IPHC-2026-MSAB022-06

Updates to the IPHC MSE Program of Work for 2026 and a review of coastwide management procedures

Prepared by: IPHC Secretariat (A. Hicks, I. Stewart; 09 April 2026)

PURPOSE

To provide the Management Strategy Advisory Board (MSAB) with an overview of work done since the 21st meeting of the Management Strategy Advisory Board (MSAB021) using the IPHC Management Strategy Evaluation (MSE) framework.

1 INTRODUCTION

Rapid investigation of various questions is possible with the fully developed MSE framework. The MSAB made a number of requests at MSAB021 for investigation with the MSE framework (IPHC-2025-MSAB021-R), but many of those requests were conditional on updating the operating model (OM). The conditioning of the operating model is part of the 2026–2027 Program of Work (IPHC-2026-MSAB022-07) 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 preliminary results of that conditioning process along with the MSE work completed since MSAB021.

2 WORK PRESENTED AT OR BEFORE THE 102ND IPHC ANNUAL MEETING (AM102)

Most of the recommendations/requests of the MSAB and Scientific Review Board (SRB) were addressed in the MSE work that was completed in 2025. This included defining the concept of Depleted, comparing and contrasting Overfished with Depleted, determining potential thresholds for Depleted, investigating productivity regimes, and conducting simulations to compare fishing intensities in a low productivity regime. These topics are summarized below with additional information presented in IPHC-2026-AM102-11.

2.1 Definitions of overfished and depleted

The SRB noted that Overfished implies that fishing was the cause of a low biomass state, whereas Depleted is agnostic about the cause of low biomass. Both definitions are important to fisheries management because managers control fishing to avoid precariously low biomass, but the population may be at low biomass for reasons that cannot be controlled by management, yet may require management action to ensure recovery. The use of dynamic reference points allows for the separation of fishing effects from other effects on population size. A dynamic relative spawning biomass (as currently used by IPHC) is appropriate to determine if the population is overfished. An absolute spawning biomass is appropriate to determine if the population is at a low population state from which recovery could be compromised, which the SRB suggested calling Depleted following the New Zealand Harvest Strategy Standard[1]. Both concepts are defined in the IPHC Harvest Strategy Policy (HSP) and are shown in Figure 1. An example level for Depleted is shown, as it is not currently defined. Overfished is currently defined as 20% of unfished spawning biomass and changes over time when calculated as an absolute spawning biomass, depending on current stock conditions. Depleted is a constant absolute spawning biomass and varies in terms of relative spawning biomass.

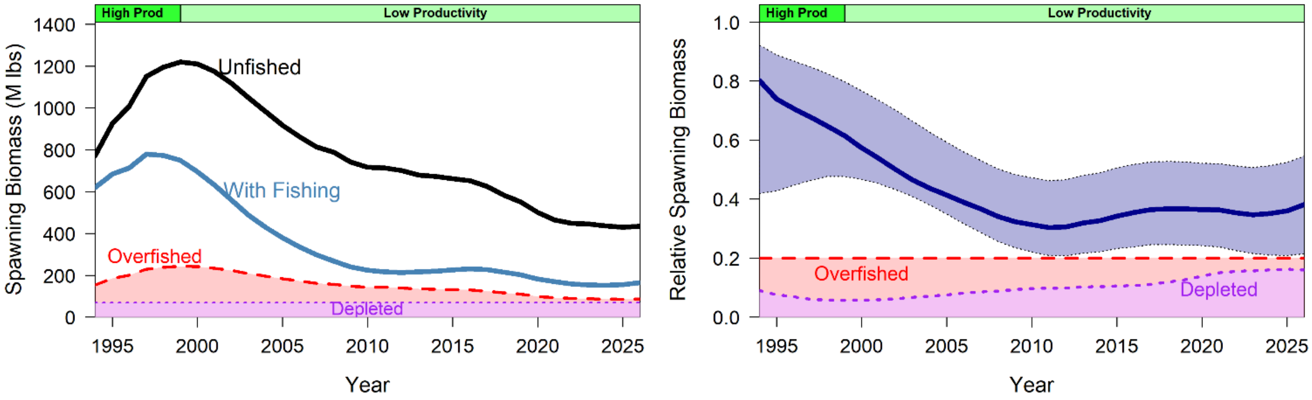

Figure 1. Estimated spawning biomass (left) if fishing had not occurred (unfished) and estimated spawning biomass from the 2025 stock assessment (with fishing). The Overfished threshold of 20% of unfished spawning biomass is shown as a dashed line and changes over time. An example "Depleted" threshold 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.

The Secretariat has currently identified two possible approaches to identify an appropriate absolute spawning biomass reference point for Depleted. The first option is to use the lowest spawning biomass observed in the estimated time series from the ensemble stock assessment, which is 2024 according to the 2025 stock assessment. The estimated spawning biomass in the 1970s may have been at similar levels seen in recent years, but recent levels are estimated to be low with much greater certainty due to data available form the IPHC's Fishery Independent Setline Survey (FISS). The advantage of choosing a specific year to define the absolute reference point (or the lowest estimated spawning biomass over a range of years) is that it scales

---

[1] https://fs.fish.govt.nz/Doc/16543/harveststrategyfinal.pdf.ashx.

to changes in the stock assessment due to updates to data and new assumptions, and it accounts for uncertainty.

Alternatively, simulation (via the MSE framework) could be used to determine this absolute spawning biomass reference point based on our scientific understanding of biological and reproductive dynamics. To explore this, we simulated the Pacific halibut population forward at a high fishing rate for 40 years under a 'worst-case' scenario, assuming low weight-at-age, low PDO (defining poor recruitment and alternative movement), and a depensation parameter in the stock-recruit curve equal to 5, which is very high for a fish stock (Liermann and Hilborn 1997). Depensation, or the Allee effect, is when recruitment of age-0 fish is further depressed when the spawning biomass is very low, resulting in low chance of recovery (Dennis 2002). This may occur because of difficulties finding mates, low fertilization rates with reduced spawning output, or increased predation with smaller numbers, and may differ across environmental regimes. Depensation is not likely to have occurred at the spawning biomass levels observed for Pacific halibut, but previous research estimated a range of potential depensation levels (see IPHC-2024-SRB025-07). After 40 years, simulated fishing stops, except for 3 million pounds representing a small amount of bycatch and subsistence fishing, and the population is simulated forward another 50 years. A bifurcation point in the spawning biomass where trajectories either recover or stabilize and those that continue to decline is then determined.

All trajectories with a spawning biomass greater than 90 M lbs recovered and no trajectories recovered when starting at a spawning biomass less than 40 M lbs (see IPHC-2025-SRB027-08 for details). A high proportion of the trajectories (greater than 50%) in the worst-case scenario recovered when above a spawning biomass near 70 M lbs. Additional simulations will be done using the reconditioned OM as part of the 2026–2027 Program of Work.

2.2 Effects of productivity regimes on the HSP

Pacific halibut exhibit high variability in weight-at-age and recruitment. Over the past 100 years, the average weight of an age 12 female Pacific halibut has ranged from below 20 pounds in recent years to near 40 pounds in the mid-1970's (Figure 2). In the last ten years, the weight of older fish has been declining or stable, but the weight of younger fish has been increasing. Recruitment is variable as well, and 1987 was one of the largest recruitments on record (Figure 3). The two long time-series models in the IPHC ensemble stock assessment (IPHC-2025-SA-01) estimated a link between the Pacific Decadal Oscillation (PDO, Mantua et al. (1997)) and average unfished equilibrium recruitment (R_0), with an estimated average recruitment more than 50% greater during a positive PDO. Previous analyses (Clark and Hare 2002; Stewart and Martell 2016) have also shown that a positive PDO phase is correlated with enhanced productivity, while productivity decreases in negative PDO phases. Although the PDO is strongly correlated with historical recruitments, it is unclear whether the effects of climate change and other recent anomalous conditions in both the Bering Sea and Gulf of Alaska are comparable to those observed in previous decades (Litzow et al. 2020).

To investigate the effects of these low and high weight-at-age and recruitment regimes, different scenarios were defined from past observations, and the population was projected 70 years with an SPR of 43%, assuming constant weight-at-age and constant average recruitment. Three levels were developed for weight-at-age: low weight-at-age was defined from a five-year period in the 2010s, high weight-at-age was defined from a five-year period in the 1970s, and current weight-at-age was defined as the most recent five-years (Figure 2). These three weight-at-age levels show different patterns and although the low weight-at-age and current weight-at-age scenarios were both low in general, they differed between the weight of young fish and older fish. The current weight-at-age scenario had larger young fish but smaller older fish. High and low recruitment regimes were defined based on the stock assessment estimates of average recruitment in positive and negative PDO regimes. The PDO is also modelled to affect movement and distribution of newly recruited (age-0) Pacific halibut. Overall, there were six scenarios crossing current, low, and high weight-at-age with low and high PDO.

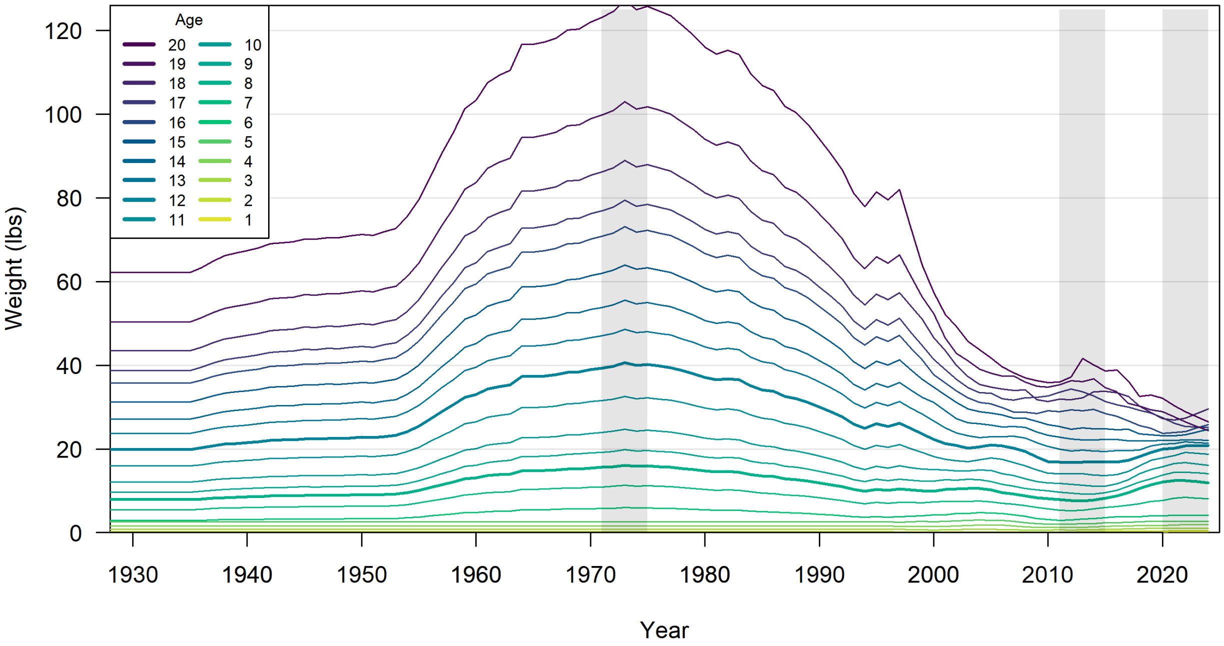

Figure 2. Average historical weight of female Pacific halibut for ages one to twenty as used in the 2024 stock assessment. Gray bands show three blocks of five years classified as *high* (1970s), *low* (2010s) and *current* (recent).

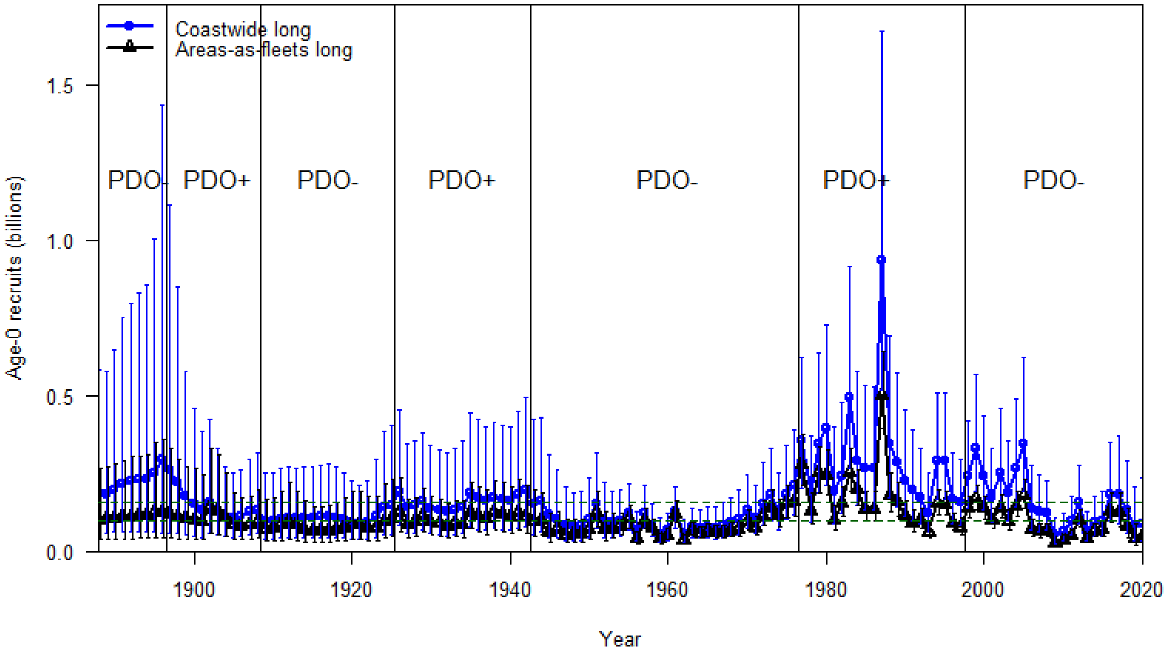

Figure 3. Trend in historical recruitment strengths (by birth year) estimated by the two long time-series stock assessment models, including the effects of the Pacific Decadal Oscillation (PDO) regimes. Figure reproduced from the 2025 stock assessment (IPHC-2026-SA-01).

The spawning biomass differed substantially across different scenarios, but the high weight-at-age scenarios showed a considerable higher spawning biomass than the others (Figure 4). The sudden increase in the spawning biomass when the projections began indicates that weight-at-age is an important driver to the spawning biomass in both the current year and future years (noting that these simulations immediately increased weight-at-age, while it is more likely to slowly change over time). Average recruitment had a significant effect as well but lagged in its effect on the spawning biomass since the fish must age into the spawning biomass. The differences due to average recruitment were more prevalent with higher weight-at-age. For a given recruitment regime, the current weight-at-age scenario resulted in a smaller spawning biomass than the low weight-at-age scenario. This indicates the importance of the older fish in the spawning biomass.

Simulated TCEYs showed the same pattern for high weight-at-age, but different patterns for low and current weight-at-age scenarios (Figure 4). Weight-at-age and recruitment both had a very large effect on the TCEY with the high weight-at-age and high recruitment scenario supporting TCEYs near 120 Mlb and the high weight-at-age and low recruitment scenario supporting TCEYs near 75 Mlb. The low and current weight-at-age scenarios resulted in TCEYs in the range of 30 to 60 Mlb, on average. The TCEY showed a different pattern in the low and current weight-at-age scenarios when compared to the spawning biomass. The TCEY was higher for the current weight-at-age scenario while the spawning biomass was higher for the low weight-at-age scenario. Young Pacific halibut are more influential to the TCEY than to the spawning biomass because many are harvested by the fishery before they become mature.

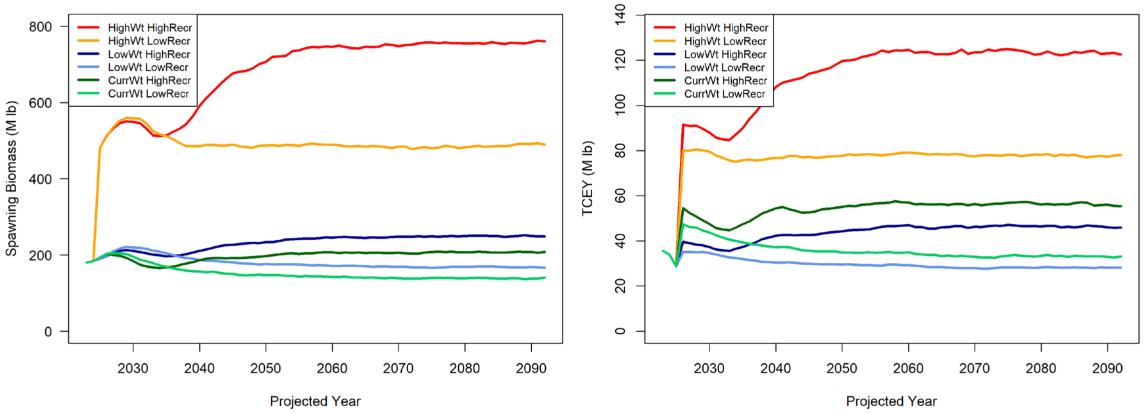

Figure 4. Simulated projections of spawning biomass (left) and TCEY (right) assuming six different regimes for combinations of weight-at-age and recruitment and an SPR of 43%. Each projection held the weight-at-age and average recruitment at the defined level for all projected years.

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, 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 5). The plot in Figure 5 is what the MSAB has referred to as trace plots (e.g. purple plots).

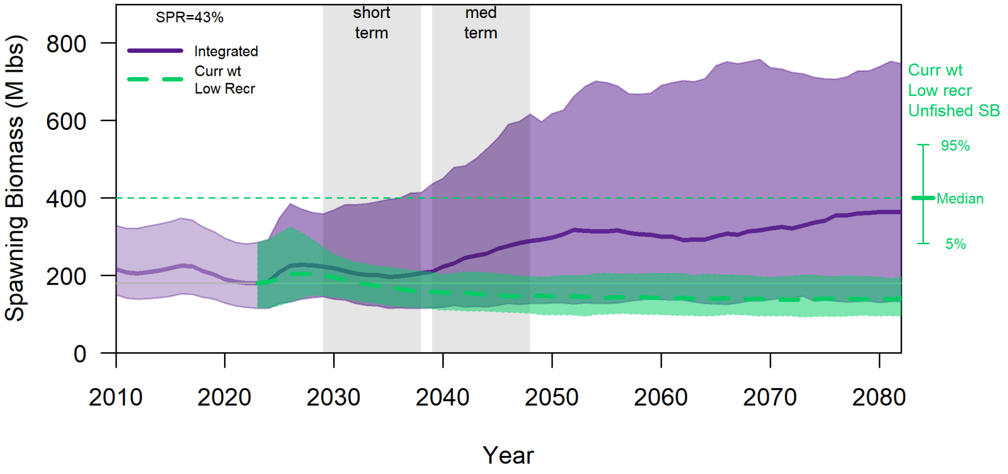

Figure 5. Simulated spawning biomass when fishing at an SPR=43% fishing intensity for productivity integrated over low and high levels (purple) and productivity assumed to remain at recent low levels (green). The 2023 median spawning biomass is shown as a horizontal grey line for reference, and the range of unfished spawning biomass for the low productivity scenario is shown on the right.

2.3 Reference fishing intensity under a low productivity scenario

The effect of the productivity regime on the optimal fishing intensity 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 MSE 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 6). 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.

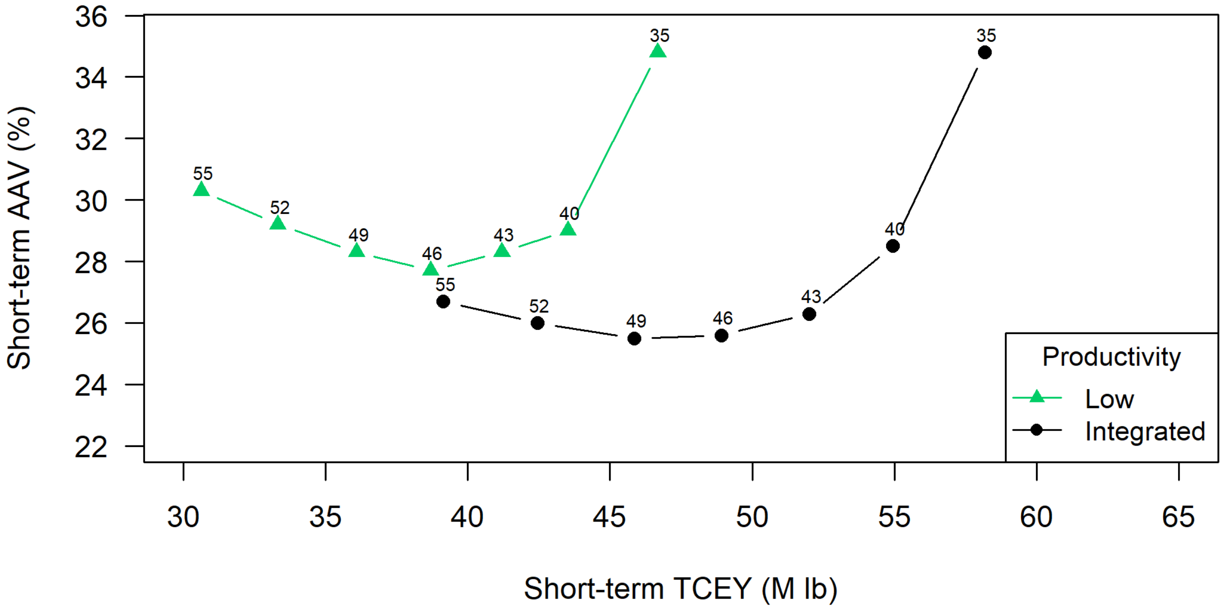

Figure 6. Trade-off between variability in the TCEY (AAV) and the TCEY for different fishing intensities (SPR labelling the points) when integrating over a range of productivity from low to high (black circles) and consistent low productivity similar to recent observations (green triangles).

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 colors 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**	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**	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

2.4 Harvest Strategy Policy Table

The 2025 stock assessment presented a harvest decision table that shows immediate-term risk metrics for 3-year projections at various fixed mortality limits. MSE simulations with a fixed fishing intensity (i.e. F_{SPR}) were conducted using the median SPR values from the 2025 stock assessment decision table and presented as the Harvest Strategy Policy table (HSP table). Short-term and long-term performance metrics associated with priority objectives are presented along with the probability that the relative spawning biomass (RSB) is less that 30% (the trigger in the 30:20 control rule), the probabilities that the long-term and short-term spawning biomass is greater than the 2023 estimated spawning biomass and 5th and 95th percentiles of the short-term TCEY. The table is intended to present risks associated with consistent application of a harvest strategy over the next 4 years and longer, as opposed to the immediate-term risks associated with mortality limits decisions presented in the stock assessment harvest decision table.

The HSP table can also be seen in the IPHC MSE Explorer (https://apps.iphc.int/MSE-Explorer/) along with results from other simulations and additional management procedures.

Table 2. Harvest Strategy Policy (HSP) table showing short-term and long-term performance metrics associated with priority objectives along with the probability that the relative spawning biomass (RSB) is less that 30% (the trigger in the 30:20 control rule), the probabilities that the long-term and short-term spawning biomass is greater than the 2023 estimated spawning biomass and 5th and 95th percentiles of the short-term TCEY for fixed fishing intensities (i.e. F_{SPR}) determined from the median fishing intensities presented in the 2025 stock assessment decision table.

2026 Alternative		***Status quo -10%***	***Status quo -5%***	***Status quo***	***Status quo +5%***	***Status quo +10%***	***$F_{46\%}$***	***3-year surplus/ $F_{43\%}$***	***MEY proxy***	***Overfishing limit***
Fixed SPR	**100%**	**54%**	**52%**	**51%**	**49%**	**48%**	**46%**	**43%**	**40%**	**35%**

Long-term Metrics										
P(RSB < 20%)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
P(RSB < 30%)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.007	0.032	0.161
P(RSB < 36%)	<0.001	<0.001	<0.001	0.001	0.014	0.023	0.066	0.195	0.372	0.692
P(SB<SB2023)	0.002	0.144	0.168	0.176	0.202	0.220	0.232	0.260	0.288	0.334

Short-term Metrics **(2029-2038)**										
Median TCEY	0.00	40.2	42.5	43.6	45.9	46.9	48.9	52.0	55.0	58.2
Median AAV	0%	26.5%	26.0%	25.9%	25.5%	25.5%	25.6%	26.3%	28.5%	34.8%
P(SB<SB2023)	0.034	0.354	0.378	0.394	0.416	0.434	0.470	0.534	0.576	0.632
TCEY interval	(0-0)	(20-73)	(21-77)	(21-79)	(21-83)	(22-85)	(23-89)	(24-94)	(25-101)	(27-108)

3 WORK COMPLETED SINCE THE 102ND IPHC ANNUAL MEETING (AM102)

The MSE work since AM102 has focused on conditioning the OM which used the following workflow.

1. Outcomes of each individual model of the ensemble stock assessment are summarized.
2. Parameters and assumptions in each individual model of the OM are linked to each individual model of the 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.

3.1 Conditioning the Operating Model (preliminary results)

The four individual models of the OM (OM1_longAAF, OM2_shortAAF, OM3_longCW, and OM4_shortCW) were conditioned through step 7. 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).

Preliminary individual models of the OM are shown in each section below. These are the results through step 7 from above, and next steps will be to determine uncertainty for each model.

3.1.1 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 7). The distribution of ‘all sizes’ (those selected by the FISS) biomass was also fit well except for Region 3 in recent years (Figure 8). This overprediction from OM1_longAAF 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). Approximately 70% of the age-0 fish settled in Region 4 in low PDO regimes and approximately 85% in high PDO years. A very small proportion 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 9). 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.

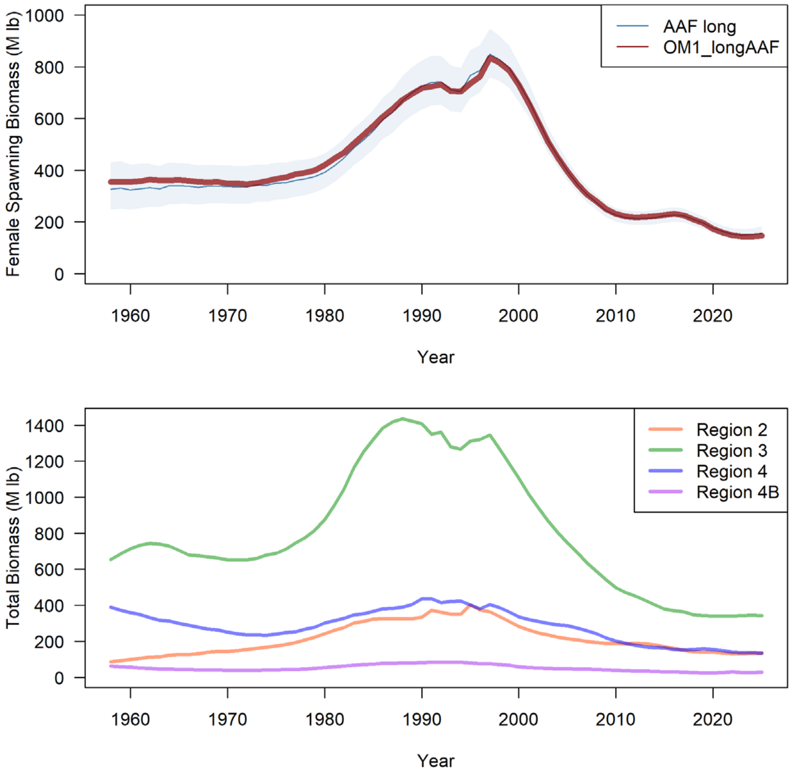

Figure 7. The spawning biomass from the OM1_longAAF model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the total biomass (all ages) in each Region from the OM1_longAAF model.

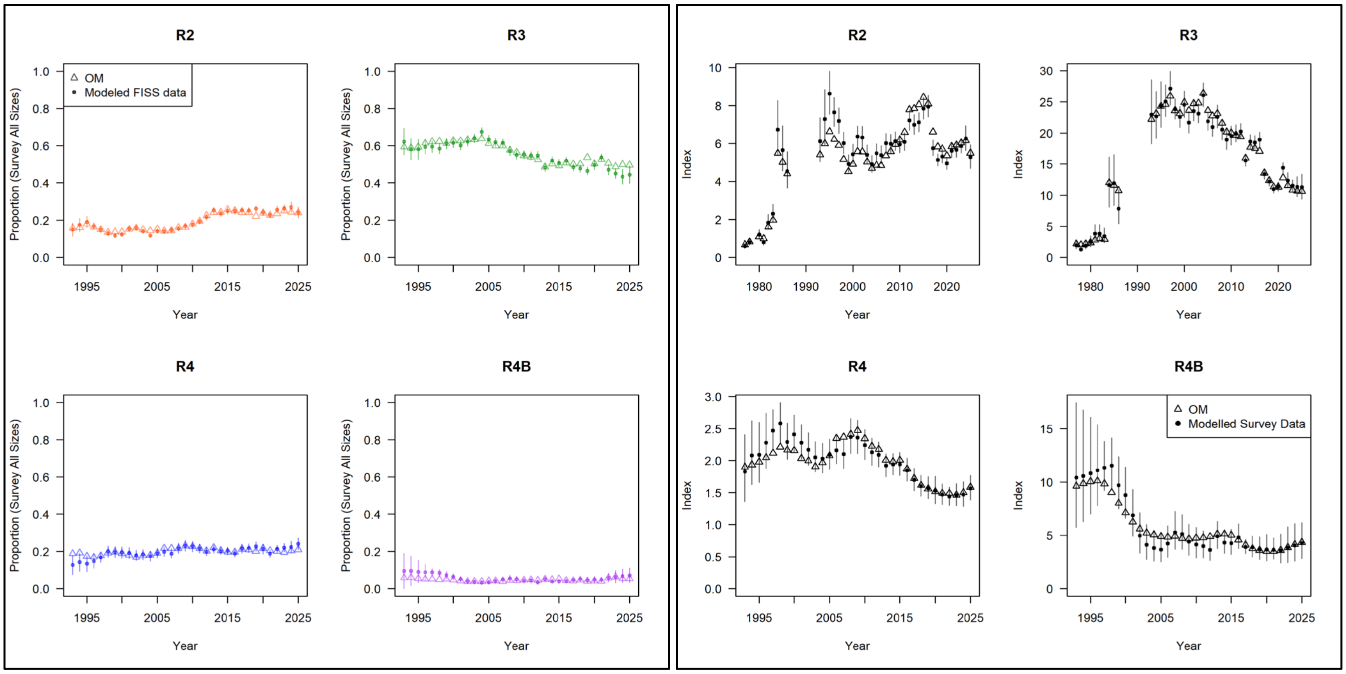

Figure 8. The left plots show the proportion of all sizes biomass in each Region from the OM1_longAAF model (triangles) and the FISS modelled output with 95% credible intervals (circles). The right plots show the predicted index from the OM1_longAAF model (triangles) and the FISS index (circles).

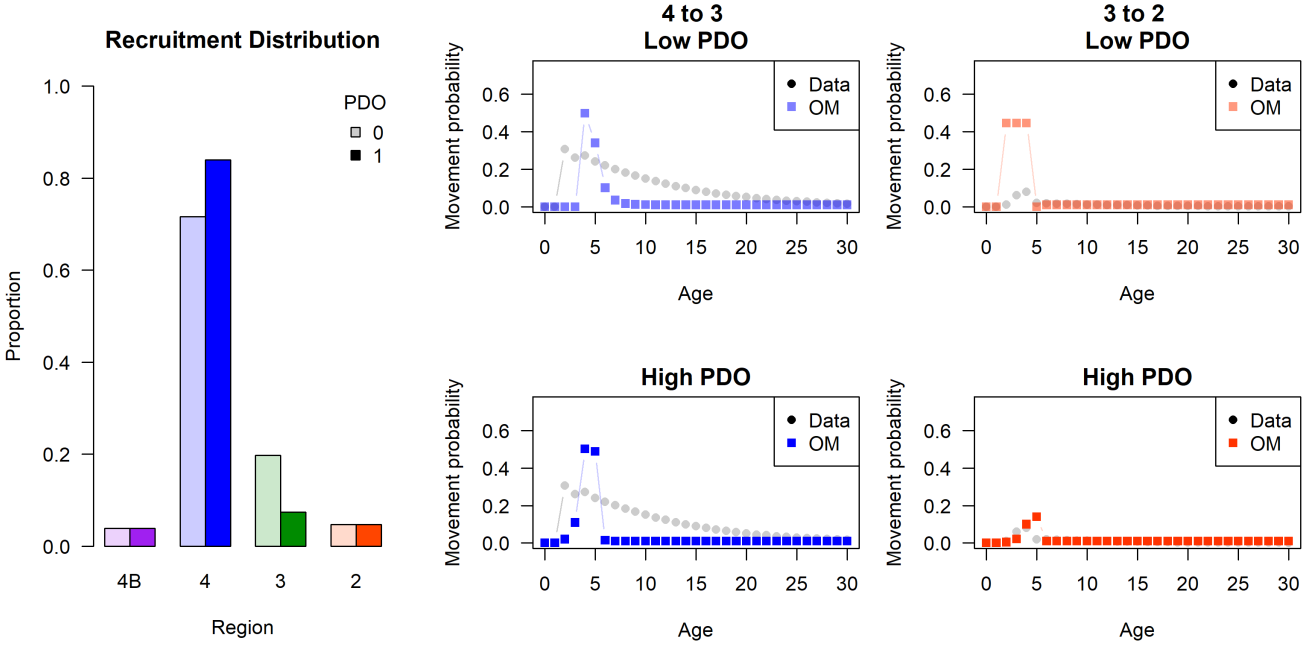

Figure 9. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot) estimated in the OM1_longAAF model. The proportion of numbers of Pacific halibut estimated in OM1_longAAF that move from Region 4 to 3 (center) and from Region 3 to 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

3.1.2 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 10). The distribution of ‘all sizes’ biomass was also fit well except for Region 3 in recent years (Figure 11). The overprediction from OM2_shortAAF 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 11). 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 12). Approximately 75% of the age-0 fish settled in Region 4 in low PDO regimes and almost 90% in high PDO years. A very small proportion 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 the high PDO regime. A similar proportion of Pacific halibut moved from Region 3 to 2 in the low PDO regime and less moved in the high PDO regime. A very small proportion of Pacific halibut 8 years and older moved from either of these regions.

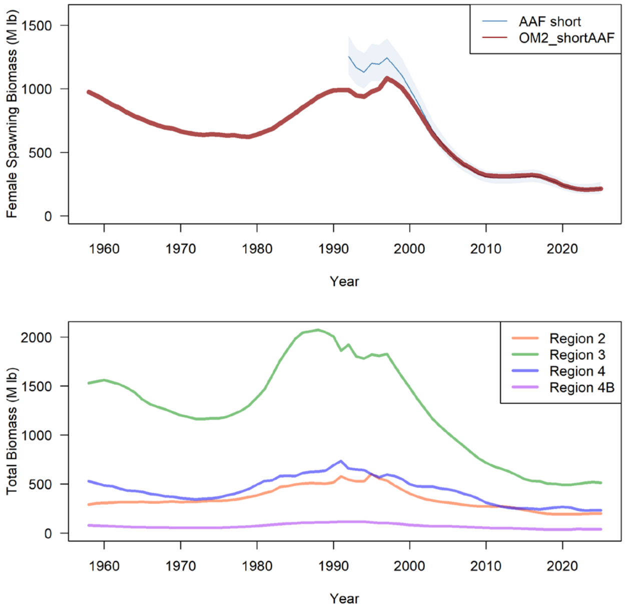

Figure 10. The spawning biomass from the OM2_shortAAF model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the total biomass (all ages) in each Region from the OM2_shortAAF model.

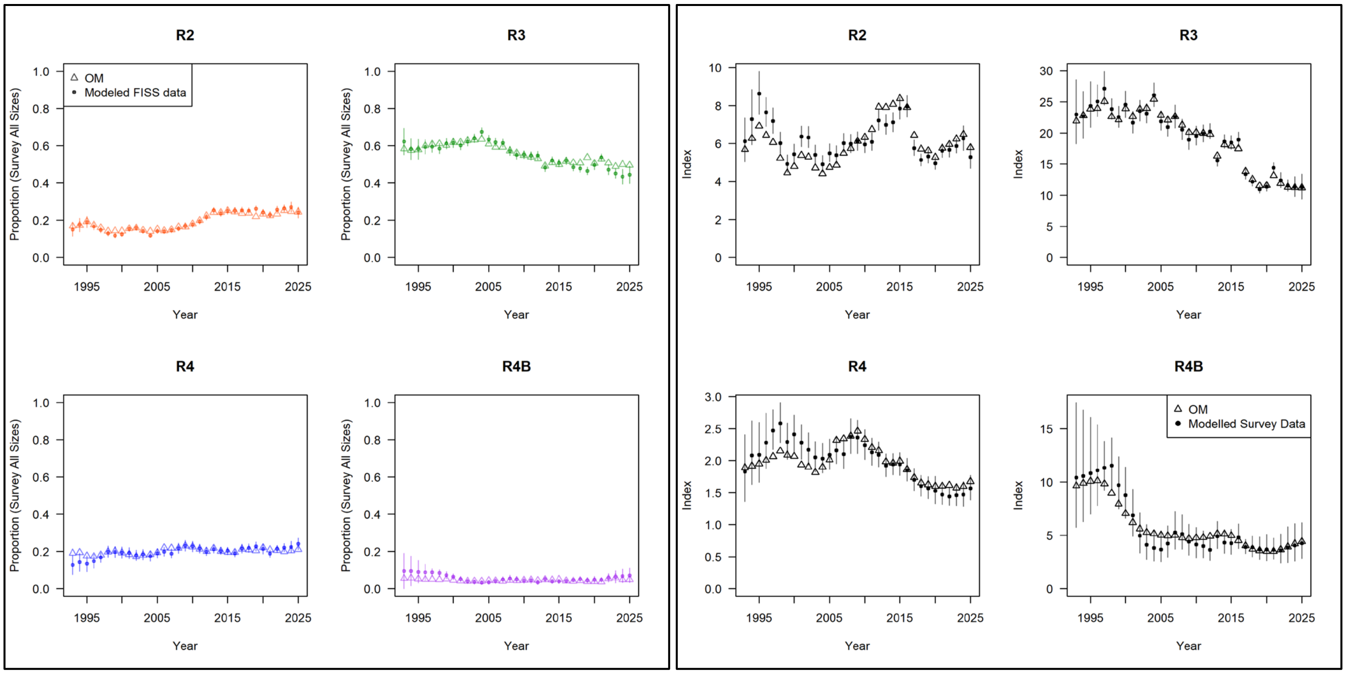

Figure 11. The left plots show the proportion of all sizes biomass in each Region from the OM2_shortAAF model (triangles) and the FISS modelled output with 95% credible intervals (circles). The right plots show the predicted index from the OM2_shortAAF model (triangles) and the FISS index (circles).

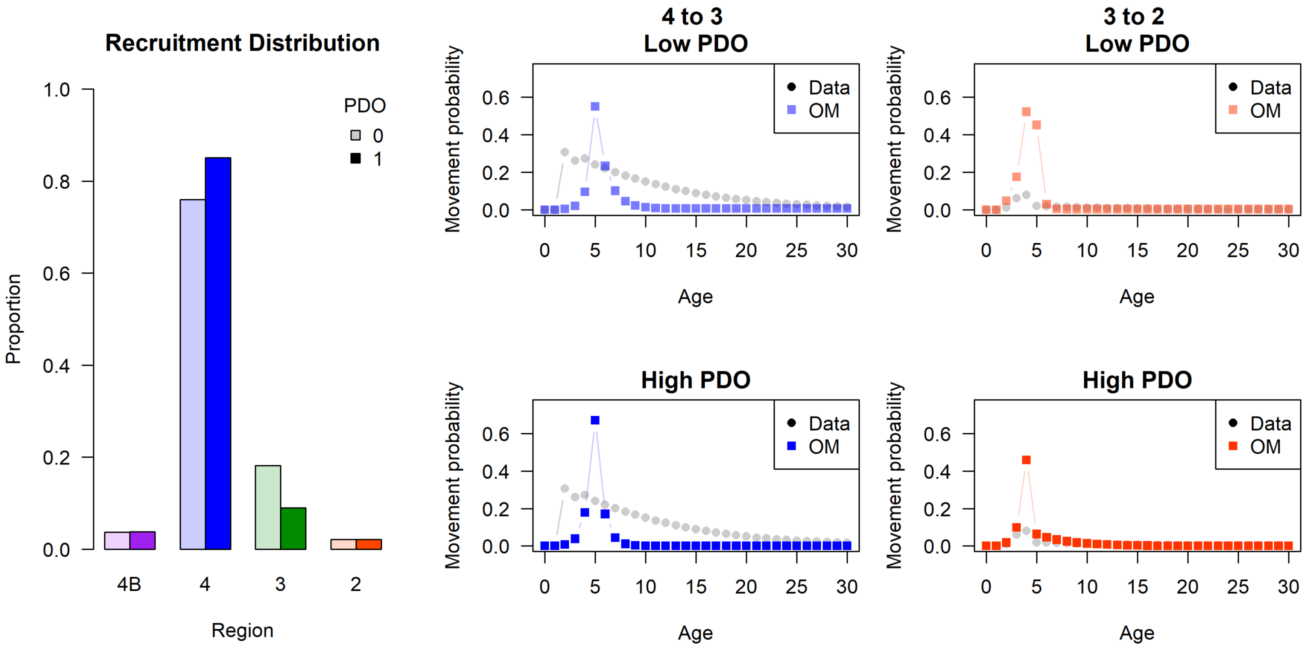

Figure 12. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot) estimated in the OM2_shortAAF model. The proportion of numbers of Pacific halibut estimated in OM2_shortAAF that move from Region 4 to 3 (center) and from Region 3 to 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

3.1.3 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 13) 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 14). The overprediction from OM3_longCW 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 14). 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 15). Approximately 75% of the age-0 fish settled in Region 4 in low PDO regimes and just over 80% in high PDO years. A very small proportion 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 15). Movement probabilities were similar across PDO regimes for Region 4 to 3 with a broader range of ages moving in low PDO regimes. Similar movement rates were estimated for Region 3 to 2. 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 10 years old.

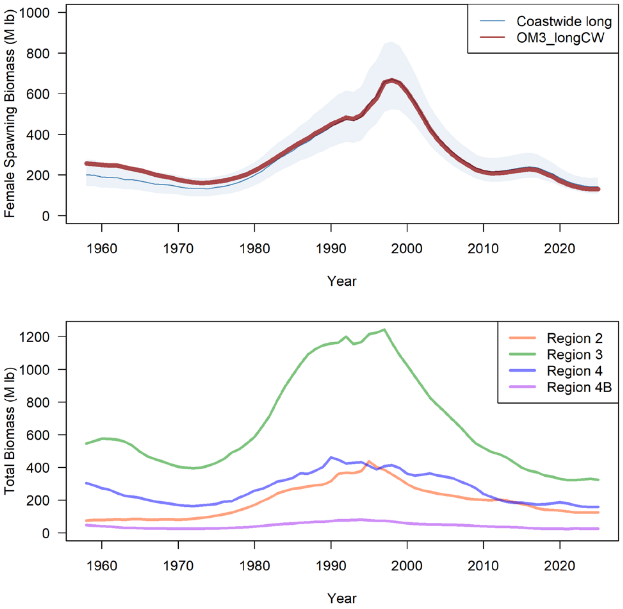

Figure 13. The spawning biomass from the OM3_longCW model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the total biomass (all ages) in each Region from the OM3_longCW model.

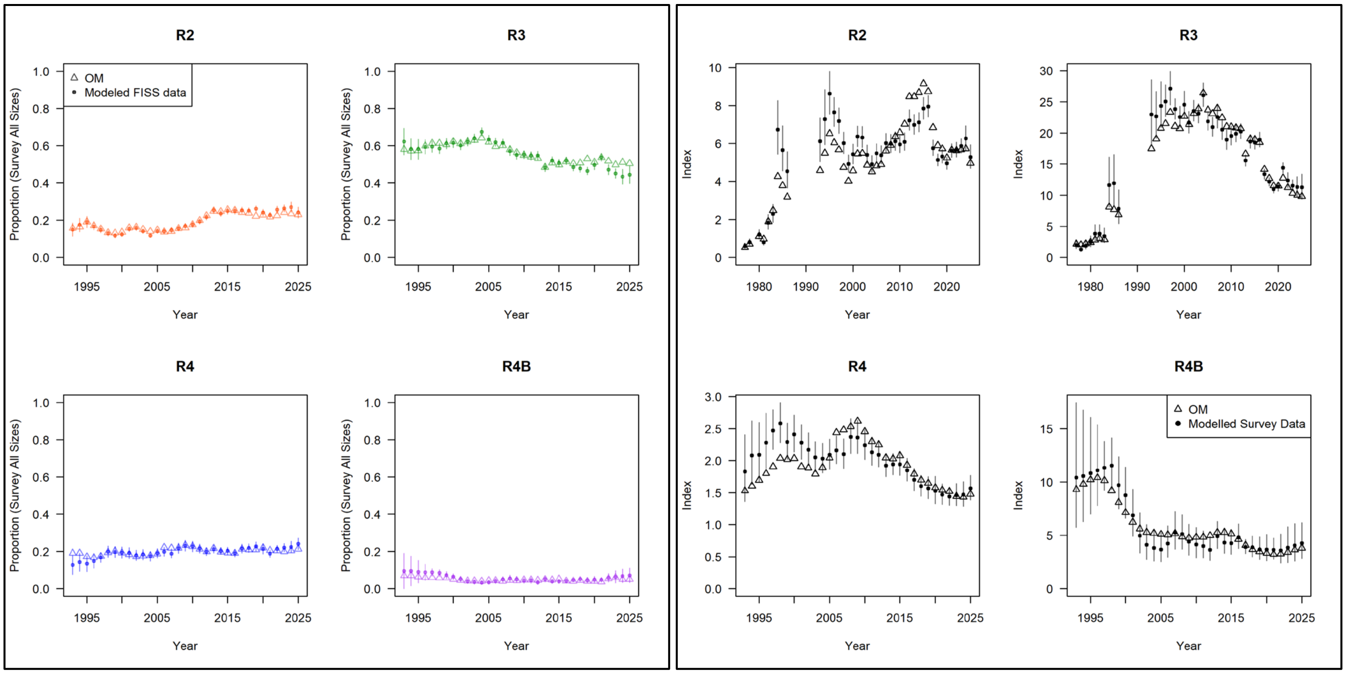

Figure 14. The left plots show the proportion of all sizes biomass in each Region from the OM3_longCW model (triangles) and the FISS modelled output with 95% credible intervals (circles). The right plots show the predicted index from the OM3_longCW model (triangles) and the FISS index (circles).

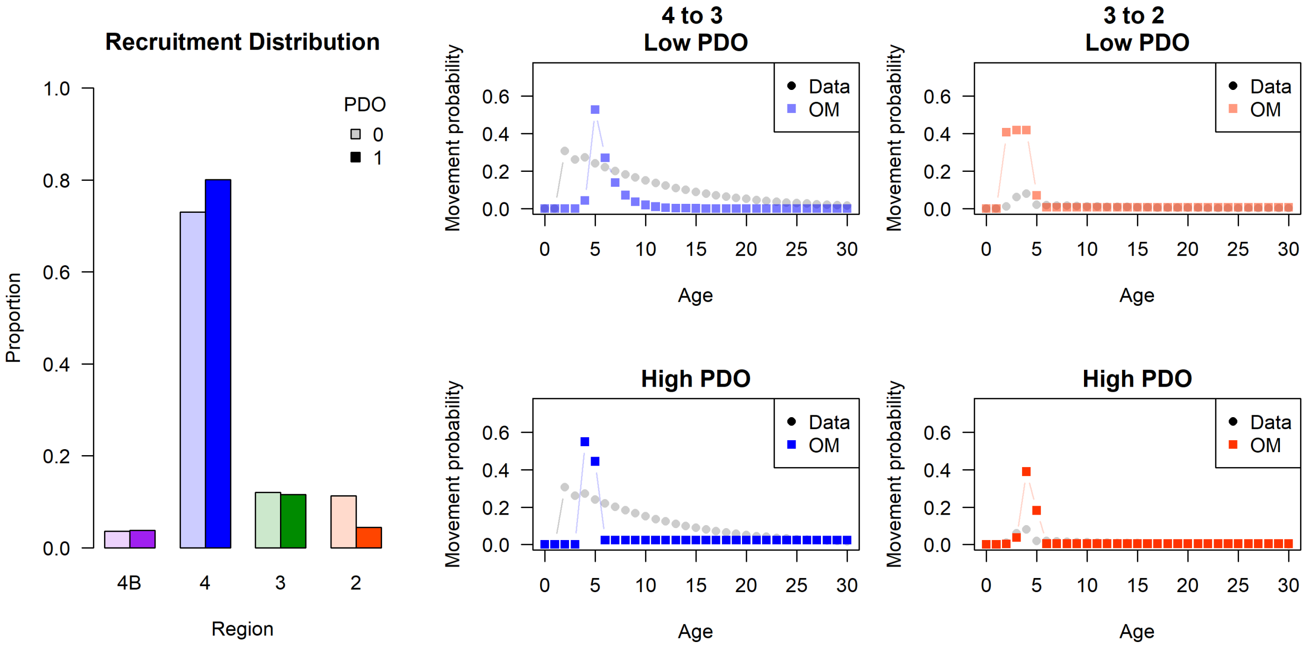

Figure 15. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot). The proportion of numbers of Pacific halibut estimated in OM3_longCW that move from Region 4 to Region 3 (center) and from Region 3 to Region 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

3.1.4 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 16). The distribution of ‘all sizes’ biomass was also fit well except for Region 3 in recent years (Figure 17). The overprediction from OM4_shortCW 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 17). 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) when the PDO was in a positive regime (Figure 18). Between 50% and 60% of the age-0 fish settled in Region 4 and between 40 and 50% in Region 3. A very small proportion 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 18). Movement probabilities were similar across PDO regimes for Region 4 to 3, but was 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, except that Pacific halibut up to age 9 showed some movement from Region 4 to 3 in high PDO years.

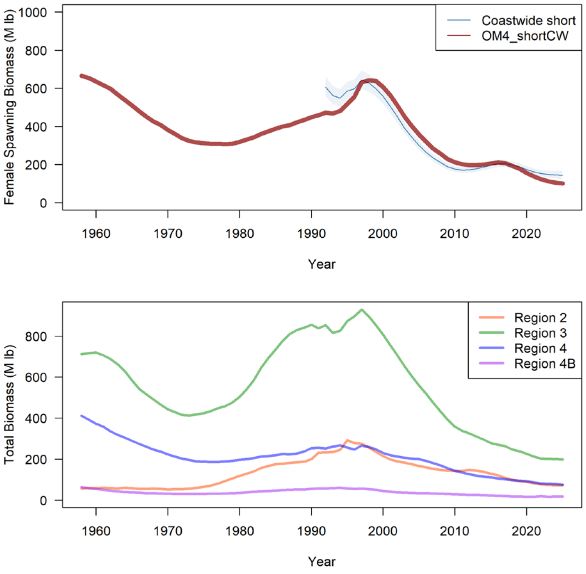

Figure 16. The spawning biomass from the OM4_shortCW model compared to the estimated spawning biomass from the long AAF assessment model (top). The bottom plot shows the total biomass (all ages) in each Region from the OM4_shortCW model.

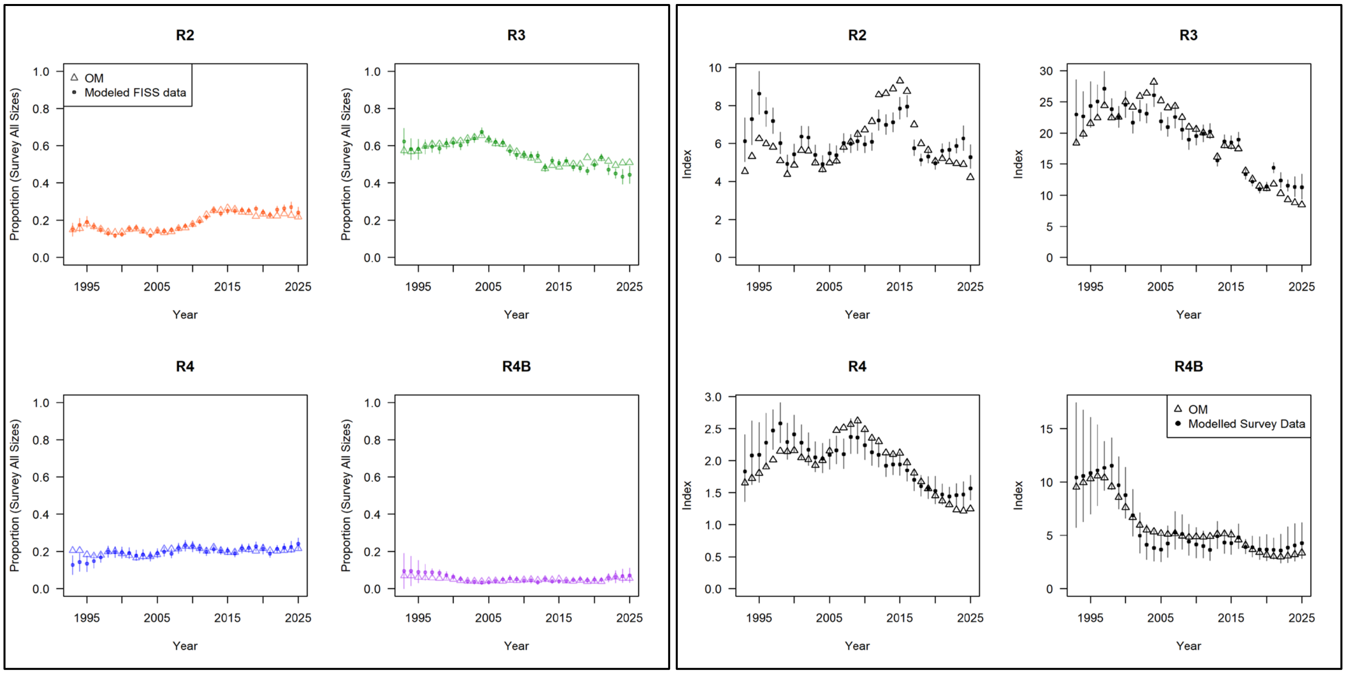

Figure 17. The left plots show the proportion of all sizes biomass in each Region from the OM4_shortCW model (triangles) and the FISS modelled output with 95% credible intervals (circles). The right plots show the predicted index from the OM4_shortCW model (triangles) and the FISS index (circles).

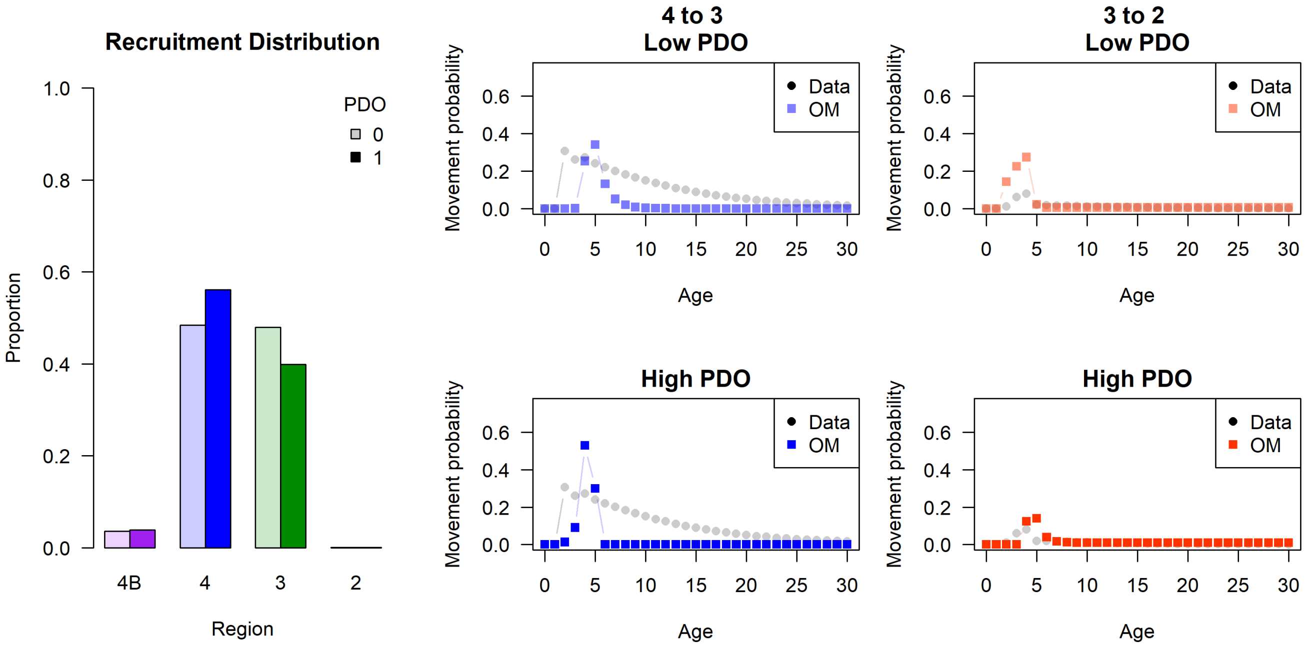

Figure 18. Distribution (proportion) of coastwide recruitment to each Region (leftmost plot). The proportion of numbers of Pacific halibut estimated in OM4_shortCW that move from Region 4 to Region 3 (center) and from Region 3 to Region 2 (right) for low PDO regimes (top) and high PDO regimes (bottom). Light grey dots are movement probabilities inferred from empirical observations.

3.1.5 Discussion of conditioning

These are preliminary results of the first steps of the conditioning process, and although major revisions to these individual models are not expected, some minor changes may occur when adding variability to the estimated parameters and other process such as steepness of the stock-recruitment relationship. Additionally, the SRB will review these results at the 28th Session of the Scientific Review Board (SRB028) and may make some recommendations for improvement.

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 19). 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 20). 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.

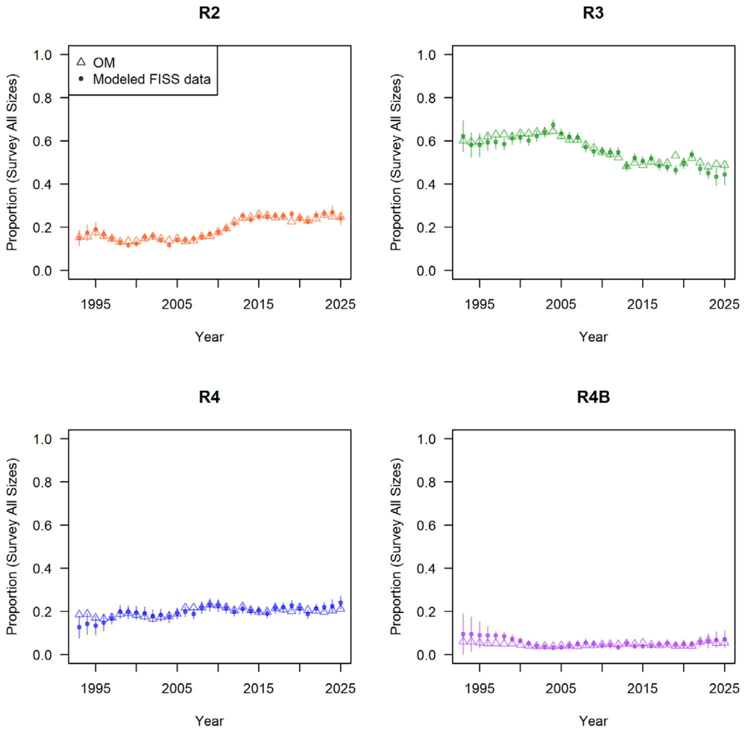

Figure 19. Results of fits to stock distribution in each Region when fitting to only stock distribution data using the OM1_longAAF model. This model is not considered for use as a conditioned model in the MSE framework but is useful to understand model fitting.

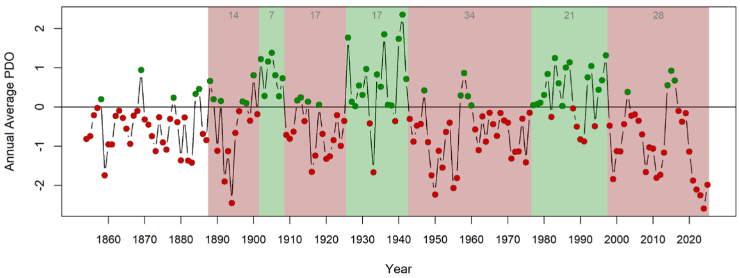

Figure 20. Annual PDO determined by averaging monthly values as of April 2026 (https://www.ncei.noaa.gov/pub/data/cmb/ersst/v5/index/ersst.v5.pdo.dat). Red and green shaded areas indicate low and high regimes, respectively, as used in the 2025 stock assessment and OM. Numbers in the shaded areas indicate the number of years for that regime.

4 REFERENCES

Clark, W.G., and Hare, S.R. 2002. Effects of climate and stock size on recruitment and growth of Pacific halibut. North American Journal of Fisheries Management **22**: 852–862.

Dennis, B. 2002. Allee effects in stochastic populations. Oikos **96**: 389–401. doi:https://doi.org/10.1034/j.1600-0706.2002.960301.x.

Liermann, M., and Hilborn, R. 1997. Depensation in fish stocks: a hierarchic bayesian meta-analysis. Can. J Fish. Aquat. Sci. **54**: 1976–1984. doi:https://doi.org/10.1139/f97-105.

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.

Mantua, N.J., Hare, S.R., Zhang, Y., Wallace, J.M., and Francis, R.C. 1997. A Pacific interdecadal climate oscillation with impacts on salmon production. Bulletin of the American Meteorological Society **78**(6): 1069–1079.

Stewart, I.J., and Martell, S.J.D. 2016. Appendix: Development of the 2015 stock assessment. International Pacific Halibut Commission.

5 RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2026-MSAB022-06 that describes MSE work completed in 2025 and early 2026, including definitions of overfished and depleted, investigations of effects of productivity regimes on the management of Pacific halibut, evaluations of fishing intensity under low productivity, and conditioning of the OM following the full stock assessment.

6 APPENDICES

Nil