Understanding MSE and its role in the management of Pacific halibut

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PURPOSE

To provide the MSAB with an overview of the IPHC Management Strategy Evaluation (MSE) and how it has supported the development of the draft IPHC Harvest Strategy Policy (HSP).

1 INTRODUCTION

MSE has been used by the Commission since 1968 (Southward 1968) to inform the Commission on best performing management strategies for the Pacific halibut fishery. In 2013, the Commission hosted the first meeting of the Management Strategy Advisory Board (MSAB), which has met at least once a year since then to advise the Commission on the MSE process. The Scientific Review Board (SRB), holding it's first meeting in 2013 as well, reviews the MSE work. The MSE process, input from the MSAB, and review by the SRB have been instrumental in the development of a HSP for the management of Pacific halibut. This document describes the history of that development and the influence of MSE on the current draft HSP.

2 MANAGEMENT STRATEGY EVALUATION

Management Strategy Evaluation is a process to identify management procedures that meet defined objectives and are robust to uncertainty. There are four basic components to MSE: objectives, management procedures (MPs), simulation/evaluation, and application. Objectives are defined with the assistance of resource users, stakeholders, and managers. Candidate MPs to evaluate are identified, based on those objectives and with input from users, stakeholders, and managers. Simulation of the fish stock and fisheries is done for each candidate MP and performance metrics associated with the objectives are reported to aid in the evaluation. Finally, the best performing MP is determined and applied in the HSP. Punt et al. (2016) provides an overview of best practices for MSE.

2.1 Objectives

The Commission has previously defined four priority coastwide objectives and associated performance metrics for evaluating MSE simulations.

> **IPHC-2023-AM099-R, para. 76.** *The Commission **RECOMMENDED** that for the purpose of a comprehensive and intelligible Harvest Strategy Policy (HSP), four coastwide objectives should be documented within the HSP, in priority order:*

a) Maintain the long-term coastwide female spawning stock biomass above a [relative spawning][1] *biomass limit reference point (B20%) at least 95% of the time.*

b) Maintain the long-term coastwide female spawning stock biomass at or above a [relative spawning][1] *biomass reference point (B36%) 50% or more of the time.*

c) Optimise average coastwide TCEY.

d) Limit annual changes in the coastwide TCEY.

IPHC-2023-AM099-R, para. 77. *The Commission* ***AGREED*** *that the performance metrics associated with the objectives in Paragraph 76 are:*

a) P(RSB): Probability that the long-term Relative Spawning Biomass (RSB) is less than the Relative Spawning Biomass Limit, failing if the value is greater than 0.05.

b) P(RSB<36%): Probability that the long-term RSB is less than the Relative Spawning Biomass Reference Point, failing if the value is greater than 0.50.

c) Median TCEY: the median of the short-term average TCEY over a ten-year period, where the short-term is 4-14 years in the future.

d) Median AAV TCEY: the average annual variability of the short-term TCEY determined as the average difference in the TCEY over a ten-year period.

There are many more potential objectives and performance metrics, which may include area- and fleet-specific concepts.

2.1.1 Biomass objective

Research in 2019 (IPHC-2019-SRB015-11 Rev_1) suggested that reducing the stock to a relative spawning biomass (RSB) of 30% would be a reasonable proxy for Maximum Sustainable Yield (MSY) and an RSB of 36% would represent a proxy for Maximum Economic Yield (MEY). Therefore, the 36% threshold for RSB was chosen for objective b), which is not a target because other objectives may result in a desire to maintain the RSB above MEY. This objective is to ensure that when consistently using an MP the biomass is above B_{MEY} more often than it is below B_{MEY}, which may occur because of natural fluctuations.

The Commission has been discussing the utility of objective b) in light of recent results indicating a current stock status above 36% (due to low recent fishing intensities) but a low level of absolute spawning biomass corresponding to low fishery and fishery-independent setline survey (FISS) catch-rates. This combination of relative spawning biomass above the 36% threshold and low absolute spawning biomass reflects recent low weight-at-age and recruitment. Some of those discussions have focused on considering a new objective related to an absolute level of spawning biomass in addition to the relative spawning biomass used to determine stock status.

[1] Bracketed text added for clarity, identifying that relative spawning biomass is used as the reference point for these objectives.

An objective to maintain the absolute spawning biomass (or FISS WPUE as a data-based proxy) above a threshold may be a useful objective for several reasons. First, the level of spawning biomass likely correlates with catch-rates in the commercial fishery, and a higher spawning biomass would likely result in a more efficient and economically viable commercial fishery as well as greater opportunity for recreational and subsistence fisheries. Second, current priority conservation objectives use dynamic relative spawning biomass which 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 (such a level is currently unknown for Pacific halibut). Lastly, an observed reference stock level in absolute biomass may have concrete meaning to stakeholders as it can be related to direct recent fishing experience. For example, the recent estimated spawning biomass may be near or below the lowest spawning biomass estimated since the mid-1970's and observed fishery catch rates were historically low in 2022 and 2023. A list of pros and cons of an absolute spawning biomass objective are provided in Table 1.

Table 1. Some pros and cons of using an absolute biomass threshold as a fishery objective to optimise fishing activities and opportunities.

Pros	Cons
Higher spawning biomass likely correlates with a more efficient fishery (e.g. catch-rates).	Defining an appropriate threshold can be challenging.
Measures the actual amount of biomass rather than the biomass relative to an unfished level.	The threshold is dependent on external factors that may not be influenced by management decisions.
Maintaining a level of absolute biomass may ensure that successful reproduction can occur.	Area-specific absolute biomass may be more important than a coastwide absolute biomass.
Absolute biomass can represent a direct reference level that is meaningful to stakeholders.	Interpretation of an appropriate absolute biomass differs among stakeholders

Further discussion is summarized in IPHC-2025-AM101-12 and suggests an additional objective, such as "maintain the coastwide female spawning biomass (or FISS WPUE) above a threshold." Further evaluation of this type of objective could be part of the MSE Program of Work for 2025.

2.1.2 Yield objective

The current objective "optimise coastwide average yield" was implemented to provide flexibility when evaluating management procedures. However, following discussions with the SRB, the flexibility is not conducive to determining a single best performing management procedure because what optimise means is not well defined. Taking a broad view, to optimise yield is a general objective that encompasses multiple more specific objectives such as achieving high yields, minimising the interannual change in yield, and maintaining high catch-rates, all of which are important to the Commission. For example, optimising yield involves balancing the trade-offs between maximising short- or long-term yield and minimising the annual change in yield.

The MSAB recommended that 'optimise' be changed to 'maximise' and this objective be given equal consideration along with minimising interannual variability in yield.

> **IPHC-2024-MSAB020-R, para 14**. *The MSAB* ***RECOMMENDED*** *that the Commission priority objective "optimise average coastwide TCEY" (c in paragraph 12) be changed to "maximise average coastwide TCEY" and that this objective along with the variability in yield objective (d in paragraph 12) be given equal consideration to allow for the evaluation of trade-offs between these two objectives.*

Changing this objective from 'optimise' to 'maximise' would not change the overall goal of the Commission to optimise yield. In fact, the two objectives "maximise yield" and "minimise interannual variability in yield" are both a part of optimising yield. Giving equal consideration to both objectives would better meet the general goal of the Commission to optimise yield.

2.1.3 Hierarchical grouping of Commission objectives

An important part of the four priority objectives of the Commission is that they are hierarchical. The objectives can be categorized into two groups (Table 2). The first group contains long-term objectives a) and b), in priority order, which define the overarching objectives of the Commission (ensuring sustainability of the stock and optimising fishing activities and opportunities) and unambiguously identifies MPs that do not support long-term objectives of the Commission. All MPs that do not meet these two objectives would not be considered as a potential reference MP. Furthermore, the sustainability objective (a) may be used to define an 'overfished' status, and the fishing opportunity objective (b) may be associated with an 'overfishing' status. The first group also clearly defines the boundaries of the management space over which Commission decision-making can apply.

The second group contains short-term objectives c) and d) which define the management objectives of the Commission related to optimal yield. A reference MP will represent a trade-off between the amount of yield and the interannual variability in that yield. The optimal trade-off may be considered differently by different users and stakeholders and may change over time, thus there is no inherent priority between these two objectives when selecting a reference MP. Justification of a reference MP is therefore provided after evaluation of this trade-off. This trade-off may also be considered during the annual decision-making process while also incorporating many other objectives.

Table 2. Commission priority objectives for the long-term sustainable management of Pacific halibut that supports optimal fishing opportunities. Light grey text shows potential additions/changes that are not in the current Commission objectives.

PURPOSE	TYPE	GOAL	GENERAL OBJECTIVE	MEASURABLE OBJECTIVE
LONG-TERM OVERARCHING OBJECTIVES DEFINING MPs TO AVOID	CONSERVATION	SUSTAINABILITY	**1.** KEEP FEMALE SPAWNING BIOMASS ABOVE A LIMIT TO AVOID CRITICAL STOCK SIZES	**a)** Maintain the long-term coastwide female relative spawning biomass above a biomass limit reference point ($RSB_{20\%}$) at least 95% of the time
	FISHERY	OPTIMISE FISHING ACTIVITIES AND OPPORTUNITIES	**2.** MAINTAIN SPAWNING BIOMASS AT OR ABOVE A LEVEL THAT SUPPORTS OPTIMAL FISHING ACTIVITIES AND OPPORTUNITIES	**b)** Maintain the long-term coastwide female relative spawning biomass at or above a biomass threshold reference point ($RSB_{36\%}$) 50% or more of the time.
				) Maintain the long-term coastwide female absolute spawning biomass at or above a biomass threshold reference point (XX) YY% or more of the time.
SHORT-TERM MANAGEMENT OBJECTIVES DEFINING A REFERENCE MP	FISHERY	OPTIMISE YIELD	**3.** PROVIDE DIRECTED FISHING YIELD WHILE LIMITING VARIABILITY IN MORTALITY LIMITS	**c)** Maximise average coastwide TCEY
				d) Limit annual changes in the coastwide TCEY

2.2 Management Procedures

An MP is a defined process to determine a mortality limit. This process is composed of multiple elements, is repeatable, and can be coded in a computer simulation to evaluate its performance. MPs are not subject to variability from the decision-making process.

Many elements of MPs for Pacific halibut mortality limits have been investigated and some of those elements are discussed below. Elements may include the fishing intensity, the frequency of stock assessments and the use of empirical rules in years without a stock assessment, size limits, constraints on the interannual change in the TCEY, and distribution of the TCEY to IPHC Regulatory Areas. Recently, the IPHC has been focusing on fishing intensity, frequency of the stock assessment, and empirical rules to determine the TCEY in years when a stock assessment would not be done.

2.3 Simulation and evaluation

The IPHC Secretariat has developed an MSE framework to rapidly investigate MPs. This framework includes conditioned operating models (OMs) representing uncertainty and variability in both the stock and fishery dynamics. The OMs are used to simulate the stock and fisheries in a closed-loop feedback system where a management procedure provides a mortality limit on an annual basis that is used by the OM to further simulate the dynamics of the population. Closed-loop feedback is essential to the MSE process. Simulations project many years into the future to represent equilibrium outcomes that are independent of the starting conditions and integrate over the entire range of uncertainty. Quantities are extracted from the simulations to calculate performance metrics used in the evaluation process.

An example of MSE simulations is shown in Figure 1. The conditioned model (the lighter early region) starts each projection from different starting points representing historical uncertainty. Individual trajectories projecting forward make up the variability that the performance metrics summarize. Capturing a wide range of uncertainties is an important aspect of MSE.

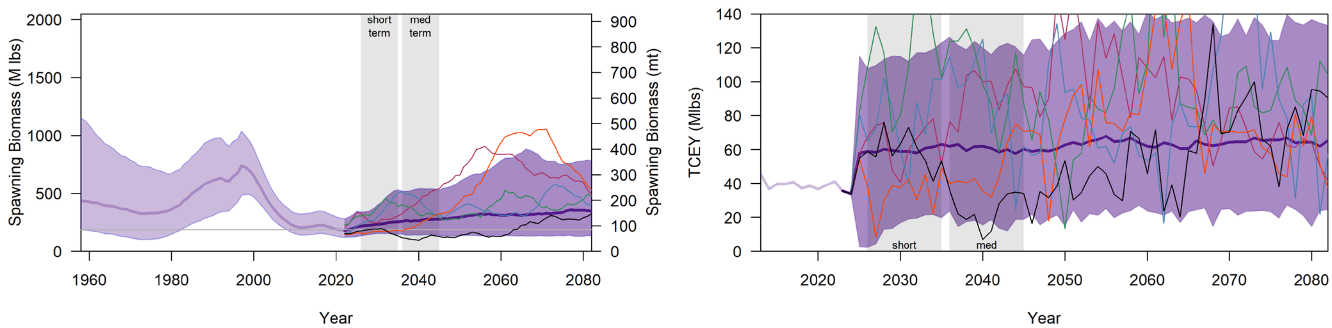

Figure 1. MSE simulations of spawning biomass (left) and TCEY (right) with a fishing intensity equal to $F_{SPR=43\%}$. The dark line is the median, the shaded area the 5th and 95th percentiles, and the individual lines example single trajectories. The short-term and medium-term periods are shown in grey. The long-term period is the last 10 years of the projection. The lighter region at the start of the simulation is the conditioned historical period.

Theoretically, evaluation should be as simple as identifying the MP that best meets the objectives. In practice, however, that can be challenging because there are trade-offs between objectives, as presented above. Discussing these trade-offs with users, stakeholders, and managers is useful to identify an MP that may be a compromise between objectives. The MSAB, SRB, and Commission meetings provide opportunities for those discussions.

3 HISTORICAL HARVEST POLICIES

The long history of the IPHC has seen numerous harvest policies to manage the Pacific halibut fisheries. During the early history of the Commission, the policy was to increase catch-rates by reducing total fishing mortality through reductions in effort and landings and shortening the fishing season (Clark 2003; Clark and Hare 2006; Southward 1968; Thompson 1937; Thompson and Bell 1934). The latter part of the 20th century and early 21st century used constant exploitation rates to determine mortality limits, with reductions in the exploitation level informed by research and simulations similar to MSE. Throughout the 20th century the focus was on area management assuming that each area was an independent management unit. Tagging studies in the early 2000's indicated that the IPHC Regulatory Areas were not independent stocks and a coastwide approach should be used to avoid biased stock size estimates and ensure sustainability of the entire Pacific halibut stock. This has been further supported by recent genetics work on stock structure. A constraint on the annual change in the mortality limit was implemented in 2001, called “slow up fast down”, and was later changed to “slow up full down”. A description of the harvest policy in the early 2000’s is given in Hare and Clark (2008) and Hare (2011). A description of historical harvest policies for Pacific halibut is given in Valero (2012).

4 DEVELOPMENT OF THE CURRENT DRAFT HARVEST STRATEGY POLICY

4.1 Coastwide SPR

After the change to coastwide management in 2006 (Clark and Hare 2006; Clark and Hare 2007a, 2007b), a constant exploitation rate was retained to determine the coastwide mortality limit. However, this was challenging because total fishing mortality came from a mixture of various gears from different areas intercepting age classes in different proportions. Exploitable biomass was therefore an abstract concept without direct application to the coastwide determination of total mortality.

An alternative approach is to adjust the fishing intensity such that the spawning potential of the coastwide stock given this fishing intensity is a pre-defined percentage of the spawning potential with any fishing. In other words, apply a fishing intensity such that in the long-term the spawning potential ratio (SPR) of fished to unfished would be a defined percentage. This is called an SPR-based approach (Goodyear 1993; Mace et al. 1996) and represents the standard management approach across most fisheries in the NE Pacific. The benefit of this approach is that it does not rely on an exploitation rate or exploitable biomass, it accounts for mortality of all sizes and from all sources, accounts for current conditions of the stock, and is widely accepted and implemented in fisheries management. SPR is different than relative spawning biomass (RSB) because SPR is calculated using spawning biomass per recruit, thus measures the spawning potential of an individual fish (i.e. how much will fishing mortality reduce its spawning potential) rather than the reduction in spawning biomass which includes reductions to recruitment due to reduced spawning biomass (i.e. the stock-recruit relationship). SPR has the benefit of managing on a per-recruit basis rather than attempting to incorporate the highly uncertain stock-recruit relationship.

Hicks and Stewart (2017) noted the problems of using exploitable biomass in the IPHC harvest policy and provided support for an SPR-based approach. The IPHC adopted an SPR-based approach in 2017 to be first used when determining total coastwide mortality limits in 2018.

> **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*** *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.*

The adopted 46% for SPR was determined from the average SPR from recent management decisions at that time, and was considered as a "hand rail" meaning that Commission decisions may depart from that fishing intensity as part of the decision making process.

The MSE process subsequently evaluated various SPR levels showing that an SPR value greater than 40% would meet fishery and conservation objectives. The Commission subsequently recommended an interim harvest policy with an SPR of 43% in 2020.

> **IPHC-2020-SS06-R, para 3**. *The Commission **NOTED** that given the results from the coastwide MSE, the following elements from the scale (coastwide) component of the management procedure meet the coastwide objectives:*
>
> *a) SPR values greater than 40%;*
>
> *b) A control rule of 30:20;*
>
> *c) Constraints on the annual change in the TCEY that either limit the annual change to 15%, use a slow-up, fast-down approach, or fix the mortality limits for three-year periods, recognizing that additional types of constraints may also meet the objectives.*
>
> **IPHC-2020-SS06-R, para 4**. *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, noting the additional components intended to apply for a period of 2020 to 2022 as defined in IPHC-2020-AM096-R paragraphs 97 b, c, d, and e. Specifically, these additional components are allocations to 2A and 2B, accounting for some impacts of U26 non-directed discard mortality, and the use of a rolling three-year average for projecting non-directed fishery discard mortality*

Given that RSBs of 30% and 36% represent reasonable proxies for MSY and MEY (IPHC-2019-SRB015-11 Rev_1), SPR values near 35% and 40% would result in RSB_{MSY} and RSB_{MEY}, respectively. A higher value of SPR (lower fishing intensity and thus RSB being greater than RSB_{MEY} more often) was justified to meet the fishery objective of minimising interannual variability in yield. Research is currently underway to determine if the MSY and MEY proxies remain consistent given recent improvements in the understanding of the biology and productivity of Pacific halibut.

The most recent MSE results show that an SPR of 43% still meets conservation and fishery objectives, but an SPR of 46% (lower fishing intensity) may minimize the interannual variability in the TCEY across SPR values (IPHC-2025-AM101-12). However, the optimal SPR is dependent on other factors in the management procedure (e.g. control rule), the allocation among areas and fisheries, and conditions of the stock (e.g. size-at-age and recruitment regime).

4.2 Harvest Control Rule

The fishing intensity is determined from a harvest control rule where the reference fishing intensity (e.g. SPR=43%) is the default at high RSB, declines between a trigger RSB and limit RSB, and is effectively zero at low RSB (Figure 2). A similar control rule with a trigger at 30% and a limit at 20% has been used since the early 2000's, although referencing a static absolute spawning biomass rather than a dynamic RSB accounting for changes in stock conditions (Clark and Hare 2006). Different values for the trigger and limit (using RSB), as well as no control rule, were evaluated in 2020 using the current MSE framework. Although differences were found with different control rules, the 30:20 trigger and limit have been retained because it appeared to balance risk to the stock and interannual variability in the TCEY.

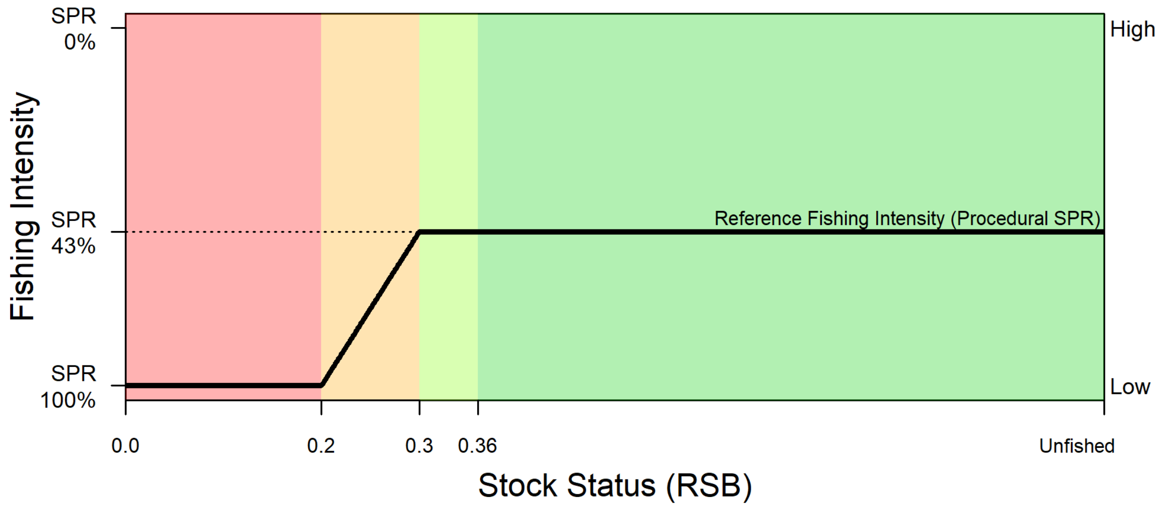

Figure 2. Harvest control rule showing the change in fishing intensity dependent on stock status defined as relative spawning biomass (RSB).

4.3 Distribution

The paradigm adopted along with a coastwide SPR was to determine the coastwide TCEY and then distribute that among IPHC Regulatory Areas. Domestic management would then allocate the TCEY to individual sectors within each IPHC Regulatory Area. The distribution of the TCEY was evaluated using the MSE and many different distribution procedures were found to meet the coastwide conservation and fishery objectives. The Commission has not adopted a specific distribution procedure but has decided to focus the MSE efforts on determining an optimal coastwide procedure and maintain distribution of the TCEY as a decision of the Commission.

> **IPHC-2024-ID006**. *The Commission **RECOMMENDED** that the Secretariat draft a revised harvest strategy policy document that will be reviewed at the IPHC Work Meeting in September 2024 (WM2024):*
>
> *a) incorporating the outcomes of ID003, ID004 and ID005 for Commission review;*
>
> *b) clearly identifying the distribution of the TCEY as a component of the decision-making process and not an output of the management procedure.*

4.4 Size limit

A size limit for landed Pacific halibut from the directed commercial fishery has been in place since 1940, beginning with a 5 pound (2.27 kg) limit (Myhre 1974). This subsequently changed to a 26 inch limit which was in place until 1973, when it changed to the current limit of 32 inches. Many analyses of the size limit have been completed (see IPHC-2021-AM097-09 for a brief review), but most recently, the MSE framework was used to investigate a 32-inch size limit, a 26-inch size limit, and no size limit (IPHC-2023-AM099-13). Results showed that reducing the size limit would result in an increase in yield, on average. However, the increased yield would be composed of Pacific halibut under 32 inches (U32) and the landings of Pacific halibut over 32 inches (O32) would decrease. There was concern that the price of U32 Pacific halibut would be less than O32 Pacific halibut, and that targeting of small Pacific halibut may occur, resulting in a reduced economic value of the fishery. Therefore, the 32-inch size limit has been maintained.

4.5 Current interim harvest strategy policy

These components combined with the decision-making process make up the current interim harvest strategy policy (Figure 3). The SPR-based MP uses a fishing intensity defined by a reference SPR of 43% which is linearly reduced when the stock is estimated below $RSB_{30\%}$ and directed fishing is halted when the stock is estimated at or below $RSB_{20\%}$. Fishery-dependent and fishery-independent data are used in the annual coastwide stock assessment to estimate the stock status and total mortality limits associated with the SPR-based fishing intensity. The MP defines a reference coastwide TCEY which is presented in a decision table along with other TCEYs representing alternative fishing intensities to assist with decision-making. Other sources of management supporting information and advice from subsidiary bodies of the IPHC assist the Commission with the decision-making process. The Commission decides on the annual coastwide TCEY (which may depart from the reference coastwide TCEY) and then decides on the distribution of the TCEY among IPHC Regulatory Areas.

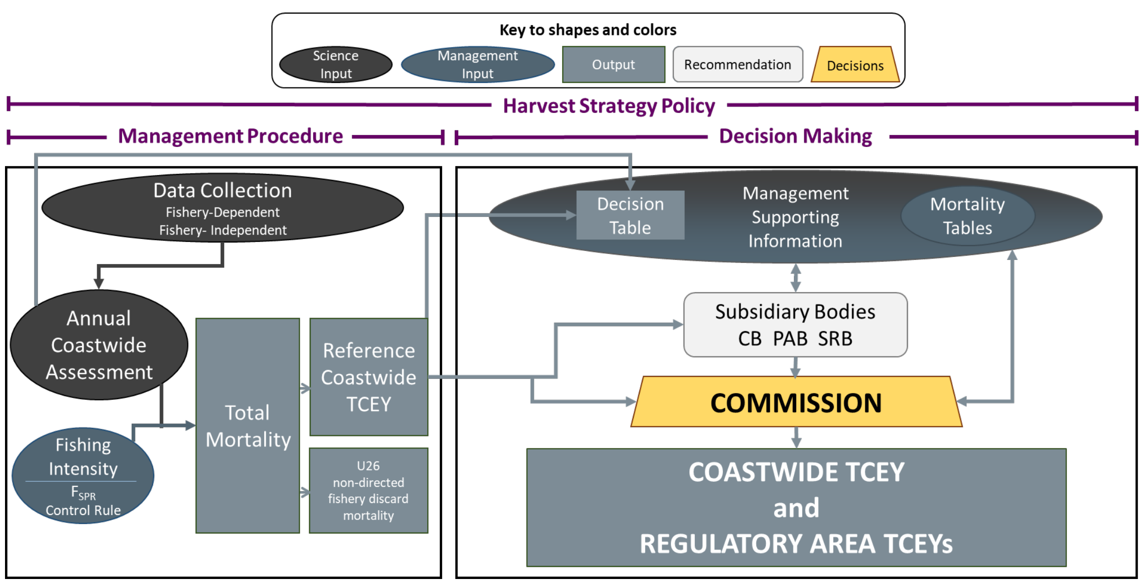

Figure 3. Illustration of the interim harvest strategy policy for the IPHC showing the determination of the coastwide TCEY (the management procedure at the coastwide scale) and the decision-making component that mainly occurs at the Annual Meeting.

A draft of the current IPHC HSP was presented at the 101st Annual Meeting of the IPHC (AM101). This draft (IPHC-2025-AM101-17) describes what an HSP is, defines objectives and key principles of the Commission, describes the development of the HSP, and presents the general elements that make up the HSP. The Commission is currently considering the draft HSP for potential adoption in 2025.

5 SUMMARY

The IPHC has used many different harvest strategies to manage Pacific halibut in the past but has not adopted a formal harvest strategy policy that defines a framework for applying a consistent and transparent approach to setting mortality limits. MSE is a common tool used to evaluate MPs for inclusion in an HSP and has been used in the last two decades to evaluate many MP elements. Recently, an MSE framework has been developed to evaluate the fishing intensity, assessment frequency, and size limits for an SPR-based management procedure. These results, presented in recent Annual Meeting documents, have influenced the development of a draft HSP (IPHC-2025-AM101-17) to be considered for adoption by the Commission in 2025.

RECOMMENDATION/S

That the MSAB **NOTE** paper IPHC-2025-MSAB021-06 providing a description the MSE process, a history of harvest policies at IPHC, and how the current MSE process has influenced the development of the draft Harvest Strategy Policy.

REFERENCES

Clark, W.G. 2003. A Model for the World: 80 Years of Model Development and Application at the International Pacific Halibut Commission. Natural Resource Modeling **16**(4): 491-503. doi:10.1111/j.1939-7445.2003.tb00125.x.

Clark, W.G., and Hare, S.R. 2006. Assessment and management of Pacific halibut: data, methods, and policy. International Pacific Halibut Commission Scientific Report No. 83. 104 p.

Clark, W.G., and Hare, S.R. 2007a. Assessment of the Pacific halibut stock at the end of 2006. IPHC Report of Assessment and Research Activities 2006. In IPHC-2021-SACH-004.

Clark, W.G., and Hare, S.R. 2007b. Motivation and plan for a coastwide stock assessment. IPHC Report of Assessment and Research Activities 2006. pp. 83-96.

Goodyear, C.P. 1993. Spawning stock biomass per recruit in fisheries management: foundation and current use. Canadian Special Publication of Fisheries and Aquatic Sciences **120**: 67-81.

Hare, S.R. 2011. Potential modifications to the IPHC harvest policy. Report of Assessment and Research Activities 2010. 177-200.

Hare, S.R., and Clark, W.G. 2008. 2007 IPHC harvest policy analysis: past, present, and future considerations. Report of Assessment and Research Activities 2007. 275-296.

Hicks, A., and Stewart, I. 2017. An update on the IPHC Management Strategy Evaluation (MSE). IPHC-2017-AM093-09.

Mace, P., Botsford, L., Collie, J.S., Gabriel, W.L., Goodyear, C.P., Powers, J.E., Restrepo, V.R., Rosenberg, A.A., Sissenwine, M.P., Thompson, G.G., and Witzig, J. 1996. Scientific review of definitions of overfishing in the U.S. fishery management plans supplemental report. NOAA Tech. Mem NMFS-F/SPO-21. 21 p.

Myhre, R.J. 1974. Setting the new halibut size limit. Western Fisheries **85**(5): 14.

Punt, A.E., Butterworth, D.S., de Moor, C.L., De Oliveira, J.A.A., and Haddon, M. 2016. Management strategy evaluation: best practices. Fish and Fisheries **17**(2): 303-334. doi:10.1111/faf.12104.

Southward, G.M. 1968. A simulation of management strategies in the Pacific halibut fishery. IPHC Scientific Report 47. 70 pp.

Thompson, W.F. 1937. Theory of the effect of fishing on the stock of halibut. Report of the International Fisheries Commission No. 12. 22 pp.

Thompson, W.F., and Bell, F.H. 1934. Biological statistics of the Pacific halibut fishery. Effect of changes in intensity upon total yield and yield per unit of gear. Report of the International Fisheries Commission No. 8. 49 pp.

Valero, J.L. 2012. Progress in the development of a management strategy evaluation for Pacific halibut. IPHC Report of Assessment and Research Activities 2011. 281-310.