IPHC–2025–SRB027–00
Last Update: 9 September 2025

27th Session of the IPHC Scientific Review Board (SRB027) – *Compendium of meeting documents*

16-18 September 2025, Seattle, WA, USA

DISTRIBUTION: IPHC WEBSITE
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BIBLIOGRAPHIC ENTRY
IPHC 2025. 27th Session of the IPHC Scientific Review Board (SRB027) - Compendium of meeting documents. Int. Pac. Halibut Comm.

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PROVISIONAL: AGENDA & SCHEDULE FOR THE 27th SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB027)

Date: 16-18 September 2025
Location: Seattle, WA, USA & Electronic
Venue: IPHC HQ (for SRB and Science advisors only) & Adobe Connect (observers)
Time: 09:00-17:00 (16-17th), 09:00-12:00 (18th) PDT
Chairperson: Dr Sean Cox (Simon Fraser University)
Vice-Chairperson: Nil

1. OPENING OF THE SESSION

2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION

3. IPHC PROCESS

3.1. SRB annual workflow (D. Wilson)
3.2. Update on the actions arising from the 26th Session of the SRB (SRB026) (D. Wilson)
3.3. Outcomes of the 101st Session of the IPHC Annual Meeting (AM101) (D. Wilson)
3.4. Observer updates (e.g. Science Advisors)

4. INTERNATIONAL PACIFIC HALIBUT COMMISSION 5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING (2027-2031)

4.1. RESEARCH

4.1.1. Biology and ecology
4.1.2. Pacific halibut stock assessment
4.1.3. Management strategy evaluation

4.2. MONITORING

4.2.1. Fishery-dependent data
4.2.2. Fishery-independent data
- IPHC Fishery-Independent Setline Survey (FISS)
  - 2026 FISS design evaluation (R. Webster)
  - Updates to space-time modelling (R. Webster)

4.2.3. Age composition data (both fishery-dependent and fishery-independent)
- Ageing methods update

5. OTHER BUSINESS

6. REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 27th SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB027)

SCHEDULE FOR THE 27th SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB027)

Tuesday, 16 September 2025		
Time	**Agenda item**	**Lead**
09:00-09:15	1. OPENING OF THE SESSION 2. ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION	S. Cox & D. Wilson
09:15-09:45	3. IPHC PROCESS 3.1 SRB annual workflow (D. Wilson) 3.2 Update on the actions arising from the 26th Session of the SRB (SRB026) 3.3 Outcomes of the 101st Session of the IPHC Annual Meeting (AM101) 3.4 Observer updates (e.g. Science Advisors)	D. Wilson
09:45-10:30	4. INTERNATIONAL PACIFIC HALIBUT COMMISSION 5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING (2027-2031)	D. Wilson
10:30-11:00	Break	
11:00-12:30	4.1 RESEARCH 4.1.1 Biology and ecology	J. Planas
12:30-13:30	Lunch	
13:30-16:00	4.1.2 Pacific halibut stock assessment	I. Stewart
16:00-17:00	SRB drafting session	SRB members
18:30-21:00	SRB Function (Location TBA)	SRB

Wednesday, 17 September 2025		
Time	**Agenda item**	**Lead**
09:00-09:30	Review of Day 1 and discussion of SRB Recommendations from Day 1	Chairperson
09:30-10:30	4.1.3 Management Strategy Evaluation	A. Hicks
10:30-11:00	Break	
11:00-12:30	4.2 MONITORING 4.2.1. Fishery-dependent data 4.2.2. Fishery-independent data • IPHC Fishery-Independent Setline Survey (FISS) ○ 2026 FISS design evaluation (R. Webster) ○ Updates to space-time modelling (R. Webster) 4.2.3. Age composition data (both fishery-dependent and fishery-independent) • Ageing methods update ○ Using artificial intelligence (AI) for supplementing Pacific halibut age determination from collected otoliths (B. Hutniczak)	R. Webster K. Ualesi B. Hutniczak
12:30-13:30	Lunch	
13:30-16:00	Offline SRB/Secretariat collaborative work session	All
16:00-17:00	SRB drafting session	SRB members
Thursday, 18 September 2025		
Time	**Agenda item**	**Lead**
09:00-09:30	5. OTHER BUSINESS	S. Cox
09:30-10:30	SRB drafting session	SRB members
10:30-11:30	Time for all participants to review the draft report	All
11:30-12:30	6. ADOPTION OF THE REPORT OF THE 27th SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB027)	S. Cox
12:30-13:30	Lunch and departure	

Last updated: 9 September 2025

LIST OF DOCUMENTS FOR THE 27th SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB027)

Document	Title	Availability
IPHC-2025-SRB027-01	Agenda & Schedule for the 27th Session of the Scientific Review Board (SRB027)	✓ 12 Jun 2025
IPHC-2025-SRB027-02	List of Documents for the 27th Session of the Scientific Review Board (SRB027)	✓ 12 Jun 2025 ✓ 9 Sept 2025
IPHC-2025-SRB027-03	Update on the actions arising from the 26th Session of the SRB (SRB026) (IPHC Secretariat)	✓ 17 Aug 2025
IPHC-2025-SRB027-04	Outcomes of the 101st Session of the IPHC Annual Meeting (AM101) (D. Wilson)	✓ 12 Jun 2025
IPHC-2025-SRB027-05	Draft: International Pacific Halibut Commission 5-Year program of integrated research and monitoring (2027-31) (D. Wilson, J. Planas, I. Stewart, A. Hicks, R. Webster, & B. Hutniczak)	✓ 17 Aug 2025
IPHC-2025-SRB027-06	Report on current and future biological and ecosystem science research activities (J. Planas, C. Dykstra, A. Jasonowicz, & C. Jones)	✓ 17 Aug 2025
IPHC-2025-SRB027-07	Development of the 2025 Pacific halibut (*Hippoglossus stenolepis*) stock assessment (I. Stewart, A. Hicks, & R. Webster)	✓ 5 Aug 2025
IPHC-2025-SRB027-08	An update of the IPHC Secretariat MSE and development of a Harvest Strategy Policy (A. Hicks & I. Stewart)	✓ 17 Aug 2025
IPHC-2025-SRB027-09	2026-28 FISS design evaluation and modelling updates (R. Webster, I. Stewart, K. Ualesi, T. Jack, & D. Wilson)	✓ 17 Aug 2025
Information papers		
IPHC-2025-SRB027-INF01	Draft IPHC Harvest Strategy Policy (A. Hicks, D. Wilson, I. Stewart)	✓ 09 Sept 2025

INTERNATIONAL PACIFIC HALIBUT COMMISSION

UPDATE ON THE ACTIONS ARISING FROM THE 26TH SESSION OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB026)

PREPARED BY: IPHC SECRETARIAT (17 AUGUST 2025)

PURPOSE

To provide the Scientific Review Board (SRB) with an opportunity to consider the progress made during the intersessional period, on the recommendations/requests arising from the SRB026.

BACKGROUND

At the SRB026, the members recommended/requested a series of actions to be taken by the IPHC Secretariat, as detailed in the SRB026 meeting report (IPHC–2025–SRB026–R) available from the IPHC website, and as provided in Appendix A.

DISCUSSION

During the 27th Session of the SRB (SRB027), efforts will be made to ensure that any recommendations/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 (such as the IPHC Staff or SRB officers);
3) a desired time frame for delivery of the action (such as by the next session of the SRB or by some other specified date).

RECOMMENDATIONS

That the SRB:

1) **NOTE** paper IPHC-2025-SRB027-03, that provided the SRB with an opportunity to consider the progress made during the inter-sessional period, in relation to the consolidated list of recommendations/requests arising from the previous SRB meeting (SRB026).
2) **AGREE** to consider and revise the actions as necessary, and to combine them with any new actions arising from SRB027.

APPENDICES

Appendix A: Update on actions arising from the 26th Session of the IPHC Scientific Review Board (SRB026).

APPENDIX A

Update on actions arising from the 26th Session of the IPHC Scientific Review Board (SRB026)

RECOMMENDATIONS

Action No.	Description	Update
SRB026–Rec.01 (para. 16)	***Research: Biology and ecology*** The SRB **RECOMMENDED** that questions about stock structure should be deprioritized in future research plans, as this question has now been answered quite robustly.	***In Progress*** **Update**: The next IRMP is currently being drafted.
SRB026–Rec.02 (para. 18)	The SRB **RECOMMENDED** that the 2025 stock assessment incorporate the new maturity ogives, however, the incorporation of new fecundity information should be delayed until the next full stock assessment when more robust data and analysis of fecundity at age/weight information are available.	***Completed*** **Update**: The preliminary 2025 stock assessment includes the updated maturity ogive and the fecundity information will be included in the next full stock assessment planned for 2028.
SRB026–Rec.03 (para. 19)	The SRB **RECOMMENDED** that the Secretariat incorporate potential environmental causes (e.g. effects of temperature) of changing maturity ogives or other changing biological parameters in the next 5YPIRM.	***In Progress*** **Update**: The next IRMP is currently being drafted.
SRB026–Rec.04 (para. 21)	***Pacific halibut stock assessment*** The SRB **NOTED** the bridging, data updates, and sensitivity analyses on the stock assessment and **RECOMMENDED** adopting those changes and moving forward with the final models presented at SRB026.	***Completed*** **Update**: The preliminary 2025 stock assessment includes all progress presented in June at SRB026.
SRB026–Rec.05 (para. 22)	The SRB **RECOMMENDED** conducting a sensitivity analysis of all ensemble models to the use of a Normal (rather than Lognormal) prior distribution on natural mortality. The Normal distribution is the least informative option when an informative prior is needed.	***Completed*** **Update**: The results of this analysis are presented in IPHC-2025-SRB027-07.
SRB026–Rec.06 (para. 23)	The SRB **RECOMMENDED** an analysis of historical performance of the decision table metrics, i.e. a retrospective analysis of stock assessment outputs used in management advice.	***Completed*** **Update**: The results of this analysis are presented in IPHC-2025-SRB027-07.

SRB026–Rec.07 (para. 24)	The SRB **RECOMMENDED** that recruitment projections in the stock assessment and Management Strategy Evaluation (MSE) incorporate a random-walk starting from the most recent reliable recruitment estimate to constrain expected short-term recruitment around recent estimates rather than immediately reverting to the stock-recruitment relationship.	***Partially completed*** **Update**: Sensitivity to projected recruitment has been explored for both the stock assessment (IPHC-2025-SRB027-07) and MSE (IPHC-2025-SRB027-08.).
SRB026–Rec.08 (para. 25)	The SRB **RECOMMENDED** deprioritizing incorporation of depredation in the assessment based on sensitivity analysis presented at SRB026. Instead, a research approach and activities should be presented in the next 5YPIRM.	***Completed*** **Update**: These topics are included in the IPHC Integrated Research and Monitoring Plan.
SRB026–Rec.09 (para. 26)	The SRB **RECOMMENDED** that a candidate state space assessment model (e.g. WHAM) be developed for Pacific halibut and presented by SRB032, tentatively scheduled for June 2028. Progress toward this modelling framework may also be presented at interim SRB meetings.	***In Progress*** **Update**: Additional work on this topic will begin after the final 2025 stock assessment is completed.
SRB026–Rec.10 (para. 30)	***Management strategy evaluation*** **NOTING** that "Overfished" implies that fishing was the cause of a current biomass state while the term "Depleted" is agnostic about the cause of low biomass, the SRB **RECOMMENDED** that the Secretariat consider defining "Overfished" relative to a dynamic reference point that incorporates productivity change while "Depleted" should refer to an absolute biomass reference point.	***Completed*** **Update**: The concept of Depleted has been discussed with the Commission and is defined in the draft Harvest Strategy Policy.
SRB026–Rec.11 (para. 31)	The SRB **RECOMMENDED** that the Secretariat/Commission adopt an absolute biomass limit defining "Depleted" to avoid low biomass levels where stock dynamics are poorly understood such that recovery projections would be unreliable.	***In Progress*** **Update**: Potential absolute biomass limits are discussed in IPHC-2025-SRB027-08.
SRB026–Rec.12 (para. 33)	The SRB **RECOMMENDED** that the Secretariat evaluate via simulation the ability to detect overfishing (based on the proposed definition) under scenarios of reduced assessment performance when defining "Overfishing" based on probabilities of stock status.	***In Progress*** **Update**: Additional work on this topic will occur after the MSE OM is updated following the completion of the 2025 full stock assessment.

SRB026–Rec.13 (para. 34)	The SRB **RECOMMENDED** that the Secretariat consider and justify alternative timelines to the three-year rebuilding period specified in the proposed definition of "overfishing" since a three-year period is probably unrealistic for rebuilding timelines.	***Completed*** **Update**: The definition of Overfishing has been updated such that it is consistent with a rebuilding plan. See document IPHC-2025-SRB027-08.
SRB026–Rec.14 (para. 41)	***Age composition data (both fishery-dependent and fishery-independent)*** The SRB **RECOMMENDED** testing whether the addition of covariates including region and sex improves the AI age estimation accuracy.	***Pending*** **Update**:
SRB026–Rec.15 (para. 44)	**NOTING** that aging plays a major role in the stock assessment and that multiple methods are being investigated, the SRB **RECOMMENDED** that the next 5YPIRM present a strategic analysis of the future of aging. This should include the following elements: a) A description of how these approaches may be used, integrated, and tested in the assessment; b) A plan for cost-benefit analysis of alternative approaches including hybrid approaches that use multiple methods; c) Implications of potential future reduced spatial coverage in the FISS on achieving age sampling goals.	***In Progress*** **Update**: The next IRMP is currently being drafted.

REQUESTS

Action No.	Description	Update
SRB026–Req.01 (para. 8)	***Outcomes of the 101st Session of the IPHC Annual Meeting (AM101)*** **RECALLING** that at the 100th Session of the IPHC, the Commission adopted a Statement on Climate Change, that is available on the IPHC website: IPHC-2024-PP-05, the SRB **AGREED** to consider and advise on the potential implications of climate change for the conservation and management of Pacific halibut, and any related impacts on the Contracting Parties. The SRB **REQUESTED** the addition of an agenda item on this topic for SRB028.	***Pending*** **Update**: Will be added and published in accordance with the IPHC Rules of Procedure (2024)

SRB026–Req.02 (para. 39)	***Fishery-independent data: Updates to space-time modelling*** The SRB **NOTED** the development of a spatial model of maturity and **REQUESTED** that the Secretariat present updates on the space-time model of maturity at age at SRB027.	***In progress*** **Update**: See paper 9.
SRB026–Req.03 (para. 43)	***Age composition data (both fishery-dependent and fishery-independent)*** The SRB **REQUESTED** an evaluation of the spatial generalization of a model trained on otoliths in one area to predict ages from otoliths collected in another area.	***Pending*** **Update**:

OUTCOMES OF THE 101ST SESSION OF THE IPHC ANNUAL MEETING (AM101)

PREPARED BY: IPHC SECRETARIAT (D. WILSON; 12 JUNE 2025)

PURPOSE

To provide the SRB with the outcomes of the 101st Session of the IPHC Annual Meeting (AM101), relevant to the mandate of the SRB.

BACKGROUND

Nil

DISCUSSION

During the course of the 101st Session of the IPHC Annual Meeting (AM101) the Commission made a number of specific recommendations and requests for action regarding the stock assessment, MSE process, and 5-year research program. Relevant sections from the report of the meeting are provided in Appendix A for the SRB's consideration.

RECOMMENDATION

That the SRB:

1) **NOTE** paper IPHC-2025-SRB027-04 which details the outcomes of the 101st Session of the IPHC Annual Meeting (AM101), relevant to the mandate of the SRB.

APPENDICES

Appendix A: Excerpts from the 101st Session of the IPHC Annual Meeting (AM101) Report (IPHC-2025-AM101-R).

APPENDIX A

Excerpts from the 101st Session of the IPHC Annual Meeting (AM101) Report (IPHC-2025-AM101-R)

RECOMMENDATIONS

Nil

REQUESTS

Management Strategy Evaluation

AM101–Req.04 (para. 53) The Commission **REQUESTED** that the Secretariat facilitate informal intersessional workshops, consisting of Commissioners and key advisors, to review and consider the draft Harvest Strategy Policy, for adoption in mid-to-late 2025.

OTHER

Para. 23. The Commission **NOTED** that at the request of the SRB (see below), the IPHC Secretariat will be updating the 5YPIRM throughout the course of 2025 with the intention of presenting a draft of the next 5YPIRM (2026-31) to the Commission at IM101 in November 2025.

> *SRB025–Rec.01 (para. 14) The SRB RECOMMENDED that the IPHC 5-year Program of Integrated Research and Monitoring be revised by SRB026 to reflect changing priorities in light of major progress on biological research and ongoing monitoring challenges.*
>
> *SRB025–Rec.02 (para. 15) The SRB RECOMMENDED incorporating evaluation of new technologies into the 5-year Program of Integrated Research and Monitoring. Initial examples include:*
>
> > *a) testing samples of AI-generated age compositions in the assessment model as soon as is practicable to determine their potential value for that purpose;*
> >
> > *b) using AI to support ageing requirements for gene-tagging and/or CKMR* [Close Kin Mark Recapture] *methods to estimate abundance. These ages would be required beyond ageing workloads for normal assessment purposes;*
> >
> > *c) epigenetic ageing (a new project beginning 2025), which could provide more reliable and unbiased ages than AI and perhaps comparable in precision to human-read ages.*

Para. 24. The Commission **NOTED** paper IPHC-2025-AM101-INF03 that summarizes the information available on the use of artificial intelligence (AI) for determining the age of fish from images of collected otoliths and provides an update on the exploratory work of implementing an AI-based age determination model for Pacific halibut.

INTERNATIONAL PACIFIC HALIBUT COMMISSION INTEGRATED RESEARCH AND MONITORING PLAN: DRAFT

PREPARED BY: IPHC SECRETARIAT (D. WILSON, J. PLANAS, I. STEWART, A. HICKS, B. HUTNICZAK, AND R. WEBSTER; 17 AUGUST 2025)

PURPOSE

To provide the SRB with an update on the development of the next Integrated Research and Monitoring Plan.

BACKGROUND

Recalling that:

a) the IPHC Secretariat conducts activities to address key issues identified by the Commission, its subsidiary bodies, the broader stakeholder community, and the IPHC Secretariat;

b) the process of identifying, developing, and implementing the IPHC's science-based activities involves several steps that are circular and iterative in nature, but result in clear project activities and associated deliverables;

c) the process includes developing and proposing projects based on direct input from the Commission, the experience of the IPHC Secretariat given its broad understanding of the resource and its associated fisheries, and concurrent consideration by relevant IPHC subsidiary bodies, and where deemed necessary, including by the Commission, additional external peer review;

Also recalling that an overarching goal of the IPHC's Integrated Research and Monitoring Plans are to promote integration and synergies among the various research and monitoring activities of the IPHC Secretariat in order to improve knowledge of key inputs into the Pacific halibut stock assessment, and Management Strategy Evaluation (MSE) processes, thereby providing the best possible advice for management decision making processes.

The 1st iteration of the Plan was formally presented to the Commission at IM097 in November 2021 (IPHC-2021-IM097-12) for general awareness of the documents ongoing development. At the 98th Session of the IPHC Annual Meeting (AM098) in January 2022, the Commission requested a number of amendments which were subsequently incorporated.

In 2023 and 2024, the plan went through two cycles of review and improvement with the SRB, with amendments being suggested and incorporated accordingly. The current plan is provided at **Appendix A** for reference.

Noting that the current 5YPIRM is due to end in 2026, the Secretariat, in collaboration with the SRB, is in the process of updating the Plan to reflect changing priorities in light of major progress on research area, as well as ongoing monitoring and funding challenges.

DISCUSSION

The SRB should note that:

a) the intention is to ensure that the next plan is kept as a '*living plan*', and is reviewed and updated annually based on the resources available to undertake the work of the Commission (e.g. internal and external fiscal resources, collaborations, internal expertise);

b) the plan focuses on core responsibilities of the Commission; and any redirection provided by the Commission;

c) each year the SRB may choose to recommend modifications to the current Plan, and that any modifications subsequently made would be documented both in the Plan itself, and through reporting back to the SRB and then the Commission.

Next steps:

The SRB is due to consider the draft of the Integrated Research and Monitoring Plan at its September meeting (SRB027: 16-18 September 2025).

Any recommendations from the SRB will be considered and incorporated into a revised draft as appropriate and provided to the Commission accordingly.

RECOMMENDATION

That the Commission:

1) **NOTE** paper IPHC-2025-SRB027-05 that provides an update on the development of the next Integrated Research and Monitoring Plan.

APPENDICES

Appendix A: IPHC Integrated Research and Monitoring Plan: Draft

APPENDIX A

INTERNATIONAL PACIFIC HALIBUT COMMISSION

INTEGRATED RESEARCH AND MONITORING PLAN

(IRMP)

BIBLIOGRAPHIC ENTRY

IPHC 2026. International Pacific Halibut Commission Integrated Research and Monitoring Plan. Seattle, WA, U.S.A. *IPHC–2026-IRMP, 49 pp.*

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ACRONYMS

AI	Artificial Intelligence
AM	Annual Meeting
CB	Conference Board
DMR	Discard Mortality Rate
FAC	Finance and Administration Committee
FISS	Fishery-Independent Setline Survey
FSC	First Nations Food, Social, and Ceremonial [fishery]
IM	Interim Meeting
IPHC	International Pacific Halibut Commission
IRMP	Integrated Research and Monitoring Plan
MP	Management Procedure
MSAB	Management Strategy Advisory Board
MSE	Management Strategy Evaluation
OM	Operating Model
PAB	Processor Advisory Board
PDO	Pacific Decadal Oscillation
QAQC	Quality assurance/quality control
RAB	Research Advisory Board
SHARC	Subsistence Halibut Registration Certificates
SRB	Scientific Review Board
TCEY	Total Constant Exploitation Yield
U.S.A.	United States of America
WM	Work Meeting

DEFINITIONS

A set of working definitions are provided in the IPHC Glossary of Terms and abbreviations: https://www.iphc.int/glossary-of-terms-and-abbreviations/

TABLE OF CONTENTS

EXECUTIVE SUMMARY

To be developed once the IRMP is developed in full

1. Introduction

The International Pacific Halibut Commission (IPHC) is a public international organisation so designated via Presidential Executive Order 11059 and established by a Convention between Canada and the United States of America. The IPHC Convention was signed on 2 March 1923, ratified on 21 July 1924, and came into effect on 21 October 1924 upon exchange. The Convention has been revised several times since, to extend the Commission's authority and meet new conditions in the fishery. The most recent change occurred in 1979 and involved an amendment to the 1953 Halibut Convention. The 1979 amendment, termed a "protocol", was precipitated in 1976 by Canada and the United States of America extending their jurisdiction over fisheries resources to 200 miles. The 1979 Protocol, along with the U.S. legislation that gave effect to the Protocol (Northern Pacific Halibut Act of 1982), has affected the way the fisheries are conducted and redefined the role of IPHC in the management of the fishery. Canada does not require specific enabling legislation to implement the protocol.

The basic texts of the Commission are available on the IPHC website: https://www.iphc.int/the-commission, and prescribe the mission of the organisation as:

*"..... **to develop the stocks of [Pacific] halibut in the Convention waters to those levels which will permit the optimum yield from the fishery and to maintain the stocks at those levels**. ....." IPHC Convention*, Article I, sub-article I, para. 2). The IPHC Convention Area is detailed in Fig. 1.

The IPHC Secretariat, formed in support of the Commission's activities, is based in Seattle, WA, U.S.A. As its shared vision, ***the IPHC Secretariat aims to deliver positive economic, environmental, and social outcomes for the Pacific halibut resource for Canada and the U.S.A. through the application of rigorous science, innovation, and the implementation of international best practice.***

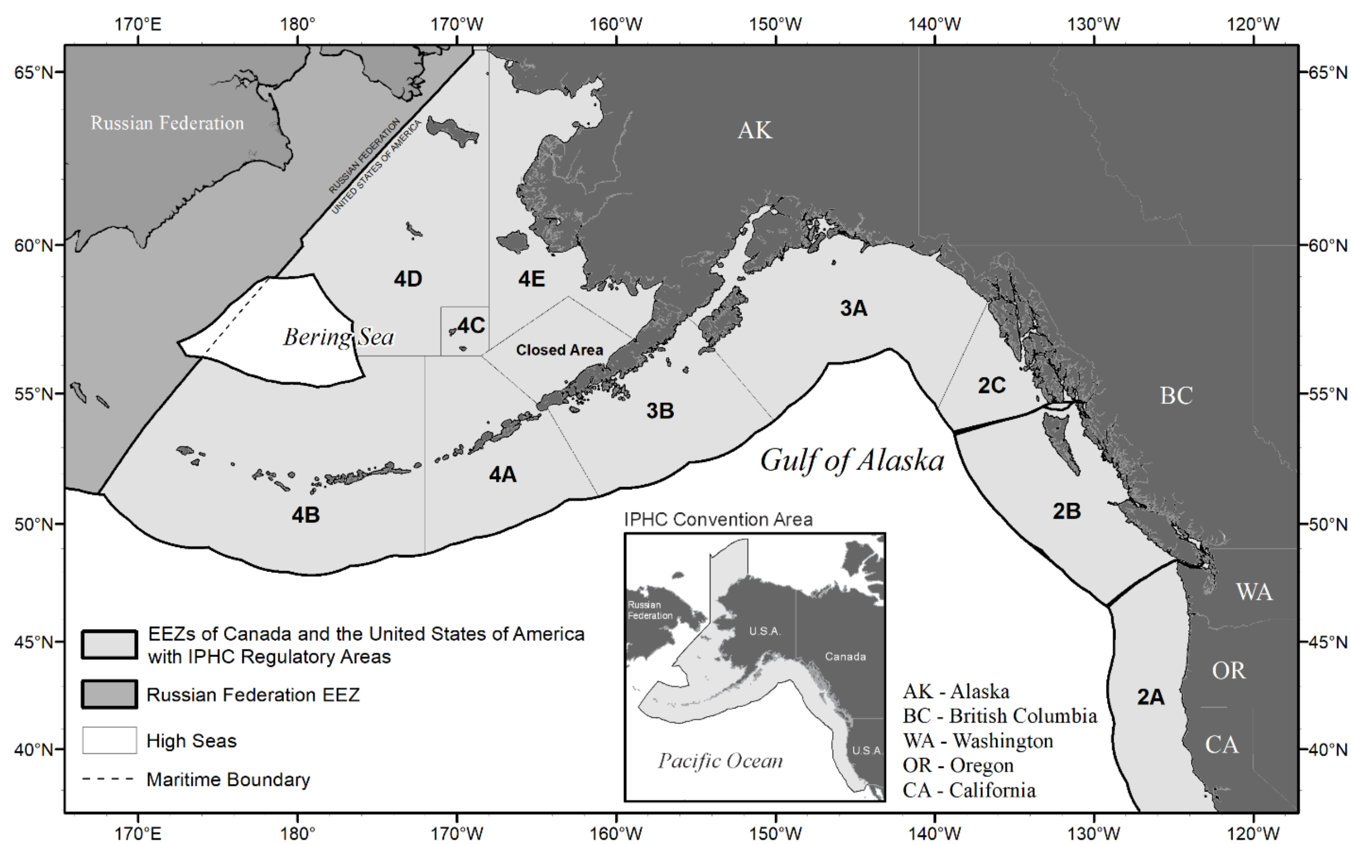

Figure 1. Map of the IPHC Convention Area (map insert) and IPHC Regulatory Areas.

2. *Objectives*

The IPHC has a long-standing history (since 1923) of collecting data, undertaking research, and stock assessment, devoted to describing and understanding the Pacific halibut (*Hippoglossus stenolepis*) stock and the fisheries that interact with it. Research at IPHC can be classified as "use-inspired basic research" (Stokes 1997) which combines knowledge building with the application of existing and emerging knowledge to provide for the management of Pacific halibut. The stock assessment, management strategy evaluation, management supporting information, and biology & ecology, all interact with each other as well as with fisheries monitoring activities in the IPHC program of integrated research and monitoring. Progress and knowledge building in one focal area influences and informs application in other core focal areas, also providing insight into future research priorities. The circular feedback loop is similar to the scientific method of observing a problem, creating a hypothesis, testing that hypothesis through research and analysis, drawing conclusions, and refining the hypothesis.

The IPHC Secretariat conducts activities to address key issues identified by the Commission, its subsidiary bodies, the broader stakeholder community, and of course, the IPHC Secretariat itself. The process of identifying, developing, and implementing our science-based activities involves several steps that are circular in nature, but result in clear research activities and associated deliverables. The process includes developing and proposing projects based on direct input from the Commission, the experience of the IPHC Secretariat given our broad understanding of the resource and its associated fisheries, and concurrent consideration by relevant IPHC subsidiary bodies, and where deemed necessary, additional external peer review.

Over the last ten (10) years, the research conducted by the IPHC Secretariat has been guided by two sequential detailed plans.

- 2017-2021: 5-Year Biological and Ecosystem Science Research Plan (IPHC–2019–BESRP-5YP).
- 2022-2026: 5-Year Program of Integrated Research and Monitoring (2022-2026) (IPHC-2022-5YPIRM)

The aim of the first plan (2017-2021) was to increase our knowledge on the biology of Pacific halibut in order to improve the accuracy of the stock assessment and in the management strategy evaluation (MSE) process. The IPHC-2019-BESRP-5YP contemplated research activities in five focal areas, namely Migration and Distribution, Reproduction, Growth and Physiological Condition, Discard Mortality Rates and Survival, and Genetics and Genomics. Research activities were highly integrated with the needs of stock assessment and MSE by their careful alignment with biological uncertainties and parameters, and the resulting prioritisation (IPHC–2019–BESRP-5YP). The outcomes of the IPHC-2019-BESRP-5YP (summarised in Appendix I of IPHC-2023-5YPIRM) provided key inputs into stock assessment and the MSE process and, importantly, provided foundational information for subsequent plans. The first plan (2017-2021) developed into a second broader and more inclusive plan that encompassed all research and monitoring activities planned and conducted by the IPHC Secretariat as described in the 5-Year Program of Integrated Research and Monitoring (2022-2026) (IPHC-2023-5YPIRM).

The 2nd Performance Review of the IPHC (IPHC-2019-PRIPHC02-R), carried out over the course of 2019, also provided a range of recommendations to the Commission on ways in which it could continue to improve on the quality of scientific advice being provided to the Commission. There were nine (9) specific recommendations relevant to the research and monitoring, as provided below. Of these, only recommendations 3 and 9 remain to be fully implemented and have been incorporated into this current IRMP:

Science: Status of living marine resources

*PRIPHC02–Rec.03 (para. 44) The PRIPHC02 **RECOMMENDED** that opportunities to engage with western Pacific halibut science and management agencies be sought, to strengthen science links and data exchange. Specifically, consider options to investigate pan-Pacific stock structure and migration of Pacific halibut.*

*PRIPHC02–Rec.04 (para. 45) The PRIPHC02 **RECOMMENDED** that:*

a) further efforts be made to lead and collaborate on research to assess the ecosystem impacts of Pacific halibut fisheries on incidentally caught species (retained and/or discarded);
b) where feasible, this research be incorporated within the IPHC's 5-Year Research Plan (https://www.iphc.int/uploads/pdf/besrp/2019/iphc-2019-besrp-5yp.pdf);
c) findings from the IPHC Secretariat research and that of the Contracting Parties be readily accessible via the IPHC website.

Science: Quality and provision of scientific advice

*PRIPHC02–Rec.05 (para. 63) The PRIPHC02 **RECOMMENDED** that simplified materials be developed for RAB and especially MSAB use, including training/induction materials.*

*PRIPHC02–Rec.06 (para. 64) The PRIPHC02 **RECOMMENDED** that consideration be given to amending the Rules of Procedure to include appropriate fixed terms of service to ensure SRB peer review remains independent and fresh; a fixed term of three years seems appropriate, with no more than one renewal.*

*PRIPHC02–Rec.07 (para. 65) The PRIPHC02 **RECOMMENDED** that the peer review process be strengthened through expanded subject specific independent reviews including data quality and standards, the FISS, MSE, and biological/ecological research; as well as conversion of "grey literature" to primary literature publications. The latter considered important to ongoing information outreach efforts given the cutting-edge nature of the Commission's scientific work.*

*PRIPHC02–Rec.08 (para. 66) The PRIPHC02 **RECOMMENDED** that the IPHC Secretariat develop options for simple graphical summaries (i.e. phase plot equivalents) of fishing intensity and spawning stock biomass for provision to the Commission.*

Conservation and Management: Data collection and sharing

*PRIPHC02–Rec.09 (para. 73) The PRIPHC02 **RECOMMENDED** that observer coverage be adjusted to be commensurate with the level of fishing intensity in each IPHC Regulatory Area.*

Conservation and Management: Consistency between scientific advice and fishery Regulations adopted

*PRIPHC02–Rec.10 (para. 82) The PRIPHC02 **RECOMMENDED** that the development of MSE to underpin multi-year (strategic) decision-making be continued, and as multi-year decision making is implemented, current Secretariat capacity usage for annual stock assessments should be refocused on research to investigate MSE operating model development (including consideration of biological and fishery uncertainties) for future MSE iterations and regularized multi-year stock assessments.*

*PRIPHC02–Rec.11 (para. 83) The PRIPHC02 **RECOMMENDED** that ongoing work on the MSE process be prioritised to ensure there is a management framework/procedure with minimal room for ambiguous interpretation, and robust pre-agreed mortality limit setting frameworks.*

The work outlined in this document builds on the previous Research and Monitoring Plans (IPHC–2019–BESRP-5YP; and IPHC-2023-5YPIRM), closing completed projects, extending efforts where needed, and adding new avenues in response to new information. Appendix I provides a detailed summary of the outcomes of the previous IPHC-2023-5YPIRM plan and the status of the work specifically undertaken. Key highlights relevant to the stock assessment and MSE include:

- Investigations on population genomics, including the delineation of a genetic baseline and genomic analyses of population structure.
- Population-level sampling and analysis of maturity and fecundity leading to incorporation of an updated maturity ogive in the 2025 stock assessment and ongoing progress toward an updated fecundity relationship.
- Investigations on methods for reducing whale depredation in the Pacific halibut commercial longline fishery.

All previously described research areas continue to represent critical sources of information for the stock assessment and MSE and thus are closely linked to management performance. The previous 5-year plans were successful in either providing direct new information to the stock assessment or building the foundation for the collection/analysis of such information in this updated plan. As noted below, some new priorities have emerged, and others have evolved based on the work completed to date. The incorporation of research objectives in the current IRMP that address climate change as a factor influencing Pacific halibut biology and ecology as well as fishery performance and dynamics constitutes a timely and relevant contribution towards advancing IPHC-led research to the forefront of fisheries science.

An **overarching goal** of this current *IPHC Integrated Research and Monitoring Plan* (IRMP) is to continue to promote integration and synergies among the various research and support activities of the IPHC Secretariat in order to improve the Pacific halibut stock assessment and MSE process and our knowledge of key inputs into the Pacific halibut stock assessment and MSE processes, in order to provide the best possible advice for management decision-making processes. In doing so, the Plan also responds to emerging challenges and opportunities, particularly those presented by advances in artificial intelligence (AI), to enhance analytical capacity, improve efficiency, and support innovation across scientific and operational domains. The intention is no longer to designate the Plan for a defined period, but rather, to annually review and update the Plan as needed, based on resources available to the IPHC, as well as new Commission directives.

Along with the implementation of the short- and medium-term activities contemplated in this IRMP and in pursuit of the overarching goal, the IPHC Secretariat will also aim to:

1) undertake cutting-edge research programs in fisheries research in support of fisheries management of Pacific halibut.
2) undertake groundbreaking methodological research.
3) undertake applied research.
4) establish new collaborative agreements and interactions with research agencies and academic institutions.
5) promote the international involvement of the IPHC by continued and new participation in international scientific organisations and by leading international science and research collaborations.
6) effectively communicate IPHC research outcomes
7) incorporate talented students and early researchers in research activities.

The research and monitoring activities conducted by the IPHC Secretariat are organized into the following five

(5) areas: stock assessment, MSE, biology and ecology, monitoring, and additional management support. The overall aim is to provide integrated research and monitoring where each area informs and benefits from the others (Fig. 2):

Research

1) **Stock assessment**: to improve the accuracy and reliability of the current stock assessment and the characterisation of uncertainty in the resultant stock management advice provided to the Commission;
2) **Management Strategy Evaluation (MSE)**: to develop an accurate, reliable, and informative MSE process to appropriately characterize uncertainty and provide for the robust evaluation of the consequences of alternative management options, known as harvest strategies, using defined conservation and fishery objectives;
3) **Biology and Ecology**: identify and assess critical knowledge gaps in the biology and ecology of Pacific halibut within its known range, including the influence of environmental conditions on population and fishery dynamics;

Monitoring

4) **Monitoring**: collect representative fishery dependent and fishery-independent data on the distribution, abundance, biology, and demographics of Pacific halibut through ongoing monitoring activities;

Integrated management support

5) **Additional management-supporting inputs**: respond to Commission requests for additional information supporting management and policy development.

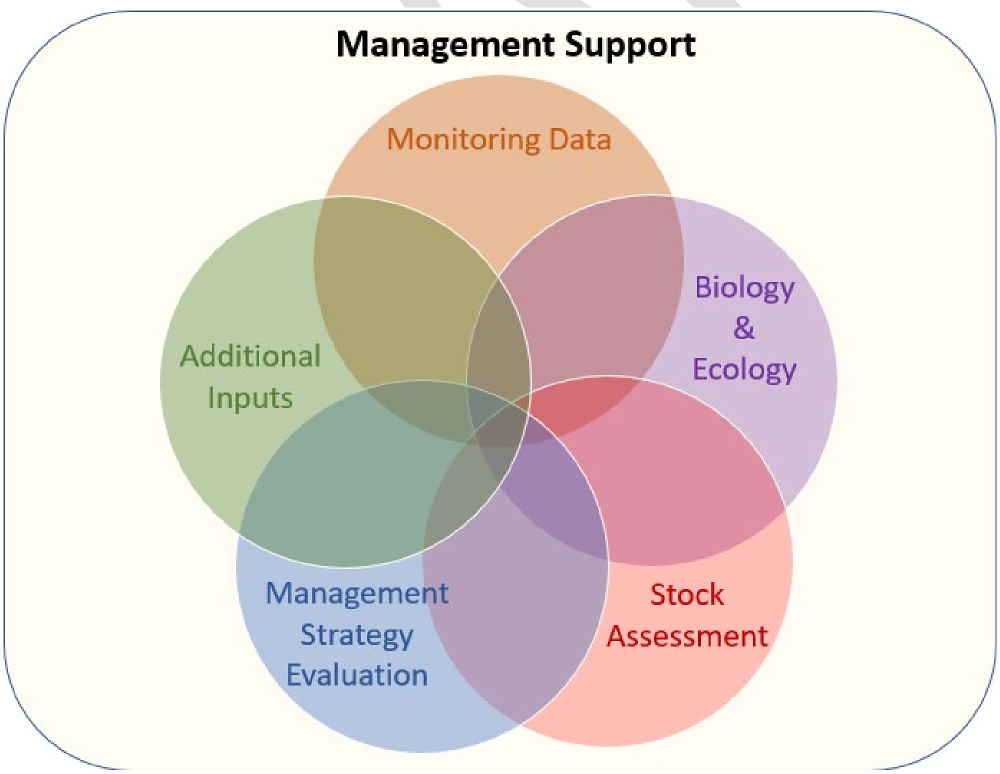

Figure 2. Core areas of the IPHC's Integrated Research and Monitoring Plan (IRMP) provide management support.

3. Strategy

The IPHC Secretariat has five (5) enduring strategic goals in executing our mission, including our overarching goal and associated science and research objectives, as articulated in our Strategic Plan (IPHC Strategic Plan (2023-27)): 1) To operate in accordance with international best practice; 2) Be a world leader in scientific excellence and science-based decision making; 3) To foster collaboration (within Contracting Parties and internationally) to enhance our science, monitoring, and management advice; 4) Create a vibrant IPHC culture; and 5) Set the standard for fisheries commissions globally.

Although priorities and tasking will change over time in response to events and developments, the Strategic Plan provides a framework to standardise our approach when revising or setting new priorities and tasking. The Strategic goals as they apply to the science and research activities of the IPHC Secretariat, are operationalised through a multi-year tactical activity matrix at the organisational and management unit (Branch) level (Fig. 3). The tactical activity matrix is described in the sections below and has been developed based on the core needs of the Commission, in developing and implementing robust, scientifically-based management decisions on an annual, and multi-year level. Relevant IPHC subsidiary bodies will be involved in project development and ongoing review.

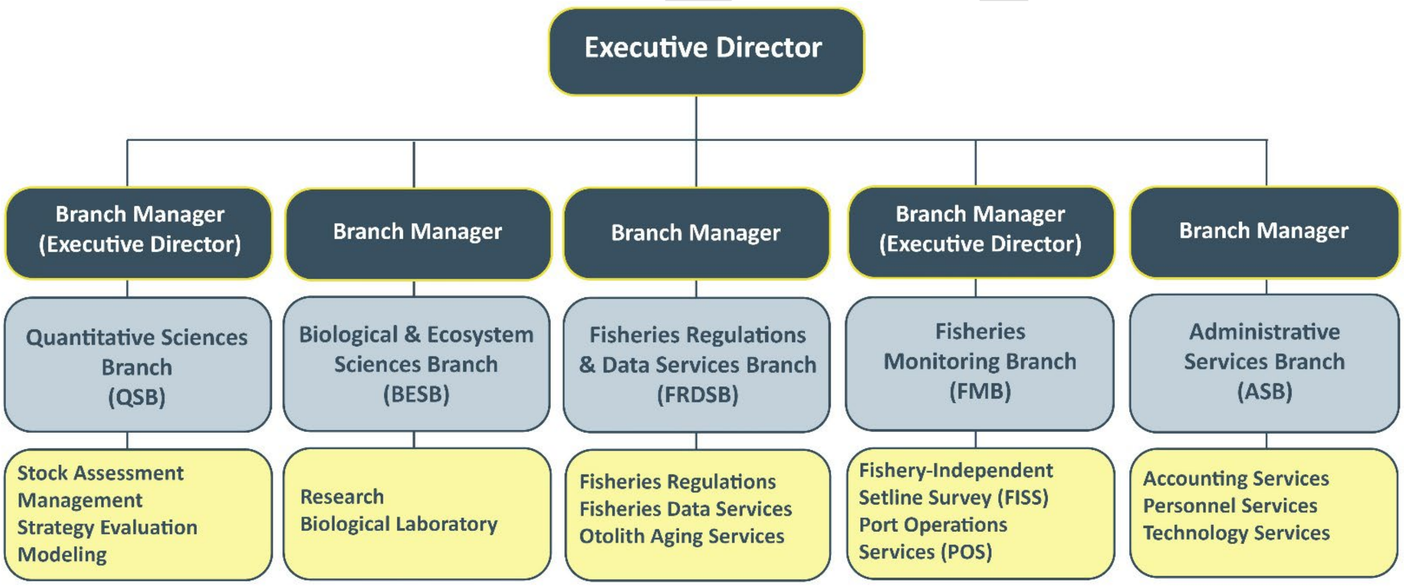

Figure 3. IPHC Secretariat organisation chart (2025).

4. Measures of Success

The Secretariat's success in implementing the IRMP will be measured according to the following criteria relevant to the stock assessment, the MSE, and for all inputs to IPHC management:

1) Timeliness – was the research conducted, analysed, published, and provided to the Commission at the appropriate points to be included in annual management decisions?
2) Accessibility – was the research published and presented in such a way that it was available to other scientists, stakeholders, and decision-makers?
3) Relevance - was the information used to inform decisions made by the Commission?
4) Impact – did the research improve the perceived accuracy of or provide a better estimate of the uncertainty associated with information for use in management?

5) Reliability - has research resulted in more consistent information provided to the Commission for decision-making.

4.1 Delivery of specified products

Each project line item will contain specific deliverables that constitute useful inputs into the understanding of the Pacific halibut stock and fisheries, the stock assessment, and the management strategy evaluation process, as well as support their implementation in the decision-making process at the level of the Commission.

4.2 Communication

The IPHC Secretariat will disseminate information about the activities contemplated in the IRMP and the resulting products to Contracting Parties, stakeholders, the scientific community, and the general public through a variety of channels:

1) IPHC website (www.iphc.int);
2) Formal documentation provided for IPHC meetings (Interim and Annual Meetings, Subsidiary Body meetings, etc.);
3) Presentations at national and international scientific conferences;
4) Published reports and peer-reviewed publications (section 4.4);
5) Outreach events;
6) Posts on social media platforms;
7) Informal presentations and interactions with partners, stakeholders, and decision-makers at varied times and venues when needed;
8) Accessible and plain-language summaries of key findings, where appropriate, to facilitate broader stakeholder engagement and understanding.

4.3 External research funding

The Secretariat has set a funding goal of at least 20% of the funds for our research and monitoring activities, to be sourced from external funding bodies on an annual basis. Continuing the successful funding-recruitment strategy adopted during the previous plans (Appendix II), the Secretariat will target available external funding opportunities that are timely and that aim at addressing key research objectives that have important implications for stock assessment and the MSE process. The IPHC Secretariat has the necessary expertise to propose novel and important research questions to funding agencies and to recruit external collaborators from research agencies and universities as deemed necessary. The IPHC Secretariat will continue to capitalise on the strong analytical contributions of quantitative scientists to the development of biological research questions within the framework of research projects funded by external as well as internal funding sources. While the external funding environment has changed substantially in recent years, we will continue with this goal and adapt accordingly.

4.4 Peer-reviewed journal publication

Publication of research outcomes in peer-reviewed journals will be clearly documented and monitored as a primary measure of success. This may include single publications at the completion of a particular project, or a series of publications throughout the project, as well as at its completion. Each sub-project shall be published in a timely manner and shall be submitted no later than 12 months after the end of the research. In the sections that follow, the expected publications from each research stream and cross-stream are defined.

5. Core focal areas – Background

The main activities of the IRMP involve 1) monitoring (fisheries-dependent and –independent data collection), 2) research (biological, ecological), and 3) modelling (FISS, stock assessment, and MSE), as outlined in the following sub-sections. These components are closely linked to one another, have goals that are integrated across the organisation, and all feed into management decision-making (Fig. 4). Additionally, management-supporting information constitutes a range of additional decision-making inputs within and beyond IPHC's current research and monitoring programs. The current program builds on the outcomes and experiences of the Commission arising from the implementation of the previous two (2) plans, and which are summarised in IPHC-2023-5YPIRM and Appendix I, respectively.

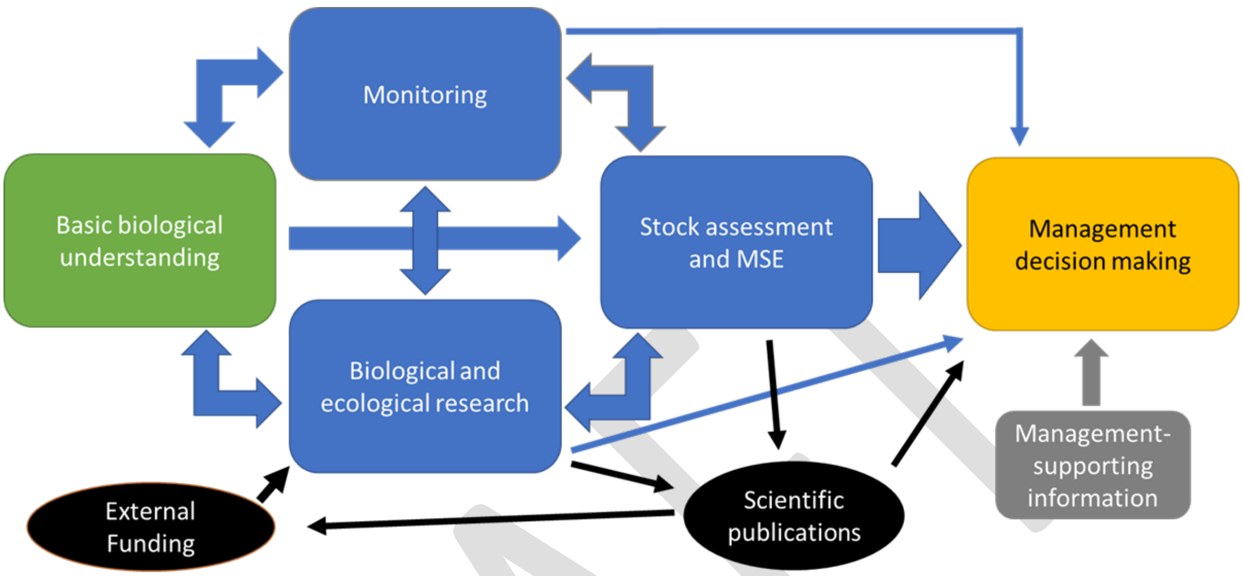

Figure 4. Flow of information from basic biological understanding of the Pacific halibut resource, through IPHC research components (monitoring, biological and ecological research, stock assessment, and MSE) to management decision-making. Management-supporting information (grey) constitutes a range of additional decision-making drivers within and beyond IPHC's current research and monitoring programs. Arrows indicate the strength (size of the arrow) and direction of information exchange. Also identified (in black) are the external links from funding and scientific publications, which supplement the IPHC's internal process.

5.1 Research

5.1.1 Stock Assessment

Focal Area Objective	To improve the accuracy and reliability of the current stock assessment and the characterisation of uncertainty in the resultant stock management advice provided to the Commission.
IPHC Website portal	https://www.iphc.int/management/science-and-research/stock-assessment

The IPHC conducts an annual stock assessment, using data from the fishery-independent setline survey (FISS), the commercial Pacific halibut and other directed and non-directed fisheries, as well as biological information from its research program and programs from other fisheries agencies. The assessment includes the Pacific halibut resource in the IPHC Convention Area, covering the Exclusive Economic Zones of Canada and the United States of America. Data sources are updated each year to reflect the most recent scientific information available for use in management decision-making.

All recent stock assessments have relied on an ensemble of four population dynamics models to estimate the probability distributions describing the current stock size, trend, and demographics. The ensemble is designed to capture both uncertainty related to the data and stock dynamics (due to estimation) as well as uncertainty related to our understanding of the way in which the Pacific halibut stock functions and is best approximated by a statistical model (structural uncertainty).

Stock assessment results are used as inputs for harvest strategy calculations, including mortality projection tables for the upcoming year that reflect the IPHC's harvest strategy policy and other considerations, as well as the harvest decision table. The harvest decision table uses the probability distributions from short-term (three-year) assessment projections to evaluate the trade-offs between alternative levels of potential yield (catch) and the associated risks to the stock and fishery.

The stock assessment research priorities have been subdivided into three categories:

1) Assessment data collection and processing;
2) technical development;
3) biological understanding and fishery yield

It is important to note that ongoing monitoring, including the annual FISS and directed commercial landings sampling activities, is not considered research and is therefore not included in this research priority list despite the critical importance of these collections. These are described in the sections below.

5.1.2 Management Strategy Evaluation (MSE)

Focal Area Objective	To develop an accurate, reliable, and informative MSE process to appropriately characterise uncertainty and provide for the robust evaluation of the consequences of alternative management options, known as harvest strategies, using defined conservation and fishery objectives.
IPHC Website portal	https://www.iphc.int/management/science-and-research/management-strategy-evaluation

Management Strategy Evaluation (MSE) is a process to evaluate alternative management options, known as harvest strategies. MSE uses a simulation tool to determine how alternative harvest strategies perform given a set of pre-defined fishery and conservation objectives, taking into account the uncertainties in the system and how likely candidate harvest strategies are to achieve the chosen management objectives.

The MSE uses an operating model that includes each part of the management cycle: the population and all fisheries, management decisions, the monitoring program, the estimation model, and potential ecosystem effects using a closed-loop simulation.

MSE is a simulation technique based on modelling the population and fisheries with closed-loop feedback from each part of the management cycle. An operating model (OM) represents aspects that are not controlled by management, such as fishery behavior, recruitment into the population, natural sources of mortality, and potential environmental and ecosystem effects. The management procedure (MP) represents the elements of the decision-making process, including data collection, estimation models (e.g. stock assessment), and harvest rules such as fishing intensity. The MP also characterizes uncertainty in the decision-making process through sampling error, estimation error, and decision-making variability.

MSE reveals the trade-offs among a range of possible management decisions, given alternative harvest strategies, preferences, and attitudes to risk. The MSE is an essential part of the process of developing, evaluating, and adopting a harvest strategy, and is used to develop and maintain a Harvest Strategy Policy.

The MSE process involves:

- Defining fishery and conservation objectives with the involvement of stakeholders and managers;
- Identifying harvest strategies (a.k.a. management procedures) to evaluate;
- Simulating a Pacific halibut population using those harvest strategies;
- Evaluating and presenting the results in a way that examines trade-offs between objectives;
- Applying a chosen harvest strategy for the management of Pacific halibut;
- Repeating this process in the future in case of changes in objectives, assumptions, or expectations.

There are many research priorities that would continue to improve the MSE framework and the presentation of future results to the Commission; they can be divided into five general categories:

1. **Objectives**: The goals and objectives that are used in the evaluation.
2. **Management Procedures (MPs)**: Specific, well-defined management procedures that can be coded in the MSE framework to produce simulated Total Constant Exploitation Yields (TCEY) for each IPHC Regulatory Area.
3. **Framework**: The specifications and computer code for the closed-loop simulations, including the operating model and how it interacts with the MP.
4. **Evaluation**: The performance metrics and presentation of results. This includes how the performance metrics are evaluated (e.g. tables, figures, and rankings), presented to the Commission and its subsidiary bodies, and disseminated for outreach.
5. **Application**: Specifications of how an MP may be applied in practice and re-evaluated in the future, including responses to exceptional circumstances.

All these categories provide inputs and outputs of the MSE process, but the Framework category benefits most from the integration of biological and ecosystem research because the operating model, the simulation of the monitoring program, the estimation model, and potential ecosystem effects are determined from this knowledge. Outcomes of the MSE process inform the Commission on updates to the Harvest Strategy Policy.

5.1.3 Biology and Ecology

Focal Area Objective	To identify and assess critical knowledge gaps in the biology and ecology of Pacific halibut within its known range, including the influence of environmental conditions on population and fishery dynamics.
IPHC Website portal	https://www.iphc.int/research/biological-and-ecosystem-science-research/

Since its inception, the IPHC has had a long history of research activities devoted to describing and understanding the biology of and fisheries for the Pacific halibut. At present, the main objectives of the Biological and Ecosystem Science Research activities at the IPHC are to: 1) identify and assess critical knowledge gaps in the biology of the Pacific halibut; 2) understand the influence of environmental conditions in the biology of the Pacific halibut and its fisheries; and 3) apply the resulting knowledge to reduce uncertainty in the stock assessment and MSE.

The primary biological research activities at the IPHC follow Commission objectives, are selected for their important management implications, and are identified and described in this current IRMP. An overarching goal of the IRMP is to promote integration and synergies among the various research activities led by the IPHC to improve our knowledge of key biological inputs that feed into the stock assessment and MSE process. The goals of the main research activities of the IRMP are therefore aligned and integrated with the IPHC stock assessment and MSE processes.

The biological research activities contemplated in the IRMP and their specific aims are detailed in Section 6. Overall, the biological research activities at the IPHC aim to provide information on 1) factors that influence the biomass of the Pacific halibut population (e.g. distribution and movement of fish among IPHC Regulatory Areas, growth patterns and environmental influences on growth in larval, juvenile and adult fish, drivers of changes in size-at-age); 2) the spawning (female) population (e.g. reproductive maturity and fecundity, skipped spawning, reproductive migrations); and 3) resulting changes in population structure and dynamics. Furthermore, the research activities of IPHC also aim to develop and evaluate methods for estimating and reducing incidental mortality of Pacific halibut, to investigate modifications of fishing gear and/or methods to reduce whale depredation and bycatch of non-targeted species, and to investigate changes in the directed Pacific halibut fishery in response to environmental, biological, and technological drivers.

5.2 Monitoring

Focal Area Objective	To collect fishery-dependent and fishery-independent data on the distribution, abundance, and demographics of Pacific halibut, as well as other key biological data, through ongoing monitoring activities.
IPHC Website portal	***Fishery-dependent data:*** • https://www.iphc.int/fisheries/commercial-fisheries/ • https://www.iphc.int/fisheries/recreational-fisheries/ • https://www.iphc.int/fisheries/subsistence-fisheries/ • https://www.iphc.int/data/time-series-datasets/ ***Fishery-independent data:*** • https://www.iphc.int/data/fishery-independent-setline-survey-fiss/ • https://www.iphc.int/data/water-column-profiler-data/

5.2.1 Fishery-dependent data

The IPHC estimates the magnitude and demographics of all Pacific halibut removals within the IPHC Convention Area and uses this information in its annual stock assessment and other analyses. These data are collected and compiled by the IPHC Secretariat and include information provided by Federal and State agencies of each Contracting Party. Specific activities in this area are described below.

5.2.1.1 Directed commercial fisheries data

The IPHC Secretariat collects logbooks, otoliths, tissue samples, and associated sex-length-weight data from directed commercial landings coastwide (Fig. 5). For each IPHC Regulatory Area, a sampling rate is determined by port and calculated annually based on the current year's mortality limits and the estimated proportion of Pacific halibut weight landed and sampled in each port. This ensures that an adequate number of biological samples is collected by IPHC Regulatory Area. Details on the data collected and sampling methods are provided in the annually updated *IPHC Directed Commercial Landings Sampling Manual* (e.g. for 2025: IPHC-2025-PSM01). Complementary to these efforts, the IPHC provides training to Tribal commercial fishery stakeholders in IPHC Regulatory Area 2A that supply additional data. In addition, the IPHC Secretariat summarises annually directed commercial fishery landings recorded by Federal and State agencies of each Contracting Party. Discard mortality for the directed commercial fishery is currently estimated using a combination of logbook, research survey, and observer data.

5.2.1.2 Recreational fisheries data

Recreational removals of Pacific halibut, including estimated recreational discard mortality, are provided by Federal and State agencies of each Contracting Party. These data are compiled annually for use in the stock assessment and other analysis.

5.2.1.3 Subsistence fisheries data

Subsistence fisheries refer to non-commercial, customary, and traditional use of Pacific halibut for direct personal, family, or community consumption, sharing as food, or customary trade. The primary subsistence fisheries include:

- the Treaty Indian Ceremonial and Subsistence fishery in IPHC Regulatory Area 2A off northwest Washington State (USA),
- the First Nations Food, Social, and Ceremonial (FSC) fishery in British Columbia (Canada), and
- the subsistence fishery in Alaska (USA), carried out by rural residents and federally recognised Native Tribes under the Subsistence Halibut Registration Certificate (SHARC) program.

Subsistence fishery removals of Pacific halibut, including estimated subsistence discard mortality, are provided by State and Federal agencies of each Contracting Party. These data are compiled annually for use in the stock assessment and other analyses.

5.2.1.4 Non-directed commercial discard mortality data

Non-directed commercial discard mortality estimates by IPHC Regulatory Area and sector are provided by State and Federal agencies of each Contracting Party and compiled annually for use in the stock assessment and other analyses.

Non-directed commercial discard mortality of Pacific halibut is estimated because not all fisheries are allowed to retain Pacific halibut, and not all discarded Pacific halibut are assumed to die. In most fisheries, non-directed commercial discard mortality is estimated directly using data from observer programs operated by Contracting Party agencies. In cases where observer data are unavailable, estimates are based on non-IPHC research surveys or other sources.

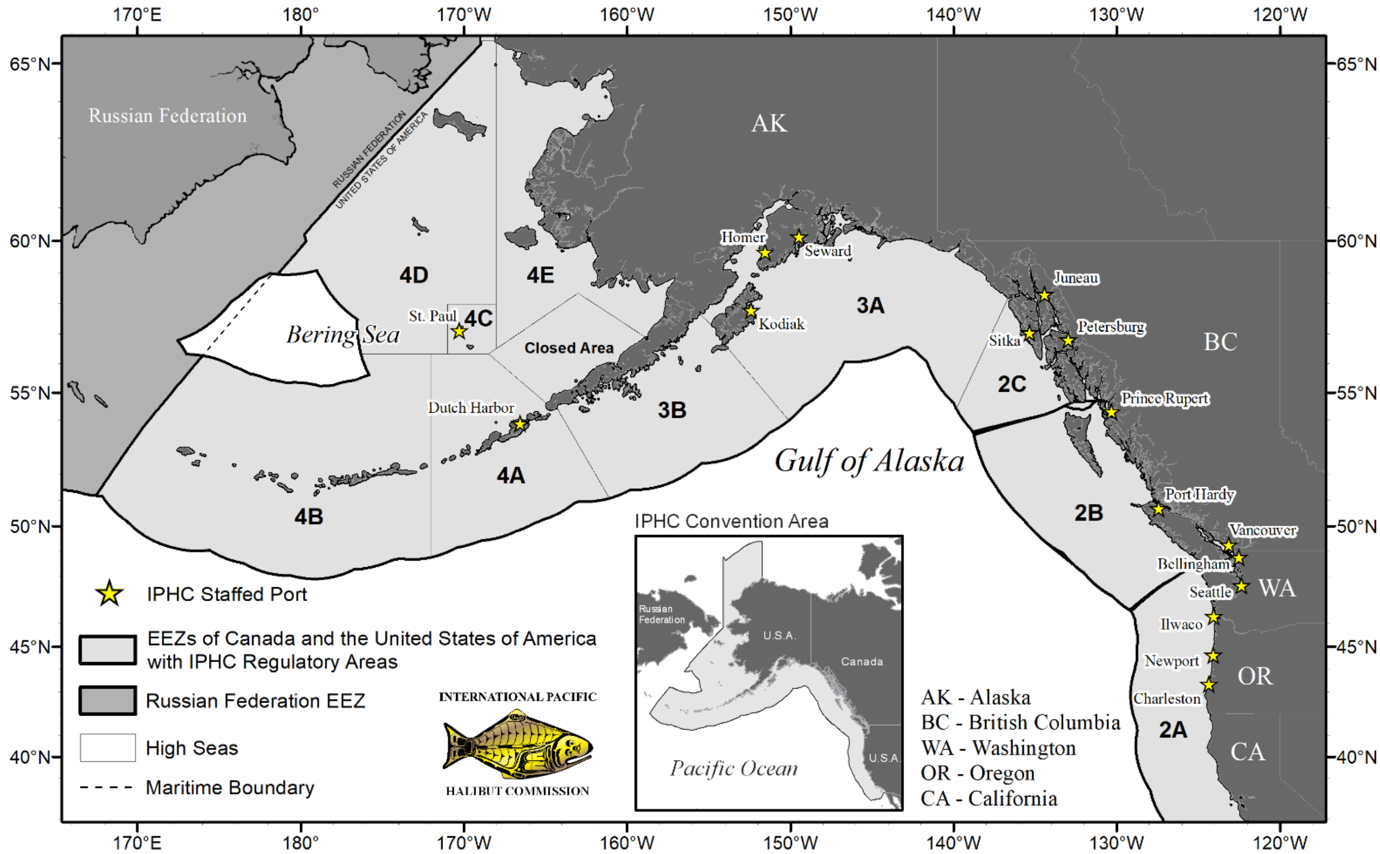

Figure 5. Ports where the IPHC has sampled directed commercial landings throughout the fishing period in recent years (note: ports sampled may change from year to year for operational reasons).

5.2.2 Fishery-independent data

Data collection and monitoring activities aimed at providing a standardised time-series of biological and ecological data that is independent of the fishing fleet.

5.2.2.1 Fishery-independent setline survey (FISS)

The IPHC Fishery-Independent Setline Survey (FISS) provides catch-rate information and biological data on Pacific halibut that are independent of the fisheries. These data, collected using standardised methods, bait, and gear, are used to estimate the primary index of population abundance used in the stock assessment. The FISS is restricted to the summer months but encompasses almost all known Pacific halibut habitat in Convention waters outside the Bering Sea, including the commercial fishing grounds in the Pacific halibut fishery. The standard FISS grid totals 1,890 stations from which a subset is sampled each year (Fig. 6). Biological data collected on the FISS (e.g. the length, weight, age, and sex of Pacific halibut) are used to monitor changes in year-class strength, biomass, growth, and mortality. In addition, records of non-target species caught during FISS operations provide the basis for estimating bait competition and are used to index species abundance over time, making them valuable to the potential management and avoidance of non-target species. Environmental data are also collected, including water column temperature, salinity, dissolved oxygen, pH, and chlorophyll concentration, to help identify the conditions in which the fish were caught, and these data can serve as covariates in space-time modeling used in the stock assessment. An example of the data collected and the methods used is provided in the annually updated FISS sampling manual (e.g. IPHC FISS Sampling Manual 2025: IPHC-2025-VSM01).

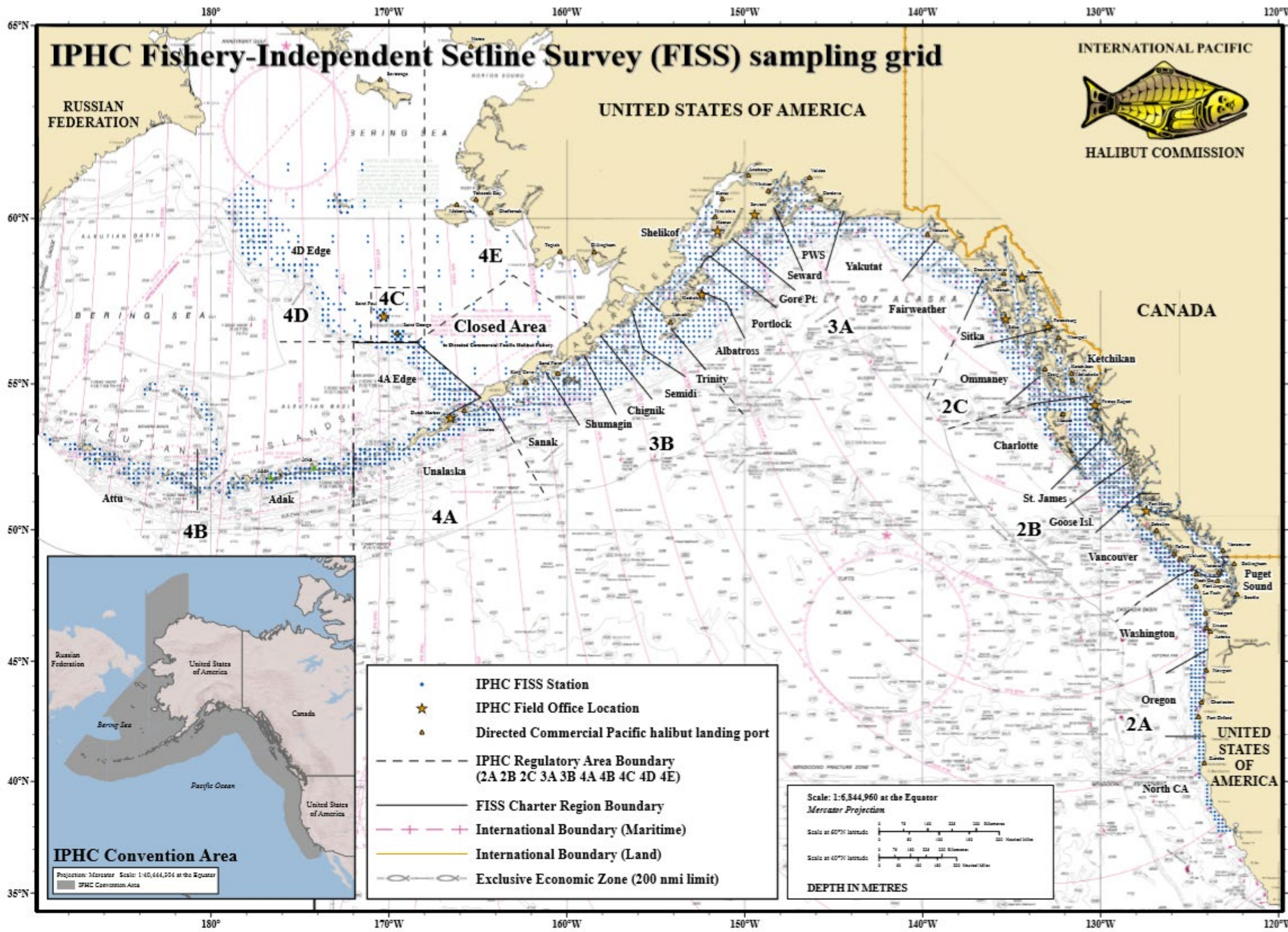

Figure 6. IPHC Fishery-Independent Setline Survey (FISS) with full sampling grid and charter regions.

Following a program of planned FISS expansions from 2014-19, a process of rationialisation of the annual FISS designs was undertaken. Currently, sampled stations are prioritised each year so that density indices will be estimated with high precision and low potential for bias. Based on funding and previous FISS results, potential FISS designs for the subsequent three years are evaluated. The resulting proposed designs and their evaluation are presented for review at the June Scientific Review Board (SRB) meetings and modified following SRB input and in-year FISS sampling results before presentation to the Commissioners at the Work Meeting and Interim Meeting. Annual biological sampling rates for each IPHC Regulatory Area are calculated based on the previous year's catch rates and an annual target of 2000 sampled fish (with 100 additional archive samples).

5.2.2.2 Fishery-independent Trawl Survey (FITS)

The IPHC relies on the NOAA Fisheries trawl surveys operating in the Bering Sea (Fig. 7), Aleutian Islands and Gulf of Alaska. The information collected from Pacific halibut caught on these surveys, together with data from the IPHC Fishery-Independent Setline Survey (FISS) is used in estimating indices of abundance and to monitor population demographics.

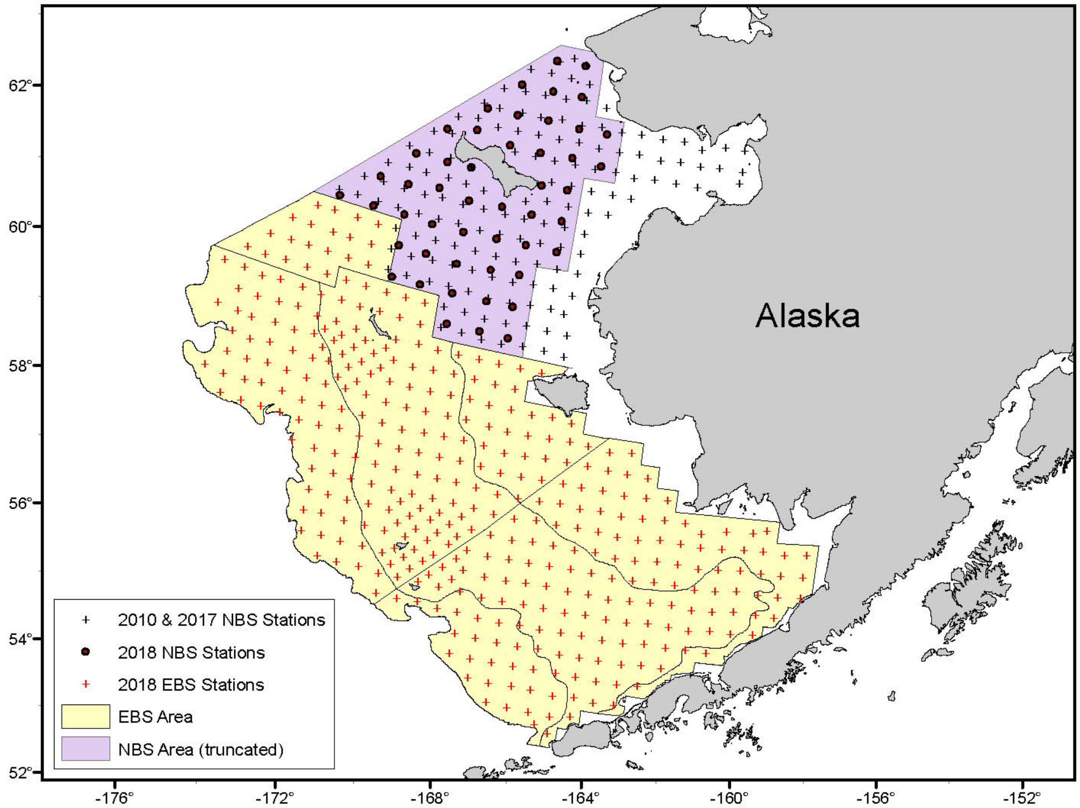

Figure 7. Representative sampling design for the NOAA Bering Sea bottom trawl survey. Black dots are stations sampled in the 2018 and black plus signs are stations sampled in subsequent Northern Bering Sea trawl surveys.

5.2.2.3 Norton Sound trawl survey

The Alaska Department of Fish and Game's annual Norton Sound trawl survey data contribute to the estimation of Pacific halibut indices of abundance in IPHC Regulatory Area 4CDE.

5.2.3 Age composition data (both fishery-dependent and fishery-independent)

Biological samples collected annually from commercial fisheries and FISS include otoliths, crystalline calcium carbonate structures found in the inner ear of fish whose growth patterns can be analysed to estimate the age of fish. Fish age is a key input to stock assessment models that inform management decisions related to fish exploitation and harvest strategies. Since its inception, the IPHC has aged over 1.5 million otoliths by trained readers under the stereoscopic microscope.

The IPHC Secretariat continues to age otoliths manually to provide the high-quality age estimates for the stock assessment. However, substantial progress has now been made toward an AI-assisted workflow. A deep-ensemble convolutional neural network (CNN) model has been developed and trained on otolith images. Adopting fine-tuning procedure, the model outputs results with progressively improving predictive accuracy. The deep ensemble approach also provides uncertainty estimates, allowing low-confidence cases to be flagged for expert review. This facilitates a mixed-method protocol where portion of high-confidence estimates is fast-tracked while manual verification is retained for the remainder.

In addition to AI-based methods, the IPHC is exploring epigenetic ageing that may offer comparable precision to traditional human-read methods, potentially expanding the toolkit for robust and scalable age estimation in the future.

5.3 Management-supporting information

To support science-based decision-making and advance the Commission's objective of developing Pacific halibut stock to the level that permits the optimum yield from the fishery over time, the IPHC Secretariat undertakes a range of supplementary analyses that provide direct input into management procedures and policy evaluations. These efforts complement the stock assessment and biological data streams by addressing specific questions raised by the Commission, domestic agencies, and other stakeholders.

In recent years, the IPHC Secretariat has undertaken a project evaluating Pacific halibut multiregional economic impact, illustrating economic interdependencies between sectors and regions to bring a better understanding of the role and importance of the Pacific halibut resource to regional economies of Canada and the United States of America. Other work has focused on regulatory questions, such as evaluating size limits and associated tradeoffs between yield optimisation, reducing discards, and economic outcomes, as well as assessing the socioeconomic and logistical challenges of implementing year-round fishing.

The IPHC Secretariat remains well-positioned to respond to requests from the Commission or Contracting Parties for technical support on a broad range of management-relevant topics. These may include, among others, socioeconomic considerations, community development, political constraints, or logistical feasibility analyses to inform emerging policy needs. Such analyses are developed collaboratively, leverage a range of available data sources and partners, and can be tailored to specific regulatory or planning contexts.

6. Core focal areas – Planned and opportunistic activities (2027-31)

The IPHC Secretariat works with IPHC advisory bodies and the Commission to identify research priorities and refine hypotheses. This process occurs via an annual schedule of meetings, as shown in Fig. 8. In May, an MSE informational session may be held to prepare stakeholders for the Management Strategy Advisory Board (MSAB) meeting in October. Recommendations related to the MSE and development of a harvest strategy are then directed to the Commission. The SRB holds two meetings each year: one in June, where requests are typically directed to IPHC Secretariat, and one in September, where recommendations are made to the Commission. The June SRB meeting has a focus on research; the September meeting represents a final check of science products to be presented to the Commission for use in management. The Research Advisory Board (RAB) meets in November to discuss ongoing research, provide guidance, and recommend new research projects. The Work Meeting (WM) is held in September to allow the IPHC Secretariat and the Commission to prepare for the Interim Meeting (IM) held in November and the Annual Meeting (AM) held in January. Outcomes from the AM include mortality limits (coastwide and by IPHC Regulatory Area), directed fishery commercial fishing period dates, domestic regulations, and requests and recommendations for the IPHC Secretariat. In conjunction with the AM are meetings of the Finance and Administration Committee (FAC), the Conference Board (CB), and the Processor Advisory Board (PAB). The Commission may also hold Special Sessions (SS) throughout the year to take up and make decisions on specific topics.

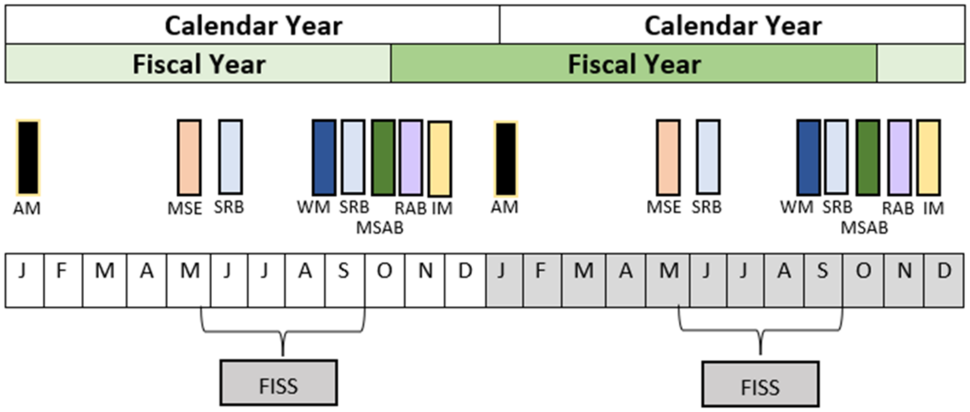

Figure 8. The typical IPHC annual meeting schedule with the calendar year and fiscal year shown. The meetings, shown in the middle row are: Annual Meeting where the Commission makes many final decisions for that year (AM), an MSE informational session (MSE), Scientific Review Board meetings (SRB), the Commission Work Meeting (WM), the Management Strategy Advisory Board meeting (MSAB), the Research Advisory Board Meeting (RAB), and the Interim Meeting (IM). The annual FISS schedule is also shown.

In addition to the annual meeting process at IPHC, individual core focal areas of research may identify and prioritise research for other core focal areas. For example, stock assessment research often identifies gaps in the knowledge of Pacific halibut biology and ecology, which then identifies priority research for the Biology and Ecology core area. Vice versa, basic biological and ecological research can identify concepts that could be better understood and result in improved implementation in any of the core areas. Furthermore, Management Strategy Evaluation can often be used to identify priority research topics for any core areas by simulation testing to identify research that may have the largest benefit to improving the management of Pacific halibut.

The top priorities of research for various categories in each of the core focal areas are provided below. The top priorities are a subset of the potential research topics in each core focal area. More exhaustive and up-to-date lists of research topics, that may extend beyond a five-year timeframe, can be found in recent meeting documents related to each core focal area.

6.1 Research

6.1.1 Stock Assessment

Within the three assessment research categories, the following topics have been identified as top priorities in order to focus attention on their importance for the stock assessment and management of Pacific halibut. A brief narrative is provided here to highlight the specific use of products from these studies in the stock assessment. More extensive lists of research topics are produced every three years as part of each full stock assessment analysis.

6.1.1.1 Stock Assessment data collection and processing

6.1.1.1.1 Commercial fishery sex-ratio-at-age via genetics

Commercial fishery sex-ratio information has been found to be closely correlated with the absolute scale of the population estimates in the stock assessment and has been identified as the greatest source of uncertainty since 2013. With only a short time-series (2017-24) of commercial sex-ratio-at-age information available for the 2025 stock assessment, the annual genetic assay of fin clips sampled from the landings remains critically important. When the time series grows longer, it may be advantageous to determine the ideal frequency at which these assays need to be conducted. This assessment priority directly informs *6.1.3.2 Reproduction* as described below.

6.1.1.1.2 Whale depredation accounting and tools for avoidance

Whale depredation represents a source of unobserved and unaccounted-for mortality in the assessment and management of Pacific halibut. Reduction of depredation mortality through improved fishery avoidance and/or catch protection would be a preferable extension and/or solution to methods for estimation. As such, research to provide the fishery with tools to reduce depredation is considered a high priority. This assessment priority directly informs *6.1.3.4.2 Fishing Innovations* as described below.

6.1.1.2 Stock Assessment technical development

6.1.1.2.1 Maintaining coordination with the MSE

The stock assessment and MSE operating models have been developed in close coordination in order to identify plausible hypotheses regarding the processes governing Pacific halibut population dynamics. Important aspects of Pacific halibut dynamics include recruitment (possibly related to extrinsic environmental factors in addition to spawning biomass), size-at-age, movement/migration, and spatial patterns in fishery catchability and selectivity. Many approaches developed as part of the tactical stock assessment have been explored in the MSE operating model, and conversely, the MSE operating model has highlighted areas of data uncertainty or alternative hypotheses for exploration in the assessment (e.g. movement rates). Although these two modelling efforts target differing objectives (tactical vs. strategic), continued coordination is essential to ensure that the stock assessment and the MSE represent the Pacific halibut similarly and provide consistent and useful advice for tactical and strategic decision-making.

6.1.1.2.2 Estimation of natural mortality

The stock assessment has been shown to be extremely sensitive to the value of natural mortality. The current approach uses four separate models to estimate management quantities, with three of these models estimating natural mortality directly from the data and one using a fixed historical assumption. Further work to determine the conditions under which natural mortality is estimable in the fourth model and plausible ranges of values for this parameter could reduce perceived and actual uncertainty in the stock assessment and the management information arising from it. As time-series of critically informative data sources like the FISS and the sex-ratio of the commercial landings grow longer, it may be possible to better integrate this source of uncertainty into the stock assessment ensemble.

6.1.1.2.3 Development of state-space models

The IPHC has relied on statistical catch-at-age models for most of its stock assessment history (Stewart and Martell 2014). New programming environments (e.g., TMB; Kristensen et al. 2016) have led to an increased use of state-space models for stock assessment (e.g. SAM, WHAM; Nielsen and Berg 2014; Nielsen et al. 2021; Stock and Miller 2021). These models provide extremely efficient capabilities for modelling random effects and sparse matrices. As the Pacific halibut stock assessment models include time-varying processes (i.e. recruitment, selectivity, and catchability), it would be ideal to treat them as random effects, rather than using the penalised likelihood approach currently employed. Although few such applications include sex-specific dynamics that can accommodate the necessary dimorphic growth capability to be applicable to Pacific halibut, development of a state-space model for Pacific halibut is prioritised in this research plan.

6.1.1.3 Stock Assessment biological inputs

6.1.1.3.1 Maturity, skip-spawning, and fecundity

Management of Pacific halibut is currently based on reference points that rely on relative female spawning biomass. Therefore, any changes to the understanding of reproductive output – either across age/size (maturity), over time (skip spawning), or as a function of body mass (fecundity) are crucially important. Each of these components directly affects the annual reproductive output estimated in the assessment. Ideally, the IPHC would have a program in place to monitor each of these three reproductive processes over time and use that information in the estimation of the stock-recruitment relationship and the annual reproductive output relative to reference points. This would reduce the potential for biased time-series estimates created by non-stationarity in these traits (illustrated via sensitivity analyses in several of the recent assessments). Building on the success of the previous research plan, we now have an updated maturity relationship included in the 2025 stock assessment. Moving forward, we will extend that research to include an updated fecundity relationship and an investigation of the potential for skip-spawning. After updated stock-wide estimates have been achieved, a program for extending this information to a time-series via transition from research to monitoring can be developed. This assessment priority directly informs *6.1.3.2 Reproduction* as described below.

6.1.1.3.2 Factors affecting size-at-age

Changes in size-at-age, along with recruitment, have been the largest contributors to the historical trends in biomass and fishery yield from the Pacific halibut stock. The relative role of potential factors underlying changes in size-at-age is not currently understood. Delineating between competition, density dependence, environmental effects, size-selective fishing, and other factors could allow improved prediction of size-at-age under future conditions and a better understanding of how management can adapt to changing trends.

6.1.2 Management Strategy Evaluation

MSE priorities have been subdivided into three categories: 1) biological parameterisation, 2) fishery parameterisation, and 3) technical development. Research provides specifications for the MSE simulations, such as inputs to the Operating Model (OM), but another important outcome of the research is to define the range of plausibility to include in the MSE simulations as a measure of uncertainty. The following topics have been identified as top priorities.

6.1.2.1 MSE Biological and population parameterisation

6.1.2.1.1 Distribution of life stages

Research topics in this category will mainly inform parameterisation of movement in the OM but will also provide further understanding of Pacific halibut movement, connectivity, and temporal variability. This knowledge may also be used to refine specific MSE objectives. Larval and juvenile distribution is a main source of uncertainty in the OM and continued research in this area will improve the OM and provide justification for parameterising temporal variability. Outcomes may also provide information on recruitment strength and the relationship with environmental factors. For example, recent work by Sadorus et al (2021) used biophysical and spatio-temporal models to examine connectivity across the Bering Sea and Gulf of Alaska. Furthermore, improved understanding of the distribution of adults resulting from ontogenetic movement will assist with conditioning the OM, verify patterns simulated from the OM, and provide information to develop reasonable sensitivity scenarios to test the robustness of MPs. Research under Section 6.1.3.1 will inform this MSE priority.

Finally, genomic analysis of population size (close-kin mark-recapture, *6.1.3.1*) is also included in this ranked category. Close-kin mark-recapture (CKMR) may provide insights into spatial relationships between juveniles and adults as well as abundance in specific regions. It would help inform the development of the OM as well as the biological sustainability objective related to maintaining a minimum spawning biomass in each IPHC Regulatory Area. An understanding of the spatial distribution of population size will help to inform this objective as well as the OM conditioning process.

6.1.2.1.2 Understanding growth variation

Changes in the average weight-at-age of Pacific halibut is one of the major drivers of changes in biomass over time. The OM currently simulates temporal changes in weight-at-age via a random autocorrelated process which is unrelated to population size or environmental factors. Ongoing research in drivers related to growth in Pacific halibut will help to improve the simulation of weight-at-age. Research under Section 6.1.3.3 will inform this MSE priority.

6.1.2.1.3 Spatial spawning patterns and connectivity between spawning populations

Further research into sub-population structure and connections between those sub-populations would provide an understanding of the importance of spatial heterogeneity in the Pacific halibut population. This may be incorporated directly into the OM, and/or into an objective to maintain spatial heterogeneity. This includes the identification of important spawning locations, temporal variability in spawning and recruitment, and the importance of spawning locations to a sustainable population and efficient fisheries across the IPHC convention area. This research is described in Section 6.1.3.1 below.

6.1.2.1.4 MSE fishery parameterisation

The definition of fisheries and their parameterisations in the MSE operating model involved consultation with Pacific halibut stakeholders, but some aspects of those parameterisations would benefit from targeted research. One specific example is knowledge of discarding and discard mortality rates in directed and non-directed fisheries. Discard mortality can be a significant source of fishing mortality in some IPHC Regulatory Areas, and appropriately modelling that mortality will provide a more robust evaluation of MPs. Research under Sections 6.1.3.4 will inform this MSE priority.

6.1.2.2 MSE technical development

Technical improvements to the MSE framework will allow for rapid development of alternative operating models and efficient simulation of management strategies for future evaluation and support of the Harvest Strategy Policy. Coordination with the technical development of the stock assessment (Section 6.1.1.2.1) is necessary to ensure consistent assumptions and hypotheses for tactical (i.e. stock assessment) and strategic (i.e. MSE) models. Investigations done in the stock assessment will inform the MSE operating model, which will then inform management and stock assessment development through investigations using the closed-loop simulation framework. Conducting assessments at intervals longer than annually may allow for additional opportunity to coordinate between stock assessment and MSE.

6.1.2.2.1 Alternative migration scenarios

Including alternative migration hypotheses in the MSE simulations will assist in identifying management procedures that are robust to this uncertainty. This exploration will draw on general research on the movement and migration of Pacific halibut, observations from FISS and fisheries data, and outcomes of the stock assessment. Identification of reasonable hypotheses for the movement of Pacific halibut is essential to the robust investigation of management procedures. Research under Section 6.1.3.1 will inform this MSE priority.

6.1.2.2.2 Realistic simulations of estimation error

Closed loop simulation uses feedback from the management procedure to update the population in the projections. The management procedure consists of data collection, an estimation model, and harvest rules; currently IPHC uses a stock assessment as the estimation model. Future development of an efficient simulation process to mimic the stock assessment will more realistically represent the current management process. This involves using multiple estimation models to represent the ensemble and appropriately adding data and updating those models in the simulated projections. Improvements to the current MSE framework include adding additional estimation models to better represent the ensemble stock assessment, ensuring that the simulated estimation accurately represent the stock assessment now and, in the future, and speeding up the simulation process.

6.1.2.2.3 Incorporate additional sources of implementation uncertainty

Implementation uncertainty consists of three subcategories: 1) decision-making uncertainty, 2) realised uncertainty, and 3) perceived uncertainty. Decision-making uncertainty is the difference between mortality limits determined from the management procedure and those adopted by the Commission. This uncertainty is currently implemented in the MSE framework but improvements could be made. Realised uncertainty is the difference between the mortality limit set by the Commission and the actual mortality realised by the various fisheries. This type of uncertainty is currently partially implemented in the MSE framework. Finally, perceived uncertainty is the difference between the realised mortality and the estimated mortality limits from the various fisheries, which would be used in the estimation model. This third type of implementation uncertainty has not been implemented in the MSE framework. Improving the implementation of decision-making uncertainty is a priority for the MSE and will assist in understanding the performance of management procedures given the flexibility desired by the Commission.

6.1.2.3 Potential Future MSE projects

Management Strategy Evaluation is an iterative process where new management procedures may be evaluated, current management procedures may be re-evaluated under different assumptions, and the understanding of the population, environment, and fisheries may be updated with new information stemming from the stock assessment and biological/ecological research. The current research priorities focus on technical development, but various elements of Management Procedures will likely be of interest once technical improvements are made. The research being done now will inform the development of the MSE in the future to ensure a robust evaluation of any management procedure.

6.1.3 Biology and Ecology

Capitalising on the outcomes of the first 5-year plan (IPHC–2019–BESRP-5YP), the second 5-year plan (IPHC-2022-5YPIRM) developed five research areas to provide key inputs for stock assessment and the MSE process. In addition to linking genetics and genomics with migration and distribution studies in the area of Migration and Population Dynamics, a novel research area on Fishing Technology was incorporated in the IPHC-2023-5YPIRM. The outcomes of IPHC-2023-5YPIRM are provided in Appendix I, and the resulting peer-reviewed publications are provided in Appendix III. The present plan (IPHC-2026-5YPIRM) describes the continuation of these five research areas into the next phase of management-serving research goals, with Fishing Technology being incorporated into a new research area that includes Mortality Estimations and Fishery Practices and Behavior. A series of key objectives for each of the five research areas has been identified that integrate with specific needs for stock assessment and MSE processes and that are ranked according to their relevance (Appendix IV and Appendix V, respectively). To further describe the IPHC Secretariat's rationale for establishing research priorities, a ranked list of biological uncertainties and parameters for stock assessment and the MSE process, and their links to research activities and outcomes derived from the IRMP is also provided.

6.1.3.1 Migration and Population Dynamics

Studies aimed at improving current knowledge of Pacific halibut distribution and population dynamics throughout all life stages in order to achieve a complete understanding of stock structure and distribution across the entire range of Pacific halibut in the North Pacific Ocean and the biotic and abiotic factors that influence it through multiple approaches. Specific objectives in this area include:

- Integrate analyses of Pacific halibut population dynamics, connectivity, and distribution changes by incorporating genomic approaches.
- Improve our understanding of the influences of oceanographic and environmental variation on connectivity, population structure, and adaptation at a genomic level using seascape genomics approaches.
- Improve our understanding of population structure.
- Improve our understanding of the contribution of known and putative (e.g. Washington coast) spawning areas to nursery/settlement areas in relation to year-class, recruit survival and strength, juvenile genetic diversity, and environmental conditions in the North Pacific Ocean.
- Improve our understanding of the relationship between the presence of juveniles in mapped nursery/settlement areas and adult distribution and abundance over temporal and spatial scales.
- Build upon the current conceptual model of Pacific halibut movement through a synthetic analysis of existing tagging data.
- Apply methods for individual identification based on computer-assisted tail image matching systems as an alternative for traditional mark and recapture tagging.

Horizon scan:

- Evaluate the potential use of environmental DNA (eDNA) for improving current understanding of Pacific halibut distribution and assist with mapping of juvenile habitat.
- Examine the feasibility of close-kin mark-recapture-based approaches to improve estimates of population size, migration rates among geographical regions, and demographic parameters (e.g. fecundity-at-age, natural mortality).

6.1.3.2 Reproduction

Studies aimed primarily at addressing several critical issues for stock assessment analysis based on estimates of female spawning biomass: 1) the sex ratio of the commercial catch; 2) revised maturity estimates, and 3) fecundity estimates. Specific objectives in this area include:

- Continued temporal and spatial analysis of female histology-based maturity-at-age estimates: identification of potential drivers (e.g. environmental, etc.) of temporal and spatial changes in maturity schedules.
- Develop and validate methods for fecundity estimations based on the auto-diametric method applied to other species.
- Provide estimates of fecundity-at-age and fecundity-at-size.
- Investigate the possible presence of skip spawning in Pacific halibut females.
- Improve accuracy in the current staging criteria of maturity status used in the field.
- Investigate possible environmental effects on the ontogenetic establishment of the phenotypic sex and their influence on sex ratios in the adult Pacific halibut population.
- Improve our understanding of the genetic basis of variation in age and/or size-at-maturity, fecundity, and spawning timing, by conducting genome-wide association studies.
- Characterise the temporal progression of reproductive development and gamete production throughout an entire annual reproductive cycle in male Pacific halibut.

6.1.3.3 Growth and size-at-age

Studies aimed at describing the role of factors responsible for the observed changes in size-at-age and at evaluating growth and physiological condition in Pacific halibut. Specific objectives in this area include:

- Investigate the effects of environmental and ecological conditions driving size-at-age and somatic growth in Pacific halibut.
- Investigate the influence of early growth (e.g. juveniles) in determining growth patterns during adulthood. Analysis of NMFS trawl data and investigation of potential early life regulatory mechanisms (e.g. epigenetic, etc.) that direct adult growth patterns.
- Investigate variation in somatic growth patterns in Pacific halibut as informed by physiological growth markers, physiological condition, energy content, and dietary influences.
- Evaluate the relationship between somatic growth, temperature, and trophic histories in Pacific halibut through the integrated use of physiological growth markers (e.g. gene expression, stable isotope profiles).
- Develop a non-invasive alternative method for aging Pacific halibut based on genetic analyses of DNA methylation patterns in tissues (fin clips). Development of an epigenetic clock and possible insights into the aging process/senescence in Pacific halibut.
- Improve our understanding of the genetic basis of variation in somatic growth and size-at-age by conducting genome-wide association studies.
- Explore emerging technological advances in genome sequencing that produce genomic and epigenetic data (e.g. PacBio, Oxford Nanopore) to assist in understanding the genetic and epigenetic basis of growth.
- Investigate the feasibility of otolith (or eye lens lamina) growth increment analyses for reconstructing individual growth histories in Pacific halibut.

Horizon scan:

- Investigate dietary composition in stomachs through metabarcoding (i.e. molecular identification of prey items in stomach contents).
- Investigate liver parasite loading and its effect on physiological conditions in Pacific halibut

6.1.3.4 Fishery dynamics and fishing technology

6.1.3.4.1. <u>Mortality estimations</u>. Studies aimed at developing and evaluating methods for estimating and reducing incidental mortality of Pacific halibut. Specific objectives in this area include:

- Incorporate experimentally-derived discard mortality rate data in the recreational fishery (based on research conducted under IPHC-2023-5YPIRM) into management.
- Review status of discard mortality rate (DMR) research conducted by the IPHC: synthesis paper of experimentally-derived DMR for Pacific halibut in different fisheries, with future research avenues and management recommendations.
- Investigate the application of electronic monitoring and AI-based analyses of discards for mortality estimations.
- Investigate new methods (e.g. AI-based) for improved estimation of depredation mortality from marine mammals.
- Support and collaborate in efforts to reduce Pacific halibut bycatch in other fisheries

- Investigate potential biological and ecological causes of mortality in Pacific halibut.

6.1.3.4.2. Fishing innovations. Studies investigating modifications of fishing gear/methods with the purpose of reducing depredation of Pacific halibut by toothed whales and reducing bycatch of non-targeted species. Specific objectives in this area include:

- Prepare a review paper summarising past and present directed (fixed) gear-related research by the IPHC.
- Investigate methods for whale avoidance and/or deterrence for the reduction of Pacific halibut depredation by whales (e.g. catch protection methods, pots).
- Investigate physiological and behavioral responses of Pacific halibut to fishing gear in order to increase the catch and reduce bycatch of non-targeted species: influence of lights on fishing gear, hook size, design or modification, pots, etc.

6.1.3.4.3. Fishery practices and behavior. Studies aimed at investigating changes in the directed Pacific halibut fishery in response to environmental, biological, and technological drivers. Specific objectives in this area include:

- Investigations into the interaction between climate change and fishing patterns
- Evaluations of the effects of sand fleas- and dogfish-prevalent areas on longline fisheries
- Tradeoffs of snap, fixed, and Autoline gear use on fishery efficiency.

6.2 Monitoring

The Commission's monitoring programs include both direct data collection by the IPHC Secretariat and coordination with domestic agencies to generate comprehensive fishery-dependent and fishery-independent information on Pacific halibut stock and fishery trends. These critical sources include estimates of fishing mortality across all fisheries encountering Pacific halibut, biological sampling from these fisheries, as well as catch rates and biological sampling from longline and trawl surveys. Monitoring data will continue to underpin the stock assessment and MSE process, support numerous biological research studies, and inform the decision-making process (Fig. 4).

6.2.1 Fishery-dependent data

The IPHC Secretariat will continue collecting fishery-dependent data from the directed commercial fishery, with a focus on maintaining adequate spatial and temporal coverage of catch, effort, and biological data. Coordination with Tribal, State and Federal agencies will continue to support the standardisation of data collection protocols, increase data collection capacity, improve reporting consistency, and help identify and fill data gaps that may impact stock assessment and management.

Collaborative work with commercial stakeholders will also continue to further the use of electronic logbooks which began in 2023, to enhance the accuracy and efficiency of data submission. The ongoing development of digital QA/QC systems will strengthen data integrity, ease operational demands, and increase the capacity of IPHC Secretariat for other advancements.

Efforts will include annual reviews of sampling distribution across ports, data collection methods, sampling rates, and QA/QC procedures, with in-season assessments of port sampling completely yearly. These initiatives aim to ensure that data collection continues to support stock assessment, MSE, and management needs, while integrating relevant research findings into long-term monitoring strategies.

6.2.2 Fishery-independent setline survey (FISS)

An annual review process for the FISS station design has been developed (Fig. 9) and is expected to continue in the coming years. This process involves scientific review of proposed FISS designs by the Scientific Review Board and includes input from stakeholders prior to review and approval of designs by the Commissioners.

Sample rates for genetic monitoring will need to be determined for future sampling. Sampling rates of otoliths for aging, archive otoliths, and tagged fish will continue to be reviewed annually to ensure the data needs of the IPHC stock assessment and research program are met. Annual FISS sampler training and data QAQC (including at the point of data collection and during post-sampling review) will ensure high-quality data from the FISS program.

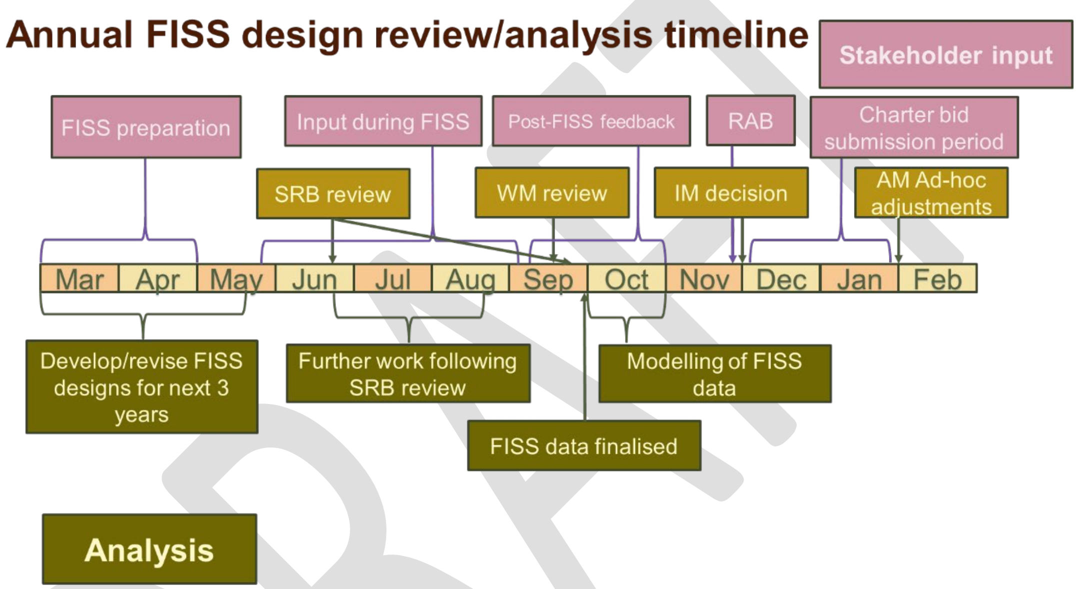

Figure 9. Timeline of annual FISS design review process.

6.2.2.1 Fishery-independent Trawl Survey (FITS)

The IPHC will continue to collaborate with NMFS on sampling procedures for Pacific halibut and on the placement of an IPHC sampler onboard a survey vessel for the collection of biological data.

6.2.3 Ageing methods (both fishery-dependent and fishery-independent)

6.2.3.1. Application of artificial intelligence (AI) for determining the age of fish from images of collected otoliths.

Progress in applying AI for determining the age of Pacific halibut from images of collected otoliths presents both opportunities and challenges, particularly in balancing gains in efficiency with the need to maintain data integrity and spatiotemporal consistency.

Integration and testing in the assessment: AI-generated ages will be introduced as an auxiliary input in a split-sample experiment. One assessment run will use the current manual series, while a parallel run will blend AI-derived ages ranked by confidence estimates (based on standard deviation scores), selecting increasing proportions (e.g., 25%, 50%, and 75%) of AI-derived ages, with manual ages used elsewhere. Additional assessment runs may explore prediction performance across regions and years that are not represented or are underrepresented in the training data, in order to understand the potential for bias when applying AI out-of-sample. Further development of accuracy and imprecision matrices will support comparisons between manual ages and different blends of AI-derived ages, based on ranked confidence thresholds. Uncertainty in management quantities and year-class strengths will be used to evaluate the robustness of incorporating AI-derived ages into the stock assessment model.

Cost-benefit analysis: The comparative scenarios will include the current manual-only protocol and hybrid protocols that apply AI-derived ages to high-confidence images. Evaluation metrics will include labor costs, turnaround time, variance in cohort-specific age compositions, and implications for stock assessment performance, particularly with respect to stability and reliability in informing mortality limit decisions.

Spatial-coverage considerations: As currently observed, AI accuracy declines when applied to otolith images from regions or years not represented in the training data. If future reductions in spatial coverage of the FISS occur, the risk of regional data imbalances in the training set may increase, potentially affecting AI reliability. However, this limitation may be mitigated over time as the training database expands to include a broader diversity of samples, potentially improving the model's generalisation across space and time. To ensure robustness in the interim, the continued inclusion of a subset of manually aged otoliths remains important. Additionally, the AI model can be fine-tuned using targeted market samples to reinforce spatial coverage and improve training representativeness when needed.

6.2.3.2. Application of an epigenetic clock for aging Pacific halibut using fin clips.

Epigenetic aging is a genetic method for aging that is based on the fact that methylation patterns on genomic DNA change predictably with age. Therefore, age-associated DNA methylation patterns can be modelled to generate molecular (i.e., epigenetic) age predictors capable of estimating chronological age with high accuracy. These are referred to as "epigenetic clocks" and can be developed from DNA isolated from any tissue, including non-lethal biological samples, such as a fin clip.

The objective of this project is to develop an epigenetic clock for Pacific halibut using fin clips from Pacific halibut of known ages. The specific objectives are (1) to identify DNA methylation signals in Pacific halibut fin tissue, (2) to develop an age prediction model based on age-associated DNA methylation patterns, and (3) to develop a targeted assay with selected age-associated epigenetic markers for cost-effective, high-throughput age estimations in Pacific halibut.

6.3 Management-supporting information

6.3.1 Potential of integrating human dynamics into management decision-making

Effective Pacific halibut management requires understanding not only biological stock dynamics, but also the human dimensions that shape fishery outcomes (Lane and Stephenson 1995). As new technologies such as AI, digital logbooks, and real-time monitoring evolve, so too does the potential to integrate human behavior, economic dependencies, and community-level impacts into the management framework.

Recent socioeconomic analyses conducted by the IPHC highlight disparities in how different regions and user groups benefit from Pacific halibut fisheries, and how external forces such as shifting markets and climate change can amplify these differences (Cheung and Frölicher 2020). Recognising these factors can improve both the fairness and resilience of fishery policies.

Looking ahead, the IPHC Secretariat aims to be prepared to integrate human dynamics, such as fleet behavior, market access, or social vulnerability, into stock assessment and MSE, where such complementary analyses may add value to the decision-making process (Lynch et al. 2018). This may include linking fishery performance metrics to socioeconomic indicators or exploring how alternative management scenarios affect community and fisher behavior. These efforts will ensure that science-based advice not only supports biological sustainability but is also responsive to the evolving realities of people and communities who depend on the resource.

7. Amendment

As with the previous two (2) plans, the IPHC Secretariat intends to maintain this IRMP document as a '*living plan'*, subject to annual reviews and updates as necessary. Revisions will reflect evolving priorities, resources available to undertake the work (e.g. internal and external fiscal resources, collaborations, internal expertise), and emerging opportunities. The IPHC Secretariat remains committed to transparency and to upholding the principles of open science in the development and implementation of this plan.

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Sadorus, Lauri L., Esther D. Goldstein, Raymond A. Webster, William T. Stockhausen, Josep V. Planas, and Janet T. Duffy-Anderson. 2020. "Multiple life-stage connectivity of Pacific halibut (*Hippoglossus stenolepis*) across the Bering Sea and Gulf of Alaska." Fisheries Oceanography 30 (2): 174-193.

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Webster, R.A., Clark, W.G., Leaman, B.M., and Forsberg, J.E. 2013. Pacific halibut on the move: a renewed understanding of adult migration from a coastwide tagging study. Canadian Journal of Fisheries and Aquatic Sciences 70(4): 642-653. doi:10.1139/cjfas-2012-0371.

ACKNOWLEDGEMENTS

To be populated

APPENDICES

Appendix I: Outcomes of IPHC-2023-5YPIRM

Appendix II: External funding received by the IPHC

Appendix III: Publications arising

Appendix IV: List of ranked research priorities for stock assessment

Appendix V: List of ranked research priorities for management strategy evaluation

APPENDIX I
OUTCOMES OF THE IPHC-2023-5YPIRM

1. Biology and Ecology

A. Outcomes by Research Area:

1. Migration and Population Dynamics

1.1. Development and application of genomic approaches. Planned research outcomes: generation of genomic resources for Pacific halibut that will support genomic research.

Main results:

- Sequencing of the Pacific halibut genome.
- Generation of a high-quality chromosome-level genome assembly for Pacific halibut and full characterisation of the genome
- Complete sequencing and annotation of the Pacific halibut genome into a publicly available online resource
- Identification of the sex determining region of the Pacific halibut genome in Chromosome 9.
- Successful mapping of single nucleotide polymorphisms used for genetic sexing into the sex determining region of the Pacific halibut genome.
- Generation of tissue-specific transcriptomes and combined transcriptome for Pacific halibut. Identification of tissue-specific transcriptomic characteristics.

1.2. Population genomic studies. Planned research outcomes: delineation of population structure within Convention Waters.

Main results:

- Application of low-coverage whole-genome resequencing to screen genomic variation at very high resolution.
- Development of a bioinformatic platform to process and analyse high-throughput whole genome sequencing data.
- Establishment of a baseline of genetic diversity by whole genome resequencing of genetic samples from spawning individuals collected from the main five spawning areas within Convention Waters.
- Lack of evidence for population structure, as evidenced by the inability of high-resolution genomics techniques to identify discrete genetic groups.
- Low ability to assign individuals back to the location in which they were sampled.
- Lack of population structure supports the modeling of the Pacific halibut stock as a single coastwide stock

1.3. Environmental influences on Pacific halibut distribution. Planned research outcomes: relationship between Pacific halibut distribution and environmental variables.

Main results:

- Establishment of baseline environmental data for Pacific halibut habitat for older juvenile and adult individuals in different Biological Regions.
- Application of environmental profiler data in spatio-temporal modeling.
- Identification of changes in Pacific halibut density and distribution of Pacific halibut in Biological Region 2 associated with low near-bottom dissolved oxygen levels. These hypoxic events are the result of seasonal upwelling.

Publications:

Jasonowicz, A.J., Simeon, A., Zahm, M., Cabau, C., Klopp, C., Roques, C., Iampietro, C., Lluch, J., Donnadieu, C., Parrinello, H., Drinan, D. P., Hauser, L., Guiguen, Y., Planas, J.V. Generation of a chromosome-level genome assembly for Pacific halibut (*Hippoglossus stenolepis*) and characterization of its sex-determining genomic region. *Molecular Ecology Resources.* 2022. 22: 2685–2700. https://doi.org/10.1111/1755-0998.13641.

Jasonowicz, A.J., Simchick, C., Planas, J. V. Tissue-specific and reference transcriptomes for Pacific halibut (*Hippoglossus stenolepis*). 2025. In Preparation.

Jasonowicz, A.J., Simchick, C., Dawson, L., Spies, I., Larson, W., Planas, J.V. Genomic support for a single stock of Pacific halibut (*Hippoglossus stenolepis*) in the Northeastern Pacific Ocean. 2025. In Preparation.

Planas, J.V., Rooper, C.N., Kruse, G.H. Integrating biological research, fisheries science and management of Pacific halibut (Hippoglossus stenolepis) across the North Pacific Ocean. *Fisheries Research*. 2023. 259: 106559. https://doi.org/10.1016/j.fishres.2022.106559.

Sadorus, L.L., Webster, R.A. and Sullivan, M.E. Environmental conditions on the Pacific halibut (Hippoglossus stenolepis) fishing grounds obtained from a decade of coastwide oceanographic monitoring, and the potential application of these data in stock analyses. *Marine and Freshwater Research*. 2024. 75: MF23175. https://doi.org/10.1071/MF23175.

Integration with Stock Assessment and MSE: The relevance of research outcomes from activities in this research area for stock assessment is in evaluating the biological support for modeling the Pacific halibut stock as a coastwide stock and in the improvement of estimates of productivity. Research outcomes will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region and represent one of the top three biological inputs into stock assessment. Additionally, current assumptions of stock structure used in the current stock assessment will be tested by these research activities. The relevance of these research outcomes for MSE is in the improvement of the parametrisation of the Operating Model and represent the top ranked biological input into the MSE.

2. Reproduction

2.1 Sex ratio of commercial landings. Planned monitoring outcomes: sex ratio information.

Main results:

- Sex ratio information for the 2017-2024 commercial landings.

2.2 Histological maturity assessment. Planned research outcomes: updated maturity schedule.

Main results:

- Application of histological ovarian development classification criteria to revise female maturity and establishment of criteria to identify immature versus mature females.
- Successful staging of ovarian samples collected in the FISS from 2022 to 2024.
- Testing of various types of models (i.e. generalised linear models (GLMs) and generalised additive models (GAMs)) to fit maturity data.
- Application of best-fit GAM models to estimate maturity ogives by Biological Region and year.
- Generation of a coastwide maturity ogive using weighed Biological Region ogives for the period 2022-2024.
- Development of a calibration factor between histology- and field (visual)-based maturity estimates.
- Integrate the calibration factor to revise FISS historical maturity data with which to investigate decadal changes in female maturity.
- Description of endocrine parameters that are associated with female developmental stages and identification of potential physiological markers for maturity.
- Collection of samples in the summers of 2023-2025 and fall of 2024 for the development of the fecundity estimation method and for generating the first estimates of fecundity.

Publications:

Fish, T., Wolf, N., Harris, B.P., Planas, J.V. A comprehensive description of oocyte developmental stages in Pacific halibut, *Hippoglossus stenolepis*. *Journal of Fish Biology*. 2020. 97: 1880-1885. doi: 10.1111/jfb.14551.

Fish, T., Wolf, N., Smeltz, T. S., Harris, B. P., and Planas, J. V. Reproductive Biology of Female Pacific Halibut (*Hippoglossus stenolepis*) in the Gulf of Alaska. *Frontiers in Marine Science.* 2022. 9:801759. doi: 10.3389/fmars.2022.801759.

Simchick, C., Simeon, A., Bolstad, K., Planas, J.V. Endocrine patterns associated with ovarian development in female Pacific halibut (*Hippoglossus stenolepis*). *General and Comparative Endocrinology*. 2024. 347: 114425. https://doi.org/10.1016/j.ygcen.2023.114425

Integration with Stock Assessment and MSE: Research activities in this Research Area aim at providing information on key biological processes related to reproduction in Pacific halibut (maturity and fecundity) and to provide sex ratio information of Pacific halibut commercial landings. The relevance of research outcomes from these activities for stock assessment is in the scaling of Pacific halibut biomass and in the estimation of reference points and fishing intensity. These research outputs will result in a revision of current maturity schedules and will be included as inputs into the stock assessment and represent the most important biological inputs for stock assessment. The relevance of these research outcomes for MSE is in the improvement of the simulation of spawning biomass in the Operating Model.

3. Growth

3.1 Identification of physiological growth markers and their application for growth pattern evaluation. Planned research outcomes: informative physiological growth markers to monitor somatic growth variation in Pacific halibut.

Main results:

- Transcriptomic profiling by RNA sequencing of white skeletal muscle from juvenile Pacific halibut subjected to temperature-induced growth manipulations.
- Identification of a set of genes that change their expression levels in response to growth suppression and to growth stimulation: growth marker identification.
- Proteomic profiling by LC-MS/MS of white skeletal muscle from juvenile Pacific halibut subjected to temperature-induced growth manipulations.
- Identification of a set of proteins that change their abundance in response to growth suppression and to growth stimulation: growth marker identification.
- Application of putative growth marker genes in the characterisation of somatic growth variation in Pacific halibut juveniles collected in the Eastern Bering Sea by the NMFS Trawl Survey.
- Transcriptomic profiling by RNA sequencing of white skeletal muscle from juvenile Pacific halibut subjected to density- and stress-induced growth manipulations under experimental conditions.

Publications:

Planas, J.V., Jasonowicz, A.J., Simeon, A., Simchick, C., Timmins-Schiffman, E., Nunn, B.L., Kroska, A.C., Wolf, N., and Hurst, T.P. Molecular mechanisms underlying thermally induced growth plasticity in juvenile Pacific halibut. *Journal of Experimental Biology*. 2025. In Review.

Integration with Stock Assessment and MSE: Research activities conducted in this Research Area aim at providing information on somatic growth processes driving size-at-age in Pacific halibut. The relevance of research outcomes from these activities for stock assessment resides, first, in their ability to inform yield-per-recruit and other spatial evaluations for productivity that support mortality limit-setting, and second, in that they may provide covariates for projecting short-term size-at-age and may help delineate between fishery and environmental effects, thereby informing appropriate management responses. The relevance of these research outcomes for MSE is in the improvement of the simulation of variability and to allow for scenarios investigating climate change.

4. Mortality and Survival Assessment

4.1 Discard mortality rate estimation in the longline Pacific halibut fishery. Planned research outcomes: full characterisation of discarded Pacific halibut in the longline fishery.

Main results:

- Hook release methods strongly influence the viability category assigned to discarded Pacific halibut in the longline fishery, with careful shaking and gangion cutting resulting in >75% of fish being assigned to the excellent viability category.
- The use of the hook stripper results in >85% of the fish being classified in the moderate and poor viability categories, and sustained injuries of medium and high severity particularly among

smaller fish. These results support minimising the use of hook strippers in non-directed fisheries to optimise survival of discarded Pacific halibut.

- High lactate plasma levels and low hematocrit were characteristic of fish assigned to the dead viability category, and were attributed to sand flee intrusion.
- Reducing the use of hook strippers and limiting soak times in areas of known sand flea activity are likely to improve viability outcomes of Pacific halibut released from commercial longline gear.

Publications:

Dykstra, C., Wolf, N., Harris, B.P., Stewart, I.J., Hicks, A., Restrepo. F., Planas, J.V. Relating capture and physiological conditions to viability and survival of Pacific halibut discarded from commercial longline gear. *Ocean & Coastal Management*. 2024. 249: 107018. https://doi.org/10.1016/j.ocecoaman.2024.107018.

4.2 Discard mortality rate estimation in the guided recreational Pacific halibut fishery. Planned research outcomes: experimentally-derived discard mortality rate, full characterisation of discarded Pacific halibut and assessment of best handling practices.

Main results:

- The mortality rate estimated from Pacific halibut captured and released in excellent viability category is 1.35%.
- The size of circle hooks (12/0 and 16/0) does not affect the size of the catch nor the types of injuries incurred by captured fish, with torn cheek being the predominant injury for both hook sizes.
- The levels of stress indicators in the blood (glucose and lactated, and cortisol to a lesser extent) increase with fight time.
- Our results on the low level of mortality associated with the release of Pacific halibut in excellent viability category is consistent with current discard mortality estimates.

Integration with Stock Assessment and MSE: The relevance of research outcomes from these activities for stock assessment resides in their ability to accurately capture trends in unobserved mortality in order to improve estimates of stock productivity and represent the most important inputs in fishery yield for stock assessment. The relevance of these research outcomes for MSE is in fishery parametrisation

5. Fishing Technology

5.1 Investigations on new methods for whale avoidance and/or deterrence for the reduction of Pacific halibut depredation by whales (e.g. catch protection methods). Planned research outcomes: information on feasibility, and performance of catch protection devices.

Main results:

- A virtual International Workshop (link) was organised in 2022 on protecting fishery catches from whale depredation with industry (affected fishers, gear manufacturers), gear researchers and scientists to identify methods to protect fishery catches from depredation.
- Development of two catch protection designs stemming from the outcomes of the International Workshop into functional prototypes.

- Successful initial testing of two selected catch protection devices (underwater shuttle and branch gear with sliding shroud system) in the field.
- As a catch protection device, the shuttle is a safe and effective gear type that entrained comparable quantities, sizes and types of fish as control (i.e. longline) gear.
- Additional testing in the presence of whales was conducted in May of 2025.

5.2 Investigate physiological and behavioral responses of Pacific halibut to fishing gear in order to reduce bycatch. Planned research outcomes: effective ways to reduce Pacific halibut bycatch and bycatch of non-targeted species.

Main results:

- Hook size did not significantly affect the catch efficiency of Pacific halibut or yelloweye rockfish.
- Circle hooks with a 45° appendage angle caught fewer yelloweye rockfish than hooks without an appendage, irrespective of hook size, and did not affect the catch efficiency of Pacific halibut.
- Hook appendages could have potential use in reducing catch rates on yelloweye rockfish in Pacific halibut longline fisheries.

Publications:

Lomeli, M.J.M., Wakefield, W.W., Abele, M., Dykstra, C.L., Herrmann, B., Stewart, I.J., and G.C. Christie. 2023. Testing of hook sizes and appendages to reduce yelloweye rockfish bycatch in a Pacific halibut longline fishery. Ocean & Coastal Management 241: 106664. https://doi:10.1016/j.ocecoaman.2023.106664.

Integration with Stock Assessment and MSE: The relevance of research outcomes from these activities for stock assessment resides in the improvement of mortality accounting through a reduction of depredation mortality, thereby increasing the available yield for directed fisheries. Depredation mortality can also be included as another explicit source of mortality in the stock assessment and mortality limit setting process depending on the estimated magnitude.

APPENDIX II
EXTERNAL FUNDING RECEIVED BY THE IPHC

Project #	Grant agency	Project name	PI	Partners	IPHC Budget ($US)	Management implications	Grant period
1	**Saltonstall-Kennedy NOAA**	Improving discard mortality rate estimates in the Pacific halibut by integrating handling practices, physiological condition and post-release survival (NOAA Award No. NA17NMF4270240)	IPHC	Alaska Pacific University	$286,121	Bycatch estimates	September 2017 – August 2020
2	**North Pacific Research Board**	Somatic growth processes in the Pacific halibut (*Hippoglossus stenolepis*) and their response to temperature, density and stress manipulation effects (NPRB Award No. 1704)	IPHC	AFSC-NOAA-Newport, OR	$131,891	Changes in biomass/size-at-age	September 2017 – February 2020
3	**Bycatch Reduction Engineering Program - NOAA**	Adapting Towed Array Hydrophones to Support Information Sharing Networks to Reduce Interactions Between Sperm Whales and Longline Gear in Alaska	Alaska Longline Fishing Association	IPHC, University of Alaska Southeast, AFSC-NOAA	-	Whale Depredation	September 2018 – August 2019
4	**Bycatch Reduction Engineering Program - NOAA**	Use of LEDs to reduce Pacific halibut catches before trawl entrainment	Pacific States Marine Fisheries Commission	IPHC, NMFS	-	Bycatch reduction	September 2018 – August 2019
5	**National Fish & Wildlife Foundation**	Improving the characterisation of discard mortality of Pacific halibut in the recreational fisheries (NFWF Award No. 61484)	IPHC	Alaska Pacific University, U of A Fairbanks, charter industry	$98,902	Bycatch estimates	April 2019 – November 2021
6	**North Pacific Research Board**	Pacific halibut discard mortality rates (NPRB Award No. 2009)	IPHC	Alaska Pacific University,	$210,502	Bycatch estimates	January 2021 –March 2022
7	**Bycatch Reduction Engineering Program - NOAA**	Gear-based approaches to catch protection as a means for minimising whale depredation in longline fisheries (NA21NMF4720534)	IPHC	Deep Sea Fishermen's Union, Alaska Fisheries Science Center-NOAA, industry representatives	$99,700	Mortality estimations due to whale depredation	November 2021 – October 2022
8	**North Pacific Research Board**	Pacific halibut population genomics (NPRB Award No. 2110)	IPHC	Alaska Fisheries Science Center-NOAA	$193,685	Stock structure	December 2021- January 2024

9	**Bycatch Reduction Engineering Program - NOAA**	Full scale testing of devices to minimize whale depredation in longline fisheries (NA23NMF4720414)	IPHC	NOAA Fisheries -Alaska Fisheries Science Center (Seattle)	$199,870	Mortality estimations due to whale depredation	November 2023 – April 2026
10	**Alaska Sea Grant**	Development of a non-lethal genetic-based method for aging Pacific halibut (R/2024-05)	IPHC, Alaska Pacific Univ. (APU)	Alaska Fisheries Science Center-NOAA (Juneau)	$60,374	Stock structure	January 2025-December 2026
				Total awarded ($)	**$1,281,045**		

APPENDIX III
PUBLICATIONS ARISING

2020:

Fish, T., Wolf, N., Harris, B.P., Planas, J.V. A comprehensive description of oocyte developmental stages in Pacific halibut, *Hippoglossus stenolepis*. *Journal of Fish Biology*. 2020. 97: 1880-1885. https://doi: 10.1111/jfb.14551.

Stewart, I.J., Hicks, A.C., and Carpi, P. 2021. Fully subscribed: Evaluating yield trade-offs among fishery sectors utilizing the Pacific halibut resource. Fisheries Research **234**. doi:10.1016/j.fishres.2020.105800.

Webster, R.A., Soderlund, E., Dykstra, C.L., and Stewart, I.J. 2020. Monitoring change in a dynamic environment: spatio-temporal modelling of calibrated data from different types of fisheries surveys of Pacific halibut. Canadian Journal of Fisheries and Aquatic Sciences **77**: 1421–1432.

Forrest, R.E., Stewart, I.J., Monnahan, C.C., Bannar-Martin, K.H., and Lacko, L.C. 2020. Evidence for rapid avoidance of rockfish habitat under reduced quota and comprehensive at-sea monitoring in the British Columbia Pacific halibut fishery. Canadian Journal of Fisheries and Aquatic Sciences **77**: 1409–1420.

2021:

Carpi, P., Loher, T., Sadorus, L., Forsberg, J., Webster, R., Planas, J.V., Jasonowicz, A., Stewart, I. J., Hicks, A. C. Ontogenetic and spawning migration of Pacific halibut: a review. *Rev Fish Biol Fisheries*. 2021. https://doi.org/10.1007/s11160-021-09672-w.

Kroska, A.C., Wolf, N., Planas, J.V., Baker, M.R., Smeltz, T.S., Harris, B.P. Controlled experiments to explore the use of a multi-tissue approach to characterizing stress in wild-caught Pacific halibut (*Hippoglossus stenolepis*). *Conservation Physiology* 2021. 9(1):coab001. https://doi:10.1093/conphys/coab001.

Loher, T., Bath, G. E., Wischniowsky, S. The potential utility of otolith microchemistry as an indicator of nursery origins in Pacific halibut (*Hippoglossus stenolepis*) in the eastern Pacific: the importance of scale and geographic trending. *Fisheries Research*. 2021. 243: 106072. https://doi.org/10.1016/j.fishres.2021.106072.

Lomeli, M.J.M., Wakefield, W.W., Herrmann, B., Dykstra, C.L., Simeon, A., Rudy, D.M., Planas, J.V. Use of Artificial Illumination to Reduce Pacific Halibut Bycatch in a U.S. West Coast Groundfish Bottom Trawl. *Fisheries Research*. 2021. 233: 105737. doi: 10.1016/j.fishres.2020.105737.

Sadorus, L., Goldstein, E., Webster, R., Stockhausen, W., Planas, J.V., Duffy-Anderson, J. Multiple life-stage connectivity of Pacific halibut (*Hippoglossus stenolepis*) across the Bering Sea and Gulf of Alaska. *Fisheries Oceanography*. 2021. 30:174-193. doi: https://doi.org/10.1111/fog.12512.

Stewart, I.J., Scordino, J.J., Petersen, J.R., Wise, A.W., Svec, C.I., Buttram, R.H., Monette, J.L., Gonzales, M.R., Svec, R., Scordino, J., Butterfield, K., Parker, W., and Buzzell, L.A. 2021. Out with the new and in with the old: reviving a traditional Makah halibut hook for modern fisheries management challenges. Fisheries **46**(7): 313–320. doi:10.1002/fsh.10603.**2022:**

Fish, T., Wolf, N., Smeltz, T. S., Harris, B. P., and Planas, J. V. Reproductive Biology of Female Pacific Halibut (*Hippoglossus stenolepis*) in the Gulf of Alaska. *Frontiers in Marine Science* 2022. 9:801759. doi: 10.3389/fmars.2022.801759.

Jasonowicz, A.C., Simeon, A., Zahm, M., Cabau, C., Klopp, C., Roques, C., Iampietro, C., Lluch, J., Donnadieu, C., Parrinello, H., Drinan, D.P., Hauser, L., Guiguen, Y., Planas, J.V. Generation of a chromosome-level genome assembly for Pacific halibut (*Hippoglossus stenolepis*) and characterization of its sex-determining genomic region. *Molecular Ecology Resources*. 2022. 22: 2685–2700. doi: https://doi.org/10.1111/1755-0998.13641.

Loher, T., McCarthy, O., Sadorus, L.L., Erikson, L.M., Simeon, A., Drinan, D.P., Hauser, L., Planas, J.V., and Stewart, I.J. 2022. A Test of Deriving Sex-Composition Data for the Directed Pacific Halibut Fishery via At-Sea Marking. Marine and Coastal Fisheries **14**(4). doi:10.1002/mcf2.10218.

Loher, T., Dykstra, C.L., Hicks, A., Stewart, I.J., Wolf, N., Harris, B.P., Planas, J.V. Estimation of post release longline mortality in Pacific halibut using acceleration-logging tags. *North American Journal of Fisheries Management*. 2022. 42: 37-49. DOI: http://dx.doi.org/10.1002/nafm.10711.

2023:

Lomeli, M.J.M., Wakefield, W.W., Abele, M., Dykstra, C.L., Herrmann, B., Stewart, I.J., and G.C. Christie.. Testing of hook sizes and appendages to reduce yelloweye rockfish bycatch in a Pacific halibut longline fishery. *Ocean & Coastal Management* .2023. 241: 106664. https://doi:10.1016/j.ocecoaman.2023.106664.

Planas, J.V., Rooper, C.N., Kruse, G.H. Integrating biological research, fisheries science and management of Pacific halibut (Hippoglossus stenolepis) across the North Pacific Ocean. *Fisheries Research*. 2023. 259: 106559. https://doi.org/10.1016/j.fishres.2022.106559.

2024:

Dykstra, C., Wolf, N., Harris, B.P., Stewart, I.J., Hicks, A., Restrepo. F., Planas, J.V. Relating capture and physiological conditions to viability and survival of Pacific halibut discarded from commercial longline gear. *Ocean & Coastal Management*. 2024. 249: 107018. https://doi.org/10.1016/j.ocecoaman.2024.107018.

Hutniczak, B., Wilson, D.T., Stewart, I.J., and Hicks, A.C. 2024. A hundred years of Pacific halibut management in the context of global events and trends in fisheries management. Frontiers in Marine Science **11**. doi:10.3389/fmars.2024.1424002.

Sadorus, L.L., Webster, R.A. and Sullivan, M.E. Environmental conditions on the Pacific halibut (Hippoglossus stenolepis) fishing grounds obtained from a decade of coastwide oceanographic monitoring, and the potential application of these data in stock analyses. *Marine and Freshwater Research*. 2024. 75: MF23175. https://doi.org/10.1071/MF23175

Simchick, C., Simeon, A., Bolstad, K., Planas, J.V. Endocrine patterns associated with ovarian development in female Pacific halibut (*Hippoglossus stenolepis*). *General and Comparative Endocrinology*. 2024. 347: 114425. https://doi.org/10.1016/j.ygcen.2023.114425

2025:

Ritchie, BA, Smeltz, TS, Stewart, IJ, Harris, BP, and N. Wolf. 2025. Exploring Spatial and Temporal Patterns in the Size-At-Age of Pacific Halibut in the Gulf of Alaska. Fisheries Management and Ecology. doi:10.1111/fme.12814.

In press peer-reviewed journal papers

Adams, GD, Holsman, K, Rovellini, A, Stewart, IJ, Privitera-Johnson, K., Essington, TE, Wassermann, SN, and Punt, AE. 2025. Implications of predator-prey dynamics for single species management. Canadian Journal of Fisheries and Aquatic Sciences.

Submitted peer-reviewed journal papers – In review

McGilliard, C.R., Ianelli, J., Cunningham, C., Hicks, A., Hanselman, D., Stram, D., Henry, A. Evaluating Bering Sea Pacific halibut bycatch management options using closed-loop simulations in a dynamic, multi-agency setting. Canadian Journal of Fisheries and Aquatic Sciences.

Planas, JV, Jasonowicz, AJ, Simeon, A, Simchick, C, Timmings-Schiffman, E, Nunn, BL, Kroska, AC, Wolf, N, Hurst, TP. Molecular mechanisms underlying thermally induced growth plasticity in juvenile Pacific halibut. Journal of Experimental Biology.

Stewart, IJ and Monnahan, CC. Diagnosing common sources of lack of fit to composition data in fisheries stock assessment models using One-Step-Ahead (OSA) residuals. Canadian Journal of Fisheries and Aquatic Sciences.

APPENDIX IV
LIST OF RANKED RESEARCH PRIORITIES FOR STOCK ASSESSMENT

Research priorities for the Pacific halibut stock assessment are delineated into three broad categories: improvements in basic biological understanding (including fishery dynamics), investigation of existing data series and collection of new information, and technical development of models and modelling approaches. The highest priority items in each of these categories are highlighted in the 5YPIRM and are expected to be the primary focus of ongoing efforts. However, it is helpful to maintain a longer list of items to inform future prioritization, to create a record of data and research needs, and to foster opportunistic and/or collaborative work on these topics when possible.

Biological understanding and fishery yield:

- *Highest priority*: Updating the fecundity-weight relationship and the presence and/or rate of skip spawning.
- *Highest priority*: The relative role of potential factors underlying changes in size-at-age is not currently understood. Delineating between competition, density dependence, environmental effects, size-selective fishing and other factors could allow improved prediction of size-at-age under future conditions.
- Movement rates among Biological Regions at the adult, juvenile and larval stages remain uncertain and likely variable over time. Long-term research to inform these rates could lead to a spatially explicit stock assessment model for future inclusion into the ensemble.
- Improved understanding of recruitment processes and larval dynamics could lead to covariates explaining more or the residual variability about the stock-recruit relationship than is currently accounted for via the binary indicator used for the Pacific Decadal Oscillation.

Potential projects relating to existing and new data sources that could benefit the Pacific halibut stock assessment:

- *Highest priority*: Continued collection of sex-ratio from the commercial landings will provide valuable information for determining relative selectivity of males and females, and therefore the scale of the estimated spawning biomass, and the level of fishing intensity as measured by SPR.
- *Highest priority*: Evaluation of the magnitude of marine mammal depredation and tools to reduce it.
- A space-time model could be used to calculate weighted FISS and/or commercial fishery age-composition data. This might alleviate some of the lack of fit to existing data sets that is occurring not because of model misspecification but because of incomplete spatial coverage in the annual FISS sampling which is accounted for in the generation of the index, but not in the standardization of the composition information.
- The work of Monnahan and Stewart (2015) modelling commercial fishery catch rates could be used to provide a standardized fishery index for the recent time-series that would be analogous to the space-time model used for the FISS.
- There is a vast quantity of archived historical data that is currently inaccessible until organized, electronically entered, and formatted into the IPHC's database with appropriate meta-data. Information

on historical fishery landings, effort, and age samples would provide a much clearer (and more reproducible) perception of the historical period.

- Additional efforts could be made to reconstruct estimates of subsistence harvest prior to 1991.
- Discard mortality estimates for the IPHC Regulatory Area 2B recreational fishery are currently unavailable, but there is an estimation system in place. Further work to develop these estimates would be preferable to the use of proxy rates from IPHC Regulatory Area 2C.
- NMFS observer data from the directed Pacific halibut fleet in Alaska could be evaluated for use in updating discard mortality rates and the age-distributions for discard mortality. This may be more feasible if observer coverage is increased and if smaller vessels (< 40 feet LOA, 12.2 m) are observed in the future. Post-stratification and investigation of observed vs. unobserved fishing behavior may be required.
- Historical bycatch length frequencies and mortality estimates should be reanalyzed accounting for sampling rates in target fisheries and evaluating data quality over the historical period.
- There are currently no comprehensive variance estimates for the sources of mortality used in the assessment models. In some cases, variance due to sampling and perhaps even non-sampling sources could be quantified and used as inputs to the models via scaling parameters or even alternative models in the ensemble.

Technical explorations and improvements that could benefit the stock assessment models and ensemble framework:

- *Highest priority*: Maintaining consistency and coordination between MSE, and stock assessment data, modelling and methodology.
- *Highest priority*: Exploration of state-space models for Pacific halibut allowing for direct estimation of the variance in time-varying processes.
- *Highest priority*: Continued exploration into the estimation of M in the short coastwide model.
- Continued refinement of the ensemble of models used in the stock assessment. This may include investigation of alternative approaches to modelling selectivity that would reduce relative down-weighting of certain data sources (see section above), evaluation of additional axis of uncertainty (e.g., steepness, as explored above), or others.
- Exploration of methods for better including uncertainty in directed and non-directed discard mortalities in the assessment (now evaluated only via alternative mortality projection tables or model sensitivity tests) in order to better include these sources uncertainty in the decision table. These could include explicit discard/retention relationships, including uncertainty in discard mortality rates, and allow for some uncertainty directly in the magnitude of mortality for these sources.
- Bayesian methods for fully integrating parameter uncertainty may provide improved uncertainty estimates within the models contributing to the assessment, and a more natural approach for combining the individual models in the ensemble (see section above).

- Alternative model structures, including a growth-explicit statistical catch-at-age approach and a spatially explicit approach may provide avenues for future exploration. Efforts to develop these approaches thus far have been challenging due to the technical complexity and data requirements of both. Previous reviews have indicated that such efforts may be more tractable in the context of operating models for the MSE, where conditioning to historical data may be much more easily achieved than fully fitting an assessment model to all data sources for use in tactical management decision making.

APPENDIX V
LIST OF RANKED RESEARCH PRIORITIES FOR MANAGEMENT STRATEGY EVALUATION

To be populated after HSPWS02 – 6 August 2025

Report on Current and Future Biological and Ecosystem Science Research Activities

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, C. DYKSTRA, A. JASONOWICZ, C. JONES, 17 AUGUST 2025)

PURPOSE

To provide the Scientific Review Board with a description of progress towards research activities described in the IPHC's five-year Program of Integrated Research and Monitoring (2022-2026).

BACKGROUND

The primary biological and ecological research activities at the IPHC that follow Commission objectives are identified and described in the IPHC Five-Year Program of Integrated Research and Monitoring (2022-2026). These activities are integrated with stock assessment (SA) and the management strategy evaluation (MSE) processes (Appendix I) and are summarized in five main areas, as follows:

1) Migration and Population Dynamics. Studies are aimed at improving current knowledge of Pacific halibut migration and population dynamics throughout all life stages in order to achieve a complete understanding of stock structure and distribution across the entire distribution range of Pacific halibut in the North Pacific Ocean and the biotic and abiotic factors that influence it.
2) Reproduction. Studies are aimed at providing information on the sex ratio of the commercial catch and to improve current estimates of maturity and fecundity.
3) Growth. Studies are aimed at describing the role of factors responsible for the observed changes in size-at-age and at evaluating growth and physiological condition in Pacific halibut.
4) Mortality and Survival Assessment. Studies are aimed at providing updated estimates of discard mortality rates in the guided recreational fisheries and at evaluating methods for reducing mortality of Pacific halibut.
5) Fishing Technology. Studies are aimed at developing methods that involve modifications of fishing gear with the purpose of reducing Pacific halibut mortality due to depredation and bycatch.

A ranked list of biological uncertainties and parameters for SA (Appendix II) and the MSE process (Appendix III) and their links to research activities and outcomes derived from the five-year research plan are provided.

SRB RECOMMENDATIONS AND REQUESTS

The SRB issued several recommendations and requests in their report of SRB026 (IPHC-2025-SRB026-R) in relation to presentation IPHC-2025-SRB026-06:

*SRB026–Rec.01 (para. 16). The SRB **RECOMMENDED** that questions about stock structure should be deprioritized in future research plans, as this question has now been answered quite robustly.*

The IPHC Secretariat is currently preparing a manuscript intended for publication in a leading peer-review journal describing the results on genomic stock structure.

SRB026–Rec.02 (para. 18). The SRB ***RECOMMENDED*** *that the 2025 stock assessment incorporate the new maturity ogives, however, the incorporation of new fecundity information should be delayed until the next full stock assessment when more robust data and analysis of fecundity at age/weight information are available:*

The IPHC Secretariat has provided the new maturity ogives to be incorporated into the 2025 stock assessment and is initiating efforts to investigate fecundity.

SRB026–Rec.03 (para. 19). The SRB ***RECOMMENDED*** *that the Secretariat incorporate potential environmental causes (e.g. effects of temperature) of changing maturity ogives or other changing biological parameters in the next 5YPIRM.*

The IPHC Secretariat has incorporated potential environmental causes of changing biological parameters in the current draft of IPHC-2026-5YPIRM.

UPDATE ON PROGRESS ON THE MAIN RESEARCH ACTIVITIES

1. Migration and Population Dynamics.

The IPHC Secretariat is currently focusing on studies that incorporate genomics approaches in order to produce useful information on population structure, distribution and connectivity of Pacific halibut. The relevance of research outcomes from these activities for stock assessment (SA) resides (1) in the introduction of possible changes in the structure of future stock assessments, as separate assessments may be constructed if functionally isolated components of the population are found (e.g. IPHC Regulatory Area 4B), and (2) in the improvement of productivity estimates, as this information may be used to define management targets for minimum spawning biomass by Biological Region. These research outcomes provide the second and third top ranked biological inputs into SA (Appendix II). Furthermore, the relevance of these research outcomes for the MSE process is in biological parameterization and validation of movement estimates, on one hand, and of recruitment distribution, on the other hand (Appendix III).

1.1. Population genomics. The primary objective of these studies is to investigate the genetic structure of the Pacific halibut population and to conduct genetic analyses to inform on Pacific halibut population dynamics and distribution within the Convention Area

Details on sample collection, sequencing, bioinformatic processing and proposed analyses utilizing low-coverage whole genome sequencing (lcWGR) to investigate Pacific halibut population structure were provided in documents IPHC-2021-SRB018-08, IPHC-2022-SRB021-09, IPHC-2023-SRB022-09, IPHC-2024-SRB024-09 and IPHC-2025-SRB026-06.

Our results from the final genomics analyses using the complete set of baseline samples confirm our initial results regarding our inability to confidently identify the presence of discrete genetic groups using unsupervised clustering analyses. Furthermore, the lack of population structure limits our ability to assign samples back to the location from which they were sampled from. In summary, our results support the notion that a single genetic group of Pacific halibut is present in IPHC Convention Waters. We are currently preparing a manuscript for publication in a leading peer-reviewed journal describing these results.

1.2. Genomics-based method for estimating age of Pacific halibut. The primary objective of this project is to develop a genetic method for aging Pacific halibut using fin tissue, a sample that can be easily collected from either live or dead individuals. This method is based on the identification of DNA methylation patterns in fin tissue that are associated with age through the development of an age estimation model (i.e., an epigenetic clock) for Pacific halibut. The first epigenetic clock was developed for humans in 2013 (Horvath, 2013), and it predicted age with great accuracy (r = 0.96) and with a mean aging error (MAE) of 3.6 years. Subsequently, epigenetic clocks have been developed for several fish species that demonstrated improved accuracy (r between 0.84 and 0.99) and lower average MAE (0.87 years, or 3.5% of the total lifespan of the species examined) (reviewed in Piferrer and Anastasiadi, 2023).

Patterns of DNA methylation (i.e. a natural process of regulation of gene expression that consists in the covalent modification of the nucleobase cytosine) in Pacific halibut will be investigated by performing genome-wide DNA methylation at single base-pair resolution using reduced representation bisulfite sequencing (RRBS) by leveraging the high-quality genome assembly available for Pacific halibut (Jasonowicz et al. 2022). This is an efficient and cost-efficient method to identify methylation patterns (i.e., CpG sites) in DNA because it targets bisulfite sequencing to a well-defined set of genomic regions with high CpG density that can be sequenced at high read depth. Age-associated DNA methylation patterns will be modelled to generate an epigenetic age predictor (i.e., epigenetic clock) for Pacific halibut constructed using elastic net penalized regression models that select a group of CpG sites that have a monotonically increasing relationship with age in the selected training data set. By implementing these linear models that select and weight age-correlated CpG sites, chronological age of Pacific halibut will be estimated based on the percentage methylation at these key CpG sites in fin tissue samples.

1.2.1. Methods.

1.2.1.1. Genetic samples. For this project, we have selected fin clips from 250 individuals collected in the FISS seasons from 2021 to 2024. These genetic samples correspond to fish with known ages (read twice by the traditional break and bake aging method) between 6 to 30 years and include 10 individual samples (5 males and 5 females) for each of the 25 years of the sample collection.

1.2.1.2. Reduced representation bisulfite sequencing: library preparation and sequencing. High-quality genomic DNA will be extracted and purified using the DNeasy Blood and Tissue Kit (Qiagen) on a total of 250 individual samples (described above). Genomic DNA will be used to construct individual RRBS libraries using the Premium RRBS Kit V2 (Diagenode) following the manufacturer's specifications. In brief, RRBS libraries will be prepared by digesting genomic DNA with the methylation sensitive restriction enzyme *MspI*, and the resulting DNA fragments will be treated with bisulfite to convert non-methylated cytosines into uracils through chemical deamination, leaving methylated cytosines unaffected. A subsequent PCR amplification step will convert uracils into thymines. Constructed RRBS libraries will be first assessed for concentration and fragment size distribution by Bioanalyzer (Agilent) and, subsequently, libraries will be pooled and sequenced on an Illumina NovaSeq platform with 50 bp paired-end for 100 cycles at a commercial sequencing provider (Novagene). Two pools of 125 samples (individual libraries) each will be run on two NovaSeq S4 lanes with an estimated output of 2.5 bilion reads generated per lane to achieve an average sequencing depth of 20x per sample (i.e., 20x coverage). This assumes 1.4 million restriction sites based on an in silico digestion of the Pacific halibut genome using *MspI* (preliminary data) and a 25% phiX spike in and a 2% of the reads corresponding to the unmethylated E. coli control used to determine bisulfite conversion efficiency (Illumina).

1.2.1.3. Sequencing data analysis and methylation calling. Prior to analysis, raw sequence reads will be quality checked using *FastQC* (Andrews et al., 2015) to ensure consistent quality across sequencing runs and to identify samples that may not be suitable for further analysis. Specifically, the raw base quality scores for each sample will be used to identify samples that were poorly sequenced and should be omitted from downstream analyses. Additionally, the presence of other sequencing artifacts may be detected at this step as well. The raw sequence reads will then be processed to remove Illumina adapter sequences and low quality reads using *Trim Galore!* (https://github.com/FelixKrueger/TrimGalore), a trimming tool designed specifically for RRBS data. Trimmed sequence reads will be aligned to a bisulfite converted index of the Pacific halibut reference genome (RefSeq assembly accession: GCF_022539355.2) excluding the sex chromosome (Chr09; Jasonowicz et al., 2022) to discard possible sex-associated methylation signals, using *bismark* (Krueger and Andrews, 2011) allowing for one mismatch. Having a high-quality reference genome available for Pacific halibut is a major benefit to this study as constructing one is costly and time consuming. Furthermore, the Pacific halibut genome has been annotated so that the locations and identity of genes are known, enabling the functional significance of methylated CpG sites present in protein coding gene regions to be inferred. The resulting sequence alignment map (SAM) files will be coordinate sorted and converted to the binary alignment map format (BAM) using *samtools* (Li et al., 2009). The methylation module in *BS-Seeker2* (Guo et al., 2013) with default settings will be used for methylation calling. For all identified CpG sites, percentage methylation will be calculated as the percentage of the number of methylated reads over the number of total reads with a 95% confidence interval. Typically, RRBS produces in the order of hundreds of thousands of CpGs (Anastasiadi and Piferrer, 2023). CpG sites with at least 20x coverage and with methylation levels in > 90% of the samples will be used for downstream analyses.

1.2.1.4. Development of an age predicting model for Pacific halibut. The sequenced genetic samples will be randomly assigned to a training (200 samples) or a testing data set (50 samples) following an 80/20 data split. Sample assignments will be conducted using *caret* to maintain equal sex ratios in each data set. The training set will be used to fit the model and the testing set will be an independent set of data that will be used to evaluate the model fit.

The relationship between otolith-derived age and percent methylation across age-correlated CpG sites in the training data set will be characterized by performing elastic net penalized regression analysis using the R package glmnet (Friedman et al., 2010) set to a 10-fold cross validation with an α-parameter of 0.5 and automatically selecting the optimal penalty parameter (λ). We expect that the age-predicting model will retain in the order of a few hundred CpG sites with a low λ value. The performance of the model in the training and testing data set will be evaluated using Pearson correlations (i.e. measuring the degree of correlation between chronological and estimated age) as a measure of accuracy, MAE as a measure of precision (i.e., how well the model fits the actual data), and relative error rates (Piferrer and Anastasiadi, 2023). Comparison of MAE between the training and testing data sets will inform on the potential overfit of the model constructed using the training data set. The linear relationship between predicted and chronological (i.e., otolith-derived) age will be visually represented and additional patterns in the data will be visualized using principal component analysis (PCA).

1.2.1.5. Identification of the genomic location of age markers. The Pacific halibut genome annotation (NCBI link) will also be used to determine if any functional genes are located within 400 bp of model selected CpG sites. This will inform whether clock CpG sites are proximal to specific annotated genes and whether methylation at those particular sites could have functional significance.

1.2.2. Results.

All 250 aged fin clips have been processed for DNA extraction. The obtained genomic DNA has been quantified, and all samples yielded enough genomic DNA to proceed with individual library construction. Library preparation for the first set of 84 samples has been conducted and two library pools have been sent out for sequencing. Sequencing data will be processed as detailed in 1.2.1.3.

2. Reproduction.

Research activities in this Research Area aim at providing information on key biological processes related to reproduction in Pacific halibut (maturity and fecundity) and to provide sex ratio information of Pacific halibut commercial landings. The relevance of research outcomes from these activities for stock assessment (SA) is in the scaling of Pacific halibut biomass and in the estimation of reference points and fishing intensity. These research outputs will result in a revision of current maturity schedules and will be included as inputs into the SA (Appendix II), and represent some of the most important biological inputs for stock assessment (please see document IPHC-2021-SRB018-06). The relevance of these research outcomes for the management and strategy evaluation (MSE) process is in the improvement of the simulation of spawning biomass in the Operating Model (Appendix III).

2.1. Sex ratio of the commercial landings. The IPHC Secretariat is finalizing the processing of genetic samples from the 2024 aged commercial landings.

2.2. Reproductive assessment. Recent sensitivity analyses have shown the importance of changes in spawning output due to changes in maturity schedules and/or skip spawning and fecundity for SA (Stewart and Hicks, 2018). Information on these key reproductive parameters provides direct input to the SA. For example, information on fecundity-at-age and -size could be used to replace spawning biomass with egg output as the metric of reproductive capability in the SA and management reference points. This information highlights the need for a better understanding of factors influencing reproductive biology and success of Pacific halibut. To fill existing knowledge gaps related to the reproductive biology of female Pacific halibut, research efforts are devoted to characterizing female reproduction in this species. Specific objectives of current studies include: 1) update of maturity schedules based on histological-based data; and 2) calibration of historical visual maturity schedules using histological-based data.

2.2.1. Update of maturity schedules based on histological-based data. The IPHC Secretariat provided an update on temporal patterns in maturity ogives by Biological Region from 2022 to 2024, and a revised coastwide maturity ogive in IPHC-2025-SRB026-06. Furthermore, the IPHC Secretariat developed a calibration between histological and visual maturity curves from the 2022-2024 data and generated calibrated maturity ogives based on FISS visual maturity data from 2002 until 2024. At present, the IPHC Secretariat is preparing a manuscript for publication in a peer-reviewed journal describing the temporal and spatial changes in histology-derived maturity ogives and ovarian developmental stages.

2.2.2. Collection of samples for fecundity estimations. The IPHC Secretariat has initiated studies that are aimed at improving our understanding of Pacific halibut fecundity. This will allow us to estimate fecundity-at-size and -age and could be used to replace spawning biomass with egg output as the metric for reproductive capability in stock assessment and management reference points. Fecundity determinations will be conducted using the auto-diametric method (Thorsen and Kjesbu 2001; Witthames et al., 2009) and IPHC Secretariat staff received training on this method by experts in the field (NOAA Fisheries, Northeast Fisheries Science Center, Wood Hole, MA) in May 2023. Ovarian samples for the development and application of the auto-diametric method to estimate fecundity in female Pacific halibut were collected during the IPHC's FISS in 2023, 2024 and 2025. In 2023, sampling was conducted only in Biological Region 3, with a total of 456 fecundity samples collected. In 2024, sampling was conducted in Biological Regions 2 and 4, with 149 and 359 fecundity samples collected, respectively. In the Fall of 2024, 273 additional fecundity samples targeting large females (85-200+ cm in fork length) were collected in Biological Region 2. In 2025, in addition to samples collected in the FISS, fecundity samples were again collected in Biological Region 2 in a special project targeting large females. This comprehensive collection of ovarian samples will be used initially for the development of the auto-diametric method, followed by actual fecundity estimations by age and by size (length and weight).

3. Growth.

Research activities conducted in this Research Area aim at providing information on somatic growth processes driving size-at-age in Pacific halibut. The relevance of research outcomes from these activities for stock assessment (SA) resides, first, in their ability to inform yield-per-recruit and other spatial evaluations for productivity that support mortality limit-setting, and, second, in that they may provide covariates for projecting short-term size-at-age and may help delineate between fishery and environmental effects, thereby informing appropriate management responses (Appendix II). The relevance of these research outcomes for the management and strategy evaluation (MSE) process is in the improvement of the simulation of variability and to allow for scenarios investigating climate change (Appendix III).

The IPHC Secretariat has conducted studies aimed at elucidating the drivers of somatic growth leading to the decline in SAA by investigating the physiological mechanisms that contribute to growth changes in the Pacific halibut. The two main objectives of these studies have been: 1) the identification and validation of physiological markers for somatic growth; and 2) the application of molecular growth markers for evaluating growth patterns in the Pacific halibut population.

A manuscript describing the results of these studies has been submitted for publication to a peer-reviewed journal (Planas et al., in review).

4. Mortality and Survival Assessment.

Information on all Pacific halibut removals is integrated by the IPHC Secretariat, providing annual estimates of total mortality from all sources for its stock assessment. Bycatch and wastage of Pacific halibut, as defined by the incidental catch of fish in non-target fisheries and by the mortality that occurs in the directed fishery (i.e. fish discarded for sublegal size or regulatory reasons), respectively, represent important sources of mortality that can result in significant reductions in exploitable yield in the directed fishery. Given that the incidental mortality from the commercial Pacific halibut fisheries and bycatch fisheries is included as part of the total removals that are accounted for in stock assessment, changes in the estimates of incidental mortality will influence the output of the stock assessment and, consequently, the catch levels of the directed fishery. Research activities conducted in this Research Area aim at providing information on discard mortality rates and producing guidelines for reducing discard mortality in Pacific halibut in the longline and recreational fisheries. The relevance of research outcomes from these activities for stock assessment (SA) resides in their ability to improve trends in unobserved mortality to improve estimates of stock productivity and represent the most important inputs in fishery yield for stock assessment (Appendix II). The relevance of these research outcomes for the management and strategy evaluation (MSE) process is in fishery parametrization (Appendix III).

4.1. Estimation of discard mortality rates in the charter recreational sector. Results from a recently completed study investigating discard mortality rates and characteristics of fish captured and released using guided recreational fishery practices are currently being prepared for publication in a peer-reviewed journal.

5. Fishing technology.

The IPHC Secretariat has determined that research to provide the Pacific halibut fishery with tools to reduce whale depredation is considered a high priority (Appendix I). This research is now contemplated as one of the research areas of high priority within the 5-year Program of Integrated Research and Monitoring (2022-2026). Towards this goal, the IPHC secretariat has been investigating gear-based approaches to catch protection as a means for minimizing whale depredation in the Pacific halibut and other longline fisheries with funding from NOAA's Bycatch Research and Engineering Program (BREP) (NOAA Awards NA21NMF4720534 and NA23NMF4720414; Appendix IV). The results and outcomes of the initial pilot phase of this project were reported in the documentation provided for the previous SRB meetings: IPHC-2022-SRB020-08 and IPHC-2024-SRB024-09.

The second phase of this project focused on further refinement and performance characterization of the shuttle device in the presence of toothed whales in IPHC Regulatory Area 4A. Field operations occurred from 21-28 May 2025 aboard the F/V Oracle (Figure 1). Eighteen sets were successfully completed, generating 15 sets of shuttle and control catch comparison data along with close to 80 hours of underwater footage combined (control, shuttle exterior, shuttle interior). Depredating orcas were present at 6 of the paired sets. Data sets are currently being imported into IPHC databases or extracted from the video, and further field trials during a quota trip are in planning stages.

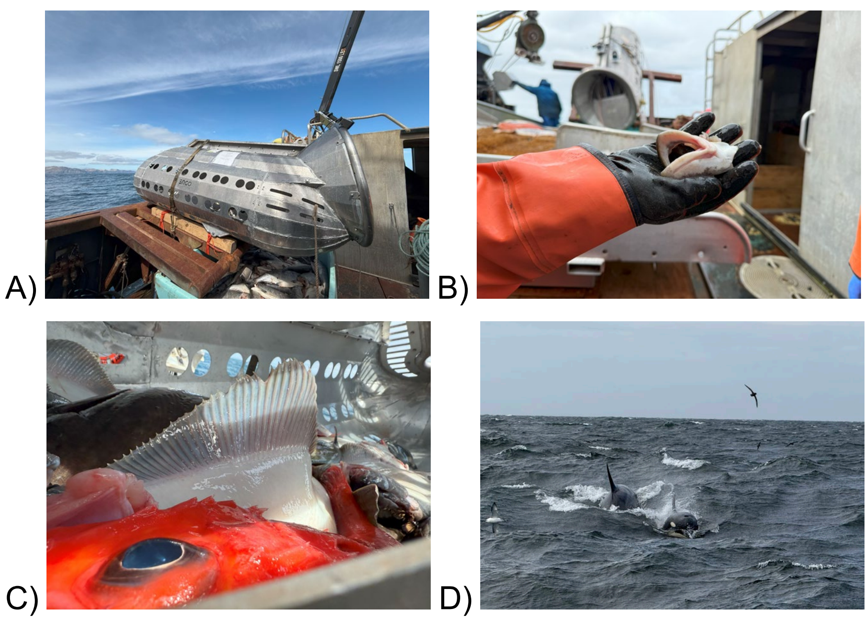

Figure 1. *A) Shuttle device in transport. B) Typical evidence (lips only) of depredation. C) Catch entrained within the shuttle. D). Killer whales rapidly approaching the hauling site.*

RECOMMENDATION/S

That the SRB:

a) **NOTE** paper IPHC-2025-SRB027-06 which provides a response to Recommendations and Requests from SRB026, and a report on current biological research activities contemplated within the IPHC's five-year Program of Integrated Research and Monitoring (2022-26).

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APPENDIX I

Integration of biological research, stock assessment (SA) and management strategy evaluation (MSE): rationale for biological research prioritization

Research areas	Research activities	Research outcomes	Relevance for stock assessment	Relevance for MSE	Specific analysis input	SA Rank	MSE Rank	Research priorization
Migration and population dynamics	Population structure	Population structure in the Convention Area	Altered structure of future stock assessments	Improve parametization of the Operating Model	If 4B is found to be functionally isolated, a separate assessment may be constructed for that IPHC Regulatory Area	2. Biological input	1. Biological parameterization and validation of movement estimates and recruitment distribution	2
	Distribution	Assignment of individuals to source populations and assessment of distribution changes	Improve estimates of productivity		Will be used to define management targets for minimum spawning biomass by Biological Region	3. Biological input		2
	Larval and juvenile connectivity studies	Improved understanding of larval and juvenile distribution	Improve estimates of productivity		Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	3. Biological input	1. Biological parameterization and validation of movement estimates	2
Reproduction	Histological maturity assessment	Updated maturity schedule	Scale biomass and reference point estimates	Improve simulation of spawning biomass in the Operating Model	Will be included in the stock assessment, replacing the current schedule last updated in 2006	1. Biological input		1
	Examination of potential skip spawning	Incidence of skip spawning			Will be used to adjust the asymptote of the maturity schedule, if/when a time-series is available this will be used as a direct input to the stock assessment			1
	Fecundity assessment	Fecundity-at-age and -size information			Will be used to move from spawning biomass to egg-output as the metric of reproductive capability in the stock assessment and management reference points			1
	Examination of accuracy of current field macroscopic maturity classification	Revised field maturity classification			Revised time-series of historical (and future) maturity for input to the stock assessment			1
Growth	Evaluation of somatic growth variation as a driver for changes in size-at-age	Identification and application of markers for growth pattern evaluation	Scale stock productivity and reference point estimates	Improve simulation of variability and allow for scenarios investigating climate change	May inform yield-per-recruit and other spatial evaluations of productivity that support mortality limit-setting		3. Biological parameterization and validation for growth projections	5
		Environmental influences on growth patterns			May provide covariates for projecting short-term size-at-age. May help to delineate between effects due to fishing and those due to environment, thereby informing appropriate management response			5
		Dietary influences on growth patterns and physiological condition			May provide covariates for projecting short-term size-at-age. May help to deleineate between effects due to fishing and those due to environment, thereby informing appropriate management response			5
Mortality and survival assessment	Discard mortality rate estimate: longline fishery	Experimentally-derived DMR	Improve trends in unobserved mortality	Improve estimates of stock productivity	Will improve estimates of discard mortality, reducing potential bias in stock assessment results and management of mortality limits	1. Fishery yield	1. Fishery parameterization	4
	Discard mortality rate estimate: recreational fishery				Will improve estimates of discard mortality, reducing potential bias in stock assessment results and management of mortality limits			4
	Best handling and release practices	Guidelines for reducing discard mortality			May reduce discard mortality, thereby increasing available yield for directed fisheries	2. Fishery yield		4
Fishing technology	Whale depredation accounting and tools for avoidance	New tools for fishery avoidance/deterence; improved estimation of depredation mortality	Improve mortality accounting	Improve estimates of stock productivity	May reduce depredation mortality, thereby increasing available yield for directed fisheries. May also be included as another explicit source of mortality in the stock assessment and mortality limit setting process depending on the estimated magnitude	1. Assessment data collection and processing		3

APPENDIX II

List of ranked biological uncertainties and parameters for stock assessment (SA) and their links to biological research areas and research activities

SA Rank	Research outcomes	Relevance for stock assessment	Specific analysis input	Research Area	Research activities
1. Biological input	Updated maturity schedule	Scale biomass and reference point estimates	Will be included in the stock assessment, replacing the current schedule last updated in 2006	Reproduction	Histological maturity assessment
	Incidence of skip spawning		Will be used to adjust the asymptote of the maturity schedule, if/when a time-series is available this will be used as a direct input to the stock assessment		Examination of potential skip spawning
	Fecundity-at-age and -size information		Will be used to move from spawning biomass to egg-output as the metric of reproductive capability in the stock assessment and management reference points		Fecundity assessment
	Revised field maturity classification		Revised time-series of historical (and future) maturity for input to the stock assessment		Examination of accuracy of current field macroscopic maturity classification
2. Biological input	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area	Altered structure of future stock assessments	If 4B is found to be functionally isolated, a separate assessment may be constructed for that IPHC Regulatory Area	Genetics and Genomics	Population structure
3. Biological input	Assignment of individuals to source populations and assessment of distribution changes	Improve estimates of productivity	Will be used to define management targets for minimum spawning biomass by Biological Region		Distribution
	Improved understanding of larval and juvenile distribution		Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	Migration	Larval and juvenile connectivity studies
1. Assessment data collection and processing	Sex ratio-at-age	Scale biomass and fishing intensity	Annual sex-ratio at age for the commercial fishery fit by the stock assessment	Reproduction	Sex ratio of current commercial landings
	Historical sex ratio-at-age		Annual sex-ratio at age for the commercial fishery fit by the stock assessment		Historical sex ratios based on archived otolith DNA analyses
2. Assessment data collection and processing	New tools for fishery avoidance/deterence; improved estimation of depredation mortality	Improve mortality accounting	May reduce depredation mortality, thereby increasing available yield for directed fisheries. May also be included as another explicit source of mortality in the stock assessment and mortality limit setting process depending on the estimated magnitude	Mortality and survival assessment	Whale depredation accounting and tools for avoidance
1. Fishery yield	Physiological and behavioral responses to fishing gear	Reduce incidental mortality	May increase yield available to directed fisheries	Mortality and survival assessment	Biological interactions with fishing gear
2. Fishery yield	Guidelines for reducing discard mortality	Improve estimates of unobserved mortality	May reduce discard mortality, thereby increasing available yield for directed fisheries	Mortality and survival assessment	Best handling practices: recreational fishery

APPENDIX III

List of ranked biological uncertainties and parameters for management strategy evaluation (MSE) and their links to biological research areas and research activities

MSE Rank	Research outcomes	Relevance for MSE	Research Area	Research activities
1. Biological parameterization and validation of movement estimates	Improved understanding of larval and juvenile distribution	Improve parametization of the Operating Model	Migration	Larval and juvenile connectivity studies
	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area		Genetics and Genomics	Population structure
2. Biological parameterization and validation of recruitment variability and distribution	Assignment of individuals to source populations and assessment of distribution changes	Improve simulation of recruitment variability and parametization of recruitment distribution in the Operating Model		Distribution
	Establishment of temporal and spatial maturity and spawning patterns	Improve simulation of recruitment variability and parametization of recruitment distribution in the Operating Model	Reproduction	Recruitment strength and variability
3. Biological parameterization and validation for growth projections	Identification and application of markers for growth pattern evaluation	Improve simulation of variability and allow for scenarios investigating climate change	Growth	Evaluation of somatic growth variation as a driver for changes in size-at-age
	Environmental influences on growth patterns			
	Dietary influences on growth patterns and physiological condition			
1. Fishery parameterization	Experimentally-derived DMRs	Improve estimates of stock productivity	Mortality and survival assessment	Discard mortality rate estimate: recreational fishery

APPENDIX IV
Summary of current external research grants

Project #	Grant agency	Project name	PI	Partners	IPHC Budget ($US)	Management implications	Grant period
1	**Bycatch Reduction Engineering Program - NOAA**	Full scale testing of devices to minimize whale depredation in longline fisheries (NA23NMF4720414)	IPHC	NOAA Fisheries - Alaska Fisheries Science Center (Seattle)	$199,870	Mortality estimations due to whale depredation	November 2023 – April 2026
2	**Alaska Sea Grant (pending award)**	Development of a non-lethal genetic-based method for aging Pacific halibut (R/2024-05)	IPHC, Alaska Pacific Univ. (APU)	Alaska Fisheries Science Center-NOAA (Juneau)	$60,374	Stock structure	December 2024- December 2026
Total awarded ($)					**$260,244**		

Development of the 2025 Pacific halibut (*Hippoglossus stenolepis*) stock assessment

PREPARED BY: IPHC SECRETARIAT (I. STEWART, A. HICKS & R. WEBSTER; 5 AUGUST 2025)

PURPOSE

To provide the IPHC's Scientific Review Board (SRB) with a response to recommendations and requests made during SRB025 (IPHC-2024-SRB025-R) and SRB026 (IPHC-2025-SRB026-R) and to provide the Commission with an update on progress toward the 2025 full stock assessment.

INTRODUCTION

The International Pacific Halibut Commission (IPHC) conducts an annual coastwide stock assessment of Pacific halibut (*Hippoglossus stenolepis*). The most recent full assessment was completed in 2022 (IPHC-2023-SA01). Following updates in 2023 and 2024, the 2025 stock assessment represents another full analysis, revisiting all data sources and structural choices. The preliminary results of this full assessment were provided to SRB026 (IPHC-2025-SRB026-07).

Starting with the final 2024 stock assessment data, models and results (Stewart and Hicks 2025b; Stewart and Webster 2025), the preliminary analysis provided a sequentially updated 'bridge' of the changes made through June 2025, including:

1) Extending the time series to include projected mortality based on limits adopted for 2025 (IPHC 2025b),
2) updating to the newest stock synthesis software version (3.30.23.1; Methot Jr 2024),
3) updating the time-series information for the Pacific Decadal Oscillation, used as a covariate to the stock-recruitment relationship,
4) retuning the constraint on the scale of male time-varying fishery selectivity (the sex-ratio of the commercial fishery) and extending this variability into the forecast,
5) improving the bootstrapping approach to pre-model calculation of maximum effective sample sizes to include ageing imprecision (Hulson and Williams 2024),
6) re-tuning the process and observation error components of these models to achieve internal consistency within each,
7) and updating the maturity ogive to reflect the recent histology-based estimates produced by the IPHC's Biological and Ecosystem Sciences Branch.

The final 2025 assessment will be produced for the IPHC's 2025 Interim (IM101) and Annual (AM102) meetings. Updated data sources, including the results of the 2025 Fishery-Independent Setline Survey (FISS), logbook and biological data from the 2025 commercial fishery, and sex-ratio information from the 2024 commercial landings-at-age will be included for the final 2025 analysis.

Starting from the preliminary stock assessment presented in June, this document focuses on addressing requests and recommendations made during SRB025 and SRB026.

SRB REQUESTS AND RECOMMENDATIONS

The SRB made a series of requests and recommendations specific to the stock assessment during SRB025 and SRB026. This section provides a response to those requests not already addressed at SRB026:

1) SRB025 (para. 20):

   *"The SRB **REQUESTED** an analysis of the relationship between commercial CPUE and the FISS WPUE at the coastwide and regional levels to investigate the strength of hyperstability/hyperdepletion in CPUE for the stock assessment in 2025. This analysis should include two scenarios: (i) the historical FISS WPUE estimates and (ii) FISS WPUE estimates calculated from reduced designs (i.e. subset the historical FISS data and recalculate WPUE from the reduced data set). The statistical model used for the analysis should account for uncertainty in the FISS index (the X-axis variable) using, for example, an error-in-variables approach like that in Harley et al. 2001 (CJFAS). This analysis represents a first step in including presumed hyperstability in scenarios that investigate the impacts of reduced FISS designs."*

2) SRB026 (para. 18):

   *"The SRB **RECOMMENDED** that the 2025 stock assessment incorporate the new maturity ogives, however, the incorporation of new fecundity information should be delayed until the next full stock assessment when more robust data and analysis of fecundity at age/weight information are available."*

3) SRB026 (para. 21):

   *"The SRB NOTED the bridging, data updates, and sensitivity analyses on the stock assessment and **RECOMMENDED** adopting those changes and moving forward with the final models presented at SRB026."*

4) SRB026 (para. 22):

   *"The SRB **RECOMMENDED** conducting a sensitivity analysis of all ensemble models to the use of a Normal (rather than Lognormal) prior distribution on natural mortality. The Normal distribution is the least informative option when an informative prior is needed."*

5) SRB026 (para. 23):

   *"The SRB **RECOMMENDED** an analysis of historical performance of the decision table metrics, i.e. a retrospective analysis of stock assessment outputs used in management advice."*

6) SRB026 (para. 24):

   *"The SRB **RECOMMENDED** that recruitment projections in the stock assessment and Management Strategy Evaluation (MSE) incorporate a random-walk starting from the most recent reliable recruitment estimate to constrain expected short-term recruitment around recent estimates rather than immediately reverting to the stock-recruitment relationship."*

7) SRB026 (para. 26):

   *"The SRB **RECOMMENDED** that a candidate state space assessment model (e.g. WHAM) be developed for Pacific halibut and presented by SRB032, tentatively scheduled for June 2028. Progress toward this modelling framework may also be presented at interim SRB meetings."*

Request 1 – Commercial and FISS CPUE

In order to better understand the spatial extent of surveys over the 32-year time series of modern FISS sampling we first summarized each annual design based on the percentage of stations sampled in each year (relative to the 1,890 stations in the full design) for each Biological Region and coastwide (Figure 1). Sampling ranged from 0% in Biological Region 4B early and late in the time series (and Biological Region 2 in 1994) to 100% in Biological Region 4B and 3 in 2017 and 2019 as the planned survey expansion was conducted across each of the IPHC Regulatory Areas. The FISS-calibrated National Oceanic and Atmospheric Administration (NOAA) and Alaska Department of fish and Game (ADFG) trawl surveys in the Bering Sea provide a strong baseline of almost two-thirds of the total stations in Biological Region 4 in all years except 2020 when the NOAA survey was cancelled due to COVID-19 precautions. Although the coverage was relatively high in Biological Region 3 for most of the time-series, some stations from the current full design had never been fished until 2019, such that there was still some potential for bias in that Region.

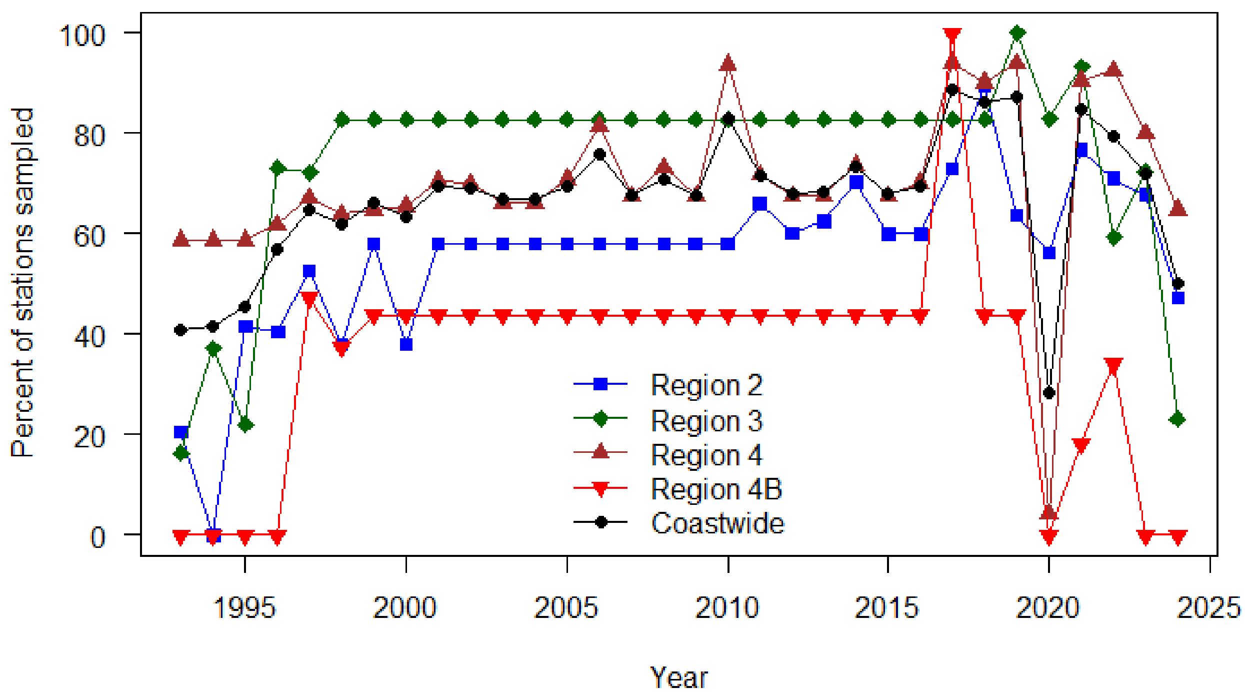

Figure 1. Annual FISS spatial coverage (as a percentage of total stations surveyed in each Biological Region and coastwide).

We divided the years into two general categories: those in which each Biological Region (or coastwide) had at least 65% coverage ('broad' suveys) and those with lower coverage ('reduced' surveys). We then compared the catch rates (Weight-Per-Unit-Effort; WPUE) of legal size Pacific halibut (O32, or over 32 inches or 81.3 cm) from the FISS to the catch rates experienced by the directed commercial longline fishery (which only lands fish above the 32 inch minimum size limit). Because the commercial fishery targets areas of higher-than-average Pacific halibut density, the raw catch rates are naturally higher than those observed in the FISS which operates on a uniform 10 nautical mile grid (Figure 2). This pattern is most pronounced in Biological Region 4 where there are broad areas of the continental shelf with very low (non-commercially viable) densities of Pacific halibut and the directed commercial fishery is concentrated on a few locations along the shelf-slope break and in areas around the few islands occurring in this Region.

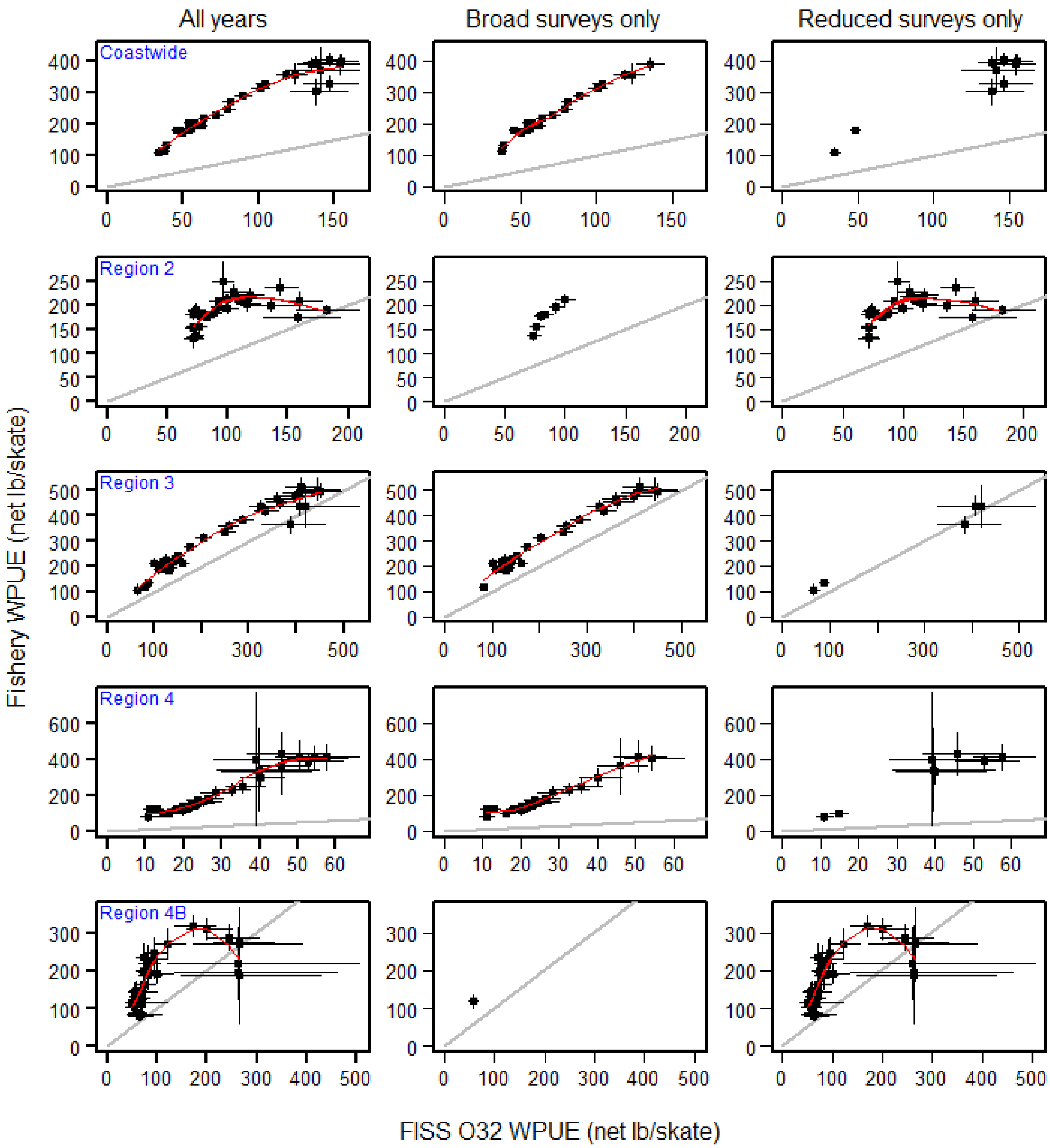

Figure 2. Relationship between FISS O32 catch rate and commercial fishery catch rate by Biological Region and Coastwide. Columns denote all years (1993-2024; left), years with at least 65% of the stations sampled (center) and years with less than 65% of stations sampled (right). Vertical and horizontal lines indicate approximate 95% credible intervals, grey diagonal line indicates a 1:1 relationship and the red lines are a loess smoother included for visualization.

We then standardized each of the catch rate time-series' by dividing each year by the mean for all years in that Region or coastwide, thereby eliminating the effects of catchability and allowing a more direct focus on the relationship between the two series (Figure 3). After this standardization it is clear that for most broad survey years there is a nearly linear relationship between FISS and commercial fishery catch rates (Figure 3, center column). For all years, and especially for years in which only reduced surveys occurred, there is a more complicated relationship between the two series. Large values, often occurring early in the time series when FISS coverage was limited, tended to show higher values for the FISS than for the commercial fishery across all areas. Smaller values with reduced surveys observed in Biological Regions 2 and 4B tended to show a steeper slope (relatively lower values for the commercial fishery than for the FISS). As it is unclear whether the FISS or the commercial fishery more closely reflects the underlying population when surveys were reduced it is difficult to delineate between potential hyperstability or hyperdepletion in one or both indices.

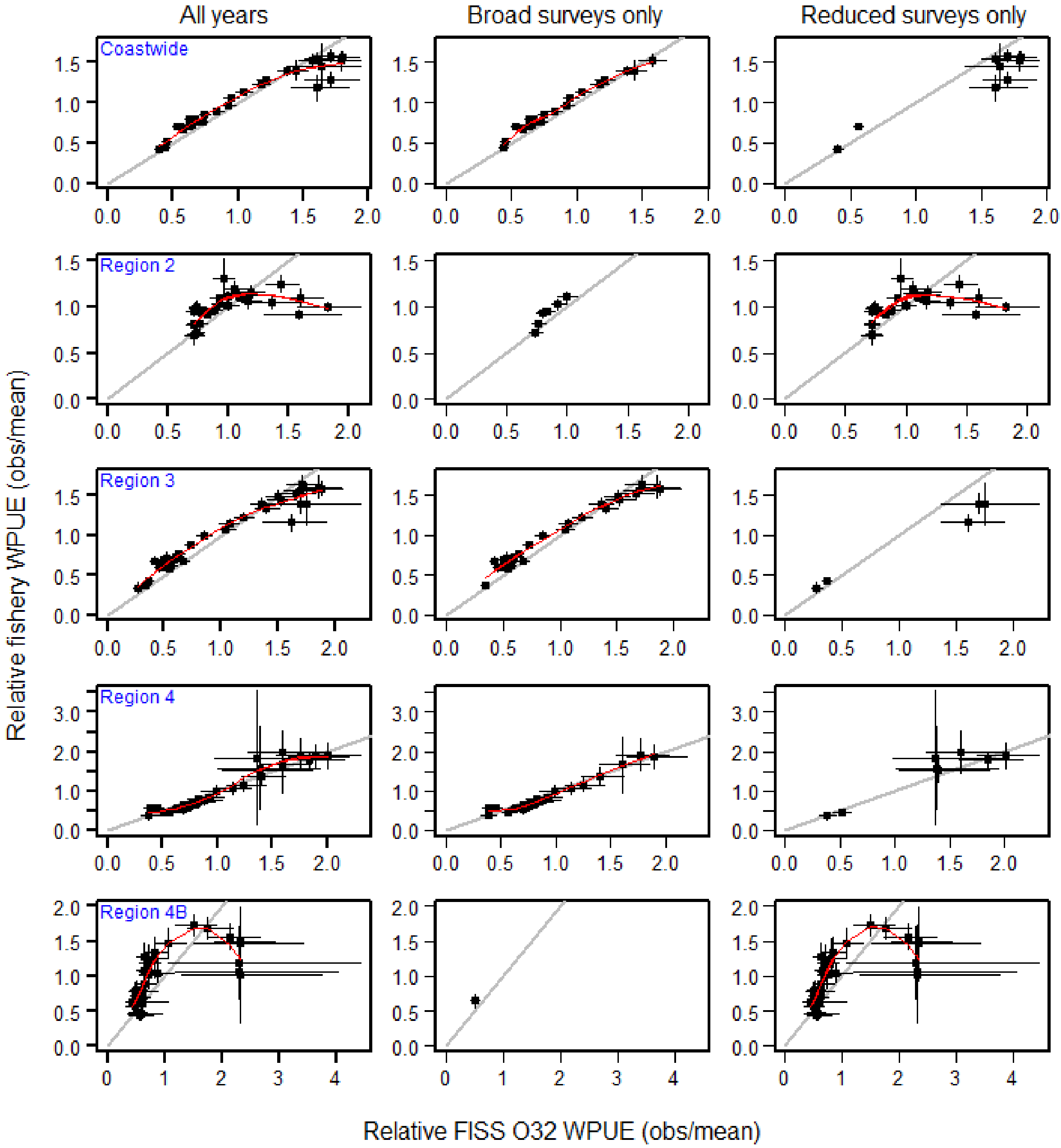

Figure 3. Identical to figure 2, except that FISS and commercial fishery catch rates have been divided by the mean across the entire time-series for that Biological Region and coastwide to account for absolute differences in catchability.

The patterns observed in this comparison are consistent with the somewhat conflicting signal in recent fishery and FISS trends, where the fishery catch-rate has shown a greater decrease than the FISS. Additional investigation of this topic is possible; however, it is unclear how to reconcile the fundamental uncertainty about which series is more reliable, especially at low observed densities and with a reduced FISS. Factors other than population trends, including whale depredation, bycatch of non-target species (e.g., Forrest et al. 2020) and shifts between targeted hook and line fishing for Pacific halibut and sablefish continue to create uncertainty in the commercial time-series, further strengthening the need for broad FISS spatial coverage.

Recommendations 2 &3 – Maturity, fecundity, and bridging

As requested, the updated maturity relationship presented at SRB026 is included in the 2025 stock assessment along with all bridging improvements. Emerging fecundity analyses will be evaluated during 2026-27 but are not planned for inclusion in the stock assessment until the full assessment scheduled for 2028. This will allow a re-analysis of the maturity relationship with additional data, inclusion of estimated skip-spawning, along with an updated fecundity relationship to be considered together as a comprehensive evaluation of reproductive capacity of the Pacific halibut stock.

Recommendation 4 – Sensitivity to priors on natural mortality

Since the 2022 full stock assessment, all four models have used a log-normal prior on natural mortality for both females and males aged 3+. This age independent prior on M was developed based on published meta-analyses (Hamel 2014; Hamel and Cope 2022), which uses the prediction interval based on a meta-analysis of the maximum observed age for a wide range of species. This approach serves as a standard prior for many North Pacific groundfish species. Both male and female Pacific halibut have been observed to age-55 (with multiple fish of both sexes exceeding age-50 indicating that this is likely to be an accurate estimate of longevity, and not an artifact of a single case of ageing imprecision). The prior median is given by:

$$M = \frac{5.4}{Age_{max}}$$

which results in a value of 0.0982, and a log(SD) of 0.438. With such a large variance, this prior is only weakly informative, but still may provide some stability for estimation of *M*.

To explore the sensitivity of current models to this choice, two alternative priors were explored: uniform over a relatively broad range of values (0.02-0.25), and a normal prior with the same expectation (0.0982) and SD tuned to approximate the upper 95th quantile from the lognormal (Figure 4).

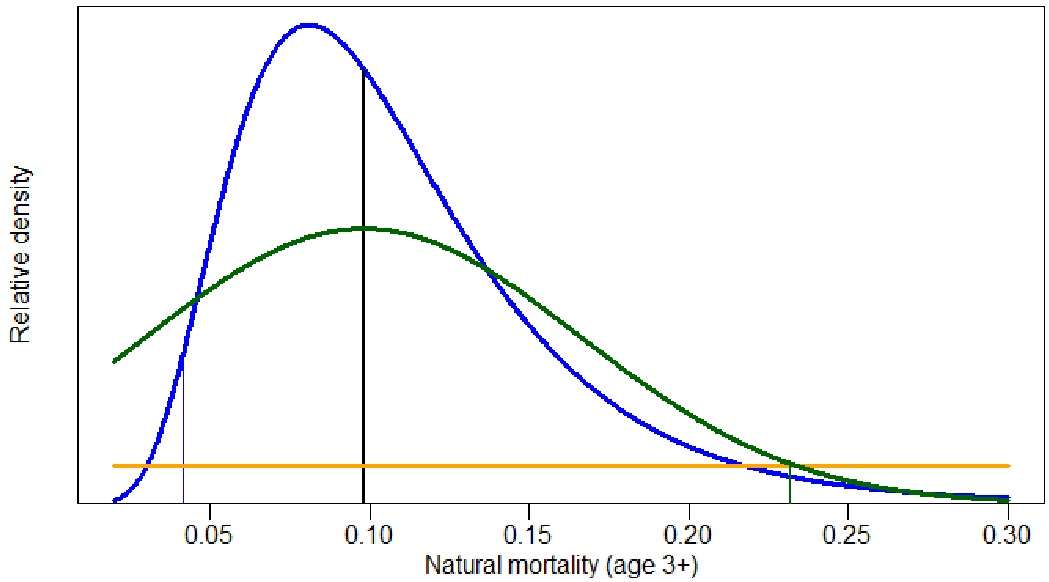

Figure 4. Three alternative priors on natural mortality: lognormal (blue), normal (green) and uniform (orange). Lognormal and normal priors both have a median value of 0.0982 (vertical black line) and identical upper 95% intervals. To facilitate visual comparison, probability density functions are scaled independently for all three distributions.

Each of these three priors was used in alternative configurations for each of the four stock assessment models. For the coastwide short model, neither the uniform or the normal prior stabilized the estimate of M below the upper bound (Figure 5), the same behavior previously identified for the log-normal prior in the preliminary assessment presented in June. For the other three models the lognormal and normal priors generally resulted in similar maximum likelihood estimates and scaling of the spawning biomass and recruitment (Figures 6-8). Even the uniform prior did not lead to an appreciably different estimate of M in any of the three models where it is not fixed, however it was slightly higher in the coastwide long model leading to a slightly larger scale of the spawning biomass and recruitment in that case (Figure 7).

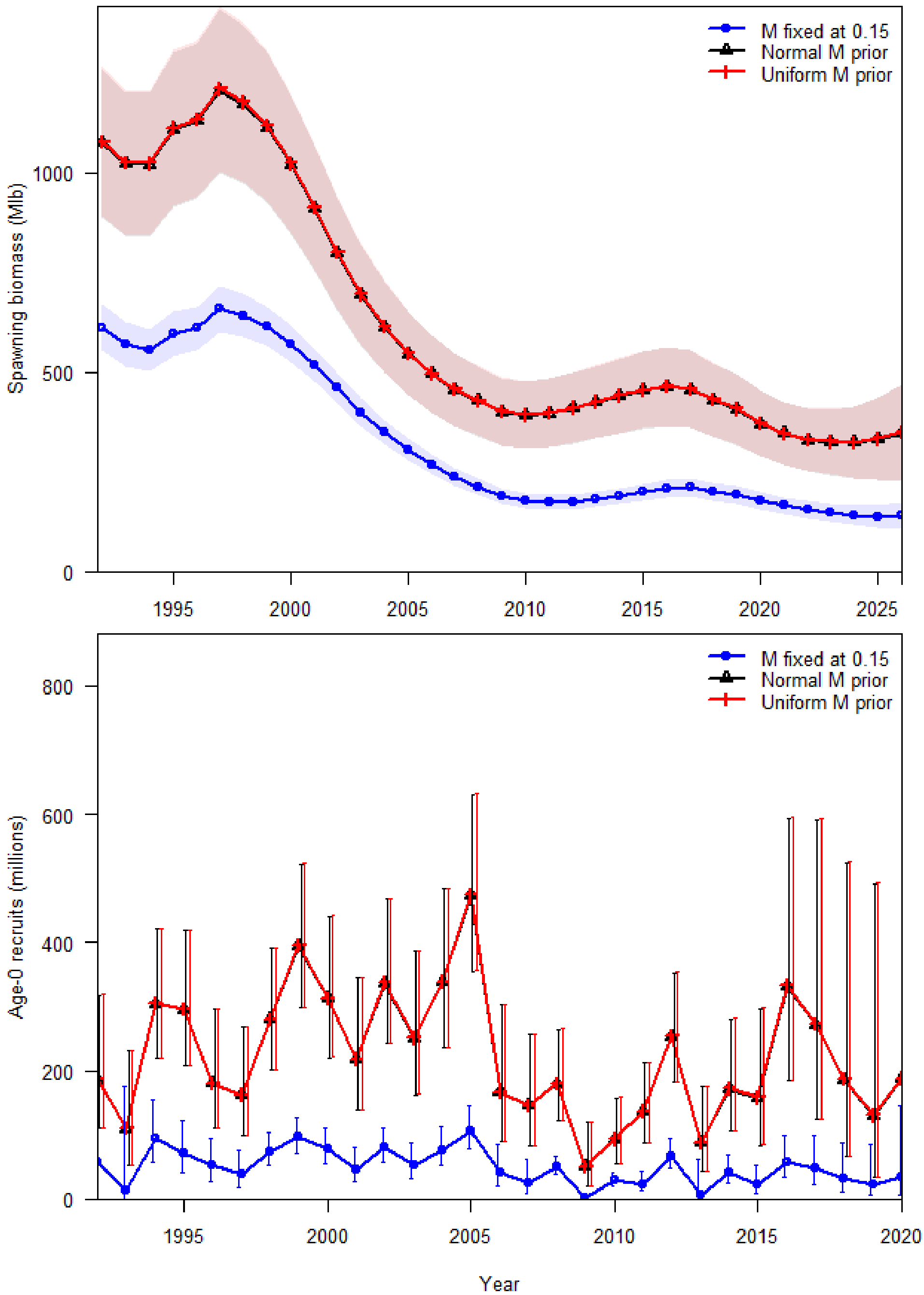

Figure 5. Time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on three alternative priors for natural mortality applied to the coastwide short model. Note that the maximum likelihood value for M was at the upper parameter bound of 0.25 when estimation was attempted with both priors in this model.

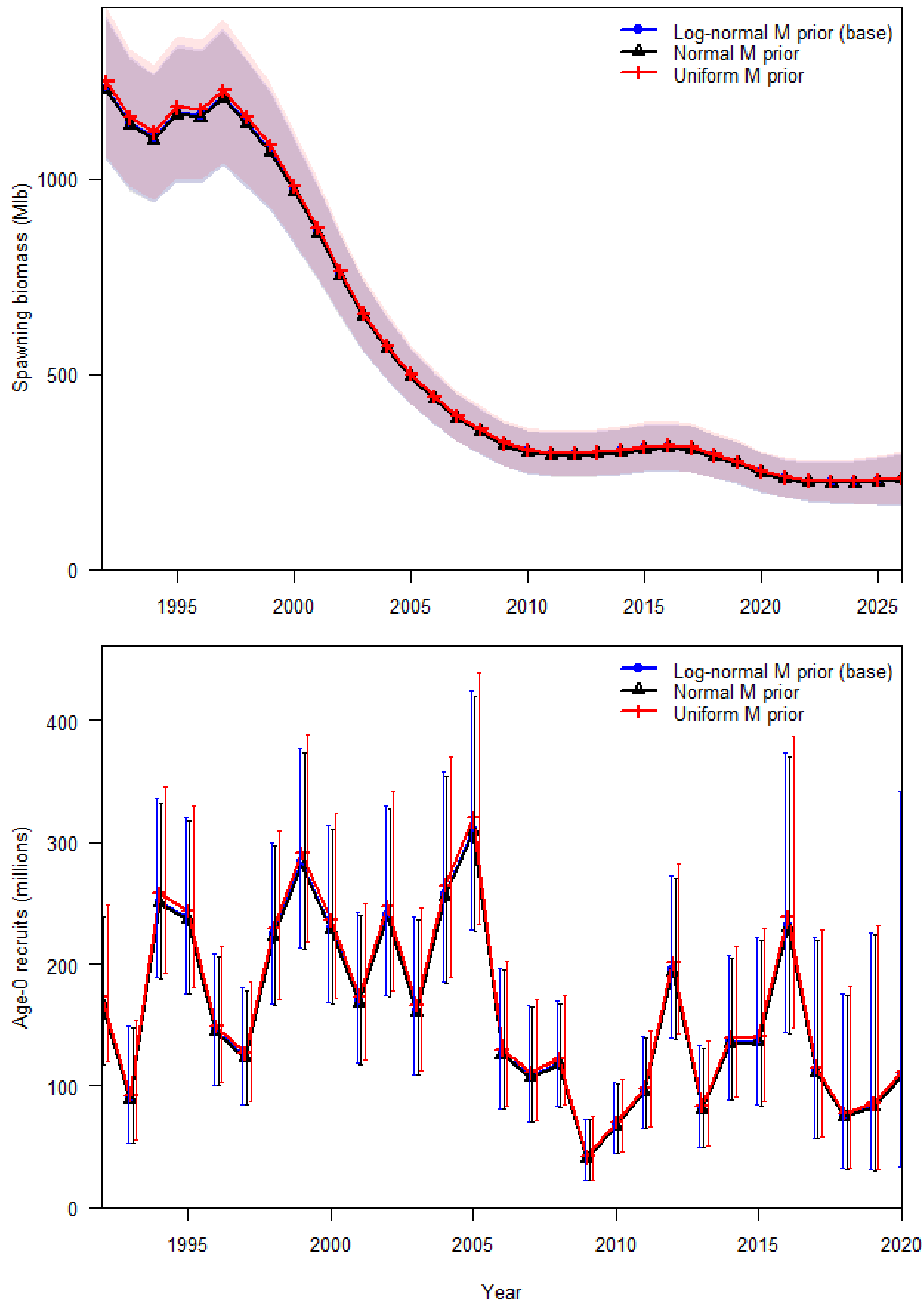

Figure 6. Time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on three alternative priors for natural mortality applied to the AAF short model.

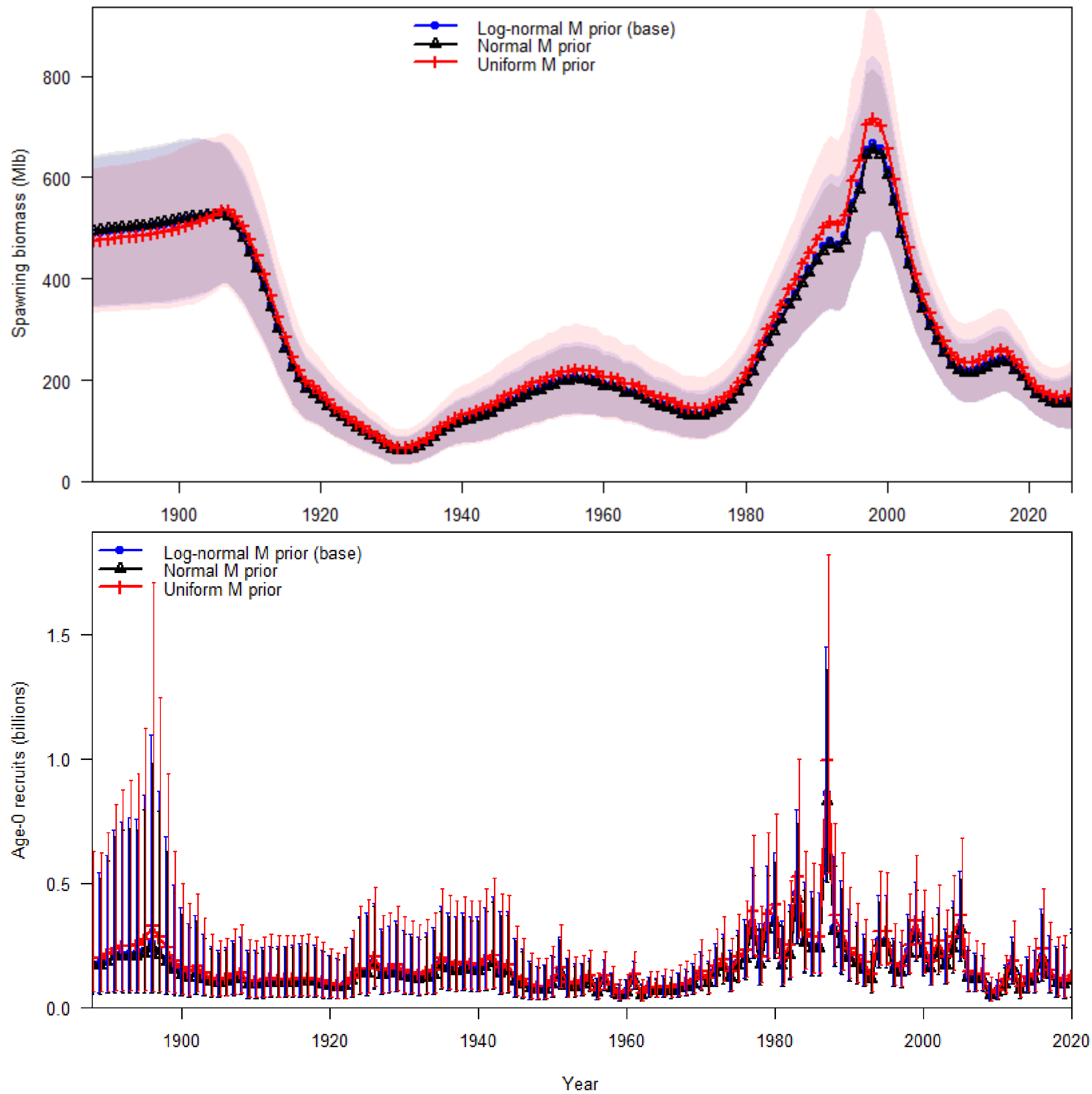

Figure 7. Time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on three alternative priors for natural mortality applied to the coastwide long model.

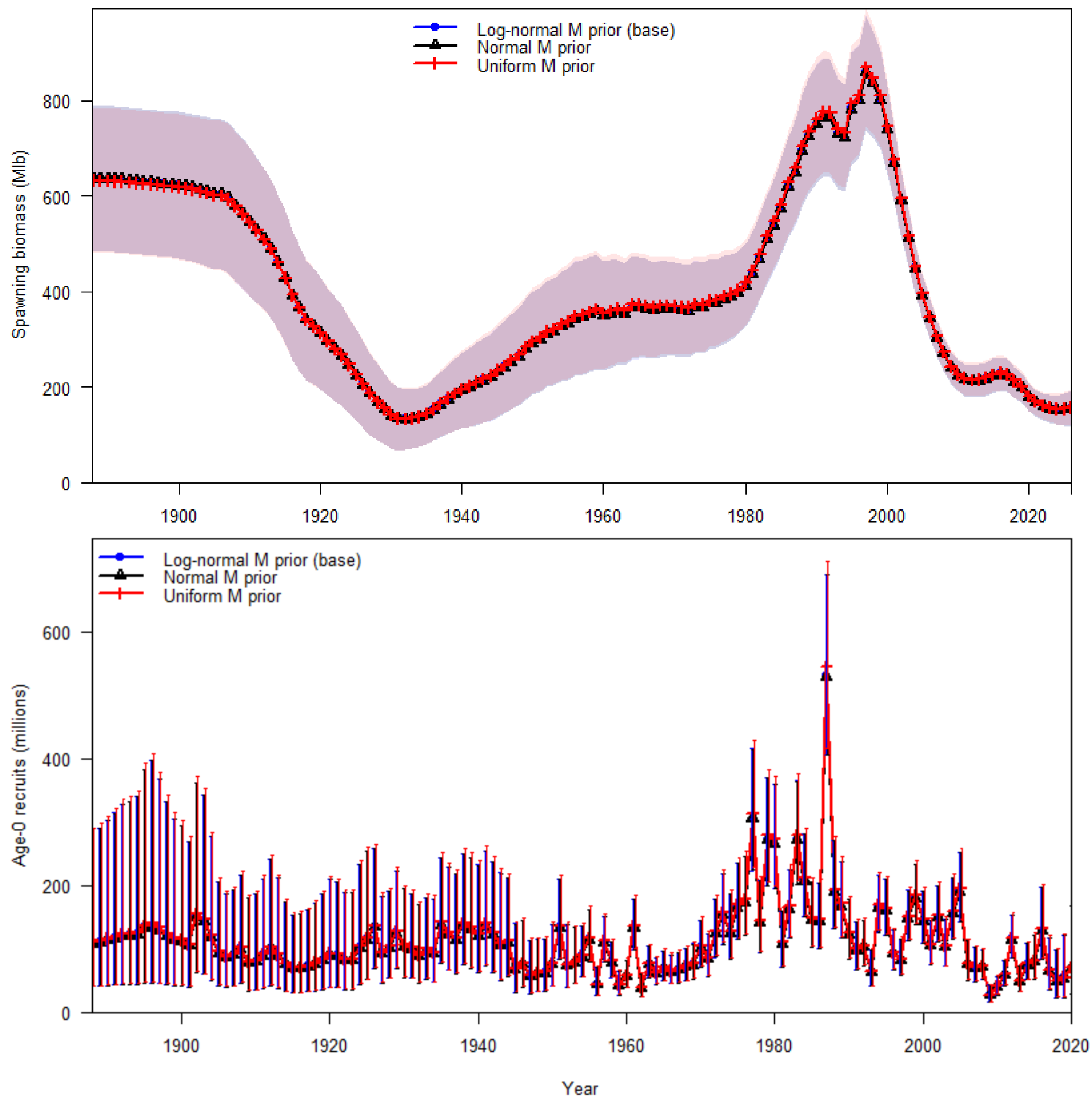

Figure 8. Time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on three alternative priors for natural mortality applied to the AAF long model.

Recommendation 5 – Retrospective evaluation of management information

The spawning biomass ('stock') trend has been the focus of considerable discussion at IPHC Annual meetings since a decision table-based approach was first introduced as part of the 2013 stock assessment. Each year, the probability of stock decline in the upcoming year, along with the probability of stock decline of at least 5% is estimated and provided for a range of alternative harvest levels. Discussion among stakeholders often includes reference to the probability of stock decline as a function of the selected mortality limits. Although the probability of stock decline is always reported as a 'risk', there is a corresponding probability of stock increase (or decline of less than 5%, which includes increases) that, along with the probability of decline, always sums to 100% for each projection. These two key decision table outputs were summarized for all assessments from 2013 through 2024 for comparison with actual estimated trends in the spawning biomass based on the 2024 final stock assessment results. For each year, either stock decline or stock increase (including declines less than 5% for that case) is the 'actual' result which can be compared to the estimated probabilities from the year before. As there is never a zero probability of one outcome or the other, the decision table cannot be considered 'wrong' or 'right'; however, if the probabilities are frequently heavily in favor of outcomes that did not subsequently occur one might infer that there is room for improvement in the estimation process.

The stock increased over 2013-2016, declined over 2017-2023 and then increased in 2024. The annual decision table generally favored a higher probability for stock increase/decrease when that was the subsequent outcome (Figure 9). In no years did the stock either actually increase or decrease with less than at least a 16% probability estimated for that outcome.

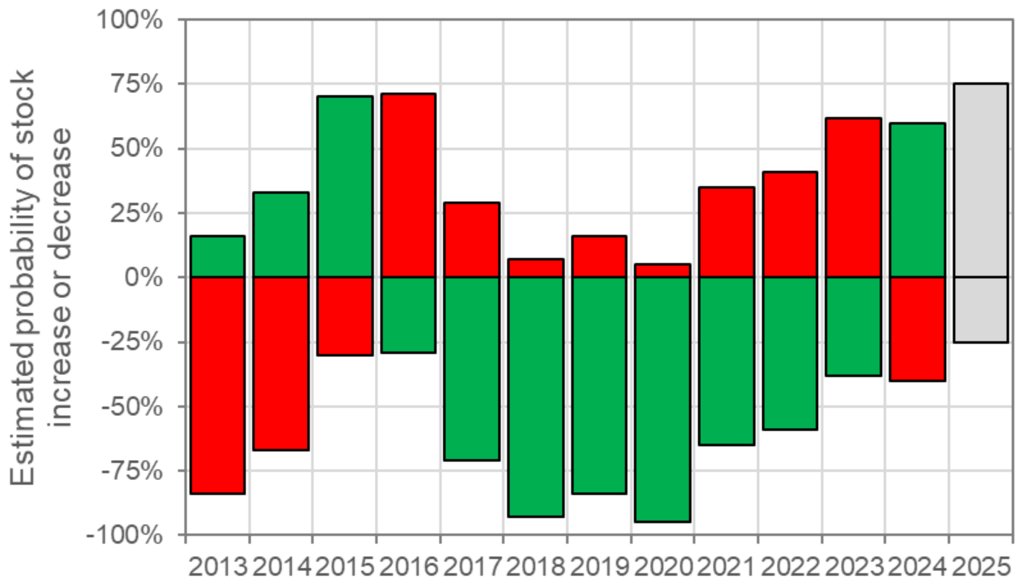

Figure 9. Time series of decision table projections for one year ahead probabilities of: stock decrease (lower half of the graph) or stock increase (upper half of the graph). Green bars indicate the actual (correct) stock trend in each year, red bars indicate probabilities corresponding to incorrect trends; green and red bars sum to 100% in each year. Grey bars in 2025 denote unknown actual stock trend.

The stock is estimated to have decreased by at least 5% over the period 2017-2021 and either increased or decreased by less than 5% in all other years. Estimated probabilities of at least a 5% stock decline were higher in years of actual stock decline of more than 5% for all years except 2022 (Figure 10). The least probable outcome occurred in 2017, the first year of stock decline greater than 5%, when it was estimated to have a 10% probability. In six of the years when the stock did not decline by at least 5% the estimated probabilities favored the actual outcome with at least a 90% probability. The maximum actual estimated decline (in 2018) was only 8%, so it is difficult to determine whether a more meaningful decline might have been forecast with greater skill.

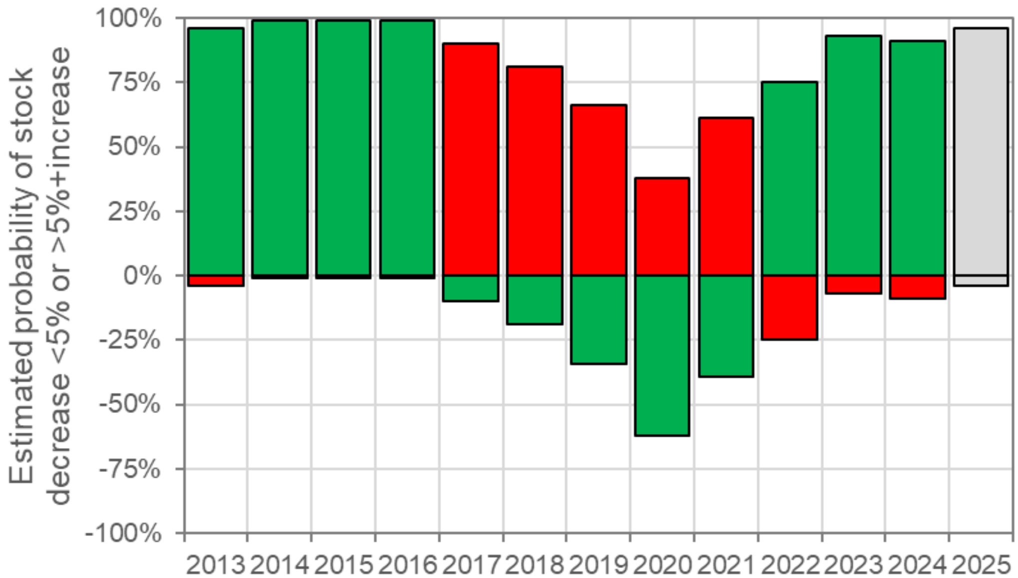

Figure 10. Time series of decision table projections for one year ahead probabilities of: stock decrease of at least 5% (lower half of the graph) or stock decrease of less than 5% or stock increase (upper half of the graph). Green bars indicate the actual (correct) stock trend in each year, red bars indicate probabilities corresponding to incorrect trends; green and red bars sum to 100% in each year. Grey bars in 2025 denote unknown actual stock trend.

Recommendation 6 – Recruitment projections

The annual stock assessment is used to produce projections extending three years into the future. This time frame was selected to minimize the impact of recruitment estimates at the end of the time series (largely uninformed by actual data) on the projected spawning biomass. The basis for the choice of three years is that maturity begins to increase rapidly at eight years old, and the FISS encounters an increasingly larger proportion of fish over ages five through eight. Therefore, fish that are five in the terminal year of the model will be only partially mature at age eight at the end of the projection period. These same fish would be an increasing component of the projected spawning biomass ages 9+ if the projection were extended to four or more years.

The approach applied in recent stock assessments for forecast recruitments has been to separate the ‘main’ recruitment vector from the more poorly informed ‘forecast’ recruitment vector based on the relative variance among the deviations compared to the average estimated variance of the deviations (Methot and Taylor 2011). Briefly, this method identifies where the variance of the recruitment deviations begins to increase rapidly at the end of the time series (usually several years before the actual last year of data; in this case approximately four years before the terminal year of the assessment). Deviations after this point are estimated in a separate ‘forecast’ vector that is not constrained to be centered on the stock-recruitment relationship (Methot Jr 2024). This ensures that deviations with little data informing them are not adjusted by the model simply to ‘balance’ the stock-recruitment function. In the case of the current Pacific halibut models including data through 2024 the forecast recruitment deviations were started in either 2015 or 2016.

The Stock Synthesis software provides for several options to adjust forecast recruitments independently from the stock-recruitment relationship. However, in the current version these options only apply to forecast recruitments occurring after the end of the time series (for the preliminary 2025 stock assessment this is in year 2025). Therefore, to explore the effects of alternative forecast recruitment assumptions on the three-year spawning biomass projections used for management, each of the four stock assessment models was adjusted to extend the main recruitment deviation vector to 2025; noting that especially in the short time series models this could result in balancing of the deviations occurring after the signal from the data but before the end of the time series (2015-2024). After extending the main recruitment deviation vector, two alternative recruitment assumptions were compared: a ‘low recruitment’ scenario, setting the forecast recruitment central tendency equal to the average observed over 2006-2015, and a ‘high recruitment’ scenario setting the forecast recruitment central tendency to the average observed over 1994-2005.

Extending the main recruitment vector through 2025 had little effect on the estimated recruitments in either of the long time-series models (Figures 11 & 12). Although the average recruitment differed substantially during the low and high periods, these fish do not mature during the forecast period and so do not affect the spawning biomass projections. For the two short time series models extending the main recruitment vector resulted in lower recruitments estimated over the period after 2016 due to balancing of the vector on the stock recruitment relationship (Figures 13 & 14). In the case of the coastwide short model, the recruitments between 2018 and 2025 were all pushed to unrealistically low values. However, although unsuitable as an actual assessment run, this alternative can still be used to compare the effects of the differing recruitment projections. The spawning biomass for both the high and low recruitment projections again did not differ, due to the fact that these recruitments do not mature during the three year projection.

Based on this evaluation, inclusion of autocorrelation in the forecast recruitments would not have an effect on the tactical stock assessment results that only extend three years into the future. Further, the use of the stock recruitment relationship as the central tendency does not lead to a rapid change in recruitment at the end of the time-series. We therefore conclude that alternative treatment of recruitment, either through inclusion of autocorrelation or productivity regimes is best explored through the Management Strategy Evaluation and not through the tactical stock assessment.

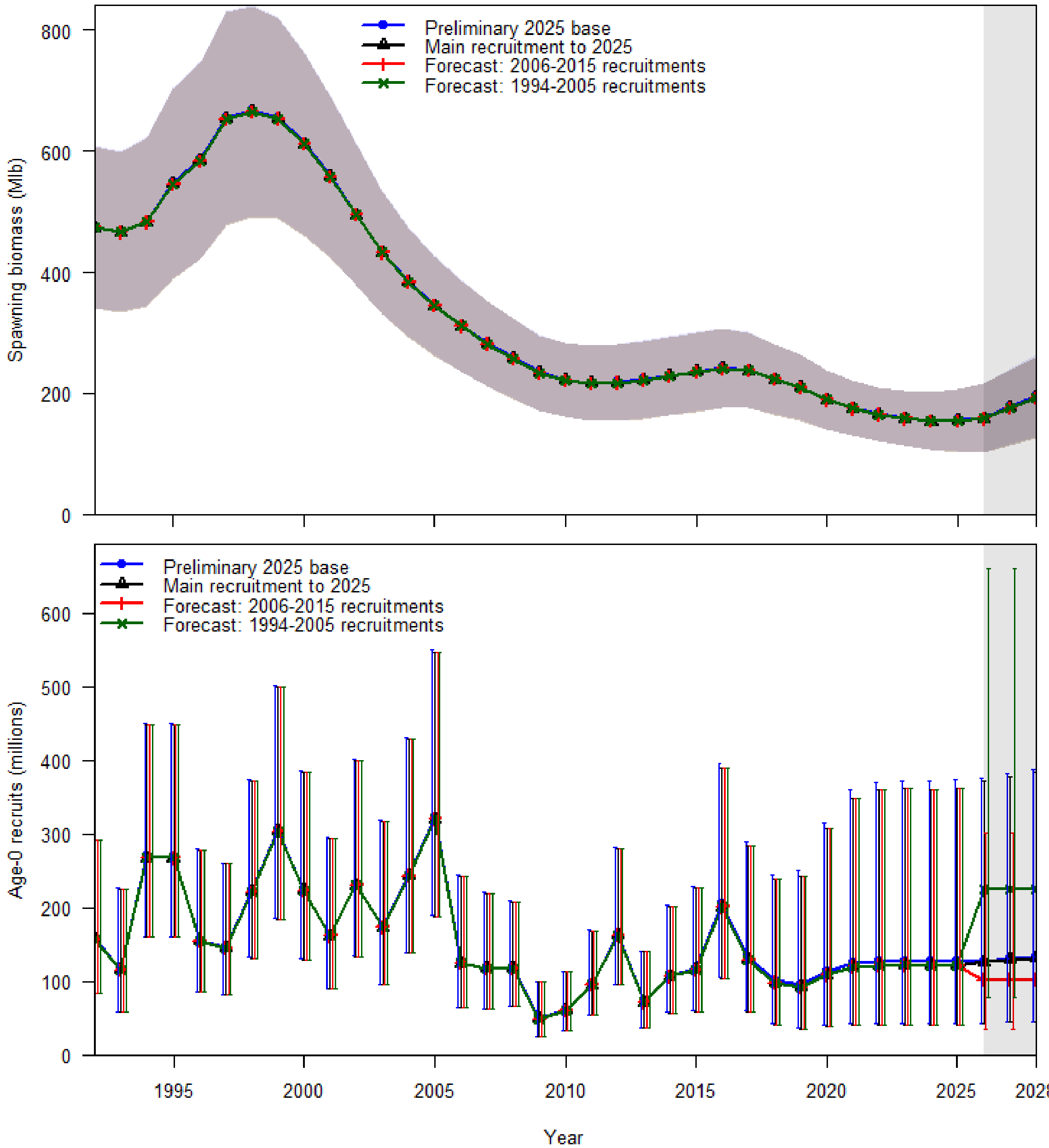

Figure 11. Recent time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on alternative recruitment projections applied to the coastwide long model. The forecast years are denoted by the shaded area.

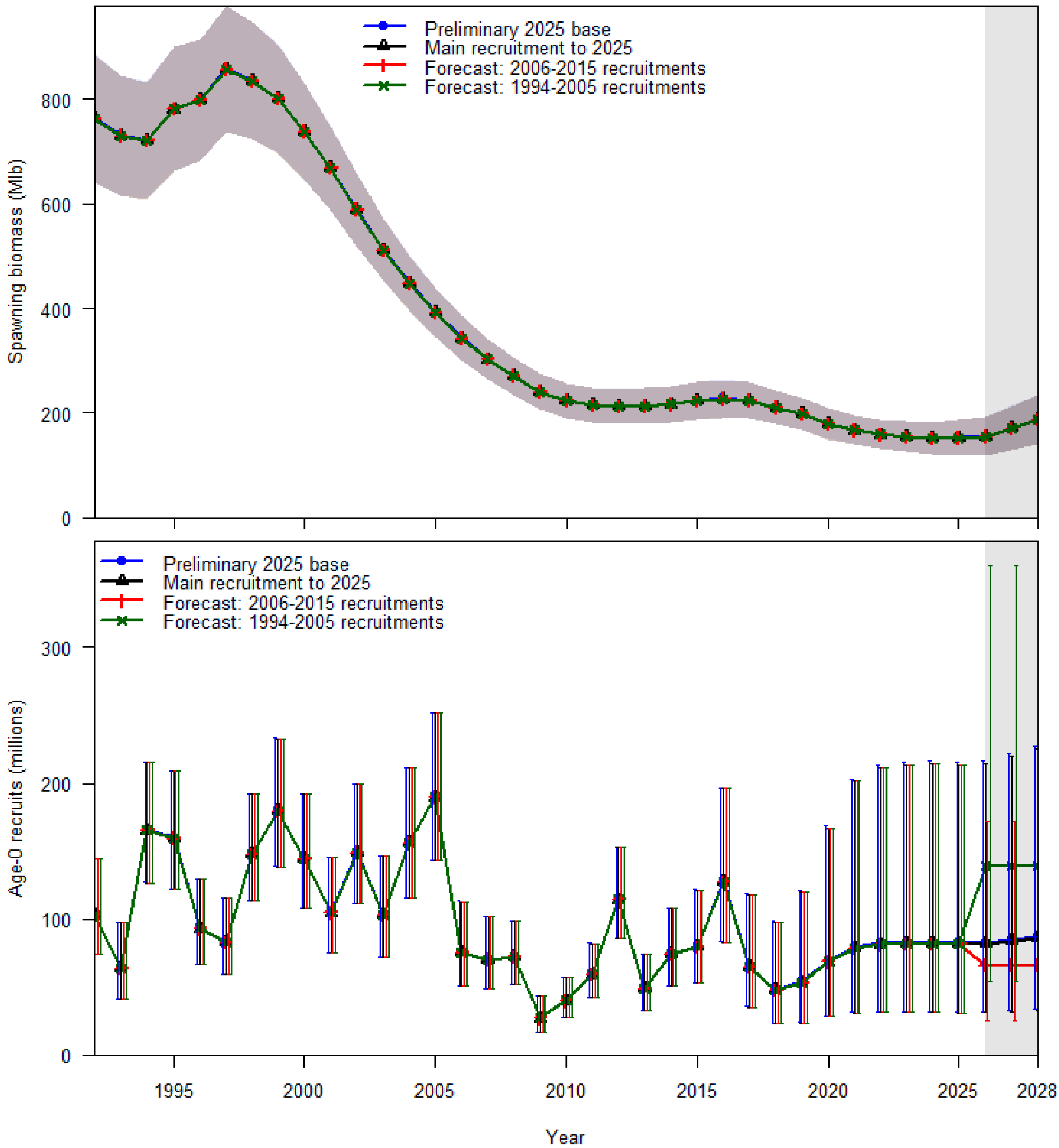

Figure 12. Recent time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on alternative recruitment projections applied to the AAF long model. The forecast years are denoted by the shaded area.

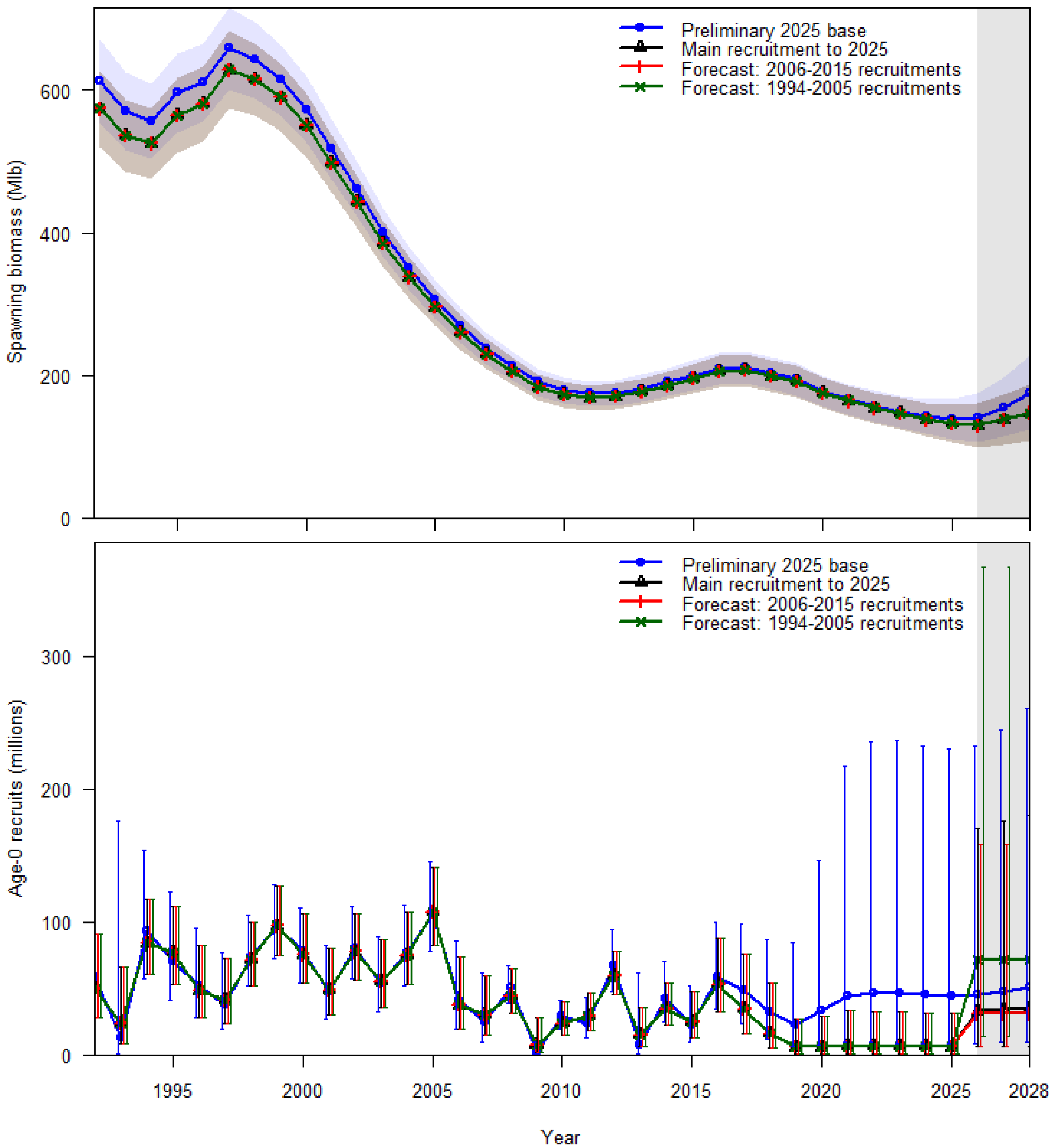

Figure 13. Time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on alternative recruitment projections applied to the coastwide short model. The forecast years are denoted by the shaded area.

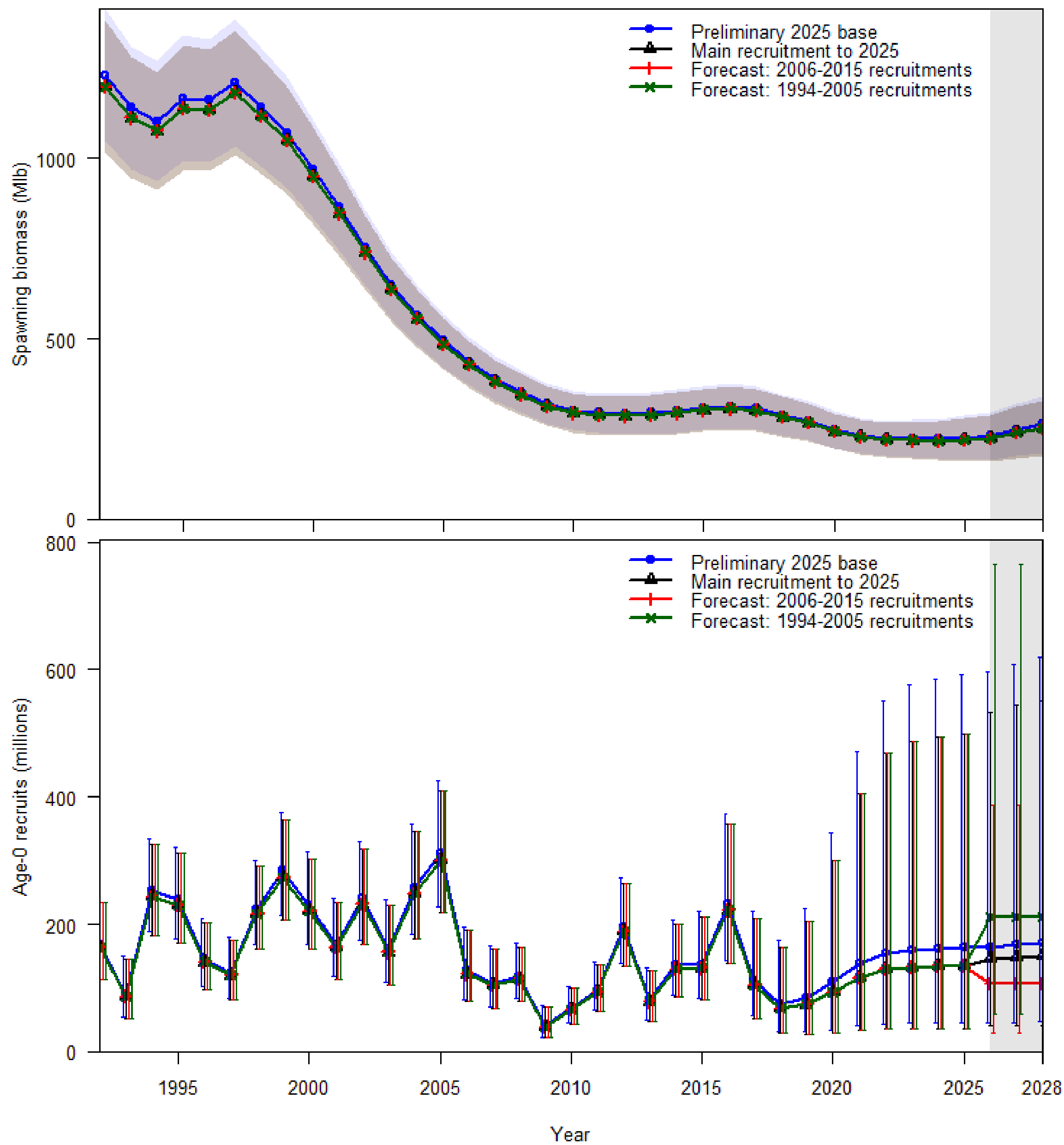

Figure 14. Time series of estimated spawning biomass (upper panel) and recruitment (lower panel) based on alternative recruitment projections applied to the AAF short model. The forecast years are denoted by the shaded area.

Recommendation 7 – Exploration of a state-space model

Progress toward the development of a state-space model for Pacific halibut will begin after this year's stock assessment has been completed.

ADDITIONAL STOCK ASSESSMENT DEVELOPMENT FOR 2025

Per standard procedures for final stock assessment preparation, the following data sources that will be included in the final 2025 stock assessment include:

1) New modelled trend information from the 2025 FISS for all IPHC Regulatory Areas.
2) Age, length, individual weight, and average weight-at-age estimates from the 2025 FISS.
3) Directed commercial fishery logbook trend information from 2025 (and any earlier logs that were not available for the 2024 assessment) for all IPHC Regulatory Areas.
4) Directed commercial fishery biological sampling from 2025 (age, length, individual weight, and average weight-at-age) and sex-ratio-at-age information from the 2024 biological samples from all IPHC Regulatory Areas.
5) Biological information (lengths and/or ages) from non-directed discards (all IPHC Regulatory Areas) and the recreational fishery (IPHC Regulatory Area 3A only) from 2024. The availability of these data routinely lags one year.
6) Updated mortality estimates from all sources for 2024 (where preliminary values were used) and estimates for all sources in 2025.

RECOMMENDATION/S

That the SRB:

a) **NOTE** paper IPHC-2025-SRB027-07, which provides a response to requests from SRB025 and SRB026, and an update on model development for 2025.

b) **REQUEST** any modifications for the final 2025 stock assessment.

c) **REQUEST** any analyses to be provided at SRB028 as part of the development of the planned 2026 update stock assessment.

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An update of the IPHC Secretariat MSE and development of a Harvest Strategy Policy

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PURPOSE

To provide the SRB with an update of the IPHC Management Strategy Evaluation (MSE) and the Harvest Strategy Policy (HSP).

1 INTRODUCTION

This document provides responses to recommendations from the 26th Session of the Scientific Review Board (SRB026) and a brief update on progress towards adoption of the Harvest Strategy Policy. The operating models (OMs) in the MSE framework were most recently conditioned using the 2022 stock assessment and will be reconditioned after the 2025 full stock assessment to reflect new understanding of the Pacific halibut population and fishery dynamics. Given that new OMs will be available in 2026, further investigations of Management Procedures (MPs) and other concepts will be done at that time.

2 RECRUITMENT

A recommendation from SRB026 was to incorporate a random walk for recruitment to maintain continuity in recent recruitment trends rather than immediately assuming the mean of the stock-recruit curve.

> **IPHC-2025-SRB026-R, para 24**. *The SRB **RECOMMENDED** that recruitment projections in the stock assessment and Management Strategy Evaluation (MSE) incorporate a random-walk starting from the most recent reliable recruitment estimate to constrain expected short-term recruitment around recent estimates rather than immediately reverting to the stock-recruitment relationship.*

To begin, an investigation of autocorrelation was conducted. This used the historical estimated recruitment deviations for the four models used in the 2024 ensemble stock assessment (Stewart and Hicks 2024) to examine the autocorrelation of the deviates as well as the deviates of a random walk in recruitment. Finally, an ARIMA model was fit to the recruitment deviations for insight into the autocorrelation.

Each of the four models in the ensemble stock assessment estimates a time-series of recruitment as a deviation from a Beverton-Holt stock-recruit relationship that is dependent on the Pacific Decadal Oscillation (PDO, Mantua et al. (1997)) being low or high. This is characterized by the following equation.

$$R'_0 \;=\; R_0 \times e^{I_y \delta} \tag{1}$$

$$R_y \;=\; f(B^{sp}_{F,y} | R'_0, B^{sp}_0, h) \times e^{(\varepsilon_y - \frac{\sigma_R^2}{2})} \tag{2}$$

where $f(B^{sp}_{F,y} | R'_0, B^{sp}_0, h)$ is the equilibrium stock-recruit relationship using female spawning biomass in year y with parameters for regime-specific equilibrium unfished mean recruitment (R'_0), equilibrium unfished spawning biomass (B^{sp}_0), and steepness (h). The regime-specific equilibrium unfished mean recruitment is modified by I_y, an indicator for low or high PDO (0 or 1), and δ is the covariate for this environmental relationship defining environment-dependent recruitment regimes. The annual deviation in recruitment, from average, for year y is e^{ε_y}. The deviation is used to indicate variability around the mean recruitment (determined from the stock-recruit relationship incorporating the PDO effects), assumes a normal distribution, and is constrained by a variance parameter (σ_R). Only the two 'long' assessment models estimate an environmental relationship, but all four current MSE models use an environmental relationship.

Recruitment is split into three periods: initial, main, and late. The main period is defined to contain recruitments that are strongly informed by data and centered such that the sum of the deviations equals zero. This ensures that the recruitment over the main period is on average centered on the stock-recruit relationship, thus allowing for the calculation of consistent reference points. Only recruitments in the defined 'main' period are used in this investigation.

Figure 1 shows the estimated recruitment deviates within each period for each stock assessment model. The main period deviates show some short intervals of positive autocorrelation (i.e. 1960s), but also times of negative autocorrelation (e.g. 1990s). The entire main period recruitment deviates show a positive autocorrelation for the first 4-8 lags in the long models, but little autocorrelation in the short models (Figure 2). The long models showed a possible negative autocorrelation at lags greater than 20 years, which may have some relation to the oscillations of the PDO.

The estimated recruitment was converted to a random walk by subtracting the estimated recruitment in year *y-1* from the estimated recruitment in year *y*. These random walk deviations are shown in Figure 3 and it appears that the autocorrelation is reduced in some intervals, such as the 1960s, but these intervals are now characterized by periods of large or periods of small oscillating random walk deviates. This is evident in the calculation of autocorrelation at various lags, showing a significant negative autocorrelation at lag 1 for three of the four models (Figure 4).

ARIMA models were fit to the recruitment deviations (ε_t) to determine the strength and significance of various autoregressive (AR) and random walk processes. An ARIMA model has three integer components, (*p*,*d*,*q*), where *p* indicates the autoregressive (AR) process, *d* indicates the degree of differencing, and *q* indicates a moving average (this last one was not tested). An ARIMA(1,0,0) is an AR(1), and an ARIMA(0,1,0) is a random walk. A number of models were fit with AR processes up to a lag of four, and a difference to a lag of 1 (which is a random walk). The AIC was used to determine the best fit model (Table 1) using the entire main period of estimated recruitment deviations, and the same period for all four models (1992–2016).

The two long models, with the entire main period, showed best fitting models with a 4th order AR process. The 4th order AR process had a weak relationship with the 2nd lag.

$$\text{AAF\_long: } \varepsilon_t = -0.02 + 0.23\varepsilon_{t-1} + 0.07\varepsilon_{t-2} + 0.21\varepsilon_{t-3} + 0.14\varepsilon_{t-4} + \tau_t \quad (3)$$

$$\text{CW\_long: } \varepsilon_t = -0.02 + 0.24\varepsilon_{t-1} + 0.05\varepsilon_{t-2} + 0.21\varepsilon_{t-3} + 0.22\varepsilon_{t-4} + \tau_t \quad (4)$$

The ARIMA model residuals appeared to have less variability than the NULL model, especially in the 1960s (Figure 5).

The ARIMA models were not significantly better than the Null model for the shorter time series of recruitment deviations when comparing AIC. The random walk showed a worse fit and higher AIC than any other model.

Table 1. AIC values for different ARIMA models fitted to the entire main period of each stock assessment model. The short models contained a subset of later years compared to the long models and the AIC for fits to that subset of years is also shown for the long models. Bold values are within two units of the lowest value.

	AAF_long	**CW_long**	**AAF_short**	**CW_short**	**AAF_long**	**CW_long**
Years	1910–2015	1925–2015	1992–2016	1992–2016	1992–2016	1992–2016
(0,0,0)	98.68	94.71	**35.81**	**69.07**	**24.11**	**22.06**
(1,0,0)	85.81	76.81	**36.22**	**70.87**	**25.95**	**23.95**
(2,0,0)	85.04	75.88	38.21	72.01	**25.23**	**22.00**
(3,0,0)	**80.17**	70.24	40.19	73.79	27.16	**23.97**
(4,0,0)	**80.10**	**67.65**	41.80	74.46	29.05	25.54
(0,1,0)	121.70	101.78	43.67	84.11	36.61	35.01

Overall, the estimated recruitment deviations from the assessment models showed some evidence of autocorrelation that may be useful to model. There were short periods of time with positive autocorrelated recruitment deviations, but also periods of time with negatively correlated recruitment deviations. The estimated recruitment deviations for the period from 1992–2016 in all models showed less support for autocorrelation. A random walk appeared to pull the deviated towards zero, but there was little evidence that it would improve the modelling of the recruitment deviations.

Further complicating this analysis is the information content of the data to inform the estimation of recruitment. Sampling variability, ageing error, and missing data may result in short periods of time with autocorrelated recruitment deviations because there is little information to discern a single recruitment event from a period of similar recruitment events. This may explain the patterns observed in the estimates of the recruitment deviations before 1980 (Figure 1).

Linking the PDO to the average recruitment partly addresses the concern from the SRB that recruitment may suddenly increase in the projection period. It is true that recruitment is centered around the stock-recruit curve, but the mean of the stock-recruit curve is adjusted depending on the regime. For example, if the current regime is low, then the recruitments in the near-term projection are also likely to be low. However, if there is a trend of poor recruitment relative to the low regime (e.g. 2006–2011), that may not be captured. The MSE projections simulate the binary PDO covariate using a semi-Markovian process that switches approximately every 10-20 years. Therefore, the near-term projections account for the current regime, which carries forward the trend in average recruitment. Figure 6 shows that the PDO starts low in 2025 for recent MSE simulations and increases to high values (slightly greater than 50%) before oscillating back down and stabilizing to 50%.

This investigation is useful to determine the evidence of autocorrelation, but simulations using the stock assessment and MSE models can indicate the effect that this concern has on management outcomes. The document IPHC-2025-SRB027-07 reports 3-year projections using the stock assessment with different recruitment assumptions. Noting that the regime is currently simulated with correlation in the MSE projections, additional runs were done with the AR(4) process on recruitment deviations from the AAF_long assessment model (Equation 3) where the error (τ_t) had mean zero and a standard deviation equal to σ_R.for that model. Additionally, a simple autocorrelated recruitment series was simulated using Equation 5.

$$\varepsilon_t = \rho\varepsilon_{t-1} + \sqrt{1-\rho^2}\tau_t \tag{5}$$

For these simulations, ρ was equal to 0.5 and τ_t was drawn from a normal distribution with mean equal to zero and a standard deviation equal to σ_R for that model. A comparison of the three methods to simulate future recruitment deviates (uncorrelated, AR(4), and $\rho = 0.5$) indicate slight differences for each method (Figure 7).

Performance metrics associated with the Commission's priority objectives are shown in Table 2 for MSE simulations with no decision-making variability, no observation error, no estimation error, and an SPR of 43%. Not using the additional simulated errors was chosen to focus on the effect of the different methods to model recruitment. The performance metrics for the runs with autocorrelated recruitment are similar to each other, but slightly different than the base scenario with uncorrelated recruitment. With autocorrelated recruitment deviations, there is very little long-term risk of being below 20% relative spawning biomass (RSB) and a slightly greater long-term chance of being below an RSB of 36%. The short-term (4-13 years) performance metrics for the two autocorrelated scenarios show a TCEY that is approximately 2 million pounds less and an increased AAV compared to the base scenario. The short-term performance metrics are similar for the two autocorrelated scenarios. We did not simulate alternative SPR values, but it is likely that they scale similarly across the scenarios. Additionally, with decision-making variability, observation error, and estimation error, the differences may be reduced.

Overall, the three-year stock assessment projections are not significantly affected by the modelling of recruitment because the spawning biomass is not affected by the modelling of near-term recruitments. The MSE results are more likely to be affected by the choice of how recruitment is modelled. There was slight evidence of autocorrelation in the estimated deviates, but that may be a natural result of estimation with ageing error and uncertainty resulting in the appearance of autocorrelation. Simulations with high levels of autocorrelation show small differences in MSE simulations that are unlikely to result in a different selection of a reference management procedure.

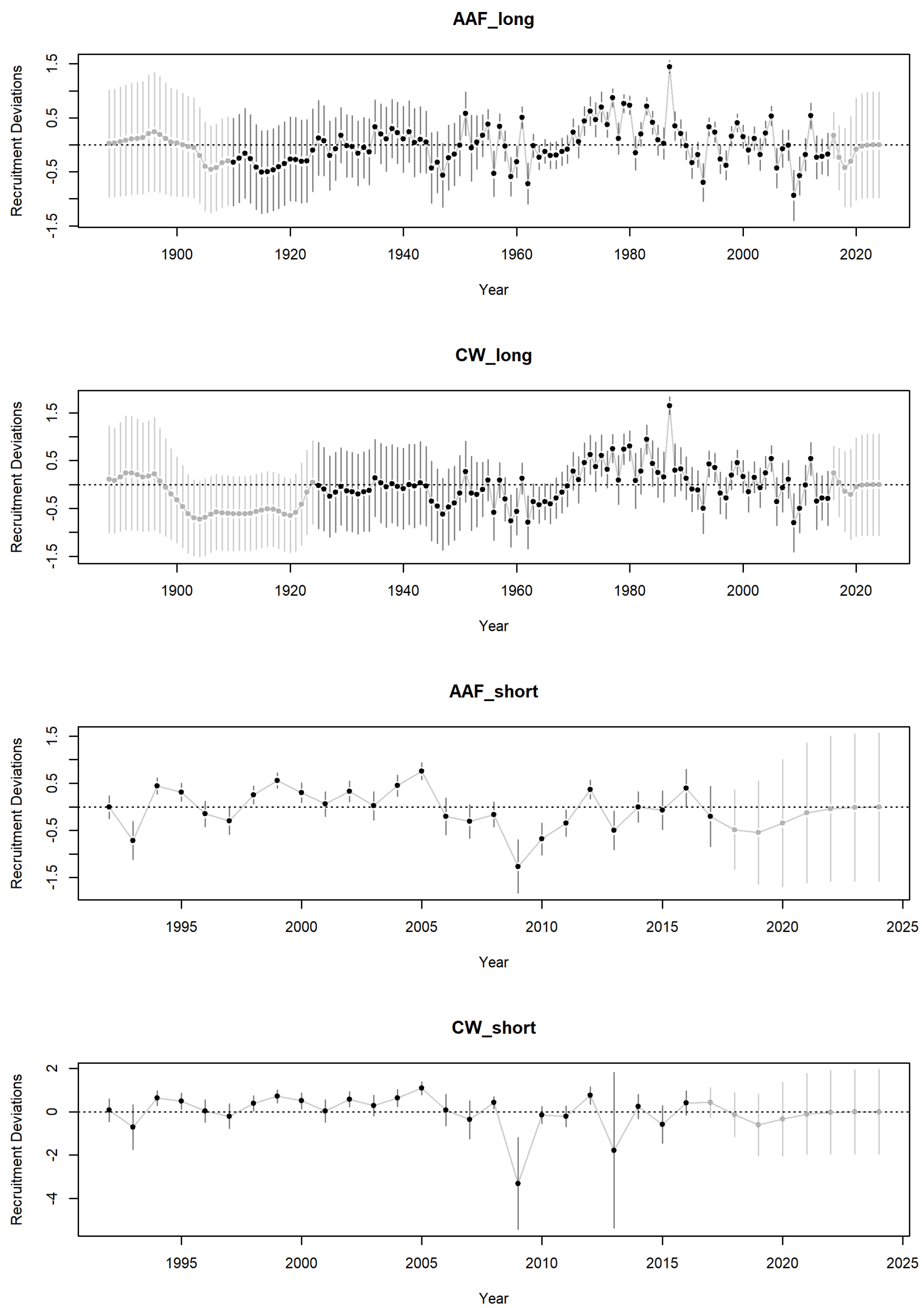

Figure 1. Estimated recruitment deviates from each stock assessment model. Dark points and lines indicate the ‘main’ period.

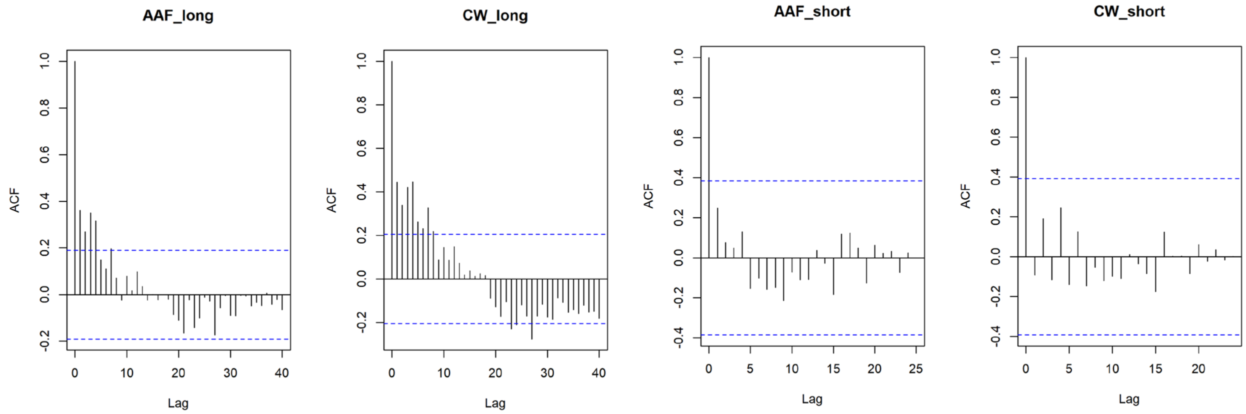

Figure 2. Autocorrelation up to 40 lags for the recruitment deviates from the long models and 25 lags for the short models. Blue horizontal dashed lines are approximate 95% significance levels.

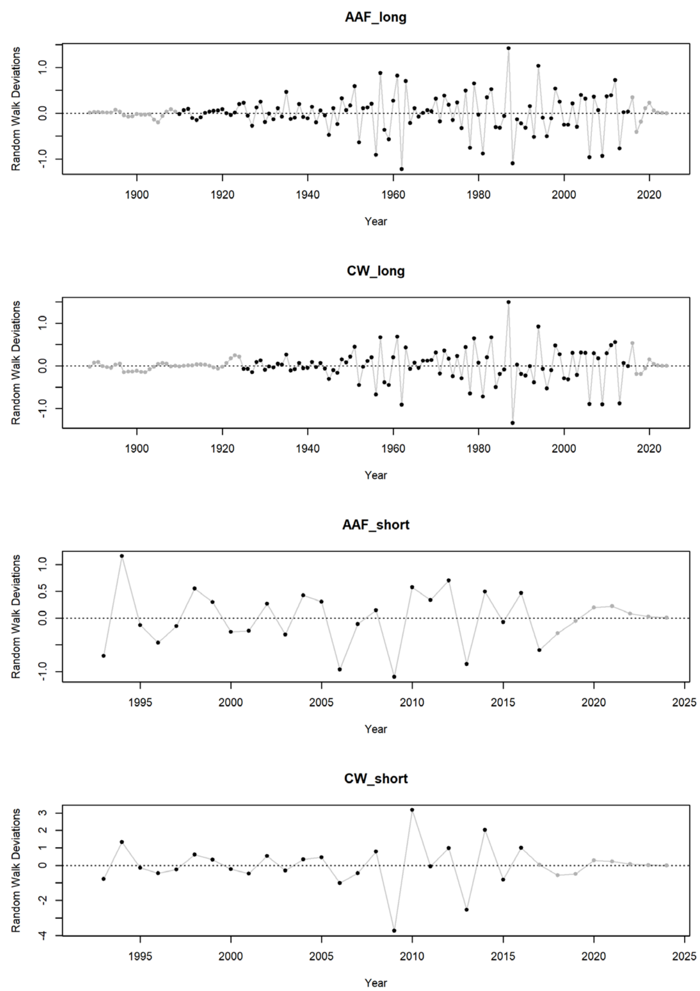

Figure 3. Random walk deviations from each stock assessment model. Dark points and lines indicate the 'main' period.

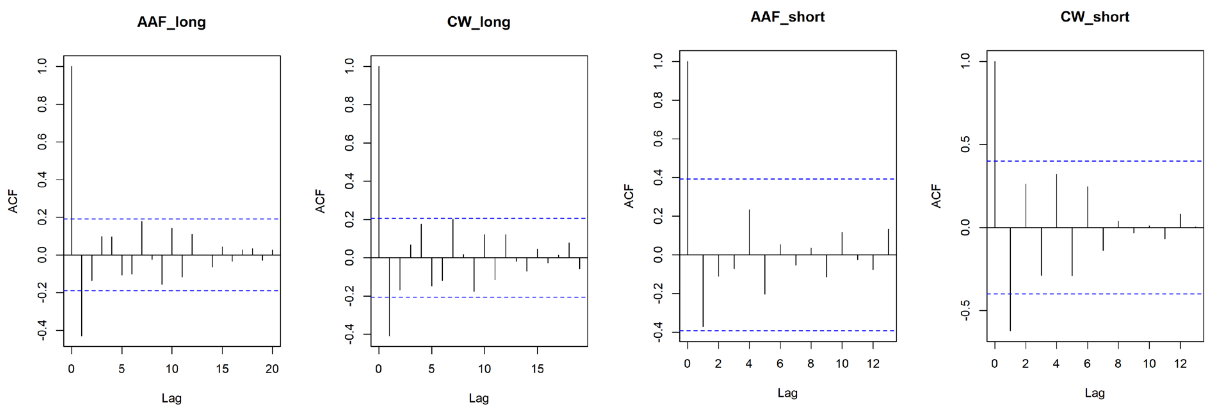

Figure 4. Autocorrelation up to 20 lags for the random walk deviates from the long models and 13 lags for the short models. Blue horizontal dashed lines are approximate 95% significance levels.

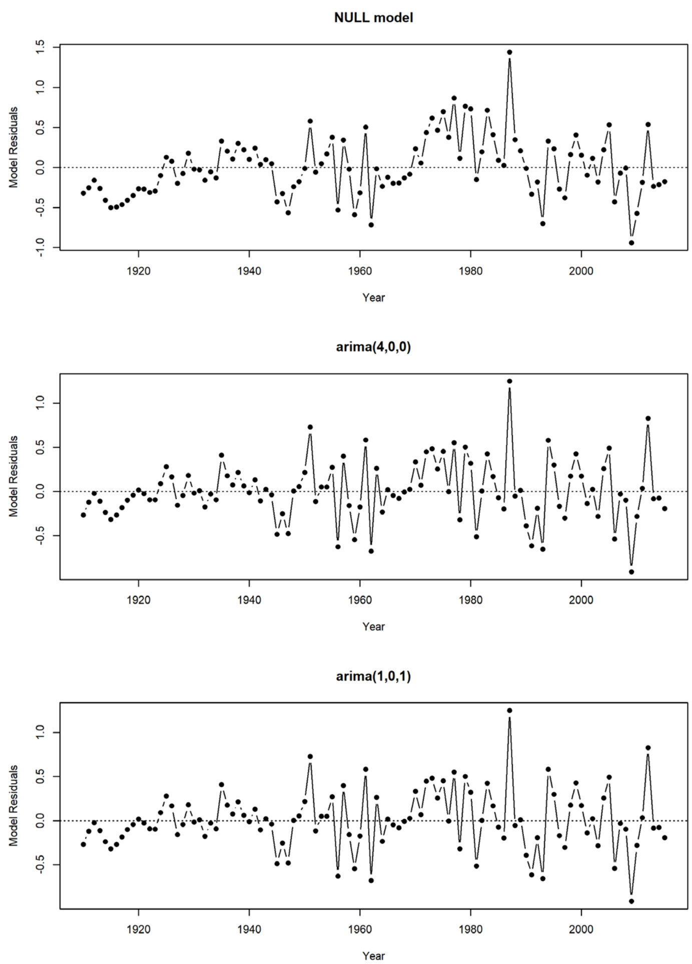

Figure 5. ARIMA model residuals for the NULL, AR(4), and ARIMA(1,0,1) models using the estimated recruitment deviations from the AAF_long assessment model.

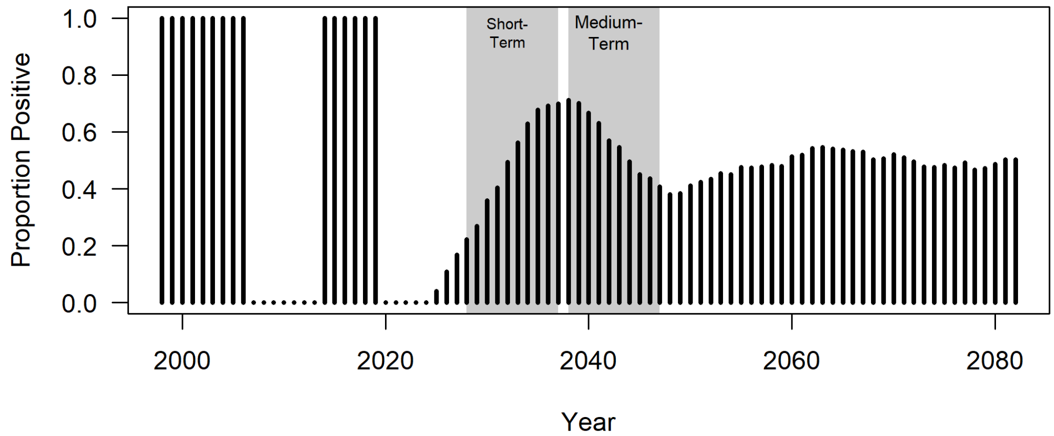

Figure 6. Proportion of simulations where the PDO was positive from 2025 MSE runs. Prior to 2025 the PDO was fixed at high or low determined from historical observations.

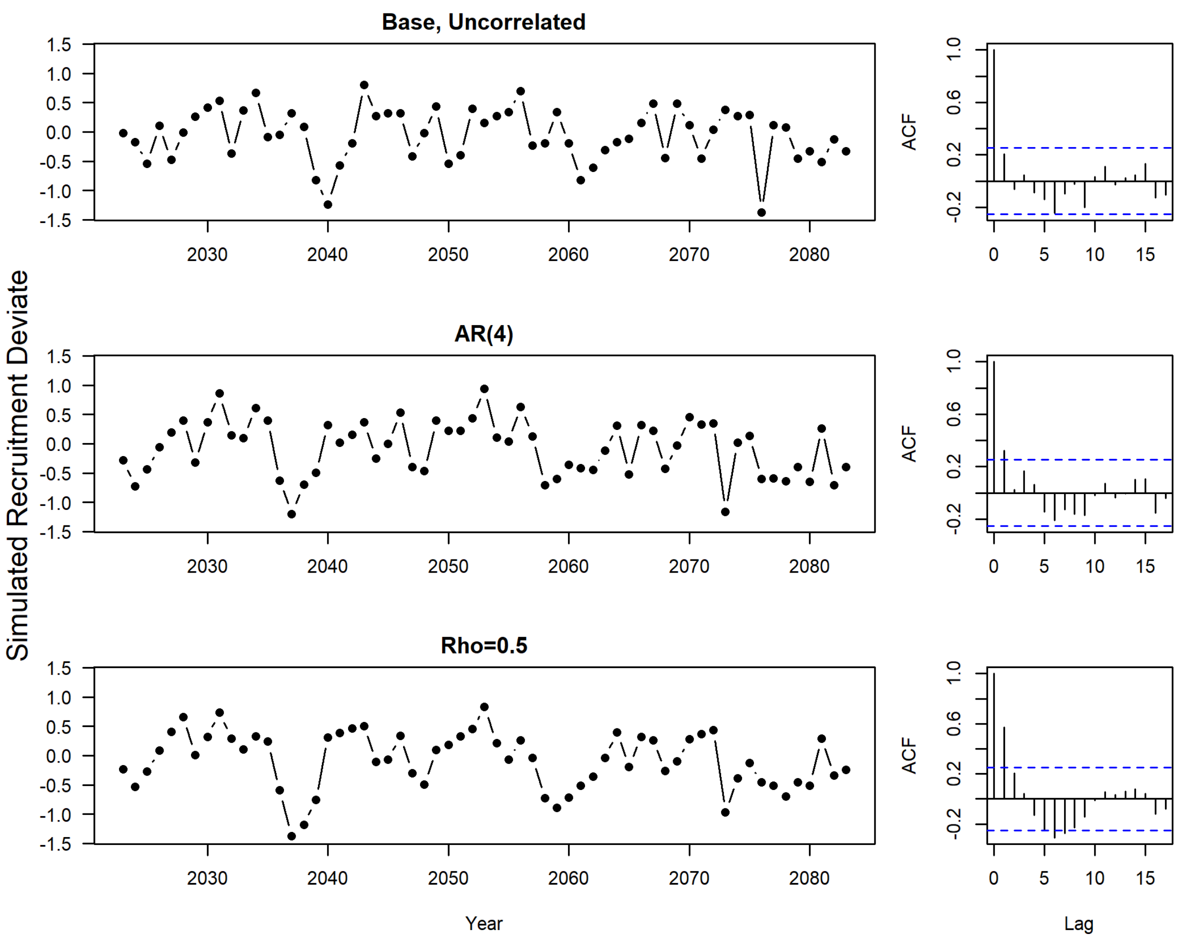

Figure 7. Simulated recruitment deviates using three methods. An example of one simulation for 60 years is show in the left column and the autocorrelation at different lags is show on the right.

Table 2. Performance metrics for MSE simulations with three options for recruitment variability assuming no decision-making variability, no observation error, and no estimation error. An SPR of 43% was used for all scenarios.

Recruitment Deviates	Uncorrelated	AR(4)	$\rho = 0.5$
P(RSB<20%)	<0.001	<0.001	<0.001
P(RSB<36%)	0.24	0.28	0.28
Median TCEY	53.8	51.8	51.6
AAV	10.8%	11.9%	12.0%

3 Definitions of Overfished and Depleted

A definition of overfished has been in the draft Harvest Strategy Policy (HSP) since its inception and reflects the effect of fishing on the stock by using dynamic unfished spawning biomass. Following review of HSPs from other countries, the SRB recommended considering an additional reference point called ‘Depleted’ that reflects the size of the stock relative to fishing and stock productivity.

> IPHC-2025-SRB026-R**, para. 30**: ***NOTING*** *that “Overfished” implies that fishing was the cause of a current biomass state while the term “Depleted” is agnostic about the cause of low biomass, the SRB* ***RECOMMENDED*** *that the Secretariat consider defining “Overfished” relative to a dynamic reference point that incorporates productivity change while “Depleted” should refer to an absolute biomass reference point.*
>
> IPHC-2025-SRB026-R**, para. 31**. *The SRB* ***RECOMMENDED*** *that the Secretariat/Commission adopt an absolute biomass limit defining “Depleted” to avoid low biomass levels where stock dynamics are poorly understood such that recovery projections would be unreliable.*

Both “Overfished” and “Depleted” are important reference points to include in an HSP. A stock may be “Depleted” without being “Overfished” due to environmental conditions or may be “Overfished” without being “Depleted” due to high fishing rates. Continued high fishing rates when a stock is “Overfished” would likely lead to a “Depleted” stock. The priority objectives in the IPHC HSP already contain a reference point to determine “Overfished”. This is $RSB_{20\%}$ in the first objective, using a dynamic relative spawning biomass, and the Secretariat recommends retaining the definition for “Overfished” that is currently in the draft HSP.

> **Overfished**: when the estimated probability that coastwide female relative spawning stock biomass is below the limit reference point ($RSB_{20\%}$) is greater than 50%.

The SRB also recommended including a reference point based on an absolute spawning biomass to determine if the stock is “Depleted,” a level where recovery projections may be unreliable due to uncertain stock dynamics. This implies a spawning biomass below the lowest level observed from which the population is known to have recovered. The Secretariat has currently identified two possible approaches to identify an appropriate absolute spawning biomass reference point.

First, the Secretariat has suggested using the lowest spawning biomass observed in the estimated time series from the ensemble stock assessment, which is 2024 based on the most recent stock assessment. The estimated spawning biomass in the 1970s is highly uncertain and may have been at similar levels seen in recent years. However, given that recent levels are known to be low with a much greater certainty, the Secretariat suggests using the 2023 or 2024 spawning biomass as this absolute reference point. The advantage of choosing a year (or the lowest estimated spawning biomass within a range of years) to define the absolute reference point is that it scales to changes in the stock assessment due to updates to data and new assumptions, accounting for uncertainty. However, it has not been seen how quickly the population may recover from this recent low period of spawning biomass.

Alternatively, simulation (via the MSE framework) could be used to identify an absolute spawning biomass reference point outside of the range of observed stock sizes where the chance of recovery is low. To explore this, we simulate the population forward at a high fishing rate for 40 years under a worst-case scenario, assuming low weight-at-age, low PDO (defining poor recruitment and alternative movement), and a depensation parameter in the stock-recruit curve equal to 5. After 40 years, fishing stops, except for 3 million pounds representing a small amount of bycatch and subsistence fishing, and the population is simulated forward another 50 years. A bifurcation point in the spawning biomass where trajectories either recover or stabilize and those that continue to decline is then estimated. The details of this approach are outlined below.

3.1 Low productivity scenarios

The low productivity scenarios are defined by low weight-at-age and a low PDO (i.e. low average recruitment and different movement patterns compared to a high PDO) resulting in a lower coastwide spawning biomass. Results of simulations comparing productivity regimes are provided in Section 3 of IPHC-2025-SRB026-08.

3.2 Determining depensation

Depensation occurs if the per-capita rate of growth decreases as the density or abundance decreases to low levels (Liermann and Hilborn 2001) and is also referred to as the Allee effect (Dennis 2002). In other words, it is inverse density dependence at low population sizes where there is reduced reproductive success. Example stock-recruit curves with different depensation parameters are shown in Figure 8.

An analysis of depensation is presented in IPHC-2024-SRB025-07. A parameter for depensation was estimated using the estimated recruitment and spawning biomass from each stock assessment model for all years in the 'main' period, as well as for negative and positive PDO years separately. The estimated depensation parameter (*d*) ranged from 0.35 to 4.49. A value of 5 was used for these simulations as a worst-case scenario and shows a strong reduction in recruitment at low spawning biomass (Figure 8).

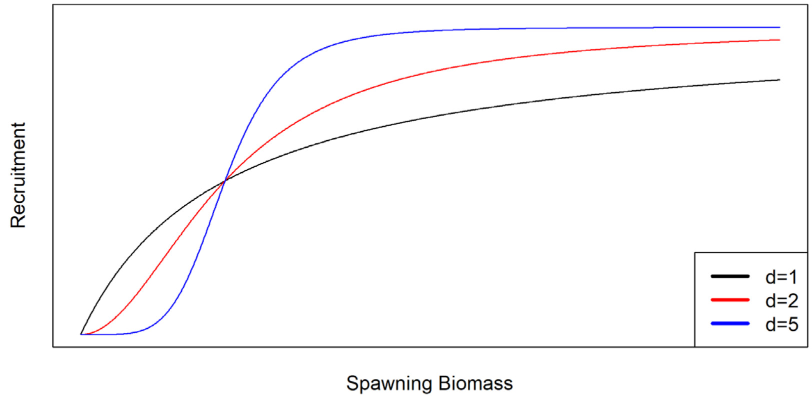

Figure 8. Three example stock-recruit curves with different depensation parameters and the same α and β parameters. When d=1, the curve is a Beverton-Holt stock-recruit curve.

3.3 Simulation results

After 40 years of fishing at a high intensity, fishing is stopped in the simulations and the probability of recovery is determined by defining a trajectory as "recovered" if it stabilized or increased to a greater spawning biomass after 50 years without fishing. Boxplots showing the spawning biomass for trajectories that recovered (Increase) and those that did not recover (Decline) are shown in Figure 9. Nearly all trajectories with a spawning biomass greater than 70 M lbs recovered and no trajectories recovered when starting at a spawning biomass less than 40 M lbs (Figure 10). A high proportion of the trajectories (greater than 50%) in the worst-case scenario recovered when above a spawning biomass near 70 M lbs, which may be a suitable proxy absolute spawning biomass for defining Depleted. Alternatively, 90 M lbs could be used as a proxy for Depleted because that is the spawning biomass where all trajectories recovered once fishing stopped.

Therefore, Depleted could be defined as follows.

> **Depleted**: when the coastwide female spawning stock biomass is estimated to be below a spawning biomass of 70 million pounds with a probability of 50% or higher.

The threshold (70 M lbs) and/or the tolerance (50%) can be modified to reflect an appropriate risk level.

The concept of these two reference points, Overfished and Depleted, is shown in Figure 11 with the Depleted threshold defined at 70 M lbs. Overfished is currently defined as 20% of unfished spawning biomass and changes over time when calculated as an absolute spawning biomass, depending on current stock conditions. In terms of relative spawning biomass, the overfished threshold is constant (20%) and the Depleted threshold varies (Figure 11).

Defining both "Overfished" and "Depleted" reference points in the IPHC HSP would highlight the differences between natural fluctuations in the population due to extrinsic forces such as the environment, and the changes in the population controlled through fishing. Certification agencies could then better determine if these changes are a result of management and be certain that low population sizes are avoided. The Commission will need to consider what response would be taken when a 'Depleted' condition is approached.

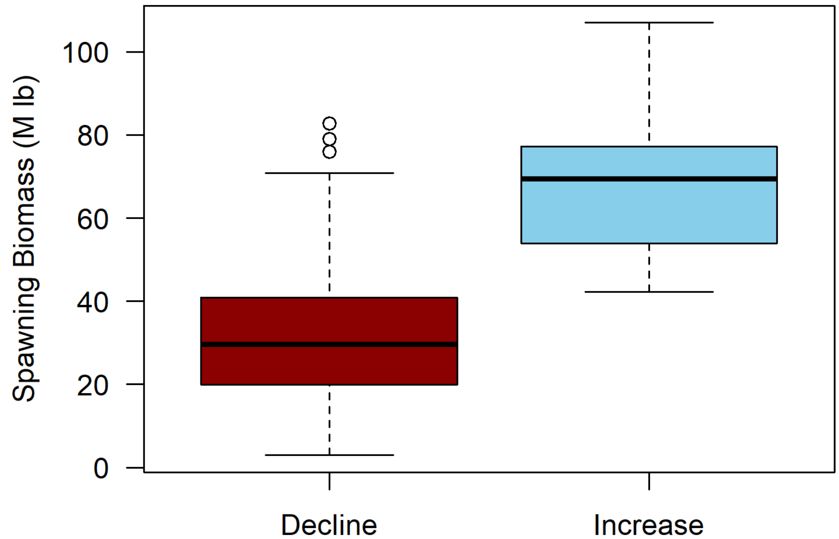

Figure 9. Boxplots of the spawning biomass for trajectories that recovered (Increase) and those that did not recover (Decline).

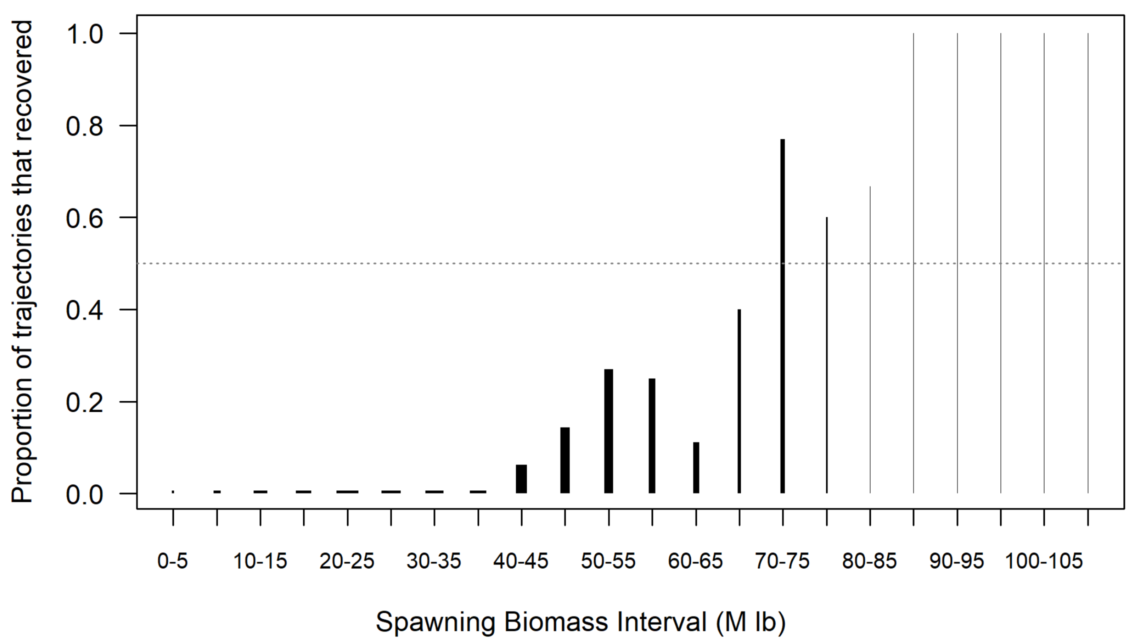

Figure 10. Proportion of trajectories that recovered at various intervals of spawning biomass in 2062 at the start of no fishing. The width of the line indicates the number of trajectories within each interval used to calculate the proportion.

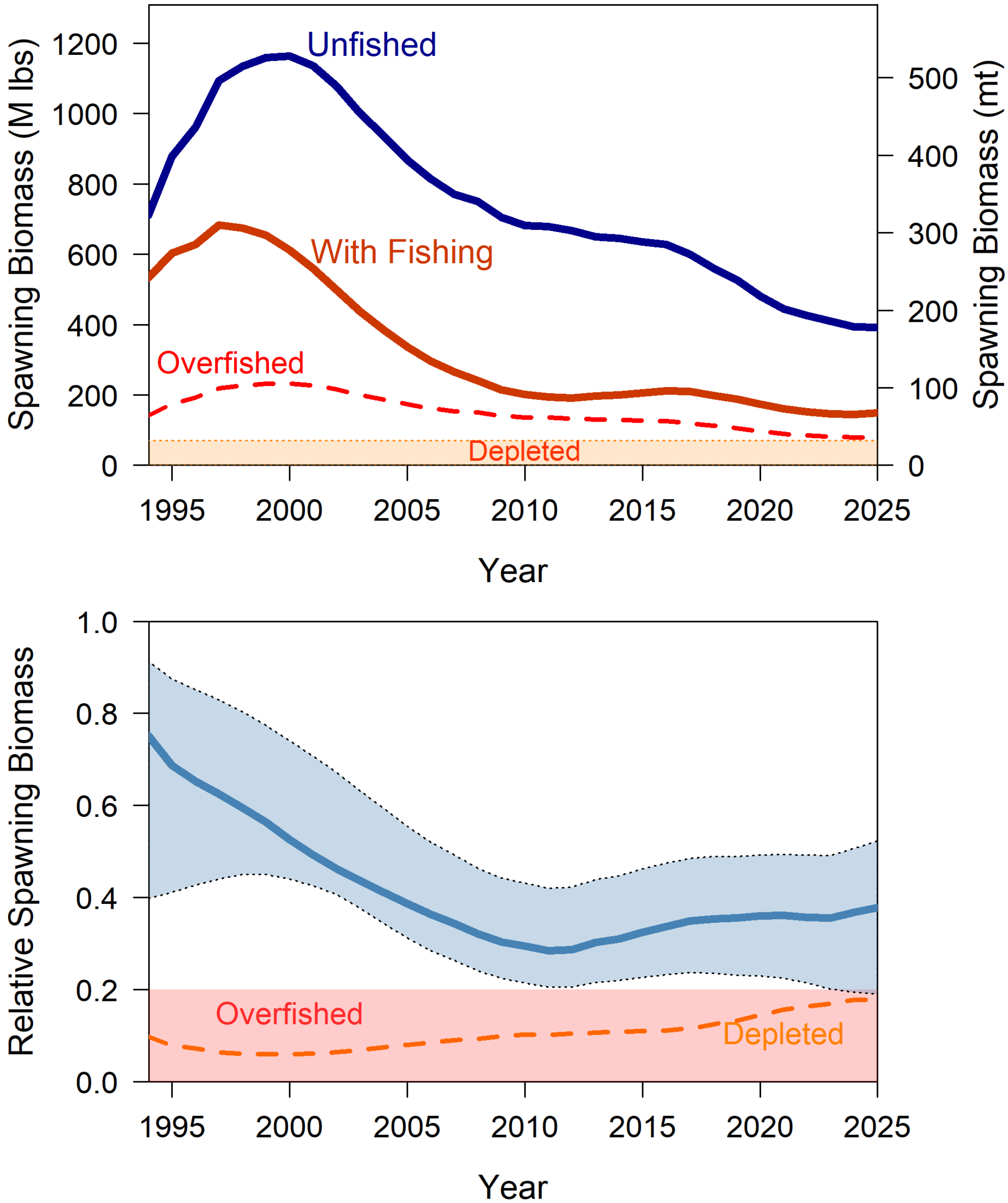

Figure 11. Estimated spawning biomass (top) if fishing had not occurred (unfished) and estimated spawning biomass from the 2024 ensemble stock assessment (with fishing). The Overfished threshold of 20% of unfished spawning biomass is shown as a dashed line. An example 'Depleted' threshold is shown as a straight horizontal line, assuming that it is defined as a constant absolute spawning biomass at 70 M lb. The relative spawning biomass ("with fishing" divided by "unfished") is shown on the bottom plot with a 95% credible interval (accounting for the covariance in the biomass estimated with and without fishing). The Overfished threshold is shown at 20%. The example Depleted value of 70 M lbs is shown as an orange dashed line.

4 DEFINITION OF OVERFISHING

A preliminary definition of overfishing was presented to the Commission at SRB026, resulting in the following recommendations.

> IPHC-2025-SRB026-R, **para. 33**. *The SRB **RECOMMENDED** that the Secretariat evaluate via simulation the ability to detect overfishing (based on the proposed definition) under scenarios of reduced assessment performance when defining "Overfishing" based on probabilities of stock status.*

> IPHC-2025-SRB026-R, **para. 34**. *The SRB **RECOMMENDED** that the Secretariat consider and justify alternative timelines to the three-year rebuilding period specified in the proposed definition of "overfishing" since a three-year period is probably unrealistic for rebuilding timelines*

The definition of "Overfishing" was incomplete in previous drafts of the HSP. Using the concept that "Overfishing" would lead to an "Overfished" state, the Secretariat proposes the following definition for "Overfishing".

> **Overfishing**: where the stock is subject to a level of fishing that would move it to an overfished state with a greater than 50% probability within three (3) years at a constant mortality (measured in biomass) or prevent it from rebuilding to a 'not overfished' state within the required timeframe and specifications of a rebuilding plan.

The benefits of this definition are (1) it is consistent with the decision table and the decision table could easily be used to define the overfishing level, (2) it provides flexibility to the Commission to allow high fishing rates if the stock is large and the Commission would prefer to fish down the stock to achieve optimum yield, (3) it is consistent with a rebuilding plan, and (4) a constant mortality spread over three years ensures that one year is not excessive.

Given this new definition, the recommendation in paragraph 34 of IPHC-2025-SRB026-R to justify alternative timelines to the three-year rebuilding period are now moot. It is consistent with the HSP to include the specifications of the rebuilding plan in the definition of overfishing. Maintaining a three-year period if above the overfished threshold and not in a rebuilding plan remains consistent with the decision table.

The simulations recommended in paragraph 33 will be completed following the reconditioning of the OM in early 2026, and will be presented at the 28th Session of the Scientific Review Board (SRB028).

5 HARVEST STRATEGY POLICY (HSP)

Workshops with Commissioners occurred in April and August 2025 to discuss potential changes to the draft HSP and how to move it forward for adoption. The next steps are for the Commission to review the edits from these workshops, possibly hold another work session, consider a new draft at the Work Meeting, and then move the HSP forward for adoption at the next Interim Meeting or Annual Meeting.

RECOMMENDATION/S

That the SRB:

1) **NOTE** paper IPHC-2025-SRB027-08 which details investigations of autocorrelation in recruitment, definitions of Overfished and Depleted, a definition of Overfishing, and a brief update on the Harvest Strategy Policy.
2) **REQUEST** any topics to add to the 2025-2026 MSE Program of Work.

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2026-28 FISS design evaluation and modelling updates

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PART 1: 2026-28 FISS DESIGN EVALUATION

PURPOSE

To present the Scientific Review Board with potential FISS designs for 2026-28, including a preliminary cost evaluation of the 2026 design options.

BACKGROUND

The IPHC's Fishery-Independent Setline Survey (FISS) provides data used to compute indices of Pacific halibut density for use in monitoring stock trends, estimating stock distribution, and as an important input in the stock assessment. Stock distribution estimates are based on the annual mean weight per unit effort (WPUE) for each IPHC Regulatory Area, computed as the average of WPUE of all Pacific halibut and for O32 (greater than or equal to 32" or 81.3cm in length) Pacific halibut estimated at each station in an area. Mean numbers per unit effort (NPUE) is used to index the trend in Pacific halibut density for use in the stock assessment models. Annual FISS designs are developed by selecting a subset of stations for sampling from the full 1890-station FISS footprint (Figure 1).

In recent years, financial constraints due to reduced catch rates, lower sales prices and higher costs have led to the implementation of FISS designs with reduced spatial footprints. Effort has been concentrated in IPHC Regulatory Areas 2B, 2C, 3A and 3B, with limited sampling in other areas (Figures 2 and 3). The Base Block Design was presented to the Commission at the September 2024 Work Meeting and the 14th Special Session of the IPHC (SS014, IPHC-2024-SS014-03) as a more efficient approach to annual sampling in the core of the stock compared to recent designs based on random selection of FISS stations. The Base Block design ensures that all charter regions in the core areas are sampled over a three-year period, while prioritizing coverage in other areas based on minimizing the potential for bias and maintaining CVs below 25% for each IPHC Regulatory Area. The Base Block design also include some sampling in all IPHC Biological Regions in each year, ensuring that trend and biological data from across the spatial range of Pacific halibut are available to the stock assessment and for stock distribution estimation. For 2025, high projected financial costs for this design meant that it was not viable to undertake without substantial supplementary funding. Therefore, IPHC Secretariat staff developed a "fiscally viable" design for 2025 that would have reduced spatial coverage for the third year in a row but at a projected loss that could be covered by revenue, supplementary funding and IPHC reserve funds. Following SS014, the final 2025 FISS design was approved via inter-sessional agreement (IPHC-2024-CR-030, IPHC-2024-CR-031; Figure 3). This design included sampling of FISS charter regions in IPHC Regulatory Areas 3A, 3B, 4A and 4B that were unsampled in either 2023, 2024 or both.

FISS history 1993-2019

The IPHC has undertaken FISS activity since the 1960s. However, methods were not standardized to a degree (e.g., the bait and gear used) that allows for simple combined analyses until 1993. From 1993 to 1997, the annual design was a modification of a design developed and implemented in the 1960s, and involved fishing triangular clusters of stations, with clusters located on a grid (IPHC 2012). Coverage was limited in most years and was generally restricted to IPHC Regulatory Areas 2B through 3B. The modern FISS design, based on a grid with 10 nmi (18.5 km) spacing, was introduced in 1998, and over the subsequent two years was expanded to include annual coverage in parts of all IPHC Regulatory Areas within the depth ranges of 20-275 fathoms (37-503 m) in the Gulf of Alaska and Aleutian Islands, and 75-275 fathoms (137-503 m) in the Bering Sea (IPHC 2012). Annually-fished stations were added around islands in the Bering Sea in 2006, and in the same year, a less dense grid of paired stations was fished in shallower waters of the southeastern Bering Sea, providing data for a calibration with data from the annual National Marine Fishery Service (NMFS) bottom trawl survey (Webster et al. 2020).

Through examination of commercial logbook data and information from other sources, it became clear by 2010 that the historical FISS design had gaps in coverage of Pacific halibut habitat that had the potential to lead to bias in estimates derived from its data. These gaps included deep and shallow waters outside the FISS depth range (0-20 fathoms and 275-400 fathoms), and unsurveyed stations on the 10 nmi grid within the 20-275 fathom depth range within each IPHC Regulatory Area. This led the IPHC Secretariat to propose expanding the FISS to provide coverage of the unsurveyed habitat in United States and Canadian waters. In 2011 a pilot expansion was undertaken in IPHC Regulatory Area 2A, with stations on the 10 nmi grid added to deep (275-400 fathoms) and shallow (10-20 fathoms) waters, the Salish Sea, and other, smaller gaps in coverage. The 10-fathom limit in shallow waters was due to logistical difficulties in standardized fishing of longline gear in shallower waters. The 400-fathom maximum depth is understood to cover the vast majority of Pacific halibut summer habitat. A second expansion in IPHC Regulatory Area 2A was completed in 2013, with a pilot survey in California waters between the latitudes of 40 and 42°N.

The full expansion program began in 2014 and continued through 2019, resulting in the sampling of the entire FISS design of 1890 stations in the shortest time logistically possible. The FISS expansion program allowed us to build a consistent and complete picture of Pacific halibut density throughout its range in Convention waters. Sampling the full FISS design has reduced bias , and, in conjunction with space-time modelling of survey data (see below), has improved precision and fully quantified the uncertainty associated with estimates based on partial annual sampling of the species range. It has also provided us with a complete set of observations over the full FISS design (Figure 1) from which an optimal subset of stations can be selected when devising annual FISS designs. This station selection process began in 2019 for the 2020 FISS and continues with the current review of design proposals for 2024-26. Note that in the Bering Sea, the full FISS design does not provide complete spatial coverage, and FISS data are augmented with calibrated data from National Marine Fisheries Service (NMFS) and Alaska Department of Fish and Game (ADFG) trawl surveys (stations can vary by year – 2019 designs are shown in Figure 1). Both supplementary surveys have been conducted approximately annually in recent years.

Rationalized FISS, 2020-25

Following the 2011-2019 program of FISS expansions, rationalized FISS designs were approved for 2020 based on random selection of over 50% of stations in the core of the stock (IPHC Regulatory Areas 2B, 2C, 3A and 3B) and sampling of all stations in selected subareas of the remaining IPHC Regulatory Areas. For the latter areas, sampling priorities were determined based on maintaining precise estimates of area-specific indices of density and ensuring low bias in index estimators. That year, the COVID19 pandemic led to a reduced FISS with sampling only in the core areas. The 2021-22 FISS sampling proceeded largely as designed, although planned stations in western IPHC Regulatory 4B in 2022 were unsampled due to a lack of viable charter bids. In some charter regions in the core areas, 100% of stations were sampled in order to achieve revenue goals (see below). The 2023 FISS design had more limited spatial coverage, with almost no FISS sampling outside of the core areas due to large projected revenue losses from designs that included extensive sampling in IPHC Regulatory Areas 2A, 4A, 4B and 4CDE. Limited sampling was carried out in northern IPHC Regulatory 2A, while planned stations around the IPHC Regulatory Area 4A/4B boundary were not sampled due to a lack of charter bids. The adopted 2024 FISS design (IPHC-2024-AM100-R) included high sampling rates in IPHC Regulatory Areas 2B and 2C, a small number of charter regions in IPHC Regulatory Areas 3A and 3B, and sampling of the southern shelf edge and Bering Sea islands in IPHC Regulatory Area 4CDE (Figure 2). The 2025 design includes stations in IPHC Regulatory Areas 3A and 3B that complement coverage in recent years (Figure 3), along with stations in IPHC Regulatory Areas 2A, 4A and 4B that have not been sampled for three or more years and is therefore expected to reduce the potential for bias in most IPHC Regulatory Areas relative to recent years (Figure 4).

Space-time modelling

In 2016, a space-time modelling approach was introduced to estimate time series of weight and numbers-per-unit-effort (WPUE and NPUE), and to estimate the stock distribution of Pacific halibut among IPHC Regulatory Areas. This represented an improvement over the largely empirical approach used previously, as it made use of additional information within the survey data regarding the degree of spatial and temporal correlation in Pacific halibut density, along with information from covariates such as depth (see Webster 2016, 2017). It also allowed a more complete accounting of uncertainty; for example, prior to the use of space-time modelling, uncertainty due to unsurveyed regions in each year was ignored in the estimation. Prior to the application of the space-time modelling, these unsampled regions were either imputed using independently estimated scalar calibrations (if fished at least once) or catch-rates at unsampled stations were assumed to be equal to the mean for the entire Regulatory Area. The IPHC's Scientific Review Board (SRB) has provided supportive reviews of the space-time modelling approach (e.g., IPHC-2018-SRB013-R), and the methods have been published in a peer-review journal (Webster et al. 2020). Similar geostatistical models are now routinely used to standardize fishery-independent trawl surveys for groundfish on the West Coast of the U.S. and in Alaskan waters (e.g., Thorson et al. 2015 and Thorson 2019) and to integrate multiple surveys off the Pacific coast of Canada (e.g., Thompson et al. 2023). The IPHC space-time models are fitted through the R-INLA package in the R software (R Core Team, 2024).

FISS DESIGN OBJECTIVES (Table 1)

Note that the secondary objective was revised at AM101 (IPHC-2025-AM101-R, para. 61).

Primary objective: *To sample Pacific halibut for stock assessment and stock distribution estimation.*

The primary purpose of the annual FISS is to sample Pacific halibut to provide data for the stock assessment (abundance indices, biological data) and estimates of stock distribution for use in management. The priority of the current rationalized FISS is therefore to maintain or enhance data quality (precision and bias) by establishing baseline sampling requirements in terms of station count, station distribution and skates per station.

Secondary objective: *Cost effectiveness.*

The FISS is intended to be cost-effective without compromising the scientific integrity of the design. Any implemented design must consider logistics and cost together with scientific integrity.

Tertiary objective: *Minimize removals and assist others where feasible on a cost-recovery basis.*

Consideration is also given to the total expected FISS removals (impact on the stock), data collection assistance for other agencies, and emerging IPHC informational needs.

Table 1 Prioritized FISS objectives and corresponding design layers.

Priority	Objective	Design Layer
Primary	Sample Pacific halibut for stock assessment and stock distribution estimation	Minimum sampling requirements in terms of: • Station distribution • Station count • Skates per station
Secondary	Cost effectiveness without compromising the scientific integrity of the FISS design.	Balance operational feasibility/logistics, cost/revenue, and scientific needs. Includes an aspirational target reserve of US$2,000,000
Tertiary	Minimize removals, assist others where feasible on a cost-recovery basis, address specific Commission informational needs.	Removals: minimize impact on the stock while meeting primary priority Assist: assist others to collect data on a cost-recovery basis IPHC policies: ad-hoc decisions of the Commission regarding the FISS design

Annual design review, endorsement, and finalisation process

Since completion of the FISS expansions in 2019, a review process has been developed for annual FISS designs created according to the above objectives:

- Step 1: The Secretariat presents preliminary design options based on the primary objective (Table 1) to the SRB for three subsequent years at the June meeting based on analysis of prior years' data. Commencing in 2024, this has included preliminary cost projections based on prior year fiscal details (revenue) and current year vessel contract cost updates;
- Step 2: Updated design options for the following year that account for both primary and secondary objectives (Table 1) are reviewed by Commissioners at the September work meeting, recognising that revenue and cost data from the current year's FISS are still preliminary at this time;
- Step 3: At their September meeting, the SRB reviews design options accounting for both primary and secondary objectives (Table 1) for comment and advice to the Commission (recommendation). FISS revenue and cost information from the current year is near-final at this time;
- Step 4: Designs are further modified to account for updates based on secondary and tertiary objectives before being finalized during the Interim and Annual meetings and the period prior to implementation:

- Presentation of FISS designs for 'endorsement' by the Commission occurs at the annual November/December Interim Meeting;
- Ad-hoc modifications to the design for the current year (due to unforeseen issues arising) are possible at the Annual Meeting of the Commission;
- The endorsed design for current year is then modified (if necessary) to account for any additional tertiary objectives or revision to inputs into the evaluation of secondary objectives prior (i.e. updated cost estimates) and logistical considerations raised by the operators of contracted vessels prior to summer implementation (February-April).

Consultation with industry and stakeholders occurs throughout the FISS planning process, at the Research Advisory Board meeting (late November) and particularly in finalizing design details as part of the FISS charter bid process, when stations can be added and other adjustments made to provide for improved logistical efficiency. We also note the opportunities for direct stakeholder input during public meetings (Interim and Annual Meetings).

Although the review process examines designs for the next three years, revisions to designs for the second and third years are expected during subsequent review periods as additional data are collected. Having design proposals available for three years instead of the next year only assists the Secretariat with medium-term planning of the FISS, and allows reviewers (SRB, Commissioners) and stakeholders to see more clearly the planning process for sampling the entire FISS footprint over multiple years.

POTENTIAL DESIGNS FOR 2026-28

BASE BLOCK DESIGN

At AM101, Secretariat staff presented the Base Block design for 2025 and subsequent years based a rotational block design (IPHC-2025-AM101-14). This design implements sampling of complete FISS charter regions (subsets of stations generally sampled by a single vessel via multiple trips) in each area rather than randomly selected stations as was previously done in the core of the stock. Sampled charter regions are rotated over two or three years depending on area. This type of design was first proposed in 2019 (IPHC-2019-IM095-07 Rev_1, Figure 4) to complement the similar subarea design proposed and adopted for areas at the ends of the stock (2A, 4A and 4B). Block designs are potentially more efficient from an operational perspective than a randomized design, as they involve less running time between stations, possibly leading to cost reductions on a per station basis.

The Base Block designs shown in Figures 5 to 7 for 2026-28 were revised from the designs presented to Commissioners at AM101 to account for the Commission-approved 2025 design. In particular, charter regions not selected in IPHC Regulatory Areas 3A and 3B in 2025 were prioritized for sampling in 2026.

Using samples generated from the fitted 2024 space-time models as simulated data for 2025-28, we projected the coefficient of variation (CV, a relative measure of precision) for mean O32 WPUE for each year of the design by area. As CVs are generally greater in the terminal year of the time series and that year is usually the most relevant for informing management, the CV values in Table 2 are for the final year of the modelled time series. For example, the values for 2027 were found by fitting the model to the data for 1993-2027, with simulated data used for 2025-27.

Table 2. Projected coefficients of variation (CVs, %) of mean O32 WPUE for the Base Block design by terminal year of time series and IPHC Regulatory Area and Biological Region.

Regulatory Area	Year 2026	2027	2028
2A	21	22	14
2B	11	7	10
2C	6	6	6
3A	8	7	8
3B	11	15	11
4A	18	22	13
4B	15	16	17
4CDE	9	9	8
Biological Region			
Region 2	6	5	5
Region 3	7	7	7
Region 4	9	10	7
Region 4B	15	16	17
Coastwide	4	4	4

Projected terminal year CVs for the Base Block design are 25% or less for all IPHC Regulatory Areas. In the core areas (2B, 2C, 3A and 3B), CVs are projected to be 15% or less (Table 2). All Biological Region CVs, except that of Region 4B, are at most 10%, while the coastwide CV is projected to be 4% in all years. The Base Block design is therefore expected to maintain precise estimates of indices of Pacific halibut density and abundance across the range of the stock. At the same time, the rotating nature of the sampled blocks means that almost all FISS stations are sampled within a 5-year period (2-3 years within the core areas) resulting in low risk of missing important stock changes and therefore a low risk of large bias in estimates of trend and stock distribution.

The 'global average' research survey CVs has been estimated to be approximately ~20%; however, this value includes estimated observation and process error (based on lack of fit in the stock assessments), and so is larger than the survey-only observation CVs projected in this report (Francis et al. 2003). In NOAA Fisheries trawl survey results in the Bering Sea (roughly analogous to one Biological Region for Pacific halibut), commercially important species showed a range of average annual model-based CVs, including: Pacific cod (5%), Walleye pollock (7%), Northern rock sole (6%), and yellowfin sole (5%) over 1982-2019 (DeFilippo et al. 2023). These values are comparable to the projected 5-9% CVs for IPHC Biological Regions that would be expected from the base block design (with the exception of Biological Region 4B), but lower than corresponding values for the Core Block and Reduced Core designs.

REDUCED LOSS DESIGN

The Base Block design is projected to result in a substantial operating loss (Table 3) and would require supplementary funding to be viable. As an alternative, the Secretariat staff has developed a preliminary design that would result in a net operating loss of approximately $500,000 (Figure 8). This Reduced Loss design maintains sampling in two revenue positive charter regions in IPHC Regulatory Area 2C, adds a revenue positive charter region to IPHC Regulatory Area 2B, and includes a subsample of 30 stations in each of three other revenue-negative charter regions from the Base Block design in IPHC Regulatory Areas 2B and 3A.The three regions with partial sampling were prioritized for 2026 as they are among the regions not sampled in the last two to three years.

Table 3 gives preliminary cost and revenue projections for Base Block and Reduced Loss designs. Projections include the following assumptions:

1. Designs are optimized for numbers of skates, with 4, 6 or 8 skate-sets used, depending on projected catch rates and bait costs.
2. 2026 Pacific halibut price and landings decline 15% and 5% respectively from 2025 values.

Regarding (2), there was a large average increase in price from 2024 to 2025, but without fully understanding the reasons for this increase, it seems precautionary to assume that prices will return to values closer to those experienced in previous years. Further, raw FISS catch rates to date imply that in most regions, the landings continue to decline and therefore it is reasonable to assume a further decline from 2025 to 2026. Prices for chum salmon bait are also anticipated to increase substantially (by 58%) based on current information.

Table 3. Comparison of preliminary projected costs and revenue for the 2026 Base Block and Reduced Loss designs ($US). (Totals may not equal the sum of individual rows due to rounding.)

Design		**Base Block**	**Reduced Loss**
Projected costs	**Base HQ (incurred even with no FISS)**	(534,000)	(534,000)
	Vessel bids	(1,306,000)	(436,000)
	Field staff expenses	(492,000)	(246,000)
	Bait	(409,000)	(195,000)
	Non-IPHC fish sales	(182,000)	(147,000)
	Other costs*	(471,000)	(279,000)
	Total costs	**(3,394,000)**	**(1,838,000)**
Projected revenue	**Total Pacific halibut sales**	1,460,000	1,260,000
	Total byproduct sales	46,000	41,000
	Total sales	**1,507,000**	**1,302,000**
Projected net revenue		**($1,887,000)**	**($537,000)**

*Other costs include staff training, personnel expenses, mailing and shipping, travel, technology, gear replacement, customs fees, bait storage fees, field supplies and equipment, equipment maintenance fees, facility rental fees, and communication fees.

Cost estimates are largely based on information from the 2025 FISS as of mid-July 2025, together with outcomes of the 2025 charter bidding process, and it is important to note

there is still high uncertainty in the catch and cost projections for 2026 at this point. Final cost and accounting information will be available at the end of the 2025 fiscal year and will be used to refine the cost projections at that time.

Intermediate Designs

Here we present several intermediate designs that could be considered if supplementary funding became available or if greater losses might be considered acceptable to the Commission (Table 4). **Importantly, cost and revenue estimates are preliminary and subject to change as inputs are revised following the 2025 FISS season.**

Option 1 in Table 4 is the Reduced Loss design (Figure 8), and Options 2 through 6 successively add stations or charter regions based on scientific priorities. Option 2 (Figure 9) samples the same charter regions as Option 1, but the partial regions are now fully sampled. IPHC Regulatory Area 4B is added in Option 3 (Figure 10), which is therefore the least expensive of the options in Table 4 that includes sampling of some kind in all Biological Regions (assuming the NOAA trawl survey provides coverage in Region 4). Option 4 (Figure 11) improves spatial coverage in Biological Region 3 by adding a charter region in IPHC Regulatory Area 3B, while Option 5 (Figure 12) adds FISS sampling to Region 4 with a charter region in IPHC Biological Region 4A. Option 6 (Figure 13) includes all charter regions from the Base Block design (Option 7, Figure 5), together with one revenue-positive region in Biological Region 2 that is not part of the Base Block Design.

Table 4. Comparison of 2026 preliminary revenue projections for the Reduced Loss design, the Base Block design and design options providing intermediate coverage. For each design, the final column shows the difference in projected revenue from the design in the previous row.

Design	**Sampled IPHC Regulatory Areas (with number of FISS charter regions)**	**Projected net revenue ($US)**	**Difference ($US)**
Option 1: Reduced Loss	2B(1 full, 2 partial), 2C(2), 3A(1 partial)	($537,000)	
Option 2	2B**(3)**, 2C(2), **3A(1)**	($591,000)	($54,000)
Option 3	2B(3), 2C(2), 3A(1), **4B(1)**	($856,000)	($265,000)
Option 4	2B(3), 2C(2), 3A(1), **3B(1)**, 4B(1)	($1,019,000)	($163,000)
Option 5	2B(3), 2C(2), 3A(1), 3B(1), 4A(1), **4B(1)**	($1,252,000)	($233,000)
Option 6	2B(3), 2C(2), 3A**(4)**, 3B**(2)**, 4A(1), 4B(1)	($1,843,000)	($591,000)
Option 7: Base Block	2B(2), 2C(2), 3A(4), 3B(2), 4A(1), 4B(1)	($1,887,000)	($44,000)

Whereas Table 4 presents options in the form of complete FISS designs, each change between design options can be thought of as a series of optional modular add-ons (Table 5) that can be added or removed from the design in any order. The order of additions presented in Tables 4 and 5 broadly represents scientific priorities, including prioritizing sampling in all IPHC Biological Regions and sampling regions that have not been included in the most recent implemented FISS designs (to reduce the risk of bias in estimates derived from FISS data). Other factors such as Commission priorities or accounting for the Secondary Objective (Table 1, e.g. by prioritizing less costly additions) may result in a different ordering than Table 5.

Table 5. Preliminary cost projections of modular changes to the Reduced Loss design that result in intermediate designs between the 2026 Reduced Loss and Base Block designs. Each of Options 2 to 7 can be added in any combination to Option 1, with the total cost found by summing the additional costs for each option selected. Note that due to rounding, some combinations may result in total cost projections that differ slightly from the values in Table 4. For reference, FISS charter regions are shown in Figure 14.

Option	Design or design change	Sampled IPHC Regulatory Areas (Option 1) (with FISS charter regions) or change from previous options (Options 2 to 7)	Net cost (Option1) or additional cost (Options 2 to 7)	Benefit/rationale
1	Reduced Loss	2B(1 full, 2 partial), 2C(2), 3A(1 partial)	($537,000)	
2	Add full sampling in all charter regions to Option 1	**2B(+2 partial)**, **3A(+1 partial)**	($54,000)	Fully sampled regions may more easily attract bids
3	Add east Adak	**4B(+1)**	($265,000)	Adds sampling in Biological Region 4B
4	Add Chignik	**3B(+1)**	($163,000)	Adds 3B sampling. Last sampled 2023.
5	Add east Unalaska	**4A(+1)**	($233,000)	Adds 4A sampling. Last sampled 2019.
6.1	Add Gore Pt	**3A(+1)**	($136,000)	Improves 3A coverage. Last sampled 2023.
6.2	Add Fairweather	**3A(+1)**	($153,000)	Improves 3A coverage. Last sampled 2023.
6.3	Add Semidi	**3B(+1)**	($159,000)	Improves 3B coverage. Last sampled 2023.
6.4	Add Shelikof	**3A(+1)**	($141,000)	Improves 3A coverage. Last sampled 2024.
7	Remove St James	**2B(−1)**	($44,000)	Removes lower-priority revenue positive region. Last sampled 2024.

Discussion

The **Base Block** design has a projected net loss of around $1,887,000 and therefore will rely on supplementary funding for implementation. Unlike the Base Block design, the preliminary **Reduced Loss** design does not have extensive spatial coverage, with sampling concentrated in regions of greatest Pacific halibut density in IPHC Biological Region 2, only 30 FISS stations in Biological Region 3, and no FISS sampling in Biological Regions 4 and 4B. Such a design comes with a greater risk of bias relative to the Base Block design due to the increased chance of stock changes being unobserved. Despite the uncertainty being properly propagated, of increasing concern is the potential for the space-time model expectations to move toward the long term mean in the absence of new data. This increased uncertainty in the index of abundance is likely to cause the assessment model to rely more heavily on the commercial fishery catch-per-unit-effort index, as was the case in 2024. Given current spatial variability and uncertainty in the magnitude of younger year classes (2016 and younger), the limited biological information from the core of the stock distribution (Biological Region 3) makes it unclear whether the stock assessment will detect a major change in year class abundance, either up or down. Although the stock assessment methods can remain unchanged, a greater portion of the actual uncertainty in stock trend and demographics will not be able to be quantified due to missing FISS data from a large fraction of the Pacific halibut stock's geographic range.

The implications for the assessment would be of increasing concern if designs like the Reduced Loss design were implemented beyond 2026 due to increasing uncertainty and risk of bias in stock trend estimates and the unrepresentativeness of the biological samples. Further, as was evident at AM100 and AM101, reduced FISS designs that do not fully inform stock distribution with annual sampling in all IPHC Regulatory areas lead to reduced stakeholder confidence in the FISS results and in the aggregate scientific information from the stock assessment. As it did with the relatively conservative mortality limits set for 2025, this may have a strong effect on the perception of risk and on decision making by the Commission if reduced survey designs continue to be consecutively implemented.

Water column profiler information from the in-progress FISS in IPHC Regulatory Area 2A shows evidence for hypoxia in parts of that area. Catch rates are well below predicted values based on the most recent surveys. We intend to prioritize the processing of dissolved oxygen data from the profiler so that these data are available prior to the 2025 Interim Meeting to help inform management regarding catch limit decisions and FISS priorities in Biological Region 2.

RECOMMENDATION

That the Scientific Review Board **NOTE** paper IPHC-2025-SRB027-09 (Part 1), which presents an evaluation of design options for 2026-28, including a preliminary option accounting for the secondary FISS objective of cost effectiveness.

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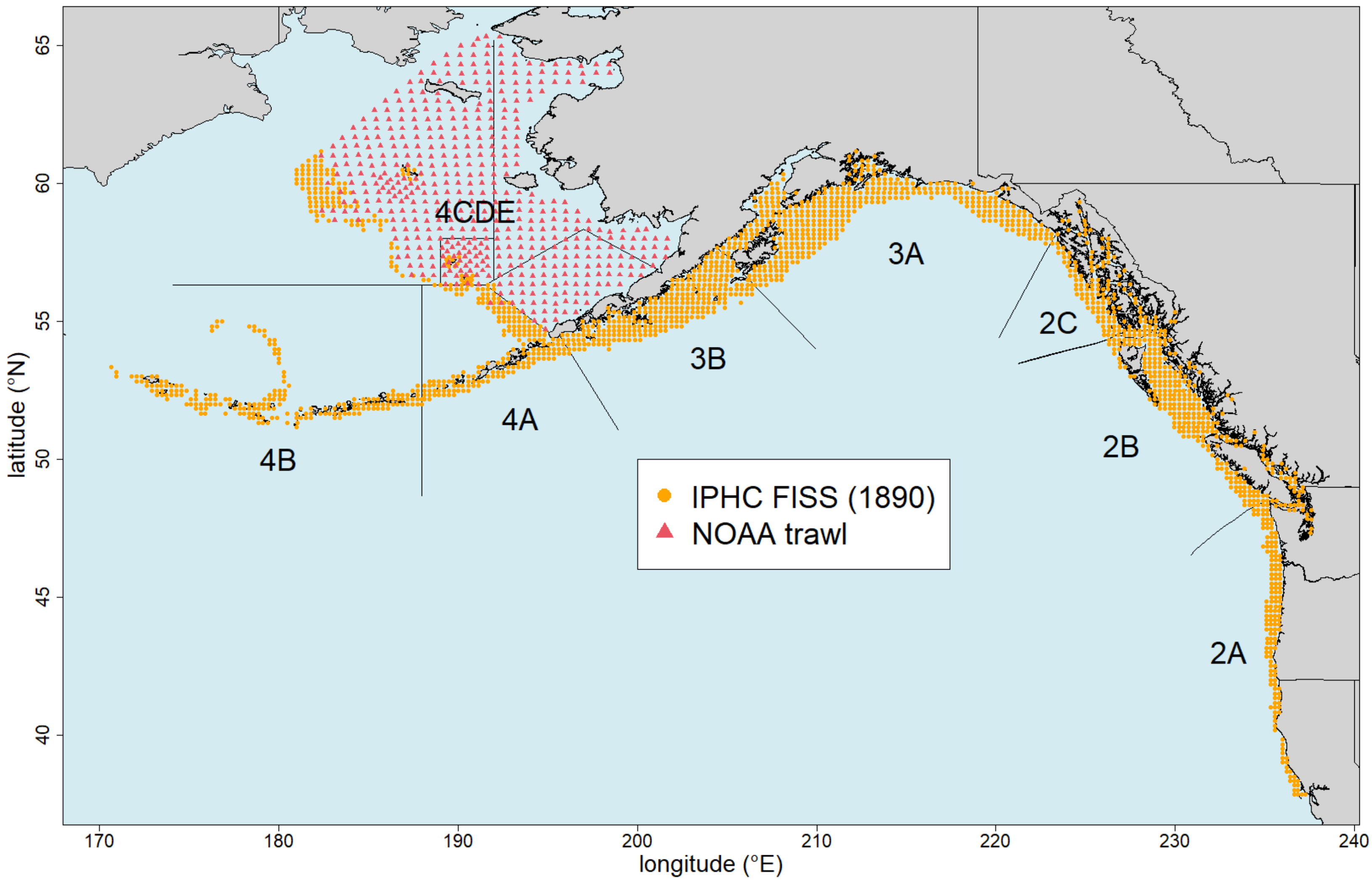

Figure 1. Map of the full 1890 station FISS design, with orange circles representing stations available for inclusion in annual sampling designs. Red triangles represent standard locations of NOAA trawl stations used to provide complementary data for Bering Sea modelling (actual NOAA trawl design can vary year-to-year).

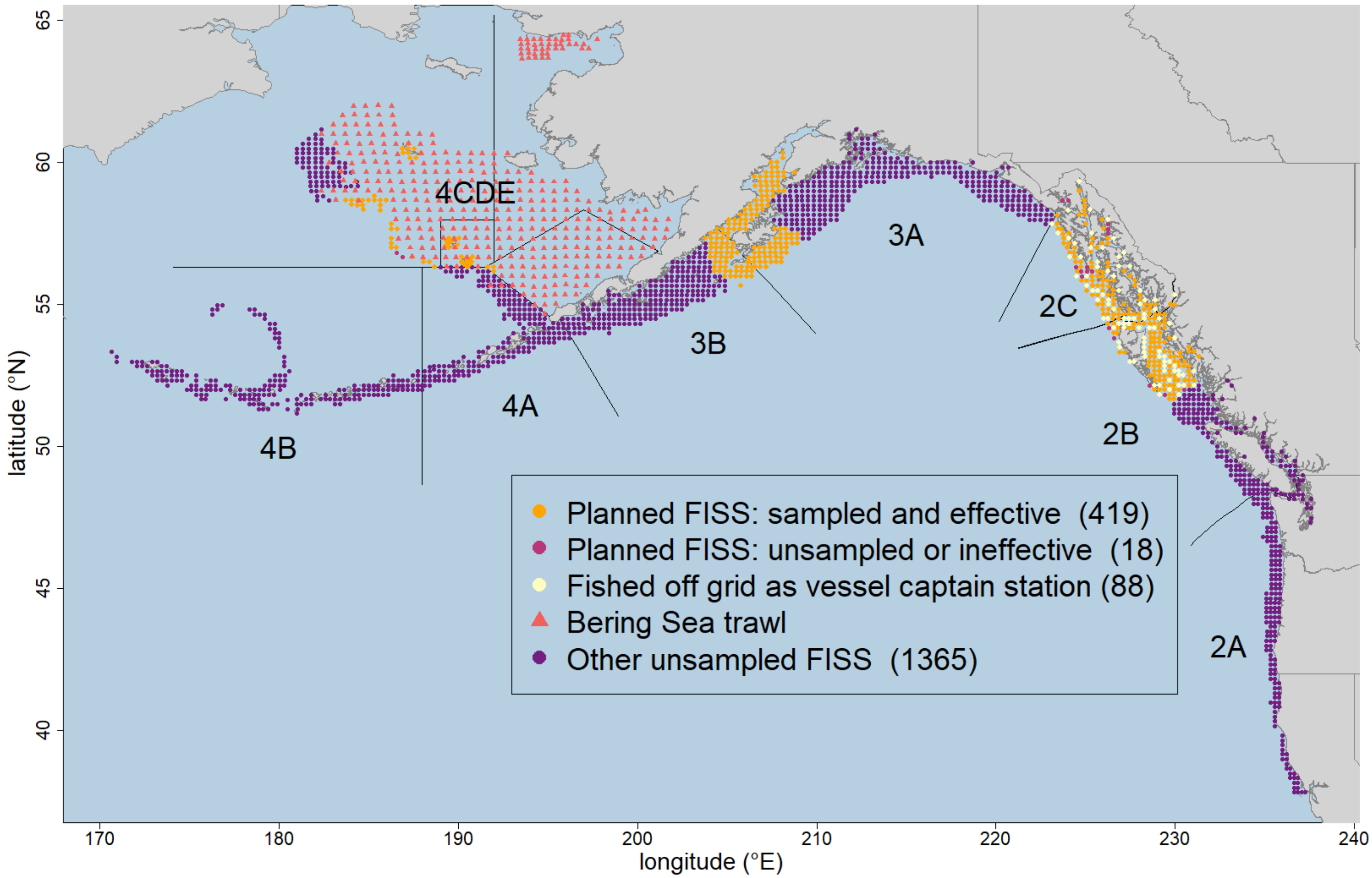

Figure 2. Map of implemented 2024 sampled FISS design showing sampled stations with data used in modelling (orange circles for FISS, red triangles for trawl), along with planned but ineffective FISS stations, FISS grid stations fished off grid as vessel captain stations and other unsampled FISS stations.

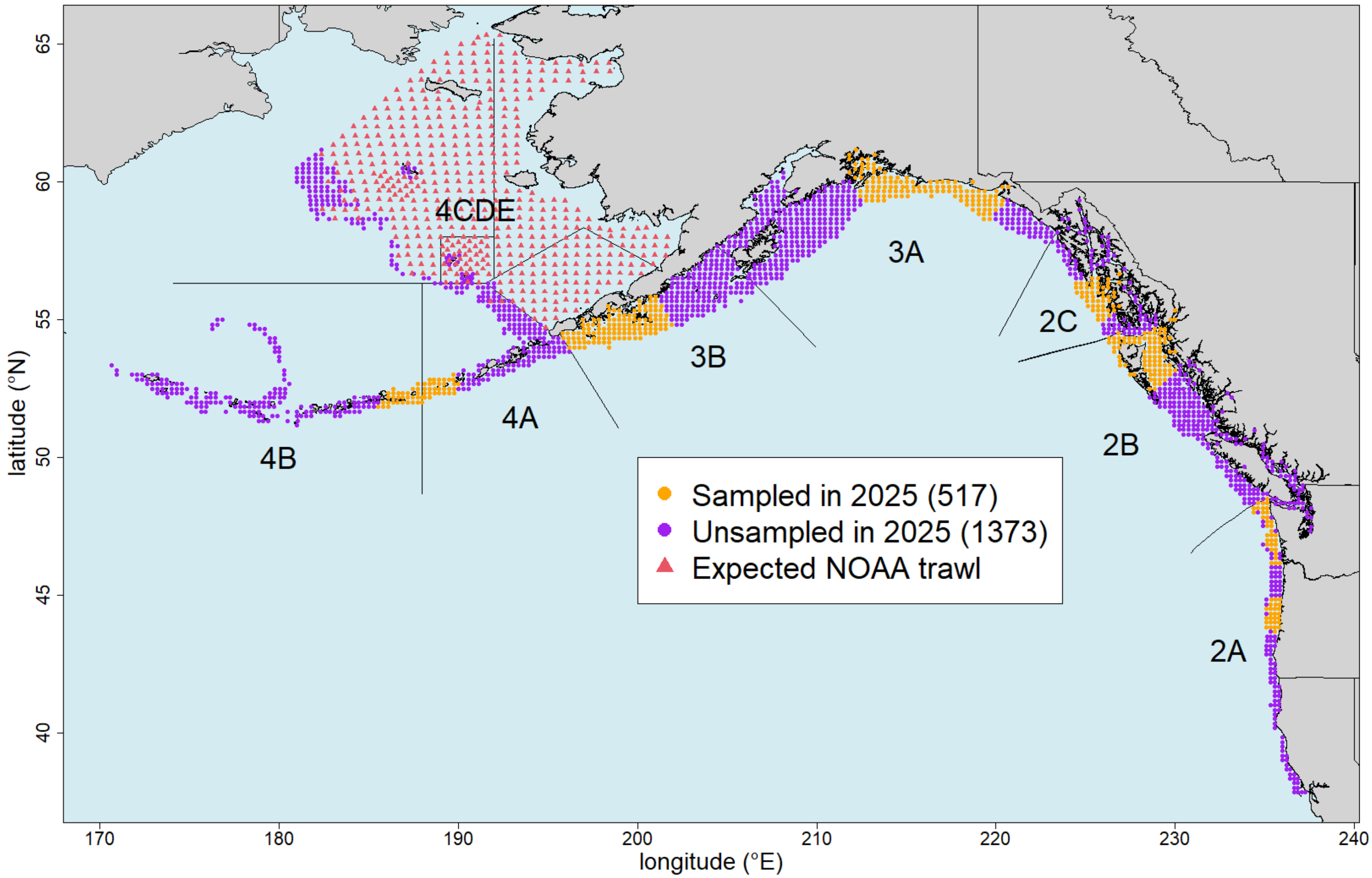

Figure 3. Adopted 2025 FISS design, with planned FISS stations shown as orange circles.

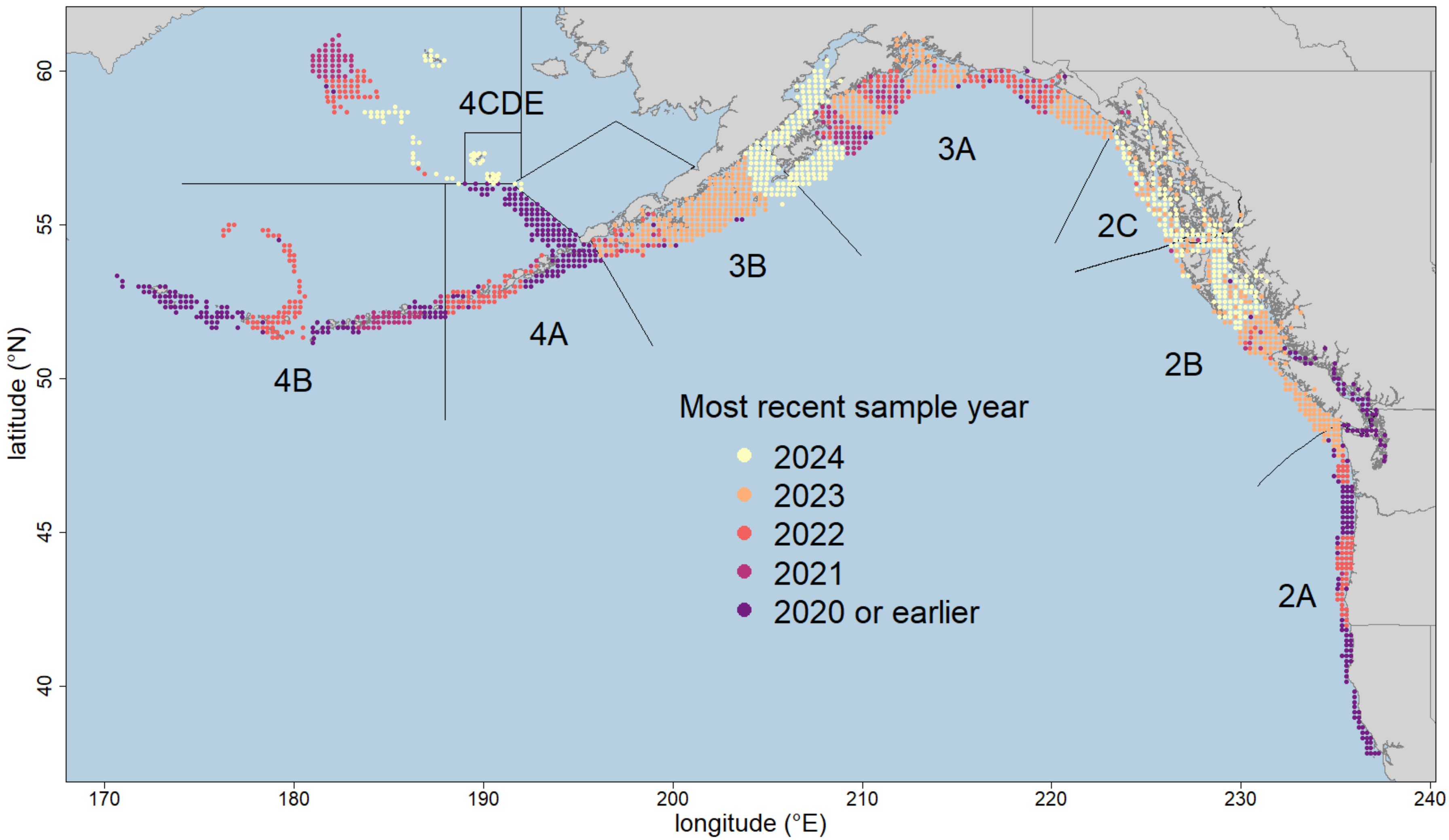

Figure 4. Map showing the most recent sample year of each station on the full FISS grid.

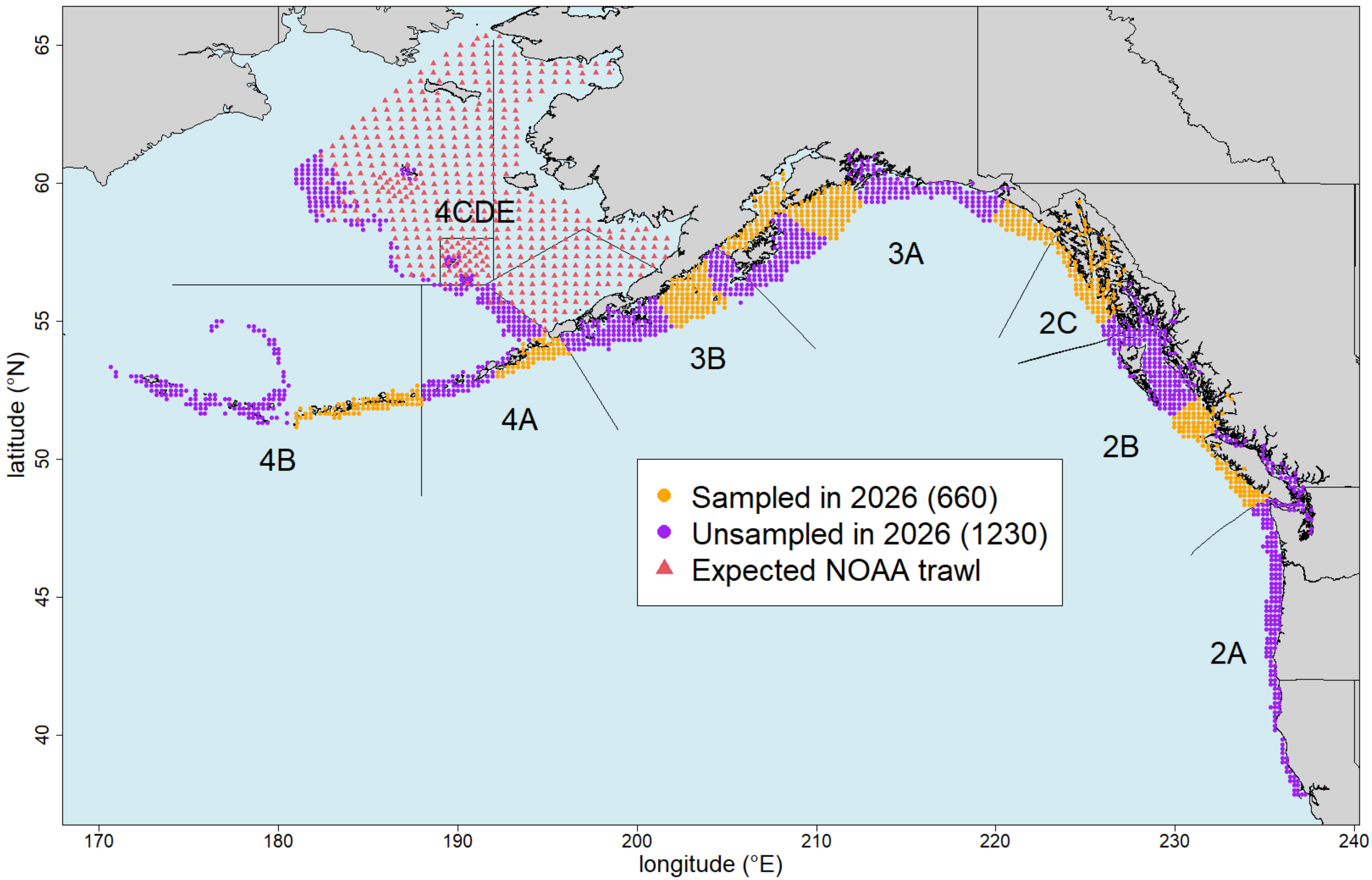

Figure 5. Base Block design for 2026 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

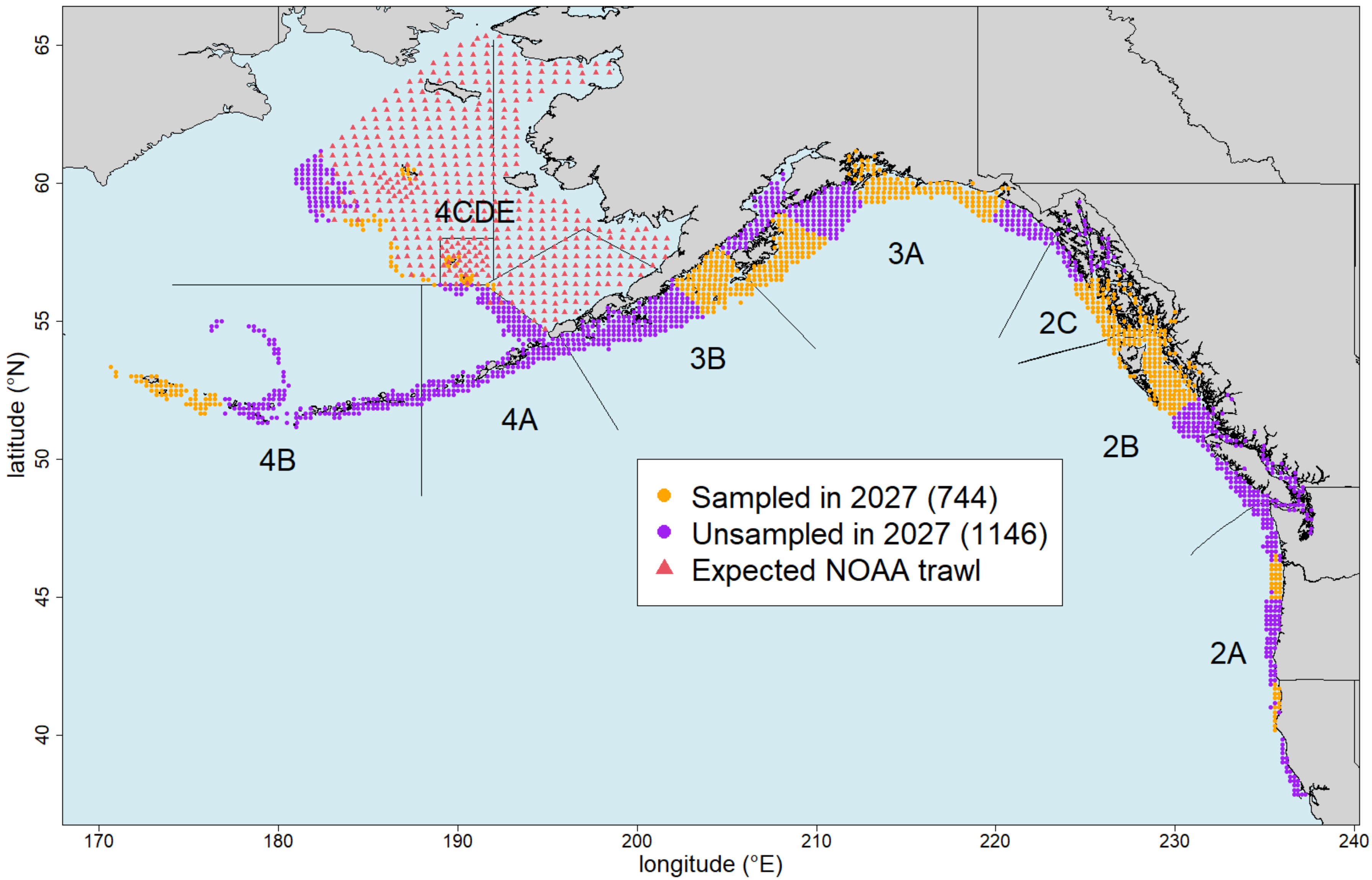

Figure 6. Base Block design for 2027 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

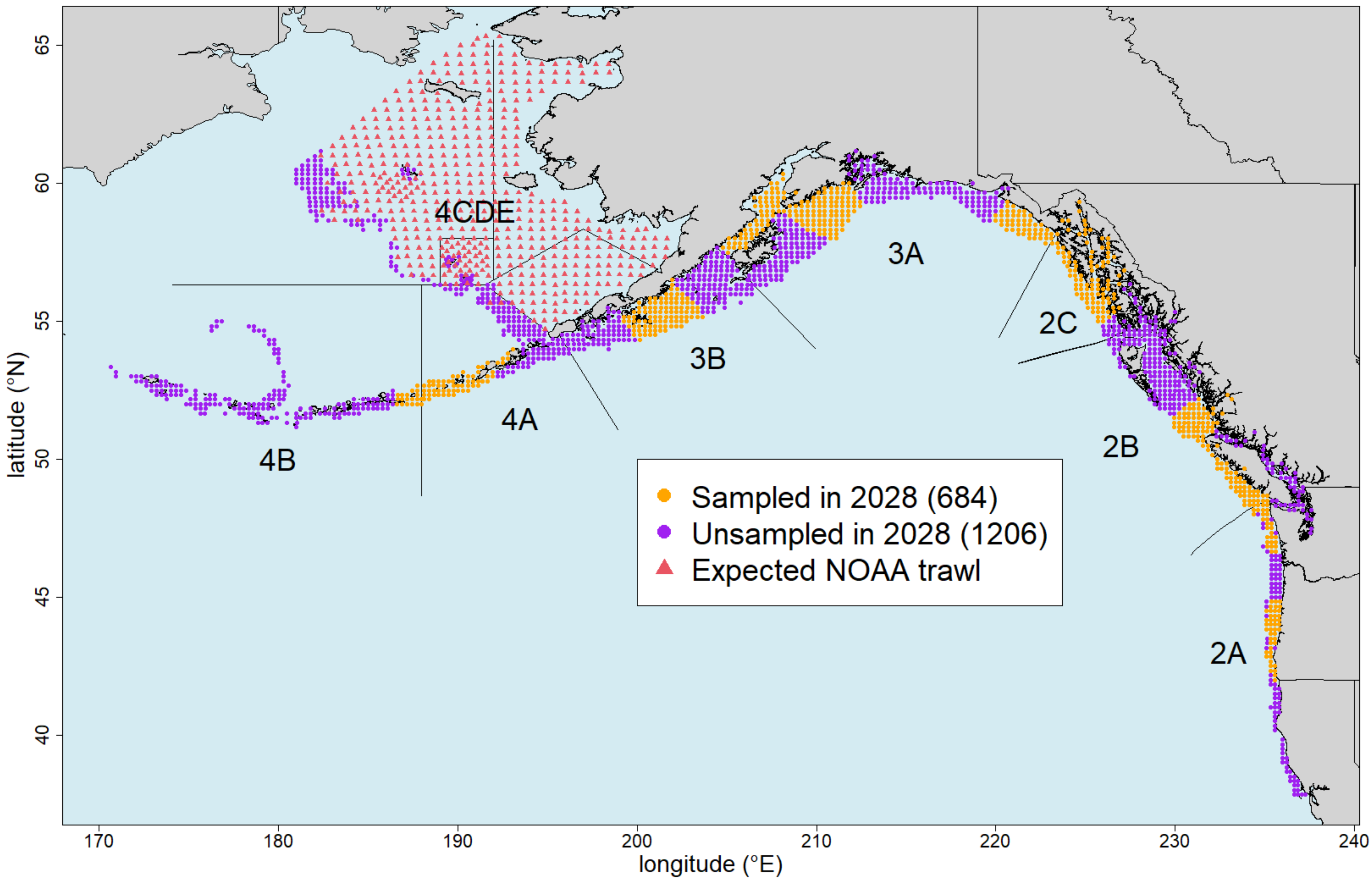

Figure 7. Base Block design for 2028 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

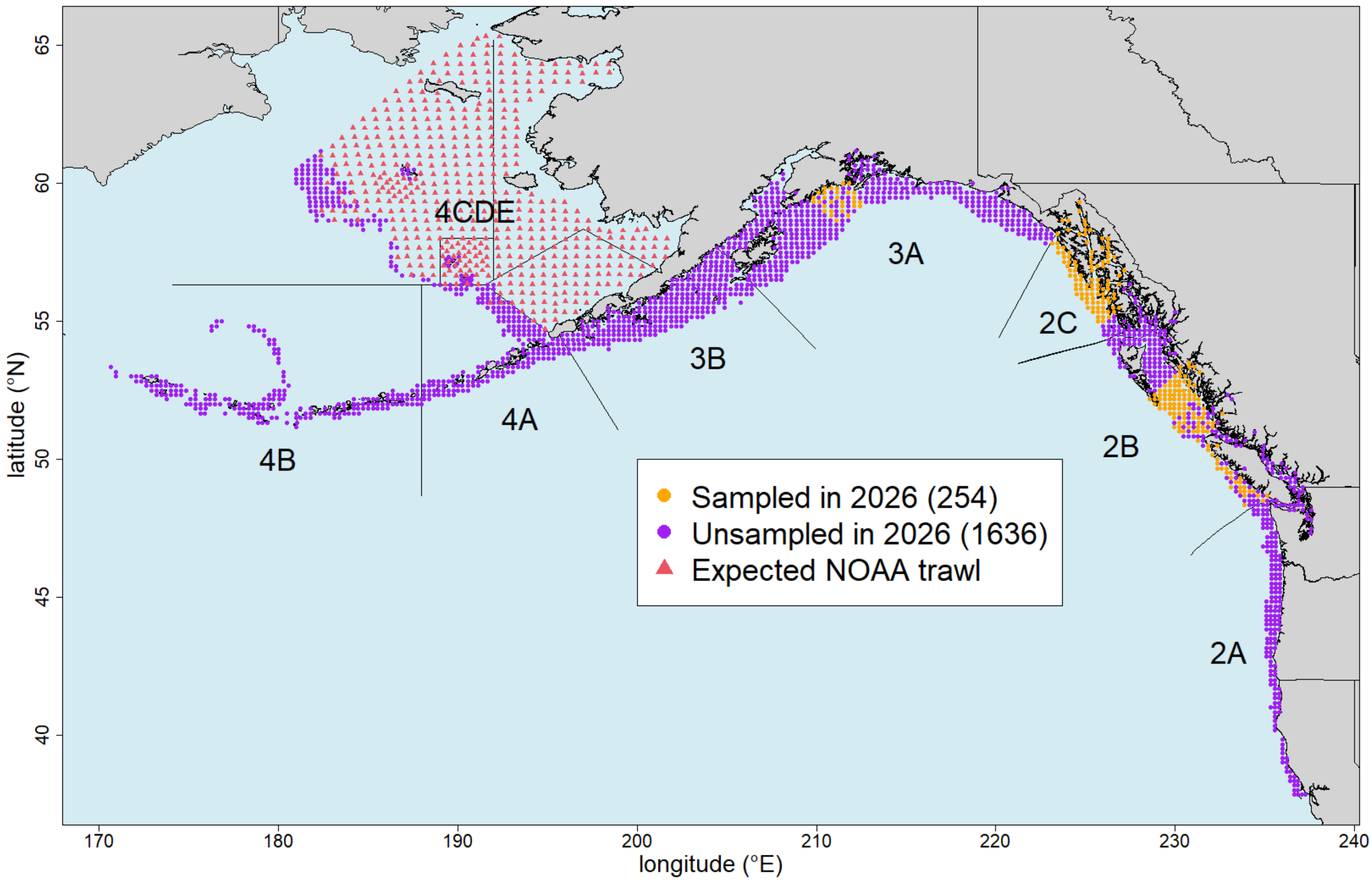

Figure 8. Preliminary Reduced Loss design for 2026 (orange circles). Note that stations in partially-sampled charter regions (2B and 3A) are only for the purpose of illustrating the spatial extent of the design. Actual stations to be fished within partially-sampled charter regions will be selected at a later date based on the priorities in Table 1.

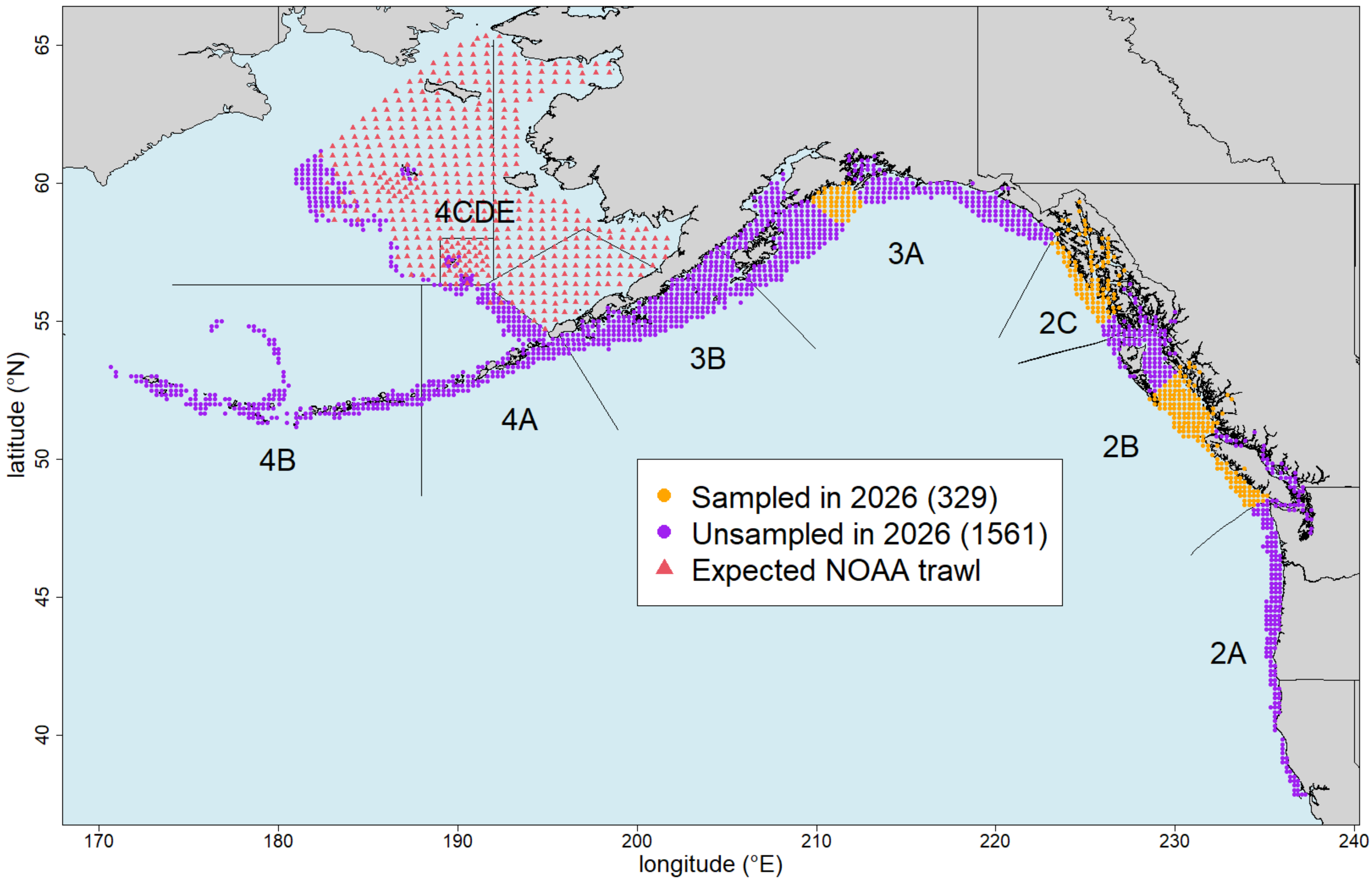

Figure 9. Preliminary Option 2 design for 2026 (orange circles).

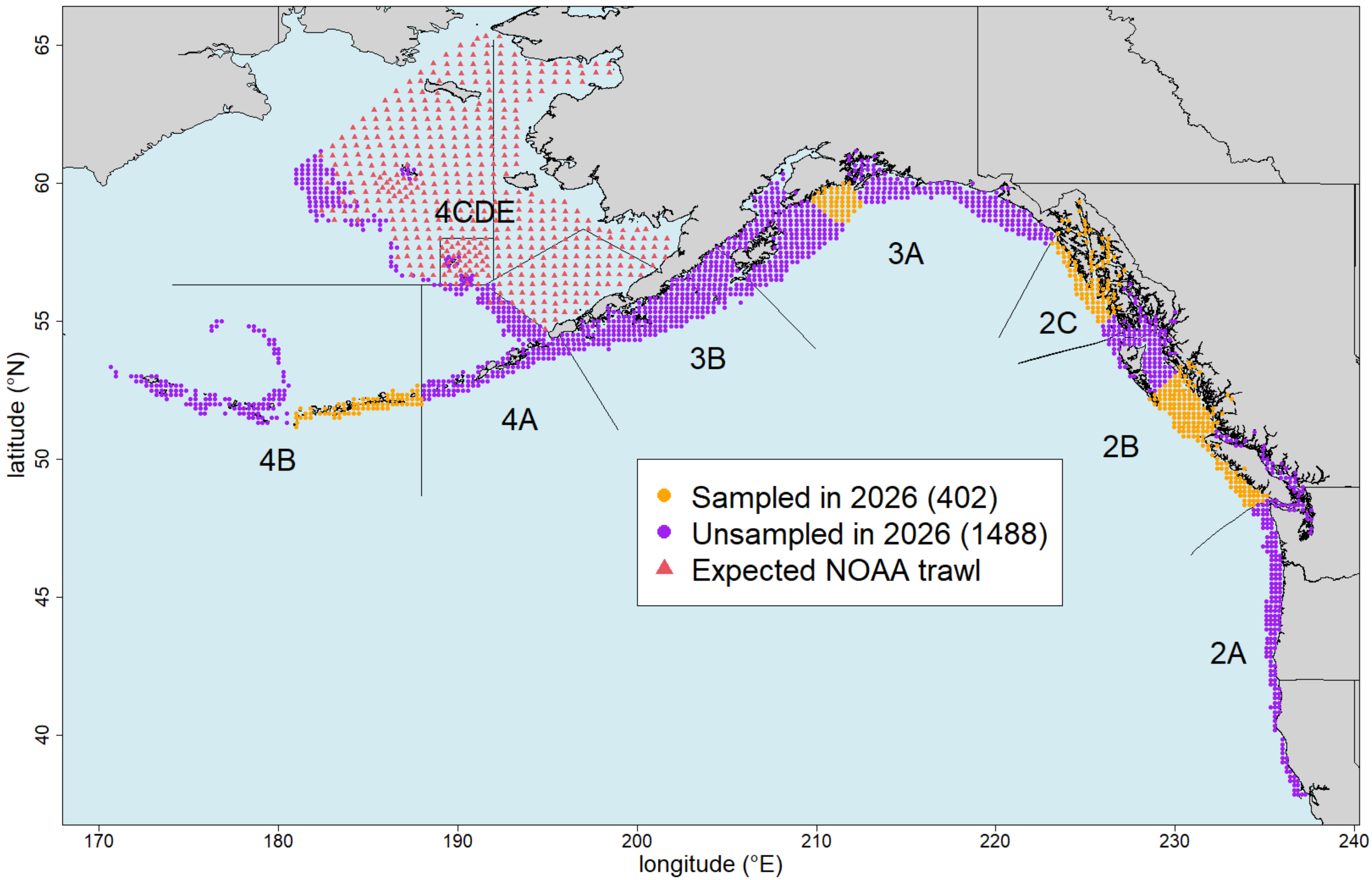

Figure 10. Preliminary Option 3 design for 2026 (orange circles).

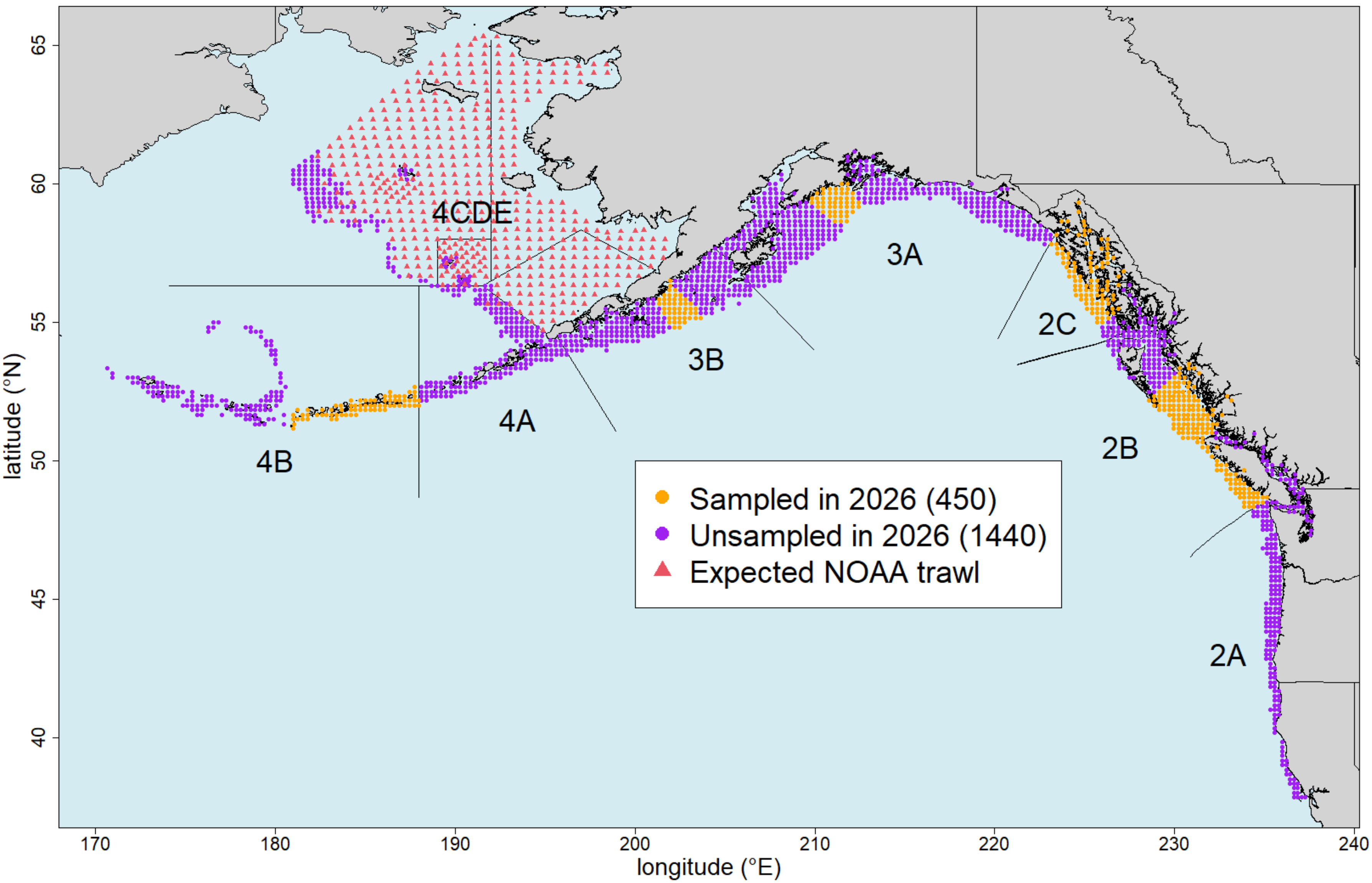

Figure 11. Preliminary Option 4 design for 2026 (orange circles).

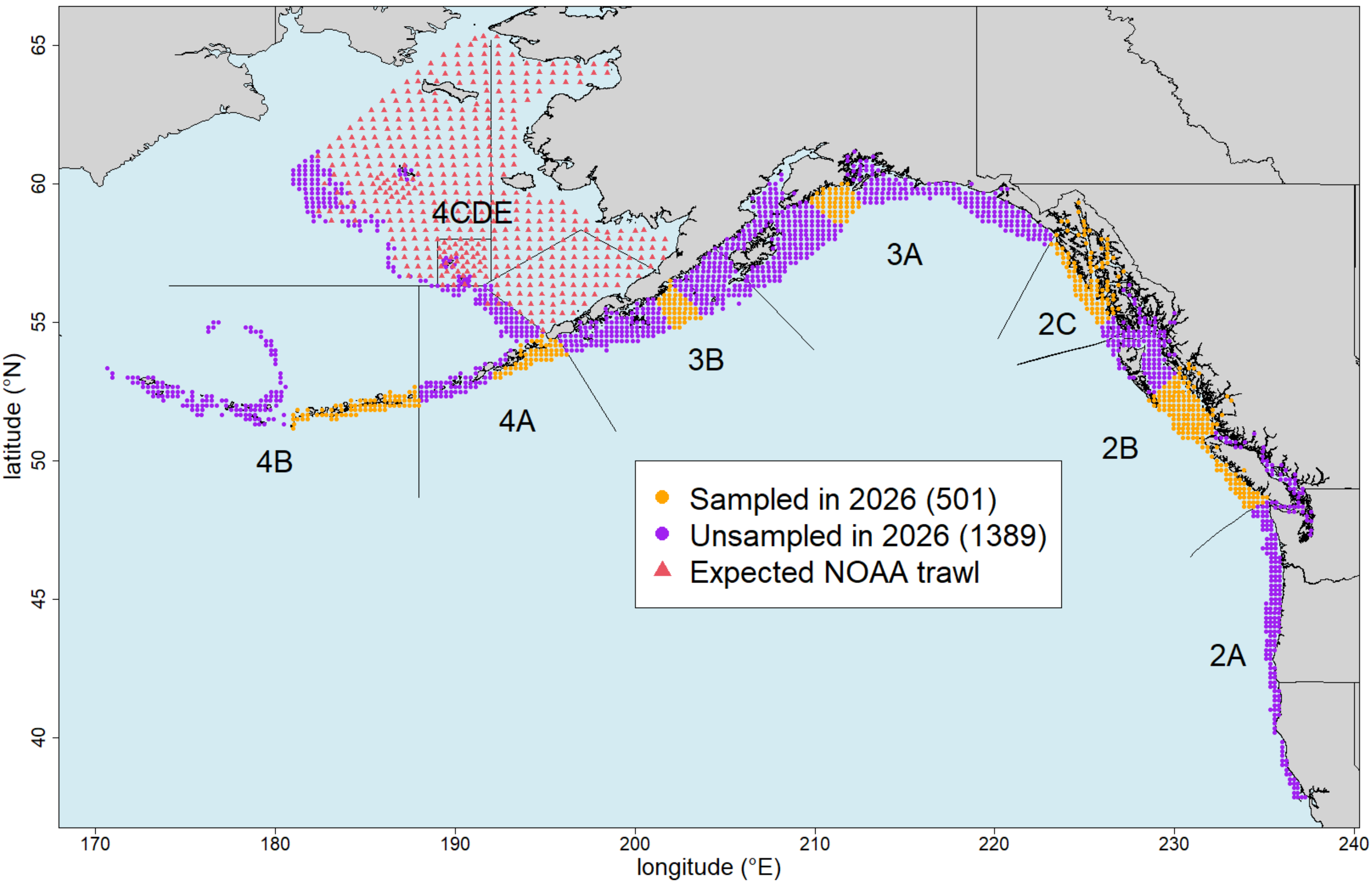

Figure 12. Preliminary Option 5 design for 2026 (orange circles).

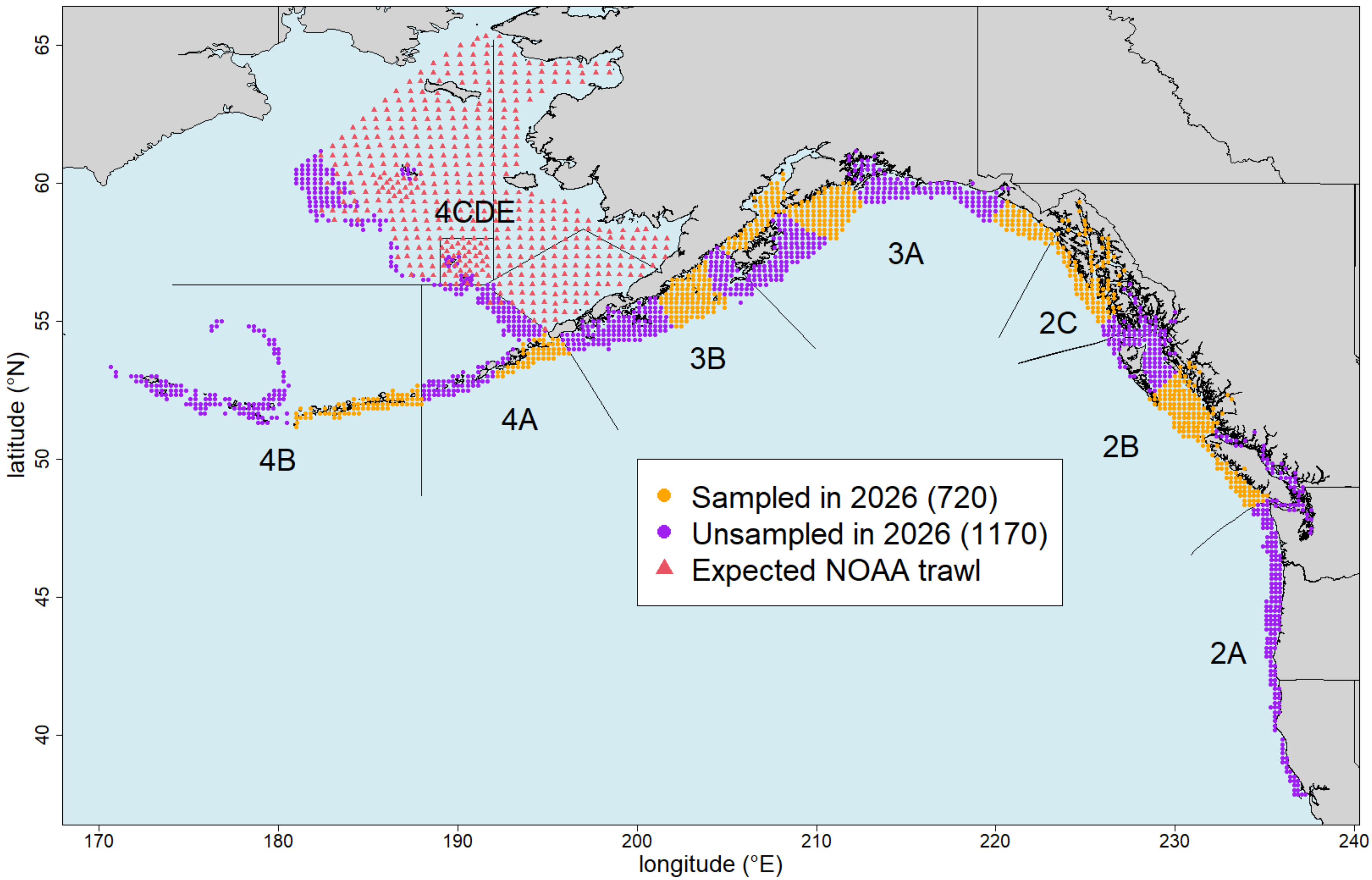

Figure 13. Preliminary Option 6 design for 2026 (orange circles).

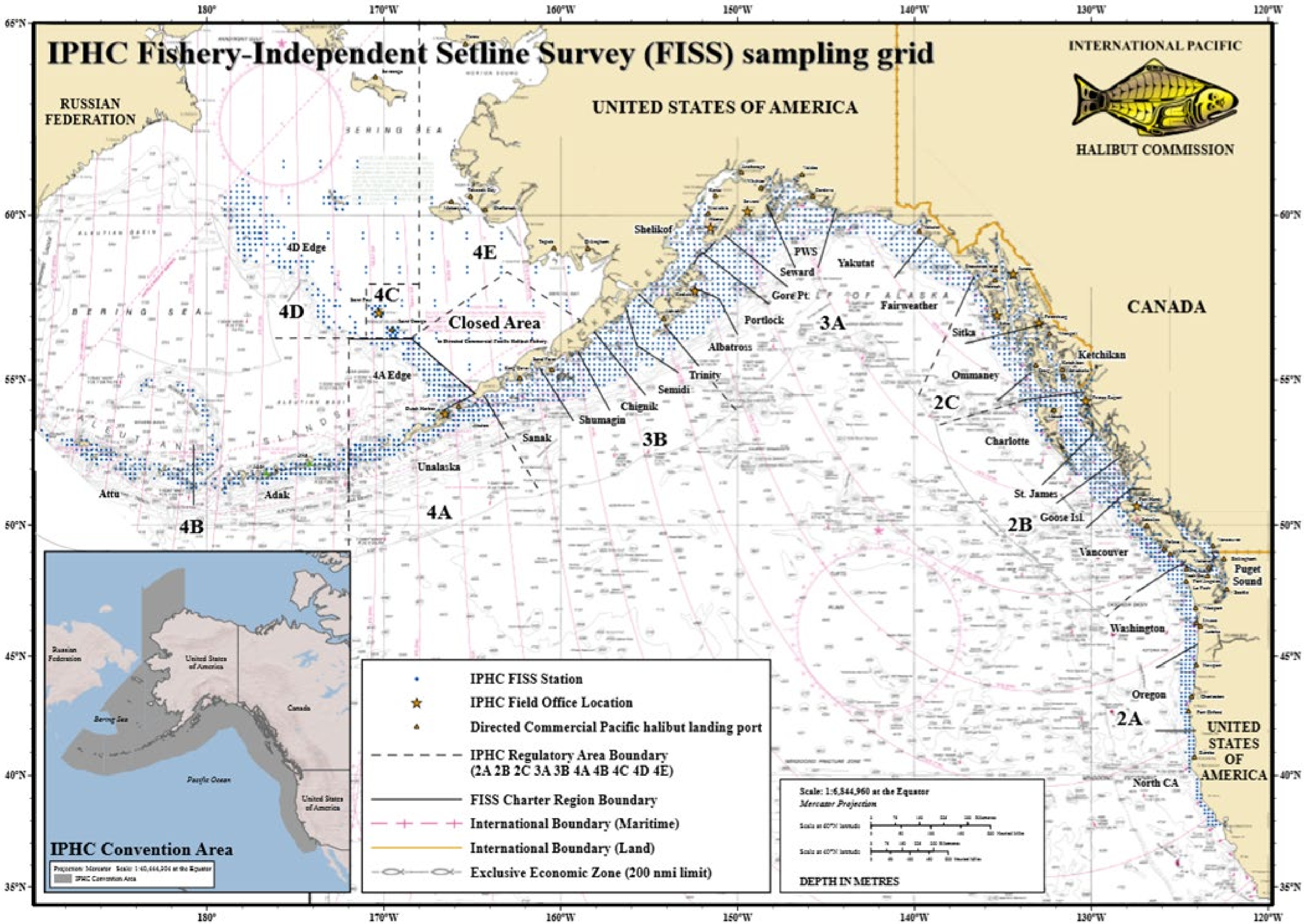

Figure 14. IPHC FISS showing full station grid and current FISS charter regions.

PART 2: MODELLING UPDATES

PURPOSE

To summarise recent work on coastwide modelling of Pacific halibut survey data, with application to histological data collected on the IPHC's fishery-independent setline survey from 2022-24.

BACKGROUND

At present, the IPHC models Pacific halibut survey data by fitting a spatio-temporal model (Webster et al. 2020) to data from each individual IPHC Regulatory Area, and aggregates model output to produce estimate for larger geographical units (Biological Regions, coastwide waters). The advantages of this approach versus a single coastwide model include:

- Smaller modelling regions allow for finer meshes (see below) without leading to prohibitively long runtimes
- Faster model runtimes due to both smaller datasets and smaller modelling regions
- Easily allows model parameters to differ among areas

The main drawbacks of splitting modelling into smaller components are (1) that there may be discontinuities at area boundaries due to differences in model parameter values between adjacent areas, and (2) samples drawn from posterior predictive distributions (used to create time series of variables of interest) will not be spatially correlated across boundaries as each area's samples are drawn independently from each other. These drawbacks have been relatively minor for the catch rate (weight and numbers per unit effort, WPUE and NPUE) data modelled to date, with no obvious discontinuities appearing on maps of model predictions (see the maps at the IPHC Space-time Explorer), and the range parameter for spatial models being small relative to the size of each area. The latter means spatial correlation declines relatively steeply with increasing distance and independence between samples on either side of an area boundary has little impact on estimates of standard deviations or coefficients of variation for estimates based on combining areas (i.e., to form Biological Region or coastwide estimates).

Recent improvements in the runtime of the spatio-temporal models (fitted via the R package, R-INLA, www.r-inla.org) have made it more likely that fitting models to coastwide data sets will not result in prohibitive computation time. While fitting coastwide models for Pacific halibut WPUE and NPUE data may now be feasible, coastwide models have utility beyond estimating time series of indices of density and abundance. The FISS also collects biological data on individual Pacific halibut, some of which has been collected over a shorter timeframe than the modern 33-year FISS, and in some instances, spatial coverage may be less spatially consistent. This is also true of oceanographic monitoring data, which sometimes has gaps in coverage due to loss or failure of the water column profiler units or recent reductions in FISS coverage. In such cases, modelling on a coastwide basis should lead to more powerful inference than restricting models to data subsets based on IPHC Regulatory Areas or a similar geographical unit.

The IPHC has collected histological data on Pacific halibut maturity on the FISS since 2022 (see Planas et al, 2025, for details). Maturity is assessed on individual female Pacific halibut, and each fish has an approximate capture location given by the midpoint of the location of the FISS set on which it was captured. Previous modelling of the relationship of maturity probability and age has used statistical methods that assume each fish is sampled independently, which ignores the likelihood of spatial correlation in the probability of maturity and the fact that fish are sampled in clusters on each set. Spatial (or spatio-temporal) modelling can account for this lack of independence.

Coastwide mesh and barrier models

The INLA approximation uses a set of basis functions defined on a triangulated mesh covering the region of interest (Lindgren and Rue 2015). IPHC data imply that Pacific halibut do not inhabit depths greater than 732 m (400 fathoms) at non-negligible densities during the summer survey period, and therefore our starting point for a modelling region is all USA and Canadian waters within 0 to 732 m from northern California to the southern Chukchi Sea. To provide an additional buffer at the region's outer edge, we extended the region a depth of 800 fathoms and further into Russian waters in the Bering Sea to account for the fact that this is not a hard boundary and that there is some correlation between values in sampled US waters and those in adjacent unsampled Russian waters. Other offsets were made to the mesh boundaries to smooth the edge and avoid narrow inlets within which R-INLA's mesh creation function would have to include many vertices and thereby increase the dimensionality of the modelling problem. The smoothing and offsetting can remove or reduce the size of islands and peninsulas, and we therefore selected values that preserved such features as much as possible to ensure that nonexistent pathways were not created in the mesh space. The coarseness of the mesh itself was defined so that the number of vertices allowed comprehensive spatial coverage without being so numerous that the model processing would become prohibitively slow. Another consideration in approximating the coastline with the triangulated mesh was ensuring that sample locations (survey stations) did not end up falling on "land". This was particularly challenging in the narrow inlets of IPHC Regulatory Areas 2B and 2C, and ultimately the selected mesh required the exclusion of a single FISS station: alternative refinements of the mesh definition led to the exclusion of more stations located on "land".

In addition to the mesh defined within IPHC habitat, the functions in R-INLA were used to define the land and deeper waters as barriers, which when used with a non-stationary barrier model (Bakka et. al, 2019) ensure that the model's correlation structure cuts off pathways through land, including large islands and peninsulas, along with areas of deeper water that Pacific halibut do not inhabit. Barrier models achieve this without additional computational cost by defining the range parameter (the distance at which the correlation between two points is small, i.e., ≈0.1) on land to be a small fraction of the value on water. The coastwide mesh for IPHC survey data, including barriers shaded in yellow, is presented in Figure 15.

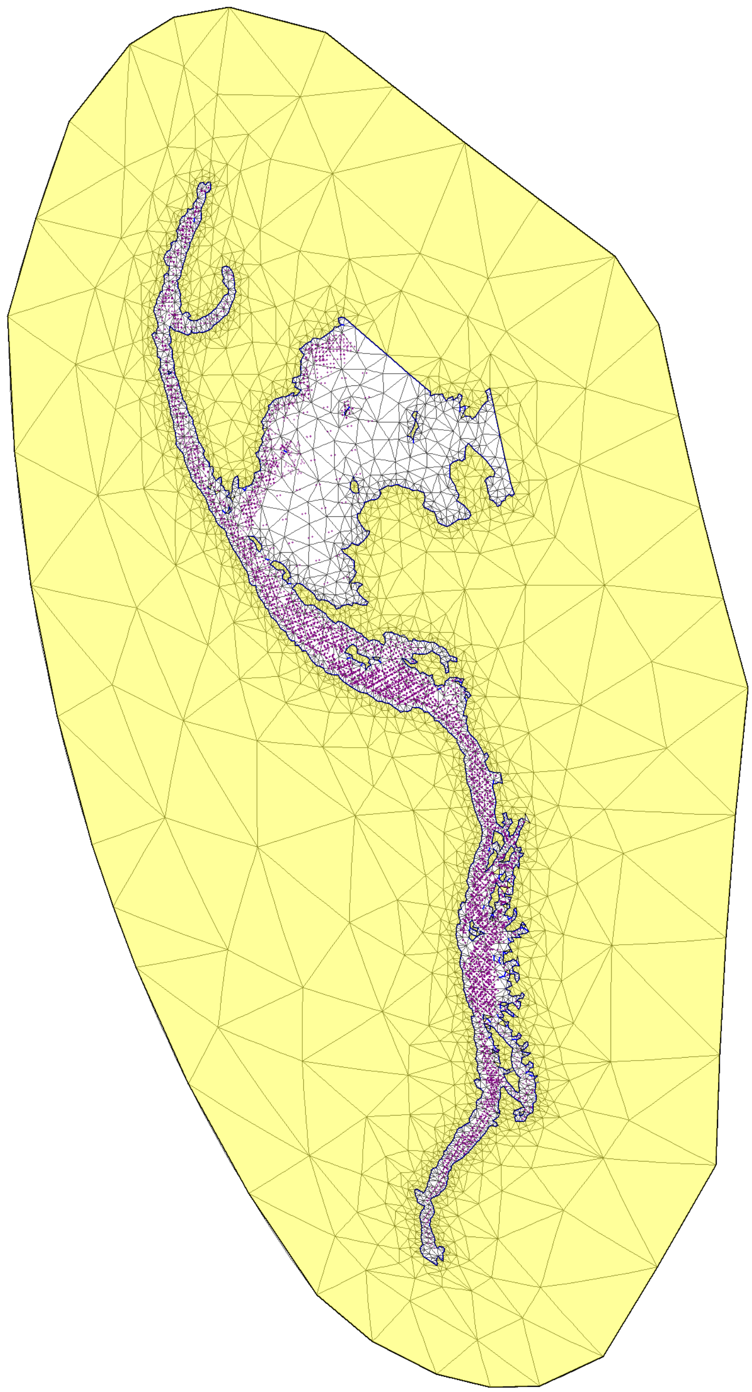

Figure 15. Triangulated mesh used in spatio-temporal modelling of histological maturity data. Barriers are shown with yellow shading**.**

Test case: histological data modelling

Currently, generalized additive models (GAMs) are used to estimate the relationship between maturity probability and age by IPHC biological region. The GAM models allows flexibility from a strict logistic model (i.e., linear on the logit scale), but as noted, still require the assumption of independent observations.

Spatio-temporal modelling of histological maturity data is still in its early stages, but to date we have fitted several models of differing complexity for modelling the relationship of maturity probability and age, including:

- Logistic models, with fixed effects for intercept and slope that vary by IPHC Biological Region, with spatially-dependent errors
- Logistic models with spatially-varying intercept and slope (i.e., slope and intercept are spatially-dependent random effects)
- Versions of the models above with added “GAM-like” flexibility through a random walk term in the age relationships.

Early model fitting to the 2022-24 data suggests that logistic models with spatially-varying parameters provide a better fit and more meaningful results than those with fixed effects for region. The latter models show sharp discontinuities at regional boundaries, something that makes no sense in biology, while the former project smooth variation in model output across space, as illustrated by A50 estimates in Figure 16. Note that the output in this figure is broadly consistent with previous GAM modelling results (Planas et al. 2025) that show lower A50 values in Biological Region 3 (Gulf of Alaska) than in adjacent Biological Regions 4 (eastern Aleutians and Bering Sea) and 2 (Southeast Alaska, British Columbia and the West Coast). However, the model output in Figure 16 is also able to show variation in A50 values *within* each Biological Region. Further output will be shown in the accompanying presentation at SRB027.

Coastwide curves can be calculated by predicting maturity probability at age for each survey station, and computing weighted averages at age using station-level mean NPUE values from the space-time modelling of catch-rate data as weights. Ongoing work includes exploring other options for flexibility in maturity relationships, expanding models to include year effects and temporal correlation, and computing cross-validation metrics for model comparisons.

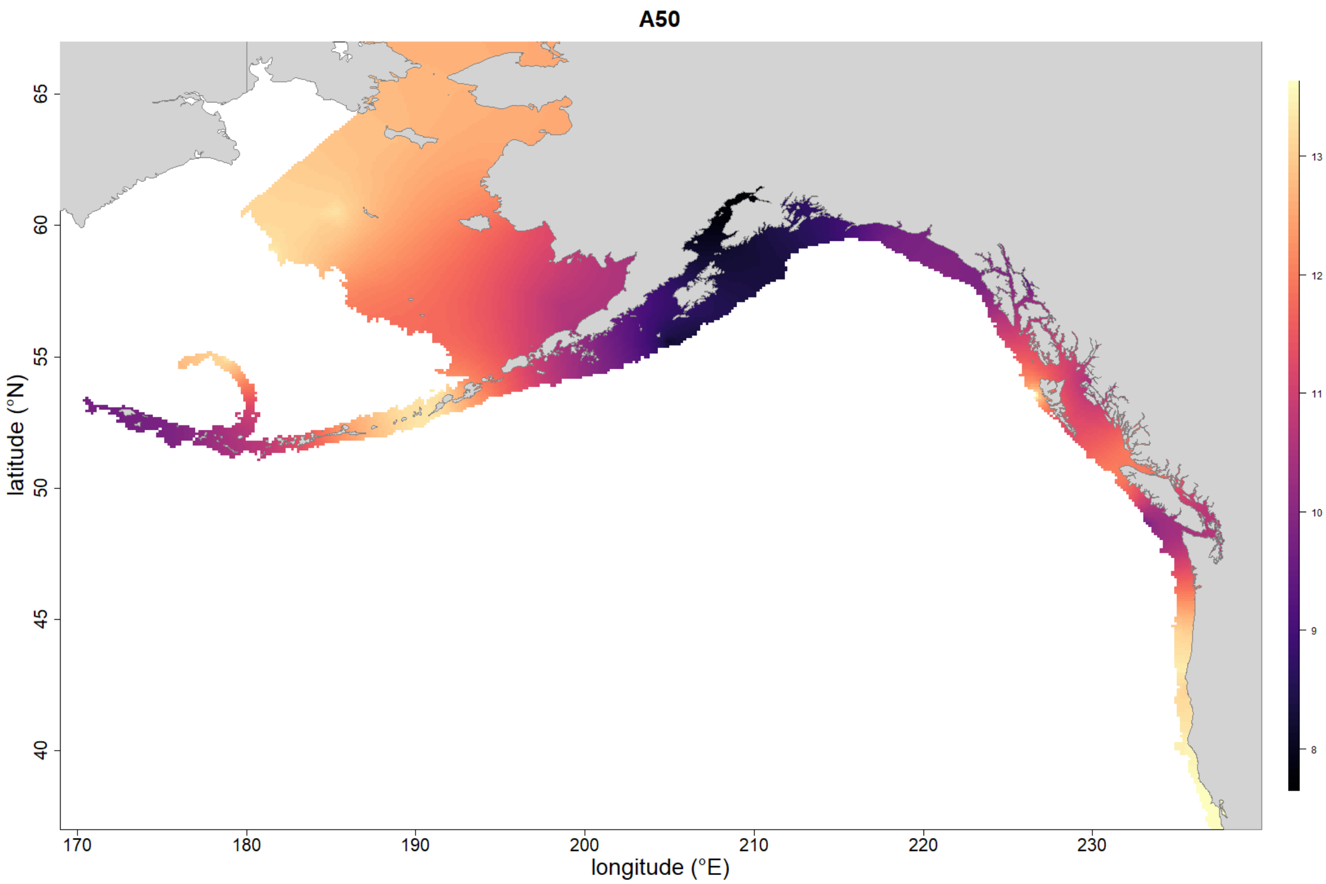

Figure 16. Projected A50 values from fitting a spatial model to 2022-24 histological maturity data with spatially-varying slope and intercept values.

RECOMMENDATION

That the Scientific Review Board **NOTE** paper IPHC-2025-SRB027-09 (Part 2), which summarises recent work on coastwide modelling of Pacific halibut survey data, using histological maturity data as a test case.

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Bakka, H., Vanhatalo, J., Illian, J. B., Simpson, D., and Rue, H. (2019). Non-stationary Gaussian models with physical barriers. Spatial Statistics 29: 268-288. https://doi.org/10.1016/j.spasta.2019.01.002

Lindgren, F., and Rue, H. (2015). Bayesian spatial modelling with R-INLA. J. Stat. Softw. 63: 1–27. https://doi.org/10.18637/jss.v063.i19

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Webster, R. A., Soderlund, E, Dykstra, C. L., and Stewart, I. J. (2020). Monitoring change in a dynamic environment: spatio-temporal modelling of calibrated data from different types of fisheries surveys of Pacific halibut. Can. J. Fish. Aquat. Sci. 77(8): 1421-1432. https://doi.org/10.1139/cjfas-2019-0240

IPHC Draft Harvest Strategy Policy

PREPARED BY: IPHC SECRETARIAT (A. HICKS, D. WILSON, I. STEWART; 9 SEPTEMBER 2025)

PURPOSE

This informational document provides the draft Harvest Strategy Policy (HSP) as of 5 September 2025.

BACKGROUND

The Commission held three workshops to discuss the draft IPHC Harvest Strategy Policy and determine a timeline for adoption. The draft following the third workshop is provided in Appendix I. The Commission will consider the HSP for adoption at the 101st Interim Meeting (IM101) in December 2025. Following adoption, additional operational documents will be written and published to describe specifics of items in the HSP (e.g. rebuilding plan, performance metrics).

APPENDICES

Appendix I: International Pacific Halibut Commission Interim: Harvest Strategy Policy

Appendix I

INTERNATIONAL PACIFIC HALIBUT COMMISSION

INTERIM: HARVEST STRATEGY POLICY

(2025)

Commissioners

Canada	United States of America
Mark Waddell	Jon Kurland
Neil Davis	Robert Alverson
Peter DeGreef	Richard Yamada

Executive Director

David T. Wilson, Ph.D.

DISTRIBUTION:
Members of the Commission
IPHC Secretariat

BIBLIOGRAPHIC ENTRY
IPHC 2025. IPHC Harvest Strategy Policy
IPHC–2025–HSP, 21 pp.

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NOTE: The following is an interim document based on an amalgamation of current IPHC practices and best practices in harvest strategy policy. Current research is ongoing and it is expected that this policy document will then be updated accordingly.

ACRONYMS

HCR	Harvest Control Rule
HSP	Harvest Strategy Policy
IPHC	International Pacific Halibut Commission
LIM	Limit
MEY	Maximum Economic Yield
MP	Management Procedure
MSAB	Management Strategy Advisory Board
MSE	Management Strategy Evaluation
NER	Net Economic Returns
OM	Operating Model
RSB	Relative Spawning Biomass
SB	Spawning Biomass (female)
SPR	Spawning Potential Ratio
SRB	Scientific Review Board
TCEY	Total Constant Exploitable Yield
THRESH	Threshold
U.S.A.	United States of America

DEFINITIONS

A set of working definitions are provided in the IPHC Glossary of Terms, Acronyms and Abbreviations: https://www.iphc.int/the-commission/glossary-of-terms-and-abbreviations

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EXECUTIVE SUMMARY

The *IPHC Harvest Strategy Policy* (HSP) provides a framework for applying a consistent and transparent science-based approach to setting mortality limits for Pacific halibut (*Hippoglossus stenolepis*) fisheries throughout the Convention Area while ensuring sustainability of the Pacific halibut population.

It defines biological, fishery, and economic objectives that apply to the development of a harvest strategy for Pacific halibut. It also identifies a management procedure and reference points for use in the harvest strategy to achieve the Commission's stated objectives. This policy, together with the *Protocol amending the Convention between Canada and the United States of America for the preservation of the [Pacific] halibut fishery of the northern Pacific Ocean and Bering Sea (1979)*[1], provides the basis to manage the risk to Pacific halibut fisheries and the Pacific halibut population.

The IPHC is responsible for determining the coastwide mortality limit and the allocation of this limit among eight (8) IPHC Regulatory Areas. The mortality limit in each IPHC Regulatory Area consists of all fishing mortality of all sizes and from all known sources, except for discard mortality of under 26-inch (U26) Pacific halibut from non-directed commercial (e.g. trawl) fisheries, which is accounted for at the coastwide level. The distribution of the mortality limit to each sector within an IPHC Regulatory Area is determined by Contracting Party domestic agencies. Therefore, this Harvest Strategy Policy is specific to the mortality limit in each IPHC Regulatory Area, across all sectors (i.e. TCEY).

Being a framework, the harvest strategy policy encompasses the entire process of the management procedure and decision-making process to determine mortality limits as well as other important considerations such as objectives, key principles, and responses to specific events. A harvest strategy, which may also be referred to as a management strategy, is the management framework necessary to achieve defined biological, fishery, and economic objectives for Pacific halibut.

> **Management Procedure (MP)**: A formulaic procedure to determine a management outcome (e.g. mortality limit) that produces a repeatable outcome and can be simulation tested.
>
> **Harvest Strategy**: The framework for managing a fish stock, including the MP and objectives.
>
> **Harvest Strategy Policy (HSP)**: The harvest strategy and decision-making process that results in endpoint management outcomes.

A goal of the IPHC Harvest Strategy Policy is the long-term sustainable use (optimum yield) of Pacific halibut through the implementation of a harvest strategy that maintains the stock at sustainable levels while supporting healthy and accessible fisheries which includes maximising economic returns in directed commercial fisheries. The Commission's current priority objectives to achieve this goal are:

1. Maintain the long-term coastwide Pacific halibut female relative spawning biomass, above a biomass limit reference point where the risk to the stock is regarded as unacceptable ($RSB_{20\%}$) at least 95% of the time;
2. Maintain the long-term coastwide Pacific halibut female relative spawning biomass at or above a threshold reference point that optimises fishing activities ($RSB_{36\%}$) at least 50% of the time;

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[1] https://www.iphc.int/uploads/pdf/basic-texts/iphc-1979-pacific-halibut-convention.pdf

3. Maximize the short-term coastwide yield while minimising annual changes in the short-term coastwide mortality limit, given the constraints above to ensure a sustainable fishery.

The harvest strategy will ensure fishing is conducted in a manner that does not lead to *overfishing*. Overfishing is defined as where the stock is subject to a level of fishing that would move it to an *overfished* state or prevent it from rebuilding to a '*not overfished*' state, within a specific time-frame and probability.

Overfished: when the estimated probability that coastwide female relative spawning stock biomass is below the limit reference point ($RSB_{20\%}$) is greater than 50%.

Overfishing: where the stock is subject to a level of fishing that would move it to an '*overfished*' state with a greater than 50% probability within three (3) years at a constant fishing mortality (measured in biomass), or prevent it from rebuilding to a '*not overfished*' state within the required timeframe and specifications of a rebuilding plan.

A transparent and systematic approach to meet the objectives of the Harvest Strategy Policy is supported by a number of requirements. These include accounting for all mortality of all sizes and from all known sources; accounting for multiple sources of uncertainty including environmental and biological; balancing risk, cost, and catch; developing threshold and limit reference points as indicators for managing Pacific halibut; robust simulation testing of management procedures; and identifying circumstances when the harvest strategy may be reconsidered and possibly updated. One threshold reference point and one limit reference point are currently defined.

Reference point	**Definition**	**Proxy**
Threshold reference point SB_{THRESH}	The female dynamic spawning biomass level supporting maximum economic yield (SB_{MEY}) and healthy fisheries.	36% of the unfished female spawning biomass ($RSB_{36\%}$).
Overfished limit reference point SB_{LIM}	The female dynamic spawning biomass level where the ecological risk to the population and the risk to the health of the fisheries is regarded as unacceptable.	20% of the unfished female spawning biomass ($RSB_{20\%}$).

The coastwide reference mortality limit from the management procedure is currently determined using the stock assessment and a fishing intensity (F_{SPR}). The reference SPR (43%) is linearly reduced when the stock status is estimated below 30% and is set to 100% (no fishing for directed fisheries) when the stock status (RSB) is estimated at or below 20% (SB_{LIM}). A rebuilding strategy must be developed if the stock is estimated to be below SB_{LIM}.

The management of Pacific halibut is an annual process with a coastwide mortality limit and allocation to each IPHC Regulatory Area decided upon by the Commission at each Session of the IPHC Annual Meeting with the input of management supporting information including mortality tables, the harvest decision table, stakeholder input, and any other requests by the Commission. A mortality table shows the resulting allocation of mortality limits to each sector within each IPHC Regulatory Area. The harvest decision table is a stock assessment output that provides an estimate of risk relative to stock trend, stock status, fishery trends, and fishery status for a range of short-term coastwide mortality levels including the coastwide reference fishing mortality.

Chapter 1 INTRODUCTION

The *IPHC Harvest Strategy Policy* (HSP) provides a framework for applying a consistent and transparent science-based approach to setting mortality limits for Pacific halibut (*Hippoglossus stenolepis*) fisheries throughout the Convention Area while ensuring sustainability of the Pacific halibut population.

It defines biological, fishery, and economic objectives that apply to the development of a harvest strategy for Pacific halibut. It also identifies a management procedure and reference points for use in the harvest strategy to achieve the Commission's stated objectives. This policy, together with the *Protocol amending the Convention between Canada and the United States of America for the preservation of the [Pacific] halibut fishery of the northern Pacific Ocean and Bering Sea (1979)*[1], provides the basis to manage the risk to Pacific halibut fisheries and the Pacific halibut population.

A harvest strategy developed under this policy will take available information about the Pacific halibut resource and apply a consistent and transparent science-based approach to setting mortality limits. A harvest strategy consistent with this policy will provide all interested sectors with confidence that the Pacific halibut fisheries are being managed for long-term economic viability, opportunity, and accessibility while ensuring long-term ecological sustainability of the Pacific halibut population. The implementation of a clearly specified harvest strategy will also provide the fishing industry with a more certain operating environment.

1.1 SCOPE

The IPHC Harvest Strategy Policy applies to the Pacific halibut population managed by the IPHC, and where overlap with domestic jurisdictional management exists (e.g. coordinated management between the IPHC and Contracting Party domestic agencies) the IPHC will seek to apply and encourage the adoption of this policy in negotiating and implementing cooperative management arrangements.

The IPHC is responsible for determining the coastwide mortality limit and the allocation of this limit among eight (8) IPHC Regulatory Areas (Figure 1). The mortality limit in each IPHC Regulatory Area consists of all fishing mortality of all sizes and from all known sources, except for discard mortality of under 26-inch (U26) Pacific halibut from non-directed commercial (e.g. trawl) fisheries, which is accounted for at the coastwide level. This mortality limit without U26 non-directed commercial discard mortality has been termed the Total Constant Exploitation Yield, or the TCEY, but mortality limit is used here.

The distribution of the mortality limit to each sector within an IPHC Regulatory Area is determined by Contracting Party domestic agencies. Therefore, this Harvest Strategy Policy is specific to the mortality limit in each IPHC Regulatory Area, across all sectors (i.e. TCEY).

[1] https://www.iphc.int/uploads/pdf/basic-texts/iphc-1979-pacific-halibut-convention.pdf

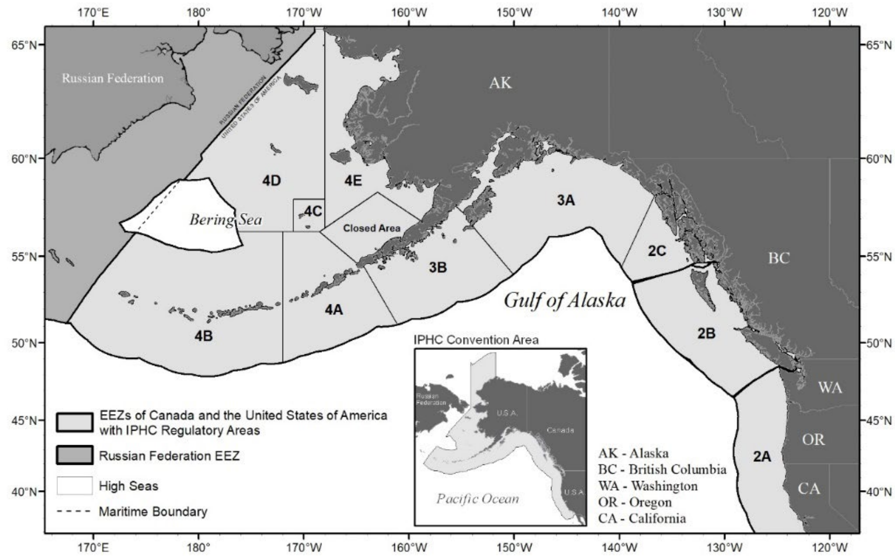

Figure 1. IPHC Regulatory Areas, where 4C, 4D, 4E, and the closed area are considered one IPHC Regulatory Area (4CDE). The IPHC Convention Area is shown in the inset.

1.2 WHAT IS A HARVEST STRATEGY POLICY (HSP)?

Being a framework, the harvest strategy policy encompasses the entire process of the management procedure and decision-making process to determine mortality limits (Figure 2) as well as other important considerations such as objectives, key principles, and responses to specific events. To determine mortality limits, the process begins with determining the coastwide scale of fishing mortality (the Management Procedure or MP). The decision-making process then occurs at the Annual Meeting of the IPHC where various forms of management supporting information are used by subsidiary bodies to provide a recommendation to the Commission of the coastwide mortality limit and allocation to each IPHC Regulatory Area. The Commission uses all this information to arrive at a final decision defining mortality limits for that year. Due to many considerations in this decision-making process, the final coastwide mortality limit may deviate from the coastwide reference mortality limit determined from the management procedure.

1.3 WHAT IS A HARVEST STRATEGY?

A harvest strategy, which may also be referred to as a management strategy, is the management framework necessary to achieve defined biological, fishery, and economic objectives for Pacific halibut. A harvest strategy will outline:

Objectives and key principles promoting sustainable, healthy, and accessible Pacific halibut fisheries.

Reference points and other quantities used when applying the harvest strategy.

Processes for monitoring and assessing the biological conditions of the Pacific halibut population and conditions of Pacific halibut fisheries in relation to biological and fishery reference levels (reference points).

Pre-determined procedures that adjust fishing mortality according to the biological status of the Pacific halibut stock and conditions of the Pacific halibut fisheries (as defined by monitoring and/or assessment). These procedures are referred to as harvest control rules or decision rules, and apply to the determination of a reference mortality limit before the decision-making process.

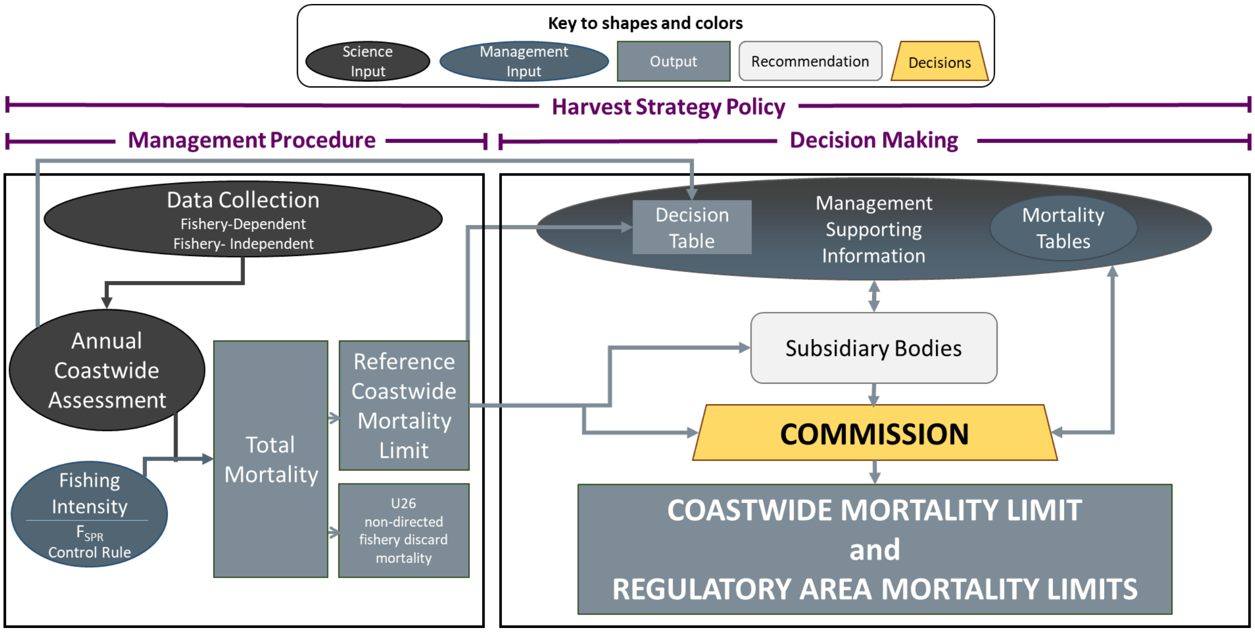

Figure 2. Illustration of the IPHC harvest strategy policy process to determine mortality limits showing the management procedure affecting the coastwide scale and the decision-making component, that considers inputs from many sources to distribute the coastwide mortality limit to IPHC Regulatory Areas and may result in the coastwide mortality limit deviating from the reference coastwide mortality limit determined from the management procedure.

A management procedure (MP) contains many of the components of a harvest strategy and is sometimes synonymous with harvest strategy. Here, we define an MP as the formulaic procedure that defines data collection, assessment, and harvest rules to determine the coastwide reference mortality limit. The MP has been shown to meet the objectives through simulation testing while also being robust to uncertainty and variability. Harvest strategy is a more general concept containing the MP as well as objectives. Simulation testing of MPs is done using Management Strategy Evaluation (MSE) operating models (OMs) with decision-making variability to ensure that a harvest strategy policy is robust to this uncertainty as well as other sources of uncertainty.

Management Procedure (MP): A formulaic procedure to determine a management outcome (e.g. mortality limit) that produces a repeatable outcome and can be simulation tested.

Harvest Strategy: The framework for managing a fish stock, including the MP and objectives.

Harvest Strategy Policy (HSP): The harvest strategy and decision-making process that results in endpoint management outcomes.

Chapter 2 OBJECTIVES AND KEY PRINCIPLES

A goal of the IPHC Harvest Strategy Policy is the long-term sustainable use (optimum yield) of Pacific halibut through the implementation of a harvest strategy that maintains the stock at sustainable levels while supporting healthy and accessible fisheries which includes maximising economic returns in directed commercial fisheries.

To achieve this goal the IPHC will implement a harvest strategy that minimises risk to the stock and pursues maximum economic yield (MEY) for the directed Pacific halibut fisheries. Maximising the net economic returns (NER) from the fishery may not always equate with maximising the profitability of the fishery. Net economic returns may consider interannual stability to maintain markets, and economic activity may also arise from opportunity for recreational and Indigenous fishing. The need to share the resources appropriately will also be considered where necessary.

The Commission's current priority objectives to achieve this goal are:

1. Maintain the long-term coastwide Pacific halibut female relative spawning biomass above a biomass limit reference point where the risk to the stock is regarded as unacceptable ($RSB_{20\%}$) at least 95% of the time;
2. Maintain the long-term coastwide Pacific halibut female relative spawning biomass at or above a threshold reference point that optimises fishing activities($RSB_{36\%}$) at least 50% of the time;
3. Maximize the short-term coastwide yield while minimising annual changes in the short-term coastwide mortality limit, given the constraints above to ensure a sustainable fishery.

The first objective is a sustainability or biological objective and the latter two objectives are fishery objectives. The objectives are hierarchical such that the previous objective must be met before considering the next, which is shown in Figure 3. This is especially important when evaluating MPs and leads to the first two objectives defining the acceptable MPs that ensure a sustainable population and fishery, and the last objective, balancing yield and variability in yield, helping to determine a reference MP that meets short-term goals within the sustainable set of MPs.

Performance metrics developed from measurable objectives are used to aid in the selection of an MP that best meets the objectives. At a minimum, a measurable objective must define a time-period over which the performance metric is calculated. Furthermore, a measurable objective may contain a threshold or limit and a tolerance for meeting that threshold or limit. For the Commission priority objectives, short-term refers to the next 4-13 years while the long-term refers to many generations in the future such that the stock and fishery would be fluctuating around an equilibrium when managed consistently. The first two objectives contain a limit or threshold and a tolerance allowing for a probabilistic performance metric to be calculated indicating a pass or fail for that objective (i.e. it either meets or does not meet the tolerance). The performance metrics for the final objective are calculated over a ten-year period from 4-13 years into the future and reported as the average yield and average variability. The trade-offs between these two can then be evaluated, requiring a decision to be made because there is typically no clear solution as one commonly improves while the other becomes less desirable. These performance metrics are used to determine the reference MP (see Section 3.7), although may be considered during the annual decision-making process.

LONG-TERM OVERARCHING OBJECTIVES DEFINING ACCEPTABLE MPs

1. SUSTAINABILITY

GENERAL OBJECTIVE	MEASURABLE OBJECTIVE
KEEP FEMALE SPAWNING BIOMASS ABOVE A LIMIT TO AVOID CRITICAL STOCK SIZES	Maintain the long-term coastwide female relative spawning biomass above a biomass limit reference point ($RSB_{20\%}$) at least 95% of the time

2. OPTIMISE FISHING ACTIVITIES AND OPPORTUNITIES

GENERAL OBJECTIVE	MEASURABLE OBJECTIVE
MAINTAIN SPAWNING BIOMASS AT OR ABOVE A LEVEL THAT SUPPORTS OPTIMAL FISHING ACTIVITIES AND OPPORTUNITIES	Maintain the long-term coastwide female relative spawning biomass at or above a biomass threshold reference point ($RSB_{36\%}$) at least 50% of the time.

SHORT-TERM MANAGEMENT OBJECTIVES INFORMING A REFERENCE MP

3. OPTIMISE YIELD

GENERAL OBJECTIVE	MEASURABLE OBJECTIVE
PROVIDE STABLE FISHING OPPORTUNITIES	Maximize the short-term coastwide yield while minimising annual changes in the short-term coastwide mortality limit.

Figure 3. Priority objectives for the long-term sustainable management of Pacific halibut that support optimal yield and fisheries opportunities. The hierarchy of the objectives is shown by the arrows. The green colour indicates a sustainability or biological goal while the blue colours indicate fishery goals.

The harvest strategy will ensure fishing is conducted in a manner that does not lead to *overfishing*. Overfishing is defined as where the stock is subject to a level of fishing that would move it to an *overfished* state or prevent it from rebuilding to a '*not overfished*' state, within a specific time-frame and probability. Where it is identified that overfishing of the stock is occurring, action will be taken immediately to cease that overfishing to ensure long-term sustainability and productivity to maximise NER.

The harvest strategy will also ensure that if the stock is overfished, the fishery must be managed such that, with regard to fishing impacts, there is a high degree of probability the stock will recover. In this case, a stock rebuilding strategy will be developed to rebuild the stock, with high certainty, to the limit female relative spawning biomass level, whereby the harvest control rules would then take effect to build the stock further to the threshold reference female relative spawning biomass level.

Overfished: when the estimated probability that coastwide female relative spawning stock biomass is below the limit reference point ($RSB_{20\%}$) is greater than 50%.

Overfishing: where the stock is subject to a level of fishing that would move it to an '*overfished*' state with a greater than 50% probability within three (3) years at a constant fishing mortality (measured in biomass), or prevent it from rebuilding to a '*not overfished*' state within the required timeframe and specifications of a rebuilding plan.

Chapter 3 DEVELOPMENT OF THE HARVEST STRATEGY

The following requirements provide the basis for a transparent and systematic approach used when developing the Harvest Strategy Policy to assist in meeting the objectives defined in Chapter 2.

3.1 ACCOUNTING FOR FISHING MORTALITY ON ALL SIZES AND FROM ALL KNOWN SOURCES

The Harvest Strategy Policy accounts for all known sources of fishing mortality on the stock and all sizes of Pacific halibut mortality, including directed commercial, recreational, subsistence, and fishing mortality from fisheries targeting species other than Pacific halibut and may be under the management of another jurisdiction, such as non-directed fishing mortality. Discard mortality of released fish is accounted for using best available knowledge. Some sources of mortality, such as whale depredation and unreported catches, may be of unknown magnitude. These should be acknowledged as an uncertainty.

3.2 VARIABILITY IN THE ENVIRONMENT AND BIOLOGICAL CHARACTERISTICS

The productivity of Pacific halibut is affected by variability in the environment and by changes in biological characteristics. The environment fluctuates naturally and is altered due to climate change and other factors, which may affect biological characteristics such as size-at-age and recruitment of age-0 fish. The following types of variability were considered when developing the Harvest Strategy Policy for Pacific halibut:

- Variability in recruitment of age-0 Pacific halibut due to unknown causes
- Variability in average recruitment of age-0 Pacific halibut due to the environment (e.g. indexed by the Pacific Decadal Oscillation, PDO).
- Variability in the geographical distribution of age-0 recruits linked to the PDO.
- Changes in weight-at-age due to unknown causes
- Variability in movement throughout the Convention Area due to the environment (e.g. linked to the PDO).

Changes in the environment were taken into account when developing the Harvest Strategy Policy and future research on additional effects of climate change on Pacific halibut fisheries and stocks will be incorporated as knowledge improves.

3.3 MONITORING

The harvest strategy includes best practices for monitoring the stock and fisheries and the collection of fishery-dependent and fishery-independent data on the distribution, abundance, and demographics of Pacific halibut, as well as other key biological data. These observations are used in the stock assessment and inform other management supporting information. Fisheries-dependent data include observations from the fisheries and should be collected across the entire geographical range and across all sectors, including landed catch and discards. Fishery-independent data include observations collected from scientifically designed surveys providing standardised biological and ecological data that are independent of the fishing fleet.

3.4 ESTABLISHING AND APPLYING MANAGEMENT ACTIONS

The harvest strategy developed under this policy specifies all required management actions or considerations for Pacific halibut, at the stock or IPHC Regulatory Area level, necessary to achieve the conservation and fishery objectives. Harvest rules are specified in the management procedure to determine a reference coastwide mortality limit (Chapter 4). This reference mortality limit is used along with management supporting information in a decision-making framework to determine mortality limits for each IPHC Regulatory Area, which may sum to a different coastwide mortality limit than the reference coastwide mortality limit. The decision-making process considers additional objectives that may be relevant at that time, and is included as a source of uncertainty in the MSE framework used to determine the reference management procedure.

3.5 BALANCING RISK, COST AND CATCH

This policy establishes a risk-based management approach, which provides for an increased level of caution when establishing harvest rules in association with increasing levels of uncertainty about stock status.

In the context of this policy, the risk, cost, and catch trade-off, refers to a trade-off between the amount of resources invested in data collection, analysis and management of Pacific halibut, and the level of catch (or fishing mortality) applied. Fishing mortality should always be constrained to levels at which scientific assessment indicates the Pacific halibut stock is not exposed to an 'unacceptable ecological risk' (that is the risk that stocks will fall below the limit reference point). The stock assessment and MSE provide analyses of this risk given recent levels of monitoring.

The management decision to be taken in this context is to account for the amount of information available about the Pacific halibut stock. The Commission may consider whether investment of more resources in data collection and analyses and/or additional management will increase the understanding of the risk to the stock from fishing and provide confidence in the sustainability of a higher level of fishing pressure or catch. Alternatively, if resources for data collection and analysis are limited to levels less than desired, the Commission may choose to set mortality limits lower to account for added uncertainty (i.e. it may be necessary to reduce the fishing intensity to manage the risk). Decisions about the trade-offs between the investment in managing risk versus the economic return of the catch taken will be transparently made, clearly documented and publicly available.

3.6 REFERENCE POINTS AND PROXIES

A reference point is a specified level of an indicator used as a basis for managing Pacific halibut. A reference point will often be based on indicators of the female spawning stock size (relative or absolute spawning biomass), the amount of harvest (fishing mortality), or on other factors such as economic return from the fishery.

A harvest strategy for Pacific halibut shall be based on 'threshold' reference points and 'limit' reference points. A threshold reference point is a level that achieves the policy objectives (e.g. acceptable levels of biological impact on the stock and desired health of the fisheries) if the indicator is at or above that level. When the stock is at or above a threshold reference point, optimal yield is possible. A limit reference point indicates a point beyond which the long-term biological health of the stock or the health of the fisheries is considered unacceptable and should be avoided. Fishing when the Pacific halibut population is below the biological limit reference point places the Pacific halibut stock at a range of biological risks, including an unacceptable risk to recruitment and productivity, and an increased risk that the stock will fail to maintain its ecological function, although risk of extinction is not a major concern. A fishery limit reference point indicates a stock level below which the directed commercial fishery is unlikely to remain profitable and opportunities for all fisheries would be severely diminished. Proxy reference points are described in Table 1.

The '*overfished*' limit reference point is defined using a dynamic limit reference point. A dynamic calculation pertains to relative spawning biomass (RSB) being the estimated value relative to the estimated spawning biomass that would have occurred without any fishing given natural variability (e.g. recruitment deviations, changes in size-at-age, etc). This measures the effect of only fishing, rather than the effect of fishing and the environment, thus defining overfished as a concept resulting from fishing where management action would have an effect. Natural variability also affects stock size and results in fluctuations of the absolute spawning biomass. These natural variations, along with fishing, may result in a '*depleted*' stock where reductions in fishing mortality may not lead to recovery without a change in the environmental conditions affecting the stock. The Commission may choose additional precautionary actions whenever needed, including when at, or approaching, a '*depleted*' state.[1]

Table 1. Proxy reference points

Reference point	Definition	Proxy
Threshold reference point SB_{THRESH}	The female dynamic spawning biomass level supporting maximum economic yield (SB_{MEY}) and healthy fisheries.	36% of the unfished female spawning biomass ($RSB_{36\%}$).
Overfished limit reference point SB_{LIM}	The female dynamic spawning biomass level where the ecological risk to the population and the risk to the health of the fisheries is regarded as unacceptable.	20% of the unfished female spawning biomass ($RSB_{20\%}$).

3.7 TECHNICAL EVALUATION OF THE HARVEST STRATEGY

This harvest strategy has been formally tested to demonstrate that it is highly likely to meet the objectives and key principles of this policy. Management strategy evaluation (MSE), a procedure where alternative management strategies are tested and compared using simulations of stock and fishery dynamics, is one of the best options to test harvest strategies and is recommended for future development of the HSP. MSE involves determining objectives, identifying MPs to evaluate, simulating those MPs with a closed-loop simulation framework, evaluating the MPs to determine which one best meets the objectives (Chapter 2), and finally adopting that MP as part of the harvest strategy. This process receives input from stakeholders throughout the annual meeting cycle and is reviewed by the IPHC Scientific Review Board (SRB). Outcomes of the evaluations are made publicly available and communicated at meetings throughout the IPHC annual process.

The MSE supporting this HSP incorporates variability and uncertainty, such as described in Section 3.2, structural uncertainty in an operating model (OM), and implementation variability from decision-making and realized fishing mortality. The MSE also represents all fishing sectors as necessary to appropriately remove different cohorts from the population and to determine if objectives are met for each sector. An important component to this HSP is the decision-making component (Figure 2) where the Commission considers management inputs and additional

[1] The concept of depleted has been added to the Harvest Strategy Policy to recognize it as important while research continues to identify an appropriate threshold and develop management procedures for when the stock approaches or surpasses a depleted state. This research will be considered when updating the HSP following the schedule in Table 2.

relevant factors when deciding on the coastwide TCEY and distribution of the TCEY to IPHC Regulatory Areas to balance risk, cost, and catch (Section 3.5), and account for current conditions. The MSE simulations use historical decisions to determine how to simulate decision-making variability, ensuring that an MP is robust to that variability as well as other sources of uncertainty.

3.8 RE-EVALUATING THE HARVEST STRATEGY AND MANAGEMENT PROCEDURE

A harvest strategy is a transparent and science-based approach to determining mortality limits and is meant to remain in place for many years. Frequent modifications or departures from the harvest strategy reduce the transparency and science-based approach. However, infrequent updates are necessary as more knowledge is gained. Therefore, it is important to specify, as part of the harvest strategy, time periods for re-evaluation of management procedures and to identify exceptional circumstances that would trigger a re-evaluation before that time period.

The IPHC currently operates off a schedule of three-years for full stock assessments, with update stock assessments in the intervening two years, and the MSE OM is updated following each full stock assessment to maintain consistent approaches and paradigms. Therefore, MPs may be re-evaluated three years after implementation, and shall not exceed two cycles (six years as shown inTable 2). The HSP may be updated on a three-year cycle corresponding to the regular re-evaluation of the MP, or as needed. An exceptional circumstance may trigger a re-evaluation of the MP sooner than three-years, which may be subsequently reflected in an update to the HSP.

An exceptional circumstance may trigger a re-evaluation before then and two exceptional circumstances to check for are defined as follows.

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

Exceptional circumstances would be reviewed by the SRB to determine if one should be declared. In the event that an exceptional circumstance is declared, the following actions are to be completed (also see Table 2).

- Review the MSE simulations to determine if the OM can be improved and MPs should be re-evaluated.
- Consult with the SRB and MSAB to identify why the exceptional circumstance occurred, what can be done to resolve it, and determine a set of MPs to evaluate with an updated OM.
- Present these recommendations to the Commission for a Commission decision whether to update the OM and re-evaluate the reference MP and alternative MPs.
- Further consult with the SRB and MSAB after simulations are complete to recommend a new MP to the Commission.
- Present these results to the Commission to identify whether a new MP is appropriate and the HSP should be updated.

The Commission may depart from the reference MP and reference TCEY in any year to account for other objectives and risk, including if an exceptional circumstance has occurred.

Table 2. Stock assessment, MSE, exceptional circumstances check, review, and decision processes on an annual basis. Year 1 could correspond to 2025, 2028, 2031, and so on. Upper case 'Y' indicates that the task is done, a lower case 'x' indicates that the task may be done. 'EC' refers to Exceptional Circumstance and 'FISS' to Fishery-Independent Setline Survey.

Year	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Example Year	2025	2026	2027	2028	2029	2030	2031	2032
FISS coastwide index	Y	Y	Y	Y	Y	Y	Y	Y
Full stock assessment	Y			Y			Y	
Update stock assessment		Y	Y		Y	Y		Y
Commission TCEY decision	Y	Y	Y	Y	Y	Y	Y	Y
MSE OM updated		Y			x			Y
MP re-evaluated		Y			x			Y
Exceptional circumstances checked	Y		Y	Y	x[1]	Y	Y	
- Consult with SRB and MSAB			x	x	x	x	x	
- Present to Commission			x	x	x	x	x	
- Re-evaluate MP due to EC			*	*	Y[2]	x*	x*	
Update HSP			x			x		

[1] The exceptional circumstance would be checked only if a new MSE OM was not updated.

[2] The MP would be re-evaluated as part of the normal three-year cycle due to an exceptional circumstance occurring in two sequential years.

* An exceptional circumstance can be declared after two sequential instances, thus re-evaluation of an MP would have a delay, unless recommended by the Commission outside of the normal process.

Chapter 4 APPLYING THE HARVEST STRATEGY

4.1 COORDINATED MANAGEMENT OF DOMESTIC STOCKS

Consistent with the *Protocol amending the Convention between Canada and the United States of America for the preservation of the [Pacific] halibut fishery of the northern Pacific Ocean and Bering Sea* (1979), the IPHC will pursue the sustainable use of Pacific halibut within fisheries managed by other jurisdictions.

4.2 COORDINATED MANAGEMENT OF INTERNATIONAL STOCKS

The IPHC Harvest Strategy Policy does not prescribe management arrangements in the case of fisheries that are managed by a Party external to the IPHC Convention. This includes management arrangements for commercial and traditional fishing in the US Treaty Tribes and Canadian First Nations, that are governed by provisions within relevant Treaties. However, it does articulate the IPHC preferred approach.

4.3 STOCK ASSESSMENT

A full stock assessment occurs triennially and incorporates all available data through the current year, investigates all data and modelling aspects, and potentially makes changes to any of these components as needed. In the intervening years, an update stock assessment is completed to include all available data through the most current year. The stock assessment includes a summary of the data available for analysis, estimates of current stock size, recent trends of stock size relative to reference points, and uncertainty in the estimates of stock size.

Decision table: The stock assessment also produces a harvest decision table containing short-term projections of various risk metrics (rows) under different levels of future harvest (columns input as a specific amount of fishing mortality, e.g. TCEY). Risk metrics include the probability of a decline in spawning biomass for the next 1 to 3 years, the probability of a decline in spawning biomass that is greater than 5% for the next 1 to 3 years, the probability that the spawning biomass is less than 20% or 30% of unfished spawning biomass in the next 1 to 3 years, the probability that the reference TCEY is less than the selected TCEY in the next 1 to 3 years, the probability that the reference TCEY is at least 10% less than the selected TCEY in the next 1 to 3 years, and the probability that the fishing intensity in the upcoming year is greater than the reference fishing intensity as specified in the MP (currently $F_{SPR=43\%}$). The harvest levels include the reference fishing mortality (i.e. TCEY determined from the MP), a range less than and greater than the reference fishing mortality, no fishing mortality (to assess short-term maximum biological productivity), various levels based on status quo (the previous year's coastwide mortality), a 3-year surplus that would maintain the spawning biomass at the same level in three years with a 50% probability, fishing mortality based on the SPR proxy for MEY, and the fishing mortality based on the SPR proxy for MSY. The decision table is one component of management supporting information and is used by the Commission to assess the risk for various mortality limits when deciding on the coastwide mortality limit for the upcoming year.

4.4 COASTWIDE REFERENCE MORTALITY LIMIT

The coastwide reference mortality limit is determined using the stock assessment and a fishing intensity (i.e. F_{SPR}) defined by a harvest control rule (Figure 4). The stock assessment estimates the stock status (dynamic RSB) which is used in the harvest control rule to determine if the fishing intensity should be reduced from the reference SPR (43%). The reference SPR is linearly reduced when the stock status (RSB) is estimated below 30% and is set to 100% (no fishing for directed fisheries) when the stock status is estimated at or below 20% (SB_{LIM}).

This management procedure determining the coastwide reference mortality limit is brought into the decision-making step as a reference value from which the Commission uses additional management supporting information to account for other relevant factors during the annual decision-making process on the coastwide TCEY and the distribution of the coastwide TCEY to IPHC Regulatory Areas. The MP provides a reference value in the decision table (see Sections 4.3 and 4.7). The MSE simulations account for this decision-making variability (see Section 3.7).

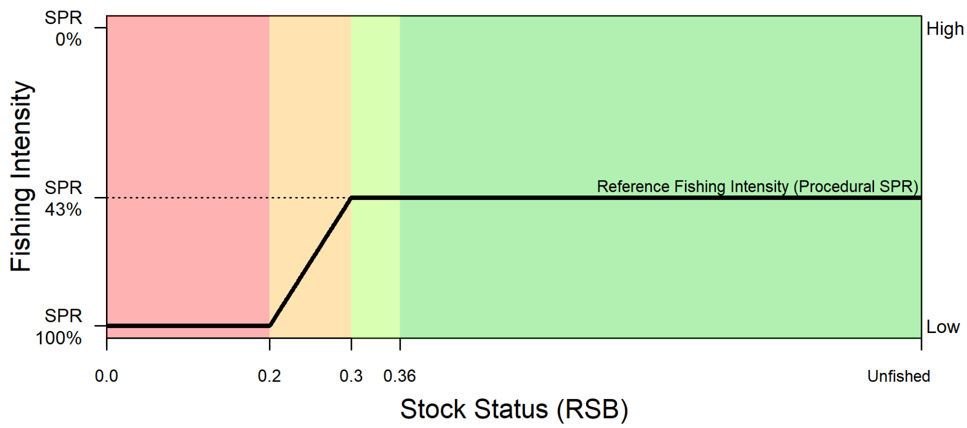

Figure 4. Harvest control rule for the fishing intensity (i.e. F_{SPR}) to determine the coastwide total mortality limit. The stock status is the dynamic relative spawning biomass (RSB) determined from the stock assessment. The reference fishing intensity is $F_{SPR=43\%}$, and is applied when stock status is above the trigger of 30%. SPR is linearly reduced between a stock status of 30% and 20%, and set to 100% when at or below 20% (no directed fishing). A stock status of 20% is also the limit reference point RSB_{LIM}. The threshold RSB, 0.36, is related to an objective to maintain the relative spawning biomass at or above $RSB_{36\%}$ at least 50 percent of the time. Colours show the area below RSB_{LIM} (red), the area 'on the ramp' (orange), the area above the trigger and below RSB_{THRESH} (light green), and the area above RSB_{THRESH} (green).

4.5 REBUILDING IF THE STOCK BECOMES OVERFISHED

If Pacific halibut is determined to be overfished (when the probability that female spawning stock biomass is below the limit reference point, RSB_{LIM}, is greater than 50%), immediate action is required to constrain directed fishing and rebuild the stock to levels that will ensure long-term sustainability and productivity, i.e. at or above RSB_{LIM}. A rebuilding strategy must be developed to rebuild the stock to above its limit reference point, for agreement by the Commission. A rebuilding strategy will be required until the stock is above the limit reference point with a reasonable level of certainty (at least a 70% probability that the stock has rebuilt to or above the limit reference point). It must ensure adequate monitoring and data collection is in place to assess the status of the stock and rebuilding progress.

Directed fishing and incidental mortality of Pacific halibut, if determined to be overfished, should be constrained as much as possible to levels that allow rebuilding to the limit reference point (RSB_{LIM}) within the specified timeframe. Once a stock has been rebuilt to above the limit reference point with a reasonable level of certainty, it may be appropriate to increase directed fishing, and increase incidental mortality in line with the harvest strategy, noting that the usual harvest strategy requirements regarding the application of the harvest control rule and risk of breaching the limit reference point will apply.

The rebuilding strategy should note where sources of mortality exist that cannot be constrained by the IPHC, and must take this mortality into account. Where practical and appropriate, the IPHC will coordinate with other jurisdictions to ensure other sources of mortality from fishing are reasonably constrained consistent with any catch sharing arrangement.

When a rebuilding strategy is being developed, it must include performance measures and details on how and when these measures will be reported. Where there is no evidence that a stock is rebuilding, or is going to rebuild in the required timeframe and probability, the IPHC will review the rebuilding strategy and make the result of the review public. If changes to the rebuilding strategy are considered necessary, such changes should be made in a timely manner.

Rebuilding plan

If the stock is determined to be overfished, a rebuilding plan should be developed as soon as possible. Requiring agreement by the Commission, a rebuilding plan could be developed at the Annual Meeting immediately following the overfished determination, assuming that the overfished determination is presented at the Interim Meeting, but shall be developed within two years after the stock is determined to be overfished (e.g. by the second Annual Meeting following the overfished determination). Guidelines for a rebuilding plan are provided in a separate IPHC document.

Rebuilding timeframes

Rebuilding timeframes are explicitly related to the minimum timeframe for rebuilding in the absence of fishing. Rebuilding timeframes should take into account Pacific halibut productivity and recruitment; the relationship between spawning biomass and recruitment; and the stock's current level of depletion.

4.6 Mortality limits for each IPHC Regulatory Area

The final outputs of the harvest strategy policy before domestic management is applied are mortality limits for each IPHC Regulatory Area. These are decided upon by the Commission at the Annual Meeting with the input of management supporting information (Section 4.7) requested by the Commission including mortality tables and the harvest decision table (see Section 4.3).

Mortality table: A mortality table shows the resulting allocation of mortality limits to each sector within each IPHC Regulatory Area. Domestic catch-sharing plans and Commission agreements on projecting non-directed discard mortality are used to fill out the details. This table can be produced for any projected year but is commonly presented for only the first projected year.

4.7 Management supporting information

The Commission may use many sources of information during the decision-making process to assess risk to the stock and fisheries. Annually produced products are the harvest decision table (Section 4.3) and mortality tables (Section 4.6). These show a range of fishing mortality and allocation options that portray the risks in various ways. The harvest decision table represents short-term projections produced from the stock assessment that are useful for tactical decision-making and is an important item in the management supporting information. Longer-term strategic implications of the choices in the harvest decision table are determined from the MSE simulations. If available, performance metrics associated with the three priority objectives (Chapter 2) determined from the most recent MSE simulations should be presented for, at a minimum, some F_{SPR} values associated with the fishing mortality options presented in the decision table.

Additional management supporting information may include, but is not limited to, socioeconomic considerations, community development, political constraints, and operational limitations. This information along with stakeholder and scientific input is used by the Commission to decide on mortality limits for each IPHC Regulatory Area distributed from a coastwide mortality limit that takes into account short-term and long-term risk to the stock and supports optimal yield from the fisheries.

4.8 Stakeholder and scientific input

Stakeholder and scientific input into the development and application of the harvest strategy is an important process to support the sustainable management of healthy Pacific halibut fisheries. Input from both sources occurs at meetings throughout the year.

Stakeholder input

Stakeholder input can occur via public testimony at any public IPHC meeting or at meetings of various IPHC subsidiary bodies, which are populated by individuals representing various interests related to Pacific halibut. This may include processors, commercial harvesters, recreational interests, subsistence fishing, and tribal or First Nations representatives. Subsidiary bodies may provide advice on management decisions, potential research topics, or guide updates to the Harvest Strategy Policy through MSE analyses.

Scientific input

Scientific input occurs through independent, external reviews, including, but not limited to, semi-annual meetings of the SRB. The SRB reviews science/research proposals, programs, products, strategy, progress, and overall performance.

4.9 Annual process

A series of meetings occurs throughout the year, leading up the Annual Meeting in January when mortality limit decisions are made. The SRB meets in June and September to peer review IPHC science products, including the stock assessment and MSE. Subsidiary bodies may meet any time during the year and provide recommendations to the Commission and may meet during the week of the Annual Meeting to advise the Commission on issues related to the management of the Pacific halibut resource in the Convention Area.

An Interim Meeting, typically late November, precedes the Annual Meeting and is when the stock assessment, stock projections, and harvest decision table are first publicly presented. The final stock assessment, stock projections, and harvest decision table are presented at the Annual Meeting, typically in late January, to support mortality limit decisions.

4.10 Updating the Harvest Strategy Policy

This Harvest Strategy Policy represents a stable framework that should be updated infrequently and only when warranted, at the discretion of the Commission. The HSP may be updated on a three-year cycle corresponding to the MSE process schedule such that changes to the HSP occur following a full MSE analysis of the harvest strategy. Table 2in Section 3.8 shows an example schedule over a six-year period.