Saint Matthew Island blue king crab stock assessment 2024

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Executive Summary

1. **Stock**: Blue king crab, *Paralithodes platypus*, Saint Matthew Island (SMBKC), Alaska.

2. **Catches**: Peak historical harvest was 4,288 t (9.454 million pounds) in 1983/84[1]. The fishery was closed for 10 years after the stock was declared overfished in 1999. Fishing resumed in 2009/10 with a fishery-reported retained catch of 209 t (0.461 million pounds), less than half the 529.3 t (1.167 million pound) total allowable catch (TAC). Following three more years of modest harvests supported by a fishery catch per unit effort (CPUE) of around 10 crab per pot lift, the fishery was again closed in 2013/14 due to declining trawl survey estimates of abundance and concerns about the health of the stock. The directed fishery resumed again in 2014/15 with a TAC of 300 t (0.655 million pounds), but the fishery performance was relatively poor with a retained catch of 140 t (0.309 million pounds). The retained catch in 2015/16 was even lower at 48 t (0.105 million pounds) and the fishery has remained closed since 2016/17.

3. **Data sources**: The data sources used in this assessment are summarized in Figure 1 and include retained catch, discards, and size compositions from the pot fishery, discards from trawl and fixed gear bycatch, size compositions and a biomass index from the National Marine Fisheries Service (NMFS) Eastern Bering Sea bottom trawl survey, and size compositions and a CPUE-based relative abundance index from the Alaska Department of Fish and Game (ADF&G) St. Matthew Island blue king crab pot survey. A notable change in the data available for this assessment is that the 2024 NMFS trawl survey did not sample the high density "corner" stations that were added to the St. Matthew Island survey area in 1983 and sampled through 2023; the planned exclusion of these corner stations was discussed at the May 2024 Crab Plan Team (CPT) meeting (NPFMC 2024). Corner stations were originally added to the survey in order to improve survey data quality for the blue king crab stocks near St. Matthew and the Pribilof Islands, but the declines in these stocks and the low probability that they will rebuild to harvestable levels in the near future motivated examination of the utility of continuing to allocate survey time and funds to sampling these stations (DePhilippo et al. 2023). Across the time series, NMFS trawl survey biomass estimates are consistently lower when corner stations are excluded than when they are included (Figure 2); size compositions are similar overall when corner stations are excluded versus included but can show large differences for individual years (Figure 3). A previous analysis found that excluding corner stations reduced the scale of, but not the trends in, biomass estimates for the St. Matthew Island blue king crab stock assessment, and that spatiotemporal model-based biomass estimates were more robust to the removal of corner stations than design-based estimates (DePhilippo et al. 2023). As requested by the Scientific and Statistical Committee (SSC) in June 2024, we present in this document the results of models 16.1a and 24.1a, which are equivalent to the main models 16.1 and 24.1, respectively, in all respects except that they exclude the trawl survey corner stations from the historical time series for NMFS trawl survey biomass and size compositions.

[1]1983/84 refers to a fishing year that extends from 1 July 1983 to 30 June 1984.

Models 16.1 and 24.1 include corner station data in the historical time series (1978-2024) for the years in which those data are available (1983-2023). Comparing the results of these models reveals the effects of corner station removal on current model output.

4. **Stock biomass**: The 2024 NMFS trawl survey biomass estimate is not comparable to the time series typically used for this assessment because the 2024 survey excluded the corner stations that have been sampled since 1983, and thus some decrease in biomass is expected: mean biomass for 1983-2023 with corner stations excluded is only 79% of the mean biomass for the same time period with corner stations included. Standardization using a spatiotemporal model is needed to produce a biomass index that is robust to changes in the set of stations surveyed over time, but this index is still under development. For that reason, the following comparisons use the 1978-2024 NMFS trawl survey time series with corner stations excluded from biomass estimates for all years. Using this time series without corner stations, the 2024 NMFS trawl survey biomass of $\geq$ 90 mm carapace length (CL) male crab is 1,833 t (47% CV; 4.04 million lb), the 15th lowest in the 47 years of the survey and the 11th lowest since 2000. The 2024 biomass is 41% of the 1978-2024 NMFS trawl survey mean biomass with corner stations excluded (4,490 t), and a 3% increase from the 2023 biomass. The mean NMFS survey biomass over the most recent three years is 35% of the time series mean value, indicating a low biomass compared to historical survey estimates. The ADF&G pot survey last occurred in 2022, when the relative biomass index was the highest since 2013, and 70% of the mean from the 12 surveys conducted since 1995. The next ADF&G pot survey is scheduled for 2025 and will be included in the 2026 assessment. The assessment model estimates do not fit either of the survey time series particularly well. For the NMFS trawl survey, estimates from model 16.1 suggest that the stock biomass is 48% of the mean model-predicted biomass, with a poor fit to the 2019 biomass observation; note that model 16.1 uses the NMFS trawl survey time series with corner stations included for those years in which they are available (1983-2023). For the ADF&G pot survey, estimates from model 16.1 suggest that the stock biomass in 2022 was 66% of the mean model-predicted biomass, with a poor fit to the 2016, 2017, and 2018 biomass observations.

5. **Recruitment**: Recruitment is based on the estimated number of male crab in the 90-104 mm carapace length (CL) size class in each year. Using the NMFS trawl survey time series with corner stations excluded, the 2024 trawl survey area-swept estimate of 252,145 male SMBKC in this size class is ranked 36th, near the lower end of the 47 years of the survey, and down from 30th in 2023. Mean recruitment over the most recent six years (2018 - 2024) is 46% of the long-term mean. In the ADF&G pot survey, the abundance of male crab in the 90-104 mm CL size class in 2022 ranked 7th in the time series (56% of the mean for the 12 available years of pot survey data) and was the highest abundance observed for this size class since 2013.

6. **Management performance**: In this assessment, estimated total male catch is the sum of fishery-reported retained catch, estimated male discard mortality in the directed fishery, and estimated male bycatch mortality in the groundfish fisheries. Based on model 16.1, the estimate for mature male biomass was above the minimum stock-size threshold (MSST) in 2023/24 and thus the stock is not in an "overfished" condition, but the model 24.1 estimate for mature male biomass in 2023/24 is below the MSST, indicating some uncertainty about the status of the stock (Tables 1 and 2). A directed fishery closure has been in place since the 2016/17 season and estimated total bycatch has remained well below the overfishing level (OFL), hence overfishing has not occurred. Computations which indicate the relative impact of fishing (i.e., the "dynamic B_0") suggest that the current spawning stock biomass has been reduced to 78% (model 16.1) or 87% (model 24.1) of what it would have been in the absence of fishing, assuming the same level of recruitment as estimated. The tables below show the status and catch specifications based on models 16.1 and 24.1 in both 1,000 t and million lb (Tables 1, 2, 3, and 4).

Table 1: Status and catch specifications (1,000 t) for model 16.1, the new base model.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2020/21	1.65	1.14	0.00	0.00	0.001	0.05	0.04
2021/22	1.63	1.18	0.00	0.00	0.001	0.05	0.04
2022/23	1.46	1.31	0.00	0.00	0.001	0.066	0.05
2023/24	1.45	1.46	0.00	0.00	0.005	0.066	0.05
2024/25		1.62				0.121	0.091

Table 2: Status and catch specifications (1,000 t) for model 24.1, with $M = 0.23$.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2020/21	1.65	1.14	0.00	0.00	0.001	0.05	0.04
2021/22	1.63	1.18	0.00	0.00	0.001	0.05	0.04
2022/23	1.5	1.31	0.00	0.00	0.001	0.066	0.05
2023/24	1.48	1.41	0.00	0.00	0.005	0.066	0.05
2024/25		1.53				0.129	0.097

Table 3: Status and catch specifications (million pounds) for model 16.1, the new base model.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2020/21	3.64	2.52	0.000	0.000	0.002	0.112	0.08
2021/22	3.59	2.59	0.000	0.000	0.002	0.112	0.08
2022/23	3.23	2.89	0.000	0.000	0.002	0.146	0.11
2023/24	3.19	3.23	0.000	0.000	0.011	0.146	0.11
2024/25		3.57				0.268	0.201

Table 4: Status and catch specifications (million pounds) for model 24.1, with $M = 0.23$.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2020/21	3.64	2.52	0.000	0.000	0.002	0.112	0.08
2021/22	3.59	2.59	0.000	0.000	0.002	0.112	0.08
2022/23	3.32	2.89	0.000	0.000	0.002	0.146	0.11
2023/24	3.27	3.1	0.000	0.000	0.011	0.146	0.11
2024/25		3.37				0.285	0.214

7. **Basis for the OFL**: Estimated mature-male biomass (MMB) on 15 February is used as the measure of biomass for this Tier 4 stock, with males measuring $\geq$ 105 mm CL considered mature. The B_{MSY} proxy is obtained by averaging estimated MMB over a specific reference period, and current Crab Plan Team (CPT) guidance recommends using the full assessment time frame (1978 - 2023) as the default reference period.

Table 5: Basis for the OFL (1,000 t) from model 16.1, the new base model.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	γ	Basis for B_{MSY}	Natural mortality
2019/20	4b	3.48	1.06	0.31	0.042	1	1978-2018	0.18
2020/21	4b	3.34	1.14	0.32	0.047	1	1978-2019	0.18
2021/22	4b	3.30	1.18	0.34	0.048	1	1978-2020	0.18
2022/23	4b	3.26	1.31	0.40	0.061	1	1978-2021	0.18
2023/24	4b	2.89	1.46	0.51	0.081	1	1978-2022	0.18
2024/25	4b	2.86	1.62	0.57	0.093	1	1978-2023	0.18

Table 6: Basis for the OFL (1,000 t) from model 24.1, with $M = 0.23$.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	γ	Basis for B_{MSY}	Natural mortality
2019/20	4b	3.48	1.06	0.31	0.042	1	1978-2018	0.18
2020/21	4b	3.34	1.14	0.32	0.047	1	1978-2019	0.18
2021/22	4b	3.30	1.18	0.34	0.048	1	1978-2020	0.18
2022/23	4b	3.26	1.31	0.40	0.061	1	1978-2021	0.18
2023/24	4b	2.97	1.41	0.47	0.096	1	1978-2022	0.23
2024/25	4b	2.93	1.53	0.52	0.108	1	1978-2023	0.23

8. **Probability density function of the OFL:** The probability density function of the OFL for models 16.1 and 24.1 is displayed in Figures 4 and 5, respectively.

9. **Basis for the ABC recommendation:** The authors recommend a 25% buffer to set the ABC in 2024. The CPT and SSC supported a 25% buffer to set the ABC for the last stock assessment in 2022 for the following reasons: 1) the stock was in a fixed rebuilding time frame; 2) there was a significant retrospective pattern on MMB estimates; 3) limited life history information was available for correctly specifying the population processes; 4) ADF&G pot survey data, which at that time were last available in 2018, had shown a declining trend; and 5) ADF&G pot and NMFS trawl survey data showed contradictory trends. All of these concerns remain applicable with the exception of (4), since the now-available 2022 ADF&G pot survey indicated increased relative abundance. An additional concern for the 2024 assessment is that the NMFS trawl survey corner stations were not surveyed in 2024, potentially adding bias to biomass estimates.

10. **Summary of rebuilding analyses:** Based on model 16.1, the estimate for mature male biomass was above the minimum stock-size threshold (MSST) in 2023/24 and thus the stock was not in an "overfished" condition for the first time since the current rebuilding plan was approved. However, the model 24.1 estimate for mature male biomass in 2023/24 is below the MSST, meaning the stock is still considered to be overfished. This discrepancy in model results indicates some uncertainty about the status of the stock; however, stock status does seem to be improving, and B/B_{MSY} is projected to be greater than 50% in 2024/2025 for both model scenarios (Tables 1, 2, 5, 6, and 7).

A. Summary of Major Changes

Changes in Management of the Fishery

There are no new changes in management of the fishery.

Changes to the Input Data

Data used in this assessment have been updated to include the most recently available fishery data and survey data. This assessment includes new biomass data from the 2024 and 2023 NMFS trawl surveys and new relative abundance data from the most recent ADF&G pot survey, which was conducted in 2022. The assessment was updated with new size composition data from the 2024 and 2023 NMFS trawl surveys and the 2022 ADF&G pot survey, as well as 2022 and 2023 groundfish trawl and fixed gear bycatch estimates based on NMFS Alaska Regional Office (AKRO) data. The ADF&G pot survey is on a semi-triennial cycle, with the next survey planned for fall 2025. The directed fishery has been closed since 2016/17, so no recent fishery data are available.

Changes in Assessment Methodology

This assessment has used the Generalized size-structured Model for Assessing Crustacean Stocks (GMACS) framework since 2016. The model, which is configured to track three stages of length categories, was first presented in May 2011 by W. Gaeuman, ADF&G, and accepted by the Crab Plan Team (CPT) in May 2012. A difference from the original approach and that used here is that natural and fishing mortalities are continuous within 5 discrete time blocks within a year, using the appropriate catch equation rather than assuming an applied pulse removal. The time blocks within a year in GMACS are controlled by changing the proportion of natural mortality that is applied to each block. Diagnostic output includes estimates of the "dynamic B_0", which is the ratio of the estimated spawning biomass relative to the spawning biomass that would have occurred had there been no historical fishing mortality. Details of this implementation and other model details are provided in Appendix A.

Changes in Assessment Results

Both surveys indicate a low population over the past 10 years (Figure 6). The ADF&G pot survey relative abundance index showed a declining trend from 2010 to 2018 before rebounding in the 2022 survey to the highest level since 2013. The NMFS trawl survey showed a decline from 2014 to 2018, and since then has not surpassed the 2016 biomass estimate. The 2024 NMFS trawl survey biomass estimate is lower than in 2023 but, since corner stations were excluded from the 2024 survey, the estimates are not comparable without adjusting for that change in survey methodology.

The reference model (model 16.1 - May) is the model that was presented as model 24.0 at the May 2024 CPT meeting. This model uses GMACS version 2.01.M.10, incorporates an error-corrected ADF&G pot survey historical time series, SSB calculation occurring in season 5 rather than season 4, and data including the 2022 ADF&G pot survey relative abundance and size compositions, 2023 NMFS trawl survey biomass and size compositions, and 2022 trawl and fixed gear bycatch information.

The base model (model 16.1) is the reference model using a more recent version of GMACS (2.20.14), updated groundfish bycatch data for the 2023/24 crab season, and updated survey data - biomass and size composition - from the 2024 NMFS trawl survey. This model has a fixed natural mortality rate of $M = 0.18$ for the entire time series except for the 1998 natural mortality spike, for which natural mortality is estimated, as does the reference model.

Alternative models presented for consideration in September 2024 are models 24.1, 16.1a, and 24.1a. Model 24.1 is model 16.1 with natural mortality fixed at $M = 0.23$ for the entire time series (except for the

1998 natural mortality spike) based on the value estimated in the 2023 Bristol Bay Red King Crab model. Compared to model 16.1, model 24.1 estimates a lower value for projected 2024/2025 MMB, a higher value for B_{MSY}, and higher values for the OFL and ABC (Table 7).

Models 16.1a and 24.1a are equivalent to models 16.1 and 24.1, respectively, in all respects except that they exclude the NMFS trawl survey corner stations from the historical time series for NMFS trawl survey biomass and size compositions. It was important to make this comparison because the corner stations were excluded from the 2024 NMFS trawl survey, and comparing survey biomass estimates over 1983-2023 with and without corner stations shows that mean estimated survey biomass without corner stations is 79% of mean estimated survey biomass with corner stations. Compared to model 16.1, model 16.1a estimates lower values for MMB, B_{MSY}, OFL, and ABC; the same pattern is evident when comparing models 24.1 and 24.1a (Table 7). These results suggest that excluding the corner stations reduces the estimated scale of the population.

Due to the likely continued exclusion of corner stations from the NMFS trawl survey in future years, leading to a need for index standardization, we recommend the development and use of a model-based biomass index for this survey in future years. A previous analysis of this stock found that model-based biomass estimates were more robust to the removal of corner stations than were design-based estimates (DeFilippo et al. 2023).

We recommend using model 24.1 as the model for harvest specifications for this stock. Model 16.1 has the advantage of greater consistency with previous assessments for this stock, but model 24.1 shows a better fit to the data and has the advantage of greater consistency with other Bering Sea king crab stocks due to using a similar natural mortality value.

B. SSC and CPT comments and author responses

Responses (not italicized) to SSC comments (italicized) on BSAI crab assessments in general (June 2024, October 2023, and October 2022)

The SSC recommends that risk tables be developed for crab assessments.

The CPT has not chosen SMBKC for risk table development in this assessment cycle, but a risk table for this stock may be developed in a future assessment.

The SSC requests that the CPT develop a process for ensuring that authors have provided a response to all previous (including at least the last assessment) SSC recommendations.

Responses to the SSC recommendations for the 2022 SMBKC assessment and the May 2024 model runs are included below.

The SSC requests that all crab authors include uncertainty intervals when showing time series of biomass/abundance estimated by the stock assessment models so that alternative models and retrospective patterns can be evaluated in the context of the modeled uncertainty.

We have included uncertainty intervals for these time series (e.g., Figures 7, 8, and 9).

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.

The CPT decided to use the entire time series of trawl survey data for crab assessment, with time blocks for parameters as necessary, and this assessment follows that practice.

The SSC suggests that the CPT and crab authors continue to evaluate whether VAST or similar approaches, when specified carefully for individual crab stocks, might provide more robust survey time series.

The authors plan to present research models using spatiotemporal model-based indices for the NMFS trawl survey time series at the January 2025 CPT modeling workshop. This effort is particularly important given the exclusion of corner stations from the 2024 NMFS trawl survey and previous research on the advantages of model-based versus design-based indices when corner stations are removed for this stock (DePhilippo et al. 2023).

The SSC recommends that all crab authors plot length compositions over years with the most recent year at the bottom of the plot.

We have followed this recommendation (e.g., Figures 10 and 11).

Responses to SSC and CPT comments on SMBKC assessment (October 2022)

Follow up on previous SSC recommendations as time allows, including exploring:

1. *Data weighting (Francis and other approaches) and evaluation of models with and without the 1998 natural mortality spike.*

We continued with the iterative re-weighting for composition data (Table 8). We did not address models without the natural mortality spike as these have been considered previously.

2. *Causes of observed retrospective patterns*

Discussion of potential causes of the observed retrospective patterns is provided in section E below, under Results: Retrospective and historical analyses.

3. *Potential explanations for the discrepancy in the time trends of the two types of survey data*

Exploration of the spatial extent and density differences between the two surveys (NMFS and ADF&G) based on all male crab ($\geq$ 90 mm CL) and all years of overlap between the two surveys was included in the model for May 2022 (May 2022 documentation Appendix C). The authors plan to use this and further analyses to better characterize catchability/availability for the pot survey.

4. *Estimates of survey biomass based on VAST compared to design-based estimates, and estimates that combine the two surveys*

The authors plan to present research models using spatiotemporal model-based indices for the NMFS trawl survey time series at the January 2025 CPT modeling workshop. Development of a spatiotemporal model-based index for the ADF&G pot survey will follow, as will investigations of a single integrated index of abundance.

5. *Random walk on catchability*

The initial model of time blocks for Q did not show much potential for this in May 2020, therefore time blocks were not a focus for the 2022 and 2024 assessments.

6. *Assumed and estimated life history parameters (e.g., natural mortality, growth, and maturity) to ensure the best available science is being used to assess this stock.*

Specific research on St. Matthew Island blue king crab life history parameters is not available and therefore data are borrowed from other stocks/species. Sensitivities of the model to increased natural mortality (M) were explored in May 2022. For May 2024, we presented model 24.0a, which estimated M using a tight prior (mean = 0.18, CV = 0.04) as in the Bristol Bay Red King Crab stock assessment, model 24.0b, which estimated M using a less restrictive prior (mean = 0.18, CV = 0.1) on M, and model 24.0c, which had M fixed to the value estimated in model 24.0a. We also performed a likelihood profile for M using model 24.0 and varying only the fixed value of M. Here, we compare model 24.1, with $M = 0.23$ (borrowed from the 2023 BBRKC SAFE), to model 16.1, with $M = 0.18$. Sensitivities to the model assumptions on growth and maturity will be explored at a later date.

Responses to SSC and CPT comments on SMBKC May 2024 model runs (June 2024)

1. *The SSC agreed with the CPT that using the M estimate from Model 24.0a as the fixed value in Model 24.0c was improper. The CPT recommended that the authors construct a new model, 24.1, which builds on 16.1 as its base but uses a fixed value for M from the 2023 BBRKC assessment (i.e., 0.23 yr-1).*

As requested, we present model 24.1, with $M = 0.23$, in this document.

2. *The SSC concurs with the CPT recommendation to bring forward Models 16.1 and 24.1 for setting harvest specifications in October 2024.*

As requested, models 16.1 and 24.1 are presented in this document and management quantities for both models are shown in Table 7.

3. *The SSC also supports the authors presenting a version of Model 16.1 in October 2024 with the corner stations dropped from all previous years. This research model would provide retrospective insights into the impacts of dropping these stations, as will occur in the 2024 EBS trawl survey, but this research model would not be used for management.*

We present models 16.1a and 24.1a, versions of model 16.1 and 24.1, respectively, with the corner stations dropped from all previous years in the NMFS trawl survey time series.

The SSC supports the CPT recommendations for future work and offers the following suggestions:

4. *Continue work to create a single index of abundance integrating data from both trawl and pot surveys using spatiotemporal approaches. The SSC suggests the authors explore the use of these methods for each survey separately before initiating work to combine them. An exploratory spatial analysis, including maps depicting the spatial structure of relevant survey observations, should be provided to support the selection of an appropriate geostatistical approach. In addition to standard diagnostic plots (i.e. Q-Q plot, residual histograms, and observed vs. predicted encounter probabilities), the distribution of spatial residuals should accompany model results (e.g., see the December 2020 SSC minutes on the use of the VAST Model for EBS Pollock).*

The authors plan to present research models using spatiotemporal model-based indices for the NMFS trawl survey time series at the January 2025 CPT modeling workshop. Development of a spatiotemporal model-based index for the ADF&G pot survey will follow, as will investigations of a single integrated index of abundance. We will include the requested maps and plots in our presentations of the results.

5. *Explore increasing the number of size bins used in the assessment models.*

We plan to present the results of these explorations in the next assessment cycle.

6. *Examine the likelihood profile on selectivity.*

We plan to present a likelihood profile on selectivity in the next assessment cycle.

7. *Correct the y-axis labels on pot survey CPUE plots.*

The y-axis labels on the pot survey CPUE plots now read "Scaled pot survey CPUE ((crab / plot lift) * 1000)".

C. Introduction

Scientific Name

The blue king crab is a lithodid crab, *Paralithodes platypus* (Brant 1850).

Distribution

Blue king crab are sporadically distributed throughout the North Pacific Ocean from Hokkaido, Japan, to southeastern Alaska (Figure 12). In the eastern Bering Sea, small populations are distributed around St. Matthew Island, the Pribilof Islands, St. Lawrence Island, and Nunivak Island. Isolated populations also exist in some other cold water areas of the Gulf of Alaska (NPFMC 1998). The St. Matthew Island Section for blue king crab is within Area Q (Figure 13), which is the Northern District of the Bering Sea king crab registration area and includes the waters north of Cape Newenham (58°39' N. lat.) and south of Cape Romanzof (61°49' N. lat.).

Stock Structure

The Alaska Department of Fish and Game (ADF&G) Gene Conservation Laboratory has detected regional population differences between blue king crab collected from St. Matthew Island and the Pribilof Islands[2]. The NMFS tag-return data from studies on blue king crab in the Pribilof Islands and St. Matthew Island support the idea that legal-sized males do not migrate between the two areas (Otto and Cummiskey 1990). St. Matthew Island blue king crab tend to be smaller than their Pribilof conspecifics, and the two stocks are managed separately. An analysis of genetic markers from blue king crab populations in Southeast Alaska, the Pribilof Islands, St. Matthew Island, Little Diomede, Chaunskaya Bay, the western Bering Sea, and two locations from Shelikov Gulf in the Sea of Okhotsk found genetic differences among all locations (Stoutamore 2014).

Life History

Like the red king crab, *Paralithodes camtshaticus*, the blue king crab is considered a shallow water species by comparison with other lithodids such as golden king crab, *Lithodes aequispinus*, and the scarlet king crab, *Lithodes couesi* (Donaldson and Byersdorfer 2005). Adult male blue king crab are found at an average depth of 70 m (NPFMC 1998). The reproductive cycle appears to be annual for the first two reproductive cycles and biennial thereafter (Jensen and Armstrong 1989), and mature crab seasonally migrate inshore where they molt and mate. Unlike red king crab, juvenile blue king crab do not form pods, but instead rely on cryptic coloration for protection from predators and require suitable habitat such as cobble and shell hash. Somerton and MacIntosh (1983) estimated SMBKC male size at sexual maturity to be 77 mm carapace length (CL). Paul et al. (1991) found that spermatophores were present in the vas deferens of 50% of the St. Matthew Island blue king crab males examined with sizes of 40-49 mm CL and in 100% of the males at least 100 mm CL. Spermataphore diameter also increased with increasing CL with an asymptote at ~100 mm CL. It was noted, however, that although spermataphore presence indicates physiological sexual maturity, it may not be an indicator of functional sexual maturity. For purposes of management of the St. Matthew Island blue king crab fishery, the State of Alaska uses 105 mm CL to define the lower size bound of functionally mature males (Pengilly and Schmidt 1995). Otto and Cummiskey (1990) reported an average growth increment of 14.1 mm CL for adult SMBKC males.

[2] NOAA grant Bering Sea Crab Research II, NA16FN2621, 1997.

Management History

The SMBKC fishery developed subsequent to baseline ecological studies associated with oil exploration (Otto 1990). Ten U.S. vessels harvested 545 t (1.202 million pounds) in 1977, and harvests peaked in 1983 when 164 vessels landed 4,288 t (9.454 million pounds) (Fitch et al. 2012; Table 9).

The fishing seasons were generally short, often lasting only a few days. The stock was declared overfished and the fishery was closed in 1999, when the stock biomass estimate was below the minimum stock-size threshold (MSST) of 4,990 t (11.0 million pounds) as defined by the Fishery Management Plan (FMP) for the Bering Sea/Aleutian Islands King and Tanner crabs ("Crab FMP"; NPFMC 1999). Zheng and Kruse (2002) hypothesized a high level of SMBKC natural mortality from 1998 to 1999 as an explanation for the low catch per unit effort (CPUE) in the 1998/99 commercial fishery and the low numbers across all male crab size groups caught in the annual NMFS eastern Bering Sea trawl survey from 1999 to 2005 (see survey data in next section). In November 2000, Amendment 15 to the Crab FMP was approved to implement a rebuilding plan for the SMBKC stock (NPFMC 2000). The rebuilding plan included a State of Alaska regulatory harvest strategy (*5 AAC 34.917*), area closures, and gear modifications. In addition, commercial crab fisheries near St. Matthew Island were limited to fall and early winter to reduce the potential for bycatch mortality of vulnerable molting and mating crab.

NMFS declared the stock rebuilt on 21 September 2009, and the fishery was reopened after a 10-year closure on 15 October 2009 with a TAC of 529 t (1.167 million pounds), closing again by regulation on 1 February 2010. Seven participating vessels landed a catch of 209 t (0.461 million pounds) with a reported effort of 10,697 pot lifts and an estimated CPUE of 9.9 retained individual crab per pot lift. The fishery remained open the next three years with modest harvests and similar CPUE, but large declines in the NMFS trawl-survey estimate of stock abundance raised concerns about the health of the stock. This prompted ADF&G to close the fishery again for the 2013/14 season. The fishery was reopened for the 2014/15 season with a low TAC of 297 t (0.655 million pounds) and in 2015/16 the TAC was further reduced to 186 t (0.411 million pounds) before the fishery was closed for the 2016/17 season. The stock was declared overfished in 2018 (NOAA 2019).

In October 2020, Amendment 50 to the Crab FMP was approved to implement a second rebuilding plan for the SMBKC stock (NOAA 2020). The primary factors limiting stock rebuilding were identified as warm bottom temperatures, low pre-recruit biomass, and northward shifts in predator populations, rather than fishing mortality. The aim of the rebuilding plan was thus to maintain a low rate of fishing mortality while awaiting ecosystem conditions conducive to stock rebuilding. The lack of stock rebuilding in Pribilof Islands blue king crab despite fisheries closures and abundant juvenile habitat has similarly been attributed to limited larval supply and warm bottom temperatures (Weems et al. 2020).

Although historical observer data are limited due to low sampling effort, bycatch of female and sublegal male crab from the directed blue king crab fishery off St. Matthew Island was relatively high historically, with estimated total bycatch in terms of number of crab captured sometimes more than twice as high as the catch of legal crab (Moore et al. 2000; ADF&G Crab Observer Database). Pot-lift sampling by ADF&G crab observers (Gaeuman 2013; ADF&G Crab Observer Database) indicates similar bycatch rates of discarded male crab since the reopening of the fishery (Table 10), with total male discard mortality in the 2012/13 directed fishery estimated at about 12% (88 t or 0.193 million pounds) of the reported retained catch weight, assuming 20% handling mortality.

These data suggest a reduction in the bycatch of females, which may be attributable to the later timing of the contemporary fishery and the more offshore distribution of fishery effort since reopening in 2009/10 (D. Pengilly, ADF&G, pers. comm.). Some bycatch of discarded blue king crab has also been observed historically in the eastern Bering Sea snow crab fishery, but in recent years it has generally been negligible. The St. Matthew Island golden king crab fishery, the third commercial crab fishery to have taken place in the area, typically occurred in areas with depths exceeding blue king crab distribution. The NMFS observer data suggest that variable, but mostly limited, St. Matthew Island blue king crab bycatch has also occurred in the eastern Bering Sea groundfish fisheries (Table 11).

D. Data

Summary of New Information

Data used in this assessment were updated to include the most recently available fishery and survey estimates. Since this stock is on a biennial assessment cycle, the new data for these models include 2023 and 2024 NMFS trawl survey biomass and size composition data as well as 2022 ADF&G pot survey abundance and size composition data. The assessment uses updated 1993-2023 groundfish and fixed gear bycatch estimates based on NMFS Alaska Regional Office data, accessed through the Alaska Fisheries Information Network. The directed fishery has been closed since the 2016/17 season, and therefore no directed fishery catch data are available. The data used in the new models are shown in Figure 1.

Major Data Sources

Major data sources used in this assessment include annual directed-fishery retained-catch statistics from fish tickets (1978/79-1998/99, 2009/10-2012/13, and 2014/15-2015/16; Table 9); results from the annual NMFS eastern Bering Sea trawl survey (1978-2024; Table 12); results from the ADF&G SMBKC pot survey (every third year during 1995-2013, every year during 2015-2018; every third year during 2022-present; Table 13); mean somatic mass given length category by year (0.7 kg for Stage-1, 1.2 kg for Stage-2, and 1.9 kg for Stage-3; fixed across years and models); size frequency information from ADF&G crab-observer pot-lift sampling (1990/91-1998/99, 2009/10-2012/13, and 2014/15-2016/17; Table 10); and the NMFS groundfish-observer bycatch biomass estimates (1991/92-2023/24; Table 11).

Figure 14 maps the stations from which SMBKC trawl survey and pot survey data were obtained. Further information concerning the NMFS trawl survey as it relates to commercial crab species is available in Daly et al. (2014); see Gish et al. (2012) for a description of ADF&G SMBKC pot survey methods. It should be noted that the two surveys cover different geographic regions and that each has in some years encountered proportionally large numbers of male blue king crab in areas not covered by the other survey (Figure 15). As discussed above, the 2024 NMFS trawl survey excluded corner stations; models 16.1a and 24.1a are versions of each of the two main models (16.1 and 24.1) with the corner stations removed from the historical time series and are presented to assess the effect of removing these stations on model outcomes. For years in which corner stations were surveyed, the St. Matthew section was separated into two strata (high and low density) and biomass and variance were estimated separately for each stratum (Zacher et al. 2024b). For each stratum, the per-station CPUE was averaged, then expanded over the total area of the stratum to obtain that stratum's biomass estimate. The two biomass estimates were added together to obtain the total estimated St. Matthew section biomass. Due to increased sampling within the high density stratum, the biomass estimate for the high density stratum had reduced variance. For years in which corner stations were not surveyed, the St. Matthew section had one stratum, with biomass estimated by multiplying the mean station-level CPUE of all standard stations in the stratum across the total section area (S. Hennessey, NOAA Fisheries Alaska Fisheries Science Center, pers. comm.).

Crab-observer sampling protocols are detailed in the crab-observer training manual (ADF&G 2013). Groundfish St. Matthew Island blue king crab bycatch data come from the NMFS Regional office and have been compiled to coincide with the St. Matthew Island blue king crab management area.

Other Data Sources

The growth transition matrix used is based on Otto and Cummiskey (1990), as in previous assessments for this stock; to the authors' knowledge, no more recent information is available. Other relevant data sources, including assumed population and fishery parameters, are presented in Appendix A, which also provides a detailed description of the model configuration used for this assessment.

E. Analytic Approach

History of Modeling Approaches for this Stock

A four-stage catch-survey-analysis (CSA) assessment model was used before 2011 to estimate abundance and biomass and recommend fishery quotas for the SMBKC stock. The four-stage CSA is similar to a full length-based analysis, the major difference being coarser length groups, which are more suited to a small stock with consistently low survey catches. In this approach, the abundance of male crab with a CL $\geq$ 90 mm is modeled in terms of four crab stages: stage 1: 90-104 mm CL; stage 2: 105-119 mm CL; stage 3: newshell 120-133 mm CL; and stage 4: oldshell $\geq$ 120 mm CL and newshell $\geq$ 134 mm CL. Motivation for these stage definitions came from the fact that, for management of the SMBKC stock, male crab measuring $\geq$ 105 mm CL are considered mature, whereas 120 mm CL is considered a proxy for the legal size of 5.5 in carapace width, including spines. Additional motivation for these stage definitions came from an estimated average growth increment of about 14 mm per molt for SMBKC (Otto and Cummiskey 1990).

Concerns about the pre-2011 assessment model led to CPT and SSC recommendations that included development of an alternative model with provisional assessment based on survey biomass or some other index of abundance. An alternative 3-stage model was proposed to the CPT in May 2011, but a survey-based approach was requested for the fall 2011 assessment. In May 2012, the CPT approved a slightly revised and better-documented version of the alternative model for assessment. The model developed and used from 2012 to 2015 was a variant of the previous four-stage SMBKC CSA model and similar in complexity to that described by Collie et al. (2005). Like the earlier model, it considered only male crab $\geq$ 90 mm in CL, but combined stages 3 and 4 of the earlier model, resulting in three stages (male size classes) defined by CL measurements of (1) 90-104 mm, (2) 105-119 mm, and (3) 120 mm+ (i.e., 120 mm and above). This consolidation was driven by concern about the accuracy and consistency of shell-condition information, which had been used in distinguishing stages 3 and 4 of the earlier model.

In 2016, the accepted SMBKC assessment model made use of the modeling framework GMACS, with a three-stage model structure (Webber et al. 2016). In that assessment, an effort was made to match the 2015 SMBKC stock assessment model while bridging to a new framework that provided greater flexibility and opportunity to evaluate model assumptions more fully. Since 2016, the assessment has continued to use GMACS, transitioning to more recent versions of GMACS as development has progressed.

Assessment Methodology

This assessment model uses the modeling framework GMACS and is detailed in Appendix A. An updated version of GMACS (version 2.20.14) was used.

Model Selection and Evaluation

The base model presented here, model 16.1, is the model recommended by the CPT and SSC in May and June 2024, respectively. The May 2024 version of the model (model 16.1 - May) uses data including the 2023 NMFS trawl survey biomass and size composition data, 2022 ADF&G pot survey abundance and size composition data, and 1993-2022 groundfish and fixed gear bycatch estimates based on NMFS AKRO data; model 16.1 - May uses GMACS version 2.01.M.10. The current version of the model (model 16.1) differs from model 16.1 - May in that it includes the 2024 NMFS survey biomass and size composition data and the 2023 groundfish and fixed gear bycatch estimates, and uses GMACS version 2.20.14. Before adding the new data to model 16.1, we verified that the model produced the same or very similar results to model 16.1 - May in order to ensure that the transition from GMACS version 2.01.M.10 to GMACS version 2.20.14 did not alter model results.

The models presented are as follows:

1. **16.1 - May**: May 2024 recommended model, using GMACS version 2.01.M.10 (2024-02-27), with a fixed $M = 0.18$ for all years except the 1998 time block in which M is estimated, updated with 2022/23 groundfish bycatch data, 2023 NMFS trawl survey data, and 2022 ADF&G pot survey data. This model includes a fully updated historical time series for the ADF&G pot survey relative abundance index and size compositions, incorporating error corrections to the historical data sets and a more transparent, replicable data processing procedure. An erroneous relative abundance data point from the 2016 ADF&G pot survey was corrected. This model also has SSB estimated in season 5 of the model rather than season 4 as in previous model versions. This change was deemed necessary after the clarification that GMACS estimates SSB at the beginning of a season (NPFMC 2024). As SSB is intended to be estimated on 15 February, and 15 February is the dividing date between seasons 4 and 5 in this model, SSB estimation should take place in season 5. The base model is model 16.1 since 2016 was the original year of model development and acceptance, and the model changes presented in May 2024 were deemed sufficient to warrant changing the model number from 16.0 to 16.1.
2. **16.1**: model 16.1 - May updated to use GMACS version 2.20.14, and including 2023/24 groundfish bycatch data and 2024 NMFS trawl survey data (biomass and size composition estimates).
3. **16.1a**: model 16.1 with data from NMFS survey corner stations removed for all years in the time series; this comparison is considered necessary because corner stations were not surveyed in 2024.
4. **24.1**: model 16.1 with a fixed $M = 0.23$ for all years except the 1998 time block in which M is estimated. The value of M is taken from the most recent BBRKC SAFE.
5. **24.1a**: model 24.1 with data from NMFS survey corner stations removed for all years in the time series; this comparison is considered necessary because corner stations were not surveyed in 2024.

Results

a. Sensitivity to new data

Model 16.1 - May is the most recent recommended model for SMBKC, from May 2024. Model 16.1 is the same model transitioned to GMACS 2.20.14 and with the addition of the groundfish bycatch data for the 2023/24 crab season as well as NMFS trawl survey data (biomass and size compositions) from the 2024 summer survey.

The 2022 ADF&G pot survey size compositions are relatively similar to previous years (Figure 10), while the 2024 NMFS trawl survey observed a greater relative abundance of larger males than in recent years (Figure 11). Comparisons of the fits of models 16.1 - May and 16.1 to the NMFS trawl survey index (Figure 16) and the ADF&G pot survey index (Figure 17) show nearly identical fits to the survey data, which is expected since there is only one new data point between these models, and demonstrates that the model produces similar results when run using GMACS 2.20.14. Estimates from models 16.1 - May and 16.1 of mature male biomass (Figure 18) are also nearly identical. As has been noted in the past, this model fits neither survey index well, with particularly poor fits to the ADF&G pot survey 2016 - 2018 data points and the 2006 - 2016 trawl survey data points.

b. Effective sample sizes and weighting factors

Observed and estimated effective sample sizes are compared in Table 14. Data weighting factors, standard deviation of normalized residuals (SDNRs), and median absolute residual (MAR) are presented in Table 8. Francis (2011) weighting was explored for this assessment in 2017 but, given the relatively few size bins in this assessment, this approach was suspended. The SDNR values for the trawl survey and pot survey are acceptable and similar across the model scenarios; the values are similar to those for most model scenarios considered in May 2022. The SDNR values for the directed pot fishery and other size compositions are also similar to previous estimates. The MAR values for the trawl survey and pot survey size compositions are adequate, ranging from 0.43 to 0.58 for the new base model (16.1).

c. Parameter estimates

Model parameter estimates for each of the models are summarized in Tables 15, 16, 17, and 18, and compared in Table 19. Negative log-likelihood values and management measures for each of the model configurations are compared in Tables 7 and 20.

There are differences in parameter estimates among models as reflected in the log-likelihood components and the management quantities. Model 24.1, with $M = 0.23$, has a lower total negative log-likelihood value than does model 16.1, with $M = 0.18$, mainly stemming from lower negative log-likelihood values for the two survey indices; the higher natural mortality value likely lends the model more flexibility to fit variations in survey abundance. As compared to models 16.1 and 24.1, respectively, models 16.1a and 24.1a both have higher total negative log-likelihood values; the models with corner stations excluded from the time series show lower negative log-likelihood values for the ADF&G pot survey index but much higher negative log-likelihood values for the NMFS trawl survey index than do models with corner stations included when available (1983-2023). The finding that the model fit to the NMFS trawl survey index is poorer when corner stations are excluded is not unexpected given that corner stations were originally added to the NMFS trawl survey in order to improve the quality of the data products (DePhilippo et al. 2023).

Selectivity estimates for the directed fishery (Figure 19) as well as recruitment (Figures 20, 21, and 22) are similar among the models, with model 24.1 having higher estimated recruitment than model 16.1, and the models with corner stations excluded having lower estimated recruitment than the corresponding models with corner stations included. Estimated mature male biomass (MMB) on 15 February is similar for models 16.1 and 24.1, particularly for the more recent years in the time series (Figure 7). The models with corner stations included (16.1 and 24.1) consistently estimate higher MMB than the models with corner stations excluded (16.1a and 24.1a) (Figures 8 and 9); the mean difference in estimated MMB between models 16.1 and 16.1a is 404 t (SE = 40 t) and the mean difference in estimated MMB between models 24.1 and 24.1a is 432 t (SE = 45 t).

Estimates of fishing mortality from the four model scenarios (16.1, 16.1a, 24.1, and 24.1a) are shown to assist with the rebuilding and reference point time frame discussions (Figure 23). Fishing mortality cannot be ruled out as being an influential factor in the current low stock status.

d. Evaluation of the fit to the data

Model scenarios 16.1 and 24.1 do not show large differences in their fits to total male ($\geq$ 90 mm CL) NMFS trawl survey biomass: both miss the recent peak in 2010 - 2011 and fit the 2012, 2014 - 2016, and 2019 data points below the lower end of their error bars, although fits to the 2021-2024 data points are better (Figure 24). These fits are most likely being pulled down by the low abundance in the ADF&G pot survey data in 2015 - 2018. These model scenarios also show similar fits to the pot survey relative abundance index, fitting the overall trends in the data but not capturing some of the high and low points (Figure 25). The models with corner stations included versus excluded are fitting different NMFS survey data sets, but show a similar pattern in terms of missing the 2010 - 2011 peak (Figures 26 and 27). The models with corner stations excluded tend to show better fits to the ADF&G pot survey data, coming closer to both high and low points in the time series (Figures 28 and 29).

Fits to the size compositions for trawl survey, pot survey, and commercial observer data are reasonable but miss the largest size category in some years for the trawl survey (Figures 30, 31, 32, and 33). Note that the models with and without corner stations are fitting different trawl survey size composition time series and so are displayed separately. Representative residual plots of the composition data generally have a similar fit to the three composition data sources (Figures 34, 35, and 36). The model fits to different types of retained and discarded catch values performed as expected given the assumed levels of uncertainty in the input data (Figure 37).

e. Retrospective and historical analyses

The retrospective pattern in MMB for 10 peels for model 16.1 is shown in Figure 38; a positive retrospective bias begins to appear with the 2016 peel. The Mohn's ρ value of 0.394 suggests model misspecification. For model 24.1, a positive retrospective pattern similarly begins to appear with the 2016 peel, and the Mohn's ρ value is 0.317 (Figure 39). The relative stability of the model MMB estimates for the 2022 - 2017 peels may be a result of the stability in NMFS trawl survey biomass estimates in the years following 2016 relative to the larger fluctuations in biomass estimates over 2013 - 2016, and/or the greater consistency in trends between the NMFS trawl survey biomass index and ADF&G relative abundance index beginning in 2017 (Figure 6).

f. Uncertainty and sensitivity analyses

Estimated standard deviations of parameters and selected management measures for the models are summarized for each individual model in Table 15. Model estimates of mature male biomass and OFL in 2024/25 are presented in Section F. The probability density function of the OFL, based on 1,000 Markov chain Monte Carlo (MCMC) draws, is shown in Figure 4 for model 16.1 and Figure 5 for model 24.1.

Jitter analysis indicated that models 16.1, 16.1a, 24.1, and 24.1a all converged to the global minimum of the objective function: for each model, none of the jitter runs showed a lower negative log-likelihood value than that of the original model run. We completed 50 jitter runs with a standard deviation of 0.2 for each of the four models. The percentage of jitter runs that showed the same total negative log-likelihood value as in the original model run was 78%, 88%, 80%, and 86% for models 16.1, 16.1a, 24.1, and 24.1a, respectively. For all four models, the remaining jitter runs showed higher negative log-likelihood values.

g. Comparison of alternative model scenarios

Model 16.1, the new base model, provides two needed updates to the old base model (16.0): the ADF&G pot survey abundance index and size composition time series are fully updated using a consistent data processing procedure, which allowed for the detection and correction of errors in the time series, and SSB estimation is moved to season 5 of the model so that it occurs on the intended date of 15 February. Model 16.1 has M fixed at 0.18 for most of the time series, only allowing M to be estimated for the 1998/1999 natural mortality event (Figure 40).

The current Crab FMP (NPFMC 2021) states that "natural mortality of adult red king crab is assumed to be about 18 percent per year ($M = 0.2$)" and, in the absence of species-specific information, $M = 0.18$ has been the value used in SMBKC assessments as well (e.g., Webber et al. 2016). However, the CPT and SSC in 2023 accepted a Bristol Bay red king crab model for harvest specifications that estimates $M = 0.23$ (Palof 2023), indicating that views may be shifting on the suitability of the $M = 0.18$ value for BSAI king crab stocks, and in spring 2024 the CPT and SSC requested a version of the SMBKC model with M fixed at the value estimated in the most recent BBRKC assessment. The resulting model 24.1 is presented here and shows a better overall fit to the data than model 16.1, in particular better fits to the survey indices, likely due to the greater flexibility provided by the higher natural mortality rate.

In spring 2024, the CPT and SSC also requested versions of the SMBKC models with corner stations removed from the NMFS trawl survey time series, since those stations were not surveyed in the summer 2024 NMFS trawl survey; models 16.1a and 24.1a are the resulting models presented here. Differences in the output of the models with versus without corner stations included in the time series emphasizes the need for a spatiotemporal model-based index for the NMFS trawl survey, as does previous research indicating that the precision of model-based indices is more robust to the removal of corner stations than is the precision of design-based estimates for the SMBKC stock (DePhilippo et al. 2023). The authors intend to present research models using a spatiotemporal model-based index for the NMFS trawl survey biomass estimates at the January 2025 CPT modeling workshop.

For fall 2024, the authors recommend using model 24.1 for harvest specifications. Although model 16.1 is also suitable, model 24.1 shows an overall better fit to the data and uses the same natural mortality value as BBRKC, providing consistency among the Bering Sea king crab stocks.

F. Calculation of the OFL and ABC

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

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

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

where B is quantified as mature-male biomass (MMB) at mating with time of mating assigned a nominal date of 15 February. Note that B is a function of the fishing mortality F_{OFL} (therefore numerical approximation of F_{OFL} is required). As implemented for this assessment, all calculations proceed according to the model equations given in Appendix A. F_{OFL} is taken to be full-selection fishing mortality in the directed pot fishery, and groundfish trawl and fixed-gear fishing mortalities are set at their geometric mean values over years for which there are data-based estimates of bycatch-mortality biomass.

The currently recommended Tier 4 convention is to use the full assessment period, currently 1978 - 2023, to define a B_{MSY} proxy in terms of average estimated MMB and to set $\gamma = 1.0$ with assumed stock natural mortality $M = 0.18$ yr^{-1} in setting the F_{MSY} proxy value γM. Note that, for models 24.1 and 24.1a the value used for M is 0.23. The parameters α and β are assigned their default values $\alpha = 0.10$ and $\beta = 0.25$. The F_{OFL}, OFL, ABC, and MMB in 2024/25 for all the models are summarized in Table 7. The currently recommended ABC is 75% of the OFL (ABC buffer = 25%).

Table 7: Comparisons of management measures for the models 16.1, 16.1a, 24.1, and 24.1a. Biomass and OFL are in tons.

Component	16.1	16.1a	24.1	24.1a
MMB_{2024}	1620.848	1381.696	1529.767	1383.466
B_{MSY}	2860.297	2456.085	2934.661	2502.285
MMB/B_{MSY}	0.567	0.563	0.521	0.553
F_{OFL}	0.093	0.093	0.108	0.116
OFL_{2024}	121.456	102.907	129.455	126.022
ABC_{2024}	91.092	77.180	97.092	94.516

G. Rebuilding Analysis and Update

This stock was declared overfished in fall of 2018, and a rebuilding plan was approved by the NPFMC in June 2020 (NPFMC 2020a). The most updated rebuilding plan can be found on the NPFMC website for the June 2020 meeting (NPFMC 2020b). This assessment was moved to a biennial assessment in early 2021, with full assessments performed in even-numbered years, which falls in line with the two-year rebuilding progress updates required under the rebuilding plan.

Notably, estimated B/B_{MSY} is greater than 50% in 2023/2024 for model 16.1, and this is the first year since the rebuilding plan was approved that the stock has reached this threshold; however note that $B/B_{MSY} <$ 50% in 2023/2024 for model 24.1 (Tables 5 and 6). Using model 16.1, the stock mature male biomass (MMB) was above the minimum stock size threshold (MMST) in 2023/2024 for the first time since the rebuilding plan was approved (Table 1); however, using model 24.1, the stock MMB remained below the MSST (Table 2). Both models 16.1 and 24.1 project $B/B_{MSY} > 50\%$ for 2024/2025. However, estimated MMB remains well below B_{MSY}; as stated in the Crab FMP, when a rebuilding plan is required, the minimum standard for a rebuilding target is B_{MSY} (NPFMC 2021).

The recovery of this stock is highly dependent upon successful recruitment, which is likely linked to climate variability but not well understood. Recruitment was likely negatively impacted by an ecosystem regime shift in the Bering Sea in 1989, and above-average bottom temperatures in recent years (NPFMC 2020b). Although the 2023 NMFS trawl survey found that water < -1 °C extended the farthest south that water in this temperature range had extended since 2015 (Zacher et al. 2024a), preliminary results from the 2024 NMFS trawl survey show water temperatures more similar to 2022 (Zacher et al. 2024b). Consistently cooler bottom temperatures might be expected to have a positive effect on St Matthew Island blue king crab recruitment, although more research on the factors affecting recruitment is needed. NMFS trawl survey biomass of males in the model has been low in 2021-2024 (Figure 16). The most recent ADF&G pot survey, which occurred in 2022, observed a relative abundance index that was the highest since 2013 (Figure 17). Model estimates of recruitment decreased in 2023, suggesting limited potential for future stock growth under current conditions (Figures 20 and 21).

Projections of the stock 10 years into the future based on both models 16.1 and 24.1 suggest stock growth when mean recruitment over the whole time series (1978-2023) is used, with the stock size projected to surpass B_{MSY} under $F = 0.18$ as well as under no directed fishery pressure ($F = 0$) (Figures 41 and 42). However, projections using a more recent recruitment period (1999 to 2023) show much more limited population growth than those drawing from the entire recruitment time series for both models 16.1 and 24.1, with the stock not projected to reach B_{MSY} by 2035 even under no directed fishery pressure ($F = 0$); under $F = 0.18$, the population is projected to remain fairly steady at a level above the minimum stock size threshold (MSST) (Figures 43 and 44). Given that recruitment estimates fall below the long-term average for every year since 2007 (Figures 20), using a more recent recruitment period likely gives more realistic projections of the future stock size trajectory.

H. Data Gaps and Research Priorities

The following topics have been listed as areas where more research on SMBKC is needed:

1. Growth increments and molting probabilities as a function of size.
2. Trawl survey catchability and selectivities.
3. Pot survey catchability and selectivities.
4. Temporal changes in spatial distributions near the island.
5. Natural mortality.

I. Projections and outlook

The outlook for recruitment is pessimistic and the abundance relative to the proxy B_{MSY} is low, although improved compared to recent years. As noted above, model estimates of recruitment decreased in 2023, suggesting limited potential for future stock growth (Figures 20 and 21). To examine the impact of historical fishing, we conducted a "dynamic-B_0" analysis, which projects the population based on estimated recruitment but removes the effect of fishing. The results of this analysis suggest that the impact of fishing has reduced the stock to about 78% (model 16.1) or 87% (model 24.1) of what it would have been in the absence of fishing (Figure 45), supporting the hypothesis that fishing pressure is not the sole contributor to the decline of this stock in recent years. The other non-fishing contributors to the observed depleted stock trend (ignoring the stock-recruit relationship) may reflect variable survival rates due to environmental conditions and also range shifts.

As discussed above, projections of the stock 10 years into the future based on both models 16.1 and 24.1 suggest stock growth when mean recruitment over the whole time series (1978-2023) is used, but projections using a more recent recruitment period (1999 to 2023) are likely more realistic and show much more limited population growth, with the stock not projected to reach B_{MSY} by 2035 even under no directed fishery pressure ($F = 0$); under $F = 0.18$, the population is projected to remain fairly steady at a level above the minimum stock size threshold (MSST) (Figures 41, 43, 42, and 44).

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K. References

Alaska Department of Fish and Game (ADF&G). 2013. Crab observer training and deployment manual. Alaska Department of Fish and Game Shellfish Observer Program, Dutch Harbor. Unpublished.

Collie, J.S., A.K. Delong, and G.H. Kruse. 2005. Three-stage catch-survey analysis applied to blue king crabs. Pages 683-714 [In] Fisheries assessment and management in data-limited situations. University of Alaska Fairbanks, Alaska Sea Grant Report 05-02, Fairbanks.

Daly, B., R. Foy, and C. Armistead. 2014. The 2013 eastern Bering Sea continental shelf bottom trawl survey: results for commercial crab species. NOAA Technical Memorandum 295, NMFS-AFSC.

DeFilippo, L., S. Kotwicki, L. Barnett, J. Richar, M.A. Litzow, W.T. Stockhausen, and K. Palof. 2023. Evaluating the impacts of reduced sampling density in a systematic fisheries-independent survey design. Front. Mar. Sci. 10:1219283.

Donaldson, W.E., and S.C. Byersdorfer. 2005. Biological field techniques for lithodid crabs. University of Alaska Fairbanks, Alaska Sea Grant Report 05-03, Fairbanks.

Fitch, H., M. Deiman, J. Shaishnikoff, and K. Herring. 2012. Annual management report for the commercial and subsistence shellfish fisheries of the Bering Sea, 2010/11. Pages 75-1776 [In] Fitch, H., M. Schwenzfeier, B. Baechler, T. Hartill, M. Salmon, and M. Deiman, E.

Evans, E. Henry, L. Wald, J. Shaishnikoff, K. Herring, and J. Wilson. 2012. Annual management report for the commercial and subsistence shellfish fisheries of the Aleutian Islands, Bering Sea and the Westward Region’s Shellfish Observer Program, 2010/11. Alaska Department of Fish and Game, Fishery Management Report No. 12-22, Anchorage.

Fournier, D.A., H.J. Skaug, J. Ancheta, J. Ianelli, A. Magnusson, M.N. Maunder, A. Nielsen, and J. Sibert. 2012. AD Model Builder: using automatic differentiation for statistical inference of highly parameterized complex nonlinear models. Optim. Methods Softw. 27:233-249.

Francis, R.I.C.C. 2011. Data weighting in statistical fisheries stock assessment models. Can. J. Fish. Aquat. Sci. 68: 1124-1138.

Gaeuman, W.B. 2013. Summary of the 2012/13 mandatory crab observer program database for the Bering Sea/Aleutian Islands commercial crab fisheries. Alaska Department of Fish and Game, Fishery Data Series No. 13-54, Anchorage.

Gish, R.K., V.A. Vanek, and D. Pengilly. 2012. Results of the 2010 triennial St. Matthew Island blue king crab pot survey and 2010/11 tagging study. Alaska Department of Fish and Game, Fishery Management Report No. 12-24, Anchorage.

Jensen, G.C., and D.A. Armstrong. 1989. Biennial reproductive cycle of blue king crab, *Paralithodes platypus*, at the Pribilof Islands, Alaska and comparison to a congener, *P. camtschatica*. Can. J. Fish. Aquat. Sci. 46: 932-940.

Moore, H., L.C. Byrne, and D. Connolly. 2000. Alaska Department of Fish and Game summary of the 1998 mandatory shellfish observer program database. Alaska Dept. Fish and Game, Commercial Fisheries Division, Reg. Inf. Rep. 4J00-21, Kodiak.

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2019. Status of Stocks 2018. Annual Report to Congress on the Status of U.S. Fisheries.

National Oceanic and Atmospheric Administration (NOAA). 2020. Fisheries of the Exclusive Economic Zone off Alaska; St. Matthew Blue King Crab rebuilding plan in the Bering Sea and Aleutian Islands. 50 CFR Part 679.

North Pacific Fishery Management Council (NPFMC). 1998. Fishery Management Plan for Bering Sea/Aleutian Islands king and Tanner crabs. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 1999. Environmental assessment/regulatory impact review/initial regulatory flexibility analysis for Amendment 11 to the Fishery Management Plan for Bering Sea/Aleutian Islands king and Tanner crabs. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 2000. Environmental assessment/regulatory impact review/initial regulatory flexibility analysis for proposed Amendment 15 to the Fishery Management Plan for king and Tanner crab fisheries in the Bering Sea/Aleutian Islands and regulatory amendment to the Fishery Management Plan for the groundfish fishery of the Bering Sea and Aleutian Islands area: A rebuilding plan for the St. Matthew blue king crab stock. North Pacific Fishery Management Council, Anchorage. Draft report.

North Pacific Fishery Management Council (NPFMC). 2007. Public Review Draft: Environmental assessment for proposed Amendment 24 to the Fishery Management Plan for Bering Sea and Aleutian Islands king and Tanner crabs to revise overfishing definitions. 14 November 2007. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 2020a. C-3 St. Matthew Island blue king crab rebuilding Council motion. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 2020b. Environmental assessment for a proposed amendment to the Fishery Management Plan for the Bering Sea and Aleutian Islands King and Tanner Crabs: rebuilding plan for St. Matthew Island Blue King Crab. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 2021. Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs. North Pacific Fishery Management Council, Anchorage.

North Pacific Fishery Management Council (NPFMC). 2024. Crab Plan Team report, May 2024. North Pacific Fishery Management Council, Anchorage.

Otto, R.S. 1990. An overview of eastern Bering Sea king and Tanner crab fisheries. Pages 9-26 [In] Proceedings of the international symposium on king and Tanner crabs. University of Alaska Fairbanks, Alaska Sea Grant Program Report 90-4, Fairbanks.

Otto, R.S., and P.A. Cummiskey. 1990. Growth of adult male blue king crab (*Paralithodes platypus*). Pages 245-258 [In] Proceedings of the international symposium on king and Tanner crabs. University of Alaska Fairbanks, Alaska Sea Grant Report 90-4, Fairbanks.

Palof, K.J. 2023. Bristol Bay Red King Crab Stock Assessment 2023. In: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands: 2023 Final Crab SAFE. North Pacific Fishery Management Council, Anchorage AK.

Paul, J.M., A. J. Paul, R.S. Otto, and R.A. MacIntosh. 1991. Spermatophore presence in relation to carapace length for eastern Bering Sea blue king crab (*Paralithodes platypus*, Brandt, 1850) and red king crab (*P. camtschaticus*, Tilesius, 1815). J. Shellfish Res. 10: 157-163.

Pengilly, D. and D. Schmidt. 1995. Harvest Strategy for Kodiak and Bristol Bay red king crab and St. Matthew Island and Pribilof blue king crab. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Special Publication Number 7, Juneau.

Somerton, D.A., and R.A. MacIntosh. 1983. The size at sexual maturity of blue king crab, Paralithodes platypus, in Alaska. Fishery Bulletin 81: 621-828.

Stoutamore, J.L. 2014. Population genetics and mating structure of blue king crab (Paralithodes platypus). Master's thesis, University of Alaska Fairbanks, SGT-14-01, 90 pp.

Webber, D., J. Zheng, and J. Ianelli. 2016. Saint Matthew Island blue king crab stock assessment 2016. In: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands: 2016 Final Crab SAFE. North Pacific Fishery Management Council, Anchorage AK.

Weems, J., W.C. Long, and G.L. Eckert. 2020. Pribilof Islands blue king crab (*Paralithodes platypus*) recruitment limitation as a potential bottleneck to rebuilding from overfished status. North Pacific Research Board Project 1608 Final Report.

Zacher, L.S., J.I. Richar, E.J. Fedewa, E.R. Ryznar, M.A. Litzow. 2024a. The 2023 Eastern and Northern Bering Sea Continental Shelf Trawl Surveys: Results for Commercial Crab Species. NOAA Technical Memorandum NMFS-AFSC-482.

Zacher, L.S., S.M. Hennessey, J.I. Richar, E.J. Fedewa, E.R. Ryznar, M.A. Litzow. 2024b. The 2024 Eastern and Northern Bering Sea Continental Shelf Trawl Surveys: Results for Commercial Crab Species. NOAA Technical Memorandum NMFS-AFSC [draft].

Zheng, J., and G.H. Kruse. 2002. Assessment and management of crab stocks under uncertainty of massive die-offs and rapid changes in survey catchability. Pages 367-384 [In] A.J. Paul,E.G. Dawe, R. Elner, G.S. Jamieson, G.H. Kruse, R.S. Otto, B. Sainte-Marie, T.C. Shirley, and D. Woodby (eds.). Crabs in Cold Water Regions: Biology, Management, and Economics. University of Alaska Fairbanks, Alaska Sea Grant Report 02-01, Fairbanks.

Tables

Table 8: Comparisons of data weights, SDNR (standard deviation of normalized residuals) and MAR (median absolute residual) values for the model scenarios.

Component.wt	Model.16.1	Model.16.1a	Model.16.May	Model.24.1	Model.24.1a
NMFS trawl survey weight	1.00	1.00	1.00	1.00	1.00
ADF&G pot survey weight	1.00	1.00	1.00	1.00	1.00
Directed pot LF weight	1.00	1.00	1.00	1.00	1.00
NMFS trawl survey LF weight	1.00	1.00	1.00	1.00	1.00
ADF&G pot survey LF weight	1.00	1.00	1.00	1.00	1.00
SDNR NMFS trawl survey	0.00	0.00	0.00	0.00	0.00
SDNR ADF&G pot survey	0.00	0.00	0.00	0.00	0.00
SDNR directed pot LF	0.65	0.67	0.66	0.65	0.68
SDNR NMFS trawl survey LF	1.20	1.21	1.25	1.16	1.22
SDNR ADF&G pot survey LF	0.90	0.98	0.90	0.91	0.99
MAR NMFS trawl survey	0.00	0.00	0.00	0.00	0.00
MAR ADF&G pot survey	0.00	0.00	0.00	0.00	0.00
MAR directed pot LF	0.43	0.41	0.44	0.53	0.49
MAR NMFS trawl survey LF	0.54	0.59	0.64	0.57	0.59
MAR ADF&G pot survey LF	0.58	0.54	0.57	0.58	0.61

Table 9: Fishery characteristics and update. Columns include the 1978/79 to 2015/16 directed St. Matthew Island blue king crab pot fishery. The Guideline Harvest Level (GHL) and Total Allowable Catch (TAC) are in millions of pounds. Harvest includes deadloss. Catch per unit effort (CPUE) in this table is the harvest number / pot lifts. The average weight is the harvest weight / harvest number in pounds. The average carapace length (CL) is the average of retained crab in mm from dockside sampling of delivered crab. Source: Fitch et al 2012; ADF&G Dutch Harbor staff, pers. comm. Note that management (GHL) units are in pounds, for conserving space, conversion to tons is ommitted.

			Harvest					
Year	Dates	GHL/TAC	Crab	Pounds	Pot lifts	CPUE	Avg wt	Avg CL
1978/79	07/15 - 09/03		436,126	1,984,251	43,754	10	4.5	132.2
1979/80	07/15 - 08/24		52,966	210,819	9,877	5	4.0	128.8
1980/81	07/15 - 09/03			CONFIDENTIAL				
1981/82	07/15 - 08/21		1,045,619	4,627,761	58,550	18	4.4	NA
1982/83	08/01 - 08/16		1,935,886	8,844,789	165,618	12	4.6	135.1
1983/84	08/20 - 09/06	8.0	1,931,990	9,454,323	133,944	14	4.9	137.2
1984/85	09/01 - 09/08	2.0-4.0	841,017	3,764,592	73,320	11	4.5	135.5
1985/86	09/01 - 09/06	0.9-1.9	436,021	2,175,087	46,988	9	5.0	139.0
1986/87	09/01 - 09/06	0.2-0.5	219,548	1,003,162	22,073	10	4.6	134.3
1987/88	09/01 - 09/05	0.6-1.3	227,447	1,039,779	28,230	8	4.6	134.1
1988/89	09/01 - 09/05	0.7-1.5	280,401	1,236,462	21,678	13	4.4	133.3
1989/90	09/01 - 09/04	1.7	247,641	1,166,258	30,803	8	4.7	134.6
1990/91	09/01 - 09/07	1.9	391,405	1,725,349	26,264	15	4.4	134.3
1991/92	09/16 - 09/20	3.2	726,519	3,372,066	37,104	20	4.6	134.1
1992/93	09/04 - 09/07	3.1	545,222	2,475,916	56,630	10	4.5	134.1
1993/94	09/15 - 09/21	4.4	630,353	3,003,089	58,647	11	4.8	135.4
1994/95	09/15 - 09/22	3.0	827,015	3,764,262	60,860	14	4.9	133.3
1995/96	09/15 - 09/20	2.4	666,905	3,166,093	48,560	14	4.7	135.0
1996/97	09/15 - 09/23	4.3	660,665	3,078,959	91,085	7	4.7	134.6
1997/98	09/15 - 09/22	5.0	939,822	4,649,660	81,117	12	4.9	139.5
1998/99	09/15 - 09/26	4.0	635,370	2,968,573	91,826	7	4.7	135.8
1999/00 - 2008/09				FISHERY CLOSED				
2009/10	10/15 - 02/01	1.17	103,376	460,859	10,697	10	4.5	134.9
2010/11	10/15 - 02/01	1.60	298,669	1,263,982	29,344	10	4.2	129.3
2011/12	10/15 - 02/01	2.54	437,862	1,881,322	48,554	9	4.3	130.0
2012/13	10/15 - 02/01	1.63	379,386	1,616,054	37,065	10	4.3	129.8
2013/14				FISHERY CLOSED				
2014/15	10/15 - 02/05	0.66	69,109	308,582	10,133	7	4.5	132.3
2015/16	10/19 - 11/28	0.41	24,076	105,010	5,475	4	4.4	132.6
2016/17				FISHERY CLOSED				
2017/18				FISHERY CLOSED				
2018/19				FISHERY CLOSED				
2019/20				FISHERY CLOSED				
2020/21				FISHERY CLOSED				
2021/22				FISHERY CLOSED				
2022/23				FISHERY CLOSED				
2023/24				FISHERY CLOSED				

Table 10: Observed proportion of crab by size class during the ADF&G crab observer pot-lift sampling. Source: ADF&G Crab Observer Database.

Year	Total pot lifts	Pot lifts sampled	Number of crab (90 mm+ CL)	Stage 1	Stage 2	Stage 3
1990/91	26,264	10	150	0.113	0.393	0.493
1991/92	37,104	125	3,393	0.133	0.177	0.690
1992/93	56,630	71	1,606	0.191	0.268	0.542
1993/94	58,647	84	2,241	0.281	0.210	0.510
1994/95	60,860	203	4,735	0.294	0.271	0.434
1995/96	48,560	47	663	0.148	0.212	0.640
1996/97	91,085	96	489	0.160	0.223	0.618
1997/98	81,117	133	3,195	0.182	0.205	0.613
1998/99	91,826	135	1.322	0.193	0.216	0.591
1999/00 - 2008/09			FISHERY CLOSED			
2009/10	10,484	989	19,802	0.141	0.324	0.535
2010/11	29,356	2,419	45,466	0.131	0.315	0.553
2011/12	48,554	3,359	58,666	0.131	0.305	0.564
2012/13	37,065	2,841	57,298	0.141	0.318	0.541
2013/14			FISHERY CLOSED			
2014/15	10,133	895	9,906	0.094	0.228	0.679
2015/16	5,475	419	3,248	0.115	0.252	0.633
2016/17 - 2023/24			FISHERY CLOSED			

Table 11: Groundfish SMBKC male bycatch biomass (t) estimates. Trawl includes pelagic trawl and non-pelagic trawl types. Source: J. Zheng, ADF&G, and author estimates based on data from R. Foy, NMFS. Estimates used after 2008/09 are from NMFS Alaska Regional Office.

Year	Trawl bycatch	Fixed gear bycatch
1978	0.000	0.000
1979	0.000	0.000
1980	0.000	0.000
1981	0.000	0.000
1982	0.000	0.000
1983	0.000	0.000
1984	0.000	0.000
1985	0.000	0.000
1986	0.000	0.000
1987	0.000	0.000
1988	0.000	0.000
1989	0.000	0.000
1990	0.000	0.000
1991	3.538	0.045
1992	1.996	2.268
1993	1.542	0.500
1994	0.318	0.091
1995	0.635	0.136
1996	0.500	0.045
1997	0.500	0.181
1998	0.500	0.907
1999	0.500	1.361
2000	0.500	0.500
2001	0.500	0.862
2002	0.726	0.408
2003	0.998	1.134
2004	0.091	0.635
2005	0.500	0.590
2006	2.812	1.451
2007	0.045	69.717
2008	0.272	6.622
2009	0.638	7.522
2010	0.360	9.564
2011	0.170	0.796
2012	0.011	0.739
2013	0.163	0.341
2014	0.010	0.490
2015	0.010	0.711
2016	0.229	1.630
2017	0.048	5.935
2018	0.001	1.224
2019	0.030	1.124
2020	0.001	0.671
2021	0.001	0.323
2022	0.001	2.118
2023	0.005	0.415

Table 12: NMFS Eastern Bering Sea trawl-survey area-swept estimates of male crab abundance (10^6 crab) and male ($\geq$ 90 mm CL) biomass (10^6 lbs). Total number of captured male crab $\geq$ 90 mm CL is also given. The "+" refer to plus group. Source: J.Richar, NMFS.

	Abundance					Biomass		
Year	Stage-1 (90-104 mm)	Stage-2 (105-119 mm)	Stage-3 (120+ mm)	Total	CV	Total (90+ mm CL)	CV	Number of crabs
1978	2.213	1.991	1.521	5.726	0.411	15.064	0.394	157
1979	3.061	2.281	1.808	7.150	0.472	17.615	0.463	178
1980	2.856	2.563	2.541	7.959	0.572	22.017	0.507	185
1981	0.483	1.213	2.263	3.960	0.368	14.443	0.402	140
1982	1.669	2.431	5.884	9.984	0.401	35.763	0.344	271
1983	1.061	1.651	3.345	6.057	0.332	21.240	0.298	231
1984	0.435	0.497	1.452	2.383	0.175	8.976	0.179	105
1985	0.379	0.376	1.117	1.872	0.216	6.858	0.210	93
1986	0.203	0.447	0.374	1.025	0.428	3.124	0.388	46
1987	0.325	0.631	0.715	1.671	0.302	5.024	0.291	71
1988	0.410	0.816	0.957	2.183	0.285	6.963	0.252	81
1989	2.169	1.154	1.786	5.109	0.314	13.974	0.271	208
1990	1.053	1.031	2.338	4.422	0.302	14.837	0.274	170
1991	1.147	1.665	2.233	5.046	0.259	15.318	0.248	197
1992	1.074	1.382	2.291	4.746	0.206	15.638	0.201	220
1993	1.521	1.828	3.276	6.626	0.185	21.051	0.169	324
1994	0.883	1.298	2.257	4.438	0.187	14.416	0.176	211
1995	1.025	1.188	1.741	3.953	0.187	12.574	0.178	178
1996	1.238	1.891	3.064	6.193	0.263	20.746	0.241	285
1997	1.165	2.228	3.789	7.182	0.367	24.084	0.337	296
1998	0.660	1.661	2.849	5.170	0.373	17.586	0.355	243
1998	0.223	0.222	0.558	1.003	0.192	3.515	0.182	52
2000	0.282	0.285	0.740	1.307	0.303	4.623	0.310	61
2001	0.419	0.502	0.938	1.859	0.243	6.242	0.245	91
2002	0.111	0.230	0.640	0.981	0.311	3.820	0.320	38
2003	0.449	0.280	0.465	1.194	0.399	3.454	0.336	65
2004	0.247	0.184	0.562	0.993	0.369	3.360	0.305	48
2005	0.319	0.310	0.501	1.130	0.403	3.620	0.371	42
2006	0.917	0.642	1.240	2.798	0.339	8.585	0.334	126
2007	2.518	2.020	1.193	5.730	0.420	14.266	0.385	250
2008	1.352	0.801	1.457	3.609	0.289	10.261	0.284	167
2009	1.573	2.161	1.410	5.144	0.263	13.892	0.256	251
2010	3.937	3.253	2.458	9.648	0.544	24.539	0.466	388
2011	1.800	3.255	3.207	8.263	0.587	24.099	0.558	318
2012	0.705	1.970	1.808	4.483	0.361	13.669	0.339	193
2013	0.335	0.452	0.807	1.593	0.215	5.043	0.217	74
2014	0.723	1.627	1.809	4.160	0.503	13.292	0.449	181
2015	0.992	1.269	1.979	4.240	0.774	12.958	0.770	153
2016	0.535	0.660	1.178	2.373	0.447	7.685	0.393	108
2017	0.091	0.323	0.663	1.077	0.657	3.955	0.600	42
2018	0.154	0.232	0.660	1.047	0.298	3.816	0.281	62
2019	0.403	0.482	1.170	2.056	0.352	6.990	0.337	105
2021	0.423	0.168	0.682	1.273	0.496	4.253	0.427	59
2022	0.620	0.372	0.763	1.754	0.452	5.216	0.497	75
2023	0.512	0.474	0.608	1.593	0.458	4.622	0.439	76
2024	0.252	0.316	0.668	1.236	0.424	4.043	0.465	34

Table 13: Size-class and total CPUE (90+ mm carapace length) with estimated CV and total number of captured crab (90+ mm carapace length) from the 96 common stations surveyed during the ADF&G St. Matthew Island blue king crab pot surveys. Source: ADF&G.

Year	Stage-1 (90-104 mm)	Stage-2 (105-119 mm)	Stage-3 (120+ mm)	Total CPUE	CV	Number of crabs
1995	1.919	3.198	6.924	12.042	0.13	4624
1998	0.964	2.763	8.805	12.531	0.06	4812
2001	1.266	1.737	5.474	8.477	0.08	3255
2004	0.112	0.414	1.141	1.667	0.15	640
2007	1.083	2.720	4.826	8.630	0.09	3325
2010	1.318	3.258	5.591	10.167	0.10	3904
2013	0.862	1.383	3.362	5.607	0.19	2153
2015	0.206	0.698	1.901	2.805	0.18	1077
2016	0.198	0.440	1.383	2.021	0.17	776
2017	0.177	0.424	1.073	1.674	0.25	643
2018	0.076	0.161	0.508	0.745	0.14	286
2022	0.630	1.030	2.432	4.089	0.14	1570

Table 14: Observed and input sample sizes for observer data from the directed pot fishery, the NMFS trawl survey, and the ADF&G pot survey.

	Number measured			Input sample sizes		
Year	Observer pot	NMFS trawl	ADF&G pot	Observer pot	NMFS trawl	ADF&G pot
1978		157			39.5	
1979		178			44.5	
1980		185			48	
1981		140			35.5	
1982		271			50	
1983		231			50	
1984		105			26.5	
1985		93			23.25	
1986		46			11.5	
1987		71			17.75	
1988		81			21	
1989		208			50	
1990	150	170		15	42.75	
1991	3393	197		25	49.5	
1992	1606	220		25	50	
1993	2241	324		25	50	
1994	4735	211		25	50	
1995	663	178	4624	25	45.75	100
1996	489	285		25	50	
1997	3195	296		25	50	
1998	1323	243	4812	25	50	100
1999		52			13.5	
2000		61			15.5	
2001		91	3255		23.25	100
2002		38			9.75	
2003		65			16.5	
2004		48	640		12.25	100
2005		42			10.75	
2006		126			31.75	
2007		250	3319		50	100
2008		167			41.75	
2009	19802	251		50	50	
2010	45466	388	3920	50	50	100
2011	58667	318		50	50	
2012	57282	193		50	49.5	
2013		74	2167		19.5	100
2014	9906	181		50	45.5	
2015	3248	153	1077	50	38.5	100
2016		108	777		27.5	100
2017		42	643		10.5	100
2018		62	286		13.75	100
2019		105			26.25	
2020						
2021		59			14.75	
2022		75	1570		18.75	100
2023		76			19	
2024		34			8.5	

Table 15: Model parameter estimates, selected derived quantities, and their standard errors (SE) for model 16.1, the new base model.

Parameter	Estimate	SE
$\log(\bar{R})$	13.871	0.188
$\log(n_1^0)$	14.926	0.176
$\log(n_2^0)$	14.505	0.211
$\log(n_3^0)$	14.316	0.208
q_{pot}	3.879	0.239
$\log(\bar{F}^{\mathrm{df}})$	-2.106	0.052
$\log(\bar{F}^{\mathrm{tb}})$	-9.997	0.070
$\log(\bar{F}^{\mathrm{fb}})$	-8.043	0.070
log Stage-1 directed pot selectivity 1978-2008	-0.899	0.179
log Stage-2 directed pot selectivity 1978-2008	-0.550	0.132
log Stage-1 directed pot selectivity 2009-2017	-0.579	0.163
log Stage-2 directed pot selectivity 2009-2017	-0.000	0.000
log Stage-1 NMFS trawl selectivity	-0.289	0.064
log Stage-2 NMFS trawl selectivity	-0.000	0.000
log Stage-1 ADF&G pot selectivity	-0.726	0.120
log Stage-2 ADF&G pot selectivity	-0.000	0.000
F_{OFL}	0.093	0.013
OFL	120.774	27.288

Table 16: Model parameter estimates, selected derived quantities, and their standard errors (SE) for model 16.1a, with corner stations removed from the NMFS trawl survey time series.

Parameter	Estimate	SE
$\log(\bar{R})$	13.743	0.189
$\log(n_1^0)$	14.891	0.189
$\log(n_2^0)$	14.401	0.237
$\log(n_3^0)$	14.233	0.226
q_{pot}	4.453	0.298
$\log(\bar{F}^{\mathrm{df}})$	-1.882	0.068
$\log(\bar{F}^{\mathrm{tb}})$	-9.856	0.073
$\log(\bar{F}^{\mathrm{fb}})$	-7.902	0.073
log Stage-1 directed pot selectivity 1978-2008	-0.970	0.195
log Stage-2 directed pot selectivity 1978-2008	-0.655	0.141
log Stage-1 directed pot selectivity 2009-2017	-0.643	0.170
log Stage-2 directed pot selectivity 2009-2017	-0.000	0.000
log Stage-1 NMFS trawl selectivity	-0.377	0.090
log Stage-2 NMFS trawl selectivity	-0.000	0.000
log Stage-1 ADF&G pot selectivity	-0.655	0.137
log Stage-2 ADF&G pot selectivity	-0.000	0.000
F_{OFL}	0.093	0.016
OFL	102.206	27.568

Table 17: Model parameter estimates, selected derived quantities, and their standard errors (SE) for model 24.1, with M = 0.23.

Parameter	Estimate	SE
$\log(\bar{R})$	14.104	0.188
$\log(n_1^0)$	15.111	0.178
$\log(n_2^0)$	14.568	0.217
$\log(n_3^0)$	14.364	0.227
q_{pot}	3.611	0.248
$\log(\bar{F}^{\mathrm{df}})$	-2.127	0.054
$\log(\bar{F}^{\mathrm{tb}})$	-10.085	0.072
$\log(\bar{F}^{\mathrm{fb}})$	-8.133	0.072
log Stage-1 directed pot selectivity 1978-2008	-1.096	0.181
log Stage-2 directed pot selectivity 1978-2008	-0.668	0.131
log Stage-1 directed pot selectivity 2009-2017	-0.768	0.171
log Stage-2 directed pot selectivity 2009-2017	-0.000	0.000
log Stage-1 NMFS trawl selectivity	-0.457	0.072
log Stage-2 NMFS trawl selectivity	-0.031	0.059
log Stage-1 ADF&G pot selectivity	-0.936	0.124
log Stage-2 ADF&G pot selectivity	-0.055	0.074
F_{OFL}	0.108	0.017
OFL	128.790	32.045

Table 18: Model parameter estimates, selected derived quantities, and their standard errors (SE) for model 24.1a, with corner stations removed from the NMFS trawl survey time series and M = 0.23.

Parameter	Estimate	SE
$\log(\bar{R})$	13.985	0.190
$\log(n_1^0)$	15.052	0.191
$\log(n_2^0)$	14.468	0.241
$\log(n_3^0)$	14.202	0.254
q_{pot}	4.115	0.318
$\log(\bar{F}^{\mathrm{df}})$	-1.888	0.071
$\log(\bar{F}^{\mathrm{tb}})$	-9.957	0.077
$\log(\bar{F}^{\mathrm{fb}})$	-8.006	0.077
log Stage-1 directed pot selectivity 1978-2008	-1.192	0.194
log Stage-2 directed pot selectivity 1978-2008	-0.777	0.140
log Stage-1 directed pot selectivity 2009-2017	-0.811	0.177
log Stage-2 directed pot selectivity 2009-2017	-0.000	0.000
log Stage-1 NMFS trawl selectivity	-0.576	0.103
log Stage-2 NMFS trawl selectivity	-0.102	0.073
log Stage-1 ADF&G pot selectivity	-0.849	0.143
log Stage-2 ADF&G pot selectivity	-0.090	0.081
F_{OFL}	0.116	0.022
OFL	125.333	36.223

Table 19: Comparisons of parameter estimates for the model scenarios.

Parameter	Model 16.1	Model 16.1a	Model 24.1	Model 24.1a
$\log(\bar{R})$	13.871	13.743	14.104	13.985
$\log(n_1^0)$	14.926	14.891	15.111	15.052
$\log(n_2^0)$	14.505	14.401	14.568	14.468
$\log(n_3^0)$	14.316	14.233	14.364	14.202
q_{pot}	3.879	4.453	3.611	4.115
$\log(\bar{F}^{\mathrm{df}})$	-2.106	-1.882	-2.127	-1.888
$\log(\bar{F}^{\mathrm{tb}})$	-9.997	-9.856	-10.085	-9.957
$\log(\bar{F}^{\mathrm{fb}})$	-8.043	-7.902	-8.133	-8.006
log Stage-1 directed pot selectivity 1978-2008	-0.899	-0.970	-1.096	-1.192
log Stage-2 directed pot selectivity 1978-2008	-0.550	-0.655	-0.668	-0.777
log Stage-1 directed pot selectivity 2009-2017	-0.579	-0.643	-0.768	-0.811
log Stage-2 directed pot selectivity 2009-2017	-0.000	-0.000	-0.000	-0.000
log Stage-1 NMFS trawl selectivity	-0.289	-0.377	-0.457	-0.576
log Stage-2 NMFS trawl selectivity	-0.000	-0.000	-0.031	-0.102
log Stage-1 ADF&G pot selectivity	-0.726	-0.655	-0.936	-0.849
log Stage-2 ADF&G pot selectivity	-0.000	-0.000	-0.055	-0.090
F_{OFL}	0.093	0.093	0.108	0.116
OFL	120.774	102.206	128.790	125.333

Table 20: Comparisons of negative log-likelihood values for the selected model scenarios.

Component	Model.16.1	Model.16.1a	Model.24.1	Model.24.1a
Pot retained catch	-68.33	-68.92	-68.99	-69.27
Pot discarded catch	5.95	5.30	4.50	4.05
Trawl bycatch discarded catch	-9.09	-9.09	-9.09	-9.09
Fixed bycatch discarded catch	-9.05	-9.07	-9.08	-9.08
NMFS trawl survey	6.74	18.28	1.06	12.30
ADF&G pot survey CPUE	85.34	69.51	75.67	59.97
Directed pot LF	-105.07	-104.62	-105.06	-104.40
NMFS trawl LF	-276.16	-232.26	-277.15	-230.00
ADF&G pot LF	-100.00	-97.83	-99.95	-97.47
Recruitment deviations	64.92	67.05	64.09	66.02
F penalty	14.49	14.49	14.49	14.49
Prior	13.71	13.71	13.71	13.71
Total	-391.04	-347.93	-410.27	-363.25
Total estimated parameters	159.00	159.00	159.00	159.00

Table 21: Population abundances ($\boldsymbol{n}$) by crab stage in numbers of crab at the time of the survey and mature male biomass (MMB) in tons on 15 February for the new base model, model 16.1.

Year	n_1	n_2	n_3	MMB	CV MMB
1978	3034434	1993545	1649379	4083	0.164
1979	4141084	2316618	2261411	5733	0.118
1980	3789602	3111874	3404264	9020	0.083
1981	1395807	3179268	4744870	9403	0.064
1982	1565890	1798811	4771274	6633	0.074
1983	840770	1412001	3348006	3886	0.107
1984	652779	866076	1870859	2564	0.133
1985	943228	619893	1315691	2258	0.153
1986	1384635	713467	1111210	2258	0.146
1987	1432476	1002074	1220844	2729	0.132
1988	1328446	1123293	1453039	3088	0.123
1989	2885982	1103532	1651237	3621	0.113
1990	1856036	1975224	1985741	4652	0.088
1991	1910939	1671966	2469629	4697	0.089
1992	2087951	1584156	2424361	4807	0.081
1993	2351964	1668836	2527495	5065	0.073
1994	1559202	1837098	2599847	4841	0.067
1995	1691805	1438092	2489825	4693	0.068
1996	1709564	1394642	2365959	4377	0.070
1997	901100	1388446	2245649	3758	0.087
1998	626597	919584	1809815	1820	0.097
1999	373703	318847	703759	1544	0.104
2000	399298	317595	783913	1681	0.082
2001	378186	331789	852849	1815	0.073
2002	129783	324479	915493	1915	0.066
2003	294692	181041	940385	1808	0.068
2004	216143	227144	904382	1795	0.068
2005	458670	197898	890447	1740	0.068
2006	682081	325890	887133	1866	0.069
2007	388439	494659	969410	2155	0.064
2008	853823	378957	1080974	2255	0.056
2009	692175	609639	1174288	2410	0.050
2010	607585	585608	1251218	2045	0.052
2011	448093	514819	1100858	1473	0.064
2012	233565	389697	782307	929	0.098
2013	228091	231982	489735	1085	0.088
2014	209020	206275	547726	1007	0.093
2015	170752	182993	515039	995	0.094
2016	166444	156274	515231	1050	0.091
2017	135733	146133	524613	1054	0.089
2018	144822	125143	523524	1031	0.087
2019	247120	123586	513471	1013	0.087
2020	200610	181166	514595	1075	0.093
2021	369000	173849	540222	1112	0.098
2022	415475	267075	574111	1267	0.098
2023	534239	324149	653519	1464	0.102

Table 22: Population abundances (***n***) by crab stage in numbers of crab at the time of the survey (1 July, season 1) and mature male biomass (MMB) in tons on 15 February for model 24.1, with M = 0.23.

Year	n_1	n_2	n_3	MMB	CV MMB
1978	3652035	2121987	1730853	4227	0.182
1979	5035268	2582366	2336216	5933	0.132
1980	4582729	3527046	3506472	9329	0.093
1981	1674081	3583469	4865889	9714	0.071
1982	1806734	1989902	4853014	6750	0.081
1983	928848	1536790	3360334	3897	0.114
1984	738967	914442	1850576	2496	0.140
1985	1097554	652944	1264327	2121	0.161
1986	1544685	772240	1043599	2130	0.156
1987	1653276	1058034	1148726	2577	0.148
1988	1570989	1204997	1370285	2937	0.145
1989	3511747	1205629	1564116	3457	0.135
1990	2217925	2247370	1923476	4674	0.100
1991	2288964	1870218	2459504	4721	0.097
1992	2530357	1773157	2421752	4837	0.088
1993	2857650	1885651	2529780	5119	0.080
1994	1862113	2088361	2619825	4965	0.073
1995	2165664	1610746	2525991	4774	0.073
1996	2151326	1635985	2400222	4531	0.073
1997	1103783	1633982	2313392	3995	0.089
1998	812126	1061324	1904034	2051	0.101
1999	518542	403350	803976	1749	0.113
2000	515367	406935	879018	1878	0.087
2001	503653	406429	940230	1980	0.077
2002	173788	399920	987487	2052	0.071
2003	375104	219727	991914	1877	0.074
2004	301616	271665	927090	1822	0.074
2005	703370	248430	894192	1744	0.075
2006	884062	458066	893344	1952	0.081
2007	593830	621165	1008859	2284	0.077
2008	1132457	510215	1139783	2416	0.061
2009	883070	771652	1252073	2621	0.057
2010	777061	710269	1344315	2240	0.057
2011	569275	618980	1190291	1657	0.070
2012	302982	467455	868238	1099	0.103
2013	293959	282019	570851	1238	0.091
2014	264690	247549	615454	1126	0.096
2015	215286	217075	567176	1081	0.096
2016	209860	183395	551397	1105	0.092
2017	162929	170985	544722	1080	0.089
2018	186537	141521	528364	1024	0.088
2019	316891	145239	503957	988	0.089
2020	251052	216823	498673	1051	0.098
2021	417405	203839	522917	1079	0.104
2022	503996	289638	551149	1212	0.105
2023	604896	363234	622281	1406	0.109

Figures

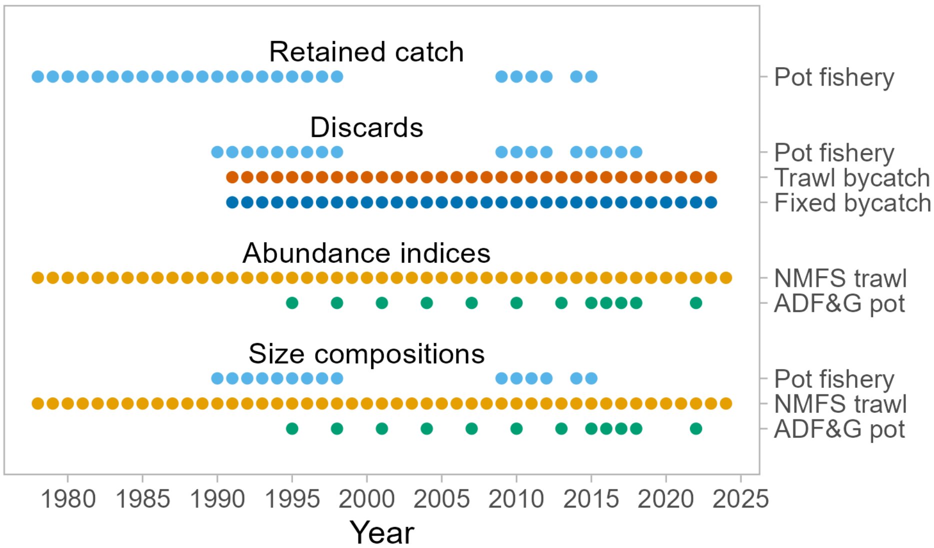

Figure 1: Data extent for the SMBKC assessment.

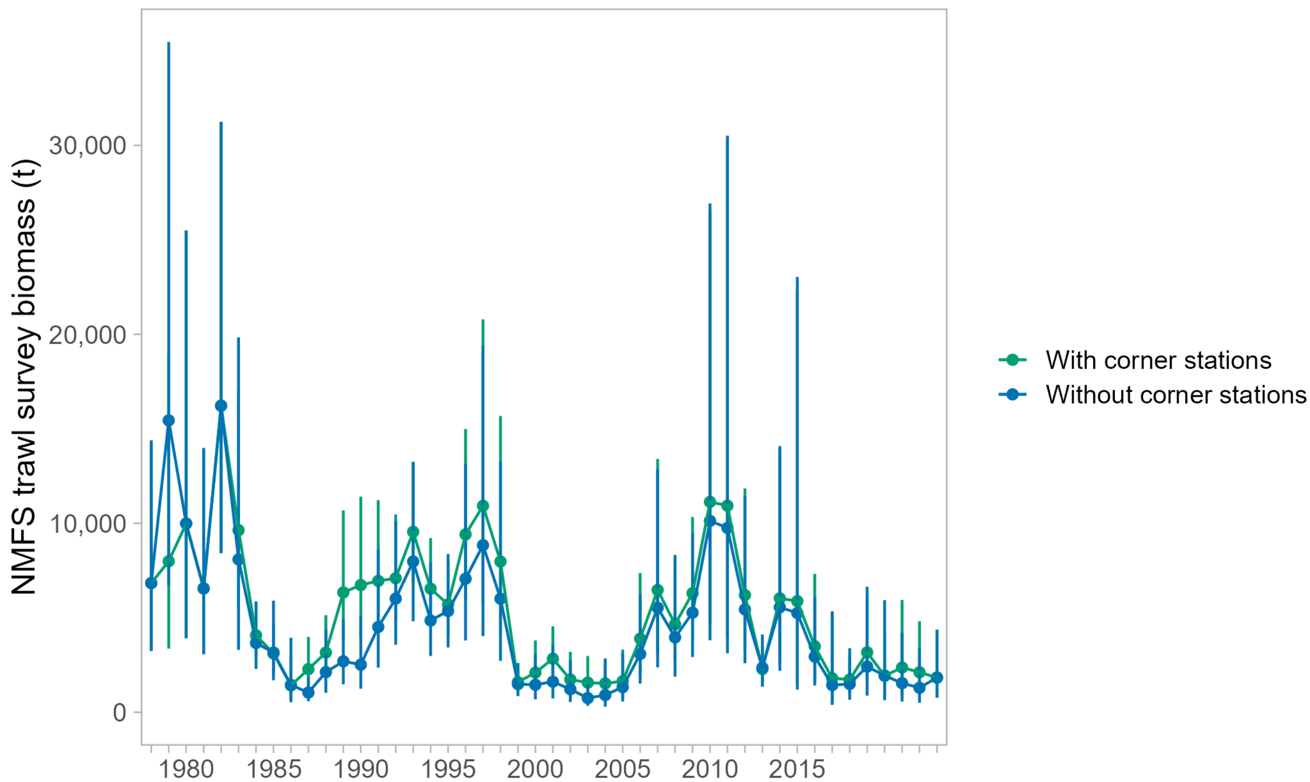

Figure 2: NMFS area-swept trawl estimates of total ($\geq$ 90 mm) male survey biomass with and without corner stations included in the time series. Error bars are plus and minus 2 standard deviations.

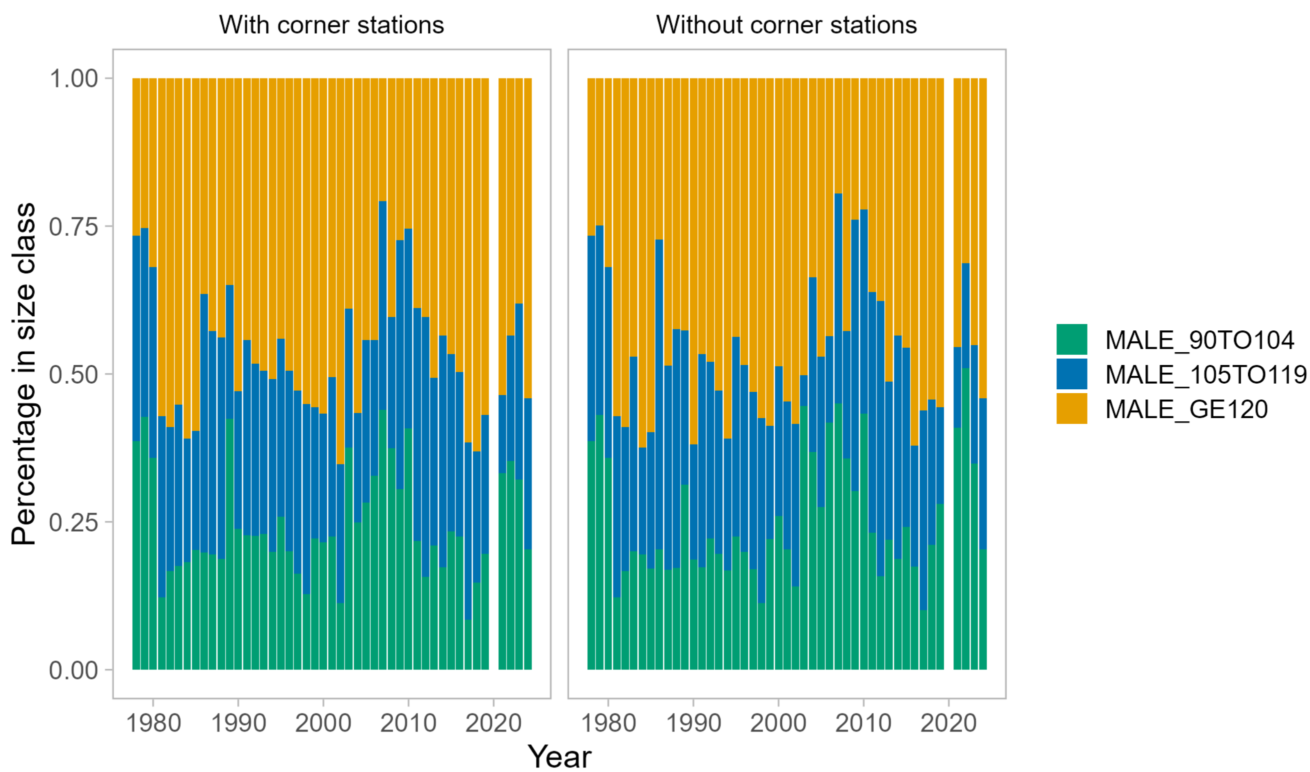

Figure 3: NMFS area-swept trawl survey size compositions for the male size classes in the model (90-104 mm, 105-119 mm, and $\geq$ 120 mm carapace length) with and without corner stations included in the time series.

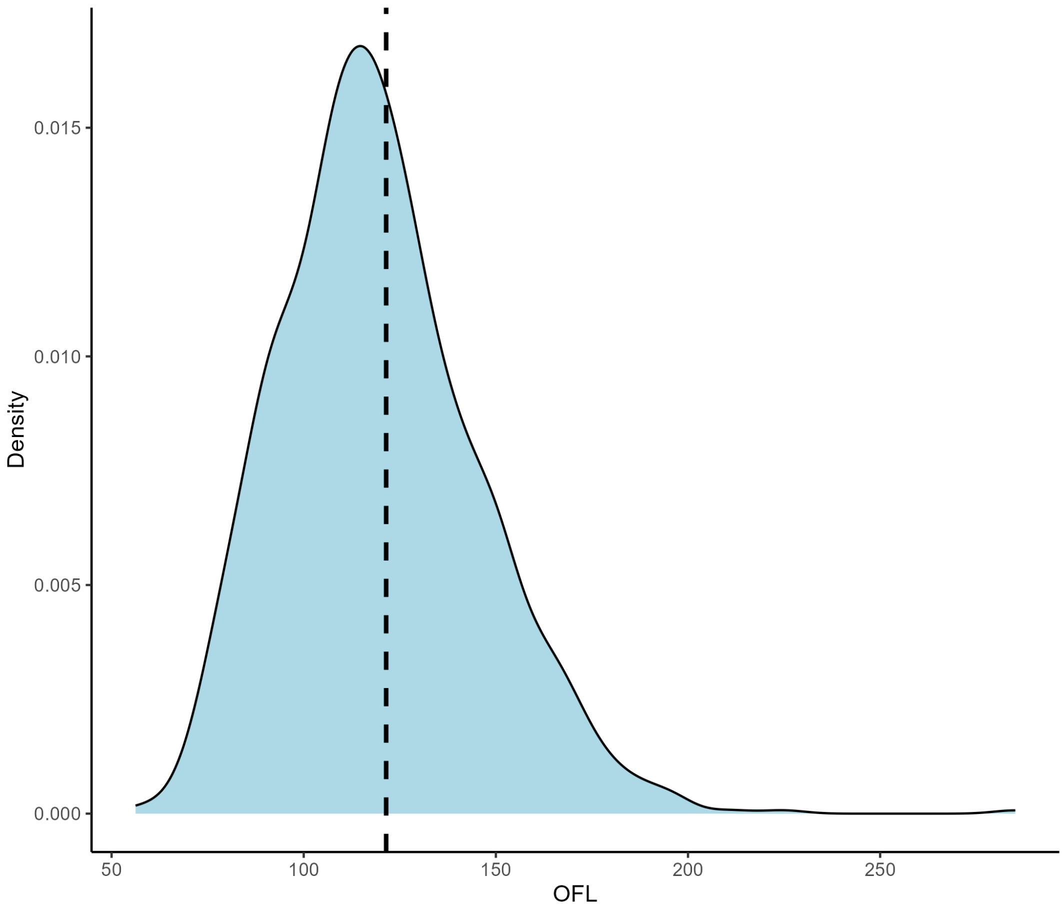

Figure 4: The probability density function of the OFL for model 16.1, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

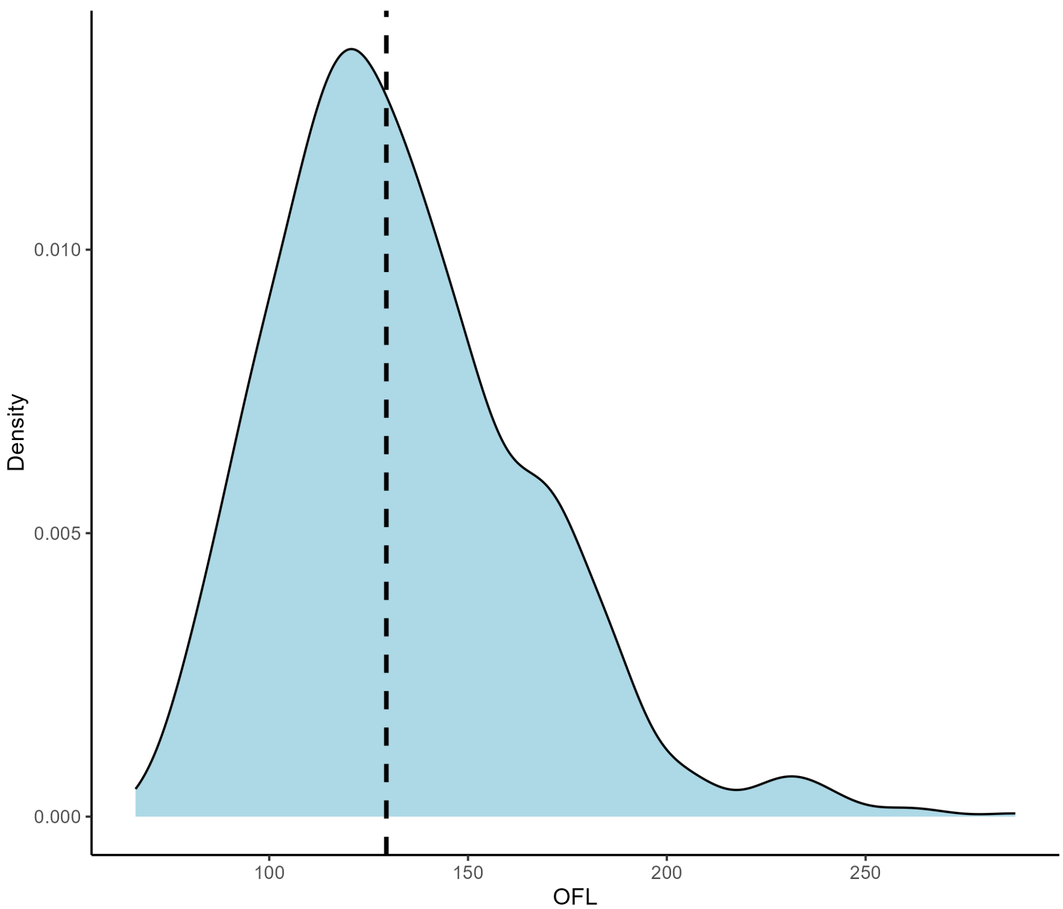

Figure 5: The probability density function of the OFL for model 24.1, based on 1,000 Markov chain Monte Carlo (MCMC) draws. The vertical dashed line represents the OFL from the original model run.

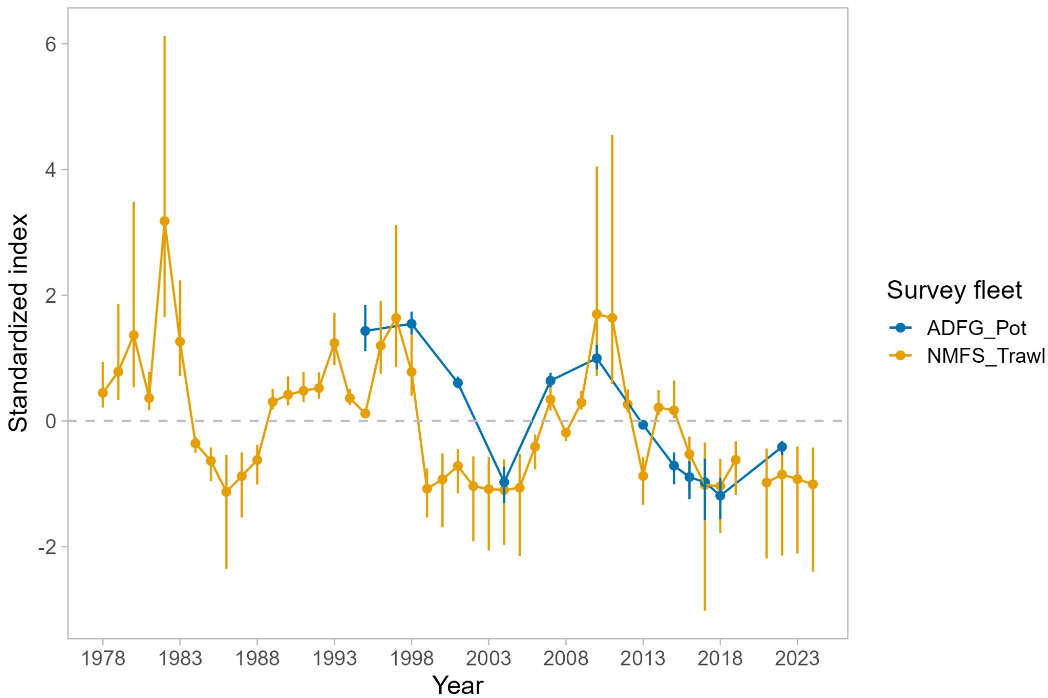

Figure 6: Standardized biomass index from the NMFS trawl survey compared to standardized abundance index from the ADFG pot survey. Indices are z-score standardized to allow for visual comparison. Dashed horizontal line represents the mean.

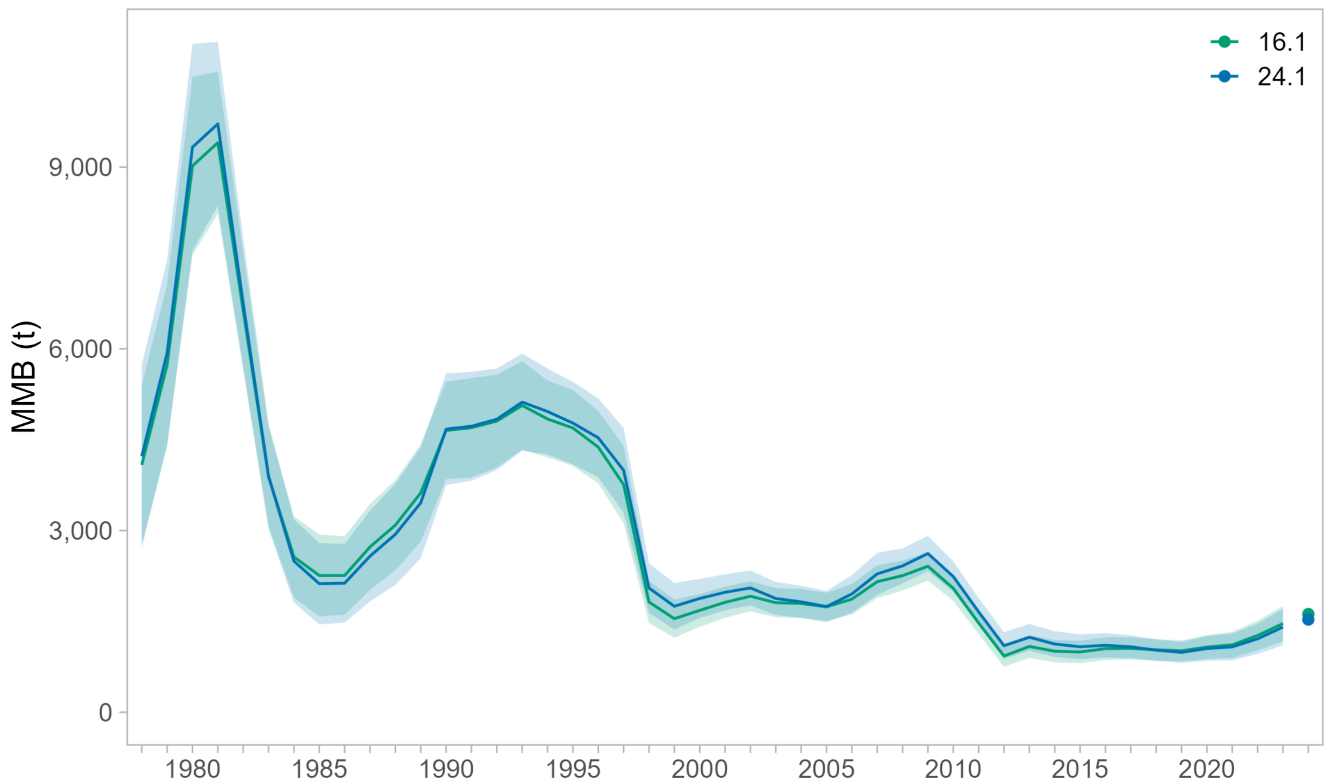

Figure 7: Comparisons of estimated mature male biomass (MMB) time series on 15 February (year + 1) during 1978-2024 for models 16.1 and 24.1. Points represent projected values for 2024/2025.

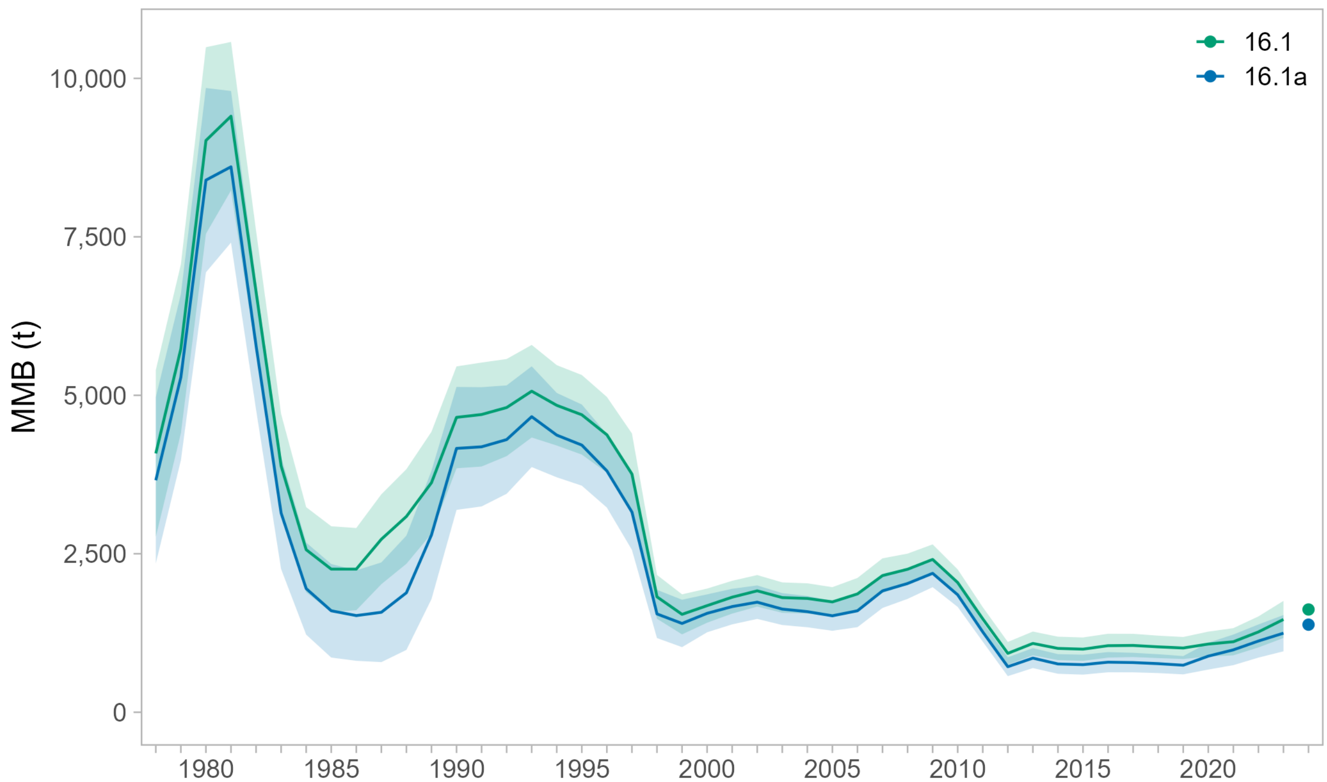

Figure 8: Comparisons of estimated mature male biomass (MMB) time series on 15 February (year + 1) during 1978-2024 for models 16.1 and 16.1a. Points represent projected values for 2024/2025.

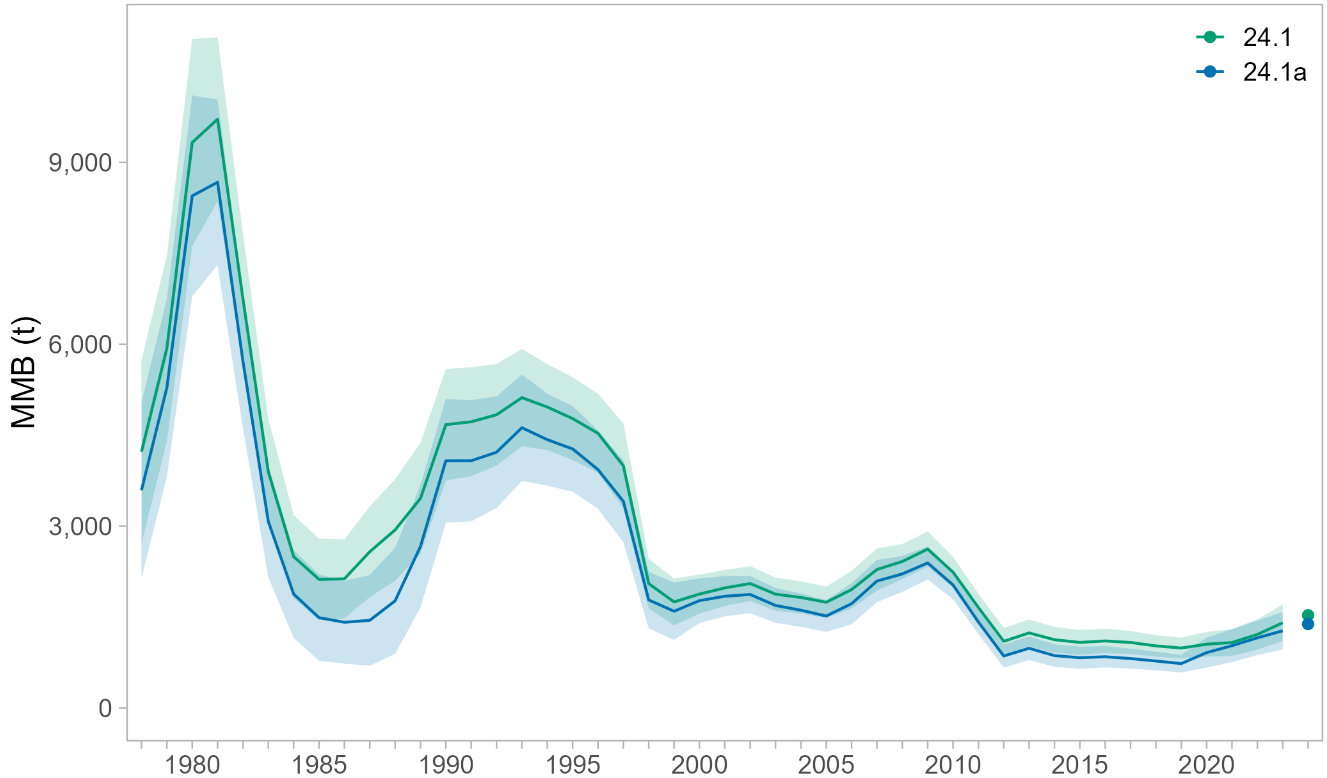

Figure 9: Comparisons of estimated mature male biomass (MMB) time series on 15 February (year + 1) during 1978-2024 for models 24.1 and 24.1a. Points represent projected values for 2024/2025.

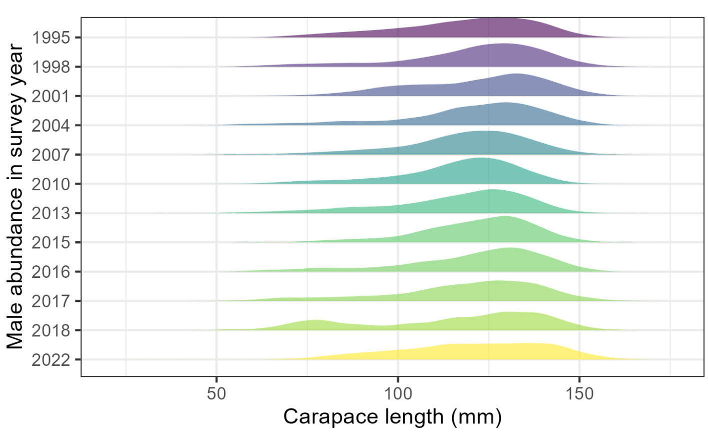

Figure 10: ADFG pot survey abundances by carapace length for male St. Matthew Island blue king crab from 1995 to 2022.

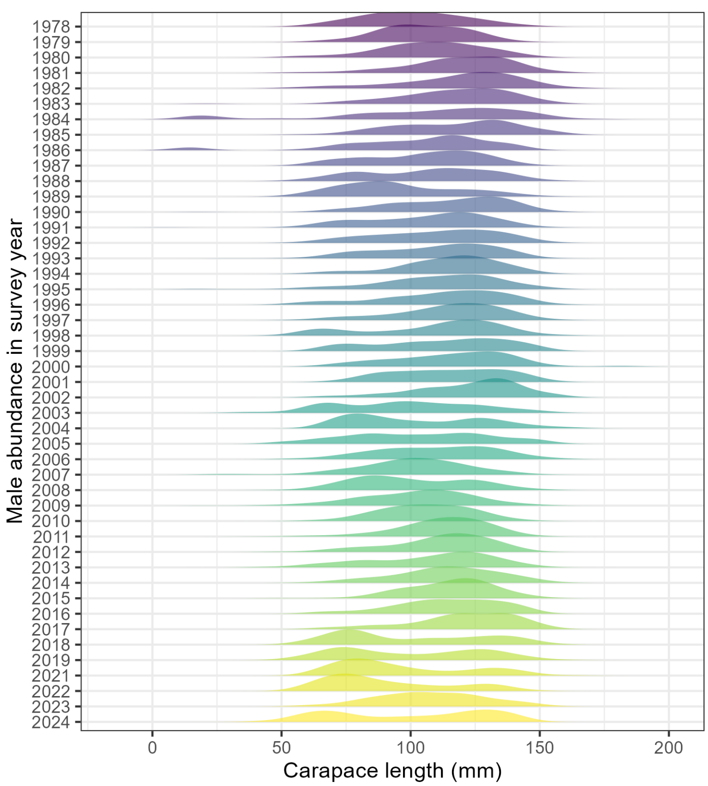

Figure 11: NMFS trawl survey abundances by carapace length for male St. Matthew Island blue king crab from 1978 to 2023.

Figure 12: Distribution of blue king crab (*Paralithodes platypus*) in the Gulf of Alaska, Bering Sea, and Aleutian Islands waters (shown in blue).

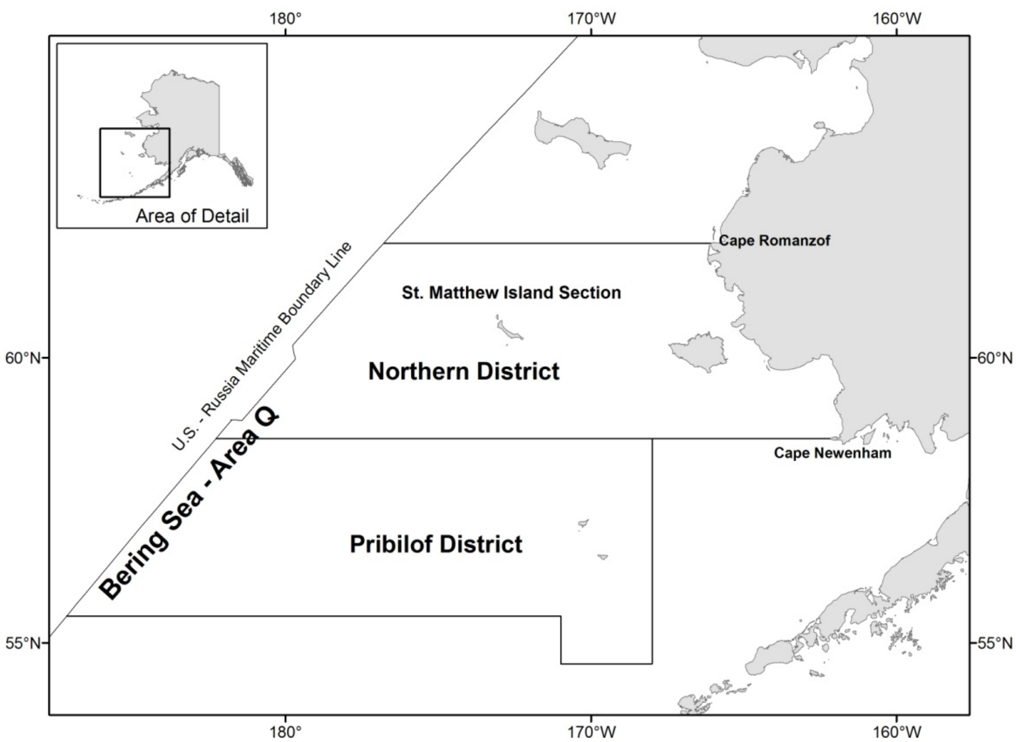

Figure 13: Blue king crab Registration Area Q (Bering Sea)

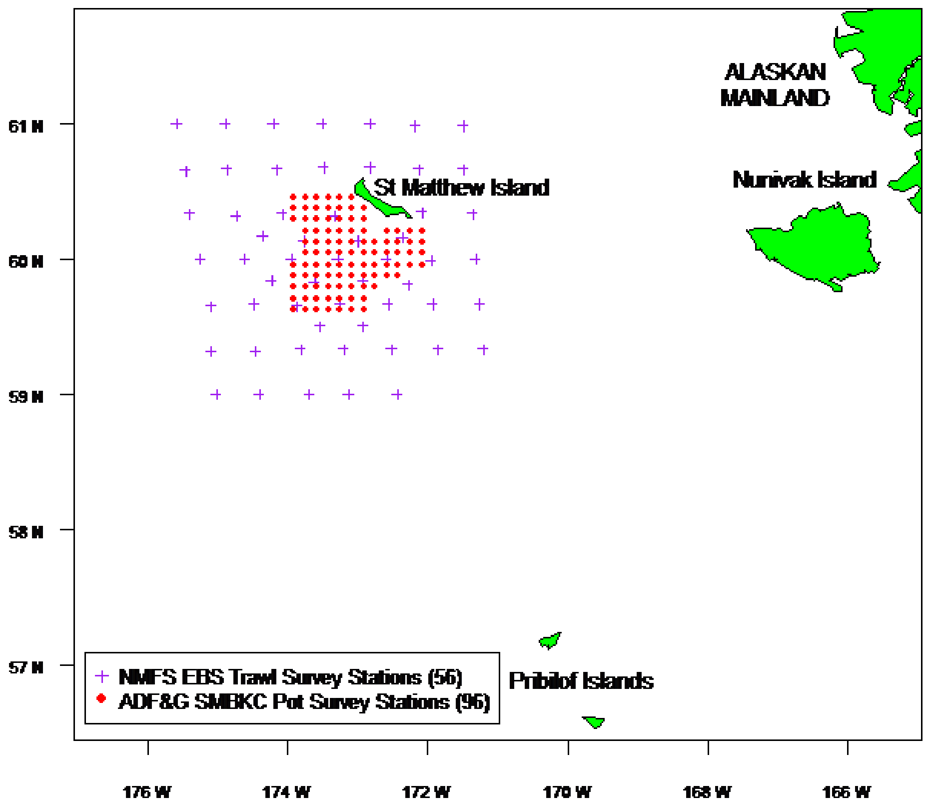

Figure 14: Trawl and pot-survey stations used in the SMBKC stock assessment.

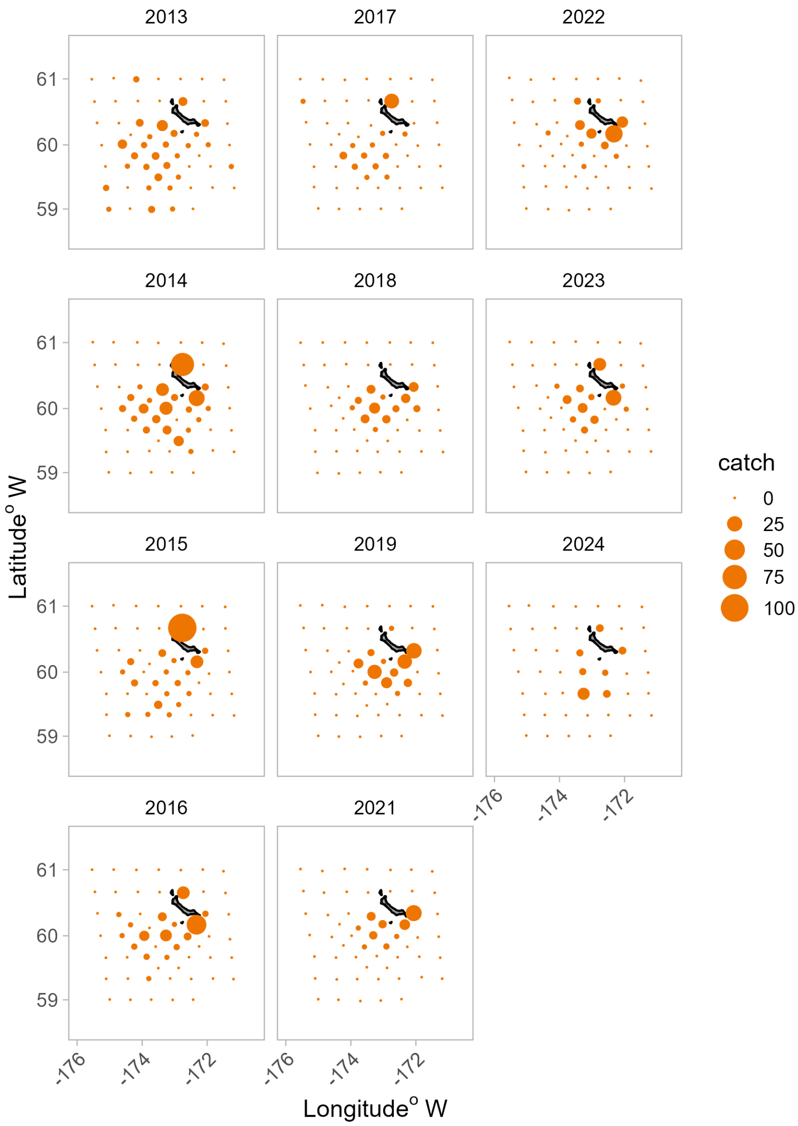

Figure 15: Catches (in numbers) of male blue king crab > 90mm CL from the 2013-2024 NMFS trawl-survey at the 56 stations used to assess the SMBKC stock; note that corner stations were not surveyed in 2024.

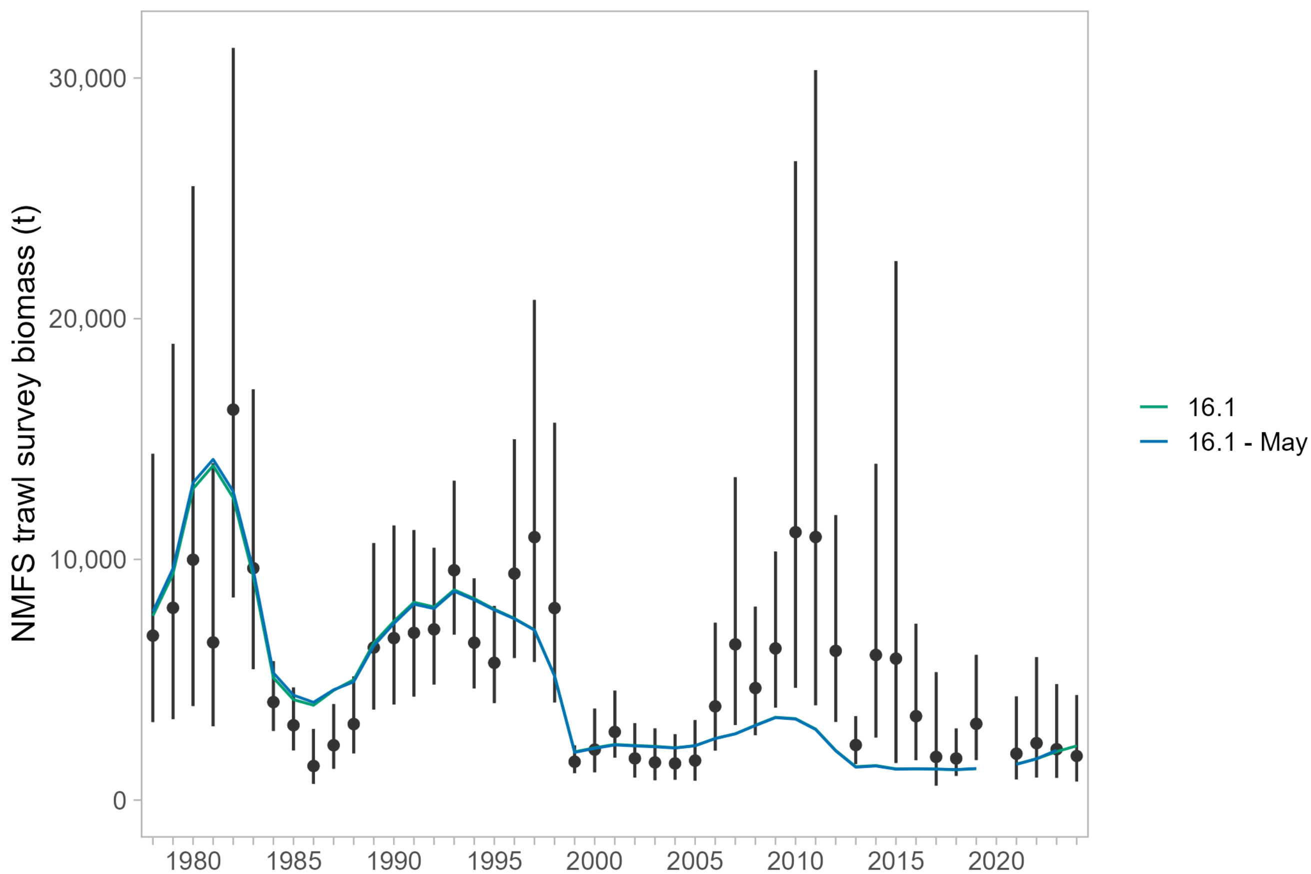

Figure 16: Fits to NMFS area-swept trawl estimates of total (> 90mm) male survey biomass for models 16.1 - May (without new data added; GMACS version 2.01.M.10) and 16.1 (with new data added; GMACS version 2.20.14). Error bars are plus and minus 2 standard deviations.

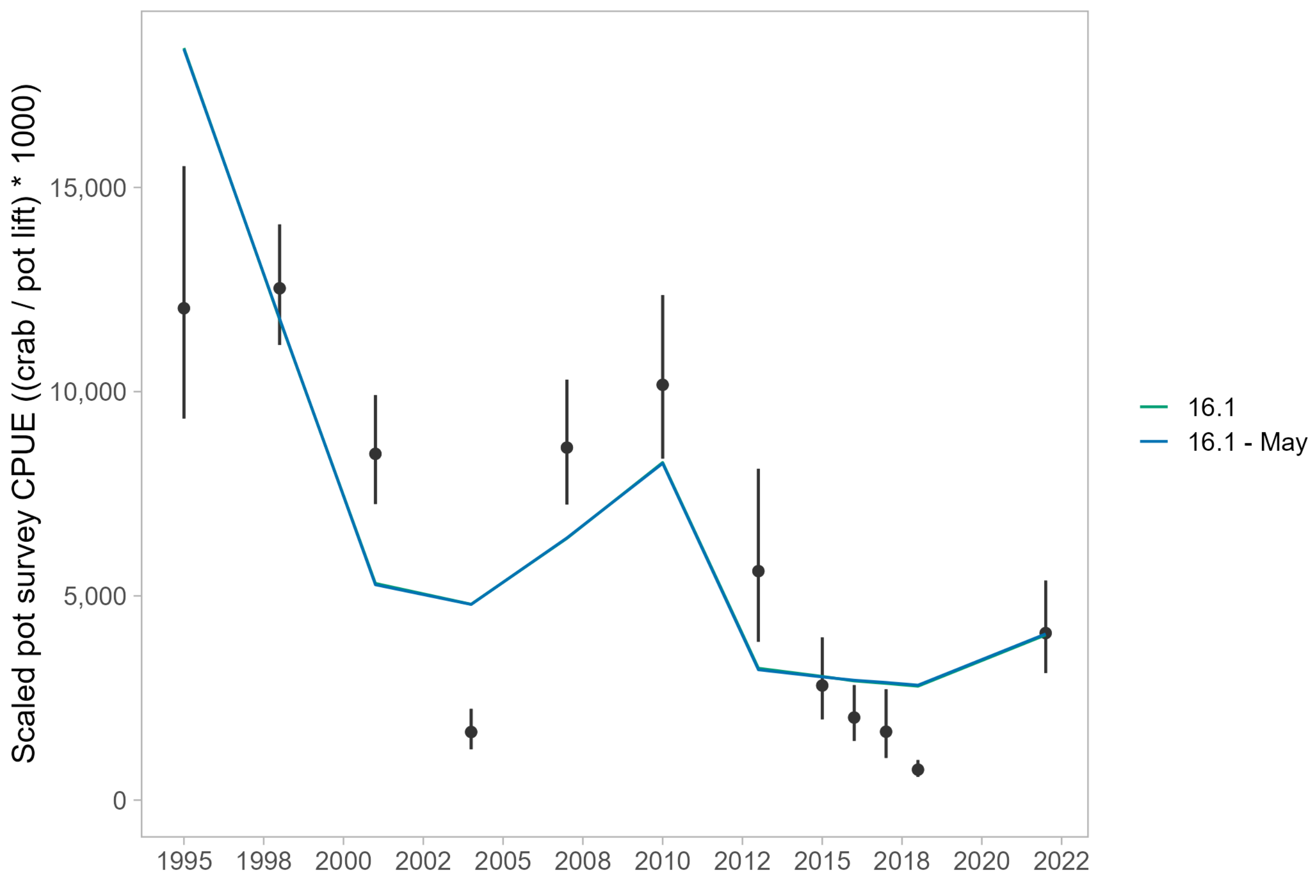

Figure 17: Comparisons of fits to CPUE from the ADFG pot surveys for 16.1 - May (without new data added; GMACS version 2.01.M.10) and 16.1 (with new data added; GMACS version 2.20.14). Error bars are plus and minus 2 standard deviations.

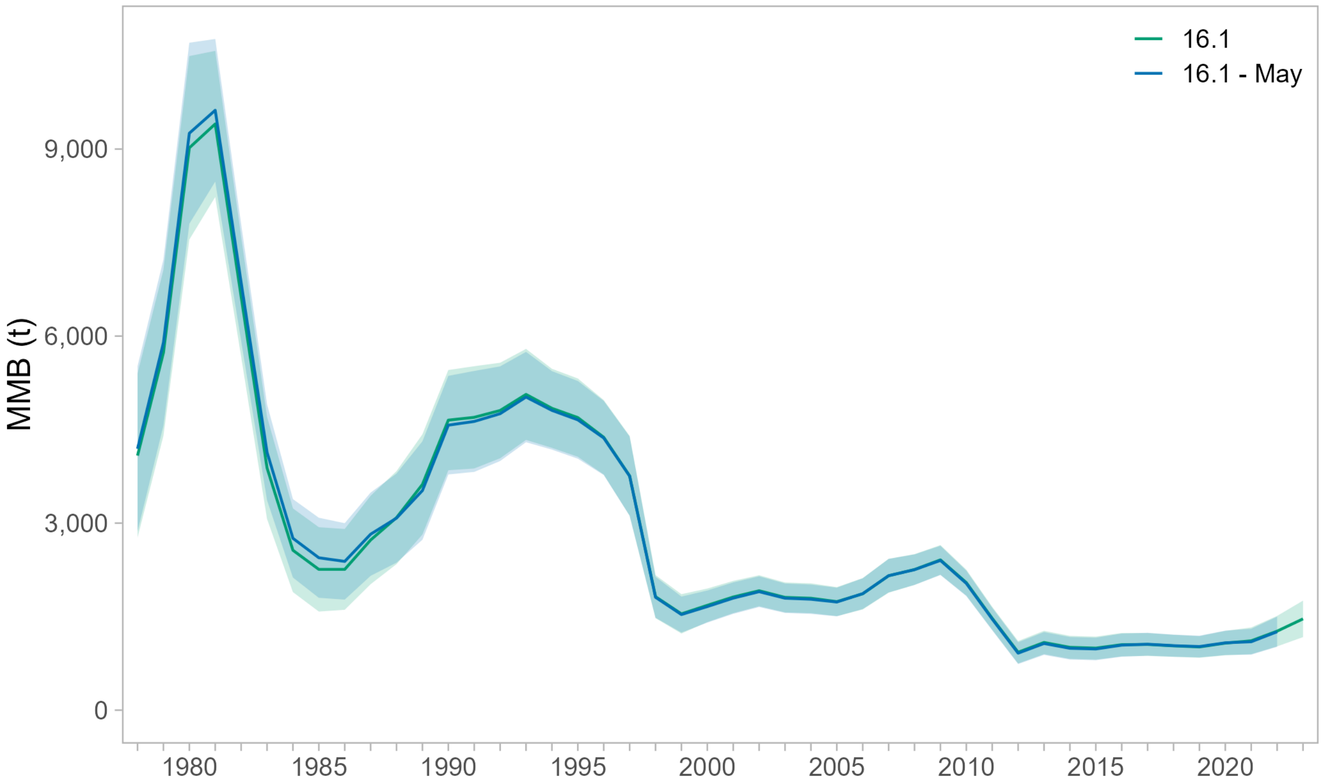

Figure 18: Estimated mature male biomass (MMB) over 1978-2024 from models 16.1 - May and 16.1; model 16.1 - May is the model recommended in May 2024 using the data then available and GMACS version 2.01.M.10, while model 16.1 is the same model translated to GMACS version 2.20.14 and updated with the data available in August 2024.

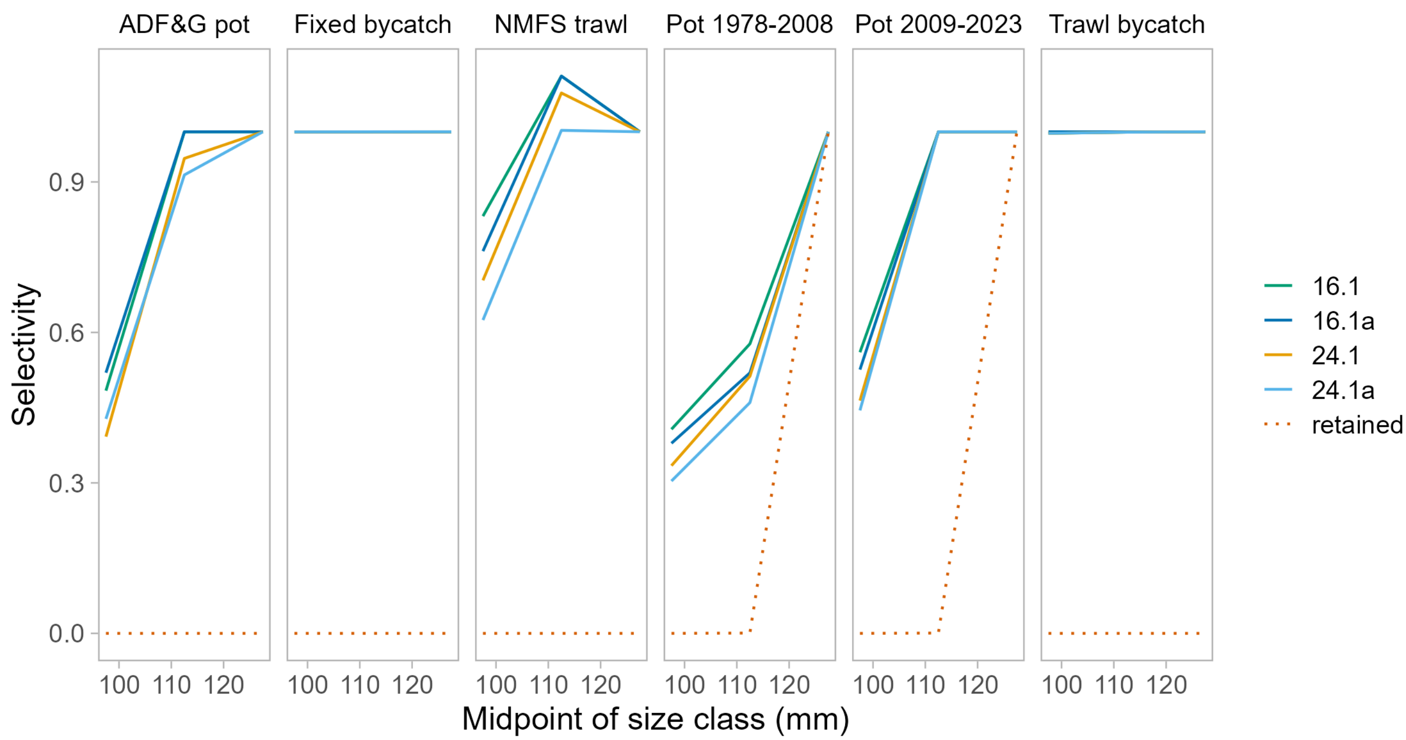

Figure 19: Comparisons of the estimated stage-1 and stage-2 selectivities for the different model scenarios (the stage-3 selectivities are all fixed at 1). Estimated selectivities are shown for the directed pot fishery, the trawl bycatch fishery, the fixed bycatch fishery, the NMFS trawl survey, and the ADFG pot survey. Two selectivity periods are estimated in the directed pot fishery, from 1978-2008 and 2009-2023. Solid lines are capture selectivities while dashed lines are retained selectivities.

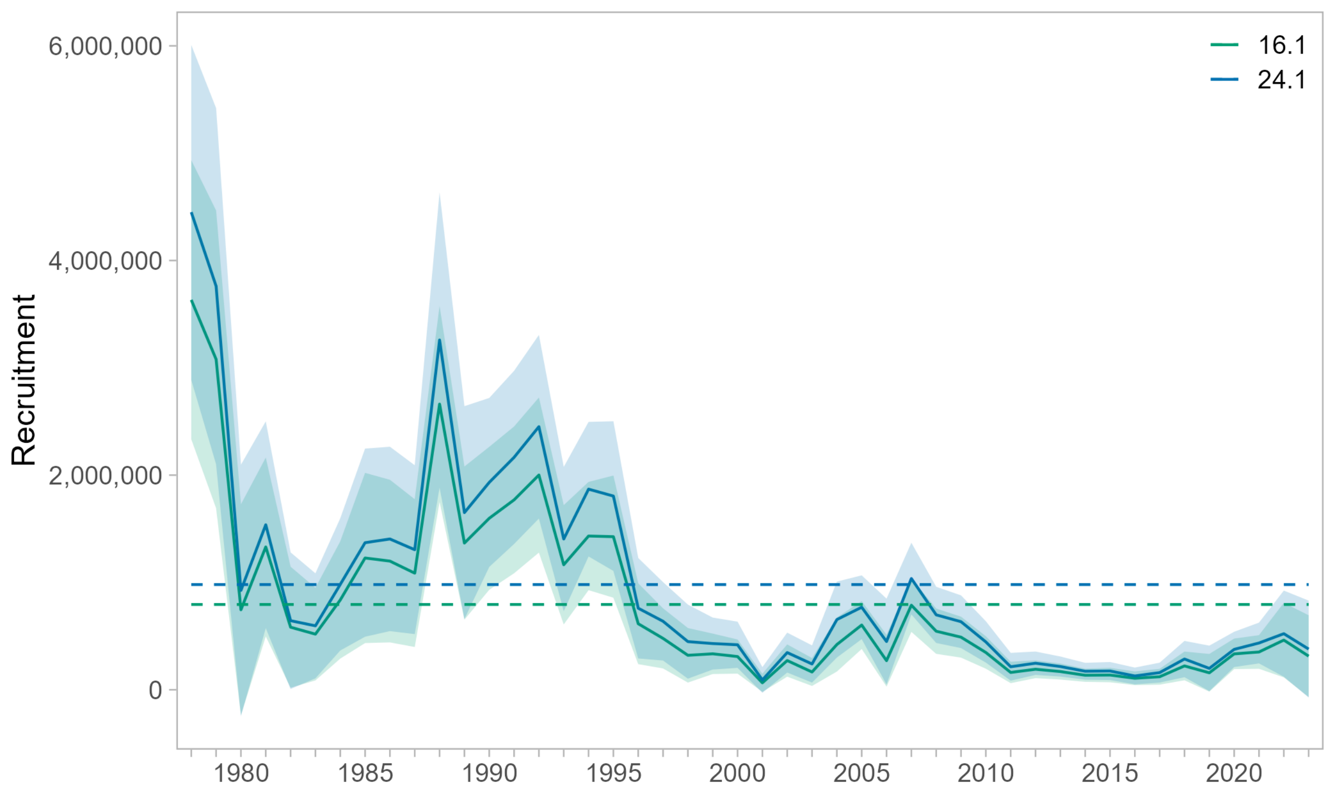

Figure 20: Estimated recruitment (in number of individuals) for 1979-2023 comparing models 16.1 and 24.1. The dashed horizontal lines represent the estimate of the average recruitment parameter ($\bar{R}$) in each model scenario.

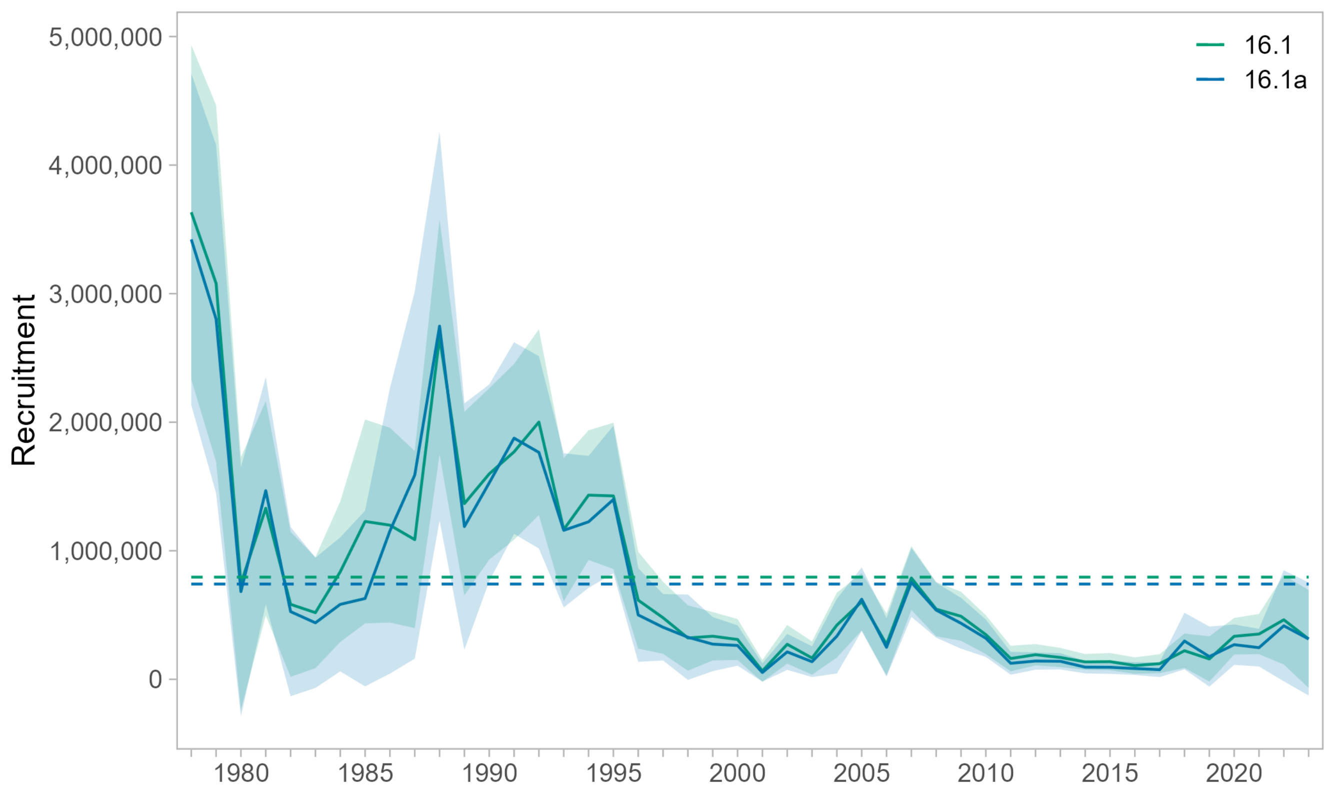

Figure 21: Estimated recruitment (in number of individuals) for 1979-2023 comparing models 16.1 and 16.1a. The dashed horizontal lines represent the estimate of the average recruitment parameter ($\bar{R}$) in each model scenario.

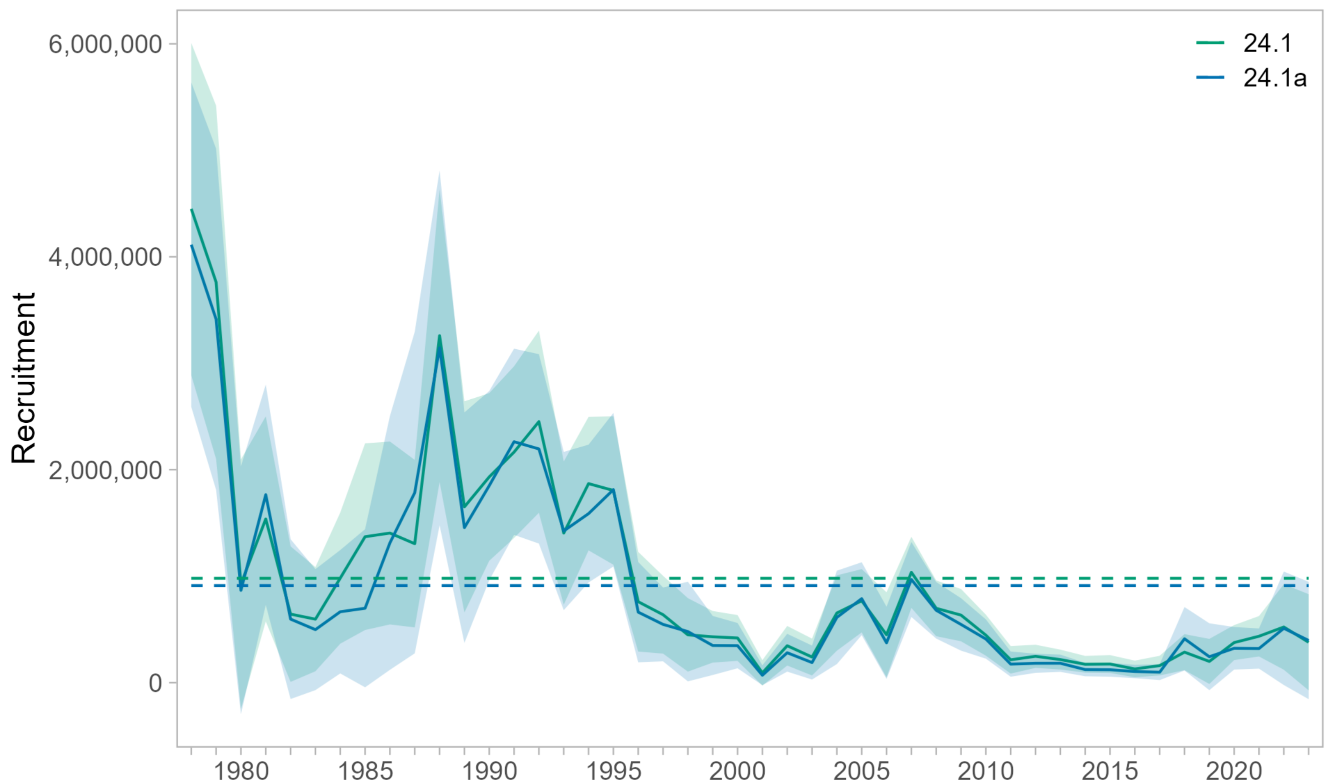

Figure 22: Estimated recruitment (in number of individuals) for 1979-2023 comparing models 24.1 and 24.1a. The dashed horizontal lines represent the estimate of the average recruitment parameter ($\bar{R}$) in each model scenario.

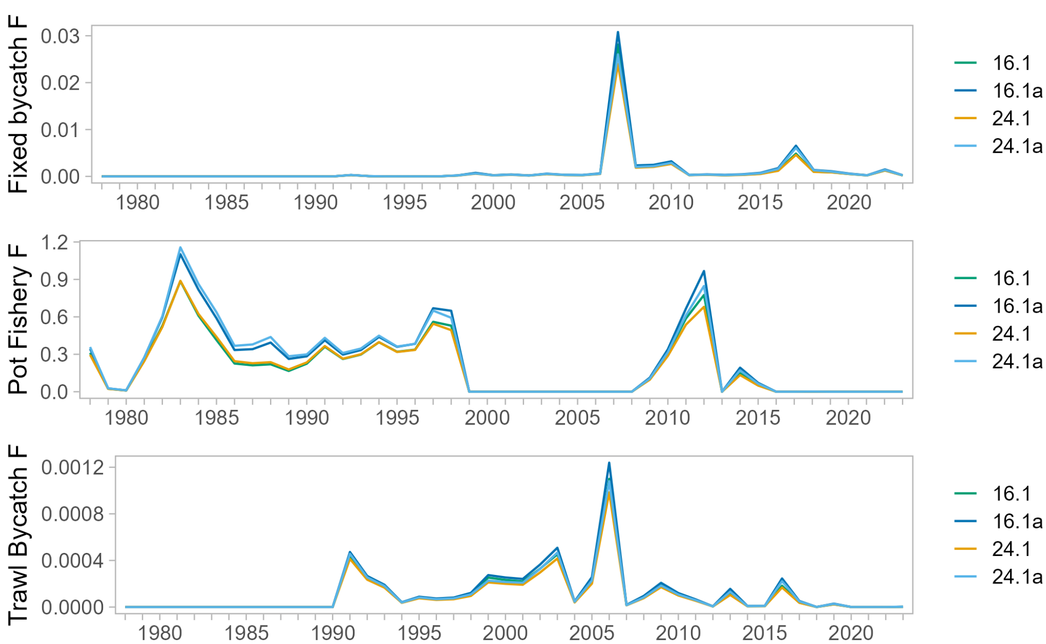

Figure 23: Fishing mortality estimates from models 16.1, 16.1a, 24.1, and 24.1a for directed and bycatch fleets

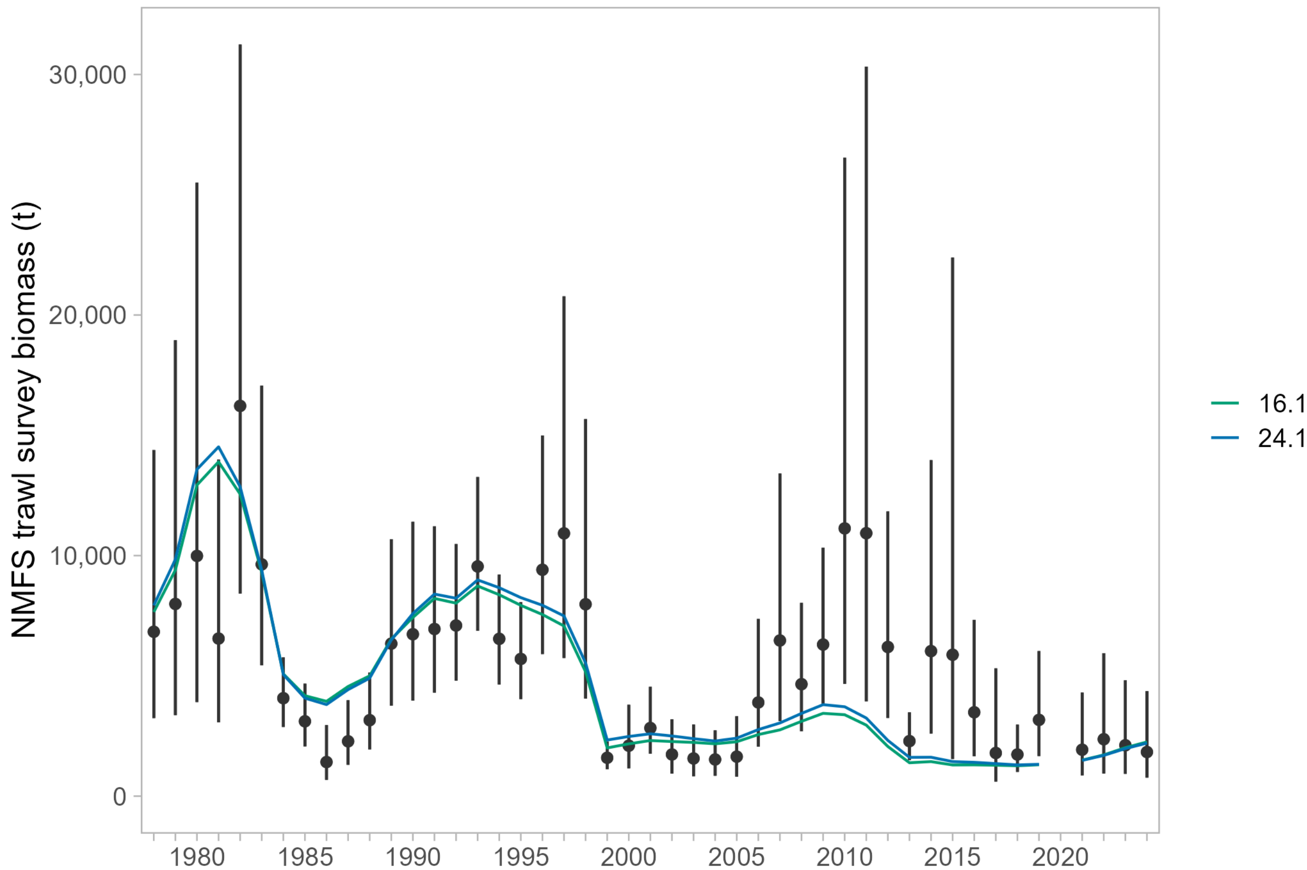

Figure 24: Comparisons of area-swept estimates of total (90+ mm CL) male survey biomass (tons) and model predictions for models 16.1 and 24.1. The error bars are plus and minus 2 standard deviations.

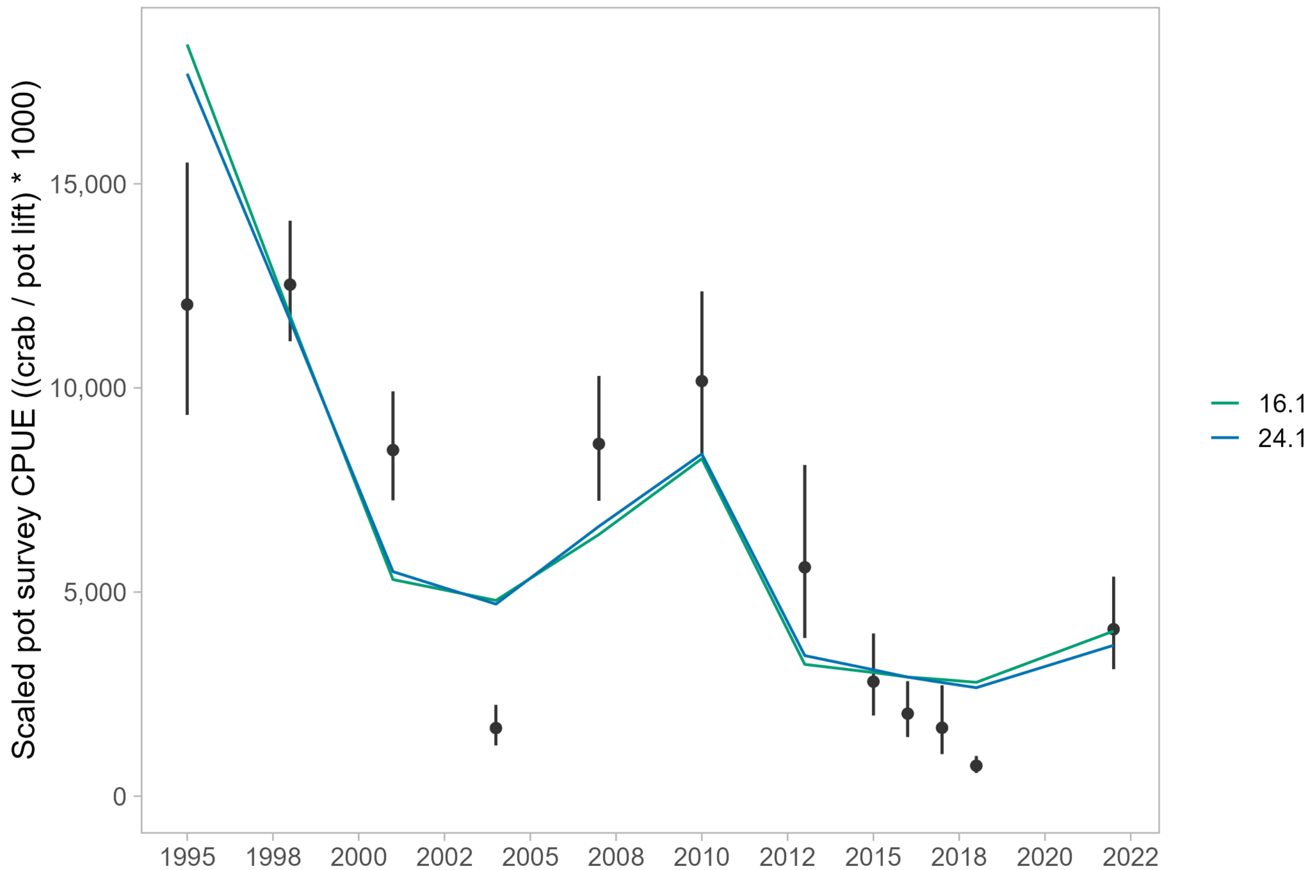

Figure 25: Comparisons of total (90+ mm CL) male pot survey CPUEs and model predictions for models 16.1 and 24.1. The error bars are plus and minus 2 standard deviations.

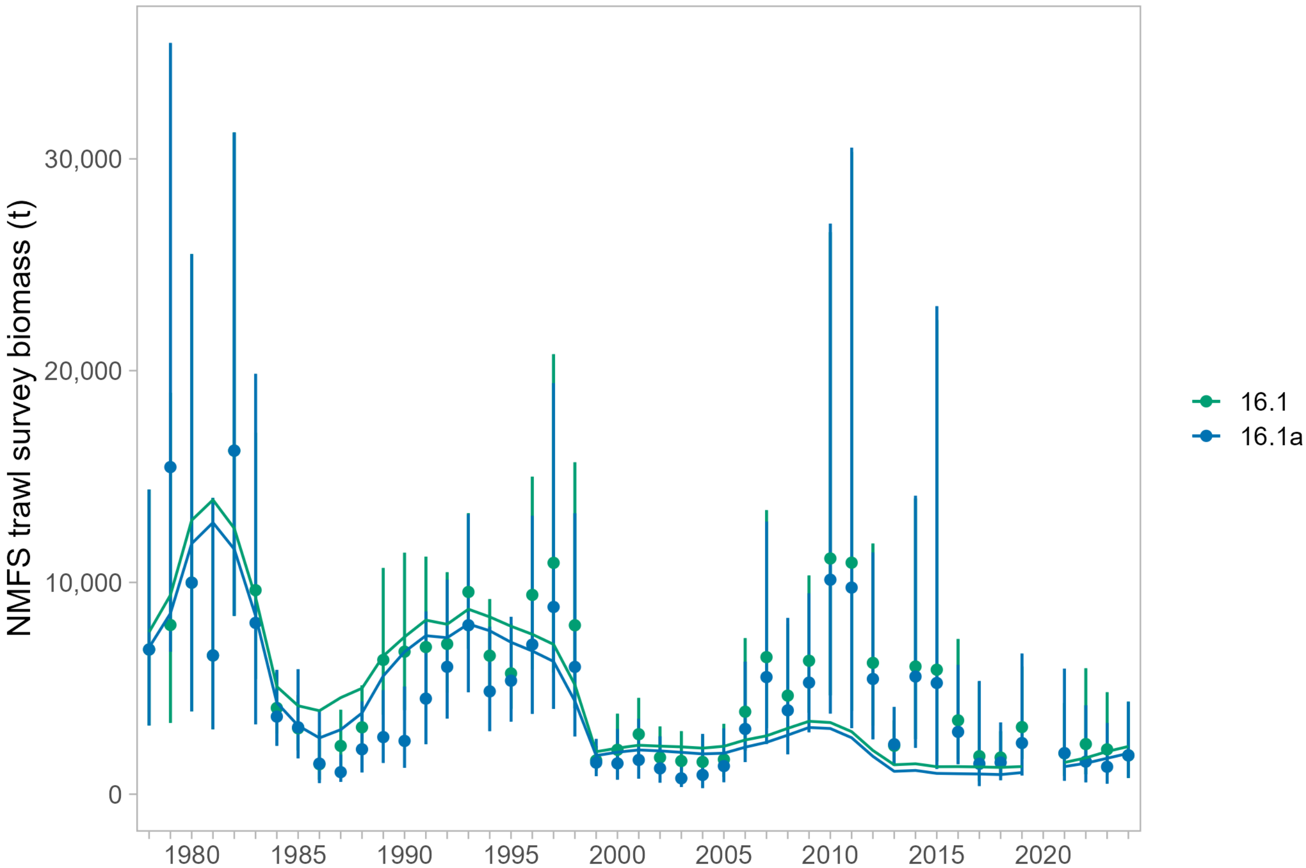

Figure 26: Comparisons of area-swept estimates of total (90+ mm CL) male survey biomass (tons) and model predictions for models 16.1 and 16.1a. The error bars are plus and minus 2 standard deviations. Note that the models are fitting different indices: model 16.1 fits the NMFS trawl survey time series with corner stations included for the years in which they are available (1983-2023, because corner stations were not sampled in 2024) while model 16.1a fits the time series with corner stations excluded. Observed biomass estimate points and error bars are colored to correspond to the model that uses them.

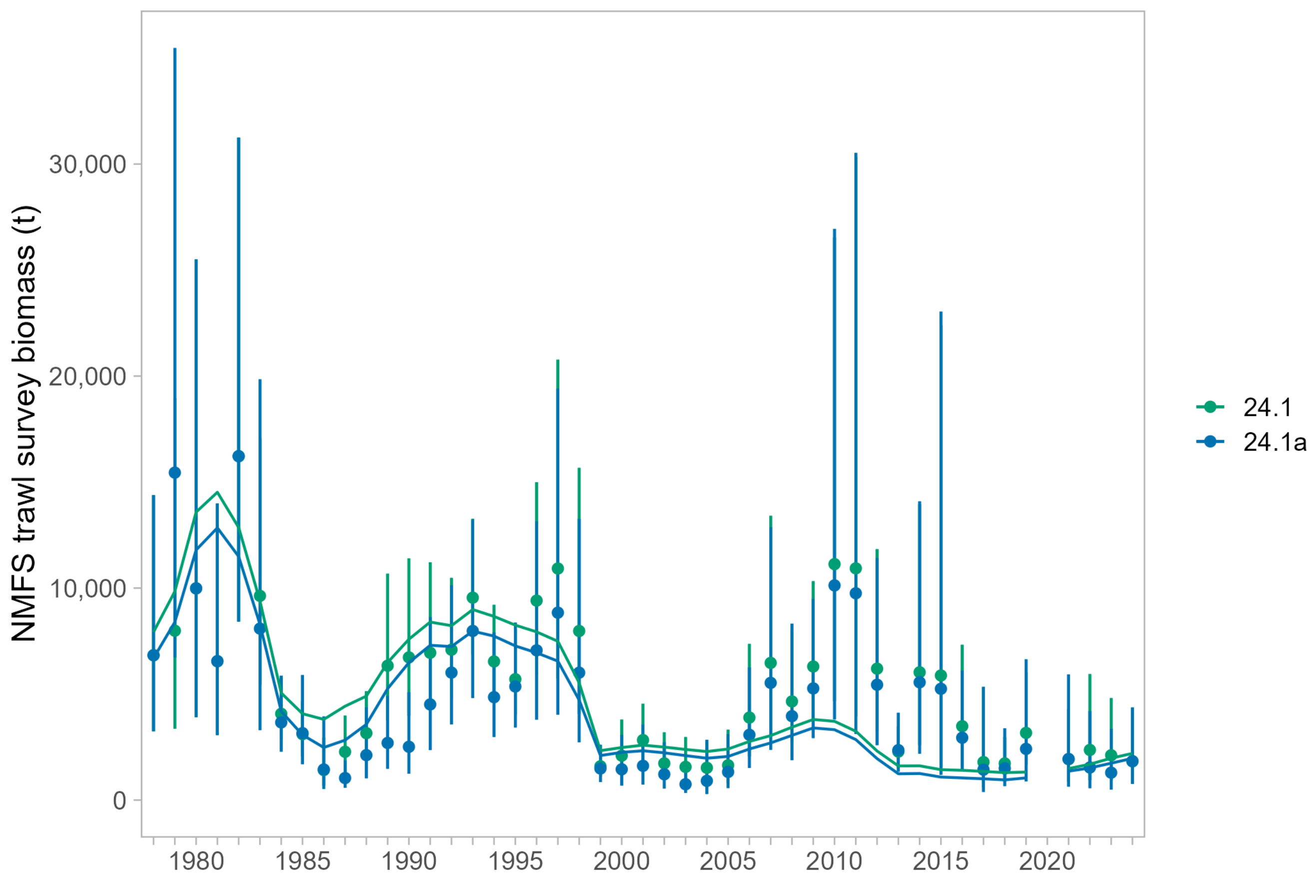

Figure 27: Comparisons of area-swept estimates of total (90+ mm CL) male survey biomass (tons) and model predictions for models 24.1 and 24.1a. The error bars are plus and minus 2 standard deviations. Note that the models are fitting different indices: model 24.1 fits the NMFS trawl survey time series with corner stations included for the years in which they are available (1983-2023, because corner stations were not sampled in 2024) while model 24.1a fits the time series with corner stations excluded. Observed biomass estimate points and error bars are colored to correspond to the model that uses them.

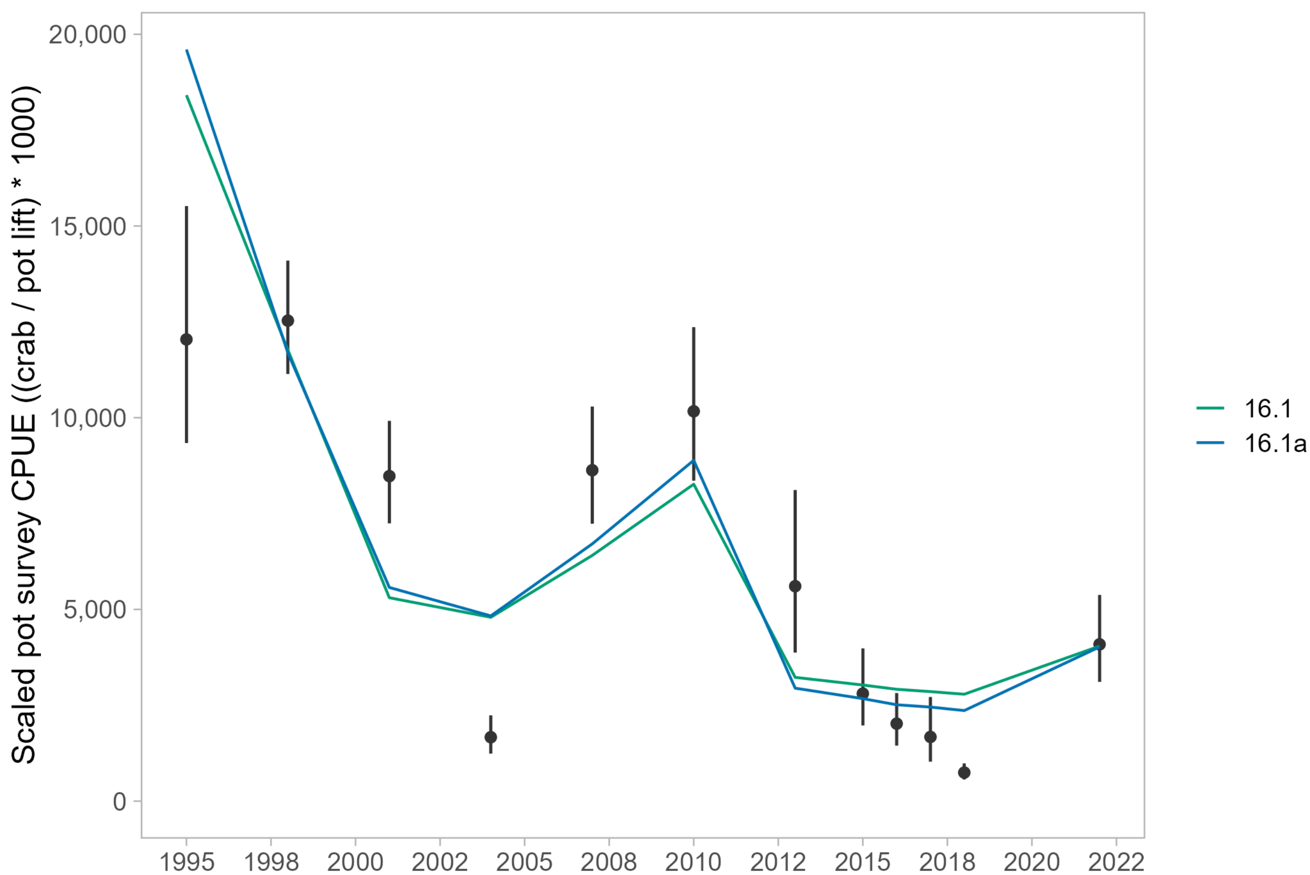

Figure 28: Comparisons of total (90+ mm CL) male pot survey CPUEs and model predictions for models 16.1 and 16.1a. The error bars are plus and minus 2 standard deviations.

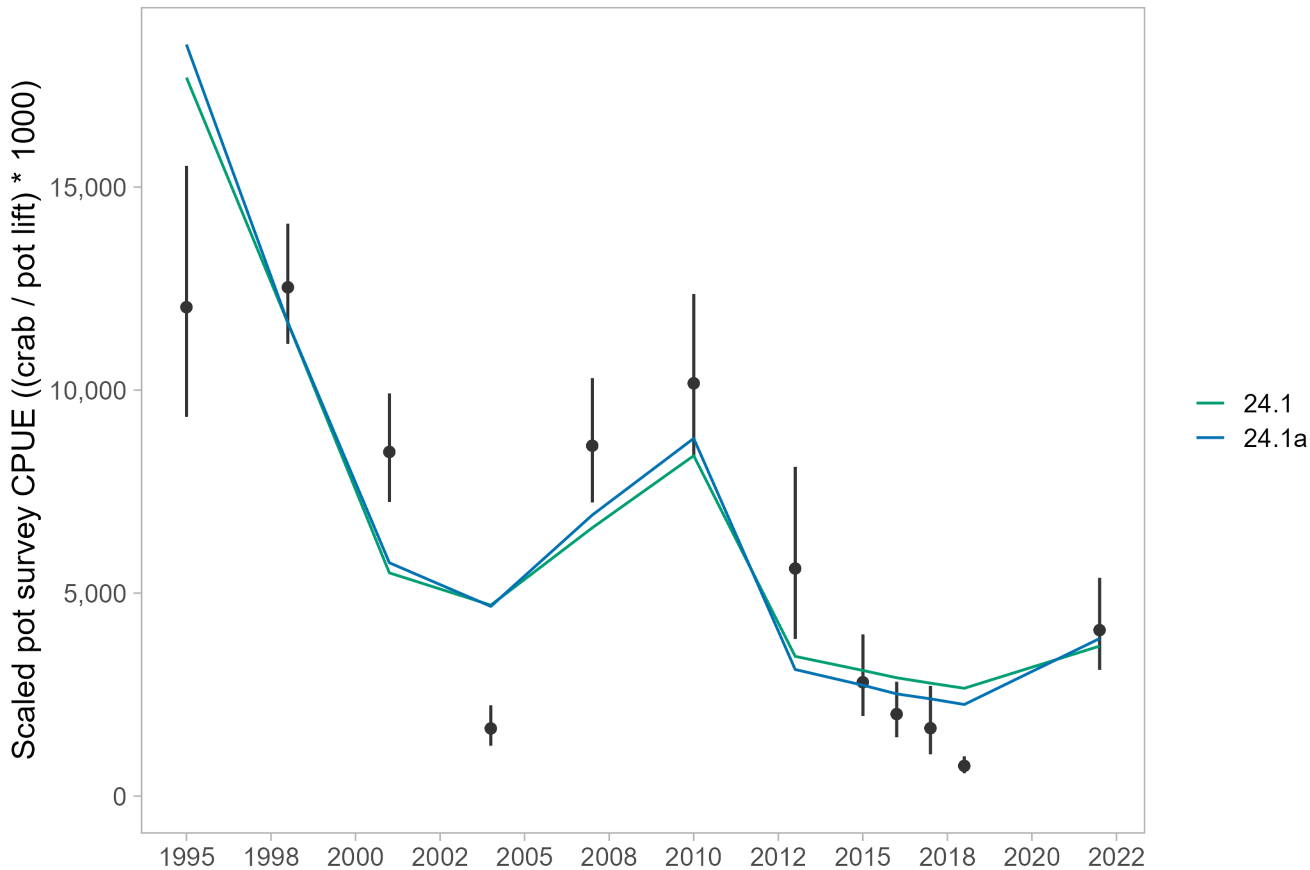

Figure 29: Comparisons of total (90+ mm CL) male pot survey CPUEs and model predictions for models 24.1 and 24.1a. The error bars are plus and minus 2 standard deviations.

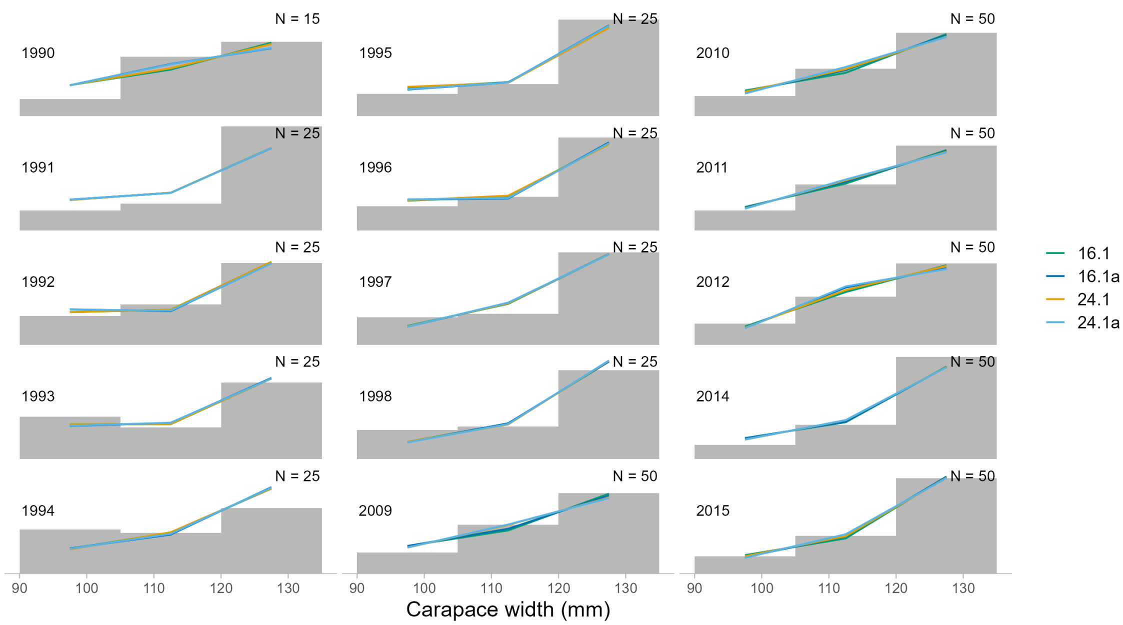

Figure 30: Observed and model estimated size frequencies of SMBKC by year retained in the directed pot fishery for the model scenarios.

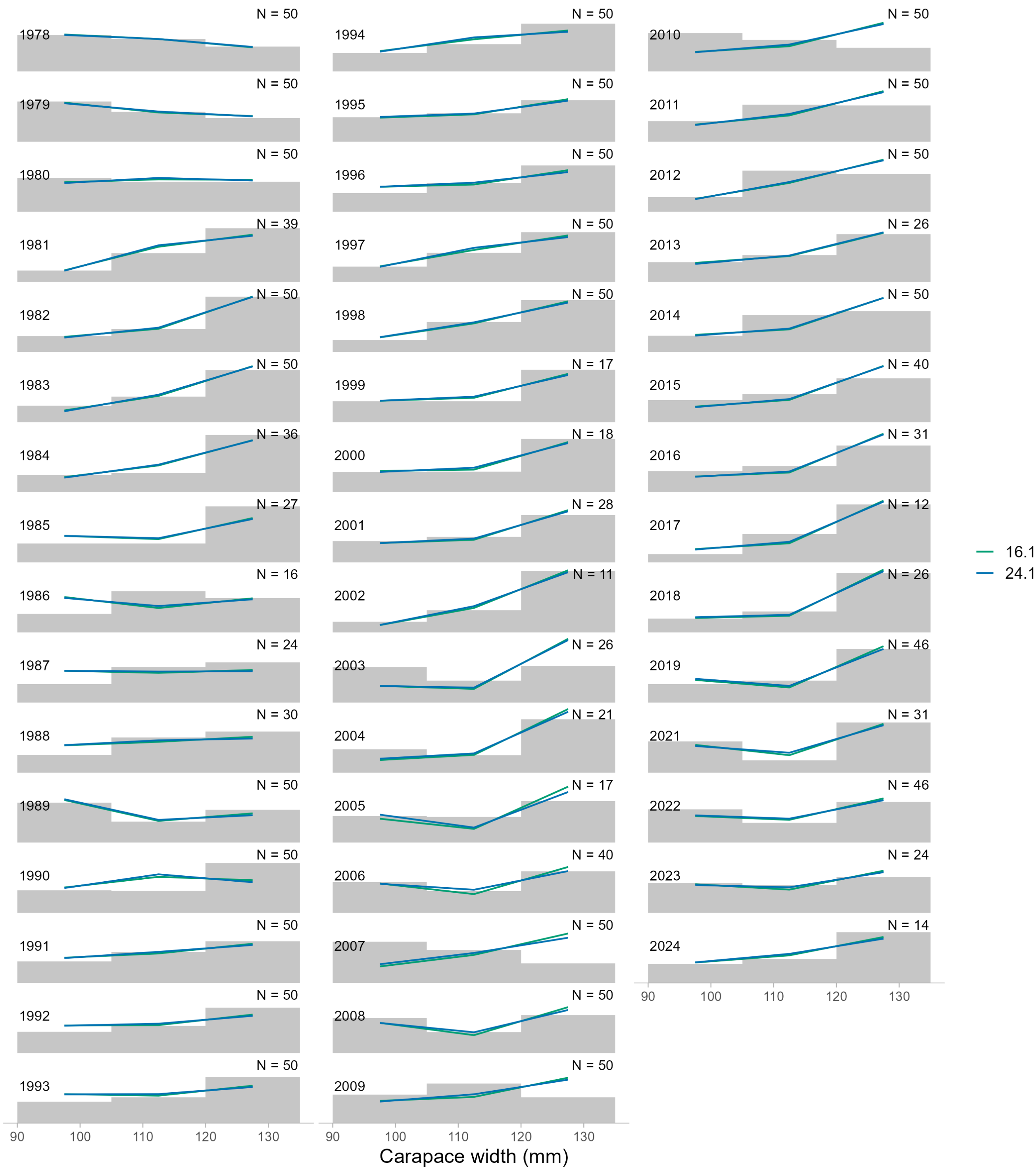

Figure 31: Observed and model estimated size frequencies of male SMBKC by year in the NMFS trawl survey for models 16.1 and 24.1, with corner stations included for the years in which they were surveyed.

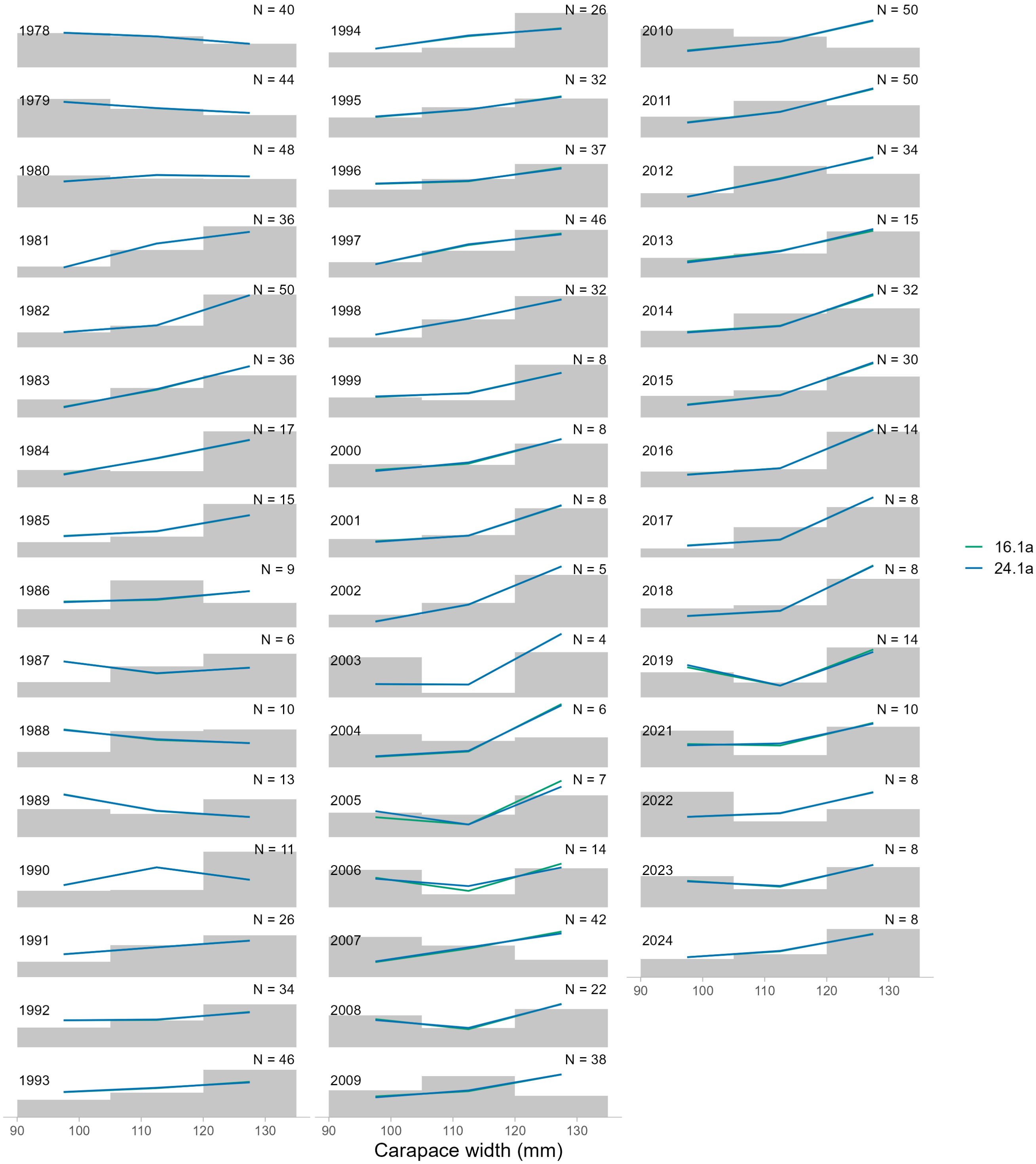

Figure 32: Observed and model estimated size frequencies of male SMBKC by year in the NMFS trawl survey for models 16.1a and 24.1a, with corner stations excluded for all years.

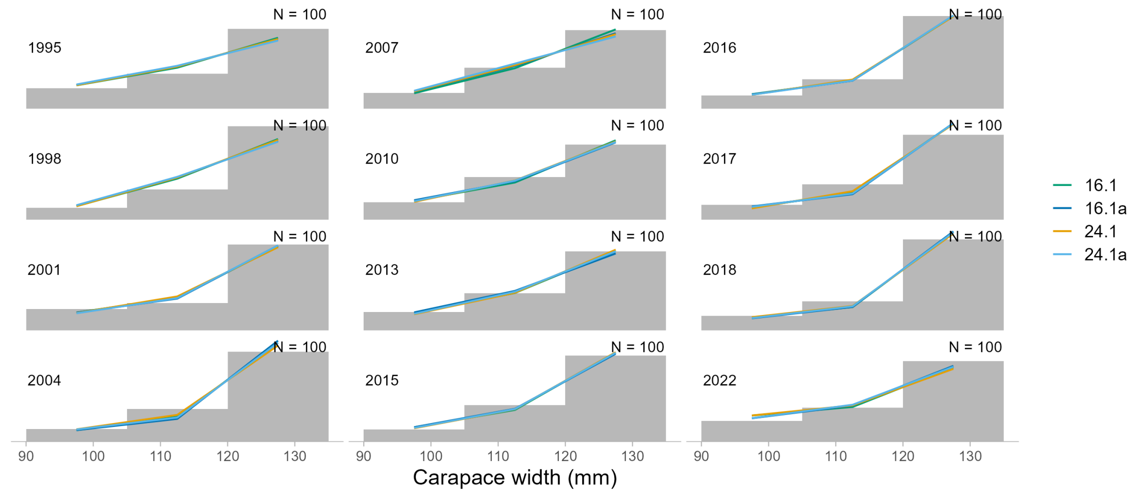

Figure 33: Observed and model estimated size frequencies of male SMBKC by year in the ADFG pot survey for the model scenarios.

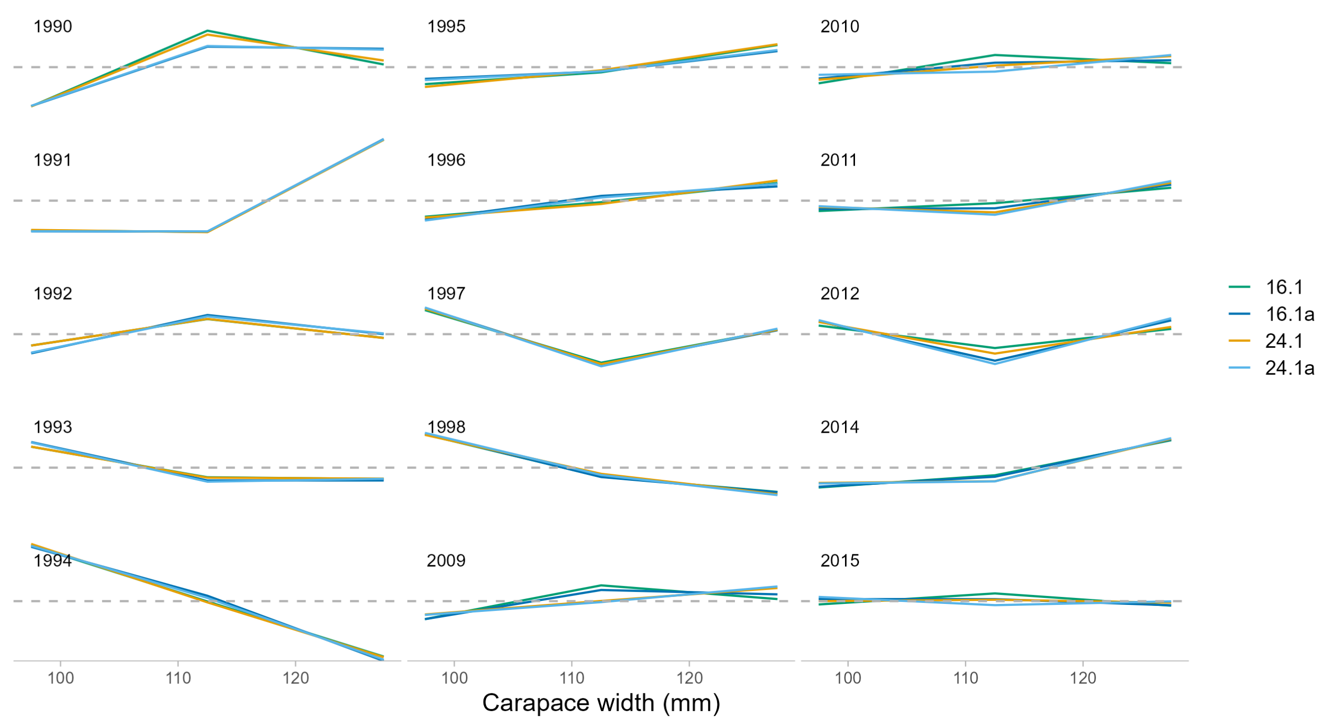

Figure 34: Line plots of residuals by size and year for directed pot fishery size composition data for all model scenarios.

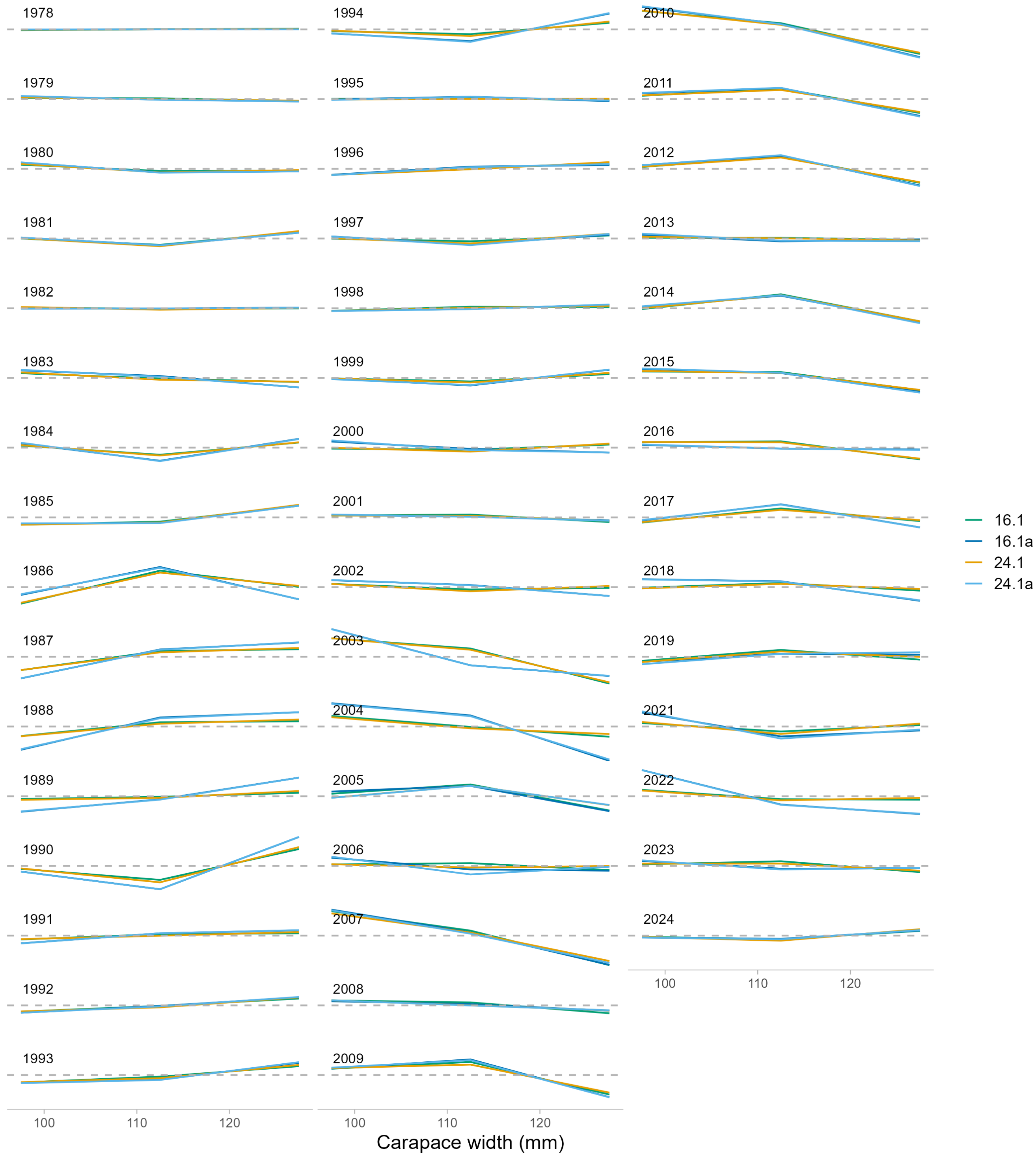

Figure 35: Line plots of residuals by size and year for NMFS trawl survey size composition data for all model scenarios.

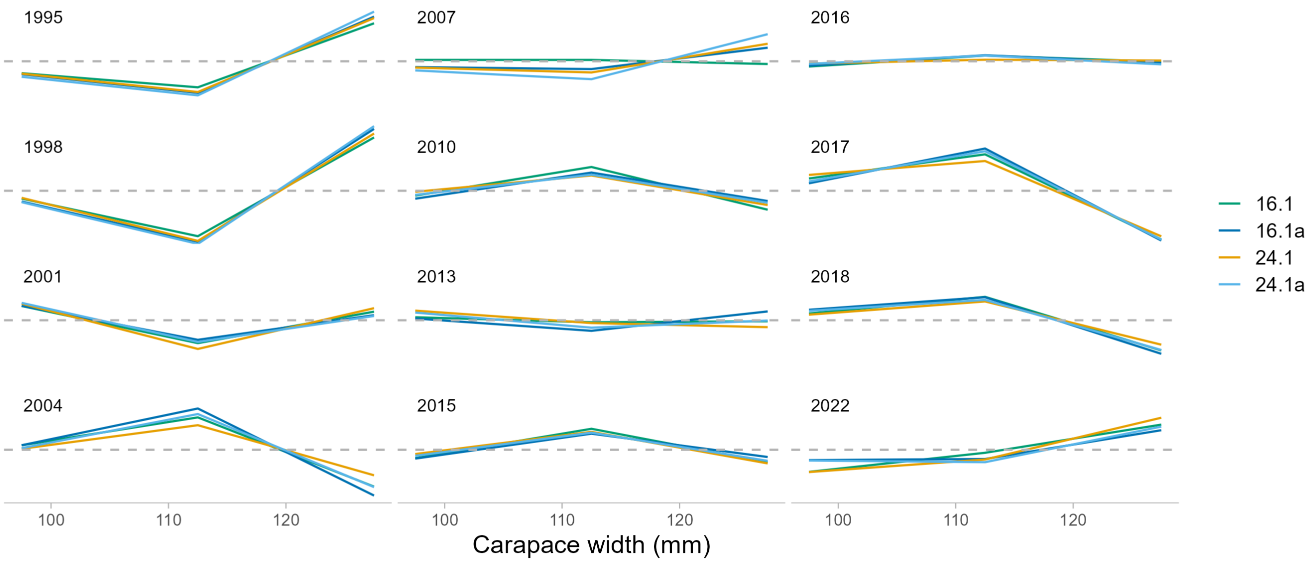

Figure 36: Line plots of residuals by size and year for ADFG pot survey size composition data for all models scenarios.

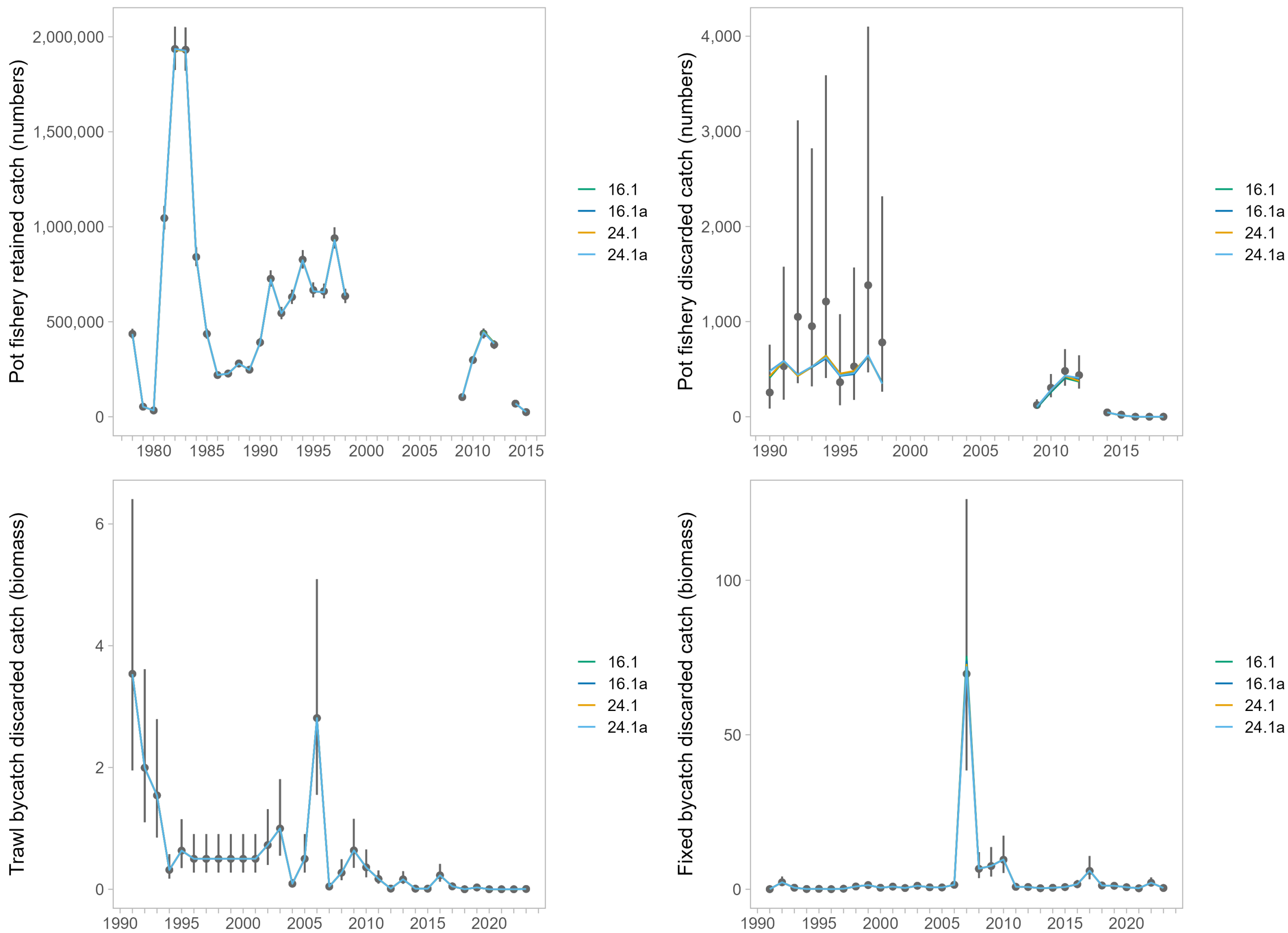

Figure 37: Comparison of observed and model predicted retained catch and bycatches in each of the models. Note the difference in units among the panels: some panels are expressed in numbers of crab, some in biomass (tons).

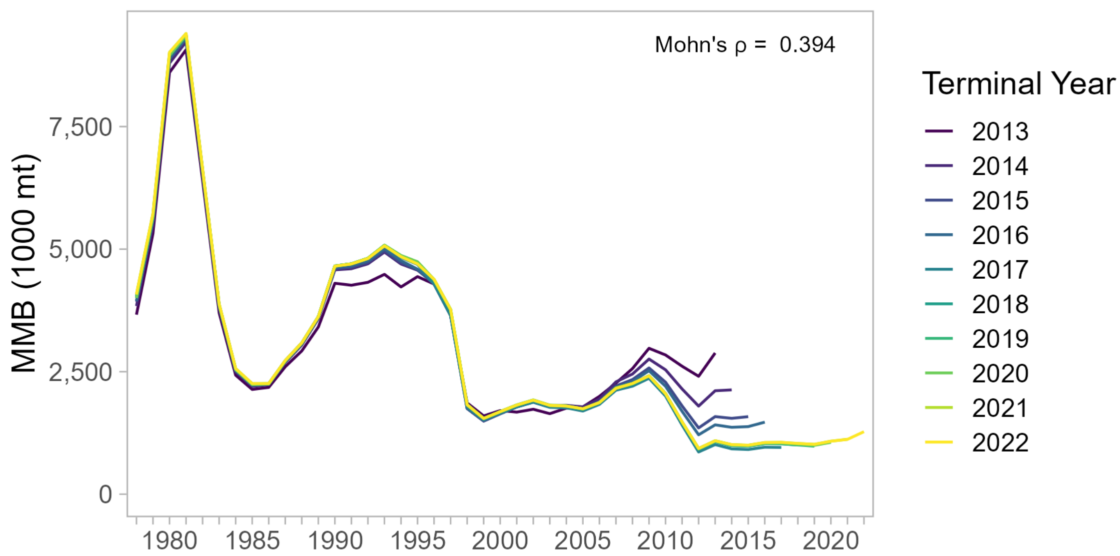

Figure 38: Retrospective pattern in mature male biomass (MMB (t)) for model 16.1 using 10 peels.

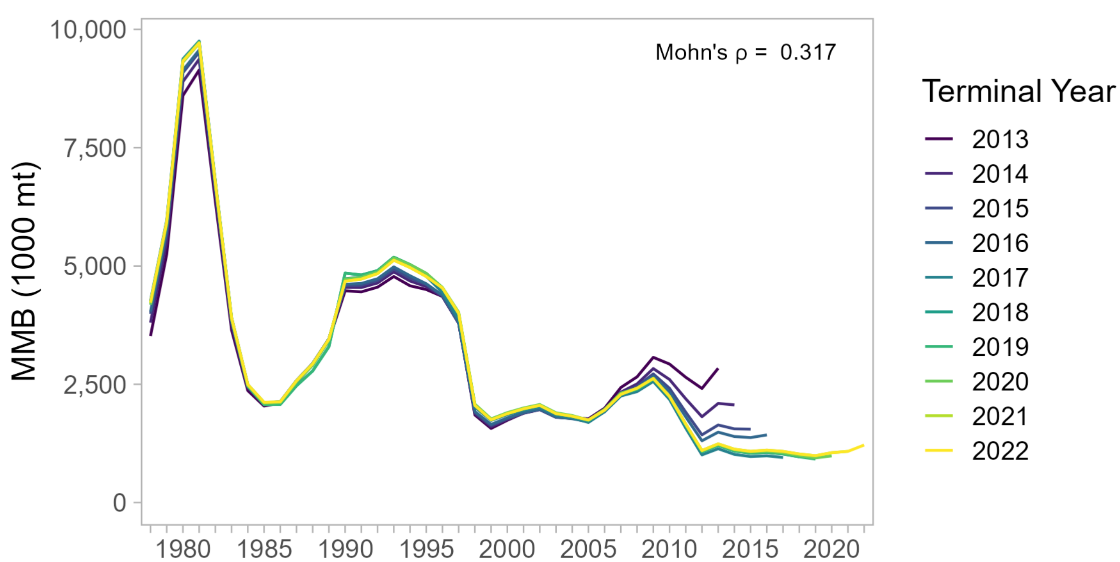

Figure 39: Retrospective pattern in mature male biomass (MMB (t)) for model 24.1 using 10 peels.

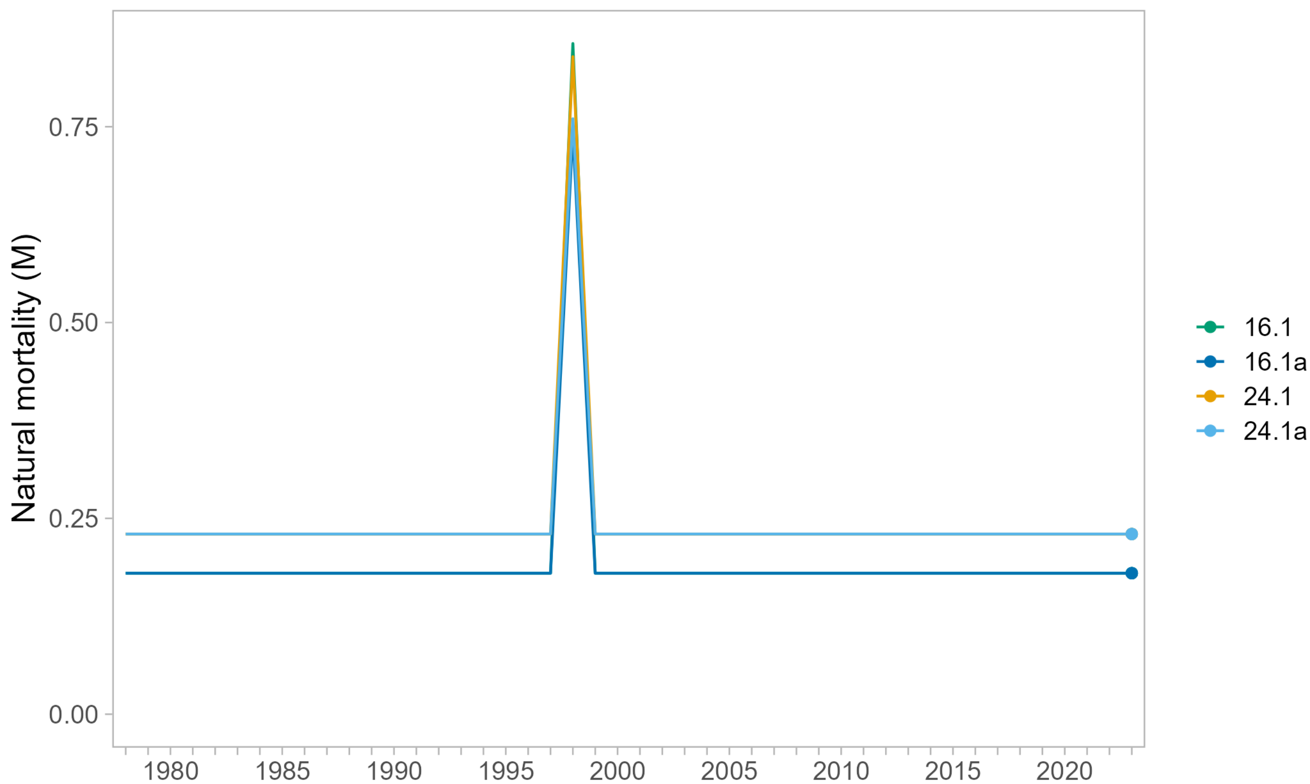

Figure 40: Time-varying natural mortality (M_t). Estimated pulse period occurs in 1998/99 (i.e., M_{1998}).

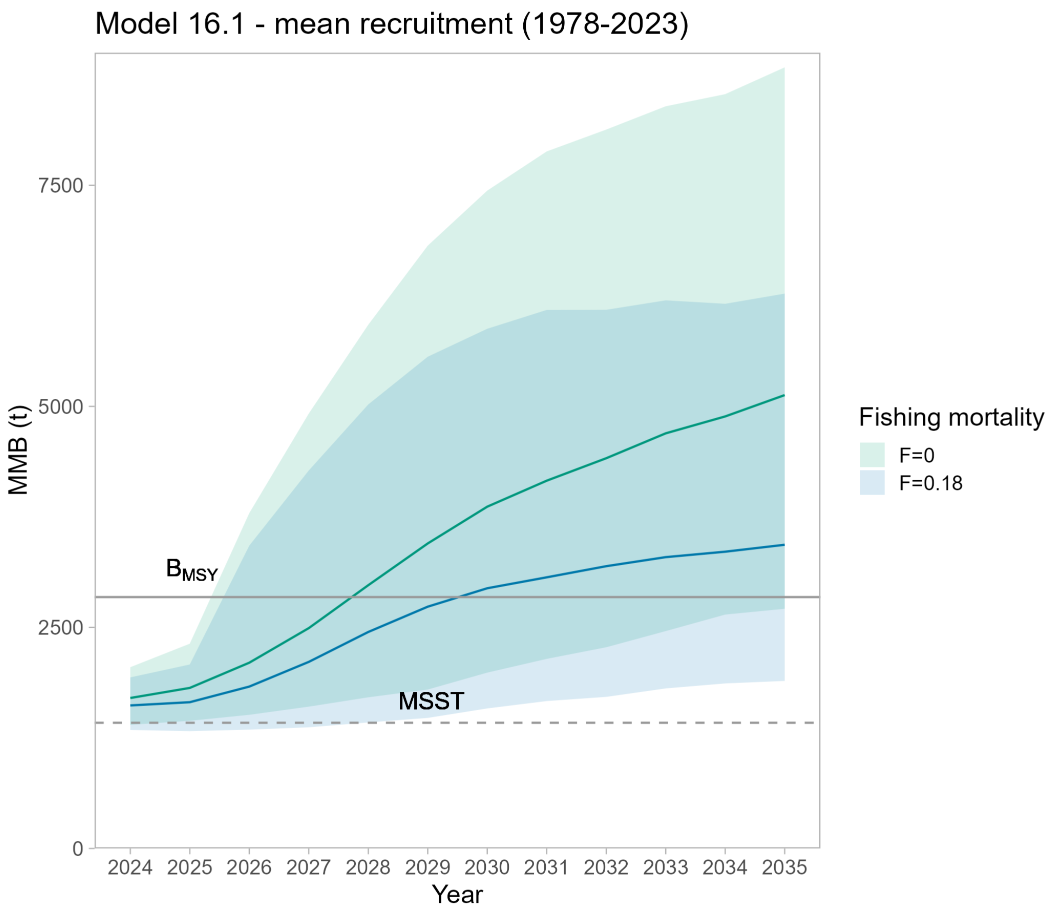

Figure 41: Mature male biomass (MMB) projections from model 16.1 for the next ten years using mean recruitment (1978 - 2023) and average bycatch levels from the last 5 years. Crab year "2024" represents Feb. 15, 2025. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY} while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$.

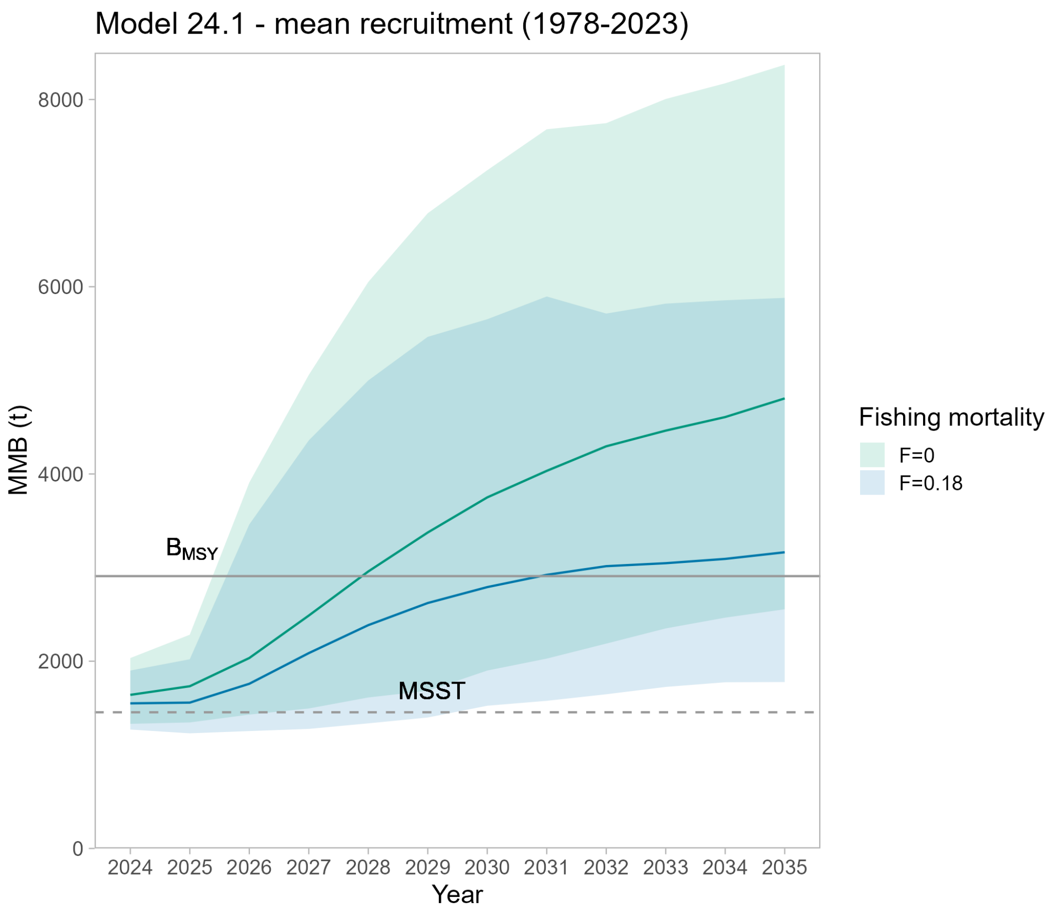

Figure 42: Mature male biomass (MMB) projections from model 24.1 for the next ten years using mean recruitment (1978 - 2023) and average bycatch levels from the last 5 years. Crab year "2024" represents Feb. 15, 2025. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY} while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$.

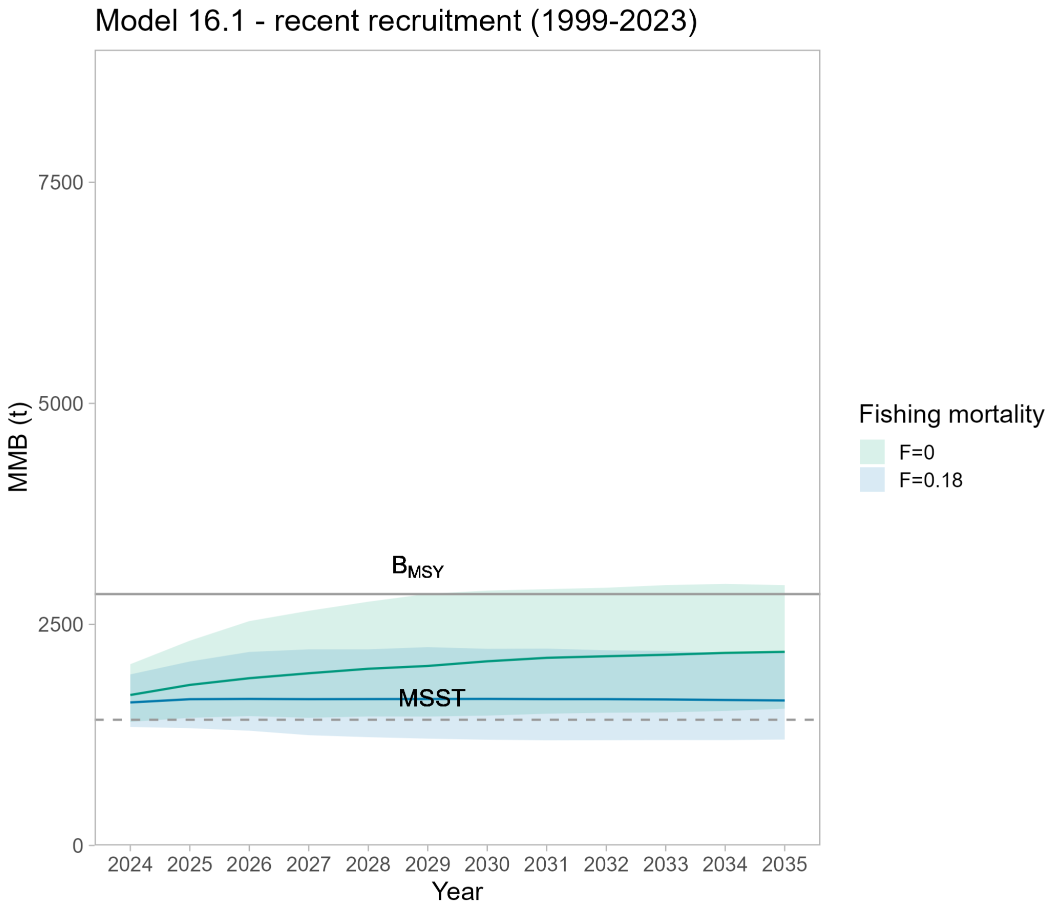

Figure 43: Mature male biomass (MMB) projections from model 16.1 for the next ten years using recent recruitment draws (1999 - 2023) and average bycatch levels from the last 5 years. Crab year "2024" represents Feb. 15, 2025. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY} while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$.

Figure 44: Mature male biomass (MMB) projections from model 24.1 for the next ten years using recent recruitment draws (1999 - 2023) and average bycatch levels from the last 5 years. Crab year "2024" represents Feb. 15, 2025. Solid colored lines represent mean projected MMB for each fishing mortality rate while shaded regions represent 0.05 to 0.95 quantiles. The solid horizontal line shows B_{MSY} while the dashed horizontal line shows MSST (the minimum stock size threshold, $0.5 * B_{MSY}$.

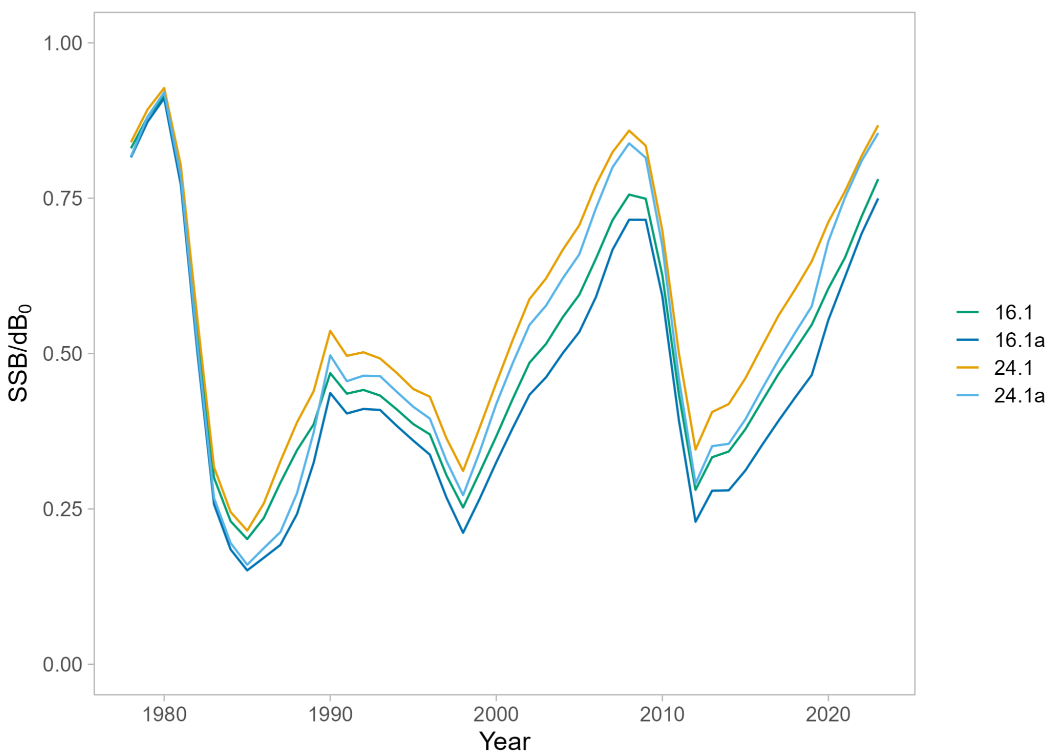

Figure 45: Comparison of spawning stock biomass (SSB) to the dynamic B_0 value (15 February, 1978-2023) for model 16.1, 16.1a, 24.1, and 24.1a.

Appendix A: SMBKC Model Description

1. Introduction

The GMACS model has been specified to account only for male crab $\geq$ 90 mm in carapace length (CL). These are partitioned into three stages (size-classes) determined by CL measurements of (1) 90-104 mm, (2) 105-119 mm, and (3) 120+ mm. For management of the St. Matthew Island blue king crab (SMBKC) fishery, 120 mm CL is used as the proxy value for the legal measurement of 5.5 inch carapace width (CW), whereas 105 mm CL is the management proxy for mature-male size (state regulation *5 AAC 34.917 (d)*). Accordingly, within the model only stage-3 crab are retained in the directed fishery, and stage-2 and stage-3 crab together comprise the collection of mature males. Some justification for the 105 mm value is presented in Pengilly and Schmidt (1995), who used it in developing the current regulatory SMBKC harvest strategy. The term "recruit" here designates recruits to the model, i.e., annual new stage-1 crab, rather than recruits to the fishery. The following description of model structure reflects the GMACS base model configuration.

2. Model Population Dynamics

Within the model, the beginning of the crab year is assumed contemporaneous with the NMFS trawl survey, nominally assigned a date of 1 July. Although the timing of the fishery is different each year, MMB is estimated at 15 February, which is the reference date for calculation of federal management biomass quantities. To accommodate this, each model year is split into 5 seasons (t) and a proportion of the natural mortality (τ_t), scaled relative to the portions of the year, is applied in each of these seasons where $\sum_{t=1}^{t=5} \tau_t = 1$. Each model year consists of the following processes with time-breaks denoted here by "Seasons." However, it is important to note that actual seasons are survey-to-fishery, fishery-to Feb 15, and Feb 15 to July 1. The following breakdown accounts for events and fishing mortality treatments:

1. Season 1 (survey period)
    - Beginning of the SMBKC fishing year (1 July)
    - $\tau_1 = 0$
    - Surveys
2. Season 2 (natural mortality until pulse fishery)
    - τ_2 ranges from 0.05 to 0.44 depending on the time of year the fishery begins each year (i.e., a higher value indicates the fishery begins later in the year).
3. Season 3 (pulse fishery)
    - $\tau_3 = 0$
    - fishing mortality applied
4. Season 4 (natural mortality until spawning)
    - $\tau_4 = 0.63 - \sum_{i=1}^{i=4} \tau_i$
5. Season 5 (natural mortality and somatic growth through to June 30th)
    - $\tau_5 = 0.37$
    - Calculate MMB (15 February)
    - Growth and molting
    - Recruitment (all to stage-1)

The proportion of natural mortality (τ_t) applied during each season in the model is provided in Table 23, see Table 9 for season 2 interaction with directed fishery timing. The beginning of the year (1 July) to the date that MMB is measured (15 February) is 63% of the year. Therefore 63% of the natural mortality must be applied before the MMB is calculated. Because the timing of the fishery is different each year, τ_2 varies and thus τ_4 varies also.

With boldface lower-case letters indicating vector quantities we designate the vector of stage abundances during season t and year y as

$$\boldsymbol{n}_{t,y} = n_{l,t,y} = \left[n_{1,t,y}, n_{2,t,y}, n_{3,t,y}\right]^\top . \tag{2}$$

The number of new crab, or recruits, of each stage entering the model each season t and year y is represented as the vector $\boldsymbol{r}_{t,y}$. The SMBKC formulation of GMACS specifies recruitment to stage-1 only during season $t = 5$, thus the recruitment size distribution is

$$\phi_l = \left[1, 0, 0\right]^\top , \tag{3}$$

and the recruitment is

$$\boldsymbol{r}_{t,y} = \begin{cases} 0 & \text{for} \quad t < 5 \\ \bar{R}\phi_l \delta_y^R & \text{for} \quad t = 5. \end{cases} \tag{4}$$

where $\bar{R}$ is the average annual recruitment and δ_y^R are the recruitment deviations each year y

$$\delta_y^R \sim \mathcal{N}\left(0, \sigma_R^2\right). \tag{5}$$

Using boldface upper-case letters to indicate a matrix, we describe the size transition matrix $\boldsymbol{G}$ as

$$\boldsymbol{G} = \begin{bmatrix} 1 - \pi_{12} - \pi_{13} & \pi_{12} & \pi_{13} \\ 0 & 1 - \pi_{23} & \pi_{23} \\ 0 & 0 & 1 \end{bmatrix}, \tag{6}$$

with π_{jk} equal to the proportion of stage-j crab that molt and grow into stage-k within a season or year.

The natural mortality each season t and year y is

$$M_{t,y} = \bar{M}\tau_t + \delta_y^M \text{ where } \delta_y^M \sim \mathcal{N}\left(0, \sigma_M^2\right) \tag{7}$$

Fishing mortality by year y and season t is denoted $F_{t,y}$ and calculated as

$$F_{t,y} = F_{t,y}^{\text{df}} + F_{t,y}^{\text{tb}} + F_{t,y}^{\text{fb}} \tag{8}$$

where $F_{t,y}^{\text{df}}$ is the fishing mortality associated with the directed fishery, $F_{t,y}^{\text{tb}}$ is the fishing mortality associated with the trawl bycatch fishery, $F_{t,y}^{\text{fb}}$ is the fishing mortality associated with the fixed bycatch fishery. Each of these are derived as

$$\begin{aligned} F_{t,y}^{\text{df}} &= \bar{F}^{\text{df}} + \delta_{t,y}^{\text{df}} \quad \text{where} \quad \delta_{t,y}^{\text{df}} \sim \mathcal{N}\left(0, \sigma_{\text{df}}^2\right), \\ F_{t,y}^{\text{tb}} &= \bar{F}^{\text{tb}} + \delta_{t,y}^{\text{tb}} \quad \text{where} \quad \delta_{t,y}^{\text{df}} \sim \mathcal{N}\left(0, \sigma_{\text{tb}}^2\right), \\ F_{t,y}^{\text{fb}} &= \bar{F}^{\text{fb}} + \delta_{t,y}^{\text{fb}} \quad \text{where} \quad \delta_{t,y}^{\text{df}} \sim \mathcal{N}\left(0, \sigma_{\text{fb}}^2\right), \end{aligned} \tag{9}$$

where $\delta_{t,y}^{\text{df}}$, $\delta_{t,y}^{\text{tb}}$, and $\delta_{t,y}^{\text{fb}}$ are the fishing mortality deviations for each of the fisheries, each season t during each year y, $\bar{F}^{\text{df}}$, $\bar{F}^{\text{tb}}$, and $\bar{F}^{\text{fb}}$ are the average fishing mortalities for each fishery. The total mortality $Z_{l,t,y}$ represents the combination of natural mortality $M_{t,y}$ and fishing mortality $F_{t,y}$ during season t and year y

$$\boldsymbol{Z}_{t,y} = Z_{l,t,y} = M_{t,y} + F_{t,y}. \tag{10}$$

The survival matrix $\boldsymbol{S}_{t,y}$ during season t and year y is

$$\boldsymbol{S}_{t,y} = \begin{bmatrix} 1 - e^{-Z_{1,t,y}} & 0 & 0 \\ 0 & 1 - e^{-Z_{2,t,y}} & 0 \\ 0 & 0 & 1 - e^{-Z_{3,t,y}} \end{bmatrix}. \tag{11}$$

The basic population dynamics underlying GMACS can thus be described as

$$\begin{aligned} \boldsymbol{n}_{t+1,y} &= \boldsymbol{S}_{t,y}\boldsymbol{n}_{t,y}, & \text{if } t < 5 \\ \boldsymbol{n}_{t,y+1} &= \boldsymbol{G}\boldsymbol{S}_{t,y}\boldsymbol{n}_{t,y} + \boldsymbol{r}_{t,y} & \text{if } t = 5. \end{aligned} \tag{12}$$

3. Model Data

Data inputs used in model estimation are listed in Table 24. The mean weight (kg) by stage, provided as a vector of weights at length each year to GMACS, is the same for all years and all models: 0.7 kg for Stage-1, 1.2 kg for Stage-2, and 1.9 kg for Stage-3.

4. Model Parameters

Table 25 lists fixed (externally determined) parameters used in model computations. In all scenarios, the stage-transition matrix is

$$\boldsymbol{G} = \begin{bmatrix} 0.2 & 0.7 & 0.1 \\ 0 & 0.2 & 0.8 \\ 0 & 0 & 1 \end{bmatrix} \tag{13}$$

which is the combination of the growth matrix and molting probabilities.

Estimated parameters are listed in Table 26 and include an estimated natural mortality deviation parameter in 1998/99 (δ^M_{1998}) assuming an anomalous mortality event in that year, as hypothesized by Zheng and Kruse (2002), with natural mortality otherwise fixed at 0.18 yr^{-1}.

5. Model Objective Function and Weighting Scheme

The objective function consists of the sum of several negative log-likelihood terms characterizing the hypothesized error structure of the principal data inputs (Table 20). A log-normal distribution is assumed to characterize the catch data and is modeled as

$$\sigma^{\text{catch}}_{t,y} = \sqrt{\log\left(1 + \left(CV^{\text{catch}}_{t,y}\right)^2\right)} \tag{14}$$

$$\delta^{\text{catch}}_{t,y} = \mathcal{N}\left(0, \left(\sigma^{\text{catch}}_{t,y}\right)^2\right) \tag{15}$$

where $\delta^{\text{catch}}_{t,y}$ is the residual catch. The relative abundance data is also assumed to be log-normally distributed

$$\sigma^{\text{I}}_{t,y} = \frac{1}{\lambda}\sqrt{\log\left(1 + \left(CV^{\text{I}}_{t,y}\right)^2\right)} \tag{16}$$

$$\delta^{\text{I}}_{t,y} = \log\left(I^{\text{obs}}/I^{\text{pred}}\right)/\sigma^{\text{I}}_{t,y} + 0.5\sigma^{\text{I}}_{t,y} \tag{17}$$

and the likelihood is

$$\sum \log\left(\delta^{\text{I}}_{t,y}\right) + \sum 0.5\left(\sigma^{\text{I}}_{t,y}\right)^2 \tag{18}$$

GMACS calculates standard deviation of the normalised residual (SDNR) values and median of the absolute residual (MAR) values for all abundance indices and size compositions to help the user come up with reasonable likelihood weights. For an abundance data set to be well fitted, the SDNR should not be much greater than 1 (a value much less than 1, which means that the data set is fitted better than was expected, is not a cause for concern). What is meant by "much greater than 1" depends on m (the number of years in the data set). Francis (2011) suggests upper limits of 1.54, 1.37, and 1.26 for $m = 5$, 10, and 20, respectively. Although an SDNR not much greater than 1 is a necessary condition for a good fit, it is not sufficient. It is important to plot the observed and expected abundances to ensure that the fit is good.

GMACS also calculates Francis weights for each of the size composition data sets supplied (Francis 2011). If the user wishes to use the Francis iterative re-weighting method, first the weights applied to the abundance indices should be adjusted by trial and error until the SDNR (and/or MAR) are adequate. Then the Francis weights supplied by GMACS should be used as the new likelihood weights for each of the size composition data sets the next time the model is run. The user can then iteratively adjust the abundance index and size composition weights until adequate SDNR (and/or MAR) values are achieved, given the Francis weights.

6. Estimation

The model was implemented using the software AD Model Builder (Fournier et al. 2012), with parameter estimation by minimization of the model objective function using automatic differentiation. Parameter estimates and standard deviations provided in this document are AD Model Builder reported values assuming maximum likelihood theory asymptotics.

Table 23: Proportion of the natural mortality (τ_t) that is applied during each season (t) in the model.

Year	Season 1	Season 2	Season 3	Season 4	Season 5
1978	0.00	0.07	0.00	0.56	0.37
1979	0.00	0.06	0.00	0.57	0.37
1980	0.00	0.07	0.00	0.56	0.37
1981	0.00	0.05	0.00	0.58	0.37
1982	0.00	0.07	0.00	0.56	0.37
1983	0.00	0.12	0.00	0.51	0.37
1984	0.00	0.10	0.00	0.53	0.37
1985	0.00	0.14	0.00	0.49	0.37
1986	0.00	0.14	0.00	0.49	0.37
1987	0.00	0.14	0.00	0.49	0.37
1988	0.00	0.14	0.00	0.49	0.37
1989	0.00	0.14	0.00	0.49	0.37
1990	0.00	0.14	0.00	0.49	0.37
1991	0.00	0.18	0.00	0.45	0.37
1992	0.00	0.14	0.00	0.49	0.37
1993	0.00	0.18	0.00	0.45	0.37
1994	0.00	0.18	0.00	0.45	0.37
1995	0.00	0.18	0.00	0.45	0.37
1996	0.00	0.18	0.00	0.45	0.37
1997	0.00	0.18	0.00	0.45	0.37
1998	0.00	0.18	0.00	0.45	0.37
1999	0.00	0.18	0.00	0.45	0.37
2000	0.00	0.18	0.00	0.45	0.37
2001	0.00	0.18	0.00	0.45	0.37
2002	0.00	0.18	0.00	0.45	0.37
2003	0.00	0.18	0.00	0.45	0.37
2004	0.00	0.18	0.00	0.45	0.37
2005	0.00	0.18	0.00	0.45	0.37
2006	0.00	0.18	0.00	0.45	0.37
2007	0.00	0.18	0.00	0.45	0.37
2008	0.00	0.18	0.00	0.45	0.37
2009	0.00	0.44	0.00	0.19	0.37
2010	0.00	0.44	0.00	0.19	0.37
2011	0.00	0.44	0.00	0.19	0.37
2012	0.00	0.44	0.00	0.19	0.37
2013	0.00	0.44	0.00	0.19	0.37
2014	0.00	0.44	0.00	0.19	0.37
2015	0.00	0.44	0.00	0.19	0.37
2016	0.00	0.44	0.00	0.19	0.37
2017	0.00	0.44	0.00	0.19	0.37
2018	0.00	0.44	0.00	0.19	0.37
2019	0.00	0.44	0.00	0.19	0.37
2020	0.00	0.44	0.00	0.19	0.37
2021	0.00	0.44	0.00	0.19	0.37
2022	0.00	0.44	0.00	0.19	0.37
2023	0.00	0.44	0.00	0.19	0.37

Table 24: Data inputs used in model estimation.

Data	Years	Source
Directed pot-fishery retained-catch number (not biomass)	1978/79 - 1998/99 2009/10 - 2015/16	Fish tickets (fishery closed 1999/00 - 2008/09 and 2016/17 - 2018/19)
Groundfish trawl bycatch biomass	1992/93 - 2023/24	NMFS groundfish observer program
Groundfish fixed-gear bycatch biomass	1992/93 - 2023/24	NMFS groundfish observer program
NMFS trawl-survey biomass index (area-swept estimate) and CV	1978-2024	NMFS EBS trawl survey
ADF&G pot-survey abundance index (CPUE) and CV	1995-2022	ADF&G SMBKC pot survey
NMFS trawl-survey stage proportions and total number of measured crab	1978-2024	NMFS EBS trawl survey
ADF&G pot-survey stage proportions and total number of measured crab	1995-2022	ADF&G SMBKC pot survey
Directed pot-fishery stage proportions and total number of measured crab	1990/91 - 1998/99 2009/10 - 2015/16	ADF&G crab observer program (fishery closed 1999/00 - 2008/09 and 2016/17 - 2018/19)

Table 25: Fixed model parameters for models 16.1 and 16.1a. Models 24.1 and 24.1a use the same values with the exception of fixed $M = 0.23$.

Parameter	Symbol	Value	Source/rationale
Trawl-survey catchability	q	1.0	Default
Natural mortality	M	0.18 yr^{-1}	NPFMC (2007)
Size transition matrix	$\boldsymbol{G}$	Equation 13	Otto and Cummiskey (1990)
Stage-1 and stage-2 mean weights	w_1, w_2	0.7, 1.2 kg	Length-weight equation (B. Foy, NMFS) applied to stage midpoints
Stage-3 mean weight	$w_{3,y}$	Depends on year	Fishery reported average retained weight from fish tickets, or its average, and mean weights of legal males
Recruitment SD	σ_R	1.2	High value
Natural mortality SD	σ_M	10.0	High value (basically free parameter)
Directed fishery handling mortality		0.2	2010 Crab SAFE
Groundfish trawl handling mortality		0.8	2010 Crab SAFE
Groundfish fixed-gear handling mortality		0.5	2010 Crab SAFE

Table 26: The lower bound (LB), upper bound (UB), initial value, prior, and estimation phase for each estimated model parameter.

Parameter	LB	Initial value	UB	Prior	Phase
Average recruitment $\log(\bar{R})$	-7	10.0	20	Uniform(-7,20)	1
Stage-1 initial numbers $\log(n_1^0)$	5	14.5	20	Uniform(5,20)	1
Stage-2 initial numbers $\log(n_2^0)$	5	14.0	20	Uniform(5,20)	1
Stage-3 initial numbers $\log(n_3^0)$	5	13.5	20	Uniform(5,20)	1
ADF&G pot survey catchability q	0	3.0	5	Uniform(0,5)	1
Stage-1 directed fishery selectivity 1978-2008	0	0.4	1	Uniform(0,1)	3
Stage-2 directed fishery selectivity 1978-2008	0	0.7	1	Uniform(0,1)	3
Stage-1 directed fishery selectivity 2009-2017	0	0.4	1	Uniform(0,1)	3
Stage-2 directed fishery selectivity 2009-2017	0	0.7	1	Uniform(0,1)	3
Stage-1 NMFS trawl survey selectivity	0	0.4	1	Uniform(0,1)	4
Stage-2 NMFS trawl survey selectivity	0	0.7	1	Uniform(0,1)	4
Stage-1 ADF&G pot survey selectivity	0	0.4	1	Uniform(0,1)	4
Stage-2 ADF&G pot survey selectivity	0	0.7	1	Uniform(0,1)	4
Natural mortality deviation during 1998 δ^M_{1998}	-3	0.0	3	Normal(0, σ^2_M)	4
Recruitment deviations δ^R_y	-7	0.0	7	Normal(0, σ^2_R)	3
Average directed fishery fishing mortality $\bar{F}^{\text{df}}$	-	0.2	-	-	1
Average trawl bycatch fishing mortality $\bar{F}^{\text{tb}}$	-	0.001	-	-	1
Average fixed gear bycatch fishing mortality $\bar{F}^{\text{fb}}$	-	0.001	-	-	1

Appendix B. Data and control files for model 16.1

The new base model (16.1) data file for 2024

```
#=====================================================================================================
# Gmacs Main  Data  File  Version 2.20.14:  Aug 24 - SM24f Sept 2024 version
# GEAR_INDEX  DESCRIPTION
#   1      : Pot fishery retained catch.
#   1      : Pot fishery with discarded catch/ total catch
#   2      : Trawl bycatch GF
#   3      : Fixed bycatch GF
#   4      : NMFS Trawl survey
#   5      : ADF&G Pot survey
#=====================================================================================================
# Fisheries:  1 Pot Fishery,  1 Pot Discard,  2 Trawl by-catch, 3 Fixed by-catch !fix why two fleet 3?
# Surveys:   4 NMFS Trawl Survey, 5 Pot Survey
#=====================================================================================================
1978  # Start year
2023  # End year (updated) last year of fishery does NOT include current survey year
5    # Number of seasons
5    # Number of fleets (fisheries and surveys)
1    # Number of sexes
1    # Number of shell condition types
1    # Number of maturity types
3    # Number of size-classes in the model
5    # Season recruitment occurs
5    # Season molting and growth occurs
5    # Season to calculate SSB
1    # Season for N output
# maximum size-class (males then females)
3
# size_breaks (a vector giving the break points between size intervals with dimension nclass+1)
90  105  120  135
# Natural mortality per season input type (1 = vector by season, 2 = matrix by season/year)
2
# Proportion of the total natural mortality to be applied each season (each row must add to 1)
0.000   0.070   0.000   0.560   0.370 #1978
0.000   0.060   0.000   0.570   0.370 #1979
0.000   0.070   0.000   0.560   0.370 #1980
0.000   0.050   0.000   0.580   0.370 #1981
0.000   0.070   0.000   0.560   0.370 #1982
0.000   0.120   0.000   0.510   0.370 #1983
0.000   0.100   0.000   0.530   0.370 #1984
0.000   0.140   0.000   0.490   0.370 #1985
0.000   0.140   0.000   0.490   0.370 #1986
0.000   0.140   0.000   0.490   0.370 #1987
0.000   0.140   0.000   0.490   0.370 #1988
0.000   0.140   0.000   0.490   0.370 #1989
0.000   0.140   0.000   0.490   0.370 #1990
0.000   0.180   0.000   0.450   0.370 #1991
0.000   0.140   0.000   0.490   0.370 #1992
0.000   0.180   0.000   0.450   0.370 #1993
0.000   0.180   0.000   0.450   0.370 #1994
0.000   0.180   0.000   0.450   0.370 #1995
0.000   0.180   0.000   0.450   0.370 #1996
0.000   0.180   0.000   0.450   0.370 #1997
0.000   0.180   0.000   0.450   0.370 #1998
0.000   0.180   0.000   0.450   0.370 #1999
0.000   0.180   0.000   0.450   0.370 #2000
0.000   0.180   0.000   0.450   0.370 #2001
0.000   0.180   0.000   0.450   0.370 #2002
0.000   0.180   0.000   0.450   0.370 #2003
0.000   0.180   0.000   0.450   0.370 #2004
0.000   0.180   0.000   0.450   0.370 #2005
0.000   0.180   0.000   0.450   0.370 #2006
0.000   0.180   0.000   0.450   0.370 #2007
0.000   0.180   0.000   0.450   0.370 #2008
0.000   0.440   0.000   0.190   0.370 #2009
0.000   0.440   0.000   0.190   0.370 #2010
0.000   0.440   0.000   0.190   0.370 #2011
```

```
0.000   0.440   0.000   0.190   0.370 #2012
0.000   0.440   0.000   0.190   0.370 #2013
0.000   0.440   0.000   0.190   0.370 #2014
0.000   0.440   0.000   0.190   0.370 #2015
0.000   0.440   0.000   0.190   0.370 #2016
0.000   0.440   0.000   0.190   0.370 #2017
0.000   0.440   0.000   0.190   0.370 #2018
0.000   0.440   0.000   0.190   0.370 #2019 (updated)
0.000   0.440   0.000   0.190   0.370 #2020 (updated 4-14-22)
0.000   0.440   0.000   0.190   0.370 #2021 (updated 8-25-22)
0.000   0.440   0.000   0.190   0.370 #2022 (updated 2-14-24)
0.000   0.440   0.000   0.190   0.370 #2023 (updated 8-14-24)
#0  0.0025  0  0.6245  0.373
# Fishing fleet names (delimited with spaces no spaces in names)
Pot_Fishery Trawl_Bycatch Fixed_bycatch
# Survey names (delimited with spaces no spaces in names)
NMFS_Trawl ADFG_Pot
# Are the fleets instantaneous (0) or continuous (1)
1 1 1 1 1
# 0- old format; 1 - new format
0
# Number  of  catch data  frames
4
# Number  of  rows  in  each  data  frame
27  18 33  33 #(updated - all should increase 1 if value for current year NO placeholder for direct fishery if closed)
##  CATCH DATA
##  Type of catch: 1 = retained, 2 = discard
##  Units of catch: 1 = biomass, 2 = numbers
##  for SMBKC Units are in number of crab for landed & 1000 kg for discards.
##  Male Retained
# year  seas   fleet  sex   obs    cv type  units mult effort  discard_mortality
1978   3     1     1     436126  0.03   1     2     1     0     0.2
1979   3     1     1     52966   0.03   1     2     1     0     0.2
1980   3     1     1     33162   0.03   1     2     1     0     0.2
1981   3     1     1     1045619 0.03   1     2     1     0     0.2
1982   3     1     1     1935886 0.03   1     2     1     0     0.2
1983   3     1     1     1931990 0.03   1     2     1     0     0.2
1984   3     1     1     841017  0.03   1     2     1     0     0.2
1985   3     1     1     436021  0.03   1     2     1     0     0.2
1986   3     1     1     219548  0.03   1     2     1     0     0.2
1987   3     1     1     227447  0.03   1     2     1     0     0.2
1988   3     1     1     280401  0.03   1     2     1     0     0.2
1989   3     1     1     247641  0.03   1     2     1     0     0.2
1990   3     1     1     391405  0.03   1     2     1     0     0.2
1991   3     1     1     726519  0.03   1     2     1     0     0.2
1992   3     1     1     545222  0.03   1     2     1     0     0.2
1993   3     1     1     630353  0.03   1     2     1     0     0.2
1994   3     1     1     827015  0.03   1     2     1     0     0.2
1995   3     1     1     666905  0.03   1     2     1     0     0.2
1996   3     1     1     660665  0.03   1     2     1     0     0.2
1997   3     1     1     939822  0.03   1     2     1     0     0.2
1998   3     1     1     635370  0.03   1     2     1     0     0.2
2009   3     1     1     103376  0.03   1     2     1     0     0.2
2010   3     1     1     298669  0.03   1     2     1     0     0.2
2011   3     1     1     437862  0.03   1     2     1     0     0.2
2012   3     1     1     379386  0.03   1     2     1     0     0.2
2014   3     1     1     69109   0.03   1     2     1     0     0.2
2015   3     1     1     24407   0.03   1     2     1     0     0.2
#2016   3     1     1     10.000  0.03   1     2     1     0     0.2
#2017   3     1     1     10.000  0.03   1     2     1     0     0.2
#2018   3     1     1     10.000  0.03   1     2     1     0     0.2 # placeholder no fishery
# Male  discards  Pot fishery
1990   3     1     1    254.9787861    0.6    2     1     1     0     0.2
1991   3     1     1    531.4483252    0.6    2     1     1     0     0.2
1992   3     1     1    1050.387026    0.6    2     1     1     0     0.2
1993   3     1     1    951.4626128    0.6    2     1     1     0     0.2
1994   3     1     1    1210.764588    0.6    2     1     1     0     0.2
1995   3     1     1    363.112032     0.6    2     1     1     0     0.2
1996   3     1     1    528.5244687    0.6    2     1     1     0     0.2
1997   3     1     1    1382.825328    0.6    2     1     1     0     0.2
1998   3     1     1    781.1032977    0.6    2     1     1     0     0.2
2009   3     1     1    123.3712279    0.2    2     1     1     0     0.2
```

```
2010   3    1    1    304.6562225    0.2    2    1    1    0    0.2
2011   3    1    1    481.3572126    0.2    2    1    1    0    0.2
2012   3    1    1    437.3360731    0.2    2    1    1    0    0.2
2014   3    1    1    45.4839749     0.2    2    1    1    0    0.2
2015   3    1    1    21.19378597    0.2    2    1    1    0    0.2
2016   3    1    1    0.021193786    0.2    2    1    1    0    0.2
2017   3    1    1    0.021193786    0.2    2    1    1    0    0.2
2018   3    1    1    0.214868020    0.2    2    1    1    0    0.2  # (updated)
#2019  3    1    1    0.0    0.2    2    1    1    0    0.2
#2020  3    1    1    0.0    0.2    2    1    1    0    0.2
#2021  3    1    1    0.0    0.2    2    1    1    0    0.2
#2022  3    1    1    0.0    0.2    2    1    1    0    0.2
#2023  3    1    1    0.0    0.2    2    1    1    0    0.2
#   Trawl   fishery discards
1991    2   2   1   3.538   0.31    2   1   1   0   0.8
1992    2   2   1   1.996   0.31    2   1   1   0   0.8
1993    2   2   1   1.542   0.31    2   1   1   0   0.8
1994    2   2   1   0.318   0.31    2   1   1   0   0.8
1995    2   2   1   0.635   0.31    2   1   1   0   0.8
1996    2   2   1   0.500   0.31    2   1   1   0   0.8
1997    2   2   1   0.500   0.31    2   1   1   0   0.8
1998    2   2   1   0.500   0.31    2   1   1   0   0.8
1999    2   2   1   0.500   0.31    2   1   1   0   0.8
2000    2   2   1   0.500   0.31    2   1   1   0   0.8
2001    2   2   1   0.500   0.31    2   1   1   0   0.8
2002    2   2   1   0.726   0.31    2   1   1   0   0.8
2003    2   2   1   0.998   0.31    2   1   1   0   0.8
2004    2   2   1   0.091   0.31    2   1   1   0   0.8
2005    2   2   1   0.500   0.31    2   1   1   0   0.8
2006    2   2   1   2.812   0.31    2   1   1   0   0.8
2007    2   2   1   0.045   0.31    2   1   1   0   0.8
2008    2   2   1   0.272   0.31    2   1   1   0   0.8
2009    2   2   1   0.638   0.31    2   1   1   0   0.8
2010    2   2   1   0.360   0.31    2   1   1   0   0.8
2011    2   2   1   0.170   0.31    2   1   1   0   0.8
2012    2   2   1   0.011   0.31    2   1   1   0   0.8
2013    2   2   1   0.163   0.31    2   1   1   0   0.8
2014    2   2   1   0.010   0.31    2   1   1   0   0.8
2015    2   2   1   0.010   0.31    2   1   1   0   0.8
2016    2   2   1   0.229   0.31    2   1   1   0   0.8
2017    2   2   1   0.048   0.31    2   1   1   0   0.8 # updated in 2020 was 0.052, now 0.48?
2018    2   2   1   0.001   0.31    2   1   1   0   0.8 # (data is 0 but small value for placeholder)
2019    2   2   1   0.030   0.31    2   1   1   0   0.8 # (updated )
2020    2   2   1   0.001   0.31    2   1   1   0   0.8 # (4-14-22)
2021    2   2   1   0.001   0.31    2   1   1   0   0.8 # (8-25-22) (data is 0 but small value for placeholder)
2022    2   2   1   0.001   0.31    2   1   1   0   0.8 # (updated 2-14-24) (data is 0 but small value for placeholder)
2023    2   2   1   0.005   0.31    2   1   1   0   0.8 # (updated 8-14-24 - bycatch_groundfish.R)
#   Fixed   fishery discards
1991    2   3   1   0.045   0.31    2   1   1   0   0.5
1992    2   3   1   2.268   0.31    2   1   1   0   0.5
1993    2   3   1   0.500   0.31    2   1   1   0   0.5
1994    2   3   1   0.091   0.31    2   1   1   0   0.5
1995    2   3   1   0.136   0.31    2   1   1   0   0.5
1996    2   3   1   0.045   0.31    2   1   1   0   0.5
1997    2   3   1   0.181   0.31    2   1   1   0   0.5
1998    2   3   1   0.907   0.31    2   1   1   0   0.5
1999    2   3   1   1.361   0.31    2   1   1   0   0.5
2000    2   3   1   0.500   0.31    2   1   1   0   0.5
2001    2   3   1   0.862   0.31    2   1   1   0   0.5
2002    2   3   1   0.408   0.31    2   1   1   0   0.5
2003    2   3   1   1.134   0.31    2   1   1   0   0.5
2004    2   3   1   0.635   0.31    2   1   1   0   0.5
2005    2   3   1   0.590   0.31    2   1   1   0   0.5
2006    2   3   1   1.451   0.31    2   1   1   0   0.5
2007    2   3   1   69.717  0.31    2   1   1   0   0.5
2008    2   3   1   6.622   0.31    2   1   1   0   0.5
2009    2   3   1   7.522   0.31    2   1   1   0   0.5
2010    2   3   1   9.564   0.31    2   1   1   0   0.5
2011    2   3   1   0.796   0.31    2   1   1   0   0.5
2012    2   3   1   0.739   0.31    2   1   1   0   0.5
2013    2   3   1   0.341   0.31    2   1   1   0   0.5
2014    2   3   1   0.490   0.31    2   1   1   0   0.5
```

```
2015    2   3   1   0.711   0.31    2   1   1   0   0.5
2016    2   3   1   1.630   0.31    2   1   1   0   0.5 # updated from 1.632
2017    2   3   1   5.935   0.31    2   1   1   0   0.5 # updates was 6.032
2018    2   3   1   1.224   0.31    2   1   1   0   0.5 # updated was 1.281
2019    2   3   1   1.124   0.31    2   1   1   0   0.5 # (updated - bycatch_groundfish.R)
2020    2   3   1   0.671   0.31    2   1   1   0   0.5 # (4-14-22 - bycatch_groundfish.R)
2021    2   3   1   0.323   0.31    2   1   1   0   0.5 # (8-25-22 - bycatch_groundfish.R)
2022    2   3   1   2.118   0.31    2   1   1   0   0.5 # (updated 2-14-24 - bycatch_groundfish.R)
2023    2   3   1   0.415   0.31    2   1   1   0   0.5 # (updated 8-14-24 - bycatch_groundfish.R)
##  RELATIVE  ABUNDANCE DATA
##  Units of abundance: 1 = biomass, 2 = numbers
##  for SMBKC pot survey Units are in  crabs for Abundance.
# 0- old format; 1 - new format
0
##  Number  of  relative  abundance indices
2
# Index Type  (1=Selecivity; 2=retention)
# AEPAEP
1 1
##  Number  of  rows  in  both  indices, need to update when survey data is added
58 # updated 2-14-24
# Survey data (abundance indices, units are mt for trawl survey and crab/potlift for pot survey)
#   Index, Year,    Seas,   Fleet,  Sex,    Maturity,   Abundance,  CV   abundance units     timing
1   1978    1   4   1   0   6832.819    0.394   1   0
1   1979    1   4   1   0   7989.881    0.463   1   0
1   1980    1   4   1   0   9986.83 0.507   1   0
1   1981    1   4   1   0   6551.132    0.402   1   0
1   1982    1   4   1   0   16221.933   0.344   1   0
1   1983    1   4   1   0   9634.25 0.298   1   0
1   1984    1   4   1   0   4071.218    0.179   1   0
1   1985    1   4   1   0   3110.541    0.21    1   0
1   1986    1   4   1   0   1416.849    0.388   1   0
1   1987    1   4   1   0   2278.917    0.291   1   0
1   1988    1   4   1   0   3158.169    0.252   1   0
1   1989    1   4   1   0   6338.622    0.271   1   0
1   1990    1   4   1   0   6730.13 0.274   1   0
1   1991    1   4   1   0   6948.184    0.248   1   0
1   1992    1   4   1   0   7093.272    0.201   1   0
1   1993    1   4   1   0   9548.459    0.169   1   0
1   1994    1   4   1   0   6539.133    0.176   1   0
1   1995    1   4   1   0   5703.591    0.178   1   0
1   1996    1   4   1   0   9410.403    0.241   1   0
1   1997    1   4   1   0   10924.107   0.337   1   0
1   1998    1   4   1   0   7976.839    0.355   1   0
1   1999    1   4   1   0   1594.546    0.182   1   0
1   2000    1   4   1   0   2096.795    0.31    1   0
1   2001    1   4   1   0   2831.44   0.245 1   0
1   2002    1   4   1   0   1732.599    0.32    1   0
1   2003    1   4   1   0   1566.675    0.336   1   0
1   2004    1   4   1   0   1523.869    0.305   1   0
1   2005    1   4   1   0   1642.017    0.371   1   0
1   2006    1   4   1   0   3893.875    0.334   1   0
1   2007    1   4   1   0   6470.773    0.385   1   0
1   2008    1   4   1   0   4654.473    0.284   1   0
1   2009    1   4   1   0   6301.47 0.256   1   0
1   2010    1   4   1   0   11130.898   0.466   1   0
1   2011    1   4   1   0   10931.232   0.558   1   0
1   2012    1   4   1   0   6200.219    0.339   1   0
1   2013    1   4   1   0   2287.557    0.217   1   0
1   2014    1   4   1   0   6029.22 0.449   1   0
1   2015    1   4   1   0   5877.433    0.77    1   0
1   2016    1   4   1   0   3485.909    0.393   1   0
1   2017    1   4   1   0   1793.76 0.599   1   0
1   2018    1   4   1   0   1730.742    0.281   1   0
1   2019    1   4   1   0   3170.467    0.337   1   0   #   (updated    -   EBSsurvey_analysis.R)
1   2021    1   4   1   0   1929.298    0.427   1   0   # updated 4-14-22
1   2022    1   4   1   0   2365.760    0.497   1   0   # updated 8-25-22
1   2023    1   4   1   0   2114.867    0.439   1   0   # updated 2-14-24
1   2024    1   4   1   0   1833.665    0.465   1   0   # updated 8-14-24
2   1995    1   5   1   0   12042   0.13    2   0
2   1998    1   5   1   0   12531   0.06    2   0
2   2001    1   5   1   0   8477    0.08    2   0
```

```
2   2004    1   5   1   0   1667    0.15    2   0
2   2007    1   5   1   0   8630    0.09    2   0
2   2010    1   5   1   0   10167   0.10    2   0
2   2013    1   5   1   0   5606    0.19    2   0
2   2015    1   5   1   0   2805    0.18    2   0
2   2016    1   5   1   0   2021    0.17    2   0
2   2017    1   5   1   0   1674    0.25    2   0
2   2018    1   5   1   0   745 0.14    2   0   #   no  smbkc   pot survey  in  2019, 2020, 2021
2   2022    1   5   1   0   4089    0.14    2   0   # updated 2-14-24

# 0- old format; 1 - new format
0
##  Number  of  length  frequency matrices
3
##  Number  of  rows  in  each  matrix
15  46  12 # (updated 8-14-24)
##  Number  of  bins  in  each  matrix  (columns  of  size  data)
3  3  3
##  SIZE  COMPOSITION DATA  FOR ALL FLEETS
##  SIZE  COMP  LEGEND
##  Sex:  1 = male, 2 = female, 0 = both  sexes combined
##  Type  of  composition:  1 = retained, 2 = discard,  0 = total composition
##  Maturity  state:  1 = immature, 2 = mature, 0 = both  states  combined
##  Shell condition:  1 = new shell,  2 = old shell,  0 = both  shell types combined
##length  proportions of  pot discarded males
##Year, Seas, Fleet,  Sex,  Type, Shell,  Maturity, Nsamp,  DataVec
  1990  3 1 1 0 0 0 15  0.1133  0.3933  0.4933
  1991  3 1 1 0 0 0 25  0.1329  0.1768  0.6902
  1992  3 1 1 0 0 0 25  0.1905  0.2677  0.5417
  1993  3 1 1 0 0 0 25  0.2807  0.2097  0.5096
  1994  3 1 1 0 0 0 25  0.2942  0.2714  0.4344
  1995  3 1 1 0 0 0 25  0.1478  0.2127  0.6395
  1996  3 1 1 0 0 0 25  0.1595  0.2229  0.6176
  1997  3 1 1 0 0 0 25  0.1818  0.2053  0.6128
  1998  3 1 1 0 0 0 25  0.1927  0.2162  0.5911
  2009  3 1 1 0 0 0 50  0.1413  0.3235  0.5352
  2010  3 1 1 0 0 0 50  0.1314  0.3152  0.5534
  2011  3 1 1 0 0 0 50  0.1314  0.3051  0.5636
  2012  3 1 1 0 0 0 50  0.1417  0.3178  0.5406
  2014  3 1 1 0 0 0 50  0.0939  0.2275  0.6786
  2015  3 1 1 0 0 0 50  0.1148  0.2518  0.6333 #no fishery so not updated
##length  proportions of  trawl survey  males
##Year, Seas, Fleet,  Sex,  Type, Shell,  Maturity, Nsamp,  DataVec
  1978  1 4 1 0 0 0 50  0.3865  0.3478  0.2657
  1979  1 4 1 0 0 0 50  0.4281  0.3190  0.2529
  1980  1 4 1 0 0 0 50  0.3588  0.3220  0.3192
  1981  1 4 1 0 0 0 39  0.1219  0.3065  0.5716
  1982  1 4 1 0 0 0 50  0.1671  0.2435  0.5893
  1983  1 4 1 0 0 0 50  0.1752  0.2726  0.5522
  1984  1 4 1 0 0 0 36.5  0.1823  0.2085  0.6092
  1985  1 4 1 0 0 0 26.75 0.2023  0.2010  0.5967
  1986  1 4 1 0 0 0 16.25  0.1984  0.4364  0.3652
  1987  1 4 1 0 0 0 24.5 0.1944  0.3779  0.4277
  1988  1 4 1 0 0 0 29.75 0.1879  0.3737  0.4384
  1989  1 4 1 0 0 0 50  0.4246  0.2259  0.3496
  1990  1 4 1 0 0 0 50  0.2380  0.2332  0.5288
  1991  1 4 1 0 0 0 50  0.2274  0.3300  0.4426
  1992  1 4 1 0 0 0 50  0.2263  0.2911  0.4826
  1993  1 4 1 0 0 0 50  0.2296  0.2759  0.4945
  1994  1 4 1 0 0 0 50  0.1989  0.2926  0.5085
  1995  1 4 1 0 0 0 50  0.2593  0.3005  0.4403
  1996  1 4 1 0 0 0 50  0.1998  0.3054  0.4948
  1997  1 4 1 0 0 0 50  0.1622  0.3102  0.5275
  1998  1 4 1 0 0 0 50  0.1276  0.3212  0.5511
  1999  1 4 1 0 0 0 17.25  0.2224  0.2214  0.5562
  2000  1 4 1 0 0 0 18 0.2154  0.2180  0.5665
  2001  1 4 1 0 0 0 27.75 0.2253  0.2699  0.5048
  2002  1 4 1 0 0 0 10.75  0.1127  0.2346  0.6527
  2003  1 4 1 0 0 0 26.5 0.3762  0.2345  0.3893
  2004  1 4 1 0 0 0 20.75  0.2488  0.1848  0.5663
  2005  1 4 1 0 0 0 16.75  0.2825  0.2744  0.4431
  2006  1 4 1 0 0 0 39.5  0.3276  0.2293  0.4431
```

```
  2007  1 4 1 0 0 0 50  0.4394  0.3525  0.2081
  2008  1 4 1 0 0 0 50  0.3745  0.2219  0.4036
  2009  1 4 1 0 0 0 50  0.3057  0.4202  0.2741
  2010  1 4 1 0 0 0 50  0.4081  0.3371  0.2548
  2011  1 4 1 0 0 0 50  0.2179  0.3940  0.3881
  2012  1 4 1 0 0 0 50  0.1573  0.4393  0.4034
  2013  1 4 1 0 0 0 26  0.2100  0.2834  0.5065
  2014  1 4 1 0 0 0 50  0.1738  0.3912  0.4350
  2015  1 4 1 0 0 0 40.5  0.2340  0.2994  0.4666
  2016  1 4 1 0 0 0 30.75  0.2255  0.2780  0.4965
  2017  1 4 1 0 0 0 12  0.0849  0.2994  0.6157
  2018  1 4 1 0 0 0 26.25  0.1475  0.2219  0.6306 #55
  2019  1 4 1 0 0 0 45.75  0.1961  0.2346  0.5692 #105 no survey so not updated
  2021  1 4 1 0 0 0 30.75  0.3323  0.1320  0.5357 #59  updated 4-14-22
  2022  1 4 1 0 0 0 46  0.3531  0.2121  0.4348 #75 updated 8-25-22
  2023  1 4 1 0 0 0 24  0.3211  0.2974  0.3815 # updated 2-14-24
  2024  1 4 1 0 0 0 14.5  0.2040  0.2555  0.5405 # updated 8-14-24
  ##length  proportions of  pot survey
  ##Year, Seas, Fleet,  Sex,  Type, Shell,  Maturity, Nsamp,  DataVec
  1995  1 5 1 0 0 0 100 0.151581  0.257254  0.591165
  1998  1 5 1 0 0 0 100  0.086263  0.223461  0.690276
  2001  1 5 1 0 0 0 100  0.158784  0.202492  0.638725
  2004  1 5 1 0 0 0 100  0.092476  0.240596  0.666928
  2007  1 5 1 0 0 0 100  0.116245  0.301801  0.581954
  2010  1 5 1 0 0 0 100  0.12951  0.316528  0.553962
  2013  1 5 1 0 0 0 100  0.137872  0.275316  0.586812
  2015  1 5 1 0 0 0 100  0.090959  0.271233  0.637808
  2016  1 5 1 0 0 0 100  0.097938  0.217784  0.684278
  2017  1 5 1 0 0 0 100  0.110656  0.262295  0.627049
  2018  1 5 1 0 0 0 100  0.109272 0.215232 0.675497 # no survey so not updated
  2022  1 5 1 0 0 0 100  0.15414 0.250955 0.594904 # updated 2-14-2024
##  Growth data (increment)
# Type of growth increment (0=ignore;1=growth increment with a CV;2=size-at-release; size-at)
0
# nobs_growth
0
#3
# MidPoint Sex Increment CV
# 97.5  1  14.1  0.2197
#112.5  1  14.1  0.2197
#127.5  1  14.1  0.2197
#  97.5  1 13.8 0.2197
#  112.5  1 14.1 0.2197
#  127.5  1 14.4 0.2197

# MidPoint Sex  MidPoint   Time-at-liberty Size-trans matrix Number of points
# Release       Recapture

# Environmental data
# 0- old format; 1 - new format
0
# Number of series
0
# Year ranges

# Indices
# Index Year Value

## eof
9999
```

The new base model (16.1) control file for 2024

```
## Sept 2024 smbkc model 16.1 version: new base model
#
## ================================================================================= ##
# Time Block_Groups to be used in the model (Block_Group 0 is the year range)
## ================================================================================= ##
# Block_Groups to be used in the model (Block_Group 0 is the model year range)
```

```
3
# Number of blocks per group (after the first block, i.e. 1 means two blocks)
1 1 1
# Block_Group definitions  (first block always start with syr; year 0 is last year)
# Block 1: styr endyr #--applies to almost everything (and always defined)
1978 2024 # Block Group 1: M and NMFS survey
# Block Group 2: directed fishery
2009 2024 # Block Group 3: directed fishery
# Block Group 3: natural mortality event
1998 1998

## ===================================================================================== ##
## GENERAL CONTROLS
## ===================================================================================== ##
1978       # First rec_dev
2023       # last rec_dev (updated annually, should be last completed crab year?)
   0       # Terminal molting (0 = off, 1 = on). If on, the calc_stock_recruitment_relationship() isn't called in the procedure
   3       # Estimated rec_dev phase
  -3       # Estimated sex_ratio
 0.5       # initial sex-ratio
#  -3       # Estimated rec_ini phase
   2       # Initial conditions (0 = Unfished, 1 = Steady-state fished, 2 = Free parameters)
   1       # Reference size-class for initial conditons = 3 only
   1       # Lambda (proportion of mature male biomass for SPR reference points)
   0       # Stock-Recruit-Relationship (0 = None, 1 = Beverton-Holt)
  1        # Use years specified to computed average sex ratio in the calculation of average recruitment for reference points (0 = off -i.e. Rec b
  200      # Years to compute equilibria
   5 # Phase for deviation parameters
1978 # First year of bias-correction - what is this? Buck had it as 1910.
1978 # First full bias-correction - what is this? Buck had it as 1920.
2050 # Last full bias-correction
2050 # Last year of bias-correction
## ------------------------------------------------------------------------------------- ##
## RECRUITMENT                                                                           ##
## ival          lb       ub       phz    prior     p1      p2        # parameter   ##
## ------------------------------------------------------------------------------------- ##
# ival       lb       ub       phz   prior     p1      p2        # parameter        #
  14.3      -7.0       30       -2       0    -7       30         # log(R0)
  10.0      -7.0       20       -1       1   -10.0     20         # log(Rini)
  13.39     -7.0       20        1       0    -7       20         # log(Rbar) (MUST be PHASE 1)
  80.0      30.0      310       -2       1    72.5    7.25        # Recruitment size distribution expected value
  0.25       0.1        7       -4       0    0.1     9.0         # Recruitment size scale (variance component)
  0.2      -10.0      0.75      -4       0  -10.0    0.75         # log(sigma_R)
  0.75      0.20      1.00      -2       3    3.0    2.00         # steepness
  0.01      0.00      1.00      -3       3    1.01   1.01         # recruitment autocorrelation
## ------------------------------------------------------------------------------------- ##
## Initial abundance                                                                     ##
## ival          lb       ub       phz    prior     p1      p2        # parameter   ##
## ------------------------------------------------------------------------------------- ##
  14.5       5.00     20.00        1       0    5.00  20.00        # logN0 vector of initial numbers at length
  14.0       5.00     20.00        1       0    5.00  20.00        # logN0 vector of initial numbers at length
  13.5       5.00     20.00        1       0    5.00  20.00        # logN0 vector of initial numbers at length

## ------------------------------------------------------------------------------------- ##
# weight-at-length input method (1 = allometry i.e. w_l = a*l^b, 2 = vector by sex, 3 = matrix by sex)
## ------------------------------------------------------------------------------------- ##
3
# Male weight-at-length
0.000748427    0.001165731    0.001930510
0.000748427    0.001165731    0.001688886
0.000748427    0.001165731    0.001922246
0.000748427    0.001165731    0.001877957
0.000748427    0.001165731    0.001938634
0.000748427    0.001165731    0.002076413
0.000748427    0.001165731    0.001899330
0.000748427    0.001165731    0.002116687
0.000748427    0.001165731    0.001938784
0.000748427    0.001165731    0.001939764
0.000748427    0.001165731    0.001871067
0.000748427    0.001165731    0.001998295
0.000748427    0.001165731    0.001870418
0.000748427    0.001165731    0.001969415
```

```
0.000748427    0.001165731    0.001926859
0.000748427    0.001165731    0.002021492
0.000748427    0.001165731    0.001931318
0.000748427    0.001165731    0.002014407
0.000748427    0.001165731    0.001977471
0.000748427    0.001165731    0.002099246
0.000748427    0.001165731    0.001982478
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001891628
0.000748427    0.001165731    0.001795721
0.000748427    0.001165731    0.001823113
0.000748427    0.001165731    0.001807433
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001894627
0.000748427    0.001165731    0.001850611
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932
0.000748427    0.001165731    0.001930932 # (updated - should this change?)
0.000748427    0.001165731    0.001930932 # (add line here each year - 4-14-22)
0.000748427    0.001165731    0.001930932 # (add line here each year - 8-25-22)
0.000748427    0.001165731    0.001930932 # (add line here each year - 2-14-24)
0.000748427    0.001165731    0.001930932 # (add line here each year - 8-14-24)
# Proportion mature by sex
0 1 1
# Proportion legal by sex
0 0 1
## ==================================================================================== ##
## GROWTH PARAMETER CONTROLS                                                            ##
## ==================================================================================== ##
1   # Maximum size-class for recruitment(males then females)
0   # use functional maturity for terminally molting animals?
## ------------------------------------------------------------------------------------ ##
#--General inputs
# ------------------------------------------------------------------------------------ ##
# Block: Block number for time-varying growth
# Block_fn: 0:absolute values; 1:exponential
# Env_L: Environmental link - options are 1:additive; 2:multiplicative; 3:exponential
# EnvL_var: Environmental variable
# RW: 0 for not random walk changes; 1 otherwise
# RW_blk: Block number for random walks
# Sigma_RW: Sigma for the random walk parameters
## ------------------------------------------------------------------------------------ ##
#--Growth transition
# ------------------------------------------------------------------------------------ ##
## Type_1: Options for the growth matrix
#  1: Pre-specified growth transition matrix             (requires molt probability)
#  2: Pre-specified size transition matrix               (molt probability is ignored)
#  3: Growth increment is gamma distributed              (requires molt probability)
#  4: Post-molt size is gamma distributed                (requires molt probability)
#  5: Von Bert.: kappa varies among individuals          (requires molt probability)
#  6: Von Bert.: Linf varies among individuals           (requires molt probability)
#  7: Von Bert.: kappa and Linf varies among individuals (requires molt probability)
#  8: Growth increment is normally distributed           (requires molt probability)
## Type_2: Options for the growth increment model matrix (if Type_1 in 3-8)
#  1: Linear
#  2: Individual
#  3: Individual (Same as 2)
#  4: Power law for mean post-molt size
#  Block: Block number for time-varying growth
## Type_1 Type_2  Block
      1     -1      0    # Growth-transition Males
```

```
# ------------------------------------------------------------------------------------- ##
#--Molt probability
# ------------------------------------------------------------------------------------- ##
## Options for the molt probability function
#  0: Pre-specified
#  1: Constant at 1
#  2: Logistic
#  3: Individual
## Type Block
    2    0    # Molt probability Males
##--the following is no longer necessary:
# molt probability function (0=pre-specified; 1=flat;2=declining logistic)
#2
# Maximum size-class for recruitment(males then females)
#1
## number of size-increment periods
#1
## Year(s) molt period changes (blank if no change)
#
## Two lines for each parameter if split sex, one line if not                            ##
## number of molt periods
#1
## Year(s) molt period changes (blank if no changes)
#
## Beta parameters are relative (1=Yes;0=no)
#1
##--end "no longer necessary"
# ------------------------------------------------------------------------------------- ##
## General parameter specificiations
##  Initial: Initial value for the parameter (must lie between lower and upper)
##  Lower & Upper: Range for the parameter
##  Prior type:
##   0: Uniform   - parameters are the range of the uniform prior
##   1: Normal    - parameters are the mean and sd
##   2: Lognormal - parameters are the mean and sd of the log
##   3: Beta      - parameters are the two beta parameters [see dbeta]
##   4: Gamma     - parameters are the two gamma parameters [see dgamma]
##  Phase: Set equal to a negative number not to estimate
##  Relative: 0: absolute; 1 relative
##  Block: Block number for time-varying selectivity
##  Block_fn: 0:absolute values; 1:exponential
##  Env_L: Environmental link - options are 0:none; 1:additive; 2:multiplicative; 3:exponential
##  EnvL_var: Environmental variable
##  RW: 0 for no random walk changes; 1 otherwise
##  RW_blk: Block number for random walks
##  Sigma_RW: Sigma used for the random walk
# Inputs for sex * type 2
## MAIN PARS:
# Initial  Lower_bound  Upper_bound Prior_type   Prior_1  Prior_2  Phase  Block Blk_fn  Env_L Env_vr   RW RW_Blk RW_Sigma
    121.5      65.0     145.0          0         0.0      999.0    -4      0      0      0     0       0    0     300    # molt_mu males or combi
    0.060       0.0       1.0          0         0.0      999.0    -3      0      0      0     0       0    0     300    # molt_cv males or combi

# EXTRA PARS: Initial  Lower_bound  Upper_bound Prior_type      Prior_1      Prior_2  Phase Reltve
#----no extra pars
#--following is no longer necessary:
## ------------------------------------------------------------------------------------- ##
## AEP Growth parameters
### ------------------------------------------------------------------------------------- ##
## ival        lb        ub     phz   prior      p1      p2        # parameter        #
## ------------------------------------------------------------------------------------- #
##  14.1      10.0      30.0        -3       0    0.0   999.0        # alpha males or combined
##   0.0001    0.0       0.01       -3       0    0.0   999.0        # beta males or combined
##   0.45      0.01      1.0        -3       0    0.0   999.0        # gscale males or combined
#   121.5      65.0     145.0       -4       0    0.0   999.0        # molt_mu males or combined
#   0.060     0.0       1.0         -3       0    0.0   999.0        # molt_cv males or combined
#--end of "no longer necessary"

# The custom growth matrix (if not using just fill with zeros)
# Alternative TM (loosely) based on Otto and Cummiskey (1990)
#  Size1....Size2....Size3
   0.1761   0.0000   0.0000
   0.7052   0.2206   0.0000
```

```
   0.1187   0.7794   1.0000

# custom molt probability matrix


## ==================================================================================== ##
## NATURAL MORTALITY PARAMETER CONTROLS                                                 ##
## ==================================================================================== ##
## baseline M: immature crab; mature M's: sex-specfic ln-scale offsets
# Relative: 0 - absolute values; 1+ - based on another M-at-size vector (indexed by ig)
# Type: 0 for standard; 1: Spline
#  For spline: set extra to the number of knots, the parameters are the knots (phase -1) and the log-differences from base M
# Extra: control the number of knots for splines
# Brkpts: number of changes in M by size
# Mirror: Mirror M-at-size over to that for another partition (indexed by ig)
# Block: Block number for time-varying M-at-size
# Block_fn: 0:absolute values; 1:exponential
# Env_L: Environmental link - options are 0: none; 1:additive; 2:multiplicative; 3:exponential
# EnvL_var: Environmental variable
# RW: 0 for no random walk changes; 1 otherwise
# RW_blk: Block number for random walks
# Sigma_RW: Sigma for the random walk parameters
# Mirror_RW: Should time-varying aspects be mirrored (Indexed by ig)
#--control info by group (ig)
#----group 1: males
## Relative? Type   Extra  Brkpts  Mirror   Block  Blk_fn Env_L   EnvL_Vr   RW  RW_blk Sigma_RW Mirr_RW
     0       0       0       0      0        3     0      0       0       0       0   0.3000     0


#----parameter values
# Initial  Lower_bound Upper_bound  Prior_type    Prior_1    Prior_2    Phase
    0.18      0.01        1            2        0.18       0.02      -4   # M for males
    1.6        0.0        2            0        0           0         3   # M for males
#    0.18      0.01        1            2        0.18       0.02      -4   # M for males

## ==================================================================================== ##
## SELECTIVITY PARAMETERS CONTROLS                                                      ##
## ==================================================================================== ##
##
# ## Selectivity parameter controls
# ## Selectivity (and retention) types
# ##  <0: Mirror selectivity
# ##   0: Nonparametric selectivity (one parameter per class)
# ##   1: Nonparametric selectivity (one parameter per class, constant from last specified class)
# ##   2: Logistic selectivity (inflection point and width (i.e. 1/slope))
# ##   3: Logistic selectivity (50% and 95% selection)
# ##   4: Double normal selectivity (3 parameters)
# ##   5: Flat equal to zero (1 parameter; phase must be negative)
# ##   6: Flat equal to one (1 parameter; phase must be negative)
# ##   7: Flat-topped double normal selectivity (4 parameters)
# ##   8: Declining logistic selectivity with initial values (50% and 95% selection plus extra)
# ##   9: Cubic-spline (specified with knots and values at knots)
# ##      Inputs: knots (in length units); values at knots (0-1) - at least one should have phase -1
# ##  10: One parameter logistic selectivity (inflection point and slope)
# ##  11: Pre-specified selectivity (matrix by year and class)

## Selectivity specifications --
# ## Extra (type 1): number of selectivity parameters to estimated
# #  Pot_Fishery      Trawl_Bycatch Fixed_bycatch NMFS_Trawl ADFG_Pot
          0               0            0           0         0 # is selectivity sex=specific? (1=Yes; 0=No)
          0               3            3           0         0 # male selectivity type
          0               0            0           0         0 # selectivity within another gear
          0               0            0           0         0 # male extra parameters for each pattern
          1               1            1           1         1 # male: is maximum selectivity at size forced to equal 1 (1) or not (0)
          3               3            3           3         3 # size-class at which selectivity is forced to equal 1 (ignored if the previous

## Retention specifications --
# #  Pot_Fishery  Trawl_Bycatch Fixed_bycatch NMFS_Trawl ADFG_Pot
          0               0            0           0         0 # is retention sex=specific? (1=Yes; 0=No)
          3               6            6           6         6 # male retention type
          1               0            0           0         0 # male retention flag (0 = no, 1 = yes)
          0               0            0           0         0 # male extra parameters for each pattern
```

```
        0              0            0          0        0 # male - should maximum retention be estimated for males (1=Yes; 0=No)

## ================================================================================== ##
## SELECTIVITY/RETENTION PARAMETER VALUES                                             ##
## ================================================================================== ##
# Inputs for type*sex*fleet:
# Selectivity male Pot_Fishery block 2
#Initial  Lower_bound  Upper_bound  Prior_type  Prior_1  Prior_2  Phase  Block  Block_fn  Env_L  EnvL_var  RW  RW_Block  Sigma
  0.4       0.001        1.0          0          0        1       3      2      0        0       0        0    0        1    #--directed fisher
  0.7       0.001        1.0          0          0        1       3      2      0        0       0        0    0        1    #--directed fisher
  1.0       0.001        2.0          0          0        1      -2      2      0        0       0        0    0        1    #--directed fisher

# EXTRA PARS: Initial  Lower_bound  Upper_bound Prior_type      Prior_1     Prior_2  Phase Reltve
  0.4       0.001        1.0          0          0        1       3      0     #--directed fishery, (2009-2023)
  1.0       0.001        1.0          0          0        1      3      0     #--directed fishery, (2009-2023)
  1.0       0.001        2.0          0          0        1      -2      0     #--directed fishery, (2009-2023). Upper bound must = 2.0

# Selectivity male trawl bycatch groundfish
  20          10.0         200          0        10       200     -3      0      0        0       0        0    0        1    #--block 1 (1978-
  60          10.0         200          0        10       200     -3      0      0        0       0        0    0        1    #--block 1 (1978-2

# Selectivity male trawl fixed gear groundfish
  40          0.0          200          0        10       200     -3      0      0        0       0        0    0        1    #--block 1 (1978-2
  60         10.0          200          0        10       200     -3      0      0        0       0        0    0        1    #--block 1 (1978-2

# Selectivity NMFS trawl survey
  0.7       0.001        1.0          0          0        1       4      0      0        0       0        0    0        1    #--block 1 (1978-2
  1.0       0.001        1.0          0          0        1       4      0      0        0       0        0    0        1    #--block 1 (1978-2
  0.9       0.001        1.0          0          0        1      -5      0      0        0       0        0    0        1    #--block 1 (1978-2

# Selectivity ADFG pot survey
  0.4       0.001        1.0          0          0        1       4      0      0        0       0        0    0        1    #--block 1 (1978-2
  1.0       0.001        1.0          0          0        1       4      0      0        0       0        0    0        1    #--block 1 (1978-2
  1.0       0.001        2.0          0          0        1      -2      0      0        0       0        0    0        1    #--block 1 (1978-2

# Inputs for type*sex*fleet:
# Retention male Pot_Fishery
#Initial  Lower_bound  Upper_bound  Prior_type  Prior_1  Prior_2  Phase  Block  Block_fn  Env_L  EnvL_var  RW  RW_Block  Sigma
  120        50           200          0         1       900      -7      0      0        0       0        0    0        1    #--directed fishe
  123       110           200          0         1       900      -7      0      0        0       0        0    0        1    #--directed fishe

# EXTRA PARS: Initial  Lower_bound  Upper_bound Prior_type      Prior_1     Prior_2  Phase Reltve
#  120        50           200          0         1       900      -7      0  #--directed fishery (2009 - 2023)
#  123       110           200          0         1       900      -7      0  #--directed fishery (2009 - 2023)

## ================================================================================== ##
## PRIORS FOR CATCHABILITY
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1   ##
##     and p2 are ignored). ival must be > 0                                          ##
## only allowed to use uniform or lognormal prior                                     ##
## if analytic q estimation step is chosen, turn off estimating q by changing the estimation phase to be -ve ##
## LEGEND                                                                             ##
##     prior: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma             ##
## ================================================================================== ##
##  LAMBDA: Arbitrary relative weights for each series, 0 = do not fit.
## SURVEYS/INDICES ONLY
## Analytic (0 = not analytically solved q, use uniform or lognormal prior; 1 = anaylytic) ##
## Lambda = multiplier for input CV, Emphasis = multiplier for likelihood                 ##

## Analytic? LAMBDA Emphasis Mirror  block Env_L EnvL_Var  RW RW_blk Sigma_RW
0      1        1      0      0     0        0   0      0       0.3         # NMFS trawl
0      1        1      0      0     0        0   0      0       0.3         # ADF&G pot

##  ival       lb         ub      prior    p1         p2     phz
    1.0        0.5        1.2       0      0.0        9.0     -4         # NMFS trawl
    0.003      0          5         0      0.0        9.0      3         # ADF&G pot


## ================================================================================== ##
## if uniform prior is specified then use lb and ub rather than p1 and p2
## ================================================================================== ##
## ADDITIONAL CV FOR SURVEYS/INDICES                                                  ##
```

```
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1   ##
##     and p2 are ignored). ival must be > 0                                         ##
## LEGEND                                                                            ##
##     prior: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma            ##
## ================================================================================= ##

## Mirror Block Env_L EnvL_Var  RW RW_blk Sigma_RW
       0     0     0        0   0      0      0.3  # NMFS
       0     0     0        0   0      0      0.3  # ADF&G


## ival                  lb     ub     prior     p1      p2      phz
   0.0000001      0.000000001   10.0     4        1.0     100     -4  # NMFS (PHASE -4)
   0.0000001      0.000000001   10.0     4        1.0     100     -4  # ADF&G

## ================================================================================= ##

## ================================================================================= ##
## PENALTIES FOR AVERAGE FISHING MORTALITY RATE FOR EACH GEAR
## ================================================================================= ##
## Mean_F   Female Offset STD_PHZ1   STD_PHZ2   PHZ_M   PHZ_F Fbar_l Fbar_h Fdev_L Fdev_h Foff_l Foff_h
   0.2              0.0     3.0      50.0        1       -1     -12     4     -10     10    -10     10  # Pot
   0.0001           0.0     4.0      50.0        1       -1     -12     4     -10     10    -10     10  # Trawl
   0.0001           0.0     4.0      50.0        1       -1     -12     4     -10     10    -10     10  # Fixed
   0.00             0.0     2.00     20.00      -1       -1     -12     4     -10     10    -10     10  # NMFS
   0.00             0.0     2.00     20.00      -1       -1     -12     4     -10     10    -10     10  # ADF&G
## ================================================================================= ##

## ================================================================================= ##
## OPTIONS FOR SIZE COMPOSTION DATA (COLUMN FOR EACH MATRIX)
## ================================================================================= ##
## LIKELIHOOD OPTIONS
##   -1) Multinomial with estimated/fixed sample size
##   -2) Robust approximation to multinomial
##   -3) logistic normal (NIY)
##   -4) multivariate-t (NIY)
##   -5) Dirichlet
## AUTOTAIL COMPRESSION
##   pmin is the cumulative proportion used in tail compression.
## ================================================================================= ##
#  1   1   1  # Type of likelihood
  2   2   2  # Type of likelihood
#  5   5   5   # Type of likelihood
  0   0   0   # Auto tail compression (pmin)
  1   2   3   # Composition splicer
  1   2   2   # Set to 1 for catch-based predictions; 2 for survey or total catch predictions
  1   1   1   # LAMBDA
  1   1   1   # Emphasis
## --------------------------------------------------------------------------------- ##

#      Initial    Lower_bound    Upper_bound  Prior_type        Prior_1        Prior_2  Phase
    1.00000000     0.10000000     5.00000000           0     0.00000000   999.00000000     -4
    1.00000000     0.10000000     5.00000000           0     0.00000000   999.00000000     -4
    1.00000000     0.10000000     5.00000000           0     0.00000000   999.00000000     -4


## ================================================================================= ##
## EMPHASIS FACTORS                                                                  ##
## ================================================================================= ##

0 # Emphasis on tagging data

 #Ret_POT Disc_POT Disc_trawl Disc_fixed
      1        1          1          1

## EMPHASIS FACTORS (Priors) by fleet: Fdev_total, Fdov_total, Fdev_year, Fdov_year
1 0 0.000 0 # Pot fishery
1 0 0.000 0 # Trawl bycatch
1 0 0.000 0 # fixed gear bycatch
1 0 0.000 0 # NMFS survey
1 0 0.000 0 # ADF&G survey
```

```
## ==================================================================================== ##
## EMPHASIS FACTORS (Priors)
## ==================================================================================== ##

## Emphasis Factors (Priors/Penalties: 13 values) ##
     10000.0000 #--Penalty on log_fdev (male+combined; female) to ensure they sum to zero
     0.0000 #--Penalty on mean F by fleet to regularize the solution
     0.0000 #--Not used
     0.0000 #--Not used
     0.0000 #--Not used
     0.0000 #--Smoothness penalty on the recruitment devs
     1.0000 #--Penalty on the difference of the mean_sex_ratio from 0.5
     0.0000 #--Smoothness penalty on molting probability
     0.0000 #--Smoothness penalty on selectivity patterns with class-specific coefficients
     0.0000 #--Smoothness penalty on initial numbers at length
     0.0000 #--Penalty on annual F-devs for males by fleet
     0.0000 #--Penalty on annual F-devs for females by fleet
     0.0000 #--Penalty on deviation parameters

## EOF
9999
```