IPHC Secretariat MSE Program of Work (2023) and an update on progress

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PURPOSE

To provide the Scientific Review Board (SRB) with an update on MSE progress in 2023 and potential tasks for 2023–2025.

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 (October 2022) and AM099 (January 2023) to reduce Monte Carlo error (e.g, increase the precision of the performance metrics). Specific scenarios have also been simulated that assumed the PDO was always high or always low.

This document describes the results from the additional simulations and outcomes of AM099. Additionally, potential MSE-related tasks for 2023–2025 are presented including further updating the operating model (OM), MPs to investigate, and defining exceptional circumstances.

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.) This allows for the most direct comparison across management procedures with the smallest number of simulations. However, it does require monitoring of Monte-Carlo error and associated precision of the results, creating a trade-off between the number of MPs and scenarios that can be investigated and the number of replicates for each.

For MSAB017, 500 replicates were performed for a large number of 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 an initial comparison of the performance of many MPs, but may be imprecise for some metrics, especially those occurring with low probability.

Therefore, the number of replicates was increased to 1100 (55 for each combination) for a small set of focal 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 due to increased precision are minor. However, greater differences were observed in long-term performance metrics related to the TCEY (not shown). 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 strongly 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 approach is likely robust across different environmental regimes. Analyses presented in this document looking at high and low PDO regimes show similar results, and also allow for the calculation of 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 integrated across PDO regime shifts. Short-term median TCEYs were less affected by the PDO. Inter-annual variability in the TCEY was similar across the PDO scenarios.

Table 3. Performance metrics related to primary objectives for scenarios integrating over cycles of PDO (both), always low PDO (Low), and always high PDO (High) with an annual assessment, estimation error, and decision-making variability (MP-A32) and an SPR of 43%. Long-term results are shown for all performance metrics and short-term (4–13 years) results are also shown for fishery-related (TCEY) metrics.

PDO	Both	Low	High
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%

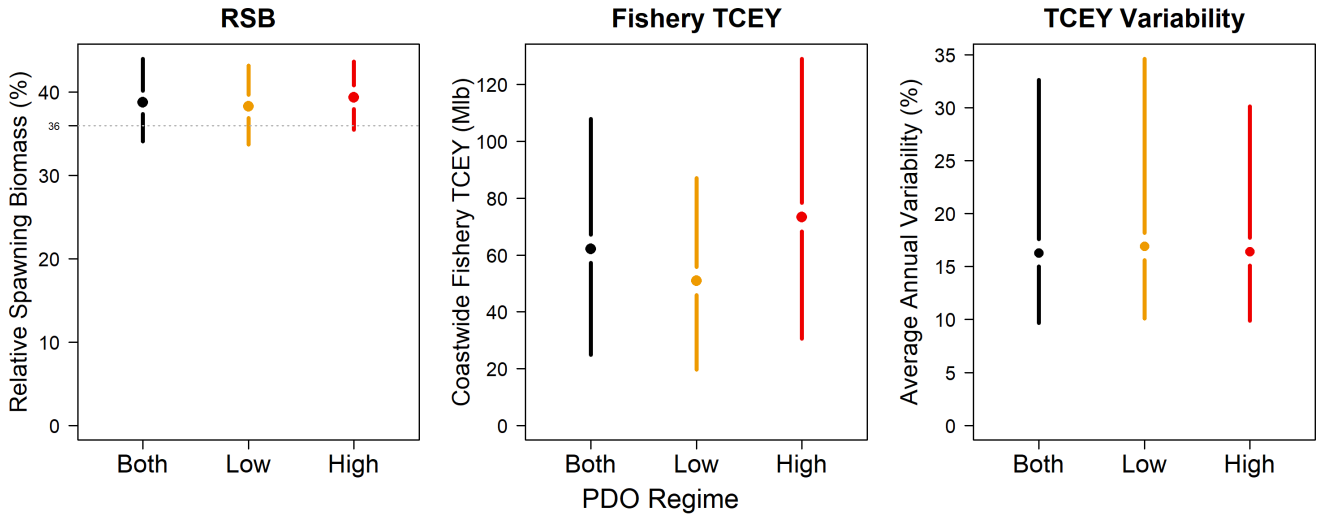

Figure 1. Long-term Relative Spawning Biomass (RSB), TCEY, and AAV for the base simulations integrating over PDO regime shifts (both) and using only low or high PDO scenarios. The reference RSB of 36% is shown as a horizontal dashed line.

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 may sometimes 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).

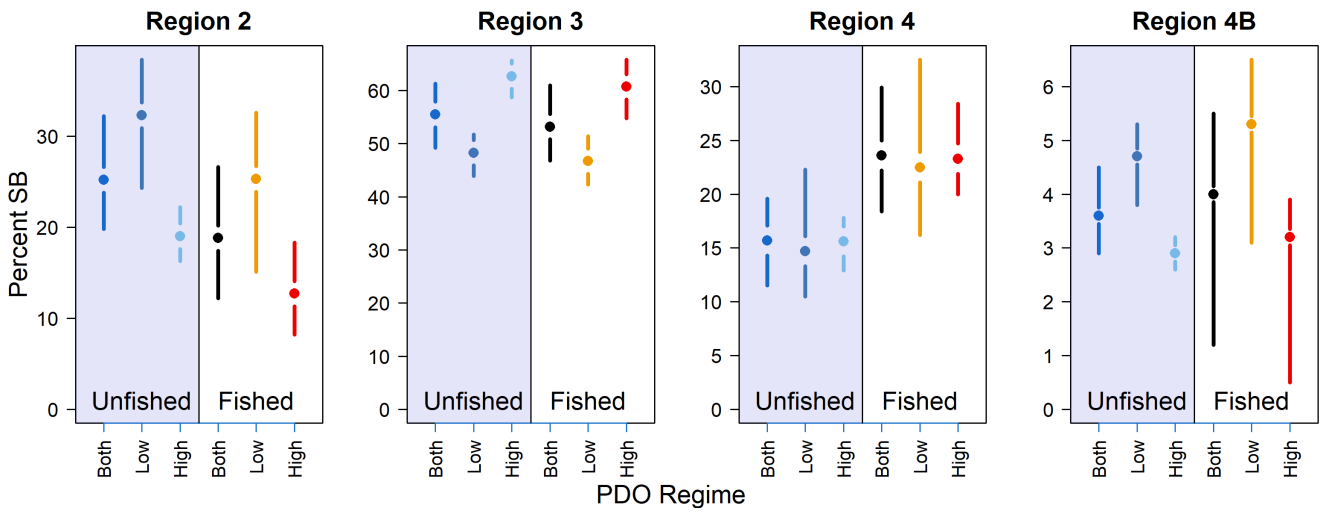

Figure 2. Percentage of spawning biomass in each Biological Region when fished with an SPR of 43% and when not fished. The PDO is modelled with low and high periods in "Both", is persistently low in "Low", and is persistently high in "High".

OUTCOMES OF AM099

The MSE Program of Work for 2021–2023 was completed and delivered at the 99th Session of the IPHC Annual Meeting (AM099; see IPHC-2023-AM099-13). The MSE framework was improved and results investigating size limits and multi-year assessments were presented and evaluated using priority objectives with associated performance metrics.

> **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 (Appendix A). Objective 2.1 has changed slightly, indicating to maintain the spawning biomass at or above a reference level. This was done to allow for the evaluation of trade-offs between the priority objectives, rather than tuning to a specific target that may have less than optimal yield-related outcomes.

Pertinent to size limits and multi-year assessment MPs, the Commission agreed to the following.

> **IPHC-2023-AM099-R, para. 84:** The Commission **AGREED** sufficient analysis has been completed and **RECOMMENDED** not to change the current 32 inch size limit.

> **IPHC-2023-AM099-R, para. 85**: The Commission **AGREED** that there is utility in continuing to explore multi-year stock assessment management procedures, in a manner consistent with the advice from SRB and MSAB.

Without an agreed upon distribution procedure, the recent MSE simulations integrated over five potential distribution procedures (see IPHC-2022-SS012-R, para 11). The Commission acknowledged that a distribution procedure has not been agreed upon at this time and provided the following.

> **IPHC-2023-AM099-R, para. 87:** The Commission **AGREED** that following agreement about a distribution procedure, the IPHC Secretariat and MSAB should reassess multi-year stock assessment management procedures, as well as coastwide elements of a management procedure such as the SPR value.

The advice from the 2022 full stock assessment (IPHC-2023-SA-01) using the current interim management procedure with an SPR of 43% was a TCEY of 52.0 Mlbs. This TCEY was higher than expected from previous assessments largely because natural mortality (*M*) was estimated higher than a previously fixed value in one of four models in the stock assessment ensemble, thus increasing the perceived productivity of the stock. In contrast to this optimistic advice, the coastwide FISS index of O32 WPUE was at its lowest value observed in the time-series (declining by 8% from the previous year) and a TCEY of 52.0 Mlbs in 2023 would have a 75% chance of a lower spawning biomass in 2024 (IPHC-2023-SA-01). The Commission departed from the current interim management procedure and chose a TCEY of 36.97 Mlbs, noting

> **IPHC-2023-AM099-R, para. 94.** The Commission **NOTED** that the adopted mortality limits for 2023 correspond to a 38% probability of stock decline through 2024, and a 36% probability of stock decline through 2026.

Although the status of the stock was above the reference relative spawning biomass of 36% and had a small chance (25%) of falling below 30% at any TCEY up to 60 Mlbs, the Commission decided to reduce the TCEY from the TCEY determined using the reference harvest level. This

decision illustrated an additional Commission objective not currently included in those used by the MSE, perhaps relating to fishery performance and/or survey catch rates relative to recent historical experience. Further exploration of this potential objective may be important to future work and will be explored during MSAB018.

The Commission also requested the investigation of exceptional circumstances, especially with respect to multi-year assessments.

> **IPHC-2023-AM099-R, para. 88**: **NOTING** paragraph 60 from the 21st Session of the SRB (SRB021), the Commission **REQUESTED** the Secretariat develop a description of options to responding to exceptional circumstances that would trigger a stock assessment in non-assessment years and additional MSE analyses.
>
> > IPHC-2022-SRB021-R, para 60: *The SRB RECOMMENDED that Exceptional Circumstances be defined to determine whether monitoring information has potentially departed from their expected distributions generated by the MSE. Declaration of Exceptional Circumstances may warrant re-opening and revising the operating models and testing procedures used to justify a particular management procedure*

As noted above by the SRB, an exceptional circumstance is a defined event that would result in re-examination of the MSE process to determine if an update to the framework and evaluation of management procedures is necessary. An exceptional circumstance, in an MSE context, is not usually defined to trigger an action within the management procedure, but a trigger can be defined in a management procedure such that action does take place. An example is the 30:20 control rule which defines a reduction in the fishing intensity when stock status is less than 30%. A similar trigger could be defined that indicates an assessment should be done in a year when one was normally not scheduled.

POTENTIAL MSE-RELATED TASKS FOR 2023–2025

Based on outcomes from AM099, there are a number of useful tasks for the MSE. These include updating the OM to be consistent with the recent full stock assessment, defining a set of MPs for evaluation, and defining exceptional circumstances.

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;* 0.195 for females and 0.174 for males) based on the two stock assessments that estimated *M*, and two models used low values of natural mortality (0.15 for females and 0.146 estimated for males) based on the two stock assessments that assumed a fixed value for female *M*. MSE projections were integrated over these four models.

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 at or above a level that optimizes fishing activities	Maintain the long-term coastwide female spawning stock biomass at or above a biomass reference point (B36%) 50% or more 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

At AM099, a full stock assessment was 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. A 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 due in part to 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 previous OM (medAAF_lowM) that corresponded to the previous assessment model with a fixed *M* (but was subsequently estimated at a higher value) would result in different outcomes, but the comparison of relative performance across MPs is likely to be similar since all MP evaluations 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.

Given that the 2022 stock assessment was a full assessment, and there was a significant paradigm shift, it would be prudent to develop a newly conditioned OM using this full assessment as a guide. Furthermore, reconditioning the OM immediately following an accepted full stock assessment (which occurs every three years) would maintain some congruency between the stock assessment and the MSE.

The process of developing an updated OM involves the following. First, four models are being conditioned based on each of the four stock assessment models.

OM1_longAAF: Starts in 1958. Parameters taken from the long AAF stock assessment model.

OM2_shortAAF: Starts in 1992. Parameters taken from the short AAF stock assessment model.

OM3_longCW: Starts in 1958. Coastwide parameters taken from the long coastwide stock assessment model. Region- and fishery-specific parameters taken from the long AAF stock assessment model.

OM2_shortCW: Starts in 1992. Coastwide parameters taken from the short coastwide stock assessment model. Region- and fishery-specific parameters taken from the short AAF stock assessment model. However, given the large difference in natural mortality between the short coastwide (*M* fixed at 0.15 for females) and the short AAF assessment models, parameters from the long AAF assessment model, or some other values, may be used or estimated.

The values used for age 3+ females and males in the OM are shown in Table 5.

Table 5. Values of natural mortality for age 3+ females and males used in the individual models of the MSE operating model.

	OM1_longAAF	OM2_shortAAF	OM3_longCW	OM4_shortCW
Female	0.184	0.213	0.215	0.150
Male	0.164	0.178	0.203	0.147

Each model was conditioned to the following four sources of information.

1. The estimated stock distribution from the modelled FISS data across the four Biological Regions.
2. The estimated spawning biomass from the corresponding stock assessment model.
3. The estimated all sizes index of abundance from the modelled FISS data for each Biological Region.
4. The estimated proportions-at-age from the FISS data for each Biological Region.

The goal of the conditioning was to create a multi-region OM that was representative of each of the four models in the stock assessment ensemble. Each source of information was weighted independently, with higher weights put on the stock distribution and spawning biomass. The conditioning is currently in progress, but preliminary results for OM1_longAAF are shown in Figure 3. Parameter uncertainty will be added at the end of the conditioning process.

Objectives and performance metrics

The Commission priority objectives are shown in Table 4, which is a subset of the Commission's primary objectives in Appendix A, which includes some area-specific objectives as well. These primary objectives have been used in past evaluations. Furthermore, the MSE Explorer has options to select many performance metrics beyond those defined by the primary objectives.

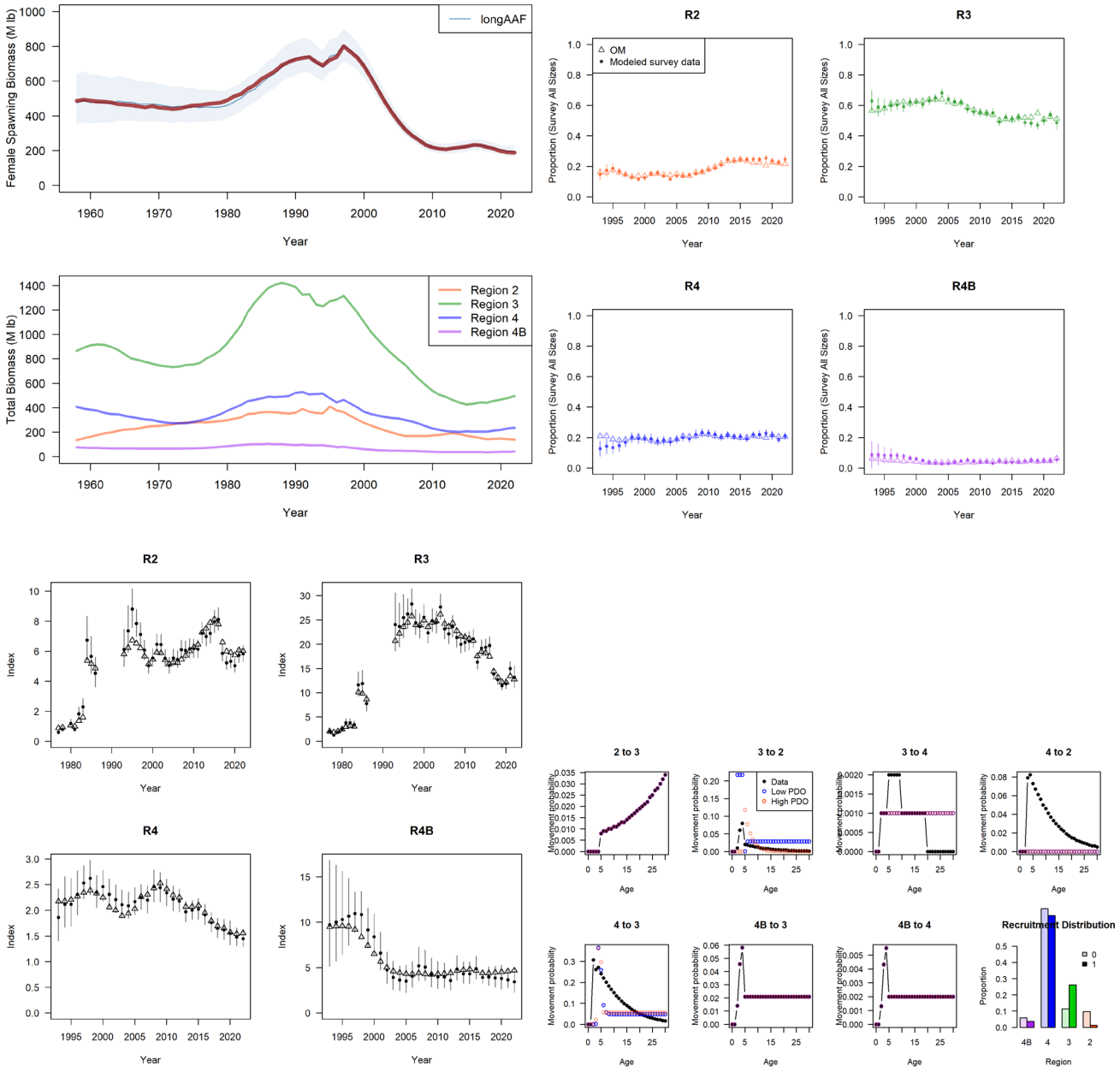

Figure 3. Outputs from conditioning OM1_longAAF. The top left is OM coastwide spawning biomass (red) with the blue polygon showing the 5th and 95th quantiles from the long AAF stock assessment model, and the OM total biomass in each Biological Region. The top right is the OM predicted proportion of all sizes fish caught in the FISS for each Biological Region (triangles) with space-time model estimates shown as filled circles and 2.5th and 97.5th quantiles. The bottom left is the OM predicted FISS all sizes index for each Biological Region (triangles) with space-time model estimates shown as filled circles and 2.5th and 97.5th quantiles. The bottom right shows the movement probabilities at age from and to each Biological Region with estimated movement probabilities in blue or red for low or high periods of the PDO, respectively. The recruitment distribution shows the proportion of coastwide recruitment in each Biological Region for low (0) or high (1) periods of the PDO.

One measurable objective that can use refinement is the Biological Region-specific objective "maintain a defined minimum proportion of female spawning biomass in each Biological Region." The purpose of this objective is to conserve geographical diversity within the spawning biomass because it is not known how each Biological Region contributes to the sustainability of the coastwide stock or individual Biological Regions. Minimum proportions, intended to be exceeded with no more than a 5% probability, were defined *ad hoc* for each Biological Region (Appendix A) based on historical estimates of distribution (Figure 4), but no recent MPs evaluated were able to meet the objective for Biological Region 4B (e.g. the "Both" for the "Fished" run in Figure 2). Further investigation of the percentage of spawning biomass in Biological Region 4B under scenarios of persistent low PDO and persistent high PDO (Figure 2) show that the percentage of spawning biomass in Biological Region 4B is much more variable when fished than when not fished, and the "high" PDO results in lower percentages of spawning biomass in that region, sometimes less than 1%.

There are several solutions to alleviate this issue and find MPs that meet the objective of maintaining coastwide spawning biomass in Biological Region 4B.

a) Determine a new value for the minimum percentage in Biological Region 4B (currently 2%).

b) Adjust the tolerance to a value great than 5%.

c) Find a management procedure that will meet the current objective. This would likely be achieved by lowering the relative harvest rate in IPHC Regulatory Area 4B. For example, a yield-per-recruit analysis suggested a relative harvest rate of 0.5 for Biological Region 4B (Table 6).

Table 6. Estimated harvest rates from a yield-per-recruit analysis in each Biological Region relative to Biological Region 3 for different years. Reproduced from Table 2 in IPHC-2020-AM096-12.

		Biological Region			
Weight-at-age	**Selectivity**	**2**	**3**	**4**	**4B**
1985	1985	1.0	1.0	0.7	0.5
1999	1999	1.0	1.0	0.8	0.5
2018	2018	1.0	1.0	1.0	0.5

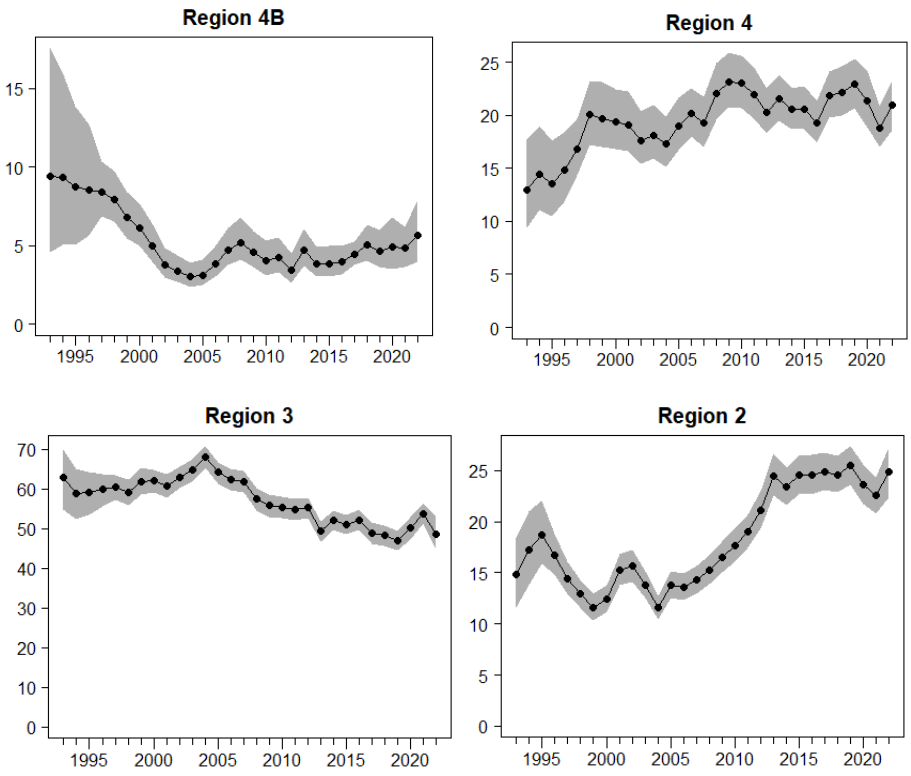

Figure 4. Estimated percent of coastwide stock biomass in each Biological Region, with 95% credible intervals, from the FISS space-time model.

Management procedures

The current interim management procedure consists of a scale component to determine the coastwide TCEY which is then passed through a distribution procedure to distribute the TCEY to each IPHC Regulatory Area (Figure 5). A decision process occurs at the end of the harvest strategy policy where the final TCEYs for each IPHC Regulatory Area may deviate from those determined by the management procedure, which occurred at AM099.

The Commission decided to depart from the reference SPR at AM099 and choose a lower TCEY. Paragraph 94 of IPHC-2023-AM099-R (see above) suggests that the Commission was not willing to accept a high chance of further declines in the spawning biomass. If that was the case, the 30:20 control rule could be revised to avoid going to low levels, although the decision was probably a combination of many factors which may include low catch rates, continually declining indices, a recent series of poor recruitment, mostly relying on one year class, and low weight-at-age.

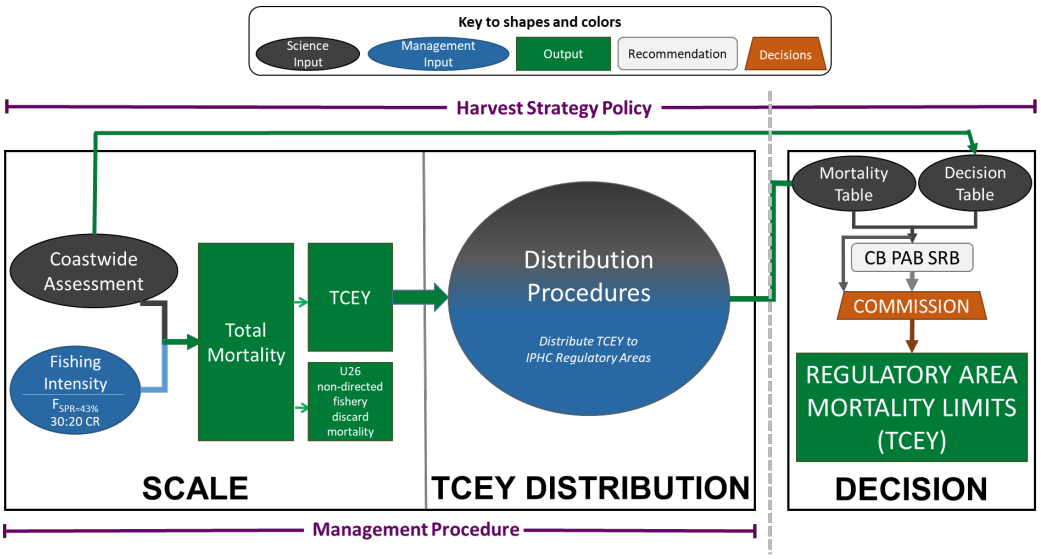

Figure 5. Illustration of the Commission interim IPHC harvest strategy policy (reflecting paragraph ID002 in IPHC-2020-CR-007) showing the coastwide scale and TCEY distribution components that comprise the management procedure. The distribution procedure is currently undefined. The decision component is the Commission decision-making process, which considers inputs from many sources.

Multi-year MPs use a simple procedure in years without an assessment to determine the TCEY. This simple procedure can be based on the FISS WPUE and adjust the TCEY up or down in proportion to the change in the FISS WPUE, thus reflecting the trend in abundance. If there is an additional concern of being at low catch-rates or below a specific FISS WPUE, a trigger could be added to reduce the TCEY even further or to trigger an assessment in a year when one normally would not occur. There would be little time to trigger an assessment after the survey results were finalized and used in the space-time modelling, however.

In paragraph 88 of the Report from AM099 (IPHC-2023-AM099-R; see above), “exceptional circumstances that would trigger a stock assessment in non-assessment years” was mentioned. It may be preferable to define this trigger as part of the management procedure because an exceptional circumstance, in the classic MSE sense, is when an observation is made outside of what was simulated in the closed-loop simulations of the MSE, requiring the MSE simulations to be reconsidered. Putting a trigger to conduct an assessment in the management procedure allows it to be evaluated as part of the MSE process.

An element can be added to the management procedure that would account for any of these factors. If low catch-rates and declining indices was an important factor in the decision to reduce the TCEY, the management procedure may incorporate an additional control rule based on the FISS O32 WPUE. For example, the fishing intensity (or TCEY) could be linearly reduced when the FISS O32 WPUE is below some value. Various values could be tested to produce the desired performance. However, the evaluation of that performance would depend on a new objective related to catch-rates or FISS WPUE.

In summary, potential elements of MPs to evaluate with the MSE include:

- Annual assessment with additional reduction in the TCEY if the FISS WPUE is below some value in an attempt to mimic decisions made at AM099. The probability of further decline in spawning biomass may also be included.
- Re-evaluate the multi-year assessment MPs evaluated previously, but with the updated OM. This includes biennial and triennial options with empirical rules to determine the TCEY for each IPHC Regulatory Area.
- Multi-year assessment with the TCEY in non-assessment years determined empirically and an assessment is triggered when the FISS WPUE is below some value, the FISS WPUE or NPUE changes by a considerable amount, or some other trigger.
- Various SPR values trigger values in the control rule, and constraints on the annual change in TCEY given a newly updated OM, and possibly an agreement on distribution of the TCEY.

EXCEPTIONAL CIRCUMSTANCES

An exceptional circumstance is defined as a process for deviating from an adopted MP (de Moor et al. 2022). The IPHC interim harvest strategy policy has a decision-making step after the MP (Figure 5), thus the Commission may deviate from an adopted MP. The SRB provided clarity at SRB021 of what an exceptional circumstance is to fit within the IPHC process.

> **IPHC-2022-SRB021-R**, para 60: The SRB **RECOMMENDED** that Exceptional Circumstances be defined to determine whether monitoring information has potentially departed from their expected distributions generated by the MSE. Declaration of Exceptional Circumstances may warrant re-opening and revising the operating models and testing procedures used to justify a particular management procedure.

This statement indicates that exceptional circumstances should be defined using observations rather than model outputs and should be compared to the distribution generated by the MSE simulations. If the observation(s) are outside of that range, revising the MSE framework and conducting additional simulations should be considered. It is important to have clear definitions for when the agreed upon MP should be re-evaluated.

The Commission may have interpreted the continued decline in abundance indices and projected spawning biomass seen at AM099 as an exceptional circumstance, but this is within the distribution of simulations from the MSE. Figure 6 shows that in the near-term, the spawning biomass has a chance of continuing to decline (21% and 16% of the simulations show a decline in the spawning biomass from 2023 to 2024 and from 2024 to 2025, respectively). However, after a few years of projections, the spawning biomass is likely to increase. In the long-term, it is not unlikely that the spawning biomass would be at levels seen recently, according to these simulations with an SPR of 43%. The stock assessment estimated the 2023 spawning biomass at 192 Mlbs in 2023 and the median simulated 2023 spawning biomass from the MSE OM was 188 Mlbs. The simulated spawning biomass in 2081 was less than the 2023 assessment spawning biomass in 19% of the simulations.

Potential exceptional circumstances could be as follows.

a) The coastwide all-sizes FISS WPUE or NPUE falls above the 97.5th percentile or below the 2.5th percentile of the simulated FISS index in a specific timeframe.

b) The observed percentage of FISS all-sizes WPUE is above the 97.5th percentile or below the 2.5th percentile of the simulated FISS index for each Biological Region in a specific timeframe. These data were used to condition the OM, so may be a reasonable choice.

c) The proportions-at-age in the coastwide or region-specific FISS observations are above the 97.5th percentile or below the 2.5th percentile of the simulated FISS proportions-at-age in a specific timeframe. Exactly how to make this comparison over all ages would have to be determined.

The all-sizes index would be a better option because to calculate O32, the OM makes an assumption of how to split the observations into U32 and O32.

An exceptional circumstance would trigger a review of the MSE simulations to determine if the OM can be improved and MPs should be re-evaluated. If a multi-year MP was implemented and an exceptional circumstance occurred in a year without a stock assessment, it may be useful to specify that a stock assessment would be completed as soon as possible along with the re-examination of the MSE.

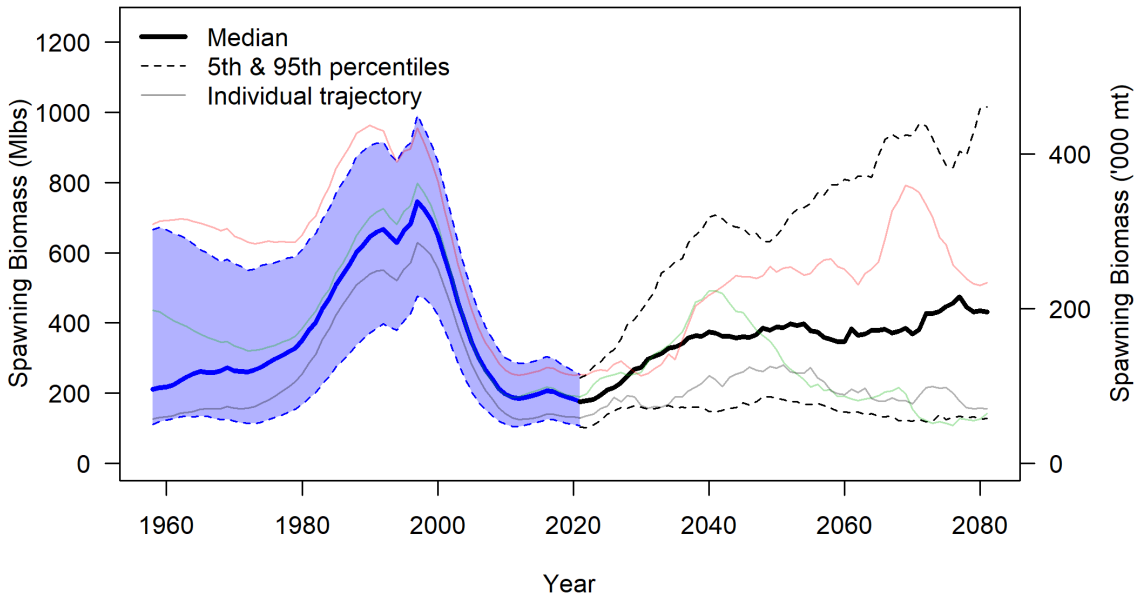

Figure 6. Median, 5th percentile, and 95th percentile of projected spawning biomass when using an SPR of 43%. Three individual trajectories (chosen *ad hoc*) are shown as thin lines to provide an idea of the variability in one trajectory over the entire period.

TWO-YEAR PROCESS FOR SRB REVIEW OF THE MSE

An MSE process may take one (1) to four (4) years, but because the MSE process at IPHC has matured and an MSE framework is in place, the timeframe for presenting results to the Commission on these topics is likely to take two years. How the SRB may engage in the MSE process over the next two years is described next.

Scientific Review Board

The SRB reviews the technical aspects of the MSE, trusting that the MSE developers are correctly implementing those details. The SRB also plays an important role in reviewing objectives and making sure that performance metrics are appropriate and correct. The Secretariat also works with the SRB to determine effective and succinct ways to present results to the Commission.

Two SRB meetings each year works well with the MSE process. SRB engagement in 2023 and 2024 may occur as follows.

Spring 2023 SRB meeting:

- Review outcomes of the Spring MSAB meeting.
- Review any technical aspects of the MSE framework that have not been reviewed before.
- Review the set of primary objectives and performance metrics to be used for evaluation.
- Review proposed MPs for evaluation and identify a set for preliminary evaluation.

Fall 2023 SRB meeting:

- Review preliminary simulation results including those related to questions of scientific interest and of interest to decision-makers.
- Assist in narrowing down the MPs to a succinct set to present to the Commission.
- Provide guidance on communicating progress.

Spring 2024 SRB meeting:

- Review outcomes of the Spring MSAB meeting.
- Review any technical aspects of the MSE framework that have not been reviewed before.
- Review the set of primary objectives and performance metrics to be used for evaluation.
- Review proposed MPs for evaluation and identify a set for evaluation.
- Provide guidance on methods for communicating results.

Fall 2024 SRB meeting:

- Review the simulation results including those related to questions of scientific interest and of interest to decision-makers.
- Assist in narrowing down the MPs to a succinct set to present to the Commission.
- Provide further guidance on communicating results.

One task of the SRB is to consider outcomes of MSAB meetings. The MSAB may best serve the Commission by considering inputs for the MSE process. One MSAB meeting per year, in May, would be sufficient, although adding in an information session when appropriate may be useful to keep MSAB members informed as they prepare for the Interim and Annual Meetings.

REFERENCES

de Moor CL, Butterworth DS, Johnston S. 2022. Learning from three decades of Management Strategy Evaluation in South Africa. ICES Journal of Marine Science. 79. 1843-1852.

RECOMMENDATION/S

1) The SRB **NOTE** paper IPHC-2023-SRB022-07 presenting simulations performed since MSAB017, outcomes of AM099, and potential MSE-related tasks for 2023–2025.
2) The SRB **NOTE** that additional simulations beyond those presented at MSAB017 resulted in more precise values of the performance metrics, but the relative comparisons between management procedures remained the same.
3) The SRB **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.
4) The SRB **ENDORSE** the process for developing and conditioning the 2023 OM, and that conditioning should occur following each full stock assessment.
5) The SRB **REQUEST** management procedures to develop and simulate using the MSE framework.
6) The SRB **REQUEST** that exceptional circumstances be based on comparing the MSE simulations to the uncertainty of modelled FISS estimates (e.g. a 95% credible interval) and if an exceptional circumstance occurred the MSE framework would be reviewed by the SRB, re-developed where necessary, and MPs would be re-evaluated as appropriate.

APPENDICES

Appendix A: Primary objectives defined by the Commission for the MSE

Appendix B: Supplementary material

APPENDIX A
PRIMARY OBJECTIVES DEFINED BY THE COMMISSION FOR THE MSE

Table A.1. Primary objectives, evaluated over a simulated ten-year period, accepted by the Commission at the 7th Special Session of the Commission (SS07). Objective 1.1 is a biological sustainability (conservation) objective and objectives 2.1, 2.2, and 2.3 are fishery objectives. Priority objectives are shown in green text.

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 the long-term coastwide female spawning stock biomass above a biomass limit reference point at least 95% of the time	*B* < Spawning Biomass Limit (B_{Lim}) B_{Lim}=20% unfished spawning biomass	Long-term	0.05	$P(SB < SB_{Lim})$
	Maintain a defined minimum proportion of female spawning biomass in each Biological Region	$p_{SB,2} > 5\%$ $p_{SB,3} > 33\%$ $p_{SB,4} > 10\%$ $p_{SB,4B} > 2\%$	Long-term	0.05	$P(p_{SB,R} < p_{SB,R,min})$
2.1 MAINTAIN SPAWNING BIOMASS AT OR ABOVE A LEVEL THAT OPTIMIZES FISHING ACTIVITIES	Maintain the long-term coastwide female spawning stock biomass at or above a biomass reference point ($B_{36\%}$) 50% or more of the time	*B*<Spawning Biomass Target (B_{Targ}) B_{Targ}=$B_{36\%}$ unfished spawning biomass	Long-term	0.50	$P(SB < SB_{Targ})$
2.2. PROVIDE DIRECTED FISHING YIELD	Optimize average coastwide TCEY	Median coastwide TCEY	Short-term		*Median* $\overline{TCEY}$
	Optimize TCEY among Regulatory Areas	Median $TCEY_A$	Short-term		*Median* $\overline{TCEY_A}$
	Optimize the percentage of the coastwide TCEY among Regulatory Areas	Median %$TCEY_A$	Short-term		*Median* $\left(\overline{\frac{TCEY_A}{TCEY}}\right)$
	Maintain a minimum TCEY for each Regulatory Area	Minimum $TCEY_A$	Short-term		*Median Min(TCEY)*
	Maintain a percentage of the coastwide TCEY for each Regulatory Area	Minimum %$TCEY_A$	Short-term		*Median Min(%TCEY)*
2.3. LIMIT VARIABILITY IN MORTALITY LIMITS	Limit annual changes in the coastwide TCEY	Annual Change (*AC*) > 15% in any 3 years	Short-term		$P(AC_3 > 15\%)$
		Median coastwide Average Annual Variability (AAV)	Short-term		*Median AAV*
	Limit annual changes in the Regulatory Area TCEY	Annual Change (*AC*) > 15% in any 3 years	Short-term		$P(AC_3 > 15\%)$
		Average AAV by Regulatory Area (AAV_A)	Short-term		*Median* AAV_A

APPENDIX B
SUPPLEMENTARY MATERIAL

The MSE technical document (IPHC-2022-MSE-01) and is available on the IPHC MSE page (https://www.iphc.int/management/science-and-research/management-strategy-evaluation).

An archived MSE Explorer contains results presented at AM099.

http://shiny.westus.cloudapp.azure.com/shiny/sample-apps/IPHC-MSE-AM099/

Results for the Low/High PDO scenarios are available in a different MSE Explorer.

http://shiny.westus.cloudapp.azure.com/shiny/sample-apps/IPHC-MSE-HighLowPDO/

Results presented at MSAB017 are available in an archived MSE Explorer

http://shiny.westus.cloudapp.azure.com/shiny/sample-apps/IPHC-MSE-MSAB017/