Aleutian Islands Golden King Crab Stock Assessment Draft Models

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Response to Comments

This report only includes responses to comments from May and June 2026. Previously unaddressed comments are being tracked separately (see Jackson 2026).

SSC June 2026

Comment: "*The author should continue developing a combined EAG/WAG model framework, including a diagnostic evaluation of whether natural mortality M is expected to be similar across the two subdistricts, as recommended by the SSC in December 2025.*"

Response: An analysis exploring the assumption of shared M is presented in this document.

Comment: "*The SSC recommends using direct CPUE reliability diagnostics and covariates, including vessel effects, spatial contraction, soak time, fishing-ground shifts, and post-rationalization behavior, as an alternative to fishery selectivity time blocks for addressing retrospective bias.*"

Response: The previous attempt at addressing retrospective bias considered those criteria to inform selectivity time blocks, but the author will have to reconsider how to use such information in a different way during a future assessment cycle. No progress was made here.

Comment: "*Continue investigating the EAG retrospective pattern using objective, data-driven criteria for selectivity time-block placement.*"

Response: The author will work with the CPT to reconicle this recommendation with the previous one.

Comment: "*Investigate and report the source of the WAG convergence failure and evaluate alternative model parameterizations to resolve convergence issues.*"

Response: Jackson (2024, 2026) discuss the source of the WAG convergence issue. The model seems to have successfully converged, but not at a plausible outcome. Further discussion on the source of the issue and an attempt at a resolution (model 26.0a2) is found in this document.

Comment: "*The SSC recommends developing a clearer area-specific risk accounting framework for EAG and WAG, even if ABC remains specified at the stock level (i.e., is a larger buffer appropriate for an area that has more uncertainty, like the retrospective bias in EAG).*"

Response: It seems that the most objective area-specific ABC was that derived from the area-specific OFL calculation. Unless there is reason to return to that approach, the CPT will have to utilize the

risk table framework to determine if area-specific concerns warrant area specific buffer considerations.

Comment: "*Continue developing the draft risk table framework.*"

Response: The risk table for this stock will reflect the most developed CPT framework at the time of the final assessment.

Comment: "*Resolve editorial inconsistencies identified by the CPT and SSC.*"

Response: Misreported total catch in 2025 was corrected in September 2026. The author will prioritize greater attention to detail in the future.

Comment: "*The SSC recommends exploring whether inverse EAG and WAG CPUE trends support development of a two-area model with movement, as time and data allow.*"

Response: Models 27.0 - 27.0b make progress towards a combined model, but do not include movement at this time.

Comment: "*Evaluate whether depth is necessary as a fixed effect in the ST-GLMM and assess sensitivity to mesh resolution and soak-time assumptions.*"

Comment: "*Exploration of a spatially-varying soak time effect within the ST-GLMM.*"

Response: CPUE standardization was not addressed during this cycle.

CPT May 2026

Comment: "*The CPT therefore recommended that it is not necessary at present to further attempt to refine the index standardization method so that research efforts can be directed at other tasks.*"

Response: That is the approach taken at this time.

Comment: "*Further development of a subdistrict-combined model. Tyler had previously provided a model based on GMACS that analyzed data for the EAG and WAG simultaneously, but that model was not taken forward for this assessment. Care needs to be taken that GMACS correctly computes the OFL for a subdistrict-combined assessment.*"

Response: Models 27.0, 27.0a, and 27.0b address combined model development.

Comment: "*Development of a potential survey that could be used to provide an index of recruitment for use in the assessment given the lack of signal on recruitment in the size-composition data. This would involve fishing a small number of index areas with short soak times. The CPT was generally supportive of the proposal to develop such a survey and encouraged discussions with industry regarding logistics*"

Response: A re-design of the cooperative survey is currently in progress and there is nothing to share at this time.

Comment: "*Address past CPT/SSC comments on maturity data.*"

Response: Analysis of maturity data will have to be revisited during a future assessment cycle.

Model Explorations

- **26.0a**: base model, accepted for specifications in May 2026;
- **26.0a2** (WAG Only): Model 26.0a, with increased weight on annual groundfish fishery bycatch observations ($\sigma = 0.5$, CV = 0.53);
- **26.0a3** (WAG Only): Model 26.0a, with estimated natural mortality in 1996;

- **27.0**: Combined version of EAG 26.0a and WAG 26.0a2, with separate fleets for EAG and WAG fisheries;
- **27.0a**: Model 27.0, with WAG growth mirrored from EAG growth;
- **27.0b**: Model 27.0a, with estimated mean recruitment subdistrict (i.e., sex) ratio and tighter penalty on recruitment proportion deviations.

WAG MLE

Multiple WAG models in the 2024 and 2026 final assessment converged to an implausible MLE, wherein a large recruitment pulse estimated across 1993 - 1995 resulted in an anomalously high groundfish fishery bycatch estimate in 1996 (see Figure 26-27, Jackson 2026). For the purpose of this comparison, the 2026 model with the erroneous bycatch estimate will be referred to as WAG 26.0a (MLE) and the base model will be referred to as WAG 26.0a (Accepted). Following the recruitment pulse, model WAG 26.0a (MLE) estimated substantially different numbers at size from 1992 to 1996 (Figure 1). This improved the fit to the increased fish ticket CPUE from 1994 to 1995 and to the first two years of the observer CPUE series (1995 and 1996), and slightly improved the fit to total catch in 1994 and 1995 (Figure 2). WAG 26.0a (MLE) compensated by estimating lower directed fishery selectivity throughout the size range (Figure 3) and aliasing the groundfish fishery as a mortality sink. The groundfish bycatch fleet had the highest discard mortality rate in 1996 (0.8), the lowest likelihood weight ($\sigma = 1$, CV = 1.3108), full selectivity at all size, and no supporting size composition data (Jackson 2024, 2026). Alternative models presented here attempted to resolve the erroneous bycatch estimate in two ways: 1) model WAG 26.0a2 increased the weight on annual bycatch observations ($\sigma = 0.5$, CV = 0.53), and 2) model WAG 26.0a3 estimated a natural mortality deviation in 1996.

Combined Model

Because AIGKC is managed as a single stock under the FMP (NPFMC 2021) yet assessed with separate EAG and WAG models that rely on shared data (e.g., EAG tagging data to inform growth and natural mortality, and WAG size at maturity data), combining the two into a single spatially explicit framework is a logical step forward. Doing so would also reduce the assessment workload and avoid the need to recompute the OFL outside of GMACS. Since current versions of GMACS do not accommodate multiple spatial domains, Jackson (2025) used the sex model domain to delineate subdistricts. The approach allowed for certain model processes to be shared (e.g. maturity, natural mortality), while others (e.g., recruitment) could be estimated separately. One drawback though is that growth data could not be shared between sexes, and thus tagging data were entered twice. To further delineate subdistricts within the model framework the CPT recommended implementing sex-specific fleets so that fleet-specific processes, like fishing mortality, for one subdistrict are not constrained as offsets from the other. The SSC recommended revisiting stock structure criteria and reconsidering whether natural mortality (M) should be shared between the EAG and WAG, and whether inverse CPUE trends support development of a spatially explicit model with movement.

Length-based estimation of M was conducted by Siddeek et al. (2022) using tagging data only available for the EAG. Here, I evaluated the assumption that natural mortality should be shared for the EAG and WAG by estimating likelihood profiles for M ranging from 0.12 yr^{-1} to 0.32 yr^{-1} using EAG 26.0a and WAG 26.0a2. Models were re-fit at each value of M, with all other parameters estimated. Since tagging data are only available for the EAG, growth parameters for EAG and WAG models were fixed at common values so that profiles of M were only constructed from subdistrict-specific data. Likelihood profiles were compared across data components to evaluate whether subdistrict-specific data supported similar values of M.

Model 27.0 is the combined version of EAG 26.0a and WAG 26.0a2. EAG and WAG data were modeled as different fleets and sexes to allow maximum separability of the subdistricts. Since season timing differs between subdistricts, the annual structure of model 27.0 was reconfigured to include eight seasons (as opposed to six) with lengths equating to the subdistrict-specific annual structure of EAG 26.0a and WAG 26.0a2.

Directed fishery selectivity was altered so that female (WAG) selectivity was zero for the EAG fleet and male (EAG) selectivity was zero for the WAG fleet. The model 27.0 parameterization was tested by fixing parameter values at MLE estimates of EAG 26.0a and WAG 26.0a2 and comparing likelihood components after one function call. Several parameters ($\bar{R}$, R_{ini}, recruitment deviations, recruitment sex ratio deviations, WAG recruitment size distribution, and WAG N_{ini} deviations) were transformed to appropriately combine models under the two-sex model structure. After the bridging comparison, model 27.0 was estimated to convergence and a jitter analysis was conducted using 100 iterations and $\sigma_{jitter} = 0.3$.

Growth data used in subdistrict-specific models rely on tagging data collected exclusively in the EAG (Blau and Pengilly 1994; Blau et al. 1998; Watson and Gish 2002; Watson 2004, 2007). Instead of using EAG tagging data to estimate growth in the WAG, model 27.0a fixes WAG growth transition based on the estimated growth parameters of the EAG and removes the duplicated tagging data. In addition, models 27.0 and 27.0a assume the mean recruitment subdistrict (i.e., sex) proportion is equal (i.e., $R_p = 0.5$) with annual logit scale deviations. Since subdistrict-specific models suggest mean recruitment is greater in the EAG, model 27.0b estimates R_p as a parameter, while maintaining annual deviations from that mean. Effectively, estimating R_p is equivalent to estimating a subdistrict offset on $\bar{R}$. However, instead of independent recruitment deviations for each subdistrict, the two sets of deviations represent total recruitment ($\varepsilon_t^R \sim \mathcal{N}(0, \sigma_R^2)$) and the apportionment of total recruitment between subdistricts ($\varepsilon_t^p \sim \mathcal{N}(0, \sigma_p^2)$). Since deviation parameters have a push (ε_t^R) and pull (ε_t^p) effect on recruitment trajectories, correlation in EAG and WAG recruitment is largely determined by the ratio of σ_R to σ_p. Models 27.0 and 27.0a fix $\sigma_R = 0.5$ and σ_p is hard-coded in GMACS as $\sigma_p = 2$, which implies negative correlation at any plausible value of R_p. Model 27.0b fixes $\sigma_p = 1$, so that correlation is approximately zero when R_p is near 0.5. This is likely to only influence recruitment estimates in years with weakly informative data. Jittering of models 27.0a and 27.0b was conducted using 100 iterations and $\sigma_{jitter} = 0.3$.

Results and Dicussion

WAG MLE

Both models WAG 26.0a2 and 26.0a3 curtail estimated groundfish fishery bycatch in 1996 (Figure 4). WAG 26.0a2 fits bycatch data marginally better than WAG 26.0a (Accepted), and is otherwise nearly identical. WAG 26.0a3 estimated an even larger recruitment pulse than WAG 26.0a (MLE) and fit the fish ticket and observer CPUE data better in 1995 and 1996, but did so by estimating natural mortality of $M = 0.98$ yr^{-1} in 1996 (base $M = 0.22$), which implies a loss of about 62% of the stock. Fishery reports in the mid to late 1990s lack any evidence of a significant mortality event in 1996. The NMFS Aleutian Islands bottom trawl survey was conducted in 1994 and 1997, but given the lapse in sampling 1995 and 1996, those data were not investigated here. The CPUE index in these years may also be less informative than WAG 26.0a3 suggests. CPUE standardization is intended to account for sample location, vessel, soak time, and depth, though model-derived CPUE indices differ minimally from the nominal index (Jackson 2026, Appendix A). Observer sampling did not cover the full distribution of fishing effort in 1995 (Figure 5). Incomplete coverage is not uncommon, but more notable in 1995 than in other years. Consequently, a better fit to observer CPUE may not justify the large spike in recruitment necessary to achieve it, and estimating an unconstrained mortality event to remove those crab without a clear biological basis is inappropriate.

Nearly all WAG 26.0a2 jitter runs (91 of 100) converged to the putative MLE and one converged to a local minimum. Eight other runs failed to converge (Table 1).

Combined Model

The range of M profiled did not include the likelihood minima for most data components (Figure 6). Taken together (i.e., the objective function), data components favored lower values of M, driven primarily by size composition data and observer CPUE index for 2005-2025, though fish ticket CPUE and tagging data favored

higher values. Catch data series were weakly informative. Longevity of GKC is unknown, though values of M below the range profiled are perhaps unlikely given the longevity of other king crab species (Matsuura and Takeshita 1989). Regardless, estimating M was not the purpose of this analysis. Aside from observer CPUE for 1995–2004, profiles took on the same relative shape and trended in the same direction by subdistrict, which is consistent with M being similar in the EAG and WAG (Figure 6). In lieu of subdistrict-specific data to inform M (e.g., tagging) or a more practical comparison, it seems reasonable to assume a shared M in both combined and subdistrict-specific models.

Running model 27.0 at one function call with parameters derived from estimates of EAG 26.0a and WAG 26.0a2 resulted in nearly identical data likelihood components (Table 2). The difference in recruitment penalty is due to the difference in recruitment parameterization and is expected. There was only minor change to fits to EAG CPUE indices and WAG size composition data when estimated to convergence, which is primarily due to size composition re-weighting (Table 5 and 6). Fits to catch data were nearly identical among all combined models (Figure 7). Differences in predicted observer CPUE near the end of the time series were due to differences in R_p (Table 7; Figure 8). Models 27.0 and 27.0a fixed R_p to 0.5 (i.e., 50/50 recruitment EAG/WAG), though the data suggest that EAG consistently receives a larger proportion of recruitment. Since recruitment proportion deviations must sum to zero, it is necessary for the model to offset positive EAG favoring deviations with large negative deviations, which it did so near the end of the time series when recruitment estimates are weakly informed (Figure 16). A similar effect was also present at the start of the model, where only retained catch data inform recruitment and size structure, leading to an erratic recruitment trajectory. Model 27.0b estimated $R_p \approx 0.59$ and resulted in annual recruitment estimates similar to EAG 26.0a and WAG 26.0a2. Estimated growth for model 27.0 aligned with estimates from subdistrict-specific models, which were already very similar. Mirroring WAG growth to EAG growth (models 27.0a and 27.0b) resulted in a nearly negligible difference and is more appropriate than entering the same data twice (Figure 15).

Mature male biomass in the EAG was slightly lower for 27.0 series models that EAG 26.0a, which appears to be driven by a difference in population scale between subdistrict-specific and combined models. Estimated observer CPUE catchability for model 27.0b was about 11% greater than EAG 26.0a for both time blocks (Table 7). Scale difference is less prominent in the WAG, with more similar MMB trajectory and $\sim 4\%$ difference in catchability (Table 7). In lieu of a likelihood profile over catchability parameters, model 27.0b was refit with the same size composition weights as EAG 26.0a and WAG 26.0a2. Using the same size composition weight scheme resulted in very little difference in likelihood components compared to the bridging version of model 27.0 (i.e., 1 function call), except for uniform priors which are not shown in Table 4. The difference in catchability may be a result of the shared recruitment structure and should be explored more. A likelihood profile of catchability parameters was not prepared at the time of writing this document, but would help diagnose how well the data inform population scale. Reference points estimated generally follow the scale difference in MMB (Table 8).

Jitter results presented for models 27.0, 27.0a, and 27.0b were limited (Table 3). A large number of runs failed before running any function calls because jittered starting values resulted in negative growth increments. An initial try at adjusting bounds on growth parameters did not resolve the issue. This mostly affected model 27.0. There were much fewer failed runs for modes 27.0a and 27.0b. Still, the limited number of successful runs suggest convergence to the MLE with few local minima in proximity.

Conclusions

The author recommended models for the 2027 final assessment are EAG 26.0a, WAG 26.0a2, and 27.0b. WAG 26.0a2 seems to avoid the erroneously large recruitment and bycatch mortality pulse during the mid-1990s that the WAG 26.0a MLE estimated. Transition to a combined model is not necessarily an improvement in model specification, but if the desire is to assess the population as a single stock, it is a step in that direction. Stock delineation of AIGKC remains somewhat unclear. The current designation of EAG and WAG separated at 174° W longitude was largely informed by historical fishing practices, though supported by evidence of low crab density in the area separating subdistricts (von Szalay et al. 2011, 2017). Tagging of adults ≥ 90

mm CL suggested only limited movement (maximum 61.2 km; Blau and Pengilly 1994), whereas population genetic analysis indicated genetic homogeneity within the region (Grant and Siddon 2018). Regardless of stock structure, the EAG and WAG share biological information including natural mortality, size at maturity, and growth, that would be more naturally integrated within a single assessment framework. The combined model could be extended to estimate metapopulation dynamics (e.g., movement) in the future as GMACS development continues. A combined model would also calculate reference points internally, avoiding the current *ad hoc* F_{OFL} calculation based on combined stock status inferred from subdistrict-specific estimates of $F_{35\%}$, $B_{35\%}$, and MMB_{prj}. Lastly, the structure of model 27.0b allows subdistrict-specific changes to model specification without maintaining multiple separate models, and subdistrict-specific outputs can be readily extracted to inform State management.

Tables

Table 1: Objective function, catch, index, and size likelihood components, key management quantities, and frequency of each outcome for 100 jitter runs with jitter scale ($\sigma_J = 0.3$) for WAG model 26.0a2. Blank rows indicate runs that did not converge.

	Model	Objective Function	Δ NLL	Catch	Index	Size	MMB_{prj}	$\mathrm{B}_{35\%}$	Max. Gradient	N
WAG	26.0a2	3,242.801	0.000	-484.050	-65.740	1,006.250	3,991	4,470	1.88e-05	91
		3,586.828	344.028	-397.110	-60.590	1,259.990	3,739	4,255	1.26e-03	1
									NA	8
WAG	26.0a	3,264.626	0.000	-445.540	-78.610	998.890	4,126	4,852	8.91e-05	40
		3,265.831	1.205	-461.010	-65.740	1,006.250	3,990	4,470	6.58e-05	45
		3,346.922	82.296	-445.710	-78.280	1,081.330	4,040	4,801	6.65e-02	1
		3,348.546	83.920	-461.280	-64.040	1,088.090	3,905	4,410	2.87e-02	1
		3,609.860	345.234	-374.070	-60.590	1,259.990	3,738	4,255	6.38e-04	2
									NA	11

Table 2: Comparison of likelihood components after one function call for the combined model (27.0) and subdistrict-specific models using parameter estimates from subdistrict-specific EAG 26.0a and WAG 26.0a2.

Process	27.0	EAG 26.0a	WAG 26.0a2
EAG Retained Catch	-453.92933	-453.92933	
EAG Total Catch	-66.20746	-66.20746	
EAG GF Byatch	32.19359	32.19359	
WAG Retained Catch	-451.85304		-451.85304
WAG Total Catch	-39.49054		-39.49054
WAG GF Byatch	7.29074		7.29074
EAG Obs CPUE 1995-2004	-12.68812	-12.68812	
EAG Obs CPUE 2005-2025	-21.04257	-21.04257	
EAG FT CPUE 1985-1998	-14.16731	-14.16731	
WAG Obs CPUE 1995-2004	-13.30693		-13.30693
WAG Obs CPUE 2005-2025	-35.16644		-35.16644
WAG FT CPUE 1985-1998	-17.26408		-17.26408
EAG Retained Size Comp.	462.23712	462.74579	
EAG Total Size Comp.	368.17862	368.14175	
WAG Retained Size Comp.	612.96210		612.73024
WAG Total Size Comp.	393.56412		393.51719
Recruitment Penalty	13.94405	12.78584	18.30792
EAG Tagging	2,698.18895	2,698.18895	
WAG Tagging	2,697.92153		2,697.92153
Objective Function	6,162.22969	3,076.26893	3,242.80055

Table 3: Objective function, catch, index, and size likelihood components, key management quantities, and frequency of each outcome for successful jitter runs with jitter scale ($\sigma_J = 0.3$) for models 27.0, 27.0a, and 27.0b. Blank rows indicate runs that did not converge.

Model	Objective Function	Δ NLL	Catch	Index	Size	MMB_{prj}	$B_{35\%}$	Max. Gradient	N
27.0	6,365.430	0.000	-972.060	-111.570	1,816.440	9,762	11,075	5.64e-04	29
	6,365.918	0.488	-972.210	-112.010	1,817.940	9,812	11,085	3.55e-04	8
	6,366.151	0.721	-972.130	-111.690	1,817.680	9,765	11,078	1.70e-02	1
	6,367.627	2.197	-972.060	-111.350	1,818.200	9,759	11,038	7.30e-04	5
	6,368.826	3.396	-972.090	-111.460	1,819.550	9,761	11,042	1.93e-03	1
								NA	1
.....									
27.0	3,667.197	0.000	-970.860	-112.240	1,822.450	9,510	11,009	2.18e-04	63
	3,667.913	0.716	-971.110	-112.560	1,824.230	9,574	11,018	3.24e-04	16
	3,669.303	2.105	-970.890	-111.950	1,824.080	9,521	10,977	1.09e-03	12
	3,670.742	3.544	-971.010	-112.070	1,825.610	9,536	10,988	4.68e-04	1
								NA	2
.....									
27.0	3,605.263	0.000	-968.770	-113.840	1,796.750	10,031	11,058	3.61e-04	91
	3,695.046	89.782	-969.250	-112.190	1,885.940	9,978	11,003	9.62e-04	2
	3,744.617	139.354	-970.390	-112.710	1,937.130	9,872	10,943	4.85e-02	1

Table 4: Comparison of likelihood components for the combined model series (27.0, 27.0a, and 27.0b), including model 27.0 run with subdistrict-specific parameters at one function call (27.0 bridge) and model 27.0b with size composition weights matching EAG 26.0a and WAG 26.0a2 (27.0b size wt).

Process	27.0 (bridge)	27.0	27.0a	27.0b	27.0b (size wt)
EAG Retained Catch	-453.929	-453.941	-453.835	-453.836	-453.787
EAG Total Catch	-66.207	-66.601	-66.107	-65.66	-65.395
EAG GF Bycatch	32.194	32.193	32.194	32.197	32.197
WAG Retained Catch	-451.853	-451.89	-451.829	-451.703	-451.958
WAG Total Catch	-39.491	-39.116	-38.574	-37.062	-40.824
WAG GF Bycatch	7.291	7.291	7.291	7.291	7.29
EAG Obs CPUE 1995-2004	-12.688	-12.558	-12.59	-12.707	-12.706
EAG Obs CPUE 2005-2025	-21.043	-20.59	-21.111	-21.601	-21.473
EAG FT CPUE 1985-1998	-14.167	-13.429	-12.849	-13.367	-13.391
WAG Obs CPUE 1995-2004	-13.307	-13.098	-13.374	-13.505	-13.421
WAG Obs CPUE 2005-2025	-35.166	-34.993	-35.342	-35.53	-35.777
WAG FT CPUE 1985-1998	-17.264	-16.907	-16.974	-17.126	-17.278
EAG Retained Size Comp.	462.237	466.683	466.171	455	460.552
EAG Total Size Comp.	368.179	375.111	378.814	380.366	365.193
WAG Retained Size Comp.	612.962	577.938	591.844	591.445	612.847
WAG Total Size Comp.	393.564	396.703	385.621	369.942	393.395
Recruitment Deviation Penalty	13.944	14.23	14.489	13.57	13.569
Recruitment Proportion Deviation Penalty		81.995	82.771	44.88	44.884
EAG Tagging	2698.189	2698.517	2704.334	2703.98	2703.558
WAG Tagging	2697.922	2698.715			
Number of Parameters	321	321	316	317	317
Objective Function	6162.23	6365.43	3667.197	3605.263	3642.369

Table 5: Input and reweighted effective sample size for retained catch size composition (number of vessel days) for subdistrict-specific models (EAG 26.0a and WAG 26.0a2), 27.0, 27.0a, and 27.0b.

		EAG					WAG			
Year	N_{obs}	26.0a	27.0	27.0a	27.0b	N_{obs}	26.0a2	27.0	27.0a	27.0b
1985	366	83	81	81	85	346	36	41	39	39
1986	221	50	49	49	51	348	36	41	39	39
1987	276	62	61	61	64	359	37	43	40	41
1988	498	113	111	110	115	368	38	44	41	42
1989	606	137	135	134	140	755	79	90	85	86
1990	213	48	47	47	49	342	36	41	38	39
1991	149	33	33	33	34	166	17	19	18	19
1992	104	23	23	23	24	104	10	12	11	11
1993	369	83	82	81	85	415	43	49	47	47
1994	777	176	173	172	180	734	77	88	83	84
1995	1,046	237	233	232	243	734	77	88	83	84
1996	615	139	137	136	142	957	100	115	108	109
1997	800	181	178	177	186	968	102	116	110	110
1998	605	137	134	134	140	525	55	63	59	60
1999	624	141	139	138	145	1,140	120	137	129	130
2000	545	123	121	120	126	1,099	115	132	125	125
2001	550	125	122	122	127	923	97	110	105	105
2002	497	112	110	110	115	695	73	83	79	79
2003	457	103	101	101	106	645	68	77	73	73
2004	333	75	74	73	77	453	47	54	51	51
2005	395	89	88	87	91	452	47	54	51	51
2006	297	67	66	65	69	312	32	37	35	35
2007	352	80	78	78	81	367	38	44	41	42
2008	310	70	69	68	72	391	41	46	44	44
2009	257	58	57	57	59	330	34	39	37	37
2010	272	61	60	60	63	305	32	36	34	34
2011	249	56	55	55	57	351	37	42	39	40
2012	277	62	61	61	64	406	42	48	46	46
2013	289	65	64	64	67	471	49	56	53	53
2014	200	45	44	44	46	531	56	63	60	60
2015	204	46	45	45	47	514	54	61	58	58
2016	271	61	60	60	63	459	48	55	52	52
2017	252	57	56	55	58	370	39	44	42	42
2018	255	57	56	56	59	361	38	43	41	41
2019	260	59	57	57	60	462	48	55	52	52
2020	286	65	63	63	66	502	52	60	57	57
2021	281	63	62	62	65	479	50	57	54	54
2022	238	54	53	52	55	341	35	40	38	39
2023	278	63	61	61	64	407	42	48	46	46
2024	247	56	55	54	57	188	19	22	21	21
2025	258	58	57	57	59	122	12	14	13	13

Table 6: Input and reweighted effective sample size for total catch size composition (number of observer days) for subdistrict-specific models (EAG 26.0a and WAG 26.0a2), 27.0, 27.0a, and 27.0b.

	EAG					WAG				
Year	N_{obs}	26.0a	27.0	27.0a	27.0b	N_{obs}	26.0a2	27.0	27.0a	27.0b
1990	67	40	39	38	38	239	100	99	104	111
1991	44	26	25	25	25	106	44	44	46	49
1992	44	26	25	25	25	85	35	35	37	39
1993	5	3	2	2	2	51	21	21	22	23
1994	121	73	71	69	69	237	99	98	103	110
1995	1,013	617	595	581	580	700	293	291	305	325
1996	615	374	361	352	352	957	400	398	417	444
1997	800	487	470	458	458	968	405	402	422	449
1998	605	368	355	347	346	525	219	218	229	243
1999	624	380	367	357	357	1,140	477	474	497	529
2000	545	332	320	312	312	1,099	460	457	479	510
2001	550	335	323	315	315	923	386	384	402	428
2002	497	302	292	285	284	695	291	289	303	322
2003	457	278	268	262	262	645	270	268	281	299
2004	333	202	195	191	190	453	189	188	197	210
2005	210	127	123	120	120	352	147	146	153	163
2006	194	118	114	111	111	250	104	104	109	116
2007	189	115	111	108	108	232	97	96	101	107
2008	148	90	87	84	84	242	101	100	105	112
2009	141	85	82	80	80	225	94	93	98	104
2010	172	104	101	98	98	211	88	87	92	98
2011	157	95	92	90	90	285	119	118	124	132
2012	143	87	84	82	81	322	134	134	140	149
2013	166	101	97	95	95	333	139	138	145	154
2014	108	65	63	61	61	353	147	146	154	164
2015	126	76	74	72	72	323	135	134	141	150
2016	176	107	103	100	100	280	117	116	122	130
2017	164	99	96	94	94	215	90	89	93	99
2018	141	85	82	80	80	237	99	98	103	110
2019	152	92	89	87	87	244	102	101	106	113
2020	158	96	92	90	90	305	127	126	133	141
2021	138	84	81	79	79	247	103	102	107	114
2022	90	54	52	51	51	226	94	94	98	105
2023	139	84	81	79	79	220	92	91	96	102
2024	116	70	68	66	66	91	38	37	39	42
2025	151	92	88	86	86	92	38	38	40	42

Table 7: Parameter estimates (standard error) among models, excluding annual deviations and initial numbers at size.

Parameter	EAG 26.0a	WAG 26.0a2	27.0	27.0a	27.0b
ln R_{ini}	9.08 (0.119)	9.3 (0.149)	9.78 (0.11)	9.74 (0.115)	9.78 (0.115)
ln $\bar{R}$	7.98 (0.082)	7.63 (0.08)	7.82 (0.078)	7.81 (0.079)	7.82 (0.079)
Logit R_p					0.36 (0.044)
EAG Rec Dist Scale	0.53 (0.07)		0.54 (0.073)	0.53 (0.072)	0.52 (0.069)
WAG Rec Dist Scale		0.49 (0.067)			
WAG Rec Dist Scale (ln offset)			-1.24e-01 (0.191)	-7.36e-02 (0.187)	-3.17e-02 (0.184)
EAG Growth α	23.5 (1.466)		23.58 (1.468)	23.66 (1.39)	23.71 (1.385)
EAG Growth β	0.08 (0.011)		0.08 (0.011)	0.08 (0.011)	0.08 (0.011)
EAG Growth σ	3.65 (0.096)		3.66 (0.097)	3.67 (0.097)	3.67 (0.097)
WAG Growth α		22.6 (1.482)	22.35 (1.486)		
WAG Growth β		0.07 (0.011)	0.07 (0.011)		
WAG Growth σ		3.67 (0.098)	3.67 (0.098)		
EAG Molt probability μ	141.56 (0.63)		141.92 (0.625)	141.92 (0.716)	141.83 (0.714)
EAG Molt probability cv	0.09 (0.004)		0.09 (0.004)	0.1 (0.005)	0.09 (0.005)
WAG Molt probability μ		141.4 (0.702)	141.17 (0.713)		
WAG Molt probability cv		0.09 (0.005)	0.09 (0.006)		
EAG Sel ln S_{50} 1981-2004	4.75 (0.031)		4.75 (0.03)	4.79 (0.034)	4.78 (0.033)
EAG Sel ln S_{Δ} 1981-2004	2.87 (0.131)		2.86 (0.129)	2.94 (0.121)	2.93 (0.121)
EAG Sel ln S_{50} 2005-2025	4.9 (0.01)		4.9 (0.01)	4.91 (0.011)	4.91 (0.01)
EAG Sel ln S_{Δ} 2005-2025	2.07 (0.057)		2.1 (0.058)	2.12 (0.057)	2.09 (0.056)
WAG Sel ln S_{50} 1981-2004		4.83 (0.021)	4.84 (0.022)	4.84 (0.024)	4.84 (0.024)
WAG Sel ln S_{Δ} 1981-2004		2.65 (0.079)	2.67 (0.079)	2.68 (0.087)	2.69 (0.084)
WAG Sel ln S_{50} 2005-2025		4.9 (0.009)	4.9 (0.009)	4.9 (0.008)	4.9 (0.008)
WAG Sel ln S_{Δ} 2005-2025		2.03 (0.049)	2.02 (0.049)	2.02 (0.048)	2.03 (0.047)
EAG Ret ln R_{50}	4.91 (0.001)		4.91 (0.001)	4.91 (0.001)	4.91 (0.001)
EAG Ret ln R_{Δ}	0.66 (0.055)		0.65 (0.056)	0.66 (0.056)	0.67 (0.054)
WAG Ret ln R_{50}		4.91 (0.002)	4.91 (0.001)	4.91 (0.002)	4.91 (0.002)
WAG Ret ln R_{Δ}		0.64 (0.065)	0.65 (0.061)	0.65 (0.062)	0.64 (0.062)
ln $\bar{F}$ EAG Directed Fishery	-9.96e-01 (3.334)		-9.29e-01 (3.334)	-8.41e-01 (3.334)	-8.95e-01 (3.334)
ln $\bar{F}$ WAG Directed Fishery		-7.12e-01 (3.334)	-7.21e-01 (3.334)	-6.80e-01 (3.334)	-6.69e-01 (3.334)
ln $\bar{F}$ EAG Groundfish Fisheries	-6.97e+00 (3.784)		-6.92e+00 (3.784)	-6.90e+00 (3.784)	-6.93e+00 (3.784)
ln $\bar{F}$ WAG Groundfish Fisheries		-7.60e+00 (3.894)	-7.63e+00 (3.894)	-7.59e+00 (3.894)	-7.57e+00 (3.894)
EAG Obs CPUE q 1995-2004	2.88e-04 (3.12e-05)		3.00e-04 (3.18e-05)	3.33e-04 (3.55e-05)	3.22e-04 (3.43e-05)
EAG Obs CPUE q 2005-2025	5.86e-04 (6.34e-05)		6.56e-04 (6.77e-05)	7.16e-04 (7.44e-05)	6.55e-04 (7.03e-05)
EAG FT CPUE q 1985-1998	5.94e-04 (5.56e-05)		6.05e-04 (5.69e-05)	6.57e-04 (6.43e-05)	6.45e-04 (6.19e-05)
WAG Obs CPUE q 1995-2004		7.99e-04 (6.91e-05)	7.93e-04 (7.02e-05)	8.25e-04 (8.31e-05)	8.36e-04 (8.29e-05)
WAG Obs CPUE q 2005-2025		1.04e-03 (8.85e-05)	1.00e-03 (8.61e-05)	1.05e-03 (8.52e-05)	1.08e-03 (8.52e-05)
WAG FT CPUE q 1985-1998		9.29e-04 (7.94e-05)	9.24e-04 (8.04e-05)	9.54e-04 (9.26e-05)	9.58e-04 (9.16e-05)
EAG ln extra cv Obs CPUE 1995-2025	-1.58e+00 (0.157)		-1.56e+00 (0.163)	-1.58e+00 (0.163)	-1.60e+00 (0.157)
EAG ln extra cv FT CPUE 1985-1998	-1.59e+00 (0.256)		-1.53e+00 (0.251)	-1.48e+00 (0.247)	-1.53e+00 (0.25)
WAG ln extra cv Obs CPUE 1995-2025		-2.06e+00 (0.155)	-2.05e+00 (0.158)	-2.07e+00 (0.157)	-2.08e+00 (0.154)
WAG ln extra cv FT CPUE 1985-1998		-1.81e+00 (0.279)	-1.78e+00 (0.269)	-1.78e+00 (0.274)	-1.80e+00 (0.281)

Table 8: Estimated reference points using a combined F_{OFL} computation for EAG 26.0a and WAG 26.0a2 and combined-subdistrict models 27.0, 27.0a, and 27.0b.

			$\bar{R}$ 1986–2021						
Model	Subdistrict	MMB_{prj}	EAG	WAG	$F_{35\%}$	$B_{35\%}$	Status	F_{OFL}	OFL
26.0a	EAG	6,680	2,669		0.52	6,687	0.96	0.49	3,491
26.0a2	WAG	3,991		1,790	0.52	4,470		0.50	
27.0		9,762	2,605	1,813	0.53	11,075	0.88	0.46	2,724
27.0a		9,510	2,591	1,776	0.54	11,009	0.86	0.46	2,551
27.0b		10,031	2,625	1,766	0.50	11,058	0.91	0.45	2,909

Figures

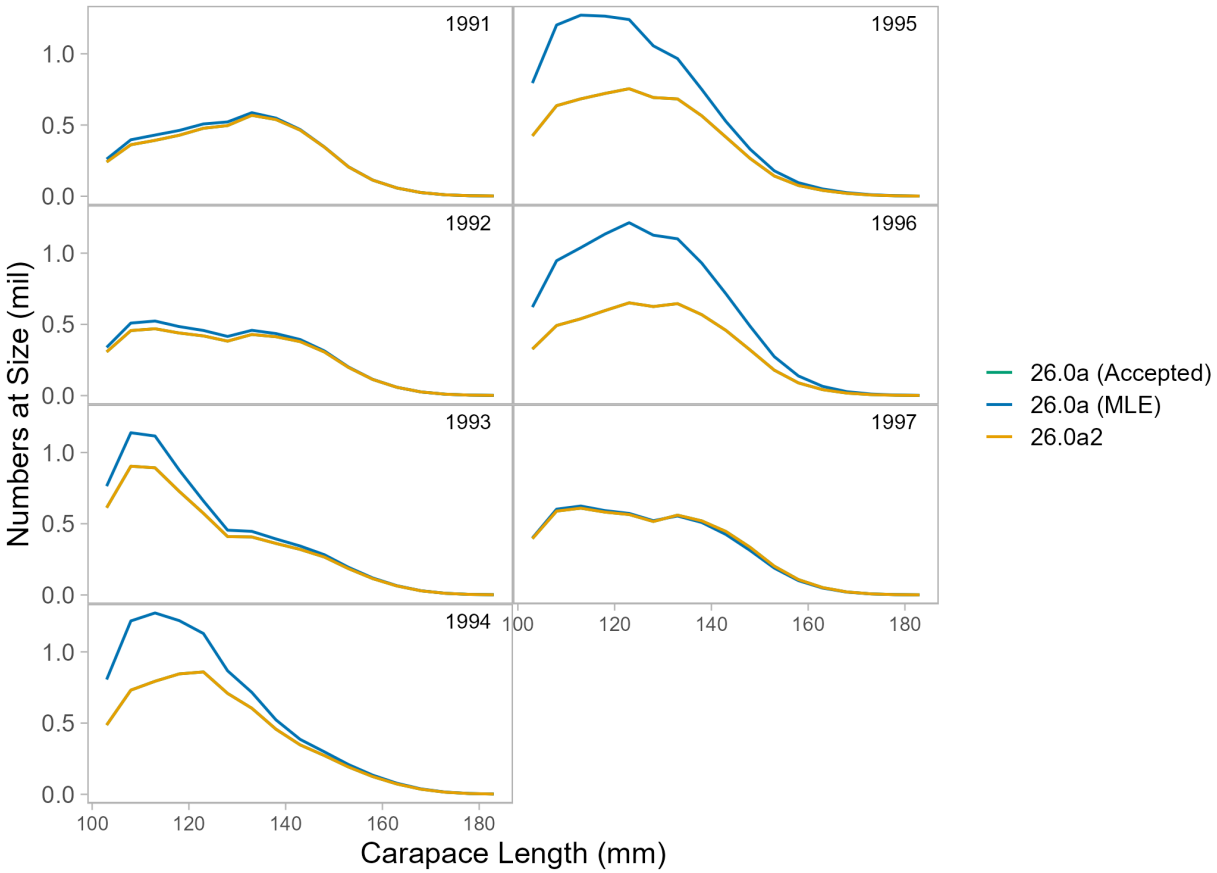


Figure 1: Numbers at size by year for models WAG 26.0a (Accepted) and WAG 26.0a (MLE).

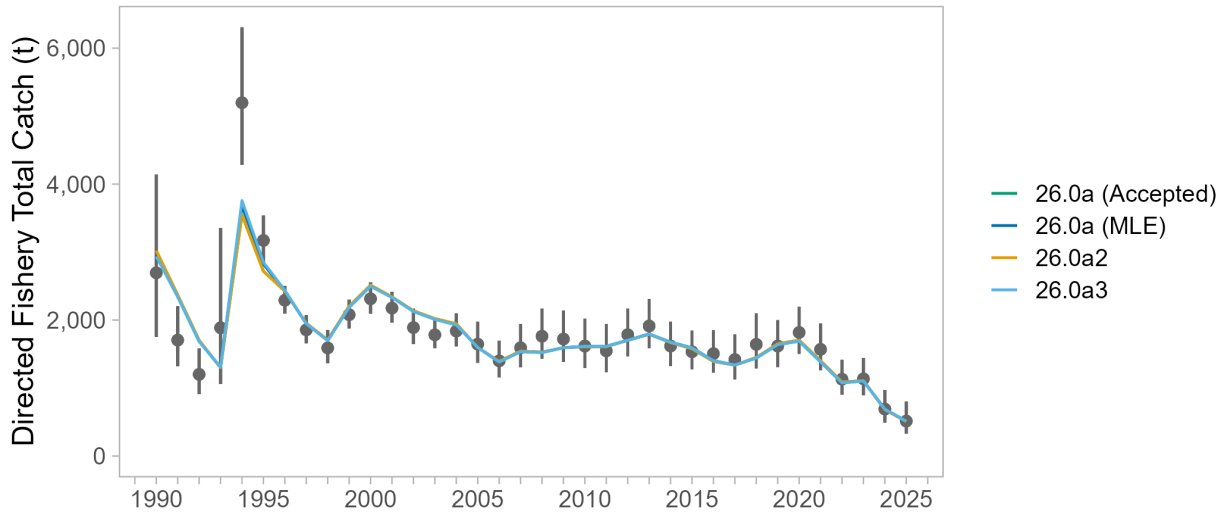


Figure 2: Fit to directed total catch for models WAG 26.0a (Accepted), 26.0a (MLE), 26.0a2, and 26.0a3.

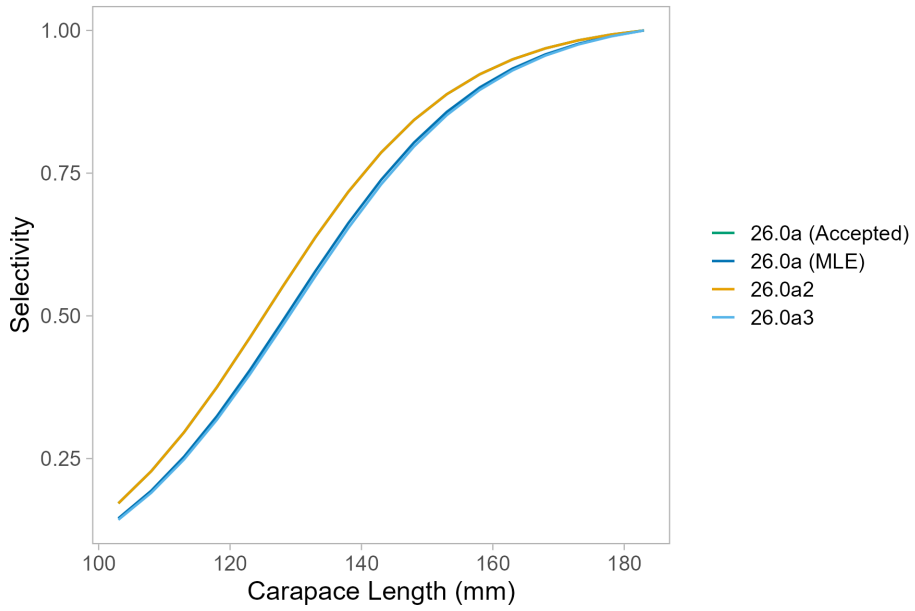


Figure 3: Directed fishery selectivity (1981 - 2004) for models WAG 26.0a (Accepted), 26.0a (MLE), 26.0a2, and 26.0a3.

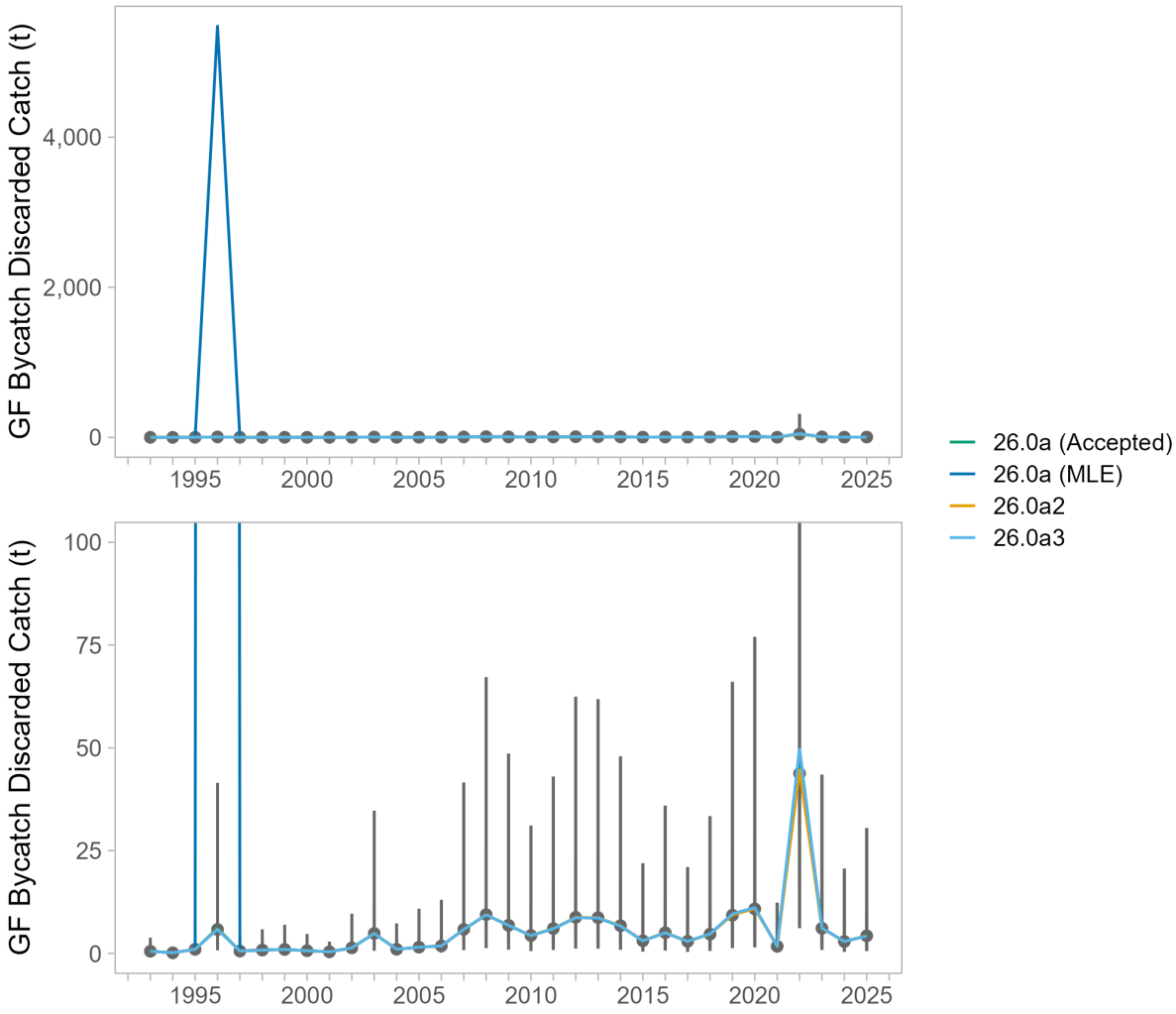


Figure 4: Fit to groundfish fishery bycatch for models WAG 26.0a (Accepted), 26.0a (MLE), 26.0a2, and 26.0a3. The bottom panel is the same as the top, but zoomed in.

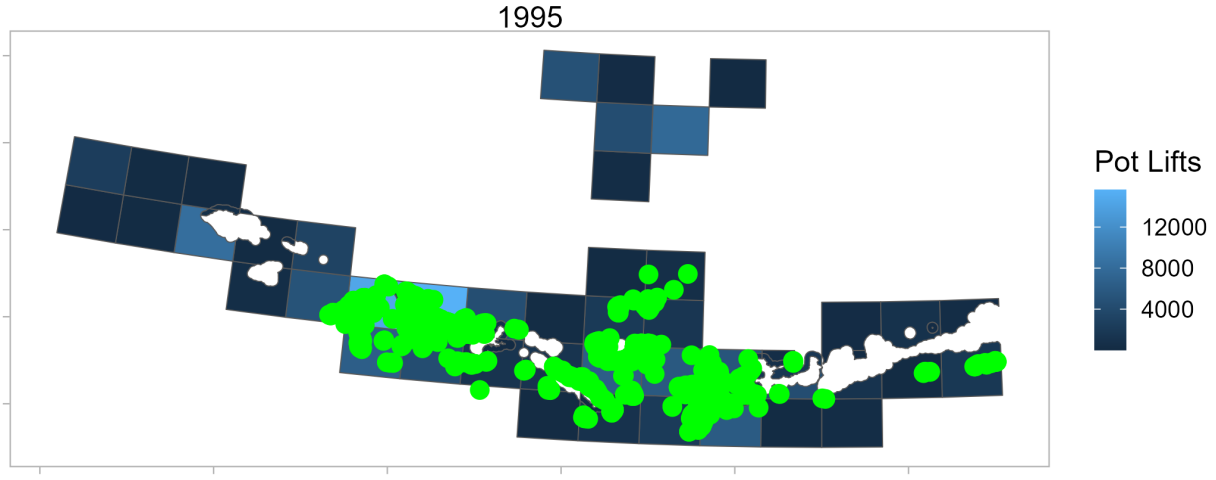


Figure 5: Map of fishery pot lifts by statistical area and observer sample locations (green dots) in 1995.

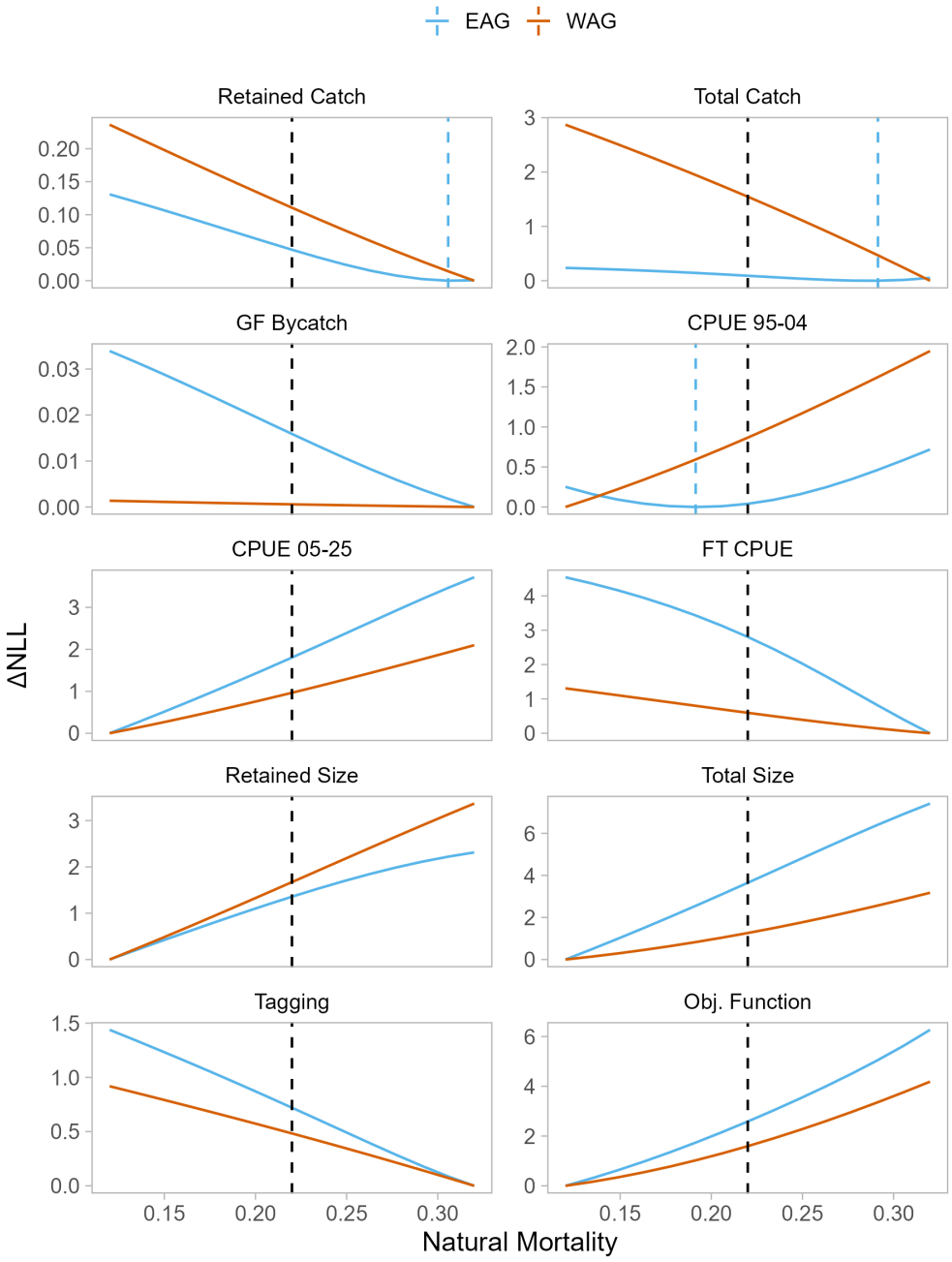


Figure 6: Likelihood profiles of natural mortality, M, by data component and subdistrict models EAG 26.0a and WAG 26.0a2. Black dashed lines indicate assumed M in assessment models (0.22 yr^{-1}) and colored dashed lines indicate minima if located within the profiled range.

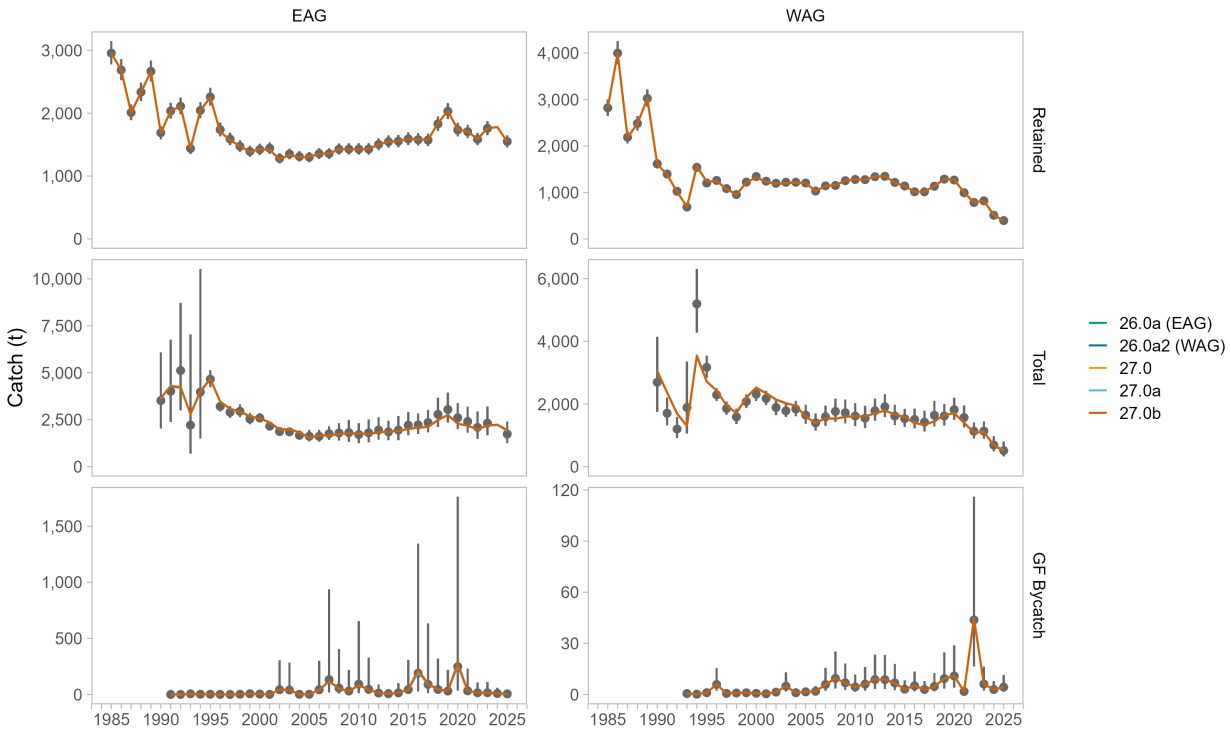


Figure 7: Comparison of model fit to retained catch, total catch, and groundfish bycatch. Error bars on observed values represent 95% confidence intervals. Observed catch for 2024 was removed due to confidentiality.

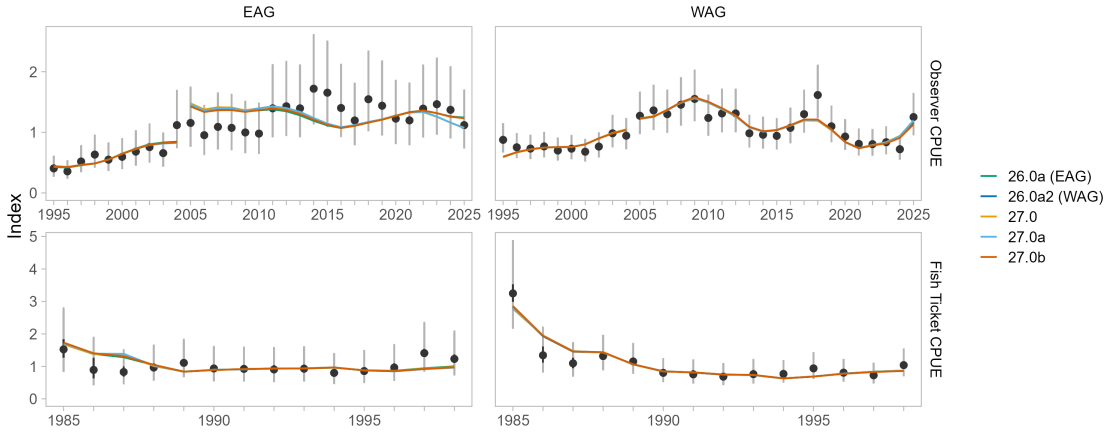


Figure 8: Comparison of fit to CPUE indices. Error bars on observed values represent 95% confidence intervals (black) and estimated additional error (grey).

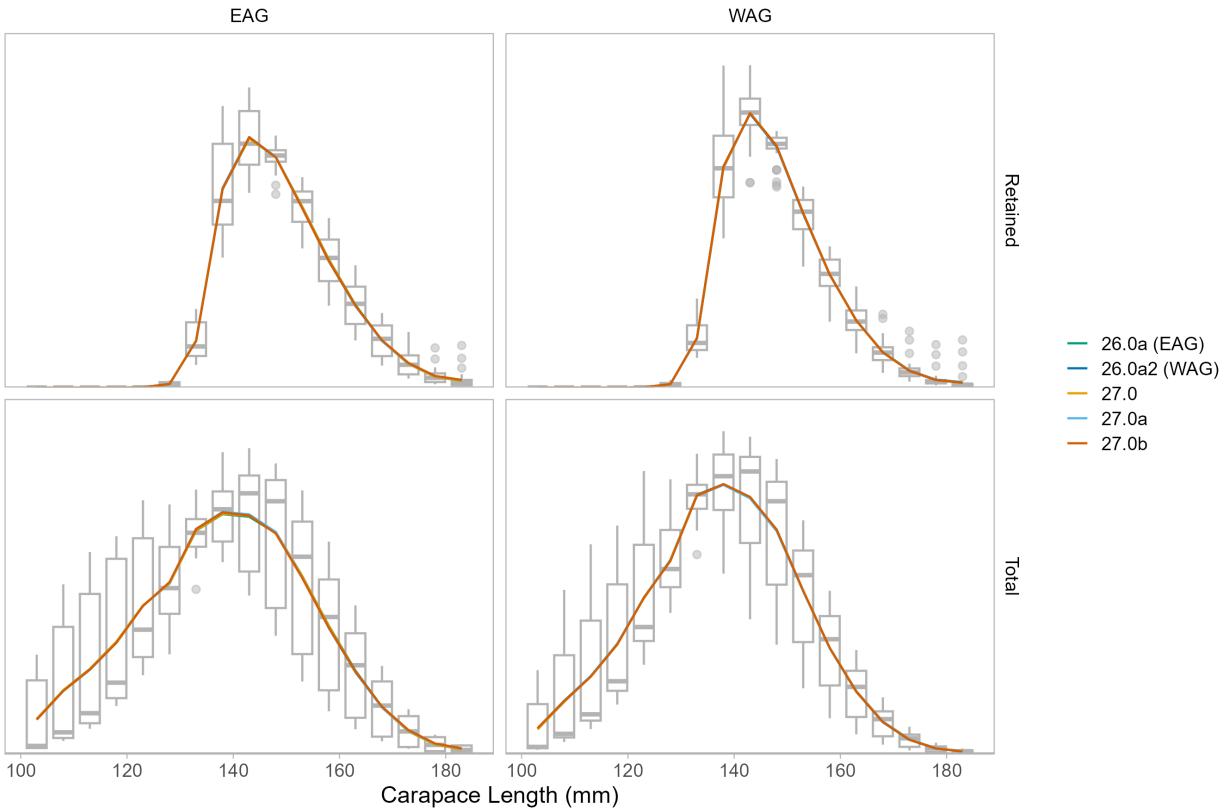


Figure 9: Comparison of fit to size composition data in aggregate. Boxplots indicate the distribution at size of annual observed data.

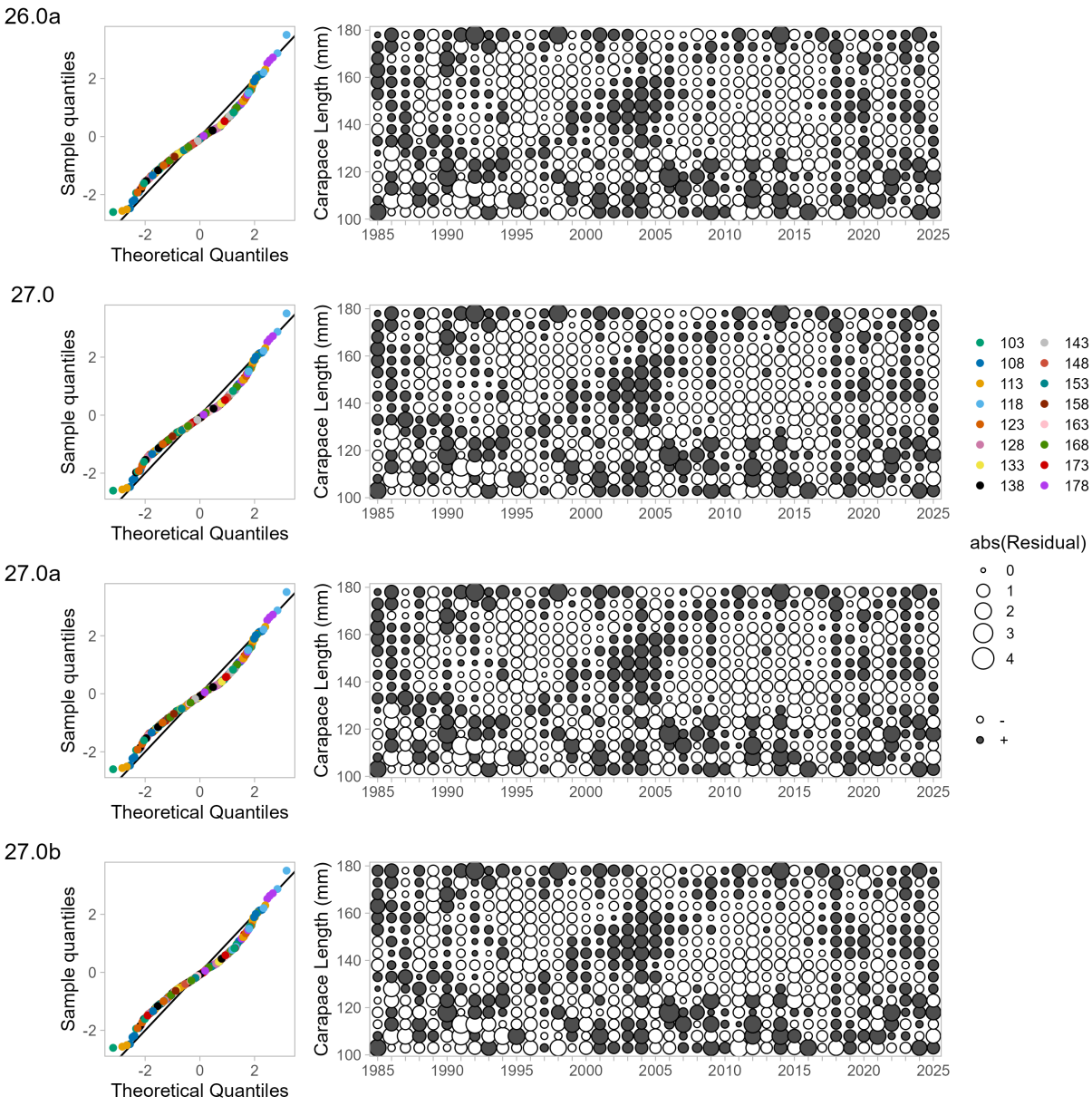


Figure 10: QQ plots and bubble plots for one step ahead residuals for fits to retained size composition data among EAG model 26.0a2, 27.0, 27.0a, and 27.0b.

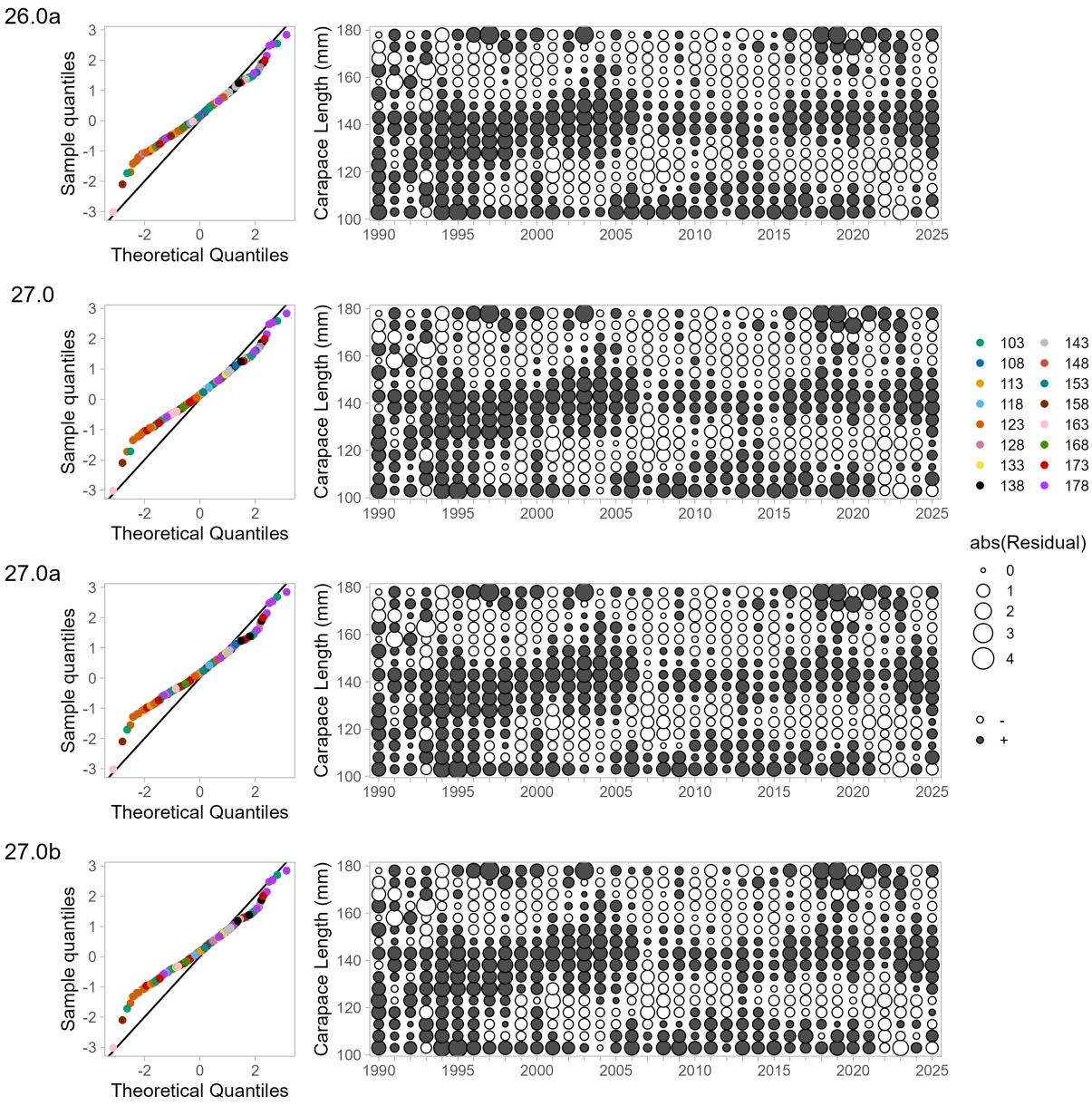


Figure 11: QQ plots and bubble plots for one step ahead residuals for fits to total size composition data among EAG model 26.0a2, 27.0, 27.0a, and 27.0b.

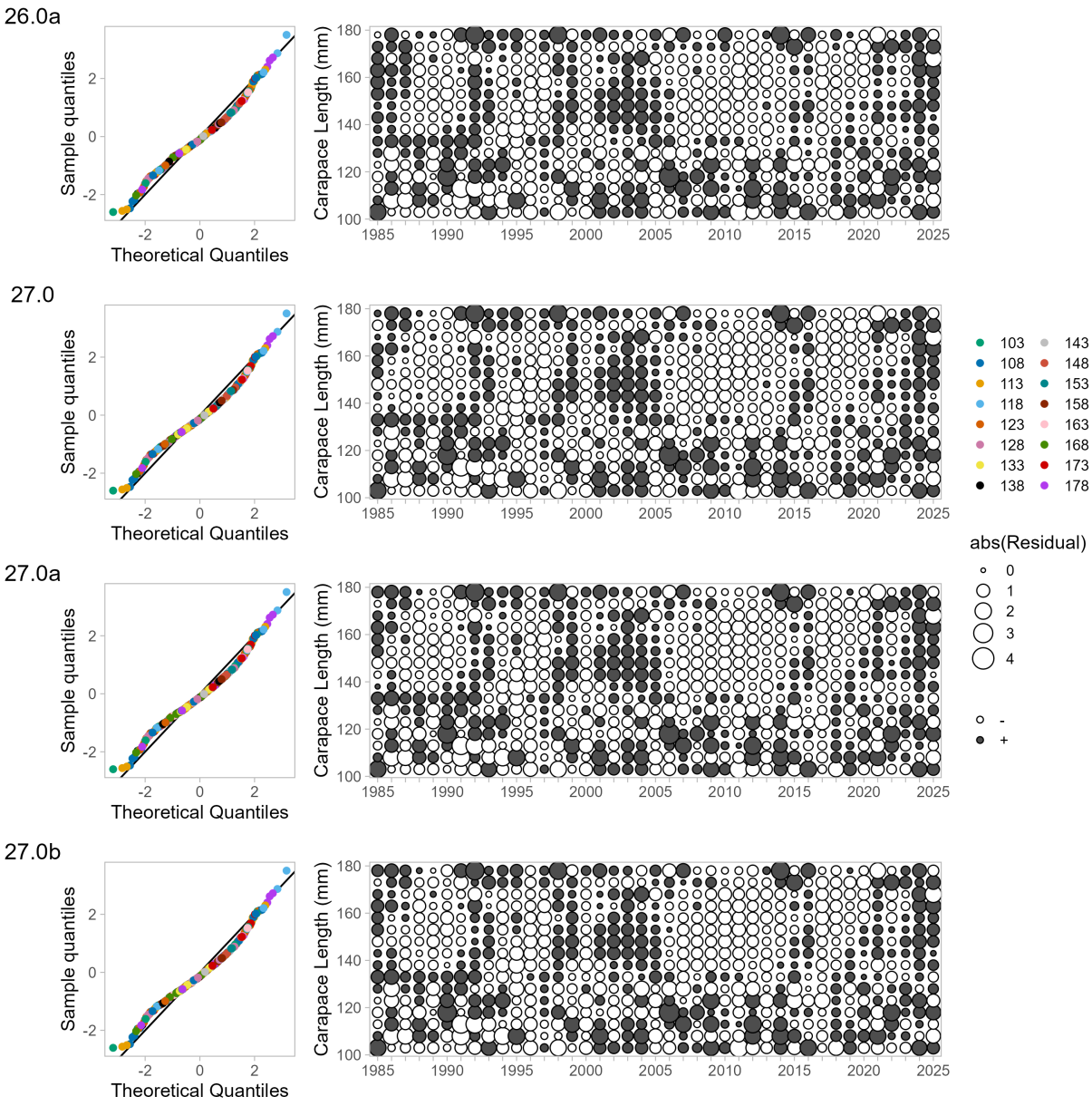


Figure 12: QQ plots and bubble plots for one step ahead residuals for fits to retained size composition data among WAG model 26.0a2, 27.0, 27.0a, and 27.0b.

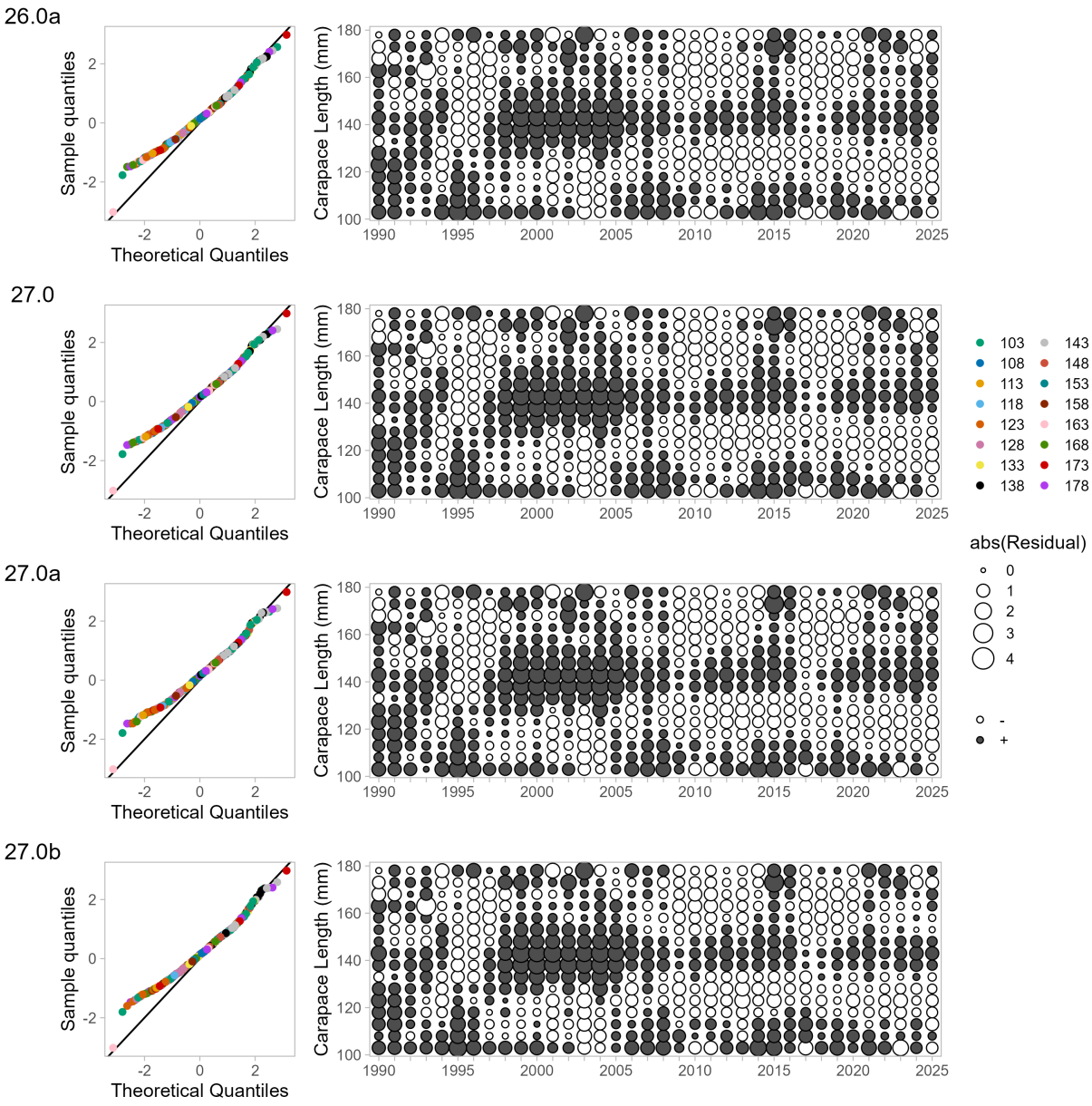


Figure 13: QQ plots and bubble plots for one step ahead residuals for fits to total size composition data among WAG model 26.0a2, 27.0, 27.0a, and 27.0b.

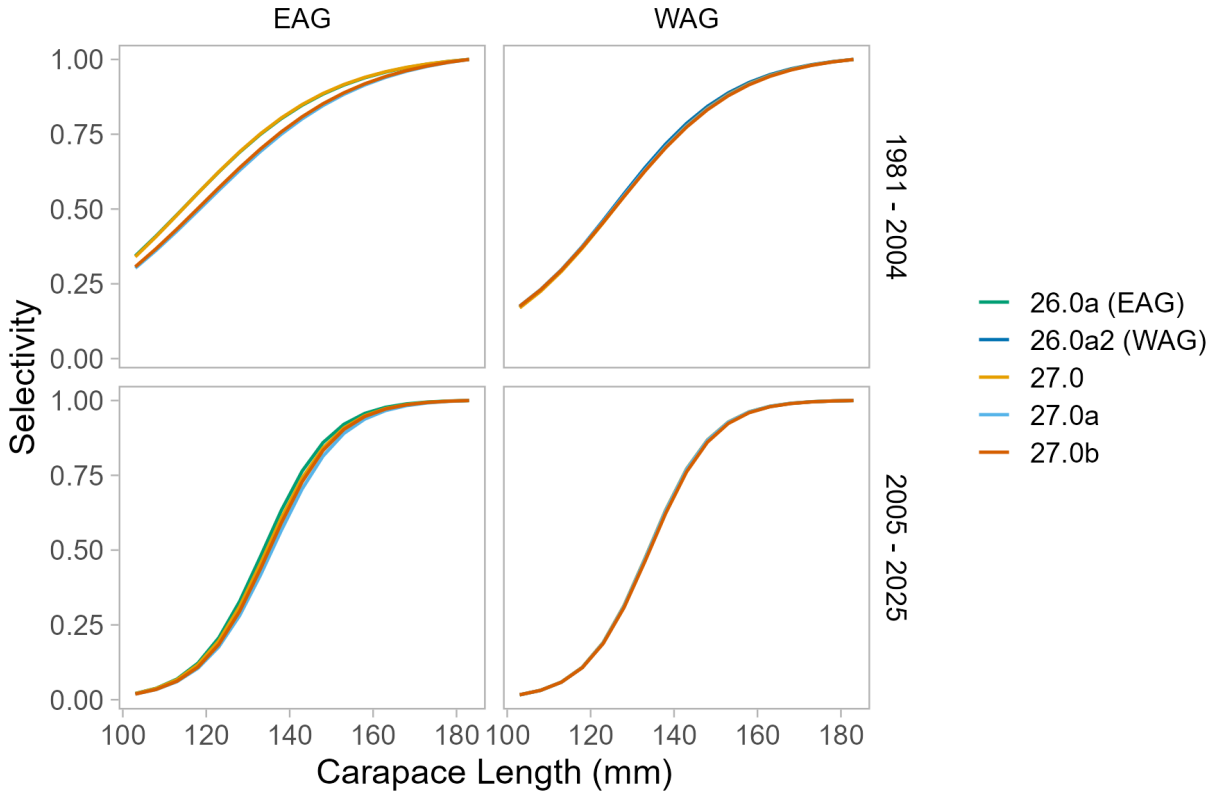


Figure 14: Comparison of model estimated selectivity time blocks by subdistrict for models EAG 26.0a, WAG 26.0a2, 27.0, 27.0a, and 27.0b.

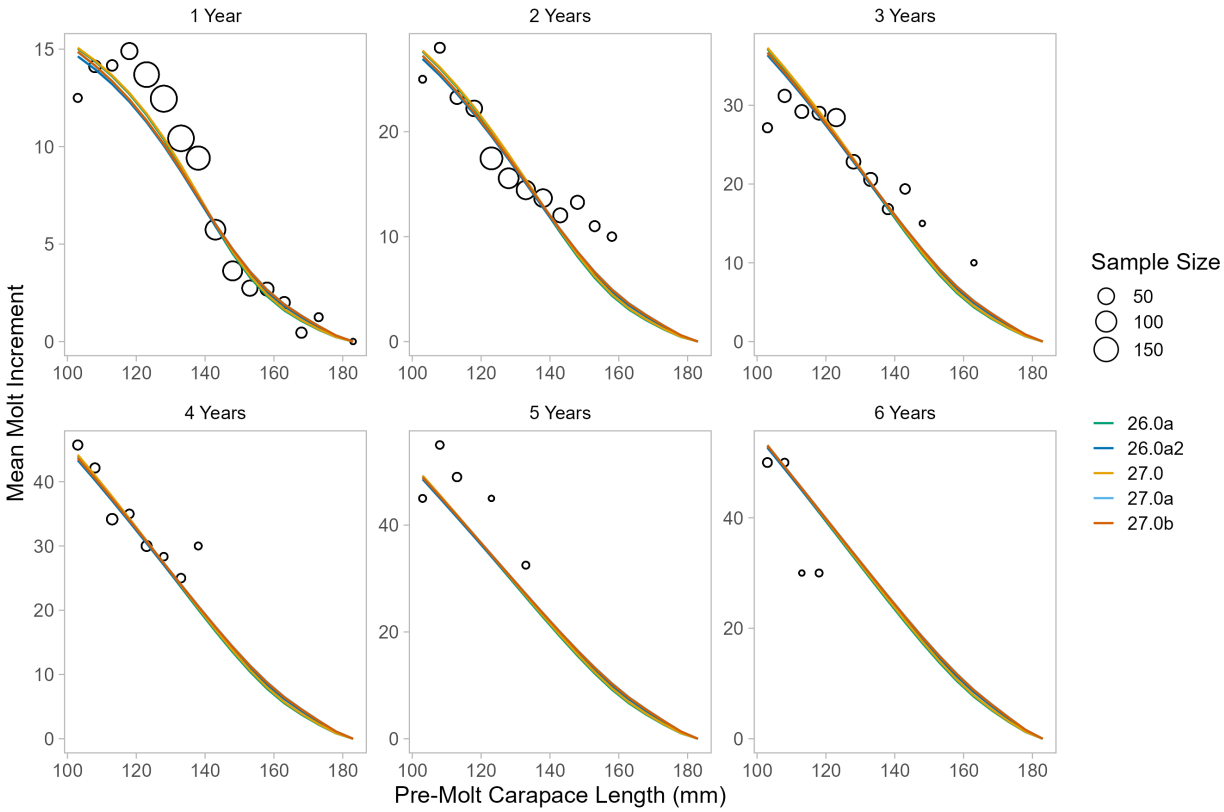


Figure 15: Comparison of model estimated growth by subdistrict for models EAG 26.0a, WAG 26.0a2, 27.0, 27.0a, and 27.0b.

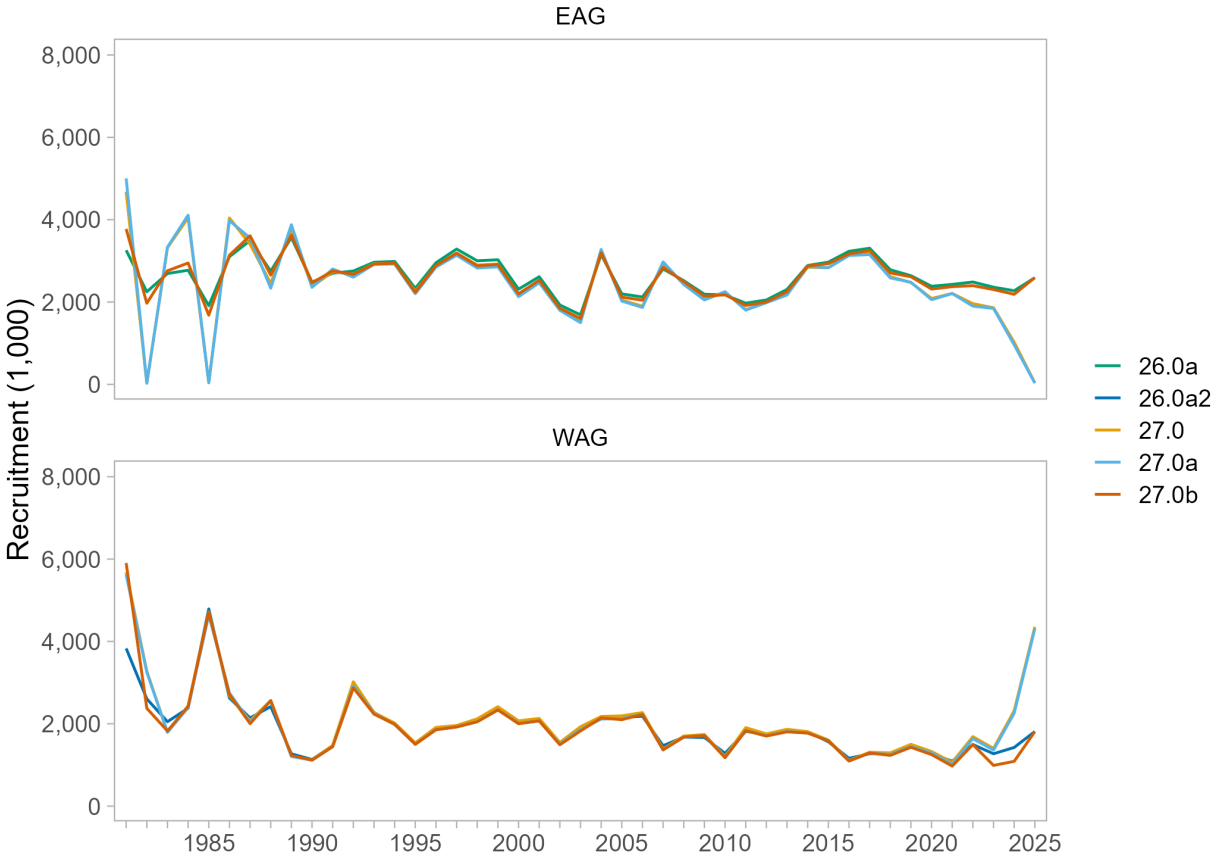


Figure 16: Comparison of model estimated recruitment by subdistrict for models EAG 26.0a, WAG 26.0a2, 27.0, 27.0a, and 27.0b.

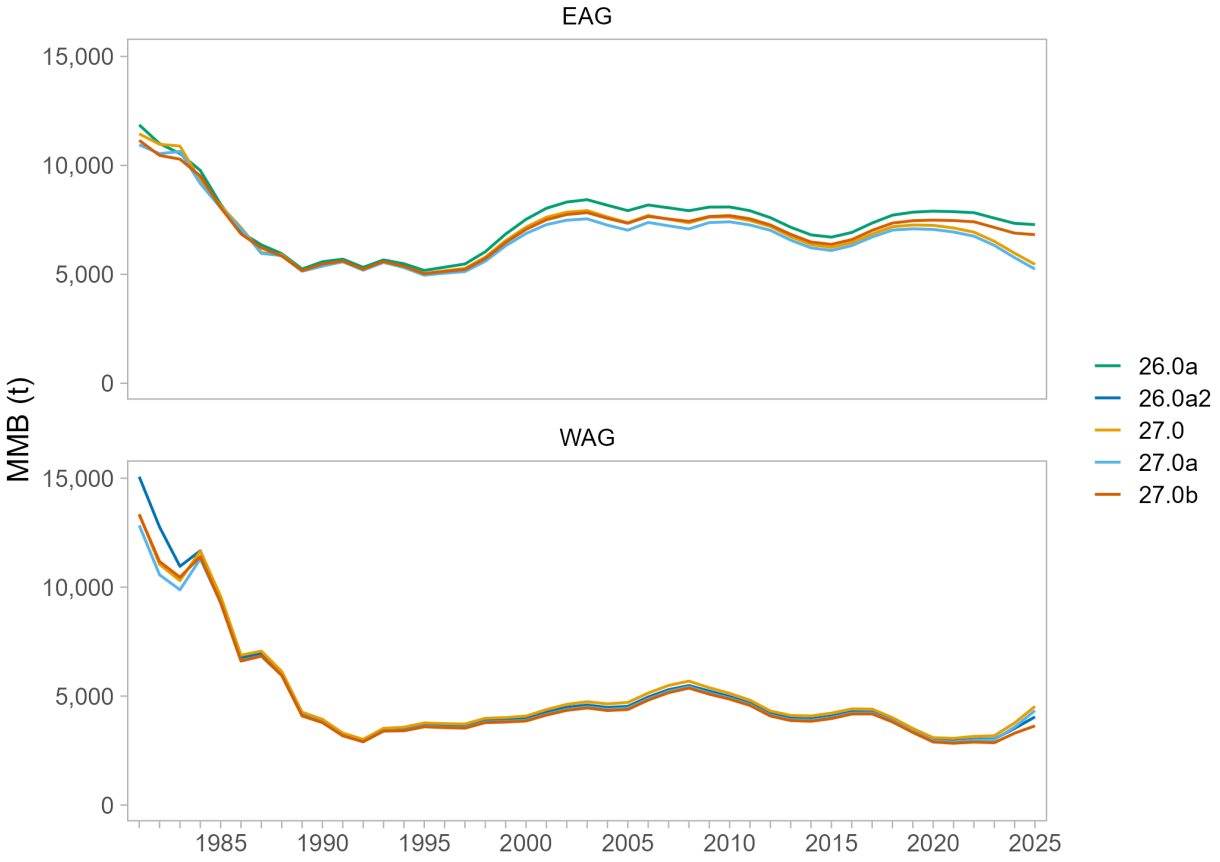


Figure 17: Comparison of model estimated mature male biomass by subdistrict for models EAG 26.0a, WAG 26.0a2, 27.0, 27.0a, and 27.0b.

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