Aleutian Islands Golden King Crab Stock Assessment Draft Models

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November 2025

Response to Comments

SSC June 2025

Comment: "*The SSC supports the recommended OFL calculation approach as specified in the current assessment. For future consideration, the SSC recommends returning to calculation of a single OFL and ABC for the combined model results (as in 2017)*"

Response: See 'Combined OFL Calculation' section below in this document. . . . .

Comment: "*The SSC recommends continued exploration into either a single-area or a two-area spatially explicit model, noting that a two-area spatially explicit model may serve as a bridge between previous separate model approaches and a combined model approach.*"

Response: The current GMACS framework is not able to accommodate subpopulation dynamics. A combined model was explored here which considers the EAG and WAG subdistricts as different sexes The approach used here is effectively a spatially stratified model without movement. . . . .

Comment: "*The authors and CPT should provide a table reporting the historical OFL buffers used in this stock to inform future discussions on the incorporation of uncertainty (see General BSAI Crab Comments)*"

Response: This will be done for the final assessment. . . . .

Comment: "*The author and CPT should explore metrics to determine if changes in CPUE are due to changes in fishing behavior (e.g. changes in number of strings or number of pots per boat) as was suggested during public testimony*"

Response: Data confidentiality requirements limit what data and analyses can be shown to address this public testimony. Data were reviewed by ADF&G staff.

In a catch limit managed fishery, totals in the number of pots fished during a season is inextricably linked to CPUE and thus abundance. Instead, I summarized the number of declared pots at vessel registration and used daily fish log (DFL) data since 2017. DFL data contain the location, set date, haul date, number of pots and CPUE of each string. Thus, I could ascertain the number, density, and performance of active pots for each vessel at any point in the season. As a conservative approach, I summarized number of active pots in the context of the mid-point of each vessel's operations within a specific location. This is typically when they have the most active gear in the water, since number of active pots by day is approximately dome-shaped. Precise timing varies by vessel and location. Data were examined at locations that were fished by multiple vessels - though not necessarily always at the same time. Spatial scale included both statistical area and 10 sq km bins based on the center latitude and longitude of each string.

The *Aleutian No 1* consistently declares more pots at registration than the *Alaska Trojan*, and did increase pots markedly in 2023 after transferring gear from the *Patricia Lee*. The *Alaska Trojan* has also increased their declared pots gradually since 2010. In all years (except 2017), the *Aleutian No 1* has fished more pots on any given day during their season, than did the *Alaska Trojan*. On an annual basis, the number of actively fishing pots at the mid-point of the season has increased for both vessels in recent years, but more drastically for the *Aleutian No 1* in 2023, which aligns with what was declared at vessel registration. While the *Alaska Trojan* has seen a decrease in CPUE that started bottoming out in 2022, the *Aleutian No 1* saw a small CPUE increase after a period of decline, despite increasing the number of pots fished.

Only a handful of statistical areas have vessel overlap for most years in which DFL data are available. Among these, it is not clear that the *Aleutian No 1* considerably displaced the *Alaska Trojan*, except for maybe in 2023. In many of these stat areas, the CPUE of the *Alaska Trojan* did not appear to be negatively impacted. On a finer scale, I combined 10 sq km bins that did or did not have overlap with other vessels fishing concurrently. The trend in CPUE during the last few seasons for these designations is not necessarily the same, but not in stark contrast. **Taken together, it doesn't appear that lack of cooperation in the WAG is impacting fishing performance in a way that would downwardly bias the overall index of abundance used in the assessment**. That said, this is a very cursory look at the data. These data were not collected to monitor vessel overlap (i.e., no sampling design) and it is difficult to disentangle the appropriate spatial scale and timing of in-season overlap that is relevant.

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Comment: "*The author should explore mechanisms for examining the impact on CPUE from within crab fleet gear conflicts or fishing behavior as well as conflicts between crab fleet gear and the gear of the trawl fleet. The current bycatch data in the trawl fisheries may not be sufficient for this, but perhaps could be augmented with data on changes in effort or catch distribution changes*"

Response: This will be explored during a future assessment cycle. . . . .

Comment: "*The author is encouraged to work with ESR authors on developing risk recommendations related to environmental changes. The SSC notes there have been long term environmental changes taking place in the Western Aleutian region*"

Response: The author will coordinate with ESR authors prior to the 2026 final assessment. . . . .

Comment: "*The author should create a timeline of the various model changes that have occurred as the models have evolved to map those changes to the historical retrospective changes (see General BSAI Crab Comments)*"

Response: This will be provided in the 2026 final assessment. . . . .

Comment: "*A spatio-temporal model is encouraged. However, the inclusion of the interaction term between soak time and year may alias changes in relative abundance. Some rationale should be given as to including that interaction or this element should be eliminated*"

Response: Better rationale for a soak time:year interaction was included in Appendix A. To avoid convergence issues, the iteration used rationalization period instead of year. The purpose in estimating the effect of soak time temporally is to capture a more meaningful effect of soak time, as the functional form of that relationship changes as vessel dynamics in the fishery change. It is possible that soak time is as much a reflection of fishery dynamics, as it is of relative abundance. . . . .

Comment: "*Keep the SSC informed about future updates on the results from skipper surveys for informing the stock assessment about changes in fishing behavior*"

Response: Updates will be provided when available. . . . .

Comment: "*Continue to work toward developing fishery-independent indices for this stock*"

Response: Development of the 2016 - 2024 fishery independent index was not prioritized during this cycle. There was no 2025 cooperative survey. . . . .

CPT May 2025

Comment: "*Examine time-varying selectivity as a possible solution to the retrospective pattern for the EAG*"

Response: See models in the 26.1 series of this document. Retrospective analysis will be revisited during the final assessment. ....

Comment: "*Routinely report "historical analyses" in assessment reports*"

Response: Will present historical analyses in final SAFE documents. ....

Comment: "*Explore refinement of the estimates of size-at-maturity (separately for the WAG and EAG and for both areas combined)*"

Response: See Appendix B of this document. ....

Comment: "*Average stage-1 sample sizes using the harmonic mean and not the arithmetic mean when calculating inputs for the stock assessment*"

Response: Harmonic mean will be used if bootstrap estimated sample sizes are considered again. ....

Comment: "*When reporting jitter analyses, restrict the x-axis range so that it is possible to detect non-convergences to objective function values close to the putative MLE*"

Response: This will be done. ....

Comment: "*Investigate the possible use of the cooperative Aleutian Islands survey in the EAG for inclusion in future assessments*"

Response: The cooperative survey index was not prioritized this cycle. See models 25.1 and 25.1b in September 2024 (Jackson 2024, link in Literature Cited).} ....

Comment: "*Tyler should meet with the ESR group to identify potential indicators that could be applicable to AI golden king crab.*"

Response: The author will coordinate with ESR authors prior to the 2026 final assessment. ....

CPT September 2024

Comment: "*CPT requested that a risk table for AIGKC be brought forward in May.*"

Response: See Appendix C of the 2025 final assessment. ....

SSC June 2024

Comment: "*The SSC requests the rationale for using the terminal year minus four year approach to define the reference period for future assessments*"

Response: See plots below. The CPT recommended using 1987 - 2021 during the 2025 final assessment and adding a year sequentially after that. The reference time series was chosen because recruitment deviations are estimated with reasonable precision during that time period following the method used for other BSAI crab stocks. There was not rigorous analysis of the optimal reference period.

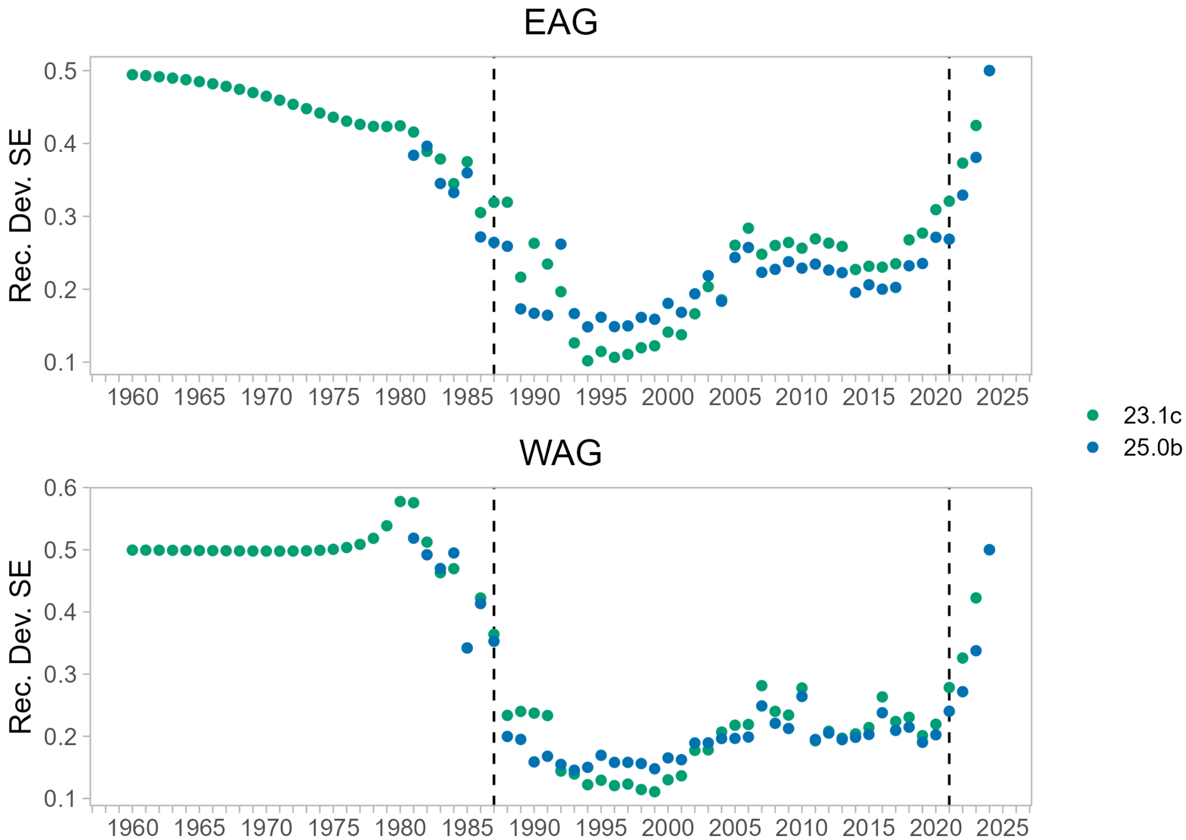

Figure 1: Standard errors of recruitment deviations for models 23.1c and 25.0b. Dotted lines indicate the reference time series for mean recruitment used in reference point calculation, 1987 - 2021.

Comment: "*The SSC recommends that the CPT explore whether to conduct this final assessment on the same cycle as other crab assessments in September/October to better align the assessment with the annual cycle of catch mortality.* "

Response: ADF&G and the CPT do not think moving the timing of the final assessment to September would be suitable because the fishery opens in August.

Comment: "*The SSC recommends prioritizing further consideration of data weighting, as the Francis re-weighting continues to be an issue in this assessment.*"

Response: See draft models from September 2024 (Jackson 2024, link below).

Comment: "*The SSC places a high priority on incorporating information from the cooperative survey into the assessment and supports the CPT recommendation to incorporate this survey as a separate fleet.*"

Response: See response above.

Comment: "*Further examination of the retrospective pattern in terms of magnitude, direction and cause continues to be important.*"

Response:

retrospective pattern in MMB appears to arise from data conflict that also results in poor fit to post rationalization observer CPUE in the EAG, which has the same retrospective pattern. Data conflict is less apparent in the WAG. Jackson 2024 discusses model misspecfication, but more work is necessary.

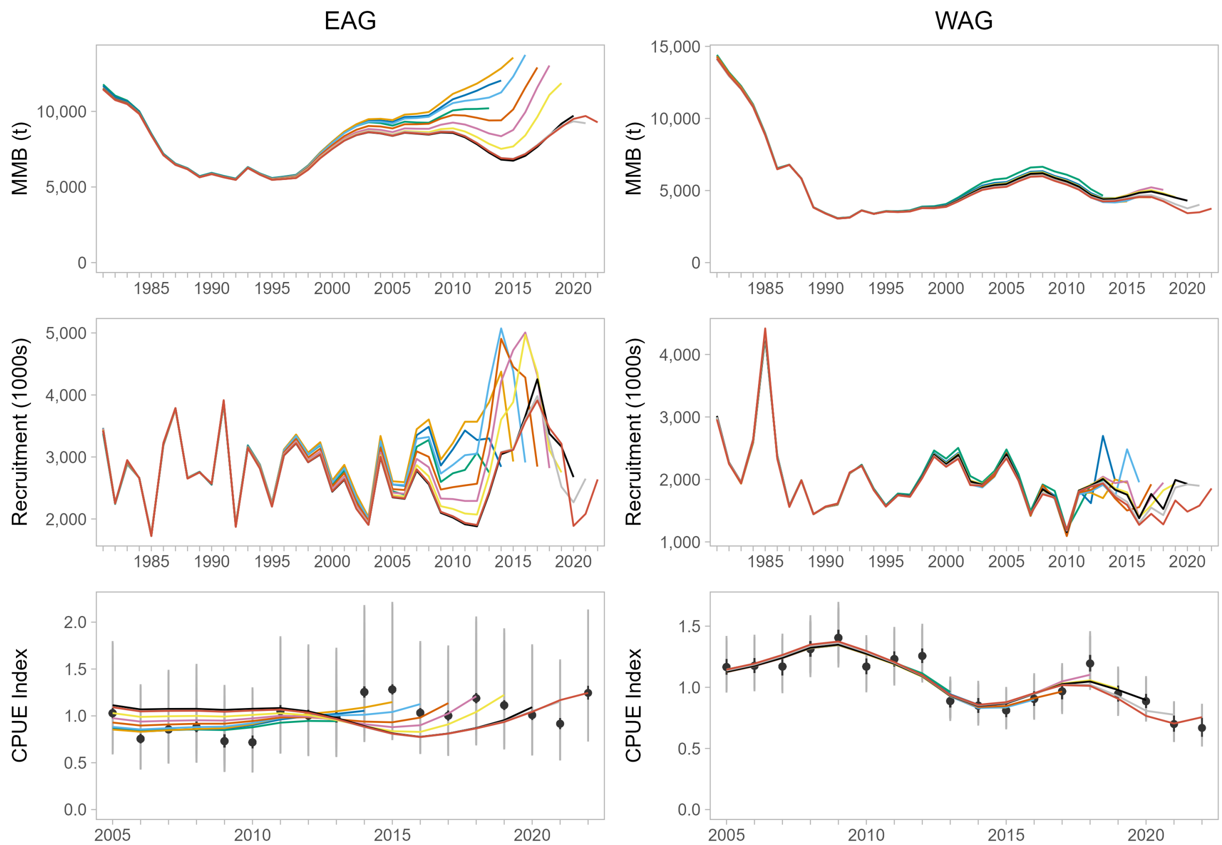

Figure 2: MMB trajectory, recruitment, and fits to observed CPUE index for EAG retrospective peels up to 10 years.

Comment: "*The CPT suggested that next year's model should be 25.0. The SSC reminds the CPT and authors that new model year numbers are only applicable if there is a major structural model change.*"

Response: Noted.

Comment: "*The current method of projecting the remaining landings for the current incomplete season seems overly complicated and the SSC recommends a more straightforward method for determining total catch be considered, such as basing it on the average fraction harvested to date.* "

Response: See Section D.2.f of the 2025 final assessment (Jackson 2025).

CPT May 2024

Comment: "*Use the standard convention for model numbering, i.e. the models for the May 2025 assessment, will be 25.xx and not 24.xx.*"

Response: This is done.

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Comment: "*Document why the 1993 bycatch and total catch size-composition data are not included in this and past assessments.*"

Response: There was no observer coverage in the 1993 crab year for EAG directed fishing and for WAG, most pots were previously removed because they were of unknown size. Those pots are now included for size composition data only, which also affects total catch estimation.

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Comment: "*Explore reasons for the retrospective pattern for the EAG.*"

Response: See above. This work is ongoing.

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Comment: "*Consider models for the EAG and WAG that allow for the bias-correction in recruitment, especially given there is virtually no information in the data on the sizes of the recruitments before 1985.*"

Response: See model 23.1c.

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Comment: "*Include the EAG cooperative survey data (index and size-composition) as an additional fleet.*"

Response: See models 25.1 and 25.1b of Jackson (2024).

. . . .

Comment: "*Fit models that assume that the size-composition data are Dirichlet-multinomial distributed instead of Francis weighting the size-composition data.*"

Response: See models 25.0c and 25.0d of Jackson (2024).

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Comment: "*Explore the reasons for the implausible values for groundfish fishing mortality in some years for some of the retrospectives and some of the jitter runs.*"

Response: This was presented at the May 2024 Plan Team meeting. The model estimated a large recruitment pulse preceding 1996, which appeared to allow for better fit to 1996 observer index data. Because size composition data in the directed fishery and the base natural mortality rate could not support such a recruitment pulse, the model 'killed off' the extra crab in the bycatch fishery which does not have associated composition data and large CV. Running the model with a .pin file that specifies appropriate starting values for F deviations or increasing the penalty on F deviations in that fleet resolves the issue.

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Comment: "*Consider starting the model in a non-equilibrium state around 1981.*"

Response: See all models subsequent of mode 25.0a and 26.0a in this document.

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Comment: "*Revisit estimation of size-at-maturity given the addition of new data.*"

Response: See Appendix B of this document.

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Comment: "*Continue exploration of CPUE standardization, including investigation of models with block:year interactions and using geostatistical methods.*"

Response: CPUE standardization using a spatiotemporal model was explored here, but will be refined and used in the assessment model during the next cycle.

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Comment: "*Explore time-varying catchability (e.g. as blocks) rather than the use of additional variance to reconcile the trends in CPUE and those in abundance. Given the known difficulties estimating time-variation in catchability, this could be explored as part of a simulation study – with initial discussions at the January 2025 modeling workshop.*"

Response: Model 26.1b and 26.1c in this analysis explore time-varying catchability, but also estimation additional observation error.

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SSC Feb 2024

Comment: "*The SSC recommends that any new substantial standardization changes should be reviewed during the next cycle, not during specifications in May/June 2024*

Response: The only revisions to CPUE standardization between model explorations and the final assessment addressed poor model diagnostics, though this will be noted for the future.

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CPT Jan 2024

Comment: "*The CPT recommends that the CPUE standardization be revised for the 2024 assessment by:*

- *exploring the use of a Tweedie instead of the negative binomial distribution;*
- *dropping the data for gear types 4 and 13 which have few observations;*
- *reporting DHARMa residuals and providing influence plots as additional diagnostics; and*
- *exploring the basic data used for the fish ticket CPUE index because the data on which the standardization is based for the current analyses include many zero observations – this may be because the extracted data may include trips for red king crab in the Aleutians. If the residual pattern for the fish ticket analysis (Fig. 44 of Appendix B) is not resolved, results should be presented in May 2024 for model runs that use and ignore the fish ticket CPUE index.*"

Response: All of these recommendations were addressed in CPUE standardization in 2025 model explorations.

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Comment: "*Include measures of uncertainty (for at least one model configuration) in the plots for the estimates of recruitment and MMB*

Response: This has been addressed.

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Comment: "*Include a plot of the survey index overlaid on the observer CPUE index (EAG)*

Response: This plot will be included in documents that evaluate models containing survey data.

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Comment: "*Describe why the MMB for the EAG declines substantially before 1980 while this is not the case for the WAG*

Response: This is explained in the 2025 final assessment (Jackson 2025).

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Comment: "*Start the y-axis for the plots of recruitment and MMB at zero*

Response: This has been addressed.

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Comment: "*Include the number of parameters in likelihood tables*

Response: This has been addressed.

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Comment: "*Apply jittering to ensure that the reported parameters correspond to the global minimum of the objective function.*

Response: Jitter analysis is now standard procedure for this assessment.

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Model Explorations

Poor fit to the index data in the EAG and the associated retrospective pattern in MMB continues to be the primary issue with the AIGKC assessment. Model explorations during the 2025 assessment cycle focused largely on data weighting, specifically as it relates to size composition and catch data. Alternative input sample sizes and using a Dirichlet multinomial likelihood function did little to resolve apparent data conflict, and an updated version of the 2024 accepted model (23.1c) was used to determine management specifications for 2025/26. Recent CPT recommendations suggest exploring time varying selectivity as a means to address model misspecification. Here, I examine changes in fleet dynamics over time in relation to current assumptions about selectivity and catchability in the directed fishery. In addition, I revisited non-equilibrium initial conditions, a spatiotemporal GLMM approach for CPUE standardization, size at maturity, and a combined EAG / WAG model. Models evaluated in this document include (See Figure 3 for flow chart):

- **23.1c**: base model, accepted for specifications in May 2025;
- **25.0a**: Model 23.1c, non-equilibrium initial conditions starting in 1981 and equal emphasis factors on all likelihood components;
- **26.0**: Model 23.1c, with spatiotemporal standardized CPUE index, catchability time-blocks 1995 - 2004 and 2005 - 2024;
- **26.0a**: Model 26.0, non-equilibrium initial conditions starting in 1981 and equal emphasis factors on all likelihood components;
- **26.1**: Model 26.0a, with additional subdistrict-specific time blocks on directed fishery selectivity;
- **26.1a**: Model 26.0a, with a random walk on directed fishery selectivity from 2005 - 2024;
- **26.1b**: Model 26.0a, with additional subdistrict-specific time blocks on directed fishery catchability;
- **26.1c**: Model 26.1, with additional subdistrict-specific time blocks on catchability.

Updates to Base Model

The 2025 final assessment was conducted using GMACS version 2.20.21. This document uses the updated version 2.20.31. A log of changes made between versions can be found at the bottom of the ADMB 2.20.31 template file (gmacsbase.tpl). None of the changes affect features used by the current AIGKC assessment. There are no differences in likelihood components or reference points for model 23.1c (Table 1 and 2).

Size at Maturity

Appendix B details an updated analysis on size at maturity. The analysis includes updated data from the at-sea observer program and ADF&G special collections. This analysis also explores differences between estimation methods used by Olson et al. (2018) and Siddeek (2022), as well as likelihood profiles and bootstrap distributions of estimated size at maturity by data source. Since size at maturity is only used for computing harvest specifications and does not influence model performance, no alternative models with varying size at maturity are presented here. The CPT should consider whether it is worth bringing forward harvest specification options with updated size at maturity for the 2026 final assessment, or if the status quo (116 mm CL) should remain until a more refined estimate is available.

Intitial Conditions and Catch Emphasis

Previous assessment models started in 1960 assuming the population was in an unfished state, with no fishing mortality until 1981 (Jackson 2025). Model 25.0a starts in a non-equilibrium state in 1981 and initial numbers at size were estimated from parameters representing initial recruitment (R_{init}) and scaled deviates for each size class. The size bin at which crab first become legally retained, 136 - 140 mm CL, was used as the reference size class. This model previously considered in September 2025, but was not brought forward for the 2025 final assessment. In addition to starting in non-equilibrium conditions, model 25.0a uses equal likelihood emphasis ($\lambda = 1$) for all catch data series.

Spatiotemporal GLMM CPUE Index

Appendix A details estimation of an abundance index based on CPUE standardization using a spatiotemporal GLMM in the R package *sdmTMB* (Anderson et al. 2024). The 'best' model estimated legal male CPUE as a function of gear type (i.e., pot size) and smooth effects of soak time and depth. Vessel was included as a random effect and spatiotemporal random effects were IID. Aside from model parameterization, this approach differs from previous assessments in that does not split CPUE standardization into pre- (1995 - 2004) and post-rationalization (2005 - present) periods. Rather, standardized CPUE is input to GMACS as a single index with time varying selectivity and catchability (detailed below). All 26.x models use the standardized CPUE index estimated in Appendix A.

Time Varying Selectivity and Catchability

Models 26.0 and 26.0a assumed time blocks for selectivity and catchability corresponding to changes in fishing operations before and after crab rationalization (i.e., 2005). These models differed in initial conditions and emphasis on catch data as described above. In May 2025 the CPT recommended revisiting selectivity time blocks in response to unresolved poor fits to EAG index data. Process error associated with selectivity and catchability here are likely related to changing fleet dynamics. It is important to clarify that "selectivity" in this context refers to the combination of animal availability to fishing grounds and selectivity by the gear (Sampson 2014). During the pre-rationalized era there was a greater number and diversity of fishing vessels with more competitive, overlapping fishing grounds and less selective fishing behavior. Crab rationalization resulted in a drastic downsizing of the fleet in both subdistricts initially, and since then there has been further consolidation of vessels and vessel-specific fishing grounds (Figure 4 - 6). These changes in fleet dynamics are clearly evidenced by observer data, but unaccounted for in the post-rationalized era.

Models in the 26.1 series explored time blocks in the post-rationalization specific to vessel composition of observer data in the EAG and WAG (since CPUE index is computed using observer data). Note that instances exist where vessels may have fulfilled observer coverage requirements in the broader AIGKC fishery, but may not be represented in the observer data at the subdistrict level (e.g., only one trip was made to the EAG and during an unobserved leg of the season). These circumstances were rare and likely not influential. Additional EAG time blocks included the the early post-rationalization fleet consolidation from 2005 - 2007, a period from 2018 - 2013 after further consolidation, a period from 2014 - 2021 corresponding to the swap of the *F/V Aleutian No. 1* and *F/V Patricia Lee*, and from 2022 to present after the departure of those vessels. WAG time blocks include 2005 - 2015 when the fishery was dominated by three vessels, 2016 - 2020 when the *F/V Early Dawn* was present and the *F/V Patricia Lee* was not, and from 2021 to present when most observed data were collected aboard the *F/V Alaska Trojan* and *F/V Aleutian No. 1* (Figure 4).

Model 26.1 used the proposed block structure for selectivity, while maintaining a single post-rationalization block for catchability. Model 26.1a was the same as model 26.1, but estimated selectivity as a random walk since crab rationalization. Model 26.1b used the proposed block structure for catchability, while maintaining a single post-rationalization block for selectivity, and model 26.1c used the proposed post-rationalization time blocks for selectivity and catchability.

Combined Model

Progress toward a combined subdistrict model for AIGKC has been a repeating recommendation by the SSC and was last presented to the CPT in January 2024. Currently, the GMACS framework does not directly accommodate multiple spatial domains. The previous approach integrated subdistricts as different directed fleets with a combined bycatch fleet based on model 23.1b (Jackson 2024). A drawback of this approach is that it does not allow for area specific recruitment deviations, which are evident in the recruitment estimates of each subdistrict. The CPT recommended treating the subdistricts as different sexes as a potential work around in GMACS allowing some model processes to be shared, while allowing greater flexibility in others.

Here, the 'base' combined subdistrict model was most closely based on model 25.0a and used the EAG as the reference sex class. The model started in non-equilibrium conditions in 1981 with initial numbers at size estimated using 136 - 140 mm CL in the EAG as the reference class. Recruitment sex ratio deviations were estimated for all years and recruitment size distributions differed between subdistricts. Weight at length, size at maturity, natural mortality were shared. Subdistrict specific models estimate growth using the same tagging data which was collected in the EAG with releases in 1991, 1997, 2000, 2003, and 2006 (Siddeek et al. 2016). The GMACS framework does not allow growth functions to be mirrored between sexes and tagging data cannot be specified as belonging to both sexes. As a stop-gap, the data were simply duplicated so molt probability and growth transition matrices could be estimated separately for either subdistrict. Directed catch, index, and size composition data were input as the same fleet, but different series by subdistrict. Bycatch data were combined because GMACS would not allow different discard moralities by sex for the same year (i.e., discard mortalities are different for EAG and WAG due to differing proportions of trawl and fixed gear bycatch). Selectivities, rentention, and catchability were estimated separately for each subdistrict. The timing of the fishery was recomputed for each year using EAG and WAG start and end dates combined. One small alteration made to GMACS 2.20.31 was to bypass the SPR sex ratio feature during reference point calculation to allow for full contribution of EAG and WAG MMB.

In addition to the model described above (AI 25.0a), model AI 26.1 used directed fishery selectivity time blocks as in EAG/WAG 26.1 and AI 26.1a modeled selectivity in the post-rationalization era as a random walk.

Retrospective Analysis and Jittering

Retrospective analysis was not performed for 26.x models due to technical difficulties associated with time blocks for catchability. These issues will be resolved before the final assessment in May. Previous analyses have demonstrated that strong retrospective patterns in the EAG likely arise from model mispecification that also leads to poor fits to CPUE index data. Thereby, models presented here that better fit index data will presumably also have improved retrospective patterns. Jittering analysis from the 2025 final assessment provided strong support for convergence to the MLE for model 23.1c (Jackson 2025). Jittering was performed here for models 26.1 and 26.1b using a jitter factor of 0.3 and 100 iterations as in the 2025 final assessment (Jackson 2025).

Model Comparisons

Intial conditions and catch emphasis

Equal emphasis on catch data series had little impact on fits to data, as expected (Figure 7 and 8). Small differences in scale of recruitment in the 1990's and since 2019 lead to slight differences in MMB in EAG. There is some difference in recruitment during the 1990's in the WAG, but recent trends are more similar (Figure 9 and 10). It is unclear why initial conditions lead to different recruitment scales in recent years, but note that this pattern was also present in model 25.0a, which weighted catch data similar to model 23.1c (Jackson 2024). Nevertheless, starting the model in 1981 is preferred as it slightly reduces the number of estimable parameters and eliminates the issue of relative high equilibrium MMB and recruitment before the data time series.

Spatiotemporal GLM CPUE index

Standardized observer CPUE index derived from a spatiotemporal model that included all years from 1995 - present resulted in a slightly different index in each rationalization period (Appendix A). Likewise, inputting a single index with catchability time blocks corresponding to crab rationalization had little impact on fits to index data and derived quantities (Figure 9 - 10). Model 23.1c should remain as the 'base' model for 2026 final assessment for posterity, but from a practical standpoint, the author would expect to favor model 26.0 or 26.0a as a 'base' alternative.

Time varying selectivity and catchability

Models 26.1 - 26.1c explore variability in the fishing process in relation to vessel dynamics. All scenarios that added selectivity blocks during post-rationalization improved fit to CPUE data and reduced observation error in the EAG (Table 6, Figure 11). As anticipated, model 26.1a was the most flexible and fit index data best. Models with catchability blocks fit marginally better than model 26.1 (Figure 11). Model 26.1 suggests that selectivity in the EAG was lower in the first half of the rationalized era (2005 - 2013), increased after the introduction of the F/V Patricia Lee (2015), and became steeper when the fleet consolidated to two vessels in 2022. Selectivity in model 26.1a followed a similar pattern, though with more interannual variability, especially during the period from 2008 - 2013 (Figure 14). Catchability in the EAG increased with each additional time block, while selectivity of model 26.1b was similar to model 26.0, and model 26.1c was less variable (Figure 15 and 14). WAG models fit index data more similarly, and model 26.1a appeared to over fit data. Selectivity time blocks were less variable that in the EAG, and there was less apparent directionality in the selectivity random walk in model 26.0a (Figure 14). Catchability estimates increased with successive time blocks, as in the EAG, except for model 26.1c during the 2021 - 2024 time block (Figure 15).

Fits to size composition data were nearly identical among all 26.x models, despite selectivity differences in the EAG (Figure 16). All models in both subdistricts underestimate total size composition proportions of 101 - 105 mm CL crab and the first two legal size classes (136 - 145 mm CL) (Figure 16 - 26). Residual patterns in total size composition data may be in part due to misfits to first year tag returns, which underestimate average molt increment in most sizes less than 140 mm CL (Figure 27 and 28). All models fit tagging data similarly, which was expected given all tag returns were specified as having been during one year of the pre-rationalization selectivity period. Siddeek et al. (2016) lists tag releases in 1991, 1997, 2000, 2003, and 2006. It is possible that timing of tag releases was dropped for simplicity during the transition to GMACS. It is worth revisiting original growth data and growth parameterization to address residual patterns in identified here. In addition, tag releases were planned for the WAG during the 2025/26 season, which hopefully generate new area-specific growth data in coming years.

Models estimated similar recruitment trajectories in the EAG until $\sim$ 2015. Model 26.0a was most similar to the base model (Figure 9). Models with selectivity time blocks did not estimate a dip in recruitment in 2022 and 2023, in fact, model 26.1c suggested recruitment continually increased from 2020 to 2023. Model

26.1b estimated a more drastic decline in recruitment from 2015 to 2022 than other models, and a strong increase during the previous two years (Figure 29). Recruitment estimates in the WAG were similar among models, expect for model 26.1a, which estimated an peak in recruitment from 2020 - 2022 as opposed to the decrease estimated by other models (Figure 29).

MMB estimates in the EAG differed in scale throughout the 2000s, but followed a similar trend. Since 2010, MMB trajectories differ based on whether multiple post-rationalization time blocks were included. Models 26.1, 26.1a, and 26.1c all estimated peaks in MMB that corresponded to MMB peaks in the WAG, though models 26.1 and 26.1a estimated a stationary trend since $\sim$ 2014, whereas model 26.1c estimated a decreasing trend (Figure 30). WAG models had less variability in MMB estimates, with model 26.1a being the exception. Model 26.1a estimated a steeply increasing MMB trend since 2021, following a strong recruitment pulse in that year which corresponded to a spike in the proportion of immature-sized crab in the composition data. That recruitment pulse was not well represented in subsequent CPUE data and estimated selectivity for 2023 and 2024 was lower than previous years - that is, the increase in MMB was likely due to the highly flexible selectivity of model 26.1a.

Assigning process variability erroneously has been shown to have adverse consequences to management advice (Fisch et al., 2023; Szuwalksi et al., 2018). Specifically, risk is most associated with mischaracterization of which process is time varying. Others have demonstrated that there is less downside if process variability is modeled in the correct process, but over-parameterized (Cronin-Fine And Punt 2021; Stewart and Monnahan 2017). Index data used here is solely fishery dependent, and fishers are incentivized to optimize high CPUE with reduced sorting by varying soak times and fishing locations. Furthermore, fleet consolidation has likely increased the influence of the highest performing vessels and fishing behaviors, prompting concerns of hyperstability. Given the history of fleet consolidation and variation in fishing behavior, it is highly plausible that time varying selectivity and/or catchability is applicable to the post-rationalization era for AIGKC.

All models that included post-rationalization process variation improved fit to EAG CPUE data, with little impact to fits to other data components. For the most part, it seems that when catchability and selectivity were allowed to vary together (model 26.1c), time varying catchability overpowered variability in selectivity. There appeared to be less consequence associated with choice of process in the WAG, though the random walk on selectivity was clearly over-paramaterized. In the EAG, the choice of how to structure selectivity variation was less clear, and there did appear to be changes to derived quantities and reference points that warrant caution (Table 8). Although a case could be made for allowing either process - or both - to vary, diagnostic analyses necessary for making a well informed recommendation were lacking here. For that reason, it may be worthwhile to bring several models forward for the final assessment assuming more in depth model diagnostics can be performed then. Model 23.1c should remain the base model and model 26.0a will bridge changes in initial conditions and CPUE standardization. Models 26.1 and 26.1b will evaluate time varying selectivity and catchability as a step function corresponding to fleet dynamics, respectively. A random walk on selectivity eliminated the subjective nature of time block designations, but is perhaps too flexible for use in harvest specifications in lieu of a more thorough investigation of process variation.

Jittering

Jittering analysis did not indicate obvious convergence issues in either subdistrict. Of 100 runs, models 26.1 and 26.1b converged in 91 and 81 run respectively. All runs converged to the MLE (Table 10), although the analysis should explore a larger jitter factor should jittering during the 2026 assessment yield a similar result. Jittering of WAG models indicated other minima. Both models 26.1 and 26.1b had 90 jitter runs converge, though with 72 (26.1) and 67 (26.1b) at the MLE (Table 10; Figure 31).

Combined Model

Combined models fit all data components similar to subdistrict-specific models, except observer CPUE (Figure 32 - 35). Poorer fit to CPUE data among combined models is likely the result of small changes in selectivity patterns for each subdistrict (Figure 36). Recruitment trends mostly mirrored subdistrict-specific models, but diverged after $\sim$ 2016, where EAG recruitment decreased and WAG recruitment increased (Figure 37). Trends in MMB had a similar discrepancy from subdistrict-specific models (Figure 38). A more thorough investigation of combined model diagnostics is needed during the next development cycle, particularly with respect to data weighting among subdistricts. The analysis presented here demonstrates progress toward a combined model, but explored too many model scenarios to examine specific concerns in detail. A combined model should be evaluated again in 2026, considering only parameterizations based on 2026 accepted models for each subdistrict. Additional, the author requests more specific guidance from the CPT and SSC as to the priority of a combined model relative to recommendations concerning the subdistrict-specific models.

Combined OFL Calculation

Since the AIGKC is considered a single sock, though separate subdistrict models have been maintained to date, it is necessary to combine ic OFL calculations. In 2017 (when the tier 3 assessment was first adopted), the CPT and SSC considered two approaches (May 2017 CPT Report):

1. Apply the OFL control rule by area and sum the OFLs by area;
2. Determine stock status for the whole stock by adding the estimates of current MMB and B_{MSY} by area. This stock status is then used to determine the ratio of F_{OFL} to $F_{35\%}$ by area, which is then used to calculate the OFLs by area, which are then added together to calculate an OFL for the entire stock.

That is, to apply the F_{OFL} control rule by subdistrict using a combined stock status ($B/B_{35\%}$) and subdistrict specific $F_{35\%}$. The SSC and CPT recommendation in 2017 was to follow the second approach that used a combined stock status. The reasoning for the choice was that the first approach would result in subdistricts being in different tiers of the F_{OFL} control rule (EAG Tier 3a, WAG Tier 3b). The 2018 final assessment reverted back to applying the F_{OFL} control rule separately by subdistrict (Siddeek et al. 2018; C-3 Council Motion, June 2018), which is the approach that seems to have been used since. The SSC recommended returning to the 2017 F_{OFL} calculation following the 2024 and 2025 final assessments. Table 11 details F_{OFL} from the 2025 final assessment using separate and combined stock status.

The choice of which approach to use seems to be a process oriented question. ADF&G treats the EAG and WAG as distinct stocks to a practical extent when setting the total allowable catch (TAC). Exploitation rates on mature male abundance are subdistrict specific (EAG 15%; WAG 20%) in the state harvest strategy and distinct TACs are set for each subdistrict. Although TACs for this stock are based solely on assessment model outputs, federal catch limits (i.e., ABC/OFL) rarely limit TAC setting. ADF&G generally has not considered risk of exceeding subdistrict specific reference points in TAC setting to date, though divergent population trends and increased conservation concern in the WAG likely warrants some consideration for the subdistrict specific management advice of the federal control rules. Under present conditions, combining stock status and recomputing F_{OFL} would have the effect of applying surplus biomass in the EAG to harvest opportunity in the WAG. While a larger F_{OFL} in the WAG may not necessarily equate to a larger TAC, the logic does not align with precautionary management of the subdistricts individually. In lieu of more comprehensive understanding of stock connectivity, it may be more prudent to remain with the status quo approach.

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Tables

Table 1: Comparison of likelihood components for EAG models 23.1c using GMACS version 2.20.21 and 2.20.31.

	EAG		WAG	
Component	v2.20.21	v2.20.31	v2.20.21	v2.20.31
Catch	-479.864	-479.864	-456.703	-456.703
Index	-44.874	-44.874	-69.515	-69.515
Size	827.284	827.284	1,016.130	1,016.130
Recruitment	19.200	19.200	24.486	24.486
Tagging	2,697.523	2,697.523	2,697.060	2,697.060
Penalites	0.152	0.152	0.075	0.075
Priors	26.793	26.793	26.793	26.793
Total	3,046.213	3,046.213	3,238.325	3,238.325

Table 2: Comparison of reference point estimates for EAG and WAG models 23.1c using GMACS version 2.20.21 and 2.20.31.

Subdistrict	Version	MMB (t)	$B_{35\%}$ (t)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2021}$	$F_{35\%}$	F_{OFL}	OFL (t)
EAG	2.20.21	6,879	6,730	1.02	2,689	0.52	0.52	2,394
EAG	2.20.31	6,879	6,730	1.02	2,689	0.52	0.52	2,394
WAG	2.20.21	3,570	4,530	0.79	1,817	0.51	0.39	765
WAG	2.20.31	3,570	4,530	0.79	1,817	0.51	0.39	765

Table 3: Comparison of likelihood components for models 23.1c and 25.0a.

	EAG		WAG	
Component	23.1c	25.0a	23.1c	25.0a
Retained Catch	-444.083	-108.413	-442.161	-105.275
Total Catch	-67.045	-30.813	-43.957	-5.732
Groundfish Bycatch	31.264	31.267	29.415	29.415
Obs CPUE 1995 - 2004	-9.763	-9.957	-10.251	-11.458
Obs CPUE 2005 - 2024	-20.600	-21.231	-42.250	-41.692
FT CPUE 1985 - 1998	-14.511	-13.816	-17.014	-17.056
Retained Size Composition	486.483	449.129	612.911	517.462
Total Size Composition	340.801	315.351	403.219	331.059
Recruitment	19.200	12.600	19.200	12.600
Tagging	2,697.523	2,698.711	2,697.523	2,698.711
Penalties	0.152	0.150	0.152	0.150
Priors	26.793	73.387	26.793	73.387
Initial Conditions	0.000	0.614	0.000	0.614
N Parameters	164.000	160.000	162.000	158.000
Total NLL	3,046.213	3,396.979	3,238.325	3,488.786

Table 4: Comparison of likelihood components for EAG models 26.0, 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

Component	26.0	26.0a	26.1	26.1a	26.1b	26.1c
Retained Catch	-443.957	-108.129	-107.985	-106.820	-108.121	-107.985
Total Catch	-66.816	-30.706	-30.681	-27.183	-30.782	-30.375
Groundfish Bycatch	31.269	31.276	31.278	31.269	31.269	31.267
Obs CPUE 1995 - 2024	-32.857	-33.936	-45.506	-49.800	-45.037	-46.004
FT CPUE 1985 - 1998	-14.303	-13.631	-13.126	-12.279	-13.707	-13.688
Retained Size Composition	483.145	451.151	451.456	472.902	413.579	423.828
Total Size Composition	335.395	306.462	314.130	158.911	327.224	291.843
Recruitment	19.138	12.529	12.432	12.916	13.305	12.830
Tagging	2,697.432	2,698.610	2,699.043	2,702.855	2,698.442	2,698.790
Penalties	0.152	0.150	0.150	0.150	0.155	0.156
Priors	27.486	74.080	96.018	66.766	60.265	82.203
Initial Conditions	0.000	0.602	0.613	0.624	0.732	0.700
N Parameters	163.000	159.000	165.000	197.000	162.000	168.000
Total NLL	3,036.084	3,388.458	3,407.823	3,250.311	3,347.325	3,343.565

Table 5: Comparison of likelihood components for WAG models 26.0, 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

Component	26.0	26.0a	26.1	26.1a	26.1b	26.1c
Retained Catch	-441.675	-105.013	-105.041	-101.604	-105.131	-105.119
Total Catch	-37.920	-4.085	-3.950	1.935	-4.012	-3.704
Groundfish Bycatch	29.412	29.413	29.412	29.412	29.410	29.411
Obs CPUE 1995 - 2024	-47.508	-51.209	-53.935	-82.252	-54.834	-54.459
FT CPUE 1985 - 1998	-17.308	-17.210	-17.208	-17.541	-17.347	-17.287
Retained Size Composition	589.201	505.562	472.872	452.491	469.431	464.290
Total Size Composition	368.245	323.144	341.773	328.958	341.911	339.307
Recruitment	23.808	17.879	18.411	17.452	19.164	18.832
Tagging	2,698.047	2,700.540	2,700.765	2,703.404	2,700.487	2,700.581
Penalties	0.074	0.074	0.074	0.071	0.075	0.075
Priors	27.486	74.089	88.714	66.774	64.878	79.503
Initial Conditions	0.000	0.683	0.750	0.773	0.765	0.773
N Parameters	161.000	157.000	161.000	195.000	159.000	163.000
Total NLL	3,191.863	3,473.867	3,472.637	3,399.872	3,444.797	3,452.203

Table 6: Estimates of added CV for observer CPUE index data by model.

Subdistrict	26.0a	26.1	26.1a	26.1b	26.1c
EAG	0.20	0.13	0.12	0.14	0.13
WAG	0.11	0.10	0.04	0.10	0.10

Table 7: Francis (2011) weights for size composition data by model.

	EAG		WAG	
Subdistrict	Retained	Total	Retained	Total
26.0a	0.229	0.624	0.146	0.487
26.1	0.229	0.602	0.167	0.448
26.1a	0.212	1.190	0.183	0.467
26.1b	0.266	0.572	0.168	0.447
26.1c	0.255	0.656	0.172	0.452

Table 8: Comparison of biological reference points for EAG models 26.0a, 26.1, 26.1a, 26.1b, and 26.c.

Model	MMB (t)	$B_{35\%}$ (t)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2021}$	$F_{35\%}$	F_{OFL}	OFL (t)
26.0	6,671	6,737	0.99	2,695	0.51	0.51	2,276
26.0a	6,843	6,707	1.02	2,670	0.52	0.52	2,315
26.1	7,268	6,575	1.11	2,618	0.50	0.50	2,137
26.1a	6,801	6,491	1.05	2,580	0.51	0.51	2,006
26.1b	5,250	6,548	0.80	2,606	0.52	0.41	1,234
26.1c	6,100	6,472	0.94	2,576	0.53	0.49	1,493

Table 9: Comparison of biological reference points for WAG models 26.0a, 26.1, 26.1a, 26.1b, and 26.c.

Model	MMB (t)	$B_{35\%}$ (t)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2021}$	$F_{35\%}$	F_{OFL}	OFL (t)
26.0	3,615	4,520	0.80	1,811	0.52	0.41	791
26.0a	3,531	4,518	0.78	1,803	0.54	0.41	747
26.1	3,476	4,509	0.77	1,798	0.52	0.39	686
26.1a	4,819	4,493	1.07	1,785	0.58	0.58	1,404
26.1b	3,176	4,499	0.71	1,794	0.53	0.36	565
26.1c	3,337	4,500	0.74	1,794	0.53	0.38	611

Table 10: Summary of 100 jitter runs with sd = 0.3 for models 26.1 and 26.1b.

Subdistrict	Model	No. Converged Runs	No. at MLE	Max Gradient	MLE
EAG	26.1	91	91	0.00958	3,407.8227
EAG	26.1b	81	81	0.00921	3,347.3252
WAG	26.1	90	72	0.00726	3,472.6375
WAG	26.1b	90	67	0.00959	3,444.7972

Table 11: MSY proxy reference points from the 2025 final assessment in comparison to the combined approach reccommended by the SSC.

Subdistrict	MMB (t)	$B_{35\%}$ (t)	Status	$F_{35\%}$	F_{OFL}	Combined Status	F_{OFL} (Combined)
EAG	6,879	6,730	1.022	0.515	0.515	0.928	0.474
WAG	3,570	4,530	0.788	0.514	0.393	0.928	0.473

Figures

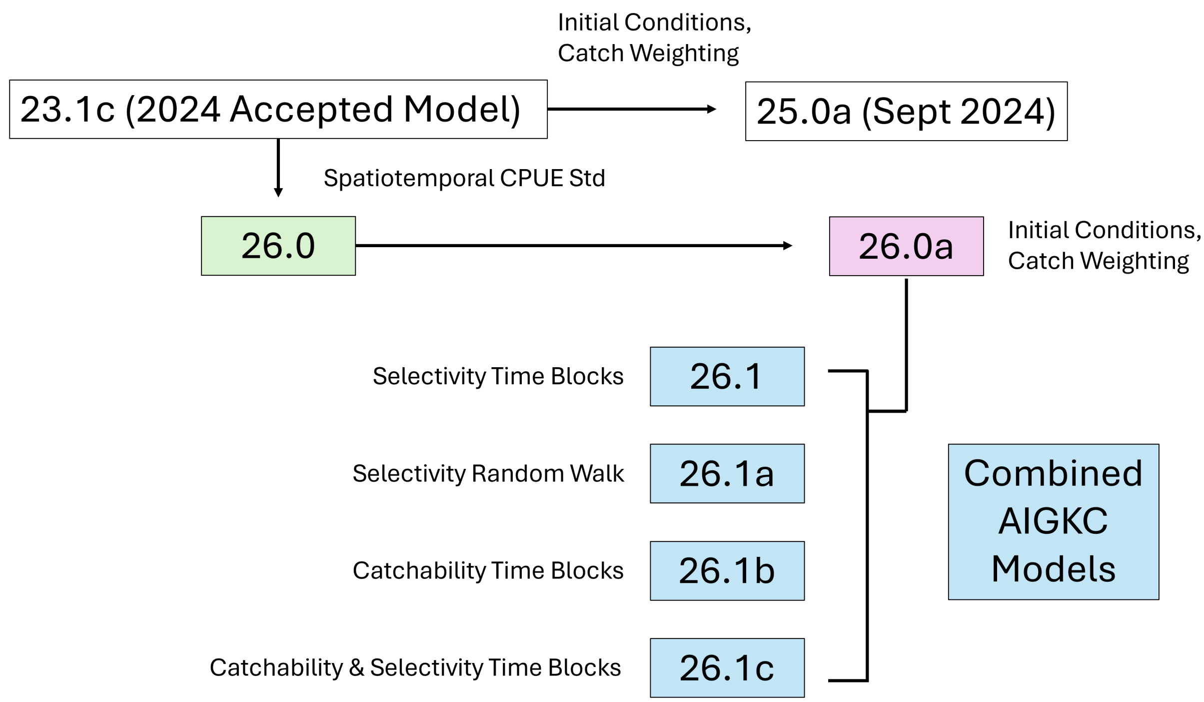

Figure 3: Flow chart of models evaluated in this analysis. Combined models were based on models 26.0a - 26.1c.

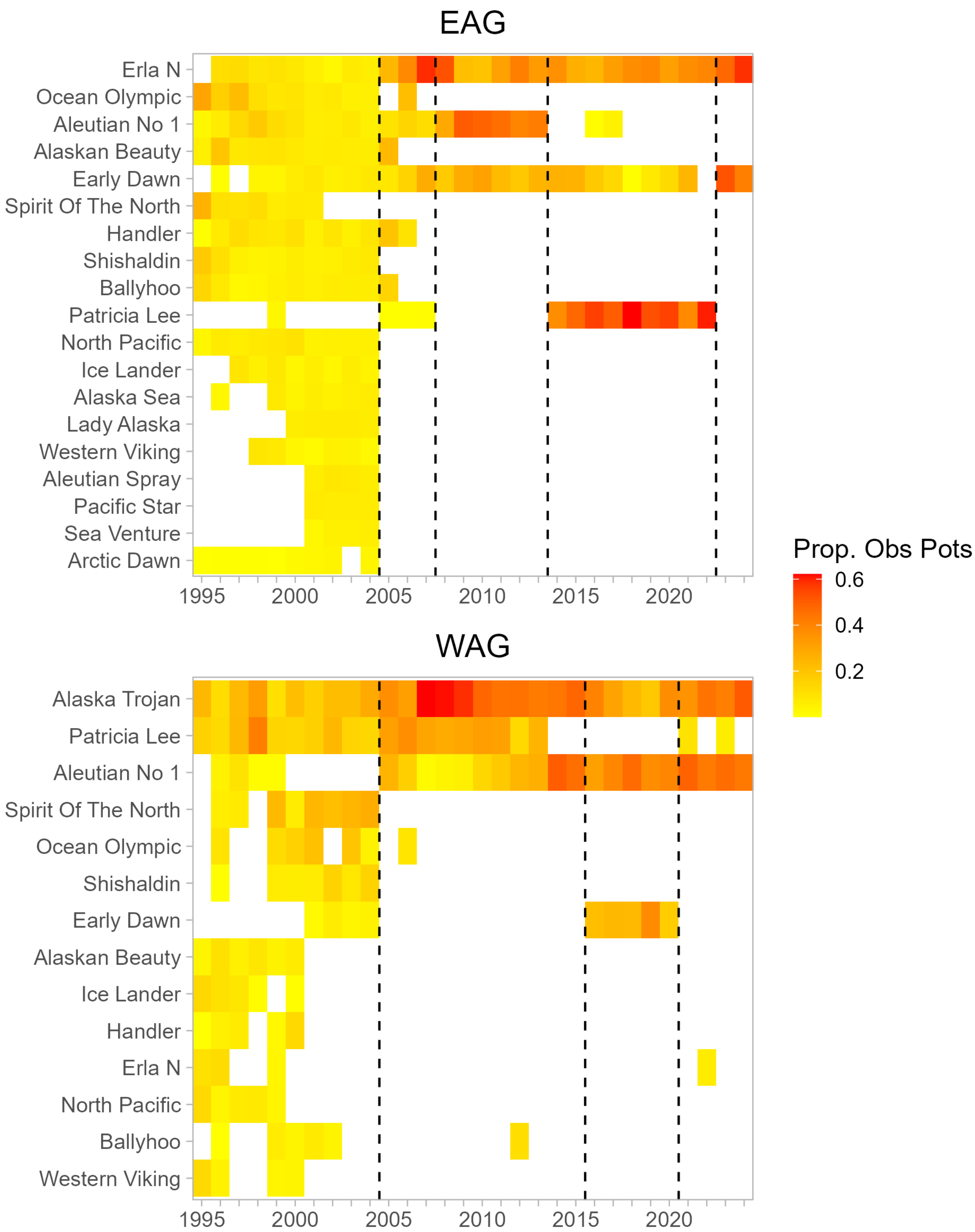

Figure 4: Proportion of observer pots by vessel and year in the EAG and WAG.

Figure 5: Vessels fishing the most observed pots within 10 km^2 cells in the EAG. Different vessels are denoted by color, and locations have been disorted while preserving clusters to protect data confidentiality.

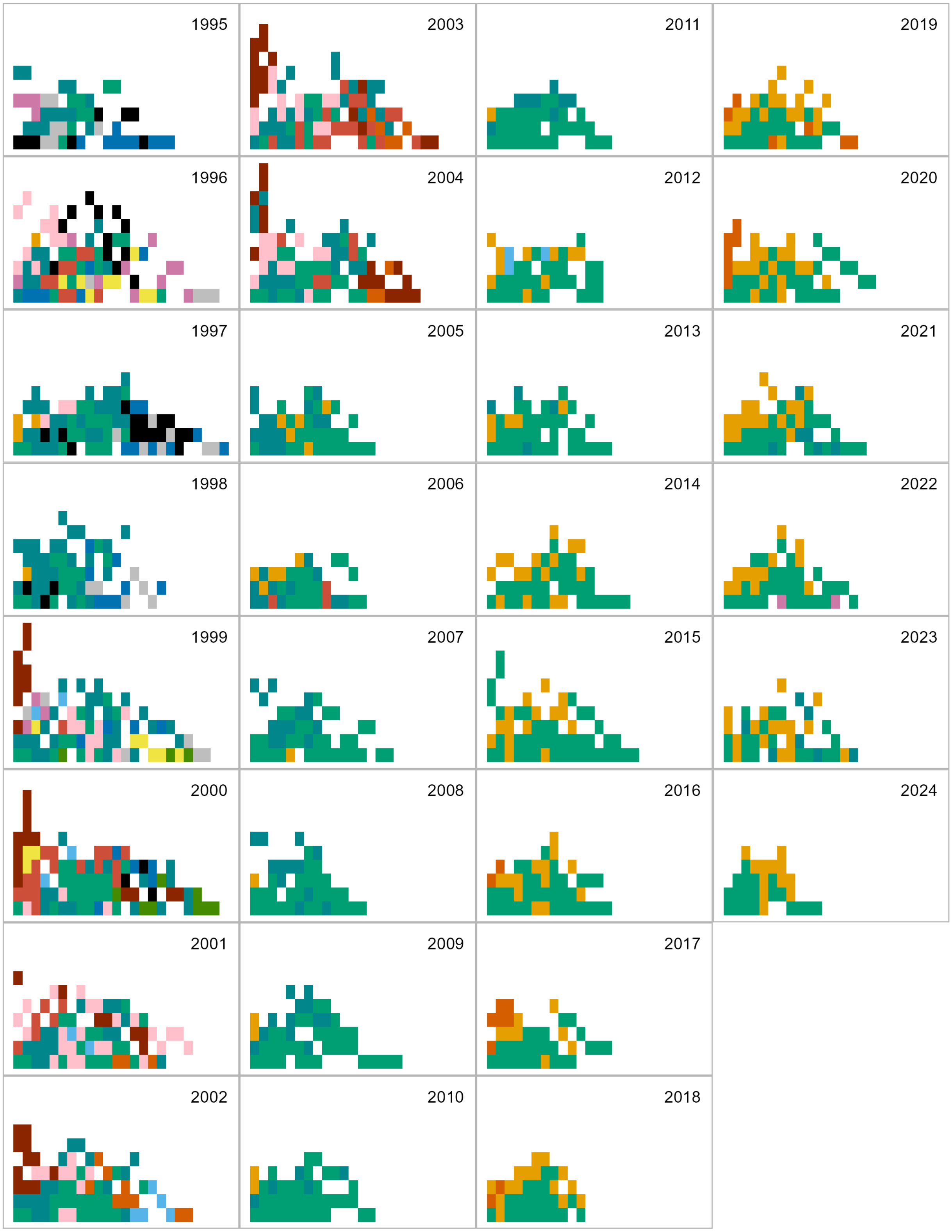

Figure 6: Vessels fishing the most observed pots within 10 km^2 cells in the WAG. Different vessels are denoted by color, and locations have been disorted while preserving clusters to protect data confidentiality.

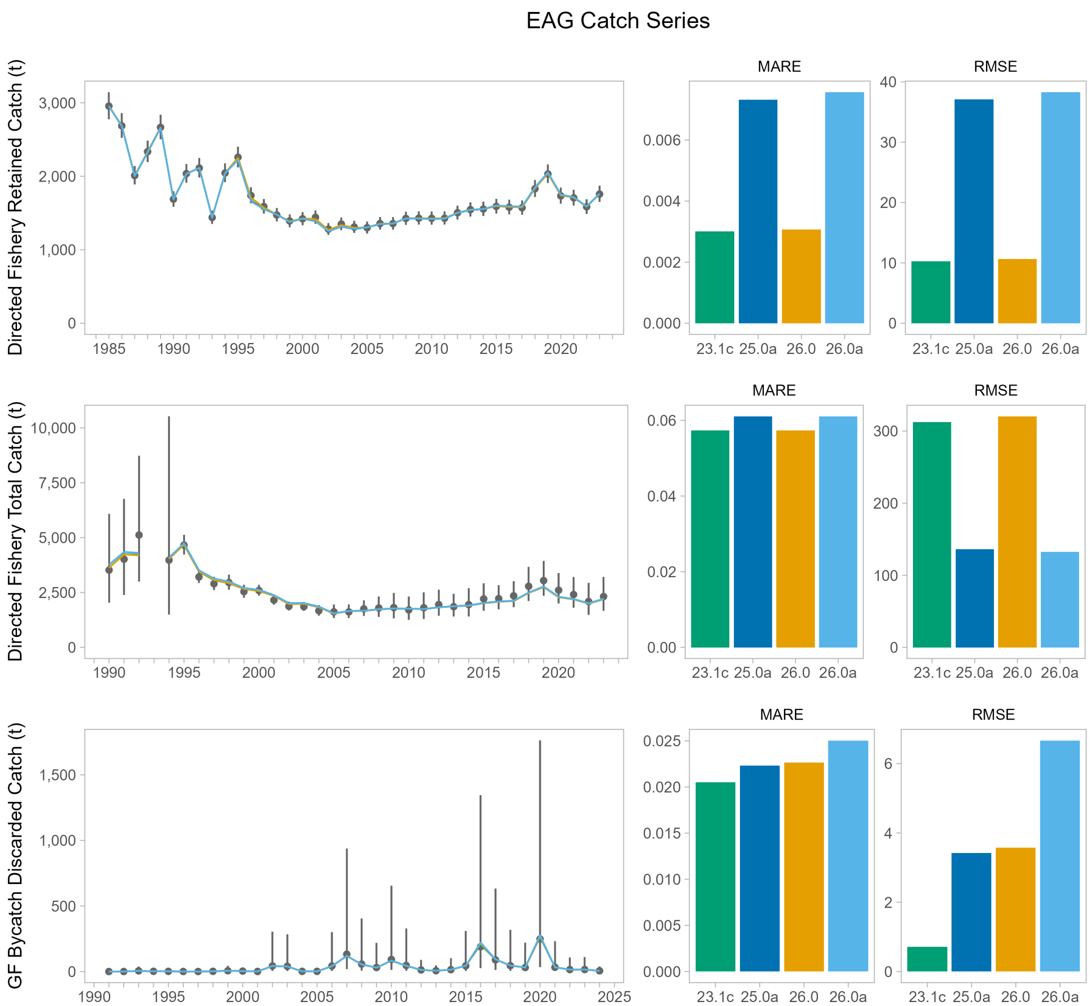

Figure 7: Fits to catch data and associated Mean Absolute Residual Error and Root Mean Square Error for EAG models 23.1c, 25.0a, 26.0, and 26.0a.

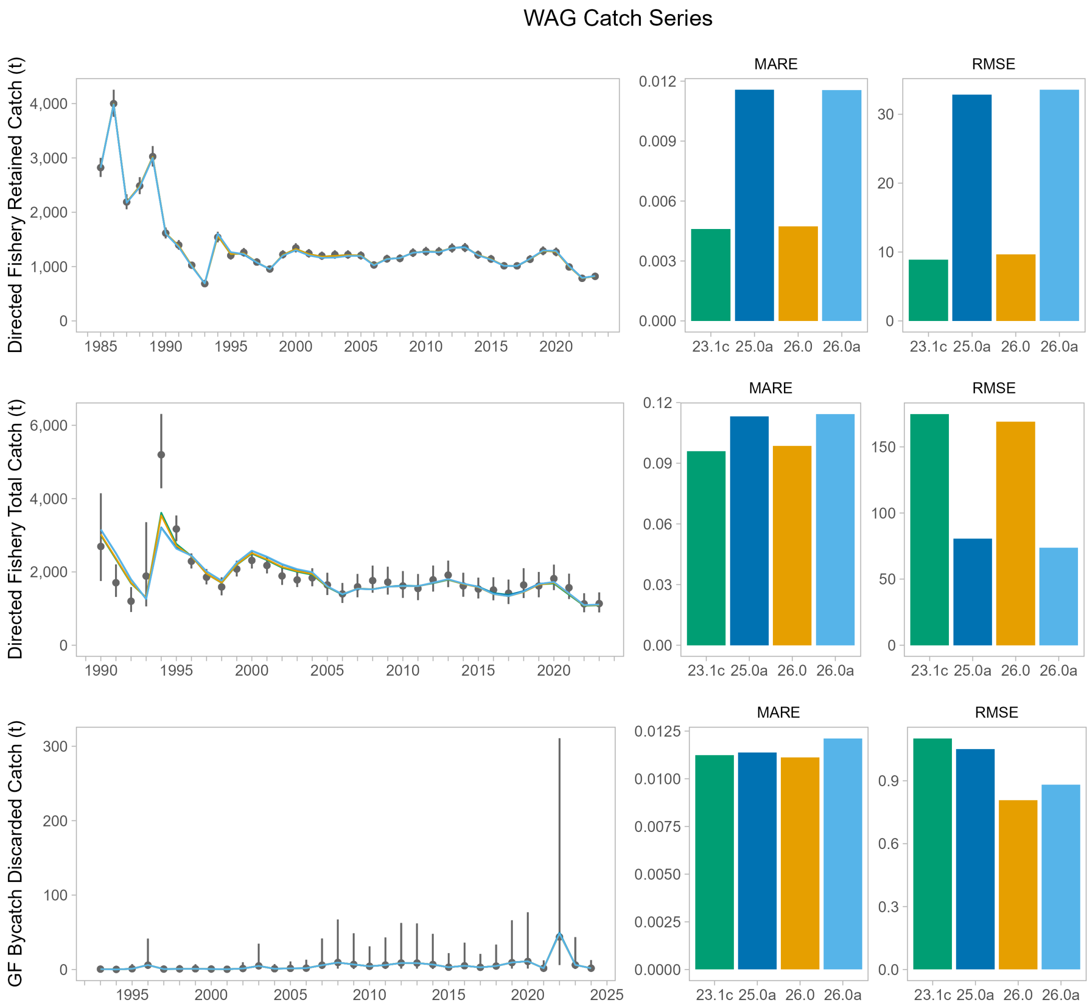

Figure 8: Fits to catch data and associated Mean Absolute Residual Error and Root Mean Square Error for WAG models 23.1c, 25.0a, 26.0, and 26.0a.

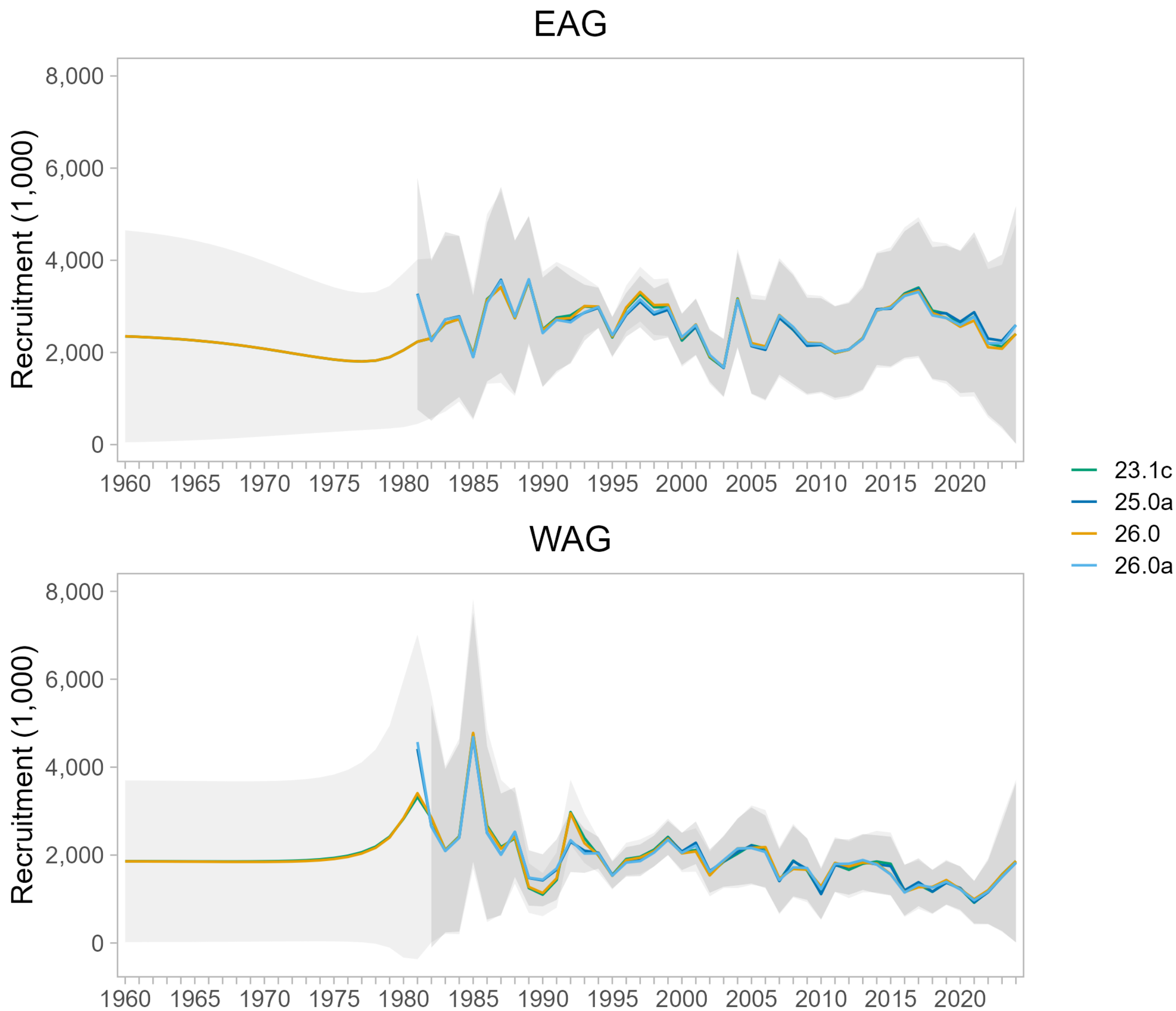

Figure 9: Recruitment estimates for models 23.1c, 25.0a, 26.0, and 26.0a. Shaded area indicates 95//% confidence intervals for model 23.1c and 25.0a.

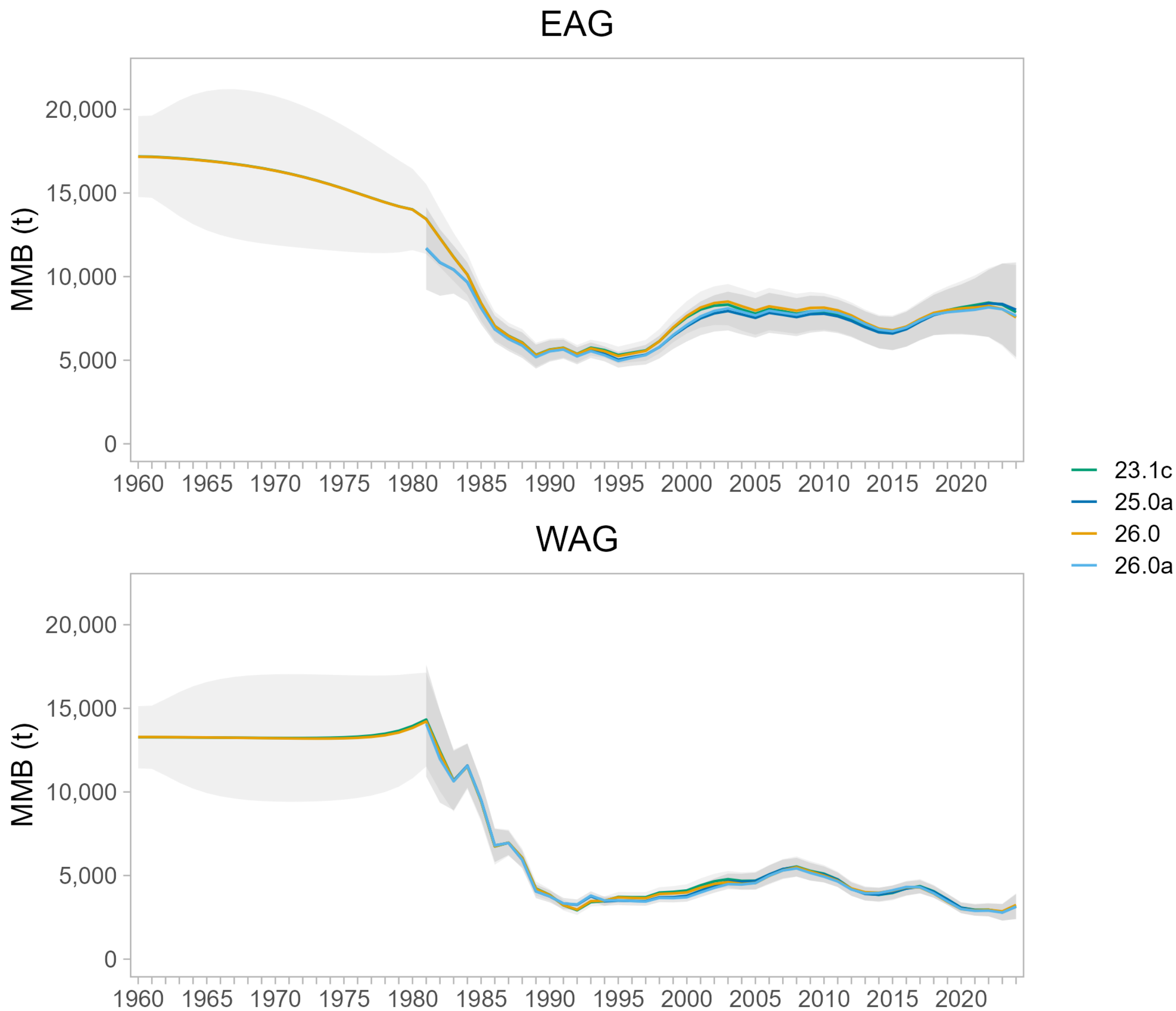

Figure 10: Mature male biomass estimates for models 23.1c, 25.0a, 26.0, and 26.0a. Shaded area indicates 95//% confidence intervals for model 23.1c and 25.0a.

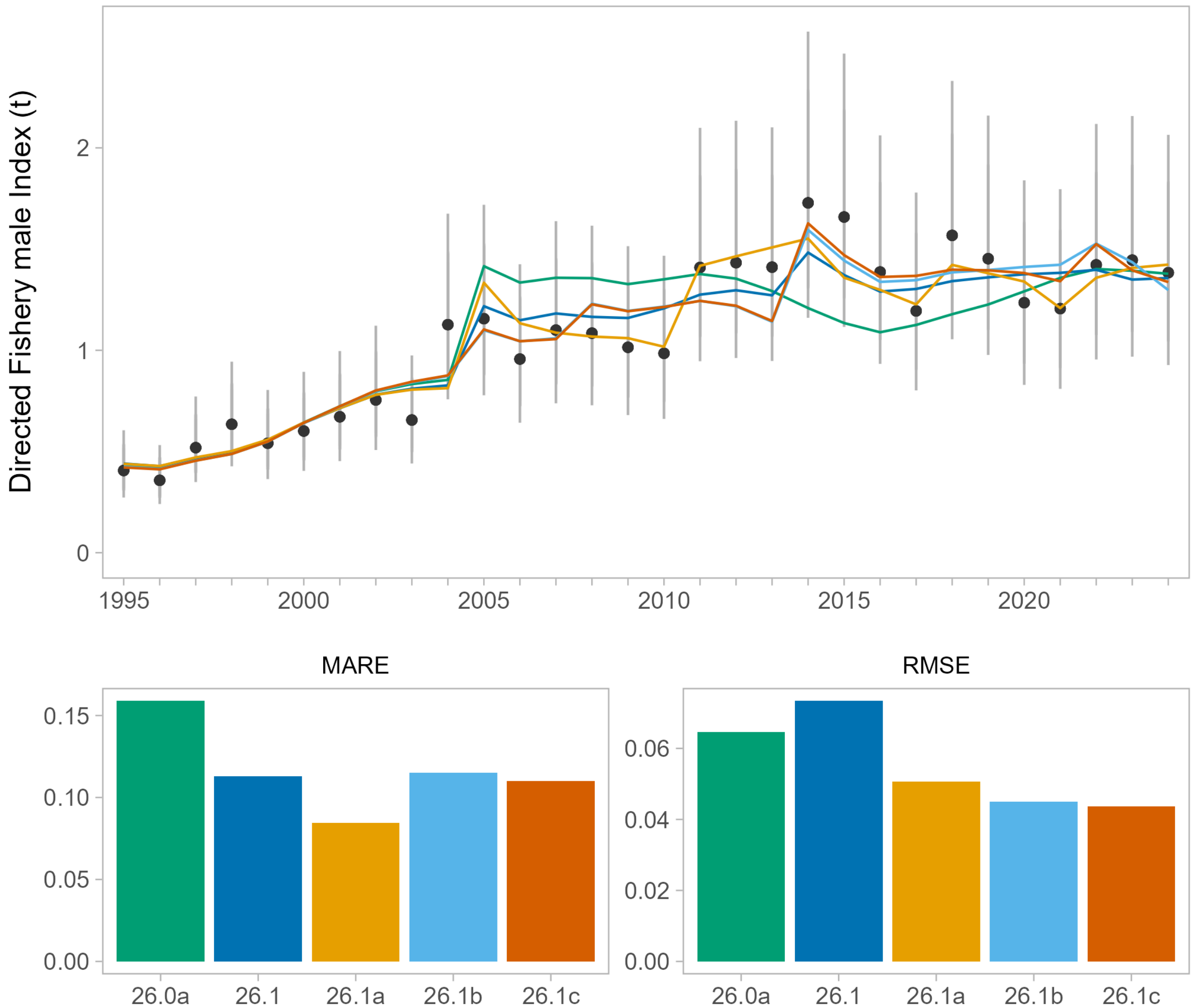

Figure 11: Fits to index data and associated Mean Absolute Residual Error and Root Mean Square Error for EAG models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c. Addition error (grey bars) is based on model 26.0a.

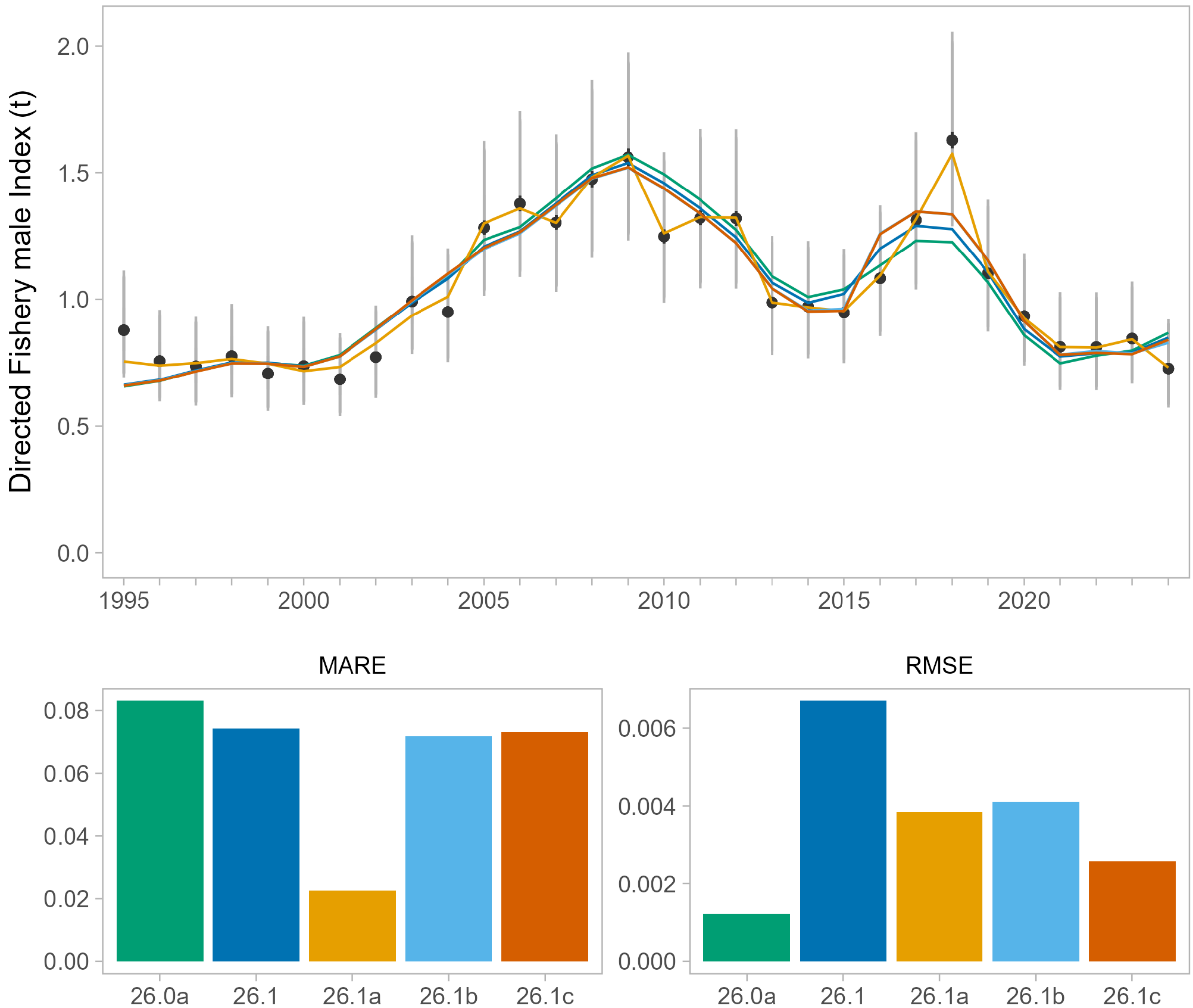

Figure 12: Fits to index data and associated Mean Absolute Residual Error and Root Mean Square Error for WAG models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

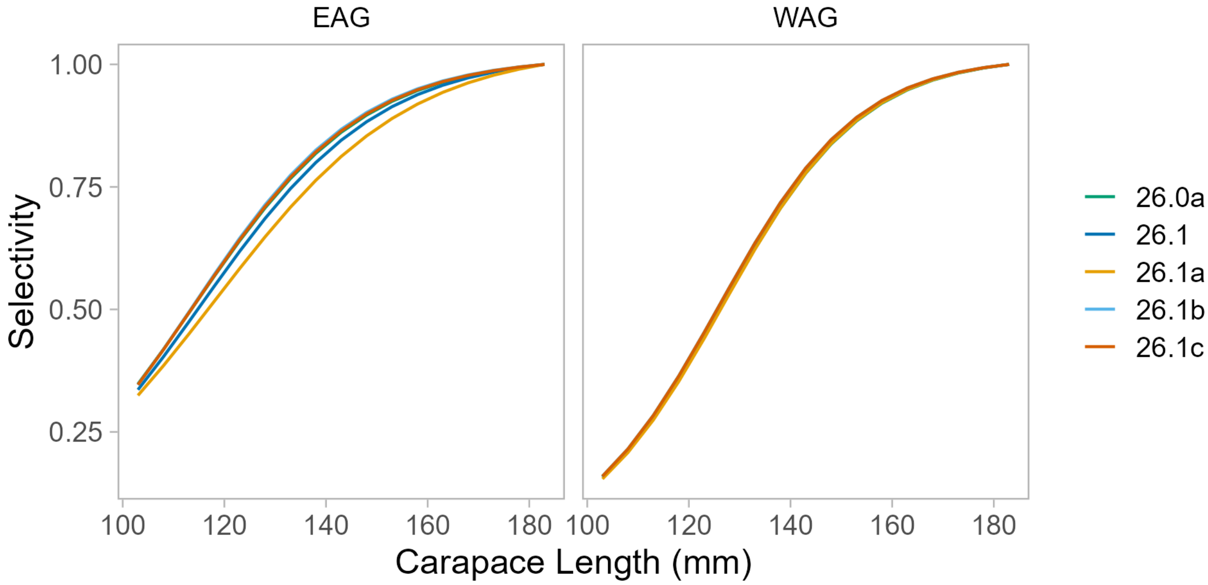

Figure 13: Selectivity in the pre-rationalization era (1981 - 2004) for models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

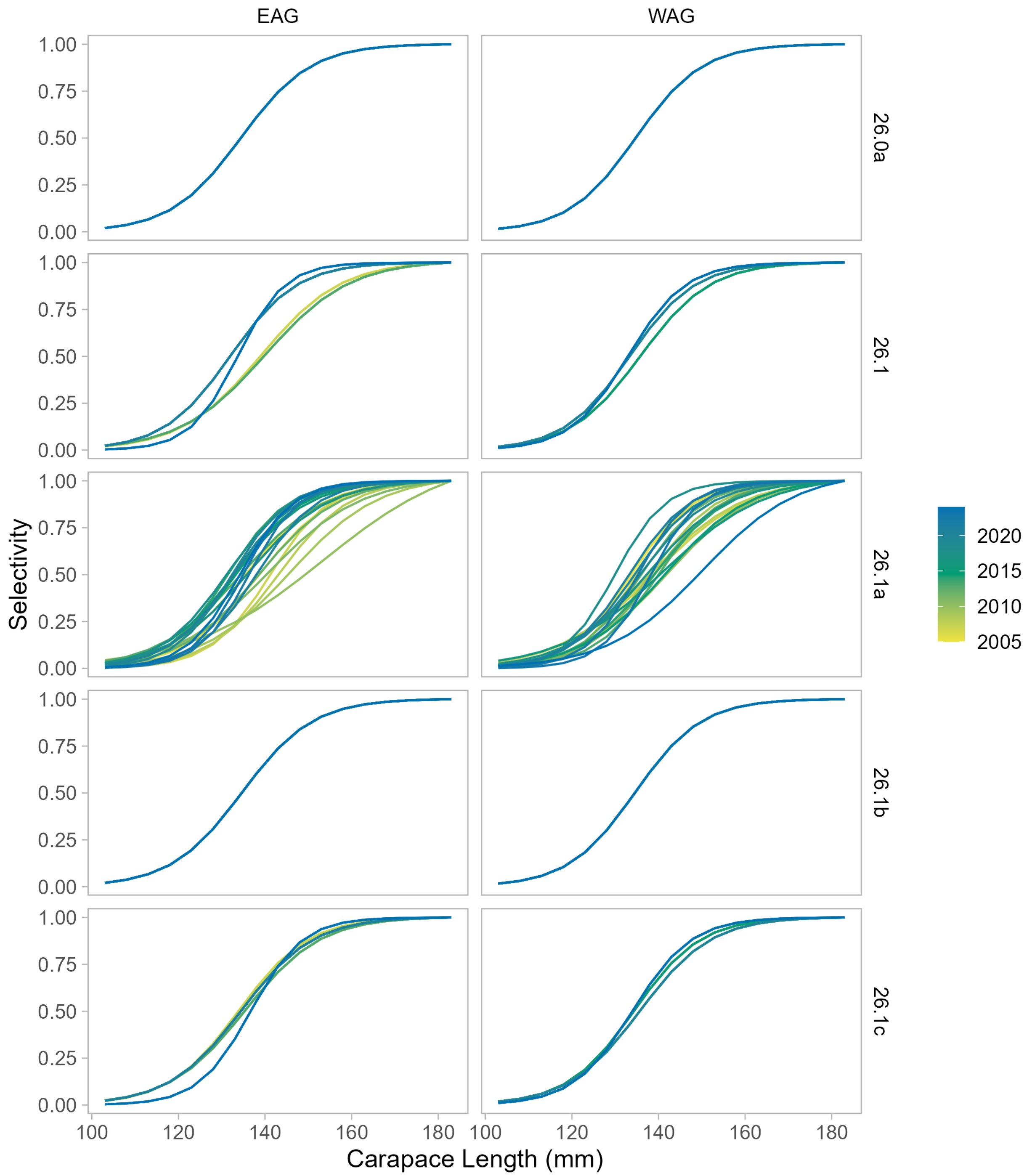

Figure 14: Selectivity in the post-rationalization era (2005 - 2024) for models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

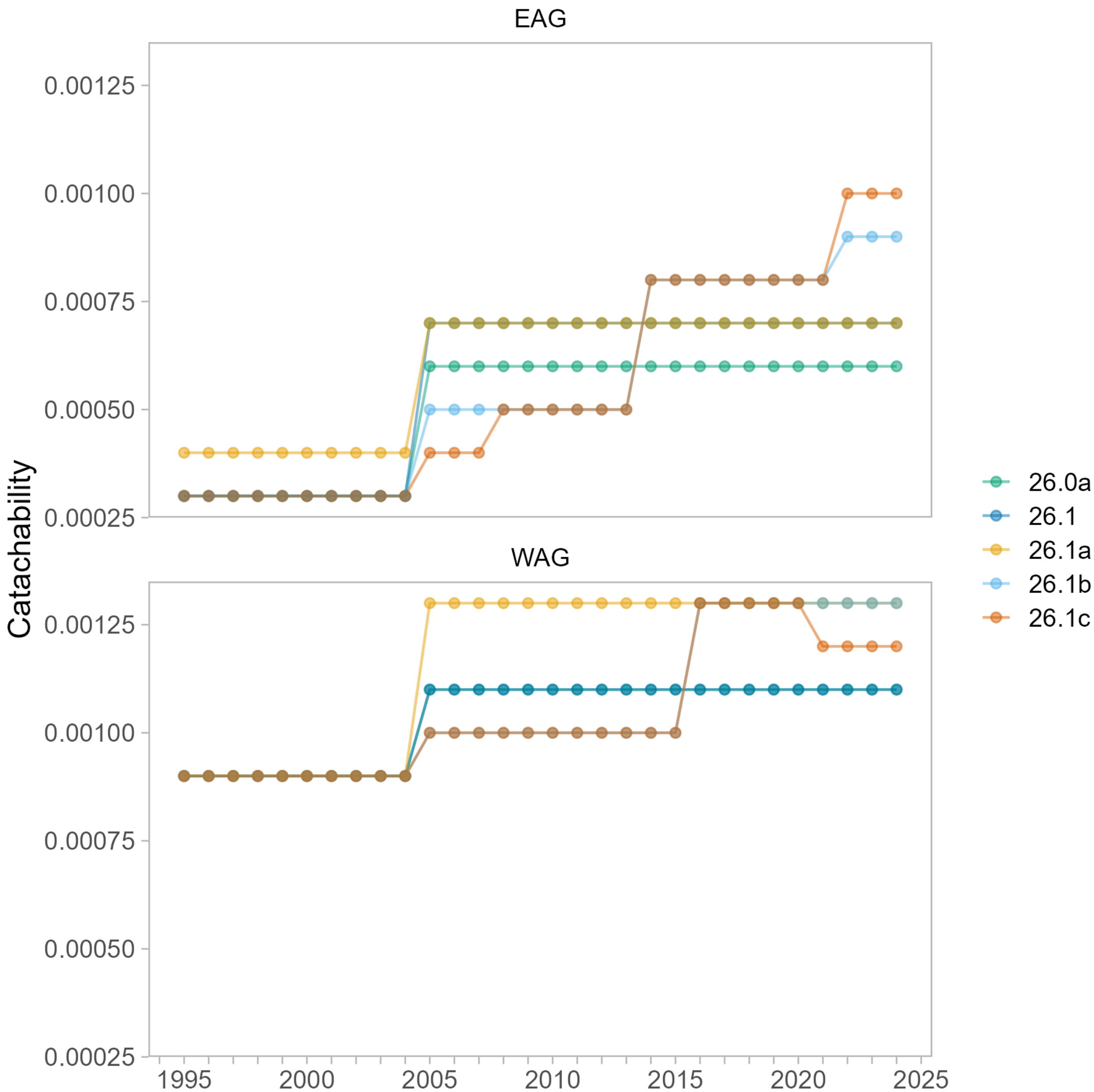

Figure 15: Time blocks in catachability for models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

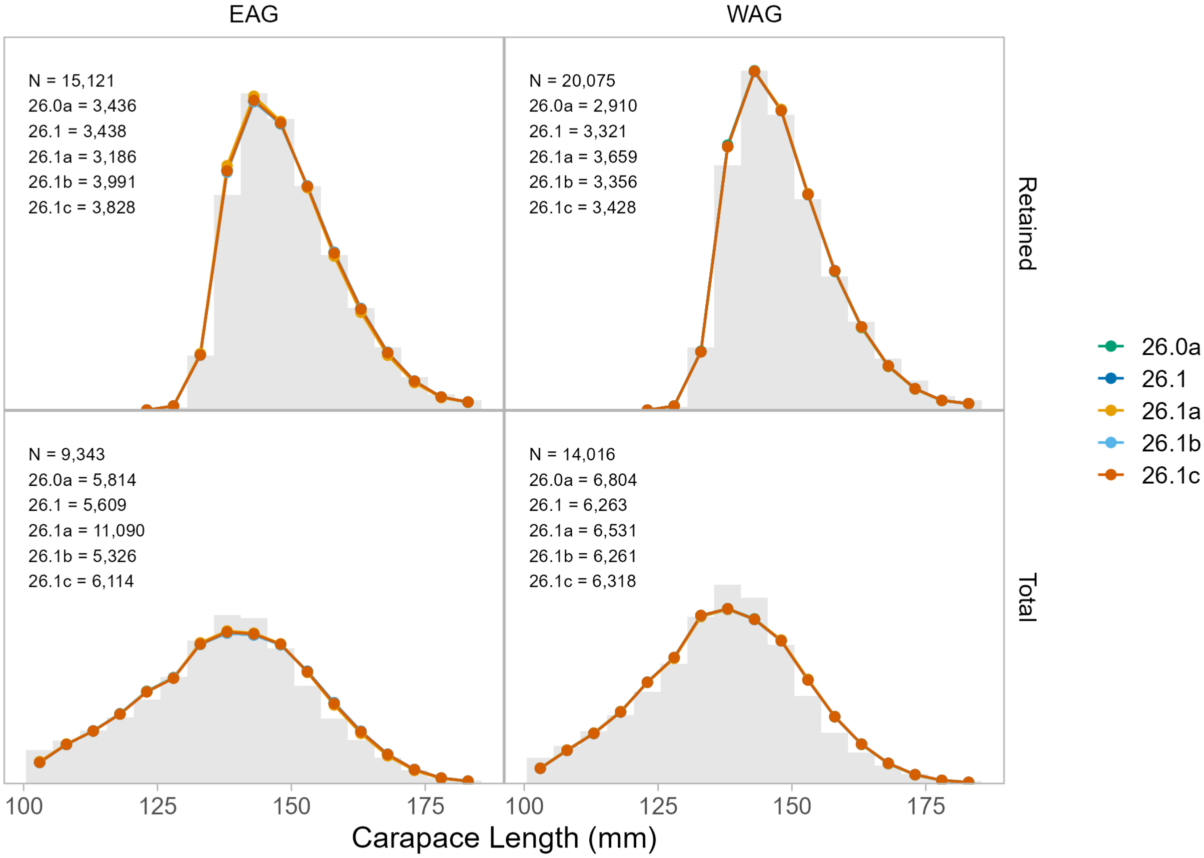

Figure 16: Aggregated size composition and reweighted sample sizes for models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

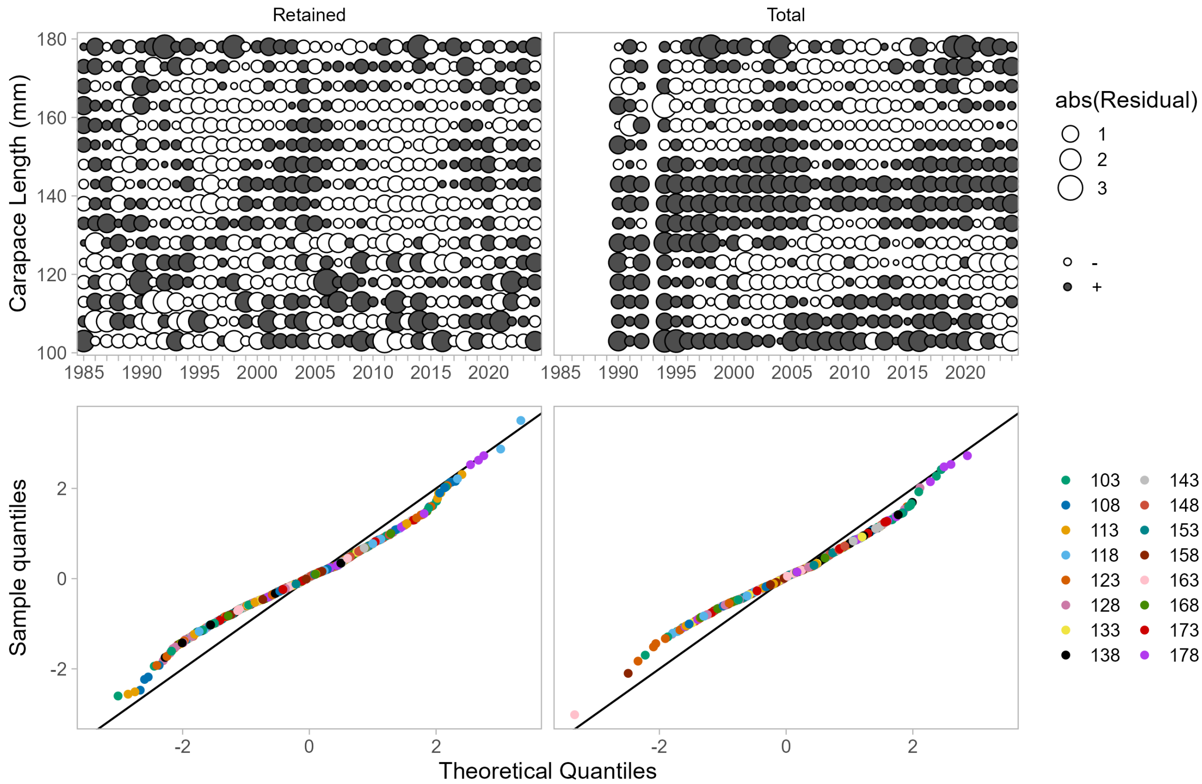

Figure 17: One step ahead residual dot plot and QQ plot for retained and total size composition data for model EAG 26.0a.

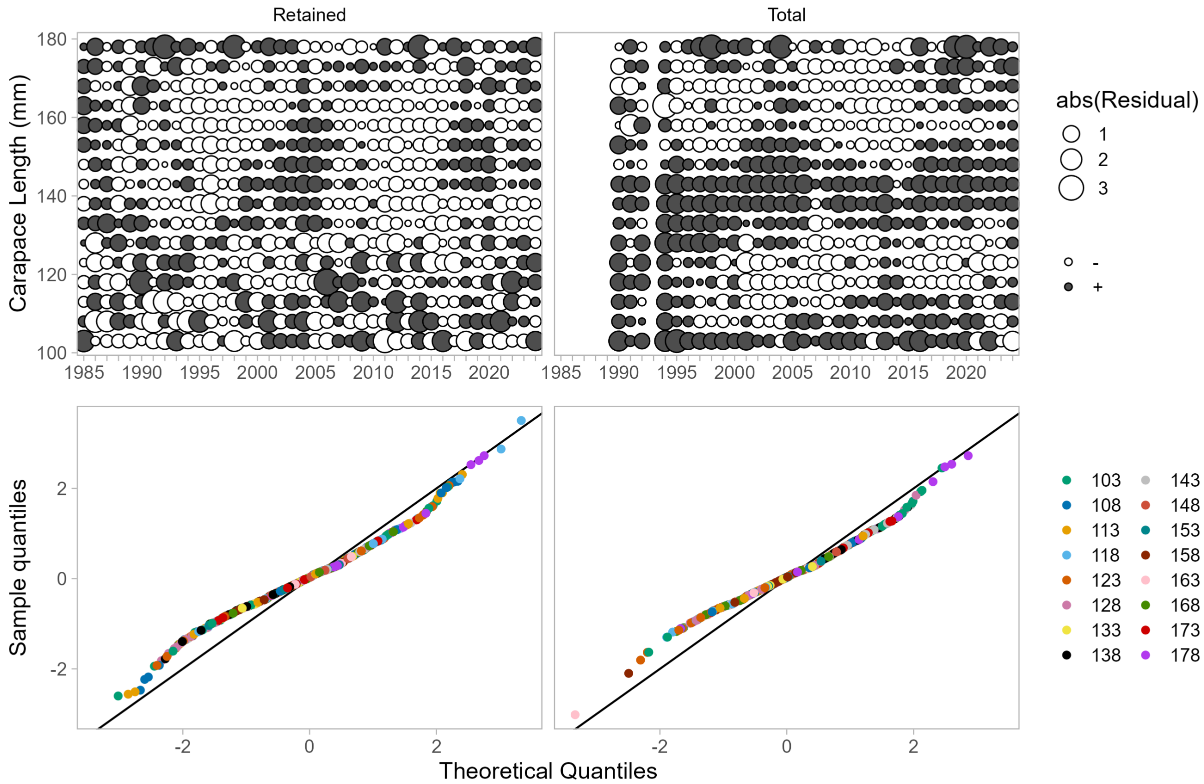

Figure 18: One step ahead residual dot plot and QQ plot for retained and total size composition data for model EAG 26.1.

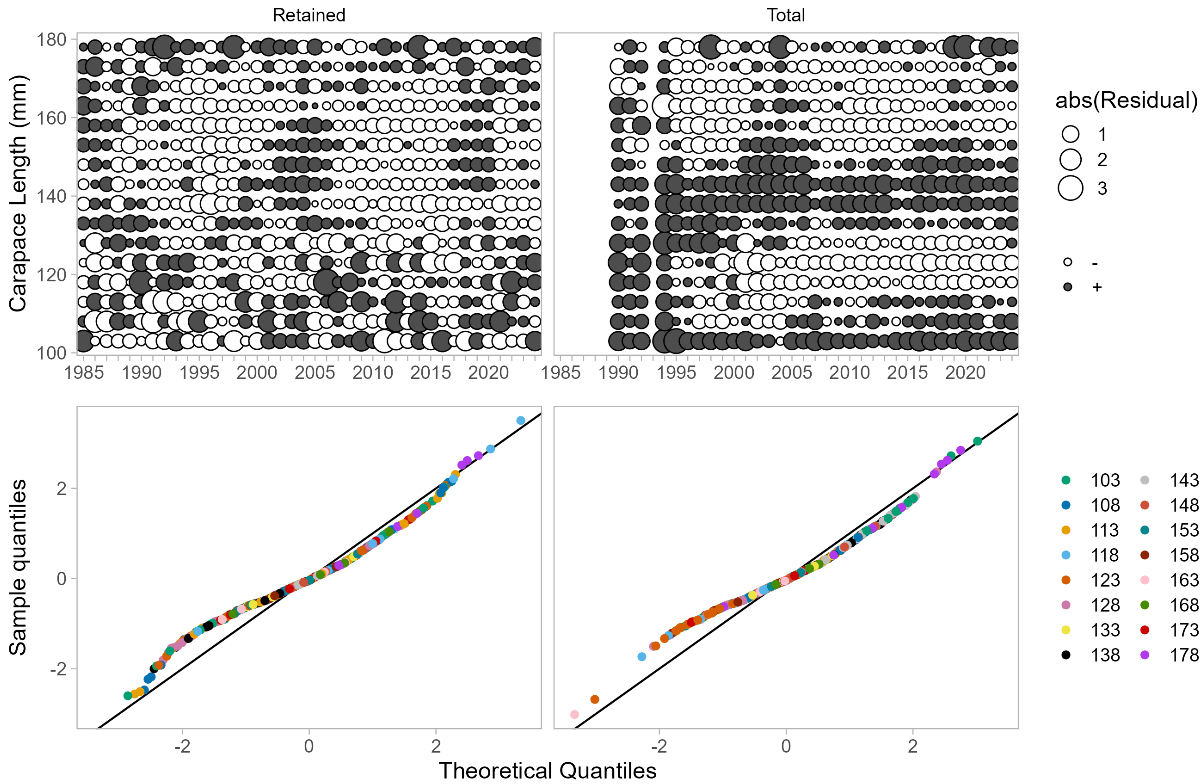

Figure 19: One step ahead residual dot plot and QQ plot for retained and total size composition data for model EAG 26.1a.

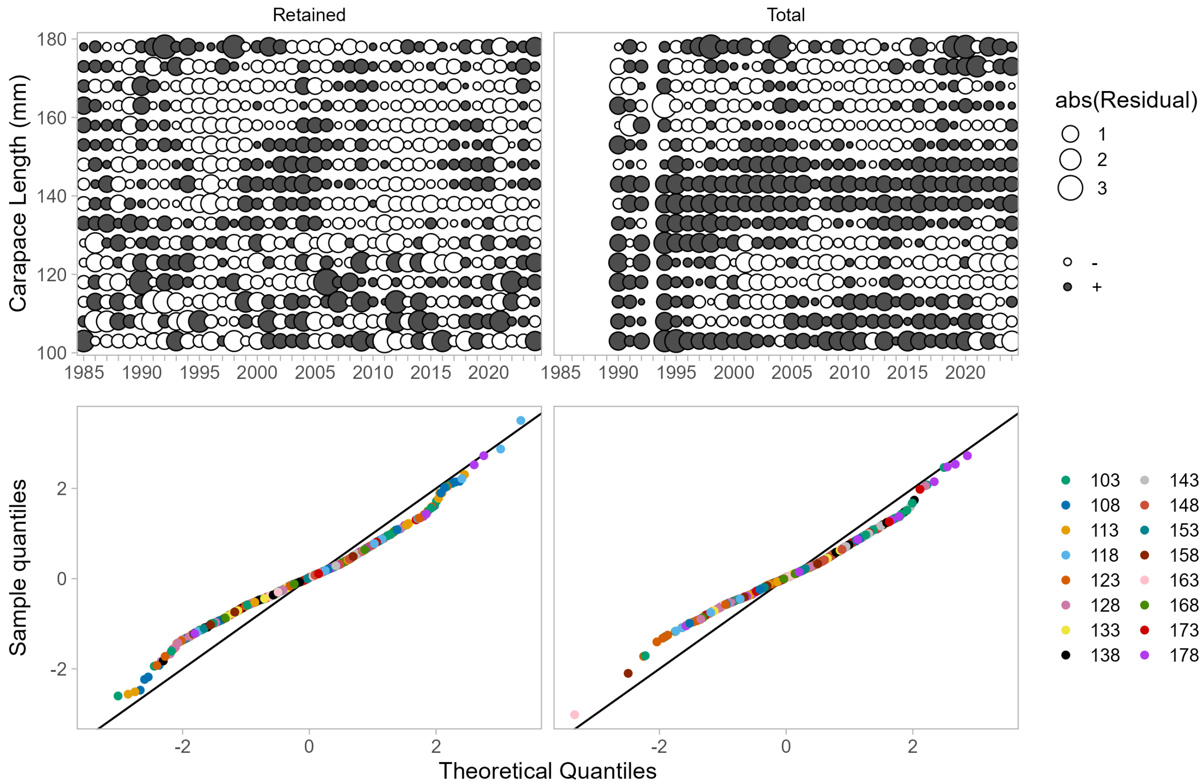

Figure 20: One step ahead residual dot plot and QQ plot for retained and total size composition data for model EAG 26.1b.

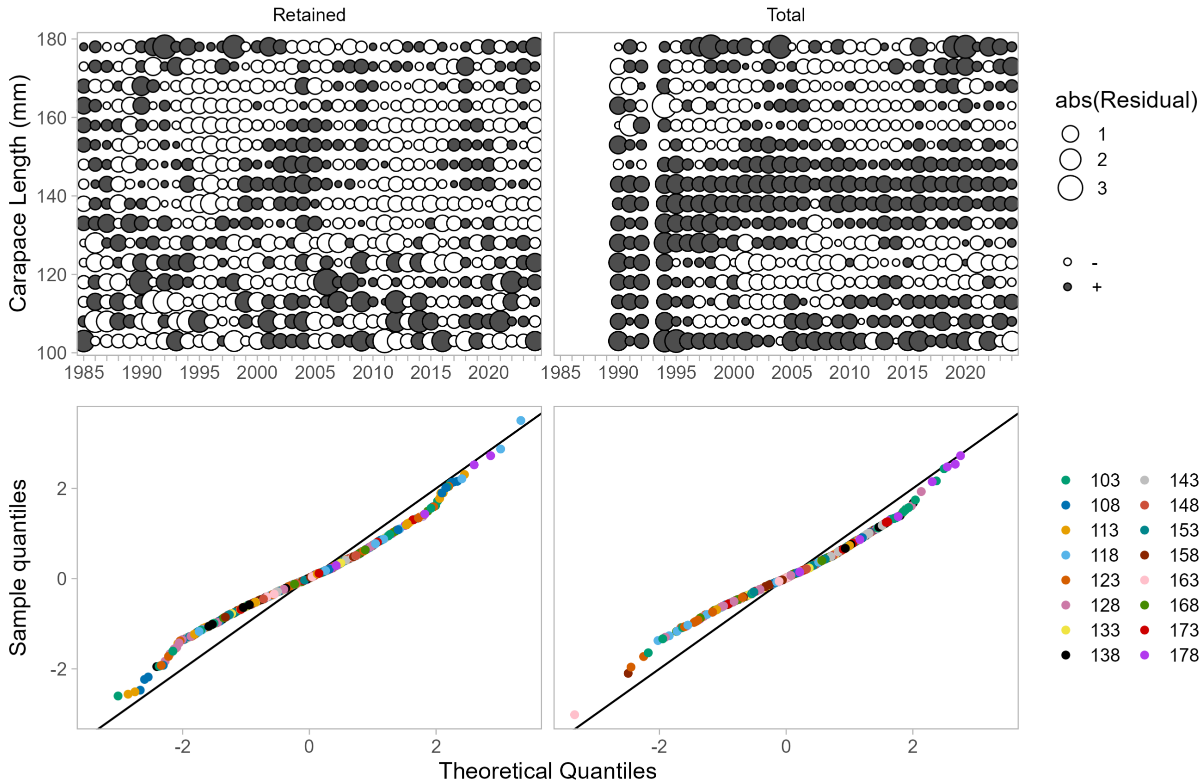

Figure 21: One step ahead residual dot plot and QQ plot for retained and total size composition data for model EAG 26.1c.

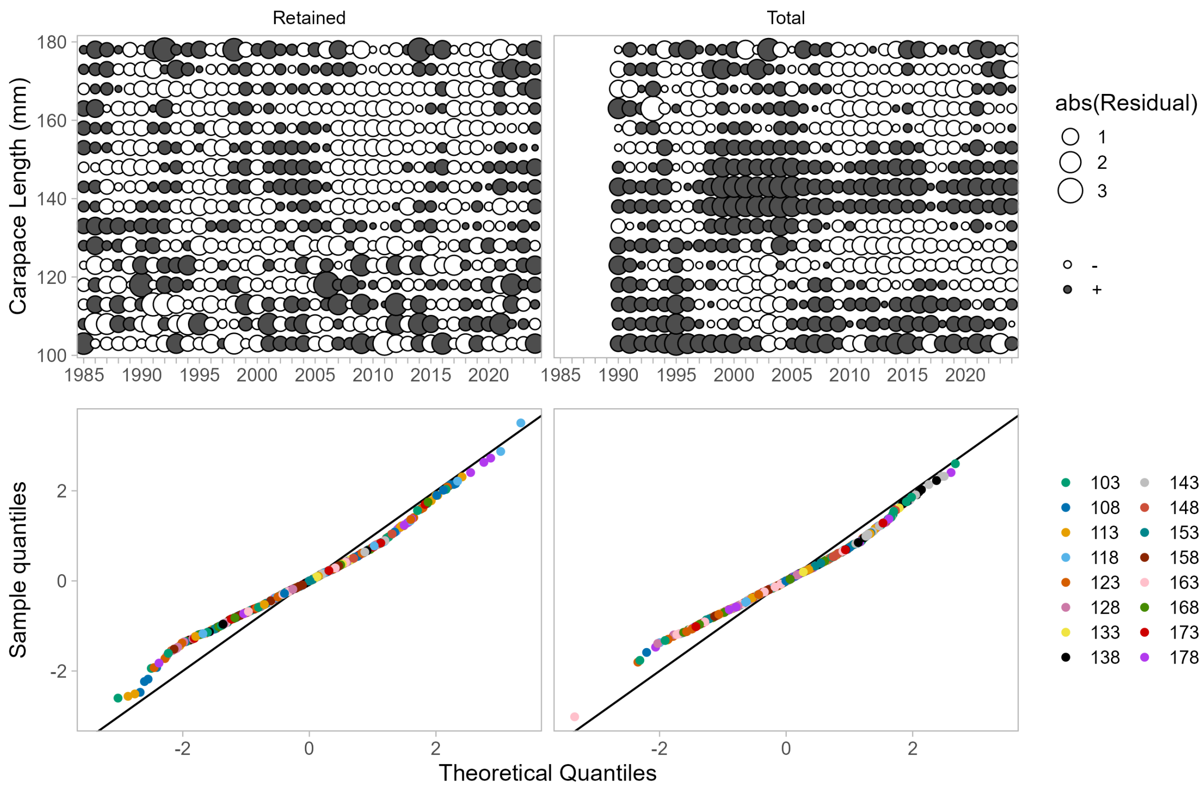

Figure 22: One step ahead residual dot plot and QQ plot for retained and total size composition data for model WAG 26.0a.
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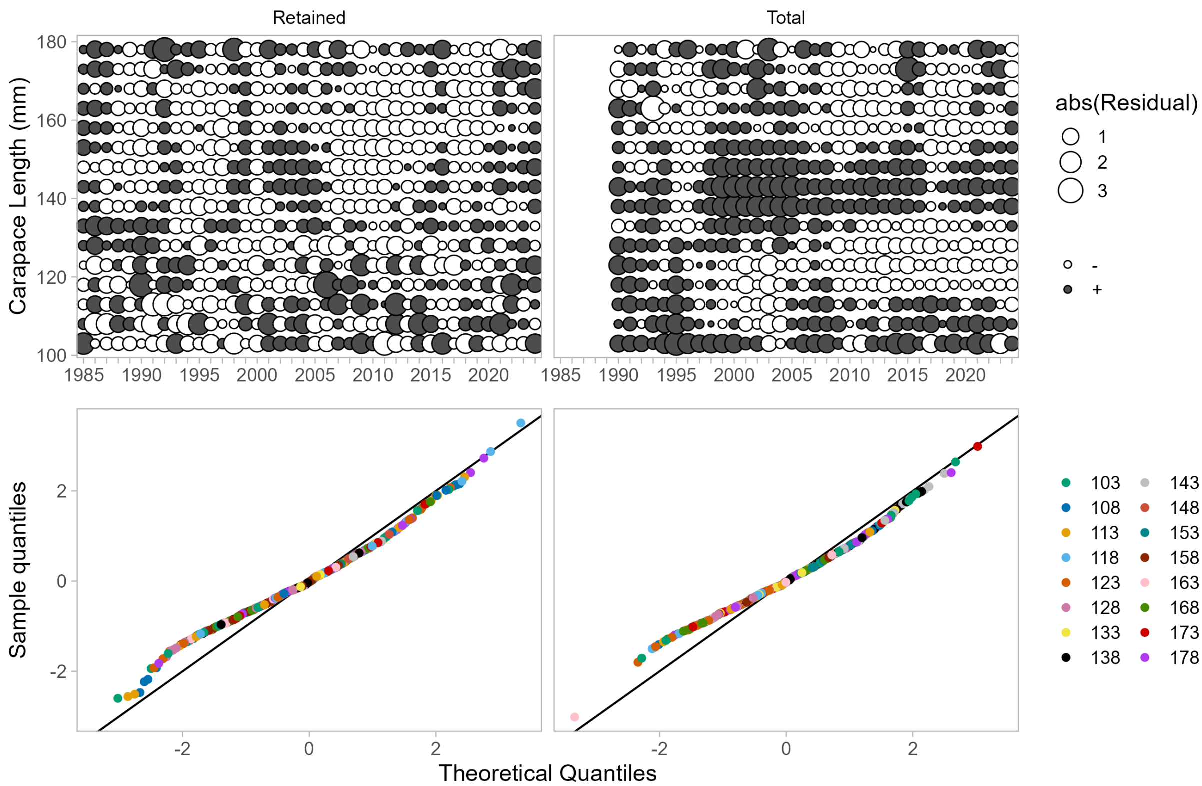

Figure 23: One step ahead residual dot plot and QQ plot for retained and total size composition data for model WAG 26.1.

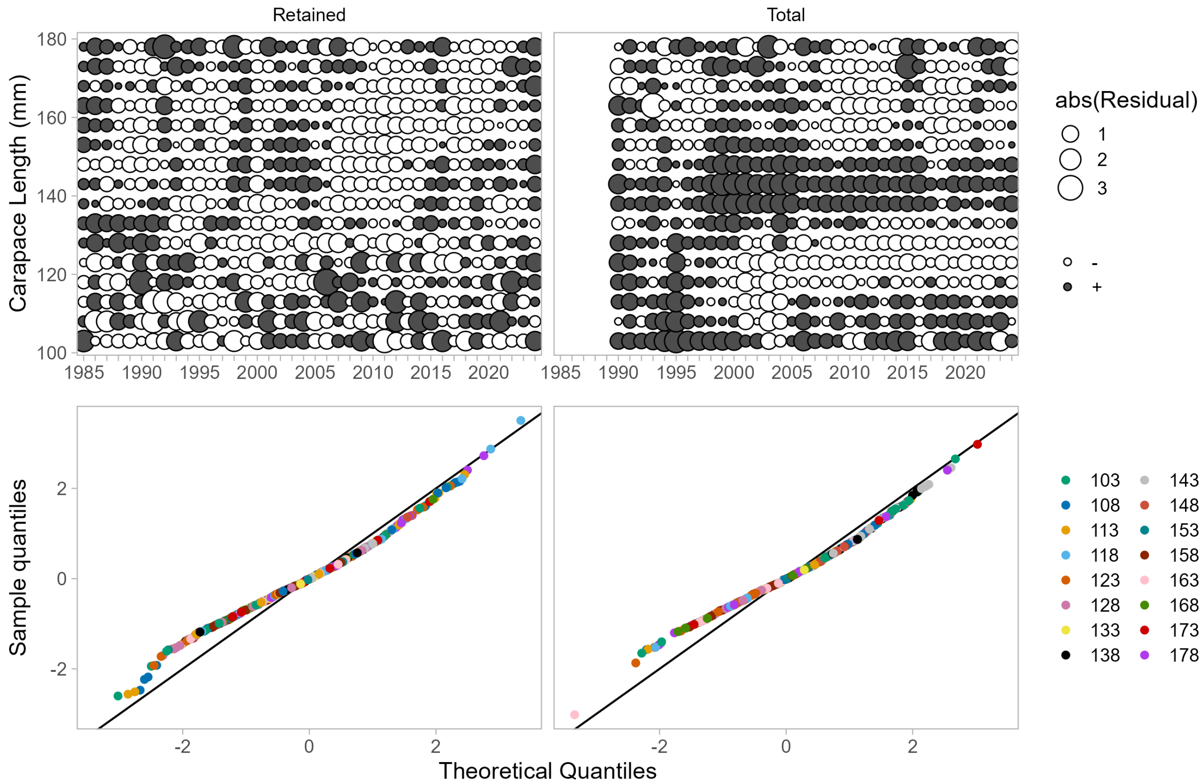

Figure 24: One step ahead residual dot plot and QQ plot for retained and total size composition data for model WAG 26.1a.

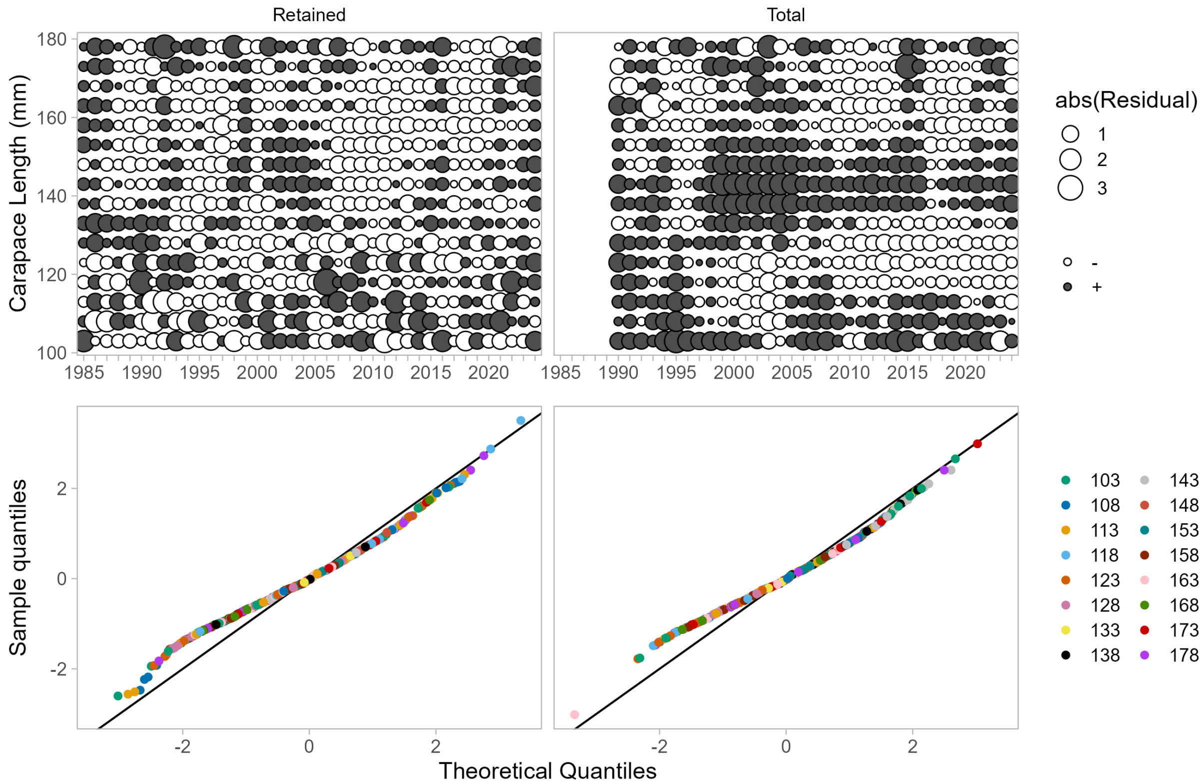

Figure 25: One step ahead residual dot plot and QQ plot for retained and total size composition data for model WAG 26.1b.

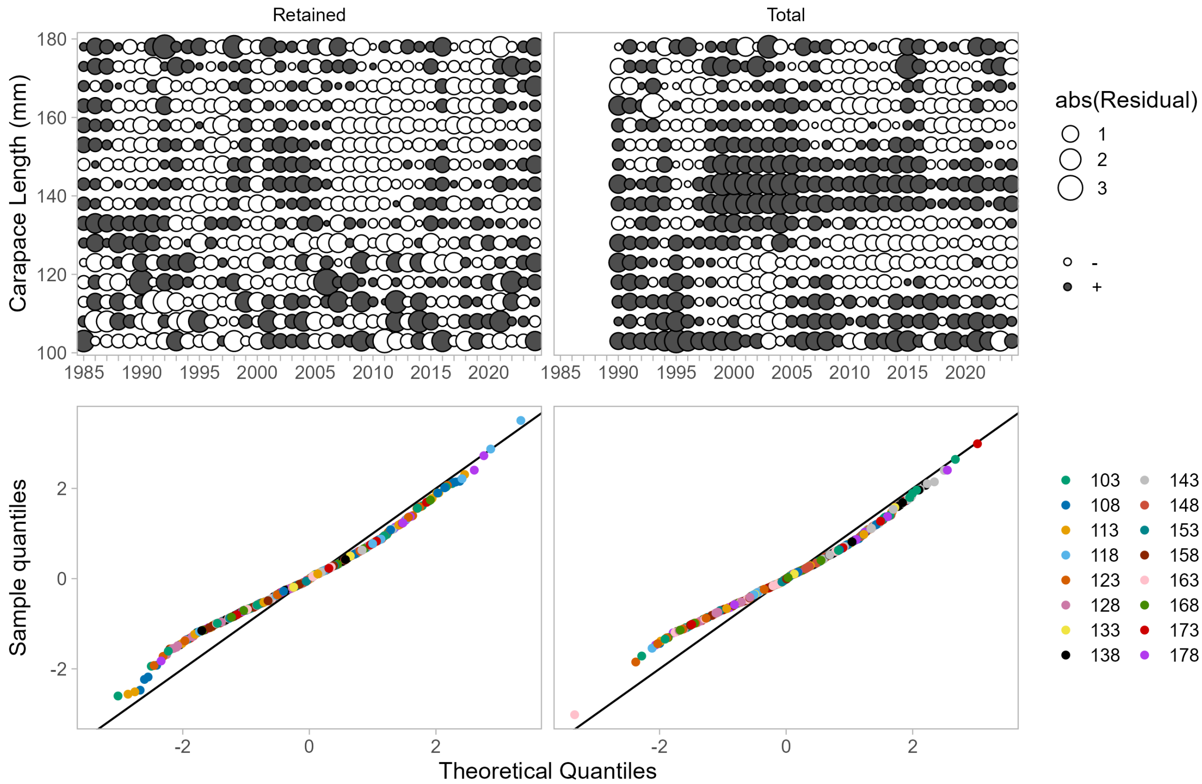

Figure 26: One step ahead residual dot plot and QQ plot for retained and total size composition data for model WAG 26.1c.

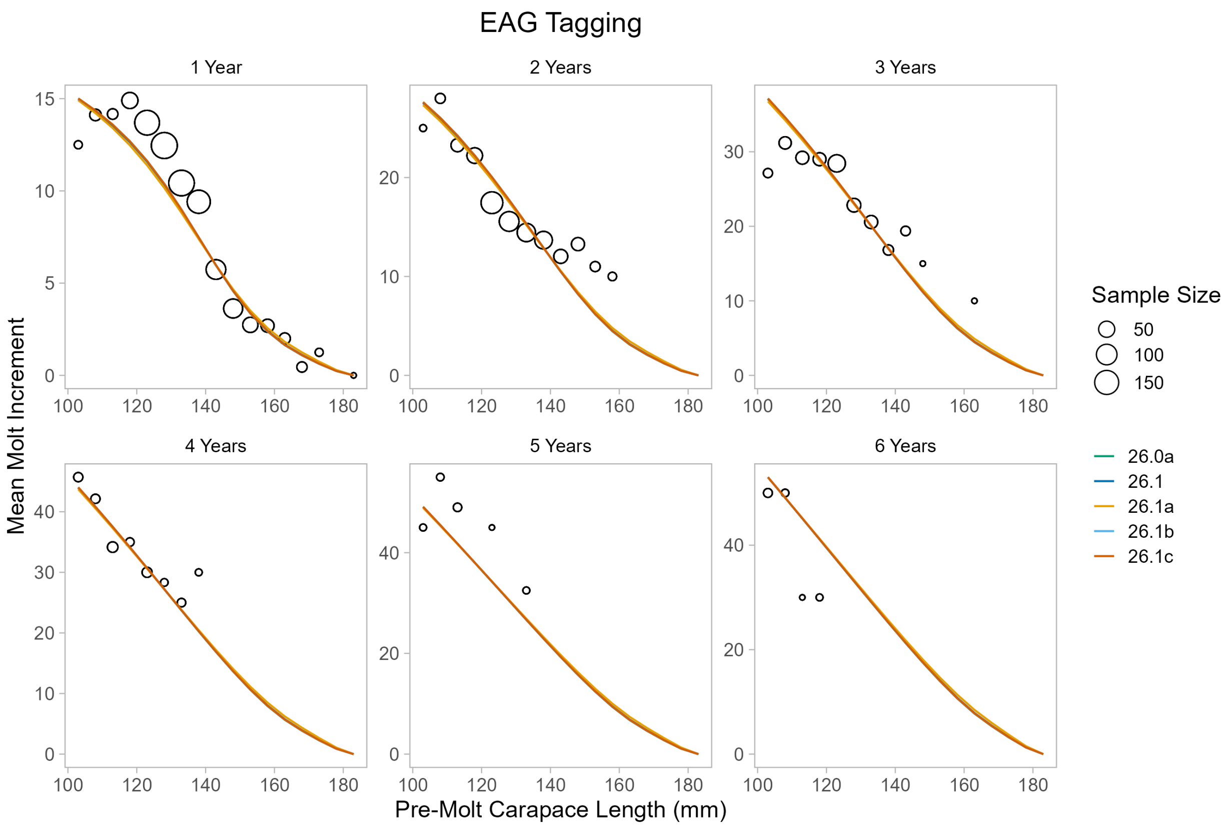

Figure 27: Mean molt increment as a function of pre-molt size based on fitted tag return data over 6 years in the EAG for model 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

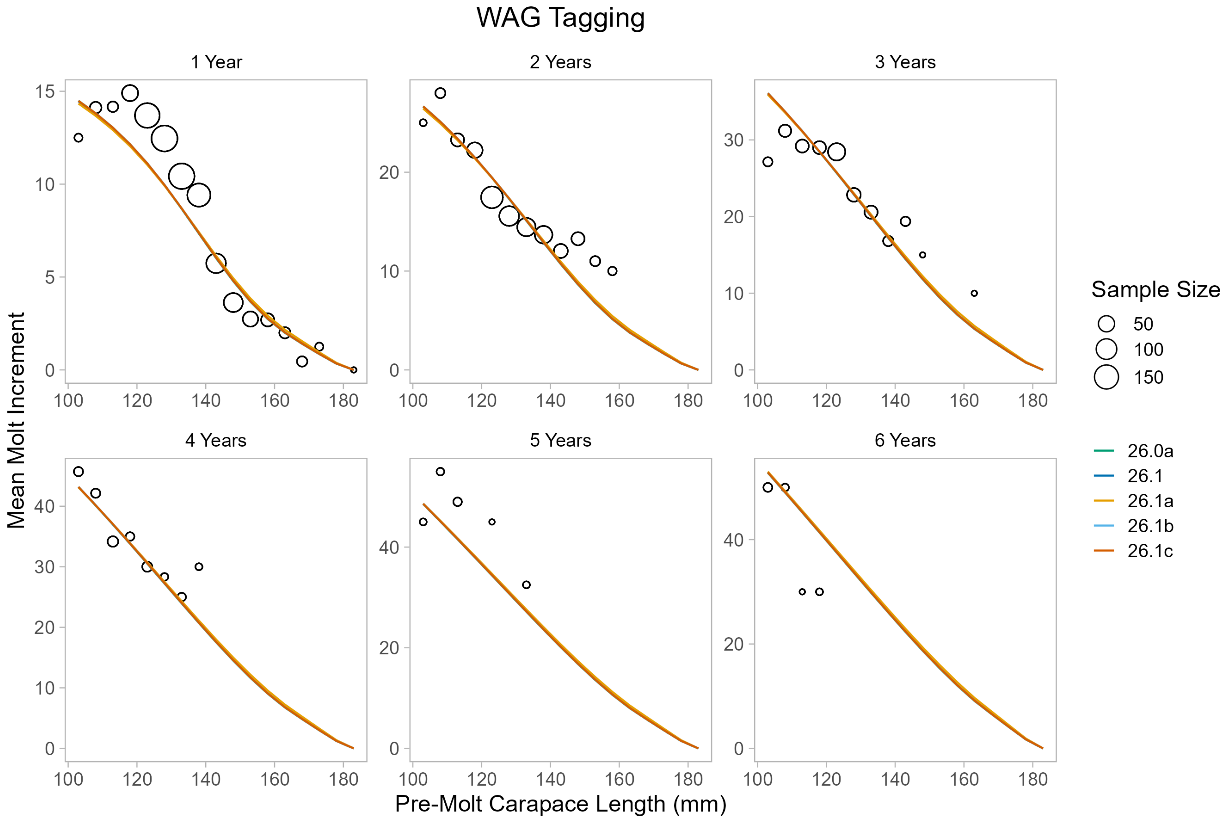

Figure 28: Mean molt increment as a function of pre-molt size based on fitted tag return data over 6 years in the WAG for model 26.0a, 26.1, 26.1a, 26.1b, and 26.1c.

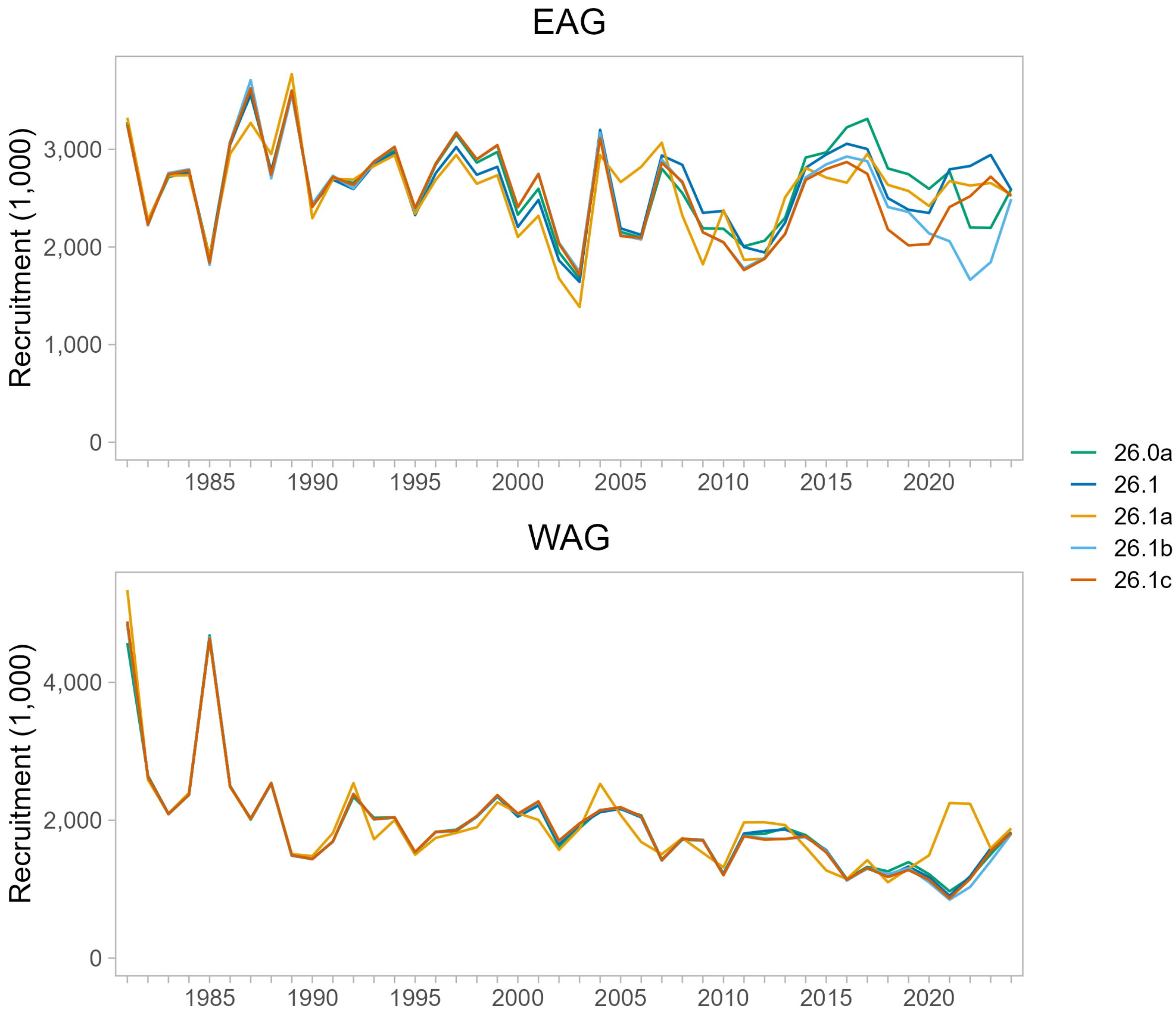

Figure 29: Recruitment estimates for models models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c. Confidence intervals are not shown due to the number of models evaluated. See Figure 9 for a comparable interval.

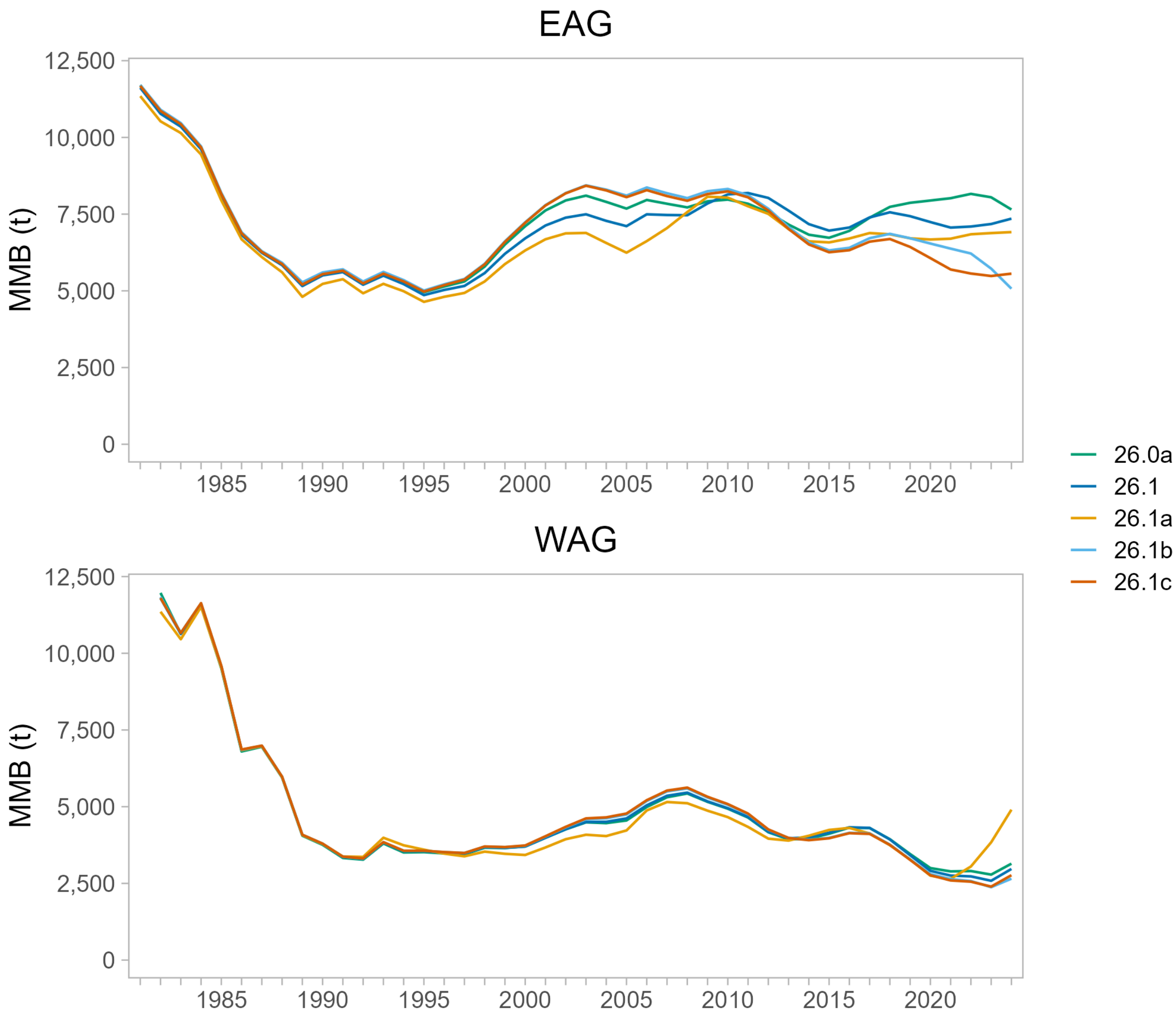

Figure 30: Mature male biomass estimates for models 26.0a, 26.1, 26.1a, 26.1b, and 26.1c. Confidence intervals are not shown due to the number of models evaluated. See Figure 10 for a comparable interval.

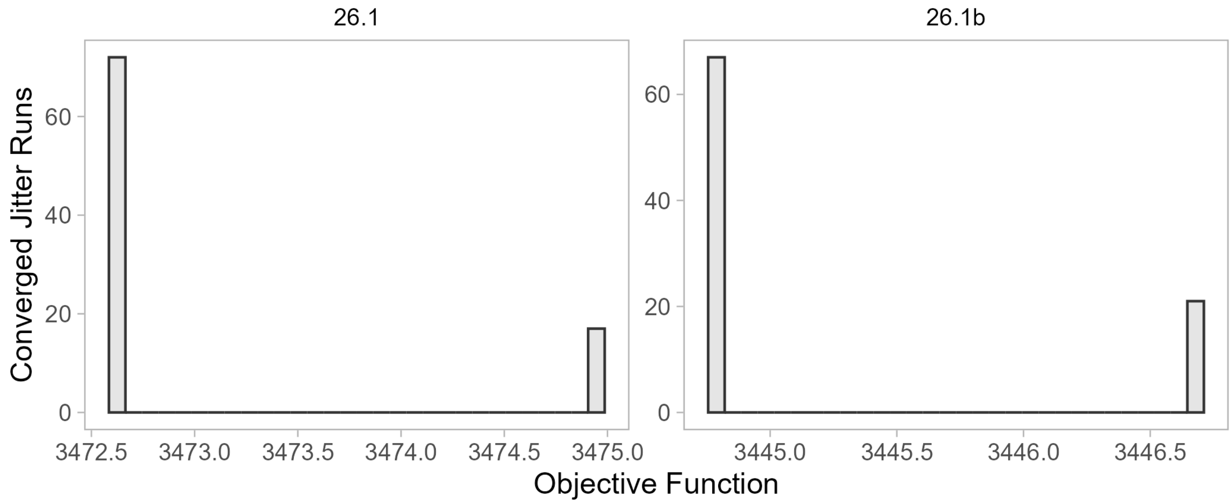

Figure 31: Histogram of objective function values for converged jitter runs of WAG models 26.1 and 26.1b.

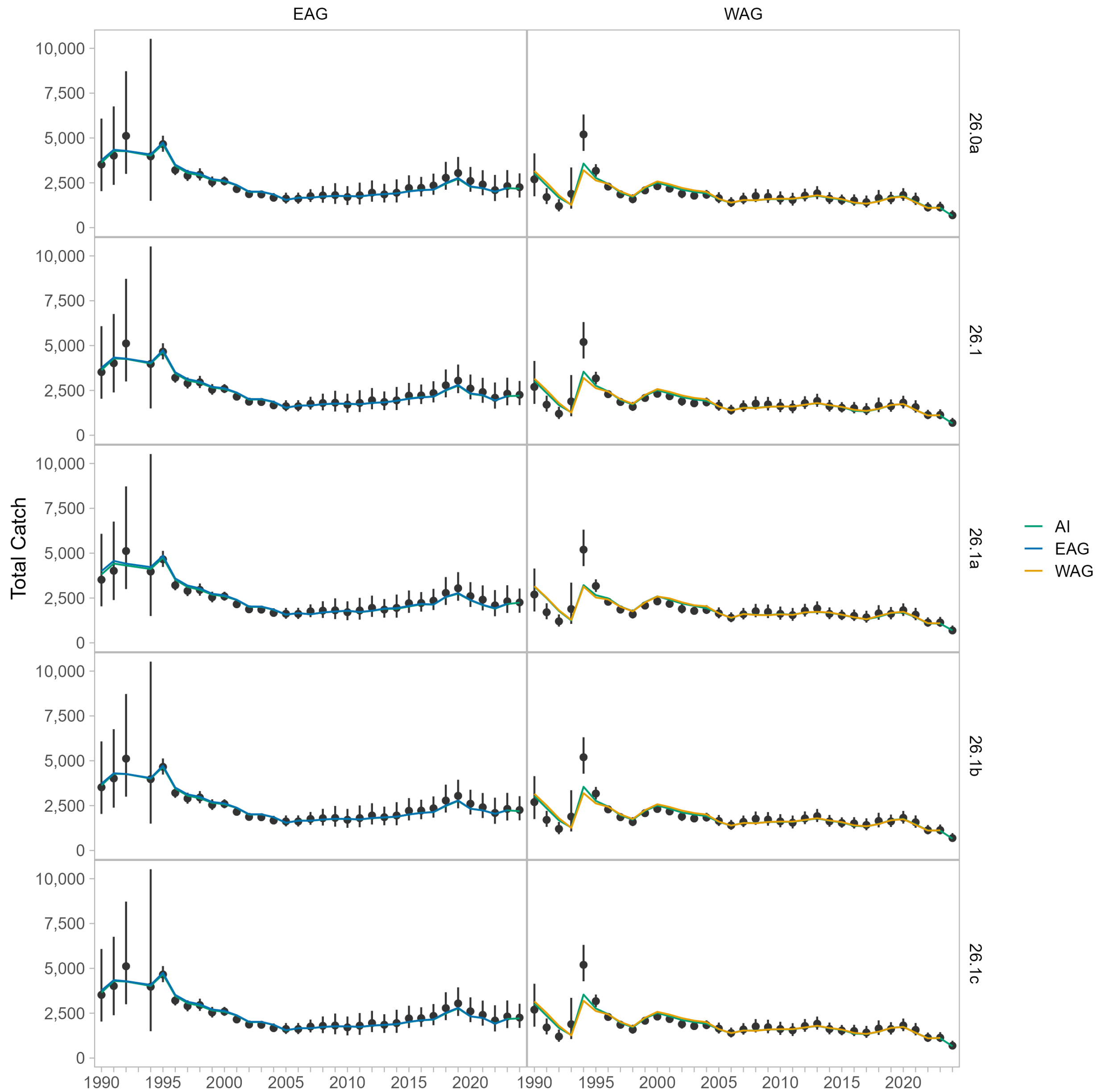

Figure 32: Fits to total catch data for combined models in comparison to district specific models 26.0a, 26.1, 26.1a, 26.1b, 26.1c

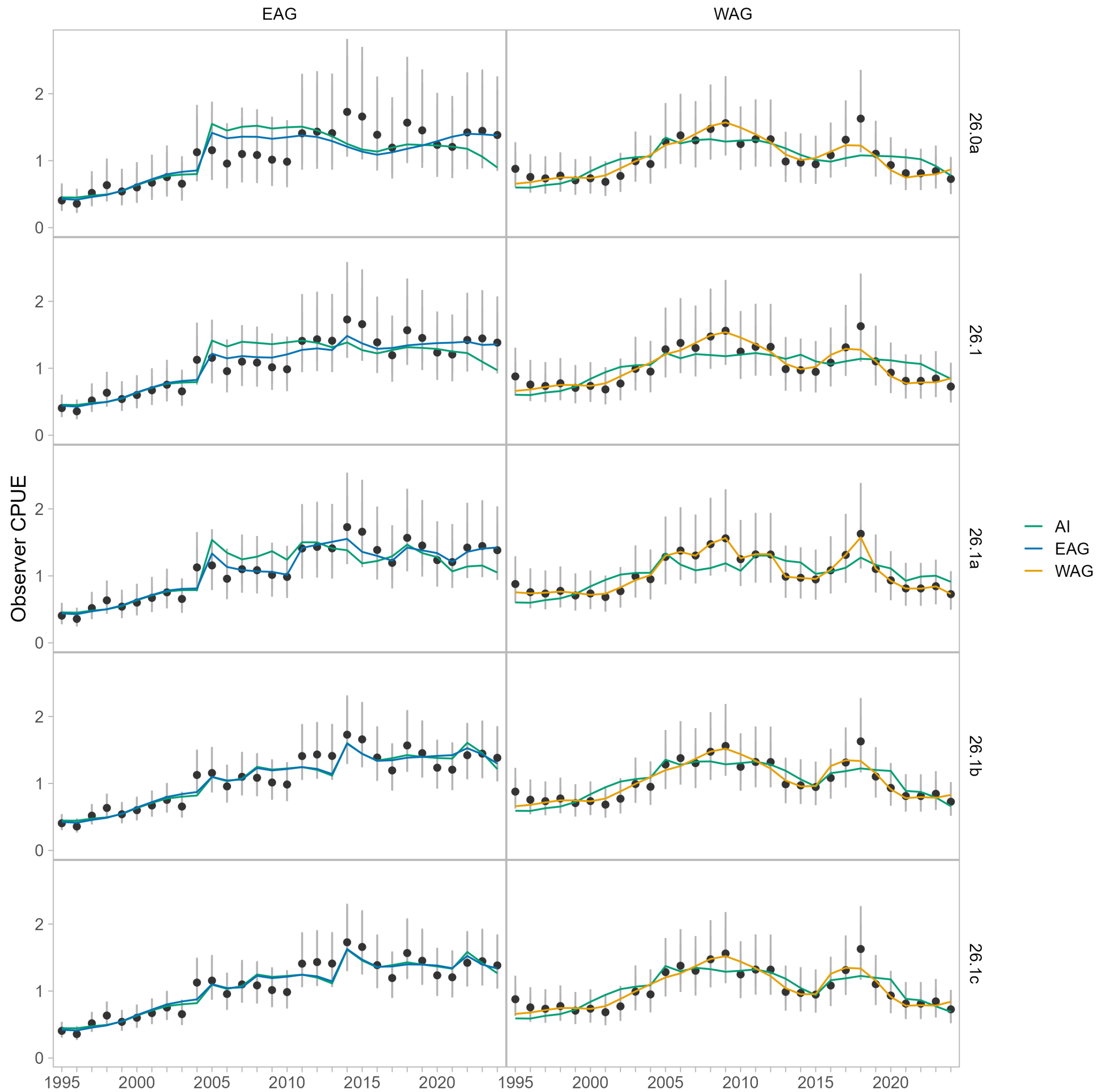

Figure 33: Fits to observer CPUE data for combined models in comparison to district specific models 26.0a, 26.1, 26.1a, 26.1b, 26.1c

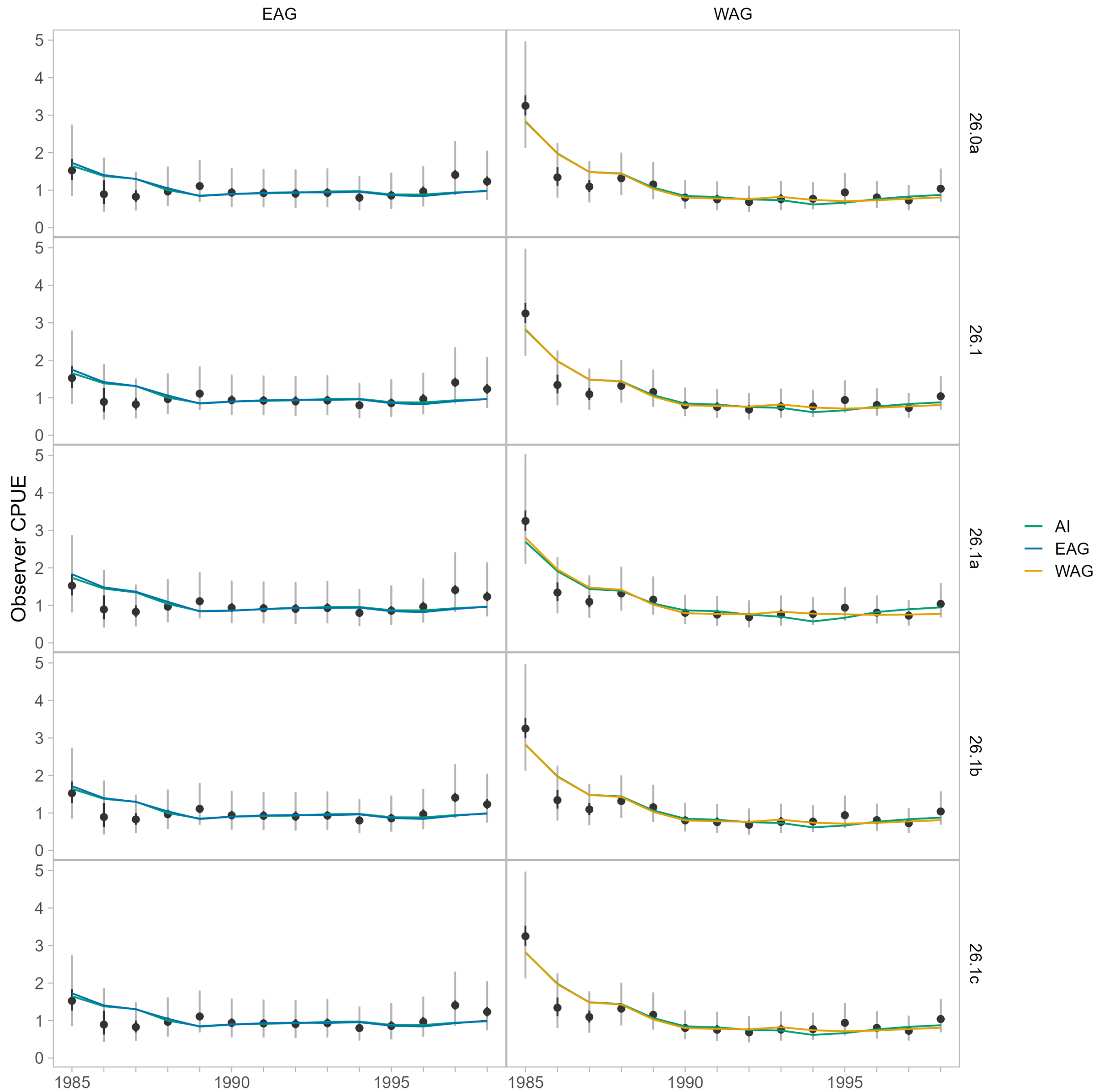

Figure 34: Fits to observer CPUE data for combined models in comparison to district specific models 26.0a, 26.1, 26.1a, 26.1b, 26.1c

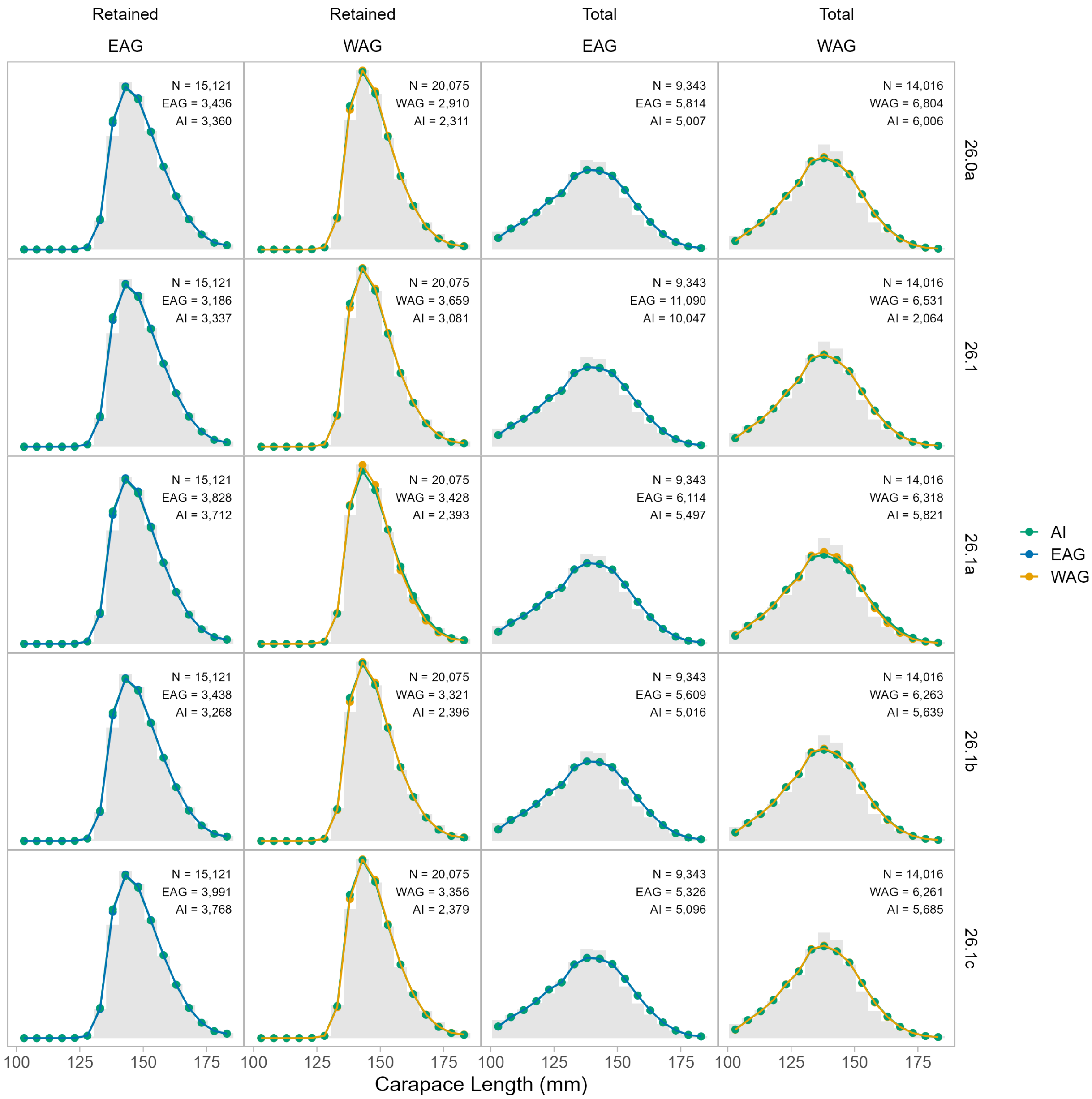

Figure 35: Fits to size composition data for combined models in comparison to district specific models 26.0a, 26.1, 26.1a, 26.1b, 26.1c

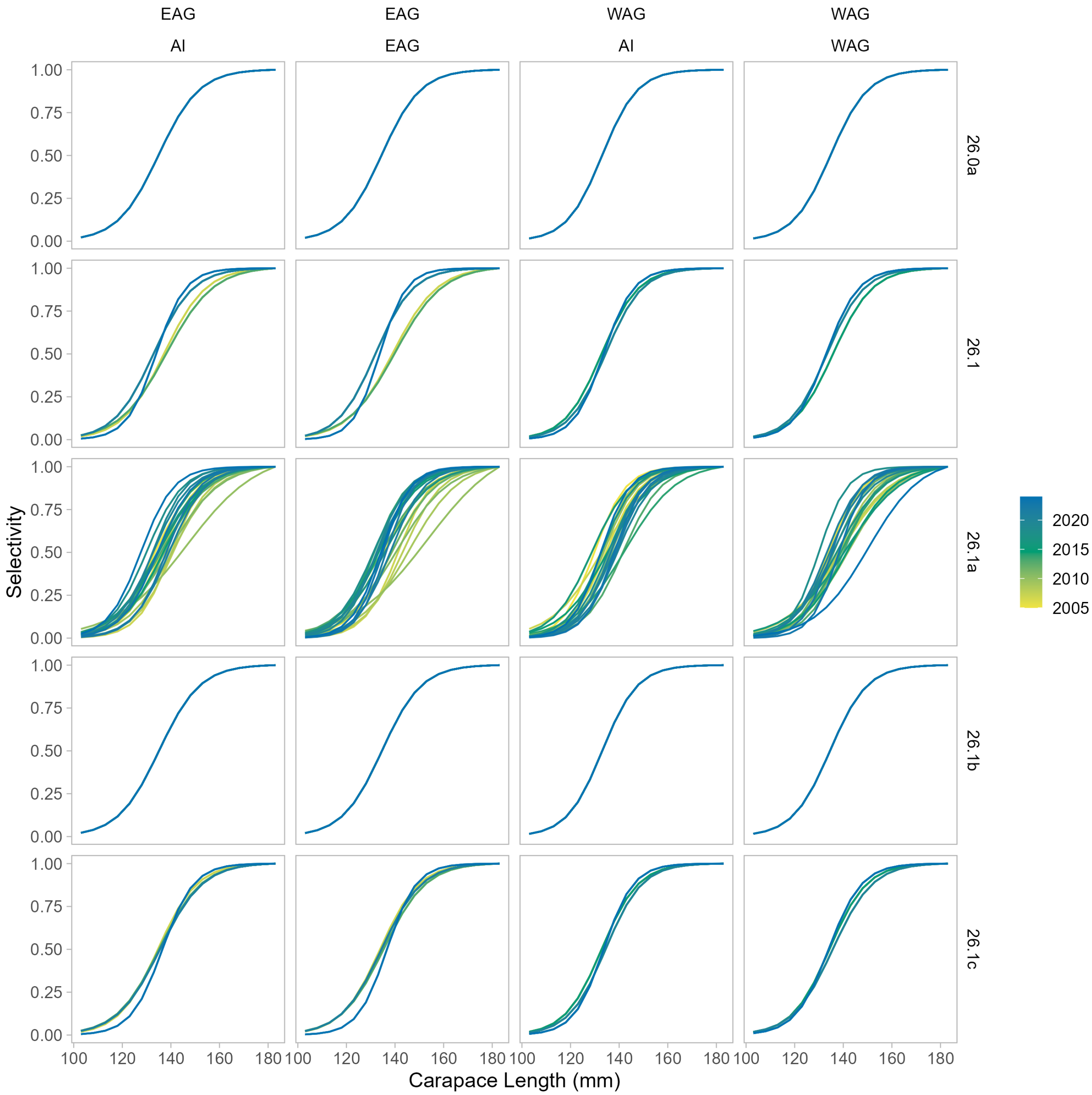

Figure 36: Post-rationalization selectivity in the directed fishery, by subdistrict for combined models (AI) and subdistrict specific models (EAG/WAG) 26.0a, 26.1, 26.1a, 26.1b, 26.1c

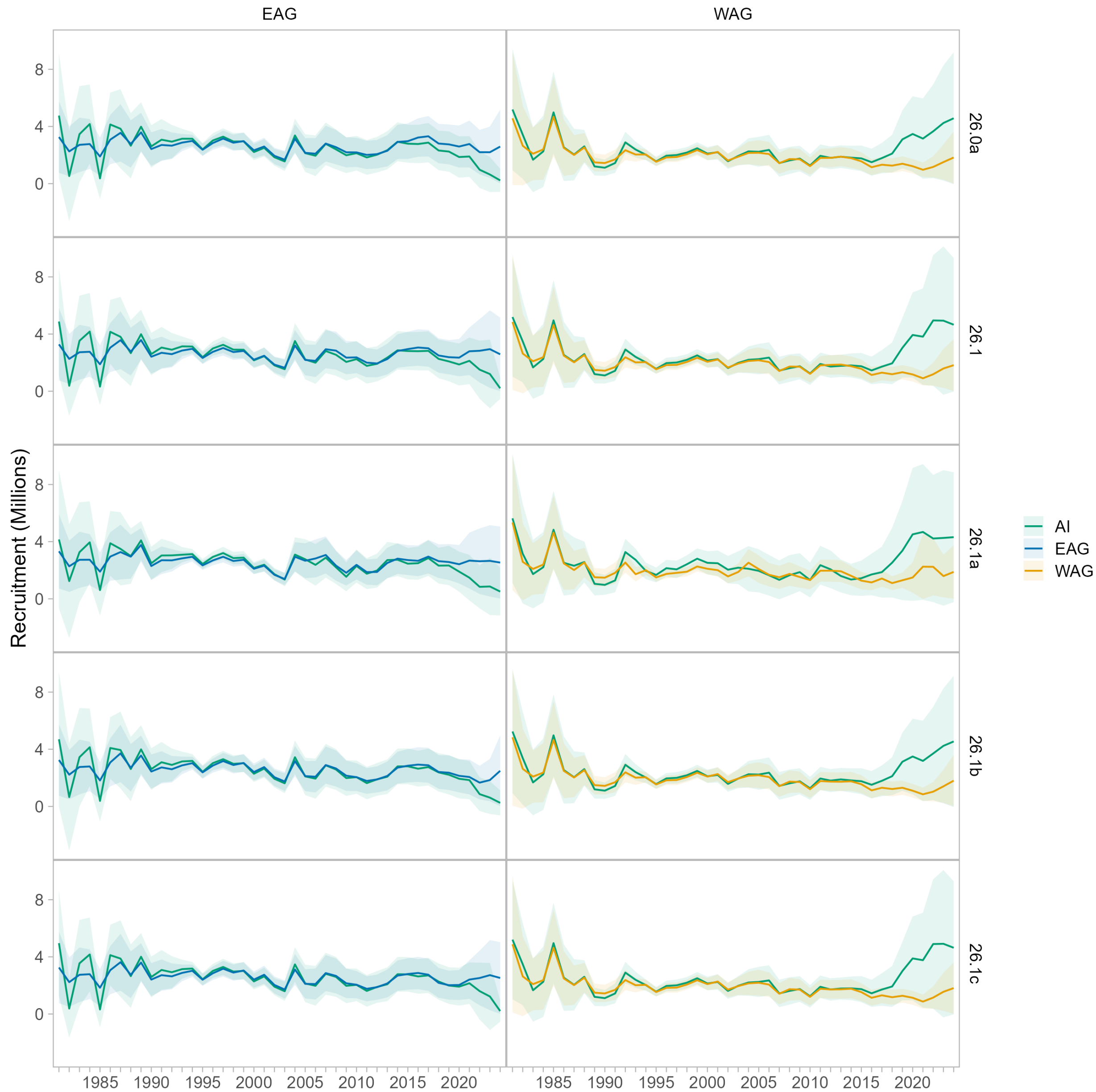

Figure 37: Recruitment estimates and 95% confidence intervals for combined models in comparison to district specific models 26.0a, 26.1, 26.1a, 26.1b, 26.1c

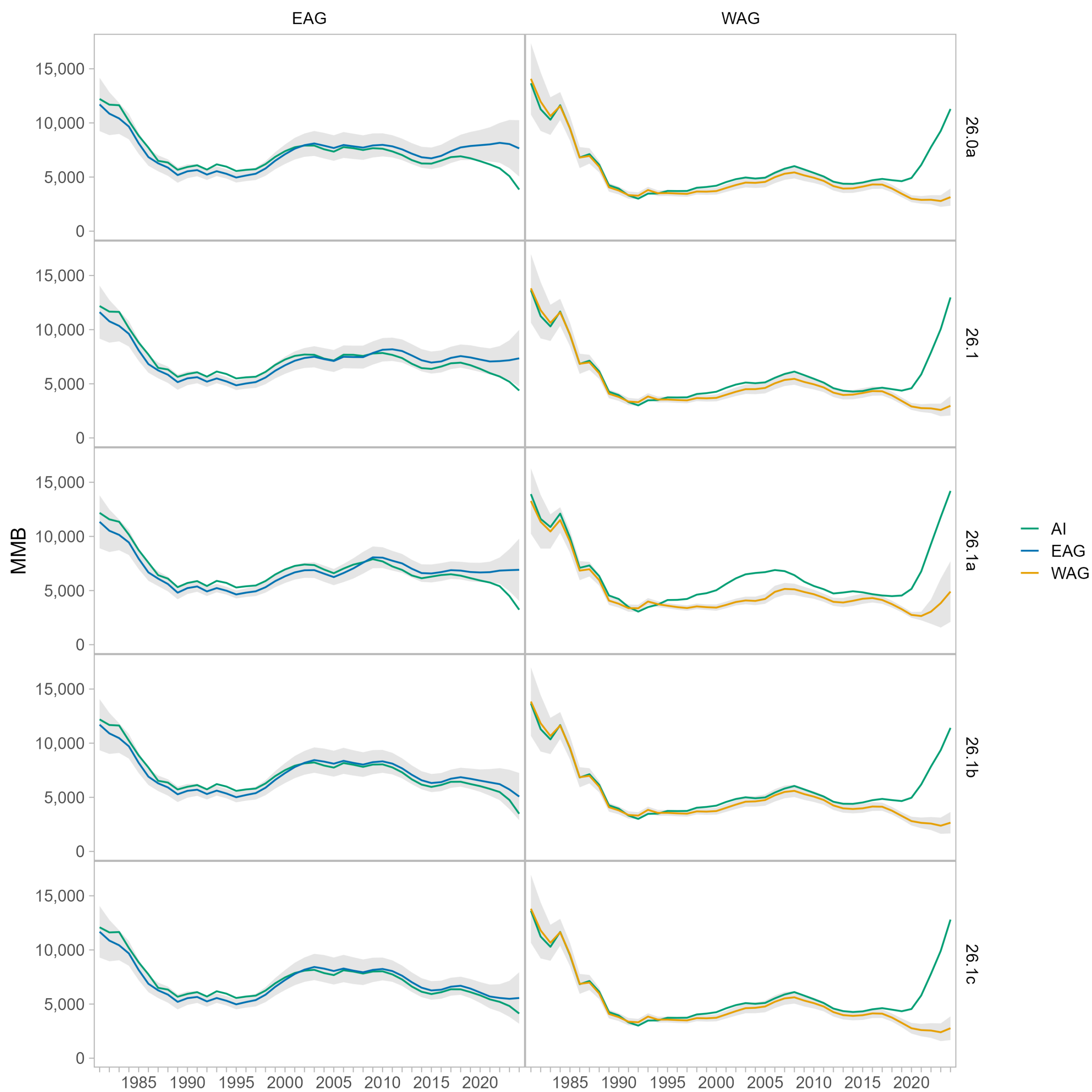

Figure 38: Mature male biomass estimates and 95% confidence intervals for combined models in comparison to district specific models 26.0a, 26.1, 26.1a, 26.1b, 26.1c