



Report on Current and Future Biological and Ecosystem Science Research Activities

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PURPOSE

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

BACKGROUND

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

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

The primary biological research activities at IPHC that follow Commission objectives are identified and described in the [IPHC Five-Year Program of Integrated Research and Monitoring \(2022-2026\)](#). These activities are summarized in five broad research areas designed to provide inputs into stock assessment and the management strategy evaluation processes ([Appendix I](#)), as follows:

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

DISCUSSION ON 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. Population genomics. conservation of natural resources. Pacific halibut in US and Canadian waters are managed as a single, coastwide stock on the basis of tagging studies and historical (pre-2010) analyses of genetic population structure that failed to demonstrate significant differentiation in the eastern Pacific Ocean. While genetic techniques previously employed in fisheries management have generally used a small number of markers (i.e. microsatellites, ~10-100), advances in genomic technology now enable whole-genome scale approaches to be conducted with lower cost and provide orders of magnitude more data (millions of markers). Using low-coverage whole genome resequencing the IPhC Secretariat has the capability to examine genetic structure of Pacific halibut in IPhC Convention Waters with unprecedented resolution. By studying the genomic structure of spawning populations, genetic signatures of geographic origin can be established and, consequently, could be used to identify the geographic origin of individual Pacific halibut and, therefore, inform on the movement and distribution of Pacific halibut.

The main purpose of the present study is to resolve the genetic structure of Pacific halibut population structure in IPhC Convention waters using state-of-the-art low-coverage whole genome resequencing methods. For this purpose, genetic samples from male and female adult Pacific halibut collected during the spawning (winter) season in five known spawning grounds have been used: Western and Central Aleutian Islands, Bering Sea, Central Gulf of Alaska and British Columbia (**Figure 1**). As a requisite for the low-coverage whole genome resequencing approach used, the IPhC Secretariat first produced a high-quality reference genome ([Jasonowicz et al., 2022](#)) that has been used to generate genomic sequences from 731 individual Pacific halibut collected from the five above-mentioned geographic areas (**Figure 1**) using low-coverage whole-genome resequencing (lcWGR).

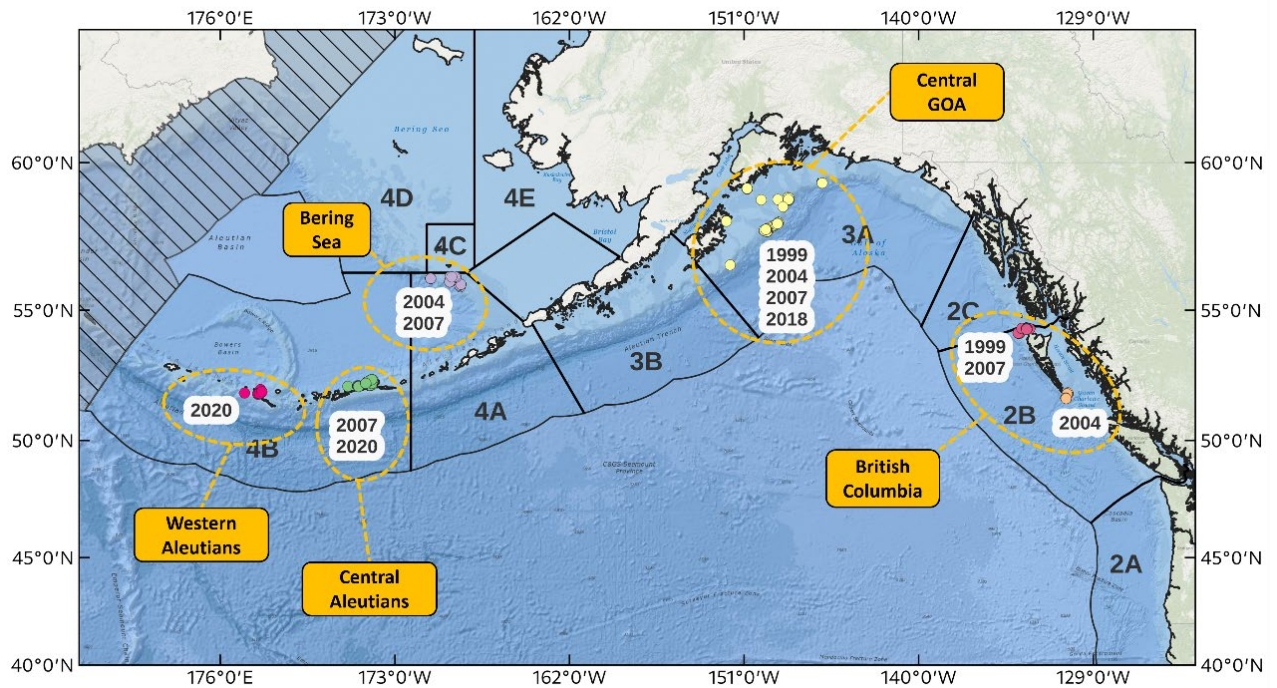


Figure 1. Map of sample collections made during the spawning season used for genomic analysis of population structure in Pacific halibut in the northeast Pacific Ocean.

Using the lcWGR approach, have identified millions of single nucleotide polymorphisms (SNPs) that have been used to evaluate population structure at the highest resolution possible. Despite the use of a very high-resolution genomic approach, our analyses of population structure using a genome-wide subset of 3.7 million SNPs, indicated that no distinct genetic groups were apparent in the dataset. Multiple methods were used to characterize population structure: principal component analysis revealed a considerable degree of genetic similarity between samples collected in different geographic areas (**Figure 2**), and unsupervised clustering methods (K-means clustering and the estimation of admixture proportions) also failed to detect discrete genetic groups (data not shown). These results suggest that there is very little spatial structure among the five spawning groups sampled in different geographic areas within IPHC Convention Waters. Furthermore, assignment testing was carried out to assess our ability to accurately assign samples back to their location in which they were collected. Assignment accuracy was estimated using cross-validation techniques and indicated a limited ability to accurately assign (~35% assignment accuracy) samples back to the geographic location in which they were collected from (data not shown), despite using a subset of 5,000 SNPs showing the highest levels of differentiation among the geographic areas sampled. We hypothesize that the absence of distinct genetic groups among our sample collections is due to a considerable degree of geneflow among the geographic areas sampled in this study and, consequently, to the genetically panmictic nature of the Pacific halibut population sampled for this study.

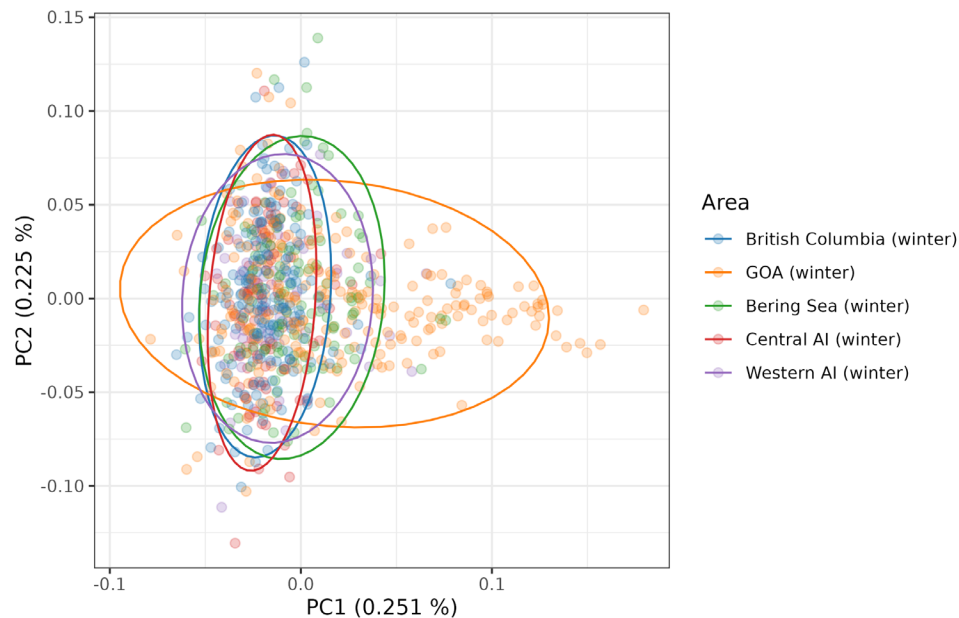


Figure 2. Genetic relationships among individual samples visualized using principal component analysis. Each point represents an individual fish and each fish is colored by the geographic area in which they were sampled. Note the lack of distinct clusters and overlap among areas. Circles represent 95%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

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

The concept of stock and the ability to define management units is central to sound management of marine fishes (Begg et al. 1999; Cadrin 2020). Advances in genomic technology have led to the development of useful and powerful tools that can aid in the delineation of management units (Bernatchez et al. 2017). Despite using very high-resolution genomic methods to characterize genomic variation in spawning groups of Pacific halibut collected over large spatial and temporal scales, the results presented

here are consistent with genetic panmixia. From a management perspective, these results support IPHC's current stock assessment practices that model the Pacific halibut stock as a single coastwide unit ([Stewart and Hicks 2024](#)).

2. Reproduction.

Research activities in this Research Area aim at providing information on key biological processes related to reproduction in Pacific halibut (maturity and fecundity) and to provide sex ratio information of Pacific halibut commercial landings. The relevance of research outcomes from these activities for stock assessment (SA) is in the scaling of Pacific halibut biomass and in the estimation of reference points and fishing intensity. These research outputs will result in a revision of current maturity schedules and will be included as inputs into the SA ([Appendix II](#)) 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) updating maturity schedules based on histological-based data; and 2) calibration of historical visual maturity schedules using histological-based data.

2.1. Update of maturity schedules based on histological-based data. The IPHC Secretariat is undertaking studies to revise maturity schedules in all four IPHC Biological Regions through histological (i.e. microscopic) characterization of maturity, as reported previously. The coastwide maturity schedule (i.e. the proportion of mature females by age) that is currently used in SA was based on visual (i.e. macroscopic) maturity classification in the field (Fishery-independent Setline Survey (FISS)). To revise currently used maturity schedules, the IPHC Secretariat has collected ovarian samples for histology during the 2022, 2023 and 2024 FISS. The 2022 FISS sampling resulted in a total of 1,023 ovarian samples collected. Due to a reduced FISS design in 2023, sampling only occurred in Biological Regions 2 and 3 and resulted in a total of 1,111 ovarian samples collected. In 2024, 411, 336 and 371 ovarian samples were collected in Biological Regions 2, 3 and 4, respectively. In total, 3,252 ovarian samples have been collected for histology between 2022 and 2024 (**Figure 3**).

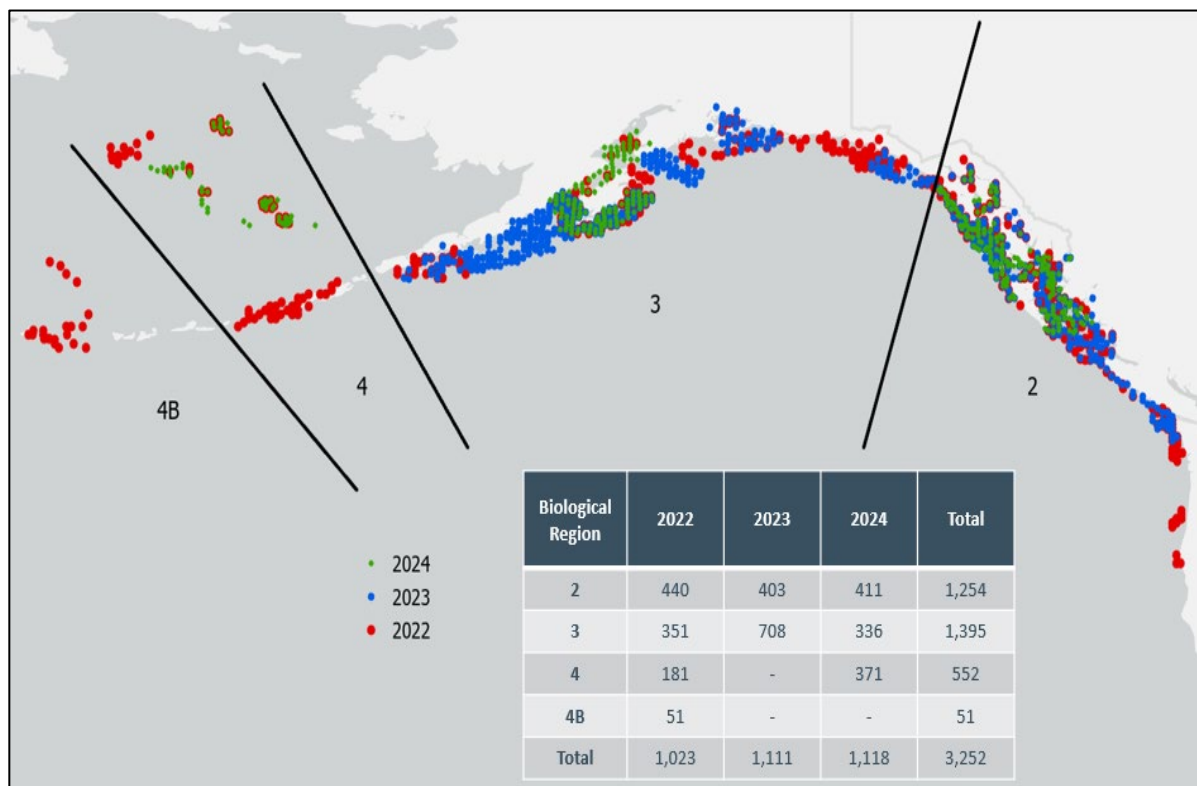


Figure 3. Map of 2022, 2023 and 2024 maturity samples for histology collected on FISS. Red dots (2022), blue dots (2023) and green dots (2024) indicate a distinct FISS station in which a sample was collected.

The IPHC Secretariat continued to collect ovarian samples in the 2025 FISS. Targets for 2025 were to collect 400 samples in Biological Regions 2 and 3, 188 in Biological Region 4, and 414 in Biological Region 4B. These samples will allow us to further investigate both spatial and temporal differences in histological-based female Pacific halibut maturity.

Ovarian samples from 2022 to 2024 were processed for histology and we finalized scoring samples for maturity using histological maturity classifications, as previously described in Fish et al. (2020, 2022). Following this maturity classification criteria, all sampled Pacific halibut females were assigned to either the mature or immature categories. Mature female Pacific halibut are deemed to have at least reached the early vitellogenesis (Vtg1) stage of oocyte development.

Maturity ogives (i.e., the relationships between the probability of maturity determined by histological assessments and variables including IPHC Biological Region, age, and year) were estimated by fitting generalized additive models (GAM) with logit link (i.e., logistic regression). We first ran again the best-fit logistic GAM models using $\log(\text{Age})$, Biological Region, and year for the 2022-2024 samples. By examining the 2024 output for the logistic GAM (**Figure 4**), Biological Region 2 once again shows older maturity-

at-age (indicated by the dashed lines for A50 and A95) and lower maturity-at-age from ages 10-20 than Biological Region 3. Biological Region 3 once again in 2024 shows a steep increase in maturity-at-age when compared to all other Biological Regions, with over 80% of mature females by age 9. Biological Region 4 shows a delayed start to maturation with only 5% of mature females at age 9 but maturation rapidly increases to ~90% mature females at age 15.

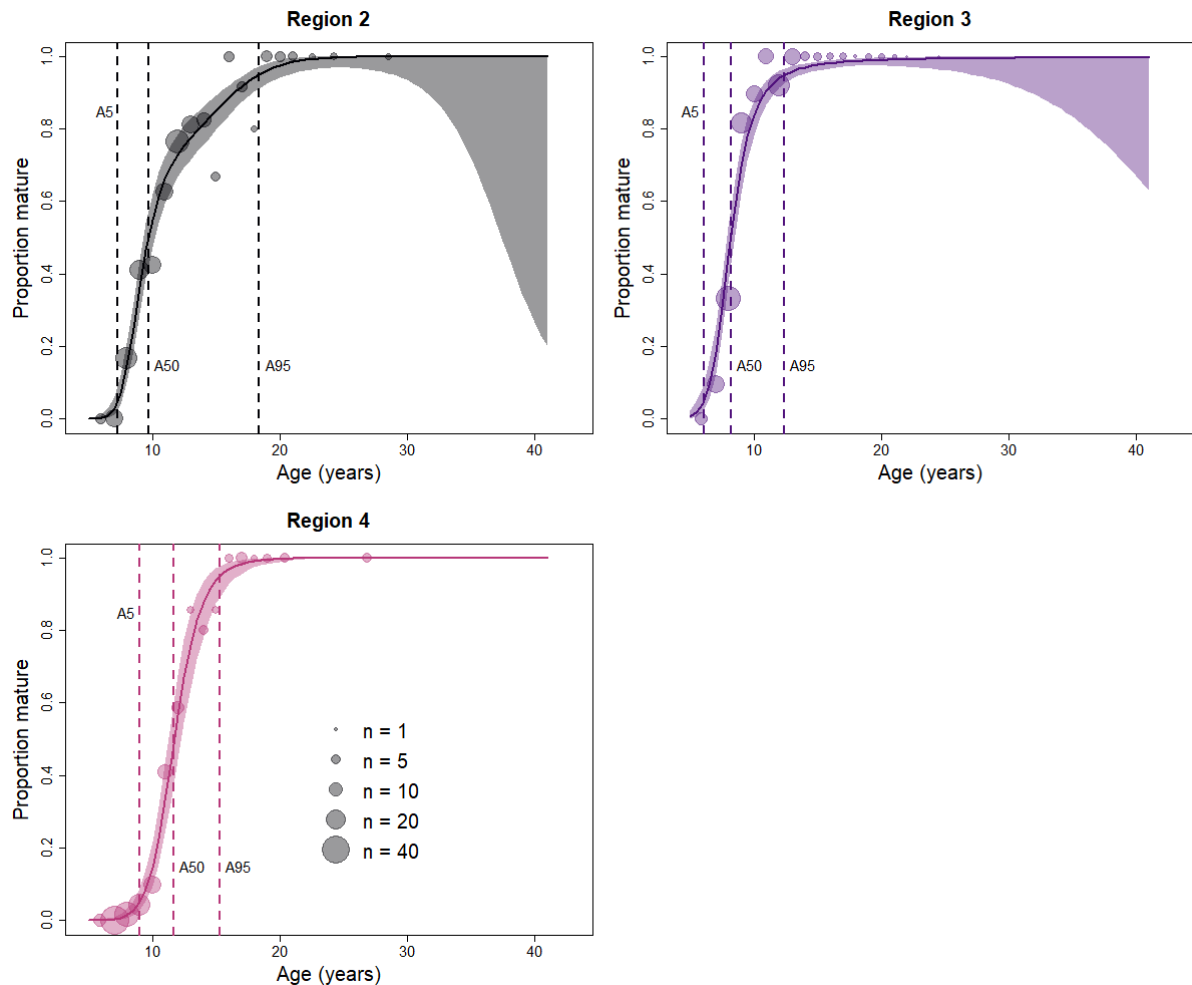


Figure 4. Female Pacific halibut age at maturity by IPHC Biological Region in 2024 using best-fit logistic GAM, with color shading indicating 95% CI for each IPHC Biological Region. Vertical dashed lines indicate proportion mature at 5% (A5), 50% (A50), and 95% (A95).

To examine temporal changes across all Biological Regions, we overlaid all three years of histological data by region (**Figure 5**). Overall, there is an observed shift to the left in maturity ogives from 2022 to 2024 in the three Biological Regions (2, 3, and 4) that have multiple years of data, indicating younger maturing females in 2024 than in 2022 and 2023. This could be indicative of a particular year class maturing through the population; however, this is difficult to discern with only three years of data. Biological Region 2 had a significant change from 2022 to 2023. With more individuals classified

as mature between the ages of 8-20 in 2023 than in 2022, the rate of maturation in Biological Region 2 increased at younger ages causing the steepness of the curve to rapidly increase. There did not appear to be a difference between 2023 and 2024 for Biological Region 2. For Biological Region 3, there is a similar trend in that the maturity ogive has progressively shifted slightly to the left from 2022 to 2024. This indicates that a higher proportion of females at any given age are mature in 2024 compared to the previous two years. Biological Region 4 also showed a shift to the left from 2022 to 2024 (no data in 2023). It will be important to continue to monitor temporal trends in histological-based maturity ogives to determine if the observed shifts in maturity ogives continue.

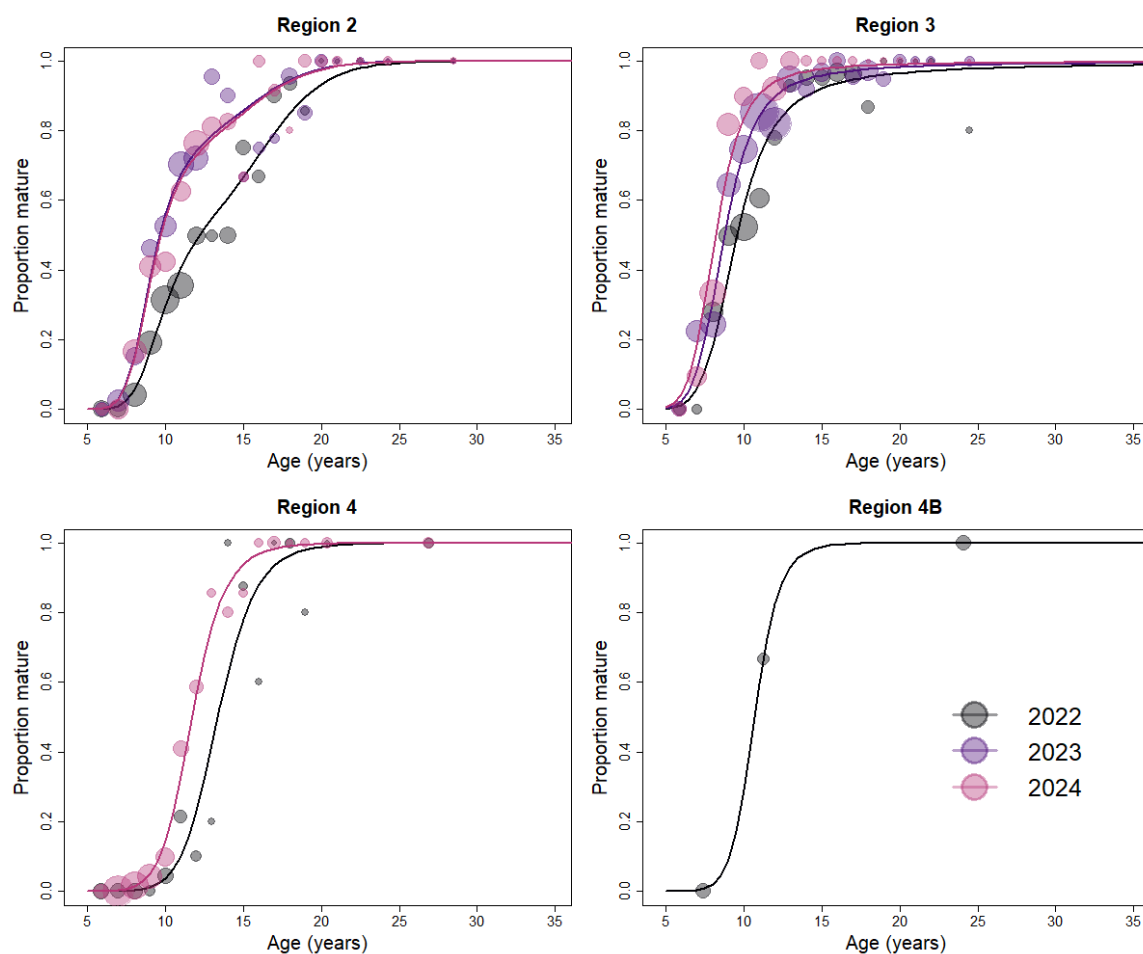


Figure 5. Female Pacific halibut age at maturity by IPHC Biological Region and year using best-fit logistic GAM.

To estimate a coastwide ogive with the 2022-2024 histology-based maturity data, we removed the year effect from the logistic GAM model and pooled all years by Biological

Region. The logistic GAM estimated maturity curves for each IPHC Biological Region. Noting that sample size was not proportional to population size for each region, we used the average estimated regional abundance proportions from 2022-2024 from IPHC's space-time modeling of FISS numbers per unit effort (NPUE) data as weights in estimating a coastwide maturity ogive (**Figure 6**). The modeled coastwide ogive for maturity-at-age falls between the maturity ogives for Biological Regions 2 and 3 (**Figure 6**). This outcome was expected as these two Biological Regions currently have the highest estimated abundance. Age at 50% maturity (A_{50}) was estimated to be 9.8 years, an almost two-year shift to younger maturing females when compared to our current maturity estimates from visual (field) data of 11.6 years.

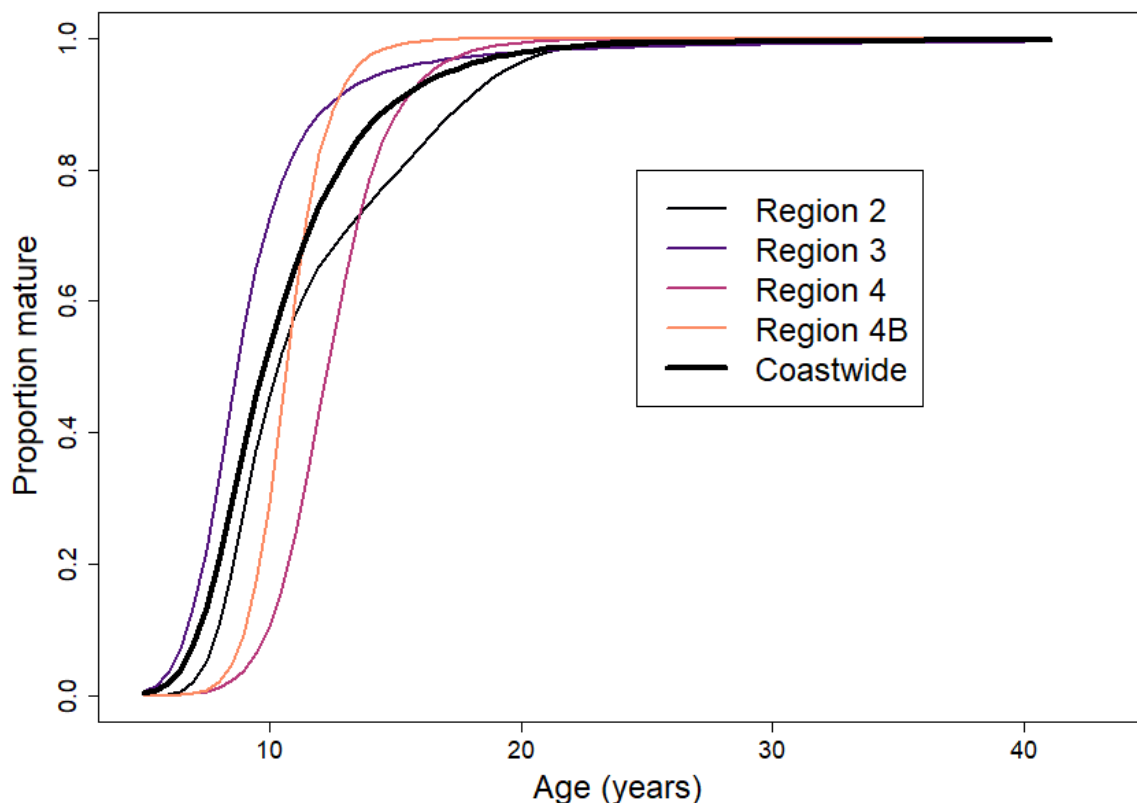


Figure 6. Coastwide maturity ogive generated from 2022-2024 average estimated regional abundance proportions (thick black line) and individual Biological Region ogives. Ogives shown without CI to better visualize differences between the coastwide and Biological Region ogives.

- 2.2. Calibration of historical visual maturity schedules using histology-based data. After creating a new coastwide maturity ogive using histology-based maturity estimates from 2022 to 2024, we investigated how visual maturity estimates have changed over the same timeframe. All females that we obtained a histology sample from also received a visual maturity estimate in the field. Using the same logistical GAM and methods used to create a coastwide ogive from the histology-based maturity data, we created a new coastwide visual maturity ogive (**Figure 7**, blue line).

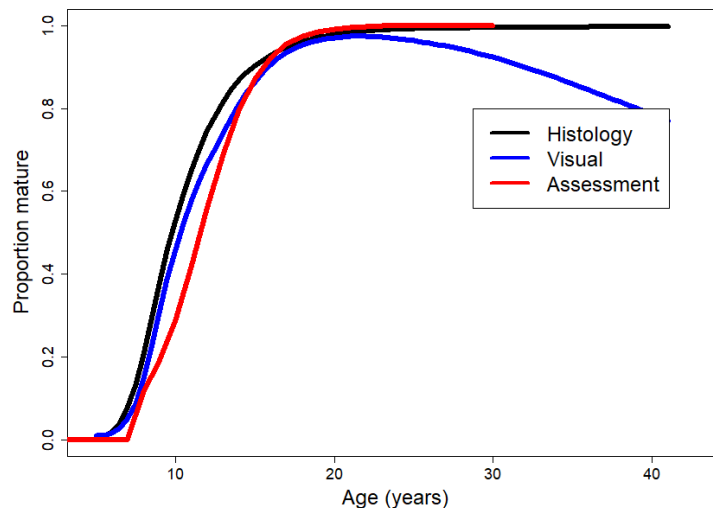


Figure 7. Coastwide maturity ogive generated from 2022-2024 average estimated regional abundance proportions using histological (black) and visual (blue) maturity estimation methods. The current coastwide ogive (red) used in stock assessment is shown for reference.

The A50 value of the 2022-2024 coastwide visual maturity ogive was calculated to be 10.3 years. When comparing the new coastwide visual ogive to the current SA ogive (**Figure 7**, red line), a shift to the left is observed, with a higher proportion of mature females observed between the ages of 8 to 13 years. The drop in the proportion of mature females for older individuals in the new visual maturity ogive was caused by two older females (25-30 years old) that were visually classified as immature in the field.

The IPHC Secretariat has visual maturity assessment data from the FISS going back to 2002 with ages determined using the current break-and-burn ageing method. To create a time series consistent with the more accurate histological assessments, we first developed a calibration between histological and visual maturity curves from the 2022-2024 data. Just as maturity curves are estimated for each Biological Region, we estimated separate calibration factors for each region. It is possible that differences between visual and histological assessments vary with time, due to observer differences and to other factors. This is something we can examine as we collect histological data over a greater number of years, although our ability to account for such factors when calibrating historical curves could be limited.

Coastwide maturity curves by year estimated from visual maturity assessment data are shown in **Figure 8**. Each curve was estimated using three-year rolling data windows,

e.g., the 2003 curve is estimated from 2002-2004 data. Three years is the minimum timeframe that ensures that there are data in all Biological Regions within each rolling window. For the ends of the visual assessment time series, i.e. 2002 and 2024, where the three-year data window includes years with no observations (2001 or 2025), we expanded the window to ensure that three years of data were included in the analysis. This indicates that the logistic GAM models for 2002 and 2003 use the same data (from 2002-2004), as is the case for 2023 and 2024 (data from 2022-2024). Corresponding calibrated curves are shown in **Figure 9**. To obtain a final coastwide calibrated visual maturity ogive for the 2002-2024 time series, we averaged across all three-year rolling data windows (i.e. 2002-2004, 2003-2005, 2004-2006, etc.). This is depicted with the mean calibrated visual ogive shown in **Figure 10** (black line).

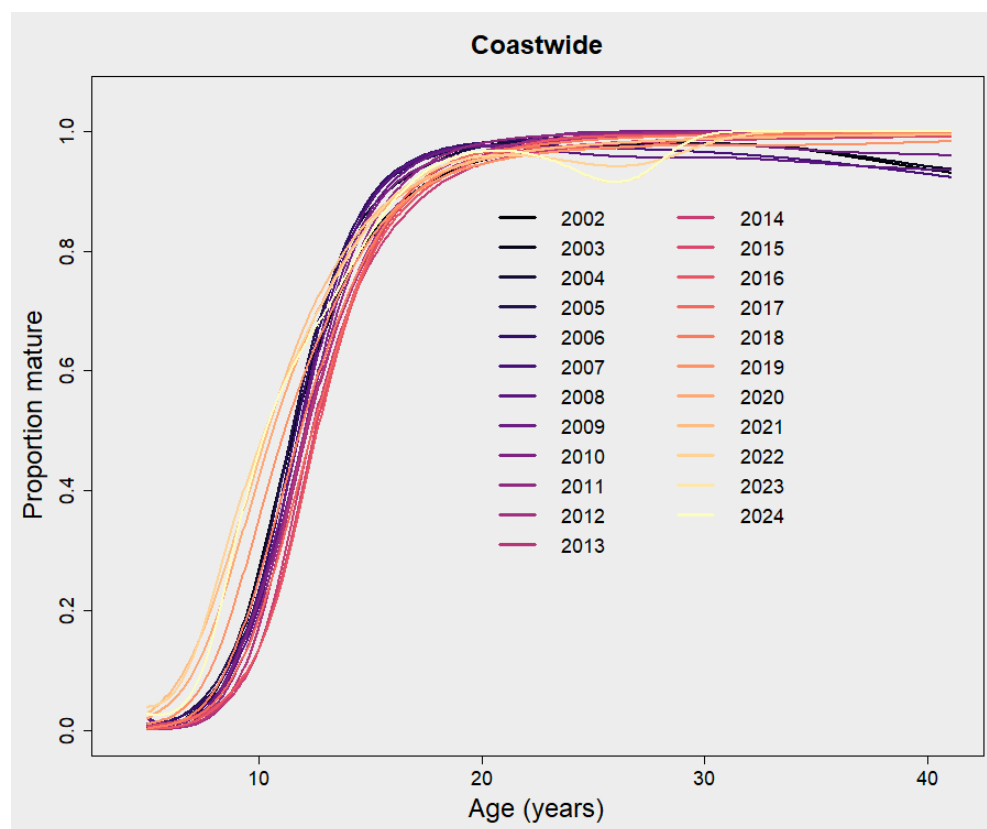


Figure 8. Estimated maturity ogives as a function of age based on visual maturity assessment data from rolling three-year data windows from 2002-2024.

When comparing the new coastwide calibrated visual maturity ogive to the current ogive used in the SA, the curve shifted slightly to the left from ages 8-15 (**Figure 10**, overlapping black and green lines). The calibrated visual ogive has a calculated A50 of 11.0 years, lower than the A50 value of 11.6 from the current SA ogive (red line) and

indicates a slight decrease in the proportion of mature females from ages 15-20 years. These shifts in the maturity curves are to be expected as the histology-based data provide a better indicator of younger maturing females, but also older immature females. It is important to note that these maturity ogives do not offer a direct comparison, given that the current SA ogive is based on visual estimates exclusively from IPHC Regulatory Areas 2B and 3A, whereas the new calibrated ogive incorporates data from all four Biological Regions. For input into the SA, we truncated the new calibrated ogive at age 7 years (**Figure 10**, green line) as histology-based maturity estimations did not find females < 7 years old that were mature. Previous maturity ogives using visual estimates truncated the curve at age 8 years.

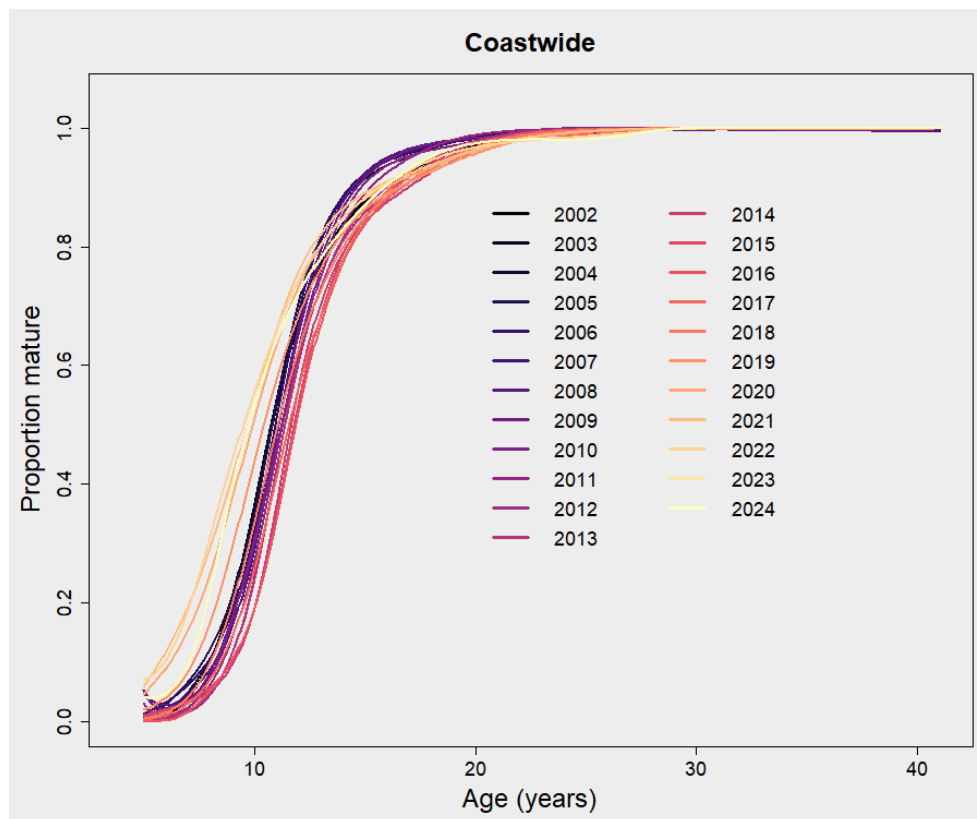


Figure 9. Estimated maturity ogives as a function of age calculated by applying the estimated calibration factors to the curves estimated from visual maturity assessment data from Figure 8.

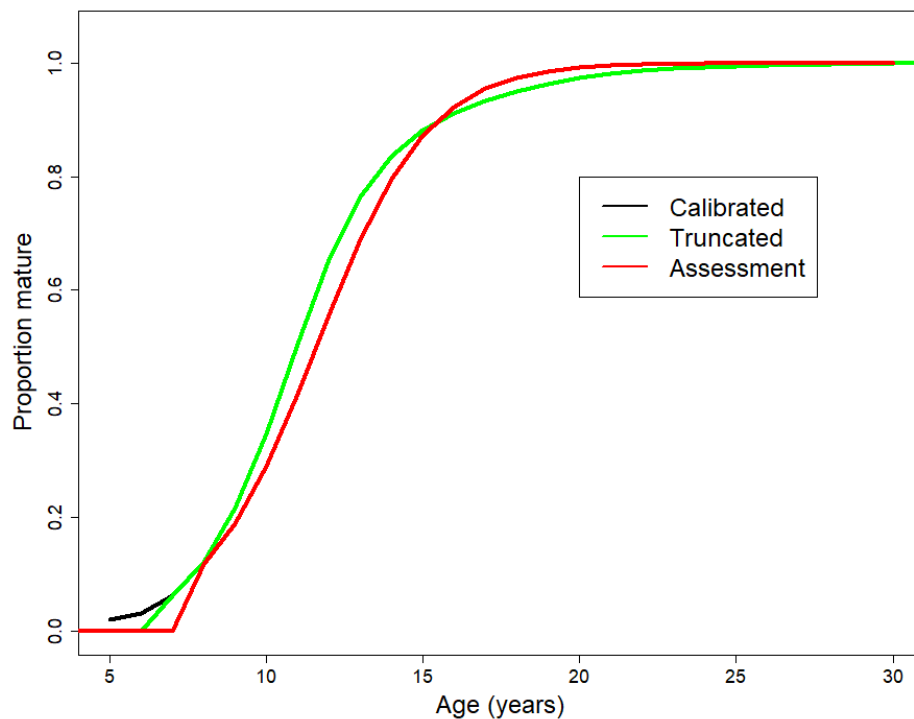


Figure 10. Estimated mean calibrated visual maturity ogive (black) with same ogive overlaid but truncated to zero at age 7 (green). Current coastwide ogive (red) used in stock assessment shown for reference.

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

3. Fishing Technology.

The IPHC Secretariat has determined that research to provide the Pacific halibut fishery with tools to reduce whale depredation is considered a high priority. This research is now contemplated as one of the research areas of high priority within the 5-year Program of Integrated Research and Monitoring (2022-2026).

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

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

This project focuses on investigating strategies aimed at protecting longline-caught fish, through low cost, easy to adopt gear modifications that securely retain catch, while breaking the 'reward cycle' in depredation. 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 11A**) and 2) a branch gear with a sliding shroud system.

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 11**). 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.

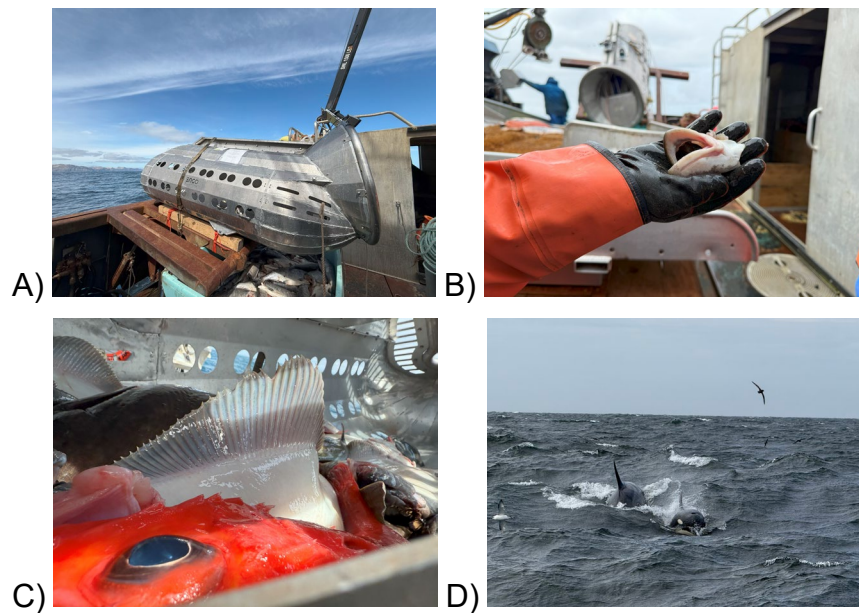


Figure 11. A) Shuttle device in transport. B) Typical evidence (lips only) of depredation. C) Catch entrained within the shuttle. D). Killer whales rapidly approaching the hauling site.

Preliminary comparisons of data from 10 sets with completed video review show good entrainment for Pacific halibut, but high escapement for sablefish (**Table 1**). Species

morphology is the predominant reason for this and simple modifications to the entry tines and to the snugness of stopper fit should easily achieve much higher retention rates.

Common Name	Encountered	Excluded	Entered	Escaped	Passed Through	Entrained
Pacific halibut	89	1 (1.1%)	88	0	8 (9.1%)	80 (90.9%)
Sablefish	160	2 (1.3%)	158	45 (28.5%)	30 (19.0%)	83 (52.5%)
Pacific cod	124	3 (2.4%)	121	13 (10.7%)	6 (5.0%)	102 (84.3%)
Rockfish	16	7 (43.8%)	9	2 (22.2%)	1 (11.1%)	6 (66.7%)
Skate	18	3 (16.7%)	15	0	2 (13.3%)	13 (86.7%)

Table 1. Numbers of fish encountered by the shuttle device that are either excluded, entered, escaped, passed through still on the hook, and/or finally entrained on 10 of 15 sets with video footage analyzed to date.

The shuttle was deployed across two skates of gear (200 hooks). Catch rate (numbers of fish) comparisons (**Figure 12**) between the control gear and the shuttle demonstrated capacity for good entrainment by the shuttle, but with variable rates overall between sets.

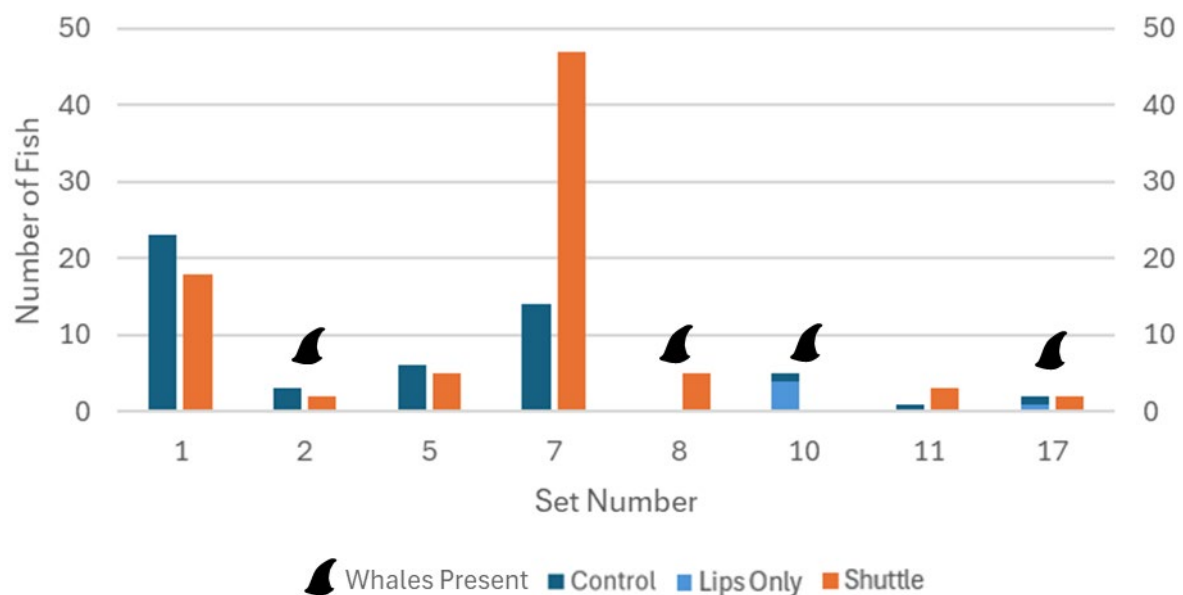


Figure 12. Preliminary catch rates for sets with paired shuttle and control gear where Pacific halibut were captured.

Video review and data analysis are ongoing. Field trials during a quota fishing trip are currently underway in the Bering Sea to provide additional metrics of the device under typical commercial fishing conditions.

RECOMMENDATION/S

- 1) That the RAB **NOTE** IPHC-2025-RAB026-06, 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
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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	Reproduction	Distribution
	Establishment of temporal and spatial maturity and spawning patterns	Improve simulation of recruitment variability and parametrization of recruitment distribution in the Operating Model		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	Bycatch Reduction Engineering Program-NOAA	Full scale testing of devices to minimize whale depredation in longline fisheries (NOAA Award Number NA23NMF4720414)	IPHC	Alaska Fisheries Science Center-NOAA	\$199,870	November 2023 – April 2026	Fishing technology	Mortality estimations due to whale depredation	3
2	Alaska Sea Grant (pending award)	Development of a non-lethal genetic-based method for aging Pacific halibut (R/2024-05)	IPHC APU	Alaska Fisheries Science Center-NOAA (Juneau)	\$60,374	January 2025-December 2026	Population dynamics	Stock structure	2
Total awarded (\$)					\$260,244				