INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC Management Strategy Advisory Board (MSAB011) – A Collection of Published Meeting Documents

07-10 May 2018, Seattle, WA

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INTERNATIONAL PACIFIC HALIBUT COMMISSION

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DRAFT: AGENDA & SCHEDULE FOR THE 11TH SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB011)

Date: 07-10 May 2018
Location: Seattle, Washington, U.S.A.
Venue: IPHC Training Room
Time: 7th: 12:00-17:00; 8th-10th: 09:00-17:00 daily
Co-Chairpersons: Mr Adam Keizer (Canada) and Vacant (U.S.A.)

1. OPENING OF THE SESSION

2. ADOPTION OF THE AGENGA AND ARRANGEMENTS FOR THE SESSION
- 2.1. IPHC website and Office 365

3. IPHC PROCESS
- 3.1. MSAB Membership and Officers
- 3.2. Update on the actions arising from the 10th Session of the MSAB (MSAB010)
- 3.3. Review of the outcomes of the 11th Session of the Scientific Review Board (SRB011)
- 3.4. Outcomes of the 94th Session of the IPHC Annual Meeting (AM094)

4. GOALS, OBJECTIVES, AND PERFORMANCE METRICS
- 4.1. A review of the goals and objectives of the IPHC MSE process
- 4.2. Classifying objectives in a hierarchy
- 4.3. Performance metrics for evaluation
  - 4.3.1. Short-term, mid-term, and long-term performance metrics

5. HARVEST STRATEGY POLICY, PART 1: SIMULATIONS TO EVALUATE FISHING INTENSITY
- 5.1. A description of the closed-loop simulation framework
- 5.2. A review of variability and scenarios
- 5.3. Management procedures related to fishing intensity
- 5.4. Preliminary closed-loop simulations results to investigate SPR with estimation error
- 5.5. Simulation design for evaluations at MSAB012 of the Scale component of the harvest strategy policy

6. HARVEST STRATEGY POLICY, PART 2: ADDRESSING STOCK AND TOTAL CONSTANT EXPLOITATION YIELD (TCEY) DISTRIBUTION
- 6.1. Review framework to investigate distributing the TCEY among IPHC Regulatory Areas and evaluate against objectives
- 6.2. Identify preliminary MPs related to distribution

7. MSAB PROGRAM OF WORK 2019-23

8. OTHER BUSINESS

8.1. IPHC meetings calendar (2019-23): MSAB

9. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 11th SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB011)

DRAFT: SCHEDULE FOR THE 11TH SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB011)

Monday, 07 May 2018		
Time	**Agenda item**	**Lead**
12:00–12:30	Arrival: light lunch provided	
12:30–12:40	1. Opening of the Session	Co-Chairpersons
12:40–12:45	2. Adoption of the agenda and arrangements for the Session	Co-Chairpersons
12:45–12:55	3.1. MSAB Membership and Officers	D. Wilson
12:55–13:15	3.2. Update on the actions arising from the 10th Session of the MSAB (MSAB010)	A. Hicks
13:15–13:30	3.3. Review of the outcomes of the 11th Session of the Scientific Review Board (SRB011)	D. Wilson
13:30–14:00	3.4. Outcomes of the 94th Session of the IPHC Annual Meeting (AM094)	D. Wilson, A. Hicks
14:00–15:00	4.1. A review of the goals and objectives of the IPHC MSE process	A. Hicks
15:00–15:30	Break	
15:30–16:00	4.1. A review of the goals and objectives of the IPHC MSE process (continued)	A. Hicks
16:00–16:30	4.2. Classifying objectives in a hierarchy	A. Hicks
16:30–17:00	Unfinished business and review of the day	Co-Chairpersons
Tuesday, 08 May 2018		
09:00–09:30	Recap of previous day	Co-Chairpersons
09:30–10:30	4.3. Performance metrics for evaluation 4.3.1. Short-term, mid-term, and long-term performance metrics	A. Hicks
10:30–11:00	Break	
11:00–12:00	5.1. A description of the closed-loop simulation framework	A. Hicks
12:00–13:00	Lunch	
13:00–14:00	5.2. A review of variability and scenarios	A. Hicks
14:00–14:30	5.3. Management procedures related to fishing intensity	A. Hicks
14:30–15:00	5.4. Preliminary closed-loop simulations results to investigate SPR with estimation error	A. Hicks
15:00–15:30	Break	
15:30–16:30	5.4. Preliminary closed-loop simulations results to investigate SPR with estimation error (cont)	A. Hicks
16:30–17:00	Unfinished business and review of the day	Co-Chairpersons

Wednesday, 09 May 2018		
09:00–09:30	Recap from previous day	Co-Chairpersons
09:30–10:30	5.5. Simulation design for evaluations at MSAB012 of the Scale component of the harvest strategy policy	A. Hicks
10:30–11:00	Break	
11:00–12:00	6.1. Review framework to investigate distributing the TCEY among IPHC Regulatory Areas and evaluate against objectives	A. Hicks
12:00–13:00	Lunch	
13:00–13:30	6.1. Review framework to investigate distributing the TCEY among IPHC Regulatory Areas and evaluate against objectives	A. Hicks
13:30-15:00	6.2. Identify preliminary MPs related to distribution	A. Hicks
15:00–15:30	Break	
15:30–16:00	Unfinished business and review of the day	Co-Chairpersons
16:00–17:00	Report drafting session	Steering Committee
Thursday, 10 May 2018		
09:00–09:30	Recap from previous day	
09:30–10:15	7. MSAB PROGRAM OF WORK 2019-23	Co-Chairpersons
10:15–10:30	8. OTHER BUSINESS 8.1. IPHC meetings calendar (2019-23): MSAB	A. Hicks
10:30–10:45	Break	
10:45–12:00	IPHC Secretariat drafting Session	IPHC Secretariat
12:00–13:00	Lunch	
13:00–17:00	9. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 11th SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB011)	Co-Chairpersons & D. Wilson

LIST OF DOCUMENTS FOR THE 11th SESSION OF THE IPHC MANAGEMENT STRATEGY ADVISORY BOARD (MSAB011)

Last updated: 1 May 2018

Document	Title	Availability
IPHC-2018-MSAB011-01	Agenda & Schedule for the 11th Session of the IPHC Management Strategy Advisory Board (MSAB011)	✓ 06 Feb 2018 ✓ 22 Mar 2018 ✓ 19 Apr 2018
IPHC-2018-MSAB011-02	List of Documents for the 11th Session of the IPHC Management Strategy Advisory Board (MSAB011)	✓ 03 Apr 2018 ✓ 19 Apr 2018
IPHC-2018-MSAB011-03	MSAB Membership and Officers (IPHC Secretariat)	✓ 04 Apr 2018
IPHC-2018-MSAB011-04	Update on the actions arising from the 10th Session of the MSAB (MSAB010) (IPHC Secretariat)	✓ 07 Apr 2018
IPHC-2018-MSAB011-05	Outcomes of the 11th Session of the IPHC Scientific Review Board (SRB011) (IPHC Secretariat)	✓ 05 Apr 2018
IPHC-2018-MSAB011-06	Outcomes of the 94th Session of the IPHC Annual Meeting (AM094) (IPHC Secretariat)	✓ 05 Apr 2018
IPHC-2018-MSAB011-07	Goals, Objectives, and Performance Metrics for the IPHC Management Strategy Evaluation (MSE) (A. Hicks)	✓ 09 Apr 2018
IPHC-2018-MSAB011-08	IPHC Management Strategy Evaluation to Investigate Fishing Intensity (A. Hicks)	✓ 10 Apr 2018
IPHC-2018-MSAB011-09	Ideas on estimating stock distribution and distributing catch for Pacific halibut fisheries (A. Hicks & I. Stewart)	✓ 19 Apr 2018
IPHC-2018-MSAB011-10	IPHC Secretariat Program of Work for MSAB Related Activities 2019-23 (A. Hicks)	✓ 07 Apr 2018
Information papers		
Nil	Nil	Nil

MSAB MEMBERSHIP AND OFFICERS

PREPARED BY: IPHC SECRETARIAT (S. KEITH; 4 APRIL 2018)

PURPOSE

To provide the MSAB with the updated membership roster and list of officers for 2018.

BACKGROUND

Rule 4 of Appendix V [Management Strategy Advisory Board (MSAB) – Terms of Reference and Rules of Procedure] of the IPHC Rules of Procedure (2017), 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…*"

The Commission noted the current MSAB membership as listed in Appendix A on 21 March 2017. This was reflected in paper MSAB IPHC-2017-MSAB09-06 "2017 MSAB Membership."

At the 9th Session of the MSAB (MSAB009), Mr. Adam Keizer of Canada and Ms. Rachel Baker of the USA were elected as Co-Chairpersons for the next biennium.

DISCUSSION

Since MSAB009, four members of the MSAB have resigned:

- Dr. Robyn Forrest (Canadian Science Advisor);
- Mr. John Woodruff (US Processing);
- Ms. Rachel Baker (NOAA-Fisheries [NMFS]); and
- Mr. Scott Meyer (Alaska Department of Fish and Game [ADFG]).

Dr. Forrest was replaced as Canadian Science Advisor by Dr. Allen (Rob) Kronlund in June 2017.

The three other vacancies remain unfilled.

NOAA-Fisheries has nominated Mr. Glenn Merrill to replace Ms. Baker as a government representative.

It is anticipated that ADFG will nominate a candidate to replace Mr. Meyer prior to the commencement of the MSAB011.

Ms. Baker's resignation also leaves vacant one of the MSAB's two Co-Chairperson positions.

In an email dated 8 March 2018, the Executive Director notified the MSAB membership of this vacancy and called for nominations for a new Co-Chairperson from the USA, in accordance with Appendix V, Section III, paragraph 5, of the IPHC Rules of Procedure (2017).

RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2018-MSAB011-03 which details current MSAB membership and officers.
2) **ELECT** a new Co-Chairperson from the USA from among its membership for the next biennium.
3) **CONSIDER** nominations to fill vacancies on the MSAB.

APPENDICES

Appendix A: MSAB Membership as of 04 April 2018

APPENDIX A
MSAB Membership as of 04 April 2018

Membership category	Member	Canada	U.S.A.	Current Term commence-ment	Current Term expiration *
Harvesters (6-8)					
1	Gabrys, Bruce		US Commercial	9-May-17	2021
2	Kauffman, Jeff		US Commercial	9-May-17	2019
3	Odegaard, Per		US Commercial	9-May-17	2021
4	Falvey, Dan		US Commercial	9-May-17	2021
5	Sporer, Chris	CDN Commercial		9-May-17	2021
6	Hauknes, Robert	CDN Commercial		9-May-17	2021
7	Vacant				
8	Vacant				
First Nations/Tribal fisheries (2-4)					
1	Lane, Jim	CDN First Nations		9-May-17	2021
2	Mazzone, Scott		US Treaty Tribes	9-May-17	2019
3	Vacant				
4	Vacant				
Government Agencies (4-8)					
1	Keizer, Adam	DFO		9-May-17	2019
2	Vacant		NOAA-Fisheries		
3	Kronlund, Rob	CDN Science Advisor		10-Jun-17	2021
4	McGilliard, Carey		US Science Advisor	9-May-17	2021
5	Culver, Michele		PFMC	9-May-17	2021
6	Cross, Craig		NPFMC	9-May-17	2021
7	Vacant		ADFG		
8	Vacant				
Processors (2-4)					
1	Parker, Peggy	US/CDN Processing	US/CDN Processing	9-May-17	2019
2	Vacant		US Processing		
3	Mirau, Brad	CDN Processing		9-May-17	2019
4	Vacant				

Membership category	Member	Canada	U.S.A.	Current Term commence-ment	Current Term expiration *
Recreational/Sport fisheries (2-4)					
1	Marking, Tom		US Sportfishing (CA)	9-May-17	2019
2	Paish, Martin	CDN Sport Fishing Advisory Board		9-May-17	2021
3	Vacant				
4	Vacant				

* MSAB member terms begin and end at the first MSAB meeting of the year

Update on actions arising from the 10th Session of the IPHC Management Strategy Advisory Board (MSAB010)

PREPARED BY: IPHC SECRETARIAT (07 APRIL 2018)

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 10th Session of the IPHC Management Strategy Advisory Board (MSAB010).

BACKGROUND

At the 10th Session of the IPHC Management Strategy Advisory Board (MSAB010), 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 in 2017, as well as including clear progress updates and document reference numbers.

RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2018-MSAB011-04, 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 10th Session of the IPHC Management Strategy Advisory Board (MSAB010).
2) **AGREE** to consider and revise as necessary, the actions arising from the MSAB010, and for these to be combined with any new actions arising from the MSAB011.

APPENDICES

Appendix A: Update on actions arising from the 10th Session of the IPHC Management Strategy Advisory Board (MSAB010)

APPENDIX A

Update on actions arising from the 10th Session of the IPHC Management Strategy Advisory Board (MSAB010)

Action No.	Description	Update
MSAB010–Rec.01 (para. 11)	**A review of the goals and objectives of the IPHC MSE process** The MSAB **AGREED** to further revise the goals, objectives, and performance metrics, as detailed at Appendix IV, at MSAB11, and also **RECOMMENDED** that the Commission review and provide guidance on them at the 94th Session of the Commission, thereby providing clear direction for the IPHC Secretariat and MSAB for action in 2018.	Completed: The Commission reviewed goals, objectives, and performance metrics at the 93rd Interim Meeting (IM093) (see report IPHC-2017-IM093-R) and followed up with Circular 2017-CR-022, which was forwarded to the Commission and the MSAB in order to solicit input from stakeholders prior to the AM094. The Commission reviewed these inputs at the AM094 (see paper IPHC-2018-MSAB011-06) and the Commission's guidance from AM094 has been incorporated into the materials prepared for the MSAB011.
MSAB010–Rec.02 (para. 32)	***Discussion of the performance metrics reported*** The MSAB **RECOMMENDED** that future iterations of the simulations focus on the reduced range of SPR targets (greater than 40%, less than 55%) based on preliminary interpretation of results, and that 2% intervals between SPR values is sufficient to interpret future results.	Completed: The recommended a range of SPR targets has been incorporated into the simulation analysis, and takes into account the Commission recommendation in paragraph 31 from IPHC-2018-AM094-R to expand the lower range of SPR values.
MSAB010–Rec.03 (para. 41)	**MSAB Program of Work 2018-22** The MSAB **RECOMMENDED** the updated Program of Work provided at Appendix VI, for the Commission's further consideration.	Completed: The Commission considered the proposed MSAB Program of Work at its 94th Annual Meeting (AM094), and made a number of additional recommendations, as detailed in Section 7.2 and 7.3 of the AM094 Report.
REQUESTS		
MSAB010–Req.01 (para. 15)	**Performance metrics for evaluation** The MSAB **REQUESTED** that the IPHC Secretariat link the goals and objectives to each reported performance metric and provide a summary of key performance metrics over the range of Management Procedures evaluated for presentation to the Commission at the 93rd Interim Meeting and the 94th Annual Meeting.	Completed: Papers IPHC-2017-IM093-10 and IPHC-2018-AM094-12 presented this information as requested by the MSAB to the Commission at the IM093 and the AM094.

Action No.	Description	Update
MSAB010–Req.02 (para. 21)	**Simulations to evaluate fishing intensity: A review of variability and scenarios** **NOTING** the current simulated bycatch mortality probability distribution is unrelated to the total mortality in the operating model, the MSAB **REQUESTED** the IPHC Secretariat to consider alternative methods to simulate bycatch mortality at various Pacific halibut abundances.	In Progress: Bycatch mortality is treated as a scenario in simulations using the operating model, using a range of mortality levels at various Pacific halibut abundances. Alternative methods will be discussed at MSAB011 and incorporated into the future simulations.
MSAB010–Req.03 (para. 22)	The MSAB **AGREED** that additions to the simulation framework are required. These include adding variability to the simulated selectivities for all sectors (e.g. changes in selectivity of bycatch due to future management changes), incorporating time-varying maturity-at-age, improvements to simulating weight-at-age, using an estimation model to introduce estimation error (and data generation with error if necessary), and incorporate implementation variability in the simulations. The MSAB **REQUESTED** that these modifications be added to the simulation framework and assumptions.	In Progress: The simulation framework and any additions needed to evaluation of fishing intensity will be discussed at MSAB011 and incorporated into the future simulations.
MSAB010–Req.04 (para. 29)	**Closed-loop simulations results** **CONSIDERING** the need to determine appropriate methods for producing and reporting short-term, medium-term, and long-term results, the MSAB **REQUESTED** the IPHC Secretariat to review literature of past MSEs with regard to principles to help define appropriate time periods, consider the development of informative methods, and communicate any concerns at the MSAB11 meeting.	In Progress: A review will be presented at MSAB011, followed by discussion for further input from MSAB members.
MSAB010–Req.05 (para. 30)	The MSAB **AGREED** that recent realized SPRs are within the range of target SPRs described in para. 24, and **REQUESTED** that the management procedures described in MSAB09-R should continue to be evaluated under the revised simulation framework.	Completed: The management procedures described in MSAB09-R continue to be evaluated in the simulation framework.
MSAB010–Req.06 (para. 31)	**CONSIDERING** the effect that operational control points (OCPs) have on the conservation, yield, and stability objectives, the MSAB **REQUESTED** that in addition to 30:20 and 40:20, additional OCPs should be evaluated as determined at subsequent meetings.	Completed: The simulation framework can accommodate testing additional OCPs specified at MSAB011.

Action No.	Description	Update
MSAB010–Req.07 (para. 43)	**IPHC meetings calendar (2018-20): MSAB** The MSAB **AGREED** that MSAB11 should take place 7-10 May 2018, and the MSAB12 take place 22-25 October 2018, and **REQUESTED** that the IPHC Secretariat include these dates in the IPHC meetings calendar for the Commissions consideration.	Completed: The Commission considered the consolidated dates for the IPHC bodies, and agreed to a modified meeting calendar as provided at: https://iphc.int/meetings/calendar/

INTERNATIONAL PACIFIC HALIBUT COMMISSION

OUTCOMES OF THE 11TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB011)

PREPARED BY: IPHC SECRETARIAT (05 APRIL 2018)

PURPOSE

To provide the MSAB with the outcomes of the 11th Session of the IPHC Scientific Review Board (SRB) relevant to the mandate of the MSAB.

BACKGROUND

The agenda of the 11th Session of the IPHC Scientific Review Board (SRB) included an agenda item dedicated to Management Strategy Evaluation (MSE).

DISCUSSION

During the course of the 11th Session of the IPHC Scientific Review Board (SRB011), 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-2018-MSAB011-05 which details the outcomes of the 11th Session of the IPHC Scientific Review Board (SRB) relevant to the mandate of the MSAB.

APPENDICES

Appendix A: Excerpt from the 11th Session of the IPHC Scientific Review Board (SRB) Report (IPHC-2017-SRB011-R).

APPENDIX A
Excerpt from the 11th Session of the IPHC Scientific Review Board (SRB) Report (IPHC-2017-SRB011-R)

7. MANAGEMENT STRATEGY EVALUATION: UPDATE

22. The SRB **NOTED** paper IPHC-2017-SRB11-08 that provided an update on the progress of the IPHC Management Strategy Evaluation process and seek recommendations from the SRB related to the Management Strategy Evaluation.

7.1 A description of the closed-loop simulations

23. The SRB **NOTED** the substantial progress in developing a very powerful simulation tool for evaluating robustness of alternative harvest policies. For example, the current simulation modeling framework could examine the expected long-term consequences of the current harvest policy.
24. The SRB **NOTED** that the current simulation framework is not yet adequate for evaluating short-term and medium-term outcomes because it assumes perfect knowledge about stock size and parameters in all future years. The SRB looks forward to SRB12 where we *expect* to see the implications of uncertainty in annual assessments and parameters.
25. The SRB **RECOMMENDED** that the IPHC Secretariat and Management Strategy Advisory Board collaborate to:
    a) further clarify and improve the presentation of the Harvest Strategy Policy (Appendix IV). This would improve not only transparency of the existing interim harvest policy, but also of the MSE process for evaluating alternatives.
    b) Review harvest policies from other bodies to develop an objectives hierarchy that explicitly prioritizes long-term conservation over short-/medium-term (e.g., 3-8 years) catch performance.
26. The SRB **NOTED** that the simulation model for projecting future changes in weight-at-age and regime shifts was presented in the type of detail that had previously been requested by the SRB; that is, with some specific equations and distributional assumptions so that the SRB could evaluate the model input, output, and parameterization, as well as alternative formulations.
27. The SRB **REQUESTED** that a quasi-extinction threshold be established so that:
    a) simulation replicates can be flagged when projected spawning biomass drops below this threshold;
    b) parameter sets causing quasi-extinction in the historical period can be dropped from the operating model initialization.
28. The SRB **REQUESTED** that the MSE simulation initialize the operating model biomass in the current year from the more precise Ensemble distribution of the current state (e.g., 2017) rather than the wider distribution obtained from the Operating model.
29. The SRB **RECOMMENDED** that the IPHC Secretariat hire a modeler/programmer to support MSE work so that timely feedback can be given the MSAB in the MSE process.

7.2 Simulation results and presenting results to the IPHC Management Strategy Advisory Board (MSAB)

See paragraphs 23 and 24.

OUTCOMES OF THE 94TH SESSION OF THE IPHC ANNUAL MEETING (AM094)

PREPARED BY: IPHC SECRETARIAT (05 APRIL 2018)

PURPOSE

To provide the MSAB with the outcomes of the 94th Session of the IPHC Annual Meeting (AM094) relevant to the mandate of the MSAB.

BACKGROUND

The agenda of the Commission's Annual Meeting (AM094) included an agenda item (Section 7) dedicated to Management Strategy Evaluation (MSE).

DISCUSSION

During the course of the 94th Session of the IPHC Annual Meeting (AM094) 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-2018-MSAB011-06 which details the outcomes of the 94th Session of the IPHC Annual Meeting (AM094) relevant to the mandate of the MSAB.

APPENDICES

Appendix A: Excerpt from the 94th Session of the IPHC Annual Meeting (AM094) Report (IPHC-2018-AM094-R).

APPENDIX A
Excerpt from the 94th Session of the IPHC Annual Meeting (AM094) Report (IPHC-2018-AM094-R).

Recommendations and Requests
RECOMMENDATIONS

Review of fishery goals and objectives: Commission directive

AM094–Rec.01 (para. 36) The Commission **RECOMMENDED** that the draft goals, objectives, and performance metrics, as detailed in Appendix IV, IPHC-2017-MSAB10-R be used for ongoing evaluation in the MSE process, and that they may be refined in the future. The objectives should be evaluated in a hierarchal manner, with conservation as the first priority.

AM094–Rec.02 (para. 39) The Commission **RECOMMENDED** that the IPHC Secretariat consider the setline survey WPUE grid across the fishery as well as other biological factors (e.g. habitat configuration, size distribution in the region etc.) and provide alternatives to the current management areas (e.g. biological regions), and that the MSAB consider additional ways to incorporate biological information into TCEY distribution procedures.

AM094–Rec.03 (para. 44) The Commission **RECOMMENDED** that long- and mid-term performance metrics for conservation objectives be considered in the MSE process for conservation objectives, and that short-term metrics be included for fishery-related objectives in the MSE process, via the MSAB.

REQUESTS

Reports of the 10th Session of the IPHC Management Strategy Advisory Board (MSAB10)

AM094–Req.01 (para. 31) The Commission **REQUESTED** that the MSAB look at SPR values consistent with recent estimated SPR values from the assessment model and lower. This would mean expanding the lower range of SPR values to below 40%.

Review of fishery goals and objectives: Commission directive

AM094–Req.02 (para. 37) The Commission **REQUESTED** that the objectives related to distributing the TCEY, as detailed in Circular IPHC-2017-CR022, be presented at MSAB11 for further stakeholder feedback.

AM094–Req.03 (para. 38) The Commission **REQUESTED** that the proposed TCEY distribution methodology of the Harvest Strategy Policy reflect an understanding of both stock distribution and fishery management distribution procedures.

Supporting report text

7. MANAGEMENT STRATEGY EVALUATION

7.1 IPHC Management Strategy Evaluation: update

27. The Commission **NOTED** paper IPHC-2018-AM094-12 which provided an update on the progress of the IPHC Management Strategy Evaluation process and seeks recommendations for future work, including a review of goals and objectives defined by the MSAB, an overview of the simulation framework to evaluate the fishing intensity and harvest control rules in the IPHC harvest strategy policy, results from the closed-loop simulations, ideas for distributing the TCEY to Regulatory Areas, and a five-year work plan.

28. The Commission **CONSIDERED** the following items:

    a) The simulation framework and assumptions as described, including introducing variability to the Operating Model, simulating weight-at-age and an environmental regime, and allocation of the Total Mortality to sectors;

    b) The long-term results looking at the outcomes of various management procedures and the trade-offs among them;

    c) Management procedures (e.g. values of SPR in combination with a control rule threshold) that would meet the goal and objectives important to the Commission, based on the results shown, and additional procedures that may be of interest to evaluate in 2018;

    d) Whether the clear separation of stock distribution (a scientific product), and distribution procedures (management decision) satisfies the Commission's recommendation to replace apportionment with a more suitable term; and

    e) The concept of distributing the TCEY to biological regions defined here as a method to satisfy the Commission's request to "initiate a process to develop alternative, biologically based stock distribution strategies."

7.2 Reports of the 10th Session of the IPHC Management Strategy Advisory Board (MSAB10)

29. The Commission **NOTED** the Report of the 10th Session of the IPHC Management Strategy Advisory Board (MSAB10) (IPHC-2017-MSAB10-R) which was presented by Mr Adam Keizer (Canada). The MSAB consists of 20 board members, 19 of which attended the Session from the two (2) Contracting Parties. A total of five (5) individuals attended the Session as Observers. In addition, two (2) IPHC Commissioners were in attendance, Mr Paul Ryall (Canada) and Mr Bob Alverson (U.S.A.).

30. The Commission **AGREED** to the updated Program of Work provided at Appendix VI of IPHC-2017-MSAB10-R.

31. The Commission **REQUESTED** that the MSAB look at SPR values consistent with recent estimated SPR values from the assessment model and lower. This would mean expanding the lower range of SPR values to below 40%.

7.3 Review of fishery goals and objectives: Commission directive

32. The Commission **NOTED** the current fishery goals, objectives, and performance metrics identified by the MSAB for the MSE process, as detailed in Appendix IV of the MSAB10 report (IPHC-2017-MSAB10-R).

33. The Commission **NOTED** the summary presentation which was in response to Circular IPHC-2017-CR022 requesting stakeholder feedback on objectives proposed by a USA Commissioner related to distributing the TCEY presented at IM093. These objectives were categorized under the overarching goals defined by the MSAB for AM094.

34. The Commission **NOTED** the other concepts proposed by a USA Commissioner related to distributing the TCEY were not stated as measurable objectives but may be useful when developing management procedures to evaluate.

35. The Commission **NOTED** that:

    a) the Commission objectives related to distributing the TCEY may be presented at MSAB11 for further stakeholder feedback.

    b) the intent of the "other Commission concepts" could be further clarified and incorporated into the MSAB process, and can be converted to measurable objectives.

    c) the MSAB may develop measurable outcomes and performance metrics associated with these Commission objectives.

36. The Commission **RECOMMENDED** that the draft goals, objectives, and performance metrics, as detailed in Appendix IV, IPHC-2017-MSAB10-R be used for ongoing evaluation in the MSE process, and that they

may be refined in the future. The objectives should be evaluated in a hierarchal manner, with conservation as the first priority.

37. The Commission **REQUESTED** that the objectives related to distributing the TCEY, as detailed in Circular IPHC-2017-CR022, be presented at MSAB11 for further stakeholder feedback.
38. The Commission **REQUESTED** that the proposed TCEY distribution methodology of the Harvest Strategy Policy reflect an understanding of both stock distribution and fishery management distribution procedures.
39. The Commission **RECOMMENDED** that the IPHC Secretariat consider the survey WPUE grid across the fishery as well as other biological factors (e.g. habitat configuration, size distribution in the region etc.) and provide alternatives to the current management areas (e.g. biological regions), and that the MSAB consider additional ways to incorporate biological information into TCEY distribution procedures.
40. The Commission **NOTED** that the current procedure to distribute the TCEY could be replaced by an interim procedure to be developed in the near term while the MSAB completes their Program of Work to deliver guidance in 2021 on scale and TCEY distribution.
41. The Commission **AGREED** to meet via an inter-sessional electronic meeting (soon after the AM094), along with the IPHC Secretariat, to discuss TCEY distribution procedures to use in the interim while long-term distribution procedures are being developed by the MSAB. MSAB representatives and the IPHC Secretariat will inform the Commission of what guidance the MSAB may be able to provide to help develop an interim distribution strategy, and how the development of an interim harvest procedure may affect the MSAB's current Program of Work.
42. The Commission **AGREED** that distributing the TCEY to regions does not necessarily need to be the first step of the TCEY distribution procedure, and other biological factors, such as habitat and size distribution, be considered.
43. The Commission **NOTED** that the work the MSAB has already completed on distribution procedures may help to inform the development of an interim distribution strategy. MSAB representatives and the IPHC Secretariat will advise the Commission of how this may affect their current Program of Work, and what guidance they may be able to provide to help develop an interim distribution strategy.
44. The Commission **RECOMMENDED** that long- and mid-term performance metrics for conservation objectives be considered in the MSE process for conservation objectives, and that short-term metrics be included for fishery-related objectives in the MSE process, via the MSAB.

Goals, Objectives, and Performance Metrics for the IPHC Management Strategy Evaluation (MSE)

PREPARED BY: IPHC SECRETARIAT (A. HICKS AND I. STEWART), 09 APRIL 2018

PURPOSE

To review the Management Strategy Advisory Board (MSAB) goals and objectives; add new, remove outdated, or update goals and objectives as necessary. Consider the directives from the Commission, including the consideration of additional objectives related to distributing the TCEY. Link goals and objectives with performance metrics, and define a set of performance metrics to use for evaluation.

BACKGROUND

Defining goals and objectives is a necessary part of a management strategy evaluation (MSE) which should be revisited often to make sure that they are inclusive and relevant. The MSAB has developed five goals with multiple objectives for each (Table 1 and Tables A1–A5 in Appendix A). Performance metrics have also been developed from the goals and objectives by defining a measurable outcome, a probability (i.e., level of risk), and time-frame over which it is desired to achieve that outcome.

GOALS AND OBJECTIVES

The five goals defined by the MSAB are:

- biological sustainability,
- fishery sustainability, access, and stability,
- minimize discard mortality,
- minimize bycatch and bycatch mortality, and
- serve consumer needs.

PRESERVING BIOCOMPLEXITY

An additional goal, preserve biocomplexity, was considered at MSAB009, but no measurable objectives were associated with it. Measurable objectives may need to be based on abundances in specific areas, which would require a multi-area model. However, it is unclear whether preserve biocomplexity should be listed as a goal on its own, or as an objective under biological sustainability. It may help to understand what is meant by preserve biocomplexity before making this decision.

The term biocomplexity does not have a simple definition, as it spans across many scientific disciplines. The National Science Foundation describes biocomplexity as referring "to phenomena that arise from the dynamic interactions that take place between biological systems, including the influence of humans and the physical environment."[1] The Oxford dictionary defines biocomplexity as "complexity as exhibited by living organisms in their structure, composition, function, and interactions; complexity of a kind considered distinctive of biological systems." It also mentions that the term biocomplexity first appeared in the 1980's. It is important to note that biodiversity has a slightly different definition that typically refers to different species. The Oxford dictionary defines

[1] https://www.nsf.gov/news/news_summ.jsp?cntn_id=100687&org=NSF&from=news

biodiversity as "the variety of plant and animal life in the world or in a particular habitat, a high level of which is usually considered to be important and desirable."

In the context of Pacific halibut, preserving biocomplexity would be a useful objective to buffer against potential changes in environmental conditions. The current understanding of biocomplexity across the geographic range of the Pacific halibut stock indicates that IPHC Regulatory Areas do not represent relevant segments of the population (Seitz et al. 2017). Even with migration along the entire coast (Valero and Webster 2012; Webster et al 2013), there are hydrographic and bathymetric obstacles that appear to delineate spawning components in the Gulf of Alaska (GOA), Bering Sea (BS), and Aleutian Islands (AI) (Seitz et al. 2017). Genetic evidence further suggests weak population structure (Drinan et al. 2016).

Population structure and spawning components are likely to buffer a population against changes in the environment. Hilborn et al. (2003) concluded that biocomplexity in stock structure plays a critical role in stability and sustainability of a fish stock. Furthermore, preserving biocomplexity in a fish stock may buffer against population declines in a variable or changing environment. Schindler et al (2010) presented evidence that population diversity within sockeye salmon has reduced the variability in the population and reduced the frequency of fishery closures. This concept can be extended to multiple species in an ecosystem (biodiversity) providing ecosystem stability, just as a diversity of assets adds stability to a financial portfolio. Schindler et al (2010) referred to the diversity in a population or in an ecosystem as a portfolio effect.

There is evidence of population structure in the population of Pacific halibut, but it is not completely understood. Recruitment to the Pacific halibut population is variable, and it is not clear what the major driving force to recruitment success is. It could be that subcomponents of the population have varying success rates in different environmental instances. Balancing the removals against the current stock distribution, to preserve biocomplexity, is likely to protect against localized depletion of spatial and demographic components of the stock that may produce differential recruitment success under changing environmental and ecological conditions. This approach is likely to provide an additional precautionary buffer against spatial recruitment overfishing and may maintain sub-population structure that is not completely understood, but important to the long-term health of the coastwide population.

The structure of two of the four current stock assessment models is developed around identifying portions of the data (both FISS and fishery) 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 recommended by the SRB during review of models developed in 2014 (Cox et al. 2016, Stewart and Martell 2015, 2016).

Regions were defined with boundaries that matched IPHC Regulatory Areas to correspond to these biological differences. The boundaries of IPHC Regulatory Areas were used for many reasons. First, data (particularly historical 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. The use of these data is mainly a stock assessment issue. Second, it is necessary to distribute TCEY to IPHC Regulatory Area for quota management, and the final outcome of a distribution procedure will reflect this. 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. Overall, it is highly unlikely that there is a set of Regions that perfectly delineates the stock biologically since different aspects of the stock differ over varying scales, and movement occurs between Regions.

However, if the goal is to preserve biocomplexity across the entire range of the Pacific halibut stock, Regions are considered by the IPHC Secretariat to be the best option for biologically-based areas to meet management needs.

Each Region had some qualities that identified it as differing biologically from adjacent Regions, despite clear evidence from tagging studies of movement among all areas at some point in the life-cycle of Pacific halibut (Valero and Webster 2012; Webster et al 2013). These qualities include sex ratios, age composition, size-at-age, historical trends, and others that could be indicative of important diversity within the greater Pacific halibut population. The four Regions are labeled as follows and composed of the listed IPHC Regulatory Areas (Figure 1):

Region 2: 2A, 2B, and 2C
Region 3: 3A and 3B
Region 4: 4A and 4CDE
Region 4B: 4B

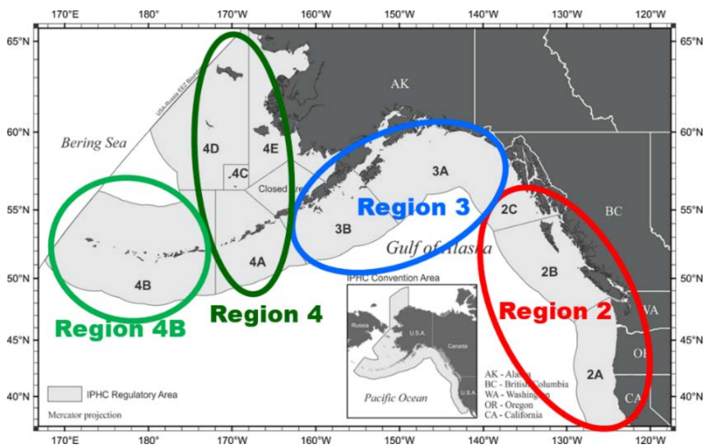

FIGURE 1. Four biological Regions. They are overlayed on IPHC Regulatory Areas with Region 2 comprised of 2A, 2B, and 2C, Region 3 comprised of 3A and 3B, Region 4 comprised of 4A and 4CDE, and Region 4B comprised solely of 4B.

PERFORMANCE METRICS

IPHC-2017-MSAB09-08 Rev 2 presented thirteen performance metrics associated with the goals and objectives in Appendix A. Table 1 presents a summary of the measurable objectives and associated performance metrics. All of the performance metrics will be easy to calculate, but the performance metrics associated with discard mortality (formerly called wastage) may have little meaning. This is because discard mortality in the current simulation model is an assumed function of the commercial+discard mortality and the size at age for an age 8 male halibut. When the commercial+discard mortality goes up, the discard mortality also increases, and when age 8 males are small, the discard mortality increases. A more meaningful calculation of discard mortality would occur if length-at-age and length-specific discards could be modeled. Unfortunately, that would require a significant amount of work given the variability in growth.

Table 1: Measurable objectives and associated performance metrics, as reported in the MSAB09 Report (IPHC-2017-MSAB09-R). Discard mortality is used to describe what was formerly known as wastage.

Biological Sustainability				
Measurable Objective	**Outcome**	**Time-frame**	**Probability**	**Performance Metrics**
Maintain a minimum of number of mature female halibut coast-wide	Number of mature female halibut less than a threshold	10 year period, long-term	0.01	Median average number of mature female halibut
Avoid very low stock sizes	dRSB < Limit of control rule	10 year period, long-term	0.05	$P(dRSB < Limit)$
Mostly avoid low stock sizes	dRSB < Threshold of control rule	10 year period, long-term	0.25	$P(dRSB < Threshold)$
When Limit < Estimated Biomass < Threshold, limit the probability of declines	SSB declines when 20%<RSB<30%	10 year period, long-term	0.05 – 0.5, depending on est. stock status	$P(SSB_{i+1} < SSB_i)$ given $20\% < RSB < 30\%$
Spawning Biomass	An absolute measure	10 year period, long-term	NA	Median $\overline{RSB}$

Fishery Sustainability, Stability, and Access				
Measurable Objective	**Outcome**	**Time-frame**	**Probability**	**Performance Metrics**
Maintain directed fishing opportunity	Fishery is open	Each year	0.05	$P(FCEY = 0)$
Maximize yield in each regulatory area		Each year	0.5	
Maintain median catch	Within ±10% of 1993-2012 average	Within 5 yrs, 10 yr per, long term		$P(FCEY > 110\%$ or $FCEY < 90\%$
Maintain average catch	> 70% of historical 1993-2012 average	10 year period, long-term	0.1	$P(FCEY < 70\%)$
Limit annual changes in TAC, coast-wide and/or by Regulatory Area	Change in FCEY < 15%	10 year period, long-term		$P\left(\frac{FCEY_{i+1} - FCEY_i}{FCEY_i} > 15\%\right)$
Absolute	FCEY	10 year period, long-term	NA	Median $\overline{FCEY}$
Absolute	Variability in FCEY	10 year period, long term		Average Annual Variability (AAV)

Table 1: Measurable objectives and associated performance metrics, as reported in the MSAB09 Report (IPHC-2017-MSAB09-R). Discard mortality is used to describe what was formerly known as wastage. Continued from above.

Minimize discard mortality				
Measurable Objective	**Outcome**	**Time-frame**	**Probability**	**Performance Metrics**
Discard mortality in the longline fishery	<10% of annual catch limit	10 year period, Long-term	0.25	$P(discardMortality > 10\%FCEY)$
Absolute	Discard Mortality	10 year period, Long-term		Median $\overline{discardMortality}$
Minimize bycatch and bycatch mortality				
Measurable Objective	**Outcome**	**Time-frame**	**Probability**	**Performance Metrics**
Serve consumer needs				
Measurable Objective	**Outcome**	**Time-frame**	**Probability**	**Performance Metrics**
Preserve biocomplexity				
Measurable Objective	**Outcome**	**Time-frame**	**Probability**	**Performance Metrics**

REPORTING RESULTS

The thirteen performance metrics described in Table 1 were expanded into many more performance metrics depending on the quantity used to calculate the metric (Appendix B). For example, the FCEY or Total Mortality could be used for yield objectives. Also, many of the performance metrics were calculated over a 10-year time period, and the metric may be reported as the probability that all observations were below a threshold, or the probability that any in a given year of the 10 years was below the threshold. These formulations have subtle differences and depend on the risk tolerance. The pertinent set of performance metrics (decided on by the MSAB) would be reported in a table as rows with the columns representing different management strategies (see Table 2 in IPHC-2017-MSAB10-09 Rev 1). Additionally, figures will be created as necessary to show specific performance metrics against the management procedures, as well as interesting trade-offs between performance metrics.

COMMISSION REVIEW OF GOALS AND OBJECTIVES

At the 93rd Interim Meeting, the Commission provided a directive to review the fishery goals and objectives identified by the MSAB. Four paragraphs from the IM093 Report (IPHC 2017) describe the directive.

IM093-R, para 37. **NOTING** the current fishery goals, objectives, and performance metrics identified by the MSAB for the MSE process, as detailed in the MSAB10 report (IPHC-2017-MSAB10-R), the Commission **AGREED** to provide guidance to the IPHC Secretariat and the MSAB on goals and objectives at the 94th Annual Meeting in January 2018.

IM093-R, para 38. **NOTING** the goals and objectives related to distributing the TCEY presented during the meeting by the U.S.A. (Table 3 [of IM093-R]), the Commission **RECOMMENDED** that they be considered at the 94th Annual Meeting in January 2018 after soliciting input from stakeholders.

IM093-R, para 39. The Commission **REQUESTED** the IPHC Secretariat to consolidate the objectives related to TCEY distribution (Table 3 [of IM093-R]) with the current goals, objectives and performance metrics provided as Appendix IV of the MSAB10 Report, for presentation at the 94th Annual Meeting in January 2018.

IM093-R, para 40. The Commission **NOTED** that providing guidance on the MSE process to the IPHC Secretariat and the MSAB at the Interim and Annual meetings would be an efficient and effective method to ensure the guidance is incorporated into the annual MSAB work plan.

A number of important directives come from this. First, the Commission will provide guidance on the MSAB goals and objectives. Second, the U.S.A. presented some objectives related to distributing the TCEY (Table 2). And third, the Commission would like input from stakeholders (see Circular IPHC-2017-CR022).

Table 2: Pacific halibut TCEY distribution goals and objectives presented by U.S.A. Commissioners at IM093. Table reproduced from IPHC-2017-IM093-R.

Goal	Objective
Biological sustainability: Preserving bio-complexity	1. Maintaining diversity in the population across IPHC Regulatory Areas. 2. Prevent local depletion at IPHC Regulatory Area scale.
Fisheries Sustainability: Maintain access and serve consumer needs.	1. Maintain commercial, recreational and subsistence fishing opportunities in each IPHC Regulatory Area. 2. Maintain processing opportunities in each IPHC Regulatory Area.
Fisheries Sustainability: Maximize yield by regulatory area	1. Distribution is responsive to IPHC Regulatory Area abundance trends and stock characteristics (ex. Fishery WPUE, age structure, size at age etc.). 2. Distribution is responsive to management precision in each IPHC Regulatory Area. 3. Minimize impact on downstream migration areas. 4. Minimize discard mortality and bycatch.
Fisheries Sustainability: Minimize variability,	1. Limit annual TCEY variability due to stock distribution in both time and scale. 2. Avoid zero sum distribution policy.

At AM094, a presentation was given relating the U.S.A. Commissioner objectives in Table 2 to the current MSAB objectives (agenda item 7.3). The classification of the U.S.A. Commissioner objectives is presented in Appendix C. Many of the U.S.A. Commissioner objectives complement the current MSAB objectives, and it would be worthwhile for the MSAB to consider them when reviewing goals and objectives.

Stakeholder feedback between IM093 and AM094, in response to Circular IPHC-2017-CR022, was limited to one response. The summary of that response is as follows. One, create measurable objectives and performance metrics for the objectives provided in Table 2. Define terms such as biocomplexity, depletion, and maintain. And, to not use fishery WPUE or defined allocations to distribute the TCEY as these may not be responsive to changes in the spatial distribution of biomass among IPHC Regulatory Areas.

The Commission provided the following guidance at AM094 related to goals and objectives.

> **AM094-R, para 32**. The Commission **NOTED** the current fishery goals, objectives, and performance metrics identified by the MSAB for the MSE process, as detailed in Appendix IV of the MSAB10 report (IPHC-2017-MSAB10-R).
>
> **AM094-R, para 33**. The Commission **NOTED** the summary presentation which was in response to Circular IPHC-2017-CR022 requesting stakeholder feedback on objectives proposed by a USA Commissioner related to distributing the TCEY presented at IM093. These objectives were categorized under the overarching goals defined by the MSAB for AM094.
>
> **AM094-R, para 34**. The Commission **NOTED** the other concepts proposed by a USA Commissioner related to distributing the TCEY were not stated as measurable objectives but may be useful when developing management procedures to evaluate.
>
> **AM094-R, para 35**. The Commission **NOTED** that:
>
> a) the Commission objectives related to distributing the TCEY may be presented at MSAB11 for further stakeholder feedback.
>
> b) the intent of the "other Commission concepts" could be further clarified and incorporated into the MSAB process, and can be converted to measurable objectives.
>
> c) the MSAB may develop measurable outcomes and performance metrics associated with these Commission objectives.
>
> **AM094-R, para 36**. The Commission **RECOMMENDED** that the draft goals, objectives, and performance metrics, as detailed in Appendix IV, IPHC-2017-MSAB10-R be used for ongoing evaluation in the MSE process, and that they may be refined in the future. The objectives should be evaluated in a hierarchal manner, with conservation as the first priority.
>
> **AM094-R, para 37**. The Commission **REQUESTED** that the objectives related to distributing the TCEY, as detailed in Circular IPHC-2017-CR022, be presented at MSAB11 for further stakeholder feedback.

The guidance from Commissioners had one request and one recommendation. The Commission requested that the objectives outline in IPHC-2017-CR022 be presented at MSAB11 for discussion (AM094-R, para 37). The recommendation was to endorse the current MSAB goals and objectives and to continue to refine them as necessary. An important piece of the guidance was to evaluate the objectives in a hierarchical manner with conservation as the first priority. This could mean that specified conservation objectives must be met for a management procedure to be considered any further. Or, it may mean that conservation objectives are given a higher weighting when evaluating the management procedures. This should be a topic of discussion at MSAB11.

RECOMMENDATION/S

That the Management Strategy Advisory Board:

1) **NOTE** paper IPHC-2018-MSAB011-07 which provides a review of the goals and objectives previously defined by the MSAB, associated performance metrics, and outcomes of IM093 and AM094 as they relate to objectives.
2) **CONSIDER** the current MSAB goals and objectives, and the objectives for distributing the TCEY identified by the Commission.
3) **RECOMMEND** additions or deletions to the MSAB goals and objectives. More specifically, the following topics should be addressed.
    a. How to incorporate the objectives for distributing the TCEY identified by the Commission.
    b. Defining objectives for goals that currently do not have objectives (4 & 5).
    c. Determining if the goal of preserving biocomplexity should be its own goal, or if it should be an objective under the goal of biological sustainability; and, defining associated measurable objectives.
4) **RECOMMEND** a practical set of performance metrics to report for the evaluation of future simulations.
5) **SUGGEST** method (e.g., tables and figures) to report the performance metrics listed here for the evaluation of future results from the simulations.

ADDITIONAL DOCUMENTATION / REFERENCES

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APPENDIX A: GOALS, MEASURABLE OBJECTIVES, AND INTENT

Table A1: Objectives for the biological sustainability goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Biological Sustainability	1.1. Keep biomass above a **limit** below which no fishing can occur	a) Maintain a minimum number ***[spawning potential ratio?]*** of mature female halibut coast-wide	0.99	Each year	• Ensure that conservation needs of the stock are met for long-term sustainability with a high degree of certainty • Regularly monitor stock biomass (i.e., continuation and improvement of survey and stock assessment efforts) to detect changes in status and abundance • **Define reference points and harvest targets (e.g., MSY)** • Take a risk-averse approach when the stock is below the threshold
		b) 2) Maintain a minimum spawning stock biomass of 20% of the unfished biomass	0.95	Each year	
	1.2. Account for all sizes in the population?	*c)*			
	1.3. Reduce harvest rate when abundance is below a threshold	d) Maintain a minimum spawning stock biomass of 30% of the unfished biomass	0.75	Each year	
	1.4. Risk tolerance and assessment uncertainty	e) When Limit < estimate biomass < Threshold, limit the probability of declines	0.05 – 0.5, depending on est. stock status	10 years	

Table A2: Objectives for the fishery sustainability goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Fishery Sustainability and Stability and Assurance of Access – Minimize Probability of Fishery Closures	2.1. Maintain an economically sufficient level of catch (i.e., target) across regulatory areas	a) Maintain directed fishing opportunity	0.95	Each year	• Ensure that the directed fishery has viable fishing opportunities every year • Provide directed fisheries that are economically beneficial to individual participants, local businesses, and broader communities • Support efforts to allow continued access to the halibut resource within acceptable conservation limits
		b) Maximize [Optimize?] yield in each regulatory area	0.5	Each year	
		c) Maintain median catch within ±10% of 1993-2012 average	?	Within 5 yrs	
		d) Maintain average catch at > 70% of historical 1993-2012 average	0.9	Each year	
	2.2. Limit catch variability	e) Limit annual changes in TAC, coast-wide and/or by Regulatory Area, to < 15%		Each year	

Table A3: Objectives for the minimize wastage goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Minimize Discard Mortality	3.1. Harvest efficiency	a) Discard mortality in the longline fishery < 10% of annual catch limit	0.75	Over 5 years	• Support fishing practices that reduce discard mortality • Regulatory revisions that promote efficiency

Table A4: Objectives for the minimize bycatch goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Minimize Bycatch and Bycatch Mortality	4.1.	a)		Over 5 years	• Support fishing practices that reduce bycatch and bycatch mortality

Table A5: Objectives to serve consumer needs goal along with intent and performance metric quantities (measurable outcome, probability, and time-frame). Acknowledgements to Michele Culver (WDFW) for originally putting this table together.

Goal	Objective	Measurable Outcome	Probability	Time-frame	Intent
Serve Consumer Needs	5.1.	a)			• Strive to avoid or minimize regulatory changes that result in large fluctuations in product availability

APPENDIX B: PERFORMANCE METRICS CONSIDERED A

Biological Sustainability

Metric	Description
Median average dRSB	Long-term average dynamic relative spawning biomass (stock status). The average is determined over a range of years at the end of a single simulated trajectory. The median is determined from multiple random simulated trajectories.
Median average # mature females	Long-term average number of mature females. The average is determined over a range of years at the end of a single simulated trajectory. The median is determined from multiple random simulated trajectories.
P(all dRSB<Limit)	The probability of stock status declining to below a 20% limit resulting in no directed fishery over all simulated trajectories. The stock would be in an overfished state and any fishing would be overfishing.
P(any dRSB_y<Limit)	The probability of stock status declining to below a 20% limit in any of the defined years, resulting in no directed fishery. The stock would be in an overfished state and any fishing would be overfishing.
P(all dRSB<Trigger)	The probability of stock status declining to below a 30% trigger resulting in a decrease in fishing intensity over all simulated trajectories. Below this trigger and above a limit has been called "being on the ramp."
P(any dRSB_y<Trigger)	The probability of stock status declining to below a 30% trigger in any of the defined years resulting in a decrease in fishing intensity. Below this trigger and above a limit has been called "being on the ramp."
P(decrease SB|onRamp)	The probability that the spawning biomass decreases when the stock status is between the limit and trigger.

Fishery Sustainability

Metric	Description
Median average SPR	Long-term average SPR. The average is determined over a range of years at the end of a single simulated trajectory. The median is determined from multiple random simulated trajectories.
Median average TM	Long-term average total mortality. The average is determined over a range of years at the end of a single simulated trajectory. The median is determined from multiple random simulated trajectories.
Median average FCEY	Long-term average FCEY. The average is determined over a range of years at the end of a single simulated trajectory. The median is determined from multiple random simulated trajectories.
Median average Commercial	Long-term average commercial halibut mortality. The average is determined over a range of years at the end of a single simulated trajectory. The median is determined from multiple random simulated trajectories.
25th% average TM	The 25th percentile of the long-term average total mortality. 25% of the simulated trajectories had an average total mortality less than this value.
25th% average FCEY	The 25th percentile of the long-term average FCEY. 25% of the simulated trajectories had an average FCEY less than this value.
25th% average Commercial	The 25th percentile of the long-term average commercial mortality. 25% of the simulated trajectories had an average commercial mortality less than this value.
75th% average TM	The 75th percentile of the long-term average total mortality. 75% of the simulated trajectories had an average total mortality less than this value (25% were greater).
75th% average FCEY	The 75th percentile of the long-term average FCEY. 75% of the simulated trajectories had an average FCEY less than this value (25% were greater).
75th% average Commercial	The 75th percentile of the long-term average commercial mortality. 75% of the simulated trajectories had an average commercial mortality less than this value (25% were greater).
P(all Comm=0)	Long-term probability over all simulations that the commercial fishery is closed.
P(any Comm=0)	Long-term probability that the commercial fishery is closed in any of the defined range of years at the end of the simulated trajectories.
P(all FCEY < 50.6 Mlbs)	The long-term probability that the FCEY from all simulated trajectories is less than 70% of the historical FCEY averaged over the years 1993-2012 (50.6 Mlbs).
P(any FCEY < 50.6 Mlbs)	The long-term probability that the FCEY is less than 70% of the historical FCEY averaged over the years 1993-2012 (50.6 Mlbs) in any of the final years of a simulated trajectory.
P(all FCEY < 65.0 Mlbs)	The long-term probability that the FCEY from all simulated trajectories is less than 90% of the historical FCEY averaged over the years 1993-2012 (65.0 Mlbs).
P(any FCEY < 65.0 Mlbs)	The long-term probability that the FCEY is less than 90% of the historical FCEY averaged over the years 1993-2012 (65.0 Mlbs) in any of the final years of a simulated trajectory.

P(all FCEY < 79.5 Mlbs)	The long-term probability that the FCEY from all simulated trajectories is less than 110% of the historical FCEY averaged over the years 1993-2012 (79.5 Mlbs).
P(any FCEY < 79.5 Mlbs)	The long-term probability that the FCEY is less than 110% of the historical FCEY averaged over the years 1993-2012 (79.5 Mlbs) in any of the final years of a simulated trajectory.
P(all decrease TM)	The long-term probability that the total mortality decreases from the previous year in a simulated trajectory.
P(any decrease TM)	The long-term probability that any of the total mortality decreases from the previous year in a defined range of years at the end of a simulated trajectory.
P(all decrease TM > 15%)	The long-term probability that the total mortality decreases by more than 15% from the previous year in a simulated trajectory.
P(any decrease TM > 15%)	The long-term probability that any of the total mortality decreases by more than 15% from the previous year in a defined range of years at the end of a simulated trajectory.
P(all increase TM > 15%)	The long-term probability that the total mortality increases by more than 15% from the previous year in a simulated trajectory.
P(any increase TM > 15%)	The long-term probability that any of the total mortality increases by more than 15% from the previous year in a defined range of years at the end of a simulated trajectory.
median AAV TM	The average annual percent change in total mortality over a defined range of years at the end of the simulated trajectory. The median is taken over all simulated trajectories.
median AAV FCEY	The average annual percent change in FCEY over a defined range of years at the end of the simulated trajectory. The median is taken over all simulated trajectories.
median AAV Commercial	The average annual percent change in commercial mortality over a defined range of years at the end of the simulated trajectory. The median is taken over all simulated trajectories.

Appendix C: Potential Objectives Defined by Commission Related to Distribution that can be Defined as a Measurable Objective

Goal	Objective
Biological Sustainability	Maintaining diversity in the population across IPHC Reg. Areas
	Prevent local depletion at IPHC Regulatory Area scale
	Minimize impact on downstream migration area
Fishery Sustainability and Stability	Maintain commercial, recreational, and subsistence fishing opportunities in each IPHC Regulatory Area
	Limit annual TCEY variability due to stock distribution in both time and scale
Minimize discard mortality	Minimize discard mortality by IPHC Regulatory Area
Minimize bycatch and bycatch mortality	Minimize bycatch by IPHC Regulatory Area
Serve consumer needs	Maintain processing opportunities in each IPHC Regulatory Area

Other Commission concepts that are not Easily Classified as a Measurable Objective

The U.S.A. Commission provided some other objectives in Table 3 of IPHC-2017-IM093-R that are not easily translated to measurable objectives. However, it would be worthwhile to further clarify these objectives, and be useful to consider them when developing management procedures. These objectives are listed below.

- Distribution is responsive to IPHC Regulatory Area abundance trends and stock characteristics (e.g., Fishery WPUE, age structure, size at age, etc.)
- Distribution is responsive to management precision in each IPHC Regulatory Area
- Avoid zero sum distribution policy

IPHC Management Strategy Evaluation to Investigate Fishing Intensity

PREPARED BY: IPHC SECRETARIAT (A. HICKS; 10 APRIL 2018)

PURPOSE

To provide an update on the progress of the IPHC Management Strategy Evaluation process to investigate fishing intensity, and seek recommendations from the MSAB related to the Management Strategy Evaluation simulation framework.

INTRODUCTION

At the 2017 Annual Meeting (AM093) Commissioners supported a revised harvest policy that separates the scale and distribution of fishing mortality (Figure 1). Furthermore, the Commission identified an interim "hand-rail" or reference for harvest advice based on a status quo SPR, which uses the average estimated coastwide SPR for the years 2014–2016 from the stock assessment. The justification for using an average SPR from recent years is that this corresponds to fishing intensities that have resulted in a stable or slightly increasing stock, indicating that, in the short-term, this may provide an appropriate fishing intensity that will result in a stable or increasing spawning biomass.

The Commission provided one request at the 94th Annual Meeting (AM094) in 2018 related to investigation of fishing intensity. This was

> **AM-094, para 31**: The Commission **REQUESTED** that the MSAB look at SPR values consistent with recent estimated SPR values from the assessment model and lower. This would mean expanding the lower range of SPR values to below 40%.

The 2017 stock assessment updated the population estimates and determined that the SPR resulting from actual total mortality from all sources in 2017 was 40%, instead of the 45% decided by Commissioners at AM093. This was an example of estimation error and something that is inherent in the process due to uncertainty in the data. The SPR of 40% was well within the confidence bounds for SPR reported in the 2017 stock assessment (30-59%), and was most likely less than the adopted SPR because of the updated estimation of recent poor recruitment. The estimation may easily go either way (above or below the adopted value).

A brief description of the simulation framework is given below, with many details provided in IPHC document IPHC-2017-MSAB10-09 Rev 1.

FRAMEWORK

The framework of the closed-loop simulations is a map to how the simulations will be performed (Figure 2). There are four main modules to the framework:

1. The **Operating Model (OM)** is a representation of the population and the fishery. It produces the numbers-at-age, accounting for mortality and any other important processes. It also incorporates uncertainty in the processes and may be composed of multiple models to account for structural uncertainty.
2. **Management Procedure**
    a. **Monitoring (data generation)** is the code that simulates the data from the operating model that is used by the estimation model. It can introduce variability, bias, and any other properties that are desired.
    b. 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. However, simplifications may be necessary to keep simulation times within a reasonable time.
    c. **Harvest Rule** is the application of the estimation model output along with the scale and distribution management procedures (Figure 1) to produce the catch limit for that year.

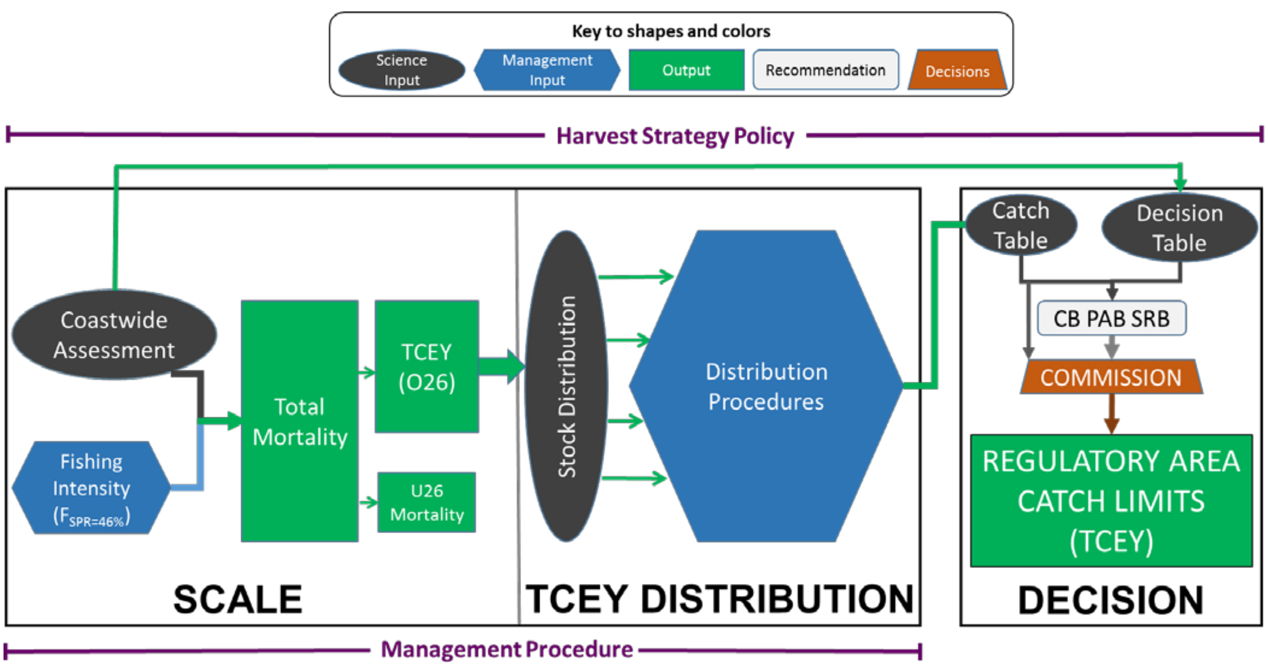

Figure 1: A pictorial description of the interim IPHC harvest strategy policy showing the separation of scale and distribution of fishing mortality. The "decision step" is when policy and decision making (not a procedure) influences the final mortality limits.

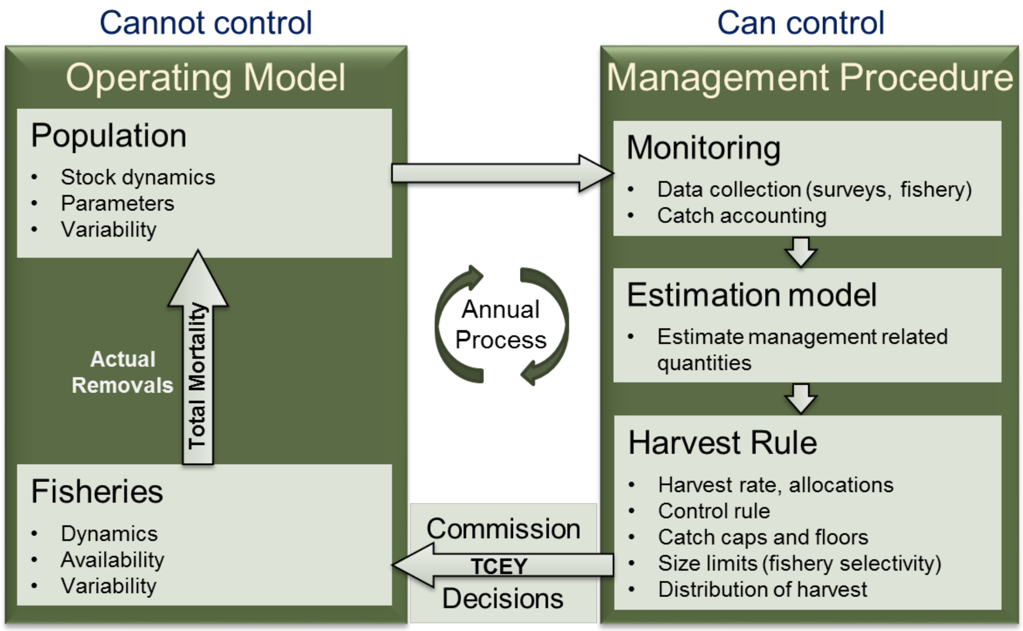

Figure 2: Diagram of the relationship between the four modules in the framework. The simulations run each module on an annual time-step, producing output that is used in the next time-step. See text for a description of operating model, monitoring, estimation model, and harvest rule.

OPERATING MODEL

For the simulations to investigate a coastwide fishing intensity, the stock synthesis (Methot and Wetzel 2013) assessment software was used as an operating model. This platform is currently used for the stock assessment, and the operating model was comprised of the two coastwide assessment models (short and long time-series) currently used in the ensemble. For future MSE evaluations (in particular, investigating the Distribution component of the harvest policy) a more complex operating model will be developed that can provide outputs by defined areas or regions and can account for migration between these areas. This model has been referred to as a multi-area model.

The current stock assessment ensemble, composed of four different assessment models, includes a cross between coastwide or fleets-as-areas structuring of the data, and the length of the time series. Using an areas-as-fleets model would require generating data and distributing catch to four areas of the coast, which would involve many assumptions. In addition, without a multi-area model, there would not be feedback from migration and productivity of harvesting in different areas. Therefore, only the two coastwide models were used, but with additional variability. These models are structured to use five general sources of removals (these are aggregated for modelling purposes and do not necessarily correspond to specific fisheries or sectors): the directed commercial halibut fishery (including research landings), commercial discard mortality (previously known as wastage), bycatch (from non-halibut-target fisheries), recreational, and subsistence. The TCEY was distributed to each source in an ad hoc manner using current available information (see below).

MANAGEMENT PROCEDURE

Monitoring (Data Generation)

It is proposed to use a simplified estimation model due to time constraints, thus no data were generated. However, if a stock assessment was simulated, there are many sources of data to generate (Appendix A).

Estimation Model

Of the four options to simulate an estimation model presented in IPHC-2017-MSAB10-09 Rev1, the No Estimation Model (previously called Perfect Information) option was used in past simulations. The No Estimation Model method assumes that the population values needed to apply the management procedure are exactly known (e.g., spawning biomass). This option is useful as a reference to better understand the performance with and without uncertainty in an estimation model. Due to time constraints, the only other option likely to be considered for simulations in 2018 is the Simulate Error option. This will be suitable to understand the effects of estimation error.

Harvest Rule

The generalized management procedure to evaluate is shown in Figure 1, but the focus will be on the Scale portion to produce results for the MSAB to evaluate before AM095 in 2019. Specifically, the portion of the management procedure being evaluated is a harvest control rule (**Figure 3**) that is responsive to stock status and consists of an SPR determining fishing intensity, a trigger level of stock status that determines when the fishing intensity begins to be linearly reduced, and a limit that determines when there is theoretically no fishing intensity (SPR=100%). For these simulations, the two coastwide models were used, thus mortality only needed to be distributed to the five coastwide sources of mortality (directed commercial, discard mortality, bycatch mortality, recreational, and subsistence).

Simulations have been used to evaluate a range of SPR values from 25% to 60% and trigger values of 30% and 40% (IPHC-2017-MSAB10-09 Rev 1). Those simulations provided insight into how those different levels of SPR would meet the objectives defined by the MSAB, but few values of SPR below 40% were tested. Future simulations will use a finer resolution of SPR values ranging from 30% to 55% and trigger points of 30% and 40%.

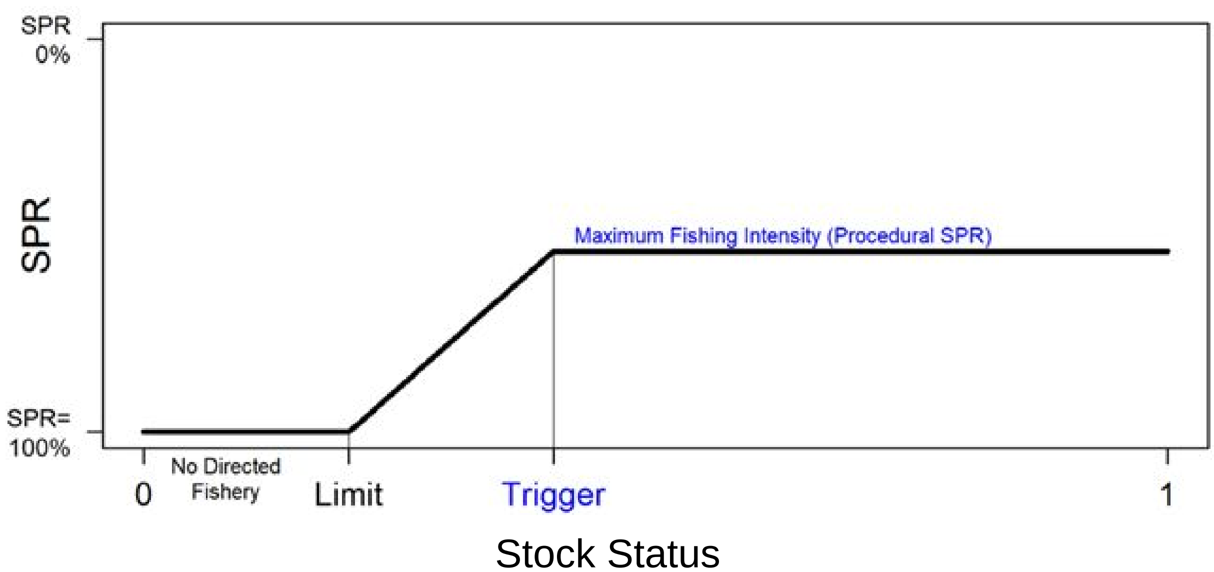

Figure 3: A harvest control rule responsive to stock status that is based on Spawning Potential Ratio (SPR) to determine fishing intensity, a trigger level of stock status that determines when the fishing intensity begins to be linearly reduced, and a limit that determines when there is theoretically no fishing intensity (SPR=100%). In reality, it is likely that only the directed fishery would cease. The Procedural SPR and the Trigger (in blue) are the two values that were evaluated.

SUMMARY OF THE FRAMEWORK

A summary of the major specifications for each component is provided below, with the components listed in a specific order where the next component is dependent on the decisions for the previous components.

1) Operating Model
   a) Stock synthesis, based on coastwide assessment models (short and long models).
   b) Five fleets, as in the assessment models (commercial, discards, bycatch, sport, personal use).
   c) Uncertainty incorporated through parameter uncertainty and model uncertainty. See Scenarios.
2) Management Procedure
   a) Estimation Models
      i) Perfect Information (as a reference if we knew population values exactly when applying the harvest rule).
      ii) Simulate error from the simulated time-series to mimic a stock assessment.
   b) Data Generation
      i) Not needed at this time.
   c) Harvest Rule
      i) Coastwide fishing intensity (F_{SPR}) with SPR ranging from 30% to 55%.
      ii) Trigger to reduce the fishing intensity (increase SPR) when stock status is below 30% or 40%
      iii) A limit to cease directed fishing when the stock status is less than 20%.
      iv) Catch assigned to sectors based on historical information (with variability)

SCENARIOS AND UNCERTAINTY

Scenarios are alternative states of nature in the operating model, which are represented by parameter and model uncertainty, as described in Appendix A. These alternative states of nature integrate over the uncertainty in the system that we cannot, or choose not to, control. The scenarios for the MSE simulations include variability in the operating model processes as described in Table 1.

Table 1: Processes and associated variability in the operating model (OM). TM refers to total mortality.

Process	Uncertainty
Natural Mortality (M)	Estimate appropriate uncertainty when conditioning OM
Recruitment	Random, lognormal deviations
Size-at-age	Annual and cohort deviations in size-at-age with bounds
Steepness	Estimate appropriate uncertainty when conditioning OM
Regime Shifts	Autocorrelated indicator based on properties of the PDO for regime shift
TM to sectors	See section on allocating TM to sectors
Proportion of TCEY	Sector specific. Sum of mortality across sectors may not equal coastwide TM

ALLOCATING SIMULATED TOTAL MORTALITY TO SECTORS

The simulated management strategy returns a coastwide recommended TCEY, which is then allocated to each of the five sectors, with variability. In reality, there is a slight difference between the Total Mortality (TM) and the TCEY because of shortfalls and overages, but those should be dealt with on a sector basis. The MSAB09 meeting in May 2017 noted that catch history, in conjunction with uncertainties and sensitivities, can be used to allocate TM to each sector. Recent sector-specific mortality or proportions of TM for each sector were used to guide the allocation using relationships between the sector specific mortality or proportions to the TM. For example, at low TM the bycatch is likely a larger proportion. Figure 4 shows the percentage of TM attributed for each sector for the past 40 years.

A summary of the methods used to allocate total mortality to the five sources is provided in Table 2. Additional details can be found in IPHC-2017-MSAB10-09.

Due to specified minimum levels of subsistence and bycatch mortality, as well as random variability, it is possible that, at low levels of total mortality, there is no directed commercial mortality and that the actual total mortality exceeds the mortality determined from the management procedure. Expected values of the mortality and proportion by source plotted against Total Mortality is shown in Figure 5.

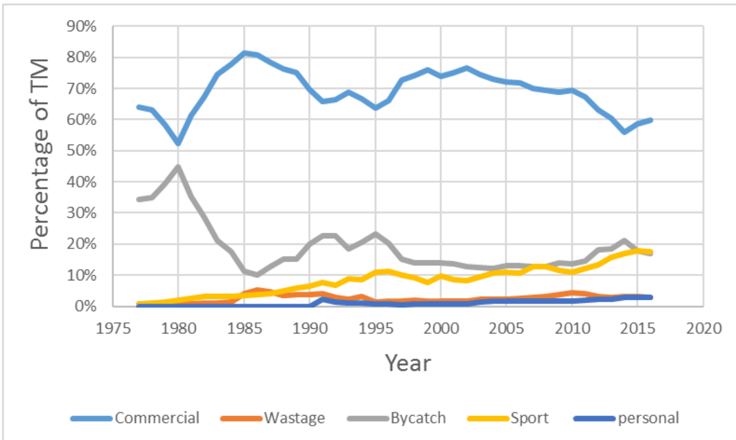

Figure 4: Percentage of Total Mortality (TM) for each sector used in the assessment model from 1976 to 2016.

Table 2: A summary of the methods to allocate total mortality to each of the five sources used in the operating model.

Source	**Method of allocating Total Mortality**
Subsistence	Randomly drawn from a lognormal distribution with a median of 1.2 million pounds (544 t) and a coefficient of variation (CV) of 15%. The 5th and 95th percentiles are approximately 0.9 million pounds (410 mt) and 1.5 million pounds (680 mt), respectively.
Bycatch	The non-directed component of the total mortality is randomly drawn from a lognormal distribution with a median of 7.0 million pounds (3,175 mt) and a CV of 20%. The 5th and 95th percentile are approximately 5.0 million pounds (2,300 mt) and 9.7 million pounds (4,400 mt), respectively. Potential improvements to the simulation of bycatch mortality will be discussed.
Recreational	The percentage of recreational mortality was linearly decreasing with total mortality when the total mortality was less than 57 million pounds (25,855 mt). The recreational mortality was randomly drawn from a lognormal distribution with a median of 7.7 million pounds (3,493 mt) and a CV of 20% when the total mortality was greater than 57 million pounds (25,855 mt).
Discard Mortality	The discard mortality was modelled as a function of the commercial plus discard mortality (total mortality minus subsistence, bycatch, and recreational mortality) and the size at age 8 for a male Pacific halibut (smaller fish likely results in more discard mortality).
Commercial	The commercial mortality is the remainder of the total mortality after subtracting the subsistence, bycatch, sport, and discard components.

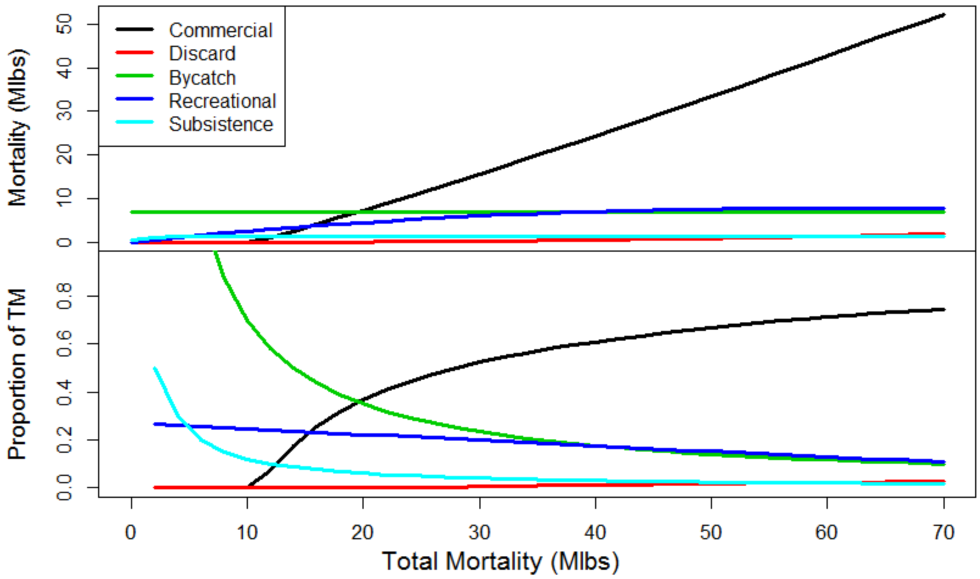

Figure 5: Average sector specific mortality (top, millions of pounds) and the sector-specific proportion of Total Mortality (TM) plotted against TM. For plotting purposes, age 8 males are 6 pounds and random variability is not included.

SIMULATING WEIGHT-AT-AGE

It is important to simulate time-varying weight-at-age because it is an influential contributor to the yield and status of Pacific halibut. There are 82 years of weight-at-age observations in the long time-series assessment models, with an observed wide range over the years (Figure 6 and Figure 7). Many years of these data have been estimated from sparse data, and the entire time-series has been smoothed to eliminate large deviations from year to year.

Important behaviors of the historical weight-at-age time-series to consider when simulating future weight-at-age are

1. the age-specific weights-at-ages tend to increase and decrease in the same year (little evidence of lags due to specific cohort effects; Figure 6 upper plot),
2. the time-series appears to be similar to a random walk with smooth trends and few large jumps in observations (partly due to the smoothing that was done; Figure 6), and
3. there appears to be some ages that do not strictly follow the general trend (evident at the end of the time series where the sampling was likely greater; Figure 6 lower plot).

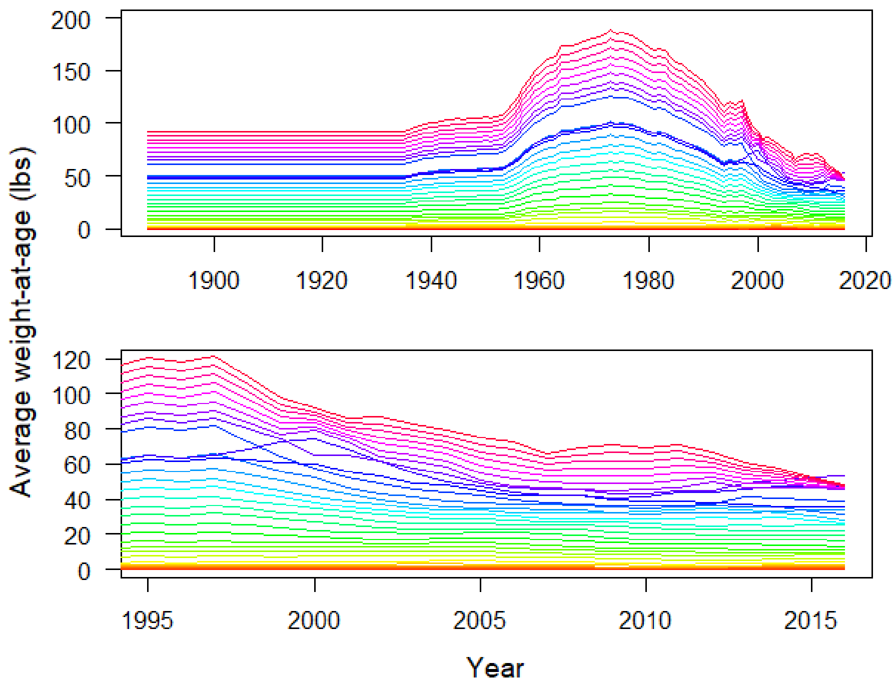

Figure 6: Historical female weight-at-age as used in the long time-series assessment models. Note that the observations are smoothed over years to reduce spurious observations.

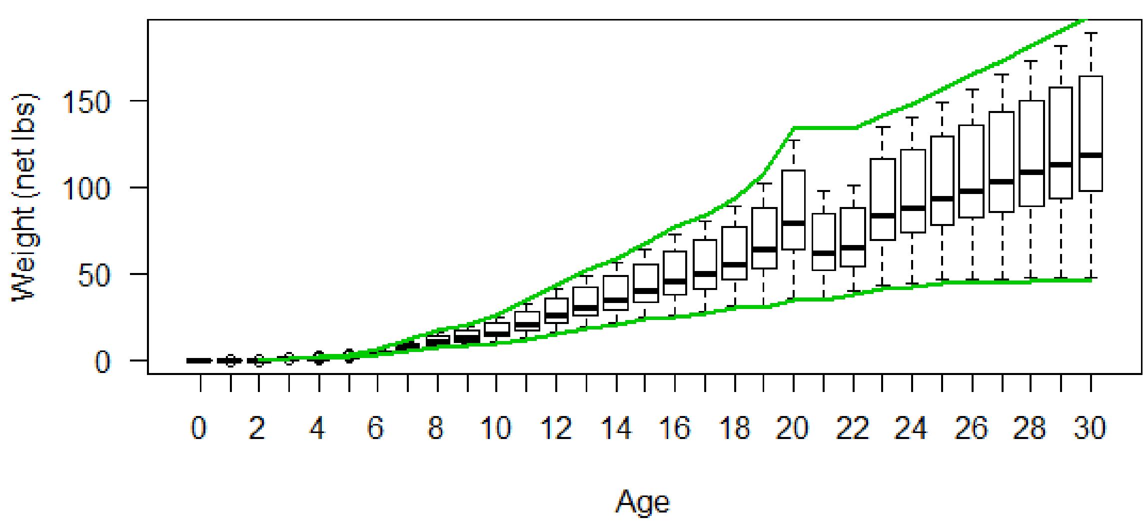

Figure 7: Boxplots of female weight at ages 0 to 30 over all historical years. The green line shows the lower and upper bounds used in the simulations.

The method used to simulate weight-at-age addressed each of these behaviors in the following ways.

1. A single deviation was generated from a normal distribution with a constant standard deviation (0.05), and was a multiplier on the current year's weight-at-age to determine the weight-at-age in the next year. This made all weights for each age increase or decrease similarly.
2. 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).
3. 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.

The random walk could potentially traverse to extremely high values or low values (obviously negative weight-at-age is not valid). 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. Two upper boundaries (ages 21 and 22) were expanded further to equal the upper boundary of age 20 (Figure 7). 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.

Example simulated weight-at-age time series are shown in Figure 8.

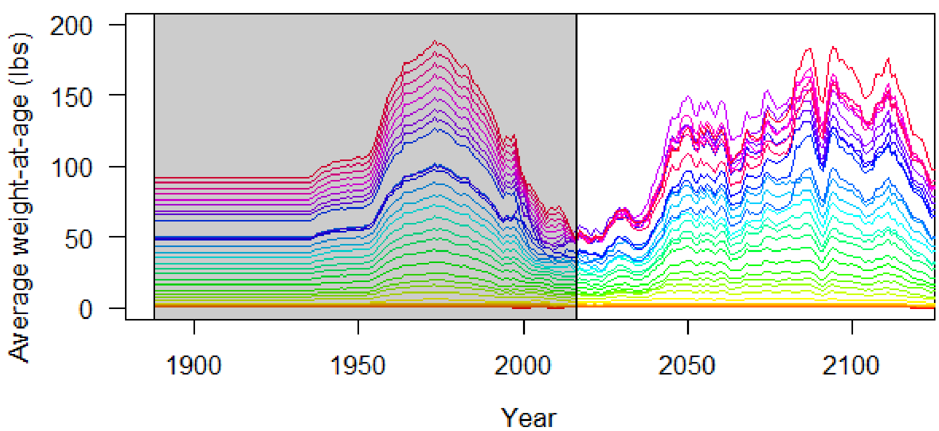

Figure 8: One potential simulated female weight at age in the historical period (1888-2016, shaded) and the simulated period (2017-2116).

SIMULATING REGIME SHIFTS

An environmental regime is used in the stock assessment to determine if average recruitment is high or low. This is based on the Pacific Decadal Oscillation (PDO, http://research.jisao.washington.edu/pdo/, Mantua et al. 1997, Figure 9) and the value is 0 or 1 depending on classified cool or warm years, respectively (Figure 10).

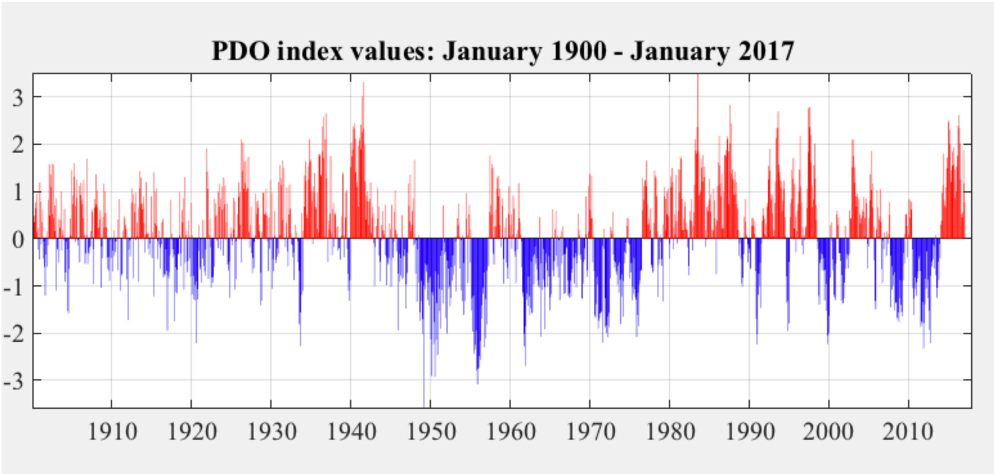

Figure 9: Pacific Decadal Oscillation (PDO) (figure from http://research.jisao.washington.edu/pdo/).

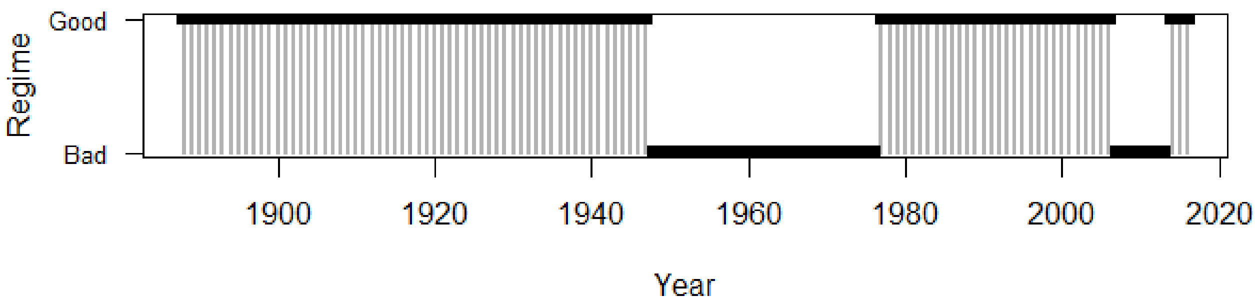

Figure 10: Good and bad regimes in the Pacific halibut stock assessment for 1888-2016.

The regime was simulated in the MSE by generating a 0 or 1 to indicate the regime in that future year. 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 the current year. However, the probability of changing to the opposite regime was a function of the length of the current regime with a probability of changing 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.

Some Additional Scenarios Not Currently Considered

Some scenarios that were not considered, but will likely be considered in the future are:

Selectivity: It may be desirable for the time-varying selectivity for at least commercial gears to be linked to changes in weight-at-age.

Migration: Migration will require a multi-area model and hypotheses about movement. A multi-area model is being developed with four regions. Migration hypotheses will be informed by tagging data as well as other observations from various fisheries and surveys.

Conditioning the Operating Model

The operating model (OM) should be a reasonable depiction of reality with an appropriate level of uncertainty. The OM consists of two stock synthesis (Methot and Wetzel 2013), models parameterized similarly to the short and long coastwide assessment models for Pacific halibut (Stewart 2015 appendix of RARA). Each model is conditioned by fitting to the same data used in the 2016 stock assessment (Stewart & Hicks 2017). To evaluate and choose management procedures that are robust to uncertainty in future states of the population, many assumptions in the assessment model were freed up to characterize a wider range of possibilities in the future. Estimating natural mortality for both sexes in both models and estimating steepness were the only changes to estimated parameters from the assessment model when conditioning.

Parameter variability was characterized by randomly sampling parameters for each simulation from a truncated multivariate normal distribution conditioned to data. Unrealistic simulated historical trajectories (e.g., the population could not support the observed catch) were eliminated.

The conditioned OM has a considerable amount of extra variability compared to the ensemble stock assessment (Figure 11). The assessment ensemble contains four individual models while the OM contains only two, which is why the trend at the end of the time series is slightly different, although well within the uncertainty.

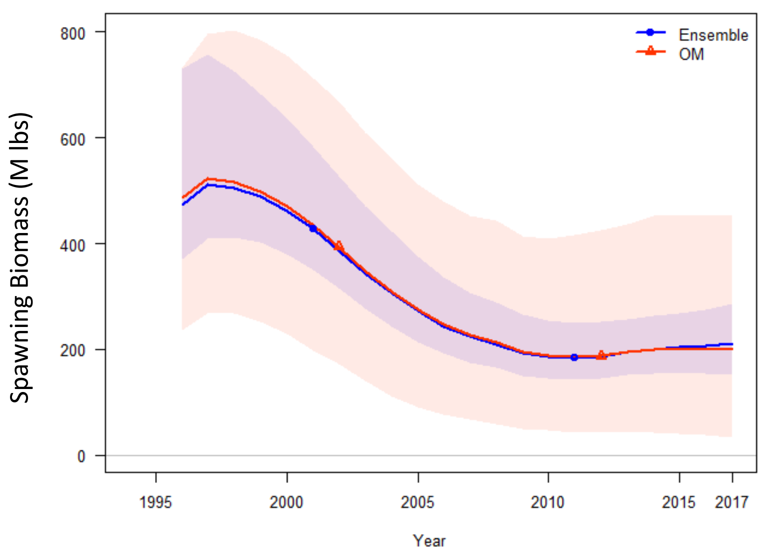

Figure 11: The conditioned operating model (red) compared to the stock assessment ensemble (blue) with 95% confidence intervals.

A potential issue highlighted at SRB11 was that starting the OM in 2017 with such a wide range of uncertainty will not adequately characterize our best knowledge of the near future (short-term) and the medium-term. However, the long-term results are appropriate since the current state would not have an effect, and the wide range of uncertainty is a result of the chosen uncertainties to evaluate harvest strategies against. One solution to provide short-term results would be to start the OM from the assessment model and its uncertainty (the blue shaded region in Figure 11). However, this may not be indicative of our best predictions for the short-term or medium-term because of the wider range of uncertainty in the parameters that will result in large deviations at the start of the simulations and because the OM is not the best representation of the current state of the population (i.e., the ensemble assessment is with four models).

Instead, we present results for the long-term to identify management procedures that meet the goals and objectives defined by the MSAB. These management procedures can then be further investigated using short-term predictions directly from the assessment model (1-3 years from the end of the time-series; 8-11 years from the most recent information on recruitment) to identify how they may affect the fishery now. For example, the decision table already presents risk metrics for various SPR values, and these results can be used to evaluate the immediate consequences to the fishery of a change in the harvest policy. Additionally, transitory behavior from the short-term to the long-term can be highlighted in future analyses. This may be describing the trends of various trajectories (e.g., catch or spawning biomass) between the short-term or long-term. For example, the short-term may indicate low catches with a higher catch on average in the long-term, but to get there, it appears that catches may be low for a short time before increasing.

The reason that it is difficult to quantify medium-term results is that we have very little predictive power for that time-period. In the short-term, we have an idea of where we currently are and what may occur in the next few years (e.g., we have some data indicating recruitment and weight-at-age). In the long-term, we are summarizing statistics over a wide range of uncertainty and all possible states (we do not need to know anything about the current state of the population). However, that uncertainty is not well described in the medium-term because it is partially dependent on the current state, but also affected by the wide range of possibilities. Therefore. it could be very misleading to present medium-term results as unbiased and informative predictions.

MSE RESULTS

Results from initial simulations were provided at MSAB010. Additional results will be presented at the MSAB011 Meeting.

RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2018-MSAB011-08 which provided an overview of the simulation framework to evaluate the harvest control rule (fishing intensity and trigger) in the IPHC Harvest Strategy Policy.
2) **CONSIDER** the simulation framework and assumptions as described, including introducing variability to the OM, simulating weight-at-age and an environmental regime, and distribution of the Total Mortality to different sources of mortality.
3) **CONSIDER** the interpretation of short-term, medium-term, and long-term results.
4) **RECOMMEND** modifications to the simulation framework and assumptions.
5) **AGREE** on additional management procedures to evaluate in 2018 and report at AM095.

ADDITIONAL DOCUMENTATION / REFERENCES

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APPENDIX A: A REVIEW OF THE HARVEST CONTROL RULE

The harvest control rule defines the fishing intensity on the coastwide stock (Figure 3) and incorporates a maximum fishing intensity and a control rule to reduce that fishing intensity when needed. It consists of a maximum fishing intensity (defined as a procedural SPR), a trigger defined by a stock status here the fishing intensity begins to be reduced (increase the procedural SPR), and a limit where theoretically the fishing intensity is set to zero. These are defined in more detail below.

MEASURES OF FISHING INTENSITY

Fishing intensity is a measure of how fishing is affecting the coastwide stock, and it is the element of the management procedure in determining the scale of the current harvest policy shown in Figure 1. An intuitive measure of fishing intensity is an exploitation rate, which is simply the catch divided by the exploitable biomass. Less intuitive, but similar, is instantaneous fishing mortality, which is used in an exponential function, as is M. These are obvious measures of fishing intensity for a single fleet, but become very complicated when considering multiple fleets with different selectivities or annual changes in selectivity.

Measures of fishing intensity have been developed that are more holistic and provide a meaningful measure of fishing effort on the stock of fish, rather than a specific portion. Many of these metrics focus on the effect of fishing on the spawning biomass, and often measure the long-term effects after fishing consistently at the same intensity. The following are some of the desired properties of a fishing intensity metric (many from pers. comm., Owen Hamel, NWFSC).

- As fishing effort increases, the fishing intensity metric also increases appropriately.
- Applies to simple as well as complex (i.e., multiple areas and fleets) models.
- Metric changes with changes in selectivity, and captures systematic changes in selectivity.
- Easy to compute.
- A scale that is easy to understand.

A commonly used metric is the spawning potential ratio (SPR), which is a measure of the effect of fishing on the long-term reproductive potential of the stock. This metric is currently used in the IPHC interim harvest policy.

SPR (spawning potential ratio) is a measure of the effect of fishing on the long-term reproductive potential of the stock. More specifically, it is the percentage of long-term, equilibrium spawning output-per-recruit when fishing at a constant fishing intensity (F_{SPR}), divided by the long-term, equilibrium spawning output-per-recruit without fishing. Spawning output for Pacific halibut is measured by spawning biomass. The higher the fishing intensity (F_{SPR}), the lower the SPR (Figure 12). For example, SPR=100% is, by definition, no fishing; and SPR=40% is a fishing level that reduces the equilibrium spawners-per-recruit (i.e., spawning potential) to 40% of the unfished level. The general equation for SPR is

$$SPR = \frac{\widetilde{SB}_F / R_F}{\widetilde{SB}_{noF} / R_{noF}} \qquad (1)$$

where $\widetilde{SB}$ is the spawning biomass simulated forward to equilibrium with fishing (F) or without fishing (noF), and R is recruitment.

SPR, in general, is slightly different than simply dividing equilibrium spawning biomass when fishing by unfished equilibrium spawning biomass because SPR is on a per-recruit basis, thus eliminating the density-dependent effects of the spawner-recruit curve and simply measuring equilibrium spawning potential. In other words, SPR is the relative spawning potential of a recruit when faced with natural and fishing mortalities. SPR-based harvest policies are commonly used in the management of many fisheries around the world, including fisheries under U.S. fishery management council jurisdiction. An $F_{SPR=46\%}$ policy is currently the interim harvest policy at IPHC. Clark (1993) recommended that a $F_{SPR=40\%}$ for groundfish fisheries would maintain a high average yield.

To calculate SPR, the biology of the species (e.g., natural mortality, maturity, etc.), the selectivity for each fishery, and an overall fishing intensity (or fishing intensities for each fishery) are needed. The calculation of SPR always uses the biology and selectivities in the year of interest, thus accounts for changes in these parameters. However, an appropriate SPR for management should be robust to these changes.

This calculation of SPR is called static %SPR by Mace et al. (1996), and we will simply refer to it as SPR. Mace et al (1996) also presented the concept of "transitional SPR", which looks at the impact of fishing on existing cohorts in the stock (those that were present back in time) and thus is more of a retrospective measure, rather than quantifying current or future impacts. We do not consider transitional SPR metrics because those metrics are better suited to determine the level at which a stock has been fished, rather than providing a metric of how the stock is to be fished. The static %SPR (from now on simply called SPR) provides a measure of SPR given the current biological regime, fishery patterns, and a fishing intensity (F_{SPR}). See Mace et al. (1996) for further discussion of the difficulties calculating transitional SPR.

The metrics SPR and F_{SPR} has been reported in previous Pacific halibut assessments and are commonly calculated in many stock assessments around the world. It is a useful metric because it accounts for complex and temporally changing population dynamics and selectivities. It can be thought of as a measure of the spawning potential given fishing under the current conditions.

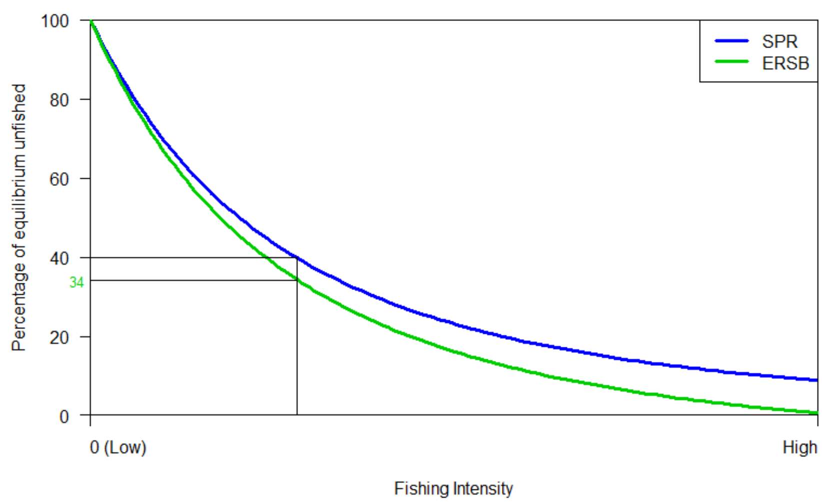

Figure 12: SPR (spawning potential ratio) and ERSB (equilibrium relative spawning biomass) plotted against fishing intensity for a generic equilibrium model with constant recruitment (unweighted SPR) and time-invariant biology and selectivity.

ERSB (Equilibrium Relative Spawning Biomass): the long-term equilibrium relative spawning biomass given a level of fishing. Relative spawning biomass (RSB) is the percentage of equilibrium spawning biomass with fishing ($F_{XX\%}$) relative to that without fishing. ERSB was called ESD, or Equilibrium Stock Depletion, by Cordue (2012), but the term relative spawning biomass is used at the IPHC instead of depletion. The calculation is simply the equilibrium spawning biomass when fishing divided by unfished equilibrium spawning biomass. The calculation uses constant recruitment, and accounts for density-dependence of the stock-recruit relationship. In other words, this is the effect of fishing on the deterministic spawning potential of the stock, which reflects the decline in recruitment as the spawning biomass declines.

$$ERSB = \frac{\widetilde{SB}_F}{\widetilde{SB}_{noF}}$$

where $\widetilde{SB}$ is the spawning biomass simulated forward to equilibrium with fishing (*F*) or without fishing (*noF*). The only difference from SPR is the division by the number of recruits, and ERSB can be easily calculated from SPR using the following equation (with a Beverton-Holt stock-recruit relationship).

$$ERSB = \frac{4hSPR + h - 1}{5h - 1} \qquad (2)$$

where *h* is steepness in the Beverton-Holt stock-recruit relationship. Notice that when steepness is equal to one (constant recruitment at all spawning stock sizes), ERSB is equal to SPR.

As with SPR, when temporal trends are present, the biology and selectivity used when calculating ERSB can affect the outcome. It is proposed to use the current conditions and project forward to determine the equilibrium spawning biomass with and without fishing. This keeps ERSB consistent with SPR and maintains the relationship in Equation (2). However, SPR and ERSB are similar metrics that can be calculated from one another, thus only one should be used for setting fishing intensity. RSB is currently used in the 30:20 control rule of the harvest policy, which may be a useful place in the harvest policy to use ERSB as a translation of the SPR value to a target RSB. However, RSB is slightly different than ERSB because the denominator in RSB is consistently B_0, which does not consider current biological conditions (but defined equilibrium conditions) when calculating. We'll discuss this more in the Control Rule section below.

CONTROL RULE

The control rule is an additional part of the harvest policy that affects the fishing intensity or FCEY. The premise of a control rule is that if the stock declines below a **trigger** reference point (typically measured using stock status) the fishing intensity is reduced, and if the stock declines below a **limit** reference point there is no harvest. This is used to avoid low stock sizes by acting in a precautionary manner when the stock size begins to approach the limit reference point. The current IPHC control rule is called a 30:20 rule because the trigger is 30% RSB and the limit is 20% RSB (Figure 13).

The multiplier can act on the fishing level (i.e., fishing intensity) or the catch (i.e., FCEY), and it would be somewhat straightforward for the fishing intensity to be adjusted. For example, if $F_{SPR=46\%}$was the fishing intensity, the F could be adjusted, or the SPR could be adjusted. The relationship between SPR and FI is nonlinear (Figure 12) thus a linear adjustment to one would result in a nonlinear adjustment to the other. It is most straightforward for the SPR to be adjusted.

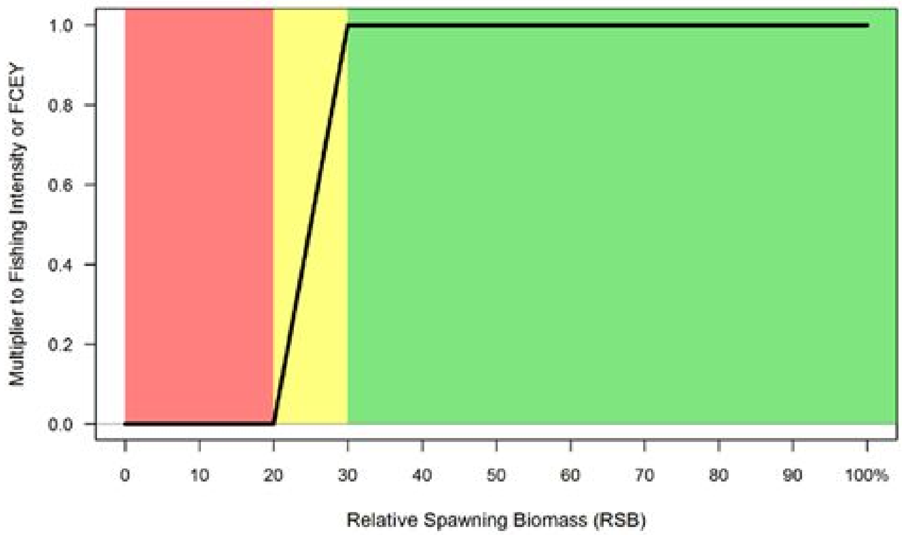

Figure 13: Control rule for the IPHC harvest strategy policy. It is commonly called a 30:20 control rule because the downward adjustment begins at a relative spawning biomass (RSB) of 30% (trigger reference point) and no harvest occurs when the RSB is below 20% (limit reference point). The adjustment may apply to the fishing intensity or to the FCEY.

Adjusting the catch may be more difficult because there are portions of the catch that are not directly controlled by the IPHC. It would be possible to adjust the FCEY, but the other components of the TCEY as well as the U26 mortality would not be adjusted. This also brings up an important point about adjusting the fishing intensity, which defines the total mortality, some of which is not controlled by the IPHC. Therefore, the fishing intensity would not decline to zero when below the limit threshold unless cross-agency management measures were agreed upon.

The current IPHC assessment used RSB to determine stock status with a static unfished equilibrium biomass (B_0), calculated assuming good size-at-age and poor recruitment, as the reference. This static definition has many potential problems. First, it is not necessarily reflective of current conditions. Second, if fishing were to stop and current conditions remained constant, the RSB would not go to one, but could be less than or greater than one. Lastly, a change in conditions could potentially result in a RSB below the trigger even without fishing. In some cases a specific static reference point may be the desired target, but not accounting for current conditions may be misleading when managing a dynamic stock subject to changing conditions.

SPR is currently used to define fishing intensity, which is an equilibrium concept using current conditions. When a target SPR is defined, a target ERSB is also defined (assuming the Beverton-Holt stock-recruit curve and a value for steepness). With a target related to stock status one may also define a trigger and limit in relation to that target (Figure 14). However, the x-axis of the control rule (stock status) should also be based on current conditions instead of a static definition.

A dynamic quantity to define current stock status is needed to be consistent with SPR and ERSB, and could be used to determine at what stock status fishing intensity is reduced. A desirable property for the current status may be that if fishing had not occurred on all age classes in the population, then the calculation of the status would result in a value of one. In other words, the current status would be a measure of the effect of fishing and not include the effect of changing conditions or recent deviations in recruitment. Dynamic B_0 (McCall et al. 1985) is a dynamic calculation of stock status that uses the conditions and recruitment deviations that the stock has recently experienced. It also corrects for the reduction in average recruitment due to the stock-recruit function. This quantity has also been used in tuna assessments (Harley et al 2015).

Using SPR and translating that to ERSB results in consistent equilibrium quantities for fishing intensity and target stock status. Dynamic B_0 is the consistent link to determine the current fishing effect on stock status, which we call dynamic RSB (dRSB). Using these three quantities (SPR, ERSB, and dRSB) provides for a control rule where each component relates to each other in a meaningful way. For example, a stock would be expected to fluctuate around a target ERSB due to natural variability in recruitment. It is likely that dropping below the trigger is not a highly desired state due to a curtailing of fishing effort, and if the trigger was near the target, it would be crossed often due to variability in the population. Setting the trigger less than the target reduces the probability of curtailing fishing effort and builds the stock back to expected levels when the current stock status is lower than desired. However, if the desire is to build back to the target as quickly as possible, a trigger closer to the target may be useful.

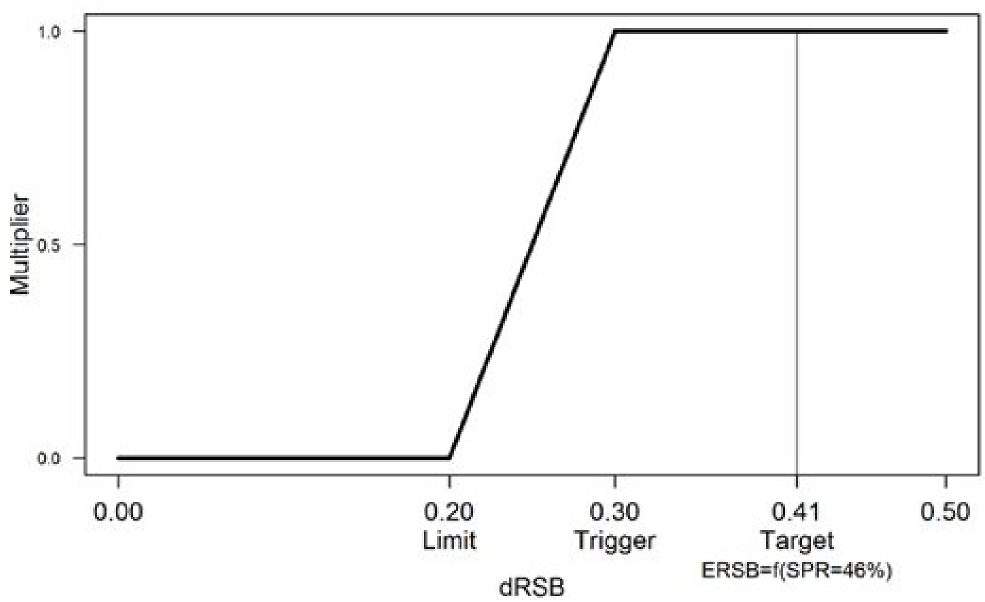

Figure 14: Components of the control rule (expressed as a multiplier on fishing intensity).

A concern may be that in extreme cases where non-fishing related influences result in a static stock status below a trigger, the dynamic approach would not reduce the fishing intensity appropriately to maintain a minimum spawning biomass or spawning abundance. Using SPR to define a fishing intensity helps to alleviate this concern since it determines a relative spawning potential. Even though SPR is based on current conditions, it still maintains a minimum spawning potential.

A consistency between reference points is useful because it helps to relate the different components of the harvest control rule to each other and define meaningful values.

INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC-2018-MSAB011-09

Ideas on estimating stock distribution and distributing catch for Pacific halibut fisheries

PREPARED BY: IPHC SECRETARIAT (A. HICKS & I. STEWART); 19 APRIL 2018

1 PURPOSE

To update the Management Strategy Advisory Board (MSAB) on discussions and ideas related to science inputs and management procedures for distributing the Total Constant Exploitation Yield (TCEY) across the IPHC Convention Area.

2 BACKGROUND

The report from the 94th Session of the IPHC Annual Meeting (AM094) included the following text related to distributing TCEY among the Regulatory Areas (IPHC-2018-AM094-R):

*37. The Commission **REQUESTED** that the objectives related to distributing the TCEY, as detailed in Circular IPHC-2017-CR022, be presented at MSAB11 for further stakeholder feedback.*

*38. The Commission **REQUESTED** that the proposed TCEY distribution methodology of the Harvest Strategy Policy reflect an understanding of both stock distribution and fishery management distribution procedures.*

*39. The Commission **RECOMMENDED** that the IPHC Secretariat consider the survey WPUE grid across the fishery as well as other biological factors (e.g. habitat configuration, size distribution in the region etc.) and provide alternatives to the current management areas (e.g. biological regions), and that the MSAB consider additional ways to incorporate biological information into TCEY distribution procedures.*

*40. The Commission **NOTED** that the current procedure to distribute the TCEY could be replaced by an interim procedure to be developed in the near term while the MSAB completes their Program of Work to deliver guidance in 2021 on scale and TCEY distribution.*

*41, The Commission **AGREED** to meet via an inter-sessional electronic meeting (soon after the AM094), along with the IPHC Secretariat, to discuss TCEY distribution procedures to use in the interim while long-term distribution procedures are being developed by the MSAB. MSAB representatives and the IPHC Secretariat will inform the Commission of what guidance the MSAB may be able to provide to help develop an interim distribution strategy, and how the development of an interim harvest procedure may affect the MSAB's current Program of Work.*

*42. The Commission **AGREED** that distributing the TCEY to regions does not necessarily need to be the first step of the TCEY distribution procedure, and other biological factors, such as habitat and size distribution, be considered.*

*43. The Commission **NOTED** that the work the MSAB has already completed on distribution procedures may help to inform the development of an interim distribution strategy. MSAB representatives and the IPHC Secretariat will advise the Commission of how this may affect their current Program of Work, and what guidance they may be able to provide to help develop an interim distribution strategy.*

The report from the 10th meeting of the Management Strategy Advisory Board (MSAB) in October 2017 included the following related to distributing the TCEY:

37. ***NOTING*** *the order of operations in the proposed TCEY distribution procedure, the MSAB AGREED that the order of stock distribution and TCEY distribution procedures is a management choice that could be evaluated.*
38. *The MSAB* ***NOTED*** *that the order of operations in the proposed TCEY distribution procedure will be subject to review at future MSAB meetings and that the specific components require further definition.*
39. *The MSAB* ***AGREED*** *that the output of the TCEY distribution procedure should be a catch table describing mortality in each IPHC Regulatory Area.*

This document expands on previous MSAB meeting papers IPHC-2017-MSAB09-09 and IPHC-2017-MSAB10-10, to report progress on the topic of distributing the TCEY.

3 DEFINITIONS AND A DESCRIPTION OF THE PROPOSED IPHC HARVEST STRATEGY POLICY

A considerable amount of discussion related to a description of the harvest strategy policy occurred at previous MSAB meetings. Figure 1 shows an updated depiction of the harvest strategy policy with terms describing the various components. These terms are defined in the IPHC glossary[1], but of note for this paper are TCEY distribution, stock distribution, and distribution procedures. The management procedure is the sequence of elements including the assessment, fishing intensity, stock distribution, and distribution procedures. The goal of the MSAB is to define a management procedure that will be used to output O26 mortality limits for each Regulatory Area that meet the long-term objectives of managers and stakeholders. The "decision" step on the right of Figure 1 is where a deviation from the management procedure may occur due to input from other sources and decisions of the Commissioners that may reflect current biological, environmental, social, and economic conditions.

4 A BACKGROUND ON THE DISTRIBUTION OF THE TCEY

As tasked by the Commission, an evaluation of the previous IPHC informal 'harvest policy' was undertaken and presented at MSAB08. That harvest policy used a procedure that took the coastwide stock assessment as an input, and output 1) the coastwide Total Constant Exploitation Yield (TCEY) (across all Regulatory Areas), and 2) the TCEY and Fishery Constant Exploitation Yield (FCEY) for each Regulatory Area. The integral input to that harvest policy was the coastwide stock assessment. The scaling of catch for that harvest policy revolved around the concept of exploitable biomass (EBio) and defined harvest rates. EBio was based on numbers-at-age, weight-at-age, and externally derived selectivity-at-age.

Given the complex but static definition of EBio, there was a divergence between EBio and the assessment which updated selectivity each year, and later allowed it to vary over time. In other words, EBio was not representative of the stock assessment results because the selectivity curves used to define EBio were out of date. It is difficult to exactly characterize what EBio is because it is a single value meant to describe a

[1] https://iphc.int/the-commission/glossary-of-terms-and-abbreviations

complex amalgamation of fleets, areas, stock size, and size-at-age. Ebio was not the biomass of fish over 26 inches (O26, 66 cm) or 32 inches (O32, 81 cm), and it was not the biomass of the stock that is encountered by the fisheries.

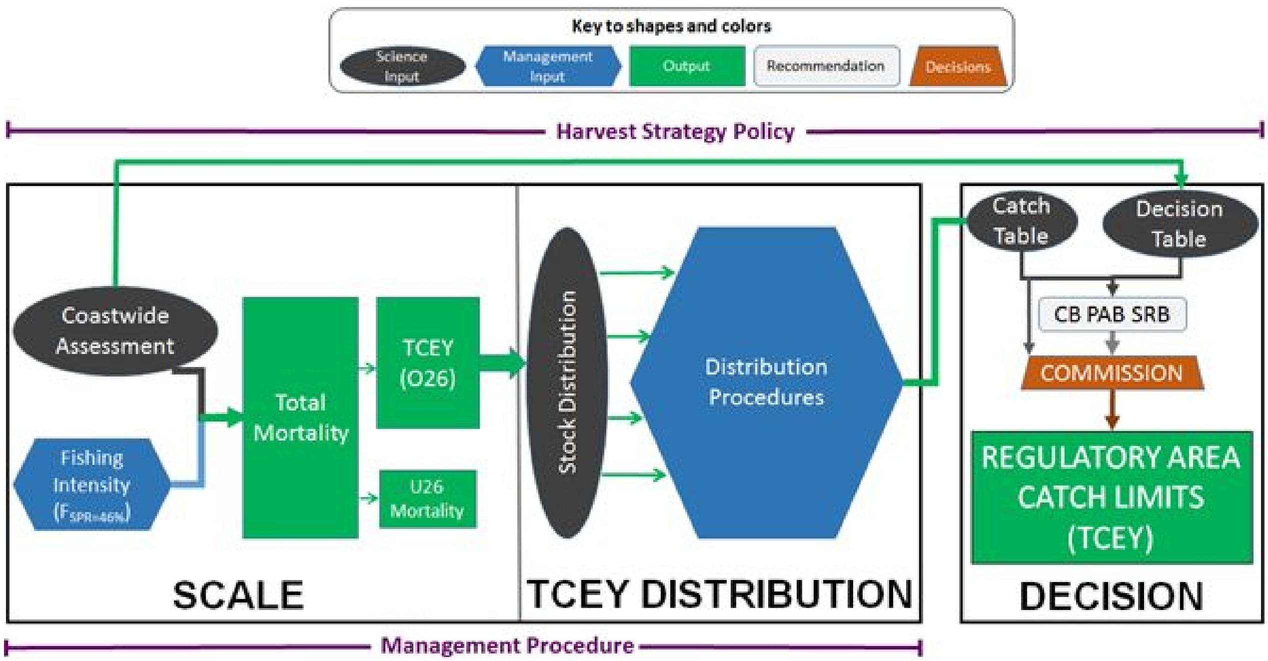

Figure 1: A revised harvest strategy policy showing the separation of scale and distribution of fishing mortality. The decision step is when policy (not a procedure) influences the final outcome.

Ebio was apportioned to IPHC Regulatory Areas using the estimated distribution of O32 biomass from the setline survey. Then, IPHC Regulatory Area-specific catch levels (TCEY) were calculated from defined harvest rates. A harvest rate of 16.125% was used for western areas (3B, 4A, 4B, and 4CDE) and 21.5% for eastern areas (3A, 2C, 2B, and 2A). These harvest rates were based on the selection of O26 fish for TCEY (Hare 2011) and were converted from values originally based on O32 fish, reflecting the size limit (Clark and Hare 2006). They were lower in the west due to the presence of small fish, a lower estimated yield-per-recruit, and greater uncertainty in historical analyses. These harvest rates were explicitly linked to EBio.

In 2017, the Commission agreed to move to an SPR-based management procedure to account for the mortality of all sizes and from all fisheries. The procedure uses a coastwide fishing intensity based on spawning potential ratio (SPR), which defines the “scale” of the coastwide catch. This eliminates the use of EBio and area-specific absolute harvest rates. Therefore, there are currently two inputs to the current management procedure for distributing the TCEY among IPHC Regulatory Areas: 1) the current estimated stock distribution and 2) relative target harvest rates.

4.1 A Background on Stock Distribution

The IPHC uses a space-time model to estimate annual Weight-Per-Unit-Effort (WPUE) for use in estimating the annual stock distribution of Pacific halibut (Webster 2018). Briefly, observed WPUE is fitted with a model that accounts for correlation between setline survey stations over time (years) and space (within Regulatory Areas). Competition for hooks by Pacific halibut and other species, the timing of the setline survey relative to annual fishery mortality, and observations from other fishery-independent surveys are also accounted for in the approach. This fitted model is then used to predict WPUE (relative density) of Pacific halibut for every setline survey station in the design (including all setline survey expansion stations), regardless of whether it was fished in a particular year. These predictions are then averaged within each IPHC Regulatory Area, and combined among IPHC Regulatory Areas, weighting by the 'geographic extent' (calculated area within the survey design depth range) of each IPHC Regulatory Area. It is important to note that this produces relative indices of abundance and biomass, but does not produce an absolute measure of abundance or biomass because it is weight-per-unit-effort scaled by the geographic extent of each IPHC Regulatory Area. These indices are useful for determining trends in stock numbers and biomass, and are also useful to estimate the geographic distribution of the stock.

This method for estimating the stock distribution has been used (first with a design-based estimator from 2008–2016, and subsequently with the space-time model in 2016 and 2017) since 2008, following the adoption of a coastwide stock assessment. There have been several workshops and reviews dedicated to evaluating the use of fishery-independent data for estimating stock distribution (IPHC 2008, 2009, 2010), with the most recent review by the IPHC's Scientific Review Board (SRB) in September 2013 (Cox et al. 2014). That review concluded that the method was imperfect, but should be unbiased, when responding to whether it represented a "scientifically objective" estimate of stock distribution. They further noted that selection of catch targets other than those based purely on biology "involves choices and trade-offs that are beyond the scope of purely science-based decision-making".

For 2018 harvest advice (IPHC-2018-AM094-11 Rev_1), the estimated stock distribution was based on the IPHC space-time model output of O32 Pacific halibut WPUE and provided an estimate of the proportion of the O32 portion of the stock in each IPHC Regulatory Area. These proportions were revised from 2016 estimates (Figure 2), indicating a larger proportion of the coastwide stock in Regulatory Areas 2C, 3A, 4A, 4B, and 4CDE in 2017 and a smaller proportion in 2A, 2B, and 3B (Table A1, Appendix A). The estimated stock distribution (proportions in each IPHC Regulatory Area) was then used to distribute the TCEY in accordance with the estimated distribution of the stock.

4.2 Using Relative Harvest Rates

The distribution of the TCEY for 2018 was shifted from the estimated stock distribution to account for additional factors related to productivity and paucity of data in each IPHC Regulatory Area. Previously, this was accomplished by applying different harvest rates in western areas (16.125% in IPHC Regulatory Areas 3B, 4A, 4B, and 4CDE)) and eastern areas (21.5% in IPHC Regulatory Areas 2A, 2B, 2C, and 3A). However, with the elimination of EBio and the use of SPR-based fishing intensity to determine the coastwide scale, the TCEY, rather than the esoteric concept of exploitable biomass was distributed. Therefore, an absolute measure of harvest rate is not necessary, but it may still be desired to shift the distribution of the TCEY away from the estimated stock distribution to account for other factors. Consistent with the previous approach, relative harvest rates were used with a ratio of 1.00:0.75, being equal to the ratio between 21.5% and 16.125%. This application shifted the target TCEY distribution away from the stock distribution by moving more TCEY into IPHC Regulatory Areas 2A, 2B, 2C, and 3A and less TCEY from IPHC Regulatory Areas 3B, 4A, 4B, and 4CDE (Table 1), thus harvesting at a higher rate in eastern IPHC Regulatory Areas.

Table 1: IPHC Regulatory Area stock distribution estimated from the 2017 space-time model O32 WPUE, IPHC Regulatory Area-specific relative target harvest rates, and resulting 2018 target TCEY distribution based on the IPHC's 2018 interim management procedure (reproduced from Table 1 in IPHC-2018-AM094-11 Rev_1).

	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
O32 stock distribution	1.7%	11.3%	16.6%	35.6%	10.0%	6.6%	4.8%	13.3%	100.0%
Relative harvest rates	1.00	1.00	1.00	1.00	0.75	0.75	0.75	0.75	--
Target TCEY Distribution	1.9%	12.4%	18.2%	38.9%	8.2%	5.4%	3.9%	10.9%	100.0%

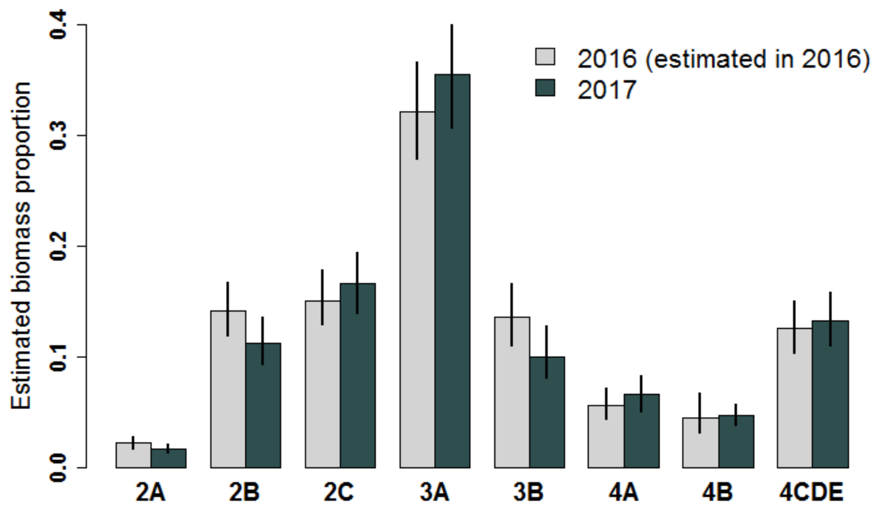

Figure 2: Estimated stock distribution based on setline survey catch of O32 Pacific halibut as estimated in 2016, and as estimated in 2017. Vertical lines indicate 95% credible intervals.

5 REDEFINING THE TCEY DISTRIBUTION PROCEDURE

TCEY distribution is the part of the management procedure for distributing the TCEY among Regulatory Areas and is composed of a purely scientific component to distribute the TCEY in proportion to its estimated biomass in each area (stock distribution) and steps to further modify the distribution of the TCEY based on additional considerations (distribution procedures). Those two components are described below.

5.1 REDEFINING STOCK DISTRIBUTION

Emerging understanding of biocomplexity across the geographic range of the Pacific halibut stock indicates that IPHC Regulatory Areas should only be considered as management units and do not represent relevant sub-populations (Seitz et al. 2017). Balancing the removals against the current stock distribution is likely to protect against localized depletion of spatial and demographic components of the stock that may produce differential recruitment success under changing environmental and ecological conditions. This concept of distributing harvest in proportion to stock distribution is widely recognized in fisheries management, particularly among salmon stocks (*portfolio effect*: Hilborn et al 2003; Schindler et al 2010). This approach provides an additional precautionary buffer against spatial recruitment overfishing and may maintain sub-population structure that is not completely understood, but important to the long-term health of the coastwide population.

The structure of two of the four current Pacific halibut stock assessment models are 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 a recommended model to include in the ensemble during the SRB review of models developed in 2014 (Cox et al. 2016, Stewart and Martell 2015, 2016).

Biological Regions were defined with boundaries that matched some of the IPHC Regulatory Area boundaries for the following reasons. First, data (particularly historical 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 Area 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. 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, and movement occurs among Biological Regions. However, if the goal is to preserve biocomplexity across the entire range of the Pacific halibut stock, Biological Regions are considered by the IPHC Secretariat to be the best option for biologically-based areas to meet management needs.

Each Biological Region has some qualities that identified it as being separate, to a certain degree, biologically from adjacent Biological Regions, despite evidence from tagging studies of movement by

Pacific halibut among all IPHC Regulatory Areas at some point in its life-cycle (Valero and Webster 2012; Webster et al 2013). These qualities include sex ratios, age composition, size-at-age, and historical trends in those data that could be indicative of biological diversity within the greater Pacific halibut population. The four Regions are labeled as follows and composed of the listed IPHC Regulatory Areas (Figure 3):

Region 2: 2A, 2B, and 2C
Region 3: 3A and 3B
Region 4: 4A and 4CDE
Region 4B: 4B

Trends over the last five years (2013–2017) indicate that population distribution, measured either via O32 or all sizes estimated WPUE of Pacific halibut from the space-time model, have been relatively stable (Figure 4 and Appendix A). However, over the time-period 1993–2017 (setline survey data prior to 1993 is insufficient to provide stock distribution estimates) there has been an increasing proportion of the coastwide stock occurring in Region 2 and a decreasing proportion occurring in Region 3. It is unknown to what degree either of these periods corresponds to historical distributions from the mid-1900s or to the average distribution likely to occur in the absence of fishing mortality.

In summary, the overall conservation goal for Pacific halibut is to maintain a healthy coastwide stock. However, given the wide geographic range of the Pacific halibut stock, there likely is stock structure that we do not fully understand and this stock structure may be important to coastwide stock health. Therefore, conservation objectives relate to where harvesting occurs, with an objective to retain viable spawning activity in all portions of the stock. One method for addressing this objective is to distribute the fishing mortality relative to the distribution of observed stock biomass. This requires defining appropriate areas for which the distribution is to be conserved. Splitting the coast into many small areas for conservation objectives can result in complications including being cumbersome to determine if conservation objectives are met, being difficult to accurately determine the proportion of the stock in that area, being subject to inter-annual variability in estimates of the proportion, forcing arbitrary delineation among areas with evidence of strong stock mixing, and not being representative of biological importance. Therefore, Biological Regions represent the most logical scale over which to consider conservation objectives related to distribution of the fishing mortality. Adjusting the distribution of the TCEY among Biological Regions to account for additional considerations, and further distributing the TCEY to IPHC Regulatory Areas would be done through steps defined in the Distribution Procedures component (Figure 5).

In addition to using Biological Regions for stock distribution, the “all sizes” WPUE from the space-time model (Table A2, Appendix A), which is largely composed of O26 Pacific halibut (due to selectivity of the setline gear), is more congruent with the TCEY (O26 catch levels) than O32 WPUE. Therefore, when distributing the TCEY to Biological Regions, the estimated proportion of “all sizes” WPUE from the space-time model should be used for consistency.

5.2 Distribution Procedures

Distribution Procedures contains the steps of further modifying the distribution of the TCEY among Biological Regions and then distributing the TCEY among IPHC Regulatory Areas within Biological Regions (Figure 5). For example, modifications at the Biological Region or IPHC Regulatory Area level may be based on differences in production between areas, observations in each area relative to other areas (e.g., WPUE), uncertainty of data or mortality in each area, defined allocations, or national shares. Data may be used as indicators of stock trends in each Region or IPHC Regulatory Area, and are included in the Distribution Procedures component because they may be subject to certain biases and include factors that may be unrelated to biomass in that Biological Region or IPHC Regulatory Area. For example, commercial WPUE is a popular source of data used to indicate trends in a population, but may not always be proportional to biomass. Types of data may be used include fishery WPUE, survey observations (not necessarily the IPHC fishery-independent setline survey), age-compositions, size-at-age, and environmental observations.

The steps in the Distribution Procedures may consider conservation objectives, but they will mainly be developed with respect to fishery objectives. Yield and stability in catch levels are two important fishery objectives that often contradict each other (i.e. higher yield often results in less stability). Additionally, area-specific fishery objectives may be in conflict across IPHC Regulatory Areas. Pacific halibut catch levels are defined for each IPHC Regulatory Area and quota is accounted for by those Regulatory Areas. Therefore, IPHC Regulatory Areas are the appropriate scale to consider fishery objectives.

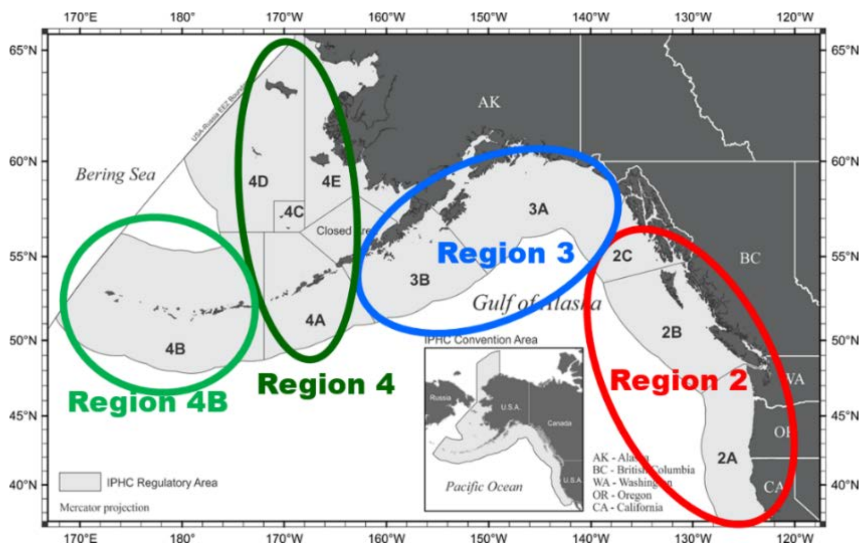

Figure 3: Biological Regions overlaid on IPHC Regulatory Areas with Region 2 comprised of 2A, 2B, and 2C, Region 3 comprised of 3A and 3B, Region 4 comprised of 4A and 4CDE, and Region 4B comprised solely of 4B.

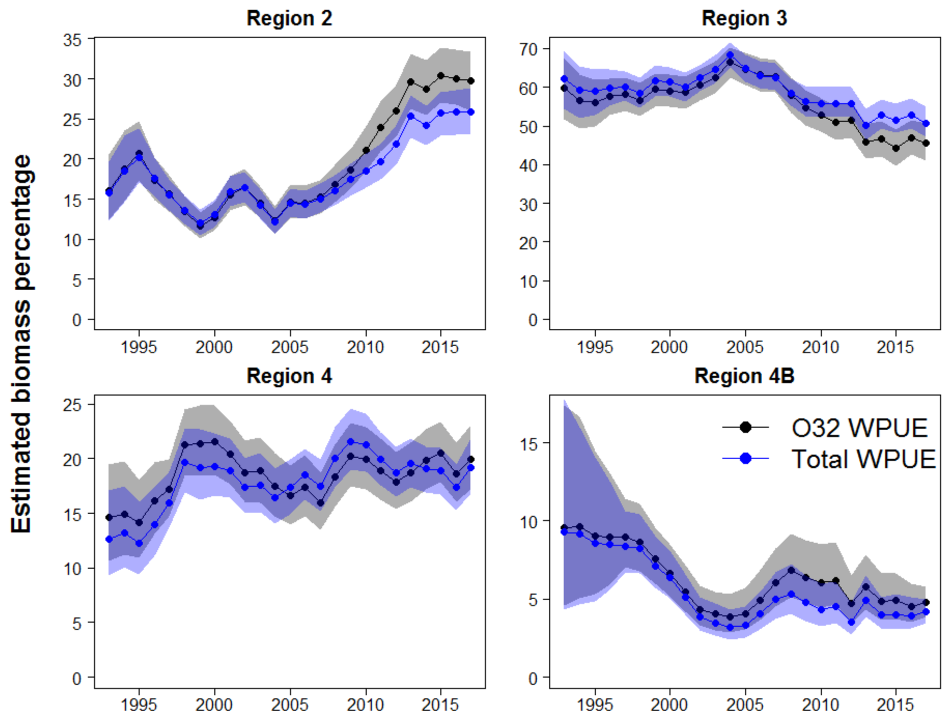

Figure 4: Estimated stock distribution (1993-2017) based on estimate WPUE from the space-time model of O32 (black series) and all sizes (blue series) of Pacific halibut. Shaded zones indicate 95% credible intervals.

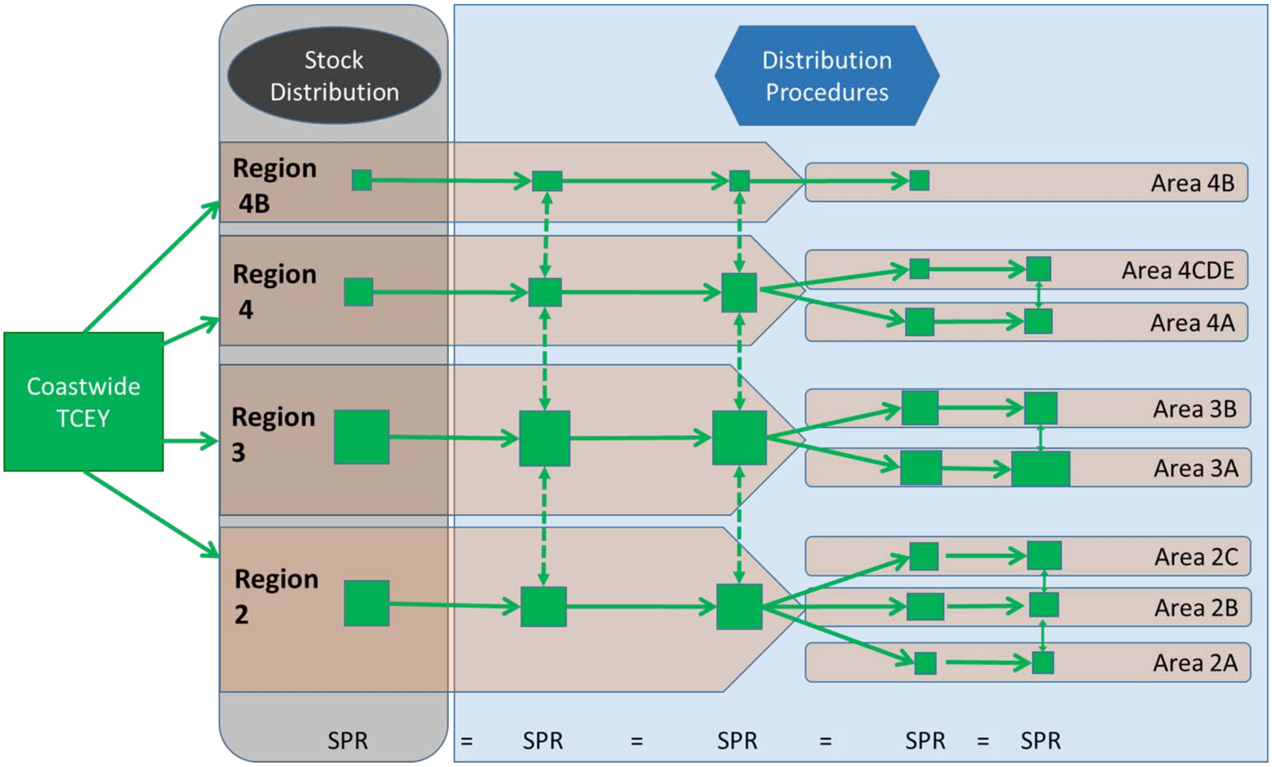

Figure 5: The process of distributing the TCEY to Regulatory Areas from the coastwide TCEY. The first step is to distribute the TCEY to Biological Regions based on the estimate of stock distribution. Following this, a series of adjustments may be made based on observations or social, economic, and other considerations. Finally, the adjusted regional TCEY's are allocated to IPHC Regulatory Areas. The allocation to IPHC Regulatory Areas may occur at any point after regional stock distribution. The dashed arrows represent balancing that is required to maintain a constant coastwide SPR.

6 A Summary of the Management Procedure for Distributing TCEY Across the Coast

The harvest strategy policy begins with the coastwide TCEY determined from the stock assessment and fishing intensity determined from a target SPR (Figure 1). When distributing the TCEY among regions, stock distribution occurs first to distribute the harvest in proportion to biomass and satisfy conservation objectives, and then is followed by adjustments across Regions and Regulatory Area based on distribution procedures to further encompass conservation objectives and consider fishery objectives. The key to these adjustments is that they are relative adjustments such that the overall fishing intensity (target SPR) is maintained (i.e., a zero sum game). Otherwise, the procedure is broken and it is uncertain if the defined objectives will be met.

A framework for a management procedure that ends with the TCEY distributed among IPHC Regulatory Areas and would encompass conservation and fishery objectives is described below.

1. **Coastwide Target Fishing Intensity:** Determine the coastwide total mortality using a target SPR that is most consistent with IPHC objectives defined by the Commission. Separate the total mortality in ≥26 inches (O26) and under 26 inches (U26) components. The O26 component is the coastwide TCEY.
   1.1. Target SPR is scheduled for evaluation at the 2019 Annual Meeting. The current interim target SPR is 46%.
2. **Regional Stock Distribution:** Distribute the coastwide TCEY to four (4) biologically-based Regions using the proportion of the stock estimated in each Biological Region for all sizes of Pacific halibut using information from the IPHC setline survey and the IPHC space-time model.
   2.1. Four Regions (2, 3, 4, and 4B) are defined above (Figure 3).
3. **Regional Allocation Adjustment:** Adjust the distribution of the TCEY among Biological Regions to account for other factors.
   3.1. For example, relative target harvest rates are part of a management/policy decision that may be informed by data and observations. 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 biological characteristics of the Pacific halibut observed in each Biological Region. The IPHC Secretariat may be able to provide Yield-Per-Recruit (YPR) and/or surplus production calculations as further supplementary information for this discussion. The regional relative harvest rates may also be determined through negotiation, which is simply an allocation agreement for further Regional adjustment of the TCEY.
4. **Regulatory Area Allocation:** Apply IPHC Regulatory Area allocation percentages within each Biological Region to distribute the Region-specific TCEY's to Regulatory Areas.
   4.1. This part represents a management/policy decision, and may be informed by data, based on past or current observations, or defined by an allocation agreement. For example, recent trends in estimated all sizes WPUE from the setline survey or fishery, 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, agreed upon percentages are also an option. This allocation to IPHC Regulatory Areas may be a procedure with multiple adjustments using different data, observations, or agreements

The four steps described above would be contained within the IPHC Harvest Strategy Policy as part of the Management Procedure, and are pre-determined steps that have a predictable outcome. The decision making process would then occur (Figure 1).

5. **Seasonal Regulatory Area Adjustment**: Adjust individual Regulatory Area TCEY limits to account for other factors as needed. This is the policy part of the harvest strategy policy and occurs as a final step where other objectives are considered (e.g. economic, social, etc.).
   5.1. Departing from the target 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 may result in unpredictable outcomes, but could also take advantage of current situations.

7 RECOMMENDATION/S

That the Management Strategy Advisory Board:

1) **NOTE** paper IPHC-2018-MSAB011-09 which describes the distribution of the TCEY component of a harvest strategy policy and continues a discussion about a framework and alternatives to distribute the TCEY.
2) **CONSIDER** the potential definitions and terms used to describe the harvest strategy policy, and in particular the TCEY distribution component containing the separation of stock distribution and distribution procedures.
3) **CONSIDER** how the TCEY distribution framework could meet conservation objectives, particularly the objective of maintaining a healthy coastwide stock.
4) **CONSIDER** how the TCEY distribution framework could meet fishery objectives, particularly the objective to maintain an economically sufficient level of catch across regulatory areas.

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Appendix A
Time-Series of Estimated Stock Distribution

Table A1: Time-series of stock distribution based on O32 WPUE estimated from the space-time model by IPHC Regulatory Area (net lb/skate).

Year	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
1993	1.6%	7.0%	7.4%	35.1%	24.7%	9.1%	9.5%	5.5%	100.0%
1994	1.5%	8.8%	8.6%	31.7%	25.0%	9.6%	9.6%	5.3%	100.0%
1995	1.3%	10.1%	9.3%	31.2%	24.9%	9.1%	9.0%	5.1%	100.0%
1996	1.3%	8.1%	8.0%	30.2%	27.4%	10.0%	9.0%	6.1%	100.0%
1997	1.3%	6.2%	8.1%	33.4%	24.8%	10.9%	9.0%	6.3%	100.0%
1998	1.4%	5.2%	6.9%	27.0%	29.7%	13.6%	8.6%	7.6%	100.0%
1999	1.4%	4.4%	5.8%	26.0%	33.4%	13.3%	7.5%	8.1%	100.0%
2000	1.4%	5.3%	6.1%	30.8%	28.3%	13.0%	6.6%	8.6%	100.0%
2001	1.4%	6.7%	7.5%	33.0%	25.6%	11.2%	5.4%	9.2%	100.0%
2002	1.1%	6.8%	8.5%	39.0%	21.6%	10.4%	4.3%	8.3%	100.0%
2003	1.1%	5.5%	7.8%	37.9%	24.7%	10.1%	4.0%	8.8%	100.0%
2004	1.3%	5.3%	5.7%	45.0%	21.4%	9.2%	3.8%	8.3%	100.0%
2005	1.5%	6.1%	7.1%	46.1%	18.6%	9.0%	4.1%	7.5%	100.0%
2006	1.3%	6.2%	7.0%	42.7%	20.5%	8.3%	4.9%	9.1%	100.0%
2007	1.2%	6.8%	7.2%	42.0%	20.8%	7.7%	6.0%	8.2%	100.0%
2008	1.3%	7.9%	7.6%	39.6%	18.4%	9.1%	6.8%	9.2%	100.0%
2009	1.1%	10.0%	7.5%	35.5%	19.3%	9.4%	6.4%	10.8%	100.0%
2010	1.6%	11.2%	8.3%	36.0%	16.8%	8.6%	6.1%	11.3%	100.0%
2011	2.0%	11.6%	10.4%	36.1%	14.8%	8.1%	6.2%	10.8%	100.0%
2012	1.7%	12.1%	12.1%	38.1%	13.4%	7.4%	4.7%	10.5%	100.0%
2013	1.9%	13.6%	14.2%	32.9%	13.0%	6.8%	5.8%	11.9%	100.0%
2014	2.0%	12.9%	13.9%	34.2%	12.3%	7.0%	4.9%	12.8%	100.0%
2015	2.4%	14.1%	13.9%	31.1%	13.1%	6.8%	4.9%	13.7%	100.0%
2016	2.0%	13.2%	14.8%	33.5%	13.3%	6.0%	4.5%	12.6%	100.0%
2017	1.7%	11.3%	16.6%	35.6%	10.0%	6.6%	4.8%	13.3%	100.0%

Table A2: Time-series of stock distribution based on all-sizes WPUE estimated from the space-time model by IPHC Regulatory Area (net lb/skate)

Year	2A	2B	2C	3A	3B	4A	4B	4CDE	Total
1993	1.7%	7.0%	7.0%	36.9%	25.4%	5.9%	9.3%	6.8%	100.0%
1994	1.6%	8.8%	8.0%	33.7%	25.5%	6.6%	9.2%	6.6%	100.0%
1995	1.5%	10.3%	8.5%	33.7%	25.3%	6.7%	8.6%	5.6%	100.0%
1996	1.4%	8.3%	7.9%	32.2%	27.7%	8.3%	8.5%	5.6%	100.0%
1997	1.3%	6.2%	8.0%	35.2%	25.0%	10.8%	8.3%	5.2%	100.0%
1998	1.4%	5.3%	6.9%	28.0%	30.5%	13.4%	8.2%	6.3%	100.0%
1999	1.4%	4.7%	6.0%	27.1%	34.5%	12.6%	7.1%	6.5%	100.0%
2000	1.3%	5.4%	6.3%	32.6%	28.7%	12.3%	6.3%	6.9%	100.0%
2001	1.4%	6.8%	7.7%	34.2%	25.9%	11.4%	5.1%	7.5%	100.0%
2002	1.1%	6.8%	8.5%	40.2%	22.2%	10.3%	3.9%	7.0%	100.0%
2003	1.0%	5.5%	7.7%	38.0%	26.6%	9.8%	3.5%	7.8%	100.0%
2004	1.1%	5.2%	5.8%	44.5%	23.8%	8.9%	3.2%	7.5%	100.0%
2005	1.3%	6.2%	7.0%	44.9%	19.9%	9.0%	3.3%	8.4%	100.0%
2006	1.1%	6.2%	7.0%	41.4%	21.7%	8.1%	4.0%	10.4%	100.0%
2007	1.0%	7.0%	7.1%	40.3%	22.2%	7.8%	5.0%	9.7%	100.0%
2008	1.1%	7.7%	7.3%	37.5%	21.1%	9.6%	5.3%	10.4%	100.0%
2009	0.9%	9.3%	7.3%	34.7%	21.5%	10.1%	4.8%	11.5%	100.0%
2010	1.2%	9.7%	7.6%	36.0%	19.9%	9.0%	4.3%	12.3%	100.0%
2011	1.5%	9.4%	8.8%	37.5%	18.3%	8.1%	4.5%	11.9%	100.0%
2012	1.4%	10.3%	10.2%	39.4%	16.5%	7.6%	3.5%	11.1%	100.0%
2013	1.5%	11.9%	11.9%	34.3%	15.8%	6.9%	4.9%	12.8%	100.0%
2014	1.5%	11.2%	11.5%	37.6%	15.1%	6.8%	4.0%	12.3%	100.0%
2015	1.9%	12.1%	11.7%	36.3%	15.1%	6.6%	4.0%	12.2%	100.0%
2016	1.7%	11.8%	12.4%	36.6%	16.2%	5.8%	3.9%	11.6%	100.0%
2017	1.4%	9.9%	14.6%	38.1%	12.6%	7.0%	4.2%	12.3%	100.0%

IPHC Secretariat Program of Work for MSAB Related Activities 2019-23

PREPARED BY: IPHC SECRETARIAT (A. HICKS); 07 APRIL 2018

PURPOSE

To update the IPHC Program of Work for MSAB related activities for the period 2019-23.

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. The order of the tasks in this work plan represents the sequential development of each task, and many subsequent tasks are dependent on the previous tasks.

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://iphc.int/the-commission/glossary-of-terms-and-abbreviations

MANAGEMENT STRATEGY EVALUATION (MSE)

Management Strategy Evaluation (MSE) is a process to evaluate alternative management strategies. This process 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 halibut population with those management procedures,
4. evaluating and presenting the results in a way that examines trade-offs,
5. applying a chosen management procedure, and
6. repeating this process in the future in case of changes in objectives, assumptions, or expectations.

Figure 1 shows these different components and that the process is not necessarily a sequential process, but there may be movement back and forth 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.

BACKGROUND

Many important tasks have been completed or started and much of the work proposed will use past accomplishments to further the Management Strategy Evaluation (MSE) process. The past accomplishments include:

1. Familiarization with the MSE process.
2. Defining goals for the halibut fishery and management.
3. Developing objectives and performance metrics from those goals.
4. Development of an interactive tool (the Shiny application).

5. Discussions about coast-wide (single-area) and spatial (multiple-area) models.
6. Presentation of preliminary results investigating fishing intensity.
7. Discussions of ideas for distributing the TCEY to Regulatory Areas.

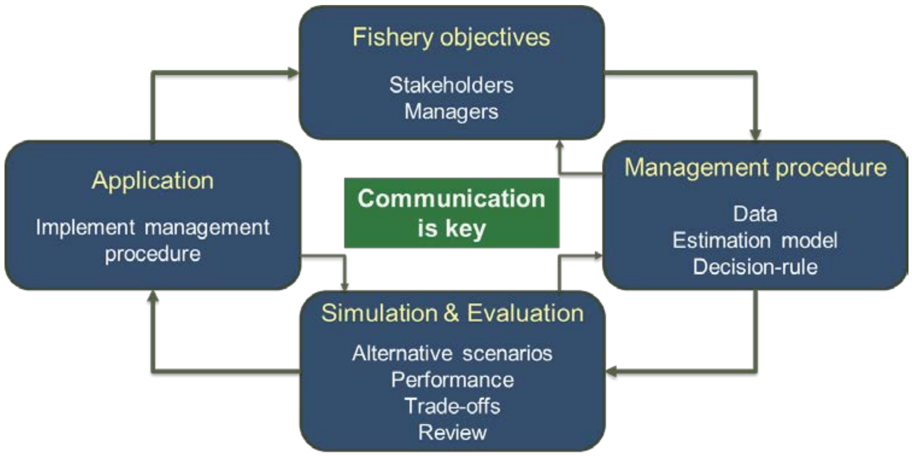

Figure 1: A depiction of the Management Strategy Evaluation (MSE) process showing the iterative nature of the process with the possibility of moving either direction between most components.

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 addressed, 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 and coding models, running simulations, reporting results, and making decisions. Along the way, there will be useful outcomes that may be used to improve existing management, and will influence recommendations for future work.

Overall, the plan is to use what has already been learned to continue making progress on the investigation of management strategies.

MAIN TASKS FOR THE NEXT 1-2 YEARS

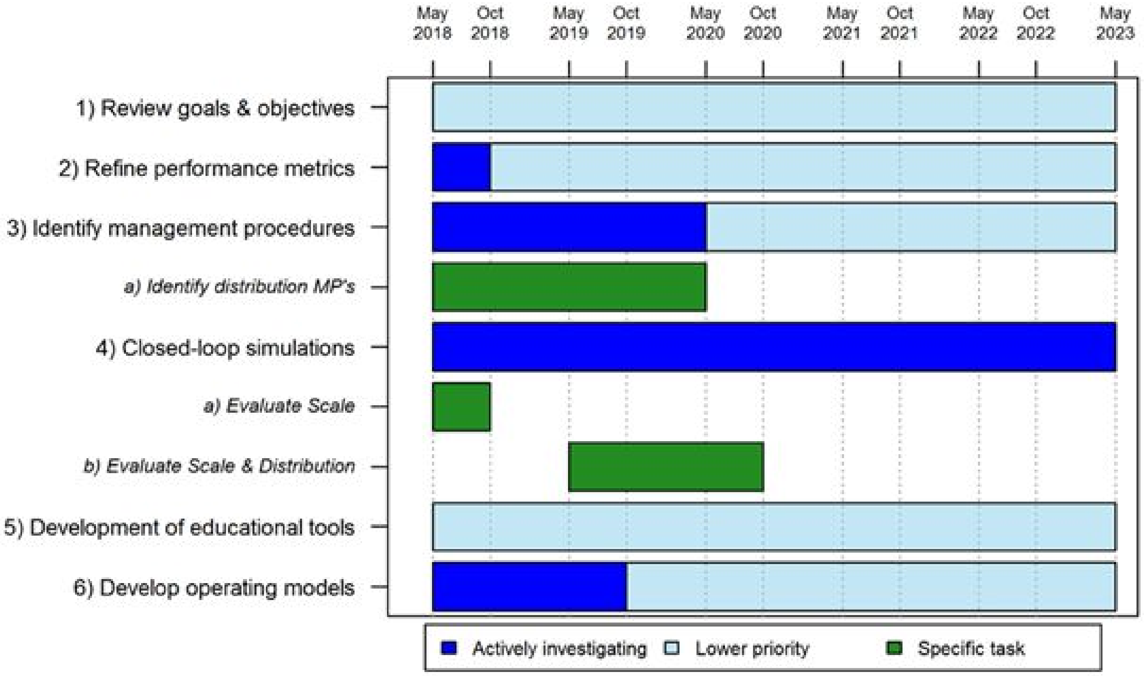

Figure 2: Gantt chart for the five-year work plan. Tasks are listed as rows. Dark blue indicates when the major portion of the main tasks work will be done. Light blue indicates when preliminary or continuing work on the main tasks will be done. Dark green indicates when the work on specific sub-topics will be done and light green shows when continuing work will be done. The end of the dark color shows when those results will be presented.

Task 1. VERIFY THAT GOALS ARE STILL RELEVANT AND FURTHER DEFINE OBJECTIVES

Timeline: Ongoing

Deliverables: A list of goals important to the management of the halibut fishery, and a set of measureable objectives associated with those goals.

Relevance: Relevant goals and measureable objectives are essential to the MSE process. They are necessary to determine what types of models are needed and how to evaluate the management strategies.

Resources: Time to review past meetings, MSAB members to confirm and verify intent of existing goals and objectives, MSAB members to assist in the development of additional goals and objectives, MSAB members to assist with the development of measureable objectives and performance metrics.

Relation to other tasks: Defining goals and objectives is critical to developing useful performance metrics (Task 2), determining applicable management procedures (Task 3), and identifying the complexity needed in the operating model (Task 6).

Description: A very important part of the MSE process is to define goals (aspirational and realistic) and turn those into measureable objectives. The first step is to define a set of goals that are important to stakeholders and managers, which has been done at past MSAB meetings. It is important to verify that these aspirations are still of interest to all MSAB members, and to determine if additional goals should be added to the list. Currently, there are five overarching goals.

1. Biological sustainability
2. Fishery (all directed fisheries) sustainability and stability
3. Assurance of access – minimize probability of fishery closures
4. Minimize bycatch mortality
5. Serve consumer needs

Measurable objectives can then be defined from these goals. Measurable objectives are objectives that have

1. an *outcome* (a specific and measurable description of what is desired),
2. a *time frame* (over what period of time is this outcome desired, which can be how far in the future and/or over a period of years), and
3. a *probability* (the tolerance for failure).

An example of defining a measureable objective may be to take the goal "assurance of access – minimize probability of fishery closures, and define the measureable objective as the predicted spawning biomass from the assessment is less than 20% of unfished equilibrium spawning biomass (*outcome*) over a ten-year period far in the future (*time frame* incorporating both components) no more than 5% of the time (*probability*).

These measurable objectives are then used to define a performance metric that is used to evaluate alternative management strategies. Measureable objectives can also be used to develop the specifics of a MSE simulation framework. For example, what spatial resolution is needed to evaluate the objectives (e.g., coast-wide single area vs. spatial operating model). The development of measureable objectives may be iterative, in that they may be revised as the MSE evolves and more is understood about the relative performance of various management procedures.

Task 2. DEVELOP PERFORMANCE METRICS TO EVALUATE OBJECTIVES

Timeline: October 2018 and ongoing

Deliverables: A list of performance metrics that would be informative to stakeholders, managers, and scientists to effectively evaluate the performance of different management strategies and the trade-offs between them.

Relevance: The performance metrics are the key to evaluating management strategies and communicating outcomes to stakeholders. Determining important metrics and finding ways to present them effectively will help with the interpretation of the MSE results.

Resources: Time to review past meetings, MSAB members to confirm and verify current metrics, MSAB members to assist with the development of various performance metrics.

Relation to other tasks: Performance metrics are the key to presenting results from the management strategy evaluations and will be used in the outcomes from Task 4 (Closed-loop simulation programming).

Description: Measurable objectives guide the development of the simulation framework for a MSE, and performance metrics are needed to gauge the performance of a management strategy relative to those objectives. For example, a measurable objective may be to keep the average catch above a specific amount (the *outcome*), in the long-term over a 10-year period (the *time frame*), at least 95% of the time (the *probability*). The performance metric, framed as a risk, could then be the probability that the average catch was less than that level in this time period (average here refers to the average over the 10-year period and the probability accounts for the many replicated simulations). Another example is that a potential aspirational goal would be to have stability in yield, which could be translated to a measurable objective as keeping the annual change in catch to less than 10% (*outcome*) over a 10-year period (*time frame*) at least 90% of the time (*probability*). The performance metric may then be, again framed as a risk, the average number of years that the absolute change in catch exceeded 10% over that 10-year period (the average number of years refers to average over simulations and is used because many replicate simulations would be done).

Other performance metrics may not be directly associated with measureable objectives, but related to aspirational goals. These could be the average catch and the average annual variability in catch, and they do not have a probability associated with them. They do, however, provide a comparison between management procedures, but can be more ambiguous in interpretation (e.g., compare an average catch of 101 tons to 100 tons, as opposed to a defined probability threshold for achieving a particular catch). If the goal is to maximize average catch or minimize average annual variability, then these performance statistics could be used to measure achievement of those goals (or to examine the trade-offs between them), but it is more difficult to gauge the performance of a metric like average catch in light of uncertainty. An important component of performance metrics is the *distribution of outcomes* under different scenarios; some scenarios may confer much greater sensitivity of results than others and the understanding of this sensitivity is critical to the evaluation of the management procedures that are tested. This is also a key element in understanding the uncertainty associated with results.

Determining important and useful metrics, as well as how to present them, is key to communicating outcomes, interpreting MSE results, evaluating trade-offs, and making decisions on management procedures. Many performance metrics have already been defined, and this task will refine those, identify new metrics, and develop ways to present them. For example, Table 1 and Figure 3 show preliminary results from the IPHC MSE for Pacific halibut that were presented in IPHC document IPHC-2018-AM094-12. The probabilities and other details are apparent in Table 1, while the trade-offs are more easily seen in Figure 3. Additionally, performance metrics can be related to past performance, such as the observed average catch over the last 2 decades, and advice will be solicited to determine if there is a historical period for comparison.

Table 1: Performance metrics determined from outputs of the closed-loop simulations for various fishing intensities indicated by a procedural Spawning Potential Ratio (SPR) and a 30:20 threshold:limit in the harvest control rule. Table reproduced from IPHC document IPHC-2017-AM094-12

	30:20 Threshold:Limit										
	High Fishing Intensity										**Low Fishing Intensity**
Procedural SPR	**25%**	**30%**	**40%**	**42%**	**44%**	**46%**	**48%**	**50%**	**55%**	**60%**	**100%**
Median average realized SPR	39%	39%	42%	44%	46%	47%	49%	51%	56%	61%	93%
Biological Sustainability											
Median average dRSB	29%	29%	34%	36%	38%	41%	43%	45%	50%	56%	92%
Median Average # of Mature Females (million)	5.87	5.97	6.73	6.98	7.19	7.59	7.91	8.03	9.01	9.75	13.63
P(dRSB<20%)	3%	3%	3%	2%	2%	2%	2%	2%	1%	1%	0%
P(dRSB<30%)	78%	64%	19%	13%	10%	7%	6%	5%	3%	2%	0%
Fishery Sustainability											
Median average Total Mortality (Mlbs)	40.09	39.56	39.91	37.62	35.27	36.37	34.71	35.50	33.48	32.72	7.63
10^{th} & 90^{th} percentiles TM (Mlbs)	13 113	13 126	13 109	13 101	14 98	13 99	13 90	13 91	13 82	12 75	7 8
Median average FCEY (Mlbs)	32.86	32.69	32.72	30.76	28.31	29.23	27.57	28.14	26.33	25.38	0.50
P(No Commercial)	11%	9%	8%	8%	7%	8%	8%	8%	8%	10%	100%
P(FCEY < 50.6 Mlbs)	69%	66%	69%	69%	72%	73%	74%	74%	77%	80%	100%
P(decrease TM > 15%)	24%	17%	6%	5%	5%	5%	5%	4%	4%	3%	27%
Median catch variability (AAV of TM)	19%	13%	7%	7%	6%	6%	6%	6%	6%	6%	20%
Median catch variability (AAV of FCEY)	25%	17%	10%	10%	10%	10%	10%	10%	10%	10%	17%
Median catch variability (AAV of Commercial)	34%	23%	13%	13%	14%	13%	14%	14%	14%	14%	0%

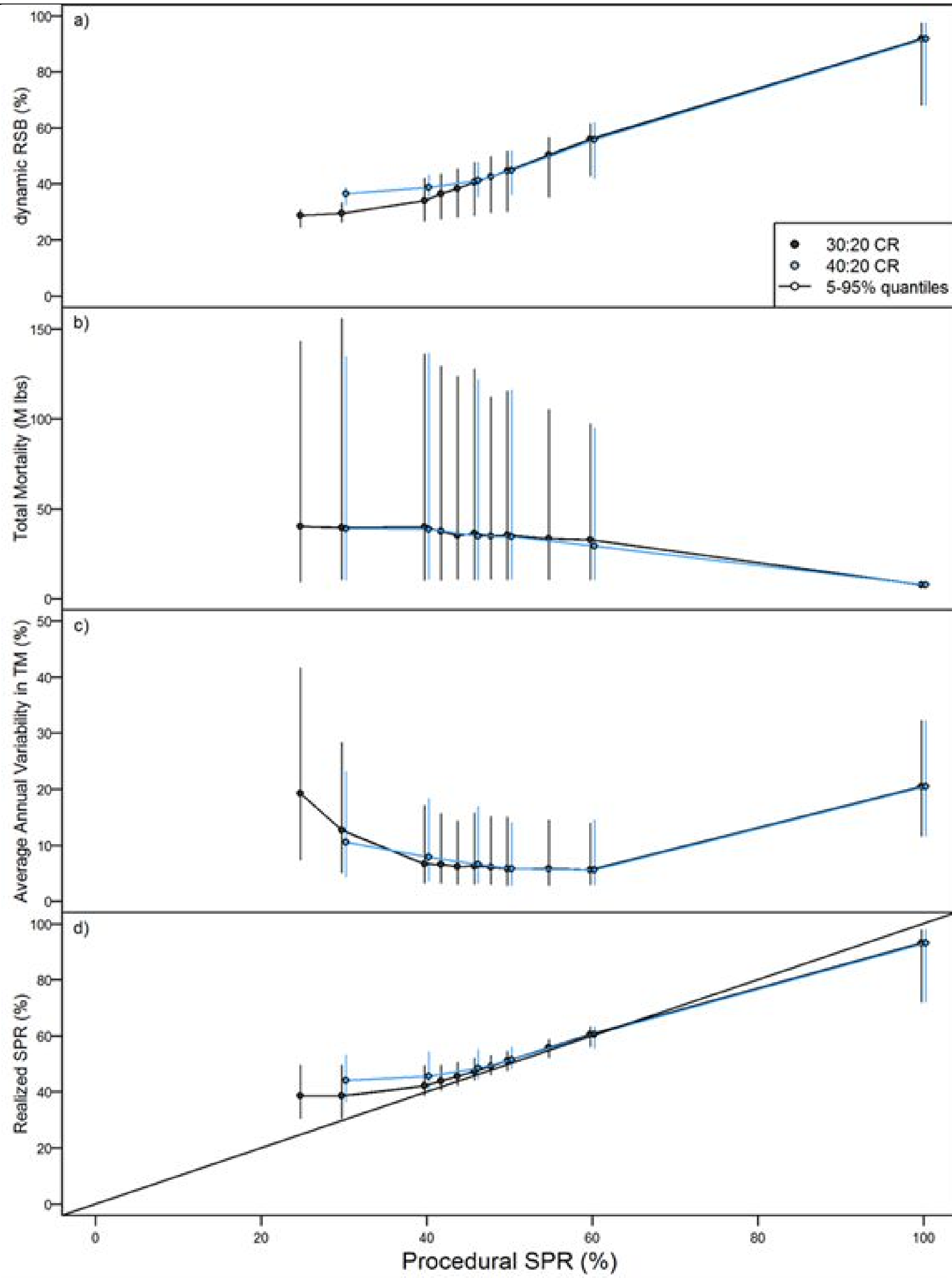

Figure 3: Performance metrics plotted against the procedural SPR (horizontal axis) for different threshold:limit combinations (30:20 in black and 40:20 in blue). Panel a) shows the dynamic relative spawning biomass (biological sustainability goal), panel b) shows the total mortality (fishery sustainability goal), and panel c) shows the average annual variability for total mortality (fishery stability goal). Panel d) shows the realized SPR.

Task 3. IDENTIFY REALISTIC MANAGEMENT PROCEDURES OF INTEREST TO EVALUATE WITH A CLOSED-LOOP SIMULATION FRAMEWORK

Timeline: 2018-19, and then ongoing.

Deliverables: Various management procedures related to scale and TCEY distribution to be tested using closed-loop simulations.

Relevance: Identifying realistic management procedures that are of interest to stakeholders, managers, and scientists will ensure that the results of the MSE are pertinent and useful to managing the Pacific halibut stock.

Resources: Discussions between IPHC staff and MSAB members.

Relation to other tasks: This task will rely on defined goals and objectives (Task 1) and will feed into the closed-loop simulation programming (Task 4).

Description: The purpose of MSE is to evaluate management procedures by examining and comparing the performance and trade-offs of each. A small enough set needs to be determined so that the simulations can be completed in a reasonable amount of time and be easily compared and contrasted. Management procedures can be identified by modifying the current one, consulting with stakeholders, or examining other fisheries. Initially, many may be identified, and then reduced to a manageable size, which can occur through further consultation and investigation with simpler models such as the equilibrium model.

A management procedure contains elements related to data collection, assessment, and harvest rules. Combined with objectives, this makes a management strategy. Some elements of management procedures that have been proposed by the MSAB are:

- **Total mortality**: Direct accounting by area for all sources of mortality in that area, including sub-legals and bycatch mortality.
- **Fishing Intensity**: SPR-based (spawning potential ratio).
- **Harvest rules**: 30:20 and 40:20 coast-wide control rules, reference harvest rate 21.5%/16.125% by IPHC Regulatory Area.

The management procedure that would be evaluated as part of the MSE process would contain all of the necessary elements to set catch levels for the stock. An example management procedure may be

- Coast-wide F_{SPR} with a 30:20 control rule to determine coast-wide total removals
- Coast-wide directed fishery catch levels apportioned to regulatory areas based on proportion of survey biomass
- Status quo recreational, subsistence, and bycatch allocation
- Annual survey to inform the stock assessment
- Status quo fishery data collected
- Annual assessment to determine total catch

The Commission at its 2017 Annual Meeting (AM093) recommended investigating a management approach based-on Spawning Potential Ratio (SPR) to account for all mortality. Spawning Potential Ratio is the long-term equilibrium spawning biomass per recruit with fishing divided by the long-term equilibrium spawning biomass per recruit without fishing. An SPR-based approach is defining a fishing level that results in a specific SPR (reduction in spawning potential) and noted as $F_{SPR=XX\%}$, where XX% is the SPR. This $F_{SPR=XX\%}$ will be treated as an element of a management procedure and evaluated with closed-loop simulation to find a level that best satisfies the defined objectives.

Management procedures related to distribution of the TCEY will be evaluated in the future. In the meantime, discussions of potential management procedures are ongoing and will need to be finalized by October 2020 to ensure enough time to perform the closed-loop simulations.

Task 4. DESIGN A CLOSED-LOOP SIMULATION FRAMEWORK AND CODE A COMPUTER PROGRAM TO EXTEND THE CURRENT SIMULATION FRAMEWORK

Timeline: 2018, and ongoing improvement after that

Deliverables: A design for a computer program that can perform closed-loop simulations for various operating models and management procedures. Once the design and framework are determined, the computer program will be written and tested. Updates will then occur as needed.

Relevance: A computer program to perform closed-loop simulations is the engine for the MSE. It will perform the simulations and create the output needed to calculate performance metrics. A good design will ensure that the code is useful to address current questions and flexible to accommodate future questions.

Resources: IPHC staff, computer programmer, MSE researcher, computing time

Relation to other tasks: This task will incorporate performance metrics (Task 2), management procedures (Task 3), and spatial model complexity and operating models (Task 6).

Description: Prior to 2017, the MSAB used an equilibrium model to introduce the concepts of a MSE. This model was used in a web-based application (the Shiny tool) because it produced results quickly and allowed MSAB members to change a few management options and see equilibrium outcomes related to biomass and yield. Those equilibrium outcomes are long-term averages of quantities that have natural variation (e.g., catches) if the fishery took place for an infinite amount of time.

Understanding the variability of the outcomes, such as yield and spawning biomass, is an important aspect of a MSE, but cannot be assessed with an equilibrium model. The equilibrium model is very useful because it produces results quickly and can be used to see the general patterns of various management strategies. However, this equilibrium model does not include the variability around the long-term equilibrium values, and does not incorporate a closed-loop simulation framework.

A closed-loop evaluation is the process of simulating the population dynamics with an operating model, as well as the feedback from the management strategy and decision-making process (Figure 4). The operating model consists of concepts that we cannot, or choose not to, control. The management procedure is what we can and choose to control. For example, the operating model will contain the population dynamics and some of the fishery dynamics that are not a part of the management process. The management procedure consists of data gathering, estimation models, and harvest rules, as well as anything else that informs the decisions affecting the fishery and fish population. Figure 4 attempts to show the annual process of a closed-loop simulation.

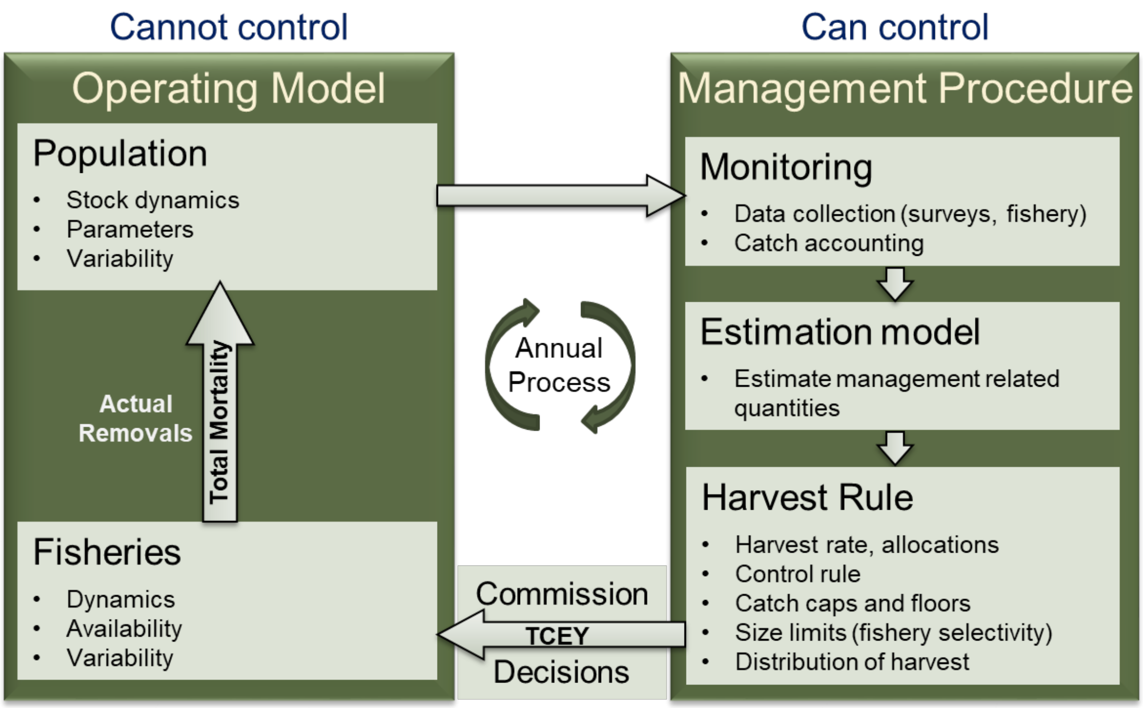

Figure 4: A flow chart of how the annual process is simulated in a closed-loop simulation.

The operating model incorporates variability in the system and additional variability can be added to various parts of the management procedure (e.g., sampling error, assessment uncertainty, and implementation error). This variability is characterized by replicate simulations, resulting in a distribution of outcomes, which can be described with summary statistics (such as the mean) or by probabilities (such as the proportion of time the catch was below a certain level). It is important to note that closed-loop simulations are different than assessment projections because they incorporate hypotheses about the system that may be beyond what is useful for tactical decision making.

The management procedure must be able to be coded in a computer program, although implementation error can be introduced to mimic a real process more closely (e.g., not consistently following the management procedure). The average of a long-term closed-loop simulation with a consistent management procedure should be very similar to the results of an equilibrium model. However, the closed-loop simulation will also provide an insight into the variability of the process.

The development of a closed-loop simulation framework (see IPHC-2017-MSAB10-09 for more details) has involved coding a program that will incorporate the following:

1. Operating model (OM). The OM is meant to represent reality, including the uncertainty about it. Multiple models making up the OM will allow for structural uncertainty and alternative hypotheses of reality. They will have to be selected, coded, and conditioned. Conditioning an operating model is to tune it such that it is the best representation of reality possible (as indicated by fits to data). Currently, the two coastwide assessment models (short and long) are used as an operating model. In the future, the fleets-as-areas models may be incorporated as well as other individual models yet to be developed.
2. Management Procedure
    a. Data monitoring. This represents the types of data that are collected (e.g., fishery age compositions, survey index), how and how often they are collected, and the processes that generate them.
    b. Estimation model. The method to assess the population can range from simple (e.g., an average of recent survey observations) to complex (e.g., an ensemble of age-structure stock assessment models using multiple sources of data), but its main purpose is to use the simulated data to provide an input for the harvest rule. The current assessment approach (ensemble modelling) is likely too time-consuming for a simulation framework, so simplifications will need to be made. The simplest approach to mimic the assessment process is to add bias and variability to the outcomes of the operating model.
    c. Harvest rule. This is a common focus of a MSE and is the set of procedures that defines how the total removals are determined. Currently, an SPR of 46% defines the fishing intensity which may be modified by a 30:20 control rule. This is not always exactly followed, so introducing implementation error will more closely mimic the current paradigm.

The framework will have to be flexible and compartmentalized to allow changes to be made for each component.

An equilibrium model still has a role in MSE and can be used, as it has been already, to quickly narrow the choices of prospective management procedures. Once the candidate management procedures are narrowed to a plausible number for simulation testing, the closed-loop simulations can be used to further investigate them and characterize the distribution of results.

The closed-loop simulation framework will first be used to evaluate management procedures related to coastwide fishing intensity to be presented at the 96th Annual Meeting in 2019. After the development of multi-area models to include in an operating model, the updated framework will be used to evaluate distribution management procedures for presentation at the 98th Annual Meeting in 2021. See Appendix A for a more specific timeline.

Task 5. DEVELOP EDUCATIONAL TOOLS THAT WILL ENGAGE STAKEHOLDERS AND FACILITATE COMMUNICATION

Timeline: 2018 and ongoing

Deliverables: Materials, programs (web-based or installed), examples, etc. that will allow users to understand the MSE process through reading or interaction.

Relevance: For a stakeholder driven process to be effective, an understanding of the process and how to interpret results is necessary. These educational tools will facilitate communication and allow users to understand trade-offs between performance metrics given alternative management procedures.

Resources: IPHC staff, MSE researcher, computer programmer

Relation to other tasks: Effective understanding and communication is key to interpreting results and fostering communication between science, stakeholders, and management. Therefore, educational tools will be useful for all tasks.

Description: An interactive tool has been developed using the equilibrium model (called the Shiny tool) and has been useful for education and the investigation of some management procedures. The development of a similar tool that incorporates closed-loop simulation results, including variability, will be developed. Incorporating closed-loop simulations and introducing variability will necessitate the output to be changed to reflect the uncertainty in the results by reporting performance metrics, and results will be shown using various graphics and tables.

In addition, the development of materials that are useful to MSAB members and their constituents to assist with understanding the MSE process and facilitate communication will be done with the guidance of MSAB members.

Task 6. FURTHER THE DEVELOPMENT OF OPERATING MODELS

Timeline: October 2019 and ongoing

Deliverables: Individual models to make up various operating models (a collection of models depicting uncertainty) that will satisfy the objectives defined by MSAB members will be supplied.

Relevance: Operating models are necessary to examine structural uncertainty and to answer specific management questions.

Resources: IPHC staff, MSE researcher, computer programmer, computing time

Relation to other tasks: The further development of operating models will be guided by the tasks necessary to complete (Appendix A). In particular, expanding the spatial complexity will be necessary to appropriately evaluate management procedures (Task 3) related to TCEY distribution against goals and objectives (Task 1). These operating models will be used within the closed-loop simulation framework (Task 4).

Description: Management advice for Pacific halibut is currently developed using an ensemble of four different models to account for structural uncertainty. This same concept extends to MSE, and using various operating models with different assumptions can help to properly characterize the overall uncertainty in the management of a fish stock.

Currently, the operating model consists of coastwide models and cannot be used to evaluate area-specific objectives, which can only be answered with a multi-area model. For example, investigating the yield in each IPHC Regulatory Area would require simulating the biomass and fishery in each Area. The spatial complexity of the model depends on the questions being asked, thus before developing an operating model it is useful to determine the extent of the objectives. This will determine the structure of the operating model; for example, whether it needs to be flexible to incorporate different area specifications, or if it can have a fixed set of areas with simple movement between them. Once the level of complexity is decided, the next step is to determine how to best model space, movement, and time. After the design of the model is complete, programming can begin. Finally, the model will need to be conditioned to halibut data before being used in a MSE to ensure that it is a reasonable depiction of reality (or at least what we understand of it), and that we have enough data and knowledge to actually define the complexity of the operating model.

Taking the time to develop the specifications of an operating model is very important. The development of a multi-area model was part of the annual assessment process, and a multi-area model developed in Stock Synthesis as part of that process may be useful to begin to investigate various hypotheses related to movement between broad areas. That progress will provide some of the framework for future operating model development. Given the complexity of this task, a fully developed multi-area model is not likely to be completed before 2020.

There are many questions that can be answered with a single-area model before transitioning to a multi-area model, and using a single-area model to answer those questions will be much more efficient. Therefore, evaluations of coastwide fishing intensity using coastwide operating models will occur in the meantime.

RECOMMENDATION/S

That the MSAB:

1) **NOTE** paper IPHC-2018-MSAB011-10 which updates the IPHC Program of Work for MSAB related activities for the period 2019-23.
2) **CONSIDER** the six tasks, descriptions, and timeline.
3) **RECOMMEND** additions or deletions to this Program of Work, or changes to the timeline and priorities.

ADDITIONAL DOCUMENTATION / REFERENCES

IPHC. 2017. Report of the 93rd Session of the IPHC Annual Meeting (AM093). Victoria, British Columbia, Canada, 23-27 January 2017. IPHC-2017-AM093-R, 61 pp. https://iphc.int/venues/details/94th-session-of-the-iphc-annual-meeting-am094

IPHC. 2018. IPHC Management Strategy Evaluation (MSE): update. IPHC-2018-AM094-12. 33 pp https://iphc.int/venues/details/94th-session-of-the-iphc-annual-meeting-am094

IPHC. 2018. Report of the 94th Session of the IPHC Annual Meeting (AM094). Portland, Oregon, United States of America, 22-26 January 2018. IPHC-2018-AM094-R. https://iphc.int/venues/details/94th-session-of-the-iphc-annual-meeting-am094 46 pp.

MSAB 2017. Report of the 10th Session of the IPHC Management Strategy Advisory Board (MSAB10). IPHC-2017-MSAB10-R. https://iphc.int/venues/details/10th-session-of-the-iphc-management-strategy-advisory-board-msab10

APPENDIX A: MSE PROGRAM OF WORK (2018-22): TIMELINE (FROM IPHC-2017-MSAB10-R)

May 2018 Meeting
Review Goals
Look at results of SPR
Review Performance Metrics
Identify Scale MP's
Review Framework
Identify Preliminary Distribution MP's
October 2018 Meeting
Review Goals
Complete results of SPR
Review Performance Metrics
Identify Scale MP'S
Verify Framework
Identify Distribution MP's
Annual Meeting 2019
Recommendation on Scale Present possible distribution MP's
May 2019 Meeting
Review Goals
Spatial Model Complexity
Identify MP's (Distn Scale)
Review Framework
October 2019 Meeting
Review Goals
Spatial Model Complexity
Identify MP's (Distn Scale)
Review Framework
Review multi-area model development
Annual Meeting 2020
Update on progress
May 2020 Meeting
Review Goals
Review multi-area model
Review preliminary results
October 2020 Meeting
Review Goals
Review preliminary results
Annual Meeting 2021
Recommendations on Scale and Distribution