Proposed new widow rockfish base model and changes from August 2025

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Introduction and proposed changes

The base model within the widow rockfish update assessment reviewed at the August 2025 Pacific Fishery Management Council (PFMC) Science and Statistical Committee (SSC) Groundfish Subcommittee (GFSC) meeting followed the 2015 benchmark assessment in its structure and assumptions, as required by the Terms of Reference for update assessments (with the exception of removing discard length composition data for the hook-and-line fleet, as discussed and approved at the meeting). For the supplemental review, recommended by the GFSC and formalized at the September PFMC meeting, we explored a larger range of options which go beyond update assessment Terms of Reference and no longer match the 2015 benchmark.

Based on this exploration, we developed an alternative model which includes the changes from the August base model described below. This alternative model produces similar results to the model reviewed in August 2025 as demonstrated in the section below on model bridging. This document also includes results of model diagnostics as well as tables of reference points and projections from the proposed new base model. This document doesn't include the full set of model output fits to data. Reviewers should refer to the r4ss files for this information, in addition to the accompanying document ("Response to requests from the PFMC SSC Groundfish Subcommittee for supplementary review of the August 2025 widow rockfish stock assessment", where the requests and responses detailed there are referenced here simply as "GFSC Request"). We will produce a complete revised assessment report after the October 2025 supplemental review reflecting the outcome of that meeting.

The STAT suggests reading the GFSC Request document first, which helps to motivate this proposed new model.

Changes to the base model that was reviewed in August 2025

1. **Use the updated Washington historical catch reconstruction.**

   The Washington Department of Fish and Wildlife (WDFW) provided a historical catch reconstruction for widow rockfish. This is the subject of GFSC Request 7 and one of the sensitivity analyses in the assessment report reviewed in August 2025.

   The three main sources used in this reconstruction included the US Fish Commission Report (UFSC), Washington Bound Volumes, and Washington Statistical Bulletin. The historical species composition was based on the various historical reports and interviews of fishermen and dockside samplers. The landings between 1981 and 2000 were also provided by WDFW, since WDFW developed and used an improved method for apportioning unidentified rockfish (URCK) category in fish tickets to the individual species landings. This improved approach relaxed the borrowing rules for missing data used in the WDFW species allocation algorithm that feeds into PacFIN. New Washington historical landings represent the best scientific information available.

2. **Simplify the fleet structure.**

   The catch from fixed gear fleets (hook-and-line and net) was combined with the bottom trawl fleet, and the composition data for the fixed gear fleets was removed.

   These fleets represent only 1.1% and 1.4% of the catch and are less likely to be representative of the population as a whole. GFSC Requests 1 (reduce influence of hook-and-line composition data) and 6 (leave-one-out analysis) indicated that data from the smaller fleets have little influence on the model results. The issues with the hook-and-line discard length data resolved prior to the August 2025 base model showed that even small amounts of data from these fleets can have undue influence on the results when combined with mismatching assumptions for selectivity and retention.

   If the data associated with the small fleets was informative of some population process not well measured by the data from the larger fleets (e.g. if the samples from smaller fish were informative about recent recruitment), then it may have been worth keeping them separate. However, they appear to just add noise to the model which does not justify the additional selectivity parameters required to treat them separately.

   In addition, the catches made by the foreign historical fishery targeting Pacific Ocean perch (1966–1976), were moved from the hake fleet to bottom trawl, consistent with other groundfish assessments.

3. **Use external estimates of discards and add them to landings, rather than estimate discards within the model.**

   The use of estimated retention functions within the model was standard practice in 2015, following a long period of large discards due to trip limits. However, discard rates have been low for widow rockfish for more than 10 years so the benefit of using retention functions to extrapolate beyond the range of observed data is reduced and the biological data from the discards are no longer as likely to be informative about dynamics of the total population. As a part of response to the GFSC Request 9, we illustrated that treating discard as catch (rather than estimating them in the model) did not have much impact on model results. Also, this approach avoids hard-to-diagnose issues that come from estimating retention curves (especially with limited amounts of data), as we encountered with the hook-and-line fleet in the August 2025 base model. For some species, the discard data may provide important information about recent recruitment because the smaller fish are being discarded. However, for this stock, removing the discard amounts and length-compositions from the likelihood had little impact on recruitment estimates (See Figure 2 in bridging section).

For the proposed new base model, we estimated bottom trawl discards and midwater trawl discards externally, using historical sources (the Pikitch study and the Enhanced Data Collection Project, EDCP), as well as West Coast Groundfish Observer Program (WCGOP) data, and added calculated discard amounts to landings of the corresponding fleets by year. The methods used to reconstruct discard amounts in different time periods are detailed below. The range of years chosen for each method approximate the time-blocks on retention that informed the different data sources in the August 2025 base model.

a. For the years 1982–1989, landings in the bottom trawl and midwater trawl fleets were scaled using fleet-specific discard rates estimated from the Pikitch study.
b. For the years 1990–2001, landings in the bottom trawl and midwater trawl fleets were scaled using fleet-specific discard rates estimated from the EDCP data.
c. For the years 2002–2023, GEMM estimates of fleet-specific discards amounts were added to the landed catch (bottom trawl + other, and midwater trawl).
d. The 2024 values were set to the average from the GEMM estimates for the period 2021–2023. All retention parameters were removed from the model.
e. Total catch in the at-sea hake fishery was fully accounted for in the August 2025 base model and was not changed other than the shifting of the foreign catch to the bottom trawl fleet as noted above.

4. **Update the data weighting to follow current best practices.** The data weighting approach was changed to match recent practices, including the use of the Francis rather than McAllister-Ianelli approach, and no longer including a 50% additional reduction in weights.

   Data weighting remains a topic of ongoing research in the stock assessment community. However, the Francis method performed better in a simulation analysis (Punt 2017) and has been the preferred approach in most recent stock assessments.

   The 50% multiplier on the data weights used in the previous assessment was an approach more common in 2015 to account for the potential double use of data since length and age are observed from the same fish. However, the sum of the adjusted input sample sizes for length and age data combined are already far lower than the number of sampled fish because they are primarily based on trips or hauls and then further reduced by the data-weighting algorithm. This 50% adjustment is no longer common practice and has not been used any other recent assessments.

5. **Change the selectivity blocking for the midwater trawl fleet.** The block that previously went from 2002 when the stock was declared overfished to 2010 when

the IFQ program began was extended to 2016 when the new midwater trawl fishery began in earnest. See GFSC Request document for further discussion on blocking of the midwater trawl fleet.

6. **Use a fecundity relationship rather than assume the number of eggs is proportional to body weight.**

   As noted in GFSC Request 13, accounting for size-dependent fecundity in rockfish stocks using the meta-analysis from Dick et al. (2017) has become standard practice in recent years and is included in the TOR and Accepted Practices Guidelines documents.

   Following standard practice for species that were not included in the meta-analysis, the predictive distributions for unobserved *Sebastes* species was used. This relationship has the number of eggs proportional to length to the power 4.043 (as opposed to body weight which was estimated as proportional to length to the power 2.99)

7. **Update bias adjustment using estimated values (modified to have full bias adjustment starting in 1970).**

   The data weighting changed the uncertainty around estimates of recent recruitment, necessitating a change in the recruitment bias adjustment settings. However, the estimated algorithm in the r4ss package continued to under-adjust the well-informed recruitments in 1970 and 1971 (see GFSC Request 5), so the inputs were modified to ensure full bias adjustment of the recruitments from 1970 onward.

Changes not included in the proposed new base model

The proposed new base model does not include a few of the changes explored as part of the GFSC requests. First, the exploration of alternative functional forms for selectivity of the West Coast Groundfish Bottom Trawl Survey (Request 4) showed that changing from cubic spline selectivity to double normal increased the likelihood significantly without resolving any clear problem with the status quo approach. Second, we explored finer-scale selectivity blocks on midwater trawl selectivity as part of open-ended Request 9, but settled on a more parsimonious change to the start year of the final block rather than using finer-scale blocks. Finally, we explored decreasing the uncertainty on the juvenile survey (Request 12), but the mismatch between large index observations in the past and the estimated size of those cohorts from age and length composition data raises concerns that the index observation in 2023 may also be an overestimate, and the estimated additional uncertainty is warranted.

Bridging from the August 2025 model to the new proposed base model

For illustration of the bridging analysis, the changes to the August 2025 base model are grouped into the following steps:

1. Adopt the new Washington historical catch reconstruction
2. Simplify fleets and include discards with landings, refine selectivity block
3. Update the status-quo data weighting (McAllister-Ianelli, lambda = 0.5)
4. Change data weighting methods (Francis, lambda = 1)
5. Add the fecundity relationship
6. Refine the recruitment bias adjustment and re-tune the weighting

None of the updates resulted in large changes in estimated population trajectories and model outputs, but several important quantities were sensitive to a few of the changes (Table 1, Figures 1 and 2).

Adding the Washington historical catch reconstruction had a relatively small impact, as was already demonstrated through a sensitivity analysis in the August 2025 assessment report.

Simplifying the fleet structure and combining discards with landings did not bring about large changes in model results either, but interacted with the Francis weighting approach applied later. Extending the block on midwater trawl selectivity did not cause any noticeable change.

The use of the Francis weighting approach (instead of McAllister-Ianelli) and using lambda = 1 (and not further down-weighting fishery composition data) resulted in the biggest change from the August 2025 base model, causing the estimates of natural mortality to go up, which translated into increases in the estimated productivity of the stock, including equilibrium catch and estimated OFLs. Relative to the August 2025 model, the updated data weighting method upweighted length data from the bottom trawl fleet and age data from all three commercial fleets (bottom trawl, midwater trawl, hake); all other composition data sources were downweighted (Table 2). For bottom trawl, in particular, this upweighting is likely in part due to the removal of discard composition data, as Stock Synthesis does not apply separate data weights to discarded and retained composition data from the same fleet. The discard compositions are very noisy and difficult to fit, so their removal allowed for upweighting of the remaining data. The decrease in the weight of West Coast Groundfish Bottom Trawl Survey (WCGBTS) conditional age-at-length data by approximately one-third, paired with upweighting of other data, is likely the major driver of the increased estimate of natural mortality, given explorations in GFSC request 6.

With the change in fecundity relationship, spawning output is now expressed in billions of eggs and no longer directly comparable with spawning biomass expressed in metric tons in previous models. This change did not have much impact on age 4+ biomass, but the spawning output time series was impacted by the changes in relative contributions of older fish. In particular, the stock status (fraction of unfished spawning output) reached a low point of 0.232 in 1998 (below the 0.25 overfished threshold) as compared to a minimum of 0.326 in 2001 in the August 2025 base model. The addition of the fecundity relationship also resulted in slightly lower estimates of OFLs and fraction unfished at the end of the time series compared to the previous step in this bridging, though still higher than the August 2025 estimates.

Finally, refining the recruitment bias adjustment and re-tuning the model (again with the Francis method) have only a small impact on the model results.

Table 1: Estimates of key parameters and derived quantities showing the bridging between the August base model and the proposed new base model. The units for B0 and B2025 are 1000s of tons for the first five models and billions of eggs for the last two.

Label	Aug 2025 model	Aug 2025 + New WA catch	Simplify fleets + include discards with landings	Update data weighting (McAllister-Ianelli, lambda = 0.5)	Change data weighting (Francis, lambda = 1)	Add fecundity relationship	Refine recruitment bias adjustment, re-weight
Estimates of key parameters							
log(R0)	10.457	10.456	10.346	10.343	10.588	10.599	10.603
M Female	0.122	0.122	0.118	0.119	0.135	0.135	0.135
M Male	0.14	0.14	0.135	0.136	0.156	0.156	0.156
Estimates of derived quantities							
Recruitment unfished millions	34.8	34.74	31.12	31.05	39.65	40.09	40.26
Unfished age 4+ bio 1000 mt	159	159.5	152.8	150.9	154	155.4	155.7
B0 1000 mt or billions of eggs	85.46	85.76	81.7	80.61	80.62	20.23	20.25
B2025 1000 mt or billions of eggs	46.93	46.98	38.37	38.22	43.67	10.37	10.4
Fraction unfished 2025	0.549	0.548	0.47	0.474	0.542	0.513	0.514
Fishing intensity 2024	1.175	1.176	1.328	1.318	1.118	1.187	1.185
Equil. catch at SPR targ. mt	5822	5827	5410	5398	6261	6016	6026
2027 OFL mt	4533	4534	3445	3504	5632	5075	5129
2027 ACL mt	4238	4239	3096	3160	5266	4745	4796

Table 2: Comparison of key data weighting quantities from the August 2025 (Aug.) and new proposed base model (New). ‘Lambda’ is the likelihood multiplier applied in the August 2025 model (Lambda = 1 for all fleets in the new proposed base model). ‘Weight x lambda’ is the product of the estimated data weighting and the lambda. ‘Sum N input’ is the sum of the input sample sizes across all observations (which differs for BottomTrawl because discard data has been removed). ‘Sum N adj.’ is that sum after adjustment by the data weighting and lambda. ‘CAAL’ is conditional age-at-length data. Entries with — indicate that fleet does not exist in the new proposed base model, and the composition data has been removed.

Type	Fleet	Lambda (Aug.)	Weight x lambda (Aug.)	Weight x lambda (New)	Sum N input (Aug.)	Sum N input (New)	Sum N adj. x lambda (Aug.)	Sum N adj. x lambda (New)
Length	BottomTrawl	0.5	0.028	0.055	14976.0	14336.4	422.2	785.0
Length	MidwaterTrawl	0.5	0.104	0.039	14908.6	14908.6	1547.2	587.2
Length	Hake	0.5	0.055	0.022	23864.6	23864.6	1317.5	532.2
Length	Net	0.5	0.248	—	1196.8	—	296.4	—
Length	HnL	0.5	0.186	—	1033.2	—	193.2	—
Length	Triennial	1.0	0.372	0.092	459.0	459.0	171.0	42.1
Length	WCGBTS	1.0	0.635	0.083	989.1	989.1	628.2	82.1
Age	BottomTrawl	0.5	0.083	0.194	8289.2	8289.2	688.3	1610.2
Age	MidwaterTrawl	0.5	0.140	0.151	8358.2	8358.2	1168.2	1258.1
Age	Hake	0.5	0.120	0.262	6051.2	6051.2	730.1	1582.5
Age	Net	0.5	0.250	—	737.8	—	184.7	—
Age	HnL	0.5	0.276	—	125.4	—	34.7	—
CAAL	WCGBTS	1.0	0.296	0.106	3243.6	3243.6	963.5	346.2

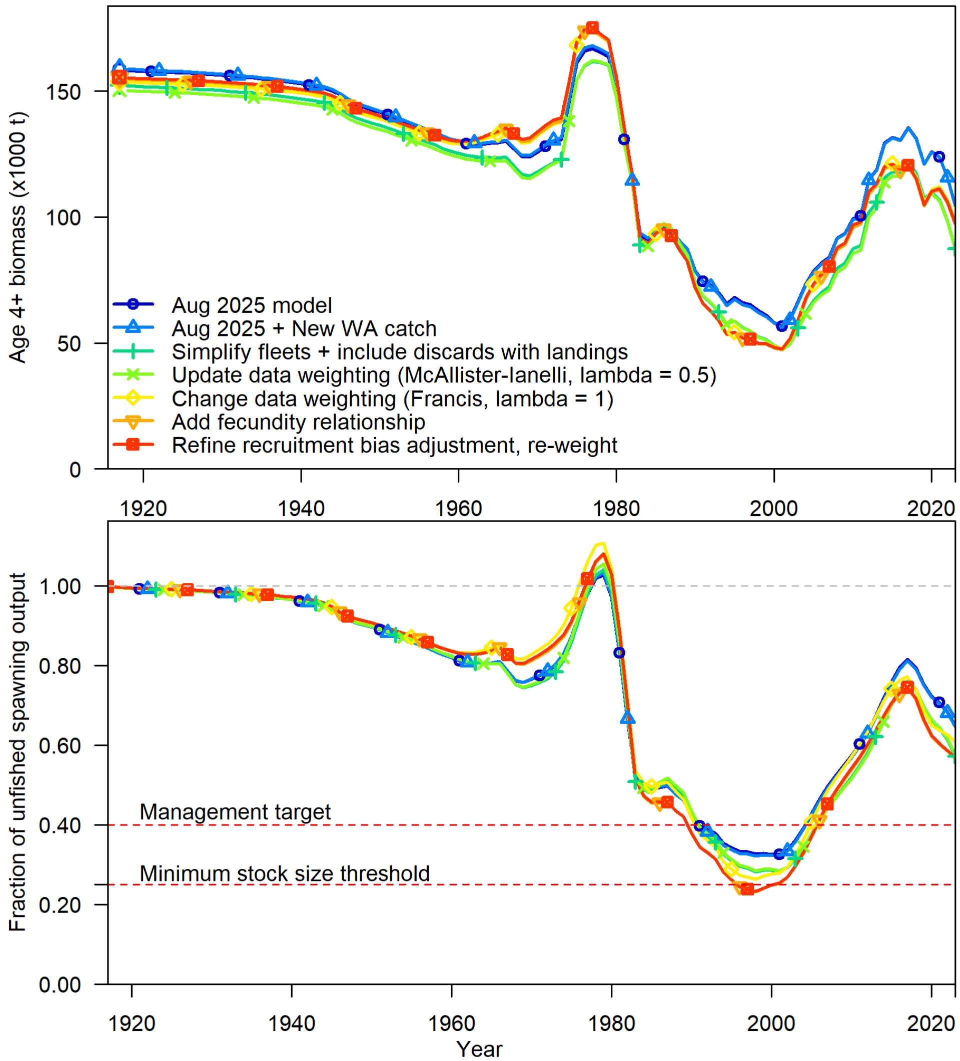

Figure 1: Time series of age 4+ biomass (top) and fraction of unfished spawning biomass (bottom) estimated in the bridging steps from the August 2025 base model to the current base models.

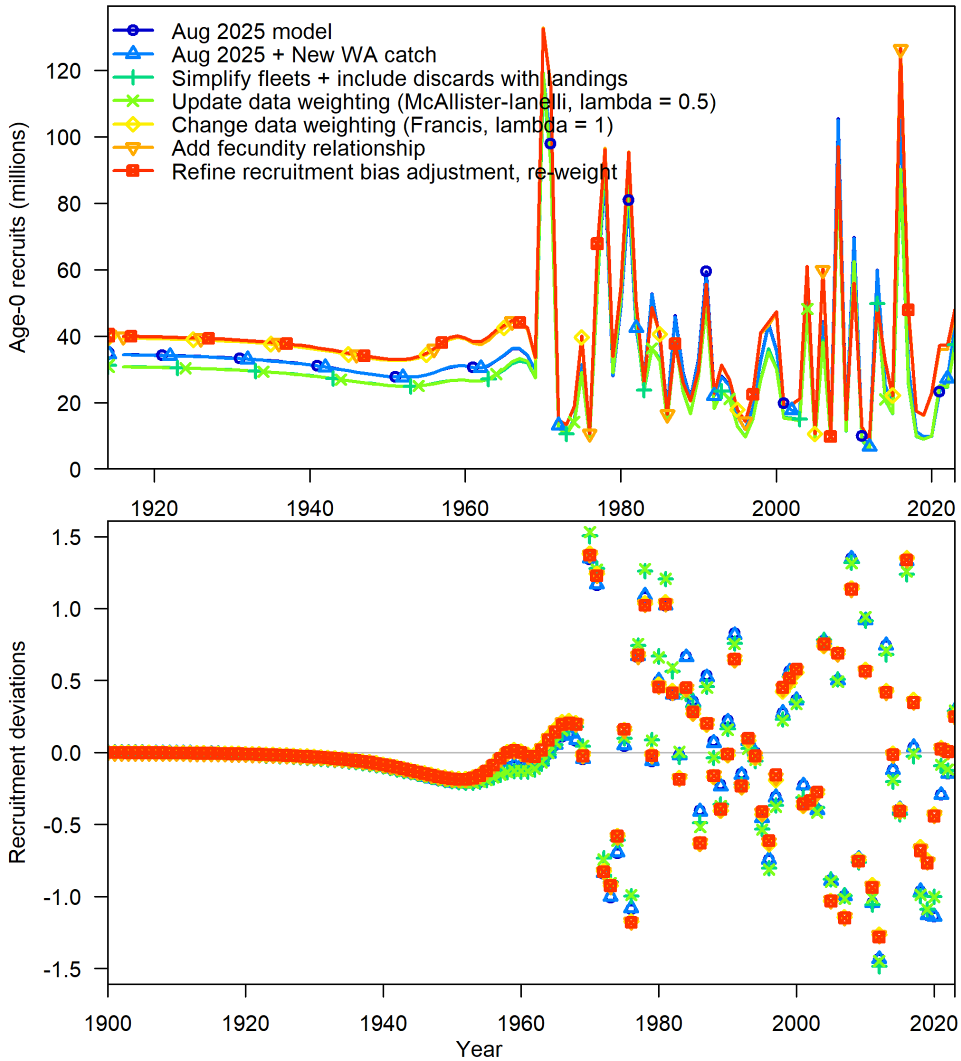

Figure 2: Time series of recruitment (top) and recruitment deviations (bottom) estimated in the bridging steps from the August 2025 base model to the current base models.

Diagnostics from the new proposed base model

A number of tests were performed to verify convergence of the model, facilitated by the {nwfscDiags} package in R (Wetzel 2025). Following conventional AD Model Builder methods (Fournier et al. 2012), we checked that the Hessian matrix for the base model was positive-definite. There were no difficulties in inverting the Hessian to obtain asymptotic variance estimates. The maximum component of the final gradient is very low (8.94e-05).

To confirm that the reported estimates were from the global best fit, we evaluated the model's ability to recover similar likelihood estimates when initialized from dispersed starting points (jitter option in SS3). Starting parameters were jittered using a setting of 0.05 for 100 iterations. This perturbs the initial values used for minimization with the intention of causing the search to traverse a broader region of the likelihood surface. The majority (56 out of 100) returned to the same objective function value as the proposed model. The remaining runs exhibited worse fit than the proposed model. The spread of this search indicates that the jitter was sufficient to search a large portion of the likelihood surface, and that the model is in a global optimum.

We also completed a set of standard model diagnostics that included retrospective analysis and likelihood profiles.

A five year retrospective yields a Mohn's rho of -0.042 for spawning output and -0.056 for fraction unfished. While these values are not particularly extreme, there is a general trend of increasing scale and fraction unfished as years are removed (Figure 3). This result is expected because the fraction of older fish in the WCGBTS increased substantially beginning in 2019. Analyses done in response to GFSC requests (separate document) indicate that sequentially peeling off individual years of WCGBTS age data leads to increasing estimates of natural mortality and unfished recruitment. The cause of this sudden increase in ages in the survey is unknown. Additionally, as years are pulled away the estimate of the size of the 2016 year class decreases towards average and the sizes of year classes since 2016 increase towards average. This is also expected as information about those recent year classes is removed.

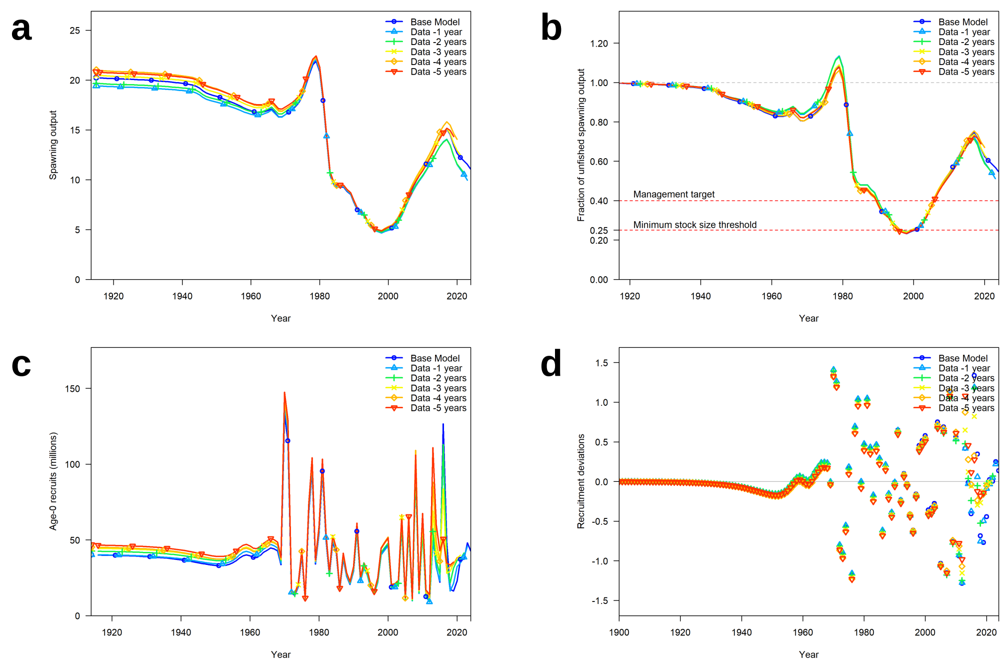

Figure 3: Patterns in (a) spawning output, (b) fraction unfished, (c) recruitment, and (d) recruitment deviations for a set of 5-year retrospective runs.

Profiles over female natural mortality indicate that the recruitment deviation prior and age data most strongly influence the estimate of natural mortality, with survey indices also being somewhat influential (Figure 4). Length data provides very little information. Relative to the August base model, all of the data sources suggest similar values of natural mortality. However, due to the updated data weighting, the WCGBTS ages, which were a key factor in the lower estimate of natural mortality relative to 2019, have a weaker pull on the estimate of natural mortality in terms of likelihood units. This leads to an overall increase in the estimate of female natural mortality. The removed fixed gear composition data was not influential on the estimate of natural mortality in the August base model. Profiles over male natural mortality behaved similarly.

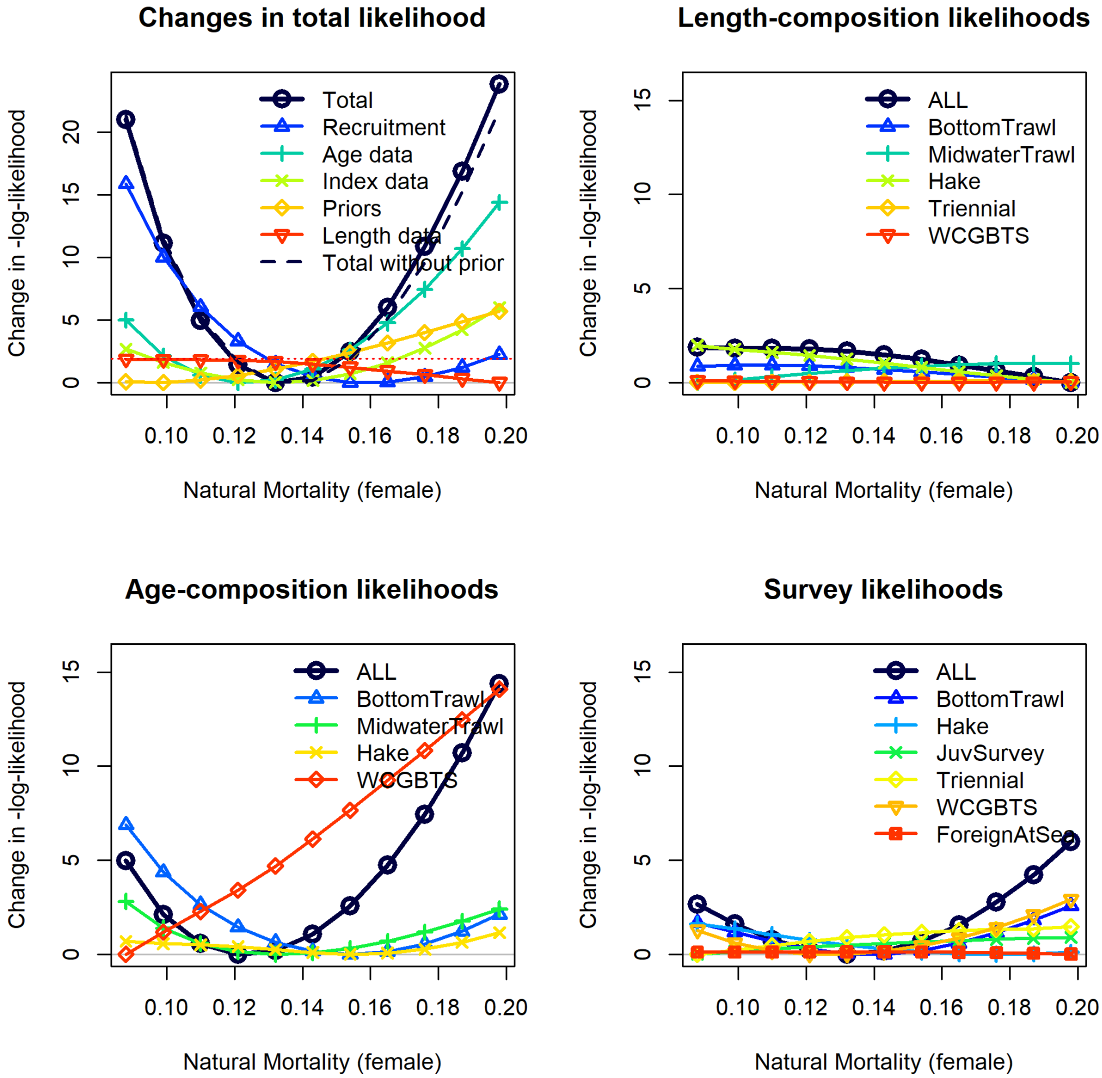

Figure 4: Likelihood components in the likelihood profile for female natural mortality (M).

Profiles over the log of unfished recruitment ($\log(R0)$), show that, similar to natural mortality, the estimate is slightly higher with this new proposed model (Figure 5). As with natural mortality, WCGBTS ages pull the scale estimate down, but the overall magnitude of that pull (as measured by likelihood units) is weaker with the new proposed base model than the August base model.

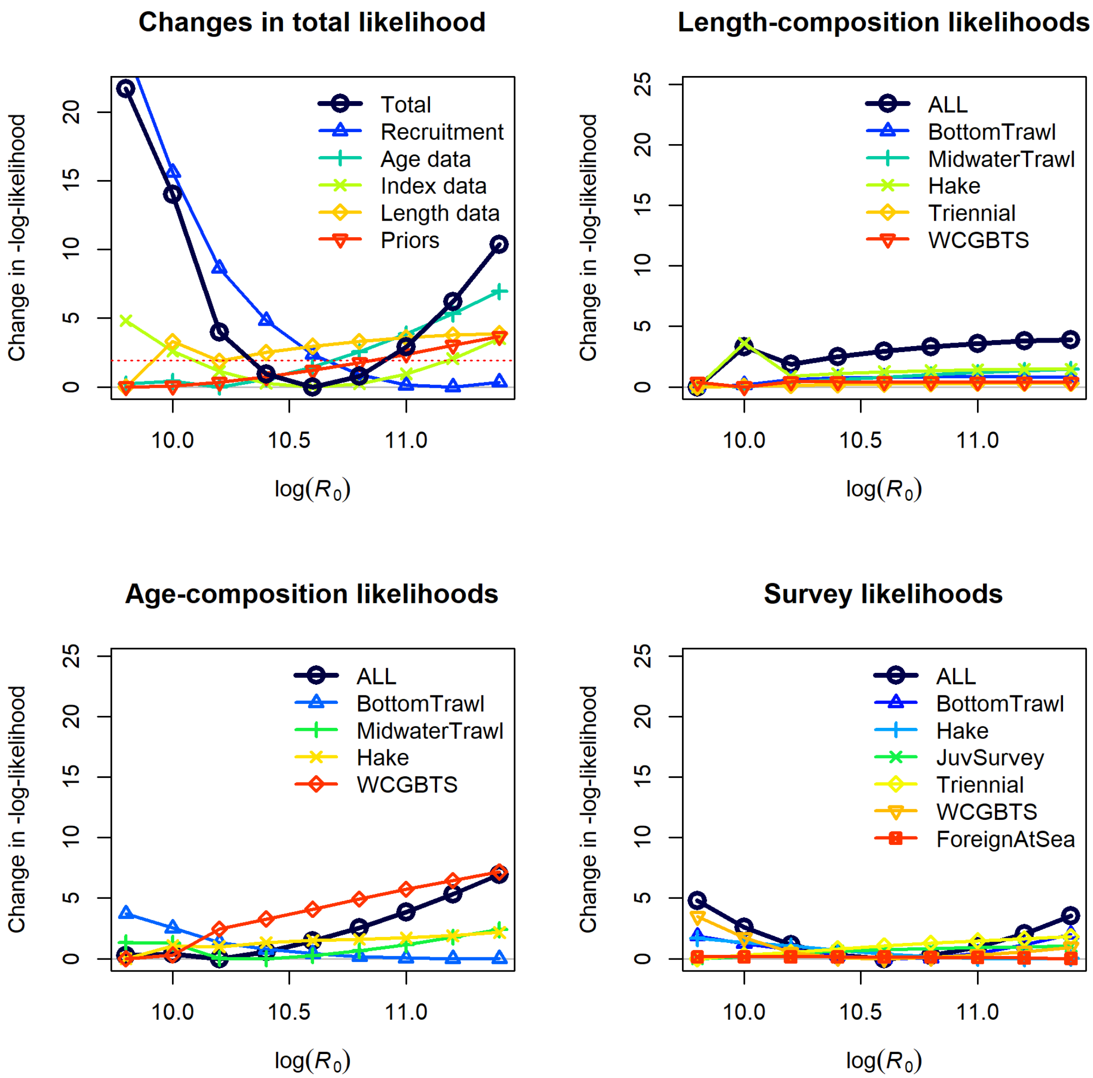

Figure 5: Likelihood components in the likelihood profile for the log of unfished recruitment ($\log(R0)$). Note that the model run at $\log(R0) = 10$ may not have converged.

Reference points and projections for new proposed base model

Reference points for the proposed new base model are reported in Table 3.

Many quantities are relatively similar to the August 2025 base model (although the spawning output is now in units of billions of eggs rather than thousands of tons). The equilibrium catch (yield) at the SPR = 50% target (6026 mt) is about 3% higher in the new base compared to the August 2025 base model (5822 mt).

A twelve-year projection of the base model using the default harvest control rule (with P* = 0.45 and sigma = 0.5) was conducted (Table 4). The resulting catch limit for 2027 is about 13% higher than the limit from the August 2025 base model. In 2036 the difference has decreased to about 5%. Given the similarity in equilibrium yield estimates noted above, the primary source of the difference is due to revised estimates of recent recruitment. Recruitment in 2017–2019 is estimated to be low in all the models considered, but estimates in the proposed new base model are not quite as low due to the change in data weighting (combined with restructuring the fleets). The WCGBTS ages and lengths are the largest source of information about these recent recruitments and those data had lower weights in the proposed new base model relative to the August 2025 base model.

Table 3: Summary of reference points and management quantities, including estimates of the 95 percent confidence intervals. SO is spawning output, SPR is the spawning potential ratio, and MSY is maximum sustainable yield.

Reference Point	Estimate	Lower Interval	Upper Interval
Unfished Spawning output	20,251	17,031	23,471
Unfished Age 4+ Biomass (mt)	155,745	131,149	180,341
Unfished Recruitment (R0)	40,256	27,963	52,548
2025 Spawning output	10,403	5,051	15,756
2025 Fraction Unfished	0.514	0.313	0.714
Reference Points Based SO40%	—	—	—
Proxy Spawning output SO40%	8,100	6,812	9,388
SPR Resulting in SO40%	0.458	0.458	0.458
Exploitation Rate Resulting in SO40%	0.087	0.079	0.094
Yield with SPR Based On SO40% (mt)	6,335	5,032	7,637
Reference Points Based on SPR Proxy for MSY	—	—	—
Proxy Spawning output (SPR50)	9,035	7,599	10,472
SPR50	0.500	—	—
Exploitation Rate Corresponding to SPR50	0.076	0.069	0.082
Yield with SPR50 at SO SPR (mt)	6,026	4,792	7,261
Reference Points Based on Estimated MSY Values	—	—	—
Spawning output at MSY (SO MSY)	5,223	4,399	6,048
SPR MSY	0.330	0.326	0.334
Exploitation Rate Corresponding to SPR MSY	0.131	0.119	0.143
MSY (mt)	6,829	5,407	8,251

Table 4: Potential OFLs (mt), ABCs (mt), ACLs (mt), the buffer between the OFL and ABC, estimated spawning output, and fraction of unfished spawning output with adopted OFLs and ACLs and assumed catch for the first two years of the projection period.

Year	Adopted OFL (mt)	Adopted ACL (mt)	Assumed Catch (mt)	OFL (mt)	Buffer	ABC (mt)	ACL (mt)	Spawning output (billions of eggs)	Fraction Unfished
2025	12,254	11,237	10,669	—	—	—	—	10.40	0.514
2026	11,382	10,392	9,824	—	—	—	—	9.47	0.468
2027	—	—	—	5,129	0.935	4,796	4,796	8.67	0.428
2028	—	—	—	5,375	0.930	4,998	4,998	8.64	0.427
2029	—	—	—	5,747	0.926	5,322	5,322	8.75	0.432
2030	—	—	—	6,061	0.922	5,589	5,589	8.93	0.441
2031	—	—	—	6,234	0.917	5,717	5,717	9.10	0.449
2032	—	—	—	6,296	0.913	5,748	5,748	9.23	0.456
2033	—	—	—	6,300	0.909	5,727	5,727	9.32	0.460
2034	—	—	—	6,287	0.904	5,683	5,683	9.38	0.463
2035	—	—	—	6,275	0.900	5,648	5,648	9.42	0.465
2036	—	—	—	6,271	0.896	5,619	5,619	9.46	0.467

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