



Report on Current and Future Biological and Ecosystem Science Research Activities

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PURPOSE

To provide the Research Advisory Board (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 CURRENT 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 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 parametrization and validation of movement estimates, on one hand, and of recruitment distribution, on the other hand ([Appendix III](#)).

- 1.1. Genetic-based method for estimating age of Pacific halibut. The primary objective of this project (funded by Alaska Sea Grant; Appendix IV) is to develop an alternative genetic method for aging Pacific halibut using fin tissue, a sample that can be easily collected from either live or dead individuals. This method is based on the identification of DNA methylation patterns (i.e. chemical modifications in DNA that do not involve changes in DNA sequence) in fin tissue that are associated with age through the development of an age estimation model (i.e., an epigenetic clock) for Pacific halibut.

To develop an epigenetic clock for Pacific halibut, we selected genetic samples (fin clips) from 249 fish collected in the FISS from 2021 to 2024 throughout IPHC Convention Waters (Figure 1) including most of IPHC's Regulatory Areas (Table 1). These genetic samples correspond to fish with known ages (read twice by the break and bake aging method) between 6 to 30 years of age and include 6-10 individual samples (aiming at equal number of males and females) per year of age (Figure 1).

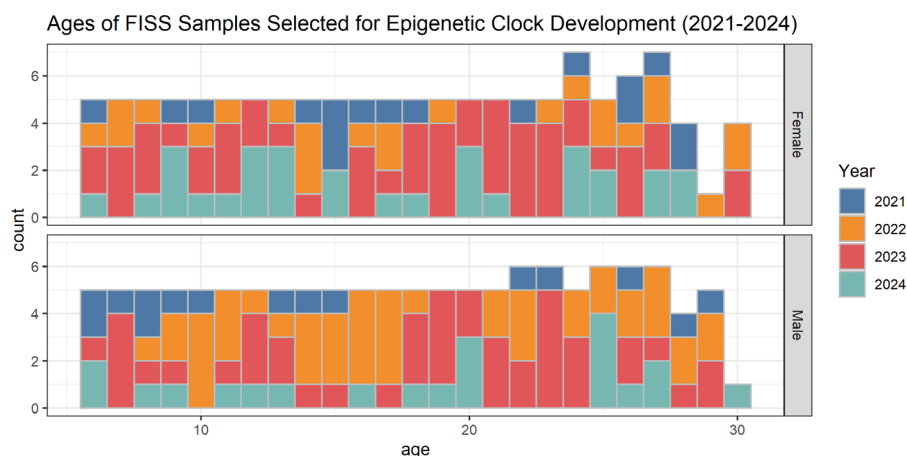


Figure 1. Histograms showing the number of female (top) and male (bottom) genetic samples by age year that are available for the development of the Pacific halibut epigenetic clock.

Year	2A	2B	2C	3A	3B	4A	4B	4D	Total
2021	1	12	12	3	0	3	1	0	32
2022	2	22	17	20	2	2	3	1	69
2023	16	32	25	14	10	0	0	0	97
2024	0	15	26	7	1	0	0	2	51
Total	19	81	80	44	13	5	4	3	249

Table 1. Number of genetic samples available by year and IPHC Regulatory Area.

To date, all 249 genetic samples have been processed for DNA extraction and sequenced to identify methylated sites in the genome and quantify the percentage of methylation at each site. Current efforts are devoted to analyze the methylation data from all individuals using a bioinformatic pipeline developed specifically for this project. Once finalized, we will characterize the relationship between otolith-derived age and percent methylation across age-correlated genomic sites using established models.

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](#)) as they represent the most important biological inputs for SA. 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](#)).

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

2.1. Update of maturity schedules based on histology and calibrated visual data. The IPHC Secretariat provided an update on spatial and temporal patterns in maturity ogives by Biological Region from 2022 to 2024, and a revised coastwide maturity ogive using histological based data in [IPHC-2025-RAB026-06](#). At present, the IPHC Secretariat has submitted a manuscript for publication in a peer-reviewed journal describing the

temporal and spatial changes in histology-derived maturity ogives and ovarian developmental stages. Furthermore, the IPHC Secretariat developed a calibration between histological and visual maturity ogives from the 2022-2024 data and produced calibrated maturity ogives based on FISS visual maturity data from 2002-2024. During this 23-year period, we observed significant shifts in the age at 50% (A_{50}) maturity (Figure 2). These results evidence two temporal shifts, one characterized by a gradual increase in the A_{50} (i.e. females maturing at a later age) from 2004 to 2016, and a second one characterized by a sharp decrease in A_{50} from 2017 to 2022 (i.e. females rapidly maturing at an earlier age). Studies are planned to identify possible drivers of these temporal shifts in maturity-at-age in female Pacific halibut.

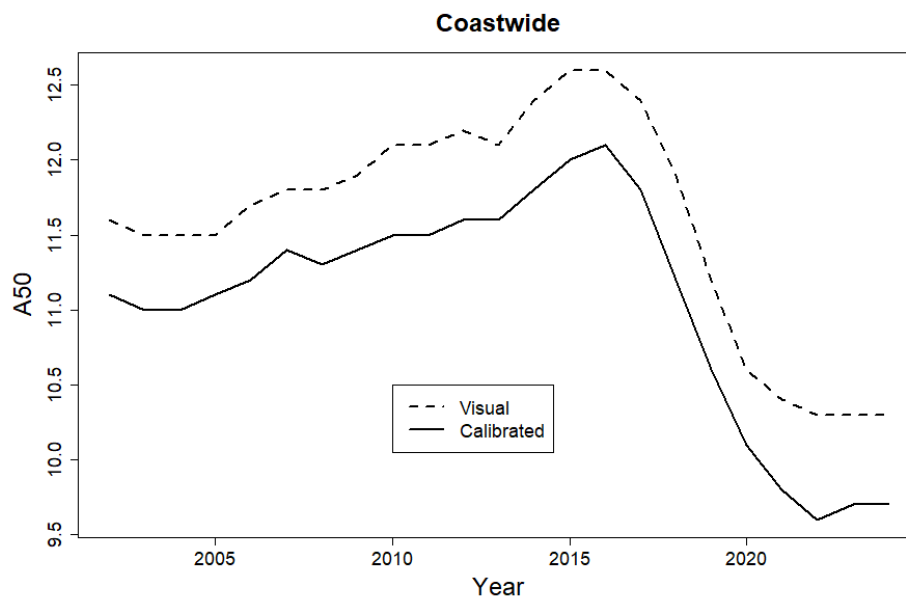


Figure 2. Coastwide A_{50} calculated from visual and calibrated maturity ogives from 2002 to 2024.

The IPHC Secretariat continued collecting ovarian samples for maturity in the 2025 and 2026 FISS seasons. In 2025, FISS sampling resulted in the successful collection of 1,276 ovarian samples from all four Biological Regions: 275 samples in Biological Region 2, 380 samples in Biological Region 3, 355 samples in Biological Region 4, and 266 samples in Biological Region 4B. In 2026, we collected 1,183 ovarian samples from Biological Regions 2, 3 and 4: 277 samples in Biological Region 2, 479 samples in Biological Region 3, and 427 samples in Biological Region 4. Unfortunately, no samples were collected in Biological Region 4B in 2026 due to the lack of FISS vessel bids. These samples will allow us to further investigate both spatial and temporal differences in histological-based female Pacific halibut maturity.

- 2.2. Fecundity estimations. The IPHC Secretariat has initiated studies that are aimed at improving our understanding of Pacific halibut fecundity. These studies 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 SA and management

reference points. Fecundity determinations will be conducted using the auto-diametric method (Thorsen and Kjesbu, 2001; Witthames et al., 2009) and IPHC Secretariat staff received training on this method by experts in the field (NOAA Fisheries, Northeast Fisheries Science Center, Wood Hole, MA) in May 2023. Ovarian samples for the development and application of the auto-diametric method to estimate fecundity in female Pacific halibut have been collected during the FISS in 2023, 2024 and 2025, as well as two special collections in IPHC Regulatory Area 2B in 2024 and 2025 (Figure 3). In 2023, sampling was conducted only in Biological Region 3, with a total of 452 fecundity samples collected. In 2024, sampling was conducted in Biological Regions 2 and 4, with 149 and 359 fecundity samples collected, respectively. In the Fall (Oct/Nov) of 2024, 271 additional fecundity samples targeting large females (85-200+ cm in fork length) were collected in Biological Region 2. This sampling was conducted to collect later developing females to help build the auto-diametric curve for fecundity estimations. In 2025, in addition to 878 samples collected in all four Biological Regions in the FISS, 242 fecundity samples were collected in Biological Region 2 in a special project targeting large females during the late summer months. This comprehensive collection of ovarian samples will be used initially for the development of the auto-diametric method, followed by actual fecundity estimations by age and by size (length and weight).

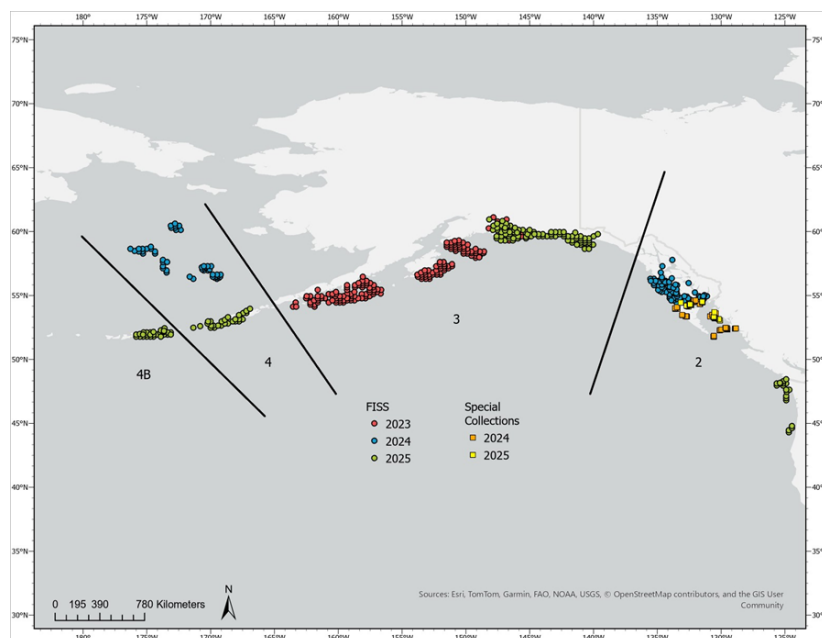


Figure 3. Coastwide map of 2023, 2024 and 2025 samples for fecundity collected in FISS (circle colors), and 2024 and 2025 special collection fecundity samples in IPHC Regulatory Area 2B (square colors).

From 2023-2025, a total of 1,154 ovarian samples from mature females (i.e. G2 field classification) were collected for fecundity estimations. When examining the age and weight distribution of mature females collected for fecundity sampling (Figures 4-5), the distribution of fish appeared to be skewed to the right for both parameters, but more pronounced for weight (Figure 5). For the mature female samples collected from 2023-2025, the total range of ages was from 6 to 38 years old, and the total range of weights was from 2 to 92 kg. The largest proportion of sampled fish was from 11 to 13 years old, and from 3 to 9 kg in weight.

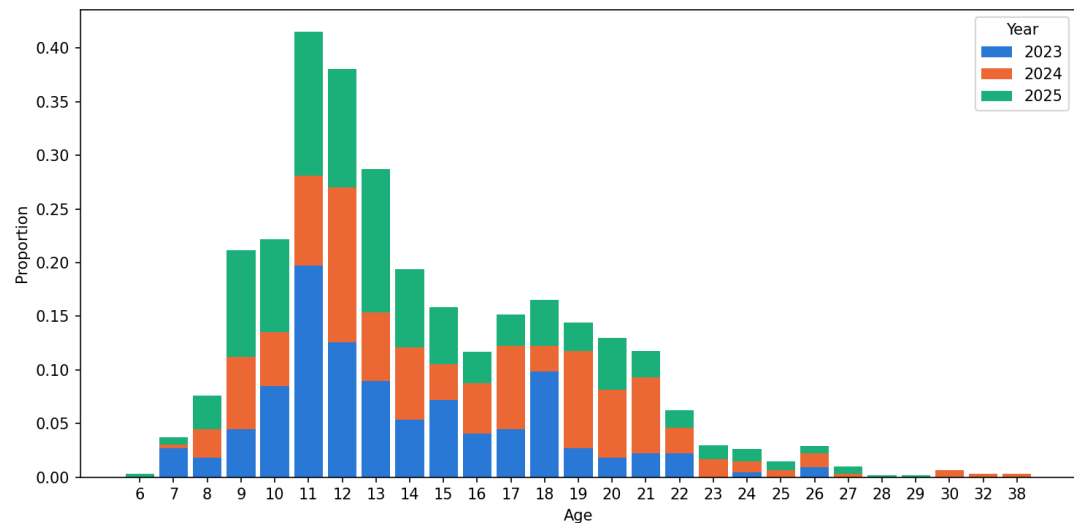


Figure 4. Stacked bar chart showing proportions of age (years) of mature (G2) female Pacific halibut collected for fecundity estimation in 2023, 2024, and 2025.

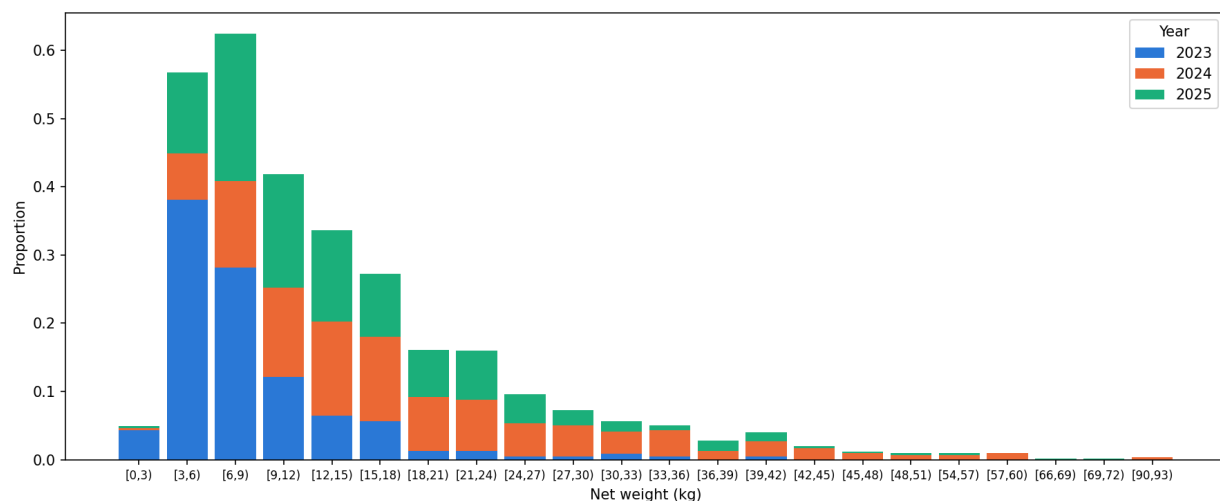


Figure 5. Stacked bar chart showing proportions of net weight (kg) of mature (G2) female Pacific halibut collected for fecundity estimation in 2023, 2024, and 2025.

To examine potential indicators of increased reproductive output of female Pacific halibut, IPHC Secretariat calculated gonadosomatic index (GSI) values for all fecundity samples that have been histologically staged. This includes all FISS samples in 2023 and 2024, as well as the special collection samples in Regulatory Area 2B in 2024 and 2025. GSI was calculated as $GSI = \frac{G}{W} \times 100$. Where G = total gonad weight (kg), and W = dressed weight (kg). We compared GSI to age (Figure 6) and weight (Figure 7) across four different female ovarian developmental stages (Vtg1, Vtg2, Vtg3, and GVM).

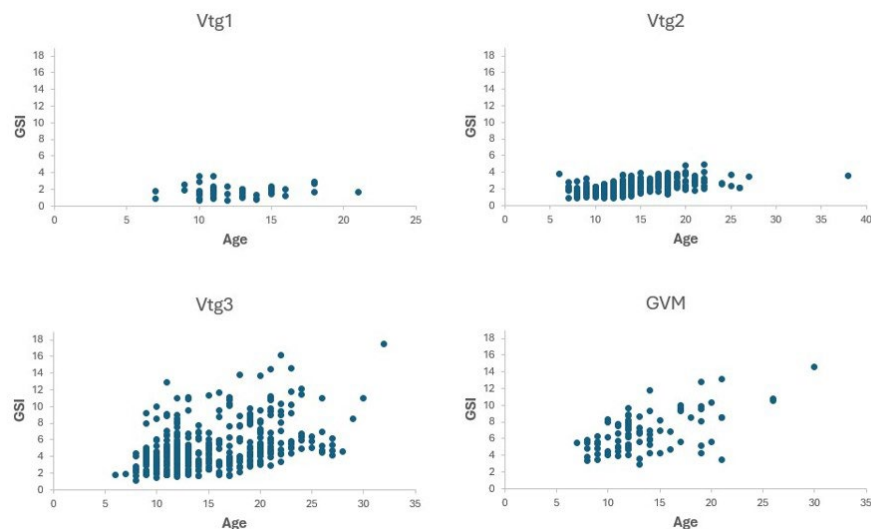


Figure 6. Gonadosomatic index (GSI) of female Pacific halibut according to age and female developmental stage (from less advanced to more advanced in maturity: Vitellogenic 1, Vtg1; Vitellogenic 2, Vtg2; Vitellogenic 3, Vtg3; Germinal Vesicle Migration, GVM).

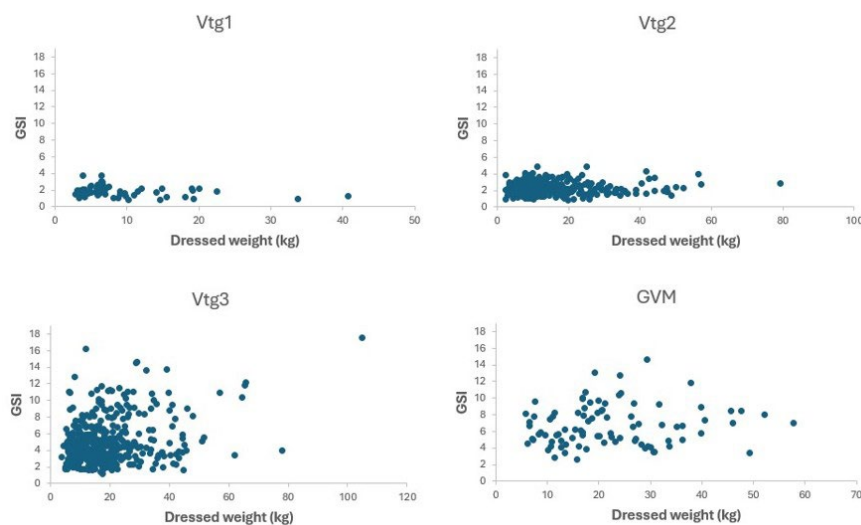


Figure 7. Gonadosomatic index (GSI) of female Pacific halibut according to weight and female developmental stage (please see legend to Figure 6 for abbreviations).

Our preliminary results show no increase in GSI with age for earlier developing females (e.g. Vtg1 and Vtg2), and a slight trend towards an increase in GSI with older females as they progress to the more advanced Vtg3 and GVM stages. When comparing GSI to weight, there is no indication of increasing gonad size with overall body weight, with higher variability in later stage developing females (Vtg3 and GVM). These preliminary results suggest that egg output might follow an isometric relationship with weight, which is the current assumption in the Pacific halibut SA.

In 2026, the IPhC Secretariat continued to collect ovarian samples during the FISS for fecundity estimation. Specifically, whole ovary weights and samples were collected from G2 (i.e. mature) females in Biological Region 2 (Sitka charter region), Biological Region 3 (Fairweather, Gore Pt., and Chignik charter regions), and Biological Region 4 (Unalaska charter region): 5, 29 and 38 samples collected, respectively. The IPhC Secretariat also collected fecundity samples from mid-September to October of 2026 (outside of FISS) during a special project in Biological Region 2 (Ommaney charter region) and Biological Region 3 (Gore Pt. charter region). In each Biological Region, 200 samples of G2 (i.e. mature) females greater than 90 cm in fork length were collected. These samples will allow the IPhC Secretariat to spatially compare fecundity estimations among multiple Biological Regions, as previous special project collections (2024 and 2025) were conducted in Biological Region 2.

3. 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 parametrization ([Appendix III](#)).

3.1. 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 2,581 metric tons (5.7 million pounds) of removals in 2025. 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 in Alaska and Canada are currently based on DMR information generated from commercial gear using circle hooks combined with rates derived for other sport fisheries for non-circle hooks, and coarsely applied to recreational hook type and creel census data (Meyer 2007). 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 IPHC conducted field studies informed by common gear and handling practices as determined by a survey of charter owners and operators. The guided recreational vessel F/V High Roller (operated by Alaska Premier Charters) was chartered by the IPHC 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) from 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, wire tagged 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, tagged (80 sPAT, 38 wire), 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.

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. The majority (97%) of Pacific halibut captured were classified in the Excellent viability category. Fish of Moderate or Poor viability were only caught on the smaller 12/0 hooks.

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) 41 wire tags (39 from IPHC Regulatory Area 2C and 2 from IPHC Regulatory Area 3A), 78 sPATs transmitted data, and two sPAT tethers (of successfully reported tags) have been recovered. Of the 76 fish with functional sPAT tags, one stopped moving for 12 hours prior to detachment (8.3 days), whereas all others were active until tag detachment. Kaplan-Meier survival analysis generated a mortality rate estimate of 1.35% (95% CI 0.00-3.95%) for Pacific halibut released in excellent condition. Final DMR estimates incorporate estimates of mortality for all viabilities (excellent, moderate, and poor) as well as ratios of hook types

used in the fishery historically. Table 2 shows how the current study of survival under recreational conditions translates to overall estimates, and how it compares to DMR estimates currently used in management.

IPHC Regulatory Area	2C	2C	3A	3A
Sector	Charter/Guided	Private/Non-guided	Charter/Guided	Private/Non-guided
Original calculated DMR	5.10%	5.60%	3.90%	4.50%
Calculated DMR - this study (95% CI)	4.41% (3.42-6.31%)	4.98% (4.09-6.68%)	3.04% (1.81-5.41%)	3.72% (2.62-5.86%)
DMR currently applied for management	6.00%	7.00%	5.00%	6.00%

Table 2. Discard mortality rates (DMR) by IPHC Regulatory Area and recreational sector in Alaska. Original calculated rates (Meyer 2007) and the rates applied by current management are contrasted to the results generated by this study.

The Alaska Department of Fish and Game (ADFG) applies slightly higher discard mortality rates than those calculated to accommodate variation from year to year in the numbers of fish released, undocumented variation in hook use (circle vs non circle) from year to year, and probable increases in mortality due to the cumulative effects of multiple recaptures. The IPHC secretariat applies discard mortality rates calculated for IPHC Regulatory Area 2C to data provided by the Department of Fisheries and Oceans Canada for discard estimates in IPHC Regulatory Area 2B.

4. 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 \(2022-2026\)](#) ([Appendix I](#)).

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.

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 focused 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. This project, that received funding from the Bycatch Reduction Engineering Program (BREP)-NOAA, was 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 8A) and 2) a branch gear with a sliding shroud system (not shown). Results from field testing conducted in May 2023 indicated that the shuttle was a safe and effective gear type which entrained comparable quantities, sizes, and types of 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.

Based on the success of the first two components of this work, the IPHC secured additional funding from BREP-NOAA to expand testing of the shuttle concept in the presence of depredating Orcas in Alaskan waters ([Appendix IV](#)). This work focused on further refinement and performance characterization of the shuttle device in the presence of toothed whales in IPHC Regulatory Area 4A. Field operations occurred from 21-28 May 2025 aboard the F/V Oracle (Figure 8). Eighteen sets were successfully completed, generating 15 sets of shuttle and control catch comparison data along with close to 80 hours of underwater footage combined (control, shuttle exterior, shuttle interior). Depredating orcas were present at 6 of the paired sets.

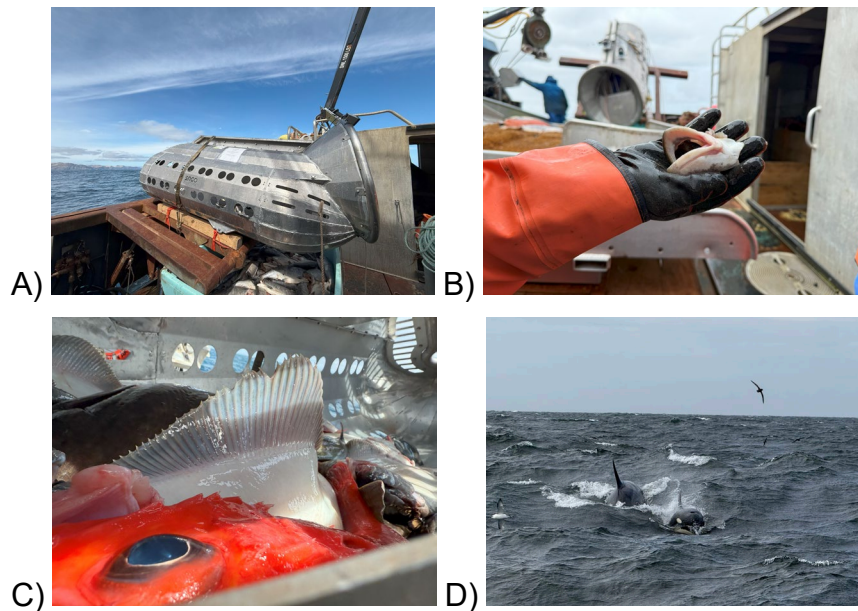


Figure 8. A) Shuttle device in transport. B) Typical evidence (lips only) of depredation. C) Catch entrained within the shuttle. D). Killer whales rapidly approaching the hauling site.

Preliminary results from video footage indicated that the shuttle device had high retention rates of Pacific halibut when compared to other frequently encountered species (Table 3). In addition, preliminary results did not show clear differences on catch rates between protected and unprotected skates, likely due to high variability among catch rates within treatments. Overall, the shuttle device demonstrated good retention capacity (up to 835 kg/1,800 lb) in the trials, with capacity for higher weight retention. Incidentally, rare footage of Orcas around the groundline at depth was also captured.

Common Name	Encountered	Excluded	Entered and Escaped	Entered and Passed Through	Retained
Pacific halibut	121	1 (0.8%)	0	9 (7.5%)	112 (93.3%)
Sablefish	186	2 (1.1%)	54 (29.4%)	34 (18.5%)	96 (52.2%)
Pacific cod	124	3 (2.4%)	13 (10.7%)	6 (5.0%)	102 (84.3%)
Rockfish	19	7 (43.8%)	2 (16.7%)	1 (8.3%)	9 (75.0%)
Skate	18	3 (16.7%)	0	2 (13.3%)	13 (86.7%)

Table 3. Numbers of fish encountered by the shuttle device that were either excluded, entered and escaped, passed through still on the hook, and/or finally entrained in 11 of 15 sets with video footage analyzed to date.

Further testing of the shuttle device was conducted under typical commercial fishing conditions in the Bering Sea in October 2025 on the same fishing vessel with an IPHC field specialist aboard to assist with data collection. No cameras were used during this phase. The shuttle was only deployed for a total of 4 sets over this effort due to weather challenges and lack of whales present on many fishing days.

RECOMMENDATION/S

- 1) That the RAB **NOTE** IPHC-2026-RAB027-06, 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 prioritization
Migration and population dynamics	Population structure	Population structure in the Convention Area	Altered structure of future stock assessments	Improve parametrization 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 delineate 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/deterrence; 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/deterrence; 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)

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 parametrization 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 parametrization of recruitment distribution in the Operating Model		Distribution
	Establishment of temporal and spatial maturity and spawning patterns	Improve simulation of recruitment variability and parametrization of recruitment distribution in the Operating Model	Reproduction	Recruitment strength and variability
3. Biological parameterization and validation for growth projections	Identification and application of markers for growth pattern evaluation	Improve simulation of variability and allow for scenarios investigating climate change	Growth	Evaluation of somatic growth variation as a driver for changes in size-at-age
	Environmental influences on growth patterns			
	Dietary influences on growth patterns and physiological condition			
1. Fishery parameterization	Experimentally-derived DMRs	Improve estimates of stock productivity	Mortality and survival assessment	Discard mortality rate estimate: recreational fishery



APPENDIX IV

Summary of current 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	Alaska Sea Grant	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-February 2027	Population dynamics	Stock structure	2
Total awarded (\$)					\$60,374				