INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC–2020–RAB021–00

21st Session of the IPHC Research Advisory Board (RAB021) – *Compendium of meeting documents*

26 February 2020, Seattle, WA, USA

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INTERNATIONAL PACIFIC HALIBUT COMMISSION

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DRAFT: AGENDA FOR THE 21st SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB021)

Date: 26 February 2020
Location: Seattle, Washington, USA
Venue: IPHC Training Room, Salmon Bay
Time: 09:00-17:15
Chairperson: Dr Josep V. Planas (IPHC 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**
   - 3.1 Update on the actions arising from the 20th Session of the RAB (RAB020)
   - 3.2 Outcomes of the 96th Session of the IPHC Annual Meeting (AM096)

4. **SEASON OVERVIEW - 2019: RAB MEMBERS**

5. **IPHC FISHERY-INDEPENDENT SETLINE SURVEY (FISS)**
   - 5.1 2020 FISS season: Design and implementation (L. Erikson & R. Webster)

6. **DESCRIPTION OF IPHC RESEARCH ACTIVITIES** (J. Planas & Project leaders)
   - 6.1 Key updates: IPHC 5-year Biological and Ecosystem Sciences Research Plan (2017-21) (J. Planas)
     - **6.1.1** Whale depredation (C. Dykstra)
     - **6.1.2** Alterations of flesh characteristics: chalky Pacific halibut (L. Sadorus)
   - 6.2 Core research streams: Updates for key ongoing research activities (Project leaders)
     - **6.2.1 Migration**
       - 6.2.1.1 Migratory behaviour and distribution of Pacific halibut (T. Loher, L. Sadorus, J. Forsberg)
     - **6.2.2 Reproduction**
       - 6.2.2.1 Reproductive assessment of the Pacific halibut population (J. Planas)
       - 6.2.2.2 Sex identification of commercial landings (A. Simeon)
     - **6.2.3 Growth**
       - 6.2.3.1 Factors affecting somatic growth in Pacific halibut (J. Planas)
     - **6.2.4 Discard mortality rates**

6.2.4.1 Discard mortality rates and post-release survival in the Pacific halibut fisheries (C. Dykstra)

6.2.5 Genetic and Genomics

6.2.5.1 Application of genetics and genomics to improve our knowledge on population structure and distribution (J. Planas, A. Jasonowicz)

7. **GUIDANCE ON, AND DISCUSSION OF, OTHER POTENTIAL APPLIED RESEARCH PROJECTS** (Chairperson)

8. **OTHER BUSINESS**

8.1 Date and place of the 22nd and 23rd Sessions of the IPHC Research Advisory Board (Chairperson)

9. **REVIEW OF THE DRAFT AND ADOPTION OF THE REPORT OF THE 21st SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB021)** (Chairperson)

SCHEDULE FOR THE 21st SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB021)

Wednesday, 26 February 2020		
Time	**Agenda item**	**Lead**
09:00-09:05	1. Opening of the Session	J. Planas
09:05-09:15	2. Adoption of the agenda and arrangements for the Session	J. Planas
09:15-09:30	3. IPHC Process	J. Planas / S. Keith
09:30-10:30	4. Season overview: RAB members	RAB Members
10:30-10:45	Break	
10:45-11:15	5. IPHC fishery-independent setline survey (FISS) 5.1 2020 FISS season: Design and implementation	L. Erikson & R. Webster
11:15-11:30	6. Description of IPHC research activities 6.1 Key updates: IPHC 5-year Biological and Ecosystem Sciences Research Plan (2017-21) 6.1.1 Whale depredation 6.1.2 Alterations of flesh characteristics: chalky Pacific halibut	J. Planas & Project leaders
11:30-12:30	6.2 Core research streams: Updates for key ongoing research activities 6.2.1 Migration 6.2.2 Reproduction 6.2.3 Growth 6.2.4 Discard mortality rates 6.2.5 Genetic and Genomics	Project leaders
12:30-13:15	Lunch	
13:15-15:15	7. Guidance on, and discussion of, other potential applied research projects	RAB Members
15:15-15:30	Break	
15:30-16:15	7. Guidance on, and discussion of, potential applied research projects (cont.)	RAB Members
16:15-16:20	8. Other business 8.1 Date and place of the 22nd and 23rd Sessions of the IPHC Research Advisory Board	J. Planas
16:20-17:15	9. Review of the draft and adoption of the report of the 21tt Session of the IPHC Research Advisory Board (RAB021)	J. Planas

INTERNATIONAL PACIFIC HALIBUT COMMISSION

IPHC-2020-RAB021-02

DRAFT: LIST OF DOCUMENTS FOR THE 21st SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB021)

LAST UPDATED: 14 FEBRUARY 2020

Document	Title	Availability
IPHC-2020-RAB021-01	Draft: Agenda & Schedule for the 21st Session of the IPHC Research Advisory Board (RAB021)	✓ 24 Jan 2020 ✓ 14 Feb 2020
IPHC-2020-RAB021-02	Draft: List of Documents for the 20th Session of the IPHC Research Advisory Board (RAB021)	✓ 24 Jan 2020 ✓ 27 Jan 2020 ✓ 14 Feb 2020
IPHC-2020-RAB021-03	Update on the actions arising from the 20th Session of the RAB (RAB020) (D. Wilson & J. Planas)	✓ 27 Jan 2020
IPHC-2020-RAB021-04	Outcomes of the 96th Session of the IPHC Annual Meeting (AM096) (IPHC Secretariat)	✓ 14 Feb 2020
IPHC-2020-RAB021-05	Overview: IPHC 5-year biological and ecosystem sciences research program (2017-21) (J. Planas)	✓ 24 Jan 2020
IPHC-2020-RAB021-06	IPHC fishery-independent setline survey (FISS) design and implementation in 2020 (R. Webster & I. Stewart)	✓ 24 Jan 2020
IPHC-2020-RAB021-07	Reproductive assessment of the Pacific halibut population (J. Planas)	✓ 24 Jan 2020
IPHC-2020-RAB021-08	Sex identification of commercial landings (J. Planas)	✓ 24 Jan 2020
IPHC-2020-RAB021-09	Factors affecting somatic growth in juvenile Pacific halibut (J. Planas)	✓ 24 Jan 2020
IPHC-2020-RAB021-10	Discard mortality rates and post-release survival in the directed Pacific halibut fishery (C. Dykstra)	✓ 24 Jan 2020
IPHC-2020-RAB021-11	Migratory behavior and distribution of Pacific halibut (T. Loher, J. Forsberg & L. Sadorus)	✓ 24 Jan 2020
IPHC-2020-RAB021-12	Population genetics and migration (J. Planas, A. Jasonowicz, T. Loher)	✓ 24 Jan 2020

Update on actions arising from the 20th Session of the IPHC Research Advisory Board (RAB020)

PREPARED BY: IPHC SECRETARIAT (D. WILSON & J. PLANAS; 27 JANUARY 2020)

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 20th Session of the IPHC Research Advisory Board (RAB020).

BACKGROUND

At the RAB020 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-2020-RAB021-03, which 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 20th Session of the IPHC Research Advisory Board (RAB020).
2) **AGREE** to consider and revise as necessary the actions, and for these to be combined with any new actions arising from RAB021.

APPENDICES

Appendix A: Update on actions arising from the 20th IPHC Research Advisory Board (RAB020)

APPENDIX A

Update on actions arising from the 20th Session of the Research Advisory Board (RAB020)

Action No.	Description	Update
RECOMMENDATIONS		
RAB020–Rec.01 (para. 10)	***IPHC Closed Area*** The RAB **AGREED** that the IPHC Closed Area (Pacific Halibut Fishery Regulations 2019, Sect. 11) is not currently meeting its intended objective of protecting juvenile Pacific halibut when it is open to non-directed fisheries, and **RECOMMENDED**, in coordination with the NPMFC, that the IPHC Secretariat examine alternative management regimes for the Closed Area, and for these to be presented at the 96th Annual Meeting in 2020.	In progress: Noting the Commission's request to reconsider the proposal at the 96th Annual Meeting in 2020, the IPHC Secretariat has submitted Regulatory Proposal A5 for AM096 (IPHC-2020-AM096-PropA5). The outcome of this discussion will be included in IPHC-2020-RAB021-04 for the RAB's information.
RAB020–Rec.02 (para. 33)	***Hook standardization*** The RAB **RECOMMENDED** that the IPHC consider standardising the FISS to use a particular model hook and to encourage each vessel to begin its FISS contract work each year with all new hooks.	Completed: The 2020 FISS vessel tender specifications include the following requirement: *"Skates shall be uniformly rigged with circle hooks (#3 (16/0) Mustad model 39965 or equivalent) in average or better condition spaced along the groundline at 18-foot (0.5 km) intervals (100 per skate)."*
REQUESTS		
RAB020–Req.01 (para. 21)	***Effects of longline gear on benthic habitats, lost gear, and spatial patterns in fishing*** The RAB **NOTED** the limitations imposed on the fishing industry by the growing number of marine conservation areas that restrict particular fishing activities, and **REQUESTED** that the IPHC consider research examining the following aspects of the longline fishery: a. The impact of longline gear on the ocean bottom, including how much habitat disturbance is created by setting and retrieving the gear; b. The magnitude and impact of lost and abandoned longline gear over time; and c. The extent of the geographic footprint (the bottom area directly affected) of longline gear.	In progress: The IPHC has added online reporting of annual gear loss and estimates of Pacific halibut mortality associated with this lost gear: https://www.iphc.int/data/time-series-datasets Calculation of disturbance and habitat interaction has not yet been undertaken.

Action No.	Description	Update
RAB020–Req.02 (para. 24)	***Black cod pot fishing*** The RAB **NOTED** the increasing use of pot gear to fish for sablefish in Alaska, and **REQUESTED** the IPHC gather data on the effect of this shift, including potentially: a. How this change affects the catch of Pacific halibut in the sablefish fishery; b. How the gear shift in the sablefish fishery might drive whale predation toward the Pacific halibut fishery; and c. The change in these effects over time.	In progress: The IPHC Secretariat reported on the first three years of using pot gear in IPHC-2020-AM096-INF02, and will continue to report the use of pot gear as part of its regular fisheries statistics reporting.
RAB020–Req.03 (para. 29)	***Impact of recreational fishery releases*** The RAB **NOTED** the possibility of engaging recreational fishers in data collection efforts in order to better characterize the population of Pacific halibut released in the fishery, and **REQUESTED** that the IPHC Secretariat begin to explore such research possibilities, including guidance and best practices that might be required.	In progress: The IPHC Secretariat has already began gathering information on capture and handling practices by the guided recreational fishery and is currently synthesizing the results that will be presented at the RAB021.
RAB020–Req.04 (para. 30)	***Impact of recreational fishery releases*** The RAB **NOTED** that recreational fishing logs may be left incomplete, in particular with regard to numbers of fish caught and released, and **REQUESTED** that the IPHC Secretariat work with relevant Contracting Party agencies to encourage and enforce complete data collection.	In progress: The IPHC Secretariat queried charter companies in IPHC Regulatory Areas 2C and 3A regarding their handling and release practices to inform a discard mortality project planned for 2020.
RAB020–Req.05 (para. 41)	***Migration*** The RAB **NOTED** the ongoing IPHC research into Pacific halibut migration, and **REQUESTED** that the IPHC Secretariat incorporate into its research the question of how changing ocean conditions might affect both migration rates and stock distribution over time.	In progress: The IPHC Secretariat is working on incorporating ocean conditions and environmental parameters into migration-related research.
RAB020–Req.06 (para. 52)	***Whale depredation*** The RAB **REQUESTED** that the IPHC Secretariat evaluate possible gear solutions for avoiding whale depredation, such as pot gear.	In progress: The IPHC Secretariat is collecting information on how to address this issue.
RAB020–Req.07 (para. 58)	***Date and place of the 21st and 22nd Sessions of the IPHC Research Advisory Board*** The RAB **REQUESTED** that the IPHC Secretariat consider dates earlier in February for RAB021 and RAB022 in order to enable better participation by current or potential RAB members.	In progress: The date for RAB021 was unable to be shifted, but RAB022 and RAB023 are scheduled to take place earlier in February (see the proposed three-year meetings calendar at IPHC-2020-AM096-15)

OUTCOMES OF THE 96TH SESSION OF THE IPHC ANNUAL MEETING (AM096)

PREPARED BY: IPHC SECRETARIAT (14 FEBRUARY 2020)

PURPOSE

To provide the RAB with the outcomes of the 96th Session of the IPHC Annual Meeting (AM096) relevant to the mandate of the RAB.

BACKGROUND

The agenda of the Commission's Annual Meeting (AM096) included an agenda items dedicated to the IPHC's 5-year Biological and Ecosystem Science Research Program, and the Report of the RAB020.

The Report of the 96th Session of the IPHC Annual Meeting was adopted on 07 February 2020 and is available for download from the IPHC website: https://iphc.int/

DISCUSSION

During the course of the Annual Meeting (AM096) the Commission made a number of specific requests and recommendations regarding the IPHC research programs. Relevant sections from the report of the meeting are provided in Appendix A for the RAB's consideration.

The Commission also approved a three-year calendar of IPHC meetings, which includes the following planned dates for RAB meetings, all currently planned to be held in the IPHC Offices in Seattle, USA.

RAB No.	Date	Location
RAB021	26 Feb 2020	Seattle, WA, U.S.A.
RAB022	10 Feb 2021	Seattle, WA, U.S.A.
RAB023	9 Feb 2022	Seattle, WA, U.S.A.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2020-RAB021-04 which provides the outcomes of the 96th Session of the IPHC Annual Meeting (AM096) relevant to the mandate of the RAB.

APPENDICES

Appendix A: Outcomes of the AM096 relevant to the mandate of the RAB

APPENDIX A
Outcomes of AM096 relevant to the mandate of the RAB

(paragraph numbering reflects the AM096 report)

7. IPHC 5-YEAR RESEARCH PROGRAM

7.1 IPHC 5-year Biological & Ecosystem Sciences research program: update

63. The Commission **NOTED** paper IPHC-2020-AM096-11 which provided a description of progress on Biological and Ecosystem Science Research by the IPHC Secretariat.

64. The Commission **NOTED** the primary biological research activities at the IPHC that follow Commission objectives are identified and described in the IPHC 5-Year Biological and Ecosystem Science Research Plan (2017-21). These activities are summarized in five broad research areas designed to provide inputs into stock assessment and the management strategy evaluation processes, as follows:

    1) **Migration**. Studies are aimed at further understanding reproductive migration and identification of spawning times and locations as well as larval and juvenile dispersal.

    2) **Reproduction**. Studies are aimed at providing information on the sex ratio of the commercial catch and to improve current estimates of maturity in female Pacific halibut.

    3) **Growth and Physiological Condition**. Studies are aimed at describing the role of some of the factors responsible for the observed changes in size-at-age and to provide tools for measuring growth and physiological condition in Pacific halibut.

    4) **Discard Mortality Rates (DMRs) and Survival**. Studies are aimed at providing updated estimates of DMRs in both the longline and the guided recreational fisheries.

    5) **Genetics and Genomics**. Studies are aimed at describing the genetic structure of the Pacific halibut population and at applying genetics and genomics to improve our current understanding of migration and distribution.

65. The Commission **NOTED** the Pacific halibut workshop co-organized by the IPHC Secretariat within the 2019 PICES Annual Meeting to bring together scientists from countries invested in the Pacific halibut resource and to establish plans to engage in international data sharing and collaborative research activities. These efforts will be continued with the organisation of a second Pacific halibut workshop that will be held at the 2020 PICES Annual Meeting and that will include topics related to climate variability and potential changes in the distribution of flatfish species in the North Pacific Ocean.

8. REPORT OF THE 20TH SESSION OF THE IPHC RESEARCH ADVISORY BOARD (RAB020)

66. The Commission **NOTED** the Report of the 20th Session of the IPHC Research Advisory Board (RAB020) (IPHC-2019-RAB020-R) which was presented by the Co-Chairperson, Dr Josep Planas.

67. The Commission **NOTED** that the RAB020 made two (2) recommendations to the Commission as follows:

IPHC Closed Area

RAB020-Rec.01 (para. 10) *The RAB AGREED that the IPHC Closed Area (Pacific Halibut Fishery Regulations 2019, Sect. 11) is not currently meeting its intended objective of protecting juvenile Pacific halibut when it is open to non-directed fisheries, and RECOMMENDED, in coordination with the NPMFC, that the IPHC Secretariat examine alternative management regimes for the Closed Area, and for these to be presented at the 96th Session of the IPHC Annual Meeting (AM096) in 2020.*

Hook standardisation

RAB020-Rec.02 (para. 33) *The RAB RECOMMENDED that the IPHC consider standardising the FISS to use a particular model hook and to encourage each vessel to begin its FISS contract work each year with all new hooks.*

68. The Commission **CONSIDERED** the recommendations made by the RAB020 and **AGREED** to take them into consideration when deliberating on relevant agenda items throughout the meeting.

7. REPORTS OF THE 14TH AND 15TH SESSIONS OF THE IPHC SCIENTIFIC REVIEW BOARD (SRB014 AND SRB015)

69. The Commission **NOTED** the Reports of the 14th and 15th Sessions of the IPHC Scientific Review Board (SRB014 - IPHC-2019-SRB014-R; SRB015 - IPHC-2019-SRB015-R) which were presented by the Chairperson, Dr Sean Cox (Simon Fraser University, Vancouver, Canada), one of the five (5) SRB members.

70. The Commission **CONSIDERED** the recommendations made by the SRB015 and **AGREED** to take them into consideration when deliberating on relevant agenda items throughout the meeting.

71. The Commission **NOTED** that the SRB015 made seven (7) recommendations to the Commission as follows:

Discard mortality in non-directed fisheries

SRB015–Rec.01 (para. 10) *The SRB RECOMMENDED that the analysis of the effects of historical discard mortality in non-directed fisheries ('bycatch'), be interpreted with caution, as there are multiple methods for evaluating how bycatch in non-directed fisheries impact stock productivity and biomass over time. The estimated rates of bycatch impact on directed fishery changed over time in part due to the variability in recruitment and/or sublegal abundance relative to the vulnerable stock. The choice of the appropriate method will depend on how the results feed into management advice.*

SRB015–Rec.02 (para. 11) *The SRB RECOMMENDED that, if a bycatch management strategy is a priority for the Commission, then the MSE process would be a more appropriate venue for evaluating methods of bycatch accounting for reasons outlined at SRB012:*
"NOTING the request for "replay" analyses, the SRB AGREED that "what if" questions about past behaviour are not appropriate for stock assessment models because those analyses do not adequately reflect the information available at the time or information feedbacks to future decision over time. An MSE analysis, on the other hand is specifically designed to answer "what if" questions under particular future scenarios while properly accounting for stock assessment errors in response to changing information." (IPHC-2018-SRB012-R, para. 23)

Independent external peer review of the IPHC stock assessment

SRB015–Rec.03 (para. 19) *The SRB RECOMMENDED that as was the case in the 2019 external peer review, any future external review would also benefit from an in-person review component. The biannual peer review that the SRB undertakes should continue as a complimentary element, thereby providing ongoing verification for the Commission.*

Pacific halibut stock assessment: 2019

SRB015–Rec.04 (para. 34) *NOTING the discussion of recommendations arising from the external peer review of the IPHC stock assessment (Section 4), the SRB RECOMMENDED that the IPHC Secretariat:*

a) Update data weighting for the 2019 assessment;

b) For SRB016:

i. evaluate the types of weightings (e.g., Dirichlet-multinomial) for compositional data;

ii. advise on the impact of data re-weighting as new information arises. This could be more sensitive as new sex-composition data are included;

iii. keep apprised of new software developments (e.g. CAPAM meeting in NZ) and report on potential future directions (e.g. if alternatives provide improved Bayesian integration or adaptations for simulation testing etc.).

Management Strategy Evaluation: Goals, Objectives and Performance Metrics

SRB015–Rec.05 (para. 41) *The SRB RECOMMENDED that if the original objective to have annual mortality limits related to local abundances was of broad interest to the Commission, then candidate management procedures be developed and tested in which regional mortality limits are set annually in proportion to modelled survey abundance trends by IPHC Regulatory Area (noting that splitting regions into Regulatory Areas would require assumptions about within-region abundance proportions).*

Management Strategy Evaluation: Dynamic reference points

SRB015–Rec.06 (para. 45) *The SRB RECOMMENDED that the MSAB define objectives independently of the management procedures used to achieve them and, instead, focus on the outcomes/consequences they wish to avoid (e.g. low catch, fishery closures, large drops in TCEY, public perceptions of poor stock status).*

Management Strategy Evaluation: Updates to MSE framework and closed-loop simulations

SRB015–Rec.07 (para. 51) *The SRB RECOMMENDED that the Commission develop a standard criterion for achieving a limited set of (or one over-arching) objectives. This would ensure that any candidate management procedure achieves common goals with differences in trade-offs between risks and benefits. Doing so will improve the efficiency of the iterative approach that is required for MSE.*

72. The Commission **NOTED** the departure of Dr Marc Mangel from the SRB in 2019 after completing six (6) years of outstanding contributions to IPHC scientific activities. As a founding member of the Board, Dr Mangel's contributions and advice have played a very large part in shaping IPHC science.

73. The Commission **CONSIDERED** the need to hold a joint meeting with the SRB members once a year to discuss and highlight matters of importance for Commissioners, and for this to be explored as a possibility.

74. The Commission **NOTED** that the IPHC Secretariat will be making a call for expressions of interest to replace applicable SRB members in the coming months. This will involve both a public announcement, and a targeted recruitment based on the expertise needs of the board.

Overview: IPHC 5-year Biological and Ecosystem Sciences Research Program (2017-21)

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, 24 JANUARY 2020)

PURPOSE

To provide the RAB with a description of the research projects proposed by IPHC Secretariat and contemplated within the Five-year Biological and Ecosystem Science Research Program (2017-21).

BACKGROUND

Since its inception, the IPHC has had a long history of research activities devoted to describing and understanding the biology of the Pacific halibut (*Hippoglossus stenolepis*). At the present time, 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; 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 are identified and described in the Five-Year Research Plan for the period 2017-21. These activities can be summarized in five broad categories: 1) Migration, 2) Reproduction, 3) Growth and Physiological Condition, 4) Discard Mortality Rates (DMRs) and Survival, and 5) Genetics and Genomics, and have been selected for their important management implications, as follows. The studies conducted on Migration are aimed at further understanding reproductive migration and identification of spawning times and locations as well as larval and juvenile dispersal. The studies conducted on Reproduction are aimed at providing information on the sex ratio of the commercial catch and to improve current estimates of maturity. The studies conducted on Growth are aimed at describing the role of some of the factors responsible for the observed changes in size-at-age and to provide tools for measuring growth and physiological condition in Pacific halibut. The proposed work on DMRs is aimed at providing updated estimates of DMRs in both the longline and the trawl fisheries. The studies conducted on Genetics and Genomics are aimed at describing the genetic structure of the Pacific halibut population and at providing the means to investigate rapid adaptive changes in response to fishery-dependent and fishery-independent influences.

In this document, we present an outline of the continuing projects proposed by the IPHC Secretariat for the coming year.

DISCUSSION

Project updates: Projects are listed in Appendix I and current grants are listed in Appendix II. An update on progress on continuing projects is provided below.

Project 621.16 ("***Genetic sex identification***") has as its main objective the identification of molecular markers for sex in order to provide a genetic method for sex identification in settings in which direct observations of sex cannot be obtained (i.e., fish at commercial offloads). In addition, this project was designed to provide genetic validation of the physical marking of sex at sea. Three single nucleotide polymorphisms (SNPs) were identified to be associated with sex and molecular assays were developed for two of the identified SNPs. These assays were estimated to have an accuracy of 97.5% in a comparison between assayed sex and visually-determined sex in a sample of 199 fish, based on an assumption that no process or recording errors existed within the visually determined data (Drinan et al., 2018). The assay was subsequently used to evaluate the accuracy of commercial sex-marking at sea in an initial phase and has now been successfully applied to provide sex information from biological samples (fin clips) collected from sampled fish from the 2017 and 2018 commercial landings. A full description of this project is included in paper IPHC-2020-RAB021-08.

Project 621.17 ("***Integrating migration and genetics research to refine Pacific halibut population structure, distribution and movement***") involves performing studies to improve our understanding of spawning site contributions to nursery areas in relation to year-class and recruit survival and strength, as well as of the relationship between nursery origin and adult distribution and abundance over temporal and spatial scales through the application of genetic, approaches to address management-relevant questions on population structure, distribution and movement. A full description of this first portion of the project is included in paper IPHC-2020-RAB021-12.

Project 642.00 ("***Assessment of mercury and other contaminants***") is the continuation of a project monitoring the prevalence of heavy metal and persistent organic pollutant contamination in the Pacific halibut population. Tissue samples for monitoring have been collected in IPHC's fishery-independent setline survey since 2002.

Project 670.11: "***Wire tagging of Pacific halibut on NMFS trawl and IPHC setline surveys***" involves the wire tagging of U32 Pacific halibut in order to further understand coastwide migratory and growth patterns of young Pacific halibut. Since 2015, 10,560 Pacific halibut have been tagged on both the NMFS trawl survey and the IPHC's fishery-independent setline survey, with a total of 123 tags recovered to date. A full description of this project is included in paper IPHC-2020-RAB021-11.

Project 672.13 ("***Discard mortality rates and discard survival assessment***") is continuing to investigate the relationship between three hook release methods (careful shake, gangion cut, and hook stripper) in the longline fishery and associated injuries with the physiological condition of fish and with post-release survival in order to update current estimates of discard mortality rates (DMR) in the directed longline Pacific halibut fishery. Furthermore, this project is also conducting investigations on the applicability and accuracy of electronic monitoring in capturing release methods and fish condition in vessels without observer coverage. This project has received funding from the Saltonstall-Kennedy NOAA grant program under project number NA17NMF4270240 (Appendix II). A full description of this first portion of the project is included in paper IPHC-2020-RAB021-10. A second component of this project involves determining mortality rates of discarded Pacific halibut in the Pacific halibut guided recreational fisheries. This study is being conducted with partial funding from a grant from the National Fish and Wildlife Foundation awarded to IPHC (Appendix II) in collaboration with academic and industry partners.

Project 673.13 ("***Sequencing the Pacific halibut genome***") aims at characterizing for the first time the genome of the Pacific halibut to support studies on population genetics, to assist in the identification of genomic regions and genes responsible for temporal and spatial adaptive phenotypic and behavioral characteristics in response to environmental and anthropogenic influences and to provide genomic resolution to genetic markers for sex, reproduction and growth that are currently being investigated. Sequencing efforts are currently under way.

Project 673.14 (*"**Identification and validation of markers for growth in Pacific halibut**"*) has continued efforts to identify and validate molecular and biochemical markers that are characteristic of specific growth patterns and that will be used to identify different growth trajectories in the Pacific halibut population and evaluate potential effects of environmental influences on growth trajectories. Initial studies have involved evaluating molecular responses of white skeletal muscle to temperature- and density-induced growth manipulations in juvenile Pacific halibut in captivity. Potential applicable molecular (gene and/or protein) markers for growth are currently being validated for their use in detecting growth trajectories using muscle samples from adult Pacific halibut. The results of this study will contribute to our understanding of the possible role of somatic growth variation in the observed changes in size-at-age in the Pacific halibut population. This project has also received funding from a grant from the North Pacific Research Board under project number 1704 (Appendix II). A full description of this project is included in paper IPHC-2020-RAB021-09.

Project 674.11 ("***Full characterization of the annual reproductive cycle in adult female Pacific halibut***") aims at fully characterizing the annual reproductive cycle of female and male Pacific halibut in order to advance our understanding of sexual maturation in this species and to improve maturity assessments and maturity-at-age estimates. Sample collection in the Portlock area in the central Gulf of Alaska began in September 2017 and continued on a monthly basis through its successful completion in August 2018. A variety of biological measures and samples were collected from thirty males and thirty females at each month for physiological analyses of reproductive parameters throughout an entire annual reproductive cycle. The results of this project will greatly assist in improving our estimates of the actual spawning biomass. A full description of this project is included in paper IPHC-2020-RAB021-07.

Project 2019-06 ("***Assessing the incidence of chalky Pacific halibut***") involved collecting information from stakeholders on the incidence of chalky flesh in Pacific halibut through surveys in order to understand the nature and timing of possible causes leading to its development. A questionnaire was distributed among processing plants in the spring of 2019 and the results are currently being summarized.

RECOMMENDATION

1) That the RAB **NOTE** paper IPHC-2020-RAB021-05, which outlined the research projects proposed by the IPHC Secretariat to the Commission and provided an overview of the 5-year research program (2017-21).

APPENDICES

Appendix I: Summary of research projects proposed to the Commission for FY2020.

Appendix II: Summary of current awarded research grants.

APPENDIX I

Summary of research projects proposed for FY2020

Project #	Project Name	Priority	Budget ($US)	Management implications
621.16	Genetic sex identification - Genomics	High	20,496	Sex composition of commercial catch
621.17	Migration and genetics	High	210,285	Population structure, distribution and movement
642.00	Assessment of mercury and other contaminants	Medium	6,741	Environmental effects
670.11	Wire tagging of halibut on NMFS trawl survey and FISS	High	15,301	Juvenile and adult distribution
672.13	Discard mortality rates and discard survival assessment	High	142,832	DMR estimates
673.13	Pacific halibut genome sequencing	High	34,000	Population changes
673.14	Identification and validation of markers for growth	High	26,369	Changes in biomass/size-at-age
673.15	Influence of thermal history on growth	High	12,500	Changes in biomass/size-at-age
674.11	Full characterization of the annual reproductive cycle	High	81,477	Maturity assessment
	Overall Total (all projects) ($US)		**$550,000**	

APPENDIX II

Summary of current awarded research grants

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 (Award No. NA17NMF4270240)	IPHC	Alaska Pacific University	$286,121	Bycatch estimates	September 2017 – August 2020
2	**North Pacific Research Board (NPRB)**	Somatic growth processes in the Pacific halibut (*Hippoglossus stenolepis*) and their response to temperature, density and stress manipulation effects (Award No. 1704)	IPHC	AFSC-NOAA-Newport, OR	$131,891	Changes in biomass/size-at-age	September 2017 – February 2020
4	**National Fish & Wildlife Foundation**	Improving the characterization of discard mortality of Pacific halibut in the recreational fisheries	IPHC	Alaska Pacific University, U of A Fairbanks, ACA	$98,902	Bycatch estimates	2020
Total awarded ($)					**$516,914**		

IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2020

PREPARED BY: IPHC SECRETARIAT (R. WEBSTER AND I. STEWART; 23 JANUARY)

PURPOSE

To provide the RAB with a summary of the proposal for a rationalised FISS design in 2020.

BACKGROUND/INTRODUCTION

2020 will be the first year of a fully re-designed FISS following completion of a series of FISS expansions, beginning with a 2011 pilot in IPHC Regulatory Area 2A, and continuing from 2014-19 covering all IPHC Regulatory Areas. This expansion program succeeded in filling large gaps in the FISS coverage, providing us with a complete FISS design based around the 10 nmi grid that will be used for annual FISS station selection in subsequent years.

The 2020 FISS design

The primary purpose of the annual FISS is to sample Pacific halibut to provide data for the stock assessment and estimates of stock distribution. The priority of a rationalised FISS is therefore to maintain or enhance data quality (precision and bias) by establishing minimum sampling requirements in terms of station count, station distribution, and skates per station. Potential considerations that could add to or modify the design are logistics and cost (secondary design layer), and FISS removals (impact on the stock), data collection assistance for other agencies, and IPHC policies (tertiary design layer). These priorities are outlined in Table 1.

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 historical sampling, combined with FISS expansions from 2014-2019, established a full FISS design of 1890 stations from California to the Bering Sea shelf edge on a 10 nmi grid from depths of 10 – 400 fm (Figure 1). Future annual FISS designs[1] will comprise a selection of stations from this full design, with all stations in the design to be sampled over subsequent years.

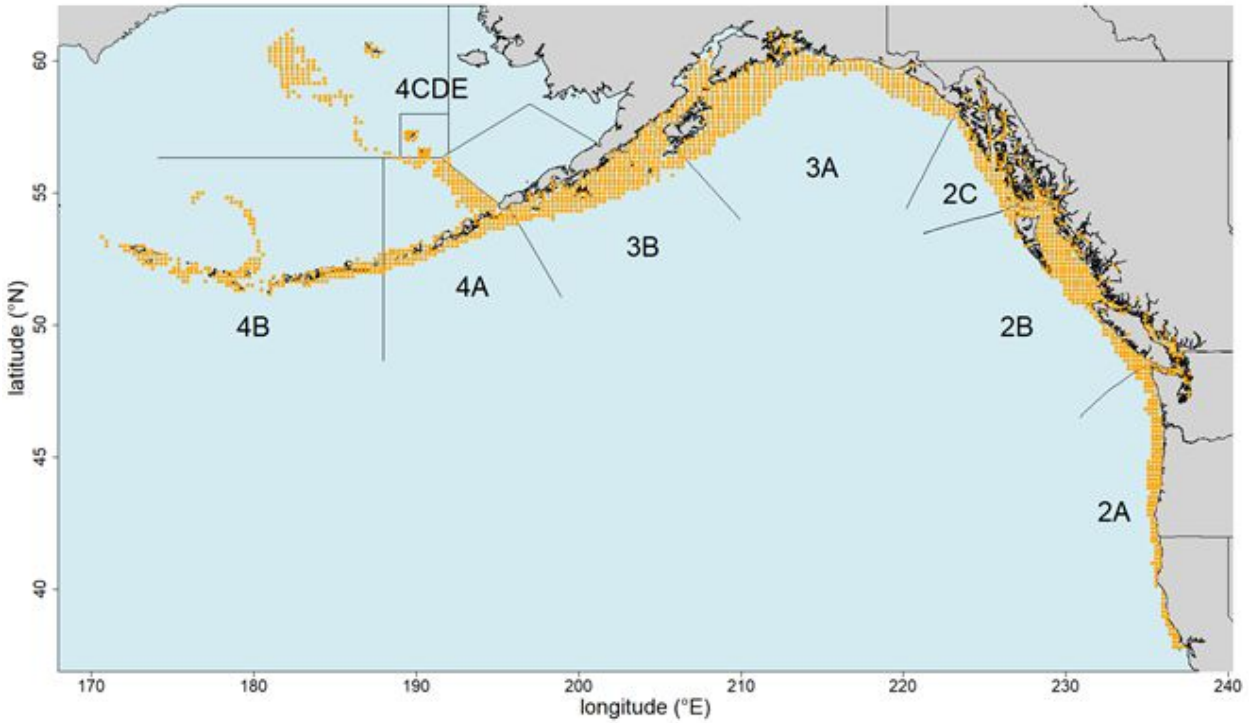


Figure 1. Map of the full FISS design to be used for station selection from 2020 onwards. Each orange circle represents a FISS station.

For 2020, the IPHC Secretariat staff's preferred design proposal represents a compromise between meeting the Primary FISS scientific priority and the Secondary logistics/cost priority (Figure 2). In the core of the stock, Regulatory Areas of 2B, 2C, 3A and 3B, a random sample of stations was selected, ensuring no bias and with sample sizes sufficient to meet FISS precision targets. In Regulatory Areas 2A, 4A and 4B, where the majority of the biomass is concentrated locally, the proposal samples only the highest-density subareas in 2020. Sampling in other parts of these Regulatory Areas will be undertaken in subsequent years at a frequency that maintains low bias in estimates obtained from the FISS data. The proposal includes fishing the full 10 nmi grid along the Regulatory Area 4CDE edge in 2020-22 (last fished in 2016. Ecosystem conditions have been anomalous in the Bering Sea for several years, making the Pacific halibut distribution more difficult to predict in unsurveyed habitat. The IPHC is interested in better understanding density trends and possible links with Pacific halibut in Russian waters

[1] Analysis of the FISS results also includes data not collected by the IPHC: NMFS and ADFG trawl surveys provide annual-triennial information from the eastern Bering Sea, northern Bering Sea and Norton Sound, reducing the need for direct FISS sampling in these areas.

in the Bering Sea, and the data obtained from sampling the full FISS grid in that area would help greatly in achieving these goals.

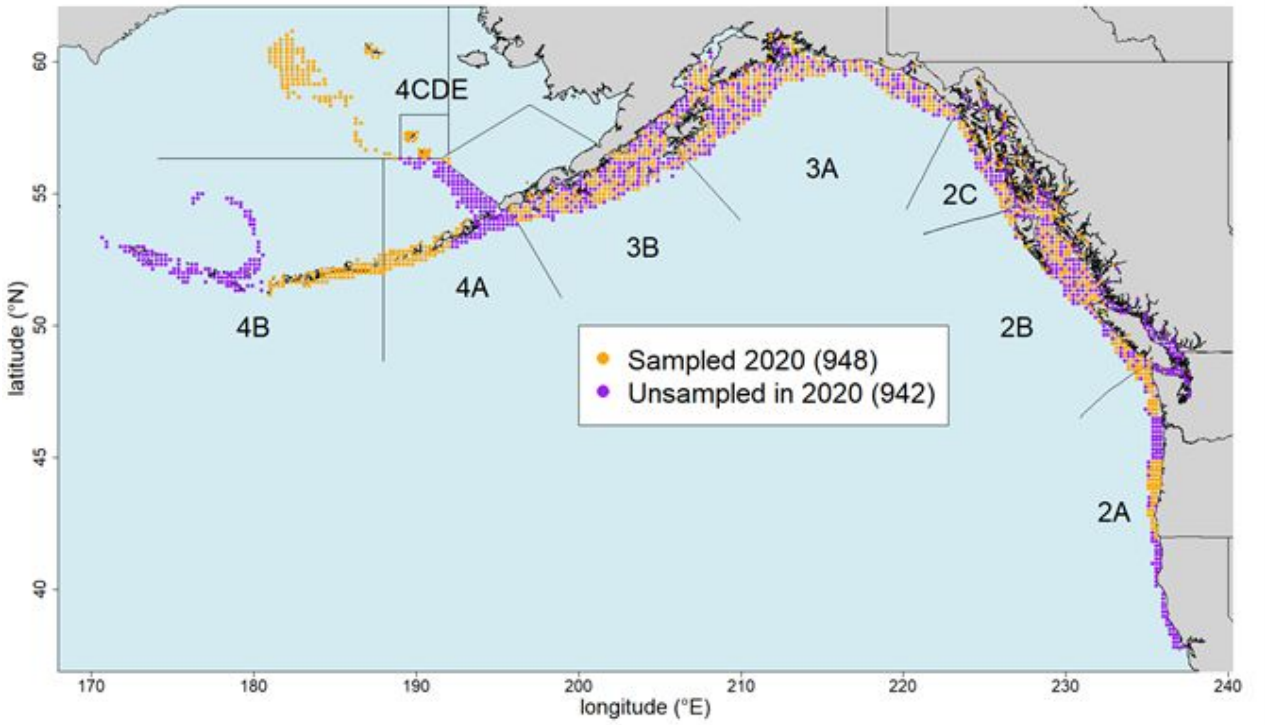


Figure 2. Proposed minimum FISS design in 2020 (orange circles) based on randomized sampling in 2B-3B, and a subarea design elsewhere. Purple circles are optional for meeting data quality criteria.

Continued snap and fixed gear comparison

The comparison of catch rates by snap and fixed gear conducted in Regulatory Area 2C in 2019 was successful, and included in the modeled results. For 2020, another comparison will be made in western Regulatory Area 4A (Figure 3) in order to: 1) reduce uncertainty in the relative catch rates, 2) compare results under different habitat conditions and size structure of the Pacific halibut population, and 3) provide additional sampling opportunity in an area with relatively high marine mammal interactions. Future comparisons may be needed before snap gear can be included as a standard gear type in the annual survey design.

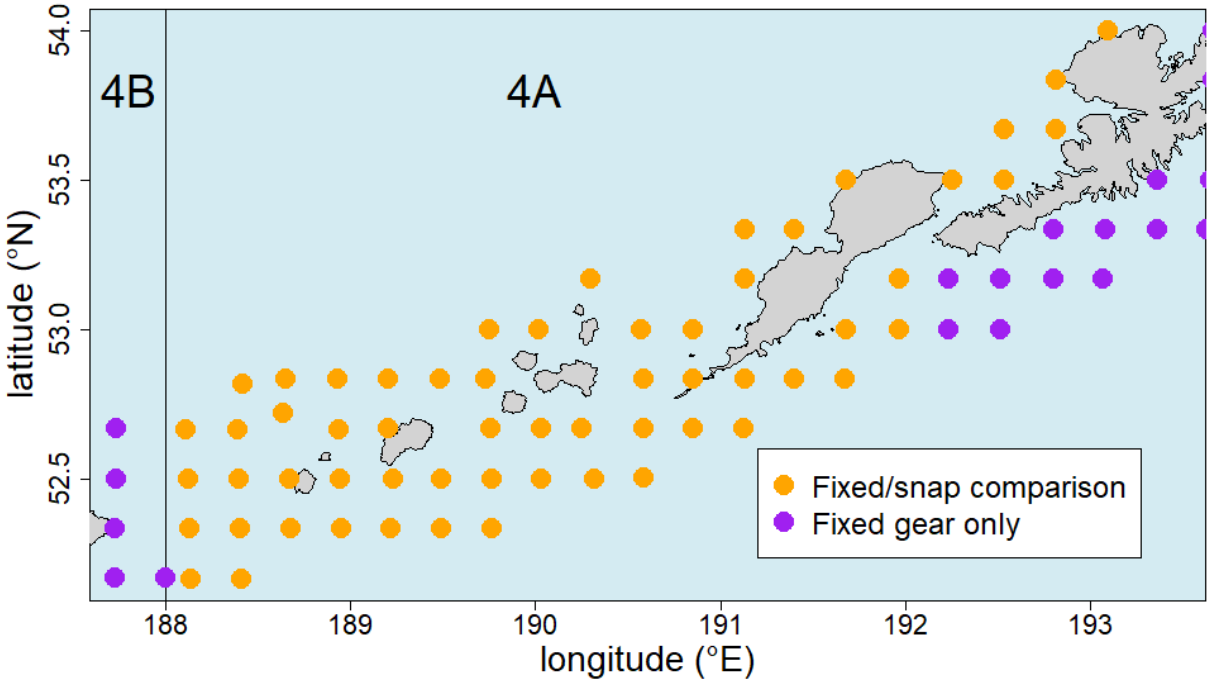


Figure 3. Proposed fixed/snap gear comparison stations in 2020 (orange circles).

RECOMMENDATION

1) That the RAB **NOTE** paper IPHC-2020-RAB021-06 which provided an overview of the International Pacific Halibut Commission's (IPHC) fishery-independent setline survey (FISS) design and implementation for 2020.

Reproductive assessment of the Pacific halibut population

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, 24 JANUARY 2020)

PURPOSE

To provide the RAB with a description of the studies designed to improve our knowledge on reproductive development in female and male Pacific halibut.

BACKGROUND

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. In particular, the female maturity schedule is used to estimate spawning stock biomass. Currently used estimates of maturity at age indicate that the age at which 50% of female Pacific halibut are sexually mature is 11.6 years on average. However, maturity is estimated with the use of macroscopic visual criteria, implying a relative level of uncertainty associated with the employed semi-quantitative assessment, and the maturity schedules for both sexes have not been revised in recent years and may be outdated. For this reason, research efforts are needed to improve our understanding of reproductive maturity in female Pacific halibut. Unfortunately, relatively little is known regarding the physiological changes that take place in the ovary during reproductive development leading to spawning in this species. The objective of this study is to understand and report the progression of reproductive development in both female and male Pacific halibut during an entire annual reproductive cycle.

DISCUSSION

Biological samples and biological information from female and male Pacific halibut were successfully collected on a monthly basis for an entire year, from September 2017 through August 2018, in the Portlock region in the Central Gulf of Alaska (Appendix I). The period of sample collection covers an entire annual reproductive cycle in female and male Pacific halibut and therefore includes all maturity stages from post-spawning and early gonadal growth and development until spawning. Biological information and biological samples include: maturity stage (classified according to current maturity scales), fork length, otoliths for aging, round weight, gonad weight, liver weight, photographic images of gonads, ovarian and testicular samples for histology, ovarian, testicular and pituitary samples for gene expression, blood samples, fin clips, and fat content.

Photographic images of all staged gonads will be contrasted with gonadosomatic index (GSI; gonad weight/round weight X 100) determinations and histological examination of ovarian and testicular staging. This will allow us to revise the morphological criteria currently used for staging the maturity status of the gonads (ovary and testis). Blood samples were collected on all fish in order to conduct a thorough endocrinological assessment of reproductive status and development in order to correlate levels of reproductive hormones and reproductive genetic markers with morphological and histological assessment of the gonads. Finally, the collected data on fat content will provide functional data on the energy stored in the fish in order to relate energy storage to sexual maturity. Energy storage will be determined by the hepatosomatic

index (HSI; liver weight/round weight X 100) and the muscle fat content as measured with the Fatmeter device.

The completed collection of morphological, histological, endocrine, and functional data from female and male Pacific halibut throughout an entire annual cycle will provide us with a better understanding of the temporal and spatial progression of sexual maturation in Pacific halibut, and will allow for a better estimation of maturity for stock assessment purposes.

Analysis of the data analyzed to date indicate that macroscopic (field) maturity staging captures changes in the maturity schedule of female Pacific halibut that are consistent with the expected peak time of spawning (January-February) and that are correlated with the changes in the gonadosomatic index (Figure 1).

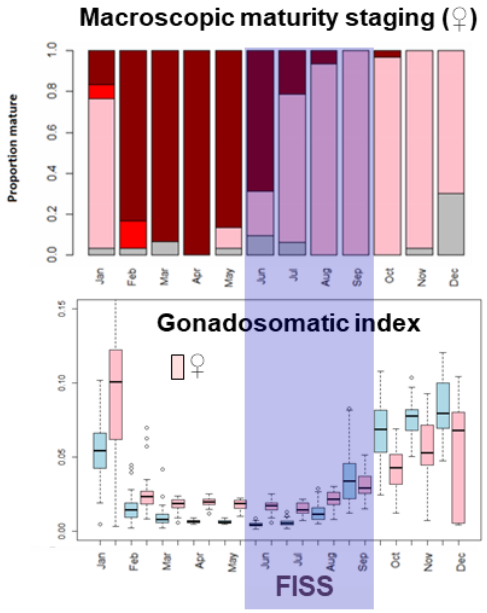


Figure 1. Top, temporal progression of macroscopic maturity stages (grey: immature; pink: maturing; red: ripe; purple: spent) during an entire annual reproductive cycle. Bottom, temporal changes in the gonadosomatic index (gonad weight/round weight X 100) during an entire annual reproductive cycle (pink: females; blue: males). Highlighted over the two graphs is the period during which macroscopic maturity stages used in stock assessment are collected in IPHC's fishery-independent setline survey (FISS).

Current efforts are also devoted to completing the microscopic maturity staging throughout the entire annual reproductive cycle in female Pacific halibut as determined by histological examination of collected ovaries. In addition, signs for skipped spawning in sampled females are also being gathered. Once finalized, microscopic maturity staging will be compared with the macroscopic (field) maturity staging in order to determine the level of accuracy of current methods used for determining maturity status in Pacific halibut females.

RECOMMENDATION

That the RAB:

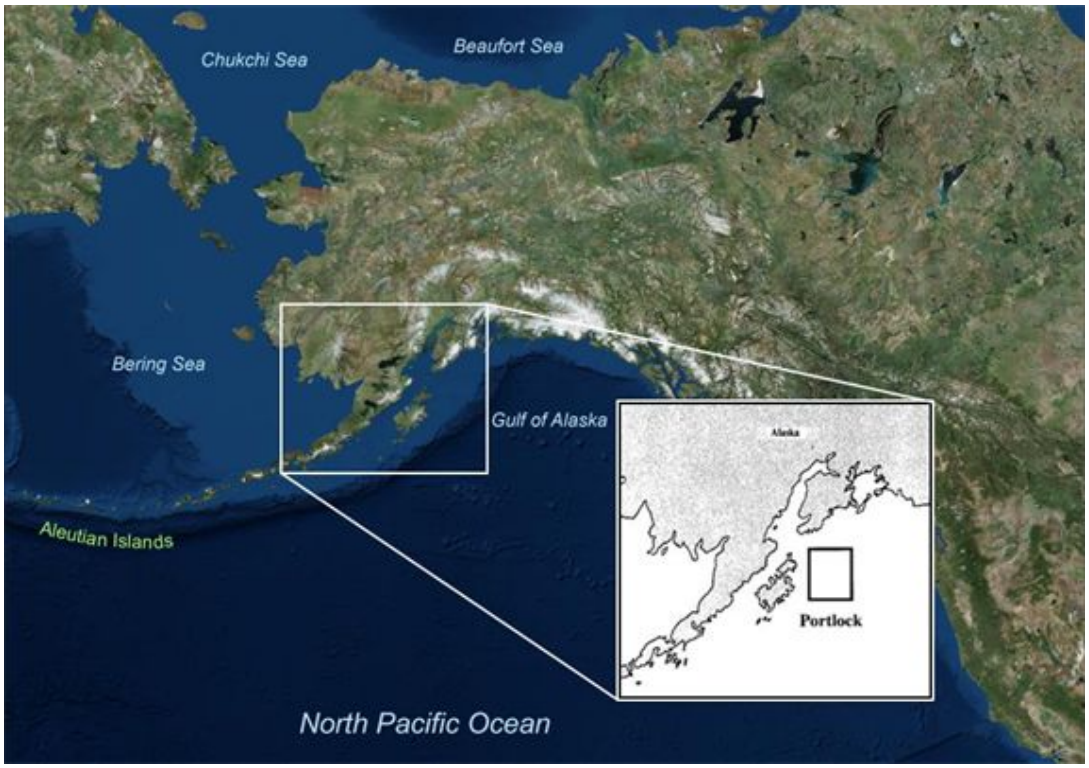
1) **NOTE** paper IPHC-2020-RAB021-07 which outlined the research project describing studies designed to improve our knowledge on reproductive development in female and male Pacific halibut.

APPENDICES

Appendix I: Geographic location of the sample collection efforts (2017-2018): the Portlock region in the Central Gulf of Alaska.

APPENDIX I

Geographic location of the sample collection efforts (2017-2018): the Portlock region in the Central Gulf of Alaska



Sex identification of commercial landings

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, A. SIMEON, 24 JANUARY 2020)

PURPOSE

To provide an update regarding the status of studies designed to provide information regarding sex ratios in commercial landings of Pacific halibut.

BACKGROUND

Declining size-at-age of Pacific halibut in recent decades, in conjunction with larger size-at-age in females and a constant minimum size limit, have led to the expectation that directed Pacific halibut harvests have become increasingly composed of females. Understanding the sex ratio of commercial landings is critical for accurate estimation of parameters such as female spawning stock biomass. However, sex data cannot be obtained from commercial landings due to the requirement that Pacific halibut be dressed at sea, and other strategies for sex identification must be pursued. In 2014, the IPHC initiated a program to generate commercial sex-ratio data that included: 1) the development of at-sea sex-marking protocols for commercial vessels, 2) testing of sex-marking methods suitable for use on commercial vessels; first in a single port (Homer, 2015), then a single regulatory area (2B, 2016), and finally coastwide (2017), and 3) the development of a genetic sex assay.

DISCUSSION

At-sea sex marking

At-sea sex marking was accomplished by marking individual Pacific halibut during dressing, as follows: for females, two knife cuts made in the dorsal (upper) fin; for males, a single cut through the white-side gill plate. At-sea sex-mark data were voluntarily obtained from two vessels in 2015 resulting in 288 fish sampled, from 16 sampled offloads (317 samples) in Regulatory Area 2B in 2016, and from 84 offloads (929 samples) coastwide in 2017. To date, the data from the marking program have suggested that commercial vessels may capture Pacific halibut that are larger at age than are encountered in the IPHC's fishery-independent setline survey, resulting in a higher proportion of female catch that would be predicted using those survey data.

Fin clip samples from at-sea sex marked fish collected during the 2016 and 2017 fishing seasons were analyzed (i.e., genotyped) using the developed genetic tests (see next section) in order to validate the individual sexes as determined by at-sea sex marking.

Genetic assay

Genetic assay development employed restriction-site associated DNA sequencing (RADseq) to identify single nucleotide polymorphisms (SNPs) that are linked to sex in Pacific halibut. Three genetic markers limited to females were investigated for use in sexing Pacific halibut and two were developed into TaqMan genotyping assays that are currently conducted at the IPHC's Biological Laboratory in Seattle. Genetic analyses from tissue samples from at-sea sex marked fish in 2016 revealed that the marking accuracy was 79%. Subsequently, genetic analyses from

tissue samples from the larger set of samples of at-sea sex marked fish in 2017 revealed that the marking accuracy was 94.2%. Although at-sea sex marking accuracy appeared to be high when large sets of samples are analyzed, the low cost and almost complete accuracy of the genetic assays, combined with the current technical capabilities of the IPHC Biological Laboratory, strongly suggest that genetic sexing of Pacific halibut constitutes the best approach for determining the sex ratio of the commercial landings. Therefore, the IPHC has now conducted in-house genetic sexing of approximately 10,000 fish landed coastwide in 2017 and a similar number in 2018 from fin clips collected by IPHC's port specialists. The results of genetic sexing have provided sex ratio information for the first time from the commercial Pacific halibut landings and this information has informed the 2019 stock assessment. Plans are underway to continue with genetic sexing with samples from the 2019 commercial landings.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2020-RAB021-08, which outlined the completion of the at-sea sex marking project and the application of genetic assays for sex identification in the commercial landings.

Factors affecting somatic growth in juvenile Pacific halibut

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, 24 JANUARY 2020)

PURPOSE

To provide the RAB with a description of the studies conducted by IPHC Secretariat on factors affecting somatic growth in juvenile Pacific halibut.

BACKGROUND

The recent decrease in size-at-age (SAA) of Pacific halibut since the 1990s, combined with low recruitment of cohorts spawned at the time of the initial decrease in SAA in the 1990s, have contributed to a decrease in exploitable Pacific halibut biomass. Despite the importance of this decrease in exploitable biomass for fisheries management, our understanding of the potential causes for the historical change in SAA is still rather scarce. Changes in SAA in Pacific halibut have been hypothesized as being attributable to a variety of causes, including a fisheries-dependent effect through size-selective harvest, changes in population dynamics of the Pacific halibut stock due to a density effect, or changes in somatic growth as a result of environmental and ecological influences. Of the different possible environmental influences, temperature is believed to play a predominant role in influencing somatic growth in the Pacific halibut. Therefore, research activities at the IPHC in this area are devoted to further understanding the potential effects of environmental conditions on somatic growth by evaluating the effects of temperature, among others, on spatial, temporal, and age-specific growth patterns in the Pacific halibut.

DISCUSSION

In order to provide information on the effects of factors that may influence growth in the Pacific halibut, the IPHC is engaged in research activities designed to develop and validate physiological tools for measuring and monitoring growth patterns (Appendix I).

The strategy that was chosen initially involved the identification of potential molecular markers for growth studies by identifying genes expressed in growth-relevant tissues such as white and red skeletal muscle and liver.

The second strategy involved the manipulation of growth rates in juvenile Pacific halibut by temperature manipulation. Through acclimation at a low temperature (2 C), growth was suppressed, whereas through temperature-induced growth compensation, growth was stimulated, resulting in two opposite growth patterns (growth suppression/slow growth versus growth induction/fast growth; Figure 1) that could be compared in order to identify those genes that respond to temperature and that, therefore, could be considered acceptable growth markers.

This strategy has resulted in the identification of a large set of potential growth markers that could be useful for the detection of different growth patterns in the wild. Current efforts are devoted to the validation of the identified potential growth markers for their use in monitoring the growth pattern of Pacific halibut in a spatial and temporal manner. A specific deliverable of these studies is the development of sensitive assays for measuring the expression levels of growth markers that can be used on skeletal muscle samples from captured Pacific halibut in order to

derive direct information on growth patterns and potential. Initially, selected growth markers will be tested using skeletal muscle samples from age-matched Pacific halibut caught in the NMFS trawl survey corresponding to three different size categories (< 40 cm; 40 – 60 cm and > 60 cm) (Figure 2). These studies will inform whether the size differences among fish of the same age (e.g., 3-yr olds) are due to growth differences. These studies are being conducted in part with funding from the North Pacific Research Board (Grant Number 1704).

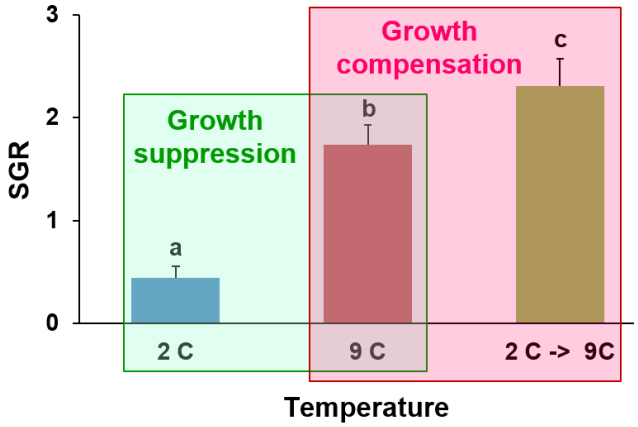


Figure 1. Effects of temperature manipulation on standard growth rate (SGR) in juvenile Pacific halibut. Growth suppression was achieved by acclimating fish at a low temperature (2 C) and growth stimulation was achieved by reacclimating at 9 C fish that were previously acclimated at 2 C as a result of growth compensation.

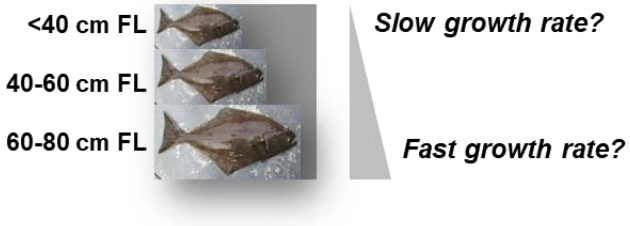


Figure 2. Proposed first application of selected growth markers to determine if size differences among Pacific halibut of the same age (age-matched) can be attributed to growth differences.

RECOMMENDATION

That the RAB:

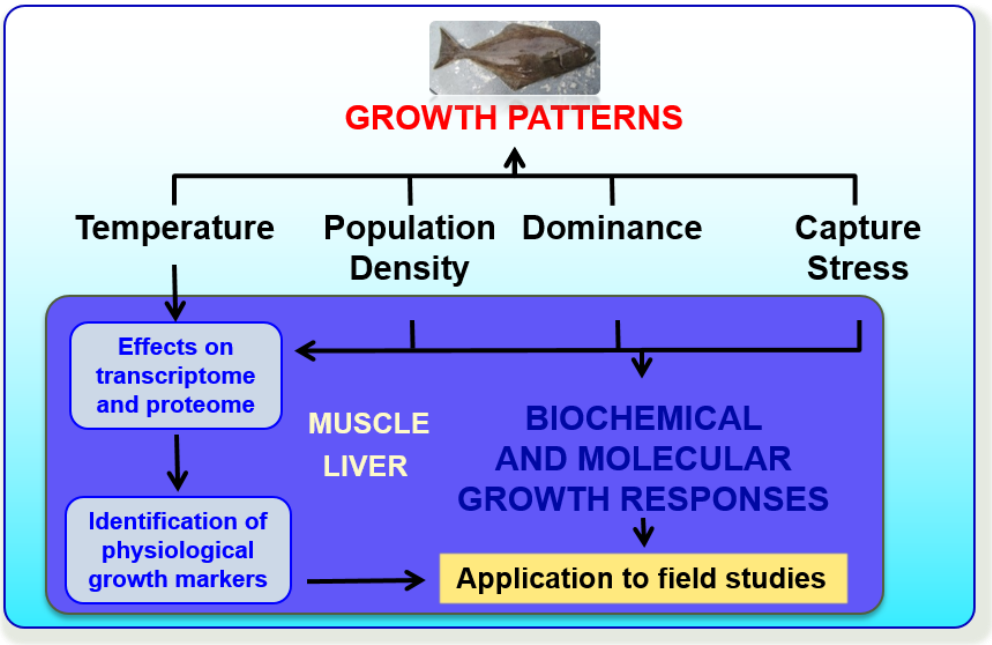
1) **NOTE** paper IPHC-2020-RAB021-09, which outlined the studies on growth in juvenile Pacific halibut by the IPHC Secretariat.

APPENDICES

Appendix I: Graphical summary of research activities related to the identification of physiological markers for growth monitoring of the Pacific halibut population.

APPENDIX I

Graphical summary of research activities related to the identification of physiological markers for growth monitoring of the Pacific halibut population



Discard mortality rates and post-release survival in the directed Pacific halibut fishery

PREPARED BY: IPHC SECRETARIAT (C. DYKSTRA, 24 JANUARY 2020)

PURPOSE

To provide the RAB with a description of the studies designed to improve our knowledge on discard mortality rates in the directed longline Pacific halibut fishery and the application of electronic monitoring.

BACKGROUND

Due to regulatory requirements, all Pacific halibut that are caught as sublegal size in the targeted fishery, and those exceeding quota limits of the vessel, cannot be retained and must be returned to the sea with minimal injury. However, through the process of capture and release, Pacific halibut incur a range of injuries and are subjected to a variety of factors that will affect their survival potential after release. Discard mortality rates (DMRs) are calculated from data collected by observers from the injury characteristics (also known as release vitality) of Pacific halibut post-capture, and are used to estimate the percentage of incidentally caught fish that are expected to die after release. Currently, post-capture DMR estimates are based on qualitative assessments of the physical condition of the fish (e.g., minor/moderate/severe/dead for longline gear) and have a certain degree of uncertainty associated with them, which in turn is a source of uncertainty in the estimation of total mortality within current International Pacific Halibut Commission (IPHC) stock assessment models. In practice, assigned DMRs and their uncertainty translate into *a priori* adjustments to expected mortality in each upcoming year, and to the catch limits that are thereafter assigned to each harvest sector. Given current low halibut yields relative to long-term mean productivity, uncertain estimates can result in undue hardship on some harvest sectors relative to others. Therefore, there is an urgent need to improve our estimates of DMR as well as to provide strategies to improve survival of incidentally caught Pacific halibut after release.

Individual variability in terms of mortality after release to the sea is expected, depending on the level of injuries and stresses incurred during the discarding process as well as on the basal physiological condition of the fish. Therefore, an accurate understanding of the types and relative levels of injuries and stresses that fish are exposed to during the discarding process in relation to the biological characteristics of the fish can be instrumental in helping better estimate the probability of survival during the discarding process. It has been well recognized that fish condition assessments that incorporate additional levels of information on the physiological characteristics of captured fish have improved the power to predict survival in discarded fish. It is important to indicate, on one hand, that the physiological condition of the captured fish may influence their susceptibility to the stress associated with capture and handling events and, hence, their potential for survival after release. On the other hand, different capture and handling procedures can elicit different physiological responses in the fish to cope with the ensuing stress, which may also influence their survival after release. These two aspects are important because they drive most of the variability associated with discard mortality.

Traditional observer programs require examining the fish (which includes looking at both sides of the fish, testing muscle tone and opercular responses) to determine vitality; something that cannot be achieved with cameras. Development of electronic monitoring (EM) systems as an

alternative to human observers highlights a need to develop the capability to convert imagery into actionable data. It has been demonstrated that EM provides information on Pacific halibut hook-release techniques (e.g. careful shake, gangion cut, hook stripper) for close to 95% of events, however the suite of vitalities incurred by each hook-release technique is unknown.

DISCUSSION

The main objective of the present project is to improve our understanding of the types and relative levels of injuries and stresses that fish are exposed to during the discarding process in relation to the biological characteristics of the fish, in order to improve our estimates of the probability of survival during the discarding process. We are measuring physiological indicators of stress and condition in a quantitative manner in relation to capture and handling events in order to understand their influence on mortality after release. Full condition assessments incorporating physiological parameters can then be used as a predictive tool to estimate DMRs if properly calibrated with the results of direct survival or behavioral studies (e.g., tagging and telemetry studies).

The work involved the random assignment of hook-release methods: 5 skates of careful shaking, 2 skates of hook stripping, and 1 skate of gangion cutting per set, using a commercial fishing vessel operating in an area southeast of Chignik, AK. All captured Pacific halibut were measured, weighed, assessed for current hooking injury, and evaluated for vitality (or release condition). Pacific halibut less than or equal to 84 cm (33 inches) fork length (FL) were sampled (blood, tissue for genetic analysis, muscle fat content and body temperature) and ocean temperature was recorded using temperature data loggers attached to each set of gear. Fish survival is being assessed by the use of pop-up archival transmitting tags (sPAT) tags containing accelerometer sensors that were deployed randomly on Pacific halibut ≤ 82 cm FL in excellent release condition and by the use of wire tags on Pacific halibut ≤ 84 cm of any release condition. Electronic monitoring equipment was also deployed during the project to collect data on the accuracy of its ability to capture release methods.

Examination of the acceleration data transmitted by sPAT tags in 2018 resulted in an estimate of 4% mortality for fish released from longlines in excellent condition. Evaluation of the EM footage found high agreement (95-100%) between the actual release method used and that determined by the EM reviewer. Vitality (injury, condition) profiles for each hook-release method are being developed to link the EM trips with hook release data to mortality estimates. Glucose, and lactate levels in the blood have been measured and the data are being analyzed on these two physiological stress indicators in relation to their ability to evidence stress responses and to associate them with other physiological conditions and capture conditions. A third blood physiological indicator, the stress hormone cortisol, is currently being measured. Furthermore, wire tag recovery will continue in 2020.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2020-RAB021-10, which described studies designed to improve our estimates of discard mortality rates in the directed Pacific halibut longline fishery.

Migratory behavior and distribution of Pacific halibut

PREPARED BY: IPHC SECRETARIAT (L. SADORUS, T. LOHER, J. FORSBERG; 24 JANUARY 2020)

PURPOSE

To provide the RAB with a description of the studies designed to improve our knowledge on distribution and migration of Pacific halibut in the northeast Pacific Ocean and eastern Bering Sea.

BACKGROUND

The IPHC is currently investigating Pacific halibut distribution and migration that encompasses all life stages via four different research projects.

U32 wire tagging

Of specific interest to the IPHC is the movement of juvenile Pacific halibut both within ocean basins (i.e., Gulf of Alaska and Bering Sea) and between them. The timing and distance traveled between nursery grounds to the adult feeding grounds varies over time and was last studied in the 1980s. Sampling platforms already being utilized for other investigations, the fishery-independent setline survey (FISS) and the NOAA-Fisheries (NMFS) trawl survey, are ideal vehicles for tagging and releasing U32 Pacific halibut during the summer months throughout their geographic range, and are currently the platforms for a spatially large-scale wire tagging effort.

Larval dispersal and connectivity

Unlike juvenile Pacific halibut which are demersal, larvae are pelagic for approximately the first six months of life and are distributed largely based on where they originated (i.e., where they were spawned) and where the currents carry them during their pelagic life stage. Of interest to the IPHC is the connectivity of larvae to nursery areas, particularly for larvae spawned in the Gulf of Alaska that settle in the Bering Sea, as well between the eastern and western sides of each basin, and the environmental drivers that may affect the magnitude of this connectivity. Also of interest are the geographic differences in larval dispersal and distribution of settled Pacific halibut related to environmental conditions. For example, note that it has been established that the counter-clockwise Alaska Coastal Current in the Gulf of Alaska flows into the Bering Sea via Aleutian Island passes, primarily Unimak Pass. The IPHC does not conduct larval surveys, but National Oceanic and Atmospheric Administration (NOAA) icthyoplankton (larval) surveys are conducted annually, and IPHC teamed with NOAA to examine these data spanning from 1972 to 2015 and model possible dispersal pathways, both at the larval and early demersal stages.

PAT tagging

The IPHC has conducted a series of pop-up archival transmitting (PAT) tag studies in the Bering Sea and Aleutian Islands (BSAI) region in order to identify winter spawning locations, determine the timing of seasonal movements, and investigate mixing of adult Pacific halibut within the BSAI

and between the Bering Sea and Gulf of Alaska. In 2018, the IPHC began a collaboration with Norton Sound Economic Development Corporation (NSEDC) and the University of Alaska, Fairbanks (UAF) to investigate dispersal of Pacific halibut in the far northeastern Bering Sea and potential connectivity between US and Russian waters. NSEDC provided tags, vessels, and logistical support for 2019 deployments. A UAF graduate student (Mr. Austin Flanigan) has been assigned to the project and will be supported at least through 2021 by a Rasmuson Fisheries Research Center (RFRC) Fellowship.

Coastwide deployment of fishery-recovery archival tags on U32 Pacific halibut

In 2018 the IPHC began a program in which electronic archival tags capable of recorded temperature, depth, and light levels for periods in excess of five years were deployed coastwide on U32 Pacific halibut. The data obtained from these tags will be used to relate rearing temperatures to growth rate and examine dispersal-at-age and -sex in Pacific halibut as they grow and recruit into the directed longline fishery.

DISCUSSION

U32 wire tagging

Each summer, IPHC deploys sea samplers on board the NMFS trawl surveys conducted in the Gulf of Alaska (biennially), Bering Sea (annually), and Aleutian Islands (biennially). The northern Bering Sea was surveyed in 2010, 2017, and 2019, and going forward has been added, at least temporarily, to the annual Bering Sea survey. Pacific halibut from 20 to 100 cm fork length are readily captured and sampled. In 2015, a pilot project was initiated on the trawl surveys to test the practicality of tagging and releasing a subsample of captured Pacific halibut with minimal impact to the regular sampling. The pilot project was considered a success and the program was fully implemented in 2016 going forward. Of the Pacific halibut captured, half are randomly selected as possible candidates for tagging. Within that subsample, a fish is tagged if it is U32 and viability is not assessed as “dead” using observer criteria. Table 1 lists project date to date.

Table 1. Release and recovery information of Pacific halibut tagged and released on board the NMFS trawl and IPHC fishery-independent setline surveys.

Wire tagging project	Years of tagging	Tags released	Tags recovered (as of 1/22/20)
Bering Sea trawl survey	2015, 2016, 2017, 2018, 2019	3,319	12
Gulf of Alaska trawl survey	2015, 2017, 2019	3,025	32
Aleutian Islands trawl survey	2016, 2018	318	2
IPHC FISS	2016, 2017, 2018, 2019	3,898	77
Total		10,560	123

In 2016, the IPHC investigated the practicality of adding U32 tagging to the FISS by conducting a pilot project in one Regulatory Area (Area 4D). The pilot project was successful and in 2017, the effort to tag and release U32 Pacific halibut was extended to the FISS in all areas where sampling rates for otoliths were less than 100 percent (i.e. Areas 2B, 2C, 3A, 3B, 4A, and 4B). U32 wire tagging will be continued on the FISS for the next several years. Area-specific tagging rates are set for all areas not sampled at 100% for otoliths, and a subsample of U32 fish not selected for otolith sampling are assessed using observer viability criteria and are subsequently tagged and released if not considered "dead". Additional information can be found in paper IPHC-2017-RARA27-R Chapters 2.5.1 and 2.5.4.

Larval dispersal and connectivity

The modeling portion of this work has concluded and the IPHC Secretariat is currently collaborating with NOAA co-authors in writing a manuscript to be published in a peer-reviewed journal later this year. Two models were utilized during this work: the first was a combination physical oceanography and larval recruitment model and the second was a spatio-temporal model. Results from the larval recruitment model indicated a large degree of larval connectivity between the Gulf of Alaska and the Bering Sea via Unimak Pass, especially from larvae originating from spawning grounds in the western Gulf and advecting to the eastern Bering Sea. There was also ample connectivity between the eastern and western Gulf of Alaska and the eastern and western Bering Sea to the Asiatic coast. The spatio-temporal model was used to examine Pacific halibut dispersal for fish aged 2-6 years using the NOAA Fisheries groundfish trawl survey data. Results indicated that at 2 years of age, young Pacific halibut are primarily in nearshore waters. By 4 years of age, a portion of the fish that originated in Bristol Bay have migrated to Unimak Pass, suggesting that they may be engaging in compensatory migration back through Unimak Pass, opposite to larval advection. By 6 years of age, halibut are widely dispersed across areas and depths. The study showed annual variations in dispersal, but there was no clear signal between warm and cold stanza years identified.

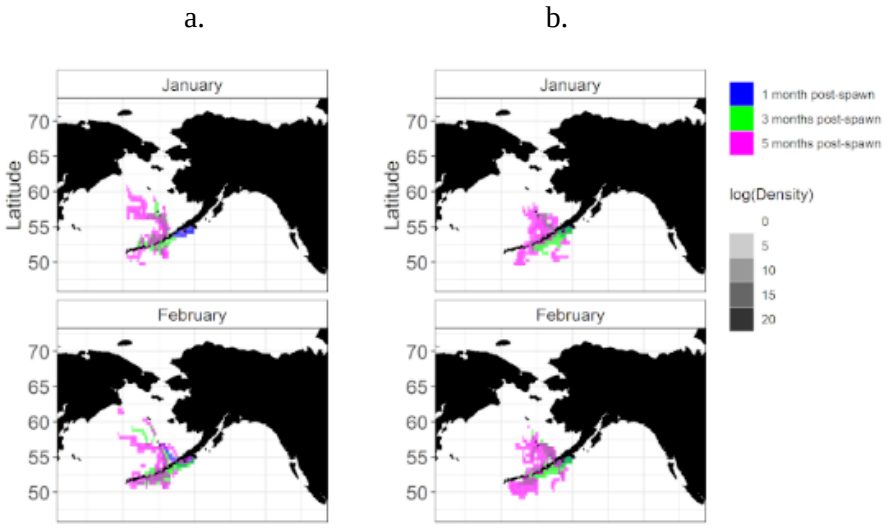


Figure 1. A sample of larval advection modelling results for Pacific halibut originating at a spawning ground in the western Gulf of Alaska during a) 2005 and b) 2009.

PAT tagging

A total of 44 Pacific halibut were tagged in 2020 with miniPAT tags (manufactured by Wildlife Computers, Redmond, Washington) in IPHC Regulatory Area 4E: in Norton Sound (n = 24), at St. Lawrence Island (Savoonga; n = 15), and during the National Marine Fisheries Service Northern Bering Sea trawl survey (n = 5). Tagging occurred 17-19 July in Norton Sound; 5-19 August at Savoonga; and 8-10 September aboard the NMFS trawl survey. The tags were programmed to release from their host fish and report their location and archived data during three periods: January 2020 (representing the spawning season); summer of 2020 (investigating summer feeding site fidelity versus emigration); and summer of 2021 (examining longer-term dispersal). Tags provided by the IPHC (n = 26) were used to tag relatively small fish (i.e., 71-93 cm fork length) while larger (97-141 cm) Pacific halibut were tagged using tags provided by NSEDC (n= 18). Deployments were designed to produce data that are comparable to the IPHC's prior PAT-tagging research that has been conducted to examine adult connectivity and spawning stock structure throughout the managed range, with the current effort being expanded to considerably broader stock demographics than any prior electronic archival tagging experiment. Of particular interest is anecdotal information that suggests that the northeastern Bering Sea Pacific halibut population may be composed of two functional groups: one that moves seasonally between this region and the continental shelf edge in US waters (e.g. Middle and Pervenets Canyons in IPHC Regulatory Area 4D), and another that may spawn in Russian waters (e.g., Navarin Canyon) and may be largely derived of individuals that were reared in Russian nurseries.

Collaborative tagging will continue in 2020. NSEDC will again provide staff and funding for vessel charters and logistical support, and has committed to the purchase 50 PAT tags to accompany 12 tags that were held over from 2019, having not been deployed due to a relative paucity of Pacific halibut encountered during the 2019 trawl survey. This year's work will include concurrent tagging of Pacific cod (*Gadus macrocephalus*) by researchers from the NMFS Alaska Fisheries

Science Center (Seattle). Both Pacific cod and Pacific halibut have been appearing in the Northern Bering Sea in increasing numbers, likely as a result of warming ocean conditions and the disappearance of winter sea ice, which may allow these species to reside in the region year-round. It is unknown to what degree migratory pathways and connectivity patterns may be similar between the two species. Analyses that consider both may have greater predictive power than attention to either species in isolation.

Coastwide deployment of fishery-recovery archival tags on U32 Pacific halibut

The coastwide U32 archival-tagging project that was initiated in 2018 continued with the deployment of 50 tags in the southeastern Bering Sea via the 2019 NMFS trawl survey platform. These tags have a long operating life (5-7 years) and will be used to study long-term ontogenetic dispersal as well as to relate the thermal conditions to which the fish are exposed to their growth. Temperature records from individual fish will be used to evaluate the degree to which fish that are reared in warm waters grow faster than those experiencing colder conditions on average. Temperature records will be related to stable isotope concentrations in collected otoliths so that this relationship can be used to reconstruct growth conditions for untagged fish and to examine temperature-dependent stock productivity patterns in time and space. Rewards will be offered for the recovery of these tags, where the reward amount will vary according to the amount of information provided to the IPHC: $300US if only the tag is returned; $400US if the tag is returned along with length and sex information and the fish's otoliths; $500US if the entire fish along with its tag is presented to an IPHC port sampler or equivalent agency biologist (e.g., fisheries observer) for sampling.

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2020-RAB021-11, which described studies designed to improve our knowledge on Pacific halibut distribution and migration at all life stages.

REFERENCE

St-Pierre, G. 1984. Spawning locations and season for Pacific halibut. Int. Pac. Halibut Comm. Sci. Rep. 70. 46 p.

Population genetics and migration

PREPARED BY: IPHC SECRETARIAT (J. PLANAS, A. JASONOWICZ, T. LOHER, 24 JANUARY 2020)

PURPOSE

To provide the RAB with a description of the studies conducted by IPHC Secretariat on population genetics and migration.

BACKGROUND

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. However, two studies published within this decade have reported significant genetic population structure that suggest that Pacific halibut residing in the Aleutian Islands may be genetically distinct from other regions. Current genetic approaches provide an improved level of resolution that may be instrumental in establishing the genetic structure of the Pacific halibut population. By studying the genetic characteristics of spawning populations, genetic signatures of geographic origin can be established and, consequently, could be used to assign Pacific halibut to their spawning origin and, therefore, inform on movement and distribution of Pacific halibut.

DISCUSSION

The main purpose of the proposed studies is to incorporate genetic analyses into migration-related research in order to improve our understanding of Pacific halibut movement and dispersal and of the genetic structure of the Pacific halibut population. The IPHC Secretariat is proposing three specific topics for investigation.

1. **Analysis of genetic variability among juvenile Pacific halibut in the Bering Sea and the Gulf of Alaska**. The aim of this study is to evaluate the genetic variability among juvenile Pacific halibut in a given ocean basin in order to infer information on the potential contribution from fish spawned in different areas to that particular ocean basin. We hypothesize that genetic variability among juvenile Pacific halibut captured in one particular ocean basin (e.g., eastern Bering Sea) may be indicative of mixing of individuals originating in different spawning grounds and, therefore, of movement. By comparing the genetic variability of fish between two ocean basins (i.e., eastern Bering Sea and Gulf of Alaska), we will be able to evaluate the extent of the potential contribution from different sources (e.g., spawning groups) in each of the ocean basins and provide indications of relative movement of fish to these two different ocean basins (Figure 1). The use of genetic samples from juvenile Pacific halibut collected in the NMFS trawl survey in the eastern Bering Sea and in the Gulf of Alaska, aged directly or indirectly through the length-age key, will allow us to provide genetic information from fish that are at or near their settlement or nursery grounds.

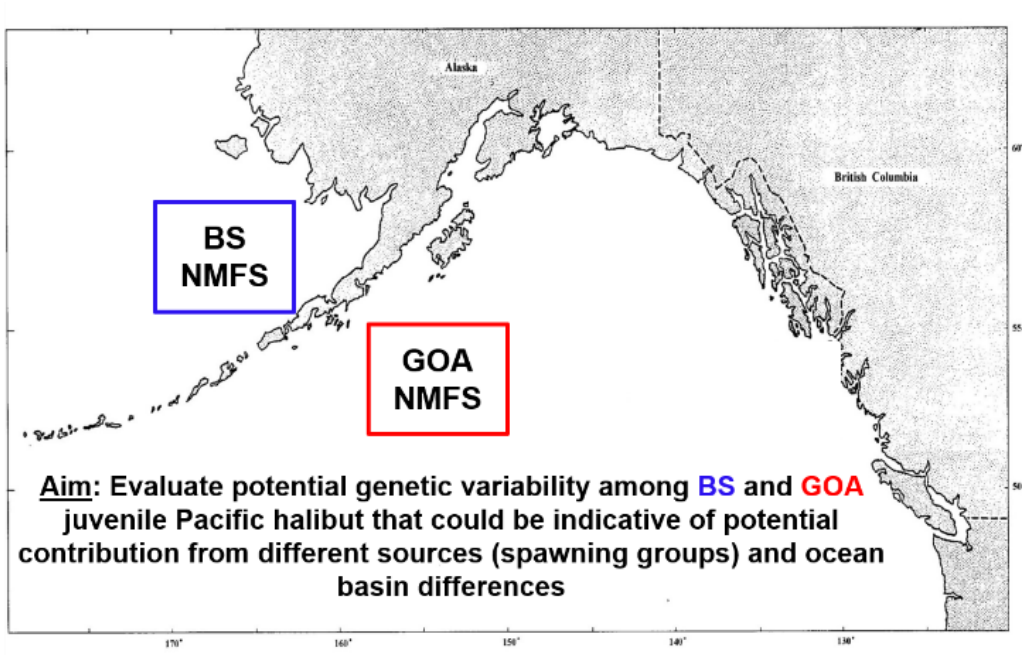


Figure 1. Map of the Northeastern Pacific Ocean where sampling for genetic analyses will take place in order to evaluate the potential genetic variability of Pacific halibut in different ocean basins.

2. **Analysis of genetic population structure in IPHC Regulatory Area 4B.** Recent studies have reported significant genetic population structure on the basis of microsatellites that suggest that Pacific halibut residing in the Aleutian Islands may be genetically distinct from other regions. In particular, differentiation of the population on either side of Amchitka Pass is indicated, suggesting a possible basis for separating IPHC Regulatory Area 4B into two management subareas. However, in order to evaluate that possibility it is advisable to re-assess those conclusions using samples specifically collected to evaluate the implied stock delineation. In particular, the existing analyses employed summer-collected (i.e., non-spawning season) samples west of Amchitka Pass and may or may not be representative of the local spawning population. Although unlikely, we cannot exclude the possibility that the observed differentiation in the Aleutian Islands may be representative of differentiation caused by dilution of the west-Aleutian sample by individuals from some other region. The proposed work would sample the local population on either side of Amchitka Pass during the spawning season so as to best characterize spawning structure and provide management advice regarding the relative justifiability for considering the western Aleutians as a genetically-distinct substock. Subsequently, genetic analyses will be conducted to evaluate the level of genetic differentiation between the two sampled areas. Sample collection will take place west and east of Amchitka Pass during the winter of 2020 in order to collect fish during the spawning season (Figure 2). A commercial fishing vessels has been chartered specifically for the purpose of collecting fin clip samples from 60 mature males and 60 mature females from each region.

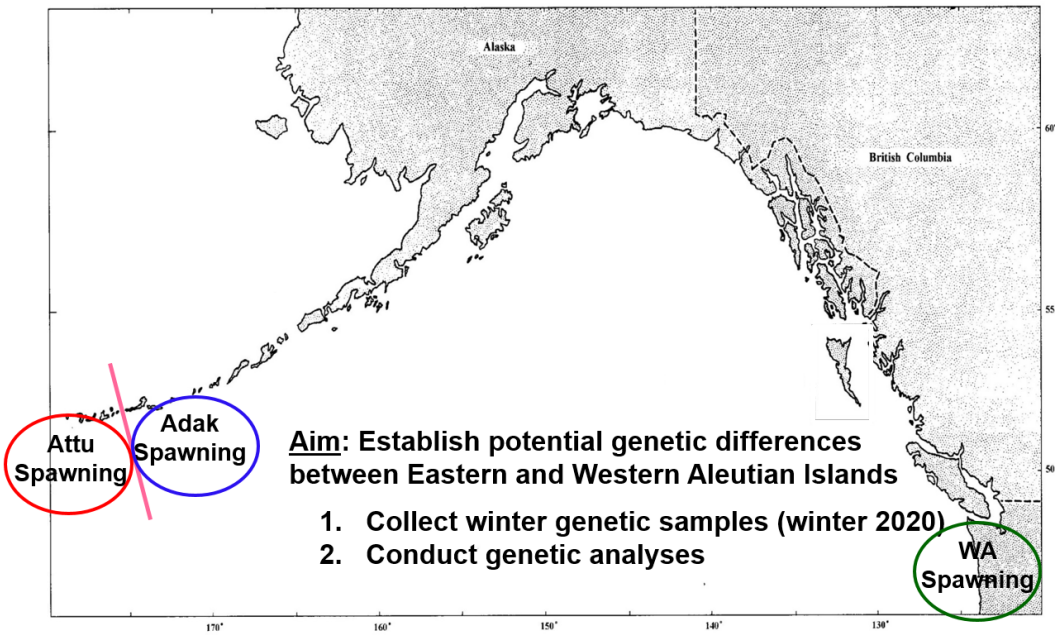


Figure 2. Map of the Northeastern Pacific Ocean where sampling for genetic analyses will take place in order to evaluate the potential genetic differences between fish spawned in the Western (Attu) and Central (Adak) Aleutian Islands.

3. **Identification of potential genetic signatures of origin or spawning groups to revise population structure**. In order to expand our proposed studies evaluating the Pacific halibut population genetic structure to the entire northeast Pacific Ocean covering the IPHC Convention Area, a broader genetic study is proposed that aims at establishing genetic baselines from known spawning groups throughout the geographic area in question. In addition to the genetic samples that would be collected in the project described above (eastern and western Aleutian Islands), we propose to collect additional winter samples from spawning fish off the Washington coast representing the southernmost spawning groups on the northeast Pacific Ocean. With these genetic samples, together with winter samples collected in the Portlock area (central Gulf of Alaska) in 2018 and in Haida Gwaii in 2004 and in the Bering Sea (Pribilof Canyon) in 2004, we plan to establish genetic signatures of these spawning groups to revise the genetic population structure with up-to-date genetic techniques (Figure 3).

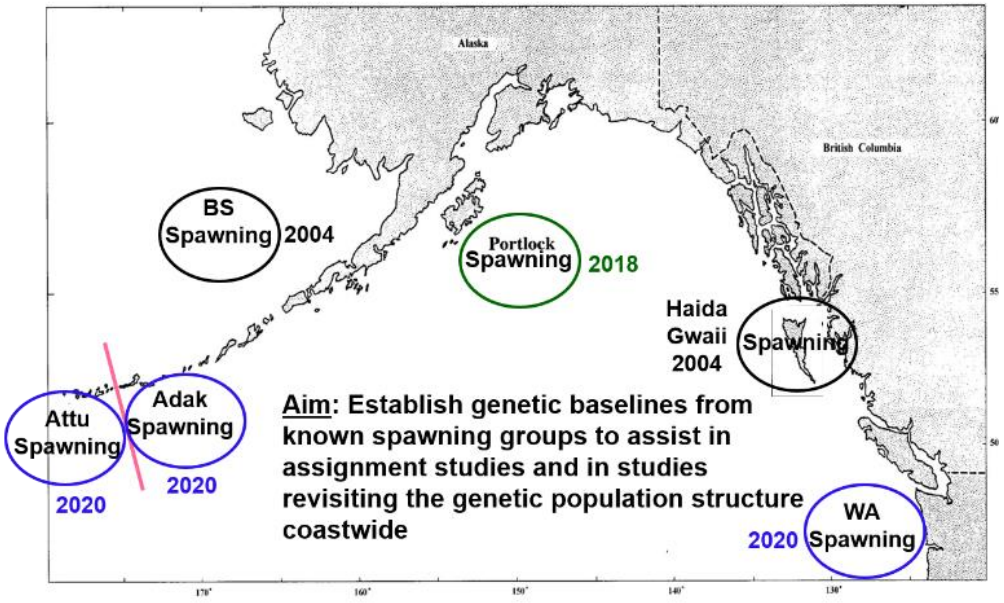


Figure 3. Map of the Northeastern Pacific Ocean where additional sampling, complementing previously collected samples, for genetic analyses will take place in order to establish the genetic characteristics of known spawning groups (genetic baselines).

RECOMMENDATION

That the RAB:

1) **NOTE** paper IPHC-2020-RAB021-12, which outlined the studies on population genetics and migration by the IPHC Secretariat.