Development of the 2023 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 SRB022 (IPHC-2023-SRB022-R) and to provide the Commission with an update of the 2023 stock assessment development.

INTRODUCTION

In 2022 the International Pacific Halibut Commission (IPHC) undertook its annual coastwide stock assessment of Pacific halibut (*Hippoglossus stenolepis*). That assessment represented a full analysis, following the previous full assessment conducted in 2019, updated in 2020 and again in 2021. Changes from the 2021 assessment were developed and reviewed by the IPHC's SRB, in June (SRB020; IPHC-2022-SRB020-07, IPHC-2022-SRB020-R) and September 2022 (SRB021; IPHC-2022-SRB021-08, IPHC-2022-SRB021-R). A summary of stock assessment results (IPHC-2023-AM099-11) was provided for the IPHC's Annual Meeting (AM099). In addition, the input data files are archived each year on the stock assessment page of the IPHC's website, along with the full assessment (IPHC-2023-SA-01) and data overview (IPHC-2023-SA-02) documents. All previous stock assessments dating back to 1978 are also available at that location.

For 2023, the Secretariat plans to conduct an updated stock assessment, consistent with the schedule for conducting a full assessment and review approximately every three (3) years. Preliminary development for the 2023 stock assessment was presented for SRB022 (IPHC-2023-SRB022-08). Topics for that review included routine software updates, exploration of alternative weighting methods for the ensemble of four models, evaluation of the frequency of directed commercial Pacific halibut fishery sex-ratio-at-age data, estimation of natural mortality, marine mammal depredation rates from logbook records and potential structural revision to the stock assessment to accommodate spatial stock structure should it be identified within the Convention area.

SRB REQUESTS AND RESULTS

The SRB made the following stock assessment requests and recommendations during SRB022:

1) SRB022–Req.02 (para. 18):

   *"**NOTING** that analysis of whale depredation has clarified that the potential scale of removals from depredation is relatively small, except in IPHC Regulatory Area 4A, the SRB **REQUESTED** that updated analysis using USA observer data be presented at SRB023 to evaluate whether incorporation of whale depredation in the stock assessment is warranted."*

2) SRB022-Rec.02 (para. 19):

   *"**NOTING** that the scale of impact from different model weighting approaches presented here is small relative to the impact of other factors in the MSE (e.g. two- vs. three-year assessment intervals and TCEY), the SRB **RECOMMENDED** that the Secretariat continue using the equal weighting approach for model averaging."*

Request – whale depredation analysis

The Secretariat established an agreement with the National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) for access to detailed at-sea observer data from vessels fishing for Pacific halibut in Alaskan waters. Although it was not possible to link the individual records with IPHC logbook data, observer information contained sufficient information for further comparisons. Observer records were first filtered to include only vessels fishing under Individual Fishing Quota (IFQ). The next step was to exclude all fishing that did not catch any Pacific halibut; this was necessary to remove any fishing targeting only sablefish (*Anoplopoma fimbria*) in deep water. IPHC Regulatory Areas were assigned based on NOAA Fisheries statistical areas, which provide a reasonable approximation in most locations and was sufficient for this preliminary investigation. There were two types of records that could represent marine mammal depredation, those that specifically observed depredation or damaged fish/gear and those that observed the marine mammal (either orca, *Orcinus orca*, or sperm, *Physeter macrocephalus* whales) but could not confirm depredation; both of these types of observation were classified here as depredation. A small number of records with obvious data errors or incomplete information were removed from the data set. Observers in Alaskan fisheries record the percent of the total fishing time they estimated that marine mammal monitoring was taking place. These values ranged from zero to 100%; however most were >50%, and a sensitivity analysis showed little difference in the percent of sets in which whales were observed when sub-setting to only those records with 25, 50, 75 or even 95% monitoring, therefore 25% monitoring was used for all subsequent analysis.

Direct comparison with logbook records indicated that observed fishing activity tended to interact less frequently (or the interaction was identified less frequently) than the rates reported by harvesters in their logbooks for both orca whales (Figure 1) and sperm whales (Figure 2). However, both data sets supported the conclusion that orca whale interactions occur at the highest frequency in Biological Regions 4 and 4B, while the rate of sperm whale interactions is highest in IPHC Regulatory Areas 2C and 3A. An important caveat to the observer data is that prior to 2013 there were no observers deployed specifically to vessels targeting only Pacific halibut. All records from this time period represent larger vessels (primarily over 60 feet or 18.3 m in length), and those fishing IFQ for at least one species other than Pacific halibut.

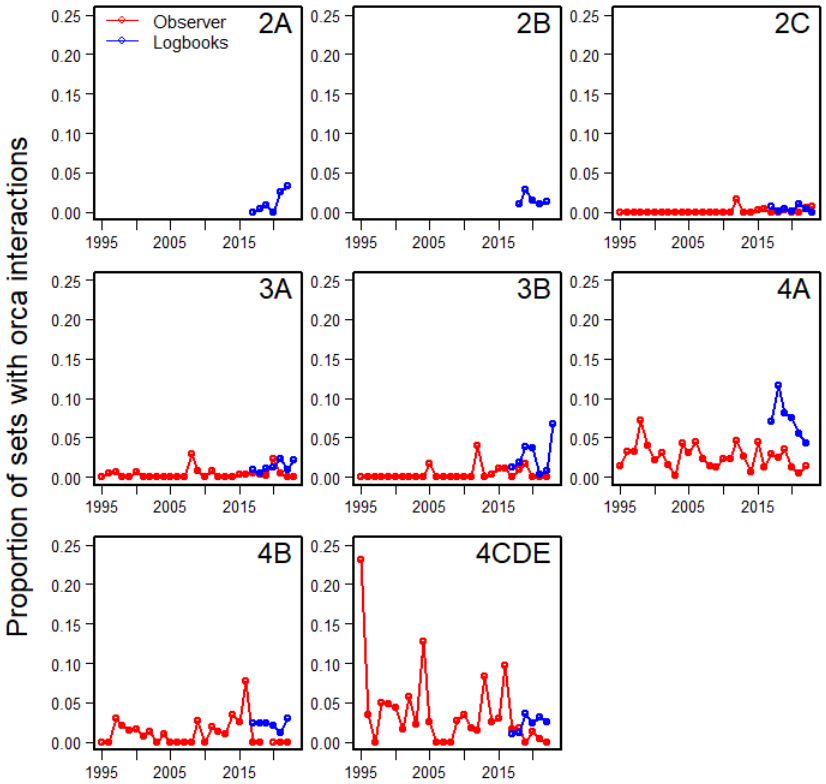

Figure 1. Proportion of observed and logbook-recorded sets with orca whale interactions by IPHC Regulatory Area.

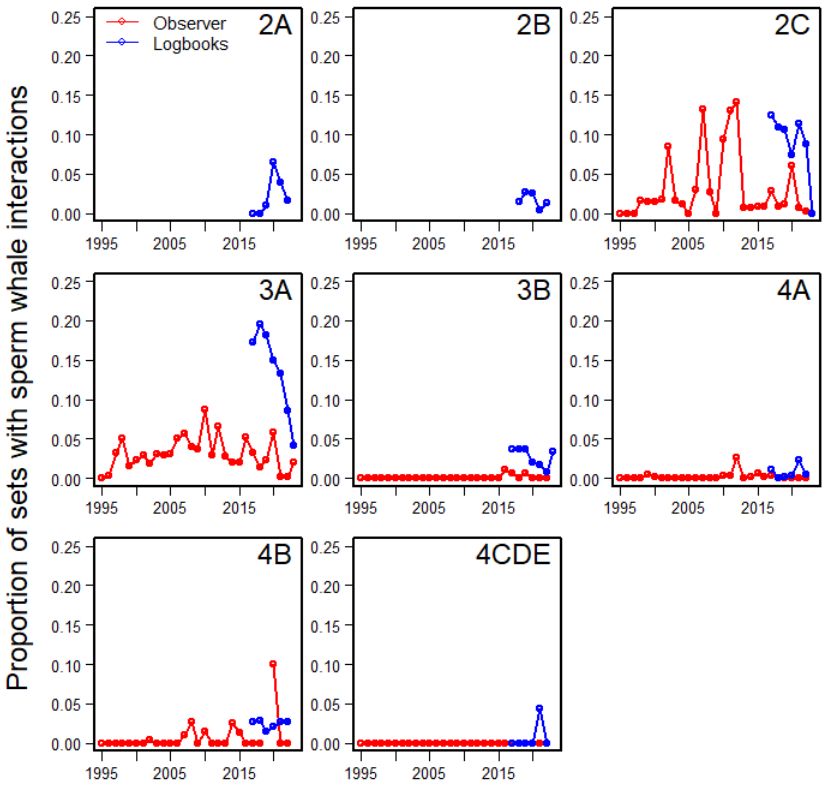

Figure 2. Proportion of observed and logbook-recorded sets with sperm whale interactions by IPHC Regulatory Area.

Based on this preliminary analysis and the generally lower rates reported by observers, further sensitivity was conducted using only logbook reported whale interactions. The subsequent analysis investigated how the formal inclusion of whale depredation might alter the stock assessment results and potentially affect management. In order to proceed with the relatively short time-series of logbook records the following simple assumptions were made:

1) the average rate at which the landed catch had been depredated (IPHC-2023-SRB022-08; $Dep_{rate} = {depredation\ mortality}/{landings}$) was calculated over the period 2017-2019, the earliest 3 years of data available;
2) This average rate was applied to the landings to estimate the depredation mortality for the time series from 1995-2016; and,
3) The same approach was taken for sublegal (Pacific halibut less than the current 32 inches or 81.3 cm minimum size limit), except that the mortality used in the stock assessment was first corrected for the discard mortality rate of 16% to represent total catch of sublegal Pacific halibut.

The additional mortality associated with whale depredation (both legal-sized and sublegal) was then added to the time-series used in each of the four stock assessment models. After re-estimating all parameters with the updated mortality time-series, each of the four models showed the expected response: the absolute level of spawning biomass was slightly larger than that estimated without whale depredation. This effect was present across the time-series, and in the range of 1-3%. The ensemble median 2023 spawning biomass estimate was 2% larger with whale depredation included.

In order to evaluate how this change would affect the mortality levels allocated to the directed fisheries, a projection of 2023 mortality due to whale depredation for both legal and sublegal Pacific halibut was needed. Similar to the approach taken in the sablefish stock assessment (Goethel et al. 2022), the three year recent average depredation mortality estimate (2020-2022) was added to the projected mortality for the directed commercial fishery for 2023. Projections were run using the adopted mortality limits for 2023 for the actual 2022 stock assessment (that did not include whale depredation) and the models including whale depredation. After adjusting the projected mortality to account for allocations among commercial, recreational, subsistence, and non-directed discards the net change to coastwide mortality was a 0.02 million pound increase over the actual adopted mortality limits set for 2023. As this is likely within the credible intervals of all the estimates of mortality included in the stock assessment the net effect should be considered negligible given the assumptions made for this analysis and at this time.

Recommendation – model weighting

All four models included in the stock assessment ensemble will be equally weighted for the final 2023 stock assessment. Further investigation of MASE and other weighting approaches will continue to be explored as the number of years for evaluation increases (since the sex-specific directed commercial fishery age composition starts in 2017) and new or existing methods for weighting multi-model stock assessments are developed.

PRELIMINARY DATA

For SRB022 sensitivity analyses to inclusion of sex-specific directed Pacific halibut commercial fishery age composition data were run. Results indicated only a small effect of adding these data each year (replacing the sexes-aggregated data available in-season) to each year's stock assessment. The genetic assays allowing for the processing of the 2022 sex-specific age composition information were completed in early August 2023. These data show the anticipated transition from a peak at older ages to the 2012 year-class in 2022 (Figure 3). When added to each of the four models in the stock assessment ensemble, the net effect was a 2.5% reduction in the estimated spawning biomass at the beginning of 2023. This suggests that the 2024 projections might be slightly more pessimistic with these data available than if they had not been processed and only the sexes-combined age composition data had been available. Although not a large effect on the results, during a period of continued stock decline it may be important to continue to provide as much detailed information for the annual stock assessment as possible. Preliminary evaluation of potential FISS designs for 2024 (IPHC-2023-SRB023-09) indicate that the FISS may have a very small geographical footprint in 2024 due to projected costs. Thus, the stock assessment may need to rely more heavily on commercial fishery trend and biological information in 2024 than in recent years with more comprehensive survey designs. For these reasons, the Secretariat recommends that the genetic analysis continue at least through 2024, pending a change in stock trend or other information.

Also of note in the recent commercial fishery age composition data is a small indication of systematic ageing bias of the 2005 year-class: the 2005 year-class has been aged at 15 years old in both 2021 and 2022 (when it should have been 16 and 17 years old) after tracking exactly from a peak at age 11 in 2016 through a peak at age 15 in 2020. This short-term anomaly, generally nonexistent in the age information for Pacific halibut, reflects the challenge of accurate age reading of older cohorts. However, the younger 2012 year class continues to track consistently from 2020-2022 and will be the most important driver of short-term stock trend and management advice.

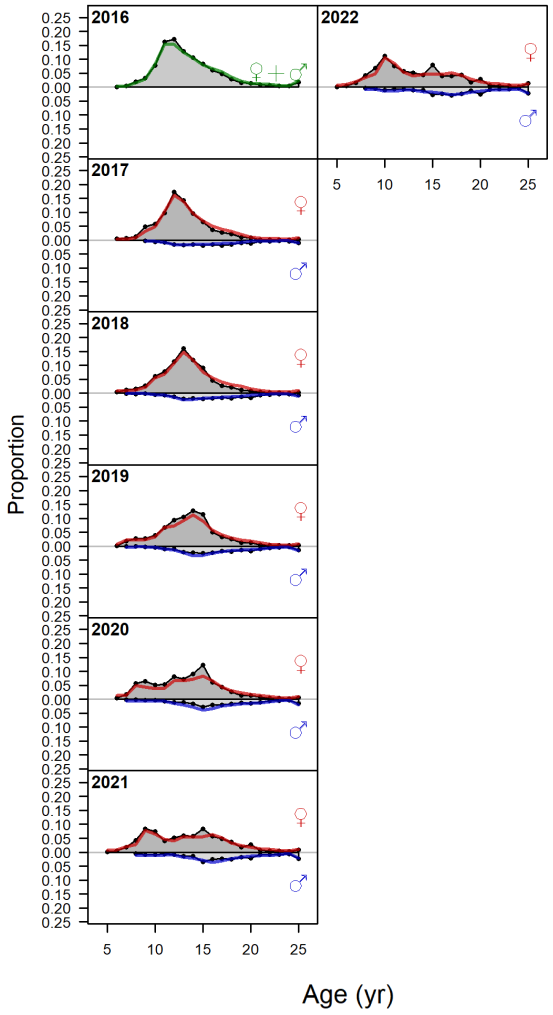

Figure 3. Fits to male (blue lines) and female (red lines) directed commercial Pacific halibut fishery age composition data (shaded polygons with black lines/points) from the short coastwide model updated from the final 2022 stock assessment with the 2022 sex-specific composition information. Sexes-aggregated data from 2016 (but not earlier years) is shown for comparison.

ADDITIONAL STEPS FOR THE FINAL 2023 STOCK ASSESSMENT

No structural changes to the stock assessment models or the ensemble weighting are anticipated for the final 2023 stock assessment beyond routine updating of time-series deviation parameters (e.g., recruitment) and iteration of the data weighting. Standard data sources that will be included in the final 2023 stock assessment include:

1) New modelled trend information from the 2023 FISS for all IPHC Regulatory Areas.
2) Age, length, individual weight, and average weight-at-age estimates from the 2023 FISS.
3) Directed commercial fishery logbook trend information from 2023 (and any earlier logs that were not available for the 2022 assessment) for all IPHC Regulatory Areas.
4) Directed commercial fishery biological sampling from 2023 (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 2022. The availability of these data routinely lags one year.
6) Updated weight-at-age for younger Pacific halibut captured in NOAA Fisheries trawl surveys in the Aleutian Islands and Bering Sea in 2022. These data also routinely lag one year.
7) Updated mortality estimates from all sources for 2022 (where preliminary values were used) and estimates for all sources in 2023.

RECOMMENDATION/S

That the SRB:

a) **NOTE** paper IPHC-2023-SRB023-06 which provides a response to requests from SRB022, and an update on model development for 2023.
b) **RECOMMEND** any changes to be included in the final 2023 stock assessment to be completed for presentation at IM099.
c) **REQUEST** any further analyses to be provided at SRB024, June 2024.

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APPENDICES

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