Saint Matthew Island Blue King Crab

Proposed Models

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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 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 (EBS) 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. Only males with carapace length (CL) $\geq$ 90 mm are included in the assessment model. Beginning in 2024, the EBS bottom trawl survey ceased sampling the high density "corner" stations that were added to the St. Matthew Island survey area in 1983 and sampled through 2023 (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). 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). We developed a spatiotemporal model-based index that takes into account sampling changes in the EBS trawl survey time series (Appendix C), and compare results from stock assessment models that use this model-based index with those of models using the traditional design-based index.
4. **Stock biomass**: Biomass of the SMBKC stock has been monitored by the NOAA EBS trawl survey (1978-2025) and the ADF&G SMBKC pot survey (1995-2025). In 2025, estimated biomass of males

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

$\geq$ 90 mm CL from the NOAA EBS trawl survey was 1861 t (CV = 0.44), up from the 2024 estimated biomass of 1858 t (CV = 0.47), but below the time series mean biomass of 5134 t. The CPUE of males $\geq$ 90 mm CL from the 2025 ADF&G pot survey was 4.59 (CV = 0.10), up from the 2022 CPUE of 4.09 (CV = 0.14), but below the time series mean CPUE of 6.90. Both EBS trawl survey estimated biomass and ADF&G pot survey estimated CPUE remain low relative to historical estimates (Figure 2). Note that the 2024 and 2025 NOAA EBS trawl survey biomass estimates are not directly comparable to 1983-2023 biomass estimates because the 2024 and 2025 surveys did not sample corner stations, and thus some decrease in biomass is expected. The spatiotemporal model-based index developed for the NOAA EBS trawl survey time series accounts for changes in survey sampling over time (Appendix C). This standardized index estimates 2025 biomass as 1777 t (CV = 0.36), down from the 2024 estimate of 2584 t (CV = 0.41) but above the 2021 - 2023 estimated biomasses.

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. The 2025 EBS trawl survey area-swept estimate of 221,749 male SMBKC in this size class is ranked 43th, near the lower end of the 48 years of the survey, and down from 40th in 2024. Mean recruitment over the most recent five years (2021 - 2025) is 43% 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 2025 ranked 9th in the time series (36% of the mean for the 13 available years of pot survey data). The relative frequency of small males not included in the model appeared to be higher than in the 2022 pot survey (Figure 3).

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 26.1, the estimate for mature male biomass was above the minimum stock-size threshold (MSST) in 2024/25 and thus the stock is not in an "overfished" condition (Tables 1 and 2). The MSST is calculated as $B_{MSY}/2$. 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. The tables below show the status and catch specifications based on model 26.1 in both 1,000 t and million lb (Tables 1 and 2).

Table 1: Status and catch specifications (1,000 t) for model 26.1, the new base model.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2021/22	1.63	1.18	0.00	0.00	0.001	0.05	0.04
2022/23	1.50	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	1.47	1.53	0.00	0.00	0.001	0.129	0.097
2025/26	1.45	1.50	0.00			0.129	0.097

Table 2: Status and catch specifications (million pounds) for model 26.1, the new base model.

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
2021/22	3.59	2.59	0.00	0.00	0.002	0.112	0.08
2022/23	3.32	2.89	0.00	0.00	0.002	0.146	0.11
2023/24	3.27	3.10	0.00	0.00	0.011	0.146	0.11
2024/25	3.23	3.37	0.00	0.00	0.002	0.285	0.214
2025/26	3.20	3.30	0.00			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 - the most recent completed crab year) as the default reference period.

Table 3: Basis for the OFL (1,000 t) from model 26.1, the new base model.

Year	Tier	B_{MSY}	Biomass (MMB_{mating})	B/B_{MSY}	F_{OFL}	γ	Basis for B_{MSY}	Natural mortality
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	0.18
2024/25	4b	2.93	1.53	0.52	0.11	1	1978-2023	0.23
2025/26	4b	2.90	1.50	0.52	0.11	1	1978-2024	0.23

8. **Probability density function of the OFL:** The probability density function of the OFL will be presented for the models chosen to appear in the 2026 SAFE report.
9. **Basis for the ABC recommendation:** The authors recommended a 25% buffer to set the ABC in 2024. The CPT and SSC supported a 25% buffer to set the ABC in 2024 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; and 4) ADF&G pot and NMFS trawl survey data showed contradictory trends. An additional concern for the 2024 assessment was that the NMFS trawl survey corner stations were not surveyed in 2024, potentially adding bias to biomass estimates, but that bias was expected to lead to biomass underestimates rather than overestimates. The authors will provide a buffer recommendation in the 2026 SAFE report, which will be presented to the CPT in September 2026.
10. **Summary of rebuilding analyses:** The estimate for mature male biomass was above the minimum stock-size threshold (MSST) in 2024/25 and thus the stock was not in an “overfished” condition for the first time since the current rebuilding plan was approved. This improvement in stock status seems to be maintained for 2025/2026, with B/B_{MSY} again estimated as greater than 50% (Tables 1 - 4).

A. Summary of Major Changes

1. Changes in Management of the Fishery

There are no new changes in management of the fishery.

2. Changes to the Input Data

Data used in this assessment have been updated to include the most recently available fishery data and survey data. This assessment includes new biomass and size composition data from the 2025 EBS trawl survey, new relative abundance and size composition data from the 2025 ADF&G pot survey, and 2024/2025 season groundfish trawl and fixed gear fisheries bycatch estimates based on NMFS Alaska Regional Office (AKRO) data. Groundfish fisheries bycatch estimates for 2025/2026 will be included in the September 2026 version of this assessment, as will biomass and size composition data from the 2026 EBS trawl survey. The directed fishery has been closed since 2016/17, so no recent fishery data are available.

3. 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 between the original approach and that used here is that natural and fishing mortalities are continuous within five 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.

In this document, we present five models. Two of these models, 24.1 and 26.0, are presented only for bridging analysis purposes and are not recommended as candidates to appear in the 2026 SAFE report.

1. Model 24.1 was accepted for harvest specifications by the CPT and SSC in 2024 and is the reference model (Stern and Palof 2024). This model used GMACS version 2.20.14.
2. Model 26.0 is model 24.1 transitioned to a newer version of GMACS, 2.20.34a.
3. Model 26.1, the new base model, is model 26.0 updated with the newly available data: 2025 EBS trawl survey biomass and size composition data, 2025 ADF&G pot survey biomass and size composition data, and 2024/2025 groundfish fisheries bycatch data.
4. Model 26.2 is model 26.1 with a spatiotemporal model-based index used in place of the design-based EBS trawl survey biomass index.
5. Model 26.3 is model 26.2 with catchability (q) for the model-based index estimated in the model rather than fixed at 1.

B. SSC and CPT comments and author responses

Responses to SSC comments on the SMBKC September 2024 SAFE (October 2024)

A significant change occurred in the 2024 NMFS bottom trawl survey, where the "corner stations" around St. Matthew Island were not sampled. These stations, added in 1983, are areas of higher crab density and have played a key role in estimating crab abundances. The decision to not sample these stations was made to prioritize survey modernization fieldwork, and their inclusion in future surveys is uncertain. The assessment showed that removing these stations reduced biomass estimates (19%) but didn't alter size composition significantly. The biomass estimates are now computed based on a single stratum, instead of high and low-density strata with corner stations. This change has introduced a consistent downward bias, possibly due to the exclusion of the corner stations, or a previous upward bias when they were included. This discrepancy deserves further investigation, highlighting the potential benefits of model-based estimates that incorporate historical corner station data to address any biases. For this assessment, using the corner stations prior to 2024 is acceptable, but this issue should be addressed in the next full assessment. This may include developing an integrated pot and trawl index, as suggested in October 2022. The expectation is that the removal of the corner stations should increase uncertainty but not introduce consistent bias unless they regularly have higher crab density than the parent station to which they are a corner of.

In this document, we present model runs using a spatiotemporal model-based biomass index that incorporates historical corner station data; the development of this index is detailed in Appendix C. Developing an integrated pot and trawl survey index using the spatiotemporal modeling approach applied here presents difficulties because an estimate of area swept would be required for pot survey observations, and it is unclear to the authors how to calculate area swept for crab pots. However, the authors plan to pursue alternative approaches for developing an integrated pot and trawl survey index.

The SSC recommends that the producers of the crab trawl survey estimates should explore showing both high and low-density strata estimates without the corner stations, alongside the one-stratum estimate seen in this assessment, to better understand potential biases.

The authors interpret this comment as applying to the NOAA staff who produce the EBS trawl survey biomass estimates, but seek clarification from the SSC about whether this recommendation is meant as a task for the authors.

In Table 8, it was noted that the SDNRs (Standardized Deviance Residuals) and MARs (Mean Absolute Residuals) for the surveys are all listed as zero, which is likely not the case. The SSC recommends the authors re-evaluate these diagnostics if they are included in future assessments.

These diagnostics are not included in this proposed model runs document.

Responses to CPT comments on the SMBKC September 2024 SAFE (September 2024)

Caitlin noted that work on standardizing the survey index to better account for the elimination of the corner stations from future surveys is underway, using both sdmTMB and VAST methods for comparison. The CPT confirmed that model-based approaches such as VAST would be appropriate for this and suggested that sdmTMB might be considered as an "easier" alternative to VAST.

The authors used sdmTMB to produce the model-based index presented in this document (Appendix C).

It was noted that elimination of the NMFS trawl survey corner station sampling increases the importance of future ADF&G pot surveys. The CPT discussed the selectivity of the pot survey vs. the trawl survey. It was noted that relating the two gears is difficult, but that the pot survey covers the spatial footprint of the population more accurately. Additionally, it is believed that the ADF&G pot surveys better sample SMBKC due to limitations of the NMFS trawl survey gear in some habitats, such as rocky bottom and nearshore areas.

The CPT discussed timing of the ADF&G pot surveys relative to the assessment, noting that the ADF&G pot survey did a better job of capturing the recent population decline, and that future ADF&G pots surveys will help to better understand the stock status. While annual pot surveys are ideal, a 3-year cycle is likely effective in capturing broad population trends. The next ADF&G pot survey will tentatively be conducted in August-September 2025.

Data from the 2025 ADF&G pot survey are included in this assessment.

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

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).

The authors presented model 24.1, with $M = 0.23$, in September 2024. That model was accepted for harvest specifications in December 2024.

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.

The authors presented 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, in September 2024.

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

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 present model runs using a spatiotemporal model-based index for the EBS trawl survey time series in this document. Documentation including maps of survey observations and diagnostics including spatial residuals are presented in the document detailing the development of the model-based index (Appendix C).

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

The authors plan to present the results of these explorations in a future assessment document.

Examine the likelihood profile on selectivity.

The authors plan to present a likelihood profile on selectivity in a future assessment document.

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

The authors made this correction.

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 4). 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 5), 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.

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 5).

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

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

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 6), 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 7).

D. Data

Summary of New Information

Data used in this assessment were updated to include the most recently available fishery and survey estimates. New data include 2025 EBS trawl survey biomass and size composition data as well as 2025 ADF&G pot survey abundance and size composition data. The assessment uses updated 1993-2024 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 sets used in the models are shown in Figure 1. Further data updates expected for the 2026 SAFE report include bycatch estimates from the 2025 crab year as well as 2026 EBS trawl survey biomass and size composition data.

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 5); results from the annual NMFS eastern Bering Sea trawl survey (1978-2025); results from the ADF&G SMBKC pot survey (every third year during 1995-2013, every year during 2015-2018; every third year during 2022-2025); 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 6); and the NMFS groundfish-observer bycatch biomass estimates (1991/92-2023/24; Table 7) (Figure 1).

Figure 6 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 (see Appendix C). As discussed above, the 2024 and 2025 NMFS trawl surveys excluded corner stations. 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). St. Matthew Island blue king crab groundfish fisheries bycatch data are provided by 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 was 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 ≥ 120 mm CL and newshell ≥ 134 mm CL. Motivation for these stage definitions came from the fact that, for management of the SMBKC stock, male crab measuring ≥ 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 ≥ 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 uses the modeling framework GMACS; model details are presented in Appendix A. An updated version of GMACS (version 2.20.34a) was used for models 26.0, 26.1, 26.2, and 26.3.

Model Selection and Evaluation

In this document, we present five models. Two of these models are presented only for bridging analysis purposes and are not recommended as candidates to appear in the 2026 SAFE report because they either use an older version of GMACS (model 24.1) or do not include the most updated data (model 26.0). The models presented are as follows:

1. Model 24.1 was accepted for harvest specifications by the CPT and SSC in 2024 and is the reference model (Stern and Palof 2024). This model used GMACS version 2.20.14.
2. Model 26.0 is model 24.1 transitioned to a newer version of GMACS, 2.20.34a. This model is presented to verify that transitioning to a newer version of GMACS does not substantially alter model results.
3. Model 26.1, the new base model, is model 26.0 updated with the newly available data: 2025 EBS trawl survey biomass and size composition data, 2025 ADF&G pot survey biomass and size composition data, and 2024/2025 groundfish fisheries bycatch data. As in the reference model, catchability (q) for the EBS trawl survey biomass index is fixed at 1.
4. Model 26.2 is model 26.1 with a spatiotemporal model-based index used in place of the design-based EBS trawl survey biomass index. Catchability for the model-based index is fixed at 1.
5. Model 26.3 is model 26.2 with catchability for the model-based index estimated in the model rather than fixed at 1.

Results

Fits to fishery catch data

Fits to fishery retained catch data were nearly identical among the five models, while fits to fishery discarded catch data were worse for the models fitting to a model-based EBS trawl survey index (Figure 7 and Table 8). Fits to bycatch in the groundfish trawl and fixed gear fisheries are better for the three models with updated data (26.1, 26.2, 26.3) than for the models without updated data (24.1 and 26.0; Table 8).

Fits to abundance indices

Fit to the EBS trawl survey design-based biomass index was improved by the addition of 2025 survey data, with model 26.1 fitting the index better than models 24.1 and 26.0 (Figure 8, Table 8). Between the models fitting to the model-based index for the EBS trawl survey, the model with estimated catchability for the model-based index (model 26.3) fit the index better than the model with fixed catchability (model 26.2) (Figure 9, Table 8). The model-estimated catchability for the NOAA EBS trawl survey in model 26.3 was 0.97 (SE = 0.12), compared to the fixed value of 1 for models 26.1 and 26.2. Model-estimated catchability for the ADF&G pot survey was similar across model scenarios: 0.0037 (SE = 0.0002) for model 26.1, 0.0032 (SE = 0.0002) for model 26.2, and 0.0032 (SE = 0.0004) for model 26.3.

Fit to the ADF&G pot survey relative abundance index was also improved by the addition of 2025 survey data, with model 26.1 again fitting the index better than models 24.1 and 26.0 (Figure 10, Table 8). Both of the models fitting to the model-based index for the EBS trawl survey fit the ADF&G pot survey index worse than model 26.1; the model with fixed catchability for the model-based index (model 26.2) fit the index better than the model with estimated catchability (model 26.3) (Figure 11, Table 8).

Fits to size compositions

Fits to size composition data from the directed fishery catch were similar across the model scenarios (Figures 12 - 17, Table 8). Fit to size composition data from the EBS trawl survey was improved by the addition of 2025 survey data, with model 26.1 fitting the index better than models 24.1 and 26.0, but worsened by the use of a model-based biomass index for the EBS trawl survey, with models 26.2 and 26.3 fitting the data more poorly than the new base model as well as the models without 2025 data added (Figures 13 and 16). Fit to size composition data from the ADF&G pot survey again was best for model 26.1, but was better for models 26.2 and 26.3 than for models 24.1 and 26.0 (Figures 14 and 17). One-Step-Ahead (OSA) residuals for model fits to size composition time series are shown in Figures 18 - 26.

Estimated population quantities

Recruitment

Estimated recruitment trajectories were nearly identical among the models in the bridging analysis, with the exception of the 2023 estimate (the terminal year for models 24.1 and 26.0), in which estimated recruitment was higher for models 24.1 and 26.0 than for model 26.1 (Figure 27). Estimated recruitment trajectories were similar between model 26.1 and the models using a model-based biomass index for the EBS trawl survey, except for a spike in recruitment in the 1980's estimated by model 26.3 but not by the other models (Figure 28). In all model scenarios, estimated recruitment in recent years remains low compared to estimates earlier in the time series.

Mature male biomass

Estimated mature male biomass (MMB) trajectories were nearly identical among the models in the bridging analysis through the years with data overlap (Figure 29). Estimated MMB trajectories differed between the new base model (26.1) and the models using a model-based biomass index for the EBS trawl survey: model 26.2, with catchability for the model-based biomass index fixed at 1, and model 26.3, with catchability for the model-based index estimated, both estimated higher MMB than the base model throughout most of the time series (Figure 30).

Estimated fishery selectivity

In all model scenarios, selectivity for the directed fishery is estimated for the two smaller size classes and fixed at 1 for the largest size class. The size classes are determined by CL measurements of (1) 90-104 mm, (2) 105-119 mm, and (3) 120+ mm. Differences in selectivity estimates among models for size class 1 are small, and even smaller for size class 2 (Figure 31).

Estimated survey selectivity

For both surveys in all model scenarios, survey selectivity is estimated for the two smaller size classes and fixed at 1 for the largest size class. For the ADF&G pot survey, estimated selectivity in size class 1 is similar across the model scenarios, but larger differences are apparent at size class 2: the new base model (26.1) estimates the lowest selectivity, while the model using a model-based index for the EBS trawl survey with fixed catchability (26.2) estimates higher selectivity, and the model using a model-based index with estimated catchability (26.3) estimates the highest selectivity (Figure 31). For the EBS trawl survey, estimated selectivity for size class 2 is greater than 1 for all model scenarios (Figure 31). This is despite the upper bound of 1 placed on this parameter in the model control file (Appendix B). Estimated selectivity for size class 2 is 1.08 for models 24.1, 26.0, and 26.1; 1.11 for model 26.2; and 1.10 for model 26.3.

Estimated fishing mortality

Estimated fishing mortalities from the directed pot fishery, bycatch in the groundfish fixed gear fisheries, and bycatch in the groundfish trawl fisheries are similar across model scenarios (Figure 32). The models using a model-based biomass index for the EBS trawl survey estimate lower fishing mortality rates in some years, but these differences are relatively small in the more recent years of the time series.

Estimated natural mortality

For all model scenarios, natural mortality is fixed at 0.23 for all years except 1998/1999, in which an estimated natural mortality pulse occurs (i.e., M_{1998}). This estimated M_{1998} is nearly identical across model scenarios, though lower for model 26.3 than for models 26.1 and 26.2 (Figure 33).

Retrospective analyses

In the previous iteration of this assessment, a positive retrospective bias appeared beginning with the 2016 peel (Stern and Palof 2024). The authors noted that the relative stability of MMB estimates for the 2022 - 2017 peels could be a result of the stability in EBS 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 EBS trawl survey biomass index and ADF&G relative abundance index beginning in 2017 (Figure 2).

Similarly, retrospective analyses for models 26.0 and 26.1 find a positive retrospective pattern beginning with the 2016 peel, though this pattern is less extreme for model 26.1 than for 26.0 (Figures 34 - 35). A slightly negative retrospective pattern is apparent for model 26.2, and a positive pattern for model 26.3 (Figures 36 - 37). The absolute value of the Mohn's ρ estimate for model 26.2 is less than half that for model 26.1, suggesting reduced model misspecification for model 26.2 compared to 26.1. However, the Mohn's ρ estimate for model 26.3 is larger than that for model 26.1.

Uncertainty and sensitivity analyses

Uncertainty for parameters and derived quantities was estimated using the covariance matrix obtained by inverting the model Hessian matrix at the MLE. Estimated standard errors of parameters for models 26.0 - 26.3 are summarized in Tables 9 - 12.

Comparison of alternative model scenarios

The authors recommend bringing forward models 26.1 and 26.2 for harvest specifications in the autumn. Model 26.1 is the previously accepted model transitioned to a newer GMACS version and updated with the most recently available data. This model showed better fits to both survey indices and size composition data from both surveys than the previously accepted model, indicating that the addition of data has improved the model fit. Models 26.2 and 26.3 both use a spatiotemporal model-based index in place of the design-based EBS trawl survey biomass index, addressing previous SSC and CPT requests to develop a model-based index for this assessment that takes into account changes in the survey design. Model 26.2 fixes catchability for the model-based index at 1, while model 26.3 estimates catchability for the model-based index. Both models 26.2 and 26.3 show poorer fits to the ADF&G pot survey index than does model 26.1, but they merit further consideration because using the model-based index addresses the bias introduced into the EBS trawl survey time series by the changes in survey station sampling that occurred in 2024 and 2025. Model 26.2 shows an improvement in the retrospective pattern compared to model 26.1, indicating a possible reduction in model misspecification. Model 26.3 shows a more extreme retrospective pattern than model 26.1 as well as a spike in estimated recruitment in the 1980's not estimated by the other models. The authors thus recommend model 26.2 over model 26.3.

Stock projections

Projections for this stock will be shown in the 2026 SAFE document.

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, 1978 to the most recent completed crab year, 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 2025/26 for all the models are summarized in Table 4. The currently recommended ABC is 75% of the OFL (ABC buffer = 25%).

Table 4: Comparisons of management measures for models 26.1, 26.2, and 26.3. Biomass and OFL are in tons. Model 26.1 is the new base model, with updated data and a newer GMACS version. Model 26.2 is model 26.1 with a model-based index for the Eastern Bering Sea (EBS) trawl survey biomass time series replacing the design-based index. Model 26.3 is model 26.2 with catchability for the EBS trawl survey estimated rather than fixed at 1.

Model	MMB_{2025}	B_{MSY}	MMB/B_{MSY}	F_{OFL}	OFL_{2025}	ABC_{2025}	MSST	M
26.1	1496	2901	0.52	0	146	102	1451	0.23
26.2	1597	2996	0.53	0	164	115	1498	0.23
26.3	1615	3072	0.53	0	163	114	1536	0.23

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 2024/2025 for model 26.1, and this is the first year since the rebuilding plan was approved that the stock has reached this threshold (Table 3). Models 26.1, 26.2, and 26.3 all project $B/B_{MSY} > 50\%$ for 2025/2026 (Table 4). 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). 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. EBS trawl survey estimated biomass of males in the model has been low in 2021-2025 and ADF&G pot survey estimated CPUE, while increasing, is still low relative to historical estimates (Figure 2). Model estimates of recruitment suggest limited potential for future stock growth under current conditions (Figures 27 - 28). Projections of the stock 10 years into the future under different recruitment expectations will be included in the 2026 SAFE.

H. Data Gaps and Research Priorities

The following topics have been identified 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

This section will appear in the 2026 SAFE.

J. Acknowledgements

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Tables

Table 5: 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 - 2025/26				FISHERY CLOSED				

Table 6: Observed proportion of crab by size class during the ADF&G crab observer pot lift sampling. Size classes are (1) 90-104 mm, (2) 105-119 mm, and (3) 120+ mm. 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 - 2025/26			FISHERY CLOSED			

Table 7: Groundfish SMBKC male bycatch biomass (t) estimates. Trawl includes pelagic trawl and non-pelagic trawl types. Source: 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
2024	0.001	0.720

Table 8: Comparisons of negative log-likelihood values for the selected model scenarios. Catch fleet values refer to the directed fishery retained catch (1), directed fishery discarded catch (2), groundfish trawl fisheries discarded catch (3), and groundfish fixed gear fisheries discarded catch (4). Index fleet values refer to the NOAA EBS trawl survey (1) and the ADFG pot survey (2). Size composition fleet values refer to the pot fishery (1), NOAA EBS trawl survey (2), and ADFG pot survey (3). Model 24.1 is the 2024 accepted model. Model 26.0 is 24.1 transitioned to a newer GMACS version. Model 26.1 is 26.0 with updated data. Model 26.2 is 26.1 with a model-based biomass index used in place of the design-based EBS trawl survey biomass index. Model 26.3 is 26.2 with catchability estimated rather than fixed for the model-based index.

Component	Model 24.1	Model 26.0	Model 26.1	Model 26.2	Model 26.3
1. Catch: fishery retained	-68.99	-68.99	-68.98	-68.46	-68.47
2. Catch: fishery discarded	4.50	4.50	4.41	6.37	6.19
3. Catch: trawl bycatch	-9.09	-9.09	-9.36	-9.36	-9.36
4. Catch: fixed gear bycatch	-9.08	-9.08	-9.35	-9.35	-9.35
1. Index: EBS trawl survey	1.06	1.06	0.31	1.46	0.71
2. Index: ADFG pot survey	75.67	75.67	74.93	79.57	80.45
1. Size comp: pot fishery	-105.06	-105.06	-105.12	-105.50	-105.09
2. Size comp: EBS trawl survey	-277.15	-277.15	-283.43	-274.76	-274.45
3. Size comp: ADFG pot survey	-99.95	-99.95	-109.15	-105.17	-105.30
rec_pen_1	64.09	64.09	67.01	66.52	66.57
rec_pen_2	0.00	0.00	0.00	0.00	0.00
rec_pen_3	0.00	0.00	0.00	0.00	0.00
tagging_1	0.00	0.00	0.00	0.00	0.00
n_pars	159.00	159.00	162.00	162.00	163.00
total	-410.27	-410.27	-425.01	-404.97	-404.76

Table 9: Summary of St. Matthew Island blue king crab estimated model parameter values and standard errors (SE) for model 26.0.

Parameter	Estimate	SE
Log(Rbar):	14.1039	0.1883
Initial_logN_for_sex_male_mature_mature_newshell_class_1:	15.1108	0.1776
Initial_logN_for_sex_male_mature_mature_newshell_class_2:	14.5679	0.2172
Initial_logN_for_sex_male_mature_mature_newshell_class_3:	14.3641	0.2268
M_male_mature_block_group_3_block_1:	0.8395	0.1327
Sel_Pot_Fishery_male_base_class_1:	-1.0956	0.1806
Sel_Pot_Fishery_male_base_class_2:	-0.6684	0.1314
Sel_Pot_Fishery_male_class_1_block_group_2_block_1:	-0.7678	0.1707
Sel_Pot_Fishery_male_class_2_block_group_2_block_1:	-0.0000	0.0000
Sel_NMFS_Trawl_male_base_class_1:	-0.4565	0.0724
Sel_NMFS_Trawl_male_base_class_2:	-0.0309	0.0590
Sel_ADFG_Pot_male_base_class_1:	-0.9360	0.1236
Sel_ADFG_Pot_male_base_class_2:	-0.0545	0.0738
Log_fbar_Pot_Fishery:	-2.1268	0.0544
Log_fbar_Trawl_Bycatch:	-10.0849	0.0718
Log_fbar_Fixed_bycatch:	-8.1328	0.0718
Survey_q_survey_2:	0.0036	0.0002

Table 10: Summary of St. Matthew Island blue king crab estimated model parameter values and standard errors (SE) for model 26.1, the new base model.

Parameter	Estimate	SE
Log(Rbar):	14.0722	0.1855
Initial_logN_for_sex_male_mature_mature_newshell_class_1:	15.1117	0.1776
Initial_logN_for_sex_male_mature_mature_newshell_class_2:	14.5719	0.2170
Initial_logN_for_sex_male_mature_mature_newshell_class_3:	14.3688	0.2262
M_male_mature_block_group_3_block_1:	0.8450	0.1325
Sel_Pot_Fishery_male_base_class_1:	-1.0994	0.1802
Sel_Pot_Fishery_male_base_class_2:	-0.6739	0.1314
Sel_Pot_Fishery_male_class_1_block_group_2_block_1:	-0.7779	0.1706
Sel_Pot_Fishery_male_class_2_block_group_2_block_1:	-0.0000	0.0000
Sel_NMFS_Trawl_male_base_class_1:	-0.4511	0.0712
Sel_NMFS_Trawl_male_base_class_2:	-0.0294	0.0580
Sel_ADFG_Pot_male_base_class_1:	-0.9720	0.1205
Sel_ADFG_Pot_male_base_class_2:	-0.0870	0.0707
Log_fbar_Pot_Fishery:	-2.1249	0.0542
Log_fbar_Trawl_Bycatch:	-10.2150	0.0710
Log_fbar_Fixed_bycatch:	-8.1267	0.0710
Survey_q_survey_2:	0.0037	0.0002

Table 11: Summary of St. Matthew Island blue king crab estimated model parameter values and standard errors (SE) for model 26.2, which uses a model-based biomass index in place of the design-based EBS trawl survey biomass index.

Parameter	Estimate	SE
Log(Rbar):	14.1210	0.1842
Initial_logN_for_sex_male_mature_mature_newshell_class_1:	15.0650	0.1725
Initial_logN_for_sex_male_mature_mature_newshell_class_2:	14.4997	0.2117
Initial_logN_for_sex_male_mature_mature_newshell_class_3:	14.3320	0.2057
M_male_mature_block_group_3_block_1:	0.8166	0.1244
Sel_Pot_Fishery_male_base_class_1:	-1.0971	0.1798
Sel_Pot_Fishery_male_base_class_2:	-0.6883	0.1296
Sel_Pot_Fishery_male_class_1_block_group_2_block_1:	-0.6694	0.1666
Sel_Pot_Fishery_male_class_2_block_group_2_block_1:	-0.0000	0.0000
Sel_NMFS_Trawl_male_base_class_1:	-0.4516	0.0663
Sel_NMFS_Trawl_male_base_class_2:	-0.0000	0.0001
Sel_ADFG_Pot_male_base_class_1:	-0.8987	0.1241
Sel_ADFG_Pot_male_base_class_2:	-0.0194	0.0716
Log_fbar_Pot_Fishery:	-2.1591	0.0481
Log_fbar_Trawl_Bycatch:	-10.3323	0.0648
Log_fbar_Fixed_bycatch:	-8.2443	0.0648
Survey_q_survey_2:	0.0032	0.0002

Table 12: Summary of St. Matthew Island blue king crab estimated model parameter values and standard errors (SE) for model 26.3, which uses a model-based biomass index in place of the design-based EBS trawl survey biomass index and estimates catchability for the model-based index.

Parameter	Estimate	SE
Log(Rbar):	14.1276	0.1981
Initial_logN_for_sex_male_mature_mature_newshell_class_1:	15.0670	0.1859
Initial_logN_for_sex_male_mature_mature_newshell_class_2:	14.5619	0.2232
Initial_logN_for_sex_male_mature_mature_newshell_class_3:	14.3702	0.2579
M_male_mature_block_group_3_block_1:	0.7997	0.1256
Sel_Pot_Fishery_male_base_class_1:	-1.0724	0.1967
Sel_Pot_Fishery_male_base_class_2:	-0.6375	0.1542
Sel_Pot_Fishery_male_class_1_block_group_2_block_1:	-0.6594	0.1737
Sel_Pot_Fishery_male_class_2_block_group_2_block_1:	-0.0000	0.0000
Sel_NMFS_Trawl_male_base_class_1:	-0.3820	0.0972
Sel_NMFS_Trawl_male_base_class_2:	-0.0055	0.0848
Sel_ADFG_Pot_male_base_class_1:	-0.8980	0.1264
Sel_ADFG_Pot_male_base_class_2:	-0.0057	0.0819
Log_fbar_Pot_Fishery:	-2.1821	0.1449
Log_fbar_Trawl_Bycatch:	-10.3530	0.1248
Log_fbar_Fixed_bycatch:	-8.2650	0.1250
Survey_q_survey_1:	0.9728	0.1245
Survey_q_survey_2:	0.0032	0.0004

Table 13: Population abundances (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 26.1.

Year	n_1	n_2	n_3	MMB	CV MMB
1978	3655258	2130566	1738942	4249	0.181
1979	5034103	2587261	2347309	5954	0.131
1980	4580083	3528011	3517558	9348	0.093
1981	1666694	3582365	4874936	9728	0.071
1982	1803959	1985933	4859366	6758	0.081
1983	926778	1534567	3363754	3902	0.114
1984	736714	913194	1852679	2498	0.140
1985	1093774	651617	1265464	2122	0.161
1986	1542212	770000	1043673	2128	0.156
1987	1646981	1056117	1147577	2573	0.148
1988	1562379	1201128	1367970	2929	0.145
1989	3496483	1199920	1559751	3444	0.135
1990	2210106	2237491	1915977	4652	0.100
1991	2275045	1863031	2448245	4695	0.097
1992	2511711	1763589	2408239	4805	0.088
1993	2837601	1872749	2512870	5077	0.080
1994	1878087	2073641	2598489	4914	0.072
1995	2171622	1614413	2503393	4738	0.073
1996	2134012	1640007	2384375	4507	0.073
1997	1112044	1625913	2301018	3964	0.088
1998	811731	1063101	1891064	2029	0.101
1999	510789	401233	794056	1730	0.112
2000	518312	402080	869415	1857	0.086
2001	496656	406491	930540	1964	0.076
2002	170439	396159	979181	2035	0.071
2003	380903	216734	983206	1860	0.074
2004	304734	273853	919264	1811	0.074
2005	684651	250803	889307	1738	0.075
2006	885131	448702	888898	1935	0.081
2007	599833	618793	1000934	2269	0.078
2008	1117406	512647	1132897	2407	0.061
2009	885379	764290	1246397	2604	0.056
2010	777510	709228	1336502	2227	0.057
2011	563203	618854	1183513	1646	0.069
2012	304571	464180	861959	1085	0.103
2013	292477	281727	564236	1226	0.091
2014	264497	246655	609923	1116	0.096
2015	218311	216679	562318	1073	0.096
2016	214297	184893	547618	1100	0.092
2017	167375	173851	542843	1080	0.089
2018	191626	144818	528653	1028	0.088
2019	323408	149025	506240	996	0.088
2020	266630	221535	502896	1063	0.097
2021	437714	213736	529949	1101	0.099
2022	532466	303725	563331	1247	0.096
2023	596164	383045	641308	1457	0.096
2024	286700	442615	747415	1695	0.097
2025	290208	294186	832089	1687	0.096

Figures

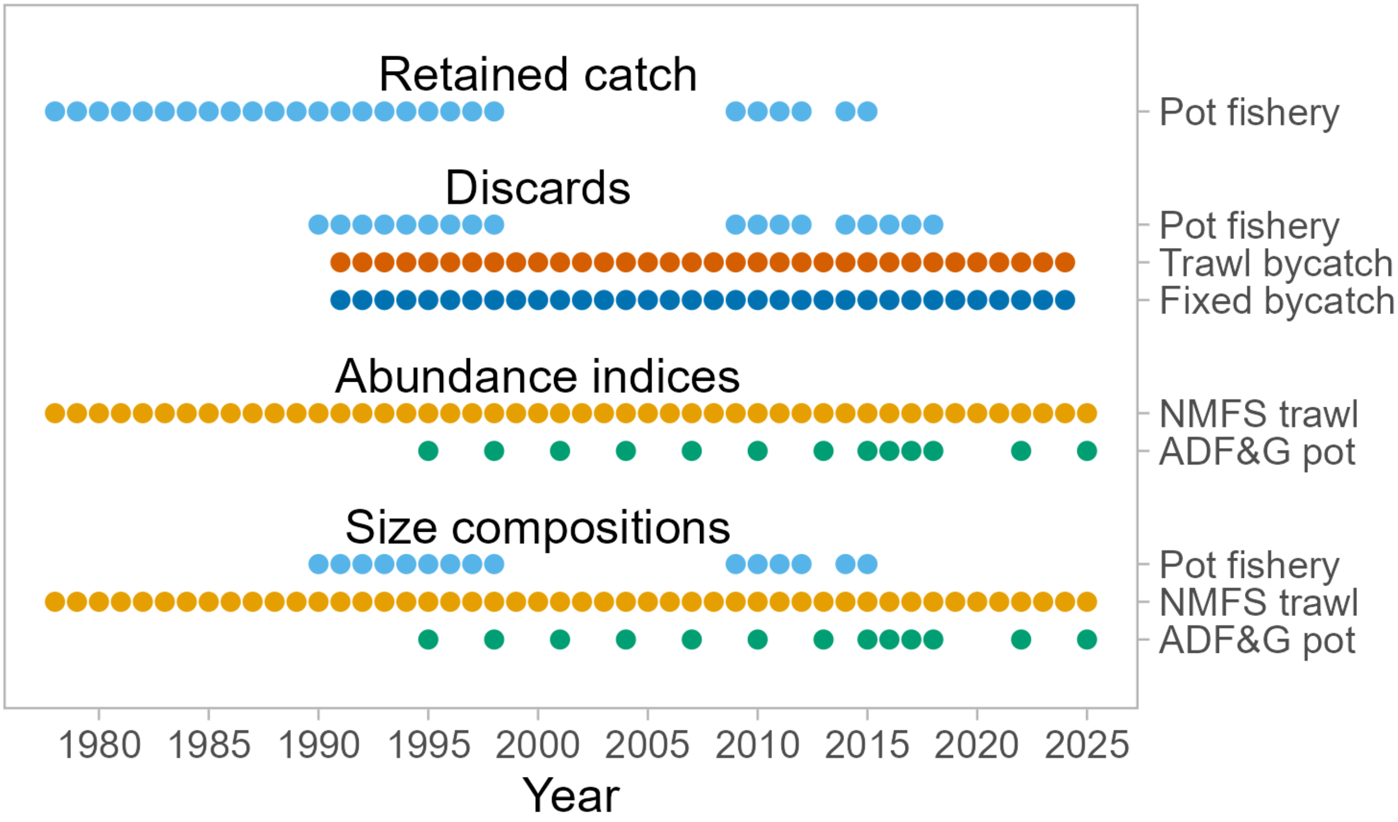

Figure 1: Data extent for the SMBKC assessment.

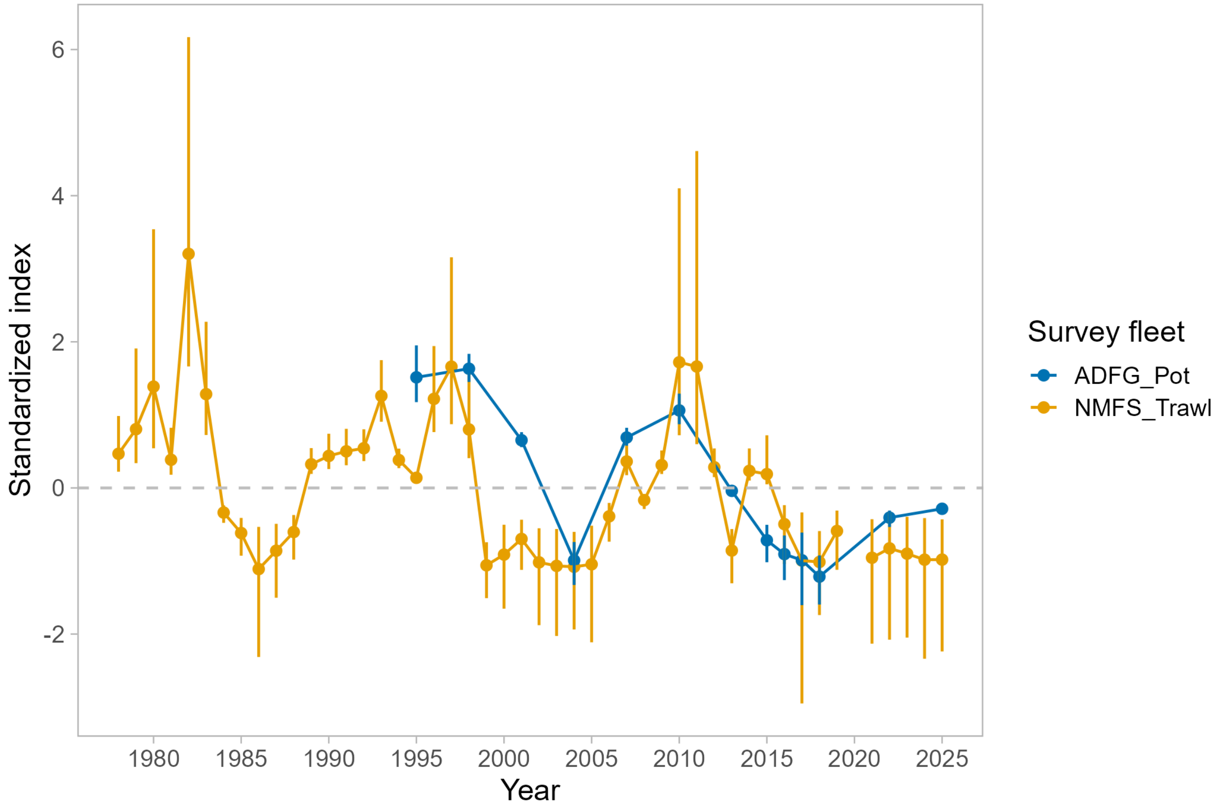

Figure 2: Standardized biomass index from the NMFS trawl survey compared to standardized abundance index from the ADFG pot survey. Indices are z-score standardized to allow for visual comparison. Dashed horizontal line represents the mean.

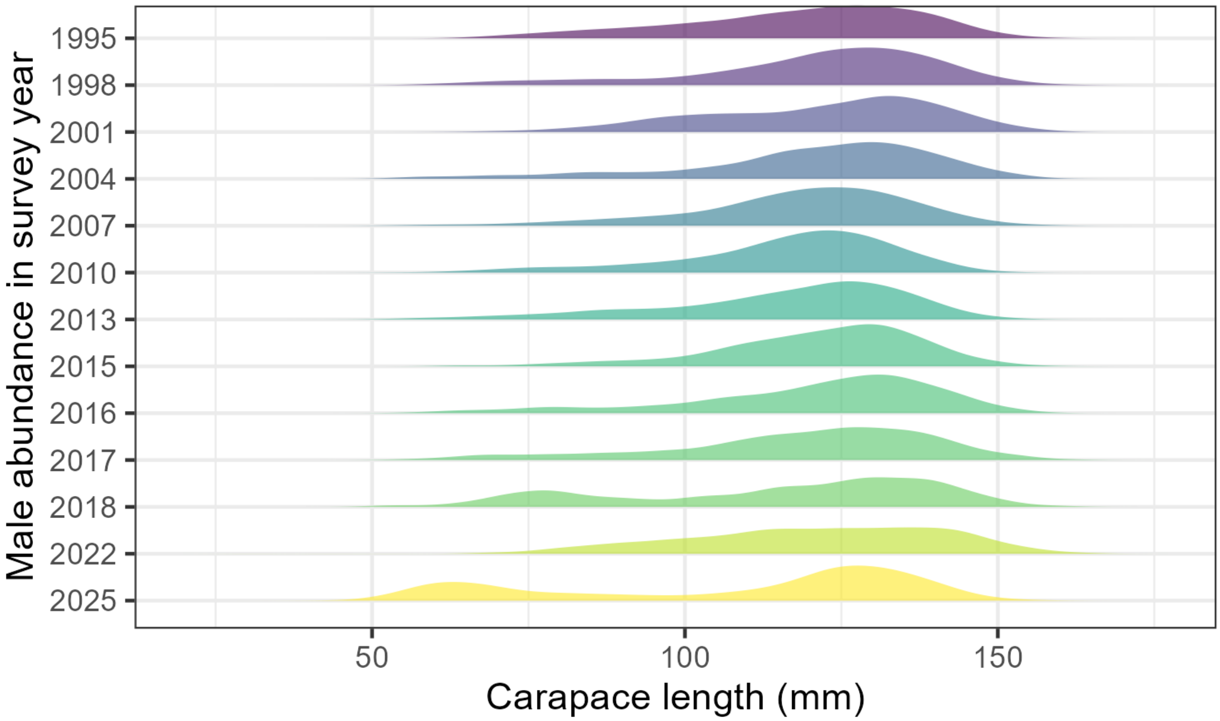

Figure 3: ADFG pot survey abundances by carapace length for male St. Matthew Island blue king crab from 1995 to 2025.

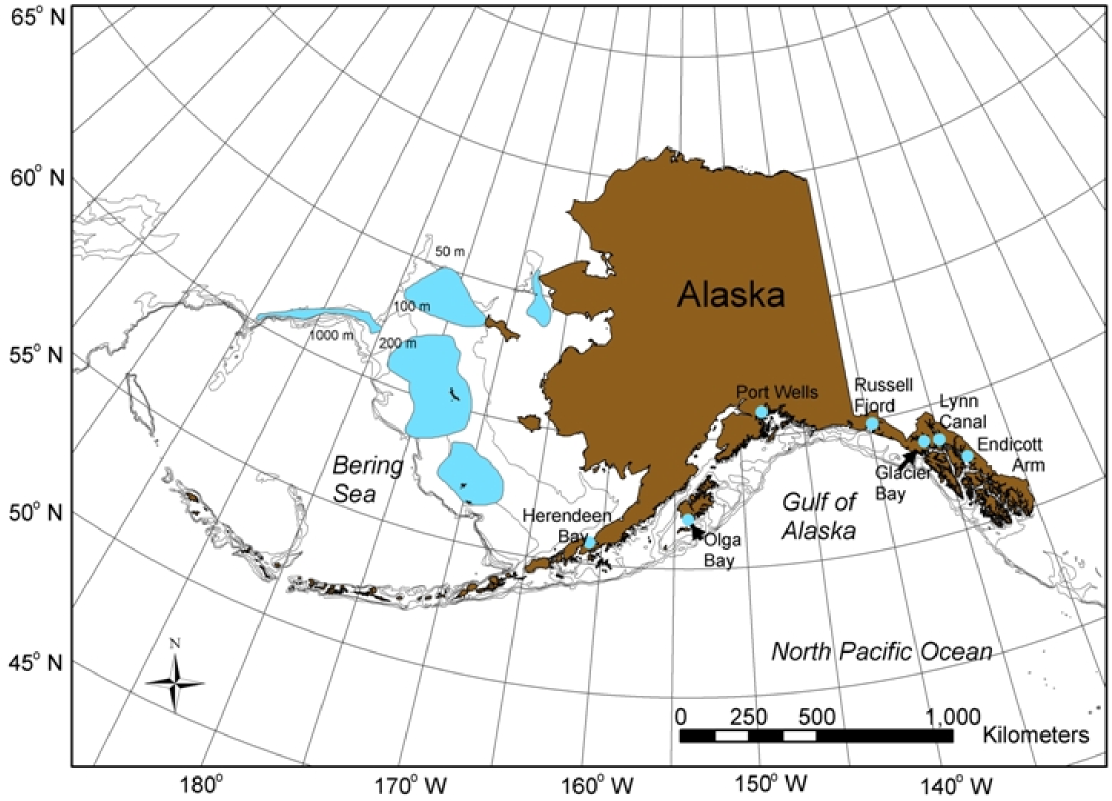

Figure 4: Distribution of blue king crab (*Paralithodes platypus*) in the Gulf of Alaska, Bering Sea, and Aleutian Islands waters (shown in blue).

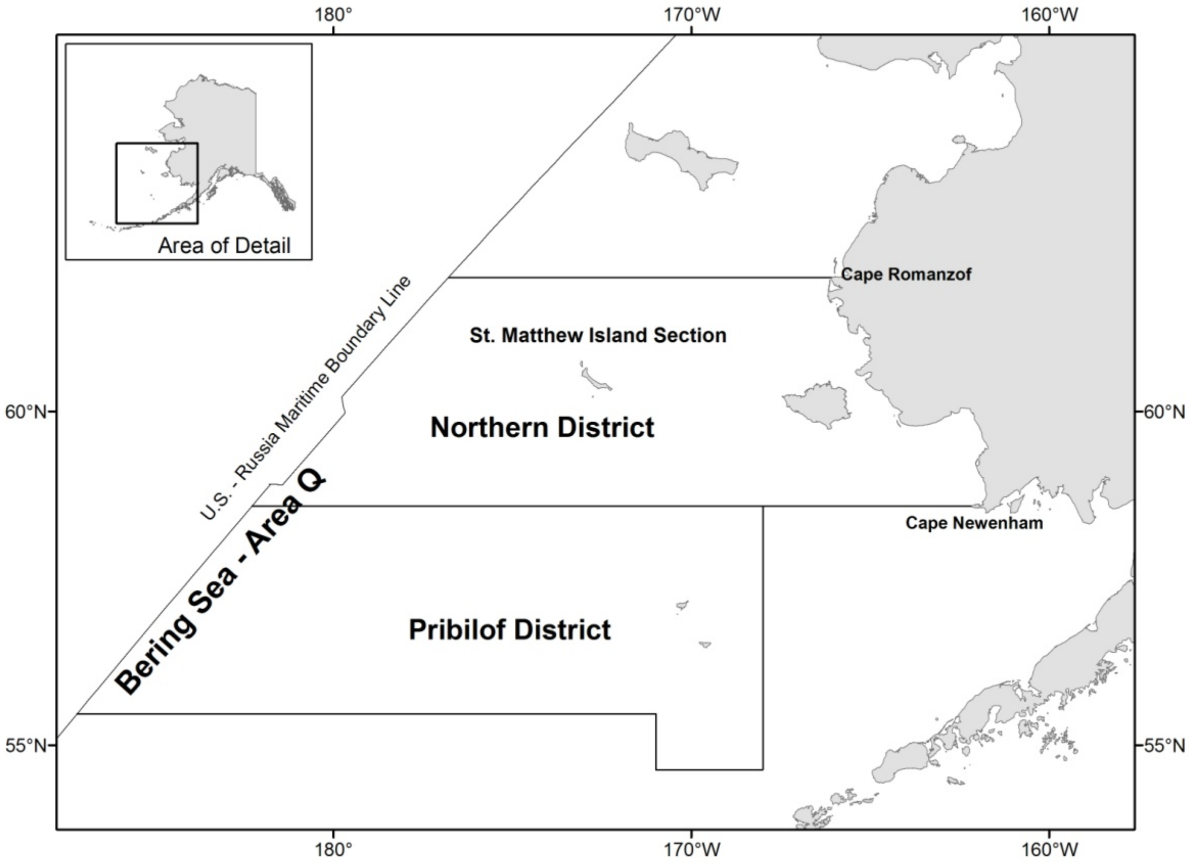

Figure 5: Blue king crab Registration Area Q (Bering Sea)

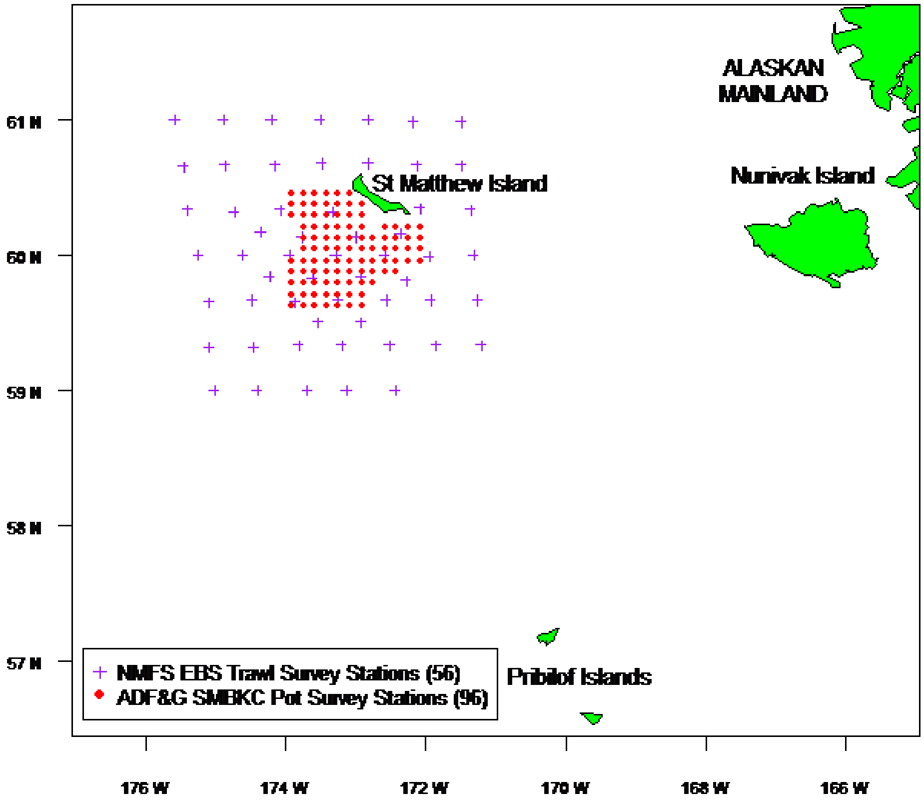

Figure 6: Trawl and pot-survey stations used in the SMBKC stock assessment.

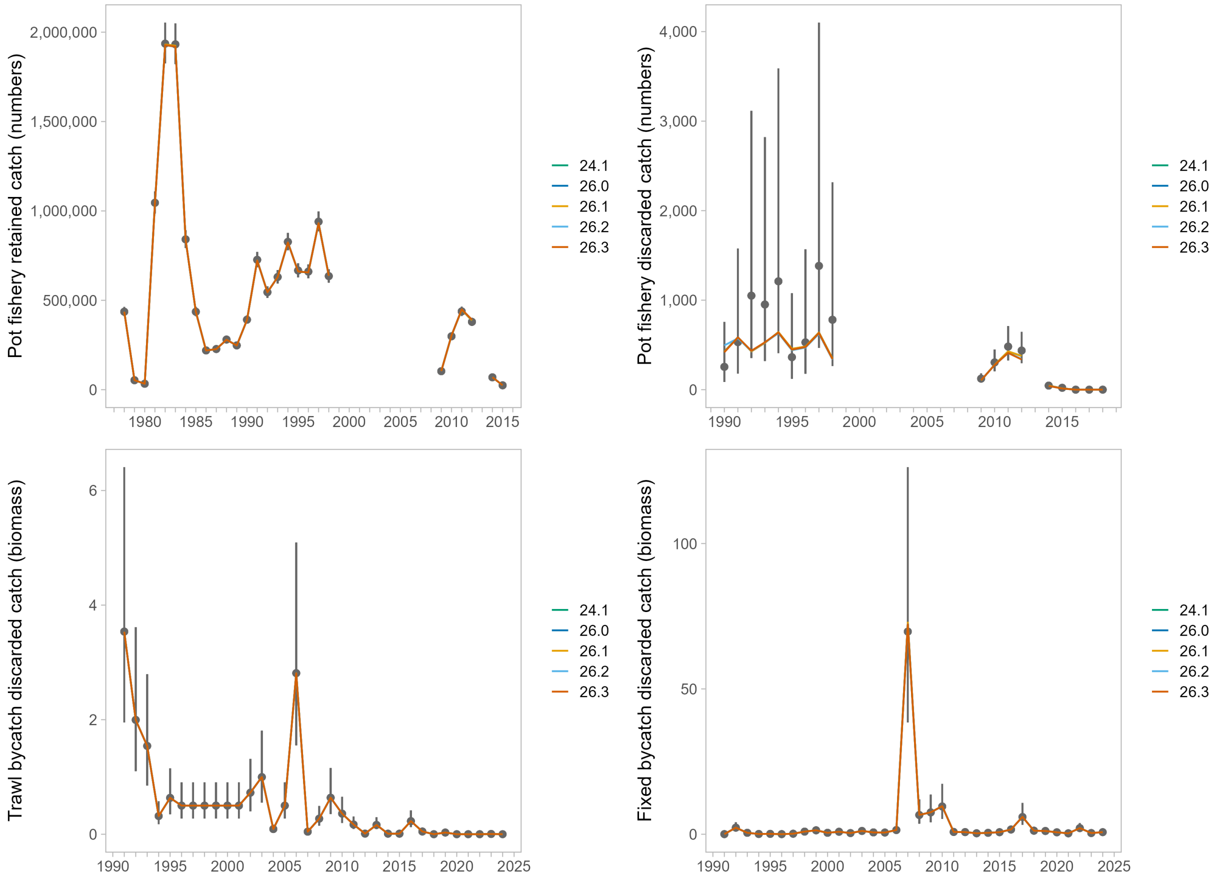

Figure 7: Comparison of observed and model-estimated retained catch and bycatches in each of the model scenarios. Note the difference in units among the panels: some panels are expressed in numbers of crab, some in biomass (tons).

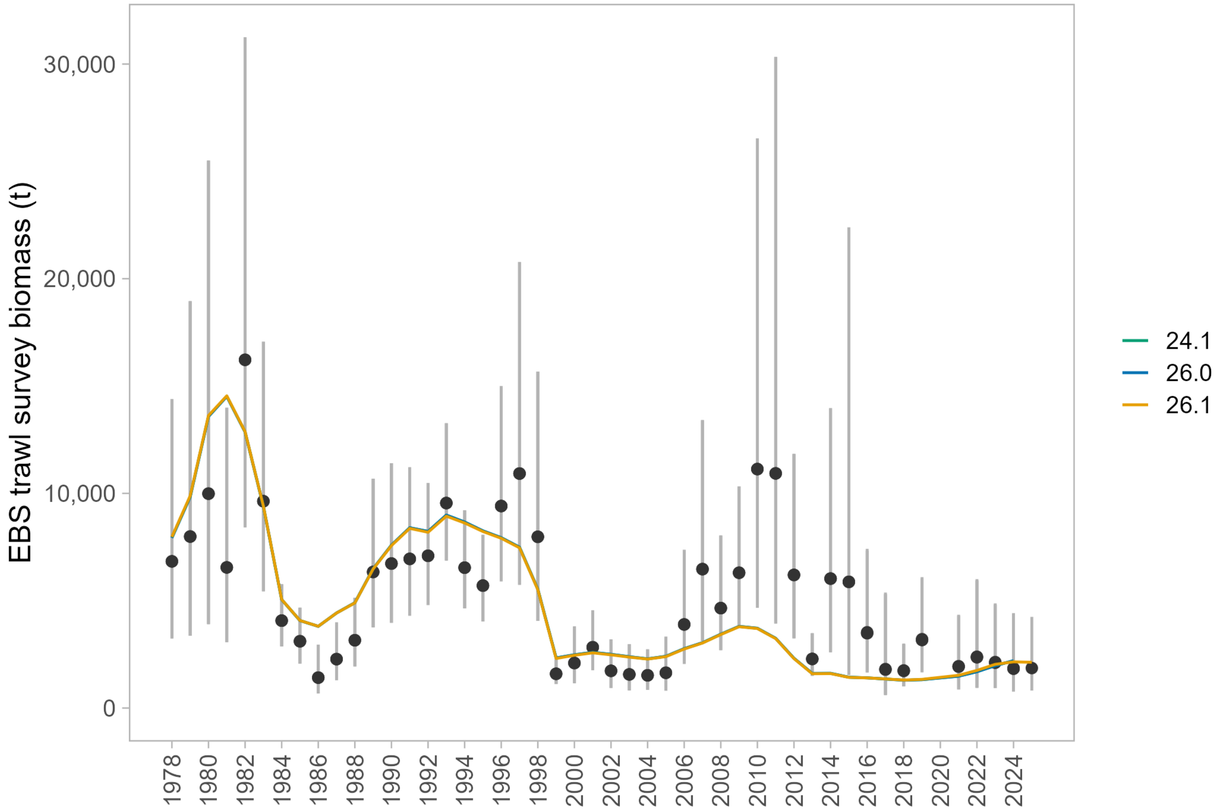

Figure 8: Model fits to the design-based biomass index from the NOAA EBS trawl survey for the reference model (model 24.1), the reference model transitioned to a newer GMACS version (model 26.0), and the new base model, with a newer GMACS version and updated data (model 26.1).

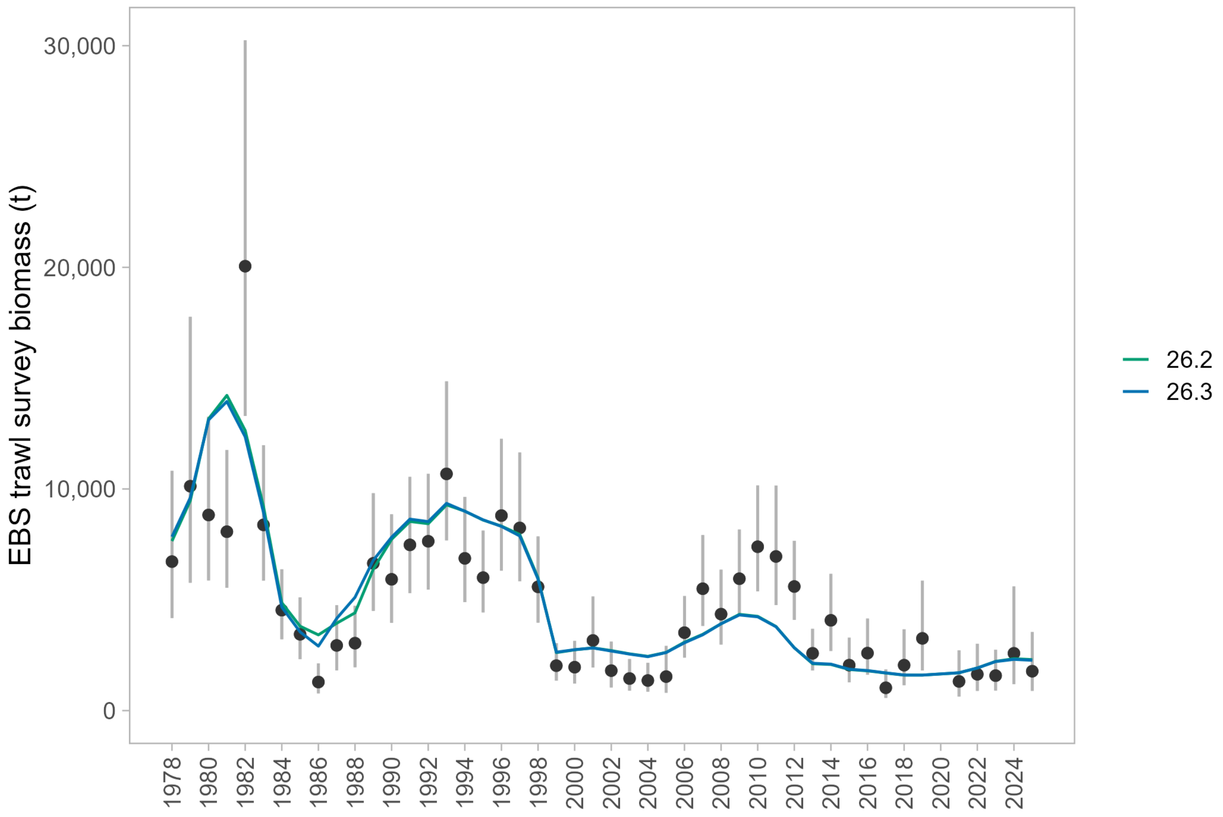

Figure 9: Model fits to the model-based biomass index from the NOAA EBS trawl survey for the models using a spatiotemporal model-based index in place of the EBS trawl survey design-based biomass estimates, with catchability for that index either fixed at 1 (model 26.2) or estimated (model 26.3).

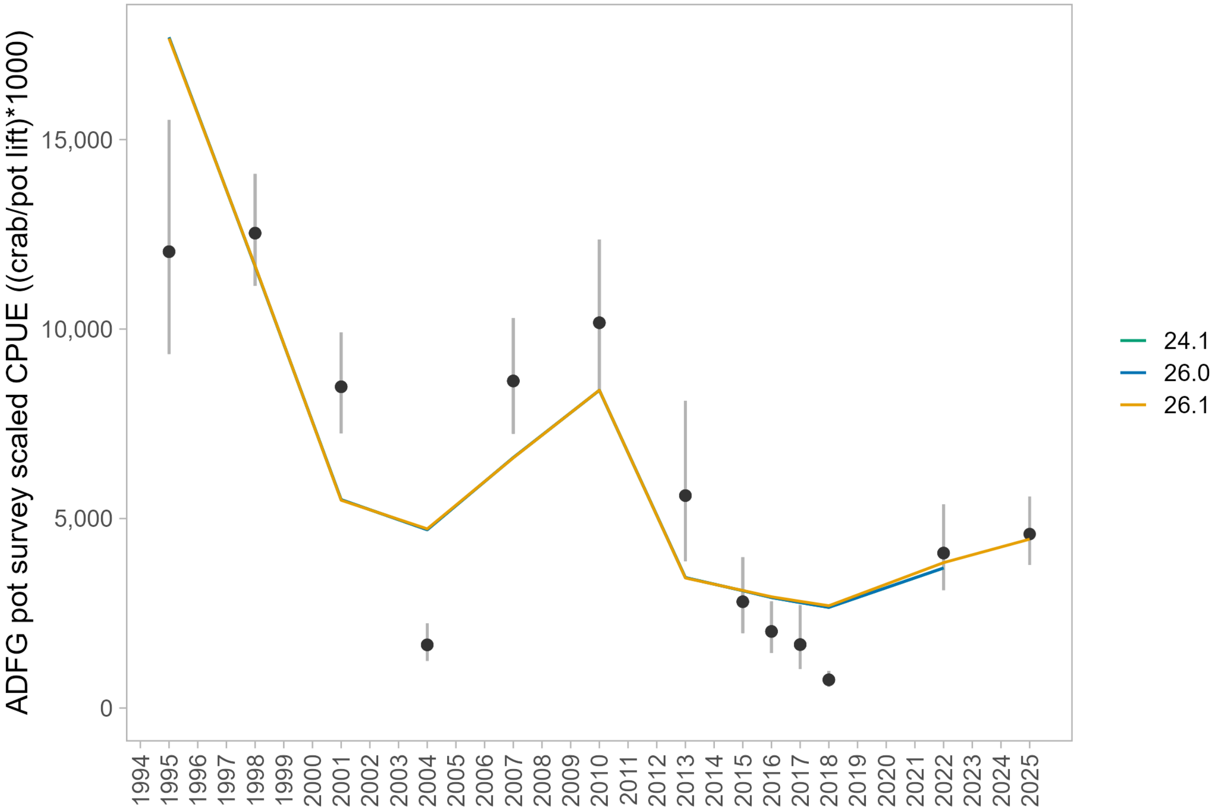

Figure 10: Model fits to the index of abundance from the Alaska Department of Fish and Game (ADFG) pot survey for the reference model (model 24.1), the reference model transitioned to a newer GMACS version (model 26.0), and the new base model, with a newer GMACS version and updated data (model 26.1).

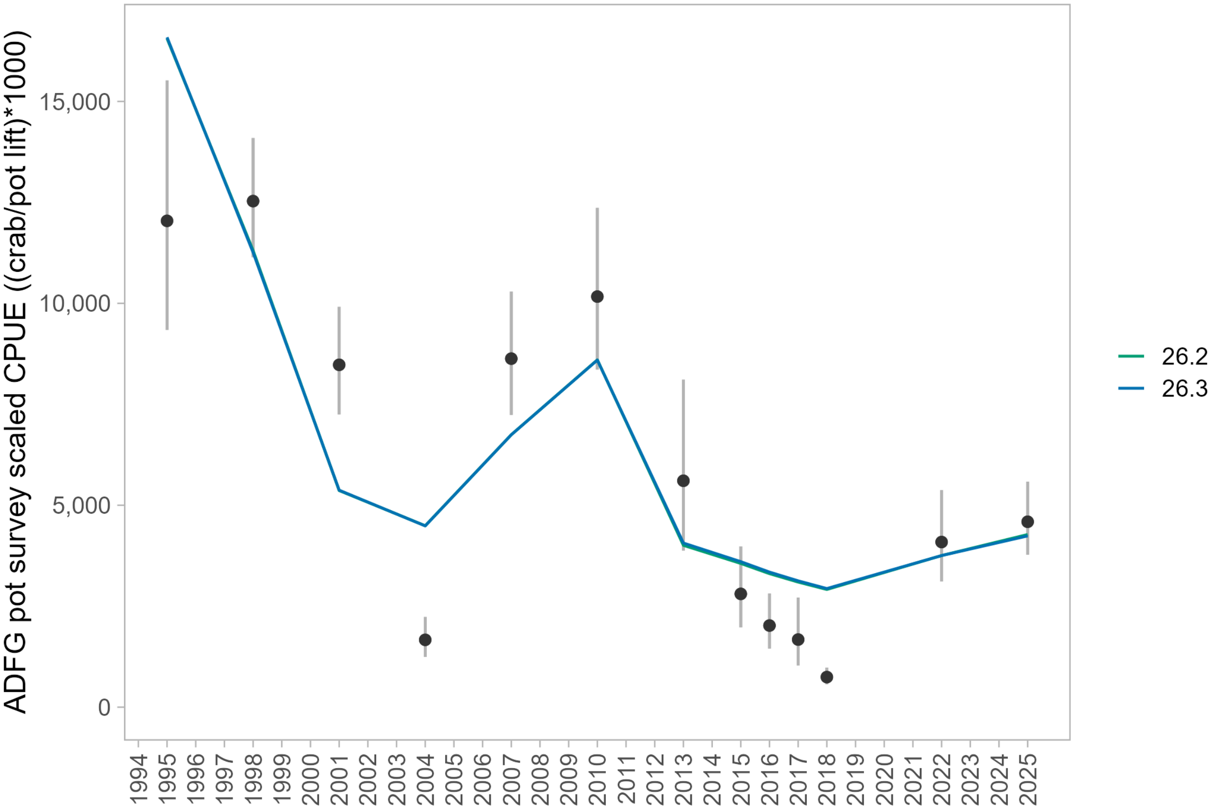

Figure 11: Model fits to the index of abundance from the Alaska Department of Fish and Game (ADFG) pot survey for the models using a spatiotemporal model-based index in place of the EBS trawl survey design-based biomass estimates, with either catchability for that index fixed at 1 (model 26.2) or estimated (model 26.3).

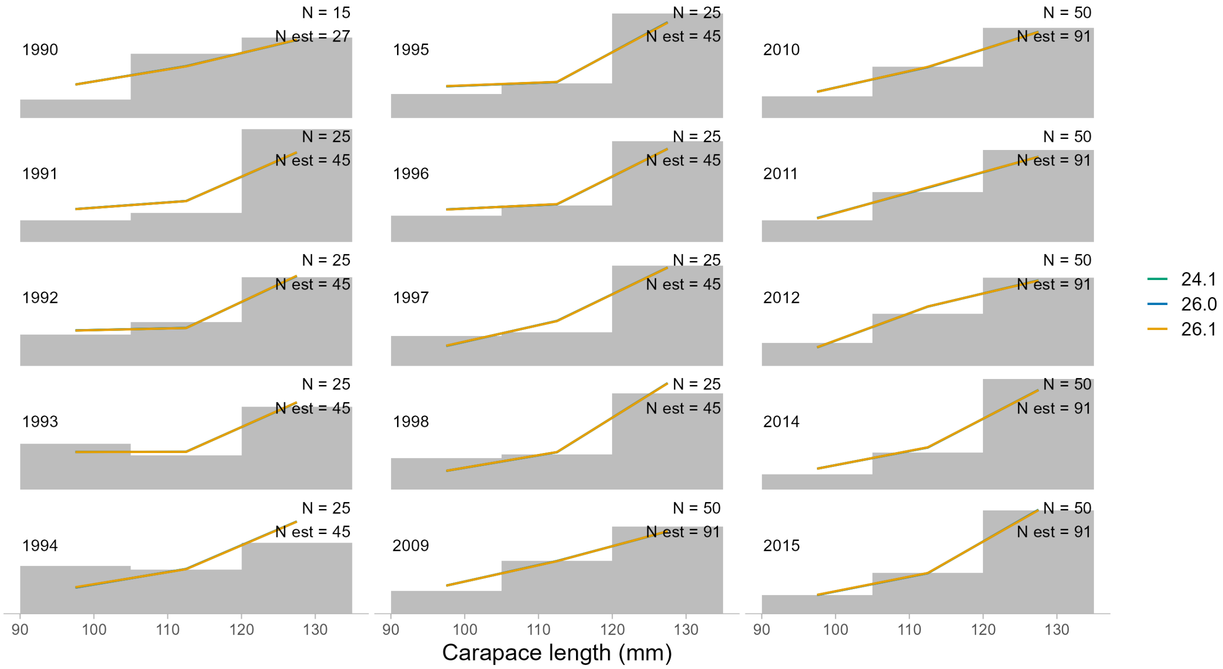

Figure 12: Observed (grey bars) and model estimated (lines) size frequencies of St. Matthew Island blue king crab retained in the directed pot fishery by year for the reference model (model 24.1), the reference model transitioned to a newer GMACS version (model 26.0), and the new base model, with a newer GMACS version and updated data (model 26.1).

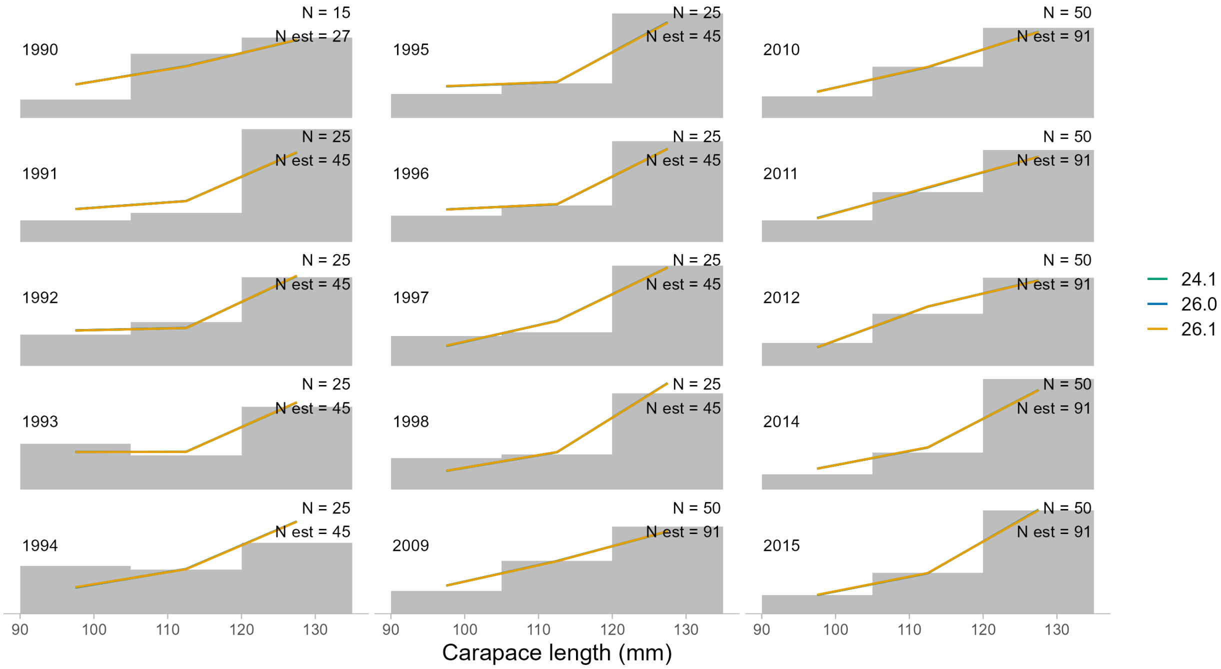

Figure 13: Observed (grey bars) and model estimated (lines) size frequencies of St. Matthew Island blue king crab in the NOAA EBS trawl survey by year for the reference model (model 24.1), the reference model transitioned to a newer GMACS version (model 26.0), and the new base model, with a newer GMACS version and updated data (model 26.1).

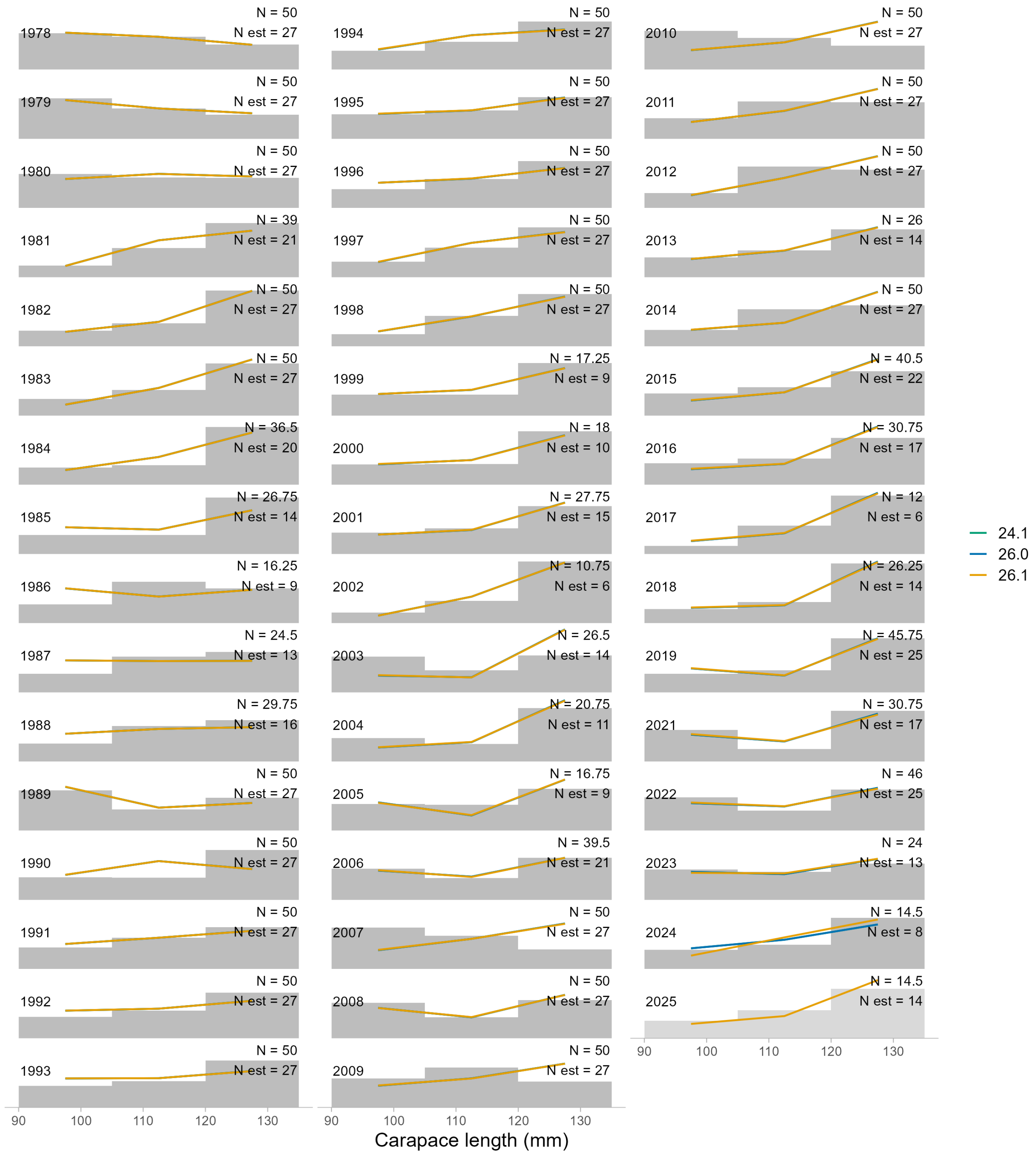

Figure 14: Observed (grey bars) and model estimated (lines) size frequencies of St. Matthew Island blue king crab in the ADFG pot survey by year for the reference model (model 24.1), the reference model transitioned to a newer GMACS version (model 26.0), and the new base model, with a newer GMACS version and updated data (model 26.1).

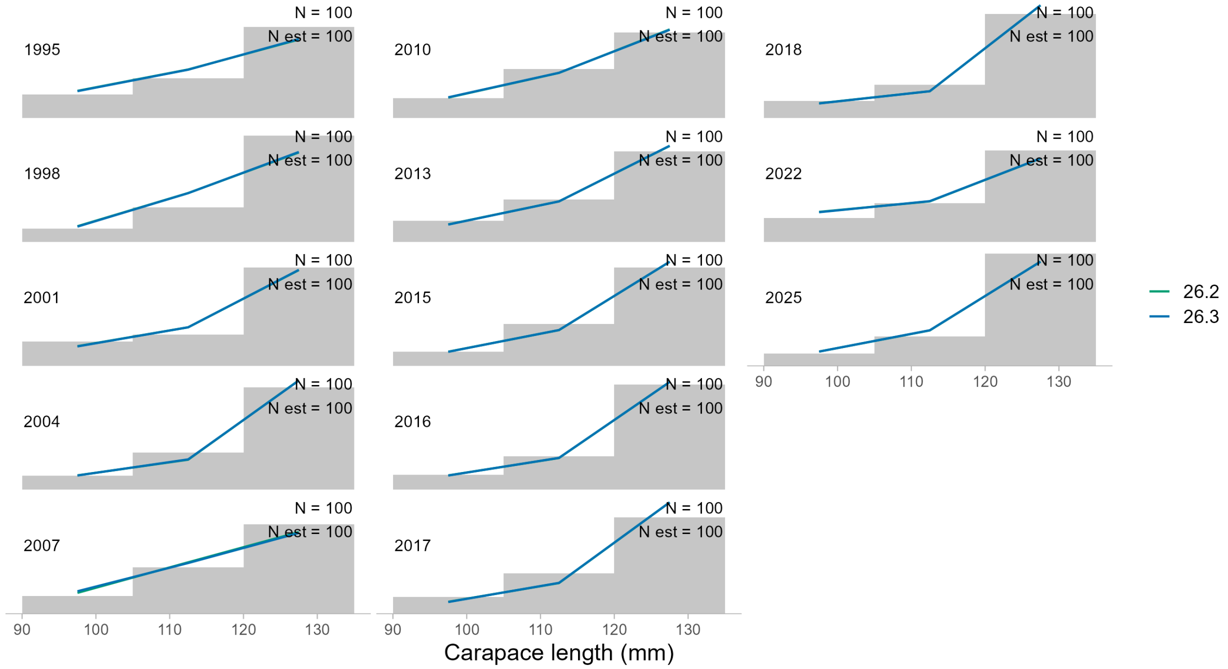

Figure 15: Observed (grey bars) and model estimated (lines) size frequencies of St. Matthew Island blue king crab retained in the directed pot fishery by year for the models using a spatiotemporal model-based index in place of the EBS trawl survey design-based biomass estimates, with catchability for that index either fixed at 1 (model 26.2) or estimated (model 26.3).

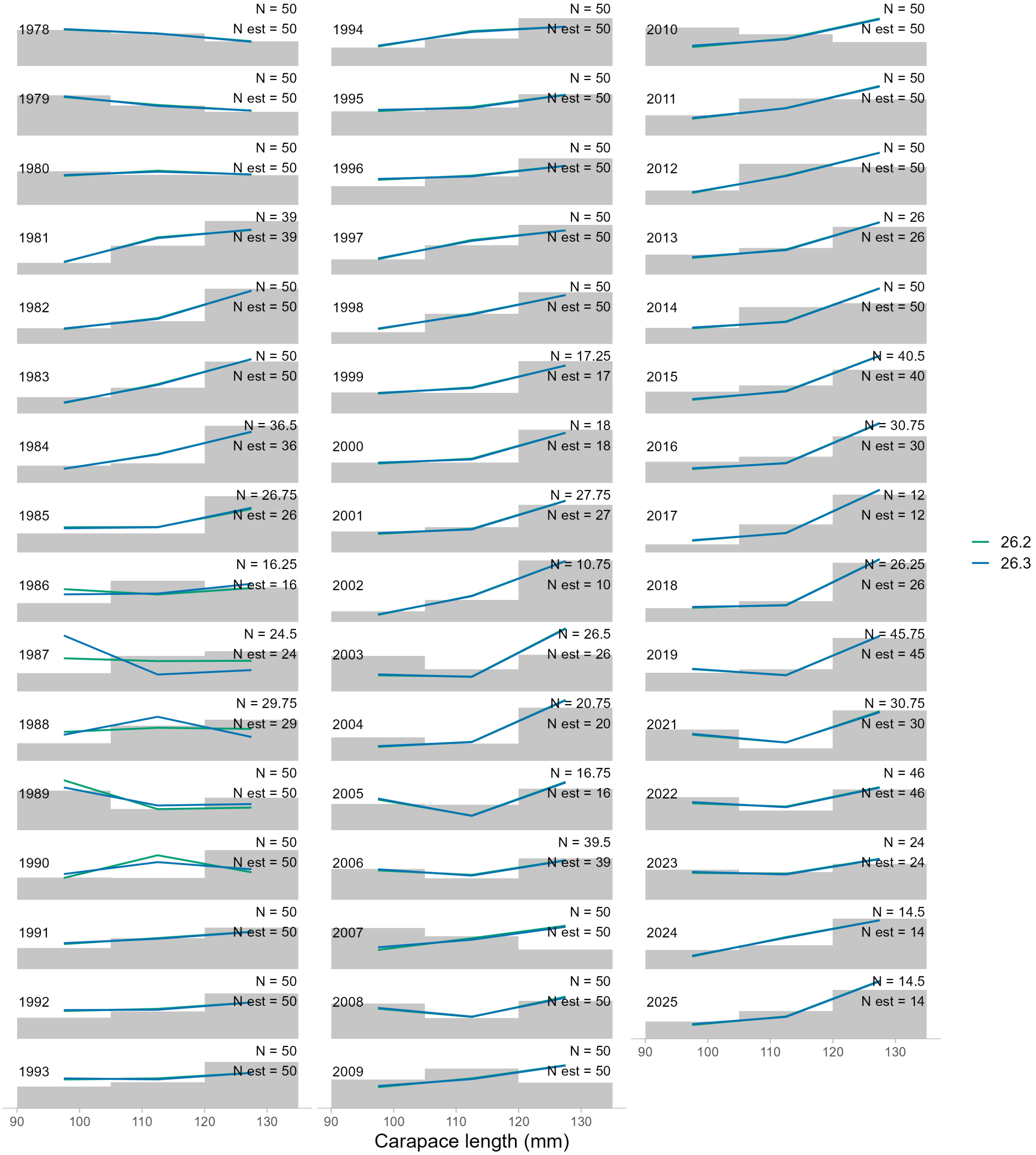

Figure 16: Observed (grey bars) and model estimated (lines) size frequencies of St. Matthew Island blue king crab in the NOAA EBS trawl survey by year for the models using a spatiotemporal model-based index in place of the EBS trawl survey design-based biomass estimates, with catchability for that index either fixed at 1 (model 26.2) or estimated (model 26.3).

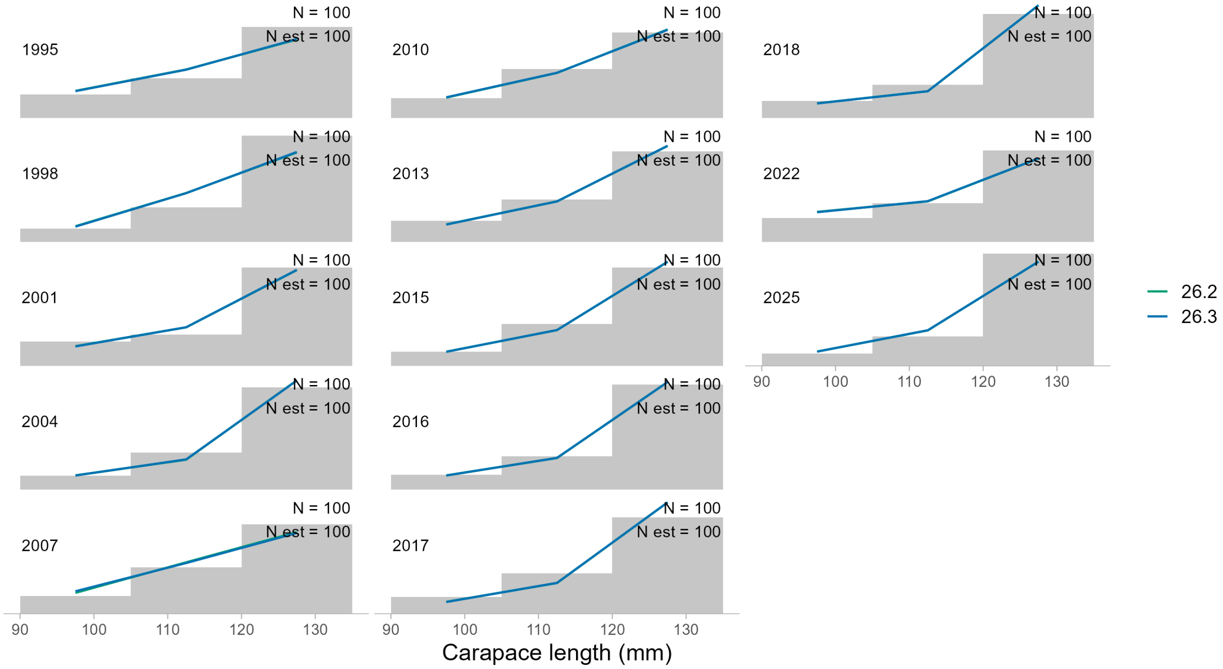

Figure 17: Observed (grey bars) and model estimated (lines) size frequencies of St. Matthew Island blue king crab in the ADFG pot survey by year for the models using a spatiotemporal model-based index in place of the EBS trawl survey design-based biomass estimates, with catchability for that index either fixed at 1 (model 26.2) or estimated (model 26.3).

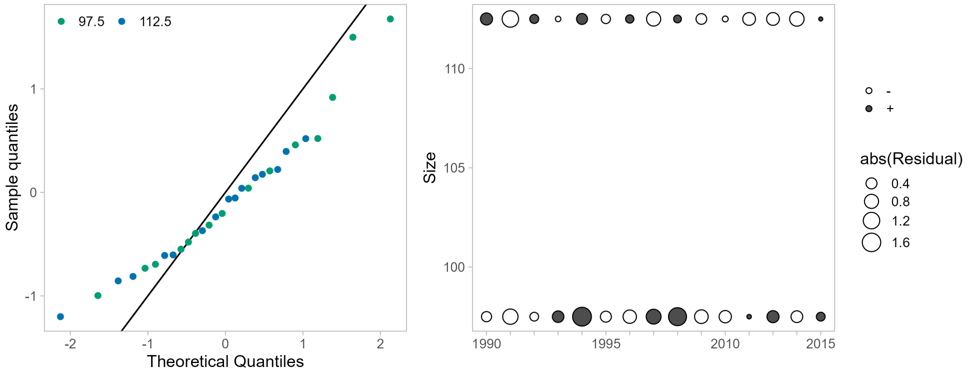

Figure 18: One-Step-Ahead residuals for model 26.1 fits to male size composition data from the directed fishery.

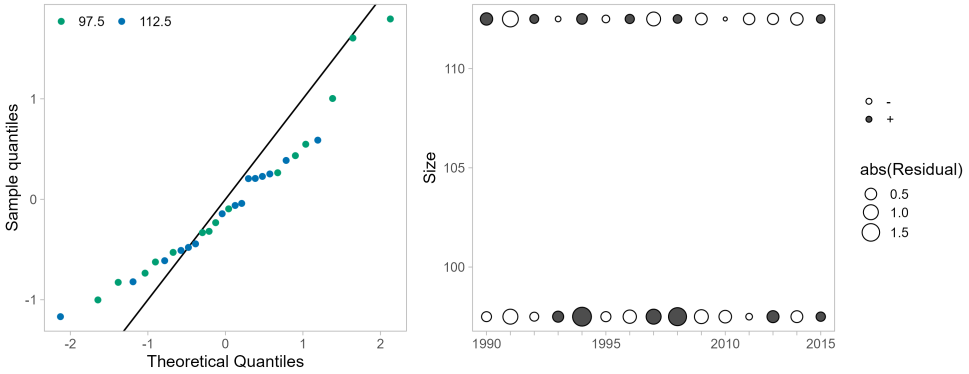

Figure 19: One-Step-Ahead residuals for model 26.2 fits to male size composition data from the directed fishery.

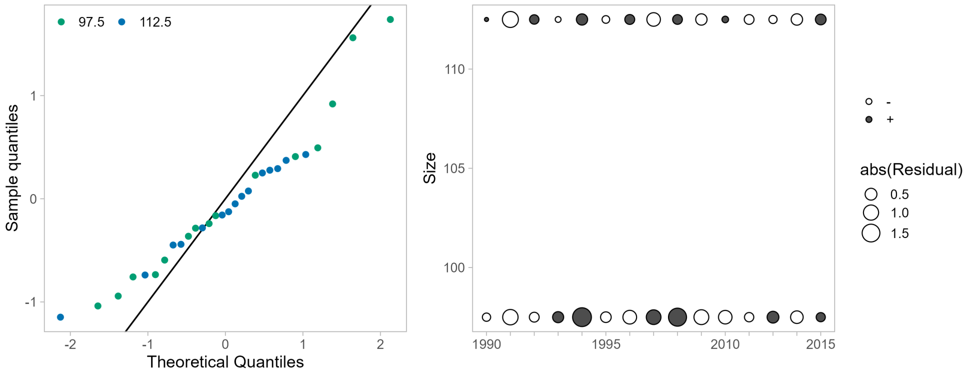

Figure 20: One-Step-Ahead residuals for model 26.3 fits to male size composition data from the directed fishery.

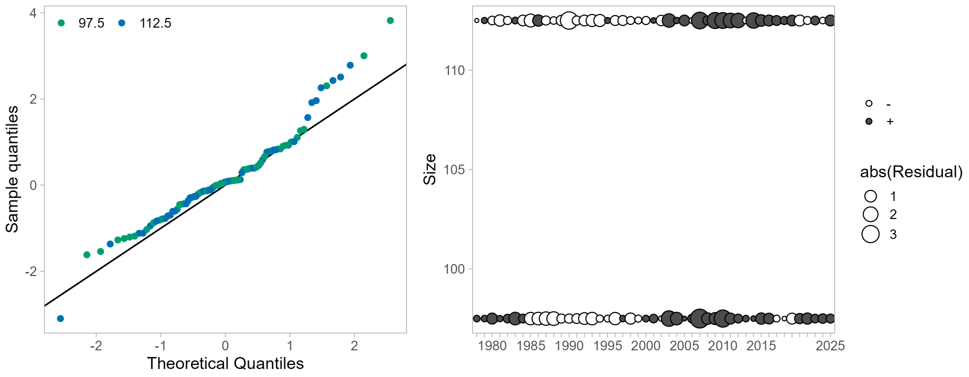

Figure 21: One-Step-Ahead residuals for model 26.1 fits to male size composition data from the NOAA EBS trawl survey.

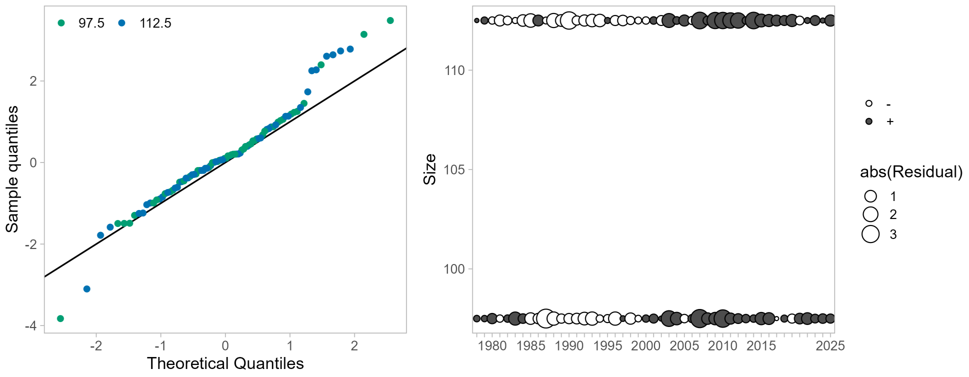

Figure 22: One-Step-Ahead residuals for model 26.2 fits to male size composition data from the NOAA EBS trawl survey.

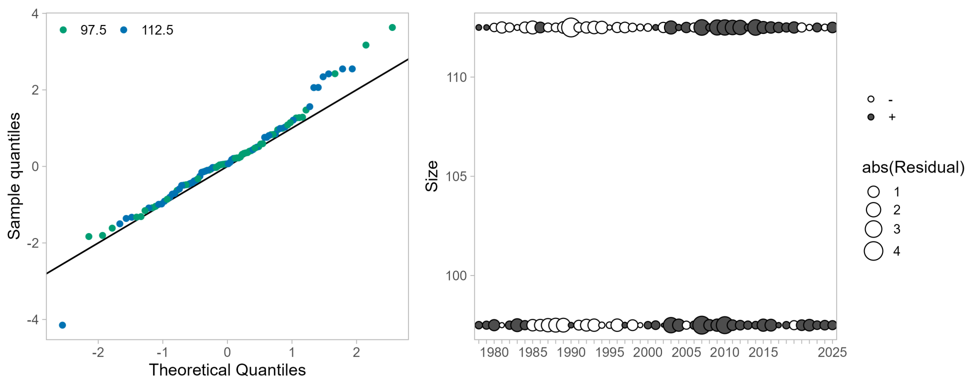

Figure 23: One-Step-Ahead residuals for model 26.3 fits to male size composition data from the NOAA EBS trawl survey.

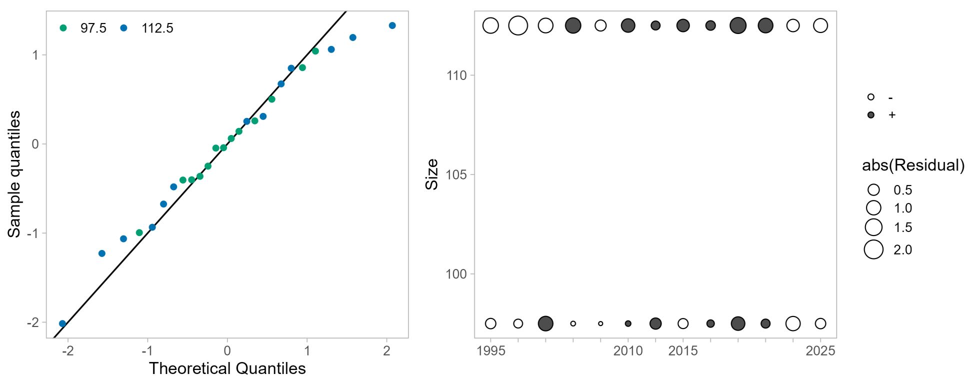

Figure 24: One-Step-Ahead residuals for model 26.1 fits to male size composition data from the ADFG pot survey.

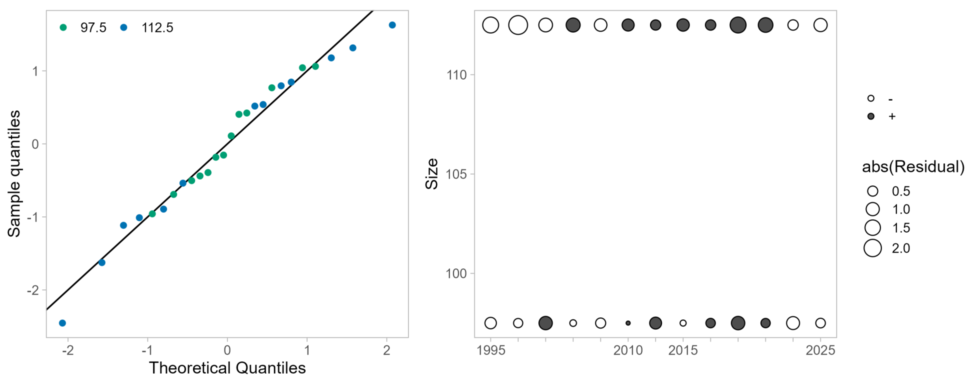

Figure 25: One-Step-Ahead residuals for model 26.2 fits to male size composition data from the ADFG pot survey.

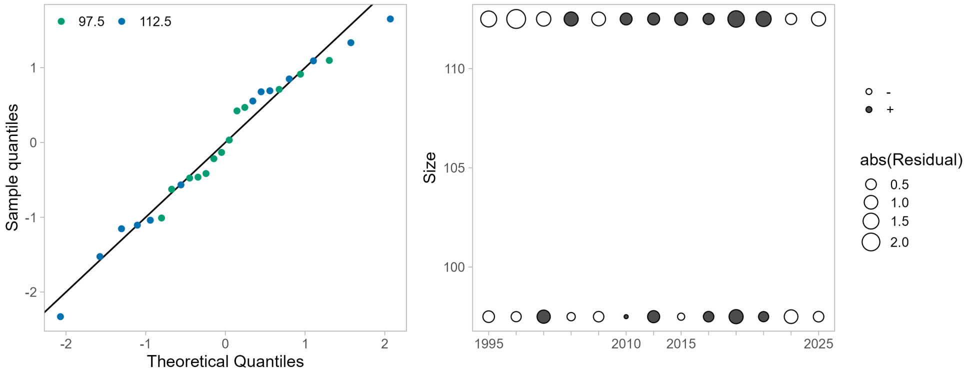

Figure 26: One-Step-Ahead residuals for model 26.3 fits to male size composition data from the ADFG pot survey.

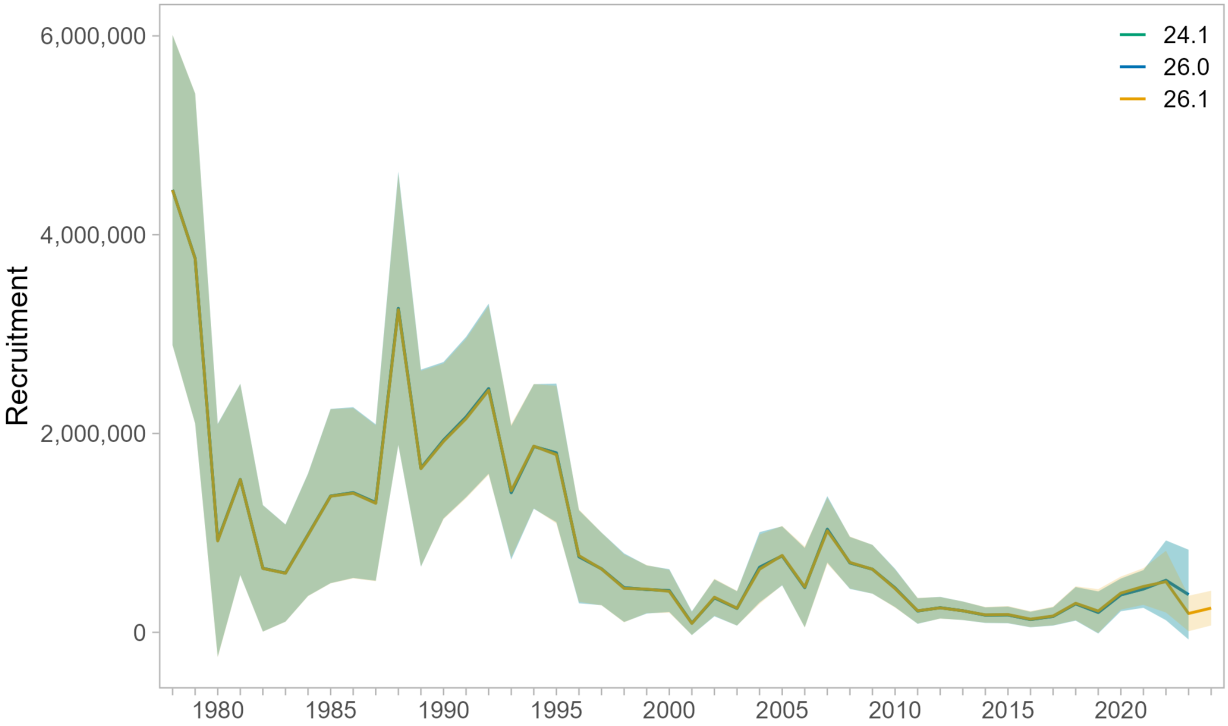

Figure 27: Estimated recruitment (in number of individuals) for the models in the bridging analysis. Models 24.1 and 26.0 include data updated through 2024 and thus estimated recruitment is displayed for 1978 - 2023. Model 26.1 includes data updated through 2025 and thus estimated recruitment is displayed for 1978 - 2024.

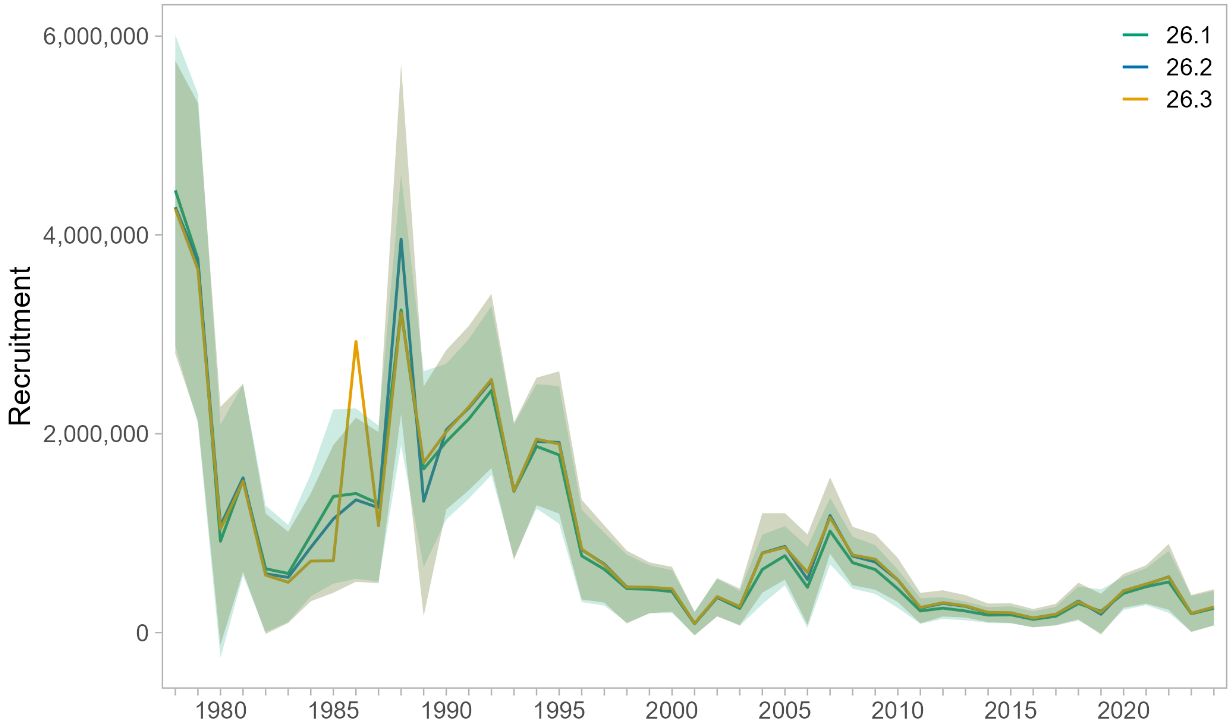

Figure 28: Estimated recruitment (in number of individuals) for 1979 - 2024 comparing the new base model (26.1) with models incorporating a model-based index for the EBS trawl survey biomass time series (26.2, 26.3). Model 26.3 allows catchability for the EBS trawl survey index to be estimated, while model 26.2 has this catchability fixed at 1.

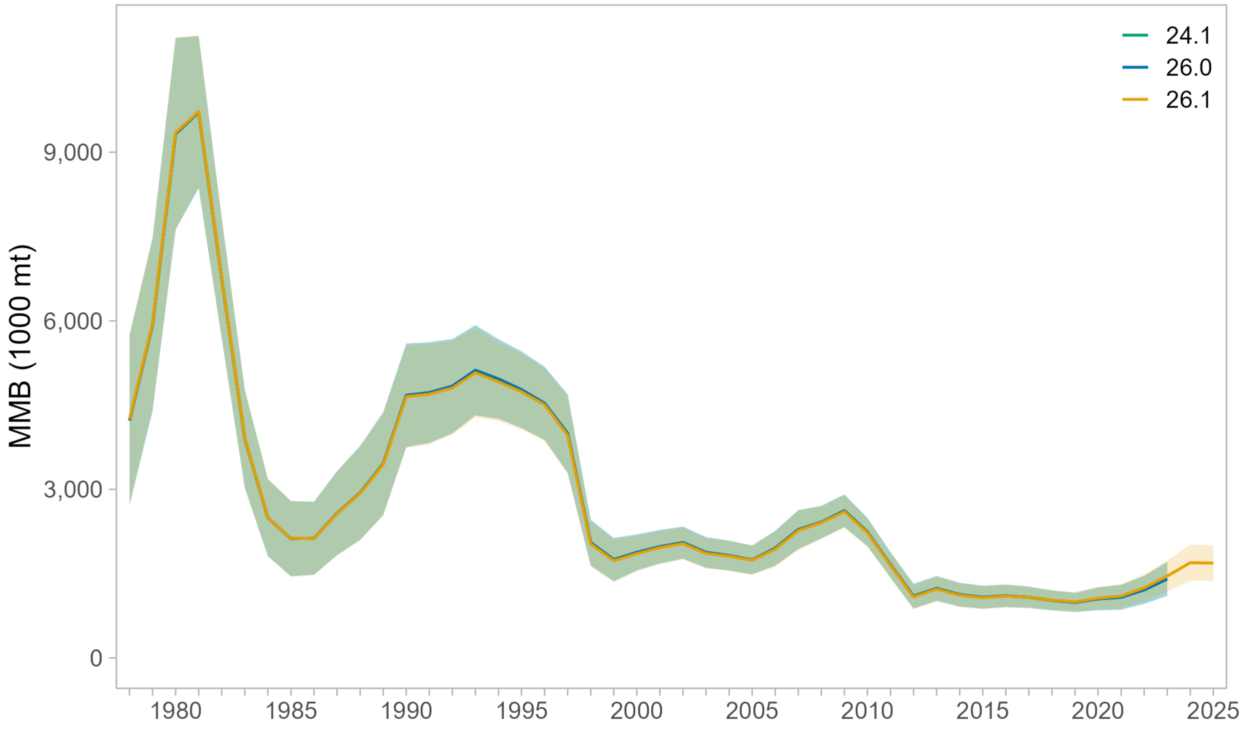

Figure 29: Comparisons of estimated mature male biomass (MMB) time series on 15 February (year + 1) during 1978-2025 for the models in the bridging analysis. Models 24.1 and 26.0 include data updated through 2024, while model 26.1 includes data updated through 2025.

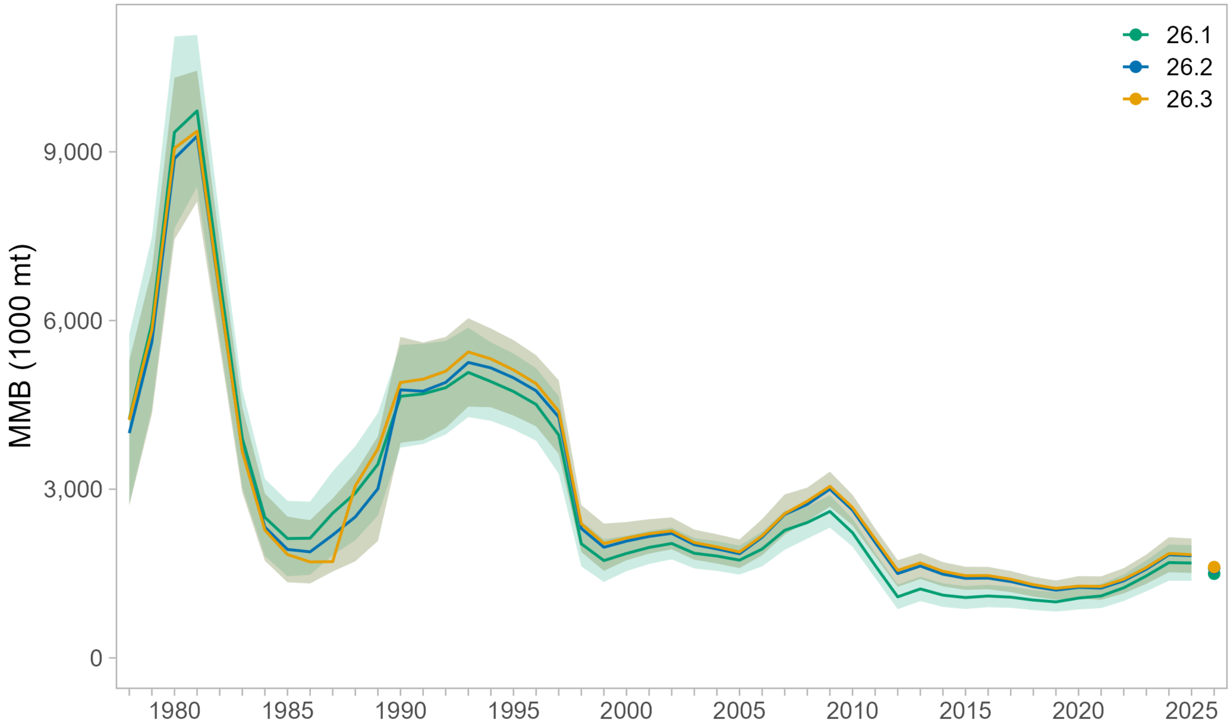

Figure 30: Comparisons of estimated mature male biomass (MMB) time series on 15 February (year + 1) during 1978-2025 for the new base model (26.1), the new base model using a model-based index for the EBS trawl survey (26.2), and the model using a model-based index with catchability estimated (26.3). Points represent projected values for 2025/2026.

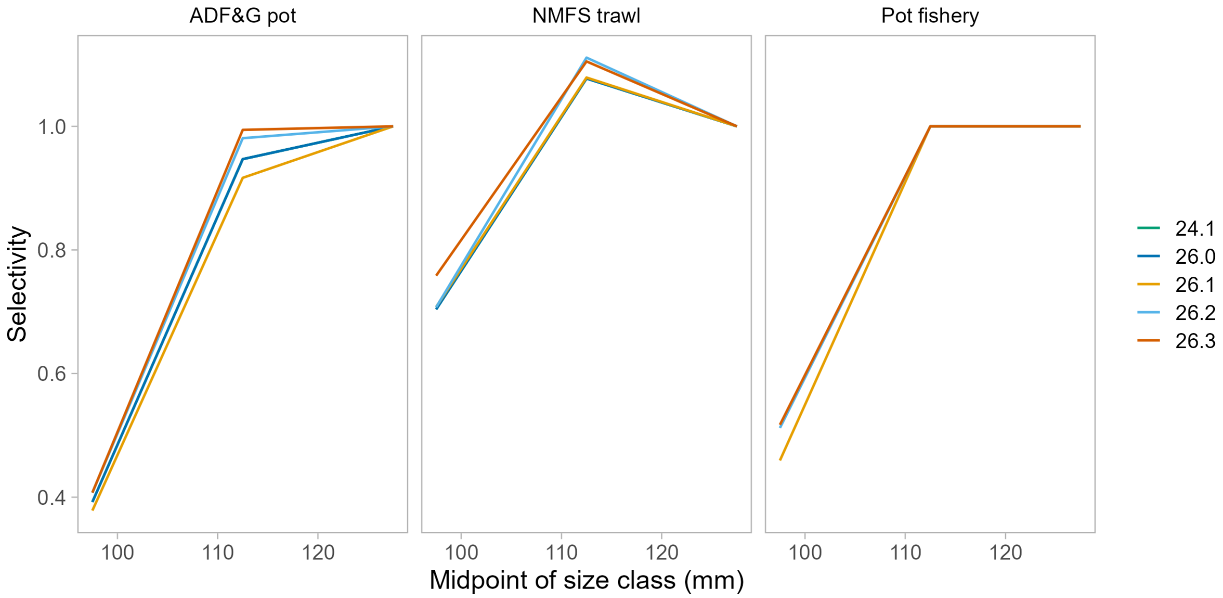

Figure 31: Comparisons of the estimated capture selectivities for the directed pot fishery, the NOAA EBS trawl survey, and the ADFG pot survey for the different model scenarios. Note that capture selectivity is estimated for size classes 1 and 2 and fixed at 1 for size class 3 for all fleets in all model scenarios.

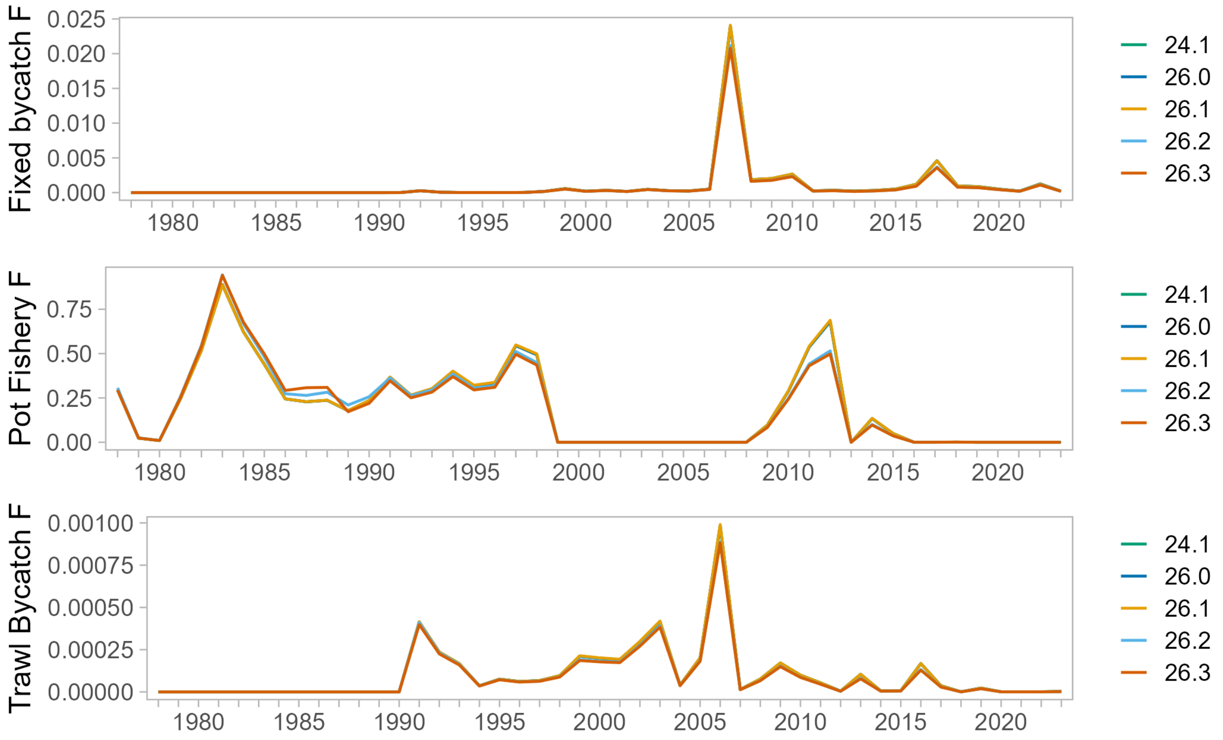

Figure 32: Fishing mortality estimates for directed and bycatch fleets for all model scenarios.

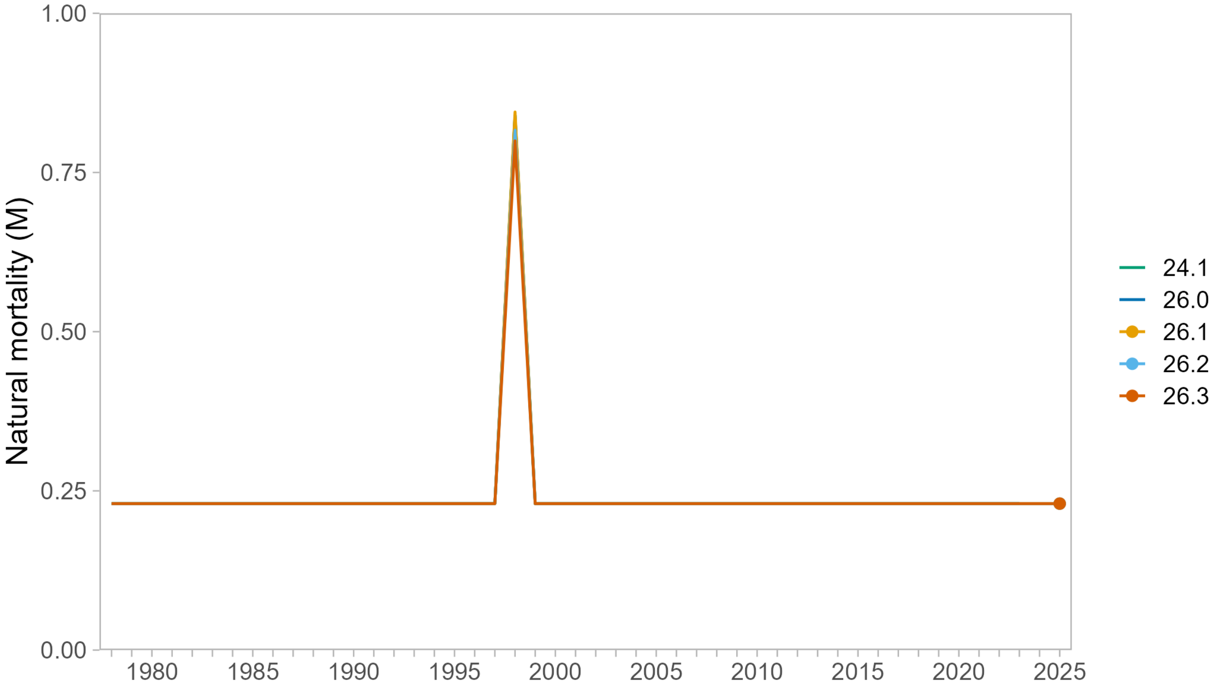

Figure 33: Time-varying natural mortality (M_t) estimates for all model scenarios. Note that, for all model scenarios, natural mortality is fixed at 0.23 for all years except 1998/1999, in which an estimated natural mortality pulse occurs (i.e., M_{1998}).

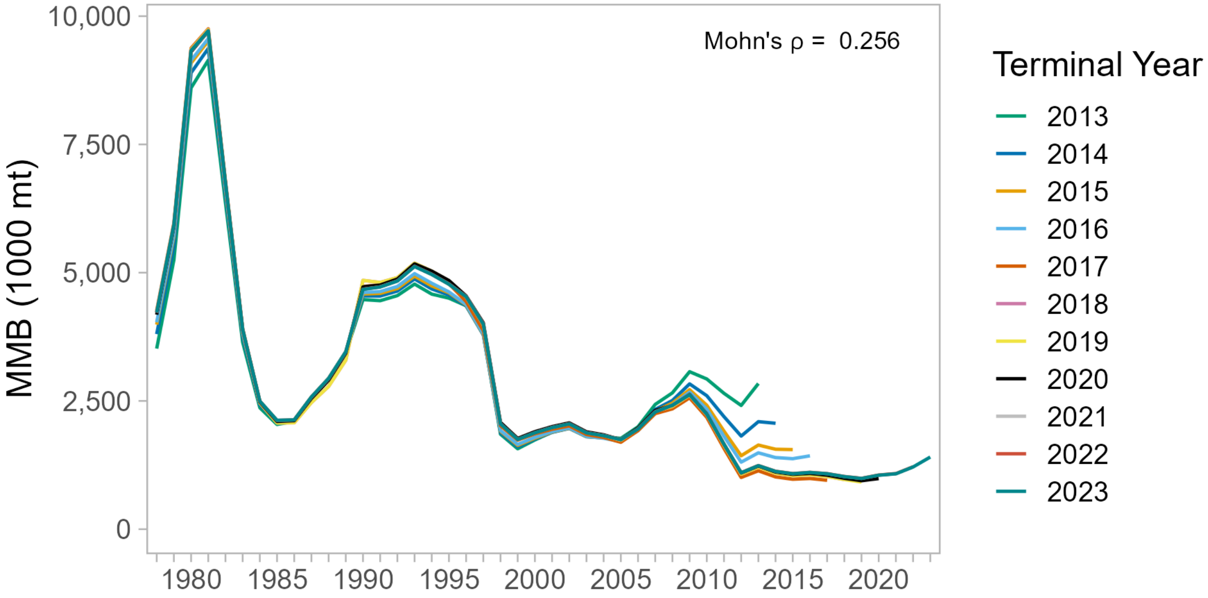

Figure 34: Retrospective pattern in mature male biomass (MMB) for model 26.0 using 10 peels.

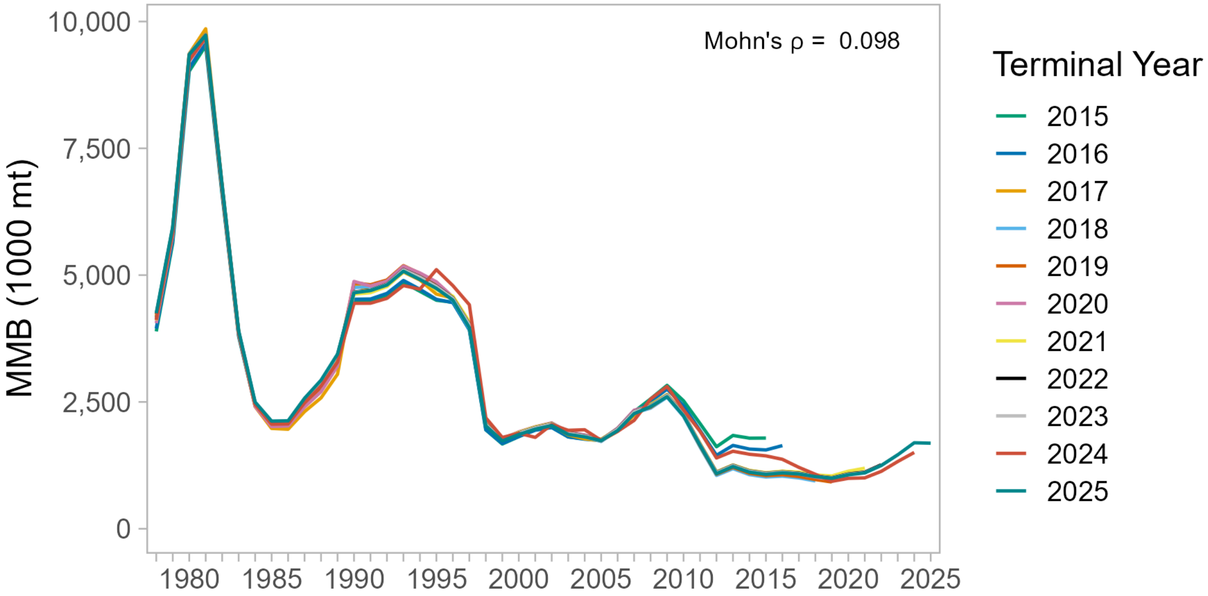

Figure 35: Retrospective pattern in mature male biomass (MMB) for model 26.1 using 10 peels.

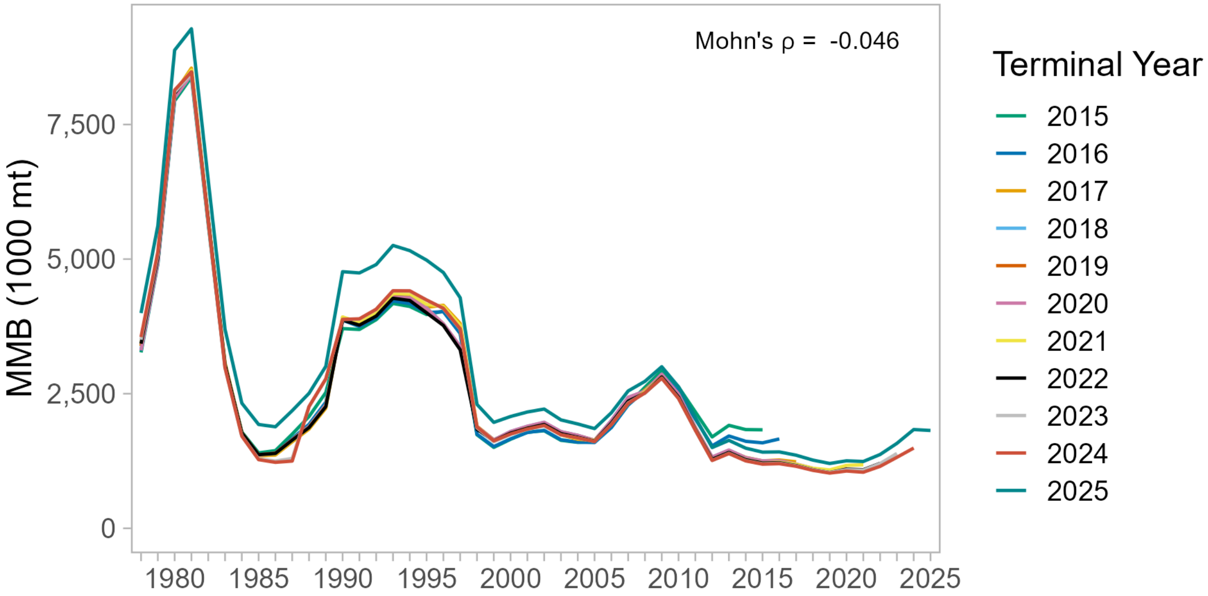

Figure 36: Retrospective pattern in mature male biomass (MMB) for model 26.2 using 10 peels.

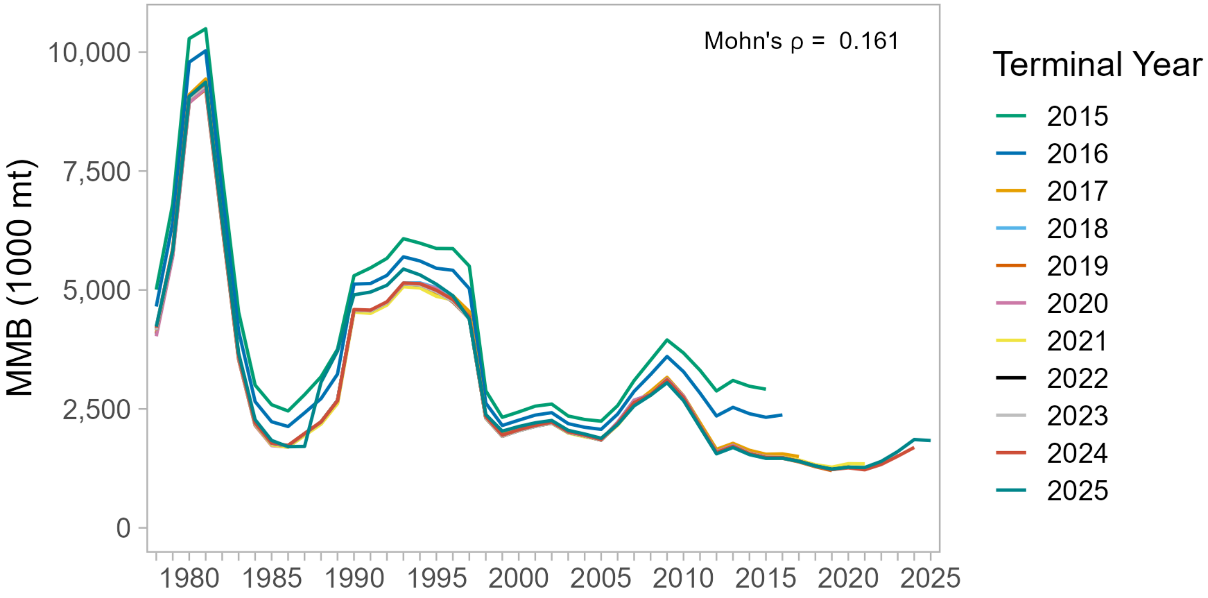

Figure 37: Retrospective pattern in mature male biomass (MMB) for model 26.3 using 10 peels.

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 EBS 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 five 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 14; see Table 5 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 lowercase 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

$$\boldsymbol{G} = \left[\begin{array}{ccc} 1 - \pi_{12} - \pi_{13} & \pi_{12} & \pi_{13} \\ 0 & 1 - \pi_{23} & \pi_{23} \\ 0 & 0 & 1 \end{array}\right], \tag{6}$$

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

$$\boldsymbol{S}_{t,y} = \left[\begin{array}{ccc} 1 - e^{-Z_{1,t,y}} & 0 & 0 \\ 0 & 1 - e^{-Z_{2,t,y}} & 0 \\ 0 & 0 & 1 - e^{-Z_{3,t,y}} \end{array}\right]. \tag{11}$$

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 15. 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 16 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 17 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 8). 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 14: 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	0.07	0	0.56	0.37
1979	0	0.06	0	0.57	0.37
1980	0	0.07	0	0.56	0.37
1981	0	0.05	0	0.58	0.37
1982	0	0.07	0	0.56	0.37
1983	0	0.12	0	0.51	0.37
1984	0	0.10	0	0.53	0.37
1985	0	0.14	0	0.49	0.37
1986	0	0.14	0	0.49	0.37
1987	0	0.14	0	0.49	0.37
1988	0	0.14	0	0.49	0.37
1989	0	0.14	0	0.49	0.37
1990	0	0.14	0	0.49	0.37
1991	0	0.18	0	0.45	0.37
1992	0	0.14	0	0.49	0.37
1993	0	0.18	0	0.45	0.37
1994	0	0.18	0	0.45	0.37
1995	0	0.18	0	0.45	0.37
1996	0	0.18	0	0.45	0.37
1997	0	0.18	0	0.45	0.37
1998	0	0.18	0	0.45	0.37
1999	0	0.18	0	0.45	0.37
2000	0	0.18	0	0.45	0.37
2001	0	0.18	0	0.45	0.37
2002	0	0.18	0	0.45	0.37
2003	0	0.18	0	0.45	0.37
2004	0	0.18	0	0.45	0.37
2005	0	0.18	0	0.45	0.37
2006	0	0.18	0	0.45	0.37
2007	0	0.18	0	0.45	0.37
2008	0	0.18	0	0.45	0.37
2009	0	0.44	0	0.19	0.37
2010	0	0.44	0	0.19	0.37
2011	0	0.44	0	0.19	0.37
2012	0	0.44	0	0.19	0.37
2013	0	0.44	0	0.19	0.37
2014	0	0.44	0	0.19	0.37
2015	0	0.44	0	0.19	0.37
2016	0	0.44	0	0.19	0.37
2017	0	0.44	0	0.19	0.37
2018	0	0.44	0	0.19	0.37
2019	0	0.44	0	0.19	0.37
2020	0	0.44	0	0.19	0.37
2021	0	0.44	0	0.19	0.37
2022	0	0.44	0	0.19	0.37
2023	0	0.44	0	0.19	0.37
2024	0	0.44	0	0.19	0.37
2025	0	0.44	0	0.19	0.37

Table 15: 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 - present)
Groundfish trawl bycatch biomass	1992/93 - 2024/25	NMFS groundfish observer program
Groundfish fixed-gear bycatch biomass	1992/93 - 2024/25	NMFS groundfish observer program
NMFS trawl-survey biomass index (area-swept estimate) and CV	1978-2025	NMFS EBS trawl survey
ADF&G pot-survey abundance index (CPUE) and CV	1995-2025	ADF&G SMBKC pot survey
NMFS trawl-survey stage proportions and total number of measured crab	1978-2025	NMFS EBS trawl survey
ADF&G pot-survey stage proportions and total number of measured crab	1995-2025	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 - present)

Table 16: Fixed model parameters for all models except 26.3, which uses the same values with the exception of trawl survey catchability (q), which it estimates.

Parameter	Symbol	Value	Source/rationale
Trawl survey catchability	q	1.0	Default
Natural mortality	M	0.23 yr^{-1}	Borrowed from BBRKC SAFE
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 17: 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_{1998}^M	-3	0.0	3	Normal(0, σ_M^2)	4
Recruitment deviations δ_y^R	-7	0.0	7	Normal(0, σ_R^2)	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 26.1

The base model (26.1) data file

```
#===========================================================================================================
# Gmacs Main  Data  File  Version 2.20.32a:  May 2026 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
2025  # 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)
0.000   0.440   0.000   0.190   0.370 #2024 (updated 2-03-26)
0.000   0.440   0.000   0.190   0.370 #2025 (updated 2-03-26)
#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
##  ---------------------------------------------------------------------------------  ##
##  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
##  ---------------------------------------------------------------------------------  ##
# 0- old format; 1 - new format
0
# Number  of  catch data  frames
4
# Number  of  rows  in  each  data  frame
27  18 34  34 #(updated - all should increase 1 if value for current year NO placeholder for direct fishery if closed)
# 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)
2024    2   2   1   0.001   0.31    2   1   1   0   0.8 # (updated 2-03-26 - bycatch_groundfish.R) (real value is 0.0005)
#   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)
2024    2   3   1   0.720   0.31    2   1   1   0   0.5 # (updated 2-03-26 - 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
60 # updated 2-04-26
# Survey data (abundance indices, units are mt for trawl survey and crab/potlift for pot survey)
#   q_index, Year,  Seas,   Fleet,  Sex,    Maturity,   Abundance,  CV   abundance units     timing    RAI_id  #<-RAI_id column is NEW as of versi
# EBS bottom trawl survey
1   1978    1   4   1   0   6832.824    0.394   1   0   1   # whole time series updated 2-04-2026, incorporating changes esp. from 2016 forward in
1   1979    1   4   1   0   7989.887    0.463   1   0   1
1   1980    1   4   1   0   9986.838    0.507   1   0   1
1   1981    1   4   1   0   6551.137    0.402   1   0   1
1   1982    1   4   1   0   16221.950   0.344   1   0   1
1   1983    1   4   1   0   9634.257    0.298   1   0   1
1   1984    1   4   1   0   4071.222    0.179   1   0   1
1   1985    1   4   1   0   3110.544    0.210   1   0   1
1   1986    1   4   1   0   1416.850    0.388   1   0   1
1   1987    1   4   1   0   2278.919    0.291   1   0   1
1   1988    1   4   1   0   3158.172    0.252   1   0   1
1   1989    1   4   1   0   6338.627    0.271   1   0   1
1   1990    1   4   1   0   6730.136    0.274   1   0   1
1   1991    1   4   1   0   6948.190    0.248   1   0   1
1   1992    1   4   1   0   7093.277    0.201   1   0   1
1   1993    1   4   1   0   9548.466    0.169   1   0   1
1   1994    1   4   1   0   6539.139    0.176   1   0   1
1   1995    1   4   1   0   5703.595    0.178   1   0   1
1   1996    1   4   1   0   9410.410    0.241   1   0   1
1   1997    1   4   1   0   10924.120   0.337   1   0   1
1   1998    1   4   1   0   7976.846    0.355   1   0   1
1   1999    1   4   1   0   1594.548    0.182   1   0   1
1   2000    1   4   1   0   2096.796    0.310   1   0   1
1   2001    1   4   1   0   2831.442    0.245   1   0   1
1   2002    1   4   1   0   1732.601    0.320   1   0   1
1   2003    1   4   1   0   1566.677    0.336   1   0   1
1   2004    1   4   1   0   1523.870    0.305   1   0   1
1   2005    1   4   1   0   1642.018    0.371   1   0   1
1   2006    1   4   1   0   3893.879    0.334   1   0   1
1   2007    1   4   1   0   6470.779    0.385   1   0   1
1   2008    1   4   1   0   4654.477    0.284   1   0   1
1   2009    1   4   1   0   6301.475    0.256   1   0   1
1   2010    1   4   1   0   11130.910   0.466   1   0   1
1   2011    1   4   1   0   10931.240   0.558   1   0   1
1   2012    1   4   1   0   6200.224    0.339   1   0   1
1   2013    1   4   1   0   2287.559    0.217   1   0   1
1   2014    1   4   1   0   6029.225    0.449   1   0   1
1   2015    1   4   1   0   5877.438    0.770   1   0   1
1   2016    1   4   1   0   3528.701    0.393   1   0   1
1   2017    1   4   1   0   1814.159    0.600   1   0   1
```

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1   2018   1   4   1   0   1750.262    0.281   1   0   1
1   2019   1   4   1   0   3206.744    0.337   1   0   1  #   (updated   -   EBSsurvey_analysis.R)
1   2021   1   4   1   0   1948.794    0.427   1   0   1  # updated 4-14-22
1   2022   1   4   1   0   2390.681    0.497   1   0   1  # updated 8-25-22
1   2023   1   4   1   0   2141.211    0.439   1   0   1  # updated 2-14-24
1   2024   1   4   1   0   1857.825    0.465   1   0   1  # updated 8-14-24
1   2025   1   4   1   0   1861.496    0.440   1   0   1  # updated 2-04-26
# ADF&G pot survey
2   1995   1   5   1   0   12042   0.13    2   0   2
2   1998   1   5   1   0   12531   0.06    2   0   2
2   2001   1   5   1   0   8477    0.08    2   0   2
2   2004   1   5   1   0   1667    0.15    2   0   2
2   2007   1   5   1   0   8630    0.09    2   0   2
2   2010   1   5   1   0   10167   0.10    2   0   2
2   2013   1   5   1   0   5606    0.19    2   0   2
2   2015   1   5   1   0   2805    0.18    2   0   2
2   2016   1   5   1   0   2021    0.17    2   0   2
2   2017   1   5   1   0   1674    0.25    2   0   2
2   2018   1   5   1   0    745    0.14    2   0   2 # no  smbkc   pot survey  in  2019, 2020, 2021
2   2022   1   5   1   0   4089    0.14    2   0   2 # updated 2-14-24. No SMBKC pot survey in 2023, 2024
2   2025   1   5   1   0   4591    0.10    2   0   2 # updated 3-10-26
999 #chk      <-NEW as of version 2.20.29

##  ---------------------------------------------------------------------------------  ##
##  SIZE  COMPOSITION DATA  FOR ALL FLEETS
##  ---------------------------------------------------------------------------------  ##
# 0- old format; 1 - new format
0
##  Number  of  length  frequency matrices
3
##  Number  of  rows  in  each  matrix
15  47  13 # (updated 2-04-26)
##  Number  of  bins  in  each  matrix  (columns  of  size  data)
3  3  3
##  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
  2025  1 4 1 0 0 0 14.5  0.1831  0.2948  0.5221 # updated 2-04-26
  ##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
  2025  1 5 1 0 0 0 100  0.080264  0.190764  0.728972 # updated 3-10-2026

##  ----------------------------------------------------------------------------------  ##
##  Growth data (increment)
###  ----------------------------------------------------------------------------------  ##
0  #-- Type of growth increment (0=ignore;1=growth increment with a CV;2=size-at-release; size-at)

0  #-- nobs_growth

# MidPoint Sex Increment CV

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

##  ----------------------------------------------------------------------------------  ##
# Environmental data
##  ----------------------------------------------------------------------------------  ##
0  #--format flag (0 = old format; 1 = new format)
0  #--Number of series
# Year ranges

# Indices
# Index Year Value

## eof
```

```
9999
```

The base model (26.1) control file

```
## SMBKC model 26.1, May 2026
## updated to GMACS v2.20.34a, new survey data added
#
## ==================================================================================== ##
# 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)
4
# Number of blocks per group (after the first block, i.e. 1 means two blocks)
1 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 0 # Block Group 1: M and NMFS survey
# Block Group 2: directed fishery
2009 0 # Block Group 3: directed fishery
# Block Group 3: natural mortality event
1998 1998
# Block Group 4: directed fishery
1978 0 # Block Group 4

## =====================================================================================##
# Treatment of environmental variable use
# Number of environmental treatments
0
# Number of links for each treatment
#1
#2
# Treatment #1
# Var power Zscore
#1     1     1990 2020
# Treatment #2
# Var power Zscore
#1     2     2000 2020
#2     1     2010 2020

## ==================================================================================== ##
## GENERAL CONTROLS
## ==================================================================================== ##
1978       # First rec_dev
2024       # 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
   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
   0 # recruitment size distribution option (0: standard way; 1: Tanner crab approach)    <-NEW as of version 2.20.29
   0 # mirror growth between sexes (0: standard way; 1: AIGKC way) <- also new

## ------------------------------------------------------------------------------------ ##
## RECRUITMENT                                                                          ##
#Initial  Lower_bound  Upper_bound Prior_type   Prior_1  Prior_2  Phase    Block  Blk_fn   Env_L  Env_vr      RW  RW_Blk  RW_Sigma
14.3    -7  30                      0        -7       30     -2    0   0   0   0   0   0   300     #   log(R0)
10  -7  20                       1       -10       20     -1    0   0   0   0   0   0   300     #   log(Rini)
13.39   -7  20                      0        -7       20      1    0   0   0   0   0   0   300     #   log(Rbar)
```

```
#13.39  -7  20                      0        -7       20      1    0   0   0   0   11  5   300     #   log(Rbar)
#13.39  -7  20                      0        -7       20      1    2   1   0   0   0   0   300     #   log(Rbar)
#13.39  -7  20                      0        -7       20      1    0   0   1   1   0   4   300     #   log(Rbar)

80  30  310                         1      72.5     7.25     -2    0   0   0   0   0   0   300     #   Recruitment
0.25    0.1 7                       0       0.1        9     -4    0   0   0   0   0   0   300     #   Recruitment
0.2 0.01    0.75                        0       -10     0.75      -4    0   0   0   0   0   0   300     #   log(sigma_R)
0.75    0.2 1                       3         3    2     -2    0   0   0   0   0   0   300     #   steepness
0.01    0   1                       3      1.01     1.01     -3    0   0   0   0   0   0   300     #   recruitment
## ---------------------------------------------------------------------------------- ##
## Initial abundance                                                                  ##
# Initial  Lower_bound  Upper_bound Prior_type   Prior_1  Prior_2  Phase  Block Blk_fn  Env_L Env_vr   RW RW_Blk RW_Sigma
14.5    5   20  0   5   20  1   0   0   0   0   0   0   300     #   logN0   vector  of  initial numbers at  length
14  5   20  0   5   20  1   0   0   0   0   0   300     #   logN0   vector  of  initial numbers at  length
13.5    5   20  0   5   20  1   0   0   0   0   0   0   300     #   logN0   vector  of  initial numbers at  length

# Initial  Lower_bound  Upper_bound Prior_type   Prior_1  Prior_2  Phase  Relative
#      0.2           0.01            1          0      0.23     0.02      4         0       # Dev par=2; linear


## ---------------------------------------------------------------------------------- ##
# 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)
```

```
0.000748427    0.001165731    0.001930932 # (add line here each year - 3-10-26)
0.000748427    0.001165731    0.001930932 # (add line here each year - 3-10-26)
# 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
# ------------------------------------------------------------------------------------- ##
## 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 co
    0.060       0.0       1.0           0         0.0      999.0    -3         0      0      0      0    0      0      300    # molt_cv males or co
# Initial  Lower_bound  Upper_bound Prior_type   Prior_1  Prior_2  Phase  Relative

# 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      3      2    0      4      300    # molt_mu males or c
#    0.060       0.0       1.0           0         0.0      999.0    -3         0      0      3      2    0      4      300    # molt_cv males or c
# Initial  Lower_bound  Upper_bound Prior_type   Prior_1  Prior_2  Phase  Relative
#    0.2          -1         1           0        0.23       0.02    -4         0       # Dev par=2; linear
#    0.3          -1         1           0        0.23       0.02    -4         0       # Dev par=2; linear
#    0.4          -1         1           0        0.23       0.02    -4         0       # Dev par=2; linear
#    0.5          -1         1           0        0.23       0.02    -4         0       # Dev par=2; linear
#    0.6          -1         1           0        0.23       0.02    -4         0       # Dev par=2; linear
#    0.7          -1         1           0        0.23       0.02    -4         0       # Dev par=2; linear


# EXTRA PARS: Initial  Lower_bound  Upper_bound Prior_type      Prior_1      Prior_2  Phase Reltve
#----no extra pars

# ------------------------------------------------------------------------------------ ##
# 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
## 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      3       2       0       4   0.3000     0


#----parameter values
# Initial  Lower_bound Upper_bound  Prior_type    Prior_1    Prior_2    Phase
    0.23      0.01         1            2          0.23        0.02      -4   # M for males
    1.6       0.0          2            0          0           0          3   # M for males
# Initial  Lower_bound Upper_bound  Prior_type    Prior_1    Prior_2    Phase
#    0.23      0.01         1            2          0.23        0.02      -4   # M for males
#    1.6        0.0         2            0          0           0          3   # M for males
#    0.1          -1         1             0        0.23        0.02      -4   # Dev par=1
#    0.2          -1         1             0        0.23        0.02      -4   # Dev par=2; linear
#    0.3          -1         1             0        0.23        0.02      -4   # Dev oar=3; power
```

```
## ===================================================================================== ##
## 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)  UPDATE 2.20.31: description now correct
# ##   6: Flat equal to one (1 parameter; phase must be negative)   UPDATE 2.20.31: description now correct
# ##   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                5             5           5         5 # 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, (2009-2024)
  1.0        0.001         1.0           0        0         1       3      0     #--directed fishery, (2009-2024)
  1.0        0.001         2.0           0        0         1      -2      0     #--directed fishery, (2009-2024). 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 (1978-2
  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

# EXTRA PARS: Initial  Lower_bound  Upper_bound Prior_type      Prior_1     Prior_2  Phase Reltve
#  0.1        0.001         1.0           0        0         1      -3      0     #--directed fishery, (2009-2024)
#  0.2        0.001         1.0           0        0         1      -3      0     #--directed fishery, (2009-2024)
#  0.3        0.001         2.0           0        0         1      -2      0     #--directed fishery, (2009-2024). Upper bound must = 2.0
```

```
# 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 - 2024)
#  123        110           200           0       1        900      -7      0   #--directed fishery (2009 - 2024)

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


### ==================================================================================== ##
## 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
##   -6) Dirichlet-Alt (Thorson et al 2016 rec'd)
## AUTOTAIL COMPRESSION
##   pmin is the cumulative proportion used in tail compression.
## ==================================================================================== ##
#  Pot_Fishery NMFS_Trawl ADFG_Pot
#   M    M    M
#  tot  tot  tot
#  N+S  N+S  N+S
#  I+M  I+M  I+M
  2   2   2     # Type of likelihood
  0   0   0     # Auto tail compression
  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
  0   1   2     # Survey to set Q for this comp
## ------------------------------------------------------------------------------------ ##
#--the number of parameters listed here must match the MAXIMUM composition splicer index
#      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
```