TSC Agency Reports – IPHC 2020

Contents

I. Agency Overview

Management of the Pacific halibut resource and fishery has been the responsibility of the International Pacific Halibut Commission (IPHC) since its creation in 1923, see Figure 1 for a map of the Convention Area. Assessing, forecasting, and managing the resource and fishery requires accurate assessments, continuous monitoring, and research responsive to the needs of managers and stakeholders. The fishery for Pacific halibut (*Hippoglossus stenolepis*) is one of the most valuable and geographically largest in the northeast Pacific Ocean. Industry participants from Canada and the United States of America have prosecuted the modern fishery and have depended upon the resource since the 1880s. Annual removals have been as high as 100 million pounds, and the long-term average of removals is 64 million pounds.

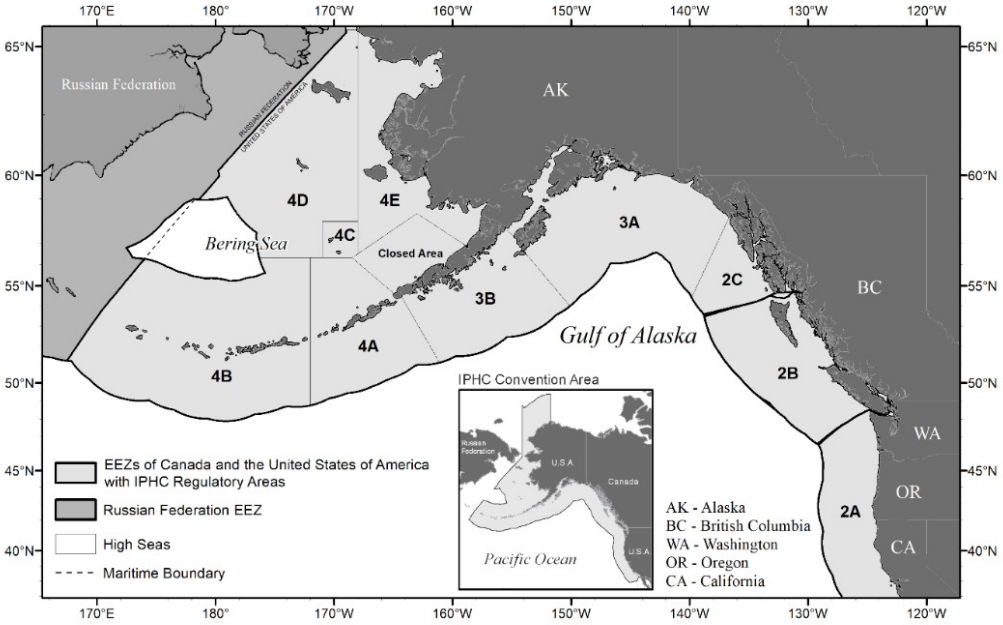

Figure 1. Map of the IPHC Convention Area and IPHC Regulatory Areas.

Staffing Updates: see https://www.iphc.int/locations/map

II. Fishery-Independent Setline Survey (FISS)

BACKGROUND

The International Pacific Halibut Commission's (IPHC's) fishery-independent setline survey (FISS) provides catch information and biological data on Pacific halibut (*Hippoglossus stenolepis)* that are collected independently of the commercial fishery. These data, which are collected using standardized methods, bait, and gear during the summer of each calendar year, provide an important comparison with data collected from the commercial fishery. The commercial fishery is variable in its gear composition and distribution of fishing effort over time, and presents a broad spatial and temporal sampling of the stock. Pacific halibut biological data collected on the FISS (e.g. the size, age, and sex composition) are used to monitor changes in biomass, growth, and mortality in adult and sub-adult components of the Pacific halibut population. In addition, records of non-target species caught during FISS operations provide insight into bait competition, rate of bait attacks, and serve as an index of abundance over time, making them valuable to the assessment, management, and avoidance of non-target species.

For details on FISS work conducted in 2019, please refer to the following paper: IPHC Fishery-Independent Setline Survey (FISS) design and implementation in 2019

III. Reserves – N/A

IV. Review of Agency Groundfish Research, Assessment, and Management

A. Pacific halibut and IPHC activities

1. Research

The primary biological research activities at the IPHC that follow Commission objectives and selected for their important management implications are identified and described in the Five-Year Research Plan for the period 2017-21:

Overview of research activities in 2019 and planned for 2020

1. Migration. Knowledge of Pacific halibut migration throughout all life stages is necessary in order to gain a complete understanding of stock distribution and the factors that influence it.

1.1. Larval distribution and connectivity between the Gulf of Alaska and Bering Sea. The IPHC Secretariat, in collaboration with AFSC NOAA EcoFoci Group, has recently completed a study investigating the level of early-life stage connectivity of Pacific halibut between the Gulf of Alaska and the Bering Sea. Two year classes, 2005 and 2009, were chosen as the primary focus of this project based on the fact that these represented relatively large and weak year classes, and "warm" and "cold" environmental regimes in the Bering Sea, respectively. Additional "warm" and "cold" years were added to the larval advection modeling component to study the environmental linkage. Larval advection modeling produced information about dispersal pathways and degree of connectivity between spawning and settlement grounds both within and between the Bering Sea and Gulf of Alaska. Results suggest that up to half of the larvae spawned in the western Gulf of Alaska have the potential to be advected into the Bering Sea through Unimak Pass, AK. While Bering Sea environmental regime did not appear to strongly correlate to region of larval delivery in the Bering Sea, there was annual variation. Application of the IPHC-developed space-time model was used to assess distribution of young fish from 2-6 years old as they move away from the settlement grounds. Dispersal is widespread with young Pacific halibut moving further offshore and to deeper depths as they age. A portion of the young fish, especially evident when modeling the 2009 cohort due to higher densities, appeared to move out of Bristol Bay southward along the Alaska Peninsula, arriving at Unimak Pass within 2-3 years. Results from this project provide a new understanding of linkages between spawning grounds, eventual settlement, and subsequent migration of young fish, as well as variability in these pathways under different environmental scenarios.

1.2. Wire tagging of U32 Pacific halibut. Wire tagging of Pacific halibut caught in the NOAA/NMFS trawl surveys, which began in 2015, was continued in 2019. In 2019, 963 and 811 Pacific halibut were tagged in the Bering Sea and Gulf of Alaska, respectively. The wire tagging effort of U32 Pacific halibut that has taken place during the IPHC's FISS in recent years was not implemented in 2019 due to work load commitments on the surveys. However, through 2019, 10,770 U32 Pacific halibut had been wire tagged and 110 of those have been recovered to date.

1.3. Electronic archival tagging. In 2019, as part of a collaborative research project with the Norton Sound Economic Development Corporation (NSEDC) and the University of Alaska Fairbanks, Pacific halibut were tagged in the eastern Bering Sea shelf with pop-up archival satellite (PAT) tags. Pacific halibut (U32 and O32) were tagged in the Norton Sound and St.

Lawrence Island regions (n = 56). The PAT 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 site fidelity versus emigration); and summer of 2021 (examining longer-term dispersal). Tags provided by the IPHC were used to tag relative small fish (i.e., 70-90 cm) and were accompanied by tagging of large (>100 cm) Pacific halibut using tags that were purchased by NSEDC. This is designed to produce data that are comparable to the IPHC's prior PAT-tagging research that was conducted to examine adult connectivity and spawning stock structure throughout the managed range, while expanding the work to examine considerably broader stock demographics than any prior electronic archival tagging experiment.

2. Reproduction. Efforts at IPHC are currently underway to address two critical issues in stock assessment for estimating the female spawning biomass: the sex ratio of the commercial landings and maturity estimations.

2.1. Sex ratio of the commercial landings. For the first time, the IPHC has generated sex information of the entire set of aged commercial landings in 2017 and 2018. Genetic assays developed in collaboration with the University of Washington have been conducted at the IPHC biological laboratory using a QuantStudio6 instrument. Fin clips from over 10,000 aged Pacific halibut collected coastwide by IPHC port samplers in 2017 were genotyped and the results indicated that commercial landings were 82% female coastwide. A similar number of tissues from commercial landings collected in 2018 have been genotyped and the results indicate that landings were 81% female coastwide, consistent with the results from the previous year. Plans are underway to genotype the entire set of aged commercial samples collected in 2019 and, therefore, the sex ratio data from commercial landings will be available for three consecutive years (2017, 2018 and 2019). The sex ratio data of the commercial landings are currently being used in stock assessment.

2.2. Maturity estimations. In order to characterize the gonadal maturation schedule, the IPHC is conducting a full characterization of the annual reproductive cycle in female and male Pacific halibut. Biological samples (gonads, blood, pituitary, otolith, fat content) were collected at monthly intervals from female (N=30) and male (N=30) Pacific halibut captured from the Portlock region in the central Gulf of Alaska throughout an entire calendar year, from September 2017 until August 2018. Formalin-fixed gonadal samples were processed for histology in early 2019 and duplicate histological slides for each sampled Pacific halibut gonad (N = 360 per sex) were stained with Hematoxylin and Eosin and are now available for staging. We have completed the analysis of the temporal progression of the four maturity classification stages (macroscopic) used for staging females in the IPHC FISS and of the gonadosomatic index (gonad weight/round weight x 100; GSI) as well as the hepatosomatic index (liver weight/round weight x 100; HSI) for both females and males. In addition, we have described the four maturity classification stages in relation to the GSH and the HSI and established criteria for the classification of the different oocyte developmental stages that is critical for accurate staging. In addition to characterizing the progression of reproductive development throughout an entire annual reproductive cycle (intraseasonal) reproductive samples, the IPHC collected samples in June 2019 in the Portlock region to compare with those collected in the same location in June 2018 and June 2017 in order to evaluate possible differences in interseasonal variation in maturity schedules. Ovarian samples from these three years have been processed for histology and are in the process of being analyzed. In order to determine whether there are spatial differences in maturity schedules, ovarian samples will

be collected during the 2020 FISS season from a number of collection areas corresponding to the four biological regions.

3. Growth. In order to improve our understanding of the possible role of growth alterations in the observed historical changes in size-at-age in Pacific halibut, the IPHC Secretariat is conducting studies aimed at: 1) the identification and validation of physiological markers for growth; and 2) the use of growth markers for evaluating growth patterns in the Pacific halibut population and the effects of environmental influences. The IPHC Secretariat is conducting investigations on the effects of temperature variation on growth performance, as well as on the effects of density, hierarchical dominance and handling stress on growth in juvenile Pacific halibut in captivity. These studies are partially funded by a grant from the North Pacific Research Board #1704 to the IPHC and the results on the effects of temperature on growth physiological indicators are being prepared for publication in a peer-reviewed journal.

4. Discard Mortality Rates (DMRs) and Survival Assessment. In order to better estimate post-release survival of Pacific halibut caught incidentally in the directed longline fishery, the IPHC Secretariat is conducting investigations to understand the relationship between fish handling practices and fish physical and physiological condition and survival post-capture as assessed by tagging. These studies are partially funded by a grant from the Saltonstall-Kennedy Grant Program NOAA to IPHC (NA17NMF4270240) and conducted as depicted in the workflow shown below:

4.1. Evaluation of the effects of **hook release techniques** on injury levels and association with the physiological condition of longline-caught Pacific halibut. The IPHC has evaluated the effects of different release techniques on injury levels (Figure 5) and the results indicate that a majority (more than 70%) of Pacific halibut released by careful shake and by gangion cutting are classified in the excellent injury category. In contrast, Pacific halibut that encounter the hook stripper are primarily classified in the medium and poor injury categories. The physiological condition of Pacific halibut subjected to the different hook release techniques is currently being assessed by relating the injury category assigned to each fish with the condition factor, fat levels and levels of blood stress indicators.

4.2. Post-release survival estimations of longline-caught Pacific halibut. In order to evaluate the survival of discarded fish, two types of tagging approaches were used. 1) Classical mark-and-recapture of released fish with wire tags: 1,027 fish (under 33 inches in length) were tagged. 2) Biotelemetric monitoring of released fish with the use of satellite-transmitting electronic archival tags equipped with accelerometers: results from a total of 79 Pacific halibut ranging from 53-81 cm FL allowed us to estimate that the DMR of U32 Pacific halibut that were categorized as being in excellent-condition at the time of their release was approximately 4%.

4.3. Application of electronic monitoring (EM) for capturing the hook release methods in the longline fishery. Evaluation of EM data whereby reviewers recorded the release method and condition of released fish evidenced a high degree (95%-100%) of agreement between the

actual release method used and that captured by EM. Therefore, once the survival estimates of fish released by the different hook release techniques are determined, these results strongly suggest that mortality rates could be deduced from EM-captured hook release techniques.

4.4. Discard mortality rates of Pacific halibut in the charter recreational fishery. The IPHC has initiated in 2019 a research project aimed at experimentally deriving DMRs from the charter recreational fishery for the first time. This project has received funding from the National Fish and Wildlife Foundation (Project # 61484). As an initial step in this project, information from the charter fleet on types of gear and fish handling practices used was collected through stakeholder meetings and on dock interviews with charter captains and operators. This information will inform the design of the experimental test fishing that will take place in 2020 and in which fish mortality will be estimated as described in 4.2.

5. Genetics and genomics. The IPHC Secretariat is exploring avenues for incorporating genetic approaches for a better understanding of population structure and distribution and is also building genomic resources to assist in genetics and molecular studies on Pacific halibut.

5.1. Genetics. 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. Three specific topics will be investigated:

5.1.1. *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. 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.

5.1.2. *Analysis of genetic population structure in IPHC Regulatory Area 4B***.** 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 (i.e., pre-2010) analyses of genetic population structure that failed to demonstrate significant differentiation in the eastern Pacific. However, more recent studies have reported significant genetic population 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 was suggested, with the caviat that genetic analyses were conducted using tissue samples collected in the summer (i.e. non-spawning season) west of Amchitka Pass and it is questionable whether they were truly representative of the local spawning population. The IPHC will begin re-evaluating the suggested structure of the Western Aleutian stock with spawning samples

that were successfully collected in early 2020 from spawning fish on either side of Amchitka Pass by an IPHC-funded research charter.

5.1.3. *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. With the genetic samples that were successfully collected in the winter of 2020, together with winter samples collected in the Portlock area (i.e. central Gulf of Alaska) in 2018 and in Haida Gwaii in 2004 and in the Bering Sea (i.e. Pribilof Canyon) in 2004, we plan on establishing genetic signatures of these spawning groups to revise the genetic population structure by whole genome resequencing.

5.2. Genomics. The IPHC Secretariat has recently completed generating a first draft sequence of the Pacific halibut genome in collaboration with the French National Institute of Agricultural Research (INRA, Rennes, France) and the School of Aquatic and Fishery Science of the University of Washington (Seattle, WA). This effort produced a high-quality chromosome-level assembly that revealed a genome of approximately 600 Mb in size and comprised into 24 chromosome pairs. In addition to genome sequencing, the IPHC Secretariat has completed transcriptome sequencing of a wide variety of tissues (N=13) in Pacific halibut including white and red skeletal muscle, liver, heart, ovary, testis, head kidney, brain, gill, pituitary, spleen and retina. Current plans regarding this extensive transcriptomic dataset include generating a reference transcriptome for the species and to create a user-friendly, searchable database to be made public in the IPHC website.

Other ongoing data collection projects

In addition to specific research projects, the IPHC collects data each year through ongoing data collection projects that are funded separately, either as part of the FISS or as part of the commercial fishery data collection program. Ongoing data collections projects include the following:

IPHC FISS

The IPHC FISS provides catch-rate information and biological data on Pacific halibut that are independent of the commercial fishery. These data, which are collected using standardized methods, bait, and gear during the summer of each year, provide an important comparison with data collected from the commercial fishery, and serve as the primary index of abundance, through the use of a spatio-temporal model (https://www.iphc.int/uploads/pdf/am/2020am/iphc-2020-am096-07.pdf) for the annual stock assessment.

Biological data collected on the FISS (e.g., the size, age, and sex composition of Pacific halibut) are used to monitor changes in biomass, growth, and mortality in adult and sub-adult components of the Pacific halibut population. In addition, records of non-target species caught during FISS operations provide insight into bait competition, rate of bait attacks, and serve as an index of abundance over time, making them valuable to the assessment, management, and avoidance of non-target species.

The Commission has conducted the FISS in selected areas during most years since 1963. The majority of the current FISS station design and sampling protocols have been consistent since 1998.

Environmental data collection aboard the IPHC FISS using water column profilers

PIs: Lauri Sadorus, Jay Walker

The IPHC collects oceanographic data using water column profilers during the IPHC FISS. The profilers collect a suite of oceanographic data, including pressure (depth), conductivity (salinity), temperature, dissolved oxygen, pH, and fluorescence (chlorophyll concentration). The IPHC has operated profilers since 2000 on a limited basis, and coastwide since 2009.

IPHC aboard National Marine Fisheries Service groundfish trawl surveys in the Gulf of Alaska, Bering Sea, and Aleutian Islands

PI: Lauri Sadorus

The National Oceanic and Atmospheric Administration (NOAA) Fisheries has conducted annual bottom trawl surveys on the eastern Bering Sea continental shelf since 1979 and the IPHC has participated in the survey on an annual basis since 1998 by directly sampling Pacific halibut from survey catches. The IPHC has participated in the NOAA Fisheries Aleutian Islands trawl survey, which takes place every two years, since 2012. Alternating year by year with the Aleutian Islands trawl survey is the NOAA Fisheries Gulf of Alaska trawl survey, which IPHC has participated in since 1996. The IPHC uses the NOAA Fisheries trawl surveys to collect information on Pacific halibut that are not yet vulnerable to the gear used for the IPHC FISS or commercial fishery, and as an additional data source and verification tool for stock analysis. In addition, trawl survey information is useful as a forecasting tool for cohorts approaching recruitment into the commercial fishery.

Commercial fishery sampling program

The IPHC positions field staff to sample the commercial landings for Pacific halibut in Alaska, British Columbia, Washington, and Oregon. Sampling of commercial landings involves collecting Pacific halibut otoliths, tissue samples, fork lengths, weights, logbook information, and final landing weights.

The collected data are used in the stock assessment and other research and the collected otoliths provide age composition data and the tissue samples provide sex composition. Lengths and weight data, in combination with age data and sex data, provide size-at-age analyses by sex. Mean weights are combined with final landing weights to estimate catch in numbers. Logbook information provides weight per unit effort data, fishing location for the landed weight, and data for research projects. Finally, tags are collected to provide information on migration, exploitation rates, and natural mortality.

In addition to sampling the catch, other objectives include collecting recovered tags, and copying information from fishing logs along with the respective landed weights, for as many Pacific halibut trips as possible throughout the entire season.

2. Assessment

The 2019 stock assessment represented a full analysis, after several years of updates, including both internal Scientific Review Board and external peer review (https://www.iphc.int/management/science-and-research/stock-assessment). The assessment produced the following scientific advice regarding the Pacific halibut stock:

1. Fishing intensity: The 2019 mortality corresponded to a point estimate of SPR = 42%; there is a 59% chance that fishing intensity exceeded the IPHC's reference level of 46%. The Commission does not currently have a coastwide fishing intensity limit reference point, making it difficult to determine if current levels of fishing intensity are consistent with the interim harvest strategy policy objectives. However, given the TAC set for 2020 is projected to produce an SPR of 42%, consistent with the range identified by the IPHC's Management Strategy Evaluation process as meeting coastwide conservation and fishery objectives, on the weight-of-evidence, the stock is classified as **not subject to overfishing**.
2. Spawning biomass: Female spawning biomass at the beginning of 2020 was estimated to be 194 million pounds (87,856 t), which corresponds to an 46% chance of being below the IPHC trigger reference point of $SB_{30\%}$, and less than a 1% chance of being below the IPHC limit reference point of $SB_{20\%}$. The stock is estimated to have been declining since 2016 and is currently at 32% of the unfished state. Therefore, the stock is considered to be '**not overfished**'.
3. Outlook: The stock is projected to decrease with at least a 51% chance over the period from 2021-23 for all mortality levels greater than 18.4 million pounds (~8,350 t), corresponding to a projected SPR of 63% due to reduced low recruitment estimated for 2006-2010. At the reference level of fishing intensity (a projected SPR of 46%) the probability of spawning biomass decline to 2021 is 89%, decreasing to 75% in three years, as the 2011 and 2012 cohorts mature.

For more information on the 2019 stock assessment and the fishery status, as well as the harvest decision table indicating levels of risk associated with various levels of removals, please refer to papers IPHC-2020-AM096-08 and IPHC-2020-AM096-09 at the IPHC website.

3. Management

The International Pacific Halibut Commission (IPHC) completed its 96th Annual Meeting (AM095) in Anchorage, Alaska, United States of America, on 7 February 2020, with Mr. Chris Oliver of the United States of America presiding as Chairperson. More than 200 Pacific halibut industry stakeholders attended the meeting, with over 140 more participating via the web. All of the Commission's public and administrative sessions during the meeting were open to the public and broadcast on the web. Documents and presentations from the Annual Meeting are available on the Annual Meeting page on the IPHC website: https://www.iphc.int/venues/details/96th-session-of-the-iphc-annual-meeting-am096. Decisions arising from this meeting, including management decisions, are documented in the following report: Report of the 96th Session of the IPHC Annual Meeting (AM096)

Other Actions

Harvest Strategy Policy: https://www.iphc.int/the-commission/harvest-strategy-policy

The Commission provided direction to the IPHC Secretariat and the Management Strategy Advisory Board (MSAB) for further work on harvest strategy policy development, noting that scale and distribution components will be evaluated and presented no later than at the 97th Annual Meeting (AM097) in 2021, for potential adoption and subsequent implementation as a harvest strategy.

V. Ecosystem Studies

[See the description of "Environmental data collection aboard the IPHC FISS using water column profilers" in the Research section on ongoing IPHC data collection projects above.]

VI. Publications

International Pacific Halibut Commission. 2019. Annual Report 2019. https://www.iphc.int/uploads/pdf/ar/iphc-2019-annual-report.pdf