Gulf of Alaska Pacific Ocean Perch - September 2025 Groundfish Plan Team

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1 Introduction

The 2025 Pacific Ocean Perch assessment has changed lead author, leading to only a few incremental changes and data examinations. The most significant update is the migration of the assessment model from the ADMB framework to RTMB. Additionally, three model changes are put forward: using the full form of the lognormal negative log-likelihood for survey biomass, estimating the second fishery selectivity time block with a double logistic model, and implementing Francis reweighting. Last, is a data exploration on how survey restratification efforts impact this assessment and area allocations. All examinations originate from the ADMB base model (model 2020.1) using 2023 data inputs.

1.1 General description:

- Tier 3a
- Not overfished/overfishing
- Operational Full Assessment for 2025

2 Model Bridging

2.1 ADMB to RTMB - Model 25

The RTMB assessment model and the associated comparison code are available on GitHub.

- RTMB Model Code:
- ADMB vs. RTMB Comparison Code:.

The RTMB model was optimized using the same parameter inputs as the ADMB model, though these inputs were unbounded in the RTMB implementation.

Key outputs (e.g., total biomass, spawning biomass) are equivalent, as shown in Table 1. The negative log-likelihood values are also nearly identical, differing by a few decimal points (Table 2).

Table 1: Key parameters and output values for comparing the GOA Pacific ocean perch assessment coded in ADMB and RTMB.

Item	ADMB	RTMB	Difference
M	0.0743	0.0743	0.0000
q	1.7361	1.7361	0.0000
Log mean recruitment	4.4492	4.4492	0.0000
Log mean F	-2.6131	-2.6131	0.0000
2024 Total biomass	649,941.00	649,941.11	0.1070
2024 Spawning biomass	227,991.00	227,991.19	0.1945
2024 OFL	47,466.30	47,466.28	-0.0154
2024 F OFL	0.1192	0.1192	0.0000
2024 ABC	39,718.90	39,718.89	-0.0104
2024 F ABC	0.0990	0.0990	0.0000

A comparison shows that the new model's results are consistent with the previous version (Figure 1, Figure 2), with negligible differences arising from numerical precision.

Table 2: Model negative log likelihood values for comparing the GOA Pacific ocean perch assessment coded in ADMB and RTMB.

Likelihood	ADMB	RTMB	Difference
Catch	0.2181	0.2181	0.0000
Survey	16.4416	16.4416	0.0000
Fish age	25.0028	25.0028	0.0000
Survey age	29.2822	29.2822	0.0000
Fish size	66.2258	66.2259	0.0001
Recruitment	10.6027	10.6027	0.0000
F regularity	6.1405	6.1405	0.0000
SPR penalty	0.0000	0.0000	0.0000
M prior	1.8299	1.8299	0.0000
q prior	0.4241	0.4241	0.0000
Sigma R prior	7.9849	7.9849	0.0000
Sub total	164.1526	164.1527	0.0001

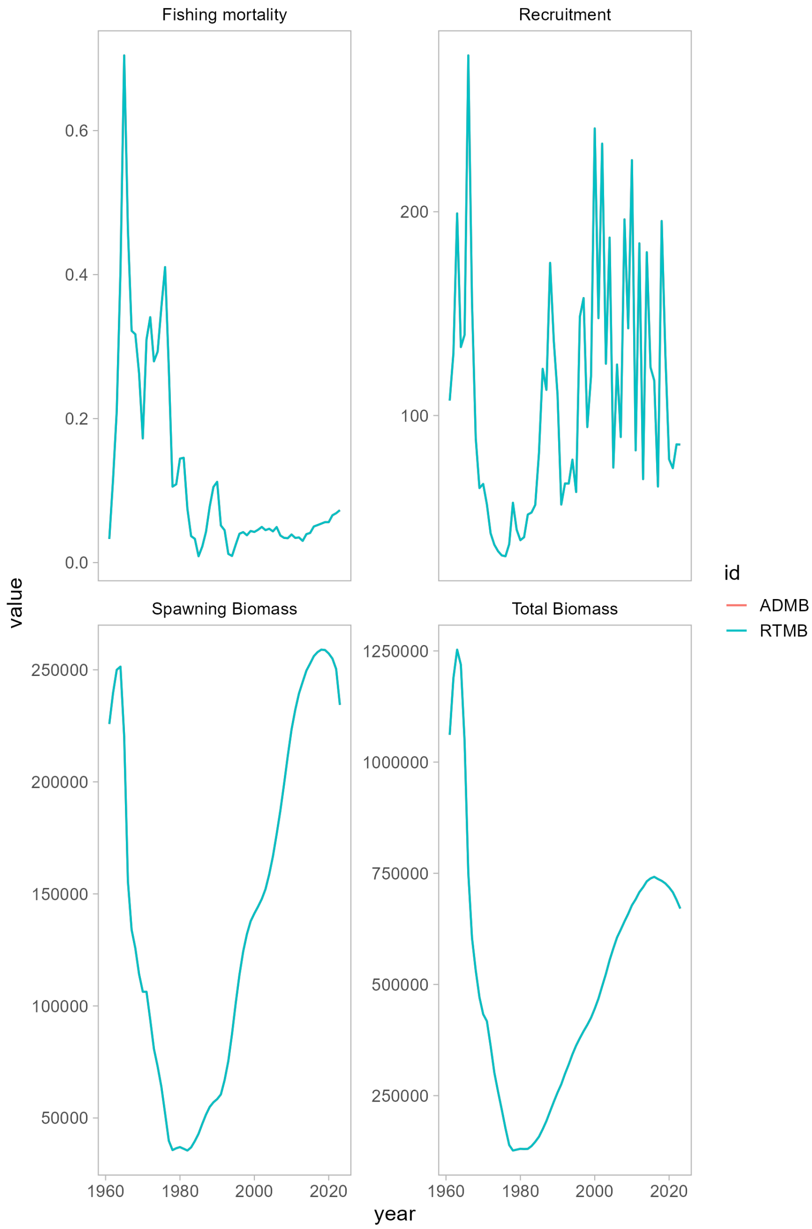

Figure 1: Comparison of key model outputs from the ADMB and RTMB Pacific ocean perch assessment models.

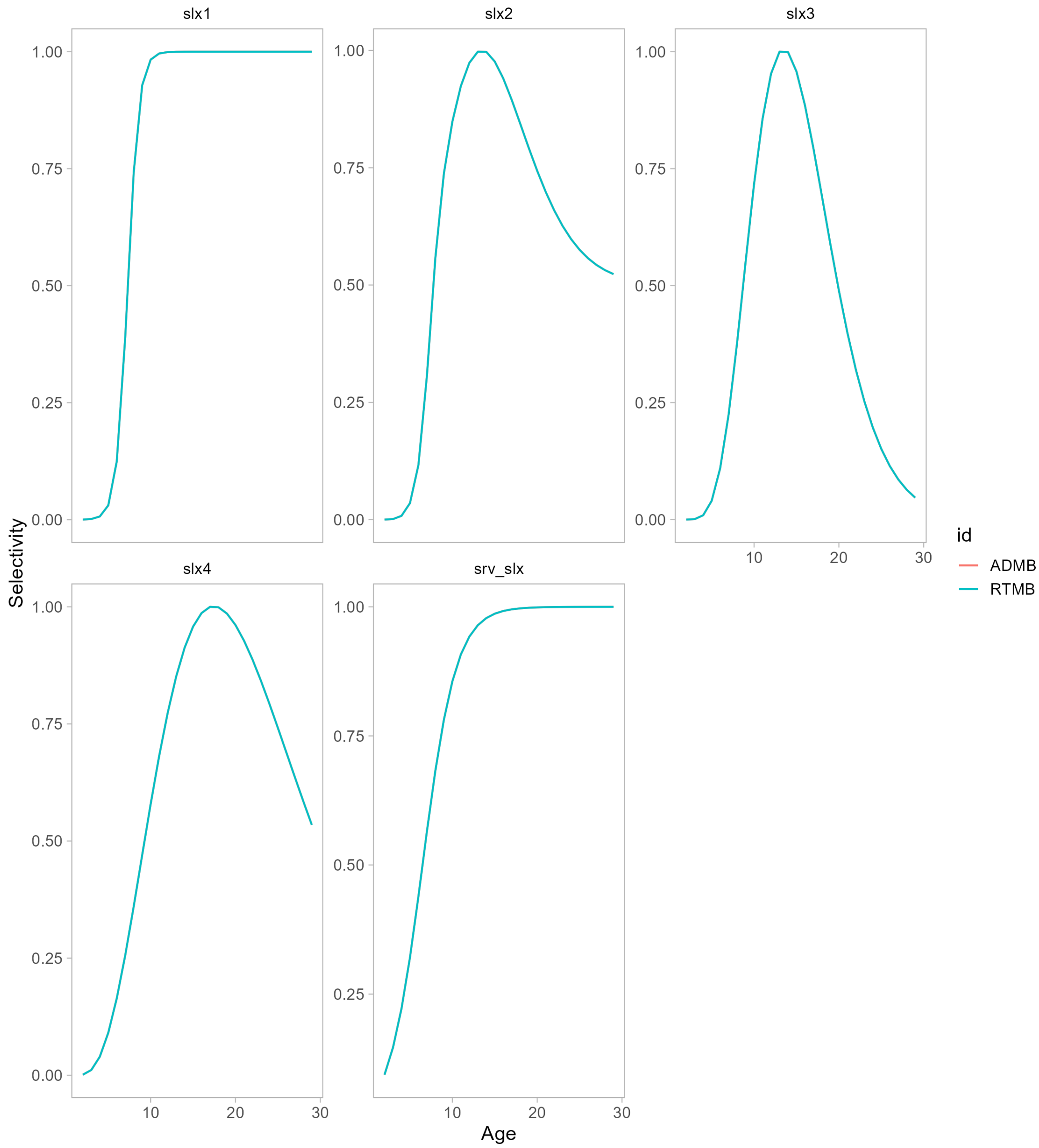

Figure 2: Comparison of fishery (4 time blocks) and survey selectivity from the ADMB and RTMB Pacific ocean perch assessment models.

3 Model changes

3.1 Survey likelihood w/bias correction (Model 25a)

Historically, the GOA POP assessment has used a simplified negative log-likelihood for survey biomass, which is a least-squares approximation of the lognormal distribution:

$$\text{nll} = \lambda \sum_{y} \frac{\left(\log(I_y) - \log(\hat{I}_y)\right)^2}{2\left(\frac{SE(I_y)}{I_y}\right)^2}$$

This simplified form is computationally convenient but does not account for the non-zero mean bias inherent in a lognormal distribution. As a result, the expected value of the model's prediction does not correctly align with the survey data on the original arithmetic scale.

To address this, the likelihood function has been updated to the full form of the lognormal negative log-likelihood. This approach incorporates a bias correction term to ensure the model's expectation is properly centered. The updated likelihood is:

$$\text{nll} = \lambda \sum_{y} \left[\log(\sigma_y) + \frac{1}{2} \left(\frac{\log\left(\frac{I_y}{\hat{I}_y^{bc}}\right)}{\sigma_y} \right)^2 \right]$$

where, σ_y is the standard deviation on the log scale, and $\hat{I}_y^{bc}$ is the bias-corrected model prediction. These terms are defined as:

$$\sigma_y = \sqrt{\log\left(1 + CV_y^2\right)} \quad \text{and} \quad \hat{I}_y^{bc} = \exp\left(-\frac{\sigma_y^2}{2}\right) \hat{I}_y$$

Since the likelihood has changed, the total nLL of m25 and m25a are not directly comparable (Table 3). However, best practices lean toward using the full nLL form. Overall, the change in likelihood form slightly increases total and spawning biomass, and the OFL and ABC (Table 4). There are no meaningful differences in key paramaters (e.g., M, q).

3.2 Fishery selectivity (Model 25b)

In the GOA POP assessment, fishery selectivity is modeled using four distinct time blocks. The selectivity blocks and their respective modeling approaches are defined as:

- Block 1 ($\leq$ 1976): Estimated using a logistic selectivity curve.
- Block 2 (1977–1995): Calculated as the average of the curves from Block 1 and Block 3. Note there was a scaling error found in the implementation of this block where the max was not 1.
- Block 3 (1996–2006): Estimated using a double logistic selectivity curve.
- Block 4 ($>$ 2006): Estimated using a double logistic selectivity curve.

By averaging two curves, Block 2 is imposing a shape that may not accurately reflect the true selectivity during that period. This could lead to bias in the estimated fishing mortality at age and, consequently, the stock status. The updated approach for Block 2 is to model it using a double logistic selectivity curve, similar to Blocks 3 and 4. This change ensures that the selectivity curve is properly scaled, with a maximum value of 1, which corrects the previous error. Selectivity for the different model outputs are available in (Figure 3), the likelihoods and parameters (are available in Table 3 and Table 4). One longstanding issue for this assessment has been a high q value, it is worth noting that when the selectivity is estimated q drops to 1.6, however, M remains consistent and somewhat elevated for such a long-lived species. When any of the models are reweighted bot q and M drop with an associated increase in total and spawning biomass as well as OFL and ABC.

Note that the Francis reweighted models all tend toward weights of ~2.8 for fishery age composition data, ~2.0 for survey age composition data, and ~0.5 for fishery size composition data. Survey selectivity is also presented (Figure 4), as it changes (shifts to slightly younger ages) for all of the reweighted models.

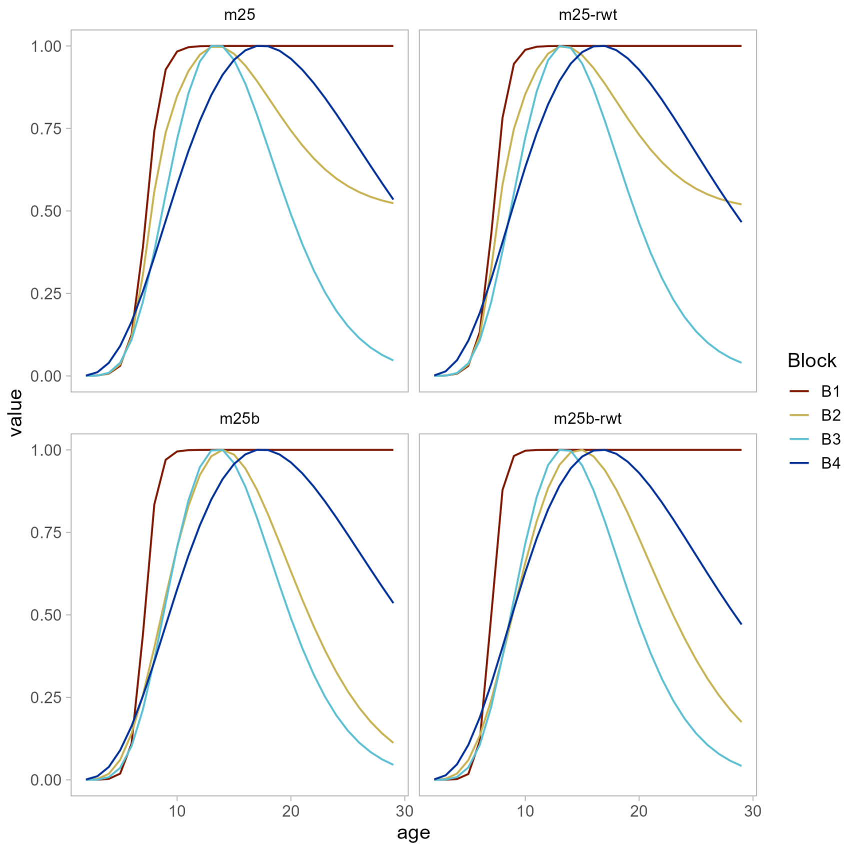

Figure 3: Fishery selectivity time blocks for models 25-25b. Models 25 and 25a, have the 2nd time block set at the average of the 1st and 3rd time blocks, m25b estimates selectivity using a double logistic model.

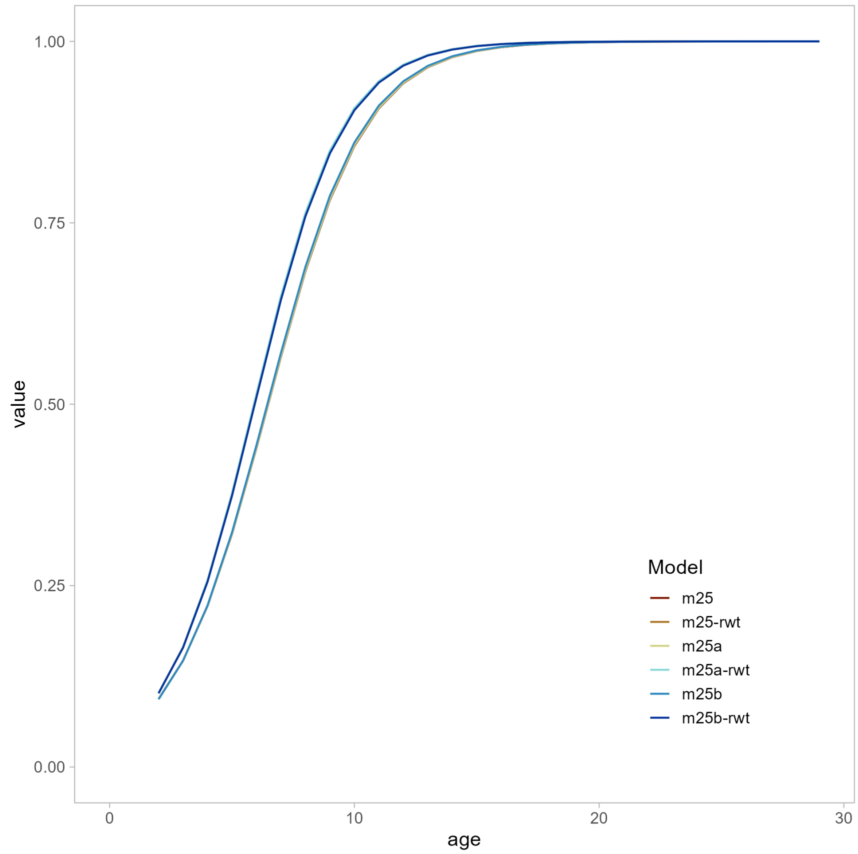

Figure 4: Survey selectivity using a double logistic model for m25b. Note that the reweighted model runs (-rwt) all have selectivity shifted to a younger age.

Table 3: Model negative log-likelihood values for comparing multiple GOA Pacific ocean perch assessments with data or model changes. Model changes are incremental: m25 is the base model, m25a updates the survey likelihood, m25b estimates the 2nd fishery selectivity time blocks using a double logistc model. The '-rwt' indicates results after accounting for Francis reweighting.

Likelihood	m25	m25a	25b	25-rwt	25a-rwt	25b-rwt
Catch	0.2180	0.2198	0.1755	0.1346	0.1357	0.1333
Survey	16.4416	7.1395	7.2334	17.1893	7.9512	7.9356
Fish age	25.0028	25.0404	26.6269	64.6063	64.2467	65.4262
Survey age	29.2822	29.3049	29.4795	54.0827	53.7984	53.1517
Fish size	66.2259	66.2486	65.7569	38.5566	38.5663	39.1691
Recruitment	10.6027	10.4299	8.8903	12.2151	11.9555	13.6445
F regularity	6.1405	6.1611	6.0170	6.3002	6.3237	5.7957
SPR penalty	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
M prior	0.4241	0.4525	0.2830	0.1484	0.1652	0.1829
q prior	1.8299	1.8757	2.5293	0.6145	0.6497	0.6903
Sigma R prior	7.9849	8.0189	8.3255	7.6706	7.7208	7.3973
Sub total	164.1527	154.8912	155.3173	201.5183	191.5133	193.5266

Table 4: Key parameters and output values for comparing multiple GOA Pacific ocean perch assessments with data or model changes. Model changes are incremental: m25 is the base model, m25a updates the survey likelihood, m25b estimates the 2nd fishery selectivity time blocks using a double logistc model. The '-rwt' indicates results after accounting for Francis reweighting.

Item	m25	m25a	m25b	m25-rwt	m25a-rwt	m25b-rwt
M	0.0743	0.0745	0.0769	0.0686	0.0688	0.0691
a50-1	6.2965	6.2959	6.1283	6.1884	6.1881	6.0098
a50-2	2.5239	2.5228	2.5690	2.5148	2.5141	2.6210
a50-3	2.7987	2.7986	2.5286	2.7460	2.7461	2.5202
a50-4	N/A	N/A	2.8002	N/A	N/A	2.7496
delta-1	1.9582	1.9564	1.5857	1.8663	1.8655	1.4743
delta-2	5.0275	5.0222	5.9092	4.9106	4.9064	6.4688
delta-3	9.6824	9.6680	4.9872	9.2424	9.2346	4.9450
delta-4	N/A	N/A	9.6804	N/A	N/A	9.2764
a50 survey	5.4801	5.4722	5.4424	4.9025	4.8998	4.9312
delta survey	5.8192	5.8042	5.7522	5.2794	5.2732	5.3114
q	1.7361	1.7598	1.6100	1.4673	1.4871	1.5072
sigma R	0.7644	0.7631	0.7516	0.7767	0.7747	0.7877
Log mean recruitment	4.4492	4.4561	4.5778	4.4765	4.4845	4.4737
Log mean F	-2.6131	-2.6188	-2.6663	-2.7270	-2.7329	-2.6963
2024 Total biomass	649,939	654,614	720,107	734,920	739,697	731,698
2024 Spawning biomass	227,991	229,412	251,854	268,324	269,862	266,338
2024 OFL	47,466	47,882	53,958	49,483	49,906	49,573
2024 F OFL	0.1192	0.1196	0.1229	0.1078	0.1081	0.1086
2024 ABC	39,719	40,065	45,132	41,659	42,014	41,717
2024 F ABC	0.0990	0.0993	0.1020	0.0901	0.0904	0.0907

4 Data explorations

4.1 GOA re-stratification (Model 25c)

4.1.1 Impacts of GAP re-stratification on POP assessment

The AFSC RACE Groundfish Assessment Program (GAP) has been revamping their data products over the last few years for improved reproducibility and consistency. Some of this has resulted in changes to the data products. For instance, there are known mismatches in size and age compositions between the (soon to be) archived data and the `gap_products` data. Historically, there were some hauls in the AI/GOA where a catch weight was recorded for a species without an associated count. The old biomass scripts for the AI-GOA would assume these `NA` catch values to be zero, which negatively biased abundance estimates calculated from these hauls. The updated database is therefore expected to have slightly higher abundance estimates for years in which these hauls occurred, with subsequent changes to the age and length composition data. Optimally all data pulls will be transitioned to the new GAP defined database(s), do be in line with contemporary standards from hereon.

One substantial change to the GAP-managed databases is a re-stratification of the GOA. Due to the area-specific design-based model expansions the biomass and numbers of POP vary by area, and the total abundance estimate changes (Figure 5).

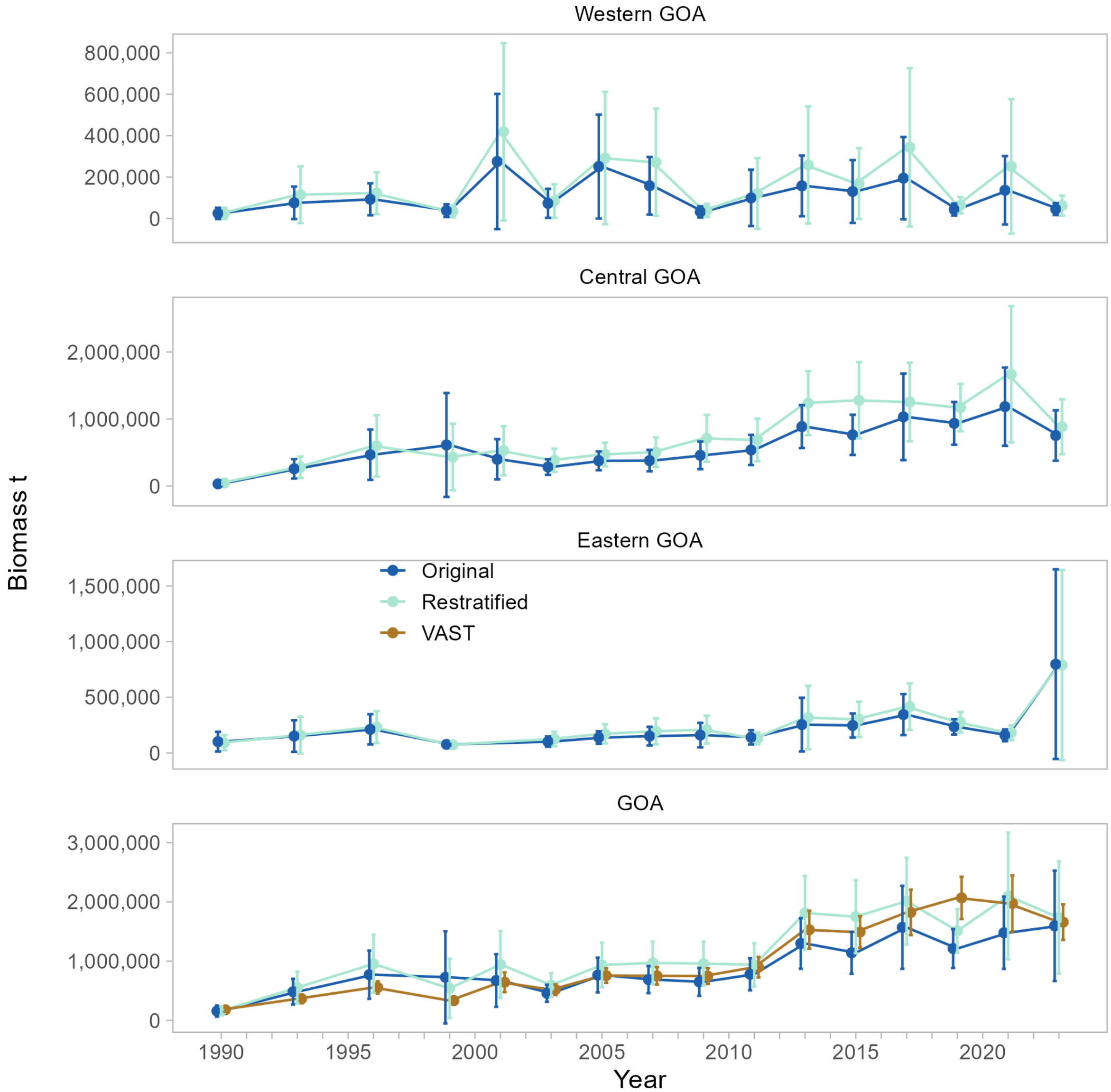

Figure 5: Comparison of groundfish trawl survey biomass estimates for GOA Pacific ocean perch based upon the original design-based estimates and the restratified design-based estimates

The overall negative log likelihood increases, which is predominately driven by an increase in the recruitment component (Table 5). There are increases in biomass and a substantal increase in q (Table 6) when the re-stratified survey biomass estimate is included in the assessment.

Table 5: Model negative log-likelihood values for comparing GOA Pacific ocean perch assessments m25b with GAP restratified survey biomass m25c. The '-rwt' indicates results after accounting for Francis reweighting.

Likelihood	m25b	m25c	25b-rwt	25c-rwt
Catch	0.1755	0.1634	0.1333	0.1171
Survey	7.2334	8.1414	7.9356	8.5064
Fish age	26.6269	26.4243	65.4262	67.3809
Survey age	29.4795	28.6189	53.1517	55.0278
Fish size	65.7569	65.2313	39.1691	38.8988
Recruitment	8.8903	13.7630	13.6445	16.9754
F regularity	6.0170	6.0233	5.7957	5.8604
SPR penalty	0.0000	0.0000	0.0000	0.0000
M prior	0.2830	0.9521	0.1829	0.6805
q prior	2.5293	1.9521	0.6903	0.4267
Sigma R prior	8.3255	7.3749	7.3973	6.7796
Sub total	155.3173	158.6448	193.5266	200.6537

Table 6: Key parameters and output values for comparing GOA Pacific ocean perch assessments m25b with GAP restratified survey biomass m25c. The '-rwt' indicates results after accounting for Francis reweighting.

Item	m25b	m25c	25b-rwt	25c-rwt
M	0.0769	0.0748	0.0691	0.0673
a50-1	6.1283	6.1300	6.0098	6.0010
a50-2	2.5690	2.5826	2.6210	2.6283
a50-3	2.5286	2.5433	2.5202	2.5285
a50-4	2.8002	2.8061	2.7496	2.7516
delta-1	1.5857	1.5940	1.4743	1.4678
delta-2	5.9092	5.9385	6.4688	6.4579
delta-3	4.9872	5.1040	4.9450	5.0157
delta-4	9.6804	9.9049	9.2764	9.3767
a50 survey	5.4424	5.6280	4.9312	5.0327
delta survey	5.7522	5.9086	5.3114	5.3950
q	1.6100	2.1316	1.5072	1.9376
sigma R	0.7516	0.7886	0.7877	0.8140
Log mean recruitment	4.5778	4.5127	4.4737	4.4391
Log mean F	-2.6663	-2.6160	-2.6963	-2.6798
2024 Total biomass	720,107	732,161	731,698	771,585
2024 Spawning biomass	251,854	260,001	266,338	283,769
2024 OFL	53,958	54,302	49,573	51,721
2024 F OFL	0.1229	0.1192	0.1086	0.1060
2024 ABC	45,132	45,423	41,717	43,530
2024 F ABC	0.1020	0.0989	0.0907	0.0886

4.1.2 Impacts of GAP re-stratification on POP apportionment

Area apportionment is completed by applying the `REMA` model to estimate random effects parameters that control the variation of estimated biomass across years and areas, and is fit to the trawl survey biomass estimates (with associated variance) for the Western, Central, and Eastern GOA. Changes to the survey biomass stratification will affect this apportionment strategy. Historical abundance estimates were restratified through code provided by Pete Hulson.

Re-stratification increases the biomass estimates for all regions in most years (Figure 6). However, the proportions by area do not substantially change (Figure 7).

As such, the area apportionments do not change substantially (Figure 8 and Table 7).

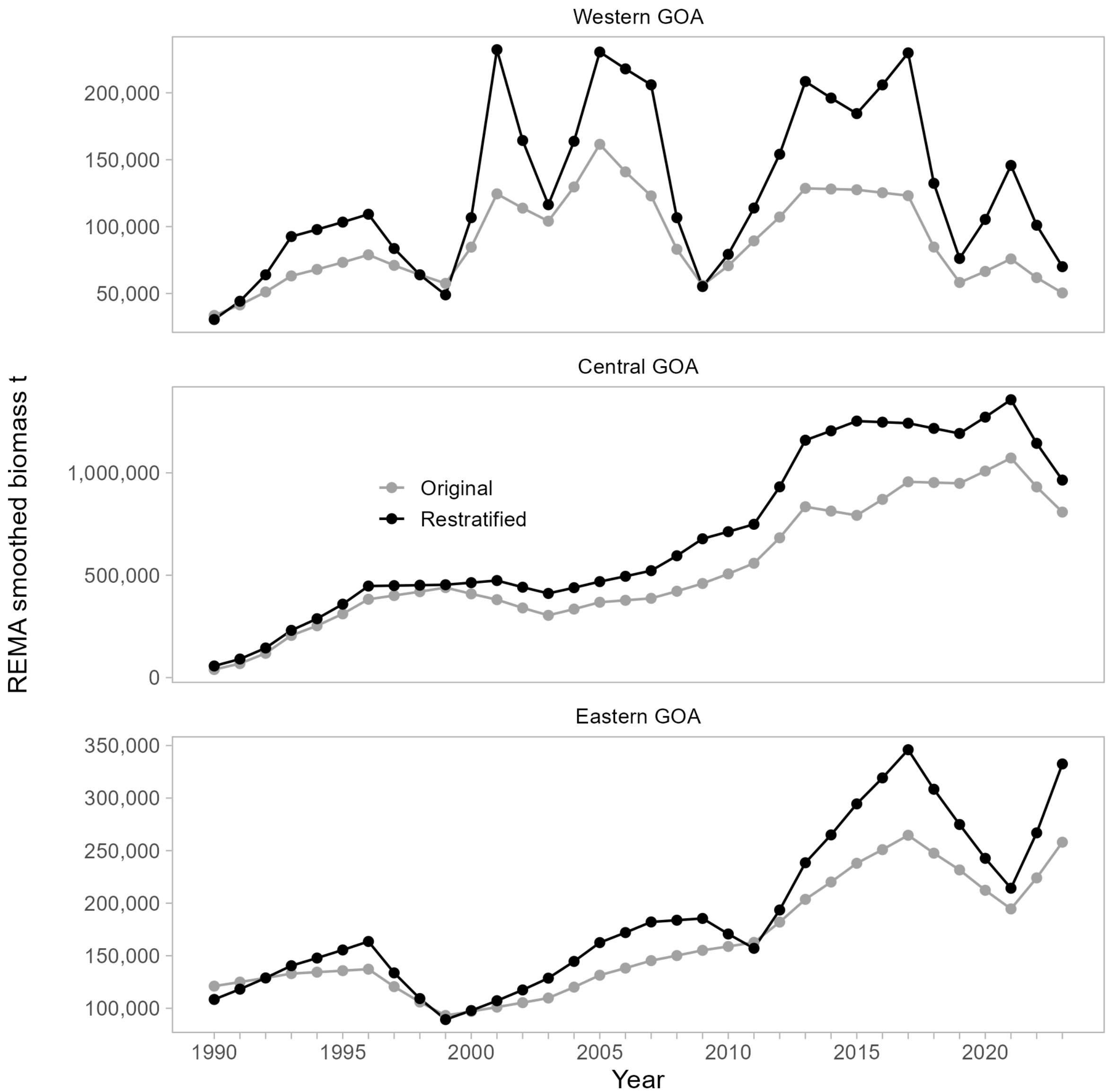

Figure 6: Biomass estimates by GOA area from the original design-based estimates and restratified estimates.

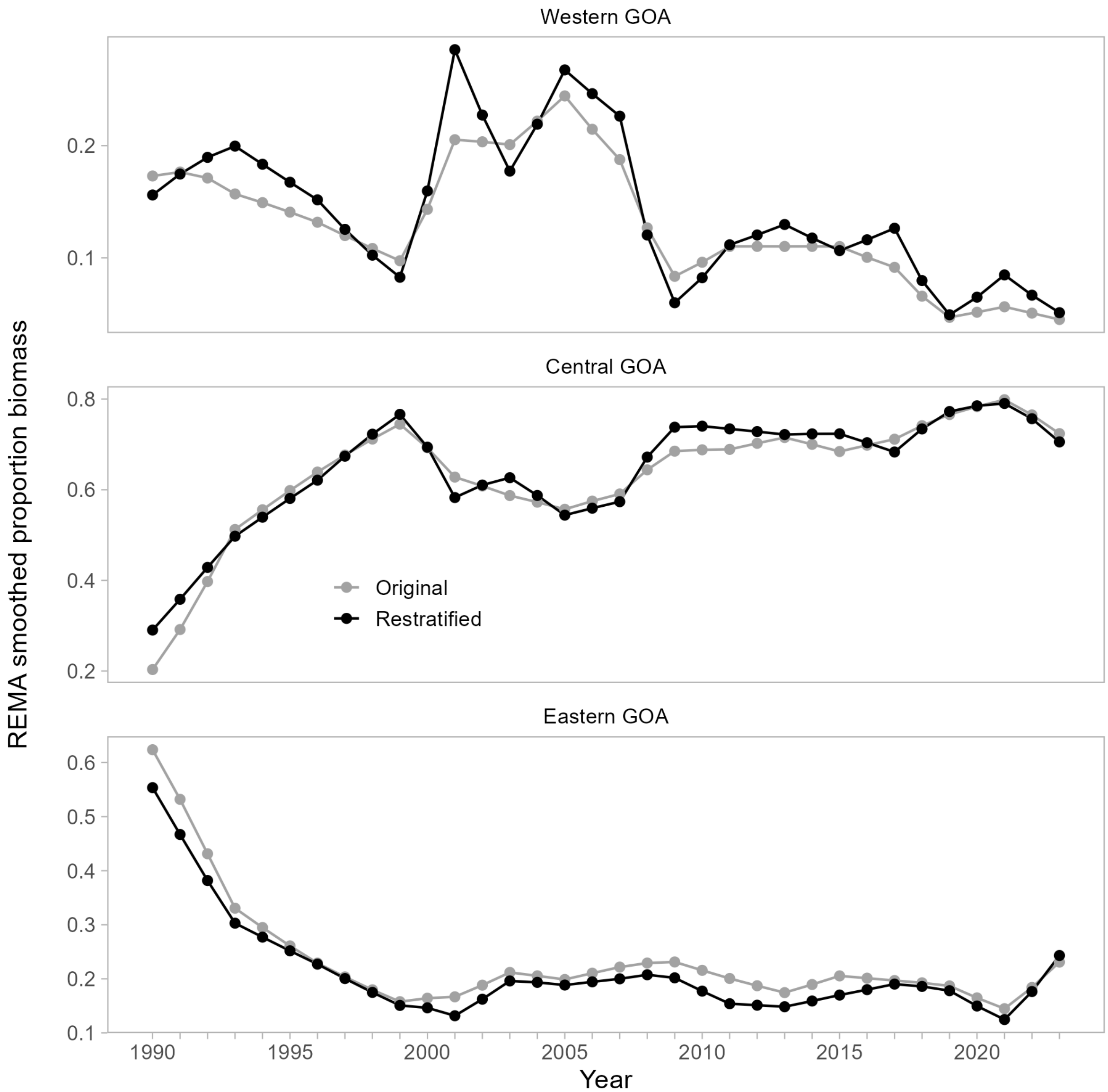

Figure 7: The proportion of biomass by GOA area from the original design-based estimates and re-stratified estimates.

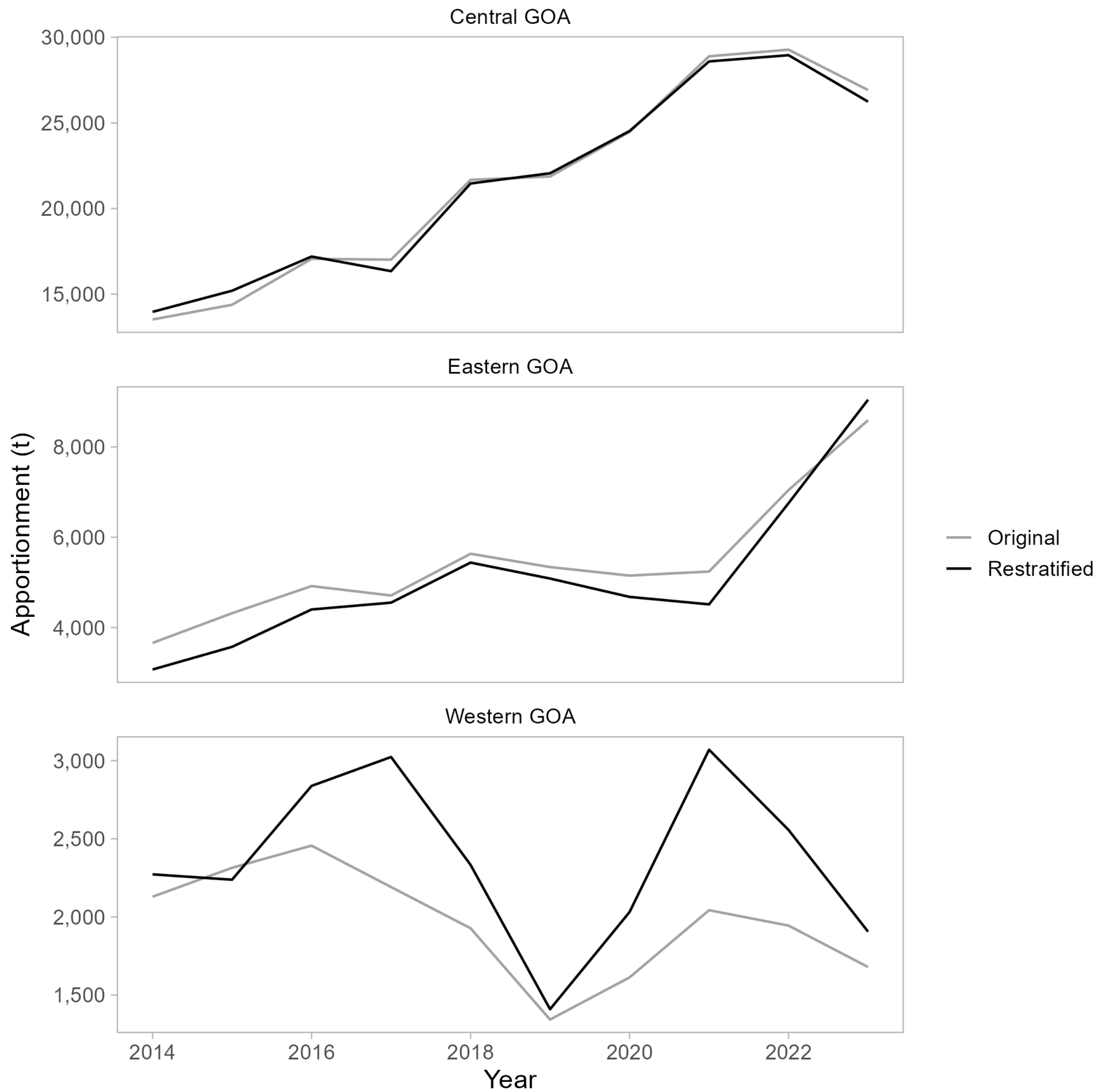

Figure 8: Annual apportionment based upon the original design-based estimates and re-stratified estimates as run through the REMA model.

Table 7: Annual regional apportionment with original survey stratification and restratified values. Note, this comparison is from the most recent REMA run e.g., without 'retrospective' peels.

Model	Year	Western GOA	Central GOA	Eastern GOA	ABC
Restratified	2014	2,272	13,966	3,071	19,309
Original		2,129	13,520	3,660	
Restratified	2015	2,238	15,201	3,573	21,012
Original		2,314	14,380	4,318	
Restratified	2016	2,838	17,199	4,400	24,437
Original		2,456	17,063	4,918	
Restratified	2017	3,023	16,343	4,551	23,918
Original		2,191	17,018	4,709	
Restratified	2018	2,333	21,464	5,438	29,236
Original		1,927	21,675	5,634	
Restratified	2019	1,409	22,061	5,085	28,555
Original		1,343	21,872	5,340	
Restratified	2020	2,031	24,528	4,679	31,238
Original		1,613	24,475	5,150	
Restratified	2021	3,070	28,593	4,514	36,177
Original		2,043	28,893	5,241	
Restratified	2022	2,557	28,957	6,754	38,268
Original		1,944	29,279	7,045	
Restratified	2023	1,905	26,242	9,045	37,193
Original		1,679	26,922	8,592	