Bristol Bay Red King Crab Stock Assessment 2025

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Executive Summary

1. **Stock**: Red king crab (RKC), *Paralithodes camtschaticus*, in Bristol Bay, Alaska.
2. **Catches**: The domestic RKC fishery began to expand in the late 1960s and peaked in 1980 with a catch of 129.95 million lb (58,943 t). The catch declined dramatically in the early 1980s and remained at low levels during the last three decades. After rationalization, catches were relatively high before the 2010/11 season but have been on a declining trend since 2014. The retained catch in 2023/24 was approximately 2.12 million lb (960 t), similar to the last open fishery in 2020/21 when retained catch was approximately 2.65 million lb (1,257 t). These season harvests follow a steady decline in total allowable catch (TAC) from 2016 on. The directed pot fishery was closed in 2021/22 and 2022/23 due to low mature female abundance in accordance with the State of Alaska harvest strategy. The magnitude of bycatch from groundfish trawl and fixed gear fisheries has been stable and small relative to stock abundance during the last 10 years. The decline of the directed pot fishery crab/pot lift (CPUE) has been much less than the retained catch decline, with the 2023/24 CPUE of 20.54 crab/potlift approximately a 13.7% decline from the average since 2000. The 2024/25 CPUE of 29.55 was a 25% increase from the average CPUE since 2000.
3. **Data sources**: Data extent is provided visually in Figure 2.
4. **Stock biomass**: Estimated mature biomass increased dramatically in the mid-1970s, then decreased precipitously in the early 1980s. Estimated mature crab abundance increased during 1985-2007 with mature females being about four times more abundant in 2007 than in 1985 and mature males being about two times more abundant in 2007 than in 1985. Estimated mature abundance was steadily declining since 2017, but appears to be increasing slowly in the last few years.The projected mature male survey biomass in 2025 is approximately 51.8% of the estimated mean survey biomass for the entire time series, which includes many periods of low biomass throughout history. The estimated mature female survey biomass was low from 2018 to 2022, but has increased since with the 2025 estimated value approximately 56.3% of the mean.
5. **Recruitment**: Estimated recruitment was high during the 1970s and early 1980s and has generally been low since 1985 (1979 year class). During 1984-2024, estimated recruitment was above the historical average (1976-2024 reference years) only in 1984, 1986, 1990, 1995, 1999, 2002, 2005, 2006, and 2010. Estimated recruitment has been low during the last 15 years, and even lower during the most recent nine years. With the low recruitment in recent years, the projected mature biomass is expected to decline during the next few years with a below-average fishing mortality of 0.167 to 0.25 yr^{-1}.
6. **Management performance**: The stock was above Minimum Stock Size Threshold (MSST) in 2024/25 (107% of B_{MSY}) and hence was not overfished. Since total catch was below the OFL (overfishing limit), overfishing did not occur. The projection using the lowest recruitment periods during 2014-2024 would not likely result in "approaching an overfished condition" based on the current harvest strategy. The current version of GMACS uses an average of sex ratios of recruitment during the reference period to estimate $B_{35\%}$, which results in a stable sex ratio (about 50%) for the reference point calculation. A

20% buffer was suggested by the CPT and SSC for 2021 - 2024, and is recommended by the author in 2025 for similar reasons to previous years; refer to Appendix E for the buffer history and Appendix D for the risk table. Tables below represent the status and catch specifications for model 24.0c.2 in 1,000 t and million lb (Tables 1 and 2).

Table 1: Status and catch specifications (1000 t) for the CPT recommended model (24.0c.2).

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2021/22	12.01	16.64	0	0.02	0.10	2.23	1.78
2022/23	9.68	18.34	0	0.02	0.11	3.04	2.43
2023/24	9.35	18.65	0.975	0.96	1.34	4.42	3.54
2024/25	9.26	19.74	1.05	1.05	1.20	5.02	4.02
2025/26		16.84				5.85	4.68

Table 2: Status and catch specifications (million lb) for the CPT recommended model (24.0c.2).

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2021/22	26.5	36.7	0	0.04	0.22	4.91	3.92
2022/23	21.34	40.44	0	0.05	0.24	6.70	5.35
2023/24	20.6	41.11	2.15	2.12	2.96	9.75	7.8
2024/25	20.42	43.51	2.31	2.31	2.64	11.07	8.86
2025/26		37.12				12.9	10.32

7. **Basis for the OFL**:

Table 3: Basis for the OFL (1000 t) from the CPT recommended model (24.0c.2).

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality
2021/22	3b	24.2	14.9	0.62	0.17	1984-2020	0.18
2022/23	3b	24.03	17.0	0.71	0.20	1984-2021	0.18
2023/24	3b	19.36	14.98	0.77	0.30	1984-2022	0.23
2024/25	3b	18.69	15.43	0.83	0.33	1984-2023	0.23
2025/26	3b	18.52	16.84	0.91	0.37	1984-2024	0.23

Table 4: Basis for the OFL (million lb) from the CPT recommended model (24.0c.2).

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality
2021/22	3b	53.4	33.0	0.62	0.17	1984-2020	0.18
2022/23	3b	53.0	37.4	0.71	0.20	1984-2021	0.18
2023/24	3b	42.7	33.0	0.77	0.30	1984-2022	0.23
2024/25	3b	41.2	34.0	0.83	0.33	1984-2023	0.23
2025/26	3b	40.84	37.12	0.91	0.37	1984-2024	0.23

8. **Probability density function of the OFL**: The estimated probability distributions of MMB and OFL in 2025 are illustrated in Figures 51, 52, and **??** for model 24.0c.2.
9. **Basis for ABC recommendation**: The ABC (acceptable biological catch) buffer was increased from 10% to 20% in 2018, and an additional buffer of 5% was added in 2020 due to the lack of a 2020 survey. A 20% buffer was recommended by the Crab Plan Team (CPT) and Scientific and Statistical Committee (SSC) for ABC estimation since 2021/22. Concerns for this stock that are still present (cold pool distributional shifts, declining trends in mature biomass, lack of large recruitment pulses, retrospective patterns), as well as low mature female abundance the in some of last few years, all contribute to a recommended 20% buffer for 2025/26. Buffer history is detailed in Appendix E.
   Risk table considerations for the buffer discussion are provided in Appendix D. This document details some of the same concerns for the stock that have been considered in the ABC buffer discussion but does not raise any new concerns. The process for using risk tables to assist in ABC buffer determination is under development for BSAI crab stocks.

A. Summary of Major Changes

1. Changes in Management of the Fishery

There are no new changes in management of the fishery.

2. Changes to the Input Data

a. Updated groundfish fisheries bycatch data during 1986-2024.
b. Updated crab fisheries data 2024/25: directed, cost-recovery, and bycatch.
c. Updated NMFS survey data for 2025: biomass and length compositions.
d. Updated length composition data for directed and non-directed fisheries.

3. Changes in Assessment Methodology

a. GMACS version was updated for proposed model runs in May 2025 (version 2.20.20, 2025-01-30); further updates were not undertaken for this document.
b. The analyses of terminal years of recruitment are updated.
c. Two models are compared in this report (See Section E.3.a for details). These models represent the 2024 accepted model and a model with minor updates to crab fishery catch data and input files:

24.0c: (2024 data, updated GMACS version) estimates male M with a tight prior + no time blocks for molt probability for males and females.

24.0c.2: model 24.0c + updated ADF&G catch time series + removing shell condition placeholder in code

4. Changes in Assessment Results

One model for consideration in setting specifications is reported here, model 24.0c.2. In the May 2025, draft report the accepted model in 2024 (24.0c) was presented using an updated GMACS version (**May proposed models BBRKC**). The May 2025 report details the GMACS version updates, as well as the updates to the ADF&G catch time series and removing the shell condition placeholder in the code. All of these minor updates to the base model from 2024 (24.0c) had minimal impact on model results and are vetted as they are updated to ensure this, resulting in the updated base model presented here, model 24.0c.2 (Figure 24).

For specification in 2025/26, model 24.0c.2 is recommended as the updated base model for BBRKC. Results for this model are presented in the specification tables in the executive summary and are summarized in Tables 1, 14, and 16.

B. Responses to SSC and CPT

CPT and SSC Comments on Assessments in General

Response to SSC Comments (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."

Response: Provided here in Figure 46.

"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."

Response: The GMACS version used is clearly defined in "Assessment Methodology", and updates to GMACS versions can be explored in more detail on the (**GMACS GitHub repo**).

"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."

Response: Historical considerations for buffers are described in Appendix E.

Response to SSC Comments (June 2024, Oct 2024):

"The SSC suggests ... guidance for constructing and interpreting jitter analyses..."

Response: The CPT reviewed this guidance and established some SOPs for jitter analysis interpretation at the May 2025 CPT meeting; the author follows this guidance here.

"The SSC would like to see additional residual diagnostics other than raw residuals for length composition data from GMACS models. The SSC encourages crab authors to collaborate with ground fish assessment authors regarding the use of One-Step-Ahead and Pearson residuals."

Response: One-Step-Ahead residuals were incorporated into GMACS output figures for use in assessment output.

"The SSC requests that the CPT consider whether distinguishing between full and update assessments, ..., would be useful for crab assessments."

Response: The CPT has not yet taken up this topic, but it is on the agenda for Sept. 2025

"The SSC suggests the CPT live link assessments and other documents in their report to facilitate review."

Response: This will be taken into consideration in spring reports and full SAFEs.

"The SSC reiterates the request for the CPT to develop a process to ensure the authors have provided responses to all previous SSC recommendations."

Response: The CPT has developed a Google sheet to track requests and further action may be discussed at the Sept 2025 meeting.

"The SSC requests the authors and CPT consider coordinating the approach to analyzing the Bering Sea Fisheries Research Foundation (BSFRF) data for two Chionoecetes crab and Bristol Bay red king crab (BBRKC) stocks, and specifically consider developing the results as a prior on selectivity for use in the models."

Response: There was some discussion among authors on this topic at the Jan 2025 modeling workshop, following Buck Stockhausen's work on this topic. The CPT has not developed a coordinated approach yet to this topic.

Response to SSC Comments (June 2023, Oct 2023):

"The SSC recommends that a"fallback" Tier 4 alternative be provided, as recommended by the Simpler Modeling workshop. When doing so the SSC asks the authors to provide plots to compare OFLs with the status quo Tier 3 models for previous years, justification for the time series used for status determination and a recommended ABC buffer."

Response: A Tier 4 fallback based on survey data and the REMA model are provided as Appendix C in this document.

"For the inclusion of trawl survey data, the SSC suggests crab assessment authors and the CPT be more explicit about best practices for which standard years are included for bottom trawl survey data."

Response: This was addressed by the CPT at our Jan 2024 meeting. See meeting minutes (**Jan 2024 CPT report**) for agreed upon "best practices".

"The SSC recommends the crab stocks begin using the established risk table format from groundfish for assessing uncertainty around buffer considerations"

Response: After viewing draft risk tables in Sept. 2024 the CPT decided to pick up a risk table format for crab stock discussion at the May 2025 meeting. The risk table framework agreed upon at this meeting will be presented with final assessments in Sept. 2025.

"The SSC recommends that uncertainty intervals be included when showing time series of biomass/abundance estimated by models.

Response: These are provided in this document.

CPT and SSC Comments on BBRKC assessment

Responses to SSC Comments (June 2025):

"It was noted that the CPUE in the 2024/25 directed fishery was higher than the last ten year average and the CPT recommended looking at the spatial aggregation of the directed fishery. The SSC agrees and recommends expanding that analysis to a spatial comparison of NMFS survey metrics, such as CPUE, average size, and sex ratio, relative to corresponding fleet metrics to the extent possible to see if increased fleet aggregation is influencing fishery CPUE and selectivity, or the retrospective patterns."

Response: A deeper dive into fishery CPUE has not yet been conducted. The assessment author is working with biologists and managers to facilitate this for May 2026. Fishery CPUE is not incorporated in the current assessment model as a data series. Observer size-composition data does not suggest any differences in male composition for the 2024/25 fishery, however few large females were caught in the fishery which is abnormal compare to the last few fishery openings, (Figure 37).

"A research model based approach to consider connectivity between the "Northern Unstratified Area" and Bristol Bay would benefit from waiting until genetic and tagging data are available to inform the spatial extent of the mating interactions between the areas."

Response: Author agrees that having genetic connectivity data will aid in development of this type of research model. Red king crab in the "Northern area" will continue to be tracked in the assessment document (Figures 58 and 59).

"Develop additional size bins for the larger females across the entire time series."

Response: Work is underway for exploration in May 2026.

"Continue to develop a common framework for using BSFRF data for snow crab, Tanner crab, and BBRKC."

Response: This is a continued area of research and modeling, which will be taking up at the Jan crab modeling workshop.

Responses to SSC Comments (June 2024/Oct 2024):

"The SSC recommends that the author bring forward a model that adds the BSFRF prior on selectivity for the 2025 assessment."

Response: May 2025 models 25.1a, 25.1b, and 25.1b2 all use the BSFRF data as a prior on selectivity. The author has concerns over moving to these models without further model exploration for the 2025 assessment and this is discussed in this document.

"The SSC agrees with the additional considerations by the CPT in their minutes prioritizing; 1) considerations of selectivity time periods based on gear types and 2) considerations of time-varying selectivity in the fishery data relative to the survey data."

Response: The selectivity models presented in this document do retain the two time blocks for survey selectivity for the NMFS time series. However, the author has not yet explored time-varying selectivity in the fishery data relative to the survey data and hopes to have some discussion with the CPT on what this exploration could look like.

"The SSC reiterates its request to evaluate whether crab biomass and fishing mortality in the northern district should be included."

Response: Since 2022, the SAFE document has tracked Northern RKC data from the NMFS trawl survey. Overall, the proportions of different size/sex groups of the Northern RKC during the most recent dozen years are higher than in the past and do not trend higher except for mature females in 2021. The high survey mature female abundance in the Northern area in 2021 was primarily from three tows and one of them is more than 50% of total mature females. The survey abundance of the Northern RKC will continue to be plotted in the SAFE report in the future. After migration patterns between BBRKC and the Northern RKC are fully understood, we will model them in the stock assessment. An assessment model that includes crab outside the Bristol Bay boundary would have to include updates to data inputs for all catch and survey time series, and also include conversations with managers on the implications of a larger spatial model. Explorations into model based indices for other Bering Sea stocks may provide an option for BBRKC to utilize the Northern district crab to design a model based index that only predicts over the traditional Bristol Bay grid. Work on this is planned for 2025/2026.

"The SSC recommends the author revisit previous CPT discussion and rationale on whether 50% handling mortality is appropriate for both pot and long-line (fixed gear) gear and to provide additional information in the next assessment."

Response: The May 2025 document includes a model run, model 24.0c.1a, that has a reduced handling mortality (20%) for the fixed gear groundfish catch in place of the historical 50% level. No measurable changes to model results were observed, and only small changes in management quantities that lie within the range of variability for those estimates (Table 16 and Figure 23). This is likely due to the small magnitude of fixed gear catch in the model compared to directed fishery catch. Ultimately a change in the handling mortality rate for fixed gear would have to be approved by the CPT. A review of the data available to inform handling mortality estimations occurred at the May 2022 CPT meeting (**HM May 2022**). At this time there are no direct research studies conducted on mortality of crab caught as bycatch in the long-line or pot groundfish fisheries. Historically ranges of 30 to 50% have been use in various Council analyses and since 2008 a 50% rate has been applied when splitting bycatch between fixed and trawl gear.

Response to CPT Comments (from May 2024):

"Including BSFRF as a 'ghost fleet' as a check on model behavior."

Response: Further exploration of the BSFRF data and its use in the BBRKC model is needed and planned for 2025/2026, it was not examined prior to May 2025.

Split the selectivity into eras to reflect the change in survey gear, but still use the same priors, perhaps with larger CVs in the early era.

Response: May 2025 models 25.1a, 25.1b, and 25.1b2 all retain the time blocks for survey selectivity estimation and use the same priors for both periods. Model 25.1b2 has larger CVs for both eras, which resulted in a similar estimation as Model 25.1b for the SE.

Selectivity and retention explorations that may include: exploring parameters that allow for the retention curve to asymptote below one, exploring splines for selectivity, and exploring models using time-varying selectivity to better understand model dynamics.

Response: Model sensitivity to selectivity and retention assumptions should be explored but was not prioritized this year. Further direction from the CPT on hypotheses for these model runs would help in determining the appropriate parameterizations to explore moving forward.

Explore including larger size bins in the model to explore dome shaped selectivity.

Response: Including larger size bins than the current model uses (>160mm for males specifically) would require re-visiting the growth matrix for this stock. This matrix has been established for some time and would require some historic data recovery to determine if larger size bin growth could be determined from the same data. To include larger size bins assumptions would need to be made for the growth matrix unless the historic data were recoverable. Additionally, raw data to add size bins to each of the size comp data sets are still in the process but an initial look at the NMFS data to determine if larger size bins should be incorporated was explored here. The May 2025 proposed models document (**May proposed models BBRKC**) displays the distribution of size composition for all years of the NMFS data and the associated lower and upper cut offs for the model. Initial exploration does not suggest a large change in size distribution over time, at least for the last 15 years.

Remove shell condition from the model since it's not being used currently

Response: Shell condition was removed from the model, reflected as model 24.0c.2, and has no measurable effect on results since it was not being implemented in the current base model.

Response to SSC Comments specific to this assessment (from October 2023):

Provide basis for the tight prior on M and catchability.

Response: The prior on trawl survey catchability is estimated with a mean of 0.896 and a standard deviation of 0.025 (CV about 0.03) that is based on double-bag experiment results (Weinberg et al. 2004). The prior on M is based on the balance of allowing M to be estimated above the default, historic 0.18 value for males but realizing the limitations of the data to estimate M freely. Future work is planned and will continue to explore the most appropriate estimation of M.

Consider tracking Dungeness crab abundance in the EBS and how this might affect BBRKC dynamics.

Response: Currently there is no abundance estimate of Dungeness crab in the EBS. Conversations have occurred between the author and regional biologist on possible general affects, with the overall consensus that these two species are likely not occupying the same habitat as juveniles/adults. However, the early life spatial occupation for both of these stocks is unknown, so there may be competition for food in these stages. Trends of Dungeness catch over time are being obtained and will be explored in future work.

Explain why equal sample sizes are used for male and female size composition data.

Response: The size composition data for surveys are entered into the model as aggregate data since they are derived from the same survey samples. Therefore the sample size for each is based on the total number of crab measured not those measured by sex.

MCMC output diagnostics, autocorrelation plots and parameter chains

Response: Some of these will be provided in Sept 2025 when a full MCMC is performed on the preferred models. The CPT still needs to have further discussions in Sept 2025 on the suite of diagnostics to report for MCMC output.

Possible effect of high 2011 recruitment as scene in survey size composition figures

Response: Size composition plots in Sept 2023 highlighted a potential recruitment event in 2011 for both males and females from the NMFS survey data (Figures 6 and 7 - Sept 2023 SAFE). This peak occurs as size classes that are not included in the assessment model (< 65mm, figures 43 and 44 - Sept 2023 SAFE), therefore this recruitment likely plays little role in the model estimates and resulting retrospective pattern since it is not seen in subsequent years to be included in the model.

Response to CPT Comments (from May 2023 / Sept 2023):

Reconsider which growth parameters are estimated vs. specified. Consider a model run with growth specified outside the model (CPT Sept 2023)

Response: The author is collaborating with biologists on the availability of more recent growth data, and investigating the feasibility of recovering the original raw data used in the historic growth specifications. Work is underway to determine the best path forward for growth parameterizations for this stock.

Survey selectivity / q / catchability. Reconsider the strong prior and shape of the selectivity curve. Consider using the BSFRF data as a prior on selectivity/catchability as was done in the snow crab assessment (CPT and SSC May/June 2023 and Sept/Oct 2023)

Response: Models presented in May 2024 (24.0 and 24.0b) reflected explorations on using the BSFRF data as a prior on selectivity - similar to snow crab (fall 2023). Further explorations on priors and shape were not explored this round, although the previous assessment author did explore some aspects in models runs between 2020 and 2022.

Revisit blocking on molting probability from tagging data (CPT and SSC May/June 2023)

Response: The blocking of molt probability for males reflects changes in the Bristol Bay ecosystem in the early 80s and has been a historic component of the current model. Models presented in May 2024 reflected removing this blocking to estimate one molting probability for the entire time series. Model 24.0c was adopted in fall of 2024.

Response to SSC/CPT comments prior to 2023: See Fall 2024 SAFE report for further historical discussion of CPT and SSC comments.

C. Introduction

1. Scientific Name

Red king crab (RKC), *Paralithodes camtschaticus*, in Bristol Bay, Alaska.

2. Distribution

Red king crab inhabit intertidal waters to depths >200 m of the North Pacific Ocean from British Columbia, Canada, to the Bering Sea, and south to Hokkaido, Japan, and are found in several areas of the Aleutian Islands, eastern Bering Sea, and the Gulf of Alaska.

3. Stock Structure

The State of Alaska divides the Aleutian Islands and eastern Bering Sea into three management registration areas to manage RKC fisheries: Aleutian Islands, Bristol Bay, and Bering Sea (ADF&G 2012). The Bristol Bay area includes all waters north of the latitude of Cape Sarichef (54°36' N lat.), east of 168°00' W long., and south of the latitude of Cape Newenham (58°39' N lat.) and the fishery for RKC in this area is managed separately from fisheries for RKC outside of this area; i.e., the red king crab in the Bristol Bay area are assumed to be a separate stock from red king crab outside of this area. This report summarizes the stock assessment results for the Bristol Bay RKC stock. In 2023 a stock structure template was developed for red king crab in the Bering Sea and can be found on the NPFMC website (**RKC Bering Sea stock structure**).

4. Life History

Red king crab have a complex life history. Fecundity is a function of female size, ranging from tens of thousands to hundreds of thousands of eggs produced (Haynes 1968; Swiney et al. 2012). The eggs are extruded by females, fertilized in the spring, and held by females for about 11 months (Powell and Nickerson 1965). Fertilized eggs are hatched in the spring, most during April-June (Weber 1967). Primiparous females breed a few weeks earlier in the season than multiparous females. Larval duration and juvenile crab growth depend on temperature (Stevens 1990; Stevens and Swiney 2007). Male and female RKC mature at 5–12 years old, depending on stock and temperature (Stevens 1990; Loher et al. 2001) and may live >20 years (Matsuura and Takeshita 1990). Males and females attain a maximum size of 227 mm and 195 mm carapace length (CL), respectively (Powell and Nickerson 1965). Female maturity is evaluated by the size at which females are observed to carry egg clutches. Male maturity can be defined by multiple criteria including spermataphore production and size, chelae vs. carapace allometry, and participation in mating in situ (reviewed by Webb 2014). For management purposes, females >89 mm CL and males >119 mm CL are assumed to be mature for Bristol Bay RKC. Juvenile RKC molt multiple times per year until age 3 or 4; thereafter, molting continues annually in females for life and in males until maturity. Male molting frequency declines after attaining functional maturity.

5. Fishery

The RKC stock in Bristol Bay, Alaska, supports one of the most valuable fisheries in the United States. A review of the history of the Bristol Bay RKC fishery is provided in Fitch et al. (2012) and Otto (1989). The Japanese fleet started the fishery in the early 1930s, stopped fishing from 1940 to 1952, and resumed the fishery from 1953 until 1974. The Russian fleet fished for RKC from 1959 to 1971. The Japanese fleet employed primarily tanglenets with a very small proportion of catch from trawls and pots. The Russian fleet used only tanglenets. United States trawlers started fishing Bristol Bay RKC in 1947, but the effort and catch declined in the 1950s. The domestic RKC pot fishery began to expand in the late 1960s and peaked in 1980 with a catch of 129.95 million lb (58,943 t), worth an estimated $115.3 million ex-vessel value. The catch declined dramatically in the early 1980s and has remained at low levels during the last two decades (Tables 9 and 10). After the early 1980s stock collapse, the Bristol Bay RKC fishery took place during a short period in the fall (usually lasting about a week) with the catch quota based on the stock assessment conducted the previous summer (Zheng and Kruse 2002). Beginning with the 2005/2006 season, new regulations associated with fishery rationalization resulted in an increase in the duration of the fishing season (October 15 to January 15). With the implementation of crab rationalization, the annual guideline harvest level (GHL) was changed to a total allowable catch (TAC). Before rationalization, the implementation errors were quite high for some years and the sum of actual catches from 1980 to 2007 was about 6% less than the sum of GHL/TAC over that period.

6. Management History

King and Tanner crab stocks in the Bering Sea and Aleutian Islands are managed by the State of Alaska through a federal king and Tanner crab fishery management plan (FMP). Under the FMP, management measures are divided into three categories: (1) fixed in the FMP, (2) frame-worked in the FMP, and (3) discretion of the State of Alaska. The State of Alaska is responsible for determining and establishing the GHL/TAC under the framework in the FMP. Harvest strategies for the Bristol Bay RKC fishery have changed over time.

Two major management objectives for the fishery are to maintain a healthy stock that ensures reproductive viability and to provide for sustained levels of harvest over the long term (ADF&G 2012). In attempting to meet these objectives, the GHL/TAC is coupled with size-sex-season restrictions. Only males $\geq$ 6.5 in carapace width (equivalent to 135mm CL) may be harvested and no fishing is allowed during molting and mating periods (ADF&G 2012). Specification of TAC is based on a harvest rate strategy. Before 1990, harvest rates on legal males were based on population size, abundance of prerecruits to the fishery, postrecruit abundance, and rates varied from less than 20% to 60% (Schmidt and Pengilly 1990). In 1990, the harvest strategy was modified, and a 20% mature male harvest rate was applied to the abundance of mature-sized ($\geq$ 120 mm CL) males with a maximum 60% harvest rate cap of legal ($\geq$ 135 mm CL) males (Pengilly and Schmidt 1995). In addition, a minimum threshold of 8.4 million mature-sized females ($\geq$ 90 mm CL) was added to existing management measures to avoid recruitment overfishing (Pengilly and Schmidt 1995). Based on a new assessment model and research findings (Zheng et al. 1995a, 1995b, 1997a, 1997b), the Alaska Board of Fisheries adopted a new harvest strategy in 1996. That strategy had two mature male harvest rates: 10% when effective spawning biomass (ESB) is between 14.5 and 55.0 million lb and 15% when ESB is at or above 55.0 million lb (Zheng et al. 1996). The maximum harvest rate cap of legal males was changed from 60% to 50%. A threshold of 14.5 million lb of ESB was also added. In 1997, a minimum threshold of 4.0 million lb was established as the minimum GHL for opening the fishery and maintaining fishery viability and manageability when the stock abundance is low. The Board modified the current harvest strategy in 2003 by adding a mature harvest rate of 12.5% when the ESB is between 34.75 and 55.0 million lb and in 2012 eliminated the minimum GHL threshold. The current harvest strategy is illustrated in Figure 1.

D. Data

1. Summary of New Information

a. Updated groundfish fisheries bycatch data during 1986-2024.
b. Updated crab fishery data: directed, cost-recovery, and bycatch data for 2024/2025
c. Updated survey data for 2025
d. Updated length-frequencies distributions for all data sets for 2024/2025

Data types and availability periods are illustrated in Figure 2.

2. Catch Data

Data on landings of Bristol Bay RKC by length and year and catch per unit effort from 1960 to 1973 were obtained from annual reports of the International North Pacific Fisheries Commission (Hoopes et al. 1972; Jackson 1974; Phinney 1975) and from the Alaska Department of Fish and Game from 1974 to 2020 (Tables 9 and 10). Bycatch data are available starting from 1990 and were obtained from the ADF&G observer database and reports (Gaeuman 2013) (Table 11). Sample sizes for catch by length and sex are summarized in Table 12. Relatively large samples were taken from the retained catch each year. Sample sizes for trawl bycatch were the annual sums of length frequency samples in the National Marine Fisheries Service (NMFS) database.

a. Catch Biomass

Retained catch and estimated bycatch biomasses are summarized in Tables 9 and 10 and illustrated in Figure 3. Retained catch and estimated bycatch from the directed fishery include the general, open-access fishery (prior to rationalization), or the individual fishery quota (IFQ) fishery (after rationalization), as well as the Community Development Quota (CDQ) fishery and the ADF&G cost-recovery harvest. Starting in 1973, the fishery generally occurred during the late summer and fall. Before 1973, a small portion of retained catch in some years was caught from April to June. The years in Tables 9 and 10 are defined as crab year from July 1 to June 30. Bycatch data for the cost-recovery fishery before 2006 were not available. In this report, pot fisheries include both the directed fishery and RKC bycatch in the Tanner crab pot fishery, and trawl fisheries and fixed gear fisheries are groundfish fisheries. Observers did not separate retained and discarded catch of legal-sized crab after 2017 in the directed pot fishery, so the male discarded biomass from the directed fishery has been estimated by the subtraction method (subtracting the retained catch from the estimated total catch) since 2018 (B. Daly, ADF&G, pers. com.).

b. Catch Size Composition

Retained catches by length and shell condition and bycatches by length, shell condition, and sex were obtained for stock assessments. From 1960 to 1966, only retained catch length compositions from the Japanese fishery were available. Retained catches from the Russian and U.S. fisheries were assumed to have the same length compositions as the Japanese fishery during this period. From 1967 to 1969, the length compositions from the Russian fishery were assumed to be the same as those from the Japanese and U.S. fisheries. After 1969, foreign catch declined sharply and only length compositions from the U.S. fishery were used to distribute catch by length.

c. Catch per Unit Effort

Catch per unit effort (CPUE) is defined as the number of retained crab per tan (a unit of fishing effort for tanglenets) for the Japanese and Russian tanglenet fisheries and the number of retained crab per potlift for the U.S. fishery (Table 10). Soak time, while an important factor influencing CPUE, is difficult to standardize. Furthermore, complete historical soak time data from the U.S. fishery are not available. Based on the approach of Balsiger (1974), all fishing effort from Japan, Russia, and U.S. were standardized to the Japanese tanglenet from 1960 to 1971, and the CPUE was standardized as crab per tan. Except for the peak-to-crash years of the late 1970s and early 1980s, the correspondence between U.S. fishery CPUE and area-swept survey abundance is poor (Figure 4). Due to the difficulty in estimating commercial fishing catchability and crab availability to the NMFS annual trawl survey data, commercial CPUE data were not used in the model.

3. National Marine Fisheries Service (NMFS) Survey Data

The NMFS has conducted annual trawl surveys of the eastern Bering Sea since 1968. Two vessels, each towing an eastern otter trawl with an 83 ft headrope and a 112 ft footrope, conducted this multispecies, crab-groundfish survey during the summer. Stations were sampled in the center of a systematic 20 X 20 nm grid overlaid in an area of approximately 140,000 nm^2. Since 1972, the trawl survey has covered the full stock distribution except in nearshore waters. The survey in Bristol Bay occurs primarily during late May and June. Tow-by-tow trawl survey data for Bristol Bay RKC during 1975-2025 were provided by NMFS. Due to survey data quality issues, only survey data after 1974 are used in the assessment models.

Abundance estimates by sex, carapace length, and shell condition were derived from survey data using an area-swept approach (Figures 5 and 6). Until the late 1980s, NMFS used a post-stratification approach, but subsequently treated Bristol Bay as a single stratum; the estimates shown for Bristol Bay in Figures 4 – 6 were made without post-stratification. If multiple tows were made at a single station in a given year, the average of the abundances from all tows within that station was used as the estimate of abundance for that station. The new time series since 2015 discards all “hot spot” tows.

In addition to the standard surveys conducted in early June (late May to early June in 1999 and 2000), a portion of the distribution of Bristol Bay RKC was resurveyed in 1999, 2000, 2006-2012, and 2021 to better assess mature female abundance. Resurveys performed in late July, about six weeks after the standard survey, included 31 stations (1999), 23 stations (2000), 31 stations (2006, 1 bad tow and 30 valid tows), 32 stations (2007-2009), 23 stations (2010), and 20 stations (2011, 2012, and 2021) with high female densities. The resurveys were necessary because a high proportion of mature females had not yet molted or mated when sampled during the standard survey time. Differences in area-swept estimates of abundance between the standard surveys and resurveys of these same stations are attributed to survey measurement errors or to seasonal changes in distribution between survey and resurvey periods. More large females were observed in the resurveys than during the standard surveys in 1999 and 2000, presumably because most mature females had not molted prior to the standard surveys. As in 2006, area-swept estimates of males >89 mm CL, mature males, and legal males within the 32 resurvey stations in 2007 were not significantly different (p = 0.74, 0.74 and 0.95; paired t-test of sample means) between the standard survey and resurvey tows. However, similar to 2006, area-swept estimates of mature females within the 32 resurvey stations in 2007 were significantly different (p = 0.03; paired t-test) between the standard survey and resurvey tows. Resurvey stations were close to shore during 2010-2012, and mature and legal male abundance estimates were lower for the re-tow than the standard survey. Following the CPT recommendation, we used the standard survey data for male abundance estimates and only the resurvey data, plus the standard survey data outside the resurveyed stations, to assess female abundances during resurvey years.

4. Bering Sea Fisheries Research Foundation Survey Data (BSFRF)

The BSFRF conducted trawl surveys for Bristol Bay RKC in 2007 and 2008 with a small-mesh trawl net and 5-minute tows (S. Goodman, BSFRF, pers. com.). The surveys occurred at similar times as the NMFS standard surveys and covered about 97% of the Bristol Bay survey area. Few Bristol Bay RKC were found outside the BSFRF survey area. Because of the small mesh size, the BSFRF surveys were expected to catch more RKC within the swept area. Crab abundances of different size groups were estimated by the kriging method. Mature male abundances were estimated to be 22.331 million crab (CV = 0.0634) in 2007 and 19.747 million crab (CV = 0.0765) in 2008. BSFRF also conducted a side-by-side survey concurrent with the NMFS trawl survey during 2013-2016 in Bristol Bay. In May 2017, survey biomass and size composition estimates from 2016 BSFRF side-by-side trawl survey data were updated. Ratios of NMFS survey abundances/total NMFS and BSFRF side-by-side trawl survey abundances are illustrated in Figures 7 and 8, and ratios of NMFS survey abundances/BSFRF side-by-side trawl survey abundances are shown in Figures 9 – 11.

As a comparison to the estimated NMFS survey catchability (0.896) at 162.5 mm CL by the double-bag experiment (Weinberg et al. 2004), we computed an overall ratio (q=0.891) of NMFS survey abundances/BSFRF side-by-side trawl survey abundances for legal crab ($\geq$ 135mm carapace length) as follows:

$$q = \frac{\sum_{y=2013,l=135mm}^{y=2016,l=\infty} r_{y,l} n_{y,l}}{\sum_{y=2013,l=135mm}^{y=2016,l=\infty} n_{y,l}}$$

where $r_{y,l}$ is the ratio of NMFS survey abundance/BSFRF side-by-side trawl survey abundance in year y and length group l, and $n_{y,l}$ is the combined survey abundance of side-by-side surveys in year y and length group l. Due to small catch, all haul data were combined to compute the ratios for each length group and year.

E. Analytic Approach

1. History of Modeling Approaches for this Stock

To reduce annual measurement errors associated with abundance estimates derived from the area-swept method, ADF&G developed a length-based analysis (LBA) in 1994 that incorporates multiple years of data and multiple data sources in the estimation procedure (Zheng et al. 1995a). Annual abundance estimates of the Bristol Bay RKC stock from the LBA have been used to manage the directed crab fishery and to set crab bycatch limits in the groundfish fisheries since 1995 (Figure 1). An alternative length-based model (research model) was developed in 2004 to include small size crab to determine federal overfishing limits. Given that the crab abundance declined sharply during the early 1980s, the LBA estimated natural mortality for different periods of years, whereas the research model estimated additional mortality beyond a base constant natural mortality during 1980-1984. In this report, we present only the research model that was fit to the data from 1975 to 2025.

2. Model Description

The original LBA model was described in detail by Zheng et al. (1995a, 1995b) and Zheng and Kruse (2002). The model combines multiple sources of survey, catch, and bycatch data using a maximum likelihood approach to estimate abundance, recruitment, selectivity, fishing mortality, catch, and bycatch of commercial pot fisheries and groundfish trawl fisheries. Since 2019, GMACS (General Model for Alaska Crab Stocks) has been used for this stock assessment. A full model description is provided in Appendix A.

a-f. See Appendix A

g. Critical assumptions of the model:

i. The base male natural mortality is estimated with a tight prior, a log-normal prior with a mean of 0.18 yr_1 for males and a CV of 0.04. The mean value was estimated assuming a maximum age of 25 and applying the 1% rule (Zheng 2005). A fixed base M of 0.18 yr_1 for males was used in accepted model until Sept. 2023, when the current estimated base male M was adopted.
ii. Survey and fisheries selectivities are a function of length. Selectivities may or may not be a function of sex except for groundfish fisheries bycatch selectivities, which are the same for both sexes. Two different NMFS survey selectivities were estimated: (1) 1975-1981 and (2) 1982-2025, based on modifications to the trawl gear used in the assessment survey.
iii. Growth is a function of length. For females, growth-per-molt increments as a function of length are estimated for three periods (1975-1982, 1983-1993, and 1994-2025) based on sizes at maturity. Once mature, female red king crab have a much smaller growth increment per molt.
iv. Annual molting probabilities are an inverse logistic function of length for males. Females are assumed to molt annually.
v. Annual fishing seasons for the directed fishery are short.
vi. The prior mean for NMFS survey catchability (Q) is estimated to be 0.896 with a standard deviation of 0.025 for some models, based on a trawl experiment by Weinberg et al. (2004); Q is assumed to be constant over time and is estimated in the model. The BSFRF survey catchability is assumed to be 1.0. The prior mean of 0.896 for NMFS survey Q (at 162.5 mm carapace length) is also close to the abundance-weighted average ratio of 0.891 for crab $\geq$ 135 mm CL across four years of side-by-side NMFS and BSFRF survey data (Figure 11).
vii. Males mature at sizes $\geq$ 120 mm CL. For convenience, female abundance is summarized at sizes $\geq$ 90 mm CL as an index of mature females.
viii. Measurement errors are assumed to be normally distributed for length compositions and are log-normally distributed for biomasses.

h. Changes to the above since previous assessment: see Section A.3 for changes to the assessment methodology.

i. Assessment results by GMACS have been compared to the previous assessment models, and the code is online and available from the author and on GitHub (**GMACS GitHub repo**). The May 2025 proposed model runs document (**BBRKC May 2025 proposed models**) details the changes to the GMACS version and base model configuration, which all have minimal affect on the model output (Figure 24).

3. Model Selection and Evaluation

a. Alternative model configurations (models):

24.0c: the base model for September 2024 based on model 23.0a (2023) and 21.1b (2022) that has the accepted updates from Sept 2023 (1 below), May 2022 (2 - 11 below) and 2024 (12 - 13 below). Basic features of this model include:

(1) An estimated constant M for males during 1980-1984, and an estimated constant (base) M for males during the other years using a log-normal prior with a mean of 0.18 and a CV of 0.04. There is an estimated constant multiplier being used to multiply male M for female M such that M for females is relative to M for males each year.

(2) Including BSFRF survey data during 2007-2008 and 2013-2016.

(3) Estimating a constant NMFS survey catchability over time in the model and assuming BSFRF survey catchability to be 1.0.

(4) Assuming the BSFRF survey selectivities as the availability to the NMFS trawl survey because the BSFRF survey gear has very small mesh sizes and has tighter contact to the sea floor. This implies that crab occurring in nearshore areas are not available to trawl survey gears.

(5) Estimating effective sample size from observed sample sizes. Stage-1 effective sample sizes are estimated as min $(0.25 * n$, N) for trawl surveys and min $(0.05 * n$, N) for catch and bycatch, where n is the sum of observed sample sizes for two sexes, and N is the maximum sample size (200 for trawl surveys, 150 for retained catch and total males from the directed pot fishery and 50 for females from the pot fishery and for both males and females from the Tanner crab and groundfish fisheries). There is justification for enforcing a maximum limit to effective sample sizes because the number of length measurements is large (Fournier et al. 1998).

(6) Standard survey data for males and NMFS survey re-tow data (if available during cold years) for females.

(7) Estimating initial year length compositions.

(8) Using total observer male biomass and total observer male length composition data in the directed pot fishery to replace discarded male biomass and discarded male length composition data.

(9) Using total male selectivity and retained proportions in the directed pot fishery to replace retained selectivity and discarded male selectivity; and due to high grading problems in some years since rationalization, estimating two logistic curves for retained proportions: one before rationalization (before 2005) and another after 2004.

(10) Equal annual effective sample sizes of male and female length compositions for all size composition data sets.

(11) Updated groundfish fisheries bycatch data.

(12) Updated version of GMACS (version 2.20.14).

(13) Removes the time block for molt probability for males and females which reduces the parameter count by 2.

24.0c.2: model 24.0c +

(14) Uses the recently updated version of GMACS (version 2.20.20).

(15) Updated catch time series for crab fisheries from ADF&G

(16) Remove shell condition placeholders from input files

b. Progression of results:

See the new results at the beginning of the report.

c. Evidence of search for balance between realistic and simpler models:

Model 24.0c.2 reflects work towards this balance to determine if simplification of the model could be warranted.

d. Convergence status/criteria: ADMB default convergence criteria.
e. Sample sizes for length composition data: observed sample sizes are summarized in Table 12.
f. Credible parameter estimates: All estimated parameters seem to be credible and within bounds.
g. Model selection criteria: The likelihood values are used to select among alternatives that could be legitimately compared by that criterion.
h. Residual analysis: Residual plots are illustrated in various figures.
i. Model evaluation is provided under Results below.
j. Jittering: The Stock Synthesis Approach is used to perform jittering to find the optimum: The Jitter factor of 0.1 is multiplied by a random normal deviation $rdev = N(0,1)$, to a transformed parameter value based upon the predefined parameter:

$$temp = 0.5 * rdev * Jitter * ln(\frac{P_{max} - P_{min} + 0.0000002}{P_{val} - P_{min} + 0.0000001} - 1)$$

with the final jittered starting parameter value back-transformed as:

$$P_{new} = P_{min} + (\frac{P_{max} - P_{min}}{1.0 + exp(-2.0 * temp)})$$

where P_{max} and P_{min} are upper and lower bounds of parameters and P_{val} is the estimated parameter value before the jittering.

Jittering was performed using GMACS for model 24.0c.2, at both a 0.1 and 0.3 SD and are summarized under section 4.f. uncertainty and sensitivity analyses (Figure 50).

Assessment Methodology

This assessment model again uses the modeling framework GMACS and is detailed in Appendix A, with GMACS input files in Appendix B. An updated version of GMACS (version 2.20.20, 2025-1-30) was used.

4. Results

a. Effective sample sizes and weighting factors

i. CVs are assumed to be 0.03 for retained catch biomass, 0.04 for total male biomass, 0.07 for pot bycatch biomasses, 0.10 for groundfish bycatch biomasses, and 0.23 for recruitment sex ratio. Models also estimate sigmaR for recruitment variation and have a penalty on M variation and many prior-densities.

ii. Initial trawl survey catchability (Q) is estimated to be 0.896 with a standard deviation of 0.025 (CV about 0.03) based on the double-bag experiment results (Weinberg et al. 2004). These values are used to set a prior for estimating Q in all models.

b. Parameter estimates and tables

i. Negative log-likelihood values and parameter estimates are summarized in Tables 16 – 17 for all models.

ii. Natural mortality estimates are shown in Table 13 for all models.

iii. Area-swept estimates of mature female abundance and model estimates of effective spawning biomass (Zheng et al. 1995b) during 2011-2024 for groundfish fisheries bycatch calculation are provided in Table 15.

iv. Abundance and biomass time series are provided in Table 18 for model 24.0c.2.

v. Recruitment time series for model 24.0c.2 are provided in Table 18.

vi. Time series of catch biomass is provided in Tables 9 and 10.

Length-specific fishing mortality is equal to selectivity-at-length times the full selection fishing mortality. Estimated full pot fishing mortalities for females and full fishing mortalities for groundfish fisheries bycatch are low due to low bycatch and handling mortality rates less than 1.0. Estimated recruits varied greatly among years (Table 18). Estimated selectivities for female pot bycatch are close to 1.0 for all mature females, and the estimated full fishing mortalities for female pot bycatch are lower than those for male retained catch and bycatch (Table 17 for model 24.0c.2).

c. Graphs of estimates

i. Estimated selectivities by length are provided in Figures 12 and 21, and estimated molting probabilities by length are illustrated in Figures 15 and 16.

One of the most important results is estimated trawl survey selectivity (Figures 12). Survey selectivity affects not only the fitting of the data but also the absolute abundance estimates. These estimated survey selectivities are generally smaller than the capture probabilities in Figure A1 because survey selectivities include capture probabilities and crab availability. The NMFS survey catchability is estimated to be 0.896 from the trawl experiment. The reliability of estimated survey selectivities will greatly affect the application of the model to fisheries management. Under- or over-estimates of survey selectivities will cause a systematic upward or downward bias of abundance estimates, respectively. Information about crab availability in the survey area at survey times will help estimate the survey selectivities. Higher estimated natural mortalities generally result in lower NMFS survey selectivities, while the estimated survey selectivities after 1981 are similar among the models.

For all models, estimated molting probabilities during 1975-2024 (Figures 15 and 16) are generally lower than those estimated from the 1954-1961 tagging data, but are similar to the 1966-1969 tagging data (Balsiger 1974). Lower molting probabilities mean more oldshell crab, possibly due to changes in molting probabilities over time or shell aging errors. Overestimates or underestimates of oldshell crab will result in lower or higher estimates of male molting probabilities. Molt probabilities for model 24.0c.2 are consistent with the previously accepted models (Figure 16).

ii. Estimated male and female survey biomasses are shown for NMFS surveys (Figures 17 and 18) and BSFRF surveys (Figures 19 and 20). Absolute mature male biomasses are illustrated in Figures 23 and 24. Mature female abundance (a trigger in the State harvest strategy) is illustrated in Figure 25.

The survey male biomass estimates in 2025 was similar to that estimated in 2024, both of which are higher than has been observed since 2015. Survey female biomass estimates increased from 2024, and is higher than most values since 2018. Estimated population biomass increased dramatically in the mid-1970s then decreased precipitously in the early 1980s. Estimated biomass generally increased during 1985-2003 for males and during 1985-2007 for females, then declined, and has steadily declined since the late 2000s with only recent small increase in the last few years (Figures 17, 18, 23, and 24). Absolute mature male biomass for the updated base model (24.0c.2) is similar to the 2024 base model for the time series (Figures 23 and 24). All models fit the catch and bycatch biomasses very well.

The fit to BSFRF survey data and estimated survey selectivities are illustrated in Figures 19 and 20.

iii. Estimated total recruitment time series are plotted in Figure 26 for model 24.0c.2 and the 2024 estimate for model 24.0c. Recruitment is estimated at the end of year in GMACS and is moved up one year for the beginning of next year. Estimated recruitment time series is similar to that estimated in 2024.

Compared to the base models used in 2022 and prior years, estimated recruitments among models with higher M values are generally higher.

Like the results of previous models, the terminal year recruitment analysis with model 24.0c.2 suggests the estimated recruitment in the last year should not be used for estimating $B_{35\%}$ (Figures 48 to 49).

iv. Estimated fishing mortality rates are plotted against mature male biomass in Figure 27 for model 24.0c.2, and estimated M and directed pot fishing mortality values over time are illustrated in Figure 28 and 29.

The average of estimated male recruits from 1984 to 2024 (Figure 26) and mature male biomass per recruit are used to estimate $B_{35\%}$. The full fishing mortalities for the directed pot fishery at the time of fishing are plotted against mature male biomass on Feb. 15 (Figure 27). Estimated fishing mortalities in most years before the current harvest strategy was adopted in 1996 were above $F_{35\%}$ (Figure 27). Under the current harvest strategy, estimated fishing mortalities were at or above the $F_{35\%}$ limits in 1998, 2005, 2007-2009 for model 24.0c.2, but below the $F_{35\%}$ limits in the other post-1995 years.

For model 24.0c.2, estimated full pot fishing mortalities ranged from 0.00 to 2.14 during 1975-2024, with estimated values over 0.40 during 1975-1982, 1984-1987, 1990-1991, 1993, 1998 and 2008 (Table 18, Figure 27). Estimated fishing mortalities for females caught in the directed pot fishery are generally small in recent years, less than 0.06 since 2000. Groundfish fisheries bycatches, both trawl and fixed gear, since 2000 are generally small and less than 0.02.

For model 24.0c.2, estimated M values are 1.02 during 1980-1984 and 0.23 for the other years for males, and 1.16 during 1980-1984 and 0.26 for the other years for females (Figure 28). Biologically, females mature earlier than males and likely have higher M values. M values for all models are listed in Table 13.

v. Estimated mature male biomass and recruitment are plotted to illustrate their relationships with model 24.0c.2 (Figure 30). Annual stock productivities are illustrated in Figure 31. Stock productivity (recruitment/mature male biomass) is generally lower during the last 20 years (Figure 31). However, there are high variations for the relation of stock productivity against mature male biomass.

Egg clutch data collected during summer surveys may provide information about mature female reproductive conditions (Figures 32 and 33). Although egg clutch data are subject to rating errors as well as sampling errors, data trends over time may be useful. Proportions of empty clutches for newshell mature females >89 mm CL are high in some years before 1990 but have been low since 1990 (Figure 32). The highest proportion of empty clutches was in 1980 and 1986, and primarily involved soft shell females (shell condition 1). Clutch fullness fluctuated annually around average levels during two periods: before 1991 and after 1990 (Figure 32). The average clutch fullness is similar for these two periods (Figure 32). Egg clutch fullness in the last ten years appears to oscillate up and down from the later period average but still remains higher than 75%.

d. Evaluation of the fit to the data.

i. Observed vs. estimated catches are plotted in Figure 34, with bycatch mortalities from different sources shown in Figure 34 for all models.

ii. Model fits to NMFS survey biomass are shown in Figures 17 and 18.

iii. Model fits to catch and survey proportions by length are illustrated in Figures 35 – 40 and one-step-ahead residual plots are shown in Figures 41 – 44.

The model fits the fishery biomass data well and the survey biomass reasonably well (Figures 17, 18, 34). Because the model estimates annual fishing mortality for directed pot male catch, pot female bycatch, and trawl and fixed gear bycatch, the deviations of observed and predicted (estimated) fishery biomass are mainly due to size composition differences. Model fits to the NMFS area-swept biomass data are similar to previous year's base model fits (Figures 17 and 18). Model fit to the length composition data is similar to the previous years (Figures 35 – 40). Model progressions are tracked well in the trawl survey data, particularly beginning in the mid-1990s (Figures 38 and 5. Cohorts first seen in the trawl survey data in 1975, 1986, 1990, 1995, 1999, 2002 and 2005 can be tracked over time. Some cohorts can be tracked over time in the pot bycatch as well (Figure 35), but the bycatch data did not track the cohorts as well as the survey data. Groundfish bycatch data provide little information to track modal progression.

One-step ahead residuals of survey size comp proportions at length are plotted to examine their patterns. Generally, residuals of proportions of survey males and females appear to be random over length and year for all models (Figures 41 – 44). Models with higher base M values (both models in this document) improve the plus group (males > 160 mm CL and females > 140mm CL) fittings slightly.

e. Retrospective and historical analyses

Retrospective analyses were conducted for this report using model 24.0c.2. The 2025 model hindcast results are based on sequentially excluding one-year of data to evaluate the current model performance with fewer data.

i. Retrospective analysis (retrospective pattern in base model or models).
   The performance of the 2025 model includes sequentially excluding one-year of data. Model 24.0c.2 produces some upward patterns during 2015-2020 with higher terminal year estimates of mature male biomass in 2015-2020 (Figure 45). Higher than expected BSFRF survey biomass during 2007-2008 and 2013-2016 and NMFS survey biomass in 2014 likely caused these patterns. Also, much lower than expected NMFS survey biomass during 2018-2019 results in lower biomass estimates in 2020 and 2021. Mohn's rho calculations for these retrospective runs were the same for both models and generally considered high (Mohn's rho = 0.1823).

Ratios of estimated retrospective recruitments to terminal estimates in 2025 as a function of number of years estimated in the model converge to 1.0 as the number of years increases (Figures 48). Standard deviations of the ratios drop sharply from one year estimated in the model to two years (Figures 49), showing great uncertainty of recruitment estimates for terminal years. Based on these results, we suggest not using recruitment estimates in a terminal year for overfishing/overfished determination.

f. Uncertainty and sensitivity analyses.

i. Estimated standard deviations of parameters are summarized in Table 17 for models 24.0c.2. Estimated standard deviations of mature male biomass are listed in Table 18.

ii. Probabilities for mature male biomass and OFL in 2025 were illustrated in Figures 51 and 52 for model 24.0c.2 using the MCMC approach.

iii. Probabilities for mature male biomass below the minimum threshold (0.5* $B_{35\%}$) in 2025 were plotted in Figure 53 for model 24.0c.2 using the MCMC approach.

iv. Sensitivity analysis for handling mortality rate was included in the SAFE report in May 2010. The baseline handling mortality rate for the directed pot fishery was set at 0.2. A 50% reduction and 100% increase respectively resulted in 0.1 and 0.4 as alternatives. Overall, a higher handling mortality rate resulted in slightly higher estimates of mature abundance, and a lower rate resulted in a minor reduction of estimated mature abundance. Differences of estimated legal male abundance and mature male biomass were small for these handling mortality rate changes.

v. Sensitivity of weights. Sensitivity of weights was examined in the SAFE report in May 2010. Weights to biomasses (trawl survey biomass, retained catch biomass, and bycatch biomasses) were reduced to 50% or increased to 200% to examine their sensitivity to abundance estimates. Weights to the penalty terms (recruitment variation and sex ratio) were respectively reduced or increased. Overall, estimated biomasses were similar under different weights except during the mid-1970s. The variation of estimated biomasses in the mid-1970s was mainly caused by the changes in estimates of additional mortalities in the early 1980s.

vi. Jittering. Model 24.0c.2 (using 100 iterations of sd =0.1, and sd = 0.3) converged on the MLE >80% of the time. Those jitter runs that did not converge to the MLE were not an improvement to the MLE.

g. Comparison of alternative model scenarios.

Sensitivity to data weighting comparisons, based on the data through 2010, were reported in the SAFE report in May 2011. Estimating length proportions in the initial year (scenario 1a) resulted in a better fit of survey length compositions at an expense of 36 more parameters than model 1. Abundance and biomass estimates with model 1a were similar between models. Using only standard survey data (scenario 1b) resulted in a poorer fit of survey length compositions and biomass than scenarios using both standard and re-tow data (scenarios 1, 1a, and 1c) and had the lowest likelihood value. Although the likelihood value was higher for using both standard survey and re-tow data for males (scenario 1) than using only standard survey for males (scenario 1c), estimated abundances and biomasses were almost identical. The higher likelihood value for scenario 1 over scenario 1c was due to trawl bycatch length compositions.

In the SAFE report in September 2020, seven models were compared. The population biomass estimates in 2020 were slightly higher than those in 2019. Absolute mature male biomasses for all models had a similar trend over time. Among the seven models, model estimated relative NMFS survey biomasses and mature biomasses were similar, especially for models 19.0a and 19.0b and for models 19.3 and 19.3a. Biomass estimates for models 19.0a and 19.0b were higher during recent years than the other five model scenarios. As expected, model 19.3b estimated a higher trawl survey catchability (>1.0), thus resulting in overall lower absolute biomass estimates. Differences of biomass estimates between models 19.0a and 19.0b and models 19.3, 19.3a, 19.3l, and 19.3h could largely be explained by different structures of natural mortality. All seven models fitted the catch and bycatch biomasses very well.

The SAFE reports in 2021 and 2022 were also focused on the themes of different structures of natural mortality and potential data time series reductions. Additionally, model exploration in May 2023 began explorations on survey catchability estimation, but those are not explored in the models here since they were not deemed appropriate for model selection at this time. In May 2024, model explorations focused on survey selectivity/ availability estimation using the BSFRF survey for prior information instead of an additional survey and removing the time block for molt probability in the base model. The accepted model in 2024 incorporated removal of the molt probability time block. In May 2025, further explorations were performed on selectivity, but only updates to GMACS versions and data updates were incorporated for 2025 specification setting (model 24.0c.2).

In this report (September 2025), only one model is brought forward - model 24.0c.2 - which is a minor update to the accepted base model in 2024 - model 24.0c. For negative likelihood value comparisons (Table 16), model 24.0c.2 using 2025 data is compared to both the 2024 accepted model and model 24.0c.2 using only up to 2024 data. The total negative likelihood values between these models are similar, with differences attributed to having another year of data in the current year's model.

Model 24.0c - which was the accepted model in 2024 - is considered the "base" model for this assessment while model 24.0c.2 is an updated version with a updated GMACS version and updated data for the ADF&G catch time series. Model 24.0c.2 was updated with data for the 2024/2025 crab year (Figure 2). Both models estimate a base M for males, using a tight prior around an M value of 0.18. In the 2023 assessment it was determined that estimating a base M for males was an improvement in overall model fit for BBRKC.

The updated base model, 24.0c.2, is recommended for specification setting in September 2025. The updates to the base model of GMACS versioning and ADF&G catch updates are vital to maintaining the base model and have little overall effect on model fit or results. Values for specifications are presented for model 24.0c.2 (Tables 1, 3, and 14).

F. Calculation of the OFL and ABC

1. Bristol Bay RKC is currently placed in Tier 3b (NPFMC 2007).
2. For Tier 3 stocks, estimated biological reference points include $B_{35\%}$ and $F_{35\%}$. Estimated model parameters are used to conduct mature male biomass-per-recruit analysis.
3. Specification of the OFL:

The Tier 3 OFL is calculated using the F_{OFL} control rule:

$$F_{OFL} = \begin{cases} 0_{directedpot} & \frac{B}{B^*} \leq \beta \\ F^* \frac{(\frac{B}{B^*} - \alpha)}{1-\alpha} & \beta < \frac{B}{B^*} \leq 1 \\ F^* & \frac{B}{B^*} > 1 \end{cases} \tag{1}$$

Where

B = a measure of the productive capacity of the stock such as spawning biomass or fertilized egg production. A proxy of B is mature male biomass (MMB) estimated at the time of primiparous female mating (February 15).

$F^* = F_{35\%}$, a proxy for F_{MSY}, which is a full selection instantaneous F that will produce MSY at the MSY producing biomass.

$B^* = B_{35\%}$, a proxy for B_{MSY}, which is the value of biomass at the MSY producing level.

β = a parameter with restriction that $0 \leq \beta < 1$. A default value of 0.25 is used.

α = a parameter with restriction that $0 \leq \alpha \leq \beta$. A default value of 0.1 is used.

Because trawl bycatch fishing mortality is not related to pot fishing mortality, average trawl bycatch fishing mortality during 2020 to 2024 is used for the per recruit analysis as well as for projections in the next section. Some discards of legal males occurred after the Individual Fishery Quota (IFQ) fishery started in 2005, but the discard rates were much lower during 2007-2013 than in 2005 after the fishing industry minimized discards of legal males. However, due to high proportions of large oldshell males, the discard rate increased greatly in 2014. The current models estimate two levels of retained proportions before 2005 and after 2004. The retained proportions after 2004 and total male selectivities are used to represent current trends for per recruit analysis and projections. Average molting probabilities during 2016-2024 are used for per recruit analysis and projections. For the models in 2025, the averages are the same since they are constant over time during at least the last 15 years.

Average recruitments during 1984-2024 are used to estimate $B_{35\%}$ (Figure 26). Estimated $B_{35\%}$ is compared with historical mature male biomass in Figure 30. The period of 1984-2024 corresponds to the 1976/77 regime shift, and the recruitment period 1984-present has been used since 2011 to set the overfishing limits. Several factors support our recommendation. First, estimated recruitment was lower after 1983 than before 1984, which corresponded to brood years 1978 and later, after the 1976/77 regime shift. Second, high recruitments during the late 1960s and 1970s generally occurred when the spawning stock was primarily located in the southern Bristol Bay, whereas the recent spawning stock has been concentrated in the middle of Bristol Bay. Oceanic current flows favor larvae hatched in the southern Bristol Bay (see the section on Ecosystem Considerations for SAFE reports in 2008 and 2009). Finally, stock productivity (recruitment/mature male biomass) was higher before the 1976/1977 regime shift.

The control rule is used for stock status determination. If total catch exceeds OFL estimated at B, then "overfishing" occurs. If B equals or declines below $_{50\%}$ B_{MSY} (i.e., MSST), the stock is "overfished." If B/B_{MSY} or $B/B_{MSYproxy}$ equals or declines below β, then the stock productivity is severely depleted, and the directed fishery is closed.

The estimated probability distributions of MMB and OFL in 2025 are illustrated in Figures 51, 52 and **??** for model 24.0c.2. Based on SSC suggestions in 2011, $ABC = 0.9 * OFL$ and in October 2018, $ABC = 0.8 * OFL$. The CPT then recommended $ABC = 0.8 * OFL$ in May 2018 (accepted by the SSC), which is used to estimate ABC in this report. Due to the stock being at low levels and the lack of a 2020 survey, the CPT recommended an additional 5% buffer in September 2020, resulting in $ABC = 0.75 * OFL$ for 2020. A 20% buffer was suggested by the CPT for 2021 - 2024, and is recommended by the author in 2025 for similar reasons to previous years (Appendix E). A risk table, which is still under development for crab stocks, is provided in appendix D, which details concerns for this stock which are similar to those listed above.

MCMC runs with 500,000 replicates and 500 draws with model 24.0c.2 are used for estimating the probability of estimated mature male biomass being below the minimum threshold ($0.5 * B_{35}$) (Figure 53). The probability (converted to a percentage) is estimated to be about 0% for model 24.0c.2 (Figure 54).

Status and catch specifications (1,000 t) (model 24.0c.2):

Table 5: Status and catch specifications (1000 t) for model 24.0c.2.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2021/22	12.01	16.64	0	0.02	0.10	2.23	1.78
2022/23	9.68	18.34	0	0.02	0.07	3.04	2.43
2023/24	9.35	18.65	0.975	0.96	1.34	4.42	3.54
2024/25	9.26	19.74	1.05	1.05	1.20	5.02	4.02
2025/26		16.84				5.85	4.68

Status and catch specifications (million lb, model 24.0c.2):

Table 6: Status and catch specifications (million lb) for model 24.0c.2.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained Catch	Total Catch	OFL	ABC
2021/22	26.5	36.7	0	0.04	0.22	4.91	3.92
2022/23	21.34	40.44	0	0.05	0.24	6.70	5.35
2023/24	20.6	41.11	2.15	2.12	2.96	9.75	7.8
2024/25	20.42	43.51	2.31	2.31	2.64	11.07	8.86
2025/26		37.12				12.9	10.32

Table 7: Basis for the OFL (1000 t) from model 24.0c.2.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality
2021/22	3b	24.2	14.9	0.62	0.17	1984-2020	0.18
2022/23	3b	24.03	17.0	0.71	0.20	1984-2021	0.18
2023/24	3b	19.36	14.98	0.77	0.30	1984-2022	0.23
2024/25	3b	18.69	15.43	0.83	0.33	1984-2023	0.23
2025/26	3b	18.52	16.84	0.91	0.37	1984-2024	0.23

The biological reference points and OFL are illustrated in Tables 14 and 16, these are based on the $B_{35\%}$ estimated from the average male recruitment during 1984-2024.

Table 8: Basis for the OFL (million lb) from model 24.0c.2.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	Basis for B_{MSY}	Natural mortality
2021/22	3b	53.4	33.0	0.62	0.17	1984-2020	0.18
2022/23	3b	53.0	37.4	0.71	0.20	1984-2021	0.18
2023/24	3b	42.7	33.0	0.77	0.30	1984-2022	0.23
2024/25	3b	41.2	34.0	0.83	0.33	1984-2023	0.23
2025/26	3b	40.84	37.12	0.91	0.37	1984-2024	0.23

G. Rebuilding Analysis

NA, not applicable for this stock

H. Data Gaps and Research Priorities

1. The following data gaps exist for this stock:

a. Information about changes in natural mortality in the early 1980s,
b. Unobserved trawl bycatch in the early 1980s,
c. Natural mortality,
d. Crab availability to the trawl surveys,
e. Juvenile crab abundance,
f. Female growth per molt as a function of size and maturity,
g. Changes in male molting probability over time,
h. A better understanding of larval distribution and subsequent recruit distribution.

2. Research priorities:

a. Estimating natural mortality,
b. Estimating crab availability to the trawl surveys,
c. Surveying juvenile crab abundance in nearshore,
d. Studying environmental factors that affect the survival rates from larvae to recruitment.

I. Projections and outlook

1. Projections

Future population projections primarily depend on future recruitment, but crab recruitment is difficult to predict due to a lack of a stock recruit relationship. Therefore, annual recruitment for the projections is a random selection from estimated recruitments during 2014-2024, a low recruitment period. Four levels of fishing mortality for the directed pot fishery are used in the projections: 0, 0.06, 0.10, 0.15 and 0.22. A fishing mortality of 0.15 is similar to the estimated F_{ofl} of 0.146 in 2020/2021, and 0.06 is similar to the F_{ofl} of 0.064 and 0.06 estimated from the last two open fishery seasons (2023/24 and 2024/25). MCMC runs with 500,000 replicates and 500 draws are used for the projection.

As expected, projected mature male biomasses are much higher without the directed fishing mortality than under other positive mortality values. At the end of 10 years, projected mature male biomass is below $B_{35\%}$ for all models with a fishing mortality of 0.10 or higher due to low recruitments (Figure 54). Due to the poor recruitment in recent years, the projected biomass is expected to decline during the next few years with a fishing mortality of greater than F = 0.15.

The stock status has been slowing increasing since 2020/21 and is approaching B_{MSY} and therefore not overfished in 2024/25. Projections can be used to determine whether the stock is "approaching an overfished condition", which is defined as "when it is projected that there is more than a 50 percent chance that the biomass of the stock or stock complex will decline below the MSST within two years" by the National Standards 1 (NS1). If the stock is not fished more than a fishing mortality of 0.22 for the directed pot fishery in the 2025/2025 and 2025/26 seasons, the projection using the lowest recruitment periods during 2014-2024 would not likely result in "approaching an overfished condition" for either model (Figure 55). With additional low recruitment estimate used to compute $B_{35\%}$, the estimated MSST would decline further in 2026.

The projections are subject to many uncertainties. Constant population parameters estimated in the models used for the projections include M, growth, and fishery selectivities. The uncertainty of abundance and biomass estimates in the terminal year also affects the projections. Uncertainties of the projections caused by these constant parameters and abundance estimates in the terminal year would be reduced by the 20% ABC buffer. However, if an extreme event occurs, like a sharp increase of M during the projection period, the ABC buffer would be inadequate, and the projections might underestimate uncertainties. The largest uncertainty is likely from recruitments used for the projections. Higher or lower assumed recruitments would cause too optimistic or too pessimistic projections. Overall, recruitments and M used for projections are main factors for projection uncertainties.

2. Near Future Outlook

The near future outlook for the Bristol Bay RKC stock ranges from a steady state to a declining trend. The three recent above-average year classes (hatching years 1990, 1994, and 1997) had entered the legal population by 2006 (Figures 5 and 6). The above-average year class (hatching year 2000) with lengths centered around 87.5 mm CL for both males and females in 2006 and with lengths centered around 112.5-117.5 mm CL for males and around 107.5 mm CL for females in 2008 has largely entered the mature male population in 2009 and the legal population by 2014 (Figures 5 and 6). However, no additional strong cohorts were observed in the survey data after this cohort through the 2010s or 2020s (Figure 5, 6, 56 and 57). A huge tow of juvenile crab of size 45-55 mm in 2011 was not tracked during 2012-2025 surveys and is unlikely to be a strong cohort. The high survey abundances of large males and mature females in 2014 cannot be explained by the survey data during the previous years and were also inconsistent with the 2016-2025 survey results (Figures 56 and 57). Due to lack of improved recruitment, mature and legal crab may continue to decline next year in the presence of higher fishing pressure.

The closure of the directed fishery for seasons 2021/22 and 2022/23 appears to have allowed abundance of male and female crab to hold steady, with survey data observing only small increases in the overall population. Effects of fishery closures on recruitment are unknown due to the 5 to 7 year lag between spawning and crab recruitment into the assessment model. Current crab abundance is still low relative to the late 1970s, and without favorable environmental conditions, recovery to the high levels of the late 1970s is unlikely in the near future.

Understanding the mechanisms behind the recruitment failure is essential to the future health of the BBRKC stock. The 5 to 7 years between spawning and recruitment to the survey size crab are an unknown for this stock. Identifying critical life history conditions would assist in predicting the future outlook of the stock. These include, but are not limited to, identifying juvenile nursery grounds and understanding juvenile survival within Bristol Bay.

Although mature crab abundance in Bristol Bay has declined in recent years, mature crab abundance and biomass north of Bristol Bay has been generally stable during the last 16 years (Figures 59 and 58). Overall, the proportions of different size groups of the Northern RKC during the most recent dozen years are higher than in the past and do not trend higher except for mature females in 2021. The high mature female abundance in the Northern area survey in 2021 was primarily from three tows and one of them is more than 50% of total mature females. The survey abundance of the Northern RKC will continue to be provided in figures in the SAFE report in the future. After migration patterns between BBRKC and the Northern RKC are more fully understood, we will examine their relationships and model them in the stock assessment.

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Tables

Table 9: Bristol Bay red king crab annual catch and bycatch mortality biomass (t) from July 1 to June 30. A handling mortality rate of 0.20 for the directed pot fishery, 0.25 for the Tanner fishery, 0.80 for trawl, and 0.50 for fixed gear was assumed to estimate bycatch mortality biomass. The male bycatch biomass in the directed pot fishery is not estimated outside of a model and not included in this table. Pot bycatch and Tanner crab fishery bycatch are estimated through expanding the mean observer bycatch per pot to total fishery pot. The pot male bycatch after 2017 is estimated through the subtraction method (B. Daly, ADFG, pers. com.). The trawl and fixed gear fishery bycatches are obtained from the NMFS database. The directed pot bycatch before 1990 and Tanner crab fishery bycatch before 1991 are not available from the observer data and thus not included in this table. These include recently updated estimates from the pot fisheries observer data in 2022.

	Retained				Bycatch			
Year	US	Cost Recovery	Foreign	Total	Females	Trawl	Fixed	Tanner
1953	1331.30		4705.60	6036.90				
1954	1149.90		3720.40	4870.20				
1955	1029.20		3712.70	4741.90				
1956	973.40		3572.90	4546.40				
1957	339.70		3718.10	4057.80				
1958	3.20		3541.60	3544.80				
1959	0.00		6062.30	6062.30				
1960	272.20		12200.70	12472.90				
1961	193.70		20226.60	20420.30				
1962	30.80		24618.70	24649.60				
1963	296.20		24930.80	25227.00				
1964	373.30		26385.50	26758.80				
1965	648.20		18730.60	19378.80				
1966	452.20		19212.40	19664.60				
1967	1407.00		15257.00	16664.10				
1968	3939.90		12459.70	16399.60				
1969	4718.70		6524.00	11242.70				
1970	3882.30		5889.40	9771.70				
1971	5872.20		2782.30	8654.50				
1972	9863.40		2141.00	12004.30				
1973	12207.80		103.40	12311.20				
1974	19171.70		215.90	19387.60				
1975	23281.20		0.00	23281.20				
1976	28993.60		0.00	28993.60		682.80		
1977	31736.90		0.00	31736.90		1249.90		
1978	39743.00		0.00	39743.00		1320.60		
1979	48910.00		0.00	48910.00		1331.90		
1980	58943.60		0.00	58943.60		1036.50		
1981	15236.80		0.00	15236.80		219.40		
1982	1361.30		0.00	1361.30		574.90		
1983	0.00		0.00	0.00		420.40		
1984	1897.10		0.00	1897.10		1094.00		
1985	1893.80		0.00	1893.80		390.10		
1986	5168.20		0.00	5168.20		200.60		
1987	5574.20		0.00	5574.20		186.40		
1988	3351.10		0.00	3351.10		598.40		
1989	4656.00		0.00	4656.00		175.20		
1990	9236.20	36.60	0.00	9272.80	639.20	259.90		
1991	7791.80	93.40	0.00	7885.10	46.80	349.40		1401.80

1992	3648.20	33.60	0.00	3681.80	395.30	293.50		244.40
1993	6635.40	24.10	0.00	6659.60	628.30	401.40		54.60
1994	0.00	42.30	0.00	42.30	0.40	87.30		10.80
1995	0.00	36.40	0.00	36.40	0.30	82.10		0.00
1996	3812.70	49.00	0.00	3861.70	1.00	90.80	41.40	0.00
1997	3971.90	70.20	0.00	4042.10	36.50	57.50	22.50	0.00
1998	6693.80	85.40	0.00	6779.20	553.90	186.10	18.50	0.00
1999	5293.50	84.30	0.00	5377.90	5.60	150.50	50.10	0.00
2000	3698.80	39.10	0.00	3737.90	164.40	81.70	4.70	0.00
2001	3811.50	54.60	0.00	3866.20	120.80	192.80	35.30	0.00
2002	4340.90	43.60	0.00	4384.50	9.10	151.20	29.20	0.00
2003	7120.00	15.30	0.00	7135.30	356.90	136.90	12.70	0.00
2004	6915.20	91.40	0.00	7006.70	171.80	173.50	15.20	0.00
2005	8305.00	94.70	0.00	8399.70	405.40	124.70	19.90	0.00
2006	7005.30	137.90	0.00	7143.20	37.50	151.70	19.60	3.80
2007	9237.90	66.10	0.00	9303.90	159.90	154.10	32.30	1.80
2008	9216.10	0.00	0.00	9216.10	144.80	136.60	15.60	4.00
2009	7226.90	45.50	0.00	7272.50	88.30	87.20	5.80	1.60
2010	6728.50	33.00	0.00	6761.50	118.50	78.70	2.40	0.00
2011	3553.30	53.80	0.00	3607.10	25.00	53.80	10.90	0.00
2012	3560.60	61.10	0.00	3621.70	11.20	32.40	14.90	0.00
2013	3901.10	89.90	0.00	3991.00	98.10	61.90	39.50	28.50
2014	4530.00	8.60	0.00	4538.60	84.90	32.00	82.70	42.00
2015	4522.30	91.40	0.00	4613.70	239.10	41.70	67.90	84.20
2016	3840.40	83.40	0.00	3923.90	123.40	59.80	27.60	0.00
2017	2994.10	99.60	0.00	3093.70	53.40	91.40	86.70	0.00
2018	1954.10	72.40	0.00	2026.50	150.10	72.60	117.30	0.00
2019	1719.80	55.50	0.00	1775.30	43.30	75.70	48.30	0.00
2020	1200.60	56.40	0.00	1257.00	15.20	78.70	17.40	0.00
2021	0.00	17.40	0.00	17.40	5.90	34.50	57.40	0.00
2022	0.00	23.10	0.00	23.10	0.90	15.20	61.90	0.00
2023	972.60	0.00	0.00	972.60	13.10	20.50	35.60	0.00
2024	1049.00	35.50	0.00	1084.50	2.10	37.30	18.90	0.04

Table 10: Annual retained catch (millions of crab) and catch per unit effort (CPUE) of the Bristol Bay red king crab fishery.

	Japanese Tanglenet		Russian Tanglenet		US Pot		Standardized
Year	Catch	CPUE	Catch	CPUE	Catch	CPUE	CPUE
1960	1.95	15.20	2.00	10.40	0.088		15.80
1961	3.03	11.80	3.44	8.90	0.062		12.90
1962	4.95	11.30	3.02	7.20	0.01		11.30
1963	5.48	8.50	3.02	5.60	0.101		8.60
1964	5.89	9.20	2.80	4.60	0.123		8.50
1965	4.22	9.30	2.23	3.60	0.223		7.70
1966	4.21	9.40	2.56	4.10	0.14	52	8.10
1967	3.76	8.30	1.59	2.40	0.397	37	6.30
1968	3.85	7.50	0.55	2.30	1.278	27	7.80
1969	2.07	7.20	0.37	1.50	1.749	18	5.60
1970	2.08	7.30	0.32	1.40	1.683	17	5.60
1971	0.89	6.70	0.26	1.30	2.405	20	5.80
1972	0.87	6.70			3.994	19	
1973	0.23				4.826	25	
1974	0.48				7.71	36	
1975					8.745	43	
1976					10.603	33	
1977					11.733	26	
1978					14.746	36	
1979					16.809	53	
1980					20.845	37	
1981					5.308	10	
1982					0.541	4	
1983					No directed	fishery	
1984					0.794	7	
1985					0.796	9	
1986					2.1	12	
1987					2.122	10	
1988					1.236	8	
1989					1.685	8	
1990					3.13	12	
1991					2.661	12	
1992					1.208	6	
1993					2.27	9	
1994					No directed	fishery	
1995					No directed	fishery	
1996					1.264	16	
1997					1.338	15	
1998					2.238	15	
1999					1.923	12	
2000					1.272	12	
2001					1.287	19	
2002					1.484	20	
2003					2.51	18	
2004					2.272	23	
2005					2.763	30	
2006					2.477	31	
2007					3.154	28	
2008					3.064	22	

2009	2.553	21
2010	2.41	18
2011	1.298	28
2012	1.176	30
2013	1.272	27
2014	1.501	26
2015	1.527	31
2016	1.281	38
2017	0.997	20
2018	0.63	20
2019	0.549	16
2020	0.455	21
2021	No directed	fishery
2022	No directed	fishery
2023	0.322	21
2024	0.34	29.6

Table 11: Total observer catch and bycatch (metric ton) of Bristol Bay red king crab. No handling mortality rates are applied. These include recently updated estimates from the pot fishery observer data in 2022. Directed pot fishery data are the result of the cost-recovery fishery when the directed fishery was closed for the 2021/22 and 2022/23 seasons

	Directed Pot Total		Bycatch Fisheries		
Year	Males	Females	Trawl	Fixed	Tanner
1975			0		
1976			853.494		
1977			1,562.31		
1978			1,650.78		
1979			1,664.93		
1980			1,295.63		
1981			274.229		
1982			718.61		
1983			525.554		
1984			1,367.55		
1985			487.576		
1986			250.758		
1987			233.045		
1988			747.996		
1989			219.023		
1990	11621.80	3196.20	324.883		
1991	9792.90	233.90	436.783		5,580.84
1992	5916.20	1976.30	366.816		962.846
1993	9516.80	3141.50	501.77		218.112
1994	62.30	1.88	109.129		39.395
1995	52.80	1.61	102.623		0
1996	3845.20	5.10	113.495	82.86	0
1997	3758.80	182.70	71.862	44.98	0
1998	15644.80	2769.30	232.58	36.92	0
1999	12112.30	28.00	188.101	100.24	0
2000	6579.70	821.90	102.161	9.45	0
2001	5711.50	604.00	241.011	70.55	0
2002	6961.40	45.60	189.018	58.38	0
2003	12166.50	1784.40	171.114	25.35	0
2004	10692.00	859.20	216.889	30.42	0
2005	13615.90	2027.10	155.924	39.80	0
2006	9254.00	187.40	189.66	39.13	15.217
2007	13871.90	799.40	192.571	64.66	7.142
2008	14894.90	724.20	170.754	31.16	16.07
2009	12218.80	441.30	109	10.00	6.499
2010	10095.40	592.60	98.4	4.60	0
2011	5665.30	124.80	67.2	18.80	0
2012	4495.50	55.90	40.5	29.70	0
2013	5305.90	490.70	77.3	78.90	113.063
2014	8113.80	424.30	40	165.40	137.786
2015	6726.80	1195.60	52.1	135.90	639.573
2016	5651.80	617.20	74.8	55.20	0
2017	4077.20	266.90	114.3	173.30	0
2018	3423.20	750.40	90.8	234.60	0
2019	3144.60	218.00	94.6	96.60	0
2020	2299.70	76.10	98.4	34.80	0
2021	33.80	29.40	43.1	114.80	0

2022	28.30	4.60	19	123.90	0
2023	1543.50	65.40	25.7	71.30	0
2024	1369.10	10.60	46.6	37.90	0.15

Table 12: Annual sample sizes (>64 mm CL) in numbers of crab for trawl surveys, retained catch, directed pot, Tanner crab, trawl, and fixed gear fishery bycatches of Bristol Bay red king crab.

	Trawl Survey		Retained	Pot Total		Bycatch Combined		
Year	Males	Females	Catch	Males	Females	Trawl	Fixed	Tanner
1975	2,815	2,042	29,570					
1976	2,699	1,466	26,450			3,003		
1977	2,734	2,424	32,596			14,703		
1978	2,735	2,793	27,529			10,439		
1979	1,158	1,456	27,900			10,049		
1980	1,917	1,301	34,747			87,152		
1981	591	664	18,029			91,806		
1982	1,911	1,948	11,466			131,469		
1983	1,343	733	0			309,374		
1984	1,209	778	4,404			505,115		
1985	790	414	4,582			200,460		
1986	959	341	5,773			2,126		
1987	1,123	1,011	4,230			998		
1988	708	478	9,833			630		
1989	764	403	32,858			4,641		
1990	729	535	7,218	2,544	696	908		
1991	1,180	490	36,928	4,696	375	275		3,131
1992	509	357	25,550	4,775	2,379	333		965
1993	725	576	32,942	10,200	5,944	5		497
1994	416	239	0	0	0	571		17
1995	685	407	0	0	0	120		
1996	755	753	8,896	642	11	1,209	756	
1997	1,280	702	16,143	10,016	906	339	1,269	
1998	1,067	1,123	17,116	24,537	9,655	1,430	1,036	
1999	765	618	18,685	6,892	40	629	1,602	
2000	734	730	14,143	32,709	8,470	729	591	
2001	599	736	13,735	25,135	5,436	795	5,029	
2002	972	826	16,837	32,317	706	1,139	3,503	
2003	1,360	1,250	18,178	44,600	12,474	516	1,872	
2004	1,852	1,271	22,465	38,772	6,666	636	2,184	
2005	1,198	1,563	27,971	94,622	26,782	1,040	2,146	
2006	1,178	1,432	18,451	73,315	3,991	1,168	1,868	140
2007	1,228	1,305	22,809	115,507	12,691	1,225	785	53
2008	1,228	1,183	24,997	89,771	8,564	1,596	1,164	145
2009	837	941	19,336	97,868	6,055	1,170	1,089	193
2010	708	1,004	20,347	69,276	6,872	901	513	
2011	531	912	10,904	42,931	1,920	439	1,190	
2012	585	707	9,084	21,404	563	281	2,977	
2013	647	569	10,396	32,332	6,051	481	8,523	814
2014	1,107	1,257	9,718	31,216	2,663	261	4,285	631
2015	615	681	11,971	24,533	7,457	409	4,472	2,872
2016	378	812	11,003	30,030	5,832	617	4,329	
2017	385	508	10,067	30,002	4,043	718	1,415	
2018	285	359	7,825	25,635	9,840	893	5,382	
2019	273	299	8,134	25,999	2,894	823	863	
2020			3,850	16,650	961	764	246	
2021	324	247	101	1,100	1433	503	120	
2022	401	319	100	1088	299	90	50	
2023	407	435	3,651	11,767	909	124	428	

2024	559	436	3,022	7,461	180	243	936
2025	540	563					

Table 13: Natural mortality estimates for model scenarios during different year blocks.

Model	Sex	baseM	1980-84
m24.0c.2	female	0.26	1.16
m24.0c.2	male	0.23	1.02
m24.0c.2-2024	female	0.26	1.16
m24.0c.2-2024	male	0.23	1.01
m24.0c.v14	female	0.26	1.16
m24.0c.v14	male	0.23	1.01

Table 14: Changes in management quantities for each scenario explored. Report quantities are derived from maximum likelihood estimates. Average recruitment is males and females combined in millions of animals.

Model	Current MMB	B35	MMB/B_{MSY}	F35	F_{OFL}	OFL	Avg Male Rec	Male M
m24.0c.2	16.84	18.52	0.91	0.40	0.36	5.85	9.69	0.23

Table 15: Area-swept estimates of mature female abundance (million crab >89mm) and model estimates of effective spawning biomass (ESB, LBA model from Zheng et al. 1995b; 1000 t) during 2011-2025 for groundfish fisheries bycatch (prohibited species catch, PSC) calculation. (*mature female abundance in 2020 is the model projected value). Note that PSC limits apply to previous-year ESB.

Year	Mature Female Abundance	Effective Spawning Biomass (1000t)
2011	28.52	19.54
2012	21.121	20.03
2013	15.694	22.38
2014	38.58	23.27
2015	18.666	21.10
2016	22.633	19.15
2017	18.497	18.04
2018	9.106	15.09
2019	8.587	12.71
2020	9.668*	11.39
2021	6.432	9.46
2022	8.004	8.89
2023	11.054	9.32
2024	11.7	10.19
2025	12.7	11.75

Table 16: Comparisons of negative log-likelihood values and some parameters for model 24.0c.2 for 2025, model 24.0c.2 (2024) and the 2024 accepted model, 24.0c, for reference.

Component	m24.0c(2024 ref)	m24.0c.2(2024)	m24.0c.2
Pot-ret-catch	-61.35	-61.23	-63.56
Pot-totM-catch	30.40	30.74	28.82
Pot-F-discC	-59.19	-59.19	-60.93
Trawl-discC	-66.52	-66.52	-67.91
Tanner-M-discC	-43.54	-43.54	-45.28
Tanner-F-discC	-43.51	-43.51	-45.24
Fixed-discC	-38.81	-38.81	-40.20
Traw-suv-bio	-39.35	-39.44	-41.39
BSFRF-sur-bio	-5.00	-5.01	-5.13
Pot-ret-comp	-4084.32	-4084.38	-4173.13
Pot-totM-comp	-2523.39	-2523.04	-2603.18
Pot-discF-comp	-1546.63	-1546.63	-1583.69
Trawl-disc-comp	-6052.16	-6052.36	-6171.05
Tanner-disc-comp	-1276.39	-1276.45	-1276.73
Fixed-disc-comp	-3598.44	-3598.29	-3734.15
Trawl-sur-comp	-7288.60	-7288.44	-7440.87
BSFRF-sur-comp	-844.58	-844.63	-844.86
Recruit-dev	74.44	74.46	74.65
Recruit-ini	0.00	0.00	0.00
Recruit-sex-R	80.45	80.46	82.02
Sex-specific-R	0.06	0.06	0.07
Ini-size-struct	33.22	33.24	33.36
PriorDensity	224.79	224.80	223.68
Tot-likelihood	-27128.41	-27127.70	-27754.69
Tot-parms	383.00	383.00	391.00
MMB35	18690.28	18648.50	18524.40
MMB-terminal	15426.58	15403.24	16836.02
F35	0.40	0.40	0.40
$Fofl$	0.32	0.32	0.36
OFL	5021.76	5018.15	5851.79

Table 17: Summary of estimated model parameter values and standard deviations for model 24.0c.2 for Bristol Bay red king crab.

Index	Name	Value	StdDev
1	Log(Rinitial):	20.0535	0.0557
2	Log(Rbar):	16.5591	0.1393
3	Recruitment-rb-males:	0.7890	0.1354
4	Recruitment-rb-females:	-0.6168	0.2188
5	Scaled-logN-for-male-mature-mature-newshell-class-2:	1.0340	0.4448
6	Scaled-logN-for-male-mature-mature-newshell-class-3:	0.7296	0.4825
7	Scaled-logN-for-male-mature-mature-newshell-class-4:	0.9348	0.3382
8	Scaled-logN-for-male-mature-mature-newshell-class-5:	0.7558	0.3115
9	Scaled-logN-for-male-mature-mature-newshell-class-6:	0.5634	0.3011
10	Scaled-logN-for-male-mature-mature-newshell-class-7:	0.5181	0.2797
11	Scaled-logN-for-male-mature-mature-newshell-class-8:	0.3527	0.2792
12	Scaled-logN-for-male-mature-mature-newshell-class-9:	0.3848	0.2652
13	Scaled-logN-for-male-mature-mature-newshell-class-10:	0.4111	0.2574
14	Scaled-logN-for-male-mature-mature-newshell-class-11:	0.1904	0.2755
15	Scaled-logN-for-male-mature-mature-newshell-class-12:	0.1762	0.2691
16	Scaled-logN-for-male-mature-mature-newshell-class-13:	0.0625	0.2782
17	Scaled-logN-for-male-mature-mature-newshell-class-14:	0.1664	0.2532
18	Scaled-logN-for-male-mature-mature-newshell-class-15:	-0.0107	0.1980
19	Scaled-logN-for-male-mature-mature-newshell-class-16:	-0.2753	0.1912
20	Scaled-logN-for-male-mature-mature-newshell-class-17:	-0.4405	0.1936
21	Scaled-logN-for-male-mature-mature-newshell-class-18:	-0.7899	0.2073
22	Scaled-logN-for-male-mature-mature-newshell-class-19:	-1.2536	0.2287
23	Scaled-logN-for-male-mature-mature-newshell-class-20:	-1.3122	0.2286
24	Scaled-logN-for-female-mature-mature-newshell-class-1:	1.5446	0.5829
25	Scaled-logN-for-female-mature-mature-newshell-class-2:	1.4776	0.4838
26	Scaled-logN-for-female-mature-mature-newshell-class-3:	1.3830	0.3844
27	Scaled-logN-for-female-mature-mature-newshell-class-4:	1.1494	0.3530
28	Scaled-logN-for-female-mature-mature-newshell-class-5:	1.0801	0.3044
29	Scaled-logN-for-female-mature-mature-newshell-class-6:	0.6170	0.3253
30	Scaled-logN-for-female-mature-mature-newshell-class-7:	0.2052	0.3612
31	Scaled-logN-for-female-mature-mature-newshell-class-8:	-0.0361	0.3643
32	Scaled-logN-for-female-mature-mature-newshell-class-9:	-0.2297	0.3544
33	Scaled-logN-for-female-mature-mature-newshell-class-10:	-0.5753	0.3727
34	Scaled-logN-for-female-mature-mature-newshell-class-11:	-0.9660	0.3829
35	Scaled-logN-for-female-mature-mature-newshell-class-12:	-1.2260	0.3870
36	Scaled-logN-for-female-mature-mature-newshell-class-13:	-1.4567	0.3853
37	Scaled-logN-for-female-mature-mature-newshell-class-14:	-1.8310	0.3738
38	Scaled-logN-for-female-mature-mature-newshell-class-15:	-1.9378	0.3699
39	Scaled-logN-for-female-mature-mature-newshell-class-16:	-1.8849	0.3500
40	Gscale-base-male:	1.0370	0.1947
41	Gscale-base-female:	1.3980	0.1215
42	Molt-probability-mu-base-male-period-1:	141.1201	0.5631
43	Molt-probability-CV-base-male-period-1:	0.0674	0.0031
44	M-base-male-mature:	0.2295	0.0063
45	M-male-mature-block-group-1-block-1:	1.4870	0.0307
46	M-base-female-mature:	0.1359	0.0185
47	Sel-Pot-Fishery-male-base-Logistic-mean:	4.7796	0.0079
48	Sel-Pot-Fishery-male-base-Logistic-cv:	2.2642	0.0413
49	Sel-Trawl-Bycatch-male-base-Logistic-mean:	5.1397	0.0470
50	Sel-Trawl-Bycatch-male-base-Logistic-cv:	2.7944	0.0404

51	Sel-Bairdi-Fishery-Bycatch-male-base-Logistic-mean:	4.6905	0.2404
52	Sel-Bairdi-Fishery-Bycatch-male-base-Logistic-cv:	2.1684	0.3039
53	Sel-Fixed-Gear-male-base-Logistic-mean:	4.7844	0.0184
54	Sel-Fixed-Gear-male-base-Logistic-cv:	2.2894	0.0752
55	Sel-NMFS-Trawl-male-base-Logistic-mean:	4.1221	0.1425
56	Sel-NMFS-Trawl-male-base-Logistic-cv:	2.2303	0.3870
57	Sel-NMFS-Trawl-male-Logistic-mean-block-group-5-block-1:	4.0887	0.2348
58	Sel-NMFS-Trawl-male-Logistic-cv-block-group-5-block-1:	3.4661	0.3554
59	Sel-BSFRF-male-base-Logistic-mean:	4.4657	0.0263
60	Sel-BSFRF-male-base-Logistic-cv:	2.5364	0.0770
61	Sel-Pot-Fishery-female-base-Logistic-mean:	4.5597	0.0181
62	Sel-Pot-Fishery-female-base-Logistic-cv:	2.1979	0.0902
63	Sel-Bairdi-Fishery-Bycatch-female-base-Logistic-mean:	4.7365	0.0895
64	Sel-Bairdi-Fishery-Bycatch-female-base-Logistic-cv:	0.9028	0.3028
65	Ret-Pot-Fishery-male-base-Logistic-mean:	4.9240	0.0015
66	Ret-Pot-Fishery-male-base-Logistic-cv:	0.6856	0.0522
67	Ret-Pot-Fishery-male-Logistic-mean-block-group-6-block-1:	4.9321	0.0019
68	Ret-Pot-Fishery-male-Logistic-cv-block-group-6-block-1:	0.7193	0.0957
69	Log-fbar-Pot-Fishery:	-1.7673	0.0428
70	Log-fbar-Trawl-Bycatch:	-4.4646	0.0737
71	Log-fbar-Bairdi-Fishery-Bycatch:	-5.6320	0.2944
72	Log-fbar-Fixed-Gear:	-6.5918	0.0648
73	Log-fdev-Pot-Fishery-year-1975-season-3:	0.8528	0.0911
74	Log-fdev-Pot-Fishery-year-1976-season-3:	0.8327	0.0720
75	Log-fdev-Pot-Fishery-year-1977-season-3:	0.7740	0.0632
76	Log-fdev-Pot-Fishery-year-1978-season-3:	0.8935	0.0559
77	Log-fdev-Pot-Fishery-year-1979-season-3:	1.1286	0.0544
78	Log-fdev-Pot-Fishery-year-1980-season-3:	2.0172	0.0584
79	Log-fdev-Pot-Fishery-year-1981-season-3:	2.5297	0.1138
80	Log-fdev-Pot-Fishery-year-1982-season-3:	0.9613	0.1488
81	Log-fdev-Pot-Fishery-year-1983-season-3:	-8.6692	0.0996
82	Log-fdev-Pot-Fishery-year-1984-season-3:	1.5063	0.0995
83	Log-fdev-Pot-Fishery-year-1985-season-3:	1.5488	0.0911
84	Log-fdev-Pot-Fishery-year-1986-season-3:	1.6273	0.0778
85	Log-fdev-Pot-Fishery-year-1987-season-3:	1.1116	0.0668
86	Log-fdev-Pot-Fishery-year-1988-season-3:	0.1427	0.0545
87	Log-fdev-Pot-Fishery-year-1989-season-3:	0.2496	0.0484
88	Log-fdev-Pot-Fishery-year-1990-season-3:	0.8956	0.0394
89	Log-fdev-Pot-Fishery-year-1991-season-3:	0.8959	0.0424
90	Log-fdev-Pot-Fishery-year-1992-season-3:	0.3838	0.0468
91	Log-fdev-Pot-Fishery-year-1993-season-3:	1.0384	0.0509
92	Log-fdev-Pot-Fishery-year-1994-season-3:	-4.1271	0.0484
93	Log-fdev-Pot-Fishery-year-1995-season-3:	-4.5257	0.0419
94	Log-fdev-Pot-Fishery-year-1996-season-3:	-0.0366	0.0405
95	Log-fdev-Pot-Fishery-year-1997-season-3:	0.0268	0.0408
96	Log-fdev-Pot-Fishery-year-1998-season-3:	0.9469	0.0436
97	Log-fdev-Pot-Fishery-year-1999-season-3:	0.5627	0.0430
98	Log-fdev-Pot-Fishery-year-2000-season-3:	-0.0284	0.0414
99	Log-fdev-Pot-Fishery-year-2001-season-3:	-0.0941	0.0409
100	Log-fdev-Pot-Fishery-year-2002-season-3:	0.0236	0.0397
101	Log-fdev-Pot-Fishery-year-2003-season-3:	0.4839	0.0384
102	Log-fdev-Pot-Fishery-year-2004-season-3:	0.4405	0.0385
103	Log-fdev-Pot-Fishery-year-2005-season-3:	0.7202	0.0390

104	Log-fdev-Pot-Fishery-year-2006-season-3:	0.4632	0.0383
105	Log-fdev-Pot-Fishery-year-2007-season-3:	0.8309	0.0384
106	Log-fdev-Pot-Fishery-year-2008-season-3:	1.0043	0.0406
107	Log-fdev-Pot-Fishery-year-2009-season-3:	0.7963	0.0417
108	Log-fdev-Pot-Fishery-year-2010-season-3:	0.6502	0.0413
109	Log-fdev-Pot-Fishery-year-2011-season-3:	0.0150	0.0396
110	Log-fdev-Pot-Fishery-year-2012-season-3:	-0.0499	0.0382
111	Log-fdev-Pot-Fishery-year-2013-season-3:	0.1486	0.0377
112	Log-fdev-Pot-Fishery-year-2014-season-3:	0.4763	0.0377
113	Log-fdev-Pot-Fishery-year-2015-season-3:	0.5438	0.0391
114	Log-fdev-Pot-Fishery-year-2016-season-3:	0.5437	0.0425
115	Log-fdev-Pot-Fishery-year-2017-season-3:	0.4584	0.0482
116	Log-fdev-Pot-Fishery-year-2018-season-3:	0.2889	0.0547
117	Log-fdev-Pot-Fishery-year-2019-season-3:	0.2410	0.0596
118	Log-fdev-Pot-Fishery-year-2020-season-3:	-0.1922	0.0598
119	Log-fdev-Pot-Fishery-year-2021-season-3:	-4.6404	0.0576
120	Log-fdev-Pot-Fishery-year-2022-season-3:	-4.6993	0.0561
121	Log-fdev-Pot-Fishery-year-2023-season-3:	-0.9840	0.0583
122	Log-fdev-Pot-Fishery-year-2024-season-3:	-1.0079	0.0622
123	Log-fdev-Trawl-Bycatch-year-1976-season-5:	0.2344	0.1130
124	Log-fdev-Trawl-Bycatch-year-1977-season-5:	0.6993	0.1100
125	Log-fdev-Trawl-Bycatch-year-1978-season-5:	0.7042	0.1083
126	Log-fdev-Trawl-Bycatch-year-1979-season-5:	0.8014	0.1094
127	Log-fdev-Trawl-Bycatch-year-1980-season-5:	1.5398	0.1130
128	Log-fdev-Trawl-Bycatch-year-1981-season-5:	1.2956	0.1253
129	Log-fdev-Trawl-Bycatch-year-1982-season-5:	2.5969	0.1216
130	Log-fdev-Trawl-Bycatch-year-1983-season-5:	2.3638	0.1124
131	Log-fdev-Trawl-Bycatch-year-1984-season-5:	3.6352	0.1121
132	Log-fdev-Trawl-Bycatch-year-1985-season-5:	2.4255	0.1119
133	Log-fdev-Trawl-Bycatch-year-1986-season-5:	1.3219	0.1124
134	Log-fdev-Trawl-Bycatch-year-1987-season-5:	0.8327	0.1099
135	Log-fdev-Trawl-Bycatch-year-1988-season-5:	1.5889	0.1054
136	Log-fdev-Trawl-Bycatch-year-1989-season-5:	0.1494	0.1041
137	Log-fdev-Trawl-Bycatch-year-1990-season-5:	0.5952	0.1042
138	Log-fdev-Trawl-Bycatch-year-1991-season-5:	1.0090	0.1055
139	Log-fdev-Trawl-Bycatch-year-1992-season-5:	0.8468	0.1056
140	Log-fdev-Trawl-Bycatch-year-1993-season-5:	1.3085	0.1082
141	Log-fdev-Trawl-Bycatch-year-1994-season-5:	-0.4543	0.1051
142	Log-fdev-Trawl-Bycatch-year-1995-season-5:	-0.7337	0.1035
143	Log-fdev-Trawl-Bycatch-year-1996-season-5:	-0.6567	0.1036
144	Log-fdev-Trawl-Bycatch-year-1997-season-5:	-1.1082	0.1035
145	Log-fdev-Trawl-Bycatch-year-1998-season-5:	0.1910	0.1041
146	Log-fdev-Trawl-Bycatch-year-1999-season-5:	-0.1010	0.1040
147	Log-fdev-Trawl-Bycatch-year-2000-season-5:	-0.8662	0.1033
148	Log-fdev-Trawl-Bycatch-year-2001-season-5:	-0.0898	0.1031
149	Log-fdev-Trawl-Bycatch-year-2002-season-5:	-0.3812	0.1028
150	Log-fdev-Trawl-Bycatch-year-2003-season-5:	-0.4776	0.1026
151	Log-fdev-Trawl-Bycatch-year-2004-season-5:	-0.2470	0.1025
152	Log-fdev-Trawl-Bycatch-year-2005-season-5:	-0.5268	0.1024
153	Log-fdev-Trawl-Bycatch-year-2006-season-5:	-0.3614	0.1022
154	Log-fdev-Trawl-Bycatch-year-2007-season-5:	-0.2903	0.1023
155	Log-fdev-Trawl-Bycatch-year-2008-season-5:	-0.3214	0.1027
156	Log-fdev-Trawl-Bycatch-year-2009-season-5:	-0.6876	0.1028

157	Log-fdev-Trawl-Bycatch-year-2010-season-5:	-0.8471	0.1028
158	Log-fdev-Trawl-Bycatch-year-2011-season-5:	-1.3089	0.1023
159	Log-fdev-Trawl-Bycatch-year-2012-season-5:	-1.8212	0.1022
160	Log-fdev-Trawl-Bycatch-year-2013-season-5:	-1.0967	0.1022
161	Log-fdev-Trawl-Bycatch-year-2014-season-5:	-1.6570	0.1023
162	Log-fdev-Trawl-Bycatch-year-2015-season-5:	-1.2738	0.1027
163	Log-fdev-Trawl-Bycatch-year-2016-season-5:	-0.7452	0.1037
164	Log-fdev-Trawl-Bycatch-year-2017-season-5:	-0.3036	0.1050
165	Log-fdev-Trawl-Bycatch-year-2018-season-5:	-0.3556	0.1064
166	Log-fdev-Trawl-Bycatch-year-2019-season-5:	-0.3153	0.1079
167	Log-fdev-Trawl-Bycatch-year-2020-season-5:	-0.3009	0.1086
168	Log-fdev-Trawl-Bycatch-year-2021-season-5:	-1.2592	0.1083
169	Log-fdev-Trawl-Bycatch-year-2022-season-5:	-2.2044	0.1090
170	Log-fdev-Trawl-Bycatch-year-2023-season-5:	-1.9584	0.1111
171	Log-fdev-Trawl-Bycatch-year-2024-season-5:	-1.3886	0.1135
172	Log-fdev-Bairdi-Fishery-Bycatch-year-1975-season-5:	0.4218	0.0683
173	Log-fdev-Bairdi-Fishery-Bycatch-year-1976-season-5:	1.2080	0.0683
174	Log-fdev-Bairdi-Fishery-Bycatch-year-1977-season-5:	1.7663	0.0683
175	Log-fdev-Bairdi-Fishery-Bycatch-year-1978-season-5:	1.6308	0.0683
176	Log-fdev-Bairdi-Fishery-Bycatch-year-1979-season-5:	1.9206	0.0683
177	Log-fdev-Bairdi-Fishery-Bycatch-year-1980-season-5:	1.9626	0.0683
178	Log-fdev-Bairdi-Fishery-Bycatch-year-1981-season-5:	1.5310	0.0683
179	Log-fdev-Bairdi-Fishery-Bycatch-year-1982-season-5:	1.0147	0.0683
180	Log-fdev-Bairdi-Fishery-Bycatch-year-1983-season-5:	-0.4491	0.0683
181	Log-fdev-Bairdi-Fishery-Bycatch-year-1984-season-5:	-0.0405	0.0683
182	Log-fdev-Bairdi-Fishery-Bycatch-year-1987-season-5:	-0.5612	0.0683
183	Log-fdev-Bairdi-Fishery-Bycatch-year-1988-season-5:	0.2819	0.0683
184	Log-fdev-Bairdi-Fishery-Bycatch-year-1989-season-5:	1.4783	0.0683
185	Log-fdev-Bairdi-Fishery-Bycatch-year-1990-season-5:	1.9564	0.0683
186	Log-fdev-Bairdi-Fishery-Bycatch-year-1991-season-5:	3.1462	0.0757
187	Log-fdev-Bairdi-Fishery-Bycatch-year-1992-season-5:	1.1725	0.1151
188	Log-fdev-Bairdi-Fishery-Bycatch-year-1993-season-5:	0.4400	0.1169
189	Log-fdev-Bairdi-Fishery-Bycatch-year-1994-season-5:	-0.8655	0.0864
190	Log-fdev-Bairdi-Fishery-Bycatch-year-2006-season-5:	-2.2285	0.0724
191	Log-fdev-Bairdi-Fishery-Bycatch-year-2007-season-5:	-3.1007	0.1054
192	Log-fdev-Bairdi-Fishery-Bycatch-year-2008-season-5:	-2.5383	0.1117
193	Log-fdev-Bairdi-Fishery-Bycatch-year-2009-season-5:	-3.6243	0.0737
194	Log-fdev-Bairdi-Fishery-Bycatch-year-2013-season-5:	-0.9522	0.0912
195	Log-fdev-Bairdi-Fishery-Bycatch-year-2014-season-5:	-0.2244	0.1156
196	Log-fdev-Bairdi-Fishery-Bycatch-year-2015-season-5:	0.9634	0.1393
197	Log-fdev-Bairdi-Fishery-Bycatch-year-2024-season-5:	-6.3097	0.1013
198	Log-fdev-Fixed-Gear-year-1996-season-5:	0.5443	0.1031
199	Log-fdev-Fixed-Gear-year-1997-season-5:	-0.1160	0.1024
200	Log-fdev-Fixed-Gear-year-1998-season-5:	-0.3478	0.1030
201	Log-fdev-Fixed-Gear-year-1999-season-5:	0.5686	0.1023
202	Log-fdev-Fixed-Gear-year-2000-season-5:	-1.8515	0.1018
203	Log-fdev-Fixed-Gear-year-2001-season-5:	0.1090	0.1014
204	Log-fdev-Fixed-Gear-year-2002-season-5:	-0.1468	0.1010
205	Log-fdev-Fixed-Gear-year-2003-season-5:	-0.9814	0.1009
206	Log-fdev-Fixed-Gear-year-2004-season-5:	-0.8092	0.1007
207	Log-fdev-Fixed-Gear-year-2005-season-5:	-0.5443	0.1006
208	Log-fdev-Fixed-Gear-year-2006-season-5:	-0.5906	0.1004
209	Log-fdev-Fixed-Gear-year-2007-season-5:	-0.0488	0.1004

210	Log-fdev-Fixed-Gear-year-2008-season-5:	-0.7572	0.1007
211	Log-fdev-Fixed-Gear-year-2009-season-5:	-1.7600	0.1005
212	Log-fdev-Fixed-Gear-year-2010-season-5:	-2.5967	0.1001
213	Log-fdev-Fixed-Gear-year-2011-season-5:	-1.1065	0.0998
214	Log-fdev-Fixed-Gear-year-2012-season-5:	-0.5405	0.0996
215	Log-fdev-Fixed-Gear-year-2013-season-5:	0.6051	0.0995
216	Log-fdev-Fixed-Gear-year-2014-season-5:	1.4570	0.0995
217	Log-fdev-Fixed-Gear-year-2015-season-5:	1.1439	0.0997
218	Log-fdev-Fixed-Gear-year-2016-season-5:	0.2473	0.1002
219	Log-fdev-Fixed-Gear-year-2017-season-5:	1.5242	0.1009
220	Log-fdev-Fixed-Gear-year-2018-season-5:	1.9186	0.1016
221	Log-fdev-Fixed-Gear-year-2019-season-5:	1.0648	0.1023
222	Log-fdev-Fixed-Gear-year-2020-season-5:	0.0209	0.1030
223	Log-fdev-Fixed-Gear-year-2021-season-5:	1.1350	0.1035
224	Log-fdev-Fixed-Gear-year-2022-season-5:	1.1549	0.1046
225	Log-fdev-Fixed-Gear-year-2023-season-5:	0.7420	0.1063
226	Log-fdev-Fixed-Gear-year-2024-season-5:	-0.0383	0.1081
227	Log-foff-Pot-Fishery:	-2.8084	0.0422
228	Log-foff-Bairdi-Fishery-Bycatch:	-0.7537	0.4582
229	Log-fdov-Pot-Fishery-year-1990-season-3:	1.9564	0.0843
230	Log-fdov-Pot-Fishery-year-1991-season-3:	-0.6987	0.0835
231	Log-fdov-Pot-Fishery-year-1992-season-3:	1.9732	0.0847
232	Log-fdov-Pot-Fishery-year-1993-season-3:	1.8067	0.0861
233	Log-fdov-Pot-Fishery-year-1994-season-3:	-0.4138	0.0846
234	Log-fdov-Pot-Fishery-year-1995-season-3:	-0.1950	0.0824
235	Log-fdov-Pot-Fishery-year-1996-season-3:	-3.7301	0.0814
236	Log-fdov-Pot-Fishery-year-1997-season-3:	-0.3353	0.0823
237	Log-fdov-Pot-Fishery-year-1998-season-3:	1.4255	0.0831
238	Log-fdov-Pot-Fishery-year-1999-season-3:	-2.7770	0.0823
239	Log-fdov-Pot-Fishery-year-2000-season-3:	1.1508	0.0813
240	Log-fdov-Pot-Fishery-year-2001-season-3:	0.8682	0.0812
241	Log-fdov-Pot-Fishery-year-2002-season-3:	-1.8870	0.0806
242	Log-fdov-Pot-Fishery-year-2003-season-3:	1.2095	0.0805
243	Log-fdov-Pot-Fishery-year-2004-season-3:	0.4161	0.0808
244	Log-fdov-Pot-Fishery-year-2005-season-3:	0.9370	0.0804
245	Log-fdov-Pot-Fishery-year-2006-season-3:	-1.2396	0.0797
246	Log-fdov-Pot-Fishery-year-2007-season-3:	-0.1898	0.0797
247	Log-fdov-Pot-Fishery-year-2008-season-3:	-0.4529	0.0802
248	Log-fdov-Pot-Fishery-year-2009-season-3:	-0.7012	0.0803
249	Log-fdov-Pot-Fishery-year-2010-season-3:	-0.2018	0.0800
250	Log-fdov-Pot-Fishery-year-2011-season-3:	-1.0849	0.0791
251	Log-fdov-Pot-Fishery-year-2012-season-3:	-1.8052	0.0785
252	Log-fdov-Pot-Fishery-year-2013-season-3:	0.2123	0.0784
253	Log-fdov-Pot-Fishery-year-2014-season-3:	-0.1949	0.0784
254	Log-fdov-Pot-Fishery-year-2015-season-3:	0.8734	0.0787
255	Log-fdov-Pot-Fishery-year-2016-season-3:	0.3275	0.0799
256	Log-fdov-Pot-Fishery-year-2017-season-3:	-0.3245	0.0819
257	Log-fdov-Pot-Fishery-year-2018-season-3:	0.9822	0.0845
258	Log-fdov-Pot-Fishery-year-2019-season-3:	-0.1032	0.0863
259	Log-fdov-Pot-Fishery-year-2020-season-3:	-0.6301	0.0859
260	Log-fdov-Pot-Fishery-year-2021-season-3:	2.9543	0.0849
261	Log-fdov-Pot-Fishery-year-2022-season-3:	1.2559	0.0848
262	Log-fdov-Pot-Fishery-year-2023-season-3:	0.2064	0.0860

263	Log-fdov-Pot-Fishery-year-2024-season-3:	-1.5946	0.0878
264	Log-fdov-Bairdi-Fishery-Bycatch-year-1975-season-5:	0.0000	0.0964
265	Log-fdov-Bairdi-Fishery-Bycatch-year-1976-season-5:	0.0002	0.0963
266	Log-fdov-Bairdi-Fishery-Bycatch-year-1977-season-5:	0.0005	0.0964
267	Log-fdov-Bairdi-Fishery-Bycatch-year-1978-season-5:	0.0004	0.0964
268	Log-fdov-Bairdi-Fishery-Bycatch-year-1979-season-5:	0.0005	0.0964
269	Log-fdov-Bairdi-Fishery-Bycatch-year-1980-season-5:	0.0000	0.0964
270	Log-fdov-Bairdi-Fishery-Bycatch-year-1981-season-5:	-0.0002	0.0964
271	Log-fdov-Bairdi-Fishery-Bycatch-year-1982-season-5:	-0.0002	0.0964
272	Log-fdov-Bairdi-Fishery-Bycatch-year-1983-season-5:	-0.0002	0.0964
273	Log-fdov-Bairdi-Fishery-Bycatch-year-1984-season-5:	-0.0001	0.0963
274	Log-fdov-Bairdi-Fishery-Bycatch-year-1987-season-5:	-0.0001	0.0964
275	Log-fdov-Bairdi-Fishery-Bycatch-year-1988-season-5:	0.0001	0.0963
276	Log-fdov-Bairdi-Fishery-Bycatch-year-1989-season-5:	0.0003	0.0964
277	Log-fdov-Bairdi-Fishery-Bycatch-year-1990-season-5:	0.0007	0.0964
278	Log-fdov-Bairdi-Fishery-Bycatch-year-1991-season-5:	2.1424	0.1586
279	Log-fdov-Bairdi-Fishery-Bycatch-year-1992-season-5:	2.4383	0.1352
280	Log-fdov-Bairdi-Fishery-Bycatch-year-1993-season-5:	1.2450	0.1393
281	Log-fdov-Bairdi-Fishery-Bycatch-year-1994-season-5:	-2.7992	0.1113
282	Log-fdov-Bairdi-Fishery-Bycatch-year-2006-season-5:	-1.5280	0.1677
283	Log-fdov-Bairdi-Fishery-Bycatch-year-2007-season-5:	-0.1444	0.1353
284	Log-fdov-Bairdi-Fishery-Bycatch-year-2008-season-5:	0.6982	0.1317
285	Log-fdov-Bairdi-Fishery-Bycatch-year-2009-season-5:	1.0517	0.1013
286	Log-fdov-Bairdi-Fishery-Bycatch-year-2013-season-5:	1.6288	0.1698
287	Log-fdov-Bairdi-Fishery-Bycatch-year-2014-season-5:	0.8442	0.1538
288	Log-fdov-Bairdi-Fishery-Bycatch-year-2015-season-5:	1.5674	0.1755
289	Log-fdov-Bairdi-Fishery-Bycatch-year-2024-season-5:	-7.1464	0.1220
290	Rec-dev-est-1975:	0.9312	0.2858
291	Rec-dev-est-1976:	0.5423	0.3055
292	Rec-dev-est-1977:	0.9788	0.2412
293	Rec-dev-est-1978:	1.5939	0.2035
294	Rec-dev-est-1979:	1.8739	0.2124
295	Rec-dev-est-1980:	1.0583	0.2580
296	Rec-dev-est-1981:	2.4108	0.1594
297	Rec-dev-est-1982:	1.4296	0.1758
298	Rec-dev-est-1983:	1.0307	0.1612
299	Rec-dev-est-1984:	-0.7748	0.2437
300	Rec-dev-est-1985:	0.2810	0.1584
301	Rec-dev-est-1986:	-0.8371	0.2380
302	Rec-dev-est-1987:	-1.2672	0.2706
303	Rec-dev-est-1988:	-1.0295	0.2220
304	Rec-dev-est-1989:	-0.0821	0.1588
305	Rec-dev-est-1990:	-0.4985	0.1782
306	Rec-dev-est-1991:	-1.9136	0.3421
307	Rec-dev-est-1992:	-0.9028	0.1923
308	Rec-dev-est-1993:	-2.0791	0.3998
309	Rec-dev-est-1994:	0.9442	0.1408
310	Rec-dev-est-1995:	-0.8607	0.2489
311	Rec-dev-est-1996:	-1.5899	0.3346
312	Rec-dev-est-1997:	-0.6247	0.1990
313	Rec-dev-est-1998:	0.4020	0.1504
314	Rec-dev-est-1999:	-0.5471	0.2188
315	Rec-dev-est-2000:	-0.6487	0.2539

316	Rec-dev-est-2001:	0.8363	0.1489
317	Rec-dev-est-2002:	-0.6353	0.2615
318	Rec-dev-est-2003:	-0.7253	0.2650
319	Rec-dev-est-2004:	0.5292	0.1522
320	Rec-dev-est-2005:	-0.1147	0.1746
321	Rec-dev-est-2006:	-0.5357	0.1839
322	Rec-dev-est-2007:	-1.0917	0.2283
323	Rec-dev-est-2008:	-0.9611	0.2292
324	Rec-dev-est-2009:	-0.0675	0.1753
325	Rec-dev-est-2010:	-0.5171	0.2152
326	Rec-dev-est-2011:	-1.1120	0.2267
327	Rec-dev-est-2012:	-1.4170	0.2168
328	Rec-dev-est-2013:	-1.9108	0.2607
329	Rec-dev-est-2014:	-1.4535	0.2170
330	Rec-dev-est-2015:	-0.7759	0.1656
331	Rec-dev-est-2016:	-1.5443	0.2364
332	Rec-dev-est-2017:	-0.8499	0.1807
333	Rec-dev-est-2018:	-1.4688	0.2514
334	Rec-dev-est-2019:	-1.2823	0.2210
335	Rec-dev-est-2020:	-1.5061	0.2483
336	Rec-dev-est-2021:	-0.6057	0.1764
337	Rec-dev-est-2022:	-0.7858	0.2008
338	Rec-dev-est-2023:	-1.5507	0.3138
339	Rec-dev-est-2024:	-0.7360	0.3077
340	Logit-rec-prop-est-1975:	0.0532	0.4950
341	Logit-rec-prop-est-1976:	-0.8063	0.5380
342	Logit-rec-prop-est-1977:	-0.1200	0.3682
343	Logit-rec-prop-est-1978:	-0.2899	0.2576
344	Logit-rec-prop-est-1979:	0.2735	0.2601
345	Logit-rec-prop-est-1980:	0.4566	0.3555
346	Logit-rec-prop-est-1981:	0.5149	0.1421
347	Logit-rec-prop-est-1982:	0.6498	0.2517
348	Logit-rec-prop-est-1983:	0.0956	0.1805
349	Logit-rec-prop-est-1984:	0.4679	0.4691
350	Logit-rec-prop-est-1985:	-0.4508	0.1709
351	Logit-rec-prop-est-1986:	0.2717	0.4375
352	Logit-rec-prop-est-1987:	-0.1537	0.4860
353	Logit-rec-prop-est-1988:	0.4021	0.4058
354	Logit-rec-prop-est-1989:	-0.0670	0.1705
355	Logit-rec-prop-est-1990:	0.1881	0.2486
356	Logit-rec-prop-est-1991:	0.7331	0.8176
357	Logit-rec-prop-est-1992:	0.3117	0.3066
358	Logit-rec-prop-est-1993:	-1.1501	0.9438
359	Logit-rec-prop-est-1994:	-0.3192	0.0896
360	Logit-rec-prop-est-1995:	1.4965	0.7785
361	Logit-rec-prop-est-1996:	0.2441	0.6992
362	Logit-rec-prop-est-1997:	0.5355	0.3548
363	Logit-rec-prop-est-1998:	-0.0752	0.1429
364	Logit-rec-prop-est-1999:	0.3235	0.3808
365	Logit-rec-prop-est-2000:	-0.6810	0.4499
366	Logit-rec-prop-est-2001:	-0.4805	0.1278
367	Logit-rec-prop-est-2002:	-0.4319	0.4507
368	Logit-rec-prop-est-2003:	-0.0362	0.4686

369	Logit-rec-prop-est-2004:	-0.3935	0.1460
370	Logit-rec-prop-est-2005:	-0.0922	0.2299
371	Logit-rec-prop-est-2006:	0.4493	0.2886
372	Logit-rec-prop-est-2007:	-0.1025	0.3786
373	Logit-rec-prop-est-2008:	-0.5195	0.3743
374	Logit-rec-prop-est-2009:	-0.6854	0.2072
375	Logit-rec-prop-est-2010:	-0.4265	0.3114
376	Logit-rec-prop-est-2011:	-0.5468	0.3678
377	Logit-rec-prop-est-2012:	-0.1494	0.3539
378	Logit-rec-prop-est-2013:	-0.4580	0.4775
379	Logit-rec-prop-est-2014:	-0.3849	0.3428
380	Logit-rec-prop-est-2015:	0.2514	0.2098
381	Logit-rec-prop-est-2016:	0.4643	0.4477
382	Logit-rec-prop-est-2017:	0.6346	0.2833
383	Logit-rec-prop-est-2018:	-0.2089	0.4497
384	Logit-rec-prop-est-2019:	0.4737	0.4036
385	Logit-rec-prop-est-2020:	0.2271	0.4512
386	Logit-rec-prop-est-2021:	-0.0977	0.2205
387	Logit-rec-prop-est-2022:	-0.1943	0.2872
388	Logit-rec-prop-est-2023:	0.2077	0.5985
389	Logit-rec-prop-est-2024:	-0.4047	0.5513
390	Survey-q-survey-1:	0.9305	0.0258
391	Log-add-cvt-survey-2:	-1.0153	0.2882

Table 18: Annual abundance estimates (mature males, legal males, and mature females in million crab), mature male biomass (MMB, 1000 t), and total survey biomass (1000 t) both estimated by the model and area swept calculated for red king crab in Bristol Bay estimated by length-based model 24.0c.2 during 1975-2025. MMB for year t is on Feb. 15, year t+1.

	Males				Females	Total	Total Survey Biomass	
Year	Mature >119mm	Legal >134mm	MMB >119mm	sd MMB	Mature >89mm	Recruits	Model Est >64mm	Area-Swept >64mm
1975	66.838	33.237	97.063	6.698	66.125		262.430	199.640
1976	76.709	40.995	112.590	6.257	98.316	78.874	301.910	327.610
1977	83.399	46.504	124.541	5.483	130.756	53.464	320.720	371.220
1978	87.656	50.988	128.826	4.704	133.937	82.719	319.210	343.190
1979	75.845	50.923	105.827	3.895	126.011	153.027	303.660	165.450
1980	55.523	40.237	27.422	1.455	126.882	202.481	288.150	247.230
1981	15.890	8.565	6.038	0.839	57.446	89.569	116.100	131.140
1982	7.478	2.359	5.650	0.625	25.803	346.371	65.620	141.900
1983	6.283	2.201	5.800	0.448	17.744	129.842	57.580	48.480
1984	6.390	2.122	4.036	0.328	17.850	87.133	49.670	152.610
1985	7.780	1.801	9.102	0.632	12.291	14.323	33.360	34.140
1986	12.779	4.676	14.710	0.996	16.868	41.167	44.580	47.430
1987	15.477	6.949	20.611	1.253	21.088	13.458	51.200	69.240
1988	15.756	8.992	25.579	1.334	26.559	8.754	55.390	54.600
1989	17.021	10.389	28.603	1.298	24.765	11.103	58.400	55.140
1990	16.315	11.126	24.750	1.227	21.941	28.634	58.360	59.450
1991	12.474	9.224	19.010	1.140	21.319	18.881	53.310	83.890
1992	10.209	6.912	17.796	1.102	23.008	4.587	49.110	37.330
1993	11.780	6.651	16.935	1.202	21.392	12.603	49.020	52.910
1994	11.836	6.752	22.947	1.329	18.061	3.887	44.880	32.100
1995	12.146	8.706	25.740	1.304	16.646	79.906	50.480	38.070
1996	12.171	9.190	23.823	1.216	24.904	13.145	59.060	43.960
1997	11.481	8.225	22.249	1.175	36.358	6.339	65.240	84.030
1998	17.488	8.198	25.711	1.453	31.284	16.644	69.500	84.100
1999	18.757	10.568	29.811	1.628	26.161	46.464	68.520	64.750
2000	16.038	11.568	29.683	1.588	28.035	17.987	70.170	67.380
2001	15.834	10.880	29.882	1.535	32.057	16.248	73.730	52.460
2002	19.085	11.084	34.151	1.582	30.727	71.736	78.700	69.090
2003	19.894	12.924	33.779	1.552	38.155	16.467	84.680	115.760
2004	17.795	12.454	31.036	1.452	47.654	15.050	86.520	130.560
2005	20.094	11.566	32.092	1.457	43.622	52.769	87.620	105.730
2006	19.032	12.394	32.383	1.419	43.763	27.716	87.550	94.480
2007	17.056	12.011	27.265	1.323	48.556	18.192	89.220	103.330
2008	17.702	10.255	26.255	1.382	45.290	10.433	86.120	113.080
2009	17.801	10.384	27.592	1.466	39.103	11.889	80.600	90.550
2010	16.731	10.797	27.201	1.437	33.983	29.055	75.630	80.500
2011	14.193	10.283	26.674	1.331	33.452	18.534	70.910	66.410
2012	12.515	9.546	24.665	1.201	35.525	10.223	68.830	60.700
2013	12.419	8.616	23.464	1.114	33.601	7.536	65.760	62.220
2014	12.126	8.314	21.487	1.043	29.458	4.599	60.680	113.140
2015	10.344	7.625	18.306	0.963	24.922	7.266	53.500	64.170
2016	8.319	6.385	15.003	0.895	21.112	14.307	46.390	60.960
2017	6.500	5.129	12.101	0.835	19.265	6.635	41.050	52.930
2018	5.650	4.078	10.648	0.806	17.749	13.288	37.900	28.800
2019	6.506	3.763	11.537	0.884	15.757	7.155	36.540	28.540
2020	7.171	4.328	13.194	0.991	14.738	8.623		

2021	8.323	4.998	16.725	1.117	13.678	6.894	36.290	28.480
2022	8.961	6.219	19.033	1.192	12.556	16.963	37.740	36.200
2023	9.253	6.767	19.504	1.238	12.953	14.167	39.560	37.970
2024	9.212	6.761	19.738	1.295	15.067	6.593	40.600	46.130
2025	10.022	6.799	16.836	0.935	15.405	14.890	41.630	49.080

Figures

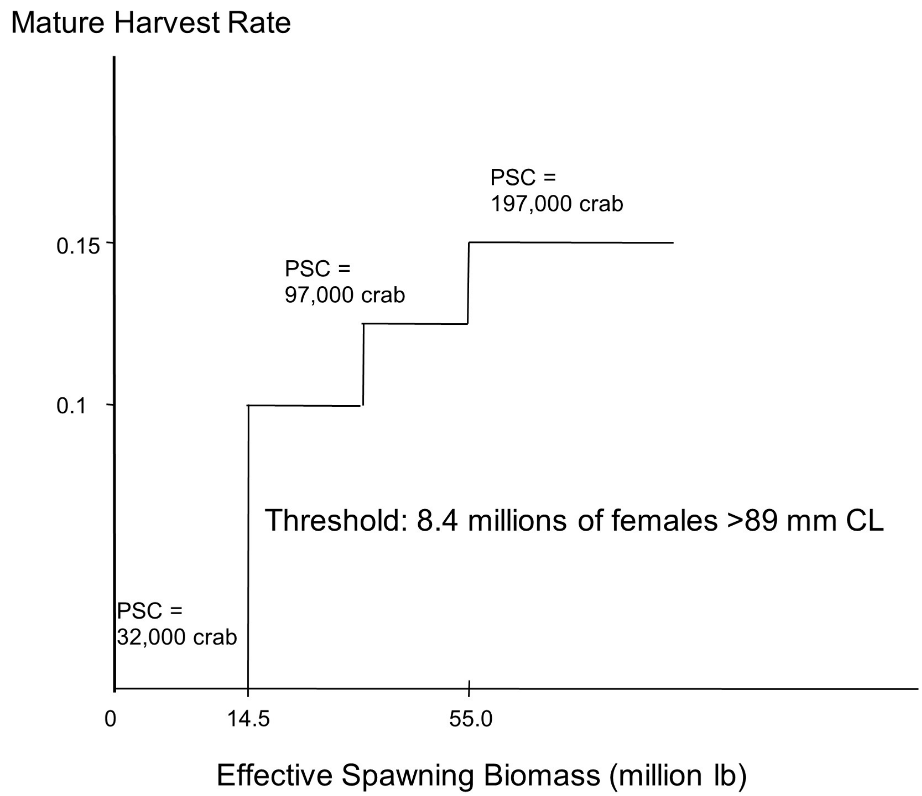

Figure 1: Current harvest rate strategy (line) for the Bristol Bay red king crab fishery and the associated annual prohibited species catch (PSC) limits (numbers of crab) of Bristol Bay red king crab in the groundfish fisheries in zone 1 in the eastern Bering Sea. Harvest rates are based on current-year estimates of effective spawning biomass (ESB, Zheng et al. 1995b), whereas PSC limits apply to previous-year ESB (Effective Spawning Biomass).

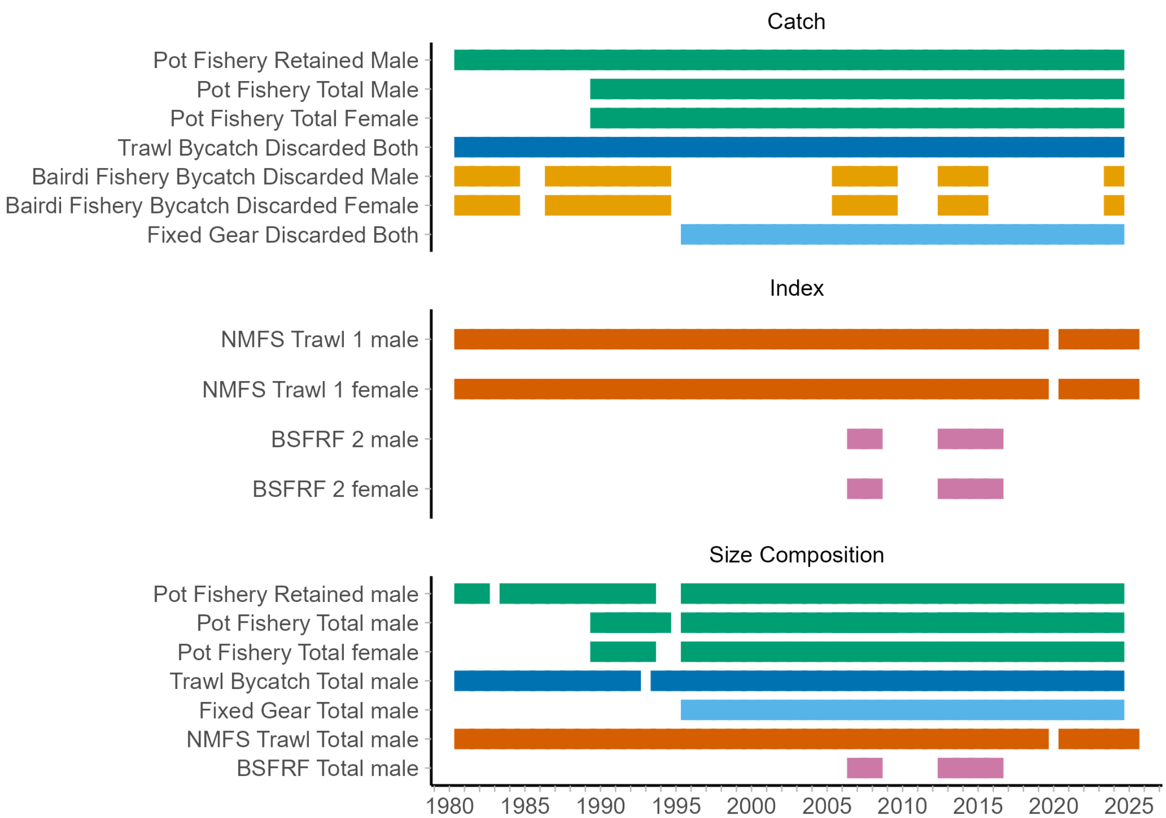

Figure 2: Data types and ranges used for the BBRKC stock assessment.

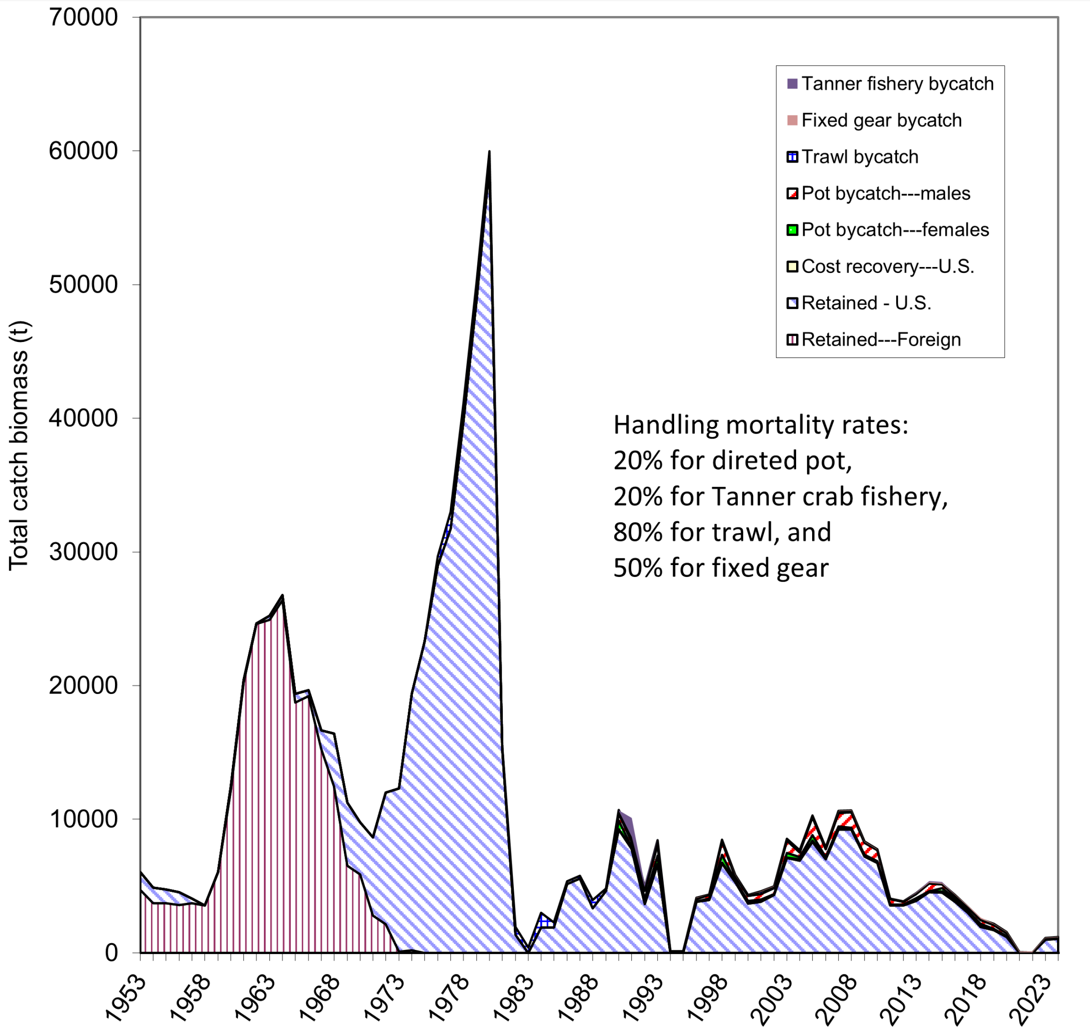

Figure 3: Retained catch biomass and bycatch mortality biomass (t) for Bristol Bay red king crab from 1953 to 2024. Directed pot bycatch data were not available from the observer program before 1990 and are not included in this figure.

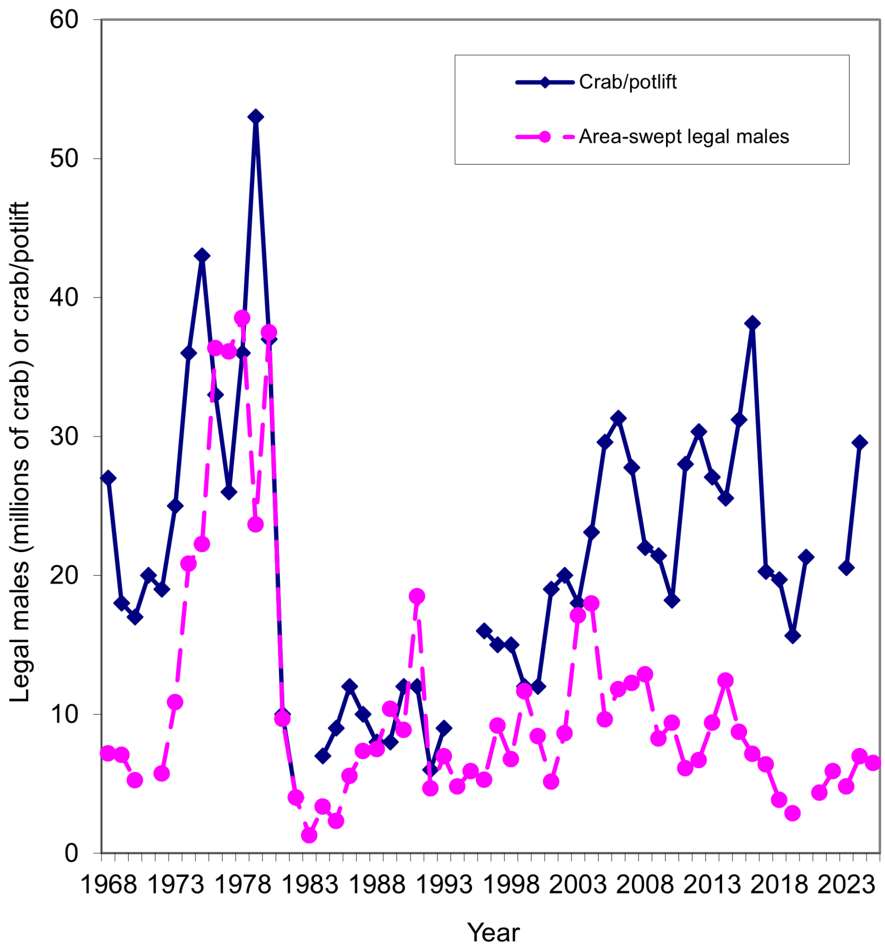

Figure 4: Comparison of survey legal male abundances and catches per unit effort for Bristol Bay red king crab from 1968 to 2024.

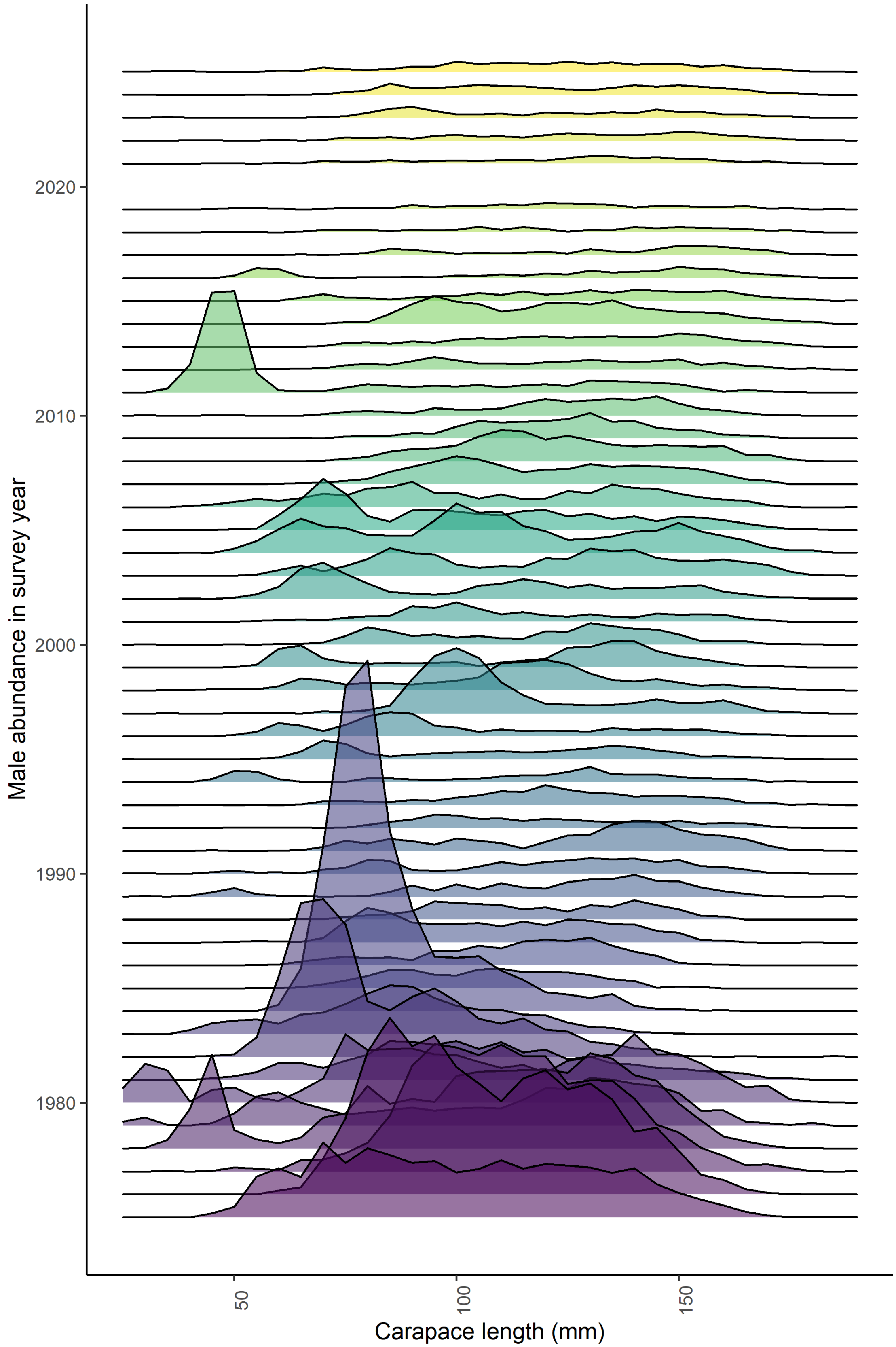

Figure 5: Survey abundances by 5-mm carapace length bin for male Bristol Bay red king crab from 1975 to 2025.

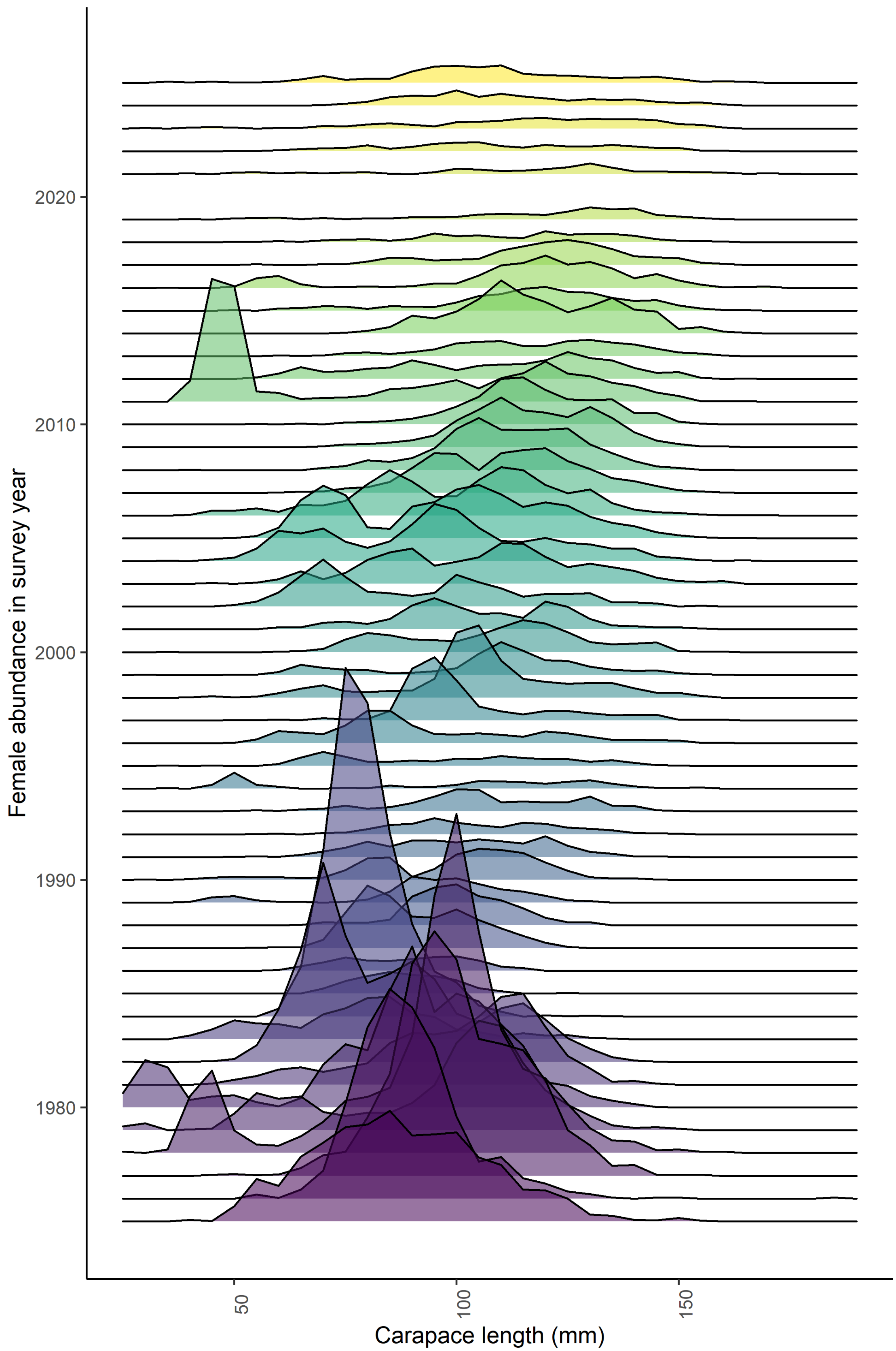

Figure 6: Survey abundances by 5-mm carapace length bin for female Bristol Bay red king crab from 1975 to 2025.

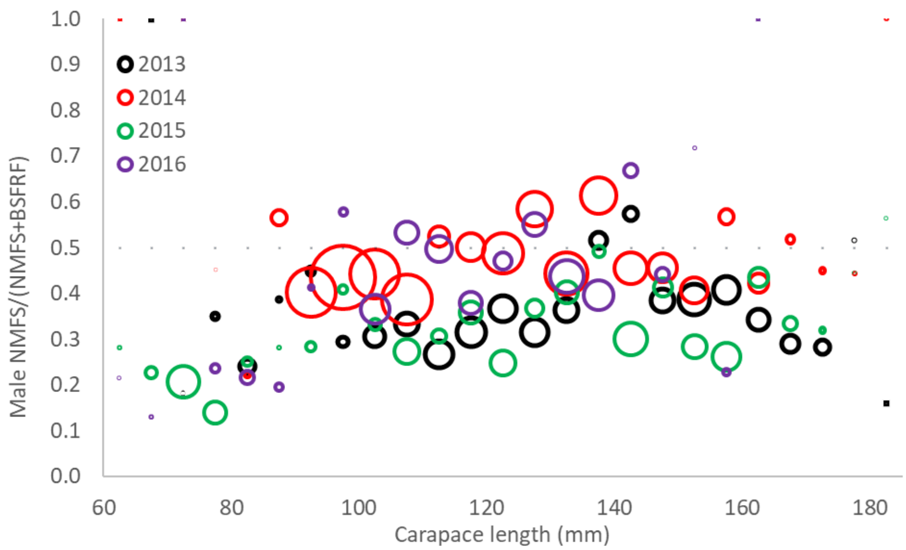

Figure 7: Comparison of NMFS survey abundance proportions of total NMFS and BSFRF side-by-side trawl surveys during 2013-2016 for male Bristol Bay red king crab. Sizes of circles are proportional to total abundances.

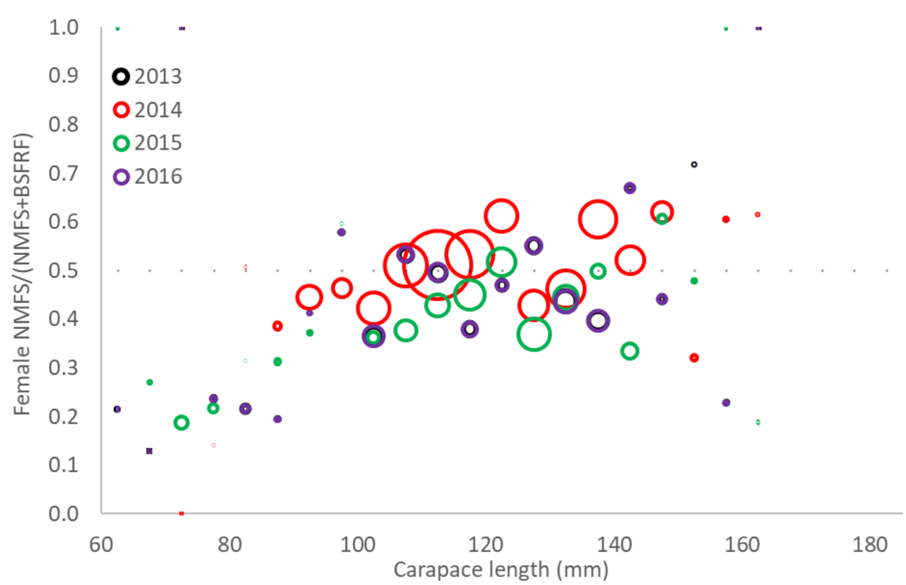

Figure 8: Comparison of NMFS survey abundance proportions of total NMFS and BSFRF side-by-side trawl surveys during 2013-2016 for female Bristol Bay red king crab. Sizes of circles are proportional to total abundances.

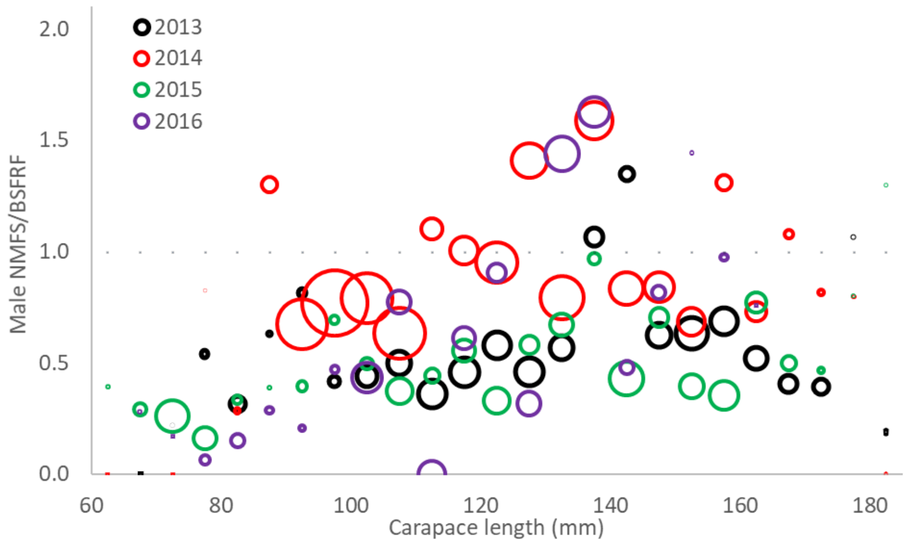

Figure 9: Comparison of ratios of NMFS survey abundances to BSFRF side-by-side survey abundances during 2013-2016 for male Bristol Bay red king crab. Sizes of circles are proportional to total abundances.

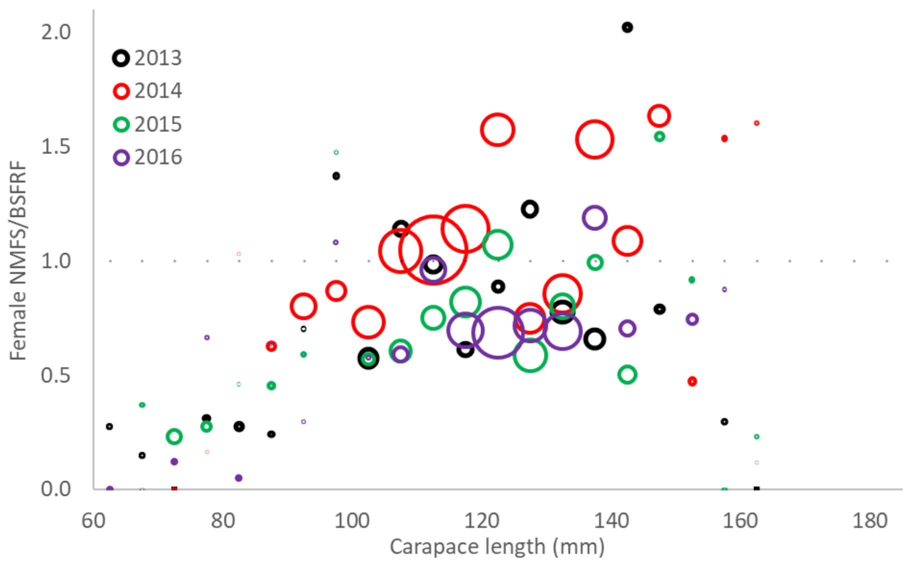

Figure 10: Comparison of ratios of NMFS survey abundances to BSFRF side-by-side survey abundances during 2013-2016 for female Bristol Bay red king crab. Sizes of circles are proportional to total abundances.

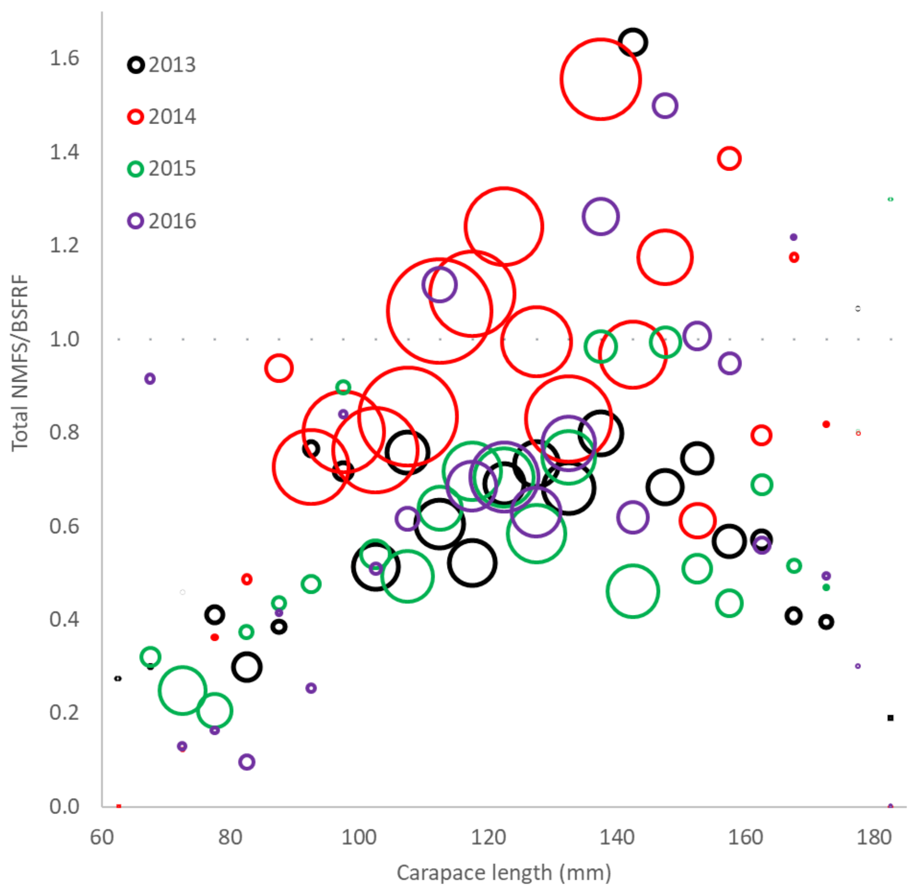

Figure 11: Comparison of ratios of NMFS survey abundances to BSFRF side-by-side survey abundances during 2013-2016 for male Bristol Bay red king crab. Sizes of circles are proportional to total abundances. The abundance-weighted average ratio is 0.891 for crab GE 135 mm carapace length from all four years of data. The approach to compute this overall ratio is documented in section D. Data, 4. Bering Sea Fisheries Research Foundation Survey Data.

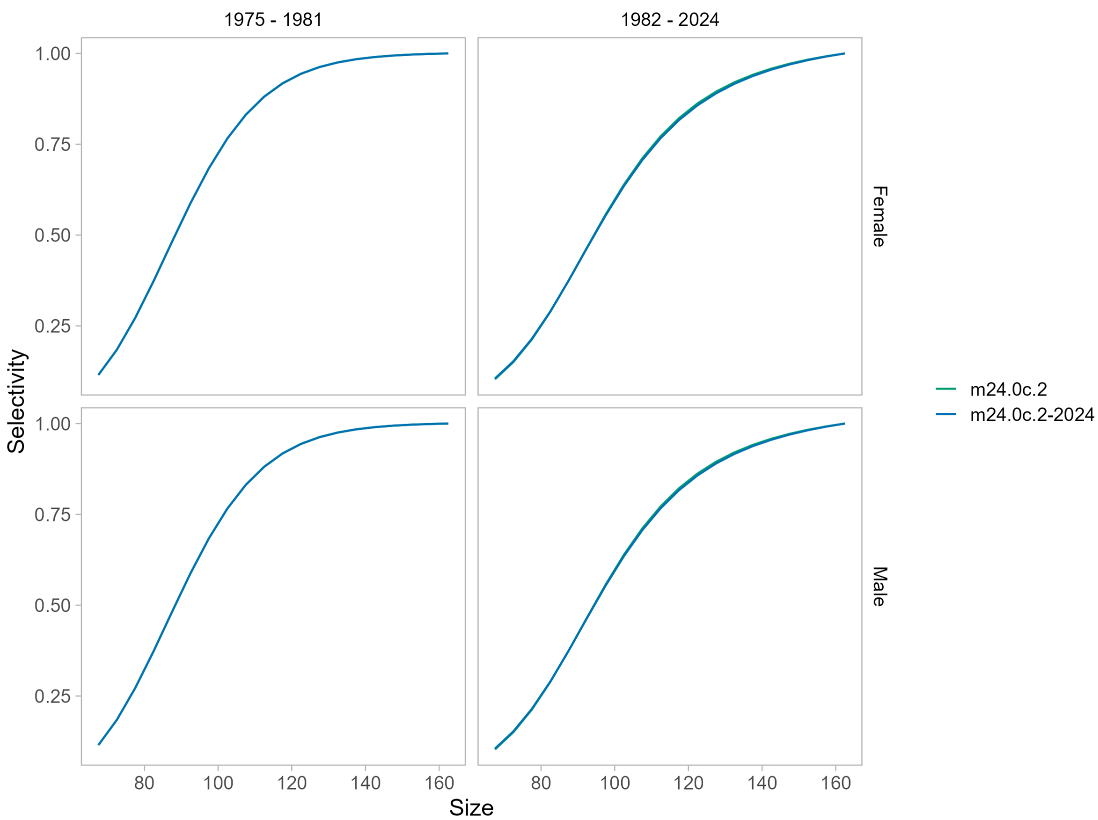

Figure 12: Estimated NMFS trawl survey selectivities under model 24.0c.2, for 2024 and 2025.

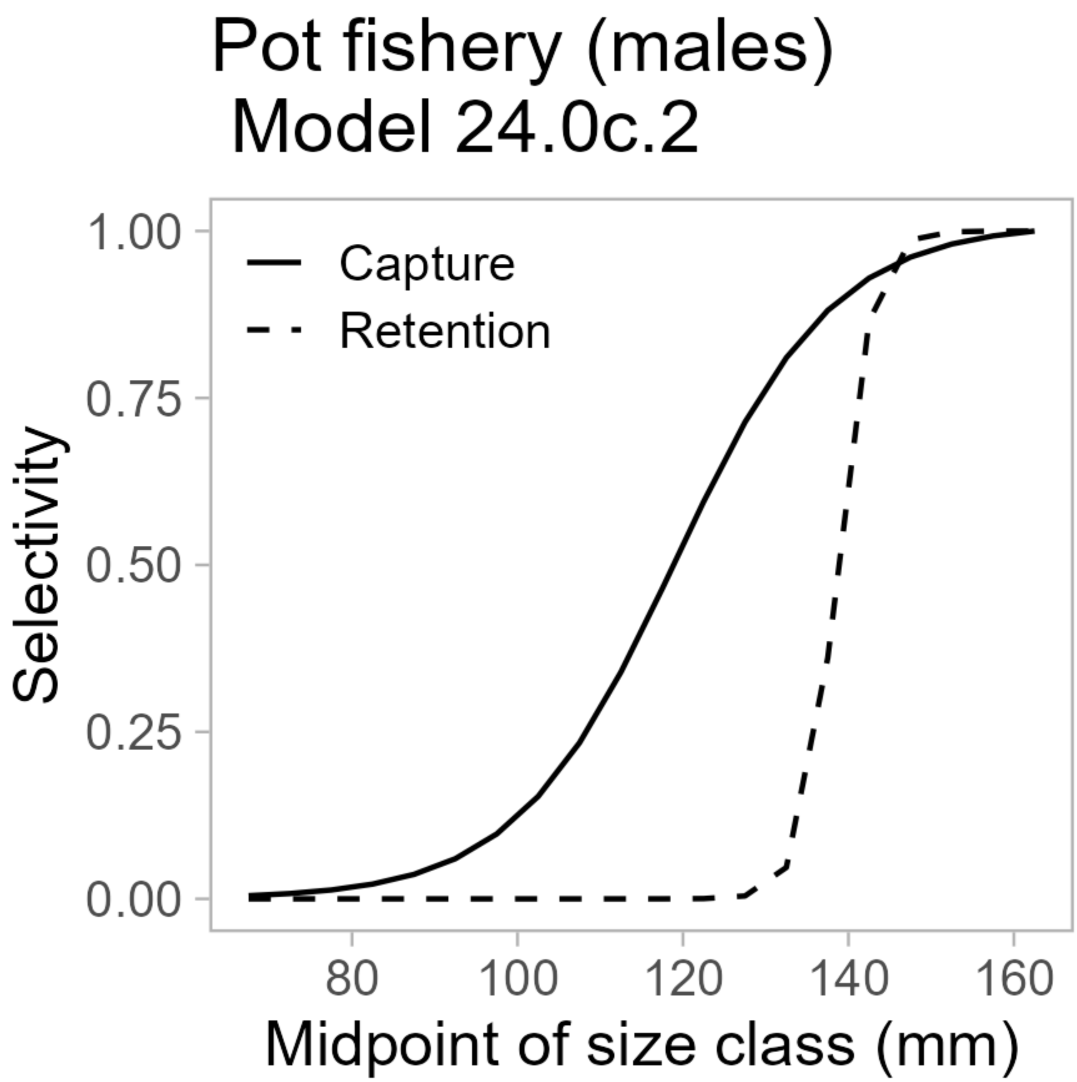

Figure 13: Estimated directed pot fishery capture and retained selectivities for males under model 24.0c.2.

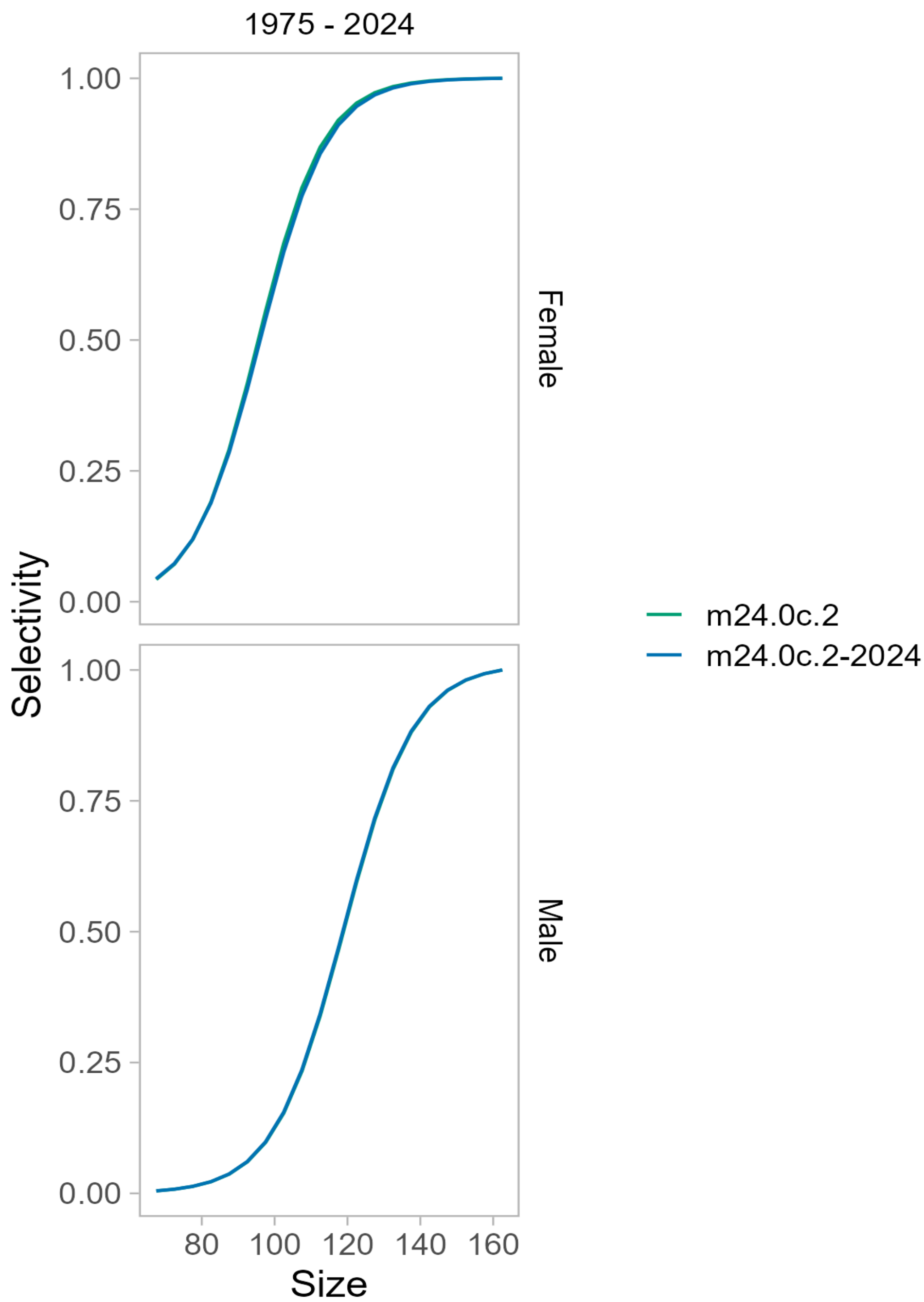

Figure 14: Estimated directed pot fishery selectivities for females and males under model 24.0c.2.

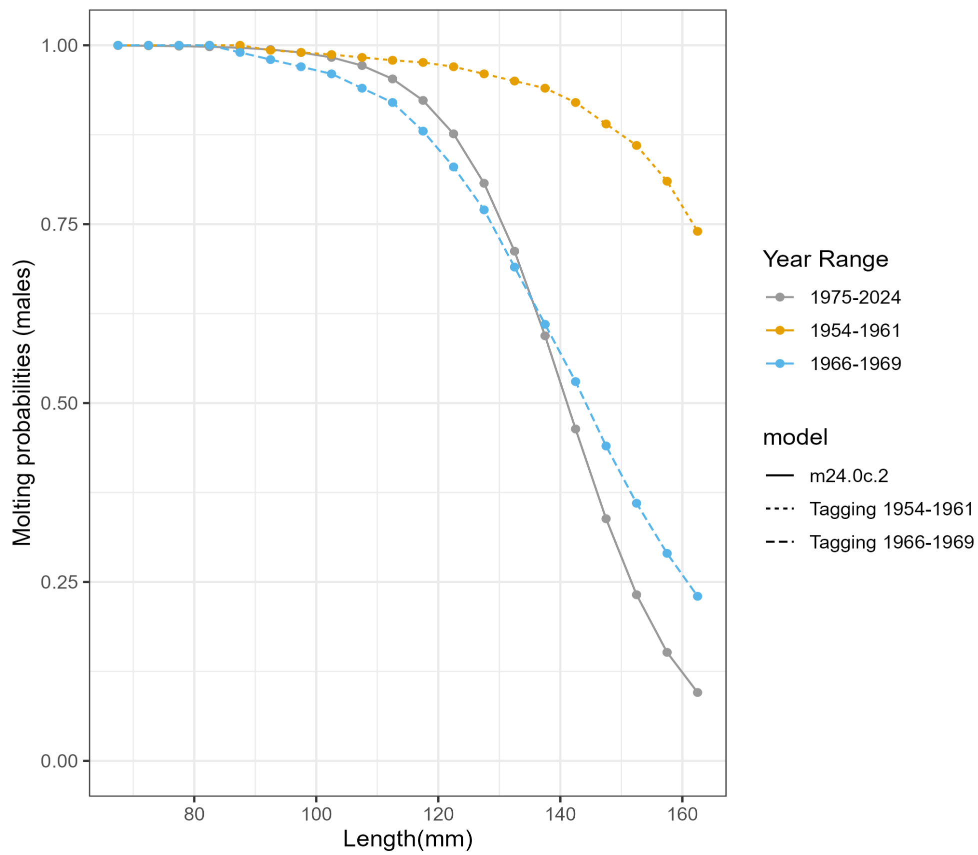

Figure 15: Comparison of estimated probabilities of molting of male red king crab in Bristol Bay for different periods with model 24.0c.2. The 1980 to 2024 molt probability for model 24.0c.2 reflects the entire time series from 1975 to 2024. Molting probabilities for periods 1954-1961 and 1966-1969 were estimated by Balsiger (1974) from tagging data. Molting probabilities for 1975-1979 and 1980-2024 were estimated with a length-based model.

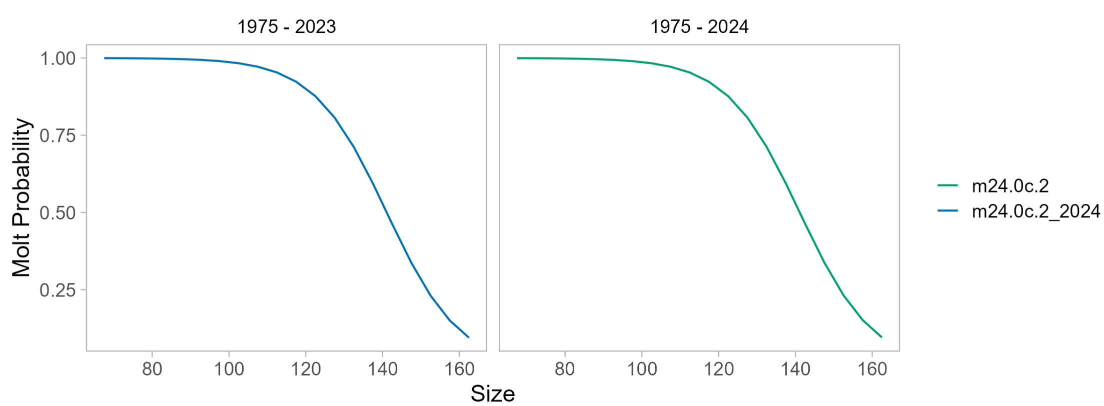

Figure 16: Comparison of estimated probabilities of molting of male red king crab in Bristol Bay with model 24.0c.2, for 2024 and 2025.

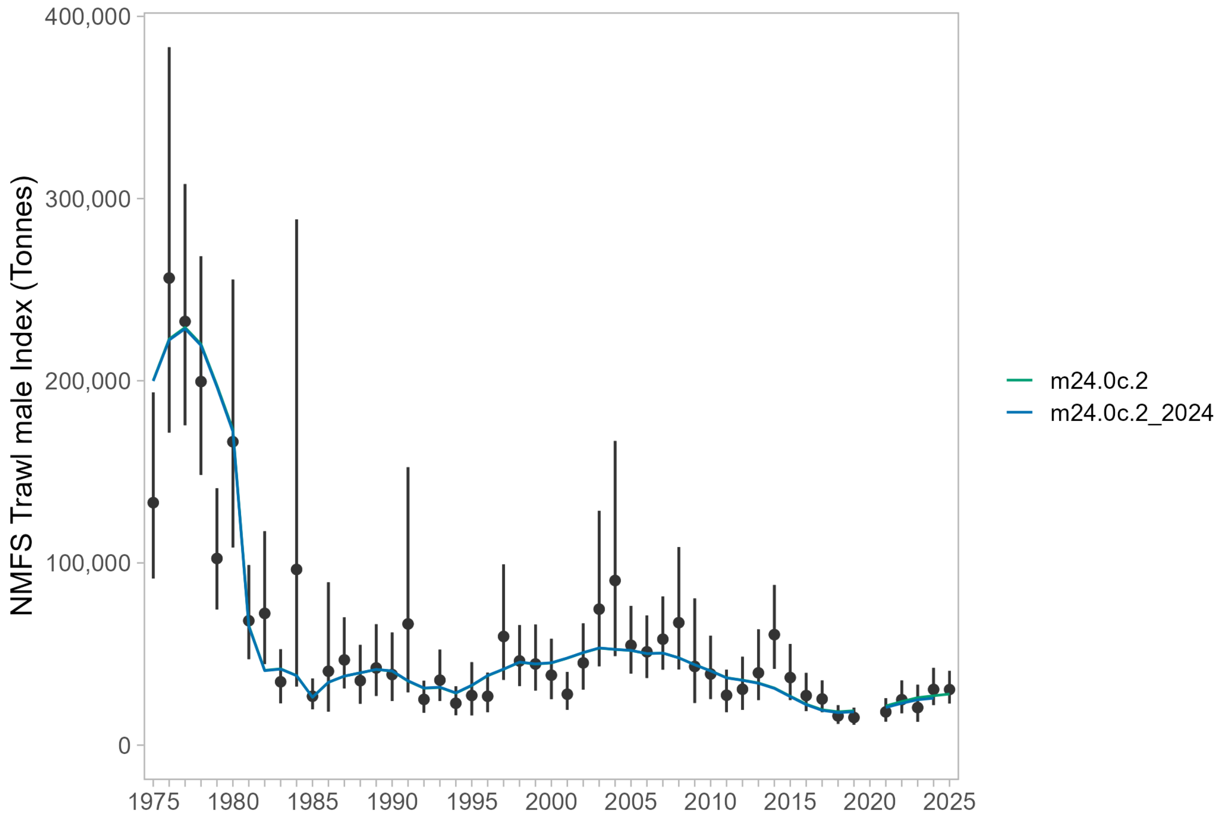

Figure 17: Comparisons of area-swept estimates of total male NMFS survey biomass and model prediction for model estimates in 2025 under model 24.0c.2, for 2024 and 2025. The error bars are plus and minus 2 standard deviations.

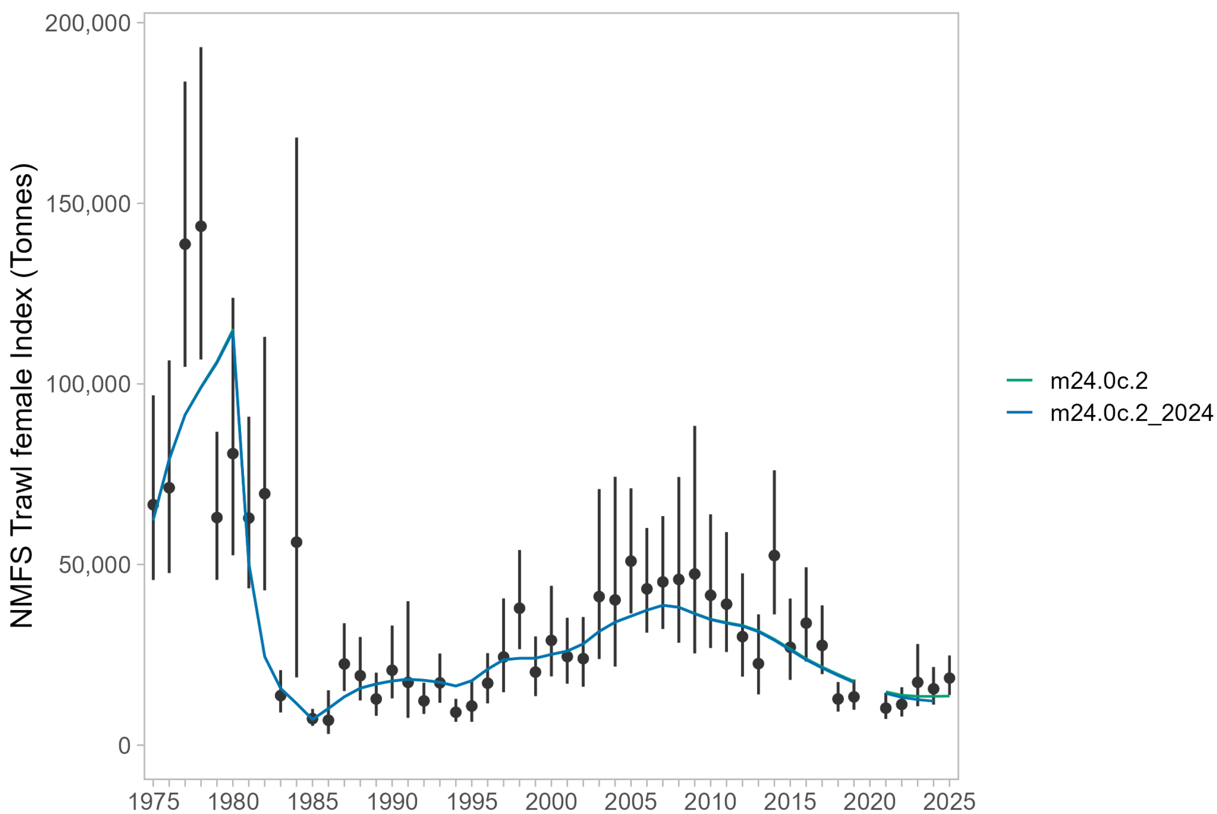

Figure 18: Comparisons of area-swept estimates of total female NMFS survey biomass and model prediction for model estimates in 2025 under model 24.0c.2, for 2024 and 2025. The error bars are plus and minus 2 standard deviations.

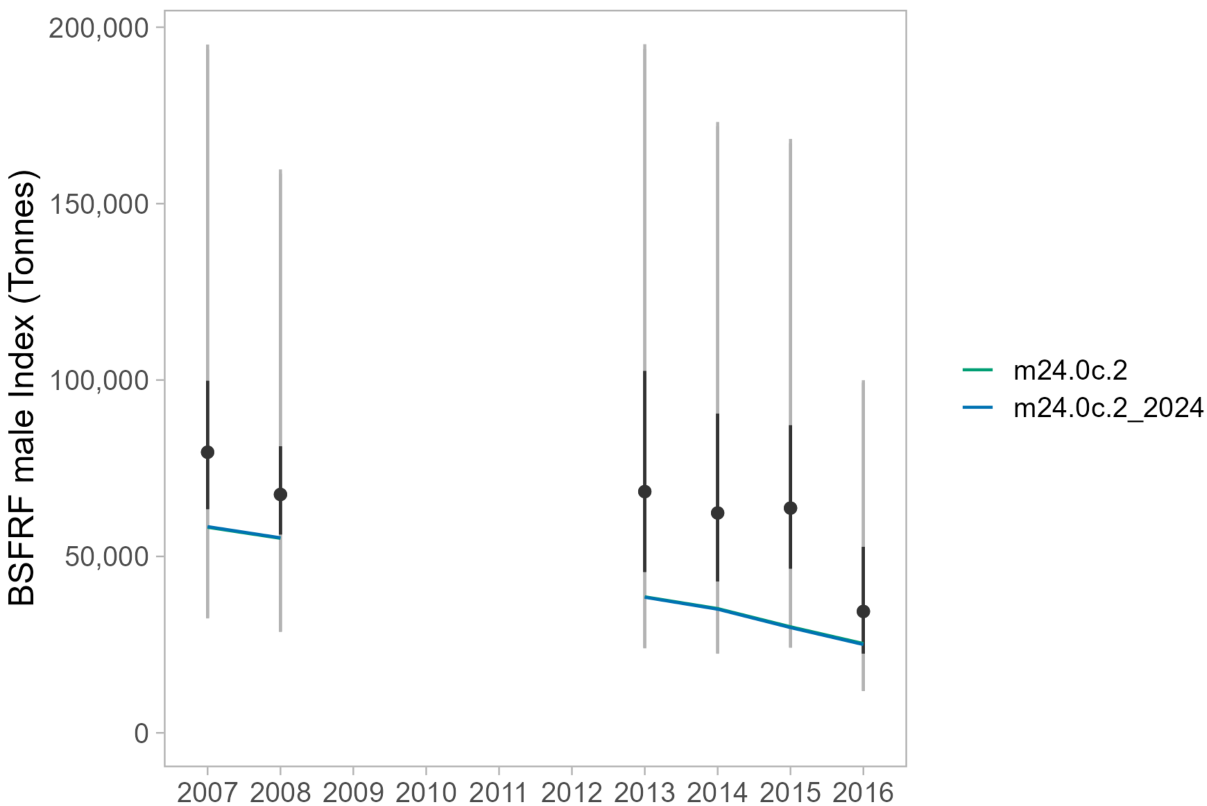

Figure 19: Comparisons of survey biomass estimates for males from the BSFRF survey and model prediction for model estimates in 2025 (model 24.0c.2, for 2024 and 2025). The error bars are plus and minus 2 standard deviations of model 24.0c.2. The BSFRF survey catchability is assumed to be 1.0 for all models.

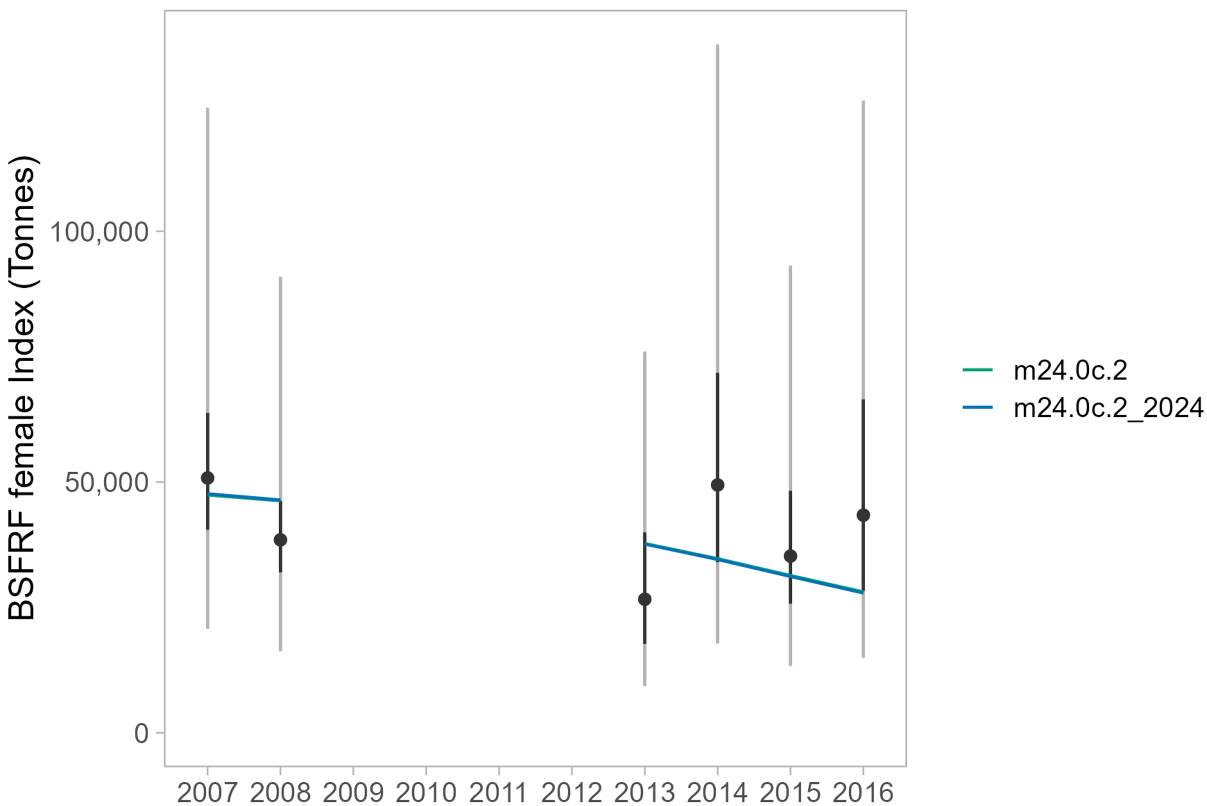

Figure 20: Comparisons of survey biomass estimates for females from the BSFRF survey and model prediction for model estimates in 2025 (model 24.0c.2, for 2024 and 2025). The error bars are plus and minus 2 standard deviations of model 24.0c.2. The BSFRF survey catchability is assumed to be 1.0 for all models.

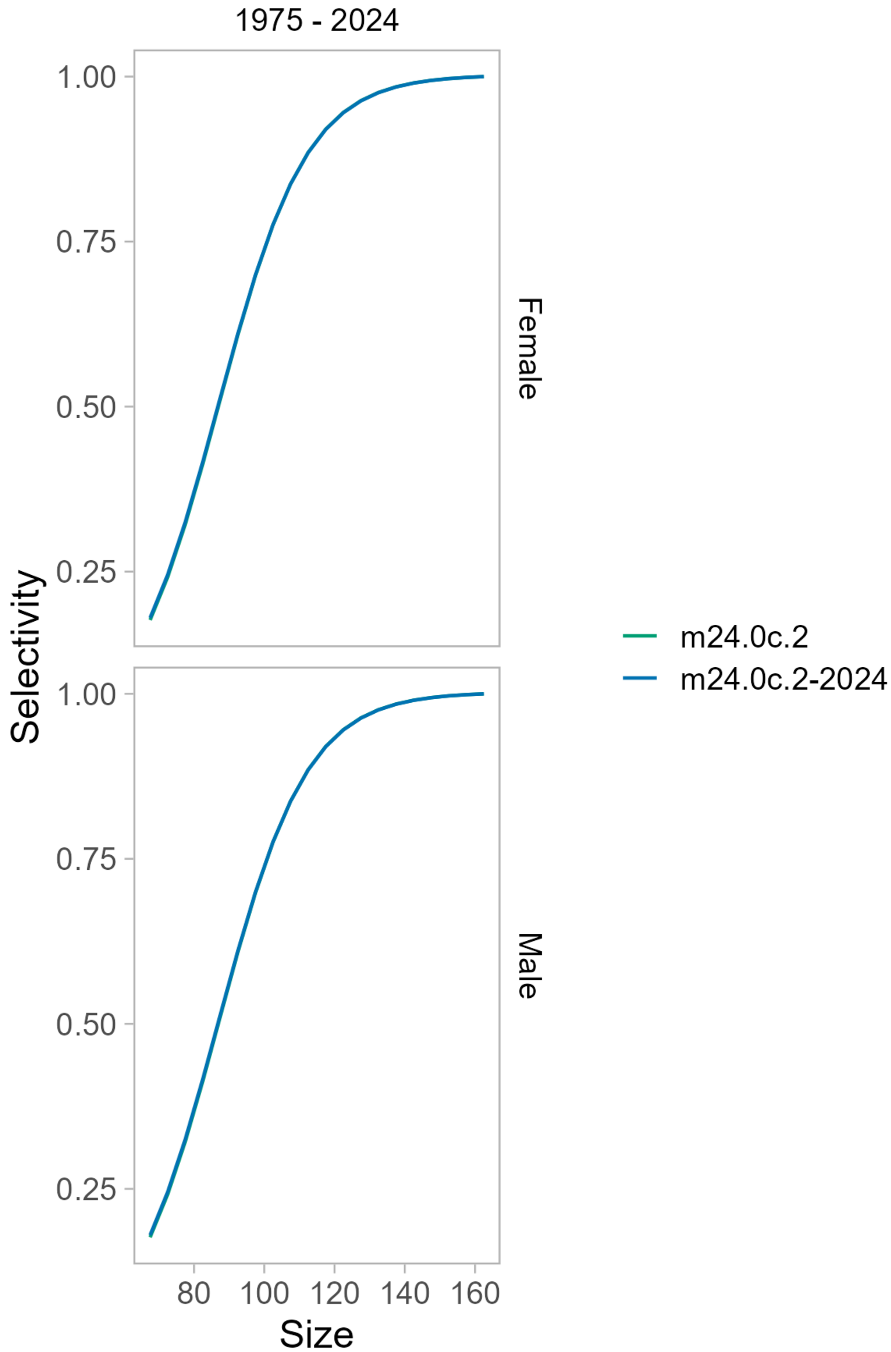

Figure 21: Estimated BSFRF trawl survey selectivities under model 24.0c.2, for 2024 and 2025.

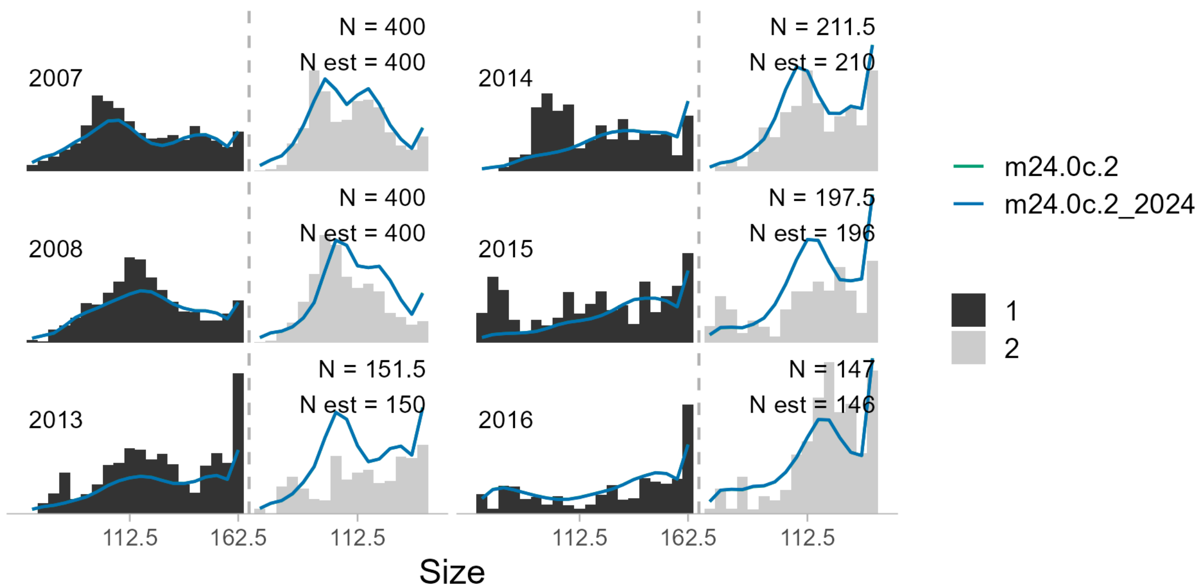

Figure 22: Comparisons of length compositions for males (1) and females (2) for the BSFRF survey and the model estimates during 2007-2008 and 2013-2016 for model 24.0c.2.

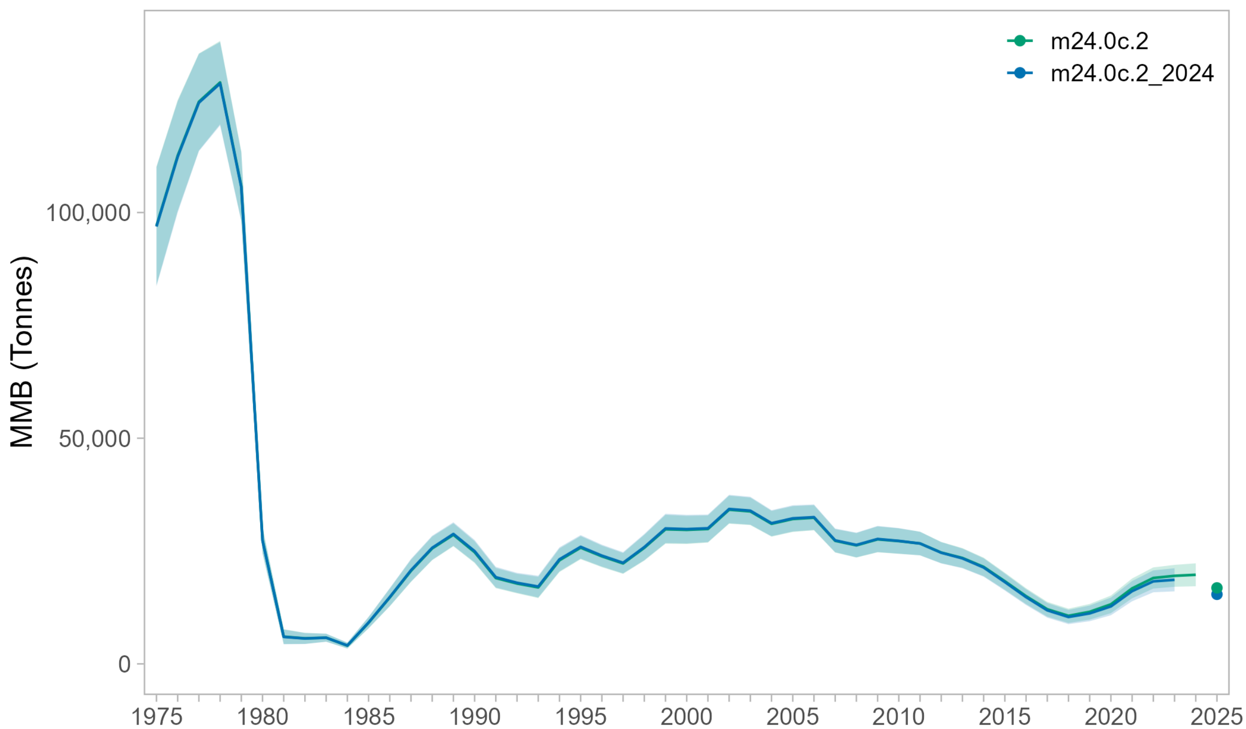

Figure 23: Estimated absolute mature male biomasses during 1975-2025 for model 24.0c.2, for 2024 and 2025. Mature male biomass is estimated on Feb. 15, year+1.

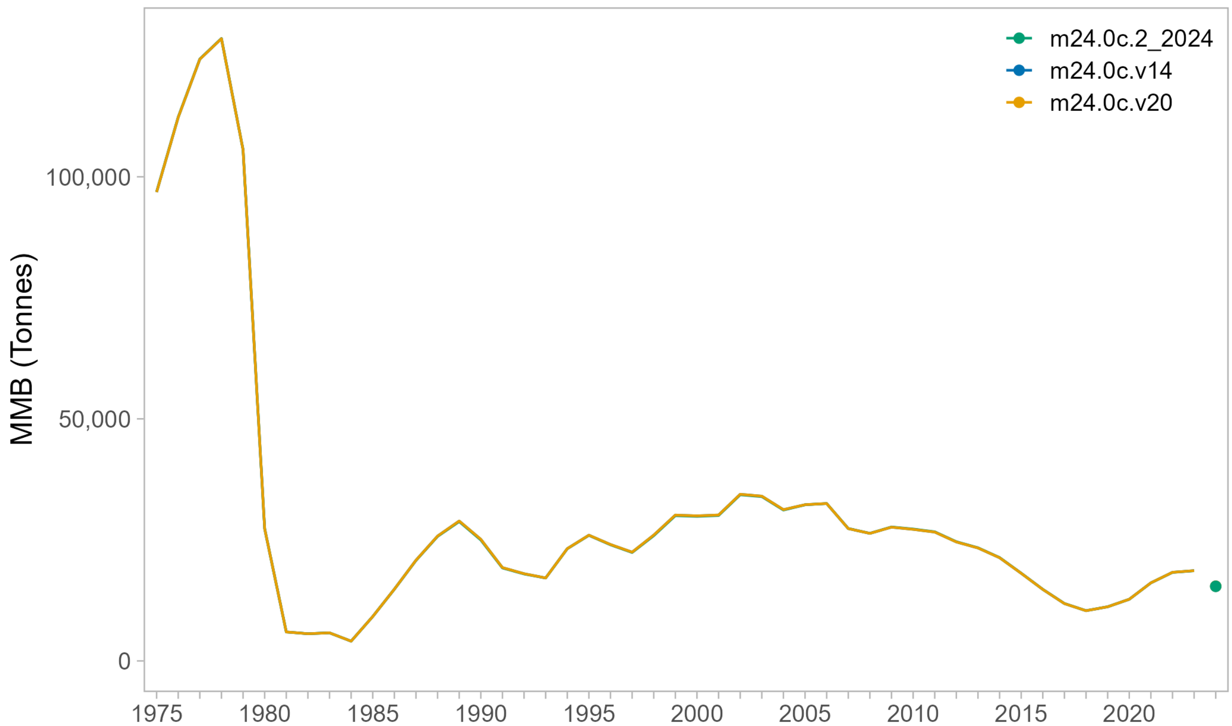

Figure 24: Estimated absolute mature male biomasses during 1975-2024 for models 24.0c (GMACS versions 14 and 20) and model 24.0c.2. Mature male biomass is estimated on Feb. 15, year+1.

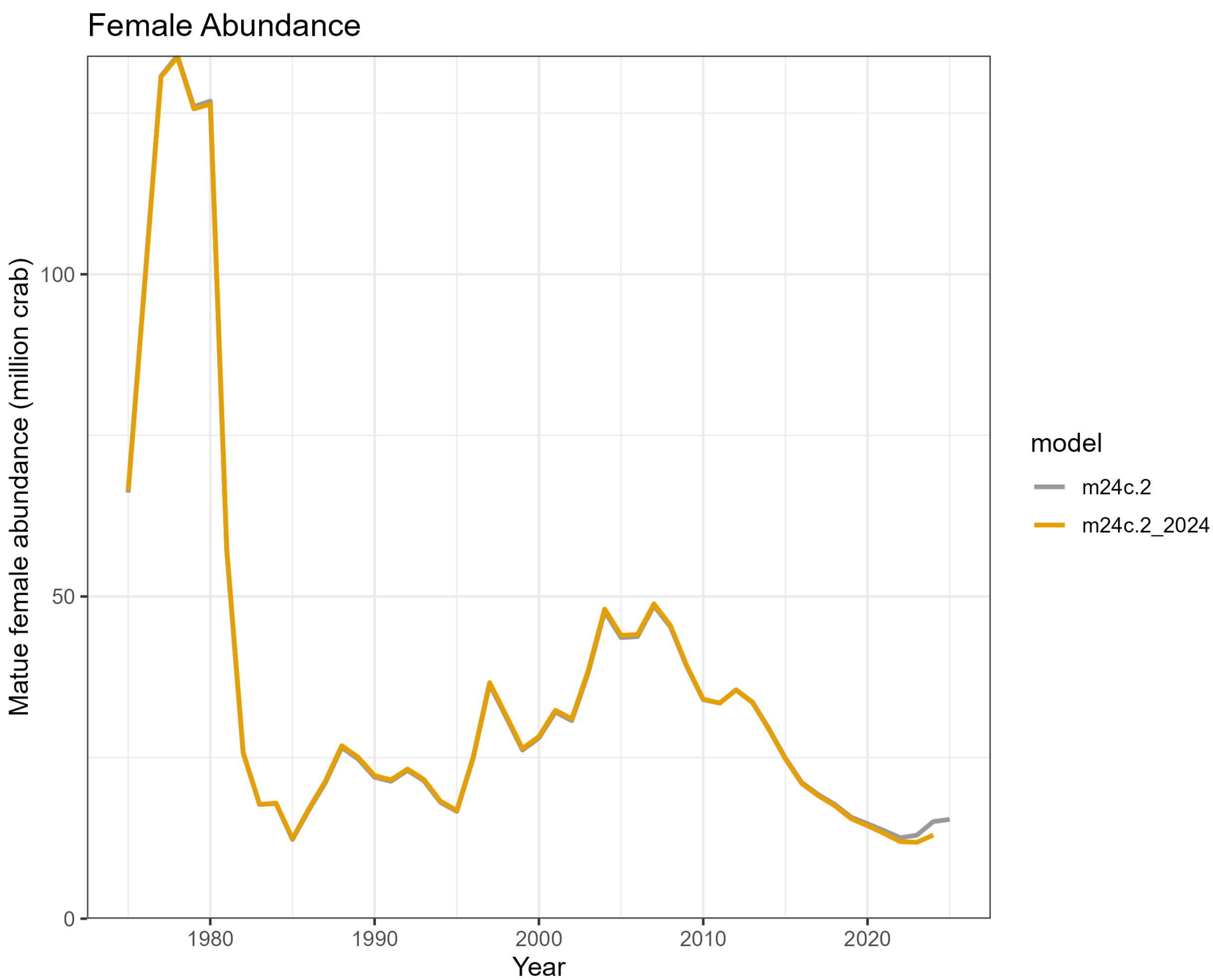

Figure 25: Estimated absolute mature female abundance during 1985-2025 for model 24.0c.2 (2024 and 2025).

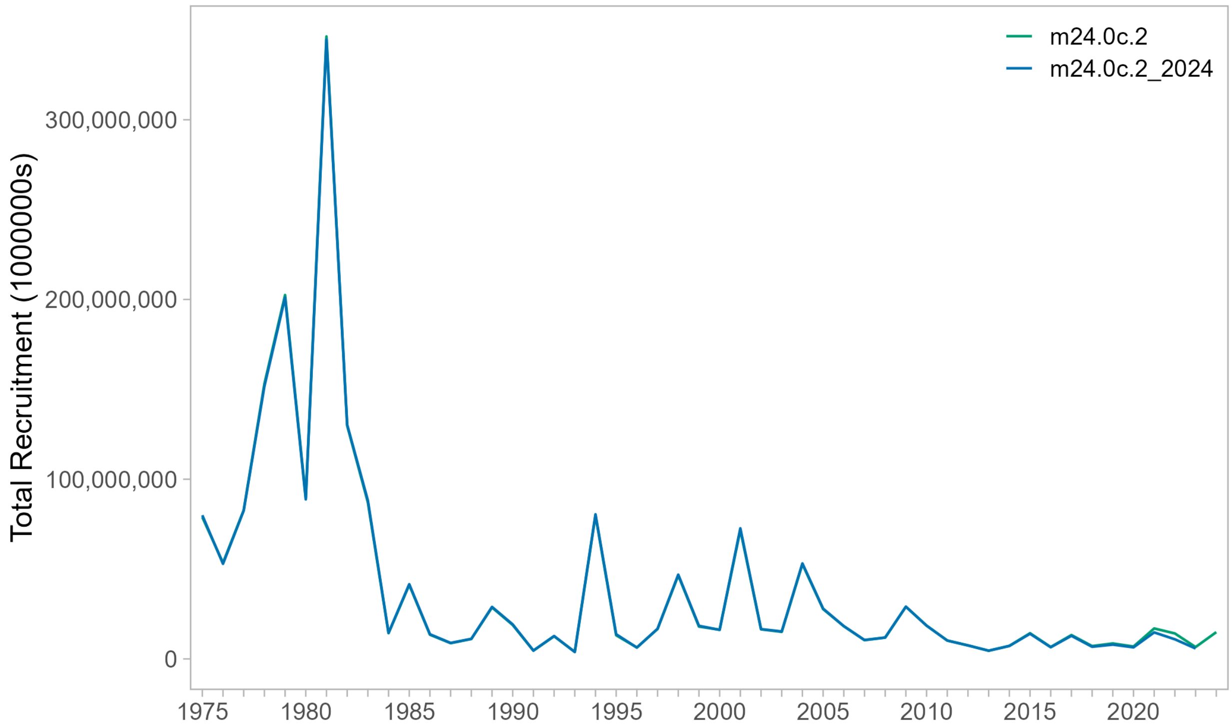

Figure 26: Estimated total (male and female) recruitment time series during 1976-2024 for model m24.0c.2, for both 2024 and 2025. Mean male recruits during 1984-2024 was used to estimate B35. Recruitment estimates in the terminal year (2025) are unreliable.

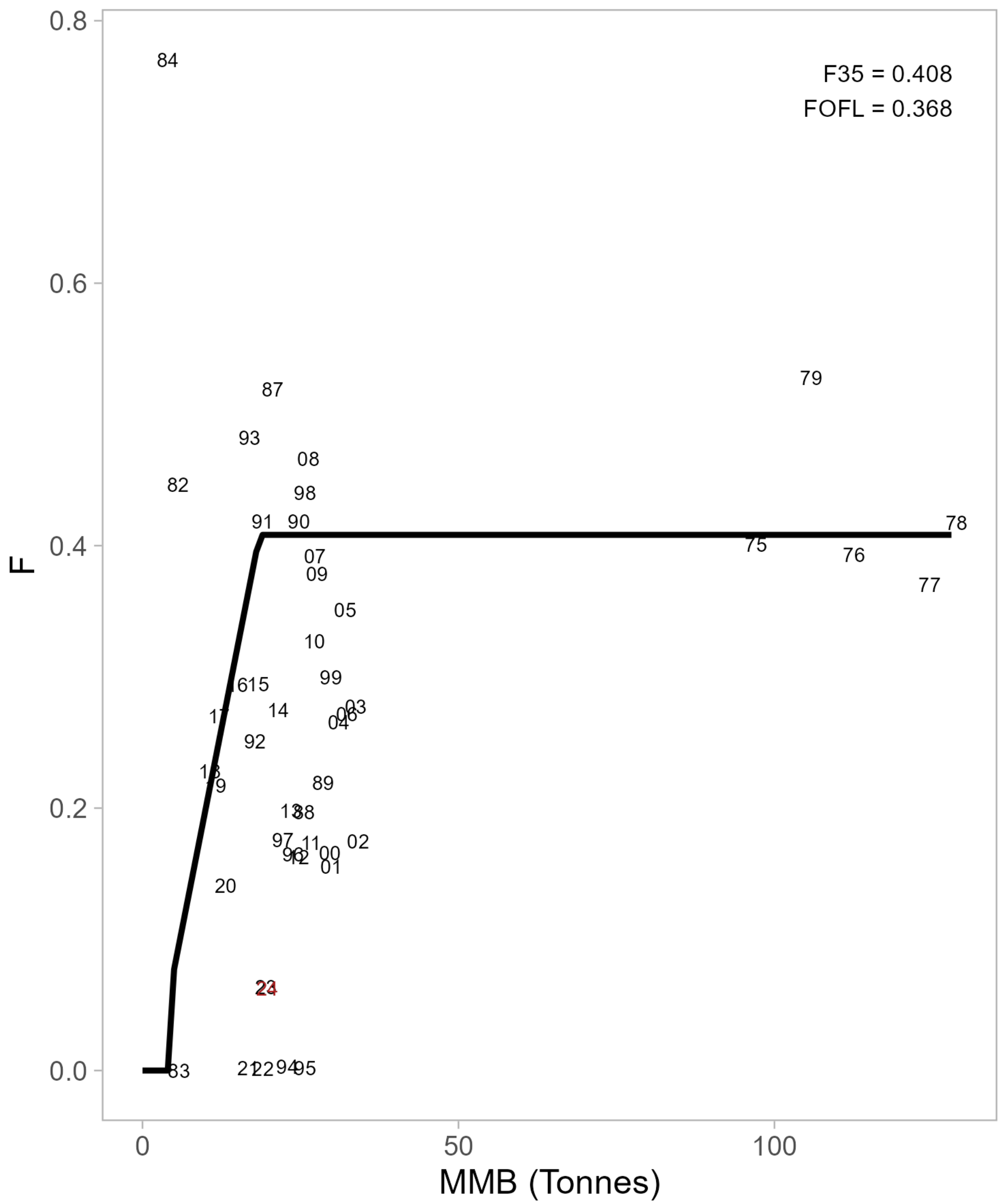

Figure 27: Relationships between full fishing mortalities for the directed pot fishery and mature male biomass on Feb. 15 during 1975-2024 under model 24.0c.2. Average of recruitment from 1984 to 2024 was used to estimate B35.

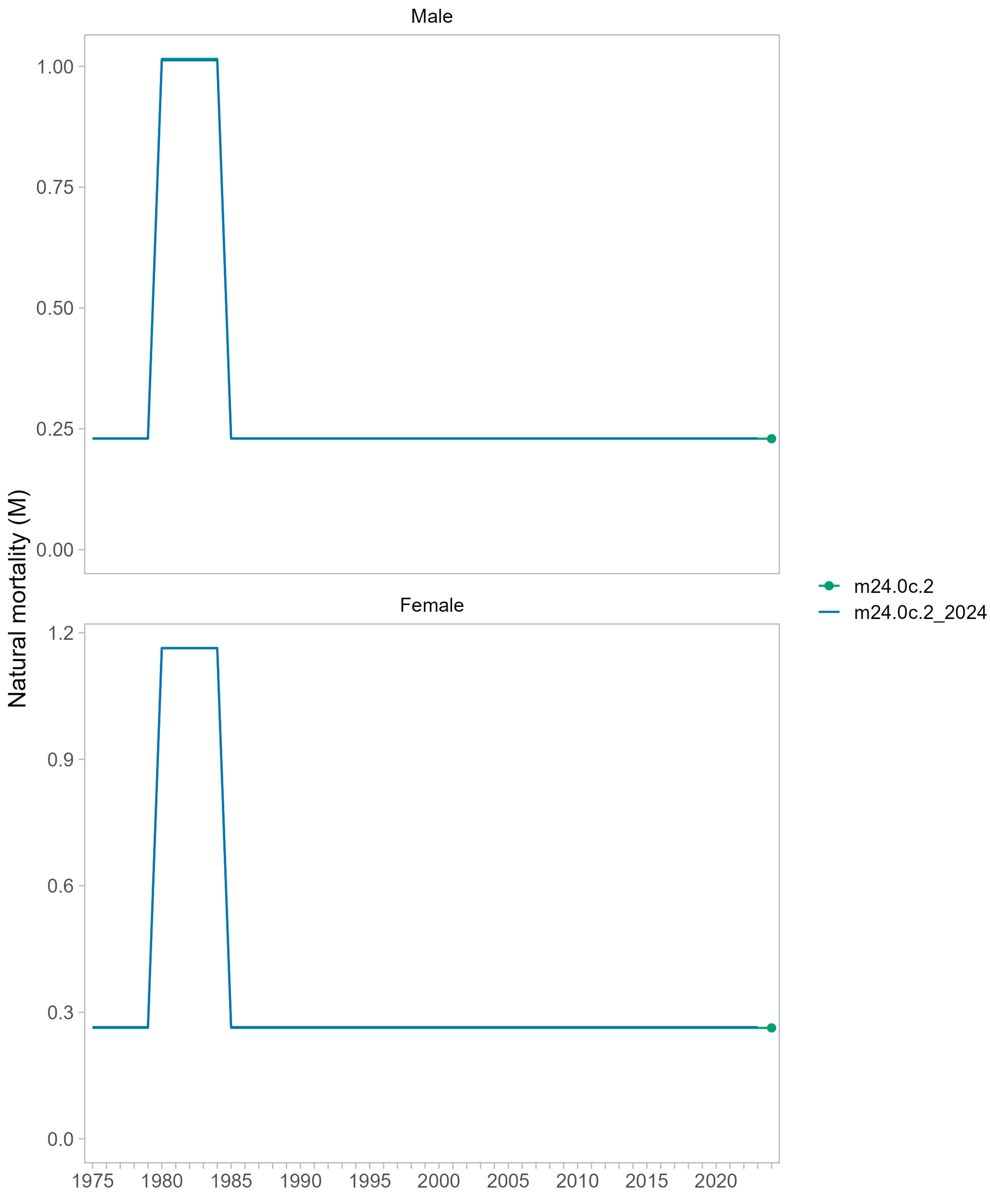

Figure 28: Comparison of estimated natural mortality for model 24.0c.2 (2024 and 2025).

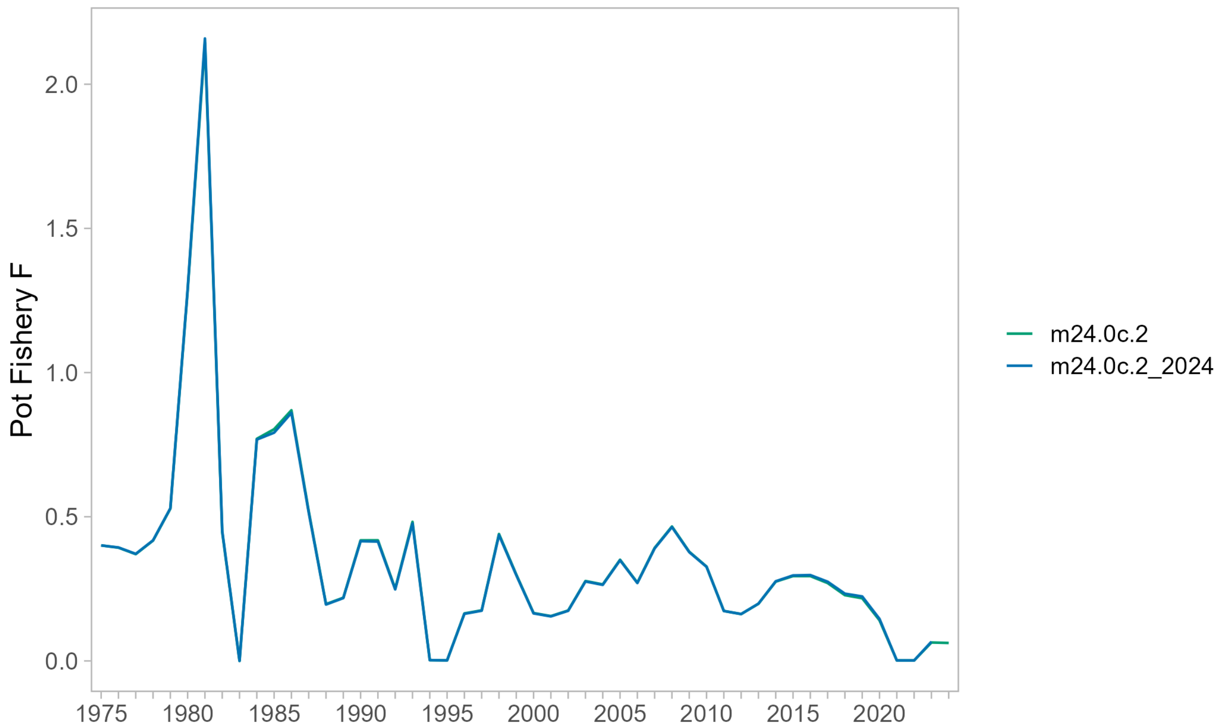

Figure 29: Comparison of estimated fishing mortality for the directed pot fishery for model 24.0c.2 (2024 and 2025).

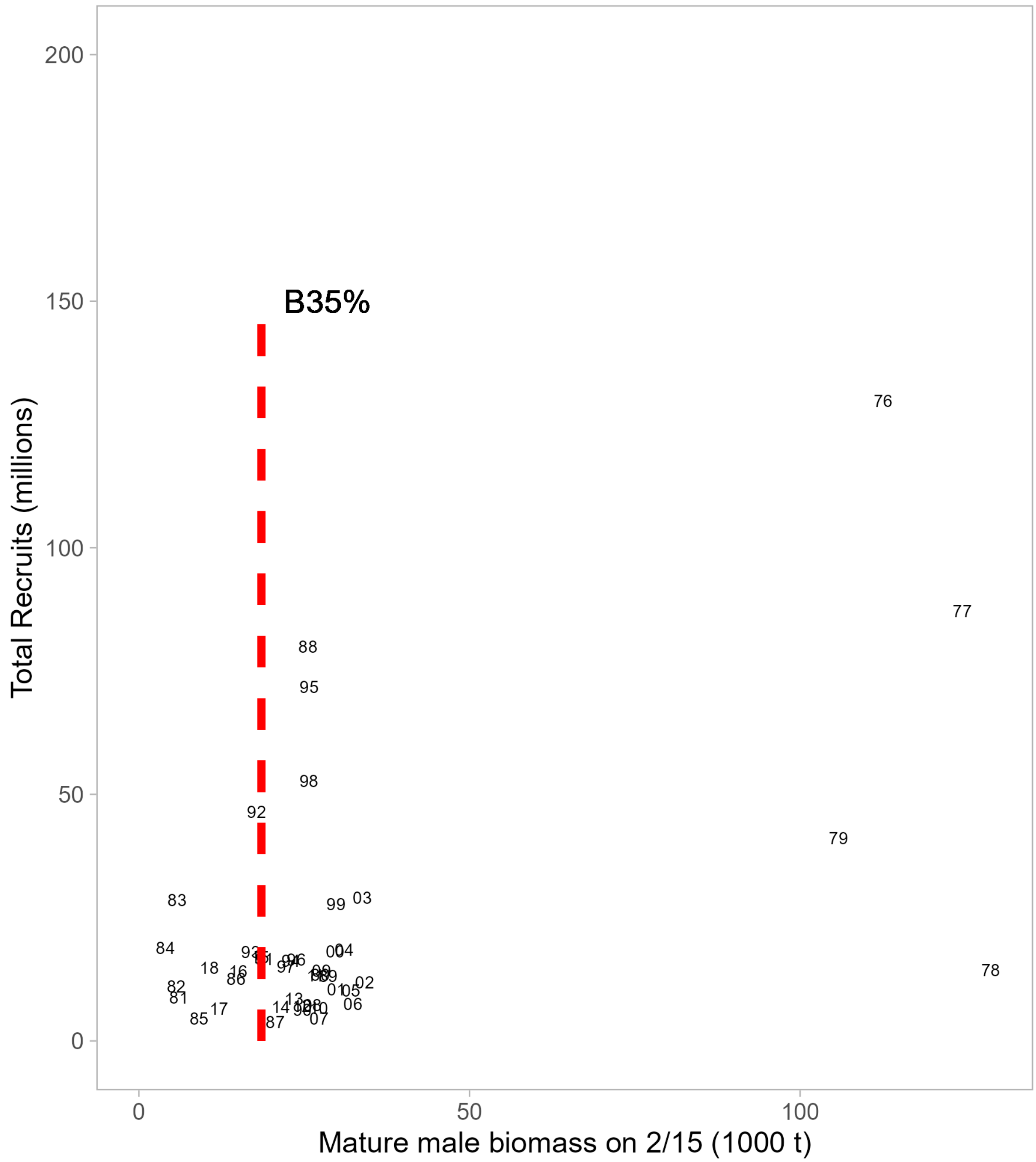

Figure 30: Relationships between mature male biomass on Feb. 15 and total recruits at age 5 (i.e., 6 year time lag) for Bristol Bay red king crab under model 24.0c.2. Numerical labels are years of mating, and the vertical dotted line is the estimated B35 based on the mean recruitment level during 1984 to 2024.

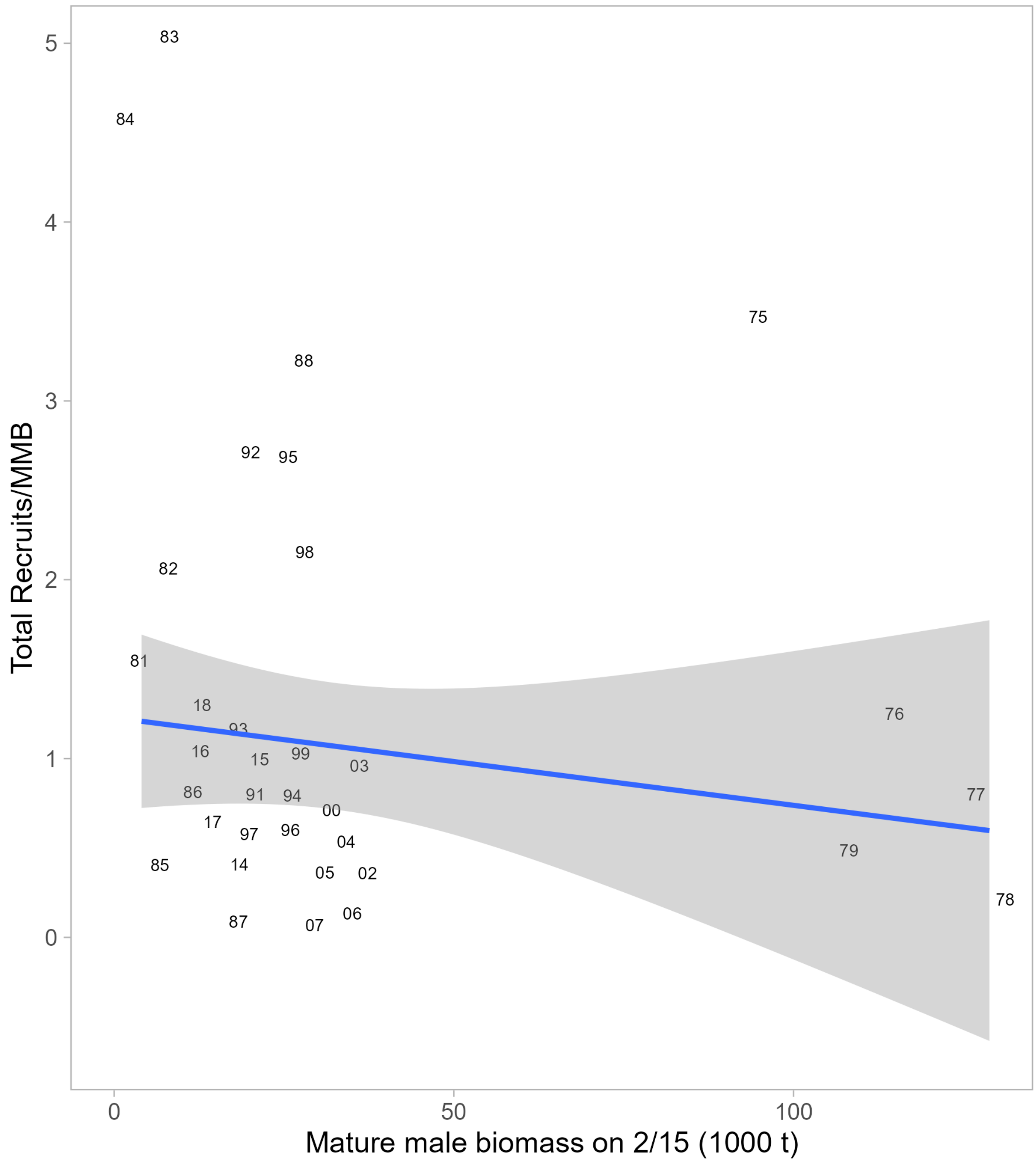

Figure 31: Relationships between recruitment per mature male biomass and mature male biomass on Feb. 15 for Bristol Bay red king crab under model 24.0c.2. Numerical labels are years of mating, and the line is the regression line for data of 1978-2018.

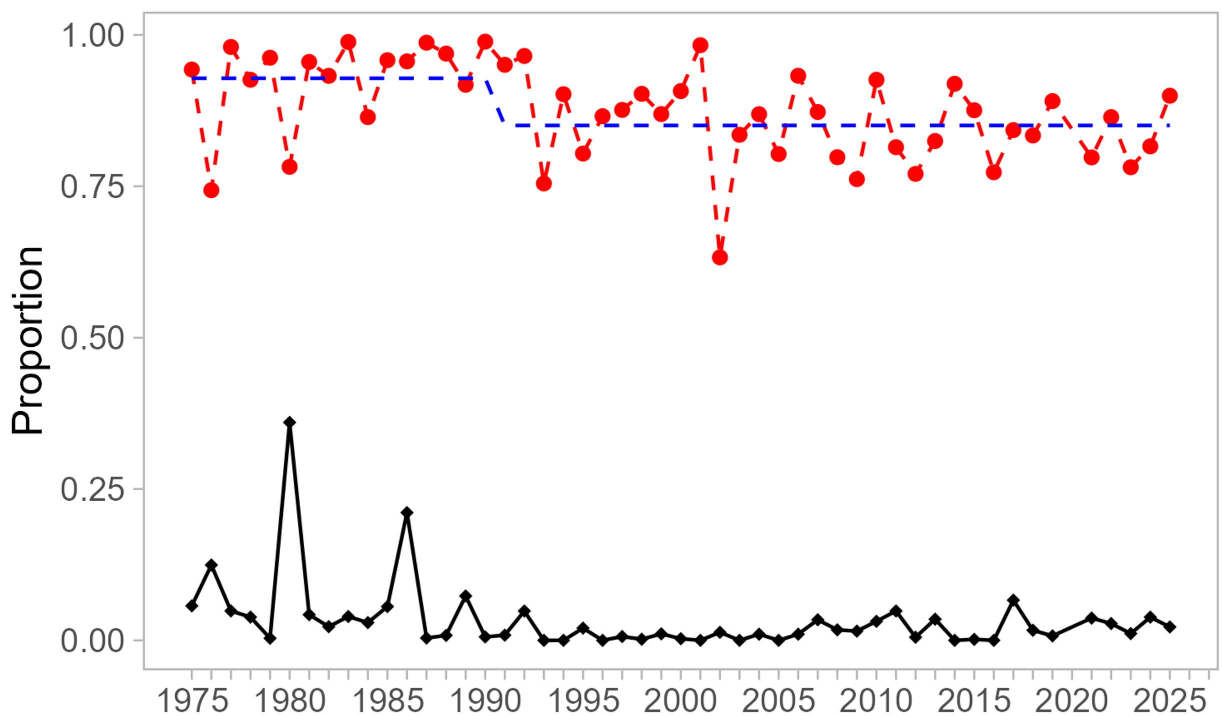

Figure 32: Average clutch fullness and proportion of empty clutches of newshell (shell conditions 1 and 2) mature female crab >89 mm CL from 1975 to 2025 from survey data. Oldshell females were excluded. The blue dashed line is the mean clutch fullness during two periods before 1992 and after 1991.

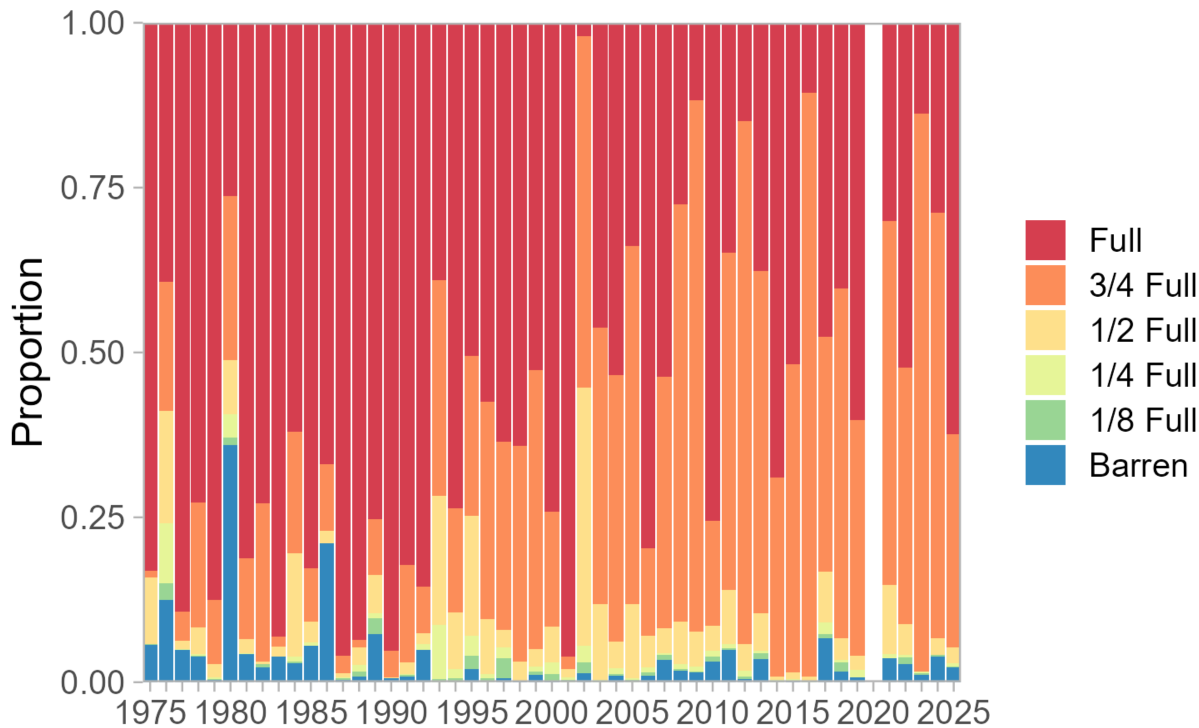

Figure 33: Clutch fullness distribution of newshell (shell conditions 1 and 2) mature female crab >89 mm CL from 1975 to 2025 from survey data. Oldshell females were excluded.

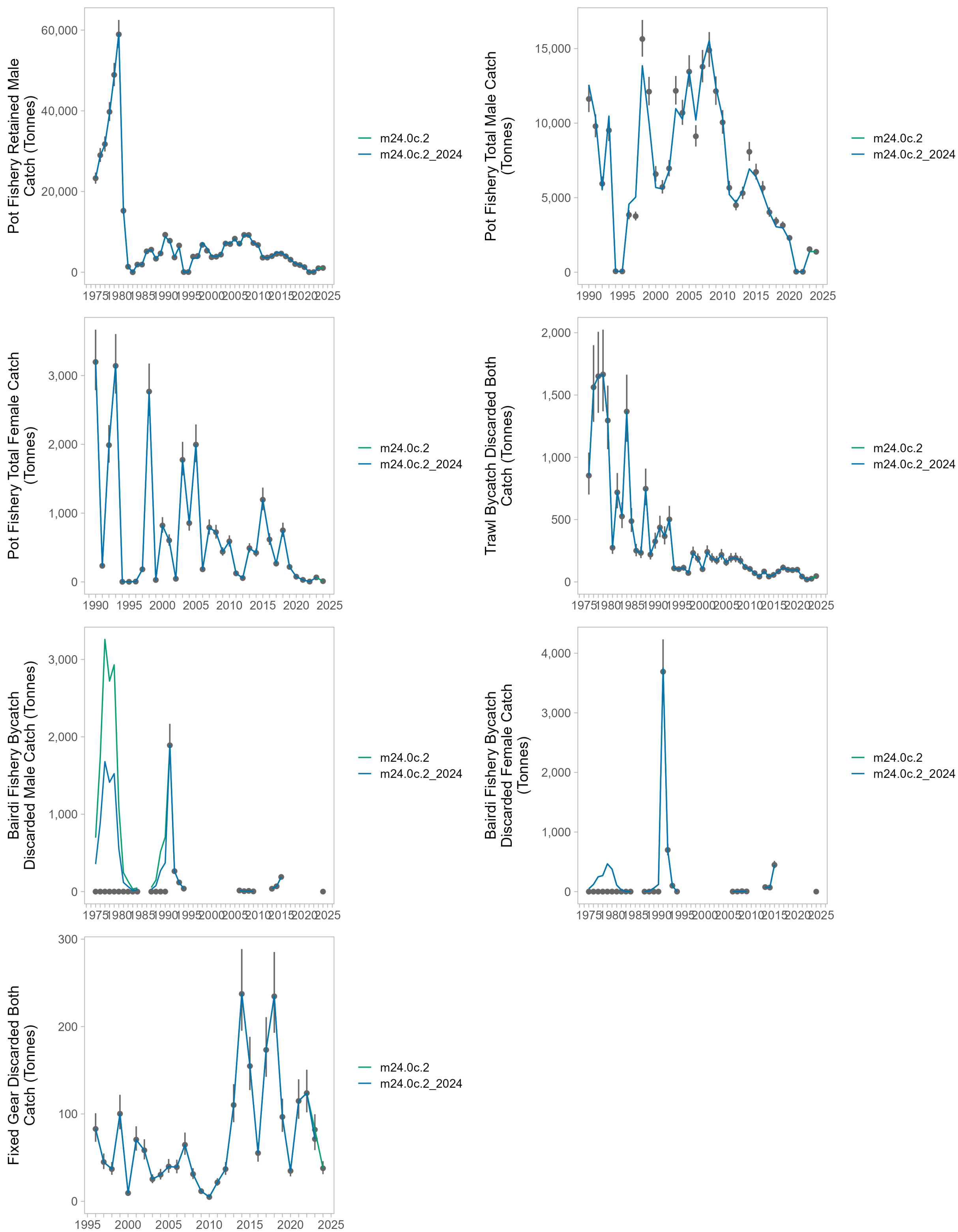

Figure 34: Observed (dots) and predicted (lines) RKC catch and bycatch biomass under model 24.0c.2, 2024 and 2025. Note that model fit for Tanner crab fishery bycatch reflects utilizing effort data for extrapolation to bycatch in the early part of the time series.

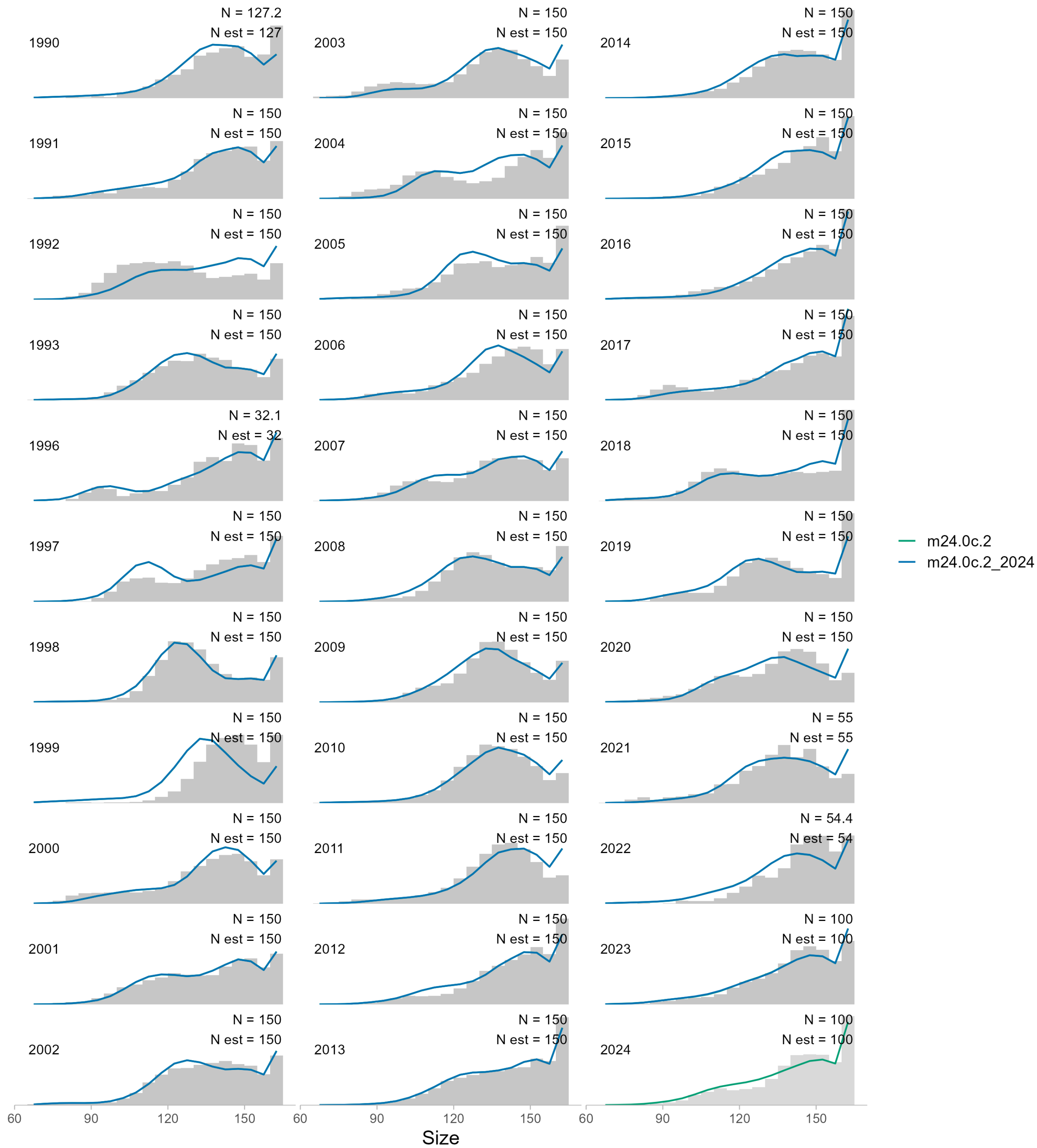

Figure 35: Observed and model estimated total observer length-frequencies of male BBRKC by year in the directed pot fishery for model 24.0c.2.

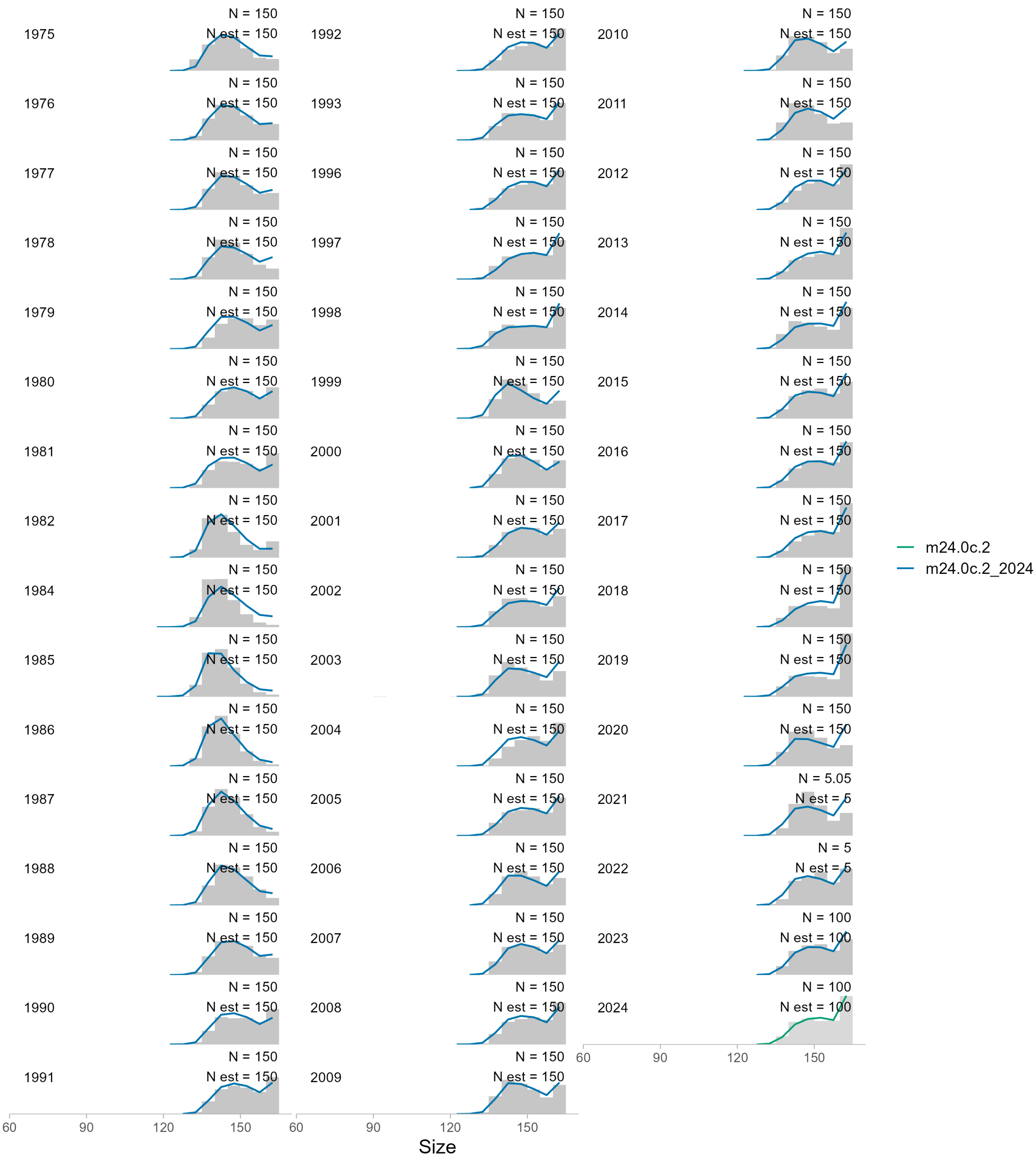

Figure 36: Observed and model estimated length-frequencies of male BBRKC by year retained in the directed pot fishery for model 24.0c.2.

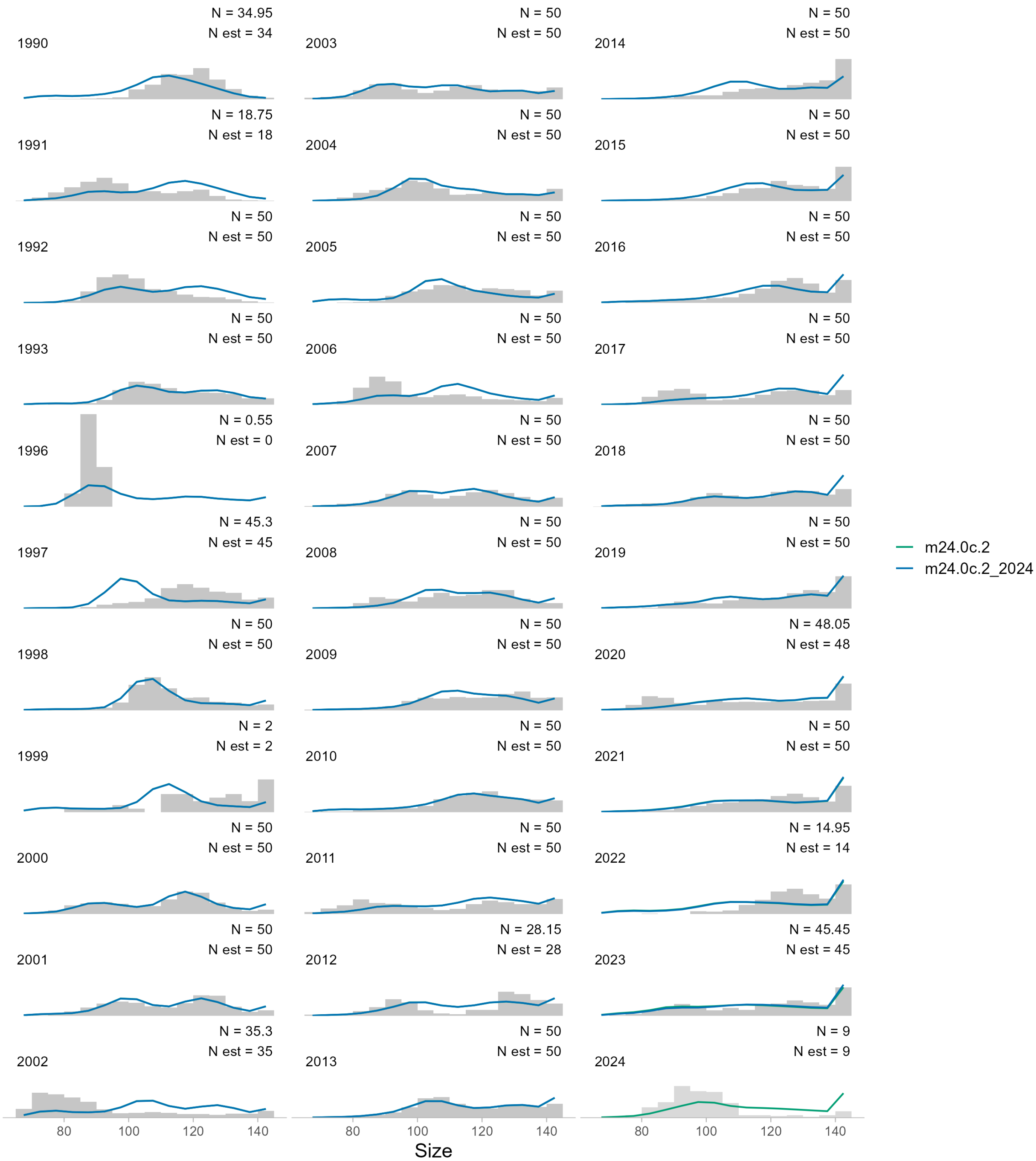

Figure 37: Observed and model estimated total observer length-frequencies of discarded female BBRKC by year in the directed pot fishery for model 24.0c.2.

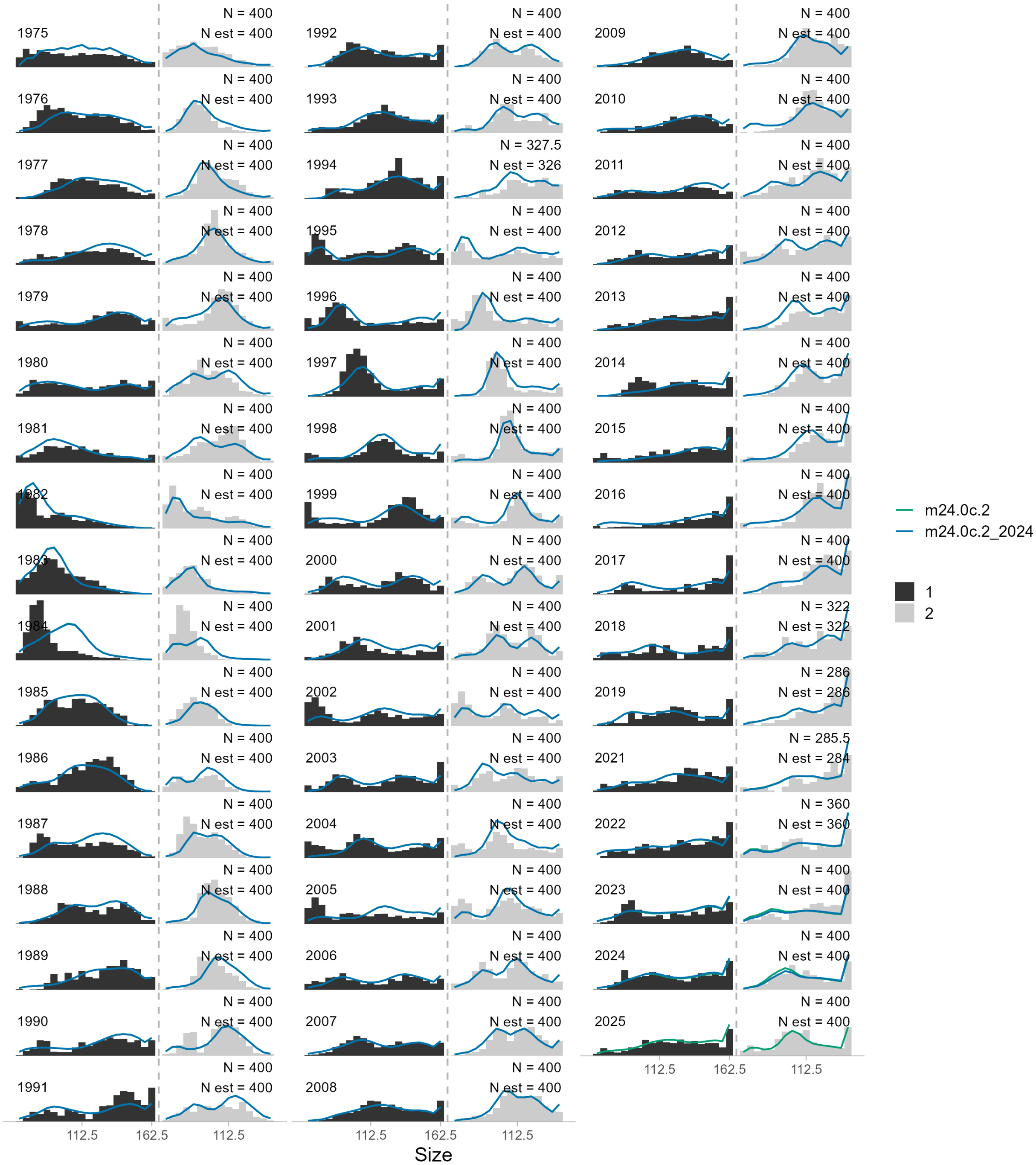

Figure 38: Comparison of area-swept and model estimated NMFS survey length frequencies of Bristol Bay male (black) and female (gray) red king crab by year for model 24.0c.2.

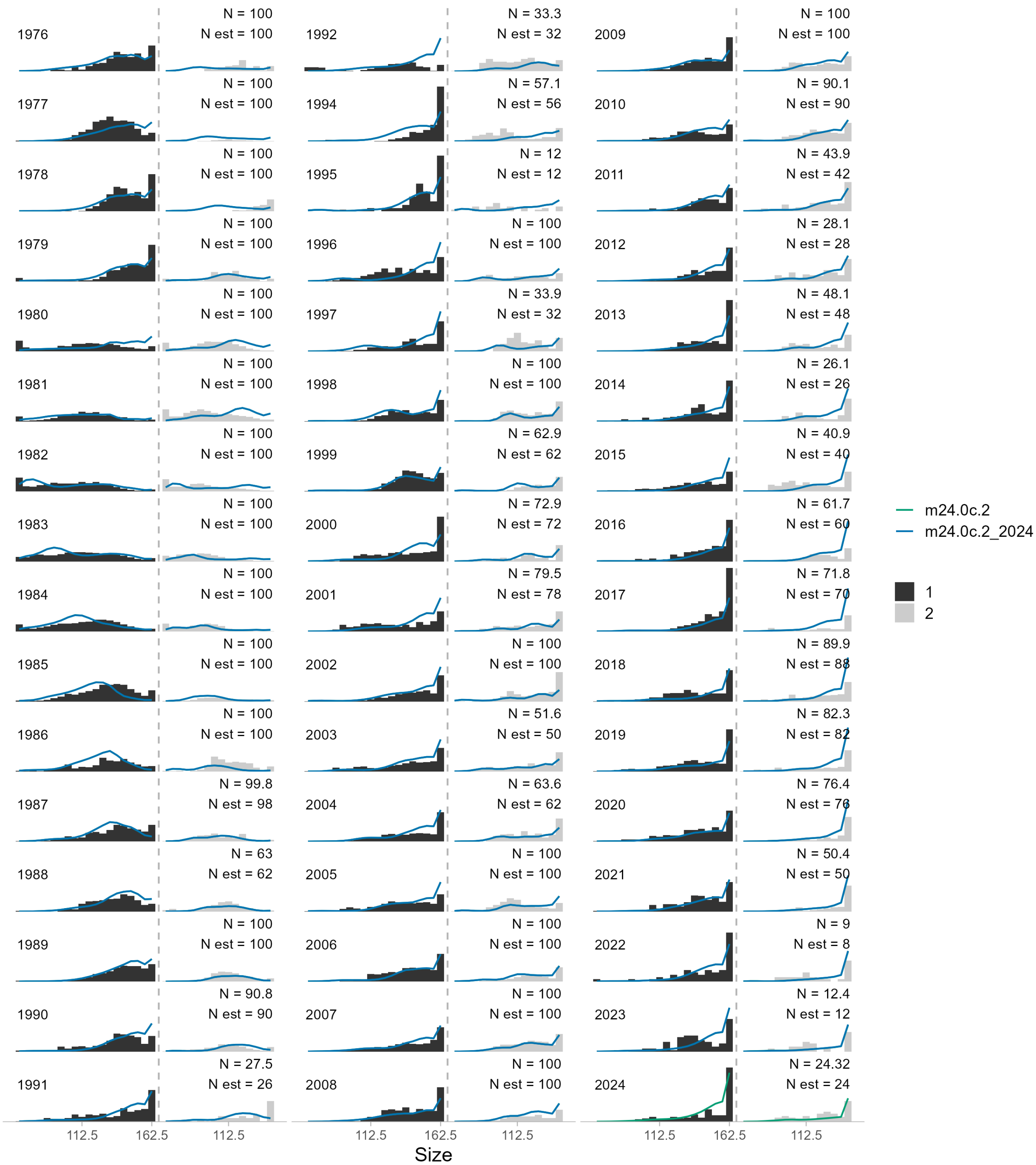

Figure 39: Comparison of observer and model estimated discarded length frequencies of Bristol Bay male (black) and female (gray) red king crab by year in the groundfish trawl fisheries bycatch for model 24.0c.2.

Figure 40: Comparison of observer and model estimated discarded length frequencies of Bristol Bay male (black) and female (gray) red king crab by year in the groundfish fixed gear fisheries bycatch for model 24.0c.2.

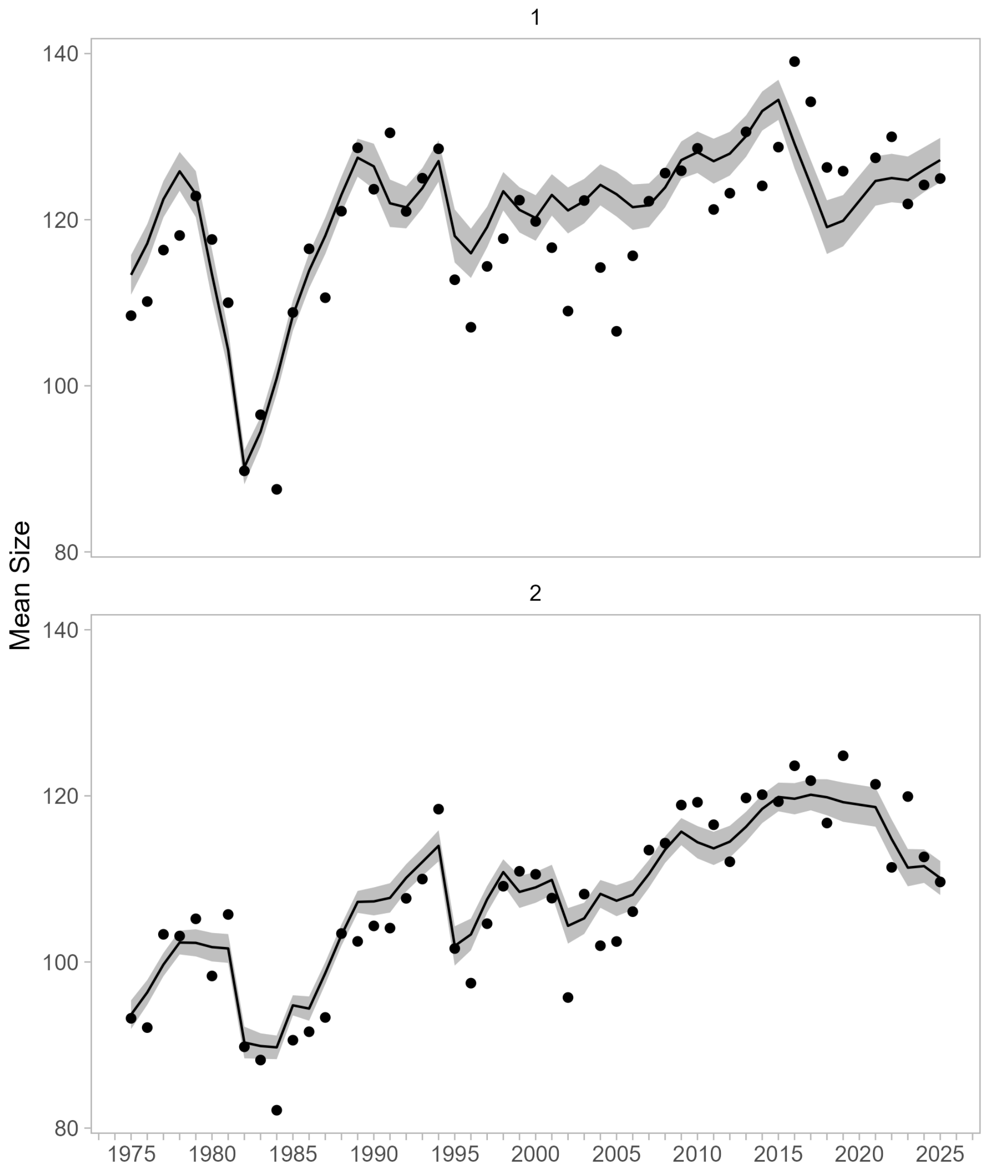

Figure 41: Mean size over all years for the NMFS survey for males (1) and females (2) under model 24.0c.2.

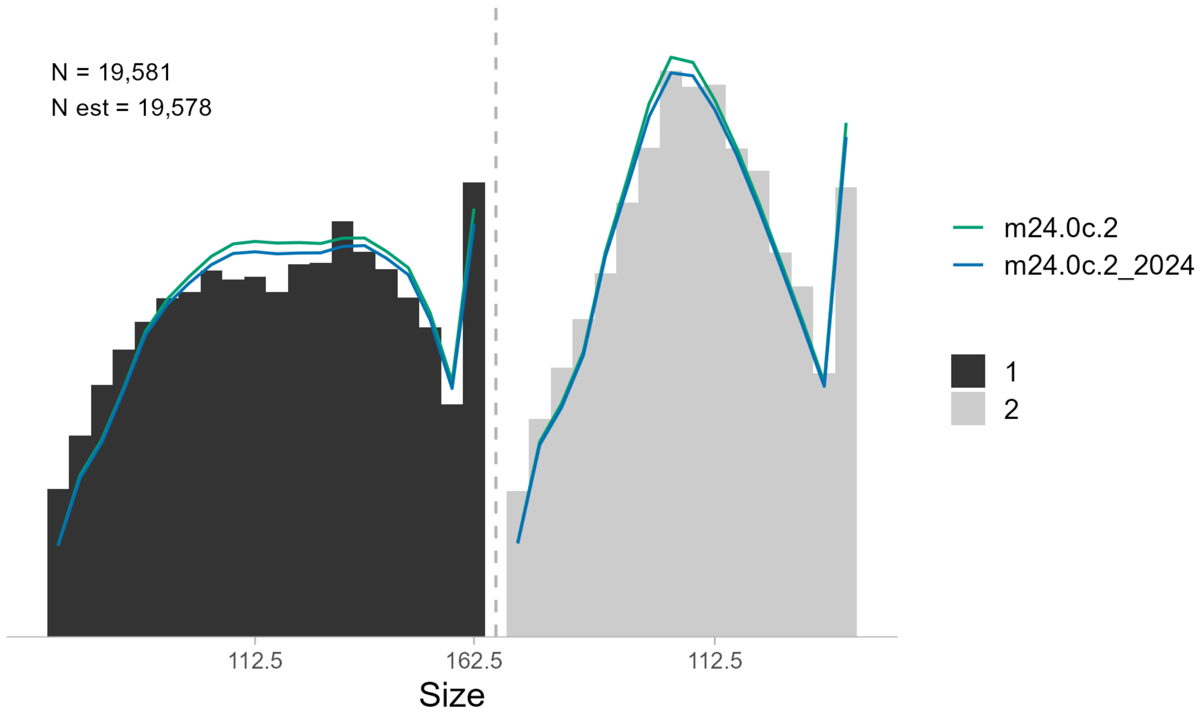

Figure 42: Aggregated size comps over all years for the NMFS survey for males (black) and females (grey) for model 24.0c.2.

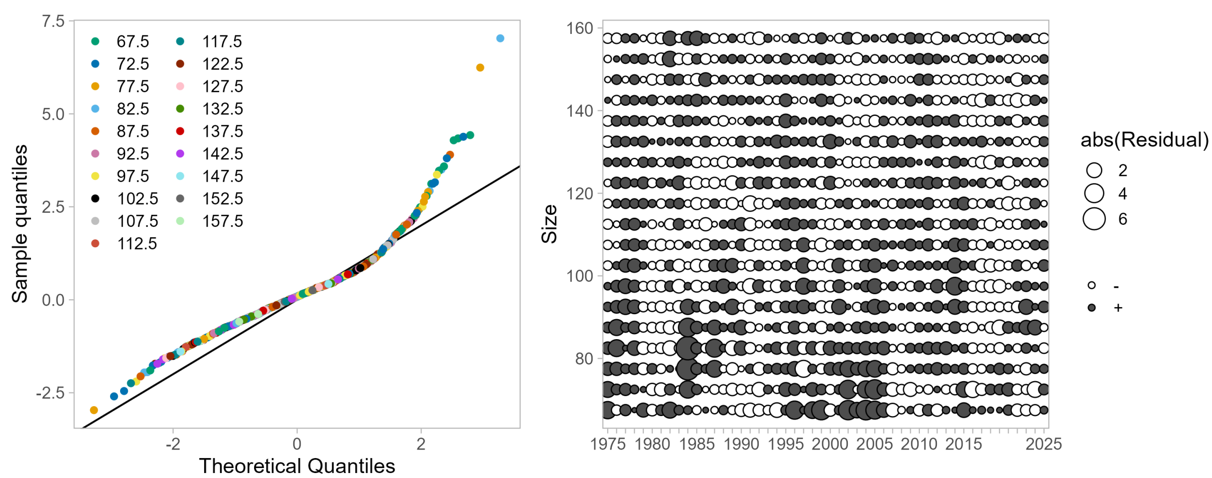

Figure 43: One-step-ahead residuals of size comps for males for the NMFS survey under model 24.0c.2 (updated base model based on 2024 accepted model).

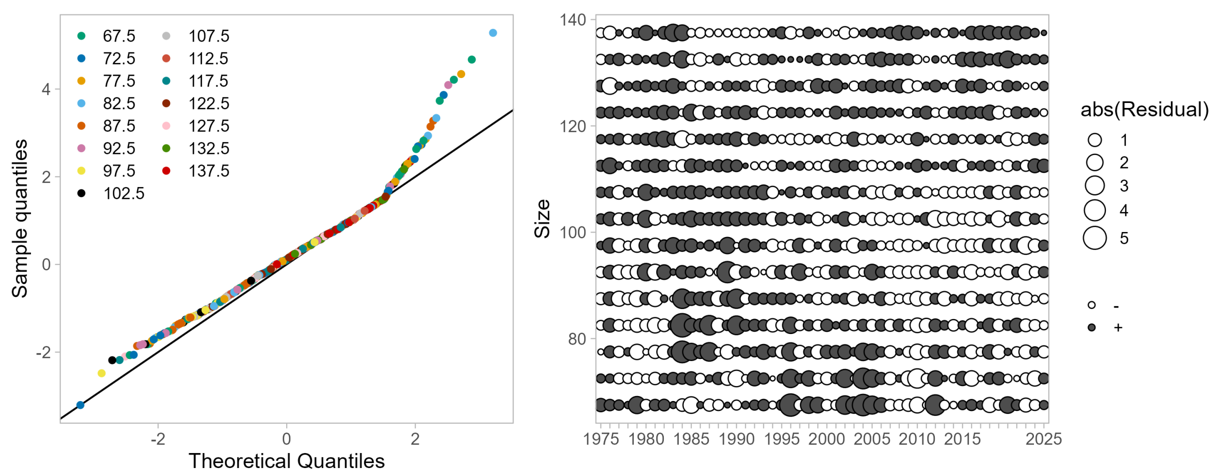

Figure 44: One-step-ahead residuals of size comps for females for the NMFS survey under model 24.0c.2 (updated base model based on 2024 accepted model).

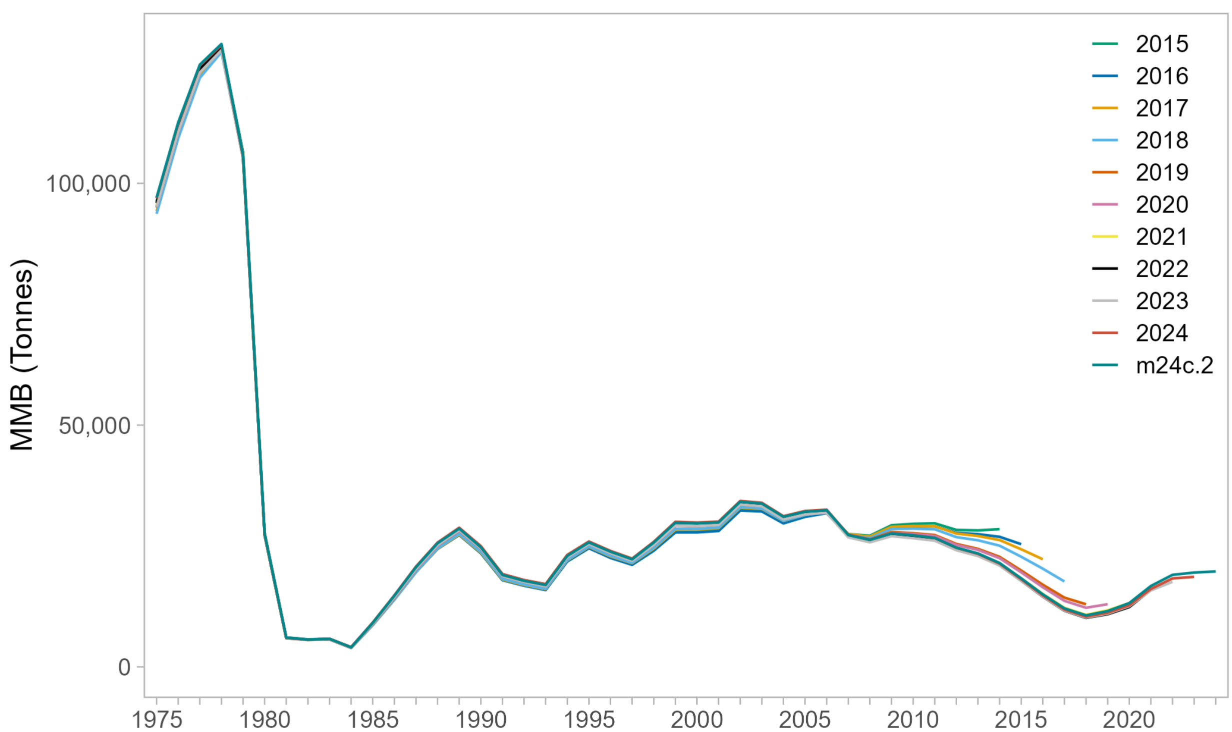

Figure 45: Comparison of retrospective estimates of mature male biomass on Feb. 15 of Bristol Bay red king crab with terminal years 2015-2025 using model 24.0c.2. These are results using the 2025 model (Mohn's rho = 0.1823). Legend shows the terminal year.

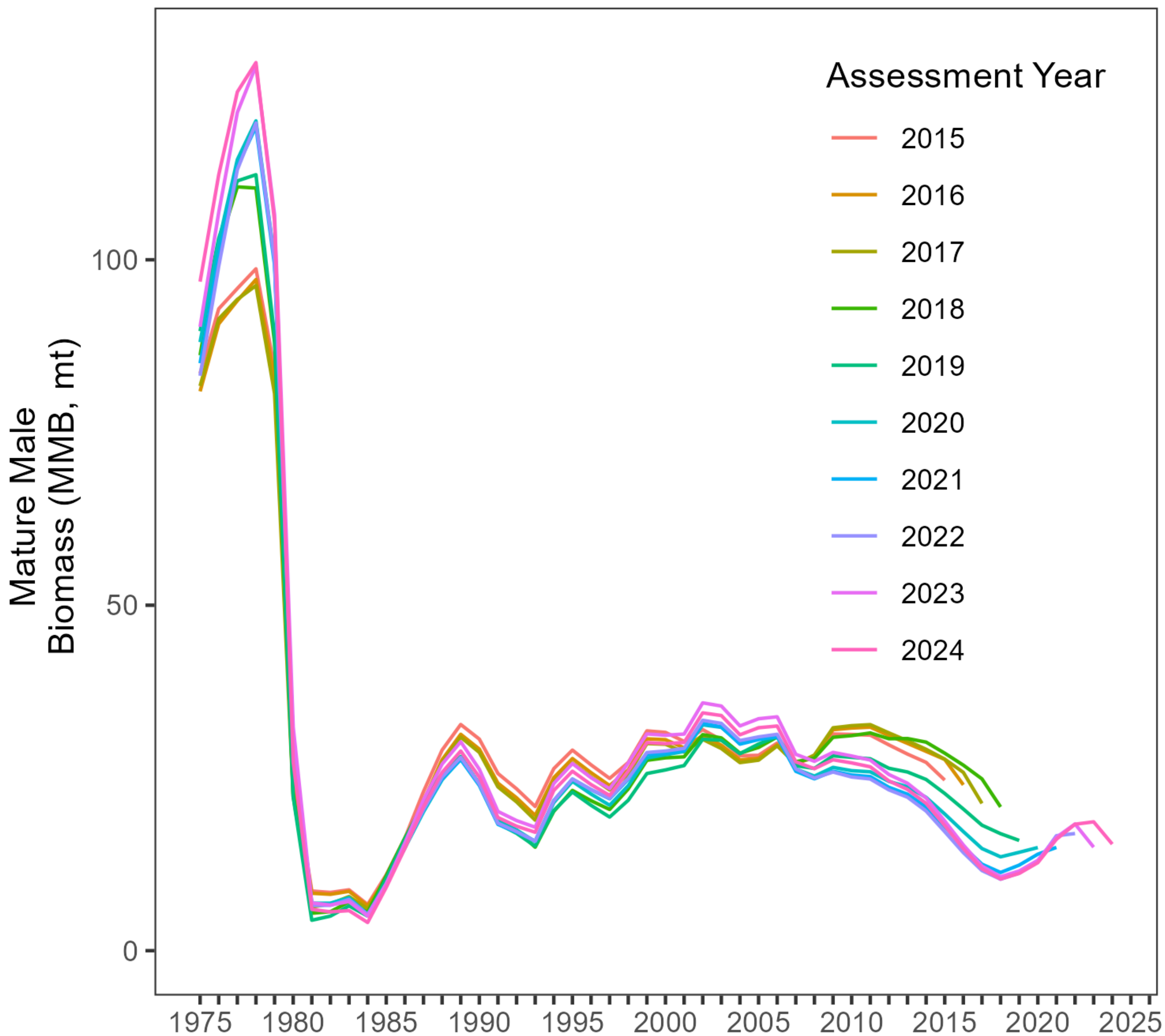

Figure 46: Comparison of historic estimates of mature male biomass on Feb. 15 of Bristol Bay red king crab with terminal years 2015-2024 using models selected in those years. Data was compiled from previously published SAFE documents reported MMB values for the chosen model for that assessment year. Legend shows the terminal assessment year.

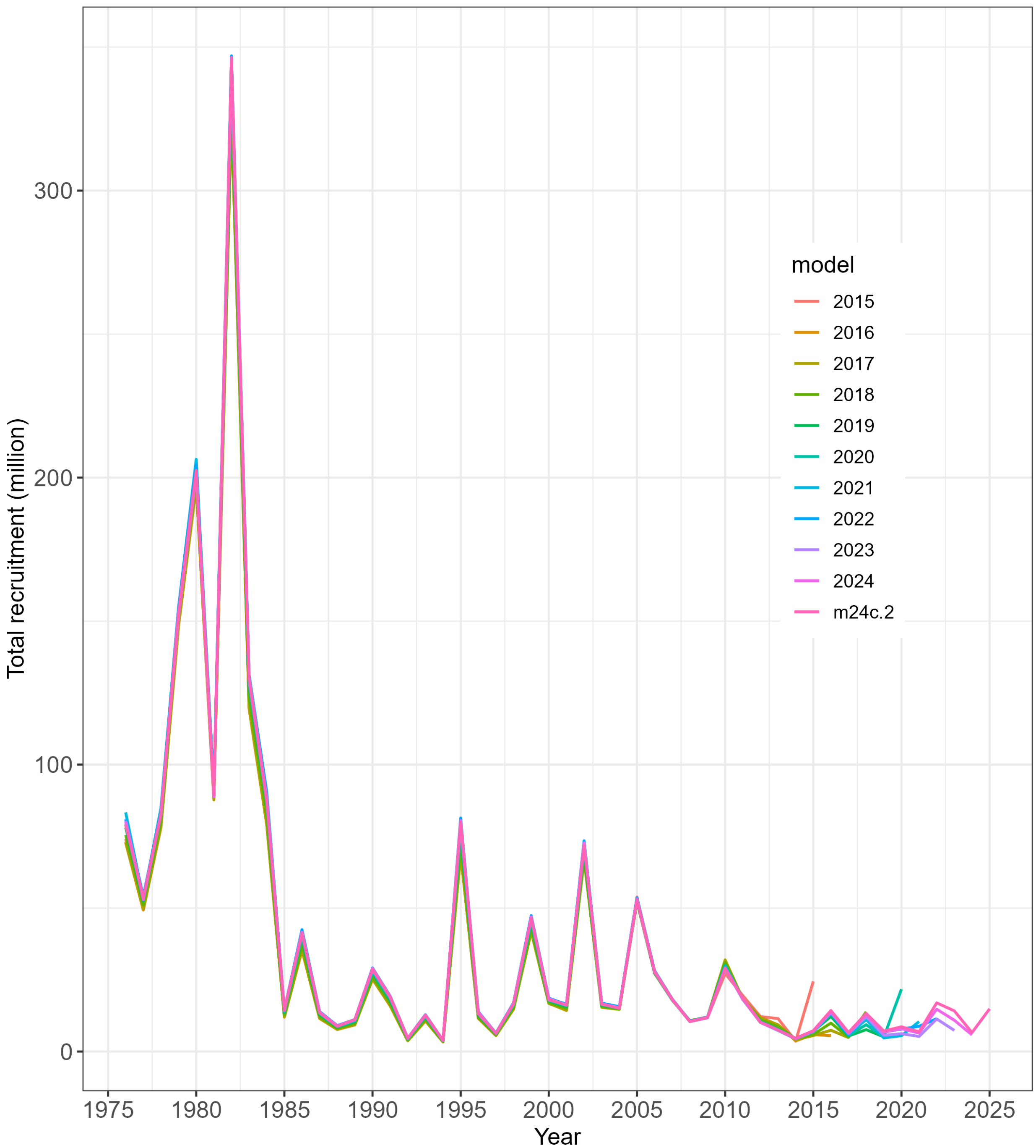

Figure 47: Comparison of retrospective estimates of total recruitment for model 24.0c.2 of Bristol Bay red king crab from 1976 to 2025 made with terminal years 2015-2025. Legend shows the terminal year.

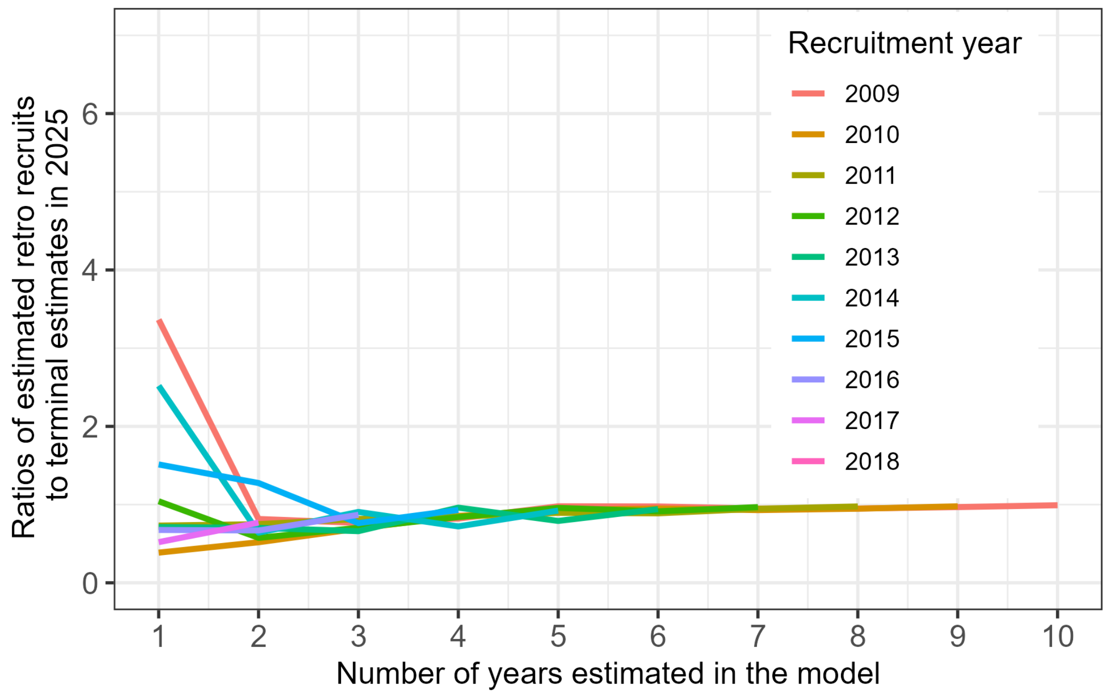

Figure 48: Evaluation of Bristol Bay red king crab retrospective errors on recruitment estimates as a function of the number of years in the model for model 24.0c.2.

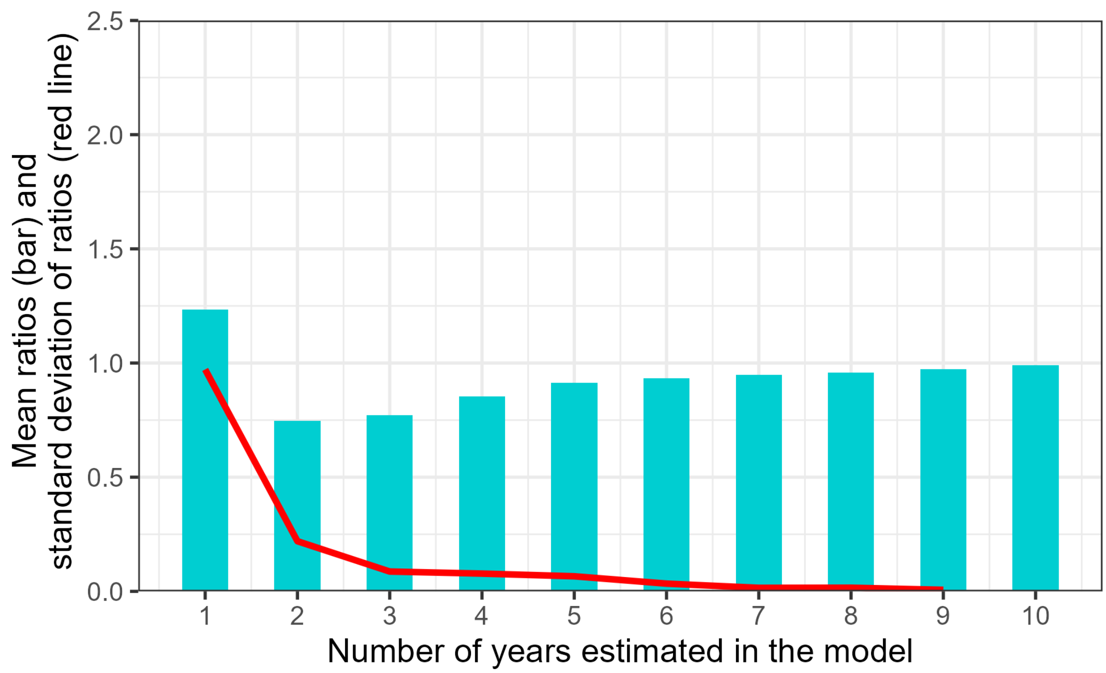

Figure 49: Mean ratios of retrospective estimates of recruitments to those estimated in the most recent year (2025) and standard deviations (red line) of the ratios as a function of the number of years in the model for model 24.0c.2.

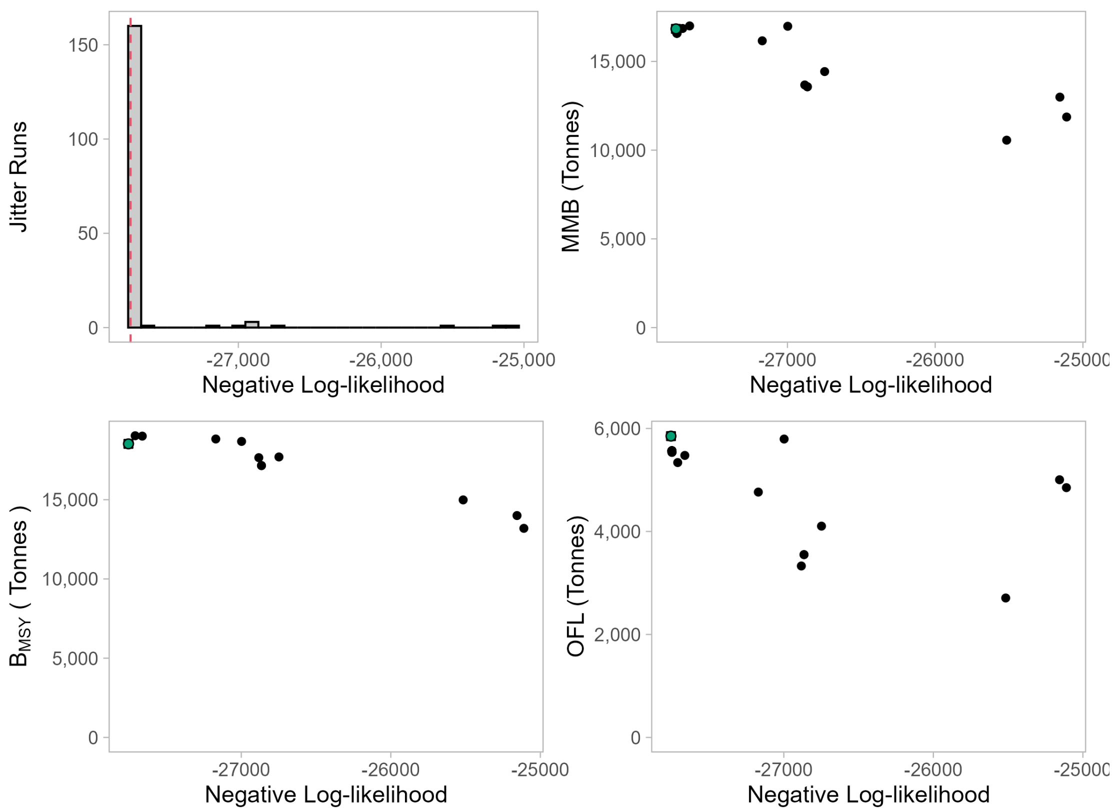

Figure 50: Jitter results for model 24.0c.2 with 100 iterations for sd=0.1 and 100 iterations for sd =0.3. MLE soution is indicated by red line or green dots.

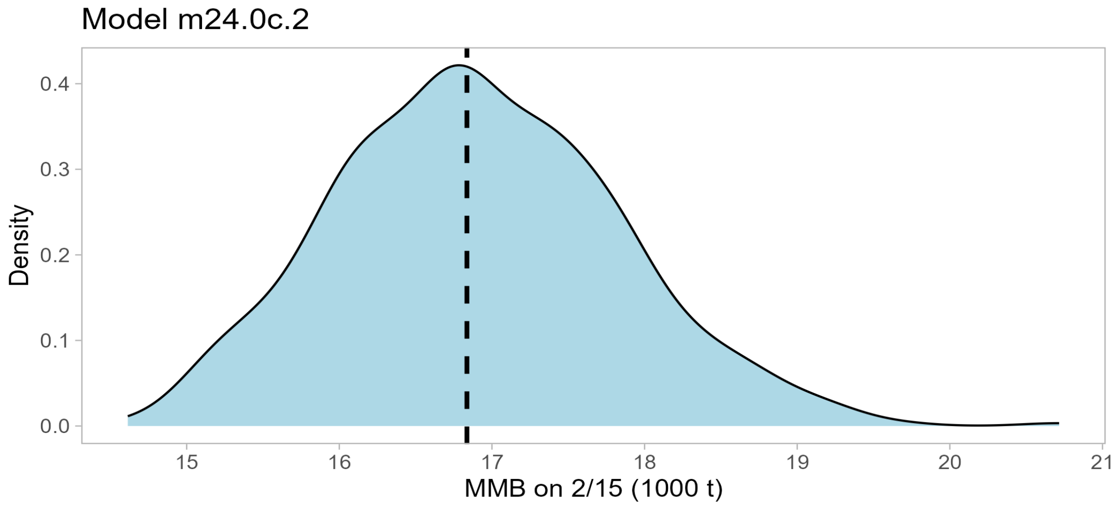

Figure 51: Histogram of estimated mature male biomass on Feb. 15, 2026, under model 24.0c.2 with the MCMC approach. The dashed line represents the MMB estimated from the MLE solution of model 24.0c.2

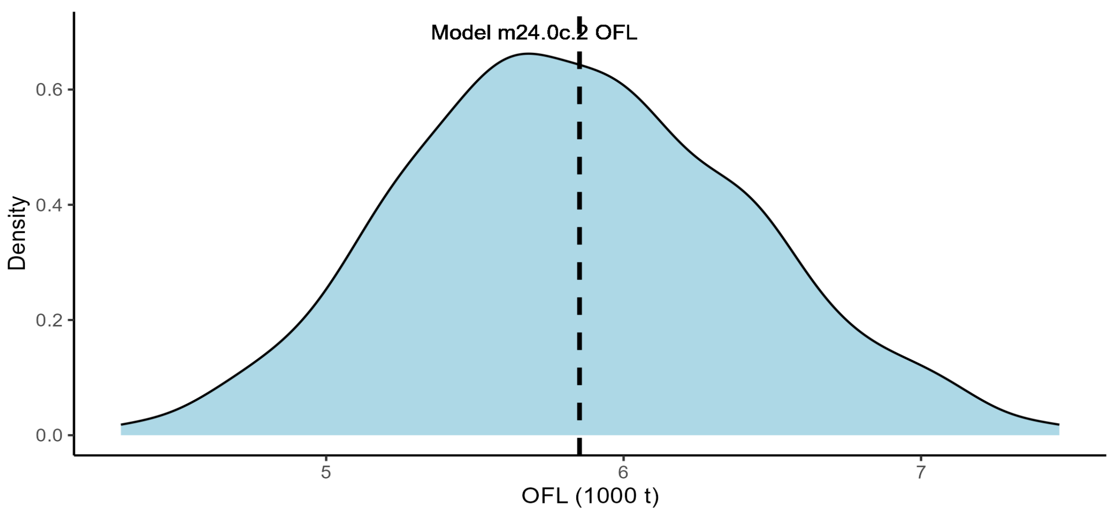

Figure 52: Histogram of the 2025/26 estimated OFL under model 24.0c.2 with the MCMC approach. The dashed line represents the OFL estimated from the MLE solution of model 24.0c.2

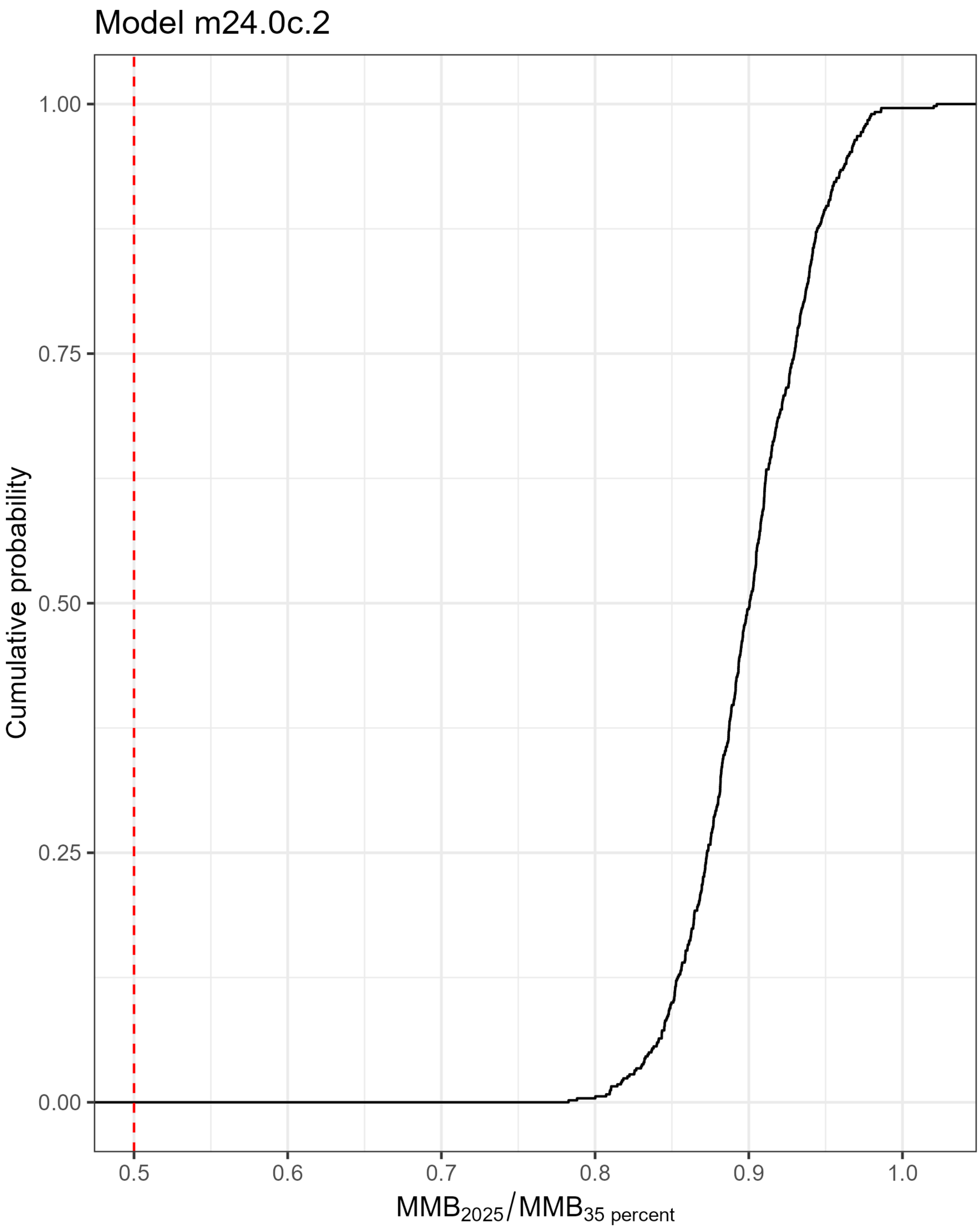

Figure 53: Cumulative probabilities of estimated ratios of MMB on Feb. 15, 2026, to corresponding estimated B35 values under model 24.0c.2 with the MCMC approach. Zero probability is below the estimated minimum thresholds.

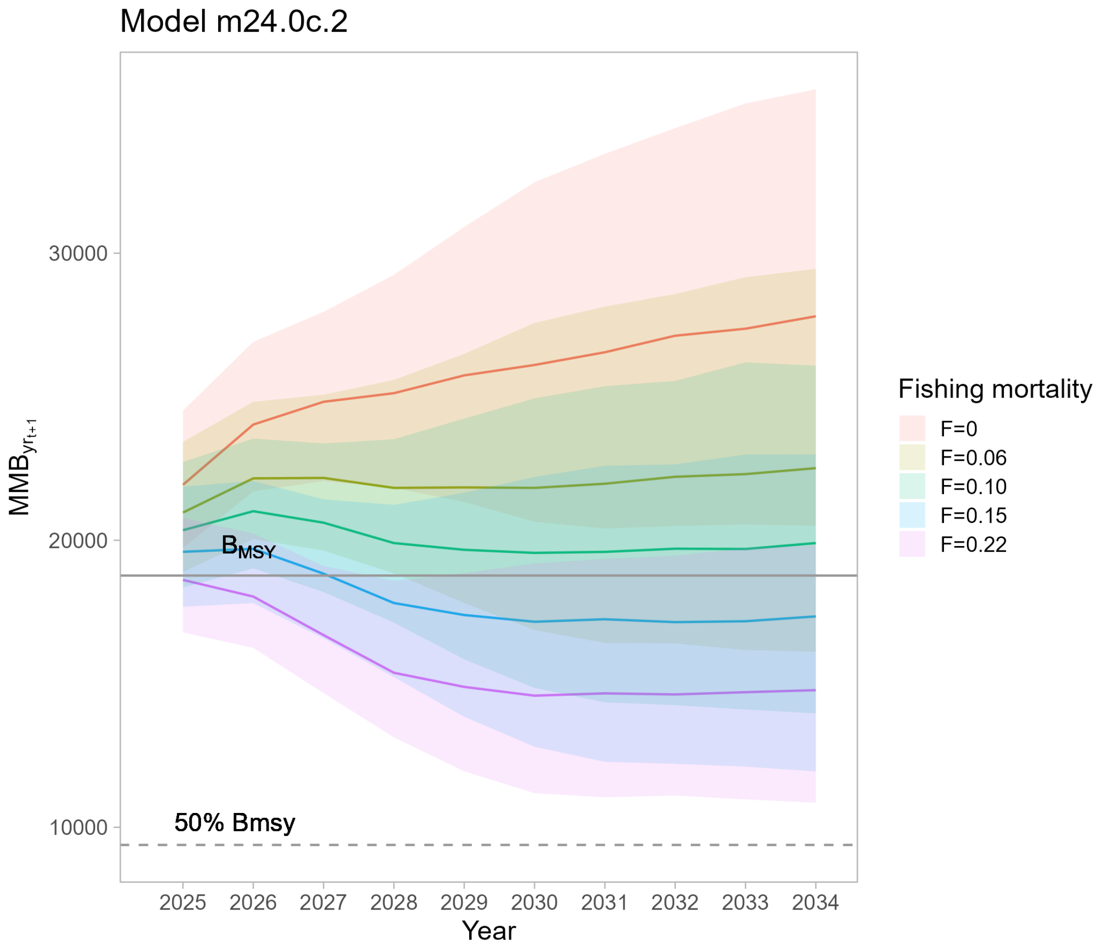

Figure 54: Projected mature male biomass (MMB) on Feb. 15 with four fishing mortalities in the directed fishery: F = 0, F = 0.10, F = 0.20, and F = 0.25, during 2025-2035. Input parameter estimates are based on model 24.0c.2. Crab year "2025" represents Feb. 15, 2026. Shaded areas represent the 0.05 to 0.95 limits.

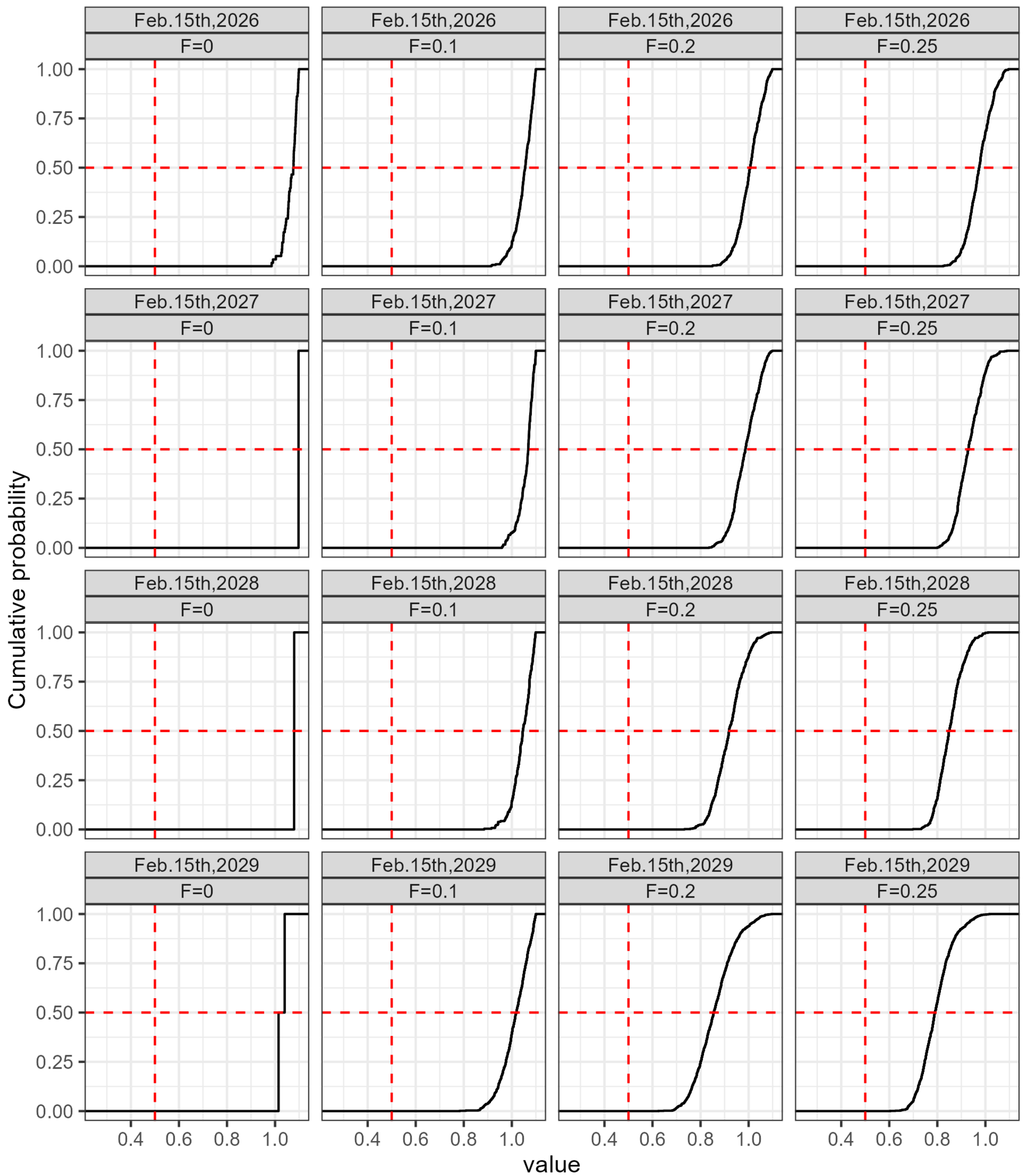

Figure 55: Cumulative probabilities of estimated ratios of MMB during 2025-2028 as represented by projected biomass on Feb.15th in year t+1, to corresponding estimated B35 values under model 24.0c.2 with the MCMC approach and four fishing mortality values. Feb. 15, 2026 represents crab year "2025".

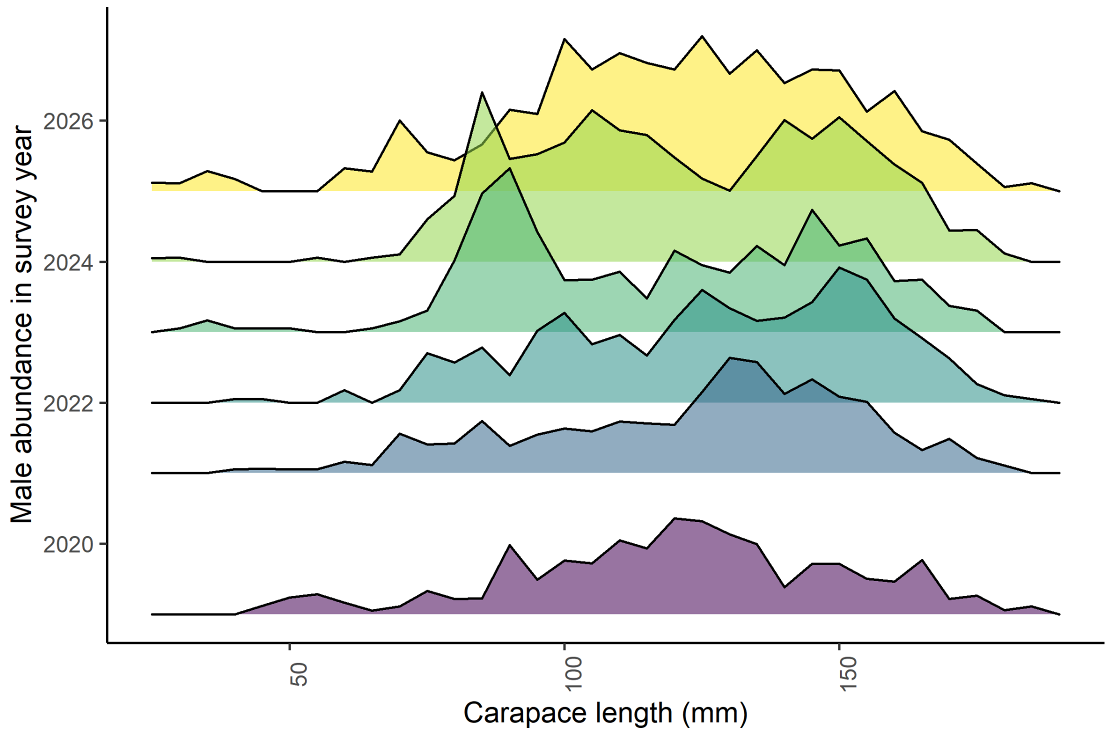

Figure 56: Length frequency distributions of male red king crab in Bristol Bay from NMFS trawl surveys during 2019-2025. For purposes of these graphs, abundance estimates are based on area-swept methods.

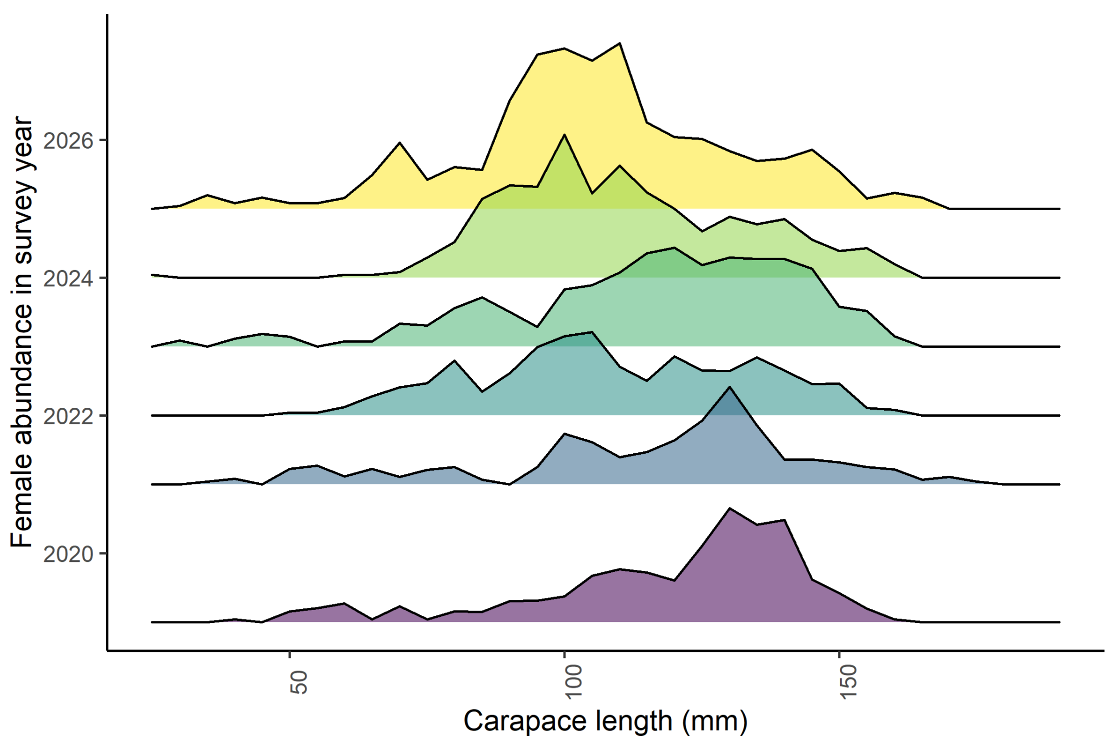

Figure 57: Length frequency distributions of female red king crab in Bristol Bay from NMFS trawl surveys during 2019-2025. For purposes of these graphs, abundance estimates are based on area-swept methods.

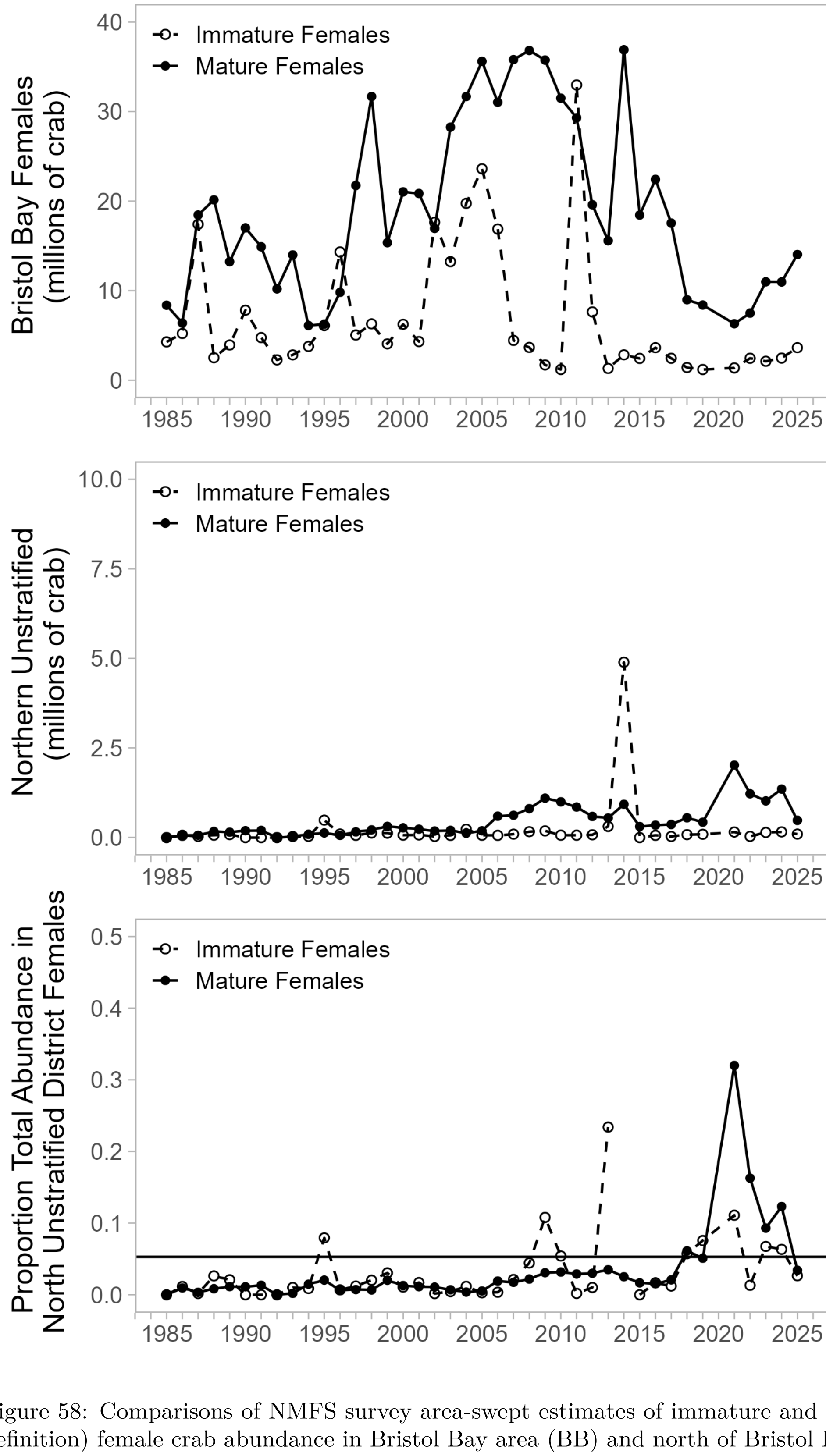

Figure 58: Comparisons of NMFS survey area-swept estimates of immature and mature (visual maturity definition) female crab abundance in Bristol Bay area (BB) and north of Bristol Bay area (North) during 1985-2025. NOTE the large scale differences between panels 1 and 2. The horizontal line in panel 3 represents the average proportion of mature crab over the entire time series.

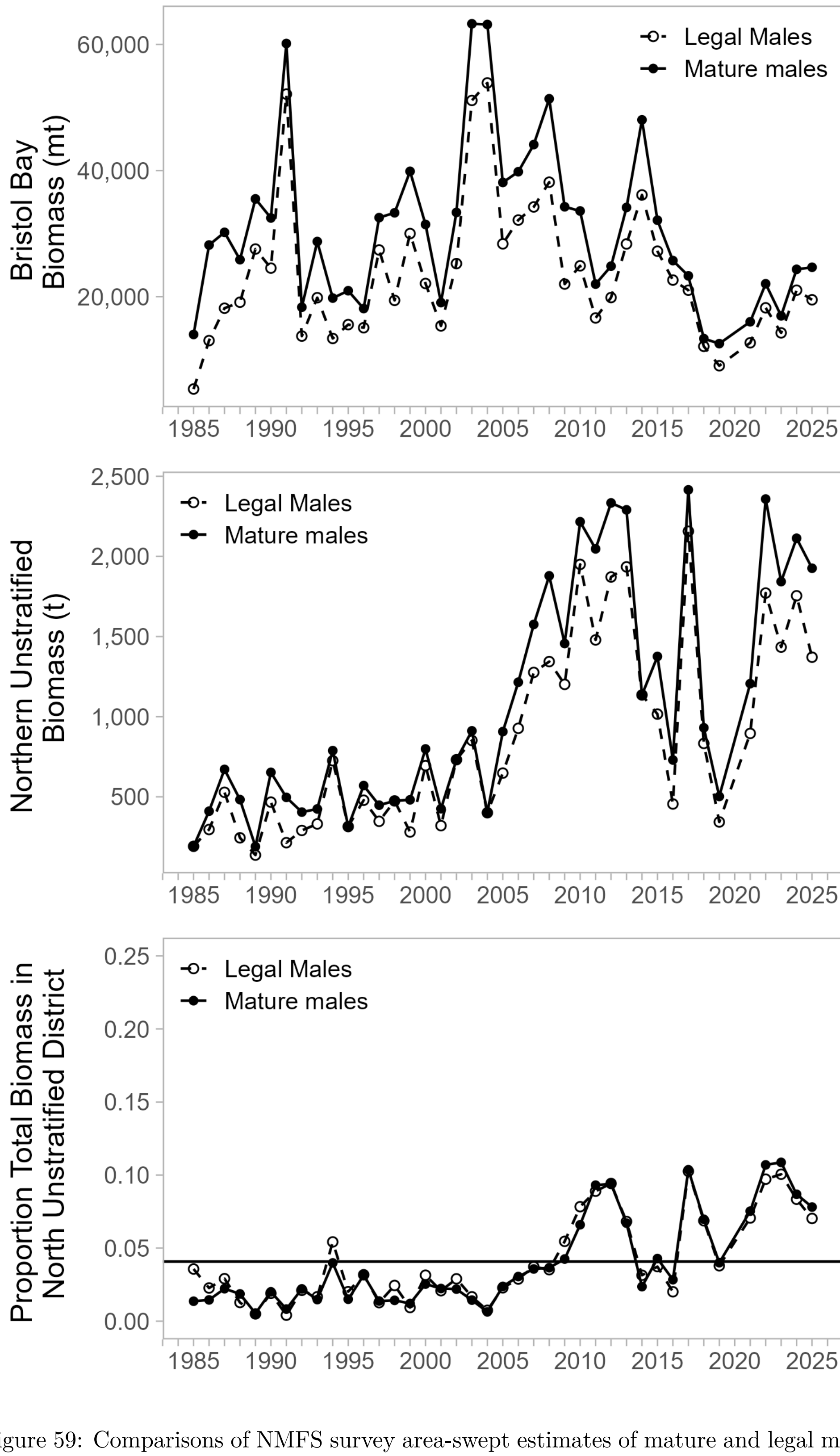

Figure 59: Comparisons of NMFS survey area-swept estimates of mature and legal male abundances in Bristol Bay area (BB) and north of Bristol Bay area (North) during 1985-2025. NOTE the large scale differences between panels 1 and 2. The horizontal line in panel 3 represents the average proportion of mature crab over the entire time series.

Appendices

Appendix A, B, and D can be found on the agenda as separate attachments.

Appendix A: Description of GMACS with Bristol Bay Red King Crab Options

Appendix B: Data files for model 24.0c.2 (more readable versions can be requested from the author - katie.palof@alaska.gov)

Appendix C: Tier 4 fallback REMA exploration

Appendix D: Draft Risk Table for BBRKC 2025

Appendix E: History of ABC buffer decisions

Appendix C. Tier 4 fallback REMA exploration

At the March 2023 simpler model working group meeting, a "fallback" option for model output was discussed to be used as an alternative option if the current assessment model is not usable. This option is detailed in the working group report under "Proposed Fallback model options".

This is a Tier 4 approach where:

- B or current year's biomass is equal to survey-estimated (ideally using the REMA R package) vulnerable male biomass. Vulnerable male biomass is male crabs likely to be susceptible to both the directed and incidental catch fisheries
- OFL = M (adjusted by the stock status as defined in the Crab FMP) * B
- ABC = buffer * OFL

REMA model for BBRKC

For BBRKC the male biomass that is determined to be vulnerable to the directed and incidental catch fisheries is the mature male biomass, crab > 119mm CL. Crab at this size are approximately one or more molt increments away from legal size and therefore are likely to be found with legal size male crab and be vulnerable to discard mortality. This modeling exercise applies two ABC buffers - one similar to the 2023 Tanner crab REMA model, where the ABC buffer is estimated to be the CV of the final year of the REMA output rounded to the nearest 5% (which for 2025 is 15%), and the Tier 3 20% buffer. The Tier 3 resulting ABC (using a buffer of 20%) is labeled ABC in the table below, and the alternative buffer calculation (using a buffer of 15%) is labeled ABC_2.

As defined by the Crab FMP, stock status is determined by the current years biomass (B) compared to the average biomass over a period of time. For consistencies with the current modeling approaches for BBRKC the time period used is 1984 to 2024, as this is the same time period that is used in the Tier 3 model for status determination.

Calculation of Reference Points

The Tier 4 OFL is calculated using the F_{OFL} control rule:

$$F_{OFL} = \begin{cases} 0 & \frac{MMB}{B_{MSY}} \leq 0.25 \\ \frac{M(\frac{MMB}{B_{MSY}} - \alpha)}{1-\alpha} & 0.25 < \frac{MMB}{B_{MSY}} < 1 \\ M & MMB > B_{MSY} \end{cases} \quad (2)$$

where MMB is quantified at the mean time of mating date (15 February), B_{MSY} is defined as the average MMB for a specified period, $M = 0.23$ yr^{-1}, and $\alpha = 0.1$. The Tier 4 OFL (Table 19) was calculated by applying a fishing mortality determined by the harvest control rule (above) to the mature male biomass at the time of mating (B_{proj} or Current B).

Table 19: Specificatoins using the REMA output on mature male NFMS trawl survey area-swept biomass (mt).

avgB	Current B	MMB/B_{MSY}	M	F_{OFL}	OFL	ABC	ABC 2
27.85	24.44	0.88	0.23	0.20	4.86	3.88	4.13

Figures

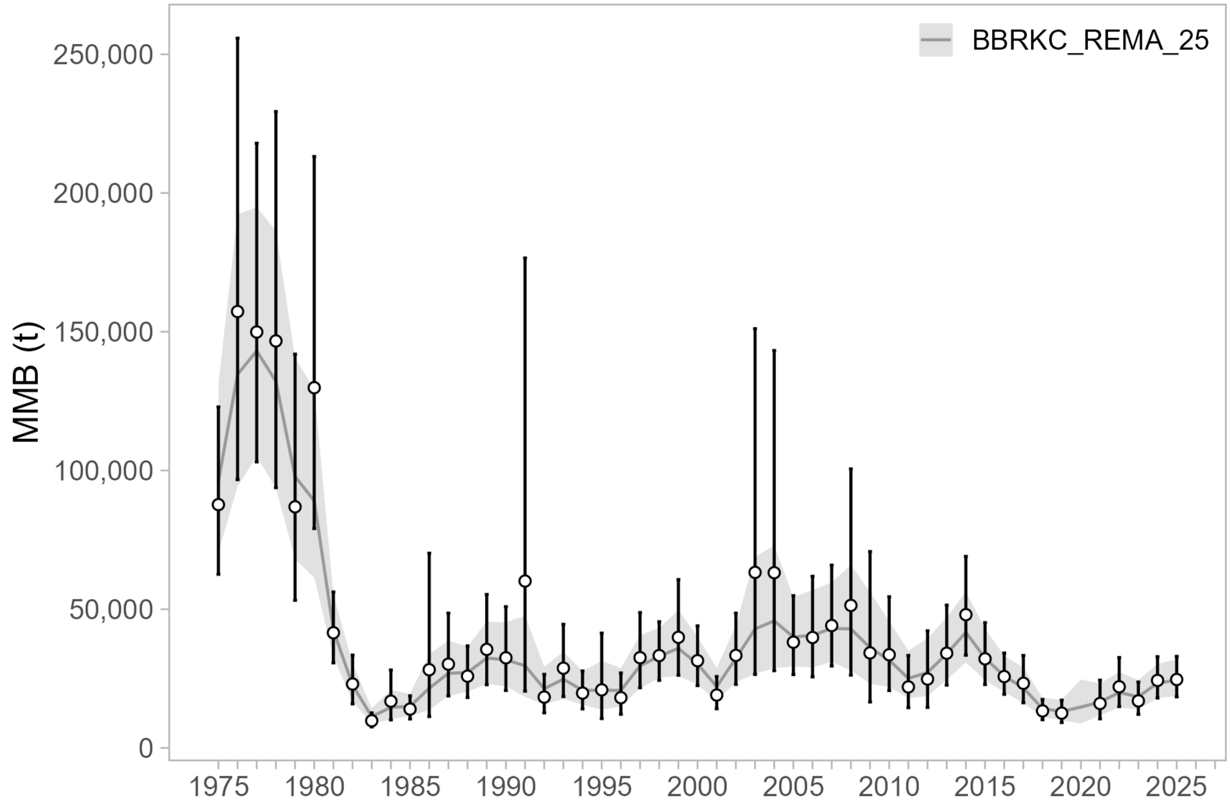

Figure 60: Comparisons of area-swept estimates of mature MALE NMFS survey biomass (males > 119 mm) and REMA model predicted fit.