INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC–2020–MSAB015–00

15th Session of the IPHC Management Strategy Advisory Board (MSAB015) – *Compendium of meeting documents*

11 – 14 May 2020, Seattle, WA, USA

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INTERNATIONAL PACIFIC HALIBUT COMMISSION

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DRAFT: AGENDA & SCHEDULE FOR THE 15th SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB015)

Date: 11-14 May 2020
Location: **Pending**: Courtenay, B.C., Canada 'or' Electronically
Venue: **Pending**: Kingfisher Oceanside Resort and Spa 'or' Electronically
Time: **Pending**: 11th: 12:00-17:00; 12th-14th 09:00-17:00 daily 'or' Electronically
Co-Chairpersons: Mr. Adam Keizer (Canada) and Dr. Carey McGilliard (U.S.A.)

1. **OPENING OF THE SESSION**

2. **ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION**

3. **IPHC PROCESS**
   - 3.1. MSAB Membership
   - 3.2. Update on the actions arising from the 14th Session of the IPHC MSAB (MSAB014)
   - 3.3. Review of the outcomes of the 15th Session of the IPHC Scientific Review Board (SRB015)
   - 3.4. Review of the outcomes and update on the actions arising from the 96th Session of the IPHC Annual Meeting (AM096) and the 6th Special Session of the IPHC (SS06).
   - 3.5. Brief review of the 2020 Program of Work

4. **A REVIEW OF MANAGEMENT PROCEDURES TO DETERMINE THE TOTAL CONSTANT EXPLOITATION YIELD (TCEY) BY IPHC REGULATORY AREAS FOR PACIFIC HALIBUT FISHERIES**
   - 4.1. Management procedures for coastwide scale
   - 4.2. Management procedures for distributing the TCEY

5. **A FRAMEWORK TO INVESTIGATE FISHING INTENSITY AND DISTRIBUTING THE TOTAL CONSTANT EXPLOITATION YIELD (TCEY) FOR PACIFIC HALIBUT FISHERIES**
   - 5.1. Framework to investigate distributing the TCEY among IPHC Regulatory Areas
   - 5.2. Multi-area operating model

6. **PRELIMINARY RESULTS INVESTIGATING FISHING INTENSITY AND DISTRIBUTING THE TOTAL CONSTANT EXPLOITATION YIELD (TCEY) FOR PACIFIC HALIBUT FISHERIES**

7. **MSAB PROGRAM OF WORK**
   - 7.1. MSAB Program of Work (2020-21) and identification of management procedures to evaluate
   - 7.2. MSAB proposed program of work (2021-23)

8. **OTHER BUSINESS**
   - 8.1. IPHC meetings calendar (2020-22)

9. **REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 15th SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB015)**

DRAFT: LIST OF DOCUMENTS FOR THE 15th SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB015)

Last updated: 10 April 2020

Document	Title	Availability
IPHC-2020-MSAB015-01	Draft: Agenda & Schedule for the 15th Session of the IPHC Management Strategy Advisory Board (MSAB015)	✓ 11 Feb 2020 ✓ 08 April 2020
IPHC-2020-MSAB015-02	Draft: List of Documents for the 15th Session of the IPHC Management Strategy Advisory Board (MSAB015)	✓ 11 Feb 2020 ✓ 10 Apr 2020
IPHC-2020-MSAB015-03	MSAB Membership (D. Wilson)	✓ 10 Apr 2020
IPHC-2020-MSAB015-04	Update on the actions arising from the 14th Session of the MSAB (MSAB014) (A. Hicks)	✓ 10 Apr 2020
IPHC-2020-MSAB015-05	Review of the outcomes of the 15th Session of the IPHC Scientific Review Board (SRB015) (IPHC Secretariat)	✓ 10 Apr 2020
IPHC-2020-MSAB015-06	Outcomes of the 96th Session of the IPHC Annual meeting (AM096) and the 6th Special Session of the IPHC (SS06) (D. Wilson & A. Hicks)	✓ 10 Apr 2020
IPHC-2020-MSAB015-07	Management procedures to determine the total constant exploitation yield (TCEY) by IPHC Regulatory Areas for Pacific halibut fisheries (P. Carpi, A. Hicks, S. Berukoff)	✓ 10 Apr 2020
IPHC-2020-MSAB015-08	A framework to investigate fishing intensity and distributing the total constant exploitation yield (TCEY) for Pacific halibut fisheries. (A. Hicks, S. Berukoff, P. Carpi, & I. Stewart)	✓ 10 Apr 2020
IPHC-2020-MSAB015-09	Preliminary results investigating fishing intensity and distributing the total constant exploitation yield (TCEY) for Pacific halibut fisheries (A. Hicks, S. Berukoff, P.Carpi, & I. Stewart)	✓ 10 Apr 2020
IPHC-2020-MSAB015-10	IPHC Secretariat Program of Work for MSAB Related Activities 2020-23 (A. Hicks, P. Carpi, & S. Berukoff)	✓ 10 Apr 2020
Information papers		
IPHC-2020-MSAB015-INF01	Technical details of the IPHC MSE framework (A. Hicks, P. Carpi, S. Berukoff)	

MSAB MEMBERSHIP

PREPARED BY: IPHC SECRETARIAT (D, WILSON; 10 APRIL 2020)

PURPOSE

To provide the MSAB with the updated membership.

BACKGROUND

Rule 4 of Appendix V [Management Strategy Advisory Board (MSAB) – Terms of Reference and Rules of Procedure] of the IPHC Rules of Procedure (2020), states:

> *4. The term of MSAB members will be four years, and members may serve additional terms at the discretion of the IPHC. Member terms have a staggered expiry such that no more than half of the member terms expire at a given time. Member continuity on the MSAB is key to the success of the MSE process. However, MSAB members serve at the discretion of the IPHC.*"

DISCUSSION

Departures/replacements:

ADFG: James Hasbrouck replaced by Sara Webster (ADFG)

USA Treaty Tribes: Matt Damiano. No replacement to-date.

RECOMMENDATION/S

That the MSAB **NOTE** paper IPHC-2020-MSAB015-03 which details the MSAB membership as of 10 October 2020.

APPENDICES

Appendix A: MSAB Membership as of 10 April 2020

APPENDIX A
MANAGEMENT STRATEGY ADVISORY BOARD (MSAB) MEMBERSHIP
(*AS OF 10 APRIL 2020*)

Membership category	Member	Canada	U.S.A.	Current Term commence-ment	Current Term expiration
Commercial harvesters (6-8)					
1	Sporer, Chris	CDN Commercial		09-May-17	08-May-21
2	Hauknes, Robert	CDN Commercial		09-May-17	08-May-21
3	Vacant	CDN Commercial			
4	Vacant	CDN Commercial			
5	Johnson, James		USA Commercial	17-Apr-19	16-Apr-23
6	Kauffman, Jeff		USA Commercial	09-May-19	08-May-23
7	Odegaard, Per		USA Commercial	09-May-17	08-May-21
8	Falvey, Dan		USA Commercial	09-May-17	08-May-21
First Nations/ Tribal fisheries (2-4)					
1	Lane, Jim	CDN First Nations		09-May-17	08-May-21
2	Vacant	CDN First Nations			
3	Mazzone, Scott		USA Treaty Tribes	09-May-19	08-May-23
4	Vacant		USA Treaty Tribes		
Government Agencies (4-8)					
1	Keizer, Adam	DFO		09-May-19	08-May-23
2	Huang, Ann-Marie	CDN Science Advisor		10-May-18	09-May-22
3	Vacant	DFO			
4	Vacant	DFO			
5	Merrill, Glenn		NOAA-Fisheries	07-May-18	06-May-22
6	McGilliard, Carey		USA Science Advisor	09-May-17	08-May-21
7	Baker, Rachel		FMC rep.	23-Oct-19	22-Oct-21
8	Webster, Sarah		ADFG	13-Sep-19	12-Sep-23
Processors (2-4)					
1	Parker, Peggy	US/CDN Processing	US/CDN Processing	09-May-19	08-May-23
2	Mirau, Brad	CDN Processing		09-May-19	08-May-23
3	Morelli, Joseph		USA Processing	29-Aug-18	28-Aug-22
4	Vacant		CDN Processing		
Recreational/ Sport fisheries (2-4)					
1	Chuck Ashcroft	CDN Sport Fishing Advisory Board		17-Apr-19	16-Apr-23

Membership category	Member	Canada	U.S.A.	Current Term commence-ment	Current Term expiration
2	Marking, Tom		USA Sportfishing (CA)	09-May-19	08-May-23
3	Braden, Forrest		USA sportfishing (AK)	17-Apr-19	16-Apr-23
4	Vacant		Open		

Update on actions arising from the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014)

PREPARED BY: IPHC SECRETARIAT (10 APRIL 2020)

PURPOSE

To provide the MSAB with an opportunity to consider the progress made during the inter-sessional period in relation to the recommendations and requests of the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014).

BACKGROUND

At the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014), participants agreed on a series of actions to be taken by the Commission, Subsidiary Bodies, and the IPHC Secretariat on a range of topics as detailed in Appendix A.

DISCUSSION

Noting that best practice governance requires the prompt delivery of core tasks assigned by the Commission, at each subsequent session of the Commission and its subsidiary bodies, attempts will be made to ensure that any recommendations and requests for action are carefully constructed so that each contains the following elements:

1) a specific action to be undertaken (deliverable);
2) clear responsibility for the action to be undertaken (i.e., a specific Contracting Party, the IPHC Secretariat, a subsidiary body of the Commission, or the Commission itself);
3) a desired time frame for delivery of the action (i.e., by the next session of an subsidiary body, or other date).

This involves numbering and tracking all action items (see Appendix A) from the MSAB, as well as including clear progress updates and document reference numbers.

RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2020-MSAB015-04, which provided the MSAB with an opportunity to consider the progress made during the inter-sessional period in relation to the recommendations and requests of the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014).
2) **AGREE** to consider and revise as necessary, the actions arising from the MSAB014, and for these to be combined with any new actions arising from the MSAB015.

APPENDICES

Appendix A: Update on actions arising from the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014)

APPENDIX A

Update on actions arising from the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014)

Action No.	Description	Update
	RECOMMENDATIONS	
MSAB014–Rec.01 (para. 34)	***A review of the coastwide goals and objectives of the IPHC MSE process*** The MSAB **RECOMMENDED** a coastwide fishery objective, in response to a request from the Commissioners, to maintain the spawning biomass above a target reference point of $RSB_{36\%}$, 50% of the time over the long-term.	COMPLETED: This objective was presented to the Commission at SS06 and recommended to be used to evaluate MSE results in 2020.
MSAB014–Rec.02 (para. 41)	***Identification of goals and objectives related to distributing the TCEY*** The MSAB **RECOMMENDED** the primary objectives and associated performance metrics detailed in Appendix V to be used for the evaluation of management procedures at MSAB015.	COMPLETED: The primary objectives were presented to the Commission at SS06 and recommended to be used to evaluate MSE results in 2020
MSAB014–Rec.03 (para. 46)	***Performance metrics for evaluation*** **NOTING** the current progress on evaluating coastwide fishing intensity, the MSAB **RECOMMENDED** that: a) a coastwide fishing intensity SPR of 43%, with a 30:20 HCR, and with one of two constraints 1) +/-15% maximum change in total mortality, and/or 2) slow up, fast down, be used in harvest strategy development process; and b) a range of management procedures including fishing intensity SPR of 40-46% be considered in light of implementation variability within the closed-loop simulations when investigating distribution.	COMPLETED: The Commission recommended a reference SPR fishing intensity of 43% at SS06 and noted that various management procedures will be evaluated in 2020.
MSAB014–Rec.04 (para. 49)	***Management procedures for coastwide scale*** The MSAB **RECOMMENDED** that SPR values of 0.3, 0.34, 0.38, 0.40, 0.42, 0.46, and 0.50 with a 30:20 control rule be evaluated at MSAB015 along with constraints defined by a maximum change in the TCEY of 15%, a slow-up fast-down approach, and/or setting quotas every third year.	COMPLETED: The Commission noted that various management procedures will be evaluated in 2020.

MSAB014–Rec.05 (para. 56)	***Management procedures for distributing the TCEY*** The MSAB **RECOMMENDED** that the management procedures listed in Table 2 in Appendix VI be evaluated at MSAB015.	COMPLETED: The Commission noted that various management procedures will be evaluated in 2020
REQUESTS		
MSAB014–Req.01 (para. 14)	***Review of the outcomes of the 14th Session of the IPHC Scientific Review Board (SRB014)*** The MSAB **REQUESTED** further clarification from the SRB on paragraphs 40–41 of IPHC-2019-SRB015-R: SRB015 (para. 40) "*The SRB NOTED the proposed objective to have annual mortality limits related to local abundances. While this could provide transparency from a policy perspective, it ignores the biological realities of movement and other processes that remain poorly understood at both coastwide and Regulatory Area scales*." SRB015–Rec.05 (para. 41) "*The SRB RECOMMENDED that if the original objective to have annual mortality limits related to local abundances was of broad interest to the Commission, then candidate management procedures be developed and tested in which regional mortality limits are set annually in proportion to modelled survey abundance trends by IPHC Regulatory Area (noting that splitting regions into Regulatory Areas would require assumptions about within-region abundance proportions)*."	IN PROGRESS: Clarification will occur at SRB016 in June 2020.

MSAB014–Req.02 (para. 55)	***Management procedures for distributing the TCEY*** The MSAB **REQUESTED** that a number of elements in distribution management procedures be included for evaluation at MSAB015: a) A coastwide constraint using a slow-up, fast-down approach with a maximum change in the TCEY of 15%; b) evaluating different relative harvest rates across IPHC Regulatory Areas or Biological Regions; c) distributing the TCEY directly to IPHC Regulatory Area; d) A fixed shares concept for all or some IPHC Regulatory Areas, Biological Regions, or Management Zones with options to distribute the TCEY to the areas without a fixed share. The determination of these shares may be fixed or varying over time; and e) A maximum fishing intensity defined by an SPR of 36% to act as a buffer when distributing the TCEY to IPHC Regulatory Areas.	IN PROGRESS: These items are currently being evaluated and progress will be presented at MSAB015

Outcomes of the 15th Session of the IPHC Scientific Review Board (SRB015)

PREPARED BY: IPHC SECRETARIAT (10 APRIL 2020)

PURPOSE

To provide the MSAB with the outcomes of the 15th Session of the IPHC Scientific Review Board (SRB015) relevant to the mandate of the MSAB.

BACKGROUND

The agenda of the 15th Session of the IPHC Scientific Review Board (SRB) included an agenda item dedicated to Management Strategy Evaluation (MSE).

DISCUSSION

During the course of the 15th Session of the IPHC Scientific Review Board (SRB015), a number of specific requests and recommendations regarding the IPHC MSE process where proposed by the SRB. Relevant sections from the report of the meeting are provided in Appendix A for the MSAB's consideration.

RECOMMENDATION

That the MSAB:

1) **NOTE** paper IPHC-2020-MSAB015-05 which details the outcomes of the 15th Session of the IPHC Scientific Review Board (SRB015) relevant to the mandate of the MSAB.

APPENDICES

Appendix A: Excerpt from the 15th Session of the IPHC Scientific Review Board (SRB015) Report (IPHC-2019-SRB015-R).

APPENDIX A
Excerpt from the 15th Session of the IPHC Scientific Review Board (SRB015) Report (IPHC-2019-SRB015-R)

7. MANAGEMENT STRATEGY EVALUATION: UPDATE

37 The SRB **NOTED** paper IPHC-2019-SRB015-09 which provided the SRB with an update on the IPHC MSE process including defining objectives, results for management procedures related to coastwide fishing intensity, a framework for distributing the TCEY, and a program of work.

Goals, Objectives and Performance Metrics

38 The SRB **NOTED** paper IPHC-2019-SRB015-INF01, which provided the outcomes of the Ad-hoc Working Group on ideas to Refine Goals, Objectives, and Performance Metrics for the IPHC Management Strategy Evaluation (MSE).

39 **NOTING** the new objectives provided in paper IPHC-2019-SRB015-09, and that objectives for minimum catch levels by IPHC Regulatory Area may be useful for evaluating management procedures, the SRB **AGREED** that proportional shares are a different concept and should also be defined for each IPHC Regulatory Area to examine trade-offs.

40 The SRB **NOTED** the proposed objective to have annual mortality limits related to local abundances. While this could provide transparency from a policy perspective, it ignores the biological realities of movement and other processes that remain poorly understood at both coastwide and Regulatory Area scales.

41 The SRB **RECOMMENDED** that if the original objective to have annual mortality limits related to local abundances was of broad interest to the Commission, then candidate management procedures be developed and tested in which regional mortality limits are set annually in proportion to modelled survey abundance trends by IPHC Regulatory Area (noting that splitting regions into Regulatory Areas would require assumptions about within-region abundance proportions).

Dynamic reference points

42 The SRB **NOTED** paper IPHC-2019-SRB015-11 Rev_1, which provided an evaluation of dynamic reference points for Pacific halibut.

43 The SRB **NOTED** that a precautionary RSB_{MSY} proxy of 30% of unfished spawning biomass, putting a proxy for RSB_{MEY} between 36% and 44%, could provide a reasonable range of values for the coastwide objective to maintain the spawning biomass around a target (objective 2.1B).

44 The SRB **NOTED** that candidate control rule development is an iterative process, and that:

a) use of the trigger from the control rule in coastwide objective 2.1A (*Maintain the female spawning biomass above a trigger reference point at least 80% of the time*) conflates the objective and management procedure;

b) avoiding a spawning biomass limit of 20% unfished with a tolerance of 0.05 is a potential conservation objective based on the analysis of MSY-related reference points and is consistent with some international standards;

c) SPR values between 38% and 48% could satisfy the coastwide conservation objective and the biomass target objective based on a proxy for SB_{MEY} between 36% and 44%, and the stability objective may be met by applying one of two constraints: a maximum annual change in the mortality limit of 15% or a slow-up fast-down approach.

45 The SRB **RECOMMENDED** that the MSAB define objectives independently of the management procedures used to achieve them and, instead, focus on the

outcomes/consequences they wish to avoid (e.g. low catch, fishery closures, large drops in TCEY, public perceptions of poor stock status).

7.1 Updates to MSE framework and closed-loop simulations

46 The SRB **NOTED** paper IPHC-2019-SRB015-10 Rev_1, which provided technical details of the IPHC MSE framework.

47 The SRB **AGREED** on the valuable contribution provided by the conceptual model and mapping reviewing the different life-history phases and putative movement and settlement patterns, and **ENCOURAGED** presenting this more broadly, linking to existing IPHC data archives, and also highlighting specific gaps in knowledge. In particular, this is useful for guiding operating model specifications.

48 The SRB **NOTED** the yield-per-recruit analysis and the changes in relative estimated $F_{0.1}$ among Biological Regions in the recent year compared to the past three decades and that this analysis along with a general understanding of the life-history of Pacific halibut in each Biological Region suggests that eastern areas may be able to sustain higher harvest rates than western areas, at least in some years.

49 The SRB **NOTED** that the distribution framework consisting of a coastwide TCEY distributed to Biological Regions based on stock distribution, relative fishing intensities, and other allocation adjustments, and then distributed to IPHC Regulatory Areas based on other data, observations, or agreement is a useful starting point for developing management procedures to distribute the TCEY.

50 The SRB **REQUESTED** that the initial performance of the above proposals for candidate management procedures be evaluated and presented at the SRB016 in 2020. At that time the appropriateness of different performance measures and objectives could be more carefully evaluated.

51 The SRB **RECOMMENDED** that the Commission develop a standard criterion for achieving a limited set of (or one over-arching) objectives. This would ensure that any candidate management procedure achieves common goals with differences in trade-offs between risks and benefits. Doing so will improve the efficiency of the iterative approach that is required for MSE.

7.2 MSAB Program of Work and delivery of timeline for 2019-21

52 The SRB **NOTED** that the full MSE results will be provided to the SRB for review no later than at the 17th Session of the SRB in September 2020 (SRB017), and that these results, including scale and distribution management procedures, will be presented to the Commission at the 97th Session of the Annual Meeting (AM097), in January 2021.

Outcomes of the 96th Session of the IPHC Annual Meeting (AM096) and 6th Special Session of the Commission (SS06)

PREPARED BY: IPHC SECRETARIAT (D. WILSON, A. HICKS; 10 APRIL 2020)

PURPOSE

To provide the MSAB with the outcomes of the 96th Session of the IPHC Annual Meeting (AM096), and the 6th Special Session of the Commission (SS06) relevant to the mandate of the MSAB.

BACKGROUND

The agenda of the Commission's 96th Session of the Annual Meeting (AM096) included an agenda item (Section 10) dedicated to Management Strategy Evaluation (MSE). The Commission also held a Special Session on 3 March 2020 to consider MSE related matters.

DISCUSSION

During the course of the 96th Session of the IPHC Annual Meeting (AM095) the Commission made a number of specific recommendations and requests for action regarding the MSE process. Relevant sections from the report of the meeting are provided in Appendix A for the MSAB's consideration.

RECOMMENDATION

That the MSAB:

1) **NOTE** paper IPHC-2020-MSAB015-06 which details the outcomes of the 96th Session of the IPHC Annual Meeting (AM096), and the 6th Special Session of the Commission (SS06), relevant to the mandate of the MSAB.

APPENDICES

Appendix A: Excerpt from the 96th Session of the IPHC Annual Meeting (AM096) Report (IPHC-2020-AM096-R), and the 6th Special Session of the Commission (SS06)

APPENDIX A
Excerpt from the 96th Session of the IPHC Annual Meeting (AM096) Report
(IPHC-2020-AM096-R)

10. MANAGEMENT STRATEGY EVALUATION

10.1 IPHC Management Strategy Evaluation: update

75. The Commission **NOTED** paper IPHC-2020-AM096-12 which provided the Commission with an update on the IPHC MSE process including defining objectives, developing management procedures for scale and distribution, a framework for distributing the TCEY, and a program of work.

76. The Commission **RECALLED** the IPHC interim Management Procedure (https://www.iphc.int/the-commission/harvest-strategy-policy) includes the following components:

    a) A biological limit (SB20%), the minimum relative spawning biomass needed to meet conservation objectives;

    b) A fishery trigger (SB30%), the relative spawning biomass below which the reference level of fishing intensity is reduced to avoid reaching the SB20% biological limit;

    c) A reference level of fishing intensity, F46%, corresponding to a Spawning Potential Ratio (SPR) of 46%;

    d) A control rule, reducing the fishing intensity linearly from the reference level at SB30% to no directed fishing at SB20%.

77. The Commission **NOTED** that non-directed fishing discard mortality is currently treated as a scenario in the MSE with a simulated level representing a reasonable range of potential non-directed fishing discard mortality based on recent observations and **RECALLED** paragraph 37 of IPHC-2017-AM093-R:

"The Commission **NOTED** the presentation of an SPR-based harvest policy to update the current harvest policy, and that MSE will be used to evaluate alternative SPR values that are robust to possible bycatch scenarios."

78. The Commission **AGREED** that although the relative spawning biomass has been retrospectively estimated to have fallen below SB30% over the period 2009-2015, it was not determined to be below the fishery trigger during that time period when the mortality limits were set.

79. The Commission **NOTED** the following recommendations from the MSAB and IPHC Secretariat, and **AGREED** to hold an inter-sessional meeting soon after the AM096 to provide direction:

    - *Recommended that the primary coastwide biological sustainability objective of maintaining the female spawning biomass above a biomass limit of SB20% at least 95% of the time be used to evaluate management procedures.*

    - *Recommended primary coastwide fishery objectives to be used for evaluation of management procedures (Table 1), including:*

        a) maintain the female spawning biomass around a proxy target biomass of SB36%;

b) limit annual changes in the TCEY; and

c) optimize directed fishing yield.

- *Recommended that the primary biological sustainability objective of conserving spatial population structure across Biological Regions be used to evaluate management procedures.*

- *Recommended primary fishery objectives at the IPHC Regulatory Area scale for evaluation of management procedures (Table 1), including*

  a) limit annual changes in the TCEY for each IPHC Regulatory Area;

  b) optimize the TCEY among IPHC Regulatory Areas;

  c) optimize a percentage of the coastwide TCEY among IPHC Regulatory Areas;

  d) maintain the TCEY above a minimum absolute level within each IPHC Regulatory Area; and

  e) maintain a percentage of the coastwide TCEY above a minimum level within each IPHC Regulatory Area;

- *Recommended 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) A constraint on the annual change in the TCEY do one of the following: limit it to 15%, use a slow-up, fast-down approach, or fix the mortality limits for three-year periods.

- *Recommended a reference SPR fishing intensity of 43% with a 30:20 control rule and allocations to 2A and 2B, as defined in IPHC-2019-AM095-R paragraphs 69 b and c, be used as an updated interim management procedure consistent with MSE results for the development of 2020 stock assessment results pending delivery of the final MSE results at AM097.*

80. The Commission **NOTED** that various elements of the scale and distribution components of the management procedure, including those listed in IPHC-2019-MSAB014-R will be evaluated for consideration at AM097 in 2021.

81. The Commission **NOTED** that an independent peer review of the MSE will take place in April 2020 and August 2020 with a report supplied to the SRB, MSAB, and Commission.

82. The Commission **NOTED** that the SRB will review MSE results in September 2020, and these results including scale and distribution management procedures will be presented to the Commission at AM097 in 2021.

83. The Commission **NOTED** that MSE is the appropriate tool to evaluate management procedures related to discard mortality for non-directed fisheries (bycatch) because it can capture downstream effects, biological implications, and the management performance relative to objectives.

10.2 Reports of the 13th and 14th Sessions of the IPHC Management Strategy Advisory Board (MSAB013 and MSAB014)

84. The Commission **NOTED** the Reports of the 13th and 14th Sessions of the IPHC Management Strategy Advisory Board (MSAB013 - IPHC-2019-MSAB013-R; MSAB014 - IPHC-2019-MSAB014-R) which was presented by Mr Adam Keizer (Canada) and Dr Carey McGillard (USA).

85. The Commission **NOTED** that the MSAB014 made five (5) recommendations to the Commission as follows:

A review of the coastwide goals and objectives of the IPHC MSE process

MSAB014–Rec.01 (para. 34) The MSAB RECOMMENDED a coastwide fishery objective, in response to a request from the Commissioners, to maintain the spawning biomass above a target reference point of RSB36%, 50% of the time over the long-term.

Identification of goals and objectives related to distributing the TCEY

MSAB014–Rec.02 (para. 41) The MSAB RECOMMENDED the primary objectives and associated performance metrics detailed in Appendix V to be used for the evaluation of management procedures at MSAB015.

Performance metrics for evaluation

MSAB014–Rec.03 (para. 46) NOTING the current progress on evaluating coastwide fishing intensity, the MSAB RECOMMENDED that:

1) a coastwide fishing intensity SPR of 43%, with a 30:20 HCR, and with one of two constraints 1) +/-15% maximum change in total mortality, and/or 2) slow up, fast down, be used in harvest strategy development process; and

2) a range of management procedures including fishing intensity SPR of 40-46% be considered in light of implementation variability within the closed-loop simulations when investigating distribution.

Management procedures for coastwide scale

MSAB014–Rec.04 (para. 49) The MSAB RECOMMENDED that SPR values of 0.3, 0.34, 0.38, 0.40, 0.42, 0.46, and 0.50 with a 30:20 control rule be evaluated at MSAB015 along with constraints defined by a maximum change in the TCEY of 15%, a slow-up fast-down approach, and/or setting quotas every third year.

Management procedures for distributing the TCEY

MSAB014–Rec.05 (para. 56) The MSAB RECOMMENDED that the management procedures listed in Table 2 in Appendix VI be evaluated at MSAB015.

86. The Commission **NOTED** that the MSAB will use the primary objectives and associated performance metrics detailed in Appendix V of IPHC-2019-MSAB014-R for the evaluation of management procedures.

87. The Commission **NOTED** that relative harvest rates will be evaluated as a component of management procedures at MSAB015 and MSAB016.

88. The Commission **NOTED** the MSE Program of Work (2019–21) and that the MSAB and IPHC Secretariat will continue its program of work with delivery of recommended

management procedures at AM097.

89. The Commission **REQUESTED** the MSAB to confirm the proposed topics of work beyond the 2021 deliverables in time for the Interim Meeting (IM096), including work to investigate and provide advice on approaches for accounting for the impacts of bycatch in one Regulatory Area on harvesting opportunities in other Regulatory Areas.

RESULTS AND ACTION ITEMS FROM THE 6th SPECIAL SESSION OF THE IPHC (SS06)

(IPHC-2020-CR-007)

I. Management Strategy Evaluation (MSE)

IPHC-2020-ID001: The Commission **RECOMMENDED** that the primary coastwide and area-specific objectives outlined in Table 1 of Appendix A be used for evaluating MSE results conditional on future consideration of the objectives after preliminary MSE results are presented at MSAB015 in May 2020.

IPHC-2020-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, 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.

APPENDIX A

Table 1. Primary measurable objectives, evaluated over a simulated ten-year period. Objective 1.1 is a biological sustainability (conservation) objective and objectives 2.1, 2.2, and 2.3 are fishery objectives. Reproduced from IPHC-2020-AM096-12.

GENERAL OBJECTIVE	MEASURABLE OBJECTIVE	MEASURABLE OUTCOME	TIME-FRAME	TOLERANCE	PERFORMANCE METRIC
1.1. KEEP FEMALE SPAWNING BIOMASS ABOVE A LIMIT TO AVOID CRITICAL STOCK SIZES AND CONSERVE SPATIAL POPULATION STRUCTURE	Maintain a female spawning stock biomass above a biomass limit reference point at least 95% of the time	*SB* < Spawning Biomass Limit (SB_{Lim}) SB_{Lim}=20% unfished spawning biomass	Long-term	0.05	$P(SB < SB_{Lim})$
	Maintain a defined minimum proportion of female spawning biomass in each Biological Region	$p_{SB,2} > 5\%$ $p_{SB,3} > 33\%$ $p_{SB,2} > 10\%$ $p_{SB,2} > 2\%$	Long-term	0.05	$P(p_{SB,R} < p_{SB,R,min})$
2.1 MAINTAIN SPAWNING BIOMASS AROUND A LEVEL THAT OPTIMIZES FISHING ACTIVITIES	Maintain the coastwide female spawning biomass above a biomass target reference point at least 50% of the time	*SB*<Spawning Biomass Target (SB_{Targ}) $SB_{Targ}=SB_{36\%}$ unfished spawning biomass	Long-term	0.50	$P(SB < SB_{Targ})$
2.2. LIMIT CATCH VARIABILITY	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
2.3. PROVIDE DIRECTED FISHING YIELD	Optimize average coastwide TCEY	Median coastwide TCEY	Short-term		*Median* $\overline{TCEY}$
	Optimize TCEY among Regulatory Areas	Median $TCEY_A$	Short-term		*Median* $\overline{TCEY_A}$
	Optimize the percentage of the coastwide TCEY among Regulatory Areas	Median $\%TCEY_A$	Short-term		*Median* $\left(\overline{\frac{TCEY_A}{TCEY}}\right)$
	Maintain a minimum TCEY for each Regulatory Area	Minimum $TCEY_A$	Short-term		*Median Min(TCEY)*
	Maintain a percentage of the coastwide TCEY for each Regulatory Area	Minimum $\%TCEY_A$	Short-term		*Median Min(%TCEY)*

Potential management procedures to determine the total constant exploitation yield (TCEY) by IPHC Regulatory Area for Pacific halibut fisheries

PREPARED BY: IPHC SECRETARIAT (P. CARPI, A. HICKS, & I. STEWART; 10 APRIL 2020)

PURPOSE

To provide an update on management procedures related to distributing the TCEY for use in the MSE process.

1. INTRODUCTION

The Management Strategy Evaluation (MSE) at the International Pacific Halibut Commission (IPHC) completed an initial phase of evaluating management procedures relative to the coastwide scale of the Pacific halibut stock and fishery. Results of the MSE simulations were presented at the 96th Session of the IPHC Annual Meeting (AM096) and endorsed by the Commission at the Intersessional Meeting held on 3 March, 2020 (IPHC-2020-CR-007). The next phase is to investigate management procedures related to the distribution of the Total Constant Exploitation Yield (TCEY). The TCEY is the mortality limit composed of mortality from all sources except under 26 inch (66.0 cm, U26) non-directed discard mortality, and is determined by the Commission at each Annual Meeting for each IPHC Regulatory Area.

A management procedure consists of three elements: the monitoring (data generation), the Estimation Model (EM) and the Harvest Rule (HR) (Figure 1). Data are generated from the Operating Model (OM) to simulate the data collection and sampling process. Variability and bias are introduced in the data in this phase. The EM is analogous to the stock assessment and simulates estimation error in the process. Using the data generated, it produces an annual estimate of stock size and status and provides the inputs for applying the HR. The HR is the application of the estimation model output using various specifications to determine mortality limits for the upcoming year or years.

This document presents and discusses the Management Procedures (MPs) for determining the TCEY for each IPHC Regulatory Area. First, a summary of recent developments in the Management Procedures for Pacific Halibut that arised from the last most recent MSAB meeting and the Commission recent meetings is provided (Section 2). Next, the general framework under which both the current and the recently proposed MPs operate is described (Section 3). It will then review the current interim management procedure, including the recent short term agreements for 2021 and 2022 (Section 4). Finally, an overview is provided of the MPs that will be tested during this second phase of the MSE process, highlighting limits and benefits of the tools used (Section 5).

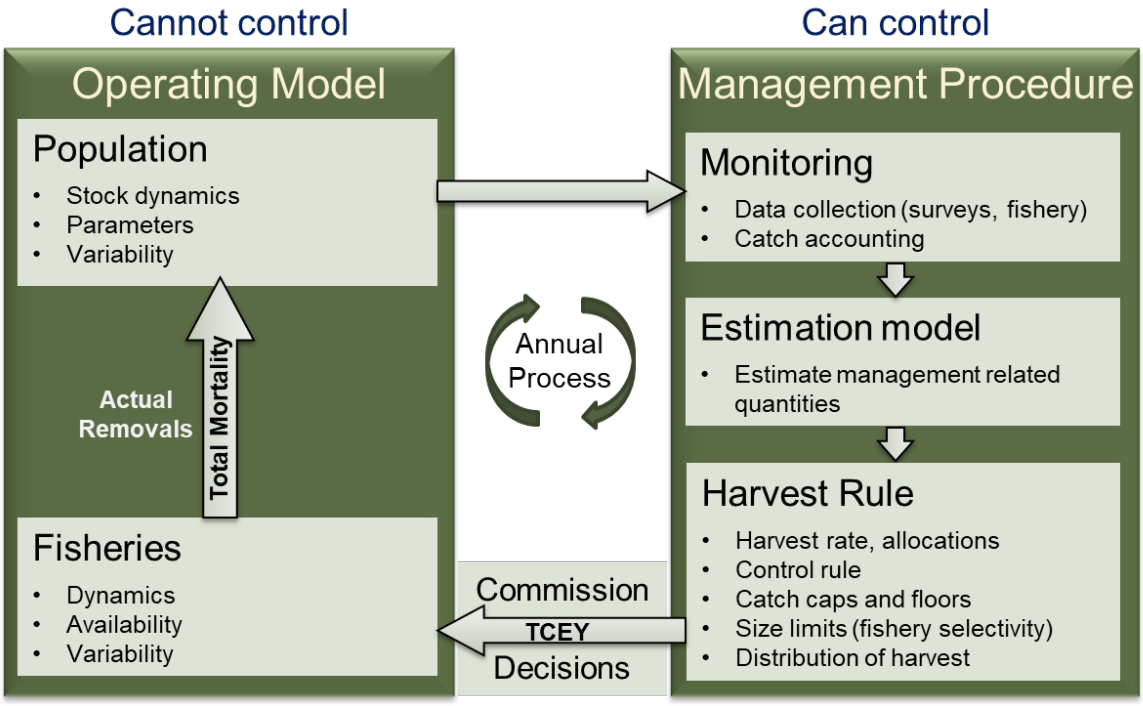

Figure 1: Illustration of the closed-loop simulation framework with the operating model (OM) and the Management Procedure (MP). The annual process represents a single loop of this framework.

2. MANAGEMENT PROCEDURES FOR COASTWIDE SCALE AND DISTRIBUTION OF THE TCEY

The 96th Session of the IPHC Annual Meeting (AM096) discussed the recommendations from the MSAB and the IPHC Secretariat on the coastwide results of the MSE and agreed to hold an inter-sessional meeting soon after AM096 to provide further direction. At the 96th Annual Meeting the Commission noted the recommendation from the MSAB after evaluating the coastwide MSE that the following harvest rule components meet the coastwide objectives (IPHC-2020-AM096-R, para 79, point 5):

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.

*SPR values in the range between 40 to 46% meet the objectives, as noted in para 52 of https://www.iphc.int/uploads/pdf/msab/msab13/iphc-2019-msab013-r.pdf.

At the 6th Special Session of the Commission, two specific recommendations were made on the MSE (IPHC-2020-CR-007):

> ***IPHC-2020-ID001:*** *The Commission* ***RECOMMENDED*** *that the primary coastwide and area-specific objectives outlined in Table 1 of Appendix A be used for evaluating MSE results conditional on future consideration of the objectives after preliminary MSE results are presented at MSAB015 in May 2020.*
>
> ***IPHC-2020-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, 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.*

These two recommendations endorse the coastwide and area-specific objectives defined at MSAB014, and the revision of the reference Spawning Potential Ratio (SPR, or fishing intensity) from 46% to 43% based on the analysis presented to SRB015 and MSAB014.

The MSAB has defined a list of candidate management procedures for distributing the coastwide TCEY. At MSAB014, the distribution framework was formalized in 3 steps: a coastwide TCEY, an optional distribution of the TCEY to Biological Regions or Management Zones, and the final distribution to IPHC Regulatory Areas. Specific elements of candidate management procedures (Table 1) were requested for evaluation at MSAB015 (paragraph 55 of IPHC-2019-MSAB014-R):

> *a) A coastwide constraint using a slow-up, fast-down approach with a maximum change in the TCEY of 15%;*
>
> *b) evaluating different relative harvest rates across IPHC Regulatory Areas or Biological Regions;*
>
> *c) distributing the TCEY directly to IPHC Regulatory Areas;*
>
> *d) A fixed shares concept for all or some IPHC Regulatory Areas, Biological Regions, or Management Zones with options to distribute the TCEY to the areas without a fixed share. The determination of these shares may be fixed or varying over time; and*
>
> *e) A maximum fishing intensity defined by an SPR of 36% to act as a buffer when distributing the TCEY to IPHC Regulatory Areas.*

3. THE GENERAL FRAMEWORK

The framework for distributing the TCEY begins with the coastwide TCEY determined from the stock assessment and fishing intensity defined by a reference SPR. The TCEY can be distributed to Biological Regions first and then to Regulatory Areas, or directly to Regulatory Areas; however, maintaining spawning biomass in each Biological Region is a primary objective. Relative adjustments can be applied in each step of the distribution process. Typically, the distribution procedure does not alter the overall fishing intensity (i.e., reference SPR).

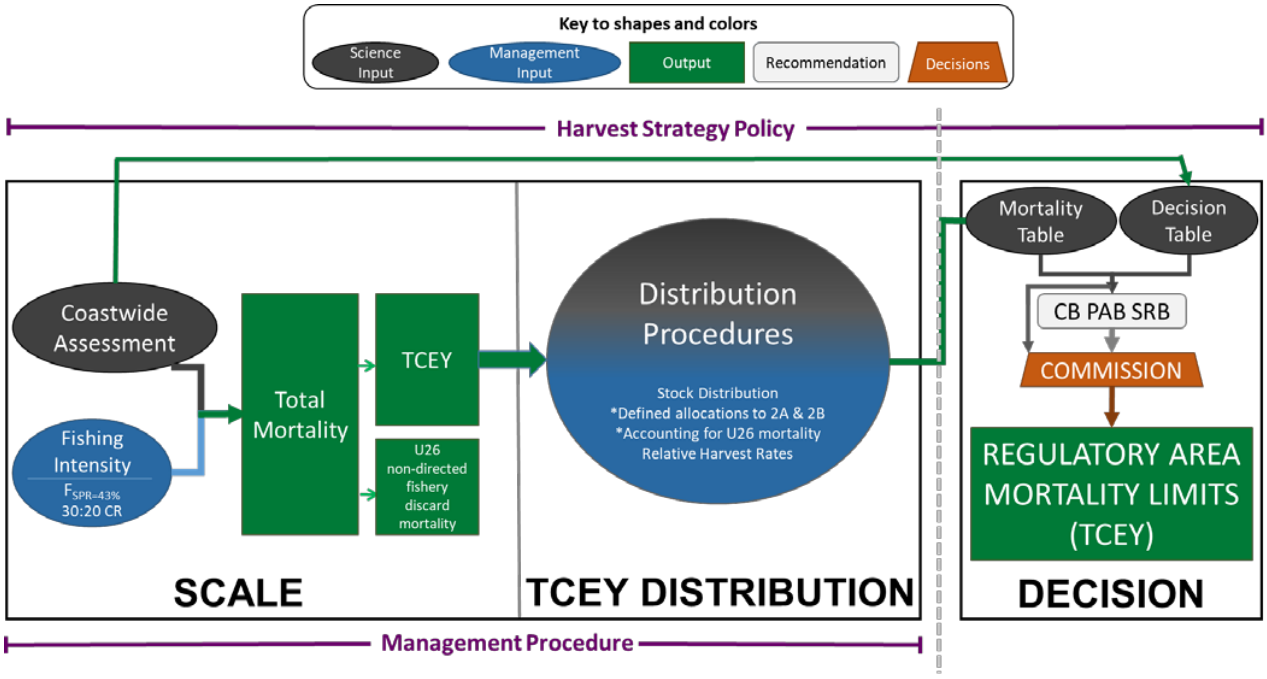

Figure 2: Illustration of the Commission interim IPHC harvest strategy policy (reflecting paragraph ID002 in IPHC CIRCULAR 2020-007) showing the coastwide scale and TCEY distribution components that comprise the management procedure. Items with an asterisk are three-year interim agreements to 2022. The decision component is the Commission decision-making procedure, which considers inputs from many sources.

The framework is described below. Only steps 1 and 3 are required and steps 2 and 4 are optional.

1. **Coastwide scale (*required*)**

   1.1. **Estimation model (science-based, *required*)**: A statistical analysis or summary of data to inform the current status of the stock and possibly projections given various mortality limits. This may be as complex as a stock assessment or as straightforward as the estimate of relative coastwide abundance/biomass from the modelled survey index.

1.2. **Reference Fishing Intensity (management-derived, *required for an assessment-based approach*):** Determine the coastwide total mortality using a reference SPR that is most consistent with IPHC coastwide objectives defined by the Commission, removing the U26 non-directed fishing discard mortality from the Total Mortality to determine the coastwide TCEY.

2. **Regional distribution (*optional*)**

2.1. **Regional Stock Distribution (science-based, *required when using the Regional step*):** Distribute the coastwide TCEY to four (4) biologically-based Regions (Figure 3) using the proportion of the stock estimated in each Biological Region for all sizes of Pacific halibut using information from the IPHC space-time model. “All sizes” WPUE is the most congruent metric to distribute the TCEY at this scale.

2.2. **Regional Relative Fishing Intensity (science-based, *optional*):** Adjust the distribution of the TCEY among Biological Regions to account for migration, productivity, and other biological characteristics of the Pacific halibut observed in each Biological Region.

2.3. **Regional Allocation Adjustment (management derived, *optional*):** Adjust the distribution of the TCEY among Biological Regions to account for other factors. This may include evaluation of recent trends in estimated quantities (such as fishery-independent WPUE), inspection of historical trends in fishing intensity, recent or historical fishery performance, and uncertainty. Regional relative harvest rates may also be determined through negotiation, leading to an allocation agreement for further regional adjustment of the TCEY.

3. **Regulatory Area Allocation (*required with at least one sub-option*)**

3.1. **Regulatory Area Stock Distribution (science-based):** Distribute the coastwide (if step 2 is omitted) or regional TCEY to IPHC Regulatory Areas using the proportion of the stock estimated in each IPHC Regulatory Area for all sizes or O32 Pacific halibut using information from the IPHC space-time model.

3.2. **Regulatory Area Allocation (management derived):** Apply IPHC Regulatory Area allocation to the coastwide TCEY (if step 2 is omitted) or within each Biological Region to distribute the TCEY to Regulatory Areas. This management or policy decision may be informed by data or defined by an allocation agreement and may include different relative harvest rates by Regulatory Area. For example, recent trends in estimated all sizes WPUE from the modelled survey or fishery data, age composition, or size composition may be used to distribute the TCEY to IPHC Regulatory Areas. Inspection of historical trends in fishing intensity or catches by IPHC Regulatory Area may also be used. Finally, predetermined fixed percentages are also an option. This allocation to IPHC Regulatory Areas may be a procedure with multiple adjustments using different information or agreements.

The steps described above would be contained within the IPHC Harvest Strategy Policy as part of the Management Procedure and are predetermined steps with a predictable outcome. The decision-making process would then occur (Figure 2: Illustration of the Commission interim IPHC harvest strategy policy (reflecting paragraph ID002 in IPHC CIRCULAR 2020-007) showing the coastwide scale and TCEY distribution components that comprise the management procedure. Items with an asterisk are three-year interim agreements to 2022. The decision component is the Commission decision-making procedure, which considers inputs from many sources.).

4. **Annual Regulatory Area Adjustment (policy, *optional*)**: Adjust individual Regulatory Area TCEY limits to account for other factors as needed. This is the policy component of the harvest strategy policy and occurs as a final step where other objectives are considered (e.g., economic, social, etc.). A departure from the reference SPR may be a desired outcome for a particular year (short-term, tactical decision making based on current trends estimated in the stock assessment) but would deviate from the management procedure and the long-term management objectives. Departures from the management procedure could take advantage of current situations but may result in unpredictable longer-term outcomes.

3.1. Coastwide TCEY

The stock assessment along with a target fishing intensity determine the coastwide Total Mortality (TM). The stock assessment model estimates the status of the stock (i.e, relative spawning biomass, RSB) and uses a target fishing intensity (i.e, SPR) to determine the TM for the next year. If the stock status is below a trigger reference level the fishing intensity for the upcoming year is reduced accordingly based on a harvest control rule (i.e., 30:20 control rule). Additional elements, such as constraints on how much the TM can change from year to year, may also occur at the coastwide level. The coastwide TM is split into the TCEY and under 26" non-directed fishery discard mortality.

3.2. Distributing the TCEY

The TCEY is then distributed to IPHC Regulatory Areas where catch sharing plans and other agreements determine the ultimate allocation to sectors within an IPHC Regulatory Area (the management procedures considered here only go as far as the TCEY in each IPHC Regulatory Area). The distribution of the TCEY has several components, that range from purely scientific, to describe the stock distribution and shifts in harvest rates due to differences in productivity, to policy driven, that modify the distribution based on additional considerations.

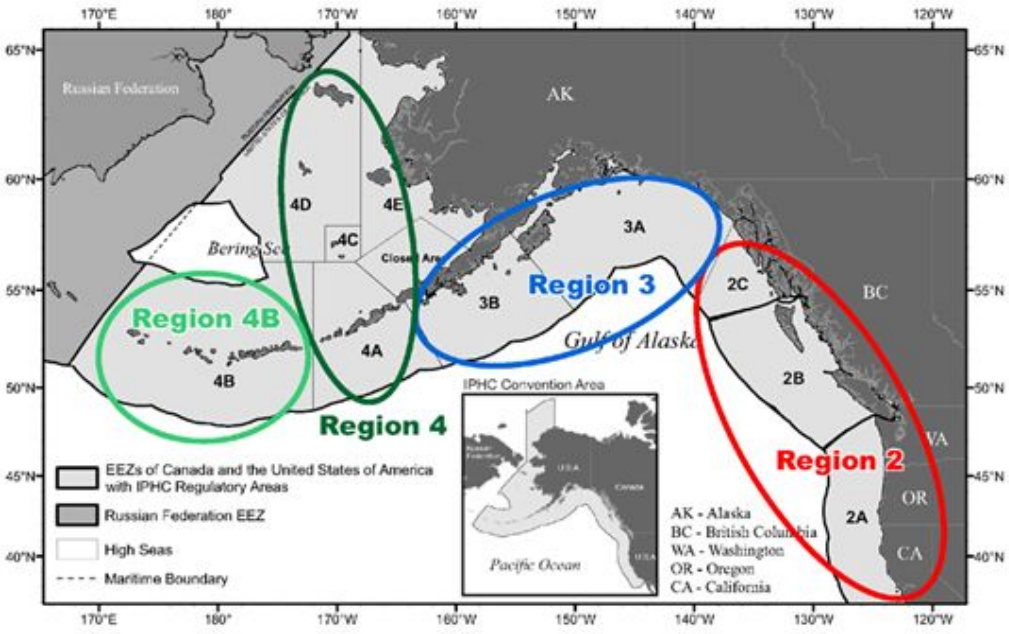

Figure 3: Biological Regions overlaid on IPHC Regulatory Areas. Region 2 comprises 2A, 2B, and 2C, Region 3 comprises 3A and 3B, Region 4 comprises 4A and 4CDE, and Region 4B comprises solely 4B.

The overarching conservation goal for Pacific halibut is to maintain a healthy coastwide stock, which implies an objective to retain viable spawning activity in all geographic components of the stock. This goal is well reflected in both the coastwide and area specific objectives defined by the MSAB (MSAB012, MSAB013, MSAB014) and recommended by the Commission at the 6th Special Session of the Commission. Pacific Halibut is a highly migratory species and years of research have contributed to an understanding of the general pattern of movement of the species and helped define Biological Regions (Figure 3). Each Biological Region encompasses multiple IPHC Regulatory Areas and shares common environmental and demographic features. In general, within a year fish move regularly across IPHC Regulatory Areas, but tend to remain within the same Biological Regions (Loher and Seitz 2006; Seitz et al. 2007; Webster et al. 2013). Hence, spawning components are defined by Biological Region. Shifts in productivity will most likely be detected at a Biological Regions level, and will affect each regional component differently. For these reasons, Biological Regions are the most logical scale over which consider conservation objectives related to distribution of the fishing mortality.

Additional steps for further modification of the distribution of the TCEY among Biological Regions and subsequent distribution among IPHC Regulatory Areas within Biological Regions may be based on external factors, such as area specific observations (e.g. fishery-dependent WPUE),

higher uncertainty of data collected or observed mortality levels in each area, defined allocations, national shares, and so on.

Overall, science (e.g., analysing data and understanding the life-history of Pacific halibut) and policy (e.g, including management objectives, fishery performance and economic considerations) in each Biological Region will help inform the construction of management procedures related to distributing the TCEY among Biological Regions and IPHC Regulatory Areas. Both these aspects have been included in the MPs proposed during MSAB014.

4. CURRENT INTERIM MANAGEMENT PROCEDURE

4.1. Coastwide TCEY

The current interim management procedure uses a coastwide reference fishing intensity (SPR) which defines the scale of the coastwide Total Mortality (TM).The TM is divided into the under 26-inch (U26) non-directed fishery discard mortality and the TCEY. The stock assessment estimates the stock status as the current spawning biomass relative to unfished spawning biomass (B0), or relative spawning biomass (RSB). The reference fishing intensity is a fishing mortality rate that would reduce the SPR in the coastwide stock to 43% ($F_{43\%}$, as recommended in IPHC-2020-ID002 of IPHC Circular 2020-007). The 30:20 harvest control rule adjusts the reference SPR if the estimated stock status falls below the 30% trigger value. Specifically, the fishing intensity is reduced linearly if the stock status falls below 30% of unfished spawning stock biomass, and is reduced to zero if the stock status falls below 20% of unfished spawning stock biomass.

4.2. Distributing the TCEY

The coastwide TCEY is then distributed among IPHC Regulatory Areas. The current interim management procedure to distribute the TCEY uses the proportion of modelled survey O32 biomass (i.e. biomass of fish over 32 inches) and 25% lower relative harvest rates in the western areas (i.e. 3B, 4A, 4CDE, and 4B) compared to the eastern areas (i.e. 2A, 2B, 2C, 3A). The lower harvest rate assigned to western areas was first implemented in 2004 (Clark & Hare 2005, Hare 2005, Hare 2006, Hare 2009) as a 'precautionary' measure based on declining trends in spawning biomass and CPUE, the presence of small fish, differences in yield-per-recruit, differences in emigration and immigration, and greater uncertainty in the data and analyses available at the time (Hare 2009). Recent changes in productivity of these areas, modelled through a simple Yield-per-Recruit (YpR) analysis, showed that the past yield-per-recruit justifications for such difference were consistent 20 to 30 years ago, but may not be hold in recent years (IPHC-2019-MSAB014-07).

4.3. Regulatory areas adjustment

The current interim procedure added further adjustments to the distributed TCEY in 2019, including a fixed 1.65 million pounds for IPHC Regulatory Area 2A and an allocation for IPHC Regulatory Area 2B based on both stock distribution and a fixed percentage. This is defined as a weighted average of 30% weight to the current interim management procedure's target TCEY distribution and 70% weight to a value of 20%. In 2020, the Commission decided to also account for some impacts of U26 non-directed fishery discard mortality from U.S. IPHC Regulatory Areas on available harvest in IPHC Regulatory Area 2B. The accounting increases the 2B TCEY by 50% of the estimated yield lost due to U26 non-directed discard mortality in Alaskan waters. These adjustments are intended to apply through 2022.

5. MANAGEMENT PROCEDURES PROPOSED

At MSAB014, a list of ten Management procedures were defined to be tested during the next phase of the MSE process (**Table 1**).

The tools used in the definition of these MPs can be grouped in three categories:

a) Modelled Survey estimates (e.g. relative biomass estimates by Biological Region, IPHC Regulatory Areas or other scale, O32 WPUE, trend in O32 WPUE, etc..).

b) Fishery Dependent Data (e.g. trend in CPUE by Biological Region, IPHC Regulatory Area or other scale).

c) Practical Tools (e.g. relative harvest rate, percentage allocation to an IPHC Regulatory Areas, proportion of adopted TCEY, etc…).

In the definition of the different MPs, the MSAB has also highlighted the importance of testing a number of additional tools, such as i) the application or not of one or more constraints to the TCEY (i.e. slow-up, fast-down with 15% maximum change in TCEY), ii) the application of O32 estimates of stock distribution or the use of the ‘all-sizes’ estimates, iii) the application or not of different harvest rates across IPHC Regulatory Areas or Biological Regions, iv) the calculation of shares using a blend of multiple sources of information, and v) the importance of the order in which each component of the distribution procedure is applied when limiting the maximum SPR. These points are reflected in the combination of different tools between MPs.

Table 1: Recommended management procedures for evaluation at MSAB015.

MP	Coastwide	Regional	IPHC Regulatory Area
MP A	SPR 30:20		• O32 stock distribution • Proportional Relative harvest rates (starting with 1.0 for 2-3A, 0.75 for 3B-4) relative to below • 1.65 Mlbs floor in 2A (para 69c AM095-R) • Formula percentage for 2B (para 69b AM095-R)
MP B	SPR 30:20 Slow-up, fast-down MaxChange15%		• O32 stock distribution • Proportional Relative harvest rates (starting with 1.0 for 2-3A, 0.75 for 3B-4) relative to below • 1.65 Mlbs floor in 2A (para 69c AM095-R) • Formula percentage for 2B (para 69b AM095-R)
MP C	SPR 30:20		• O32 stock distribution • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4)
MP D	SPR 30:20 Slow-up, fast-down MaxChange15%		• O32 stock distribution • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4)
MP E	SPR 30:20		• O32 stock distribution • Relative harvest rates (0.75 for 4B, 1 for others) •
MP F	SPR 30:20	Biological Regions, O32 stock distribution Rel HRs: R2=1, R3=1, R4=0.75, R4B=0.75	• O32 stock distribution • Relative harvest rates not applied • 1.65 Mlbs floor in 2A (para 69c AM095-R) • Formula percentage for 2B (para 69b AM095-R)
MP G	SPR 30:20	Biological Regions, O32 stock distribution Rel HRs: R2=1, R3=1, R4=1, R4B=0.75	• O32 stock distribution • Relative harvest rates not applied • 1.65 Mlbs floor in 2A (para 69c AM095-R) • Formula percentage for 2B (para 69b AM095-R)

MP	Coastwide	Regional	IPHC Regulatory Area
MP H	SPR 30:20 Max FI (36%)		First • O32 stock distribution • Relative harvest rates (1.0 for 2-3A, 0.75 for 3B-4) Second within buffer • 1.65 Mlbs floor in 2A (para 69c AM095-R) • Formula percentage for 2B (para 69b AM095-R)
MP I	SPR 30:20		• 5-year shares determined from 5-year O32 stock distribution (vary over time)
MP J	SPR 30:20	National Shares: 20% to 2B, 80% to other	• O32 stock distribution

5.1. Coastwide TCEY

All the management procedures proposed at MSAB014 for testing are based on the current interim MP including a fishing intensity (SPR), and a harvest control rule (30:20). Different constraints are also tested across the different management procedures. In particular, i) a slow-up,fast-down constraint, which implies a TM limit increases by one-third of the increase suggested by harvest control rule and a TM limit decreases by one-half of the decrease suggested by the harvest control rule; ii) a maximum change in the TCEY from one year to the next not higher than 15% in either direction, and iii) a maximum fishing intensity not higher than an SPR of 36% (meaning a SPR greater than or equal to 36%). The first two constraints are used together in two of the MPs and were chosen because they both met objectives in different ways in the coastwide MSE. The third constraint was chosen because it is consistent with the analysis on dynamic reference points presented at MSAB014 (IPHC-2019-MSAB014-07), which identifies a potential range for SPR_{MSY} to likely be between 30 and 35%.

5.2. Distributing the TCEY

Most of the management procedures proposed distribute the TCEY directly to IPHC Regulatory Areas, and only two MPs distribute first to Biological Regions. In one MP, a fixed allocation is introduced at the coastwide level, assigning 20% to IPHC Regulatory Area 2B and 80% to all other areas. The modelled survey O32 stock distribution is the main tool used for distributing the TCEY both at the Biological Region and IPHC Regulatory Area levels, and it is used in all ten MPs. Different relative harvest rate adjustments are used across different MPs, to test the effects on western and eastern areas given the potential changes in productivity that may have occurred in the last decade. This tool is also applied to Biological Regions when distributing the TCEY to regions first. Finally, about half of the MPs include the interim adjustments for IPHC Regulatory Areas 2A and 2B.

5.3. Considerations on the tools used

The use of modelled survey O32 stock distribution to distribute the TCEY at the IPHC Regulatory Area level disregards the U32 portion of the surveyed biomass, some of which is still included in the TCEY. In this respect, the use of the "all sizes" modelled survey estimates is more logically consistent: the "all sizes" stock distribution is largely composed of O26 Pacific halibut due to the selectivity of the setline gear, and is therefore more congruent with the TCEY (mainly O26 catch levels).

One of the primary biological objectives is to maintain the proportion of Pacific halibut spawning biomass in each Biological Region. However, most of the proposed MPs distribute the coastwide TCEY directly to IPHC Regulatory Areas. The omission of this intermediate step may affect the success of the MPs to meet the conservation objectives.

The fixed TCEY of 1.65 million pounds for Regulatory 2A, and partially fixed allocation in Regulatory Area 2B ensure stability in those Areas. However, this approach may limit yield in years when the stock biomass is high, and may result in lower biomass in those Areas (and Region 2 overall) in times of reduced productivity. These agreements also affect the remainder of the TCEY distributed across other IPHC Regulatory Areas.

The coastwide MSE has tested several MPs for coastwide scale, and has identified the limits of some of those. In particular, it has highlighted the tradeoffs between catch opportunities and catch stability: higher catch in certain years are achieved at the cost of stability in the TCEY from year to year. Many of the MPs listed in Table 1 don't take into account any constraint: the new MSE results will show whether constraints have the same roles for the achievement of area-specific objectives. An alternative to coastwide constraints might be the addition of constraints at the Biological Region or IPHC Regulatory Areas level to achieve area-specific objectives.

Finally, some of the MPs in Table 1 are very complex due to the combination of multiple elements. In general, simplicity is preferred because it will facilitate transparency in the overall process for determining mortality limits.

6. RECOMMENDATIONS

That the MSAB:

a) **NOTE** paper IPHC-2020-MSAB015-07 which includes discussion on management procedures to distribute the TCEY

b) **RECOMMEND** that the distribution framework consisting of a coastwide TCEY distributed to Biological Regions based on stock distribution, relative fishing intensities, and other allocation adjustments, and then distributed to IPHC Regulatory Areas based on other data, observations, or agreement is a useful starting point for developing management procedures to distribute the TCEY, although the coastwide TCEY may be distributed directly to IPHC Regulatory Areas.

c) **AGREE** that the tools listed here are the tools to be considered for the development of management procedures to evaluate in 2020.

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8. APPENDICES

Nil

Development of a framework to investigate fishing intensity and distributing the total constant exploitation yield (TCEY) for Pacific halibut fisheries

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PURPOSE

To provide an update of International Pacific Halibut Commission (IPHC) Management Strategy Evaluation (MSE) activities relating to the definition and development of a framework to evaluate management procedures for distributing the TCEY.

1 INTRODUCTION

The Management Strategy Evaluation (MSE) at the International Pacific Halibut Commission (IPHC) has completed an initial phase of evaluating management procedures (MPs) relative to the coastwide scale of the Pacific halibut stock and fishery, and has embarked on developing a framework to additionally investigate MPs related to distributing the Total Constant Exploitation Yield (TCEY) to IPHC Regulatory Areas. The TCEY is the mortality limit composed of mortality from all sources except under-26-inch (66.0 cm, U26) non-directed discard mortality, and is determined by the Commission at each Annual Meeting for each IPHC Regulatory Area.

The development of an MSE framework aims to support the scientific, forecast-driven study of the trade-offs between fisheries management scenarios. Crafting this tool requires

- the definition and specification of a multi-area operating model;
- an ability to condition model parameters using historical catch and survey data and other observations;
- integration with, use of, or comparison against stock assessment outputs or data;
- identification and development of management procedures with closed-loop feedback into the operating model;
- definition and calculation of performance metrics to evaluate the efficacy of applied management procedures.

Updates on the recent efforts in these areas are outlined in Section 2. Likewise, a significant effort developing the software underpinning these simulations is underway, which is outlined in section 3.

2 FRAMEWORK ELEMENTS

The MSE framework includes elements that simulate the Pacific halibut population and fishery (Operating Model, OM) and management procedures with a closed-loop feedback (Figure 1). Specifications of some elements are described below, with additional technical details in document IPHC-2019-MSAB015-INF01.

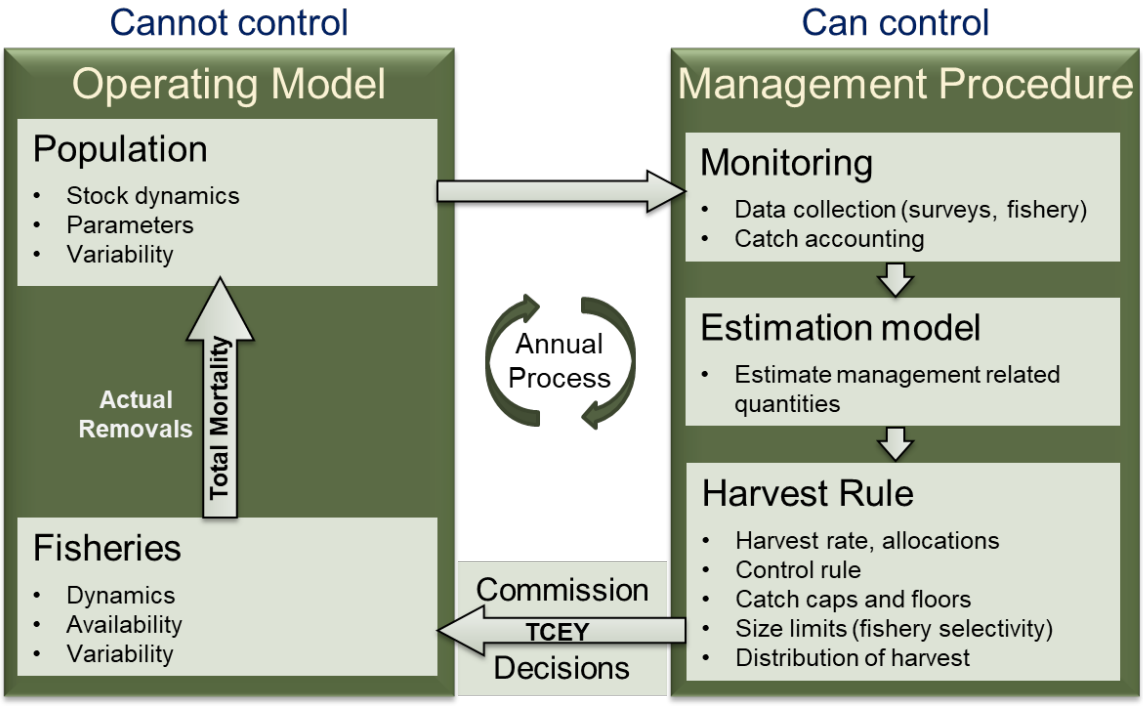

Figure 1: Illustration of the closed-loop simulation framework with the operating model (OM) and the Management Procedure (MP). This is the annual process on a yearly timescale.

2.1 Multi-area operating model

The generalized operating model is able to model multiple spatial components, which is necessary because mortality limits are set at the IPHC Regulatory Area level (Figure 2) and some objectives are defined at that level. Written in the programming language C++ with JavaScript Object Notation (JSON) input files, the OM is flexible, fast, modular, and easily adapted to many different assumptions. The operating model is a simulation tool and does not currently perform estimation or optimisation but will be a very useful tool for many investigations of the Pacific halibut fishery in the future.

The technical details of the multi-area operating model, which continues to be under development, are supplied in document IPHC-2019-MSAB015-INF01. Some background information on specific components and the incorporation of uncertainty is supplied below.

2.1.1 General process of the operating model

The use of multiple input JSON-formatted files allows for the simulation of many configurations of the Pacific halibut population and associated fisheries. Any number of areas/regions can be specified along with any number of fisheries that operate in those areas at a specified time in the year. Various parameters, such as natural mortality, movement probabilities, selectivity, etc., are specified and most can vary over time, region, sex, fishery, and age where relevant.

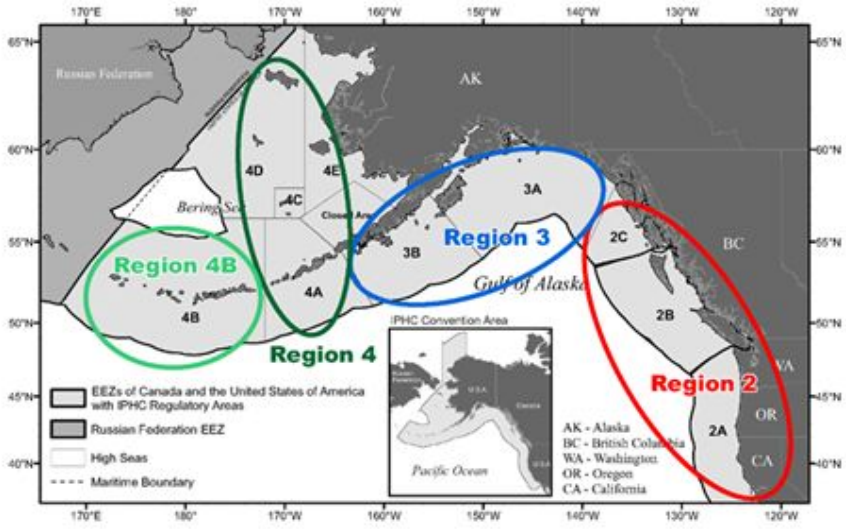

Figure 2: Biological Regions overlaid on IPHC Regulatory Areas. Region 2 comprises 2A, 2B, and 2C, Region 3 comprises 3A and 3B, Region 4 comprises 4A and 4CDE, and Region 4B comprises solely 4B.

The OM begins by calculating the unfished equilibrium population given an input set of biological parameters. It then simulates the annual process during what is called an “initial period” with a fixed mortality level for each fleet (i.e., catch + discard mortality). This initial period allows for the stock to distribute across modelled areas to an equilibrium state given recruitment deviations and fishing mortality. During a subsequent “main period”, the population and dynamics are simulated using input annual fishing mortality, time-varying parameters such as selectivity, recruitment variability, and annual movement between areas. The parameterized model that is run through the main period is called the conditioned model. It is from this point that closed-loop simulations, called the “projection period,” begin.

The projection period can occur in four different ways:

1. A script written for the R statistical language (R Core Team 2020) containing all of the details of the management procedure being evaluated is called by the OM at the beginning of the year to determine the total mortality (TM) for each fishery. The TMs are read back into the OM along with other projected annual processes (e.g., weight-at-age as described below) to simulate the fish population one year forward.

2. A script written for the R statistical language calls the OM which reads in a saved state from disk using TileDB[1], containing the stock state at the start of the projection period as a result of development from the initial period to the end of the main period. After projecting the fish population and fisheries one year forward, the state is written back to disk and the R script performs external calculations such as the management procedure to determine total mortality.
3. The OM is self-sufficient and performs "no estimation error" closed-loop simulations using the spawning potential ratio (SPR) and simple procedures to determine the TM for each fishery.
4. The framework including the OM and management procedures are part of one executable with OM and MP specifications defined through JSON input files.

The first method, where the OM calls an R script containing the details of the management procedure, is currently used, and the other three methods are currently under development.

2.1.2 Population and fishery spatial specification

The emerging understanding of Pacific halibut diversity across the geographic range of its stock indicates that IPHC Regulatory Areas should be only considered as management units and do not represent relevant sub-populations (Seitz et al. 2017). The structure of two of the four current Pacific halibut stock assessment models was developed around identifying portions of the data (fishery-independent and fishery-dependent data) that correspond to differing biological and population processes within the larger Pacific halibut stock. This approach, referred to as 'areas-as-fleets' is commonly used in stock assessments (Waterhouse et al. 2014), and was the approach recommended for inclusion in the ensemble developed in 2014 during the SRB review of models and used in all assessments since (Cox et al. 2016, Stewart & Martell 2015, 2016).

Biological Regions (Figure 2) were therefore defined with boundaries that matched some of the IPHC Regulatory Area boundaries for the following reasons. First, data for stock assessment and other analyses are most often reported at the IPHC Regulatory Area scale and are largely unavailable for sub-Regulatory Area evaluation. Particularly for historical sources, there is little information to partition data to a portion of a Regulatory Area. Second, it is necessary to distribute TCEY to IPHC Regulatory Areas for quota management. If a Region is not defined by boundaries of IPHC Regulatory Areas (i.e. a single IPHC Regulatory Area is in multiple Regions) it will be difficult to create a distribution procedure that accounts for biological stock distribution and distribution of the TCEY to Regulatory Areas for management purposes. Further, the structure of the current directed fisheries do not delineate fishing zones inside individual IPHC Regulatory Areas, so there would be no way to introduce management at that spatial resolution. It is unlikely that there is a set of Regions that accurately delineates the stock biologically since different aspects of the stock differ over varying scales, biological boundaries may shift over time, and movement occurs among Biological Regions.

[1] https://tiledb.com/

To a certain degree, Pacific halibut within the same Biological Region share common biological traits different from adjacent Biological Regions. These traits include sex ratios, age composition, and size-at-age, and historical trends in these data may be indicative of biological diversity within the greater Pacific halibut population. Furthermore, tagging studies have indicated that within a year, larger Pacific halibut tend to undertake feeding and spawning migrations within a Biological Region, and movement between Biological Regions typically occurs between years (Loher and Seitz 2006; Seitz et al. 2007; Webster et al. 2013).

Given the goals to divide the Pacific halibut stock into somewhat biologically distinct regions and preserve biocomplexity across the entire range of the Pacific halibut stock, Biological Regions are considered by the IPHC Secretariat, and supported by the SRB (paragraph 31 IPHC-2018-SRB012-R), to be the best option for biologically-based areas to meet management needs. They also offer an appropriate and parsimonious spatial separation for modeling inter-annual population dynamics.

However, as mentioned earlier, mortality limits are set for IPHC Regulatory Areas and thus directed fisheries operate at that spatial scale. Furthermore, since some fishery objectives have been defined at the IPHC Regulatory Area level, the TCEY will need to be distributed to that scale. Even though the population is modelled at the Biological Region scale, fisheries can be modelled at the IPHC Regulatory Area scale by using an areas-as-fleets approach within Biological Regions. This requires modelling each fleet with separate selectivities and harvest rates that operate on the biomass occurring in the entire Biological Region in each year. The following is a discussion of the pros and cons of this method.

First, modelling the population dynamics at the IPHC Regulatory Area scale would require intra-annual dynamics to be modelled, dividing the year into seasons to model movement between IPHC Regulatory Areas. There is evidence that such intra-annual movements occur (Loher and Seitz, 2006) and fisheries in adjacent IPHC Regulatory Areas may intercept the same pool of fish (Loher 2011). Using Biological Regions assumes that all fisheries within a Region have access to the pool of Pacific halibut in that Region in that year. This greatly simplifies the calculations and eliminates the need to parameterize intra-annual movement. However, if a fishery does not interact with the pool of fish in a Biological Region, harvest rates determined for each fishery may be inaccurate because the biomass to which selectivity is applied would be incorrect , and some fisheries may intercept ages/sizes of Pacific halibut that they commonly do not interact with. This is unlikely to occur and will have very little effect on the results of this MSE because harvest rates are not explicitly used in the management procedures (mortality limits are used for management) and similarity of age/size compositions were used to define Biological Regions.

Additionally, calculating statistics specific to IPHC Regulatory Areas requires assumptions about distribution of biomass within a Biological Region. For example, simulating the observed proportion of biomass in each IPHC Regulatory Area (e.g., to mimic the current interim management procedure) requires simulating a survey biomass for each IPHC Regulatory Area. Likewise, determining some objectives related to IPHC Regulatory Area may be difficult to calculate (such as the proportion of O26 fish in each IPHC Regulatory Area). The distribution of

the population within a Biological Region is currently approximated assuming specified proportions of the population in each IPHC Regulatory Area within a Biological Region. These proportions are constant over ages and allows for the calculation of statistics specific to IPHC Regulatory Areas. Future improvements to the framework will allow for different option such as determining proportions from historically observed distributions and accounting for year to year variability.

Fisheries were defined by IPHC Regulatory Areas (or combinations of areas if fishing mortality in that area was small) in four general categories (e.g., sectors) consistent with the definitions in the stock assessment ((IPHC-2020-AM096-09 Rev_2): **directed** representing the O32 mortality from the directed fisheries, sublegal directed fishery **discards** representing the U32 mortality from the directed fisheries, **non-directed** discard mortality representing the mortality from non-directed fisheries, and **recreational/subsistence** combined into one fishery. Table 1 shows the summed mortality for each of these sectors by IPHC Regulatory Area or Biological Region. Twenty-five fisheries were defined as a sector/area combination based on the amount of mortality in the combination and data availability (Table 2).

Table 1: Summed mortality (millions of net pounds) from 1992 through 2019 by fisheries and IPHC Regulatory Area or Biological Region. Darker colors indicate higher values.

Year	2A	2B	2C	3A	3B	4A	4CDE	4B
Commercial	17.5	259.8	205.5	551.2	252.4	78.2	72.5	62.8
Sublegal discards	0.5	7.1	5.2	16.7	10.7	2.1	1.3	0.8
Non-directed discard mortality		28.3			109.8		167.8	16.2
Recreational/Subsistence	12.1	39.2	70.3	134.9	1.3	1.7	2.3	0.1

2.1.3 Maturity

Spawning biomass for Pacific halibut is currently calculated from a maturity-at-age ogive that is assumed to be constant over years. There is currently no evidence (IPHC-2020-SA-02) for skip spawning or maternal effects (increased reproductive output or offspring survival for larger/older females) and they are not modelled, but could be added. Stewart & Hicks (2017) examined the sensitivity to a trend in declining spawning potential (caused by a shift in maturity or increased skip spawning) and found that under that condition there was a bias in both scale and trend of recent estimated spawning biomass. Ongoing research on maturity and skip spawning will help to inform future implementations of the basis for and variability in the determination of spawning output.

Table 2: The twenty-five fisheries in the OM, the IPHC Regulatory Areas they are composed of, and the 2019 mortality (millions of net pounds) for each.

Fishery	IPHC Regulatory Areas	2019 Mortality
Directed2A	2A	0.89
Directed 2B	2B	5.22
Directed 2C	2C	3.67
Directed 3A	3A	8.16
Directed 3B	3B	2.31
Directed 4A	4A	1.45
Directed 4B	4B	1.00
Directed 4CDE	4CDE	1.65
Discards2A	2A	0.03
Discards2B	2B	0.13
Discards2C	2C	0.06
Discards3A	3A	0.32
Discards3B	3B	0.15
Discards4A	4A	0.09
Discards4B	4B	0.03
Discards4CDE	4CDE	0.07
NonDirected2	2A, 2B, 2C	0.46
NonDirected3	3A, 3B	2.13
NonDirected4	4A, 4CDE	3.84
NonDirected4B	4B	0.17
RecSubsist2A	2A	0.48
RecSubsist2B	2B	1.27
RecSubsist2C	2C	2.26
RecSubsist3	3A, 3B	3.9
RecSubsist4	4A, 4CDE	0.06

2.1.4 Weight-at-age

Empirical weights-at-age by region for the population, fisheries, and survey are determined using observations from the FISS and the fisheries, as is done with the stock assessment models (IPHC-2019-AM095-08 and as described in detail in Stewart and Martell (2016). Smoothed observations of weight-at-age from NMFS trawl surveys were used to augment ages 1-7 fishery and survey weights-at-age. Population weight-at-age is smoothed across years to reduce observation error. Finally, survey and population weight-at-age prior to 1997 is scaled to fishery data because survey observations are limited if present at all.

2.1.5 Movement

Many data sources are available to inform Pacific halibut movement. Decades of tagging studies and observations have shown that important migrations characterize both the juvenile and adult stages and apply across all regulatory areas. The conceptual model of halibut ontogenetic and seasonal migration, including main spawning and nursery grounds, as per the most current knowledge, was presented in IPHC-2019-MSAB014-08 and was used to assist in parameterizing movement rates in the OM.

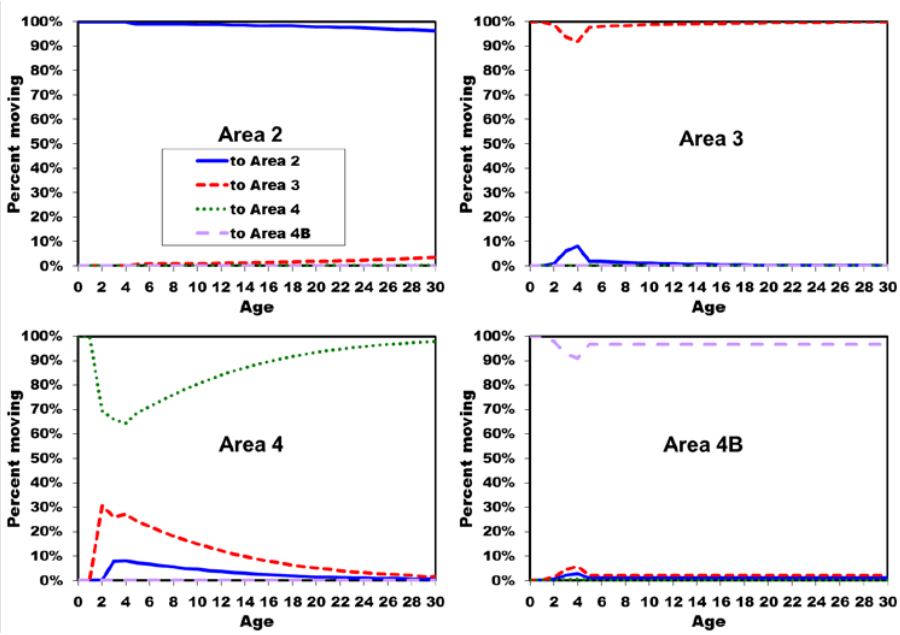

Figure 3: Estimated aggregate annual movement rates by age from Biological Regions (panels) based on currently available data (from IPHC-2019-AM095-08).

In 2015, the many sources of information were assembled into a single framework representing the IPHC's best available information regarding movement-at-age among Biological Regions. Key assumptions in constructing this hypothesis included:

- ages 0-1 do not move (most of the young Pacific halibut reported in Hilborn et al. (1995) were aged 2-4),
- movement generally increases from ages 2-4,
- age-2 Pacific halibut cannot move from Region 4 to Region 2 in a single year, and
- relative movement rates of Pacific halibut age 2-4 to/from Region 4 are similar to those observed for 2-4 year-old Pacific halibut compared to older Pacific halibut in Region 3.

Based on these assumptions, appreciable emigration is estimated to occur from Region 4, decreasing with age. Pacific halibut age-2 to age-4 move from Region 3 to Region 2 and from Region 4B to Regions 3 and 2, and some movement of older Pacific halibut is estimated to occur from Region 2 back to Region 3 (Figure 3).

The conceptual model and assembled movement rates were used to inform the development of the MSE operating model framework and is being used as a starting point to incorporate variability and alternative movement hypotheses in Pacific halibut movement dynamics. Movement in the OM is modelled using a transition matrix as the proportion of individuals that move from one Biological Region to another for each age class in each year.

2.1.6 Fishery and survey selectivity and retention

Selectivity and retention determine the age composition of fishery mortality and ensure the removal of appropriate numbers-at-age from the population when mortality occurs in the annual time-step. Selectivity represents the proportion at each age that is encountered by the gear. Retention represents the proportions-at-age that are retained and landed if caught (i.e., 1 - retention is the proportion-at-age that is released). The product of selectivity and retention is called the "keep curve" and represents the proportions-at-age from the population that are landed. Some fish that are not retained may survive; thus a discard mortality rate is used to indicate the proportion of fish that are not retained and die after release.

Parameters for selectivity and retention were determined from the estimated parameters in the recent stock assessment (IPHC-2020-AM096-09_Rev_2) including annual deviations in selectivity for the directed fisheries and the survey.

2.1.7 Uncertainty in the operating model

Uncertainty is important to consider, as the goal of an MSE is to develop management procedures that are robust to uncertainty. The OM should simulate potential states of the population in the future, uncertainties within the management procedure, and variability when implementing the management procedure.

2.1.7.1 Projected population variability

Variability in the projected population is a result of initializing the population with a range of parameters to recreate a range of historical trajectories and including additional variability in certain population processes in the projection. Uncertainty in input parameters was determined from the stock assessment models when conditioning the OM. An entire set of parameters was sampled from a multinormal distribution to account for correlations between them. These sets of parameters resulted in multiple historical population trajectories from which to begin the projections. The major sources of uncertainty in the OM are described in Table 3.

Table 3: Major sources of variability in the operating model (OM).

Process	Uncertainty
Natural Mortality (M)	Estimate appropriate uncertainty when conditioning OM
Steepness	Estimate appropriate uncertainty when conditioning OM
Recruitment	Random, lognormal deviations
Size-at-age	Annual and cohort deviations in weight-at-age with bounds
Regime Shifts	Autocorrelated indicator based on properties of the PDO for regime shift
Sector mortality	See section on allocating mortality to sectors within an area
Selectivity	See section on directed fishery selectivity
Implementation	See section on implementation variability

Projected weight-at-age

Weight-at-age varies over time historically, and the projections capture that variation using a random walk from the previous year. It is important to simulate time-varying weight-at-age because it is an influential contributor to the yield and status of Pacific halibut. This variability was implemented using the same general procedure as in the coastwide MSE (IPHC-2018-MSAB011-08), with a few modifications to allow for slight departures between regions and fisheries.

The method used to simulate weight-at-age was as follows.

1. A single deviation was generated from a normal distribution with a constant standard deviation (0.05) and the exponential was used as a multiplier on the current year's weight-at-age for all regions and fisheries to determine the weight-at-age for those regions and fisheries in the next year. This made all weights for each age, region, and fishery increase or decrease similarly.
    a. A random walk was used where the weight-at-age in the next year was generated from the weight-at-age in the current year. The deviation in (1) was also correlated with past deviations to simulate periods of similar trends (ρ=0.5).
2. Deviations for each age 6 and greater were generated from a normal distribution with a constant coefficient of variation for each age (0.01), resulting in standard deviations scaled by the mean weight-at-age observed over all historical years with observations. This allows for larger deviations for older fish and provides a mechanism for the mean weight of a specific age to depart from the overall trend simulated in step 1.
    a. This was done separately for the population weight-at-age in each Biological Region and for each fishery. This allows for them to slightly deviate from each other capturing potential different trends for each as well as observation error.

The overall deviate in 1) above is the main driver of weight-at-age and captures the observation that weight-at-age varies over time.

A random walk can traverse to extremely high or low values. Therefore, boundary conditions were set to limit the range over which weight-at-age could vary. The boundary limits were determined from the observed range of weight at each age and expanded 5% beyond the minimum and maximum weight at each age observed. The random walk simulations remained within the bounds by applying the following algorithm.

1. If a weight-at-age was simulated to be beyond the bounds, the deviations for only the ages where the age-specific bounds were exceeded were reduced by one-half and applied again to determine if it still exceeded the bounds.
2. Repeat step (1) until no age-specific bounds were exceeded.

Linkage between average recruitment and environmental conditions

The average recruitment (R_0) is related to the Pacific Decadal Oscillation index[2], expressed as a positive or negative regime (IPHC-2020-SA-02). R_0 is multiplied by $e^{I\delta}$, where I is an indicator of the negative (0) or positive (1) regime, and δ is a parameter determining the magnitude of that multiplier. The parameter δ was determined from the stock assessment.

The regime was simulated in the MSE by generating a 0 or 1 to indicate the regime in that future year, as described in IPHC-2018-MSAB011-08. To encourage runs of a regime between 15 and 30 years (an assumption of the common periodicity, although recent years have suggested less), the environmental index was simulated as a semi-Markov process, where the next year depends on recent years. However, the probability of changing to the opposite regime was a function of the length of the current regime with a probability of changing being equal to 0.5 at 30 years, and a very high probability of changing at 40 years. The simulated length of a regime was most often between 20 and 30 years, with occasional runs between 5 and 20 years or greater than 30 years.

Time-varying selectivity

Time-varying selectivity is estimated in the stock assessment for only the directed fishery in historical years in order to allow for spatial availability and changes in weight-at-age in these coastwide models. The coastwide MSE followed a similar approach by linking changes in selectivity to weight-at-age. Changes in selectivity may be related to changes in weight-at-age because weight-at-age is a proxy for changes in size. Changes in spatial availability is also a factor in time-varying coastwide selectivity, and the multi-area OM may alleviate some of that variability.

A similar approach is used when projecting in the multi-area OM, and the details are still being developed.

Implementation variability

Implementation variability consists of two components. The first is the departure from the management procedure during the decision-making process. For example, the MP may result in a total mortality of 40 Mlbs, but the decision may be to implement a total mortality of 36 Mlbs for various economic and social reasons. The second component of implementation variability is the fact that the fisheries do not achieve the mortality limits exactly. In recent years, the actual total fishery mortality has been slightly less than mortality limits, although some sectors have exceeded the limits.

Both components of implementation variability are modelled in the OM, although the details are still being determined.

2.2 Management Procedure

The management procedure consists of three elements. Monitoring (data generation) is the code that simulates the data from the operating model and are used by the estimation model. It simulates the data collection and sampling process and can introduce variability, bias, and any

[2] https://oceanview.pfeg.noaa.gov/erddap/tabledap/cciea_OC_PDO.htmlTable?time,PDO

other properties that are desired. The Estimation Model (EM) is analogous to the stock assessment and simulates estimation error in the process. Using the data generated, it produces an annual estimate of stock size and status and provides the advice for setting the catch levels for the next time step. Simplification of the full stock assessment ensemble are necessary to keep simulation times within reason. The Harvest Rule is the application of the estimation model output along with the scale and distribution management procedures (Figure 1) to produce the mortality limit for that year. The details of the management procedures are in development and concepts described in IPHC-2020-MSAB015-07 are being considered.

2.2.1 Uncertainty in the management procedure

The major source of uncertainty in the management procedure is from the generation of data. The data generation step simulates the process of observation by resampling from probability distributions that approximate the uncertainty in the observed data. These simulated data are then fed into two stock assessment models to approximate the stock assessment ensemble. The two models are the short coastwide and long coastwide models using stock synthesis and slightly simplified to reduce run time. Extensive testing showed that the averages of these two estimation models provide a reasonable approximation to the full stock assessment while keeping run times to a reasonable amount. Using actual stock assessment models will better characterize the variability than the simpler approach (autocorrelated estimation error about the true population values) used in the coastwide MSE for simulating estimation error. The estimated values from the data generation and estimation model steps are used in the application of the harvest rule to determine mortality limits by IPHC Regulatory Area, and the simulated application of this rule will therefore include errors in the status as well as the size of the population, which will be propagated into management actions.

3 RECOMMENDATIONS

That the MSAB:

a) **NOTE** paper IPHC-2020-MSAB015-08 which provides an update on the development of the IPHC MSE framework, a description of the specifications of the multi-area operating model, and a brief overview of the implementation of management procedures.

b) **RECOMMEND** alternative specifications and additional features needed to evaluate management procedures related to coastwide scale and distribution of the TCEY in 2020, also **NOTING** document IPHC-2020-MSAB015-INF01.

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5 APPENDICES

Nil

Preliminary results investigating fishing intensity and distributing the total constant exploitation yield (TCEY) for Pacific halibut fisheries

PREPARED BY: IPHC SECRETARIAT (A. HICKS, P. CARPI, S. BERUKOFF, & I. STEWART; 10 APRIL 2020)

PURPOSE

To describe preliminary results for closed-loop simulations of management procedures with coastwide scale and distribution components.

1 INTRODUCTION

The first full MSE results incorporating coastwide scale and distribution components of the management procedure (Figure 1) will be presented at the 97th IPHC Annual Meeting (AM097) in January 2021. Therefore, results of simulations incorporating various management procedures based on the framework shown in Figure 1 will be reviewed by the SRB and evaluated by the MSAB in 2020. This document presents preliminary results using the simulation framework described in IPHC-2020-MSAB015-08 to inform further development of management procedures to simulate for evaluation at MSAB016.

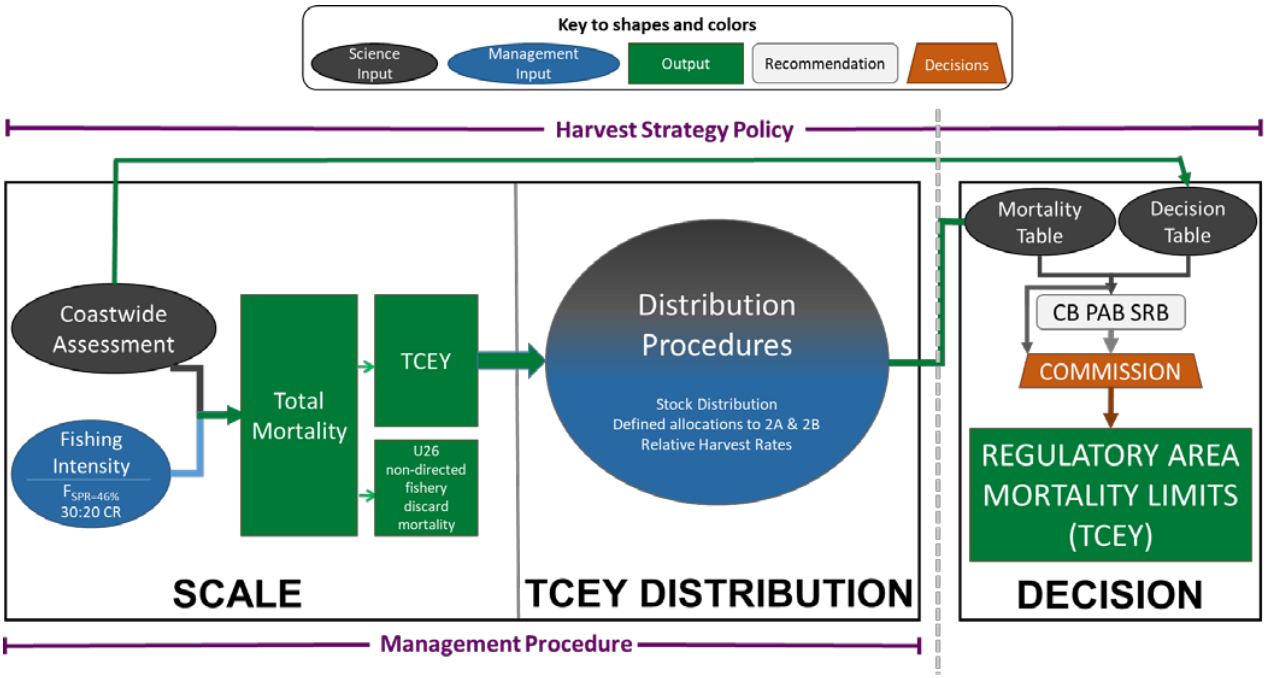

Figure 1: Illustration of the Commission interim IPHC harvest strategy policy (as revised for 2019-2022) process showing the coastwide scale and TCEY distribution components that comprise the management procedure. The decision component is the Commission decision-making procedure, which considers inputs from many sources.

When developing the simulation framework and before running simulations, the priorities were to verify and validate the operating model (OM), condition multi-area operating models to represent the range of possible states of the Pacific halibut stock and fisheries, characterize uncertainty in the Pacific halibut stock and fisheries, and verify that the framework correctly applies the management procedures and provides the proper feedback in the closed-loop simulations. The outcomes of these priorities are presented below.

2 VERIFYING AND CONDITIONING THE MSE FRAMEWORK CODE

2.1 VERIFICATION

Verification of the operating model is the process of confirming that the calculations are correct, and that the outcomes follow the appropriate fishery and population dynamics as intended. Many types of verification were done with the operating model including outputting results of specific calculations to confirm that they were correct, examining specific test cases to ensure that the model does what it is expected to do (e.g., return to equilibrium biomass in a projection without fishing), and comparing outputs of the OM to other similarly parameterized population models such as stock synthesis (SS; Methot and Wetzel 2013). Validating the OM against a model like SS is useful because SS has been tested and validated for many years and is currently used to conduct many stock assessments. The entire framework was also validated by examining known test cases and comparing simple simulations that were done as part of the coastwide MSE to similar simulations performed with this new framework.

The model calculations were verified by examining numbers-at-age, biomass, and other derived quantities given known inputs such as catch. Equilibrium conditions were also achieved with no fishing. The short coastwide assessment model was mimicked with the OM by first entering all of the appropriate parameters estimated in the assessment model, simulating through the same time-period, and then comparing outputs such as numbers-at-age, fishery selectivity, fishery mortality, and spawning biomass. Specific inputs to the OM (e.g., recruitment deviations) were tuned to account for different structure in the two models until the comparisons matched. Parameters with the same concept in the two models (e.g., natural mortality) were not changed unless there was a different interpretation between the two models.

The output quantities from the OM matched very closely to the outputs from the short coastwide assessment model using SS (Figure 2). Slight differences between the two models are due to minor differences in the assumptions of processes and the rounding of parameters input into the OM. The spawning biomass trajectories from the two models are a near-exact match suggesting that the calculations in the OM are valid, for at least these assumptions.

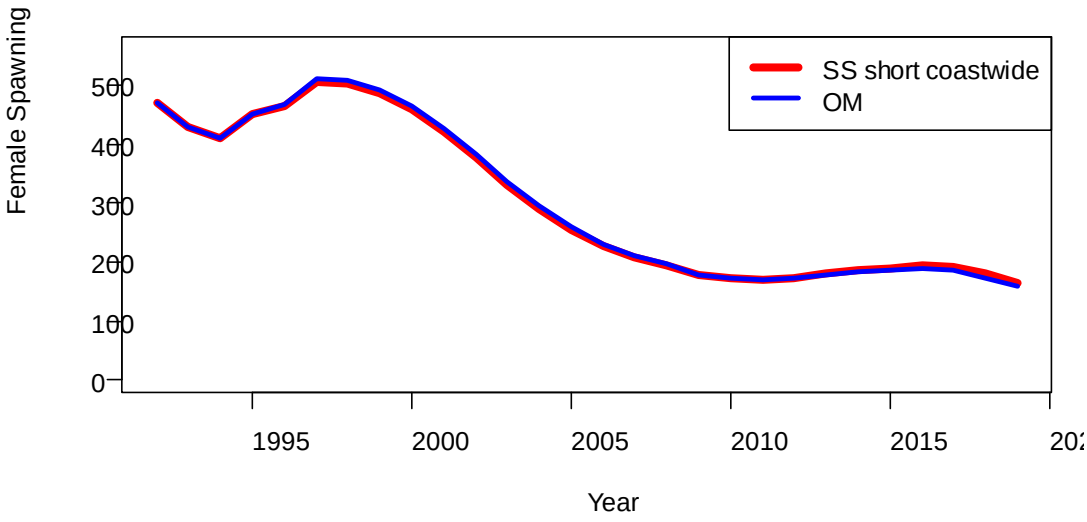

Figure 2: Predicted spawning biomass trajectories from the operating model (OM, blue) and the short coastwide assessment model using Stock Synthesis (SS, red).

2.2 CONDITIONING MULTI-AREA OPERATING MODELS

Multi-area OMs are still being conditioned at the time of writing this document. It is expected that these models will be presented at MSAB015.

The multi-area OMs are conditioned by comparing OM outputs to various outputs from the coastwide assessment ensemble and to regional data sources. Specifically, the coastwide predicted spawning biomass, regional survey trends, regional stock distribution, and survey and fishery age compositions are used in the conditioning process. The conditioning is currently done manually because an optimization routine has not yet been implemented in the OM.

2.3 CHARACTERIZING UNCERTAINTY

Uncertainty was characterized in two ways. First, for an individual operating model, input parameters were varied by randomly choosing a parameter from a reasonable range or identifying key values of specific parameters to include in an experimental design approach. More detail is given in IPHC-2020-MSAB015-08.

2.4 VERIFY THE FRAMEWORK

The framework is currently being verified in a number of ways, including repeating some of the simulations performed with the coastwide MSE framework. These results will be presented at MSAB015.

3 SIMULATION RESULTS

Simulation results were not complete at the time of publication and will be presented in future revisions of this document.

4 RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2020-MSAB015-09 which present preliminary results from the IPHC MSE simulations incorporating scale and distribution components of the management procedure.
2) **NOTE** that the validation of the OM and framework showed expected results and matched prior coastwide simulations closely.
3) **RECOMMEND** additional performance metrics and methods to present results for evaluation at MSAB016.

5 ADDITIONAL DOCUMENTATION / REFERENCES

IPHC-2019- MSAB014-09. 2019. IPHC Secretariat Program of Work for MSAB Related Activities 2019-23. 20 September 2019. 17 pp. https://iphc.int/uploads/pdf/msab/msab014/iphc-2019-msab014-09.pdf

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IPHC Secretariat Program of Work for MSAB Related Activities in 2020 and 2021–24

PREPARED BY: IPHC SECRETARIAT (A. HICKS, P. CARPI, & S. BERUKOFF; 8 APRIL 2020)

PURPOSE

To update the IPHC Program of Work for MSAB related activities for the periods 2020 and 2021–24.

1 INTRODUCTION

This Program of Work is a description of activities related to the Management Strategy Advisory Board (MSAB) that IPHC Secretariat staff will engage in for the next five years. It describes each of the priority tasks, lists some of the resources needed for each task, and provides a timeline for each task. However, this work plan is flexible and may be changed throughout this period with the guidance of the MSAB, Science Review Board (SRB) members, and Commission. This document focuses on the tasks for 2020 and references longer term tasks described in IPHC-2019-MSAB014-09.

It is important to have a set of working definitions, and this is especially true to the Management Strategy Evaluation (MSE) process since it involves many technical terms that may be interpreted or used differently by different people. A set of working definitions are provided in the IPHC Glossary of Terms and abbreviations: https://www.iphc.int/the-commission/glossary-of-terms-and-abbreviations

1.1 MANAGEMENT STRATEGY EVALUATION (MSE)

Management Strategy Evaluation (MSE) is a process to evaluate alternative management procedures and identify those that are robust to uncertainty and meet the defined objectives. This process, in general, involves the following:

1. defining fishery goals and objectives with the involvement of stakeholders and managers,
2. identifying management procedures to evaluate,
3. simulating a population with application of the management procedures,
4. evaluating and presenting the results in a way that examines trade-offs between objectives,
5. applying a chosen management procedure, and
6. repeating this process in the future to address changes in objectives, assumptions, and expectations.

Figure 1 shows these different components and that the process is not necessarily sequential but may iterate between components as learning progresses. The involvement of stakeholders and managers in every component of the process is extremely important to guide the MSE and evaluate the outcomes.

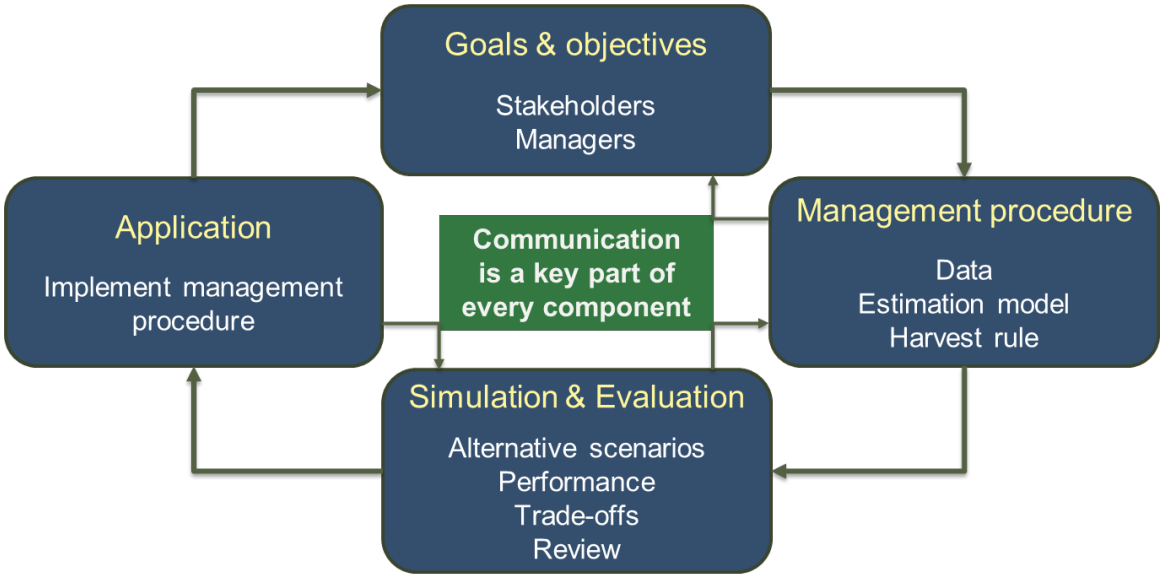

Figure 1: A depiction of the Management Strategy Evaluation (MSE) process showing the iterative nature of the process with the possibility of moving either direction between most components.

1.2 BACKGROUND

Many important tasks have been completed or started regarding the MSE for Pacific halibut (*Hippoglossus stenolepis*). Much of the work proposed will use past accomplishments to further the MSE process. The past accomplishments include the following:

1. Familiarization with the MSE process.
2. Defining conservation and fishery goals.
3. Defining objectives and performance metrics for those goals.
4. Developing coast-wide (single-area) and spatial (multiple-area) models.
5. Identifying management procedures for the coastwide fishing intensity and distributing the TCEY to IPHC Regulatory Areas.
6. Presentation of results investigating coastwide fishing intensity.

Management Strategy Evaluation is a process that can develop over many years with many iterations. It is also a process that needs monitoring and adjustments to make sure that management procedures are performing adequately. Therefore, the MSE work for Pacific halibut fisheries will be ongoing as new objectives are defined, more complex models are built, and results are updated. This time will include continued consultation with stakeholders and managers via the MSAB meetings, defining and refining goals and objectives, developing operating models, running simulations, and reporting results. Along the way, there will be useful outcomes that may be used to improve existing management and will influence recommendations for future work. Embracing this iterative process, the program of work identifies the tasks to continue to make progress on the investigation of management strategies.

2 MAIN TASKS FOR THE NEXT 5 YEARS

Task 1: Review, update, and further define goals and objectives

Task 2: Develop performance metrics to evaluate objectives

Task 3: Identify realistic management procedures of interest to evaluate

Task 4: Design and code a closed-loop simulation framework

Task 5: Further the development of operating models

Task 6: Run closed-loop simulations and evaluate results

Task 7: Develop tools that will engage stakeholders and facilitate communication

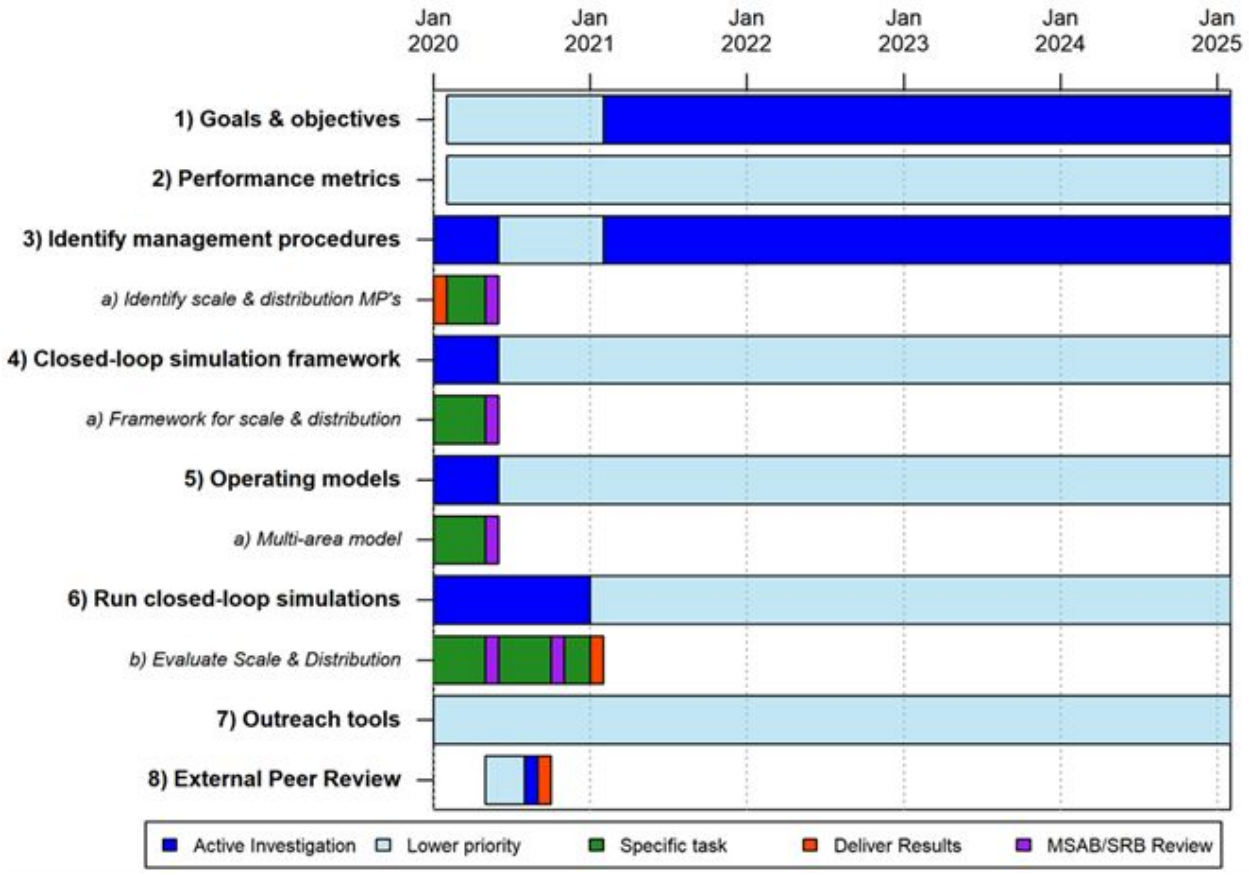

Figure 2: Gantt chart for the five-year work plan. Tasks are listed as rows. Dark blue indicates when the major portion of the main tasks work will be done. Light blue indicates when preliminary or continuing work on the main tasks will be done. Dark green indicates when the work on specific sub-topics will be done. Red areas show when results will be presented to the Commission. Purple areas show when the task will be reviewed by the MSAB and/or the SRB.

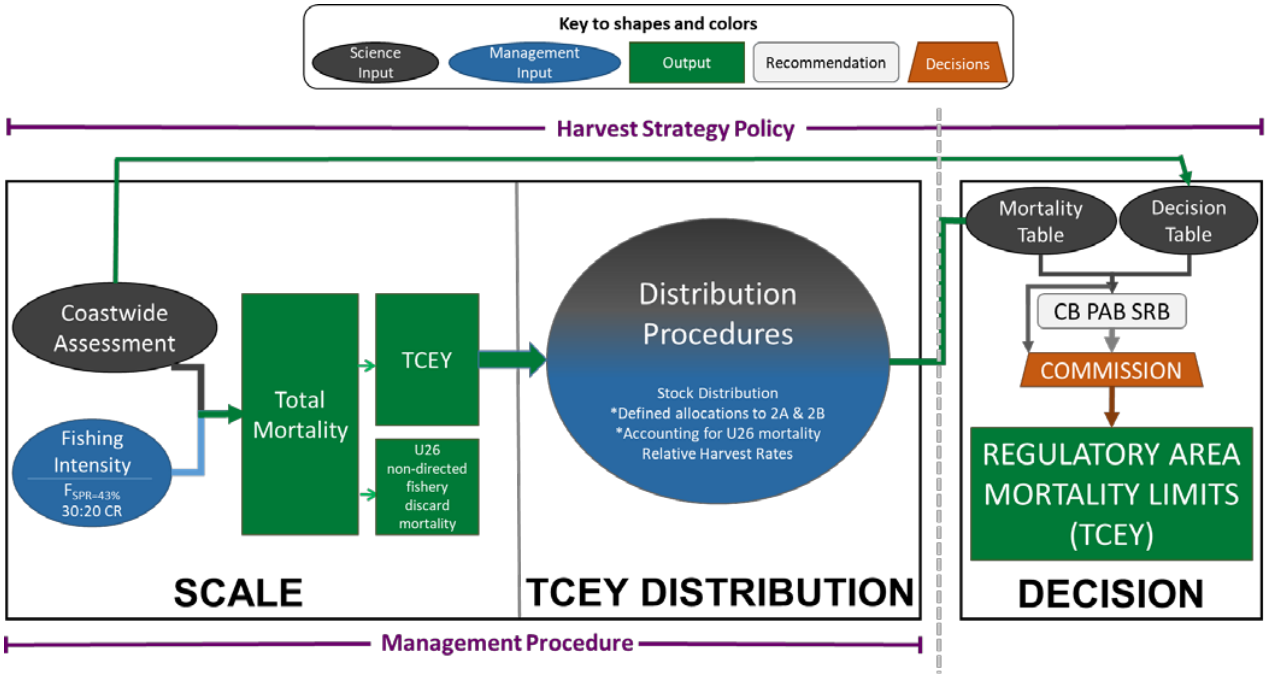

Figure 3: Illustration of the Commission interim IPHC harvest strategy policy (reflecting paragraph ID002 in IPHC CIRCULAR 2020-007) showing the coastwide scale and TCEY distribution components that comprise the management procedure. Items with an asterisk are three-year interim agreements to 2022. The decision component is the Commission decision-making procedure, which considers inputs from many sources.

3 PROGRAM OF WORK FOR 2020

The first full MSE results incorporating coastwide scale and distribution components of the management procedure (Figure 3) will be presented at the 97th IPHC Annual Meeting (AM097) in January 2021. Therefore, results of simulations incorporating various management procedures based on the framework shown in Figure 3 will be reviewed by the SRB and evaluated by the MSAB in 2020. There are three main tasks to accomplish in 2020: 1) identify management procedures incorporating coastwide and distribution components to simulate, 2) condition a multi-area operating model and prepare a framework for closed-loop simulations, and 3) present results in various ways in order to evaluate the management procedures. These three main tasks are described below and Table 1 identifies the tasks that will be undertaken at each MSAB and SRB meeting in 2020.

4 IDENTIFY REALISTIC MANAGEMENT PROCEDURES OF INTEREST TO EVALUATE

The coastwide MSE investigated management procedures related to the coastwide fishing intensity including the SPR associated with a fishing mortality rate (F_{SPR}), the trigger in a control rule determining at what level of relative spawning biomass the fishing intensity is linearly reduced, and various constraints that dampen the annual change in the TCEY. The results from

the coastwide MSE provided insight into options and a range of SPR values to further evaluate along with distribution procedures. These are listed in paragraph 49 of IPHC-2019-MSAB014-R.

> *49. The MSAB RECOMMENDED that SPR values of 0.3, 0.34, 0.38, 0.40, 0.42, 0.46, and 0.50 with a 30:20 control rule be evaluated at MSAB015 along with constraints defined by a maximum change in the TCEY of 15%, a slow-up fast-down approach, and/or setting quotas every third year.*

Table 1: Tasks to complete in 2020 at the two scheduled MSAB meetings.

May 2020 MSAB Meeting (MSAB015)
Review Goals and Objectives (Distribution & Scale)
Review simulation framework
Review multi-area model
Review preliminary results
Identify MPs (Distribution & Scale)
June 2020 SRB Meeting (SRB016)
Review simulation framework
Review multi-area model
Review preliminary results
September 2020 SRB Meeting (SRB017)
Review penultimate results
October 2020 MSAB Meeting (MSAB016)
Review final results
Provide recommendations on MPs for scale and distribution
Annual Meeting 2021
Presentation of first complete MSE product to the Commission Recommendations on Scale and Distribution MP

Various procedures related to distributing the TCEY were discussed at MSAB014 and listed in paragraphs 55, 57, and 58 of IPHC-2019-MSAB014-R.

> *55. The MSAB **REQUESTED** that a number of elements in distribution management procedures be included for evaluation at MSAB015:*
>
> a) *A coastwide constraint using a slow-up, fast-down approach with a maximum change in the TCEY of 15%;*
>
> b) *evaluating different relative harvest rates across IPHC Regulatory Areas or Biological Regions;*
>
> c) *distributing the TCEY directly to IPHC Regulatory Area;*
>
> d) *A fixed shares concept for all or some IPHC Regulatory Areas, Biological Regions, or Management Zones with options to distribute the TCEY to the areas without a fixed share. The determination of these shares may be fixed or varying over time; and*

e) *A maximum fishing intensity defined by an SPR of 36% to act as a buffer when distributing the TCEY to IPHC Regulatory Areas.*

57. *The MSAB **NOTED** additional elements for distribution procedures to consider as sensitivities when developing management procedures for evaluation at MSAB015 as follows:*

    a. *a constraint applied to the TCEY for each IPHC Regulatory Area using a slow-up, fast-down approach with a maximum change in the TCEY of 15%;*

    b. *using O32 estimates of stock distribution or "all sizes" estimates of stock distribution from the modelled survey results;*

    c. *evaluating different relative harvest rates across IPHC Regulatory Areas or Biological Regions (e.g. harvest rates for Biological Region 2, IPHC Regulatory Areas 2A and/or 4CDE);*

    d. *calculating shares across Biological Regions, Management Zones, or IPHC Regulatory Areas using approaches that blend multiple sources of information (e.g., using historical TCEYs and stock distribution results for all IPHC Regulatory Area, a 5-year window of estimated stock distribution, etc.);*

    e. *the importance the order of applying elements in the distribution procedure when limiting the maximum SPR (i.e. using a buffer).*

58. *The MSAB **NOTED** additional elements for distribution procedures to consider when developing management procedures for evaluation at MSAB016 as follows:*

    a. *a constraint applied to the TCEY for each IPHC Regulatory Area using a slow-up, fast-down approach;*

    b. *a constraint applied to the TCEY for each IPHC Regulatory Area implementing a maximum change in the TCEY of 15%;*

    c. *a maximum fishing intensity defined by an SPR of 40% to act as a buffer when distributing the TCEY to IPHC Regulatory Areas;*

    d. *adjusting relative harvest rates to reflect current stock productivity (note that this will be explored before MSAB015);*

    e. *using trends in fishery CPUE to adjust allocation percentages by IPHC Regulatory Area (note that this will be explored before MSAB015);*

    f. *additional approaches to first distribute the TCEY to Biological Region or Management Zone.*

There are many combinations of elements and it would be nearly impossible to simulate and evaluate all possible combinations. Therefore, seventeen specific procedures for distributing the TCEY to IPHC Regulatory Areas were identified in Table 1 of Appendix VI in IPHC-2019-MSAB014-R. These management procedures form the basis of the management procedures that will be simulated and evaluated in 2020.

The outcome of MSAB015 will be a list of specific management procedures to evaluate at MSAB016.

5 RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2020-MSAB015-10 which describes the IPHC Program of Work for MSAB related activities for the periods 2020 and 2021–2024.
2) **NOTE** the delivery date of January 2021 (97th Annual Meeting) for the first complete MSE results including Scale and Distribution components of the management procedure for potential adoption by the Commission and subsequent implementation.
3) **RECOMMEND** additions or deletions to this Program of Work, or changes to the timeline, priorities, and deliverables.
4) **RECOMMEND** management procedures with coastwide scale and distribution elements to simulate in 2020 and evaluate at MSAB016.

6 ADDITIONAL DOCUMENTATION / REFERENCES

IPHC-2019- MSAB014-09. 2019. IPHC Secretariat Program of Work for MSAB Related Activities 2019-23. 20 September 2019. 17 pp. https://iphc.int/uploads/pdf/msab/msab014/iphc-2019-msab014-09.pdf

IPHC-2019-MSAB014-R. Report of the 14th Session of the IPHC Management Strategy Advisory Board (MSAB014). Seattle, WA, U.S.A. 21–24 October 2019. 27 pp. https://iphc.int/uploads/pdf/msab/msab014/iphc-2019-msab014-r.pdf