Updates to evaluations of the current interim harvest policy

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PURPOSE

To provide the Management Strategy Advisory Board (MSAB) with additional evaluations performed since the 17th Session of the IPHC Management Strategy Advisory Board (MSAB017) and improvements to the MSE framework.

BACKGROUND

Evaluations of size limits and multi-year assessments were completed in 2022 and provided at the 99th Session of the IPHC Annual Meeting (AM099) in document IPHC-2023-AM099-13. Some additional simulations for a small set of management procedures (MPs) were performed between MSAB017 and AM099 to reduce Monte Carlo error (e.g, increase the precision of the performance metrics). Additionally, some additional scenarios were simulated that assumed the PDO was always high or always low.

The fisheries in the operating model (OM) are specified by IPHC Regulatory Area because many of the Commission objectives used to evaluate MPs are specific to IPHC Regulatory Areas and the OM is spatially structured by Biological Region. This makes it necessary to distribute the TCEY across the fisheries to appropriately remove biomass from each Biological Region and allow for the calculation of necessary performance metrics. Even though distribution procedures are not currently being evaluated and there is no specific agreement on a single distribution procedure, they are part of the MP and need to be included in the simulations. Therefore, these simulations follow Commission advice from the 12th Special Session of the IPHC (SS012) and integrate over five distribution procedures.

> **IPHC-2022-SS012-R, para 11**: *The Commission RECOMMENDED the following five distribution procedures to be used in the management strategy evaluation of size limits and multi-year assessments, noting that these distribution procedures are for analytical purposes only and are not endorsed by both parties, thus would be reviewed in the future if the Commission wishes to evaluate them for implementation.*
>
> > *a) Baseline based on recent year O32 FISS results, relative harvest rates of 1.0 for IPHC Regulatory Areas 2-3A, relative harvest rates of 0.75 for IPHC Regulatory Areas 3B-4, and no application of the current interim agreements for 2A and 2B;*
> >
> > *b) Baseline based on recent year O32 FISS results, relative harvest rates of 1.0 for IPHC Regulatory Areas 2-3A, relative harvest rates of 0.75 for IPHC Regulatory Areas 3B-4, and current interim agreements for 2A and 2B;*

c) Baseline based on recent year O32 FISS results with 1.65 Mlbs to 2A and 20% of the coastwide TCEY to 2B;

d) Baseline based on recent year O32 FISS results, relative harvest rates of 1.0 for IPHC Regulatory Areas 2-3, 4A, and 4CDE, a relative harvest rate of 0.75 for IPHC Regulatory Area 4B, and no agreements for 2A and 2B;

e) Baseline based on recent year O32 FISS results, relative harvest rates of 1.0 for IPHC Regulatory Areas 2-3, 4A, and 4CDE, a relative harvest rate of 0.75 for IPHC Regulatory Area 4B, and current interim agreements for IPHC Regulatory Areas 2A and 2B

Three of the five distribution procedures contain agreements for IPHC Regulatory Areas 2A and 2B (b, c, and e). Decision-making variability for these two areas is set to zero when agreements are in place.

This document describes the results from the additional simulations and discusses further improvements to the MSE framework.

ADDITIONAL SIMULATIONS FOR AM099

The simulations for MSAB017 and AM099 integrated four individual models in the OM and five distribution procedures. For each model and each distribution procedure, the same set of randomly generated values are used (e.g. future recruitments, weight-at-age, PDO, etc.) so that one combination of OM model and distribution procedure does not randomly overwhelm the results, and comparisons would be meaningful across models, if desired. However, this results in a reduced effective sample size (replicates) compared to a truly random process. These concerns are alleviated with more replicates, but each replicate takes hours, resulting in a trade-off between precision of the results and time spent running simulations.

For MSAB017, 500 replicates were performed for most management procedures (see http://shiny.westus.cloudapp.azure.com/shiny/sample-apps/IPHC-MSE-MSAB017/). Therefore, there were 25 replicates for each OM model and distribution procedure combination. This provided insights into the performance of many MPs, but may not be an accurate representation of the distribution of potential outcomes.

The number of replicates was increased to 1100 (55 for each combination) for a small set of MPs to present at AM099 (see http://shiny.westus.cloudapp.azure.com/shiny/ sample-apps/IPHC-MSE-AM099/). This small set included three (3) size limits (none, 26-inches, and 32-inches that are labelled MP-A0, MP-A26, and MP-A32, respectively), three biennial assessment options (Table 1) with a 32-inch size limit (labeled MP-Ba32, MP-Bb32, and MP-Bc32), and one option with a triennial assessment (option b in Table 1) and a 32-inch size limit (labelled MP-Tb32). These seven (7) MPs were all projected with an SPR equal to 43% and simulated decision-making variability (only on the distribution of the TCEY). Five of the MPs (MP-A0, MP-A26, MP-A32, MP-Bb32, and MP-Tb32) were also simulated with no decision-making variability. All results can be viewed on the MSE Explorer for AM099, and some results are presented in IPHC-2023-AM099-13. Some insights are provided here.

Table 1. Three options for setting the TCEY in non-assessment years for the multi-year management procedures.

a. The same TCEY from the previous year for each IPHC Regulatory Area.
b. Updating the coastwide TCEY proportionally to the change in the coastwide FISS O32 WPUE and updating the distribution of the TCEY using FISS results and the applied distribution procedure.
c. Maintaining the same coastwide TCEY as the previous year but updating the distribution of the TCEY using FISS results and the applied distribution procedure.

Focusing on the five MPs and four objectives shown in Table 2, the differences are minor. However, greater differences were observed in long-term performance metrics related to the TCEY. For example, the long-term median average TCEY for MP-A32 was 72.1 Mlbs with 500 replicates, but was 62.2 Mlbs with 1100 replicates. Overall, the interpretations and comparisons from MSAB017 are valid and consistent with the updated results presented at AM099.

Table 2. Results of five MPs with 500 replicates (MSAB017) and 1100 replicates (AM099). The first two performance metrics (probabilities) are long-term statistics and the second two (TCEY) are short-term (4-14 years).

MP name	**MP-A0**	**MP-A26**	**MP-A32**	**MP-Bb32**	**MP-Tb32**
Assessment Frequency	**Annual**	**Annual**	**Annual**	**Biennial**	**Triennial**
Size Limit	**0**	**26**	**32**	**32**	**32**
Empirical Rule	**–**	**–**	**–**	**b**	**b**
500 replicates					
P(RSB<20%)	PASS	PASS	PASS	PASS	PASS
P(RSB<36%)	0.143	0.143	0.148	0.156	0.225
Median TCEY	60.1	59.8	58.2	58.5	58.4
Median AAV TCEY	18.0%	18.2%	18.5%	19.0%	14.2%
1100 replicates					
P(RSB<20%)	PASS	PASS	PASS	PASS	PASS
P(RSB<36%)	0.174	0.174	0.180	0.164	0.197
Median TCEY	60.5	59.9	58.3	58.5	58.3
Median AAV TCEY	17.2%	17.5%	17.8%	17.0%	14.1%

EFFECTS OF THE PDO ON REFERENCE POINTS AND DISTRIBUTION

Document IPHC-2019-SRB015-11 showed that, for Pacific halibut, biomass-based reference points, such as MSY and B_0, are affected by a change in environmental regime, but relative reference points, such as relative spawning biomass (RSB) and SPR_{MSY}, are similar across regimes. This indicates that a consistent SPR-based management regime is likely robust across different environmental regimes. Analyses presented in this document looking at high and low PDO regimes shows similar results, and also provides performance metrics specific to the IPHC MSE.

The median relative spawning biomass (RSB) when fishing at an SPR equal to 43% was similar for the high and low PDO scenarios (Table 3 and Figure 1). However, even though the median was near 36%, there was a higher probability that the RSB was less than 36% for the low PDO scenario. The long-term median TCEY was 18% less for the low PDO scenario and 18% more for the high PDO scenario when compared to the median TCEY for the base simulations that modelled PDO regime shifts. Short-term median TCEYs were less different. Inter-annual variability in the TCEY was similar across the PDO scenarios.

Table 3. Performance metrics related to primary objectives for scenarios with modeled cycles of PDO (both), always low PDO (Low), and always high PDO (High) with an annual assessment, estimation error, and decision-making variability. Long-term results are shown for all performance metrics and short-term (4–13 years) results are also shown for fishery sustainability TCEY metrics.

MP name	**MP-A32**	**MP-A32**	**MP-A32**
PDO	**Both**	**Low**	**High**
SPR	**0.43**	**0.43**	**0.43**
Replicates	1100	1100	1100
Long-Term Metrics			
Median RSB	38.8%	38.3%	39.4%
P(RSB_y<20%)	<0.001	<0.001	<0.001
P(RSB<36%)	0.180	0.231	0.114
Median TCEY	62.21	50.88	73.35
P(any3 change TCEY > 15%)	0.852	0.844	0.832
Median AAV TCEY	16.3%	16.9%	16.4%
Short-term Metrics (4-13 yrs)			
Median TCEY	58.3	56.0	61.7
P(any3 change TCEY > 15%)	0.906	0.895	0.896
Median AAV TCEY	17.8%	17.6%	17.6%

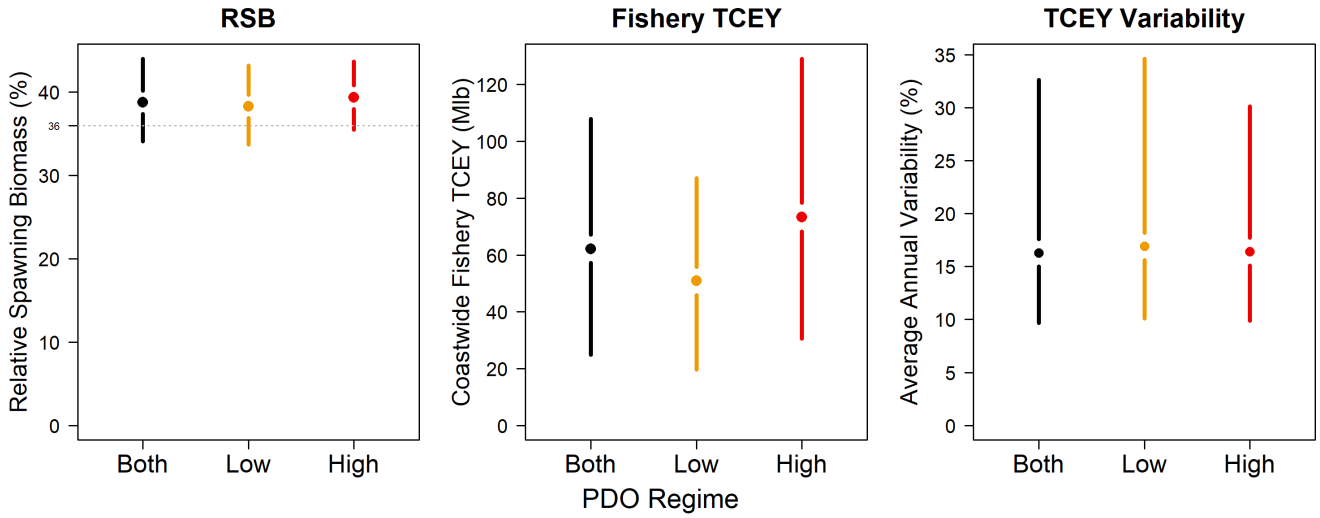

Figure 1. Long-term Relative Spawning Biomass (RSB), TCEY, and AAV for the base simulations modelling PDO regime shifts and the low and high PDO scenarios. The target RSB objective of 36% is shown as a horizontal dashed line.

The percentage of spawning biomass in each Biological Region is affected by fishing under an SPR-based management procedure integrated over five distribution procedures (Figure 2). The distribution of spawning biomass across the Biological Regions is also affected by the PDO regime because movement, recruitment distribution, and average recruitment are dependent on the PDO regime. Region 2 shows a reduction in the percentage of spawning biomass with fishing, and the low PDO results in a higher percentage. Region 3 shows a slight reduction in the percentage of spawning biomass with fishing and a higher percentage of spawning biomass with a high PDO. Region 4 shows a higher percentage of spawning biomass with fishing and is largely unaffected by the PDO regime. Region 4B has variable results with fishing and across PDO regimes.

Even though we cannot “manage” the PDO regime, it is useful to understand the effects of the PDO regime on the results, allowing for the separation of the effects of fishing from the effects of the environment. For Pacific halibut, the environment sometimes may have a larger effect on the distribution of spawning biomass than fishing does (at an SPR of 43% using the five distribution procedures defined earlier).

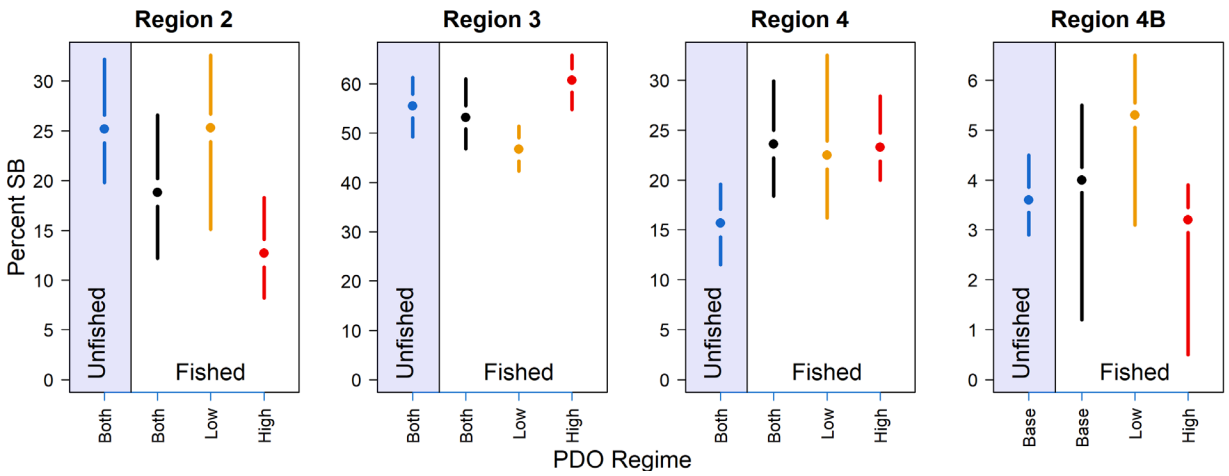

Figure 2. Percentage of spawning biomass in each Biological Region for an unfished population and for a fished population.

SPECIFYING OBJECTIVES

The Commission defined a small set of priority coastwide objectives and associated performance metrics for current evaluations.

> **IPHC-2023-AM099-R, para. 76.** The Commission **RECOMMENDED** that for the purpose of a comprehensive and intelligible Harvest Strategy Policy (HSP), four coastwide objectives should be documented within the HSP, in priority order:
>
> a) Maintain the long-term coastwide female spawning stock biomass above a biomass limit reference point (B20%) at least 95% of the time.
>
> b) Maintain the long-term coastwide female spawning stock biomass at or above a biomass reference point (B36%) 50% or more of the time.
>
> c) Optimise average coastwide TCEY.
>
> d) Limit annual changes in the coastwide TCEY.
>
> **IPHC-2023-AM099-R, para. 77**. The Commission AGREED that the performance metrics associated with the objectives in Paragraph 76 are:
>
> a) P(RSB): Probability that the long-term Relative Spawning Biomass (RSB) is less than the Relative Spawning Biomass Limit, failing if the value is greater than 0.05.
>
> b) P(RSB<36%): Probability that the long-term RSB is less than the Relative Spawning Biomass Reference Point, failing if the value is greater than 0.50.
>
> c) Median TCEY: the median of the short-term average TCEY over a ten-year period, where the short-term is 4-14 years in the future.
>
> d) Median AAV TCEY: the average annual variability of the short-term TCEY determined as the average difference in the TCEY over a ten-year period.

These priority objectives and performance metrics (also presented in Table 4) come from a larger list of objectives which includes objectives specific to Biological Regions and IPHC Regulatory Areas.

UPDATING THE OPERATING MODEL

The evaluations presented at AM099 and in this document were based on an operating model consisting of four multi-region models that were conditioned using data, results, and assumptions from the 2021 stock assessment (IPHC-2022-SA-01). Two of these OM models used high values of natural mortality (*M*) based on the two stock assessments that estimated *M* (0.195 for females and 0.174 for males), and two models used low values of natural mortality (*M*) based on the two stock assessments that assumed a fixed value for female *M* (0.15 for females and 0.146 estimated for males). MSE projections were integrated over these four models.

At AM099, a full stock assessment was also presented that estimated natural mortality in three out of four of the models in the ensemble (IPHC-2023-SA-01), as opposed to only two models in previous years. The new estimate of female *M* in the model that previously fixed female *M* was greater than the previous fixed value of 0.15. Comparison of 2022 ensemble stock assessment results with previous stock assessments indicates that the estimates of spawning biomass from the 2022 ensemble were consistent with those from the 2012-2021 assessments. However, projections were more optimistic because of the increase in estimated productivity of the stock resulting from 3 out of 4, rather than 2 out of 4 models, with higher natural mortality.

Updating the model in the OM (medAAF_lowM) that corresponded to the previous assessment model with a fixed M that was subsequently estimated in the 2022 assessment would result in different outcomes, but the comparison across MPs is likely to be similar since all MPs would contain the update. Furthermore, the MSE simulations included variability in natural mortality, thus even with a change in the median value of *M* there will still be some overlap with past simulations.

Figure 3 shows that the median average long-term relative spawning biomass is similar for each model in the OM, but the median average short-term TCEY differs for the areas-as-fleets model with a higher M (medAAF). The median TCEY is likely to increase when replacing the medAAF_lowM with an areas-as-fleets model in the OM based on the recent 'short AAF' model in the stock assessment. The value of M is not the sole driver of the increase in TCEY, as seen with the low TCEY in the medCW model. Other parameters, such as unfished recruitment (R_0) also affect productivity and yield.

Table 4. Priority coastwide objectives.

General Objective	Measurable Objective	Measurable Outcome	Time-frame	Tolerance	Performance Metric
1.1. Keep female spawning biomass above a limit to avoid critical stock sizes and conserve spatial population structure	Maintain a female spawning stock biomass above a biomass limit reference point at least 95% of the time	SB < Spawning Biomass Limit (SB_{Lim}) SB_{Lim}=20% unfished spawning biomass	Long-term	0.05	$P(SB < SB_{Lim})$ PASS/FAIL
2.1 Maintain spawning biomass around a level that optimizes fishing activities	Maintain the coastwide female spawning biomass above a biomass target reference point at least 50% of the time	SB<Spawning Biomass Target (SB_{Targ}) SB_{Targ}=36% unfished spawning biomass	Long-term	0.50	$P(SB < SB_{Targ})$
2.3. Provide Directed Fishing Yield	Optimize average coastwide TCEY	Median coastwide TCEY	Short-term		Median $\overline{TCEY}$
2.2. Limit Variability in Mortality Limits	Limit annual changes in the coastwide TCEY	Median coastwide Average Annual Variability (AAV)	Short-term		Median AAV

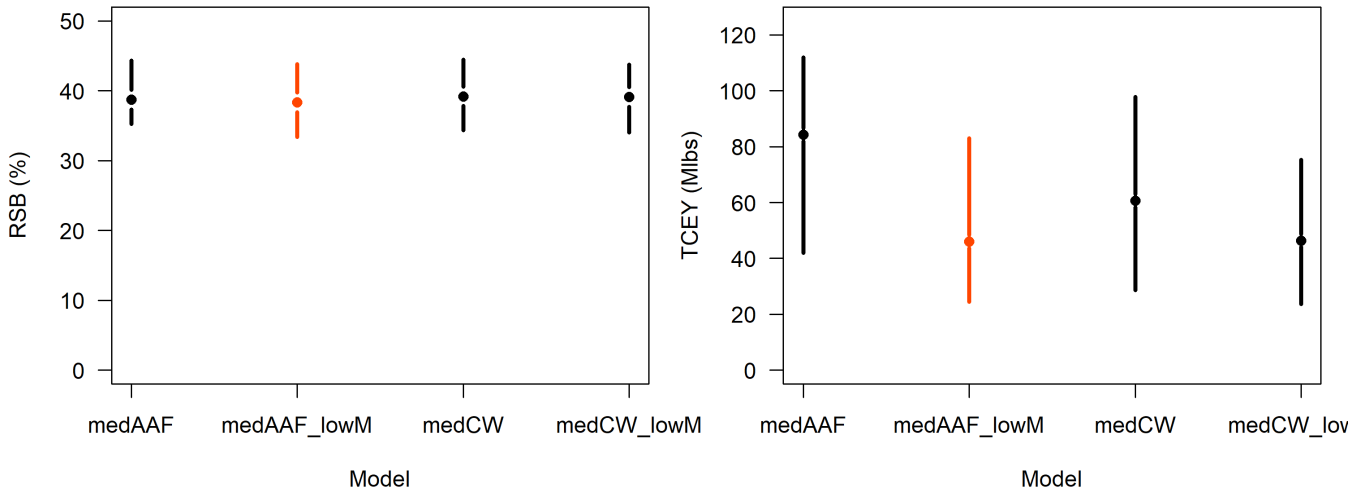

Figure 3. Median (circle) and 5th and 95th quantiles (lines) for long-term relative spawning biomass and short-term TCEY for each model in the OM. The medAAF_lowM model (red) would be updated to use a higher natural mortality to correspond to the 2022 stock assessment.

The reference SPR of 43% has been supported by the MSAB for a number of reasons, such as to avoid triggering the control rule and to reduce interannual variability in the TCEY. The similarities of the relative spawning biomass in Figure 3 suggest that an updated OM would not change the basis for an SPR of 43%. However, once the OM is updated to correspond to the 2022 stock assessment, simulations will be performed to investigate this.

RECOMMENDATION/S

1) The MSAB **NOTE** paper IPHC-2023-MSAB018-06 presenting simulations performed since MSAB017, priority objectives defined by the Commission, and potential outcomes after updating the operating model.
2) The MSAB **NOTE** that additional simulations beyond those presented at MSAB017 resulted in more precise and slightly different values of the performance metrics, but the comparisons between management procedures remained the same.
3) The MSAB **NOTE** that different PDO regimes (i.e. always high or always low)
    a. had little effect on the priority conservation objective, but low PDO resulted in low TCEYs and high PDO resulted in high TCEYs;
    b. affected the long-term distribution of spawning biomass differently in each Biological Region and;
    c. may have as much or a larger effect on the long-term distribution of spawning biomass in each Biological Region than fishing with the current interim harvest strategy policy does.

APPENDICES

Nil