Preliminary results investigating fishing intensity and distributing the total constant exploitation yield (TCEY) for Pacific halibut fisheries

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PURPOSE

To describe preliminary results for closed-loop simulations of management procedures with coastwide scale and distribution components.

1 INTRODUCTION

The first full MSE results incorporating coastwide scale and distribution components of the management procedure (Figure 1) will be presented at the 97th IPHC Annual Meeting (AM097) in January 2021. Therefore, results of simulations incorporating various management procedures based on the framework shown in Figure 1 will be reviewed by the SRB and evaluated by the MSAB in 2020. This document presents preliminary results using the simulation framework described in IPHC-2020-MSAB015-08 to inform further development of management procedures to simulate for evaluation at MSAB016.

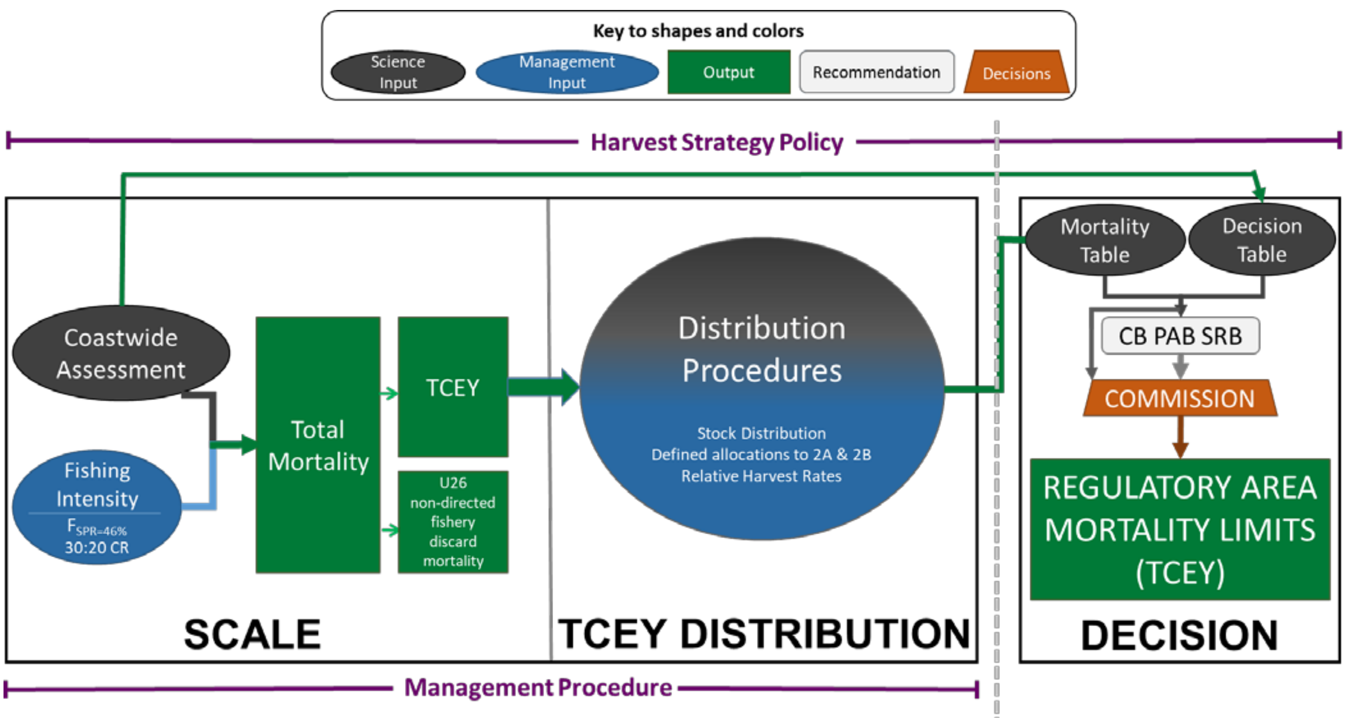

Figure 1: Illustration of the Commission interim IPHC harvest strategy policy (as revised for 2019-2022) process showing the coastwide scale and TCEY distribution components that comprise the management procedure. The decision component is the Commission decision-making procedure, which considers inputs from many sources.

When developing the simulation framework and before running simulations, the priorities were to verify and validate the operating model (OM) code, condition multi-area operating models to represent the range of possible states of the Pacific halibut stock and fisheries, characterize uncertainty in the Pacific halibut stock and fisheries, and verify that the framework correctly applies the management procedures and provides the proper feedback in the closed-loop simulations. The outcomes of these priorities are presented below.

2 VERIFYING AND CONDITIONING THE MSE FRAMEWORK CODE

2.1 VERIFICATION

Verification of the operating model code is the process of confirming that the calculations are correct, and that the outcomes follow the appropriate fishery and population dynamics as intended. Many types of verification were done with the operating model including outputting results of specific calculations to confirm that they were correct, examining specific test cases to ensure that the model does what it is expected to do (e.g., return to equilibrium biomass in a projection without fishing), and comparing outputs of the OM code to other similarly parameterized population models such as stock synthesis (SS; Methot and Wetzel 2013). Validating the OM code against a model using SS is useful because SS has been tested and validated for many years and is currently used to conduct many stock assessments. The entire framework was also validated by examining known test cases and comparing simple simulations that were done as part of the coastwide MSE to similar simulations performed with this new framework.

The OM calculations were verified by examining numbers-at-age, biomass, and other derived quantities given known inputs such as catch. Equilibrium conditions were also achieved with no fishing. The short coastwide and long coastwide assessment models were mimicked with the OM by first entering all of the appropriate parameters estimated in the assessment model, simulating through the same time-period, and then comparing outputs such as numbers-at-age, fishery selectivity, fishery mortality, and spawning biomass. Specific inputs to the OM (e.g., recruitment deviations) were tuned to account for different structure in the two models until the comparisons matched. Parameters with the same concept in the two models (e.g., natural mortality) were not changed unless there was a different interpretation between the two models. Functional forms that were implemented differently, such as the double normal selectivity, were parameterized by finding the parameters for the OM that minimized the difference between the SS selectivity-at-age and the OM selectivity-at-age.

The output quantities from the models built using the OM code matched very closely to the outputs from the short coastwide and long coastwide assessment models using SS (Figure 2). Slight differences between the two models are due to minor differences in the assumptions of processes and the rounding of parameters input into the OM. The spawning biomass trajectories from the two models are a near-exact match suggesting that the calculations in the OM are valid, for at least these assumptions.

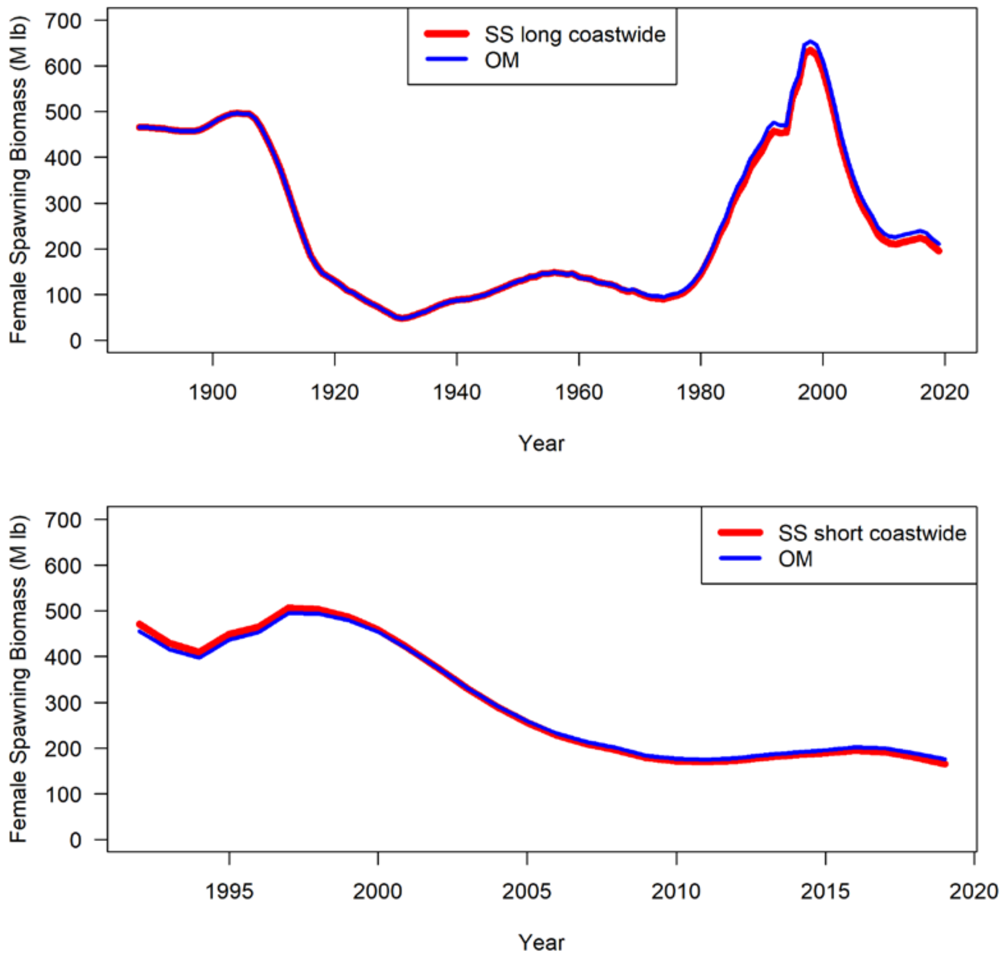

Figure 2: Predicted spawning biomass trajectories from the operating model (OM, blue) and the long coastwide (top) and short coastwide (bottom) assessment models using Stock Synthesis (SS, red).

Further exploration was done by projecting the short and long coastwide OM models forward one-hundred years using a constant total mortality, a constant weight-at-age equal to the weight-at-age in 2019, and no further changes in commercial selectivity. Annual recruitment variability was simulated along with recruitment regimes for low and high average recruitment. Total mortality levels were allocated to sectors as was done with the coastwide MSE (i.e., non-directed discard mortality (bycatch) and subsistence are assigned random values from pre-defined distributions even when total mortality was zero, recreational is determined from a relationship with total biomass, and commercial is allocated the remainder). A ‘No Fishing’ procedure was also simulated which set the total mortality to zero for all sectors.

The one-hundred year projections (a single trajectory) show that spawning biomass is reduced with higher mortality levels (Figure 3, left panels), but varies due to recruitment variability. The relative spawning biomass reaches 1.0 with no fishing mortality, and stabilizes at levels less than 1.0 when fishing mortality is applied (Figure 3, right panels). Note that a zero constant total mortality procedure still implies some non-directed discard mortality.

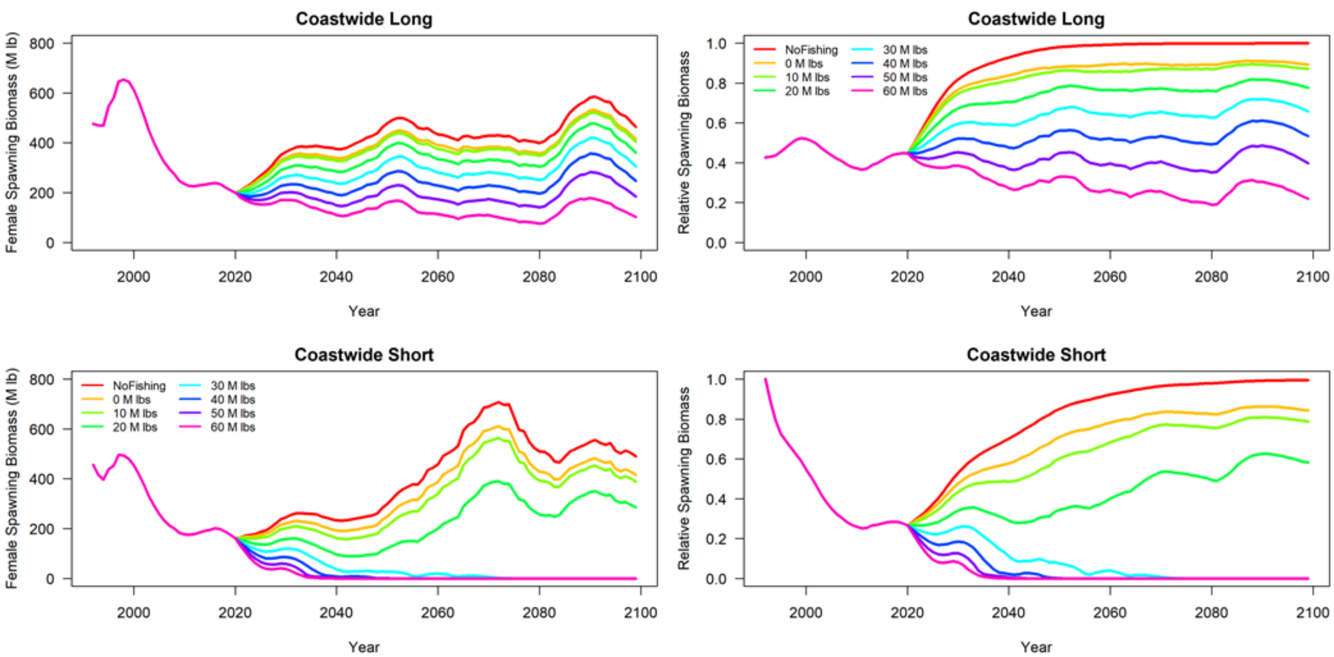

Figure 3: Projections of female spawning biomass (M lb, left) and relative spawning biomass (right) for the coastwide long and coastwide short operating models under different constant total mortality procedures. The 'No Fishing' procedure is zero fishing mortality from all fisheries. The '0 M lbs' procedure has some fishing mortality from the non-directed discards. These trajectories are a single trajectory and does not incorporate the full range of uncertainty. Therefore, labels indicate the procedure name and not necessarily the actual realized total mortality.

2.2 Conditioning multi-area operating models

Multi-area OMs are still being conditioned at the time of writing this document. It is expected that these models will be presented at MSAB015.

The multi-area OMs are conditioned by comparing OM outputs to various outputs from the coastwide assessment ensemble and to regional data sources. Specifically, the coastwide predicted spawning biomass, regional survey trends, regional stock distribution, and survey and fishery age compositions are used in the conditioning process. The conditioning is currently done manually because an optimization routine has not yet been implemented in the OM.

2.3 Characterizing uncertainty

Uncertainty is characterized in two ways. First, for an individual operating model, input parameters were varied by randomly choosing a parameter from a reasonable range or identifying key values of specific parameters to include in an experimental design approach. Second, projections included random variation of weight-at-age, deviations of recruitment from the mean recruitment determined from the stock-recruit relationship, recruitment regimes affecting average recruitment, and commercial selectivity. More detail is given in IPHC-2020-MSAB015-08.

2.4 VERIFY THE FRAMEWORK

The management procedure component of the framework is currently being verified in a number of ways, including repeating some of the simulations performed with the coastwide MSE framework. Some of these verifications are presented below and results relative to the emulation of the coastwide MSE framework will be presented at MSAB015.

2.4.1 Data generation and the estimation models

Estimation error is inherent to the management process and is due to uncertainty in the data and the structural assumptions of the assessment models. To simulate estimation error of management quantities an ensemble of estimation models is used, which is analogous to the stock assessment. This is a more sophisticated approach than the one used in the past coastwide MSE because it generates data with error from the OM and then estimates management quantities using two estimation models to mimic the stock assessment ensemble. This approach will capture the correlated error and potential biases in the estimated management quantities.

The two estimation models are combined as an ensemble to represent a simplified version of the stock assessment ensemble currently used for Pacific halibut. The two coastwide models were chosen from the four currently used in the stock assessment ensemble and streamlined to increase efficiency and reduce the time of the MSE simulations, yet retain the complexity and uncertainty captured by the full stock assessment ensemble. The short and long coastwide models represent the uncertainty in natural mortality rates (estimated in the long time-series but fixed for females in the short time-series), the environmental effect on recruitment (estimated only in the long time-series), as well as other structural and parameter assumptions.

The streamlining of the coastwide models consisted of reducing the amount of data included (e.g. fewer years with age composition, long coastwide model starting from 1935, etc.) and fixing some of the estimated parameters. This considerably reduces the run time, but retains the overall stock perception (and structural uncertainty), especially for the most recent years (Figure 4).

The OM simulates a population from which it is possible to derive data similar to observations from the actual Pacific halibut fishery. More specifically, numbers-at-age for each sex in each region is calculated for each year of the simulated population, and given numbers-at-age, selectivity at age, weight-at-age, and provided assumptions on catchability, various indices of abundance (i.e. NPUE and CPUE) and proportions-at-age for each fishery can be derived. Appropriate error is then introduced to these simulated observations to represent the data sampled from the fishery.

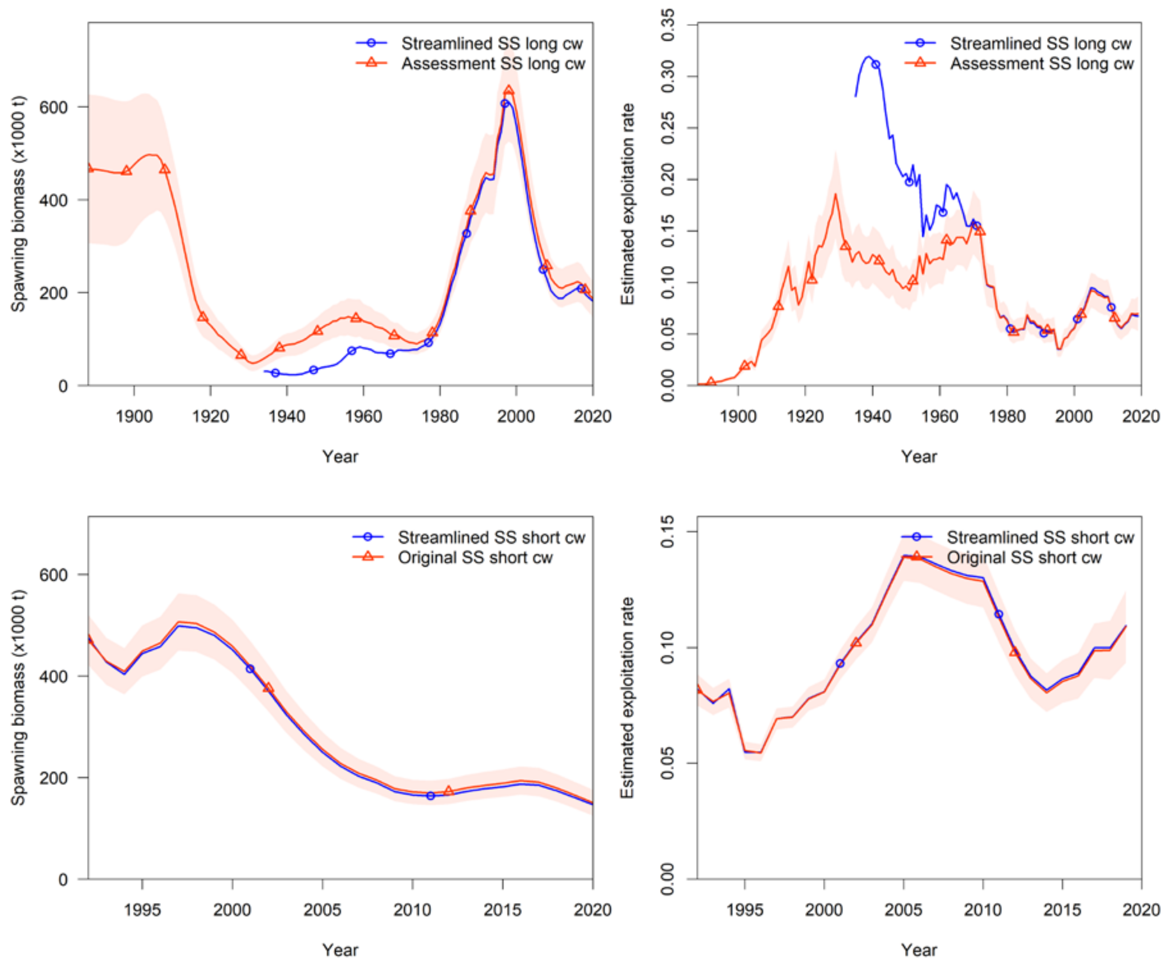

Figure 4: A comparison between the streamlined (blue lines) long coastwide (top panels) and short coastwide (bottom panels) estimation models and the assessment models (red lines) used in the ensemble for Pacific halibut.

The conditioned long and short coastwide OMs were used to verify the data generation code. Index data (NPUE and WPUE) generated from these OMs are very similar to the data used in the 2019 stock assessment (Figure 5). The differences observed are due to the OM overestimating the numbers-at-age, compared to the stock assessment model, and to some small differences in the selectivity-at-age. These data could be used when conditioning the OMs to reduce these differences. Furthermore, the generation of catch-at-age from these OMS are similar to the observed catch-at-age used in the 2019 stock assessment (not shown here).

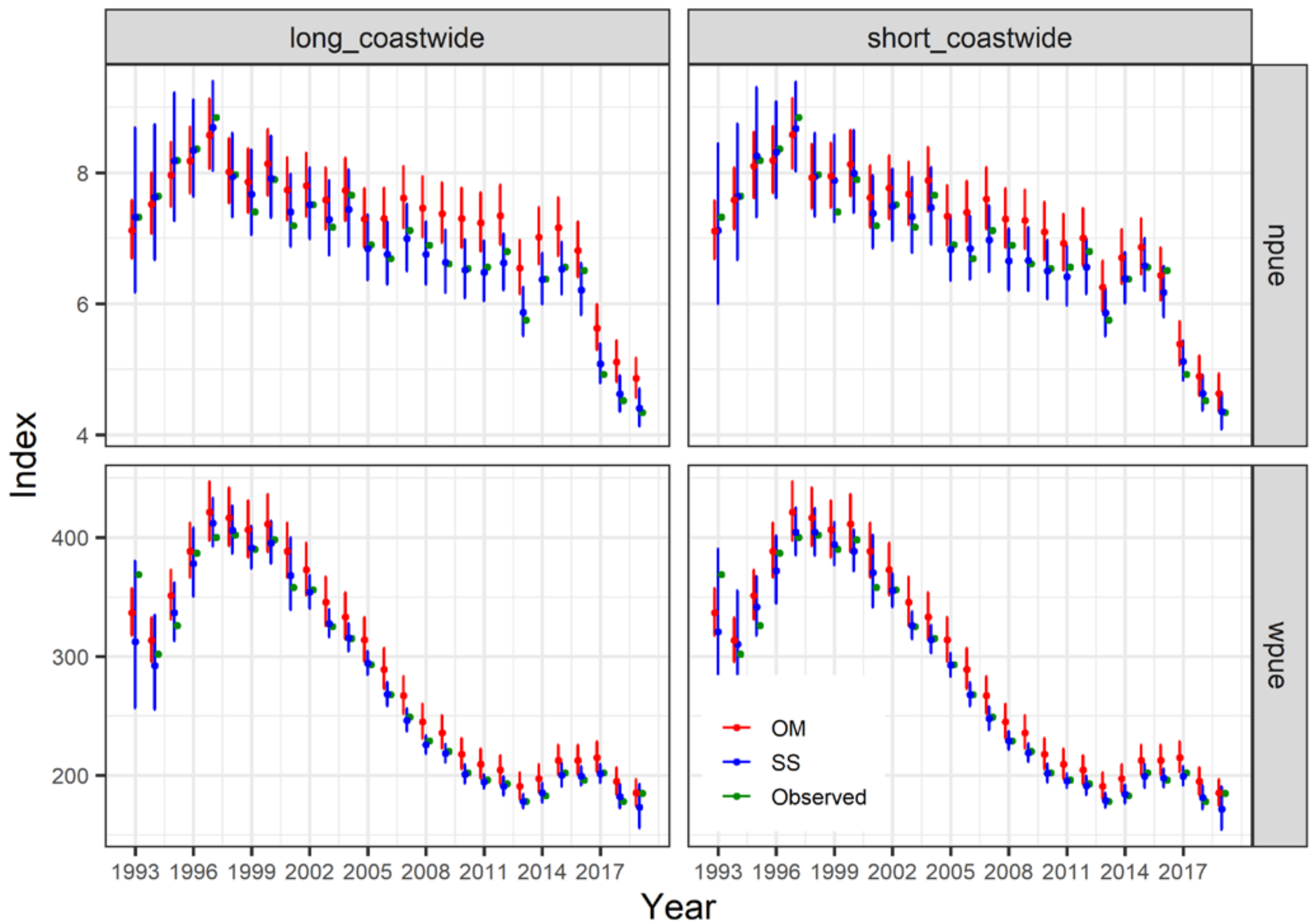

Figure 5: A comparison between generated indices from long coastwide (panels to the left) and short coastwide (panels to the right) OMs (red lines) and estimated values from the long and short coastwide 2019 stock synthesis (SS) assessment models respectively (blue lines) for the survey NPUE (top panels) and the commercial WPUE (bottom panels). Observed data (green points) from the sampling programs are included for reference.

3 SIMULATION RESULTS

Simulation results were not complete at the time of publication and will be presented and discussed during MSAB015.

4 RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2020-MSAB015-09 Rev_1 which present preliminary results from the IPHC MSE simulations incorporating scale and distribution components of the management procedure.
2) **NOTE** that the verification of the OM and framework matched coastwide expectations closely.
3) **RECOMMEND** additional performance metrics and methods to present results for evaluation at MSAB016.

5 ADDITIONAL DOCUMENTATION / REFERENCES

IPHC-2019- MSAB014-09. 2019. IPHC Secretariat Program of Work for MSAB Related Activities 2019-23. 20 September 2019. 17 pp. https://iphc.int/uploads/pdf/msab/msab014/iphc-2019-msab014-09.pdf

IPHC-2019-MSAB014-R. Report of the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014). Seattle, WA, U.S.A. 21–24 October 2019. 27 pp. https://iphc.int/uploads/pdf/msab/msab014/iphc-2019-msab014-r.pdf

Methot, R.D., and Wetzel, C.R. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fish. Res. 142(0): 86-99. doi:http://dx.doi.org/10.1016/j.fishres.2012.10.012