INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC–2024–RAB025–00

Last Update: 15 November 2024

25th Session of the IPHC Research Advisory Board (RAB025) – *Compendium of meeting documents*

19-20 November 2024, Seattle, WA, USA

Commissioners

Canada	United States of America
Paul Ryall	Jon Kurland
Neil Davis	Robert Alverson
Peter DeGreef	Richard Yamada

Executive Director

David T. Wilson, Ph.D.

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LAST UPDATE: 15 November 2024

BIBLIOGRAPHIC ENTRY

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DRAFT: AGENDA FOR THE 25th SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB025)

Date: 19-20 November 2024
Location: Seattle, Washington, USA
Venue: IPHC HQ office
Time: 19th: 09:00-16:00; 20th: 09:00-12:00
Chairperson: Dr David T. Wilson (Executive Director)
Vice-Chairperson: Dr Josep V. Planas (Biological & Ecosystem Sciences Branch Manager)

1. **OPENING OF THE SESSION** (Chairperson)
2. **ADOPTION OF THE AGENDA AND ARRANGEMENTS FOR THE SESSION** (Chairperson)
3. **IPHC PROCESS** (Chairperson)
   - 3.1 Update on the actions arising from the 24th Session of the RAB (RAB024)
   - 3.2 Outcomes of the 100th Session of the IPHC Annual Meeting (AM100)
4. **SEASON OVERVIEW – 2024: RAB MEMBERS**
5. **INTERNATIONAL PACIFIC HALIBUT COMMISSION 5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING (2022-26)**

   5.1 RESEARCH

   5.1.1 Biology and ecology
   - Description of IPHC Biological and Ecosystem Sciences Research (Core research streams)

   5.2 MONITORING

   5.2.1 Fishery-dependent data

   5.2.2 Fishery-independent data
   - 2024 FISS season: Design and implementation (T. Jack)
   - IPHC Fishery-Independent Setline Survey (FISS)
     - 2025 FISS design evaluation (R. Webster)
6. **GUIDANCE ON, AND DISCUSSION OF, OTHER POTENTIAL APPLIED RESEARCH PROJECTS** (Chairperson & Vice-Chairperson)
7. **OTHER BUSINESS**
8. **REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 25th SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB025)** (Chairperson)

SCHEDULE FOR THE 25th SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB025)

Tuesday, 19 November 2024		
Time	**Agenda item**	**Lead**
09:00-09:05	1. Opening of the Session	D. Wilson
09:05-09:15	2. Adoption of the agenda and arrangements for the Session	D. Wilson
09:15-09:30	3. IPHC Process	D. Wilson
09:30-10:30	4. Season overview: RAB members	RAB Members
10:30-10:45	Break	
10:45-10:55	5. International Pacific Halibut Commission 5-year program of integrated research and monitoring (2022-26)	D. Wilson
10:55-11:40	5.1 Research: Biology and Ecology - Description of IPHC Biological and Ecosystem Sciences Research (Core research streams)	J. Planas & Project leaders
11:40-12:30	5.2 Monitoring: 5.2.1 Fishery-dependent data 5.2.2 Fishery-independent data • 2024 FISS season: Design and implementation • IPHC Fishery-Independent Setline Survey (FISS) - 2025 FISS design evaluation	B. Hutniczak T. Jack R. Webster
12:30-13:30	Lunch	
13:30-16:00	6. Guidance on, and discussion of, other potential applied research projects	RAB Members
16:30-21:00	RAB Function/dinner	All
Wednesday, 20 November 2024		
Time	**Agenda item**	**Lead**
09:00-10:15	Guidance on, and discussion of, other potential applied research projects (cont.)	RAB Members
10:15-10:30	7. Other business	D. Wilson
10:30-10:45	Break	
10:45-12:00	8. Review of the draft and adoption of the report of the 24th Session of the IPHC Research Advisory Board (RAB024)	D. Wilson
12:00-13:00	Lunch	

INTERNATIONAL PACIFIC HALIBUT COMMISSION

LIST OF DOCUMENTS FOR THE 25th SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB025)

LAST UPDATED: 15 NOVEMBER 2024

Document	Title	Availability
IPHC-2024-RAB025-01	Agenda & Schedule for the 25th Session of the IPHC Research Advisory Board (RAB025)	✓ 28 Jun 2024 ✓ 15 Nov 2024
IPHC-2024-RAB025-02	List of Documents for the 25th Session of the IPHC Research Advisory Board (RAB025)	✓ 28 Jun 2024 ✓ 17 Oct 2024 ✓ 15 Nov 2024
IPHC-2024-RAB025-03	Update on the actions arising from the 24th Session of the RAB (RAB024) (D. Wilson & J. Planas)	✓ 10 Oct 2024
IPHC-2024-RAB025-04	Outcomes of the 100th Session of the IPHC Annual Meeting (AM100) (D. Wilson)	✓ 09 Oct 2024
IPHC-2024-RAB025-05	International Pacific Halibut Commission 5-Year program of integrated research and monitoring (2022-26): Updates (D. Wilson, J. Planas, I. Stewart, A. Hicks, B. Hutniczak, & R. Webster)	✓ 09 Oct 2024
IPHC-2024-RAB025-06	Report on current and future biological and ecosystem science research activities (J. Planas, C. Dykstra, A. Jasonowicz, C. Jones)	✓ 15 Oct 2024
IPHC-2024-RAB025-07	IPHC Fishery-independent setline survey (FISS) design and implementation in 2024 (K. Ualesi, R. Rillera, T. Jack, & K. Coll)	✓ 15 Oct 2024
IPHC-2024-RAB025-08	2025-27 FISS Design evaluation (R. Webster, I. Stewart, K. Ualesi, T. Jack, & D. Wilson)	✓ 17 Oct 2024

Update on actions arising from the 24th Session of the IPHC Research Advisory Board (RAB024)

PREPARED BY: IPHC SECRETARIAT (D. WILSON & J. PLANAS; 10 OCTOBER 2024)

PURPOSE

To provide the RAB with an opportunity to consider the progress made during the inter-sessional period, in relation to the recommendations and requests of the 24th Session of the IPHC Research Advisory Board (RAB024).

BACKGROUND

At the previous RAB meeting, a series of actions were agreed upon for implementation by the IPHC Secretariat. These action items and progress made on their implementation are detailed in Appendix A.

DISCUSSION

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

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

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

RECOMMENDATIONS

That the RAB:

1) **NOTE** paper IPHC-2024-RAB025-03, that provided the RAB with an opportunity to consider the progress made during the inter-sessional period, in relation to the recommendations and requests of the 24th Session of the IPHC Research Advisory Board (RAB024).
2) **AGREE** to consider and revise as necessary the actions, and for these to be combined with any new actions arising from RAB025.

APPENDICES

Appendix A: Update on actions arising from the 24th IPHC Research Advisory Board (RAB024)

APPENDIX A

Update on actions arising from the 24th Session of the Research Advisory Board (RAB024)

Action No.	Description	Update
	RECOMMENDATIONS	
RAB024-Rec.01 (para. 11)	***International Pacific Halibut Commission 5-year program of Integrated Research and Monitoring (2022-26)*** **NOTING** the substantial potential of incorporating AI techniques to supplement the IPHC Secretariat's current aging protocol informing on the population age structure and serving as input to the Pacific halibut stock assessment, the RAB **RECOMMENDED** continuing with the proposed project and method validation as part of the IPHC 5-year Program of Integrated Research and Monitoring (2022-26).	Completed & Ongoing: Update: will be provided as a part of the **IPHC-2024-RAB025-05** presentation.
RAB024-Rec.02 (para. 18)	***Research: Whale depredation mitigation strategies involving longline catch protection devices*** The RAB **NOTED** paper IPHC-2023-RAB024-06, that provided a description of an ongoing study designed to identify and test new tools to minimize marine mammal depredation of hook-captured Pacific halibut and **RECOMMENDED** that the IPHC continue efforts towards this goal.	In Progress: Update: The IPHC Secretariat, under a new research grant from BREP-NOAA (NA23NMF4720414), is planning continuation of this work during 2025.
RAB024-Rec.03 (para. 24)	***Monitoring: Fishery-independent data - 2023 FISS season: Design and implementation*** The RAB **SUPPORTED** an annual FISS design with sufficient coverage across all Biological Regions and **RECOMMENDED** that the IPHC Secretariat continue efforts to obtain supplementary funding for FISS activities that would support this goal.	Completed & Ongoing: Update: The IPHC Secretariat continues a range of efforts to secure supplemental and voluntary contributions from a range of sources. Updates will be provided at RAB025.

Action No.	Description	Update
RAB024-Rec.04 (para. 30)	***Monitoring: Fishery-independent data - 2024 FISS design evaluation*** The RAB **RECOMMENDED** that any changes in the standardized FISS design, including vessel captain stations and bait changes, be carefully accounted for in the Secretariat's analytical work and presented to the Commission.	Completed & Ongoing: Update: Modelling work in 2024 includes fitting space-time models with and without vessel captain stations to assess whether their inclusion is likely to result in biased estimates. Bait differences are accounted for in the 2024 models.
RAB024-Rec.05 (para. 32)	The RAB **RECOMMENDED** maintaining the oceanographic sampling program to provide a continuous source of data on environmental conditions experienced by Pacific halibut.	In Progress: The IPHC Secretariat is seeking means other than traditional funding through fish sales to fund this activity.
RAB024-Rec.06 (para. 33)	***Guidance on, and Discussion of, other Potential Applied Research Projects*** The RAB **RECOMMENDED** continued efforts to obtain supplementary funding to support studies on whale depredation and other fishing technology advances given the correlation between fishing techniques and gear and the viability of Pacific halibut fisheries.	Completed & Ongoing: Update: The IPHC Secretariat has recently received supplementary funding from the Bycatch Reduction Engineering Program-NOAA program (Award Number NA23NMF4720414) to continue fishing technology research.

Action No.	Description	Update
	REQUESTS	
RAB024-Req.01 (para. 5)	***IPHC Process: Update on the actions arising from the 23rd Session of the RAB (RAB023)*** **NOTING** a potential issue raised regarding bycatch being caught in Alaskan State waters leading to closures of areas to longline fishing gear by ADFG, the RAB **REQUESTED** that the IPHC Secretariat investigate and share outcomes with the RAB intersessionally, and at RAB025.	Completed & Ongoing: Update: The IPHC reached out to the ADFG to gather additional information for the RAB. Following the emergency closure in October 2023 caused by rockfish bycatch, the ADFG submitted a proposal to the Alaksa Board of Fisheries to grant the commissioner the authority to close areas to commercial fishing with specific gear types by emergency order (see Proposal 5), with a decision expected in December 2024. The ADFG has determined that this authority is necessary to conserve the resource and prevent overharvest of a bycatch rockfish species. The RAB can seek further information from Forrest Bowers, Acting Director, Division of Commercial Fisheries, at forrest.bowers@alaska.gov.
RAB024-Req.02 (para. 19)	***Monitoring: Fishery-dependent data*** The RAB **NOTED** the ongoing discussions regarding e-logbooks being developed for the fleet in Alaska, USA, and while some concerns were raised, Canadian RAB members highlighted the benefits of e-logbooks used by the Canadian fleet and encouraged information sharing among RAB members over the coming year. Thus, the RAB **REQUESTED** that the IPHC Secretariat keeps the fleet informed regarding preserving data confidentiality arising from the use of electronic logbooks.	Completed & Ongoing: Update: Additional clarification was provided to the Conference Board (CB094) by the e-logbook provider in Alaska.

Action No.	Description	Update
RAB024-Req.03 (para. 31)	***Monitoring: Fishery-independent data - 2024 FISS design evaluation*** **NOTING** that FISS landings and sale includes U32 fish, and that this may have been a factor in the reduced prices for Pacific halibut in 2023, the RAB **REQUESTED** the IPHC Secretariat undertake an analysis of IPHC FISS prices versus commercial vessel prices received in 2023 and share the findings with the RAB and Commission.	Completed & Ongoing: Update: The IPHC Secretariat set up a process for monitoring prices throughout the FISS season. While the average IFQ price in 2023 was approximately 4.0% lower than the FISS price, the 2024 prices were nearly identical, with the difference of about 1%, despite including U32 Pacific halibut.

OUTCOMES OF THE 100TH SESSION OF THE IPHC ANNUAL MEETING (AM100)

PREPARED BY: IPHC SECRETARIAT (D. WILSON, 9 OCTOBER 2024)

PURPOSE

To provide the RAB with the outcomes of the 100th Session of the IPHC Annual Meeting (AM100), relevant to the mandate of the RAB.

BACKGROUND

The agenda of the Commission's Annual Meeting (AM100) included several agenda items relevant to the RAB:

3. IPHC PROCESS

3.1 Update on actions arising from the 99th Session of the IPHC Annual Meeting (AM099), 2023 Special Sessions, intersessional decisions, and the 99th Session of the IPHC Interim Meeting (IM099) (D. Wilson)

- ***IPHC-2024-AM100-03*** *Update on actions arising from the 99th Session of the IPHC Annual Meeting (AM099), 2022 Special Sessions, intersessional decisions, and the 99th Session of the IPHC Interim Meeting (IM099) (D. Wilson)*
- ***IPHC-2024-AM100-INF02*** *International Pacific Halibut Commission (IPHC) statement on climate change (IPHC)*

3.2 Report of the IPHC Secretariat (2023) (D. Wilson & B. Hutniczak)

- ***IPHC-2024-AM100-04*** *Report of the IPHC Secretariat (2023) (D. Wilson & B. Hutniczak)*

3.3 2nd IPHC Performance Review (PRIPHC02): Implementation of recommendations (D. Wilson)

- ***IPHC-2024-AM100-05*** *Implementation of the Recommendations from the 2nd IPHC Performance Review (PRIPHC02) (D. Wilson)*

3.4 Report of the 18th Session of the IPHC Management Strategy Advisory Board (MSAB018) (Co-Chairpersons)

- ***IPHC-2023-MSAB018-R*** *Report of the 18th Session of the IPHC Management Strategy Advisory Board (MSAB018)*

3.5 Reports of the IPHC Scientific Review Board (SRB Chairperson)

- ***IPHC-2023-SRB022-R*** *Report of the 22nd Session of the IPHC Scientific Review Board (SRB022)*
- ***IPHC-2023-SRB023-R*** *Report of the 23rd Session of the IPHC Scientific Review Board (SRB023)*

3.6 Report of the 24th Session of the IPHC Research Advisory Board (RAB024) (RAB Chairperson and Vice-Chairperson)

- ***IPHC-2023-RAB024-R*** *Report of the 24th Session of the IPHC Research Advisory Board (RAB024)*

3.7 International Pacific Halibut Commission 5-year program of Integrated Research and Monitoring (2022-26) (D. Wilson, J. Planas, I. Stewart, A. Hicks, B. Hutniczak, & R. Webster)

- ***IPHC-2024-AM100-06*** *International Pacific Halibut Commission 5-Year program of integrated research and monitoring (2022-26) (D. Wilson, J. Planas, I. Stewart, A. Hicks, B. Hutniczak, & R. Webster)*

4. *FISHERY* MONITORING

4.1 Fishery-dependent data overview (2023) (B. Hutniczak)

- ***IPHC-2024-AM100-07 Rev_1*** *Fisheries data overview (2023) (B. Hutniczak, H. Tran, T. Kong, K. Sawyer van Vleck. & K. Magrane)*

4.2 Fishery-independent data overview (2023)

4.2.1 IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2023 (K. Ualesi)

- ***IPHC-2024-AM100-08 Rev_1*** *IPHC Fishery-independent setline survey (FISS) design and implementation in 2023 (K. Ualesi, R. Rillera, T. Jack, & K. Coll)*

5. *STOCK* STATUS OF PACIFIC HALIBUT (2023)

5.1 Space-time modelling of survey data (R. Webster)

- ***IPHC-2024-AM100-09*** *Space-time modelling of survey data (R. Webster)*

5.2 Stock Assessment: Data overview and stock assessment (2023)

- ***IPHC-2024-AM100-10*** *Data overview and stock assessment for Pacific halibut (Hippoglossus stenolepis) at the end of 2023 (I. Stewart, A. Hicks, R. Webster, D. Wilson)*

6. *MANAGEMENT* STRATEGY EVALUATION

6.1 IPHC Management Strategy Evaluation: update (A. Hicks)

- ***IPHC-2024-AM100-11*** *IPHC Management Strategy Evaluation and Harvest Strategy Policy updates (A. Hicks, I. Stewart, & D. Wilson)*

7. *HARVEST* DECISION TABLE 2024

7.1 Stock projections and harvest decision table 2024-2026 (I. Stewart & A. Hicks)

- ***IPHC-2024-AM100-12*** *Stock projections and harvest decision table for 2024-2026 (I. Stewart & A. Hicks)*

8. *FISS* DESIGN EVALUATIONS 2024-2028

8.1 2024-28 FISS design evaluation (R. Webster)

- ***IPHC-2024-AM100-13*** *2024, and 2025-28 FISS Design evaluation (R. Webster, I. Stewart, K. Ualesi, & D. Wilson)*

9. *BIOLOGICAL* AND ECOSYSTEM SCIENCES – PROJECT UPDATES

9.1 Report on Current and Future Biological and Ecosystem Science Research Activities (J. Planas)

- ***IPHC-2024-AM100-14*** *Report on Current and Future Biological and Ecosystem Science Research Activities (J. Planas)*

DISCUSSION

During the course of the 100th Session of the IPHC Annual Meeting (AM100) 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 RAB's consideration.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2024-RAB025-04 which details the outcomes of the 100th Session of the IPHC Annual Meeting (AM100), relevant to the mandate of the RAB.

APPENDICES

Appendix A: Excerpts from the 100th Session of the IPHC Annual Meeting (AM100) Report (IPHC-2024-AM100-R).

APPENDIX A
Excerpts from the 100th Session of the IPHC Annual Meeting (AM100) Report
(IPHC-2024-AM100-R)

RECOMMENDATIONS

Nil

REQUESTS

Statement on Climate Change

*AM100–Req.01 (para. 8) The Commission **ADOPTED** the Statement on Climate change and **REQUESTED** that the IPHC Secretariat publish the statement on the website. The Secretariat will provide annual updates to the Commission on how the Statement is being implemented.*

OTHER

2024-28 ISS design evaluation

*Para. 73. The Commission **AGREED** to the goal of maintaining sufficient FISS sampling to ensure a maximum annual CV of 25% in each IPHC Regulatory Area, decreasing to 15% as financial considerations allow, and including FISS biological sampling in all Biological Regions (but not necessarily all Regulatory Areas) each year.*

*Para. 79. The Commission **AGREED** that supplementary funding is needed to sustain the FISS moving forward and to explore options for funding, e.g. from Contracting Parties or external partners.*

INTERNATIONAL PACIFIC HALIBUT COMMISSION 5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING (2022-26): UPDATES

PREPARED BY: IPHC SECRETARIAT (D. WILSON, J. PLANAS, I. STEWART, A. HICKS, B. HUTNICZAK, AND R. WEBSTER; 09 OCTOBER 2024)

PURPOSE

To provide the RAB with an annual opportunity to comment on the IPHC's 5-year Program of Integrated Research and Monitoring (2022-26) (the 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;

d) the IPHC Secretariat commenced implementation of the new Plan in 2022 and will keep the Plan under review on an ongoing basis.

Also recalling that an overarching goal of the IPHC 5-year Program of Integrated Research and Monitoring (2022-26) is 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.

DISCUSSION

The RAB should note that:

a) the intention is to ensure that the new integrated 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.

Updates: The Secretariat is currently in the process of updating the Plan to meet the request of the SRB at it's 24th Session, as per the below text:

> ***International Pacific Halibut Commission 5-year program of integrated research and monitoring (2022-26)***
>
> SRB024–Req.01 (para. 14) *The SRB **REQUESTED** 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.*

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2024-RAB025-05 that provides the latest iteration of the IPHC 5-year program of Integrated Research and Monitoring (2022-26).

APPENDICES

Appendix A: Updated: IPHC 5-year program of Integrated Research and Monitoring (2022-26)

INTERNATIONAL PACIFIC HALIBUT COMMISSION

5-YEAR PROGRAM OF INTEGRATED RESEARCH AND MONITORING

(2022 - 2026)

INTERNATIONAL PACIFIC

HALIBUT COMMISSION

BIBLIOGRAPHIC ENTRY

IPHC 2023. International Pacific Halibut Commission 5-Year program of integrated research and monitoring (2022-26). Seattle, WA, U.S.A. *IPHC–2023-5YPIRM, 58 pp.*

INTERNATIONAL PACIFIC HALIBUT COMMISSION

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ACRONYMS

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
MSAB	Management Strategy Advisory Board
MSE	Management Strategy Evaluation
OM	Operating Model
PAB	Processor Advisory Board
PDO	Pacific Decadal Oscillation
PHMEIA	Pacific halibut multiregional economic impact assessment [model]
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://iphc.int/the-commission/glossary-of-terms-and-abbreviations

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EXECUTIVE SUMMARY

An overarching goal of the *IPHC 5-Year Program of Integrated Research and Monitoring (2022-26)* is to promote integration and synergies among the various research and support activities of the IPHC Secretariat in order to improve our knowledge of key inputs into the Pacific halibut stock assessment and Management Strategy Evaluation (MSE) processes, and to provide the best possible advice for management decision-making processes.

Along with the implementation of the short- and medium-term activities contemplated in this *IPHC 5-Year Program of Integrated Research and Monitoring (2022-26)*, and in pursuit of the overarching objective, the IPHC Secretariat will also aim to:

1) undertake cutting-edge research programs in fisheries research in support of Pacific halibut fisheries management;
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 organizations and by leading international science and research collaborations;
6) effectively communicate IPHC research outcomes;
7) incorporate talented students and early researchers in research activities contemplated.

The research and monitoring activities conducted by the IPHC Secretariat are directed towards fulfilling the following four (4) objectives within areas of data collection, biological and ecological research, stock assessment, and Management Strategy Evaluation (MSE). In addition, the IPHC responds to Commission requests for additional inputs to management and policy development which are classified under management support.

The Secretariat's success in implementing the *IPHC 5-Year Program of Integrated Research and Monitoring (2022-26)* 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, analyzed, 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 – did the research improve the perceived accuracy of the stock assessment, MSE, or decisions made by the Commission?
4) Impact – did the research allow for more precision or a better estimate of the uncertainty associated with information for use in management?
5) Reliability – has the research resulted in more consistent information provided to the Commission for decision-making?

1. Introduction

The International Pacific Halibut Commission (IPHC) is a public international organization 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 organization 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 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.***

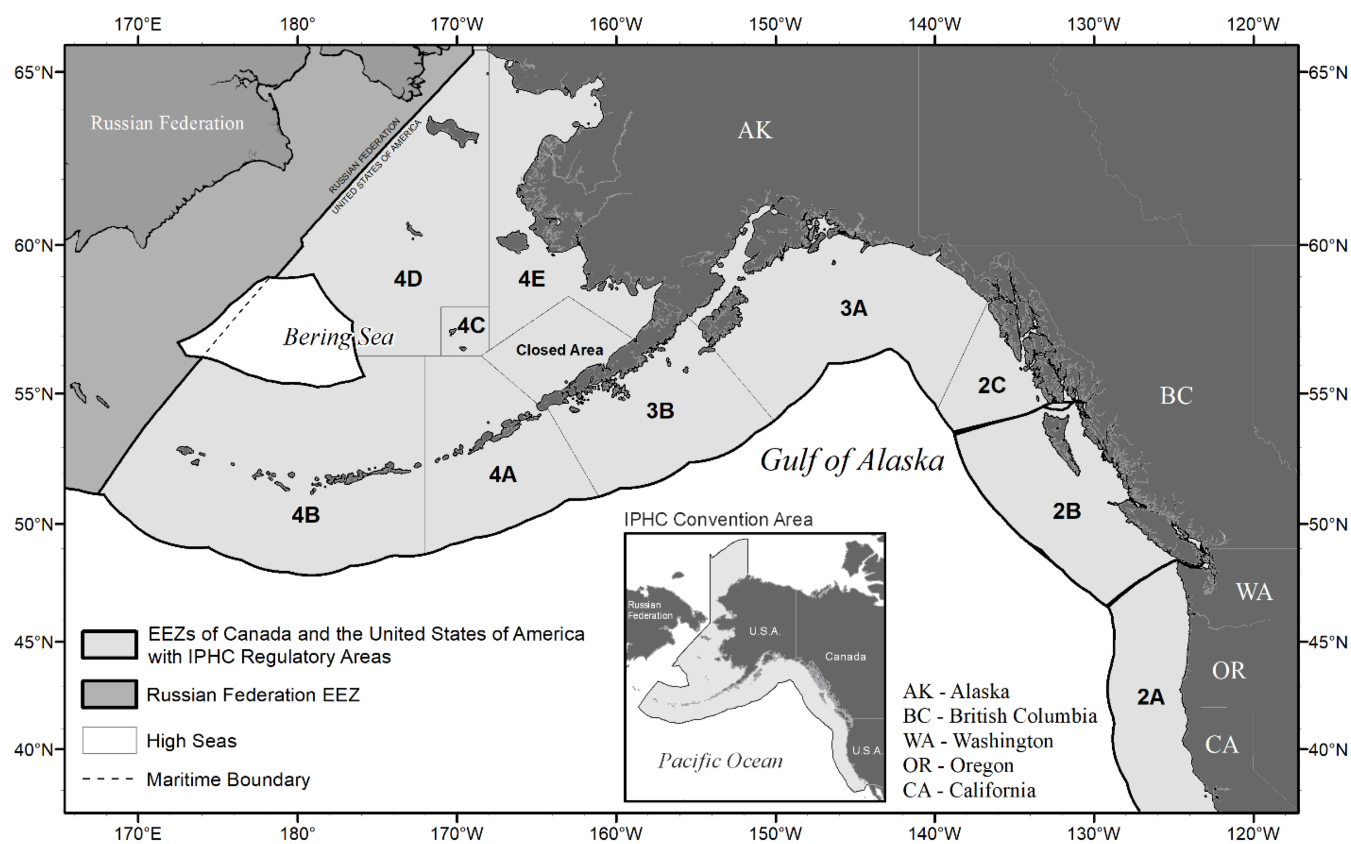

Figure 1. Map of the IPHC Convention Area (map insert) and IPHC Regulatory Areas.

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.

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 five years (2017-2021), the research conducted by the IPHC Secretariat has been guided by a 5-Year Biological and Ecosystem Science Research Plan (IPHC–2019–BESRP-5YP) that aimed at improving 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 prioritization (Appendix I). The outcomes of the IPHC-2019-BESRP-5YP have provided key inputs into stock assessment and the MSE process and, importantly, have provided foundational information for the successful pursuit of continuing and novel objectives within the new 5-Year Program of Integrated Research and Monitoring (2022-2026) (5YPIRM) (Appendix I).

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 as provided below:

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 regularised 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 a 5-Year Biological and Ecosystem Science Research Plan (IPHC–2019–BESRP-5YP), closing completed projects, extending efforts where needed, and adding new avenues in response to new information. Appendix I provides a detailed summary of the previous plan and the status of the work specifically undertaken. Key highlights relevant to the stock assessment and MSE include:

- Completion of the genetic assay for determining sex from tissue samples, processing of commercial fishery samples collected during 2017-2020, inclusion of this information in the 2019 and subsequent stock assessments, and transfer of this effort from research to ongoing monitoring.
- Incremental progress toward population-level sampling and analysis of maturity and fecundity.
- Continued development of the understanding of physiological and environmental mechanisms determining growth for future field application.
- Published estimates of discard mortality rates for use in data processing and management accounting.
- Collection of genetic samples and genome sequencing to provide a basis for ongoing evaluation of stock structure at population-level and finer scales.

All previously described research areas continue to represent critical areas of uncertainty in the stock assessment and thus are closely linked to management performance. The previous 5-year plan was 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 5YPIRM 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 the *IPHC 5-Year Program of integrated research and monitoring (2022-26)* is therefore to promote integration and synergies among the various research and support activities of the IPHC Secretariat in order to improve 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.

Along with the implementation of the short- and medium-term activities contemplated in this *IPHC 5-Year Program of Integrated Research and monitoring (2022-26)*, and in pursuit of the overarching objective, 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 organizations and by leading international science and research collaborations.
6) effectively communicate IPHC research outcomes
7) incorporate talented students and early researchers in research activities contemplated.

The research and monitoring activities conducted by the IPHC Secretariat are directed towards fulfilling the following four (4) **objectives** within areas of data collection, biological and ecological research, stock assessment, and MSE. In addition, the IPHC responds to Commission requests for additional inputs to management and policy development which are classified under management support. The overall aim is to provide a program of integrated research and monitoring (Fig 2):

Research

1) **Stock assessment**: apply the resulting knowledge to improve the accuracy and reliability of the current stock assessment and the characterization 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 any additional information supporting management and policy development.

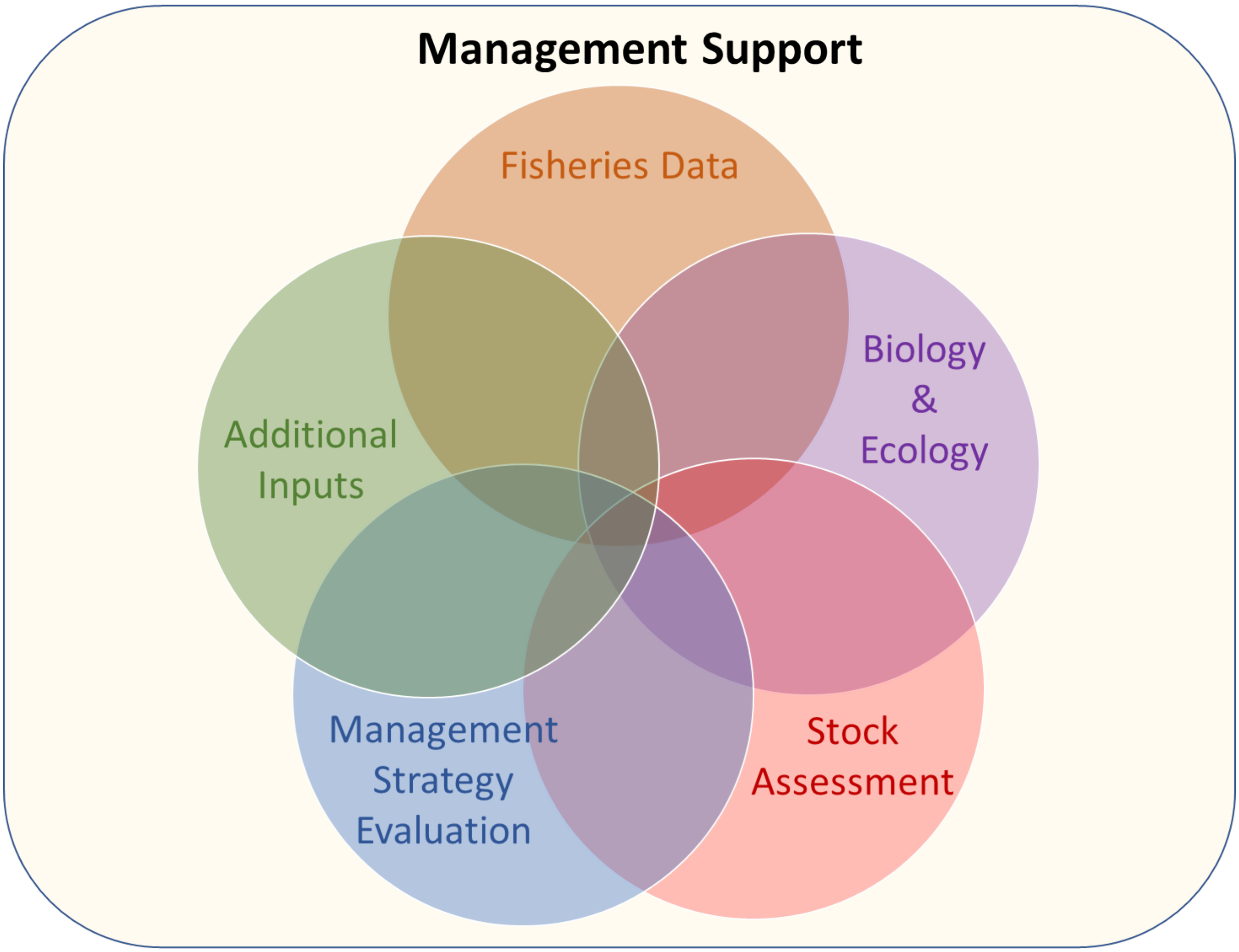

Figure 2. Core areas of the IPHC's program of integrated research and monitoring providing management support.

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 (2019-23)): 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 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, will be 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.

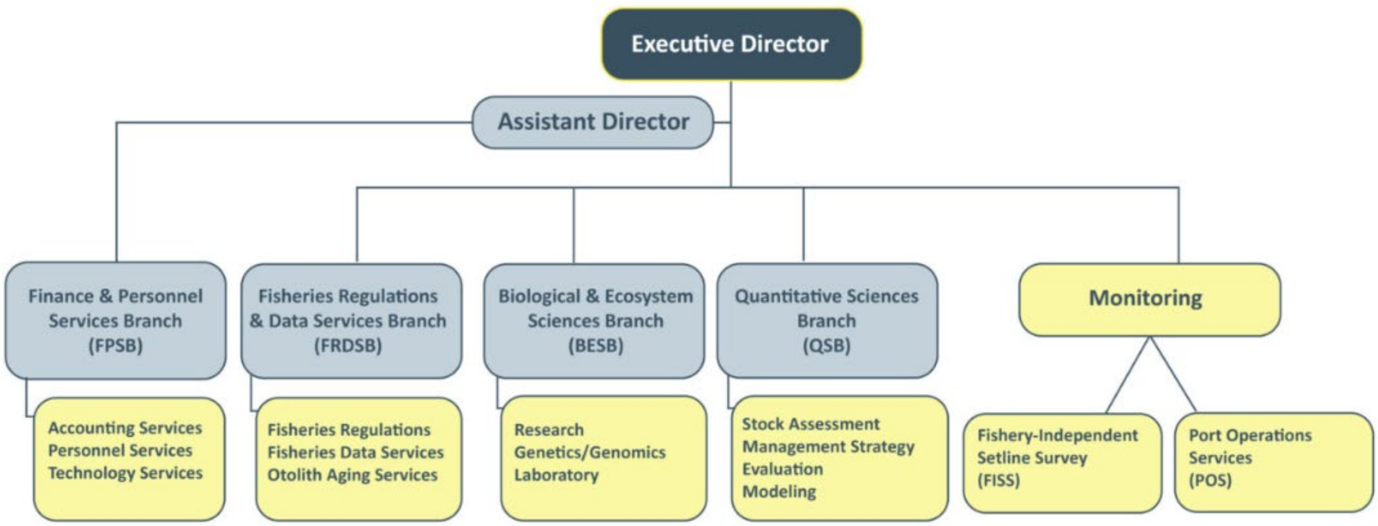

Figure 3. IPHC Secretariat organisation chart (2023).

4. *Measures of Success*

The Secretariat's success in implementing the *IPHC 5-Year Program of Integrated Research and Monitoring (2022-26)* 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, analyzed, 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 - did the research improve the perceived accuracy of the stock assessment, MSE or decisions made by the commission?
4) Impact – did the research allow for more precision or 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 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 IPHC 5-Year Program of Integrated Research and Monitoring (2022-2026) 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) Social media outlets (e.g. Facebook, Twitter, LinkedIn, etc.);
7) Informal presentations and interactions with partners, stakeholders, and decision-makers at varied times and venues when needed.

4.3 External research funding

The Secretariat has set a funding goal of at least 20% of the funds for this program to be sourced from external funding bodies on an annual basis. Continuing the successful funding-recruitment strategy adopted during the previous 5-yr research plan (IPHC–2019–BESRP-5YP) (Appendix I), the Secretariat will identify and select external funding opportunities that are timely and that aim at addressing key research objectives (as outlined in Appendix II and summarized in Appendix V) 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 capitalize 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.

4.4 Peer-reviewed journal publication

Publication of research outcomes in peer-reviewed journals will be clearly documented and monitored as a 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 goals of the main activities of the *5-Year program of integrated research and monitoring (2022-26)* are integrated across the organisation, involving 1) monitoring (fisheries-dependent and –independent data collection), and 2) research (biological, ecological), modelling (FISS and stock assessment), and MSE, as outlined in the following sub-sections. These components are closely linked to one another, and all feed into management decision-making (Fig. 4). Additionally, management-supporting information constitute a range of additional decision-making drivers 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 2017-21 5-Year Biological and Ecosystem Science Research Plan (IPHC–2019–BESRP-5YP), and which is summarized in Appendix I.

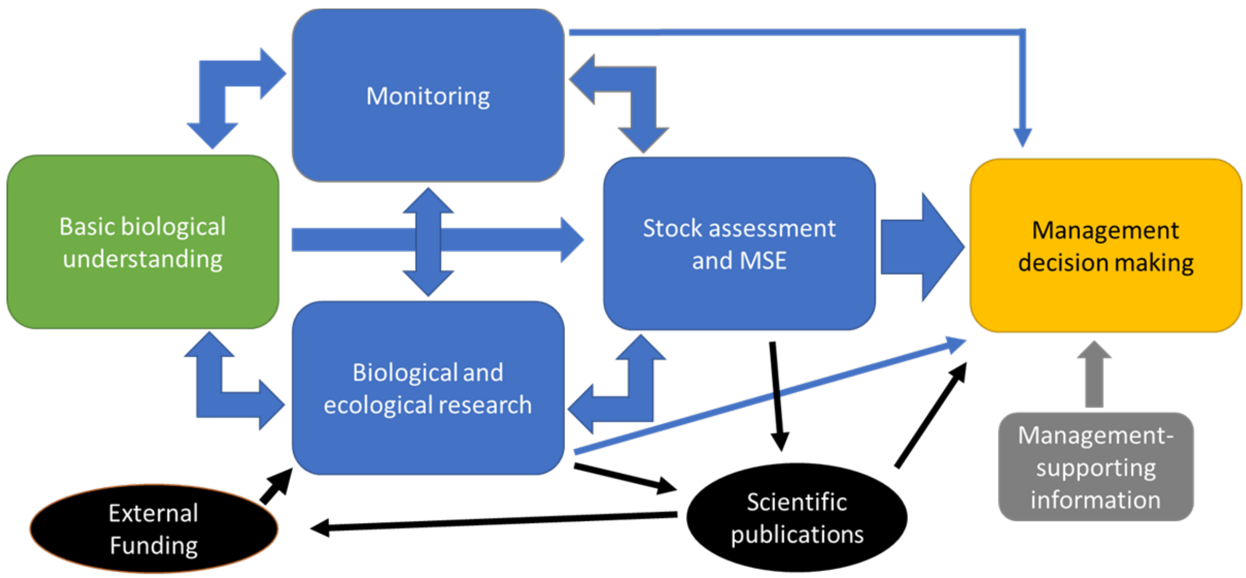

Figure 4. Flow of information from basic biological understanding of the Pacific halibut resource, through IPHC research components (monitoring, biological and ecological research, stock assessment, and MSE) to management decision-making. Management-supporting information (grey) constitute a range of 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 accuracy and reliability of the current stock assessment and the characterization 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 fisheries, as well biological information from its research program. 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.

The 2021 stock assessment 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 which provides a direct tool for the management process. 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 four categories:

1) Assessment data collection and processing;
2) technical development;
3) biological inputs; and
4) fishery yield.

It is important to note that ongoing monitoring, including the annual FISS and directed commercial landings sampling programs 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 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.
IPHC Website portal	https://www.iphc.int/management/science-and-research/management-strategy-evaluation

Management Strategy Evaluation (MSE) is a process to evaluate the consequences of 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.

MSE is a simulation technique based on modelling each part of a management cycle. The MSE uses an operating model to simulate the entire population and all fisheries, factoring in management decisions, the monitoring program, the estimation model, and potential ecosystem effects using a closed-loop simulation.

Undertaking an MSE has the advantage of being able to reveal the trade-offs among a range of possible management decisions. Specifically, to provide the information on which to base a rational decision, given harvest strategies, preferences, and attitudes to risk. The MSE is an essential part of the process of developing, evaluating and agreeing to a harvest strategy.

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 tasks that would continue to improve the MSE framework and the presentation of future results to the Commission. The tasks can be divided into five general categories, which are common to MSE in general:

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 will not only inform the Commission on trade-offs between harvest strategies and assist in choosing an optimal strategy for management of the Pacific halibut resource but will inform the prioritization of research activities related to fisheries monitoring, biological and ecological research, stock assessment, and fishery socioeconomics.

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/management/science-and-research/biological-and-ecosystem-science-research-program-bandesrp

Since its inception, the IPHC has had a long history of research activities devoted to describe and understand the biology of the Pacific halibut. At present, the main objectives of the Biological and Ecosystem Science Research Program at 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 fishery; and 3) apply the resulting knowledge to reduce uncertainty in current stock assessment models.

The primary biological research activities at the IPHC that follow Commission objectives and that are selected for their important management implications are identified and described in the proposed IPHC 5-Year Program of Integrated Research and Monitoring (2022-2026). An overarching goal of the 5-Year Program of Integrated Research and Monitoring (2022-2026) 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 5-Year Program of Integrated Research and Monitoring (2022-2026) are therefore aligned and integrated with the IPHC stock assessment and MSE processes. The IPHC Secretariat conducts research activities to address key biological issues based on the IPHC Secretariat's own input as well as input from the IPHC Commissioners, stakeholders and particularly from specific subsidiary bodies to the IPHC, including the Scientific Review Board (SRB) and the Research Advisory Board (RAB).

The biological research activities contemplated in the 5-Year Program of Integrated Research and Monitoring (2022-2026) 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, skipped spawning, reproductive migrations); and 3) resulting changes in population dynamics. Furthermore, the research activities of IPHC also aim to provide information on the survival of regulatory-discarded Pacific halibut in the directed fisheries with the objective to refine current estimates of discard mortality rates and develop best handling practices, and reduce whale depredation and Pacific halibut bycatch through gear modifications and through a better understanding of behavioral and physiological responses of Pacific halibut to fishing gear. The proposed timeline of activities and of staffing and funding indicators are provided in Appendix VI and Appendix VII, respectively.

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/datatest/commercial-fisheries • https://www.iphc.int/data/datatest/pacific-halibut-recreational-fisheries-data • https://www.iphc.int/datatest/subsistence-fisheries • https://www.iphc.int/data/time-series-datasets ***Fishery-independent data:*** • https://www.iphc.int/management/science-and-research/fishery-independent-setline-survey-fiss • https://www.iphc.int/data/datatest/fishery-independent-setline-survey-fiss • https://www.iphc.int/datatest/data/water-column-profiler-data

5.2.1 Fishery-dependent data

The IPHC estimates all Pacific halibut removals taken in the IPHC Convention Area and uses this information in its yearly stock assessment and other analyses. The data are compiled by the IPHC Secretariat and include data from 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). A sampling rate is determined for each port by IPHC Regulatory Area. The applicable rate is calculated from the current year's mortality limits and estimated percentages of weight of fish landed, and estimated percentages of weight sampled in that port to allow for collection of the target number of biological samples by IPHC Regulatory Area. An example of the data collected and the methods used are provided in the annually updated directed commercial sampling manual (e.g. IPHC Directed Commercial Landings Sampling Manual 2022). Directed commercial fishery landings are recorded by the Federal and State agencies of each Contracting Party and summarized each year by the IPHC. Discard mortality for the directed commercial fishery is currently estimated using a combination of research survey (U.S.A.) and observer data (Canada).

5.2.1.2 Non-directed commercial discard mortality data

The IPHC accounts for non-directed commercial discard mortality by IPHC Regulatory Area and sector. Non-directed commercial discard mortality estimates 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 have 100% monitoring and not all Pacific halibut that are discarded are assumed to die. The IPHC relies upon information supplied by observer programs run by Contracting Party agencies for non-directed commercial discard mortality estimates in most fisheries. Non-IPHC research survey information or other sources are used to generate estimates of non-directed commercial discard mortality in the few cases where fishery observations are unavailable. Non-directed fisheries off Canada British Columbia are monitored and discard mortality information is provided to IPHC by DFO. NOAA Fisheries operates observer programs off the USA West Coast and Alaska, which monitor the major groundfish fisheries. Data collected by those programs are used to estimate non-directed commercial discard mortality.

5.2.1.3 Subsistence fisheries data

Subsistence fisheries are non-commercial, customary, and traditional use of Pacific halibut for direct personal, family, or community consumption or sharing as food, or customary trade. The primary subsistence fisheries are 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 by rural residents and federally recognized native tribes in Alaska (USA) documented via Subsistence Halibut Registration Certificates (SHARC). Subsistence fishery removals of Pacific halibut, including estimated subsistence discard mortality, are provided by State and Federal agencies of each Contracting Party, estimated, and compiled annually for use in the stock assessment and other analysis.

5.2.1.4 Recreational fisheries data

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

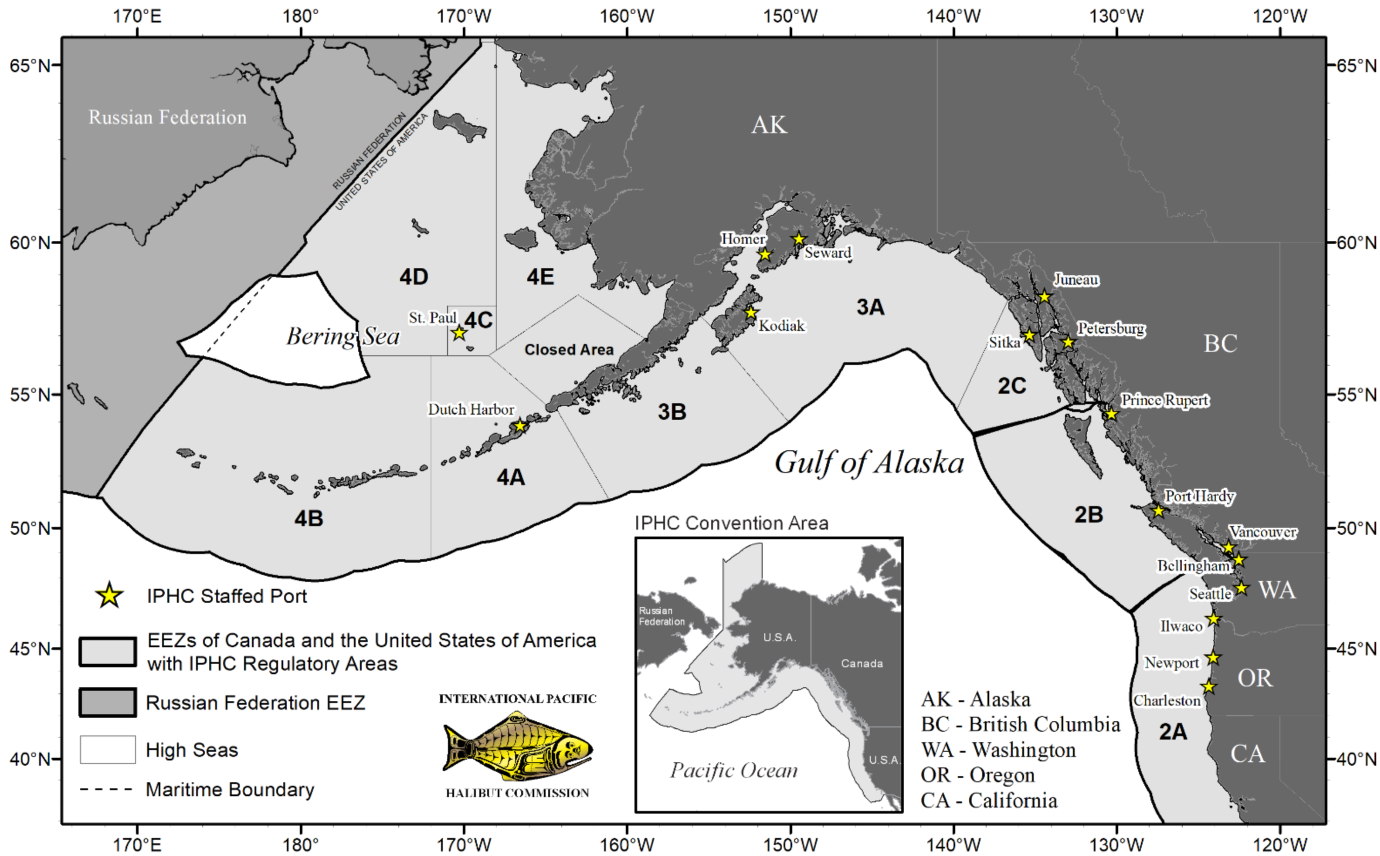

Figure 5. Ports where the IPHC has sampled directed commercial landings throughout the fishing period in recent years (note: ports sampled may change from year-to-year for operational reasons).

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 fishery. These data, collected using standardized 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 the commercial fishing grounds in the Pacific halibut fishery, and almost all known Pacific halibut habitat in Convention waters outside the Bering Sea. The standard FISS grid totals 1,890 stations (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 biomass, growth, and mortality. In addition, records of non-target species caught during FISS operations provide insight into bait competition, and serve as an index of 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 co-variates in space-time modeling used in the stock assessment. An example of the data collected and the methods used are provided in the annually updated FISS sampling manual (e.g. IPHC FISS Sampling Manual 2022).

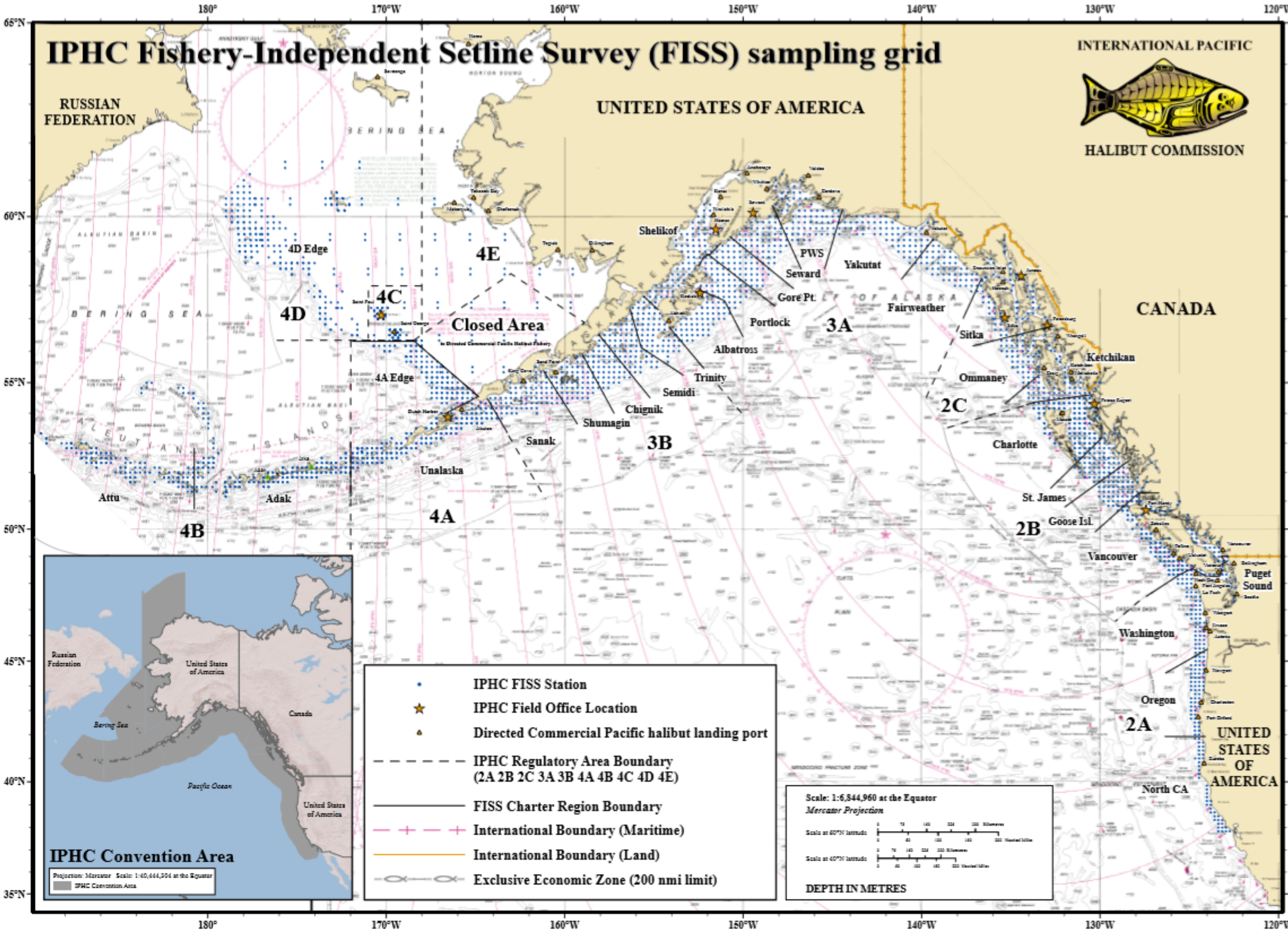

Figure 6. IPHC Fishery-Independent Setline Survey (FISS) with full sampling grid shown.

Quality control and sampling rate estimations: Following a program of planned FISS expansions from 2014-19, a process of rationialisation of the FISS was undertaken. The goal was to ensure that, given constraints on resources available for implementing the FISS, station selection was such that density indices would be estimated with high precision and low potential for bias. An annual design review process has been developed during which potential FISS designs for the subsequent three years are evaluated according to precision and bias criteria. The resulting proposed designs and their evaluation are presented for review at the June Scientific Review Board (SRB) meetings and potentially modified following SRB input 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 has participated routinely in the NOAA Fisheries trawl surveys operating in the Bering Sea (Fig. 7, annually since 1998), Aleutian Islands (intermittently since 1997) and Gulf of Alaska (since 1996). The information collected from Pacific halibut caught on these surveys, together with data from the IPHC Fishery-Independent Setline Survey (FISS) and commercial Pacific halibut data, are used directly in estimating indices of abundance and in the stock assessment and to monitor population trends, growth/size, and to supplement understanding of recruitment, distribution, and age composition of young Pacific halibut.

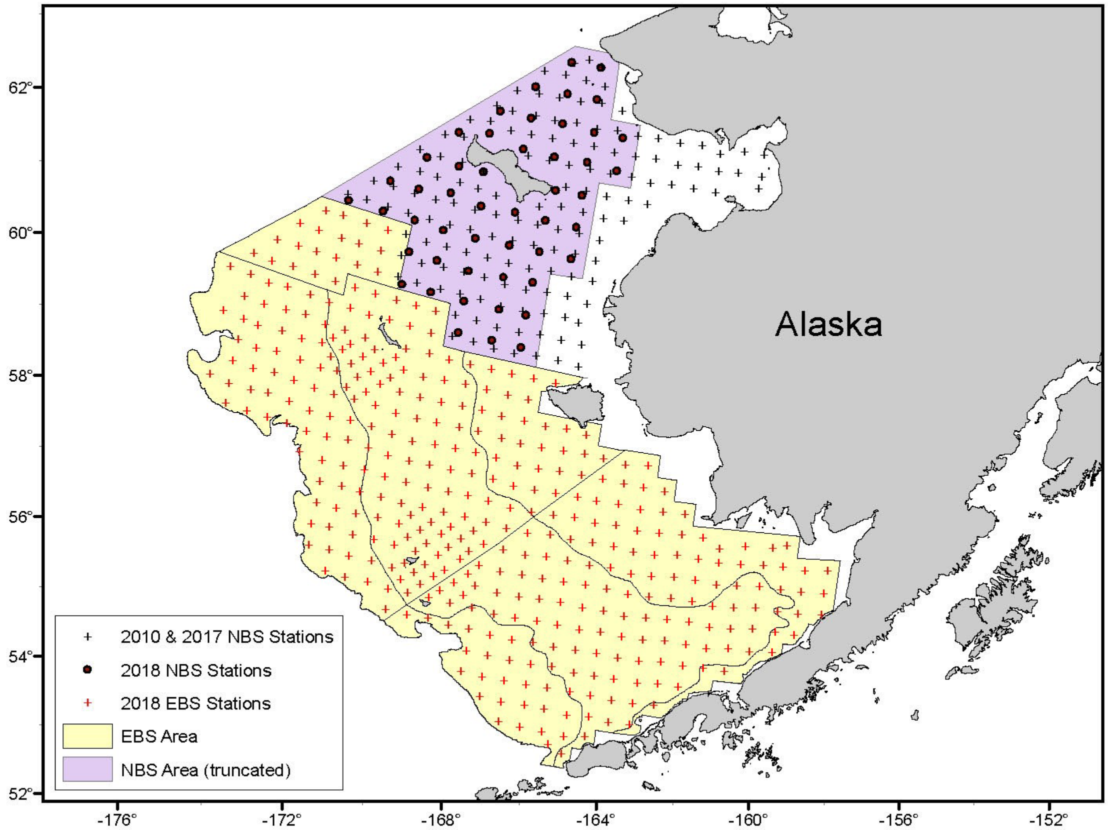

Figure 7. Sampling station design for the 2018 NOAA Bering Sea bottom trawl survey. Black dots are stations sampled in the 2018 "rapid-response" Northern Bering Sea trawl survey and black plus signs are stations sampled in standardized Northern Bering Sea trawl survey.

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 4E.

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

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

5.3 Management-supporting information

Successful fisheries management requires rigorous application of the scientific method of problem solving in the development of strategic alternatives and their evaluation on the basis of objectives that integrate ecosystem and human dynamics across space and time into management decision-making (Lane and Stephenson, 1995). This underscores the importance of a holistic understanding of a broad range of factors to deliver on the Commission's objective to develop the stocks of Pacific halibut to the levels that permit the optimum yield from the fishery over time. Management-supporting information beyond IPHC's current research and monitoring programs relate to, among others, socioeconomic considerations, community development, political constraints, and operational limitations.

Responding to the Commission's "*desire for more comprehensive economic information to support the overall management of the Pacific halibut resource in fulfillment of its mandate*" (economic study terms of reference adopted at FAC095 and endorsed at AM095 in 2019), between 2019 and 2021 the IPHC conducted a socioeconomic study. The study's core product, Pacific halibut multiregional economic impact assessment (PHMEIA) model, describes 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 (see project report). The model details the within-region production structure of the Pacific halibut sectors (fishing, processing, charter) and cross-regional flows of economic benefits. The model also accounts for economic activity generated through sectors that supply fishing vessels, processing plants, and charter businesses with inputs to production, by embedding Pacific halibut sectors into the model of the entire economy of Canada and the USA. The PHMEIA model fosters stakeholders' better understanding of a broad scope of regional impacts of the Pacific halibut resource. The results highlight that the harvest stage accounts for only a fraction of economic activity that would be forgone if the resource was not available to fishers in the Pacific Northwest. Moreover, the study informs on the vulnerability of communities to changes in the state of the Pacific halibut stock throughout its range, highlighting regions particularly dependent on economic activities that rely on Pacific halibut. Leveraging multiple sources of socioeconomic data, the project provides complementary input for designing policies with desired effects depending on regulators' priorities which may involve balancing multiple conflicting objectives. A good understanding of the localized effects is pivotal to policymakers who are often concerned about community impacts, particularly in terms of impact on employment opportunities and households' welfare.

The economic impact assessment is supplemented by an analysis of the formation of the price paid for Pacific halibut products by final consumers (end-users) that is intended to provide a better picture of Pacific halibut contribution to the gross domestic product (GDP) along the entire value chain, from the hook-to-plate. This supplemental material is available in IPHC's Pacific halibut market analysis.

6. Core focal areas – Planned and opportunistic activities (2022-2026)

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 four core focal areas: 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 has been working with IPHC advisory bodies, such as the Scientific Review Board (SRB), and the Commission to conduct scientific research in a way that utilizes the scientific method. Problems are often identified by an advisory body or Commission and hypotheses are developed by the IPHC Secretariat. Research is reviewed by the SRB and refined hypotheses are presented to advisory bodies and the Commission. This process occurs via an annual schedule of meetings, as shown in Fig. 8. In May, an MSE informational session may be held if there is significant progress in the MSE such that it would be useful to prepare stakeholders for the Management Strategy Advisory Board (MSAB) meeting in October. Recommendations related to the MSE, and development of a harvest strategy directed to the Commission are a result of the MSAB meeting. 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 and is a working session with 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 season 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.

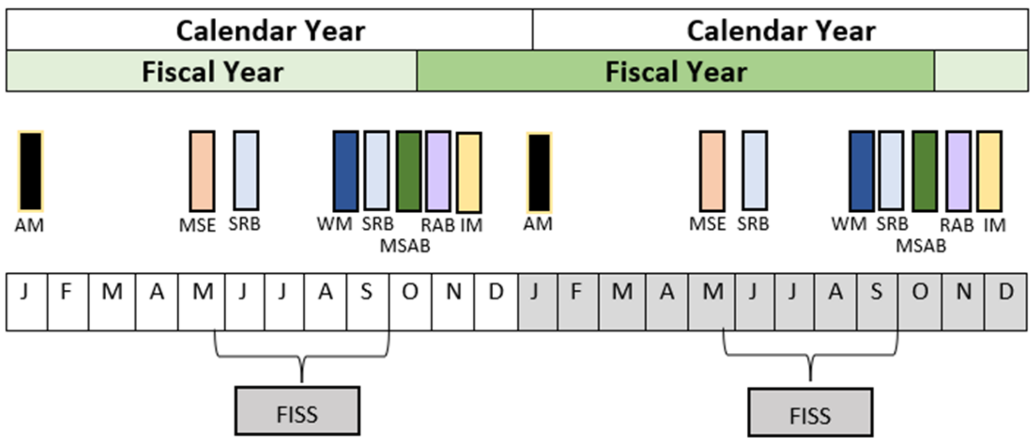

Figure 8. The typical IPHC annual meeting schedule with the calendar year and fiscal year shown. The meetings, shown in the middle row are: Annual Meeting where the Commission makes many final decisions for that year (AM), an MSE informational session (MSE), Scientific Review Board meetings (SRB), the 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 prioritize 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 four 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.

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 four years (2017-20) of commercial sex-ratio-at-age information available for the 2021 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. Development of approaches to use archived otoliths, scales or other samples to derive historical estimates (if possible) could provide valuable information on earlier time-periods (with differing fishery and biological properties), and therefore potentially reconcile some of the considerable historical uncertainty in the present stock assessment. 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 currently represents a source of unobserved and unaccounted-for mortality in the assessment and management of Pacific halibut. A logbook program has been phased in over the last several years, in order to record whale interactions observed by commercial harvesters. Estimation of depredation mortality, from logbook records and supplemented with more detailed data and analysis from the FISS represents a first step in accounting for this source of mortality; however, such estimates will likely come with considerable uncertainty. Reduction of depredation mortality through improved fishery avoidance and/or catch protection would be a preferable extension and/or solution to basic estimation. As such, research to provide the fishery with tools to reduce depredation is considered a closely-related high priority. This assessment priority directly informs *6.1.3.4 Mortality and Survival Assessment* 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 Data weighting

The stock assessment currently relies on iterative "Francis" weighting of the age compositional data using a multinomial likelihood formulation (Francis 2011) based on the number of samples available in each year. Exploration of a stronger basis for input sample sizes through analysis of sampling design, estimation of sample weighting and alternative likelihoods may all provide for a more stable approach and a better description of the associated uncertainty.

6.1.1.2.3 Environmental covariates to recruitment

The two long time-series models included in the stock assessment ensemble allow for the Pacific Decadal

Oscillation (PDO; Mantua et al. 1997) to be a binary covariate indicating periods of higher or lower average recruitment. This relationship has been observed to be consistent since its development over 20 years ago (Clark et al 1999) and is re-estimated in each year's stock assessment models. With additional years of data, evaluation of the strength of this relationship, as compared to other metrics of the PDO (e.g., annual deviations, running averages) or other indicators of NE Pacific Ocean productivity should be undertaken in order to provide the best estimates and projections of Pacific halibut recruitment and to provide for alternative hypotheses for use in the MSE. This assessment priority partially informs *6.1.3.2 Reproduction* as described below.

6.1.1.2.4 'Leading' parameter estimation

Stock assessments are generally very sensitive to the estimates of leading parameters (stock-recruitment parameters, natural mortality, sex-specific dynamics, etc.). For Pacific halibut some of these are fully integrated into the estimation uncertainty (average unexploited recruitment), or partially integrated (e.g. estimation of natural mortality in two of the four models). 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 integrate additional leading parameters directly in the assessment models and/or include them as nested models within the ensemble.

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). However, at present we have only historical time-aggregated estimates of maturity and fecundity schedules. Therefore, the current research priority is to first update our estimates for each of these traits to reflect current environmental and biological conditions. After current 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 Stock structure of IPHC Regulatory Area 4B relative to the rest of the convention area

The current stock assessment and management of Pacific halibut assume that IPHC Regulatory Area 4B is functionally connected with the rest of the stock, i.e., that recruitment from other areas can support harvest in Area 4B and that biomass in Area 4B can produce recruits that may contribute to other Areas. Tagging (Webster et al. 2013) and genetic (Drinan et al. 2016) analyses have indicated the potential for Area 4B to be demographically isolated. An alternative to current assessment and management structure would be to treat Area 4B separately from the rest of the coast. This would not likely have a large effect on the coastwide stock assessment as Area 4B represents only approximately 5% of the surveyed stock (Stewart and Webster 2022). However, it would imply that the specific mortality limits for Area 4B could be very important to local dynamics and should be separated from stock-wide trends. Therefore, information on the stock structure for Area 4B has been identified as a top priority. This assessment priority directly informs *6.1.3.1 Migration and Population Dynamics* as described below.

6.1.1.3.3 Meta-population dynamics (connectivity) of larvae, juveniles, and adults

The stock assessment and current management procedure treat spawning output, juvenile Pacific halibut abundance, and fish contributing to the fishery yield as equivalent across all parts of the Convention Area. Information on the connectivity of these life-history stages could be used for a variety of improvements to the assessment and current management procedure, including: investigating recruitment covariates, structuring spatial assessment models, identifying minimum or target spawning biomass levels in each Biological Region, refining the stock-recruitment relationship to better reflect source-sink dynamics and many others. Spatial dynamics have been highlighted as a major source of uncertainty in the Pacific halibut assessment for decades and will continue to be of high priority until they are better understood. This assessment priority directly informs *6.1.3.1 Migration and Population Dynamics* as described below.

6.1.1.4 Stock Assessment fishery yield

6.1.1.4.1 Biological interactions with fishing gear

In 2020, 16% of the total fishing mortality of Pacific halibut was discarded (Stewart et al. 2021). Discard mortality rates can vary from less than 5% to 100% depending on the fishery, treatment of the catch and other factors (Leaman and Stewart 2017). A better understanding of the biological underpinnings for discard mortality could lead to increased precision in these estimates, avoiding potential bias in the stock assessment. Further, improved biological understanding of discard mortality mechanisms could allow for reductions in this source of fishing mortality, and thereby increased yield available to the fisheries. This assessment priority directly informs *6.1.3.4 Mortality and Survival Assessment* as described below.

6.1.1.4.2 Guidelines for reducing discard mortality

Much is already known about methods to reduce discard mortality, in non-directed fisheries as well as the directed commercial and recreational sectors. Promotion and adoption of best handling practices could reduce discard mortality, lead to greater retained yield, and reduce the potential uncertainty associated with large quantities of estimated mortality due to discarding. This assessment priority directly informs *6.1.3.4 Mortality and Survival Assessment* as described below.

Outside of the four general assessment categories, the IPHC has recently considered adding close-kin genetics (e.g., Bravington et al. 2016) to its ongoing research program (see section 6.1.3.1). Close-kin mark-recapture can potentially provide estimates of the absolute scale of the spawning output from the Pacific halibut population. This type of information can be fit directly into the stock assessment, and if estimated with a reasonable amount of precision, even a single data point could substantially reduce the uncertainty in the scale of total population estimates. Further, close-kin genetics may provide independent estimates of total mortality (and therefore natural mortality conditioned on catch-at-age), relative fecundity-at-age, and the spatial dynamics of spawning and recruitment. All of these quantities could substantially improve the structure of the current assessment and reduce uncertainty. Data collection of genetic samples from 100% of the sampled commercial landings has been in place since 2017 (as part of the sex-ratio monitoring) and from the FISS since 2021. The genetic analysis required to produce data allowing the estimation of reproductive output and other population parameters from close-kin mark-recapture modelling is both complex and expensive, and it could take several years for this project to get fully underway. This five-year plan should consider a pilot evaluation, such that a broader study could be undertaken in the future, providing the likely results would meet the Commission's objectives and prove possible given financial constraints. Research related to close-kin genetics would be pursued under *6.1.3.1 Migration and Population Dynamics* as described below.

6.1.2 Management Strategy Evaluation

MSE priorities have been subdivided into three categories: 1) biological parameterisation, 2) fishery parameterization, 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 parameterization

6.1.2.1.1 Distribution of life stages and stock connectivity

Research topics in this category will mainly inform parameterization of movement in the OM, but will also provide further understanding of Pacific halibut movement, connectivity, and the temporal variability. This knowledge may also be used to refine specific MSE objectives to reflect reality and plausible outcomes. Research under Section 6.1.3.1 will inform this MSE priority.

This research includes examining larval and juvenile distribution which is a main source of uncertainty in the OM that is currently not fully incorporated. Outcomes 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.

Also included in this number one priority is stock structure research, especially regarding IPHC Regulatory Area 4B. The dynamics of this IPHC Regulatory Area are not fully understood and it is useful to continue research on the connectivity of IPHC Regulatory Area 4B with other IPHC Regulatory Areas.

Finally, genomic analysis of population size is also included in this ranked category because that would help inform 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 Spatial spawning patterns and connectivity between spawning populations

An important parameter that can influence simulation outcomes is the distribution of recruitment across Biological Regions. Continued research in this area will improve the OM and provide justification for parameterising temporal variability. Research includes assigning individuals to spawning areas and establishing temporal and spatial spawning patterns. Outcomes may also provide information on recruitment strength and the relationship with environmental factors. For example, recent work by Sadorus et al (2020) used a biophysical and spatio-temporal models to examine connectivity across the Bering Sea and Gulf of Alaska. Furthermore, close-kin mark-recapture (Bravington et al. 2016) may provide insights into spatial relationships between juveniles and adults as well as abundance in specific regions. Research under Sections 6.1.3.1 and 6.1.3.2 will inform this MSE priority.

6.1.2.1.3 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.

6.1.2.1.4 MSE fishery parameterization

The specifications of fisheries and their parameterizations involved consultation with Pacific halibut stakeholders but some aspects of those parameterizations 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 and 6.1.3.5 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. 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 stock assessment, which will then be informed by investigations using the closed-loop simulation framework. Multi-year assessments 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) realized 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 not implemented in the MSE framework but has been requested by the SRB and the independent peer review of the MSE. Realized uncertainty is the difference between the mortality limit set by the Commission and the actual mortality realized by the various fisheries. This type of uncertainty is currently partially implemented in the MSE framework. Finally, perceived uncertainty is the difference between the realized 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. Implementing decision-making uncertainty is a priority for the MSE and will assist in understanding the performance of management procedures when they may not be followed exactly.

6.1.2.3 MSE Program of Work for 2021–2023

Following the 11th Special Session of the IPHC, an MSE program of work for 2021–2023 was developed. Seven tasks were identified that pertained to further developments of the MSE framework, evaluation of alternative MPs, and improvements in evaluation and presentation of results. Table 1 lists these tasks and provides a brief description. Additional details can be found in the program of work available on the MSE webpage.

Table 1. Tasks recommended by the Commission at SS011 (IPHC-2021-SS011-R para 7) for inclusion in the IPHC Secretariat MSE Program of Work for 2021–23.

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

6.1.2.4 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 Program of Work (Table 1) focuses on two elements of Management Procedures, but in the future other elements may be of interest, such as distribution procedures. 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

Capitalizing on the outcomes of the previous 5-year plan (IPHC–2019–BESRP-5YP) (Appendix I), the IPHC Secretariat has identified five research areas that will provide key inputs for stock assessment and the MSE process. In addition to linking genetics and genomics with migration and distribution studies in the newly coined area of Migration and Population Dynamics, the IPHC Secretariat has incorporated a novel research area on Fishing Technology. A series of key objectives for each of the five research areas have been identified that integrate with specific needs for stock assessment and MSE processes and that are ranked according to their relevance (Appendix II). 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 IPHC 5-Year Program of Integrated Research and Monitoring (2022-2026) are provided in Appendix III and Appendix IV.

6.1.3.1 Migration and Population Dynamics

Genetic and genomic studies 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 (specifically excluding satellite tagging). Specific objectives in this area include:

- Improve current knowledge of the genetic structure of the Pacific halibut population through the use of state-of-the-art low-coverage whole genome resequencing approaches. Establishment of genetic signatures of spawning sites.
- Improve our understanding of the mechanisms and magnitude of larval connectivity in the North Pacific Ocean. Identification of environmental and biological predictors of larval abundance and recruitment.
- Improve our understanding of spawning site contributions to nursery/settlement areas in relation to year-class, recruit survival and strength, and environmental conditions in the North Pacific Ocean. Measure of genetic diversity of Pacific halibut juveniles from the eastern Bering Sea and the Gulf of Alaska.
- Improve our understanding of the relationship between nursery/settlement origin and adult distribution and abundance over temporal and spatial scales. Genomic assignment of individuals to source populations and assessment of distribution changes.
- Integrate analyses of Pacific halibut connectivity and distribution changes by incorporating genomic approaches.
- Improve estimates of population size, migration rates among geographical regions, and demographic parameters (e.g. fecundity-at-age, survival rate), through the application of close-kin mark-recapture-based 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.
- Exploration and development of alternative methods for aging Pacific halibut based on genetic analyses of DNA methylation patterns in tissues (fin clips).
- Exploration of methods for individual identification based on computer-assisted tail image matching systems as an alternative for traditional mark and recapture tagging.

6.1.3.2 Reproduction

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

- Continued improvement of genetic methods for accurate sex identification of commercial landings from fin clips and otoliths in order to incorporate recent and historical sex-at-age information into the stock assessment process.
- Improve our understanding of the temporal progression of reproductive development and gamete production during an entire annual reproductive cycle in female and male Pacific halibut.
- Update current maturity-at-age estimates.
- Provide estimates of fecundity-at-age and fecundity-at-size.
- Investigate the possible presence of skip spawning in Pacific halibut females.

- Improve accuracy in 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 potential temporal and spatial changes in maturity schedules and spawning patterns in female Pacific halibut and possible environmental influences.
- 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.

6.1.3.3 **Growth**

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:

- Evaluate possible variation in somatic growth patterns in Pacific halibut as informed by physiological growth markers, physiological condition, energy content and dietary influences.
- Investigate the effects of environmental and ecological conditions that may influence somatic growth in Pacific halibut. Evaluate the relationship between somatic growth and temperature and trophic histories in Pacific halibut through the integrated use of physiological growth markers.
- Improve our understanding of the genetic basis of variation in somatic growth and size-at-age by conducting genome-wide association studies.

6.1.3.4 Mortality and Survival Assessment

Studies aimed at providing updated estimates of discard mortality rates (DMRs) for Pacific halibut in the guided recreational fisheries and at evaluating methods for reducing mortality of Pacific halibut. Specific objectives in this area include:

- Provide information on the types of fishing gear and fish handling practices used in the Pacific halibut recreational (charter) fishery as well as on the number and size composition of discarded Pacific halibut in this fishery.
- Establish best handling practices for reducing discard mortality of Pacific halibut in recreational fisheries.
- Investigate new methods for improved estimation of depredation mortality from marine mammals.

6.1.3.5 Fishing Technology

Studies aimed at developing methods that involve modifications of fishing gear with the purpose of reducing Pacific halibut depredation and bycatch. Specific objectives in this area include:

- Investigate new methods for whale avoidance and/or deterrence for the reduction of Pacific halibut depredation by whales (e.g. catch protection methods).
- Investigate physiological and behavioral responses of Pacific halibut to fishing gear in order to reduce bycatch.

6.2 Monitoring

The Commission's extensive monitoring programs include both direct data collection and coordination with domestic agencies to produce both fishery-dependent and fishery-independent information on the stock and fishery trends, and other information. These critical sources include estimates of fishing mortality from 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 provide the basis for stock assessment and MSE analysis, many biological research studies, and some inputs directly to the decision-making process (Figure 4). While not the primary focus of this 5-year plan, a basic summary of the components led by the IPHC and those that are provided by domestic agencies is provided below.

6.2.1 Fishery-dependent data

Data collection and monitoring activities aimed at providing standardised time-series of mortality, fishery, and biological data from both direct target fisheries as well as fisheries that incidentally catch Pacific halibut. Directed commercial fisheries data are managed by IPHC. Non-directed commercial discard mortality data, subsistence fisheries data, and recreational fisheries data are managed by Contracting Party domestic agencies.

6.2.1.1 Directed commercial fisheries data

6.2.1.2 Annually review the spatial distribution of sampling effort among ports, data collection methods, sampling rates, and quality assurance/quality control (QAQC) processes, including in-season review of port sampling activities

Ensure current data collection efforts meet current and future needs of stock assessment, MSE and management. Collaborate and coordinate with other Secretariat functions to develop methods and procedures for incorporating promising research results into long-term monitoring program. The IPHC relies on domestic and Tribal agency programs to report annual mortality from incidental catches in non-directed commercial fisheries, catches from subsistence fisheries, and catches from recreational fisheries. Non-directed commercial discard mortality data

Annually collaborate with observer programs and other partners to ensure robust data collection and sampling, QAQC processes, and reporting of incidental catch and mortality, as well as biological sampling.

6.2.1.3 Subsistence fisheries data

Annually collaborate with Tribal, State and Federal agencies of each Contracting Party to ensure high quality data collection, sampling, and reporting in the subsistence fisheries in Canada and the United States of America.

6.2.1.4 Recreational fisheries data

Annually collaborate with National/State agencies of each Contracting Party to ensure and validate high quality data and reporting of recreational fishery mortality estimates and biological data.

6.2.2 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.

6.2.2.1 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 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.

Direct weighing of Pacific halibut has been integrated into the annual FISS sampling since 2019 and will continue into the future to ensure accurate estimation of WPUE and other weight-derived quantities. 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 point of data collection and during post-sampling review) will ensure high quality data from the FISS program. Procedures are reviewed annually.

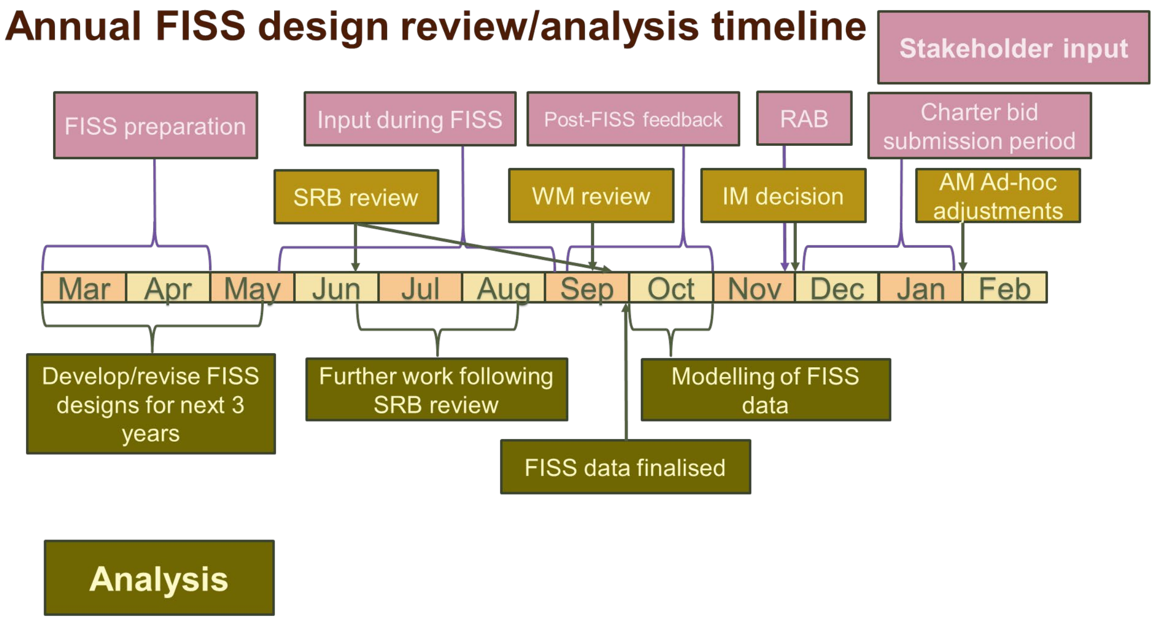

Figure 9. Timeline of annual FISS design review process.

6.2.2.2 Fishery-independent Trawl Survey (FITS)

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

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

The IPHC Secretariat is looking at options for supplementing current Pacific halibut ageing protocol with automatized ageing that does not require extensive otolith-reader training. The IPHC is investigating the potential use of artificial intelligence (AI) for determining the age of Pacific halibut from images of collected otoliths. The Secretariat is in the process of initializing creation of a database of pictures with expert-provided labels, utilizing previously aged otoliths, and assessing the option for the development of a Convolutional Neural Network (CNN) model specifically designed for image classification to determine Pacific halibut age. The goal is to create an AI-based age determination system that complements traditional methods for reliable fish stock assessment and management advice.

6.3 Potential of integrating human dynamics into management decision-making

The evolution of modern fisheries management is taking a transformative turn, emphasizing the integration of human dynamics into decision-making processes. As our world becomes more interconnected through globalization, understanding the intricate human dimension of the fisheries sector is emerging as a critical aspect of sustainable resource management. This forward-looking approach seeks to proactively address challenges while capitalizing on new opportunities.

In a global marketplace where local and imported products compete for consumer attention, vulnerability to disruptions, as evidenced by the COVID-19 pandemic (OECD 2020), has highlighted the need for adaptable strategies embracing the broader picture encompassing external influences. Recent IPHC's socioeconomic study underlines the far-reaching impacts of such dynamics, showcasing the income fluctuations experienced by households dependent on Pacific halibut during the pandemic. Acknowledging these complexities, there is a growing realization of the need for expanding the scope of management-supporting information the IPHC provides beyond stock condition.

The question of how small remote communities can capitalize on the high prices that the final customers are paying for premium seafood products demands innovative thinking. In 2021, fresh Alaskan Pacific halibut fillets routinely sold for USD 24-28 a pound, and often more, in downtown Seattle (e.g. USD 38 at Pike Place Market). Pacific halibut dishes at the restaurants typically sell for USD 37-43 for a dish including a 6oz fish portion. The IPHC's socioeconomic study detailed the geography of impacts of the Pacific halibut fisheries, providing a coherent picture of the exposure of fisheries-dependent households by location to changes in resource availability, but paying closer attention to quantifying leakage of economic benefits from communities strongly involved in fisheries, highlighted that the local earnings often do not align with how much fishing occurs within the community. This suggests the need for research focused on how to operationalize social equity in the context of the globalized market dynamics and the pursuit of stock sustainability.

In parallel, the accelerating impacts of climate change is placing fisheries at the forefront of environmental challenges. The rapid increase in water temperature off the coast of Alaska in 2014-16, termed *the blob*, exemplifies the changes that disrupt ecosystems and fisheries (Cheung and Frölicher 2020), and may have a long-term impact on Pacific halibut distribution. The consequences may include shifts in the distribution of benefits, but possibly go further, affecting the stability of agreements over allocation of a shared resource. Research on decision quality under fast-progressing climate-induced changes to stock distribution emerges as an avenue for impactful work.

Conflicting objectives among stakeholders regarding the use of limited resource in the context of globalization, calls for social equity and climate change are a major challenge of decision-making in fisheries management. Integrating approaches aimed at understanding the human dynamics and external factors with stock assessment and MSE can assist fisheries in bridging the gap between the current and the optimal performance without compromising the stock biological sustainability. For example, socioeconomic performance metrics presented alongside already developed biological/ecological performance metrics would supplement IPHC's portfolio of tools for assessing policy-oriented issues (as requested by the Commission, IPHC-2021-AM097-R, AM097-Req.02) and support decision-making. Moreover, continuing investment in understanding the human dimension of Pacific halibut fishing can also inform on other drivers such as human behavior or human organization that affect the dynamics of fisheries, and thus contribute to improved accuracy of the stock assessment and the MSE (Lynch et al.2018). As such, it can contribute to research integration at the IPHC and provide a complementary resource for the development of harvest control rules.

Lastly, Pacific halibut value is also in its contribution to the diet through subsistence fisheries and importance to the traditional users of the resource. To native people, traditional fisheries constitute a vital aspect of local identity and a major factor in cohesion. One can also consider the Pacific halibut's existence value as an iconic fish of the Pacific Northwest. Recognizing and adopting such an all-encompassing definition of the Pacific halibut resource contribution, the IPHC echoes a broader call to include the human dimension into the research on the impact of management decisions, as well as changes in environmental or stock conditions.

7. Amendment

The intention is to ensure the plan is kept as a '*living plan'*, that 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). The IPHC Secretariat is committed to ensuring an exceptional level of transparency and commitment to the principles of open science.

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APPENDICES

Appendix I: Outcomes of the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21)

Appendix II: Biological research areas in the 5-Year Program of Integrated Research and Monitoring (2022-2026) and ranked relevance for stock assessment and management strategy evaluation

Appendix III: List of ranked research priorities for stock assessment

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

Appendix V: Proposed schedule of outputs

Appendix VI: Proposed schedule with funding and staffing indicators

APPENDIX I

Outcomes of the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21) (IPHC–2019–BESRP-5YP)

A. Outcomes by Research Area:

1. Migration and Distribution.

1.1. Larval and juvenile connectivity and early life history studies. Planned research outcomes: improved understanding of larval and juvenile distribution.

Main results:

- Larval connectivity between the Gulf of Alaska and the Bering Sea occurs through large island passes across the Aleutian Island chain.
- The degree of larval connectivity between the Gulf of Alaska and the Bering Sea is influenced by spawning location.
- Spawning locations in the western Gulf of Alaska significantly contribute Pacific halibut larvae to the Bering Sea.
- Pacific halibut juveniles counter-migrate from inshore settlement areas in the eastern Bering Sea into the Gulf of Alaska through Unimak Pass.
- Elemental signatures of otoliths from juvenile Pacific halibut vary geographically at a scale equivalent to IPHC regulatory areas.

Publications:

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.

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.

Links to 5-Year Research Plan (2022-2026):

- Evaluate the level of genetic diversity among juvenile Pacific halibut in the Gulf of Alaska and the Bering sea due to admixture.
- Assignment of individual juvenile Pacific halibut to source populations.

Integration with Stock Assessment and MSE: The relevance of research outcomes from activities in this research area for stock assessment is 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. The relevance of these research outcomes for MSE is in the improvement of the parametrization of the Operating Model and represent the top ranked biological input into the MSE.

2. Reproduction.

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

Main results:

- Establishment of TaqMan-based genetic assays for genotyping Pacific halibut in the IPHC Biological Laboratory.
- Sex ratio information for the 2017-2020 commercial landings.
- Transfer of genotyping efforts for sex identification to IPHC monitoring program.

Links to 5-Year Research Plan (2022-2026):

- Monitoring effort.

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

Main results:

- Oocyte developmental stages have been characterized and fully described in female Pacific halibut for the first time.
- Oocyte developmental stages have been used for the classification of female developmental stages and to be able to characterize female Pacific halibut as group synchronous with determinate fecundity.
- Female developmental stages have been used for the classification of female reproductive phases and to be able to characterize female Pacific halibut as following an annual reproductive cycle with spawning in January and February.
- Female developmental stages and reproductive phases of females collected in the central Gulf of Alaska have been used to identify the month of August as the time of the transition between the Vtg2 and Vtg3 developmental stages marking the beginning of the spawning capable reproductive phase.
- Future gonad collections for revising maturity schedules and estimating fecundity can be conducted in August during the FISS.

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.

Links to 5-Year Research Plan (2022-2026):

- Revision of maturity schedule by gonad collection during the FISS, as informed by previous studies on reproductive development.

- Estimation of fecundity by age and size, as informed by previous studies demonstrating determinate fecundity.

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.

Main results:

- Transcriptomic profiling by RNAseq of white skeletal muscle from juvenile Pacific halibut subjected to growth suppression and to growth stimulation resulted in the identification of a number of genes that change their expression levels in response to growth manipulations.
- Proteomic profiling by LC-MS/MS of white skeletal muscle from juvenile Pacific halibut subjected to growth suppression and to growth stimulation resulted in the identification of a number of proteins that change their abundance in response to growth manipulations.
- Genes and proteins that changed their expression levels in accordance to changes in the growth rate in juvenile Pacific halibut were selected as putative growth markers for future studies on growth pattern evaluation.

Publications:

Planas et al. 2022. In Preparation.

Links to 5-Year Research Plan (2022-2026):

- Application of identified growth markers in studies aiming at investigating environmental influences on growth patterns and at investigating dietary influences on growth patterns and physiological condition.

3.2 Environmental influences on growth patterns. Planned research outcomes: information on growth responses to temperature variation.

Main results:

- Laboratory experiments under controlled temperature conditions have shown that temperature affects the growth rate of juvenile Pacific halibut through changes in the expression of genes that regulate growth processes.

Publications:

Planas et al. 2022. In Preparation.

Links to 5-Year Research Plan (2022-2026):

- Identification of temperature-specific responses in skeletal muscle through comparison between transcriptomic responses to temperature-induced growth changes and to density- and stress-induced growth changes.
- Application of growth markers for additional studies investigating the link between environmental variability and growth patterns and the effects of diet (prey quality and abundance) on growth and physiological condition.

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: experimentally-derived DMR.

Main results:

- Different hook release methods used in the longline fishery result in specific injury profiles and viability classification.
- Plasma lactate levels are high in Pacific halibut with the lowest viability classification.
- Mortality of discarded fish with the highest viability classification is estimated to be between 4.2 and 8.4%.

Publications:

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; doi:10.1093/conphys/coab001.

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

Links to 5-Year Research Plan (2022-2026):

- Integration of information on capture and handling conditions, injury and viability assessment and physiological condition will lead to establishing a set of best handling practices in the longline fishery.

4.2 Discard mortality rate estimation in the guided recreational Pacific halibut fishery. Planned research outcomes: experimentally-derived DMR.

Main results:

- Field experiments testing two different types of gear types (i.e. 12/0 and 16/0 circle hooks) resulted in the capture, sampling and tagging of 243 Pacific halibut in IPHC Regulatory Area 2C (Sitka, AK) and 118 in IPHC Regulatory Area 3A (Seward, AK).
- The distributions of fish lengths by regulatory area and by hook size were similar.

Links to 5-Year Research Plan (2022-2026):

- Estimation of discard mortality rate in the guided recreational fishery.
- Integration of information on capture and handling conditions, injury and viability assessment and physiological condition linked to survival.
- Establishment of a set of best handling practices in the guided recreational fishery.

Integration with Stock Assessment and MSE: The relevance of research outcomes from these activities for stock assessment resides in their ability to improve 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 parametrization

5. Genetics and genomics.

5.1 Generation of genomic resources for Pacific halibut. Planned research outcomes: sequenced genome and reference transcriptome.

Main results:

- A first draft of the chromosome-level assembly of the Pacific halibut genome has been generated.
- The Pacific halibut genome has a size of 602 Mb and contains 24 chromosome-size scaffolds covering 99.8% of the complete assembly with a N50 scaffold length of 27 Mb at a coverage of 91x.
- The Pacific halibut genome has been annotated by NCBI and is available as NCBI Hippoglossus stenolepis Annotation Release 101 (https://www.ncbi.nlm.nih.gov/assembly/GCA_022539355.2/).
- Transcriptome (i.e. RNA) sequencing has been conducted in twelve tissues in Pacific halibut and the raw sequence data have been deposited in NCBI's Sequence Read Archive (SRA) under the bioproject number PRJNA634339 (https://www.ncbi.nlm.nih.gov/bioproject/PRJNA634339) and with SRA accession numbers SAMN14989915 - SAMN14989926.

Publications:

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. In Press*. doi: https://doi.org/10.1111/1755-0998.13641.

Jasonowicz et al. 2022. In Preparation.

Links to 5-Year Research Plan (2022-2026):

- Genome-wide analysis of stock structure and composition.

5.2 Determine the genetic structure of the Pacific halibut population in the Convention Area. Planned research outcomes: genetic population structure.

Main results:

- The collection of winter genetic samples in the Aleutian Islands completed the winter sample collection needed to conduct studies on the genetic population structure of Pacific halibut in the Convention Area.
- Initial results of low coverage whole genome resequencing of winter samples indicate that an average of 26.5 million raw sequencing reads per obtained per sample that provided average individual genomic coverages for quality filtered alignments of 3.2x.

Links to 5-Year Research Plan (2022-2026):

- Fine-scale delineation of population structure, with particular emphasis on IPHC Regulatory 4B structure.

Integration with Stock Assessment and MSE: The relevance of research outcomes from these activities for stock assessment resides 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 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 stock assessment. Furthermore, the relevance of these research outcomes for MSE is in biological parametization and validation of movement estimates and of recruitment distribution.

B. List of ranked biological uncertainties and parameters for stock assessment (SA) and their links to research areas and activities contemplated in the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21)

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

C. List of ranked biological uncertainties and parameters for management strategy evaluation (MSE) and their links to research areas and activities contemplated in the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21)

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

D. External funding received during the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21):

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 characterization 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 minimizing 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	$193,685	Stock structure	December 2021- January 2024
				Total awarded ($)	**$1,020,801**		

E. Publications in the peer-reviewed literature resulting from the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21):

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.

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.

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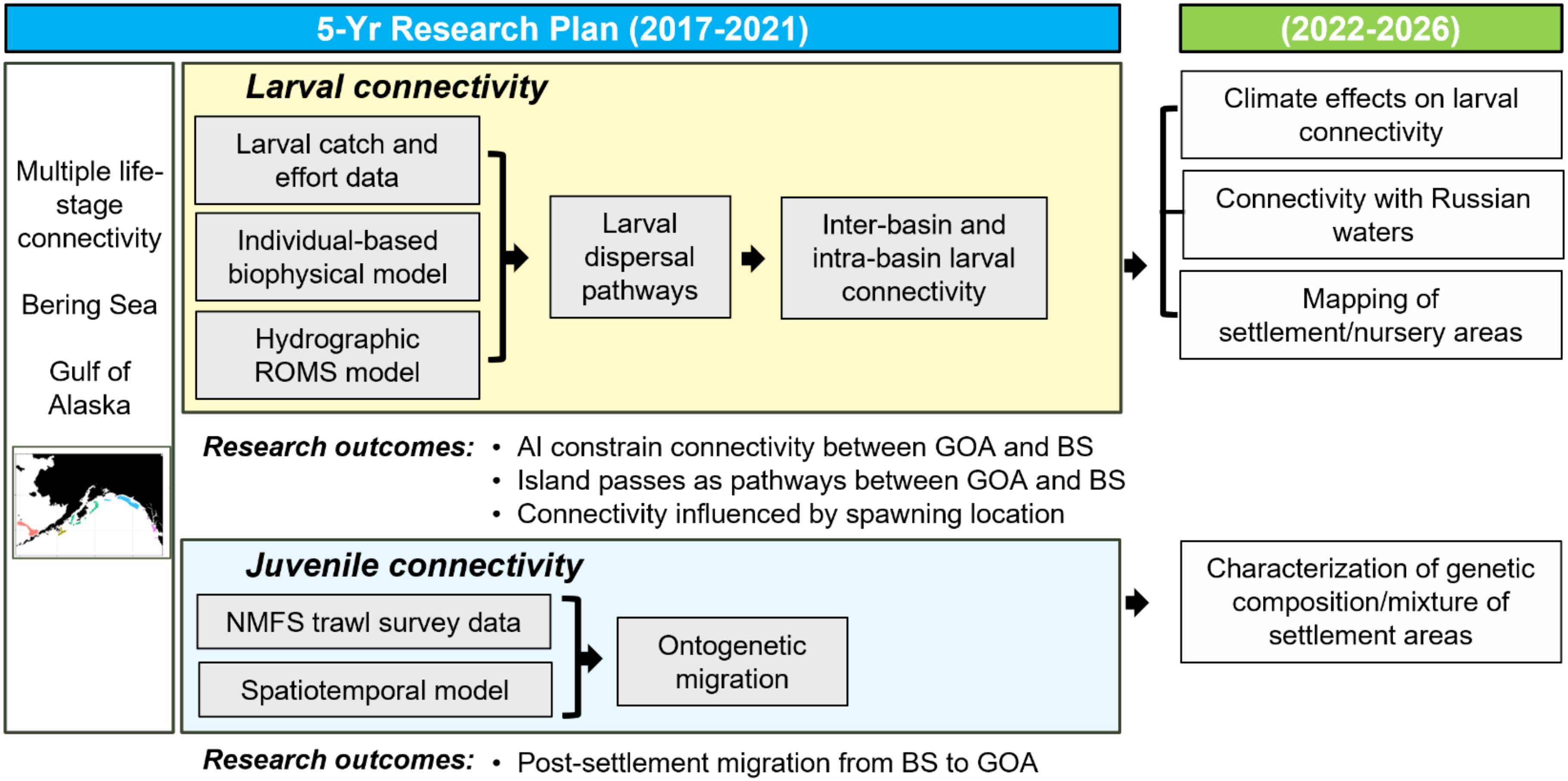
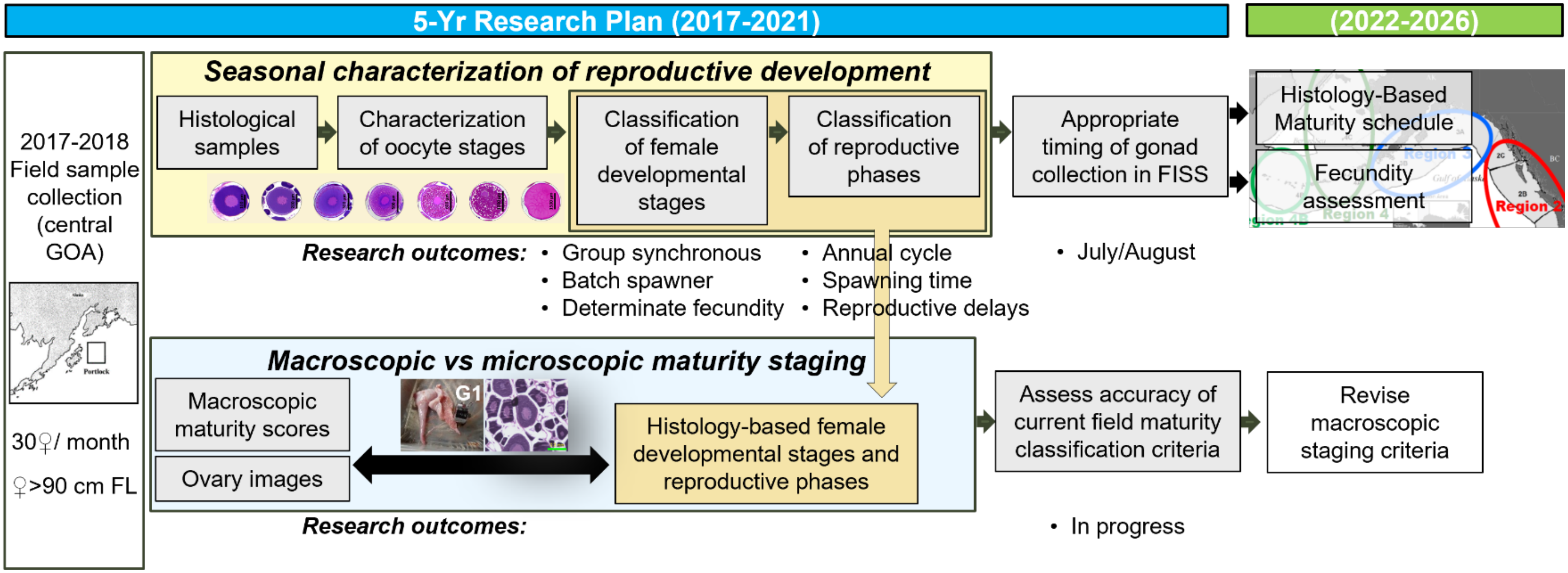
F. Flow chart of progress resulting from the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21) by research area leading to the IPHC 5-Year Program of Integrated Research and Monitoring (2022-2026)

1. Migration and Distribution

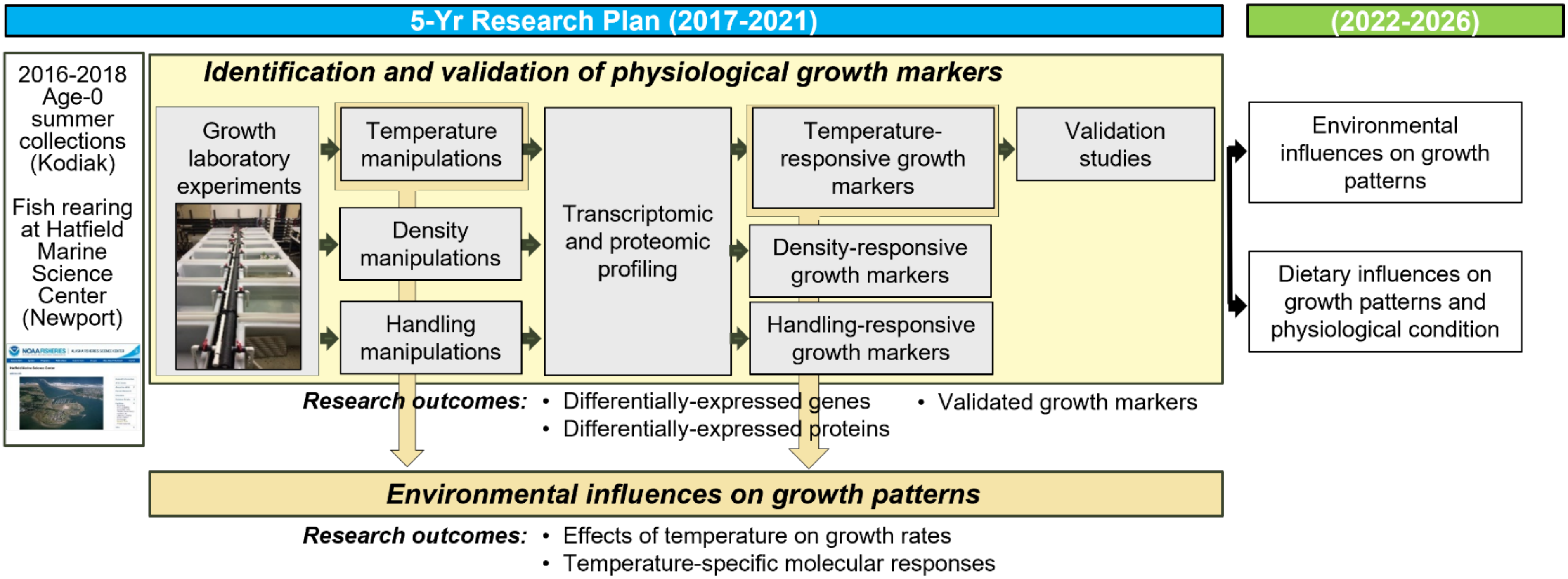


2. Reproduction



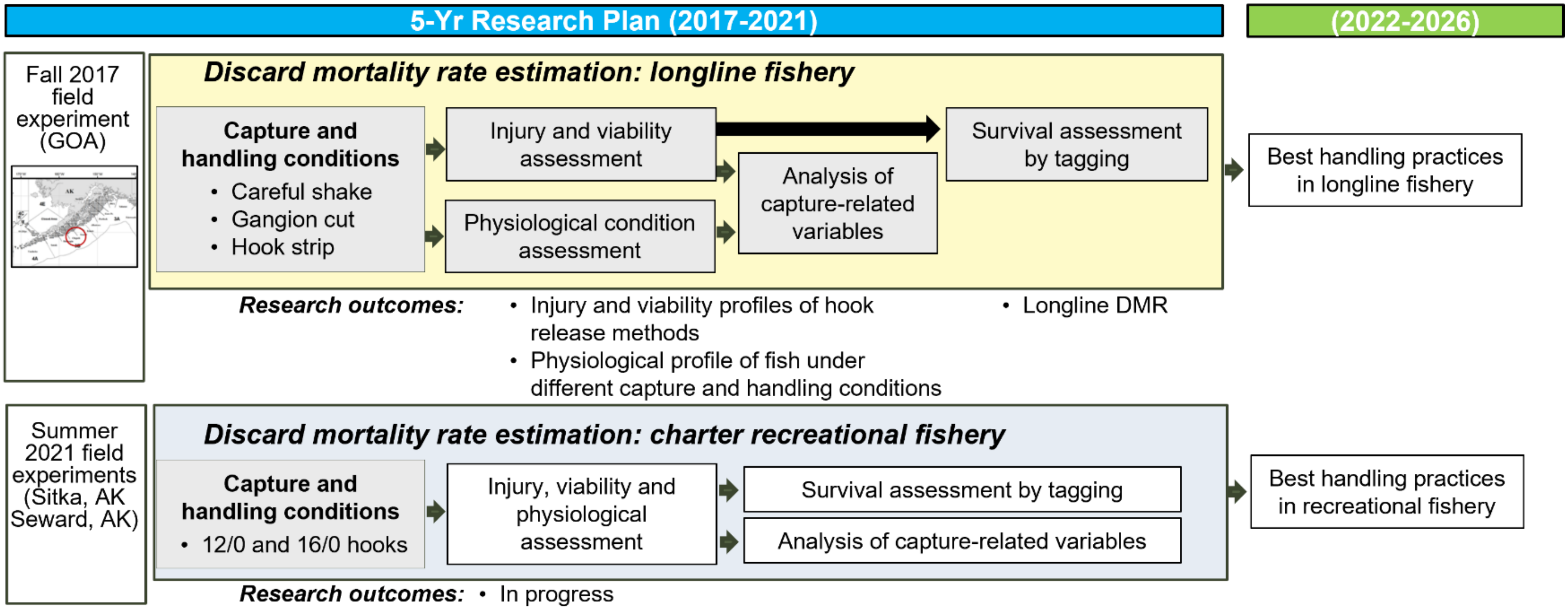
Staff involved: Teresa Fish, MSc APU (2018-2020), Crystal Simchick, Ian Stewart, Allan Hicks, Josep Planas
Funding: IPHC (2018-2020)
Publications (2): Fish et al. (2020) *J. Fish Biol*. **97**: 1880–1885 ; Fish et al. (2022) Front. Mar. Sci. 9:801759

3. Growth



Staff involved: Andy Jasonowicz, Crystal Simchick, Josep Planas
Funding: NPRB Grant#1704 (Sept. 2017-Feb. 2020)
Publications: Planas et al. (in preparation)

4. Mortality and Survival Assessment

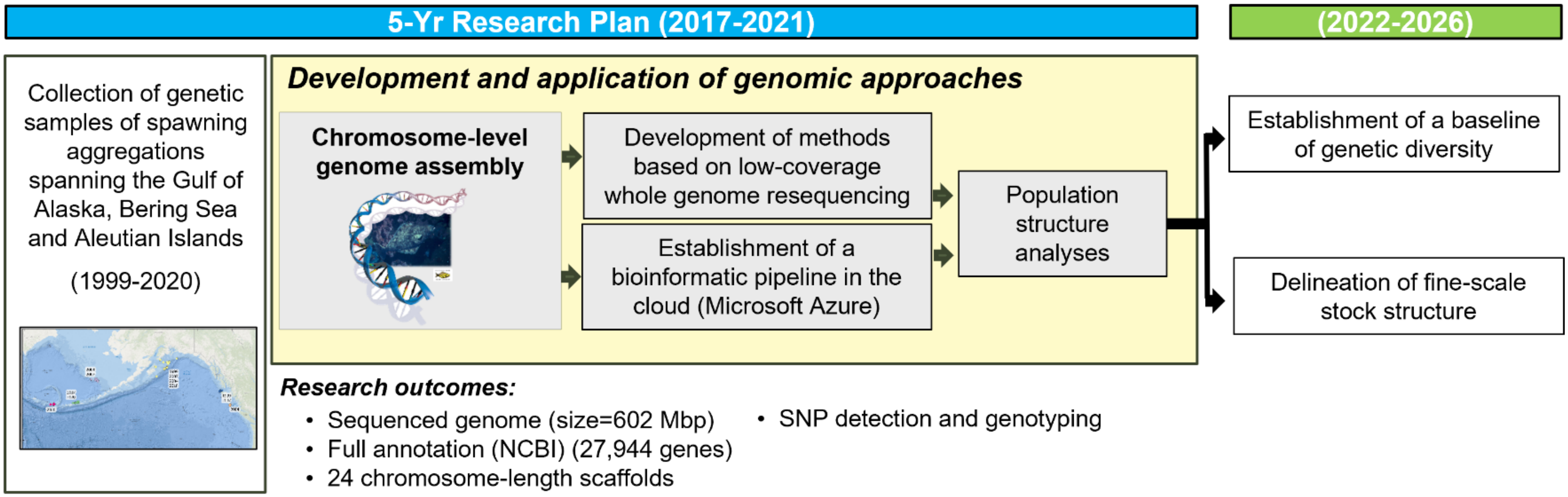


Staff involved: Claude Dykstra, Allan Hicks, Ian Stewart, Josep Planas

Funding (3): Saltonstall-Kennedy NOAA (Sept. 2017-Aug. 2020); NFWF (Apr. 2019-Nov. 2021); NPRB#2009 (Jan. 2021-Mar. 2022)

Publications (2): Kroska et al. (2021) *Conserv. Physiol.*; Loher et al. (2022) *North Amer. J. Fish. Manag. 42: 37-49*

5. Genetics and Genomics



Staff involved: Andy Jasonowicz, Josep Planas
Funding: IPHC, NPRB#2110
Publications: Jasonowicz et al. (2022) *Mol. Ecol. Resour. (In Review)*

APPENDIX II

Biological research areas in the 5-Year Program of Integrated Research and Monitoring (2022-2026) and ranked relevance for stock assessment and management strategy evaluation (MSE)

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 III

List of ranked research priorities for stock assessment

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	Migration and population dynamics	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		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	Fishing technology	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	Fishing technology	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 IV

List of ranked research priorities for management strategy evaluation (MSE)

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 and population dynamics	Larval and juvenile connectivity studies
	Stock structure of IPHC Regulatory Area 4B relative to the rest of the Convention Area			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 V

List of ongoing and planned research projects (Will be linked to the website)

Research Project #	Project Title	Abstract	Objectives	Deliverables	Progress report	5YPRIM Research area	Management implications	Specific inputs into management	Period of Performance	PI	Funding source	Budget	Research prioritization for SA/MSE
1	Leveraging multiple genomic approaches to investigate population structure and dynamics of Pacific halibut	The Pacific halibut (Hippoglossus stenolepis) is a key flatfish species in the North Pacific Ocean ecosystem that supports important commercial, recreational and subsistence fisheries and that is managed as a single stock by the International Pacific Halibut Commission. The overarching goal of the present study is to advance our understanding of Pacific halibut population structure and dynamics in a changing climate through the use of genomic approaches to inform fishery management. In particular, we seek to improve our current understanding of stock structure among spawning groups of Pacific halibut in the northeast Pacific Ocean by conducting low coverage whole genome resequencing, a method that allows the characterization of genomic variation at the highest resolution possible and with which we will establish a baseline of Pacific halibut genetic diversity. Subsequently, we will leverage the obtained genomic data to identify markers that display high differentiation among the different genetic baseline datasets. The results from this study will inform on the delimitation of management units and provide preliminary information on stock composition in the Pacific halibut fishery, as well as provide a tool to monitor changes in distribution associated with climate change.	1. Investigate fine scale Pacific halibut population structure in the northeast Pacific Ocean using low coverage whole genome resequencing: characterization of neutral and adaptive variation at very high resolution among spawning groups leading to the identification of millions of genome-derived genetic markers. 2. Develop a high-throughput genetic marker panel consisting of a selection of genome-derived, high resolution markers	1.Establishment of a baseline of Pacific halibut genetic diversity. The genomic data produced will represent a detailed baseline of Pacific halibut genetic structure and diversity at neutral and adaptive markers over a large geographical scale (Gulf of Alaska, Aleutian Islands and Bering Sea) and over a broad temporal scale (last 30 years). 2.Delineation of fine-scale Pacific halibut stock structure. 3. Assignment of individuals to source populations and assessment of distribution changes.	IPHC-2023-SRB022-09/NPRB Interim Report July 2023/IPHC-2023-WM2023-12	Migration and Population Dynamics	1. Altered structure of future stock assessments and MSE operating models. 2. Improve estimates of productivity. 3. Improve understanding of population distribution and the effects of distributing fishing effort.	If IPHC Regulatory Area 4B is found to be functionally isolated, a separate assessment may be constructed for that IPHC Regulatory Area. Research outcomes will be used to define management targets for minimum spawning biomass by Biological Region.	12/01/2021-02/16/2024	Josep Planas	External (North Pacific Research Board; Project No. 2110)	$193,685	Priority Rank #2
2	Mapping of Pacific halibut juvenile habitat	The IPHC Secretariat recently completed a study to investigate the connectivity between spawning grounds and possible settlement areas based on a biophysical larval transport model (Sadorus et al., 2021; https://doi.org/10.1111/fog.12512). Although it is known that Pacific halibut, following the pelagic larval phase, begin their demersal stage as roughly 6-month-old juveniles, settling in shallow nursery (settlement) areas, near or outside the mouths of bays (Carpi et al., 2021; https://doi.org/10.1007/s11160-021-09672-w), very little information is available on the geographic location and physical characteristics of these areas. In order to fill this knowledge gap, the IPHC Secretariat has initiated studies to identify potential settlement areas for juvenile Pacific halibut throughout IPHC Convention Waters.	1. Collect data sources on juvenile Pacific halibut presence. 2. Create a map of suitable settlement habitat by combining available bathymetry information (e.g. benthic sediment composition and shoreline morphological data) and information on recorded presence of age-0, age-1 and age-2 Pacific halibut juveniles as well as absence of young Pacific halibut noted by various nursery habitat projects focused on other flatfish species.	Map of juvenile Pacific halibut habitat.	IPHC-2023-SRB022-09/IPHC-2023-WM2023-12	Migration and Population Dynamics	Improve estimates of productivity	Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	01/01/2023-12/31/2025	Josep Planas	Internal	$0	Priority Rank #2
3	Female reproductive assessment	In fisheries, understanding the reproductive biology of a species is important for estimating the reproductive potential and spawning biomass of the stock and, consequently, for optimizing management of the species. Recent sensitivity analyses have shown the importance of changes in spawning output in female Pacific halibut due to changes in maturity schedules, in fecundity estimations and/or in skip spawning for stock assessment (Stewart and Hicks, 2020). These results highlight the need for a better understanding of factors influencing reproductive biology and spawning success in Pacific halibut. In order to fill existing knowledge gaps related to the reproductive biology of female Pacific halibut, research efforts are being conducted to characterize female reproductive capacity in this species. Improved knowledge on key aspects of the reproductive physiology of Pacific halibut (e.g., maturity schedules, fecundity, etc.) will provide an updated and more comprehensive description of reproductive capacity and success in this important species.	1.Produce an accurate description of oocyte developmental stages in female Pacific halibut that can be used to classify female maturity stages. 2.Describe changes in female and male maturity stages throughout an entire annual reproductive cycle based on histological assessment and physiological parameters that will be used to revise current estimates of female and male age-at-maturity. 3.Compare macroscopic (based on field observations) and microscopic (based on histological assessment) female and male maturity stages and revise maturity criteria used in FISS. 4.Update maturity schedules based on histological classification of female maturity. 5. Conduct investigations on fecundity and on the incidence of skip-spawning in female Pacific halibut. 6.Conduct investigations on possible temporal and spatial changes in reproductive performance (maturity, fecundity, skip-spawning) in female Pacific halibut.	1. Updated maturity schedule coastwide. 2. Fecundity-at-age and -size estimates. 3. Revised field maturity classification. 4. Information on skip-spawning.	IPHC-2023-SRB022-09/IPHC-2023-WM2023-12	Reproduction	Scale biomass and reference point estimates. Improve estimates of spawning biomass in the stock assessment and improve simulations of spawning biomass in the MSE operating model.	Research outcomes will be included in the stock assessment, replacing the current maturity schedule last updated in 2006. Research outcomes 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. Research outcomes 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. Research outcomes will result in revised time-series of historical (and future) maturity for input to the stock assessment.	01/01/2017-12/31/2026	Josep Planas	Internal	$51,834 (FY2024)	Priority Rank #1
4	Gear-based approaches to catch protection as a means for minimizing whale depredation in longline fisheries	In the north Pacific, both Killer (Orcinus orca) and Sperm (Physeter macrocephalus) whales are involved in depredation behavior in Pacific halibut (Hippoglossus stenolepis). In 2011 and 2012 fisheries observers estimated that 6.9% of Pacific halibut sets were affected by whale depredation in the Bering Sea. Reductions in catch per unit effort (CPUE) when whales were present ranged across geographic regions from 5 15-57% for Pacific halibut. These impacts also incur significant time, fuel, and personnel costs to fishing operations. From a fisheries management perspective, depredation creates an additional and highly uncertain source of mortality, loss of data (e.g. compromised survey activity), and reduces fishery efficiency. Stock assessments of both Pacific halibut (Stewart et al. 2020) and sablefish (Goethel et al. 2020) have adjusted their analysis of fishery independent data to account for the effects of whale depredation on catch rates. In the sablefish assessment, fishery limits are also adjusted downward to reflect expected depredation during the commercial fishery. Meanwhile, potential risks to the whales include physical injury due to being near vessels and gear, disruption of social structure , and developing an artificial reliance on food items that can be affected by fishery dynamics. Many efforts have been made over the years to mitigate this problem, with fishers generally limited to simple methods that can be constructed, deployed, or enacted without significantly disrupting normal fishing operations, or without violating gear regulations. Existing approaches include catch protection, physical and auditory deterrents, and spatial or temporal avoidance. These approaches have had variable degrees of success and ease of adoption in each fishery but none have provided a long-term solution. There are increasing data sources supporting the notion that technologies which reduce initial contact between gear and depredators will reduce the likelihood of foraging attempts around the gear, thereby sustaining levels of target catch while simultaneously reducing risk of depredator mortality and gear damage. Recent studies using physical catch protection methods include the development of underwater shuttles that unhook, and transport catch to the surface (Patagonian toothfish), light and expandable 'slinky' pots (sablefish), and flashers or mesh panels attached to the gear to obscure catch (tuna) (IPHC 2022). While slinky pots had quick uptake in the sablefish longline fishery, depredation occurring with this gear has been reported (Goethel et al. 2022), demonstrating the urgency of ongoing challenges to interrupting the reward cycle underpinning this problem.	1. Identify potential methods for protecting hook captured fish from whale depredation. 2. Develop and field-test several simple low-cost catch-protection designs that can be deployed effectively using current longline fishing techniques.	1. Cost effective prospective terminal gear modifications designed to protect longline catch from whale depredation. 2. Demonstration of the functionality of these proof-of-concept catch protection devices in field tests and provide direction for further modifications and larger scale experimental testing.	IPHC-2023-SRB022-09/IPHC-2023-WM2023-12/BREP Interim Report May 2023	Fishing technology	Improve mortality accounting. Improve estimates of stock productivity.	Research outcomes 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.	11/01/2021-10/30/2023	Claude Dykstra/Ian Stewart	External (Bycatch Reduction Engineering Program - NOAA: Project NA21NMF4720534)	$99,700	Priority Rank #3
5	Use of artificial intelligence (AI) for determining the age of Pacific halibut from images of collected otoliths	The IPHC Secretariat is looking at options for supplementing current Pacific halibut ageing protocol with automatized ageing that does not require extensive otolith-reader training. The IPHC is investigating the potential use of artificial intelligence (AI) for determining the age of Pacific halibut from images of collected otoliths. The Secretariat is in the process of initializing creation of a database of pictures with expert-provided labels, utilizing previously aged otoliths, and assessing the option for the development of a Convolutional Neural Network (CNN) model specifically designed for image classification to determine Pacific halibut age. The goal is to create an AI-based age determination system that complements traditional methods for reliable fish stock assessment and management advice.	1. Develop a labeled image database from previously aged otoliths 2.Train and validate a CNN model for automated ageing 3. Verify the accuracy of the CNN model against traditional ageing methods	1. Predictive CNN model for ageing Pacific halibut complementing traditional methods 2. A report comparing CNNI model performance to traditional ageing techniques	N/A	Age composition data (both fishery-dependent and fishery-independent)	Age data is a critical input for stock assessment.	AI-driven age determination offers a critical enhancement to stock assessment methodologies, aiding in the estimation of growth rates, maturity, and population structure of Pacific halibut.	09/2023-12/2024+	Barbara Hutniczak	Internal	$0	Priority Rank #1

Proposed

Research Project #	Project Title	Abstract	Objectives	Deliverables	Progress report	5YPRIM Research area	Management implications	Specific inputs into management	Requested period of performance	PI	Targeted funding source	Requested budget	Research prioritization for SA/MSE
1	Genomic analyses of Pacific halibut in Washington State waters to inform population structure and dynamics affecting coastal communities	Current studies at the IPHC, with funding from a grant from the North Pacific Research Board (Project #2110; 2022-2024), are devoted to the application of genome-based approaches (i.e. low coverage whole genome resequencing, lcWGR) to investigate stock structure among known spawning groups of Pacific halibut in the Gulf of Alaska (as far South as Haida Gwaii), Bering Sea and Aleutian Islands. By leveraging the recently sequenced and annotated reference Pacific halibut genome (Jasonowicz et al., 2022; GCF_022539355.2), the IPHC has conducted lcWGR for a total of 600 individual samples from the above-mentioned spawning groups at a coverage of 3X. This effort has so far resulted in the identification of 11.5 million autosomal single nucleotide polymorphisms (SNPs), of which 4 million SNPs have a minor allele frequency higher than 0.05. Considerable progress is currently being made towards using genome approaches to establish a genetic baseline for the available spawning groups, and towards the development of genomic tools aimed at addressing important ecological, environmental, and management-related issues with respect to Pacific halibut in the Gulf of Alaska, Bering Sea and Aleutian Islands. However, the lack of genetic samples from spawning groups off the WA coast limits the application of the above-mentioned genomic tools to advance our understanding of population structure, movement, connectivity, adaptive characteristics, and environmental responses of Pacific halibut in Convention waters. Although no major spawning ground has been mapped south of Cape St. James in the southern tip of Haida Gwaii (St. Pierre, 1984), archeological records along with traditional and ecological knowledge from Indian Tribes (e.g., Makah tribe, etc.) that fished Pacific halibut in the winter off the WA coast indicate that Pacific halibut, at least historically, spawned in what is now IPHC Regulatory Area 2A (Salmen-Hartley, 2018). Additionally, contemporary reports of spawning Pacific halibut south of Cape Flattery and the existence of suitable spawning habitat for Pacific halibut (i.e., deep areas off the continental slope, 200-600 m) are strongly indicative of the presence of spawning grounds for Pacific halibut off the WA coast. Therefore, the identification of potential winter spawning groups of Pacific halibut in WA waters and their biological (i.e., genetic and reproductive) characterization are important for addressing key issues related to Pacific halibut that impact coastal communities within Convention Waters. The overarching goal of this proposal is to characterize the genetic composition of Pacific halibut found off the WA coast using state-of-the-art genomic approaches. The results of this proposal will improve our understanding	1. To identify winter spawning groups of Pacific halibut off the WA coast with the use of traditional and ecological knowledge and collect biological samples. 2. To characterize the reproductive condition of female and male Pacific halibut off the WA coast during the winter spawning season. 3. To generate and incorporate genomic data from winter spawning groups off the WA coast to existing data from winter spawning groups in other geographic areas in the northeastern Pacific Ocean to establish an expanded baseline of Pacific halibut genetic diversity.	1. Information on Pacific halibut spawning groups off the WA coast: location information, spawning time and collection of biological (genetic and reproductive) samples. 2. Extended baseline of Pacific halibut genetic diversity and delineation of fine-scale Pacific halibut stock structure in WA waters and coastwide.	N/A	Migration and Population Dynamics	Altered structure of future stock assessments and MSE operating models. Improved estimates of productivity coastwide.	Information of stock structure of the Pacific halibut population in Convention waters will inform management actions by validating management units. Research outcomes will be used to define management targets for minimum spawning biomass by Biological Region.	02/01/2024-1/31/2026	Josep Planas	External (Washington Sea Grant). Full proposal submitted in May 2023. Proposal not selected for funding.	$288,652	Priority Rank #2
2	Full scale testing of devices to minimize whale depredation in longline fisheries	In the north Pacific, both Killer (Orcinus orca) and Sperm (Physeter macrocephalus) whales are involved in depredation behavior in Pacific halibut (Hippoglossus stenolepis). In 2011 and 2012 fisheries observers estimated that 6.9% of Pacific halibut sets were affected by whale depredation in the Bering Sea (Peterson et al. 2014). Reductions in catch per unit effort (CPUE) when whales were present ranged across geographic regions from 5 15-57% for Pacific halibut (Peterson et al. 2014). These impacts also incur significant time, fuel, and personnel costs to fishing operations. From a fisheries management perspective, depredation creates an additional and highly uncertain source of mortality, loss of data (e.g. compromised survey activity), and reduces fishery efficiency. Stock assessments of both Pacific halibut (Stewart et al. 2020) and sablefish (Goethel et al. 2020) have adjusted their analysis of fishery independent data to account for the effects of whale depredation on catch rates. In the sablefish assessment, fishery limits are also adjusted downward to reflect expected depredation during the commercial fishery. Meanwhile, potential risks to the whales include physical injury due to being near vessels and gear, disruption of social structure (e.g., Chilvers and Corkeron 2001), and developing an artificial reliance on food items that can be affected by fishery dynamics. Many efforts have been made over the years to mitigate this problem, with fishers generally limited to simple methods that can be constructed, deployed, or enacted without significantly disrupting normal fishing operations, or without violating gear regulations. Existing approaches include catch protection, physical and auditory deterrents, and spatial or temporal avoidance. These approaches have had variable degrees of success and ease of adoption in each fishery (Werner et al. 2015) but none have provided a long-term solution. There are increasing data sources supporting the notion that technologies which reduce initial contact between gear and depredators will reduce the likelihood of foraging attempts around the gear, thereby sustaining levels of target catch while simultaneously reducing risk of depredator mortality and gear damage. Recent studies using physical catch protection methods include the development of underwater shuttles that unhook, and transport catch to the surface (Patagonian toothfish), light and expandable 'slinky' pots (sablefish), and flashers or mesh panels attached to the gear to obscure catch (tuna) (IPHC 2022). While slinky pots had quick uptake in the sablefish longline fishery, depredation occurring with this gear has been reported (Goethel et al. 2022), demonstrating the	1. Assess the performance of catch protection devices to effectively reduce depredation of longline captured fish in the presence of toothed whales. 2. Assess the performance metrics of catch protection devices on the size, number, and condition of fish successfully entrained in the devices	1. Further define and develop previously identified high priority work that can break the reward cycle of depredation behavior and thereby suppress its prevalence. 2. Build on strategies to protect already captured fish in cost effective manners that are compatible with currently employed hook and line fishing practices in the North Pacific halibut fishery.	N/A	Fishing technology	Improved accuracy of mortality estimates. Improve estimates of productivity	Will be used to generate potential recruitment covariates and to inform minimum spawning biomass targets by Biological Region	11/1/2023-04/30/2025	Claude Dykstra/Ian Stewart	External (Bycatch Reduction Engineering Program - NOAA). Full proposal submitted in March 2023. Awarded.	$199,870	Priority Rank #3
3	Development of a non-lethal genetic-based method for aging Pacific halibut	Robust methods to estimate the ages of commercially exploited fish species are critical for stock assessment. Furthermore, when combined with data on other biological characteristics; such as length/weight, maturity, movement, and distribution; the age distribution or age structure of a fish population provides essential information on population dynamics related to age, predicted reproductive status, life history stage, etc. For Pacific halibut; an ecologically, economically and culturally important fish species in Alaska; age estimations are critical to our understanding of the composition of the stock for sustainable management, of historical changes in size-at-age, maturity-at-age, year class strength, mortality, etc., as well as of the response of the Pacific halibut stock to current and future climate variability. For many managed groundfish species, such as Pacific halibut, age has been traditionally estimated by manually counting the number of annuli or concentric lamellae present in sagittal otoliths (i.e. calcified structures located in the head that are used for balance and hearing) under a compound microscope. The International Pacific Halibut Commission (IPHC) has used sagittal otoliths for aging Pacific halibut since 1914, employing a method referred to as "surface aging" until 2002 and switching to a methodological variation known as "break-and-burn" thereafter (Forsberg, 2001). However, for various reasons, alternative methods to traditional otolith age estimations are being explored, developed and applied in fisheries. One of these is a genetic method for aging based on the known observation that the methylation patterns on genomic DNA change predictably with age. DNA methylation (DNAm) is an epigenetic modification of the DNA that consists in the covalent modification of cytosine, one of the four nucleobases found in DNA, and that regulates the expression of genes. 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. Epigenetic clocks have been developed for many vertebrate species, including fish, with high accuracy (r between 0.84 and 0.99) and an average MAE of 0.87 years, that corresponds to 3.5% of the total lifespan of the species examined. Since DNA sequencing for measuring methylation levels is becoming cost effective and is a high throughput technique with little or no inherent human error or bias, epigenetic clocks have moved to the forefront among the alternative methods for aging that are currently available for fish species. The	1. To identify DNA methylation signals in Pacific halibut fin tissue. 2. To develop an age prediction model based on DNA methylation patterns: an epigenetic clock for Pacific halibut. 3. To develop a targeted DNA methylation assay for larger scale age estimations.	1. Reduced representation genome-wide map of DNA methylation at single base-pair resolution for Pacific halibut fin tissue. 2. Age predicting model for Pacific halibut using fin tissue.	N/A	Migration and Population Dynamics/Female Reproductive Assessment/Growth	Age is a critical input for stock assessment.	Age is a key biological input into stock assessment as it is used for estimating fish growth, fish maturity and fecundity-at-age, and mortality rates as well as population structure. Age distribution of Pacific halibut captured in the different fisheries and surveys is used in stock assessment.	02/01/2024-1/31/2026	Josep Planas	External (Alaska Sea Grant). Full proposal submitted in May 2023. Decision expected January 2024.	$60,374	Priority Rank #1

APPENDIX VI

Proposed schedule of outputs

	2022		2023		2024		2025		2026	
Biology and Ecology										
Migration and population dynamics										
Reproduction										
Growth										
Mortality and survival assessment										
Fishing technology										
Stock Assessment										
Management Strategy Evaluation										
Monitoring										

APPENDIX VII

Proposed schedule of funding and staffing indicators: Biology and Ecology

Research areas	Research activities	Required FTEs/Year	IPHC FTEs/Year	2022	2023	2024	2025	2026	IPHC Funds	Grant Funds
Migration and Population Dynamics	Larval and juvenile connectivity and early life history studies	0.45	0.45		RB1	RB2			Yes	NPRB #2100
	Population structure	0.4	0.8		RB1				No	NPRB #2110
	Adult migration and distribution	0.4							No	NPRB #2110
	Close-kin mark-recapture studies	1	0						No	Planned
	Seascape genomics	1	0						No	Planned
	Genome-wide association analyses	1	0						No	Planned
	Genomic-based aging methods	1	1		RS 1				Yes	No
Reproduction	Maturity-at-age estimations	0.75	0						Yes	No
	Fecundity assessment	0.5	0.25			RB4	RS 2		Yes	No
	Examination of accuracy of current field macroscopic maturity classification	0.25							Yes	No
	Sex ratio of current commercial landings	0.5	0.75	LT					Yes	No
	Recruitment strength and variability	0.5	0				RS 2		Yes	Planned
Growth	Environmental influences on growth patterns	0.5	0.5		MSc student				No	Planned
	Dietary influences on growth patterns and physiological condition	0.5	0.2		RB3				No	Planned
Mortality and survival assessment	Discard mortality rate estimate: recreational fishery	0.5	1						No	NPRB #2009
	Best handling practices: recreational fishery	0.5		RB 3					No	NPRB #2009
	Whale depredation accounting and tools for avoidance	0.5							No	BREP
	Biological interactions with fishing gear	0.5							No	BREP

IPHC staff (Planned):

RS1: Research Scientist 1(PhD; Life History Modeler I). Full time temporary position (100% research;
RS2: Research Scientist 1(PhD; Life History Modeler II). Full time temporary position (100% research;
RB1: Research Biologist 1 (Geneticist; MSc). Full time temporary position (until April 2022; 1 FTE). 55% of salary covered by Grant NPRB#2110.
RB2: Research Biologist 2 (Early Life History; MSc). Full time permanent position (40% research; 0.4 FTE)
RB3: Research Biologist 3 (DMR; MSc). Full time permanent position (100% research; 1 FTE)
RB4: Research Biologist 4 (Maturity and Fecundity; MSc). Full time permanent position (100% research; 1 FTE)
LT: Laboratory Technician (MSc). Full time temporary position (100% research; 1 FTE)

Report on Current and Future Biological and Ecosystem Science Research Activities

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, C. DYKSTRA, A. JASONOWICZ, C. JONES, 15 OCTOBER 2024)

PURPOSE

To provide the RAB with a description of the biological and ecosystem science research projects conducted and planned by the IPHC Secretariat and contemplated within the Five-year Program of Integrated Research and Monitoring (2022-2026).

BACKGROUND

The main objectives of the Biological and Ecosystem Science Research at the IPHC are to:

1) identify and assess critical knowledge gaps in the biology of the Pacific halibut (*Hippoglossus stenolepis*);
2) understand the influence of environmental conditions; and
3) apply the resulting knowledge to reduce uncertainty in current stock assessment models.

The primary biological research activities at 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 summarized in five broad research areas designed to provide inputs into stock assessment and the management strategy evaluation processes (Appendix I), 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.
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.

DISCUSSION ON THE MAIN RESEARCH ACTIVITIES

1. Migration and Population Dynamics.

   The IPHC Secretariat is currently conducting studies on Pacific halibut juvenile habitat and movement through conventional wire tagging, as well as studies that incorporate genomics approaches in order to produce useful information on population structure and 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 management and strategy evaluation process is in biological parametization and validation of movement estimates, on one hand, and of recruitment distribution, on the other hand (Appendix III).

   1.1. Population genomics. Understanding population structure is imperative for sound management and conservation of natural resources. Pacific halibut in US and Canadian waters are managed as a single, panmictic population on the basis of tagging studies and historical (pre-2010) analyses of genetic population structure that failed to demonstrate significant differentiation in the eastern Pacific Ocean. However, more recent studies have reported significant genetic population structure suggesting that Pacific halibut residing in the Aleutian Islands may be genetically distinct from other regions. Advances in genomic technology now enable researchers to examine entire genomes at unprecedented resolution. While genetic techniques previously employed in fisheries management have generally used a small number of markers (i.e. microsatellites, ~10-100), whole-genome scale approaches can now be conducted with lower cost and provide orders of magnitude more data (millions of markers). Using low-coverage whole genome resequencing we have the capability to examine genetic structure of Pacific halibut in IPHC Convention Waters with unprecedented resolution. By studying the genomic structure of spawning populations, genetic signatures of geographic origin can be established and, consequently, could be used to identify the geographic origin of individual Pacific halibut and, therefore, inform on the movement and distribution of Pacific halibut.

        The main purpose of the present study is to conduct an analysis of Pacific halibut population structure in IPHC Convention waters using state-of-the-art low-coverage whole genome resequencing methods. For this purpose, genetic samples from male and female adult Pacific halibut collected during the spawning (winter) season in five known spawning grounds have been used: Western and Central Aleutian Islands, Bering Sea, Central Gulf of Alaska and British Columbia (Figure 1). Furthermore, temporal replicates at many of these locations are available and have enabled the IPHC Secretariat to evaluate the stability of genetic structure over time, ensuring confidence in the results. As a requisite for the low-coverage whole genome resequencing approach used, the IPHC Secretariat first produced a high-quality reference genome (Jasonowicz et al., 2022) that has been used to generate genomic sequences from 570 individual Pacific halibut collected from the five above-mentioned geographic areas (Figure 1) using low-coverage whole-genome resequencing (lcWGR).

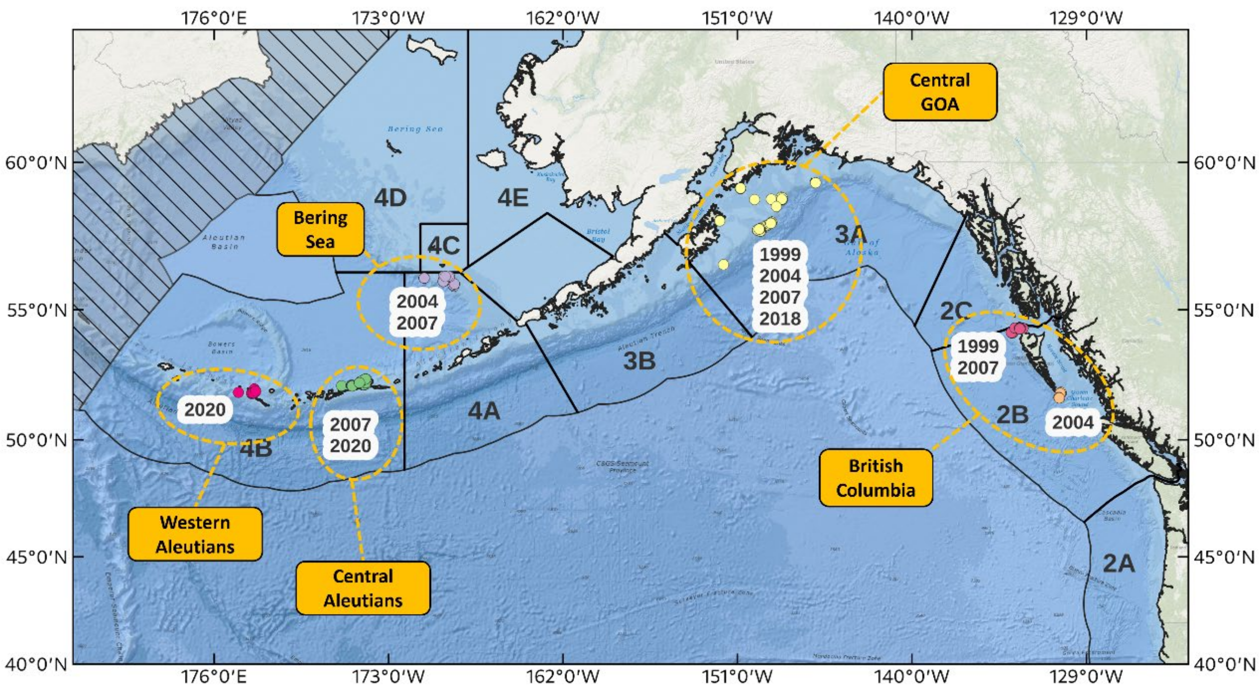


Figure 1. Map of sample collections made during the spawning season used for genomic analysis of population structure in Pacific halibut in the northeast Pacific Ocean.

Using the lcWGR approach, we identified approximately 10.2 million single nucleotide polymorphisms (SNPs) that have been used to evaluate population structure at the highest resolution possible. Despite the use of a very high-resolution genomic approach, preliminary analyses of population structure using a genome-wide subset of 4.7 million SNPs, indicated that no distinct genetic groups were apparent in the dataset. Multiple methods were used to characterize population structure: principal component analysis revealed a considerable degree of genetic similarity between samples collected in different geographic areas (Figure 2), and unsupervised clustering methods (K-means clustering and the estimation of admixture proportions) also failed to detect discrete genetic groups (data not shown). These results suggest that there is very little spatial structure among the five spawning groups sampled in different geographic areas within IPHC Convention Waters. Furthermore, assignment testing was carried out to assess our ability to accurately assign samples back to their location in which they were collected. Assignment accuracy was validated using cross-validation techniques and indicated a limited ability to accurately assign samples back to the geographic location in which they were collected from (data not shown). We hypothesize that the absence of distinct genetic groups among our sample collections is due to a considerable degree of geneflow among the geographic areas sampled in this study and, consequently, to the genetically panmictic nature of the Pacific halibut population sampled for this study.

The lack of structure observed here is not surprising given our current knowledge and understanding of Pacific halibut biology. Annual migration rates estimated from tag recovery data suggest that there is ample opportunity for individuals to move among IPHC Regulatory Areas throughout their lives (Webster et al. 2013). Analysis of tag recovery data has shown that approximately 11% of Pacific halibut tags are recovered in a different IPHC Regulatory Area than they are released (Carpi et al. 2021). This varies by Regulatory Area but for most IPHC Regulatory Areas, the percentage of migrants observed exceeds 10% (Carpi et al. 2021). Additionally, strong oceanographic connectivity between the Bering Sea and Gulf of Alaska has been linked to a considerable degree of larval exchange between these areas. It has been estimated that 47%-58% of larvae originating from spawning grounds in the Western Gulf of Alaska are transported to the Bering Sea (Sadorus et al. 2021). These rates can still be as high as 4.5%-8.6% for larvae originating from spawning grounds in the Eastern Gulf of Alaska (Sadorus et al. 2021).

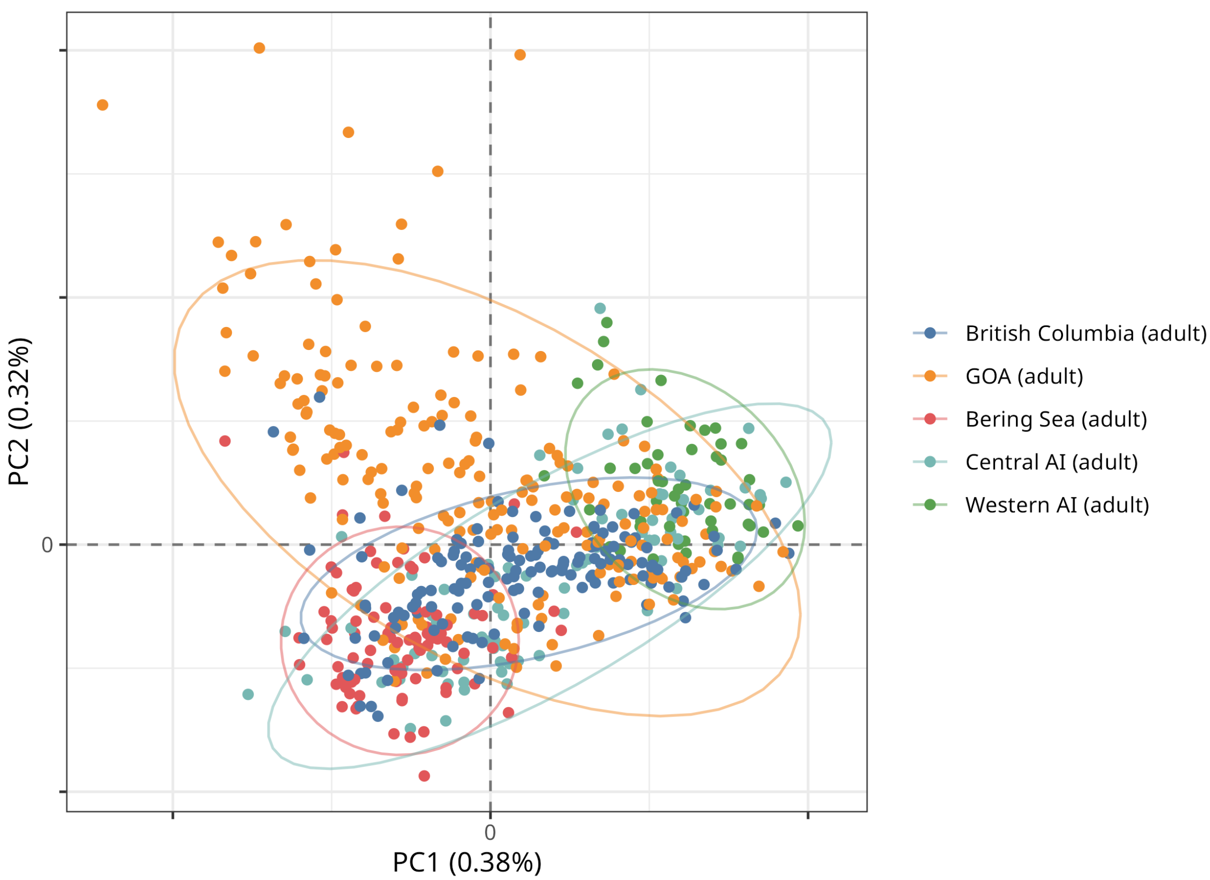


Figure 2. Genetic relationships among individual samples visualized using principal component analysis. Each point represents an individual fish and each fish is colored by the geographic area in which they were sampled. Note the lack of distinct clusters and overlap among areas. Circles represent 95% confidence ellipses.

The concept of a stock and the ability to define management units is central to sound management of marine fishes (Begg et al. 1999; Cadrin 2020). Advances in genomic technology have led to the development of useful and powerful tools that can aid in the delineation of management units (Bernatchez et al. 2017). Despite using very high-resolution genomic methods to characterize genomic variation in spawning groups of Pacific halibut collected over large spatial and temporal scales, the results presented here are consistent with genetic panmixia. However, while it is important to note that we cannot simply prove that panmixia exists by failing to reject it, the results presented here are consistent with the current assessment practices of the Pacific halibut stock in IPHC Convention Waters which is treated as a single coastwide stock (Stewart and Hicks 2024).

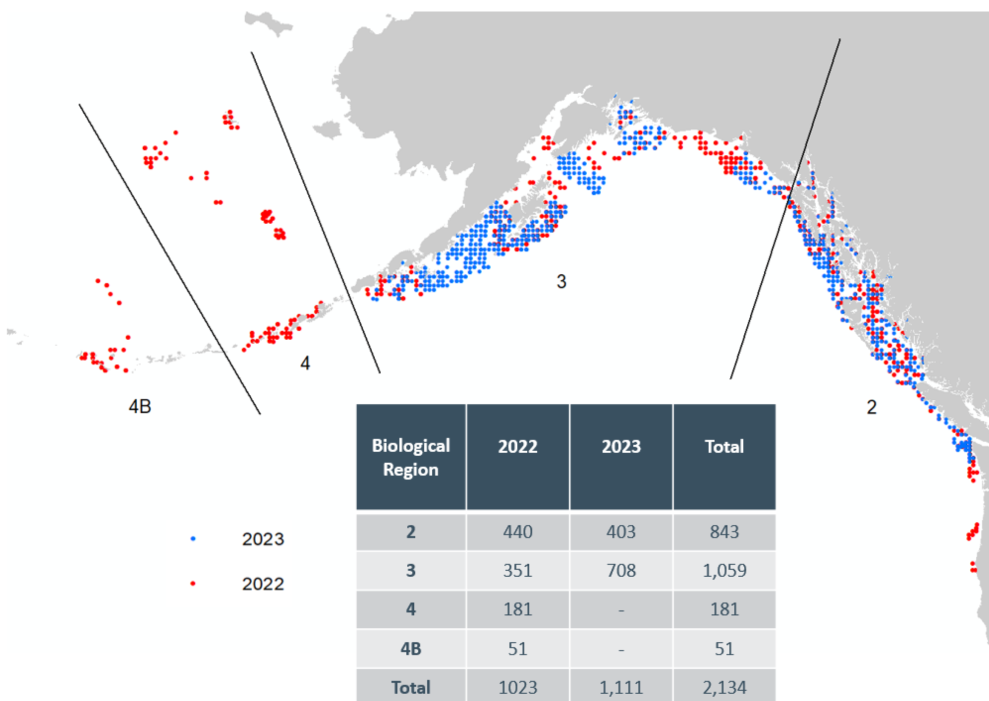
2. Reproduction.

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 the most important biological inputs for stock assessment. The relevance of these research outcomes for the management and strategy evaluation process is in the improvement of the simulation of spawning biomass in the Operating Model (Appendix III).

Each year, the fishery-independent setline survey (FISS) collects biological data on the maturity of female Pacific halibut that are used in the stock assessment to estimate spawning stock biomass. Currently used estimates of maturity at age using macroscopic visual criteria collected in the FISS indicate that the age at which 50% of female Pacific halibut are sexually mature is 11.6 years on average. However, female maturity schedules have not been revised in recent years and may be outdated. In addition, the currently used macroscopic visual criteria used to score female maturity in the field have an undetermined level of uncertainty and need to be contrasted with more accurate microscopic (i.e. histological) criteria. In order to address these issues, the IPHC Secretariat has conducted for the first time a thorough histological assessment of the temporal progression of female developmental stages and reproductive phases throughout an entire reproductive cycle. The outcomes of these studies have paved the way for upcoming studies to update and improve the accuracy of maturity schedules based on histological-based data and to guide efforts towards assessing fecundity in Pacific halibut.

In brief, the results obtained by ovarian histological examination indicate that female Pacific halibut follow an annual reproductive cycle involving a clear progression of female developmental stages towards spawning within a single year. These results provide foundational information for upcoming studies aimed at updating maturity ogives by histological assessment and at investigating fecundity in Pacific halibut. One of the most important results obtained show that the period of time when gonad samples can be collected in the FISS (June-August) is an appropriate temporal window during which Pacific halibut females that are developing towards the spawning capable reproductive phase and, therefore, considered mature for stock assessment purposes, can be identified. Furthermore, the potential use of easily obtained biological indicators in predictive models to assign reproductive phase in Pacific halibut was demonstrated. The results of these studies have been published in the journals *Journal of Fish Biology (*Fish et al. 2020, https://doi.org/10.1111/jfb.14551), and *Frontiers in Marine Science (*Fish et al. 2022; https://doi.org/10.3389/fmars.2022.801759).

2.1. Update of maturity schedules based on histological-based data. The coastwide maturity schedule (i.e. the proportion of mature females by age) that is currently used in SA is based on visual (i.e. macroscopic) maturity data collected in IPHC's Fishery-Independent Setline Survey (FISS). However, the coastwide maturity schedule has not been revised in recent years and it may have an undetermined degree of uncertainty. For this reason, the IPHC Secretariat is undertaking studies to revise the female maturity schedule coastwide and in all four IPHC Biological Regions through histological (i.e. microscopic) characterization of maturity. To accomplish this objective, the IPHC Secretariat started collecting ovarian samples for histology during the 2022 and 2023 FISS seasons. The 2022 FISS sampling resulted in a total of 1,023 ovarian samples collected in Biological Regions 2, 3, 4 and 4B. Due to a reduced FISS design, in 2023 sampling only occurred in Biological Regions 2 and 3 and 1,111 ovarian samples were collected (Figure 3).



Biological Region	2022	2023	Total
2	440	403	843
3	351	708	1,059
4	181	-	181
4B	51	-	51
Total	1023	1,111	2,134

Figure 3. Map of 2022 and 2023 maturity samples for histology collected on FISS. Red dots (2022) and blue dots (2023) indicate a distinct FISS station in which a sample was collected.

When examining the age and length distribution of fish collected for sampling in 2022 and 2023, the distribution of fish appeared to be right-skewed for both parameters, but more pronounced for age (Figure 4). For the samples collected in 2023, the total range of ages was from 5 to 33 years old, and the total range of lengths was from 50 to 190 cm. The largest proportion of sampled fish was from 7 to 10 years old, and from 80 to 90 cm in length. A Welch's two sample t-test was used to determine differences between age and length samples for 2022 and 2023. No significant difference was found among years for age ($t(1994.2) = -1.71$, $p = 0.09$) and length ($t(1984.4) = 1.75$, $p = 0.08$) (data not shown).

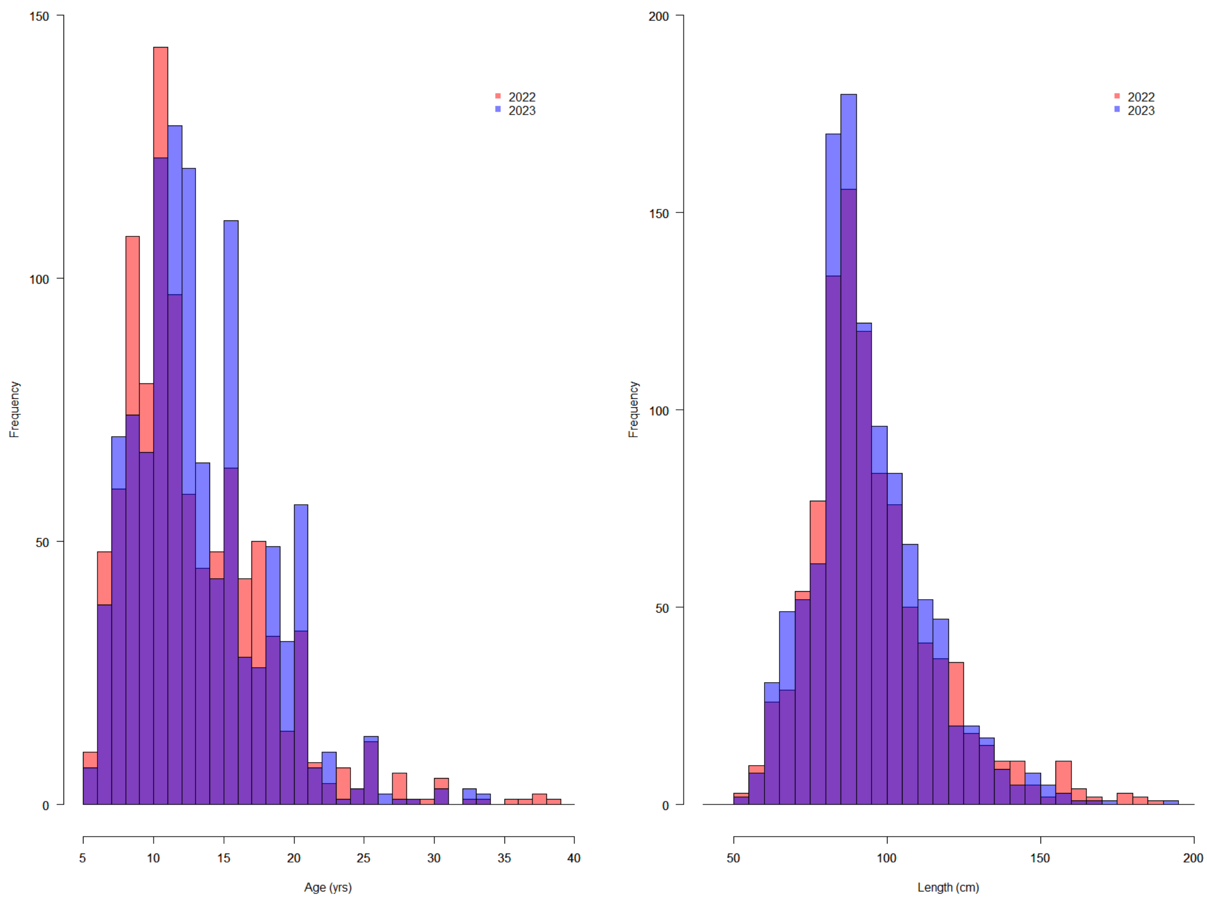


Figure 4. Histograms showing distribution of age and length of female Pacific halibut collected for maturity samples in the 2022 (red) and 2023 (blue) FISS. The purple color indicates overlap between the two years.

Ovarian samples from 2022 and 2023 were processed for histology and IPHC Secretariat staff finalized scoring samples for maturity using histological maturity classifications, as previously described in Fish et al. (2020, 2022). Following this maturity classification criteria, all sampled Pacific halibut females were assigned to either the mature or immature categories. Mature female Pacific halibut are deemed to have at least reached early vitellogenesis (Vtg1) for oocyte development.

Maturity ogives (i.e., the relationships between the probability of maturity determined by histological assessments and variables including IPHC Biological Region, age, and year) were estimated by fitting generalized additive models (GAM) with logit link (i.e., logistic regression) to the 2022 and 2023 data using year as a factor (Figure 5). When comparing Biological Regions 2 and 3 (the only two Biological Regions with two consecutive years of data) spatial and temporal differences in maturity ogives become apparent. First, the maturity ogive for Biological Region 2 shows lower steepness than that for Biological Region 3 in both years, indicating that Biological Region 2 has a lower proportion of mature females from ages 7 to 25 than Biological Region 3 over the period of ovarian sample collection during the FISS. Second, the maturity ogive in Biological Region 2 increased markedly in steepness between 2022 and 2023, indicating an increase in the proportion of mature females at younger ages, whereas the maturity ogive in Biological Region 3 was very similar across the two years. Future collection of ovarian samples in additional years will be required to establish any potential temporal and/or spatial differences in maturity ogives.

The models estimated maturity-at-age curves for each IPHC Biological Region. Due to a significant year effect in the GAM model, IPHC Secretariat pooled the maturity data by region to remove the year effect from the model. Noting that sample size was not proportional to population size for each region, we used the estimated regional abundance proportions from IPHC's most recent FISS space-time model as weights in estimating a coastwide maturity ogive (Figure 6). The value of the coastwide ogive at each age is calculated as the abundance proportion at age times the proportion mature at age summed across regions. The modeled coastwide ogive for maturity-at-age appear to fall between the maturity ogives for Biological Regions 2 and 3. This is expected as these two regions currently have the highest estimated abundance. Maturity is used to assign the numbers of fish at each age in the SA model to either a reproductive or non-reproductive state. The total reproductive output of these fish in the SA is then estimated by multiplying the number of reproductive fish at each age by their average somatic weight and then by the fecundity per age or body weight (currently assumed to be 1 for all body weights and ages). Therefore, defining our coastwide maturity ogive in terms of numbers of fish is consistent with its use in the SA. Conversely, defining it in terms of biomass would require converting back to maturity in numbers for use in the SA. Age at 50% maturity was calculated from the coastwide ogive using an optimizing routine in R 4.3.2 (function optim). Age at 50% maturity (A50) was calculated to be 10.3 years, which is over one year younger than our current estimates from macroscopic (field) data of 11.6 years. This is indicating that a higher proportion of female Pacific halibut are maturing at a younger age than previously indicated, which could have implications for overall spawning stock biomass (SSB) estimates.

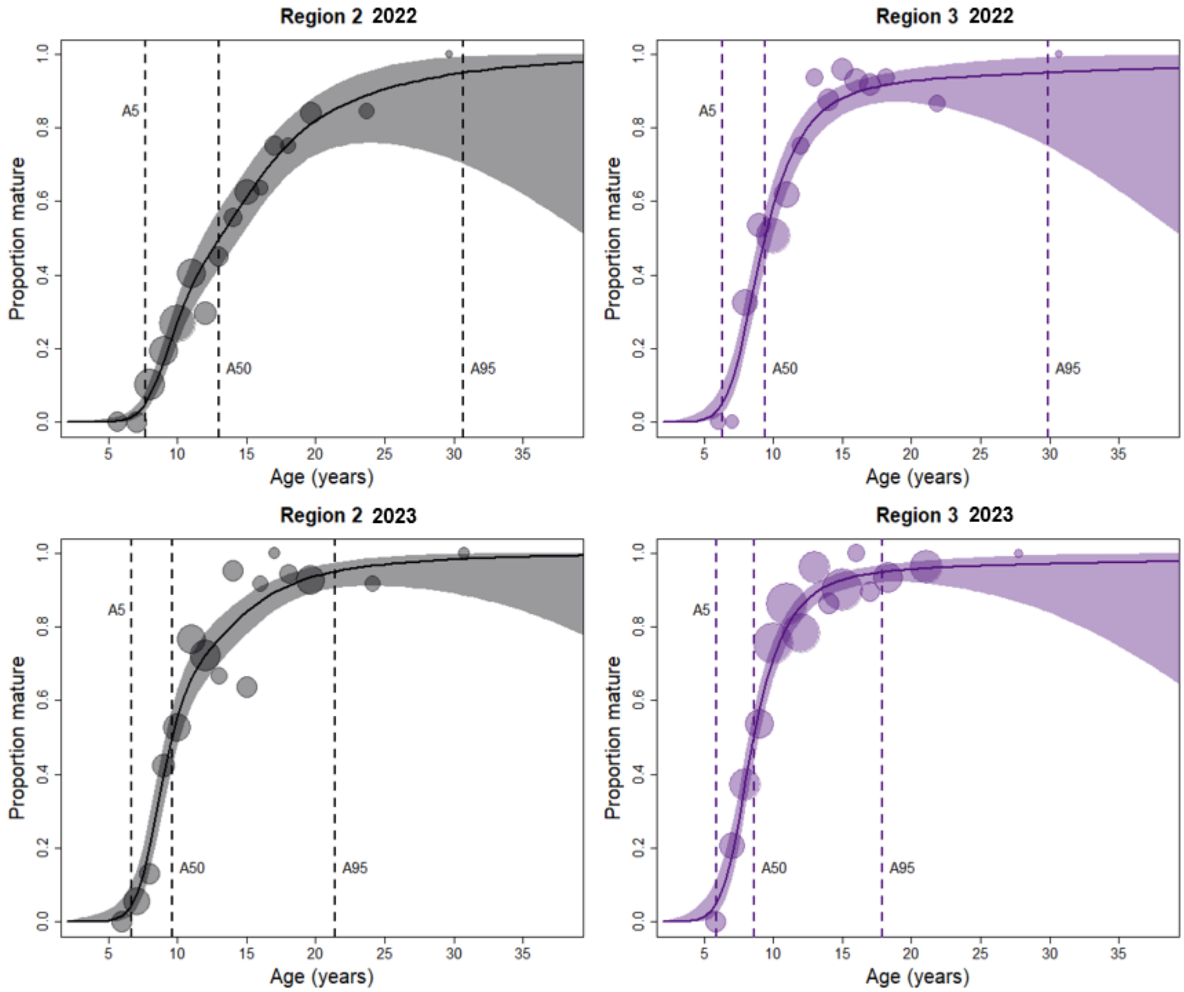


Figure 5. Female Pacific halibut age-at-maturity by IPHC Biological Region and year using best-fit GAM, with color shading indicating 95% CI for each IPHC Biological Region. Vertical dash lines indicate age at 5% (A5), 50% (A50), and 95% (A95) maturity.

IPHC Secretariat continued to collect ovarian samples in the 2024 FISS. A total of 1,118 samples were collected for 2024, with 411 samples in Biological Region 2, 336 in Biological Region 3, and 371 in Biological Region 4. These samples will allow us to further investigate both spatial and temporal differences in histological-based female Pacific halibut maturity.

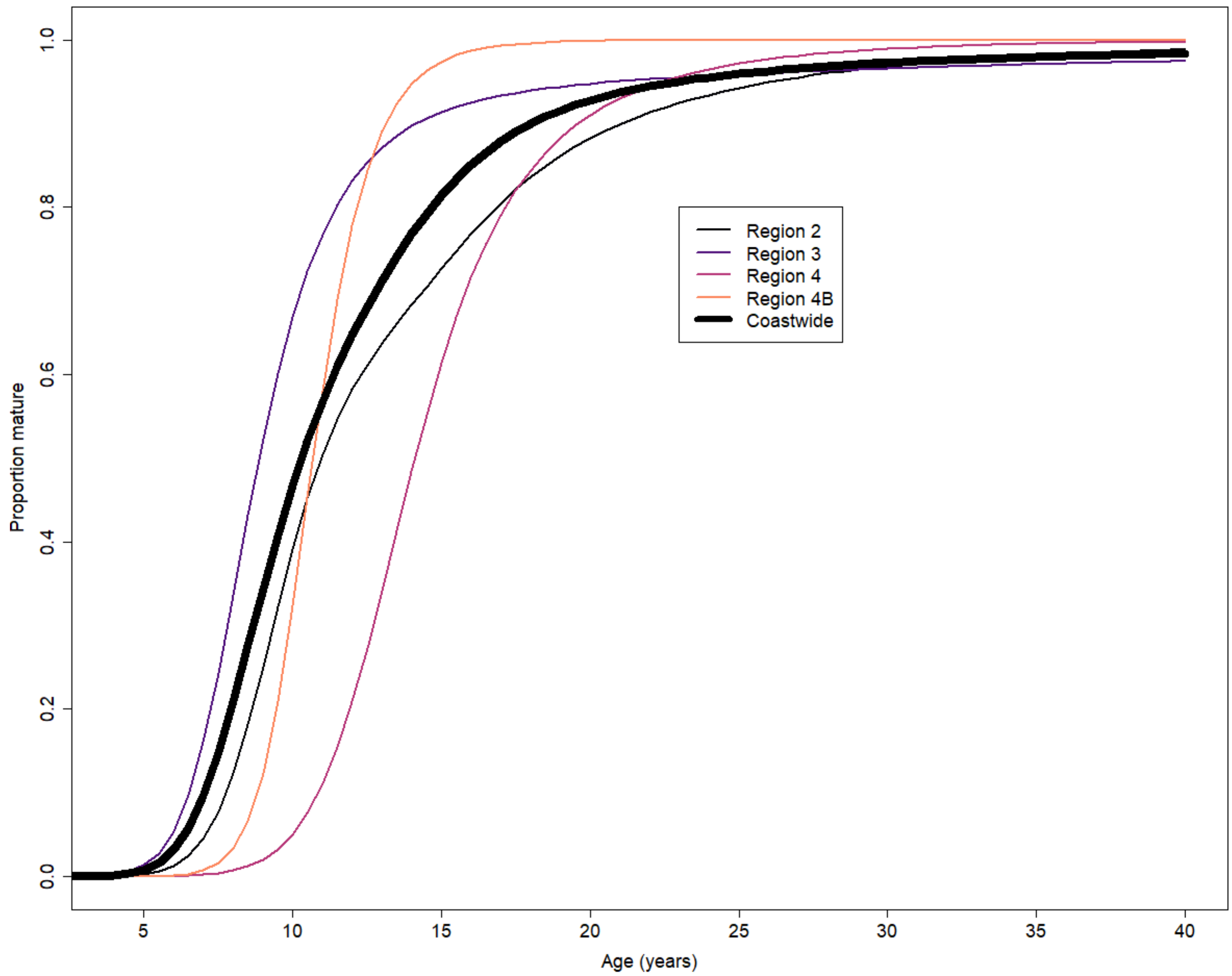


Figure 6. Coastwide maturity-at-age ogive (thick black line) generated from estimated regional abundance proportions. Shown without CI to better visualize differences between the coastwide and Biological Region ogives.

2.2. 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). 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 fecundity estimations were collected during the 2023 FISS. Sampling was conducted in IPHC Biological Region 3, with a total of 456 fecundity samples collected. In 2024, sampling was conducted in IPHC Biological Regions 2 and 4, with 149 and 359 fecundity samples collected, respectively, for a total of 508 fecundity samples in 2024. Using histology, as described in 2.2.1, only samples deemed mature will be processed for fecundity estimations.

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 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 process is in the improvement of the simulation of variability and to allow for scenarios investigating climate change (Appendix III).

The IPHC Secretariat has completed a study funded by the North Pacific Research Board (NPRB Project No. 1704; 2017-2020) to identify relevant physiological markers for somatic growth. This study resulted in the identification of 23 markers in skeletal muscle that were indicative of temperature-induced growth suppression and 10 markers in skeletal muscle that were indicative of temperature-induced growth stimulation. These markers represented genes and proteins that changed both their mRNA expression levels and abundance levels in skeletal muscle, respectively, in parallel with changes in the growth rate of Pacific halibut. A manuscript describing the results of this study is currently in preparation (Planas et al., in preparation).

In addition to temperature-induced growth manipulations, the IPHC Secretariat has conducted similar studies as part of NPRB Project No. 1704 to identify physiological growth markers that respond to density- and stress-induced growth manipulations. The respective justifications for these studies are that (1) population dynamics of the Pacific halibut stock could be affected by fish density, and (2) stress responses associated with capture and release of discarded Pacific halibut may affect subsequent feeding behavior and growth. Investigations related to the effects of density and stress exposure are still underway.

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 (SA). 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 for 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 the SA, changes in the estimates of incidental mortality will influence the output of the SA 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 SA resides in their ability to improve trends in unobserved mortality in order to improve estimates of stock productivity and represent the most important inputs in fishery yield for SA (Appendix II). The relevance of these research outcomes for the management and strategy evaluation process is in fishery parametization (Appendix III).

For this reason, the IPHC Secretariat is conducting two research projects to investigate the effects of capture and release on survival and to improve estimates of DMRs in the directed longline and guided recreational Pacific halibut fisheries:

4.1. Evaluation of the effects of hook release techniques on injury levels and association with the physiological condition of captured Pacific halibut and estimation of discard mortality using remote-sensing techniques in the directed longline fishery.

The IPHC Secretariat, with funding by a grant from the Saltonstall-Kennedy Program NOAA (NA17NMF4270240; 2017-2020), has completed studies to evaluate the effects of hook release techniques on injury levels, their association with the physiological condition of captured Pacific halibut and, importantly, has generated experimentally derived estimates of discard mortality rate (DMR) in the directed longline fishery. The initial results on individual survival outcomes for Pacific halibut released in excellent condition (as the viability category assigned to the fish following capture) indicate a range of DMRs between 4.2% (minimum) and 8.4% (maximum), that is consistent with the currently applied DMR value of 3.5%. These results have been published in the journal *North American Journal of Fisheries Management (*Loher et al. 2022; https://doi.org/10.1002/nafm.10711).

The IPHC Secretariat has also concluded investigations on the relationships among hook release techniques (e.g., gentle shake, gangion cutting, and hook stripping), injury levels, stress levels and physiological condition of released fish, as well as the environmental conditions that the fish experienced during capture. Gentle shake and gangion cutting resulted in the same injury and viability outcomes with 75% of sublegal fish in Excellent condition, while the hook stripper produced the poorest outcomes (only 9% in Excellent condition). Hook stripping also resulted in more severe injuries, particularly with respect to tearing injuries, whereas gentle shake and gangion cutting predominantly resulted in a torn cheek, effectively the injury incurred by the hooking event. Physiological stress indicators (plasma levels of glucose, lactate, and cortisol) did not significant change with viability outcomes, except for higher lactate plasma levels in fish categorized as Dead. Hematocrit was significantly lower in fish that were categorized as Dead. Furthermore, 89% of fish classified as Dead were infiltrated by sand fleas, present in several sets in deeper and colder waters. Our results indicated that avoiding the use of hook strippers and minimizing soak times in areas known to have high sand flea activity result in better survival outcomes. These results have been published in the journal *Ocean and Coastal Management (*Dykstra et al. 2024; https://doi.org/10.1016/j.ocecoaman.2024.107018).

4.2. Discard mortality rates of Pacific halibut in the charter recreational fishery.

The Pacific halibut recreational fishery (combined guided and unguided) is an important contributor (20%) to the total fishery-induced mortality, with 3,473 metric tons (7.6 million pounds) of removals in 2021. Under current regulations, the number of fish captured, handled and discarded by the Pacific halibut recreational fisheries is significant. Capture-related events impose stress and injury to the fish and, consequently, decrease the survival of discarded fish. In contrast to the trawl and longline Pacific halibut fisheries, discard mortality rates (DMRs) have not been determined experimentally in the recreational fisheries and are currently based on DMR information generated from commercial gear using J-hooks combined with rates derived for other sport fisheries, and coarsely applied to recreational hook type and creel census data. This project aims at better understanding the role of fishing practices and capture conditions on injury profile, physiological stress levels and survival in the Pacific halibut recreational fisheries in order to estimate DMRs. Recent reductions in Pacific halibut catch limits place added importance for improved DMR estimates applied to the recreational fishery.

The primary components of this project were to: 1) collect information on hook types and sizes and handling practices used in the guided recreational Pacific halibut fisheries of the central and eastern Gulf of Alaska (IPHC Regulatory Areas 2C and 3A) that account for a significant portion (83%) of coastwide recreational mortalities; 2) quantify relationships between gear types employed and the size composition of captured Pacific halibut; 3) characterize injury profiles and physiological stress levels in relation to commonly-employed capture and handling protocols, and; 4) quantify and characterize survival of discarded Pacific halibut in order to evaluate the relative accuracy of currently-employed DMRs. Funding for these projects was provided by the National Fish and Wildlife Foundation and the North Pacific Research Board.

The first component of the existing project was initiated in May of 2019 and was composed of fleet outreach exercises that were conducted in the Alaskan ports of Homer, AK and Seward, AK in IPHC Regulatory Area 3A, and in Juneau, AK and Sitka, AK in IPHC Regulatory Area 2C. Working directly with each port's charter association and the ADF&G, stakeholder meetings were conducted in order to explain project objectives, solicit the involvement of local guided recreational fishing captains, receive feedback with respect to project logistics, and answer questions and concerns that fleet members might have regarding the work. This was followed by the distribution of a voluntary survey – developed in collaboration with the University of Alaska, Fairbanks – soliciting detailed information regarding gear configurations (hook types and sizes) employed and fish handling practices (e.g., fish manipulated by hand or net, hook-release method, time out of water), that was administered to guided recreational fishing captains via the IPHC's commercial port sampling program over the course of the 2019 fishing season. Results showed that the guided recreational fleet predominantly uses circle hooks (75-100%), followed by jigs. Predominant hook release methods included reversing the hook (54%) or twisting the hook out with a gaff (40%), and the fish were generally handled by supporting both the head and tail (65%), while other discard techniques reported included handling by the operculum (10%) or by the tail alone

(10%). The data obtained from the 2019 guided recreational fleet survey provided the basis for structuring the field work that was conducted during the summer of 2021.

The second component of the study was to conduct field studies informed by common gear and handling practices as determined by the fleet survey. The IPHC Secretariat chartered the guided recreational vessel F/V High Roller (operated by Alaska Premier Charters) from 21-27 May 2021 in IPHC Regulatory Area 2C (out of Sitka, AK). The research charter in IPHC Regulatory Area 3A (out of Seward, AK) was conducted on the fishing vessel Gray Light (operated by Graylight Fisheries) on 11-16 June 2021. The fishing vessels were required to fish 6 rods at a time, three (3) rigged with 12/0 circle hooks and three (3) rigged with 16/0 circle hooks to establish a comparison of the two most common gear types used in the Pacific halibut recreational fishery.

In IPHC Regulatory Area 2C, we captured, sampled and released 243 Pacific halibut that were on average 80.1 ± 19.0 cm in fork length (range from 52 to 149 cm) and 7.4 ± 7.5 Kg in weight (range from 1.5 to 49.75 Kg). In IPHC Regulatory Area 3A (Seward, AK), we captured, sampled, and released 118 Pacific halibut that were on average 72.5 ± 14.1 cm in fork length (range from 42 to 110 cm) and 5.0 ± 3.3 Kg in weight (range from 0.55 to 17 Kg). Therefore, a total of 361 Pacific halibut were captured, sampled, and released in the two research charters conducted.

For all Pacific halibut captured in IPHC regulatory area 2C, we recorded the time from hooking to release, length and weight, the injury code and release viability category using the standard IPHC criteria, and air and fish temperature. In addition, from each fish we collected a blood sample, measured somatic fat content with the use of a Distell Fat Meter, took a picture of the hooking injury, collected a fin clip for genetic sexing and tagged the fish with an opercular wire tag prior to release. Pacific halibut captured in IPHC Regulatory Area 3A were subjected to the same sampling protocol except for 80 fish that were tagged with acceleration-logging survivorship pop-up archival transmitting (sPAT) tags. sPAT-tagged fish were selected only among those fish that were classified in the “excellent” viability category and did not have a blood sample taken to minimize handling-related stress. The deployed sPAT tags were programmed to be released after 96 days. Seventy-six (76) of the 80 sPAT tags provided useable data reports. Survival analysis (R package = “survival”) produced a mortality rate estimate of 1.35% with a 95% CI of 0.0-3.95%. This estimate represents the first field corroborated estimate of recreational discard mortality and is consistent with the supposition that fish discarded in the recreational fishery from circle hooks in excellent condition have a mortality rate that is arguably lower than 3.5%, as is currently used for Excellent viability fish released in the commercial fishery (Meyer, 2007). Furthermore, these results affirm the use of current recreational discard mortality estimation methodologies embedded in mortality estimates that feed into the SA and MSE process.

Fish size distributions were nearly identical between the two IPHC Regulatory Areas. Larger hooks (16/0) caught significantly larger fish compared to the smaller hook (12/0) for fish caught out of Seward, but no difference in fish sizes by hook size was seen in fish landed out of Sitka. Hook size had no effect on injury distributions. The majority (97%) of Pacific halibut captured were classified in the Excellent viability category.

Using the collected blood samples, stress parameters measured in the plasma (i.e. blood constituents without red blood cells) of captured and released Pacific halibut included the stress hormone cortisol and the metabolites glucose and lactate. Plasma cortisol, glucose and lactate levels did not vary by release viability, nor by fish recovered to date, but appeared to increase with fight time, suggestive of a positive relationship between stress levels and fight time in recreationally captured Pacific halibut. Interestingly, the observed plasma cortisol, glucose and lactate levels were markedly lower than those measured in commercially caught individuals.

To date, of the 281 fish that were tagged with opercular wire tags (243 fish in IPHC Regulatory Area 2C and 38 in IPHC Regulatory Area 3A) 38 tags have been recovered (36 from IPHC Regulatory Area 2C and 2 from IPHC Regulatory Area 3A). Of the 80 fish tagged with sPAT tags, seven were recaptured by the fishery, and an additional two tethers have been recaptured since the main body successfully reported in data.

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. 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).

Removal of captured fish from fishing gear (known as depredation) is a growing problem among many hook-and-line fisheries worldwide. In the north Pacific Ocean, both Killer (*Orcinus orca*) and Sperm (*Physeter macrocephalus*) whales are involved in depredation behavior in Pacific halibut, sablefish (*Anoplopoma fimbria*), and Greenland turbot (*Reinhardtius hippoglossoides*) longline fisheries. In 2011 and 2012, fisheries observers estimated that 21.4% of sablefish sets, 9.9% of Greenland turbot sets, and 6.9% of Pacific halibut sets were affected by whale depredation in the Bering Sea (Peterson et al. 2014). Reductions in catch per unit effort (CPUE) when whales were present ranged across geographic regions from 55%-69% for sablefish, 54%-67% for Greenland turbot, and 15-57% for Pacific halibut (Peterson et al. 2014). These impacts also incur significant time, fuel, and personnel costs to fishing operations. From a fisheries management perspective, depredation creates an additional and highly uncertain source of mortality, loss of data (e.g. compromised survey activity), and reduces fishery efficiency. Stock assessments of both Pacific halibut and sablefish have adjusted their analysis of fishery-independent data to account for the effects of whale depredation on catch rates. In the sablefish assessment, fishery limits are also adjusted downward to reflect expected depredation during the commercial fishery. In recent years, whale depredation has been limiting fishers' ability to harvest their Greenland turbot allocations and they have been well below (35-78% in the last 5 years) the total allowable catch for that fishery. Meanwhile, potential risks to the whales include physical injury due to being near vessels and gear, disruption of social structure and developing an artificial reliance on food items that can be affected by fishery dynamics.

Many efforts have been made over the years to mitigate this problem, with fishers generally limited to simple methods that can be constructed, deployed, or enacted without significantly disrupting normal fishing operations, or without violating gear regulations. Existing approaches include catch protection, physical and auditory deterrents, and spatial or temporal avoidance. These approaches have had variable degrees of success and ease of adoption, but none have solved the problem. Terminal gear modification and catch protection have been identified as an avenue with the highest likelihood of ‘breaking the reward cycle’ in depredation behaviors. Particularly for Pacific halibut and Greenland turbot, two species whose catches are prohibited and closely regulated, respectively, in trawl fisheries and that are difficult to capture efficiently in pots, novel approaches to protection of longline catch are necessary.

This project focuses on investigating strategies aimed at protecting longline-caught fish, through low cost, easy to adopt gear modifications that securely retain catch, while breaking the ‘reward cycle’ in depredation. The project, that received funding from the Bycatch Reduction Engineering Program (BREP)-NOAA, has been structured in two parts. First, in early 2022 we conducted a virtual International Workshop (link) 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.

The second part of the project involved developing the top catch protection design outcomes of the Workshop into functional prototypes and conducting field testing in longline sea trials. The two selected catch protection devices were: 1) an underwater shuttle (Figure 7) and 2) a branch gear with a sliding shroud system.

The results from the field testing conducted in May 2023 indicated that the shuttle was a safe and effective gear type which entrained comparable quantities, sizes, and types fish as the control gear, whereas the sliding shroud and branch gear had substantial logistical issues that would need to be addressed before scaling up to a fishery level.

A)  B)  C) 

Figure 7. Shuttle unit stowed on vessel (A), shuttle being hoisted onto vessel during retrieval (B), and fish contained within the shuttle before emptying on deck (C).

Based on the success of the first two components of this work, the IPHC was successful in securing additional funding from BREP-NOAA to expand testing of the shuttle concept in the presence of depredating Orcas in Alaskan waters (Appendix IV). The work will further examine refinements (attachment protocols, gangion/hook strength), statistical testing of catch rates, and catch composition (size ranges, species, catch volume) when using the device, as well as allow for quantification of removals of fish from non-shuttle treatments by depredating whales. The work was initially scheduled for 2024; however, our initial requests for tenders did not generate sufficient interest and the grant period of performance has been extended until April of 2026 to accommodate conducting the field work in 2025. For that purpose, the IPHC Secretariat is preparing requests for tenders for submission in late 2024.

RECOMMENDATION/S

1) That the RAB **NOTE** IPHC-2024-RAB025-06, that provides a report on current and planned biological and ecosystem science and research activities contemplated in the IPHC's Five-Year Program of Integrated Research and Monitoring (2022-2026).

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APPENDICES

Appendix I: Biological research areas in the 5-Year Program of Integrated Research and Monitoring (2022-2026) and ranked relevance for stock assessment and management strategy evaluation (MSE).

Appendix II: List of ranked research priorities for stock assessment

Appendix III: List of ranked research priorities for management strategy evaluation (MSE)

Appendix IV: Summary of current competitive research grants awarded to IPHC

APPENDIX I

Biological research areas in the 5-Year Program of Integrated Research and Monitoring (2022-2026) and ranked relevance for stock assessment and management strategy evaluation (MSE)

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 research priorities for stock assessment

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	Migration and population dynamics	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		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	Fishing technology	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	Fishing technology	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 research priorities for management strategy evaluation (MSE)

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

APPENDIX IV

Summary of current competitive research grants awarded to IPHC

Project #	Grant agency	Project name	PI	Partners	IPHC Budget ($US)	Grant period	Research area	Management implications	Research prioritization
1	**Bycatch Reduction Engineering Program- NOAA**	Full scale testing of devices to minimize whale depredation in longline fisheries (NOAA Award Number NA23NMF4720414)	IPHC	Alaska Fisheries Science Center- NOAA	$199,870	November 2023 – April 2026	Fishing technology	Mortality estimations due to whale depredation	3
2	**Alaska Sea Grant (pending award)**	Development of a non-lethal genetic-based method for aging Pacific halibut (R/2024-05)	IPHC APU	Alaska Fisheries Science Center- NOAA (Juneau)	$60,374	January 2025- December 2026	Population dynamics	Stock structure	2
Total awarded ($)					**$260,244**				

IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2024

PREPARED BY: IPHC SECRETARIAT (K. UALESI , T. JACK, R. RILLERA, K. COLL; 15 OCTOBER 2024)

PURPOSE

To provide a summary of the IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2024.

BACKGROUND

The annual IPHC Fishery-Independent Setline Survey (FISS) of the Pacific halibut stock was augmented from 2014-2019 with expansion stations that filled in gaps in coverage in the annual FISS. Prior to 2020, the standard grid of stations comprised 1,200 stations. Following the completion in 2019, expansion stations were added to the standard grid in all IPHC Regulatory Areas, now totaling 1,890 stations for the full FISS design (Figure 1), within the prescribed depth range of 18 to 732 metres (10 to 400 fathoms).

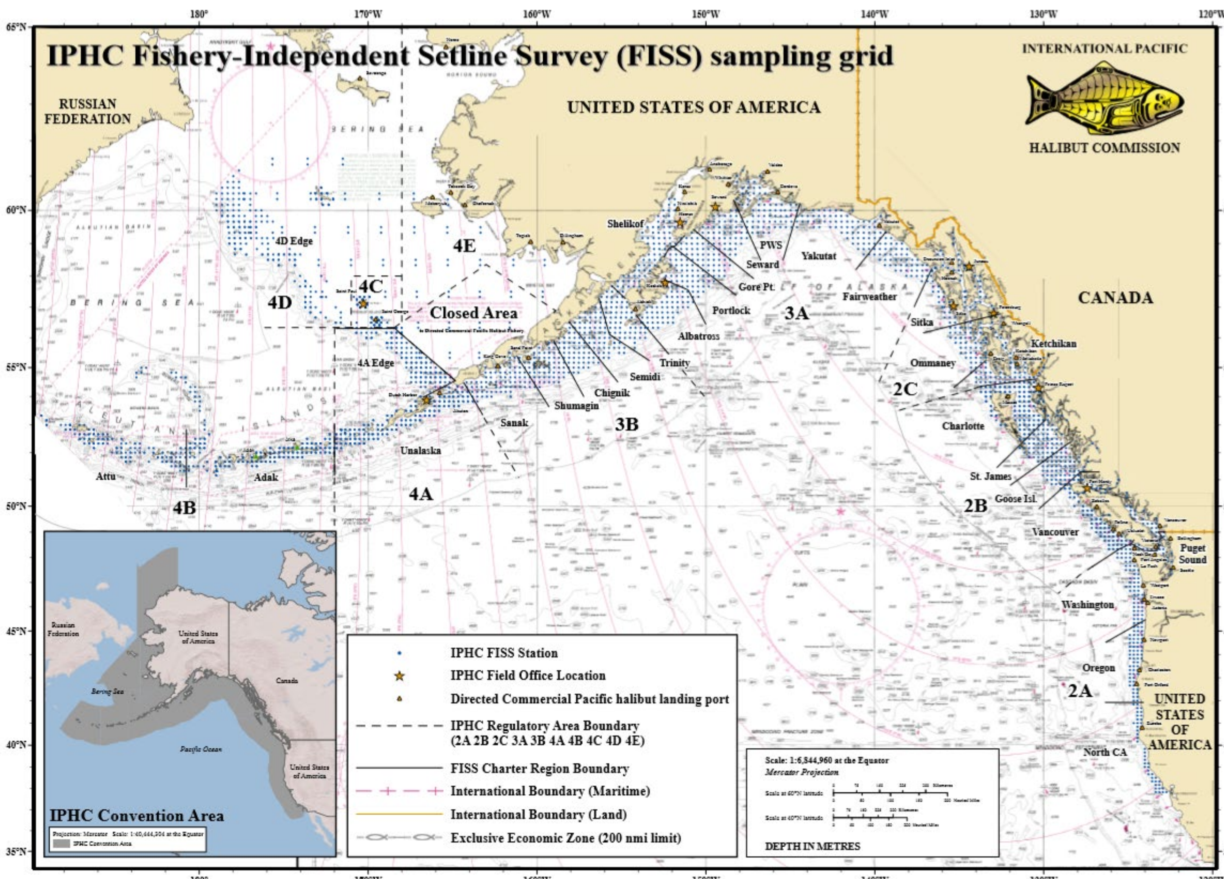

Figure 1. IPHC Fishery-Independent Setline Survey (FISS) with full sampling grid shown.

Prior to 2019, only fixed gear was used to fish FISS sets. With increasing use of snap gear in the commercial fishery, this restriction has limited the number of vessels available for the FISS. Further, any differences between snap and fixed gears (including catch rate differences and differences in fishing locations) may affect our understanding of trends in commercial fishery indices. This has motivated the need for a study comparing the two gear types with this work being done in 2019, 2020, and again in 2021. While no study was completed in 2022, we recognized the increased use of snap gear and integrated snap gear into the FISS tender specifications for 2023 and 2024.

Beginning in 2019, individual weight data were collected coastwide from Pacific halibut caught on the FISS to eliminate questions that have arisen regarding the accuracy of estimates that depend on these weights, including weight per unit effort (WPUE) indices of density. Data from IPHC collections from commercial landings and other sources had provided evidence that the current standard length-net weight curve used for estimating Pacific halibut weights on the FISS may have been over-estimating weights on average in most IPHC Regulatory Areas, and that the relationship between weight and length may vary spatially.

2024 FISS design

At IM099, the Commission agreed on an optimized version of the revenue positive design:

> IPHC-2023-IM099-R, para. 51: *The Commission **AGREED** on an optimized design for the 2024 FISS as provided at Appendix IV, that balances the Commission's primary and secondary objectives for the FISS. Specifically, the 2024 design shall include Options 1, 2, and 3…. In addition, Option 4 shall be included in the RFT process but is not yet endorsed. Once bids are received and evaluated in February 2024, the Commission will make a final decision on whether to proceed or not with Option 4, based on bids and logistical constraints at that time and potentially a new option* [Option 9] *for IPHC Regulatory Area 4CDE.*

On 22 December 2023, the 2024 FISS Tender Specifications were published to the IPHC website with a deadline of 4 February 2024 for tenders.

At IM099 the Commission **AGREED** on a 2024 design that included Options 1, 2 and 3. In the 2024 FISS tender specifications, Option 4 and Option 9 were also included as tentative design additions for the Commission's review in February 2024. A special session was held on 13 February where the final 2024 FISS design was **ENDORSED**.

The design (Figure 2) comprised sampling of subareas within IPHC Regulatory Areas 2B, 3A, 3B, 4CDE intended to balance the Commissions primary and secondary objectives for the FISS. 2024, sampling in IPHC Regulatory Areas 2C included 100% of the full FISS design.

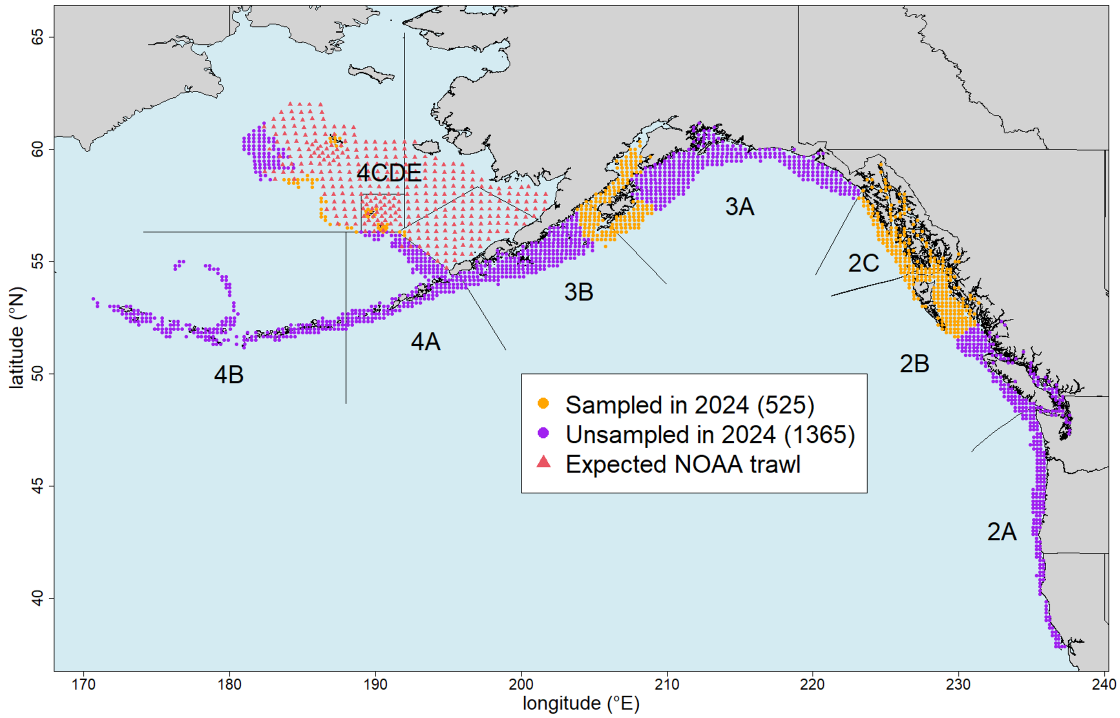

Figure 2. Map of the 2024 FISS design endorsed by the Commission on 13 February 2024 (IPHC-2024-MR-002). Purple circles were not sampled in 2024.

MATERIALS AND METHODS

The IPHC's FISS design encompasses nearshore and offshore waters of the IPHC Convention Area (Fig. 1). The IPHC Regulatory Areas are divided into 29 charter regions, each requiring between 10 and 46 charter days to complete. FISS stations are located at the intersections of a 10 nmi by 10 nmi square grid within the depth range occupied by Pacific halibut during summer months (18 – 732 m [10 – 400 fm]). Figure 2 depicts the 2024 FISS station positions, and IPHC Regulatory Areas.

Fishing vessels are chosen through a competitive bid process where up to four (4) charter regions per vessel may be awarded and typically 8-15 vessels are chosen. In 2024, the process was clearly documented on the IPHC website for accountability and transparency purposes: Vessel Recruiting - IPHC.

In 2024, five (5) vessels were chartered to complete the FISS, as detailed in IPHC-2024-MR-003 Notification of IPHC Fishery-Independent Setline Survey (FISS) 2024 Contract Awards - IPHC.

Sampling protocols

IPHC Setline Survey Specialists (Field) collected data according to protocols established in the 2024 FISS Sampling Manual (IPHC-2024-VSM01).

Sampling challenges - 2024

Of the 525 FISS stations planned for the 2024 FISS season, 507 (97%) were effectively sampled.

Not sampled: A total of three (3) initially planned stations were not sampled in 2024. Two stations in the Sitka charter region were unsampled as they were within Glacier Bay National Park and we were not permitted to complete these stations within the park this year. There was also one station in the St James charter region that was unsampled as it was located in the Hecate Marine Protected Area.

Ineffective stations: Coastwide, fifteen (15) stations were deemed ineffective due to orca depredation (n=2), sperm whale depredation (n=9), sand fleas (n=3), and setting and gear issues (n=1).

Bait (Chum salmon & Pink salmon)

The minimum quality requirement for FISS bait is No. 2 semi-bright (Alaska Seafood Marketing Institute grades A through E), headed and gutted, and individually quick-frozen chum or pink salmon. Bait usage is based on 0.17 kilograms (0.37 pounds) per hook resulting in approximately 136 kilograms (300 pounds) per eight skate station. Bait quality was monitored and documented throughout the season and found to meet the standard as described above.

Pre-season: In October 2024 (IPHC Media Release 2023-014), the Secretariat made pre-season bait purchases of approximately 30 tonnes (66,000 lbs) of chum salmon and 30 tonnes (66,000 lbs) of pink salmon to ensure a smooth start to the 2024 FISS.

RESULTS

Interactive views of the FISS results are provided via the IPHC website here:

https://www.iphc.int/data/setline-survey-catch-per-unit-effort

As in previous years, legal-sized (O32) Pacific halibut caught on the FISS were sacrificed in order to obtain biological data and were retained for sale. In addition, beginning in 2020, sub-legal (U32) Pacific halibut randomly selected for otolith sampling were also retained and sold. This helped to offset costs of the FISS. FISS vessels also retained for sale incidentally captured rockfish (*Sebastes spp*.) and Pacific cod (*Gadus macrocephalus*) as these species rarely survive the barotrauma resulting from capture. Most vessel contracts provided the vessel a lump sum payment, along with a 10% share of the Pacific halibut proceeds and a 50% share of the incidental catch proceeds.

The 2024 FISS chartered 5 commercial longline vessels (three Canadian and two USA) during a combined 29 trips and 275 charter days (Tables 1). Otoliths were removed from 5,771 fish coastwide. Approximately 153 tonnes (337,674 pounds) of Pacific halibut, 22 tonnes (48,993 pounds) of Pacific cod, and 27 tonnes (60,044 pounds) of rockfish were landed from the FISS stations.

Table 1a. Effort and landing summary by FISS charter region and vessel for all 2024 stations and all Pacific halibut (sampled U32 and all O32).

IPHC Regulatory Area	Charter Region	Vessel	Vessel Number[1]	Charter Days[2]	Planned Stations	Effective Stations[3]	Pacific halibut Sold (t)[4]	Pacific halibut Sold (lb)[4]	Average Price USD/kg[5]	Average Price USD/lb[5]
2B	Charlotte	*Bold Pursuit*	20875	41	89	88	31	68,361	$15.88	$7.20
2B	St. James	*Vanisle*	21912	35	60	57	16	36,071	$16.27	$7.38
2C	Ketchikan	*Pender Isle*	27282	22	43	43	18	39,170	$11.88	$5.39
2C	Ommaney	*Pender Isle*	27282	26	52	46	36	78,604	$13.97	$6.34
2C	Sitka	*Vanisle*	21912	33	52	47	19	41,234	$12.72	$5.77
3A	Albatross	*Kema Sue*	41033	25	49	49	10	21,325	$11.98	$5.43
3A	Shelikof	*Kema Sue*	41033	32	64	64	11	23,970	$12.52	$5.68
3B	Trinity	*Kema Sue*	41033	28	56	56	10	22,250	$12.03	$5.45
4CDE	4CDE South	*Saint Peter*	76769	33	60	58	3	6,689	$6.81	$3.09
Total		**5 Vessels**		**275**	**525**	**507**	**153**	**337,674**	**$13.71**	**$6.22**

1 Canada: Vessel Registration Number and USA: ADF&G vessel number.

2 Days are estimated - some vessels fished two charter regions in one day.

3 Stations that did not meet setting parameters or deemed ineffective are excluded.

4 Net weight (head-off, dressed, washed). May not sum to correct total due to rounding.

5 Ex-vessel price.

Table 1b. Effort and landing summary by FISS charter region and vessel for all 2024 stations and O32 Pacific halibut.

IPHC Regulatory Area	Charter Region	Vessel	Vessel Number[1]	Charter Days[2]	Planned Stations	Effective Stations[3]	Pacific halibut Sold (t)[4]	Pacific halibut Sold (lb) [4]	Average Price USD/kg [5]	Average Price USD/lb [5]
2B	Charlotte	*Bold Pursuit*	20875	41	89	88	30	66,960	$15.90	$7.21
2B	St. James	*Vanisle*	21912	35	60	57	16	35,293	$16.28	$7.39
2C	Ketchikan	*Pender Isle*	27282	22	43	43	17	38,217	$11.89	$5.39
2C	Ommaney	*Pender Isle*	27282	26	52	46	35	77,088	$14.02	$6.36
2C	Sitka	*Vanisle*	21912	33	52	47	18	39,652	$12.81	$5.81
3A	Albatross	*Kema Sue*	41033	25	49	49	9	19,684	$11.99	$5.44
3A	Shelikof	*Kema Sue*	41033	32	64	64	10	22,756	$12.58	$5.70
3B	Trinity	*Kema Sue*	41033	28	56	56	9	20,796	$12.12	$5.50
4CDE	4CDE South	*Saint Peter*	76769	33	60	58	2	4,692	$7.66	$3.47
Total		**5 Vessels**		**275**	**525**	**507**	**147**	**325,138**	**$13.82**	**$6.27**

1 Canada: Vessel Registration Number and USA: ADF&G vessel number.

2 Days are estimated - some vessels fished two charter regions in one day.

3 Stations that did not meet setting parameters or deemed ineffective are excluded.

4 Net weight (head-off, dressed, washed). May not sum to correct total due to rounding.

5 Ex-vessel price.

Table 1c. Effort and landing summary by FISS charter region and vessel for all 2024 stations and sampled U32 Pacific halibut.

IPHC Regulatory Area	Charter Region	Vessel	Vessel Number[1]	Charter Days[2]	Planned Stations	Effective Stations[3]	Pacific halibut Sold (t)[4]	Pacific halibut Sold (lb) [4]	Average Price USD/kg [5]	Average Price USD/lb [5]
2B	Charlotte	*Bold Pursuit*	20875	35	89	88	1	1,401	$14.82	$6.72
2B	St. James	*Vanisle*	21912	41	60	57	0	778	$15.56	$7.06
2C	Ketchikan	*Pender Isle*	27282	22	43	43	0	953	$11.27	$5.11
2C	Ommaney	*Pender Isle*	27282	26	52	46	1	1,516	$11.46	$5.20
2C	Sitka	*Vanisle*	21912	33	52	47	1	1,582	$10.41	$4.72
3A	Albatross	*Kema Sue*	41033	25	49	49	1	1,641	$11.87	$5.38
3A	Shelikof	*Kema Sue*	41033	32	64	64	1	1,214	$11.41	$5.17
3B	Trinity	*Kema Sue*	41033	28	56	56	1	1,454	$10.65	$4.83
4CDE	4CDE South	*Saint Peter*	76769	33	60	58	1	1,997	$4.81	$2.18
Total		**5 Vessels**		**275**	**525**	**507**	**6**	**12,536**	**$10.84**	**$4.92**

1 Canada: Vessel Registration Number and USA: ADF&G vessel number.

2 Days are estimated - some vessels fished two charter regions in one day.

3 Stations that did not meet setting parameters or deemed ineffective are excluded.

4 Net weight (head-off, dressed, washed). May not sum to correct total due to rounding.
5 Ex-vessel price.

Vessels chartered by the IPHC delivered fish to nine (9) different ports (Tables 2). Fish sales were awarded based on obtaining a fair market price. When awarding sales, the Commission considered the price offered, the number of years that a buyer had been buying and marketing

Pacific halibut, how fish were graded at the dock (including the determination of No. 2 and chalky Pacific halibut), and the promptness of settlements following deliveries. Individual sales were evaluated after each event to ensure that the buyer was meeting IPHC standards. Average prices increased from $13.31/kg in 2023 to $13.71/kg in 2024 (Tables 3). This represents a 2.9% increase in price.

Table 2a. FISS Pacific halibut landings by port for all Pacific halibut (sampled U32 and all O32), 2024[1,2].

Offload Port	Trips	Tonnes	Pounds	Total USD	Average Price (USD/kg)	Average Price (USD/lb)
Dutch Harbor	1	1.33	2,930	$8,143.80	$6.13	$2.78
Homer	4	14.65	32,297	$180,104.77	$12.29	$5.58
Ketchikan	2	17.00	37,487	$201,573.05	$11.85	$5.38
Kodiak	4	15.99	35,248	$193,256.64	$12.09	$5.48
Petersburg	1	6.75	14,889	$89,416.45	$13.24	$6.01
Port Hardy	3	14.18	31,265	$226,385.03	$15.96	$7.24
Prince Rupert	8	55.23	121,755	$879,730.37	$15.93	$7.23
St. Paul	2	1.71	3,759	$12,508.33	$7.34	$3.33
Sitka	4	26.33	58,044	$308.603.90	$11.72	$5.32
Grand Total	**29**	**153**	**337,674**	**$2,099,722.34**	**$13.71**	**$6.22**

[1] Net weight (head-off, dressed, washed).
[2] Prices based on net weight.

Table 2b. FISS Pacific halibut landings by port for O32 Pacific halibut, 2024[1,2].

Offload Port	Trips	Tonnes	Pounds	Total USD	Average Price (USD/kg)	Average Price (USD/lb)
Dutch Harbor	1	0.89	1,970	$5,791.80	$6.48	$2.94
Homer	4	13.87	30,573	$171,261.09	$12.35	$5.60
Ketchikan	2	16.58	36,549	$196,775.80	$11.87	$5.38
Kodiak	4	14.82	32,663	$179,960.03	$12.15	$5.51
Petersburg	1	6.41	14,138	$86,036.95	$13.42	$6.09
Port Hardy	3	14.02	30,903	$223,860.54	$15.97	$7.24
Prince Rupert	8	54.06	119,192	$862,641.97	$15.96	$7.24
St. Paul	2	1.23	2,722	$10,506.92	$8.51	$3.86
Sitka	4	0	56,428	$301,264.90	$11.77	$5.34
Grand Total	**29**	**147**	**325,138**	**$2,038,100.00**	**$13.82**	**$6.27**

[1] Net weight (head-off, dressed, washed).
[2] Prices based on net weight.

Table 2c. FISS Pacific halibut landings by port for sampled U32 Pacific halibut, 2024[1,2].

Offload Port	Trips	Tonnes	Pounds	Total USD	Average Price (USD/kg)	Average Price (USD/lb)
Dutch Harbor	1	0.44	960	$2,352.00	$5.40	$2.45
Homer	4	0.78	1,724	$8,843.68	$11.31	$5.13
Ketchikan	2	0.43	938	$4,797.25	$11.28	$5.11
Kodiak	4	1.17	2,585	$13,296.61	$11.34	$5.14
Petersburg	1	0.34	751	$3,379.50	$9.92	$4.50
Port Hardy	3	0.16	362	$2,524.49	$15.37	$6.97
Prince Rupert	8	1.16	2,563	$17,088.40	$14.70	$6.67
St. Paul	2	0.47	1,037	$2,001.41	$4.25	$1.93
Sitka	4	0.73	1,616	$7,339.00	$10.01	$4.54
Grand Total	**29**	**6**	**12,536**	**$61,622.34**	**$10.84**	**$4.92**

[1] Net weight (head-off, dressed, washed).
[2] Prices based on net weight.

Table 3a. FISS landings (total pounds and price) of all Pacific halibut (sampled U32 and all O32) by IPHC Regulatory Area in 2024[1].

IPHC Regulatory Area	2B	2C	3A	3B	4CDE	Total Weight and Average Price
Tonnes	47	72	21	10	3	153
Pounds	104,432	159,008	45,295	22,250	6,689	337,674
Price USD/kg	$16.01	$13.13	$12.26	$12.02	$6.81	$13.71
Price USD/lb	$7.26	$5.96	$5.56	$5.45	$3.09	$6.22

1 Net weight (head-off, dressed, washed)

Table 3b. FISS landings (total pounds and price) of O32 Pacific halibut by IPHC Regulatory Area in 2024[1].

IPHC Regulatory Area	2B	2C	3A	3B	4CDE	Total Weight and Average Price
Tonnes	46	70	20	9	2	147
Pounds	102,253	154,957	42,440	20,796	4,692	325,138
Price USD/kg	$16.03	$13.19	$12.30	$12.12	$7.66	$13.82
Price USD/lb	$7.27	$5.98	$5.58	$5.50	$3.47	$6.27

1 Net weight (head-off, dressed, washed)

Table 3c. FISS landings (total pounds and price) of sampled U32 Pacific halibut by IPHC Regulatory Area in 2024[1].

IPHC Regulatory Area	2B	2C	3A	3B	4CDE	Total Weight and Average Price
Tonnes	1	2	1	1	1	6
Pounds	2,179	4,051	2,855	1,4054	1,997	12,536
Price USD/kg	$15.08	$11.00	$11.67	$10.65	$4.81	$10.84
Price USD/lb	$6.84	$4.99	$5.29	$4.81	$2.18	$4.92

1 Net weight (head-off, dressed, washed)

FISS timing

The months of June, July, and August are targeted for FISS fishing every year. In 2024, this activity took place from 24 May through 15 August. On a coastwide basis, FISS vessel activity was highest in intensity at the beginning of the FISS season and declined in early August as boats finished their charter regions (Figure 3). All FISS activity was completed by mid-August.

Area	Year	Week 21	Week 22	Week 23	Week 24	Week 25	Week 26	Week 27	Week 28	Week 29	Week 30	Week 31	Week 32	Week 33	Week 34	Week 35	Week 36	Week 37	Week 38	Week 39	Week 40
2A	2023			42%	58%																
	2022			10%	18%	19%	19%	19%	16%												
	2021			19%	15%	13%	8%	23%	10%	14%											
	2019		8%	15%	14%	9%	14%	12%	13%	14%											
	2018		10%	11%	9%	8%	12%	10%	4%	7%	6%	10%	3%	8%	1%						
	2017		8%	7%	7%	5%	6%	7%	1%	6%	4%	7%	10%	8%	8%	4%	6%	4%	2%		
2B	2024		13%	6%	4%			13%	10%	11%	16%	19%	8%								
	2023	1%	16%	12%	13%	15%	13%	9%	9%	4%	4%	3%									
	2022		2%	10%	9%	9%	8%	7%	10%	14%	16%	13%	2%								
	2021			16%	12%	9%	11%	6%	9%	6%	5%	6%	5%	5%	2%	8%					
	2020						2%	14%	16%	11%	6%	6%	10%	7%	1%	9%	13%	6%			
	2019		8%	8%	8%	2%	4%	8%	18%	11%	8%	11%	9%	5%							
	2018		7%	9%	10%	10%	10%	12%	10%	4%	10%	8%	9%	1%							
	2017		10%	10%	7%	8%	5%	15%	18%	17%	10%										
2C	2024		6%	10%	12%	22%	15%	11%	20%	3%											
	2023						9%	18%	14%	20%	3%		12%	8%	9%	7%					
	2022			12%	10%	8%	9%	7%	16%	10%	5%	12%	5%	7%							
	2021		1%	19%	8%	9%	9%	7%	7%	10%	12%	10%	7%								
	2020							14%	11%	7%	9%	6%	7%	18%	14%	8%	5%				
	2019		1%	11%	13%	5%	11%	8%		5%	9%	10%	12%	12%	4%						
	2018					1%	10%	18%	13%	13%	9%	9%	7%	9%	9%	4%					
	2017		15%	15%	10%	15%	13%					7%	9%	15%	2%						
3A	2024				6%	11%	13%	13%	3%	6%	13%	19%	8%	8%							
	2023			8%	7%	15%	14%	19%	7%	9%	8%	6%	8%								
	2022			11%	17%	16%	10%	5%	3%					5%	3%	8%	11%	5%	6%		
	2021			6%	12%	10%	6%	8%	7%	9%	10%	12%	7%	7%	2%	2%	1%				
	2020						0%	13%	11%	12%	16%	12%	11%	7%	5%	4%	5%	3%			
	2019		7%	18%	17%	13%	10%	7%	4%	3%	3%	1%	2%		0%	1%	7%	7%	1%		
	2018		15%	15%	12%	9%	7%	8%	2%	8%	5%	6%	5%	4%	2%	2%					
	2017		14%	9%	11%	11%	9%	10%	9%	8%	6%		3%	3%	2%	3%					
3B	2024		5%	32%	14%	5%			32%	5%			5%								
	2023		6%	13%	7%		7%	2%	9%	14%	11%	11%	10%	7%	2%						
	2022					3%	37%	38%	22%												
	2021			5%	8%	6%	9%	4%	8%	20%	18%	13%	9%								
	2020							14%	21%	19%	16%	3%	12%	12%	3%						
	2019		5%	5%	10%	9%	3%	4%	7%		6%	4%	6%	12%	12%	9%	6%	2%			
	2018		15%	16%	6%	15%	7%		5%	6%	10%	7%	5%	2%	5%						
	2017		5%	19%	22%	23%	12%	13%	6%												
4A	2022									21%	28%	10%	19%	7%	16%						
	2021				4%	21%	27%	13%	13%							15%	8%				
	2019						6%	19%	12%	14%	12%	14%	10%		14%						
	2018						14%	16%	18%	22%	14%	2%	15%								
	2017					4%	7%	13%	14%	23%	12%	13%	15%								
4B	2022				32%	30%	28%	10%													
	2021					19%	11%							38%	16%	8%	8%				
	2019				16%	13%	12%	7%	12%	3%	17%	19%									
	2018				11%	17%	7%	6%							15%	17%	18%	10%			
	2017				16%	14%	11%	12%	11%	6%	4%	7%	6%	6%	5%						
4CDE	2024					17%	23%	23%	35%	2%											
	2022								23%	22%	9%	7%	27%	12%							
	2021						9%	26%		28%	37%										
	2019												5%	31%	10%	15%	12%		14%	10%	4%
	2018										11%	32%	12%	9%	21%	15%					
	2017						7%	9%		19%	19%	16%	17%	14%							

INTERNATIONAL PACIFIC HALIBUT COMMISSION

Figure 3. Percent of the total FISS stations completed by IPHC Regulatory Area during each week of the year (2017-2023). Week 21 begins in late May or early June depending on the year.

RECOMMENDATION/S

That the RAB:

1) **NOTE** paper IPHC-2024-RAB025-07 that provides a summary of the IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2024.

APPENDICES

Nil.

2025 and 2026-27 FISS designs

PREPARED BY: IPHC SECRETARIAT (R. WEBSTER, I. STEWART, K. UALESI, T. JACK, D. WILSON; 17 OCTOBER 2024)

PURPOSE

To provide the Research Advisory Board with design options considered by the Commission for the 2025 Fishery-Independent Setline Survey (FISS) together with potential designs for 2026-27.

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 81.3 cm 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).

At the Commission Work Meeting (2024), the Commission was presented with three sets of FISS designs for 2025-29 based on rotating blocks of stations (the Base Block and Core Block designs) and on a reduced design based on the implemented 2024 FISS design (the Reduced Core design). These sets of designs were intended to represent FISS coverage achievable under different levels of available supplementary funding. This paper focuses on two designs considered by the Commission: the Base Block design (2025-27) which provides extensive sampling coverage over 3+ year period, and a fiscally viable design for 2025 that includes sampling in all IPHC Biological for lowest projected cost.

The Commission will further consider the 2025 FISS design options at the 14th Special Session of the IPHC (SS014), scheduled for 31 October 2024 (IPHC-2024-SS014-03).

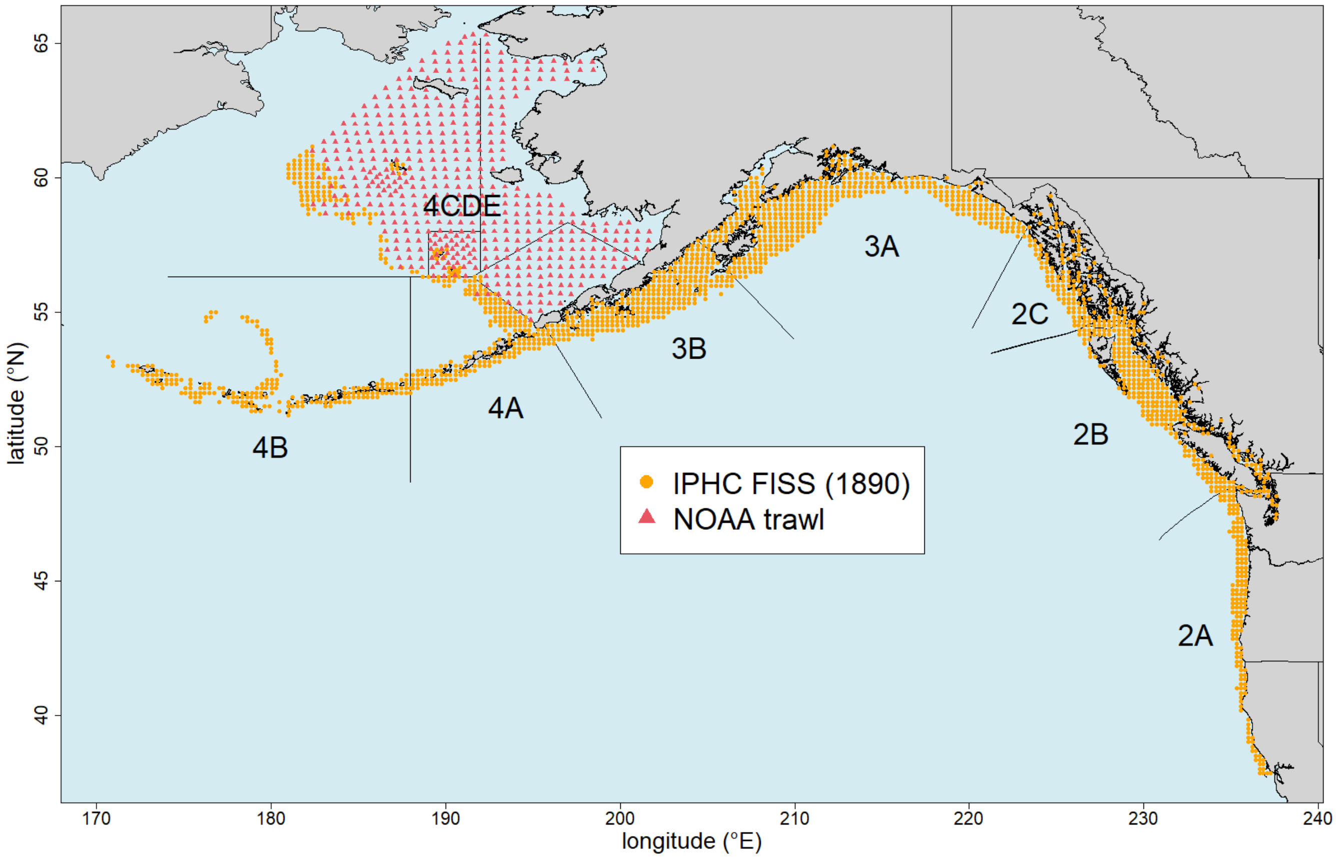

Figure 1. Map of the full 1890 station FISS design, with orange circles representing stations available for inclusion in annual sampling designs. Red triangles represent the locations NOAA trawl stations used to provide complementary data for Bering Sea modelling (not all are sampled each year).

FISS DESIGN OBJECTIVES (Table 1) – current Commission decision

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 the IPHC's management procedure. The priority of the current rationalised 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: *Long-term revenue neutrality.*

The FISS is intended to have long-term revenue neutrality, and therefore any implemented design must consider both logistical and cost considerations.

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 IPHC policies.

Table 1 Prioritization of 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	Long term revenue neutrality	Logistics and cost: operational feasibility and cost/revenue neutrality
Tertiary	Minimize removals and assist others where feasible on a cost-recovery basis.	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

THE OPTIMAL FIVE-YEAR ROTATIONAL FISS DESIGN

Base Block design

The **Base Block design** (Figures 2 to 4) when implemented on an annual basis ensures that all charter regions in the core areas are sampled over a three-year period, while prioritizing coverage in other areas based on minimising the potential for bias and maintaining CVs below 25% for each IPHC Regulatory Area, and below 15% for the core of the stock (IPHC Regulatory Areas 2B, 2C, 3A and 3B). The **Base Block design** also includes some sampling in all IPHC Biological Regions in each year, ensuring that both trend and biological data from across the spatial range of Pacific halibut in Convention waters are available to the stock assessment and for stock distribution estimation. From the perspective of meeting the Primary Objective of the FISS (Table 1), the **Base Block design** can be considered the optimal rotational design.

We note that paragraph 72 of the AM100 report (IPHC-2024-AM100-R) states:

> *The Commission NOTED that the use of the base block design (Figures 7 to 11 of paper IPHC-2024-AM100-13) will be the focus of future planning and annual FISS proposals from the Secretariat.*

***Base Block design - Costs and Revenue:* – 2025 Base Block Design: Figure 2**

Key numbers

2025	**$**	**Notes**
Total Projected Cost	US$3,829,000	**Base HQ costs:** US$606,000 (incurred even if no FISS is conducted) **Vessel bids**: $1,525,000 **Field staff:** $459,000 **Bait estimate**: $356,000
Total Projected Revenue*	US$$1,771,000	US$1,692,000 from Pacific halibut sales US$79,000 from byproduct sales
Net	**-US$2,058,000**	**Not fiscally possible without a large influx of supplementary funds.**

*Assumptions:

1) no bid inflation for 2025 (compared to 2024);
2) 5% decline in landings from observed 2024 rates;
3) no change in average price.

Due to the rotational nature of the Base Block design overall costs and revenue are likely to be generally comparable year-to-year. However, especially for large designs, the sensitivity to small fluctuations in price and catch rates is high. For example, a +/-10% change in price and landings beyond what is projected for 2025 could result in net profit/loss of US$1,546,000 to US$2,302,000. This type of uncertainty cannot be reduced and will compound over a longer time horizon, making projections of cost beyond the upcoming year of limited value.

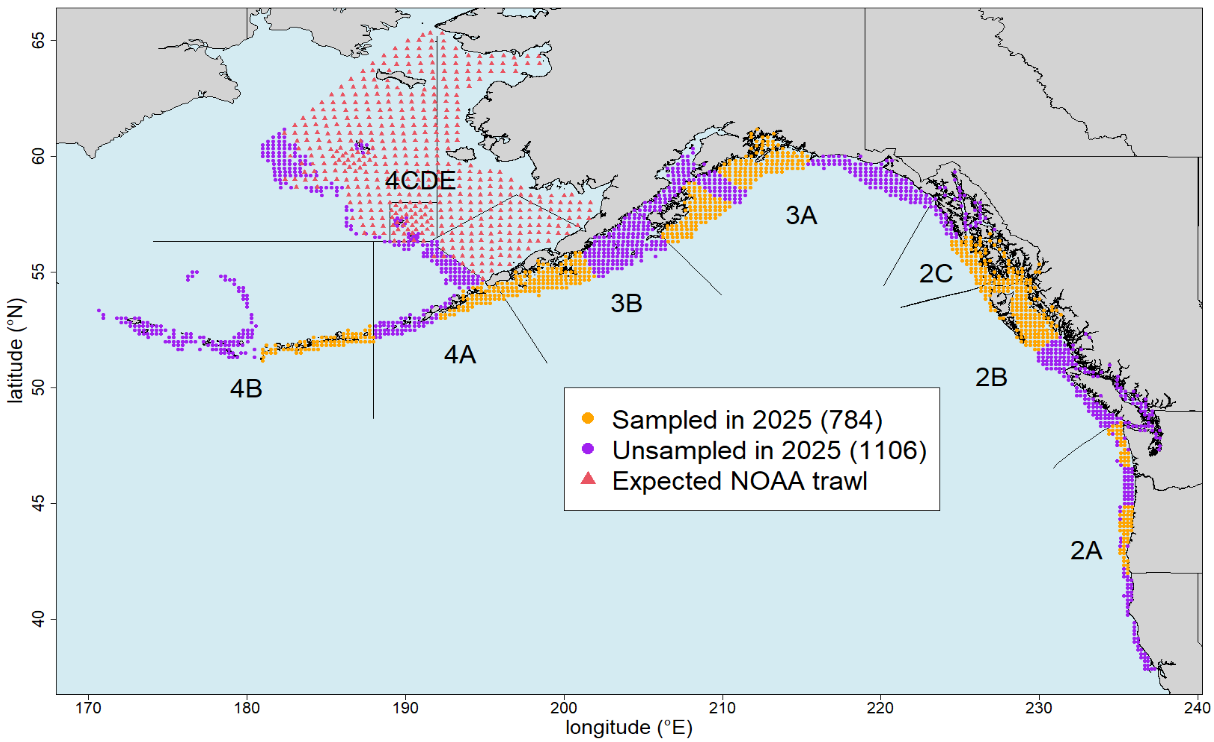

Figure 2. Base Block design for 2025 (orange circles). Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

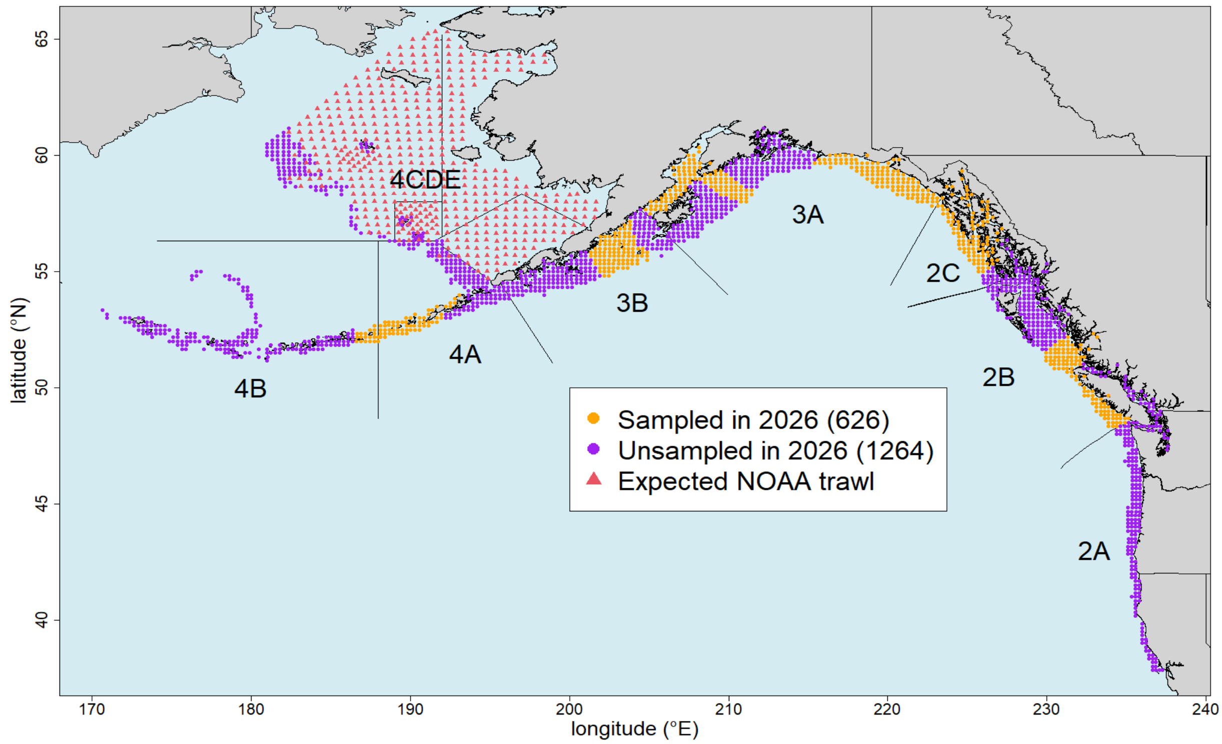

Figure 3. Base Block design for 2026 (orange circles) – indicative only. Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

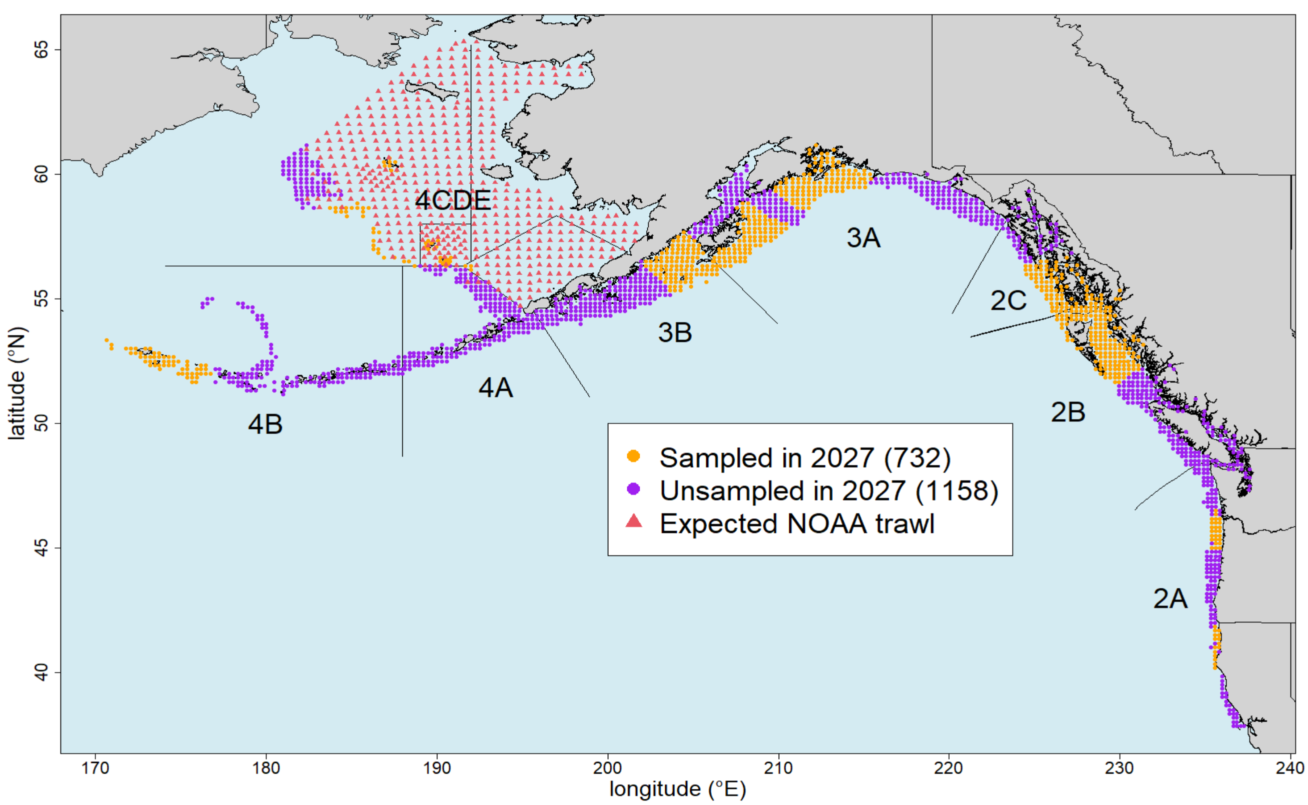

Figure 4. Base Block design for 2027 (orange circles) – indicative only. Design is based on fishing 2-4 complete blocks of stations (charter regions) in the core areas (2B, 2C, 3A and 3B) and previously implemented subareas elsewhere.

A FISCALLY VIABLE FISS DESIGN OPTION FOR 2025

The 2024 FISS showed continued declines in average catch rates in most IPHC Regulatory Areas, resulting in projected losses for even the lowest cost 2025 designs. Our starting point was therefore not a revenue-neutral design, but one that maintains sampling in all IPHC Biological Regions in order to provide basic data for the IPHC stock assessment, while aiming to limit the financial loss.

Only two charter regions, one each in IPHC Regulatory Areas 2B and 2C, are projected to be revenue-positive in 2025. In addition, supplementary funding has been made available for sampling 60 stations in each of IPHC Regulatory Areas 4A/4B and IPHC Regulatory Area 2A (these two sets of 60 stations are each considered to be a single charter region when projecting costs). To ensure sampling in all Biological Regions, the most cost-effective charter regions in each of IPHC Regulatory Areas 3A and 3B are also included to creating a fiscally viable design that also meets basic data needs (Figure 5).

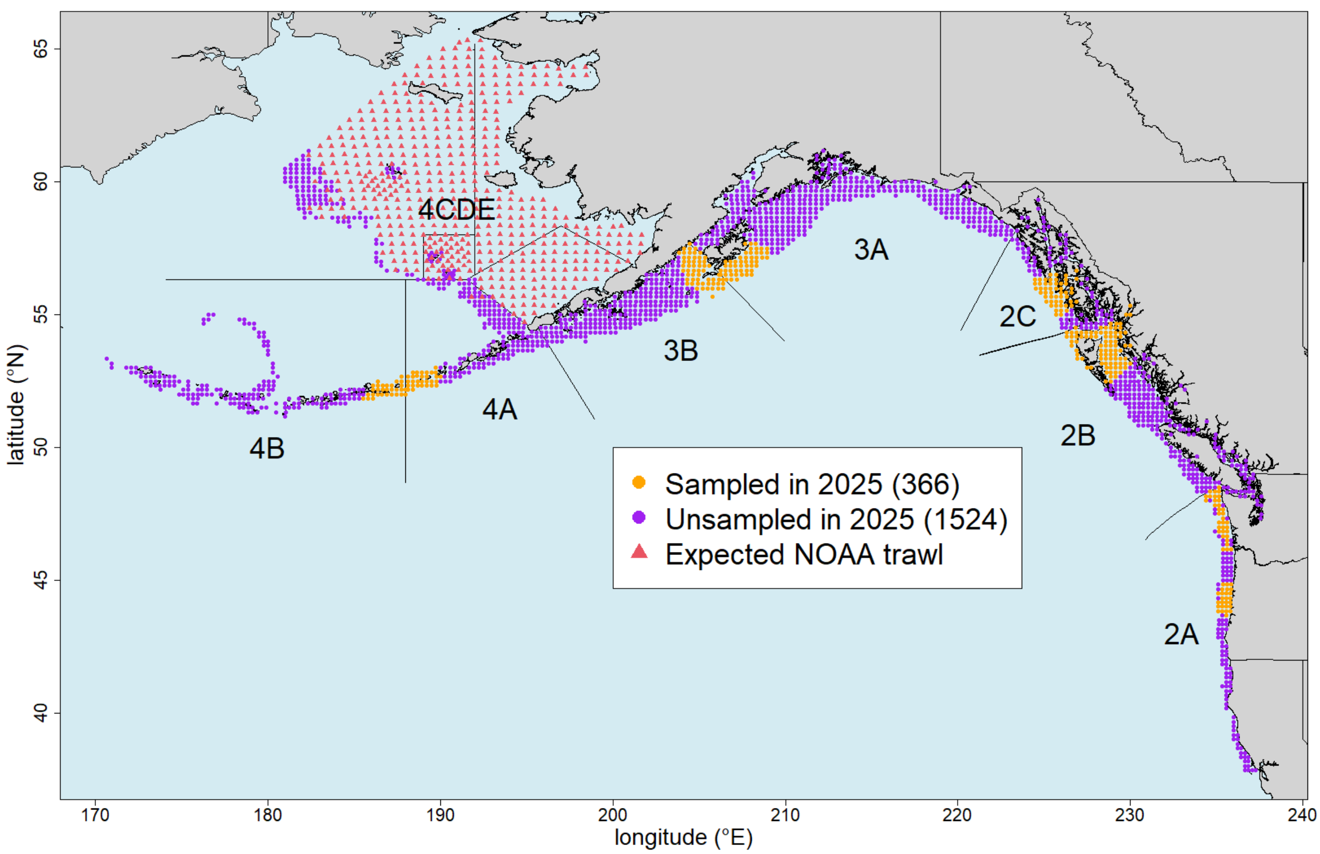

Figure 5. A fiscally viable FISS design for 2025 that includes the two most cost-effective charter regions in Biological Region 3, as well as projected revenue-positive charter regions in Biological Region 2, and stations in IPHC Regulatory Areas 2A and 4A/4B covered by supplementary funding.

A fiscally viable FISS design option for 2025: Figure 5 - Costs and Revenue:

Key numbers

2025	$	Notes
Total Projected Cost	US$2,102,000	**Base HQ costs:** US$606,000 (incurred even if no FISS is conducted) **Vessel bids:** $691,000 **Field staff:** $197,000 **Bait estimate:** $179,000
Total Projected Revenue*	US$1,141,000	US$1,098,000 from Pacific halibut sales US$43,000 from byproduct sales
Supplementary Funding (known)	US$387,000	USA Supplementary Funding (Received) - for sampling in 2A and 4A/4B.
Net	**-US$574,000**	**To be covered by any additional supplementary funding received in-year, and the IPHC Fund 50 (Reserve).**

*Assumptions:

1) no bid inflation for 2025 (compared to 2024);
2) 5% decline in landings from observed 2024 rates;
3) no change in average price.

Note that the results presented for preliminary 2025 FISS design projections include continued increased costs and decreased catch rates.

The IPHC Secretariat has recommended that the Commission move forward with the fiscally viable 2025 FISS design option described above (Figure 5), with the assumption that additional supplementary funding will become available in early 2025, and that any remaining deficit will be covered by the IPHC Reserve Fund (50 – Reserve). Should additional supplementary funding not become available, we are comfortable covering the full amount of the deficit from the Reserve Fund for one (1) year.

POTENTIAL BIAS IN FISCALLY VIABLE DESIGN.

Indices of Pacific halibut density can change by large amounts over short periods, with annual changes of 15% or more regularly observed at the level of Biological Region and IPHC Regulatory Area (IPHC-2024-SS014-03). Over a three-year period, large changes in indices of density are the norm, including at the coastwide level. Lack of sampling or low spatial coverage in an area or region means such changes are fully or largely unobserved, leading to biased estimates of indices, stock trends, and stock distribution. The greater the unobserved change, the greater the bias. Designs such as that implemented in 2024 and the 2025 fiscally viable design (Figure 5) therefore have high potential for bias in area, regional and coastwide estimates, particularly as 2025 would be the second or third year with reduced coverage for much of the stock.

Including the habitat covered by the annual NOAA trawl survey in the Bering Sea, implementation of the fiscally viable design (Figure 5) means either FISS or trawl sampling will cover about 60% of habitat in each of 2024 and 2025. Based on this level of sampling coverage and historical levels of change (IPHC-2024-SS014-03), we would expect coastwide indices of abundance to have bias of up to +/-15% following the 2025 FISS. However, bias could be much higher in Biological Regions 3 and 4B, which would have had lower levels of sampling than the coast as a whole for two or more years following completion of the 2025 FISS.

Recently completed simulation analyses explored the effect on stock assessment results of a cumulative bias in the FISS index of 15% over the upcoming period from 2025-2027 (IPHC-2024-SRB025-06). If the true FISS trend were going down by 15%, but due to a reduced design the FISS index was estimated to be flat over this same period, the estimates of spawning biomass, fishing intensity (SPR) and probability of stock decline in 2028 at the same harvest level would be biased. The simulation results indicated that this bias correspond to a 2-3% overestimate of spawning biomass, a 1% overestimate of SPR (underestimate of fishing intensity) and a 9% underestimate of the probability of stock decline in 2028. Based on recent harvest decision tables, to account for a 9% underestimate of the probability of stock decline the coastwide TCEY would need to be reduced by approximately 4 million pounds, equating to approximately US$24 million in landed catch. Thus, under significantly reduced FISS designs accounting for potential bias in management decisions could have a significant impact on short-term fishery yields and revenue. While the true degree of bias would be unknown (at least until the next comprehensive FISS design was completed), this level of bias (15%) is possible in the reduced designs evaluated here.

RECOMMENDATION

That the Research Advisory Board **NOTE** paper IPHC-2024-RAB025-08 that presents potential FISS designs for 2025, 2026, and 2027.

REFERENCES

IPHC 2024. Report of the 100th session of the IPHC Annual Meeting (AM100). IPHC-2024-AM100-R. 55 p.

Stewart, I. and Hicks, A. 2024. Development of the 2024 Pacific halibut (*Hippoglossus stenolepis*) stock assessment. IPHC-2024-SRB025-06. 12 p.

Webster, R. A., Stewart, I., Ualesi, K., Jack,T. and Wilson, D. 2024. 2025 and 2026=29 FISS designs. IPHC-2024-SS014-03. p 21.