IPHC Management Strategy Evaluation and Harvest Strategy Policy Updates for 2023

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PURPOSE

To provide the Commission with an update of the Management Strategy Evaluation (MSE) process and the Harvest Strategy Policy.

EXECUTIVE SUMMARY

Outcomes of the 18th Session of the IPHC Management Strategy Advisory Board

The 18th Session of the IPHC Management Strategy Advisory Board (MSAB018) occurred in May 2023 and discussed membership, past evaluations, and a Program of Work. In summary, the MSAB

a. discussed MSAB member succession planning and the potential for the designation of alternate members;
b. were interested in developing outreach materials explaining the effect of the environment (i.e. Pacific Decadal Oscillation) on coastwide and regional stock dynamics and the relative effect of fishing;
c. requested that the evaluation of annual and multi-year assessments be done subsequent to an agreement on a distribution procedure and include elements such as multi-year management procedures (MPs), constraints on the coastwide TCEY, smoothing elements on the calculation of stock distribution, and various SPR values; and
d. discussed what an exceptional circumstance is and potential responses to an exceptional circumstance.

See IPHC-2023-MSAB018-R for more details on the outcomes of MSAB018.

Updated 2023 operating model

The IPHC's MSE Operating Model for 2023 has been updated to reflect the 2022 stock assessment ensemble and is performing well for evaluating management procedures. The Scientific Review Board (SRB) reviewed the IPHC's MSE Operating Model (OM) for 2023 at the 22nd Session of the SRB (SRB022) and the 23rd Session of the SRB (SRB023) and endorsed the 2023 OM. Further adjustments may be made, at the request of the Commission.

Specific details of the 2023 OM are available on the IPHC MSE Research Website in the document "Technical Details of the IPHC MSE Framework" (IPHC-2023-MSE-02).

Objectives and performance metrics

Four priority coastwide objectives are currently endorsed for the MSE.

a. Maintain the long-term coastwide female spawning stock biomass above a biomass limit reference point ($B_{20\%}$) at least 95% of the time.

b. Maintain the long-term coastwide female spawning stock biomass at or above a biomass threshold reference point ($B_{36\%}$) at least 50% of the time.

c. Optimise average coastwide TCEY.

d. Limit annual changes in the coastwide TCEY.

It may be prudent to consider an absolute spawning biomass, or catch-rate, threshold in a new objective to meet some concerns expressed at the 99th Session of the IPHC Annual Meeting (AM099). This may be a possible topic for the next MSAB meeting.

An objective to maintain the absolute spawning biomass above a threshold may be a useful objective for several reasons. First, the level of spawning biomass likely correlates with catch-rates in the fishery, and a higher spawning biomass would likely result in a more efficient and economically viable fishery. Second, current priority conservation objectives use dynamic relative spawning biomass (accounting for the effects of fishing and not the environment) to determine stock status, and stock conditions may result in a low absolute spawning biomass with a satisfactory stock status. Third, a minimum absolute coastwide spawning biomass may be necessary to ensure successful reproduction. Lastly, an observed reference stock level may have concrete meaning to stakeholders.

Management Procedures (MPs)

The MSAB and the SRB have provided requests to investigate various MP elements. The following describes these elements of MPs that could be evaluated as part of the current MSE Program of Work.

Priority

- **Annual and multi-year stock assessment MPs:** These are management procedures that conduct a stock assessment annually or every 2nd or 3rd year and use an empirical MP based on the FISS survey trends to determine the TCEY in non-assessment years.
- **Fishing intensity:** A range of SPR values (i.e. fishing intensity, currently 43%) and alternative trigger reference points (currently 30%) in the harvest control rule.
- **FISS reductions:** Investigate scenarios where the FISS effort is reduced or occasionally eliminated in various IPHC Regulatory Areas.

Secondary

- **Constraints:** A constraint on the coastwide TCEY to reduce inter-annual variability. Past examples include a 15% constraint and a slow-up/fast-down approach.

Additional

- **Absolute spawning biomass**: Elements related to maintaining the spawning biomass above an absolute threshold.

- **Stock distribution:** A method to reduce the inter-annual variability in the estimates of stock distribution if used to distribute the TCEY to IPHC Regulatory Areas. This may include using the average of the stock distribution estimates over the past 3 years, for example.
- **TCEY distribution**: Procedures to distribute the TCEY to IPHC Regulatory Areas.

Exceptional Circumstances

An exceptional circumstance is an event that is beyond the expected range of the MSE evaluation and triggers specific actions that should be taken to re-examine the harvest strategy. The IPHC interim harvest strategy policy has a decision-making step after the MP, thus the Commission may deviate from an adopted MP as part of the harvest strategy policy, and this decision-making variability is included in the MSE simulations.

The Secretariat, with the assistance of the SRB and MSAB, is defining exceptional circumstances and the response that would be initiated, as well as potential triggers in a management procedure that would result in a stock assessment being done (if time allows) in a year that would normally not have one scheduled (e.g. in multi-year MPs). Working with the SRB, the following potential exceptional circumstances have been defined:

a) The coastwide all-sizes FISS WPUE or NPUE from the space-time model falls above the 97.5th percentile or below the 2.5th percentile of the simulated FISS index for two or more consecutive years.

b) The observed FISS all-sizes stock distribution for any Biological Region is above the 97.5th percentile or below the 2.5th percentile of the simulated FISS index over a period of 2 or more years.

c) Recruitment, weight-at-age, sex ratios, other biological observations, or new research indicating parameters that are outside the 2.5th and 97.5th percentiles of the range used or calculated in the MSE simulations.

Furthermore, the following actions may take place if an exceptional circumstance is declared.

a) A review of the MSE simulations to determine if the OM can be improved and MPs should be reevaluated.

b) If a multi-year MP was implemented and an exceptional circumstance occurred in a year without a stock assessment, a stock assessment would be completed as soon as possible along with the re-examination of the MSE.

c) Consult with the SRB and MSAB to identify why the exceptional circumstance occurred, what can be done to resolve it, and determine a set of MPs to evaluate with an updated OM.

d) Further consult with the SRB and MSAB after simulations are complete to identify whether a new MP is appropriate.

Results

MSE simulations are currently being conducted, with a priority on multi-year assessments and SRB-requested FISS scenarios. Results will be added to the MSE Explorer website as they become available.

Past analyses 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, such as periods of low or high productivity, as indicated by the Pacific Decadal Oscillation (PDO). Analyses investigating persistent high and low PDO regimes show similar results, and provide performance metrics specific to the IPHC MSE.

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. The median relative spawning biomass and the average annual variability (AAV) for the TCEY were similar across low and high PDO scenarios. The median TCEY for the persistent high PDO scenario was 1.6 times greater than the median TCEY for a persistent low PDO. The percentage of spawning biomass in each Biological Region may be affected by fishing under an SPR-based management procedure by the PDO regime because movement, recruitment distribution, and average recruitment are dependent on the PDO regime. For Pacific halibut, the environment sometimes may have a larger effect on the distribution of spawning biomass than fishing does (at a range SPR values from 40% to 46%). These results are dependent upon the full harvest strategy, and different distribution procedures would likely produce different outcomes.

IPHC Harvest Strategy Policy

A Harvest Strategy Policy (HSP) provides a framework for applying a science-based approach to setting harvest levels. At IPHC, this would be specific to the TCEY for each IPHC Regulatory Area throughout the Convention Area. Currently, IPHC has not formally adopted a harvest strategy policy, but has set harvest levels under an SPR-based framework with elements adopted at multiple Annual Meetings of the IPHC since 2017.

Adopting an HSP is important for any fisheries management authority because it outlines the long-term vision for management and specifies the framework for a consistent and transparent science-based approach to setting mortality limits. An HSP:

- identifies an appropriate method to manage natural variability and scientific uncertainty,
- accounts for risk and balances trade-offs,
- reduces the time needed to make management decisions,
- ensures long-term sustainability and profitability,
- increases market stability due to a more predictable management process,
- adheres to the best practices of modern fisheries management that is consistent with other fisheries management authorities and certification agencies, and
- allows for the implementation of the precautionary approach.

Overall, an HSP spells out the management process, which benefits the fish, the stakeholders, and other interested parties.

An HSP can be divided into three components: management procedure, harvest strategy, and policy. A management procedure is an agreed upon procedure that determines an output that meets the objectives defined for management. The MP is reproducible and is codified such that it can be consistently calculated. The harvest strategy component contains the MP but is broader and encompasses the objectives as well as additional procedures that produce that final necessary outputs, but may not be procedural and pre-defined. For example, at the IPHC the harvest strategy consists of the procedure to determine the coastwide TCEY as well as the concept of distributing the TCEY to each IPHC Regulatory Area. Currently, the determination of the coastwide TCEY is defined using a harvest control rule and reference fishing intensity, but there is not an agreed upon procedure to distribute the TCEY. However, a reference TCEY distribution may be useful to inform the decision-making process. The policy component is the aspect of decision-making where management may deviate from the outputs of the harvest strategy to account for other objectives not considered in the harvest strategy. This may be to modify the coastwide TCEY and/or the distribution of the TCEY to account for economic factors, for example. At IPHC, the policy component occurs at the Annual Meeting of the IPHC where stakeholder input is considered along with scientific information to determine the mortality limits for each IPHC Regulatory Area.

The IPHC Secretariat is currently in the process of updating the IPHC harvest strategy policy document, which was last edited in 2019, and a draft HSP is available for consideration by the Commission (outline in Appendix B). This draft may be adopted as an interim HSP, but some additional MSE work is necessary for a final HSP, noting that the HSP may be updated at any time following additional MSE-related work. The draft HSP includes a description of the decision-making process and the flexibility that the Commission would have when making management decisions. This decision-making uncertainty is included in the MSE analysis of risk.

INTRODUCTION

MSE is used to evaluate management procedures with the ultimate goal of identifying a harvest strategy, as part of a harvest strategy policy (HSP), that meets management objectives and is robust to uncertainty and variability. An HSP provides a framework for applying a science-based approach to setting harvest levels. At IPHC, this would be specific to the TCEY for each IPHC Regulatory Area throughout the Convention Area. Currently, IPHC has not formally adopted a harvest strategy policy, but has set harvest levels under an SPR-based framework with elements adopted at multiple Annual Meetings of the IPHC since 2017. To formally define and subsequently adopt an IPHC harvest strategy, a few tasks remain. These include evaluating multi-year Management Procedures (MPs) and determining if the current reference fishing intensity (SPR=43%) still meets IPHC objectives. Additions and edits to the current draft harvest strategy policy document are also necessary for the adoption of a formal harvest strategy policy.

The Management Strategy Evaluation (MSE) Program of Work for 2021–2023 (IPHC-2021-MSE-02) was completed in early 2023 and presented at the 99th Session of the IPHC Annual Meeting (AM099). This document describes ongoing MSE work, including updates to the operating model, considering new objectives and performance metrics, evaluating various elements of management procedures (MPs), defining exceptional circumstances, and updating the Harvest Strategy Policy document.

OUTCOMES OF THE 18TH SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD

The 18th Session of the IPHC Management Strategy Advisory Board (MSAB018) met virtually in May 2023 and discussed membership, past evaluations, and a Program of Work. The meeting was well attended and there continues to be a high level of interest and involvement from Management Strategy Advisory Board (MSAB) members. The report for MSAB018 (IPHC-2023-MSAB018-R) is available online.

The MSAB discussed MSAB member succession planning and the potential for the designation of alternate members. Some members expressed interest in having alternates available in case the member is unable to attend a meeting or ends their term. The MSAB requested that domestic agency staff consider providing text to update the IPHC Rules of Procedure.

> **IPHC-2023-MSAB018-R, para. 10:** ***NOTING*** *the extensive discussion surrounding MSAB member succession planning and how the appointment of alternates may be useful, the MSAB* ***REQUESTED*** *that domestic agency staff from the Contracting Parties consider drafting text to amend the IPHC Rules of Procedure to allow alternates to be designated for MSAB members, for Commission consideration in the future.*

Results of MSE simulations assuming a persistent low or high PDO were presented at MSAB018. These results, not available at AM099, were also presented at the fifth conference for Effects of Climate Change on the Worlds Oceans (ECCWO5) and the PICES 2023 Annual Meeting (PICES-2023). For the PICES meeting similar MSE simulations were performed using the updated operating model (OM) for 2023, without decision-making variability, estimation error, or observation error. Variable weight-at-age was used. These updated results, presented in the Results Section below, are very similar to the previous analysis presented at MSAB018.

MSAB members were interested in these results and requested that outreach materials be developed explaining the effects of the environment (i.e. Pacific Decadal Oscillation) on coastwide and regional stock dynamics and the relative effect of fishing.

> **IPHC-2023-MSAB018-R, para. 21:** *The MSAB **REQUESTED** that outreach materials be developed that synthesize the effect of the PDO (e.g. via recruitment) on the coastwide and regional stock dynamics and the relative effect of fishing. This may be a pamphlet or poster to be reviewed at a future MSAB meeting.*

A major outcome of MSAB018 was the request that the evaluation of annual and multi-year assessments be done subsequent to an agreement on a distribution procedure and include elements such as multi-year management procedures (MPs), constraints on the coastwide TCEY, smoothing elements on the calculation of stock distribution, and various SPR values.

> **IPHC-2023-MSAB018-R, para. 29:** *The MSAB **REQUESTED** that subsequent to an agreement on a distribution procedure by the Commission, the evaluation of annual and multi-year assessments include, but not limited to, the following concepts.*
>
> *a) Annual changes in the TCEY driven by FISS observations in non-assessment years of a multi-year MP;*
>
> *b) A constraint on the coastwide TCEY to reduce inter-annual variability and the potential for large changes in assessment years of a multi-year. This may be a 10% or 15% constraint, a slow-up fast-down approach, or similar approach;*
>
> *c) A smoothing element in the distribution procedure to account for uncertainty in the estimates of stock distribution and reduce the variability in area-specific TCEYs. For example, this may include a 3-year rolling average of stock distribution estimates;*
>
> *d) SPR values ranging from 30% to 56% and alternate trigger reference points in the harvest control rule.*

This is consistent with an agreement by the Commission at AM099.

> **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 MSAB also discussed exceptional circumstances and gained a better understanding of what an exceptional circumstance is and what details need to be defined.

> **IPHC-2023-MSAB018-R, para. 42:** *The MSAB **AGREED** that FISS observations (coastwide or by area/region) are useful to define the limits defining an exceptional circumstance and that individual years may be used as well as observed trends over time.*

IPHC-2023-MSAB018-R, para. 43: *The MSAB **NOTED** that the defined responses to an exceptional circumstance may include: a) reviewing the MSE framework including the operating model; b) examining objectives; c) evaluating additional MPs; d) completing a stock assessment at the next appropriate time.*

IPHC-2023-MSAB018-R, para. 44: *The MSAB **AGREED** that there are other circumstances within the acceptable range simulated by the MSE when one may deviate from an adopted MP because of an unexpected event. For example, a high probability of predicted declines in the spawning biomass under the interim management procedure may have been contributing factors in the decision to depart from the interim management procedure in 2023, even though these declines were within the simulated range of MSE results.*

Finally, the MSAB requested that MSAB019 be held in the Spring of 2024.

IPHC-2023-MSAB018-R, para. 47: The *MSAB **REQUESTED** that MSAB019 be held in May 2024, rather than October 2024, as previously noted by the Commission, and that future MSAB meetings occur prior to the June SRB meeting in that same year.*

Operating Model

The IPHC's MSE Operating Model for 2023 has been updated to reflect the 2022 stock assessment ensemble and is performing well for evaluating management procedures. The Scientific Review Board (SRB) reviewed the IPHC's MSE Operating Model (OM) for 2023 at the 22nd Session of the SRB (SRB022) and the 23rd Session of the SRB (SRB023) and endorsed the 2023 OM. The SRB recommended updating the operating model following full stock assessments.

IPHC-2023-SRB022-R, para. 26: *The SRB RECOMMENDED that reconditioning the operating model should be limited to situations where the stock assessment has changed significantly. This likely means a three-year schedule for reconditioning the operating model in the year following each full stock assessment.*

It is expected that this OM will be used until after the next full assessment is completed, but further adjustments may be made, at the request of the Commission.

The OM is a spatially-explicit, age-structured population dynamics model with movement among four Biological Regions. Multiple fishing sectors are modelled within IPHC Regulatory Areas along with landings and discard mortality. The OM incorporates four individual models and integrates them into an ensemble to account for structural uncertainty and differing hypotheses about recruitment and distribution. The estimated historical spawning biomass and projected biomass with no fishing mortality and with fishing intensity equal to a spawning potential ratio (SPR) of 43% are shown in Figure 1. Individual trajectories of spawning biomass are also shown in Figure 1, which show similar increases and decreases with and without fishing. This is because weight-at-age and recruitment are large drivers of spawning biomass while fishing at a constant SPR has a large effect on the overall scale of spawning biomass.

The 2023 OM is consistent with the assumptions used in the 2022 assessment (i.e. three of the four models in the stock assessment ensemble estimated female natural mortality at values greater than 0.18). Long-term performance metrics related to spawning biomass and short-term performance metrics for the TCEY from simulations using the 2022 OM and the 2023 OM with the same specifications of an MP (SPR=43%) were similar (Table 1). The short-term median average TCEY was approximately 59 million pounds and the median average annual variability (AAV) for the TCEY changed from 17 to 19%. The probability of the long-term spawning biomass being less than 36% of unfished spawning biomass changed from 0.31 to 0.35. Even though the 2022 stock assessment showed a large increase in the TCEY based on SPR=43% when compared to 2021 stock assessment outputs, the MSE outputs are very similar due to the inclusion of additional uncertainty on natural mortality in the 2022 and 2023 OMs. Therefore, past MSE results remain relevant.

One difference between the two OMs is a performance metric related to the 2023 estimate of spawning biomass. In the 2023 OM there is a higher chance that the spawning biomass in 4-13 years (short-term) will be less than the 2023 spawning biomass. This is due to additional information defining the spawning biomass trajectory in recent years.

Simulated trajectories of spawning biomass, with and without fishing, are shown in Figure 1. Specific details of the 2023 OM are available on the IPHC MSE Research Website in the document "Technical Details of the IPHC MSE Framework" (IPHC-2023-MSE-02).

Table 1. Performance metrics for the same management procedure simulated with the 2022 OM and the 2023 OM. The MP uses an SPR=43%, a 30:20 control rule, and an annual assessment.

Period	Performance Metric	2022 OM	2023 OM
Long-term	P(RSB<20%)	PASS	PASS
	P(RSB<36%)	0.31	0.35
Short-term	Median average TCEY	59.0	59.2
	Median AAV TCEY	18.8%	17.0%
	$P(SB_{2027\text{-}2036} < SB_{2023})$	0.17	0.29

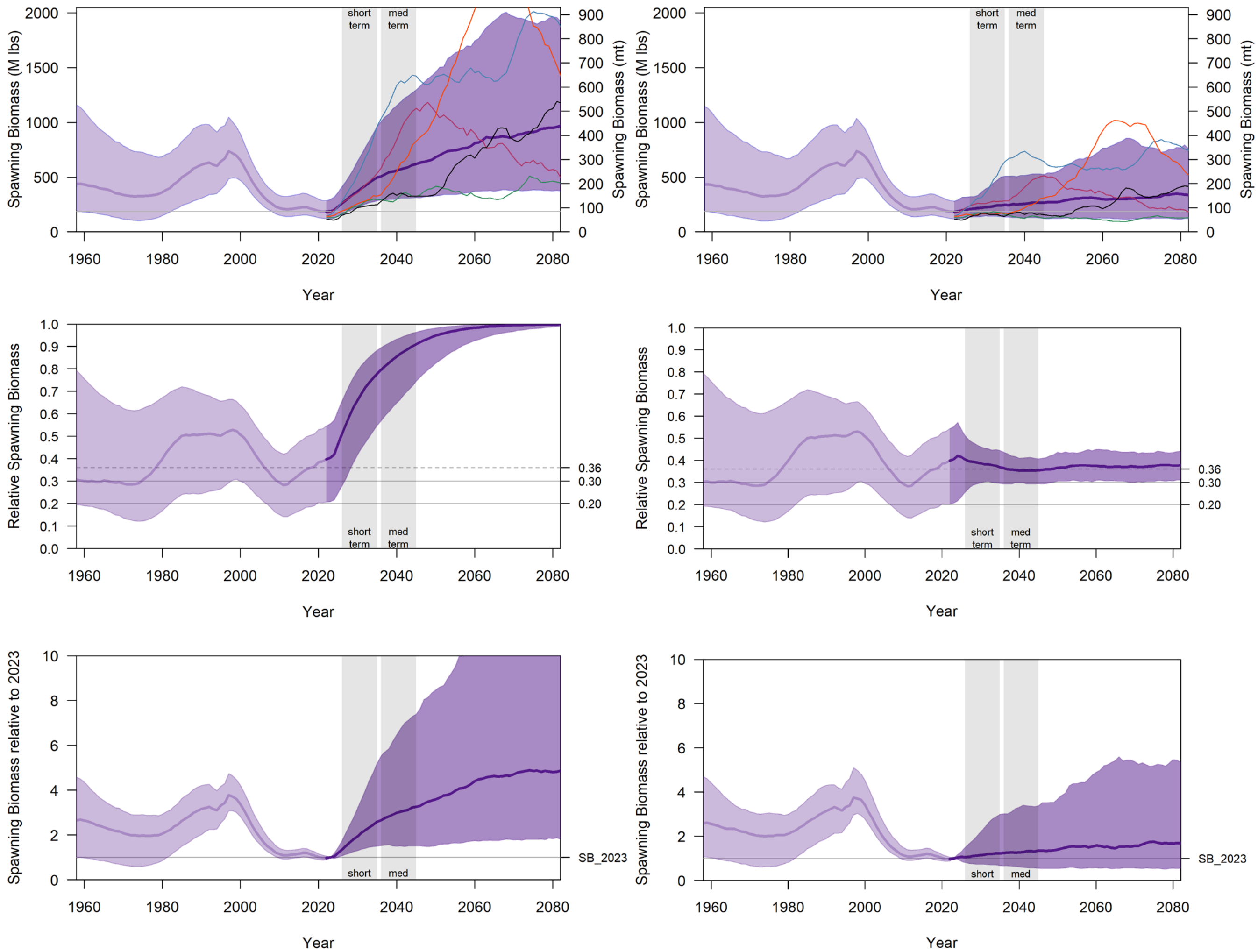

Figure 1. Simulated spawning biomass (top row), relative spawning biomass (middle row), and spawning biomass relative to the spawning biomass in 2023 (bottom row) assuming no fishing mortality (left column) and a fishing intensity equal to an SPR of 43% (right column). The median is shown by the thick dark line and the 5th and 95th percentiles are shown as the shaded polygon (the darker polygon indicates the projected time-period). Individual trajectories of spawning biomass are shown as small lines of different colors. Grey vertical panels indicate the short and medium time-periods used for calculating performance metrics.

OBJECTIVES AND PERFORMANCE METRICS

Four priority coastwide objectives are currently endorsed for the MSE.

- Maintain the long-term coastwide female spawning stock biomass above a biomass limit reference point ($B_{20\%}$) at least 95% of the time.
- Maintain the long-term coastwide female spawning stock biomass above a biomass target reference point ($B_{36\%}$) at least 50% of the time.
- Optimise average coastwide TCEY.
- Limit annual changes in the coastwide TCEY.

Additional area-specific objectives are listed in Appendix A. The IPHC Secretariat is working with the SRB to develop a region-specific objective to conserve spatial structure that is informative of the changes in biomass within a region. This would be a secondary objective to consider after meeting all priority objectives.

> **IPHC-2023-SRB023-R, para 24.** *The SRB* ***RECOMMENDED*** *that an objective to maintain spatial population structure be added or redefined to maintain the spawning biomass in a Biological Region above a defined threshold relative to the dynamic unfished equilibrium spawning biomass in that Biological Region with a pre-defined tolerance. The percentage and tolerance may be defined based on historical patterns and appropriate risk levels recognizing the limited fishery control of biomass distribution.*

The result 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 ensemble, thus increasing the perceived productivity of the stock. In contrast to this result, 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 resulted in a 75% chance of a lower spawning biomass in 2024. The Commission departed from the current interim management procedure at AM099 and chose a TCEY of 36.97 Mlbs for 2023, 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 target 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 consistent with the reference harvest level. This decision may be a precautionary measure given the changes in the stock assessment as well as other identified risks, but even though the reference mortality limit was larger than in previous assessments, the estimates of spawning biomass were similar to past stock assessments.

Related to these concerns at AM099, the SRB made a recommendation to re-evaluate what they called the target objective. This is objective (b): to maintain the relative spawning biomass above $B_{36\%}$.

> **IPHC-2023-SRB023-R, para. 25.** *The SRB* ***RECOMMENDED*** *that the Commission re-evaluate the target objective for long-term coastwide female spawning stock biomass given that estimated 2023 female spawning biomass (and associated WPUE), which was well-above the current target B36%, in part triggered harvest rate reductions from the interim harvest policy. Such ad-hoc adjustments limited the value of projections and performance measures from MSE.*

However, instead of updating the $B_{36\%}$ relative spawning biomass objective, it may be prudent to consider an absolute spawning biomass, or catch-rate, threshold in a new objective.

Most fisheries management authorities use an absolute spawning biomass threshold because they do not consider dynamic unfished spawning biomass (dynamic B_0). Instead, reference points are defined as a percentage of a static B_0 that is calculated using a pre-defined productivity regime. This, however, conflates environmental effects with fishing effects. A compromise is to determine status of the stock using a dynamic approach to account for only fishing effects, and to also define an absolute spawning biomass limit to avoid low stock levels (even if not caused by fishing) below a value that may result in unacceptably low catch-rates and the potential for reduced reproduction.

Clark and Hare (2006) noted that "[t]he Commission's paramount management objective is to maintain a healthy level of spawning biomass, meaning a level above the historical minimum that last occurred in the mid1970s." The Commission currently has conservation objectives to maintain the spawning biomass above certain thresholds, measured as relative spawning biomass, but these reference points are relative to dynamic unfished spawning biomass, thus may not indicate when spawning biomass is at a low level resulting from non-fishing effects (e.g. weight-at-age and recruitment). An absolute biomass threshold would ensure that the biomass of fish available is above a desired level.

An objective to maintain the absolute spawning biomass above a threshold may be a useful objective for several reasons. First, the level of spawning biomass likely correlates with catch-rates in the fishery, and a higher spawning biomass would likely result in a more efficient and economically viable fishery. Second, current priority conservation objectives use dynamic relative spawning biomass (accounting for the effects of fishing and not the environment) to determine stock status, and stock conditions may result in a low absolute spawning biomass with a satisfactory stock status. Third, a minimum absolute coastwide spawning biomass may be necessary to ensure successful reproduction. Lastly, an observed reference stock level may have concrete meaning to stakeholders. For example, the recent estimated spawning biomass may be near or below the lowest spawning biomass estimated since the mid-1970's (Figure 1) and the Commission noted historically low observed fishery catch rates in 2022.

> **IPHC-2023-AM099-R, para 56.** *The Commission **NOTED** that there are additional risks associated with the stock condition and mortality limit considerations for 2023 that are not quantitatively captured in the decision table, these include:*
>
> > *a) Historically low observed fishery catch rates corresponding to reduced efficiency/performance in 2022;*

The threshold and the tolerance for being below that threshold are not obvious choices. Clark and Hare (2006) used the estimated spawning biomass in 1974, which subsequently produced recruitment resulting in an increase in the stock biomass. However, there is a high uncertainty in the estimates of historical absolute spawning biomass before the 1990's. Recent estimates of spawning biomass may be reasonable as they are relevant to concerns of low catch-rates, but it is unknown how and if the stock will quickly recover from this current state. Setting an absolute spawning biomass to avoid low catch-rates may also *de facto* protect the stock from serious harm (i.e. avoid dropping below the current relative spawning biomass limit of 20%).

An alternative way to think about this is to define a population biomass limit reference point for relative spawning biomass as a threshold for which dropping below would cause serious harm to the stock (the Commission has adopted $SB_{20\%}$), and a fishery biomass limit reference point on some quantity that would result in serious hardships to the fishery. The fishery biomass limit reference point could be defined using absolute spawning biomass, CPUE, FISS WPUE, or some other metric. Note that a fishery biomass limit reference point is a different objective than a fishing intensity limit, where the former is a threshold used to maintain catch-rates and the latter is a threshold used to indicate the potential for overfishing. As mentioned above, a fishery absolute spawning biomass limit may add extra protection for the stock by further reducing the probability of breaching existing limit and threshold reference points. The Secretariat will discuss objectives with the MSAB and SRB; a new one related to absolute spawning biomass may be phrased as

> Maintain the long-term coastwide female spawning stock biomass (or FISS WPUE or fishery catch-rates) above a threshold at least XX% of the time.

The IPHC Secretariat is currently reporting the priority Performance Metrics associated with the priority objectives, which is a subset from the range of metrics presented in Appendix A:

P(RSB<20%): Probability that the long-term Spawning Biomass is less than the Spawning Biomass Limit: SB_{Lim}=20% of unfished spawning biomass. This is associated with objective (a) and is reported as a pass if the probability is less than 0.05.

P(RSB<36%): Probability that the Spawning Biomass is less than the Spawning Biomass Threshold: SB_{Thresh}=36% of unfished spawning biomass. This is associated with objective (b) and is reported as pass if the probability is less than 0.50 and as a numeric probability.

Median TCEY: The median of the short-term average TCEY over a ten-year period. This is a measure of the TCEY in the next 4–13 years and is associated with objective (c). This is only reported if the spawning biomass objectives are passed.

Median AAV TCEY: The median of the average annual variability of the short-term TCEY determined as the average difference in the TCEY over a ten-year period. This is a measure of the inter-annual variability of the TCEY in the next 4–13 years and is associated with objective (d). This is reported only if the spawning biomass limit objective is passed.

The MSAB also requested that a new performance metric be developed to assist with evaluating multi-year MPs.

> **IPHC-2023-MSAB018-R, para. 38:** *The MSAB REQUESTED new performance metrics representing the change in the TCEY in non-assessment years and the change in TCEY in assessment years be developed for the evaluation of multi-year assessment MPs.*

The Secretariat will continue to work with the MSAB regarding how to calculate these new performance metrics, and will then report them in the MSE Explorer.

MANAGEMENT PROCEDURES (MPS)

A management procedure (MP) is a defined method for making fishery management decisions, such as determining mortality limits, and contains three main elements: 1) methods for monitoring the stock, 2) methods to assess the stock, and 3) harvest rules for determining the management decisions (Figure 2). IPHC currently monitors the Pacific halibut stock by collecting fishery-dependent and fishery-independent data. The IPHC estimation model is the currently the ensemble assessment, but a combination of the ensemble assessment and a simple empirical model based on the FISS results is being considered (see multi-year assessments below). The harvest rule consists of other details related to management including size limits (currently 32-inches), fishing intensity (a current reference fishing intensity of SPR=43%), and a 30:20 control rule. A management procedure is a clear formulation for determining the management outcomes and use coded in the MSE framework to determine management outcomes which are fed back into the OM (Figure 2). Implementing the desired management procedure in practice reduces the amount of time necessary for decision making and provides transparency in the management process.

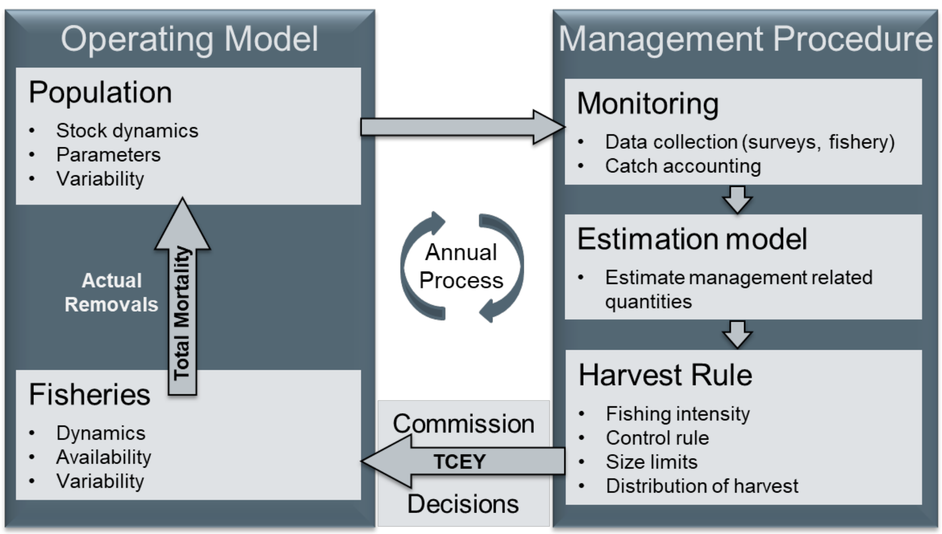

Figure 2. Three elements of a management procedure and how it fits into the MSE closed-loop simulation framework.

The MSAB (see **IPHC-2023-MSAB018-R, para. 29** above) and the SRB have provided requests to investigate various MP elements.

> **IPHC-2023-SRB023-R, para. 29:** *The SRB* ***RECOMMENDED*** *evaluating fishing intensity and frequency of the stock assessment elements of management procedures and FISS uncertainty scenarios using the MSE framework. MP elements related to constraints on the interannual change in the TCEY and calculation of stock distribution may be evaluated for a subset of the priority management procedures as time allows.*

> **IPHC-2023-SRB023-R, para. 64:** ***NOTING*** *the presentation demonstrating how secondary FISS objectives influence choices for future FISS designs that may have already been endorsed by the SRB based only on primary objectives, the SRB* ***RECOMMENDED*** *that the MSE include some scenarios in which the FISS is skipped […] because of occasional (or functional) economic constraints on executing full FISS designs. Such simulation scenarios would provide some indication of the potential scale of impacts on MP performance of maintaining long-term revenue neutrality of the FISS.*

The following describes these elements of MPs that could be evaluated as part of the current (2024–2026) MSE Program of Work, in priority order.

Annual and multi-year stock assessment MPs

These are management procedures that conduct a stock assessment annually, every 2nd year (biennially), or every 3rd year (triennially). The biennial and triennial MPs use an empirical procedure based on the FISS survey trends to determine the TCEY in non-assessment years. The following empirical procedures for the coastwide TCEY are being considered:

a. Update the coastwide TCEY proportionally to the change in the coastwide FISS O32 WPUE.

Evaluation of multi-year stock assessment MPs is a high priority.

Fishing intensity

The fishing intensity is determined by finding the fishing rate (F) that would result in a defined spawning potential ratio (F_{SPR}). Because the fishing rate changes depending on the stock demographics, SPR is a better indicator of fishing intensity and its effect on the stock. A range of SPR values (adopted reference SPR is currently 43%) and possibly alternative trigger reference points (currently 30%) in the harvest control rule will be investigated. This was also recommended by the MSAB (see **IPHC-2023-MSAB018-R, para. 29** above).

Evaluation of a range of fishing intensities is a high priority.

FISS reductions

The FISS design was reduced in 2022 and 2023 to maintain revenue neutrality and further reductions may be necessary. The Commission is interested in understanding how FISS designs may affect management outcomes, as noted in the report from the 99th Interim Meeting (IM099).

> **IPHC-2023-IM099-R, para. 38:** *The Commission NOTED that:*
>
> *a) to understand how reductions in the FISS design may affect management outcomes, the evaluation of FISS design scenarios using the MSE framework was recommended by the SRB at SRB023;* [see IPHC-2023-SRB023-R paragraphs 29 and 64 as shown above].

The Secretariat will investigate scenarios where the FISS effort is reduced or occasionally eliminated in various IPHC Regulatory Areas. Work is currently being done to determine how

FISS design changes affects the inputs into the MSE. A number of different scenarios will be investigated, ranging from full FISS designs with high precision to reduced FISS designs and missed years showing low precision.

Evaluation of FISS scenarios is a high priority.

Constraints on the coastwide TCEY

One of the priority objectives is to limit annual changes in the coastwide TCEY. Due to variability in many different processes (e.g. population, estimation, and decision making) the interannual variability of the TCEY from MSE simulations is typically higher than 15%. Over the past ten years, the interannual variability (average annual variability or AAV) in the adopted coastwide TCEY was 5.7% and the AAV of the reference coastwide TCEY was 14.7%. The percent change in the adopted coastwide TCEY ranged from -16% to 19% across years, and ranged from -21% to 29% for the coastwide reference TCEY across years (Table 2).

Table 2. Percent change in the adopted TCEY from the previous year for each IPHC Regulatory Area and coastwide, and for the coastwide reference TCEY determined from the interim management procedure in place for that year.

	2A	2B	2C	3A	3B	4A	4B	4CDE	Coastwide Adopted	Coastwide Reference
2014	0.0%	-1.8%	9.0%	-29.4%	-36.5%	-35.8%	-22.8%	-16.4%	-19.4%	-8.6%
2015	-4.5%	3.5%	13.3%	7.9%	-0.3%	25.6%	2.7%	19.3%	8.1%	6.0%
2016	18.9%	4.2%	5.5%	-1.9%	-8.3%	-0.5%	-10.5%	-4.7%	-0.1%	2.3%
2017	16.7%	1.0%	7.6%	1.6%	16.7%	-7.7%	-2.2%	-5.7%	2.9%	7.7%
2018	-10.2%	-14.7%	-9.9%	-3.2%	-17.8%	-3.3%	-4.5%	-5.7%	-8.7%	-20.7%
2019	25.0%	-3.8%	0.0%	7.7%	-11.3%	11.5%	13.3%	10.5%	3.8%	29.0%
2020	0.0%	0.0%	-7.7%	-9.6%	7.6%	-9.8%	-9.7%	-2.5%	-5.2%	-20.3%
2021	0.0%	2.5%	-0.9%	14.8%	0.0%	17.1%	6.9%	2.1%	6.6%	22.3%
2022	0.0%	8.0%	1.9%	3.9%	25.0%	2.4%	3.6%	3.0%	5.7%	5.7%
2023	0.0%	-10.3%	-1.0%	-17.0%	-5.9%	-17.6%	-6.2%	-6.1%	-10.3%	26.0%

The recent decision-making process has reduced the interannual variability in the coastwide TCEY over the last ten years. The adopted TCEYs have a smaller range than the reference TCEYs and tend to cluster around 39 million pounds (Figure 3). The adopted TCEYs also tend to be closer to the status quo (i.e. the TCEY from the previous year) than the reference TCEYs when the reference TCEY difference from status quo was not near zero (Table 2 & Figure 3). This is akin to saying the change from one year to the next is less for the adopted TCEYs than the reference TCEYs. The spawning biomass has been relatively stable during the last ten years and it is not known how the recent decision-making process would react to an increasing or decreasing spawning biomass.

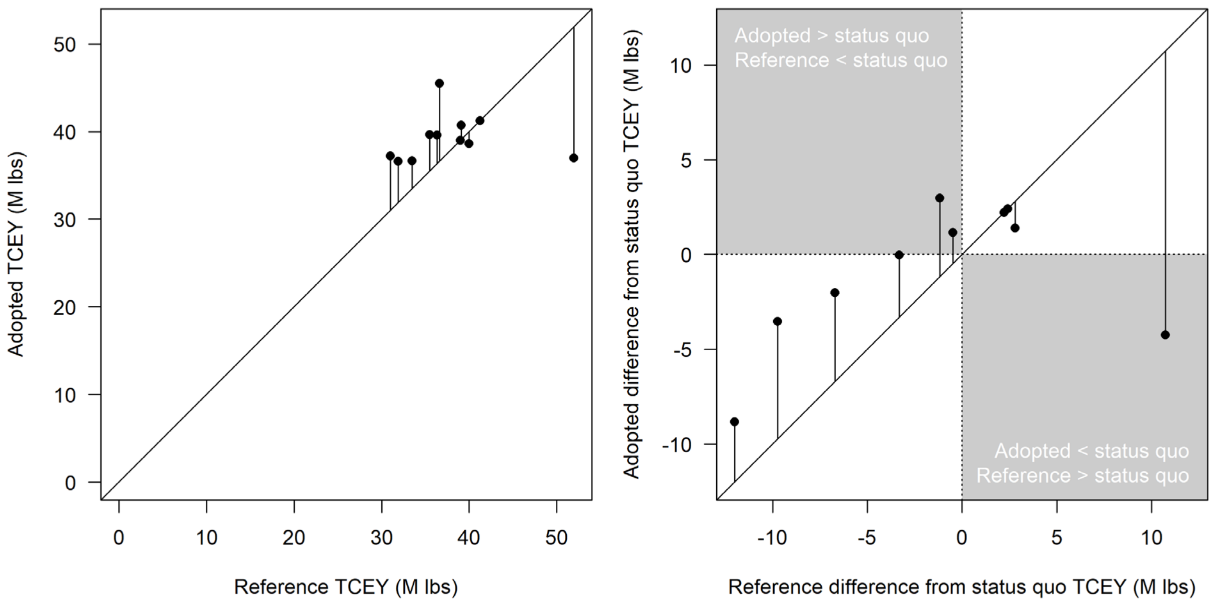

Figure 3. The adopted TCEY vs the reference TCEY (left) and the adopted difference from the status quo TCEY vs the reference difference from the status quo TCEY (right) for the last ten years. The 1:1 line shows when the two are equal. The grey quadrants in the right plot show when the adopted and reference TCEY differences from the status quo are opposite.

This interannual variability in the coastwide reference TCEY can be reduced by adding a constraint in the MP, mimicking the recent decision-making process. The MSAB has suggested many different constraints including a 15% constraint on the change in the coastwide TCEY from one year to the next, and a slow-up/fast-down approach. The MSAB requested further investigating constraints on the coastwide TCEY (see **IPHC-2023-MSAB018-R, para. 29** above).

Evaluating constraints on the coastwide TCEY is a secondary priority.

Additional MPs to evaluate

There are an endless number of MPs that could be evaluated with the MSE framework. Some potential MPs of interest include an element related to maintaining the absolute spawning biomass above a threshold, a method to reduce the interannual variability in the estimate of stock distribution, and specific procedures for distribution of the TCEY to IPHC Regulatory Areas.

An MP to maintain the absolute spawning biomass above a threshold could be similar to the control rule currently used for stock status. A ramp could reduce the fishing intensity when the absolute spawning biomass (or catch-rates) fall below a specified threshold. Alternatively, a reduced reference fishing intensity could be used to avoid low stock sizes and be tuned to meet current Commission objectives. However, an objective to avoid low absolute spawning biomass or catch-rates would be necessary (see Objectives and performance metrics section above).

The MSAB suggested investigating methods to reduce the interannual variability in the estimates of stock distribution at MSAB018 (see **IPHC-2023-MSAB018-R, para. 29** above). This may include using the average of the stock distribution estimates over the past 3 years, for example. This approach would recognize that there is a lag between the most recent estimate and the next year's fishery, such that there may be actual changes in the distribution, and also that there is observation variability in the estimates themselves, particularly given recent reductions in the FISS design.

The distribution of the TCEY to IPHC Regulatory Areas is not a part of the MP in the harvest strategy, but it is a required output of the harvest strategy. Investigating methods to produce a reference TCEY distribution to inform the decision-making process may be useful to assist the Commission. This could be a part of the products presented at the Annual Meeting. It would also be useful to include in the MSE simulations as a starting point from which decision-making variability is then applied. Currently, the estimated stock distribution and past relative harvest rates are used in the MSE simulations, and decision-making uncertainty is then applied.

EXCEPTIONAL CIRCUMSTANCES

An exceptional circumstance is an event that is beyond the expected range of the MSE evaluation and triggers specific actions that should be taken to re-examine the harvest strategy. Exceptional circumstances and actions taken if one or more is met is a process for deviating from an adopted harvest strategy (de Moor et al. 2022) and is useful to ensure that the adopted harvest strategy is retained unless there are indications that the MSE may not be accurate. The IPHC interim harvest strategy policy has a decision-making step after the MP, thus the Commission may deviate from an adopted MP as part of the harvest strategy policy, and this decision-making variability is included in the MSE simulations.

Defining exceptional circumstances involves defining events that would lead to re-examination of the MSE process to determine if an update to the framework and evaluation of management procedures is necessary. The SRB provided clarity at SRB021 of what an exceptional circumstance is relative to 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.

An exceptional circumstance, in an MSE context, is not usually defined to trigger an action within the management procedure. An example of a trigger within the MP is the 30:20 control rule which defines a reduction in the fishing intensity when stock status is less than 30%.

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 nonassessment years and additional MSE analyses.*

The Secretariat, with the assistance of the SRB and MSAB, is defining exceptional circumstances and the response that would be initiated, as well as potential triggers in a management procedure that would result in a stock assessment being done (if time allows) in a year that would normally not have one scheduled (e.g. in multi-year MPs). For example, 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, a stock assessment would be completed as soon as possible along with the re-examination of the MSE. Additionally, the SRB recommended to define a threshold for persistent deviation such that an exceptional circumstance is really an exception rather than a one-year outlier.

IPHC-2023-SRB022-R, para 28: *The SRB* ***RECOMMENDED*** *that exceptional circumstance (i) be evaluated annually based on comparisons between the simulation distribution (e.g. a 95% interval) of FISS values from MSE simulations to the realized FISS estimates; and (ii) be clearly distinguished from "unusual conditions". For example, exceptional circumstances should have a high threshold for persistent (i.e. more than a single year) deviation from MSE simulations.*

IPHC-2023-SRB022-R (para. 29). *The SRB* ***RECOMMENDED*** *that an initial response to a suspected "exceptional circumstance" should include presentation at the next SRB meeting to establish whether the situation meets the definition of an "exceptional circumstance" and to formulate a response.*

Working with the SRB, the following potential triggers for an exceptional circumstance have been defined.

IPHC-2023-SRB023-R, para. 27: ***RECOGNIZING*** *the spatial variability of environmental factors that influence population dynamics, the SRB* ***RECOMMENDED*** *that an exceptional circumstance be defined based on regional as well as stockwide deviations from expectations. For example, an exceptional circumstance could be declared if any of the following are met:*

a) The coastwide all-sizes FISS WPUE or NPUE from the space-time model falls above the 97.5th percentile or below the 2.5th percentile of the simulated FISS index for two or more consecutive years.

b) The observed FISS all-sizes stock distribution for any Biological Region is above the 97.5th percentile or below the 2.5th percentile of the simulated FISS index over a period of 2 or more years.

c) Recruitment, weight-at-age, sex ratios, other biological observations, or new research indicating parameters that are outside the 2.5th and 97.5th percentiles of the range used or calculated in the MSE simulations.

Furthermore, the following actions may take place if an exceptional circumstance is declared.

> **IPHC-2023-SRB023-R, para. 28:** *The SRB **RECOMMENDED** that if an exceptional circumstance occurred the following actions would take place:*
>
> *a) A review of the MSE simulations to determine if the OM can be improved and MPs should be reevaluated.*
>
> *b) If a multi-year MP was implemented and an exceptional circumstance occurred in a year without a stock assessment, a stock assessment would be completed as soon as possible along with the re-examination of the MSE.*
>
> *c) Consult with the SRB and MSAB to identify why the exceptional circumstance occurred, what can be done to resolve it, and determine a set of MPs to evaluate with an updated OM.*
>
> *d) Further consult with the SRB and MSAB after simulations are complete to identify whether a new MP is appropriate.*

If there are other concerns that are not exceptional, i.e. an unexpected event, a stock assessment could be initiated without declaring an exceptional circumstance. However, the time available to prepare, conduct, and review a stock assessment must be taken into account.

> **IPHC-2023-MSAB018-R, para. 32:** *The MSAB NOTED that there are logistical considerations (e.g. data availability, time to fit models) when an assessment is desired in a non-assessment year, especially if a request for an assessment is made between the time the FISS results are available and the Annual Meeting*

RESULTS

MSE simulations are currently being conducted, with a priority on multi-year assessments and SRB-requested FISS scenarios. Results will be added to the MSE Explorer website as they become available.

Past analyses (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 investigating persistent high and low PDO regimes show similar results, and also provide performance metrics specific to the IPHC MSE.

Results of MSE simulations assuming a persistent low or high PDO were presented at the 18th Session of the MSAB (MSAB018), the fifth conference for Effects of Climate Change on the Worlds Oceans (ECCWO5), and the PICES 2023 Annual Meeting (PICES-2023). These results showed that fishing and the environment affect the proportion of spawning biomass in each Biological Region in different ways.

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). However, even though the median was near 38%, there was a higher probability that the RSB was less than 36% for the low PDO scenario. The long-term median TCEY was 22% less for the low PDO scenario and 26% more for the high

PDO scenario when compared to the median TCEY for the base simulations that modelled cyclical PDO regime shifts. The median average TCEY for a persistent high PDO was 1.6 times greater than the TCEY for a persistent low PDO. Inter-annual variability in the TCEY was the same for the persistent low and high PDO scenarios, but less than the AAV when PDO regime shifts were modelled because the changing PDO adds additional variability.

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, 32-inch size-limit, no decision-making variability, no estimation error, no observation error, and an SPR of 43%. Long-term results are only shown for all performance metrics.

	PDO	**Both**	**Low**	**High**
Long-term metrics	Median RSB	38.8%	37.6%	39.2%
	P(RSB<20%)	<0.001	<0.001	<0.001
	P(RSB<36%)	0.238	0.329	0.157
	Median TCEY (Mlbs)	65.6	51.4	83.0
	Median AAV TCEY	5.2%	4.5%	4.5%
	Median TCEY Region 2 (Mlbs)	20.5	19.1	21.2
	Median TCEY Region 3 (Mlbs)	33.7	23.0	48.7
	Median TCEY Region 4 (Mlbs)	8.1	6.6	9.4
	Median TCEY Region 4B (Mlbs)	2.4	2.2	2.6

The percentage of spawning biomass in each Biological Region is affected by fishing under an SPR-based management procedure (Figure 4). 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 scenario results in a higher percentage than the persistent high PDO scenario. Region 3 shows a similar 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 a higher percentage of spawning biomass with fishing and a higher spawning biomass for the low PDO scenario.

A range of fishing intensities from SPR=40% to SPR=46% were simulated to determine the response to low or high fishing intensities (Table 4 and Figure 5). The range of fishing intensity had a much smaller effect that the PDO. The percentage of spawning biomass in Region 3 was mostly unresponsive to fishing intensity.

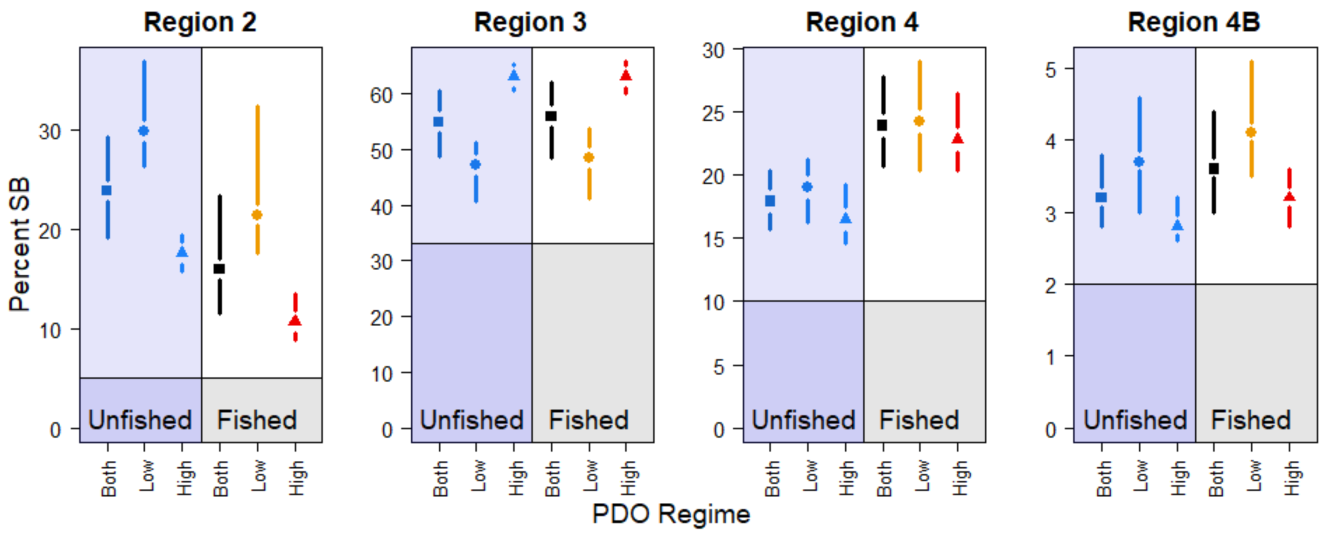

Figure 4. Percentage of spawning biomass in each Biological Region when fished with an SPR of 43% (no estimation error, no observation error, and no implementation error) and when not fished. The PDO is modelled with cyclical low and high periods in “Both”, is persistently low in “Low”, and is persistently high in “High”. The darker shaded area indicates the area below the threshold in the spatial conservation objective (Appendix A).

Table 4. 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, 32-inch size-limit, no decision-making variability, no estimation error, and no observation error, and SPR values equal to 40% and 46%. Long-term results only are shown for all performance metrics.

	PDO **SPR**	**Both** **0.40**	**Low** **0.40**	**High** **0.40**	**Both** **0.46**	**Low** **0.46**	**High** **0.46**
Long-term metrics	Median RSB	35.7%	34.5%	36.0%	42.0%	40.9%	42.4%
	P(RSB<20%)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	P(RSB<36%)	0.569	0.676	0.501	0.053	0.102	0.024
	Median TCEY (Mlbs)	68.3	53.7	86.8	62.7	49.0	79.0
	Median AAV TCEY	5.3%	4.9%	4.7%	5.1%	4.4%	4.4%
	Median TCEY Region 2 (Mlbs)	21.1	19.6	22.0	19.7	18.4	20.4
	Median TCEY Region 3 (Mlbs)	35.3	24.1	51.0	32.0	22.0	46.5
	Median TCEY Region 4 (Mlbs)	8.6	6.9	9.9	7.7	6.2	8.8
	Median TCEY Region 4B (Mlbs)	2.5	2.3	2.8	2.3	2.1	2.5

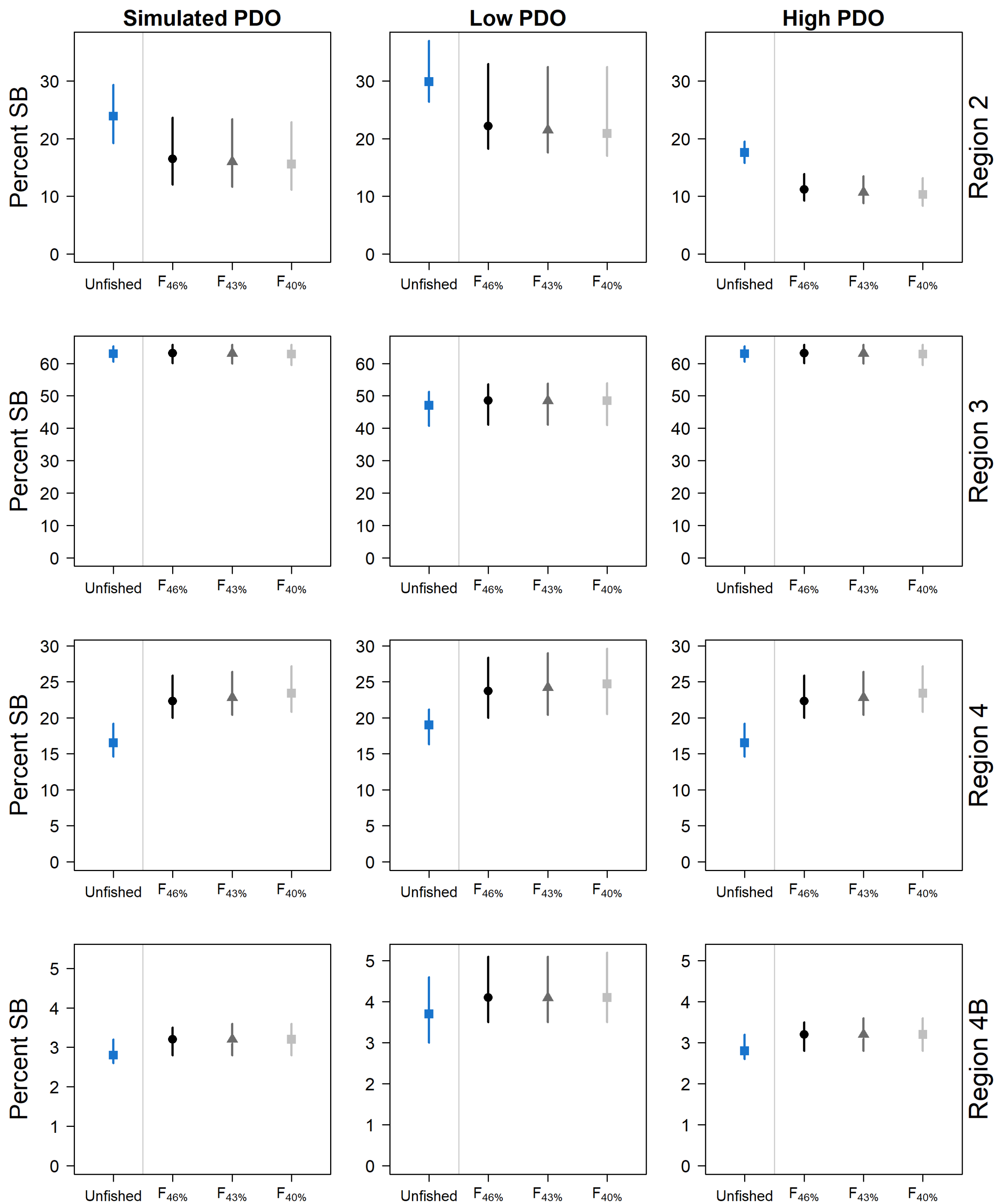

Figure 5. Percent biomass in each Region (rows) for simulated PDO, low PDO, and high PDO (columns) at different levels of fishing intensity.

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 a range SPR values from 40% to 46%). These results are dependent upon the full harvest strategy, and different distribution procedures would likely produce different outcomes.

IPHC Harvest Strategy Policy

A Harvest Strategy Policy (HSP) provides a framework for applying a science-based approach to setting harvest levels. At IPHC, this would be specific to the TCEY for each IPHC Regulatory Area throughout the Convention Area. Currently, IPHC has not formally adopted a harvest strategy policy, but has set harvest levels under an SPR-based framework with elements adopted at multiple Annual Meetings of the IPHC since 2017.

An HSP document outlines the policy and process of setting mortality limits for a fishery. It also identifies objectives or standards for fisheries management. Many fisheries management authorities have harvest strategy policy documents that cover many stocks, thus are generalised, and often take into account the level of information available for a fishery. For example, New Zealand has a Harvest Strategy Standard document that "is a policy statement of best practice in relation to the setting of fishery and stock targets and limits for fishstocks in New Zealand's Quota Management System (QMS)." This Harvest Strategy Standard was approved by the New Zealand Minister of Fisheries and has the purpose of "establishing a consistent and transparent framework for decision-making to achieve the objective of providing for utilisation of New Zealand's QMS species while ensuring sustainability." New Zealand also has an "Operational Guidelines for New Zealand's harvest Strategy Standard" document with technical and implementation guidelines. This technical document contains information on calculations, roles and responsibilities, and the process of setting management targets. Other documents outlining harvest strategies are fishery management plans (FMP) from the Fishery Councils in the United States of America and the Fishery Decision-Making Framework Incorporating the Precautionary Approach in Canada. The FMP for Groundfish of the Bering Sea and Aleutian Islands Management Area describes "management policy and objectives to guide its development of management recommendations." There are many other examples of documented harvest strategies including a overarching harvest strategy policy and a harvest strategy for each fishery in Australia and resolutions for tuna commissions like the Inter-American Tropical Tuna Commission (IATTC).

Adopting an HSP is important for any fisheries management authority because it outlines the long-term vision for management and specifies the framework for a consistent and transparent science-based approach to setting mortality limits. An HSP:

- identifies an appropriate method to manage natural variability and scientific uncertainty,
- accounts for risk and balances trade-offs,
- reduces the time needed to make management decisions,
- ensures long-term sustainability and profitability,
- increases market stability due to a more predictable management process,

- adheres to the best practices of modern fisheries management that is consistent with other fisheries management authorities and certification agencies, and
- allows for the implementation of the precautionary approach.

Overall, an HSP spells out the management process, which benefits the fish, the stakeholders, and other interested parties.

To move towards formally adopting a harvest strategy policy at the IPHC in the near term, the SRB recommended separating the coastwide TCEY management procedure from the distribution procedure.

> **IPHC-2023-SRB023-R, para. 30:** *The SRB **RECOMMENDED** that the Commission consider revising the harvest policy to (i) determine coastwide TCEY via a formal management procedure and (ii) negotiate distribution independently (e.g. during annual meetings). Such separated processes are used in other jurisdictions (e.g. most tuna RFMOs, Mid Atlantic Fishery Management Council, AK Sablefish, etc.).*

The coastwide TCEY determined from the MP in the harvest strategy would be an input into the allocation decision-making process.

An HSP can be divided into three components: management procedure, harvest strategy, and policy (Figure 6). A management procedure is an agreed upon procedure that determines an output that meets the objectives defined for management. The MP is reproducible and is codified such that it can be consistently calculated. The harvest strategy component contains the MP but is broader and encompasses the objectives as well as additional procedures that produce that final necessary outputs, but may not be procedural and pre-defined. For example, at the IPHC the harvest strategy consists of the procedure to determine the coastwide TCEY as well as the concept of distributing the TCEY to each IPHC Regulatory Area. Currently, the determination of the coastwide TCEY is defined using a harvest control rule and reference fishing intensity, but there is not an agreed upon procedure to distribute the TCEY. However, a reference TCEY distribution may be useful to inform the decision-making process. The policy component is the aspect of decision-making where management may deviate from the outputs of the harvest strategy to account for other objectives not considered in the harvest strategy. This may be to modify the coastwide TCEY and/or the distribution of the TCEY to account for economic factors, for example. At IPHC, the policy component occurs at the Annual Meeting of the IPHC where stakeholder input is considered along with scientific information to determine the mortality limits for each IPHC Regulatory Area.

The IPHC Secretariat is currently in the process of updating the IPHC harvest strategy policy document, which was last edited in 2019, and a draft HSP is available for consideration by the Commission (outline in Appendix B). This draft may be adopted as an interim HSP, but some additional MSE work is necessary for a final HSP, noting that the HSP may be updated at any time following additional MSE-related work. The necessary MSE tasks to complete include investigating multi-year assessments with empirical rules to determine the coastwide TCEY in non-assessment years, and examining additional fishing intensities (i.e. SPR values) for each of those options. The draft HSP includes a description of the decision-making process and the flexibility that the Commission would have when making management decisions. This decision-making uncertainty is included in the MSE analysis of risk.

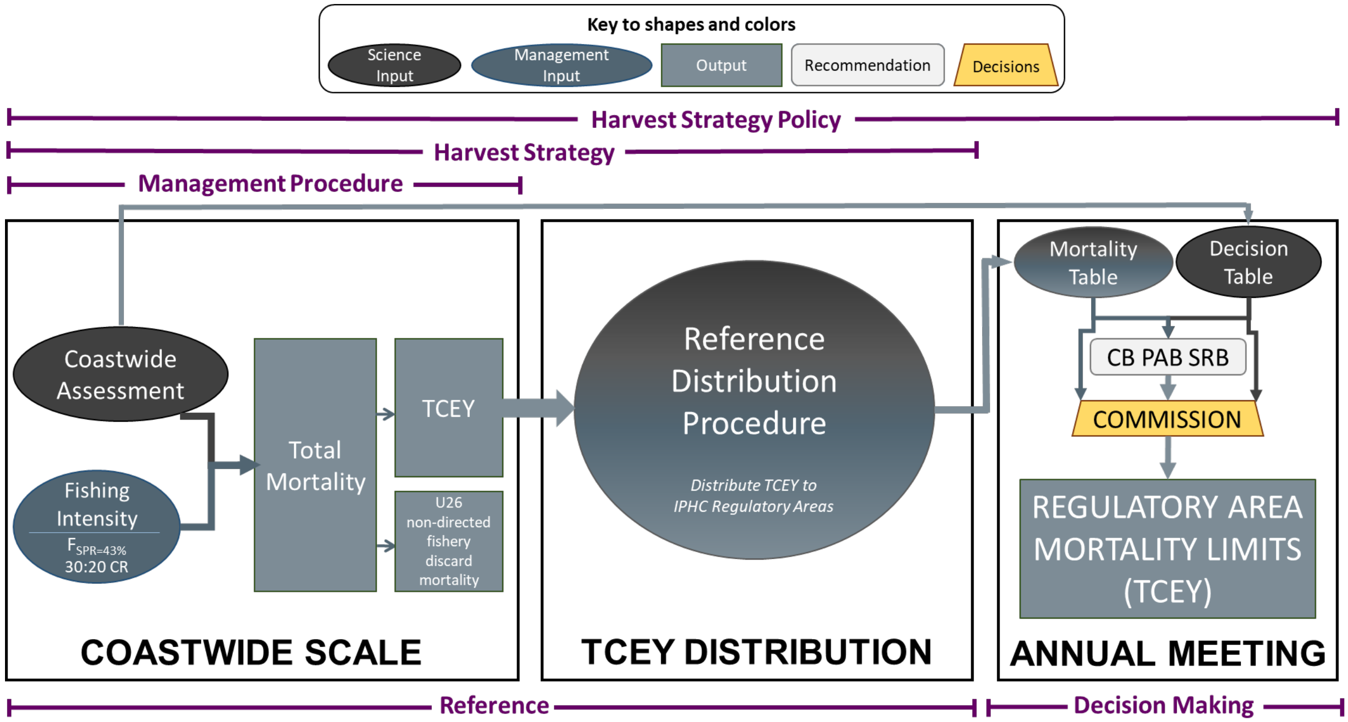

Figure 6. Illustration of the harvest strategy policy for IPHC showing the coastwide scale (management procedure), the TCEY distribution (part of the harvest strategy), and the policy component that mainly occurs at the Annual Meeting.

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de Moor, C.L., Butterworth, D., and Johnston, S. 2022. Learning from three decades of Management Strategy Evaluation in South Africa. ICES Journal of Marine Science **79**: 1843-1852.

APPENDICES

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

Appendix B: Outline of a draft IPHC harvest strategy policy

Appendix C: Supplementary material

Appendix A
Objectives used by the Commission for the MSE

Table B1. 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 ($B_{20\%}$) at least 95% of the time	B < Spawning Biomass Limit (B_{Lim}) B_{Lim}=20% unfished spawning biomass	Long-term	0.05	$P(SB < SB_{Lim})$ Fail if greater than 0.05
	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 Reference (B_{Thresh}) B_{Thresh}=$B_{36\%}$ unfished spawning biomass	Long-term	0.50	$P(SB < SB_{Thresh})$ Fail if greater than 0.5
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* $\overline{\left(\frac{TCEY_A}{TCEY}\right)}$
	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
OUTLINE OF A DRAFT IPHC HARVEST STRATEGY POLICY

Chapter 1 Introduction

1.1 Scope

1.2 What is a Harvest Strategy Policy (HSP)?

1.3 What is a Harvest Strategy?

Chapter 2 Objectives and Key Principles

Chapter 3 Development of the Harvest Strategy

3.1 Accounting for fishing mortality on all sizes and from all sources

3.2 Variability in the environment and biological characteristics

3.3 Monitoring Standards

3.4 Establishing and applying decision rules

3.5 Balancing risk, cost and catch

3.6 Reference points and proxies

3.7 Technical evaluation of the harvest strategy

3.8 Re-evaluating the harvest strategy and management procedure

Chapter 4 Applying the harvest strategy

4.1 Jointly-managed domestic stocks

4.2 Jointly-managed international stocks

4.3 Stock assessment

4.4 Coastwide mortality limit

4.5 Rebuilding if the stock becomes overfished

4.6 Mortality limits for each IPHC Regulatory Area

4.7 Common outputs used for decision-making

4.8 Stakeholder and scientific input

4.9 Annual process

APPENDIX C
SUPPLEMENTARY MATERIAL

The IPHC MSE Research website contains additional documents with more detailed information.

https://www.iphc.int/management/science-and-research/management-strategy-evaluation

This includes a technical description of the MSE framework in document IPHC-2023-MSE-02.

The MSE Explorer will be updated as additional results are produced. Links to the current MSE Explorer as well as archived results are available at

http://iphcapps.westus2.cloudapp.azure.com/