Update on the IPHC Secretariat MSE Program of Work (2021–2023)

PREPARED BY: IPHC SECRETARIAT (A. HICKS & I. STEWART; 22 OCTOBER 2021)

PURPOSE

To provide the Commission with an update of progress on the Management Strategy Evaluation (MSE) program of work for 2021–2023.

1 INTRODUCTION

The current interim management procedure (MP) at the International Pacific Halibut Commission (IPHC) is shown in Figure 1.

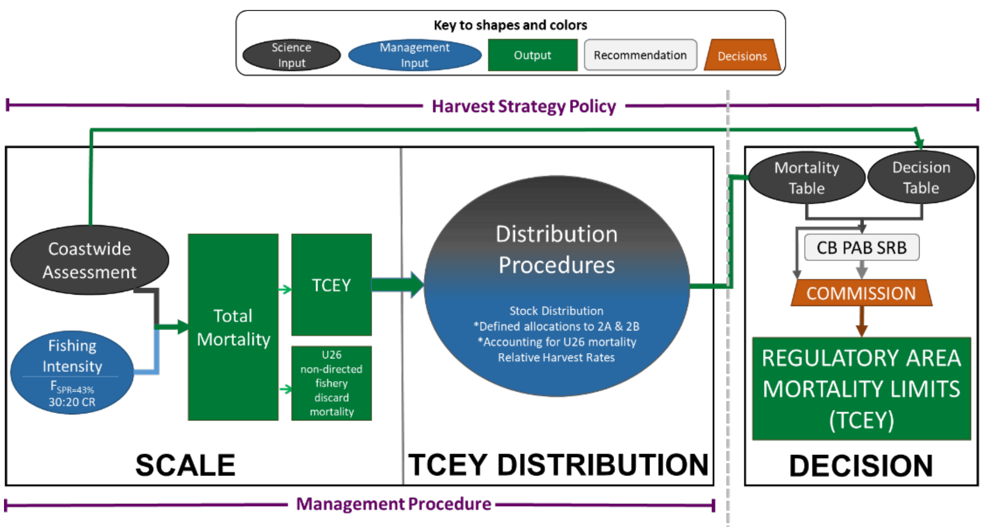

Figure 1. Illustration of the Commission interim IPHC harvest strategy policy (reflecting paragraph ID002 in IPHC-2020-CR-007) showing the coastwide scale and TCEY distribution components that comprise the management procedure. Items with an asterisk are interim agreements in place through 2022. The decision component is the Commission decision-making procedure, which considers inputs from many sources.

The Management Strategy Evaluation (MSE) at the IPHC completed an evaluation in 2021 of management procedures (MPs) relative to the coastwide scale and distribution of the Total Constant Exploitation Yield (TCEY) to IPHC Regulatory Areas for the Pacific halibut fishery using a recently developed framework. The development of this MSE framework supports the evaluation of the trade-offs between fisheries management scenarios. The MSE framework with a multi-area operating model (OM) and three options for examining estimation error is described in Hicks et al. (2020) with technical details available in IPHC-2021-MSE-01. Descriptions of the MPs evaluated and simulation results are presented in Hicks et al. (2021). Additional tasks were identified at the 11th Special Session of the IPHC (IPHC-2021-SS011-R) to supplement and extend this analysis for future evaluation (Table 1). Document IPHC-2021-MSE-02 contains details of the current MSE Program of Work.

Table 1. Tasks recommended by the Commission at SS011 (IPHC-2021-SS011-R para 7) for inclusion in the IPHC Secretariat MSE Program of Work for 2021–2023.

ID	Category	Task	Deliverable
F.1	Framework	Develop migration scenarios	Develop OMs with alternative migration scenarios
F.2	Framework	Implementation variability	Incorporate additional sources of implementation variability in the framework
F.3	Framework	Develop more realistic simulations of estimation error	Improve the estimation model to more adequately mimic the ensemble stock assessment
F.5	Framework	Develop alternative OMs	Code alternative OMs in addition to the one already under evaluation.
M.1	MPs	Size limits	Identification, evaluation of size limits
M.3	MPs	Multi-year assessments	Evaluation of multi-year assessments
E.3	Evaluation	Presentation of results	Develop methods and outputs that are useful for presenting outcomes to stakeholders and Commissioners

This document provides updates on the progress for the framework related tasks and the MP related tasks. Improvements to the evaluation and presentation of results are not presented in this document, but will continue to be worked on in 2022 with input from the MSAB.

2 FRAMEWORK

The framework category consists of three tasks (F.1, F.2, and F.3) that will improve the OM and lead to the completion of the fourth task (F.5) to develop alternative operating models. Current progress has been made on incorporating implementation variability and developing migration scenarios and are the only two tasks reported here.

2.1 Task F.1: Develop migration scenarios

Conditioned movement rates at age in the current OM differed from historically estimated rates for some Regions. This may be due to a number of reasons, two of which are described below.

First, the estimated movement rates from past data may have been reflective of smaller spatial and temporal scales than the entire IPHC Convention Area covered in the OM. The OM was not conditioned to the same observations that the data-determined movement rates were estimated from. Instead, the OM was attempting to describe broad scale historical population trends over the last 100+ years.

Second, the distribution of age-0 recruits (called recruitment distribution) was fixed at the same proportions for each Biological Region over all years in the OM, but it is likely that these proportions actually vary across years. Time-varying recruitment distribution has an affect on movement because it places age-0 recruits in specific regions and movement rates have to 'move' the fish to the places they are expected to be based on data that are representative of older fish. If the distribution of recruits is not correct, movement rates will be estimated differently in the OM than from direct observations of adult movement.

Sadorus et al. (2020) found that recruits were more likely to end up the Bering Sea in "warm years" for most spawning areas in the Gulf of Alaska. Furthermore, "cold years" were likely to have less dispersal to the west in the Bering Sea and "warm years" were more likely to have more dispersal to the northwest from spawning in the Western Gulf of Alaska. Therefore, in the Operating Model with four Biological Regions this may be modelled by allowing the recruitment distribution to change with the phase of the Pacific Decadal Oscillation (PDO; Mantua et al. 1997), thus higher proportions of recruits would go to Regions 4 and 4B in years of a positive PDO.

The OM code was updated in 2021 to allow for time-varying recruitment distribution that is tied to the low and high phases of the PDO, as defined in the stock assessment. Initial investigations conditioning the OM with time-varying recruitment distribution showed the expected pattern of the proportion recruited to western regions (Figure 2), improved expectations of movement rates (relative to historical estimates), and produced similar fits to the spawning biomass trajectory (estimated from the stock assessment ensemble) and distribution of O32 Pacific halibut (estimated from FISS data).

This improvement in the modelling of recruitment was necessary before beginning the identification of movement scenarios.

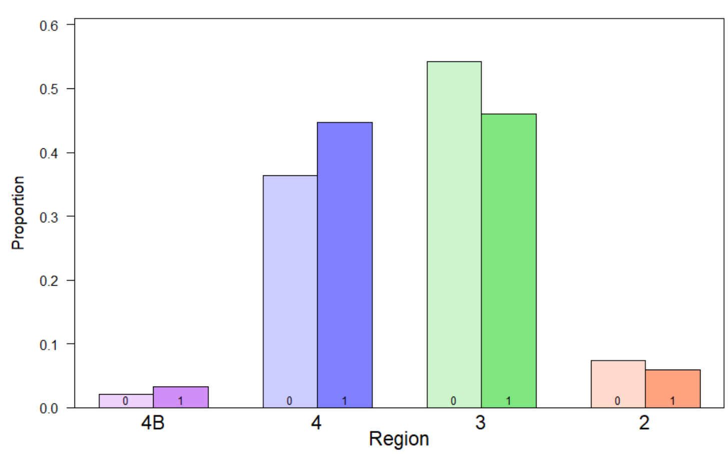

Figure 2. Proportion of coastwide recruitment assigned to each Biological Region in the OM in low PDO years (left bars shown with a 0) and high PDO years (right bars shown with a 1).

2.2 Task F.2: Implementation variability and uncertainty

Implementation variability is defined as the deviation of the fishing mortality from the mortality limit determined from an MP. It can be thought of as what is believed to have happened compared to the limits that were set. It is useful to define four different fishing mortalities that are subject to different types of implementation variability.

- **MP mortality limit**: This is the mortality limit determined from the management procedure which is calculated from a defined method without ambiguity and is repeatable.
- **Adopted mortality limit**: This is the mortality limit determined by the Commission after reviewing all inputs from the stock assessment, subsidiary bodies, and public. It is determined in the "decision" step of Figure 1 which are put into the regulations.
- **Estimated fishing mortality**: This is the perceived mortality after fishing occurs that is determined from landings, at-sea samples, discard mortality rates, and any other observations used in catch accounting. It may also be determined from methods or assumptions that do not used direct observations of catches or landings (e.g. effort). These estimates have sampling uncertainty and are used in estimation models, such as the stock assessment.
- **Actual fishing mortality**: This is the mortality that actually occurred from fishing activities. It is unknown in reality but is used in the OM which simulates the Pacific halibut population. Estimated fishing mortality may affect actual fishing mortality in cases where in-season management uses estimates of fishing mortality to determine if fisheries should be closed or opened.

These four types of mortality are hierarchically related to each other as shown in Figure 3. There are multiple pathways to modelling estimated and actual fishing mortalities. For example, estimated fishing mortality may be a function of the adopted mortality limit or a function of the actual fishing mortality. Actual fishing mortality may be a function of the adopted mortality limit or a function of the estimated fishing mortality. These pathways may differ for different sectors.

We have identified three types of implementation variability that define these relationships. If there is no implementation variability, then all four types of fishing mortality are equal to each other.

1. **Decision-making** variability is the difference between the MP mortality limits and the adopted mortality limits set by the Commission.
2. **Realized** variability is the difference between the adopted mortality limits set by the Commission and the actual mortality resulting from fishing.
3. **Perceived** variability is the variation that determines the estimated fishing mortality, which can differ importantly from actual mortality.

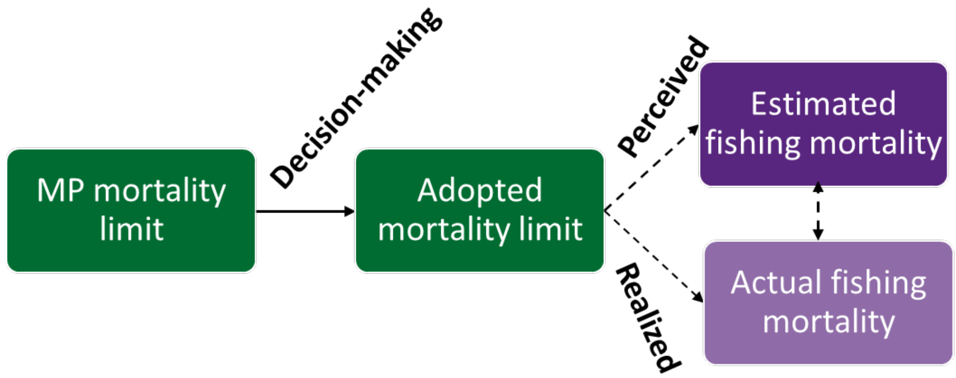

Figure 3. The hierarchy between four fishing mortality types (green and purple boxes) and where implementation variability occurs (black text). Dashed lines indicate that the estimated and actual fishing mortalities could be modelled from different pathways (e.g., estimated fishing mortality is a function of the adopted mortality limit or a function of the actual fishing mortality). Actual fishing mortality is not known in reality but is used in the OM, thus is shown in a lighter color.

Variability is defined as the inherent heterogeneity in the data or population, which cannot be reduced. On the other hand, uncertainty is defined as the incomplete understanding of the data, estimate, or process. Uncertainty can be reduced to zero with increased sampling. With these definitions, we refer to historical variations in implementation of mortality limits as implementation variability, and the future simulation of potential variations in the implementation of mortality limits as implementation uncertainty. Variability has already happened in the past and can be determined and not changed, whereas future simulations are uncertain about the variations, thus simulate a range of possible deviations.

To identify reasonable methods to simulate implementation uncertainty in the MSE, we considered some possible hypotheses and looked at historical implementation variability. First, decision-making uncertainty can be applied to the MP mortality limit ($TCEY_t$) as a multiplier.

$$\widetilde{TCEY}_t = TCEY_t \varepsilon_I$$

where $\widetilde{TCEY}_t$ is the adopted mortality and ε_I is the multiplier. Using observations from 2014 to 2021 of the MP mortality limit determined from the interim management procedure and the adopted mortality limits set by the Commission for that year and IPHC Regulatory Area, the multipliers are shown in Figure 4. These years were chosen because they used a relatively consistent management procedure, although as noted in the following paragraphs from Annual Meeting reports, explicit use of SPR was added in 2017, additional agreements were added in 2019 and 2020, and the reference SPR changed from 46% to 43% in 2021.

> ***IPHC-2017-AM093–R* (para. 29) NOTING** *that the IPHC Secretariat and the IPHC Scientific Review Board (SRB) have demonstrated that Ebio is outdated and inconsistent with current assessment results, and that numerous elements of the current harvest policy are reliant on Ebio, and that the Commission has agreed that the current harvest policy is considered to be outdated (IPHC–2016–IM092–R, items 21, 22), the Commission*

***RECOMMENDED** IPHC–2017–AM093–R Page 8 of 61 that reference to all elements of the current harvest policy reliant on Ebio, as well as the use of the Blue line, be eliminated subsequent to the close of the 93rd Session of the Commission. The "status quo SPR" (F46%) may serve as an interim "hand rail" that allows all participants to gauge this and future years' catch limit discussions in comparison to previous years.*

***IPHC-2020-AM096-R** **(para. 97)** The Commission **ADOPTED**: a)[…]; and b) a fixed TCEY for IPHC Regulatory Area 2A of 1.65 million pounds is intended to apply for a period from 2019-2022, subject to any substantive conservation concerns; and c) a share-based allocation for IPHC Regulatory Area 2B. The share will be defined based on a weighted average that assigns 30% weight to the current interim management procedure's target TCEY distribution and 70% on 2B's recent historical average share of 20%. This formula for defining IPHC Regulatory Areas 2B's annual allocation is intended to apply for a period of 2019 to 2022. For 2020, this equates to a share of 18.2% before accounting for U26; and […]*

***IPHC-2020-CR-007** **(ID002).** The Commission **RECOMMENDED** a reference SPR fishing intensity of 43% with a 30:20 control rule be used as an updated interim harvest policy consistent with MSE results pending delivery of the final MSE results at AM097 […]*

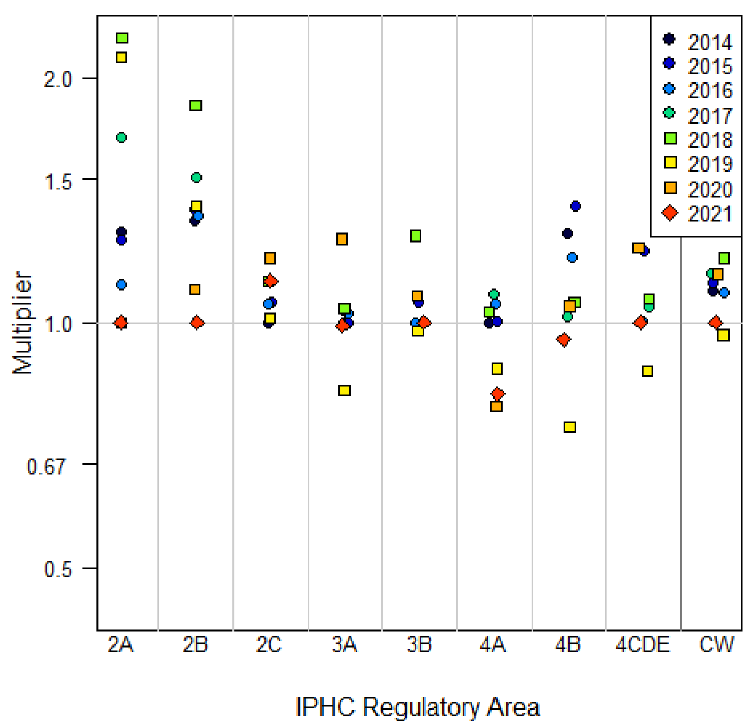

Figure 4. Multipliers for the difference between MP mortality limits and adopted mortality limits from 2014 to 2021. "CW" refers to coastwide.

The Commission does not necessarily choose multipliers for each IPHC Regulatory Area or attempt to keep the coastwide TCEY at the same value as the TCEY determined from the MP (i.e., the right column in Figure 4 is not always at 1.0), but the decisions made for each IPHC Regulatory Area are not independent of each other. Therefore, there is correlation between the multipliers in each IPHC Regulatory Area for a specific year, which must be accounted for when simulating decision-making uncertainty.

This investigation of past decisions can inform the development of methods to simulate decision-making uncertainty. To further aid in the development, six potential decision-making response hypotheses were identified from discussions with the SRB and MSAB, as well as from past observations.

1) When the TCEY is high the Commission may be less inclined to increase the coastwide TCEY above the MP TCEY (the multipliers become closer to 1).
2) When the TCEY is decreasing from the previous year, the multiplier is typically above 1, whereas when the TCEY is increasing, it is typically around 1. The SRB made a recommendation related to this scenario.

   SRB019–Rec.06 (para. 35) ***NOTING*** *the inclusion of uncertainty stemming from implementation* ***uncertainty****, the SRB* ***RECOMMENDED*** *that the IPHC Secretariat develop, for presentation at SRB020, alternative scenarios that represent implementation* ***bias****, i.e. the potential for quota reductions called for by the management procedure to be less likely implemented than quota increases.*

3) When the stock status is less than 30%, the Commission may deviate (increased fishing intensity/higher TCEY) from the MP. An extreme example is that they may decide to not set the TCEY to zero when the relative spawning biomass is less than 20%, as defined by the interim control rule.
4) When coastwide stock status is above 30% (trigger point of CR) the multiplier may be increasingly greater than one as the TCEY becomes lower or is below some threshold.
5) When the decision table from the assessment indicates a lower risk of stock decline or falling below 30% RSB, the multiplier may become increasingly greater than 1.
6) When there is an agreement for an IPHC Regulatory Area, the implementation variability is much less, or near 1.0 for these areas.

2.2.1 Method to simulate decision-making uncertainty

The multiplier to simulate decision-making uncertainty is drawn from a lognormal distribution with correlation between multipliers for each IPHC Regulatory Area. The mean ($\boldsymbol{\mu_\varepsilon}$) and standard deviation ($\boldsymbol{\sigma_\varepsilon}$) of that distribution are modified as follows depending on the TCEY from the MP.

$$\boldsymbol{\mu_\varepsilon}\ or\ \boldsymbol{\sigma_\varepsilon} = \begin{cases} \boldsymbol{\bar{x}}\ or\ \boldsymbol{s} & TCEY < TCEY_{low} \\ \boldsymbol{a} + \boldsymbol{b} * TCEY & TCEY_{low} \le TCEY \le TCEY_{high} \\ \mathbf{1.0}\ or\ \boldsymbol{s}/\mathbf{2} & TCEY > TCEY_{high} \end{cases}$$

Using IPHC Regulatory Area 2A as an example (no TCEY agreement in place), with a coastwide $TCEY_{low}$ of 30 Mlbs and a coastwide $TCEY_{high}$ equal to 60 Mlbs, the distribution of simulated multipliers gets closer to 1 as the TCEY increases (Figure 5).

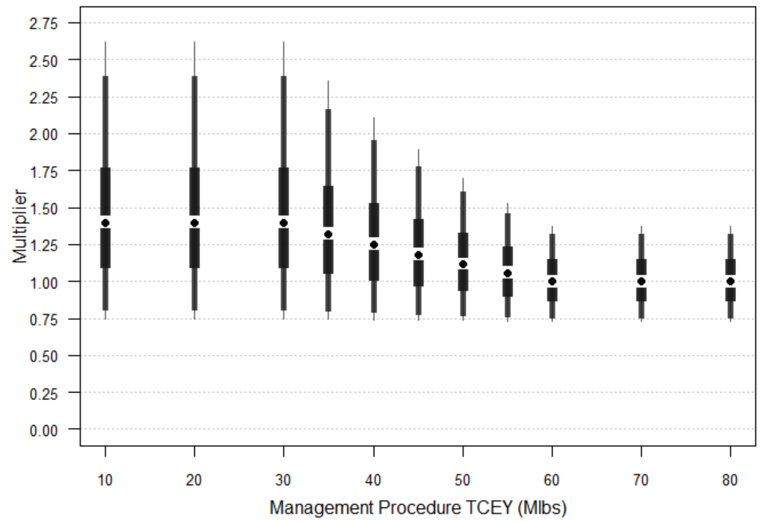

Figure 5. Simulated multipliers for IPHC Regulatory 2A at different values of the coastwide TCEY and without an agreement on the 2A TCEY. The thickest portion of the vertical bar represents the 25th and 75th percentiles, followed by the 5th and 95th percentiles, and then the 2.5th and 97.5th percentiles.

The above method may directly address, indirectly or partial address, or not address each management response hypothesis as follows.

1) This is an attempt to directly account for hypothesis 1.
2) This does not take into account decreases or increases. For example, in 2013, the Commission specifically chose to not take the entire decrease. However, it partially addresses hypothesis 2 because as the TCEY increases the multiplier becomes closer to 1, and vice versa.
3) Hypothesis 3 is indirectly addressed because when the stock status is low, the multiplier is more likely to be above 1 because the TCEY will likely be low as well. However, a multiplier on a very low number is still a low number, therefore a minimum on the adopted TCEY may be a scenario to explore.
4) This is an attempt to directly account for hypothesis 4, which is a special case of hypothesis 1.
5) This does not account for the decision table, but if there is a high risk of falling below 30%, the TCEY is likely to be low. Hypothesis 5 suggests the opposite (that the Commissioners will act in a cautionary manner to avoid falling below 30%) of the method proposed above. Therefore, this method does not address hypothesis 5 but could be investigated separately.
6) This method does not address hypothesis 6, but a simple modification when an agreement is in place could be easily implemented for these special case MPs.

Actual decision-making variability is likely more complex than this simple method. In fact, some IPHC Regulatory Areas show a consistent adopted TCEY over a range of MP TCEYs (e.g., 4B in Figure 6). However, the goal of including decision-making uncertainty in the MSE simulations isn't to exactly simulate what the pattern is, but to identify the effect of decision-making uncertainty and identify MPs that are robust to a plausible amount of uncertainty. Therefore, simulations will be done with and without decision-making uncertainty to identify MPs that are robust to this uncertainty.

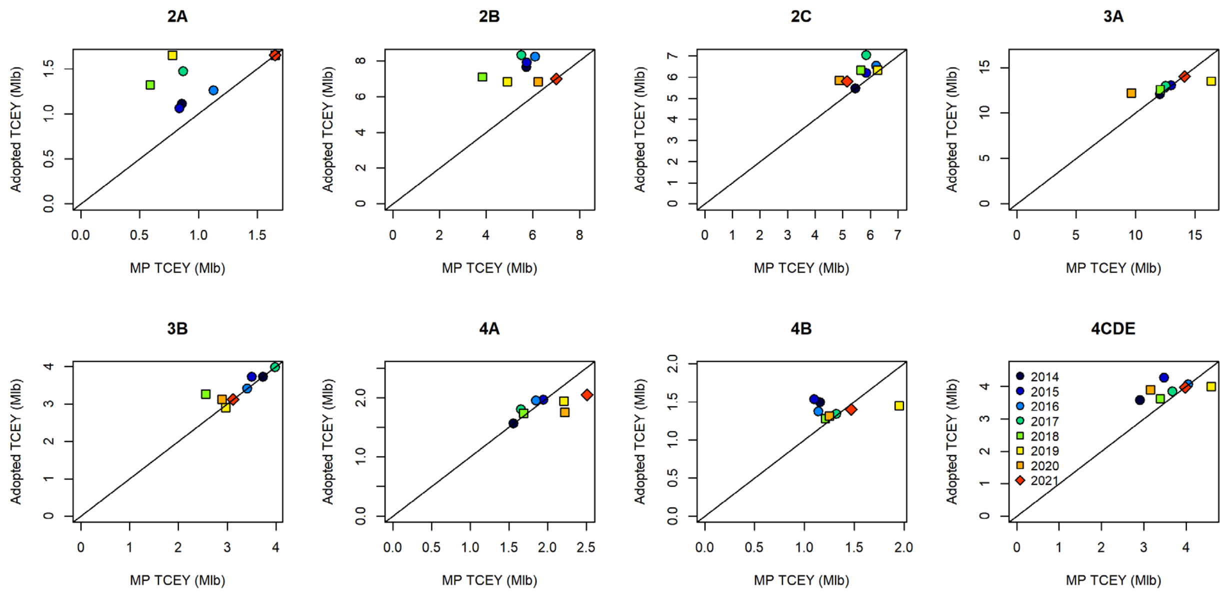

Figure 6. Adopted TCEYs plotted against MP TCEYs for each IPHC Regulatory Area and years 2014 to 2021.

Realized uncertainty is currently implemented in the OM by simulating a range of actual non-directed discard mortality, recreational mortality, and subsistence mortality. These are likely the largest sources of realized variability in the Pacific halibut fisheries.

Perceived uncertainty is currently not simulated in the OM but will be considered as work progresses.

3 MANAGEMENT PROCEDURES

Two categories of MPs were prioritised in the MSE Program of Work for 2021–2023. One was the investigation of size limits (M.1) and the other was to investigate multi-year stock assessments (i.e. not conducting the stock assessment annually; M.3). The investigation of SPR-based MPs, as was done for 2021 will also continue as needed to evaluate the performance of a range of MPs.

3.1 Size limits

Pacific halibut have shown highly variable size- and weight-at-age over time. Studies on growth and analysis of length data continue, but recent population modelling of Pacific halibut has converted numbers-at-age to biomass using weight-at-age relationships directly, instead of using intermediate length-at-age calculations. The OM follows the direct weight-at-age method to avoid modelling the complexities of changing length-at-age relationships over time. However, this means that defining size-based quantities, such as needed for size limits or U26/O32 metrics, for example, must be approximated. The OM currently uses static distributions of length-at-ages (Figure 7) determined from pooled coastwide data to determine quantities such as O32 WPUE from the Fishery-Independent Setline Survey (FISS).

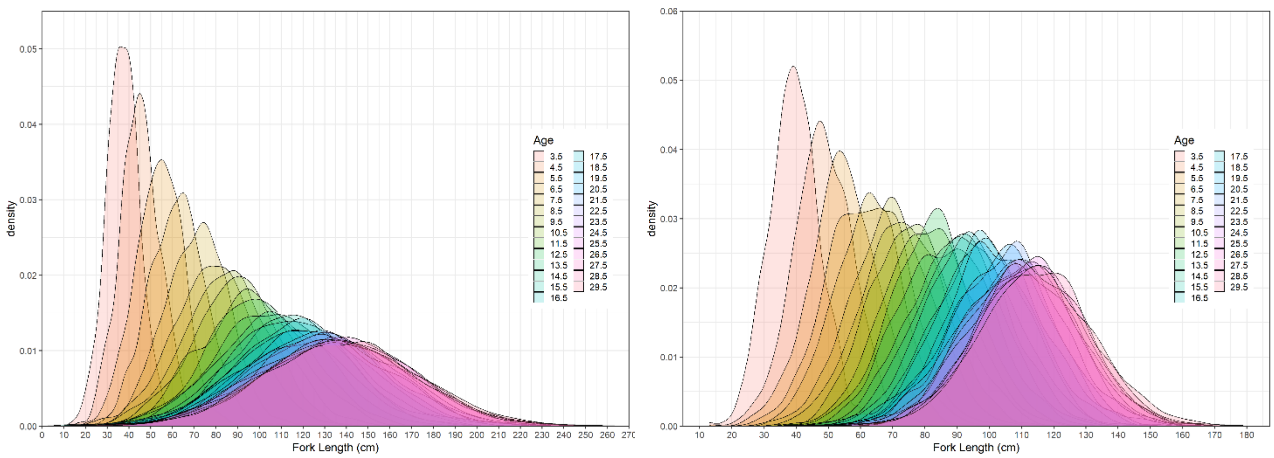

Figure 7. Distribution of length-at-ages 3 to 25 for female (left) and male (right) Pacific halibut.

3.1.1 Modelling time-varying length in the OM

There are two paths for incorporating time-varying length-based processes in the OM. One is to model it independently, not linked to population processes, and use it to calculate size-based quantities only when necessary. The second is to model length-at-age and weight-at-length explicitly such that weight-at-age is determined from these two growth functions.

Modelling length through length-at-age distributions to determine the probability that a specific age fish is above a defined size is the quickest solution as this is partially implemented in the current OM. These length-at-age distributions, however, are currently static across years in the OM, but could be updated through simulation on an annual basis in the projections to simulate time-varying changes in length-at-age. This would require investigating historical data to understand the annual variation, and then coding a method to apply the annual variation in the OM. The most simple and quickest method would be to determine a mean length from the simulated mean weight-at-age using an assumed weight-length relationship. This may not, however, capture the population effects of a size limit and completely account for changes in selectivity with changes in a size limit. Time would be spent determining appropriate simulation methods and then updating the OM code, but some simulations could be completed for the 99th Annual Meeting in 2023 along with other tasks in the MSE program of work.

The second method of directly modelling length-at-age and weight-at-length to determine weight-at-age is much more involved, requiring many changes to the OM, but would be a more complete method of modelling length and weight for the population. Length bins in the population would be directly modelled allowing for length-based processes such as selectivity and movement. However, this is difficult and could be inaccurate due to the complexities of modelling time-varying length for Pacific halibut and the wide range of lengths observed for a single age class. It is a more complete method for modelling length in a population, but also a source of variability that may be distracting when providing management advice. Additionally, it would take a considerable amount of time to determine the appropriate methods and to code the operating model. Some simulations could be completed by the 99th Annual Meeting in 2023 if this was the only task for the MSE framework in the MSE Program of Work.

3.1.2 Multi-year stock assessments

Management procedures with multi-year assessments incorporate a process where the stock assessment occurs at intervals longer than annually. The mortality limits in a year with the stock assessment can be determined as in previously defined MPs, but in years without a stock assessment, the mortality limits would need an alternative approach. This may be as simple as maintaining the same mortality limits for each IPHC Regulatory Area in years with no stock assessment, or as complicated as invoking an alternative MP that does not require a stock assessment (such as an empirical-based MP relying only on data/observations).

Simulations using an MP where the stock assessment occurs biennially and the mortality limits remain unchanged from the previous year were performed using the 2020 MSE framework. The specifications of the simulation model are the same as reported in Hicks et al. (2020), Hicks et al. (2021), and IPHC-2021-MSE-01. The MP specified as A was used with the addition of a biennially assessment (Table 2). Coastwide performance metrics for MP-A with and without the biennial mortality limit specification are shown in Table 3 along with MP-D and MP-J which were the best performing MPs from the previous MSE simulations.

The biennial mortality limit specification improved the coastwide performance metrics related to variability in the TCEY compared to MP-A with an annual mortality limit specification. The median average TCEY was less than MP-A and MP-D, but slightly higher than MP-J. The median relative spawning biomass was above the 36% target, but slightly closer than MP-A.

Table 2. Specifications of MPs with an annual stock assessment and management advice (MP-A, MP-D, and MP-J), and with a biennial stock assessment and mortality limit specification (MP-A2).

Element	MP-A	MP-A2	MP-D	MP-J
Maximum coastwide TCEY change of 15%				
Maximum Fishing Intensity buffer (SPR=36%)				
O32 stock distribution				
O32 stock distribution (5-year moving average)				
All sizes stock distribution				
Fixed shares updated in 5th year from O32 stock distribution				
Relative harvest rates of 1.0 for 2-3A, and 0.75 for 3B-4				
Relative harvest rates of 1.0 for 2-3, 4A, 4CDE, and 0.75 for 4B				
Relative harvest rates by Region: 1.0 for R2-R3, 0.75 for R4-R4B				
1.65 Mlbs fixed TCEY in 2A				
Formula percentage for 2B				
National Shares (2B=20%)				
Frequency of stock assessment & mortality limits				

Table 3. Coastwide long-term performance metrics for the biological sustainability objective and P(all RSB<36%) and short-term performance metrics for the remaining fishery sustainability objectives for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit setting process (A2). All results use an SPR value of 43% with simulated estimation error.

Input SPR/TM	**43**	**43**	**43**	**43**
Management Procedure	**A**	**A2**	**D**	**J**
Biological Sustainability				
P(any RSB_y<20%)	<0.01	<0.01	0.01	<0.01
Fishery Sustainability				
P(all RSB<36%)	0.25	0.28	0.44	0.28
Median average TCEY (Mlbs)	39.92	38.31	40.22	37.90
P(any3 change TCEY > 15%)	0.44	0.36	0.10	0.00
Median AAV TCEY	12.1%	9.0%	5.9%	9.5%

MP-A2 shows a different pattern of variability that is not completely captured with the performance metrics presented in Table 3. The variability performance metrics with the biennial mortality limit specification show improvements because half of the years in a ten-year period have no change in the TCEY compared to an MP with an annual mortality limit specification while the other half may show a slightly larger change. Trajectories of the projected TCEY for a 60-year period show the biennial specification process in MP-A2 (Figure 8). Comparing the trajectories for MP-A and MP-A2 shows that the biennial process generally follows the annual process but with steps. However, there are cases where the biennial process takes longer to catch up (e.g. the start of the trajectory) and where the biennial process does not unnecessarily change the TCEY (e.g. near the year 2065 for some simulations).

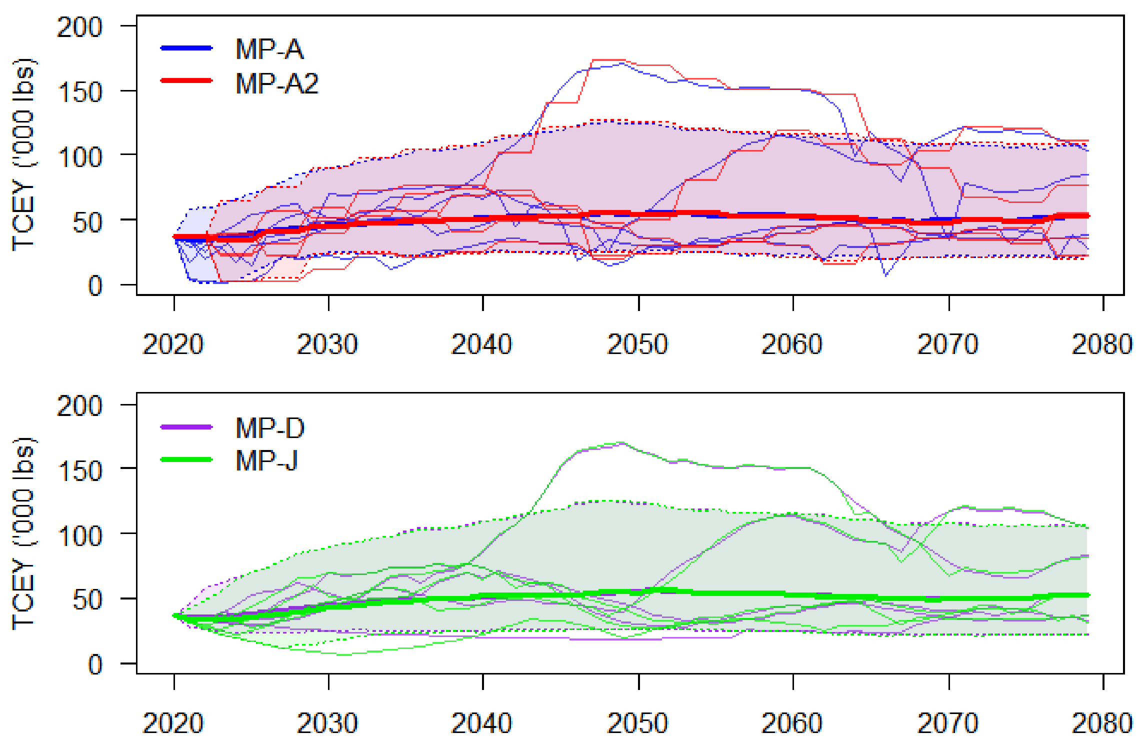

Figure 8. Trajectories of TCEY for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit specification process (A2). All results use an SPR value of 43% with simulated estimation error. The 5th and 95th quantiles are shown as a shaded polygon. Five individual trajectories are shown as thin lines and the median of all simulations is shown as a thick line.

Different performance metrics may help to understand the differences between annual stock assessment MPs and multi-year assessment MPs. Three new performance metrics are reported in Table 4 to provide a better indication of how the TCEY may change in a given year. Over a ten-year period these are, the probability that the TCEY exceeds a change greater than 15% in any one year [P(any1 change TCEY > 15%)], the probability that the TCEY exceeds a change greater than 15% in any two years [P(any2 change TCEY > 15%)], and the median maximum absolute percentage change (up or down) in the TCEY over a 10-year period (Median max abs % change TCEY). Table 4 shows that all of these performance metrics are highest for MP-A2, indicating that the change in the TCEY is typically higher in years when it changes compared to an annual mortality limit specification process. Additional performance could be developed, such as a metric for cumulative change over a number of years to bring the measure of variability on the same temporal scale.

Table 4. Additional coastwide short-term and long-term performance metrics for the fishery sustainability objectives related to TCEY variability for MPs A, D, and J with an annual mortality limit setting process, and MP-A with a biennial mortality limit specification process (A2). All results use an SPR value of 43% with simulated estimation error.

	Short-term				**Long-term**			
Input SPR/TM	**43**	**43**	**43**	**43**	**43**	**43**	**43**	**43**
Management Procedure	**A**	**A2**	**D**	**J**	**A**	**A2**	**D**	**J**
Fishery Sustainability								
P(any1 change TCEY > 15%)	0.75	0.93	0.56	0.00	0.46	0.67	0.17	0.00
P(any2 change TCEY > 15%)	0.63	0.74	0.26	0.00	0.31	0.32	0.02	0.00
Median max absolute % change TCEY	18%	23%	11%	15%	13%	21%	9%	14%

Overall, there is a clear trade-off between slightly higher biennial change and consistency within each two-year period. The benefits to a biennial mortality limit specification include stability for a two-year period and resources needed for conducting a stock assessment can be directed towards other research such as improving the stock assessment or MSE. However, it is likely that the change in the mortality limit every other year may be larger than desired for an annual process. These trade-offs must be considered when analysing an MP with a static biennial mortality limit specification.

The mortality limit does not need to be held constant in years when there is no stock assessment, but may instead use other methods to determine a mortality limit. The projection from the stock assessment may be used, or an empirical, data-driven approach can inform changes to the mortality limit. This may reduce the potential for large changes with biennial stock assessments, would make immediate use of FISS results in intervening years, and could be extended to periods of longer than two years between stock assessments.

An alternative approach that would not require a stock assessment for setting mortality limits in any year would be to adopt an empirical-based MP as the method for setting annual mortality limits. The stock assessment would be used at a defined interval to verify that management is effective and to potentially tune the MSE OM and existing MP (Cox and Kronlund 2008). Any of the MPs mentioned in this section, empirical- or model-based or a hybrid of the two, can be evaluated using the current MSE framework.

Recommendation/s

That the Commission

a) **NOTE** paper IPHC-2021-IM097-13 describing progress on the MSE Program or Work for 2021–2023, including progress on modelling the distribution of recruitment and its effects on estimated movement, simulating implementation uncertainty, methods to investigate size limits, and multi-year assessments.

b) **NOTE** that implementation uncertainty will be incorporated to evaluate the robustness of MPs to plausible departures from the MP determined TCEY.

c) **RECOMMEND** an approach for investigating size limits using the MSE framework.

d) **RECOMMEND** elements of management procedures related to multi-year assessments, including holding the TCEY constant, incorporating empirical approaches in non-assessment years, and using an MP without a stock assessment.

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Appendices

Nil