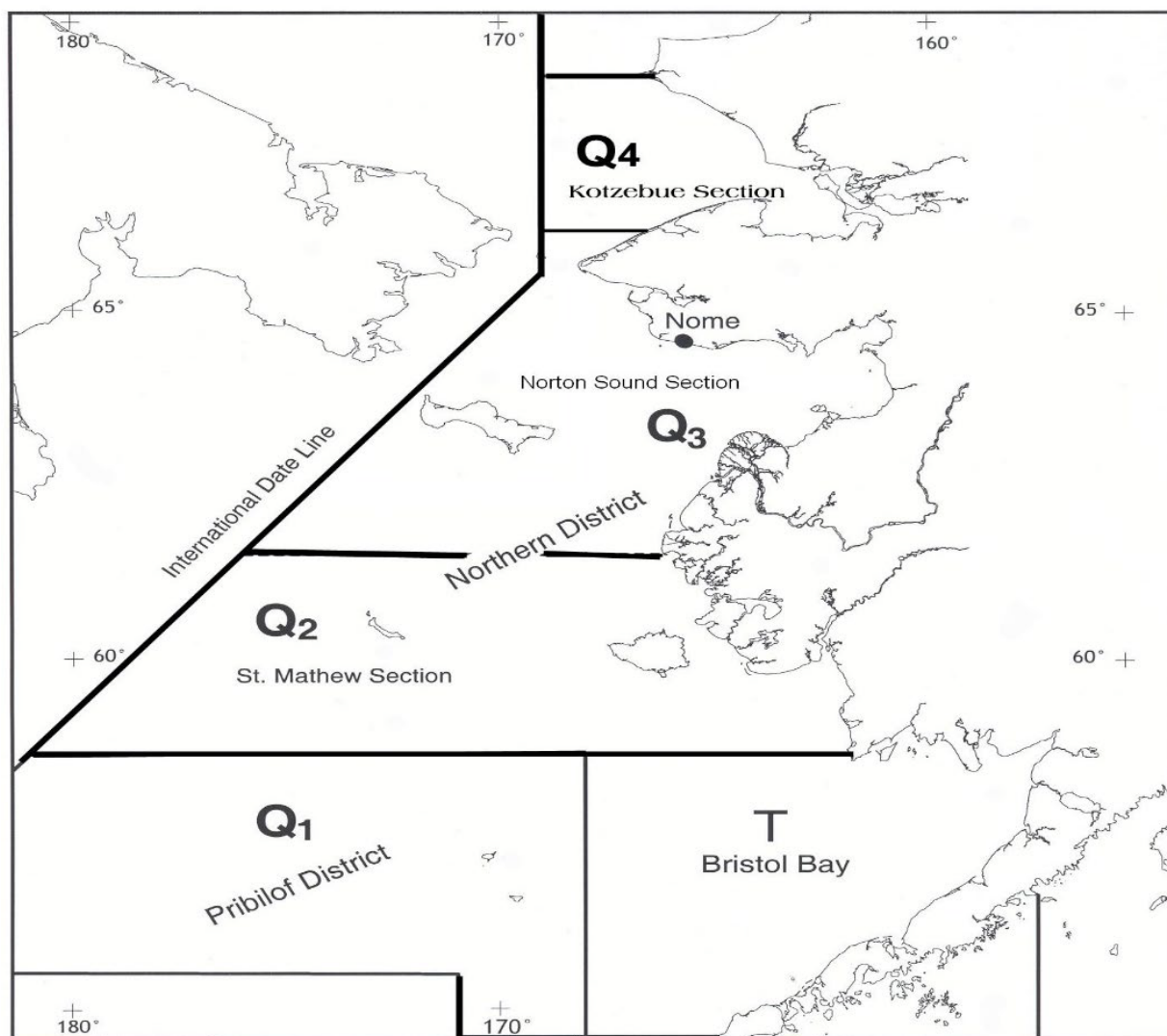


Figure 12: King crab fishing districts and sections of Alaska Department of Fish and Game Registration Area Q. Source: Menard et al. (2022).

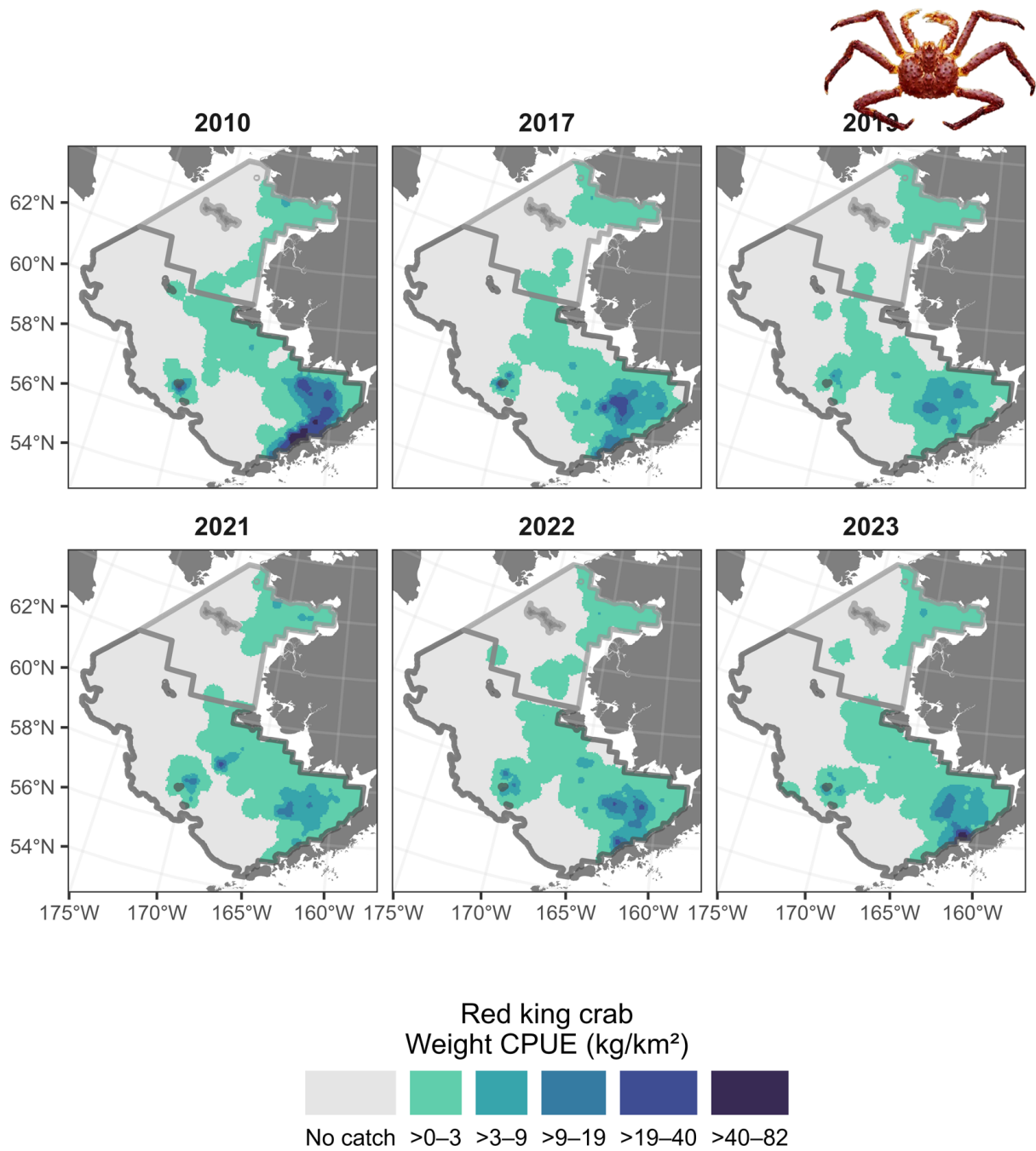


Figure 13: Distribution of red king crab from the 2010, 2017, 2019, and 2021-2023 Eastern and Northern Bering Sea trawl surveys. Source: Markowitz et al. (2023).

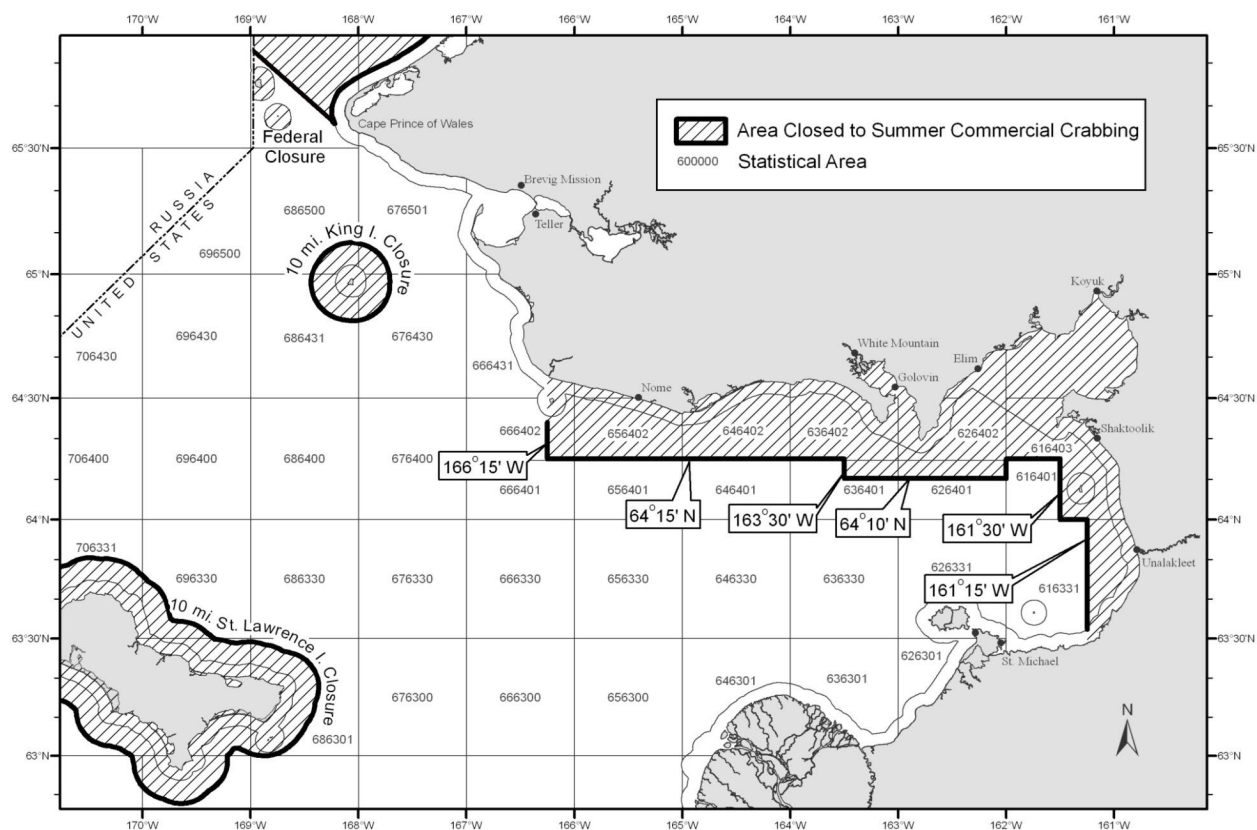


Figure 14: Waters closed to the Norton Sound summer commercial crab fishery. Source: Menard et al. (2022).

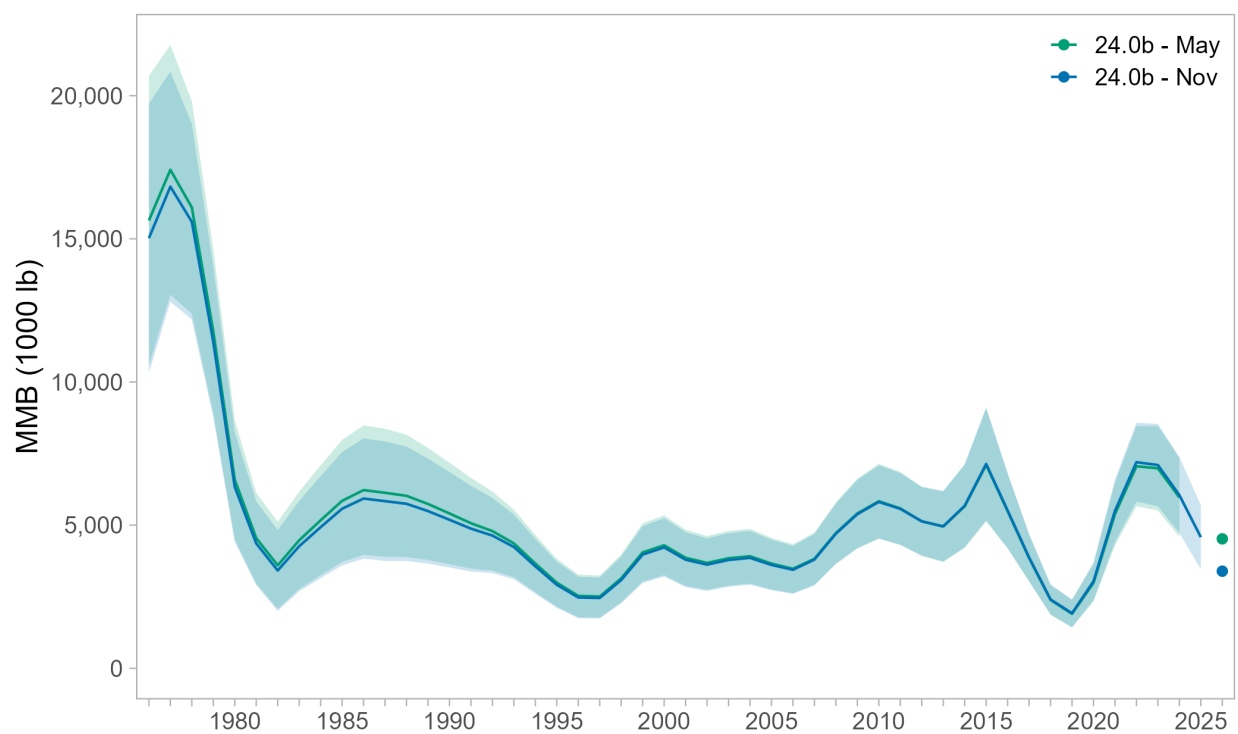


Figure 15: Comparisons of estimated mature male biomass (MMB) time series over 1976-2025 for models 24.0b - May (including only data updated through 2024) and model 24.0b (including data updated through 2025). Points represent projected values for 2026.

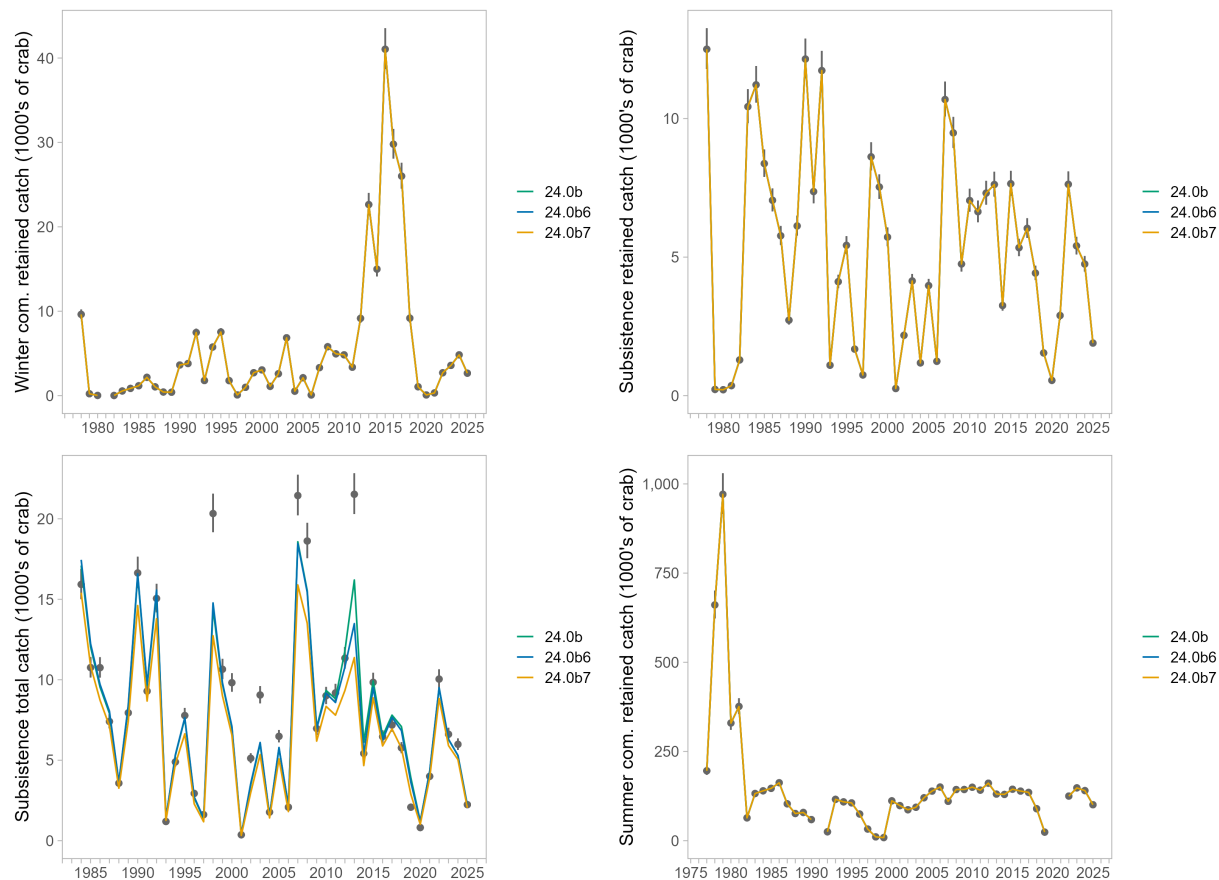


Figure 16: Observed and model-estimated catch of male red king crab caught in the winter commercial, summer commercial, and subsistence fisheries for models 24.0b, 24.0b6, and 24.0b7. Model 24.0b is the base model. Model 24.0b6 is model 24.0b with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab stock assessment. Model 24.0b7 is model 24.0b with selectivity parameters for the winter commercial fishery shared with the summer commercial fishery. Note that subsistence total catch was not fitted in these models (emphasis set to 0).

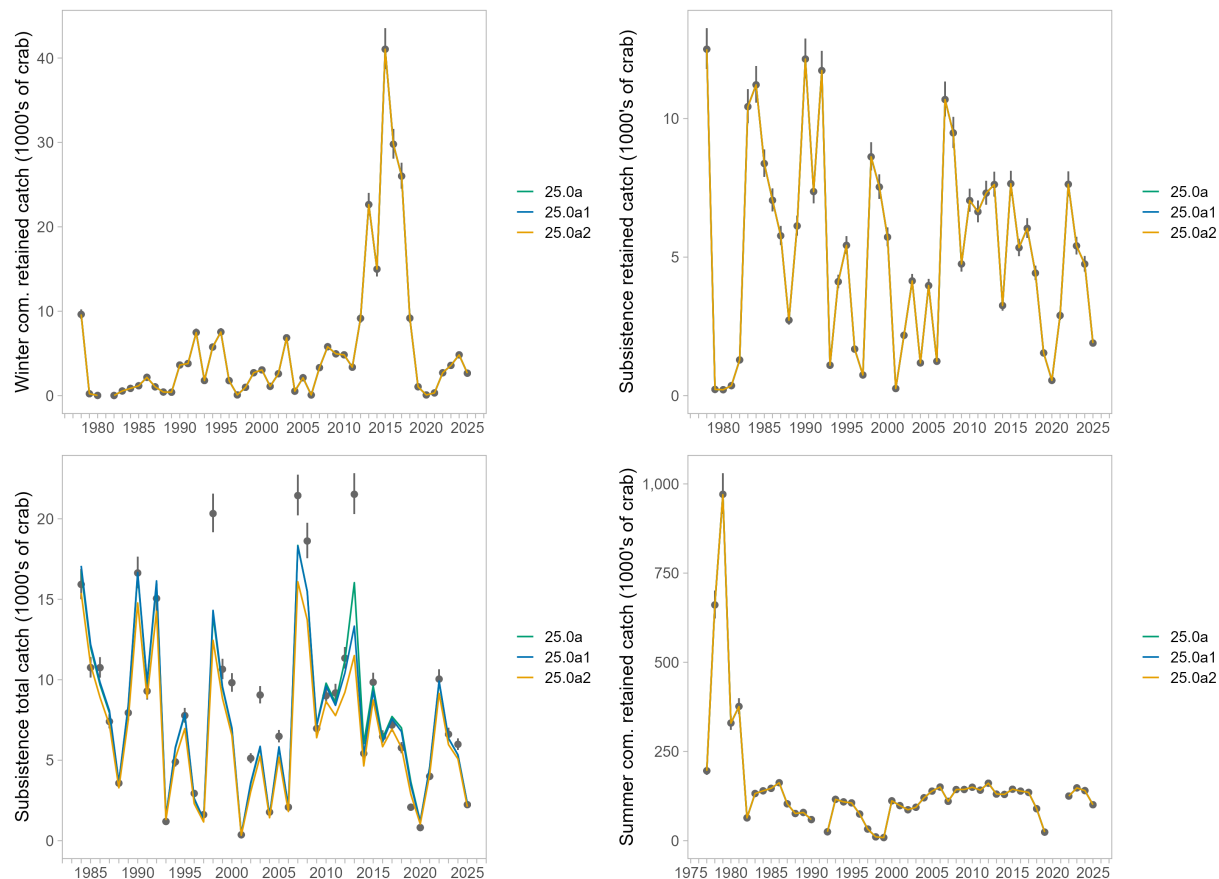


Figure 17: Observed and model-estimated catch of male red king crab caught in the winter commercial, summer commercial, and subsistence fisheries for models 25.0a, 25.0a1, and 25.0a2. Model 25.0a is model 24.0b with shell condition excluded and with natural mortality for small males fixed at 0.23 rather than 0.18. Model 25.0a1 is model 25.0a with an upper bound on F for the winter commercial fishery borrowed from the Bristol Bay red king crab stock assessment. Model 25.0a2 is model 25.0a with selectivity parameters for the winter commercial fishery shared with the summer commercial fishery. Note that subsistence total catch was not fitted in these models (emphasis set to 0).

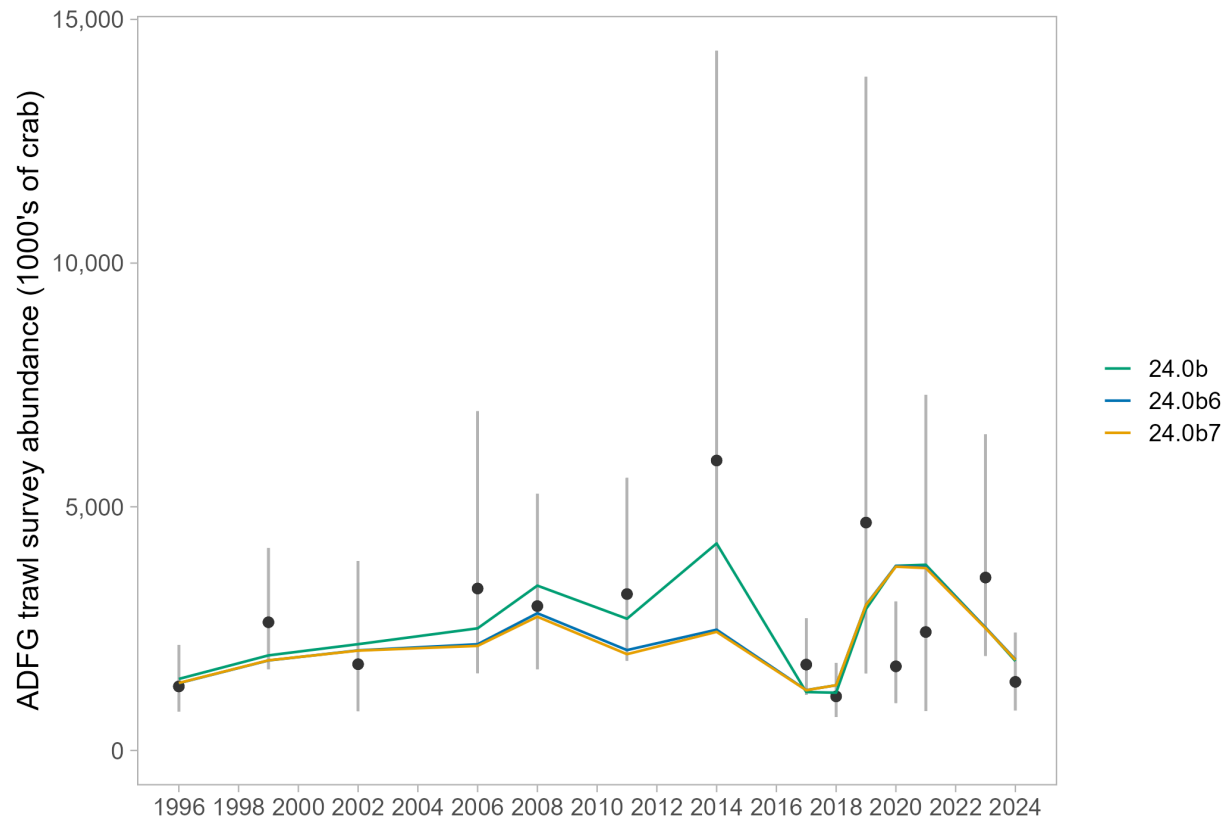


Figure 18: Model fits to the design-based index of abundance from the Alaska Department of Fish and Game (ADFG) trawl survey for models 24.0b, 24.0b6, and 24.0b7.

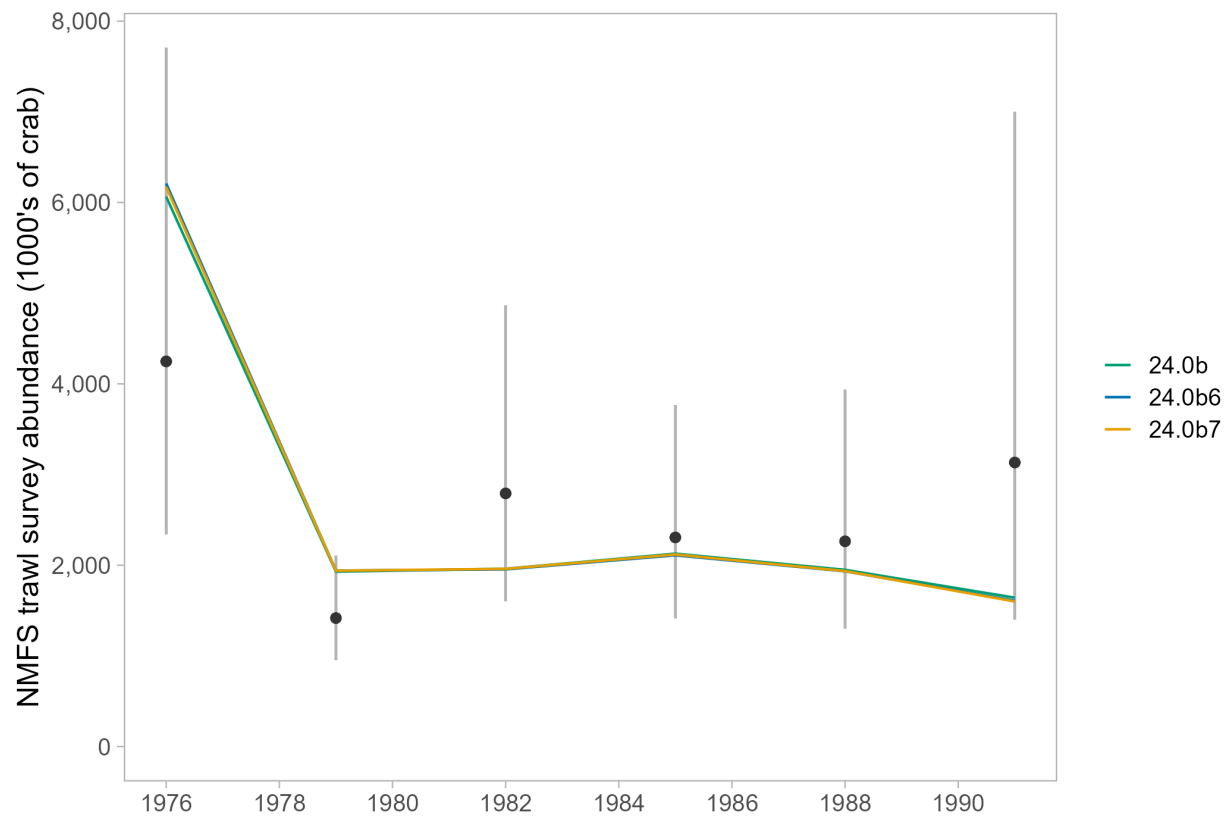


Figure 19: Model fits to the design-based index of abundance from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for models 24.0b, 24.0b6, and 24.0b7.

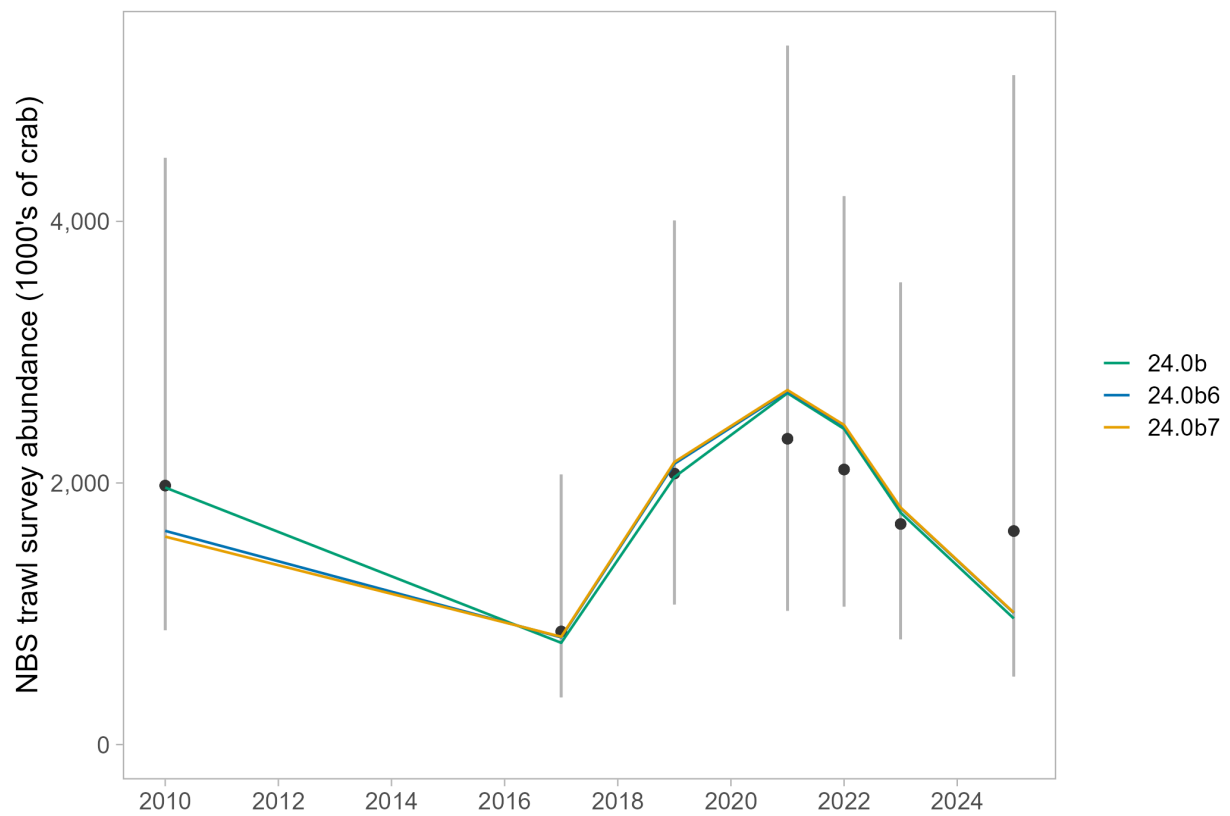


Figure 20: Model fits to the design-based index of abundance from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for models 24.0b, 24.0b6, and 24.0b7.

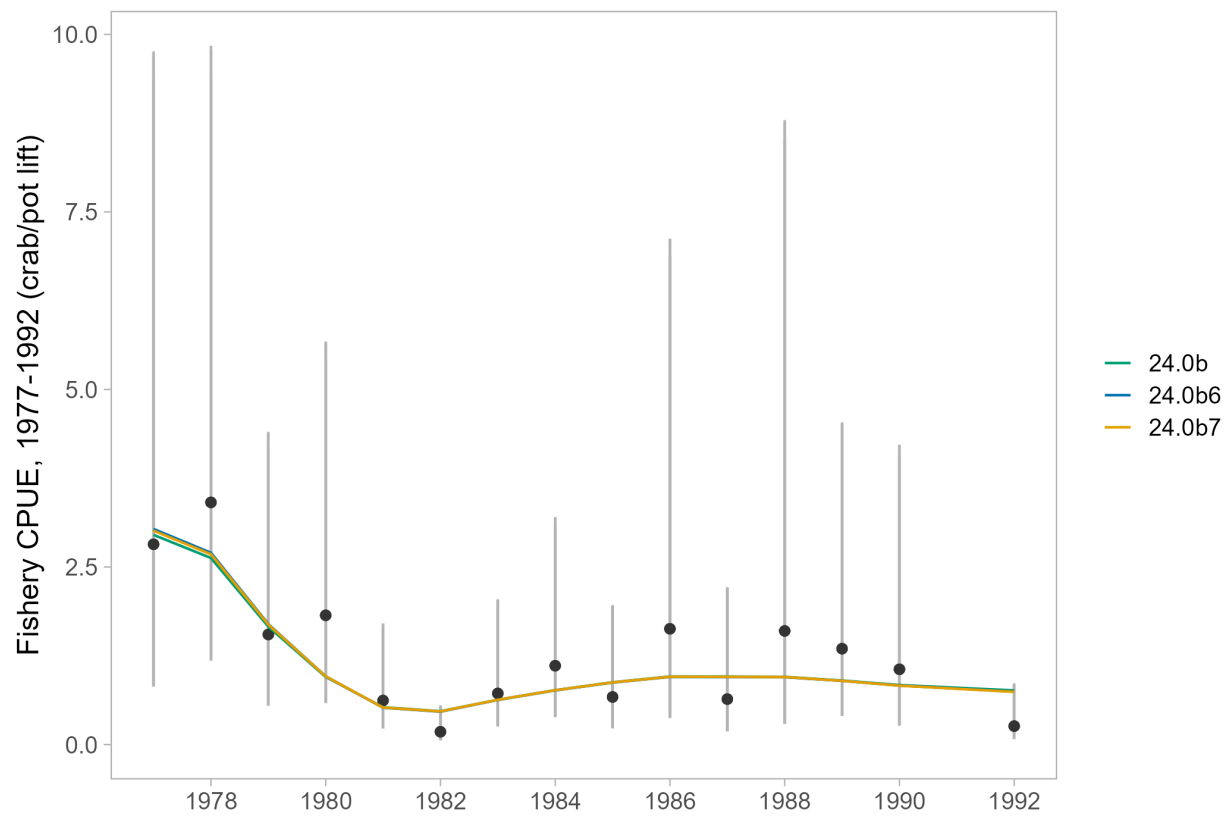


Figure 21: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1977-1992) for models 24.0b, 24.0b6, and 24.0b7.

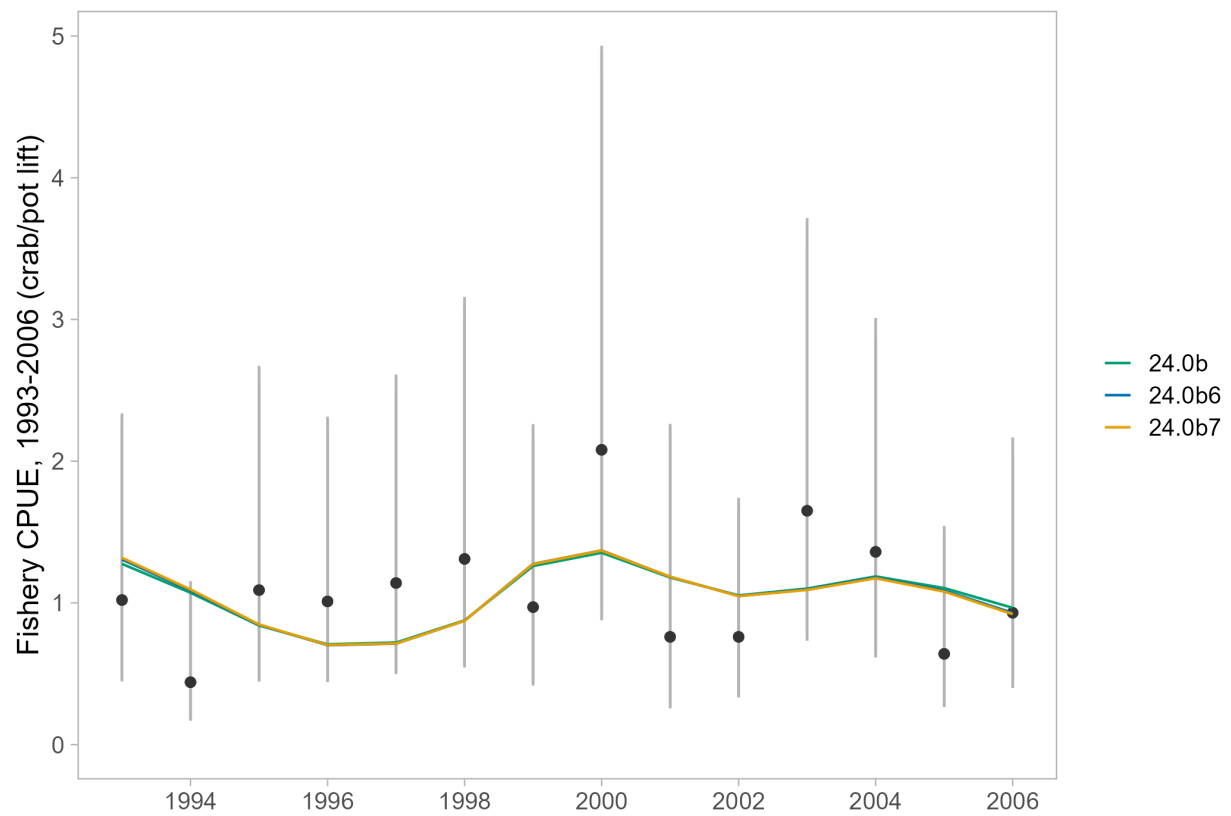


Figure 22: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1993-2006) for models 24.0b, 24.0b6, and 24.0b7.

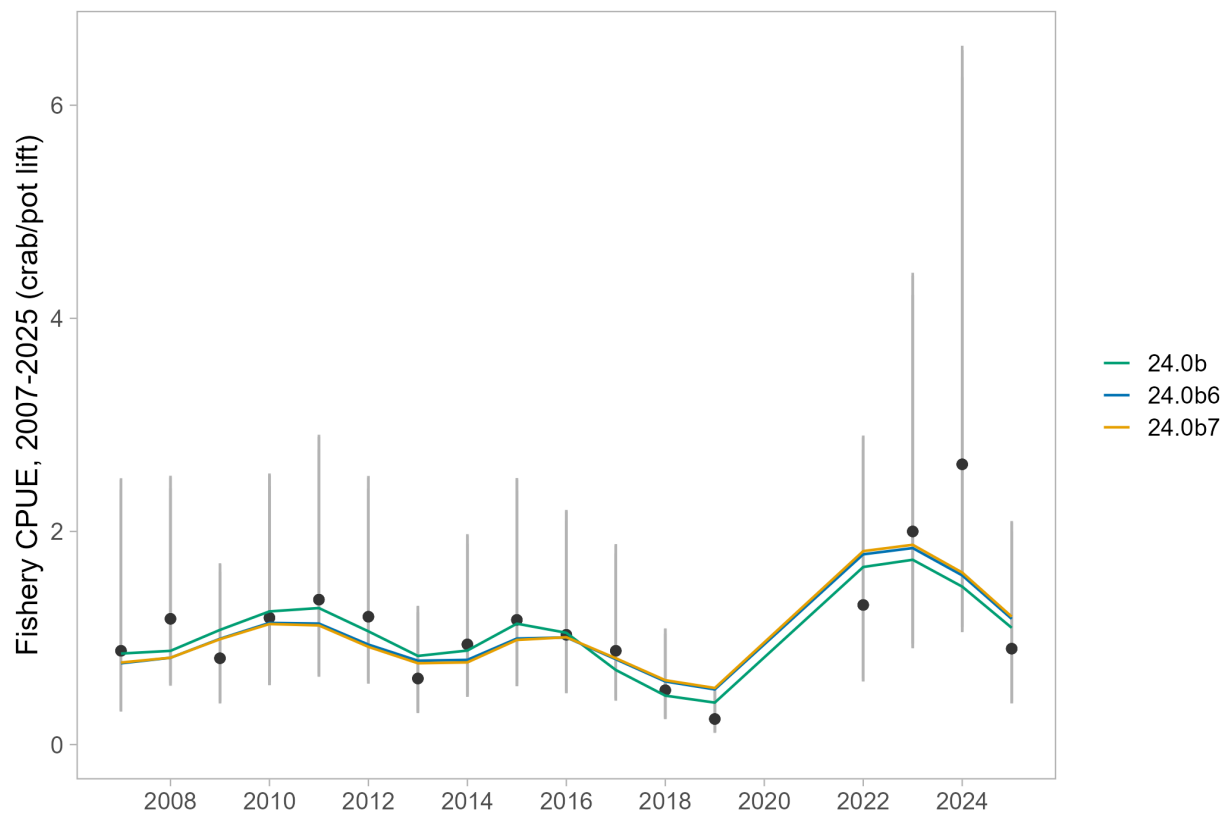


Figure 23: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (2007-2025) for models 24.0b, 24.0b6, and 24.0b7.

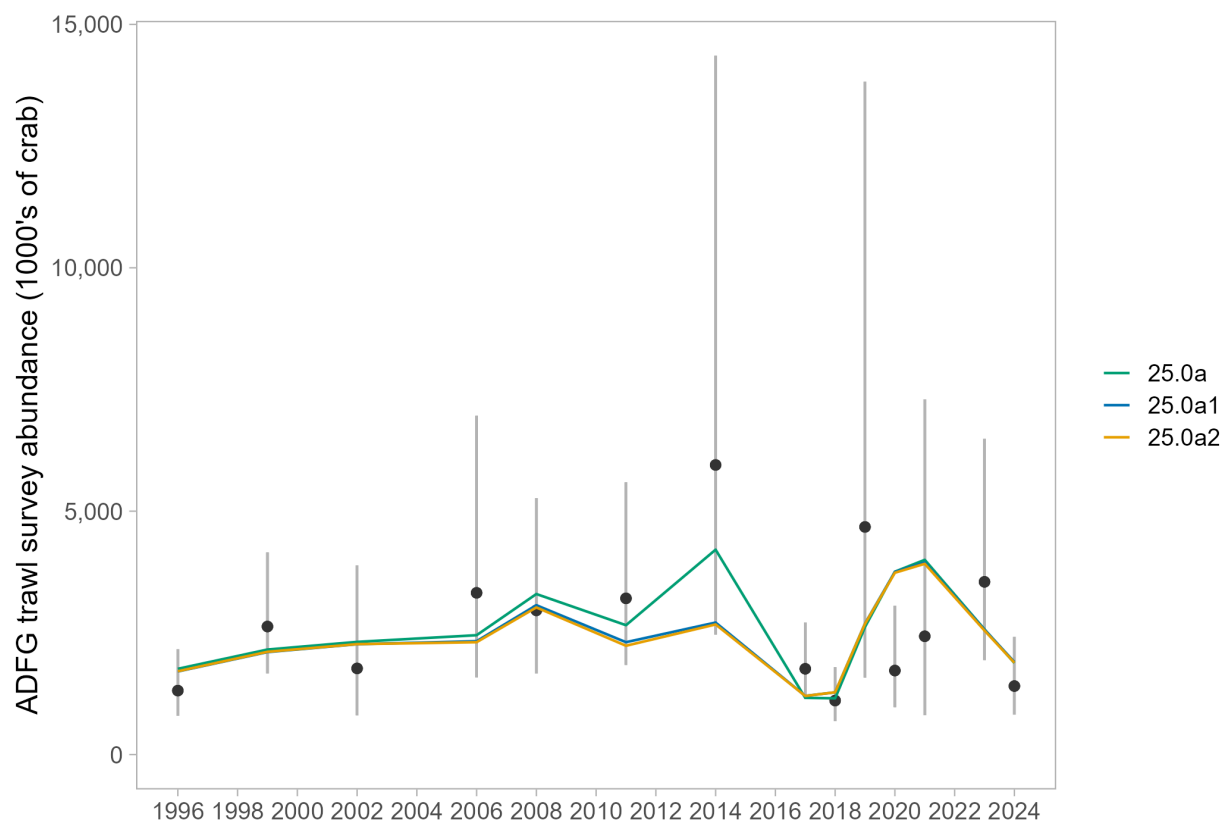


Figure 24: Model fits to the design-based index of abundance from the Alaska Department of Fish and Game (ADFG) trawl survey for models 25.0a, 25.0a1, and 25.0a2.

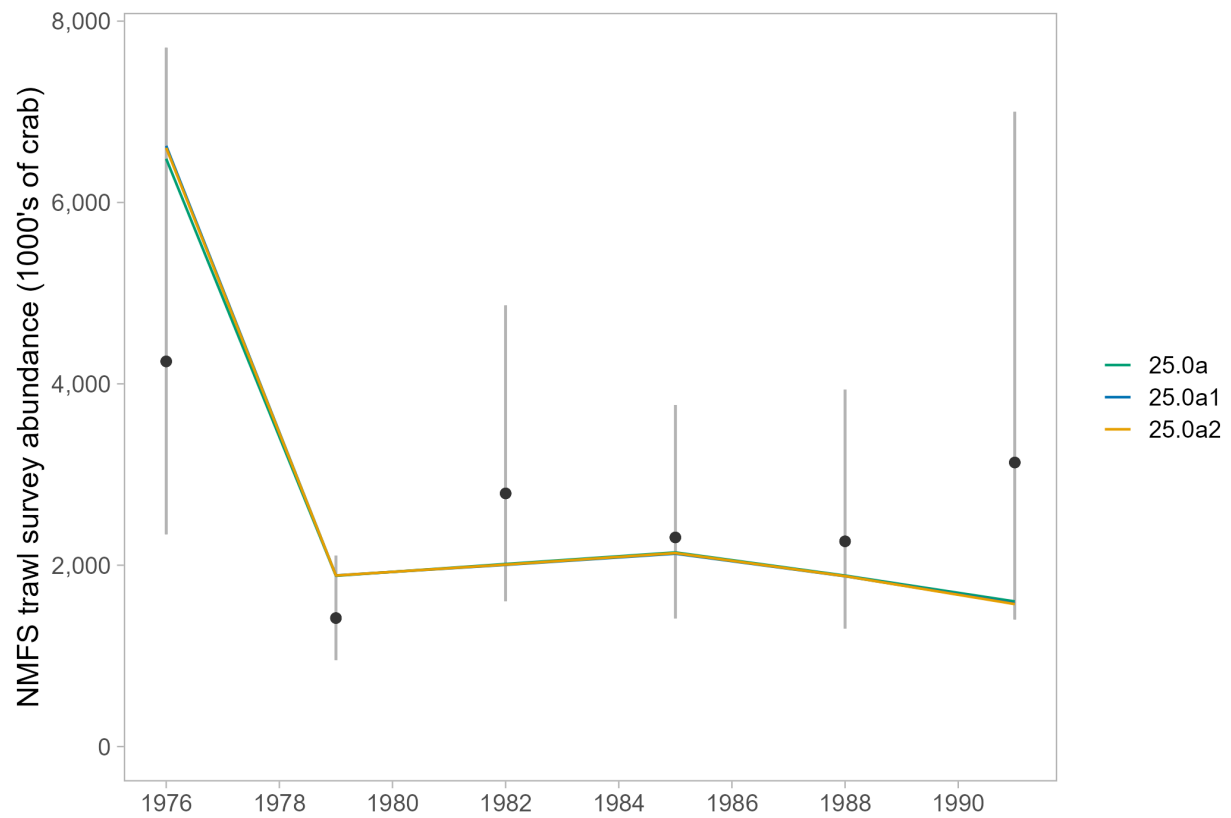


Figure 25: Model fits to the design-based index of abundance from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for models 25.0a, 25.0a1, and 25.0a2.



Figure 26: Model fits to the design-based index of abundance from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for models 25.0a, 25.0a1, and 25.0a2.

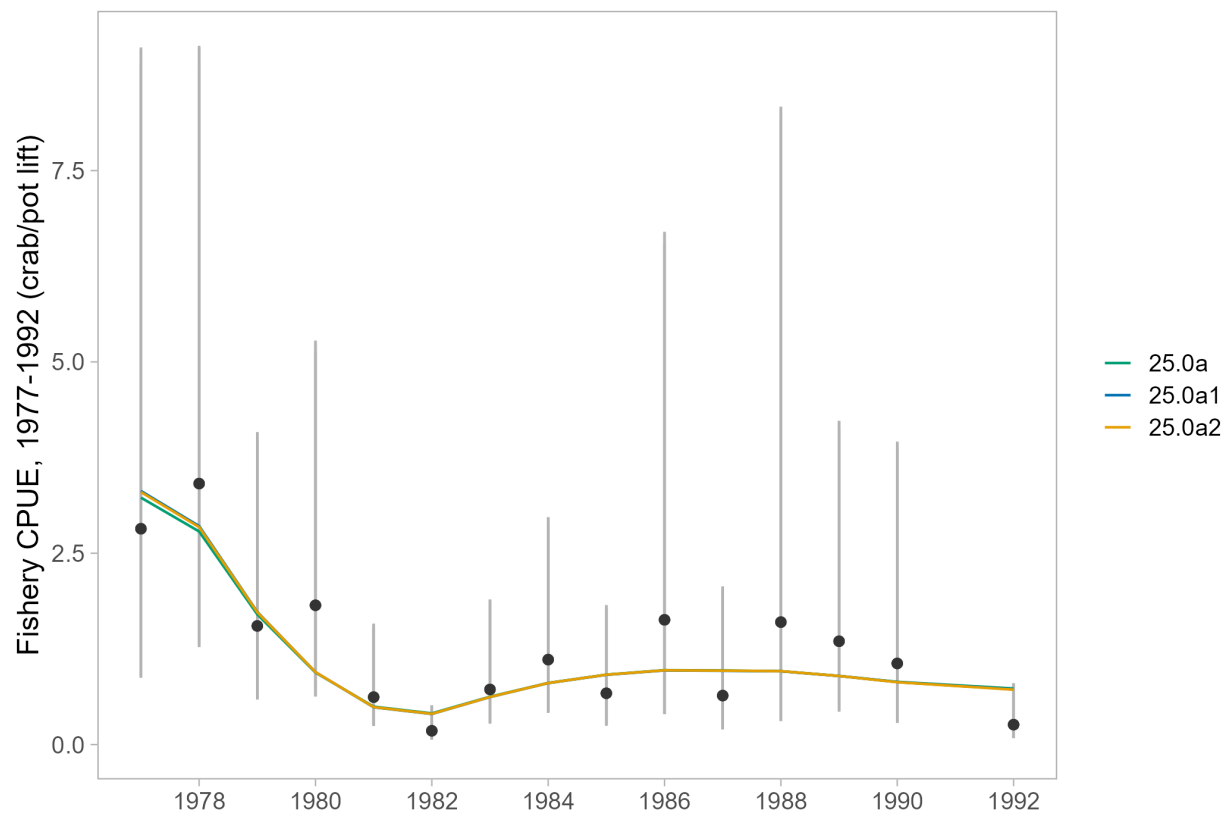


Figure 27: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1977-1992) for models 25.0a, 25.0a1, and 25.0a2.

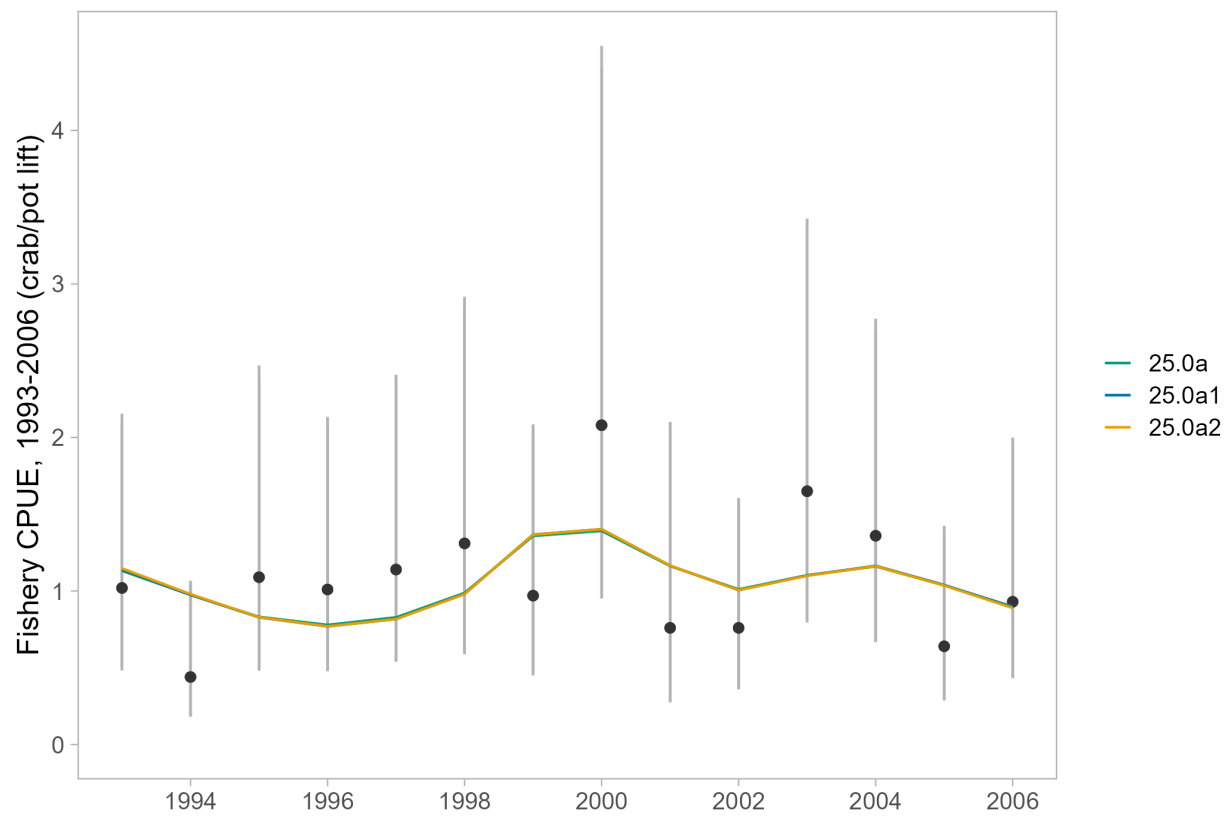


Figure 28: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (1993-2006) for models 25.0a, 25.0a1, and 25.0a2.

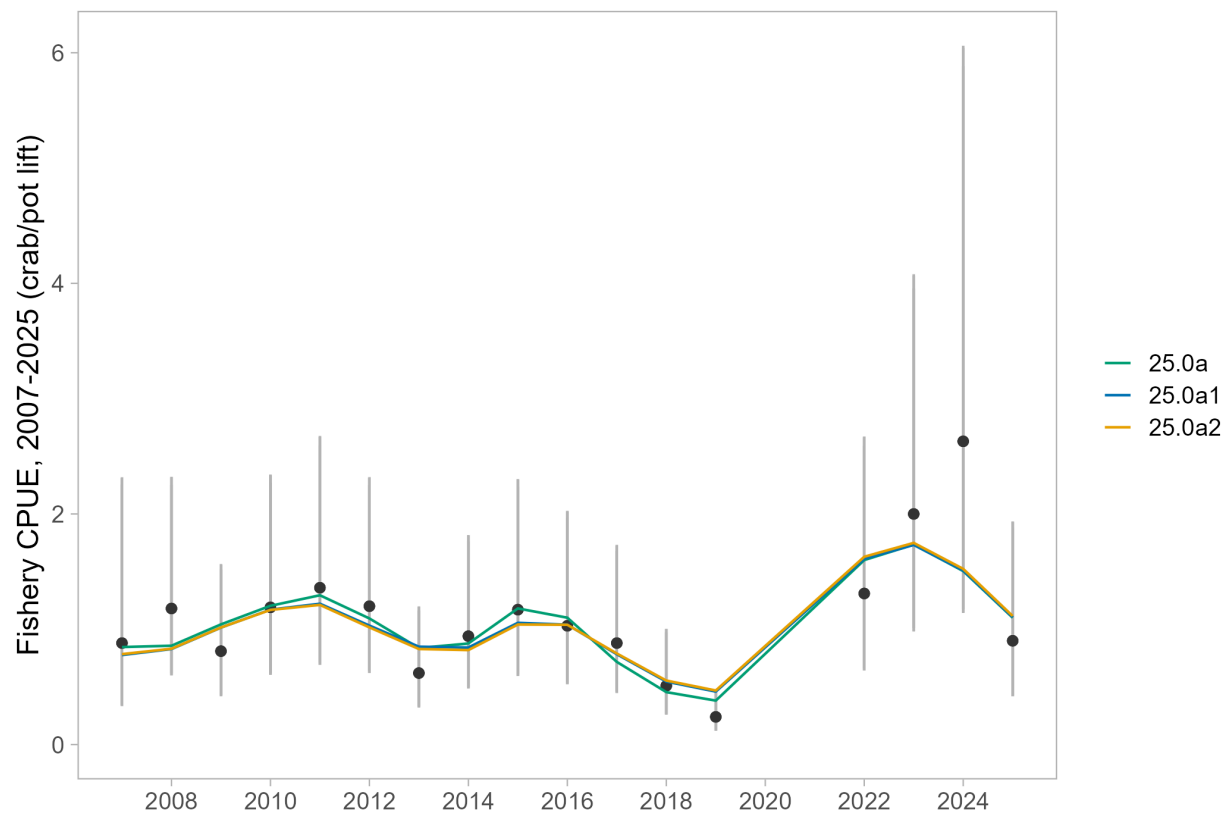


Figure 29: Model fits to the summer commercial fishery standardized catch per unit effort (CPUE) index (2007-2025) for models 25.0a, 25.0a1, and 25.0a2.

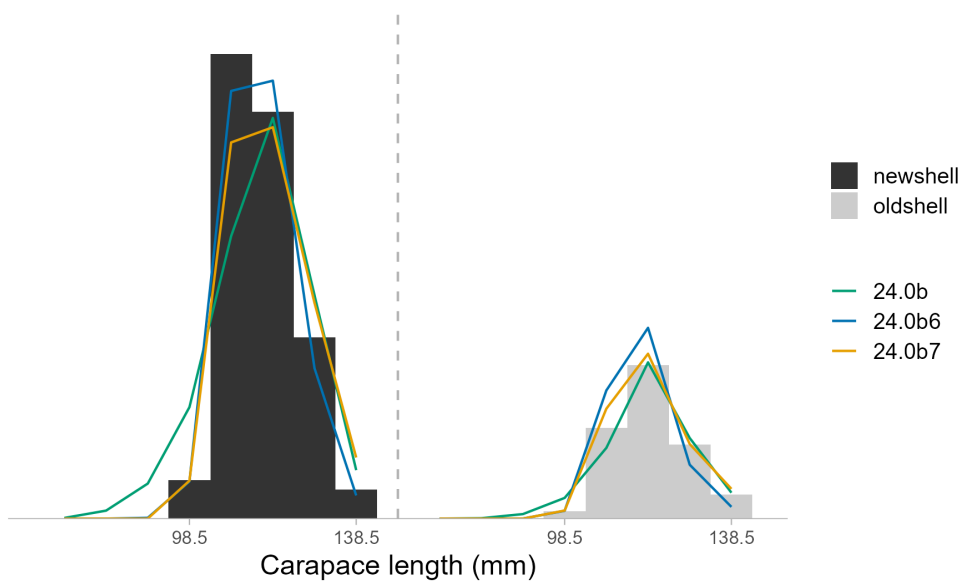


Figure 30: Aggregated observed and model-estimated size frequencies of male red king crab retained in the directed winter commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

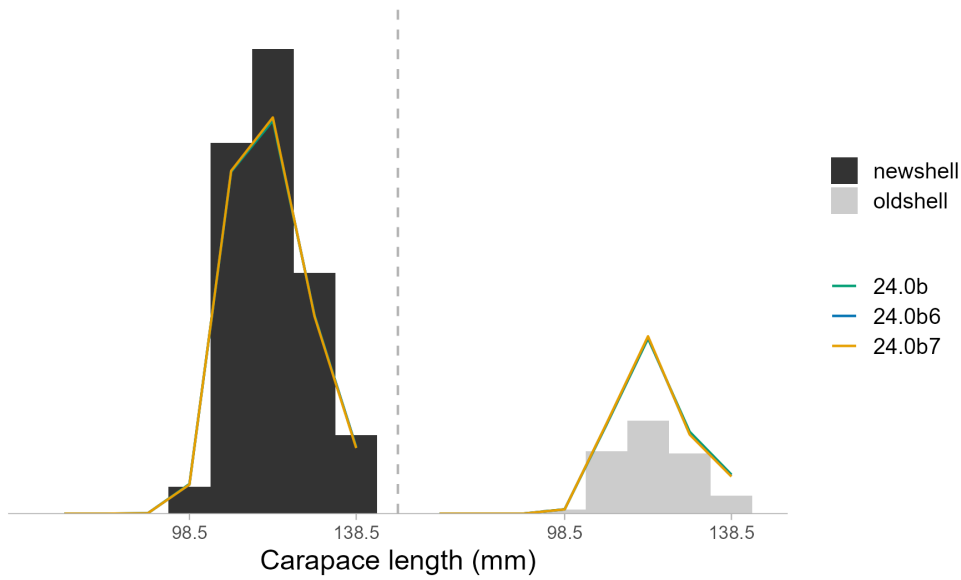


Figure 31: Aggregated observed and model-estimated size frequencies of male red king crab retained in the directed summer commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

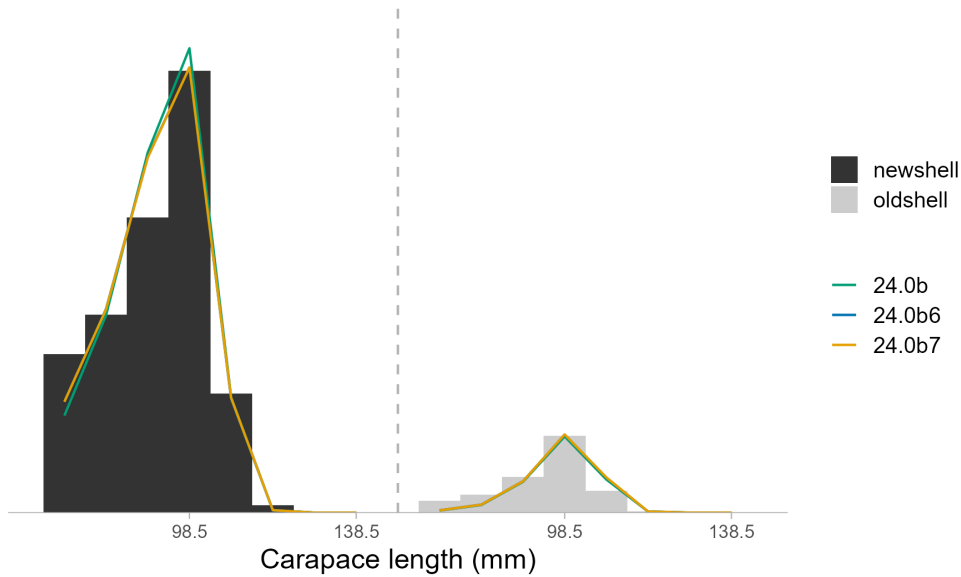


Figure 32: Aggregated observed and model-estimated size frequencies of male red king crab discarded in the directed summer commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

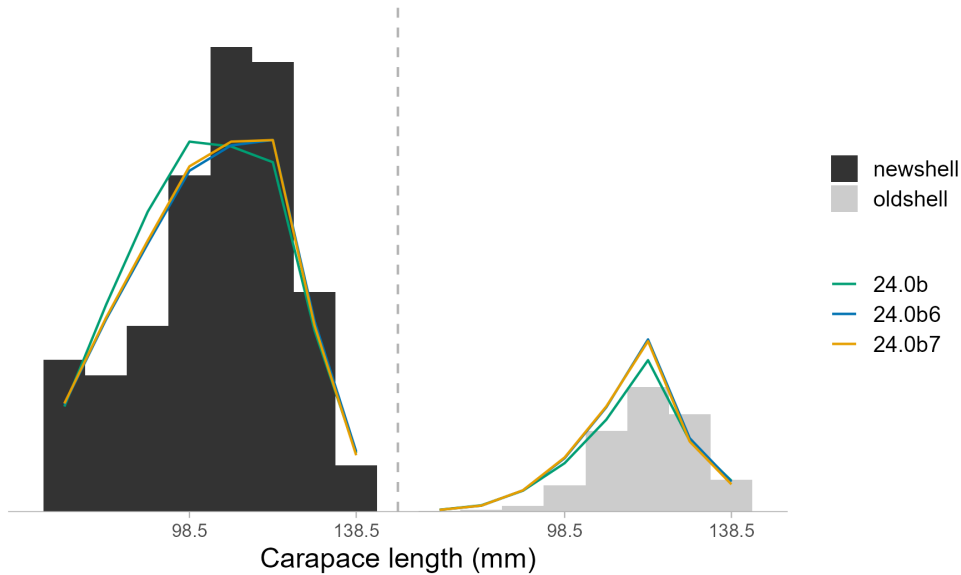


Figure 33: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the directed summer commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

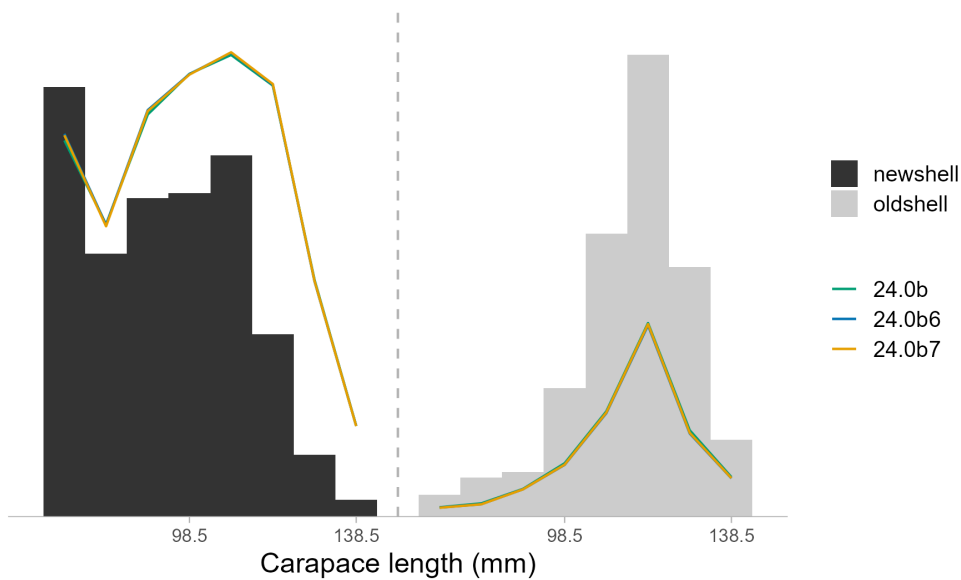


Figure 34: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

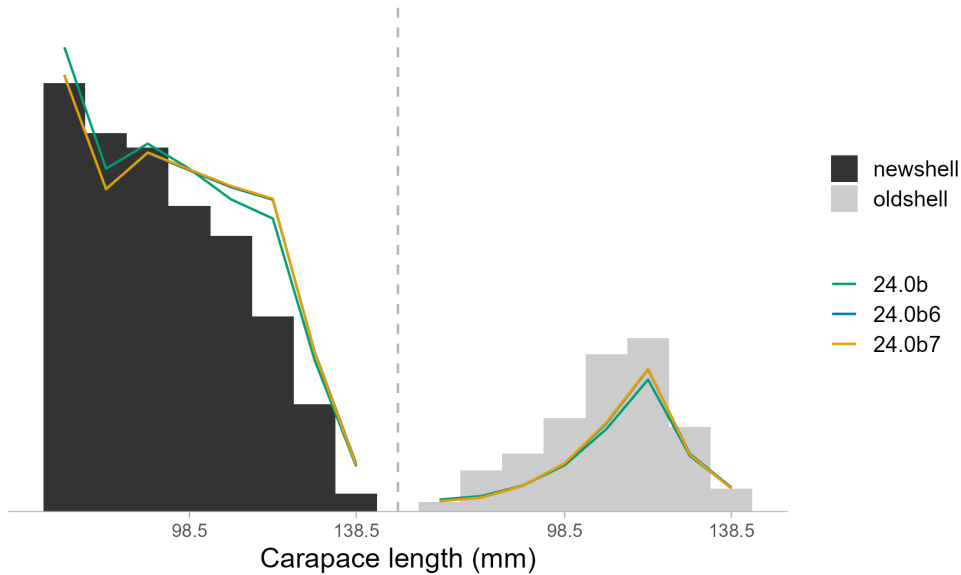


Figure 35: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) trawl survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

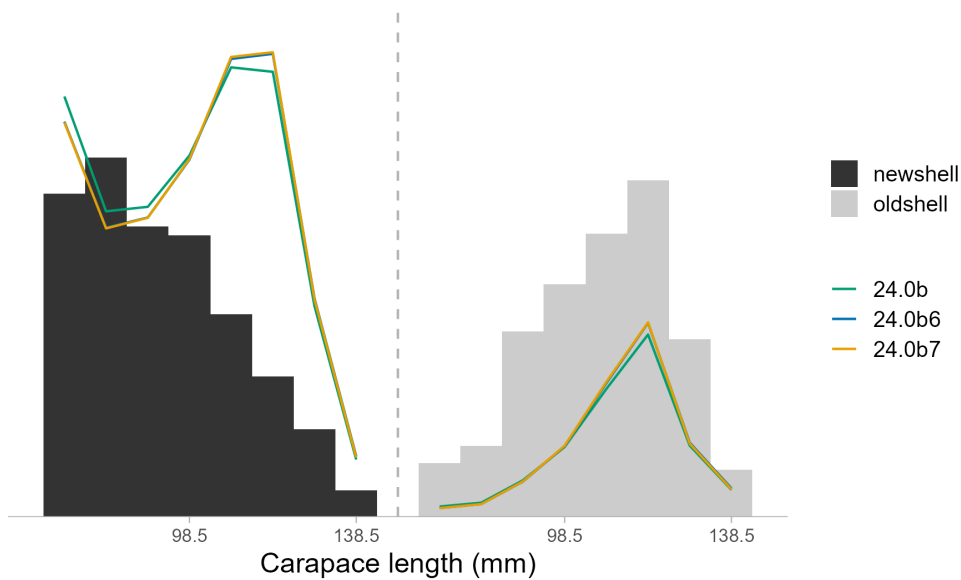


Figure 36: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

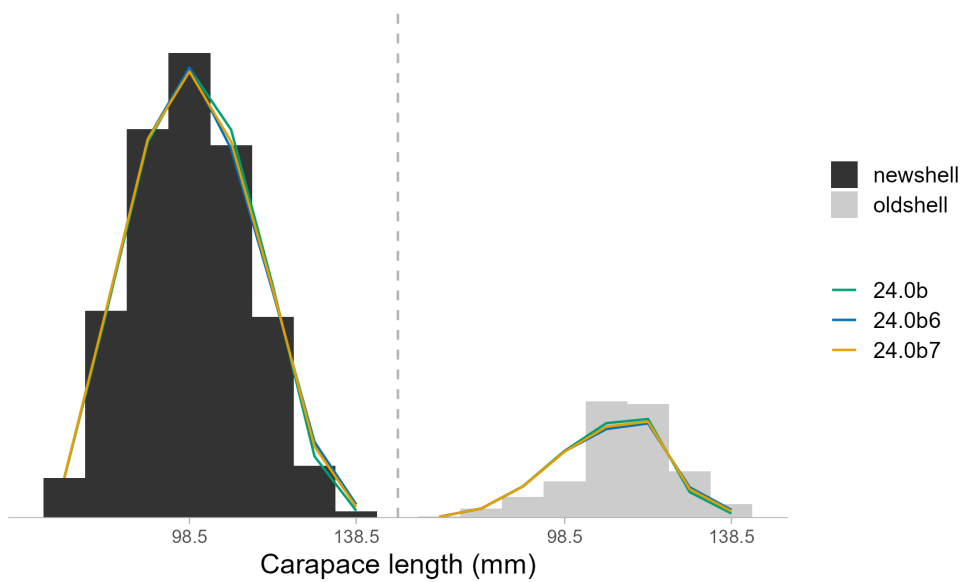


Figure 37: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) winter pot survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

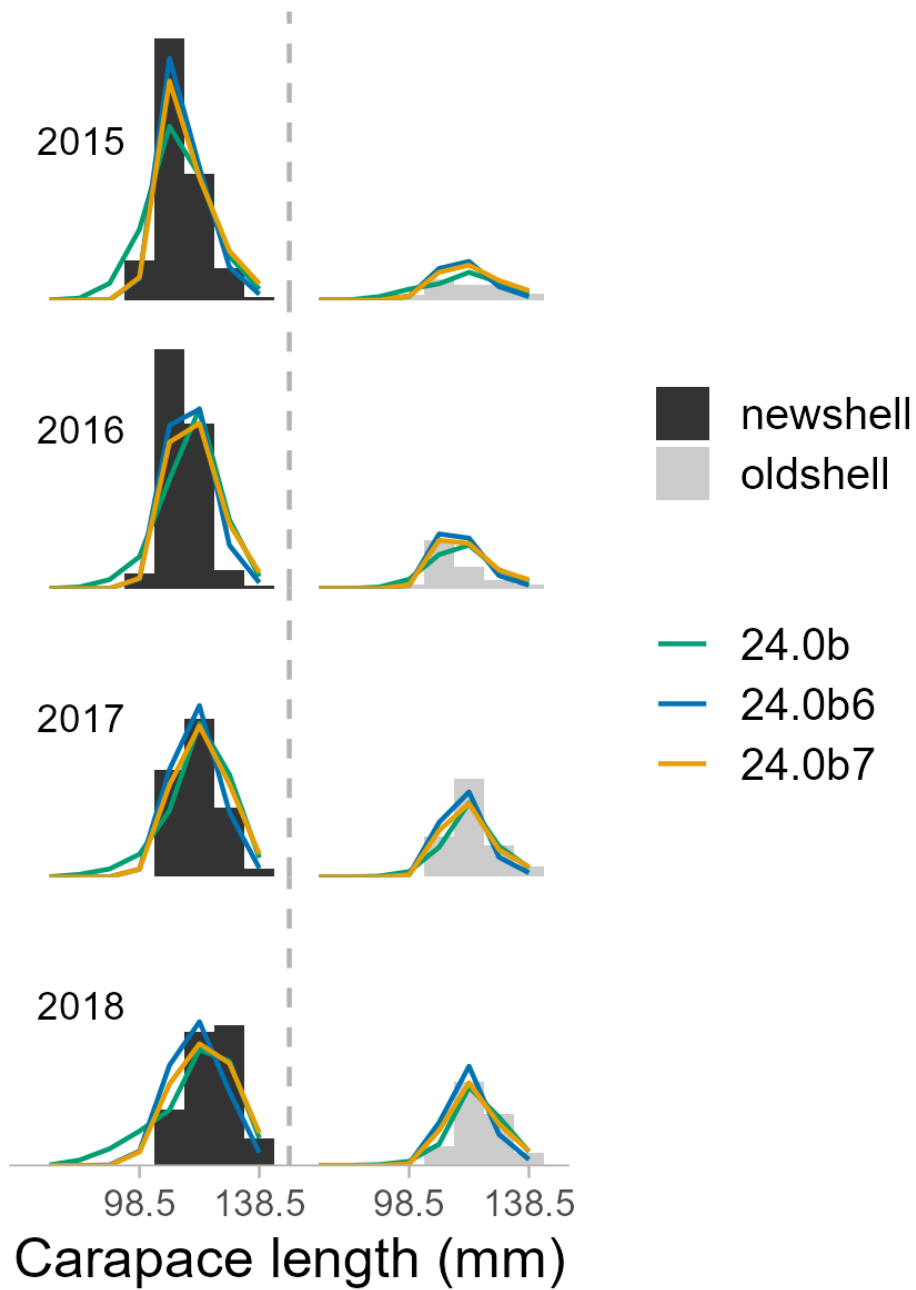


Figure 38: Annual observed and model-estimated size frequencies of male red king crab retained in the directed winter commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

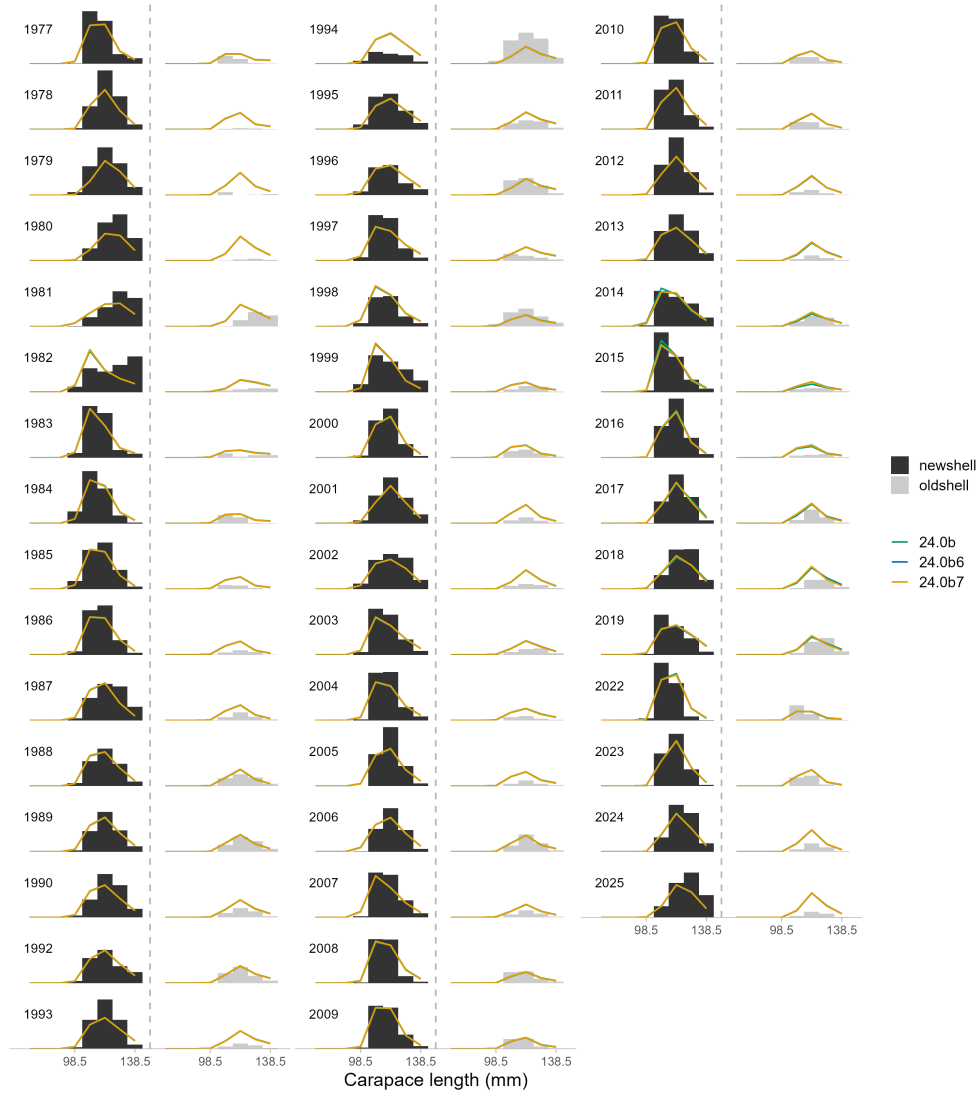


Figure 39: Annual observed and model-estimated size frequencies of male red king crab retained in the directed summer commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

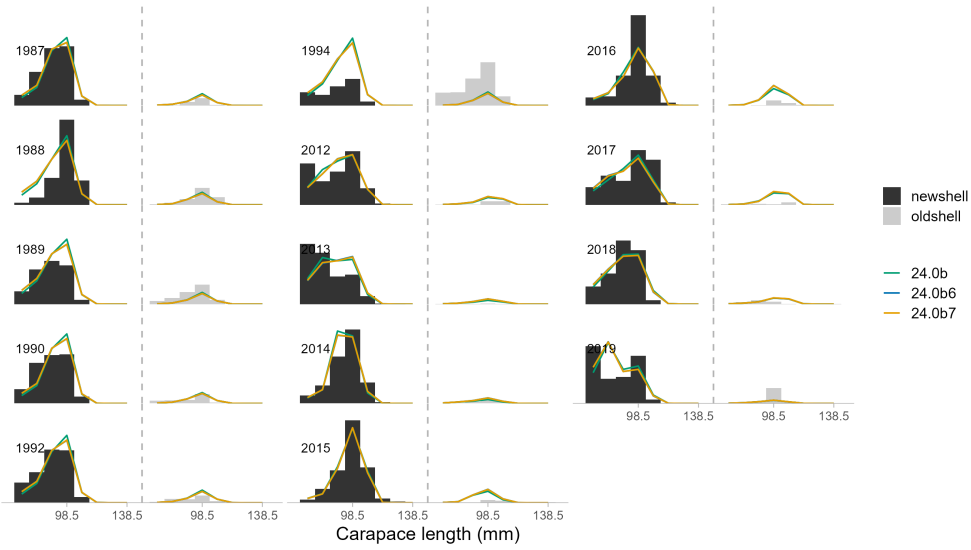


Figure 40: Annual observed and model-estimated size frequencies of male red king crab discarded in the directed summer commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

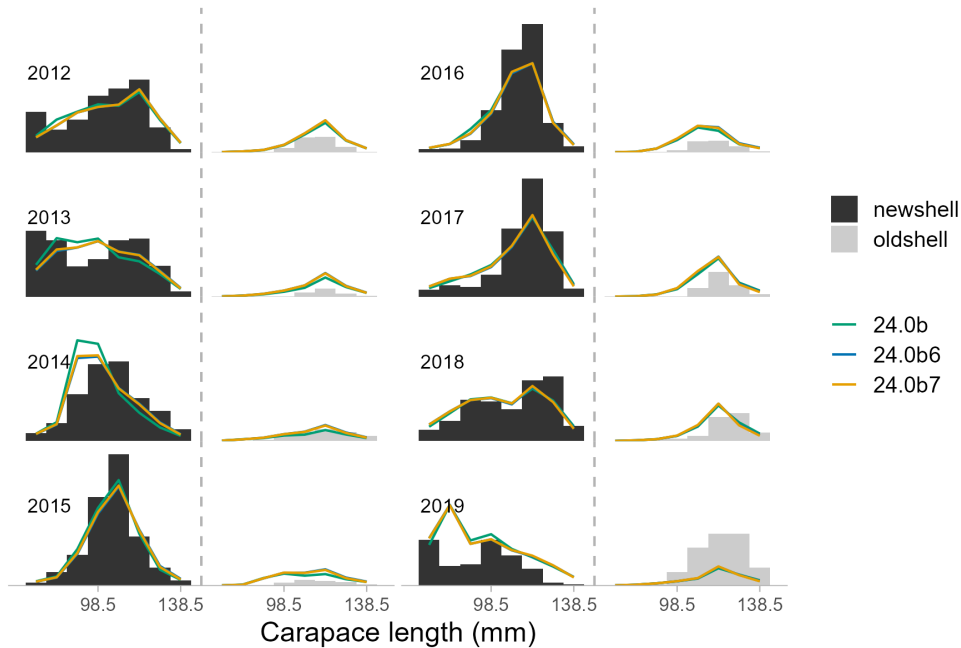


Figure 41: Annual observed and model-estimated size frequencies of all male red king crab caught in the directed summer commercial fishery for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

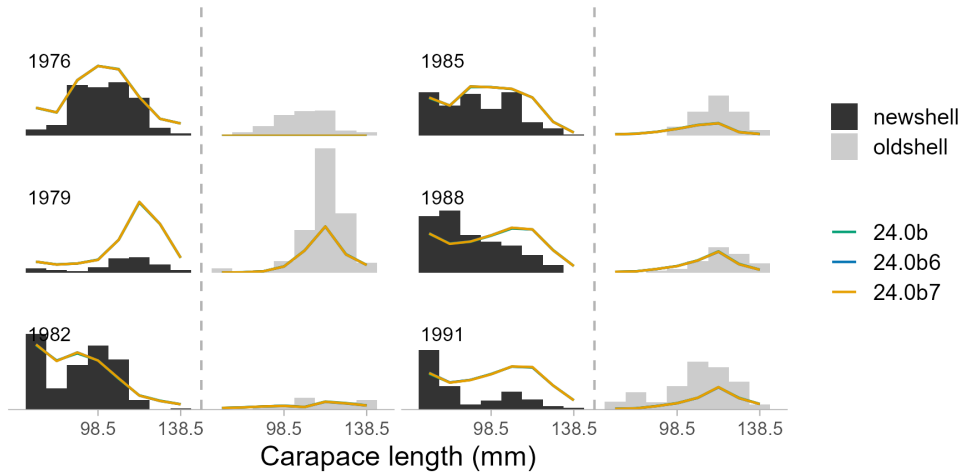


Figure 42: Annual observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

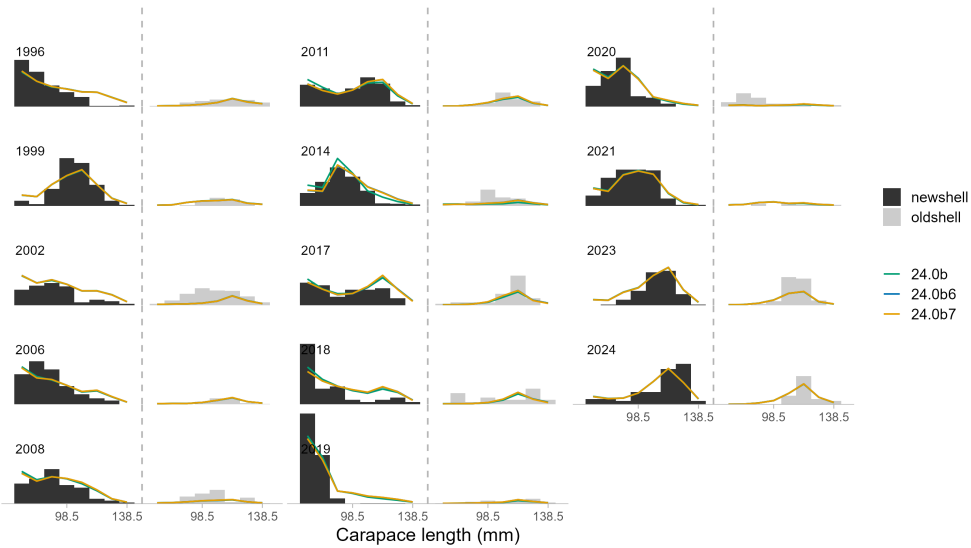


Figure 43: Annual observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) trawl survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

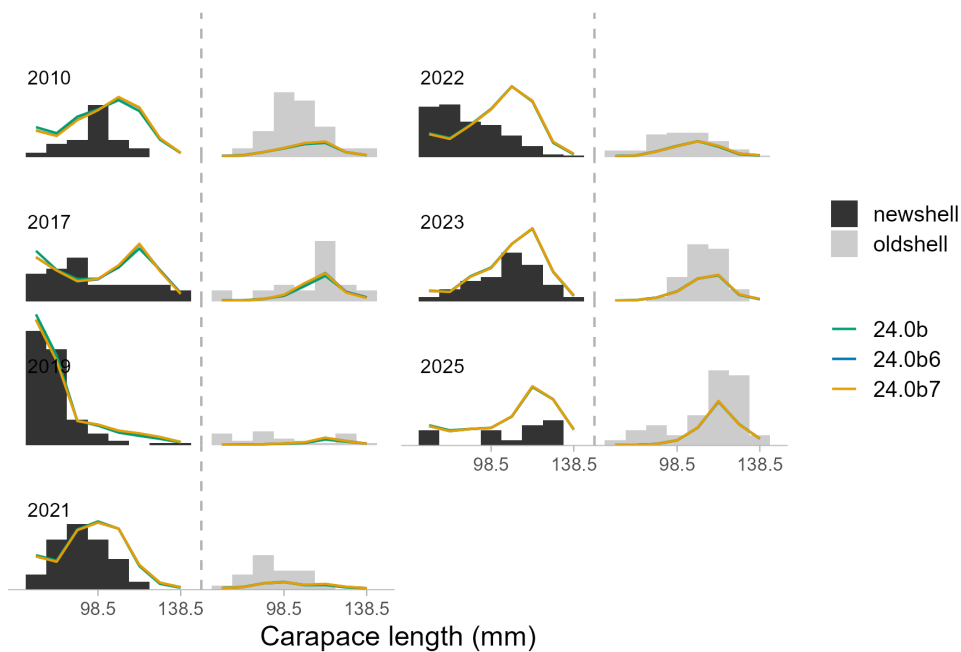


Figure 44: Annual observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

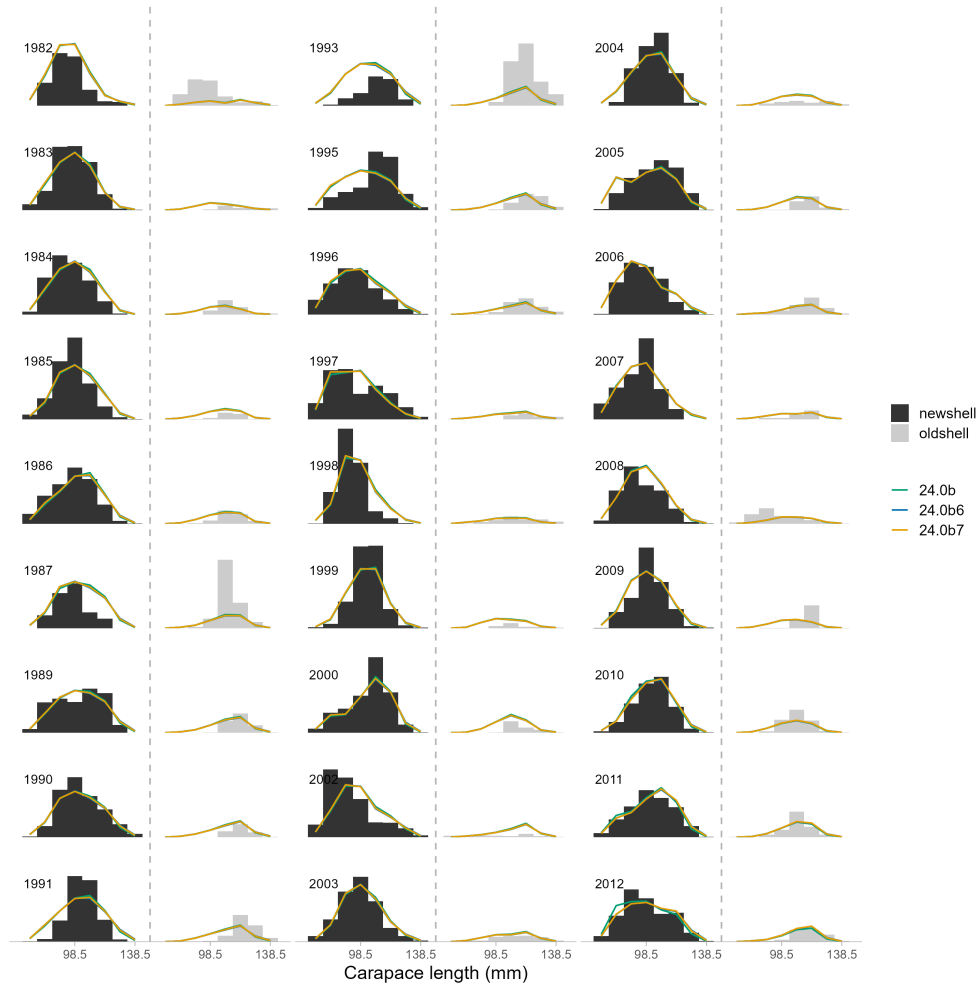


Figure 45: Annual observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) winter pot survey for models 24.0b, 24.0b6, and 24.0b7. Black bars represent crab classified as newshell and grey bars represent crab classified as oldshell.

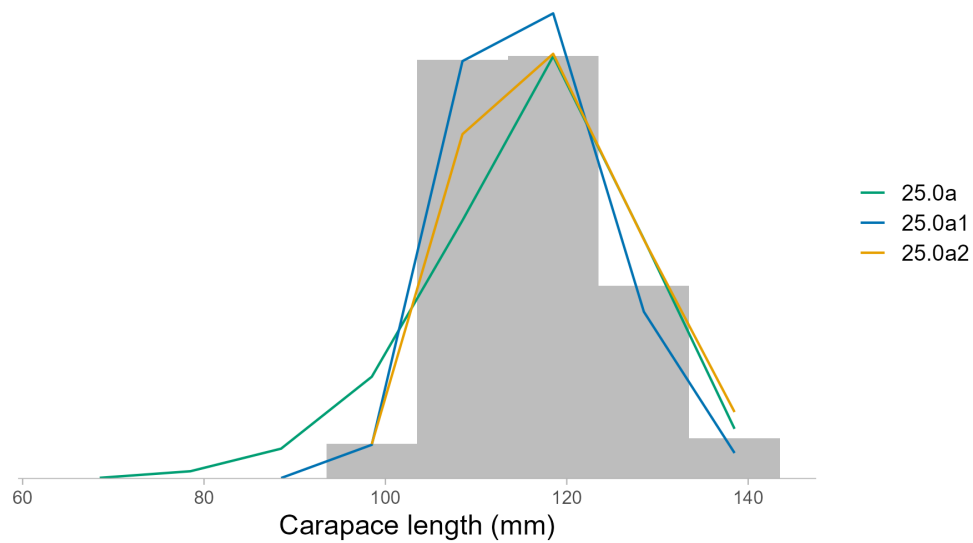


Figure 46: Aggregated observed and model-estimated size frequencies of male red king crab retained in the directed winter commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

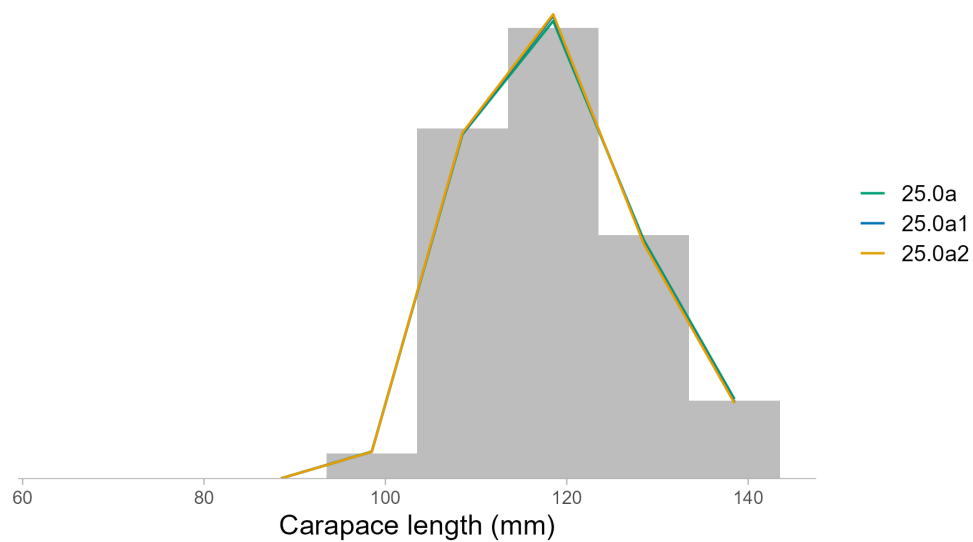


Figure 47: Aggregated observed and model-estimated size frequencies of male red king crab retained in the directed summer commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

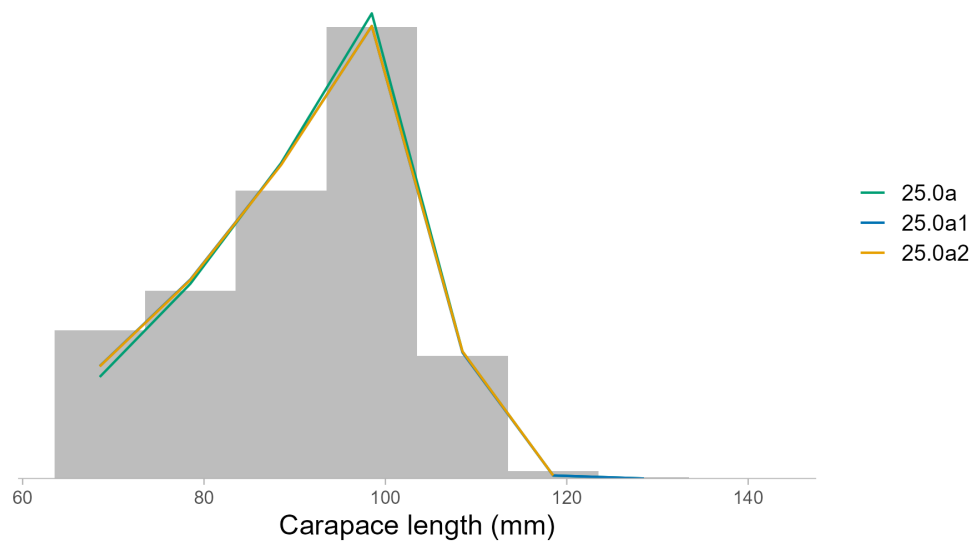


Figure 48: Aggregated observed and model-estimated size frequencies of male red king crab discarded in the directed summer commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

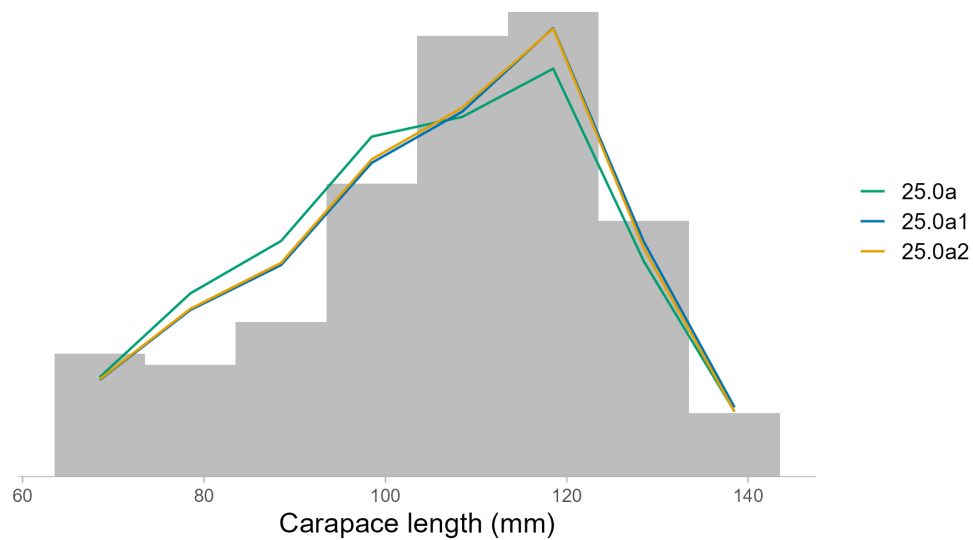


Figure 49: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the directed summer commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

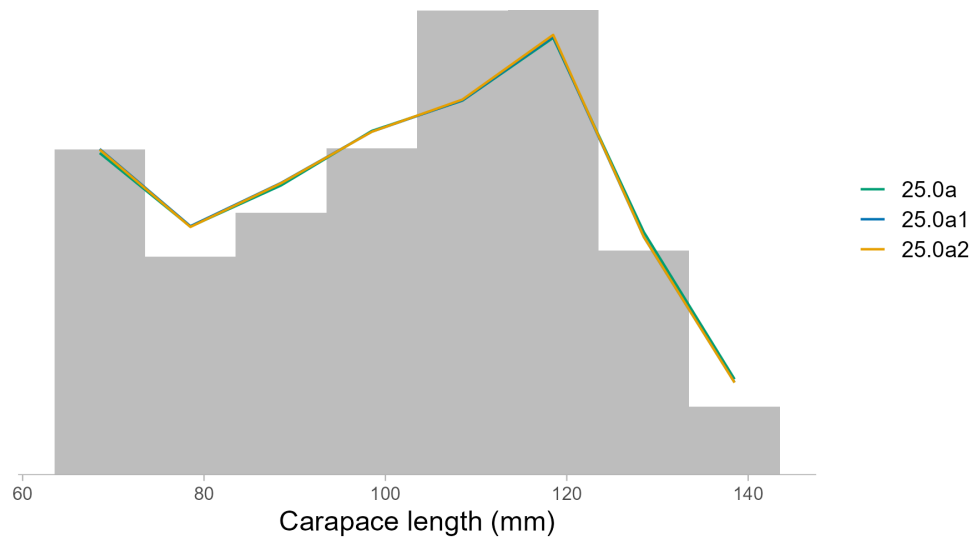


Figure 50: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for models 25.0a, 25.0a1, and 25.0a2.

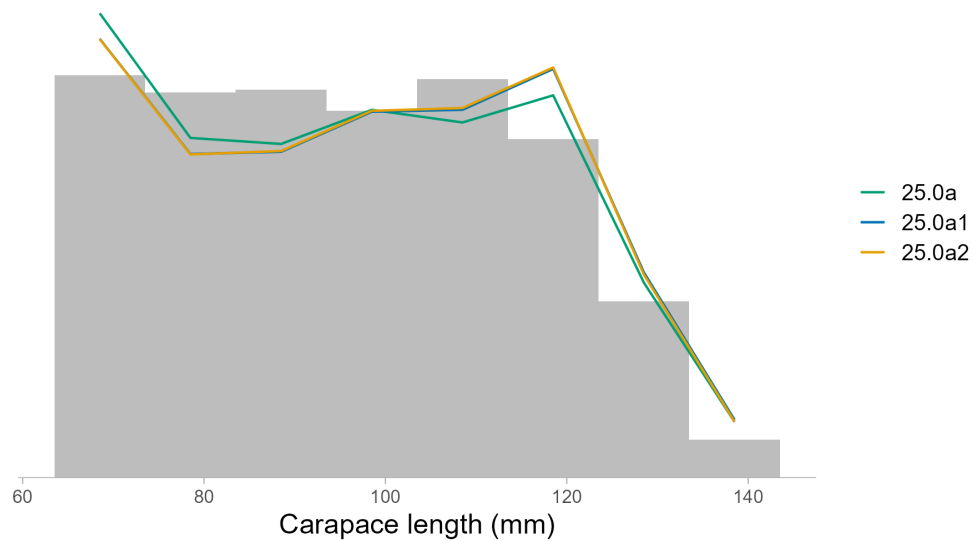


Figure 51: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) trawl survey for models 25.0a, 25.0a1, and 25.0a2.

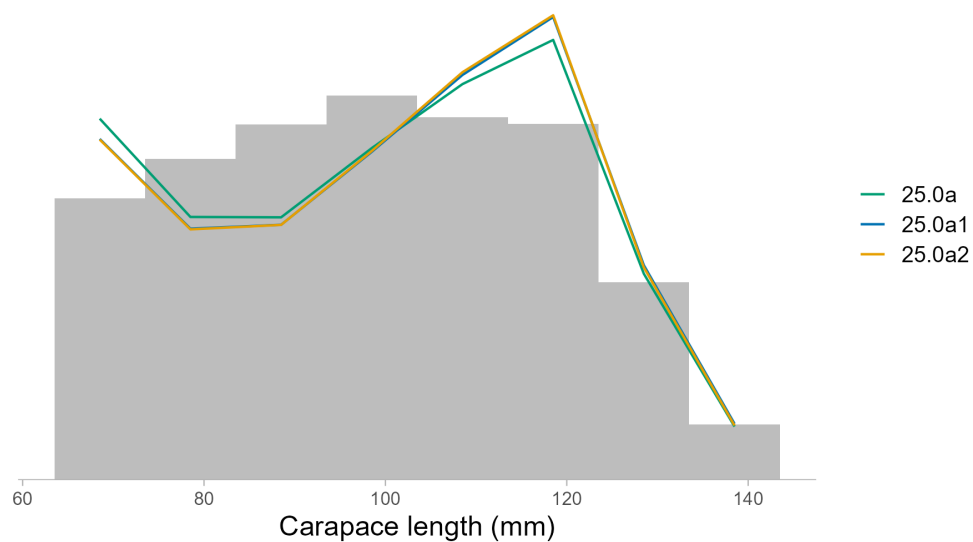


Figure 52: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for models 25.0a, 25.0a1, and 25.0a2.

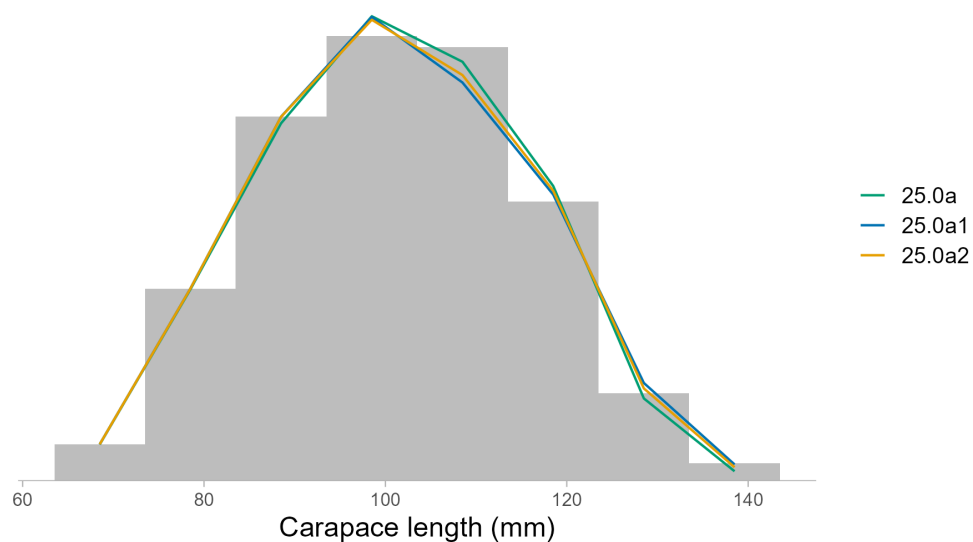


Figure 53: Aggregated observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) winter pot survey for models 25.0a, 25.0a1, and 25.0a2.

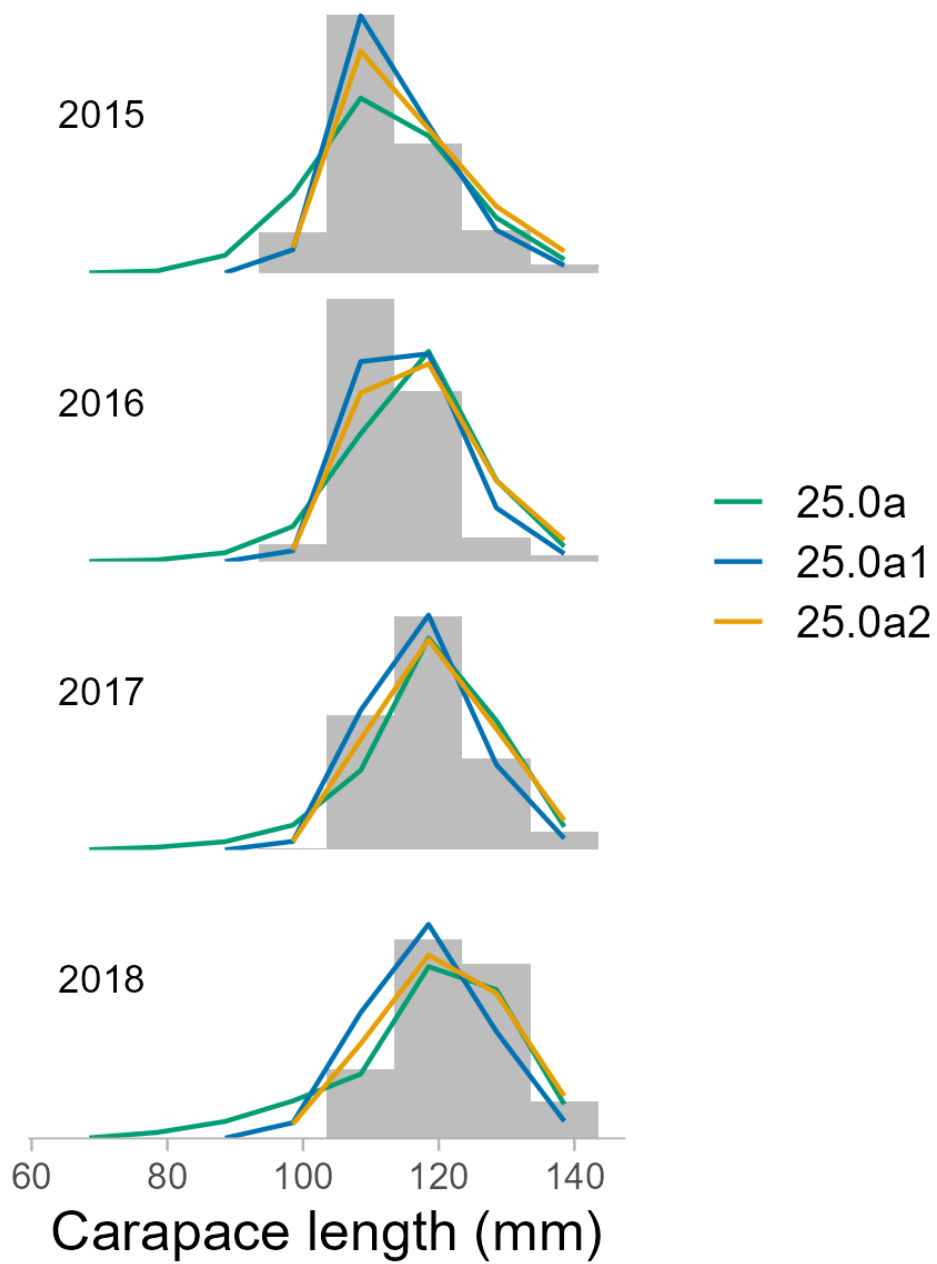


Figure 54: Annual observed and model-estimated size frequencies of male red king crab retained in the directed winter commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

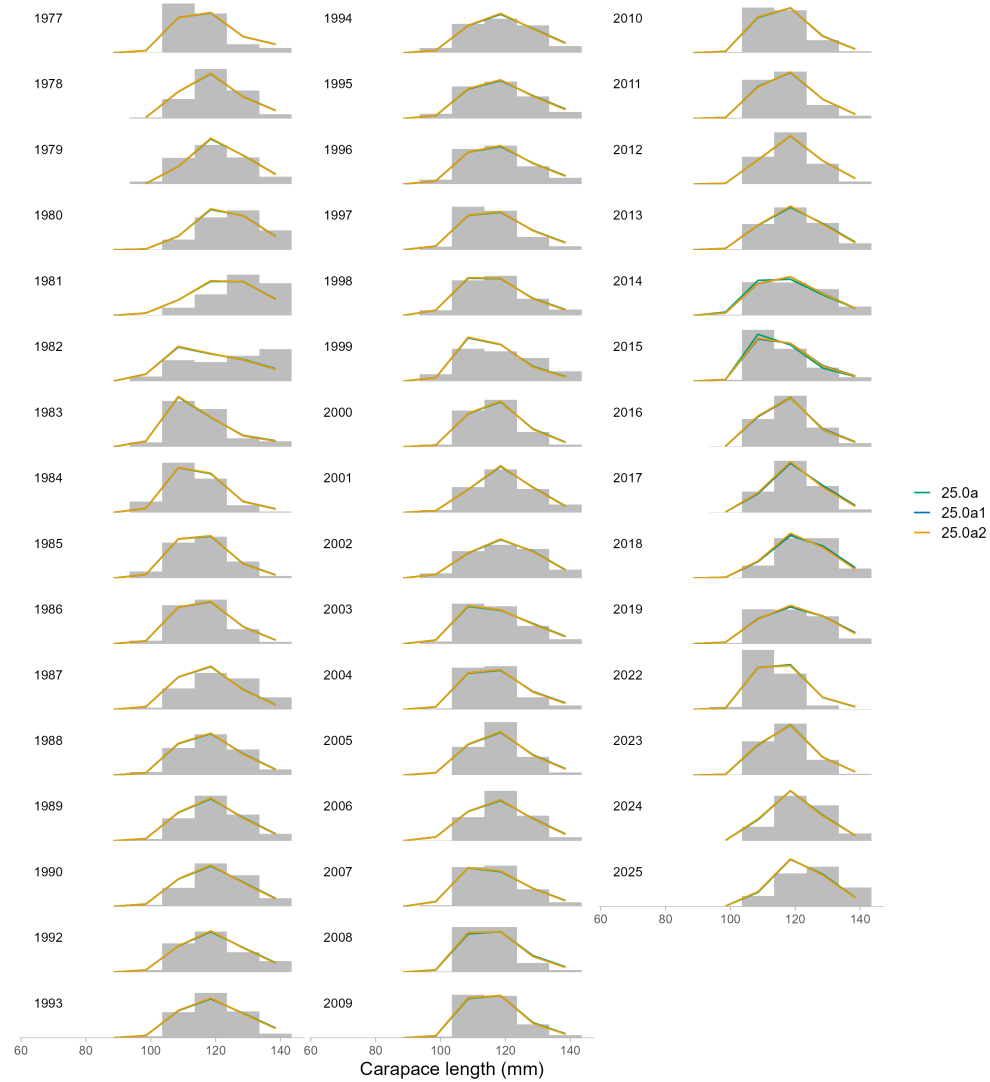


Figure 55: Annual observed and model-estimated size frequencies of male red king crab retained in the directed summer commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

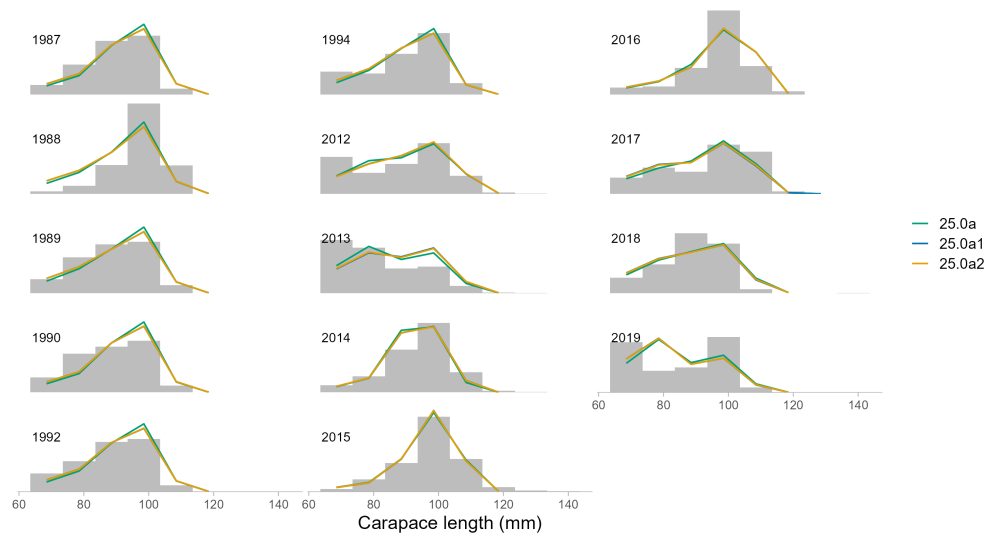


Figure 56: Annual observed and model-estimated size frequencies of male red king crab discarded in the directed summer commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

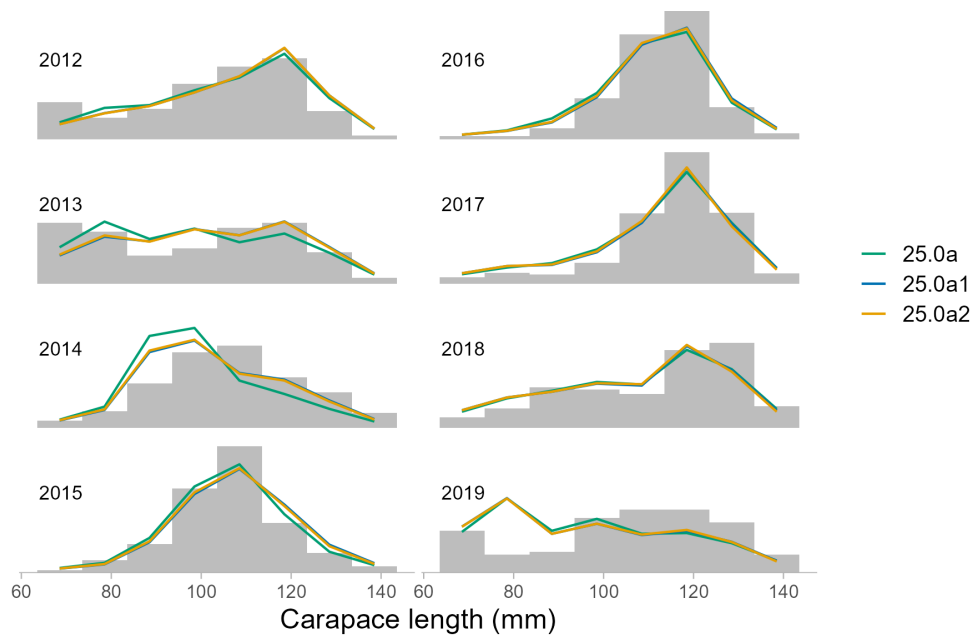


Figure 57: Annual observed and model-estimated size frequencies of all male red king crab caught in the directed summer commercial fishery for models 25.0a, 25.0a1, and 25.0a2.

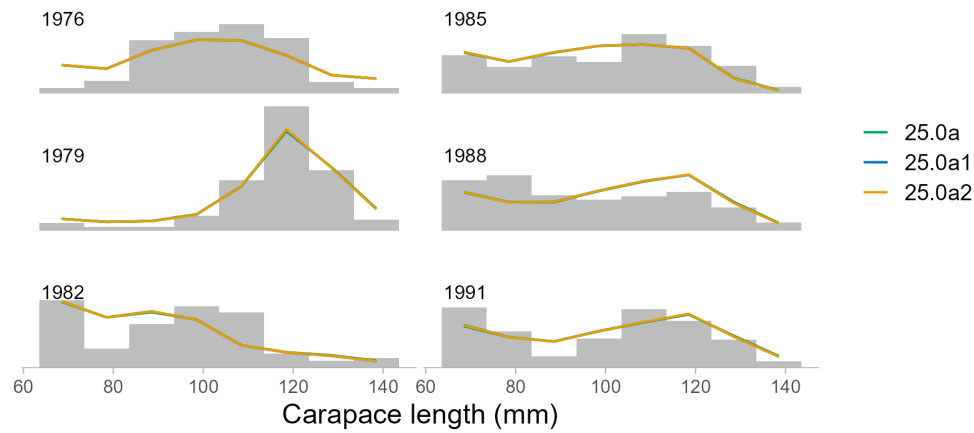


Figure 58: Annual observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey for models 25.0a, 25.0a1, and 25.0a2.

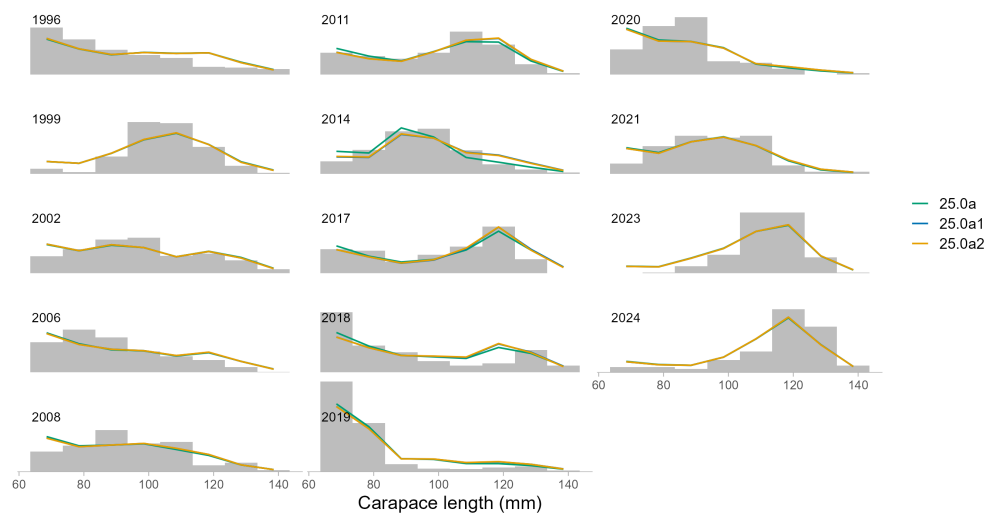


Figure 59: Annual observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) trawl survey for models 25.0a, 25.0a1, and 25.0a2.

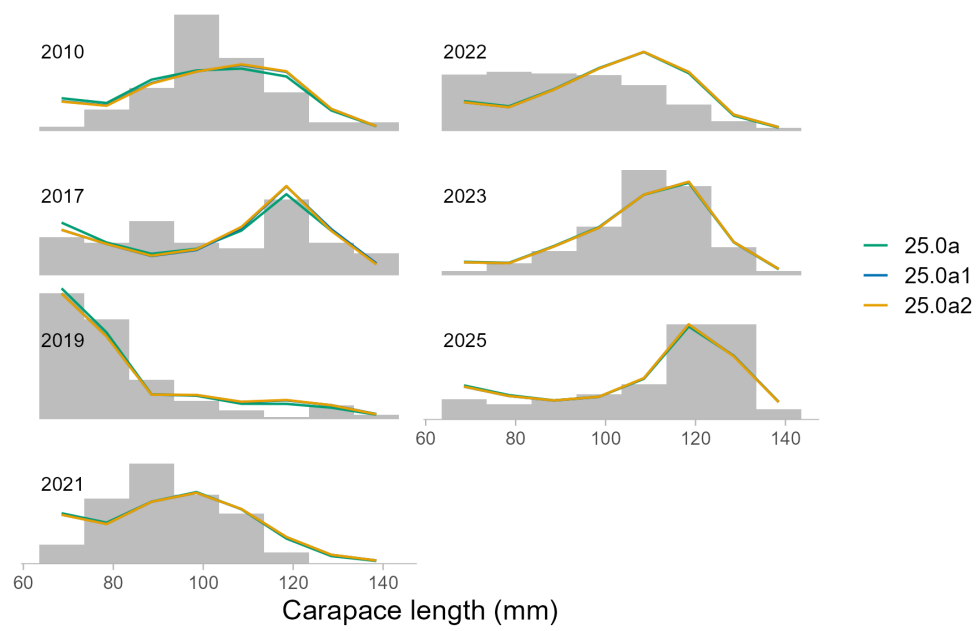


Figure 60: Annual observed and model-estimated size frequencies of all male red king crab caught in the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey for models 25.0a, 25.0a1, and 25.0a2.

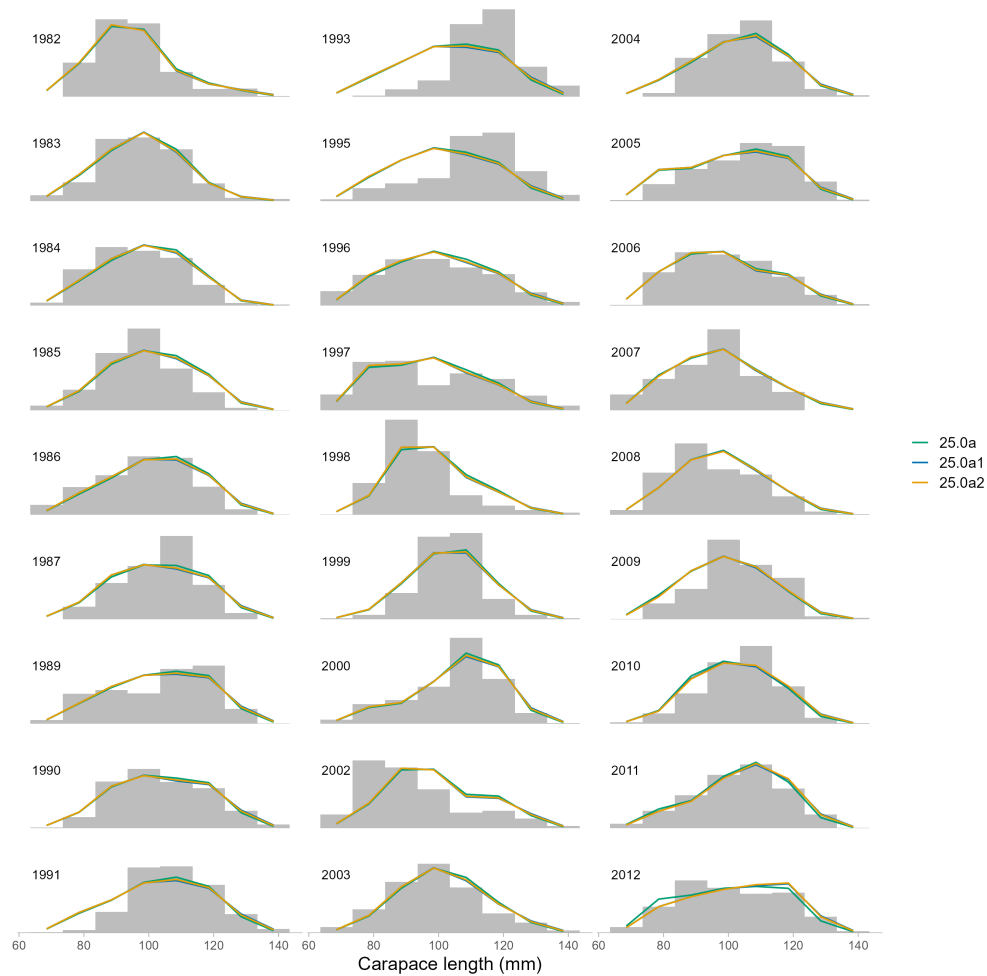


Figure 61: Annual observed and model-estimated size frequencies of all male red king crab caught in the Alaska Department of Fish and Game (ADFG) winter pot survey for models 25.0a, 25.0a1, and 25.0a2.

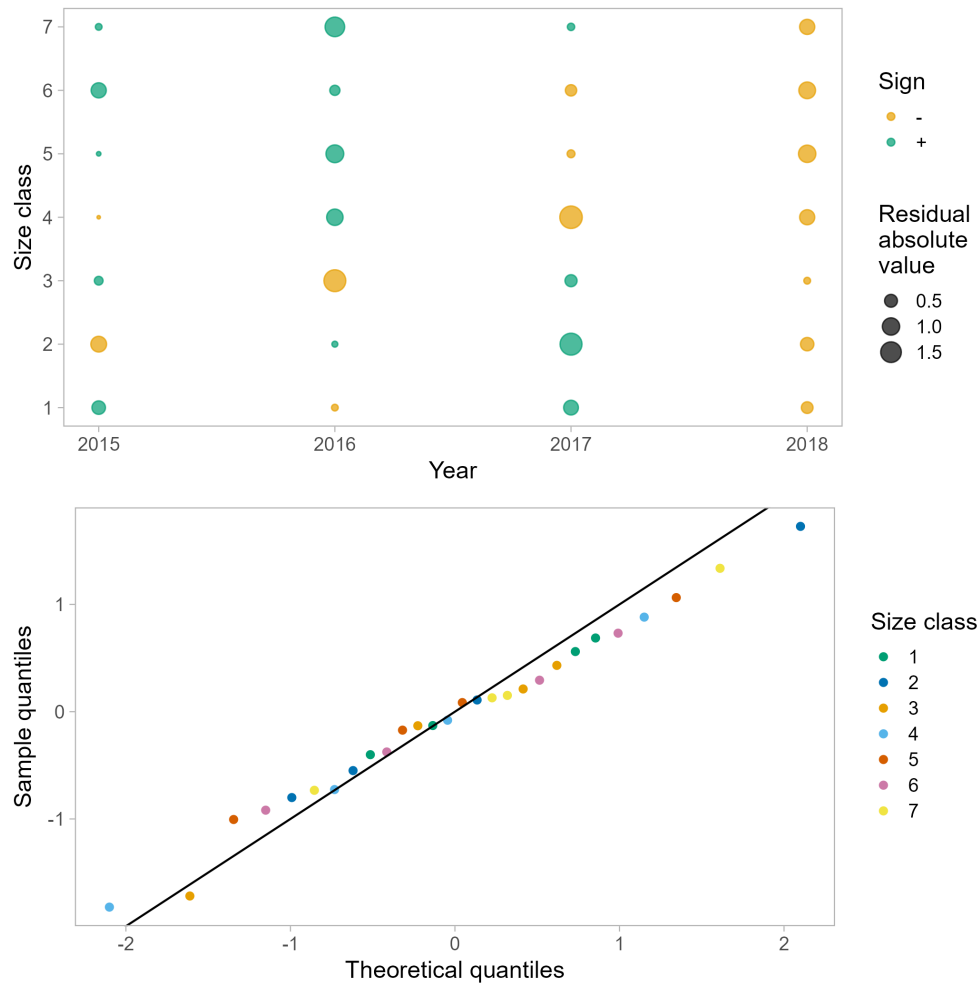


Figure 62: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the winter commercial fishery retained catch.

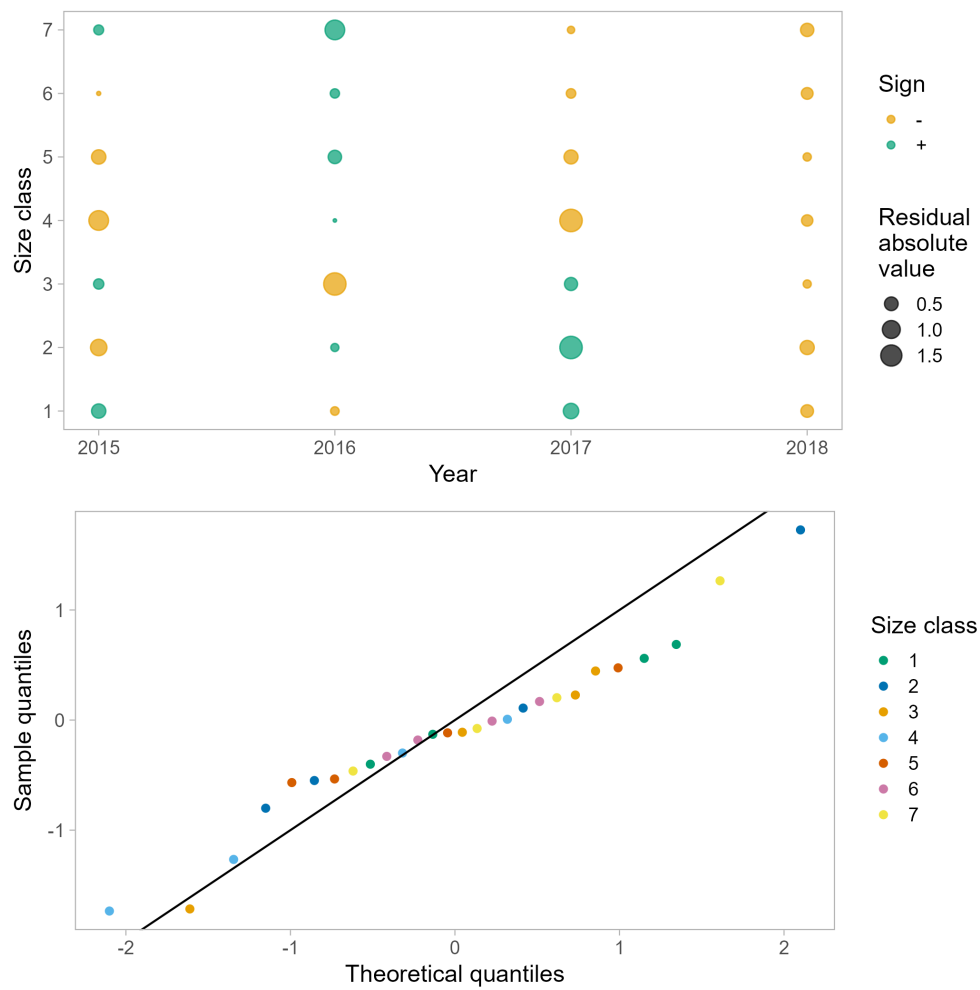


Figure 63: One-Step-Ahead residuals for model 24.0b6 fits to oldshell male size composition data from the winter commercial fishery retained catch.

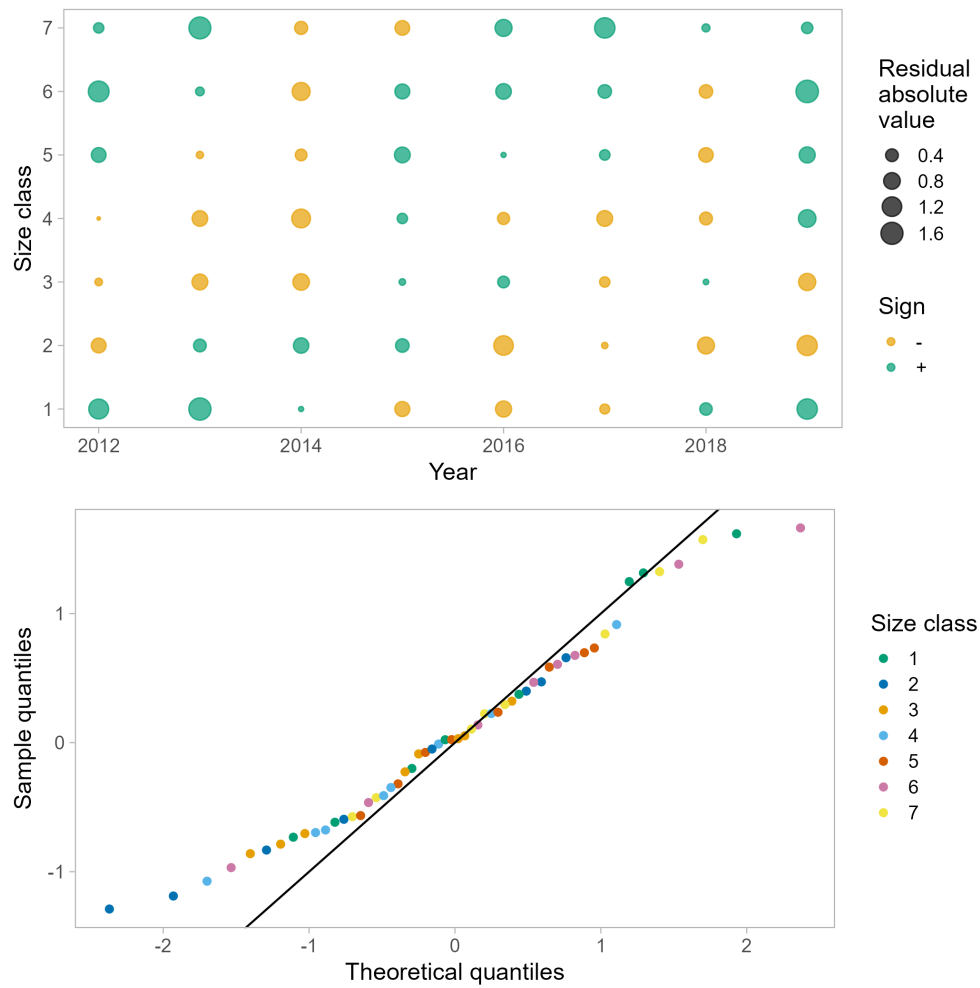


Figure 64: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the summer commercial fishery total catch.

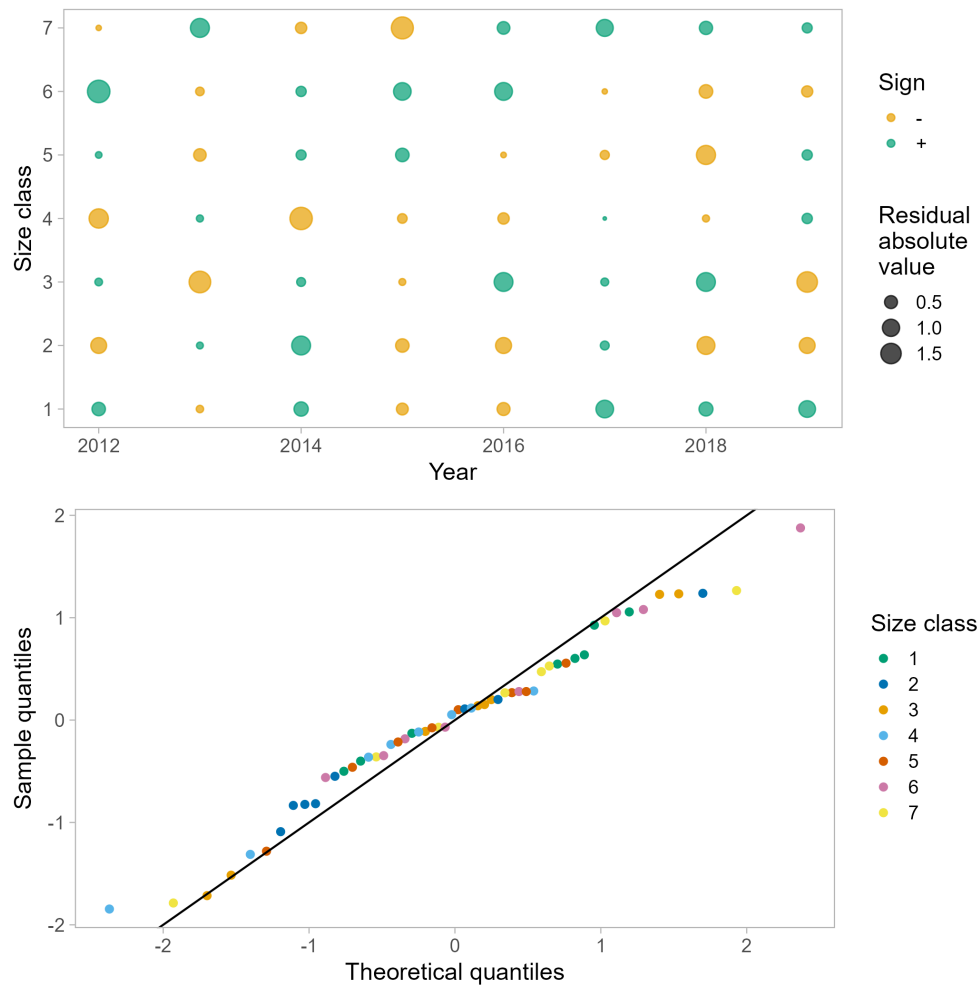


Figure 65: One-Step-Ahead residuals for model 24.0b6 fits to oldshell male size composition data from the summer commercial fishery total catch.

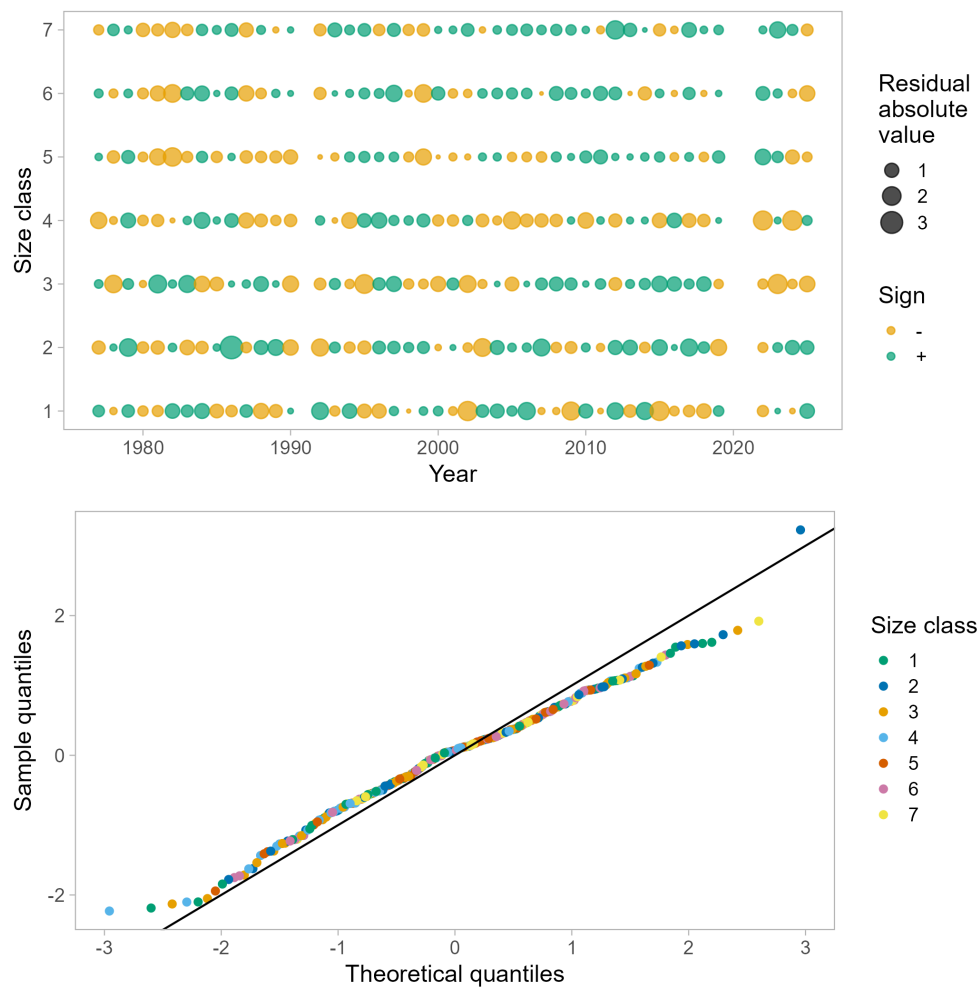


Figure 66: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the summer commercial fishery retained catch.

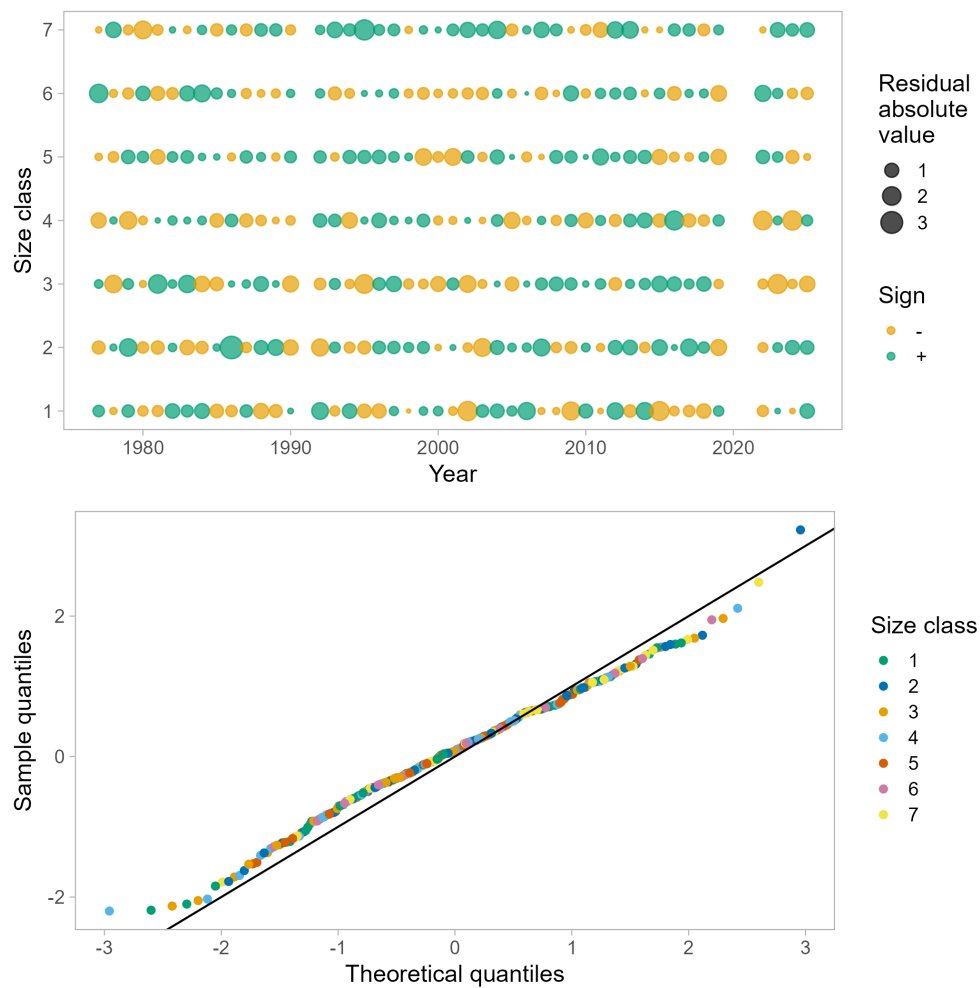


Figure 67: One-Step-Ahead residuals for model 24.0b6 fits to oldshell male size composition data from the summer commercial fishery retained catch.

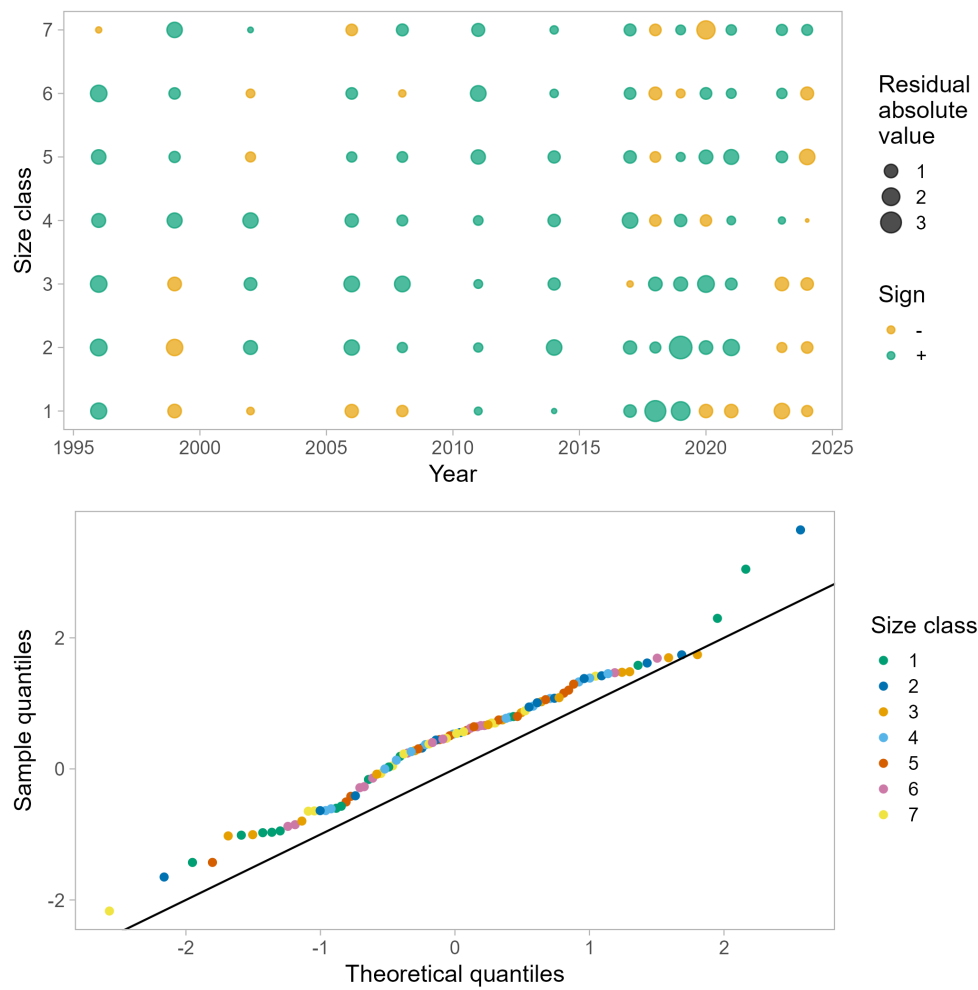


Figure 68: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

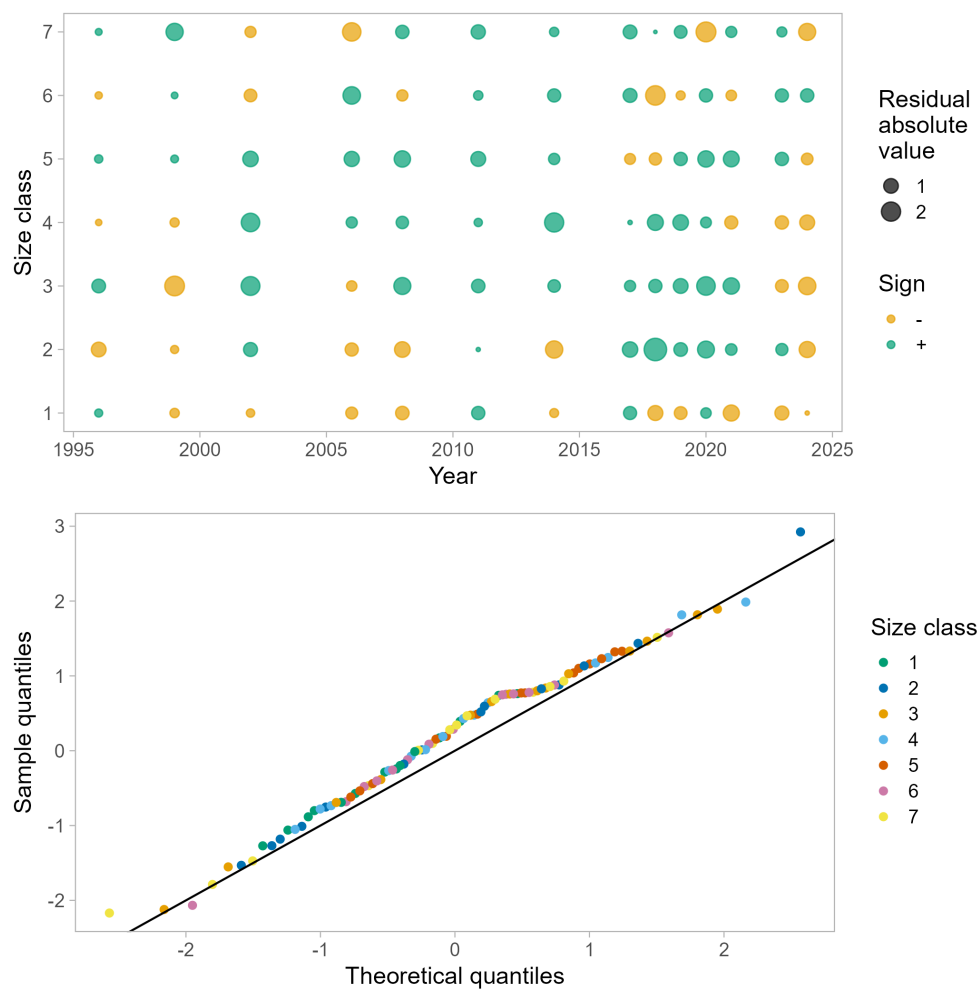


Figure 69: One-Step-Ahead residuals for model 24.0b6 fits to oldshell male size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

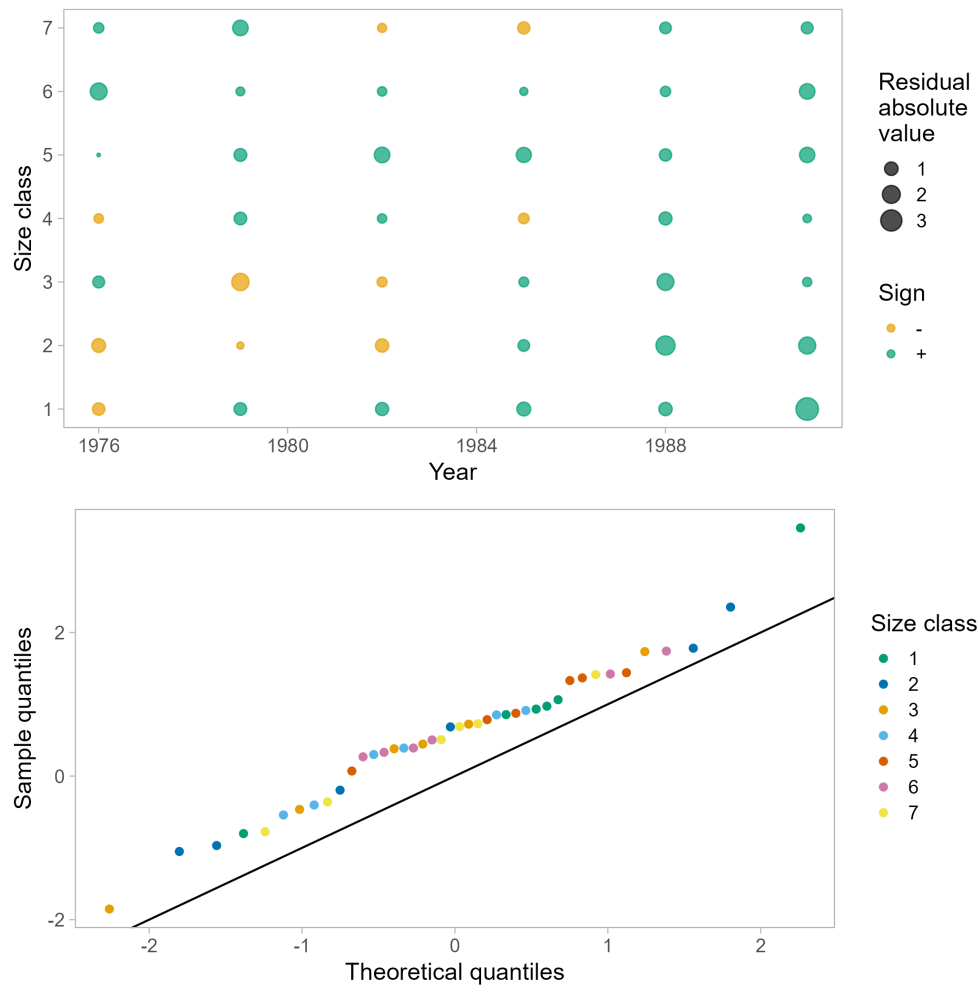


Figure 70: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

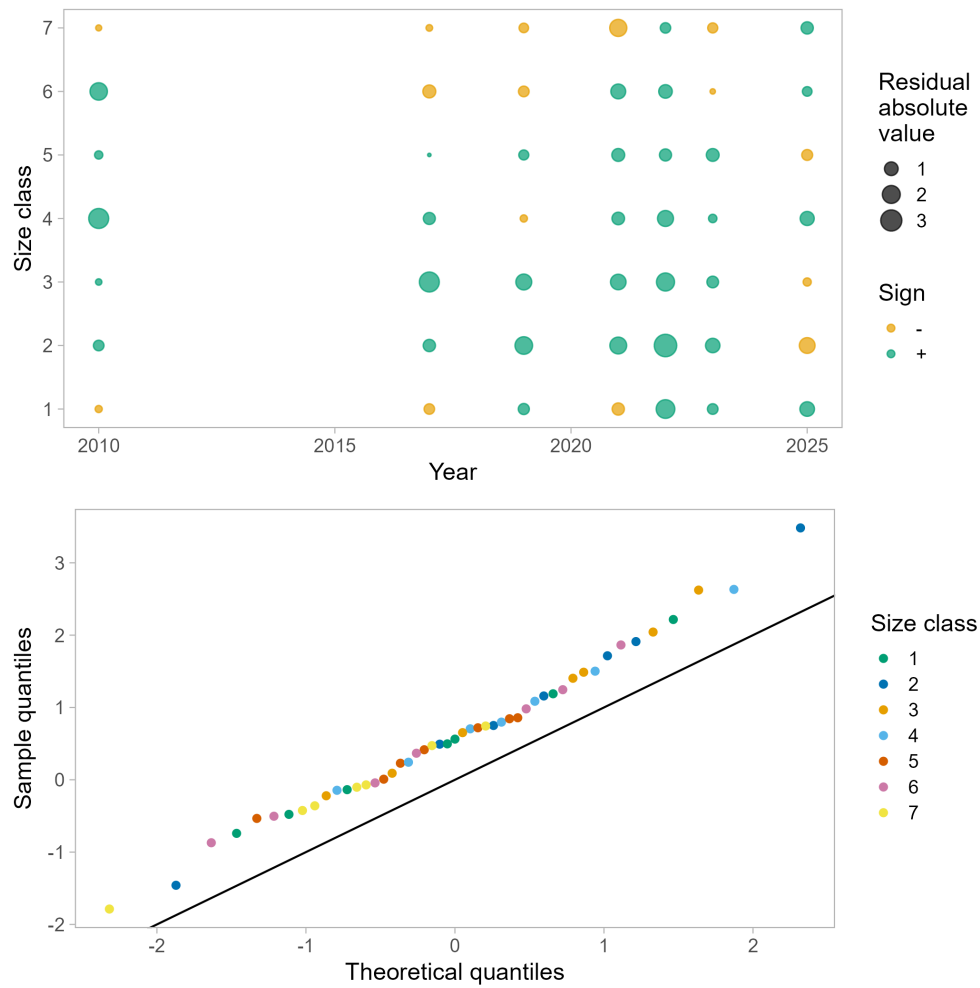


Figure 71: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

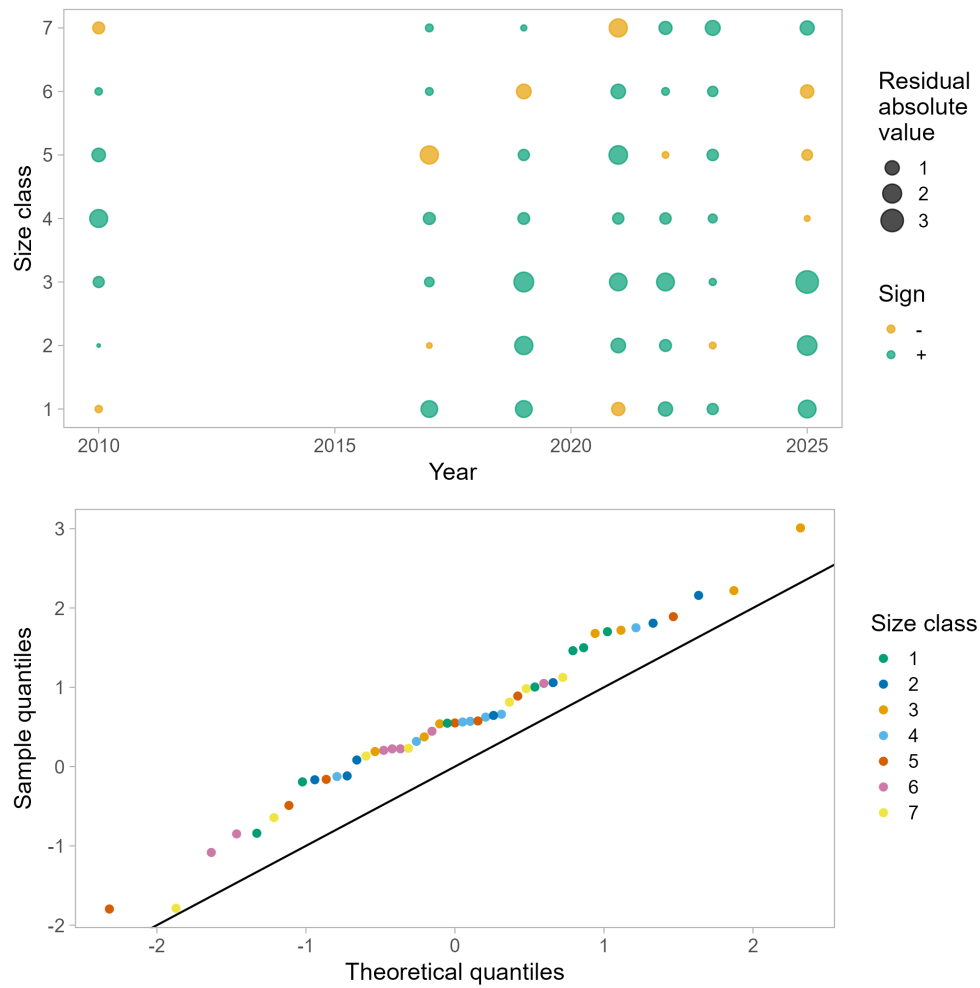


Figure 72: One-Step-Ahead residuals for model 24.0b6 fits to oldshell male size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

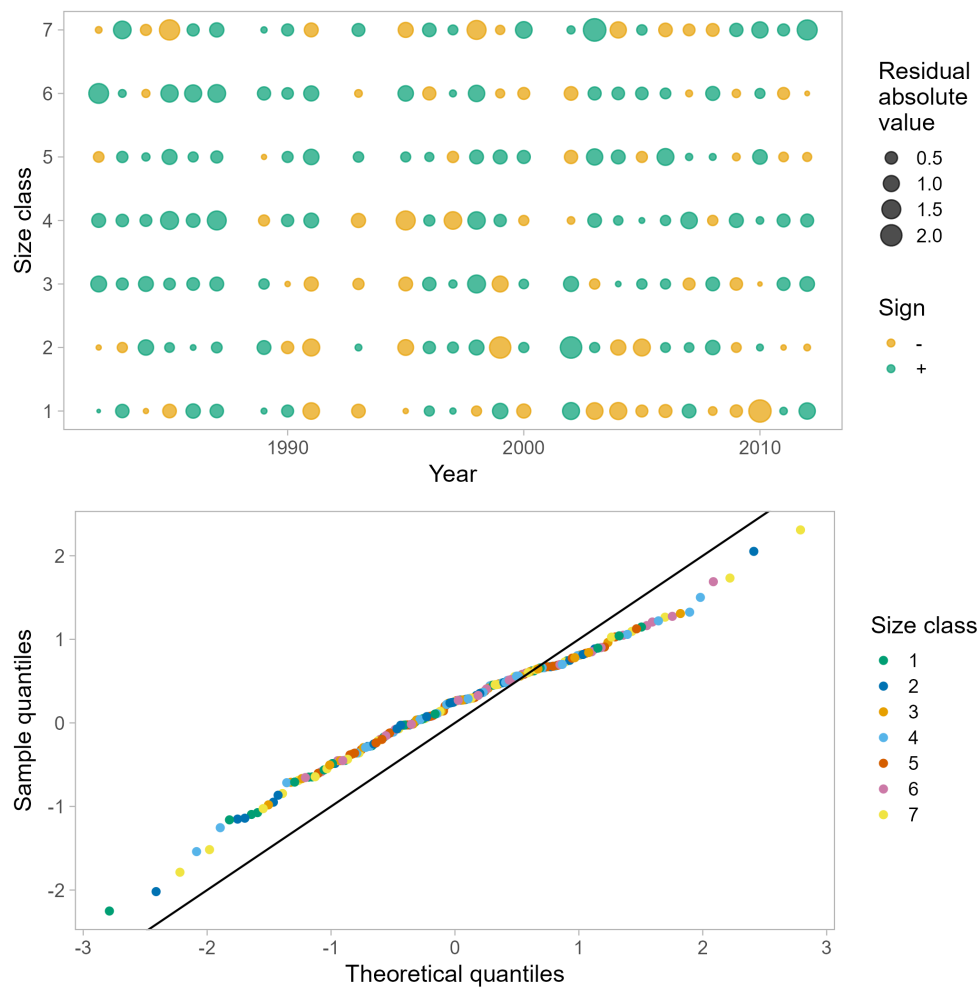


Figure 73: One-Step-Ahead residuals for model 24.0b6 fits to newshell male size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

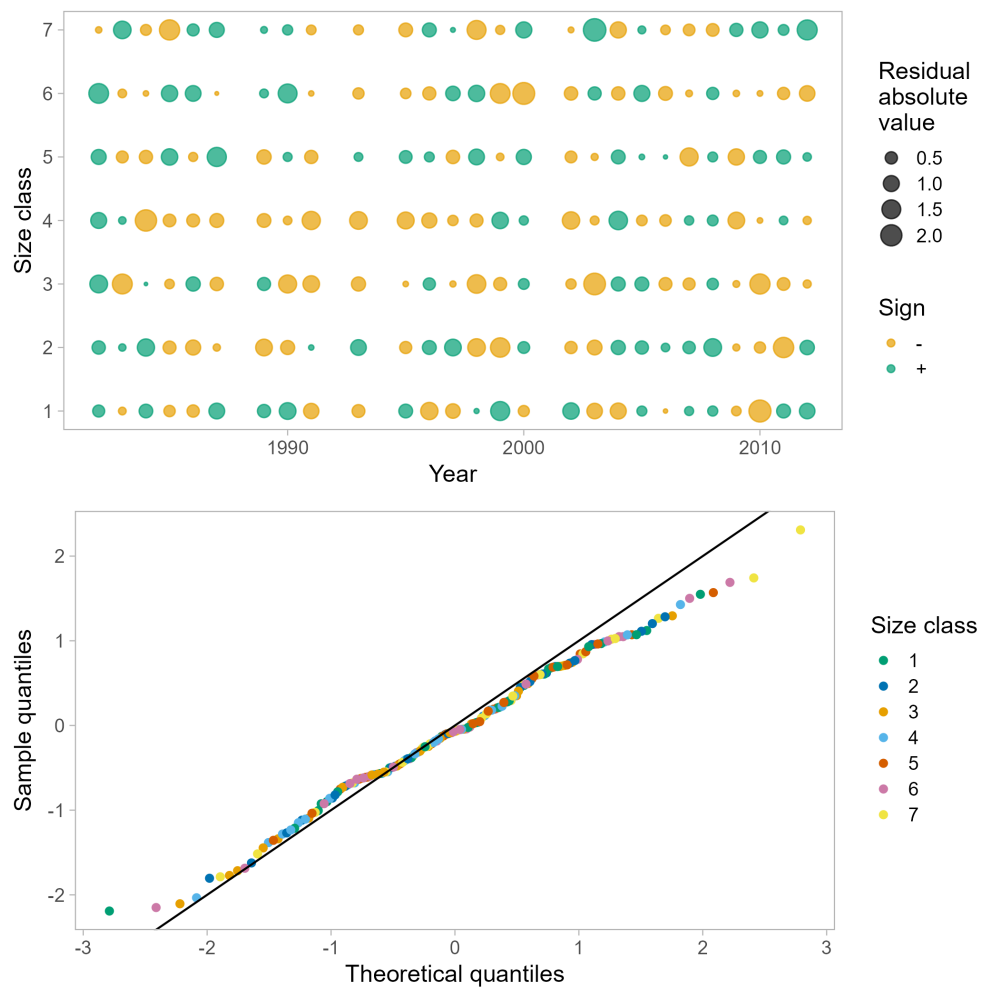


Figure 74: One-Step-Ahead residuals for model 24.0b6 fits to oldshell male size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

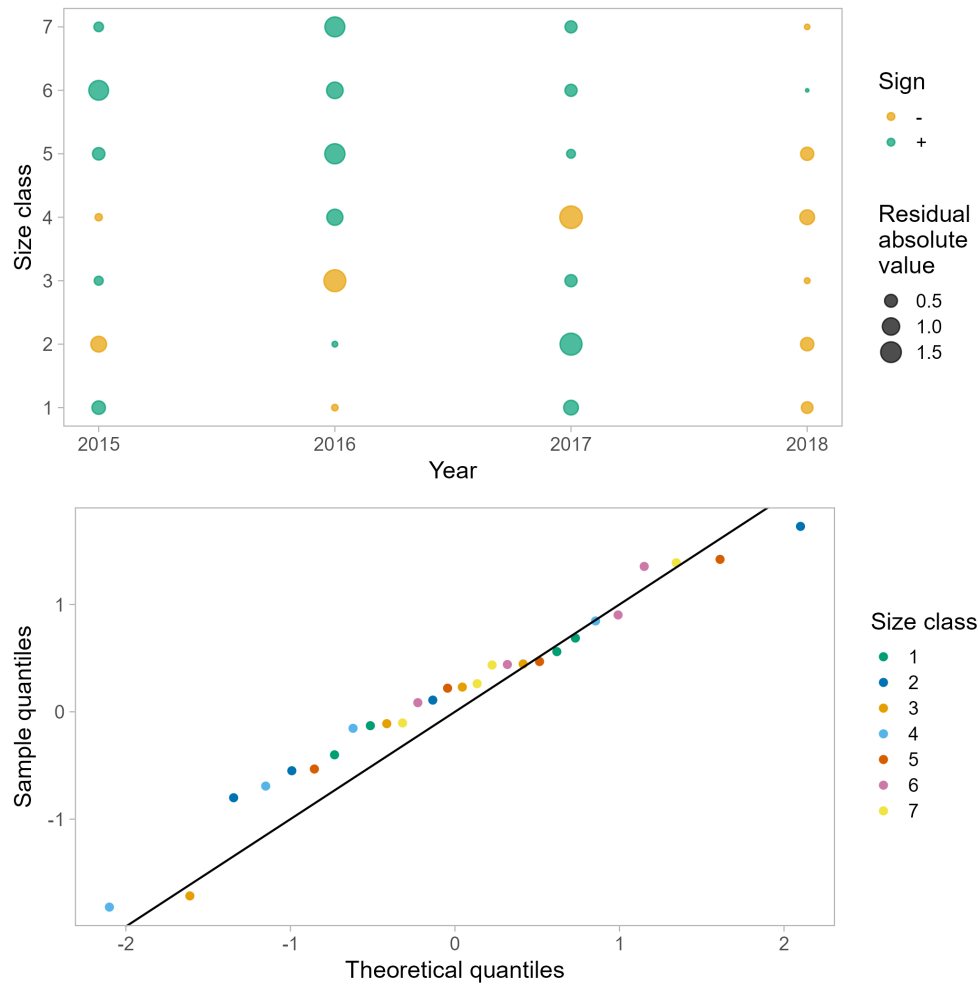


Figure 75: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the winter commercial fishery retained catch.

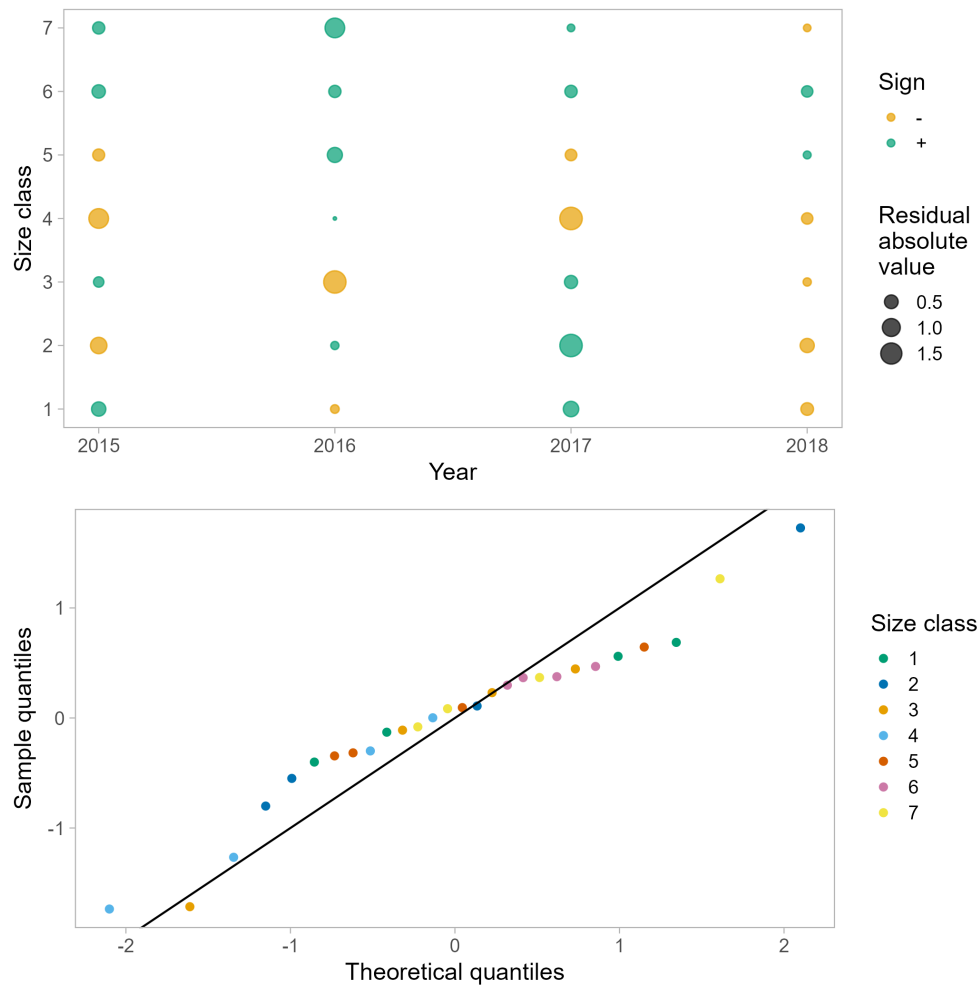


Figure 76: One-Step-Ahead residuals for model 24.0b7 fits to oldshell male size composition data from the winter commercial fishery retained catch.

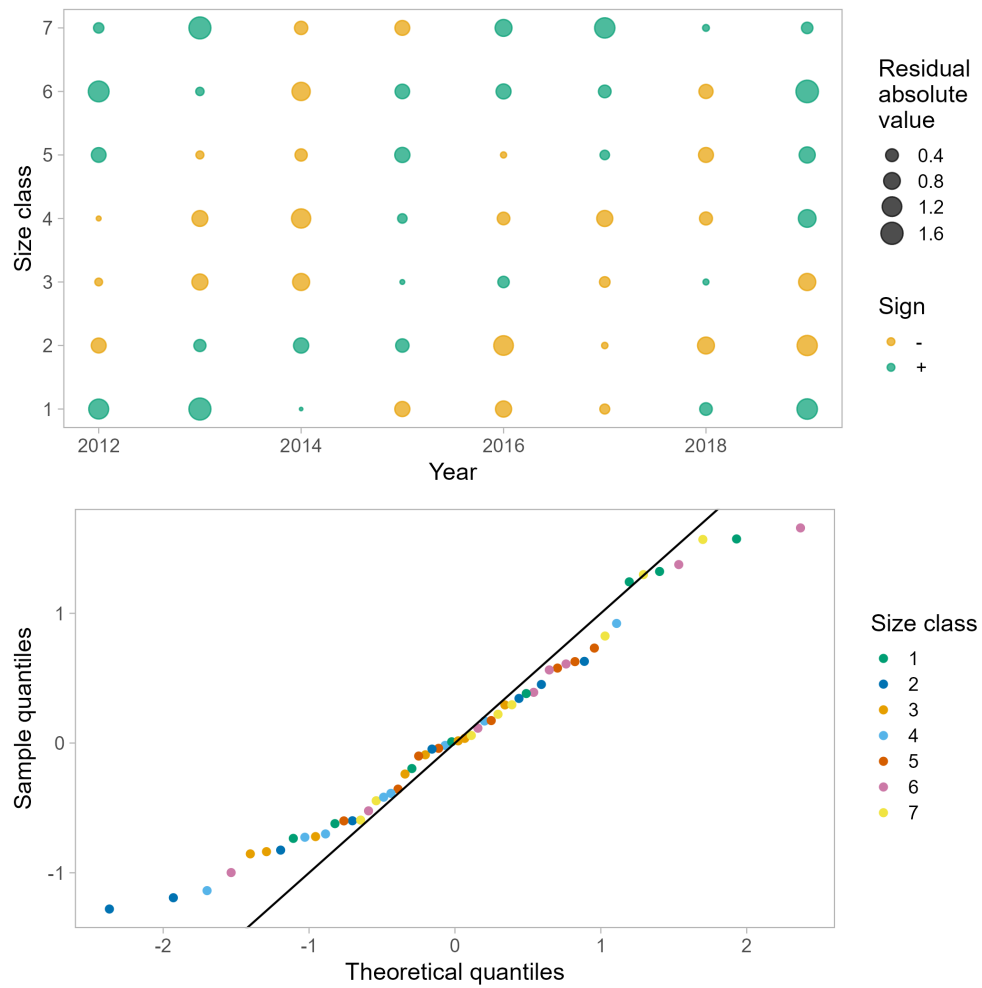


Figure 77: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the summer commercial fishery total catch.

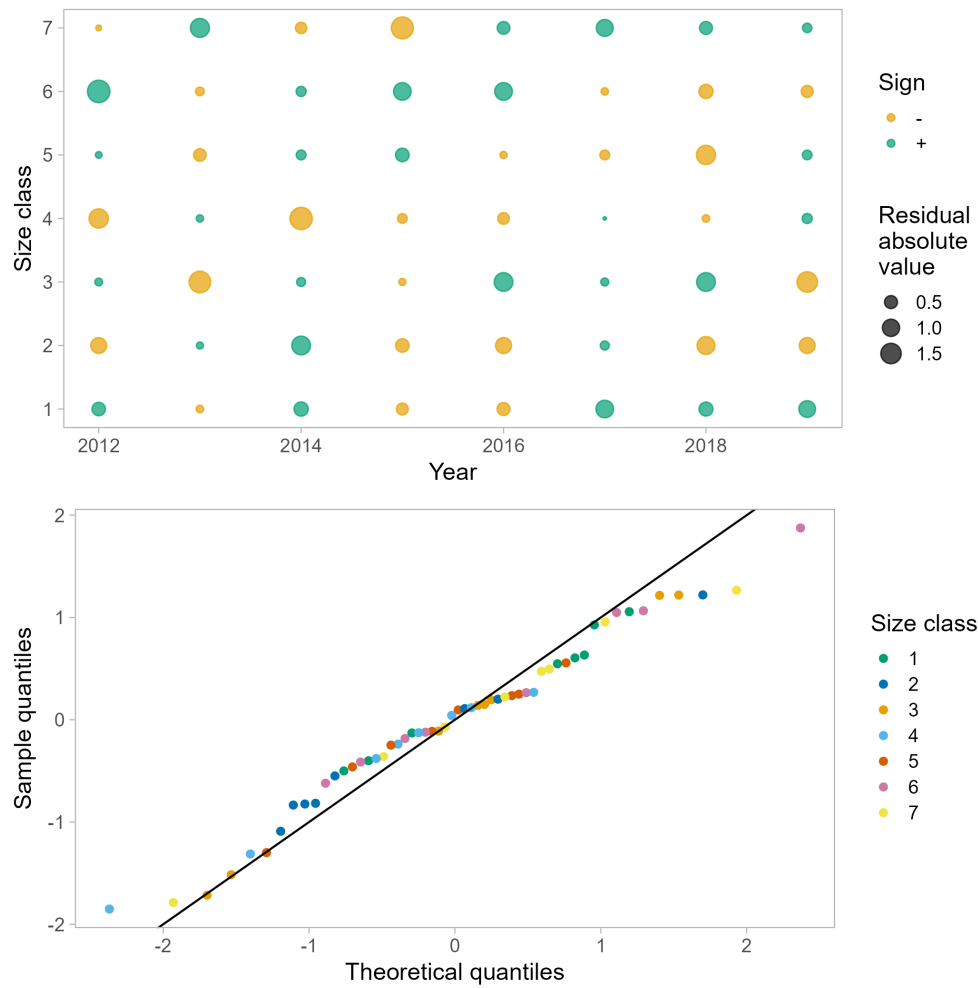


Figure 78: One-Step-Ahead residuals for model 24.0b7 fits to oldshell male size composition data from the summer commercial fishery total catch.

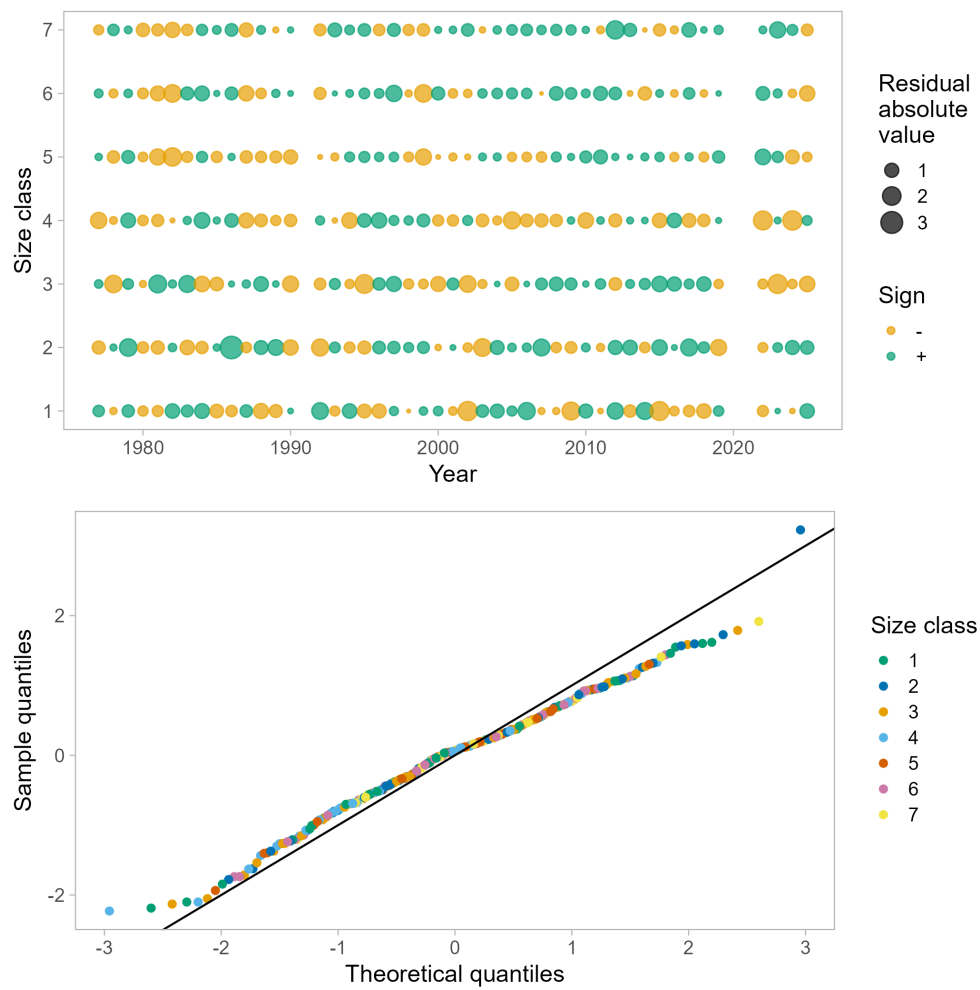


Figure 79: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the summer commercial fishery retained catch.

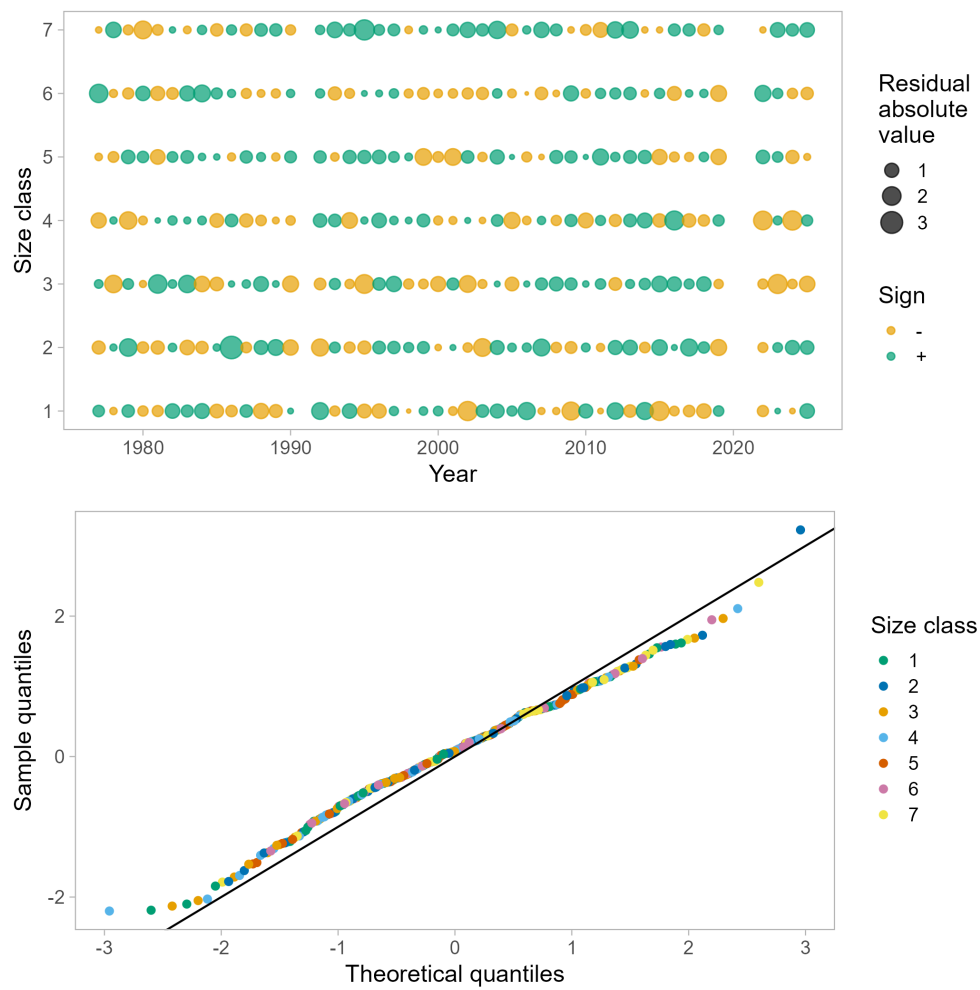


Figure 80: One-Step-Ahead residuals for model 24.0b7 fits to oldshell male size composition data from the summer commercial fishery retained catch.

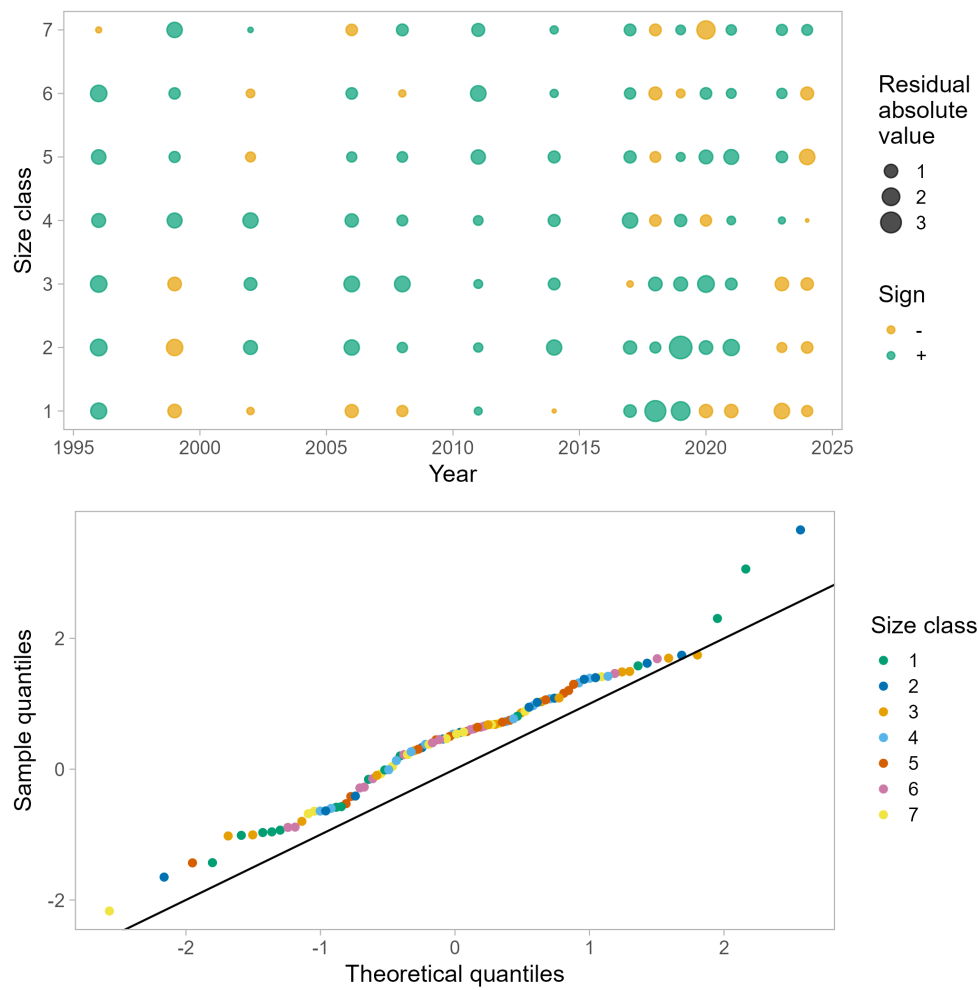


Figure 81: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

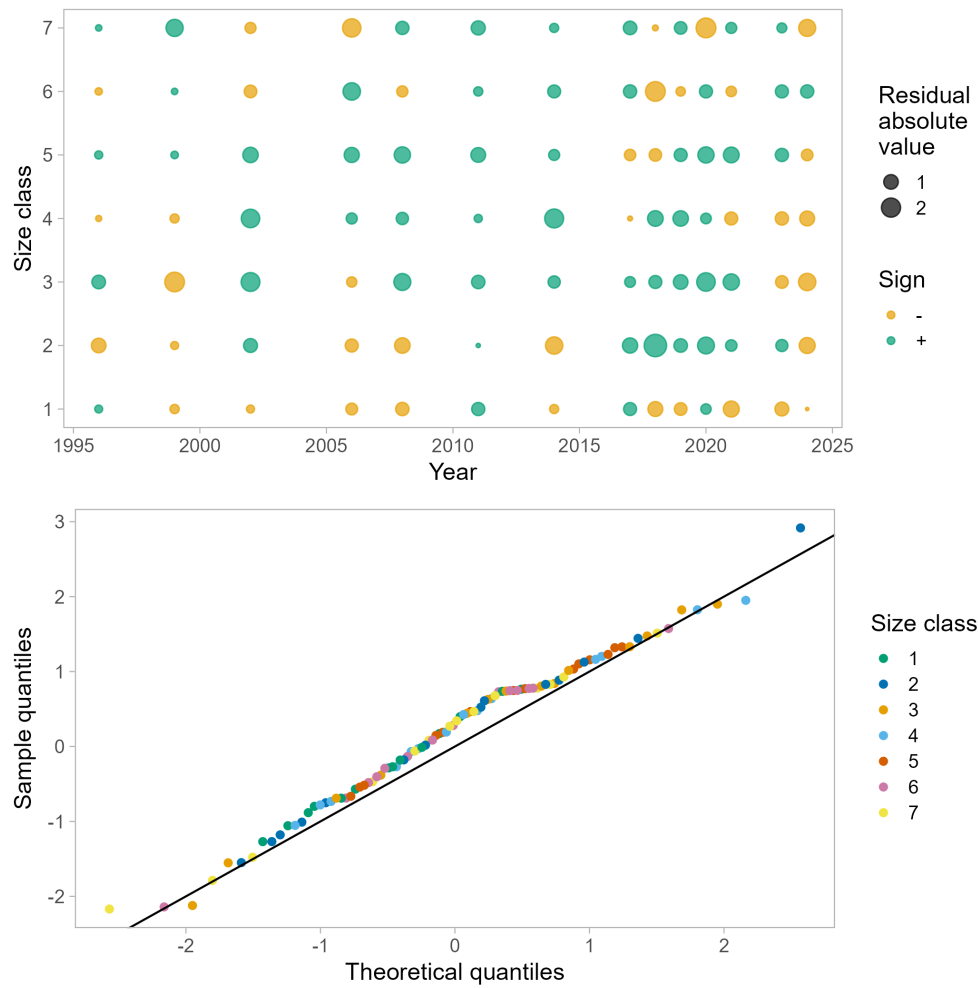


Figure 82: One-Step-Ahead residuals for model 24.0b7 fits to oldshell male size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

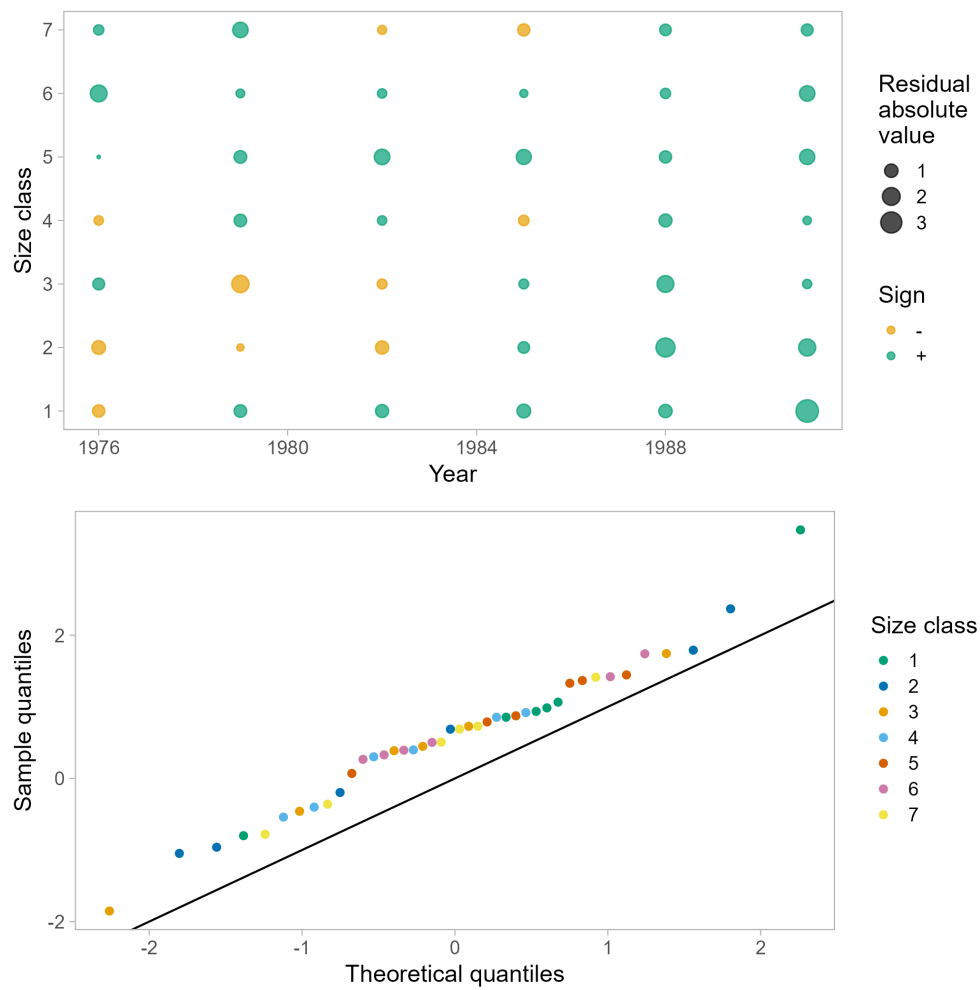


Figure 83: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

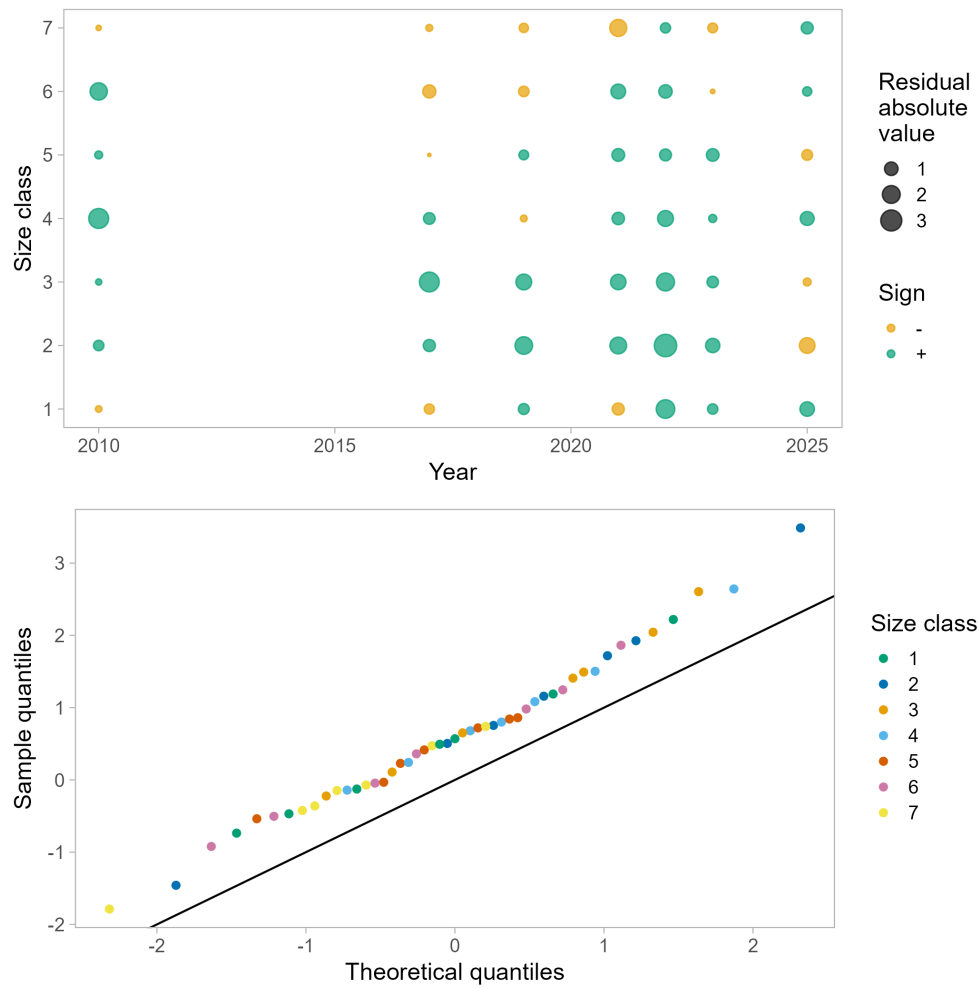


Figure 84: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

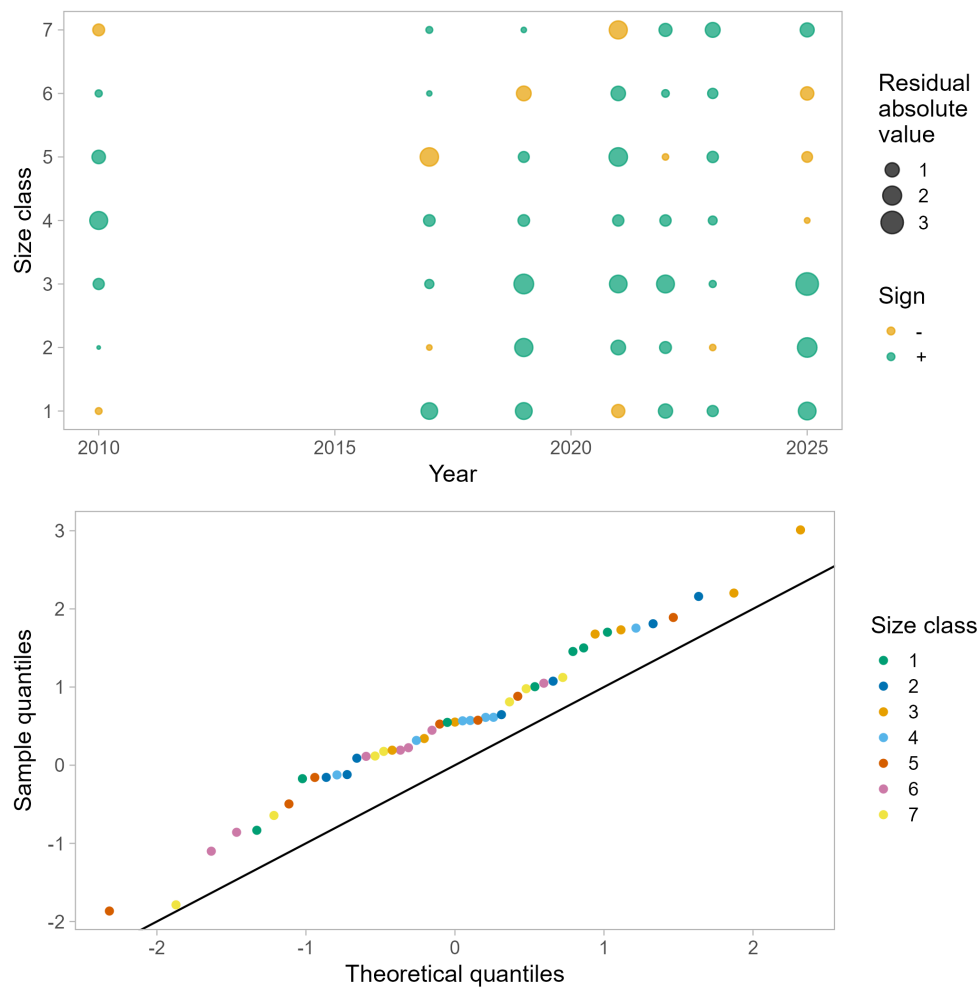


Figure 85: One-Step-Ahead residuals for model 24.0b7 fits to oldshell male size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

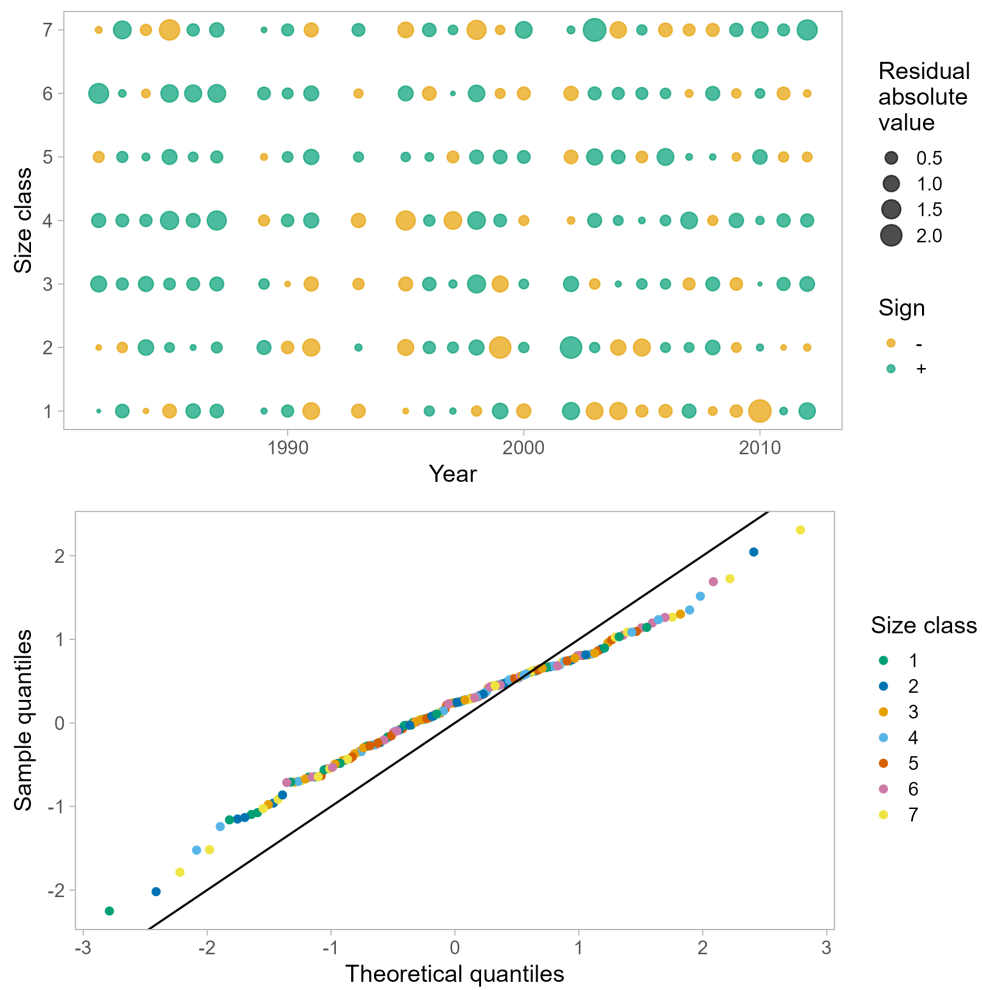


Figure 86: One-Step-Ahead residuals for model 24.0b7 fits to newshell male size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

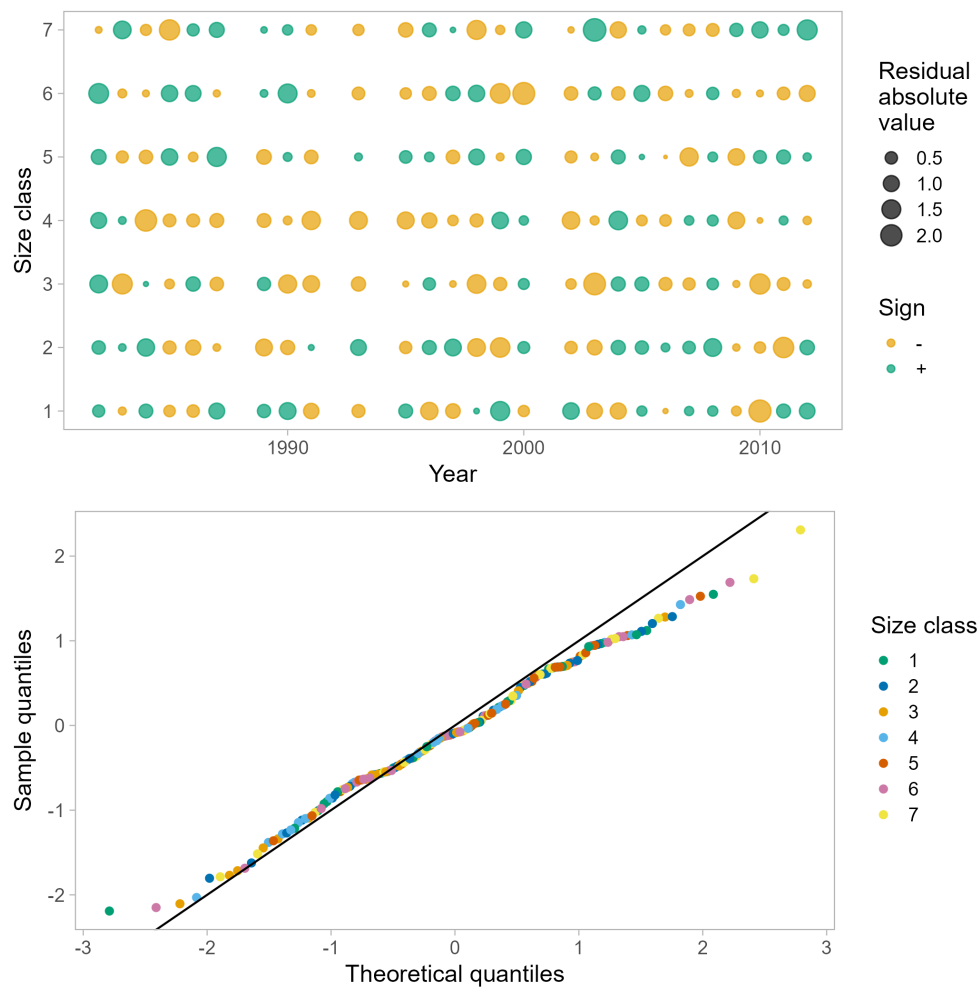


Figure 87: One-Step-Ahead residuals for model 24.0b7 fits to oldshell male size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

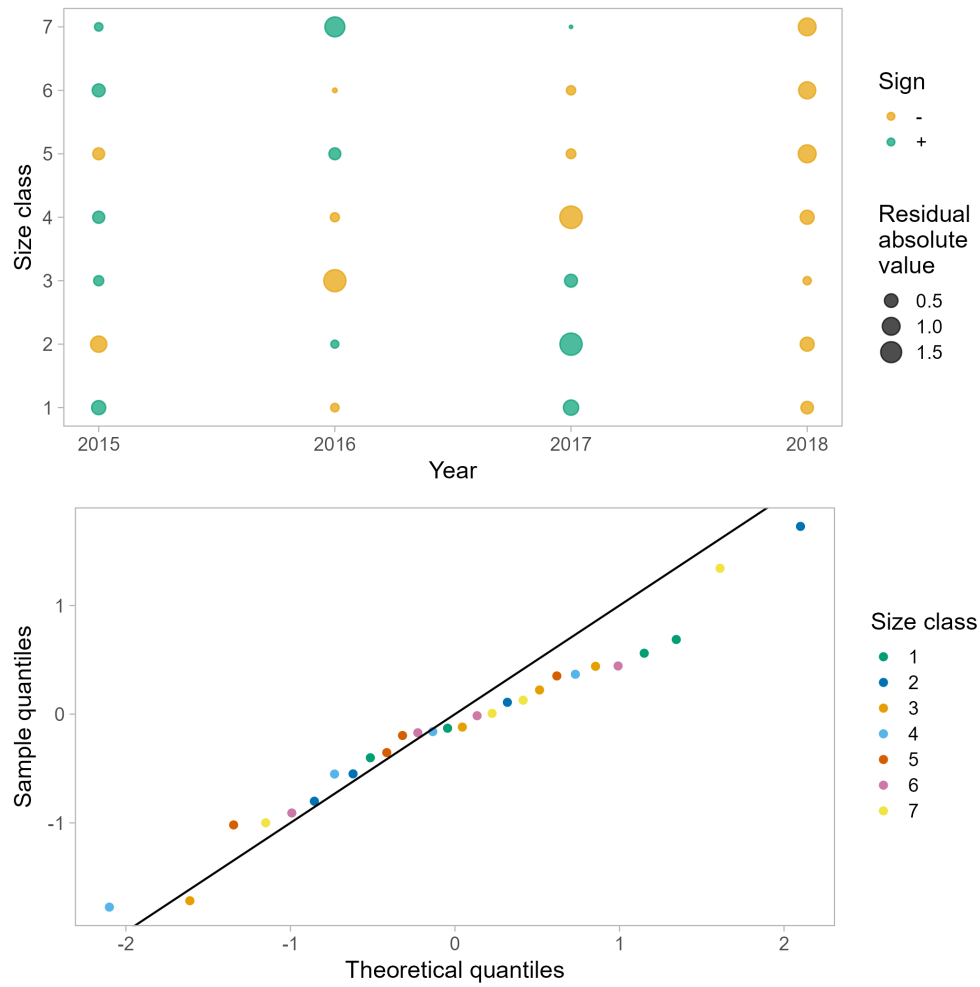


Figure 88: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the winter commercial fishery retained catch.

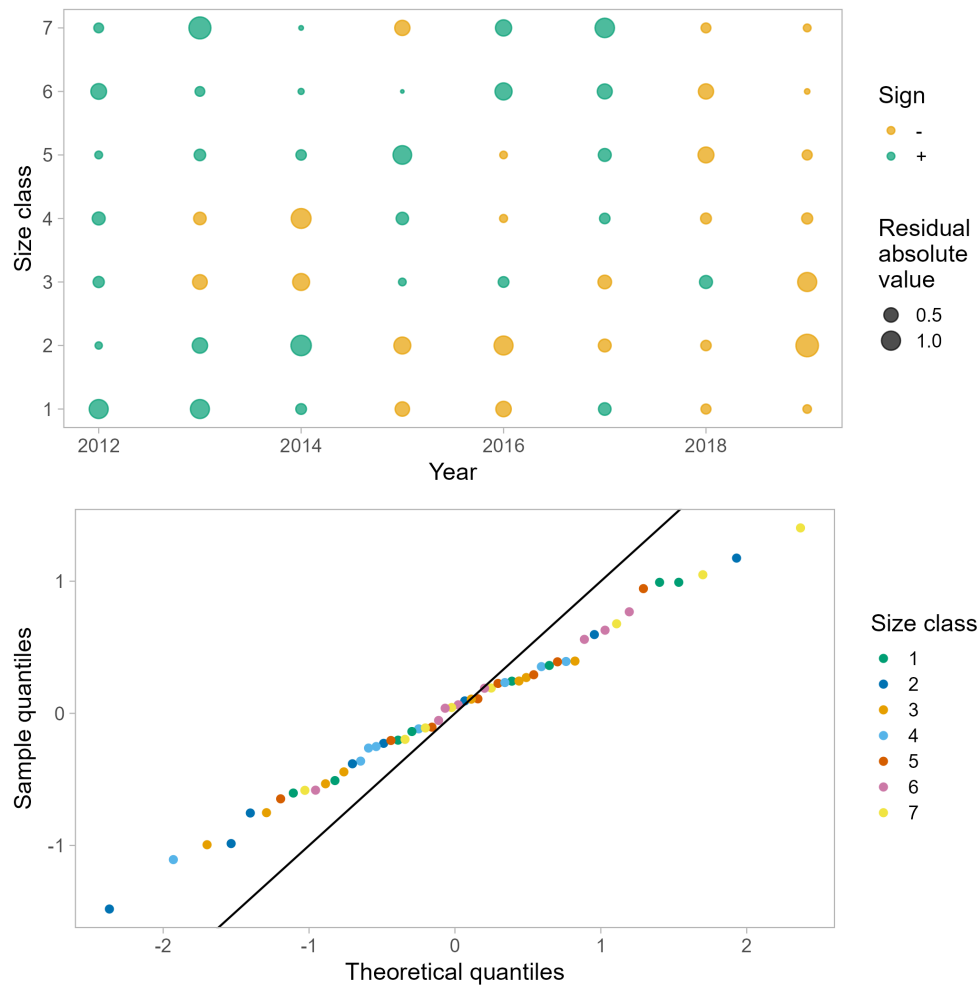


Figure 89: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the summer commercial fishery total catch.

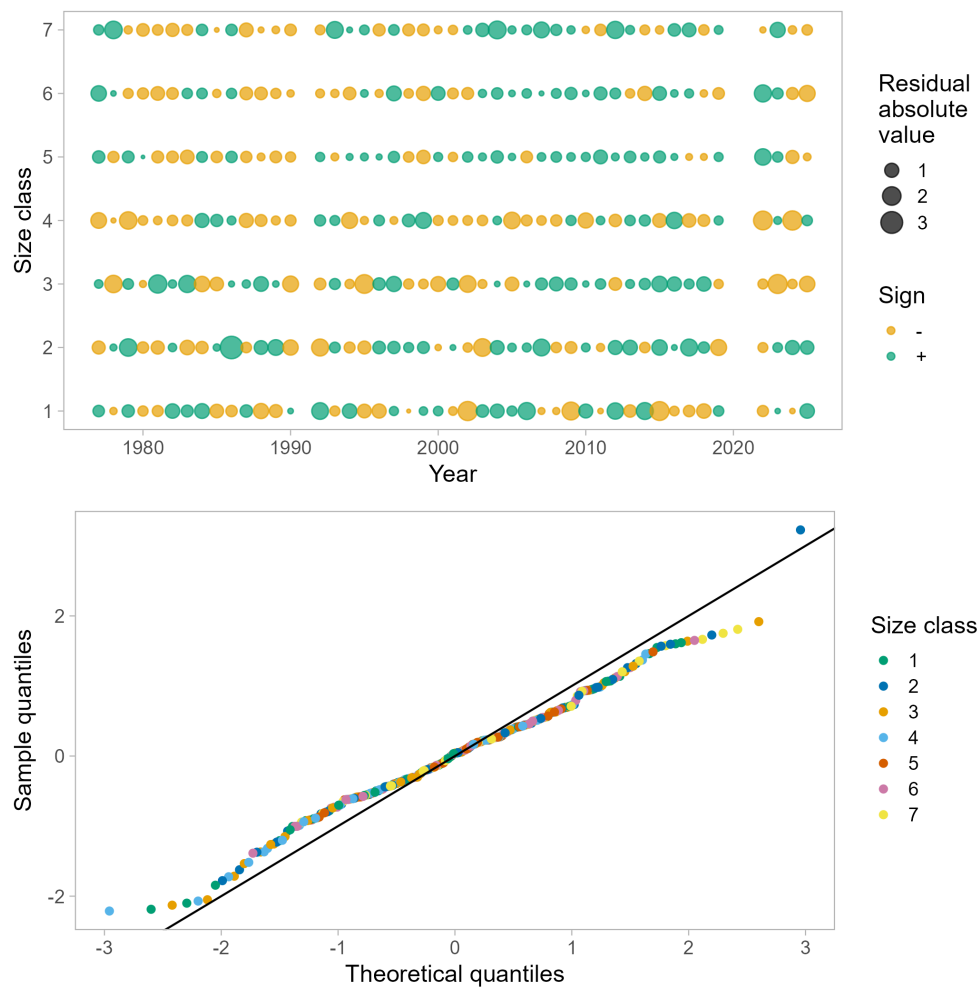


Figure 90: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the summer commercial fishery retained catch.

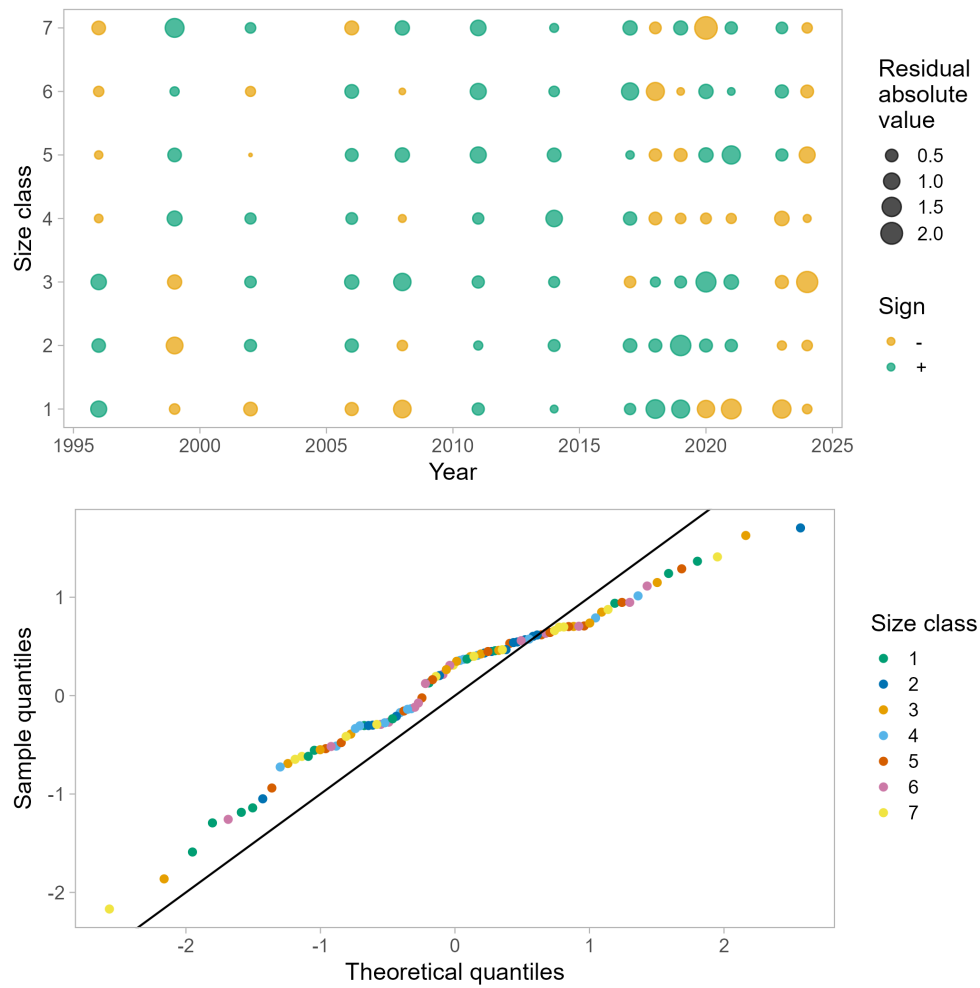


Figure 91: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

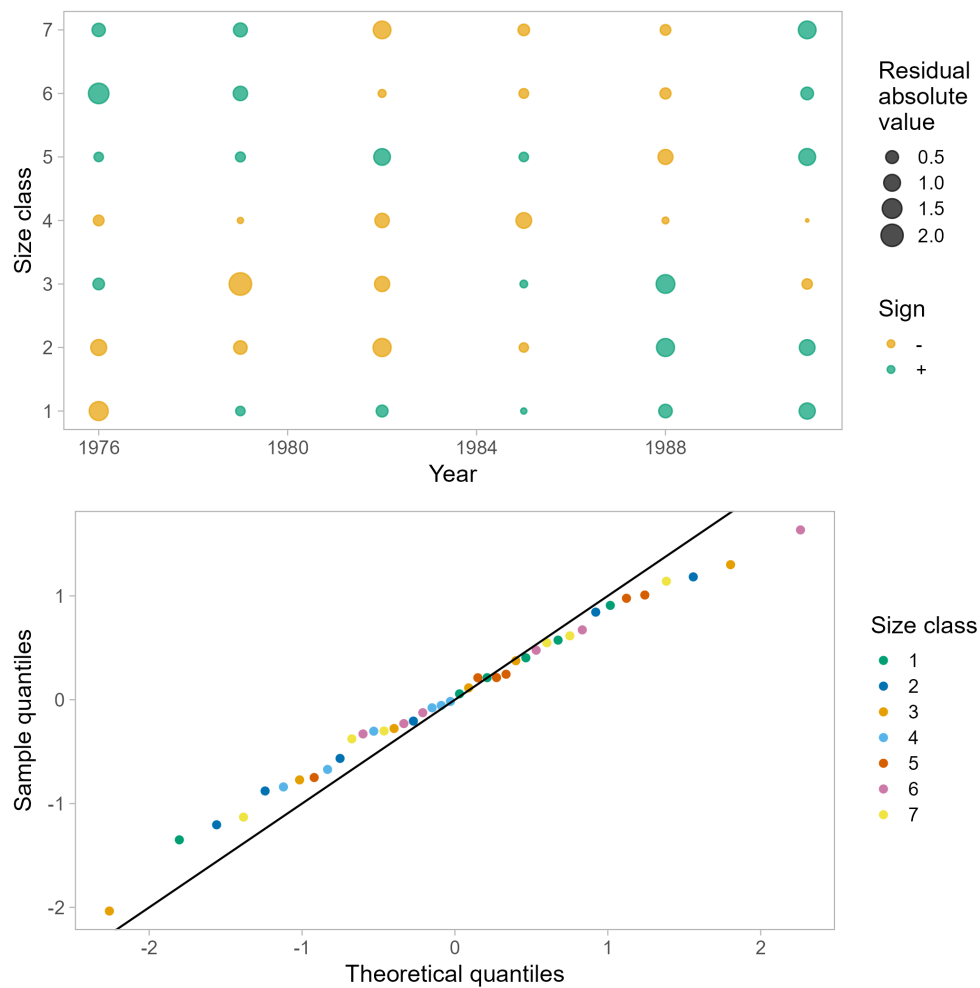


Figure 92: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

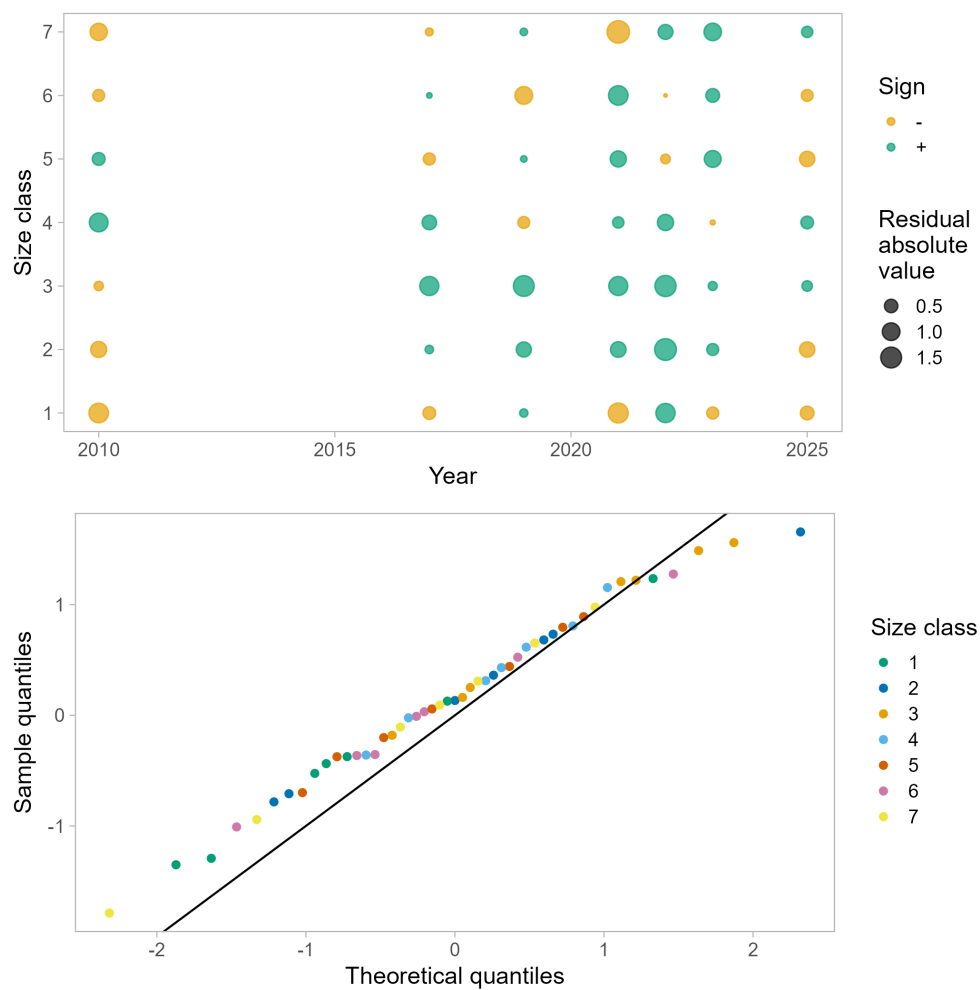


Figure 93: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

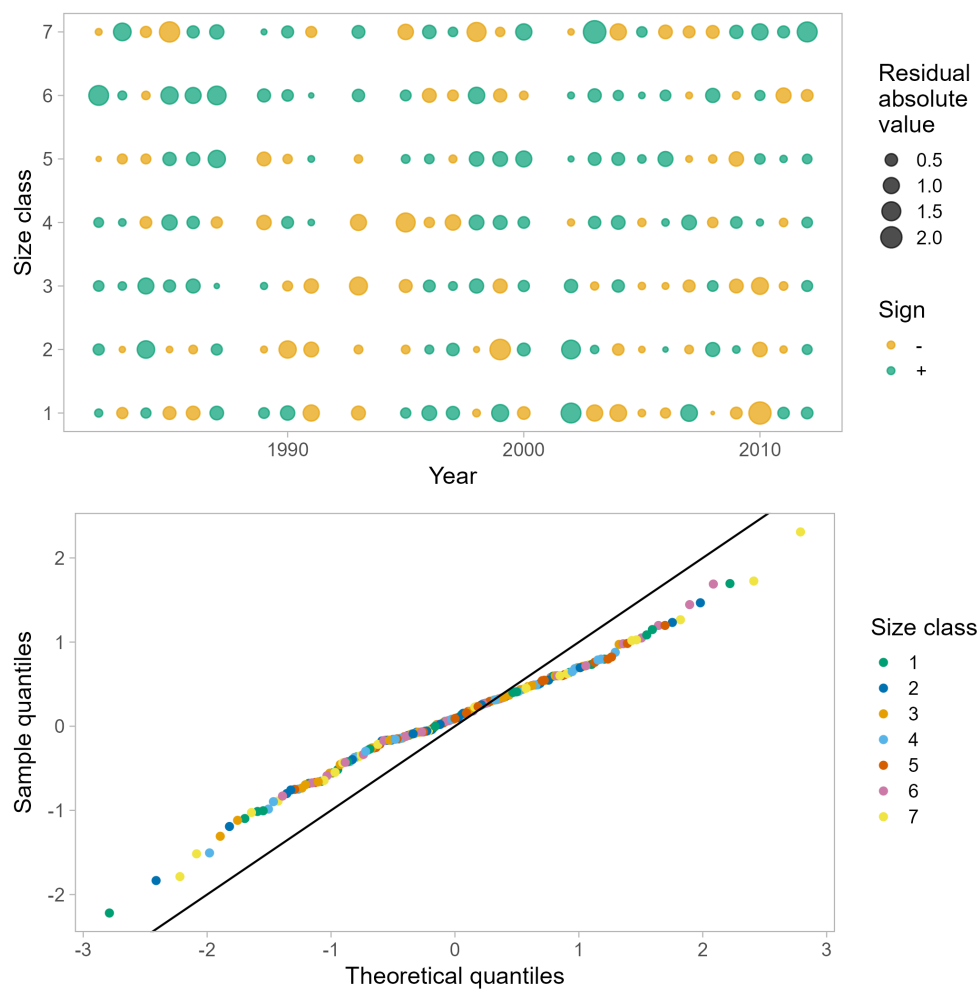


Figure 94: One-Step-Ahead residuals for model 25.0a1 fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

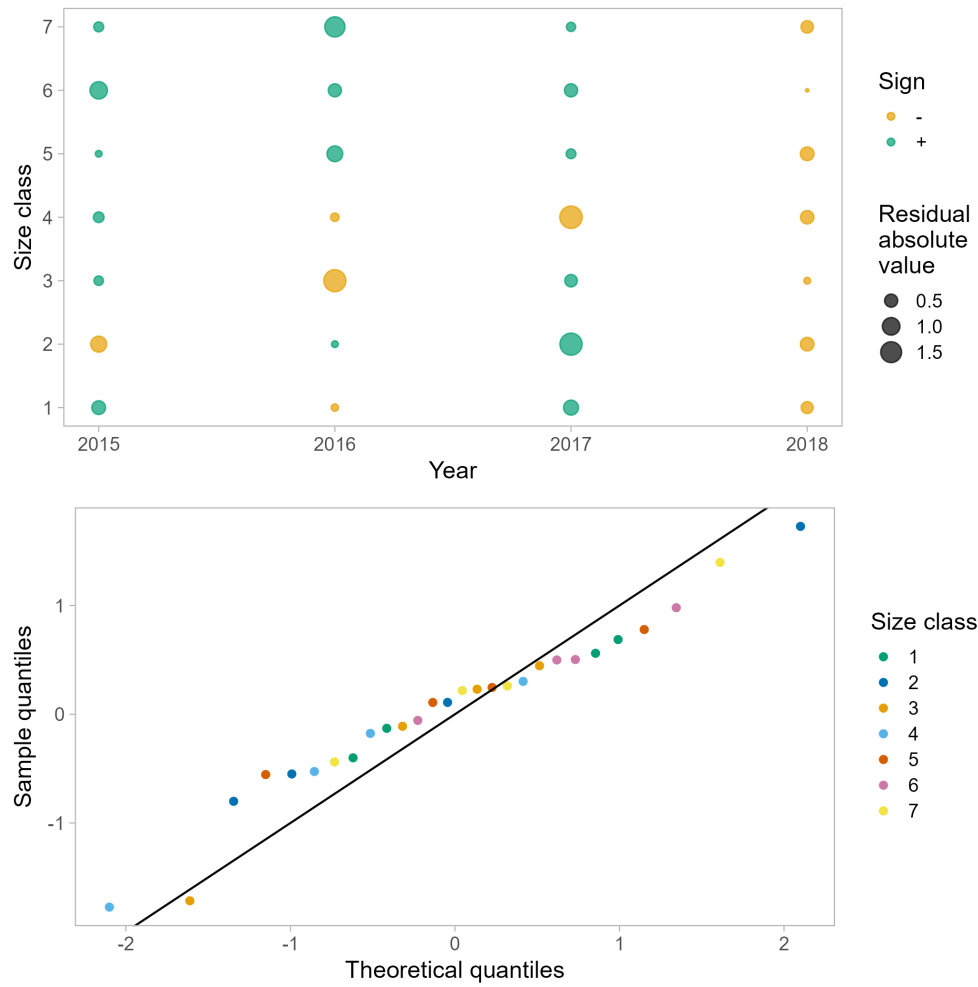


Figure 95: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the winter commercial fishery retained catch.

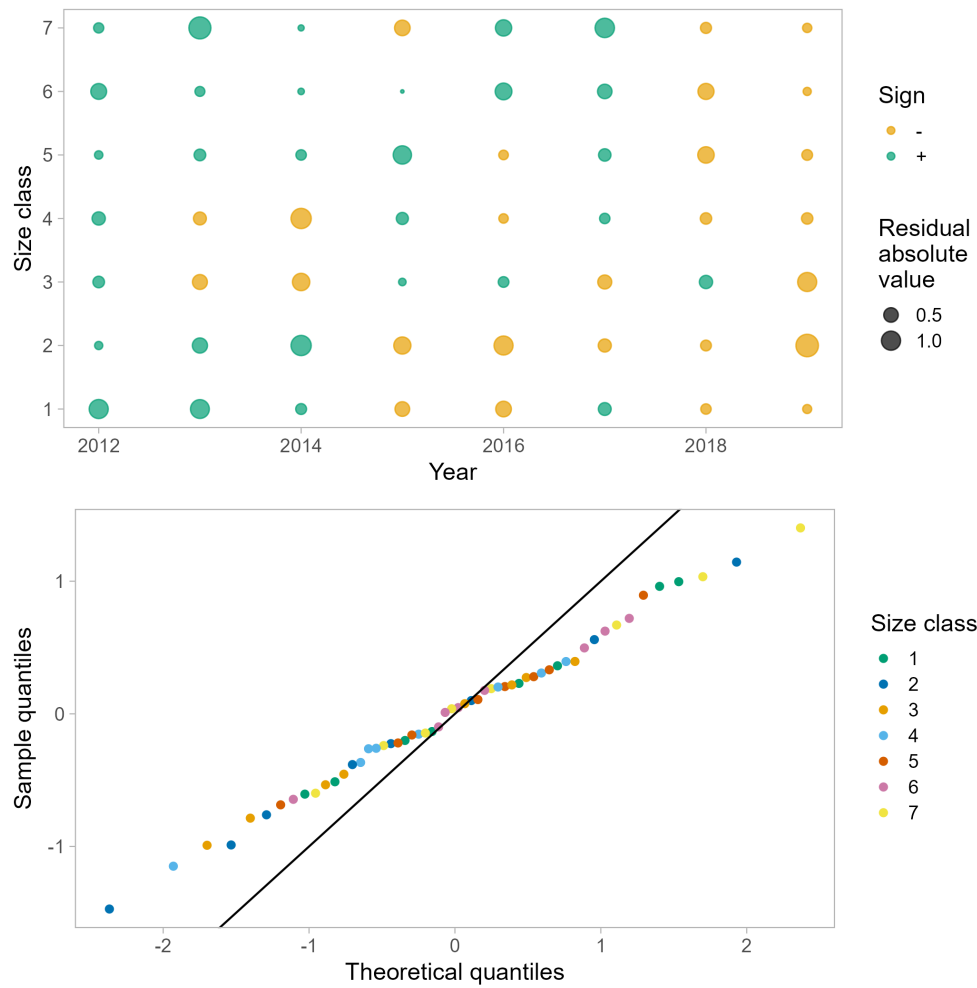


Figure 96: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the summer commercial fishery total catch.

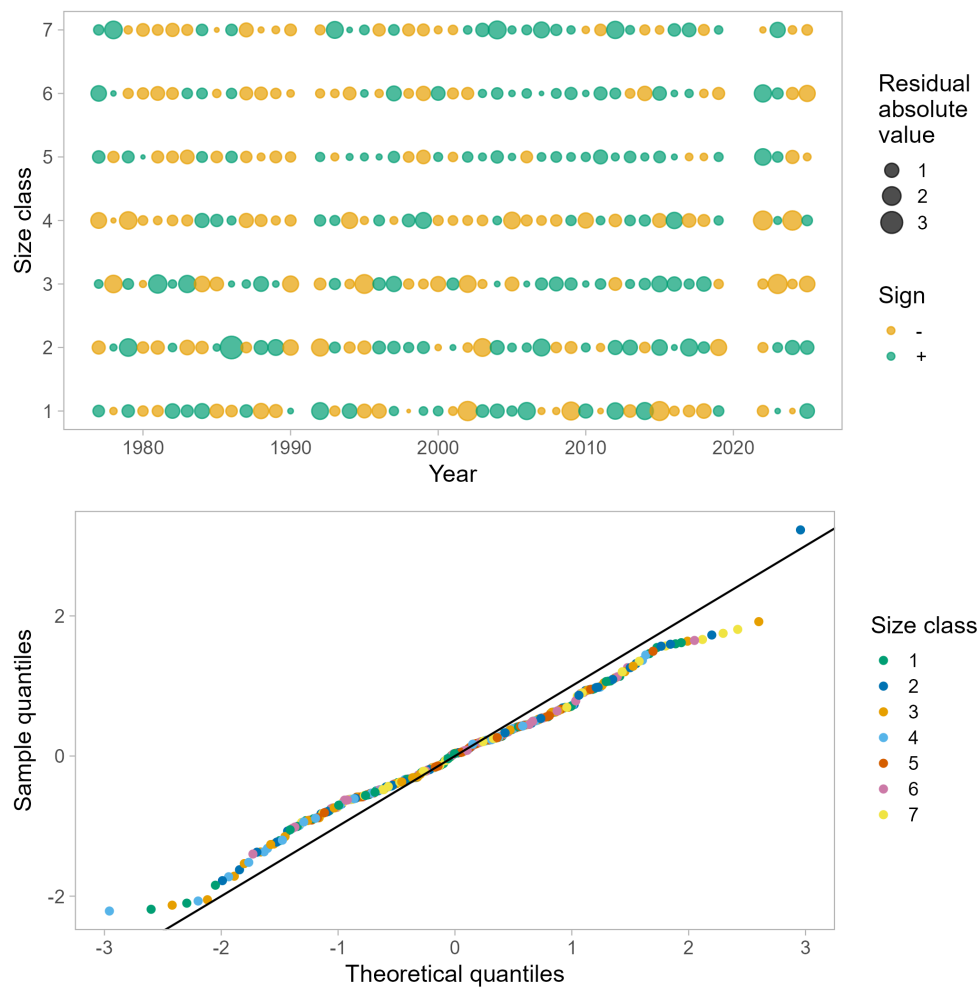


Figure 97: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the summer commercial fishery retained catch.

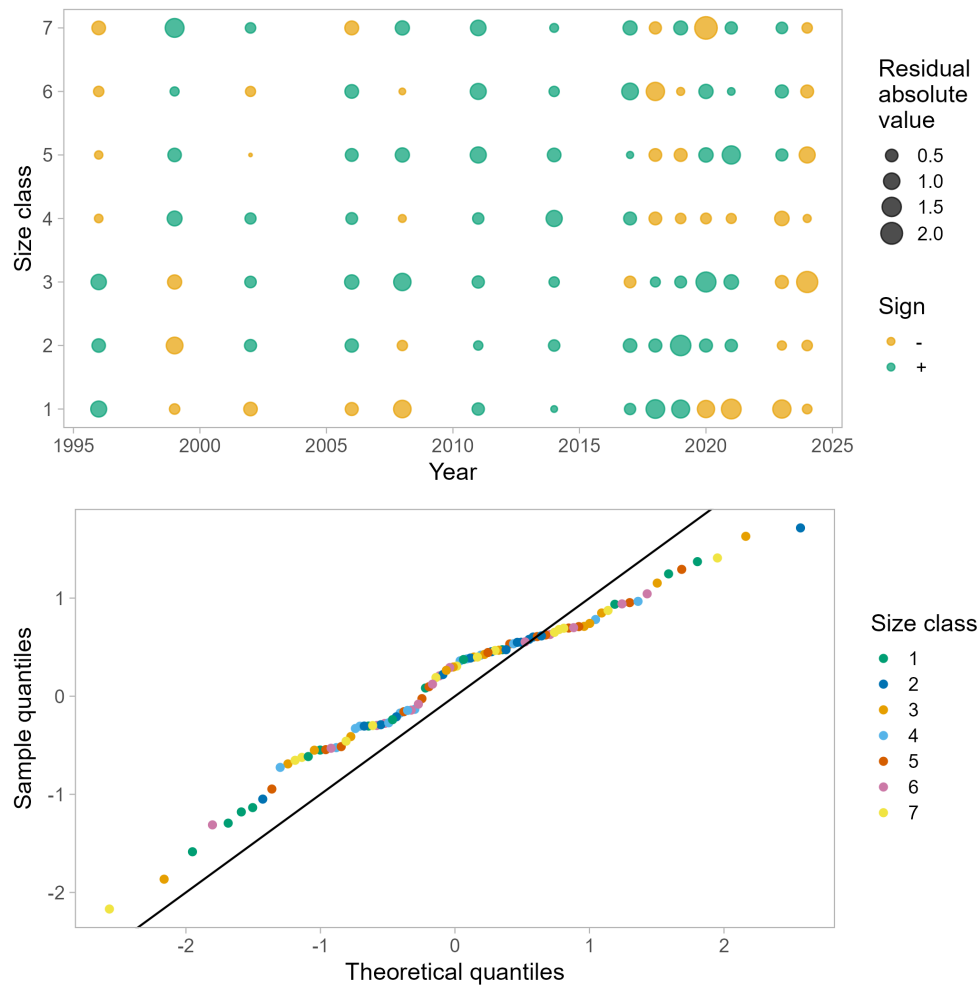


Figure 98: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the Alaska Department of Fish and Game (ADFG) trawl survey.

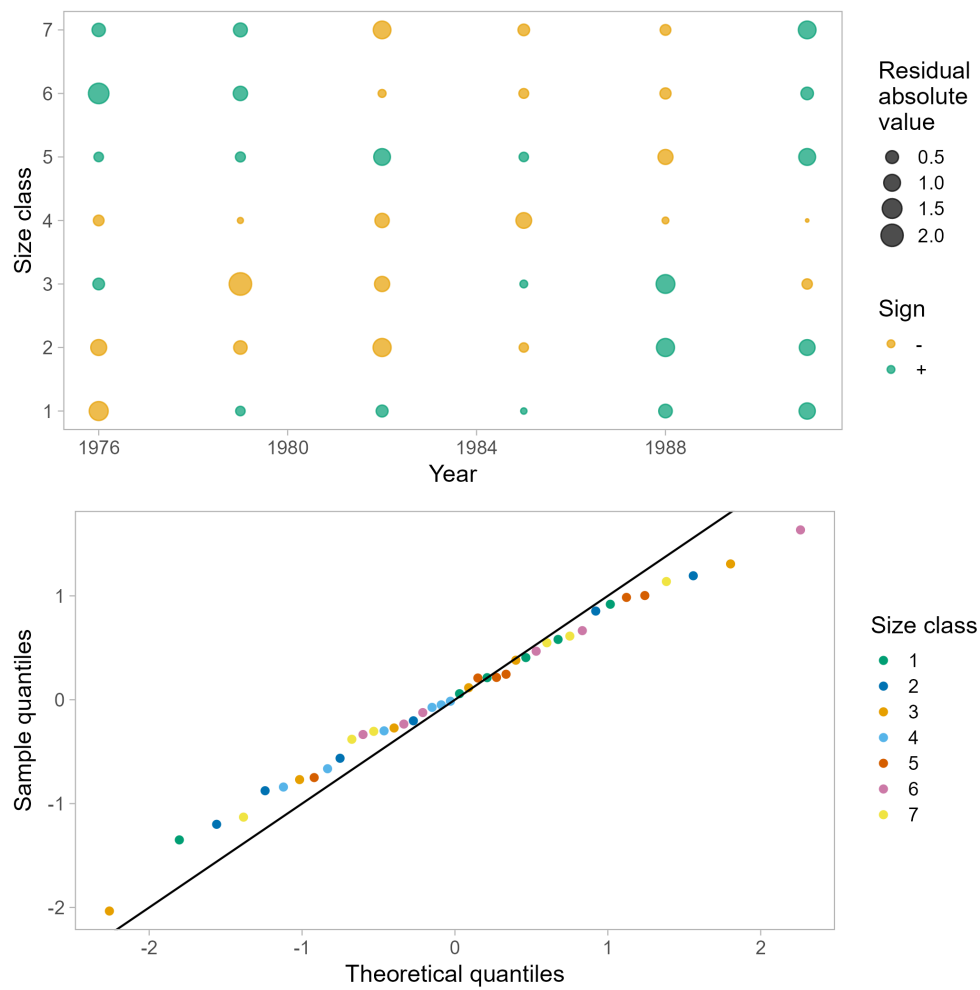


Figure 99: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Norton Sound trawl survey.

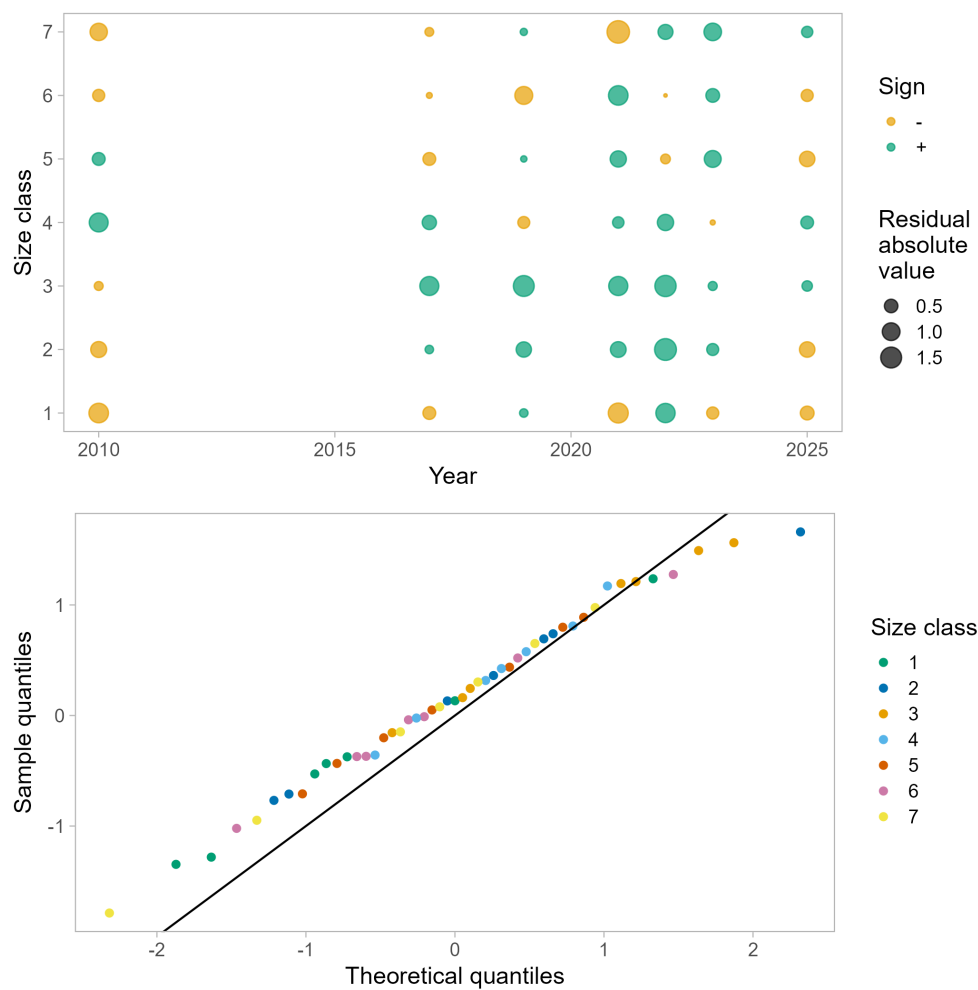


Figure 100: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the National Oceanic and Atmospheric Administration (NOAA) Northern Bering Sea (NBS) trawl survey.

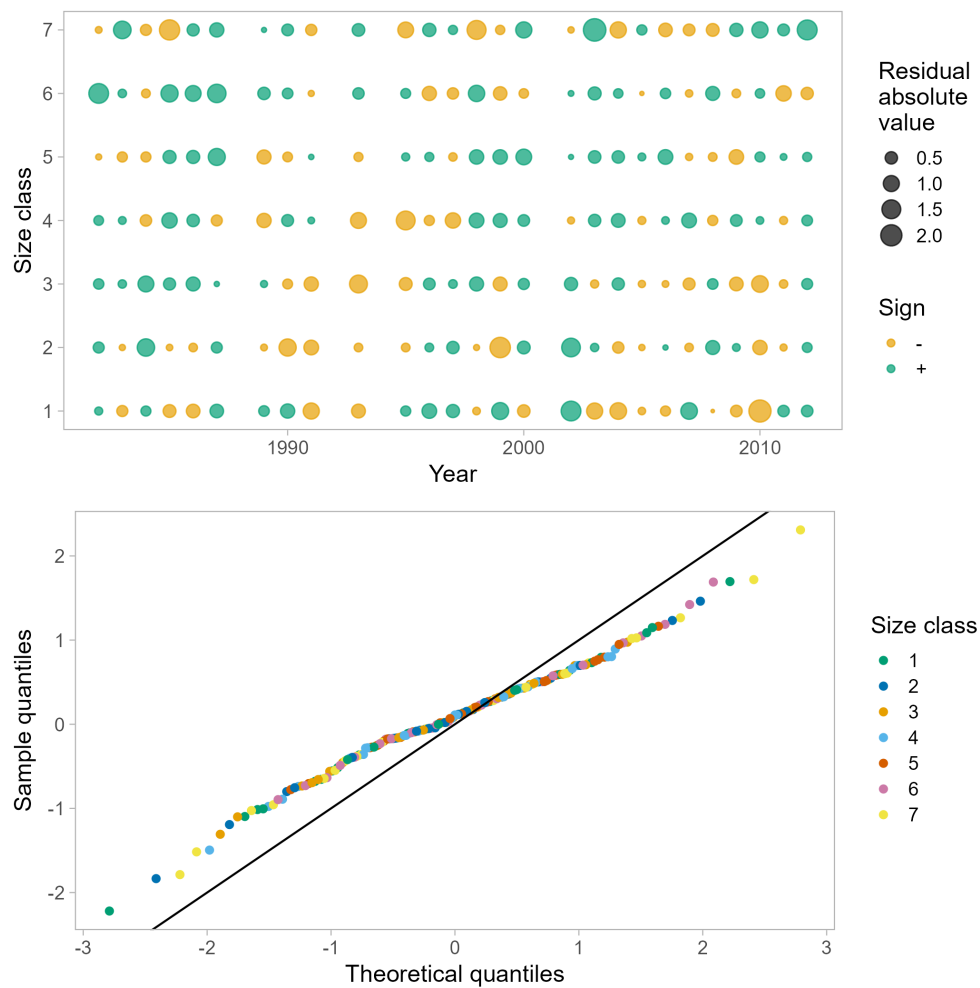


Figure 101: One-Step-Ahead residuals for model 25.0a2 fits to size composition data from the Alaska Department of Fish and Game (ADFG) winter pot survey.

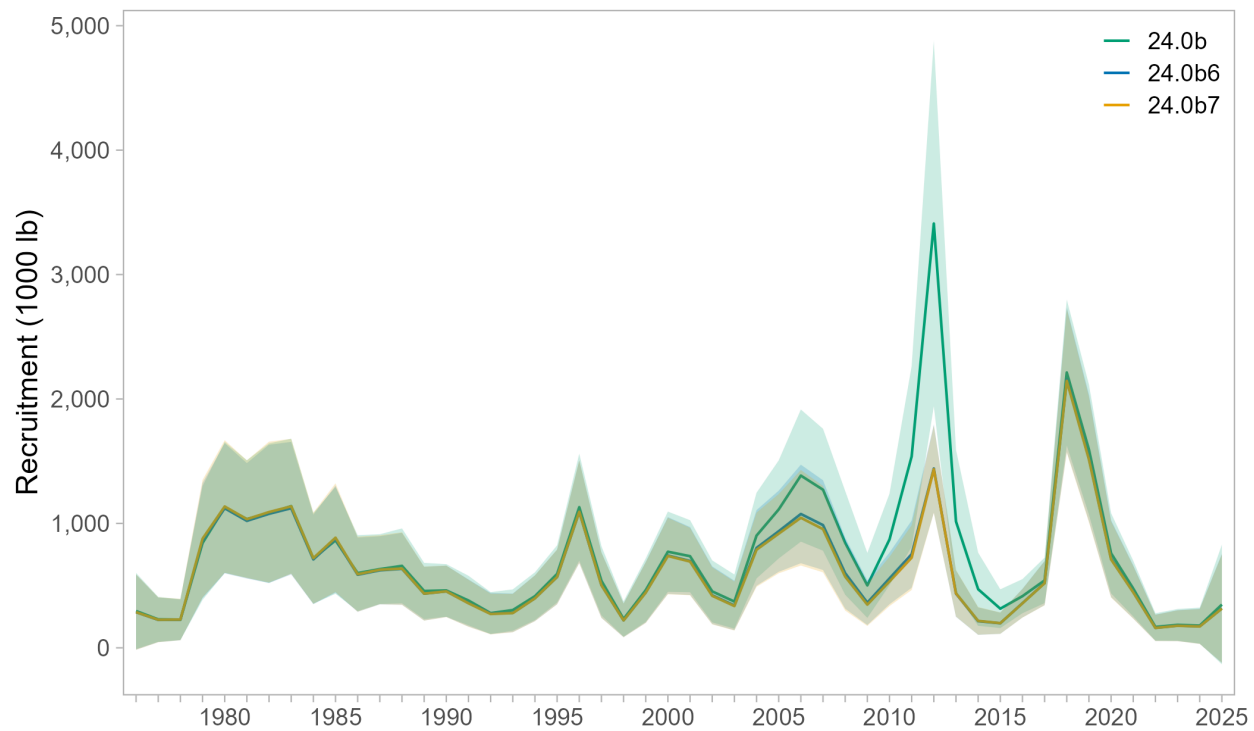


Figure 102: Estimated recruitment (1000 lb) over 1976-2025 for models 24.0b, 24.0b6, and 24.0b7.

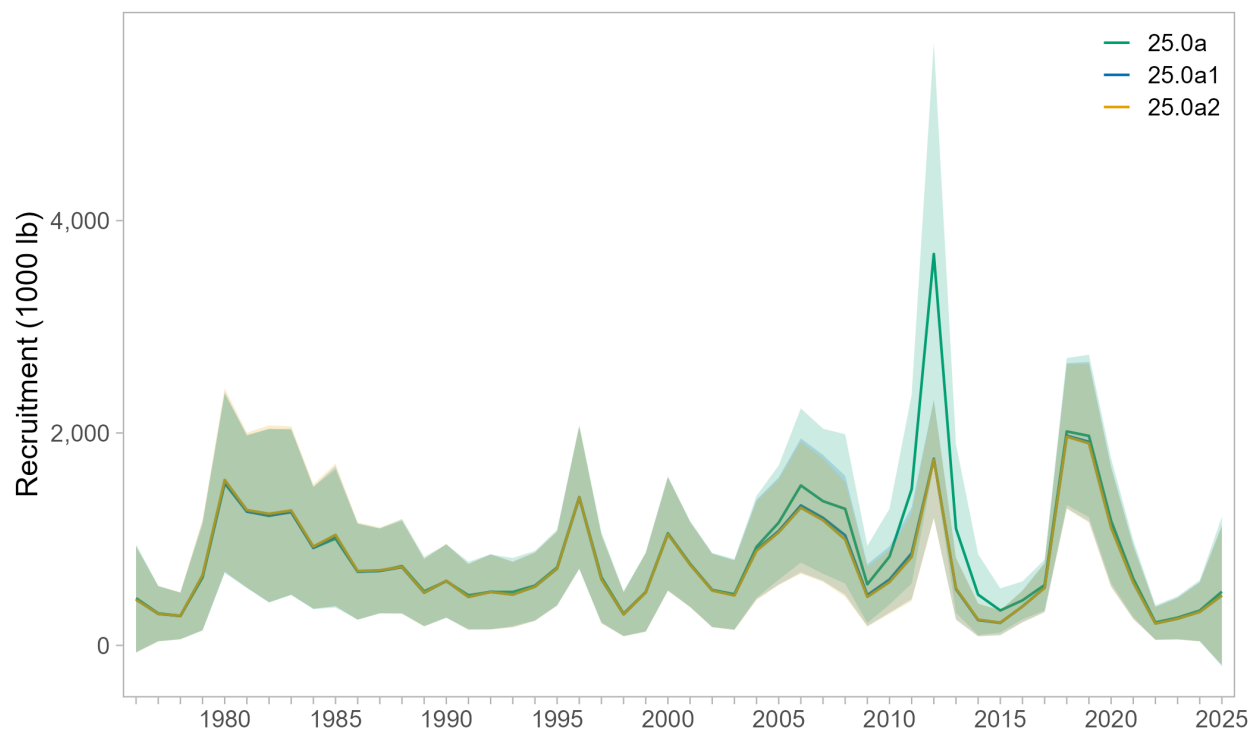


Figure 103: Estimated recruitment (1000 lb) over 1976-2025 for models 25.0a, 25.0a1, and 25.0a2.

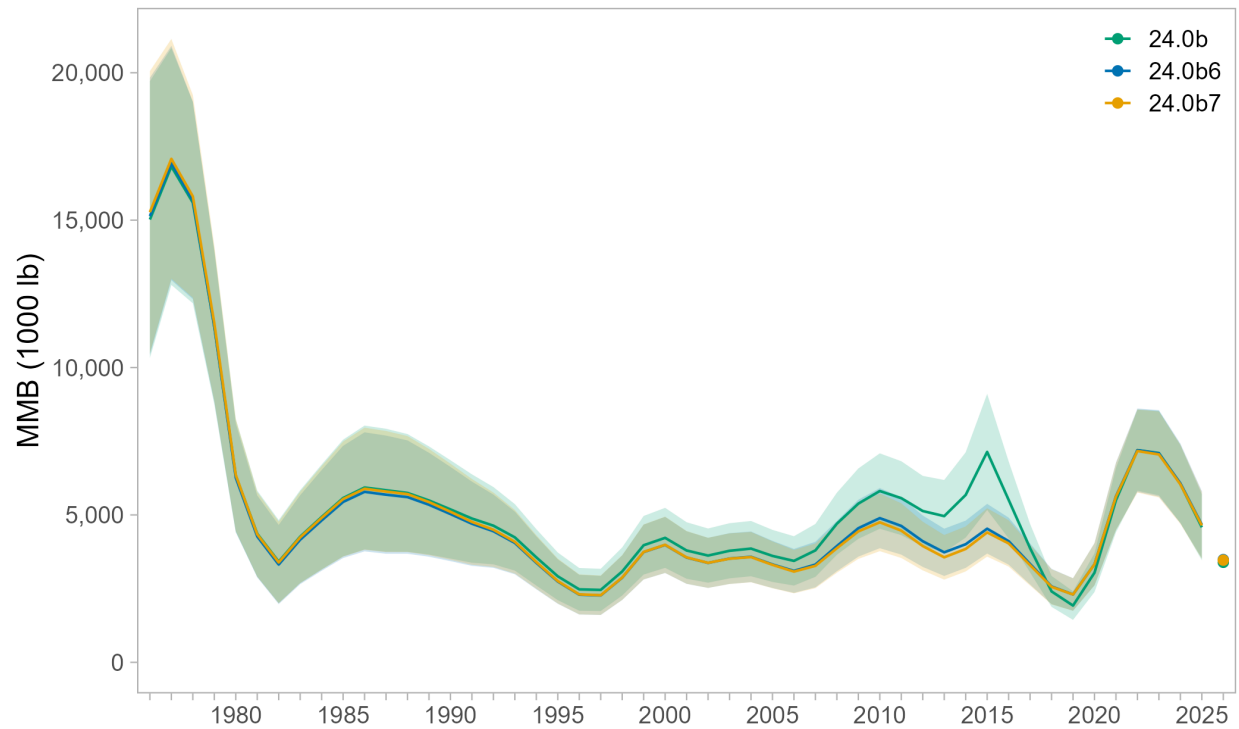


Figure 104: Comparisons of estimated mature male biomass (MMB) time series over 1976-2025 for models 24.0b, 24.0b6, and 24.0b7. Points represent projected values for 2026.

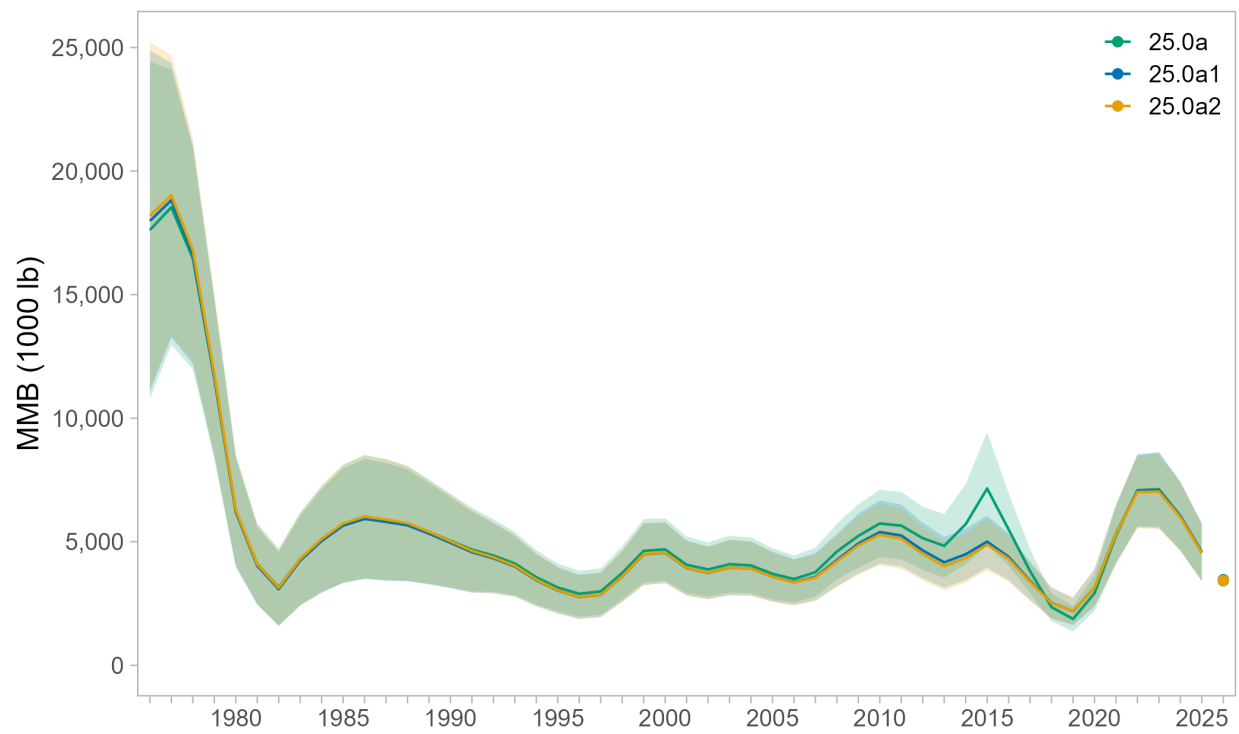


Figure 105: Comparisons of estimated mature male biomass (MMB) time series over 1976-2025 for models 25.0a, 25.0a1, 25.0a2. Points represent projected values for 2026.

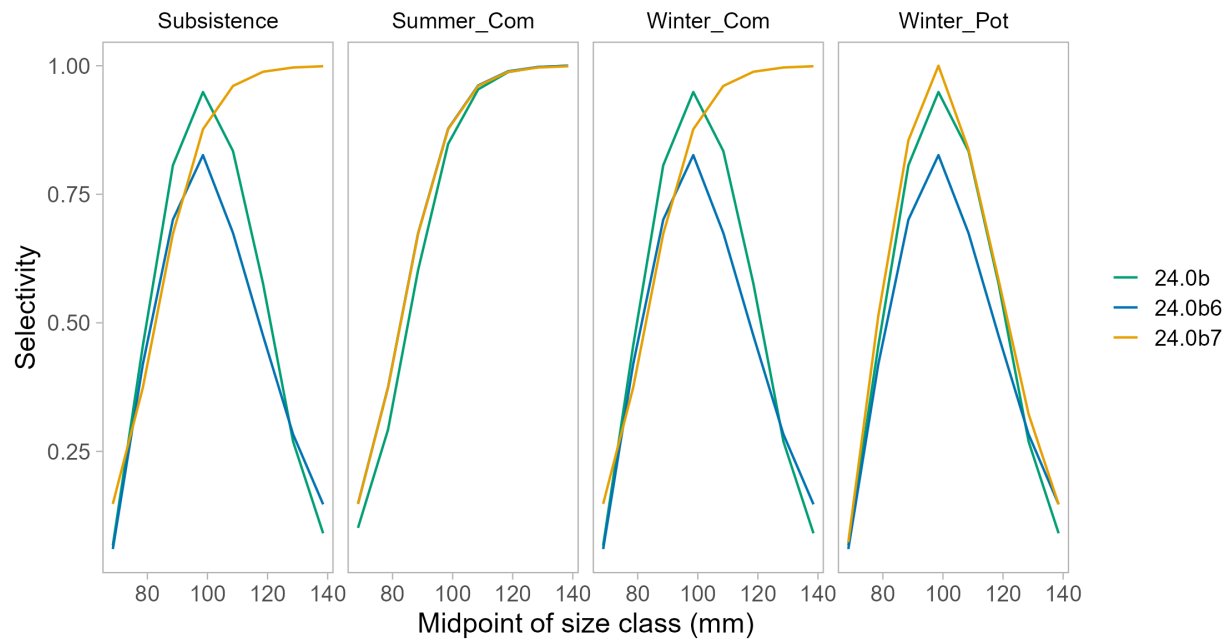


Figure 106: Comparisons of estimated fishery capture selectivities in the summer commercial, winter commercial, and winter subsistence fisheries for models 24.0b, 24.0b6, and 24.0b7.

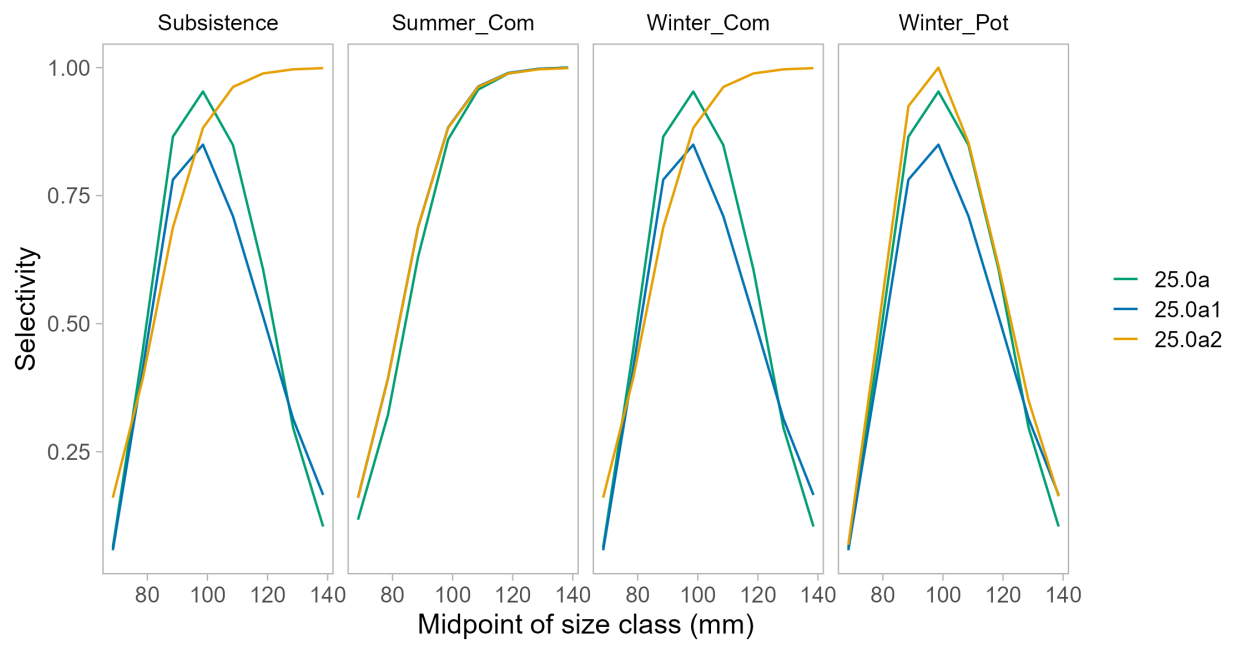


Figure 107: Comparisons of estimated fishery capture selectivities in the summer commercial, winter commercial, and winter subsistence fisheries for models 25.0a, 25.0a1, and 25.0a2.

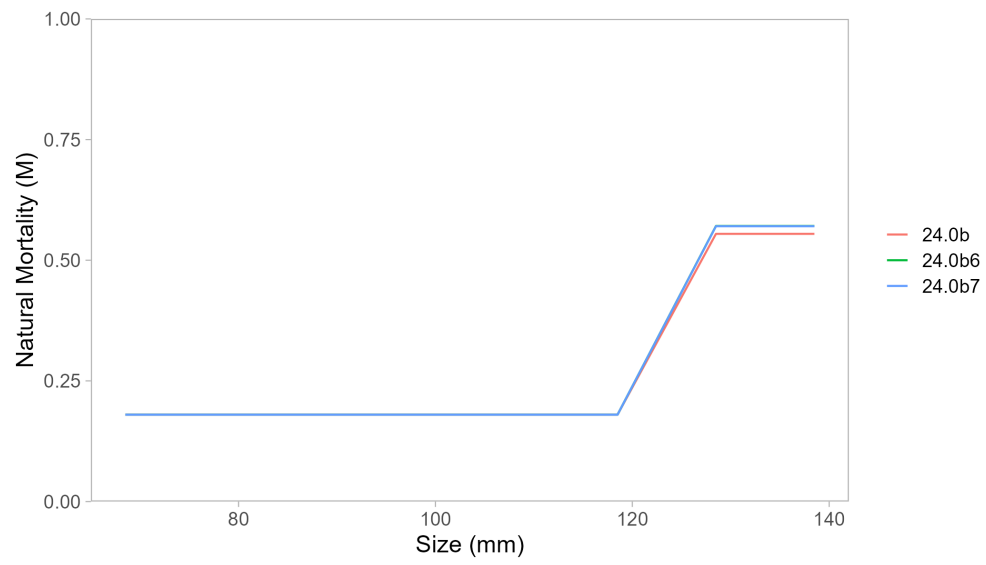


Figure 108: Natural mortality estimates for models 24.0b, 24.0b6, and 24.0b7.

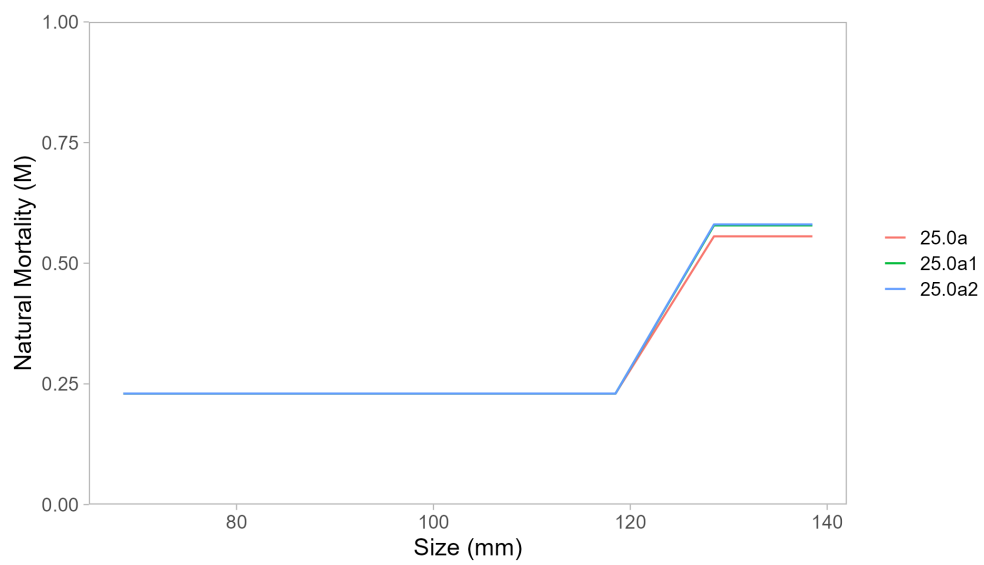


Figure 109: Natural mortality estimates for models 25.0a, 25.0a1, and 25.0a2.

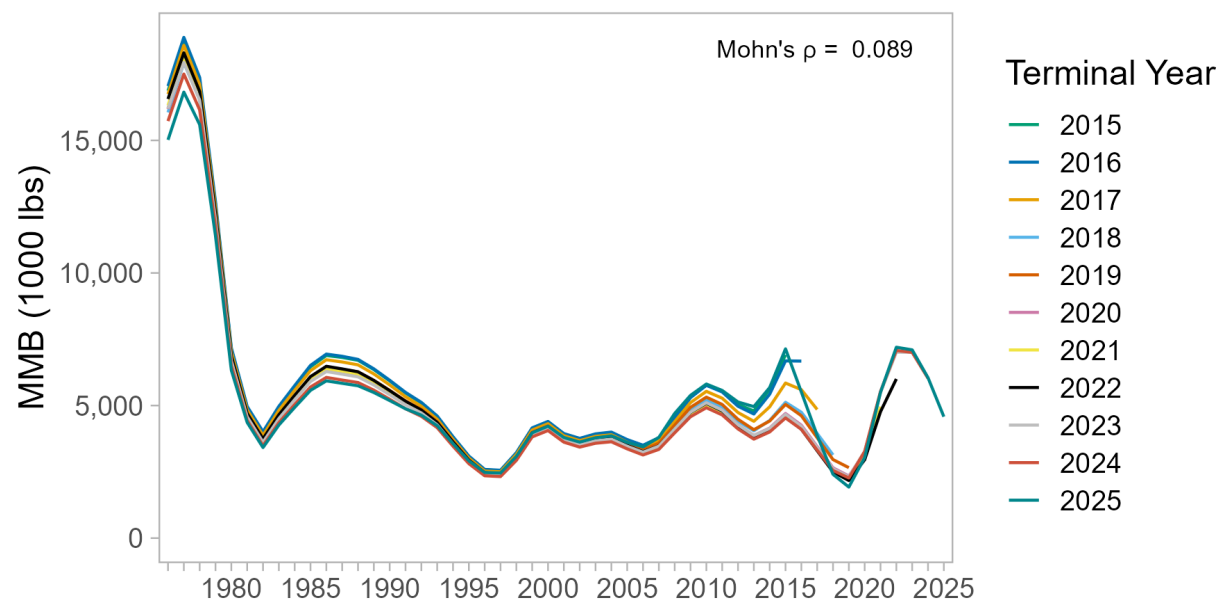


Figure 110: Retrospective patterns in estimated mature male biomass (MMB) for the base model, 24.0b.

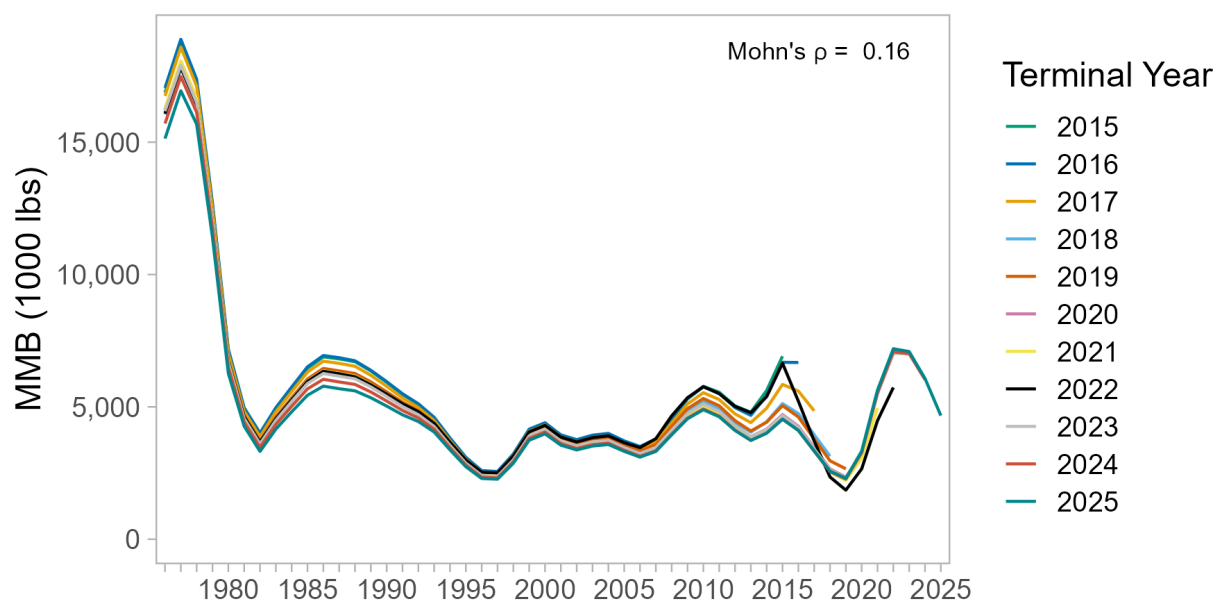


Figure 111: Retrospective patterns in estimated mature male biomass (MMB) for model 24.0b6, with an upper bound from BBRKC on the fishing mortality rate for the winter commercial fishery.

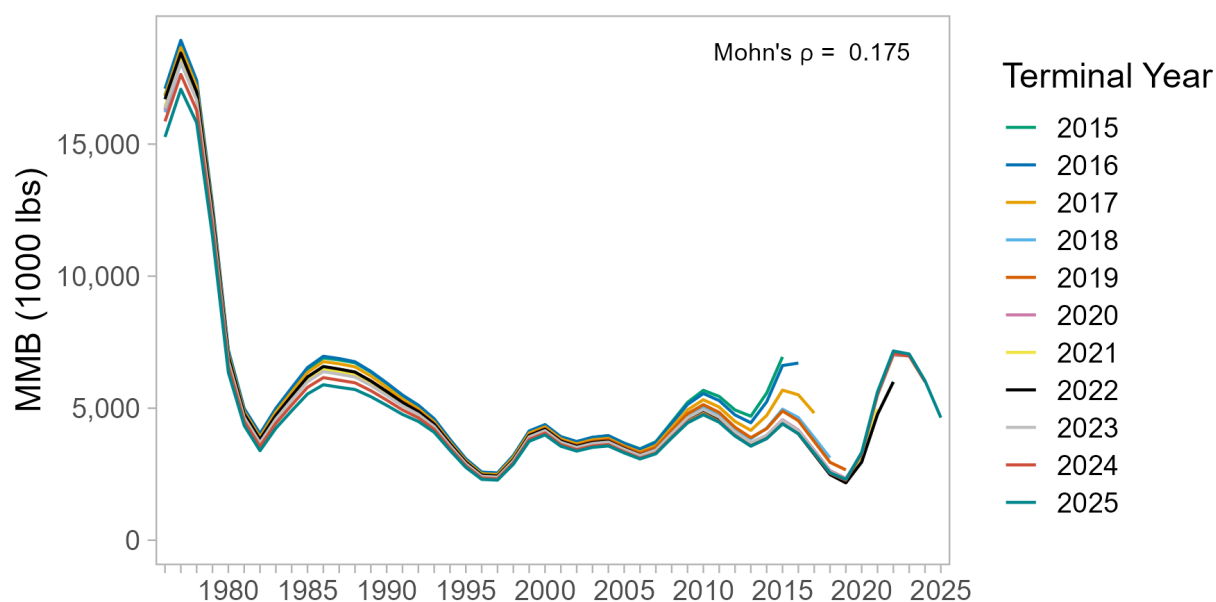


Figure 112: Retrospective patterns in estimated mature male biomass (MMB) for model 24.0b7, with selectivity for the winter commercial fishery and subsistence fishery sharing parameters with the summer commercial fishery selectivity.

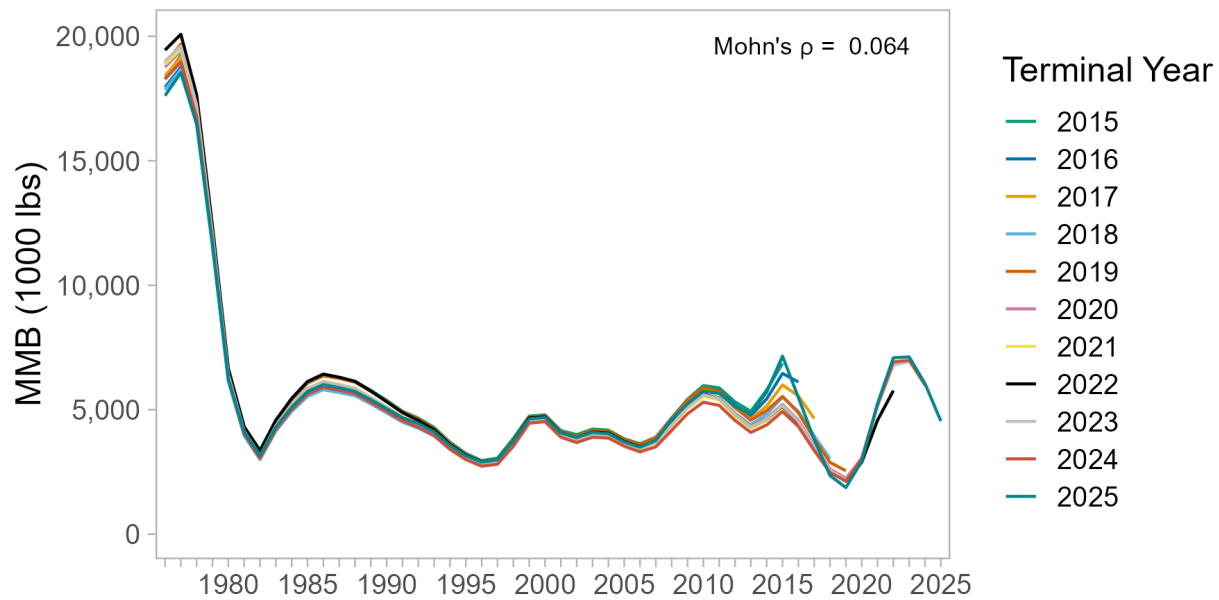


Figure 113: Retrospective patterns in estimated mature male biomass (MMB) for model 25.0a, with shell condition removed and natural mortality for small males fixed at $M = 0.23$.

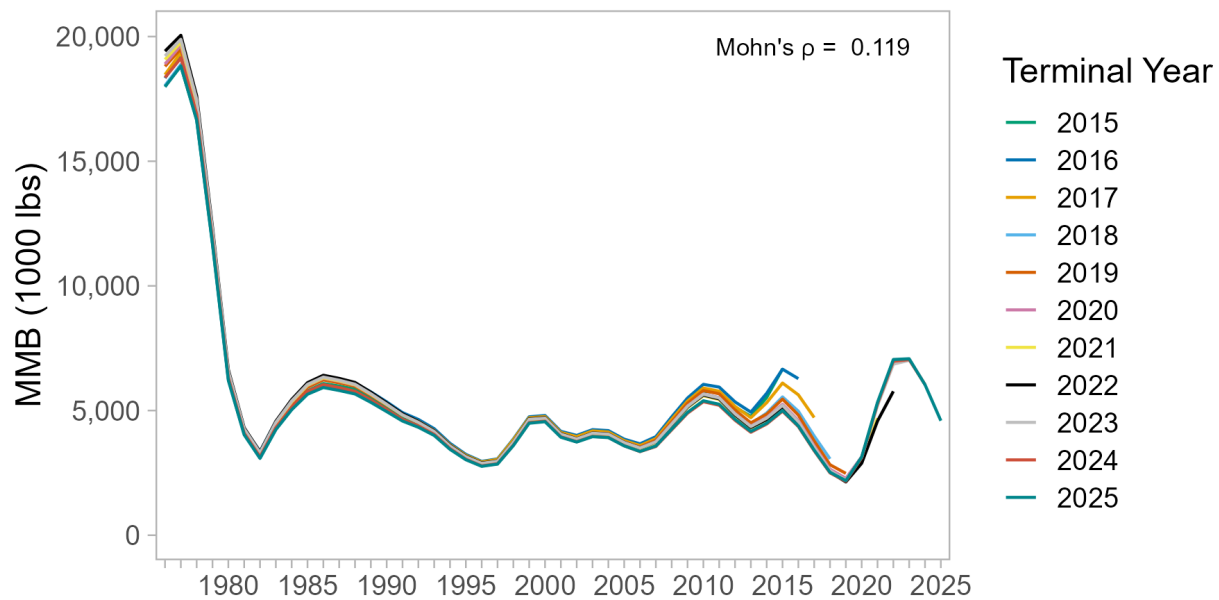


Figure 114: Retrospective patterns in estimated mature male biomass (MMB) for model 25.0a1, with an upper bound from BBRKC on the fishing mortality rate for the winter commercial fishery.

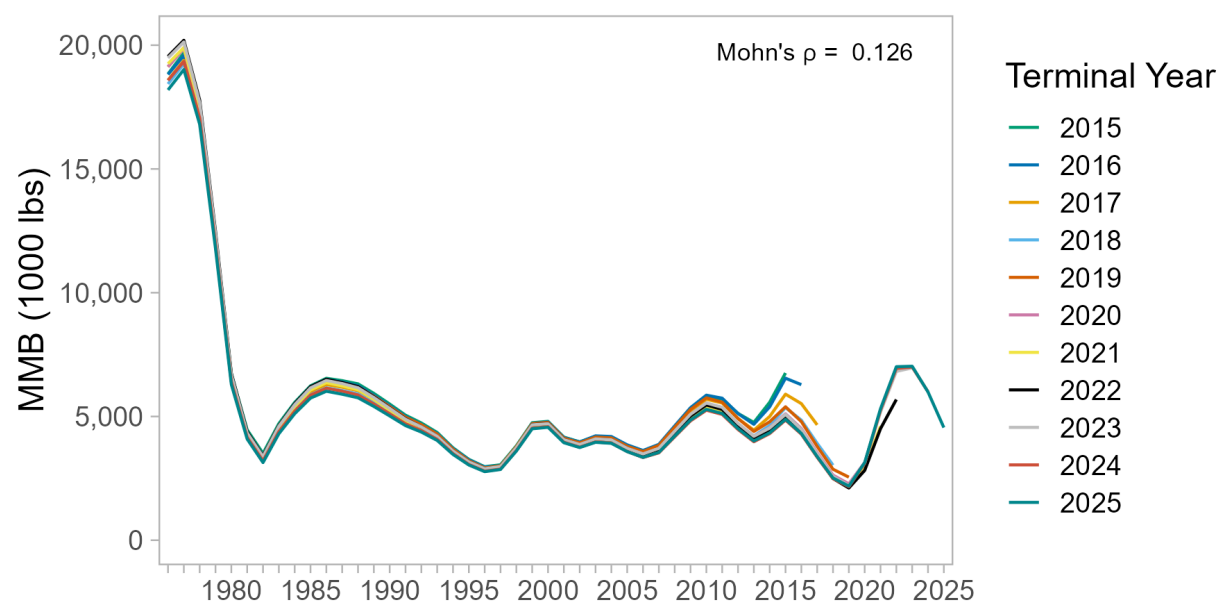


Figure 115: Retrospective patterns in estimated mature male biomass (MMB) for model 25.0a2, with selectivity for the winter commercial fishery and subsistence fishery sharing parameters with the summer commercial fishery selectivity.