INTERNATIONAL PACIFIC HALIBUT COMMISSION

An update of the IPHC Secretariat MSE Program of Work

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PURPOSE

To provide the Scientific Review Board (SRB) with the MSE Program of Work for 2026–2027 and an overview of work done since the 27th Session of the Scientific Review Board (SRB027) using the IPHC Management Strategy Evaluation (MSE) framework.

UPDATES IN REV_1 (5 MAY 2026)

Additional work conditioning the operating model (OM) was completed after the first posting of this document. This revised document updates Section 2.1.1 with a final conditioned OM representing historical uncertainty determined from 1000 simulated trajectories for each individual model.

1 INTRODUCTION

The SRB made a number of recommendations at SRB027 (IPHC-2025-SRB027-R) for investigation with the MSE framework for Pacific halibut (*Hippoglossus stenolepis*), of which many were related to updating the draft IPHC Harvest Strategy Policy (HSP). After incorporating those recommendations, the IPHC HSP was adopted by the Commission in December 2025. Other tasks are better done after the MSE Operating Model is conditioned following the full 2025 stock assessment. The conditioning of the operating model is part of the 2026–2027 Program of Work and began in early 2026 using the 2025 full stock assessment to reflect new understanding of the Pacific halibut population and fishery dynamics. This document presents the MSE Program of Work for 2026–2027 along with currently available results.

2 MSE PROGRAM OF WORK FOR 2026–2027

The IPHC HSP defines a 3-year timeline for the MSE process. The Operating Model (OM) is updated every third year, following the full stock assessment. After updating the OM, management procedures (MPs) are re-evaluated to ensure that they continue to meet the objectives of the Commission. Other tasks, pending the updated OM, are also described below.

The Commission noted prioritised topics for the 2026–2027 MSE Program or Work at the 102nd Session of the IPHC Annual Meeting (AM102).

> **IPHC-2026-AM102-R, para. 56**. *The Commission NOTED that the 2026 MSE and HSP Program of Work will include the following high priority topics:*
>
> a) *Update and recondition the MSE Operating Model in accordance with the schedule defined in the Harvest Strategy Policy;*
>
> b) *Evaluate a range of SPR values to determine if the optimal reference coastwide fishing intensity is different than the current reference fishing intensity (F43%) defined in the HSP;*

c) *Investigate productivity regimes to determine how the Pacific halibut population and fisheries respond to different productivity regimes, if the optimal reference fishing intensity differs across productivity regimes, and how productivity regimes may be incorporated into a Management Procedure;*

d) *Further develop the Depleted concept and identify a limit reference point below which recovery of the Pacific halibut population would be uncertain.*

IPHC-2026-AM102-R, para. 57. *The Commission NOTED that the 2026 MSE and HSP Program of Work will include the following low priority topics, which may not be completed before AM103:*

a) *Improve the estimation model used in the MSE framework to better characterize the stock assessment in the simulations;*
b) *Evaluate potential management actions to invoke when approaching a depleted limit reference point;*
c) *Evaluate additional elements of Management Procedures which may include a triennial assessment frequency, constraints and smoothers on the interannual change in the TCEY, and empirical rules to determine the reference TCEY in years without a stock assessment;*
d) *Determine reference points using the updated MSE Operating Model (e.g. FMSY and MSY);*
e) *Develop guidance documents for the Harvest Strategy Policy (e.g. specifications of a rebuilding plan).*

IPHC-2026-AM102-R, para. 58. *The Commission NOTED that the 2026 MSE and HSP Program of Work should not include topics related to the distribution of the TCEY, as this is part of the decision-making process and not part of the management procedure, as described in the Harvest Strategy Policy.*

IPHC-2026-AM102-R, para. 59. *The Commission NOTED that outcomes of the 2026 MSE workplan (e.g. an optimal fishing intensity) may be used to update the Harvest Strategy Policy in the future.*

2.1 High priority tasks

The Commission identified four high priority tasks for the MSE Program of Work, which are either defined by the HSP or essential to ensuring that the HSP reflects the current knowledge of the Pacific halibut stock and fisheries.

2.1.1 Condition the MSE Operating Model

Immediately following a full stock assessment, which occurs every three years, the MSE operating model is conditioned using updated data streams, newly estimated parameters from the stock assessment, and an improved understanding of processes driving Pacific halibut population dynamics and fisheries. This is also an opportunity to implement improved and updated OM code incorporating current best practices. Once the OM is conditioned, the process does not need to be repeated until after the next full stock assessment, or an exceptional circumstance occurs (see Section 3.8 of the IPHC HSP). However, after each update stock assessment, mortality, weight-at-age, and other data or inputs may be updated to reflect recent realizations (steps 3–6).

The conditioning process is time-consuming and involves the following workflow.

1. Outcomes of each individual model of the 2025 ensemble stock assessment are summarized.
2. Parameters and assumptions in each individual model of the OM are linked to each individual model of the 2025 ensemble stock assessment and updated to match those in the stock assessment.
3. Mortality and weight-at-age for each fishery is extended to the most recent year.
4. Weight-at-age for the survey and population is updated and extended to the most recent year.
5. The Pacific Decadal Oscillation (PDO) is updated to the most recent year (and revised for this development cycle based on the new series used in the 2025 stock assessment).
6. An optimized OM executable is compiled and a directory structure for each individual model is created.
7. Parameters for each individual model (e.g. movement, recruitment distribution, average recruitment, initial fishing mortality) are estimated based on fits to regional stock distribution, regional indices of abundance, age compositions, and the estimated spawning biomass from the linked individual stock assessment model.
8. Individual historical trajectories are created for each individual model of the OM using estimated uncertainty and correlations between parameters.
9. Inputs and outputs for each individual trajectory is saved to the appropriate directory and a reduced set of necessary inputs is saved to GitHub for distribution among computers and for record keeping.

2.1.1.1 Conditioning the Operating Model

The four individual models of the OM (OM1_longAAF, OM2_shortAAF, OM3_longCW, and OM4_shortCW) were conditioned through all steps above. The conditioning process balanced the fits to the four sources of information (stock distribution, regional indices of abundance, age compositions, and the estimated spawning biomass from the stock assessment) in an ad hoc manner by determining the best parameter values when fitting to each source alone, and then adjusting weights of the likelihood component for each source such that no one source showed a severe lack of fit. Stock distribution and recent years of estimated spawning biomass were given the highest priority for good fits. The age compositions were given a low weight due to the number of observations potentially overwhelming the likelihood and less importance for evaluating coastwide management procedures (MPs).

Each model starts in 1958, even those based on the short assessment models, with estimated recruitment deviations from the long assessment models and an average fishing mortality informing the initial population. The population trajectory was then derived through 2025 based on the parameter set. Estimated parameters included the proportion of recruitment in each region for low and high PDO regimes, a scalar for the initial average fishing mortality, and movement parameters from Region 4 to 3 and 3 to 2 for low and high PDO regimes. Movement between other adjacent regions was fixed at empirical rates determined from historical data and it was assumed that movement did not occur between non-adjacent regions in an annual time-step (see the MSE Technical document).

The individual models of the OM are shown in each section below. These include uncertainty for each model.

OM1_longAAF

OM1_longAAF is based on the parameters and estimated spawning biomass of the long areas-as-fleets (AAF) stock assessment model. This included natural mortality rates for age 3+ female and male Pacific halibut equal to 0.181 and 0.164, respectively.

The OM1_longAAF model closely matched the spawning biomass for the long AAF assessment model (Figure 1). The distribution of 'all sizes' (those selected by the FISS) biomass was also fit well except for Region 3 in recent years (Figure 2). This overprediction in Region 3 was a result of a slight underfitting in all other Regions. The FISS index fit reasonably well although showed departures in the 1990s in Regions 2, 4, and 4B (Figure 3). The index was closely matched in recent years for all Regions.

A large proportion of the recruitment was distributed to Region 4 and was higher when the PDO was in a positive regime (Figure 3). Approximately 70% of the age-0 fish settled in Region 4 in low PDO regimes and nearly 80% in high PDO years. A very small proportion was distributed to Region 4B.

Movement was only estimated from Region 4 to Region 3 and from Region 3 to Region 2 (Figure 3). Movement probabilities were similar across PDO regimes for Region 4 to 3, but was shifted to younger ages in the high PDO regime. Fewer Pacific halibut moved from Region 3 to 2 in the high PDO regime. A very small proportion of Pacific halibut 6 years and older moved from either of these regions.

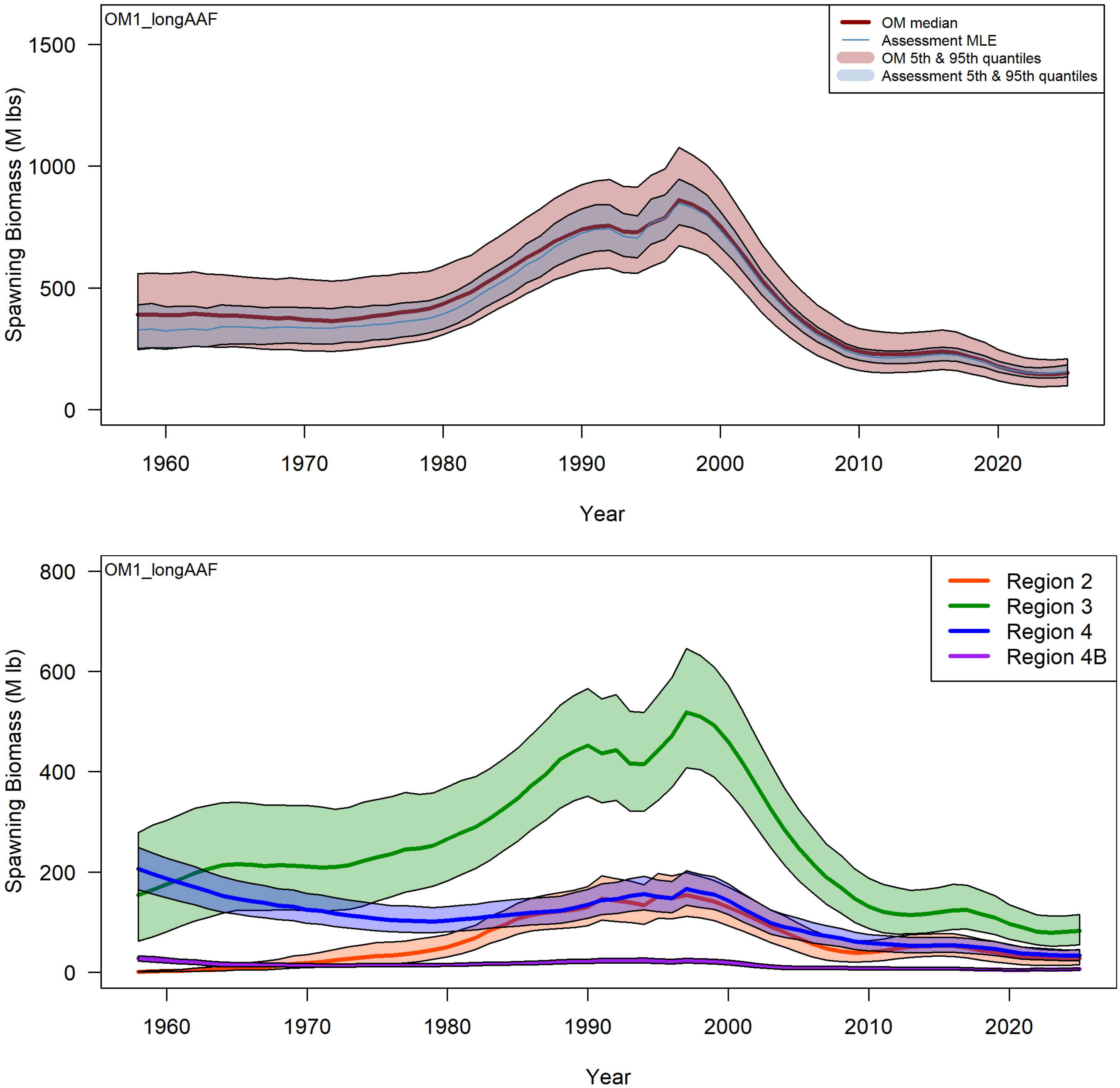
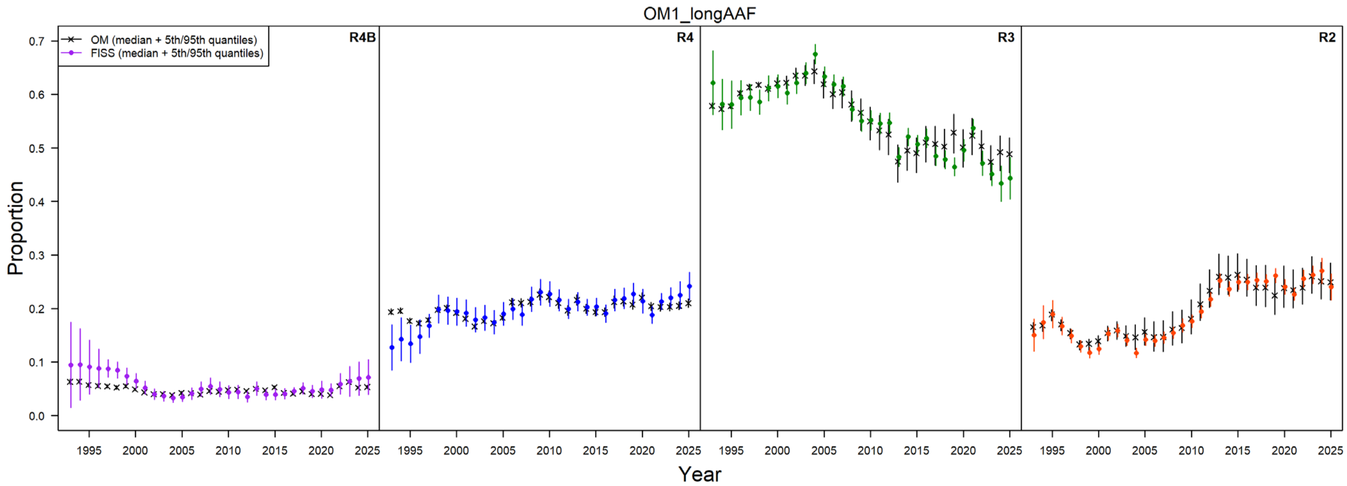


Figure 1. The spawning biomass from the OM1_longAAF model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the spawning biomass in each Region from the OM1_longAAF model.



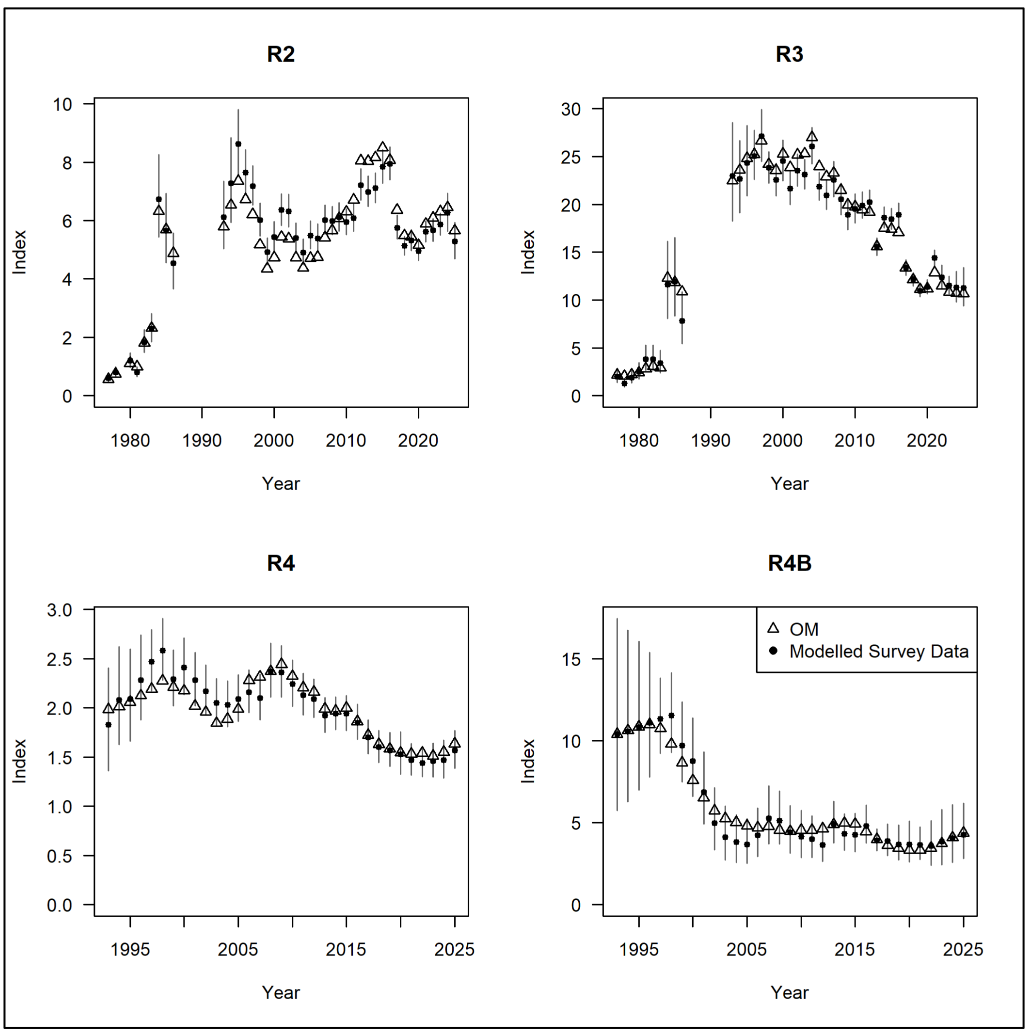


Figure 2. The top plots show the proportion of all sizes biomass in each Region from the OM1_longAAF model (triangles) and the FISS modelled output with 95% credible intervals (circles). The bottom plots show the predicted index from the OM1_longAAF model (triangles) and the FISS index (circles).

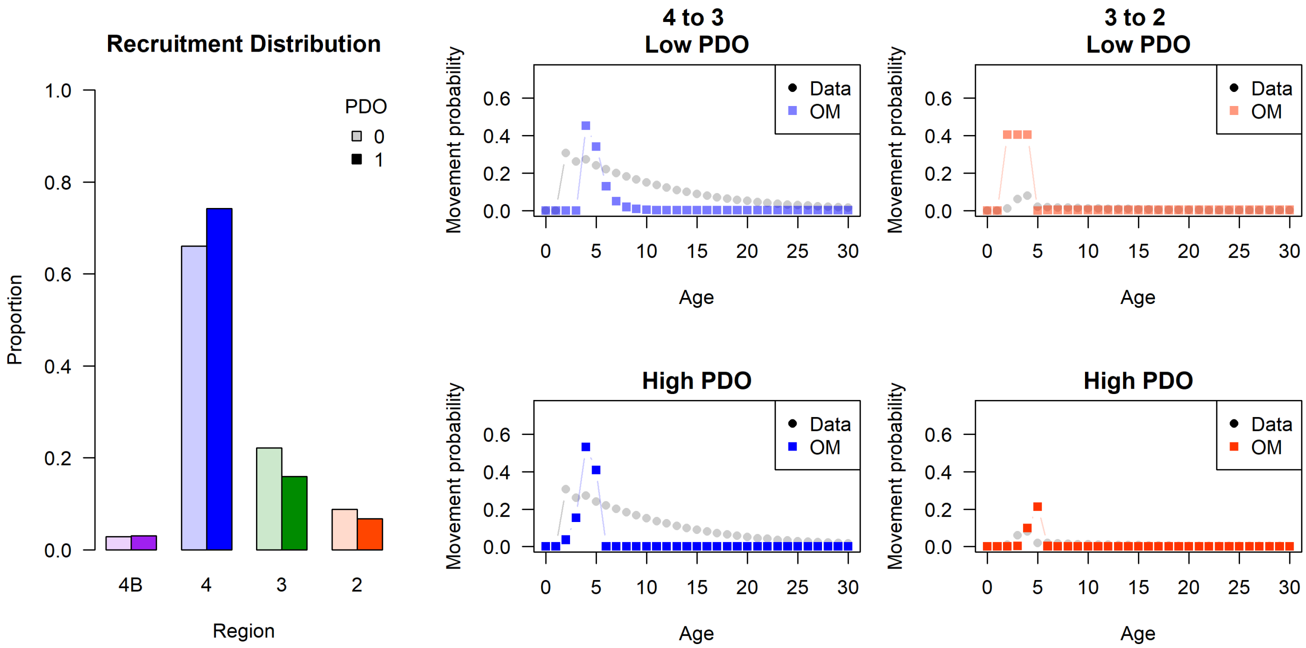


Figure 3. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot) estimated in the OM1_longAAF model. The proportion of numbers of Pacific halibut estimated in OM1_longAAF that move from Region 4 to 3 (center) and from Region 3 to 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

OM2_shortAAF

OM2_shortAAF is based on the parameters and estimated spawning biomass of the short AAF stock assessment model. This included natural mortality rates for age 3+ female and male Pacific halibut equal to 0.214 and 0.180, respectively.

The OM2_short AAF model closely matched the spawning biomass for the short AAF assessment model, except for the beginning of the assessment time-series, which is not well estimated in the stock assessment (Figure 4). The distribution of 'all sizes' biomass was also fit well except for Regions 3, 4, and 4B in recent years (Figure 5). The overprediction in Region 3 was a result of a slight underfitting in all other Regions. The FISS index fit reasonably well although showed departures in the 1990s in Regions 2, 4, and 4B (Figure 5). The index was closely matched in recent years for Regions 3 and 4B.

A large proportion of the recruitment was distributed to Region 4 and was higher when the PDO was in a positive regime (Figure 6). Approximately 85% of the age-0 fish settled in Region 4 in low PDO regimes and over 95% in high PDO years. A very small proportion was distributed to Region 4B.

Movement was only estimated from Region 4 to Region 3 and from Region 3 to Region 2 (Figure 6). Movement probabilities were similar across PDO regimes for Region 4 to 3, but peaked slightly higher in the high PDO regime. A smaller proportion of Pacific halibut moved from Region 3 to 2 in the high PDO regime when compared to the low PDO regime. A very small proportion of Pacific halibut 8 years and older moved from either of these regions.

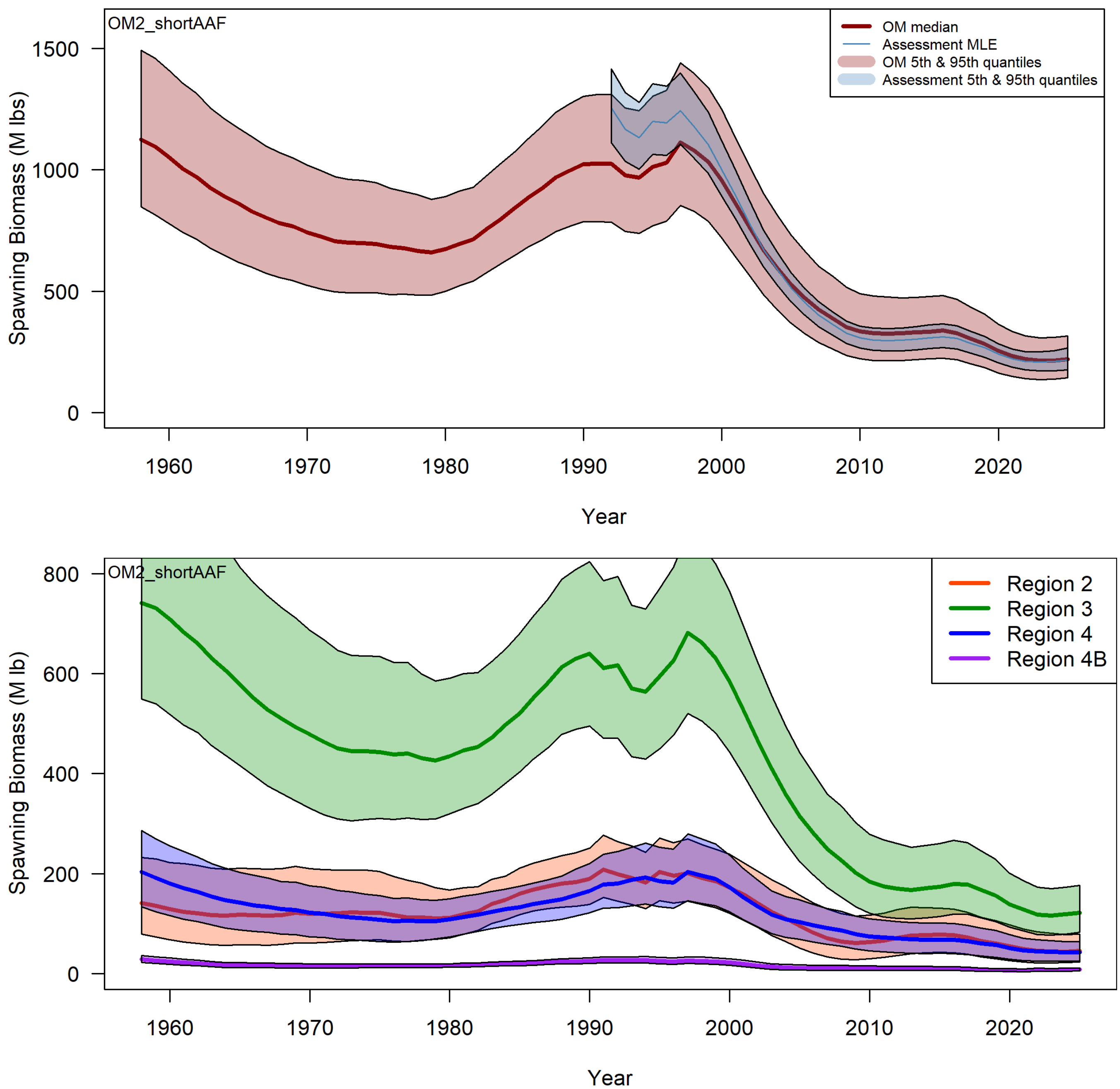
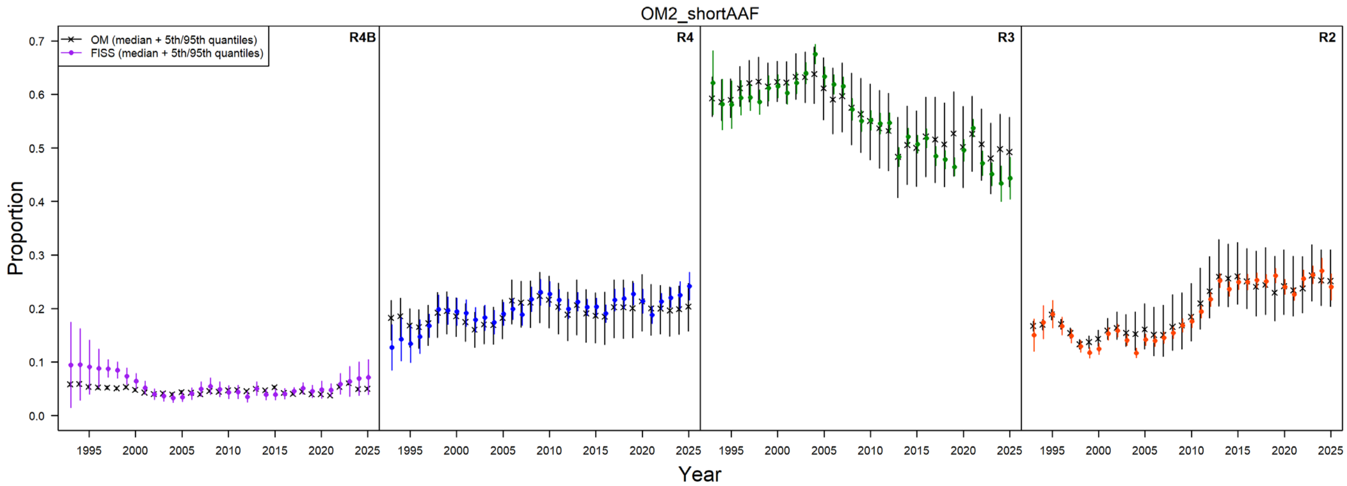


Figure 4. The spawning biomass from the OM2_shortAAF model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the spawning biomass in each Region from the OM2_shortAAF model.



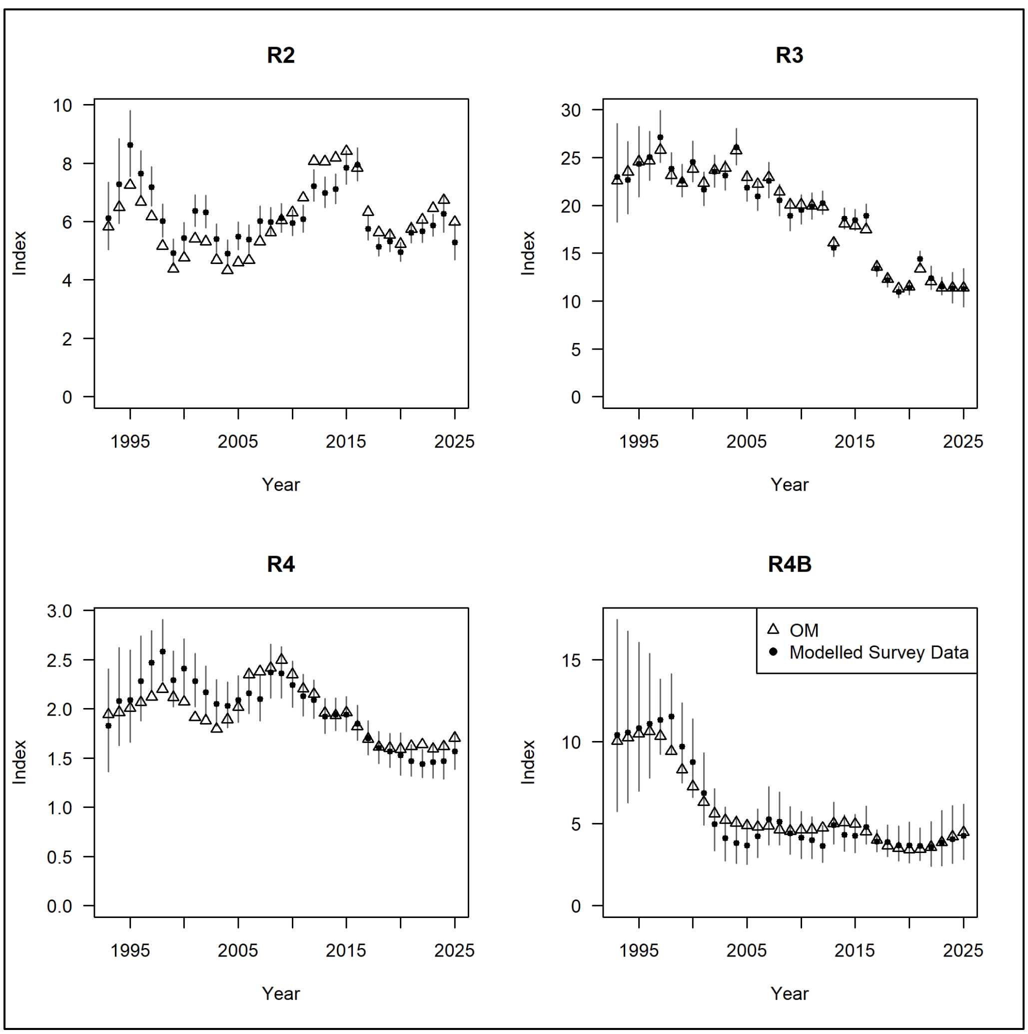


Figure 5. The top plots show the proportion of all sizes biomass in each Region from the OM2_shortAAF model (triangles) and the FISS modelled output with 95% credible intervals (circles). The bottom plots show the predicted index from the OM2_shortAAF model (triangles) and the FISS index (circles).

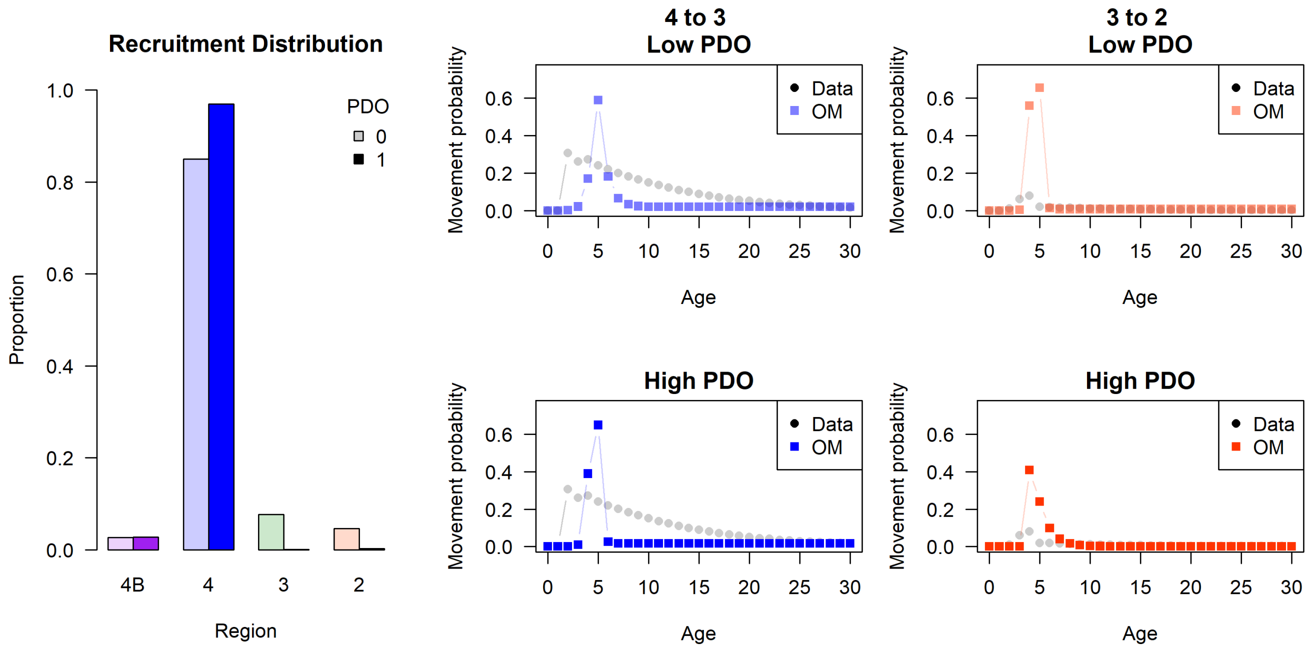


Figure 6. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot) estimated in the OM2_shortAAF model. The proportion of numbers of Pacific halibut estimated in OM2_shortAAF that move from Region 4 to 3 (center) and from Region 3 to 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

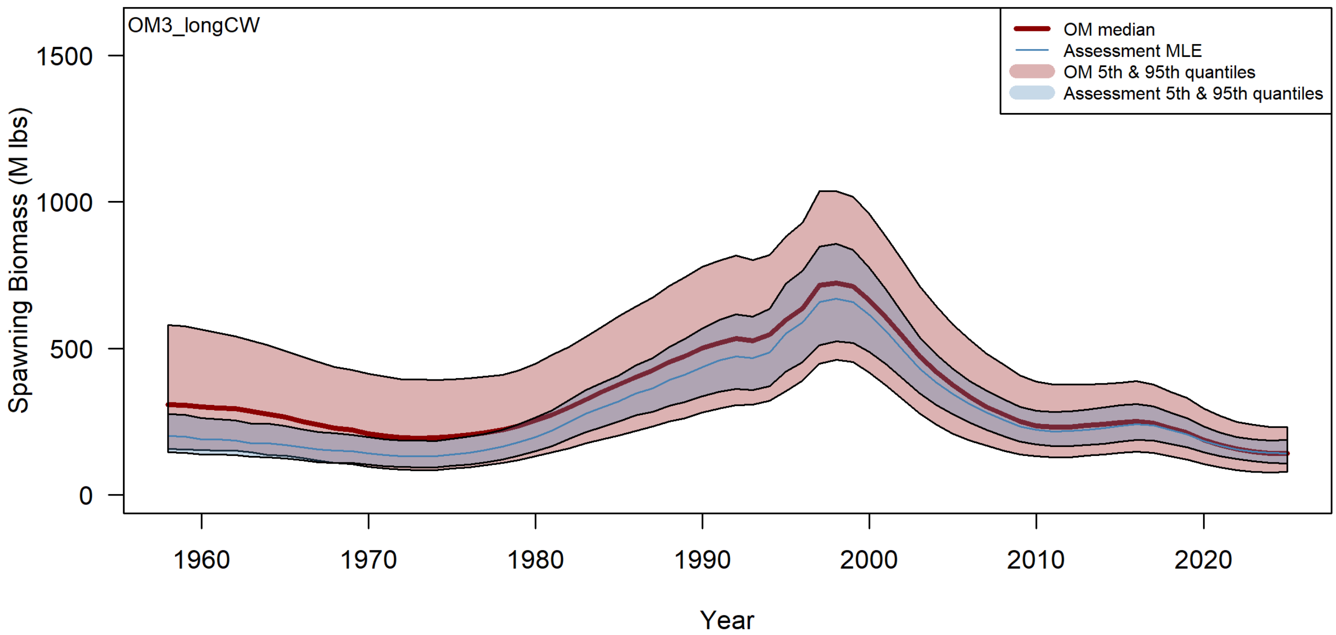
OM3_longCW

OM3_longCW is based on the parameters and estimated spawning biomass of the long coastwide stock assessment model. This included natural mortality rates for age 3+ female and male Pacific halibut equal to 0.229 and 0.199, respectively.

The OM3_longCW model closely matched the spawning biomass for the long coastwide assessment model (Figure 7) with a slight departure at the beginning of the series. The distribution of 'all sizes' biomass was also fit well except for Region 3 in recent years (Figure 8). The overprediction in Region 3 was a result of a slight underfitting in all other Regions. The FISS index fit reasonably well although showed departures in the 1990s in Regions 2, 4, and 4B (Figure 8). The index was closely matched in recent years for all Regions.

A large proportion of the recruitment was distributed to Region 4 and was higher when the PDO was in a positive regime (Figure 9). Slightly less than 80% of the age-0 fish settled in Region 4 in low PDO regimes and just over 80% in high PDO years. Very small proportions of recruitment were distributed to Regions 2 and 4B, except that a larger proportion was in Region 2 in low PDO years.

Movement was only estimated from Region 4 to Region 3 and from Region 3 to Region 2 (Figure 9). Movement probabilities were similar across PDO regimes for Region 4 to 3 with a broader range of ages moving in low PDO regimes. Higher movement across ages 2-4 was seen in from Region 3 to 2 in low PDO years. A very small proportion of Pacific halibut 6 years and older moved from either of these regions, except that from 4 to 3 in the low PDO higher movement rates were observed for Pacific halibut up to 9 years old.



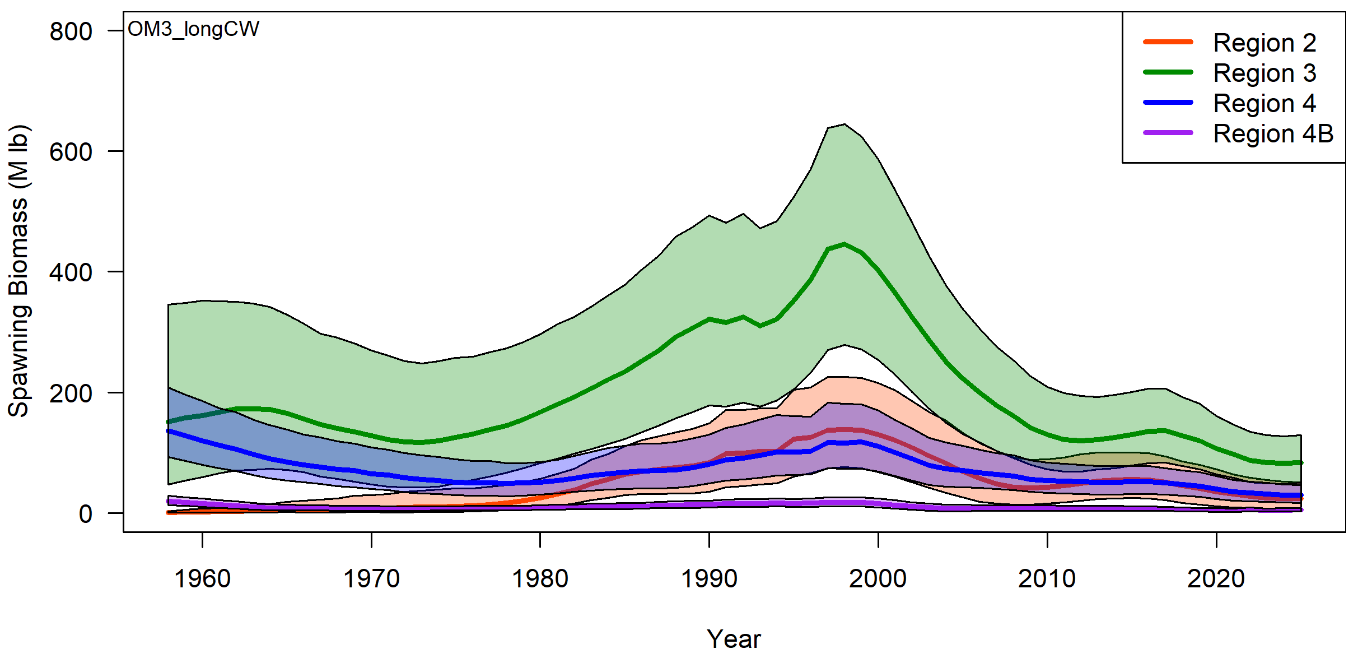
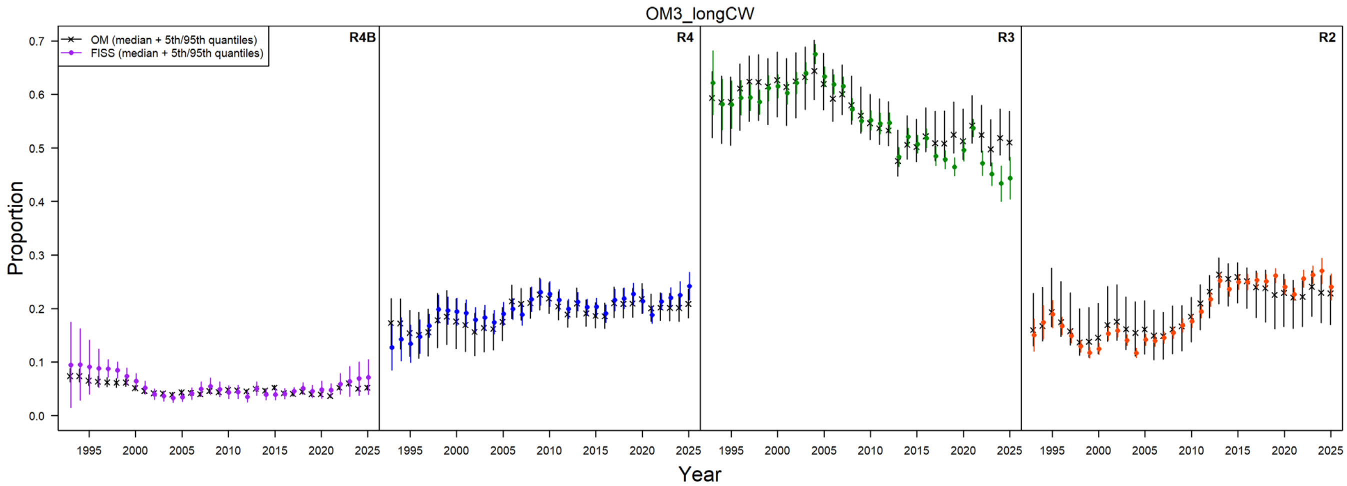


Figure 7. The spawning biomass from the OM3_longCW model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the spawning biomass in each Region from the OM3_longCW model.



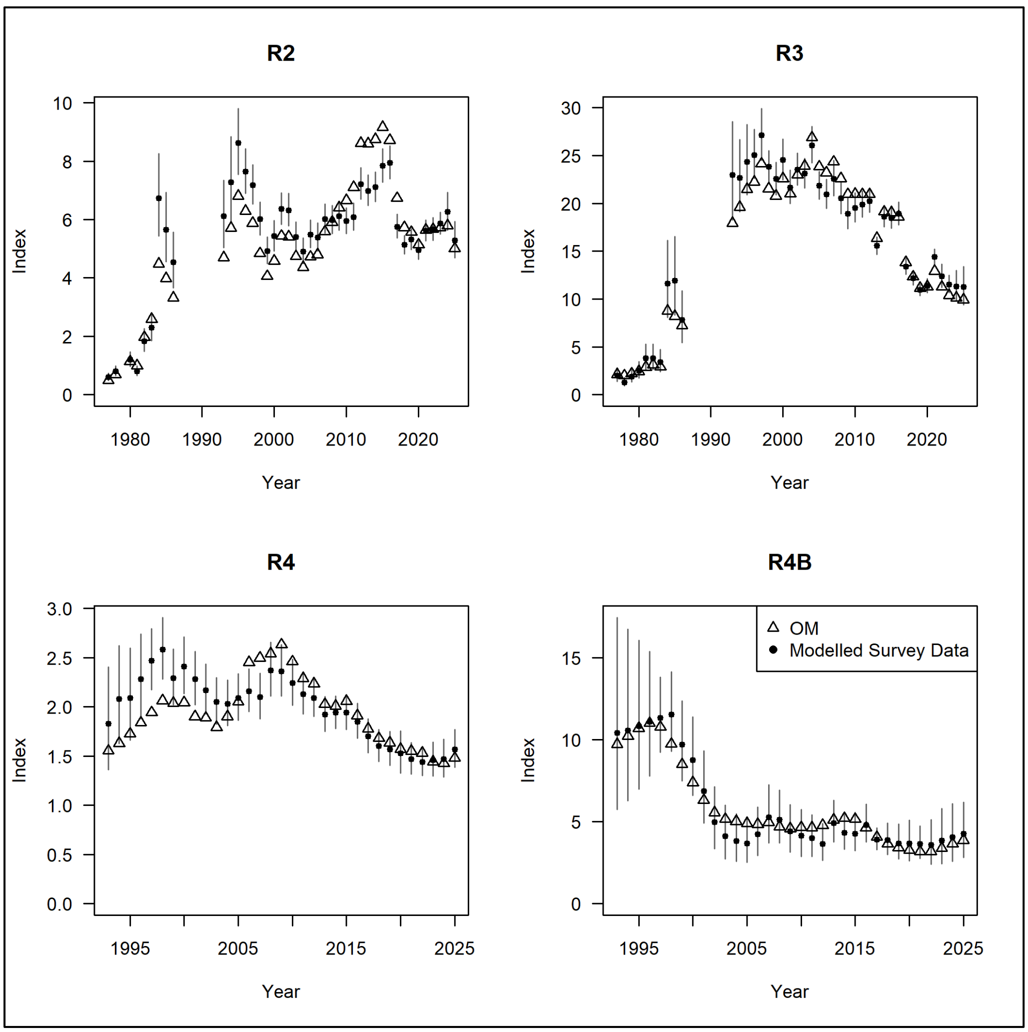


Figure 8. The top plots show the proportion of all sizes biomass in each Region from the OM3_longCW model (triangles) and the FISS modelled output with 95% credible intervals (circles). The bottom plots show the predicted index from the OM3_longCW model (triangles) and the FISS index (circles).

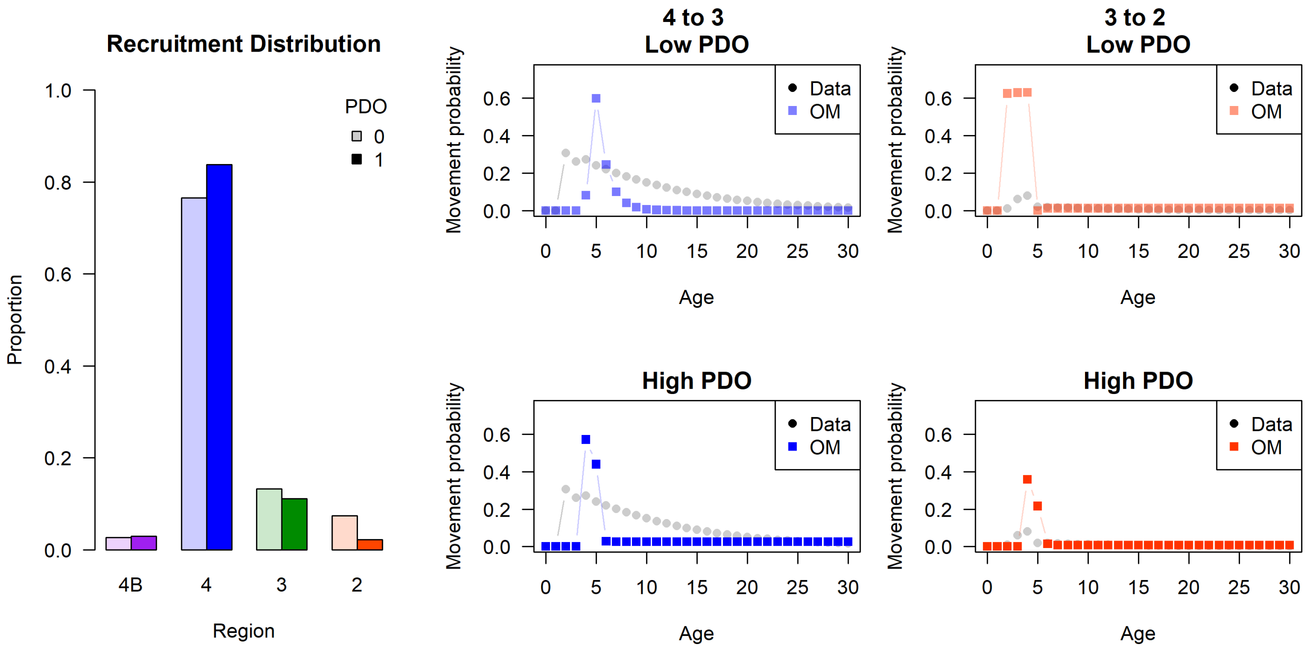


Figure 9. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot). The proportion of numbers of Pacific halibut estimated in OM3_longCW that move from Region 4 to Region 3 (center) and from Region 3 to Region 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

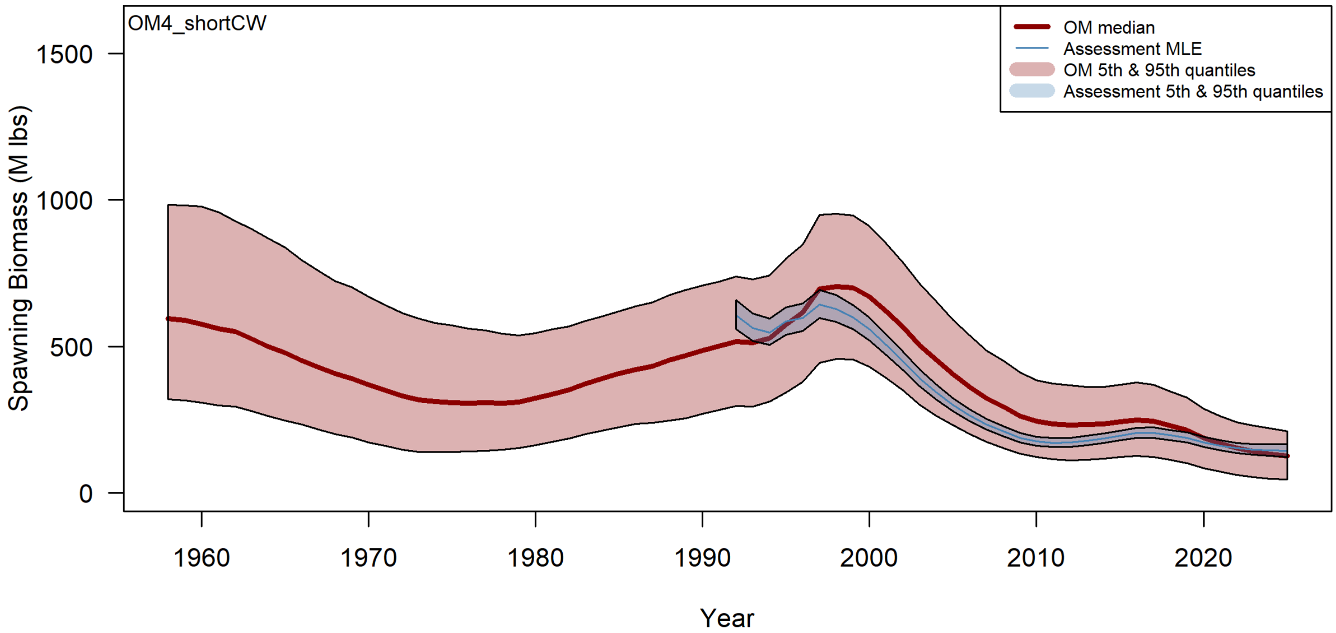
OM4_shortCW

OM4_shortCW is based on the parameters and estimated spawning biomass of the short coastwide stock assessment model. This included natural mortality rates for age 3+ female and male Pacific halibut equal to 0.150 and 0.163, respectively.

The OM4_shortCW model spawning biomass was similar to the short coastwide assessment model spawning biomass, but showed overfitting in the 1990s and a downward trend in recent years (Figure 10). The distribution of 'all sizes' biomass was also fit well except for Region 3 in recent years (Figure 11). The overprediction in Region 3 was a result of slight underfitting in all other Regions. The FISS index fit was not as good as other models and showed departures throughout the time-series in all regions (Figure 11). Overall, the OM4_shortCW model was unable to fit the data as well as the other models.

Similar proportions of recruitment were distributed to Regions 4 and 3, but was slightly higher in Region 4 (and thus lower in Region 3) (Figure 12). Very small proportions were distributed to Regions 2 and 4B.

Movement was only estimated from Region 4 to Region 3 and from Region 3 to Region 2 (Figure 12). Movement probabilities were similar across PDO regimes for Region 4 to 3, but peaked slightly higher in high PDO regimes. Fewer Pacific halibut moved from Region 3 to 2 in the high PDO regime. A very small proportion of Pacific halibut 6 years and older moved from either of these regions.



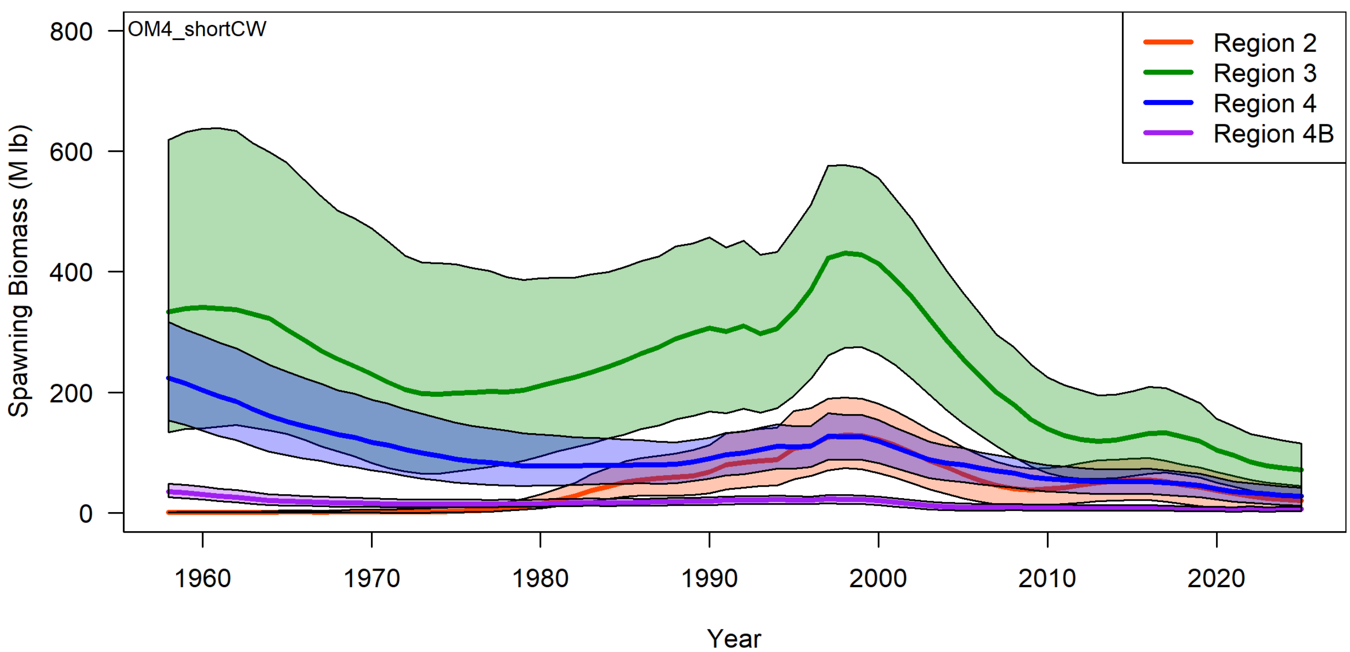
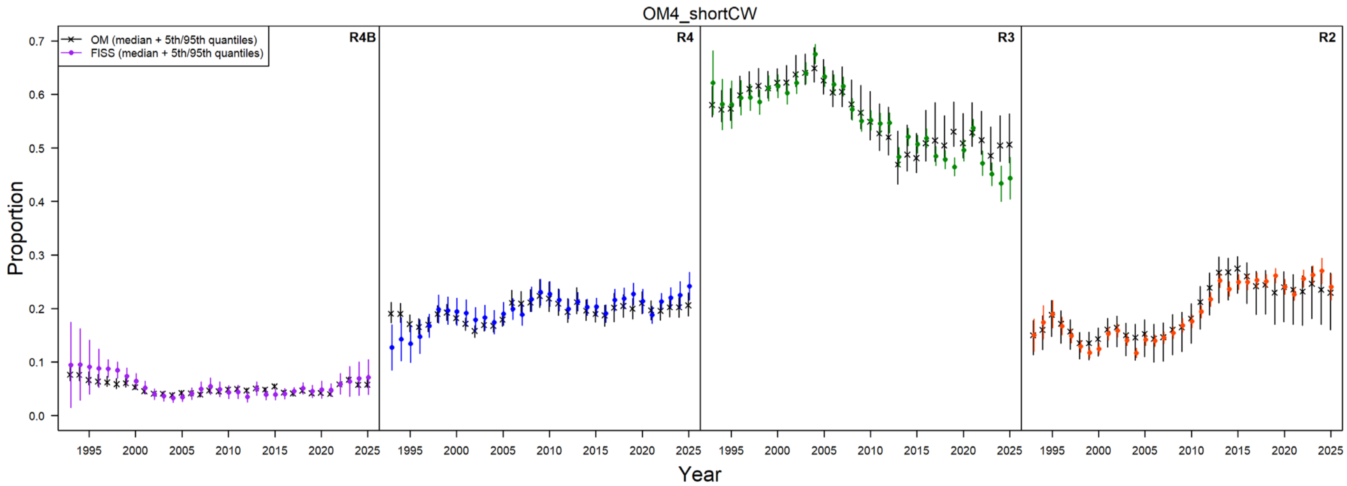


Figure 10. The spawning biomass from the OM4_shortCW model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the spawning biomass in each Region from the OM4_shortCW model.



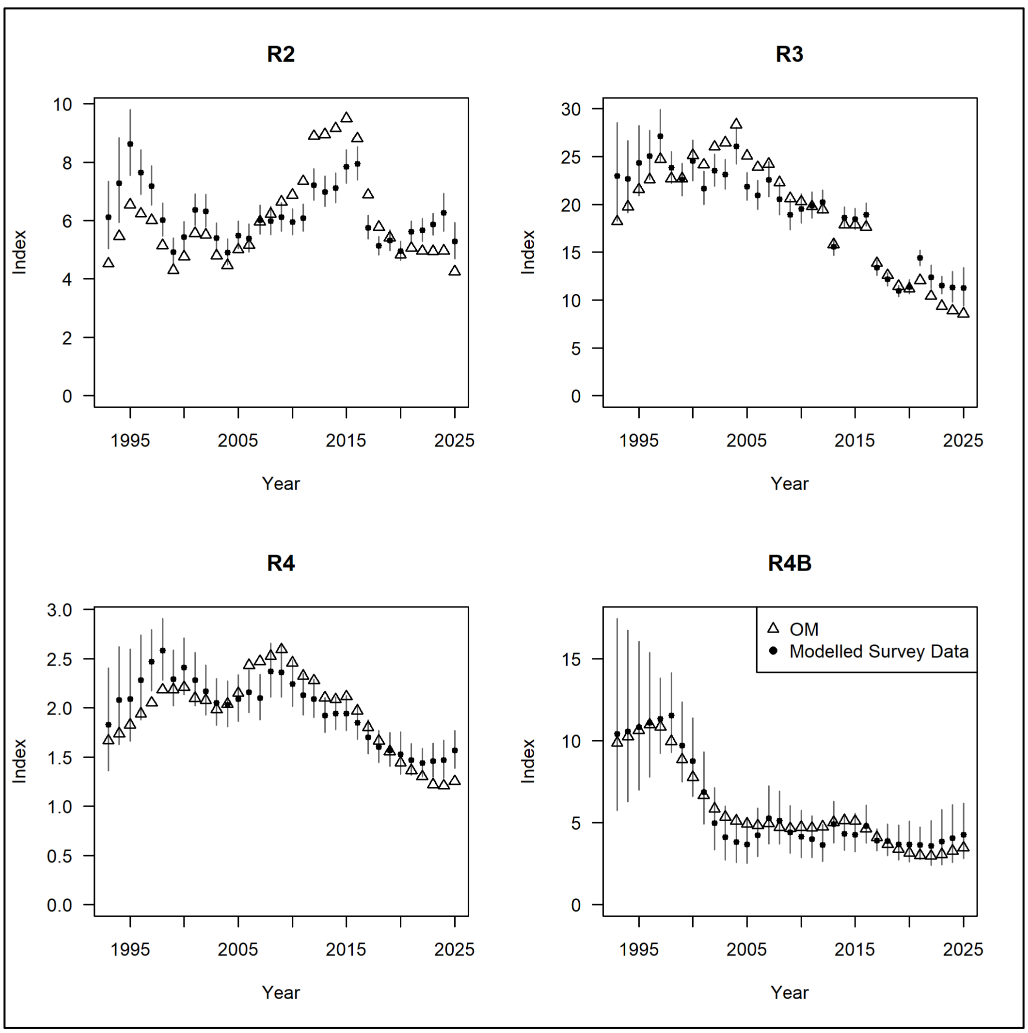


Figure 11. The top plots show the proportion of all sizes biomass in each Region from the OM4_shortCW model (triangles) and the FISS modelled output with 95% credible intervals (circles). The bottom plots show the predicted index from the OM4_shortCW model (triangles) and the FISS index (circles).

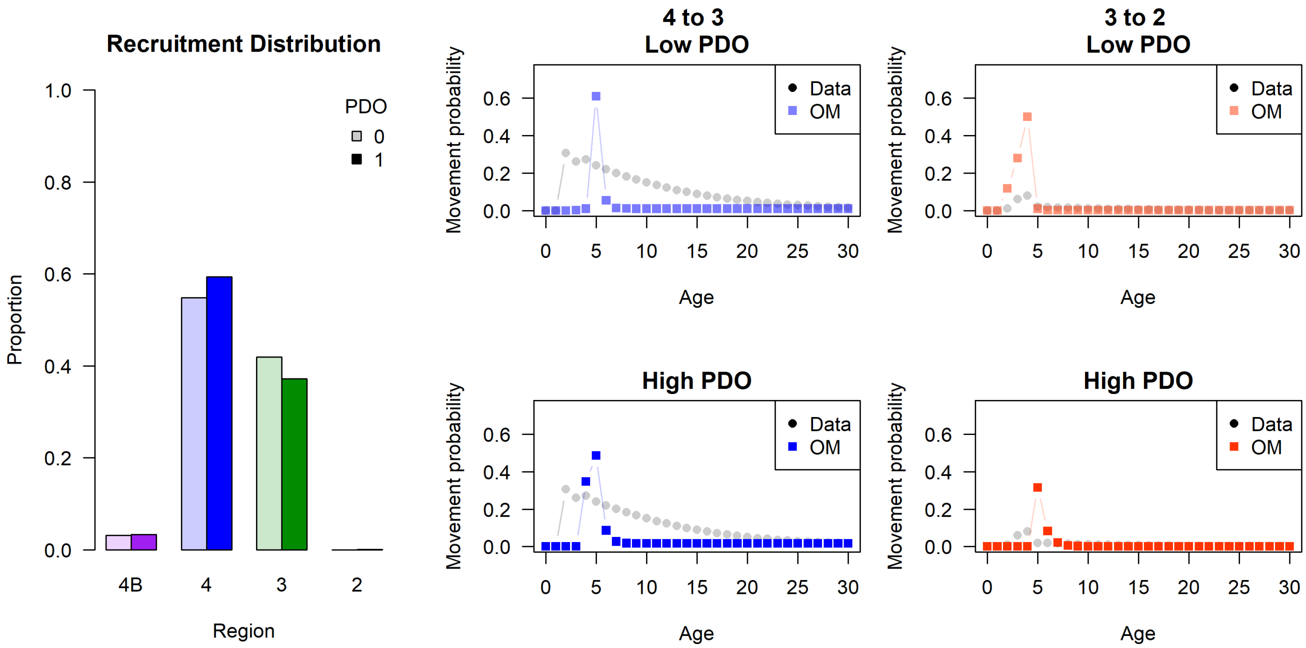


Figure 12. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot). The proportion of numbers of Pacific halibut estimated in OM4_shortCW that move from Region 4 to Region 3 (center) and from Region 3 to Region 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

2.1.1.2 Discussion of conditioning

All of the models captured the recent trends in the spawning biomass but showed consistent overfitting to the distribution in Region 3 in recent years. It is not certain why this occurs, and no combination of parameters could be found that rectified this while simultaneously fitting all the data sources reasonably well. For example, fitting to only stock distribution data with the OM1_longAAF model still showed this overfitting (Figure 13). It is possible that the response of Pacific halibut dynamics to the environment (e.g. PDO) has changed in recent years, whether through movement, recruitment distribution, or some other factor. The 2025 stock assessment has classified the PDO in a low regime since 1998, and recent years have seen the lowest annual average PDO in the entire time-series (Figure 14). However, the North Pacific Ocean has been recently experiencing warmer regional temperatures and novel relationships between climate variables and the PDO (Litzow et al. 2020). It is possible that these novel processes are causing a change in population parameters that the OM models are unable to capture. It will be important to capture this uncertainty when determining variability in the OM.

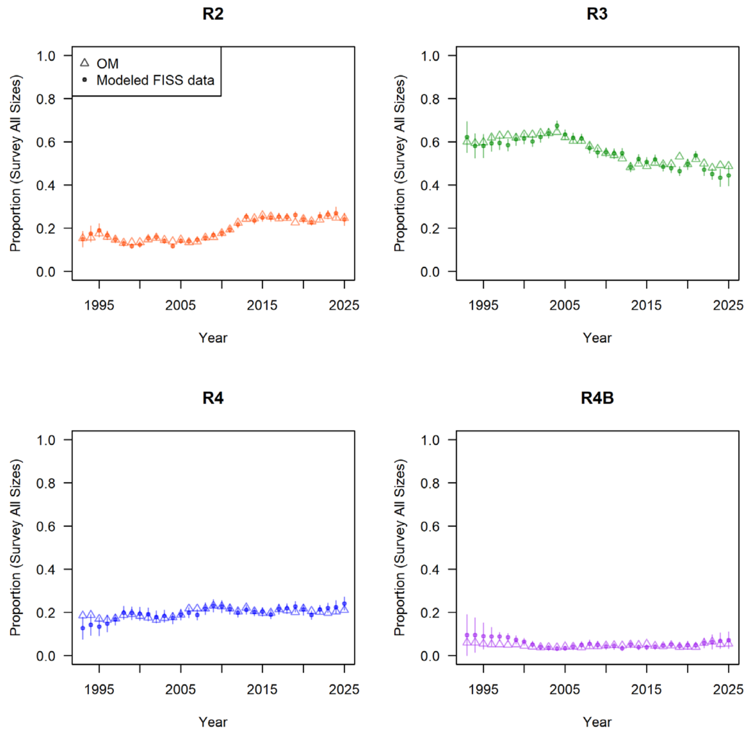


Figure 13. Results of fits to stock distribution in each Region when fitting to only stock distribution data using the OM1_longAAF model. This model is not considered for use as a conditioned model in the MSE framework but is useful to understand model fitting.

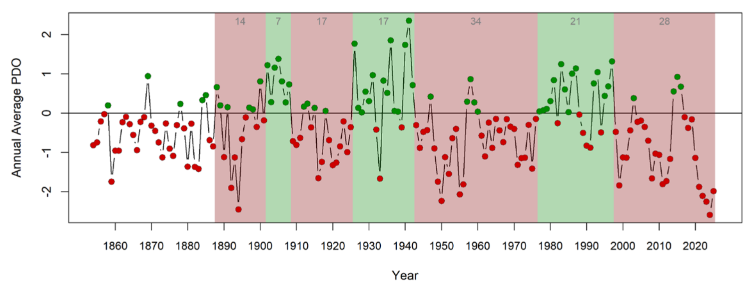


Figure 14. Annual PDO determined by averaging monthly values as of April 2026 (https://www.ncei.noaa.gov/pub/data/cmb/ersst/v5/index/ersst.v5.pdo.dat). Red and green shaded areas indicate low and high regimes, respectively, as used in the 2025 stock assessment and OM. Numbers in the shaded areas indicate the number of years for that regime.

A goal of the MSE is to capture the variability and uncertainty in the population dynamics, therefore determining uncertainty is an important part of the conditioning process. Using OM1_longAAF, one-hundred (100) trajectories were determined via parametric bootstrap using covariance matrices estimated in the 2025 long AAF stock assessment model (with the addition of steepness) and during the OM conditioning process. The final OM models will each use 1000 samples.

The median spawning biomass estimated from OM1_longAAF was slightly higher than the estimate from the 2025 long AAF stock assessment model and the estimate when conditioning OM1_longAAF, showing the asymmetry in the uncertainty interval (Figure 15). The uncertainty in the OM was slightly greater than the uncertainty in the ensemble stock assessment because additional parameters were modelled and considered when determining the overall uncertainty (e.g. steepness, movement, and recruitment distribution).

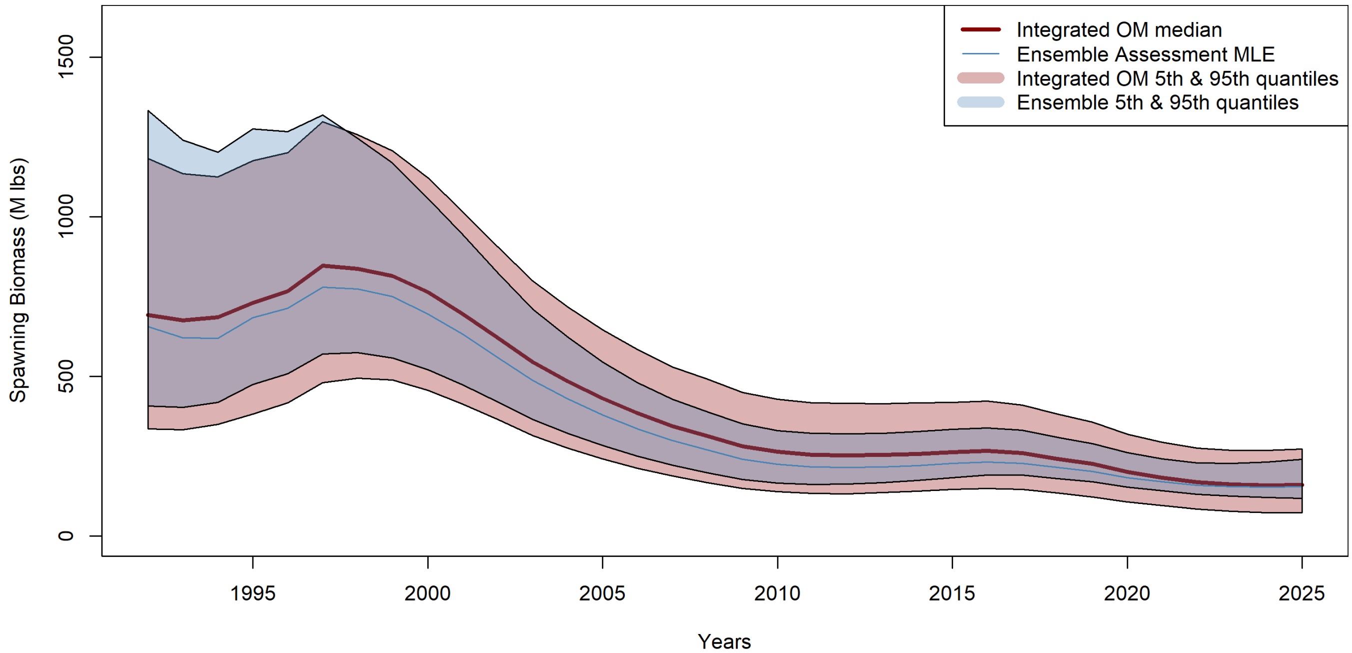


Figure 15. Estimated spawning biomass from the 2025 ensemble stock assessment model with a 90% credible interval (blue) and from the Integrated OM with bootstrapped 5th and 95th quantiles (red).

2.1.2 Evaluate a range of SPR values

The IPHC HSP defines a reference fishing intensity ($F_{SPR=43\%}$) that was determined to meet the Commission's objectives using past MSE simulations. With an updated OM, it is useful to ensure that the reference fishing intensity continues to be the optimal fishing intensity to meet those objectives. Therefore, a range of fishing intensities (i.e. SPR values) should be evaluated.

At MSAB021 a recommendation was made to evaluate a range of SPR values.

> **IPHC-2025-MSAB021-R, para. 36**: *The MSAB REQUESTED further evaluations of the following MP elements, after the OM is conditioned following the full 2025 stock assessment:*
>
> *a) fishing intensities including, but not limited to, SPRs of 40%, 43%, 46%, 52%, 55%, and 100% (no directed fishing); …*

This is a reasonable range to determine an optimal reference fishing intensity, and additional values will be added if necessary.

2.1.3 Investigate productivity regimes

Recent MSE work has involved investigating the effects of low or high productivity on management outcomes (see IPHC-2025-AM102-11 and IPHC-2026-MSAB022-06), and has found that the range of productivity historically observed for Pacific halibut has profound effects on the magnitude of biomass and mortality limits (Figure 16). Weight-at-age and average recruitment are currently identified as the two major components influencing historical productivity. Low and high PDO regimes have been linked to low and high average recruitment, respectively, and are modelled in the OM. PDO regimes are also parameterized to change the distribution of age-0 recruits and movement of all ages in the OM. Environmental or density-dependent linkages have not been determined for weight-at-age, but low, current, and high periods have been identified from historical observations. There are three main concepts to explore when investigating productivity regimes: determine 1) how the Pacific halibut population and fisheries respond to different productivity regimes, 2) if the optimal reference fishing intensity differs across productivity regimes, and 3) how productivity regimes may be incorporated into a Management Procedure.

Pacific halibut have been in what can be called a low productivity period (e.g. low weight-at-age and low recruitment) for at least the last 15 years. MSE simulations integrating across the full range of observed biological characteristics for Pacific halibut assume that weight-at-age will likely increase and the PDO will soon switch to a positive regime, therefore spawning biomass and the TCEY have a high probability of increasing in the simulated future. However, previous simulations assuming that weight-at-age remains similar to the recent 5 years (current weight) and the PDO remains in a negative regime (low recruitment) show a potential further decline in the spawning biomass (Figure 17).

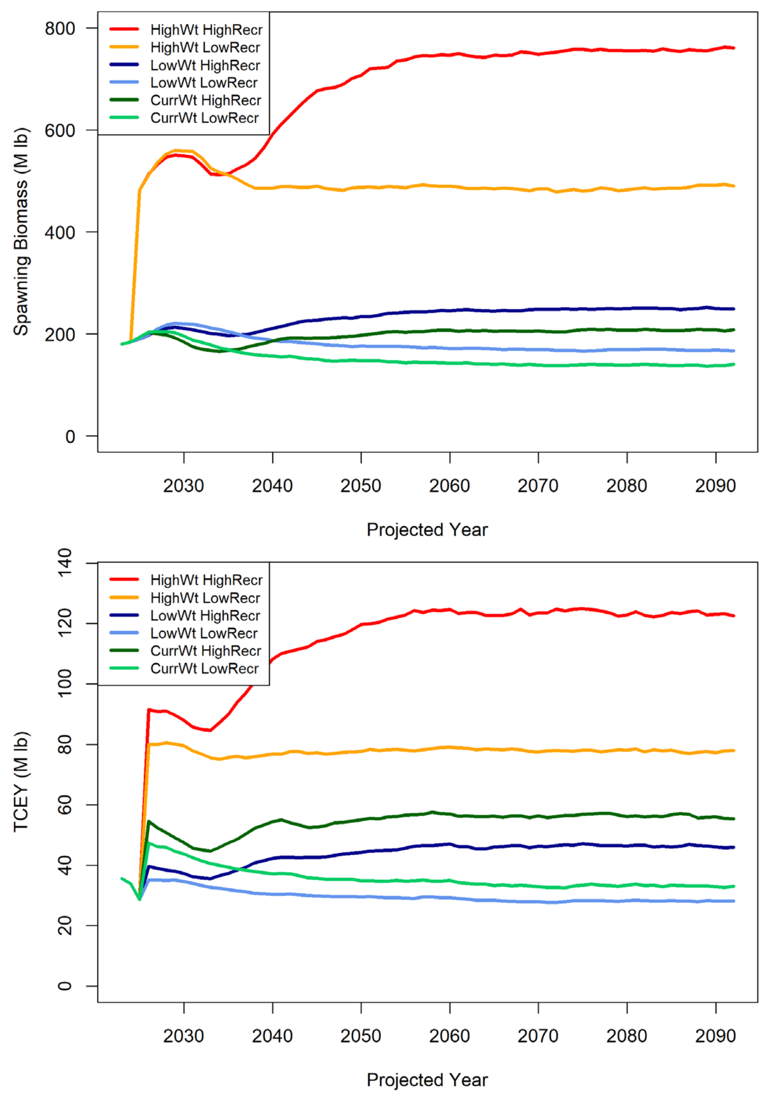


Figure 16. Simulated projections, using the OM from 2025, of spawning biomass (left) and TCEY (right) assuming six different regimes for combinations of weight-at-age and recruitment and an SPR of 43%. Each projection held the weight-at-age and average recruitment at the defined level for all projected years.

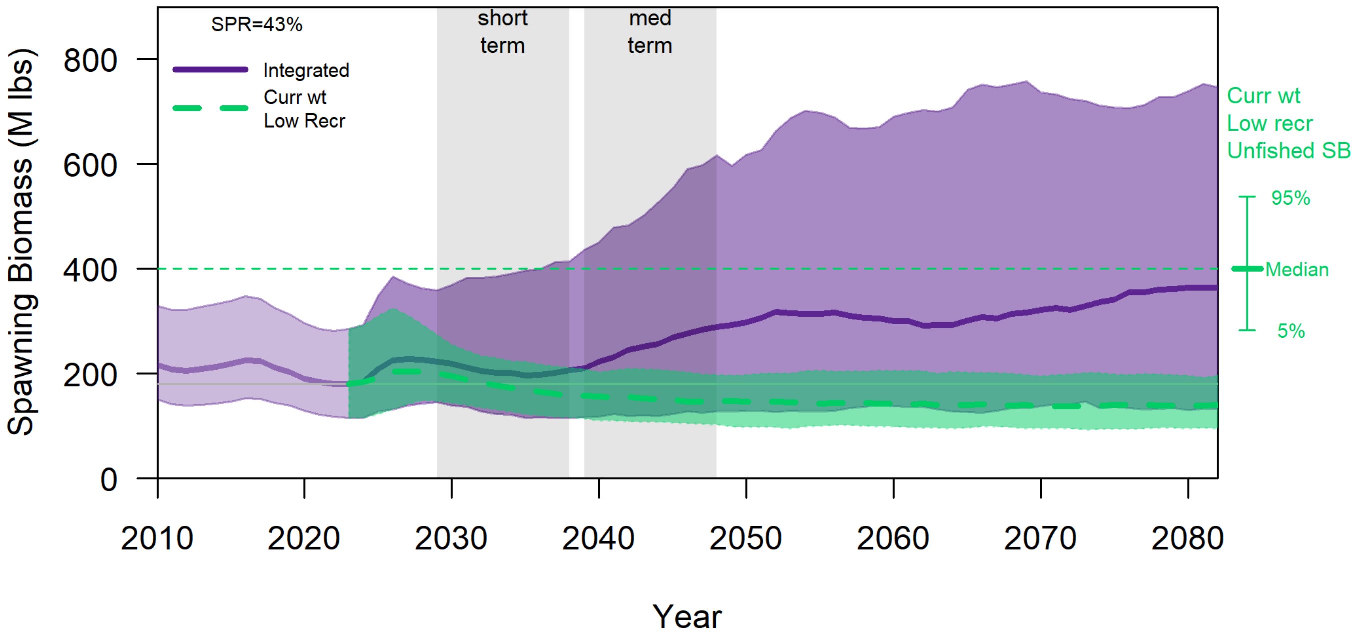


Figure 17. Simulated spawning biomass, using the 2025 OM, when fishing at an SPR=43% fishing intensity for productivity integrated over low and high levels (purple) and productivity assumed to remain at recent low levels (green). The 2023 median spawning biomass is shown as a horizontal grey line for reference, and the range of unfished spawning biomass for the low productivity scenario is shown on the right.

Another interesting aspect of investigating productivity regimes is the effect of the productivity regime on the optimal fishing intensity. This was investigated by conducting MSE simulations across various SPR values assuming a low productivity scenario (i.e. current weight-at-age and negative PDO) and comparing the performance metrics associated with the four priority objectives to the simulation results integrating over changes in weight-at-age and a cyclical PDO. The probability that the short-term spawning biomass will be less than the spawning biomass in 2023 was also compared for both sets of simulations (Table 1). The median TCEY is less for the low productivity scenario and the AAVs slightly higher. The probability that the relative spawning biomass is less than 36% is also higher for the low productivity scenario and this performance metric is not met with an SPR of 40% assuming constant low productivity. The short-term probability of being below the 2023 spawning biomass is also higher for the low productivity scenario with an approximate 1 in 2 chance for the low productivity scenario with an SPR of 43% versus an approximate 1 in 3 chance with integrated productivity (i.e. simulated low and high periods of productivity).

The trade-offs between the TCEY and variability in the TCEY (AAV) are similar for the integrated productivity and low productivity scenario (Figure 18). There are slight differences between the AAVs at different fishing intensities with the lowest AAVs occurring between SPRs of 43% and 52%. The AAV increased at a faster rate for lower SPRs in the low productivity scenario compared to integrated productivity. However, the TCEY increased by approximately 1 M lbs per every 1% reduction in SPR. Further defining what an optimal fishery is would help evaluate this trade-off.

Table 1. Performance metrics for different SPR values and simulations integrating over changes in weight-at-age and cyclical PDO and assuming a recent (i.e. low) productivity scenario (i.e. current weight-at-age and negative PDO). Green colours indicate that the performance metrics passes and red indicates that it does not.

	Integrated (low & high) Productivity						
	SPR (%)	**40**	**43**	**46**	**49**	**52**	**55**
Long-term	**P(RSB<20%)**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	0.372	0.195	0.066	0.014	0.001	<0.001
Short-term	**Median TCEY (M lb)**	55.0	52.0	48.9	45.9	42.5	39.1
	AAV	28.5%	26.3%	25.6%	25.5%	26.0%	26.7%
	P(SB < SB_{2023})	0.401	0.350	0.297	0.254	0.214	0.179

	Recent (low) Productivity						
	SPR (%)	**40**	**43**	**46**	**49**	**52**	**55**
Long-term	**P(RSB<20%)**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	0.677	0.462	0.236	0.081	0.016	<0.001
Short-Term	**Median TCEY (M lb)**	43.5	41.2	38.7	36.1	33.3	30.6
	AAV	29.0%	28.3%	27.7%	28.3%	29.2%	30.3%
	P(SB < SB_{2023})	0.609	0.543	0.466	0.390	0.312	0.241

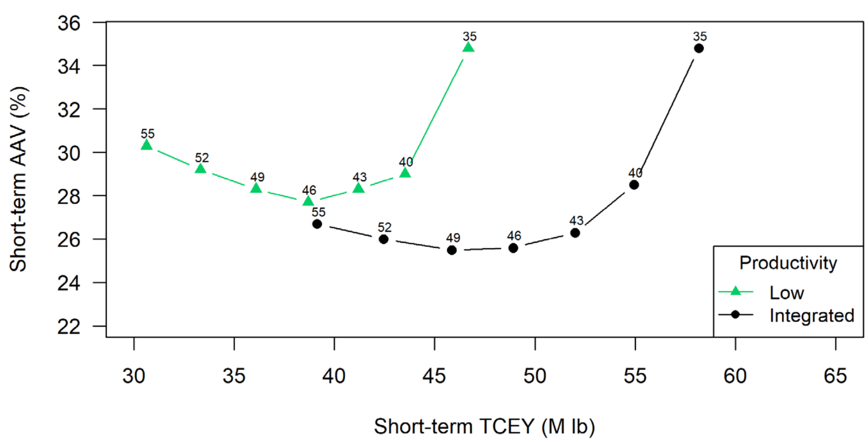


Figure 18. Trade-off between variability in the TCEY (AAV) and the TCEY for different fishing intensities (SPR labelling the points) when integrating over a range of productivity from low to high (black circles) and consistent low productivity similar to recent observations (green triangles).

Using the newly conditioned OM, productivity regimes will be defined and fixed in the projections. Projections will be used to evaluate a range of SPR values to gain an understanding of the effect of productivity on the optimal fishing intensity, and the Secretariat will work with the MSAB, SRB, and Commissioners to identify additional MPs to evaluate that directly incorporate and respond to productivity. Finally, the Secretariat will work with the MSAB and SRB to identify the most effective ways to present these results to better understand the effects that changing productivity has on the Pacific halibut population and fisheries.

2.1.4 Further develop the Depleted concept and identify a limit reference point

The IPHC HSP defines two limit biomass reference points (Figure 19) where going below either of them is to be avoided with a high probability. The first is a dynamic relative spawning biomass that measures only the effect of fishing. The second, called the Depleted limit reference point, is an absolute spawning biomass that measures the effect of fishing and the environment. The potential for recovery of the population is uncertain if it is below the Depleted limit reference point. The specific value for a Depleted reference point has not been determined.

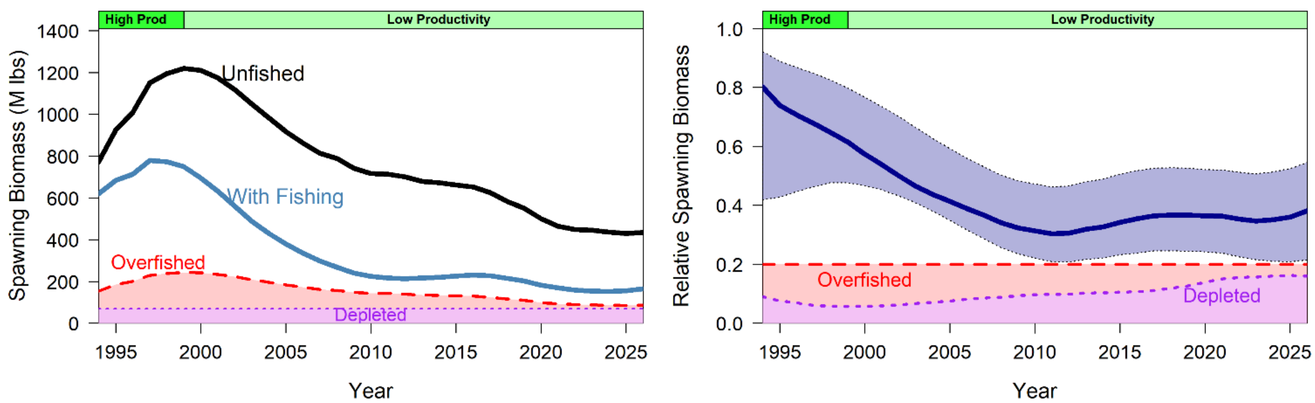


Figure 19. Estimated spawning biomass (left) if fishing had not occurred (unfished) and estimated spawning biomass from the 2025 stock assessment (with fishing). The Overfished threshold of 20% of unfished spawning biomass is shown as a dashed line and changes over time. An example "Depleted" threshold is shown as a straight horizontal line, assuming that it is defined as a constant absolute spawning biomass. The relative spawning biomass ("with fishing" divided by "unfished") is shown on the right with a 95% credible interval (accounting for the covariance in the biomass estimated with and without fishing). The Overfished threshold is shown at 20% and the example Depleted value is shown in purple.

Simulations were conducted in 2025 with the previously conditioned OM (see Section 3 of IPHC-2025-SRB027-08) to determine an absolute biomass below which the potential for recovery would be uncertain. These simulations assumed a 'worst-case' scenario of low productivity and a depensatory spawner-recruit relationship at low spawning biomass. This work was incomplete and will be expanded in 2026 using the newly conditioned OM and further determination of scenarios. The SRB suggested the following.

> **IPHC-2025-SRB027-R. para 23**. *The SRB RECOMMENDED increasing simulation sample sizes to achieve a smooth curve so that a "depleted" threshold can be identified as the lowest spawning stock biomass that results in near 100% probability of recovery.*

Furthermore, the SRB recommended defining an exceptional circumstance if the stock is estimated to be below the Depleted limit reference point because the MP determined from the MSE process should avoid this with high probability and thus would be theoretically unlikely. If the stock was depleted, it may indicate a misspecification within the MSE framework that should be investigated. A definition for this type of exceptional circumstance will be determined with assistance from the MSAB and SRB, and then presented to the Commission for adoption into the IPHC HSP.

> **IPHC-2025-SRB027-R. para 21.** *The SRB RECOMMENDED defining an "exceptional circumstance" if the stock is determined to be "depleted" as this state is unlikely to occur under the circumstances in which the HSP is implemented and may be indicative of a need for model revision*

2.2 Low priority tasks

The Commission, MSAB, and SRB identified additional tasks which are a lower priority than those defined above. These may be possible to complete in 2026 or 2027, but may also be extended into the next MSE Program of Work.

2.2.1 Improve the estimation model in the MSE framework

The closed-loop simulations in the MSE framework consist of an OM and an MP (Figure 20). Within the MP there are three subcomponents. The monitoring subcomponent determines what data are sampled and with what precision. The estimation model uses those data to determine outputs necessary for management (e.g. stock status, mortality limits, etc.). The harvest rule consists of other items necessary for the management of Pacific halibut, such as size limits, distribution of the harvest, and control rules.

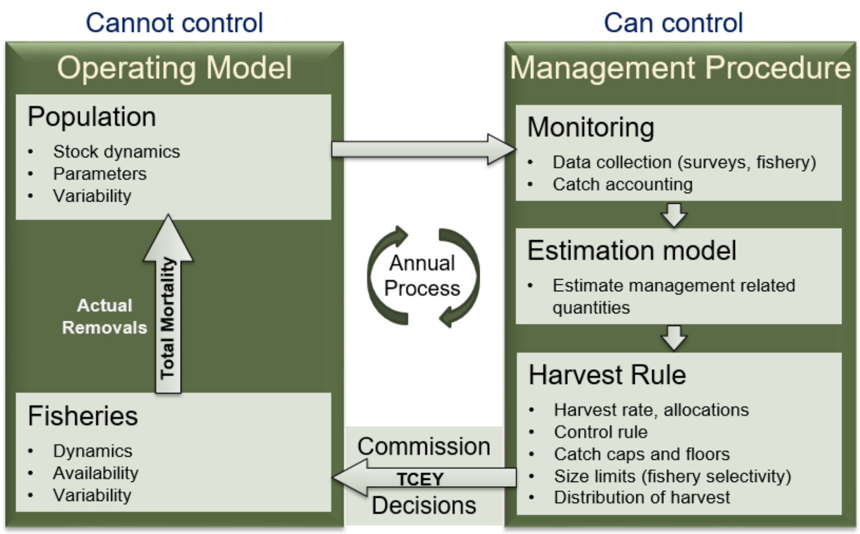


Figure 20. An illustration of the closed-loop simulation within the MSE framework.

Implementing a full ensemble stock assessment in a simulation framework is not technically feasible at this time. Therefore, estimation models in MSE frameworks are typically simplifications of the actual stock assessment to reduce the simulation time but still mimic the behaviours of the stock assessment. The current estimation model mimics the stock assessment with a simple approach of adding correlated random variability to stock status and the mortality limit, which was tuned to outputs of past stock assessments. This method, however, is not capturing potential lags and biases in estimated quantities, and cannot simulate different assumptions in the stock assessment. Following an SRB recommendation, work has begun on better mimicking the stock assessment within the MSE framework.

IPHC-2025-SRB027-R, para 24. *The SRB RECOMMENDED considering the development of an assessment model within the MSE framework. This would have multiple benefits including:*

a) facilitating analysis of the economic consequences of reduced FISS sampling and the associated increased potential for bias in assessment-relevant metrics such as WPUE, the maturity schedule, size-at-age, and age composition.

b) Understanding the impacts of uncertainty in natural mortality on management performance.

2.2.2 Evaluate potential management actions when approaching the depleted limit reference point

Once a Depleted limit reference point is determined (see Section 2.1.4), specific management actions to incorporate into a management procedure if this reference point is reached will be evaluated using the MSE framework. This may be a control rule that reduces fishing intensity as the stock approaches a limit reference point to complement the current 30:20 control rule that uses stock status as its operational control points. Other management actions to investigate include adjusting the reference fishing intensity based on the perceived productivity regime.

2.2.3 Evaluate additional elements of Management Procedures

The MSE framework has been used to evaluate many elements of management procedures other than fishing intensity (i.e. SPR). These include constraints or smoothers on the annual change in the TCEY, assessment frequencies other than annual, and alternative control rules. The MSAB has found the investigations useful and has made a number of requests to continue evaluating these as well as new elements.

IPHC-2025-MSAB021-R, para 23. *The MSAB AGREED that a constraint would help to reduce interannual variability in the TCEY when using an annual or triennial assessment frequency.*

IPHC-2025-MSAB021-R, para 36. *The MSAB REQUESTED further evaluations of the following MP elements, after the OM is conditioned following the full 2025 stock assessment:*

a) fishing intensities including, but not limited to, SPRs of 40%, 43%, 46%, 52%, 55%, and 100% (no directed fishing);

b) a triennial assessment frequency;

c) various empirical rules to determine the reference coastwide TCEY in non-assessment years;

d) control rules with triggers at higher values than $RSB_{30\%}$ or based on absolute spawning biomass relative to the spawning biomass estimated at the beginning of 2024.

IPHC-2025-MSAB021-R, para 37. *The MSAB REQUESTED evaluating constraints and smoothers, along with MP elements listed in para. 36, that would potentially reduce the interannual variability in the TCEY, including:*

a) a 3-year rolling average (arithmetic or geometric) on the FISS O32 WPUE used in the empirical rule in a triennial stock assessment frequency;

b) constraints applied only to non-assessment years and/or applied only to assessment years;

c) a phase-in approach for the change in TCEY in assessment years;

d) using the trends in fishery CPUE and/or FISS WPUE to determine if a bigger reduction should be taken than suggested by the unconstrained reference TCEY to curtail further reductions in the SB.

The Secretariat will work with the MSAB and SRB to clearly identify candidate MPs incorporating these elements for evaluation.

2.2.4 Update estimates of reference points

The Secretariat last conducted an in-depth analysis of reference points in 2019 and reported the results in IPHC-2019-SRB015-11 Rev_1. That analysis reported estimates of MSY-based reference points that were used in the development of objectives and the definition of overfishing. Since 2019, there have been many updates to the stock assessment and the OM, as well as new data available. Repeating this analysis with the updated OM and stock assessment will ensure that the HSP reflects the most up-to-date information.

2.2.5 Develop guidance documents for the Harvest Strategy Policy

The HSP document is a high-level description of the harvest strategy policy that does not describe all concepts in detail. Therefore, the development of supplementary guidance documents describing some concepts in more detail is necessary for the management of Pacific halibut. Supplementary documents to be developed may include

1. Guidelines for developing a rebuilding plan for Pacific halibut that would apply if it was determined to be overfished;
2. Other guideline documents as determined by the Commission.

Guideline documents will be developed and adopted after input from the MSAB, SRB, and Commission.

2.2.6 Incorporate autocorrelated recruitment in projections

The Secretariat reported results of investigations of autocorrelated recruitment for Pacific halibut and its use in the MSE framework in document IPHC-2025-SRB027-08. This was in response to an SRB request from the 26th Session of the SRB.

> **IPHC-2025-SRB026-R, para 24**. *The SRB RECOMMENDED that recruitment projections in the stock assessment and Management Strategy Evaluation (MSE) incorporate a random-walk starting from the most recent reliable recruitment estimate to constrain expected short-term recruitment around recent estimates rather than immediately reverting to the stock-recruitment relationship.*

These results showed some evidence of autocorrelated recruitment that may be useful to model. MSE simulations with and without autocorrelated projected recruitment showed slight differences in performance metrics. The MSE framework is capable of including autocorrelated recruitment and further discussion with the SRB will determine if this is appropriate for evaluating MPs.

2.2.7 Update objectives and performance metrics

The three priority Commission objectives are defined in the HSP and additional objectives considered by the MSAB are presented in Appendix A. It is useful to occasionally revisit objectives to clarify them or add new ones. For example, there have been recent discussions regarding the development of an objective related to absolute spawning biomass or a depleted level (see Section 2.1.4).

It is also useful to review the performance metrics related to the objectives. This ensures that MSE results are presented using applicable and understandable metrics. The SRB suggested considering fishery performance metrics.

> **IPHC-2025-SRB027-R, para 22.** *The SRB RECOMMENDED considering some fishery performance indicators that represent metrics directly observable by stakeholders, e.g. fishery CPUE.*

These types of fishery performance indicators would be best associated with general objective 2.2: Provide Directed Fishery Yield (Appendix A). Discussions with the MSAB and Commission will determine if new objectives should be adopted and new performance metrics be reported.

3 DISCUSSION

Tasks for the 2026–2027 MSE Program of Work are divided into high priority and low priority. High priority tasks are already underway, and some low priority tasks require completion of high priority tasks. A list of all tasks is provided below.

1. High priority tasks
    - 1.1. Condition the MSE Operating Model
    - 1.2. Evaluate a range of SPR values
    - 1.3. Investigate productivity regimes
    - 1.4. Further develop the depleted concept and identify a limit reference point
2. Low priority tasks
    - 2.1. Improve the estimation model in the MSE framework
    - 2.2. Evaluate potential management actions when approaching the depleted limir reference point
    - 2.3. Evaluate additional elements of the Management Procedures
    - 2.4. Update estimates of reference points
    - 2.5. Develop guidance documents for the Harvest Strategy Policy
    - 2.6. Incorporate autocorrelated recruitment in projections
    - 2.7. Update objectives and performance metrics

4 REFERENCES

Litzow, M.A., Malick, M.J., Bond, N.A., Cunningham, C.J., Gosselin, J.L., and Ward, E.J. 2020. Quantifying a Novel Climate Through Changes in PDO-Climate and PDO-Salmon Relationships. Geophysical Research Letters **47**(16). doi:10.1029/2020gl087972.

5 RECOMMENDATIONS

That the SRB:

1) **NOTE** paper IPHC-2026-SRB028-08 Rev_1 that describes tasks included in the MSE Program of Work for 2026–2027 and work towards completing those tasks.
2) **REQUEST** additional tasks to be included in the MSE Program of Work for 2026–2027.

6 APPENDICES

Appendix A: Primary objectives used by the Commission for the MSE evaluations

APPENDIX A
PRIMARY OBJECTIVES USED BY THE COMMISSION FOR THE MSE EVALUATIONS

Table A1. Primary objectives, evaluated over a simulated ten-year period, accepted by the Commission at the 7th Special Session of the Commission (SS07). Objective 1.1 is a biological sustainability (conservation) objective and objectives 2.1, 2.2, and 2.3 are fishery objectives. Priority objectives are shown in green text.

GENERAL OBJECTIVE	MEASURABLE OBJECTIVE	MEASURABLE OUTCOME	TIME-FRAME	TOLERANCE	PERFORMANCE METRIC
1.1. KEEP FEMALE SPAWNING BIOMASS ABOVE A LIMIT TO AVOID CRITICAL STOCK SIZES AND CONSERVE SPATIAL POPULATION STRUCTURE	Maintain the long-term coastwide female relative spawning biomass above a biomass limit reference point ($RSB_{20\%}$) at least 95% of the time	*RSB* < Spawning Biomass Limit (RSB_{Lim}) RSB_{Lim}=20% unfished spawning biomass	Long-term	0.05	$P(RSB < RSB_{Lim})$ Fail if greater than 0.05
	Maintain a defined minimum proportion of female spawning biomass in each Biological Region	$p_{SB,2} > 5\%$ $p_{SB,3} > 33\%$ $p_{SB,4} > 10\%$ $p_{SB,4B} > 2\%$	Long-term	0.05	$P(p_{SB,R} < p_{SB,R,min})$
2.1 MAINTAIN SPAWNING BIOMASS AT OR ABOVE A LEVEL THAT OPTIMIZES FISHING ACTIVITIES	Maintain the long-term coastwide female relative spawning biomass at or above a biomass reference point ($RSB_{36\%}$) 50% or more of the time	*RSB*<Spawning Biomass Reference (RSB_{Thresh}) RSB_{Thresh}=$RSB_{36\%}$ unfished spawning biomass	Long-term	0.50	$P(RSB < RSB_{Thresh})$ Fail if greater than 0.5
2.2. PROVIDE DIRECTED FISHING YIELD	Optimize average coastwide TCEY	Median coastwide TCEY	Short-term		*Median* $\overline{TCEY}$
	Optimize TCEY among Regulatory Areas	Median $TCEY_A$	Short-term		*Median* $\overline{TCEY_A}$
	Optimize the percentage of the coastwide TCEY among Regulatory Areas	Median $\%TCEY_A$	Short-term		*Median* $\overline{\left(\frac{TCEY_A}{TCEY}\right)}$
	Maintain a minimum TCEY for each Regulatory Area	Minimum $TCEY_A$	Short-term		*Median Min(TCEY)*
	Maintain a percentage of the coastwide TCEY for each Regulatory Area	Minimum $\%TCEY_A$	Short-term		*Median Min(%TCEY)*
2.3. LIMIT VARIABILITY IN MORTALITY LIMITS	Limit annual changes in the coastwide TCEY	Annual Change (*AC*) > 15% in any 3 years	Short-term		$P(AC_3 > 15\%)$
		Median coastwide Average Annual Variability (AAV)	Short-term		*Median AAV*
	Limit annual changes in the Regulatory Area TCEY	Annual Change (*AC*) > 15% in any 3 years	Short-term		$P(AC_3 > 15\%)$
		Average AAV by Regulatory Area (AAV_A)	Short-term		*Median* AAV_A

$$AAV_t = \frac{\sum_{t+1}^{t+9} |TCEY_t - TCEY_{t-1}|}{\sum_t^{t+9} TCEY_t}$$

$$AC_t = \frac{|TCEY_t - TCEY_{t-1}|}{TCEY_{t-1}}$$