Development of the 2026 Pacific halibut (*Hippoglossus stenolepis*) stock assessment

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PURPOSE

To provide the IPHC's Scientific Review Board (SRB) with a response to recommendations and requests made during SRB028 (IPHC-2026-SRB028-R) and an update on the development of the 2026 stock assessment.

INTRODUCTION

The International Pacific Halibut Commission (IPHC) conducts an annual coastwide stock assessment of Pacific halibut (*Hippoglossus stenolepis*). The most recent full assessment was completed in 2025 (IPHC-2026-SA01, IPHC-2026-SA02, and detailed model evaluation presented during SRB026: IPHC-2025-SRB026-07). That analysis followed updates in 2023 (IPHC-2024-SA01) and 2024 (IPHC-2025-SA01). The 2026 stock assessment is planned as an update analysis, updating data sources but not revisiting all data processing and model development.

Major topics explored during the 2025 full assessment included:

1) updating the time-series information for the Pacific Decadal Oscillation, used as a covariate to the stock-recruitment relationship,
2) improving the bootstrapping approach to pre-model calculation of maximum effective sample sizes to include ageing imprecision (Hulson and Williams 2024),
3) re-tuning the process and observation error components of assessment models to achieve internal consistency,
4) and updating the maturity ogive to reflect the recent histology-based estimates produced by the IPHC's Biological and Ecosystem Sciences Branch.

The results of the final 2025 assessment (IPHC-2026-AM102-10), including stock projections and the harvest decision table (IPHC-2026-AM102-12), were generally consistent with those from previous stock assessments.

The final 2026 assessment will be produced for the IPHC's 102nd Session of the IPHC Interim Meeting (IM102, 1 December 2026) and the 103rd Session of the IPHC Annual Meeting (AM103, 25–28 January 2027) meetings. Updated data sources, including the results of the 2026 Fishery-Independent Setline Survey (FISS), logbook and biological data from the 2026 commercial fishery, and sex-ratio information from the 2025 commercial landings-at-age will be included for the final 2026 analysis.

Following the 2026 stock assessment development reported for SRB028 (IPHC-2026-SRB028-07), this document summarizes progress made on outstanding recommendations from SRB028, other development for 2026 as well as a brief prospectus on important upcoming research that may affect the update in 2027, the full stock assessment planned for 2028, and related analyses.

SRB REQUESTS AND RECOMMENDATIONS

The SRB made one request specific to the stock assessment during SRB028:

1) SRB028-Req.04 (para. 21):

*"**NOTING** the progress presented in IPHC-2026-SRB028-07 on assembling a list of state space modelling platforms and their associated features, the SRB **REQUESTED** an update at SRB029 on progress to develop initial models, including approaches to mimic essential features of the Pacific halibut assessment (e.g. sex specific modelling) using other means (e.g. the spatial area features in multi-WHAM)."*

Based on the comparison provided for SRB028 of existing state-space model platforms that are used for production stock assessment (Table 1 in IPHC-2026-SRB028-07), we settled on WHAM (Stock and Miller 2021), SPoRC (Cheng et al. 2026) and CEATTLE (Adams et al. 2022) as top contending platforms from which to begin development for Pacific halibut. The CEATTLE platform currently includes more major features needed for Pacific halibut than the others, but none of them includes all the features currently employed in Stock Synthesis (Methot and Wetzel 2013).

As a simple starting point a CEATTLE model input file was developed with the following specifications:

- two (2) fleets (one survey and one fishery),
- uses ages 1-20 for both the data inputs and the modelled population dynamics,
- spans the period 1992-2025,
- fixes natural mortality for female Pacific halibut at the value used in the coastwide short stock assessment model (0.15) and fixes natural mortality for male Pacific halibut at the estimate from the coastwide short model (0.13),
- employs simple time-invariant logistic selectivity with a single offset between males and females for both fleets,
- starts the modelled period with a fully estimated initial age structure and offset to account for pre-modelled period fishing mortality, and
- treats recruitment as a random effect around a log- time-series mean, with estimated log-standard deviation.

For comparison, the current coastwide short model (the simplest of the four used in the stock assessment ensemble; described in IPHC-2025-SRB026-07) includes six fleets (directed commercial, commercial discards, recreational, non-directed commercial, subsistence and the IPHC's Fishery Independent Setline (longline) Survey; FISS). That model includes population dynamics from ages 0-30 and allows for variable plus and minus groups by fleet and year for the observed age composition data. That model estimates male natural mortality and employs time-varying selectivity for both the fishery and survey fleets as well as domed selectivity for the directed discards, the non-directed commercial and the recreational fleets. That model also estimates a non-equilibrium initial age structure and recruitment deviations around a S-R function with one estimated parameter (log-R0) and one fixed parameter (steepness of 0.75) and a variance constrained by a tuned sigma (Methot and Taylor 2011).

The current CEATTLE model is still very preliminary, with only a small subset of the model features and parameter combinations explored so far. Further work will add features to more closely resemble the coastwide short model and explore the estimability of additional parameters

(e.g., time-varying selectivity, natural mortality, etc.). However, based on initial exploration there are a number of features that will not be able to be replicated without adding to the CEATTLE code. These include the following.

- More complex options for offsetting male and female selectivity including a different asymptote for males.
- Assigning ageing error matrices by year, instead of only by fleet which requires separating fleets to deal with the transition between surface ages (fishery <2001; FISS <1998,1999-2001) and break-and-bake ages.
- Separating the age-range for the observations from the age-range over which to calculate the population dynamics. In Stock Synthesis, the dynamics were extended to age 30 in order to capture the critically important growth occurring at the older age classes (particularly for the calculation of reference points where fishing does not truncate the age structure). Data have been aggregated using 'tail compression' which allows for the proportions at age to be aggregated at the youngest and oldest ages until they reach a threshold (the smallest observation considered potentially meaningful in the data; often 0.001). This avoids having a multinomial (or other composition likelihood) that includes a large number of structural zeroes (ages that are not ever selected at any point in the time series). This also allows for different 'plus groups' by data source. For halibut this approach has been used to aggregate surface ages to age 20 where the bias is much less influential than for older ages, while still extending the observed age distributions to age 25 for break-and-bake ages to provide unbiased information on natural mortality and the relative selectivity of the oldest fish in the population.
- Relatedly, the choice to use age 20 for the population dynamics also truncates the population maturity vector such that no modelled age reaches 100% maturity.

The CEATTLE model has the ability to 'mirror' selectivity and catchability among fleets, so additional fleets can be added to address the ageing method change as well as separate the fishing mortality and demographics of the various fishing fleets. The available suite of reference points is still yet to be explored.

Although considerable development is still needed before the results of this model are potentially useful for management, the treatment of recruitment variability appears promising. Despite the fact that sigma R is estimated on a different scale for age-1 than for age-0, the range of estimated deviations appears similar and the variability may actually be propagated better in CEATTLE due to the random-effects estimation of sigma R, especially toward the end of the time-series (Figure 1) as the signal in the data on incoming year classes disappears (the youngest fish in the survey are around age-5 and in the fishery a couple of years later due to the minimum size limit).

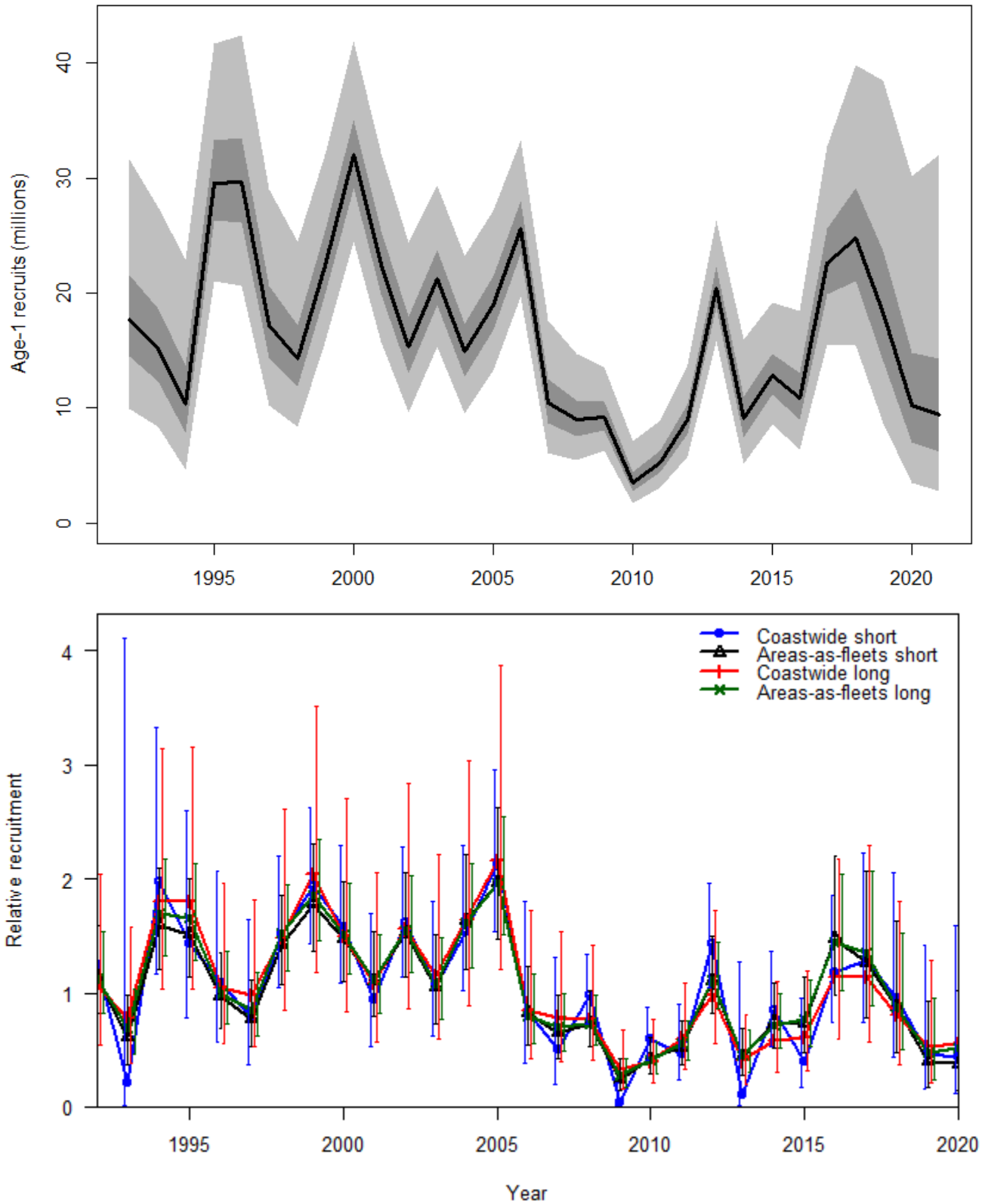

Figure 1. Estimated recruitments from the exploratory CEATTLE model (top panel) and the four models comprising the 2025 stock assessment model ensemble. Note that recruitments in the CEATTLE model occur at age-1 and so are offset one year from those in the Stock Synthesis models where recruitment occurs at age-0.

Next steps for the exploratory CEATTLE model will include bringing the configuration into as close alignment with the current coastwide short model as is possible and then comparing incremental changes in a step-wise manner to explore how a model that could potentially be used for management performs. Such a model could ultimately replace the coastwide short model in the current ensemble, be added to the ensemble (with or without sharing weighting with the current coastwide short model) or become the basis for an alternative ensemble including other state-space model configurations.

Further testing in preparation for the full stock assessment in 2028 will include a similar approach to development of models implemented in the WHAM and SPoRC platforms such that the detailed suite of features and effect of those features on management quantities can be compared across the three.

DASHBOARD DEVELOPMENT

Based on the 2025 stock assessment results presented at AM102, a stock status dashboard was developed. This page is intended to provide the salient results from the annual data overview and stock assessment summary in an accessible and intuitive manner. Secretariat staff will continue to develop and refine the content to provide easy interactive access to current stock status and assessment information.

ADDITIONAL STOCK ASSESSMENT DEVELOPMENT FOR 2026

Per standard procedures for final stock assessment preparation, the following data sources that will be included in the final 2026 stock assessment include:

1) New modelled trend information from the 2026 FISS for all IPHC Regulatory Areas.
2) Age, length, individual weight, and average weight-at-age estimates from the 2026 FISS.
3) Directed commercial fishery logbook trend information from 2026 (and any earlier logs that were not available for the 2025 assessment) for all IPHC Regulatory Areas.
4) Directed commercial fishery biological sampling from 2026 (age, length, individual weight, and average weight-at-age) from all IPHC Regulatory Areas.
5) Biological information (lengths and/or ages) from non-directed discards (all IPHC Regulatory Areas) and the recreational fishery (IPHC Regulatory Area 3A only) from 2025. The availability of these data routinely lags one year.
6) Updated mortality estimates from all sources for 2025 (where preliminary values were used) and estimates for all sources in 2026.

No preliminary data was available from 2026 in time for this document; however, preliminary raw catch rates from the 2026 FISS suggest mixed trends among IPHC Regulatory Areas with overall levels similar to 2025. Actual trends and interpretation of those trends for the coastwide stock, biological regions and individual IPHC Regulatory Areas will depend heavily on the results of the space-time modelling, including accounting for differences in the design from 2025, the age distribution of the catch and accounting for hook competition, especially where appreciable numbers of non-target species (e.g. dogfish) were encountered.

PROSPECTUS OF FUTURE ASSESSMENT MODEL AND DATA CHANGES

The development of the IPHC's research priorities is directly tied to the needs of the stock assessment and harvest strategy policy analyses, such that the IPHC's research projects will provide timely information about key biological and ecosystem processes that can then be incorporated directly into analyses supporting the management of Pacific halibut. Research priorities for the Pacific halibut stock assessment are delineated into three broad categories: data collection and processing, technical development of models and modelling approaches, and biological inputs. The highest priority items in each of these categories are highlighted in the Integrated Research and Monitoring Plan and are the primary focus of ongoing efforts. A longer list of research items can be found in the 2025 full stock assessment (IPHC-2025-SRB026-07).

Data collection and processing

This section represents projects relating specifically to existing and new data sources that could benefit the Pacific halibut stock assessment:

- Continued collection of sex-ratio from the directed commercial landings

  The ability to effectively estimate the effects of fishing, natural mortality, and other leading stock assessment parameters currently depends on the relatively short time-series of commercial fishery sex-ratio-at-age (2017-2024, with 2025 pending for inclusion in this year's stock assessment). Estimates have been consistent, and so no abrupt changes are expected, but future stock assessments will benefit from the information informing relative selectivity of males and females in the directed commercial fishery, and therefore the scale of the estimated spawning biomass, and the level of fishing intensity as measured by SPR.

- Whale depredation and tools to reduce it

  The magnitude of marine mammal depredation is unknown with no clear avenue to estimate it reliably. Unaccounted for mortality manifests as apparent low productivity in stock assessment results and therefore a biased estimate of the stock's ability to support fishery yield. If marine mammal depredation can be eliminated or at least reduced and/or estimated more precisely, mortality will be better accounted for, and our estimates of reference points will be improved. This research is unlikely to have large and immediate effects on stock assessment results but could substantially improve our understanding of stock dynamics in the long term.

Technical development

There are a variety of technical explorations and improvements that could benefit the stock assessment models and the ensemble framework. Larger changes (such as entirely new data sets) naturally fit into full assessment analyses; however, incremental changes may be possible during updated assessments when and if new information or methods become available. Technical research priorities include:

- Maintaining consistency and coordination between MSE, and stock assessment data, modelling and methodology

  Every cycle of stock assessment and MSE conditioning includes an exchange of information between the two platforms, both to ensure consistency as well as to benefit from the results learned through each analysis. Most recently, the analysis and treatment of weight-at-age has benefitted from extensive exploration during the conditioning of the MSE operating model.

- Estimation of natural mortality (*M*)

  Of the four models currently included in the stock assessment, only one, the coastwide short model, relies on a fixed value (0.15 for females) for natural mortality. This model is highly sensitive to the choice of fixed value (Figure 1), which is somewhat lower than the other three model estimates. This value could be updated, through direct estimation in the model, development of an alternative model structure capable of estimating it, or via indirect analyses outside the assessment. A substantially different estimate/fixed value could have a relatively large effect on our perception of the stock biomass level, and to a much lesser degree the recent trend and sustainable fishing mortality rate.

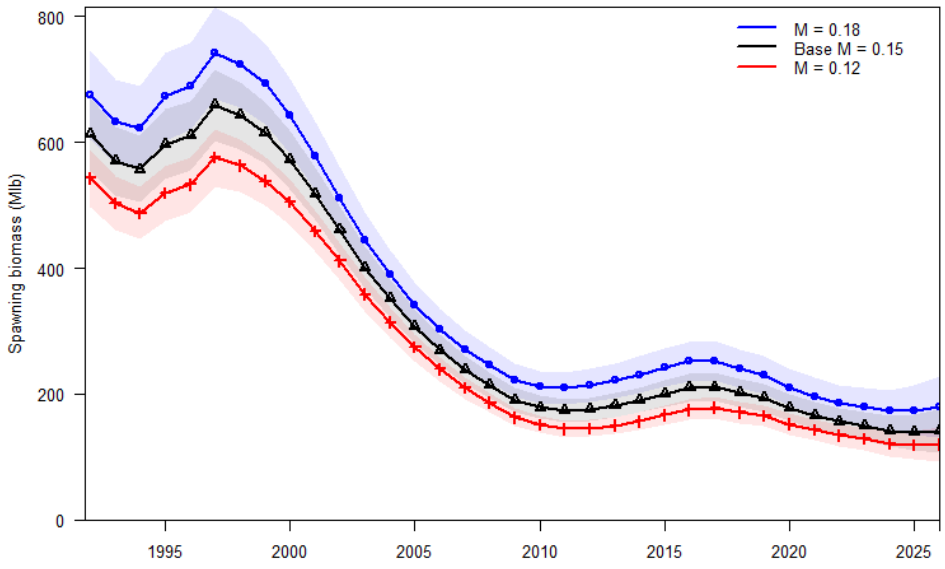

Figure 1. Sensitivity of the estimated spawning biomass from the 2025 coastwide short model to alternative fixed values of female *M*.

- Development of state-space models for Pacific halibut

  *State-space models allow for more efficient statistical estimation of time-varying processes (e.g., recruitment or changes in selectivity). The SRB has identified this as a priority for the next full stock assessment planned for 2028 (initially in SRB026 [para. 26]: "The SRB **RECOMMENDED** that a candidate state space assessment model (e.g. WHAM) be developed for Pacific halibut and presented by SRB032, tentatively scheduled for June 2028. Progress toward this modelling framework may also be presented at interim SRB meetings."). Adding a new model to the ensemble that may*

produce differing results could have a potentially large effect on the stock assessment output, including trends, status and reference points.

Biological inputs

Key areas for improvement in biological understanding include:

- Updating the fecundity-weight relationship and the presence and/or rate of skip spawning

  This information has the potential to substantially revise our understanding of reproductive output from the Pacific halibut stock, particularly if an increasing relationship of egg-output to body weight and/or appreciable skip spawning are estimated to occur.

- The relative role of potential factors underlying changes in size-at-age

  Correctly delineating between the effects of environmental processes, population density, competition with other species, and the effects of fishing on growth rates is a critical step in determining reference points and sustainable harvest rates. Accurate information on the factors affecting size-at-age would better inform the harvest strategy for Pacific halibut.

RECOMMENDATION/S

That the SRB:

a) **NOTE** paper IPHC-2026-SRB029-06, which provides a response to requests from SRB028 and an update on stock assessment development for 2026.

b) **REQUEST** any analyses to be provided at SRB030 as part of the development of the planned 2027 update stock assessment.

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