Management Strategy Evaluation: 2026 updates

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PURPOSE

To provide the Commission with an update on progress of the Management Strategy Evaluation (MSE) 2026 Program of Work approved by the Commission at the 102nd Annual Meeting (AM102), and provide information for decisions regarding: 1) an update to the reference fishing intensity in the Harvest Strategy Policy (HSP), 2) continuing work to identify a depleted reference point for Pacific halibut, and 3) a request to evaluate other elements of management procedures.

BRIEF SUMMARY OF PROGRESS ON HIGH-PRIORITY TASKS

Below is a summary of progress and outcomes for each high-priority task of the 2026 MSE Program or Work.

Task A: Condition the Operating Model (*Completed*)

1) The operating model (OM) has been updated and conditioned to data through 2025 and to the 2025 stock assessment.
2) This OM will be used to evaluate management procedures (MPs) until after the full stock assessment in 2028, unless an exceptional circumstance is declared.

Task B: Evaluate a range of SPR values (*Results available*)

1) Various SPR values from 55% to 40% have been evaluated assuming integrated (low and high) productivity, decision-making variability, estimation uncertainty, and observation error.
2) All SPR values evaluated met the objectives to be above $RSB_{20\%}$ and at or above $RSB_{36\%}$.
3) There is a trade-off between the short-term TCEY and variability in the TCEY (AAV):
   a) The median short-term TCEY increased at lower SPR values (i.e. higher fishing intensity) with smaller gains at higher fishing intensities. For example, the median TCEY increased by 2.7 Mlbs moving from an SPR of 55% to 52% and increased by 1.9 Mlbs moving from an SPR of 43% to 40%.
   b) The AAV increased with fishing intensity going from an SPR of 49% to an SPR of 40%, but remained similar at lower fishing intensities (SPRs from 55% to 49%).
4) There is approximately a 1 in 4 chance that the short-term spawning biomass (SB) would be less than the SB experienced in 2023 with an SPR of 46%, and 1 in 3 at an SPR = 43%.
5) The chance that a long-term total mortality less than 34 Mlbs occurs is minimized at an SPR value between 46% and 49%.

Task C: Investigate productivity regimes (*Results available*)

1) Fixed productivity based on current weight-at-age and low PDO (e.g. low recruitment) was evaluated for the same range of SPR values and resulted in the following.
   a) The objective to be at or above $RSB_{36\%}$ was not met for an SPR of 43% and less.
   b) There is approximately a 1 in 2 chance that the short-term spawning biomass (SB) would be less than the SB experienced in 2023 with an SPR of 46%.

Task D: Identify a depleted limit reference point for Pacific halibut (*In progress*)

1) Discussions with the Scientific Review Board have highlighted important concepts.

Below is a summary of results to inform the decision-making process related to the MSE and HSP.

Decision: **Update the reference SPR in the Harvest Strategy Policy (HSP) from the current SPR of 43% to an SPR of 46%.**

- SPR values in the range of 40% to 55% are reasonable choices for a reference fishing intensity, but the higher fishing intensities (e.g. SPRs of 40 or 43%) do not meet priority objectives in low productivity scenarios.
- SPR values from 55% to 40% met the objectives to be above $RSB_{20\%}$ and at or above $RSB_{36\%}$ when integrating over low and high productivity.
- SPR values greater than 43% met the objectives to be above $RSB_{20\%}$ and at or above $RSB_{36\%}$ for low productivity based on recent conditions.
- Variability in the TCEY was similar to SPR values 49% and greater, regardless of productivity assumptions.
- Gains in the TCEY are reduced when moving between high fishing intensities (e.g. an SPR of 55% to 52%) compared to moving between low fishing intensities (e.g. an SPR of 43% to 40%).
- The fishing intensity to achieve Maximum Sustainable Yield (MSY) is less than an SPR of 40%, but closer to 40% when assuming low productivity. It is also uncertain and 80% of MSY can be obtained across a wide range of SPR values, including 46%.

Decision: **Include identifying a depleted limit reference point for Pacific halibut as a high priority task in 2027.**

- Discussions with the SRB and MSAB have highlighted the importance of continuing this analysis.
- The SRB has requested an investigation of how this concept may be used by other fisheries management bodies.

Decision: **Request evaluating the following elements of MPs: a triennial assessment frequency, empirical rules to determine the reference TCEY in years without a stock assessment, and constraints and smoothers on the interannual change in the TCEY including minimum and maximum TCEYs.**

- Evaluating elements of MPs was identified as a low-priority task for 2026.
- The MSAB requested to evaluate these same general elements.
- The RAB expressed interest in evaluating a minimum TCEY.

INTRODUCTION

The International Pacific Halibut Commission (IPHC) adopted the IPHC Harvest Strategy Policy (HSP) at the 101st Session of the IPHC Interim Meeting (IM101; IPHC-2025-IM101-R, para. 25) and requested a number of items to be added to the MSE Program of Work for 2026 (IPHC-2025-IM101-R, para. 26). The Commission noted priority items for the 2026 MSE Program of 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.*

The Commission also noted lower priority items for the 2026 MSE Program of Work.

> **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).*

This paper presents an update on progress for these topics.

CONDITION THE OPERATING MODEL

The MSE operating model (OM) consists of four individual regional models based on the four models in the stock assessment ensemble, which includes new updates made during the full stock assessment in 2025. The models in the stock assessment ensemble are an Areas-As-Fleets (AAF) long time-series model (longAAF), an AAF using a short time-series starting in 1992 (shortAAF), a coastwide (CW) long time-series model (longCW), and a CW short time-series model (shortCW). Recent updates to the stock assessment that were incorporated into the MSE OM included updating the time-series information for the Pacific Decadal Oscillation, re-tuned recruitment variability, and an updated maturity ogive to reflect the recent histology-based estimates produced by the IPHC's Biological and Ecosystem Sciences Branch.

Each individual model in the MSE OM begins in 1952 to avoid technical challenges associated with highly uncertain but low spawning biomass and population dynamics bottlenecks in the 1920s and 1930s. This later start date, however, still captures important historical changes in the Pacific halibut stock. The parameters and assumptions from each stock assessment model were used to initialize the associated individual model in the MSE OM while unfished equilibrium recruitment, movement, and recruitment distribution parameters were estimated during the conditioning process to best fit the estimated spawning biomass from the associated assessment model, the stock distribution estimated from the FISS, and the age compositions estimated from the FISS. Variability was added by sampling from the distribution of parameters to produce 125 individual trajectories for each of the four models. The MSE OM integrates over these four models to include parameter and structural uncertainty.

The median integrated spawning biomass for the 2026 MSE OM with 5th and 95th percentiles is shown in Figure 1. The estimated spawning biomass from the ensemble stock assessment, shown in blue for comparison, is similar when comparing the medians but has less variability for most of the time-series. The MSE OM is designed to represent additional uncertainties to ensure that the best performing management procedures (MPs) are robust to many sources of uncertainty.

An additional component of conditioning the OM is to simulate variability into the future. Each individual trajectory characterizes uncertainty in the projections, including simulated variability for weight-at-age, recruitment, and fishery selectivity. Along with fishing mortality, weight-at-age and recruitment are the biggest factors influencing the biomass of the stock in the past and the future.

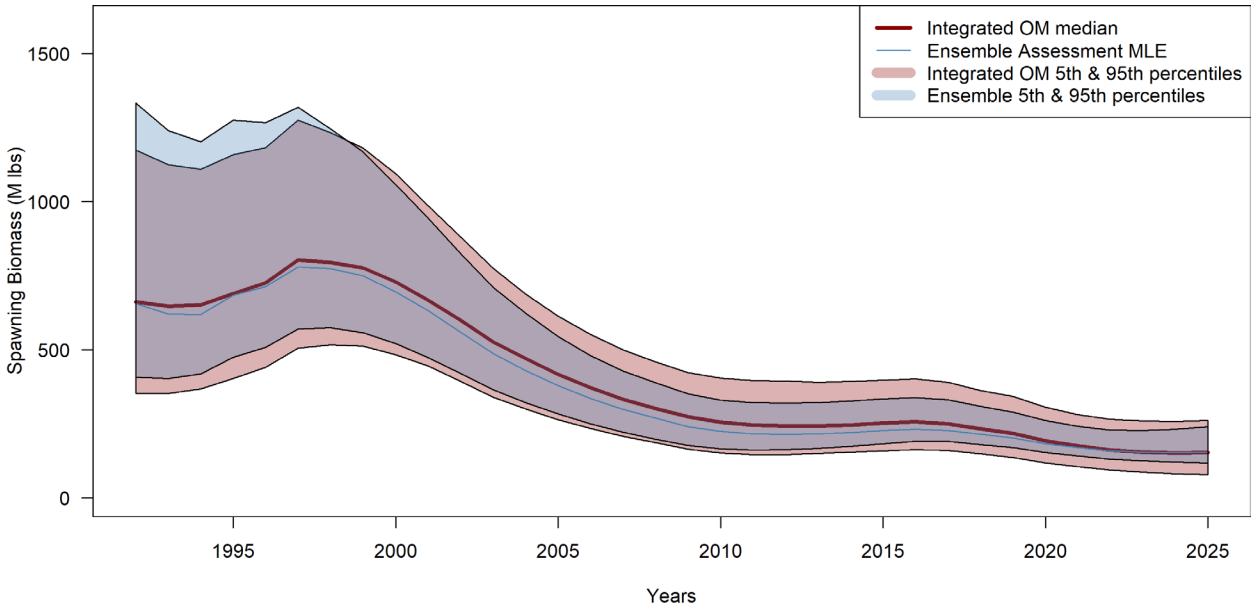


Figure 1. Integrated conditioned spawning biomass for the MSE Operating Model in 2026. The red line shows the median and the red polygon encompasses the 5th and 95th percentiles of 500 simulated trajectories integrated over the four individual models. The blue line and polygon show the median and 5th and 95th percentiles from the stock assessment ensemble for comparison.

A new analysis of weight-at-age was conducted that provided insight into some of the factors influencing weight-at-age. Using modern random effects models, it was found that year and age were both important effects to predict weight-at-age, which suggests that fish in the same cohort experience a similar trajectory of weight-at-age being below or above average over their lifetime, with some variability (Figure 2). The estimated relationships in the random effects model were used to simulate weight-at-age in the future with variability. Figure 3 shows three examples of simulated weight-at-age and how they compare to historical weight-at-age. The main objective was to capture the oscillations in weight-at-age over decadal time scales.

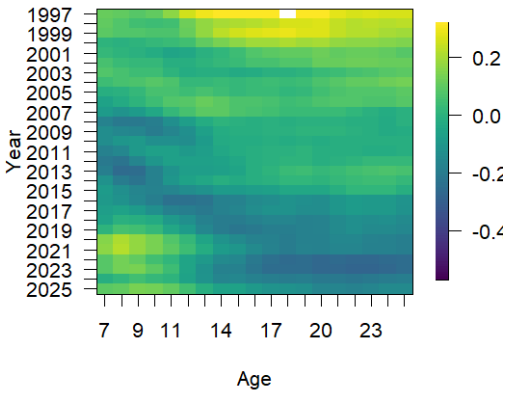


Figure 2. Estimated year and age effects for female Pacific halibut weight-at-age showing deviations from an overall average weight at each age. Blue colours indicate low weight-at-age and yellow colours indicate high weight-at-age. Consistent coloration along a diagonal suggests that a cohort experienced similar low or high weight-at-age across its lifetime.

Recruitment was simulated into the future with annual random deviations representing a departure from average recruitment determined from the stock-recruit relationship. Average recruitment is dependent on the PDO regime, where high average recruitment occurred in high PDO regimes, and low average recruitment occurred in low PDO regimes. The difference in average recruitment between the two regimes was determined from the stock assessment models where high average recruitment was about 1.5 times greater than low average recruitment. The PDO regime was simulated as high or low with a typical period of 10-20 years before switching to the opposite regime.

The parameter and structural uncertainty along with the variability in weight-at-age and recruitment results in a considerable amount of uncertainty in the spawning biomass, especially when projected 70 years into the future (Figure 4). This is consistent with the estimated dynamics and past observations of Pacific halibut.

Overall, the newly conditioned OM reflects the current understanding of the Pacific halibut stock while also incorporating a scientifically plausible range of variability for the robust evaluation of MPs. The updated range of projected spawning biomass is narrower than the simulation results from 2025, which is mostly due to improved methods to simulate weight-at-age and average recruitment (Figure 4). At the beginning of the projections, the median spawning biomass and the median TCEY remain low, representing the persistence of low productivity in the short-term. At the end of the time-series, the median spawning biomass and median TCEY are similar to previous results, but the variability is narrower, representing an improved method to model weight-at-age where extreme high and low weight-at-age (e.g. levels that have been recently experienced) have lower chances of occurring compared to the methods used in 2025. Figure 5 shows that fixing weight-at-age at levels seen in the last five years and keeping the projected PDO in the low regime results in a similar spawning biomass and TCEY levels in short-term projections, but lower levels in the long-term. These results highlight the importance of evaluating results for specific weight-at-age and PDO scenarios to understand the effect these have on the outcomes (also see below).

The 2026 performance metrics associated with the Commission's priority objectives show small differences when compared to those determined in 2025 for an SPR of 43% (Table 1). The new results show a slightly higher probability of exceeding the 36% relative spawning biomass (RSB) threshold (at or above with a probability of 0.5). The median short-term TCEY is slightly lower and the short-term AAV is larger. These differences are mostly due to updates in the understanding of Pacific halibut population dynamics (e.g. maturity and natural mortality) and to weight-at-age projections. Additionally, the short-term probability that the spawning biomass is less than the 2023 estimated spawning biomass is greater because the 2026 OM has a more gradual increase away from recent low productivity.

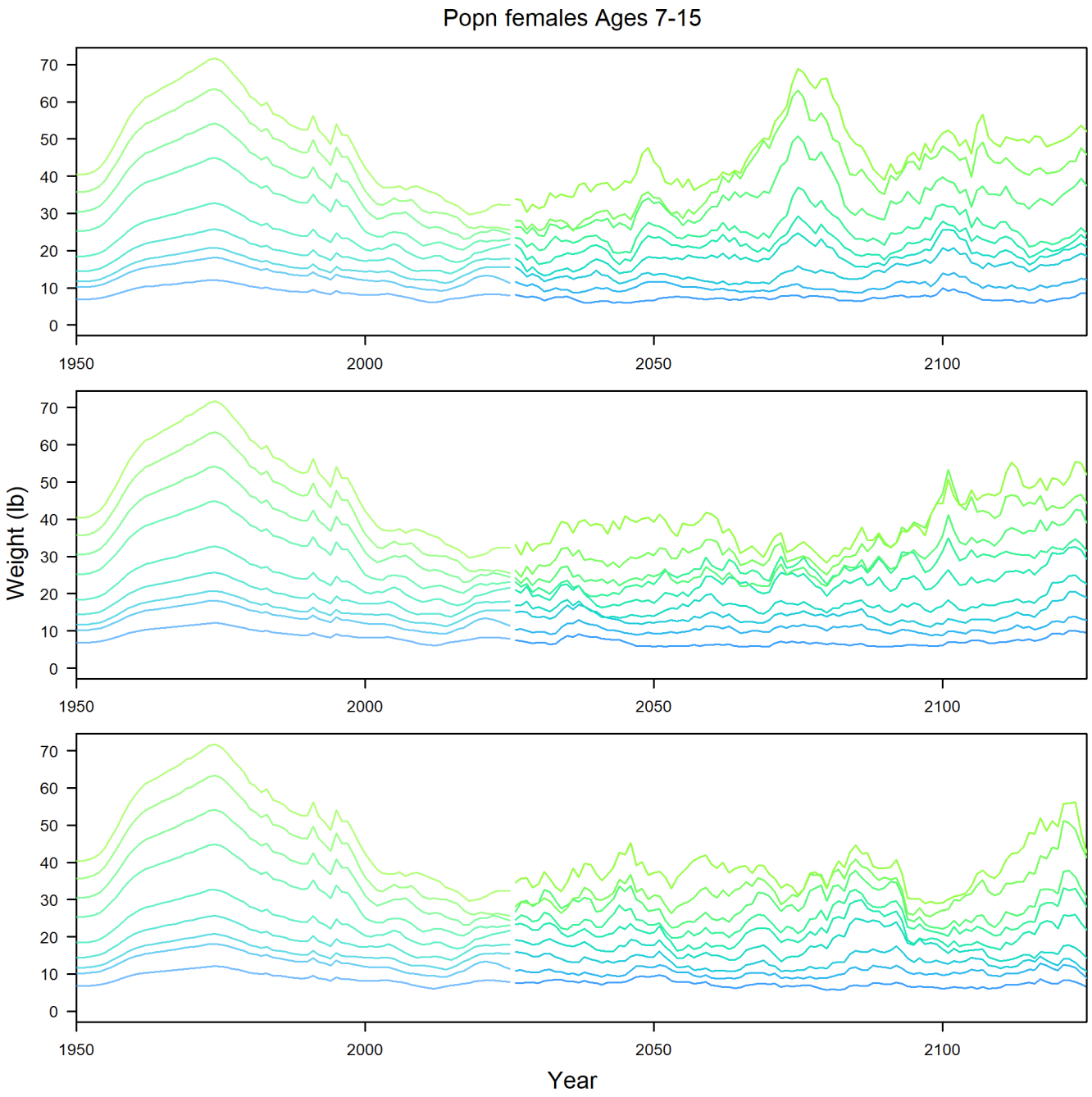


Figure 3. Historical weight-at-age and three examples of simulated weight-at-age for female Pacific halibut in Region 2 for ages 7 to 15 using a random effects model with year and age effects. The break in the time-series between 2025 and 2026 represents the transition from estimated to simulated trends.

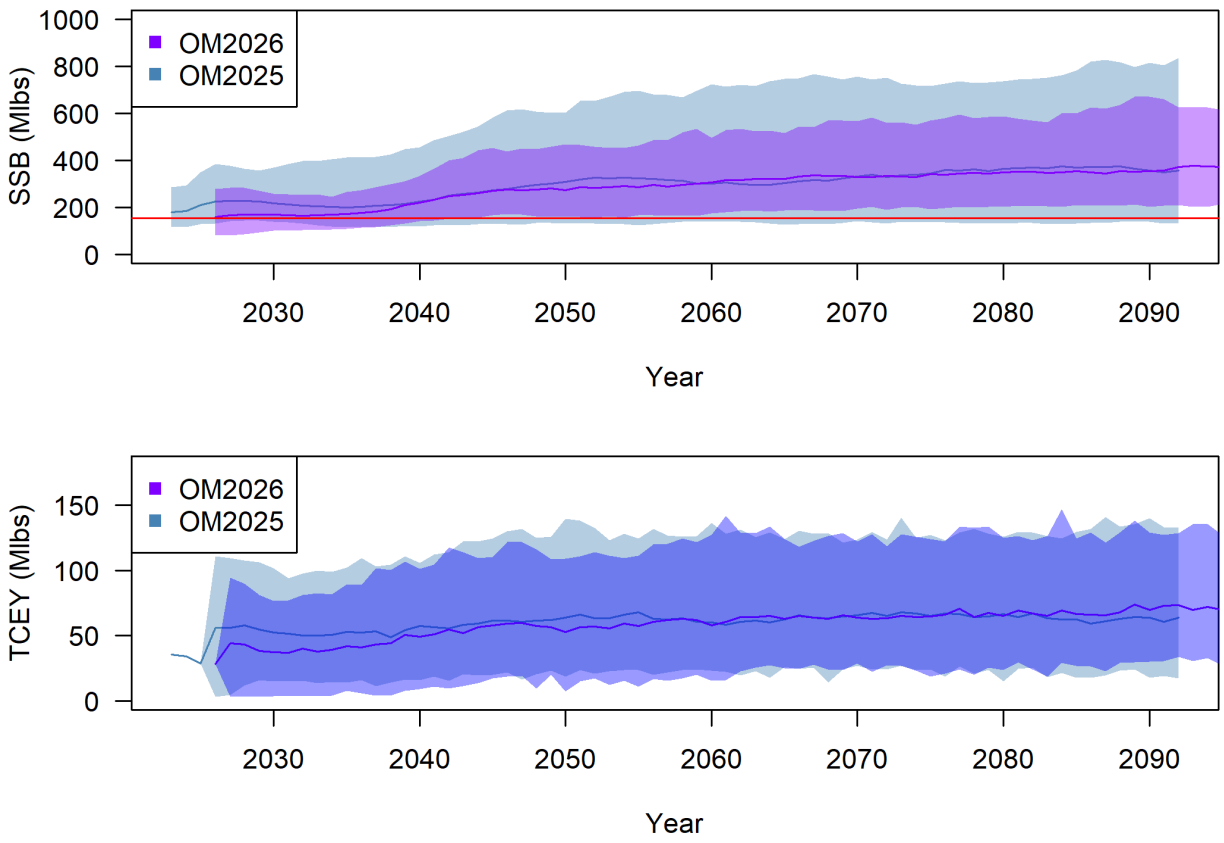


Figure 4. Projected spawning biomass (top) and the corresponding TCEY (bottom) based on harvesting at an SPR of 43%. Simulations include decision-making variability, estimation error, and observation uncertainty. Results using the updated simulation framework for 2026 are shown in purple (OM2026) and the results using the 2025 framework with the same options are shown in blue (OM2025). The red horizontal line is at a spawning biomass of 153 Mlbs to reflect the lowest estimated spawning biomass (2024) from the recent stock assessment.

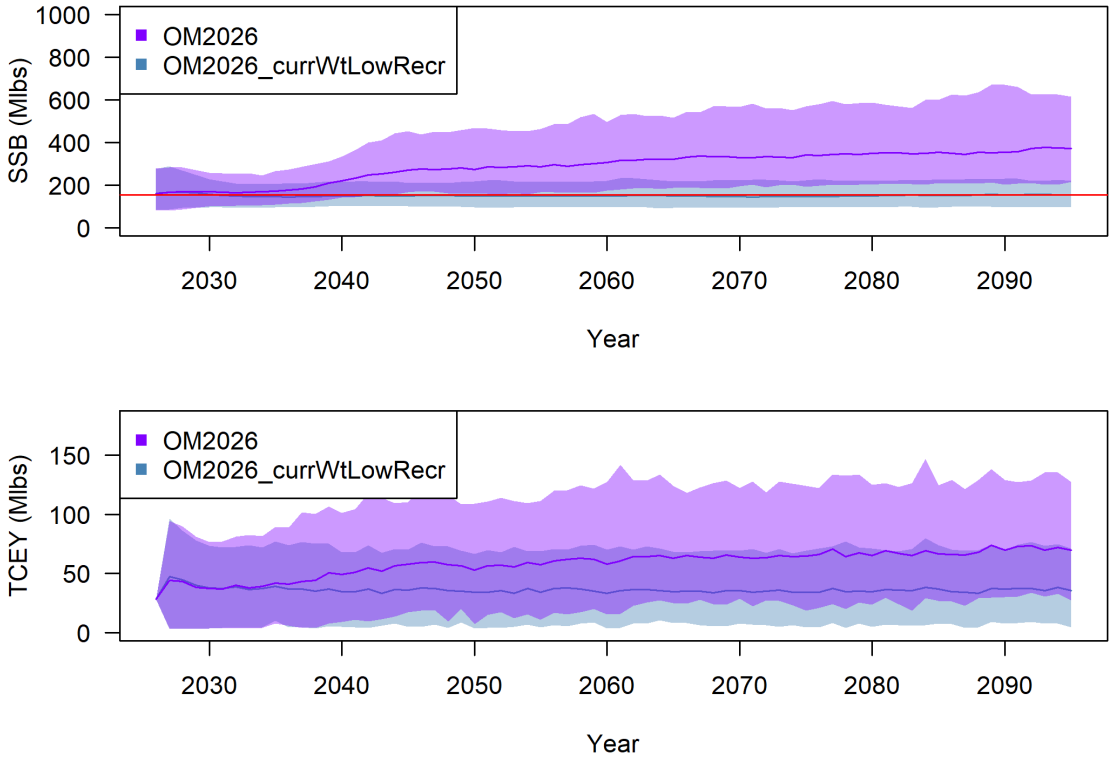


Figure 5. Projected spawning biomass (top) and the corresponding TCEY (bottom) based on harvesting at an SPR of 43%. Simulations include decision-making variability, estimation error, and observation uncertainty. Results using the 2026 OM are shown in purple (OM2026) and the results fixing weight-at-age at recent levels seen in the last five years and keeping the projected PDO at low values are shown in blue (OM2026_currWtLowRecr). The red horizontal line is at a spawning biomass of 153 Mlbs to reflect the lowest estimated spawning biomass (2024) from the 2025 stock assessment.

Table 1. Performance metrics from 2025 simulations (OM2025) and new simulations (OM2026) for an SPR value of 43%, comparing a scenario integrating over changes in weight-at-age and cyclical PDO and a low productivity scenario (i.e. current weight-at-age and negative PDO). A green colour indicates that the performance metric passes and red indicates that it does not, which applies to only the probabilistic long-term objectives.

		Integrated (low & high) Productivity			Recent (low) Productivity	
		OM2025	**OM2026**		**OM2025**	**OM2026**
	SPR (%)	**43**	**43**		**43**	**43**
Long-term	**P(RSB<20%)**	<0.001	<0.001		<0.001	<0.001
	P(RSB<36%)	0.195	0.263		0.462	0.629
Short-term	**Median TCEY**	52.0	40.7		41.2	37.0
	AAV	26.3%	36.5%		28.3%	34.6%
	P(SB < SB_{2023})	0.350	0.338		0.543	0.573

EVALUATE A RANGE OF SPR VALUES

Simulations across a range of spawning potential ratio (SPR) values (i.e. different fishing intensities) were evaluated against the Commission's objectives. The Management Strategy Advisory Board (MSAB) defined a minimum set of SPR values during its recent 22nd Session of the MSAB meeting in May 2026.

> **IPHC-2026-MSAB022-R, para. 37 (MSAB022–Req.06):** *The MSAB **REQUESTED** further evaluations of the following MP elements:*
>
> *a) fishing intensities including, but not limited to, SPRs of 40%, 43%, 46%, 49%, 52%, 55%, and 100% (no fishing), as well as no directed fishing (e.g. bycatch only);*

Although considerable improvements to the simulation code were made to speed up the simulations, this remains a time-consuming process and the full set of results examining this range of SPR values for all potential MP elements are currently not available. However, results for the minimum set of SPR values, annual stock assessments, and no constraints are shown in Table 2 and Figure 6. The MSE Explorer (https://apps.iphc.int/MSE-Explorer/) will be updated as additional results become available.

All SPR values pass the conservation objective of keeping the spawning biomass above 20% of unfished spawning biomass. They all also pass the objective to be at or above 36% of unfished spawning biomass. The trade-off between the yield (TCEY) and variability in yield (AAV) shows that variability (as a percentage of the TCEY) decreases at a faster rate from an SPR of 40% to an SPR of 46%. The AAV increases at lower fishing intensities (e.g. SPR=55%) because the absolute amount of change in the TCEY is similar, but the actual TCEY is decreasing.

Table 2. Performance metrics associated with Commission priority objectives for a range of SPR values simulated with integrated (low and high) productivity. The performance metric P(SB<SB_{2023}) is an additional metric to indicate the short-term spawning biomass relative to a recent low spawning biomass.

	SPR (%)	55	52	49	46	43	40
Long-term	P(RSB<20%)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	<0.001	0.001	0.015	0.088	0.263	0.479
Short-term	Median TCEY	30.7	33.4	35.9	38.7	40.7	42.6
	AAV	32.9%	32.4%	32.8%	33.8%	36.5%	39.3%
	P(SB < SB_{2023})	0.125	0.163	0.217	0.274	0.338	0.393

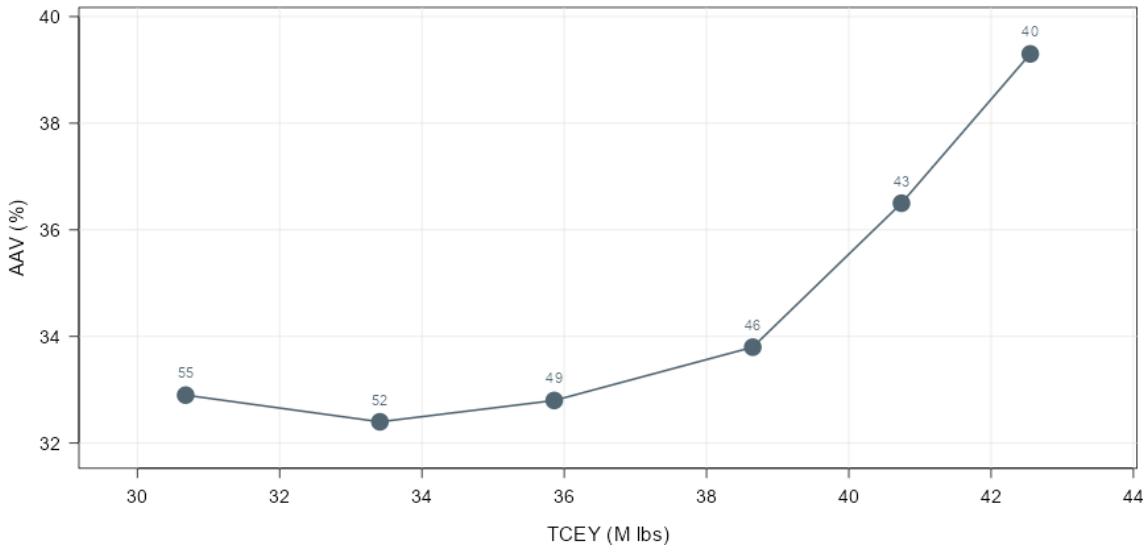


Figure 6. The trade-off between average annual variability in the TCEY (AAV) and the TCEY. Points are labelled by the input SPR.

The determination of an appropriate reference SPR requires the consideration of trade-offs between these performance metrics. A higher fishing intensity (i.e. lower SPR) results in a higher TCEY but potential higher change in the TCEY from year to year, and the variability is similar at SPRs of 49% and higher. Therefore, to minimise variability, an SPR between 49% and 52% would be optimal, with 49% producing the largest TCEY. The risk to the stock dropping below 36% relative spawning biomass increases with higher fishing intensity, but is within the tolerance for SPRs at or greater than 40%.

It may be useful to consider other performance metrics available in the MSE Explorer (http://apps.iphc.int/MSE-Explorer/), in addition those associated with the four priority objectives, when determining an optimal fishing intensity. An additional performance metric not associated with the Commission's priority objectives, but informative relative to recent experiences, is the probability that the short-term projected spawning biomass will be less than the spawning biomass in 2023. This is approximately a 1 in 8 chance with an SPR of 55%, a 1 in 6 chance with an SPR of 52%, a 1 in 5 chance with an SPR of 49%, a 1 in 4 chance with an SPR of 46%, and a 1 in 3 chance with an SPR of 43% (Table 2). Another additional performance metric is the probability that the Total Mortality (typically 2-4 Mlbs greater than the TCEY) will be less than 34 Mlbs in *any* year in the long-term 10-year period. This performance metric was specified early in the MSE process by the MSAB and can easily be respecified to reflect the TCEY and a different quantity. The probability is high at low fishing intensities because the harvest rate is low and is higher at high fishing intensities because the TCEY is more variable and declines in the biomass lead to occasional low TCEYs. SPR values of 46% and 49% result in a minimum probability that any year in the long-term 10-year period has a total mortality less than 34 Mlbs (Figure 7). The use of *any* in this performance metric differs from a probability that it may occur over *all* years because it determines if the event occurred based on the 10-year period (any year in that 10-year period below the threshold would result in the event occurring). The probability is then calculated over the 500 simulations. There are many other performance metrics that may be useful to determine an optimal MP, many of which are available in the MSE-Explorer.

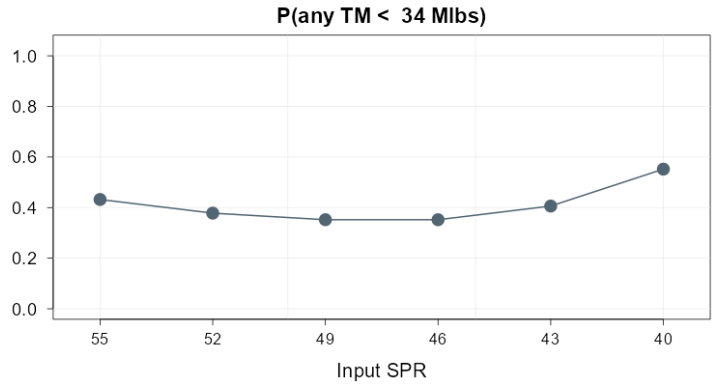


Figure 7. The probability that the Total Mortality is less than 34 Mlbs in any year of the long-term 10-year period.

Two other types of analyses may also be beneficial to determining an optimal fishing intensity. These are to examine the equilibrium yield curve to determine the fishing intensity associated with maximum sustainable yield and to consider specific productivity scenarios, such as current conditions. Both topics are described below.

INVESTIGATE PRODUCTIVITY REGIMES

Pacific halibut experience variable productivity over time, which is important to capture in the MSE projections. However, it is also useful to examine simulations where productivity is held constant in order to better understand the importance of environmental influences on key outcomes, such as mortality limits. Six scenarios defined by low, high, and current weight-at-age crossed with low or high PDO (affecting average recruitment, movement, and age-0 distribution) can be simulated for comparison to the fully integrated results. The MSAB was also interested in these investigations.

> **IPHC-2026-MSAB022-R, para. 38 (MSAB022–Req.09):** *The MSAB **REQUESTED** conducting simulations assuming the following productivity regimes with a subset of the MPs from paras. 37 and 38 and all other sources of variability:*
>
> *a) low recruitment and low weight-at-age;*
> *b) low recruitment and current weight-at-age (the current perceived productivity regime);*
> *c) high recruitment and low weight-at-age.*

Three levels of weight-at-age were chosen to capture the high and low periods, but to also capture the differences in younger and older age classes during the low periods in recent years (Figure 8). The Low period (2011–2015) captures smaller young fish and larger old fish, while the Current period (2021–2025) captures larger young fish and smaller old fish, when compared to each other. The High period (1971–1975) shows average weight-at-age up to four times greater than in 2025 for the older age classes.

The two long time-series models in the IPHC ensemble stock assessment (IPHC-2025-SA01) estimated a link between the Pacific Decadal Oscillation (PDO, Mantua et al. (1997)) and average unfished equilibrium recruitment (R0), 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 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 9). 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 currently not capturing.

The productivity has a large effect on the outcomes of the simulations with regard to spawning biomass and mortality limits. The median average long-term TCEY when integrating over all types of productivity and managing with an SPR of 43% was 70 Mlbs. If productivity was to remain as we have seen in the last five years (current weight, low PDO) the median average long-term TCEY managing with an SPR of 43% would be 36 Mlbs, similar to recent realized TCEYs. A productivity regime with current weight and high PDO results in a median average long-term TCEY of 72 Mlbs when managing with an SPR of 43%. The performance metrics associated with the Commission's priority objectives, including short-term fishery objectives, are less different for these two productivity scenarios and the integrated results because the integrated results gradually increase from current conditions (Table 3). Figure 5 shows the projected spawning biomass and projected TCEY when integrating over productivity and when assuming current productivity.

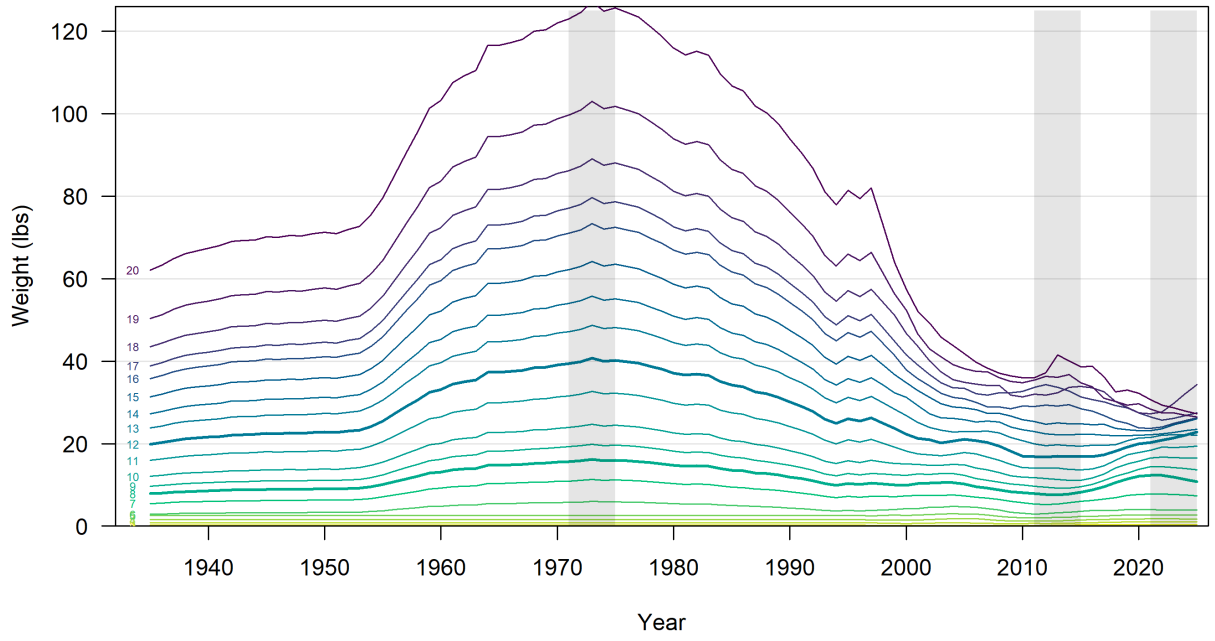


Figure 8. Average historical weight-at-age for Pacific halibut showing three different weight-at-age scenarios defined by the average over 5-year time-periods. High is from 1971–1975, Low is from 2011-2015, and Current is from 2021-2025.

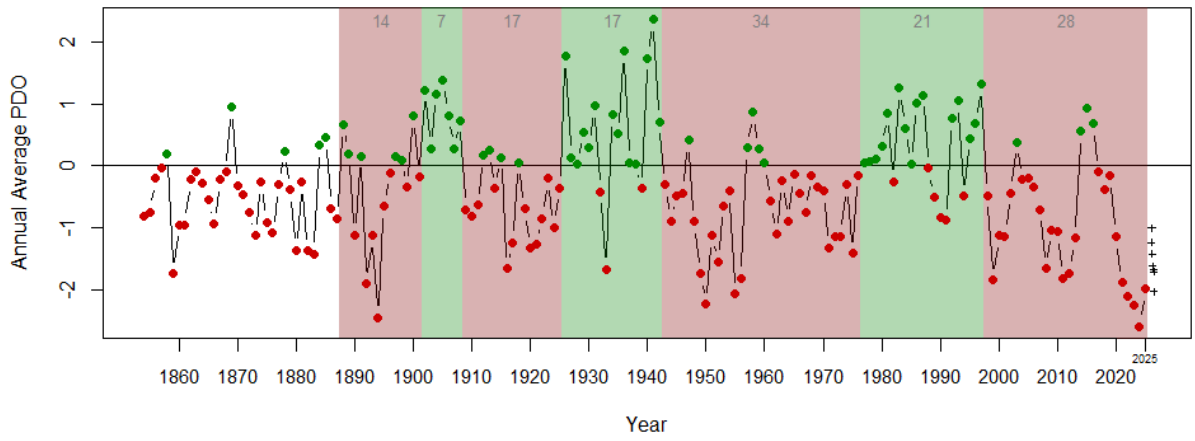


Figure 9. Historical annual mean Pacific Decadal Oscillation (PDO) (data from https://www.ncei.noaa.gov/pub/data/cmb/ersst/v5/index/ersst.v5.pdo.dat). Green colors indicate positive PDO values and periods of expected high productivity for Pacific halibut. Red colors indicate negative PDO values and periods of expected low productivity for Pacific halibut. Gray numbers at the top indicate the number of years in that productivity regime. Plus symbols (+) at the end of the time-series are monthly PDO values in 2026 through July.

The productivity regimes affect the priority objectives in different ways (Figure 10). Regardless of the productivity regime, the conservation objective (maintaining the RSB greater than 20%) is always met, which is due to the 30:20 control rule reducing the realized fishing intensity. The current weight-at-age and low PDO productivity regime (similar to what has been recently experienced) fails to meet the fishery objective to maintain the RSB at or above levels that support optimal fisheries ($RSB_{36\%}$) with SPR values of 43% or less. A productivity regime with current weight-at-age and high recruitment fails to meet this objective at an SPR of 40%. The short-term median TCEY was less for the current weight-at-age and low PDO productivity regime when compared to the integrated productivity, but the short-term median TCEY was similar for the integrated productivity and current weight-at-age with high PDO productivity regimes. The AAVs showed similar patterns except that the AAV was greater for the current weight-at-age with low PDO productivity regime, mainly because the TCEY was less and AAV is a percentage of the interannual variability in the TCEY. The trade-off between short-term TCEY and short-term AAV is shown in Figure 11.

Overall, the current weight-at-age affects the spawning biomass and shows a higher risk to the RSB as well as a higher probability that the projected short-term spawning biomass is less than the spawning biomass in 2023 (Table 3). The PDO has a large effect on average recruitment, which affects the TCEY. Low recruitment results in reduced TCEYs while high recruitment can support high TCEYs because of consistent influxes of young Pacific halibut, but results in a reduction to the spawning biomass, which is likely due to fewer older fish in the population and more younger fish that have recently matured and have had the opportunity to spawn and contribute to the spawning potential.

Table 3. Performance metrics from simulations for an SPR value of 43%, comparing three productivity scenarios: integrating over changes in weight-at-age and cyclical PDO, recent low productivity (i.e. current weight-at-age and negative PDO), and current weight-at-age paired with a positive PDO. A green colour indicates that the performance metric passes and red indicates that it does not, which applies to only the probabilistic long-term objectives.

		Integrated (low & high) Productivity					
	SPR (%)	**55**	**52**	**49**	**46**	**43**	**40**
Long-term	**P(RSB<20%)**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	<0.001	0.001	0.015	0.088	0.263	0.479
Short-term	**Median TCEY**	30.7	33.4	35.9	38.7	40.7	42.6
	AAV	32.9%	32.4%	32.8%	33.8%	36.5%	39.3%
	P(SB < SB_{2023})	0.125	0.163	0.217	0.274	0.338	0.393

		Recent Productivity (current weight, low PDO					
	SPR (%)	**55**	**52**	**49**	**46**	**43**	**40**
Long-term	**P(RSB<20%)**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	0.026	0.081	0.219	0.421	0.629	0.776
Short-term	**Median TCEY**	27.9	30.2	32.7	35.0	37.0	39.0
	AAV	34.7%	33.6%	32.6%	33.1%	34.6%	38.0%
	P(SB < SB_{2023})	0.288	0.362	0.435	0.506	0.573	0.632

		Current weight, high PDO					
	SPR (%)	**55**	**52**	**49**	**46**	**43**	**40**
Long-term	**P(RSB<20%)**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	<0.001	0.002	0.030	0.147	0.370	0.617
Short-term	**Median TCEY**	34.7	37.6	40.5	43.3	45.6	47.8
	AAV	30.2%	29.3%	29.0%	30.1%	31.9%	35.5%
	P(SB < SB_{2023})	0.224	0.288	0.350	0.416	0.484	0.541

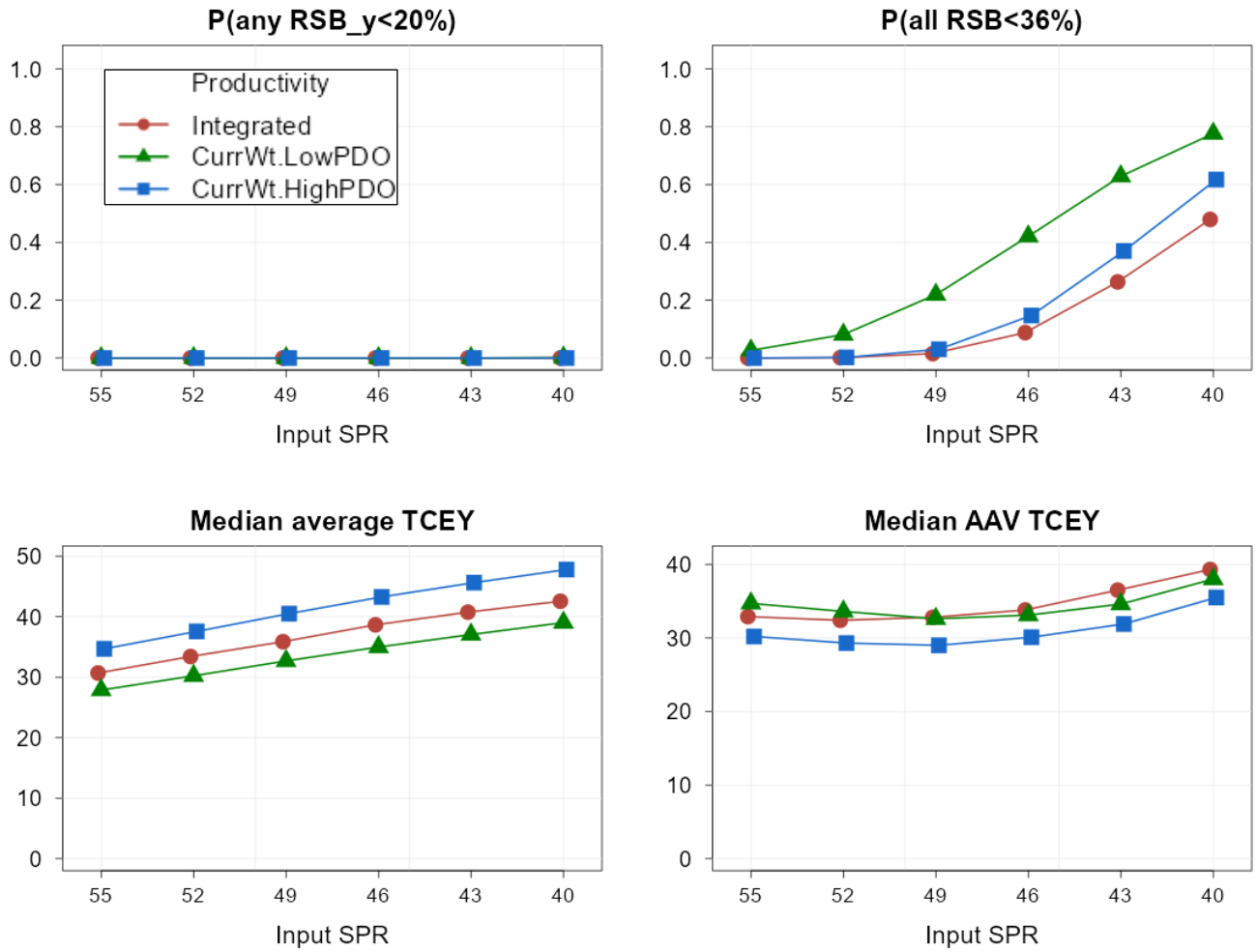


Figure 10. Plots of performance metrics for priority objectives over a range of SPR values and integrated productivity (red circles), current weight-at-age and low PDO productivity (green triangles), and current weight-at-age and high PDO productivity (blue squares).

It is important to note that the future is uncertain and productivity will certainly not remain constant, which is why it is integrated into the simulations. Even though what was experienced in the past may not be experienced in the future, the integrated simulations provide a range of possibilities for strategic planning. The specific scenarios assuming consistent productivity provide additionally understanding of the population and ensure that the evaluation of all candidate management procedures is robust to a wide range of stock conditions. It is possible to develop an MP that is dependent on the current perceived productivity regime, which would require evaluation using the MSE framework.

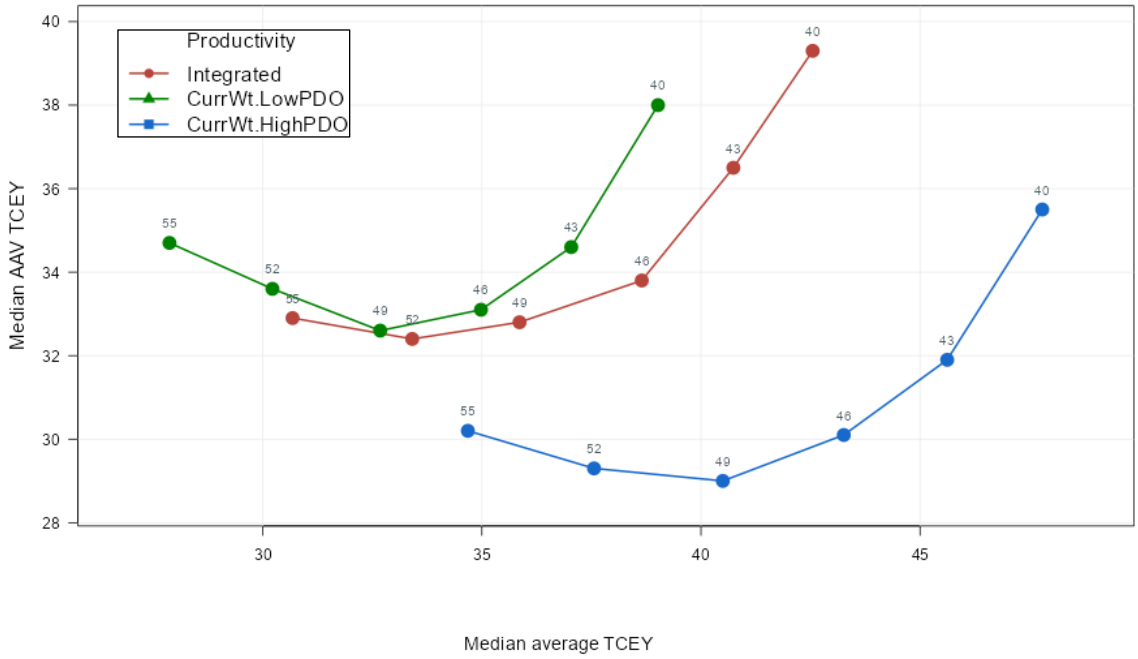


Figure 11. Trade-offs between average annual variability (AAV) in the short-term TCEY and the median short-term TCEY for different SPR values with integrated productivity, current weight-at-age with low PDO, and current weight-at-age with high PDO.

FURTHER DEVELOP THE DEPLETED CONCEPT

The IPHC HSP describes two reference points related to spawning biomass:

- **Overfished**: the female dynamic spawning biomass level where the ecological risk to the population and the risk to the health of the fisheries is regarded as unacceptable.
- **Depleted**: the female absolute spawning biomass level below which the potential for recovery is uncertain.

The overfished level is defined as when the estimated probability that coastwide female relative spawning stock biomass is below the limit reference point ($RSB_{20\%}$) is greater than 50%. Depleted does not have a definition and is currently being investigated.

Overfished implies that fishing was the cause of a low biomass state, whereas a depleted condition could be caused by fishing or other factors. 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 increase the chance of 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. Both concepts are shown in Figure 12. 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.

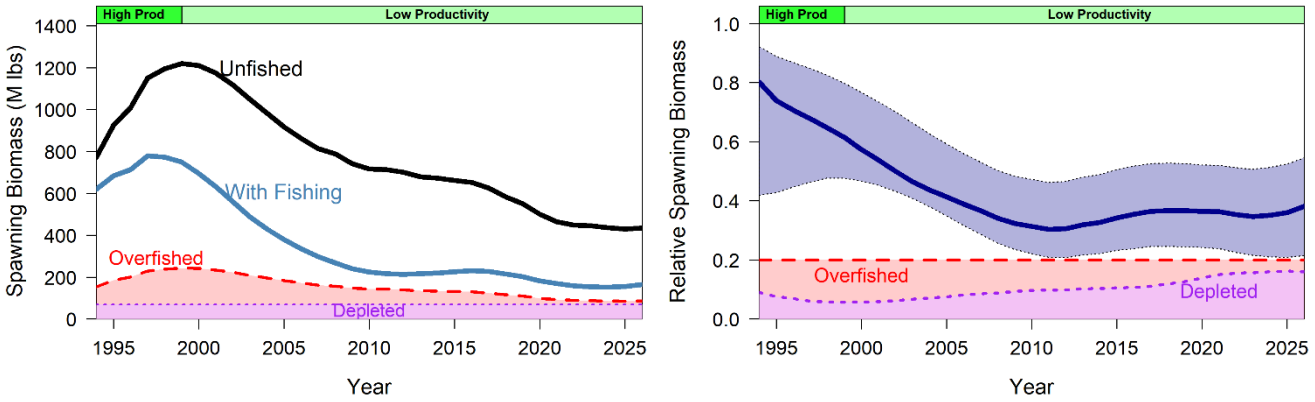


Figure 12. Estimated spawning biomass (left) if fishing had not occurred (unfished) and estimated spawning biomass from the 2025 stock assessment (with fishing). The Overfished threshold of 20% of unfished spawning biomass is shown as a dashed line and changes over time. An example "Depleted" threshold 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 mapped onto the relative spawning biomass scale is shown in purple.

Absolute spawning biomass is an appropriate measure for a depleted reference point because it directly relates to fecundity (i.e. egg production). The current understanding of Pacific halibut egg production is that it is directly related to body size. For example, a 100-pound mature female Pacific halibut produces four times more eggs than a 25-pound mature female Pacific halibut. Therefore, absolute spawning biomass is a measure of reproductive potential for the stock, and if reproductive potential approaches or drops below a critical level, management response would be warranted. Current research on fecundity by the Secretariat may suggest using reproductive output instead of spawning biomass to account for potential nonlinear reproductive potential over different sizes of Pacific halibut; it would be an easy switch to account for this but would have important effects on estimated reference points.

The Secretariat has currently identified three possible approaches to identify an appropriate absolute spawning biomass reference point for defining a depleted stock condition.

1. Use the lowest spawning biomass observed in the estimated time series from the stock assessment, which is 153 Mlbs in 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 from the IPHC's Fishery Independent Setline Survey (FISS).
2. Use a low spawning biomass level that was associated with a high recruitment event. This could be 215 Mlbs that produced the 2012 year-class, according to the 2025 stock assessment.
3. Use simulation (via the MSE framework) to determine an absolute spawning biomass reference point where the potential for recovery is uncertain based on our scientific understanding of biological and reproductive dynamics. This would involve simulating the Pacific halibut population forward at a high fishing rate for many years under a

'worst-case' scenario (e.g. low weight-at-age, low PDO) and then transition to simulating without fishing. A bifurcation point in the spawning biomass where trajectories either recover or stabilize and those that continue to decline could indicate an appropriate depleted threshold that accounts for uncertainty.

The Secretariat discussed the concept of depleted with the Scientific Review Board (SRB) at SRB029, and the SRB made a request for more information. This request followed a preference from the SRB to focus on determining appropriate details for methods 1 and 2 above, noting that method 3 may be informative but is dependent on assumptions.

> **IPHC-2026-SRB029-R, para. 24 (SRB029–Req.10):** ***NOTING*** *that "recovery" is part of the depleted definition, but is not defined itself, the SRB* ***REQUESTED*** *that the Secretariat review how these reference points are defined within other management systems and present, at SRB030, some potential recovery thresholds or definitions that recognise the difference between short (e.g. positive trend) and long-term (e.g. persistent high biomass) aspects of recovery. Alternatively, the Secretariat could redefine "depleted" based on the avoidance of further declines in biomass.*

Furthermore, two requests were made by the MSAB related to determining a depleted reference point.

> **IPHC-2026-MSAB022-R, para. 41 (MSAB022–Req.11):** *The MSAB* ***REQUESTED*** *to conduct MSE simulations to determine appropriate methods of determining when the Pacific halibut stock is recovered after having been defined as depleted.*
>
> **IPHC-2026-MSAB022-R, para. 42 (MSAB022–Req.12):** *The MSAB* ***REQUESTED*** *that simulations to determine a depleted limit reference point be used to understand the interactions between overfished and depleted (e.g. when could a stock be defined as overfished but not depleted, and vice versa) as well as interactions between rebuilt and recovered.*

The Secretariat will continue to work with the SRB and MSAB to refine these approaches and determine an appropriate depleted reference point and definition of recovered if classified as depleted.

IMPROVE THE ESTIMATION MODEL

Work has begun on developing an estimation model for use in the MSE framework. An estimation model mimics the stock assessment and produces outcomes with uncertainty that are used in the MP. The estimation model needs to run quickly because it is used in many years of each of the 500 simulations. Therefore, it is typically a simplification of the actual stock assessment process, but specified to capture the general behaviours of the stock assessment. Two requests from SRB029 are applicable to this topic.

IPHC-2026-SRB029-R, para. 25 (SRB029–Req.11): ***NOTING*** *that the stability of the projections depends on the assumed levels of assessment and implementation uncertainty, the SRB REQUESTED that at SRB030 the Secretariat present materials describing how assessment and implementation uncertainty are included in the MSE and potential alternative approaches.*

IPHC-2026-SRB029-R, para. 26 (SRB029–Req.12): ***RECALLING*** *the following recommendation from SRB027:*

> *SRB027–Rec.09 (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.*

the SRB ***REQUESTED*** *that the Secretariat present options for implementing an assessment model within the MSE, including investigating potential state-space options which can run faster.*

The development of the estimation model will include building custom models and investigating generalized stock assessment packages in parallel with the current investigation being conducted for the stock assessment. This includes packages such as CEATTLE and SPoRC.

EVALUATE POTENTIAL MANAGEMENT ACTIONS WHEN APPROACHING A DEPLETED LIMIT REFERENCE POINT

Before management actions are developed when approaching a depleted limit reference point, additional progress on defining the depleted limit reference point and a definition of recovered must be made. Potential management actions will be considered following further work on defining a depleted limit reference point (see above).

EVALUATE ADDITIONAL MANAGEMENT PROCEDURES

The Commission, MSAB, and Research Advisory Board (RAB) have identified various elements of MPs that are of interest to investigate. These include a triennial assessment frequency with various empirical rules to determine the TCEY in non-assessment years, constraints and smoothers on the interannual change in the TCEY, and a minimum TCEY. These elements, and any others defined by the Commission, will be evaluated in 2027.

IPHC-2026-MSAB022-R, para. 37 (MSAB022–Req.06): *The MSAB* ***REQUESTED*** *further evaluations of the following MP elements:*

b) a triennial assessment frequency with various empirical rules to determine the reference coastwide TCEY in non-assessment years.

IPHC-2026-MSAB022-R, para. 38 (MSAB022–Req.08): *The MSAB* ***REQUESTED*** *evaluating constraints and smoothers, along with MP elements listed in para. 37, 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.

IPHC-2025-RAB026-R, para. 36 (RAB026-Req.07): *The RAB **REQUESTED** the consideration of an investigation of a floor coastwide mortality limit (e.g. a minimum Total Constant Exploitation Yield (TCEY)) be conducted as part of the MSE process to understand potential risks to the Pacific halibut stock and fisheries for this type of management procedure.*

DETERMINE REFERENCE POINTS USING THE UPDATED MSE OPERATING MODEL

The previous analysis of reference points for the Pacific halibut stock was completed in 2019 (IPHC-2019-SRB015-11 Rev_1) and defined a precautionary SPR associated with maximum sustainable yield (SPR_{MSY}) at 35%, which is used as the overfishing limit in the HSP. Many improvements in the knowledge of Pacific halibut have occurred since then that may affect reference points, including updated age-at-maturity and natural mortality estimates. An analysis of reference points is underway using this updated knowledge in the stock assessment and the MSE framework.

The updated MSE framework was used to calculate the equilibrium yield curve by simulating various SPR levels without a control rule and no decision, estimation, or observation variability to determine the long-term, equilibrium yield across fishing intensities assuming integrated productivity. The peak of the curve defines maximum sustainable yield (MSY) and can be associated with SB_{MSY}, RSB_{MSY}, and SPR_{MSY}. More work needs to be done to identify the uncertainty, but preliminary results indicate that SPR_{MSY} may be less than previously determined. Previous results showed a range of 29% to 35% for SPR_{MSY} while the current simulations suggest a range between 22% to 30% having less than a 2% difference in the long-term median TCEY (Figure 13). The range of SPR from less than 20% to 46% shows less than an 20% difference in the long-term median TCEY. In other words, the equilibrium yield curve is flat across a range of SPR values, drops off quickly with SPR less than 22%, and drops below 80% of the maximum at SPRs greater than 46% when integrating over low and high productivity regimes.

Without a control rule, the fishing intensity has full effect and can reduce the population to low levels. An SPR of 22% would result in a median RSB of 15%, well below the objective to maintain the RSB above 20%. The minimum SPR (i.e. maximum fishing intensity without a control rule) to meet this objective would be 34% (Figure 13). The integrated productivity of the stock with periods of high-weight-at-age and high recruitment allows the stock to be fished to low relative spawning biomass levels, but with minimal gains in the long-term equilibrium TCEY.

For the low productivity scenario (current weight-at-age and low PDO) the yield (i.e. long-term equilibrium TCEY) is less and SPR_{MSY} is near a value of 36% (Figure 13). The decline on either side of SPR_{MSY} is more gradual than with integrated productivity and 80% of MSY could be achieved at SPR values near 24% to greater than 54%. An SPR of 36% would result in an

RSB near 24%. However, an SPR of 40% would just meet the objective to maintain the stock above 20% RSB with a 95% probability. Other productivity scenarios are currently being evaluated. For example, SPR_{MSY} is near 28% with the assumption of current weight and high PDO productivity.

Overall, the fishing intensity associated with maximum sustainable yield for Pacific halibut is uncertain across a wide range of SPR values and depends on assumptions of productivity. Considering the objective to maintain the RSB above 20% with a 95% probability results in SPR values near the current overfishing limit (SPR=35%) defined in the HSP. The future analysis will identify the variability in absolute and relative reference points across productivity scenarios and evaluations will continue to determine if the SPR_{MSY} and overfishing limit should be updated given current understanding of Pacific halibut population dynamics.

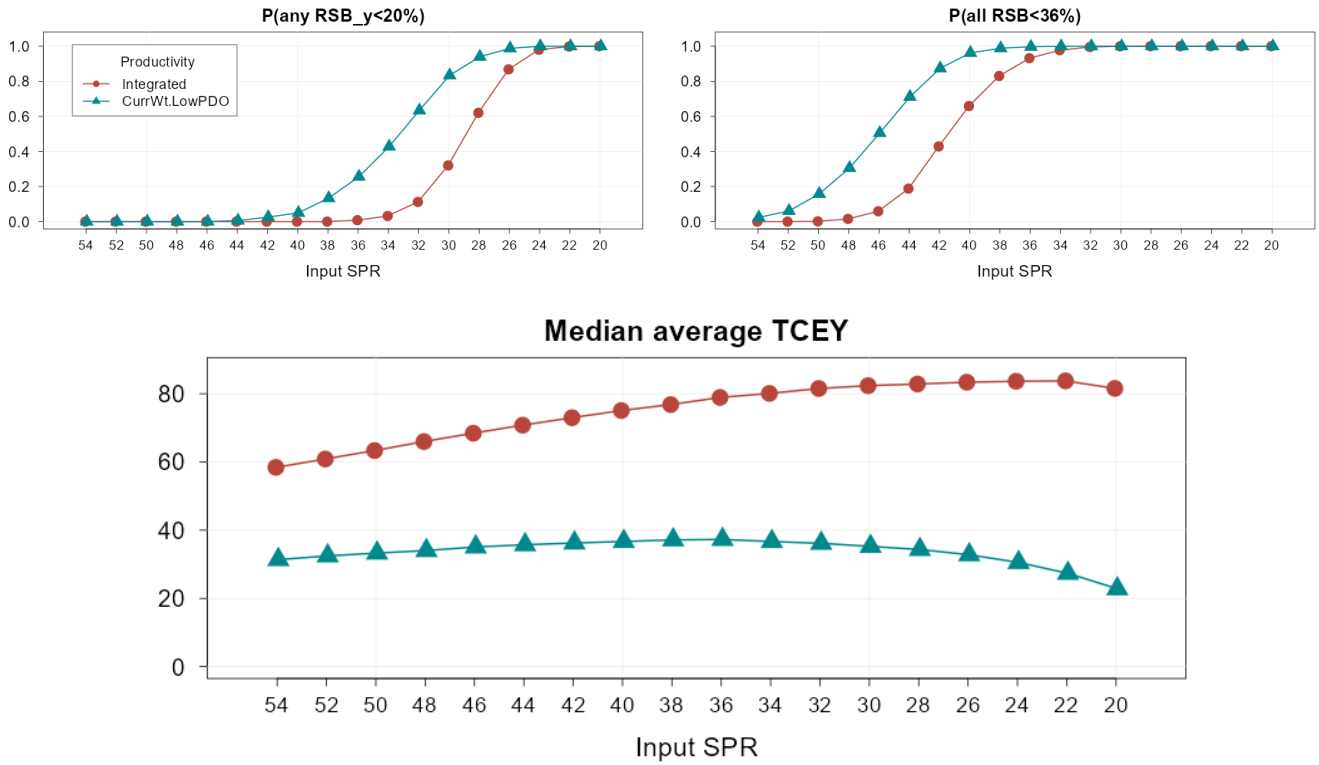


Figure 13. The performance metrics for simulations with a range of SPR values without a control rule and no decision, estimation, or observation error.

DEVELOP GUIDANCE DOCUMENTS FOR THE HSP

The development of guidance documents to supplement the harvest strategy policy (HSP) will begin in 2027. An example document is describing rebuilding guidelines.

ADDITIONAL CONSIDERATIONS

The SRB and MSAB made additional requests to better understand the MSE framework, the concept of depletion and associated objectives, and the short- and long-term consequences of current decisions.

> **IPHC-2026-SRB029-R, para. 27 (SRB029–Req.13):** *The SRB **REQUESTED** that PDO projections be developed that are based on time series analysis of the historical record. This will allow the projections to equilibrate at proportions that are consistent with the historical data rather than 50/50 (high/low phase).*

> **IPHC-2026-MSAB022-R, para. 24 (MSAB022–Req.01):** *The MSAB **NOTED** that the 70% probability for a stock to be rebuilt from an overfished status has not been simulation tested and determined appropriate for the management of Pacific halibut, and **REQUESTED** that this definition and other methods to declare a stock rebuilt be simulation tested using the MSE framework.*
>
> **IPHC-2026-MSAB022-R, para. 29 (MSAB022–Req.04):** *The MSAB **REQUESTED** that the HSP Table be expanded to include long and short-term projections using a fixed productivity regime based on current perceived productivity and additional performance metrics such as the median RSB and median absolute spawning biomass.*
>
> **IPHC-2026-MSAB022-R, para. 46 (MSAB022–Req.13):** *The MSAB **REQUESTED** that the 23rd Session of the MSAB include an agenda item to discuss objectives and performance metrics focused on a depleted limit reference point (if determined), and an objective related to an absolute spawning biomass to be at or above.*

SUMMARY OF PROGRESS ON THE MSE 2026 PROGRAM OF WORK

Significant progress has been made on the tasks in the 2026 MSE and HSP Program of Work, but additional work is necessary which will benefit from the guidance of the Commission, SRB, MSAB, and RAB. The Operating Model has been updated and conditioned, results are available for a range of SPR values suggested by the MSAB, two productivity regimes have been investigated, and a path forward has been identified for the depleted concept, which are all high priority tasks. Some low priority tasks are in progress and may become high priority tasks in 2027.

Table 4. Summary of progress that has been made on the high- and low-priority tasks in the 2026 MSE and HSP Program of Work.

Priority	Task	Status	Progress to date	Next steps
High	Recondition OM	Completed	The Operating Model (OM) has been updated and conditioned. It has been used to conduct simulations.	Continue to use the OM for simulations. Check annually for exceptional circumstances.
	Evaluate a range of SPR values	Results available	Simulations for SPR values from 40% to 55% have been completed with integrated productivity.	A similar range of SPR values will be used as other elements of MPs are specified.
	Investigate productivity regimes	Results available	Two regimes simulated, both with current weight-at-age: consistent low PDO and consistent high PDO.	Productivity regimes will continue to be used to evaluate MPs. Other regimes may be used in 2027.
	Further develop the depleted concept	In progress	Discussions with the SRB at SRB029 have identified a path forward.	Continue this work as a high priority in 2027.
Low	Improve the estimation model	In progress	Development is in the early phases.	Consider as a high priority in 2027.
	Evaluate potential management actions when approaching a depleted limit reference point	Waiting	Dependent on further development of the depleted concept.	Begins following further progress on the development of the depleted concept.
	Evaluate additional elements of management procedures	In progress	Various elements of MPs have been identified.	To be investigated in 2027. Identify if any elements are high priority.
	Determine reference points	Preliminary results available	Some simulations are complete.	Additional analyses and investigations are necessary.
	Develop guidance documents for the HSP	To begin in 2027	Not yet started.	Development begins in 2027.

RECOMMENDATION/S

That the Commission:

1) **NOTE** paper IPHC-2026-IM102-10 which provides an update on progress for the MSE Program of Work in 2026 and initial results from the updated MSE framework.
2) **NOTE** that the MSE operating model (OM) has been reconditioned for 2026 using updated stock assessment inputs and improved weight-at-age and recruitment simulation methods, resulting in a more gradual increase away from current productivity and a narrower range of projected spawning biomass than the 2025 OM.
3) **NOTE** that simulations across a range of SPR values from 55% to 40% and productivity scenarios have been conducted with the following conclusions.
   a) All SPR values evaluated with integrated productivity met the objectives to be above $RSB_{20\%}$ and at or above $RSB_{36\%}$.
   b) The objective to be at or above $RSB_{36\%}$ was met for SPR values higher than 43% assuming low productivity similar to what has been recently experienced (i.e. current weight-at-age and low PDO).
   c) There is a trade-off between the short-term TCEY and the short-term variability in the TCEY (AAV) where the median short-term TCEY increased at lower SPR values (i.e. higher fishing intensity) and showed larger gains between low fishing intensities, and the AAV increased from an SPR of 49% to an SPR of 40% and remained similar for SPRs from 55% to 49%.
   d) There is approximately a 1 in 4 chance that the short-term spawning biomass (SB) would be less than the SB experienced in 2023 with an SPR of 46%, and this chance increases to 1 in 2 assuming recent low productivity.
4) **NOTE** that productivity has an effect on short-term projected outcomes and a larger effect on long-term projected outcomes.
5) **NOTE** that the Secretariat has identified three candidate approaches for defining an absolute spawning biomass reference point for Depleted and will continue to work with the SRB and MSAB on this topic.
6) **NOTE** that low-priority tasks for the 2026 MSE Program of Work are in progress or waiting for other tasks to complete before beginning.
7) **RECOMMEND** updating the reference SPR in the Harvest Strategy Policy (HSP) from the current SPR of 43% to an SPR of 46%.
8) **RECOMMEND** including the identification of a depleted limit reference point for Pacific halibut as a high-priority task in the 2027 MSE Program of Work.
9) **RECOMMEND** including the evaluation of the following elements of management procedures as a high-priority task in the 2027 MSE Program of Work:
   a) a triennial assessment frequency and empirical rules to determine the reference TCEY in years without a stock assessment, and
   b) constraints and smoothers on the interannual change in the TCEY including minimum and maximum TCEYs.

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